# Appendix D
# Other Social Effects
## Fargo-Moorhead Metropolitan Area Flood Risk Management

Final Feasibility Report and
Environmental Impact Statement

July 2011

US Army Corps of Engineers ®

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# Appendix D

# Other Social Effects

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# 1.0 Introduction

The Fargo-Moorhead metropolitan area has a relatively high risk of flooding. The highest river stages have usually occurred as a result of spring snowmelt, but summer rainfall events have also led to significant flood damages. The residents of Fargo-Moorhead have been successful at preventing significant damages during past flood events by constructing emergency levees along large portions of the Red River. Constructing the emergency levees takes significant financial and human resources, causes business and traffic disruptions, and is taxing to the social fabric of the communities. Although the emergency levees have been successful in the past, they are at high risk of catastrophic failure, which would result in significant damage in the area.

Because of the high risk, flood risk management alternatives are being evaluated for the area. These alternatives are being studied through the Fargo-Moorhead Flood Risk Management Feasibility Study being conducted by the U.S. Army Corps of Engineers (USACE), St. Paul District.

## 1.1 Purpose

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

## 1.2 Study Area

The study area extends along the Red River, between Abercrombie, ND, and the Canadian border (Figure D-1). It includes portions of 12 counties in North Dakota and Minnesota and the Fargo-Moorhead Metropolitan Statistical Area (MSA). The MSA covers portions of Cass County, ND, and Clay County, MN. During the early phases of this study, the Fargo-Moorhead metro area was considered the extent of the study area; therefore, the initial screening of alternatives only considered impacts to the residents of the Fargo-Moorhead metro area (Section 3 of this appendix). The study area was expanded during later phases of the study to include the areas upstream and downstream of the metro area (Section 4 of this appendix).

## 1.3 Overview of Other Social Effects

The USACE views “social well-being factors as constituents of life that influence personal and group definitions of satisfaction, well-being, and happiness. The distribution of resources; the character and richness of personal and community associations; the social vulnerability and resilience of individuals, groups, and communities; and the ability to participate in systems of governance are all elements that help define well-being and influence to what degree water resources solutions will be judged as complete, effective, acceptable, and fair.” (USACE, 2009) It is the OSE account that considers these elements and assures that they are properly weighted, balanced, and considered during the planning process under the USACE’s Four Accounts Planning Framework.

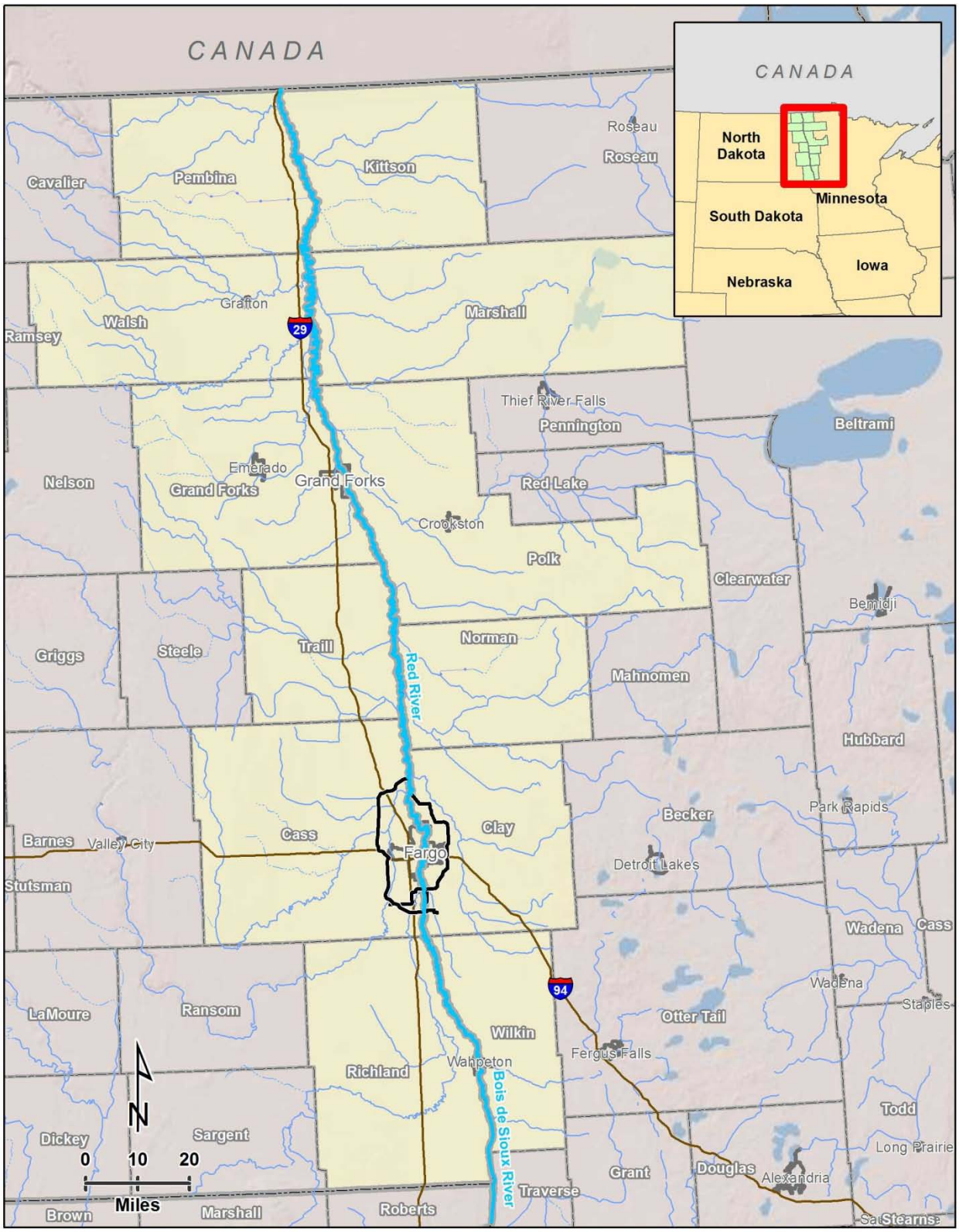



**Figure D-1: Study Area**

This appendix follows the guidance set forth by the USACE Institute for Water Resources (IWR) in the *Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning* (USACE, 2009). The handbook describes the procedures for analyzing and using OSE criteria in the planning process by identifying seven social factors that describe the social fabric of a community. The social factors are based on conventional psychological Human Needs Theory and Abraham Maslow's Hierarchy of Needs. Table D-1 lists and describes the social factors.

**Table D-1: Social Factors**

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

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

## 1.4 Organization of Appendix

The OSE appendix is organized as follows:

- Section 1 provides an introduction to OSE
- Section 2, Community Characteristics and Other Social Effects Factors, provides background information on the socioeconomic and a baseline profile of the social factors of the study area. This describes the existing and future without project conditions for the study area.
- Section 3, Initial Screening of Alternatives, provides an initial evaluation and screening of the flood risk management alternatives considered
- Section 4, Evaluation of Alternatives, provides a detailed OSE analysis of the alternatives carried forward in the study
- Section 5, References, lists the references cited in this appendix.

# 2.0 Community Characteristics and Other Social Effects Factors

This section describes the existing and future without project conditions, including socioeconomic characteristics and a baseline profile of the communities and residents of the study area. Without project conditions serve as the basis for evaluating alternatives.

## 2.1 Socioeconomic Characteristics of the Study Area

This section presents an overview of the major socioeconomic characteristics and trends, including demographics and economics, of the study area. The data were developed from various data sources including the latest 2010 U.S. Census. In certain instances where 2010 Census Data was not available, data from the 2000 U.S. Census was utilized. Other data sources that were analyzed include the Population and Housing Narrative Profile of the American Community Survey (ACS) for the years 2006, 2007, 2008, and 2009 U.S. Census Bureau estimates.

### 2.1.1 Population Size and Composition

According to the 2009 ACS, the population of the Fargo-Moorhead metropolitan area is estimated to be 194,839 persons. Based on the 2010 census, the total population in the 12-county study area is estimated to be 377,631 persons (U.S. Census Bureau, 2010 Census). As reported by the 2009 ACS estimates, the gender ratio within the metro area is nearly 1:1 (50 percent male and 50 percent female) and the median age is 30.2 years. Nationally, the population is 51 percent female and the median age is 36.7 years. Persons under 18 years old represent 23 percent of the population, which is lower than the national percentage of 25 percent. The percentage of residents over the age of 65 years (10.2 percent) is also lower in the metro area than the national percentage of 13 percent (U.S. Census Bureau, 2009 ACS). The communities downstream of the metro area have lower percentages of persons under 5 years old, but higher concentrations of persons over 65 years old. It can generally be said of the downstream communities that, on average, they have a slightly higher percentage of older persons than is found in the metro area.

With the exception of Clay County, MN and Polk County, MN, and Grand Forks and Cass Counties, ND, all the other counties in the study area experienced a decline in population between 2000 and 2010. The decreases ranged from 4.4 percent to as much as 16.1 percent. Over the past 50 years, the communities downstream of the Fargo-Moorhead metro area have seen population losses of between 10 and 35 percent. The population of nearly every city and township between Fargo-Moorhead and Thompson, ND has decreased, with the exception of Oakport and Kragnes Townships, which are located immediately downstream of the metro area (U.S Census Bureau, 2000).

### 2.1.2 Household Structure

The ACS estimates from 2009 indicate that the average size of the 84,330 households in the metro area is 2.3 persons, compared to an average size of 2.6 persons nationally. In 2000, there were nearly 70,000 households in the metro area and a total 128,262 households in the 12-county study area (U.S. Census Bureau, 2000 Census). In the metro area, more than half (58 percent) of these households consisted of families (46 percent married couples and 12 percent other). The majority of nonfamily households consisted of persons living alone, which represented 32 percent of all households. The percentage of married-couple families closely mirrored ACS estimates for the United States as a whole (50 percent); the percentage of households of persons

living alone was higher than the estimate for the United States (27 percent); and the percentage of other nonfamily households in the United States was correspondingly lower (6 percent nationally).

### 2.1.3 Race and Ethnic Diversity

While ethnic diversity in the metro area stands markedly lower than that in the United States as a whole, there seems to be an upward trend in the ratio of non-White residents to White residents. Between 2000 and 2010, nearly all the counties in the study area reported an increase in their share of minority persons. While an estimated 13 percent of U.S. residents were foreign-born in 2006 through 2008, only 4 percent of persons living in the metro area during that period were foreign-born (U.S. Census Bureau, 2009 ACS) . Between 2000 and 2005, immigrants accounted for 54 percent of the Fargo-Moorhead metro area's growth. The universities in the Fargo-Moorhead metro area also attract a foreign student population, adding to its diversity.

Tables D-2 and D-3 show the racial and ethnic characteristics of the North Dakota and Minnesota counties, from upstream to downstream based on the latest 2010 Census.

**Table D-2: Population Characteristics of Study Areas–North Dakota**

| Race | North Dakota | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Richland County | | Cass County | | Traill County | | Grand Forks County | | Walsh County | | Pembina County | |
| | Number | % | Number | % | Number | % | Number | % | Number | % | Number | % |
| **White** | 15,507 | 95.0% | 137,308 | 91.7% | 7,809 | 96.2% | 60,358 | 90.3% | 10,391 | 93.5% | 7,077 | 95.5% |
| Non-Hispanic White | 15,351 | 94.1% | 135,530 | 90.5% | 7,693 | 94.7% | 59,271 | 88.6% | 9,834 | 88.4% | 6,947 | 93.7% |
| Hispanic White | 156 | 1.0% | 1,778 | 1.2% | 116 | 1.4% | 1,087 | 1.6% | 557 | 5.0% | 130 | 1.8% |
| **Non-White** | 814 | 5.0% | 12,470 | 8.3% | 312 | 3.8% | 6,503 | 9.7% | 728 | 6.5% | 336 | 4.5% |
| Black or African American alone | 110 | 0.7% | 3,428 | 2.3% | 42 | 0.5% | 1,361 | 2.0% | 25 | 0.2% | 21 | 0.3% |
| American Indian and Alaska Native alone | 330 | 2.0% | 1,827 | 1.2% | 64 | 0.8% | 1,657 | 2.5% | 168 | 1.5% | 144 | 1.9% |
| Asian alone | 88 | 0.5% | 3,532 | 2.4% | 21 | 0.3% | 1,292 | 1.9% | 36 | 0.3% | 11 | 0.1% |
| Native Hawaiian and Other Pacific Islander alone | 9 | 0.1% | 52 | 0.0% | 1 | 0.0% | 40 | 0.1% | 4 | 0.0% | 2 | 0.0% |
| Some other race alone | 67 | 0.4% | 798 | 0.5% | 89 | 1.1% | 553 | 0.8% | 345 | 3.1% | 58 | 0.8% |
| Two or more races | 210 | 1.3% | 2,833 | 1.9% | 95 | 1.2% | 1,600 | 2.4% | 150 | 1.3% | 100 | 1.3% |
| **Total** | 16,321 | 100.0% | 149,778 | 100.0% | 8,121 | 100.0% | 66,861 | 100.0% | 11,119 | 100.0% | 7,413 | 100.0% |
| **Minority Population** | 970 | 5.9% | 14,248 | 9.5% | 428 | 5.3% | 7,590 | 11.4% | 1,285 | 11.6% | 466 | 6.3% |

*Source: U.S. Department of Commerce, U.S. Census Bureau, 2010. SF1 and SF3 Tables.*

**Table D-3: Population Characteristics of Study Areas–Minnesota**

| Race | Minnesota | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wilkin County | | Clay County | | Norman County | | Polk County | | Marshall County | | Kittson County | |
| | Number | % | Number | % | Number | % | Number | % | Number | % | Number | % |
| **White** | 6,381 | 97.0% | 54,684 | 92.7% | 6,455 | 94.2% | 29,495 | 93.3% | 9,119 | 96.6% | 4,484 | 98.5% |
| Non-Hispanic White | 6,294 | 95.7% | 53,434 | 90.6% | 6,293 | 91.8% | 28,497 | 90.2% | 8,952 | 94.8% | 4,434 | 97.4% |
| Hispanic White | 87 | 1.3% | 1,250 | 2.1% | 162 | 2.4% | 998 | 3.2% | 167 | 1.8% | 50 | 1.1% |
| **Non-White** | 195 | 3.0% | 4,315 | 7.3% | 397 | 5.8% | 2,105 | 6.7% | 320 | 3.4% | 68 | 1.5% |
| Black or African American alone | 15 | 0.2% | 842 | 1.4% | 13 | 0.2% | 270 | 0.9% | 26 | 0.3% | 11 | 0.2% |
| American Indian and Alaska Native alone | 64 | 1.0% | 803 | 1.4% | 109 | 1.6% | 453 | 1.4% | 43 | 0.5% | 4 | 0.1% |
| Asian alone | 18 | 0.3% | 846 | 1.4% | 25 | 0.4% | 218 | 0.7% | 19 | 0.2% | 16 | 0.4% |
| Native Hawaiian and Other Pacific Islander alone | 0 | 0.0% | 21 | 0.0% | 0 | 0.0% | 2 | 0.0% | 3 | 0.0% | 0 | 0.0% |
| Some other race alone | 27 | 0.4% | 528 | 0.9% | 92 | 1.3% | 497 | 1.6% | 148 | 1.6% | 12 | 0.3% |
| Two or more races | 71 | 1.1% | 1,275 | 2.2% | 158 | 2.3% | 665 | 2.1% | 81 | 0.9% | 25 | 0.5% |
| **Total** | 6,576 | 100.0% | 58,999 | 100.0% | 6,852 | 100.0% | 31,600 | 100.0% | 9,439 | 100.0% | 4,552 | 100.0% |
| **Minority Population** | 282 | 4.3% | 5,565 | 9.4% | 559 | 8.2% | 3,103 | 9.8% | 487 | 5.2% | 118 | 2.6% |

*Source: U.S. Department of Commerce, U.S. Census Bureau, 2010. SF1 and SF3 Tables.*

Based on 2010 U.S. Census data, downstream communities in both North Dakota and Minnesota had smaller minority populations than Cass County, ND and Clay County, MN with the exceptions being Grand Forks County, ND and Polk County, MN (U.S. Census Bureau, 2010 Census). As reported by the 2010 U.S. Census, the Hispanic/Latino population downstream of Fargo represents 2.4 percent of the entire population. Within Moorhead, Hispanic persons account for 4.5 percent of the total population. As reported by the 2000 U.S. Census, comparing the populations that "speak English less than 'very well'" finds larger non-English proficient

populations in Fargo and Moorhead than in their respective downstream communities (U.S. Census Bureau, 2000). In North Dakota, the non-English proficient population downstream is 4.5 percent smaller, on average, than in Fargo. In Minnesota, the difference between the downstream communities and Moorhead is 6.4 percent (U.S. Census Bureau, 2000).

