Appendix O
Plan Formulation

Fargo-Moorhead Metropolitan Area Flood Risk Management

Final Feasibility Report and Environmental Impact Statement

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US Army Corps of Engineers ®

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APPENDIX O
PLAN FORMULATION

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1.0 INTRODUCTION

Appendix O describes the planning process used during the Fargo-Moorhead Metropolitan Area Flood Risk Management Feasibility Study. It documents the major activities performed, assumptions made and conclusions drawn during the various phases of the study.

1.1 TEAM DEFINITIONS

1.1.1 Project delivery team (PDT): the team directly responsible for conducting the study and preparing the feasibility report and environmental impact statement. The PDT includes staff from the St. Paul District Corps of Engineers, the non-federal sponsors, and the Corps Non-structural Flood-Proofing Committee as well as private-sector contractors hired to assist with the project.

1.1.2 Vertical team: the Corps staff at the Mississippi Valley Division office and Headquarters who are responsible for oversight and policy review.

1.1.3 Agency Technical Review (ATR) team: an independent team responsible for conducting technical review of the study products. The ATR team includes Corps staff primarily from Omaha District and the Corps Cost Engineering Directory of Expertise who were not directly involved in preparation of the study products.

1.1.4 Independent External Peer Review (IEPR) panel: a panel of technical experts independent of the Corps of Engineers who are responsible for conducting an independent external peer review as required by Section 2034 of the Water Resources Development Act of 2007.

1.1.5 Metropolitan Flood Management Committee: the combined elected bodies for Fargo and Cass County, North Dakota and Moorhead and Clay County, Minnesota.

1.1.6 Metro Flood Study Work Group (MFSWG): a work group formed to advise the Metropolitan Flood Management Committee regarding flood-related issues. The MFSWG consisted of two representatives from each of the elected bodies for Fargo and Cass County, North Dakota and Moorhead and Clay County, Minnesota plus one representative from the Buffalo-Red River Watershed District in Minnesota and one from the Cass County Water Resource District in North Dakota.

1.2 PLANNING POLICY

The U.S. Army Corps of Engineers conducts planning efforts in accordance with the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, established by the Water Resources Council in 1983. These principles and guidelines, referred to as the "P&G," establish federal water resource planning policy for the Corps, Bureau of Reclamation, Tennessee Valley Authority, and the Natural Resources Conservation Service (formerly Soil Conservation Service).

Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, defines the specific planning policies of the Corps of Engineers based upon the P&G. The Corps has published several other ERs, guidance letters and engineering circulars pertinent to specific aspects of planning and project implementation.

Federal planning efforts must comply with federal laws including the National Environmental Policy Act (NEPA) and the Clean Water Act. The Corps must also comply with applicable executive orders such as EO 11988, Floodplain Management.

1.3 PLANNING PROCESS

The Corps' planning process consists of six major steps:

(1) Specification of water and related land resources problems and opportunities
(2) Inventory, forecast and analysis of water and related land resources conditions within the study area
(3) Formulation of alternative plans
(4) Evaluation of the effects of the alternative plans
(5) Comparison of the alternative plans
(6) Selection of the recommended plan based upon the comparison of the alternative plans

The six steps are presented in a linear fashion, but the actual planning process is not linear. In fact, the six steps are applied in several iterations over time as more information is developed to inform the process. Early iterations focus on defining the problems and assessing the existing conditions while also exploring possible solutions. Later iterations focus on formulation, evaluation and comparison of alternative actions, but they still seek to clarify the problems and expected future conditions.

This appendix explains how the planning process was applied in the Fargo-Moorhead Metro feasibility study.

1.4 STUDY GOALS

The Project Delivery Team along with the non-federal sponsors developed the following study goals:

1) To understand the flood problems in the greater Fargo-Moorhead Metropolitan area and develop a regional system to reduce flood risk.
2) To determine the Federal Government's role in implementing flood risk reduction measures in Fargo-Moorhead.
3) To document study findings in a Feasibility Report and appropriate National Environmental Policy Act (NEPA) document (either an Environmental Assessment or an Environmental Impact Statement).
4) If appropriate, recommend implementation of a federal project to U.S. Congress.

1.5 NATIONAL PLANNING OBJECTIVES

The national or federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements. Contributions to national economic development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation.

The Corps has added a second national objective for Ecosystem Restoration in response to legislation and administration policy. This objective is to contribute to the nation's ecosystems through ecosystem restoration, with contributions measured by changes in the amounts and values of habitat.

1.6 PUBLIC CONCERNS

A number of public concerns were identified during the course of the study. Initial concerns were expressed in the Sponsors' study request. Additional input was received through coordination with the sponsors, coordination with other agencies, public review of draft and interim products, and through public meetings. The public concerns that are related to the establishment of planning objectives and planning constraints are as follows:

- Flooding and impacts to rural and urban infrastructure
- Potential for flood risk management measures employed in one place to increase flood stages or impact water quality elsewhere
- Desire for additional flood storage in the watershed
- Desire for wetland and grassland restoration in the watershed
- Desire for increased recreational opportunities in the study area
- Need to protect limited groundwater resources
- Need to protect riverine habitat and connectivity

1.7 PROBLEMS AND OPPORTUNITIES

The evaluation of public concerns reflects a range of needs and desires perceived by the public. This section describes these needs in the context of problems and opportunities that can be addressed through water and related land resource management. The problems and opportunities are based upon the without project conditions that are described in Chapter 3, Alternatives in the main report.

1.7.1 Problems

The primary problem identified in the study area is a high risk of flood damage to urban infrastructure from the Red River of the North, the Wild Rice River (ND), the Buffalo River, and the Sheyenne River and its tributaries, the Maple River, Lower Rush River and Rush River. Flooding also causes damage to rural infrastructure and agricultural land

and disrupts transportation and access to properties within the study area. The study area has estimated average annual flood damages of more than $194.8 million.

1.7.2 Opportunities

There are opportunities to increase and improve wildlife habitat in conjunction with measures to reduce flood risk. Wildlife habitat in the study area has been significantly altered by various human activities associated with conversion of native prairie for agricultural uses and urban development.

Flood risk reduction measures that involve land use changes could provide opportunities to increase recreation in conjunction with reducing flood risk.

1.8 PLANNING OBJECTIVES

The national objectives are general statements that are not specific enough for direct use in plan formulation; maximizing national economic development (NED) and restoring ecosystem functions are the overarching goals for this study. The water and related land resource problems and opportunities identified in this study must be stated as specific planning objectives to provide focus for the formulation of alternatives. These planning objectives reflect the problems and opportunities in the study area and represent desired positive changes from the future without-project conditions. The planning objectives are specified as follows:

- Reduce flood risk and flood damages in the Fargo-Moorhead metropolitan area.
- Restore or improve degraded riverine and riparian habitat in and along the Red River of the North, Wild Rice River (North Dakota), Sheyenne River (North Dakota), and Buffalo River (Minnesota) in conjunction with other flood risk management features.
- Provide additional wetland habitat in conjunction with other flood risk management features.
- Provide recreational opportunities in conjunction with other flood risk management features.

1.9 PLANNING CONSTRAINTS

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated. The planning constraints identified in this study are as follows:

- Avoid increasing peak Red River flood stages, either upstream or downstream
- Comply with the Boundary Waters Treaty of 1909 and other pertinent international agreements.
- Avoid negatively impacting the Buffalo Aquifer in Minnesota.
- Minimize loss of floodplain in accordance with Executive Order 11988, Floodplain management

1.10 STUDY PRODUCT

The product of the study is a decision document in the form of an integrated feasibility report and environmental impact statement. The report documents the information generated during the study and the recommendations of the Corps of Engineers. To be implementable as a federal project, a project must have the support of the non-federal sponsor(s) and a demonstrated federal interest in implementing the plan. To obtain federal authorization for a flood risk management project, the plan formulation process must adhere to laws, policies, and regulations that define the planning process.

1.11 NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

Federal policy requires that the feasibility study must identify the plan that reasonably maximizes net national economic development (NED) benefits consistent with protecting the environment. That plan, the "NED plan," establishes the baseline for federal cost sharing during implementation. A different plan that is more acceptable to the non-federal sponsor may be recommended as a "locally preferred plan" if it has positive net economic benefits and is approved by the Assistant Secretary of the Army for Civil Works (ASA(CW)). The non-federal sponsor would be responsible for all locally preferred plan implementation costs in excess of the federal share of the NED plan implementation costs.

2.0 PLANNING TIMELINE SUMMARY

This study was conducted in several phases beginning in June 2006. The major phases were as follows:

- Reconnaissance (June 2006-September 2008)
- Feasibility Phase 1 (September 2008-May 2009)
- Feasibility Phase 2
  - Screening #1 (May 2009-November 2009)
  - Screening #2 (November 2009-March 2010)
- Feasibility Phase 3 (March 2010-September 2010)
- Feasibility Phase 4 (September 2010-July 2011)

3.0 RECONNAISSANCE (Jun 2006 - Sep 2008)

Reconnaissance study efforts for the Fargo-Moorhead area were initiated at the request of the City of Fargo in a letter dated June 16, 2006. The letter requested that the Corps "conduct studies to determine the feasibility of developing a flood control project along 2nd Street from 5th Avenue North to 2nd Avenue South, and along 4th Street from 2nd to 10th Avenues South, under the authority provided by Section 205 of the 1948 Flood Control Act, as amended."

In discussions with staff of the cities of Fargo, North Dakota and Moorhead, Minnesota, it was agreed that the study should be expanded to include the entire metropolitan area and the surrounding region. Because of the increased scope, the study team opted to conduct the study as a specifically authorized study instead of using the Section 205

Continuing Authority, as requested. The Red River of the North Reconnaissance Study approved in September 2002 and conducted under the authority of a September 30, 1974 resolution of the Senate Committee on Public Works allowed for supplemental 905(b) analyses to be prepared as needs arose in the basin. This was the authority selected for the Fargo-Moorhead reconnaissance effort.

The reconnaissance study received funding in April 2007 and was conducted between June 2007 and April 2008. The primary problem identified in the study area was flooding. The reconnaissance study evaluated relatively short segments of levee/floodwall in both Fargo and Moorhead. The study determined that at least one reach of levee could be economically justified, so there was federal interest in conducting a cost-shared feasibility study. The study also recommended that the feasibility study consider larger potential solutions that could benefit the entire region.

4.0 FEASIBILITY PHASE 1 (Sep 2008 – May 2009)

4.1 PHASE 1 ACTIVITIES

The feasibility study began on September 22, 2008 with the execution of a feasibility cost share agreement between the Corps of Engineers and the cities of Fargo, North Dakota and Moorhead, Minnesota. Public meetings were held in November 2008 to make the public aware of the study and to solicit information about the problems, opportunities, and range of potential solutions developed during the reconnaissance study. The first phase of study was scoped to be a low-detail assessment of the future without project condition and two primary regional flood risk management concepts: a levee/floodwall system and a diversion channel system. The intent was to assess the potential viability of these two concepts before investing substantial resources in a full feasibility level of detail for the full array of measures identified in the reconnaissance phase. The work of this phase was dominated by hydrologic, hydraulic and economic analyses, although geotechnical investigations and consideration of non-structural measures were also begun. The record-setting flood of 2009 occurred near the end of this phase of study, which keenly increased public and political interest in the results. A feasibility scoping meeting (FSM) was held on May 19, 2009 with Corps Mississippi Valley Division and Headquarters staff. Public meetings were held on May 19-20, 2009 to share the initial findings and request public input on the range of potential alternatives and impacts.

4.2 PHASE 1 REVIEW AND COORDINATION

4.2.1 <u>Agency Technical Review</u>

Prior to the Feasibility Scoping Meeting (FSM) documentation was sent to the Agency Technical Review (ATR) team which consisted of Corps staff primarily from the Omaha District. The documents, which included: the main report, hydraulics appendix and preliminary HEC-RAS model, hydrology appendix, geotechnical appendix for credit to existing levees, and the economic appendix and preliminary HEC-FDA model; were provided to the ATR team on March 16, 2009. The review resulted in 106 comments. The PDT responded to most of the comments, but a number of the comments were left open, and the plan was to backcheck them upon review of the next draft report to be prepared for Alternative Formulation Briefing documentation.

4.2.2 Feasibility Scoping Meeting (FSM)

The Feasibility Scoping Meeting was held on May 19, 2009. The PDT and the Vertical Team discussed the preliminary planning efforts, the range of alternatives, and the proposed planning activities needed to complete the study. The results of the meeting were documented in a memorandum (See Attachment 1 - FSM Memo).

4.3 PHASE 1 KEY ASSUMPTIONS

4.3.1 Future without project assumptions

The future without project assumptions were key to the analysis and were discussed in the FSM documentation submitted to the ATR team and the vertical team. Comments from both the ATR and vertical teams addressed these assumptions. The key assumptions for this phase were:

- The city of Fargo's potential "Southside Flood Control Project" was assumed to not be in place as part of the future without project condition. This is consistent with guidance in IWR 88-R-2, National Economic Development Procedures Manual - Urban Flood Damage, Volume 1, Page VI-3, paragraph 6 which states: "If local action is planned to occur only as the result of no Federal action, the project should not be assumed as part of the "without" condition. Local interests should not be penalized for their own incentive."
- No credit was given to flood fights and emergency measures. The vertical team requested that a sensitivity analysis be completed in the future to provide the decision makers with this information.
- Climate change was not included in the Phase 1 analyses, although there appeared to be an increasing trend in both peak flows and flood frequency in recent decades. The vertical team agreed that it would be appropriate to use an expert opinion elicitation process to obtain recommendations on this topic and to use those recommendations.
- Loss of life was not considered as part of the initial economic analysis. The vertical team requested that a loss of life analysis be completed to supplement the Other Social Effects (OSE) account, but no dollar value was to be placed on the loss of life.

4.3.2 Hydrology

The hydrologic information used in Phase 1 was the best available data when the work began in 2008. It was based on earlier work done by the Corps after the 1997 flood. The Corps hydrology was different from the data used by the Federal Emergency Management Agency (FEMA) in updating flood insurance maps, because FEMA's flows were based upon an earlier administrative determination. Phase 1 hydrology did not include the 2009 flood, the flood of record at the Fargo gage, because it did not occur until after the initial analyses were under way

4.3.3 Hydraulic Modeling
Phase 1 hydraulic modeling was primarily steady-state HEC-RAS based on the most recent FEMA flood insurance study completed at the time.

4.4 PHASE 1 CONCLUSIONS

The preliminary study found that a levee system would cost approximately $625 million and have a benefit/cost ratio (BCR) of 1.0. The preliminary diversion concept without a control structure was estimated to cost $909 million and have a BCR of 0.65. The preliminary economic analyses estimated expected average annual flood damages at more than $64 million, with single event damages ranging from $2.1 billion for a 1-percent chance event to $6.6 billion for a 0.2-percent chance event. On the basis of the preliminary findings, the non-federal sponsors elected to continue the feasibility study.

5.0 FEASIBILITY PHASE 2, SCREENING #1 (May 2009 – Nov 2009)

5.1 PHASE 2, SCREENING #1 ACTIVITIES

5.1.1 General
Phase 2 considered the full array of potential measures to address flood risk in the study area. Coordination began in earnest with federal and state natural resource agencies regarding issues and concerns and potential ways to cooperate on the study. A notice of intent to prepare a draft environmental impact statement (EIS) was published in the Federal Register on May 5, 2009. The study team held public and agency meetings to solicit input on problems and opportunities, project scoping, affected resources and potential effects. A scoping document dated September 14, 2009 was prepared to summarize the potential alternatives and impacts to be considered during the remainder of the study.

In June and July 2009, the Fargo City Commission and Moorhead City Council coordinated with the boards of Cass County, North Dakota and Clay County, Minnesota, to form a Metropolitan Flood Management Committee consisting of their four elected governing bodies plus one member from the Southeast Cass Water Resource Management District and one from the Buffalo-Red River Watershed District. Each of the boards appointed representatives to serve on a smaller Metropolitan Flood Study Work Group (MFSWG) whose purpose was to oversee study activities and make recommendations to the larger elected bodies. The MFSWG first met on August 26, 2009.

During this Phase a cursory technical analysis of all proposed measures was conducted. Screening criteria were developed in partnership with the non-federal sponsors. These criteria were then used to screen the proposed measures and to select those that warranted additional analysis. Using the preliminary technical information, professional judgment was used to assess the measures against the screening criteria. Those measures that appeared to be most viable, either alone or in combination with other measures, were refined and further developed so that accurate costs and economic benefits could be determined. Using all of the information developed, the PDT compared the alternative measures and plans to each other to screen out inferior plans and identify the optimal plans. Initial screening results were presented at public meetings in October 2009.

An in-progress review (IPR) was held in November with the vertical team (Corps Mississippi Valley Division and Headquarters staff).

Following the public meetings, IPR and further coordination with the sponsors and the MFSWG, an "Alternatives Screening Document" was prepared and distributed to the public to document the team's alternative screening process.

5.1.2 Array of Measures and Alternatives

Several measures were identified for consideration in evaluating future possible actions in the Fargo-Moorhead metropolitan area. Input provided at public meetings and directly from stakeholders provided a wide array of initial measures that were considered. Some of the measures constituted complete alternative plans, while others could be combined to make complete alternatives. The measures identified initially for evaluation were:

- No Action: Continue emergency measures

- Nonstructural measures
  - Buy and relocate flood-prone structures
  - Flood proofing
  - Elevate structures
  - Flood warning systems
  - Flood insurance
  - Wetlands
  - Grasslands

- Flood barriers
  - Levees
  - Floodwalls
  - Invisible floodwalls
  - Gate closures
  - Pump stations

- Increase conveyance
  - Diversion channels around the study area
    - In Minnesota
    - In North Dakota
  - Increase conveyance in Oakport Coulee
  - Cutoff channels (to short-cut existing meanders)
  - Flattening the slopes on riverbank
  - Replacing bridges

- Underground tunnels
- Interstate 29 viaduct
- Dredge river deeper and wider

- Flood storage
  - Large dams upstream
  - Distributed storage
  - Controlled field runoff
  - Storage ponds, also used for water conservation
  - Pay landowners for water retention

Details of the various measures and alternatives are described in the Alternatives Screening Document dated December 2009 (see Attachment 4).

5.1.3 Detailed Alternatives Developed

5.1.3.1 In addition to a cursory review of all proposed measures, the study team developed more detailed conceptual plans involving non-structural measures, diversion channels and flood barriers. Three scales of non-structural plans (1-percent, 0.5-percent, and 0.2-percent chance) including the non-structural measures listed above, as well as other potential non-structural measures . Eleven different structural plans were analyzed based on 5 alignments: Minnesota Long Diversion (25,000, 35,000, and 45,000 cfs), Minnesota Short Diversion (25,000, 35,000 and 45,000 cfs), North Dakota East Diversion (35,000 cfs), North Dakota West Diversion (35,000 and 45,000 cfs), and in-town levees (2-percent and 1-percent chance).

5.1.3.2 Diversion channel alignments and cross sections took several considerations into account. The Phase 1 diversion was located in Minnesota, because a Minnesota diversion would be shorter and was likely to be less expensive than a longer alignment in North Dakota. The six primary constraints on the initial diversion channel alignment were the Buffalo River, the Buffalo Aquifer, the City of Dilworth, Minnesota, the Burlington Northern and Santa Fe rail yard at Dilworth, the southern extent of development along the Red River, and the Wild Rice River. The channel's downstream outlet was located upstream of the confluence of the Red and Buffalo rivers so that the diversion would not cross the Buffalo River. The City of Dilworth is located east of Moorhead, Minnesota and west of the Buffalo Aquifer; the diversion was located as far east as possible in order to avoid Dilworth without impacting the Buffalo Aquifer and to minimize impacts to the rail yard. The southern end of the channel was located far enough south to benefit the majority of developed areas south of Fargo while staying downstream (north) of the confluence of the Red and Wild Rice rivers.

In Phase 2, the nine separate diversion alternatives analyzed included a total of four separate alignments, two in Minnesota and two in North Dakota. The alignments studied in Minnesota were roughly based on the alignment used during Phase 1. These basic alignments were modified based on the following considerations:

- Alignments were shortened where reasonable to reduce footprint and cost.
- Alignments were moved to relatively lower ground to minimize the excavation required.
- Alignments cross roads and railroads at or as close to 90 degrees as possible to minimize bridge lengths.
- Alignments avoid populated areas to minimize buyouts where possible.
- Inlet and outlet locations were selected at river bends with favorable hydraulic orientations to direct flow into or out of the diversion.
- Alignments were adjusted to avoid FEMA deed-restricted properties

The North Dakota West diversion alignment was based roughly on an alignment that was originally developed as part of the Southside Flood Control project. This alignment was also modified from its original location, based mainly on the total diversion length and ground elevations. The North Dakota East alignment, while similar to the North Dakota West alignment through much of its length, followed a portion of the existing Horace to West Fargo Sheyenne River Diversion alignment. Both North Dakota alignments cross the Sheyenne, Maple, Lower Rush and Rush rivers at or as close to 90 degrees as possible to minimize hydraulic structure size and cost. The diversion outlet was located downstream of the Red River-Sheyenne River confluence to avoid crossing the Sheyenne River twice.

The North Dakota diversion alignments and the Minnesota diversion tie-back levee between the Red River and the Sheyenne River south of Fargo, North Dakota were located to keep flood water out of the Rose Creek watershed, which flows north into the southern portion of Fargo.

5.1.3.3 The initial levee alignments in both Fargo and Moorhead were located as close to the river as geotechnical considerations would allow in order to minimize impacts to existing development. Floodwalls were not included in the preliminary designs.

5.1.3.4 Non-structural plans were developed for the entire study area. The details of the non-structural plans are described in Appendix P Non-Structural.

5.1.4 Climate and Hydrologic Uncertainty

To address the climate and hydrologic uncertainty that was identified in Phase 1, an Expert Opinion Elicitation (EOE) panel was convened in September 2009. The panel consisted of six panel members and five invited observers with expertise related to hydrology or climatology. The panel concluded that there were two distinct hydrologic periods in the Red River Valley: wet and dry. They recommended that this be addressed by developing separate wet and dry discharge-frequency curves and then using a probability to combine them over time. The study area experienced a wet cycle beginning in the early 1940's and continuing to the present, and the panel concluded that continued wet conditions were more likely than a return to a drier period within the Corps' 50-year period of analysis. The panel thought that traditional hydrologic analyses using the entire period of record (including both dry and wet times) would underestimate flood flows expected over the period of analysis. Upon completion of the EOE process, Saint Paul District began coordination with the Corps Hydrologic Engineering Center to implement the EOE panel's recommendations. Information on the EOE panel can be found in Appendix A, Hydrology.

5.2 PHASE 2, SCREENING #1 REVIEW AND COORDINATION

5.2.1 In Progress Review (November 5, 2009)

An in Progress Review (IPR) was held with the Corps vertical team on November 5, 2009 in Fargo, North Dakota to discuss study progress and to verify the decisions that had been made up to that point in the project. This included the elimination of levee plans from further consideration. See the Attachment 2 Memorandum for Record of the IPR.

5.3 PHASE 2, SCREENING #1 KEY ASSUMPTIONS

5.3.1 Future without project assumptions

The assumptions in Phase 2 regarding future without project conditions generally followed the assumptions in Phase 1. Those being:

- The Southside project was not be included, as FEMA withdrew its funding and support for the project.
- No credit was given to emergency flood fights.
- Benefits were accounted based on future growth assumptions, as a cost avoidance benefit.

5.3.2 Hydrology and Hydraulic Modeling

Design and screening of levee and diversion channel alternatives along with economic analyses were based on Phase 1 hydrology (without the 2009 flood event) and steady-state hydraulic modeling.

5.4 PHASE 2, SCREENING #1 PROCESS

5.4.1 Alternative Screening Criteria

Key study team members and representatives of the non-federal sponsors met to develop screening criteria to focus evaluation and design efforts on the most implementable conceptual stand-alone alternatives. Corps planning guidance requires that plans be evaluated against four criteria listed in the United States Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G): completeness, effectiveness, efficiency and acceptability. Other criteria deemed significant by participating stakeholders are also used to evaluate alternatives. The screening criteria represent the most critical factors to be considered in selecting plans for further evaluation. The following criteria were used to assess the overall characteristics of each alternative to identify those alternatives most likely to meet the project purpose and objectives.

Effectiveness: Whether the measure or alternative would be effective in maintaining an acceptable level of flood risk management for the Fargo-Moorhead Metropolitan Area. This is one of the P&G criteria. The team assessed conceptual measures for their potential to contribute substantially to the overall effectiveness of any alternative.

Environmental Effects: Direct and indirect effects of natural resources and cultural resources. Direct effects are those effects associated with the construction. Indirect effects are those effects that occur as a result of changed environmental conditions resulting from the construction or operation of the project. This criterion related to the planning objectives to restore or improve riverine, riparian and wetland habitat, and a desire to minimize environmental impacts and produce an environmentally sustainable project. It is also a component of overall effectiveness.

Social Effects: Direct and indirect effects on socio-economic resources such as transportation, regional growth, public safety, employment, recreation, public facilities, and public services. This criterion is a component of overall effectiveness.

Acceptability: Controversy and potential effects on community cohesion and compliance with policy are indicators of acceptability. This criterion is one of the P&G criteria.

Implementability: This criterion considered the existence of significant outstanding technical, social, legal or institutional issues that could affect the ability to implement the alternative. This is related to the P&G criterion for acceptability.

Cost: The first cost of the project, costs of local operations and maintenance, and long-term residual costs. Cost is related to two P&G criteria: efficiency and acceptability. Cost alone was not used to eliminate any alternatives, but was considered in relation to the other criteria.

Risk: The uncertainties, vulnerabilities, and potential consequences of the alternative. Risk is related to the P&G criteria of effectiveness and acceptability.

Separable Mitigation: This criterion considered the potential need for mitigation resulting from the project's implementation to address environmental, hydraulic or other impacts. Is mitigation possible, what does it cost, and how does it impact the project cost? This criterion is related to all four of the P&G criteria.

Cost Effectiveness: This criterion was a comparison of expected economic benefits and estimated costs for each alternative and between alternatives. This is a primary consideration in determining whether there is a federal interest in the project and to what extent federal participation can be justified. This is a component of the P&G criteria of efficiency.

5.4.2 Preliminary Conceptual Alternative Screening

Key study team members and representatives of the non-federal sponsors met to discuss how the various measures could be combined into alternative plans and how these measures and conceptual alternatives rated against the criteria. The process was subjective and based on the collective professional judgment of those present. At this point in the planning process, the evaluation was mainly qualitative, because very little quantitative data was available. The results of the preliminary alternative screening were reported in the Alternatives Screening Document dated December 2009, (Attachment 4). The Alternatives Screening Summary Matrix from that report is reproduced as Table 1.

Table 1: Alternatives Screening Summary Matrix

Resource Category	Alternative: Future Without Project Conditions	Flood Barriers	Diversion Channels	Non-Structural Measures
Alternative Description	Emergency measures currently being pursued in the project area will continue to be implemented as necessary due to flooding. These include raising levees, constructing temporary levees and floodwalls in various areas, and sandbagging.	This alternative includes the use of permanent flood barrier systems including levees, floodwalls, invisible floodwalls, gate closures, and pump stations. Two different top profiles to reliably contain the 2% chance flood and the 1% chance flood. Initial analyses were based on constructing levees in both Fargo and Moorhead to the design levels and assessing the costs and economic benefits of the plans.	Route flood flows around the metropolitan area. Several potential alignments will be considered, including alignments in both Minnesota and North Dakota and incorporating the existing Sheyenne Diversion from Horace to West Fargo.	Relocation of structures, buyout and demolition of structures, elevation of structures, removal of basement, dry flood proofing, wet flood proofing, land acquisition, flood management plans, vertical construction for residential occupancy. Additionally flood warning, preparedness, evacuation plans and pertinent equipment installation, and nonstructural berms, levees, and floodwalls are considered.
Effectiveness	(Low) Not expected to provide consistent/reliable long-term risk reduction. Emergency measures are temporary, demand high number of workers in extreme weather, are a risk to human health.	(Moderate) Levees and other properly designed and constructed flood barriers can prevent damages from most flood events that do not exceed their maximum design event.	(High) Effectively eliminate flooding for small events, but require flood fighting for large events. Diversions generally provide robust risk reduction.	(High) Effectively reduces risk to structures and their contents up to the design event. Floods would still have potentially large impacts on infrastructure, evacuation routes, and daily life and business activities.
Environmental Effects - Natural Resources	(Negative) Emergency levees are susceptible to erosion, feeding sediment into the river. They adversely impact terrestrial vegetation, and borrow sites.	(Neutral) Resources affected along embankment alignment. Wetland mitigation may be required. Open space between barrier and river will provide benefits. Larger riparian areas.	(Neutral) Issues such as fish passage and sedimentation arise. Also, wetlands and ground water may be impacted. The channel would be designed to include wetland and/or prairie swale type habitat within the diversion channels which could lead to increased habitat quantity and value from the existing conditions.	(Positive) Removal/relocation of homes allows to develop riparian habitat, restoration of wetlands, greenway area for recreational and ecosystem benefits.
Environmental Effects - Cultural Resources	(Negative) Excavating borrow material, building temporary levees/floodwalls, removing temporary levees/floodwalls all have the potential to have adverse effects on cultural resources. Failure of the temporary levees/floodwalls would also have adverse impacts to cultural properties/resources.	(Negative) There are a number of historical structures that would be directly or indirectly impacted by the construction of the in-town levees, and mitigation would be required for the adverse impacts. Potential for adverse impacts on deeply buried archeological sites, and historical structures and requires mitigation.	(Negative) High potential for impact to archeological sites within the area, particularly buried sites where channels leave, enter, or cross rivers. Historical structures may be directly or indirectly impacted.	(Neutral) A number of historical structures would be directly or indirectly impacted. Potential adverse impact to archeological sites. The alternative would also minimize the chance of flooding to historical structures.
Social Effects	(High Negative) Negative effect on businesses, transportation, recreational facilities, and public services. Emergency measures failure may result in loss of community, community cohesion, public safety, and potential loss of life.	(Moderate Positive) Positive: improved public safety during flood events, regional business growth, less frequent emergency actions, addition of recreational components. Negative: 1000 structures removed, road closures during floods. Failure would result in significant threat to public safety.	(High Positive) A large amount of agricultural land would be necessary. Regional growth, public safety, employment, and recreation would all benefit from the project.	(High Negative) Required evacuation during floods would adversely effect transportation, business, regional growth. Large percentage of structures would be impacted by the required modifications.
Acceptability	(Low) Not acceptable as a long term solution. Eventually flood fighting will adversely effect the local community and region.	(Moderate) Alternative will disrupt community cohesion by removal of approximately 1000 structures, railroad lines, increased flood stages upstream, and will not meet sponsors desired level of protection.	(Moderate) This plan is acceptable but will impact a number of agricultural properties. There could also be actual or perceived downstream impacts due to increased flood stages that may need to be addressed. Controversy will be more of an issue depending on which diversion is selected.	(Low) Necessary modifications to individual structures would be extremely controversial and have little support from local sponsors.
Implementability	(Moderate) Legal and technical issues complicate implementation of emergency measures. Obtaining rights of access on short notice is difficult and controversial. Maximum level of protection limited by natural ground..	(Moderate) Difficulty in timely implementation. Feasible protection can be constructed up to a maximum of 1% chance level.	(High) There are some technical issues to implementing this plan, the largest concern would be with the Red River control structure and the tributary structures. Diversions have been successfully used in other projects in the Red River Valley.	(Low) Difficult implementing due to enormous number of affected properties.
Cost	(Extremely High) Extremely high costs ($74 million / year). 500yr event may exceed $6 billion.	(High) 2% chance flood protection estimated at $840 million, and $902 million for 1% chance level of protection. The 1% levee plan would leave the community susceptible to residual damages averaging more than $20 million annually.	(Medium) Costs for the nine diversion alternatives investigated range from $962 million to $1.46 billion. The plans all reduce the residual risk to the communities to less than $14 million annually and would allow for emergency flood fighting if necessary.	(Extremely High) 1% and 0.2% chance floods estimated to cost $1.6 billion and $4.7 billion respectively. Even if the 1% or the 0.2% plans were developed the community would still be at risk of flooding and there would be residual damages to local infrastructure.
Risk*	(Extremely low) Extremely low level of risk reduction and there would be a high risk of future flooding. Reliability of emergency measures is poor. Mobilizing man power is difficult and unreliable, and those people are placed at risk. Unreliable protection as a result of construction measures.	(Moderate) This plan will provide risk reduction up to the design event; once that event is exceeded catastrophic damages will occur. This plan may also induce additional growth between the 1% chance and 0.2% chance flood plains resulting in greater risk to the community over time.	(High) Flood stages are no higher than they would have been without the project in place. They are not fool-proof and significant residual risk often remains from flood events larger than design event, and there is potential for channel blockage from debris and ice.	(Moderate) High risk to public infrastructure, looting and property damage, evacuation routes. Population relocation may be required.
Separable Mitigation	(High) Repair of damaged properties following flood event is necessary resulting in large costs for removal and repair.	(Moderate) The plan may result in quantifiable damages resulting from increased flood stages up and downstream and would require mitigation with option such as upstream storage, ring levees, and non-structural solutions.	(Moderate to High) If project causes increased flood damages downstream, mitigation would be required such as ring levees, buyouts, and relocations. Aquatic resource mitigation may be required and would be more likely with the tributary structures.	(Low) None is anticipated.
Cost Effectiveness	(Moderate) Emergency measures are cost effective, because they prevent damages far in excess of their cost.	(Moderate) From the investigated levee plans only 1% chance levee was determined cost effective.	(Low-High) Smaller diversions were found to provide better cost effectiveness, and all of the Minnesota short diversions were cost effective	(Low) Not cost effective with BCRs of less than 0.35.
Recommendation	The future without project (no action) alternative should be retained as the base condition for comparison with all other alternatives.	Levee plans should no longer be considered as a stand-alone alternative. The levee plans would provide a limited level of risk reduction, have large short term social impacts, high costs, and relies on emergency measures for larger flood events.	Diversion concept should be retained for further refinement. Preliminary analysis shows that the Minnesota Short Diversion appears implementable, effective, and cost effective.	Non-structural measures should no longer be considered as stand-alone alternatives

* Risk is measured based on the risk reduction, therefore a plan with a rating of high would have a high level of risk reduction, meaning the community would be less susceptible to flooding.

Table 1: Alternatives Screening Summary Matrix

Resource Category	Alternative: Flood Storage	Tunneling	Bridge Replacement or Modification	Interstate 29 Viaduct
Alternative Description	Preserve natural floodplain areas, restore wetalnds, build dams and other water retention facilities to hold water during flood events. Impoundments may be designed to remain dry until a flood event or to retain a pool during nonflood times for conservation or water supply purposes.	A series of tunnels underneath the city to convey the water and reduce the water levels in the river.	Bridges can restrict the flow during flood events. Raising or modifying bridges can increase conveyance in the channel and reduce flood stages.	Reconstructing the Interstate 29 corridor to serve as an open viaduct during floods was proposed. The reconstructed corridor would function as an interstate highway during non-flood times.
Effectiveness	(Low) Very difficult to ensure that the system would be reliable and effective. A model of system of impoundments with 400,000 acre feet of storage indicated that it could reduce the 1% chance flood stage in Fargo-Moorhead by less than 1.6 feet.	(High) Tunneling, would be effective in reducing flood risk, eliminating emergency measures during smaller floods. Large floods would also see a reduction in flood risk. Overall flood risk reduction is dependent on tunnel capacity.	(Low) Not an effective stand alone measure. Removing the bridges entirely has only minor effects.	(High) Would effectively provide flood risk management, reducing flood risk for small and large events.
Environmental Effects - Natural Resources	(Positive) May be both beneficial and detrimental, with dams causing adverse effects, and off-channel storage can be beneficial. Off-channel storage located on poorly-drained agricultural sites, former wetlands, or drained lakes can be environmentally beneficial if designed and managed properly.	(Negative) There are adverse effects on aquatic habitat due to loss of fish passage and potential sedimentation. Potential adverse effects on areas where spoil material would be placed.	(Neutral) No appreciable adverse effects.	(Negative) Issues such as fish passage and sedimentation arise. There would be little opportunity to provide any environmental enhancements to the project as it would also function as an interstate highway.
Environmental Effects - Cultural Resources	(Negative) Flood storage project may cover cultural resources and impact archeological resources.	(Neutral) Possible adverse impact to archeological resources near tunnel inlet/outlet and location of spoil material placement are possible. Cultural resources in the existing floodplain in the Fargo-Moorhead area would receive benefits from tunneling and would not be as prone to flooding.	(Negative) Potential for impact to archeological sites near bridge abutments and piers. Potential to adversely affect National Register eligible or listed bridges.	(Positive) Minimal impacts could occur at the inlet and outlet of the corridor. Historic structures would be less likely to flood and would benefit from this alternative.
Social Effects	(Moderate Positive) Large amounts of agricultural land would be necessary for acquisition or may be impacted. Depending on the depth of the storage areas and timing of storage, there could be a potential for recreational opportunities such as boating, fishing, or hunting.	(High Positive) Alternative requires a substantial amount of agricultural land. Regional growth, public safety, employment, and recreation would all benefit from the project.	(Low Positive) There would be minimal impact to transportation during construction, and emergency evacuation routes would be able to stay open during flood events.	(Moderate Positive) There would be major negative impacts to the transportation and evacuation route during flood events. Positive effects that may be seen are regional growth, public safety, and employment.
Acceptability	(Low) Very difficult to implement in reasonable amount of time. Issues with land acquisition such as legal processes and scarcity in economical storage.	(Moderate) There could be actual or perceived downstream impact that will need to be addressed. There would also be an adverse impact to the aquatic habitat.	(Low) Because of minimal levels of risk reduction this plan is not acceptable.	(High) The resulting impact to the transportation would not be acceptable. Elevation of the interstate would bring the project to the acceptability of the diversion.
Implementability	(Low) It is likely that additional flood storage will be built upstream of the study area, but that storage alone is not likely to adequately reduce flood risk to the study area over the next 50 years.	(Moderate) There are technical issues such as sedimentation and maintenance for an underground project to make sure the functionality of the alternative over a long-term.	(High) Alternative is implementable with no major issues.	(Low) Significant technical issues raising or lowering the road which involve demolition and reconstruction.
Cost	(Extremely High) Cost range from $160-$543 million depending on level of protection and type of plan. The communities would still face a large residual flood costs.	(Extremely High) Typical costs range from $100 - $350 million per mile.	(Extremely High) No estimates were prepared. Alternative would not reduce the residual flood risk. If this alternative were constructed the community would still have a residual flood risk of nearly $74 million annually.	(High) Estimated cost of $1.4 - 4.0 billion, with large operation and maintenance cost.
Risk*	(Moderate) Able to help with small events, but the estimated stage reduction for large events is not significant.	(High) Large flood risk reduction is achieved with this alternative. There is minimal risk of sudden or catastrophic failure. Residual risk often remains from flood events larger than the design event, and emergency flood fighting would still be required for those extremely rare events which could lead to risks similar to the without project condition.	(Extremely Low) Community would continue to be at risk of flooding.	(Moderate) Risks include ice jams, access to evacuation routes during floods, maintenance of the structure, backwater during minor floods. The risk of floods would decrease significantly, similar to the diversion channels.
Separable Mitigation	(Moderate) Mitigation depends on the project location, and is likely that it would not be possible to adequately mitigate environmental impacts.	(Moderate) If alternative results in increased flood damage downstream, mitigation would be required.	(Low) None is anticipated.	(Moderate) If project causes increased flood damages downstream, mitigation would be required such as ring levees, buyouts, and relocations. Aquatic resource mitigation may be required.
Cost Effectiveness	(Low) Unlikely to be economically justifiable for large systems, but may be considered for small areas.	(Low) Alternative is much more expensive than diversion with similar benefits.	(Low) Unlikely to be cost effective.	(Low) Cost similar to diversion alternative plus additional to demolish and reconstruct the roadway, with similar benefits to the diversions.
Recommendation	Flood storage should no longer be considered as a stand-alone alternative for the Fargo-Moorhead area as part of this project. Local communities should continue to seek opportunities for storage in the basin.	There would be a number of positive aspects to a tunnel alternative, however due to the cost of this alternative being substantially greater than any of the diversion channels while providing similar benefits, and other uncertainties with long term maintenance and repair, it is recommended that no additional study of tunnels be conducted.	Bridge replacement/modification should not be considered further as a stand-alone plan, but should be retained for possible inclusion in an overall plan if it can be incrementally justified.	The I-29 viaduct concept should no longer be considered for further analysis.

* Risk is measured based on the risk reduction, therefore a plan with a rating of high would have a high level of risk reduction, meaning the community would be less susceptible to flooding.

Table 1: Alternatives Screening Summary Matrix

Resource Category	Alternative: Dredging and Widening the River	Wetland and Grassland Restoration	Cut-off Channels
Alternative Description	Digging the Red River channel deeper and wider to allow for more flow to pass through the Fargo-Moorhead Metropolitan Area was proposed. This alternative could also be looked at underneath existing bridges to prevent the damming effect the bridges can create.	Restoration of grassland and wetlands to reduce peak runoff and serve as water storage during flooding events was proposed.	Building cut-off channels across meanders in the cities was proposed. It would provide the water a straighter path through the city and potentially reduce peak stages.
Effectiveness	(Low) Very limited hydraulic effectiveness and would likely negatively affect the stability of the river banks. Sedimentation following project implementation would be a concern and if maintenance was not completed properly any benefits of the project would be lost.	(Low) Effects are localized with no likely major benefit for Fargo-Moorhead Metropolitan Area. The effectiveness would be expected to be less than that of flood storage.	(Low) Alternative is not effective as a stand-alone.
Environmental Effects - Natural Resources	(Negative) There would be increased sedimentation, displacement of mussels, erosion issues, riparian forest habitat loss, aquatic habitat impacted, and wildlife mortality issues during dredging.	(Positive) Wetland and grassland habitat would greatly be enhanced and provide associated benefits to the water quality downstream.	(Negative) Alternative would impact riparian habitat, geomorphology of the stream, and fishery resource when flow exceeds design event.
Environmental Effects - Cultural Resources	(Negative) High potential for impact to archeological resources located on river banks.	(Neutral) There are a number of cultural sites within the study area so there is potential for adverse impacts to archeological sites.	(Negative) Alternative has potential to affect historical structures, and high potential to affect archeological sites.
Social Effects	(High Negative) Alternative would change appearance and function of the river. Properties along the river would need to be acquired due to slope stability issues which would require that the banks be cut back to allow for a deeper channel.	(Moderate Positive) Large amounts of land acquisition is required impacting agriculture and urban areas, and potentially transportation. Benefits are recreational opportunities such as hunting.	(High Negative) Social effects similar to existing condition with a similar risk of flooding.
Acceptability	(Low) Not an acceptable alternative and violates many local and national policies.	(Moderate) Alternative impacts a large number of landowners, and does not provide a lot of flood risk reduction.	(Low) Alternative is unacceptable to the resource agencies and potentially violates state and federal policies.
Implementability	(Low) Not Implementable.	(Low) The project is difficult implementing due to large amount of impacted land, and legal issues.	(Low) Not implementable as a stand-alone.
Cost	(High) Excessive – operations and maintenance costs would be large and long term. Environmental mitigation costs would be extreme. The communities would face large residual risks and if continued dredging was not maintained any benefits of the project would be lost.	(Extremely High) Cost is expected to be large, exceeding that of the storage alternative.	(Extremely High) No estimates were prepared. Cost of residual damage is assumed to be similar to the existing condition.
Risk*	(Low) There would be risk of project failure due to sedimentation. The community would still be at risk of flooding.	(Low) The impact of implementation of this alternative would not provide sufficient flood risk reduction leaving the areas at high risk of future flooding.	(High) There would possibly be large environmental impacts and community will continue to be at high flood risk.
Separable Mitigation	(Extremely High) Not possible to mitigate environmental impacts.	(Low) None is anticipated.	(Low) Besides replacement of trees, none is anticipated.
Cost Effectiveness	(Low) Not determined, but it is likely that the costs will outweigh the benefits.	(Low) Unlikely to be cost effective for flood damage reduction.	(Low to moderate) Cost effectiveness would be site specific.
Recommendation	Dredging and widening the river should no longer be considered.	Restoring wetlands and grasslands should no longer be considered as a stand-alone alternative, but may be considered for inclusion to mitigate for other adverse project effects where it can be incrementally justified.	Cut-off channels should not be considered as stand-alone alternatives but should be retained for possible inclusion in an overall plan where they could be incrementally justified.

* Risk is measured based on the risk reduction, therefore a plan with a rating of high would have a high level of risk reduction, meaning the community would be less susceptible to flooding.

5.4.3 Detailed screening

The analyses completed in the first part of Phase 2 allowed for significant screening of the stand-alone alternatives. Five of the six diversions located in Minnesota and the larger of two levee/floodwall plans were found to be cost-effective, with benefit/cost ratios (BCR) ranging from 1.0 to 1.22. Two of the diversions located in North Dakota had BCRs above 0.9 but less than 1.0. The non-structural plans were not cost effective, with BCRs less than 0.4.

Table 2 presents the results of the initial cost-effectiveness analyses of the levee and diversion alternatives. Table 3 presents the expected flood stages with various capacities of diversion channel.

Table 2 - Initial cost-effectiveness analysis results

Fargo-Moorhead Metro Feasibility Study
Initial Screening Results, October 2009
Screened Alternatives Ranked by Net Benefits

Alternative	First Cost *	Avg Annual Net Benefits *	Residual Damages *	B/C Ratio
MN Short Diversion 25K	962	11.0	14.3	1.22
MN Short Diversion 35K	1,092	9.4	9.3	1.17
Levee 1% chance (100-year)	902	7.7	20.9	1.17
MN Long Diversion 25K	1,055	5.6	15.0	1.10
MN Short Diversion 45K	1,264	2.5	7.4	1.04
MN Long Diversion 35K	1,260	0.3	9.8	1.00
ND East Diversion 35K	1,337	-3.1	9.2	0.95
ND West Diversion 35K	1,363	-4.4	9.2	0.94
Levee 2% chance (50-year)	840	-5.3	37.1	0.88
ND West Diversion 45K	1,439	-6.7	7.6	0.91
MN Long Diversion 45K	1,459	-8.3	8.2	0.89

* In millions of dollars

Note: Expected average annual damages without a project are $73.7 million.

Table 3 -Estimated flood stages assuming various diversion capacities

	STAGE at the FARGO GAGE		
	2% Chance	**1% Chance**	**0.2% Chance**
	(50-year)	(100-year)	(500-year)
Existing Condition	37.8	39.5	43.9
25k Diversion	29.1	30.4	39.2
35k Diversion	28.8	29.2	35.9
45k Diversion	27.1	27.2	30.4

5.4.4 National Economic Development (NED) plan

The first screening analyses indicated that the NED plan would most likely be a diversion located in Minnesota, but additional study was needed to determine the optimal channel capacity. Of the plans analyzed, the smallest capacity diversion had the highest net benefits, so an even smaller plan would need to be studied to be sure the optimal capacity was identified.

5.4.5 Tolerable level of risk

5.4.5.1 Diversion alternatives

The non-federal sponsors indicated a desire for a project that would minimize the need for most flood fighting activities up to the 0.2-percent chance event. A project that would produce a flood stage of approximately 36 feet on the Fargo gage during a 0.2-percent chance event would meet that objective and result in a tolerable level of risk for the communities. The first Phase 2 screening results indicated that a diversion capacity of approximately 30,000 to 35,000 cfs could reduce stages to the desired level, but it was likely that the NED plan would be smaller. Therefore, further development of diversion plans larger than the potential NED plan would be necessary to meet the study goals.

5.4.5.2 Levee alternatives

The largest levee plan considered would only reliably contain the 1-percent chance event. Higher levee plans would not be feasible because there is no higher natural ground available at which to begin and end the line of protection. Therefore, the sponsors did not request further work to refine levee plans as a potential locally preferred alternative. Since the levee plans were both outperformed by the diversion plans, the levee concept was dropped from consideration.

5.4.6 Locally preferred diversion alignment

The non-federal sponsors indicated that a North Dakota diversion alignment was locally preferable to a Minnesota alignment for a variety of reasons. Federal policy would not allow implementation of a plan that was not cost-effective. Although the first Phase 2 screening found that the North Dakota plans had BCRs less than 1.0, they were close enough to warrant further refinement to reduce project cost and increase benefits.

5.4.7 Other undetermined impacts

Additional study was also needed to assess potential environmental impacts, downstream stage impacts, and additional benefit categories that were not yet fully analyzed. These benefit categories included transportation benefits and benefits attributable to reductions in tributary flooding afforded only by the North Dakota diversion alternatives.

5.5 PHASE 2, SCREENING #1 CONCLUSIONS

The combined conclusions of both the preliminary conceptual alternative screening (using the screening criteria) and the detailed screening (using the economic analyses) are presented in this section.

5.5.1 Preliminary plans eliminated from further consideration as stand-alone alternatives

The following alternatives were not recommended for further evaluation as stand-alone alternatives for this project:

- Flood Barriers and associated measures
- Tunneling
- Interstate 29 Viaduct
- Dredging and Widening the River
- Increase conveyance in Oakport Coulee

5.5.1.1 Flood barriers and associated measures were eliminated as conceptual alternatives because they were both less effective and less cost effective than diversion plans in providing a high level of risk reduction. The top elevation of flood barrier alternatives is limited to the highest natural ground available to begin and end the levee; within the study area, flood barriers could not be certified to contain floods larger than about a 30,000 cfs event. Such a plan would leave unacceptably high residual risk in excess of $20 million annually (based on the preliminary screening analysis). The levee plans that were evaluated would also have had large short term social impacts, due to the need to remove over 1,000 structures in the urban flood plain.

Professional judgment was applied in comparing the diversion concept to the levee concept at this stage of the screening. It was recognized that several cost and benefit categories had not been assessed, but the overall potential for levees to overtake diversions as the NED plan appeared to be low. The following uncertainties would likely increase the overall cost of the levee plans, reducing their net benefits relative to the diversion plans:

- Levees would increase stages upstream and possibly cause damages that were not included in the economic analysis
- The levee plans were based only on earthen levees; use of floodwalls would likely increase levee costs.
- Impacts to historical properties were not fully assessed, but costs were likely greater for the levee plans than for diversion plans.

Floodproofing cost savings and transportation benefits were not included in the preliminary analyses for the diversion or levee plans, but these benefits would likely be greater for the diversion plans, thus further reducing the chance that levees would be the NED plan if additional factors were considered.

5.5.1.2 Tunneling was eliminated due to cost-effectiveness. Large tunnels could be used to divert flows under the communities and provide benefits similar to a diversion channel. It was estimated that at least three 30-foot diameter tunnels approximately 25 miles long would be needed to provide approximately 25,000 cubic feet per second capacity. Real estate interests would be required to tunnel under private property, and real estate would also be required to dispose of the 10,370,000 cubic yards of excavated material. Sedimentation and maintenance issues with an underground project would result in high operation and maintenance costs. Research on other tunneling projects found that costs for a single bore tunnel varied from approximately $37 million per mile for the San Antonio, Texas River Tunnel to $677 million per mile for a proposed Port of Miami project, but typical costs range from $100 million to $350 million per mile. Assuming $50 million per mile, the three tunnels proposed for the Fargo-Moorhead project would cost $3.75 billion.

5.5.1.3 Reconstructing the Interstate 29 (I-29) corridor to serve as an open viaduct during floods was eliminated due to cost-effectiveness and operability concerns. The viaduct would function as an interstate highway during non-flood times. It would essentially be a diversion channel with an interstate highway either on the bottom or elevated. Operation and maintenance costs of the corridor and the roadway would be high, and flooding would interfere with use of the Interstate for transportation. Residual damages would be similar to the diversion channels. Concerns with this alternative included ice jams, access to evacuation routes during flood events, and long term maintenance of the structures. Local drainage and snow melt year-round and backwater into the channel during minor flood events would inundate a highway located at the bottom of the channel. Excavation volumes per mile for this alternative would be similar to those of a comparable diversion plan, although the total length could be shorter. Demolition and reconstruction of the existing interstate would cost at least $400 million. Real estate would be required to dispose of the excavated material. Total cost of this alternative would likely be $1.4 billion to $4.0 billion. The costs would likely exceed any diversion alternative considered. Because the concept would provide benefits similar to a diversion channel at greater cost, it did not appear to be cost effective.

5.5.1.4 Digging the Red River channel deeper and wider to allow for more flow to pass through the Fargo-Moorhead metropolitan area was considered, as well as increasing conveyance in Oakport Coulee. Excavation to widen the river channel could also be considered beneath existing bridges to prevent the damming effect the bridge constriction can create. These alternatives were eliminated for several reasons, including environmental impacts and cost effectiveness. These alternatives, if implemented on a hydraulically effective scale, would be highly detrimental to the riverine and riparian ecosystems and would likely not be permittable. They would also not be consistent with the planning objectives to restore and improve these aquatic ecosystems. Operations and maintenance costs would be high and long-term. Environmental mitigation costs would be extreme, assuming mitigation would be possible. The communities would still face large residual risks, and if continued dredging was not maintained, any benefits of the project would be lost.

5.5.2 Preliminary plans dropped as stand-alone plans but retained for possible inclusion
The following measures were retained for possible inclusion as features of the alternative plans where they could be incrementally economically justified:

- Non-Structural Measures
- Flood Storage
- Wetland and Grassland Restoration
- Bridge Replacement or Modification
- Cut-Off Channels
- Levees

5.5.2.1 Non-structural measures were eliminated as stand-alone plans because they were not found to be cost effective. Additionally, non-structural measures would not address the large disruptions to transportation and businesses that could last more than a month during extended flood events. Three levels of comprehensive stand-alone non-structural plans were investigated for the study area: 1-percent chance, 0.5-percent chance and 0.2-percent chance (based on Phase 1 hydrology) . None of the plans were cost-effective, with total costs of $1.6 billion, $3.3 billion and $4.7 billion and benefit/cost ratios of 0.35, 0.37 and 0.31, respectively. Due to the extremely flat nature of the floodplain, it appears that it is not efficient to address flooding on an individual structure basis over the entire Fargo-Moorhead study area. Non-structural measures were retained for possible application in smaller areas not benefited by other features of the final plan where they could be economically justified. The entire non-structural analysis can be found in Appendix P.

5.5.2.2 Flood storage and wetland and grassland restoration were eliminated as stand-alone alternatives because they would be both less effective and less cost effective than diversion plans in providing a high level of risk reduction. Flood storage involves both preserving natural floodplain areas and also building dams and other water retention facilities to hold water during flood events. Flood storage concepts include large dams, distributed smaller storage sites, controlled field runoff, use or modification of the constructed road network to store water (the "waffle plan"), storage ponds used for water conservation, and payment to landowners for water retention. These facilities could be located in any watershed upstream of the Fargo-Moorhead Metropolitan area and distributed throughout that area. Distributed storage could require many small structures that could take a long time to construct and would potentially be difficult to operate. The potentially large number of structures such as suggested in the "waffle plan" would require hundreds of gates to be closed at the proper time by individuals in the field, making implementation difficult and reducing the long term reliability of the plan. Estimates of potential stage reduction that could be achieved with flood storage varied from less than 1.6 feet to 5 feet for approximately a 1-percent chance event, depending on various assumptions. The Corps' Fargo-Moorhead and Upstream feasibility study found that 200,000 to 400,000 acre feet of storage would need to be constructed to achieve a stage reduction of 1.6 feet at the Fargo gage for a 32,000 cfs flood event. Stage reductions during larger floods would be even smaller. The study team and sponsors agreed that such a level of stage reduction would leave unacceptable residual flood risk in the study area, and would not be able to meet the purpose and need of this study. The diversion plans could provide much larger and more reliable stage reductions for a similar financial investment. These measures were retained for possible application where they could be economically justified.

5.5.2.3 Bridge replacement or modification was eliminated as a stand-alone alternative because it would not be effective in substantially reducing flood risk in the study area. This concept was retained for possible application as part of an overall plan where it could be economically justified.

5.5.2.4 Cut-off channels were eliminated as a stand-alone alternative because they would not be effective in substantially reducing flood risk in the study area. This concept was retained for possible application as part of an overall plan where it could be economically justified.

5.5.2.5 Levees were retained for inclusion in diversion alternatives. Tie-back levees at the inlet of diversion alternatives are crucial for diverting flows into the diversion channel. Small in-town levees could be used to allow more flows through the existing Red River channel and could be part of an overall plan where it could be economically justified.

<u>5.5.3 Preliminary plans retained for further evaluation</u>

The following stand-alone alternatives were recommended for further evaluation:

- Future Without Project Condition--No Action (continue emergency measures)
- Diversion Channels

5.5.3.1 The no action alternative was retained as the baseline condition to which all other alternatives are compared.

5.5.3.2 The diversion channel concept was retained for further refinement. The preliminary analysis indicated that the Minnesota Short diversion was the most cost effective of all plans considered and would be implementable and highly effective. All of the diversions studied produced lower residual damages than the levee alternatives. Since the most cost effective plan identified was the smallest capacity diversion considered, it was noted that a smaller capacity might be optimal. The final array of plans must bracket the National Economic Development (NED) plan which maximizes the net NED benefits.

It was also noted that none of the North Dakota alignments provided positive net benefits, but the preliminary economic analyses omitted potential economic benefits from tributary flooding that would be uniquely addressed by a North Dakota diversion. Any diversion could impact fish passage and riverine habitat. Further analysis was needed to optimize the capacity and alignment of the diversion concept and address potential impacts to the aquatic habitat.

5.5.3.3 The preliminary analyses produced information that supported further screening of the diversion alternatives at this screening step. The following paragraphs discuss conclusions drawn from the preliminary analyses that reduced the number of diversion plans retained for further analysis.

The initial diversion concept presented in May 2009 was a passive diversion channel without an operable river control structure; this concept was not economically justified with a benefit to cost ratio of approximately 0.65. All of the subsequent diversion concepts included a river control structure that dramatically improved performance with a modest increase in cost. Therefore, no diversions lacking a control structure were carried forward.

The Minnesota Short alignment outperformed the Minnesota Long alignment, and there were no significant unique benefits or avoidance of any adverse environmental effects associated with the Minnesota Long alignment, so that alignment was dropped from consideration.

The North Dakota East alignment outperformed the North Dakota West alignment, and there were no significant unique benefits or avoidance of any adverse environmental effects associated with the North Dakota West alignment, so that alignment was dropped from consideration.

5.5.4 Additional Alternative Development

The surviving diversion alternatives were differentiated by 1) their location in either Minnesota or North Dakota, and 2) their capacity. Nonstructural measures were considered as additional features in the areas immediately upstream of the diversions and in the areas near the downstream end of the diversions, where the diversions provided little or no benefit.

5.5.4.1 Minnesota versus North Dakota location: There were several issues related to the location of the diversion that were pertinent to plan formulation:

- Preliminary screening showed that the Minnesota alignment appeared to provide optimal net benefits (noting that additional analysis was needed to capture known but omitted benefits of the North Dakota plans).
- The Minnesota alignment would impact an existing rail yard east of Dilworth, Minnesota.
- Significantly more economic benefits accrue to properties in North Dakota regardless of channel location. That led to a public perception that Minnesota would suffer disproportionate harm if the diversion were located in Minnesota.
- North Dakota alignments cross five tributaries (Wild Rice, Sheyenne, Maple, Lower Rush, and Rush Rivers); Minnesota alignments cross none.

- Tributary crossings introduce additional environmental impacts.
- Tributary crossings provide flood risk reduction for flood events on the tributaries as well as the Red River.

- The North Dakota alignment benefits a greater geographic area and removes 50 more square miles from the 1-percent chance floodplain than the Minnesota alignment. (The North Dakota and Minnesota diversions remove 80 and 30 square miles, respectively, from the 1-percent chance floodplain.)
- The sponsors and a majority of stakeholders preferred a North Dakota alignment.

5.5.4.2 Channel capacity is directly related to the project's effectiveness in reducing flood stages. On the basis of the initial design data (presented in Table 3, above), the sponsors indicated that a capacity of approximately 30,000-35,000 cfs would provide a tolerable level of residual risk, and they requested that these capacities be included in the array for both Minnesota and North Dakota alignments as potential locally preferred alternatives. The initial screening analysis indicated that a smaller capacity would likely optimize the net economic benefits.

5.5.5 <u>Array of remaining alternatives</u>
An array of remaining alternatives was formulated using those management measures or plans that survived the screening described above. The following plans were included in the array of alternatives for further consideration:

- MN20K: Minnesota Short Diversion, 20,000 cubic feet per second (cfs) capacity
- MN25K: Minnesota Short Diversion, 25,000 cfs capacity
- MN30K: Minnesota Short Diversion, 30,000 cfs capacity
- MN35K: Minnesota Short Diversion, 35,000 cfs capacity
- ND30K: North Dakota East Diversion, 30,000 cfs capacity
- ND35K: North Dakota East Diversion, 35,000 cfs capacity
- The preceding plans with the addition of nonstructural measures

6.0 FEASIBILITY PHASE 2, SCREENING #2 (Nov 2009 – Mar 2010)

6.1 PHASE 2, SCREENING #2 ACTIVITIES

6.1.1 <u>General</u>
Between November 2009 and February 2010 the plans were refined in order to determine the NED plan and to develop a locally preferred plan to more fully address the planning objectives. The Red River control structure and diversion inlet works were redesigned to substantially improve fish passage. The tributary structures in the North Dakota alternative were all redesigned to reduce cost and address potential environmental impacts to fish passage and geomorphology. The North Dakota channel dimensions were optimized to reduce cost and improve hydraulic efficiency. A shorter diversion was considered northwest of Fargo to intercept the Maple, Lower Rush and Rush rivers as an

additional measure to be implemented with a Minnesota diversion alternative. Coordination with natural resource agencies continued with greater focus on the potential adverse impacts of the diversion plans and measures to avoid, minimize and mitigate for those impacts. The economic analysis was expanded to assess transportation benefits, future development cost avoidance, and flood damage reduction benefits on the Sheyenne River and its tributaries. A sensitivity analysis providing various levels of economic credit to emergency levees was completed. Non-structural alternatives were evaluated for areas upstream and downstream of the diversion features. A value engineering study was completed (see Attachment 4). An unsteady HEC-RAS hydraulic model was developed to assess downstream stage increases caused by the various diversion alternatives. A loss of life analysis was completed for the future without project condition. A cost and schedule risk analysis was completed. Results of the second screening were presented at public meetings on February 1-3, 2010.

The Metro Flood Study Work Group met several times between December 2009 and March 2010 to discuss issues of plan selection, cost-sharing and sponsorship for project construction, operation and maintenance. On March 18, 2010, the work group voted to recommend the North Dakota 35,000 cfs channel as its locally preferred alternative.

6.2 PHASE 2, SCREENING #2 REVIEW AND COORDINATION

6.2.1 Agency Technical Review (ATR)

The information developed throughout the feasibility study was presented to the ATR team in the form of a draft report on February 16, 2010. The documents provided to the ATR team included:

- Draft Feasibility Report with associated EIS
- Appendix A Hydrology
- Appendix B Hydraulic appendix and HEC-RAS models
- Appendix C Economics, Social and HEC-FDA model
- Appendix D Not Used
- Appendix E Cultural Resources
- Appendix F Environmental – EIS is part of main report
- Appendix G Real Estate
- Appendix H Geotechnical – Credit to existing Levees
- Appendix I Geotechnical Analysis
- Appendix J Structural
- Appendix K Civil Design
- Appendix L Cost Engineering and Cost and Schedule Risk Assessment model
- Appendix M Recreation and Aesthetics
- Appendix N Not Used
- Appendix O Plan Formulation
- Appendix P Non-Structural
- Appendix Q Public Involvement and Comments

The review resulted in 136 comments, of which 28 were critical comments. The PDT responded to the comments and the ATR team backchecked the responses prior to the Alternative Formulation Briefing. The ATR documentation was provided to both the vertical team and the Independent External Peer Review (IEPR) team for the first of two IEPRs.

6.3 PHASE 2, SCREENING #2 KEY ASSUMPTIONS

6.3.1 Future without project assumptions
The future without project assumptions remained the same as in Screening #1. (See paragraph 5.3.1)

6.3.2 Hydrology
"Phase 2" hydrology was developed during the first Phase 2 screening step and used during the second screening analyses. Phase 2 hydrology incorporated the 2009 flood event into the entire period of record. Phase 2 flows were higher than Phase 1 for more frequent events but lower for the larger, less frequent events. Phase 2 hydrology indicated that at the Fargo gage a flow of 30,000 cfs had a 1-percent chance of exceedance, and a flow of 25,500 cfs had a 2-percent chance of exceedance. For reference, the 2009 flood had a flow of approximately 29,200 cfs at the Fargo gage.

From October 2009 through March 2010, the Corps Hydrologic Engineering Center (HEC) in Davis, California worked with St. Paul District on revised flow frequency curves. These efforts affected both the traditional "full period of record" analyses and those based on the climate change expert panel recommendations. HEC's revised curves were not available for use during Phase 2.

6.3.3 Hydraulic Modeling
The team used a steady-state HEC-RAS model calibrated to the 2006 event for all Phase 2 economic analyses and comparisons of stage reduction in town. An unsteady HEC-RAS model was built to assess downstream impacts.

During the latter part of the second screening in Phase 2, the team calibrated the existing conditions steady-state model to the 2009 event but did not use it for the screening analyses; the recalibrated model was not available until the end of Phase 2, and it showed approximately 1 foot higher stages than the 2006 calibrated model but matched better with the unsteady model.

6.4 PHASE 2, SCREENING #2 PROCESS

6.4.1 Second Phase 2 Screening
The array of alternatives that remained after the first screening was optimized with a focus on reducing the costs and increasing the benefits for the alternatives. This analysis focused on identifying more cost effective solutions for the river structures, the addition of fish passage and further optimizing the channel excavation to reduce costs. Additional benefits were calculated for transportation and flood proofing cost savings.

During this phase a cost and schedule risk assessment was completed on both the Minnesota and North Dakota alternatives. The assessment was in compliance with ECB No. 2007-17, dated September 2007 and was completed using the "Cost and Schedule Risk Analysis Guidance" dated 17 May 2009 and developed by the Directory of Expertise for Civil Works Cost Engineering (Walla Walla District). Staff of the Directory of Expertise assisted in completing the cost and schedule risk assessment. The assessment resulted in the overall project contingencies for the Minnesota alternatives increasing from 25 percent to 34 percent and from 24 percent to 36 percent on the North Dakota alternatives. The contingencies developed from this assessment are included in the costs in Table 4.

Table 4 – Screening #2 Alternatives with Cost and Schedule Risk Assessment

Screened Alternatives Ranked by Net Benefits with Cost and Schedule Risk Assessment

Alternative	Cost [1]	Avg Annual Net Benefits [1]	Residual Damages [1]	B/C Ratio
MN Short Diversion 10K[2]	$730	$1.3	$40.3	1.03
MN Short Diversion 15K[2]	$800	$11.4	$31.0	1.28
MN Short Diversion 20K	$871	$16.2	$22.7	1.41
MN Short Diversion 25K	$980	$15.5	$18.1	1.36
MN Short Diversion 30K	$1,050	$15.1	$14.8	1.33
MN Short Diversion 35K	$1,143	$12.2	$13.3	1.26
ND East Diversion 30K	$1,231	$13.3	$11.4	1.26
ND East Diversion 35K	$1,295	$11.7	$9.7	1.22

1. In millions of dollars

2. Linear Cost Extrapolations used.

Expected average annual damages without a proejct were $77.1 million.

The analyses completed during the second screening showed that the MN20K plan had the largest net benefits of the plans analyzed, so therefore it was the apparent NED plan. The MN20K plan was the smallest of the plans considered in the array at the beginning of the second screening. In order to bracket the NED plan, MN15K and MN10K plans were analyzed to ensure that they were not the NED plan. The analysis included development of actual benefits for the smaller plans and a linear extrapolation of costs.

All of the plans considered had a BCR greater than 1.0, meaning that any plan could be selected by the non-federal sponsors as a locally preferred plan.

Table 5 presents the expected flood stages with various capacities of diversion channel as calculated in Phase 2.

Table 5 – Stage at Fargo Gage with Diversion Channels (Phase 2)

	Stage at Fargo Gage (ft)		
	2-percent Chance (50-year)	1-percent Chance (100-year)	0.2-percent Chance (500- year)
Existing Condition	37.8	39.5	43.9
MN Alignment			
20K	30.8	32.8	40.6
25K	29.8	31.4	38.9
30K	29.8	31.1	36.9
35K	29.8	30.3	34.9
ND Alignment			
30K	29.3	29.4	37.0
35K	28.8	29.3	34.9

It should be noted that the apparent differences in performance shown in Table 5 between the larger Minnesota and North Dakota plans were due to better refinement of the models for the North Dakota plans. No actual differences in performance were expected for comparable capacity regardless of the alignment. As a result, the economic analyses presented in Table 4 would be expected to underestimate the net benefits for the Minnesota plans relative to the North Dakota plans.

The following information is intended to provide context for the stages shown in Table 5. Flood stages lower than 30.0 on the Fargo gage present only minor flood impacts to low-lying roads. Above the stage of 30.0, more extensive emergency actions are required, including temporary levees along Second Street in downtown Fargo and other locations. The major threat to homes begins at about a stage of 33.0, and significant emergency actions are required up to a stage of 40.0. Above a stage of 40.0, emergency actions are extreme. Lines of protection must extend many miles, and several portions of emergency levees exceed normally recommended heights for sandbag construction. During the 2009 flood of record, more than 80 miles of emergency measures were required to attain a line of protection equal to a stage of approximately 42.0. The actual 2009 peak flood stage was 40.82 on the Fargo gage.

6.4.2 Non-structural measures

Non-structural measures were assessed both upstream of the diversion alignments and in areas near the downstream end of the project that receive little or no stage reduction from the project. It was determined that no additional non-structural measures could be economically justified in addition to a North Dakota diversion. No non-structural measures were economically justified upstream of the diversions. However, non-structural measures downstream were incrementally justified in conjunction with all of the Minnesota diversions. The non-structural measures had benefit to cost ratios of 1.04

for the MN20K plan and 1.14 for the MN25K, MN30K and MN35K plans. The non-structural features would add average annual net benefits of $17,156 for MN20K and $49,903 for the other three Minnesota plans. (Appendix P) These additional costs and benefits are not included in Table 4 above.

The nonstructural mitigation measures proposed near the downstream end of the Minnesota diversions consisted of buyouts, elevation, and construction of flood walls in the vicinity of Harwood, North Dakota. For the MN20K plan there were 57 residential structures, 1 commercial structure, and 1 critical facility (ID 400802 public school) included. For the larger Minnesota plans there are 51 residential structures and 1 critical facility (ID 400802 public school) included.

The non-structural measures in combination with all of the Minnesota alternatives being considered had net benefits greater than 1. Therefore with the selection of any Minnesota diversion alternative the non-structural plan would be added as a justified increment to that plan and would become part of the NED plan.

6.4.3. <u>Downstream impacts to flood stages</u>
An unsteady HEC-RAS model was created to determine how the various diversion plans would affect flood stages downstream. Preliminary modeling indicated that operating a 35,000 cfs diversion could increase flood stages downstream up to approximately 10 inches during a 1-percent chance event. The model showed that the flood duration would not be affected, but the higher stage would likely arrive about 1 day earlier. Smaller more frequent events were also analyzed, and a preliminary takings analysis was prepared. It was determined that the project did not affect the magnitude, duration or frequency of flooding downstream enough to rise to the level of a taking for any of the Minnesota alternatives. The predicted induced impacts of the project under the North Dakota alignment were sufficient to raise takings concerns. Agricultural damages were expected to be minimal, because the large Red River floods occur in the months of March and April when there is still frost in the ground and no crops are planted. Most of the structures in the floodplain downstream were either already affected by a 1-percent chance event, or they were in communities that were planning to build significant levees in the future. Both of these factors affect the takings determination. If the threshold for a taking is not met, the project could not compensate or mitigate for the incremental flood damages that may be caused by the project.

<u>6.4.4 Incremental measures eliminated from further consideration</u>
Following the development of the diversion alternatives, additional consideration was given to flood storage, wetland and grassland restoration, bridge replacement or modification, and the use of cut-off channels. It was determined that these measures would not provide any additional economically justified benefits. This is due to the fact that the diversion alternatives provided a very high level of flood risk reduction, and they captured a large portion of the benefits that could be captured by a project.

The study team evaluated a shorter diversion northwest of Fargo to intercept only the Maple, Lower Rush and Rush rivers as an additional measure to be implemented with a Minnesota diversion alternative. The northwest diversion was not cost-effective as an incremental measure, so it was dropped from further consideration. Additional information about incremental measures and how they were eliminated from further consideration can be found in section 8.4.2.

6.5 STUDY DEVELOPMENTS AT THE END OF PHASE 2

6.5.1 Effects of the Recalibrated Hydraulic Model

As described in paragraph 6.3.3, the steady-state hydraulic model was recalibrated to the 2009 event late in the second screening in Phase 2. The new model showed approximately 1 foot higher stages than the 2006 calibrated model but matched better with the unsteady model being used to determine downstream impacts. In order to verify the NED evaluation, the MN20K and MN35K plans were evaluated with the recalibrated model, and economic benefits were recalculated. Using the recalibrated model resulted in significantly greater damages in the without-project condition ($104 million average annual damages compared to $77 million with the earlier model). Net benefits of each plan were substantially increased, and the MN35K plan saw greater increases in net benefits than the MN20K plan. Based upon the new model results, the net benefits for these two plans differed by approximately 5 percent. From this information, it became clear that the NED plan could be larger than the MN20K plan if all plans were reevaluated.

6.5.2 Hydrologic assumptions

As described in paragraph 6.3.2, efforts were taken from October 2009 through March 2010 to develop revised hydrologic data based upon the recommendations of the climate change expert opinion elicitation panel. Saint Paul District worked with the Corps Hydrologic Engineering Center to refine the traditional hydrologic analysis and to implement the non-traditional approach recommended by the EOE panel. After the draft report went to the Agency Technical Review team for review in February 2010, these hydrologic data were finalized. Both the revised traditional analysis and the non-traditional EOE analysis resulted in higher flows for all frequencies than what had been used in the economic analyses in Phase 2. After considering both sets of data, it was determined that using the non-traditional approach recommended by the EOE panel for all future economic analyses would better represent the actual conditions being seen in the Red River Basin and provide a more likely estimate of expected future conditions.

6.5.3 Implications for the final screening

The combination of the revised hydraulic and hydrologic data had two primary implications for plan formulation. First, the data validated the earlier screening of major conceptual alternatives. Second, it showed that additional work was needed to determine the NED plan.

Both the revised hydraulics and hydrology resulted in higher stages for any given frequency of event. All of the other conceptual alternatives—levee/floodwalls, upstream storage, and non-structural measures—would perform far less efficiently than diversions with a larger flow regime than what was assumed during screening. Therefore, this data confirmed that the diversion concept was superior and that the NED plan would be a diversion.

Because the increased stage from the hydraulic change alone increased net benefits disproportionately for the largest and smallest plans, it was not known how additional stage increases resulting from changing the hydrologic assumptions would affect the NED calculations. For that reason, all of the Minnesota diversion capacities would need to be evaluated using the recalibrated model and higher flows in order to identify the NED plan. There was also a possibility that the NED plan could be one of the North Dakota plans.

7.0 FEASIBILITY PHASE 3 (Mar 2010 – Sep 2010)

7.1 PHASE 3 ACTIVITIES

Plan formulation activities early in Phase 3 focused on using the non-traditional hydrology and re-calibrated hydraulic models to identify the NED plan. The hydraulic models used to determine downstream impacts were refined and updated using the new hydrology. Coordination with the railroads was conducted to identify and address impacts to the railyard near Dilworth, Minnesota and to refine cost estimates for railway bridges in both the Minnesota and North Dakota plans. The diversion channel alignments, cross sections, and the locations of the hydraulic structures were refined to address geotechnical concerns and to reduce the risk to the Buffalo Aquifer in Minnesota. Coordination with the non-federal sponsors and the Corps vertical team continued throughout Phase 3; the sponsors requested a locally preferred plan and in April 2010 the ASA(CW) approved the request to tentatively recommend a locally preferred plan. A draft feasibility report and environmental impact statement (DEIS) was published for public review and comment in May 2010. Concurrent with public review, the study team conducted field surveys for HTRW, cultural resources, wetland delineation and additional geotechnical investigations. Hydraulic modeling of downstream impacts also continued during the public review period. Phase 3 concluded with a decision to extend the study schedule to allow for additional hydraulic modeling of downstream impacts and investigation of measures to minimize those impacts.

7.2 PHASE 3 REVIEW AND COORDINATION

7.2.1 Alternative Formulation Briefing (AFB)

An AFB was held in the St. Paul District Office on April 26, 2010. The PDT, vertical team and staff from the Assistant Secretary of the Army for Civil Works (ASA(CW)) attended. The draft report and associated review documents were submitted to the vertical team on March 26, 2010. The report addressed as many ATR comments as possible, and acknowledged outstanding issues needing further attention. A Project Guidance Memorandum dated May 24, 2010 identified changes required prior to release of the draft report and environmental impact statement for public review in accordance with the National Environmental Policy Act (NEPA). (Attachment 3)

7.2.2 Approval to tentatively recommend a Locally Preferred Plan (LPP)

U.S. Army Corps of Engineers policy requires the Corps to recommend the NED plan unless an exception from policy is obtained from the ASA(CW). Meetings were held with the Metropolitan Flood Management Committee on February 1, 2010 and with the Metro Flood Study Work Group (MFSWG) on February 4, 2010 to present the results of Phase 2 screenings. These groups were asked if they were still interested in a LPP and a deadline of April 15, 2010 was set to receive a formal request. After February 4, the MFSWG met weekly to discuss the project. On March 18, 2010, the work group voted to recommend the North Dakota 35,000 cfs channel as its locally preferred alternative. In its motion to select the ND35K plan, the work group noted that this plan provided "500-year flood protection to the FM metro area for the Red, Wild Rice, Sheyenne, Maple, Rush and Lower Rush Rivers" and "protection for the greatest amount of land and for the greatest number of citizens." The non-federal sponsors provided a letter dated March 29, 2010 that formally identified the North Dakota 35,000 cfs diversion as the LPP. St. Paul District forwarded the non-federal sponsors' request for a LPP to the vertical team on April 8, 2010 for coordination with the Office of the ASA(CW). The ASA(CW) visited the study area on April 25, 2010 and approved the necessary exception from policy on April 28, 2010. The exception allowed St. Paul District to prepare the draft feasibility report and environmental impact statement tentatively recommending the ND35K plan as a LPP.

7.2.3 Public Review

7.2.3.1 The draft feasibility report and environmental impact statement (DEIS) was released for public review in May 2010. The public review period ended on August 9, 2010. Comments were received from individuals and representatives of local, state and federal governmental agencies as well as non-profit organizations.

7.2.3.2 Public meetings, landowner meetings, and downstream stakeholder meetings were held in June 2010, information on these meetings can be found in Appendix Q.

7.2.4 Independent External Peer Review (IEPR)

The same document submitted to the vertical team for the AFB was also submitted to the independent external peer review panel. An initial IEPR meeting was held on April 2, 2010. IEPR of the draft report was completed on July 6, 2010.

7.3 PHASE 3 KEY ASSUMPTIONS

7.3.1 Hydrology and Hydraulics

"Phase 3" hydrology and hydraulics were used to complete the final screening and to determine the NED plan. The Phase 3 hydrology was based on the results of the EOE panel which divided the Red River's historic hydrologic record into "wet" and "dry" periods and recommended assuming continued wet conditions in project year zero changing progressively to drier conditions in years 25 and 50. Late in Phase 3, the hydrology of the Sheyenne River was refined to better reflect recent flood events.

Phase 3 hydrology included the following flows:

	Year 0	Year 25	Year50
2-percent chance exceedance (cfs):	29,300	27,441	25,764
1-percent chance exceedance (cfs):	34,700	32,921	31,304
0.2 percent chance exceedance (cfs):	61,700	57,641	54,034

Phase 3 hydraulics used a steady-state HEC-RAS model calibrated to the 2009 flood event for diversion channel design. The expected 1-percent chance stage at the Fargo gage was 42.4 feet at Year 0.

An unsteady HEC-RAS model was used to assess upstream and downstream impacts.

7.4 PHASE 3 PROCESS

7.4.1 Phase 3 Screening

Early in Phase 3 all of the Minnesota diversion capacities were evaluated using the recalibrated model and higher flows in order to identify the NED plan. The ND35K diversion was also evaluated at this time to verify that the NED plan was not a North Dakota diversion and to ensure adequate analysis was completed on the LPP. The cost estimates were updated to include detailed analysis of the railroad crossings and recent geotechnical analysis.

The Phase 3 final array of alternatives was analyzed in May 2010 to identify the NED plan. The initial Phase 3 work showed that the MN35K plan maximized net economic benefits, so therefore it was the apparent NED plan. The MN35K plan was the largest of the plans considered in the array at the beginning of Phase 3. In order to bracket the NED plan, MN40K and MN45K plans were analyzed to ensure that they were not the NED plan. Hydraulic models were developed for the MN40K and MN45K alternatives to fully define the with-project flood stages and economic benefits for those alternatives.

Costs for the MN40K and MN45K plans were estimated based upon linear extrapolation from the detailed estimates of the smaller Minnesota alternatives. Figure 1 illustrates the linear nature of the cost curve for these alternatives and supports the methodology used. The Phase 3 analyses determined that the NED plan was the MN40K plan, with maximum average annual net benefits of $105.6 million. The results of the Phase 3 cost-effectiveness analysis are presented in Table 6.

Figure 1 - Linear Extrapolation of Costs for the MN40K and MN45K Alternatives

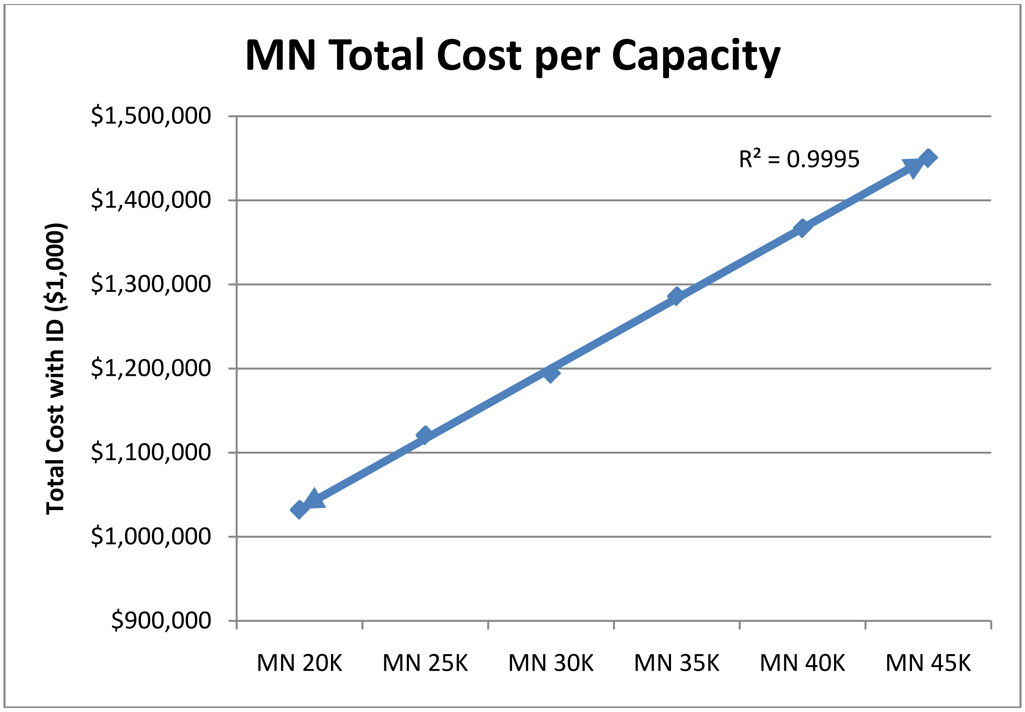


Table 6 – Phase 3 screening with updated hydrology and hydraulics

Screened Alternatives Ranked by Net Benefits with Cost and Schedule Risk Assessment

Alternative	Cost [1]	Avg Annual Net Benefits [1]	Avg Annual Benefits [1]	Residual Damages [1]	B/C Ratio
MN Short Diversion 20K	$1,032	$87.0	$140.0	$55.9	2.64
MN Short Diversion 25K	$1,121	$98.8	$156.4	$39.5	2.71
MN Short Diversion 30K	$1,194	$101.7	$163.1	$32.8	2.66
MN Short Diversion 35K	$1,286	$104.9	$171.0	$24.9	2.59
MN Short Diversion 40K [2]	$1,367	$105.6	$175.9	$20.0	2.50
MN Short Diversion 45K [2]	$1,450	$104.9	$179.5	$16.4	2.41
ND East Diversion 35K	$1,462	$95.4	$171.1	$24.8	2.26

1. In millions of dollars with interest during construction and discounting included
2. Estimate based on linear extrapolation
Expected average annual damages without a project were $195.9 million.

Table 7 presents the expected flood stages with various capacities of the diversion channel as calculated in Phase 3.

Table 7 - Phase 3 estimated flood stages assuming various diversion capacities

	Stage at Fargo Gage (ft)	
	1% Chance (100- year)	0.2% Chance (500- year)
Existing Condition (Stage)	42.4	46.7
Existing Condition (CFS)	34,700	61,700
Work Group Goal	30	36
20K Diversion Channels	36.9	43.7
25K Diversion Channels	34.8	42.4
30K Diversion Channels	33.6	41.9
35K ND Diversion Channel	30.6	40.0
35K MN Diversion Channel	31.9	39.6
40K Diversion Channels	31.9	37.6
45K Diversion Channels	31.9	35.3

The Metro Flood Study Work Group (MFSWG) was provided with the economic analysis of the Minnesota diversion plans and the expected flood stages with the diversion channels on May 13, 2010. Using the revised hydrology and re-calibrated hydraulic model, the study team found that the 35K diversion channels would no longer meet the non-federal sponsors' earlier goal, a stage of 36 at the Fargo gage during a 0.2-percent chance event. The work group requested that information be developed to determine what size diversion could meet their goals, and this is also included in Table 7. It was determined that a 45K diversion would be the smallest diversion that would meet the non-federal sponsors' earlier goal.

7.4.2 Reconsideration of the Locally Preferred Plan (LPP)

On April 28, 2010, the Assistant Secretary of the Army for Civil Works authorized the Corps to tentatively recommend the ND35K plan as a LPP (See Attachment 6 - approval letter). After considering the Phase 3 results, the non-federal sponsors reaffirmed their preference for the ND35K plan as the LPP. It was noted that the revised hydrology and hydraulics affected the nominal performance of the LPP, and the ND35K plan would no longer produce the locally desired stage of 36.0 on the Fargo gage for a 0.2-percent chance event.

7.4.3 Dismissal of the MN40K (NED) plan and the MN45K plan

Selection of the ND35K plan as the LPP made further consideration of the NED plan (MN40K) unnecessary. Federal cost sharing for the LPP could not be based on the NED plan, because the LPP produced fewer total average annual benefits than the NED plan, at $171.1 million and $175.9 million, respectively. Instead, federal cost sharing would be based upon a smaller Minnesota alternative that produced a comparable level of benefits to the LPP. Table 6 shows that the MN35K plan and the LPP produced comparable benefits, at $171.0 million and $171.1 million, respectively. Since the MN35K plan would serve as the basis for federal cost sharing, there was no need to fully develop the MN40K (NED) plan. For purposes of the feasibility study, it was only necessary to demonstrate that the NED plan was larger than the MN35K plan. For that reason, the MN40K (NED) plan and the MN45K plan were dismissed from further consideration, and the MN35K plan would be refined for comparison with the LPP for cost-sharing purposes. The MN35K plan was therefore identified as the Federally Comparable Plan (FCP).

