Alternatives Screening Document
Fargo-Moorhead Metropolitan Area Flood Risk Management

US Army Corps of Engineers®

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December 2009

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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.

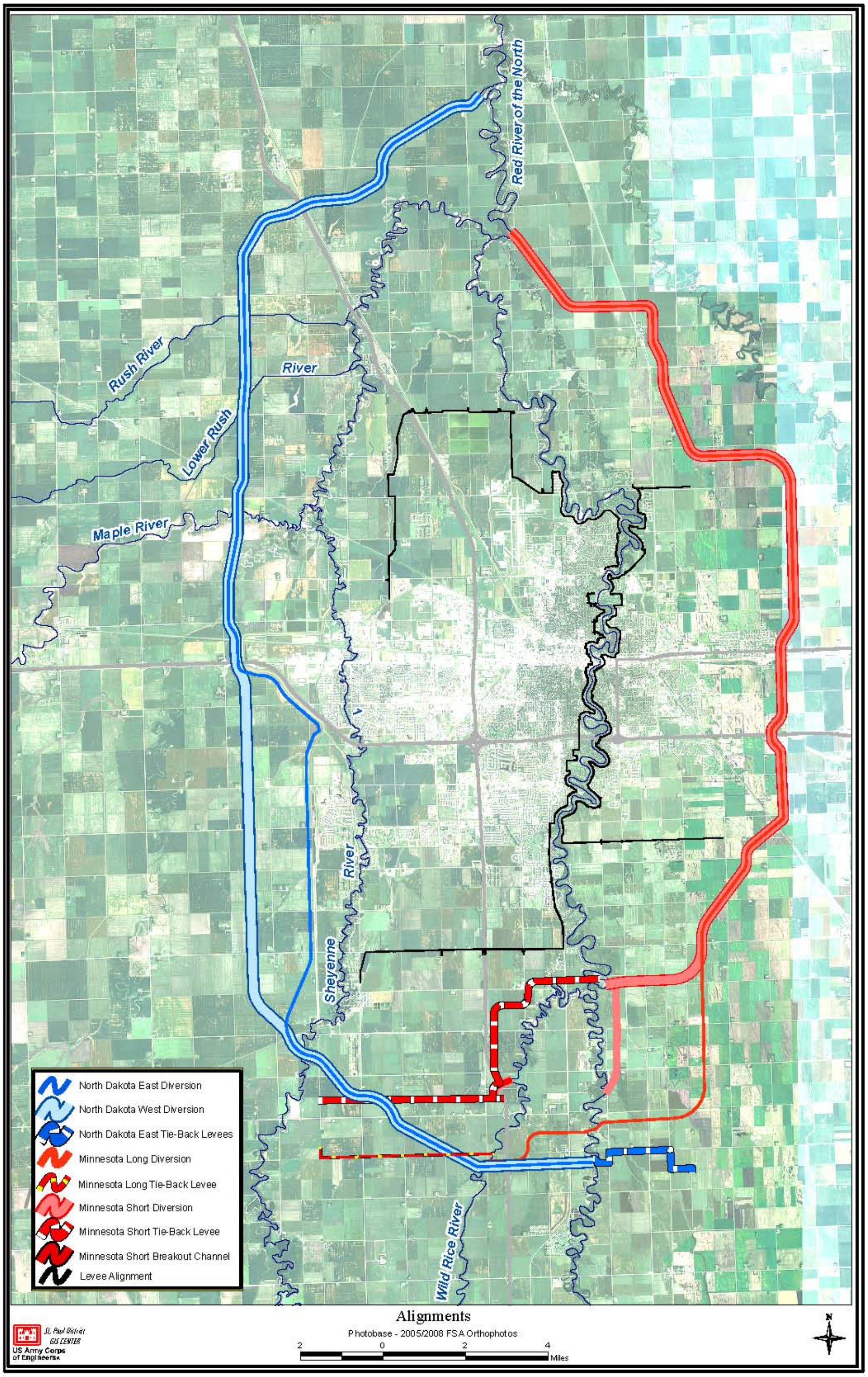
Cost: The first cost of the project, costs of local operations and maintenance, and long-term residual costs.

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.