The percentage of residents who speak a language other than English at home was markedly lower in the Fargo-Moorhead metro area than in the United States as a whole (20 percent of persons more than 5 years old nationally vs. 6 percent in the metro area). Approximately one-third of these persons speak Spanish (U.S. Census Bureau, 2009 ACS).

### 2.1.4 Education

According to the 2000 census, 39 percent of the population in the Fargo-Moorhead metro area had an associate degree or higher (compared to 27 percent nationally). In 2009, the percentage of residents in the metro area with an associate degree or higher increased to 45 percent of the population (U.S. Census Bureau, 2009 ACS). During the same time period, persons with a high school diploma accounted for nearly 26 percent of the population in the metro area compared to 29 percent nationally.

As more recent data on the educational attainment of the population is not available for the all 12 study area counties, data from the 2000 U.S. Census was utilized to better understand the levels of educational attainment. All the downstream study area counties in ND had higher percentage of persons with a high school diploma compared to levels exhibited in Fargo. Similarly, the downstream counties in Minnesota had persons with higher levels of persons with a high school diploma than was found in Moorhead. However, persons with College and Bachelor's degrees were higher in Fargo and Moorhead compared to the downstream counties in their respective states. Tables D-4 and D-5 show the levels of educational attainment in the study area counties in North Dakota and Minnesota.

**Table D-4: Educational Attainment in Study Areas–North Dakota**

| Geographic Area | High School Graduates (age 25+) | College Graduates (age 25+) |
|---|---|---|
| **North Dakota** | 27.9% | 24.5% |
| **Cass County** | 22.9% | 26.9% |
| **Pembina County** | 31.9% | 24.0% |
| **Walsh County** | 32.1% | 24.2% |
| **Grand Forks County** | 24.4% | 27.7% |
| **Traill County** | 25.9% | 27.4% |
| **Richland County** | 27.4% | 25.0% |

*Source: U.S. Department of Commerce, U.S. Census Bureau, 2000.*

**Table D-5: Educational Attainment in Study Areas–Minnesota**

| Geographic Area | High School Graduates (age 25+) | College Graduates (age 25+) |
|---|---|---|
| **Minnesota** | 28.8% | 24.0% |
| **Clay County** | 28.2% | 25.4% |
| **Kittson County** | 34.5% | 22.9% |
| **Marshall County** | 37.0% | 21.5% |
| **Polk County** | 31.7% | 23.9% |
| **Norman County** | 34.9% | 24.9% |
| **Wilkin County** | 32.5% | 23.5% |

*Source: U.S. Department of Commerce, U.S. Census Bureau, 2000.*

### 2.1.5 Housing

In 2009 (U.S. Census Bureau, 2009 ACS) there were 87,115 occupied housing units in the metro area, compared to 73,356 in 2000 (U.S. Census Bureau, 2000 Census). Nearly six percent of the housing units stood vacant (much lower than the national average of 12 percent), 58 percent were single-unit structures, 39 percent were multi-unit structures, and 3 percent were mobile homes. The median value of owner-occupied housing units was $142, 800. Table D-6 shows the housing data for the study area (U.S. Census Bureau, 2009 ACS).

**Table D-6: Housing Data in the Study Area**

| Geographic Area | Housing Units | Percent of Occupied Housing Units |
|---|---|---|
| **North Dakota** | 309,043 | 88.3% |
| **Cass County** | 64,139 | 95.2% |
| **Pembina County** | 4,067 | 83.3% |
| **Walsh County** | 5,739 | 85.1% |
| **Grand Forks County** | 29,304 | 91.5% |
| **Traill County** | 3,760 | 89.5% |
| **Richland County** | 7,695 | 86.8% |
| **Minnesota** | 2,301,307 | 89.6% |
| **Clay County** | 22,976 | 92.7% |
| **Kittson County** | 2,738 | 75.5% |
| **Marshall County** | 4,885 | 85.4% |
| **Polk County** | 14,677 | 85.2% |
| **Norman County** | 3,499 | 84.0% |
| **Wilkin County** | 3,106 | 87.0% |

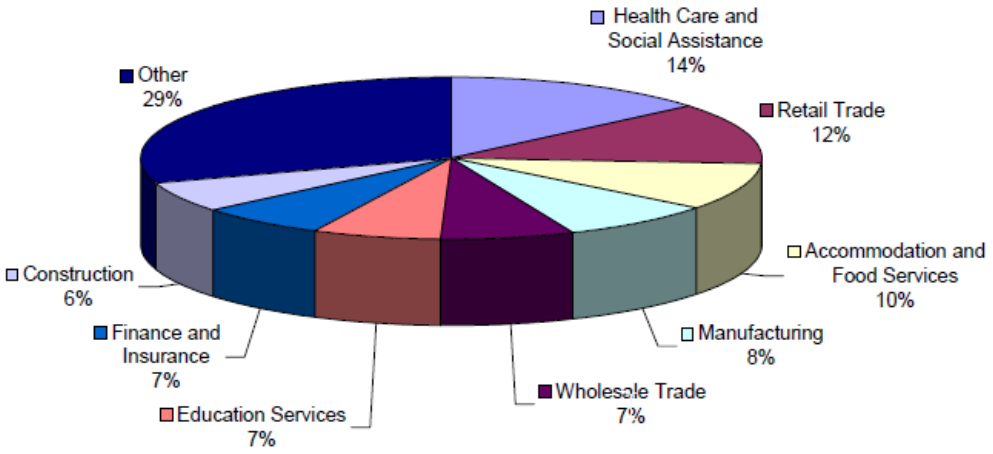
*Source: U.S. Department of Commerce, U.S. Census Bureau, 2005-2009 American Community Survey 5-Year Estimates.*

Based on 2009 estimates (U.S. Census Bureau, 2009 ACS), the median monthly housing cost for mortgaged owners was lower than the comparable national statistic ($1,316 in the metro area and

$1,486 nationally). For non-mortgaged owners the cost was $446, which is comparable to the national statistic of $419 and for renters the cost was $597, which is markedly lower than the $817 national statistic. Nearly 14 percent of non-mortgaged owners spent 30 percent of their household income on housing, compared to 16 percent nationally; 46 percent of renters (50 percent nationally) fell into this category. More than three-quarters (77.7 percent) of residents lived in the same house they had lived in 1 year before.

### 2.1.6 Industrial and Occupational Structure

Historically, the economy in the metro area has been dependent on agriculture, however, that has changed substantially in recent decades, shifting to retail trade, healthcare, higher education, and manufacturing. The top 10 employers in the Fargo-Moorhead metro area are Sanford Health System, North Dakota State University, Microsoft, US Bank Service Center, and Innovis Health. Figure D-2 shows the percentage of employees by industry.




*Source: Greater Fargo Moorhead Economic Development Corporation (January 2010)*

**Figure D-2: Employees by Major Industry in the Fargo-Moorhead Metro Area (2nd Quarter 2009)**

The Fargo-Moorhead metro area has one of the lowest unemployment rates in the Nation. In October 2009, the unemployment rate in the metro area was 3.7, and the national unemployment average during March 2009 was 8.6 percent (U.S. Bureau of Labor and Statistics, 2009). As recently as December 2010, the State unemployment average in North Dakota was 3.8 percent and in Minnesota it was 6.9 percent, compared to the national average of 9.4 percent (U.S. Bureau of Labor and Statistics, 2010).

### 2.1.7 Journey to work

For commutes to work in Fargo-Moorhead metropolitan area, the proportion of workers who drove alone was somewhat higher than in the United States as a whole (82 percent versus 76 percent nationally), and the proportion who carpooled (9 percent) or used public transportation (1

percent) were somewhat lower. Notably, an estimated 7.1 percent of occupied households had no vehicle available (ACS pooled data from 2006–2008).

The mean travel time to work in all 12 counties in the study area was less than 25 minutes and, with the exception of Marshall and Norman Counties, MN, commute times were less than 20 minutes (U.S. Census Bureau, 2000).

## 2.2 Baseline Profile of Communities

This section presents a baseline profile of the communities in the study area. This profile follows the seven social factors described in Section 1.3. It reflects how residents of the study area perceive themselves and their communities, describes the quality of life in the area, and identifies the challenges residents face from flooding. The baseline profile provides a context from which to assess the impacts of the proposed alternatives. These are considered the existing and future without project conditions social characteristics.

Data and information for the baseline profile were collected from multiple sources, including local nonprofit organizations, interviews with local representatives (conducted in December 2009 and January 2010), observations of the study area, and research conducted by sociologists following major flood events in other areas. The information on the impacts of repeated flood threats and successful "flood fights" (steps a community takes before an event to reduce flood damage to their homes and businesses) draws significantly from the 2009 flood event.

### 2.2.1 Health and Safety

#### 2.2.1.1 Loss-of-Life

Flooding in the study area poses a loss of life hazard to residents, flood fight workers, and volunteers in the form of levee failure, drowning and hypothermia. A loss-of-life analysis for the without project condition is presented in Attachment 1.

#### 2.2.1.2 Stress

An issue of great concern to the study area's residents is the threat of catastrophic flooding. The frequency and magnitude of the flooding and continual flood risk takes a toll on both the mental and physical health of the residents. Residents have reported a high stress level caused by the flood threat, including loss of sleep and mental anguish. Although the residents of the metro area have not lost a flood fight, the threat of doing so always exists.

Residents face two forms of stress related to the ongoing flood threat: 1) the chronic stress caused by the continuing threat of flooding and annual flood fights, and 2) the stress that would be created if they ever lost a flood fight. Research on the effects of stress (generally defined as an environmental change followed by an attempt by the individuals experiencing the stress to adapt) on health has established the detrimental effects of stress—particularly chronic stress—on physical and mental health. The well-documented health effects of stress include physical illness, mental illness, and substance abuse (Dodge and Martin, 1970; House, Umberson, and Landis, 1986; Langer and Michael, 1963; Pearlin, 1989; Thoits, 1995). This research also clearly shows that these health effects do not occur uniformly in populations; certain groups (e.g., minorities, low-income populations) experience much more severe effects than persons with higher incomes or non-minority groups.

The effects of this stress on the community were evident during in-depth interviews with individuals involved in coordinating volunteers and aiding Fargo's residents during flood events and flood fights. It was clear not only that this stress exists, but that it can also be very difficult to detect because the culture of the community involves exhibiting high levels of resilience. This was clearly reflected in comments from the Fargo Emergency Manager, Leon Schlafman. When asked whether the community hopes not to have to fight the flood again, he initially responded, "We did it, we can do it again." Although this response was very stoic, Schlafman admitted that a high level of fear exists in the community.

Professor Robert Littlefield of North Dakota State University echoed the theme of resilience in his description of the spring 2009 event. "When everyone said, 'We need help' [to fight the flood], everyone came. No one left when they said, 'Go home and rest.'" Littlefield noted a strong ethos of "one individual can make a difference" in both the community culture and the flood fight. He also noted, though, that the flood fight and the continued threat of flooding have taken a toll on the community; although residents are very willing to fight—with what he characterized as a "we built it, we'll keep it" mentality—residents are tired, stating unequivocally that "we need a permanent solution [to the flooding]."

Ruth Bachmeier of Fargo Cass Public Health stated that there were high levels of stress from the flood event. She pointed out that if no permanent solution to the ongoing flooding is found, "we'll continue to have more stressors on stressed people."

Time and again, residents' stoicism, unwillingness to complain, and unease with asking for or receiving help were witnessed. One relief official summed it up by saying, "We put a pretty good face on." Fargo Cass Public Health's Bachmeier provided a similar account, stating simply, "We don't talk about mental health much here, it's taboo." One disaster coordinator stated that she and friends in the mental health field have wondered aloud, "When does that smoldering fire flame up?"

As one disaster relief coordinator said, “We have disaster fatigue. We’ve been through this so many times, it’s almost second nature. But we’re already seeing stressors [December 2009] from a wet fall—people saying, ‘Oh, my God, are we doing to do this again? We have this cumulative stress. I’ve heard stories—we just cleaned up from [20]05, now we have 6 feet of water.”

The stress on those who help the victims is also apparent. One disaster coordinator stated that, during the flood fight, “The last thing I did every day, when I went to work, was look around my house and hope it was still there when I came back.”

The interview material outlined above gives a good sense of the stress caused by the ongoing threat of flooding and flood fights. Given the stress, many of the individuals interviewed stated that it would be a “huge hardship” or “almost unthinkable” to have to fight a flood again. When the effects of the flood event are coupled with the effects of the ongoing threat of flooding, one can expect them to be both widespread and persistent.

#### 2.2.1.3 Health Care and Emergency Facilities

Access to critical facilities can be limited during floods. In some cases critical facilities need to be evacuated. In addition to interrupting trauma care, the temporary closing of medical facilities would result in the interruption of normal public health operations.

Medical facilities in the Fargo-Moorhead metro area that are at risk due to flooding include the Roger Maris Cancer Center, Multiple Sclerosis MS Center, Parkinson’s Clinic, Eating Disorder Institute, Pediatric Cardiology Clinic, Sanford Heart Center, and Innovis Health Cancer Center (www.gfmedc.com/healthcare), and several other facilities.

Rural communities are separated from their larger urban neighbors. The four nearest cities downstream of the metro area are 16 to 23 miles from an urgent care facility and 23 to 35 miles from a hospital.

The evacuation of special needs or vulnerable populations presents additional risks. In addition to the previously mentioned medical facilities, there are eight nursing homes, multiple assisted-living facilities and group homes, and two large congregate living facilities. Critical care and nursing home patients, particularly dementia patients, may suffer negative effects during evacuation.

During the 2009 event, many of the health care facilities in the metro area evacuated their patients and residents. Hospitals airlifted many of their critical patients to hospitals in Grand Forks, ND, Sioux Falls, SD, and Minneapolis and St. Paul, MN. Other special needs or vulnerable populations were evacuated to facilities outside of the study area.

#### 2.2.1.4 Other Health and Safety Hazards

Other health and safety hazards due to flooding include: large-scale community evacuation, potential contamination of the drinking water supply, and spoilage of food through loss of refrigeration or floodwater contamination. Flooding of buildings introduces multiple contaminants into the water including sewage, fuel oil, pesticides, and solvents. The cleanup of flooded structures exposes individuals to potential adverse health effects from exposure to contaminants, bacteria, and molds.

### 2.2.2 Economic Vitality

The metro area's business environment has proven to be an economic engine for the region, and it continues to grow. According to the Greater Fargo-Moorhead Economic Development Corporation (GFMEDC), the metro area is ranked:

- No. 5 in *Forbes* ranking of the Top College Towns for Jobs in May 2009.
- No. 7 in *Forbes* ranking of the Best Places for Business and Careers in March 2009. The index ranks cities according to the cost of doing business, educational attainment of the population, income growth, projected job growth, and net migration. This is the sixth consecutive year that Fargo has been among the top 10 for small metropolitan areas.
- No. 1 city in North Dakota for entrepreneurial startups, according to *Business Week.*
- No. 8 in MSN and CareerBuilder.com's October 2008 list of the 25 Best Markets to Find a Job.

With one of the lowest unemployment rates in the Nation, the Fargo-Moorhead metro area has, for the last 5 years, experienced gains in income and employment that exceed the national average. Also, according to Moody's Economy.com, the Fargo-Moorhead economy continues to rank among the highest in vitality for U.S. metropolitan areas (GFMEDC, 2009). Although the median household income is below the national average, residents describe the area as economically prosperous.

The Fargo-Moorhead metro area unemployment rate in October 2009 was 3.5 percent, which increased from 1.6 percent in October 2000 despite seasonal fluctuations (Job Service North Dakota, 2010). The unemployment rate in March 2009 hit a 10-year high at 5.1 percent, coinciding with the flood event. Unemployment increased temporarily because businesses were closed due to the flood fight efforts.

There is a perception in the community that flood risk to some extent hinders growth. Following the 2009 flood event, the GFMEDC distributed a questionnaire to major local business owners, asking how a flood and the continued flood threat would affect them. The results of the survey revealed anxiety among business owners, and indicated that many of the businesses would leave the region in the event of a failed flood fight. In some cases, the loss of business in the metro area would have an impact at a national level, as business owners stated that they would rebuild operations outside of the United States.

Despite the continued flood risk, there is a lack of preparedness among business owners. Many prudent preparedness measures, such as developing a disaster plan, organizing methods to contact employees following an event, and having essential documents stored offsite, are not

typically taken. This lack of preparedness could hinder business recovery efforts in the aftermath of a catastrophic event.