7.4.4 Validation of earlier screening steps

The Phase 3 economic analyses completed in May 2010 validated the October 2009 and January 2010 screening steps. Decisions made at earlier steps were based on the best hydraulic and hydrologic data available at that time. Subsequent information indicated that the earlier assumptions underestimated both the flow frequency and expected flood stages. As a result, all of the plans previously considered and screened out during the earlier screening steps, including levee and storage alternatives, would provide more benefits but would leave higher residual flood risk than was identified at the time. The best available data at the conclusion of feasibility Phase 3 confirmed that the diversion channel concept was the only concept that could achieve a high level of flood risk reduction in the study area.

7.4.5 Downstream and upstream impacts

At the end of Phase 3, there were two primary issues related to downstream impacts of the diversion plans. The first issue was the potential effect of induced economic damages on identification of the NED plan. The second issue was the inability to determine the full extent of the impacts and identify the location where impacts dissipated to a negligible amount, which made it necessary to modify the LPP. These issues are discussed below.

7.4.5.1 No effects on selection of NED plan: At the end of Phase 3, the analysis of downstream impacts of the diversions was incomplete. However, it was determined that downstream impacts would not affect the selection of the NED plan. All of the Minnesota diversions would have similar performance up to their design capacity; for any given flood, each channel would divert the same amount of water up to its full capacity. All of the diversions would convey similar flows for more frequent events, and differences in downstream impact would primarily occur in the larger less frequent events. Economic damages due to downstream impacts would not vary significantly with the size of channel, because the infrequent events would add relatively little to the annualized damages. Since downstream impacts would be relatively similar for all of the alternatives, downstream impacts would not affect the identification of the NED plan, and it was not necessary to quantify the impacts from the smaller plans in order to identify the

NED plan. During Phase 3, downstream impacts were only modeled for the MN35K and ND35K plans.

7.4.5.2 Throughout Phases 1-3 of the study, the diversion alternatives were designed to have only downstream stage increases and it was expected that any downstream stage increases would be relatively small and dissipate relatively quickly. Prior to release of the Draft Report and Environmental Impact Statement in May 2010, the unsteady HEC-RAS models showed downstream impacts to Halstad, MN. Following the release of the Draft Report the models were extended downstream to Thompson, ND (101 river miles downstream of the diversion outlet). The models showed impacts at Thompson of nearly 16 inches for a 1-percent chance event with the ND35K diversion. Based on these results, it was determined that additional modeling was required to identify a point downstream with minimal to no impacts and that consideration would need to be given to other options such as upstream staging.

7.5 PHASE 3 COMPARISON OF ALTERNATIVES

Comparison of alternatives is the fifth step in the planning process, which is based on the evaluation of the impacts of the alternatives, the fourth step in the planning process. The information in section 7.5 of this appendix was presented in the May 2010 Draft report, and is presented here for historical documentation of the planning process. Section 8 of this appendix includes similar information for the final screening completed in Phase 4.

7.5.1 Comparison of Plan Features

Features of the alternative plans are displayed in a comparative format in Table 8. The costs of these features are included in Table 9, also in a comparative format.

Table 8 – Comparison of Alternative Plan Features

CHANNEL ALIGNMENT PARAMETERS	Minnesota Short Alignment				ND East Alignment
	20K	25K	30K	35K	35K
Top Width (feet)					
Red River to Wild Rice	1880	2020	2000	2150	2450
Wild Rice to Sheyenne					2320
Sheyenne to Outfall					2300
Bottom Width (feet)					
Red River to Wild Rice	175	240	300	360	300
Wild Rice to Sheyenne					100
Sheyenne to Outfall					125
Depth (max. excavation feet)	30	30	30	30	29
Excavation quantities (million yd^3)	36	42	49	55	67
Low flow channel required: Depth 3 ft Bottom Width 10 ft	√	√	√	√	√
Length of Alignment (miles)	25	25	25	25	36
Channel extension needed	3.7	3.7	3.7	3.7	
Length of tie back levee (miles)	9.9	9.9	9.9	9.9	3.3
Height of Levee (feet)	8	8	8	8	8
Hydraulic Structures					
Drop Structures	1	1	1	1	3
River Crossings	0	0	0	0	5
Highway Bridges	20	20	20	20	18
Rail Road Bridges	4	4	4	4	4
Number of Houses Impacted	5	5	5	5	6
Number of Acres Impacted	4,485	5,455	5,965	6,415	6,560
Acres of Wetlands Impacted - worst case					
Directly	13				33
Indirectly (due to lowering of groundwater)	85				193
Stage @ Fargo Gage					
0.2 % Event (500yr) (ft)	43.7	42.4	41.9	39.6	40
1% Event (100yr) (ft)	36.9	34.8	33.6	31.9	30.6
Max. Downstream Stage Increase (inches) 1% Event	TBD			9.4	10.4
Land removed from 1% floodplain ($miles^2$)	30				80

Table 9 – Comparison of Alternative Plan Costs including Recreation (December 2009Unit Pricing)

		Minnesota Short Alignment				ND East Alignment
Account	Item	**20K**	**25K**	**30K**	**35K**	**35K**
01	Lands & Damages	36,954	41,108	45,195	49,282	60,593
02	Relocations	76,534	84,396	92,911	94,050	82,251
06	Fish and Wildlife Facilities	50,920	50,920	50,920	50,920	82,960
08	Roads, Relocations and Bridges	147,708	148,271	148,834	149,397	54,971
09	Channels & Canals	380,177	429,732	466,924	524,576	741,990
11	Levees, Floodwalls, & Floodproofing	16,101	14,922	14,922	14,922	2,386
14	Recreation Facilities	28,067	28,067	28,067	28,067	28,486
30	Planning, Engineering and Design	104,926	113,446	120,387	129,290	148,957
31	Construction Management	48,965	52,942	56,181	60,335	69,514
	Total First Costs	**$890,352**	**$963,804**	**$1,024,341**	**$1,100,839**	**$1,272,108**
	Annual OMRR&R Diversion Cost	$1,883	$2,057	$2,217	$2,375	$3,318
	Annual OMRR&R Recreation Cost	$47	$47	$47	$47	$47
	Toal Annual OMRR&R	$1,930	$2,104	$2,264	$2,422	$3,069
	All costs in thousands ($1,000)					

7.5.2 System of Accounts

7.5.2.1 Methodology

The Economic and Environmental Principles for Water and Related Land Resources Implementation Studies, established by the Water Resources Council in 1983, created four accounts to facilitate evaluation and effects of alternative plans:

- The national economic development (NED) account displays changes in the economic value of the national output of goods and services
- The environmental quality (EQ) account displays non-monetary effects on significant natural and cultural resources
- The Regional economic development (RED) account registers changes in the distribution of regional economic activity that result from each alternative plan.
- The other social effects (OSE) account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

7.5.2.2 National Economic Development (NED)

The intent of comparing alternative flood risk management plans in terms of national economic development is to identify the beneficial and adverse effects that the plans may have on the national economy. Beneficial effects are considered to be increases in the economic value of the national output of goods and services attributable to a plan. Increases in NED are expressed as the plan's economic benefits, and the adverse NED effects are the investment opportunities lost by committing funds to the implementation of a plan. Comparison of the plans under consideration in Phase 3 using the NED account is shown on Table 10. The values for net benefits shown on the tables are the differences between the average annual economic benefits and the average annual cost associated with each plan. Table 6 indicates the current annual net benefits of the MN40K plan are the greatest and the MN40K plan is therefore the NED plan. However, as explained in section 3.6.5, it was not necessary to fully describe the NED plan once it was demonstrated that the LPP was a smaller capacity plan, and the NED plan was dropped from further consideration. The MN35K plan was kept for comparison to the LPP for cost-sharing purposes.

The no action alternative has zero net benefits and results in average annual damages in excess of $194.8 million.

Table 10 - National Economic Development (NED) Account (all dollar values in thousands)

	Minnesota Short				North Dakota
	20K	25K	30K	35K	East 35K
Total Diversion First Cost	$856,110	$929,562	$990,099	$1,066,597	$1,237,355
Interest During Construction and Discounting	$176,066	$191,183	$203,634	$219,368	$224,549
Present worth of Investment	$1,032,176	$1,120,745	$1,193,733	$1,285,965	$1,461,904
Annualized Investment Cost	$51,172	$55,563	$59,182	$63,754	$72,477
Annual OMRR&R Cost	$1,883	$2,057	$2,217	$2,375	$3,318
Average Annual Diversion Charges	$53,055	$57,620	$61,399	$66,129	$75,795
Total Recreation First Cost	$34,242	$34,242	$34,242	$34,242	$34,753
Interest During Construction and Discounting	$2,280	$2,280	$2,280	$2,280	$760
Present worth of Investment	$36,522	$36,522	$36,522	$36,522	$35,513
Annual Recreation First Cost	$1,811	$1,811	$1,811	$1,811	$1,761
Annual Recreation OMRR&R Cost	$47	$47	$47	$47	$47
Average Annual Recreation Charges	$1,858	$1,858	$1,858	$1,858	$1,808
Flood Damage Reduction Benefit	$132,629	$148,756	$155,438	$163,372	$160,197
Flood Proofing Cost Savings	$5,960	$6,240	$6,240	$6,240	$9,993
Flood Insurance Adminstrative Cost Saving	$1,000	$1,000	$1,000	$1,000	$958
Incremental Non-Structural Flood Risk Benefit	$430	$414	$414	$414	
Avg. Annual Diversion Benefit	$140,019	$156,410	$163,092	$171,026	$171,148
Avg. Annual Recreation Benefit	$5,355	$5,355	$5,355	$5,355	$5,130
Annual Net Diversion Benefit	**$86,964**	**$98,790**	**$101,693**	**$104,897**	**$95,353**
Annual Net Recreation Benefit	$3,497	$3,497	$3,497	$3,497	$3,322
Total Annual Net Benefit	$90,461	$102,287	$105,190	$108,394	$98,675
Diversion Benefit-Cost Ratio	**2.64**	**2.71**	**2.66**	**2.59**	**2.26**
Recreation Benefit-Cost Ratio	2.88	2.88	2.88	2.88	2.84
Benefit-Cost Ratio	**2.65**	**2.72**	**2.66**	**2.59**	**2.27**

1. Costs and Benefits are given in $1,000's
2. Assumes a 50 year period of analysis - 4 3/8% interest rate.
3. Assumes a 7.5 year period of construction for MN diversions and 8.5 years for ND diversions
4. No credit is given to flood fight reliability

7.5.2.3 Environmental Quality (EQ)

The environmental quality account is another means of evaluating the alternatives to assist in making a plan recommendation. The EQ account is intended to display the long-term effects that the alternative plans may have on significant environmental resources. Significant environmental resources are defined by the Water Resources Council as those components of the ecological, cultural and aesthetic environments which, if affected by the alternative plans, could have a material bearing on the decision-making process. Significance is derived from institutional, public or technical recognition that a resource or an effect is significant. A comparison of the effects that the Phase 3 alternatives may have on the EQ resources is shown in Table 11.

Table 11 – Environmental Quality (EQ) Account

Resources	No Action	MN Diversion 20K	MN Diversion 25K	MN Diversion 30K	MN Diversion 35K	ND Diversion 35K
Flooding	Expected Annual Flood Damage of $195.9 million	Expected Annual Flood Damage reduced by $140.0 million	Expected Annual Flood Damage reduced by $156.4 million	Expected Annual Flood Damage reduced by $163.1 million	Expected Annual Flood Damage reduced by $171.0 million	Expected Annual Flood Damage reduced by $171.1 million
Air Quality	No Effect	Minor degradation from extensive and lengthy construction period	Minor degradation from extensive and lengthy construction period	Minor degradation from extensive and lengthy construction period	Minor degradation from extensive and lengthy construction period	Minor degradation from extensive and lengthy construction period
Water Quality	No Effect	Temporary minor adverse impacts on surface w ater quality during construction.	Temporary minor adverse impacts on surface w ater quality during construction.	Temporary minor adverse impacts on surface w ater quality during construction.	Temporary minor adverse impacts on surface w ater quality during construction.	Temporary minor adverse impacts on surface w ater quality during construction.
Erosion and Sedimentation	Continued Erosion during flooding	Less Erosion and Sedimentation During Flooding, possible geomorphologic issues on Red River.	Less Erosion and Sedimentation During Flooding, possible geomorphologic issues on Red River.	Less Erosion and Sedimentation During Flooding, possible geomorphologic issues on Red River.	Less Erosion and Sedimentation During Flooding, possible geomorphologic issues on Red River.	Less Erosion and Sedimentation During Flooding, possible geomorphologic issues on Red River and tributaries.
Water Quantity	No Effect	Dow nstream stage increase expected to be less than the MN35k diversion	Dow nstream stage increase expected to be less than the MN35k diversion	Dow nstream stage increase expected to be less than the MN35k diversion	Dow nstream stage increase 4.6-9.4 inches 1 percent event	Dow nstream stage increase 5.3-10.4 inches 1 percent event
Ground Water	No Effect	Slightly low ered w ater table near diversion channel	Slightly low ered w ater table near diversion channel	Slightly low ered w ater table near diversion channel	Slightly low ered w ater table near diversion channel	Slightly low ered w ater table near diversion channel
Aquifers	No Effect	Small potential to influence aquifers	Small potential to influence aquifers	Small potential to influence aquifers	Small potential to influence aquifers	Small potential to influence aquifers
Aquatic Habitat	Improved due to ongoing efforts to improve fish passage	Loss of 10 acres of habitat w ith large closure structure at Red River. Less than significant impacts to aquatic species migrational corridors	Loss of 10 acres of habitat w ith large closure structure at Red River. Less than significant impacts to aquatic species migrational corridors	Loss of 10 acres of habitat w ith large closure structure at Red River. Less than significant impacts to aquatic species migrational corridors	Loss of 10 acres of habitat w ith large closure structure at Red River. Less than significant impacts to aquatic species migrational corridors	Loss of habitat of approximately 37 acres w ith large structures at 6 rivers. Less than significant impacts to aquatic species migrational corridors

Table 12 – Environmental Quality (EQ) Account (continued)

Resources	No Action	MN Diversion 20K	MN Diversion 25K	MN Diversion 30K	MN Diversion 35K	ND Diversion 35K
Riparian Habitat	No Effect	Increase in habitat value for approximately 1,200 acres in the form of grass sw ale near the bottom of the diversion. Loss of 74.5 acres at river connections	Increase in habitat value for approximately 1,600 acres in the form of grass sw ale near the bottom of the diversion. Loss of 74.5 acres at river connections	Increase in habitat value for approximately 1,800 acres in the form of grass sw ale near the bottom of the diversion. Loss of 74.5 acres at river connections	Increase in habitat value for approximately 2,000 acres in the form of grass sw ale near the bottom of the diversion. Loss of 74.5 acres at river connections	Increase in habitat value for approximately 1,000 acres in the form of grass sw ale near the bottom of the diversion. Loss of 137.75 acres at river connections
Wetlands	No Effect	Direct impact to 17 acres of w etlands by construction of project, Indirect impact to 85 acres from low ering of groundw ater elevation	Direct impact to 17 acres of w etlands by construction of project, Indirect impact to 85 acres from low ering of groundw ater elevation	Direct impact to 17 acres of w etlands by construction of project, Indirect impact to 85 acres from low ering of groundw ater elevation	Direct impact to 17 acres of w etlands by construction of project, Indirect impact to 85 acres from low ering of groundw ater elevation	Direct impact to 32.5 acres of w etlands by construction of project, Indirect impact to 192 acres from low ering of groundw ater elevation
Upland Habitat	No Effect	Potential for increased habitat benefit	Potential for increased habitat benefit	Potential for increased habitat benefit	Potential for increased habitat benefit	Potential for increased habitat benefit
T and E species	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect
Floodplains (E.O. 11988)	112 sq miles in floodplain during .01 year event out of 261 sq miles in project area	Not analyzed for the environmental quality account	81.7 sq miles remain in floodplain, 30.5 sq miles taken out during a 1-percent chance event	Not analyzed for the environmental quality account	80.9 sq miles remain in floodplain, 31.3 sq miles taken out during a 1-percent chance event	30.7 sq miles remain in floodplain. 81.3 sq miles taken out of floodplain during 1-percent chance event
Cultural Resources	No Effect	Potential for impacts along diversion channel. Higher potential for impacts along the river banks	Potential for impacts along diversion channel. Higher potential for impacts along the river banks	Potential for impacts along diversion channel. Higher potential for impacts along the river banks	Potential for impacts along diversion channel. Higher potential for impacts along the river banks	Potential for impacts along diversion channel. Higher potential for impacts along the river banks
Prime and Unique Farmland	No Effect	Not analyzed	Approximately 5500 acres of prime and unique farmland w ill be removed	Not analyzed	Approximately 5700 acres of prime and unique farmland w ill be removed	Approximately 5400 acres of prime and unique farmland w ill be removed
Economic Resources	Continued potential for property damage and business losses due to damaging flood events.	Significant reduction in property damage and lost business.	Significant reduction in property damage and lost business.	Significant reduction in property damage and lost business.	Significant reduction in property damage and lost business.	Significant reduction in property damage and lost business.

7.5.2.4 Regional Economic Development (RED)

The regional economic development account is intended to illustrate the effects that the alternatives would have on regional economic activity, specifically, regional income and regional employment. The comparison of possible effects that the plans may have on these resources is shown in Table 13. The completed RED analysis is included in Appendix C, Economics. The RED analysis only analyzed the MN20K, MN35K and ND35K plans. These plans were selected based on the likelihood of one of those plans ultimately being selected as the recommended plan. This analysis was completed based on the information contained in Table 4 and was not updated to reflect the final analysis. The RED analysis shows that the regional changes in economic output for the MN20K, MN35K and ND35K range between $323 and $332 million annually.

Table 13 – Regional Economic Development (RED) Account

	Without Project Conditions	North Dakota East 35K cfs	Minnesota Short 35K cfs	Minnesota Short 20K cfs
Changes in Economic Output*		$332,455	$329,715	$323,755
Annual Net Change in Employment	(1,665)	895	815	677
Changes in Tax Revenues*	$(5,900) - (18,600)	$12,109	$11,968	$10,922
Average Annual Benefits*		$67,355	$63,795	$54,390
Annual Regional Flood Damages*	$61,676	$8,007	$11,042	$18,666
Changes in Annual Tax Revenue *	$(7,781)	$4,327	$3,917	$3,140
Annual Loss of Business Income*	$65,000			
Gross Regional Product Annual Growth Rate^	1.29 - 2.18	3.09 - 4.11	3.09 - 4.11	3.09 - 4.11

* $1,000 ^ %

7.5.2.5 Other Social Effects (OSE)

The other social effects (OSE) account typically includes long-term community impacts in the areas of public facilities and services, public safety, recreational opportunities, transportation and traffic and man-made and natural resources.

A loss of life analysis was completed for the future without project condition. (See Appendix D, Other Social Effects). The analysis showed that a failure of emergency levees during large flood events could cause considerable loss of life. Assuming that the floodplains were 98% evacuated prior to an anticipated levee breach or overtopping, four deaths could be expected during a 1-percent chance event; the toll increases to 12 deaths for a 0.2-percent chance event. History has shown that residents in the study area do not evacuate, preferring to stay and maintain the emergency flood barriers. Assuming that the floodplains were not evacuated and an unanticipated failure of emergency levees occurred, expected deaths were estimated at 200 and 594 for the 1-percent chance and 0.2-percent chance floods, respectively. With a diversion project in place, the potential for loss of life is expected to be significantly lower. An engineered permanent project would be far less likely to fail and would significantly reduce the frequency, duration and magnitude of flood events in the developed areas.

A comparison of the effects that the Phase 3 alternatives would have on OSE resources is shown on Table 14. The diversion alternatives considered all provide a high level of flood risk management, which results in the OSE impacts being similar for all of the Phase 3 alternatives, with the larger diversions performing better than the smaller diversions.

Table 14 – Other Social Effects (OSE) Account

		Minnesota Short Alignment				ND East Alignment
	No Action	20K	25K	30K	35K	35K
Public Health and Safety	Emergency floodfight activities would still be required, posing high risk of injury and death.	Project would improve public safety by reducing flood risk and the need for emergency actions.	Project would improve public safety greater than the smaller plans by reducing flood risk and the need for emergency actions.	Project would improve public safety greater than the smaller plans by reducing flood risk and the need for emergency actions.	Project would improve public safety greater than the smaller plans by reducing flood risk and the need for emergency actions.	Project would improve public safety greater than the smaller plans by reducing flood risk and the need for emergency actions.
Public Facilities and Services	Public facilities and services would continue to be impacted from floods.	Project would reduce impacts to public facilities and services.	Project would reduce impacts to public facilities and services greater than the smaller plans.	Project would reduce impacts to public facilities and services greater than the smaller plans.	Project would reduce impacts to public facilities and services greater than the smaller plans.	Project would reduce impacts to public facilities and services greater than the smaller plans.
Recreation and Public Access	Recreation would continue to be part of the community as currently plan.	Recreational features would be added to the project to enhance existing services.	Recreational features would be added to the project to enhance existing services.	Recreational features would be added to the project to enhance existing services.	Recreational features would be added to the project to enhance existing services.	Recreational features would be added to the project to enhance existing services.
Traffic and Transportation	Traffic and transportation would continue to be largely disrupted during flood events.	Some local traffic patterns will change as part of the project, overall traffic and transportation will see large benefits.	Some local traffic patterns will change as part of the project, overall traffic and transportation will see large benefits.	Some local traffic patterns will change as part of the project, overall traffic and transportation will see large benefits.	Some local traffic patterns will change as part of the project, overall traffic and transportation will see large benefits.	Some local traffic patterns will change as part of the project, overall traffic and transportation will see large benefits.

7.5.3 Formulation Criteria

The final array of alternative plans is compared using four formulation criteria established by the United States Water Resources Council in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources

Implementation Studies (P&G). These criteria are completeness, effectiveness, efficiency and acceptability.

7.5.3.1 Completeness

The P&G defines completeness as the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. A complete plan includes all elements necessary to function independently to achieve the planning objectives. It is an indication of the degree to which the outputs of the plan are dependent upon the actions of others or on factors beyond the control of the planners.

The no action alternative requires extensive emergency construction to prevent flood damage for all floods larger than a 10-percent chance event.

All of the diversion channel alternatives have a high likelihood of significantly reducing flood damage and flood risk, but none of the plans will eliminate flood risk. Any of the Minnesota or North Dakota 30K and 35K alternatives would substantially reduce the need for emergency floodfighting up to the 1-percent chance event on the Red River. For larger and less frequent events, diversion plans allow for additional in-town flood barriers (either permanent or temporary) to be constructed. The combination of the diversion channel and emergency flood fighting for those extremely rare events provides a very high level of risk reduction to the communities of Fargo and Moorhead. Diversions smaller than the 30K alternatives would need more extensive additional flood barriers in town more frequently than the larger diversions would.

The North Dakota diversions are more complete solutions to the regional flood problem, because they would reduce the risk of flooding from the major tributaries in the North Dakota portion of the study area that are not addressed by the Minnesota diversions.

The diversion channel alternatives require relatively minimal operations. Operations are necessary at the control structure on the Red River for the Minnesota plan. The North Dakota plan will require operations at the Red River control structure, Wild Rice control structure, and the Maple River tributary structure. The operations and maintenance of these structures and all project features will be dictated in the Operations and Maintenance manual that will be provided to the non-federal sponsors upon transfer of the project.

The non-federal sponsors will be responsible for the long-term maintenance of the project along with the eventual repair, rehabilitation, and replacement of project features. Maintenance would include but not be limited to mowing and vegetation management, repair of erosion, debris removal and routine maintenance of mechanical equipment. Failure to maintain the project over the long-term could impact the completeness of the plan. It is unlikely that the non-federal sponsors would neglect the long-term maintenance requirements for any of the plans considered in the final array of alternatives.

The diversion plans are complete plans that, once constructed, would include all features necessary to produce the estimated economic benefits described in this report.

7.5.3.2 Effectiveness

The P&G defines effectiveness as a measure of the extent to which a plan achieves its objectives. All of the plans in the final array partially achieve the planning objectives.

All of the alternatives considered in the final array of alternatives meet the criteria of effectiveness to varying degrees, see Table 15. The objectives of this study as described in Section 2.5 of this report and repeated here were to:

- Reduce flood risk and flood damages in the Fargo-Moorhead metropolitan area.
- Restore or improve degraded riverine and riparian habitat in and along the Red River of the North, Wild Rice River (North Dakota), Sheyenne River (North Dakota), and Buffalo River (Minnesota) in conjunction with other project features.
- Provide additional wetland habitat in conjunction with other project features.
- Provide recreational opportunities in conjunction with other project features.

Table 15 – Effectiveness in meeting planning objectives.

	Minnesota Short Alignment				ND East Alignment
	20K	25K	30K	35K	35K
Reduce Flood Risk	Reduces flood damages by 71%.	Reduces flood damages by 80%.	Reduces flood damages by 83%.	Reduces flood damages by 87%.	Reduces flood damages by 87%.
Residual Damages*	$55,881	$39,490	$32,808	$24,874	$24,752
River system afforded flood risk benefits	Red and Wild Rice Rivers	Red and Wild Rice Rivers	Red and Wild Rice Rivers	Red and Wild Rice Rivers	Red, Wild Rice, Sheyenne, Maple, Rush and Lower Rush Rivers
Restore/ Improve Riverine and Riparian Habitat	No specific improvement to the Riverine or Riparian habitat	No specific improvement to the Riverine or Riparian habitat	No specific improvement to the Riverine or Riparian habitat	No specific improvement to the Riverine or Riparian habitat	No specific improvement to the Riverine or Riparian habitat
Provide additional Wetland Habitat	Provides additional 530 acres of wetlands in the project area.	Provides additional 725 acres of wetlands in the project area.	Provides additional 910 acres of wetlands in the project area.	Provides additional 1090 acres of wetlands in the project area.	Provides additional 593 acres of wetlands in the project area.
Provide Recreational Opportunities.	Provides multiple recreational features including multi-purpose trails.	Provides multiple recreational features including multi-purpose trails.	Provides multiple recreational features including multi-purpose trails.	Provides multiple recreational features including multi-purpose trails.	Provides multiple recreational features including multi-purpose trails.
* In thousands					

7.5.3.3 Efficiency

As defined in the P&G, efficiency is a measure of the cost-effectiveness of an alternative. Cost-effectiveness considers not only economic costs, but also other intangible costs such as environmental impacts and opportunity costs. All of the diversion alternatives have net benefits greater than 1 and are considered to be efficient. A breakdown of the net benefits and residual damages associated with each of the diversion alternatives is provided in Table 16. The larger diversions also result in a lower frequency of emergency flood fights, lower risk to lives and property and considerably better effectiveness during extreme flood events.

Table 16 – Efficiency of plans – Net Benefits (all dollar values are in thousands)

		Minnesota Short Alignment				ND East Alignment
	NO Action	20K	25K	30K	35K	35K
Net Benefits of Plan (NED)	$0	$86,964	$98,790	$101,693	$104,897	$95,353
Residual Damages	$195,900	$55,881	$39,490	$32,808	$24,874	$24,752

7.5.3.4 Acceptability

Acceptability is defined in the P&G as the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies. All of the plans in the final array are in accordance with federal law and policy. All of the alternatives are considered acceptable for implementation, however there are slight differences in the level of acceptability. This information is summarized in the sections below.

7.5.3.4.1 Alignment

There is a strong desire from the non-federal sponsors and the public to have the diversion plan constructed in North Dakota. The North Dakota alignment would be considered highly acceptable to the non-federal sponsors. The Minnesota alignments are also acceptable, as the non-federal sponsors and the public have indicated that doing nothing is not an option; however they generally prefer the North Dakota alignment and officially requested the ND35K plan as a locally preferred plan.

7.5.3.4.2 Downstream Effects

Prior to release of the May 2010 Draft Report, the best available downstream hydraulic models ended at Halstad, Minnesota. The diversion plans would all have potential downstream effects, and public concerns were raised regarding those effects. All of the diversions in the final array could cause increased flood stages downstream of the project. Analysis was conducted only for the MN35K and ND35K alternatives to determine the maximum extent of downstream impacts. The assumption was that the smaller diversions would have smaller downstream impacts for events at which their capacity was exceeded.

Downstream of the MN35K plan, the increase to the peak stage during a 1-percent chance event, with no emergency protection in place, was estimated to be 6.8 inches or less, depending upon location. The 1-percent chance event peak was estimated to arrive and recede about one day earlier than under existing conditions. The increase to the peak stage during a 10-percent chance event, with no emergency protection in place, was estimated to be 4.3 inches or less, depending upon location. The timing of the 10-percent chance event peak would be nearly unchanged.

Downstream of the ND35K plan, the increase to the peak stage during a 1-percent chance event, with no emergency protection in place, was estimated to be 7.9 inches or less, depending upon location. The 1-percent chance event peak would arrive and recede about 1.5 days earlier than under existing conditions. The increase to the peak stage during a 10-percent chance flood event, with no emergency protection in place, is estimated to be 24.7 inches or less, depending upon location. The 10-percent chance event peak would arrive and recede up to about one day earlier than under existing conditions immediately downstream of the diversion, but the timing at Halstad would be nearly unchanged.

The North Dakota alignment ha greater downstream effects than the Minnesota alignments and would therefore be less acceptable to downstream interests.

7.5.3.4.3 Tolerable level of risk

The non-federal sponsors indicated in November 2009 that a flood stage of approximately 36.0 on the Fargo gage for a 0.2-percent chance event would be tolerable. The non-federal sponsors indicated that this level is tolerable because they are confident that they would be successful with flood fighting efforts up to the stage of 36.0. Lesser stage reductions would be undesirable. Larger plans reduce flood risk to a greater degree and are, therefore, more acceptable than smaller plans from the perspective of tolerable level of risk. The analysis completed in May 2010 shows that a diversion capacity of 45,000 cfs would be required to achieve the desired stage reduction for both the Minnesota and North Dakota alignments. The 45,000 cfs alignments in both Minnesota and North Dakota would result in a 0.2-percent chance stage of 35.3. The 35,000 cfs alternatives result in a 0.2 percent chance stage of 40.0. The non-federal sponsors indicated that such a stage reduction would be acceptable.

7.5.3.4.4 Natural Resource Impacts

Impacts to the natural resources are a concern to the public and many organizations. The North Dakota alternatives generally have more natural resource impacts than the Minnesota alternatives because they cross five tributary streams. However, the North Dakota alignment provides flood risk management benefits to a larger geographic area and for more people. See Chapter 5, Environmental Consequences, of this report for more detail.

7.5.3.4.5 Floodplain Impacts

Executive Order 11988 requires federal agencies to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. This study has shown that a diversion channel in either Minnesota or North Dakota is the only feasible concept that will sufficiently reduce flood risk along the Red River in Fargo and Moorhead. Therefore, there is not a practicable alternative located outside the floodplain, and locating the project in the floodplain is necessary to achieve the project purpose. The primary planning objective is to reduce flood risk in the entire metropolitan area, including areas adjacent to the Wild Rice, Sheyenne, Maple, Rush and Lower Rush rivers. The North Dakota alignment significantly reduces flood frequency on approximately 80 square miles currently located in the 1-percent chance event floodplain. The North Dakota alignment reduces flood risk from all of the rivers in the North Dakota portion of the study area. The Minnesota alignment significantly reduces flood frequency on approximately 30 square miles currently located in the 1-percent chance event floodplain, but it does not address the North Dakota tributaries to the Red River. Because of the different impacts on existing floodplain, the Minnesota plans are more acceptable than the North Dakota plans to people and agencies concerned with expanding floodplain development and protection of existing floodplain function. However, as detailed in the Economics Appendix (Appendix C), the Fargo-Moorhead metropolitan area is expected to grow at a rate of 266 acres per year, regardless of whether a flood risk management project is constructed. The LPP would generally prohibit development in portions of the staging area that would have flood depths of 3 feet or greater at the 1-percent chance event, reducing impacts on the floodplain. Any floodplain impacts created by any of the alternatives have been minimized, and will continue to be minimized, during the design phase of the project. All of the Phase 3 alternatives are in compliance with Executive Order 11988 and are acceptable from that perspective.

7.5.4 Trade-off Analysis

The first trade-off to be considered in evaluating the final alternative plans is to distinguish between the No Action Alternative and the other action alternatives. This is followed by the trade-off between the action alternatives.

7.5.4.1 Action versus No Action

The no action alternative does not meet any of the planning objectives. It has no positive benefits or impacts since it is the basis from which the impacts and benefits are measured. The no action alternative leaves the study area at significant and unacceptable risk from flooding. Federal involvement in future flood-fighting can be expected in the absence of a federal flood risk management project. This feasibility study has shown from a variety of perspectives that there is a federal and non-federal interest in taking action to reduce the flood risk in the study area.

7.5.4.2 Trade-Offs between Action Alternatives

The second level of trade-offs to consider is those between the action alternatives. Of the action alternatives considered, there are two key elements that result in trade-offs: the size of the alternative selected and the location of the alternative.

In comparing the size of the diversion channels it is apparent that the largest plans (35,000 cfs) meet the four criteria in the P&G better than any of the smaller plans. In each of the four accounts (completeness, effectiveness, efficiency and acceptability) the 35,000 cfs plans outperform the smaller plans. Based on the comparison of the four criteria the larger alternatives should be selected over the smaller alternatives.

In comparing the location of the diversion channels, the tradeoffs are not clear cut. The North Dakota plans meet the completeness, effectiveness, and local acceptability criteria better than the Minnesota plans. The Minnesota plans meet the criteria of efficiency better than the North Dakota plans. The Minnesota plans are more acceptable regarding the natural resources and downstream impacts.

Both size and location affect the cost of the alternatives. The North Dakota alternatives are more expensive than their comparably-sized Minnesota alternatives. The larger capacity channels cost more than smaller channels regardless of location. Thus, there is a trade-off between cost and both effectiveness and acceptability. Higher cost improves effectiveness, but at some point cost becomes unacceptable. Determination of the NED plan is tied directly to costs and economic benefits, but the determination of a locally preferred plan may take other tradeoffs into consideration. Tradeoffs related to cost are primarily non-federal political considerations that cannot be resolved with a technical analysis.

7.6 PHASE 3 CONCLUSIONS

7.6.1 NED Plan: Based on the Phase 3 analyses, the MN40K plan was the plan that reasonably maximized the net national economic development benefits and was therefore the NED plan. No further analysis was needed to define the NED plan.

7.6.2 Locally Preferred Plan (LPP): The ND35K plan was identified as the LPP and the tentatively selected plan in the May 2010 Draft Report and Environmental Impact Statement. However, due to the extent of the downstream impacts, it was necessary to consider modifications to the ND35K plan, including options that would cause upstream impacts. This is discussed below in section 8.0.

7.6.3 Federally Comparable Plan (FCP)
The LPP provided fewer total average annual benefits than the NED plan. Therefore, as described in section 7.4.3, it was necessary to develop a plan smaller than the NED plan that could be compared to the LPP for cost-sharing purposes. Table 6 shows that the MN35K plan would provide similar total average annual benefits and residual damages compared to the LPP. Therefore, the federal investment in the LPP should be capped at the investment that would have been made for the comparable MN35K plan.

8.0 FEASIBILITY PHASE 4 (Sep 2010 – Jul 2011)

8.1 PHASE 4 ACTIVITIES

8.1.1 General. Phase 4 was primarily conducted to consider physical and operational changes to the ND35K plan needed to minimize the downstream impacts. Efforts were also made to address issues raised during the formal NEPA review of the DEIS, which ended on August 9, 2010. During Phase 4, a revised locally preferred plan was developed that included a 20,000 cfs diversion channel combined with upstream staging and storage. The ASA(CW) approved identifying the revised LPP as the tentatively selected plan on April 28, 2011. A notice of availability of the Supplemental Draft Feasibility Report and Environmental Impact Statement (SDEIS) was published in the *Federal Register* on May 6, 2011. Public meetings and a formal hearing were held during the official NEPA comment period, which ended on June 20, 2011. Responses to the comments were developed, and appropriate revisions of the report were made prior to its finalization in July 2011.

8.1.2 NED Plan. Plan formulation to determine the NED plan and the federally comparable plan were completed in Phase 3. No further analyses were conducted on the Minnesota diversion alternatives in Phase 4 except to fully define their downstream impacts and update cost estimates.

8.2 PHASE 4 REVIEW AND COORDINATION

8.2.1 ATR Review

The information developed as part of Phase 4 was presented to the ATR team in the form of a draft report on March 14, 2011. The review focused on the changes in the document from the previous review. The documents provided to the ATR team included:

- Draft Feasibility Report with associated EIS
- Appendix A Hydrology
- Appendix B Hydraulic appendix and HEC-RAS models
- Appendix C Economics, and HEC-FDA model
- Appendix D Other Social Effects
- Appendix F Environmental – EIS is part of main report
- Appendix J Structural
- Appendix L Cost Engineering and Cost and Schedule Risk Assessment model
- Appendix P Non-Structural

The review resulted in 307 comments. The PDT responded to the comments and the ATR team backchecked the responses prior to the public release of the Supplemental Draft Feasibility Report in April 2011.

8.2.2 IEPR Review

A second IEPR review began on April 21, 2011 to assess the SDEIS and supporting analyses. IEPR comments will be addressed after completion of the Final EIS in accordance with Corps review policy.

8.2.3 In-Progress Review, April 13, 2011

An In-Progress Review (IPR) was held with the Corps vertical team on April 13, 2011 to discuss study progress, discuss the project impacts, and to verify the decisions that had been made up to that point in the project. This resulted in concurrence to release the Supplemental Draft Report to the public.

8.2.4 In-Progress Review, June 9, 2011

An In-Progress Review (IPR) was held with the Corps vertical team on June 9, 2011 to discuss and resolve vertical team comments on the Supplemental Draft Report.

8.2.5 Metro Flood Work Group

Information developed as part of Phase 4 was presented to the Metro Flood Work Group on March 30, 2011. The non-federal sponsors and local partners provided a letter dated April 6, 2011 that reconfirmed their support for the LPP, which was identified as the North Dakota diversion with upstream staging and storage.

8.3 PHASE 4 KEY ASSUMPTIONS

8.3.1 Hydrology

Phase 4 used the "wet" hydrologic assumptions for year zero from Phase 3.1 hydrology for design of the North Dakota diversion channel and to determine upstream and downstream impacts for that plan and the FCP. The channel design for the North Dakota diversion channel was analyzed for the 10, 2, 1 and 0.2-percent chance design events and the 1997, 2006, 2009 and 2010 historic events.

8.3.2 Hydraulics

In order to develop a design that incorporated the benefits of upstream storage and staging of water, the designers were required to use unsteady HEC-RAS models in Phase 4. All channel design prior to Phase 4 was completed using steady-state HEC-RAS models that could not assess the effects of storage and staging. The unsteady models used in Phase 3 to assess upstream and downstream impacts became the primary models for final design of the North Dakota diversion.

8.3.3 The NED plan and FCP were defined in Phase 3, and no additional economic analyses were needed in Phase 4 except to reflect the upstream and/or downstream impacts of the final plans—no changes were made that affected the hydraulic performance of the diversions within the benefitted area.

8.4 PHASE 4 PROCESS

8.4.1 Phase 4 Process

Phase 4 focused on extending and refining the unsteady HEC-RAS hydraulic models and using the models to assess several strategies to minimize project impacts. These strategies included shifting the diversion further north (to near the MN35K plan's inlet), staging water upstream on the Red and Wild Rice rivers, passing additional water through the protected area in the Maple River's natural channel, and using off-channel storage areas along the diversion channel. The study team assessed several different channel sizes and slopes in combination with various amounts of upstream staging and temporary storage within the protected area to achieve a definable impacted area. The control structures in the design were operated as necessary to achieve the desired hydraulic conditions in the Red River channel through Fargo-Moorhead.

8.4.2 Phase 4 Alternatives Formulation

A number of flood risk management measures were considered in detail in Phase 1. The Alternatives Screening Document (Attachment 4 of Appendix O) concluded that a number of these measures be carried forward based on their likelihood of meeting screening criteria. The measures selected to be carried forward were formulated into different alternatives as stand-alone plans (stand-alone plans only involve implementing one measure), and combination plans (two or more measures implemented together). Different scales of each measure were also considered. Consideration is also given to dependency and combinability of measures. The following measures were carried forward in the Alternatives Screening Document to be considered as stand-alone and combination measures:

Future without project condition - No Action
Diversion Channels

The following measures were carried forward to be considered in combination only:

Non-Structural Measures
Flood Storage
Bridge Replacement or Modification
Wetland and Grassland Restoration
Cut-Off Channels
Levees.

8.4.2.1 Additional Measures

After the Phase 1 screening a number of additional measures were considered. These measures include “staging” water upstream of the diversion channel, control structures, aqueducts, tie-back levees, and smaller levees in the metro. Some of these concepts were introduced in the Phase 2 and 3 of the formulation but are discussed here. Some of these measures were formulated in order to reduce the induced impacts downstream of the diversion channel alternatives identified in Phases 2 and 3. None of these measures are considered stand-alone measures as they do not address the significant flood risk problem in the study area. The Phase 3 screening and selection of diversions as the only stand-alone alternatives is considered to be still valid, however, these additional measures will be considered as incremental features to improve the performance of diversion channel alternatives (as measured by efficiency, or other screening criteria). The following additional measures are discussed below:

Staging
Control Structures
Aqueducts
Tie-Back Levees
Smaller Levees
Northern Inlet for the North Dakota Diversion
Increasing flows through tributary channels
Adjusting Tie-Back Levee location for Minnesota Diversion.

8.4.2.1.1 Staging

Staging is a measure intended to change the timing and volume of total flows passing around the communities, with the result of reducing downstream impacts. This measure requires gate operations at the control structures to backup flows upstream of the diversion channel and tie-back levees. The result is a temporary pool upstream of the diversion which will impact several thousand acres during gate operations.

Staging requires acquisition of a large amount of land for retaining flows. Some of the land acquired can be used for improving wildlife habitat and restoring wetland and grasslands. For this reason, staging has synergistic effect when combined with wetland and grassland restoration.

8.4.2.1.2 Control Structures

Control structures (in some places referred to as hydraulic structures) are concrete structures that can be located on the rivers or at the inlet of the diversion channel. A control structure has the advantage of creating hydraulic head at the diversion inlet and forcing flows down the diversion channel while restricting flows down the main stem channel. Control structures can be gated or un-gated. Gates add the ability to regulate the passage of flows through the main channel and diversion channel. Conceptual images of control structures can be found in the main report and in Appendix F- Hydraulic Structures of Attachment 5 to the main report.

8.4.2.1.3 Aqueducts

Aqueducts (in some places referred to as hydraulic structures, crossing structures, or tributary structures) are needed at locations where diversions cross tributary streams. Any of the North Dakota diversions would require crossing structures at the Wild Rice, Sheyenne, and Maple Rivers. Crossing structures allow a minimum flow of the tributary stream to pass over the diversion channel in order to maintain connectivity between the portions of the tributary upstream and downstream of the diversion channel.

8.4.2.1.4 Tie-Back Levees

Tie-back levees are a necessary feature for any diversion channel alternative in order to prevent flows from bypassing the diversion channel. The size and scale of tie-back levees are determined by the scale of diversion channel and the operating plan of the control structure (if the alternative includes a control structure).

8.4.2.1.5 Smaller Levees

Smaller levees are considered for parts of the Fargo-Moorhead Metro where damages occur at relatively frequent flood events. Smaller levees differ from the levee plans developed in Phase 1 in that the Phase 1 levees were scaled large enough to serve as a stand-alone flood risk management plan. Smaller levees are not intended to serve as a stand-alone plan, but rather to augment the risk reduction afforded by diversions, and possibly make smaller diversions more efficient. Potential small levees would be placed in segments and at locations where damages occur frequently. Smaller levees are similar to existing projects in Fargo, such as the Ridgewood levee/VA floodwall and Dike West. Smaller levees could also be used to allow additional base flows through town, resulting in the diversion channel being operated less frequently.

8.4.2.1.6 Northern Inlet for North Dakota Diversion

This inlet for the North Dakota diversion was initially considered near river mile 479. Moving the inlet North near river mile 469 was considered as a measure to minimize downstream impacts. It was determined that this measure could result in reduced downstream impacts, however it could not eliminate them independently. It would also leave a number of existing developed properties outside the protected area.

8.4.2.1.7 Increasing Flows through Existing Tributary Channels (More Passivity) – North Dakota Diversions

Consideration was given to reducing the amount of flows diverted from tributaries (Sheyenne and Maple Rivers) into the North Dakota diversion. It was determined that this measure alone would not significantly reduce downstream impacts.

8.4.2.1.8 Adjusting Tie-Back Levee Northward for Minnesota Diversion

Shifting the tie-back levees for the Minnesota diversions northward was considered as a measure for reducing downstream impacts. It was determined that this measure alone would not significantly reduce impacts.

8.4.2.2 Phase 4 Array of Measures

The Alternatives Screening Document (Attachment 4 of this appendix) contains a discussion of measures. The following is a list of measures carried forward from the screening document as well as the additional measures from the previous section. This is the final list of measures to be considered in alternatives formulation:

- Diversion Channels-Minnesota Side (dependent on tie-back levees, exclusive of North Dakota diversion channels)
- Diversion Channels-North Dakota Side (dependent on tie-back levees and aqueducts, exclusive of Minnesota diversion channels)
- Non-Structural Measures
- Flood Storage
- Bridge Replacement or Modification
- Wetland and Grassland Restoration (synergistic with staging)
- Cut-Off Channels
- Tie-Back Levees (dependent on diversion channels)
- Staging water (dependent on diversion channels, tie-back levees, and control structures, synergistic with wetland and grassland restoration)
- Control Structures (dependent on diversion channels)
- Aqueducts (dependent on North Dakota diversion channels)
- Smaller levees

Based on the dependency and exclusivity of the additional measures and the measures carried forward, there are 384 possible combinations of measures that form alternative plans.

8.4.3 Phase 4 Preliminary Screening of Alternatives

The 384 combinations of measures are evaluated, compared, and screened in the following sections. Phase 4 screening criteria include effectiveness, environmental effects, social effects, acceptability, implementability, cost, risk, separable mitigation, and cost effectiveness (efficiency). These are the same criteria used in previous screenings and are discussed in detail in section 5.4.1 of this appendix.

The screening results from previous phases are still valid, meaning diversion channels are the only feasible stand-alone alternatives. Combination alternatives are evaluated on an incremental basis, with the goal of identifying measures that improve the performance of diversion alternatives (as measured by screening criteria). Although each alternative is evaluated based on all screening criteria, only the most critical criteria are discussed in detail.

8.4.3.1 Combinations of Diversions and Smaller Levees

Combinations with smaller levees are evaluated based on a cursory economic analysis of NED benefits. Smaller levees were considered for three reaches (Fargo North, Fargo South, and the Lindenwood area – see appendix C of the main report for figures displaying reaches) and for larger and smaller diversions. A fully detailed economic model for smaller levees was not developed. The analysis conducted is a sensitivity analysis with best-case assumptions in favor of the possible benefits that could be attained by the smaller levees.

Large diversions (MN40K) have low residual average annual damage within the target reaches, on the order of $9.6 million. Smaller levees could potentially reduce residual damages by 50% to $4.8 million, with average annual benefits of $4.8 million. It is unlikely that smaller levees could be formulated at an average annual cost of less than $4.8 million.

Smaller diversions (MN20K) have a larger residual average annual damage. For the three target reaches residual risk is approximately $5.4 million (Fargo North), $16 million (Fargo South), and $4.7 million (Lindenwood area). Making the generous assumption that three smaller levees in the target reaches could reduce residual damages by 50%, the total benefits for each would be $2.9 million, $8 million, and $2.35 million, a total of $13.3 million.

Assuming average annual costs of smaller levees in the three target reaches would be less than 1/3 of the incremental benefits, incremental net benefits sum to $9.3 million. The addition of $9.3 million in net benefits to the MN20K diversion would not yield net benefits higher than those of the MN40K diversion. Table 17 shows the resulting net benefits.

Table 17 – Incremental Levee Analysis

Plan	Net Benefits (millions)
MN20K	87.0
Incremental levees	9.3
MN20K with small levees	96.3
MN40K	105.6

Combinations with Minnesota diversions and smaller levees are not likely to result in an NED plan and are therefore screened from further consideration. This eliminates 96 of the 384 combinations. Following this preliminary screening, combinations of North Dakota diversions and smaller levees were retained for consideration as a possible locally preferred plan, although it is unlikely that they would be a cost effective increment. They could still be a component of a locally preferred plan if desired locally or for environmental mitigation.

8.4.3.2 Combinations of Diversions without Control Structures
Evaluation of net benefits shows that diversions without control structures are marginally feasible (net benefits close to zero) or unfeasible, and that adding control structures greatly improves the efficiency. Therefore, all combination alternatives involving diversions without control structures will not be carried forward. This eliminates 96 of the 288 remaining combinations.

8.4.3.3 Combinations of Minnesota Diversions and without Non-Structural Measures
It was found that increments of non-structural measures are feasible when added to combinations with Minnesota diversions (see section 3.5.5. Non-structural measures; and Appendix P-Non-Structural for more information). This eliminates Minnesota diversions without non-structural measures (32 of the remaining 192 combinations).

8.4.3.4 Combinations of Minnesota Diversions and Staging
The incremental benefits of staging measures are the avoided downstream damages. Preliminary economic analysis shows that induced downstream damages caused by Minnesota Diversions are between $200,000 and $500,000 annually (see Appendix C Economics). Staging measures also improve the effectiveness of smaller diversion channels. It is estimated that staging measures could save approximately $8.9 million in diversion channel excavation costs (average annual). This is because staging will result in

higher water levels upstream of the diversion which results in a smaller channel carrying greater flows; it also places water into storage which means less water will need to pass around the communities. The combination of these two items will allow for a smaller diversion which could provide the same or similar benefits to the community.

The incremental annual costs of staging measures are estimated to be between $10 million and $15 million (See Appendix C Economics) compared to the annual cost of $200,000 to $500,000 for the downstream impacts. Therefore, staging measures are not efficient increments for Minnesota Diversion combinations. This eliminates 16 of the remaining 160 combinations. Following this preliminary screening, staging measures were retained for North Dakota diversion combinations for possible inclusion in a locally preferred plan.

8.4.3.5 Combinations of Diversions and Flood Storage or Wetland-Grassland Restoration
Flood storage, including the "waffle" concept, combinations were considered based on the alternatives developed in the Fargo-Moorhead and Upstream Feasibility Study (FM Upstream). The most effective system of flood storage formulated in the FM Upstream study was a 400,000 acre-foot system. This would entail creating a number of small impoundments between 2,000 acre-feet and 20,000 acre feet distributed throughout the Red River Basin and sub-basins upstream of Fargo-Moorhead. The exact size and locations of the impoundments was not determined.

Such a system of flood storage would be effective in reducing flood damages basin-wide, and could reduce the peak 1-percent chance event flood stage at Fargo by 1.6 ft. The storage system would be more effective at more frequent events, and could potentially reduce the peak 5-percent chance event stage by over 7 ft. This system has the potential to reduce expected annual damages in the Fargo-Moorhead Metro by 21 percent.

As a last-in-place increment, flood storage is feasible because it provides benefits basin-wide; however its effectiveness in reducing damages in the Fargo-Moorhead Metro is greatly diminished with a diversion already in place. It would continue to be feasible to implement a diversion even after storage is in place due to the limited effectiveness of storage to benefit the Fargo-Moorhead Metro.

Wetland and grassland restoration measures are similar to flood storage in that they store water and reduce runoff; however restoration sites are operated to maximize environmental quality. Typical wetland restoration projects are designed to hold water level fluctuations to less than two feet in order to avoid environmental impacts in the wetland. Flood storage impoundments would be designed to fluctuate as much as the terrain or embankments would allow in order to maximize storage. Wetland and grassland restoration could be implemented on a similar geographic scale as flood storage, however it would be less effective in reducing peak flows.

Wetland/grassland restoration measures provide opportunities to improve environmental quality and wildlife habitat. Flood storage, if operated carefully, could provide environmental benefits of the same kind, though to a smaller degree.

The following conclusions are pivotal in the evaluation of flood storage and wetland/grassland restoration:

1. There are opportunities to implement flood storage and wetland/grassland restoration basin-wide. These measures could have substantial cumulative benefits basin-wide; however they are relatively ineffective in reducing the significant problem of flooding in the Fargo-Moorhead Metro area.

2. It would be difficult and time consuming to implement a 400,000 acre-foot storage system as a unique measure. The most cost effective and timely way to implement a storage system is in increments, creating small impoundments as opportunities arise.

3. A system of flood storage is likely unable to offset downstream impacts induced by diversion channels. However, it would be effective in changing the frequency of how often the diversion channel would operate, making it operate less often.

4. Although flood storage and wetland/grassland restoration measures may provide environmental quality benefits and additional wildlife habitat, they would not be justified as an increment to this project, nor would they have much ability to reduce flood damages in the project area.

5. There would be the potential for large impacts from implementing flood storage and wetland/grassland restoration measures. If 400,000 acre feet of storage was needed and the average depth was 10 feet, then 40,000 acres (62.5 square miles) of land would be necessary. It would also be necessary to construct structural features to contain the water. The depth of the flood storage in wetlands and grasslands would be lower than with storage areas; assuming an average depth of 2 feet, wetland/grassland restoration would require 200,000 acres (312.5 square miles) to store 400,000 acre feet. Impacting that amount of land from either storage or wetland/grassland restoration would likely have significant impacts to people, homes, agriculture, and the environment.

Flood storage and wetland/grassland restoration increments do not effectively address the problems and opportunities identified in this study. Although there are opportunities to implement these measures on a large scale as an effective basin-wide measure, the implementation would need to take place in increments over a long period of time and in many locations. Based on effectiveness and difficulty of implementation, increments of flood storage and wetland/grassland restoration are not carried forward for further consideration. Screening combinations with Minnesota diversions and flood storage or wetland/grassland restoration eliminates 12 of the remaining 144 combinations.

Following this preliminary screening, combinations with North Dakota diversions and flood storage or wetland/grassland restoration were retained for inclusion as a possible locally preferred plan, although it is unlikely that they would be a cost effective increment. They could still be a component of a locally preferred plan if desired locally.

8.4.3.6 Combinations of North Dakota Diversions and Staging without Non-Structural Measures

Staging measures result in significant stage increases upstream of the diversion channel. It is anticipated that due to these large stage increases non-structural measures will be justified based on the increase in damages to properties that would remain in the area upstream in the absence of mitigation. This will eliminate all combinations of a North Dakota diversion and staging measures, but without non-structural measures (32 out of the remaining 132 combinations).

8.4.3.7 Combinations with Bridge Modifications or Channel-Cutoffs

Bridge modifications are relatively costly and are unlikely to be feasible as last-in-place increments with a diversion. Diversions reduce stage-frequency relationships through the metro area and make bridge modifications less beneficial.

Channel cut-offs also tend to be ineffective as last-in-place increments with diversions, and carry relatively high costs due to their potential to have large environmental impacts.

Screening bridge modifications and channel cutoffs eliminates 75 of the remaining 100 combinations.

8.4.3.8 Phase 4 Final Array of Combinations

The remaining 25 combinations can be classified into three alternatives: a Minnesota diversion with no staging, a North Dakota diversion with no staging, and a North Dakota diversion with staging. There are eight combinations with a North Dakota diversion and staging, 16 with a North Dakota diversion without staging, and one Minnesota diversion without staging. Table 18 displays the three remaining alternatives and identifies the items that may or may not be included in a possible combination.

The Minnesota diversion is fully defined and there is only one combination plan that remains. The North Dakota diversions plans include 24 remaining combinations. These combinations include four measures that may or may not be included in those plans: Non-Structural Measures, Flood Storage, Wetland/Grassland Restoration, and smaller levees. This analysis has shown that, with the exception of non-structural, none of these measures could be economically justified with the Minnesota diversion and, unless specifically requested as part of a locally preferred plan, no additional consideration is warranted. This analysis has shown that non-structural measures as part of the North Dakota diversion could be found to be economically justified; however inclusion of those measures would only be considered if specifically requested as part of a locally preferred plan. The other measures would not be economically justified but could be considered as part of a locally preferred plan. However, the flood storage and wetland/grassland restoration measures would be very difficult to implement on a large scale due to the number of sites required, the technical challenges to operate all of the sites, the large area that would be impacted, along with the social and environmental impacts of those sites.

Table 18 – Final Array of Combinations

*"y" indicates measures is in place in plan, "n" indicates measure is not in place, "?" indicates a variable that may or may not be included in a particular combination.

Diversion Channels-Minnesota Side	Diversion Channels-North Dakota Side	Non-Structural Measures	Flood Storage	Bridge Replacement or Modification	Wetland and Grassland Restoration	Cut-Off Channels	Staging water	Control Structures	Tie-Back Levees	Smaller levees	Aqueducts	Plan Name
n	y	?	?	n	?	n	n	y	y	?	y	North Dakota Diversion without Staging
n	y	y	?	n	?	n	y	y	y	?	y	North Dakota Diversion with Staging
y	n	y	n	n	n	n	n	y	y	n	n	Minnesota Diversion without Staging

The final selection of alternatives, as well as the size and scale of measures is discussed in section 8.4.4.

8.4.4 <u>Phase 4 Final Alternatives</u>

8.4.4.1 Phase 4 Alternatives Considered

The Phase 4 analysis focused on ways to minimize the overall project impacts. This resulted in three plans being considered: the FCP as defined in Phase 3, the ND35K as defined in Phase 3, and the LPP, which is the North Dakota diversion with upstream storage and staging. The non-federal sponsors did not request any further consideration be given to those combination plans considered in section 8.4.3 of this appendix, and all remaining combinations were dropped from further consideration.

8.4.4.2 North Dakota West and East Alignments

Prior to finalizing the North Dakota diversion alignment, it was proposed that the North Dakota West diversion alignment be given additional consideration based on information provided by a number of local entities. The North Dakota West alternative was initially eliminated from further consideration because it was believed at the time that there were no significant unique benefits or avoidance of any adverse environmental effects associated with the North Dakota West alignment (see section 3.4 of the Main Report for more details).

The North Dakota West alignment generally runs 1.5 miles to the west of the North Dakota East Diversion between Horace, ND and West Fargo. A formal request to consider moving the diversion to the West alignment was based on local concerns that were identified during the comment period that was held for the Notice of Intent to prepare a Supplemental Draft Environmental Impact Statement which was published in the Federal Register on December 27, 2010.

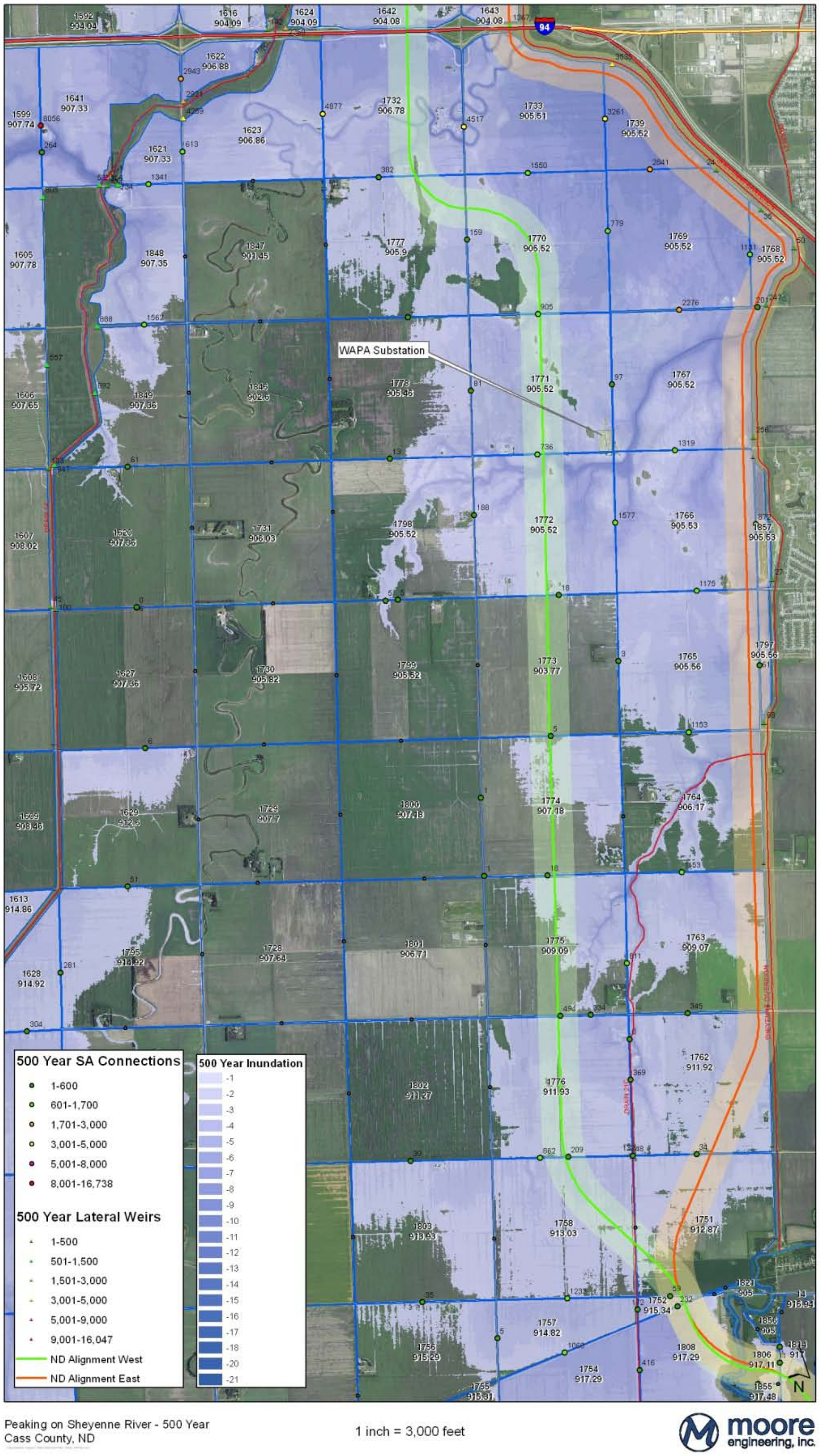
Comparisons between the East and West alignments were based on the following:

- Western Area Power Administration substation
- Impacts to natural resources including wetlands and floodplains
- Benefits to additional homes and emergency access
- Benefit of a straighter channel and interaction with existing diversions
- Level of protection for the existing community of West Fargo
- Benefits to local communities of developing in former floodplain areas

8.4.4.1.1 Western Area Power Administration substation

The Western Area Power Administration (WAPA) substation is located approximately 1 mile to the west of the existing Horace to West Fargo diversion and 3 miles to the south of I-94. The substation serves the Fargo-Moorhead Metro area with power and is a critical piece of infrastructure. The Fargo-Moorhead Metro area also has two other substations serving the area that are currently flood prone and are benefited with either North Dakota diversion alignment. The WAPA substation was constructed to an elevation between 907 and 909. Although the facility has been built to a relatively high elevation, access to the facility during flood events can be limited. The facility has built in redundancy including back-up transformers, and the critical aspects of the facility are all overhead. The overall power system in the region also has redundancy built in; however during large flood events there would likely be threats to other facilities that serve the region.

Figure 2 – Sheyenne River Floodplain – 0.2-percent chance event.



The Sheyenne River floodplain can be seen in Figure 2 for the 0.2-percent chance event (500-year); although it is not clear on the map, the WAPA substation is not flooded. During the Sheyenne River 0.2 percent chance event, flood levels near the WAPA substation reach an elevation of 905.5. Therefore the WAPA substation is 1.5 feet higher than the 0.2-percent chance event and generally not subject to direct flooding except from extremely large and infrequent flood events.

Access to the facility can be limited during flood events and this occurred during the flood of 2009 when access was limited from all directions. During flood events up to nearly the 1-percent chance event, access to the substation is open from the west, however events exceeding the 1-percent chance would result in no road access from any direction.

Due to the relatively high elevation of the WAPA substation, the fact that two other substations will be protected in the region, and that access is maintained up to nearly a 1-percent chance event there would be limited risk reduction to the facility by locating it within the protected area. The WAPA is responsible for the facility; if WAPA believes there is a significant risk to the facility or the region's power supply, measures could be taken that address the situation much sooner than they could be addressed by the proposed diversion project.

8.4.4.2.2 Impacts to natural resources including wetlands and floodplains

The West alignment would impact 208 acres of wetlands; the East alignment would impact 150 acres of wetlands. Although either plan has impacts to wetlands, they are primarily farmed wetlands. Therefore the general quality of these wetlands is poor and they provide minimal habitat value.

The West alignment would remove 9.2 square miles of the 1-percent chance event Sheyenne River floodplain. Removing this area from the floodplain essentially results in lost storage. As was found with previous modeling of the downstream impacts, when areas were removed from the floodplain and storage was lost there were downstream impacts. Therefore the removal of this area would likely cause downstream impacts during a 1-percent chance event on the Sheyenne River with a coincidental flow event on the Red River. The study has been primarily focused on the Red River event with coincidental flow events on the tributaries and no models have been developed to assess the exact impact, however it can be said with certainty that there would be impacts.

8.4.4.2.3 Benefits to additional homes and emergency access

The West alignment would provide benefits to additional homes as a result of removing the 9.2 square miles from the flood plain. This includes the Willow Creek subdivision with 24 homes. The homes in the area would be benefited by relocating the diversion to the West alignment.

Emergency access during flood events is critical both to ensure that the public can be assisted by emergency personnel and to ensure they can evacuate the area during flood events. Interchange 324 on I-94 was identified by local officials as critical to the emergency services in the area. The elevations of the interchange are all above the existing 1-percent chance event Sheyenne River floodplain, however the roadways to the north and south would be inundated by flood waters. The exception to this would be for the additional 9.2 square miles of benefited area that could be accessed during a flood event with the West alignment.

Properties to the northeast of the interchange would be within the benefited area of either alignment and access to these areas can be obtained by other routes such County Road 10 or 17.

8.4.4.2.4 Benefit of a straighter channel and interaction with existing diversions
The existing Sheyenne Diversion project consists of two parts: the Horace to West Fargo diversion and the West Fargo diversion. Both the East and West Fargo-Moorhead Diversion alignments make the existing Horace to West Fargo diversion channel unnecessary. With either alignment the existing Horace to West Fargo diversion would be abandoned. The portion of the existing Sheyenne Diversion from West Fargo to its outlet (the West Fargo diversion) would remain to divert Sheyenne River flows around West Fargo.

Significant analysis and data collection has gone into the development of the diversion channel design. As can be seen in Appendix I, Geotechnical Engineering, direction changes in the alignment are not anticipated to have significant erosion or operational issues; neither alignment would be considered superior to the other from a technical standpoint. Lessons learned from the existing Sheyenne Diversion project have been incorporated to ensure that any diversion channel will be stable.

In sum, either the East or West alignment will provide a significantly greater level of risk reduction from flooding from the Sheyenne River, and both alignments would include similar modifications to the existing Sheyenne Diversion project.

8.4.4.2.5 Level of protection for the existing city of West Fargo
The city of West Fargo is subject to flooding from the Red River for events larger than the 1-percent chance event and would be entirely inundated during a 0.2-percent chance Red River flood event. Either diversion alignment would provide a significant level of flood risk reduction to the community of West Fargo from the Red River flooding.

West Fargo is also threatened from Sheyenne River flooding. The existing Sheyenne Diversion consists of two portions, the Horace to West Fargo diversion and the West Fargo diversion. The Horace to West Fargo portion can safely pass approximately a 1-percent chance Sheyenne River flood event. The West Fargo portion can safely pass a Sheyenne River flood event in excess of the 0.2-percent chance event. Either the North Dakota East or West diversion would significantly reduce the flood risk along the Sheyenne River between Horace and West Fargo.

8.4.4.2.6 Benefits to local communities of developing in former floodplain areas
The Corps of Engineers and other Federal agencies must comply with Executive Order (EO) 11988 Floodplain Management when designing or permitting projects. One goal of EO 11988 is to "avoid direct or indirect support of floodplain development wherever there is a practicable alternative." If avoiding the floodplain altogether is not practicable, EO 11988 requires Federal agencies to "minimize potential harm to or within the floodplain." The communities of West Fargo, Horace, and Cass County have indicated a desire to develop into areas that are currently floodplain and subject to regular flooding. They have developed long term goals to develop in the floodplain areas that would be between the East and West diversion alignments and would like to see these areas removed from the floodplain. While the West diversion alignment would significantly reduce flood risk from riverine flooding, much of the area between the East and West alignments is extremely low and would still be threatened during large rain events. Allowing citizens to build in the existing floodplain would increase overall flood damages in the future. Flooding could also impact emergency access in these areas and cause catastrophic loss during rainfall flood events. As can be seen in Figure 2 the area proposed for development has significant flooding today, however there are areas depicted on the map just to the west that would not be in the existing 0.2-percent chance event floodplain and would provide practicable alternatives for future development.

8.4.4.2.7 Conclusion on East Alignment versus West Alignment
Based on the items listed above that have been individually and collectively considered, the North Dakota West diversion channel is screened from further consideration. The East alignment will have less impact to the floodplain, less overall impact to wetlands, and will provide no appreciable benefits to the WAPA substation. Although the West alignment would reduce flood risk to existing homes, the loss of floodplain and the likelihood of future damages in low-lying areas outweighs the potential economic benefits from the federal perspective.

The East alignment minimizes floodplain impacts, provides a reasonable balance between protecting existing development and preserving the floodplain, and is a practicable alternative to the West alignment.

8.4.4.3 Alternative Scenarios for LPP Diversion
The Metro Flood Management Committee working group requested that additional scenarios be investigated to assist with local decision making for the project. This information was to be provided based on a rough technical analysis with a primary focus of identifying any possible cost saving measures. In addition, local entities including Oxbow, ND and Cass County requested that consideration be given to moving the inlet of the North Dakota diversion alignment south of Oxbow to reduce flood risk for the towns of Oxbow and Hickson, as well as the Bakke Subdivision.

As part of this analysis six scenarios were investigated and a report was developed, see Attachment 7. The investigation included the following scenarios:

- Scenario 1 - Enlarge storage area 1 and reduce upstream staging
- Scenario 2 - Eliminate storage area 1 and reduce upstream staging and increase downstream impacts
- Scenario 3 - Add large storage cell on downstream end of diversion and reduce upstream staging
- Scenario 4 - Eliminate storage area 1 and eliminate staging (basically ND35K plan)
- Scenario 5 - Eliminate storage area 1 and increase upstream staging
- Scenario 6 - Diversion alignment south of Oxbow, Hickson, and Bakke ND.

8.4.4.3.1 Scenarios 1 and 3

Scenarios 1 and 3 were developed to determine if the addition of storage areas could be a cost effective way to reduce the upstream staging. These scenarios in essence just transfer where the storage is located and does not impact the quantity of storage which is necessary for the project. The results of the analysis were that increasing the size of Storage Area 1 or constructing another storage area downstream would not be cost effective, nor would they have any other appreciable environmental benefits, since the water would simply be shifted to another location. If pursued, Scenario 1 and 3 would increase the project cost by approximately $62 and $78 million, respectively. For the above reasons, Scenarios 1 and 3 have been eliminated from further consideration. However, the Corps will continue to look at the appropriate combination of features (storage areas and staging) to determine the optimal operation for the project, and will provide supplemental NEPA documentation should future project design differ from the selected alternative, making it appropriate to do so.

8.4.4.3.2 Scenario 2

Scenario 2 was developed to determine if elimination of Storage Area 1 and increased downstream impacts would be cost effective. The analysis included stage increases of greater than 6 inches at Thompson, ND for the 1-percent chance event compared to existing conditions. Although not completely analyzed, these impacts would likely continue into Canada If Storage Area 1 is eliminated, additional land would be likely be removed from the floodplain, raising issues of compliance with Executive Order 11988. Scenario 2 would decrease the project cost by approximately $105 million, but would cause additional downstream impacts similar to the ND35K alternative. For the above reasons, Scenario 2 has been eliminated from further consideration. As with Scenarios 1 and 3, the Corps will continue to look at the appropriate combination of features (storage areas and staging) to determine the optimal operation for the project, and will provide supplemental NEPA documentation as necessary.

8.4.4.3.3 Scenario 4

Scenario 4 is essentially the ND35K plan, which has been fully analyzed in this EIS.

8.4.4.3.4 Scenario 5

Scenario 5 was to eliminate Storage Area 1 and increase the upstream staging to account for the loss of Storage Area 1. This would result in additional staging of approximately 1.2 feet to offset the loss of additional storage, which would require larger structures, increases in levee length and height, and the acquisition of additional land for staging. If Storage Area 1 is eliminated, additional land would be likely be removed from the floodplain, raising issues of compliance with Executive Order 11988. Furthermore, fish passage would likely be adversely impacted, since the project would operate for a longer duration. If pursued Scenario 5 would decrease the project cost by approximately $7 million, without consideration for environmental costs or impacts. For the above reasons, Scenario 5 has been eliminated from further consideration. As with the other scenarios, the Corps will continue to look at the appropriate combination of features (storage areas and staging) to determine the optimal operation for the project, and will provide supplemental NEPA documentation as necessary.

8.4.4.3.5 Scenario 6

Prior to the alternative scenario investigation an initial assessment was completed to determine if moving the North Dakota diversion channel alignment south could be pursued. It was determined that moving the diversion alignment south would likely have several adverse consequences. These consequences are due in part to the fact that moving the diversion channel south of the town of Oxbow would take additional land out of the floodplain, which would require additional storage. In addition, the topography in the area is such that the best upstream staging area is located in the Oxbow area, immediately upstream of the current diversion alignment. South of Oxbow, the land rises more quickly, which reduces the available storage volume on each acre of land. The investigation identified that for the diversion channel to move south it would take approximately 2.6 feet of additional staging to offset the loss of additional storage. This would require larger structures, increases in levee length and height, and impact approximately 5,900 acres of additional land. This could impact communities further upstream and involve additional technical challenges with constructing higher structures and levees. If pursued Scenario 6 would increase the project cost by approximately $35 million, without consideration for environmental impacts. Furthermore, moving the alignment south from its current location would have implications under EO 11988, which requires that federal projects minimize floodplain impacts and do not induce development of the floodplain. The current diversion channel alignment would have fewer impacts to the floodplain while still providing flood risk management for the Red River and the five tributaries. For these reasons, the scenario of moving the channel alignment south of Oxbow has been eliminated from further consideration.

8.4.5 Distributed Flood Storage versus Upstream Staging and Storage

The 200,000 acre feet of staging and storage as part of the LPP is effective and reliable storage. The further away storage is located from Fargo-Moorhead, the less effective and reliable it becomes and the smaller the benefits. To have an equal amount of effective storage further upstream, other studies have estimated that 2-5 times more storage is required. The total acre-feet required would be significantly more than what is needed with the LPP. This is because of the fact that the storage would have to be located in the right place for each particular flood event. To implement the effective storage upstream equal to the 200,000 acre feet in the storage and staging areas would require many sites, which would result in greater impacts to more people, property, agriculture, and the environment. Storage would likely require upwards of 60,000 acres. Even if distributed storage were feasible it would be very difficult to implement on a large scale due to the number of sites required, the technical challenges to operate all of the sites, and the environmental impacts of the large area that would be impacted. The North Dakota State Water Commission published a paper titled Flood Retention: Not Always the Silver Bullet, referenced in Section 1.5.1.9, which reached similar conclusions.

Based on that information, distributed storage is screened from further consideration as an alternative to upstream staging and storage. The upstream staging and storage is more implementable from a logistical perspective, will have greater reliability, and will have less overall impacts than distributed storage.

8.4.6 Consideration of 20-percent flow reduction

The Red River Basin Commission has proposed a 20-percent flow reduction plan to reduce flood damages to the basin. The plan for 20-percent flow reduction is based on the 1997 flood, which is a relatively small flood event in the Fargo-Moorhead area of 28,000 cfs. The 20-percent reduction would provide some benefits for that event, but it would not significantly reduce the flood risk to the Fargo-Moorhead area. The proposed diversion project is designed for flows in excess of 61,000 cfs. To achieve the 20-percent reduction for a large flood event, such as 61,000 cfs, would require much more storage than is practical to implement upstream of Fargo-Moorhead, due to the number of sites required and the availability of sites. Even if it was possible to construct enough upstream storage to reduce a 0.2-percent (500-yr) event by 20-percent, the resulting peak flow at the Fargo gage would exceed that seen in 2009 by more than 60-percent (48,800 cfs). In addition, the large acreage required to implement the 20-percent flow reduction plan would have an impact on property owners, agriculture, and the environment.

Based on that information the 20-percent flow reduction is screened from further consideration.

8.4.7 Flows from Devils Lake

Flows from Devils Lake could have both a water quantity and water quality impact on the Fargo-Moorhead area. If Devils Lake were to overtop, flow estimates for a controlled overflow are 3,000 cfs and flow estimates for an uncontrolled overflow with erosion are approximately 14,000 cfs. If a North Dakota alignment diversion channel (LPP or ND35K) were in place, it would have the capacity to capture those flows during flood events and provide flood risk management benefits to the communities. With a Minnesota alignment diversion channel (FCP) or no diversion channel, the communities could be subject to additional flooding if the flows from Devils Lake were coupled with a spring or summer flood event.

8.5 PHASE 4 COMPARISON OF ALTERNATIVES

Comparison of alternatives is the fifth step in the planning process, which is based on the evaluation of the impacts of the alternatives, the fourth step in the planning process. The more detailed evaluations of the impacts of the alternatives are presented in Chapter 5, Environmental Consequences, of the main report.

8.5.1 Comparison of Plan Features

Features of the alternative plans (LPP, FCP, and ND35K) are displayed in a comparative format on Table 19. The costs of these features are included on Table 20, also in a comparative format.

Table 19 – Final Comparison of Alternative Plan Features

CHANNEL ALIGNMENT PARAMETERS	LPP	FCP	ND35K
Maximum top width (feet)	2200	2800	2450
Bottom width (feet)			
Maximum	250	400	300
Minimum	100	225	100
Diversion			
Maximum depth (from natural ground)	28	30	29
Excavation (million cu. yards)	55	55	67
Low flow channel (3 ft X 10 ft)	√	√	√
Length of diversion channel (miles)	36	25	36
Channel extension (miles)	--	3.69	--
Length of tie back levee (miles)	10.1	9.86	3.26
Height of levee (feet)	17	8	8
Length of Storage Area 1 levee (miles)	12	--	--
Height of Storage Area 1 levee (feet)	17	--	--
Acres of flood storage area	4360	--	--
Number of houses in diversion footprint	6	5	6
Acres in project footprint (diversion & levees)	8054	6415	6560
Acres of wetlands impacted - worst case	1153	976	1053
Hydraulic structures			
Drop structures	4	1	3
River crossings	6	0	6
Highway bridges	19	20	18
Railroad bridges	4	4	4
Stage at Fargo gage			
0.2 % chance event (500yr) (ft)	40	39.6	40
1% chance event (100yr) (ft)	30.8	31.9	30.6
Stage impacts for 1% chance event			
Downstream max stage increase (inches)	3.5	12.5	25
Number of structures impacted downstream	1533*	3616*	3405*
Upstream max stage increase (inches)	98.8	6.8	0.2
Number of structures impacted upstream	838**	36	--
Land removed from 1% floodplain (sq. miles)	69	30	80

* Calculated to Drayton, ND

** Including Storage Area 1, Staging Area and structures upstream of the Staging Area

Table 20 – Final Comparison of Alternative Plan Costs including Recreation (October 2011 Price Level)

Account	Item	LPP	FCP	ND35k
01	Lands & Damages	278,372	73,617	66,076
02	Relocations	154,291	109,709	110,444
06	Fish and Wildlife Facilities	61,987	25,053	100,261
08	Roads, Relocations and Bridges	60,045	164,383	65,590
09	Channels & Canals	783,778	604,135	877,583
11	Levees, Floodwalls, & Floodproofing	143,435	25,328	3,983
14	Recreation Facilities	29,800	25,845	31,832
30	Planning, Engineering and Design	183,850	142,249	182,714
31	Construction Management	85,790	66,382	85,265
	Total First Costs	**$1,781,348**	**$1,236,701**	**$1,523,748**
	Annual OMRR&R Diversion Cost	$3,501	$3,508	$3,436
	Annual OMRR&R Recreation Cost	$130	$40	$130
	Toal Annual OMRR&R	$3,631	$3,548	$3,566
	All costs in thousands ($1,000)			

8.5.2 System of Accounts

8.5.2.1 Methodology

The Economic and Environmental Principles for Water and Related Land Resources Implementation Studies, established by the Water Resources Council in 1983, created four accounts to facilitate evaluation and effects of alternative plans:

- The national economic development (NED) account displays changes in the economic value of the national output of goods and services
- The environmental quality (EQ) account displays non-monetary effects on significant natural and cultural resources
- The regional economic development (RED) account registers changes in the distribution of regional economic activity that result from each alternative plan.
- The other social effects (OSE) account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

8.5.2.2 National Economic Development (NED)

The intent of comparing alternative flood risk management plans in terms of national economic development is to identify the beneficial and adverse effects that the plans may have on the national economy. Beneficial effects are considered to be increases in the economic value of the national output of goods and services attributable to a plan. Increases in NED are expressed as the plan’s economic benefits, and the adverse NED effects are the investment opportunities lost by committing funds to the implementation of a plan. Comparison of the plans under consideration using the NED account is shown in Table 21. The values for net benefits shown on the tables are the differences between the average annual economic benefits and the average annual cost associated with each plan. Table 6 indicates the current annual net benefits of the MN40K plan are the greatest and the MN40K plan is therefore the NED plan. However, as explained in section 7.4.3 of this appendix, it was not necessary to fully describe the NED plan once it was demonstrated that the LPP was a smaller capacity plan, and the NED plan was dropped from further consideration. The MN35K plan, the FCP, was kept for comparison to the LPP for cost-sharing purposes.

The no action alternative has zero net benefits and results in equivalent annual damages in excess of $194.8 million.

Table 21 - National Economic Development (NED) Account (all dollar values in thousands)

	LPP	FCP	ND35k
Total Diversion First Cost	$1,745,033	$1,205,207	$1,484,913
Interest During Construction and Discounting	$296,914	$232,405	$252,655
Present worth of Investment	$2,041,947	$1,437,611	$1,737,568
Annualized Investment Cost	$97,097	$68,360	$82,623
Annual OMRR&R Cost	$3,501	$3,508	$3,436
Induced Damages	$0	$153	$153
Average Annual Diversion Charges	$100,598	$72,021	$86,212
Total Recreation First Cost	$36,315	$31,494	$38,835
Interest During Construction and Discounting	$791	$2,015	$801
Present worth of Investment	$37,106	$33,509	$39,636
Annual Recreation First Cost	$1,764	$1,593	$1,885
Annual Recreation OMRR&R Cost	$130	$40	$130
Average Annual Recreation Charges	$1,894	$1,633	$2,015
Flood Damage Reduction Benefit	$162,800	$164,800	$162,800
Flood Proofing Cost Savings	$10,430	$6,240	$10,017
Flood Insurance Adminstrative Cost Saving	$960	$1,000	$960
Incremental Non-Structural Flood Risk Benefit	$627	$414	$0
Avg. Annual Diversion Benefit	$174,817	$172,454	$173,777
Avg. Annual Recreation Benefit	$5,130	$5,355	$5,130
Annual Net Diversion Benefit	**$74,219**	**$100,433**	**$87,565**
Annual Net Recreation Benefit	$3,236	$3,722	$3,115
Total Annual Net Benefit	$77,455	$104,155	$90,680
Diversion Benefit-Cost Ratio	**1.74**	**2.39**	**2.02**
Recreation Benefit-Cost Ratio	2.71	3.28	2.55
Benefit-Cost Ratio	**1.76**	**2.41**	**2.03**

1. Costs and Benefits are given in $1,000's
2. Assumes a 50 year period of analysis - 4 1/8% interest rate.
3. Assumes a 7.5 year period of construction for MN diversions and 8.5 years for ND diversions
4. No credit is given to flood fight reliability
5. Base Year is 2019.
6. All figures in October 2011 dollars
7. Non-Structural Costs are included in Diversion Costs

8.5.2.3 Environmental Quality (EQ)

The environmental quality account is another means of evaluating the alternatives to assist in making a plan recommendation. The EQ account is intended to display the long-term effects that the alternative plans may have on significant environmental resources. Significant environmental resources are defined by the Water Resources Council as those components of the ecological, cultural and aesthetic environments which, if affected by the alternative plans, could have a material bearing on the decision-making process. Significance is derived from institutional, public or technical recognition that a resource or an effect is significant. A comparison of the effects that the diversion channel alternatives may have on the EQ resources is shown in Table 22.

Table 22 – Environmental Quality (EQ) Account

	Alternatives			
Resources	**No Action**	**LPP**	**FCP**	**ND35K**
Flooding	Expected Annual Flood Damage of $194.8 million	Expected Annual Flood Damage reduced by $162.8 million	Expected Annual Flood Damage reduced by $164.8 million	Expected Annual Flood Damage reduced by $162.8 million
Air Quality	No Effect	Minor degradation from extensive and lengthy construction period	Minor degradation from extensive and lengthy construction period	Minor degradation from extensive and lengthy construction period
Water Quality	No Effect	Temporary minor adverse impacts on surface w ater quality during construction.	Temporary minor adverse impacts on surface w ater quality during construction.	Temporary minor adverse impacts on surface w ater quality during construction.
Erosion and Sedimentation	Continued Erosion during flooding	No significant geomorphic issues	No significant geomorphic issues	No significant geomorphic issues
Water Quantity	No Effect	Dow nstream stage increase 0.5-3.5 inches, upstream stage increase 1.3-98.8 inches, 1 percent event	Dow nstream stage increase 0.7-12.5 inches, upstream stage increase 6.8 inches, 1 percent event	Dow nstream stage increase 7.6-25.4 inches, upstream stage increase 0.1-0.2 inches, 1 percent event
Ground Water	No Effect	Slightly low ered w ater table near diversion channel	Slightly low ered w ater table near diversion channel	Slightly low ered w ater table near diversion channel
Aquifers	No Effect	Small potential to influence aquifers	Small potential to influence aquifers	Small potential to influence aquifers
Aquatic Habitat	Improved due to ongoing efforts to improve fish passage	Loss of 46 acres of habitat w ith structures at Red River and tributaries. Potentially significant impacts to aquatic species migrational corridors	Loss of 10 acres of habitat w ith large closure structure at Red River. Less than significant impacts to aquatic species migrational corridors	Loss of habitat of approximately 37 acres w ith large structures at 6 rivers. Less than significant impacts to aquatic species migrational corridors

Table 22 - Environmental Quality (EQ) Account (continued)

	Alternatives			
Resources	**No Action**	**LPP**	**FCP**	**ND35K**
Riparian Habitat	No Effect	Increase in habitat value for approximately 1900 acres in the form of grass swale near the bottom of the diversion. Loss of 118 acres at river connections and along channel.	Increase in habitat value for approximately 2,000 acres in the form of grass swale near the bottom of the diversion. Loss of 42 acres at river connections	Increase in habitat value for approximately 1900 acres in the form of grass swale near the bottom of the diversion. Loss of 118 acres at river connections and along channel.
Wetlands	No Effect	Could directly or indirectly impact approximately 1153 acres of wetlands	Could directly or indirectly impact approximately 976 acres of wetlands	Could directly or indirectly impact approximately 1053 acres of wetlands
Upland Habitat	No Effect	Potential for increased habitat benefit	Potential for increased habitat benefit	Potential for increased habitat benefit
T and E species	No Effect	No Effect	No Effect	No Effect
Floodplains (E.O. 11988)	112 sq miles in floodplain during .01 year event out of 261 sq miles in project area	37.5 sq miles remain in floodplain. 69.8 sq miles taken out of floodplain during 1-percent chance event	80.9 sq miles remain in floodplain, 31.3 sq miles taken out during a 1-percent chance event	30.7 sq miles remain in floodplain. 81.3 sq miles taken out of floodplain during 1-percent chance event
Cultural Resources	No Effect	Potential for impacts along diversion channel. Higher potential for impacts along the river banks	Potential for impacts along diversion channel. Higher potential for impacts along the river banks	Potential for impacts along diversion channel. Higher potential for impacts along the river banks
Prime and Unique Farmland	No Effect	Approximately 6878 acres of prime and unique farmland will be removed	Approximately 5889 acres of prime and unique farmland will be removed	Approximately 6540 acres of prime and unique farmland will be removed
Economic Resources	Continued potential for property damage and business losses due to damaging flood events.	Significant reduction in property damage and lost business.	Significant reduction in property damage and lost business.	Significant reduction in property damage and lost business.