### 2.2.3 Social Connectedness

Residents in the area typically describe the Fargo-Moorhead metro area as a good place to live, citing quality health care, a good location, good schools, low unemployment, and a relatively prosperous economy. There is a strong belief in local leaders and residents rely heavily on the decisions of local leaders during flooding events. A large portion of the community is also involved in religious activities that enable social and cultural bonding.

During the 2009 flood fight, residents of the study area came together to protect their communities. In Fargo there were approximately 100,000 volunteers fighting the flood, and in Moorhead there were approximately 20,000. Past flooding events, while negatively impacting the region, have also served as a major social event, as people from all walks of life and from all over the area pulled together to save their community. In the process, people got to know their neighbors very well.

Evidence from the interviews indicates that the social networks connecting friends and family in the area are strong. This is not an area that appears to have high levels of social isolation. Social networks appear to be large and extensive, and to contain high proportions of strong ties to close friends and family, as well as weaker ties to neighbors. This creates the *potential* for high levels of social support, for individuals to help each other.

Two key forms of social support exist during disasters: instrumental social support (tangible aid) and emotional support. Instrumental support can come from either strong or weaker ties, but it is more likely to come from strong ties. Research shows that individuals whose social networks contain a higher proportion of strong ties and are more dense (i.e., with a higher proportion of network members who are connected to one another) before a disaster are more likely than people whose networks lack these characteristics to receive instrumental social support from their networks (Hurlbert, Haines, and Beggs, 2000). Put simply, research suggests that, because dense networks with stronger ties are more likely to give support on a routine basis, individuals are more likely to get support during and after a disaster if they're embedded in that type of social network.

Given the anecdotal evidence collected about social networks in the area, it is expected that high levels of instrumental social support would be given and received in the community. The evidence gathered during interviews supports that expectation. Evidence abounds that high levels of instrumental social support were often given, with neighbors, friends, and family helping each other to deal with the flood fight and the effects of the flooding. For example, disaster relief volunteer Charlotte Robbins noted that there are a fair number of "snowbirds" in the metro area—people who travel to warmer parts of the country during the winter. When the 2009 flood event occurred, some of these snowbirds had not yet returned to their houses. Robbins noted that their friends or family members typically cared for their property. Another disaster coordinator stated that very little of his funds go into sheltering, because residents of the area "can always find a place to stay, with family and friends."

All evidence gathered suggests that, despite the strong social networks and the high levels of instrumental social support in the area, emotional support may well be lacking. As one disaster

coordinator stated, “One of our biggest needs is emotional and spiritual care. We have folks who don’t know how to ask for help. It’s a very foreign thing for them.”

### 2.2.4 Identity

The study area was occupied by a number of Native American tribes before the arrival of Europeans and other immigrants. Some of these tribes included the Dakota/Lakota Nation, the Assiniboine, and the Cheyenne. Other occupants included French-Canadian fur trappers, who roamed the region and mixed with the Chippewa Native Americans to form a group called the Metis. The largest ethnic groups in the region today (from largest to smallest) are Norwegian, German, Other (Asian, African American, Arab, Latino), Swedish, Irish, English, and French.

When settlement activities began in earnest around the mid-1800s, railroads played a major role in development. The study area experienced rapid population growth due to the availability of cheap, fertile farmland. There were 74,360 farms in North Dakota in 1910, a number that has been declining since 1950. North Dakota is the most rural State in the Nation, with farms covering 90 percent of the land area.

While the study area’s population is very homogenous compared to the national average, its residents are very welcoming and helpful to new immigrants. A number of civic organizations and volunteers donate time and resources to refugees. Grand Forks and Fargo also host a World Refugee Day as part of the United Nation’s effort to spotlight the plight of the world’s refugees.

In addition to being welcoming to refugees, the residents of the study area have a long history of an attitude of “fight and recover.” In 1893, a fire broke out in Fargo and destroyed 31 city blocks. Despite the devastation, the residents immediately set about to rebuild, making the city better than it had been before. The same “fight and recover” attitude remains today, evidenced by the residents’ willingness to band together and protect their communities from the floods that continue to threaten the area.

Research done by Professor Littlefield supports this impression of the culture of the area and of the community’s determination. In an analysis of newspaper data from the period in which the 2009 flood fight occurred, he identified three dominant images in the photographs: 1) men—although women were strongly represented among individuals fighting the flood, pictorial representations in the media tended to focus much more on men; 2) machines, with representations of the machinery used to fight the flood and to “dominate nature” (as Littlefield summarized it, this was very much a “we will win” theme); and 3) military, with representations of National Guard personnel—uniformed individuals standing ready to protect and preserve the area from the flood threat.


Another relief coordinator noted the ethnic heritage, describing it as a "Norwegian, German culture of 'we pull ourselves up by our bootstraps.' We're a very determined people—quitting is not in our makeup. Everything they have could be on the street, for the trash, and folks here would say, 'I'm OK, help the guy down the street.'"

### 2.2.5 Social Vulnerability and Resiliency

The metro area has a relatively high risk of flooding. A 500-year flood event would flood almost the entire city of Fargo and a large portion of Moorhead. While residents have never lost a flood fight, there is a pronounced threat of a catastrophic flood event that the community is not prepared to handle.

Despite the fact that flood threats persist and that each year could bring another flood event, there seems to be little recognition among the residents that a flood fight could be lost, resulting in catastrophic flooding. When asked whether a culture of preparedness exists in the area, Fargo Emergency Manager Leon Schlafman responded primarily in terms of the residents' willingness to fight and recover. It appears that they are very prepared to fight floods but not to lose flood fights or to deal with the effects of a catastrophic event. As Sarah Lepp of First Link stated bluntly, "There's a strong belief that it won't happen here."

Many prudent preparedness measures appear to remain "off the radar" for a number of residents. So, although a willingness and readiness to fight floods exists, there also seems to be a very different culture of preparedness than that seen in other high-risk areas, such as those that are prone to hurricanes.

Fortunately, the residents' demonstrated strong desire to fight floods and protect their community could also be a benefit in the recovery efforts if a catastrophic flood event occurred. The "we pull ourselves up by our bootstraps" attitude mentioned earlier demonstrates the potential resiliency of the community to a catastrophic event.

It is important to recognize that certain components of the population are more vulnerable than others. For example, any housing lost in rural communities would be difficult to replace on a temporary basis. If appropriate accommodations could not be found with family or friends, rural residents would be forced to seek them in Fargo, Moorhead, or Grand Forks, which would place them some distance away from their property, jobs, and social networks. Research has also established that vulnerable populations (e.g., minorities, low-income) tend to bear the effects of an event more strongly. During the 2009 flood event, low-wage workers suffered greater economic hardship and were more affected by business closures and transportation difficulties.

### 2.2.6 Participation

Residents in the study area exhibit a high rate of participation in civic activities. For example, in Fargo the average voter turnout for presidential election years is above the national average (in 2008, 67.8 percent in Fargo vs. 56.8 percent nationally). In the 2010 election, voters turned out in record numbers.

There are a number of media outlets in the study area, including local radio stations, newspapers, and television stations. Local governments also hold public forums for civic issues.

As part of the Fargo-Moorhead Metro Feasibility Study, the study team has held a number of public meetings. Turnout has been high, both in the metro and rural areas, and citizens continue to voice their concerns, opinions and questions related to flood risk management. The study team has generally found the public to be well informed and interested in issues that affect their community.

The turnout of thousands of volunteers for the 2009 flood fight and the support churches provided during the evacuation further shows evidence of a high participation rate. The residents of Fargo, in particular, have great confidence in local officials. During the 2009 flood fight, residents relied on the mayor's experience and judgment on whether to evacuate.

The volunteer effort encompassed more than 100,000 volunteers in Fargo; it is estimated that approximately 70 percent came from the immediate local area. Notably, students (university and high school students initially, and middle school students later) played a highly visible role in fighting the flood. Schools in Fargo closed for nearly 2 weeks, and local schools provided bag lunches and bused students to the Fargo Dome to assist with the sandbagging efforts. Even West Fargo, which experienced virtually no flooding, sent students to assist in the effort.

Sandbag production was a monumental task, with approximately a half-million sandbags produced per day during the entire 2009 flood fight period, for a total of approximately 3 million sandbags in a 1-week period. As the Fargo Emergency Manager stated, "We attacked it like war" in Fargo. Professor Littlefield offered a similar characterization, stating that the area was "a battle zone."

### 2.2.7 Leisure and Recreation

The metro area has a number of recreational activities, including ice-skating, figure skating, youth and adult hockey, volleyball, basketball, track, soccer, walking, cross-country skiing, ballroom dancing, table tennis, and broom ball. There are also 39 casinos in public establishments, with profits used for public causes. The area features neighborhood and regional public parks covering over 3,000 acres, 7 public golf courses within Fargo-Moorhead, and soccer

and softball/baseball complexes. Biking and walking trails run for more than 99 miles throughout Fargo, Moorhead and West Fargo. There are a number of annual celebrations, including the Fargo Film Festival, Downtown Street Fair, Pioneer Days, Fargo Blues Festival, and Christmas on the Prairie.

Residents of the study area tend to be active in recreational activities. This is evidenced by the numbers that participate in sporting events throughout the year. Many residents are engaged in hunting or fishing. Fargo-Moorhead is a regional hub for the arts, with many local painters, musicians, street fairs, and music venues.

The planning commissions in Fargo and Moorhead aim to increase the "walkability" of their cities and neighborhoods. Participants in Moorhead planning workshops suggested that a park should be within walking distance of all homes and that they would like to see an increase in the connectivity of neighborhoods. The City of Fargo also aims to use smart growth principles to keep the city as compact as possible to limit expensive infrastructure and keep down the cost of energy.

Outside the metro area, numerous parks line the river. Boaters have access to the water from boat ramps on both sides of the river. There are also several shore-fishing facilities. In the unincorporated areas of Clay County, parks and recreation is the second largest land-use category, accounting for 3 percent of the land area. There are five area state parks provide year-round outdoor recreation activities within a short driving distance of Fargo Moorhead. Most state parks provide camping, swimming, boating/canoeing, fishing and hiking/biking/snowmobile trails. The Cities of Grand Forks and East Grand Forks are about 90 miles from Fargo-Moorhead and offer additional recreation opportunities.

### 2.2.8 Summary of Baseline Profile

Residents of the study area represent a cohesive community with a great deal of fortitude. As the data show, this is not an affluent community, but it is much more ethnically and racially homogenous than the U.S. population and highly cohesive, culturally. This strong community has banded together repeatedly to fight floods and, to date, has succeeded in its efforts. Residents clearly have strong spirits and many reasons to be proud. The scope of the volunteer effort to fight floods and the level of coordination involved is clearly exceptional and highly effective. These characteristics are repeatedly highlighted, both in the media's and in residents' accounts of what has transpired. The community clearly takes pride in its ability to band together to fight floods.

However, qualitative evidence suggests that effects of the stress created by the chronic flood threat and of the acute stress created by flood fights lie under the surface. Given the continued threats and the empirical research on the effects of chronic stress, there is little doubt that flood risk is a social cost to the community.

The baseline profile indicates that there is a high level of risk to Health and Safety and Economic Vitality in the study area. The level of risk to Health and Safety is evidenced by the chronic mental and physical stress of the continued flood threat. Flooding also presents a risk to life (discussed in Attachment 1). Because the metro area is a regional healthcare hub, a catastrophic event would cause widespread Health and Safety concerns, as regional residents would have to travel farther for health care services. The economy of the metro area has been very robust and is an economic driver for the region. A very large flood would impact many businesses and homes,

and would be extremely costly. Damage from smaller floods has occurred frequently in the past. Numerous flood fights have also been costly. If a catastrophic event did occur, long-term consequences could result, as there is a potential for businesses to relocate to other regions.

# 3.0 Initial Evaluation of Other Social Effects

This section includes a brief description of the alternatives considered during the initial plan formulation stage and the assessment of the OSE of the alternatives. The evaluation and screening of these alternatives was completed in earlier phases of the study. This section re-evaluates the alternatives based on other social effects in order to reaffirm previous screenings and for the purposes of developing an OSE screening tool. Alternatives are screened in Appendix O of the main report based on a range of criteria, not limited to OSE.

The assessment contained in this section is based on the seven social factors described in Section 1.3. Assessing each social factor involved evaluating a set of metrics that are pertinent to that social factor.

As discussed in Section 1.2, the Fargo-Moorhead metro area was considered the extent of the study area in the early phases of the study; consequently, the initial screening of alternatives only considered impacts to the residents of the Fargo-Moorhead metro area. The study area was expanded during later phases of the study to include the areas upstream and downstream of the metro area (Section 4 of this appendix).

## 3.1 Description of Alternatives

Ten with-project alternatives were identified during the initial plan formulation stage. The alternatives were developed to a concept level of detail for initial screening purposes (see Appendix O of the Main Report) for more information on the alternatives and on the initial screening process). The initial screening relied on existing information, the development of new information, expert judgment, public input, and existing studies.

The initial flood risk management alternatives developed are:

1. Flood barriers
2. Diversion channels
3. Non-structural measures
4. Flood storage
5. Tunneling
6. Bridge replacement or modification
7. Interstate 29 (I-29) viaduct
8. Dredging and widening
9. Wetland and grassland restoration
10. Cut-off channels

Each alternative is described briefly below.

### 3.1.1 Flood Barriers

Flood barriers would include using permanent flood barrier systems, such as levees, floodwalls, gate closures, and pump stations.

### 3.1.2 Diversion Channels

Diversion channels would route flood flows around the metro area, reducing flood stages in the natural channels through the area. Control structures on the Red River would be required to divert flows into the diversion channels and drop structures would be required to allow local drainage to enter these channels. Four separate alignments (each involving a diversion channel and one or more tie-back levees) have been analyzed as part of this study.

### 3.1.3 Non-structural Measures

Non-structural measures would reduce the risk to property by altering individual residential and non-residential structures rather than redirecting floodwaters away from property. Non-structural measures would involve a variety of actions, including acquiring structures, relocating structures to other parts of a property, and elevating structures above the design flood level.

### 3.1.4 Flood Storage

Flood storage would involve both preserving natural floodplain areas and 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. Facilities would be located in any watershed upstream of the Fargo-Moorhead metro area and distribution would be throughout that area.

### 3.1.5 Tunneling

Large tunnels would be used to divert flows under the communities, functioning in a similar manner as a diversion channel, only underground. It was estimated that three 30-foot diameter tunnels of approximately 25 miles in length would be required. The tunnels would require easements to tunnel under private property and disposal areas for approximately 10 million cubic yards of excavated material.

### 3.1.6 Bridge Replacement or Modification

Bridges can restrict flow during flood events. Under this alternative, bridges crossing the Red River would be replaced or modified to increase conveyance in the channel and reduce flood stages.

### 3.1.7 Interstate 29 Viaduct

The I-29 corridor would be reconstructed to serve as an open viaduct during floods. The reconstructed corridor would function as an interstate highway during non-flood times. During a flood event, it would essentially be a diversion channel.

### 3.1.8 Dredging and Widening

Dredging and widening would involve digging the Red River channel deeper and wider to allow more flow to pass through the Fargo-Moorhead metro area. This alternative could also be considered under existing bridges to prevent the damming effect the bridges can create.

### 3.1.9 Wetland and Grassland Restoration

Wetland and grassland restoration would include restoring drained wetlands and grasslands, and changing land use practices in the watersheds upstream of the Fargo-Moorhead metro area. The wetlands and grasslands would reduce peak runoff, change flood frequency, and store water during flooding. The features would be distributed throughout the upstream portion of the Red River Basin and would generally provide low-level storage that would primarily be used for wetlands and habitat.

### 3.1.10 Cut-off Channels

Building cut-off channels across meanders in the river would provide a straighter path for the water to follow through the Fargo-Moorhead metro area and would potentially reduce peak flood stages. The channels would be designed with a bottom elevation above a certain design stage to allow the river to flow naturally until a design event, when the excess would flow into the cut-off channel. Four cut-off channels in the Fargo-Moorhead metro area were constructed as part of a Federal flood control project completed in 1963.

## 3.2 Initial Screening Methodology

The initial screening of alternatives and evaluation of the impacts of the alternatives on the communities have been captured in a screening matrix. The seven social factors evaluated in the baseline profile were carried through to the initial screening phase to provide a basis of assessment.

### 3.2.1 Social Factor Metrics

Metrics have been identified for each of the social factor categories. These metrics relate to potential impacts on a community as a result of implementing an alternative. They are based on standard metrics developed by the IWR, however Regional Healthcare was included under the Health and Safety social factor because the metro area is a considered a regional healthcare center—with the potential to impact people well outside of the immediate study area. The metrics and their descriptions are presented in Table D-7.

**Table D-7: Description of Metrics**

| Social Factor/Metric | Description |
|---|---|
| **Health and Safety** | |
| Mental Health | Issues affecting the overall mental health of a person, such as anxiety and stress (e.g., threat of flooding, transportation concerns, noise) |
| Physical Health | Issues affecting a person's physical health (e.g., air quality, diseases) |
| Physical Safety | Safety issues that could cause bodily harm to a person (e.g., floodwaters, crime) |
| Regional Healthcare | Issues affecting the healthcare services provided in the region (e.g., impacts to hospitals and specialized clinics) |
| **Economic Vitality** | |
| Business Climate | Issues affecting the ability of a community to retain and attract businesses |
| Employment Opportunities | Issues affecting the availability of a community to provide employment opportunities for residents |
| Financial Impacts | Issues affecting a person or group's standard of living (e.g., taxes, property values) |
| Municipal Services | Issues affecting the local tax base and the ability to provide municipal services |
| **Social Connectedness** | |
| Community Cohesion | Issue affecting local social networks, including personal networks |
| Community Facilities | Issues affecting access to local community-related facilities (e.g., libraries, community centers, religious establishments) |
| **Identity** | |
| Cultural Identity | Issues affecting sense of cultural identify within a community (e.g., historical or cultural significance) |
| Community Identify | Issues affecting sense of community identity (e.g., local sports, how others see the area) |
| **Social Vulnerability and Resiliency** | |
| Residents of Study Area | Issues affecting the overall risk to the population within the study area |
| Socially Vulnerable Groups | Issues affecting socially vulnerable groups (e.g., low-income, minority, elderly, and disabled populations, and children) |
| **Participation** | |
| Public Participation | Issues affecting overall public involvement in community matters (e.g., trust in local officials, public interest in community) |
| **Leisure and Recreation** | |
| Recreational Activities | Issues affecting access to or availability of recreational activities (e.g., parks, trails, viewsheds) |

In addition to the social factors described in the handbook, impacts to the human environment should also consider Environmental Justice (EJ) and Public Safety. These topics are critical components of the impacts to the human environment and are intertwined with many components of the OSE analysis. Although these topics are not explicitly covered in the OSE

analysis, they are addressed in other sections of the overall study (see Chapter 5 of the Main Report).

### 3.2.2 Scoring

Because some social factors are not easily quantified, this evaluation relies on a scoring system with a scale of -3 to +3, with -3 indicating significant negative effects on a particular metric and +3 indicating significant beneficial effects (see Table D-8). **The score is an assessment of the relative impact an alternative would have on a particular metric in relation to the without-project alternative. The assessment is made from an overall planning perspective (not necessarily reflecting impacts to individuals or small groups)**. For example, a diversion channel to reduce flooding might have a significant beneficial effect to the residents at risk of flooding and be given a score of +3 for the Residents of Study Area metric. On the other hand, a small scale non-structural alternative (relocation) might benefit the residents being relocated and leave a large majority of the residents susceptible to flooding; therefore, it would receive a score of 0 or +1 (most of the residents would be susceptible to the same flood risk with relocation as with the without-project alternative).

**Table D-8: Key to Scoring Metrics in Matrix**

| Score | In Relation to the Without-Project (No Action) Alternative, the With-Project Alternative Has… |
|---|---|
| -3 | Significant negative effects (“show-stopper”) |
| -2 | Moderate negative effects |
| -1 | Minor negative effects |
| 0 | Negligible effects (no impact) |
| +1 | Minor beneficial effects |
| +2 | Moderate beneficial effects |
| +3 | Significant beneficial effects |

## 3.3 Evaluation of Social Factors

As identified during the baseline assessment, the mental stress associated with the continued threat of flooding and the flood fight efforts is a significant issue to the communities in the study area. The baseline assessment also identified continued Economic Vitality as a major concern in the study area. It has been shown that flooding poses a risk to the Economic Vitality of the region due to costly flood fights, numerous past floods, and the risk of a catastrophic event. Therefore, the Health and Safety and Economic Vitality social factors weigh heavily in the overall OSE evaluation of the alternatives.

The results of the initial screening of alternatives are presented in Table D-9. Following Table D-9 is a brief overview of each alternative, with special attention paid to any metrics with a score of -3 or +3 to help decision makers understand the particular issue and why the score was selected.

## Table D-9: Initial Screening of Alternatives

| Social Factor and Metrics | Alternatives | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flood Barriers | | Diversion Channels | | Non-structural Measures | | Flood Storage | | Tunneling | | Bridge Replacement or Modification | | Interstate 29 Viaduct | | Dredging and Widening | | Wetland and Grassland Restoration | | Cut-off Channels | |
| | D | E | D | E | D | E | D | E | D | E | D | E | D | E | D | E | D | E | D | E |
| Health and Safety | | | | | | | | | | | | | | | | | | | | |
| Mental Health | 2 | 2 | 3 | 3 | 0 | 0 | 2 | 2 | 3 | 3 | 0 | 1 | 3 | 3 | 1 | 1 | 0 | 1 | 1 | 1 |
| Physical Health | 2 | 2 | 3 | 2 | 0 | 0 | 2 | 2 | 3 | 2 | 0 | 1 | 3 | 2 | 1 | 1 | 0 | 1 | 1 | 1 |
| Physical Safety | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 1 |
| Regional Healthcare | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 2 | 0 | 3 | 0 | 1 | 0 | 3 | 0 | 1 | 0 | 1 | 0 | 1 |
| Economic Vitality | | | | | | | | | | | | | | | | | | | | |
| Business Climate | 2 | 2 | 2 | 3 | 0 | 0 | 2 | 2 | 3 | 3 | 0 | 1 | 3 | 3 | 1 | 1 | 0 | 1 | 1 | 1 |
| Employment Opportunities | 2 | 2 | 2 | 3 | 0 | 0 | 2 | 2 | 3 | 3 | 0 | 1 | 3 | 3 | 1 | 1 | 0 | 1 | 1 | 1 |
| Financial Impacts | -1 | 1 | -2 | 1 | 0 | 0 | -1 | 1 | -2 | 1 | 0 | 0 | -2 | 1 | -1 | 1 | 0 | -1 | -1 | 1 |
| Municipal Services | -1 | 2 | -2 | 2 | 0 | 0 | -1 | 1 | 0 | 2 | 0 | 0 | -1 | 2 | 0 | 1 | -1 | 0 | 0 | 1 |
| Social Connectedness | | | | | | | | | | | | | | | | | | | | |
| Community Cohesion | -1 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 1 |
| Community Facilities | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 1 |
| Identity | | | | | | | | | | | | | | | | | | | | |
| Cultural Identity | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Community Identify | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| Social Vulnerability and Resiliency | | | | | | | | | | | | | | | | | | | | |
| Residents of Study Area | -1 | 2 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 1 |
| Socially Vulnerable Groups | -1 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 1 |
| Participation | | | | | | | | | | | | | | | | | | | | |
| Public Participation | 1 | 2 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 1 | 1 | 2 | 0 | 1 | 0 | 1 | 1 | 1 |
| Leisure and Recreation | | | | | | | | | | | | | | | | | | | | |
| Recreational Activities | -1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |

**Notes:**

- Impacts are measured in comparison to the Without-Project Alternative
- D = impacts to daily lifes (no flooding); E = impacts during a flood event
- Scores can range from -3 (significant negative impact) to +3 (significant beneficial impact)
- No more than 25 percent of the metric scores for an alternative should be either a -3 or +3

### 3.3.1 Flood Barriers

Although the construction of flood barriers would require the acquisition of nearly 1,000 homes, the larger community would experience the benefits of a large reduction in flood risk. The cities of Grand Forks North Dakota and East Grand Forks Minnesota implemented a large scale levee system that has provided opportunities for park space, recreation, and river access. Flood barriers in Fargo Moorhead could provide similar opportunities. A residual risk also remains due to overtopping or a catastrophic breach of the barriers. Flood barriers potentially induce stage increases upstream or downstream.

### 3.3.2 Diversion Channels

Although the diversion channels would require large tracts of land for construction, communities at risk would receive significant beneficial effects and reduced flood risk. However, the financial cost of the alternative and the loss of tax base might be a burden to communities. Diversion channels have residual flood risk, however they usually do not make the consequences of a catastrophic flood worse. Diversion channels likely induce upstream or downstream stage increases.

### 3.3.3 Non-structural Measures

Non-structural measures reduce flood risk by reducing the amount of damage caused by flooding without modifying flood behavior. These measures include elevation, relocation, acquisition, and floodproofing of structures, local levees or floodwalls (small and around individual structures), flood warning systems, flood preparedness plans, and flood insurance. Non-structural plans can be considered on a comprehensive basis for the large portions of the study area, or just for specific problem areas. A large scale non-structural plan will reduce risks to health and safety and reduce the need to flood fight.

### 3.3.4 Flood Storage

Flood storage alternatives entail creating a number of impoundments of various size distributed throughout the Red River Basin and sub-basins upstream of Fargo-Moorhead. Flood storage alternatives are effective in reducing flood stages for more frequent events and could have substantial benefits basin-wide. The impoundments would require a large amount of land, mostly farm fields. Flows would likely be stored into the growing season.

### 3.3.5 Tunneling

Impacts of the tunneling alternative are similar to those of the diversion channels alternative, although at a smaller scale. The financial cost of tunneling would be very high and might be a burden to communities. Tunnels have residual flood risk, however they usually do not make the consequences of a catastrophic flood worse.

### 3.3.6 Bridge Replacement or Modification

Bridge replacement or modification reduces stages by minimizing the obstruction that bridges create during high flows. Generally bridge replacement or modification is effective in local reaches and for smaller flood events, but do little for reaches further away from bridges. There is

generally a high cost associated with bridge replacement and modification. The alternative would have minimal impacts on the daily life of residents.

### 3.3.7 Interstate 29 Viaduct

Construction of the I-29 viaduct would result in similar impacts as the diversion channel alternative, however on a smaller scale. There would be substantial disruption of traffic patterns associated with this alternative.

### 3.3.8 Dredging and Widening

The dredging and widening alternative would reduce flood risk. However, risk reduction is anticipated to be small, leaving a large residual risk to residents. The alternative would have minimal impacts on the daily life of residents. This alternative would have substantial impacts to ecosystems.

### 3.3.9 Wetland and Grassland Restoration

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

### 3.3.10 Cut-off Channels

The cut-off channels alternative would provide flood risk reduction. However, risk reduction is anticipated to be small, leaving a large residual risk to residents. The alternative would have minimal impacts to the daily life of residents.

## 3.4 Summary of Initial Screening of Project Alternatives

Based on the results of the initial screening of alternatives, none of the alternatives appear to have significant negative effects on the residents and communities in the study area. Significant positive effects for the Health and Safety and Economic Vitality could be realized from the flood barriers, diversion channels, non-structural and flood storage alternatives.

# 4.0 Alternatives Analysis

Based on the alternatives screening from Appendix O of the Main Report, four alternatives were carried forward for further analysis. The following section presents the OSE analysis of these alternatives, which takes into consideration greater refinement of the specific characteristics of the alternatives and additional analysis of the impacts of the alternatives.

## 4.1 Description of Alternatives Carried Forward

During the Phase IV screening of alternatives, four alternatives were carried forward (see section 8.4 of Appendix O): the No Action Alternative, one Minnesota Diversion alternative, and two North Dakota Diversion alternatives

The selected alignment of diversion channel for each alternative would be outside of the metro area through land that is currently in agricultural use. For each diversion alternative, a control structure would be required on the upstream portion of the Red River to divert flows into the selected diversion channel and drop structures would be required to allow local drainage to enter the diversion channel. Tie-back levees at the southern limits of the project area would be necessary to tie into high ground. No tie-back levees would be necessary at the north limits of the project area. Land use plans adopted by Clay County, MN, and Cass County, ND, do not include any proposals for future development along the proposed alignments. Based on the proposed alignment for the Minnesota Short Diversion, the City of Dilworth could experience some loss of developable land.

Section 3.11 through 3.13 of the Main Report provide a detailed description of the alternatives carried forward. A brief description of the three alternatives along with maps is provided below.

### 4.1.1 ND35K – North Dakota Diversion – 35,000 cfs with Downstream Impacts

The ND35K would divert floodwaters through North Dakota along a 36-mile-long diversion channel. The diversion channel would start approximately 4 miles south (upstream) of the confluence of the Red and Wild Rice Rivers and extending west and north around the cities of Horace, Fargo, West Fargo, and Harwood, ND (see Figure D-3). The diversion capacity for this alternative is 35,000 cubic feet per second (cfs). The ND35K induces downstream stage increases greater than 2-feet in some areas during certain flood events. Few mitigation measures for the downstream impacts would be economically justified.

This alternative would include substantial recreation features similar to those discussed in Appendix M of the Main Report.

### 4.1.2 LPP (Locally Preferred Plan) – North Dakota Diversion with Staging, Storage Cell, and Upstream Impacts

The LPP would follow the same alignment as the ND35K (see Figure D-4). The diversion capacity for this alternative is approximately 20,000 cfs. A storage cell would be placed at the southern end of the project area. The control structures, diversion inlet weir and the tie-back levees would be designed to stage water upstream and in the storage cell. The LPP would increase stages upstream by more than 8-feet during a 1-percent chance flood event. The LPP would require buying out and relocating between 800 and 1,200 structures upstream, between 200 and 400 of which are households.

This alternative would include substantial recreation features as discussed in Appendix M of the FEIS.

### 4.1.3 FCP (Federally Comparable Plan) – Minnesota Short Diversion – 35,000 cfs with Downstream Impacts

The FCP would divert floodwaters through Minnesota along a 25-mile-long diversion channel (see Figure D-5). The diversion channel would start at the confluence of the Red and Wild Rice Rivers and extend east and north, ending near the confluence of the Red and Sheyenne Rivers. The diversion capacity for this alternative is 35,000 cubic feet per second. The FCP induces downstream stage increases greater than 1-foot in some areas during certain flood events. Few mitigation measures for the downstream impacts would be economically justified.

This alternative would include substantial recreation features similar to those discussed in Appendix M of the Main Report.