8.5.2.4 Regional Economic Development (RED)

The regional economic development account is intended to illustrate the effects that the alternatives would have on regional economic activity, specifically, regional income and regional employment. The comparison of possible effects that the plans may have on these resources is shown in Table 23. The completed RED analysis is included in Appendix C, Economics. The RED analysis only analyzed the MN20K, MN35K and ND35K plans. These plans were selected for analysis based on the likelihood of one of those plans ultimately being selected as the recommended plan. This analysis was completed based on the information contained in Table 4 and was not updated to reflect the final analysis. The RED analysis shows that the regional changes in economic output for the MN20K, MN35K and ND35K range between $323 and $332 million annually.

Table 23 – Regional Economic Development (RED) Account

	Without Project Conditions	North Dakota East 35K cfs	Minnesota Short 35K cfs	Minnesota Short 20K cfs
Changes in Economic Output*		$332,455	$329,715	$323,755
Annual Net Change in Employment	(1,665)	895	815	677
Changes in Tax Revenues*	$(5,900) - (18,600)	$12,109	$11,968	$10,922
Average Annual Benefits*		$67,355	$63,795	$54,390
Annual Regional Flood Damages*	$61,676	$8,007	$11,042	$18,666
Changes in Annual Tax Revenue *	$(7,781)	$4,327	$3,917	$3,140
Annual Loss of Business Income*	$65,000			
Gross Regional Product Annual Growth Rate^	1.29 - 2.18	3.09 - 4.11	3.09 - 4.11	3.09 - 4.11

* $1,000   ^ %

8.5.2.5 Other Social Effects (OSE)

This section describes the Other Social Effects (OSE) component of the Fargo-Moorhead Flood Risk Management Feasibility Study. Implementing flood risk management alternatives could have varying impacts on the life of the residents and the social fabric of the communities in the study area. By considering the human impact and evaluating alternatives from an OSE perspective, the analysis can be used in alternative plan formulation and in the decision making process for choosing an alternative that maximizes social benefits.

Social well-being factors are constituents of life that influence personal and group definitions of satisfaction, well-being, and happiness. The distribution of resources; the character and richness of personal and community associations; the social vulnerability and resilience of individuals, groups, and communities; and the ability to participate in systems of governance are all elements that help define well-being and influence to what degree water resources solutions will be judged as complete, effective, acceptable, and fair. It is the OSE account that considers these elements and assures that they are properly weighted, balanced, and considered during the planning process under the Corps' Four Accounts Planning Framework.

A loss of life analysis was completed for the future without project condition and for a scenario assuming failure of the selected plan. (See Appendix D, Other Social Effects). The analysis showed that a failure of emergency levees during large flood events could cause considerable loss of life. Assuming that the floodplains were 98% evacuated prior to an anticipated levee breach or overtopping, four deaths could be expected during a 1-percent chance event; the toll increases to 12 deaths for a 0.2-percent chance event. History has shown that residents in the study area do not evacuate, preferring to stay and maintain the emergency flood barriers. Assuming that the floodplains were not evacuated and an unanticipated failure of emergency levees occurred, expected deaths were estimated at 200 and 594 for the 1-percent chance and 0.2-percent chance events, respectively. With a diversion project in place, the potential for loss of life is expected to be significantly lower. An engineered permanent project would be far less likely to fail and would significantly reduce the frequency, duration and magnitude of flood events in the developed areas.

The Corps uses seven social factors to describe the social fabric of a community. The social factors are based on conventional psychological Human Needs Theory and Abraham Maslow's Hierarchy of Needs. Table 24 lists and describes the social factors.

Table 24 – Social Factors

Social Factor	Description
Health and Safety	Refers to perceptions of personal and group safety and freedom from risks
Economic Vitality	Refers to the personal and group definitions of quality of life, which is influenced by the local economy's ability to provide a good standard of living
Social Connectedness	Refers to a community's social networks within which individuals interact; these networks provide significant meaning and structure to life
Identity	Refers to a community member's sense of self as a member of a group, in that they have a sense of definition and grounding
Social Vulnerability and Resiliency	Refers to the probability of a community being damaged or negatively affected by hazards, and its ability to recover from a traumatic event
Participation	Refers to the ability of community members to interact with others to influence social outcomes
Leisure and Recreation	Refers to the amount of personal leisure time available and whether community members are able to spend it in preferred recreational pursuits

Source: Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning (USACE, 2009).

A comparison of the effects that the diversion channel alternatives would have on OSE resources is shown on Table 25. The diversion channel alternatives considered all provide a high level of flood risk management, which results in the OSE impacts being similar for all of the diversion channel alternatives.

Table 25 – Other Social Effects (OSE) Account

	No Action	LPP	FCP	ND 35K
Public Health and Safety	High level of flood risk in entire region with associated stress and anxiety, risk to regional health care system, and impacts to emergency access during floods. High potential for loss of life during floodfights.	Project would significantly reduce risk to regional health care system and stress in F-M. No change to flood risk downstream. Overall reduction in upstream flood risk due to relocations out of the floodplain. Moderate increase in flood risk upstream where homes remain.	Project would significantly reduce risk to regional health care system and stress in F-M. Flood risk would slightly increase upstream and moderately increase downstream.	Project would significantly reduce risk to regional health care system and stress in F-M. Would increase flood risk downstream. No change to upstream flood risk.
Economic Vitality	Current regional economy is strong. If a catastrophic flood occurs, economic impacts will be extensive and long-lasting.	Project would significantly benefit the regional economy, especially in the F-M metro area. Minimal changes downstream. Significant impacts upstream in staging area and Storage Area 1--businesses would be relocated; agricultural use of land impacted; reduction of local tax base.	Project would significantly benefit the regional economy, especially in the F-M metro area. Slightly decreased economic vitality downstream due to increased flood stages. Slight decrease upstream due to increased flood stages. Reduction of local tax base due to loss of ag land due to channel construction.	Project would significantly benefit the regional economy, especially in the F-M metro area. Decreased economic vitality downstream due to increased flood stages. Little change upstream. Reduction of local tax base due to loss of ag land due to channel construction.
Social Connectedness	High levels of instrumental social support will continue throughout the region. Population of downstream communities will continue to decline following the historic trend.	Project would cause significant social disruption for communities within the staging area and Storage Area 1 (Oxbow, Hickson, Bakke Addition, Comstock). Metro area would see less frequent disruptions due to floodfights. Impacts to local road network could increase social separation for rural residents. Little change downstream.	F-M metro area would see less frequent disruptions due to floodfights. Impacts to local road network could increase social separation for rural residents. Slight change upstream in area with upstream impacts. Downstream residents would experience some increased social disruption during floods.	F-M metro area would see less frequent disruptions due to floodfights. Impacts to local road network could increase social separation for rural residents. Little change upstream. Downstream residents would experience some increased social disruption during floods.
Identity	Strong European heritage, welcome attitude toward immigration, work ethic and "fight and recover attitude" toward flood fighting will continue throughout the region.	Project would be detrimental for communities within the staging area and Storage Area 1 (Oxbow, Hickson, Bakke Addition, Comstock). Elsewhere, the project would not likely affect cultural and community identity significantly. Perception of metro versus rural bias may increase.	Project would not likely affect cultural and community identity significantly. Perception of metro versus rural bias may increase.	Project would not likely affect cultural and community identity significantly. Perception of metro versus rural bias may increase.
Social Vulnerability and Resilience	F-M Region is highly vulnerable to catastrophic flood damage, but residents would likely band together during recovery. Resilience of rural communities may be lower due to lack of temporary housing options. Low-income residents are more vulnerable to short-term impacts of flood fighting.	Project would significantly reduce the F-M metro area's vulnerability to floods, allowing them to focus on other social needs. Little change downstream. Overall reduction in upstream vulnerability due to relocations out of the floodplain. Moderate increase in vulnerability upstream where homes remain.	Project would significantly reduce the F-M metro area's vulnerability to floods, allowing them to focus on other social needs. Slight change upstream in areas with upstream impacts. Downstream vulnerability would increase slightly. Resilience of rural communities may be lower due to lack of temporary housing options.	Project would significantly reduce the F-M metro area's vulnerability to floods, allowing them to focus on other social needs. Little change upstream. Downstream vulnerability would increase. Resilience of rural communities may be lower due to lack of temporary housing options.
Civic Participation	Residents in the study area exhibit a high rate of participation in civic activities like flood fights, elections and public meetings.	Project would negatively affect civic participation of residents in upstream communities within the staging area and Storage Area 1. Little effect on participation by F-M metro and downstream residents.	Project has perceived disporportionate impacts to Minnesota residents that could affect civic participation. Slight impacts on upstream residents in area with upstream impacts. Downstream flood stage impacts could lead to a decrease in participation downstream.	Project has little effect on participation by F-M metro and upstream residents. Downstream flood stage impacts could lead to a decrease in participation downstream.
Leisure and Recreation	Residents of the region are active. Recreational facilities would continue to be provided in the communities as currently planned.	Project features would increase recreational opportunities and reduce time spent on flood fighting in the F-M metro area. Little change downstream.	Project features would increase recreational opportunities and reduce time spent on flood fighting in the F-M metro area. Little change upstream in areas with upstream impacts. Would slightly increase flood fighting downstream.	Project features would increase recreational opportunities and reduce time spent on flood fighting in the F-M metro area. Little change upstream. Would increase flood fighting downstream.

8.5.3 Formulation Criteria

The final array of alternative plans is compared using four formulation criteria established by the United States Water Resources Council in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G). These criteria are completeness, effectiveness, efficiency and acceptability.

8.5.3.1 Completeness

The P&G defines completeness as the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. A complete plan includes all elements necessary to function independently to achieve the planning objectives. It is an indication of the degree to which the outputs of the plan are dependent upon the actions of others or on factors beyond the control of the planners.

The no action alternative requires extensive emergency construction to prevent flood damage for all floods larger than a 10-percent chance event.

All three of the diversion channel alternatives (LPP, FCP and ND35K) have a high likelihood of significantly reducing flood damage and flood risk, but none of the plans will eliminate flood risk. Any of the three diversion channel alternatives would substantially reduce the need for emergency floodfighting up to the 1-percent chance event on the Red River. For larger and less frequent events, diversion plans allow for additional in-town flood barriers (either permanent or temporary) to be constructed. The combination of the diversion channel and emergency flood fighting for those extremely rare events provides a very high level of risk reduction to the communities of Fargo and Moorhead.

The North Dakota diversions (LPP and ND35K) are more complete solutions to the regional flood problem, because they would reduce the risk of flooding from the major tributaries in the North Dakota portion of the study area that are not addressed by the Minnesota diversion (FCP).

The diversion channel alternatives require relatively minimal operations. Operations are necessary at the control structure on the Red River for the FCP. The LPP and ND35K plans will require operations at the Red River control structure, the Wild Rice River control structure, and closure of a structure on Wolverton Creek. The operations and maintenance of these structures and all project features will be dictated in the Operation and Maintenance manual that will be provided to the non-federal sponsors upon completion of the project.

The non-federal sponsors will be responsible for the long-term maintenance of the project along with the eventual repair, rehabilitation, and replacement of project features. Maintenance would include but not be limited to mowing and vegetation management, repair of erosion, debris removal and routine maintenance of mechanical equipment.

Failure to maintain the project over the long-term could impact the completeness of the plan. It is unlikely that the non-federal sponsors would neglect the long-term maintenance requirements for any of the plans considered in the final array of alternatives.

The diversion plans are complete plans that, once constructed, would include all features necessary to produce the estimated economic benefits described in this report.

8.5.3.2 Effectiveness

The P&G defines effectiveness as a measure of the extent to which a plan achieves its objectives. All of the plans in the final array partially achieve the planning objectives.

All of the alternatives considered in the final array of alternatives meet the criteria of effectiveness to varying degrees, see Table 26. The objectives of this study as described in section 1.8 of this appendix and repeated here were to:

- Reduce flood risk and flood damages in the Fargo-Moorhead metropolitan area.
- Restore or improve degraded riverine and riparian habitat in and along the Red River of the North, Wild Rice River (North Dakota), Sheyenne River (North Dakota), and Buffalo River (Minnesota) in conjunction with other project features.
- Provide additional wetland habitat in conjunction with other project features.
- Provide recreational opportunities in conjunction with other project features.

Table 26 – Effectiveness in meeting planning objectives.

	No Action	LPP	FCP	ND35K
Reduce Flood Risk	No benefit	Reduces expected flood damages by 84%.	Reduces expected flood damages by 85%.	Reduces expected flood damages by 84%.
Total average annual benefits	$0	$174.8 million	$172.5 million	$173.8 million
Average annual residual damages	$194.8 million	$32 million	$30 million	$32 million
River system afforded flood risk benefits	None	Red, Wild Rice, Sheyenne, Maple, Rush and Lower Rush Rivers	Red and Wild Rice Rivers	Red, Wild Rice, Sheyenne, Maple, Rush and Lower Rush Rivers
Restore/ Improve Riverine and Riparian Habitat	None	No specific improvement to the Riverine or Riparian habitat	No specific improvement to the Riverine or Riparian habitat	No specific improvement to the Riverine or Riparian habitat
Provide additional Wetland Habitat	None	Provides additional 1450 acres of wetlands in the project area.	Provides additional 1515 acres of wetlands in the project area.	Provides additional 1527 acres of wetlands in the project area.
Provide Recreational Opportunities	None	Provides multiple recreational features including multi-purpose trails.	Provides multiple recreational features including multi-purpose trails.	Provides multiple recreational features including multi-purpose trails.

8.5.3.3 Efficiency

As defined in the P&G, efficiency is a measure of the cost-effectiveness of an alternative. Cost-effectiveness considers not only economic costs, but also other intangible costs such as environmental impacts and opportunity costs. All three of the diversion alternatives have net benefits greater than 1 and are considered to be efficient (the FCP is the most efficient). A breakdown of the net benefits and residual damages associated with each of the diversion alternatives is provided in Table 27.

Table 27 – Efficiency of plans – Net Benefits (all dollar values are in thousands)

	NO Action	LPP	FCP	ND35k
Net Benefits of Plan (NED)	$0	$74,219	$100,433	$87,565
Residual Damages	$194,800	$32,000	$30,000	$32,000

8.5.3.4 Acceptability

Acceptability is defined in the P&G as the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies. The LPP and FCP are in accordance with federal law and policy and would be considered acceptable for implementation; however there are differences in the level of acceptability. The ND35K plan has downstream impacts that make it unacceptable. This information is summarized in the sections below.

8.5.3.4.1 Alignment

There is a strong desire from the non-federal sponsors and the public to have the diversion plan constructed in North Dakota. A North Dakota alignment would be considered highly acceptable to the non-federal sponsors. The Minnesota alignment is also acceptable, as the non-federal sponsors and the public have indicated that doing nothing is not an option; however they generally prefer the North Dakota alignment and officially requested the North Dakota alignment as the locally preferred plan.

8.5.3.4.2 Upstream and Downstream Effects

The diversion plans would all have impacts either upstream or downstream, and public concerns have been raised regarding those effects. Analysis was conducted on the LPP, ND35K and FCP to determine the maximum extent of the impacts. Impacts from any of the diversion channel alternatives that are less than 0.05 feet are considered 0 due to the capabilities and variability of the model being used to assess the impacts. The estimated stage increases (and decreases) are shown in Table 28 through Table 31.

Table 28 – Upstream and downstream stage impacts (10-percent chance event)

10% Chance (10-Year) Event			
Location	Stage Increase (Inches)		
	LPP	**FCP**	**ND35K**
Downstream Locations			
Emerson Gage	--	0.1	--
Pembina Gage	--	0.1	--
Drayton Gage	0.1	0.1	--
ND SH#17/MN SH317	0.2	0.1	--
Co. Hwy 15	0.1	0.1	--
Oslo Gage	0.5	0.1	--
DS Grand Forks Levees	1.0	0.2	--
Grand Forks Gage	1.3	0.2	--
LPP Maximum DS Impact Location	1.4	--	--
32nd Ave, Grand Forks	1.3	0.4	--
Thompson Gage	0.5	1.2	12.2
Hwy 25/Co.Rd 221	0.5	1.4	13.3
ND35K Maximum Impact Location	--	--	13.9
DS Sandhill River/Climax	0.4	1.6	13.6
Nielsville	0.4	1.6	12.6
DS Marsh River	0.5	1.6	11.9
US Goose River/Shelly	0.4	1.8	12.0
Halstad Gage	-1.4	1.8	7.6
Hendrum	-3.0	1.9	8.0
Perley	-6.5	2.4	11.4
Georgetown	-5.2	1.8	10.6
FCP (MN35K) Maximum Impact Location	--	2.9	--
Upstream Locations			
US FCP Diversion	--	1.6	--
US ND Wild Rice River	-61.8	-1.8	-65.2
US LPP Diversion	98.8	--	-0.6
Hickson Gage	79.0	0.5	0.6
Abercrombie	1.3	0.0	--

Table 29 – Upstream and downstream stage impacts (2-percent chance event)

2% Chance (50-Year) Event			
Location	Stage Increase (Inches)		
	LPP	**FCP**	**ND35K**
Downstream Locations			
Emerson Gage	--	0.7	--
Pembina Gage	--	1.3	--
Drayton Gage	1.0	1.2	--
ND SH#17/MN SH317	0.8	1.2	--
Co. Hwy 15	0.6	1.1	--
Oslo Gage	0.5	0.4	--
DS Grand Forks Levees	1.3	0.8	--
Grand Forks Gage	2.2	1.2	--
32nd Ave, Grand Forks	3.4	2.8	--
LPP Maximum DS Impact Location	4.6	--	--
Thompson Gage	2.9	6.7	20.9
Hwy 25/Co.Rd 221	2.5	8.8	26.9
ND35K Maximum Impact Location	--	--	29.4
DS Sandhill River/Climax	2.5	9.2	29.3
Nielsville	2.2	9.6	25.3
FCP (MN35K) Maximum Impact Location	--	9.7	--
DS Marsh River	1.9	8.5	22.2
US Goose River/Shelly	1.4	8.0	17.3
Halstad Gage	0.0	4.8	10.3
Hendrum	-1.4	4.9	15.1
Perley	-3.8	4.0	9.4
Georgetown	-2.8	3.6	8.0
Upstream Locations			
US FCP Diversion	--	-1.8	--
US ND Wild Rice River	-112.9	0.6	-112.2
US LPP Diversion	85.2	--	0.0
Hickson Gage	55.0	0.4	0.2
Abercrombie	1.7	0.1	--

Table 30 – Upstream and downstream stage impacts (1-percent chance chance event)

1% Chance (100-Year) Event			
Location	Stage Increase (Inches)		
	LPP	**FCP**	**ND35K**
Downstream Locations			
Emerson Gage	--	0.7	--
Pembina Gage	--	2.0	--
Drayton Gage	1.0	1.7	--
ND SH#17/MN SH317	0.8	1.6	--
Co. Hwy 15	0.6	1.8	--
Oslo Gage	0.7	1.1	--
DS Grand Forks Levees	1.8	2.5	--
Grand Forks Gage	2.9	4.1	--
LPP Maximum DS Impact Location	3.5	--	--
32nd Ave, Grand Forks	3.4	5.8	--
Thompson Gage	0.5	7.0	15.8
Hwy 25/Co.Rd 221	-0.2	10.7	23.6
ND35K Maximum Impact Location	--	--	25.4
DS Sandhill River/Climax	-0.5	11.8	25.3
FCP (MN35K) Maximum Impact Location	--	12.5	--
Nielsville	-0.5	12.4	22.8
DS Marsh River	-0.4	10.7	19.4
US Goose River/Shelly	-0.5	9.2	15.1
Halstad Gage	-0.7	6.2	10.4
Hendrum	-0.7	6.6	11.3
Perley	-3.4	6.6	7.6
Georgetown	-3.0	5.8	8.4
Upstream Locations			
US FCP Diversion	--	6.8	--
US ND Wild Rice River	-107.9	5.3	-105.1
US LPP Diversion	98.8	--	0.2
Hickson Gage	64.6	-0.1	0.1
Abercrombie	1.3	0.0	--

Table 31 – Upstream and downstream stage impacts (0.2-percent chance event)

0.2% Chance (500-Year) Event			
Location	Stage Increase (Inches)		
	LPP	**FCP**	**ND35K**
Downstream Locations			
Emerson Gage	--	1.0	--
Pembina Gage	--	2.2	--
Drayton Gage	1.3	1.0	--
ND SH#17/MN SH317	0.8	1.0	--
Co. Hwy 15	1.1	1.2	--
Oslo Gage	0.6	0.8	--
DS Grand Forks Levees	1.4	1.9	--
Grand Forks Gage	2.6	4.6	--
LPP Maximum DS Impact Location	3.2	--	--
FCP (MN35K) Maximum Impact Location	--	5.6	--
32nd Ave, Grand Forks	2.8	5.6	--
Thompson Gage	-0.6	2.4	7.2
Hwy 25/Co.Rd 221	-1.4	3.4	6.6
DS Sandhill River/Climax	-1.8	3.8	7.9
ND35K Maximum Impact Location	--	--	8.4
Nielsville	-1.9	4.4	7.7
DS Marsh River	-1.7	4.1	7.3
US Goose River/Shelly	-1.6	3.7	6.5
Halstad Gage	-2.6	1.7	3.7
Hendrum	-3.6	0.8	1.4
Perley	-4.3	-0.4	0.6
Georgetown	-4.0	-0.5	0.2
Upstream Locations			
US FCP Diversion	--	-2.3	--
US ND Wild Rice River	-15.7	2.9	-9.0
US LPP Diversion	78.0	--	1.7
Hickson Gage	34.2	-0.1	-0.4
Abercrombie	0.1	0.0	--

Downstream of the FCP diversion channel, the increase to the peak stage during a 1-percent chance event, with no emergency protection in place, is estimated to be 12.5 inches or less, depending upon location. The 1-percent chance event peak would arrive and recede about one day earlier than under existing conditions. The increase to the peak stage during a 10-percent chance event, with no emergency protection in place, is estimated to be 2.9 inches or less, depending upon location. The timing of the 10-percent chance event peak would be nearly unchanged. Upstream of the FCP diversion channel the impact would be 7.0 inches or less for a 1-percent chance event and 2.0 inches or less for a 10-percent chance event.

Downstream of the ND35K plan diversion channel, the increase to the peak stage during a 1-percent chance event, with no emergency protection in place, is estimated to be 25.0 inches or less, depending upon location. The 1-percent chance event peak would arrive and recede about 1.5 days earlier than under existing conditions. The increase to the peak stage during a 10-percent chance flood event, with no emergency protection in place, is estimated to be 13.9 inches or less, depending upon location. The 10-percent chance event peak would arrive and recede up to about one day earlier than under existing conditions immediately downstream of the diversion, but the timing at Halstad would be nearly unchanged. Upstream of the ND35K diversion channel the impact would be 0.2 inches or less for the 1-percent chance event and would have a benefit of 0.6 inches for the 10-percent chance event.

Downstream of the LPP diversion channel, the increase to the peak stage during a 1-percent chance event, with no emergency protection in place, is estimated to be 3.5 inches or less, depending upon location. The 1-percent chance event peak would arrive and recede about approximately the same as under existing conditions. The increase to the peak stage during a 10-percent chance flood event, with no emergency protection in place, is estimated to be 1.4 inches or less, depending upon location. The 10-percent chance event peak would arrive and recede approximately the same as under existing conditions downstream of the diversion. Upstream of the LPP diversion channel the impact would be 98.8 inches for the 1-percent event and 98.8 inches for the 10-percent chance event.

The acceptability of each plan from the standpoint of flood stage impacts depends on one's location: it would be expected that downstream interests would prefer the LPP with its minimal downstream impacts, but upstream interests would prefer either the FCP or the ND35K plan. Although the impacts of the ND35K plan were not fully modeled, the ND35K plan has large downstream impacts as far as Thompson, ND, and the impacts would likely extend into Canada because the FCP impact is 0.7 inch at Emerson, Manitoba for the 1-percent chance event, and the ND35K impacts are routinely larger than the FCP impacts. Preliminary legal analysis showed that most of the induced downstream impacts of the ND35K plan or the FCP would not rise to the level of a taking under the Fifth Amendment of the U.S. Constitution. Even though mitigation for increased stages would not be a federal requirement, the non-federal sponsors wanted to include mitigation in their desired locally preferred plan. The vast extent of the downstream impacts of the ND35K plan made it impractical to mitigate for that plan, which made the ND35K plan unacceptable to the non-federal sponsors. Although the LPP has large upstream impacts, they are in a smaller defined area that allows the sponsors to mitigate the impacts by acquiring real estate interests and employing non-structural measures effectively.

8.5.3.4.3 Tolerable level of risk

The non-federal sponsors indicated in November 2009 that a flood stage of approximately 36.0 on the Fargo gage for a 0.2-percent chance event would be tolerable because they were confident that they would be successful with flood fighting efforts up to the stage of 36.0. The analysis completed in May 2010 showed that a diversion capacity of 45,000 cfs would be required to achieve the desired stage reduction for both the Minnesota and North Dakota alignments. The information available in May 2010 showed that the 45,000 cfs alignments in both Minnesota and North Dakota would result in a 0.2-percent chance stage of 35.3 (see Appendix O, section 7.4.1).

The Metro Flood Study Work Group considered this information on May 13, 2010 and chose to support the ND35K plan with its associated performance rather than requesting a 45,000 cfs alternative that would have either cost significantly more or been located in Minnesota.

The LPP, FCP and ND35K alternatives all would result in a 0.2-percent chance stage of 40.0 or less, based on the Phase 3 analyses.

8.5.3.4.4 Natural Resource Impacts

Impacts to the natural resources are a concern to the public and many organizations. The North Dakota alternatives generally have more natural resource impacts than the FCP because they cross five tributaries. However, the North Dakota alignment provides flood benefits to a larger geographic area and for more people. See Chapter 5, Environmental Consequences, of this report for more detail.

8.5.3.4.5 Floodplain Impacts

Executive Order 11988 requires federal agencies to avoid direct or indirect support of floodplain development wherever there is a practicable alternative, and then to minimize impacts to the floodplain. This study has shown that a diversion channel in either Minnesota or North Dakota is the only feasible concept that will sufficiently reduce flood risk along the Red River in Fargo and Moorhead. Therefore, there is not a practicable alternative located outside the floodplain, and locating the project in the floodplain is necessary to achieve the project purpose. The primary planning objective is to reduce flood risk in the entire metropolitan area, including areas adjacent to the Wild Rice, Sheyenne, Maple, Rush and Lower Rush rivers. The LPP and ND35K plans significantly reduce flood frequency on approximately 70 and 80 square miles, respectively, currently located in the 1-percent chance event FEMA floodplain. The LPP and ND35K plans reduce flood risk from all of the rivers in the North Dakota portion of the study area. The FCP significantly reduces flood frequency on approximately 30 square miles currently located in the 1-percent chance event floodplain, but it does not address the Sheyenne River and its tributaries. Because of the different impacts on existing floodplain, the FCP alignment is more acceptable than the LPP or ND35K plan alignment to people and agencies concerned with expanding floodplain development and protection of existing floodplain function. However, as detailed in the Economics Appendix (Appendix C), the Fargo-Moorhead metropolitan area is expected to grow at a rate of 266 acres per year, regardless of whether a flood risk management project is constructed. Any floodplain impacts created by any of the possible alternatives will be minimized as much as possible. All three of the diversion channel alternatives (LPP, FCP, or ND35K) are in compliance with Executive Order 11988 and are acceptable from that perspective.

8.5.3.5 Compliance with planning constraints

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated. The planning constraints identified in section 1.9 of this appendix and repeated here were:

- Avoid increasing peak Red River flood stages, either upstream or downstream
- Comply with the Boundary Waters Treaty of 1909 and other pertinent international agreements.
- Avoid negatively impacting the Buffalo Aquifer in Minnesota.
- Minimize loss of floodplain in accordance with Executive Order 11988, Floodplain Management

As the study developed it was acknowledged that it would not be possible to develop a large scale regional flood risk management project without causing impacts. The LPP, FCP and ND35K plans reduce flood risk for 70, 30, and 80 square miles, respectively, of highly developed or developable land. This study has shown that there are no options that could provide a high level of flood risk reduction to the region and achieve the constraint of avoiding increasing peak Red River flood stages, either upstream or downstream. Therefore this constraint was violated by each of the remaining alternatives, the LPP, FCP, and ND35K.

The LPP and FCP do not violate the three remaining constraints. The FCP was designed to avoid impacts to the Buffalo Aquifer. The ND35K has downstream impacts that would require international coordination under the Boundary Waters Treaty of 1909.

8.5.4 Trade-off Analysis

The first trade-off to be considered in evaluating the final alternative plans is to distinguish between the No Action Alternative and the other action alternatives. This is followed by the trade-off between the action alternatives.

8.5.4.1 Action versus No Action

The no action alternative does not meet any of the planning objectives. It has no positive benefits or impacts since it is the basis from which the impacts and benefits are measured. The no action alternative leaves the study area at significant and unacceptable risk from flooding. Federal involvement in future flood-fighting can be expected in the absence of a federal flood risk management project. This feasibility study has shown from a variety of perspectives that there is a federal and non-federal interest in taking action to reduce the flood risk in the study area.

8.5.4.2 Trade-Offs between Action Alternatives

The second level of trade-offs to consider is those between the action alternatives.

In comparing the size of the diversion channels each of the diversions being considered (LPP, FCP, and ND35K) all provide approximately the same amount of economic benefits. Therefore there is no tradeoff that can be made based on the economic benefits.

In comparing the location of the diversion channels, the tradeoffs are not clear cut. The North Dakota plans (LPP and ND35K) meet the completeness, effectiveness, and local acceptability criteria better than the Minnesota plan (FCP). The FCP meets the criteria of efficiency better than the LPP or ND35K plan. The FCP is also more acceptable regarding natural resources and the downstream/upstream impacts.

Cost is another consideration for trade-offs. The LPP and ND35K alternatives are more expensive than the FCP. The LPP costs more than the ND35K, due to the costs related to minimizing the downstream impacts through storage and staging. Therefore, there is a trade-off between cost and both effectiveness and acceptability. Higher cost improves effectiveness, but at some point cost becomes unacceptable.

Determination of the NED plan is tied directly to costs and economic benefits, but the determination of a locally preferred plan may take other tradeoffs into consideration. Tradeoffs related to local acceptability and cost are primarily non-federal political considerations that cannot be resolved with a technical analysis.

8.6 PHASE 4 CONCLUSIONS

8.6.1 NED Plan
The NED plan was identified in Phase 3 of the planning process as the MN40K diversion and no changes were made to that plan during Phase 4. This plan was eliminated from further consideration in Phase 3 and is only identified here as a point of reference.

8.6.2 FCP
The FCP was identified in Phase 3 of the planning process as the MN35K diversion. In Phase 4 the hydraulic models needed to assess downstream impacts were extended to Emerson, Manitoba, Canada. The models show that there would be no significant impacts to stages in Canada from the FCP. The economic value of the induced damages was included in the total project cost. This plan sets the basis for cost sharing of the LPP.

8.6.3 ND35K
The ND35K plan was identified in Phase 3 of the planning process. In Phase 4 the only change to the ND35K was to adjust the alignment northwest of Harwood, ND to avoid Drain 13. The hydraulic models were not extended beyond Thompson, ND. The hydraulic modeling to Thompson was compared with the extended models for the FCP, and it was concluded that hydraulic impacts of the ND35K plan would likely extend into Canada because the impacts from the ND35K were generally greater than those of the FCP. The economic value of the induced damages was included in the total project cost.

8.6.4 LPP
The LPP was identified in Phase 4 of the planning process. This plan is a modification of the ND35K diversion which incorporates features that allow upstream storage and staging designed to minimize the downstream impacts and the extent of those impacts.

8.6.5 Conclusion—Selected plan
The LPP is the selected plan based on the request of the non-federal sponsors and the analysis contained in this report. The selected plan will undergo continued refinement and improvement in the design and implementation phases. Extensive efforts will be taken to work with the non-federal sponsors, impacted communities and resource agencies to ensure that the project is implemented in a timely and effective manner.

9.0 CORPS POLICY CONSIDERATIONS

9.1 SYSTEMS/WATERSHED CONTEXT

The selected plan (LPP) substantially reduces flood risk in the largest urban area in North Dakota and western Minnesota. It greatly enhances the stability of the governmental, economic, educational, medical and social infrastructure for the entire Red River Basin region, which contributes to the national economy. The LPP addresses flooding from the Red River of the North and five of its tributaries in the study area. Significant portions of two counties in two states receive benefits from the project. The plan was developed in partnership with the cities of Fargo, North Dakota and Moorhead, Minnesota. Cass

County and the Cass County Joint Water Resource District in North Dakota and Clay County and the Buffalo-Red River Watershed District in Minnesota participated heavily in the project development process.

The Corps invited the following agencies to be formal Cooperating Agencies:

- U.S. Environmental Protection Agency
- Federal Emergency Management Agency
- U.S. Fish and Wildlife Service
- North Dakota State Water Commission
- North Dakota Department of Game and Fish
- North Dakota Department of Health
- North Dakota State Historic Preservation Office
- Minnesota Department of Natural Resources
- Minnesota Pollution Control Agency
- Minnesota State Historic Preservation Office

Although some of these agencies expressed initial interest in serving as Cooperating Agencies, no formal agreements were executed. In discussing the opportunity with these agencies, it was generally determined that there were insufficient agency resources to take on tasks beyond each agency's official mission. Despite the absence of a formal agreement, all of the agencies participated in the planning process at appropriate times and provided the necessary input to ensure that issues were raised and addressed as soon as possible in the process.

9.2 ENVIRONMENTAL OPERATING PRINCIPLES

The seven Environmental Operating Principles listed below were followed during the entire planning process as indicated in the paragraph below.

1. Strive to achieve environmental sustainability. An environment maintained in a healthy, diverse, and sustainable condition is necessary to support life.
2. Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.
3. Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.
4. Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.
5. Seek ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycle of our processes and work.
6. Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.

7. Respect the views of individuals and groups interested in Corps activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the Nation's problems that also protect and enhance the environment.

The selected plan **strives to achieve environmental sustainability** by incorporating features to facilitate fish passage, minimize impacts to geomorphology, and minimize any other environmental impacts caused by the project. The feasibility study team coordinated extensively with the appropriate environmental agencies in order to **proactively consider environmental consequences** so that appropriate measures could be included in the project design and as mitigation where necessary. The project provides an appropriate **balance and synergy among human development activities and natural systems** by reducing the risk of flooding to the largest urban area in North Dakota and western Minnesota, thereby avoiding the significant environmental and economic damage that would be caused by repeated flood fighting actions and eventual catastrophic flooding of the Fargo-Moorhead metropolitan area. The plan is consistent with all applicable laws and policies, and the Corps and its non-federal sponsors **accept corporate responsibility and accountability** for the project in accordance with those laws and policies. The study team has used **appropriate ways and means to assess cumulative impacts to the environment** through the use of engineering models, environmental surveys, and discussion with natural resource agencies. The project design has evolved to address as many concerns as possible, and **appropriate mitigation** will be included to address remaining impacts. Study activities including hydrologic, hydraulic, economic, geomorphic, geotechnical, cultural resource, and HTRW surveys will **increase the integrated scientific knowledge base** for the Red River Basin. The feasibility study process included numerous public and agency meetings as well as a project website to interact with **individuals and groups interested in the study activities**. Through those meetings and written interactions, the study team **listened actively and respectfully** to project proponents and opponents alike in an effort to find innovative solutions to the flooding problems in the study area.

9.3 CAMPAIGN PLAN

The four goals and underlying objectives of the Corps of Engineers campaign plan are listed below. This study directly meets the following goals and objectives: 2a, 2b, 2c, 4a, and 4b.

1. Ready for All Contingencies - Deliver USACE support to combat, stability and disaster operations through forward deployed and reach back capabilities.
    a. USACE is ready, responsive and reliable in delivering high performance, all-hazard, contingency mission execution in a world-wide theater of operations.
    b. Prepare Theater Engineer Commands (TEC) to support Combatant Commanders throughout the spectrum of operations.
    c. Establish human resources and family support programs that promote readiness and quality of life.
    d. Institutionalize USACE capabilities in interagency policy and doctrine

2. Engineering Sustainable Water Resources – Deliver enduring and essential water resource solutions through collaboration with partners and stakeholders.
    a. Deliver integrated, sustainable, water resources solutions.
    b. Implement collaborative approaches to effectively solve water resource problems.
    c. Implement streamlined and transparent regulatory processes to sustain aquatic resources.
    d. Enable Gulf Coast recovery.
3. Delivering Effective, Resilient, Sustainable Solutions – Deliver innovative, resilient, sustainable solutions to the Armed Forces and the Nation.
    a. Deliver sustainable infrastructure via consistent and effective military construction and real estate support to customers
    b. Improve resilience and lifecycle investment in critical infrastructure.
    c. Deliver reliable infrastructure using a risk-informed asset management strategy.
    d. Develop and apply innovative approaches to delivering quality infrastructure.
4. Recruit and Retain Strong Teams – Build and cultivate a competent, disciplined, and resilient team equipped to deliver high quality solutions.
    a. Identify, develop, maintain, and strengthen technical competencies in selected Communities of Practice (CoP).
    b. Communicate strategically and transparently.
    c. Standardize business processes.
    d. Establish tools and systems to get the right people in the right jobs, then develop and retain this highly skilled workforce.

The development of the plan and the information contained in the report is an **integrated, sustainable, water resource solution** that was developed through the use of collaborative approaches to effectively address the problem of flood risk management in the Fargo-Moorhead Metropolitan area. The information was presented to the non-federal sponsors and the public through the use of clear and strategic communications with an emphasis on transparency. This resulted in a plan that would sustain the aquatic resources of the nation while providing a high level of flood risk management to the citizens of the Fargo-Moorhead Metropolitan area.

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APPENDIX O
ATTACHMENT 1

Feasibility Scoping Meeting Memorandum for Record

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CEMVP-PM-A October 17, 2009
Updated status of issues noted in the PGM for the Subject FSM

CEMVP-PM-A June 23, 2009

MEMORANDUM FOR RECORD

SUBJECT: Feasibility Scoping Meeting (FSM) – Fargo-Moorhead Metro Feasibility Study, Red River of the North.

1. Subject meeting was held on 19-May-09 via teleconference. The primary purpose of the meeting was to discuss the future without project, discuss the plan formulation strategy, and resolve any policy issues through the involvement of the sponsors and Corps vertical team. The primary project purpose is to reduce flood risk.

2. Attendance during the Feasibility Scoping Meeting: **MVP**: Aaron Snyder, Craig Evans, Mike Wyatt, Molly McKegney, Jon Sobiech, Mike Lesher, Jeff McGrath, Kurt Heckendorf, Michael Bart. **MVD**: Robert Petersen, Susan Smith, David Vigh, Frankie Griggs, Bitsy Sloan, and Larry Kilgo. **HQ**: Zoltan Montvai, John Lucyshyn, Tom Hughes, Scott Murphy, Lee Ware. **City of Fargo**: April Walker. **City of Moorhead**: Bob Zimmerman.

3. MVP received written comments from MVD. Comments and responses are included in Enclosure 1.

4. A list of 7 possible policy issues were identified by the Project Delivery Team and provided to the vertical team in advance of the meeting. See Enclosure 2. Additional topics are included in the “Issues and Discussions” below.

5. The team will take a 4-pronged approach for formulation: they will develop stand alone levee/floodwall, diversion, non-structural, and internal drainage measures which will be combined and then screened as part of the initial screening.

6. Issues and Discussions

    a. Future without project conditions – The city of Fargo’s “Southside Flood Control Project” is on a parallel track with the Corps Metro feasibility study, and it would provide protection for a portion of the Corps study area. The city intends to implement their project only if there is no Federal project, or as a locally preferred plan within a larger Federal project. MVP considered having two future without-project conditions. The vertical team advised against this and recommended having one future without condition and then using the other as a sensitivity analysis. **The vertical team indicated that the team should assume that the southside project is not in place for the future without-project condition.** This appears to be consistent with guidance in IWR 88-R-2, National Economic Development Procedures Manual - Urban Flood Damage, Volume 1, Page VI-3, paragraph 6 which states: "If local action is planned to occur only as the result of no Federal action, the project should not be assumed as part of the "without" condition. Local interests should not be penalized for their own incentive." **MVP understands that the economic analysis should assume no southside project in place. MVP will assess alternatives to the proposed southside project in order to define the NED plan, and impacts of the southside project will be assessed as a potential locally preferred plan.**

NOTE: During the NEPA scoping meeting that was held on 20-May-09 with state and federal agencies, EPA commented that the Fargo Southside project and the feasibility study appear to be connected actions, so they think it is not appropriate to develop two separate EIS analyses. The city of Fargo wants to continue independently in case the Corps study stalls or does not find a Federal interest. The city and FEMA are considering how to resolve the issue, but it is unresolved at this time.

OCT 2009 Status: FEMA withdrew its support for the Fargo-Southside project, because the project had grown beyond the scope of the original FEMA grant from 1997. The city of Fargo put the Southside project on hold pending the results of the Corps Feasibility study. Depending on what the NED plan looks like, the City may ask to include portions of the Southside project as a locally preferred plan.

b. Flood fights and Emergency Levees – During the ATR and some previous project discussions it was suggested that credit be given to the emergency flood fighting activities that have been successful in the past. MVP indicated that past successful flood fights are not reliable over the long term, they are reliant on predictions from the National Weather Service, the project area is in the upper portion of the basin with short times to respond, FEMA does not give credit to emergency measures under 44 CFR 65.10, and no insurance company is willing to credit those measures. HQ stated that the efforts in an emergency are one time justified events and those measures are removed following the event, so no long term reliability can be given. MVD indicated that credit should not be given to the emergency measures, however some justification should be given as to why this is the case. **MVP should have discussions with the ATR team regarding the minimal probability of success. It should be acknowledged that the probability is not 0 but is very low, and MVP should discuss this in the report. A sensitivity analysis should also be conducted to provide the decision makers with the information. The analysis should include residual damage, prevention of future flood fighting costs, and loss of life.**

OCT 2009 Status: Econ analysis did not give credit for flood fights. ATR issues will be addressed when we revise the draft report.

c. Credit to existing levees – MVP completed the credit to existing levees based on ETL 1110-2-556 which was rescinded, and MVP was looking for guidance on what should be done. This was coordinated with MVD and the PCX prior to the meeting. **The vertical team concurred that MVP should use the analysis that it had already conducted and should continue to follow ETL 1110-2-556.**

d. Climate Change – MVP was looking for guidance on how to incorporate climate change or climate variability into the analysis. MVP proposed using expert elicitation to determine the best way to proceed. There appears to be a 40-year trend of increasing peak flows in the basin, and this should be addressed. HQ indicated this can be handled with a sensitivity analysis. IWR is leading the Corps climate change and MVP should contact Lynn Martin. **The vertical team concurred with seeing expert elicitation to determine the best path forward and the use of a sensitivity analysis.**

OCT 2009 Status: An Expert Opinion Elicitation panel was convened on 28-30 Sep 2009. Discussion was good, but results are unclear. Currently working with HEC to determine how to use the EOE panel results and to refine other aspects of the hydrology that have arisen during the study.

e. Loss of Life – MVP was seeking guidance on how loss of life should be addressed. MVP plans to do an analysis on the statistical loss of life that could be expected during existing and proposed conditions, with a focus on failure of emergency levees. The Corps currently uses population at risk for budgeting purposes. ASA(CW) has not been willing in the past to quantify a benefit associated with potential loss of life. **MVP should conduct a loss of life analysis for the future without project condition (assuming flood fighting) and for the tentatively recommended plan; however no dollar value should be attributed to this. The report should describe qualitatively any changes to the population at risk caused by our project and describe the effectiveness of evacuations.**

OCT 2009 Status: MVP is waiting for the tentatively recommended plan to be defined before proceeding with loss of life analyses.

f. Study Scope –
1) Geographic Scope - This study is focused on the Fargo-Moorhead Metropolitan region. There is some interest in looking at the whole RRN basin. This is a regional plan for FRM and is not considering a holistic solution for the entire RRN basin. MVP proposes to use the Fargo-Moorhead Upstream Feasibility study to analyze upstream storage and use

that existing analysis for this feasibility study. **The vertical team concurred with the current approach.**

2) Ecosystem Restoration – The draft report identifies planning objectives to restore degraded riverine and riparian habitat, provide additional wetland habitat, and provide recreational opportunities in conjunction with other project features. MVP does not plan to propose stand-alone ecosystem restoration features, but some FRM alternatives will provide opportunities to meet these objectives. See comment #2 in Enclosure 1. **The vertical team concurred with this approach.**

g. Executive Order 11988 – MVP will develop federal alternatives to reduce flood risk south of Fargo as part of the plan formulation and should consider future development pressures. Executive order 11988 indicates that we are not supposed to encourage development in a floodplain unless there is no practicable alternative. The city of Fargo anticipates that the area within the proposed southside project will be developed over time even if no flood project is built. Checklist item #43 – MVP should take all reasonable measures to eliminate/mitigate impacts, there is no special cost sharing. **Any locally preferred plan would need to be approved by the ASA(CW), and we expect EO 11988 to be a factor in making that decision. The report will discuss development that is expected to occur over time in the absence of a flood control project**

OCT 2009 Status: EO 11988 is still expected to be an issue. The currently proposed diversion alternatives need to be further refined to minimize impacts on the existing floodplain. We expect Fargo may request a locally preferred plan that may follow closely the earlier proposed Fargo Southside flood control project which takes additional land out of the floodplain.

h. Non-Structural – Checklist item #46 – No special action is necessary from MVP. **MVP will work with the non-structural flood proofing committee and the feasibility documentation will be sufficient.**

i. Changes to the P&G – MVP was looking for guidance on changes to the P&G. The vertical team indicated those impacts are unknown at this time and that MVP should not worry about it.

j. MVP requested Vertical Team assistance to streamline the planning process to meet our aggressive schedule. We are assuming that a capability level of funding will be provided (FY10 appropriations will be a test). Vertical Team suggested that we keep Eric Thaut and the FRM PCX involved, especially regarding the Independent External Peer Review.

OCT 2009 Status: It appears that FY 2010 funding will be sufficient to complete the feasibility study. Schedule remains extremely aggressive.

7. The Feasibility Scoping meeting was very productive and it helped to clarify the direction of the study and what needs to be done moving forward. The next scheduled vertical team meeting is the Alternative Formulation Briefing scheduled for April 2010. MVP may request earlier in-progress reviews as this project progresses and will welcome Vertical Team assistance and guidance at any time deemed appropriate by MVD or the MVD-RIT.

Craig Evans
Project Manager

Aaron Snyder
Project Manager

Enclosure 1: MVD comments and MVP responses
Enclosure 2: Fargo-Moorhead Metro FSM – Issues to Discuss

Fargo-Moorhead FSM
MVD Comments and MVP Responses

1. COMMENT: Paragraph 3j of the MVD approval memo of the Section 905(b) analysis indicates that the inclusion of the phrase "and allied purposes" does not specifically include environmental restoration. Has MVP-OC made an assessment of the study authority to determine if the phrase "and allied purposes" is broad enough to authorize the investigation of ecosystem restoration as a project purpose?

RESPONSE: MVD-OC and MVP-OC are coordinating this issue. It may not be pertinent, since MVP is not proposing stand-alone ecosystem restoration features.

OCT 2009 status: MVD-OC and MVP-OC have concluded that there is no legal issue. MVD-PD-N indicated via e-mail on 11-Sep-09 that there is no policy issue either. Issue is closed. MVP will proceed with the understanding that the phrase "and allied purposes" is sufficient to support the types of ecosystem restoration we anticipate with this project.

2. COMMENT: The documentation is very unclear as to ecosystem restoration. The Project Study Issue Checklist seems to indicate that MVP is formulating for an aquatic ecosystem restoration component. However, ecosystem restoration (ER) is not mentioned on page 1 in the Report Purpose and Scope and, on page 9, National and Local Planning Goals, the document indicates that they are not formulating for ER, but there may be incidental ER benefits. Without a clear understanding of the study purpose, problems, opportunities, and objectives, it will be very difficult to have clearly defined plan formulation. If the PDT is formulating for flood risk management (FRM) alone, but anticipates the possibility of incidental ER benefits, I would suggest the Project Study Issue Checklist be revised to indicate that they are not formulating for ER (especially since there are a number of potential policy issues identified for ER). Suggest this be discussed at the FSM and any inconsistencies between the documents corrected. Also suggest during the FSM that the PDT step the meeting participants through the plan formulation process that has occurred to date.

RESPONSE: The draft report identifies planning objectives to restore degraded riverine and riparian habitat, provide additional wetland habitat, and provide recreational opportunities in conjunction with other project features. MVP does not plan to propose stand-alone ecosystem restoration features, but some FRM alternatives will provide opportunities to meet these objectives. For instance, flood-plain evacuation could lead to increased acres of habitat, and diversion channels could be built to incorporate wetland habitat. Such features are consistent with the Corps Environmental Operating Procedures, and could possibly be needed for mitigation of other features. **MVP will revise the Project Study Issue Checklist to show that we are not formulating for ER, but we do not want to lose track of any potential issues there might be with formulation because of the inclusion of incidental ER features.**

3. COMMENT: It is unclear why 2 scenarios are being used for the future without project condition. Does the reasonable future condition include the Southside Flood Control Project or not? This needs to be discussed at the FSM.

RESPONSE: Discussion during the FSM resolved this issue. MVP will assume that the Southside project is not in place for purposes of economic analysis and determining the NED plan. We anticipate that the Sponsor will want to include the Southside project as a locally preferred plan if it is not the NED plan.

4. COMMENT: The problem identified on page 17 is related to FRM, yet the opportunities are related to ER and recreation. Normally, there is a correlation between problems and opportunities which provides the foundation for the formulation process.

RESPONSE: The Corps Planning Manual, IWR Report 96-R-21, page 70 discusses the definition of problems and opportunities. According to that document, the difference between a problem and an opportunity is one's point of view—a problem is a current negative condition that needs to be fixed, and an opportunity is a positive future condition that can be achieved. In the case of Fargo-Moorhead, we chose to frame the flood issues as a problem and the environmental issues as opportunities. The objectives that spring from these problem and opportunity statements should be clear, at least after the discussion at the FSM.

5. COMMENT: There are a number of critical ATR comments which must be resolved.

RESPONSE: Concur. We will work with the ATR team to resolve those issues as we continue the study.

6. COMMENT: The MVP transmittal memo correctly identifies policy and procedural issues which should be discussed at the FSM. With regard to expediting the study, have discussions with the sponsor taken place regarding possibly advancing some Phase 3 work items? I note that if you could advance the CWRB by 1-2 months, you may be able to complete a Chief's Report by 31 Dec 10, which would position the project in case Congress would elect to contingently authorize the project in a potential WRDA 2010.

RESPONSE: We believe the current schedule, which calls for the CWRB in September 2010, will allow for completion of a Chief's Report by 31-Dec-2010 and a contingent authorization.

7. COMMENT: Main report and appendices use several different terms (100-year event, 100-year frequency, 1-percent chance, 1% chance event) to reference the same flood event. To be consistent and to comply with ER 1110-2-1450 suggest using the terms "[x] percent chance exceedance flood" or "x percent flood".

RESPONSE: Concur. We will revise the text for consistency prior to the AFB submittal.

8. COMMENT: The economic appendix page c-1, paragraph 2 lists a different 1 percent flood elevation for the Fargo gage than listed in the main report on page 11 paragraph ©.

RESPONSE: Concur. The main report talks about the "FEMA 100-year" stage, which is different from what the Corps is using for our analyses. MVP plans to use higher flows and stages to better reflect the hydrologic record; FEMA has chosen an administratively determined flow that is lower than the "best available information." Future reports will need to make the distinction more clearly between our numbers and FEMA's.

Fargo-Moorhead Metro FSM – Issues to Discuss
19-May-09

1) Future without project conditions
    a. Southside project and other projects: Assume both in place and not. Two future without project conditions because it is a major uncertainty for the future and we will know better later in the planning process. Not enough information at this time.

    b. Flood-fights and emergency levees. What is an appropriate assumption regarding their effectiveness? Uncertainties about getting protection in place (rain events can also happen here), Uncertainties about performance. If required to do this will use the alignments city used in this flood fight.

    c. Credit to existing levees: ETL 1110-2-556 being rescinded, plan to use what we have already done. (Geotech – did coordinate this with MVD and FRM PCX).

2) Climate Change

3) Loss of Life Discussions

4) Study scope: This study is focused on the F-M region. There is some interest in looking at the whole RRN basin. This is a regional plan for FRM, if there is a push for a holistic solution for the basin we will not make our schedule.

    a. Proposals for flood storage are not likely to have a Federal interest, so the implementation will need to be at the State or Watershed District level. We could help put a basin-wide plan together, but that will take more time and should be part of the Red River Basin Wide Study not this one.

    b. Ecosystem restoration: will be related to FRM measures, not stand-alone measures unless needed for mitigation.

5) Executive Order 11988.
    a. How will this impact us?
    b. City will want to incorporate the Southside project eventually—will there be an issue with that from anyone?
    c. Checklist item #43 “land development opportunities” and special cost sharing—does this apply to our situation?

6) Non-structural: are there any landmines here? (Checklist item #46) Anticipate some areas can only be helped using a non-structural approach.

7) Streamlining the planning process—any help Vertical Team can offer will be greatly appreciated.

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APPENDIX O
ATTACHMENT 2

November 2009 In-Progress Review Memorandum for Record

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CEMVP-PD-F November 19, 2009

MEMORANDUM FOR RECORD

SUBJECT: In-Progress Review – Fargo-Moorhead Metro Feasibility Study, Red River of the North, 5-Nov-09.

AGENDA

0800 Introductions

0810 Purposes:
1) Make the Corps' vertical team aware of the issues and preliminary findings
2) Seek concurrence with alternative screening done to date
3) Obtain vertical team recommendations for the path forward

0815 Study Overview

0835 Discussion of Issues

0920 Summary and Follow-up Actions

0930 Tour Overview

1000 Tour

1130 Lunch

1230 Resume tour

1500 Conclude tour
and prepare for 3:30 p.m. Metro Flood Management Work Group meeting

ISSUES DISCUSSED

1) Future without project conditions
    a. Southside project—not included in future without project condition
    b. Flood-fights and emergency levees – no credit will be given in the economic analyses (assume they are not effective). A sensitivity analysis will be completed to show how this assumption affects the NED plan. Need to be careful about double counting—including the cost of future flood-fights but not the benefits, although we know the costs are real but benefits are not guaranteed. Also need to describe dangers associated with flood-fighting and the (non-economic) value of avoiding emergency operations.

c. Feasibility report needs to project how development would occur without a project and with the project to compare over the 50-year period of analysis.
d. If development would require fill to raise homes above the flood plain, avoiding the cost of that fill could be a benefit of the project.

2) Climate Change Expert Opinion Elicitation results
   a. EOE panel was held 28-30 Sep 2009.
   b. Panel found that traditional hydrologic analysis probably underestimates the risk of flooding in the next 30-50 years.
   c. Panel recommended splitting the hydrologic record into dry and wet periods and making assumptions/sensitivity runs about when the wet cycle will end.
   d. HEC is assisting MVP to incorporate EOE recommendations into the final analyses.

3) Executive Order 11988
   a. ND and MN diversion plans cannot be seen as practicable alternatives to each other, since the ND plan benefits a different and larger geographic area. But we should look at a separate Maple River diversion in addition to the MN diversion to see if that provides similar benefits to the ND diversion alone.
   b. Potential locally preferred tie-back levee alignments may still cause EO 11988 issues.

4) Revised Principles and Guidelines—changes are still in progress. HQ will get info to us ASAP, but we need to follow the current P&G for now.

5) Preliminary Screening results
   a. Major conclusion: focus on diversions and levees
      i. Our work so far supports dropping levee plans from consideration if requested by the Sponsors. Levees have significantly higher residual risk; diversions are more effective and more cost-effective.
   b. Uncertainties
      i. Mitigation costs
         1. Fish passage
         2. Hydraulic impacts
      ii. Additional benefits
         1. Tributary flooding
         2. Transportation
         3. Advanced Replacement
         4. Floodproofing cost savings
   c. **<u>Corps Vertical Team concurs with screening actions to date</u>** as described in the draft Screening Document. Vertical Team will furnish comments in the near future to allow us to finalize the screening document

and use that text in the feasibility report and EIS. This includes elimination of all levee alternatives from further consideration as the National Economic Development Plan. No other levee plans will be examined unless based on the request of the local sponsors as a locally preferred plan. The levee plans are being eliminated with the following uncertainties:

i. Upstream impacts of the levee alternatives were not included in the costs, initial calculations indicate a 0.8 foot increase for the 100-year event increasing to 3.8 feet for a 500-year event. Downstream diversion impacts are on the magnitude of 0.3 feet for the 100-year.
ii. The current levee plans were based only on earthen levees, use of floodwalls would be assumed to increase levee costs.
iii. Advanced replacement benefits have not been included for the diversion or levee plans, benefits would be assumed to be greater for levee plan.
iv. Floodproofing cost savings benefits have not been included for the diversion or levee plans, benefits would be assumed to be greater for the diversion plans.
v. Transportation benefits have not been included, benefits would be assumed to be greater for the diversion plans.
vi. Impacts to historical properties have not be fully assessed, costs are assumed to be greater for the levee plans.
vii. Mitigation costs have not been included, costs would be assumed to be greater for the diversion plans although the plan is to avoid and minimize prior to the need for mitigation.

In addition to those considerations the levee options could only provide a 100-year level of risk reduction to the communities, this level of risk reduction may not be an acceptable level of risk reduction for the communities or the Federal government. By comparison, the new Corps levee at Grand Forks/ East Grand Forks has a top elevation equivalent to the 500-year flood profile and the diversion project at Winnipeg, Manitoba has a level of protection exceeding a 700-year event.

6) Locally preferred plans—what factors influence ASA(CW) approval?
   a. ASA(CW) will look at the impacts of the plans, agency views, mitigation needs, etc.
   b. We need to look at alignments that would bring the diversion back to the RRN earlier and describe the hydraulic issues that make that undesirable.

7) Communication Plan
   a. MVP plans to release an unofficial “tentatively selected plan” to the public in Jan 2010 with appropriate caveats. Caveats will include noting that study results are preliminary and not supported by the Corps until

b. Other technical information may be released throughout the study as long as it is caveated in a similar fashion.

ATTENDEES

HQUSACE: Zoltan Montvai, John Lucyshyn, Mark Matusiak, Tom Hughes

MVD: Larry Kilgo, Ken Klaus, Susan Smith, Brandy Alexander, Robert Petersen, Cassandra Price, Burke S. Torrey

MVP: Col. Jon Christensen, Craig Evans, Aaron Snyder, Jon Sobiech

Fargo: Mayor Dennis Walaker, Mark Bittner, Nathan Boerboom

Moorhead: Bob Zimmerman,

Cass County: Keith Berndt

ND DOT: Bob Walton

Moore Engineering: Jeffry Volk, Lee Beauvais

Houston Engineering: Gregg Thielman

APPENDIX O
ATTACHMENT 3

Alternative Formulation Briefing Project Guidance Memorandum

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DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
WASHINGTON, D.C. 20314-1000

MAY 24 2010

CECW- MVD

MEMORANDUM FOR: Commander Mississippi Valley Division (ATTN: CEMVD-PD-SP)

SUBJECT: HQUSACE Policy Compliance Review, Fargo-Moorhead Metropolitan Area

1. Reference is made to CEMVP-PD-F memorandum dated 26 March 2010, subject: Fargo-Moorhead Metro Alternative Formulation Briefing Documents.

2. The Alternative Formulation Briefing (AFB) for the Fargo-Moorhead Metropolitan study was held on 26 April 2010 at the St. Paul District. Complete documentation of discussions and decisions reached during the AFB is provided in the enclosed project guidance memorandum (PGM). The AFB was held to provide an agency review of the project issues and to discuss remaining activities needed to be accomplished in order to complete the draft feasibility report.

3. As a result of the AFB all policy issues are resolved. The draft feasibility report may be released for public and agency review contingent on including information in the draft report as discussed in the PGM. The PGM presents the policy review comments, responses, discussions, and required actions.

4. The draft report shall be submitted to CECW-MVD for policy compliance review concurrently with the release for public review. To assist in expediting the Washington level concurrent review process, the submittal should include a compliance memorandum that specifies where and how each of the enclosed comments is addressed in the draft report.

5. Questions regarding this guidance should be directed to John Lucyshyn at 202-761-4515.

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Encls

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20 May 2010

FARGO-MOORHEAD
FLOOD RISK MANAGEMENT FEASIBILITY STUDY
ALTERNATIVE FORMULATION BRIEFING
DRAFT PROJECT GUIDANCE MEMORANDUM

1. BACKGROUND.

A. Alternative Formulation Briefing (AFB).

1) The AFB meeting was held in the St. Paul District Office on April 26, 2010. Staff from HQUSACE, MVD, St. Paul District, the non-federal sponsors and engineering firms working for the sponsors participated in the discussion. (See attached attendance list.) This memorandum summarizes the discussion, conclusions and required actions agreed upon at the meeting.

2) A follow-on teleconference was held on May 5, 2010 with the vertical team to discuss environmental mitigation issues, as requested at the AFB meeting (per action item 2.A.b below). Results of the phone conference are reflected in this memorandum.

B. Study Area. The Fargo-Moorhead metropolitan area is located in the Red River of the North Basin. Fargo and Moorhead are situated on the west and east banks, respectively, of the Red River of the North. Although Fargo-Moorhead is located along the Red River, the Wild Rice, Sheyenne, Maple and Rush Rivers in North Dakota and the Buffalo River in Minnesota also cross the study area. The Red River originates at the confluence of the Otter Tail and Bois de Sioux Rivers south of Fargo, North Dakota. The river is approximately 453 river miles and flows north where it empties into Lake Winnipeg in Manitoba, Canada. The study area is approximately 2,810 square miles and had a population of 174,367 in 2000. It is estimated that the population in the Fargo-Moorhead metropolitan region will increase to 227,150 by 2015. The Fargo-Moorhead metropolitan area is the largest urban area in North Dakota and a principal regional economic and social center.

C. Problem. Because of the relatively low elevation and flat topography, the majority of the study area is located in the regulatory floodplain. As a result, when the river flows over the banks, much of Fargo and Moorhead are susceptible to being inundated with flood waters. The Red River of the North has exceeded the National Weather Service flood stage of 18 feet in 47 of the past 108 years, and every year from 1993 through 2010. Flooding in Fargo-Moorhead typically occurs in late March and early April. Average annual flood damages in the Fargo-Moorhead metropolitan area are estimated to be over $77 million. 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.

D. Study 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 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 local sponsors and the federal government. Funds to initiate the feasibility study were provided in the Consolidated Appropriations Act, 2008, approved December 26, 2007 (Public Law 110-161).

E. Plan Formulation. The feasibility study team collected pertinent data on engineering, economic, social and environmental information needed to evaluate the study objectives. Potentially affected landowners and interested parties were identified, and potential issues and opportunities were defined. An array of possible flood risk reduction measures and alternatives were considered and screened to define the costs, benefits, and impacts to the project area. The study analyzed a number of possible measures that could reduce the flood risk in the Fargo- Moorhead Metropolitan area. These measures included: No Action - Continue emergency measures; Nonstructural measures; Flood barriers; Increase conveyance; and Flood storage. The alternatives went through an initial screening that used the following criteria: Effectiveness, Environmental Effects, Social Effects, Acceptability, Implementability, Cost, Risk, Separable Mitigation, and Cost Effectiveness. This analysis was included in the Alternatives Screening Document dated December 2009. The analysis resulted in two diversion concepts being carried forward: a diversion in Minnesota and a diversion in North Dakota.

The plans that were analyzed in detail were the:

No Action – synonymous with "Without Project Condition"
MN20k: Minnesota Short Diversion, 20,000 cubic feet per second (cfs) capacity
MN25k: Minnesota Short Diversion, 25,000 cfs capacity
MN30k: Minnesota Short Diversion, 30,000 cfs capacity
MN35k: Minnesota Short Diversion, 35,000 cfs capacity
ND30k: North Dakota East Diversion, 30,000 cfs capacity
ND35k: North Dakota East Diversion, 35,000 cfs capacity

The design, alignments, and features were refined and a baseline cost estimate for each plan was completed.

F. Recommended Plan. The NED plan was identified as the MN20K diversion and the LPP was identified as the ND35K diversion. The MN20K diversion channel would be a 25 mile diversion channel with a base width of 175 feet, a maximum depth of 30 feet, and includes 20 highway bridges, 4 railroad bridges, and a Red River Control Structure. This plan would provide protection to Fargo and Moorhead residents up to a 1-percent chance (100 year) flood. The NED plan would start just north of the confluence of the Red and Wild Rice Rivers and extend north and east around the cities of Moorhead and Dilworth and re-enter the Red River Fargo-Moorhead Metro Feasibility ES-11 near the confluence of the Red and Sheyenne Rivers. The diversion channel and spoils would affect approximately 4,485 acres.

The ND35K diversion channel would be a 36 mile diversion channel that would start approximately four miles south of the confluence of the Red and Wild Rice Rivers and would re-enter the Red River north of the confluence of the Red and Sheyenne Rivers. The LPP would incorporate the existing Horace to West Fargo Sheyenne River diversion channel. The channel bottom width varies between from 100 and 300 feet and has a maximum depth of 32 feet. The plan includes 18 highway bridges, four railroad bridges, and would approximately 6,560 acres.

2. REVIEW OF ALTERNATIVE FORMULATION BRIEFING DOCUMENTATION.

A. GENERAL.

Incomplete nature of report. Several portions of the report (e.g., part 4.2.1.4 on page 95, states that "information for the Maple River and Wild Rice River will be included in the final report") indicate that additional information is needed to complete the report. The environmental impacts and mitigation plan has not been fully developed. Economic impacts of increased flooding, a takings analysis, and an evaluation of mitigation alternatives for those impacts have not been completed. Completion and review of the full report will be necessary prior to its final approval.

<u>MVP Response</u>: Concur. The established schedule has additional ATR and vertical team reviews scheduled prior to the report's final approval; the vertical team review is scheduled to begin in August. A preliminary takings analysis was completed and will need to be revisited based on the new hydrology. All data gaps will be finalized in the final version of the report, which will be able to incorporate some of the survey information being collected this summer. It is unlikely that mitigation for the downstream stage impacts would be economically justified. The analysis will first determine if there is a taking, then determine if there is a justified solution and then any unmitigated damages will be included in the project as a cost. The non-Federal sponsors will continue to be actively involved in this effort.

Discussion: The downstream hydraulic impacts of the NED Plan and Locally Preferred Plan were discussed in detail, along with options to mitigate. The district advised that it is unlikely that mitigation would be economically justified as an incremental feature (social or environmental) or justified as a result of a takings analysis. If this is the case unmitigated damages would need to be included as an economic cost in the economic analysis. It was also recognized that non-Federal Sponsor could chose to include downstream mitigation measures should the mitigation measures be found to be not supportable either economically or thru a takings analysis. It was agreed that the draft report going out for public review would discuss the range of impacts.

Required Action: The district will more fully develop the mitigation plans utilizing the most recent hydrologic and hydraulic data. Any unmitigated downstream hydraulic damages would need to be included as an economic cost in the economic analysis. The draft report going out for public review at a minimum will discuss the range of downstream hydraulic impacts with the final report presenting the full analysis.

B. PROBLEMS, NEEDS AND OPPORTUNITIES.

1. <u>Problems and Opportunities.</u> There is no clear 'problem and opportunity' statement. Per the Planning Manual and Planning Guidance Notebook (ER-1105-2-100), the first step of the planning process is a clearly defined statement of problem and need. A clear statement of problem and opportunity provides a focal point for all stakeholders.

a. Additionally, the problems listed for the proposed project do not include ecological problems; however, there are ecological objectives for the proposed project. The opportunities for the flood risk management portion of the proposed study do not adequately reflect the plan formulation that has been conducted.

b. Furthermore, the primary problem cited is "high risk of flood damage to urban infrastructure", yet this is not specific to the cause of flooding, timing, or importance.
c. Opportunities are limited to improving wildlife habitat.
d. ER 1105-2-100 App E Para E3 states that problems and opportunities should be defined in terms of their nature, cause, location, dimensions, origin, timeframe, and importance. Be specific on the sources of flooding, as well as the timing and overall significance of the flooding. Also be specific to the location and significance of improving wildlife habitat. As such, the problems and opportunities should be revised in accordance with the above-comments.

MVP Response: Concur. The PDT will revisit the Problems and Opportunities to ensure they adequately capture the information located in other portions of the report. The revisions will not impact the plan formulation nor the efforts completed to date. Additionally, the PDT coordinated the development of the problems and opportunities with the local sponsors, natural resource agencies, and had particularly heavy involvement from the EPA.

Required Action: The district will revisit the Problems and Opportunities discussion in the main report to ensure discussions adequately capture the information located in other portions of the report and ensure the draft main report to be released to the public fully documents the problems and opportunities identified.

2. Objectives. The objectives that are identified for the study are extremely vague and do not allow for sufficient evaluation of the project alternatives. ER 1105-2-100 E Para E3 states "Objectives, as well as constraints, are written statements that should generally include the following four types of information: effect (the verb that expresses the intent to bring about an objective and not to violate a constraint); subject (what is to be changed for the better through meeting the objective or not changed through avoiding a constraint); location (often the study area, which defines where the objective is to be achieved); and timing and duration (often the study period of analysis, which define when and how long the objective is to be achieved or the constraint to be avoided). Developing specific, flexible, measurable, realistic, attainable, and acceptable objectives and constraints is critical to the success of the entire planning process." The objectives must be restated consistent with the ER.

MVP Response: Concur. The PDT will revisit the Objectives to ensure they adequately capture the information located in other portions of the report. The revisions will not impact the plan formulation nor the efforts completed to date. Additionally, the PDT coordinated the development of the problems and opportunities with the local sponsors, natural resource agencies, and had particularly heavy involvement from the EPA.

Required Action: The district will revisit the Objectives discussion in the main report to ensure it captures the information located in other portions of the report and will ensure the draft main report to be released to the public fully documents the study objectives.

C. WITHOUT PROJECT CONDITIONS.

1. Flood Fighting. The text indicates that no credit is taken for flood fighting although it has been very successful in reducing damages for the most recent flooding events. It is not evident in the main report material what the costs of these flood fighting efforts have been or how they might vary for different flooding events. Since it is indicated that flooding is somewhat predictable based on snow melt, it is anticipated that the level of efforts expended by public employees and community volunteers during these emergency actions would vary by event. It isn't evident from the main report how these efforts are captured as part of emergency costs in the damage analysis. The Economics Appendix has much more information on emergency costs including the residuals anticipated for the various diversion plans. HQ suggests that more information be provided in the main report so that the reader can get a basic understanding of the emergency costs incurred and how they translate into benefits. Table 12 on page 69 alludes to reduced risk and emergency actions, but makes no distinction between the impacts of the diversion plans regarding the extent of reduction. The emergency costs should be specifically addressed under the without-project conditions text as a basis for impact assessment under the with-project conditions. See ER 1105-2-100, paragraph 2-4.b.(1).

MVP Response: Concur the information from the economics appendix will be added to the main report and the emergency costs will be specifically addressed. We will talk about the sensitivity analysis in the main report.

Required Action: As identified in the response the district will add information from the economics appendix to the main report and the emergency costs will be specifically addressed.

2. Base Year. The text doesn't clearly state what the assumed base year is for the analyses. This defines the start of the 50-year period of analysis and should be discussed in the without-project condition section. It is critical to the forecasting of future without-project conditions and comparison of alternative effects over time. The Implementation Requirements shown in Section 3.9 indicate the project completion date is in October 2018, which may be the base year. However, Table 19 shows construction continuing into 2019, so it isn't clear what the base year is assumed to be. Page C-74 of the Economics Appendix shows the flood proofing cost savings calculation over the period 2018-2068. Clarification is needed per ER 1105-2-100, paragraph 2-4.b.(1).

MVP Response: Concur. MVP will revise the analyses to make the two plans directly comparable regarding the base year. This will be adjusted in the future as we are completing a detailed construction schedule for both the NED and LPP plans.

Discussion: The district indicated it is preparing a detailed schedule for both the NED plan and the LPP and will coordinate with the Office of Water Project Review (OWPR) to ensure that the analysis is correct and will adjust the benefits accordingly.

Required Action: The district will prepare a detailed schedule for both the NED plan and the LPP and coordinate with the OWPR to ensure that the analysis is performed correctly and will adjust the benefits accordingly.

3. Period of Analysis. Paragraph 2-4.j. of ER 1105-2-100 requires that the period of analysis be the same for each alternative plan. However page C-60 of the Economic Appendix indicates that the MN diversion plans could be implemented after 6.5 years of construction and the ND diversion plans would require 8.5 years. In order to compare these plans on a comparable period of analysis, the ND plans should be shifted to the same 50-year timeframe as those in MN using the appropriate economic factors. This may make the ND plans more competitive, since the construction costs would be discounted for comparison.

MVP Response: Concur. MVP will revise the analyses to make the two plans directly comparable regarding the period of analysis. MVP will coordinate changes with OWPR to be sure the intent of the comment has been addressed.

Required Action: The district will revise the analyses to make the two plans directly comparable regarding the period of analysis. Prior to revising the report, the changes will be coordinated with OWPR to ensure the intent of the comment has been addressed.

4. Reach Delineation. Economic Appendix (pg C-7) does not adequately address land use and the reasoning of the subdivision of the reaches. ER 1105-2-100 states that floodplain characteristics and land use should be determined. Existing land use and characteristics must be determined before its actual use can be estimated. Recommend further explanation of project area and reach delineation and land use.

MVP Response: Concur. The information will be added regarding the reasoning for the reaches.

Discussion: The district explained that reaches were determined by beginning damage elevation and other factors such as existing infrastructure and geographic location. The district agreed to add a better description of how reaches were determined to the economics appendix and will include a description of the location in terms of river miles, existing structures, etc.

Required Action: The District will add appropriate discussion in the report concerning the rationale for reach delineations

D. FORMULATION OF ALTERNATIVE PLANS.

1. Screening of Management Measures. The AFB document, in particular Appendix O, does not adequately discuss how the management measures were screened, retained, and/or combined into alternatives. Management measures form the basis of alternatives, and typically lack the details that are required to evaluate alternatives. Utilizing cost to screen management measures or even an initial array of alternatives without adequate detail could lead to a flawed formulation process. Additionally, the screening of management measures by mitigation is not appropriate as sufficient detail is not yet included to evaluate the effects of each measure. It is typically not possible to quantify compensatory mitigation requirements from features or activities that lack detailed designs, locations, etc. Some management measures such as flood barriers, were described as having low positive impacts in Section 2.2.3. However, in Section 2.2.3.1 titled Natural Resources, it states that the effects would be neutral. A table should be provided that demonstrates the rationale used to evaluate the management measures. Moreover the management measures that are listed in Section 1.6 seem to be different than the management measures that are evaluated in Section 2.4. The document needs to more fully document the screening process taking into account the requirements identified above.

MVP Response: Concur. The information will be clarified in the main report and in Appendix O. The information will be updated by including more detail from the Alternatives Screening Document attached to Appendix O. This document provides adequate rationale for the screening that was completed. Although there was a large list of initial screening criteria, some of those were weighted differently. For example, the separable mitigation was included as requested by the local sponsors and was important for their decision making, but it did not necessarily lead to the dismissal of any measures. Tables are used in Appendix O to clarify this information; this will be added to other portions of the report.

Discussion: The district agreed to review the discussions in the report to ensure they accurately explain the screening process. The details surrounding the alternative selection/ screening process will be presented in the main report rather than in an Appendix.

Required Action: As noted in discussion.

2. <u>Screening of Alternatives.</u> Reasons for why the particular Alternative Screening Criteria were chosen and how they were measured and quantified in comparing alternatives is not clearly explained. It is difficult to determine why these screening criteria were uniquely used and if they have individual weighting separate from criteria such as completeness, effectiveness, efficiency and acceptability. In ER 1105-2-100 paragraph 2-3 it is suggested that each alternative plan should be formulated in consideration of the four criteria. If the 11 criteria presented in the Alternatives Screening Document cover these criteria it should be explained why this is the case and why this particular method of screening was used. Recommend adding an explanation of the criteria used, why they were selected, and how this fits in with the prescribed methods of evaluation in ER 1105-2-100.

MVP Response: Concur. The PDT will add information on why each criterion was selected and how this fits with the prescribed methods.

Required Action: The district will revise the report to include appropriate information on why each screening criterion was selected and how it fits with the prescribed methods.

3. Ecosystem Restoration Measures. The plan formulation for the proposed project lists two objectives as having ecosystem restoration intentions; however, the initial formulation of management measures, subsequent screening, and formulation of alternatives do not discuss ecosystem restoration until further into the report. It appears that some management measures or alternatives were eliminated due to environmental degradation; however, there is not mention of how these measures or alternatives would perform in regards to the objectives. As such, the plan formulation should be revised to include an evaluation of ecosystem restoration potential for each of the measures and alternatives.

MVP Response: The primary objective of the study is flood risk management. If individual measures were not able to substantially contribute to flood risk management, they were screened out early in the process. As the study progressed it was determined that very few opportunities in the project area for ecosystem restoration would have a federal interest except as incidental components of a flood risk reduction project. The Objectives will be clarified to identify FRM as the primary objective and that ecosystem restoration is secondary to FRM. The main report will be clarified to discuss any environmental measures that were considered where relevant, this will be completed by pulling information out of the alternative screening document.

Discussion: The district affirmed that FRM is the primary objective and that the report will be revised to identify FRM as the primary objective and that ecosystem restoration is secondary to FRM. Although not apparent at this time, there still may be opportunities for restoration associated with potential downstream hydraulic mitigation measures.

Required Action: The district will revise the report to clarify the planning objective and pull info out of the alternatives screening document to explain how ecosystem objectives were considered.

4. Alternative Development. Page 24 of the main report indicates that no further consideration was being given to grassland, wetland, and storage measures as stand-alone features, but they would be considered further in combined plans with diversions.

Additionally, the Economic Appendix states there is a possibility for incremental non-structural measures. However, further discussions of plan formulation in the main text do not mention these measures being considered in combination with the diversion plans. Additional rationale needs to be presented in the main text on what consideration was given to these measures in combination with diversion and how they were written off during further formulation in order to present a complete and logical formulation story.

MVP Response: Partially Concur. Non-structural measures are included in the NED plan but not the LPP, as discussed in paragraph 3.3.5 on page 52 of the main report. The wetland and grassland restoration measures were similar to storage, and it was determined that they would not be incrementally justified along with any of the diversion channels. This is primarily due to the large costs associated with these plans and their limited ability to provide any incremental flood risk management benefits. This information will be taken from the screening document and included in the main report.

Required Action: The district will revise the main report to include additional information regarding how grassland and wetland restoration were screened out. It was agreed that information from the Alternatives Screening Document should be used to pull information into the report.

5. NED Plan. The MN20K diversion plan is designated as the NED plan in the text, however it is also noted that with the reanalysis of hydrology the NED plan designation may change. It is important to establish the NED plan per 2-3.f.(1) of ER 1105-2-100 prior to release of the draft report because the NED plan forms the basis for cost sharing when a larger LPP is proposed for recommendation and the waiver package being coordinated through ASA(CW) for approval as well as the draft feasibility report must detail the incremental differences between the LPP and NED plans. Further discussion is needed at the AFB regarding the NED plan designation based on the latest available information and consideration of the various review concerns which have potential to impact the plan formulation.

MVP Response: Concur. The NED plan should be identified by May 10, 2010 and will be incorporated into the draft report prior to public release. The incremental differences will be included in the draft report, this will be based on each line of the cost estimate. This information will be presented to the vertical team for final approval to release the draft report to the public and for concurrent MVD/HQ review. Following the updating of the H&H, information will be included in the main report indicating why the changes do not impact the results of the screening, and actually strengthen it. An ATR will be completed on the updated work.

Discussion: The district agreed to prepare appropriate read ahead information to describe and summarize the final NED analyses for the vertical review team and will arrange for a vertical team Teleconference to discuss. The LPP and NED plan will need to be developed in the same level of detail because the NED plan will form the basis for Federal share in the LPP. The district will also discuss effects the revised hydrology will have on the alternatives screening analysis and confirm that the screening based on the traditional analysis remains valid.

Required Action: Prior to release of the draft report to the public the district will arrange for a vertical team teleconference call to discuss the results of the updated NED plan identification.

6. Value Engineering Study. It is difficult to determine if any of the VE study comments / recommendations were incorporated into the alternatives. This information should be included in the report documentation.

MVP Response: The VE comments were considered with further development of the plans. Most of the VE recommendations were not able to be implemented. The VE report will be updated to include responses from the PDT, and these will be included in the VE report for the final report.

Required Action: The district will draft responses to the VE recommendations and include in the VE report for the final report.

E. EVALUATION AND COMPARISON OF PLANS.

1. Downstream Effects. Section 3.5.3.4.2 indicates that the diversion plans would all have downstream effects that have not been analyzed except for the MN35K and ND35K diversion plans to identify maximum extent. It is indicated that additional analyses will be conducted for only the LPP and NED Plans. However, it is unclear how significant the differences might be between various scale plans and whether there is potential for these considerations to affect the NED plan designation. For example, what is the extent of any "new" acreage that would be subject to inundation by the induced rises in downstream flood elevations? Other factors that should be addressed include how the increased flood elevations would affect structures, traffic patterns, access to residences, provision of emergency services, and agricultural land use.

These analyses should be performed for each of the detailed alternatives utilizing the most recent H&H analysis as a basis for plan comparison and selection. Per E-18.f. , ER 1105-2-100 induced flooding damages should be investigated to determine if mitigation is warranted and if not, unmitigated damages should be accounted for in the economic analysis and the impacts displayed and discussed in the report. Clarification is needed as to the effects of the induced flooding on the detailed alternative plan formulation and NED plan designation.

MVP Response: Concur. The NED and LPP plans will be updated based on the new H&H analysis, and this will be included in the final report. In general, the area that will be impacted will already be under water and there will be minimal additional disruption or damages caused by the additional downstream stages. The PDT will complete an economic analysis of the downstream impacts based on the future without project condition. Although the downstream impacts are expected to vary between the plans, it was assumed that those variations between the plans would not be significant, therefore the screening of the alternatives would be valid. This will be verified by the results of the final NED and LPP evaluations. The downstream impacts that will be provided to the public in the Draft report will be identified as preliminary and new numbers will be provided to the public as soon as possible. The future without project condition includes levees to the 100-year plus 3 feet for the communities of Georgetown, Perley, and Hendrum. Halstad has a 250-year levee already in place.

Discussion: The district indicated that additional hydraulic modeling based on revised hydrology will be required to assess downstream hydraulic effects. The district will ensure that unsteady modeling for both the LPP and NED plan is completed for the final report. The district clarified that the extent of downstream impacts is most likely just past Halstad and that there is no increased agricultural damage because of the time of the year floods usually occur—March and April, when no crops are planted. It was agreed that the district will need to account for induced damages and demonstrate that the difference in impacts between the plans does not influence the determination of the NED plan. The district advised that if the updated hydraulic downstream analysis would identify significant environmental effects additional public review would be required to comply with NEPA. It was agreed the draft report could be released to the public without final resolution of the downstream impact numbers but the draft report will need to be clear that the impacts are preliminary. It was recognized that there is risk associated with going out for public review before final impacts are determined.

The district further explained that many of the downstream communities currently have plans for state project engineered levees that are at 100-yr + 3 feet of protection; these levees will probably be in place prior to the completion of the proposed Fargo-Moorhead project; and that future without project conditions in the feasibility study assume that new levees are in place for the downstream communities.

Required Action: For the NED plan and LPP the district will present the downstream hydraulic effects based on results the revised hydraulic modeling reflecting the updated hydrology and will discuss in the report any effects on plan formulation.

2. Additional wetland habitat, Table 13. It is unclear how the alternatives would provide increases in the acres of wetland habitat in the study area. Is the additional wetland provided in the bottom of the diversion channels?

MVP Response: Concur. The wetlands will be at the bottom of the diversion.

Discussion: The district clarified that wetlands in the project area are of poor quality in the region.

Required Action: The report will address how the alternatives would provide for increases in the acres of wetland habitat in the study area.

3. Other Social Effects. Table 12 presents information on the Other Social Effects account however in most cases the information presented for each OSE consideration uses the identical general statement for each alternative. This provides little value for distinguishing between the effects of the alternatives. It would be anticipated that the plan effects would vary for the MN versus ND alternatives and various scales of diversion. The text should be clarified to provide more definitive information on the other social effects for each of the scales of the diversion alternatives as a basis for comparison.

MVP Response: Concur, the table will be updated. Generally all of the plans under consideration provide a large level of flood risk reduction, this results in the other social effects being very similar on size and location. Will add info on impacts of the NED plan to Dilworth and will add downstream effects discussion to the OSE portion.

Discussion: The district indicated it review the table and clarify impacts where necessary. Since all the plans under consideration provide 100-yr protection or better, from a social perspective all the plans perform strongly. There was an issue in the City of Dilworth where concern was raised overt the diversion cutting off developable lands. The district indicated this concern was analyzed and will be addressed in the report.

Required Action: The district will update the other social effects table as noted in the MVP response.

4. Expected Average Annual Damages. Table 9 shows the NED account analysis for the various plans based on the analyses conducted prior to incorporating the EOE panel recommendations. It is noted that the average annual diversion benefit varies between $61,780,000 and $71,454,000 for the various MN short alternatives based on the EAAD of $77.1M, whereas table 6 indicates residual damages would vary between 15,290,000 and 26,490,000 for EAAD= $104,000,000 (benefits would increase substantially and would vary from $77.060,000 to $88,710,000). Please clarify why the EAAD and benefits differ so significantly between the information presented in the two tables and why formulation results would not be expected to change based on the revised H&H information.

MVP Response: Concur. The numbers will be reviewed and updated for the draft report.

Required Action: As noted in the MVP response.

5. Interest During Construction (IDC). In Table 9, page 61 the values shown for IDC on the North Dakota plans are much higher than the MN plans in comparison. For instance, the 35K MN plan has a first cost of $999,733,000 with IDC of $149,047,000 whereas the 30K ND plan has a cost of $1,026,030,000 and IDC of $210,856,000. So a $27M cost difference results in a $60M IDC difference. These differences are not explained in the main report, but page C-60 of the Economic Appendix indicates the construction period for ND plans would be 8.5 years while the MN plans would take 6.5 years. It is not clear why the schedules/and IDC calculations would vary so significantly between the MN and ND plans. Is this due to the extent of structures in the ND plan? It is also unclear why the construction period would be the same for all the MN plans. Further explanation should be provided to support the assumed construction periods and the basis for IDC calculations, since this has potential to impact the formulation. See D-3.e.(11) of ER 1105-2-100.

MVP Response: Concur. A critical path analysis was completed and determined the construction schedules for each of the diversion alternatives. The difference has to do primarily with how the large tributary structures are constructed and brought on line. The Maple River structure is the critical path on the ND diversion, and the rail yard modification is the critical path on the MN diversion. A detailed construction schedule will be completed for both alternatives. The plans will be revisited to ensure that the IDC is comparable.

Discussion: The district advised they are currently working on a detailed schedule and phasing for both the ND and MN alignments. Currently the district is comparing the NED 2018 numbers to the LPP 2020 number because the NED plan will take two years less to construct. The district is recommending comparing the two plans using 2020 numbers. This will make the IDC comparable.

Required Action: The district will explain the construction schedules for the NED plan and LPP in the main report and their impact on the cost estimates. The economic analysis will be revised to reflect the different schedules.

6. <u>Beneficial Effects on Floodplains.</u> Table 9 shows that economic benefits for Flood Insurance Administrative Cost Savings are the same ($1,000,000) for all the diversion plans. Flood Proofing Costs Savings are the same for the two ND plans ($10,430,000) and for all of the larger MN diversion plans ($6,240,000) with the MN 20K plan slightly less ($5,960,000). However, the information in Table 10 under Floodplains (EO 11988) states that floodplains were not analyzed for the ND30K, MN20K (NED Plan), and MN30K. For the diversion plans analyzed the floodplain area taken out of the 1% chance event floodplain varies between 30.5 sq. mi. (MN25K) and 81.3 sq. mi. (ND35K). Given these variations and the limited analyses conducted it isn't clear why the FIA cost savings would be shown as the same for each alternative or how flood proofing cost savings could be estimated for the various plans with confidence. Please provide further explanation, since these benefit categories have significant values relative to the difference in benefits between plans.

MVP Response: Concur. The information provided will be clarified, generally speaking all plans considered significantly reduce the 1% chance floodplain and there are only minor differences between the 20K-35K plans. The FIA cost savings is based on the number of existing policies in place under the existing conditions, this will be revisited to consider refinancing that may take place.

Discussion: The district explained that flood proofing cost savings were based on flood outlines from the contractor. The district had different flood plains for different project alignments. Benefits varied with channel size. Flood insurance cost savings is based on existing policies. The ATR reviewer made the comment that they haven't considered future changes to flood insurance. The assumption is that FEMA regulations will not change.

Required Action: The district will revisit the FIA cost savings to consider refinancing that may take place and revise the report to clarify that generally all plans considered significantly reduce the 1% chance floodplain and there are only minor differences between the 20K-35K plans.

7. Sanitary Sewers. Economic Appendix (C-12) discusses damages accruing in the existing conditions caused by backwater flow through the sewer system. Please clarify how the beginning damage elevations were adjusted downward to the lower zero-damage elevation for the sanitary sewer basin and how this information was used in the damage calculations.

MVP Response: Concur. Information will be included in the draft report as well as discussions on what other incremental measures could be used to reduce sewer backups.

Required Action: The district will include discussion in the report addressing what other incremental measures could be employed to reduce sewer backup.

F. MITIGATION

1. Use of ratios in mitigation planning. Several sections of the main report (examples include Sections 3.8.1.3, 5.2.1.8, 5.4.1.9 and 5.5) state that mitigation acreage ratios of 2:1 would be utilized for wetlands, geomorphic/fisheries and riparian impacts. This proposal is inconsistent with paragraph C-3(d)(5) of ER 1105-2-100, which states that habitat-based evaluation methodologies shall be used to the extent possible to describe and evaluate ecological resources and impacts associated with alternative plans.

MVP Response: Concur - The mitigation portion of the report will be updated and better defined to ensure that it is policy compliant. The initial report used a 2:1 replacement approach, which should result in a conservative cost estimate to address the mitigation needs in the future. It is acknowledged that ER1105-2-100 requires specific habitat evaluation, including CE/ICA of mitigation actions. A large amount of survey work is ongoing, and any results from that will be used to complete the analysis in the feasibility report. The report will be updated to include all of the items discussed in WRDA 2007, Section 2036. MVP will coordinate with MVD/HQ on the mitigation approach and will receive future guidance on this.

The updated mitigation plan will not be available for the May draft report to be released for public review, but it will be included in the August 2010 submittal for the CWRB. The CE/ICA will be done after completion of the mitigation analysis, the intent is to develop a plan that can be included in the final report.

Discussion: A follow-on vertical team conference call was held on 5 May to discuss the mitigation approach in more detail. Based on this teleconference it was decided that: 1) the 2:1 ratio approach will be removed from the draft report scheduled to be released in May 2010; 2) A habitat evaluation will be completed for the impacts and to determine the mitigation requirements. There are existing models that might be approved for use or could be. Coordination with the ECO-PCX is necessary; 3) An appendix on adaptive management will be developed for the August report. This will include pre and post-project monitoring plans, post-construction mitigation monitoring costs and metrics that can be used to assess the mitigations effectiveness; 4) There are two options for mitigation the first being stream remeandering and riparian corridor restoration, the second being dam removal downstream (note this would not be for fish connectivity mitigation but to mitigate for the riparian impacts); and 5) The second approach would constitute out-of-kind mitigation, but may be environmentally preferable, and will need to be closely coordinated with the natural resource agencies, and letters of support should be provided .

Required Action: As noted in the discussion.

2. <u>CE/ICA needed for mitigation plan</u>. Neither the main report nor the Environmental Appendix F contains a CE/ICA for the mitigation plan. The use of CE/ICA is required consistent with paragraph C-3(e)(8) of ER 1105-2-100.

MVP Response: Concur - The mitigation portion of the report will be updated and better defined to ensure that it is policy compliant. See response to comment F.1.

Required Action: For the final report appropriate CE/ICA analysis will be performed to support the selected mitigation plan.

3. <u>Proposed mitigation plan for wooded areas, Section 5.2.1.8, page 187</u>. This section of the report states that the loss of wooded areas would be replaced at a ratio of 2:1 by tree plantings along the recreational corridor of the LPP. Plates 1-3 of Appendix M show that the recreation corridor is along certain segments of the ND 35 diversion channel. In the absence of a habitat-based analysis, it is unclear whether the proposed plantings would adequately replace the functions of the wooded areas lost due to the construction activities, or would result in either over-mitigation or under-mitigation of the impacts. The mitigation for loss of wooded areas should be evaluated using both a habitat-based assessment and CE/ICA, consistent with ER 1105-2-100.

MVP Response: Concur - The mitigation portion of the report will be updated and better defined to ensure that it is policy compliant. See response to comment F.1.

Required Action: See F.1.

4. <u>Mitigation costs inconsistent between main report and Appendix F</u>. Table 42 on pages 242-243 of the main report states that mitigation costs are $43,903,000 for while an un-named 11 by 17 inch table in Appendix F gives the mitigation cost for the ND Alignment as $60,518,726. Given the title of Table 42, the $43 million figure accounts only for fisheries mitigation measures. HQUSACE recommends that costs for all needed mitigation measures, including riparian and wetlands losses, be incorporated in Section 5 of the main report. Also, it is unclear whether the riparian losses discussed in Section 5 refer to the same resource as the loss of wooded areas discussed in Section 5.2.1.8 of the main report.

MVP Response: Concur. The tables and information will be updated and verified for the draft report.

Required Action: Section 5 will be updated to include all needed mitigation measures, including riparian and wetlands losses. The tables and information will be updated and verified for the draft report.

5. <u>Mitigation performance standards, monitoring and adaptive management</u>. The draft feasibility report should include mitigation performance standards, mitigation monitoring costs and duration, and an adaptive management plan, as discussed in the August 31, 2009 implementation guidance for Section 2036(a) of WRDA 2007.

MVP Response: Concur. The information required in Section 2036 will be included in the final report, this will include: Draft performance standards and monitoring plans for mitigation; costs for monitoring all mitigation areas; and adaptive management (including monitoring) to implement if original project is not effective. See response to comment F1.

Discussion: The district explained that the project will create many more acres of wetland in the bottom of the channel than the project is affecting. A question was raised -- Does the vertical team concur that it would be acceptable to use those wetland acres to mitigate for the wetland loss as long as the resource agencies concur? Before this could be answered it was explained that we need to know enough about what will be created to justify the claim that the project is self-mitigating. The discussion then focused on how to address performance standards and mitigation requirements of Section 2036. Specifically, the district will need to write performance standards into the feasibility report that can be used to verify impacts after the project is constructed. It was recommend to the district speak with the Regulatory folks about suitable standards that could be used. The district was advised to be careful in writing performance standards, because the Corps will be accountable for whatever mitigation it claims will be offered. In addition the current plan has no adaptive management included. Adaptive management needs to be part of the plan until those wetlands are successful. If it is determined the mitigation doesn't perform as intended, the adaptive management will need to be modified (this adaptive management could go beyond 5-yrs). But it was pointed out that adequate analysis need to be performed upfront and not use adaptive management as a solution.

Required Action: The district will include performance standards and monitoring plans for mitigation in the report as noted in the comment. The district will also include appropriate discussion of contingency measures and adaptive management (including monitoring) to implement if original proposed mitigation does not perform as intended.

6. <u>Consideration of mitigation banks</u>. Section 2036(c) of WRDA 2007 directs that the Secretary, where appropriate, shall first consider the use of the mitigation bank if the bank contains sufficient available credits to offset the impact and the bank is approved in accordance with the Mitigation Rule (73 Fed. Reg. April 10 2008). The November 6, 2008 implementation guidance for this section of WRDA states that the analysis and documentation of the rationale for the determination concerning the use of banks should be included in the project decision document. Also, please be advised that the mitigation bank does not have to be capable of providing all of the mitigation needed for the project in order to be eligible for consideration. The implementation guidance is available at the following link:
http://www.usace.army.mil/CECW/Documents/cecwp/leg_manage/wrda2007/sec_2036c.pdf

MVP Response: Concur. Mitigation banks will be considered and information will be included in the final report. There are currently no mitigation banks in the study area.

Required Action: The district will consider use of mitigation banks and include appropriate discussion in the final report.

7. <u>Refinement of Mitigation Plan.</u> The text indicates that the mitigation plans require refinement during PED. Page 236 indicates that the costs and features may differ from what is described in the text. It further indicates that mitigation was developed based on only existing data to assess potential impacts and no detailed studies, analyses, or modeling was performed. An appropriate level of detail is needed to evaluate the project impacts through the period of analysis and mitigation requirements should be identified based on an average annual habitat value as a basis for CE/ICA analyses. The checklist indicates on page 2 that there is no CE/ICA analysis, but it is pending. Based on the checklist guidance (page 2) an issue paper should be submitted when analyses are proposed for deferral into PED. This does not appear to be included in the AFB package and should be discussed during the AFB due to its potential for changing the costs of the various plans.

MVP Response: Concur - The mitigation portion of the report will be updated and better defined to ensure that it is policy compliant. See response to comment F.1.

Discussion: It was agreed that the mitigation analysis cannot be put off to PED.

Required Action: The mitigation portion of the report will be updated and better defined to ensure that it is policy compliant, including requirements of Section 2036 of WRDA 2007.

G. ENVIRONMENTAL AND ENVIRONMENTAL COMPLIANCE.

1. <u>Cultural resources.</u> Part 4.2.2 on pages 115-119 indicate that historically significant resources may exist in the project area. Part 5.4.2 on pages 234-235 indicate that at least one listed or eligible historic property could be affected by either the NED or LPP plans. As the report acknowledges, further information and analysis of the potential impact of the NED or LPP plans on cultural resources will need to be provided, along with an explanation of appropriate measures to be taken to assess such potential impacts and to coordinate with appropriate state officials.

MVP Response: Concur. Information on the cultural resources and how impacts will be addressed will be included in the final report.

Required Action: The district will include information on the cultural resources and how impacts will be addressed will be included in the final report

2. <u>Water Quality Effects.</u> The Environmental Quality table lists no expected water quality effects for any alternative, however the document later states (Sec 5.2.1.2.2, P. 126) that all diversion alternatives would create temporary minor adverse impacts (3.5.2.3, p 64). All possible impacts and environmental effects should be clearly identified in the AFB document as well as all pertinent agency coordination.

MVP Response: Concur. The report will be clarified to list impacts and environmental effects.

Required Action: As noted in the response.

3. Sediment Transport. Because the TSP involves significant changes to the flow regime for the Red and Sheyenne Rivers, changes to sediment movement could impact the stream habitat. The sediment transport analysis seems inadequate to support conclusions presented in the report. Please provide more detail on the sediment transport that demonstrates the TSP will maintain proper aquatic habitat.

MVP Response: Concur. The PDT is using the limited data that is available and is coordinating with the appropriate resource agencies to design the project to minimize impacts to geomorphology. Additional information was gathered during the 2010 flood event to address these concerns, but the data will not be available in time to be incorporated into the final report. Some mitigation is assumed for geomorphic impacts that will not be adequately addressed by design. Based on the available info, we do not anticipate major issues. The river systems contain mostly fines (silts and clay) the project will allow 2-yr or greater flows on the tributaries and 5-yr flows on the Red these are anticipated to be high enough so that sediment transport won't be an issue. The final report will include a qualitative analysis of bed sediment transport concerns. Adaptive management will be used to address residual concerns.

Discussion: The district explained that geomorphology is an issue the resource agencies are most concerned about regarding adaptive management. Based on the available info, the district does not think there will be major issues. Mostly fines (silts and clay). 2-yr flows on tributaries and 5-yr flow on the Red will be high enough so that sediment transport won't be an issue. The district is confident these concerns will not affect O&M of hydraulic structures and will use the new info that is currently being collected and analyzed by the USGS based on the 2010 flood event to verify assumptions. USGS data will not be available before the end of June 2010. The district will have a qualitative analysis of bed sediment transport concerns by June, but will not have a quantitative analysis until the final report submittal. Some mitigation was included on the Wild Rice River, because there is more bed load in that river. Adaptive management will be used to address residual concerns.

Required Action: The district will include qualitative data in draft report to be released to the public with quantitative data included in the final report.

4. <u>Status of environmental coordination activities and resource agency views</u>. The main report should contain a brief summary of resource agency views and environmental coordination activities, as noted in ER 1105-2-100, Exhibit G-5, item 10. Appendix Q, Public Involvement and Coordination, includes letters from several Federal and State resource agencies, as well as non-governmental environmental organizations.

MVP Response: The main report will be updated to include the information on the coordination and the information from the resource agencies. This will be much more important after we receive the formal responses from the agencies on the draft report.

Required Action: The district will include a summary of info already presented in Appendix Q into the main report.

5. <u>Environmental Compliance Status Table</u>. Table 17 on page 85 presents information on the status of project compliance with applicable statutes and laws. The status is shown as Full Compliance or N/A for each of the statutes and EOs. This is not appropriate at this stage of the study and compliance status should reflect the current status of compliance, not what is anticipated at the study completion. Please revise to show partial compliance based on the studies and coordination accomplished to date and revise the text to correct for typo errors which have shifted the statute names and status into incorrect locations. See 2.b. of Exhibit H-4 in ER 1105-2-100.

MVP Response: Concur. The information will be reviewed and updated to reflect the current status.

Required Action: As noted in the response.

6. <u>Pending Environmental Compliance.</u> As described in the Project Study Issue Checklist accompanying the District's transmittal, substantial environmental compliance remains "pending." Similarly, as indicated in part 3.9.4 on page 88 of the report, the sponsor still requires additional state or local permits. These environmental compliance and permitting requirements will need to be completed prior to final approval of the report.

MVP Response: Partially Concur. The required environmental compliance issues will be completed for the final report. However, it is not necessary to obtain permits to complete the feasibility study and report. The sponsors cannot apply for permits until there is an authorized plan and detailed plans and specifications are completed.

Required Action: The required environmental compliance issues will be completed for the final report, recognizing that the non-Federal sponsors cannot apply for permits until there is an authorized plan and detailed plans and specifications are completed.

H. LEGAL.

1. <u>District legal review</u>. CEMVP's March 26, 2010 transmittal memo states that the St. Paul Office of District Counsel has reviewed the main report and that "[n]o significant legal issues are apparent at this time." This review should be memorialized in a written certification of the report's legal sufficiency signed by the District Counsel. *See* ER 1105-2-100 para. 7.d. (requiring that "decision documents [] be reviewed throughout the study process for their compliance with law and policy") and ER 1105-2-100 Appendix H, page H-2.d.3. ("District and Division Counsel are responsible for ensuring the legal sufficiency of each decision document") ("District Counsel is responsible for the legal review of each decision document and signing a certification of legal sufficiency.").

MVP Response: Concur. A certification of legal review indicating that there are no significant issues at this time will be provided for the final report and all future submittals.

Required Action: As noted in the response.

2. <u>Reliance on future WRDA.</u> Part 3.9 on page 84 of the report states that the "schedule for project implementation assumes authorization in the proposed Water Resources Development Act of 2010." Given that an actual draft WRDA 2010 has not yet been formally proposed or moved forward in the legislative process, suggest this be revised to read "schedule for project implementation assumes authorization in a Water Resources Development Act of 2010 if enacted, or other future WRDA."

MVP Response: Concur. The report will be updated as suggested.

Required Action: As noted in the response.

3. <u>Cost sharing</u>.

a. Cost sharing calculation. The report does not make sufficiently clear how the sponsor's cost share is calculated. As reflected in the Executive Summary on pages ES-8 and ES-9, and in parts 3.9.2 and 3.9.3 on pages 87 and 88 of the report, the project includes a $523,061 Federal share, and a $590,245 non-Federal share, for a total project cost of $1,113,306. Similarly, the chart in Table 18 includes a substantial cash contribution ($426,057) toward the cost of the flood risk management features, it is not clear how this number is calculated or how the sponsor is in fact providing its required 35 percent cost share. Similarly, with regard to the recreation features, it is not clear how the sponsor's cash contribution amounts to its 50 percent cost share.

MVP Response: Concur. The report will be clarified to show how the NED plan is the driving factor in the cost sharing. The incremental costs of the LPP will be identified as 100% the responsibility of the local sponsors. Tables will be added to show the incremental difference in the plans.

Discussion: The non-Federal sponsors will be required to cost share more than 50% of the cost because they have chosen the LPP and not the NED plan. The report will need to step through the cost sharing process and show how the total Federal cost share was determined. The district expects to get sponsor's letter before July 14th stating that they agree to pay the additional project costs beyond 50% for the LPP. This letter will be in final document, but not in document out for public review.

Required Action: The report will be revised to clearly explain why the NED plan is the driving factor in the cost sharing. The incremental costs of the LPP will be identified as 100% the responsibility of the non-Federal sponsors. Appropriate tables will be added to the report show the incremental difference in the plans. Cost apportionment tables for both LPP and NED plan will also be included.

b. "Special cost sharing." Page 4 of the Project Study Issue Checklist makes reference to "special cost sharing". It is not clear from the report what this means. From the local cooperation items listed in the recommendations section of the report, traditional cost sharing appears to be contemplated. The District should clarify this statement

MVP Response: The answer to Checklist item #43 will be changed to the following: "NO. No special cost-sharing applies, per the FSM discussion." No special cost sharing is anticipated--standard cost sharing is assumed for all project items, and the non-Federal sponsor will pay 100% for all costs in excess of the NED plan.

Required Action: As noted in the response.

4. <u>Sponsor letter of intent and financial self-certification.</u> Part 3.9.5 on page 88 of the report indicates that the local sponsor supports the project and has certified its financial capability to implement the tentatively selected plan. However, the sponsor's written commitment to the project, in the form of a letter of intent and the aforementioned financial certification, do not appear to be included in the report. These items should be included to ensure that sufficient local support for the project will enable it to be implemented, as required by ER 1105-2-100, Appendix G, at G-9 ("The non-Federal sponsor's acceptance of, or desired departures from, the terms of the applicable model PCA must be presented, including: 1) applicable cost sharing and financial policies; 2) policies regarding provision and valuation of non-Federal lands, easements, rights-of-way, and disposal areas provided by non-Federal sponsors; 3) policies governing non-Federal project construction; and, 4) other provisions required by law and policy for new start construction projects.").

MVP Response: Concur. The report will be clarified. The sponsors will be providing their letter of intent and financial self certification on July $15^{th.}$ They have provided a letter requesting the LPP. This letter was submitted with the LPP waiver request.

Required Action: As noted in the response.

5. Items of Local Cooperation. The items of local cooperation included in the Recommendation, Section 8.0 include no provisions for the sponsors to pay for LPP costs in excess of the Federal cost share for the NED plan. These items appear to be the standard requirements and indicate the local share is a minimum of 35% and would not exceed 50% of the total FRM costs. Table 18 shows the FRM share as $573,124,000 out of a total FRM cost of $1,079,065,000 or 53.1%. Appropriate cost sharing requirements should be included that address the non-Federal share exceeding 50% of the project costs based on the responsibility of the sponsors to pay for the additional LPP costs for the larger plan.

MVP Response: Concur. The items of local cooperation were updated just after the draft went to print, it now includes a statement on how the locals will pay the entire increment for the LPP.

Required Action: The draft report will include appropriated provisions related to non-Federal requirements associated with recommendation of the LPP.

I. COST ESTIMATING.

1. MCACES. The MCACES cost estimate (for NED and LPP) should be included in the report as prescribed in ER 1110-2-1302 (see paragraph 8.0) and ER 1105-2-100 (see Exhibit H).

MVP Response: Concur. This information will be included in the final report.

Required Action; The district will remove Exhibits A through G in Appendix L Cost engineering and include the MCACES estimates for the NED plan and LPP in the report.

2. Cost and Schedule Risk Assessment (CSRA). The information presented in paragraph L13.0 describes the CSRA process and procedures for the development of contingency. However, it is not very clear who participated in the meetings. Also, it is not evident the CSRA results have been reviewed and approved. The requirement for cost risk analysis is prescribed ER 1110-2-1302 (see paragraph 20) and ETL-1110-2-573 (see Appendix G).

MVP Response: Concur. The CSRA will be included in the cost appendix in the August report. The report will be updated to include information on who participated. The participants were the local sponsors, Corps PDT members, AE team members, and a member of the Cost Engineering DX in Walla Walla District. Walla Walla will be completing a second CSRA based on the final costs of the NED and LPP plans, this will be included in the final report.

Discussion: The district explained that Walla Walla Cost DX assisted us with the CSRA and that the final CSRA will be included final report.

Required Action: The district will include the CSRA in the cost appendix in the final report.

3. Total Project Cost Summary (TPCS). A TPCS should be submitted as prescribed in ER 1110-2-1302. Guidance for preparing a TPCS is described in ETL 1110-2-573.

MVP Response: Concur. The TPCS will be provided as prescribed; all costs in the feasibility report will be to the October 2009 price level.

Required Action: Project cost for the NED plan and LPP in the final feasibility report should be in October 2009 price level.

4. Executive Summary TPCS. The Total Project Cost for the recommended plan stated in the Executive Summary (ES) is not consistent with the cost stated in the Project Cost Summary Sheet (PCSS) in Appendix L. The ES shows $1,113,307,000 based on October 2009 price level. However, the PCSS shows $1,113,726,000 based on December 2009 price level. Also, Table 2 in the ES shows $1,113,306,000.

MVP Response: Concur. The numbers in the report will be checked for consistency.

Required Action: As noted in the response.

5. Inconsistent Cost Data. Table 8 of the main report has an anomaly regarding the costs for levees and floodwalls for the various MN Short Alignment alternatives. Although

Table 7 shows each alternative to have a 9.9 mile long tie-back levee with a height of 8 feet, the costs in Table 8 for the 20K, 25K, 30K, and 35K plans are shown as 13,561, 12,682, 14,992, and 12,682 for the plans, respectively. It is unclear why plan costs would vary in that manner, based on the description in Table 7 and whether this could potentially impact formulation when considered with other comments. Clarification is needed to assure costs are accurately estimated as a basis for alternative comparisons.

MVP Response: Concur. The numbers will be reviewed and corrected, and any oddities that are correct will be explained in the text.

Required Action: As noted in the response.

6. Excavation Costs. Comparison of information shown in Tables 7 and 8 shows that the ND plans have significantly higher costs for channels and canals in comparison to the MN plans. For example the ND 30K plan has costs of $620,367,000 versus $524,576,000 for MN35K despite the fact that the MN plan involves an additional 1mcy of excavation (55 vs. 54 mcy). It isn't apparent why the costs should vary so significantly between the two alignments- the ND plan costs about $95,000,000 more to excavate 1mcy less material. Is this a function of the river crossings and drop structures required for the ND plans? Please explain.

MVP Response: The information will be checked for accuracy.

Discussion: Concern was raised concerning suitability of excavated material to be used to construct levees. The district explained that there is such a massive quantity of material that is being excavated in order to construct the diversion channel that they are not very concerned about material qualities. The built up on the banks of the diversion channel are more for disposal than for the levees. However, for the LPP levees will be required. The MN side doesn't need levees in middle reaches. The upstream and downstream ends for the MN do need levees for the 500-yr level of protection.

Required Action: As noted in the response.

7. Fully Funded Estimate. Table 19 on page 88 shows the schedule of funding for the LPP from FY11 through FY19. The first line for Federal E&D costs shows all funding occurring between FY 11 and FY14, with no funding scheduled between FY15 and FY19 where the majority of construction is taking place. This raises a question as to whether the

E&D shown is fully accounting for the engineering during construction requirements versus Preconstruction Engineering and Design. Please clarify to assure the appropriate E&D costs are included in the fully funded project cost and planning.

MVP Response: Concur. The E&D was assumed to be for the entire design effort, however this will be modified based on the comment and spread out over the entire project implementation period.

Discussion: It was clarified that some additional material for concrete structures and rip rap, but all other material will come from excavation of the channel

Required Action: As noted in the response E&D costs will be spread out over the entire project implementation period.

8. <u>Cost Apportionment.</u> Table 18 on page 87 shows the cost apportionment for the LPP (ND35K plan). Values are missing or shown as zero in the total column for two entries (Planning Engineering & Design, Fish and Wildlife Facilities) that need to be corrected. The subtotal for flood risk management should show FRM rather than FDR, consistent with the heading. In addition, the report will need to clearly explain the cost sharing for the NED plan as a basis for comparison to show that the LPP is being cost shared appropriately.

MVP Response: Concur. The information will be reviewed and corrected.

Required Action: As noted in the response.

J. REAL ESTATE.

1. Is it assumed that all spoil material from the channel excavation will be used in the project area and that no disposal areas will be required? Will there be any additional material needs such as Borrow Material? If so then this must be addressed.

MVP Response: Concur. The spoil will all be in the project area and no borrow is anticipated. Aggregate for concrete structures and riprap will be needed.

Required Action: The REP will address use of spoil material from the channel and need of borrow material.

2. Does the Fee Estate include any Mineral Restrictions?

MVP Response: No mineral restrictions are needed.

Required Action: The REP will address no mineral restrictions are needed

3. The REP states that there are previous Federal Project lands in the area. Recommend that these lands be placed on future mappings to insure their placement.

MVP Response: Concur. The information will be added for the draft report.

Required Action: As noted in the response.

4. The current acquisition schedule in paragraph 16 shows a total of 87 months from the time that the PCA is signed until the Real Estate is made available. If there is indication of phasing the construction for this project, then a brief sentence stating such should be included.

MVP Response: Concur. A detailed construction schedule is being developed that will have phasing, this will be completed for the final report (submitted in August).

Required Action: As noted in the response.

5. The estimate of project costs in the Tentatively Selected Plan Table 16 in the Draft Feasibility Report do not match the Real Estate Plan totals in the REP listed on page 10.

MVP Response: Concur. The costs will be corrected.

Required Action: As noted in the response.

6. The REP paragraph 12 mentions relocations that have not been fully determined. There is a relocations figure in the feasibility report in Table 16 that has a figure. Where did this figure come from?

MVP Response: Concur. The utility relocation information should be very good in the report and was determined by identifying each of the impacted utilities. Information is still being developed on business and real estate relocations and this will be included in the final report.

Discussion: The district explained that it does not have a clear idea of business and real estate relocations at this time and it will be able to refine this as more information is available.

Required Action: Information on business and real estate relocations will be included in the final report.

7. The REP does not have a Sponsor Capability Checklist attached.

MVP Response: Concur. The checklist will be included in the final report once the official non-federal sponsor has been identified.

Required Action: As noted in the response.

K. MISCELLANEOUS.

1. The Table of Contents should be updated to correspond to the pages of the main report where the topics are discussed. For example, the Recommendations section is found on page 251, not 243; the Environmental Consequences are found on page 125, not 121.

MVP Response: Concur. The TOC will be updated. We had some issues with the auto formatting which have been corrected.

Required Action: As noted in the response.

2. On page ES-3, text is missing some words in the last sentence of paragraph 4 concerning the 6,560 acres. It is not clear what is intended as written- appears to be the surface area needs for the project features as explained on page 187.

MVP Response: Concur. The text will be corrected.

Required Action: As noted in the response.

3. On page 27 the text shown as bold heading, “Figure 8 through” should be converted to text as the start of the paragraph in future versions.

MVP Response: Concur. The text will be corrected.

Required Action: As noted in the response.

4. Page 76, second paragraph- The first cost of the LPP is missing three zeros, and should read as $1,113,307,000.

MVP Response: Concur. Three zeros are pretty significant! The information will be corrected.

Required Action: As noted in the response.

5. Table 14 on page 71 shows the net benefits of the No Action Plan as -$77,100,000, the EAAD. This doesn't make sense as there are no benefits or costs to that alternative. The table should be revised to show to show zero net benefits and $77,100,000 as the residual damages for the No Action plan.

MVP Response: Concur. The information will be corrected.

Required Action: As noted in the response.

6. Reference is made to the Rush River and Lower Rush River however figures generally show Rush River for both locations. Please label appropriately for clarity.

MVP Response: Concur. The figure labels will be corrected.

Required Action: As noted in the response.

7. Numerous sections of the AFB document reference geographic locations, project features, and other sites but do not support such references with maps. In addition, some of the maps are not legible due to the quality of reproduction, scale and detail, or lack of notations. The quantity and quality of the illustrations should be reviewed for quality control. Clear delineations of project boundaries and state/municipal boundaries should also be provided. For the draft and final report consideration should be given to use of fold out pages to increase the size and readability.

MVP Response: Concur. Maps and other information will be reproduced in larger forms when possible, and maps will be updated. It is challenging with such a large project area.

Required Action: As noted in the response.

8. Content Ratio. Economic Appendix (C-15) states that the content damage functions are based on a content-to-structure value ratio of 100%. This is not correct. The content damages are a function of structure value without any implied valuation of content value. In order to use these damage curves with the flood damage analysis package, you need to set content value to 100% of structure value to get the software to correctly use the content damage curves.

MVP Response: Concur. This information will be reviewed and corrected.

Required Action: As noted in the response.

ATTACHMENT 1
AFB ATTENDEES

Attendees (In Person)

Name	Affiliation	Name	Affiliation
Elizabeth Killian	USACE-MVP	Kevin Bluhm	USACE-MVP
Tom Crump	USACE- Regional Planning Div. North	Jeff DeZellar	USACE-MVP
Susan Smith	USACE-MVD	Jeff Hansen	USACE-MVP
Tom Hughes	USACE-HQ	Lance Awsumb	USACE-MVP
Larry Kilgo	USACE-MVD	David Kollars	USACE-MVP
Edith Pang	USACE-MVP	Tony Fares	USACE-MVP
Chanel Kass	USACE-MVP	Jim Merritt	CECC-MV
Mike Lesher	USACE-MVP	Joe Willging	MVP-OC
Renee Turner	USACE-MVD U-5	Buddy Torrey	CEMVD-PD-SP
Rayford Wilbanks	USACE-MVD	Elliott Stefanik	CEMVD-PD-E
John Lucyshyn	USACE-RIT	Jeff McGrath	CEMVP-PD-F
Zoltan Montvai	USACE-MVD-RIT	Mark Nelson	CEMVP-RE
Craig Evans	USACE-MVP-PD-F	Alex Nelson	MVP-EC-H
Tom Koopmeiners	USACE-MVP	Kurt Heckendorf	CEMVP-EC-D
Jodi Kormanik-Sonterre	USACE-MVD	Mark Bittner	City of Fargo
Frankie Griggs	USACE-MVD	Cliff Fitzsimmons	OASA(CW)
Eric Wittine	USACE-MVP	Katie Young	CEMVP-PD-F
Chris Fassero	USACE- Omaha	Aaron Snyder	USACE-MVP-PM-A
Jon Sobiech	USACE- MVP		
April Walker	City of Fargo		

Participants By VTC

Name	Affiliation
Bob Zimmerman	City of Moorhead
Jody Bertrand	City of Moorhead
Lee Beauvais	Moore Engineering
Gregg Thielman	Houston Engineering

Particpants by Phone

Name	Affiliation
Lee Ware	USACE-OWPR
Mark Matusiak	USACE-OWPR
Miguel Jumilla	USACE-OWPR
Stuart McClean	HQUSACE
Steven Fischer	PA from NWK
Roger Perk	USACE-MVR
Kelly Baerwaldt	PA from MVR
Julie Watkins	PA from SAM
Durund Elzey	PA from MVN
Steve Fischer	PA from NWK
Charissa Kelly	PA from SWF
Melissa Montag	PA from SPK
Ray Wimbrough	PA from SAJ
Joy Muncy	IWR
David Schulenberg	PA from LRB

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APPENDIX O
ATTACHMENT 4

Alternatives Screening Document

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Alternatives Screening Document
Fargo-Moorhead Metropolitan Area Flood Risk Management

Prepared by:
U.S. Army Corps of Engineers
St. Paul District
190 Fifth Street East, Suite 401
St. Paul, Minnesota 55101-1638

December 2009

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Fargo-Moorhead Metropolitan Area
Flood Risk Management
ALTERNATIVES SCREENING DOCUMENT

December 2009

Prepared by:

U.S. Army Corps of Engineers
St. Paul District
190 Fifth Street East, Suite 401
St. Paul, Minnesota 55101-1638

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1.0 INTRODUCTION

1.1 PURPOSE AND AUTHORITY

This Alternatives Screening Document was prepared to document the results of the screening process for the initial array of alternatives and to identify the alternatives that will be considered in greater detail. The initial array of alternatives being considered was developed as part of the National Environmental Policy Act (NEPA) scoping process as presented in the document titled *Scoping Document Fargo-Moorhead Metropolitan Area Flood Risk Management Environmental Impact Statement* dated September 2009 and prepared by the U.S. Army Corps of Engineers.

The Fargo-Moorhead Metropolitan Area is located in the Red River of the North basin. This study is authorized by a September 30, 1974, Resolution of the Senate Committee on Public Works.

A Reconnaissance Report for the Fargo-Moorhead Metropolitan Area was approved by the Corps' Mississippi Valley Division on April 8, 2008. Based on the recommendations contained in the Reconnaissance Report, the City of Fargo North Dakota; the City of Moorhead Minnesota, and the Federal Government entered into a Feasibility Cost Share Agreement on September 22, 2008. The feasibility study is cost shared 50/50 between the two non-Federal sponsors and the Federal Government. Funds to initiate the feasibility study were provided in the Consolidated Appropriations Act, 2008, approved December 26, 2007 (Public Law 110-161).

The study will produce a decision document in the form of a feasibility report and associated NEPA document in accordance with the Corps' Planning Guidance Notebook, ER 1105-2-100, and the Project Management Plan. The feasibility study will investigate measures to reduce flood risk and analyze the potential for Federal participation in implementing a flood damage reduction project in the Fargo-Moorhead Metropolitan Area.

The feasibility study will focus on reducing flood risk in the entire Fargo-Moorhead Metropolitan Area.

The Corps of Engineers issued a Notice of Intent in the Federal Register on May 5, 2009.

1.2 PROJECT BACKGROUND

The Fargo-Moorhead Metropolitan Area has a relatively high risk of flooding. The highest river stages usually occur as a result of spring snowmelt, but summer rainfall events have also caused significant flood damages. The Red River of the North has exceeded the National Weather Service flood stage of 18 feet in 50 of the past 107 years, and every year from 1993 through 2009. The study area is between the Wild Rice River (North Dakota), the Sheyenne River, and the Red River of the North; interbasin flows complicate the hydrology of the region and contribute to extensive flooding. Average annual flood damages in the Fargo-Moorhead Metropolitan Area are currently estimated at over $74 million.

Fargo and Moorhead have become accustomed to dealing with flooding. Sufficient time is usually available to prepare for flood fighting because winter snowfall can be monitored to predict unusual spring runoff. Both communities have well documented standard operating procedures for flood fights. Both communities avoided major flood damages in the historic floods of 2009 and 1997 by either raising existing levees or building temporary barriers. Since the 1997 flood, and in the aftermath of the 2009 flood, both communities have implemented mitigation measures, including acquisition of more than 100 floodplain homes, raising and stabilizing existing levees, installing permanent pump stations, and improving storm sewer lift stations and the sanitary sewer system. 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. Failure of emergency measures would be catastrophic and could result in billions of dollars in damages.

1.3 PURPOSE, NEED AND PLANNING OBJECTIVES

1.3.1 Purpose and Need

The purpose of the proposed action is to reduce flood risk, flood damages and flood protection costs related to the flooding in the Fargo-Moorhead Metropolitan Area.

1.3.2 Objectives

- Reduce flood risk and flood damages in the Fargo-Moorhead Metropolitan Area.
- Restore or improve degraded riverine and riparian habitat in and along the Red River of the North, Wild Rice River (North Dakota), Sheyenne River (North Dakota), and Buffalo River (Minnesota) in conjunction with other project features.
- Provide additional wetland habitat in conjunction with other project features.
- Provide recreational opportunities in conjunction with other project features.

1.4 PRIOR STUDIES, REPORTS, AND PROJECTS

1.4.1 Reports

Since the 1940s, the Corps of Engineers and others have prepared numerous reports on the Red River of the North basin. The following reports contain the most relevant information for the current effort:

1.4.1.1. House Document 185, 81st Congress, 1st Session, dated May 24, 1948. This report proposed a comprehensive plan for the Red River of the North basin. The plan included channel improvements, levees and floodwalls in Fargo and Moorhead. Other components of the plan included the Orwell Reservoir on the Otter Tail River in Minnesota; channel improvements on the lower Sheyenne, Maple and Rush Rivers in North Dakota; channel improvements on the Mustinka, Otter Tail, Wild Rice, Marsh and Sand Hill Rivers in Minnesota; channel improvements along the Bois de Sioux and upper Red Rivers near Wahpeton, North Dakota/Breckenridge, Minnesota; and local flood protection works on the Red River in Grand Forks, North Dakota/East Grand Forks, Minnesota. The study found that channel improvements along the lower 31.6 miles of the Wild Rice River in North Dakota were economically justified, but the majority of affected local interests did not support the project, so it was not recommended. The report specifically recommended no further investigations in the Buffalo River basin and several other basins in Minnesota.

1.4.1.2. Section 205, Flood Control Reconnaissance Report, Red River of the North at Fargo, North Dakota, Corps of Engineers, May 1967. This study evaluated the potential to build a portion of the levee in Fargo that had been approved as part of the 1948 comprehensive plan but was later omitted from the constructed project. The study concluded that the proposed project was not economically feasible and did not warrant further Federal involvement at that time.

1.4.1.3. Fargo-Moorhead Urban Study, Corps of Engineers, May 1985. This study was a cooperative Federal, State and local planning effort aimed at developing viable solutions to water and related land resource problems, needs and concerns for 1980 to 2030. The study area encompassed 13 townships in Cass County, North Dakota, and Clay County, Minnesota. The study addressed water supply, water conservation, flood risk management, energy conservation and water resources data management. The study evaluated the potential to construct levees, floodwalls and channel modifications in Fargo and Moorhead. The report concluded that extremely long levees or floodwalls would be required to ring the urban areas to provide adequate protection from larger floods, and the costs would greatly exceed the damages prevented. Therefore, Federal participation in Fargo and Moorhead flood risk management projects was not recommended. However, the report did support further studies for flood control in Harwood and Rivertree Park, North Dakota.

1.4.1.4. "Living with the Red," International Joint Commission, November 2000. In June 1997, following record-setting flooding on the Red River of the North, the governments of Canada and the United States asked the International Joint Commission (IJC) to examine and report on the causes and effects of damaging floods in the Red River basin and to make recommendations on means to reduce, mitigate and prevent harm from future flooding. The IJC established the International Red River Basin Task Force to undertake the necessary studies. The task force produced its report in April 2000. The IJC's report, entitled "Living with the Red," was completed in November 2000. These reports included discussion of the flooding in the Fargo-Moorhead area. The report cited hydraulic and hydrologic analyses conducted after the 1997 flood that indicated flood risks in the Fargo-Moorhead area likely were greater than previously thought. The report supported a basin-wide flood mitigation approach including reduction in flows, strengthening of existing protection structures, and use of other techniques. The report recommended that Federal, State and local governments should "expedite the study of flood risk potential and implement plans for flood protection measures for the Fargo-Moorhead area."

1.4.1.5. Reconnaissance Study, Red River Basin, Minnesota, North Dakota, South Dakota, Corps of Engineers, September 2001. This study, supported by supplemental information, was approved in October 2002. The study recommended three initial feasibility studies to be followed by additional studies throughout the basin. Only the initial three studies were approved in 2002. The additional proposed studies would be considered for approval on the basis of additional 905(b) analyses. The Fargo-Moorhead and Upstream feasibility study, currently underway, was one of the initial studies recommended and approved in the reconnaissance study.

1.4.1.6. Final Environmental Impact Statement (FEIS) for the Red River Valley Water Supply Project, U.S. Department of the Interior, Bureau of Reclamation, December 21, 2007. The purpose of the proposed project is to meet the comprehensive water quality and quantity needs of the Red River Valley through the year 2050. The needs were identified as municipal, rural and industrial water; water quality; aquatic environment; recreation; and water conservation measures. The preferred alternative would import water to the Red River basin from the Missouri River via the Garrison Diversion and the Sheyenne River.

1.4.1.7. Fargo-Moorhead Downtown Framework Plan Update, Fargo-Moorhead Council of Governments, City of Fargo, and City of Moorhead, June 2007. This report builds upon earlier planning efforts in both Fargo and Moorhead. Many of the concepts presented depend on implementation of effective flood risk management strategies.

1.4.1.8. Scoping Document, Fargo-Moorhead Metropolitan Area Flood Risk Management Environmental Impact Statement, Corps of Engineers, September 2009. This document lays out the alternatives that will be considered as part of the Fargo-Moorhead Metropolitan Feasibility Study. The alternatives were determined from meetings with Federal, State, and local agencies and other entities; four public meetings; a scoping meeting; and written comments provided by agencies, organizations, and the interested public.

1.4.2. Current Studies

The following studies are being conducted:

1.4.2.1. Fargo-Moorhead and Upstream Feasibility Study, Corps of Engineers. The study began in August 2004. The study area is the entire headwaters of the Red River of the North upstream (south) of the Fargo-Moorhead Metropolitan Area. The major tributaries are the Mustinka, Bois de Sioux, and Otter Tail Rivers in Minnesota and the Wild Rice River in North Dakota. The study is evaluating alternatives that would restore wetland habitat and reduce flood damages. The major underlying assumption is that a system of surface water storage sites upstream of Fargo-Moorhead would reduce flood stages and flood damages downstream. It is also assumed that water storage could be accomplished in ways that would restore aquatic ecosystems and increase habitat for wildlife. Phase 1 analyses, completed in June 2005, showed that distributed flood storage could provide significant economic benefits, but additional study of environmental benefits is needed to justify a Federal project. The North Dakota State Water Commission and the city of Moorhead are jointly sponsoring the study. Additional cost-share partners include the Southeast Cass Water Resource District; Richland County Water Resource District; Red River Joint Water Resource District; city of Fargo; Buffalo-Red River Watershed District; Bois de Sioux Watershed District; Minnesota Department of Natural Resources; Minnesota Board of Water and Soil Resources; Minnesota Pollution Control Agency; South Dakota Department of Game, Fish, and Parks; and Red River Basin Commission.

1.4.2.2. Fargo Southside Flood Control Project, City of Fargo, North Dakota. Since the 1997 flood, the City of Fargo and the Southeast Cass County Water Resource District have been planning for a flood risk management project to protect developments in the area south of Fargo and north and west of the Wild Rice River up to 4 miles south of its confluence with the Red River. Several alternatives have been explored, including combinations of levees, diversion channels, channel modifications, and flood storage. The study is currently on hold pending completion of the Fargo-Moorhead Metropolitan Area Flood Risk Management study.

1.4.2.3. Oakport Township, Minnesota. The Buffalo-Red River Watershed District is working on a flood risk management reduction project for Oakport Township. The project would be designed to protect areas of town to a level equal to the 2009 flood plus 3 feet. The project includes two ring levees on either side of Oakport Coulee. The project would also include buying some homes that cannot be protected by the levee system. A Corps of Engineers study performed under the Section 205 Continuing Authorities Program was terminated in December 2002 after it was determined that national economic benefits were insufficient to support further Federal efforts.

1.4.2.4. Flood Insurance Study Update, Federal Emergency Management Agency (FEMA). FEMA is updating the flood insurance maps for the Fargo-Moorhead area. As a result of recent flood events and revised hydrologic and hydraulic modeling, FEMA is likely to increase the 1-percent-chance flood elevation on the order of 1 foot above the current administratively determined elevation.

1.4.3 Existing Water Resource Projects

1.4.3.1. The Lake Traverse project, including White Rock Dam and Reservation Dam, provides flood storage at the headwaters of the Bois de Sioux and Red River of the North. The project was authorized by the 1936 Flood Control Act, and construction was completed in 1948. The project is operated by the St. Paul District, Corps of Engineers.

1.4.3.2. Baldhill Dam and Lake Ashtabula provide water storage for flood control and water supply on the Sheyenne River. The project was authorized by the 1944 Flood Control Act, and construction was originally completed in 1951. The dam was modified in 2004 to raise the flood control pool by 5 feet. (The pool raise was part of the Sheyenne River project.)

1.4.3.3. The Orwell Dam provides water storage for flood control and water supply on the Otter Tail River. The dam was included in the Corps' 1947 comprehensive plan for the Red River basin and authorized by the Flood Control Acts of 1948 and 1950. Construction of the dam was completed in 1953; it provides 8,600 acre-feet of storage.

1.4.3.4. Fargo levees: The Corps participated in a permanent flood control project completed in Fargo in 1963. The project was recommended in the Corps' 1947 comprehensive plan for the Red River basin and authorized by the Flood Control Acts of 1948 and 1950. The project included four channel cutoffs, the Midtown Dam, and a 3,500-foot levee east of 4th Street South between 1st Avenue South and 10th Avenue South. The top of levee is at approximately a 40.0-foot stage. The city later extended the levee south to 13th Avenue. Fargo has several other publicly and privately owned sections of levee throughout the city. The current line of protection has top elevations that vary from a stage of 30 feet to 42 feet, but several reaches are at or below 37 feet. (Note: the proposed new FEMA 1-percent-chance flood stage is expected to be approximately 39.3 feet.)

1.4.3.5. Moorhead levees: No federally constructed levees are in Moorhead. The Corps proposed an 1,800-foot-long levee in the 1947 comprehensive plan for the Red River basin. It was authorized by the Flood Control Acts of 1948 and 1950, but the city declined to participate in the project. The city has built four small levees and several lift stations and control structures on storm water lines that can be closed or operated during high-water events. The city has also installed valves on the sanitary sewer lines at several individual flood-prone residences to prevent floodwater from inundating the system. The city also builds emergency levees when necessary.

1.4.3.6. The Sheyenne River project was authorized by the 1986 Water Resources Development Act. The project originally included four components: a 5-foot raise of the Baldhill Dam flood control pool; a dam to provide approximately 35,000 acre-feet of storage on the Maple River; a 7.5-mile flood diversion channel from Horace to West Fargo, North Dakota; and a 6.7-mile flood diversion channel at West Fargo. The Southeast Cass Water Resource District and the St. Paul District, Corps of Engineers, signed cost share agreements for the West Fargo Diversion project in 1988 and the Horace to West Fargo Diversion in 1990. The projects were essentially completed in 1993 and 1994, respectively. A pump station was added to the West Fargo project in 2003 and emergency generators were provided in 2007. The Maple River dam was deauthorized in 2002 for Federal participation, and the Southeast Cass Water Resource District completed the project without Federal assistance in 2007. These projects protect the cities of Horace and West Fargo and the west side of Fargo from Sheyenne River flooding. From Horace to West Fargo, the system is designed for a 1-percent-chance event plus 2 feet. At West Fargo, the channel and left bank levee contain the 1-percent-chance event plus 2 feet; the right bank levee is higher, providing the city with protection from the Standard Project Flood plus 3 feet. Although these features reduce the risk associated with Sheyenne River flooding, these cities are still potentially affected by floods on the Wild Rice and Red Rivers that are larger than the 1-percent chance event.

1.4.3.7. A Section 208 (1954 Flood Control Act) clearing and snagging project was completed in Fargo-Moorhead in 1991 to remove trees affected by Dutch elm disease. Dead and dying trees were removed along a 9.7-mile reach of the Red River.

1.4.3.8. Three Section 14 (1946 Flood Control Act) emergency streambank protection projects were completed in Fargo between 2001 and 2003. Erosion from the Red River of the North occurred at three separate project locations. At Reach A, erosion along 4,100 feet of riverbank threatened a levee near 37th Avenue. At Reach B, erosion along a 950-foot reach threatened Kandi Lane and North Broadway and utilities located beneath them. At Reach C, erosion along a 1,900-foot reach threatened Elm Street between 13th and 17th Avenues North and the utilities located beneath it. The erosion progressed to within 50 feet of the roadway. The projects involved shaping the banks and placing rockfill or granular fill and riprap along the eroded areas.

1.4.3.9. Two Section 206 (1996 Water Resource Development Act) aquatic ecosystem restoration projects were implemented to improve fish passage over two dams on the Red River within the metropolitan area. Rock slope fishways were constructed at the 12th Avenue North Dam and the 32nd Avenue South Dam in 2002 and 2004, respectively. A similar fishway was constructed at the Midtown Dam in 1998 without Corps construction assistance.

1.4.3.10. A Section 205 (1948 Flood Control Act) small flood control project is under construction for Fargo's Ridgewood neighborhood. The project will tie into a recently reconstructed floodwall at the Department of Veterans Affairs hospital.

1.5 DEVELOPMENT AND SCREENING OF ALTERNATIVES

The initial development and screening of alternatives relied on existing information, the detailed development of new information, hydrology from Phase I of the feasibility study, expert judgment, and public input, along with prior reports, studies, and projects that were conducted in the Red River basin. There may be changes to some technical information presented in this Screening Document those changes will be incorporated into the final feasibility report and are not expected to change the results of the initial screening. The potential effects and issues identified for each of the alternatives were derived from those sources.

1.6 ALTERNATIVE DEVELOPMENT

Several alternatives have been identified for consideration in evaluating future possible actions in the Fargo-Moorhead Metropolitan Area. Input provided at public meetings and directly from stakeholders provided a wide array of initial alternatives that were considered. The alternatives identified initially for evaluation were:

No Action: Continue emergency measures

Nonstructural measures
- Buy and relocate flood-prone structures
- Flood proofing
- Elevate structures
- Flood warning systems
- Flood insurance
- Wetlands

Grasslands

Flood barriers
- Levees
- Floodwalls
- Invisible floodwalls
- Gate closures
- Pump stations

Increase conveyance
- Diversion channels around the study area
  - In Minnesota
  - In North Dakota
- Increase conveyance in Oakport Coulee
- Cutoff channels (to short-cut existing meanders)
- Flattening the slopes on riverbank
- Replacing bridges
- Underground tunnels
- Interstate 29 viaduct
- Dredge river deeper and wider

Flood storage
- Large dams upstream
- Distributed storage
- Controlled field runoff
- Storage ponds, also used for water conservation
- Pay landowners for water retention

1.7 ALTERNATIVE SCREENING CRITERIA

Screening criteria were developed to focus evaluation and design efforts on the most implementable alternatives. The following criteria were used to assess the overall characteristics of each alternative to identify those alternatives most likely to meet the project purpose and objectives.

Effectiveness: Whether the alternative would be effective in maintaining an acceptable level of flood risk management for the Fargo-Moorhead Metropolitan Area.

Environmental Effects: Direct and indirect effects of natural resources and cultural resources. Direct effects are those effects associated with the construction. Indirect effects are those effects that occur as a result of changed environmental conditions resulting from the construction or operation of the project.

Social Effects: Direct and indirect effects on socio-economic resources such as transportation, regional growth, public safety, employment, recreation, public facilities, and public services.

Acceptability: Controversy and potential effects on community cohesion and compliance with policy are indicators of acceptability.

Implementability: Whether there are significant outstanding technical, social, legal or institutional issues that affect the ability to implement the alternative.

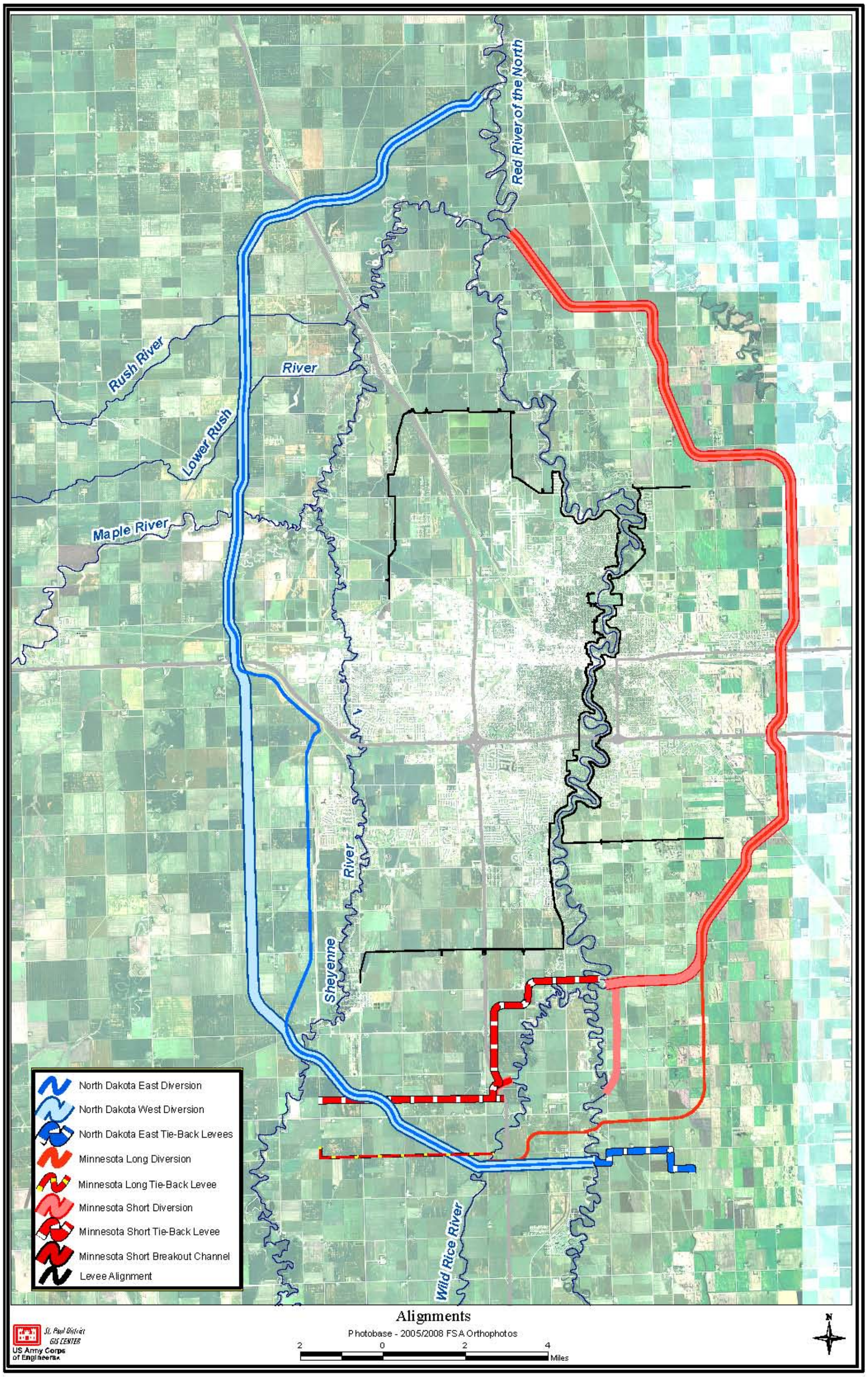
Cost: The first cost of the project, costs of local operations and maintenance, and long-term residual costs.

Risk: The uncertainties, vulnerabilities, and potential consequences of the alternative.

Separable Mitigation: Whether there is a need for mitigation resulting from the project's implementation to address environmental, hydraulic or other impacts. Is mitigation possible, what does it cost, and how does it impact the project cost?

Cost Effectiveness: Comparison of expected economic benefits and estimated costs for each alternative and between alternatives.

Figure 1: Fargo-Moorhead Metropolitan Feasibility Study Area and Screening Alignments



2.0 SCREENING RESULTS

2.1 FUTURE WITHOUT PROJECT CONDITION (NO ACTION)

2.1.1 Alternative Description

This alternative assumes no Federal project is implemented, but the types of emergency measures currently employed in the project area would continue to be implemented as necessary due to flooding. These emergency measures include such actions as temporarily raising existing levees to protect the cities of Fargo and Moorhead as well as surrounding cities, constructing temporary levees and floodwalls in various areas, and sandbagging. During the 2009 flood, more than 80 miles of temporary measures were built in less than two weeks, including the placement of more than three million sandbags by thousands of volunteers. The local governments would continue to implement local measures to assist with future flood fights, this includes construction of small segments of levees and floodwalls and continued buyouts of flood prone structures. If no alternatives were determined to be feasible for federal implementation the local sponsors would pursue larger scale flood risk management solutions such as the Southside flood control project or upstream storage which has been studied by the local sponsors. The measures identified with this alternative are the base condition to which other alternatives are to be compared for impact assessment under NEPA.

2.1.2 Effectiveness

This alternative does not provide consistent reliable long-term flood risk management especially during high flow events. The emergency measures are only temporary and are only beneficial for one-time events; following those events these measures are removed. Emergency measures demand extremely high numbers of temporary untrained workers in extreme weather conditions, resulting in varying quality of the constructed measures. Although heroic emergency measures saved the city from destruction in both 1997 and 2009, this approach cannot be expected to provide effective long-term risk reduction for the area. The effectiveness of this alternative is low.

2.1.3 Environmental Effects

This alternative would have moderate negative impacts.

2.1.3.1 Natural Resources

The emergency levees used for flood fights are very susceptible to erosion; as a result more sediment is distributed in the Red River and other tributaries. Terrestrial vegetation, including trees shrubs and herbaceous plants, is adversely impacted by the placement of the levees. Excavation at the borrow sites also has adverse impacts. Overall the effects on natural resources would be negative.

2.1.3.2 Cultural Resources

Much of the project area has not been surveyed for cultural resources. However, existing information indicates that there is potential for effects on unknown cultural resources along the Red River and tributaries. Excavating borrow material, building temporary levees/floodwalls, removing temporary levees/floodwalls all have the potential to have adverse effects on cultural resources. Failure of the temporary levees/floodwalls would also have adverse impacts to cultural properties/resources. Overall the effects on cultural resources would be negative.

2.1.4 Social Effects

Flood-fighting causes extreme impacts to the community. Businesses shut down, transportation routes including emergency routes are affected, and recreational facilities are negatively impacted. During flood events all focus is on the emergency protection which results in a lack of public services during those events. Over the long term, the flood risk makes the community less attractive for businesses than less flood-prone areas. Failure of emergency measures during a large flood would mean loss of nearly the entire community, loss of community cohesion, decreased public safety, and potential loss of life. The alternative would have highly negative social effects.

2.1.5 Acceptability

This alternative is not an acceptable long-term solution for the sponsors or the nation. Although flood-fighting has been largely successful in the past, continued reliance on flood fighting would eventually have adverse effects on the local community and the region. The sponsors have indicated that a level of permanent protection in excess of the 100-year event is necessary for local acceptability. The alternative has a low level of acceptability.

2.1.6 Implementability

This alternative represents the base condition that would be implemented in the absence of a Federal project. Legal and technical issues complicate implementation of emergency measures. Obtaining rights-of-entry on short notice is difficult and controversial. The maximum level of protection is limited to the highest natural ground available to begin and end emergency barriers. The time available to implement the emergency measures varies during each event; in 2009 the communities had one week to construct more than 80 miles of emergency levees. This alternative was successfully implemented in both 1997 and 2009. The alternative is moderately implementable.

2.1.7 Cost

A 500-year flood event could exceed $6 billion in damages to the community. Average annual damages from all flood events has been calculated to be in excess of $74 million. Emergency flood fighting in 2009 cost an estimated $60 million. This alternative has extremely high costs.

2.1.8 Risk

The probability is extremely high that the community would continue to be at risk of flooding from both spring run-off and summer rainfall events. The effectiveness of emergency measures is very poor. Emergency measures in the Fargo-Moorhead area are typically constructed by volunteers working in adverse weather conditions with temperatures below freezing. Frozen sandbags and materials placed on frozen ground cannot be adequately compacted to eliminate voids. Because of the large extent of emergency levees needed, it is difficult to mobilize manpower to the correct locations to ensure a successful flood fight. People who remain in flood-prone areas to build temporary measures are at high risk if those measures fail unexpectedly. In 2009 only small portions of the community evacuated if the emergency measures would have failed the community would have been filled with very cold water and there would have been a large potential for hypothermia and loss of life. Emergency levees block roads adversely impacting the public’s ability to move and evacuate during a catastrophe. This alternative has extremely high risk.

2.1.9 Separable Mitigation

Repair of damaged properties following flood event is necessary. The costs for removal and repair are large. This includes repair and replacement of material (borrow) used in the construction of the emergency measures which typically comes from nearby agricultural fields and sports fields. The 2009 flood required repair and cleaning of many roads within the community. This alternative has a high level of separable mitigation.

2.1.10 Cost Effectiveness

Emergency measures are cost effective, because they prevent damages far in excess of their cost when they are successful. Over the long-term these measures would not be cost effective as failures would result in large damages to the communities. This alternative is moderately cost effective.

2.1.11 Recommendation

The future without project (no action) alternative should be retained as the base condition for comparison with all other alternatives.

2.2 FLOOD BARRIERS

2.2.1 Alternative Description

This feasibility study evolved from the city of Fargo's initial request that the Corps study a levee and floodwall plan to protect the city's downtown area. The communities in the study area have historically relied on both temporary and permanent levees to prevent flood damages, and they have been largely successful. Any Federal project would consist only of permanent features.

For the initial screening, this study analyzed flood barrier systems at two different top profiles to reliably contain the 2-percent chance flood and the 1-percent chance flood. Initial analyses were based on constructing levees in both Fargo and Moorhead to the design levels and assessing the costs and economic benefits of the plans.

This alternative includes the use of permanent flood barrier systems including levees, floodwalls, invisible floodwalls, gate closures, and pump stations. Levees are engineered embankments built to keep flood waters on one side and remain dry on the other side. Floodwalls are typically concrete and steel structures that provide a barrier to flood water both underground and above ground. Invisible floodwalls are floodwalls with removable portions above ground that can be installed only when needed during floods. Gate closures are placed where storm sewers pass through the levee or floodwall. The gates would remain open except during floods, when they would be closed to prevent flood waters from passing through the line of protection. During floods, storm drainage and snow melt inside the protected area would be redirected to pump stations designed to lift the water over the flood barrier. These features would be considered alone and in concert with other potential measures as part of a flood risk management system for the study area.

Closure structures would be built where roads and railroads cross the line of protection. During floods, the roads and railroads would be closed to traffic before flood waters reach the closure elevation, and traffic would resume only after the risk of flooding had passed.

The unique geology of the Fargo-Moorhead area makes it difficult to construct permanent features near the river banks. Earthen levees would need to be located hundreds of feet landward of the river to remain stable. Floodwalls could be located somewhat closer to the river banks, but they are significantly more expensive to build and maintain. More than 1,000 existing structures along the river, including homes and businesses, would be removed to build the barrier system and vacate the land on the flooded side of the system.

It would be possible to build new recreation facilities and habitat areas adjacent to the river between the North Dakota and Minnesota barriers if the land riverward of the barriers is vacated. Such facilities could include trails for walking, biking or skiing and additional access to the river for boating. Floodplain forest and prairie restoration areas could be incorporated into a flood barrier plan.

2.2.2 Effectiveness

Flood barriers would be effective in maintaining a reduced level of flood risk for the Fargo-Moorhead Metropolitan Area. Levees would reduce the susceptibility to frequent flooding in the area and would minimize the impacts of emergency measures. However, flood barriers would only be effective up to the design event and a maximum of approximately the 1-percent chance exceedence flood level. This alternative is moderately effective.

2.2.3 Environmental Effects

This alternative would have low positive impacts

2.2.3.1 Natural Resources

Some wetland and upland resources would be affected by the construction of levees/floodwalls. Some mitigation may be required for impacts on wetlands and tree removal, but the impacts would likely be offset with the increased open space between the barriers and the river. This may provide environmental benefits by reconnecting the river to a larger floodplain and creating more opportunity for riparian woodland habitat. Riprap in the river could have in-stream impacts. There is potential for loss of floodplain connectivity upstream and downstream of reaches of the levee. Overall the effects on natural resources would likely be neutral.

2.2.3.2 Cultural Resources

There are a number of historical structures that would be directly or indirectly impacted by the construction of the levees, and mitigation would be required for the adverse impacts. There are also a number of deeply buried archeological sites within the study area, so there is great potential for adverse impacts to cultural resources. The barriers would prevent flooding of historical structures which could be extensively damaged during flood events. Overall the effects on cultural resources would likely be negative.

2.2.4 Social Effects

This alternative would provide several positive social effects. Public safety would be better than in the base condition for most flood events. Regional business growth could continue as a result of the decreased risk to the infrastructure. Emergency actions would be needed much less frequently, reducing physical and mental stresses of recurring flood fights. Recreational components could be integrated into the project that would provide benefits. Public facilities and services would be able to continue during flood events.

A flood barrier plan would also have negative social effects. The risk of catastrophic failure for events larger than the design event poses a significant threat to public safety, especially if growth occurs in currently undeveloped areas within the protected area. There would be a loss of more than 1,000 structures due to the construction of the project. The impacts on local transportation during flood events would be large. Road relocations and closures would be necessary for the alternative to function. During large flood events the cities would be essentially shut off from each other, and major evacuation routes could be closed. An evacuation plan would need to be developed to address potential flood-fighting issues.

The alternative would have moderate positive social effects.

2.2.5 Acceptability

The removal of more than 1,000 structures would have significant impacts on community cohesion. This plan would impact the major railroad line that runs though Fargo-Moorhead, and flood barriers would likely increase flood stages upstream by confining the river through the urban area. It may be possible to mitigate for otherwise unacceptable economic impacts. The sponsors have indicated that a level of permanent protection in excess of the 1-percent chance level is necessary for local acceptability, however if there are no other options permanent protection at the 1-percent level could be pursued. This alternative is moderately acceptable.

2.2.6 Implementability

This plan could be implemented and is technically feasible for levels up to the 1-percent chance level. There would be large social impacts to the local communities which could make timely implementation difficult. Flood barriers must start and end at naturally high ground so flood water cannot get around the ends of the system. The floodplain in the Fargo-Moorhead area is very flat and only slightly above the 1-percent chance flood elevation. On the North Dakota side, the highest ground upstream is located on the ridge east of Horace, ND, effectively limiting the height of any North Dakota levees to about the 1-percent chance flood level, including allowances for risk and uncertainty. The ground on the Minnesota side is higher, but barriers must be extended several miles away from the river to reach sufficient elevations. It is not technically feasible to build certifiable barriers higher than the 1-percent chance level in the Fargo-Moorhead area due to these constraints. This alternative is moderately implementable.

2.2.7 Cost

Two levee plans were considered in detail for the screening analysis. Initial cost estimates for the two levee plans evaluated were $840 million for a levee to reliably contain a 2-percent chance flood (50-year) and $902 million to contain a 1-percent chance flood (100-year). The 1-percent levee plan would leave the community susceptible to residual damages averaging more than $20 million annually. This alternative has high costs.

2.2.8 Risk

Levees and other properly designed and constructed flood barriers can prevent damages from most flood events that do not exceed their maximum design event. However, flood events may overtop the barriers or cause unexpected breaches at levels below the design event, leading to catastrophic failure of the system. For that reason, there is always residual flood risk to areas "protected" by flood barriers. That risk is often misunderstood or ignored by people using those areas. This plan would provide risk reduction up to the design event; once that event is exceeded the risk for catastrophic damages would be increased. This plan may also induce additional growth between the 1-percent chance and 0.2-percent chance flood plains resulting in greater risk to the community over time. This alternative has a moderate level of risk reduction.

2.2.9 Separable Mitigation

It is possible that mitigation may be necessary to offset measurable economic impacts to upstream and downstream landowners from increased flood stages. These impacts could possibly be mitigated with upstream storage, ring levees, or non-structural solutions. Not all stage increases result in measurable damages, and no mitigation would be included to address perceived damages that cannot be quantified. Impacts to natural resources would likely be offset with the establishment of the riparian corridor and mitigation for those impacts would not be necessary. This alternative has a moderate level of separable mitigation.

2.2.10 Cost Effectiveness

Of the two levee plans investigated, only the 1-percent chance levee was determined to be cost effective. The 1-percent chance levee provided nearly $7.7 million average annual net benefits and had a benefit to cost ratio (BCR) of 1.17. The BCR for the smaller levee was 0.88. The alternative is moderately cost effective.

2.2.11 Recommendation

The levee plans would provide a limited level of risk reduction, have large short term social impacts, high costs and are moderately cost effective. Therefore it is recommended that levee plans be removed from further consideration as a stand alone plan. The levee plans are being eliminated with the following uncertainties:

- 2.2.11.1 Upstream impacts of the levee alternatives were not included in the costs, initial calculations indicate a 0.8-foot increase for the 100-year event increasing to 3.8 feet for a 500-year event.
- 2.2.11.2 The current levee plans were based only on earthen levees; use of floodwalls would be assumed to increase levee costs.

2.2.11.3 Advanced replacement, flood proofing cost savings, and transportation benefits have not been included but are anticipated to be relatively low.

2.2.11.4 Impacts to historical properties have not been fully assessed, the costs for this are anticipated to be high.

2.2.11.5 Environmental mitigation costs have not been included, these costs are anticipated to be low.

2.3 DIVERSION CHANNELS

2.3.1 Alternative Description

This alternative would involve diversion channels to route flood flows around the metropolitan area, thus reducing stages in the natural channel through town. A control structure would be required on the Red River to divert flows into the diversion channel and drop structures would be necessary to allow local drainage to enter the diversion channel. Tie-back levees at the southern limits of the project would be necessary to tie into high ground. No tie-back levees at the north end of the project would be necessary.

Nine separate diversion plans were analyzed during the initial screening, including a total of four separate alignments, two in Minnesota and two in North Dakota, and various capacities. The Red River control structure allows for the maximum benefit for a given diversion channel capacity by reducing water surface elevations immediately downstream of the structure. Additionally, the control structure allows the water surface elevation upstream of the project to remain at a near natural elevation to prevent erosion-causing velocities in the Red River at the upstream end of the project. Because of the Wild Rice River's proximity to the Red at the south end of the project, three of the four alignments also include control structures on the Wild Rice River. The North Dakota alignments would require additional hydraulic structures where the diversion alignments cross the Wild Rice, Sheyenne, Maple and Rush Rivers.

The Minnesota short alignment is approximately 25 miles long, starting near the confluence of the Wild Rice and Red Rivers and ending near the confluence of Sheyenne and Red Rivers. Three separate diversion capacities were analyzed for the Minnesota alignments including 25,000, 35,000, and 45,000 cubic feet per second (cfs). The channel configuration should have a maximum depth of approximately 30 feet due to geotechnical concerns, and channel bottom widths ranged from 250 to 500 feet. The Minnesota short alignment includes 20 highway bridges and 4 railroad bridges. The flow split between the diversion channel and the Red River would be controlled by a combination of a control structure on the Red River at the south end of the project and a weir at the entrance to the diversion channel.

The Minnesota long alignment started approximately 3 miles south of the confluence of the Red and Wild Rice Rivers and would end at the Red River near the confluence of the Red and Sheyenne Rivers. The alignment would be approximately 29 miles long. Because this alignment begins south of the confluence of the Red and Wild Rice Rivers, an extension of the diversion channel would be required between the Red and Wild Rice Rivers. The tie-back levee would be required to extend west from the Wild Rice control structure to higher ground.

The North Dakota west alignment would start approximately 4 miles south of the confluence of the Red and Wild Rice Rivers and extended west and north around the cities of Horace, Fargo, West Fargo, and Harwood and would end at the Red River north of the confluence of the Red and Sheyenne Rivers near the city of Georgetown, Minnesota. The alignment would be approximately 35 miles long. The North Dakota east alignment generally followed the North Dakota west alignment except that, after crossing the Sheyenne River, it would use the existing Horace to West Fargo Sheyenne River Diversion corridor between Horace and I-94. The North Dakota east alignment would be approximately 36 miles long.

The North Dakota alignments would require an extension of the diversion channel between the Red and Wild Rice Rivers which would begin south of the confluence of the Red and Wild Rice Rivers, like the Minnesota long alignment. The tie-back levee associated with these alternatives would extend east from the Red River control structure to high ground. The North Dakota west alignment was analyzed for 35,000 and 45,000 cfs, and the North Dakota east alignment was analyzed for 35,000 cfs. The channel configuration for each event was largely determined based on the minimum excavation quantity for a given capacity rather than by the maximum recommended excavation depth as was used for the Minnesota alignments. The channel bottom width for both capacities would be 100 feet, and the maximum depth would be approximately 32 feet. The North Dakota alignments would include 18 highway bridges and 4 railroad bridges. A combination of control structures on the Red and Wild Rice Rivers at the south end of the project, along with a weir at the entrance to the diversion channel, would control the flow split between the Red and Wild Rice River channels and the diversion channel. This alignment would cross several rivers, including the Sheyenne, Maple, Lower Rush, and Upper Rush. Hydraulic structures would be necessary at the point where the diversion channel crosses these rivers. The purpose of these hydraulic structures would be to allow some base flow to continue down the various rivers while diverting excess water during flood events to the diversion channel. This would result in added flood protection along all of the affected tributaries downstream of the crossing.

2.3.2 Effectiveness

Diversion channels would be very effective in reducing flood risk in the Fargo-Moorhead Metropolitan Area. The smallest diversion considered in the screening exercise (25,000-cfs capacity) would reduce a 0.2-percent chance event to approximately the 1-percent chance stages through town, and a 1-percent chance event would be reduced to less than 10-percent chance stages. The communities begin emergency measures between the 15 and 20-year events meaning that a diversion would nearly eliminate the need for emergency measures during smaller, more frequent floods, but flood fighting would still be needed for events approximately 1-percent chance or larger. Larger diversion alternatives could nearly eliminate the need for flood fighting except for the extremely rare and large events. This alternative is highly effective.

2.3.3 Environmental Effects

This alternative would have moderately positive impacts.

2.3.3.1 Natural Resources

There is a potential for adverse effects on aquatic habitat from the structures necessary on the Red River and the tributaries. Those structures could impact fish passage which could result in adverse effects on fish populations in the Red River. Agencies have identified that fish passage would have to be a key design criterion. Sedimentation in the diversion channel or on the Red River could be a potential issue resulting in adverse effects to aquatic habitat and the river ecology.

The diversion channels could have potential adverse effects on the aquatic resources caused by impacts to fish passage and fish trapping. The alternative would be designed to ensure that impacts to aquatic habitat would be minimized to the greatest extent possible and that the overall impact to the resource would be less than significant. Wetlands along the alignment would be intercepted by the channel and removed or drained, and the channel would impact the depth of groundwater near the channel. The channel would be designed to include wetland and/or prairie swale-type habitat within the diversion channels which could lead to increased habitat quantity and value compared to the existing conditions.

The Minnesota diversion would run close to the Buffalo Aquifer which provides some of the region's drinking water. The project would be designed to ensure that the aquifer would not be impacted with any of the Minnesota diversion alignments. The North Dakota diversions could have greater adverse effects on the aquatic habitat due to the 5 tributary structures (Wild Rice, Sheyenne, Maple, Lower Rush, and Rush Rivers) which would be necessary where the diversion channel intersects those rivers.

Overall the effects on natural resources would likely be neutral.

2.3.3.2 Cultural Resources

Historical structures might be directly or indirectly impacted by the construction of a diversion channel. Mitigation would be required for any significant adverse effects. There are also a number of deeply buried archaeological sites within the study area, so there is great potential for adverse impacts to archeological sites. A number of historical structures located inside the benefited area would be less prone to future flooding.

Overall the effects on cultural resources would likely be negative.

2.3.4 Social Effects

The diversion channel would require a large amount of agricultural land, and in excess of 10 homes would be removed along any of the alignments. The reduced flood risk would lead to continued regional growth, public safety would improve as the risk of catastrophic flooding would be largely minimized, employment would continue to grow with the region and businesses would not need to provide support for regular emergency measures, recreational features would be included along the project alignment that would benefit the public. Local transportation would be negatively affected by the limited number of bridges crossing the diversion channel, although the bridge locations would be optimized to ensure these impacts were as minimal as possible, and the channel would be designed to allow for future expansion of the local infrastructure. During flood events local transportation and evacuation routes would remain open and accessible to the public. This alternative would have high positive social effects.

2.3.5 Acceptability

The diversion channel would impact a number of agricultural properties which currently do not experience flooding. This could create the perception of a rural versus urban conflict and have negative effects on community cohesion in the region. There could also be actual or perceived downstream impacts due to increased flood stages that may need to be addressed. These impacts could add to the perception of rural versus urban conflict. Within the communities during non-flood events the community would be allowed to grow with minimal threat of flooding for the future. The diversion channels could limit growth on the outside of the channels and future expansion may be required at some point to expand beyond the channel, this would require additional bridges and infrastructure. If the diversion channel were placed in Minnesota there could be conflicts between the two states, Minnesota and North Dakota, as the majority of the benefits occur in North Dakota, but the impacts of construction would be in Minnesota. However, it is important to note that the diversion channel would provide large benefits to Minnesota, and the Corps of Engineers does not consider state boundaries when identifying the best plan for the nation. If the diversion channel were placed in North Dakota there would be potential impacts to the aquatic habitat which may not be consistent with national or Corps policies. The sponsors have indicated that a level of permanent protection in excess of the 1-percent chance level is necessary for local acceptability, however if there are no other options permanent protection at the 1-percent level could be pursued. This alternative would be moderately acceptable.

2.3.6 Implementability

Implementing this plan has some technical issues: the largest concern would be with the Red River control structure and designing it in a manner that would be both hydraulically and environmentally sound. A North Dakota diversion would have additional technical challenges with building the structures that intercept the tributaries. These structures would be extremely complex and would need to accommodate fish passage; it is uncertain if that can be achieved.

Diversions have been employed successfully on other projects in the Red River basin, including projects at Breckenridge, Minnesota; Grand Forks, North Dakota/East Grand Forks, Minnesota; and, most notably, Winnipeg, Manitoba. A diversion channel is being proposed as part of the recently approved Roseau, Minnesota, project. This alternative could be constructed in a timeframe currently estimated at 8-10 years.

Several legal and institutional issues would need to be resolved prior to any implementation, including how the lands would be acquired, how the local tax base would be impacted, who would operate and maintain the project, who would pay for the project and how the costs of the project would be shared. The local sponsors have set up a committee which consists of the Moorhead City Council, Fargo City Commission, the boards for Clay County, Minnesota and Cass County, North Dakota and the two watershed/water resource districts to develop the answers to those questions.

This alternative would be highly implementable.

2.3.7 Cost

Costs for the nine diversion alternatives investigated range from $962 million to $1.46 billion. Although the North Dakota diversion plans are longer and more expensive than the Minnesota alignments, they would benefit a larger area and a greater number of people. They would also provide benefits from floods on the tributaries on the Dakota side. However, the North Dakota alignments with their tributary crossing structures would be significantly more complicated and expensive to operate and maintain and have greater potential for negative environmental effects than the Minnesota alignments. The plans all reduce the residual risk to the communities to less than $14 million annually and would allow for emergency flood fighting if necessary. This alternative has a medium cost.

2.3.8 Risk

Diversions generally provide a high level risk reduction because they cannot fail suddenly and catastrophically. If a diversion fails to perform, flood stages are no higher than they would have been without the project in place. However, diversions do not eliminate flood risk, and they are not fool-proof. Some residual risk often remains from flood events larger than the design event, and emergency flood fighting would still be required for those extremely rare events which could lead to risks similar to the without project condition. There is a potential for blockage of the channel due to ice and debris which would be most likely where structures were located either in the diversion channel or on the rivers. This is greater for the 5 tributary structures for the North Dakota alignments. Overall this alternative provides a high level of risk reduction.

2.3.9 Separable Mitigation

If the project causes increased flood damages downstream, economic impacts could result in the need for ring levees, relocations, or buyouts in downstream locations. Impacts to the aquatic resources that cannot be addressed through project design could result in the need for mitigation, possibly including increasing fish passage at other locations in the basin. Mitigation may be necessary for fish passage on the tributaries and it is possible that the impacts may be too large to mitigate. This alternative has a moderate to high level of separable mitigation.

2.2.10 Cost Effectiveness

Of the nine diversion plans investigated in preliminary screening, five provided positive net benefits and four did not. The Minnesota Short Diversion plans significantly outperformed the Minnesota Long Diversion plans, providing average annual net benefits ranging from $2.5 million to $11.0 million. The smallest diversion, with a channel capacity of 25,000 cfs, provided the greatest net benefits and had a benefit to cost ratio (BCR) of 1.22. None of the North Dakota plans were found to be cost effective, with BCRs ranging from 0.91 to 0.95 and average annual net benefits ranging from -$6.7 million to -$3.1 million. At an optimal capacity, a diversion would be highly cost effective.

2.2.11 Recommendation

The diversion concept should be retained for further refinement. Preliminary analysis indicates that the Minnesota Short diversion is the most cost effective of the diversions being considered and would be implementable and highly effective. Additional study is needed to optimize the capacity and alignment of the plan and address impacts to the aquatic habitat. Additional assessment is needed for the North Dakota plans to determine potential economic benefits from tributary flooding and potential impacts or mitigation for aquatic habitat.

2.4 NON-STRUCTURAL MEASURES

2.4.1 Alternative Description

Non-structural measures remove damageable property from flood waters rather than redirecting the flood waters away from property. Non-structural measures include a variety of actions, such as evacuating flood plains, relocating structures, and elevating structures above the design flood level.

2.4.1.1 Relocation of Structures:

This measure allows for moving structures as part of the project and buying the land upon which the structures are located. It makes most sense when structures can be relocated from a high flood hazard area to an area that is completely out of the floodplain. Due to the relatively flat nature of the floodplain this is not possible within Fargo and may not be possible within Moorhead. Therefore, any structure relocation would consist of moving the structure from an area of high flood hazard to an area of lower flood hazard and then using the nonstructural measure of elevation to achieve the desired level of flood risk reduction within the metropolitan area. Development of relocation sites where structures could be moved to achieve the planning objectives and retain such aspects as community tax base, neighborhood cohesion, etc., would be investigated as part of any relocation project. This measure is applicable anywhere in the metropolitan area.

2.4.1.2 Buyout and Demolition of Structures:

This measure requires buying the structures and the land as part of the project. The structures are either demolished or sold to others and relocated to a location beyond the floodplain, all as part of the project. This measure will be considered and is applicable anywhere in the metropolitan area. This approach has been implemented on a small scale by the local communities and since the 1997 flood more than 100 flood prone structures have been removed. Ecosystem restoration and/or recreational amenities could be pursued on the purchased lands for either this option or the Relocation of Structures option.

2.4.1.3 Elevation of Structures:

This measure requires lifting the structure above a particular flood event. In the metropolitan area, the most acceptable elevation measure might be on extended foundation walls. Because most of the structures to be elevated have basements under them, the concept would be to elevate the basement off the ground. Then, depending on the design flood elevation, the elevated basement could be fully developed if the basement floor was above the Flood Insurance Rate Map (FIRM) base flood elevation (BFE) or the design flood elevation, whichever is higher. Basements could be kept undeveloped and wet flood proofed to equalize hydrostatic force or could be developed with more comprehensive wet flood proofing concepts. Owners with fully developed pre-elevated basements would be compensated if the post-elevated basement cannot be developed. This measure is applicable anywhere in the metropolitan area unless the required elevation is greater than 15 feet above the adjacent grade. Velocity and hydrodynamic force would also have to be considered. This measure is generally applicable throughout the metropolitan area depending on flood depth and floodway location. Local building codes required that new construction be built approximately 1.3 to 2.5 feet above the 100-year base flood elevation which has resulted in a lot of new construction using fill to get to that elevation and constructing on top.

2.4.1.4 Removal of Basement:

This measure requires filling the existing basement without elevating the remainder of the structure. This measure could be used if the structure's first floor was above the BFE or above the design elevation, whichever is higher. Adding onto the side of the structure as part of the project would be possible with this measure so as to compensate the owner for the lost basement space. If the add-on is not possible because of lot constraints or because the owner opposed it, compensation to the owner for the lost basement space could be in order. This measure would only be applicable where the design flood depth is relatively small [first floor already above the design depth]. Hydrodynamic force would also be a consideration. This measure is applicable throughout the metropolitan area.

2.4.1.5 Dry Flood Proofing

This measure concerns waterproofing the structure, which can be done to residential structures as well as all other types. This measure achieves flood risk reduction but it is not recognized by the National Flood Insurance Program (NFIP) for any flood insurance premium rate reduction if applied to residential property. Based on tests at the Corps' Engineering Research and Development Center (ERDC), a "conventional" built structure can generally only be dry flood proofed up to 3 feet on the walls. A structural analysis of the wall strength would be required if it was desired to achieve higher protection. A sump pump is required and perhaps a French drain system is installed as part of the project. Closure panels are used at openings. This concept does not work with basements. It would not work with crawl spaces in the metropolitan area because of the long duration of flooding. This measure would work in the metropolitan area if design flood depths are generally less than 3 feet and on an appropriate structure as discussed. Hydrodynamic force would also be a consideration. This measure has potential applicability throughout the metropolitan area.

2.4.1.6 Wet Flood Proofing

This measure is applicable as either a stand alone measure or as a measure combined with other measures such as elevation as discussed above. As a stand alone measure, all construction materials and finishing materials need to be water resistant. All utilities must be elevated above the design flood elevation. Because of these requirements, wet flood proofing of finished residential structures is generally not recommended. Wet flood proofing is quite applicable to commercial and industrial structures when combined with a flood warning, flood preparedness, flood response plan. This measure is generally not applicable to large flood depths and high velocity flows.

2.4.1.7 Berms, Levees, and Floodwalls

This measure is applicable to locations within the metropolitan area. As nonstructural measures, berms, levees and walls are generally no higher than 6 feet above grade and are not certifiable for the NFIP, meaning that flood insurance and floodplain management requirements of the NFIP are still applicable in the protected area. These nonstructural measures are intended to reduce the frequency of flooding but not eliminate floodplain management and flood insurance. These measures can be used for all types of structures in the metropolitan area. They can be around a single structure or a small group of structures. With application of these measures to be nonstructural, they cannot raise the water surface elevation of the 100-year flood by any amount. These measures must be placed with velocity in mind. The local communities have been working to implement these types of solutions for some of the most flood prone properties, individual landowners have also been building their own berms, levees, and floodwalls.