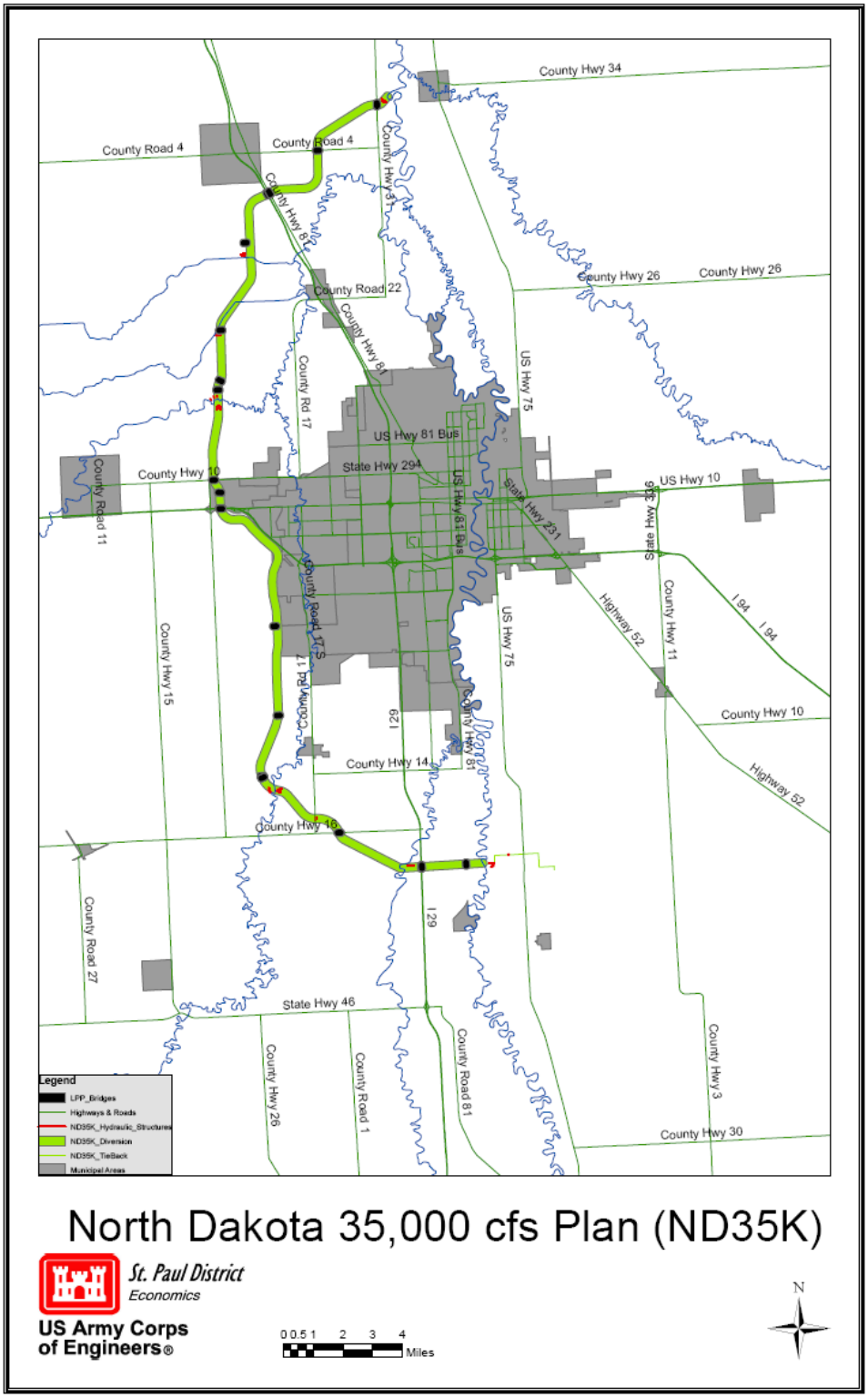



**Figure D-3: North Dakota 35,000 cfs Plan (ND 35K)**

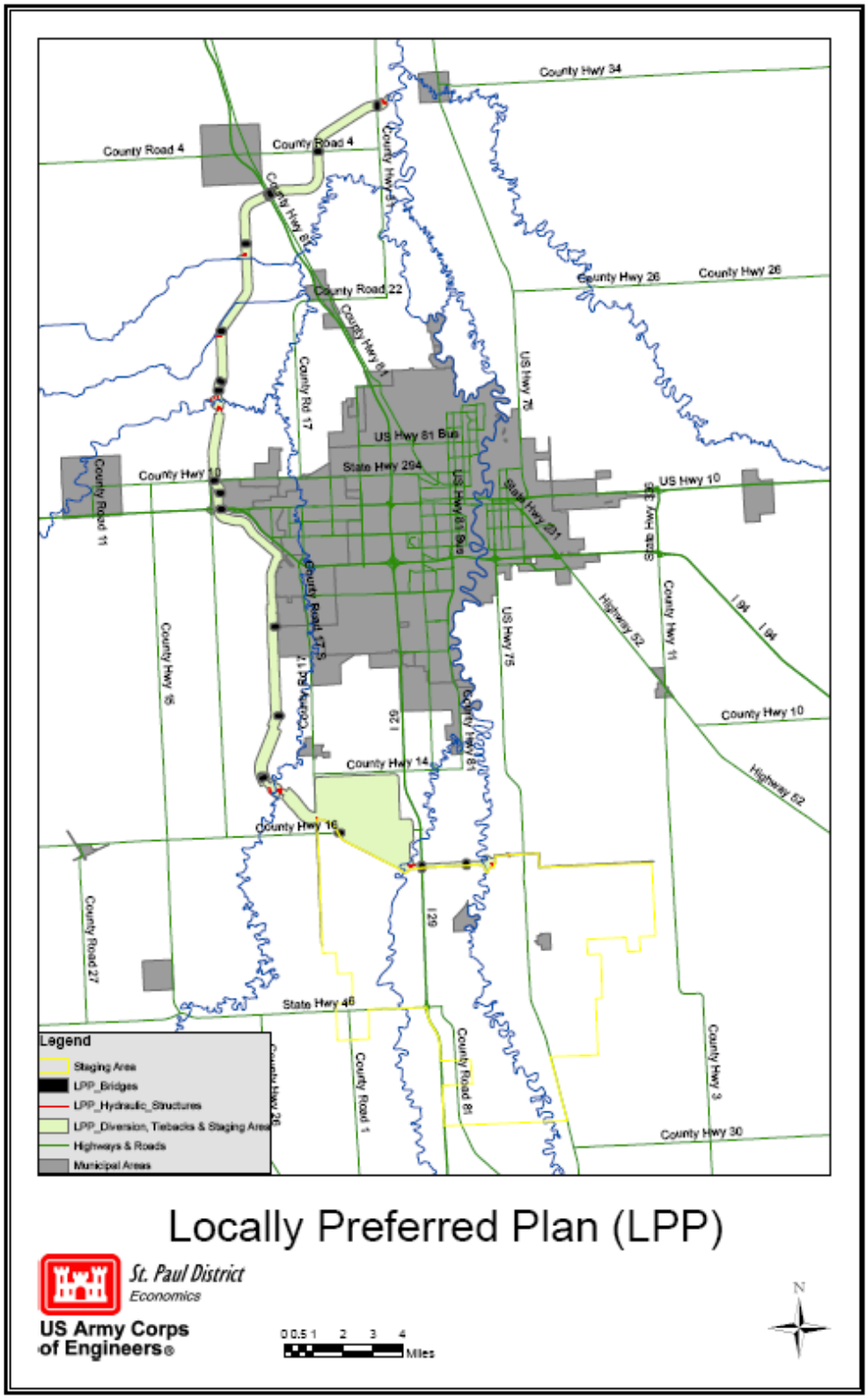



**Figure D-4: Locally Preferred Plan (LPP)**

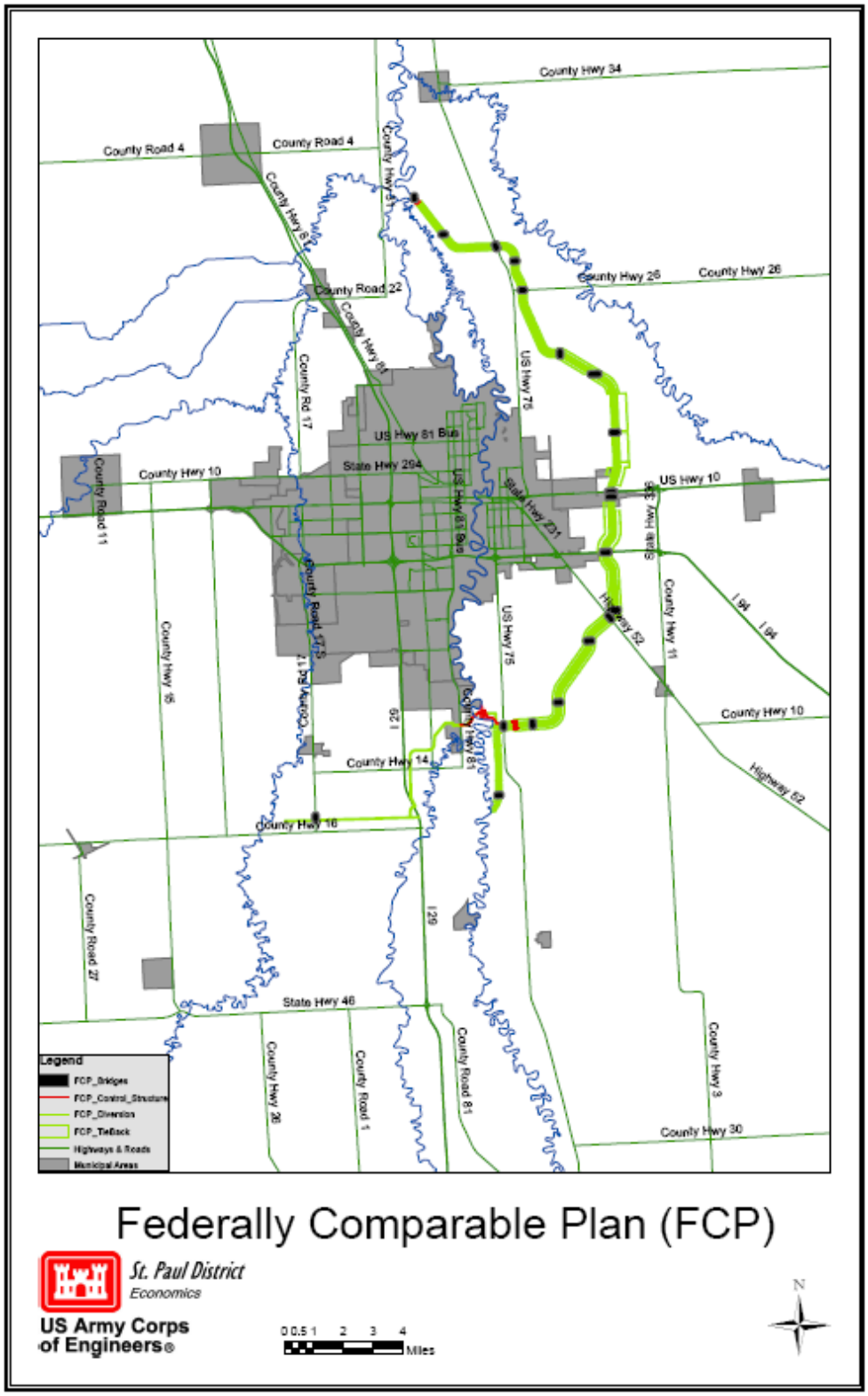



**Figure D-5: Federally Comparable Plan (FCP)**

## 4.2 Revision to the Study Area

During the initial screening of alternatives, the study area was identified as the Fargo-Moorhead metropolitan area. However, further analysis determined that the alternatives had the potential to induce flood damage outside of the metro area. To account for induced impacts, the study area was expanded from Abercrombie, ND, to the border with Canada. To better evaluate the impacts, the study area was divided into four subareas. These subareas and the identified impacts are described in Table D-10. See Chapter 5 of the Main Report for additional information on the impacts of the alternatives.

**Table D-10: Impacts to Subareas**

| Subarea | Location | Impact During 1-Percent-Annual-Chance Flood Event |
|---|---|---|
| Area 1 (upstream of metro area) | Abercrombie, ND (approximately River Mile 523), to north of Oxbow, ND (approximately River Mile 478) | The LPP could cause induced flooding of up to 99 inches.<br>The FCP could cause induced flooding of up to 7 inches. |
| Area 2 (metro area) | North of Oxbow, ND (approximately River Mile 478), to south of Georgetown, ND (approximately River Mile 433) | Area 2 would see a reduction in floodwater under all alternatives. |
| Area 3 (immediately downstream of metro area) | Georgetown, ND (approximately River Mile 433), to south of Thompson, ND (approximately River Mile 316) | The ND35K could cause induced flooding of up to 26 inches.<br>The FCP could cause induced flooding of up to 13 inches.<br>The LPP could reduce flood stages by up to 3 inches. |
| Area 4 (downstream of Area 3) | South of Thompson, ND (approximately River Mile 316), to the Canadian border (approximately River Mile 155) | The ND35K could cause induced flooding of up to 16 inches.<br>The FCP could cause induced flooding of up to 7 inches.<br>The LPP could cause induced flooding of up to 4 inches. |

## 4.3 Other Social Effect Evaluation of Alternatives

The OSE evaluation of the alternatives was framed around the seven social factors used during the initial screening of alternatives. However, the evaluation took into consideration additional detail and information on the alternatives and their potential impacts. The metrics and scoring system for each social factor were the same as those used in the initial screening (Section 3). As with the initial screening, the evaluation of alternatives was in relation to the without-project condition. As noted earlier, Environmental Justice is addressed in section 5.2.3.3 of the Main Report.

### 4.3.1 Health and Safety

As identified during the baseline assessment, the stress associated with the continued threat of flooding and the flood fight efforts is a significant issue to the communities in the study area; therefore, the Health and Safety social factor weighs heavily in the overall OSE evaluation of the alternatives. Table D-11 shows the results of the refined evaluation by subarea. An overall evaluation of each alternative follows.

**Table D-11: Health and Safety Social Factor**

| Social Factor: Health and Safety | Metrics | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ND35K | Mental Health | | Physical Health | | Physical Safety | | Regional Healthcare | |
| | D | E | D | E | D | E | D | E |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Area 2 (Fargo-Moorhead metro area) | 3 | 3 | 2 | 2 | 0 | 3 | 0 | 3 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | -1 | 0 | -1 | -1 | 0 | -1 | 0 | -1 |
| Area 4 (downstream of Area 3) | -1 | -1 | -1 | -1 | 0 | -1 | 0 | -1 |
| **LPP** | | | | | | | | |
| | D | E | D | E | D | E | D | E |
| Area 1 (upstream of the Fargo-Moorhead metro area) | -1 | -1 | 0 | -1 | 0 | -1 | 0 | -1 |
| Area 2 (Fargo-Moorhead metro area) | 3 | 3 | 3 | 3 | 0 | 3 | 0 | 3 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Area 4 (downstream of Area 3) | -1 | -1 | -1 | -1 | 0 | -1 | 0 | -1 |
| **FCP** | | | | | | | | |
| | D | E | D | E | D | E | D | E |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Area 2 (Fargo-Moorhead metro area) | 3 | 3 | 3 | 3 | 0 | 3 | 0 | 3 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | -1 | -1 | -1 | -1 | 0 | -1 | 0 | -1 |
| Area 4 (downstream of Area 3) | -1 | -1 | -1 | -1 | 0 | -1 | 0 | -1 |

#### 4.3.1.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, the residents would be expected to experience similarly high levels of stress and anxiety as they do under the without-project conditions.

Area 2 would be expected to experience a significant decrease in flood-related stress due to the reduction in flooding. This reduction of stress is anticipated to be similar to that experienced by the residents of Grand Forks, ND, when permanent flood risk management measures were

constructed following the 1997 flood event. Stress would be reduced during a flood event as well as throughout the year.

Area 3 would be expected to see an increase in flood-related stress due to the increase in flood stages during flood events. Residents in Area 4 could also see an increase in stress associated with flooding, but the impacts would be minimal and might not be noticeable.

Healthcare centers are concentrated in the metro area, with many residents inside and outside the study area relying on medical services provided by existing facilities. The risk of an interruption to these services would be greatly reduced with The ND35K, which allows for the continued operation of the healthcare facilities during an event.

#### 4.3.1.2 LPP

The LPP would have a negative impact on the current flooding conditions in Area 1; therefore, the residents would be expected to experience higher levels of stress and anxiety than they do under the without-project conditions. This stress could increase due to the relocation of residents, which would disrupt daily activities and social networks. However, it is anticipated that the relocated residents would settle in areas that are not prone to flooding, thereby reducing their overall flood-related stress.

Area 2 would be expected to experience a significant decrease in flood-related stress due to the reduction in flooding. This reduction of stress is anticipated to be similar to that experienced by the residents of Grand Forks, ND, when permanent flood risk management measures were constructed following the 1997 flood event. Stress would be reduced during a flood event as well as throughout the year.

The LPP would decrease flood stages slightly in Area 3 and increase stages slightly in area 4; therefore, the residents would be expected to experience similar levels of stress and anxiety as they do under the without-project conditions. The positive and negative impacts to areas 3 and 4 are small (smaller than the ND35K and FCP) and might not be noticeable.

The metro area is the healthcare center for the region, with many residents inside and outside the study area relying on medical services provided by existing facilities. The risk of an interruption to these services would be greatly reduced with The LPP, which allows for the continued operation of the healthcare facilities during an event.

#### 4.3.1.3 FCP

The FCP would have some impact on the current flooding conditions in Area 1; the impacts to Area 1 are small, and the residents would be expected to experience similarly high levels of stress and anxiety as they do under the without-project conditions.

Area 2 would be expected to experience a significant decrease in flood-related stress due to the reduction in flooding. This reduction of stress is anticipated to be similar to that experienced by the residents of Grand Forks, ND, when permanent flood risk management measures were constructed following the 1997 flood event. Stress would be reduced during a flood event as well as throughout the year.

Area 3 would be expected to see an increase in flood-related stress due to the increase in flood stages during flood events. Residents in Area 4 could also see an increase in stress associated with flooding, but the impacts would be minimal and might not be noticeable.

The metro area is the healthcare center for the region, with many residents inside and outside the study area relying on medical services provided by existing facilities. Risk to these services would be greatly reduced with The FCP, which allows for continued operation during an event.

#### 4.3.1.4 Overview of Health and Safety Social Factor

It is important to note that the upstream and downstream communities already experience flooding, and that the health and safety concerns noted above currently exist. There are already flood fights and the danger of local levees overtopping; therefore, the increased frequency of flood events and water levels from the alternatives could increase this risk. While removing the stress, anxiety, and related psychological effects of flooding from those living in the metro area, a successful flood risk mitigation project in the metro area might, to some degree, intensify this burden on the downstream or upstream communities with induced impacts. The impact could be heightened by the residents' perception of their inability to affect any change or otherwise influence the decision making of people living in the metro area.