2.4.1.8 Flood Warning, Preparedness, Evacuation Plans and Pertinent Equipment Installation

These measures are applicable to the metropolitan area. All of the above nonstructural measures with the exception of buyout and of relocation to a completely flood free site require the development and implementation of flood warning/preparedness planning. The development of such plans and the installation of pertinent equipment such as data gathering devices [rain gages, stream gages], data processing equipment [computer hardware and software], and dial out devices [cellular, land line] can be part of the project. The communities in the area have developed emergency operation plans for floods and those plans are updated during and after flood events. The City of Fargo and the City of Moorhead have a reverse 911 system which can relay messages to neighborhoods related to where volunteer workers are needed to help with emergency measures and to order evacuations.

2.4.1.9 Land Acquisition

Land acquisition can be in either the form of fee title or permanent easement with preference to fee title. Land use after acquisition is open space use via deed restriction that prohibits any type of development that can sustain flood damages or restrict flood flows. Land acquired as part of a nonstructural project can be converted to a new use such as ecosystem restoration and/or recreation that is open space based such as trails, canoe access, etc. Conversion of previously developed land to open space means that infrastructure no longer needed, such as utilities, streets, sidewalks, etc., can be removed as part of the project. The conversion to new use [ecosystem restoration and/or recreation] can also be part of the project. By incorporating “new uses of the permanently evacuated floodplains” into the nonstructural flood risk reduction project, the economic feasibility of the buyout or relocation is enhanced. This feasibility enhancement is due to partial transfer from flood risk reduction costs to ecosystem restoration and also by adding benefits [and costs] of recreation. This effect would be determined by use of the “Separable Costs/Remaining Benefits” guidance. Other Federal agencies such as the Natural Resources

Conservation Service (NRCS) have permanent easement programs to restore wetlands in "evacuated" floodplains that could be used in a collaborative mode with a Corps nonstructural program. The local communities have focused on the purchase of flood prone properties in the past and would likely continue to do so.

2.4.1.10 Floodplain Management Plans

A floodplain management plan (FPMP) is required of the Corps non-Federal project sponsor. The intent of an FPMP is to "protect" the Corps' partnered project from diminishing the frequency of flood risk reduction provided by the project. This activity is required of a non-Federal sponsor but, if done during the feasibility phase of study, can be cost shared on the same basis as the feasibility study. This method makes sense for the sponsor from the cost share and from the holistic flood risk reduction perspectives. This latter perspective makes sense for the Corps as well. By integrating the FPMP with the feasibility study, both the FPMP and the ultimate project are bettered. This should be done within this feasibility study.

2.4.1.11 Vertical Construction for Residential Occupancy

This concept refers to condominium living within floodplains, where the at-grade floor is used for open-space uses and the upper stories (which are all above even the most infrequent floods) are used for residences. This vertical construction is proposed for consideration within the metropolitan area, especially in Fargo, because no area close to Fargo is high enough above the Red River floodplain, or that of its tributaries, for flood-free residential construction. This situation may be the same for Moorhead. This concept to change residential construction from single-family homes to vertical construction would probably face tough political/social criticism. However, it merits consideration if the metropolitan area is to achieve a significant flood risk reduction in the long term.

2.4.1.12 Flood Insurance

The National Flood Insurance Program (NFIP) could be utilized more to reduce the individual risk to flooding. This program can help to rebuild after a flood; however it does not prevent the flood from occurring and would still have large residual impacts on public safety and infrastructure.

2.4.1.13 Wetland Restoration and Grassland Restoration

Wetland and Grassland restoration are discussed in Section 2.10.

2.4.2 Effectiveness

Non-structural measures would be very effective for risk reduction to structures and their contents; however non-structural measures would not reduce flood impacts on local infrastructure including streets, sewers, storm drainage systems, pumping stations, and other critical facilities. The alternative would only be effective up to the design event. The plan would also not be effective in maintaining evacuation routes. During prior flood events, citizens of Fargo and Moorhead have chosen to stay and fight the floods rather than evacuating the cities. The plan would not be effective in preventing disruption to daily life and business activities during a flood event. This alternative would be highly effective.

2.4.3 Environmental Effects

This alternative would have moderately positive impacts

2.4.3.1 Natural Resources

The removal/relocation of homes would create opportunities to develop riparian habitat along the river corridor. Opportunities to restore wetlands, and provide more greenway for recreational and ecosystem benefits would also exist. The removal/relocation of homes would impact the areas that would be moved into as new infrastructure would need to be developed. Impacts from this would be expected to be minimal.

Overall the effects on natural resources would likely be positive.

2.4.3.2 Cultural Resources

There would be a number of historical structures that would be directly or indirectly impacted by non-structural measures, and mitigation would be required for the adverse effects. Some historical structures may be modified from their historical condition while flood proofing, raising, etc. The alternative would minimize the threat of flooding to a number of historical properties. There are a number of cultural sites within the study area, so there is potential for adverse impacts to archeological sites.

Overall the effects on cultural resources would likely be neutral.

2.4.4 Social Effects

During flood events, evacuation would be required causing large disruptions to transportation and businesses potentially lasting more than a month. A large percentage of the structures in the study area would need to be either removed, relocated, or modified to achieve a standard level of protection, so nearly the entire community would be affected, reducing community cohesion and changing the entire appearance of the city. Regional growth could be negatively affected because businesses would not want disruptions from the evacuations that would be necessary with this alternative. However, if recreation features were built on vacated lands, the project could provide significant recreational benefits during non-flood times. This alternative would have high negative social effects.

2.4.5 Acceptability

The necessary modifications to thousands of individual structures would be extremely controversial and would be politically difficult resulting in little support from the local sponsors. Community cohesion would be disrupted during the implementation of this alternative and there could be long term issues with frequent flooding that would limit access to many structures during flood events. The sponsors have indicated that a level of permanent protection in excess of the 1-percent chance level is necessary for local acceptability, however if there are no other options permanent protection at the 1-percent level could be pursued. This alternative would have a low level of acceptability.

2.4.6 Implementability

This project would be very difficult to implement, because it directly affects an enormous number of property owners. Forcing the public to raise structures may not be possible, reducing the overall effectiveness of the plan. There would be legal issues as to what authorities would be used to force people to modify their structures. It would take a great deal of time to implement the project due to the large number of structures being modified. This alternative would have a low level of Implementability.

2.4.7 Cost

For the initial screening, stand-alone non-structural plans were developed for the 1-percent chance flood level and the 0.2-percent chance flood level. Total cost for the 1-percent chance level was $1.6 billion, and the total cost for the 0.2-percent chance flood level was $4.7 billion. Even if the 1-percent or the 0.2-percent plans were developed the community would still be at risk of flooding and there would be residual damages to local infrastructure. This alternative would have extremely high costs.

2.4.8 Risk

The risk of flooding to public infrastructure would remain. Evacuation routes would continue to be flooded. During flood events the population could be required to be evacuated in excess of a month when looting and property damage would be a concern. The properties modified would be protected up to the design event but there would be the residual risk of flood damage above that event. This alternative has a moderate level of risk reduction.

2.4.9 Separable Mitigation

No separable mitigation is anticipated. This alternative has a low level of separable mitigation.

2.4.10 Cost Effectiveness

Two levels of stand-alone non-structural plans were investigated for the study area: 1-percent chance and 0.2-percent chance. Neither plan was cost-effective, with BCRs of 0.35 and 0.31, respectively. Due to the extremely flat nature of the floodplain, it appears that it is not efficient to address flooding on an individual structure basis over the entire Fargo-Moorhead study area. The alternative has a low level of cost effectiveness.

2.4.11 Recommendation

Non-structural measures should no longer be considered as stand-alone alternatives. However, the non-structural concept should be retained as a possible measure for smaller areas not otherwise benefited by the project or to mitigate for adverse effects caused by the project.

2.5 FLOOD STORAGE

2.5.1 Alternative Description

Flood storage involves both preserving natural floodplain areas and also building dams and other water retention facilities to hold water during flood events. Flood storage concepts include large dams, distributed smaller storage sites, controlled field runoff, use or modification of the constructed road network to store water (the “waffle plan”), storage ponds used for water conservation, and payment to landowners for water retention. These facilities would be located in any watershed upstream of the Fargo-Moorhead Metropolitan area and distribution would be throughout that area.

Natural storage in the floodplain occurs as the water rises and fills up low-lying areas adjacent to the rivers. Constructed flood storage projects (impoundments) would be located on the main channel of a river or “off-channel” on a ditch or other manmade connection to a river. Impoundments could be designed to remain dry until a flood event, or to retain a pool during non-flood times for conservation or water supply purposes.

Three Corps-owned flood storage projects in the Red River basin benefit the study area: Lake Traverse, Orwell Lake, and Lake Ashtabula. Opportunities exist to build additional flood storage, but previous Corps studies have found insufficient national economic interest to support Federal involvement in such projects. The studies have also shown that flood storage alone cannot provide an acceptable level of risk reduction for the Fargo-Moorhead Metropolitan Area.

Despite the lack of Federal financial involvement, the Cass County Joint Water Resource District recently built a dam on the Maple River upstream and approximately 35 miles southwest of Fargo. The Bois de Sioux Watershed District in the headwaters of the Red River basin and the Buffalo-Red River Watershed District are also designing and constructing flood storage projects. These smaller projects provide incremental benefits, but they are not sufficient to prevent major flood damages in the Fargo-Moorhead Metropolitan Area. It is likely that additional flood storage would be built upstream of the study area, but that storage alone is not likely to adequately reduce flood risk to the study area over the next 50 years.

2.5.2 Effectiveness

The effectiveness of flood storage depends on many factors, including distance from the benefited area, volume of water retained, timing of the storage, size of the drainage area controlled, and the amount of runoff contributed from the controlled area during each particular flood event. Because each flood event is different with respect to the major sources and timing of runoff, it would be very difficult to ensure that a system of remote storage sites would be reliably effective at reducing flood stages in the Fargo-Moorhead area.

The St. Paul District's Fargo-Moorhead and Upstream Area Feasibility Study is assessing the viability of multipurpose projects to provide both flood storage and aquatic ecosystem restoration. In 2005, Phase 1 of that study determined that it may be possible to build 400,000 acre-feet of flood storage in the watershed using projects of 2,000 to 20,000 acre-feet each. (Note: this capacity is the most storage determined to be possible, due to limits of topography and landowner willingness.) An impoundment downstream of White Rock Dam near the North Dakota/South Dakota border that could provide up to 60,000 acre-feet of storage was also considered. A model of such a system of impoundments indicated that it could reduce the 1-percent chance flood stage in Fargo-Moorhead by less than 1.6 feet.

The Energy and Environmental Research Center (EERC) at the University of North Dakota conducted a study of the "Waffle concept" to use the existing road network with additional water control structures to store flood water from spring floods on farm fields. According to EERC's final report for the Waffle Project, dated December 2007, between 49,000 and 100,900 acre-feet of Waffle storage could be obtained upstream of Fargo-Moorhead (calculated from Table 7, page 47). The study found that flood stages in Fargo-Moorhead during the 1997 flood (nearly a 1-percent chance flood event) could have been reduced by 3.3 to 4.4 feet if the Waffle Project had been in place (Table 16, page 68).

This alternative would have a low level of effectiveness.

2.5.3 Environmental Effects

This alternative would have moderate positive impacts

2.5.3.1 Natural Resources

Flood storage would have both potential beneficial and adverse impacts on habitat types resulting from the land-use changes. Dams on the main stems of rivers are generally considered detrimental to the environment. Dams affecting existing wetlands are also less likely to provide true environmental benefits. Off-channel storage located on poorly-drained agricultural sites, former wetlands, or drained lakes can be environmentally beneficial if designed and managed properly.

Overall the effects on natural resources would likely be positive.

2.5.3.2 Cultural Resources

Flood storage projects could result in cultural resources being covered by the storage pools; construction could also have impacts on archeological resources. A number of cultural sites are within the upper Red River watershed, so the potential exists for adverse impacts on archeological sites.

Overall the effects on cultural resources would likely be negative.

2.5.4 Social Effects

Large amounts of land would be necessary to implement a flood storage project of sufficient scale to benefit the Fargo-Moorhead area. For a Federal project, most of that land would need to be taken out of agricultural production, potentially impacting rural communities. Transportation impacts could result because roads may need to be relocated. The waffle concept envisioned paying farmers to store spring runoff temporarily on active farmland, which may have fewer social impacts. Although most flood storage projects would provide benefits in the local area, it may be perceived that the benefits of these projects were mainly for the urban areas while the rural areas would be providing the land necessary for the project. Depending on the depth of the storage areas and timing of storage, recreational opportunities such as boating, fishing, or hunting might be provided. This alternative would have moderate positive social effects.

2.5.5 Acceptability

This alternative would affect a large number of landowners and would not provide a large amount of flood risk reduction for the Fargo-Moorhead area. Controversy between the urban areas and the rural areas could arise over the need for project lands. Depending on the location the storage areas could have a large impact to rural communities which would need to be relocated. Transportation disruptions could have negative impacts on community cohesion. The sponsors have indicated that a level of permanent protection in excess of the 1-percent chance level is necessary for local acceptability, however if there are no other options permanent protection at the 1-percent level could be pursued. This alternative would have a low level of acceptability.

2.5.6 Implementability

The project would be difficult to implement in a reasonable amount of time, less than 10 years. Acquisition of land needed for permanent projects has legal issues. Appropriate and economical storage sites are scarce in the watershed upstream of Fargo-Moorhead. Local implementation of small projects within the basin could be a viable local solution, but the individual projects would not likely have a major impact on flooding in the Fargo-Moorhead Metropolitan Area. Implementing the waffle concept would require significant coordination, study and political action by various stakeholders in three States, and appears not to be implementable in the near-term. A large number of landowners would be impacted along with transportation impacts that create a rural versus urban controversy. The local communities would need to develop special institutional and legal arrangements to ensure that they had the authority to implement the project. This alternative would have a low level of Implementability.

2.5.7 Cost

The Fargo-Moorhead and Upstream study estimated that a system of flood storage sites to provide between 200,000 and 400,000 acre-feet of storage would cost between $160 million and $400 million to construct. EERC's estimates of the present value of 50-year implementation costs for the Waffle Plan ranged from $208 million to $543 million, depending on acreage and the amounts paid to farmers (EERC, 2007, p. 151). Even with those concepts in place there would still be large residual damages in the Fargo-Moorhead area. This alternative would have extremely high costs.

2.5.8 Risk

Flood storage could provide significant stage reductions for smaller, more frequent flood events, but its effect on larger events is less dramatic. Estimated stage reductions in Fargo-Moorhead for a 1-percent chance flood range from less than 1.6 feet to 4.4 feet. Stage reductions for larger events are smaller. This alternative would leave the communities with significant residual flood risk and the need for continued flood fighting. Dams on main stems of rivers must be carefully designed with adequate emergency spillways in order to avoid the risk of catastrophic failure during a large flood event. Because the origin of major spring runoff cannot be predicted there is no guarantee that sufficient storage could be built to capture it in any given flood event. This alternative would provide a moderate level of risk reduction.

2.5.9 Separable Mitigation

The need for mitigation would depend on the location and project design. It is likely that it would not be possible to adequately mitigate for the environmental impacts at some main stem locations, while other sites could provide environmental benefits and need no separable mitigation. Mitigation of hydraulic impacts, possibly by purchasing flowage easements, would also probably be necessary as far upstream as water could be impounded. This alternative has a moderate level of separable mitigation.

2.5.10 Cost Effectiveness

Prior studies have been inconsistent regarding the cost-effectiveness of flood storage. It appears unlikely that a large system of flood storage projects would be economically justified from a Federal perspective, although some individual projects may be justified. Only preliminary economic benefits of the system were assessed for the Fargo-Moorhead area, but those results showed that the National Economic Development benefits would equal less than one third of the cost, making it unlikely that there is sufficient federal interest based solely on flood damage reduction.

An economic analysis presented in the Waffle plan report indicated that the Waffle concept may be economically justified, but there are several outstanding technical, social and political issues and institutional arrangements that need additional development before the concept could be implemented. The Waffle concept, as described in the report, does not fit any existing Corps of Engineers implementation authorities.

It is important to note that lack of Federal economic justification does not imply that flood storage should not be built or is not justified from a regional or local perspective. On the contrary, it is probable that local jurisdictions would find compelling reasons to construct flood storage projects that are effective on a small scale. Agricultural areas and rural infrastructure located downstream of small impoundments receive substantial benefits during summer rainstorms and spring snow-melt events.

The alternative has a low level of cost effectiveness.

2.5.11 Recommendation

Flood storage should no longer be considered as a stand-alone alternative for the Fargo-Moorhead area. The flood storage concept should be retained for possible implementation to mitigate for any adverse impacts of other plans or where it can be otherwise incrementally justified. The local communities should continue to seek opportunities for storage in the basin.

2.6 TUNNELING

2.6.1 Alternative Description

Large tunnels would be used to divert flows under the communities; this would function similar to a diversion channel, just underground. It was estimated that at least three 30-foot diameter tunnels approximately 25 miles long would be needed to provide approximately 25,000 cubic feet per second capacity. Tunneling would require little real estate acquisition, very little bridge or road building or modification, and the soil in the project area is very soft and would be easy to bore. Real estate interests would still be required to tunnel under private property, and real estate would also be required to dispose of the 10,370,000 cubic yards of excavated material.

2.6.2 Effectiveness

Tunneling, similar to diversion channels, would be very effective in reducing flood risk in the Fargo-Moorhead Metropolitan area. The effectiveness of the diversion channels is presented here to demonstrate what the impacts of tunneling could be. The smallest diversion considered in the screening exercise (25,000 cfs capacity) would reduce a 0.2-percent chance event to approximately 1-percent chance stages through town, and a 1-percent chance event would be reduced to less than 10-percent chance stages. The communities begin emergency measures between the 15 and 20-year events meaning that a diversion would nearly eliminate the need for emergency measures during smaller, more frequent floods, but flood fighting would still be needed for events approximately 1-percent chance or larger. Larger diversion alternatives could nearly eliminate the need for flood fighting except for the extremely rare and large events. This alternative is highly effective.

2.6.3 Environmental Effects

This alternative would have moderate negative impacts

2.6.3.1 Natural Resources

There would be potential adverse effects to habitat types due to land-use changes where the spoil material would be placed, aquatic habitat could be impacted due to loss of fish passage and potential sedimentation issues.

Overall the effects on natural resources would likely be negative.

2.6.3.2 Cultural Resources

Archeological resources near the tunnel inlet and where the spoil material is placed could be impacted. Cultural resources could be in or near the spoil areas and could be negatively impacted. Cultural resources in the existing floodplain in the Fargo-Moorhead area would receive benefits from tunneling and would not be as prone to flooding.

Overall the effects on cultural resources would likely be neutral.

2.6.4 Social Effects

Tunneling would still require a fairly large amount of agricultural land. The reduced flood risk would lead to continued regional growth, employment would continue to grow with the region and businesses would not need to provide support for regular emergency measures. Public safety would improve as the risk of catastrophic flooding would be largely minimized, however there would be risks to public safety at the inlet location of the tunnels, especially during high flow events. Local transportation would not be impacted due to the tunnel being underground. During flood events local transportation and evacuation routes would remain open and accessible to the public. This alternative would have high positive social effects.

2.6.5 Acceptability

Tunneling would have positive impacts on community cohesion. There could also be actual or perceived downstream impacts due to increased flood stages that may need to be addressed. These impacts could create a perception of a rural versus urban conflict. Within the communities during non-flood events the community would be allowed to grow with minimal threat of flooding for the future. There would be impacts to the aquatic habitat which may not be consistent with National or Corps policies. The sponsors have indicated that a level of permanent protection in excess of the 1-percent chance level is necessary for local acceptability, however if there are no other options permanent protection at the 1-percent level could be pursued. This alternative would be moderately acceptable.

2.6.6 Implementability

There are several technical issues to implementing a tunnel plan. The largest concern would be ensuring that the project would be able to function over the long-term. Sedimentation and maintenance issues with an underground project would be difficult. Tunnel plans have been employed successfully in San Antonio, Texas and the Port of Miami.

This alternative would be moderately implementable.

2.6.7 Cost

Research on other tunneling projects found that costs for a single bore tunnel varied from approximately $37 million per mile for the San Antonio, Texas River Tunnel to $677 million per mile for a proposed Port of Miami project, but typical costs range from $100 million to $350 million per mile. Assuming $50 million per mile, the three tunnels proposed for the Fargo-Moorhead project would cost $3.75 billion. This alternative would have extremely high costs.

2.6.8 Risk

Tunnels provide a high level risk reduction because they cannot fail suddenly and catastrophically. If a tunnel fails to perform, flood stages are no higher than they would have been without the project in place. However, tunnels would not eliminate flood risk, and are not fool-proof. Significant residual risk often remains from flood events larger than the design event, and emergency flood fighting would still be required for those extremely rare events which could lead to risks similar to the without project condition. There is a potential for blockage of the tunnel due to ice, debris, and sediment which would be most likely at the tunnel inlet. This alternative has a high level of risk reduction.

2.6.9 Separable Mitigation

If the project causes increased flood damages downstream, economic impacts could result in the need for ring levees, relocations, or buyouts. Impacts to the aquatic resources that cannot be addressed through project design could result in the need for mitigation, possibly including increasing fish passage at other locations in the basin. This alternative has a moderate level of separable mitigation.

2.6.10 Cost Effectiveness

The benefits of a tunnel alternative would be similar to a diversion channel with similar capacity. Considering the estimated cost of the tunneling, it does not appear that tunneling would be cost effective. The alternative has a low level of cost effectiveness.

2.6.11 Recommendation

There would be a number of positive aspects to a tunnel alternative, however due to the cost of this alternative being substantially greater than any of the diversion channels while providing similar benefits, and other uncertainties with long term maintenance and repair, it is recommended that no additional study of tunnels be conducted.

2.7 BRIDGE REPLACEMENT OR MODIFICATION

2.7.1 Alternative Description

Bridges can restrict the flow during flood events. Raising or modifying bridges can increase conveyance in the channel and reduce flood stages.

2.7.2 Effectiveness

The existing bridges in the study area were included in the hydraulic models for this study. Removing the bridges entirely had only minor effects on predicted flood stages. Modifying individual structures may provide some benefits, but it would not be effective as a stand-alone measure. This alternative would have a low level of effectiveness.

2.7.3 Environmental Effects

This alternative would have neutral impacts.

2.7.3.1 Natural Resources

No appreciable adverse effects. Overall the effects on natural resources would likely be neutral.

2.7.3.2 Cultural Resources

A number of cultural sites are in the study area so there is potential for adverse impacts to archeological sites near the bridge abutments and along the bridge piers. Overall the effects on cultural resources would likely be negative.

2.7.4 Social Effects

Impacts to transportation during construction would be minimal. Emergency evacuation routes would be able to stay open during flood events. Additional lands may be needed for construction. This alternative would have low positive social effects.

2.7.5 Acceptability

This alternative would have minimal impacts to community cohesion and little controversy would be expected. The sponsors have indicated that a level of permanent protection in excess of the 1-percent chance level is necessary for local acceptability, however if there are no other options permanent protection at the 1-percent level could be pursued. This alternative would provide only minor levels of flood risk reduction. This alternative would have a low level of acceptability.

2.7.6 Implementability

This alternative would be implementable and it has no major issues. This alternative has a high level of Implementability.

2.7.7 Cost

No estimates for bridge modification were prepared for this study. If this alternative were constructed the community would still have a residual flood risk of nearly $74 million annually. This alternative would have extremely high costs.

2.7.8 Risk

The community would continue to be at risk of flooding. This alternative has a extremely low level of risk reduction.

2.7.9 Separable Mitigation

No separable mitigation would be necessary. This alternative has a low level of separable mitigation.

2.7.10 Cost Effectiveness

Based on prior experience on other projects and on the hydraulic modeling conducted for this project, it appears unlikely that raising or modifying bridges would be cost effective in Fargo-Moorhead. This alternative has a low level of cost effectiveness.

2.7.11 Recommendation

This alternative should not be considered further as a stand-alone plan, but should be retained for possible inclusion in an overall plan if it can be incrementally justified.

2.8 INTERSTATE 29 VIADUCT

2.8.1 Alternative Description

Reconstructing the Interstate 29 (I-29) corridor to serve as an open viaduct during floods was considered. The reconstructed corridor would function as an interstate highway during non-flood times. It would essentially be a diversion channel with an interstate highway either on the bottom or elevated.

2.8.2 Effectiveness

The corridor, like a diversion channel, would be very effective in providing flood risk management for the Fargo-Moorhead Metropolitan Area. This level of risk reduction could provide a high level of flood risk management. For events in excess of the design event it would reduce the possibility of catastrophic failures and the cities would likely be able to flood fight those events. This alternative is highly effective.

2.8.3 Environmental Effects

This alternative would have low negative impacts.

2.8.3.1 Natural Resources

The alternative could have potential adverse effects on the aquatic resources caused by impacts to fish passage and fish trapping. The alternative would be designed to ensure that impacts to aquatic habitat would be minimized to the greatest extent possible and that the overall impact to the resource would be less than significant. The channel would impact the depth of groundwater near the channel. There would be little opportunity to provide and environmental enhancements to the project as it would also function as an interstate highway.

Overall the effects on natural resources would likely be negative.

2.8.3.2 Cultural Resources

Cultural resource impacts would be minimal. They would mainly occur at the inlet and outlet of the corridor. Historic structures would be less likely to flood and would benefit from this alternative. Overall the effects on cultural resources would likely be positive.

2.8.4 Social Effects

Traffic would face major disruptions during flood events, unless the highway was elevated. I-29 serves as a major evacuation route during flood events, which would be a major life-safety issue. Regional growth, public safety, and employment would be affected positively. The project would have minimal positive impacts on recreation because those features could only be incorporated at the inlet and outlet channels. This alternative would have moderate positive social effects.

2.8.5 Acceptability

This plan would eliminate a major transportation route for the duration of a flood event which would not be acceptable. If I-29 were elevated the project would have the same acceptability as the diversion channels. The sponsors have indicated that a level of permanent protection in excess of the 1-percent chance level is necessary for local acceptability, however if there are no other options permanent protection at the 1-percent level could be pursued. This alternative would be highly acceptable.

2.8.6 Implementability

Making a raised road in the corridor or putting the road on the bottom of the corridor would have significant technical issues. The project would require demolition of the existing infrastructure, construction of the diversion channel and reconstruction of the infrastructure. This would cause long disruptions to interstate traffic during construction. This alternative has a low level of implementability.

2.8.7 Cost

Excavation volumes per mile for this alternative would be similar to those of a comparable diversion plan, although the total length could be shorter. Demolition and reconstruction of the existing interstate would cost at least $400 million. Real estate would be required to dispose of the excavated material. Total cost of this alternative would likely be $1.4 billion to 4.0 billion. Operation and maintenance costs of the corridor and the roadway would be high. Residual damages would be similar to the diversion channels. This alternative has high costs.

2.8.8 Risk

Concerns with this alternative include ice jams, access to evacuation routes during flood events, and long term maintenance of the structures. Local drainage and snow melt year-round and backwater into the channel during minor flood events would inundate a highway located at the bottom of the channel. The risk of floods would decrease significantly, similar to the diversion channels. This alternative has a moderate level of risk reduction.

2.8.9 Separable Mitigation

If the project causes increased flood damages downstream, economic impacts could result in the need for ring levees, relocations, or buyouts in downstream locations. Impacts to the aquatic resources that cannot be addressed through project design could result in the need for mitigation, possibly including increasing fish passage at other locations in the basin. Mitigation may be necessary for fish passage on the Red River. This alternative has a moderate to high level of separable mitigation.

2.8.10 Cost Effectiveness

The cost to excavate the I-29 viaduct would be similar to the diversion alternatives, but the total cost would include additional demolition and reconstruction of the interstate corridor. The costs appear to exceed any diversion alternative being considered. Because the concept would provide similar benefits at greater cost, it does not appear to be cost effective. This alternative would have a low level of cost effectiveness.

2.8.11 Recommendation

The I-29 viaduct concept should no longer be considered for further analysis.

2.9 DREDGING AND WIDENING THE RED RIVER

2.9.1 Alternative Description

Digging the Red River channel deeper and wider to allow for more flow to pass through the Fargo-Moorhead Metropolitan Area was considered. This alternative could also be looked at underneath existing bridges to prevent the damming effect the bridges can create.

2.9.2 Effectiveness

This alternative would have very limited hydraulic effectiveness and would likely have negative effects on the stability of the riverbanks throughout the length of the project. Sedimentation following project implementation would be a concern, and if maintenance was not completed properly, any benefits of the project would be lost. This alternative has a low level of effectiveness.

2.9.3 Environmental Effects

This alternative would have high negative impacts.

2.9.3.1 Natural Resources

Dredging and widening the channel would have a variety of potential adverse effects. Increased sedimentation, displacement of mussels, erosion issues, riparian forest habitat loss, aquatic habitat, and wildlife mortality issues would need to be addressed. Overall the effects on natural resources would likely be negative.

2.9.3.2 Cultural Resources

Dredging and widening the channel would have a large potential impact on archeological resources, which are typically located on riverbanks, and would be disturbed by this alternative. These impacts would require costly mitigation. Overall the effects on cultural resources would likely be negative.

2.9.4 Social Effects

This alternative would change the appearance and function of the river in Fargo and Moorhead. Properties along the river would need to be acquired to address slope stability issues, which would require that the banks be cut back to allow for a deeper channel. Local bridges would need to be modified to accommodate the larger channel and dredging operations. This alternative would have high negative social effects.

2.9.5 Acceptability

This alternative is not acceptable and violates many local and national policies. There would be a great deal of controversy. This alternative has a low level of acceptability.

2.9.6 Implementability

It is not possible to implement this project. This alternative has a low level of Implementability.

2.9.7 Cost

Costs would be excessive. Operations and maintenance costs would be high and long-term. Environmental mitigation costs would be extreme, assuming mitigation would be possible. The communities would still face large residual risks, and if continued dredging was not maintained, any benefits of the project would be lost. This alternative has extremely high costs.

2.9.8 Risk

The project would be at risk of failure due to sedimentation. The community would still be at risk of flooding. This alternative has a low level of risk reduction.

2.9.9 Separable Mitigation

It would probably not be possible to mitigate for the environmental impacts of this alternative. This alternative would have extremely high levels of separable mitigation.

2.9.10 Cost Effectiveness

Cost effectiveness was not determined, but it is very unlikely that benefits would outweigh costs. This alternative would have a low level of cost effectiveness.

2.9.11 Recommendation

This concept to dredge and widen the Red River should no longer be considered for further analysis.

2.10 WETLAND AND GRASSLAND RESTORATION

2.10.1 Alternative Description

This alternative includes restoration of drained wetlands, restoration of grasslands, and changes in land use practices in the watersheds upstream of the Fargo-Moorhead Metropolitan Area. These features would reduce peak runoff, change flood frequency, and serve as water storage during flooding. The features would be distributed throughout the upstream portion of the basin and would generally provide low level storage that would be primarily used for wetlands and habitat.

2.10.2 Effectiveness

Effects would be primarily localized. Major beneficial effects on flood damage reduction in the Fargo-Moorhead Metropolitan Area are unlikely. The effectiveness in any given year would depend on the antecedent conditions. A significant effect on flood flows in the Fargo Moorhead Metropolitan area would likely require landscape scale changes and major modifications. The effectiveness would be expected to be less than that of flood storage. This alternative has a low level of effectiveness.

2.10.3 Environmental Effects

This alternative would have high positive impacts.

2.10.3.1 Natural Resources

Wetland and grassland habitat would be greatly enhanced. Associated benefits such as reduced sedimentation, turbidity downstream, and improvements in water quality would be expected. Overall the effects on natural resources would likely be positive.

2.10.3.2 Cultural Resources

A number of cultural resource sites are within the study area so there is potential for adverse impacts to archeological sites. Converting land use to wetland or grassland would likely require minimal excavation or fill activities causing minor temporary impacts. Overall the effects on cultural resources would likely be neutral.

2.10.4 Social effects

Large amounts of land would be necessary for the implementation of this alternative, primarily impacting agricultural production. Roads may need to be relocated, which would have impacts on transportation. The flood benefits of these projects could be mainly for the urban areas while the rural areas would be providing the land necessary for the project. The alternative could create recreational opportunities such as hunting and bird watching. This alternative would have moderately positive social effects.

2.10.5 Acceptability

This alternative would affect a large number of landowners and would not provide a large amount of flood risk reduction for the Fargo-Moorhead Area. Conflict between the urban areas and the rural areas could arise because of the need for project land. It may be acceptable to implement this in conjunction with another alternative. The sponsors have indicated that a level of permanent protection in excess of the 1-percent chance level is necessary for local acceptability, however if there are no other options permanent protection at the 1-percent level could be pursued. This alternative has a moderate level of acceptability.

2.10.6 Implementability

The project would be difficult to implement in a reasonable amount of time, and there are legal issues with the ability to acquire the land necessary for the project. Site identification could be difficult, and ensuring that the restoration was located in the right areas to provide the necessary storage to ensure reliability of the system could be a challenge. Local implementation of small projects within the basin could be a viable local solution, but the benefits would not likely have a major impact on flooding in the Fargo-Moorhead Metropolitan Area. This alternative has a low level of implementability.

2.10.7 Cost

The cost of this alternative is expected to be high. It would be higher than that of flood storage alone because of the need to have a greater number of shallow storage sites along with the costs to ensure the proper native plant species get established. This alternative would have an extremely high cost.

2.10.8 Risk

The project would likely provide less than the 1.6 feet of stage reduction identified in the flood storage alternative for a 1 percent chance event at Fargo-Moorhead. The communities would remain at risk of flooding. Identification and implementation of this alternative in a reasonable timeframe is also unlikely. This alternative would have low level of risk reduction.

2.10.9 Separable Mitigation

No separable mitigation would be necessary. This alternative would have a low level of separable mitigation.

2.10.10 Cost Effectiveness

Restoring wetlands and grasslands is not likely to be cost-effective for flood damage reduction. It may be considered cost-effective for environmental purposes. This alternative would have a low level of cost effectiveness.

2.10.11 Recommendation

Restoring wetlands and grasslands should no longer be considered as a stand-alone alternative, but may be considered for inclusion to mitigate for other adverse project effects where it can be incrementally justified.

2.11 CUT-OFF CHANNELS

2.11.1 Alternative Description

Building cut-off channels across meanders in the cities was considered. Such channels would provide the water a straighter path through the city and potentially reduce peak stages. The channels would be designed with a bottom elevation above a certain design stage to allow the river to flow naturally up until a design event at which time the excess flow would flow into the cut-off channel. Four cut-off channels in the Fargo-Moorhead Area were constructed as part of the Federal flood control project completed in 1963.

2.11.2 Effectiveness

Cut-off channels would not be effective as a stand alone alternative. They could be used in conjunction with a levee plan to increase conveyance in the channel and reduce upstream stages. This alternative has a low level of effectiveness.

2.11.3 Environmental Effects

This alternative would have high negative environmental effects.

2.11.3.1 Natural Resources

Cut off channels would have a potential adverse effect on the fishery resource in the Red River when the flows exceed the design event. Riparian habitat would be negatively affected because of loss of woodlands from construction. Channels could disrupt the normal geomorphology of the stream, and if erosion occurred, the river channel could be permanently altered. Overall the effects on natural resources would likely be negative.

2.11.3.2 Cultural Resources

A number of historical structures could be directly or indirectly affected by flood storage measures, and mitigation would be required for the adverse effects. A number of cultural sites are in the study area, so there is potential for adverse impacts on archeological sites. Overall the effects on cultural resources would likely be negative.

2.11.4 Social Effects

Flooding in the Fargo-Moorhead area would likely continue and the social effects would be similar to the existing condition. This alternative would have highly negative social effects.

2.11.5 Acceptability

This alternative is not acceptable to the resource agencies and potentially could violate a number of State and Federal policies. The sponsors have indicated that a level of permanent protection in excess of the 1-percent chance level is necessary for local acceptability, however if there are no other options permanent protection at the 1-percent level could be pursued. This alternative has a low level of acceptability.

2.11.6 Implementability

This alternative is not implementable as a stand alone alternative. It could be implemented as an additional measure for other plans if acceptability issues can be overcome. This alternative has a low level of Implementability.

2.11.7 Cost

Costs were not estimated for screening purposes. It would be assumed that residual damages would continue within the community resulting in similar damages as the existing condition. The costs of this alternative are extremely high.

2.11.8 Risk

Environmental impacts would possibly be large and the community would continue to be at risk of flooding. This alternative would have a high level of risk.

2.11.9 Separable Mitigation

Impacts to the aquatic resources that cannot be addressed through project design could result in the need for mitigation, possibly including increasing fish passage at other locations in the basin. The loss of riparian habitat caused by the cut-off channel will have to be mitigated. This alternative would have a low level of separable mitigation.

2.11.10 Cost Effectiveness

Cost effectiveness would be site specific and no specific analysis has been conducted. It is anticipated that there would be a low to moderate level of cost effectiveness.

2.11.11 Recommendation

Cut-off channels should not be considered as a stand-alone alternative but should be retained for possible inclusion in an overall plan where they could be incrementally justified.

3.0 RECOMMENDATION

The following stand-alone alternatives are recommended for further evaluation:

- Future without Project Condition--No Action
- Diversion Channels

The following alternatives are not recommended for further evaluation as stand-alone alternatives for this project:

- Levees/Floodwalls
- Non-Structural Measures
- Flood Storage
- Tunneling
- Bridge Replacement or Modification
- Interstate 29 Viaduct
- Dredging and Widening the River
- Wetland and Grassland Restoration
- Cut-Off Channels

The following measures should be considered for possible inclusion as features of the overall plans evaluated in detail where they can be incrementally justified:

- Non-Structural Measures
- Flood Storage
- Bridge Replacement or Modification
- Wetland and Grassland Restoration
- Cut-Off Channels

Table 1: Alternative Screening Summary

Fargo-Moorhead Metro Feasibility Study
Initial Screening Results, October 2009
Screened Alternatives Ranked by Net Benefits

Alternative	First Cost *	Avg Annual Net Benefits *	Residual Damages *	B/C Ratio
MN Short Diversion 25K	962	11.0	14.3	1.22
MN Short Diversion 35K	1,092	9.4	9.3	1.17
Levee 1% chance (100-year)	902	7.7	20.9	1.17
MN Long Diversion 25K	1,055	5.6	15.0	1.10
MN Short Diversion 45K	1,264	2.5	7.4	1.04
MN Long Diversion 35K	1,260	0.3	9.8	1.00
ND East Diversion 35K	1,337	-3.1	9.2	0.95
ND West Diversion 35K	1,363	-4.4	9.2	0.94
Levee 2% chance (50-year)	840	-5.3	37.1	0.88
ND West Diversion 45K	1,439	-6.7	7.6	0.91
MN Long Diversion 45K	1,459	-8.3	8.2	0.89

* In millions of dollars

Note: Expected average annual damages without a project are $73.7 million.

Table 2: Alternatives Screening Summary Matrix

Resource Category	Alternative: Future Without Project Conditions	Flood Barriers	Diversion Channels	Non-Structural Measures
Alternative Description	Emergency measures currently being pursued in the project area will continue to be implemented as necessary due to flooding. These include raising levees, constructing temporary levees and floodwalls in various areas, and sandbagging.	This alternative includes the use of permanent flood barrier systems including levees, floodwalls, invisible floodwalls, gate closures, and pump stations. Two different top profiles to reliably contain the 2% chance flood and the 1% chance flood. Initial analyses were based on constructing levees in both Fargo and Moorhead to the design levels and assessing the costs and economic benefits of the plans.	Route flood flows around the metropolitan area. Several potential alignments will be considered, including alignments in both Minnesota and North Dakota and incorporating the existing Sheyenne Diversion from Horace to West Fargo.	Relocation of structures, buyout and demolition of structures, elevation of structures, removal of basement, dry flood proofing, wet flood proofing, land acquisition, flood management plans, vertical construction for residential occupancy. Additionally flood warning, preparedness, evacuation plans and pertinent equipment installation, and nonstructural berms, levees, and floodwalls are considered.
Effectiveness	(Low) Not expected to provide consistent/reliable long-term risk reduction. Emergency measures are temporary, demand high number of workers in extreme weather, are a risk to human health.	(Moderate) Levees and other properly designed and constructed flood barriers can prevent damages from most flood events that do not exceed their maximum design event.	(High) Effectively eliminate flooding for small events, but require flood fighting for large events. Diversions generally provide robust risk reduction.	(High) Effectively reduces risk to structures and their contents up to the design event. Floods would still have potentially large impacts on infrastructure, evacuation routes, and daily life and business activities.
Environmental Effects - Natural Resources	(Negative) Emergency levees are susceptible to erosion, feeding sediment into the river. They adversely impact terrestrial vegetation, and borrow sites.	(Neutral) Resources affected along embankment alignment. Wetland mitigation may be required. Open space between barrier and river will provide benefits. Larger riparian areas.	(Neutral) Issues such as fish passage and sedimentation arise. Also, wetlands and ground water may be impacted. The channel would be designed to include wetland and/or prairie swale type habitat within the diversion channels which could lead to increased habitat quantity and value from the existing conditions.	(Positive) Removal/relocation of homes allows to develop riparian habitat, restoration of wetlands, greenway area for recreational and ecosystem benefits.
Environmental Effects - Cultural Resources	(Negative) Excavating borrow material, building temporary levees/floodwalls, removing temporary levees/floodwalls all have the potential to have adverse effects on cultural resources. Failure of the temporary levees/floodwalls would also have adverse impacts to cultural properties/resources.	(Negative) There are a number of historical structures that would be directly or indirectly impacted by the construction of the in-town levees, and mitigation would be required for the adverse impacts. Potential for adverse impacts on deeply buried archeological sites, and historical structures and requires mitigation.	(Negative) High potential for impact to archeological sites within the area, particularly buried sites where channels leave, enter, or cross rivers. Historical structures may be directly or indirectly impacted.	(Neutral) A number of historical structures would be directly or indirectly impacted. Potential adverse impact to archeological sites. The alternative would also minimize the chance of flooding to historical structures.
Social Effects	(High Negative) Negative effect on businesses, transportation, recreational facilities, and public services. Emergency measures failure may result in loss of community, community cohesion, public safety, and potential loss of life.	(Moderate Positive) Positive: improved public safety during flood events, regional business growth, less frequent emergency actions, addition of recreational components. Negative: 1000 structures removed, road closures during floods. Failure would result in significant threat to public safety.	(High Positive) A large amount of agricultural land would be necessary. Regional growth, public safety, employment, and recreation would all benefit from the project.	(High Negative) Required evacuation during floods would adversely effect transportation, business, regional growth. Large percentage of structures would be impacted by the required modifications.
Acceptability	(Low) Not acceptable as a long term solution. Eventually flood fighting will adversely effect the local community and region.	(Moderate) Alternative will disrupt community cohesion by removal of approximately 1000 structures, railroad lines, increased flood stages upstream, and will not meet sponsors desired level of protection.	(Moderate) This plan is acceptable but will impact a number of agricultural properties. There could also be actual or perceived downstream impacts due to increased flood stages that may need to be addressed. Controversy will be more of an issue depending on which diversion is selected.	(Low) Necessary modifications to individual structures would be extremely controversial and have little support from local sponsors.
Implementability	(Moderate) Legal and technical issues complicate implementation of emergency measures. Obtaining rights of access on short notice is difficult and controversial. Maximum level of protection limited by natural ground..	(Moderate) Difficulty in timely implementation. Feasible protection can be constructed up to a maximum of 1% chance level.	(High) There are some technical issues to implementing this plan, the largest concern would be with the Red River control structure and the tributary structures. Diversions have been successfully used in other projects in the Red River Valley.	(Low) Difficult implementing due to enormous number of affected properties.
Cost	(Extremely High) Extremely high costs ($74 million / year). 500yr event may exceed $6 billion.	(High) 2% chance flood protection estimated at $840 million, and $902 million for 1% chance level of protection. The 1% levee plan would leave the community susceptible to residual damages averaging more than $20 million annually.	(Medium) Costs for the nine diversion alternatives investigated range from $962 million to $1.46 billion. The plans all reduce the residual risk to the communities to less than $14 million annually and would allow for emergency flood fighting if necessary.	(Extremely High) 1% and 0.2% chance floods estimated to cost $1.6 billion and $4.7 billion respectively. Even if the 1% or the 0.2% plans were developed the community would still be at risk of flooding and there would be residual damages to local infrastructure.
Risk*	(Extremely low) Extremely low level of risk reduction and there would be a high risk of future flooding. Reliability of emergency measures is poor. Mobilizing man power is difficult and unreliable, and those people are placed at risk. Unreliable protection as a result of construction measures.	(Moderate) This plan will provide risk reduction up to the design event; once that event is exceeded catastrophic damages will occur. This plan may also induce additional growth between the 1% chance and 0.2% chance flood plains resulting in greater risk to the community over time.	(High) Flood stages are no higher than they would have been without the project in place. They are not fool-proof and significant residual risk often remains from flood events larger than design event, and there is potential for channel blockage from debris and ice.	(Moderate) High risk to public infrastructure, looting and property damage, evacuation routes. Population relocation may be required.
Separable Mitigation	(High) Repair of damaged properties following flood event is necessary resulting in large costs for removal and repair.	(Moderate) The plan may result in quantifiable damages resulting from increased flood stages up and downstream and would require mitigation with option such as upstream storage, ring levees, and non-structural solutions.	(Moderate to High) If project causes increased flood damages downstream, mitigation would be required such as ring levees, buyouts, and relocations. Aquatic resource mitigation may be required and would be more likely with the tributary structures.	(Low) None is anticipated.
Cost Effectiveness	(Moderate) Emergency measures are cost effective, because they prevent damages far in excess of their cost.	(Moderate) From the investigated levee plans only 1% chance levee was determined cost effective.	(Low-High) Smaller diversions were found to provide better cost effectiveness, and all of the Minnesota short diversions were cost effective	(Low) Not cost effective with BCRs of less than 0.35.
Recommendation	The future without project (no action) alternative should be retained as the base condition for comparison with all other alternatives.	Levee plans should no longer be considered as a stand-alone alternative. The levee plans would provide a limited level of risk reduction, have large short term social impacts, high costs, and relies on emergency measures for larger flood events.	Diversion concept should be retained for further refinement. Preliminary analysis shows that the Minnesota Short Diversion appears implementable, effective, and cost effective.	Non-structural measures should no longer be considered as stand-alone alternatives

* Risk is measured based on the risk reduction, therefore a plan with a rating of high would have a high level of risk reduction, meaning the community would be less susceptible to flooding.

Table 2: Alternatives Screening Summary Matrix

Resource Category	Alternative: Flood Storage	Tunneling	Bridge Replacement or Modification	Interstate 29 Viaduct
Alternative Description	Preserve natural floodplain areas, restore wetalnds, build dams and other water retention facilities to hold water during flood events. Impoundments may be designed to remain dry until a flood event or to retain a pool during nonflood times for conservation or water supply purposes.	A series of tunnels underneath the city to convey the water and reduce the water levels in the river.	Bridges can restrict the flow during flood events. Raising or modifying bridges can increase conveyance in the channel and reduce flood stages.	Reconstructing the Interstate 29 corridor to serve as an open viaduct during floods was proposed. The reconstructed corridor would function as an interstate highway during non-flood times.
Effectiveness	(Low) Very difficult to ensure that the system would be reliable and effective. A model of system of impoundments with 400,000 acre feet of storage indicated that it could reduce the 1% chance flood stage in Fargo-Moorhead by less than 1.6 feet.	(High) Tunneling, would be effective in reducing flood risk, eliminating emergency measures during smaller floods. Large floods would also see a reduction in flood risk. Overall flood risk reduction is dependent on tunnel capacity.	(Low) Not an effective stand alone measure. Removing the bridges entirely has only minor effects.	(High) Would effectively provide flood risk management, reducing flood risk for small and large events.
Environmental Effects - Natural Resources	(Positive) May be both beneficial and detrimental, with dams causing adverse effects, and off-channel storage can be beneficial. Off-channel storage located on poorly-drained agricultural sites, former wetlands, or drained lakes can be environmentally beneficial if designed and managed properly.	(Negative) There are adverse effects on aquatic habitat due to loss of fish passage and potential sedimentation. Potential adverse effects on areas where spoil material would be placed.	(Neutral) No appreciable adverse effects.	(Negative) Issues such as fish passage and sedimentation arise. There would be little opportunity to provide any environmental enhancements to the project as it would also function as an interstate highway.
Environmental Effects - Cultural Resources	(Negative) Flood storage project may cover cultural resources and impact archeological resources.	(Neutral) Possible adverse impact to archeological resources near tunnel inlet/outlet and location of spoil material placement are possible. Cultural resources in the existing floodplain in the Fargo-Moorhead area would receive benefits from tunneling and would not be as prone to flooding.	(Negative) Potential for impact to archeological sites near bridge abutments and piers. Potential to adversely affect National Register eligible or listed bridges.	(Positive) Minimal impacts could occur at the inlet and outlet of the corridor. Historic structures would be less likely to flood and would benefit from this alternative.
Social Effects	(Moderate Positive) Large amounts of agricultural land would be necessary for acquisition or may be impacted. Depending on the depth of the storage areas and timing of storage, there could be a potential for recreational opportunities such as boating, fishing, or hunting.	(High Positive) Alternative requires a substantial amount of agricultural land. Regional growth, public safety, employment, and recreation would all benefit from the project.	(Low Positive) There would be minimal impact to transportation during construction, and emergency evacuation routes would be able to stay open during flood events.	(Moderate Positive) There would be major negative impacts to the transportation and evacuation route during flood events. Positive effects that may be seen are regional growth, public safety, and employment.
Acceptability	(Low) Very difficult to implement in reasonable amount of time. Issues with land acquisition such as legal processes and scarcity in economical storage.	(Moderate) There could be actual or perceived downstream impact that will need to be addressed. There would also be an adverse impact to the aquatic habitat.	(Low) Because of minimal levels of risk reduction this plan is not acceptable.	(High) The resulting impact to the transportation would not be acceptable. Elevation of the interstate would bring the project to the acceptability of the diversion.
Implementability	(Low) It is likely that additional flood storage will be built upstream of the study area, but that storage alone is not likely to adequately reduce flood risk to the study area over the next 50 years.	(Moderate) There are technical issues such as sedimentation and maintenance for an underground project to make sure the functionality of the alternative over a long-term.	(High) Alternative is implementable with no major issues.	(Low) Significant technical issues raising or lowering the road which involve demolition and reconstruction.
Cost	(Extremely High) Cost range from $160-$543 million depending on level of protection and type of plan. The communities would still face a large residual flood costs.	(Extremely High) Typical costs range from $100 - $350 million per mile.	(Extremely High) No estimates were prepared. Alternative would not reduce the residual flood risk. If this alternative were constructed the community would still have a residual flood risk of nearly $74 million annually.	(High) Estimated cost of $1.4 - 4.0 billion, with large operation and maintenance cost.
Risk*	(Moderate) Able to help with small events, but the estimated stage reduction for large events is not significant.	(High) Large flood risk reduction is achieved with this alternative. There is minimal risk of sudden or catastrophic failure. Residual risk often remains from flood events larger than the design event, and emergency flood fighting would still be required for those extremely rare events which could lead to risks similar to the without project condition.	(Extremely Low) Community would continue to be at risk of flooding.	(Moderate) Risks include ice jams, access to evacuation routes during floods, maintenance of the structure, backwater during minor floods. The risk of floods would decrease significantly, similar to the diversion channels.
Separable Mitigation	(Moderate) Mitigation depends on the project location, and is likely that it would not be possible to adequately mitigate environmental impacts.	(Moderate) If alternative results in increased flood damage downstream, mitigation would be required.	(Low) None is anticipated.	(Moderate) If project causes increased flood damages downstream, mitigation would be required such as ring levees, buyouts, and relocations. Aquatic resource mitigation may be required.
Cost Effectiveness	(Low) Unlikely to be economically justifiable for large systems, but may be considered for small areas.	(Low) Alternative is much more expensive than diversion with similar benefits.	(Low) Unlikely to be cost effective.	(Low) Cost similar to diversion alternative plus additional to demolish and reconstruct the roadway, with similar benefits to the diversions.
Recommendation	Flood storage should no longer be considered as a stand-alone alternative for the Fargo-Moorhead area as part of this project. Local communities should continue to seek opportunities for storage in the basin.	There would be a number of positive aspects to a tunnel alternative, however due to the cost of this alternative being substantially greater than any of the diversion channels while providing similar benefits, and other uncertainties with long term maintenance and repair, it is recommended that no additional study of tunnels be conducted.	Bridge replacement/modification should not be considered further as a stand-alone plan, but should be retained for possible inclusion in an overall plan if it can be incrementally justified.	The I-29 viaduct concept should no longer be considered for further analysis.

* Risk is measured based on the risk reduction, therefore a plan with a rating of high would have a high level of risk reduction, meaning the community would be less susceptible to flooding.

Table 2: Alternatives Screening Summary Matrix

Resource Category	Alternative: Dredging and Widening the River	Alternative: Wetland and Grassland Restoration	Alternative: Cut-off Channels
Alternative Description	Digging the Red River channel deeper and wider to allow for more flow to pass through the Fargo-Moorhead Metropolitan Area was proposed. This alternative could also be looked at underneath existing bridges to prevent the damming effect the bridges can create.	Restoration of grassland and wetlands to reduce peak runoff and serve as water storage during flooding events was proposed.	Building cut-off channels across meanders in the cities was proposed. It would provide the water a straighter path through the city and potentially reduce peak stages.
Effectiveness	(Low) Very limited hydraulic effectiveness and would likely negatively affect the stability of the river banks. Sedimentation following project implementation would be a concern and if maintenance was not completed properly any benefits of the project would be lost.	(Low) Effects are localized with no likely major benefit for Fargo-Moorhead Metropolitan Area. The effectiveness would be expected to be less than that of flood storage.	(Low) Alternative is not effective as a stand-alone.
Environmental Effects - Natural Resources	(Negative) There would be increased sedimentation, displacement of mussels, erosion issues, riparian forest habitat loss, aquatic habitat impacted, and wildlife mortality issues during dredging.	(Positive) Wetland and grassland habitat would greatly be enhanced and provide associated benefits to the water quality downstream.	(Negative) Alternative would impact riparian habitat, geomorphology of the stream, and fishery resource when flow exceeds design event.
Environmental Effects - Cultural Resources	(Negative) High potential for impact to archeological resources located on river banks.	(Neutral) There are a number of cultural sites within the study area so there is potential for adverse impacts to archeological sites.	(Negative) Alternative has potential to affect historical structures, and high potential to affect archeological sites.
Social Effects	(High Negative) Alternative would change appearance and function of the river. Properties along the river would need to be acquired due to slope stability issues which would require that the banks be cut back to allow for a deeper channel.	(Moderate Positive) Large amounts of land acquisition is required impacting agriculture and urban areas, and potentially transportation. Benefits are recreational opportunities such as hunting.	(High Negative) Social effects similar to existing condition with a similar risk of flooding.
Acceptability	(Low) Not an acceptable alternative and violates many local and national policies.	(Moderate) Alternative impacts a large number of landowners, and does not provide a lot of flood risk reduction.	(Low) Alternative is unacceptable to the resource agencies and potentially violates state and federal policies.
Implementability	(Low) Not Implementable.	(Low) The project is difficult implementing due to large amount of impacted land, and legal issues.	(Low) Not implementable as a stand-alone.
Cost	(High) Excessive – operations and maintenance costs would be large and long term. Environmental mitigation costs would be extreme. The communities would face large residual risks and if continued dredging was not maintained any benefits of the project would be lost.	(Extremely High) Cost is expected to be large, exceeding that of the storage alternative.	(Extremely High) No estimates were prepared. Cost of residual damage is assumed to be similar to the existing condition.
Risk*	(Low) There would be risk of project failure due to sedimentation. The community would still be at risk of flooding.	(Low) The impact of implementation of this alternative would not provide sufficient flood risk reduction leaving the areas at high risk of future flooding.	(High) There would possibly be large environmental impacts and community will continue to be at high flood risk.
Separable Mitigation	(Extremely High) Not possible to mitigate environmental impacts.	(Low) None is anticipated.	(Low) Besides replacement of trees, none is anticipated.
Cost Effectiveness	(Low) Not determined, but it is likely that the costs will outweigh the benefits.	(Low) Unlikely to be cost effective for flood damage reduction.	(Low to moderate) Cost effectiveness would be site specific.
Recommendation	Dredging and widening the river should no longer be considered.	Restoring wetlands and grasslands should no longer be considered as a stand-alone alternative, but may be considered for inclusion to mitigate for other adverse project effects where it can be incrementally justified.	Cut-off channels should not be considered as stand-alone alternatives but should be retained for possible inclusion in an overall plan where they could be incrementally justified.

* Risk is measured based on the risk reduction, therefore a plan with a rating of high would have a high level of risk reduction, meaning the community would be less susceptible to flooding.

APPENDIX O
ATTACHMENT 5

Value Engineering Study Report

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ST. PAUL DISTRICT
VALUE ENGINEERING STUDY

U.S. Army Corps of Engineers

VALUE ENGINEERING STUDY SUMMARY REPORT

FARGO-MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT

FARGO, NORTH DAKOTA & MOORHEAD, MINNESOTA

U.S. Army, Engineering District
St. Paul, Minnesota

VALUE ENGINEERING TEAM STUDY

DOD SERVICE: USACE
CONTROL NO: CEMVP-VE-10-01
VALUE ENGINEERING OFFICER: Robert Dempsey

Value Engineering Study on the

FARGO-MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT

December 2009
U.S. Army Engineer District, St. Paul

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VALUE ENGINEERING TEAM STUDY

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VALUE ENGINEERING TEAM STUDY

PROJECT DESCRIPTION AND BACKGROUND

PROJECT TITLE: Fargo-Moorhead Flood Risk Management Project
PROJECT LOCATION: Fargo, North Dakota & Moorhead, Minnesota.

The Fargo-Moorhead area, population 196,000, is located in Cass County ND & Clay County MN on the Red River. The community has a long history of dealing with flooding on the Red River and has been subjected to recent flood events in 2009, 2001 & 1997. The communities have flood control levees and a diversion channel project around sections of West Fargo on a reach of the Sheyenne River but the community has no comprehensive flood control system to protect it from a 100 year event. To that end the community and the U.S. Army Corps of Engineers have initiated planning studies aimed at identifying a project that would provide a permanent 100 year level of protection in the Fargo-Moorhead area. Project management for that effort requested a Value Engineering (VE) study be performed on the feasibility level report that identifies nine alternatives that would convey flood flows both through the city and around their perimeter utilizing 700-1000' wide channels measuring 20-30' in depth.

Figure 1 – Vicinity Map

Any of the proposed project alignments in the feasibility report are estimated to cost in excess of $900M which invokes the requirements of Engineering Regulation ER 11-1-321 (Value Engineering) requiring all projects and procurements greater than $1M in scope to have an appropriate VE study completed. This effort targeted only the alignments developed in the feasibility report and does not satisfy the project VE requirement by it self. As the project moves forward into design, additional studies on the selected design features would be required.

EXECUTIVE SUMMARY

Fargo- Moorhead Metro Flood Risk Management Study

Value Engineering is a process used to study the functions a project is to provide. As a result, it takes a critical look at how these functions are met and develops alternative ways to achieve the same function while increasing the value of the project. In the end, it is hoped that the project will realize a reduction in cost, but adding value over reducing cost is the focus of VE.

The VE study was initiated during the week of 30 Nov – 4 December 2009 at the Marriot Courtyard hotel in Moorhead, Minnesota. The team reviewed the Fargo-Moorhead (F-M) Metro feasibility report and cost estimates published in September of 2009 which details proposed project features of nine potential project alignments to divert a significant portion of floodwaters that currently threaten the community into diversion channels that could be constructed along the perimeter of either city. The team also completed a general tour of the vicinity to become familiar with the project site. VE team personnel then applied their engineering skills to develop the ideas presented in this report. VE ideas presented in this report will be reviewed by the Project Delivery team for comment prior to this report being finalized.

The VE study was accomplished as follows:

30 November - 8 a.m. – Project Manager briefing on the Feasibility Study.
10 a.m. – Travel to Moorhead, Minnesota
3 p.m. – Site Visits along West Fargo & City Levee projects.

1-3 December 8 -4:30 p.m. – VE Team Discussion and Report Preparation

4 December 8 a.m. - Return to District office and Continue VE report preparation

Both Local Sponsors and the City of Winnipeg (Diversion project) personnel were invited to participate in this VE study. One representative, Ms. April Walker from the City of Fargo, was able to attend. The team received additional informational briefings from the Project Manager and members of the feasibility report team during the study.

The project was studied using the Corps of Engineers standard VE methodology, consisting of five phases:

Information Phase: The Team studied drawings, figures, descriptions of project work, and cost estimates to fully understand the work to be performed and the functions to be achieved. Cost Models (see Appendix C) were compared to determine areas of relative high cost to ensure that the team focused on those parts of the project which offered the most potential for cost savings.

Speculation Phase: The Team speculated by conducting brainstorming sessions to generate ideas for alternative designs. All team members contributed ideas and critical analysis of the ideas was discouraged (see Appendix B).

Analysis Phase: Evaluation, testing and critical analysis of all ideas generated during speculation was performed to determine potential for savings and possibilities for risk. Ideas were ranked by priority for development. Ideas which did not survive critical analysis were deleted.

Development Phase: The priority ideas were developed into written proposals by VE team members during an intensive technical development session. Proposal descriptions, along with sketches, technical support documentation, and cost estimates were prepared to support implementation of ideas. Additional VE Team Comments were included for items of interest which were not developed as proposals, and these comments follow the study proposals.

Presentation Phase: Presentation is a two-step process. The published VE Study Report is distributed for review by project supporters and decision-makers. A briefing is later conducted to decide which proposals merit implementation into project design. The Summary of Proposals follows on the next page.

As this study was focused on nine separate alignments, the VE team did not focus on any individual alignment but decided to generically review all alignments presented in the feasibility report. Time constraints further reduced this review to the primary corridors of the alignments as the 25,000, 35,000 and 45,000 CFS capacity channels which generally follow the same geographic pathways from inlet to outlet on both the Minnesota and North Dakota sides (See figure #2). The team then examined these alignments in the speculation and analysis phase of the study for possible cost and functional improvements.

One hundred and two ideas for ways to improve project function or reduce costs were generated during the speculation phase of this study. The analysis phase of the study reduced the number of ideas to fifty-five for development. Twenty three ideas became candidates for further review which were evaluated. Like ideas were then combined to generate eleven cost proposals which, if accepted, can result in improved project function and lower cost to one or more of the feasibility report alignments. Twenty two of the ideas were reviewed and grouped into fourteen design comments.

BACKGROUND INFORMATION:

The following information was provided to the team for this VE study. It is presented here as background information. The recommendations developed in this report are founded in this information and the cost and engineering appendices to this report.

(*Excerpted from 2009 Moore Engineering Report*):

"PROJECT OBJECTIVES

The main objectives of this study were to develop a total of nine alternatives for potential diversions. The diversion alternatives studied included three capacities in each of two alignments through Minnesota and a total of three combined capacities in two alignments through North Dakota. The products of this study include preliminary hydraulic, civil, and structural design as well as cost estimates and property needs for each alternative. Additionally, water surface profiles on the Red River were provided for eight separate frequency events for each of the nine alternatives for use by the Corps of Engineers in determining the economic benefit.

3 SUMMARY OF PROJECT ALTERNATIVES AND FEATURES

The nine separate project alternatives analyzed include a total of four separate alignments, two in Minnesota and two in North Dakota. The alignments studied in Minnesota are roughly based on alignments used during Phase I of the FM Metro Study. These basic alignments were modified based on several considerations including total diversion length and existing ground elevation. The first diversion alignment in North Dakota was based roughly on an alignment that was originally created by Moore engineering as part of work done for the City of Fargo on the Southside Flood Control project. This alignment was also modified from its original location, based mainly on the total diversion length and ground elevations. The second North Dakota alignment, while similar to the first through much of its length, follows a portion of the existing Horace to West Fargo Sheyenne River Diversion alignment.

All of the alignments include control structures on the Red River at the south end of the project as well as a number of drop structures to allow adjacent drainage to enter the channel. The Red River control structure allows for the maximum benefit for a given diversion channel capacity by reducing water surface elevations immediately downstream of the structure. Additionally, the control structure allows the water surface elevation upstream of the project to remain at a near natural elevation to prevent erosion causing velocities in the Red River at the upstream end of the project. Because of the Wild Rice River's proximity to the Red at the south end of the project, three of the four alignments also include control structures on the Wild Rice River. The North Dakota alignments required additional hydraulic structures where the diversion alignments cross several rivers. Each diversion alternative also includes a tie-back levee at the southern limits of the project. No tie-back levees at the north end of the project are included in the scope of this project. A more detailed discussion of the alignments follows.

3.1 Minnesota Short Alignment

The Minnesota short alignment starts just north of the confluence of the Red and Wild Rice Rivers and extends north around the Cities of Moorhead and Dilworth and ultimately re-enters the Red River near the confluence of the Red and Sheyenne Rivers. The alignment is approximately 25 miles long. In addition to the main diversion channel, this alignment requires additional channels upstream of the Red River control structure to prevent stage increases upstream of the project along the Red and Wild Rice Rivers. A supplementary channel parallels the Red River upstream of the entrance to the diversion channel to allow for additional capacity to offset the breakouts to Drains 27 and 53. This secondary "Minnesota short extension channel" is approximately 3 miles long and has a 50 foot bottom width. A second, shorter channel, the Wild Rice River breakout channel, was added near the intersection of I-29 and Cass Highway 16. This channel, which is less than one mile long and crosses under I-29, will convey water across I-29 that would have naturally broken out to Drain 27 and has a 50 foot bottom width. Three separate diversion capacities were analyzed for the Minnesota short alignment including 25,000 cfs, 35,000 cfs, and 45,000 cfs. The total flow analyzed is based on a 0.2% (500-year) Red River event. The channel configuration for each event was largely determined by the maximum recommended excavation depth of approximately 30 feet. The channel bottom widths for the 25,000 cfs, 35,000 cfs, and 45,000 cfs channels are 250 feet, 380 feet, and 500 feet respectively. Excavation quantities, being the largest portion of the construction for the diversion alternatives, are approximately 48 million, 62 million, and 74 million cubic yards for the 25,000 cfs, 35,000 cfs, and 45,000 cfs channels respectively. The Minnesota short alignment also includes 20 highway bridges and four railroad bridges. The flow split between the diversion channel and the Red River is controlled by a combination of a control structure on the Red River at the south end of the project and a weir at the entrance to the diversion channel.

3.2 Minnesota Long Alignment

The Minnesota long alignment starts approximately three miles south of the confluence of the Red and Wild Rice Rivers and extends north around the Cities of Moorhead and Dilworth and ultimately re-enters the Red River near the confluence of the Red and Sheyenne Rivers. The alignment is approximately 29 miles long. Because this alignment begins south of the confluence of the Red and Wild Rice Rivers, an extension of the diversion channel is included between the Red and Wild Rice Rivers. The tie-back levee associated with this alternative extends west from the Wild Rice control structure to relatively high ground.

The same three capacities that were analyzed for the Minnesota short alignment were analyzed for the Minnesota long alignment. Similar to the short alignment, the channel configuration for each event was largely determined by the maximum recommended excavation. The channel bottom widths for the 25,000 cfs, 35,000 cfs, and 45,000 cfs channels are 265 feet, 400 feet, and 530 feet respectively. The portion of the diversion connecting the Red and Wild Rice Rivers is 100 feet wide. Excavation quantities for the 25,000 cfs, 35,000 cfs, and 45,000 cfs channels are approximately 53 million, 70 million, and 87 million cubic yards respectively. The Minnesota long alignment includes 21 highway bridges and four railroad bridges. The flow split between the diversion channel and the Red River is controlled by a combination of control structures on the Red and Wild Rice Rivers at the south end of the project and a weir at the entrance to the diversion channel.

3.3 North Dakota West Alignment

The North Dakota west alignment starts approximately four miles south of the confluence of the Red and Wild Rice Rivers and extends west and north around the Cities of Horace, Fargo, West Fargo, and Harwood and ultimately re-enters the Red River north of the confluence of the Red and Sheyenne Rivers near the City of Georgetown MN. The alignment is approximately 35 miles long. Because this alignment begins south of the confluence of the Red and Wild Rice Rivers, like the Minnesota long alignment, an extension of the diversion channel is included between the Red and Wild Rice Rivers. The tie-back levee associated with this alternative extends east from the Red River control structure to high ground. The North Dakota west alignment was analyzed for 35,000 cfs and 45,000 cfs. Like the Minnesota alignments, the capacities analyzed are based on a 0.2% (500-year) Red River event. The channel configuration for each event was largely determined based on the minimum excavation quantity for a given capacity rather than by the maximum recommended excavation depth as was used for the Minnesota alignments. The channel bottom width for both capacities is 100 feet and the excavation quantities are approximately 58 million and 73 million cubic yards for the 35,000 cfs and 45,000 cfs capacities, respectively. The North Dakota west alignment includes 18 highway bridges and four railroad bridges.

A combination of control structures on the Red and Wild Rice Rivers at the south end of the project, along with a weir at the entrance to the diversion channel, control the flow split between the Red and Wild Rice River channels and the diversion channel. Additionally, this alignment crosses several rivers, including the Sheyenne, Maple, Lower Rush, and Upper Rush. Hydraulic structures are necessary at the point where the diversion channel crosses these rivers. The purpose of these hydraulic structures is to allow some base flow to continue down the various rivers while diverting excess water during flood events to the diversion channel. The result of this is added flood protection along all of the affected rivers.

3.4 North Dakota East Alignment

The North Dakota east alignment generally follows the North Dakota west alignment except that, after crossing the Sheyenne River, it utilizes the existing Horace to West Fargo Sheyenne River Diversion corridor between Horace and I-94. The alignment is approximately 36 miles long.

The North Dakota east alignment was analyzed only for 35,000 cfs. The channel configuration for this alternative is similar the 35,000 cfs North Dakota west alignment, with a maximum depth of approximately 32 feet and an approximate excavation quantity of 62 million cubic yards. The North Dakota west alignment, like the North Dakota east alignment, includes 18 highway bridges and four railroad bridges. The North Dakota east diversion alignment includes all of the same hydraulic structures as are necessary in the North Dakota west alignment.

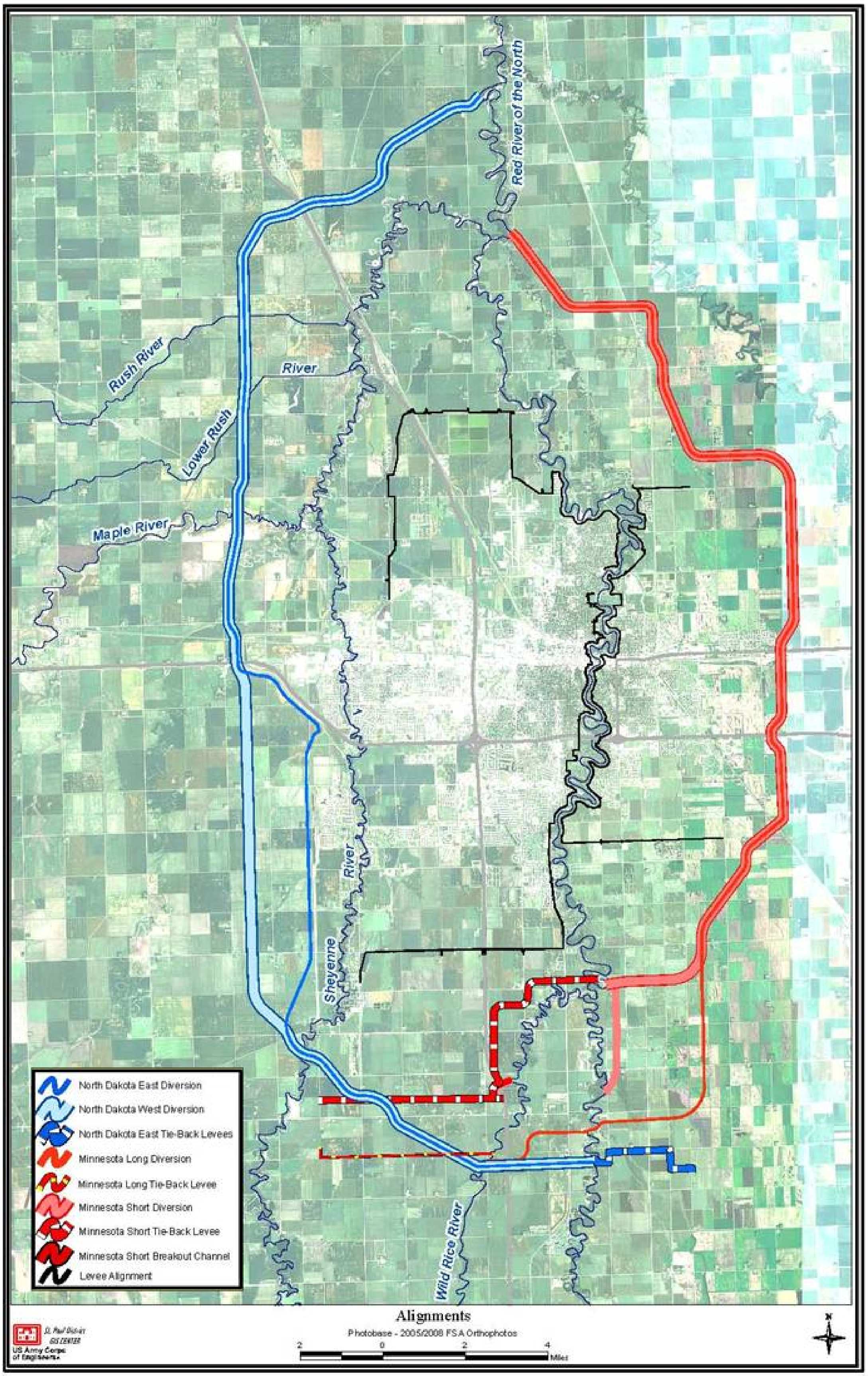


Figure 2 – Minnesota and North Dakota Diversion Channel alignments
As presented in the Fargo-Moorhead Metro feasibility report.

F-M Alternative Cost Summary:

The following table summarizes the nine feasibility alignment construction costs as they were presented to the VE team for review:

Fargo-Moorhead Metro Feasibility Study
Initial Screening Results, October 2009
Screened Alternatives Ranked by Net Benefits

Alternative	First Cost *	Avg Annual Net Benefits *	Residual Damages *	B/C Ratio	Downstream Impacts **
MN Short Diversion 25K	962	11.0	14.3	1.22	2.1
MN Short Diversion 35K	1,092	9.4	9.3	1.17	2.5
Levee 1% chance (100-year)	902	7.7	20.9	1.17	?
MN Long Diversion 25K	1,055	5.6	15.0	1.10	?
MN Short Diversion 45K	1,264	2.5	7.4	1.04	3.0
MN Long Diversion 35K	1,260	0.3	9.8	1.00	?
ND East Diversion 35K	1,337	-3.1	9.2	0.95	?
ND West Diversion 35K	1,363	-4.4	9.2	0.94	?
Levee 2% chance (50-year)	840	-5.3	37.1	0.88	?
ND West Diversion 45K	1,439	-6.7	7.6	0.91	?
MN Long Diversion 45K	1,459	-8.3	8.2	0.89	?

* In millions of dollars
** Inches during 1% Chance flood (100-year)
Note: Expected average annual damages without a project are $73.7 million.

Table 1- F-M Feasibility study summary table.

In order to understand what features are includes in the construction cost of each option the VE team broke down the MN Short Diversion 25,000 CFS to better understand how where the project resources were being spent:

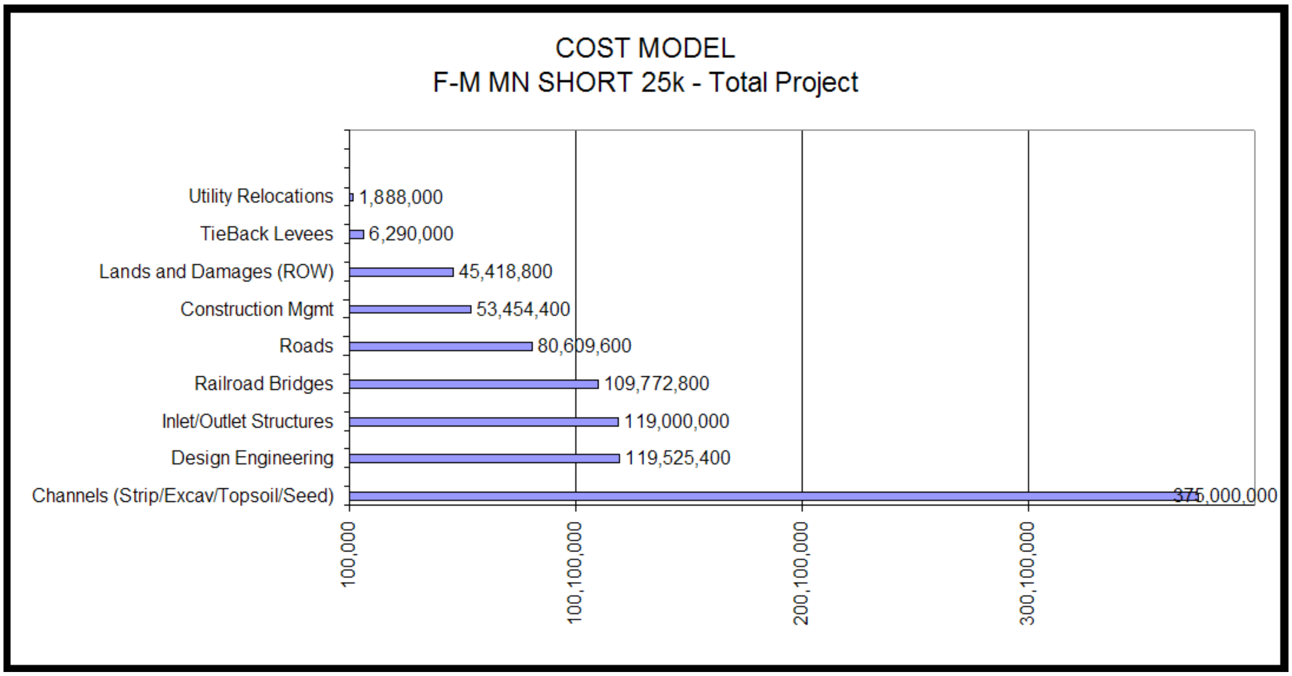


Figure 3 – MN Short 25K Diversion Cost model breakout (without interest)

The cost model breakout pinpoints the highest potential items to study. The items with higher cost have the greatest potential for project savings in a review. In the MN short 25,000 CFS alignment, the channels and railroad construction items have the greatest potential for cost savings. The design engineering cost will decrease with any savings identified in the construction cost and cannot in itself be studied.

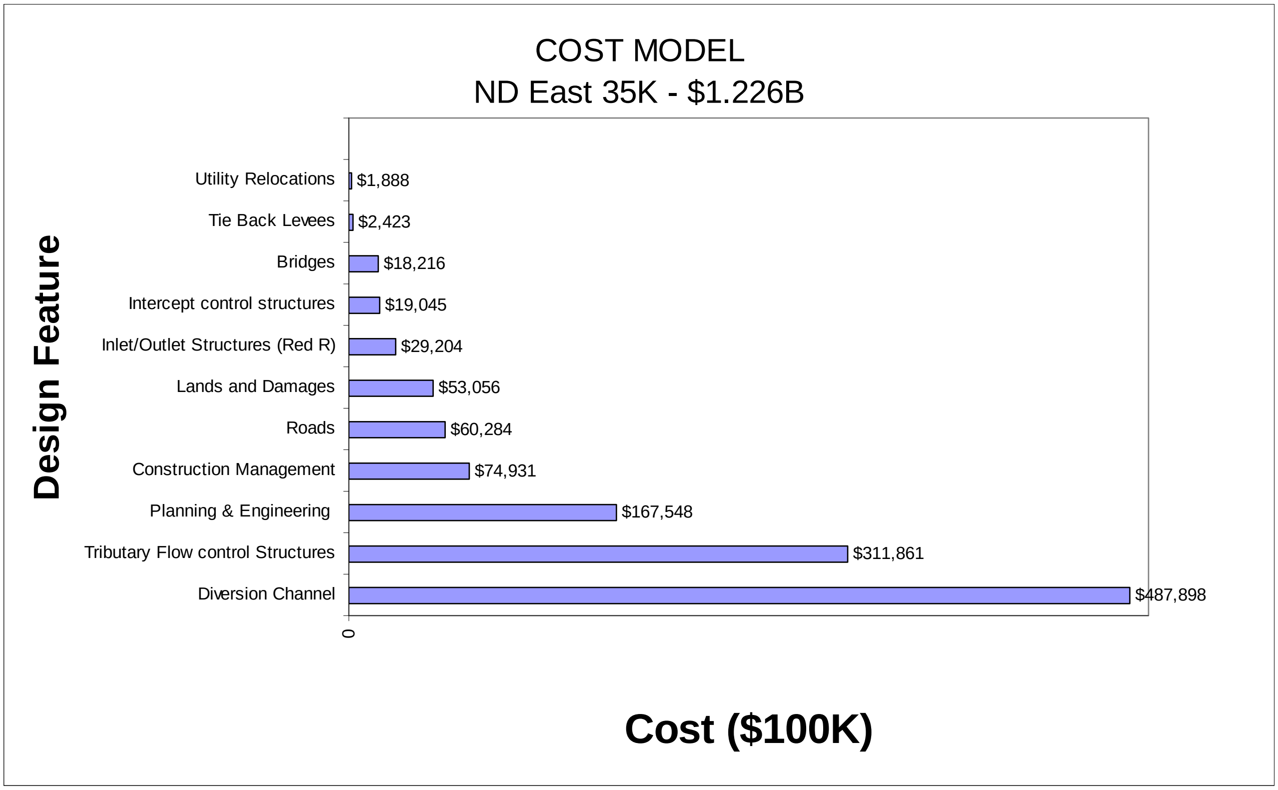


Figure 4 – ND East Cost model.

The ND East alignment had a similar cost model distribution. The significant differences between the MN and ND option are the addition of the Tributary Control Structures (Maple/Rush/Sheyenne R) and additional diversion construction on the ND side.

From this point the VE team reviewed both the MN and ND alignments in an attempt to identify design decisions that significantly influenced feasibility alignments and their associated project costs. The team identified 11 high potential ideas which were assigned a VE Proposal number 1-11 and are presented in detail in this report. This VE study is unique as each proposal may only apply to the MN or ND side and the ideas presented may only improve cost or function to a single alignment or to all alignments depending on the proposal. Once a single alignment is selected for design, several of these VE proposals may be eliminated from further consideration.

VALUE ENGINEERING TEAM STUDY

SUMMARY OF PROPOSALS

PROPOSAL No.	DESCRIPTION	SAVINGS
P1	Realign ND diversion East of the Sheyenne River …………………………..$245.4M Protect Harwood, ND by ring levee (applies to ND west/east)	
P2	Realign MN diversion by shortening channel & Re-orienting outlet works (Applies to MN alignments)……………………..$25.8M	
P3	Begin ND Diversion channel further North …………………………………$142M	
P4	Redesign Wild Rice Diversion for MN alignments ..………………………-$2.05M	
P5	Replace bridged crossings with at grade crossings……….………….$3.7M/Bridge	
P6	Realign N end of ND diversion/outlet further South…………..……………. $17.4M	
P7	Construct U-Channel through areas of multiple bridges.…………………….$1M	
P8	Redesign intercept inlet works ………………………………..$3M(MN) - $4M(ND)	
P9	Raise in-city protection to 100 year level…………………………………..-$10.56M	
P10	Railroad yard relocation (MN Alignment)…………………………………… $81M	

*** TOTAL POTENTIAL CUMULATIVE SAVINGS (MN –Aligns)** ***$122M MN***
** **TOTAL POTENTIAL CUMULATIVE SAVINGS (ND –Aligns)** ***$407M ND***

Additional costs recommended – complete Fargo city levees - $10M

Proposal	Minnesota Alignment	North Dakota Alignment	
1- Re-align ND end		$245M	
2- Re-Align MN end	$25.8M		
3- Re-Align ND start		$142M	
4. Re-designWild Rice Diversion	-$2.05M		
5. Replace bridges with at grade x-ing	$3.7M/bridge – 4 est. $12M	$3.7M/Bridge -5 est. $18M	
6. Realign ND outlet S		$17.4M	
7. U channel @multiple bridges	$1M	$1M	
8. Road Bypass			
9 Redesign intercept	$3M	$4M	
10 Complete city levees	-$10M	-$10M	
11 RR yard purchase	$81M		
Potential Cost Savings	$123M savings $12.05M Costs	$410M savings $10.0M Costs	

A detailed Proposal breakdown follows:

DESCRIPTION: Reroute ND Diversion East of Sheyenne River

ORIGINAL DESIGN: The North Dakota East alignment generally follows the North Dakota West alignment except that, after crossing the Sheyenne River, it utilizes the existing Horace to West Fargo - Sheyenne River Diversion corridor between Horace and I-94. The alignment is approximately 36 miles long. The channel configuration has a maximum depth of approximately 32 feet and an approximate excavation quantity of 62 million cubic yards. The North Dakota east alignment includes 18 highway bridges and four railroad bridges. The North Dakota east diversion alignment includes many of the hydraulic structures as are necessary in the North Dakota west alignment.

PROPOSED DESIGN: The proposed design is to revise the channel alignment in the northern part of the ND channel reach. North of the West Fargo diversion, the proposed channel would be realigned east of the Sheyenne River and discharge into the Red River of the North south of confluence of the Sheyenne River (See Drawing No. 1 on next page).

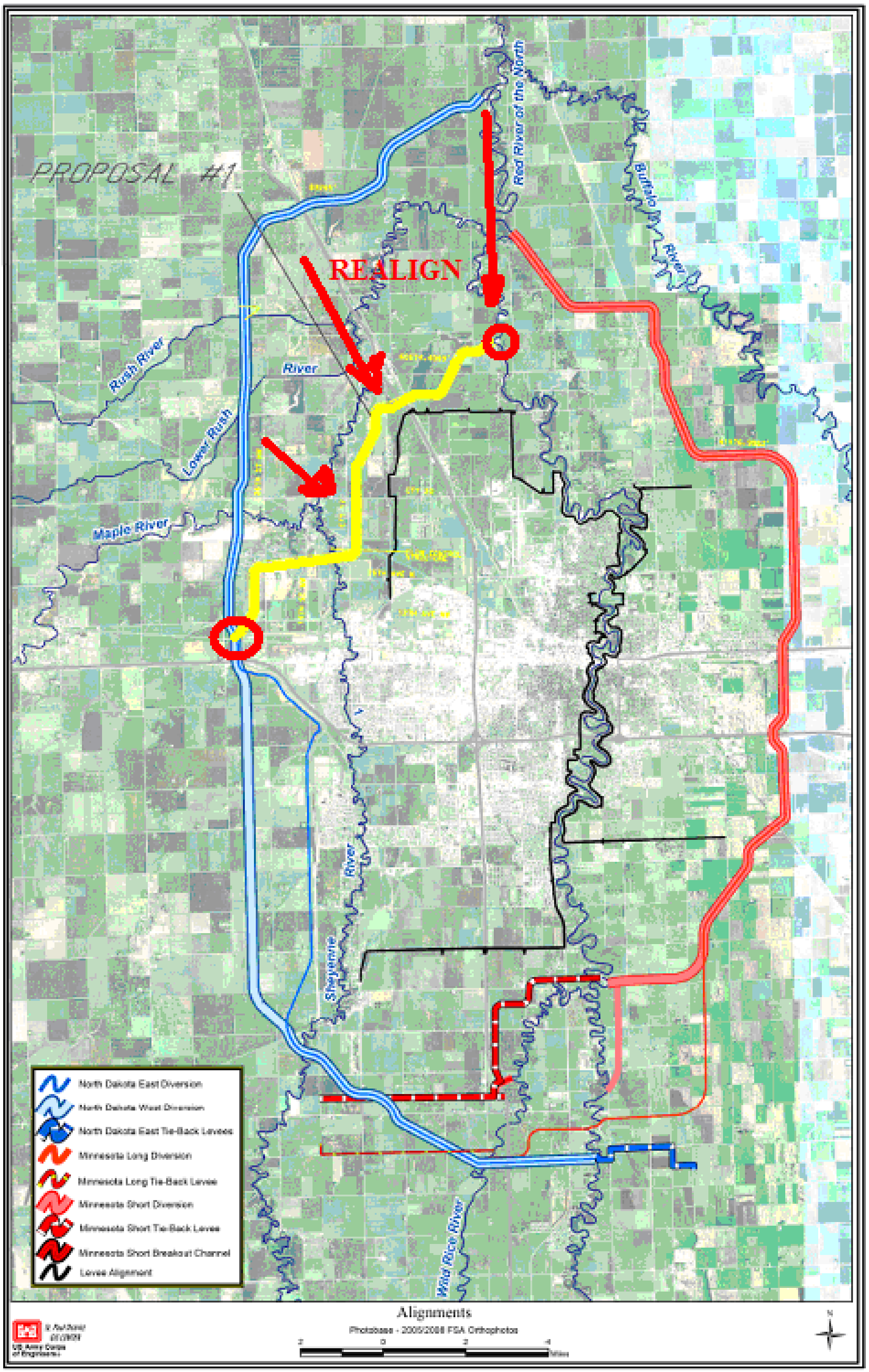
ADVANTAGES:
1. The length of channel is shortened thus reducing real estate & construction project costs.
2. Eliminates the need for flow control structures at the Maple River, Lower Rush and Rush River tributaries thus reducing costs.
3. Reduce construction duration
4. Fewer local drains to construct.

DISADVANTAGES:
1. No added flood protection along affected tributaries.
2. Ring levee may needed to support benefits for city of Harwood
3. Additional bridges are required

JUSTIFICATION: This proposal maintains flood protection for the F-M Metro area while significantly reducing project costs. Flood protection for F-M Metro area is not affected thus preserving major benefits of protecting developed areas while not protecting as much undeveloped areas.

Drawing No. 1

REVISED ALIGNMENT EAST OF SHEYENNE RIVER



	COST ESTIMATE WORKSHEET				
	Proposal #1 - Realign ND East				
	DELETIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
					$0
	Channel North of Fargo Diversion	FT	89265	$3,000.00	$267,795,000
	Flow Control Structure - Maple River	LS	1	$77,908,600.00	$77,908,600
	Flow Control Structure - Lower Rush River	LS	1	$48,644,500.00	$48,644,500
	Flow Control Structure - Rush River	LS	1	$49,937,100.00	$49,937,100
	Bridge: 25th Street SE	LS	1	$3,200,000	$3,200,000
	2 - 2x 72" local drains	EA	2	$874,552.00	$1,749,104
	2 1 x 72" local drains	EA	2	$451,928.00	$903,856
					$0
					$0
					$0
			Total Deletions		$450,138,160
	ADDITIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
					$0
	Channel East of Sheyenne River	FT	60674.4	$3,000.00	$182,023,200
	Flow Control Structure @ Sheyenne River	LS	1	$54,000,000	$54,000,000
	Bridge: CR17	LS	1	$3,200,000	$3,200,000
	Bridge: CR20	LS	1	$3,200,000	$3,200,000
	Bridge: 12th Ave NW	LS	1	$3,200,000	$3,200,000
	(Note: some bridges could be at-grade				$0
	crossings- see VE Proposal 5)				$0
					$0
					$0
					$0
					$0
			Total Additions		$245,623,200
			Net Cost Decrease		$204,514,960
	Engineering and Construction Mgmt		Mark-ups	20.00%	$40,902,992
			Total Cost Decrease		$245,417,952
	All Mark-ups included in Unit Prices. Contingency or S&I applied.				

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: 2 - REJECTED PAGE NO: 1 OF 4

DESCRIPTION: Realign Minnesota Channel alignment north of Dilworth, MN.

ORIGINAL DESIGN: The Minnesota alignment follows a 136,256 foot path from the south side of Fargo through Dilworth, MN before rejoining with the Red River to the north of Fargo, ND. The major interception points on the Red River on the upstream and downstream ends appear to be locked in by hydraulic requirements. Sections of the channel between these two points are detailed in the feasibility plan as shown below in Figure #1. While the south end of the alignment appears to be locked in by a series of gateway openings (freeway & railroad) available to fit the channel through – the northern section appears to be routed on an alignment to contain the Town of Kragnes within the project limits.

PROPOSED DESIGN: In the northern reaches of the MN side feasibility design(s) the channel stays eastward of Moorhead before turning westward after passing the Town of Kragnes. By re-aligning the channel further west than the alignment presented in the feasibility study (as shown below in figure #1), the design channel could be shortened by 6,000-8,000 linear feet. This could also reduce the number of bridges and local drainage inlets in this reach by 1. Thought to placing the MN alignment into the coulee located east of the current Red River channel might also be considered. Realignment as show below could reduce the diversion channel's length by an estimated 7,000'. In addition the feasibility plan outlet works for this alignment is plotted to be in a location that would block current Red River flows (See Figure #2) and could be relocated. Shortening channel leading to the outlet work would also shorten the project length by 500-1000' (Also see VE proposal # 5 for constructing at- grade crossings to further reduce bridges in the alignment).

Should additional protection for Kragnes be required it might be possible to construct tie-back levees with excess channel cut soils. Flooding threat to this area was attributed as being backwater effects Buffalo River and not Red River flooding (project manager).

For purposes of obtaining a VE cost savings for this proposal a gross cost per foot of constructed channel was extracted from the Cost estimates provided. Channel excavation costs (Stripping, Excavation, topsoil and seeding) and lands account for approximately 55% of the project cost (J. Hansen 1 Sep MN Short 25K Cost summary sheet). For the purpose of this study a unit cost per foot of channel was therefore calculated to be 55% of project cost and a smaller share or Design & Construction management costs (40% for less detailed design) / Length of constructed channel (136,256') to yield a estimated channel construction cost ($381.4M). The 14581' southern channel was also considered into the unit cost of excavation.

Cost to Construct 1' of 250' wide channel = $2700 L.Ft.

Realign MN Short 25K channel further west

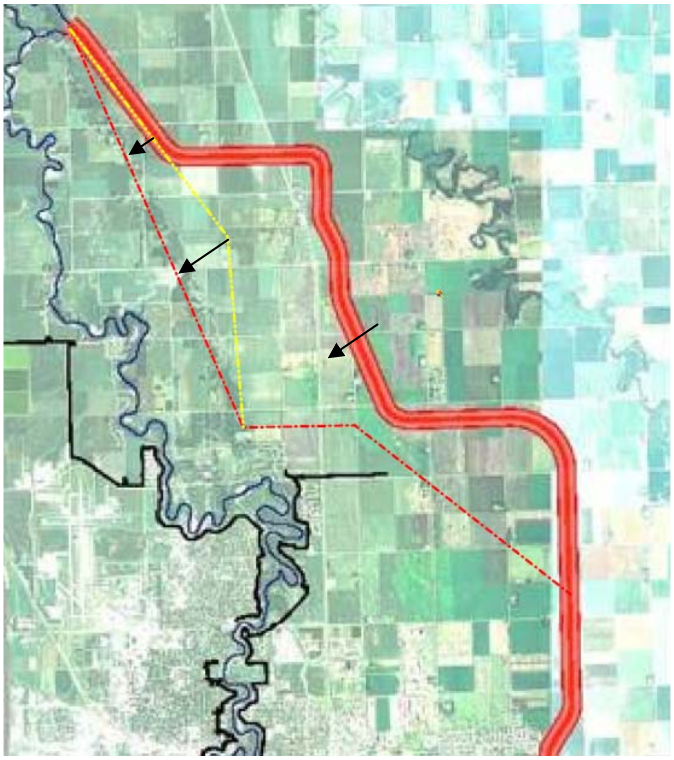
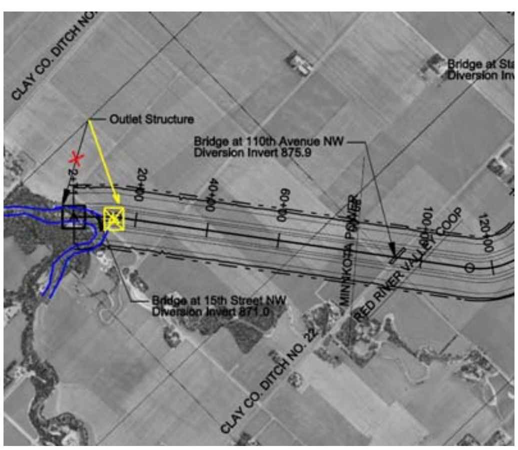
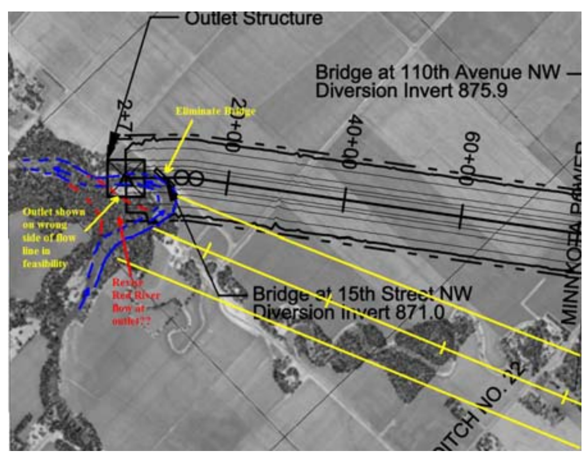


Figure 1 – North half of MN Channel Alignment – Change: Move channel westward.

Outlet Design: The outlet design as presented in the feasibility also appears to be set near the center of the existing Red River channel in the feasibility report (see below). Revision of the outlet design is required. Unidentified costs may be required to properly construct a hydraulic outlet in this area.



(Note outlet too far into channel-move east)



(Orient outlet to match channel flow)

Figure #2 & #3 – Moving channel westward or relocating outlet further east are two
Cost savings ideas contained in this proposal.

ADVANTAGES: Cost savings with no loss of project function. The proposed alignment is 7000' (1.3 miles shorter) (5%) than the feasibility plan and could be constructed faster & cost less. Fewer bridges and inlets in the area would be required as a result of this alignment change. The lands in this area were represented to the study team as lying above the floodplain and are not protected by these future works – so there would be no loss in protected area. Revising the channel outlet location by 1000' would also correct what appears to be an error in the feasibility location and relocation would result in less blockage of flow in the Red River if constructed further upstream as shown in figure #3.

DISADVANTAGES: The town of Kragnes loses any protection it may have received from the channel construction. Re-alignment does present the possible loss of existing environmental habitat if existing river channel is folded into the diversion alignment. Mitigation land acquisition may be required for loss of habitat. Channel orientation (diagonal to area north-south roads) requires bridges to be lengthened.

JUSTIFICATION: Cost savings estimated at $25.8M or 3% of the project cost.

COST ESTIMATE WORKSHEET

Proposal #2 - Revise MN Short 25K Northern alignment

DELETIONS

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
					$0
1	Delete 1 hwy bridge (hwy 100?)	ea	1	$3,700,000.00	$3,700,000
2	Construct 7000' less channel	foot	7,000	$2,700.00	$18,900,000
3	Relocate channel outlet 800' U/S	foot	800	$2,700.00	$2,160,000
4	1 less local drainage inlet	ea	1	$1,100,000.00	$1,100,000
					$0
			Total Deletions		$25,860,000

ADDITIONS

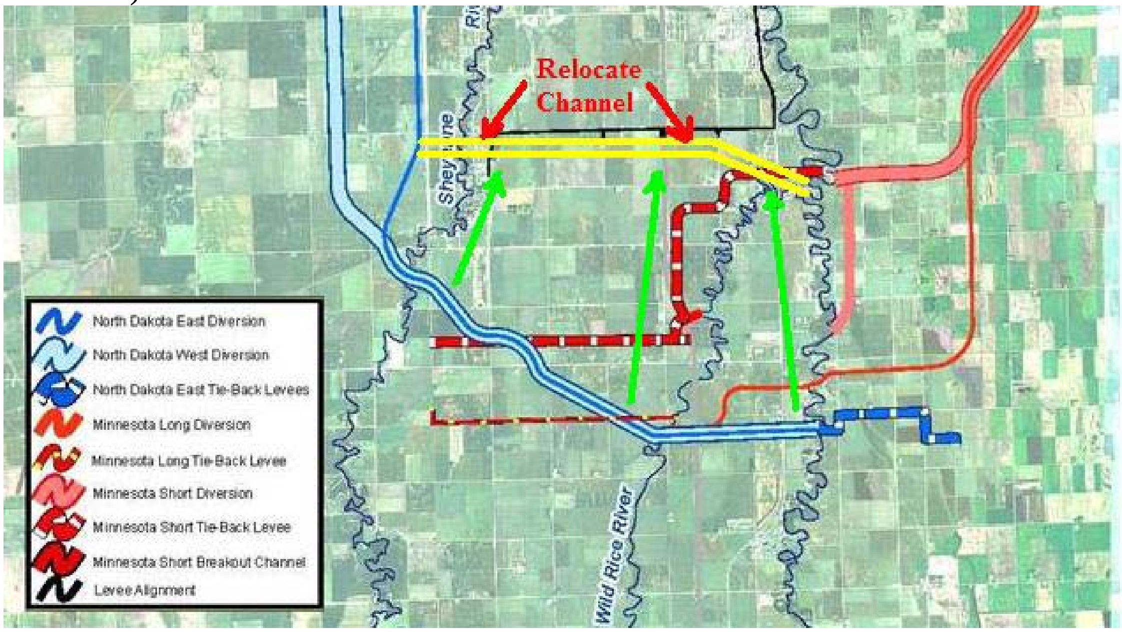
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	None				$0
	Mitigating land?				$0
					$0
			Total Additions		$0
			Net Cost Decrease		$25,860,000
			Mark-ups	0.00%	$0
			Total Cost Decrease		$25,860,000

All Mark-ups included in Unit Prices. Contingency or S&I applied.

DESCRIPTION: Shorten ND East Diversion

ORIGINAL DESIGN: The North Dakota East Diversion starts at the Red River upstream of the confluence with the Wild Rice River. It intersects the Wild Rice, Sheyenne, Maple, Lower Rush, and Rush Rivers over a total length of 191,948 feet.

PROPOSED DESIGN: Start the diversion just downstream of the confluence of the Red and Wild Rice Rivers. Proceed west to the existing Horace Diversion and join the original design path. This cuts 22,490 feet from the length of the channel, or 11.72% of the length. (Tie back levee issues not addressed).



ADVANTAGES: This eliminates the intersection structures with the Wild Rice River. Because it intersects the Sheyenne River downstream of the Horace Diversion inlet and captures the water from the West Fargo Diversion, it is possible that neither Sheyenne River crossing will require an inlet to the diversion. It shortens the diversion by about 4 miles. It eliminates the railroad bridge near Horace and the 48th Street and 46th Street (and possibly the 44th Street) road bridges. (It does require a second intersection structure with the Sheyenne River.) Because the channel is shorter, there would be less maintenance on the finished channel.

DISADVANTAGES: It significantly reduces the protected area. Because the Sheyenne River is "perched," it might not be possible to start the diversion below the confluence of the Red and the Wild Rice Rivers and flow downhill to the Sheyenne before reaching more heavily developed neighborhoods. Depending on how far the Maple River could back into the Sheyenne, an inlet might be needed at the downstream crossing or below it (after the confluence of the Sheyenne and Maple Rivers).

JUSTIFICATION: Reduced cost- $140,000,000.

**Note that both the original estimate and this proposal do not include a necessary bridge where U.S. Highway 81 Bus. Crosses proposed channel at the south end of the diversion just west of the Red River. (This will be added to the Comment list as an omission)

COST ESTIMATE WORKSHEET

Speculation Item # 3 - Realign ND East channel further north

DELETIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
				$0
Delete Channel construction	ft	11,000	$2,700.00	$29,700,000
Delete local inlets	ea	4	$1,100,000.00	$4,400,000
Delete Wild Rice diversion structure		1	$79,978,800.00	$79,978,800
Delete Sheyenne Diversion structure		1	$53,784,500.00	$53,784,500
44th street bridge	ea	1	$2,966,900.00	
46th street bridge	ea	1	$2,975,800.00	$2,975,800
48th street bridge	ea	1	$2,975,900.00	$2,975,900
Railroad bridge	ea	1	$3,571,000.00	$3,571,000
Less land acquisition (assume -10%)	acres	640	$6,500.00	$4,160,000
				$0
				$0
		Total Deletions		$181,546,000

ADDITIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
				$0
Sheyenne Diversion Structure	ea	1	$55,000,000.00	$55,000,000
Real estate (Horace) relocate houses?	acres	10	$300,000.00	$3,000,000
				$0
		Total Additions		$58,000,000
		Net Cost Decrease		$123,546,000
Reduces E&D / CM**		Mark-ups	15.00%	$18,531,900
		Total Cost Decrease		$142,077,900

DESCRIPTION: Modify Wild Rice Diversion Channel - MN Short Alignment

<u>ORIGINAL DESIGN</u>: The Minnesota Short alignment contains provisions for tie back levees and a 4000' diversion channel section on the North Dakota side of the Red River along the west bank of the Wild Rice. The tie back levee extends several miles to the west before ending near the Sheyenne River. Breakout flows from the Wild Rice and Sheyenne Rivers are forecast to move eastward and cross I-29 through a new 50' wide channel and freeway bridges proposed for this area (Moore-Appendix E- plate 6- see Figure 1).

North

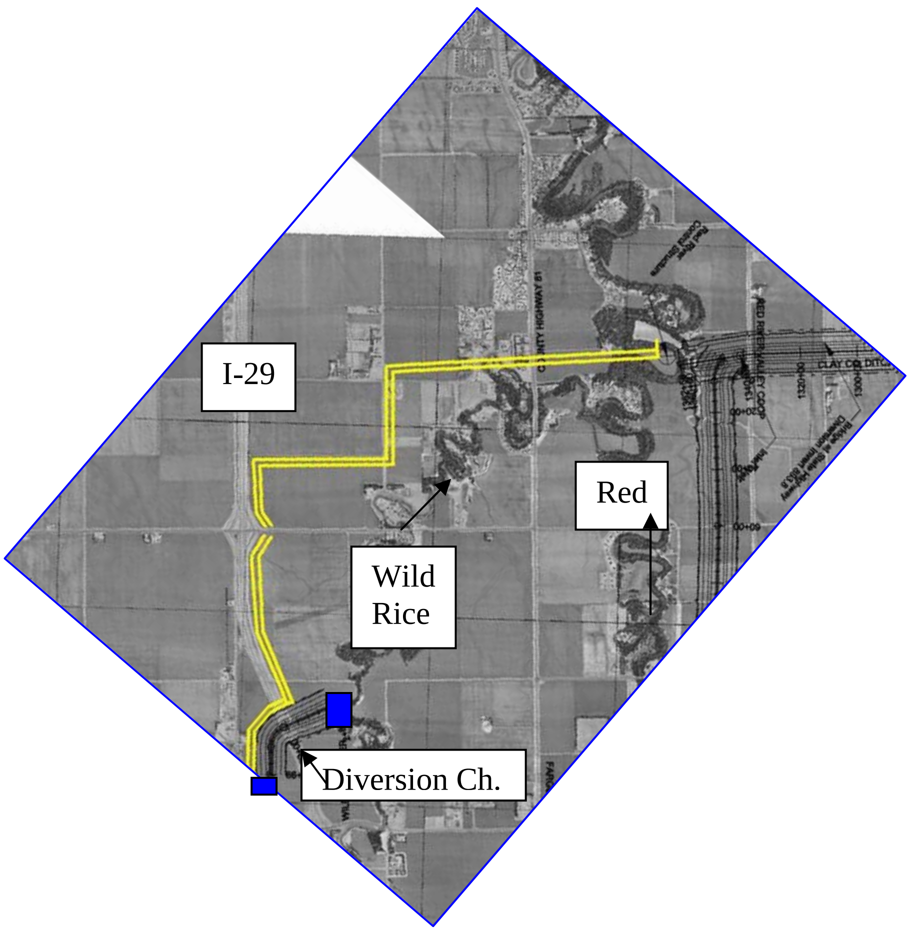
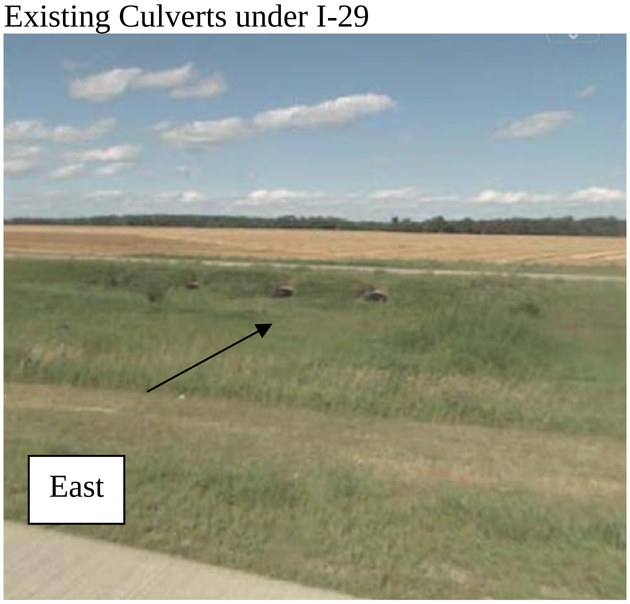


Figure 1- Tie Back Levees connecting to Diversion Channel under I-29 at the Wild Rice River South of Fargo, ND.

<u>ADDITIONAL SITE INFORMATION:</u> There are two existing I-29 bridges; located 5500' south of the proposed new breakout diversion channel that span the Wild Rice River. The existing bridge decks are at Elev. 917 while the new bridge decks are estimated to be at Elev. 922.2. The bridge deck on the existing bridge over the Wild Rice is at elev. 917 and low steel is at elevation 913. The existing span is 220' long and the proposed span for the new I-29 diversion channel overpass is 300' long. At elevation 917, the freeway typically does not flood during an event.

Photo #1(East) & #2 (west) – View from existing bridges over Wild Rice River on I-29 S. of Fargo. Bridge Deck Elev. 917 – Low Chord – Elev. 913

Existing Culverts under I-29



Photos #3 & #4 - Views East and West at proposed Diversion channel site under I-29 (S. Fargo, ND) - Note existing culverts near elevation 914’. Road Elevation is 917’.

<u>PROPOSED DESIGN</u>: The feasibility design as presented is a combination of levees and a freeway underpass channel that is designed to convey breakout flows from the Sheyenne and Wild Rice Rivers back to the Wild Rice River. Examination of this portion of the project site shows the existing I-29 bridge over the Wild Rice River would be smaller than the new bridge built to span the proposed diversion. The new levee also cuts off Rose Coulee and other potential drains from channeling breakout flows through town as is currently done.

The proposed design would be to reconstruct the I-29 bridges spanning the Wild Rice River to both widen and raise the low bridge steel out of the flood and increase capacity through the bridge opening. This "improvement" to the channel is projected to curtail some of the breakout flow but if additional measures were still needed, Levees and channel sections could be constructed to divert breakout flows southward, back to the main river channel.

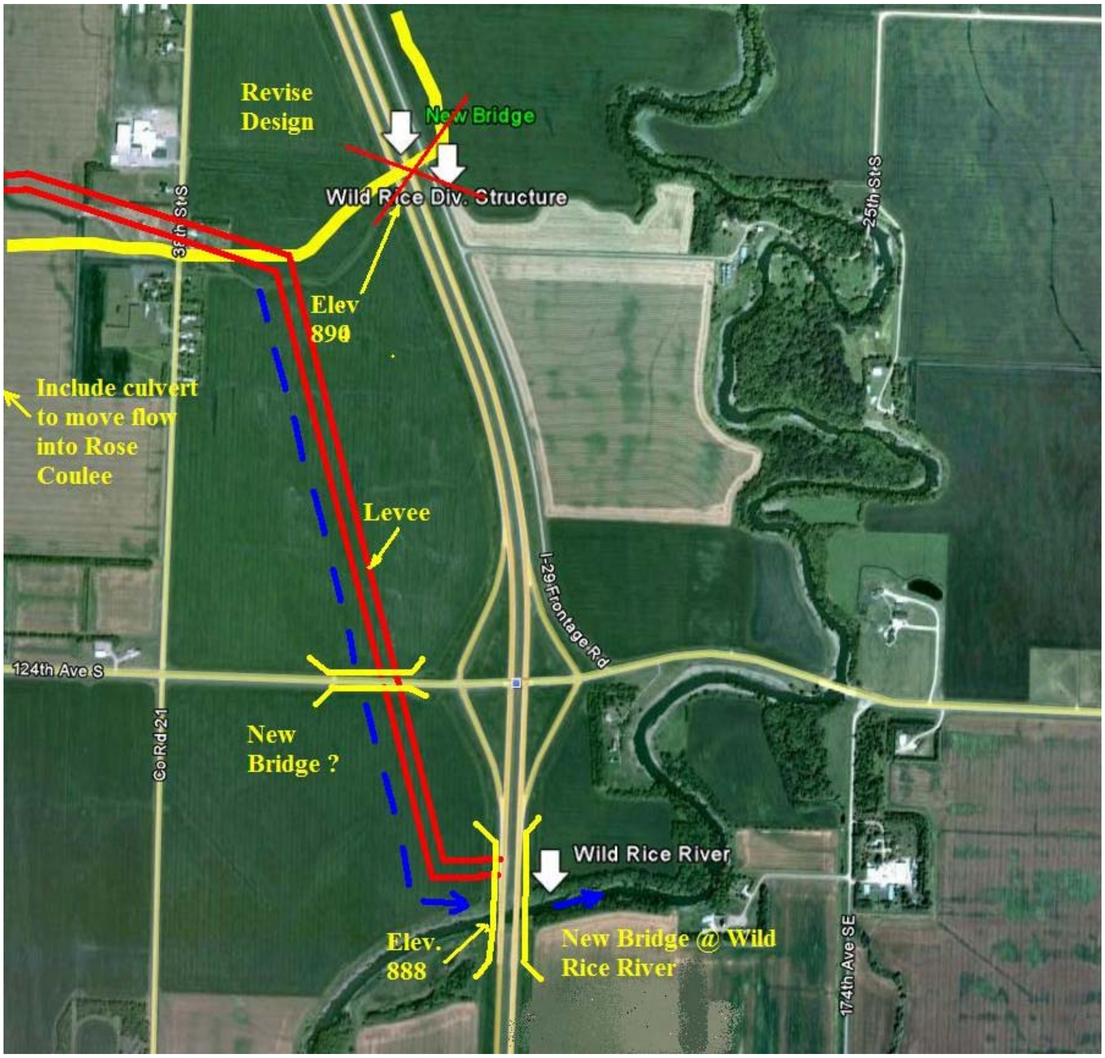


Figure #2 – Reconstruct I-29 bridges to eliminate flow constriction at current bridge And channel all flows through this point. Material excavated to build channels to convey flows back to the Wild Rice River would be side-cast to create protective levee for I-29.

ADVANTAGES: Potentially eliminates a set of "new" bridges and replaces a set of bridges that negatively impact the hydraulic design in the area. Less Bridge maintenance (3 vs. 4 bridges) and proposed plan retires an older set of bridges & reduces excavation and improves ice flow under existing I-29 bridges. Deletes requirement for new drop structure at new channel.

DISADVANTAGES: A third bridge may be required at 124th Street. Evaluation of the 124th Street Bridge over the Wild Rice east of I-29 might also be required.

JUSTIFICATION: Improves hydraulic design over current situation by removing bridge constriction, reduced future bridge maintenance & improved ice passage.

DESCRIPTION: Modify Wild Rice Diversion Channel - MN Short Alignment .

COST ESTIMATE WORKSHEET

Proposal P-4 - Modify Wild Rice Diverson plan

DELETIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
Delete new I-29 Bridge SB	ea	1	$3,093,100.00	$3,093,100
Delete new I-29 Bridge NB	ea	1	$3,093,100.00	$3,093,100
Eliminate 4000' diversion channel	ft	4,000	$1,080.00	$4,320,000
Eliminate Drop Structure **	ea	1	$250,000.00	$250,000
Modify Levee Plan- reduce by 30%	ea	0.33	$6,290,100.00	$2,075,733
				$0
		Total Deletions		$12,831,933

** Cost not in feasibility estimate

ADDITIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
Demo I-29 Bridges NB & SB @ WR river	ea	1	$400,000.00	$400,000
Rebuild I-29 Bridges NB and SB	ea	2	$3,500,000.00	$7,000,000
				$0
New `124th St Bridge * optional ?	ea	1	$2,552,000.00	$2,552,000
New diversion channel	ft	5,500	$800.00	$4,400,000
				$0
				$0
				$0
		Total Additions		$14,352,000
		Net Cost Decrease		-$1,520,067
		Mark-ups	35.00%	-$532,023
		Total Cost Decrease		-$2,052,090

All Mark-ups included in Unit Prices. Contingency or S&I applied.

Proposal results in a net cost - not factored in are savings in bridge maintenance and reduced future bridge replacement cost. Improved project function (larger hydraulic opening) not factored in.

**Note: The cost estimate and design plates for this section of the project (Fig 1) provided to the VE team may be missing the cost of a drop structure at the head of the diversion channel a $250,000 cost was assumed to be necessary and was added to the cost equation for this option.

PROPOSAL NO: 5 - ACCEPTED PAGE NO: 1 OF 3

DESCRIPTION: Cross channel using at grade crossing (low Flow) vs. bridges

ORIGINAL DESIGN: The feasibility design(s) call for bridges to traverse the diversion channels to maintain area access. In the Mn Short 25,000K option there are 20 proposed highway bridges and 4 railroad bridges that cross the 136,256' long diversion adding $55.56M to the project estimate. The bridges in this feasibility report typically exceed 500' in span. A typical bridge adds $2M in construction cost and an estimates $500K in design and construction management cost. Currently there are 39 roads that cross the proposed Mn Short 25K channel alignment.

Bridge list:			
	Interstate 29 (SB & NB)	50th Ave S	15th Street NW
	110th Avenue S.	Interstate 94 (EB & WB)	110th Ave N
	State Highway 75 south	US Hwy 10 (EB & WB)	90th Ave N
	80th Ave S	28th Ave N	
	60th Ave S	57th Avenue N.	
	CSAH 52	CR14	
	State Highway 75 north	100th Ave N	

PROPOSED DESIGN: Revise the bridge plan to convert some crossings to an at grade culvert crossing in the base of the channel. Typically this roadway would be closed during flood events limiting the number of bridges that could be converted to this option. Only secondary road bridges would be considered for this option and bridge designs would remain on primary roadways. From the VE team review of the proposed alignments, there are several locations where the channel design was placed at right angles to area roads to minimize the bridge lengths (and therefore bridge cost – but increasing channel cost). Designing at grade crossings into the design would also allow the channel alignment to be straightened; decreasing channel length and further reducing project cost.

ADVANTAGES: Cost savings, potential to construct additional crossings in the project area at reduced cost which would improve safety and reduce fuel consumption in the area. There would be less bridge maintenance and no future replacement costs for structures. Some bridge designs in the feasibility report require lengthy grade increases to have the bottom girders clear estimated flood heights. The use of at-grade crossings would also eliminate the need to re-grade sections of road approaching bridges resulting in an additional project savings of $0 to $50,000 per bridge. Bridges in this area can be icy during winter driving season requiring additional salt/sand operations.
No ice jams that could occur at bridge deck locations. Area intercept control structures could be redesigned as ditch drainage along the roadway – current construction cost for a single 72" inlet is $600K.

DISADVANTAGES: Flash flooding could occur in the channel, fog and icy conditions could also develop in the crossings. Construction of roads into the channel cut introduces the potential for undesired off road activities in the project area. Roads would need to be closed during floods which require blocking structures and signage to direct traffic to nearest bridge crossings. Roads are blocked once flooding begins and only bridged crossings could be used. Bridges might also be used for utility crossings. Side slopes of the channel are too steep for road grades 14%, therefore additional excavation to reduce this slope to 8% is recommended. Post flood roadway cleanups & possible repair would be necessary.

VALUE ENGINEERING PROPOSAL

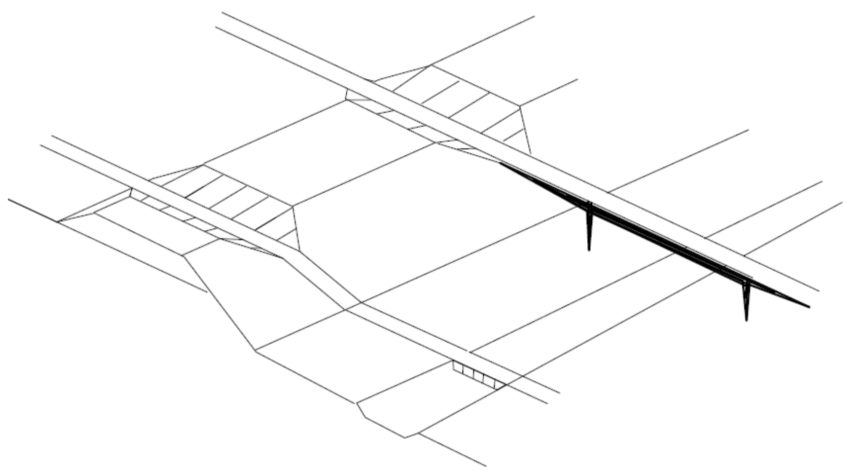
PROPOSAL NO: 5 PAGE NO: 2 OF 3

DESCRIPTION: Cross channel using at grade crossing (Low Flow)vs. bridges

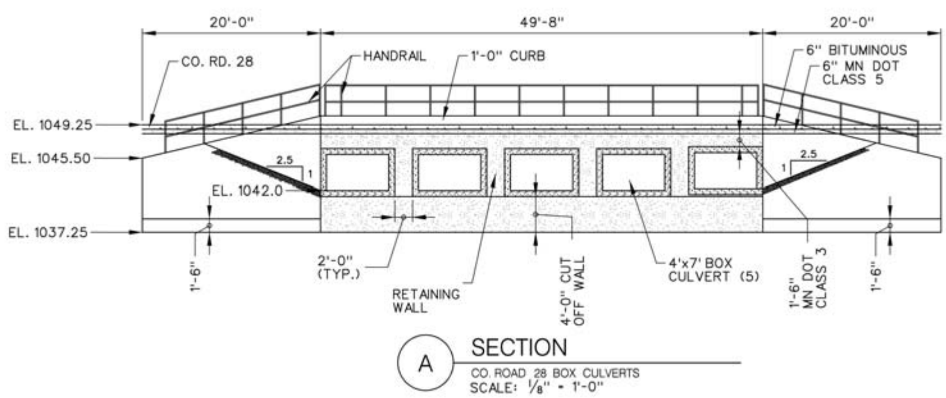
JUSTIFICATION: Cost and increased public access in the project area. Each alignment needs to be reviewed to determine which bridges might be replaced by at grade crossings. An estimated $2.2M can be saved at each converted crossing. To benefit public access in the area more at grade crossings might be used.

DRAWINGS & SKETCHES

EXAMPLE OF A LOW FLOW CHANNEL/ROAD CROSSING



SKETCH – At grade vs. Bridged channel crossing



Possible low flow crossing at channel grade
(Add knock down railings)

COST ESTIMATE WORKSHEET

Proposal #5 - at--grade channel crossing

DELETIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
Use Typical Secondary bridge				$0
15th Street NW MN Short	ea	1	$2,185,000.00	$2,185,000
Delete local drainage inlet - 2 of 7	ea	2.0	$600,000.00	$1,200,000
				$0
				$0
		Total Deletions		$3,385,000

ADDITIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
				$0
Double Box Culverts (2- 4x9')	lf	84	$1,100.00	$92,400
Install double box	lf	84	$550.00	$46,200
Guardrails	lf	200	$200.00	$40,000
Slope end sections	ea	4	$8,000.00	$32,000
precast drop wall	ea	4	$1,950.00	$7,800
Transport box culvert	ea	14	$450.00	$6,300
Transport end section	ea	4	$450.00	$1,800
Excavate roadway	cy	2,000	$5.00	$10,000
surfaced roadway 34.5' W	lf	1,500	$210.00	$315,000
gates/signage	ea	1	$20,000.00	$20,000
Local drainage interception structures	ea	2	$100,000.00	$200,000
		Total Additions		$771,500
		Net Cost Decrease		$2,613,500
Contingency 25% E&D 15%		Mark-ups	40.00%	$1,045,400
		Total Cost Decrease		$3,658,900

Note- Low flow crossings have not been designed- estimate only.

DESCRIPTION: Re-align north end of North Dakota East diversion channel along the south side of 25th Street SE (County Road 4)

ORIGINAL DESIGN: The original design has the north end of the North Dakota East diversion channel extending northeast from the 25th Street SE/171st Avenue SE intersection and discharging to the Red River between 23rd and 24th Streets SE. This is related to VE proposal #1 – but the re-alignment is north of the Sheyenne river.

PROPOSED DESIGN: Re-align the north end of the North Dakota diversion channel to remain south of 25th Street SE, extending the channel directly east of the 25th Street SE/171st Avenue SE intersection until it discharges to the Red River.

ADVANTAGES:

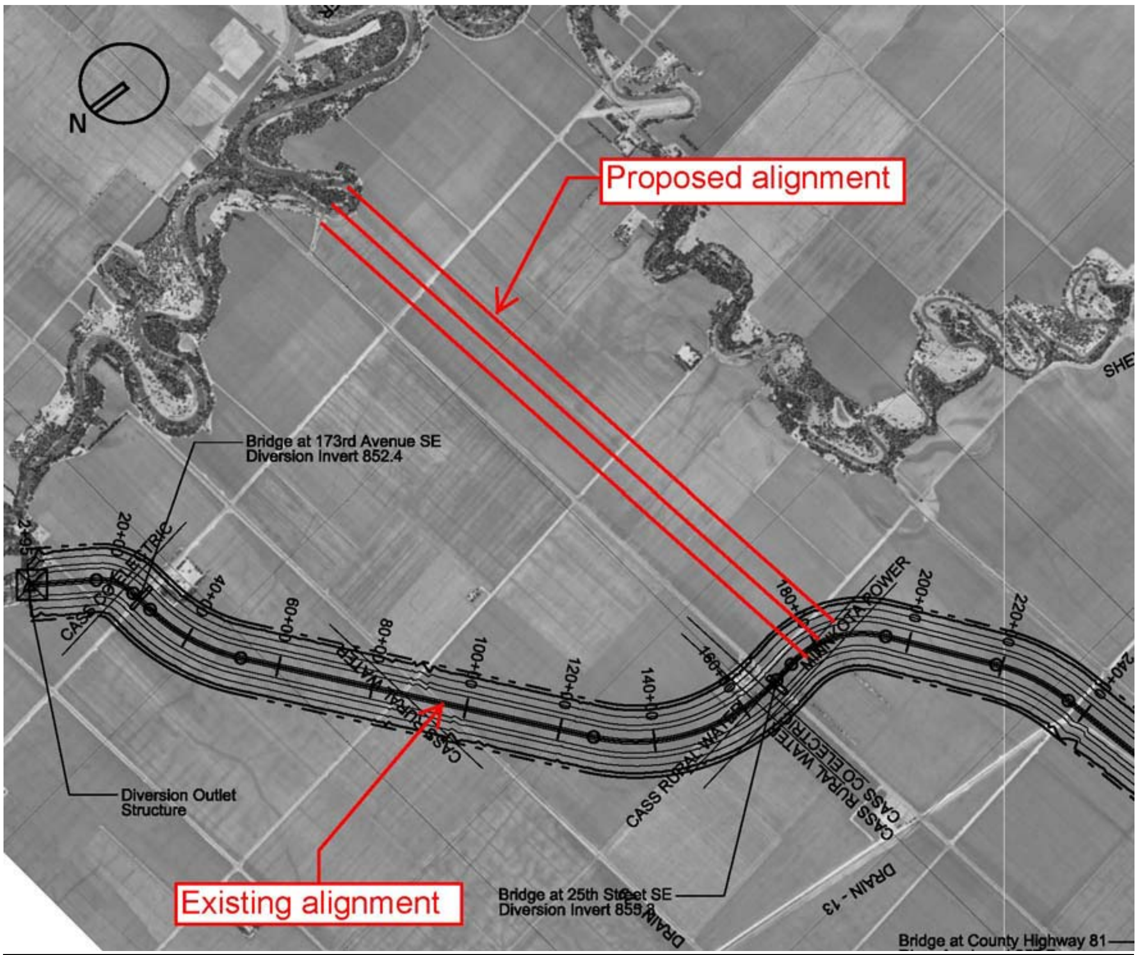
1) Reduce diversion channel length by approximately 4,000 feet
2) Eliminate the 25th Street SE bridge
3) Eliminate 24th Street SE road crossing (no bridge is included in the existing cost estimate)
4) Eliminates utility crossing shown in drawing #1
5) Eliminate at least 1 local drain.

DISADVANTAGES: Unknown hydraulic impact.

JUSTIFICATION: This proposal has the potential to save $17.6 million in channel excavation and bridge construction costs without adding any additional road crossings.

Drawing No. 1

RELOCATED DIVERSION CHANNEL ALIGNMENT, NORTH END OF NORTH DAKOTA EAST ALIGNMENT



	COST ESTIMATE WORKSHEET				
	Speculation Item # P6				
	Realign ND channel outlet further South				
	DELETIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	Channel excavation	LF	17,600	$2,722.00	$47,907,200
	25th Street SE bridge	LS	1	$3,192,300.00	$3,192,300
	Eliminate 1 local Drain	ea	1	$1,100,000.00	$1,100,000
	Less Land Acquisiton (2%)	acres	120	$6,500.00	$780,000
			Total Deletions		$52,979,500
	ADDITIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	Channel excavation	LF	13,650	$2,722.00	$37,155,300
					$0
					$0
			Total Additions		$37,155,300
			Net Cost Decrease		$15,824,200
	35% on features only		Mark-ups		$1,775,305
	(bridges,inlet, land)		Total Cost Decrease		$17,599,505
	All Mark-ups included in Unit Prices. Contingency or S&I applied.				

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: 7 - ACCEPTED PAGE NO: 1 OF 3

DESCRIPTION: Integral Concrete Abutment/Channel Wall at Bridges

ORIGINAL DESIGN: The North Dakota east alignment generally follows the North Dakota west alignment except that, after crossing the Sheyenne River, it utilizes the existing Horace to West Fargo Sheyenne River Diversion corridor between Horace and I-94. The alignment crosses I-29 on the North side of Fargo where there a 4 bridges in close proximity. The bridges are included for I-29 (2), County 81, and a Railroad bridge. The current design is to provide 4 independent bridges spanning a trapezoidal earth channel design.

PROPOSED DESIGN: The proposed design is to provide a rectangular channel integrating the bridge abutments with a channel wall (See Drawing No. 1 on next page). In between bridges could be earth channel or T-wall side channel walls.

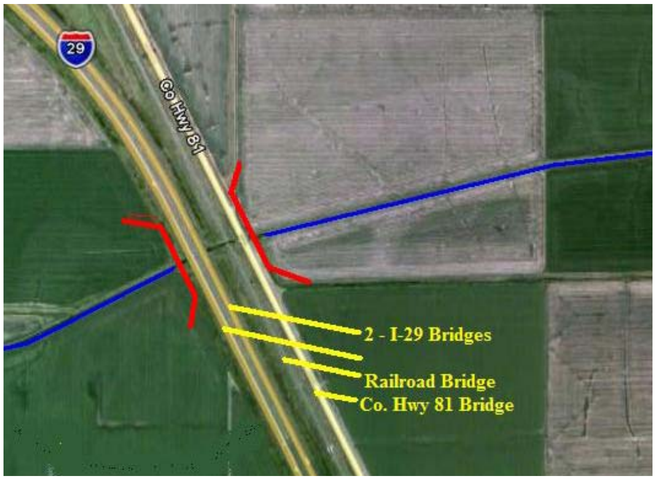
ADVANTAGES:

1. The each bridge span length is reduced by about 169 feet
2. Reduce construction duration
3. Smaller foot print
4. Could reduce beam sizes if 3 support column design is retained
5. Could consider 2 beam support bridge/longer spans
6. Less Ice blockage problem with reduced column design
7. Less bridge maintenance.

DISADVANTAGES:

1. Additional excavation and scour protection
2. Large gravity abutments are required to retain soil
3. Longer span (2 column bridge) has deeper beams – may need more road track raise.

JUSTIFICATION: The proposal saves initial cost of construction of bridges and requires a smaller foot print thus reducing initial impacts.

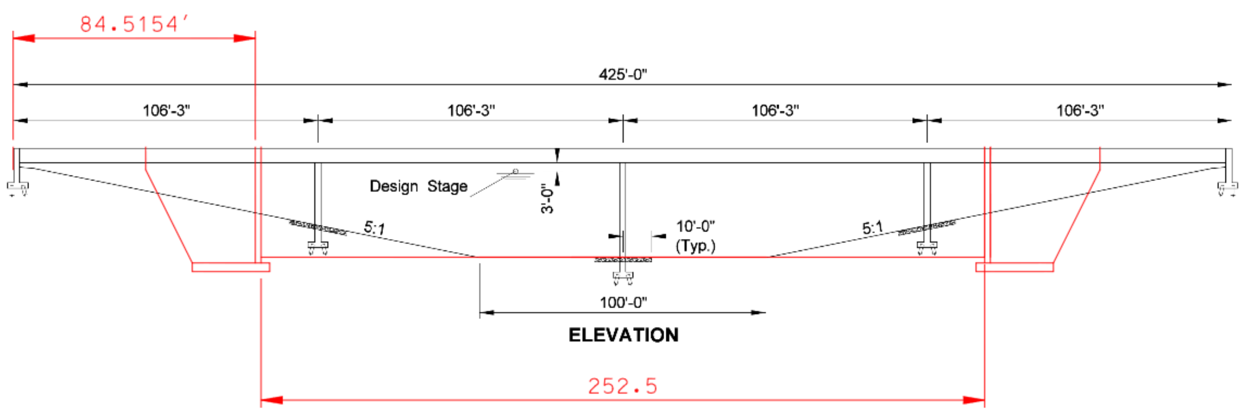


Drawing No. 1

CURRENT BRIDGE COSTS AND PROPOSED SECTION

Bridge Cost Estimates						
Location	Bridge Area (SF)	Cost per SF	Approach Road Cost	Temporary Bypass Cost	Bridge Cost	Total Cost
Interstate 29 (NB-South)	17,000	$115	$35,000	$80,000	$1,955,000	$2,070,000
Interstate 29 (SB-South)	17,000	$115	$35,000	$80,000	$1,955,000	$2,070,000
48th Street SE	12,200	$130	$10,000	$55,000	$1,585,000	$1,650,000
170th Avenue SE	12,200	$130	$0	$55,000	$1,585,000	$1,640,000
Railroad Bridge 4	7,200	$205	$120,000	$385,000	$1,475,000	$1,980,000
46th Street SE	12,200	$130	$0	$55,000	$1,585,000	$1,640,000
44th Street SE	12,200	$130	$5,000	$55,000	$1,585,000	$1,645,000
41st Street SE	12,200	$130	$5,000	$55,000	$1,585,000	$1,645,000
Interstate 94 (EB)	18,063	$115	$0	$80,000	$2,075,000	$2,155,000
Interstate 94 (WB)	18,063	$115	$0	$80,000	$2,075,000	$2,155,000
Railroad Bridge 3	15,200	$165	$140,000	$760,000	$2,510,000	$3,410,000
36th Street SE	12,200	$130	$15,000	$55,000	$1,585,000	$1,655,000
33rd Street SE	12,963	$130	$20,000	$55,000	$1,685,000	$1,760,000
Railroad Bridge 2	7,650	$205	$235,000	$385,000	$1,570,000	$2,190,000
31st Street SE	12,963	$130	$15,000	$55,000	$1,685,000	$1,755,000
28th Street SE	12,963	$130	$20,000	$55,000	$1,685,000	$1,760,000
Interstate 29 (SB-North)	18,063	$115	$45,000	$80,000	$2,075,000	$2,200,000
Interstate 29 (NB-North)	18,063	$115	$45,000	$80,000	$2,075,000	$2,200,000
Railroad Bridge 1	7,650	$205	$565,000	$385,000	$1,570,000	$2,520,000
County Hwy 81	12,963	$130	$30,000	$55,000	$1,685,000	$1,770,000
25th Street SE	12,963	$130	$30,000	$55,000	$1,685,000	$1,770,000
173rd Avenue SE	13,725	$130	$45,000	$55,000	$1,785,000	$1,885,000
					Total ND East - 35,000 CFS	$43,525,000

The bridges in this proposal are the 3rd-6th bridges from the bottom of the table. (I-29 SB-north $2.2M, I-29 NB- North $2.2M, RR Bridge #1 @ $2.52M and County Rd 81 bridge $1.77M)



	COST ESTIMATE WORKSHEET				
	Speculation Item # 7				
		DELETIONS			
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
					$0
	1 Bridge Spans Reduced(using avg $/SF)	SF	7267	$142.00	$1,031,914
	Excavation	CY	4,141	$5	$20,704
					$0
			Total Deletions		$1,052,618
		ADDITIONS			
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	Qty - 1 Bridge span				$0
	Abutment Concrete				
	Side Walls	CY	607	$525	$318,733
	Footing	CY	270	$525	$141,750
	Front wall	LB	258	$525	$135,450
	Rebar	CY	153,240	$1	$176,226
	Excavation	CY	1,851	$5	$9,253
	Riprap		280	$84.00	$23,520
					$0
					$0
			Total Additions		$804,932
			Net Cost Decrease		$247,685
			Mark-ups	0.00%	$0
			Total Cost Decrease		$247,685
	Total Cost Decrease for 4 bridges ==>				$990,742
	All Mark-ups included in Unit Prices. Contingency or S&I applied.				
***	Could also be applied to Proposal 11 - MN RR yard				

DESCRIPTION: Alternatives for local drainage side inlets

ORIGINAL DESIGN: Existing drainage ditch flow is directed to a drop inlet structure that outlets to the diversion channel (see Drawing No. 1).

PROPOSED DESIGN:

9-1) Raise the outlet elevation into the diversion channel and add riprap (see Drawing No. 2)
9-2) "Neck in" fill at local drainage side inlets (see Drawing No. 3)
9-3) Move riser to inside of spoil berm, either by extending the drainage ditch channel across the berm (see Drawing No. 4) or installing a horizontal pipe through the berm (see Drawing No. 5)
9-4) Downsize inlet structures for smaller drainage ditches that don't require a 72-inch pipe to pass flow (the current plans assume 72" pipes for all drainage ditch intercepts)

ADVANTAGES:

9-1) Decrease vertical and horizontal pipe lengths; reduce excavation needed for pipe placement
9-2) Decrease horizontal pipe length
9-3) If the drainage ditch channel is extended across the spoil berm, which has up to a 300-foot top width, a significant amount of pipe can be eliminated. If horizontal pipe was still used to transfer drainage ditch flow to the inside of the spoil berm, moving the riser to the inside of the berm would require less excavation
9-4) Reduce pipe sizes

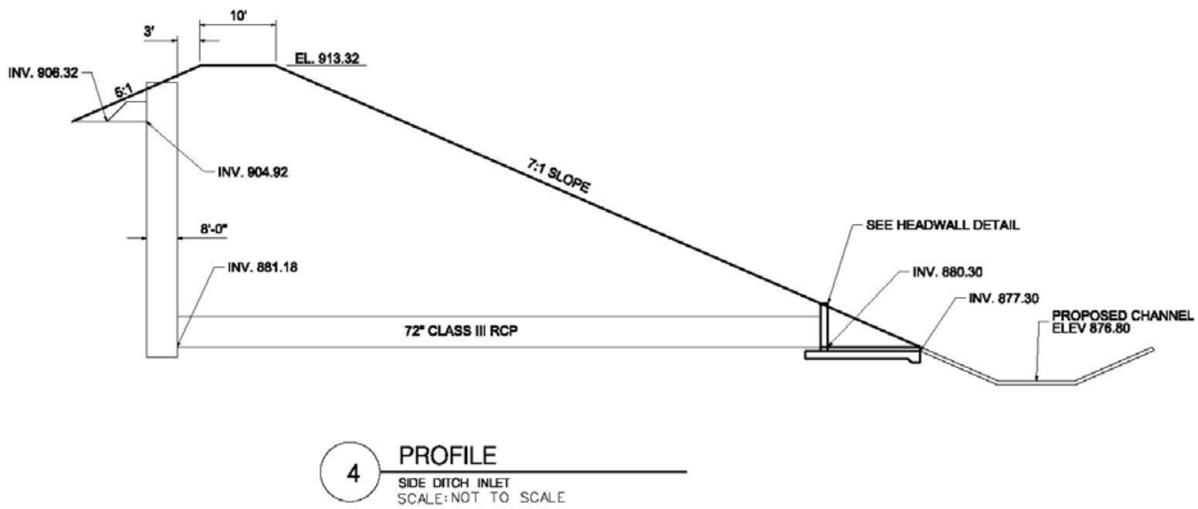
DISADVANTAGES:

9-1) Requires riprap along diversion channel side slope below pipe outlet; may lead to erosion of diversion channel side slopes
9-2) Increased diversion channel side slope increases the possibility of erosion.
9-3) Extending the drainage ditch across the spoil berm reduces the top-of-berm elevation, which may reduce the capacity of the diversion channel.
9-4) None

JUSTIFICATION: If changes are made to all of the drainage side inlets, this proposal has the potential to save up to $4.8 million dollars for the North Dakota west alignment and up to $3.9 million dollars for the Minnesota short alignment. A cost estimate was not performed for Proposal 9-4 as this requires hydraulic analysis beyond the scope of this VE report. However, it is assumed that the drainage side inlets in the final design will be based on specific hydraulic computations, which will most likely lead to a reduction in pipe sizes and therefore a reduction in cost.

Drawing No. 1

FLOOD CONTROL-SIDE INLET (TYPICAL)

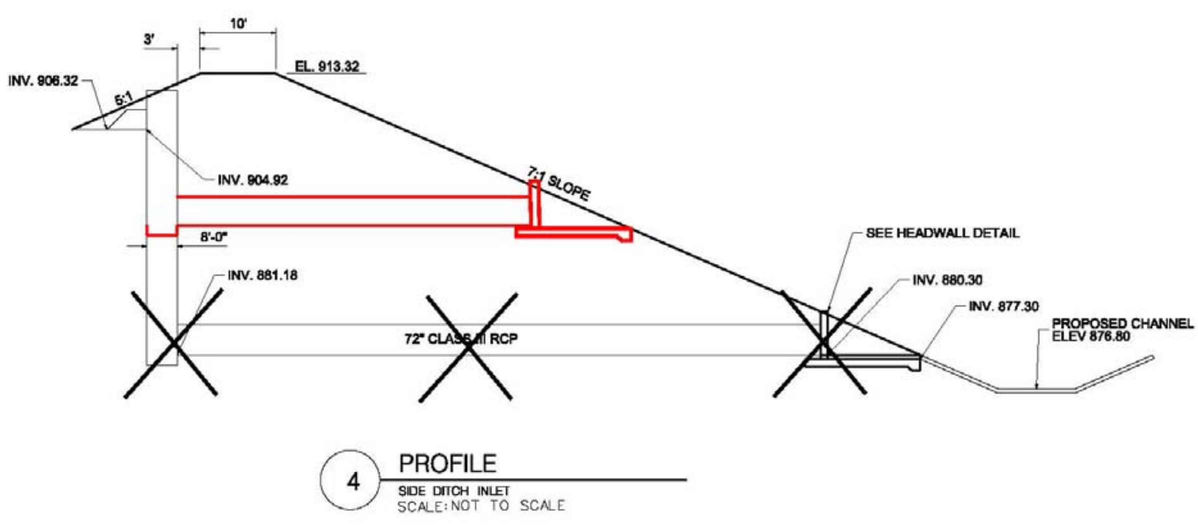


Sheet Reference Number S-412,
Flood Control - Side Inlet (typical)

Drawing No. 2

FLOOD CONTROL-SIDE INLET P9-1

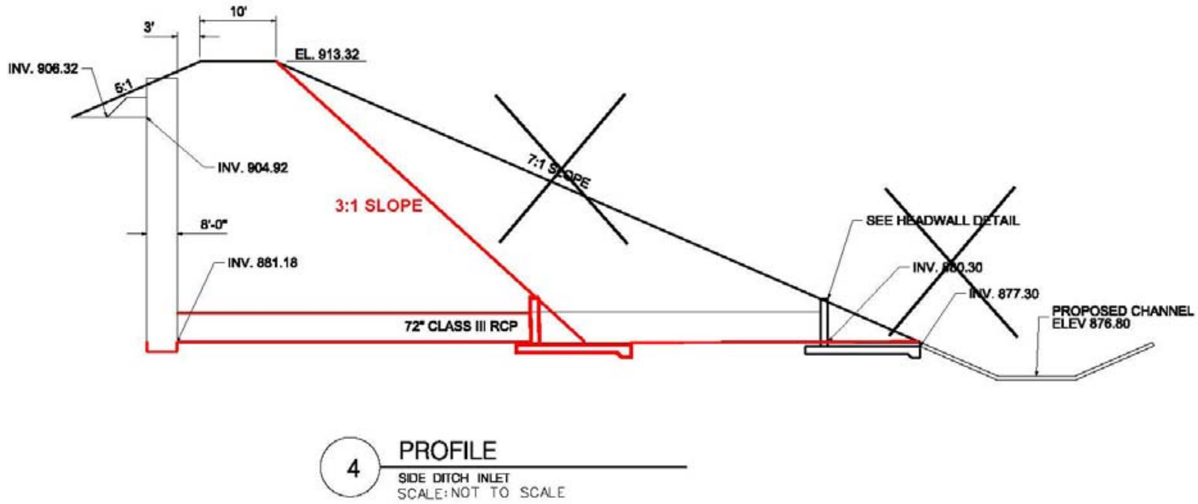
RAISE OUTLET ELEVATION



Sheet Reference Number S-412,
Flood Control - Side Inlet (typical)

Drawing No. 3

FLOOD CONTROL-SIDE INLET P9-2
"NECK IN" FILL AT INLET

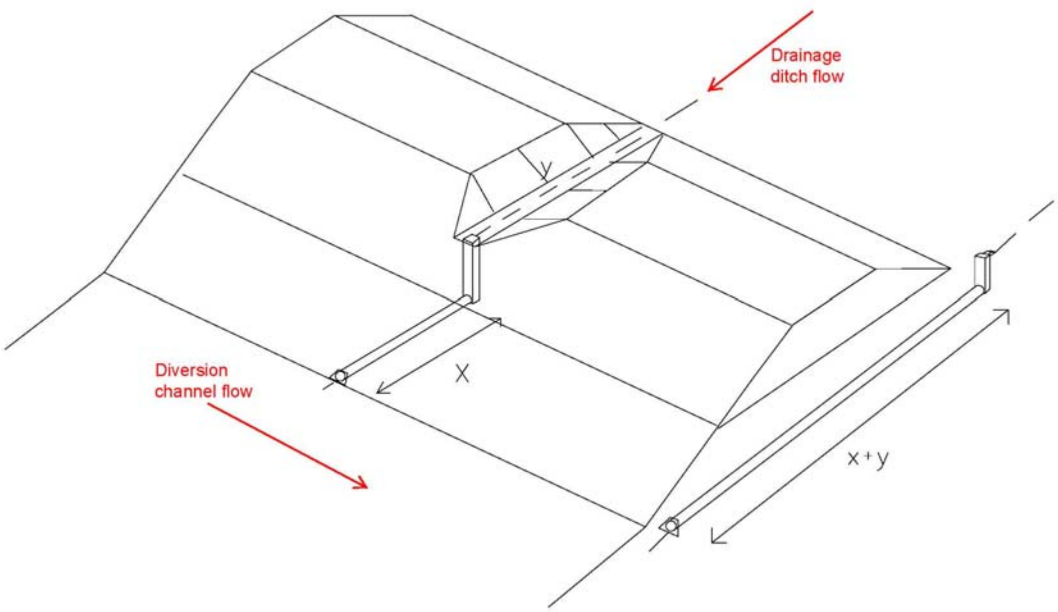


Sheet Reference Number S-412,
Flood Control - Side Inlet (typical)

Drawing No. 4

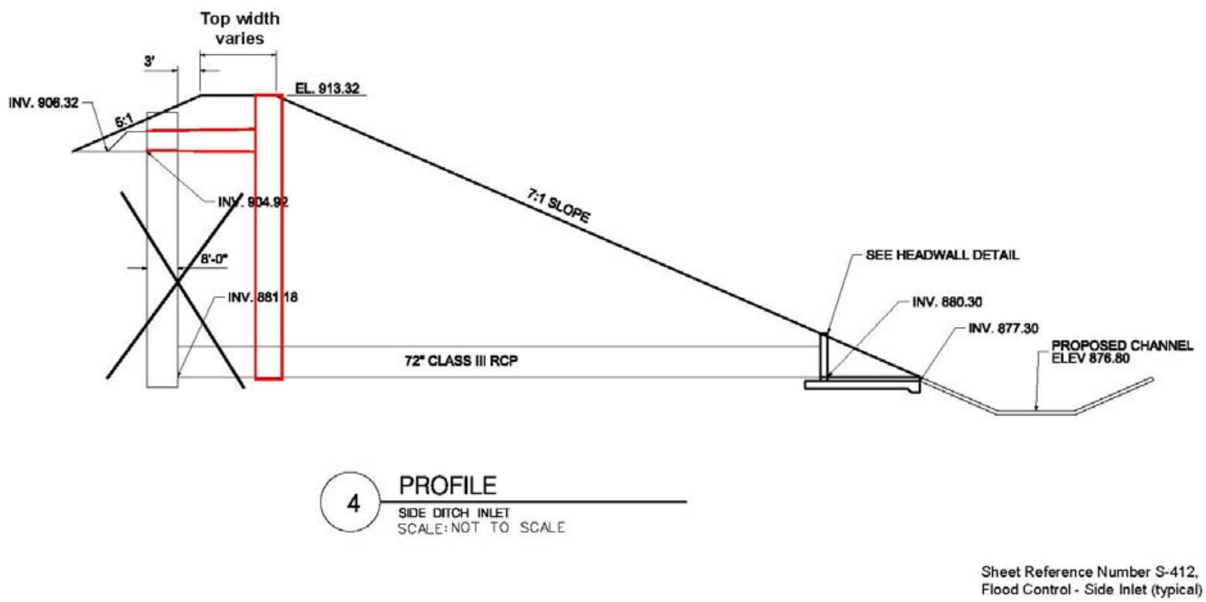
FLOOD CONTROL-SIDE INLET P9-3A

MOVE RISER TO INSIDE OF SPOIL BERM BY EXTENDING DRAINAGE DITCH



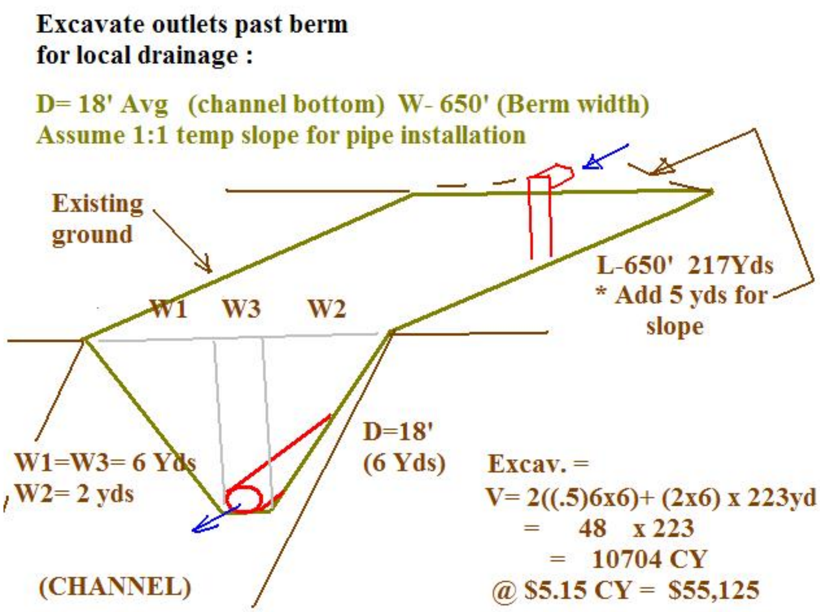
Drawing No. 5

FLOOD CONTROL-SIDE INLET P9-3B
MOVE RISER TO INSIDE OF SPOIL BERM USING HORIZONTAL PIPE



Drawing No. 6

FLOOD CONTROL-SIDE INLET
EXCAVATION ESTIMATE



	COST ESTIMATE WORKSHEET				
	Speculation Item # P9-1 ND West Alignment				
	Raise pipe outlet elevation				
	DELETIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	96" Reinforced Concrete Manhole	LF	1,085	$3,000.00	$3,255,000
	72" Reinforced Concrete Pipe	LF	18,725	$400.00	$7,490,000
	Excavation - single pipe (see Dwg. 6)	CY	160,560	$5.15	$826,884
	Excavation - double pipe (see Dwg. 6)	CY	133,800	$5.15	$689,070
					$0
					$0
					$0
					$0
					$0
					$0
					$0
			Total Deletions		$12,260,954
	ADDITIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	96" Reinforced Concrete Manhole	LF	455	$3,000.00	$1,365,000
	72" Reinforced Concrete Pipe	LF	14,350	$400.00	$5,740,000
	Riprap (single pipe: 1'T x 22.6'W x 146.4'L)	CY	1,838	$56.00	$102,935
	Riprap (double pipe: 1'T x 31.8'W x 146.4'L)	CY	1,724	$56.00	$96,559
	Geotextile fabric (22.6'W x 146.4'L)	SY	5,514	$9.00	$49,630
	Geotextile fabric (31.8'W x 146.4'L)	SY	5,173	$9.00	$46,555
					$0
			Total Additions		$7,400,679
			Net Cost Decrease		$4,860,275
			Mark-ups	0.00%	$0
			Total Cost Decrease		**$4,860,275**
	Notes:				
	1. Assume 15 single pipe structures, 10 double pipe structures (ND West alignment)				
	1. Assume elevations and slopes from Dwg. 2 to determine pipe lengths				
	2. Unit costs from BARR cost estimate, eff. Date 8/26/2009				
	3. Assume spoil berm top width = 300'				
	4. Assume top of manhole at 912.0, new outlet invert 898.0, 0.0035 ft/ft pipe slope				
	5. 1' thick riprap blanket extends down slope from new invert (898) to old (877.3); 22.7' wide (single pipe), 31'10" wide (double pipe)				
	6. Assume no excavation for proposed, as pipes will be at existing ground elevation				

COST ESTIMATE WORKSHEET

Speculation Item # P9-2 ND West Alignment
"Neck-in" fill at inlet to diversion channel

DELETIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
72" Reinforced Concrete Pipe	LF	18,725	$400.00	$7,490,000
				$0
				$0
				$0
		Total Deletions		$7,490,000

ADDITIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
72" Reinforced Concrete Pipe	LF	14,105	$400.00	$5,642,000
				$0
				$0
				$0
		Total Additions		$5,642,000
		Net Cost Decrease		$1,848,000
		Mark-ups	0.00%	$0
			Total Cost Decrease	**$1,848,000**

1. Assume 15 single pipe structures, 10 double pipe structures (ND West alignment)
2. Assume elevations and slopes from Dwg. 3 to determine pipe lengths
3. Unit costs from BARR cost estimate, eff. Date 8/26/2009
4. Assume spoil berm top width = 300'
5. Assume excavation amount won't change

	COST ESTIMATE WORKSHEET				
	Speculation Item # P9-3a ND West Alignment				
	Move riser to inside of spoil berm by extending drainage ditch				
	DELETIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	72" Reinforced Concrete Pipe	LF	18,725	$400.00	$7,490,000
	Excavation - single pipe (see Dwg. 6)	CY	160,560	$5.15	$826,884
	Excavation - double pipe (see Dwg. 6)	CY	133,800	$5.15	$689,070
					$0
					$0
			Total Deletions		$9,005,954
	ADDITIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	72" Reinforced Concrete Pipe	LF	8,435	$400.00	$3,374,000
	Excavation - single pipe (see Dwg. 6, L=360)	CY	86,400	$5.15	$444,960
	Excavation - double pipe (see Dwg. 6, L=360')	CY	72,000	$5.15	$370,800
					$0
					$0
			Total Additions		$4,189,760
			Net Cost Decrease		$4,816,194
			Mark-ups	0.00%	$0
			Total Cost Decrease		**$4,816,194**
	1. Assume 15 single pipe structures, 10 double pipe structures (ND West alignment)				
	2. Assume elevations and slopes from sheet S-412 to determine pipe lengths				
	3. Unit costs from BARR cost estimate, eff. Date 8/26/2009				
	4. Assume spoil berm top width = 300'				
	5. Set riser 10' into spoil berm to permit access during flooding				

	COST ESTIMATE WORKSHEET				
	Speculation Item # P9-3b ND West Alignment				
	Move riser to inside of spoil berm using horizontal pipe				
	DELETIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	Excavation - single pipe (see Dwg. 6)	CY	160,560	$5.15	$826,884
	Excavation - double pipe (see Dwg. 6)	CY	133,800	$5.15	$689,070
					$0
					$0
			Total Deletions		$1,515,954
	ADDITIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	Excavation - single pipe (see Dwg. 6, L=360)	CY	86,400	$5.15	$444,960
	Excavation - double pipe (see Dwg. 6, L=360')	CY	72,000	$5.15	$370,800
					$0
					$0
			Total Additions		$815,760
			Net Cost Decrease		$700,194
			Mark-ups	0.00%	$0
			Total Cost Decrease		**$700,194**
	1. Assume 15 single pipe structures, 10 double pipe structures (ND West alignment)				
	2. Assume elevations and slopes from Dwg. 5 to determine pipe lengths				
	3. Unit costs from BARR cost estimate, eff. Date 8/26/2009				
	4. Assume spoil berm top width = 300'				
	5. Set riser 10' into spoil berm to permit access during flooding				
	6. Assume no excavation for pipe through spoil berm (above ground elevation)				

COST ESTIMATE WORKSHEET

Speculation Item # P9-1 MN Short Alignment
Raise pipe outlet elevation

DELETIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
96" Reinforced Concrete Manhole	LF	899	$3,000.00	$2,697,000
72" Reinforced Concrete Pipe	LF	15,515	$400.00	$6,206,000
Excavation - single pipe (see Dwg. 6)	CY	74,928	$5.15	$385,879
Excavation - double pipe (see Dwg. 6)	CY	147,180	$5.15	$757,977
				$0
				$0
				$0
				$0
		Total Deletions		$10,046,856

ADDITIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
96" Reinforced Concrete Manhole	LF	377	$3,000.00	$1,131,000
72" Reinforced Concrete Pipe	LF	11,890	$400.00	$4,756,000
Riprap (single pipe: 1'T x 22.6'W x 146.4'L)	CY	858	$56.00	$48,037
Riprap (double pipe: 1'T x 31.8'W x 146.4'L)	CY	1,897	$56.00	$106,215
Geotextile fabric (22.6'W x 146.4'L)	SY	2,573	$9.00	$23,160
Geotextile fabric (31.8'W x 146.4'L)	SY	5,690	$9.00	$51,211
				$0
		Total Additions		$6,115,623
		Net Cost Decrease		$3,931,234
		Mark-ups	0.00%	$0
		Total Cost Decrease		**$3,931,234**

Notes:
1. Assume 7 single pipe structures, 11 double pipe structures (MN Short alignment)
1. Assume elevations and slopes from Dwg. 2 to determine pipe lengths
2. Unit costs from BARR cost estimate, eff. Date 8/26/2009
3. Assume spoil berm top width = 300'
4. Assume top of manhole at 912.0, new outlet invert 898.0, 0.0035 ft/ft pipe slope
5. 1' thick riprap blanket extends down slope from new invert (898) to old (877.3); 22.7' wide (single pipe), 31'10" wide (double pipe)

	COST ESTIMATE WORKSHEET				
	Speculation Item # P9-2 MN Short Alignment				
	"Neck-in" fill at inlet to diversion channel				
	DELETIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	72" Reinforced Concrete Pipe	LF	15,515	$400.00	$6,206,000
					$0
			Total Deletions		$6,206,000
	ADDITIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	72" Reinforced Concrete Pipe	LF	11,687	$400.00	$4,674,800
					$0
					$0
			Total Additions		$4,674,800
			Net Cost Decrease		$1,531,200
			Mark-ups	0.00%	$0
				Total Cost Decrease	**$1,531,200**
	1. Assume 7 single pipe structures, 11 double pipe structures (MN Short alignment)				
	2. Assume elevations and slopes from Dwg. 3 to determine pipe lengths				
	3. Unit costs from BARR cost estimate, eff. Date 8/26/2009				
	4. Assume spoil berm top width = 300'				
	5. Assume excavation amount won't change				

COST ESTIMATE WORKSHEET

Speculation Item # P9-3a MN Short Alignment
Move riser to inside of spoil berm by extending drainage ditch

DELETIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
72" Reinforced Concrete Pipe	LF	15,515	$400.00	$6,206,000
Excavation - single pipe (see Dwg. 6)	CY	74,928	$5.15	$385,879
Excavation - double pipe (see Dwg. 6)	CY	147,180	$5.15	$757,977
				$0
		Total Deletions		$7,349,856

ADDITIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
72" Reinforced Concrete Pipe	LF	6,989	$400.00	$2,795,600
Excavation - single pipe (see Dwg. 6, L=360)	CY	40,320	$5.15	$207,648
Excavation - double pipe (see Dwg. 6, L=360')	CY	79,200	$5.15	$407,880
				$0
		Total Additions		$3,411,128
		Net Cost Decrease		$3,938,728
		Mark-ups	0.00%	$0
		Total Cost Decrease		**$3,938,728**

1. Assume 7 single pipe structures, 11 double pipe structures (MN Short alignment)
2. Assume elevations and slopes from sheet S-412 to determine pipe lengths
3. Unit costs from BARR cost estimate, eff. Date 8/26/2009
4. Assume spoil berm top width = 300'
5. Set riser 10' into spoil berm to permit access during flooding

	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	Excavation - single pipe (see Dwg. 6)	CY	74,928	$5.15	$385,879
	Excavation - double pipe (see Dwg. 6)	CY	147,180	$5.15	$757,977
			Total Deletions		$1,143,856
	ADDITIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	Excavation - single pipe (see Dwg. 6, L=360)	CY	40,320	$5.15	$207,648
	Excavation - double pipe (see Dwg. 6, L=360')	CY	79,200	$5.15	$407,880
					$0
			Total Additions		$615,528
			Net Cost Decrease		$528,328
			Mark-ups	0.00%	$0
			Total Cost Decrease		**$528,328**
	1. Assume 7 single pipe structures, 11 double pipe structures (MN Short alignment)				
	2. Assume elevations and slopes from Dwg. 5 to determine pipe lengths				
	3. Unit costs from BARR cost estimate, eff. Date 8/26/2009				
	4. Assume spoil berm top width = 300'				
	5. Set riser 10' into spoil berm to permit access during flooding				
	6. Assume no excavation for pipe through spoil berm (above ground elevation)				

DESCRIPTION: Raise In-City protection to 100 Year Levels

(25K plan doesn't protect downtown Fargo during 100-year (Elm St closed, 2nd St. dike installed))

ORIGINAL DESIGN: The design would use a diversion channel to route flood flows around the metropolitan area resulting in lower stages in the natural channel through town. The design for a MN 25,000 cfs diversion channel would lower the expected water surface elevation at the River Gage in Fargo as illustrated in the table below.

	Stage at the Fargo Gage		
	2% Chance (50% Year)	1% Chance (100 Year)	0.2% Chance (500 Year)
Existing Condition	37.8 RG	39.5 RG	43.9 RG
25 K Condition	29.1 RG	30.4 RG	39.2 RG

The residual flow on a 100 year and 500 year events through the natural channel would require emergency measures to continue. Please see the attached map indicating the current levels of protection. With a residual stage of 30.4 feet 0.62 miles (3317 feet) of temporary measures would still be required for the 100 year flood fight within Fargo to protect to a stage of 31 feet. In addition 28.12 miles (148,513 feet) of temporary measures would still be required for the 500 year event within Fargo to protect to a stage of 40 feet.

Moorhead would not need to build any temporary lines of protection for the proposed 100 year water surface elevation. Moorhead begins sandbagging efforts at a River gage of 33.5 feet and would require extensive effort at the anticipated 39.2 River Gage that would still be expected for the 500 year event.

PROPOSED DESIGN: The proposed design includes construction of the MN 25,000 cfs channel as it was originally designed but also includes construction of a floodwall from 4th Avenue North to Northern Pacific Avenue and from Main Avenue to the existing 4th street levee. The floodwall would be designed to accommodate the anticipated 500 year flow with an additional 3' foot of freeboard resulting in a top of wall at a River Gage of 42.2.

North of Main avenue this would require a structural floodwall of approximately 12 feet in height at a length of 2400 feet. This would require 5 temporary road closures. These closures are at the following locations: on 2nd Street just north of 4th Avenue North, on 4th Avenue North at the intersection with 2nd street North, on 3rd Avenue North at the intersection with 2nd Street North, on 2nd street at intersection with 1st Avenue North, and on Northern Pacific Avenue at approximately the intersection with 1st Street North.

South of Main Avenue the structural floodwall height would be approximately 11 feet for a length of 1500 feet with 2 temporary closures just south of Main Avenue and at the tie in point with the 4th Street levee.

ADVANTAGES: The addition of permanent flood walls with temporary road closures decreases the vulnerability of the system during events. It also decreases the cost to fight future events. Greater reliability provides reduced residual risk.

DISADVANTAGES: Raises the overall cost of the project.

JUSTIFICATION: Significant losses could still be experienced without the inclusion of additional measures. Many properties will remain at risk for those events around the 100 year recurrence interval and higher. It is important to note that the City has already faced at least one event higher than the 100 year recurrence.

The Flood fight costs would continue to be incurred and would require extreme mobilization to provide temporary measures. During the levee construction the amount of truck traffic increases and due to the nature of their work they are often provided priority over the rest of the traveling public, while necessary, this disrupts the traffic flow and can create hazardous conditions for the traveling public.

In addition each flood event that requires these mobilizations decreases the lifespan of City infrastructure and roads. Storm sewers in the vicinity of the earth levees become clogged with materials and require cleaning following an event. Inlets are often damaged, curb lines are destroyed from the effort of constructing the levees in the street. The levee removal process destroys the pavement markings and requires their replacement.

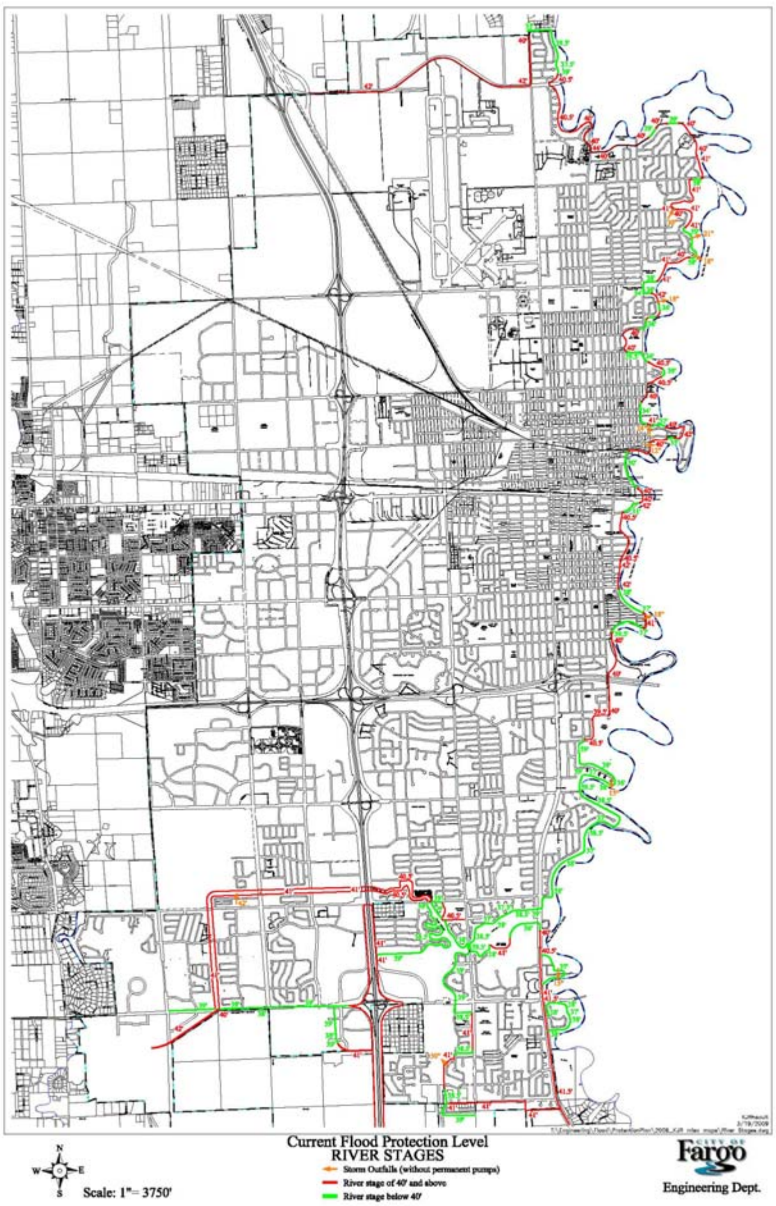
These temporary measures also have a significant impact to the environment, during an emergency earth levees are in direct contact with flood waters. They are not vegetated and have no other erosion protection applied to them. Therefore the floodwaters pick up soil particles and they are discharged down river.

Drawing No. 1

FARGO TEMPORARY PROTECTION REQUIRED BY RIVER STAGE

(EARTH LEVEES, SANDBAGS, AND INNOVATIVE FLOOD FIGHT PRODUCTS)

River Stage	Cum Temp Prot (Feet)	Cum Temp Prot (Miles)	River Stage	Cum Temp Prot (Feet)	Cum Temp Prot (Miles)	River Stage	Cum Temp Prot (Feet)	Cum Temp Prot (Miles)	River Stage	Cum Temp Prot (Feet)	Cum Temp Prot (Miles)
30	2,252	0.42	33	3,317	0.62	36	10,663	2.01	39	88,401	16.74
31	3,317	0.62	34	3,705	0.7	37	20,746	3.92	40	148,513	28.12
32	3,317	0.62	35	4,315	0.81	38	47,093	8.91	41	222,842	42.2
									42	244,143	46.23



COST ESTIMATE WORKSHEET

Speculation Item # P 10
Raise City Protection to 100 yr levels

DELETIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
				$0
		Total Deletions		$0

ADDITIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
R.C. Floodwall 8-12 feet	SF	36,380	$70.00	$2,546,600
R. C. Floodwall Footing 8-12 feet	LF	3,900	$940.00	$3,666,000
Removable Floodwall	SF	8,920	$200.00	$1,784,000
Removable Floodwall Footing	LF	760	$600.00	$456,000
		Total Additions		$8,452,600
		Net Cost Decrease		-$8,452,600
		Mark-ups	25.00%	-$2,113,150
		Total Cost Decrease		-$10,565,750

All Mark-ups included in Unit Prices. Contingency or S&I applied.

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: 10 - REJECTED PAGE NO: 1 OF 6

DESCRIPTION: MN RR Yard relocation issues

ORIGINAL DESIGN: The alignments for the Minnesota diversions cross an area just east of Dilworth, MN that contains an existing railroad switching yard facility. The feasibility report indicates the yard will be relocated at a cost of $90M to facilitate construction of a 500' wide diversion channel through the area. This relocation represents 10% of the estimated $926M project cost. The feasibility design still requires a two track bridge cross the channel at this location to facilitate rail traffic once the diversion channel is built. The crossing does not require significant modifications in grade in this according to the bridge design tables in the feasibility report.

Photo P-11.1 Feasibility report showing Channel/RR crossing area. (Report Plate 7)

PROPOSED DESIGN: There are two design options forwarded by the VE review team that could be considered in the Railroad yard area:

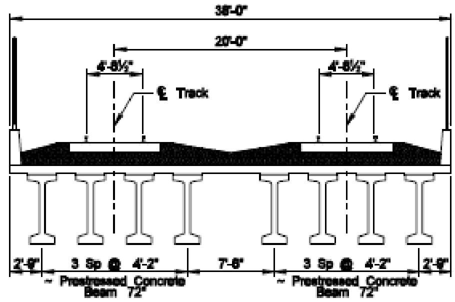
A. Design a rectangular channel section to cross under the existing rail yard and cross in the area designated in the feasibility study. The estimated width of a U-Channel design for the MN 25,000 CFS option is 400' in width. The VE team walked the area and found that there are 5 tracks and a rail crew access road that cross in the proposed channel area. The team also observed a straight section of rail yard long enough to construct a 400' wide U-channel through the area without requiring significant disruption to the switching yards located to the east and west of this are

DESCRIPTION: MN RR Yard relocation issues .

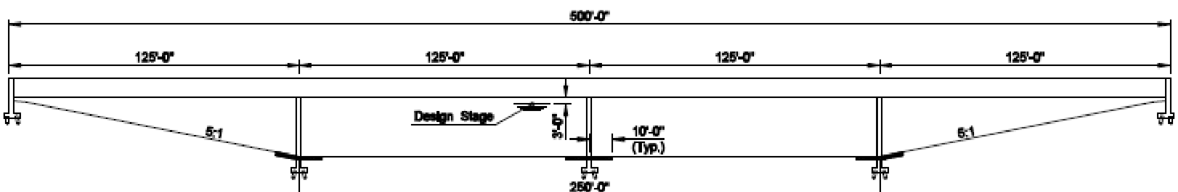
Photo P11.1 – Proposed Mn Diversion channel area through rail yard -Dilworth, MN

This proposal would construct the channel through the area and maintain current usage of the area for the railroad by construction of new RR bridges. The spoil banks normally side cast in the design would be hauled to an alternate disposal location to minimize width of the channel through the yard.

Utilizing a U-channel section would reduce the bridge lengths similar to the cost savings of Proposal 07 which reduced bridge costs by $250K a bridge on the North Dakota side.



Typical Section



ELEVATION
25,000 CFS

Proposed 500’ Bridge design for Harwood Area railroad crossing of new Diversion channel (MN 25,000) (Railroad Bridge #1).

B. The second proposed design for the railroad yard would be to miss the existing rail facility entirely. The existing rail yard extends some 6000' to the east before the multiple tracks converge into the main line set of two tracks. At this location there is a grain storage facility and a self storage business on the north side of the tracks.