The LPP would result in the least induced impacts to the downstream communities as a whole, while also benefiting the large population of the metro area. It is expected that the residents in the upstream areas affected by the LPP would relocate to areas not prone to flooding, thereby reducing their flood-related stress in the long run. The ND35K and FCP would have similar benefits and induced impacts from a Health and Safety perspective.

The metro area is also considered a regional employment center. A catastrophic flood event would cause significant unemployment in the region, resulting in increased stress caused by loss of wages. Implementation of any of the alternatives would reduce the risk of a catastrophic event.

It is also important to recognize that none of the alternatives considered would eliminate flood risk. Although the risk of failure of a properly designed and constructed project is very small, Attachment 2 to this Appendix evaluates the potential for loss of life due to a breach of the LPP tie-back levees.

### 4.3.2 Economic Vitality

As identified during the baseline assessment, the study area is economically robust, with relatively low unemployment and a solid and diverse employment base. However, the economic development of the region would suffer greatly if a catastrophic event occurred. The various diversion alignments also impact development in different ways. Therefore, the Economic Vitality social factor also weighs heavily in the overall OSE evaluation of the alternatives. An additional metric ("Development") was added to the analysis to address land development impacts caused by the alternatives. Table D-12 shows the results of the refined evaluation by subarea. An overall evaluation of each alternative follows.

**Table D-12: Economic Vitality Social Factor**

| Social Factor: Economic Vitality | Metrics | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ND35K | Business | | Employment | | Financial | | Municipal | | Development | |
| | D | E | D | E | D | E | D | E | D | E |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Area 2 (Fargo-Moorhead metro area) | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 0 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | -1 | -2 | -1 | -2 | -1 | -1 | -1 | -1 | -2 | 0 |
| Area 4 (downstream of Area 3) | 0 | -1 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **LPP** | | | | | | | | | | |
| | D | E | D | E | D | E | D | E | D | E |
| Area 1 (upstream of the Fargo-Moorhead metro area) | -1 | -2 | -2 | -2 | -1 | 0 | -1 | 0 | -3 | 0 |
| Area 2 (Fargo-Moorhead metro area) | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 0 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Area 4 (downstream of Area 3) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **FCP** | | | | | | | | | | |
| | D | E | D | E | D | E | D | E | D | E |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Area 2 (Fargo-Moorhead metro area) | 2 | 3 | 2 | 3 | -2 | 3 | -2 | 3 | 2 | 0 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | -1 | -2 | -1 | -2 | -1 | -1 | -1 | -1 | -2 | 0 |
| Area 4 (downstream of Area 3) | 0 | -1 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 |

#### 4.3.2.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, the residents would be expected to experience similar economic growth and vitality as they do under the without-project conditions.

Area 2 would be expected to experience a significant benefit in Economic Vitality due to the reduction flood risk. This reduction in risk is anticipated to allow the metro area to continue to attract business from outside the area and to grow economically. Existing businesses would be less vulnerable and might be willing to expand in the area as opposed to moving to another region. Due to the reduction in flood risk, future land development could be undertaken at a reduced cost.

Area 3 could see a decrease in Economic Vitality, particularly in the agricultural sector, due to the increase in downstream flood stages during flood events. Residents in Area 4 could also experience decreased Economic Vitality associated with increased flooding; however, the impacts would be minimal and might not be noticeable. Due to the increase in flood risk, future land development in these areas would be more costly.

The ND35K would permanently remove a large tract of land within Area 2 from agricultural production, affecting the agricultural output and tax base of the local communities. The reduction

in tax base and the cost of the project could limit the ability of the local municipalities to provide services to its residents.

#### 4.3.2.2 LPP

The LPP would greatly impact the Economic Vitality of Area 1. Due to the induced flooding and acquisitions of structures, it would be expected that businesses would relocate to other areas in the region. Future land development would be limited in Area 1 due to restrictions imposed by flowage easements and the increase in flood risk. A loss of tax revenue may impact the ability of local municipalities to provide services to the remaining residents in their jurisdictions.

Area 2 would be expected to experience a significant benefit in Economic Vitality due to the reduction in flood risk. This reduction in risk is anticipated to allow the metro area to continue to attract business from outside the area and to grow economically. Existing businesses would feel less vulnerable and might be willing to expand in the area rather than in another region. Due to the reduction in flood risk, future land development could be undertaken at a reduced cost.

Minimal impacts on the flood risk are expected for Areas 3 and 4; therefore, the impacts to Economic Vitality would be similar to the without-project condition.

Among the three alternatives, the LPP would permanently remove the most land from agricultural production. Although it is anticipated that much of the land in the storage and staging areas could continue to be farmed, flood risk would be increased, and building of structures to support farming would be limited in those areas. These changes could reduce the agricultural output and tax base of the local communities. This reduction could limit the services provided by the municipalities to its residents.

#### 4.3.2.3 FCP

Similar to the ND35K, The FCP would have little impact on the current flooding conditions in Area 1; therefore, the residents would be expected to experience similar economic growth and vitality as they do under the without-project conditions.

Area 2 would be expected to experience a significant benefit in Economic Vitality due to the reduced flood risk. This reduction is anticipated to allow the metro area to continue to attract businesses from outside the area and to grow economically. Existing business owners would feel less vulnerable and might be willing to expand in the area. However, the community of Dilworth, MN, has expressed concern over the potential impact the Minnesota short alignment would have. The diversion channel would replace approximately 1,116 acres of undeveloped land, 407 of which could otherwise be developed in the next 30 years. Due to the reduction in flood risk, future land development could be undertaken at a reduced cost. However, municipalities in Minnesota have expressed concern that the alignment of the diversion channel would limit their development opportunities.

Area 3 would be expected to see a decrease in Economic Vitality, particularly in the agricultural sector, due to the increase in flood stages during flood events. Residents in Area 4 could also experience an impact to Economic Vitality associated with increased flooding; however, the impacts would be minimal and might not be noticeable. Due to the increase in flood risk, future land development would be more costly.

The FCP would permanently remove a large tract of land in Area 2 from agricultural production, affecting the agricultural output and tax base of the local communities. The reduction in tax base and the cost of the project could limit the local municipalities' ability to provide services to its residents.

#### 4.3.2.4 Overview of Economic Vitality Social Factor

The metro area is a regional employment center. A catastrophic flood event would cause significant business losses and higher unemployment. Implementing any of the alternatives would greatly reduce the risk and add to the Economic Vitality to the metro area.

The LPP would result in the least induced impacts to downstream communities, while also benefiting the large population of the metro area. However, The LPP would also permanently remove the most land from agricultural production, thereby reducing the agricultural output and tax base of the local communities.

### 4.3.3 Social Connectedness

The baseline profile indicated that residents in the study area have strong Social Connectedness, which has helped them during the frequent flood fight efforts. As part of their daily life, residents participate in various activities at community facilities such as schools, churches and hospitals. Although Social Connectedness is important, it was not weighted as heavily in the overall planning process as Health and Safety and Economic Vitality. Table D-13 shows the results of the refined evaluation by subarea. An overall evaluation of each alternative follows.

**Table D-13: Social Connectedness Social Factor**

| Social Factor: Social Connectedness | Metrics | |
|---|---|---|
| **ND35K** | **Community** | **Community** |
| | **D / E** | **D / E** |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 / 0 | 0 / 0 |
| Area 2 (Fargo-Moorhead metro area) | -1 / 2 | 0 / 2 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | -2 / -2 | 0 / -1 |
| Area 4 (downstream of Area 3) | 0 / 0 | 0 / -1 |
| **LPP** | | |
| | **D / E** | **D / E** |
| Area 1 (upstream of the Fargo-Moorhead metro area) | -3 / -1 | -3 / -1 |
| Area 2 (Fargo-Moorhead metro area) | -1 / 2 | 0 / 2 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | 0 / 0 | 0 / 0 |
| Area 4 (downstream of Area 3) | 0 / 0 | 0 / 0 |
| **FCP** | | |
| | **D / E** | **D / E** |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 / 0 | 0 / 0 |
| Area 2 (Fargo-Moorhead metro area) | -1 / 2 | 0 / 2 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | -2 / -2 | 0 / -1 |
| Area 4 (downstream of Area 3) | 0 / 0 | 0 / -1 |

#### 4.3.3.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, the residents would not be expected to experience impacts to their Social Connectedness. It is expected that they would still band together during a flood fight, as they do under the without-project conditions.

Area 2 would be expected to experience a significant benefit from the ND35K from the reduced flood risk. The flood fight efforts that have mobilized the community in the past would not be expected to occur, and implementing the alternative would result in little disruption to normal community activities during a flood event. Impacts on the local road network from the alignment of the diversion channel might cause the rural residents to experience disruption of and separation from current activities.

Area 3 could see an increase in flooding, causing potential impacts on the daily activities and community life of the residents, such as increased disruption to school and church activities. Communities in Area 3 have expressed concern that the additional flooding resulting from the ND35K could drive residents away from affected areas and cause property value depreciation.

Over the past 50 years, the downstream communities have seen population losses of between 10 and 35 percent. Every downstream city and township between Fargo-Moorhead and Thompson, ND, has lost population, with the exception of Oakport and Kragnes Townships, MN, which are immediately north of the metro area. The incremental increase in downstream flood risk associated with the proposed project is not likely to change the historic trends appreciably. The more significant causes of these trends are noted in the *Clay County Comprehensive Plan*, which cites the "city's distance from the major growth areas within the County and surrounding land use patterns" as current impediments to growth.

Residents in Area 4 could also experience an impact on Social Connectedness with increased flooding, but the impacts would be minimal and might not be noticeable.

#### 4.3.3.2 LPP

The LPP would cause significant social disruptions for the communities and residents in Area 1, with the potential for a large number of residents to be displaced. This could be especially detrimental to small towns, such as Oxbow, ND, which prides itself on having a small-town character. The relocations would disrupt such community activities as school and church functions, as well as the social networks among residents. Local school district officials have expressed concern that this alternative would conflict with their future school development plans.

Area 2 would be expected to experience a significant benefit from the LPP from a reduced flood risk. The flood fight efforts that have mobilized the community in the past would not be expected to occur as frequently, and flood events would result in less frequent disruption to normal community activities during a flood event after implementation of the alternative. The impacts to the local road network from the alignment of the diversion channel might cause the rural residents to experience the disruption of and separation from current activities.

The LPP would have little impact on the current flooding conditions in Areas 3 and 4; therefore, the residents would not be expected to experience impacts to their Social Connectedness. It is expected that they would still band together during a flood fight.

#### 4.3.3.3 FCP

As with the ND35K, the FCP would have little impact on the current flooding conditions in Area 1; therefore, the residents would not be expected to experience impacts to their Social Connectedness. It is expected that they would still band together during a flood fight.

Area 2 would be expected to experience a significant benefit from the FCP from a reduced flood risk. The flood fight efforts that have mobilized the community in the past would not be expected to occur, and flood events would result in little disruption to normal community activities during a flood event after implementation of the alternative. The impacts on the local road network from the alignment of the diversion channel might cause the rural residents to experience minor disruption and separation from current activities. However, the larger population within the area would not be impacted.

Area 3 could see an increase in flooding, causing potential impacts to the daily activities and community life of the residents, such as an increase in the disruption to school and church activities. Communities in Area 3 have expressed concern that the additional flooding resulting from the FCP could drive residents away from affected areas and cause property value

depreciation. Over the past 50 years, the downstream communities have seen population losses of between 10 and 35 percent. Every downstream city and township between Fargo-Moorhead and Thompson, ND, has lost population, with the exception of Oakport and Kragnes Townships, MN, which are immediately north of the metro area. The incremental increase in flood risk associated with the proposed project is not likely to change the historic trends appreciably. The more significant causes of these trends are noted in the *Clay County Comprehensive Plan*, which cites the "city's distance from the major growth areas within the County and surrounding land use patterns" as current impediments to growth.

Residents in Area 4 could also experience an impact on Social Connectedness with increased flooding, but the impacts would be minimal and might not be noticeable.

#### 4.3.3.4 Overview of Social Connectedness Social Factor

The LPP would have a significant impact on the Social Connectedness of the communities and residents of Area 1 due to the relocation of residents. The ND35K and FCP could have negative impacts on the Social Connectedness in Area 3 because of the induced downstream flooding and disruptions to daily activities. All three alternatives would benefit Area 2 because the flood risk would be reduced, as would disruptions to daily activities during an event.

All three alternatives would create additional burdens on communities outside of Area 2 affected by induced flood impacts, which may result in resentment toward the residents and political institutions of the metro area. This resentment would increase an already apparent social, cultural, and political divide in the region. Increasing frustration and resentment could be expected, given the sentiments these residents have expressed and their perception of their political situation.

### 4.3.4 Identity

The baseline profile indicated the residents of the study area identify with their Scandinavian roots and a pioneering spirit. This Identity has helped residents during the frequent flood fight efforts, with a "we pull ourselves up by our bootstraps" attitude. Although Identity is important, it was not weighted as heavily in the overall planning process as Health and Safety and Economic Vitality. Table D-14 shows the results of the refined evaluation by subarea. An overall evaluation of each alternative follows.

**Table D-14: Identity Social Factor**

| Social Factor: Identity | Metrics | |
|---|---|---|
| **ND35K** | **Cultural** | **Community** |
| | **D / E** | **D / E** |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 / 0 | 0 / 0 |
| Area 2 (Fargo-Moorhead metro area) | 0 / 0 | 0 / 1 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | 0 / 0 | -1 / -1 |
| Area 4 (downstream of Area 3) | 0 / 0 | -1 / -1 |
| **LPP** | | |
| | **D / E** | **D / E** |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 / 0 | -2 / -1 |
| Area 2 (Fargo-Moorhead metro area) | 0 / 0 | 0 / 1 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | 0 / 0 | 0 / 0 |
| Area 4 (downstream of Area 3) | 0 / 0 | 0 / 0 |
| **FCP** | | |
| | **D / E** | **D / E** |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 / 0 | 0 / 0 |
| Area 2 (Fargo-Moorhead metro area) | 0 / 0 | 0 / 1 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | 0 / 0 | -1 / -1 |
| Area 4 (downstream of Area 3) | 0 / 0 | -1 / -1 |

#### 4.3.4.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, the residents would not be expected to experience impacts to their Identity as a result of the similar economic growth and vitality as the experience under the without-project conditions. It is expected that they would still band together during a flood fight.

Area 2 would be expected to experience a significant benefit from the ND35K from a reduction in flood risk and the need for flood fight efforts. Although Area 2 would not be expected to change in cultural make-up as a result of implementing the alternative, implementation might reduce the residents' perception that they live in a flood-prone community.

Area 3 would be expected to see an increase in flooding. This induced flooding could increase the residents' perception that they, as rural residents, are not as important as residents of the metro area.

Residents in Area 4 could also experience an impact on their Identity that is associated with increased flooding, but the impact would be minimal and might not be noticeable.

#### 4.3.4.2 The LPP

The LPP would cause significant disruptions to the communities and residents in Area 1. Due to the mitigation measures, a large number of residents might be displaced. This could be particularly detrimental to small towns, such as Oxbow, ND, which prides itself on having a small-town character. Some citizens in Area 1 claim a family heritage in the area longer than 100 years with historic ties to the land. While farming of the land may continue, people would not be allowed to reside in large parts of Area 1. Churches and other social identity groups within Area 1 would be significantly affected as members relocate to other communities.

Area 2 would be expected to experience a significant benefit from the LPP from a reduction in flood risk and the need for flood fight efforts. Although Area 2 would not be expected to change in cultural make-up as a result of implementing the alternative, implementation might reduce the residents' perception that they live in a flood-prone community.

The LPP would have little impact on the current flooding conditions in Areas 3 and 4; therefore, the residents would not be expected to experience impacts to their Identity.

#### 4.3.4.3 FCP

As with the ND35K, the FCP would have little impact on the current flooding conditions in Area 1; therefore, the residents would not be expected to experience impacts to their Identity with respect to the without-project conditions. It is expected that they would still band together during a flood fight.

Area 2 would be expected to experience a significant benefit from the FCP from a reduction in flood risk and the need for flood fight efforts. Although Area 2 would not be expected to change in cultural make-up as a result of implementing the alternative, implementation might reduce the residents' perception that they live in a flood-prone community.

Area 3 would be expected to see an increase in flooding. This induced downstream flooding could increase the residents' perception that they, as rural residents, are not as important as residents of the metro area.

Residents in Area 4 could also experience an impact on their Identity associated with increased flooding, but the impact would be minimal and might not be noticeable.