To determine whether of not this option was cost effective- the VE team calculated the per foot cost of the MN short 25,000 CFS channel and found that the average excavation cost per foot of project was $2600/L. Ft. of channel. To extend the channel further east would move the alignment as shown below:

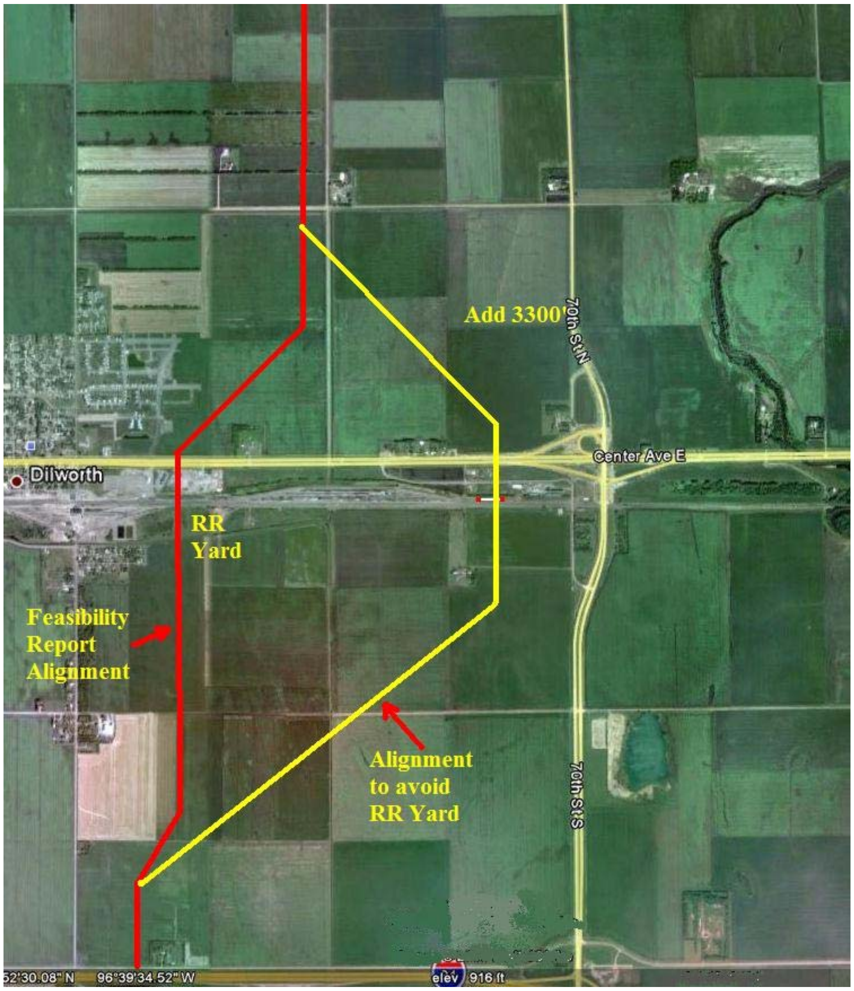


Photo11.4 – Possible channel alignment to avoid crossing rail yard.

Photo P11.6 – Photo looking west from County Hwy 11 toward Rail yard. The Diversion channel could be moved further east into this area to avoid Rail yard and its associated relocation cost.

This alignment extends the project by 3300’ which would increase the channel length and project excavation cost.

ADVANTAGES:

A. Reduced cost, less disruption to area businesses and employment. Smaller bridges,

B. Move project away from city limits, increased safety.

C. Reduced cost, additional water storage capacity (3300’ more channel), less disruption to area businesses & area employment and less bridges than option A of this VE proposal – with only two rail tracks to cross.

DISADVANTAGES: A. Additional structures (2 additional bridges will be required), additional construction time and bridge maintenance. Channel cut runs a few 100 ‘ from an existing sewage lagoon to the west of the project – seepage?

DESCRIPTION: MN RR Yard relocation issues .

B. Longer alignment, additional land acquisition. Cost to relocate self storage business. This alignment is closer to the Buffalo Aquifer which was roughly identified as lying beneath County Hwy 11 alignment to areas further east but could factor in this option.

JUSTIFICATION: Same project function at a lower cost.

Both options A& B will generically cost $10M to construct. Relocation of the entire rail yard would be avoided at an estimated $90M. The net benefit to constructing either option is an $80M Savings to MN 25K – increasing the project B/C ratio from 1.22 to 1.30

Alternative B has added benefit of fewer structures than Alternative A and is generically located in a safer location away from Housing area in Dilworth and the sewage lagoons near the rail yard. See cost estimates.

Note: Additional savings ($1M) would be possible if Proposal 7 (u-channel @ multiple bridges) is adopted to reduce bridge sizes.

COST ESTIMATE WORKSHEET

Proposal #11 -Eliminate RR yard relocation
Alternative A - U Channel + Bridges

DELETIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
Railroad yard relocation cost	EA	1	$90,000,000.00	$90,000,000
Railroad bridge construction cost (#1)	ft	500	$7,490.00	$3,745,000
Reduced excavation	cy	4,141	$5.00	$20,705
				$0
				$0
		Total Deletions		$93,765,705

ADDITIONS

Alt. A. -3 bridge through RR yard

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
1- 2 track RR bridge @400'	ft	400	$7,490.00	$2,996,000
1- 2 track RR bridge @400'	ft	400	$7,490.00	$2,996,000
1- 1 track/road access bridge@400	ft	400	$6,000.00	$2,400,000
From Proposal #7				
Move berm to disposal area (not sidecast)	cy	12,500	$2.00	$25,000
U - Channel costs (abutments/wall/riprap)	ea	3	$805,000.00	$2,415,000
		Total Additions		$10,832,000
		Net Cost Decrease		$82,933,705
	E&D	Mark-ups	10.00%	$8,293,371
	Alt A	Total Cost Decrease		$91,227,076

Alt. B. - extend channel east -avoid yard

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
Additional channel Excavation	ft	3,300	$2,600.00	$8,580,000
Relocated RR bridge	ea	500	$7,490.00	$3,745,000
topsoil/seeding	ea	1	$100,000.00	$100,000
(Business relocations considered equal to feasbility alignment - gravel operation moved in feasibility -self store operation in this alternative)				
		Total Additions		$12,425,000
		Net Cost Decrease		$81,340,705
	E&D	Mark-ups	10.00%	$8,134,071
	Alt A	Total Cost Decrease		$89,474,776

Alternative A Saves an estimated	$82.9M
Alternative B saves an estimated	$81.4M

COMMENT LIST

The following value "Comments" were proposed during the study or were identified during proposal development. These comments represent substantial ideas that should be reviewed by the design team to add value to the project but were not selected as cost saving proposals due to time or other informational constraints.

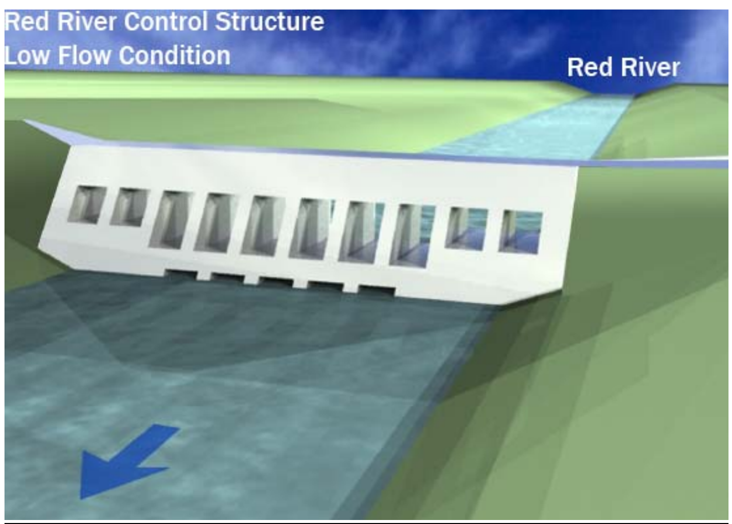
C1. Plan Recreation Facilities into Project Construction. The current plan could be improved by adding recreational features into the project. Though the current plan is to add recreational features in the future, several ideas were identified. Some of these features may require pre-planning and would require some consideration during the project design. Additionally, some features should be considered in the initial design/construction as costs will tend to increase with time. The vast area that will be impacted by a diversion channel provides an almost unlimited opportunity for recreational features. The following list are some features that could be incorporated into the project:

a. Bike paths
b. Horse Trails and associated parking/entry points
c. ATV Park and or Trails (do to erosion, maybe limited to spoil berms)
d. Hiking Trails
e. Open Air Amphitheater
f. Fishing Ponds
g. Garden Plots
h. With minimum low flow, Tubing/Kayaking/canoeing
i. Cross County Skiing
j. Sledding Parks
k. Wildlife Management Area/Hunting

C2 - Beneficial use of Channel Spoil Material (Speculation List Item No 11). The current plan produces significant quantities of spoil material that could have beneficial uses. Potential uses include local and private flood control outside the protected area or other private or public projects requiring fill. A program could be developed that allows for individuals or agencies to apply for use and any cost associated with loading and hauling of spoil material would be covered by the applicant.

C3 - Farming of Channel Side Slopes. The current plan indicates side slopes of 1 on 7 and it was not clear if farming would be allowed or how effective farming would be on these slopes. An evaluation of channel slide slopes and how it might affect farm productivity and channel design should be considered. The evaluation would balance the effects of side slope on farm productivity, channel hydraulics, and real estate requirements.

C4 – Construct diversion channel structure capable of passing ice jams. While the actual design of a diversion structure is yet to come, news reports from the Winnipeg diversion project cited icing problems with their diversion channel this year. Design considerations for gates should include those that will not be affected by late season ice. Having at least one submergible gate to pass ice through might be considered. Tainter gate designs used on the Mississippi River have shown good serviceability in winter conditions should also be considered.



C5 – Add a bridge to Diversion structure design for local access across Red River. The opportunity to create another river crossing exists with the construction of the proposed diversion structure. The closest bridges that span the Red River in this location are 2.4 miles south or north of the proposed diversion location. This bridge would be above flood levels and allow access to the diversion inlet from the ND side. The 110th street bridge located 2.4 miles south might be closed during a flood.

C6 - Manage Diversion Channel to Support Wetland/Wildlife. The current plan could be improved by adding wetland/wildlife management plan that would provide environmental enhancement. The plan could vary from a simple conservation program (similar to CRP land) or prairie restoration program to an actively managed wetland/

wildlife refuge. The simple conservation/restoration plan could reduce soil erosion, reduce sedimentation in river, establish wildlife habitat and enhance wetland resources. An actively managed plan could provide for periodic flooding of diversion channel and/or a minimum flow to support wetland growth and wildlife habitat. The actively managed plan would require a flow control or low flow structure at the upstream end.

C7 – Send percentage of diversion flow into Buffalo River. Investigate capability of channeling flows eastward toward the Buffalo River. Aquifer issue may rule this option out.

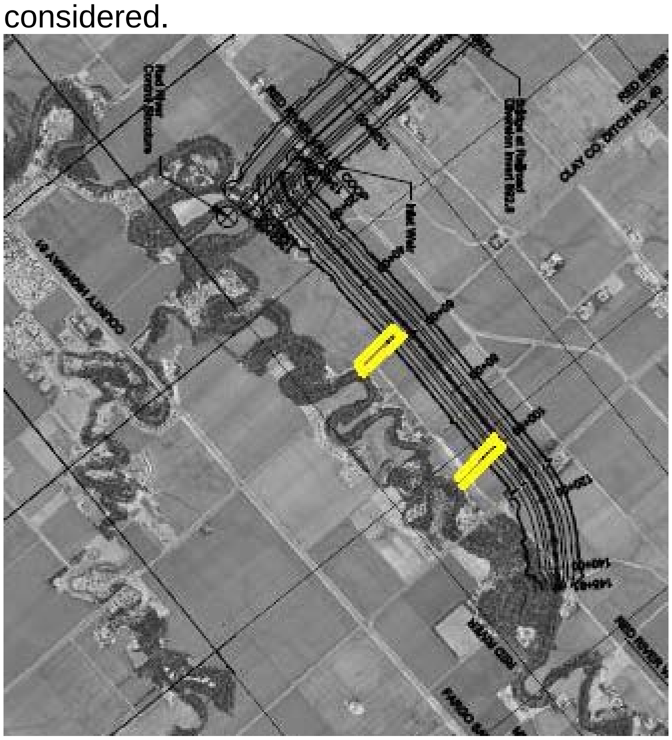
C8- Develop project with and Ice friendly design. Recent experiences in Winnipeg and past experiences in Minnesota require all new construction should not constrict ice flow which typically results in localized flooding. Consider adequate clearance or passages for ice flow.

C9 - Vary spoil berm elevation. Constructing a higher spoil berm on the side of the diversion channel closer to Fargo/Moorhead should be considered. A slightly higher berm on the "city" side of the diversion channel would provide added flood protection by allowing flow exceeding the capacity of the diversion channel to flow away from heavily populated areas.

C10 - Road raise for North Dakota Alignment tie-back levees . The North Dakota East and West Alignments include a tie-back levee extending east from the Red River control structure to high ground. Approximately 1.5 miles of the proposed levee alignment runs along 130th Avenue South. Raising this road and incorporating it into the tie-back levee would reduce the amount of material needed to construct the levee.

***C11 -* Minnesota Short Diversion -- Lateral Drains above Inlet**. There is an extension of the Minnesota Short Diversion to the upstream of the primary inlet. Rather than make this a uniform cross-section channel from its own inlet point to the diversion, make it a tapered channel with multiple entrance points: a "manifold" collection channel drawing water from potential break-out points along the reach between the most upstream inlet to the primary inlet. The image shows three possible locations.

__C12 - Cutoff channels in the Red River upstream of the diversion__. To reduce stage impacts, cutoff channels in the Red River upstream of the diversion structure should be considered.



Add additional connections to limit stage Increases U/S of diversion structure.

C13 - Low flow channel within diversion channel. The original diversion channel design calls for a flat bottom channel, which would cause low flows to meander around and more quickly degrade the channel bottom. A V-channel section within the flat bottom channel would limit low flows to the center of the channel and prevent low flow meandering and channel degradation, thereby reducing the need for channel maintenance.

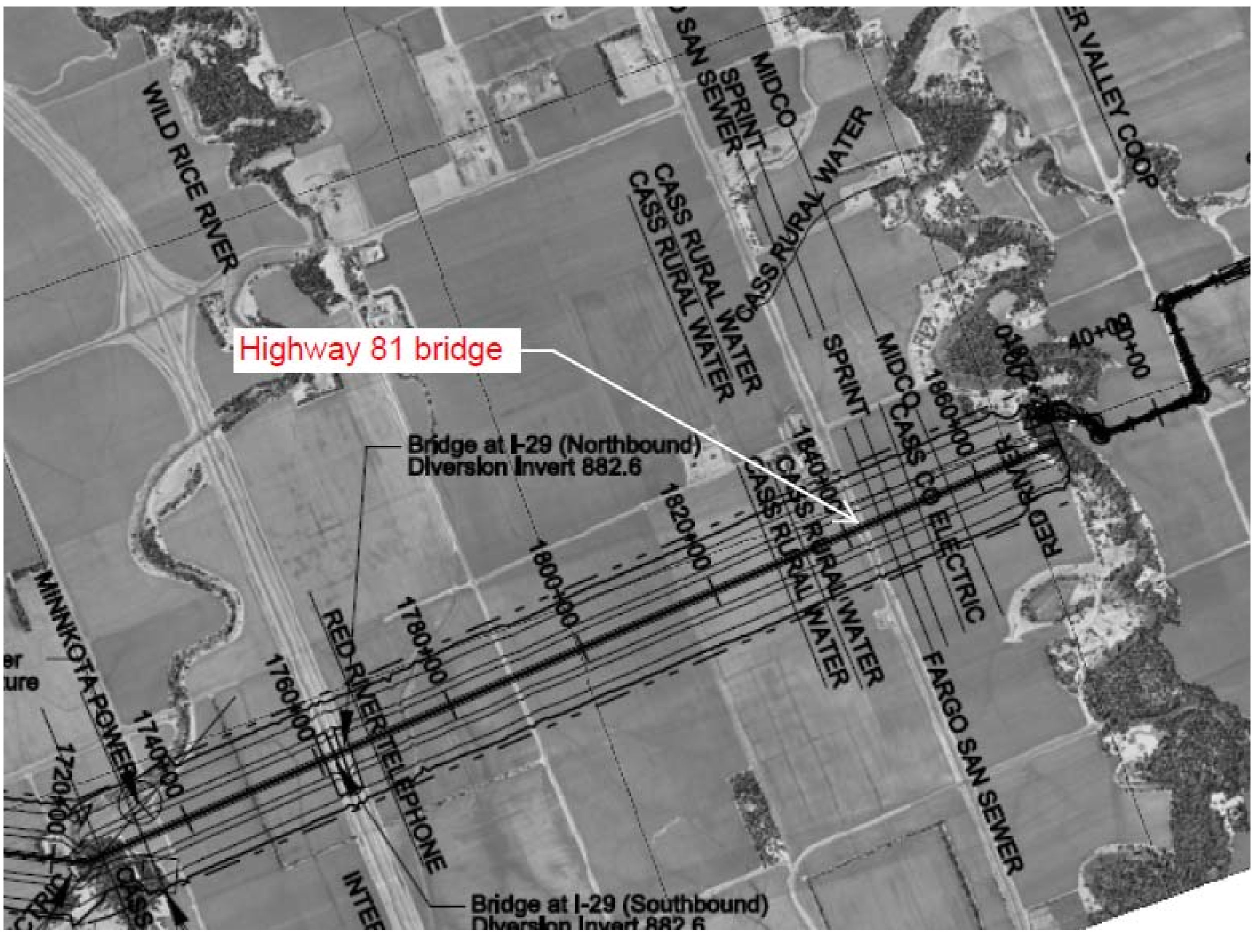
C14 - Low flow crossing for segmented farm fields. For portions of the diversion channel cutting across farm fields, Texas crossings should be installed to allow farmers access to both segments of their field. When possible, landowners with property on both sides of the diversion channel could be reorganized in a land “swap” to establish cropland located on only one side of the channel. This would eliminate the need for low flow crossings to provide access to segmented cropped areas.

C15 – Address safety issues during floods. Operation of the diversion channel will decrease flood issues for residents in some areas and introduce new hazards into others. All activities that might be allowed in the diversion channel during “normal” non-flood years (See comment C-1) will need to be suspended during operation of the channel. Should at grade crossings be permitted (P-5) they would be closed during operation of the diversion. Gates and signage should be developed that restrict floodway usage. News articles from Winnipeg indicate that they sound a horn when the diversion is opened. With a minimum channel length of 25 miles a single horn would not be sufficient. Development of the O&M manual and public warning system in the area would be required as this project advances.

Typical closure gate. During floods all roads/trails crossings would require closure.

C16 - Select grass mixes for weed control and directly seed clay in channels.
Grass seed mixes should be selected to prevent weed growth in the diversion channel. This will reduce maintenance costs and provide ecological diversity for the project. Also, the possibility of eliminating topsoil placement in the diversion channel and directly seeding the exposed natural soils should be investigated. Removing top soil from the diversion channel would reduce the cost of the Minnesota Short 35K alignment by $5.59M.Items that follow were identified during the development of VE team ideas for the written report:

***C17 -* Add Bridge on US Hwy 81 Bus to ND alignments** . The North Dakota East 35 K cost estimate is to be missing a bridge construction cost at Highway 81. This would be the first bridge across the diversion after the inlet.



Add bridge cost to project estimates.

<u>C18a - Minnesota Railroad Yard Crossing</u>. The Minnesota diversion crosses a BNSF railroad yard near Dilworth. The estimate includes a railroad bridge at $6.75M. This bridge would need to carry not only railroad tracks (presumably at least the 7 that exist) but vehicle and pedestrian traffic that supports railroad operations. It seem like the estimate might be low for the amount of bridge width required.

***<u>C18b</u>* <u>- Minnesota Railroad Yard Crossing</u>**. The railroad bridge at the BNSF Dilworth yard will require deep girders, perhaps 10 feet, to support train weight. These girders will impede channel flow. Please verify there will be sufficient channel cross-section below the girders to allow the required channel flow. One solution is to use plate girders on the sides, but this does not allow redundancy.

<u>C18c -Minnesota Railroad Bridge (northernmost)</u> The northernmost customer of the railroad is 1.5 miles north of Moorhead. According to the Dilworth yard manager, the railroad would probably be willing to abandon its line to the north and the project could thus save the cost of the bridge.

***<u>C19</u>* <u>- Add Drop Structure for Western diversion channel - MN short alignments – to the project cost estimate.</u>** Drop structure contained on plans is not found in cost estimate for the project.

***<u>C20</u>* <u>- Use a maximum 2-3% grade on transition section on major roads.</u>** The 6% transitional grades cited in this report are steeper than the average grade found on the national freeway system where it is constructed on flat lands. Max 2-3% is cited as an acceptable slope. This will increase approach modification cost(s) at all bridges.

<u>C21 – Review Utility relocation estimates – ND and MN are the same figure.</u> The utility relocation costs on both the MN short 25K and ND East 35K are listed at $1,888,000 – having 10 additional miles of channel on the ND side is likely to result in additional utility relocation costs. Revise estimate.

<u>FEASIBILITY IDEAS-</u>

Additional VE ideas were brought forward that the team did not develop due to time constraints and they appeared to be off the principle task of studying ND or MN alignment issues. They are recorded here for potential later development by the PDT team or next VE review.

VALUE ENGINEERING FEASIBILITY IDEAS

F1. Determine future status of the West Fargo Diversion channel? Abandoned sections are projected if North Dakota alignment is selected. Should these be filled or closed for safety?

F2. Parallel channels were discussed in our briefing in ND alignments in the Horace to West Fargo reach- but only 1 channel was shown on the handouts. Are there two channels planned?

F3. Item 9.05 in the FMM cost estimate is not clear if it includes both MN inlets on the Red River - the main diversion structure and a inlet structure for the 14500' long – southern extension?

F4. In areas where flow line is higher than existing grades will we need pump stations for Local interception drains?

F5. New Utility towers that span new channel will likely be built on new fill- settlement issues?

F6. Power relocation estimate $350K seems low for this (MN) project. One set of power towers that can span the 400' wide channel are costly. Review cost.

F7. Existing condition river (water) level table neglects the effects of flood fighting. Red River rises through town as local measures are implemented. (Source: City representative).

F8. Develop a comprehensive exterior drainage plan.

F9. Wave action may be a concern. Wide channels and lengthy straight sections may erode banks- do we need rock protection on some sections of channel?

F10. Review Winnipeg Diversion Channel lessons learned.

F11. Are there any 100-yr farmsteads or historical building issues in either alignment?

F12. If spoil banks were placed on only one side of the channel would it be easier on local farmers, improved drainage or result in other operational benefits?

SUPPORTING DOCUMENTS

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SPECULATION LIST

IDEA #	Fargo-Metro Feasibility Study - VE Idea List PROPOSALS	Code	#
6	Align ND diversion east of Sheyenne	P	1
75	Ring dike Harwood	P	1
12	Realign MN diversion (shorten, protect towns with levees)	P	2
56	Re-orient MN short outlet to Red further south	P	2
60	Move MN short alignment west of Kragnes, provide ring levee if necessary	P	2
16	Start ND diversion further north to reduce excavation	P	3
35	Re-route the Sheyenne around Fargo	P	3
46	Move ND east inlet d/s of Wild Rice/Red confluence	P	3
49	S. end of ND diversion shortened	P	3
40	Re-align MN short levee toward Wild Rice/I-29	P	4
41	Dig new channel along I-29 to Wild Rice (get rid of new I-29 crossing)	P	4
43	Modify bridges to reduce construction ("Texas crossings", reduce bridge span, etc.)	P	5
57	15th Street NW bridge (MN short), change skew angle of approach or make Texas crossing	P	5
58	In Kragnes (MN short), consolidate bridges to east of town	P	5
59	Texas crossing at middle Kragnes proposed bridge	P	5
48	N. end of ND diversion, go directly east to Red River	P	6
52	Tunnel under I-29/Co81/RR crossing of ND diversion (near Harwood), or combine bridges	P	7
	P8 eliminated (merged with P2)	P	8
65	Inlets for localized drainage discharge higher in diversion channel (w/riprap)	P	9
66	"Neck/bend" berm fill at localized drainage inlets to reduce pipe length	P	9
67	If can't do 66, move riser to inside of berm top (300' top width)	P	9
68	Downsize outlet structures	P	9
83	25K plan doesn't protect downtown Fargo during 100-year (Elm St closed, 2nd St. dike installed)	P	10
26	Explore options for railroad yard (tunnel, bridges, etc.) – Identify multiple tracks issue.	P	11
	Bypass costs are included in multiple lane road estimates	P	12
	VE COMMENT list		
7	Plan recreation facilities into construction	C	1
8	Bike path	C	1
9	Horse trail	C	1
10	Frisbee golf	C	1
18	ATV park	C	1
19	Hiking trail	C	1
84	Amphitheater	C	1
85	Fishing ponds	C	1
86	Garden plots	C	1
88	Tubing/kayaking/canoeing	C	1
89	Cross country skiing	C	1
90	Sledding hill	C	1
11	Find beneficial use for spoil/cut material	C	2
13	Allow farming in channel	C	3
14	Diversion structure w/ tainter gate design	C	4
15	Add bridge over diversion structure	C	5
17	Wildlife (CRP) preserve	C	6
94	Develop management plan to periodically flood diversions/create wetland	C	6
87	Prairie restoration	C	6
30	Percentage of MN diversion sent to Buffalo River	C	7
31	Build ice passage into diversion	C	8
32	Ice friendly design	C	8
47	Vary embankment elevation/make one bank lower	C	9
51	Road raise for levee feature ND East (east of Red River)	C	10
72	Lateral side drains vs. 3-mile extension channel	C	11

74	"Manifold" inlets at MN short north inlet	C	11
73	Cutoff channels in Red u/s of diversion to reduce stage impacts	C	12
76	Low flow channel within diversion channel	C	13
77	Low flow crossing for segmented farm fields	C	14
78	Address safety issues during floods (patrols, signage, etc.)	C	15
92	Select grass mixes for weed control	C	16
93	Directly seed clay in channels, no topsoil	C	16
	Select bridge designs that don't block flow - requiring smaller approaches	C	17
	Re-organize segmented farms to one side of the channel	C	14

FEASIBILTIY IDEAS

54	Future status of West Fargo diversion channel?	RI
55	Parallel channel question, dwgs show merged design	RI
62	9.05 in cost estimate, does this include both MN south inlets	RI
69	Question? cost estimate = $888M in VE, slide = $962M	RI
70	During flood do we need pump stations for local drainage ditches?	RI
79	Powerline towers built on berms? Possible foundation issues	RI
80	Power relocation estimate ($350K) seems small	RI
81	Existing condition river level table neglects flood fighting (would raise Red levels)	RI
82	25K channel requires flood fight efforts in Fargo at 500-year flood	RI
91	Comprehensive drainage plan, exterior etc.	RI
97	Consider wave action protection in diversion channels (very wide channels)	RI
98	Review Winnipeg diversion lessons learned	RI
99	100-yr farmstead/historical building issues?	RI
100	Place spoil material on one side of channel only (better local drainage, less side slopes)	RI
101	Quantity calculation checks? 45M for MN short vs. 60M hand calc w/25' avg depth	RI

1	Pump Water into diversion Channel	X
3	Hybrid levee/channel system	X
20	Tunnel under I-29 diversion	X
21	Sell water to those who need it	X
22	Move continental divide	X
24	Build to 700-yr level of protection (consortium wants this)	X
25	Use no diversion structures (consortium wants this)	X
33	Haul ice away before flood	X
34	Pump tributaries over diversion channel	X
37	Relocated Fargo	X
38	Ring levee Fargo	X
44	New I-94/38th interchange if ND diversion not combined w/ Horace channel	X
45	Buyouts	X
50	How does existing W. Fargo operate with overlap	X
53	Merge Rush/Lower Rush/Maple Rivers to one structure	X
61	MN short 3-mile extension to south not same x-section as diversion channel	X
63	MN short x-section at 30' depth, discrepancy in channel width on plate	X
64	Does estimate include 3.6M cubic yds for 3-mile extension?	X
71	Widen entrance channel (MN short) to accept additional water, eliminate 3-mile extension	X
95	Grazing rights in diversion channel	X
96	Life jackets/swimming lessons for residents	X
4	Divert Sheyenne River to Red River	X
5	Connection channel b/w Red/Cheyenne	X

2	Do nothing	BD
23	Merge Horace and ND diversion plan	BD
36	Optimize diversion channel size/minimize control structures	BD
42	Minimize structures	BD

27	Dredge Red River through town	PS
28	Straighten Red River	PS
29	Upstream retention	PS

FUNCTION ANALYSIS SYSTEM TECHNIQUE (FAST) DIAGRAM

NOT COMPLETED FOR FEASIBILITY LEVEL STUDY

APPENDIX D: PDT TEAM REVIEW COMMENTS

FMM Feasibility VE Study - Comments

Proposal	Civil	PM	Structures	Geotech	H&H	Environmental
#1						
Realign ND diversion East of the Sheyenne River & protect Harwood, ND with ring levees.	The ND alignment is a locally preferred alignment and therefore they chose the locations to be taken out of the flood plain to include Harwood. By placing a ring levee around Harwood it would defeated the local sponsors goal of eliminating the small town from becoming isolated each flood season. In addition, the Federal Government would not be able to play a role in a ring levee proposal for the town of Harwood because the Benefit to Cost ratio is not above 1.0 and therefore the local sponsors would have to come up with other means on their own to accomplish this proposal in full.					
#2						
Realign MN diversion by shortening channel & re-orienting outlet works.	This proposal is to realign and shorten the MN diversion by shifting the alignment to the West of Kragness. The alignment is to include the town of Kragness to eliminate their flooding from the Buffalo River which is to the East of the town. If the channel were aligned to exclude the town of Kragness it would also make the city of Moorhead feel as though they are being squeezed for future development which was not acceptable for their city's acceptance of the MN diversion alternative				Figures 2 & 3 regarding the outlet design and location of the MN alignment were agreed and completed during phase 3 of the feasibility study.	
#3						
Begin ND diversion channel further North.	Again, the ND alignment is a locally preferred alignment and therefore they chose the general location for the inlet. Their reasoning for the location of the inlet being further South than the MN alignment was to accommodate the city of Fargo's current future plans of development and to protect the city from the Wild Rice River flooding to the South.	To eliminate and relocate the 10 houses of Horace will not be acceptable to the Locally Preferred Plan sponsors.			With the new location proposed of the inlet structure it is very probable that a control structure of some sort will need to be placed at the intercept of the Wild Rice River and the Red River of the North due to the amount of water build up that will occur. This is a similar concept to the extension channel on the MN alignment that was needed for conveyance, no structure at the proposed ND inlet on the Wild Rice will potentially disrupt the design of the channel.	
#4						
Redesign Wild Rice Diversion for MN alignments.	Agreed…This is a possibility to consider during plans and specifications if the MN alignment is chosen.					
#5						
Replace bridged crossings with at grade crossings.			The level of design that has been done is only feasibility level and for the purpose of feasibility the cost needs to be as close as possible to construction cost and therefore actual bridges were only considered at this stage. This is an option to look into during plans and specifications as each crossing will need to be considered individually. The major issue with this idea is the impedance it will cause with the low flow channel. The purpose of the low flow channel was to continually pass enough flow through the channel so that it did not change the environmental habitat that will be meandering through for example the northern end of the ND alignment. This idea will require the concurrence of the natural resource agencies, the safety council for the required work to patrol the roads during every rain storm as well as the hydraulics department to ensure the overall channel purpose will not be affected. This is a possibility for cost savings and will be considered during plans and specifications.			

#6						
Realign North end of ND diversion/outlet further South.	As the ND alignment is a locally preferred alignment the inlet and outlet locations were generally chosen by the local sponsors. During plans and specifications the exact locations will be further surveyed and analyzed for project acceptance and local sponsor acceptance.					
#7						
Construct U-Channel through areas of multiple bridges.				This is a possible betterment that could be considered during plans and specifications, but additional geotech modeling would be required because of the poor stability with the interaction of the Brenna and Argusville interface around 30-35 feet below ground surface.		
#8						
Redesign intercept inlet works.			Concepts #4 & #6 should be farther examined during the plans and specifications stage of the project.	After completeing phase 3 design of the channel two significant changes have been made. The channel was having stability issues with the depth of the channel on the ND alignment and the MN alignment was having uplift issues with the Buffalo aquifer. To eliminate these issues both alignment designs now include a minimum of a 50 foot bench to increase the neutral block on global stability analysis. The second alteration to the design was side slopes being maintained at a 7:1. Drawing #2 of the proposal shows the invert 72" pipe being raised, this would cause too much errosion for stability purposes of the channel. Drawing #3 reverts to a side slope of 3:1, this is also not possible with the requirements of stability factors		
#9						
Raise in city protection to 100 year level		Due to the phase 3 hydrology of the synthetic events and calibration with the 2009 flood event it has been found that the cities of Fargo and Moorhead now have never faced a 100 year event. The cities goal of passing a 100 year event with a stage no greater than 30.0 feet at the Fargo gage and a 500 year event with a stage no greater than 36.0 feet at the Fargo gage is now no longer feasible with the 25K cfs plan. It has been determined that the National Economic Development plan through further analysis is the MN 40K plan. The cities have come to agreement that the ND 35K cfs plan provides enough protection and is what they can afford, therefore the ND 35K plan is now compared with what is known as the Federally Comparable Plan, FCP, the MN 35K plan. The FCP is the plan that provides equal benefits to the Locally Preferred Plan. In conclusion, it is no longer possible due to the development in the hydrology and hydraulics for the cities to raise their in town level of protection to the 100 year, without sacrificing a dramatically large levee footprint along the Red River of the North.				
#10						
Railroad yard relocation.	Due to the constraints of the Buffalo Aquifer it is as impossible to construct the diversion channel East of BNSF's rail yard as it is for them to shift or expand their rail yard any farther East. This was learned in a conference with BNSF where they explained to the FMM PDT that their last refueling station lies just East of their rail yard and they had looked into expanding East, but were not able to because of the Buffalo Aquifer proximity the rail yard.		The other part of this proposal involved constructing the diversion channel through the rail yard. After the conference with BNSF they explained that this was not an acceptable design option for them due to safety and operation. The safety factor included for them how dangerous it is to have a car derail over the diversion channel in the yard, where they would have to drag it off the bridged rail yard. The operation for the rail yard required that they not be interrupted with this construction and if they are to make use of their existing rail yard while under construction they expressed the need for an ulternate functioning location because they would not be able to shut down the main line or any switching on bridges even if they			

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APPENDIX O
ATTACHMENT 6

ASA(CW) Approvals to tentatively recommend the Locally Preferred Plan

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DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

APR 28 2010

MEMORANDUM FOR DEPUTY COMMANDING GENERAL FOR CIVIL AND EMERGENCY OPERATIONS

SUBJECT: Fargo-Moorhead Metropolitan Area, North Dakota and Minnesota – Deviation from the National Economic Development Plan

I am responding to the Mississippi Valley Division Regional Integration Team's memorandum of April 19, 2010, that requests an exception to the policy that requires the U.S. Army Corps of Engineers to recommend the National Economic Development (NED) Plan. The exception would allow the Corps to recommend a Locally Preferred Plan (LPP) for flood damage reduction improvements in the Fargo-Moorhead Metropolitan Area in a pending draft feasibility report and draft environmental impact statement. The request indicates that the cities of Fargo, North Dakota, and Moorhead, Minnesota, as the non-Federal sponsors, and Cass and Clay counties have requested implementation of the LPP in lieu of the NED Plan.

After reviewing the materials you provided, I have decided to grant the requested policy exception because the LPP would significantly reduce flood damages, the risk of loss of life, and the need for emergency flood fighting measures. The LPP would reduce average annual damages about $17,000,000 more than the NED Plan and reduce the residual damages to about $9,704,000 (about 13 percent of damages without a project) compared to $22,667,000 for the NED Plan. The LPP would remove about 80 square miles from the 100-year floodplain, which is about 50 square miles more than the NED Plan. The LPP would benefit about 6,625 more people and protect about 3,100 more structures than the NED Plan. As proposed, the non-Federal sponsors would be responsible for the extra costs of the LPP, so the Federal cost would remain the same for the NED Plan and the LPP, currently estimated at $505,940,000. The non-Federal cost share would increase from about $272,430,000 with the NED Plan to about $573,543,000 with the LPP.

The Corps has indicated that the St. Paul District is currently revising the hydrologic, hydraulic, economic, and mitigation analyses for the NED Plan and the LPP, and that these revisions may change the NED Plan designation to a larger capacity diversion in Minnesota. Such a change would decrease the differences between the NED Plan and the LPP described above. This approval is subject to the Corps finding that the differences in effects between the NED Plan and the LPP are similar to or smaller than those described above.

The St. Paul District may prepare a draft report and environmental impact statement recommending the LPP. I concur that the added cost of the LPP relative to the NED Plan, currently estimated at $301,133,000, would be a non-Federal cost, with the remainder of the first cost shared 65 percent Federal, 35 percent non-Federal consistent with current policy.

Jo-Ellen Darcy

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

APR 2 8 2011

MEMORANDUM FOR DEPUTY COMMANDING GENERAL FOR CIVIL AND EMERGENCY OPERATIONS

SUBJECT: Fargo-Moorhead Metropolitan Area, North Dakota and Minnesota – Deviation from the National Economic Development (NED) Plan

I am responding to the U.S. Army Corps of Engineers' April 25, 2011, memorandum requesting that I confirm that the policy exception that I provided on April 28, 2010, to support efforts to reduce flood risks in the Fargo-Moorhead Metropolitan Area remains valid or that I grant a new policy exception. The Corps' request would enable the St. Paul District to release a supplemental draft feasibility report and environmental impact statement, which tentatively selects a Locally Preferred Plan (LPP) in lieu of the NED Plan. The memorandum identifies significant changes in the ongoing feasibility study. The request includes an April 6, 2011, letter from the non-Federal sponsors requesting the tentative selection of the LPP for implementation and acknowledging that they would be responsible for all costs in excess of the Federal share of the Federally Comparable Plan (FCP).

After reviewing the materials provided, I have determined that the LPP and NED Plan have changed significantly during the past year and that my previous policy exception is no longer valid. I have determined that the revised LPP does warrant a new exception because the revised LPP would significantly diminish flood damages, reduce the risk of loss of life, and lessen the need for emergency flood fighting measures. The Corps may publicly release the supplemental draft feasibility report and environmental impact statement and therein identify the LPP as the tentatively selected plan with the non-Federal sponsors responsible for the non-Federal cost share of the FCP in accordance with Section 103(a) of the Water Resources Development Act of 1986, as amended, plus the added costs of the LPP.

Jo-Ellen Darcy

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

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APPENDIX O
ATTACHMENT 7

Red River Diversion - Alternatives Scenario Analysis

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RED RIVER DIVERSION

FARGO – MOORHEAD METRO FLOOD RISK MANAGEMENT PROJECT, FEASIBILITY STUDY, PHASE 4

ALTERNATIVE SCENARIOS ANALYSIS

Report for the cities of Fargo, North Dakota & Moorhead, Minnesota

FINAL REPORT: April 8, 2011

TABLE OF CONTENTS

FIGURES

TABLES

1.0 BACKGROUND AND OVERVIEW

1.1 PURPOSE FOR STUDY

This report is a follow up to the February 28, 2011 report entitled "*Red River Diversion, Fargo - Moorhead Metro Flood Risk Management Project, Feasibility Study, Phase 4, Report for the US Army Corps of Engineers, and the cities of Fargo, ND & Moorhead, MN*". The purpose of the alternative scenario analysis was to develop preliminary hydraulic designs for several design modifications to the Locally Preferred Plan (LPP) presented in the February 28, 2011 report that would still match the hydraulic profiles through Fargo-Moorhead that were developed with the LPP. The costs and impacts associated with these alternative scenarios provide necessary information for decision making officials to consider when evaluating and the LPP.

1.2 PHASE 4 SUMMARY (FEBRUARY 28, 2011 REPORT)

The February 28, 2011 technical report documents the Phase 4 design and impact analysis for the LPP and the impact analysis for the Federally Comparable Plan (FCP). The FCP was not redesigned from the Phase 3 design. The LPP and FCP alignments are shown in Figure 1. The Phase 4 LPP design incorporates "smart storage" (Storage Area 1) and staging on the upstream side of the project in order to eliminate adverse downstream impacts. This in turn reduces the amount of flow required to pass through the diversion and allows for a smaller diversion channel. The inclusion of these features to the project required the use of HEC-RAS unsteady flow models for the project feasibility design. Previously, steady flow models were used for the project feasibility design and unsteady flow models were utilized for the determination of project impacts. An extensive effort was required to develop unsteady flow models that were suitable for the feasibility level design. The development of the existing conditions unsteady flow models, along with the subsequent modifications for the LPP design, are discussed in great detail in Appendix B of the February 28, 2011 report. The result of the Phase 4 LPP design is that the downstream impacts are adequately mitigated by staging 6.50 feet and 8.25 feet of water upstream of the diversion for the 1-percent and 0.2-percent chance floods, respectively. The inundation areas associated with staging for these two events are shown in Figure 2 and Figure 3. The water surface profiles for existing conditions and for the LPP are shown in Figure 4. The estimated project cost of the Phase 4 LPP is $1,760,453,000. See Table 17 for detailed breakdown of the estimated costs.

1.3 OVERVIEW OF ALTERNATIVE SCENARIOS ANALYSIS

The analysis of the alternative scenarios was completed by modifying the Phase 4 HEC-RAS unsteady flow models developed for the Phase 4 LPP to reflect the geometry changes associated with each scenario. With the exception of one scenario, the alternatives follow the Phase 4 LPP alignment and include modifications to specific design features and operations. While generally following guidelines related to hydraulic and other environmental impacts set out during previous design phases, the potential modifications may include additional impacts not included in previous phases of design or impacts that were considered by some parties to be too large during previous EIS comment periods. In each scenario, only the 1-percent and 0.2-percent chance events were analyzed as it was assumed that upstream and downstream impacts would be less of a concern for more frequent events. The six alternative scenarios considered for this analysis are briefly described below.

1. Preliminary hydraulic design of a modified LPP including a larger “smart storage” area and reduced upstream staging.
2. Preliminary hydraulic design of a modified LPP with no “smart storage” area, reduced upstream staging and allowing some downstream impacts (generally in the 3” to 6” range at Thompson).
3. Preliminary hydraulic design of a modified LPP including Storage Area 1 with the addition of one or more large off stream storage areas downstream of the project and reduced upstream staging.
4. Preliminary hydraulic design of a modified LPP with no “smart storage” and with no upstream staging.
5. Preliminary hydraulic design of a modified LPP including no “smart storage” but including increased upstream staging.
6. Preliminary hydraulic design of a modified LPP including Storage Area 1 with the south end of the diversion alignment modified to a location south of Hickson, Oxbow and Bakke Subdivision.

In each case, the location and magnitude of the hydraulic impacts of the scenario when compared to existing conditions, both upstream and downstream of the project, has been determined and the results are provided in a series of summary tables and maps. Feasibility cost estimates have been developed for each alternative. These cost estimates have used the Phase 4 LPP cost estimates as a basis but have been developed to a lower level of detail. The cost estimates include costs related to mitigating hydraulic impacts upstream and downstream of the project based on the Phase 4 LPP design, but do not include any considerations for increased or decreased mitigation requirements as result of the environmental impacts associated with the modifications involved with the alternative scenarios. The background information on the development of these alternative scenarios and the results for each one are discussed in further detail in this report.

2.0 MODELING

2.1 HYDROLOGY

<u>C2.1.1 Design Event Hydrology.</u> The Phase 4 LPP was designed for only the 10-, 2-, 1- and 0.2-percent chance events, in all cases using the hydrology scenario corresponding to project year zero. The geometries for each return period event were identical, but the gate operations for the control structures were adjusted to meet the flow criteria established for each structure and each design event. For this alternative scenario analysis, only the 1-percent and 0.2-percent chance events were modeled and analyzed for impacts because it was assumed that upstream and downstream impacts would be less of a concern for more frequent events. Refer to Appendix A in the February 28, 2011 report for background information on the development of the hydrology used in this analysis.

2.2 HYDRAULICS

2.2.1 Existing Conditions Models. The existing conditions models for Phase 4 were produced by Houston Engineering, Inc. (HEI). HEI had developed earlier versions of the unsteady flow models used to analyze the previous diversion designs. These models underwent extensive updates due to the modeling needs presented in Phase 4, including the addition of hundreds of storage areas and the extension of the model downstream to Drayton, North Dakota and upstream to Abercombie, North Dakota. The Sheyenne River and Maple River systems were also added to the models. The updated models were completed through collaboration with other members of the design team- USACE, Moore Engineering, Barr Engineering and HDR Engineering- with support provided for GIS analysis, hydrologic modeling and peer reviews. HEI has documented the development of these models in Appendix B of the February 28, 2011 report.

2.2.2 Reference Model. The existing conditions models discussed above include separate geometry files representing conditions with and without emergency protection measures in place within the project area. These emergency measures would be structural barriers like clay levees, sand bag levees and flood walls that were used by the communities for protection during actual flood events. The existing conditions models were calibrated to measured high water marks during the 2009 spring flood. The existing conditions model was also verified with the 1997, 2006, and 2010 historic flood events. Because the emergency measures were in place during the historic flood events, they are reflected in the geometry used in the models in order to get an accurate calibration. After calibration, the emergency levees were removed to produce the geometry for the unprotected condition. This allows for the determination of the full benefits of the project by comparing it to the damages that would be incurred if nothing was done to protect the communities. All impacts presented in this report reference the "without emergency protection" condition for both existing and with-project conditions.

2.2.3 Phase 4 With-Project Conditions Models. The design for Phase 4 of this study involved new aspects, namely storage cells and staging upstream of the FM Metro area, which could not be properly accounted for with the steady state models that had been used in the previous phases. The design and subsequent impact analysis for Phase 4 was based on the unsteady flow models developed by HEI for existing conditions. While the design for Phase 4 shifted to an unsteady flow modeling methodology, the premise behind the design for the diversion channel and the associated hydraulic structures remained essentially the same. The addition of the upstream storage and staging added additional components to the design, but they simply resulted in different design discharges for the diversion channel and structures. Appendix C in the February 28, 2011 report details the modifications made to the existing conditions models to develop the with-project models for Phase 4. The impacts associated with the Phase 4 LPP design for the 1-percent and 0.2-percent chance events are shown in Table 1 and Table 2, respectively.

Table 1: Phase 4 LPP – 1-Percent Chance Flood Impacts

North Dakota Diversion (LPP) - 1% Chance Event							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.73	119255	801.81	120751	0.08	1496
ND SH#17/ MN SH317	1223286	804.09		804.16		0.07	
Co. Hwy 15	1315673	805.08		805.13		0.05	
Minimum Impact Location	1410241	811.47		811.51		0.04	
Oslo Gage	1416287	813.01		813.07		0.06	
DS Grand Forks Levees	1533523	827.98		828.13		0.15	
Grand Forks Gage	1558518	832.97	107980	833.21	110497	0.24	2517
Maximum Impact Location	1573768	835.27		835.56		0.29	
32nd Ave, Grand Forks	1580152	835.83		836.11		0.28	
Thompson Gage	1667877	847.35	82926	847.39	82608	0.04	-317
Co. Hwy 25/ Co. Rd 221	1726274	854.46		854.44		-0.02	
DS Sandhill River/ Climax	1763746	857.34		857.30		-0.04	
Nielsville	1829877	861.66	75745	861.62	76038	-0.04	293
DS Marsh River	1864960	863.43		863.40		-0.03	
US Goose River/ Shelly	1891054	865.36		865.32		-0.04	
Halstad Gage	1981580	869.09	71581	869.03	70992	-0.06	-589
Hendrum	2038409	873.75	67278	873.69	66095	-0.06	-1183
Perley	2129181	878.50	61723	878.22	57044	-0.28	-4679
Georgetown	2194021	883.36		883.11		-0.25	
North River/ Clay Co. Hwy 93	2305647	893.73		886.48		-7.25	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.08		890.50		-8.58	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.86 (41.12*)	34875	893.54 (30.8*)	11718	-10.32	-23157
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.71		897.66		-10.05	
US ND Wild Rice River	2484618	910.70		901.71		-8.99	
US LPP Diversion	2531315	914.65		922.88		8.23	
Hickson Gage	2563754	917.52	21730	922.90	18655	5.38	-3075
Abercrombie	2764835	935.62	23000	935.73	23000	0.11	0

2-28-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

Table 2: Phase 4 LPP – 0.2-Percent Chance Flood Impacts

North Dakota Diversion (LPP) - 0.2% Chance Event							
Location	Station	Existing No Protection		ND Diversion (FCP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	804.12	168364	804.23	171002	0.11	2638
ND SH#17/ MN SH317	1223286	805.99		806.06		0.07	
Co. Hwy 15	1315673	806.74		806.83		0.09	
Minimum Impact Location	1410241	812.15		812.19		0.04	
Oslo Gage	1416287	813.88		813.93		0.05	
DS Grand Forks Levees	1533523	829.92		830.04		0.12	
Grand Forks Gage	1558518	836.36	146225	836.58	149112	0.22	2887
Maximum Impact Location	1561353	838.53		838.80		0.27	
32nd Ave, Grand Forks	1580152	839.75		839.98		0.23	
Thompson Gage	1667877	850.69	112422	850.64	111394	-0.05	-1027
Co. Hwy 25/ Co. Rd 221	1726274	859.38		859.26		-0.12	
DS Sandhill River/ Climax	1763746	862.75		862.60		-0.15	
Nielsville	1829877	867.04	107296	866.88	105953	-0.16	-1344
DS Marsh River	1864960	868.06		867.92		-0.14	
US Goose River/ Shelly	1891054	869.30		869.17		-0.13	
Halstad Gage	1981580	871.54	101754	871.32	92746	-0.22	-9007
Hendrum	2038409	875.77	97650	875.47	90871	-0.30	-6779
Perley	2129181	879.89	90756	879.53	79857	-0.36	-10899
Georgetown	2194021	884.48		884.15		-0.33	
North River/ Clay Co. Hwy 93	2305647	895.35		892.96		-2.39	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	900.31		898.32		-1.99	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.8 (43.06*)	61717	902.77 (40.03*)	29865	-3.03	-31852
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	909.13		907.08		-2.05	
US ND Wild Rice River	2484618	911.54		910.23		-1.31	
US LPP Diversion	2531315	915.94		922.44		6.50	
Hickson Gage	2563754	919.69	35636	922.54	32491	2.85	-3145
Abercrombie	2764835	940.90	44308	940.91	44308	0.01	0

2-28-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

2.2.4 Alternative Scenarios With-Project Models. Each scenario is discussed in detail in Section 3 below, including the required modifications to the LPP unsteady flow models. In each case, only the design features identified for modification were altered in the original geometry files. However, the models include hydraulic structures with gates that are operated within the model with the use of rules that were developed to maintain specific discharges and water surface profiles within the protected area. With the alternative scenarios, the flow conditions can be changed enough that the rules had to be adjusted to maintain the desired results within the protected area.

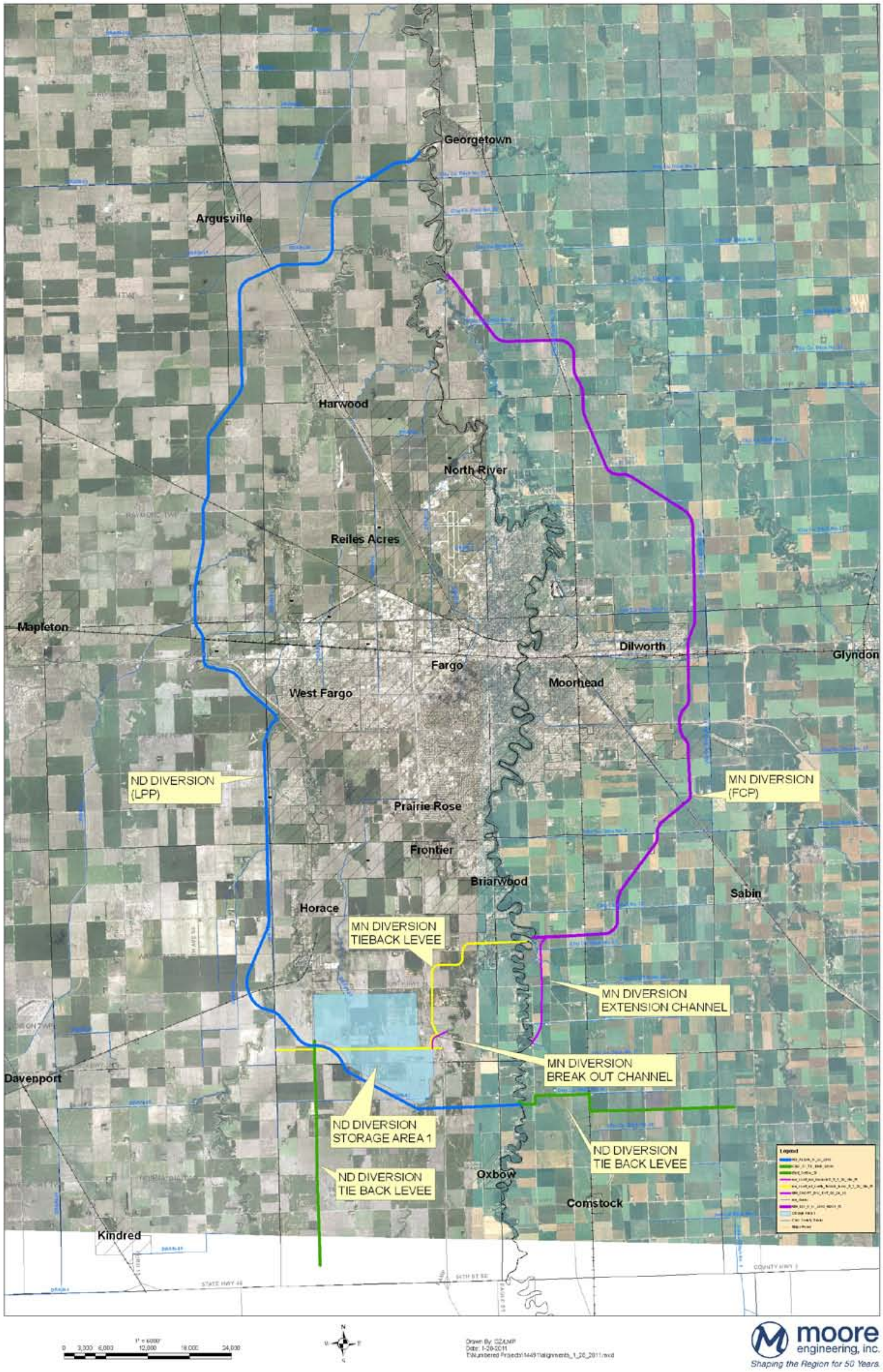

Figure 1: Red River Diversion Channel Alignments (FCP and LPP)

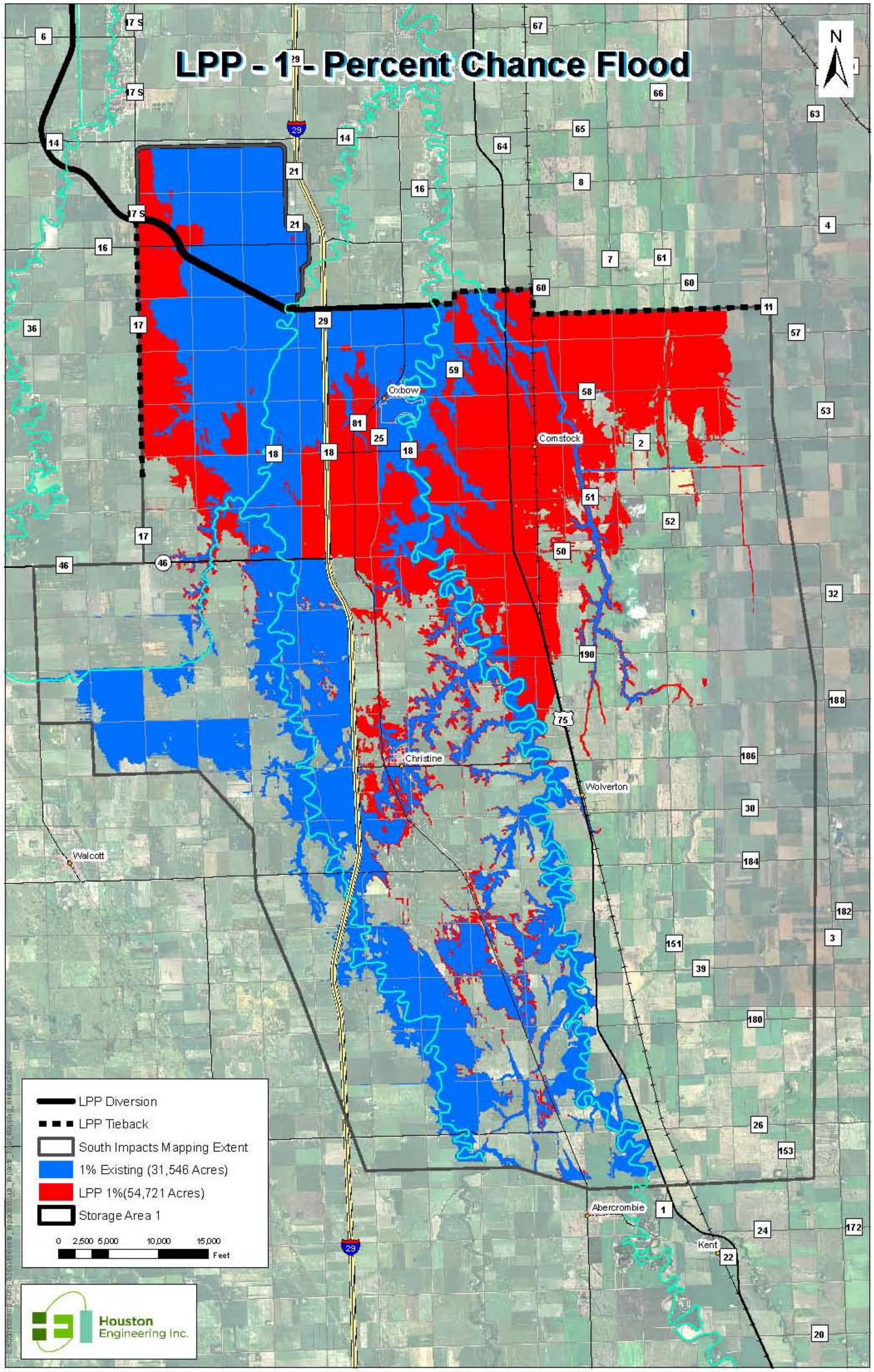

Figure 2: LPP 1-Percent Chance Flood Inundation Map

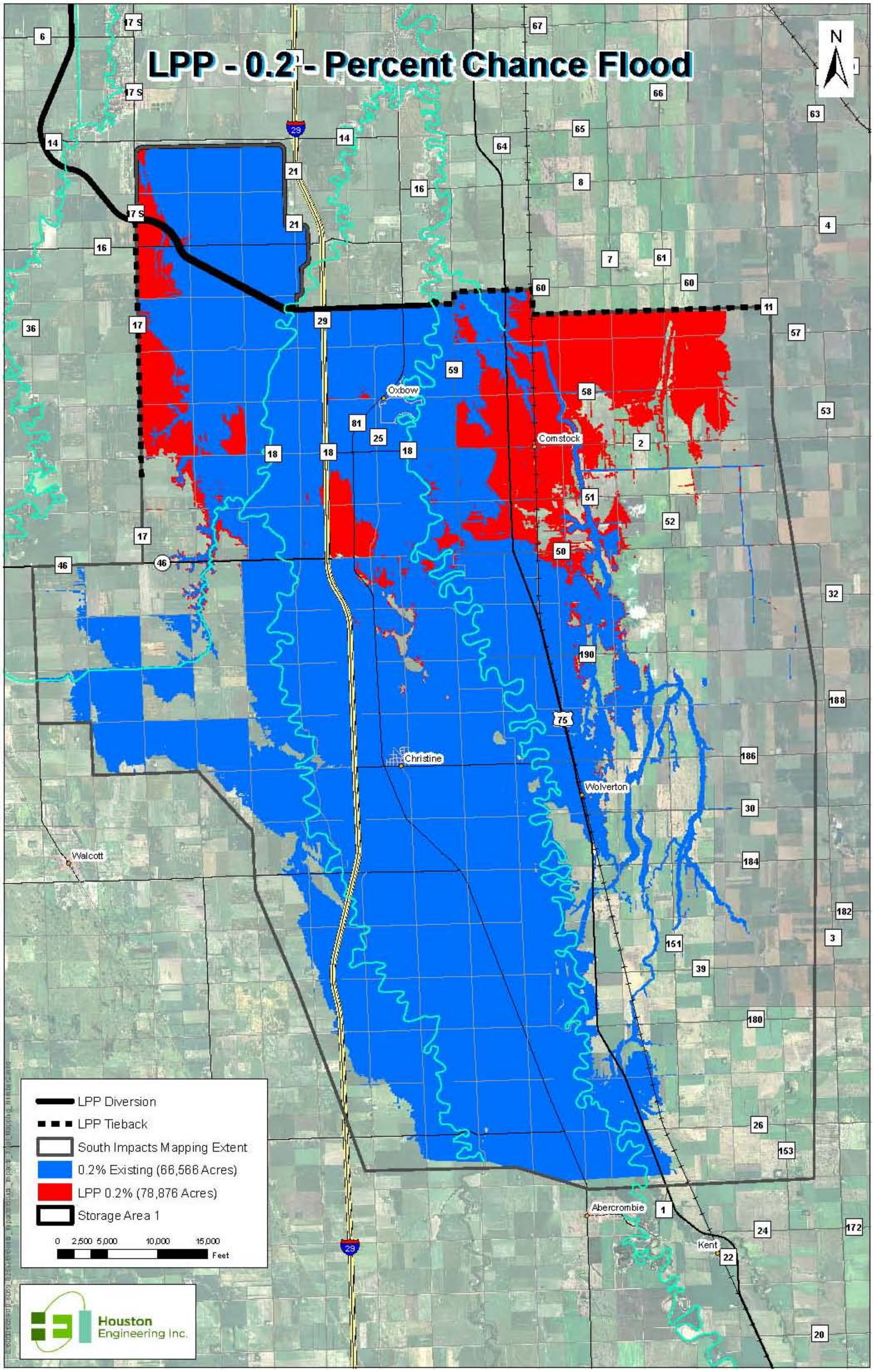

Figure 3: LPP 0.2-Percent Chance Flood Inundation Map

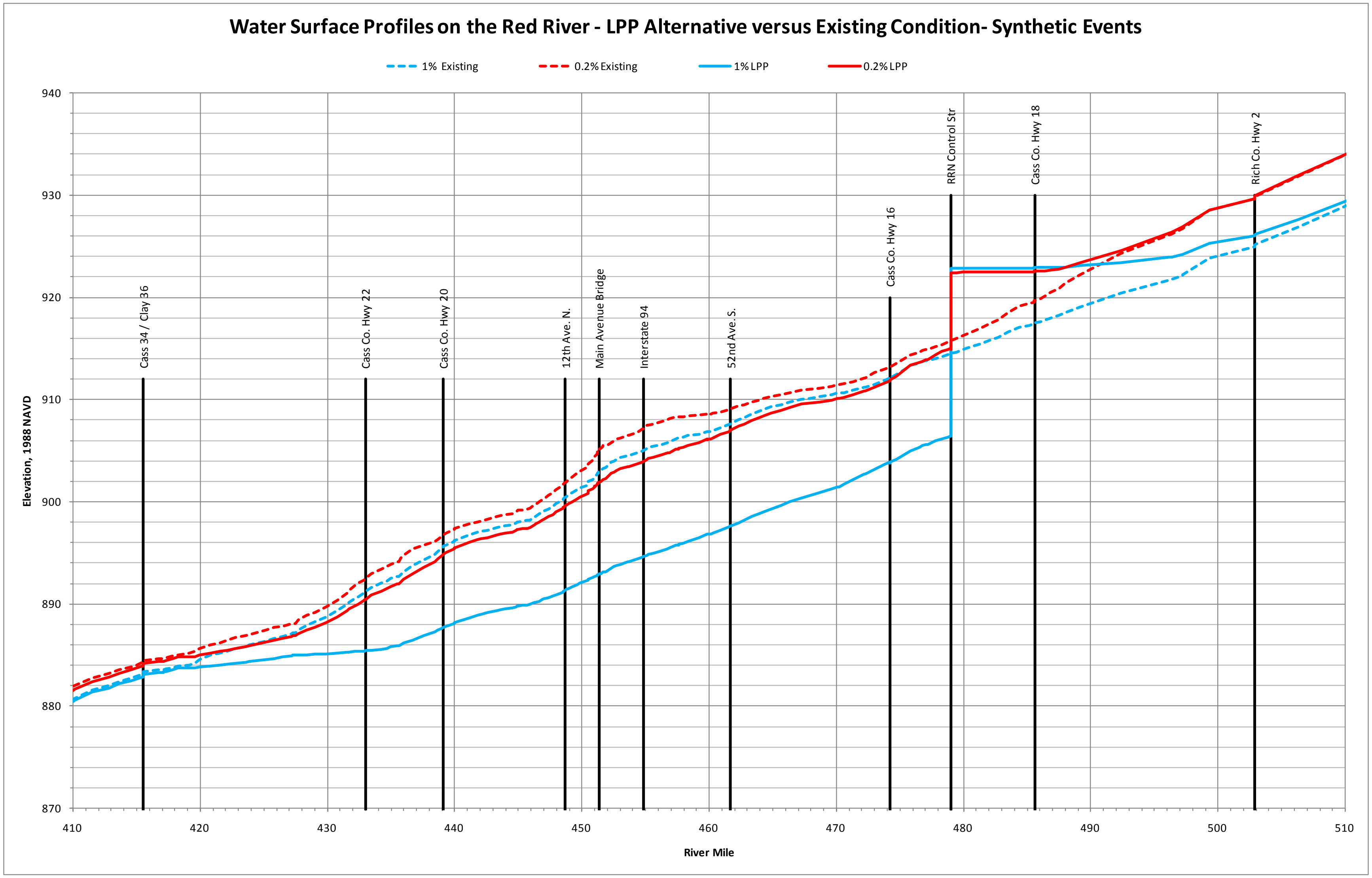

Figure 4: Water Surface Profiles on the Red River- LPP vs. Existing Condition

3.0 ALTERNATIVE SCENARIOS ANALYSIS

3.1 SCENARIO 1

3.1.1 Description. Scenario 1 includes preliminary hydraulic design of a modified LPP including a larger "smart storage" area (Storage Area 1) and reduced upstream staging.

3.1.2 Development. The original footprint of Storage Area 1 in the February 28, 2011 report covered an area north of the LPP alignment to an area just south of Cass Highway 14 (100^{th} Ave). This area was extended further north to just south of 76^{th} Ave with Scenario 1. Storage Area 1 included in the Phase 4 LPP design was 4,160 acres, with 55,800 acre-feet of volume at an elevation of 923. With Scenario 1, the enlarged storage area is 6,120 acres, with 85,800 acre-feet of volume at an elevation of 923. The location of the larger Storage Area 1 in relation to the overall project is shown in Figure 5 and is shown in greater detail in Figure 6.

For this scenario, the water surface elevations at the Fargo Gage and downstream of the diversion were kept approximately the same as what was presented for the LPP in the February 28, 2011 report. Since the storage capacity of Storage Area 1 was increased, additional water was passed into the diversion channel in order to maintain the same level of downstream impacts as with the Phase 4 LPP design. This required that the diversion inlet weir be increased from 90 to 100 feet. The gate operations for the control structures on the Wild Rice River, Red River, and Wolverton Creek were not changed from what was included in the Phase 4 LPP for this scenario.

3.1.3 Costs. The estimated cost of a Scenario 1 LPP project is $1,822,018,300. A breakdown of the estimated costs associated with this project is included in Table 17.

3.1.4 Impacts. Compared to existing conditions, the increase in water surface elevations upstream of the Red River control structure for the 1-percent and 0.2-percent chance events is approximately 7.6 and 6.0 feet, respectively. When compared to the results presented for the LPP in the February 28, 2011 report, the upstream staging decreased 0.64 and 0.52 feet for the 1-percent and 0.2-percent chance events, respectively. As mentioned previously, the water surface elevations at the Fargo Gage and downstream of the diversion were kept approximately the same as what was presented for the LPP in the February 28, 2011 report. The impacts of Scenario 1 for the 1-percent and 0.2-percent chance events with respect to existing conditions are presented in Table 3 and Table 4, respectively. The impacts of this scenario in relation to the Phase 4 LPP design are presented in Table 15 and Table 16. The inundation areas associated with the upstream staging for each event are shown in Figure 7 and Figure 8, respectively.

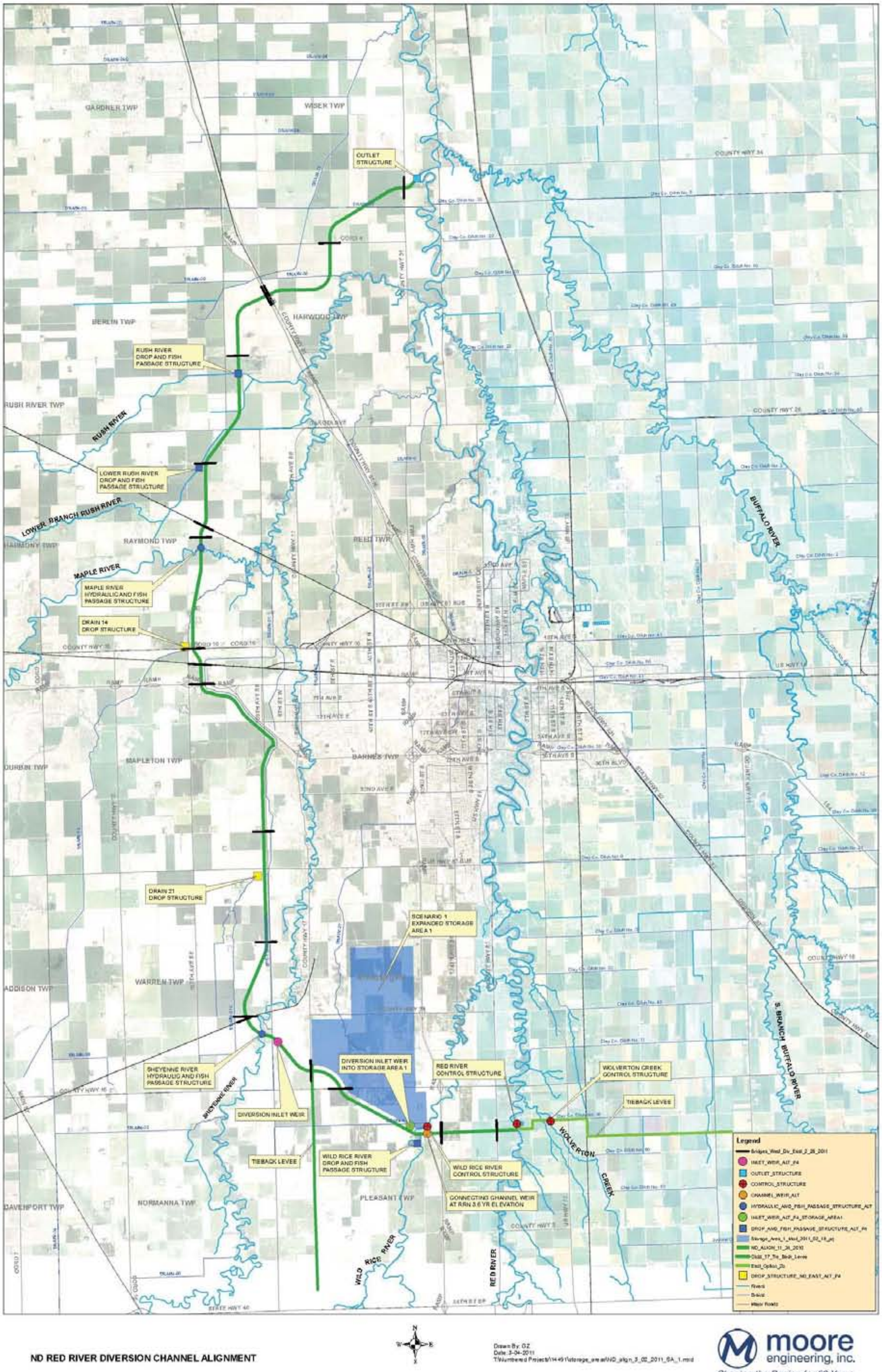

Figure 5: Scenario 1 Layout

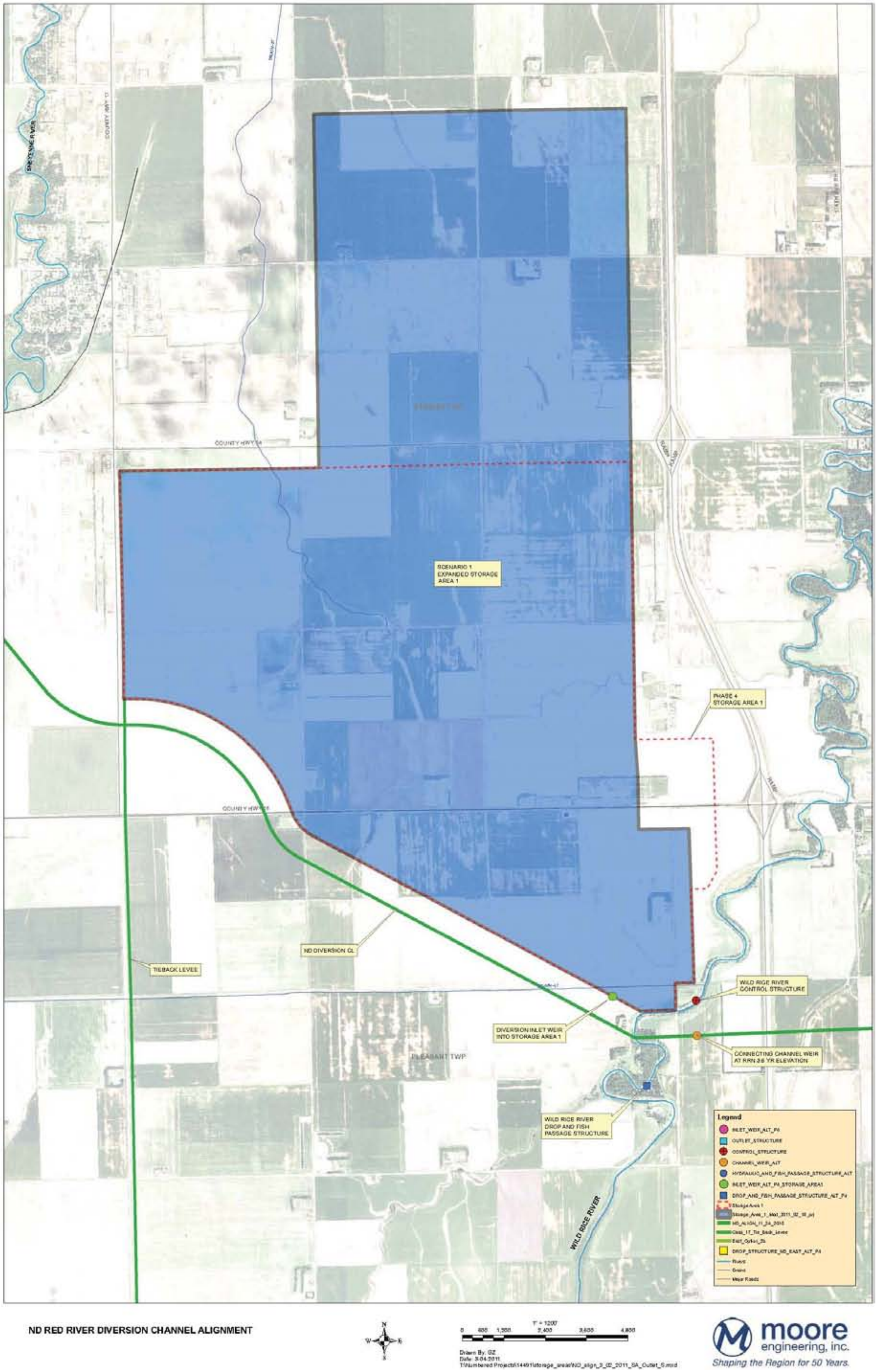

Figure 6: Scenario 1- Expanded Storage Area 1 Layout

Table 3: Scenario 1– 1-Percent Chance Flood Impacts

North Dakota Diversion (LPP) - 1% Chance Event- Scenario 1							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.73	119255	801.79	120546	0.06	1291
ND SH#17/ MN SH317	1223286	804.09		804.15		0.06	
Co. Hwy 15	1315673	805.08		805.12		0.04	
Minimum Impact Location	1408098	811.34		811.37		0.03	
Oslo Gage	1416287	813.01		813.06		0.05	
DS Grand Forks Levees	1533523	827.98		828.11		0.13	
Grand Forks Gage	1558518	832.97	107980	833.19	110245	0.22	2265
Maximum Impact Location	1573768	835.27		835.53		0.26	
32nd Ave, Grand Forks	1580152	835.83		836.08		0.25	
Thompson Gage	1667877	847.35	82926	847.37	82493	0.02	-433
Co. Hwy 25/ Co. Rd 221	1726274	854.46		854.42		-0.04	
DS Sandhill River/ Climax	1763746	857.34		857.28		-0.06	
Nielsville	1829877	861.66	75745	861.60	75918	-0.06	173
DS Marsh River	1864960	863.43		863.38		-0.05	
US Goose River/ Shelly	1891054	865.36		865.31		-0.05	
Halstad Gage	1981580	869.09	71581	869.03	70744	-0.06	-837
Hendrum	2038409	873.75	67278	873.68	65966	-0.07	-1313
Perley	2129181	878.50	61723	878.23	57037	-0.27	-4686
Georgetown	2194021	883.36		883.10		-0.26	
North River/ Clay Co. Hwy 93	2305647	893.73		886.37		-7.36	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.08		890.39		-8.69	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.86 (41.12*)	34875	893.42 (30.68*)	11593	-10.44	-23282
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.71		897.55		-10.16	
US ND Wild Rice River	2484618	910.70		901.60		-9.10	
US LPP Diversion	2531315	914.65		922.24		7.59	
Hickson Gage	2563754	917.52	21730	922.27	19516	4.75	-2215
Abercrombie	2764835	935.62	23000	935.72	23000	0.10	0

3-04-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

Table 4: Scenario 1– 0.2-Percent Chance Flood Impacts

North Dakota Diversion (LPP) - 0.2% Chance Event- Scenario 1							
Location	**Station**	**Existing No Protection**		**ND Diversion (LPP)**		**Difference (ft) Project vs. Existing No Protection**	
		Elevation (ft)	**Discharge (cfs)**	**Elevation (ft)**	**Discharge (cfs)**	**Elevation (ft)**	**Discharge (cfs)**
Drayton Gage	1062362	804.12	168364	804.22	169109	0.10	745
ND SH#17/ MN SH317	1223286	805.99		806.06		0.07	
Co. Hwy 15	1315673	806.74		806.82		0.08	
Minimum Impact Location	1410241	812.15		812.19		0.04	
Oslo Gage	1416287	813.88		813.93		0.05	
DS Grand Forks Levees	1533523	829.92		830.03		0.11	
Grand Forks Gage	1558518	836.36	146225	836.56	148864	0.20	2887
Maximum Impact Location	1561353	838.53		838.77		0.24	
32nd Ave, Grand Forks	1580152	839.75		839.95		0.20	
Thompson Gage	1667877	850.69	112422	850.62	111230	-0.07	-1191
Co. Hwy 25/ Co. Rd 221	1726274	859.38		859.24		-0.14	
DS Sandhill River/ Climax	1763746	862.75		862.57		-0.18	
Nielsville	1829877	867.04	107296	866.85	105705	-0.19	-1591
DS Marsh River	1864960	868.06		867.90		-0.16	
US Goose River/ Shelly	1891054	869.30		869.15		-0.15	
Halstad Gage	1981580	871.54	101754	871.31	96680	-0.23	-5074
Hendrum	2038409	875.77	97650	875.45	90590	-0.32	-7060
Perley	2129181	879.89	90756	879.52	79588	-0.37	-11168
Georgetown	2194021	884.48		884.14		-0.34	
North River/ Clay Co. Hwy 93	2305647	895.35		892.88		-2.47	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	900.31		898.18		-2.13	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.8 (43.06*)	61717	902.57 (39.83*)	29092	-3.23	-32625
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	909.13		906.94		-2.19	
US ND Wild Rice River	2484618	911.54		910.13		-1.41	
US LPP Diversion	2531315	915.94		921.92		5.98	
Hickson Gage	2563754	919.69	35636	922.04	34272	2.35	-1365
Abercrombie	2764835	940.90	44308	940.91	44308	0.01	0

3-04-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

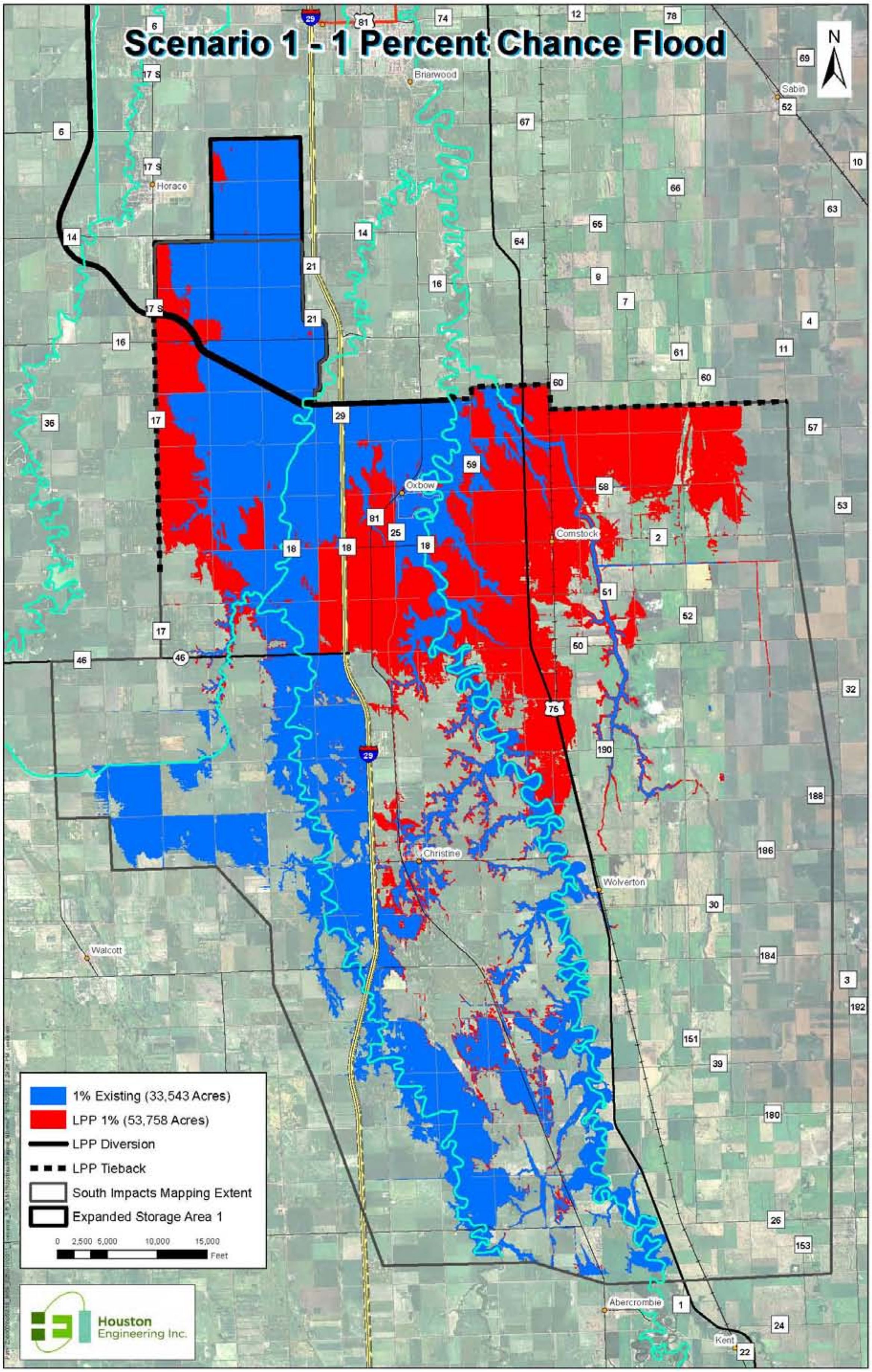

Figure 7: Scenario 1- 1-Percent Chance Flood Inundation Map

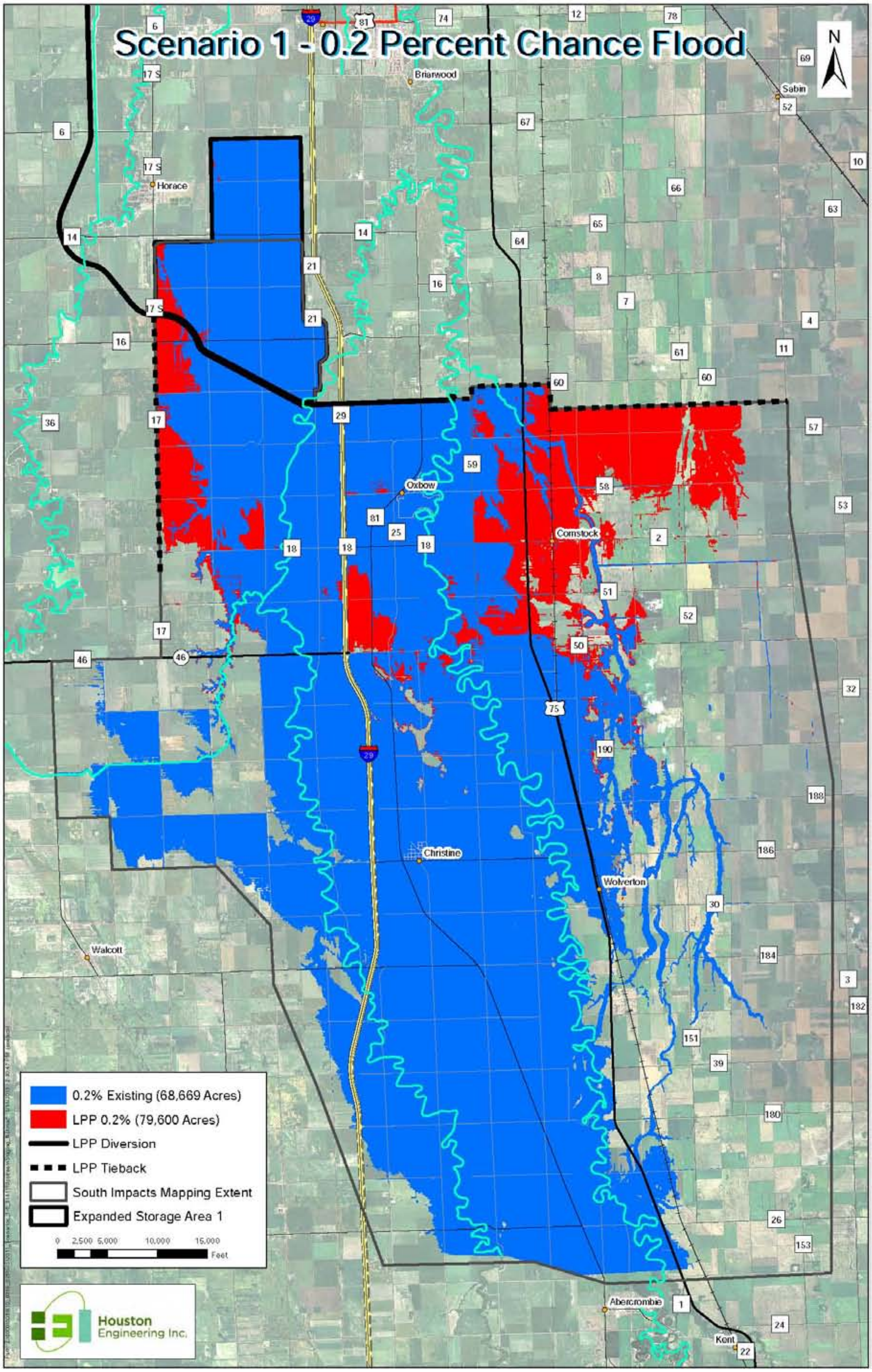

Figure 8: Scenario 1- 0.2-Percent Chance Flood Inundation Map

3.2 SCENARIO 2

<u>3.2.1 Description.</u> Scenario 2 includes preliminary hydraulic design of a modified LPP with no "smart storage" area (i.e., no Storage Area 1), and reduces upstream staging while allowing some adverse downstream impacts (generally in the 3 to 6 inch range at Thompson).