#### 4.3.4.4 Overview of Identity Social Factor

The ND35K and FCP would not likely affect cultural and community Identity significantly. The LPP could have negative impacts on the Identity of the towns and residents in Area 1, who would be displaced as a result of the mitigation measures and might lose the Identity associated with small towns. The ND35K and FCP could have negative impacts on the Identity of residents located in Areas 3 and 4, the downstream portion subject to increased flood risk. This induced downstream flooding could increase the residents' perception that they, as rural residents, are not as important as residents of the metro area. Area 2 would benefit from all of the alternatives.

### 4.3.5 Social Vulnerability and Resilience

Although residents of the metro area have not yet lost a flood fight, there is a pronounced threat of a catastrophic flood event for which the community is not prepared. As identified during the baseline assessment, the residents' demonstrated strong desire to fight the flood and protect their

community could also be a benefit in the recovery efforts if a catastrophic flood event occurred. Table D-15 shows the results of the refined evaluation of Social Vulnerability by subarea. An overall evaluation of each alternative follows.

**Table D-15: Social Vulnerability and Resiliency Social Factor**

| Social Factor: Social Vulnerability and Resiliency | Metrics | |
|---|---|---|
| **ND35K** | **Residents of** | **Socially** |
| | **D / E** | **D / E** |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 / 0 | 0 / 0 |
| Area 2 (Fargo-Moorhead metro area) | 0 / 3 | 0 / 2 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | 0 / -2 | 0 / -1 |
| Area 4 (downstream of Area 3) | 0 / -1 | 0 / -1 |
| **LPP** | | |
| | **D / E** | **D / E** |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 / -2 | 0 / -1 |
| Area 2 (Fargo-Moorhead metro area) | 0 / 3 | 0 / 2 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | 0 / 0 | / 0 |
| Area 4 (downstream of Area 3) | 0 / 0 | 0 / 0 |
| **FCP** | | |
| | **D / E** | **D / E** |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 / 0 | 0 / 0 |
| Area 2 (Fargo-Moorhead metro area) | 0 / 3 | 0 / 2 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | 0 / -2 | 0 / -1 |
| Area 4 (downstream of Area 3) | 0 / -1 | 0 / -1 |

#### 4.3.5.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, the residents would not be expected to experience any adverse impacts to Social Vulnerability. It is expected that they would still band together during a flood fight.

Area 2 would be expected to experience a significant benefit from the ND35K from a reduction in flood risk and the need for flood fight efforts. The residents would experience a decrease in Social Vulnerability from a catastrophic flood event, allowing them to focus their efforts on other tasks.

Residents in Area 3 would see an increase in flooding. The induced flooding would expose additional residents to flooding and increase damage to property. The increased depth of flood

waters may overtop existing and emergency flood risk management measures designed to protect the residents.

Residents in Area 4 would also be exposed to increased risk due to induced flooding; however, the impacts would be minimal.

#### 4.3.5.2 LPP

The LPP would cause significant disruptions to the communities and residents in Area 1. A large number of residents might be relocated under this alternative. However, it is anticipated that they would relocate to areas that are not prone to flooding, thus reducing their Social Vulnerability. Residents not relocated would experience greater risk during an event. Area 2 would be expected to experience a significant benefit from the LPP from a reduction in flood risk and the need for flood fight efforts. The residents would experience a decrease in their Social Vulnerability to a catastrophic flood event, allowing them to focus their efforts on other tasks.

The LPP would have little impact on the current flooding conditions in Areas 3 and 4; therefore, the residents would not be expected to experience negative impacts from the alternative.

#### 4.3.5.3 FCP

The FCP would have little impact on the current flooding conditions in Area 1; therefore, the residents would not be expected to experience adverse impacts to Social Vulnerability. It is expected that they would still band together during a flood fight.

Area 2 would be expected to experience a significant benefit from the FCP from a reduction in flood risk and the need for flood fight efforts. The residents would experience a decrease in their Social Vulnerability to a catastrophic flood event, allowing them to focus their efforts on other tasks.

Residents in Area 3 would see an increase in flooding. The induced flooding would expose additional residents to flooding and increase the damage to property. The increased depth of flood waters may overtop existing and emergency flood risk management measures designed to protect residents.

Residents in Area 4 would also be exposed to increased risk due to induced flooding; however the impacts would be minimal.

#### 4.3.5.4 Overview of Social Vulnerability and Resiliency Social Factor

All of the alternatives would significantly reduce the flood risk to the large population in Area 2. However, this benefit comes at a cost to residents outside of the Fargo-Moorhead metro area.

The ND35K and FCP would increase the flood risk to downstream residents in Areas 3 and 4. Area 3 would be particularly affected and could see flood stages increase by 12.5 to 24 inches during a 1-percent-chance event. This induced flooding would cause additional hardship in an area that already has significant risk.

The LPP would increase the flood risk in Area 1; however mitigation measures would relocate residents who would be impacted by induced flooding. The mitigation measure could lower the overall risk to residents by relocating them to areas not prone to flooding. Therefore, it is

anticipated that The LPP would have the greatest benefit to the residents of the overall study area.

### 4.3.6 Participation

In the metro area, Participation is high. As discussed in the baseline profile, thousands of volunteers turned out during the 2009 flood fight, and local churches provided valuable support during the evacuation. The residents of Fargo, in particular, have great confidence in local officials to keep them out of harm's way. During the initial screening of alternatives, it was thought that Participation would not be significantly impacted by the diversion channels. However, as the impacts of the current alternative are realized by the residents of the study area, Participation has become a greater social factor in the overall OSE evaluation. Table D-16 shows the results of the refined evaluation by subarea. An overall evaluation of each alternative follows.

**Table D-16: Participation Social Factor**

| Social Factor: Participation | Metrics |
|---|---|
| **ND35K** | **Public** |
| | **D / E** |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 / 0 |
| Area 2 (Fargo-Moorhead metro area) | 1 / 2 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | -1 / -2 |
| Area 4 (downstream of Area 3) | -1 / -1 |
| **LPP** | |
| | **D / E** |
| Area 1 (upstream of the Fargo-Moorhead metro area) | -2 / -2 |
| Area 2 (Fargo-Moorhead metro area) | 1 / 2 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | 0 / 0 |
| Area 4 (downstream of Area 3) | 0 / 0 |
| **FCP** | |
| | **D / E** |
| Area 1 (upstream of the Fargo-Moorhead metro area) | 0 / 0 |
| Area 2 (Fargo-Moorhead metro area) | -2 / 2 |
| Area 3 (immediately downstream of Fargo-Moorhead metro area) | -1 / -2 |
| Area 4 (downstream of Area 3) | -1 / 1 |

#### 4.3.6.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, it is anticipated that there would be little change in Participation in this area.

Area 2 would significantly benefit from the ND35K, leading to the residents having greater confidence in the agencies and local politician of the area.

The ND35K would negatively impact the residents of Areas 3 and 4. The induced flooding could lead to less confidence in the agencies and local politicians by the residents of these areas and to greater animosity toward the population of the Fargo-Moorhead metro area.

#### 4.3.6.2 LPP

The LPP would negatively affect the residents of Area 1. The induced flooding and relocations could lead to less confidence in the agencies and local officials by the residents of these areas and to greater animosity toward the population of the Fargo-Moorhead metro area.

Area 2 would significantly benefit from the LPP, leading to the residents having greater confidence in the agencies and local officials of the area.

The LPP would have little impact on the current flooding conditions in Areas 3 and 4; therefore, it is anticipated that there would be little change in Participation in this area.

#### 4.3.6.3 FCP

Similar to the ND35K, the FCP would have little impact on the current flooding conditions in Area 1; therefore, it is anticipated that there would be little change in Participation in this area.

Area 2 would significantly benefit from the FCP; however, during public meetings and workshops, many residents in Minnesota expressed a deep dissatisfaction with the FCP. Because the majority of the benefits are on the North Dakota side of the river and the diversion channel would cause land loss and disruptions in Minnesota, they feel that they would be disproportionately burdened by this alternative. This dissatisfaction could lead to loss of confidence in public officials to look after their interests.

The FCP would negatively affect the residents of Areas 3 and 4. The induced flooding could lead to residents of these areas having less confidence in the agencies and local officials and more animosity toward the population of the Fargo-Moorhead metro area.

#### 4.3.6.4 Overview of Participation Social Factor

Because all of the alternatives have impacts on areas outside of the Fargo-Moorhead metro area, it can be expected that residents of these areas would lose confidence in the ability of the agencies and local officials to protect them, resulting in a decrease in Participation.

Following public meetings, it became evident that the residents of Minnesota felt disproportionately affected by the FCP. This resistance could create difficulties implementing this alternative.

Overall, the LPP would negatively affect the fewest residents in the study area, although residents of Area 1 would be expected to lose confidence in public officials due to the induced flooding and relocations.

### 4.3.7 Leisure and Recreation

In general, area residents are active. The number and variety of activities in the area indicate that the recreational facilities are widely used by residents. During the baseline profile, Leisure and Recreation was not seen as a significant concern of the residents; therefore, it did not weigh as heavily as other social factors. Table D-17 shows the results of the refined evaluation of Leisure and Recreation by subarea. An overall evaluation of each alternative follows.

**Table D-17: Leisure and Recreation Social Factor**

| Social Factor: Leisure and Recreation | Metrics |
|---|---|
| ND35K | Recreational Activities |
| | D / E |
| Upstream Impact Area 1 -- Abercrombie to Oxbow | 0 / 0 |
| Metro Impact Area -- Fargo-Moorhead (north of Oxbow to south of Georgetown) | 2 / 2 |
| Downstream Impact Area 1 -- Georgetown to Thompson | 0 / -1 |
| Downstream Impact Area 2 -- Thompson to the Canadian Border | 0 / 0 |
| **LPP** | |
| | D / E |
| Upstream Impact Area 1 -- Abercrombie to Oxbow | 1 / -1 |
| Metro Impact Area -- Fargo-Moorhead (north of Oxbow to south of Georgetown) | 2 / 2 |
| Downstream Impact Area 1 -- Georgetown to Thompson | 0 / 0 |
| Downstream Impact Area 2 -- Thompson to the Canadian Border | 0 / 0 |
| **FCP** | |
| | D / E |
| Upstream Impact Area 1 -- Abercrombie to Oxbow | 0 / 0 |
| Metro Impact Area -- Fargo-Moorhead (north of Oxbow to south of Georgetown) | 3 / 2 |
| Downstream Impact Area 1 -- Georgetown to Thompson | 0 / -1 |
| Downstream Impact Area 2 -- Thompson to the Canadian Border | 0 / 0 |

#### 4.3.7.1 ND35K

The ND35K would have little impact on the current flooding conditions in Area 1; therefore, it would not be expected to have an impact on Leisure and Recreation.

Area 2 would see a significant reduction in flood levels from the ND35K. Because fewer efforts would need to be expended for flood fighting, and recreational activities would be accessible during a flood event, residents of Area 2 would see a benefit in Leisure and Recreation.

The ND35K would negatively impact the residents of Areas 3 and 4. The induced flooding could lead to greater flood fight effort and less access to recreational areas during a flood event. Therefore, the ND35K would to lead to less Leisure and Recreation for the residents.

#### 4.3.7.2 LPP

The LPP would negatively affect the residents of Area 1. The induced flooding could lead to greater flood fight effort and less access to recreational areas during a flood event. However, the relocation of residents and the implementation of the storage cell could increase the land area available for recreational purpose. Leisure and Recreation benefits could be experienced by residents of a larger area if the land is converted to passive recreation purposes, such as nature viewing.

Area 2 would see a significant reduction in flood levels from the LPP. Because fewer efforts would need to be expended for flood fighting, and recreational activities would be accessible during an event, residents of Area 2 would see a benefit in Leisure and Recreation.

The LPP would have little impact on the current flooding conditions in Areas 3 and 4; therefore it would not be expected to have an impact to Leisure and Recreation.

#### 4.3.7.3 FCP

Similar to the ND35K, the FCP would have little impact on the current flooding conditions in Area 1; therefore, it would be expected to have no impact on Leisure and Recreation.

Area 2 would see a significant reduction in flood levels from the FCP. Because fewer efforts would need to be expended for flood fighting, and recreational activities would be accessible during an event, residents of Area 2 would see a benefit in Leisure and Recreation.

The FCP would negatively affect the residents of Areas 3 and 4. The induced flooding could lead to greater flood fight effort and less access to recreational areas during a flood event. Therefore, the ND35K would to lead to less Leisure and Recreation for the residents.

#### 4.3.7.4 Overview of Leisure and Recreation Social Factor

All of the alternatives would provide Leisure and Recreation benefits for the residents of Area 2 by reducing efforts needed for flood fight and allowing access to recreation activities during a flood event. The recreation features that are part of each plan will also provide additional recreation opportunities near Area 2. However, residents outside of the Fargo-Moorhead metro area would be negatively affected during a flood event by varying degrees, depending on the alternative.

Due to the mitigation activities, the LPP could increase the amount of land area available for recreational activities. These activities would benefit the residents of a larger area than Area 1. Therefore, the LPP would have the greatest overall benefits to Leisure and Recreation.

## 4.4 Summary of Alternative Analysis

Three with-project alternatives were carried forward for further analysis following the initial screening. All three alternatives involved the construction of a diversion channel that would divert floodwaters around the Fargo-Moorhead metro area. Although the Fargo-Moorhead metro area would significantly benefit from a reduction in flood risk, further analysis revealed that areas outside the metro area would be negatively affected, leading to an expansion of the study area. The OSE analysis of the three alternatives took into consideration additional information on the impacts of the alternatives on the residents of the study area.

During the baseline profile, the Health and Safety and Economic Vitality social factors were identified as most important to the residents of the study area. Therefore, these social factors were weighed more heavily during the analysis of alternatives. Implementation of any of the alternatives would significantly improve both the Health and Safety and Economic Vitality social factors of the residents of Area 2. Preserving the medical infrastructure and economic activities in Area 2 would indirectly benefit the entire study area. However, areas outside of the Fargo-Moorhead metro area would not receive any direct benefits from the alternatives, and depending on the alternative, these areas would be negatively affected due to increased flood risk. It is anticipated that the LPP would have the least negative impacts due to the mitigation measures and a smaller population in the negatively affected area.

The Participation social factor took on greater prominence throughout the study as residents of the study area became more aware of the alternatives and engaged in the process through public meetings and workshops. During these meetings, it became apparent that there was opposition to the FCP from residents in Minnesota, who felt that they were disproportionately bearing the burden of the impacts of the alignment of the diversion channel while receiving relatively few benefits. This opposition could hurt residents' confidence in the ability of resource agencies and local officials to look out for their best interests.

Due to the smaller population and mitigation measures, it is anticipated that the LPP would have the greatest social benefit in the study area as a whole. The only significant negative impacts on social factors was identified for the residents in Area 1, who would experience a significant disruption in the Social Connectedness social factor due to the relocations associated with the mitigation measures. The impacts on this social factor may be lessened by certain types of mitigation measures, such as relocating the town and all of the residents as a whole.

# 5.0 References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**Attachment 1**

Fargo-Moorhead Metro Feasibility Study
Analysis of the potential for loss of life due to flooding
January 5, 2009

5 Pages

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**Fargo-Moorhead Metro Feasibility Study**
**Analysis of the potential for loss of life due to flooding**
**January 5, 2009**

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Under existing conditions, a potential for the loss of life due to flooding of the Red River of the North exists in the greater Fargo-Moorhead area. An analysis of the magnitude of the potential for loss of life must consider two distinct scenarios:

- An anticipated overtopping of the levees
- An unexpected, sudden levee failure during a flood event

## Anticipated Failure

In the case of an anticipated failure, the flood is predicted and an evacuation order is implemented throughout the city. It is assumed that the evacuation order will be given with adequate warning time such that 100% of the population receives and reacts to the warning well before the actual overtopping of the levees. The loss of life potential applies to only the small percentage of the population that makes the decision not to evacuate.

An accounting of the Population at Risk (PAR) for various flood events was performed by taking the water surface profiles (developed with steady flow modeling), and intersecting it with a 30ft x 30ft Digital Elevation Model (DEM) based on the most recent elevation dataset in order to create a depth grid for each flood event across the entire floodplain. These depth grids were then used to extract depths at each of the structures used in the project economic analysis. The structures were then split up into depth classes in order to calculate the PAR and estimated Loss of Life (LOL). Results are shown in Table 1 below.

| | # of structures | | | | | |
|---|---|---|---|---|---|---|
| | | | Depth of Flooding | | | |
| Event | wet | dry | <2' | 2' - 13' | 13' - 15' | >15 |
| 10yr | 300 | 48580 | 93 | 196 | 3 | 8 |
| 20yr | 559 | 48321 | 197 | 339 | 10 | 13 |
| 50yr | 2582 | 46298 | 2057 | 490 | 13 | 22 |
| 100yr | 13439 | 35441 | 9086 | 4254 | 54 | 45 |
| 200yr | 34570 | 14310 | 18972 | 15444 | 61 | 93 |
| 500yr | 41908 | 6972 | 9736 | 31954 | 78 | 140 |

**Table 1. Depth of Flooding in Fargo-Moorhead**

In order to estimate the population associated with each structure, a gross average population per structure was calculated as the total metro population (202,684 people) was divided by the number of structures (48,880). This resulted in an average population of 4.15 people per structure. This is a gross approximation that did not account for differences in structure occupancy types (e.g. Residential, Commercial, Agricultural, Health), but is considered adequate for this level of analysis.