<u>3.2.2 Development.</u> Storage Area 1 included in the Phase 4 LPP design was removed from the model geometry, and the original geometry from the existing conditions model encompassing this area was inserted back into the model. For reference, Storage Area 1 included in the Phase 4 LPP design was 4,160 acres, with 55,800 acre-feet of volume at an elevation of 923.

For this scenario, the water surface elevation at the Fargo Gage was kept approximately the same as what was presented for the LPP in the February 28, 2011 report. Additional water was passed into the diversion channel to meet the criteria of approximately 6 inches of impact at Thompson. This required that the diversion inlet weir be increased from 90 to 150 feet. The gate operations for the Red River were modified to meet these criteria, while the gate operations for the Wild Rice and Wolverton Creek structures were not changed from what was included in the Phase 4 LPP. Multiple iterations of increasing the diversion inlet weir length, date and time of opening of gates, and/or gate rate opening was conducted. The Red River gate operations were not significantly modified from those presented for the LPP in the February 28, 2011 report, so as to provide a comparable operation and project performance.

<u>3.2.3 Costs.</u> The estimated cost of a Scenario 2 LPP project is $1,655,474,800. A breakdown of the estimated costs associated with this project is included in Table 17.

<u>3.2.4 Impacts.</u> Compared to existing conditions, the increase in water surface elevations upstream of the Red River control structure for the 1-percent and 0.2-percent chance events is approximately 7.5 and 6.0 feet, respectively. When compared to the results presented for the LPP in the February 28, 2011 report, the upstream staging decreased 0.71 and 0.55 feet for the 1-percent and 0.2-percent chance events, respectively. As mentioned previously, the water surface elevation at the Fargo Gage was kept approximately the same as what was presented for the LPP in the February 28, 2011 report.

The water surface elevations compared to existing conditions at Thompson for the 1-percent and 0.2-percent chance events increase 0.52 and 0.20 feet, respectively. The maximum downstream impact for the 1-percent chance event is 0.77 feet, whereas the Phase 4 LPP in the February 28, 2011 report had a maximum downstream impact of 0.29 feet. The minimum downstream impact for the 1-percent chance event is 0.07 feet, whereas the Phase 4 LPP had a minimum downstream impact of 0.04 feet. The maximum downstream impact for the 0.2-percent chance event is 0.47 feet compared to a maximum downstream impact of 0.27 feet with the Phase 4 LPP design. The minimum downstream impact for the 0.2-percent chance event is 0.06 feet, whereas the Phase 4

LPP had a minimum downstream impact of 0.04 feet. The impacts of Scenario 2 for the 1 and 0.2-percent chance events in relation to existing conditions are presented in Table 5 and Table 6, respectively. The impacts of this scenario in relation to the Phase 4 LPP design are presented in Table 15 and Table 16. The inundation areas associated with the upstream staging for each event are shown in Figure 9 and Figure 10, respectively.

Table 5: Scenario 2– 1-Percent Chance Flood Impacts

North Dakota Diversion (LPP) - 1% Chance Event- Scenario 2							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.73	119255	801.92	122897	0.19	3642
ND SH#17/ MN SH317	1223286	804.09		804.27		0.18	
Co. Hwy 15	1315673	805.08		805.22		0.14	
Minimum Impact Location	1408098	811.34		811.41		0.07	
Oslo Gage	1416287	813.01		813.11		0.10	
DS Grand Forks Levees	1533523	827.98		828.25		0.27	
Grand Forks Gage	1558518	832.97	107980	833.41	112531	0.44	4551
32nd Ave, Grand Forks	1580152	835.83		836.38		0.55	
Thompson Gage	1667877	847.35	82926	847.87	86384	0.52	3459
Co. Hwy 25/ Co. Rd 221	1726274	854.46		855.17		0.71	
DS Sandhill River/ Climax	1763746	857.34		858.09		0.75	
Maximum Impact Location	1813905	860.78		861.55		0.77	
Nielsville	1829877	861.66	75745	862.42	79734	0.76	3990
DS Marsh River	1864960	863.43		864.07		0.64	
US Goose River/ Shelly	1891054	865.36		865.88		0.52	
Halstad Gage	1981580	869.09	71581	869.36	75114	0.27	3533
Hendrum	2038409	873.75	67278	874.00	70404	0.25	3125
Perley	2129181	878.50	61723	878.57	62579	0.07	856
Georgetown	2194021	883.36		883.40		0.04	
North River/ Clay Co. Hwy 93	2305647	893.73		887.59		-6.14	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.08		890.81		-8.27	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.86 (41.12*)	34875	893.49 (30.75*)	11554	-10.37	-23320
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.71		897.58		-10.13	
US ND Wild Rice River	2484618	910.70		901.64		-9.06	
US LPP Diversion	2531315	914.65		922.17		7.52	
Hickson Gage	2563754	917.52	21730	922.22	18276	4.70	-3454
Abercrombie	2764835	935.62	23000	935.76	23000	0.14	0

3-04-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

Table 6: Scenario 2– 0.2-Percent Chance Flood Impacts

3-04-2011

North Dakota Diversion (LPP) - 0.2% Chance Event- Scenario 2							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	804.12	168364	804.29	171759	0.17	3395
ND SH#17/ MN SH317	1223286	805.99		806.12		0.13	
Co. Hwy 15	1315673	806.74		806.88		0.14	
Minimum Impact Location	1408098	812.00		812.06		0.06	
Oslo Gage	1416287	813.88		813.96		0.08	
DS Grand Forks Levees	1533523	829.92		830.13		0.21	
Grand Forks Gage	1558518	836.36	146225	836.75	151224	0.39	2887
Maximum Impact Location	1577593	839.50		839.97		0.47	
32nd Ave, Grand Forks	1580152	839.75		840.21		0.46	
Thompson Gage	1667877	850.69	112422	850.89	114799	0.20	2377
Co. Hwy 25/ Co. Rd 221	1726274	859.38		859.65		0.27	
DS Sandhill River/ Climax	1763746	862.75		863.06		0.31	
Nielsville	1829877	867.04	107296	867.37	109806	0.33	2509
DS Marsh River	1864960	868.06		868.35		0.29	
US Goose River/ Shelly	1891054	869.30		869.56		0.26	
Halstad Gage	1981580	871.54	101754	871.63	101481	0.09	-273
Hendrum	2038409	875.77	97650	875.72	95126	-0.05	-2524
Perley	2129181	879.89	90756	879.74	85676	-0.15	-5080
Georgetown	2194021	884.48		884.31		-0.17	
North River/ Clay Co. Hwy 93	2305647	895.35		892.88		-2.47	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	900.31		898.17		-2.14	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.8 (43.06*)	61717	902.54 (39.8*)	28917	-3.26	-32800
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	909.13		906.91		-2.22	
US ND Wild Rice River	2484618	911.54		910.11		-1.43	
US LPP Diversion	2531315	915.94		921.89		5.95	
Hickson Gage	2563754	919.69	35636	922.04	31941	2.35	-3696
Abercrombie	2764835	940.90	44308	940.91	44308	0.01	0

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

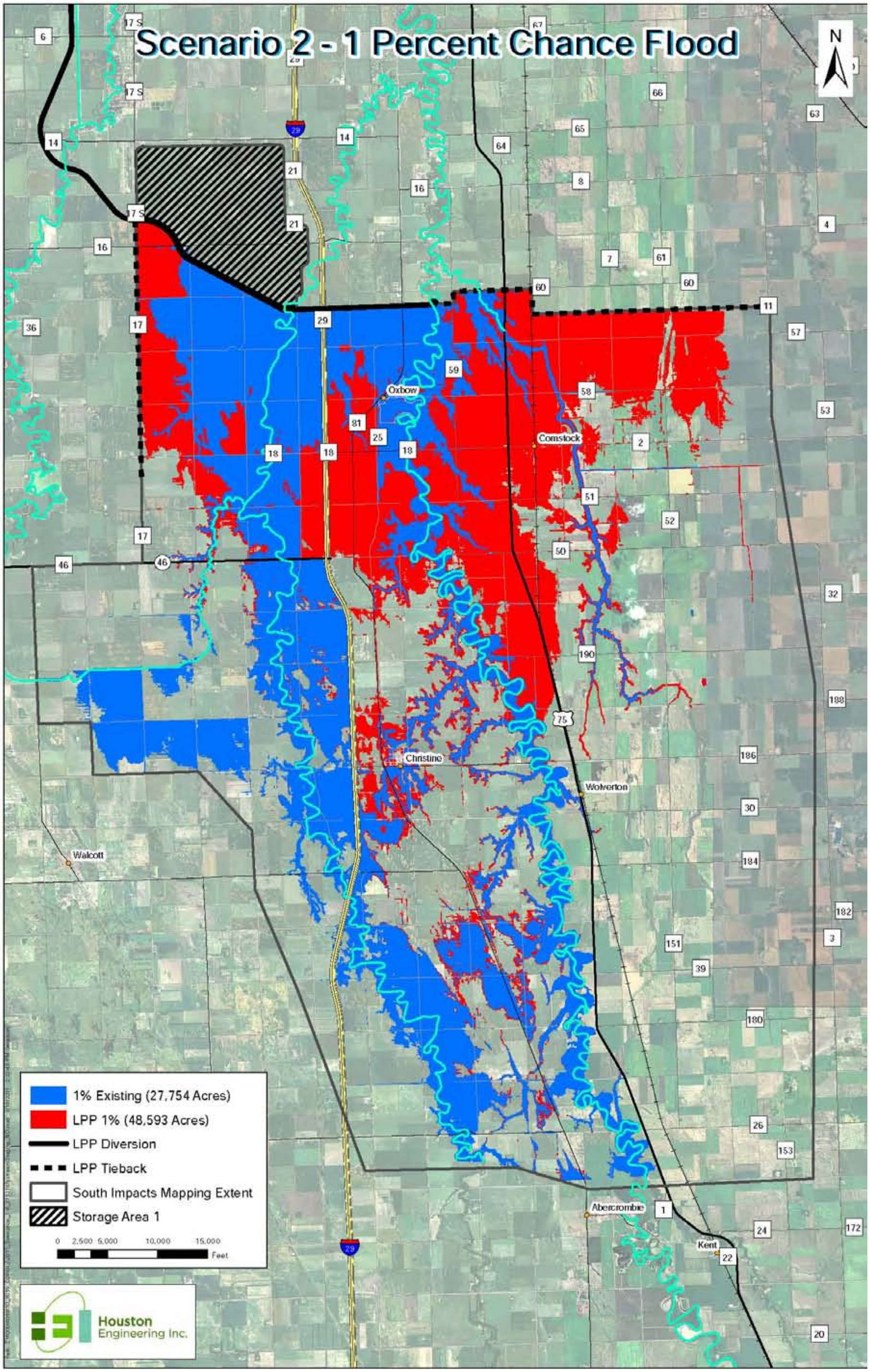

Figure 9: Scenario 2- 1-Percent Chance Flood Inundation Map

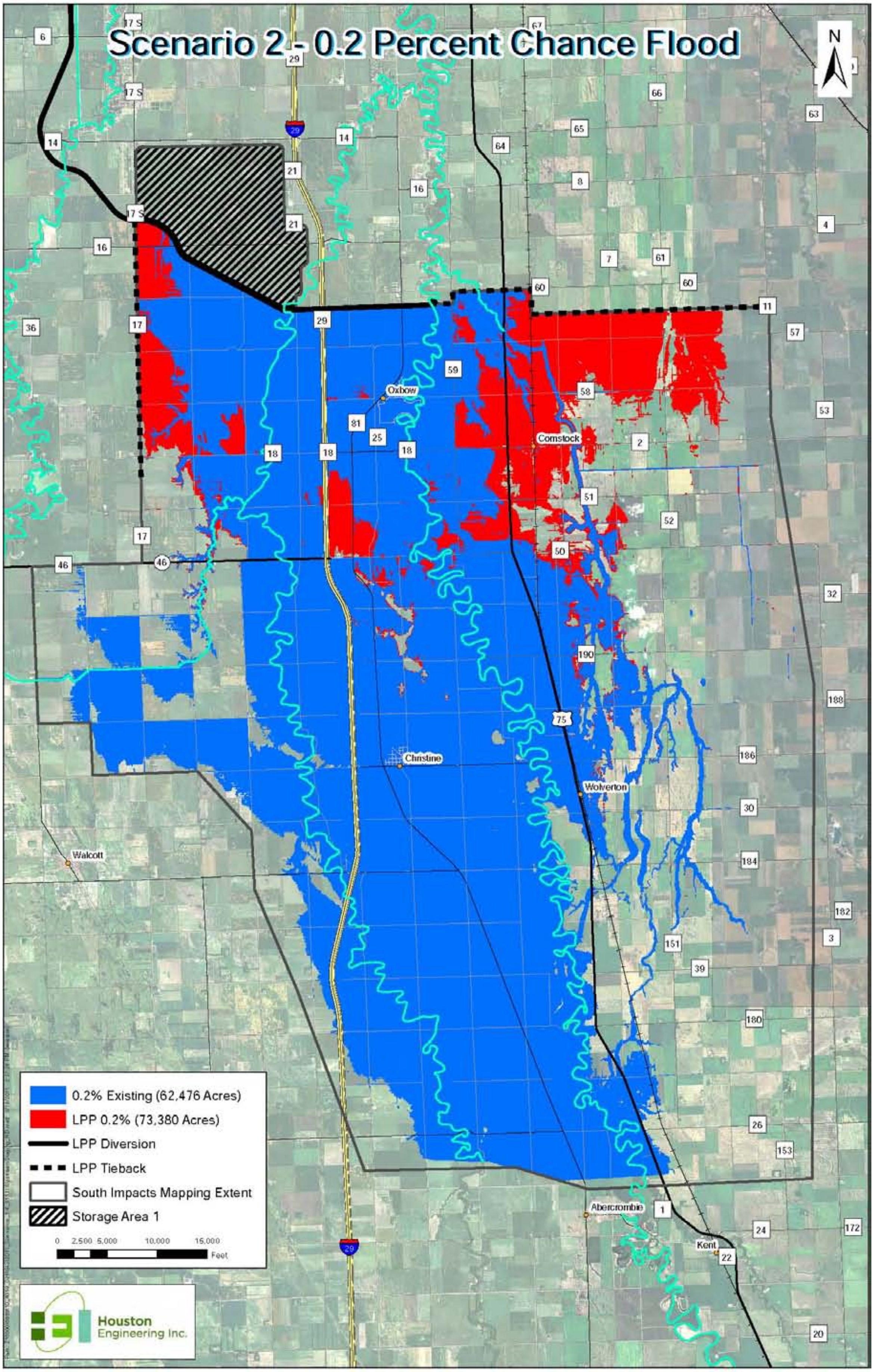

Figure 10: Scenario 2- 0.2-Percent Chance Flood Inundation Map

3.3 SCENARIO 3

3.3.1 Description. Scenario 3 includes preliminary hydraulic design of a modified LPP including Storage Area 1 with the addition of one or more large off stream storage areas downstream of the project along with reduced upstream staging.

3.3.2 Development. An initial screening analysis for this scenario was performed with two sites identified at a location near the outlet of the LPP diversion. Each site was analyzed separately, and also in conjunction with the other. One site was located just downstream (north) of the diversion outlet, and is referred to as "Outlet Storage Downstream," which is shown in Figure 11. The other site was located just upstream (south) of the diversion outlet, and is referred to as "Outlet Storage Upstream." The purpose of these sites is to pull water off the diversion only during the peak of high flows, thus preserving the volume available in these storage areas until the water surface elevation in the diversion channel becomes high enough to flow into them. The storage areas and cross sections included in the existing conditions model that encompass the area of each of these sites were either removed or modified accordingly from the LPP geometry.

Outlet Storage Downstream is approximately 3,650 acres, with a volume of 21,500 acre-feet at an elevation of 885, and 39,700 acre-feet at an elevation of 890. Outlet Storage Upstream is smaller in size and volume potential with an area of 1,545 acres and volume of 4,565 acre-feet at an elevation of 885, and 12,260 acre-feet at an elevation of 890.

For Outlet Storage Downstream, the weir controlling flows into the site was set at an elevation 0.5, 1.0, 1.5, and 2.0 feet below the 1-percent chance water surface elevation in the diversion channel included in the Phase 4 LPP. For Outlet Storage Upstream, the weir controlling flows into the site was set at an elevation 0.5 and 1.0 feet below the 1-percent chance water surface elevation in the diversion channel associated with the Phase 4 LPP. There was no added benefit between 0.5 and 1.0 feet for this site, and therefore the 1.5 and 2.0 feet options were not analyzed. The length of the weir at the Outlet Storage Downstream site was 4,000 feet, and the length of the weir at the Outlet Storage Upstream site was 5,000 feet. For the combined analysis, the same weir length at both of the storage sites was kept, while the crest for the weirs at Outlet Storage Downstream and Outlet Storage Upstream were set at an elevation 1.5 and 0.5 feet below the 1-percent chance water surface elevation, respectively. These elevations of 1.5 and 0.5 feet provided the most benefit downstream when these sites were analyzed separately. The gate operations for the control structures on the Wild Rice River, Red River, and Wolverton Creek were not changed from the Phase 4 LPP design for the initial screening of this scenario.

After analyzing the two storage sites separately and then combined, it was determined that the upstream site did not provide nearly the amount of benefit as the downstream site and that there was no added benefit by combining these two sites. Therefore, the results presented for scenario 3 are for Outlet Storage Downstream only. For this scenario, the water surface elevations at the Fargo Gage and downstream of the diversion were kept approximately the same as what was presented for the LPP in the February 28, 2011 report. Since available storage associated with Outlet Storage Downstream provided a benefit downstream by reducing impacts, additional water was passed into the diversion channel in order to maintain the same level of downstream impacts as with the Phase 4 LPP design. This required that the diversion inlet weir be increased from 90 to 110 feet. The gate operations for the Red River were modified from the Phase 4 LPP settings in order to meet these criteria, while the gate operations for the Wild Rice and Wolverton Creek structures were not changed. Multiple iterations were conducted by increasing the diversion inlet weir length, in addition to modifying the date and time of the gate opening. The gate operations were not significantly modified from those presented for the Phase 4 LPP in the February 28, 2011 report, so as to provide a comparable operation and project performance.

3.3.3 Costs. The estimated cost of a Scenario 3 LPP project is $1,838,260,600. A breakdown of the estimated costs associated with this project is included in Table 17.

3.3.4 Impacts. Compared to existing conditions, the increase in water surface elevations upstream of the Red River control structure for the 1-percent and 0.2-percent chance events is approximately 7.6 and 5.9 feet, respectively. When compared to the results presented for the LPP in the February 28, 2011 report, the upstream staging decreased 0.62 feet for both the 1-percent and 0.2-percent chance events. For more frequent events, the addition of this storage area could increase downstream impacts because the weir may prevent water from reaching areas that would have been inundated under existing conditions. For example, under existing conditions the 2-percent chance flood would inundate the floodplain, but the weir on the proposed storage area would prevent flows from a 2-percent chance flood from entering the storage area occupying the same area. As mentioned previously, the water surface elevations at the Fargo Gage and downstream of the diversion were kept approximately the same as what was presented for the LPP in the February 28, 2011 report. The impacts of Scenario 3 for the 1-percent and 0.2-percent chance events in relation to existing conditions are presented in Table 7 and Table 8, respectively. The impacts of this scenario in relation to the Phase 4 LPP design are presented in Table 15 and Table 16. The inundation areas associated with the upstream staging for each event are shown in Figure 12 and Figure 13, respectively.

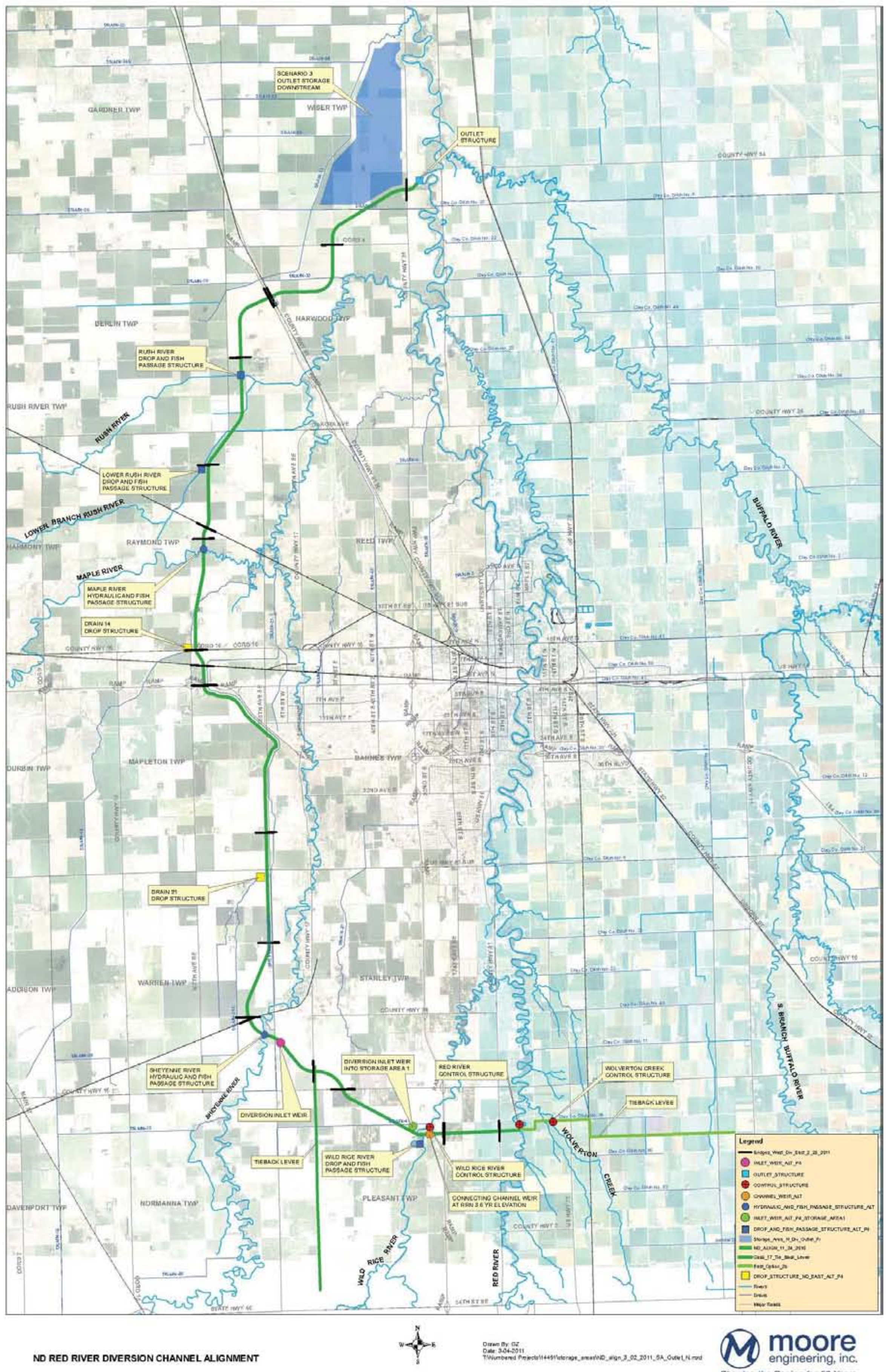

Figure 11: Scenario 3- Downstream Storage Layout

Table 7: Scenario 3– 1-Percent Chance Flood Impacts

North Dakota Diversion (LPP) - 1% Chance Event- Scenario 3-Downstream Storage Area							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.73	119255	801.82	120982	0.09	1727
ND SH#17/ MN SH317	1223286	804.09		804.17		0.08	
Co. Hwy 15	1315673	805.08		805.14		0.06	
Minimum Impact Location	1408098	811.34		811.38		0.04	
Oslo Gage	1416287	813.01		813.08		0.07	
DS Grand Forks Levees	1533523	827.98		828.15		0.17	
Grand Forks Gage	1558518	832.97	107980	833.25	110844	0.28	2864
Maximum Impact Location	1572542	835.22		835.55		0.33	
32nd Ave, Grand Forks	1580152	835.83		836.14		0.31	
Thompson Gage	1667877	847.35	82926	847.39	82562	0.04	-363
Co. Hwy 25/ Co. Rd 221	1726274	854.46		854.44		-0.02	
DS Sandhill River/ Climax	1763746	857.34		857.30		-0.04	
Nielsville	1829877	861.66	75745	861.61	75812	-0.05	68
DS Marsh River	1864960	863.43		863.39		-0.04	
US Goose River/ Shelly	1891054	865.36		865.30		-0.06	
Halstad Gage	1981580	869.09	71581	868.99	70024	-0.10	-1557
Hendrum	2038409	873.75	67278	873.61	64662	-0.14	-2616
Perley	2129181	878.50	61723	878.16	55836	-0.34	-5887
Georgetown	2194021	883.36		883.43		0.07	
North River/ Clay Co. Hwy 93	2305647	893.73		886.52		-7.21	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.08		890.46		-8.62	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.86 (41.12*)	34875	893.46 (30.72*)	11585	-10.40	-23289
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.71		897.56		-10.15	
US ND Wild Rice River	2484618	910.70		901.60		-9.10	
US LPP Diversion	2531315	914.65		922.26		7.61	
Hickson Gage	2563754	917.52	21730	922.30	18948	4.78	-2783
Abercrombie	2764835	935.62	23000	935.73	23000	0.11	0

3-08-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

Table 8: Scenario 3– 0.2-Percent Chance Flood Impacts

3-08-2011

North Dakota Diversion (LPP) - 0.2% Chance Event- Scenario 3-Downstream Storage Area							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	804.12	168364	804.22	171125	0.10	2761
ND SH#17/ MN SH317	1223286	805.99		806.06		0.07	
Co. Hwy 15	1315673	806.74		806.82		0.08	
Minimum Impact Location	1410241	812.15		812.19		0.04	
Oslo Gage	1416287	813.88		813.93		0.05	
DS Grand Forks Levees	1533523	829.92		830.03		0.11	
Grand Forks Gage	1558518	836.36	146225	836.56	148819	0.20	2887
Maximum Impact Location	1561353	838.53		838.77		0.24	
32nd Ave, Grand Forks	1580152	839.75		839.95		0.20	
Thompson Gage	1667877	850.69	112422	850.64	111449	-0.05	-973
Co. Hwy 25/ Co. Rd 221	1726274	859.38		859.27		-0.11	
DS Sandhill River/ Climax	1763746	862.75		862.60		-0.15	
Nielsville	1829877	867.04	107296	866.87	105698	-0.17	-1598
DS Marsh River	1864960	868.06		867.91		-0.15	
US Goose River/ Shelly	1891054	869.30		869.16		-0.14	
Halstad Gage	1981580	871.54	101754	871.33	95980	-0.21	-5774
Hendrum	2038409	875.77	97650	875.44	89998	-0.33	-7652
Perley	2129181	879.89	90756	879.52	79646	-0.37	-11110
Georgetown	2194021	884.48		884.73		0.25	
North River/ Clay Co. Hwy 93	2305647	895.35		892.95		-2.40	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	900.31		898.28		-2.03	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.8 (43.06*)	61717	902.69 (39.95*)	29543	-3.11	-32174
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	909.13		907.02		-2.11	
US ND Wild Rice River	2484618	911.54		910.18		-1.36	
US LPP Diversion	2531315	915.94		921.82		5.88	
Hickson Gage	2563754	919.69	35636	921.98	33108	2.29	-2528
Abercrombie	2764835	940.90	44308	940.91	44308	0.01	0

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

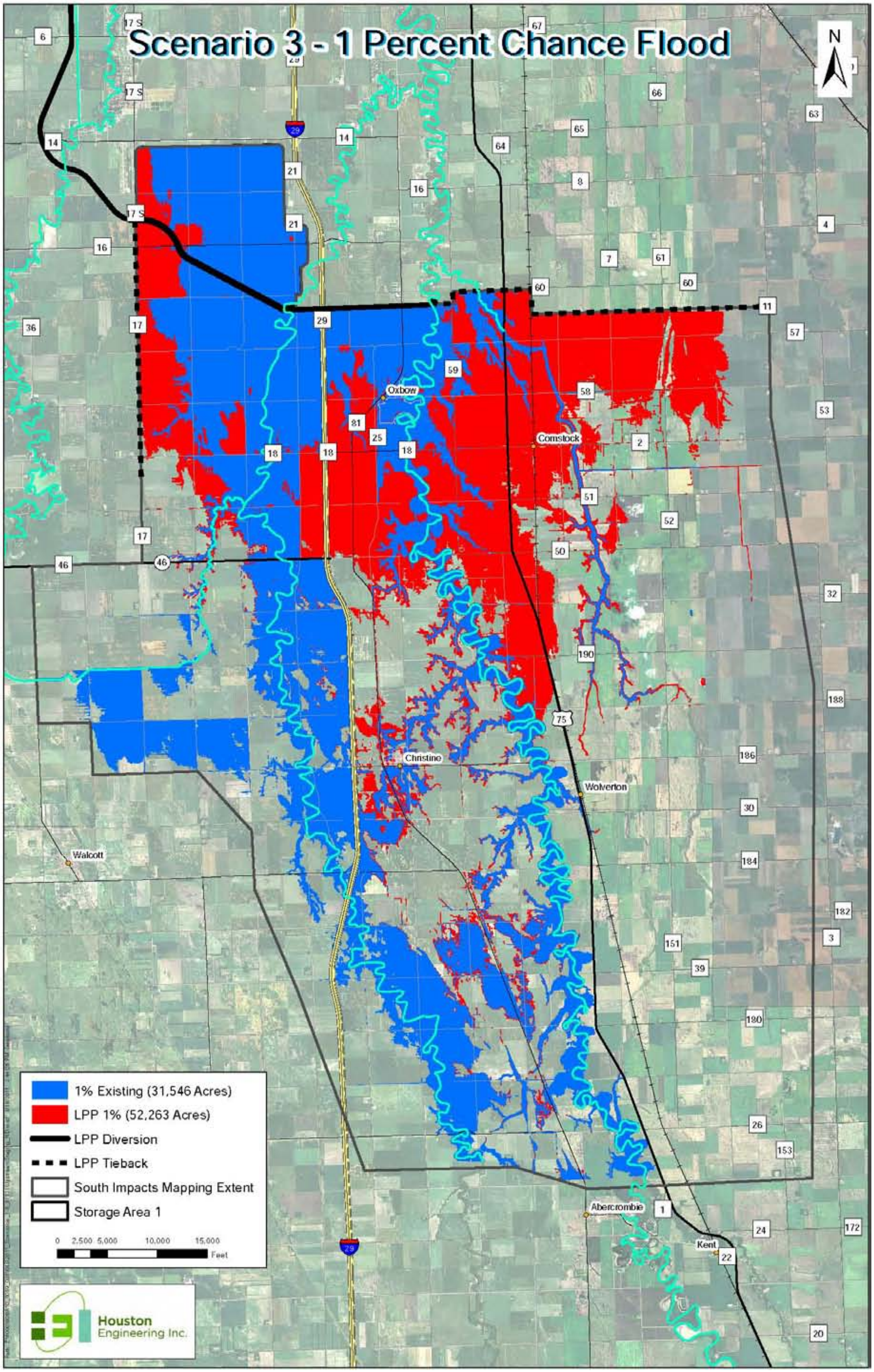

Figure 12: Scenario 3- 1-Percent Chance Flood Inundation Map

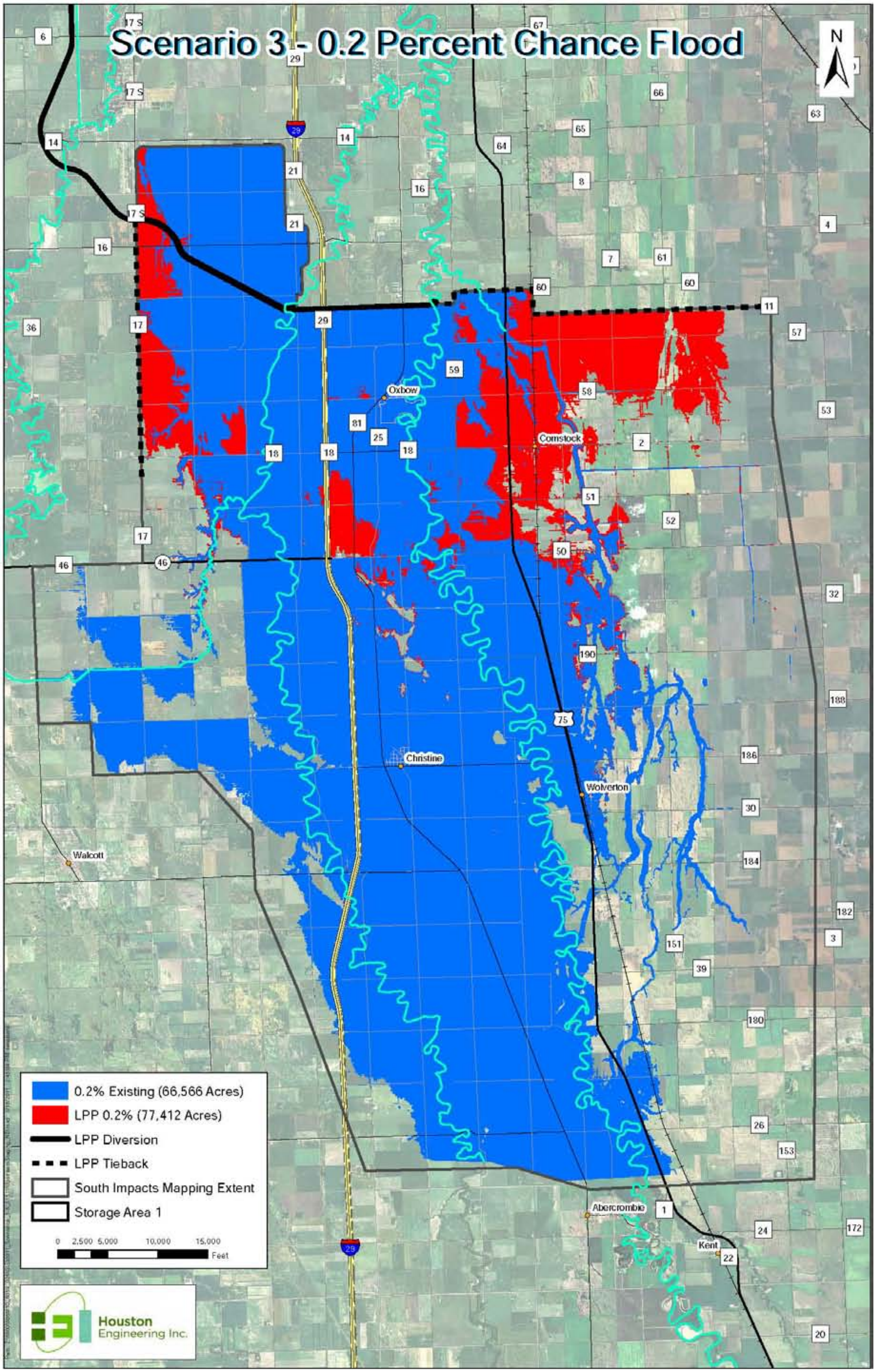

Figure 13: Scenario 3- 0.2-Percent Chance Flood Inundation Map

3.4 SCENARIO 4

3.4.1 Description. Scenario 4 includes preliminary hydraulic design of a modified LPP with no "smart storage" and with no staging. This is essentially the Phase 3 design incorporated into the latest unsteady flow models with modifications made as necessary for model stability and operational goals.

3.4.2 Development. The Phase 4 LPP diversion geometry was replaced with the Phase 3 design for this scenario. This Phase 3 design is associated with a diversion channel capable of diverting 35,000 cfs from the Red and Wild Rice Rivers for the 0.2-percent chance event. In addition, Storage Area 1 was removed from the LPP geometry, and the existing conditions geometry for this area was inserted back into the model geometry. The channel and hydraulic structure dimensions for this scenario can be found in the Phase 3.1 report entitled "*Fargo – Moorhead Metro Flood Risk Management Project, Feasibility Study Report for the US Army Corps of Engineers, and the Cities of Fargo, ND & Moorhead, MN Phase 3 (Phase 3.1 Hydrology)*" published on July 30, 2010.

Modifications to the diversion inlet weir were performed to ensure that the project design of 35,000 cfs for the 0.2-percent chance event was being diverted into the diversion channel, while still maintaining the criteria of no significant increase in upstream water surface elevations and maintaining approximately the same water surface elevation at the Fargo Gage as the Phase 4 LPP design. The diversion inlet weir geometry for this scenario involves a two tier configuration, with a 270 foot bottom width set at an elevation of 903.9 feet, and a top weir spanning a total width of 2,130 feet set at an elevation of 914.51 feet. Previous phases of this study used a three tiered weir configuration, to ensure that adequate performance for more frequent events such as the 10-percent chance event was maintained. Since the scope of this analysis did not include events smaller than a 1-percent chance event, a three tiered weir configuration was not developed. Any future analysis for events smaller than the 1-percent chance event would need modifications to the current two tier configuration used for this scenario.

3.4.3 Costs. The estimated cost of a Scenario 4 LPP project is $1,505,470,000. This estimate was developed by the USACE during Phase 3 of the study.

3.4.4 Impacts. The water surface elevations compared to existing conditions at Thompson for the 1-percent and 0.2-percent chance events increase 1.33 and 0.57 feet, respectively. The maximum downstream impact for the 1-percent chance event is 2.17 feet, whereas the Phase 4 LPP in the February 28, 2011 report had a maximum downstream impact of 0.29 feet. The minimum downstream impact for the 1-percent chance event is 0.18 feet, whereas the Phase 4 LPP had a minimum downstream impact of 0.04 feet. The maximum downstream impact for the 0.2-percent chance event is 1.07 feet compared to a maximum downstream impact of 0.27 feet with the Phase 4 LPP design. The minimum downstream impact for the 0.2-percent chance event is 0.13 feet, while the Phase 4 LPP had a minimum downstream impact of 0.04 feet. The impacts of Scenario 4 for the 1 and 0.2-percent chance events in relation to existing conditions are presented in Table 9 and Table 10, respectively. The impacts of this scenario in relation to the Phase 4 LPP design are presented in Table 15 and Table 16.

Table 9: Scenario 4– 1-Percent Chance Flood Impacts

North Dakota Diversion (LPP) - 1% Chance Event- Scenario 4							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.73	119255	802.19	127915	0.46	8661
ND SH#17/ MN SH317	1223286	804.09		804.50		0.41	
Co. Hwy 15	1315673	805.08		805.43		0.35	
Minimum Impact Location	1408098	811.34		811.52		0.18	
Oslo Gage	1416287	813.01		813.27		0.26	
DS Grand Forks Levees	1533523	827.98		828.59		0.61	
Grand Forks Gage	1558518	832.97	107980	834.01	118988	1.04	11008
32nd Ave, Grand Forks	1580152	835.83		837.14		1.31	
Thompson Gage	1667877	847.35	82926	848.68	93049	1.33	10123
Co. Hwy 25/ Co. Rd 221	1726274	854.46		856.39		1.93	
DS Sandhill River/ Climax	1763746	857.34		859.41		2.07	
Maximum Impact Location	1813905	860.78		862.95		2.17	
Nielsville	1829877	861.66	75745	863.77	87867	2.11	12122
DS Marsh River	1864960	863.43		865.27		1.84	
US Goose River/ Shelly	1891054	865.36		866.92		1.56	
Halstad Gage	1981580	869.09	71581	870.12	86012	1.03	14430
Hendrum	2038409	873.75	67278	874.72	81528	0.97	14250
Perley	2129181	878.50	61723	879.29	75002	0.79	13279
Georgetown	2194021	883.36		884.00		0.64	
North River/ Clay Co. Hwy 93	2305647	893.73		888.39		-5.34	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.08		891.39		-7.69	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.86 (41.12*)	34875	893.78 (31.04*)	10689	-10.08	-24185
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.71		897.09		-10.62	
US ND Wild Rice River	2484618	910.70		900.28		-10.42	
US LPP Diversion	2531315	914.65		916.00		1.35	
Hickson Gage	2563754	917.52	21730	918.24	21828	0.72	98
Abercrombie	2764835	935.62	23000	935.66	23000	0.04	0

3-04-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

Table 10: Scenario 4– 0.2-Percent Chance Flood Impacts

North Dakota Diversion (LPP) - 0.2% Chance Event- Scenario 4							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	804.12	168364	804.48	177240	0.36	8876
ND SH#17/ MN SH317	1223286	805.99		806.24		0.25	
Co. Hwy 15	1315673	806.74		806.99		0.25	
Minimum Impact Location	1410241	812.15		812.28		0.13	
Oslo Gage	1416287	813.88		814.03		0.15	
DS Grand Forks Levees	1533523	829.92		830.32		0.40	
Grand Forks Gage	1558518	836.36	146225	837.15	156371	0.79	2887
32nd Ave, Grand Forks	1580152	839.75		840.73		0.98	
Thompson Gage	1667877	850.69	112422	851.26	119705	0.57	7283
Co. Hwy 25/ Co. Rd 221	1726274	859.38		860.19		0.81	
DS Sandhill River/ Climax	1763746	862.75		863.69		0.94	
Maximum Impact Location	1806800	865.87		866.94		1.07	
Nielsville	1829877	867.04	107296	868.06	116763	1.02	9466
DS Marsh River	1864960	868.06		868.97		0.91	
US Goose River/ Shelly	1891054	869.30		870.14		0.84	
Halstad Gage	1981580	871.54	101754	872.07	111678	0.53	9925
Hendrum	2038409	875.77	97650	876.19	104903	0.42	7253
Perley	2129181	879.89	90756	880.11	97828	0.22	7072
Georgetown	2194021	884.48		884.69		0.21	
North River/ Clay Co. Hwy 93	2305647	895.35		892.83		-2.52	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	900.31		898.03		-2.28	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.8 (43.06*)	61717	902.28 (39.54*)	27760	-3.52	-33957
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	909.13		906.67		-2.46	
US ND Wild Rice River	2484618	911.54		909.88		-1.66	
US LPP Diversion	2531315	915.94		916.00		0.06	
Hickson Gage	2563754	919.69	35636	919.66	35560	-0.03	-76
Abercrombie	2764835	940.90	44308	940.90	44308	0.00	0

3-04-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

3.5 SCENARIO 5

3.5.1 Description. Scenario 5 includes preliminary hydraulic design of a modified LPP with no "smart storage" but including increased upstream staging.

3.5.2 Development. Storage Area 1 included in the Phase 4 LPP design was removed from the model geometry, and the original geometry for this area from the existing conditions model was inserted back into the model. For reference, Storage Area 1 included in the Phase 4 LPP design was 4,160 acres, with 55,800 acre-feet of volume at an elevation of 923.

For this scenario, the water surface elevations at the Fargo Gage and downstream of the diversion were kept approximately the same as what was presented for the LPP in the February 28, 2011 report. To maintain these criteria, additional staging was needed. This required that the diversion inlet weir be decreased from 90 to 75 feet. The gate operations for the Red River from the Phase 4 LPP were modified to meet these criteria, while the gate operations for the Wild Rice and Wolverton Creek structures were not changed. Multiple iterations of decreasing the diversion inlet weir length, date and time of opening of gates, and/or gate rate opening were conducted. The gate operations were not significantly modified from those presented for the LPP in the February 28, 2011 report, so as to provide a comparable operation and project performance.

3.5.3 Costs. The estimated cost of a Scenario 5 LPP project is $1,785,344,236. A breakdown of the estimated costs associated with this project is included in Table 17.

3.5.4 Impacts. Compared to existing conditions, the increase in water surface elevations upstream of the Red River control structure for the 1-percent and 0.2-percent chance events is approximately 9.4 and 7.7 feet, respectively. When compared to the results presented for the LPP in the February 28, 2011 report, the upstream staging increased 1.18 and 1.16 feet for the 1-percent and 0.2-percent chance events, respectively. The impacts for the 1-percent and 0.2-percent chance events are shown in Table 11 and Table 12, respectively. As mentioned previously, the water surface elevations at the Fargo Gage and downstream of the diversion were kept approximately the same as what was presented for the LPP in the February 28, 2011 report. The impacts of Scenario 5 for the 1-percent and 0.2-percent chance events in relation to existing conditions are presented in Table 11 and Table 12, respectively. The impacts of this scenario in relation to the Phase 4 LPP design are presented in Table 15 and Table 16. The inundation areas associated with the upstream staging for each event are shown in Figure 14 and Figure 15, respectively.

Table 11: Scenario 5– 1-Percent Chance Flood Impacts

North Dakota Diversion (LPP) - 1% Chance Event- Scenario 5							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.73	119255	801.82	121008	0.09	1753
ND SH#17/ MN SH317	1223286	804.09		804.17		0.08	
Co. Hwy 15	1315673	805.08		805.14		0.06	
Minimum Impact Location	1408098	811.34		811.38		0.04	
Oslo Gage	1416287	813.01		813.07		0.06	
DS Grand Forks Levees	1533523	827.98		828.14		0.16	
Grand Forks Gage	1558518	832.97	107980	833.24	110742	0.27	2762
Maximum Impact Location	1574433	835.27		835.59		0.32	
32nd Ave, Grand Forks	1580152	835.83		836.14		0.31	
Thompson Gage	1667877	847.35	82926	847.40	82658	0.05	-267
Co. Hwy 25/ Co. Rd 221	1726274	854.46		854.45		-0.01	
DS Sandhill River/ Climax	1763746	857.34		857.31		-0.03	
Nielsville	1829877	861.66	75745	861.63	76167	-0.03	422
DS Marsh River	1864960	863.43		863.41		-0.02	
US Goose River/ Shelly	1891054	865.36		865.33		-0.03	
Halstad Gage	1981580	869.09	71581	869.03	70952	-0.06	-629
Hendrum	2038409	873.75	67278	873.68	65974	-0.07	-1304
Perley	2129181	878.50	61723	878.21	56675	-0.29	-5048
Georgetown	2194021	883.36		883.08		-0.28	
North River/ Clay Co. Hwy 93	2305647	893.73		887.06		-6.67	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.08		890.65		-8.43	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.86 (41.12*)	34875	893.52 (30.78*)	11434	-10.34	-23441
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.71		897.52		-10.19	
US ND Wild Rice River	2484618	910.70		901.50		-9.20	
US LPP Diversion	2531315	914.65		924.06		9.41	
Hickson Gage	2563754	917.52	21730	924.08	16458	6.56	-5272
Abercrombie	2764835	935.62	23000	935.79	23000	0.17	0

3-04-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

Table 12: Scenario 5– 0.2-Percent Chance Flood Impacts

North Dakota Diversion (LPP) - 0.2% Chance Event- Scenario 5							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	804.12	168364	804.24	169298	0.12	934
ND SH#17/ MN SH317	1223286	805.99		806.08		0.09	
Co. Hwy 15	1315673	806.74		806.84		0.10	
Minimum Impact Location	1408098	812.00		812.04		0.04	
Oslo Gage	1416287	813.88		813.94		0.06	
DS Grand Forks Levees	1533523	829.92		830.06		0.14	
Grand Forks Gage	1558518	836.36	146225	836.61	149493	0.25	2887
Maximum Impact Location	1561353	838.53		838.83		0.30	
32nd Ave, Grand Forks	1580152	839.75		840.01		0.26	
Thompson Gage	1667877	850.69	112422	850.66	111646	-0.03	-775
Co. Hwy 25/ Co. Rd 221	1726274	859.38		859.30		-0.08	
DS Sandhill River/ Climax	1763746	862.75		862.64		-0.11	
Nielsville	1829877	867.04	107296	866.92	106359	-0.12	-937
DS Marsh River	1864960	868.06		867.96		-0.10	
US Goose River/ Shelly	1891054	869.30		869.21		-0.09	
Halstad Gage	1981580	871.54	101754	871.34	97336	-0.20	-4418
Hendrum	2038409	875.77	97650	875.49	91110	-0.28	-6540
Perley	2129181	879.89	90756	879.54	80087	-0.35	-10669
Georgetown	2194021	884.48		884.15		-0.33	
North River/ Clay Co. Hwy 93	2305647	895.35		892.89		-2.46	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	900.31		898.19		-2.12	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.8 (43.06*)	61717	902.56 (39.82*)	29043	-3.24	-32674
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	909.13		906.93		-2.20	
US ND Wild Rice River	2484618	911.54		910.11		-1.43	
US LPP Diversion	2531315	915.94		923.60		7.66	
Hickson Gage	2563754	919.69	35636	923.66	29566	3.97	-6070
Abercrombie	2764835	940.90	44308	940.91	44308	0.01	0

3-04-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

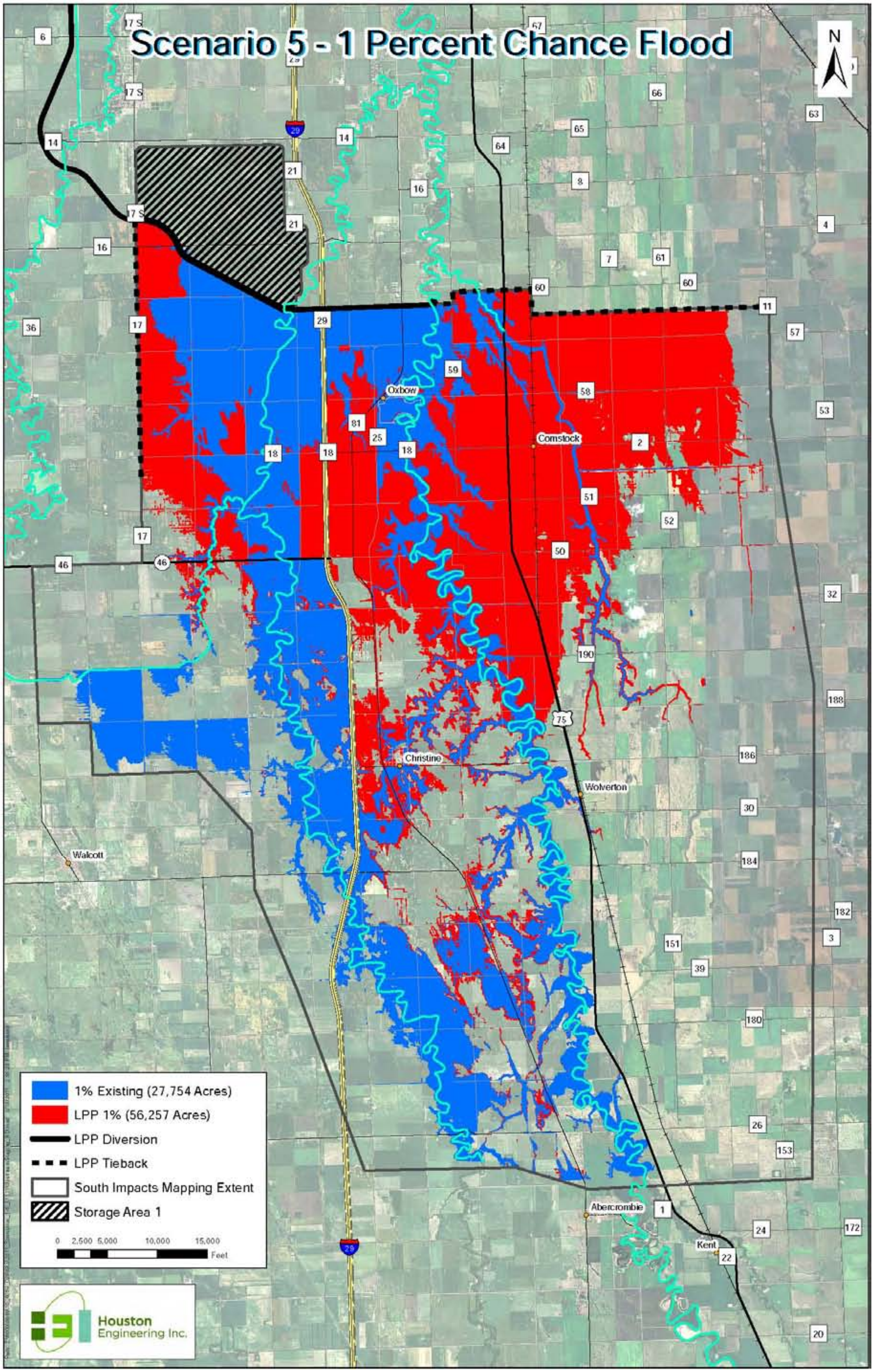

Figure 14: Scenario 5- 1-Percent Chance Flood Inundation Map

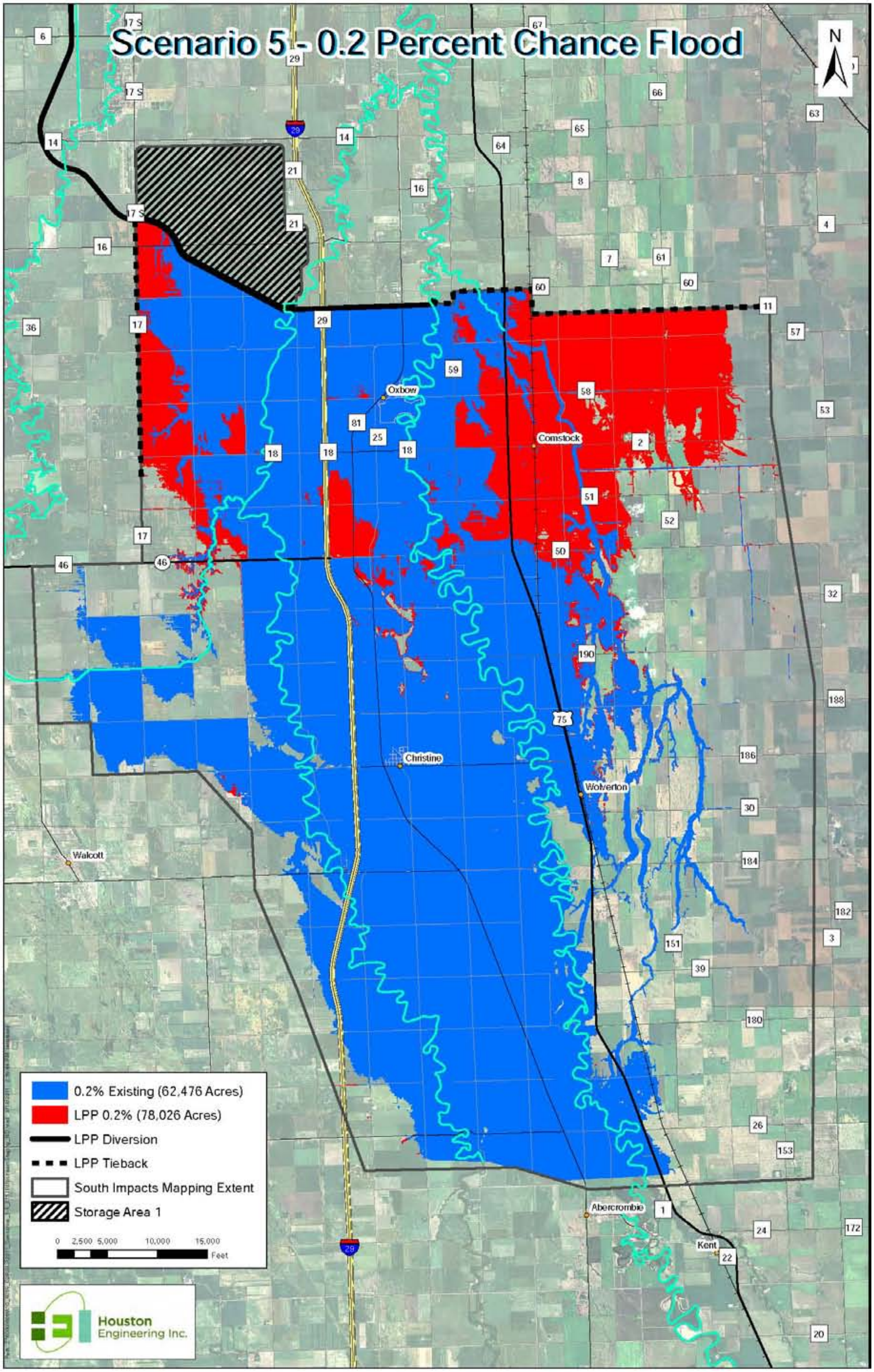

Figure 15: Scenario 5- 0.2-Percent Chance Flood Inundation Map

3.6 SCENARIO 6

3.6.1 Description. Scenario 6 includes the preliminary hydraulic design of a modified LPP with the south end of the diversion alignment moved to provide protection to the communities of Hickson, ND, Oxbow, ND, and the Bakke Subdivision (Oxbow Area). The proposed Scenario 6 diversion alignment begins at the Red River in the S1/2 of Section 24, Pleasant Township and extends west to the west side of Interstate 29. It then progresses north along the west side of Interstate 29 until it meets the original Phase 4 LPP diversion channel near the Wild Rice River control structure.

3.6.2 Development. For this scenario, the water surface elevations at the Fargo Gage and downstream of the diversion were kept approximately the same as what was presented for the LPP in the February 28, 2011 report. To maintain these criteria while providing protection to the Oxbow Area, additional staging was necessary above what was included in the original LPP. The additional staging required the diversion inlet weir be narrowed from 90 to 70 feet. The gate operations for the Red River were modified to match the LPP criteria, while the gate operation for the Wild Rice River structure was not changed from the Phase 4 LPP. Multiple iterations of decreasing the diversion inlet weir length, date and time of opening of gates, and/or gate rate opening were conducted. The gate operations were not significantly modified from those presented for the LPP in the February 28, 2011 report, so as to provide a comparable operation and project performance.

3.6.3 Costs. The estimated cost of a Scenario 6 LPP project is $1,795,054,900. A breakdown of the estimated costs associated with this project is included in Table 17.

3.6.4 Impacts. Compared to existing conditions, the increase in water surface elevations upstream of the Red River control structure for the 1-percent and 0.2-percent chance events is approximately 8.0 and 5.5 feet, respectively. Since the Red River control structure is in a different location for Scenario 6 than the original LPP, a direct upstream stage comparison is difficult to present. Generally, the 1-percent chance staged elevation for Scenario 6 is 2.6 feet higher than the original LPP. As mentioned previously, the water surface elevations at the Fargo Gage and downstream of the diversion were kept approximately the same as what was presented for the LPP in the February 28, 2011 report. The impacts of Scenario 6 for the 1 and 0.2-percent chance events in relation to existing conditions are presented in Table 13 and Table 14, respectively. The impacts of this scenario in relation to the Phase 4 LPP design are presented in Table 15 and Table 16. The inundation areas associated with the upstream staging for each event are shown in Figure 16 and Figure 17, respectively.

Table 13: Scenario 6– 1-Percent Chance Flood Impacts

North Dakota Diversion (LPP) - 1% Chance Event- Scenario 6 | 3-21-2011

Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	801.73	119255	801.81	120871	0.08	1617
ND SH#17/ MN SH317	1223286	804.09		804.17		0.08	
Co. Hwy 15	1315673	805.08		805.14		0.06	
Minimum Impact Location	1408098	811.34		811.38		0.04	
Oslo Gage	1416287	813.01		813.07		0.06	
DS Grand Forks Levees	1533523	827.98		828.14		0.16	
Grand Forks Gage	1558518	832.97	107980	833.23	110644	0.26	2664
Maximum Impact Location	1573768	835.27		835.57		0.30	
32nd Ave, Grand Forks	1580152	835.83		836.13		0.30	
Thompson Gage	1667877	847.35	82926	847.40	82657	0.05	-269
Co. Hwy 25/ Co. Rd 221	1726274	854.46		854.45		-0.01	
DS Sandhill River/ Climax	1763746	857.34		857.31		-0.03	
Nielsville	1829877	861.66	75745	861.63	76149	-0.03	405
DS Marsh River	1864960	863.43		863.41		-0.02	
US Goose River/ Shelly	1891054	865.36		865.33		-0.03	
Halstad Gage	1981580	869.09	71581	869.04	71065	-0.05	-516
Hendrum	2038409	873.75	67278	873.69	66326	-0.06	-952
Perley	2129181	878.50	61723	878.22	56966	-0.28	-4757
Georgetown	2194021	883.36		883.10		-0.26	
North River/ Clay Co. Hwy 93	2305647	893.73		886.65		-7.08	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	899.08		890.46		-8.62	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	903.86 (41.12*)	34875	893.42 (30.68*)	11472	-10.44	-23402
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	907.71		897.49		-10.22	
US ND Wild Rice River	2484618	910.70		901.50		-9.20	
Co. Rd 16 / Co. Rd 4	2516193	913.59		905.07		-8.52	
Hickson Gage / US LPP Diversion	2563754	917.52	21730	925.47	14607	7.95	-7123
Abercrombie	2764835	935.62	23000	935.91	23000	0.29	0

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

Table 14: Scenario 6– 0.2-Percent Chance Flood Impacts

North Dakota Diversion (LPP) - 0.2% Chance Event- Scenario 6							
Location	Station	Existing No Protection		ND Diversion (LPP)		Difference (ft) Project vs. Existing No Protection	
		Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
Drayton Gage	1062362	804.12	168364	804.23	169237	0.11	873
ND SH#17/ MN SH317	1223286	805.99		806.07		0.08	
Co. Hwy 15	1315673	806.74		806.83		0.09	
Minimum Impact Location	1410241	812.15		812.19		0.04	
Oslo Gage	1416287	813.88		813.93		0.05	
DS Grand Forks Levees	1533523	829.92		830.05		0.13	
Grand Forks Gage	1558518	836.36	146225	836.59	149216	0.23	2887
Maximum Impact Location	1561353	838.53		838.81		0.28	
32nd Ave, Grand Forks	1580152	839.75		839.99		0.24	
Thompson Gage	1667877	850.69	112422	850.63	111297	-0.06	-1125
Co. Hwy 25/ Co. Rd 221	1726274	859.38		859.26		-0.12	
DS Sandhill River/ Climax	1763746	862.75		862.59		-0.16	
Nielsville	1829877	867.04	107296	866.87	105941	-0.17	-1355
DS Marsh River	1864960	868.06		867.92		-0.14	
US Goose River/ Shelly	1891054	869.30		869.16		-0.14	
Halstad Gage	1981580	871.54	101754	871.31	96965	-0.23	-4789
Hendrum	2038409	875.77	97650	875.47	93481	-0.30	-4169
Perley	2129181	879.89	90756	879.52	79789	-0.37	-10967
Georgetown	2194021	884.48		884.15		-0.33	
North River/ Clay Co. Hwy 93	2305647	895.35		892.98		-2.37	
19th Ave N Fargo/ 28th Ave N Moorhead	2360321	900.31		898.36		-1.95	
Fargo Gage (13th Ave S, 12th Ave S)	2388223	905.8 (43.06*)	61717	902.86 (40.12*)	30241	-2.94	-31476
52nd Ave S Fargo/ 60th Ave S Moorhead	2438085	909.13		907.14		-1.99	
US ND Wild Rice River	2484618	911.54		910.30		-1.24	
Co. Rd 16 / Co. Rd 4	2516193	914.66		913.81		-0.85	
Hickson Gage / US LPP Diversion	2563754	919.69	35636	925.15	28778	5.46	-6858
Abercrombie	2764835	940.90	44308	940.91	44308	0.01	0

3-21-2011

* Flood stage at USGS Gaging Station 05054000, Fargo, ND

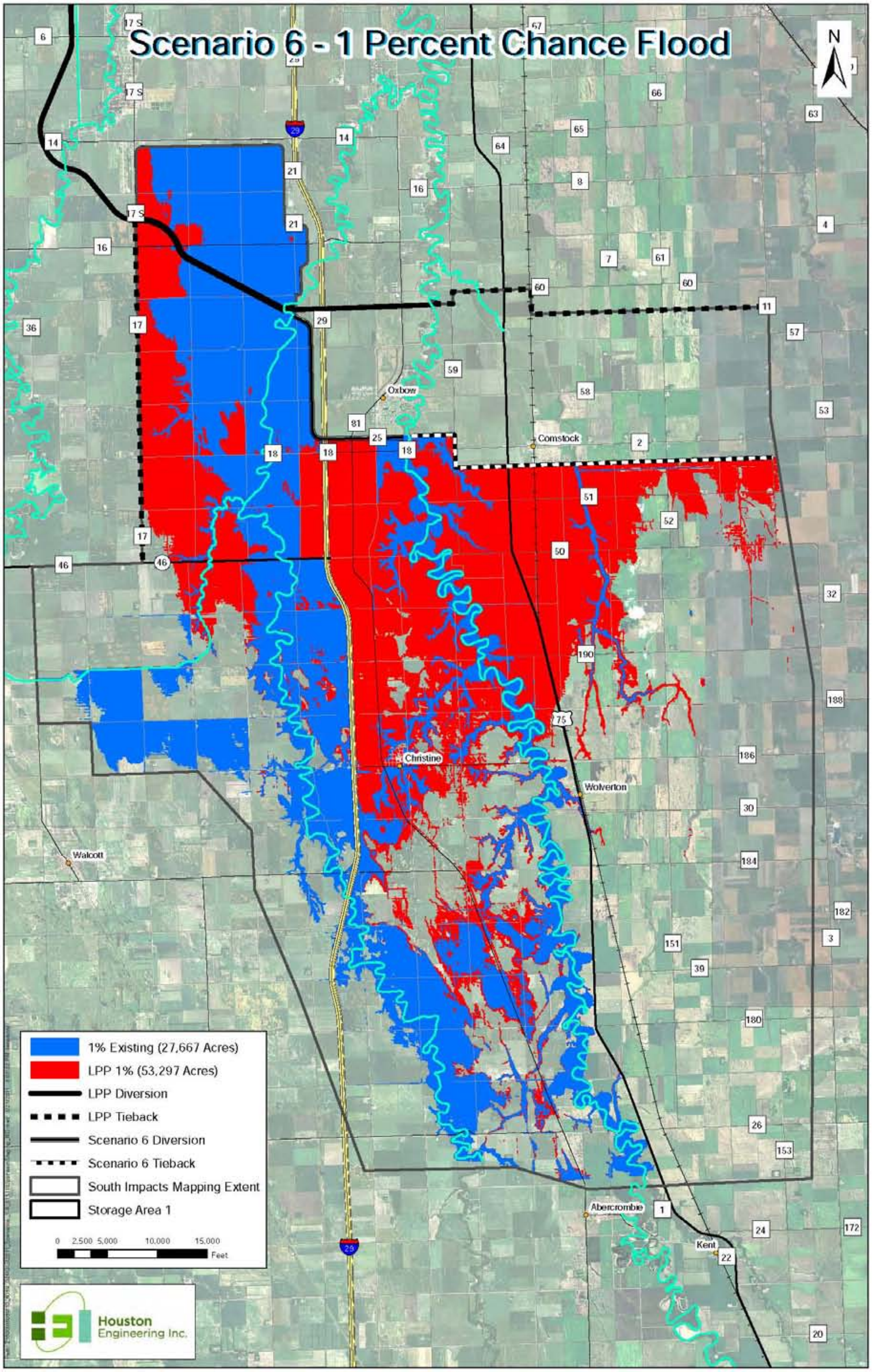

Figure 16: Scenario 6- 1-Percent Chance Flood Inundation Map

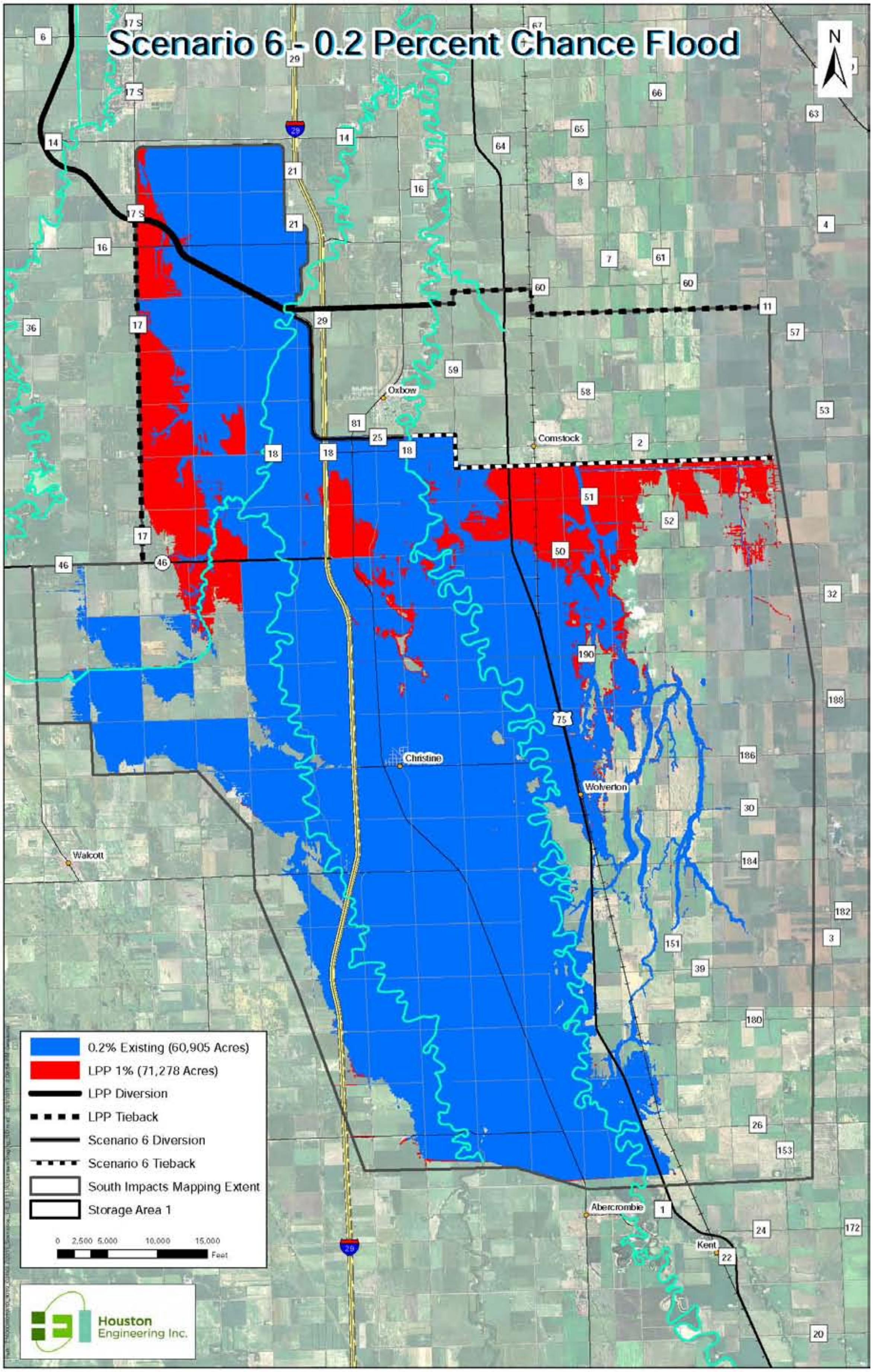

Figure 17: Scenario 6- 0.2-Percent Chance Flood Inundation Map

3.7 IMPACT COMPARISON

Table 15 and Table 16 provide a summary of the impacts associated with each scenario when compared to the Phase 4 LPP design for the 1-percent chance and 0.2-percent chance floods, respectively.

Table 15: Alternative Scenarios- 1-Percent Chance Flood Impact Summary

Alternative Scenario Analysis Summary - 1% Chance Event (Scenario vs. Phase 4 LPP)

		Existing (No Protection)	Phase 4 LPP ND Diversion	Scenario #1	Scenario #2	Scenario #3	Scenario #4	Scenario #5	Scenario #6
Location	**Station**	Elevation (ft)	**Elevation (ft)**	**Elevation (ft)**	**Elevation (ft)**	**Elevation (ft)**	**Elevation (ft)**	**Elevation (ft)**	**Elevation (ft)**
Grand Forks Gage	1558518	832.97	**0.24**	-0.02	0.20	0.04	0.80	0.03	0.02
Thompson Gage	1667877	847.35	**0.04**	-0.02	0.48	0.00	1.29	0.01	0.01
Hendrum	2038409	873.75	**-0.06**	-0.01	0.31	-0.08	1.03	-0.01	0.00
Fargo Gage (13th Ave S, 12th Ave S)[1]	2388223	41.12	**-10.32**	-0.12	-0.05	-0.08	0.24	-0.02	-0.12
US LPP Diversion[2]	2531315	914.65	**8.23**	-0.64	-0.71	-0.62	-6.88	1.18	---
Hickson Gage (Staging Area)	2563754	917.52	**5.38**	-0.63	-0.68	-0.60	-4.66	1.18	2.57
Minimum Impact			**0.04**	-0.01	0.03	0.00	0.14	0.00	-0.04
Location (River Station)			**(1410241)**	(1408098)	(1408098)	(1408098)	(1408098)	(1408098)	(1408098)
Maximum Impact			**0.29**	-0.03	0.48	-0.02	1.88	0.03	(0.29)
Location (River Station)			**(1573768)**	(1573768)	(1813905)	(1573768)	(1813905)	(1574433)	(1573768)
Inundation Area Upstream of Project[3]									
		Area (Acres)	**Area (Acres)**	**Area (Acres)**	**Area (Acres)**	**Area (Acres)**	**Area (Acres)**	**Area (Acres)**	**Area (Acres)**
Additional 1% Inundation Area (above existing)			**23,175**	20,215	20,839	20,717	0	28,503	25,630

[1] Flood stage at USGS Gaging Station 05054000, Fargo, ND

[2] Upstream LPP Diversion Location for Scenario #6 is at the Hickson Gage

[3] Inundation Areas Upstream of Project correspond to Scenario Inundation Maps

Table 16: Alternative Scenarios- 0.2-Percent Chance Flood Impact Summary

Alternative Scenario Analysis Summary - 0.2% Chance Event (Scenario vs. Phase 4 LPP)

		Existing (No Protection)	Phase 4 LPP ND Diversion	Scenario #1	Scenario #2	Scenario #3	Scenario #4	Scenario #5	Scenario #6
Location	**Station**	Elevation (ft)	**Elevation (ft)**	**Elevation (ft)**	**Elevation (ft)**	**Elevation (ft)**	**Elevation (ft)**	**Elevation (ft)**	**Elevation (ft)**
Grand Forks Gage	1558518	836.36	**0.22**	-0.02	0.17	-0.02	0.57	0.03	0.01
Thompson Gage	1667877	850.69	**-0.05**	-0.02	0.25	0.00	0.62	0.02	-0.01
Hendrum	2038409	875.77	**-0.30**	-0.02	0.25	-0.03	0.72	0.02	0.00
Fargo Gage (13th Ave S, 12th Ave S)[1]	2388223	43.06	**-3.03**	-0.20	-0.23	-0.08	-0.49	-0.21	0.09
US LPP Diversion[2]	2531315	915.94	**6.50**	-0.52	-0.55	-0.62	-6.44	1.16	
Hickson Gage (Staging Area)	2563754	919.69	**2.85**	-0.50	-0.50	-0.56	-2.88	1.12	2.61
Minimum Impact			**0.04**	0.00	0.02	0.00	0.09	0.00	0.00
Location (River Station)			**(1410241)**	(1410241)	(1408098)	(1410241)	(1410241)	(1408098)	(1410241)
Maximum Impact			**0.27**	-0.03	0.20	-0.04	0.80	0.03	0.03
Location (River Station)			**(1561353)**	(1561353)	(1577593)	(1561353)	(1806800)	(1561353)	(1561353)
Inundation Area Upstream of Project[3]									
		Area (Acres)	**Area (Acres)**	**Area (Acres)**	**Area (Acres)**	**Area (Acres)**	**Area (Acres)**	**Area (Acres)**	**Area (Acres)**
Additional 0.2% Inundation Area (above existing)			**12,310**	10,931	10,904	10,846	0	15,550	10,373

[1] Flood stage at USGS Gaging Station 05054000, Fargo, ND

[2] Upstream LPP Diversion Location for Scenario #6 is at the Hickson Gage

[3] Inundation Areas Upstream of Project correspond to Scenario Inundation Maps

3.8 COST COMPARISON

The preliminary feasibility costs for each scenario were estimated by Barr Engineering (Barr) with input from Moore Engineering and HEI. A breakdown of the costs associated with the original Phase 4 LPP design and each alternative scenario are included in Table 17. Barr had completed the cost estimate for the Phase 4 LPP design that was included in the February 28, 2011 report. Unless otherwise noted, these cost estimates utilized the Phase 4 FCP and LPP cost estimates as a basis but were developed to a lower level of detail. The cost estimates include costs related to mitigating hydraulic impacts upstream and downstream of the Phase 3 LPP project, but do not include any considerations for increased or decreased mitigation requirements as a result of the environmental impacts associated with the modifications involved with the alternative scenarios.

Table 17: Alternative Scenarios Analysis- Feasibility Cost Summary

Fargo-Moorhead Metro Flood Risk Management Project
LPP North Dakota Diversion
Additional Alternative Scenario Concepts - Opinion of Cost Summary
Revised 3-22-2011 based on USACE DRAFT TPCS (3-4-2011) with Additional Scenerios

Additional Scenario Costs shown are Project Costs in 2010 US Dollars, including Contingency. Costs do not include temporaral escalation and are not fully funded amounts.

Item	Description	Phase 4 Contract Cost	(1) Phase 4 Contingency	Phase 4 Contingency %	Phase 4 Project Cost	Phase 4 Percent of Total	(2) Scenario 1 Enlarged Storage Area 1 Smart Storage & Reduced Upstream Staging	(2) Scenario 2 Eliminate Storage Area 1 (No Smart Storage) and Reduced Upstream Staging with Some Impacts at Thompson	(2) Scenario 3 Storage Area 1 with Addition of One Large Off-Stream Storage Area Downstream and Reduced Upstream Staging	(2) Scenario 4 Eliminate Storage Area 1 and Eliminate Staging	(2) Scenario 5 Eliminate Storage Area 1 and Increase Upstream Staging	(2) Scenario 6 Storage Area 1 with Modified Diversion Alignment to a Location South of Hickson, Oxbow and Bakke
1	**LANDS & DAMAGES** (3)											
	ROW and Easements - Diversion Channel (and Storage Area 1)	44,554,000	11,138,500	25%	65,705,000	3.3%	77,646,800	43,560,100	86,246,600	Phase 3 LPP	43,560,100	67,892,900
	ROW and Easements - Upstream Staging Area	156,823,351	39,205,900	25%	239,766,900	11.5%	239,766,900	239,766,900	239,766,900	Phase 3 LPP	320,898,400	227,592,900
2	**RELOCATIONS**											
	Utility Relocations	15,862,000	3,966,100	25%	19,828,100	1.2%	19,828,100	19,828,100	19,828,100	Phase 3 LPP	19,828,100	20,374,300
	Roadway Bridges, Road Raises & Local Road Construction	103,611,800	25,903,000	25%	129,514,800	7.6%	129,514,800	129,514,800	129,514,800	Phase 3 LPP	151,405,000	115,785,000
6	**FISH & WILDLIFE FACILITIES**											
	Environmental Mitigation Features	73,135,700	18,284,000	25%	91,419,700	5.4%	91,419,700	91,419,700	91,419,700	Phase 3 LPP	91,419,700	91,419,700
8	**ROADS, RAILROADS & BRIDGES**											
	Railroad Bridges	46,497,500	11,624,400	25%	58,121,900	3.4%	58,121,900	58,121,900	58,121,900	Phase 3 LPP	58,121,900	58,121,900
9	**CHANNELS AND CANALS**											
	Diversion Channel	320,911,600	80,229,800	25% (35% Alt. 6)	401,141,400	23.5%	401,141,400	401,141,400	401,141,400	Phase 3 LPP	401,141,400	414,720,000
	Diversion Channel Landscape Plantings	1,098,000	274,500	25%	1,372,500	0.1%	1,372,500	1,372,500	1,372,500	Phase 3 LPP	1,372,500	1,372,500
	Control Structure on Red River	47,355,300	11,838,900	25%	59,194,200	3.5%	59,194,200	59,194,200	59,194,200	Phase 3 LPP	61,842,000	63,608,000
	Hydraulic Structure at Wolverton Creek	4,290,500	1,072,700	25%	5,363,200	0.3%	5,363,200	5,363,200	5,363,200	Phase 3 LPP	5,363,200	5,363,200
	Hydraulic Structure at Wild Rice River	29,348,100	7,337,000	25%	36,685,100	2.1%	36,685,100	36,685,100	36,685,100	Phase 3 LPP	37,400,000	37,876,000
	Hydraulic Structure - East Weir (at Connecting Channel)	219,666	54,916	25%	274,600	0.0%	274,600	274,600	274,600	Phase 3 LPP	274,600	274,600
	Hydraulic Structure - Inlet Weir to Diversion	9,786,200	2,446,600	25%	12,232,800	0.7%	12,232,800	12,232,800	12,232,800	Phase 3 LPP	12,232,800	12,232,800
	Hydraulic Structures at Sheyenne River	49,677,800	12,419,600	25%	62,097,400	3.6%	62,097,400	62,097,400	62,097,400	Phase 3 LPP	62,097,400	62,097,400
	Hydraulic Structure - Drain 14 - Large Drain Structure	8,236,300	2,059,100	25%	10,295,400	0.6%	10,295,400	10,295,400	10,295,400	Phase 3 LPP	10,295,400	10,295,400
	Hydraulic Structures at Maple River	45,108,900	11,277,300	25%	56,386,200	3.3%	56,386,200	56,386,200	56,386,200	Phase 3 LPP	56,386,200	56,386,200
	Hydraulic Structures at Lower Rush River	17,256,300	4,314,100	25%	21,570,400	1.3%	21,570,400	21,570,400	21,570,400	Phase 3 LPP	21,570,400	21,570,400
	Hydraulic Structures at Rush River	17,215,100	4,303,900	25%	21,519,000	1.3%	21,519,000	21,519,000	21,519,000	Phase 3 LPP	21,519,000	21,519,000
	Small Drain Structures (2)	504,800	126,185	25%	631,000	0.0%	631,000	631,000	631,000	Phase 3 LPP	631,000	631,000
	Large Drain Structure (1)	448,900	112,200	25%	561,100	0.0%	561,100	561,100	561,100	Phase 3 LPP	561,100	561,100
	Side Channel Inlets 1x72" (19)	8,342,900	2,085,700	25%	10,428,600	0.6%	10,428,600	10,428,600	10,428,600	Phase 3 LPP	10,428,600	10,428,600
	Side Channel Inlets 2x72" (7)	5,616,800	1,404,200	25%	7,021,000	0.4%	7,021,000	7,021,000	7,021,000	Phase 3 LPP	7,021,000	7,021,000
	Outlet to Red River	22,007,700	5,502,000	25%	27,509,700	1.6%	27,509,700	27,509,700	27,509,700	Phase 3 LPP	27,509,700	27,509,700
11	**LEVEES AND FLOODWALLS**											
	Tie-Back Levee - TBL East 2B (Constructed in MN)	18,576,700	4,644,300	25% (35% Alt. 5, 6)	23,221,000	1.4%	23,221,000	23,221,000	23,221,000	Phase 3 LPP	28,561,000	19,771,000
	Tie-Back Levee - TBL Cass 17 (Constructed in ND)	6,320,100	1,580,100	25% (35% Alt. 5, 6)	7,900,200	0.5%	7,900,200	7,900,200	7,900,200	Phase 3 LPP	10,500,000	12,800,000
	Levee - Connecting Channel - Reach 2018 (ND-23, 26)	1,683,300	420,900	25% (35% Alt. 5, 6)	2,104,200	0.1%	2,104,200	2,104,200	2,104,200	Phase 3 LPP	2,600,000	19,400,000
	Levee - Connecting Channel - Reach 2019 (ND-25)	6,969,900	1,742,500	25% (35% Alt. 5, 6)	8,712,400	0.5%	8,712,400	8,712,400	8,712,400	Phase 3 LPP	11,100,000	0
	Storage Area 1 Embankment and Inlet	57,964,900	14,491,200	25% (35% Alt. 1, 6)	72,456,100	4.2%	112,670,000	0	72,456,100	Phase 3 LPP	0	92,750,000.00
	Storage Area 1 Closure/Drainage Structure (North)	5,169,800	1,292,600	25%	6,462,400	0.4%	6,462,400	0	6,462,400	Phase 3 LPP	0	6,462,400
	Storage Area 1 Closure/Drainage Structure (East)	5,169,800	1,292,600	25%	6,462,400	0.4%	6,462,400	0	6,462,400	Phase 3 LPP	0	6,462,400
	Storage Area 1 Road Raise for Levees	1,987,500	496,900	25%	2,484,400	0.1%	3,557,000	0	2,484,400	Phase 3 LPP	0	2,517,000
	New Items Shown Below in Italic:											
	Levee - Connecting Channel Reach 2017 and 2018 (where Storage Area 1 Embankment is not created)			35%			0	20,580,000	0	0	24,453,836	0
	Downstream Storage Area			35%			0	0	44,010,000	0	0	0
	Downstream Storage AreaRoad Raise			25%			0	0	3,541,000	0	0	0
14	**RECREATION FACILITIES**											
	Recreation Facilities	23,219,700	5,805,200	25%	29,024,900	1.7%	29,024,900	29,024,900	29,024,900	Phase 3 LPP	29,024,900	29,824,500
30	**PLANNING, ENGINEERING & DESIGN (PED)**											
	PED	143,446,000	35,861,500	25%	179,307,500	10.5%	184,992,000	168,707,000	185,932,000	Phase 3 LPP	174,699,000	184,373,000
31	**CONSTRUCTION MANAGEMENT (CM)**											
	CM	66,942,000	16,735,500	25%	83,677,500	4.9%	86,330,000	78,730,000	86,768,000	Phase 3 LPP	81,526,000	86,041,000
	Total	**$1,365,358,917**	**$341,343,901**		**$1,760,453,000**	**100.0%**	**$ 1,822,018,300**	**$ 1,655,474,800**	**$ 1,838,260,600**	**$ 1,505,470,000**	**$ 1,785,344,236**	**$ 1,795,054,900**
	Change from Phase 4						$61,565,300	-$104,978,200	$77,807,600	-$254,983,000	$24,891,236	$34,601,900

(1) Allowance for costs that will be in the Project Cost and are not included in Contract Cost. Does not account for changed conditions either in final design or during construction.
(2) All costs shown are for the purposes of conceptual alternatives comparison only. A detailed cost estimate for each alternative would be required to reduce uncertainty with the estimates shown.
(3) Lands and Damages costs are based on the information included in the document "Preliminary Real Estate Summary, Fargo-Moorhead Metropolitan Feasibility Study, Phase 4" provided by Brett Coleman (USACE - St. Paul District) via e-mail on March 12, 2011 and supplemental information provided by Rodney Peterson (USACE - St. Paul District) via e-mail on March 16, 2011. Using the methodologies outlined in these documents, the Lands and Damages costs for the various scenarios were updated for this study.

Revision to Phase 4 LPP Item Estimated by;
- **Houston Engineering, Inc.**
- **Moore Engineering, Inc.**
- **Structure Estimates by MEI and Easement Estimates by HEI**
- **Barr Engineering Co. (In lieu of revised costs per USACE, Alternative 6 Revisions to 02 Relocations: Utility Relocations, 06 Fish and Wildlife Facilities and 14 Recreation Facilities made on diversion mileage ratio basis)**
- **PED assumed as 15% on construction costs (NOT including 01 Lands & Damages), CM assumed as 7% on construction costs (NOT including 01 Lands & Damages)**
- **Item Assumed To be Unchanged from Phase 4 (No Revision Provided by USACE)**