For the analysis it was assumed that 98% percent of the population would decide to evacuate upon receiving the warning of imminent levee failure. Those who remain are subject to a fatality rate which depends on the depth of flooding at their structure. The fatality rates used are shown in Table 2 below. Based on this information, an estimated LOL was calculated for various flood events.

| **Fatality Rates for those remaining in their homes** | |
|---|---|
| 0' - 2' | **0** |
| 2' - 13' | **0.0002** |
| 13' - 15' | **0.12** |
| >15' | **0.91** |

**Table 2. Fatality Rates used in analysis**

| Event | Estimated PAR | Reamining After Evacuation | Estimated LOL |
|---|---|---|---|
| 10yr | 858 | 17 | **1** |
| 20yr | 1501 | 30 | **1** |
| 50yr | 2177 | 44 | **2** |
| 100yr | 18050 | 361 | **4** |
| 200yr | 64670 | 1293 | **8** |
| 500yr | 133403 | 2668 | **12** |

**Table 3. Estimated Loss of Life in Fargo-Moorhead (anticipated failure w/ evacuation order)**

Note that PAR & LOL was determined for various flood events, including smaller, more frequent events. Considering the fact that the area has successfully contained floods in excess of the 100-year magnitude, an evacuation would not likely be ordered for these events. The PAR is calculated for the all events to highlight the increased level of risk for larger floods as compared to smaller floods.

## Unexpected Failure

In the case of an unexpected failure, the potential for loss of life is significantly greater than for the case of an anticipated failure. As warning time is greatly diminished, the potential for loss of life applies of the entire population that lives within the ultimate inundated area. An unexpected failure could occur during a relatively frequent event and cause significant LOL due to the lack of adequate warning.

To determine a worst case LOL for unexpected failure, 0% evacuation is assumed and the same fatality rates based on depth at individual structures that were used for the anticipated failure scenario are applied. To assume 0% evacuation is to assume that the entire city floods immediately with no warning and no time to attempt to evacuate. In the event of an actual unexpected failure, the arrival of flood waters at an individual structure will depend on proximity to the breach, the size of the levee breach, available storage capacity of the area behind the levees, and topography of the protected area. In the case of Fargo, a large north-to-south ridge would tend to delay or meter floodwaters that cross it. Embankments at Main Avenue, Interstate 94, Interstate 29, and the railroad lines

would have a similar delaying effect. Therefore the assumption of 0% evacuation (shown below in Table 4) should be considered a maximum Loss of Life event, and an extreme upper bound for a sudden failure scenario.

| Event | Estimated PAR | Estimated LOL | |
|---|---|---|---|
| | | Lower Bound 98% Evac | Extreme Upper Bound 0% Evac |
| | | ** | *** |
| 10yr | 858 | **1** | **32** |
| 20yr | 1501 | **1** | **54** |
| 50yr | 2177 | **2** | **90** |
| 100yr | 18050 | **4** | **200** |
| 200yr | 64670 | **8** | **394** |
| 500yr | 133403 | **12** | **594** |

** i.e. Anticipated Failure
*** i.e. Unexpected Failure, no Warning

**Table 4. Estimated maximum LOL in Fargo-Moorhead (no warning)**

*Unexpected Failure: Rate of Rise Analysis*

The actual arrival time and rate of rise of floodwaters in the cities of Fargo and Moorhead in the event of an unexpected levee failure would be determined by the actual location of the breach, the river stage, the size of the breach, the formation time of the breach, as well as other factors. An estimate for the rate of rise of floodwaters after a breach was performed using an HEC-RAS unsteady levee breach model with the intent of addressing the worst case in terms of location, flood event, and breach conditions.

The city interior was modeled as a series of storage areas connected by weir flow between the defining ridges within the topography (e.g. I-94, RR embankments, Main Ave). The levee was breached at the highest levee in the area near Island Park. The Red River was assumed to maintain an elevation of 906' through the levee breach model run. The following breach parameters were used: 250' Breach Bottom Width, 0.5 Side Slopes, 880' breach bottom elevation, 2 hour breach formation time.

The levee breach model resulted in a maximum rate of rise in the storage cells near to the breach of approximately 20 feet per hour. Storage cells located further away from the location of the breach experienced a slightly slower rate of rise and experienced some delay in the arrival. Overall, the water rose very fast, with the great majority of the storage cells reaching their maximum water surface elevation of 906' within less than 24 hours. The modeled water level rise for all storage cells are plotted against time and shown in Chart 1.

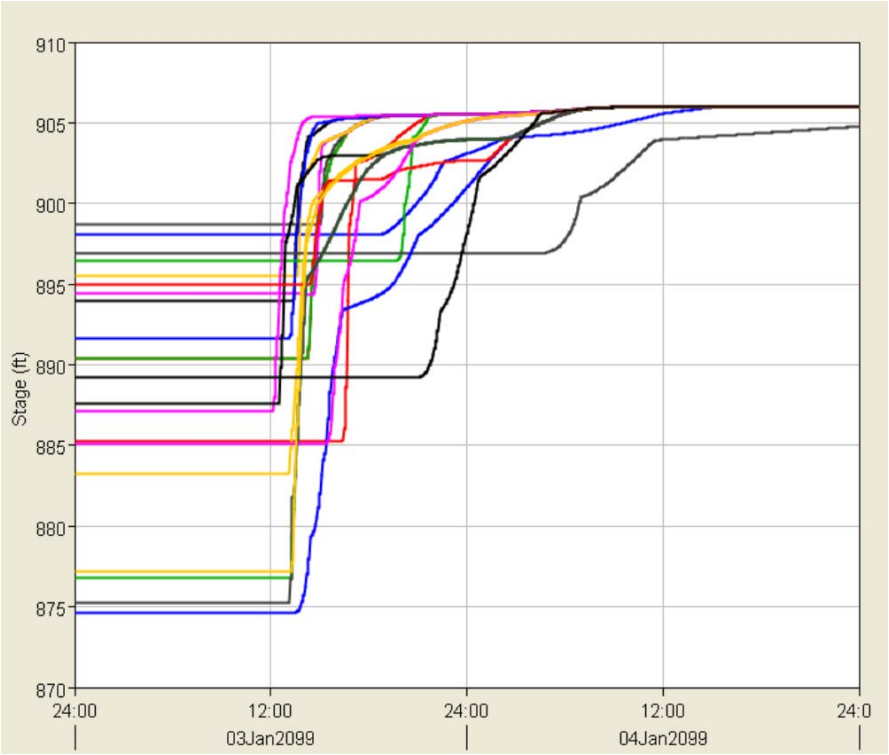


**Chart 1. Rate of Rise from Levee Breach at various locations within City of Fargo**

## Other Considerations

Special consideration should be given to a variety of complex conditions that are likely to surround a sudden failure of the levee system during a large flood event.

- *Active Flood Fight:* It is possible that a large group of emergency flood workers (sandbaggers) could be working near to the area of the breach. Evacuation capacity for a large group may be limited in terms of vehicle rider space (busses are commonly used to shuttle sandbaggers) and available evacuation routes.
- *Extreme Weather Conditions:* Spring-time snow-melt driven flood events are typical for the Fargo-Moorhead Area, and are often accompanied by extreme temperatures and weather conditions. In the event of a levee failure, hypothermia would likely present the primary Loss of Life threat rather than drowning. The fatality rates would likely be higher than those derived from empirical data.
- *Warning Time for a Piping Failure:* During a flood fight, constant levee surveillance is emphasized. It is possible that an active failure would be identified with enough warning time to evacuate much of the population.
- *Topography of the Fargo Floodplain:* The elevation of the floodplain on the North Dakota side of the Red River of the North generally drops off from east to west and slopes away from the river. This topography has to potential to cut off the evacuation routes and leave some individuals who are trying to escape floodwaters stranded in the event of a major flood event or levee breach.
- *Grand Forks, ND Levee Breach, 1997:* An unexpected levee breach due to overtopping was experienced in the Red River Basin in April of 1997 at Grand Forks and East Grand Forks. No evacuation of the population took place until

after the levee had been overtopped, and emergency evacuation required the use of helicopters to carry people that were stranded on isolated high ground. The event resulted in no loss of life.

- *Erodability of Frozen Clay Levees:* Typically, studies that investigate levee breach formation examine non-frozen material. It has been noted that during a spring flood event on the Red River, the existing earthen embankments are typically frozen and are more resistant to erosion than in their unfrozen state. It is possible that if earthen levees were to breach in the Fargo-Moorhead area, the breach opening would be relatively small and reduce the rate of rise of floodwaters in the interior area.
- *Secondary Levees:* During a flood event, it is typical for secondary/back-up levees to be construction in some vulnerable areas to serve to purpose of containing levee a potential levee breach in a smaller area and not allowing floodwaters to spread throughout the urban interior.
- *High Alert of Population:* During an extreme flood event, even if an evacuation order is not issued, the population is typically situational aware of the elevated river stage and the temporary nature of the flood protection system. In the event of a failure, reaction times would likely be faster than for an un-aware population.
- *Continued Floodplain Development:* The Fargo-Moorhead area is experiencing population growth and continued development within the floodplain. This trend increases exposure to the risk to loss of life in the area over time.

**With Project Conditions**

A feasibility report for Flood Risk Mitigation is being developed for the Fargo-Moorhead metro area which will consider various diversion channel alternatives. The alternatives being considered follow different alignments and have different capacities, but all share a similar design concept of a gated control structure upstream of the cities that would hold water levels at similar to existing conditions upstream and reduce flood flows through town while passing flood flows into the diversion channel. The designs also include a tie back levee upstream of the project area.

The diversion channel will eliminate the need to construct emergency levees through the urban area for all but the extreme flood events (depending on the size of the diversion selected), and thus greatly diminish the risk of loss of life due to a failure of the urban levees.

With the construction of a diversion channel the potential for failure is still present, but the probability of failure is greatly reduced as a new system would consist of well designed, engineered features as opposed to the temporary nature of the current flood fight scheme.

Potential failure modes of the feasibility study alternatives include structural failure of the control structure, seepage and piping at the tie-back levee, overtopping of the tie-back levee, seepage and piping of the diversion channel containment levee, and overtopping of diversion channel containment levee. In general, these failure modes all would lead to inundation of primarily rural areas with very low population densities as compared with to the areas threatened by the failure of the existing system.

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**Attachment 2**

**Fargo –Moorhead Metro Feasibility Study**
**Levee Breach and Loss of Life Analysis**
**Draft Report – June 29 2011**

**Table of Contents**

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**Fargo –Moorhead Metro Feasibility Study**
**Levee Breach and Loss of Life Analysis**
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*Hydraulic Modeling*

An unsteady HEC-RAS model was provided by the St. Paul District for the Locally Preferred Plan (LPP), which includes the Red River Diversion through Fargo, North Dakota. Part of the Scope of Work included splitting two storage areas into several, to better model the flow of water through the protected area. The St. Louis District split these areas into smaller storage areas, and connected them with new storage area connections in the model. The HEC-GeoRAS toolbar for ArcGIS 9.3 was utilized to complete this work. At the request of the St. Paul District, additional storage areas were added to the model, along the Red River in Moorhead, Minnesota. Storage Area Connections and Lateral Structures were added in this area as well.

In many locations, there are culverts that run underneath the roads that separate the storage areas. In order to correctly model the flow of water between the storage areas, these connections were placed in the HEC-RAS model. Aerial photography, provided by the St. Paul District, was used to identify the locations of culverts along the storage area connection lines. The Birdseye View option on the Bing Maps website was also used to confirm the location and shape/size of the culverts. If the culvert was visible but not measureable, the shape seen on the maps was used and dimensions were estimated using engineering judgment. If the culvert was seen but the shape was unknown, the dimensions were assumed. This 'default culvert' was a concrete box culvert, 2.9' rise by 2.9' span. This matches the assumptions used in the rest of the model when survey information was not available. Figure 1 shows an example of a culvert that was located using aerial photography (on the left) and dimensioned using Bing Maps (on the right).

Figure 1 – Example of Storage Area Connection Culvert modeled in HEC-RAS

The following plans were run: 10 year; 10 year with levee breach; 100 year; 100 year with levee breach; 2 x 500 year; and 2 x 500 year with levee breach. The levee breach was identical for all of the runs. The base width of the breach was 500', side slopes of 0 (vertical walls), invert elevation of 908', and formation time of 2 hours. The location of the levee breach was on a storage area connection between storage area "Area 1" and storage area "WRSA329" and the breach occurred at the peak water surface elevation of the flood. It's very likely that emergency levees would be constructed through the projected area for the 2 x 500 year event, which would increase loss of life potential, but in order to see the loss of life effect due to the staging area alone emergency levees were not included as part of this analysis.

The model output was generated using RAS Mapper, the new GIS tool built in to the HEC-RAS program. RAS Mapper allows the user to generate depth grids and arrival time grids for all of the executed plans in the project. Depth grids show how deep the flooding will be in the study area, and the arrival time grids show when the flooding arrives (when the depth of flooding reaches 2' at a given location).

*Loss of Life Modeling*

To model the consequences for all of the plans, the HEC-FIA program was used. HEC-FIA is typically used to compute the economic consequences (structural damages, agricultural damages, etc) of a specific event. With population data, it can also compute loss of life. This is especially critical when dealing with scenarios like levee breaches. Since the economic consequences have been previously modeled using other software, this work focused on the loss of life computations using the HEC-FIA program.

The St. Paul District provided a structure inventory, exported from the HEC-FDA model used previously in this study, which included approximately 50,000 structures. The inventory included data such as structure coordinates, occupancy type, and population (both day and night). A hazard area polygon was created that shows areas inundated to at least 2' of depth. This polygon identifies the areas at risk during a flood event. HEC-FIA uses the hazard area polygons, along with the depth grids and arrival time grids to determine loss of life for each of the simulations.

Three different groups of parameters were used to estimate loss of life for the Levee Breach runs. They appear in Table 1 below. The base estimate of loss of life uses reasonable estimates for the warning issuance, mobilization curve, and evacuation velocity. A sensitivity analysis was performed to provide an extreme upper and lower bound for the loss of life estimate.

Table 1 – Parameters Used in HEC-FIA for Loss of Life Simulation for Levee Breach Runs

| | Base Estimate | Extreme Lower Bound | Extreme Upper Bound |
|---|---|---|---|
| **Warning System** | EBS, Sirens, Auto-Dial Telephones | EBS, Sirens, Auto-Dial Telephones | EBS |
| **Mobilization Curve** | Above Average (ultimate evacation = 100%) | Above Average (ultimate evacation = 100%) | Below Average (ultimate evacation = 93%) |
| **Evacuation Velocity** | 10 mph | 15 mph | 5 mph |
| **Warning Issuance Time** | Initiation of Breach | 24 hours prior to Initiation of Breach | 4 hours after Initiation of Breach |
| **Fatality Rates** | FIA Defaults 0.0002/0.12/0.91 | Defaults -20% 0.00016/0.096/0.728 | Defaults +20% 0.00024/0.144/1.092 |
| **Fatality Zone Depths** | FIA Defaults (1-story) 2'/13'/15' | Defaults +1' 2'/14'/16' | Defaults -1' 2'/12'/14' |

Breach Initiation times were estimated using the arrival time grids for the various plans. The HEC-RAS model used 12 hour intervals for the output, which decreases the accuracy of the breach initiation time. In the future, an alternative to using the arrival time grids would be to decrease the intervals for the HEC-RAS output so that a better estimate of breach initiation time can be taken from the model.

A Double-Warning Time was used for all of the breach runs. This allows the user to simulate different warning times for structures based on their location, in relation to the inundation areas. It was assumed that structures experiencing flooding during a normal event (100yr for example) would be notified well in advance of the levee breach and would have ample time to evacuate. The initial warning time for this zone was set at the start of the simulation (15 March 2006, 1200). The other structures that would experience flooding due to the levee breach alone would be warned according to the three different scenarios listed in Table 1 on the previous page. This allows us to determine the loss of life that is directly attributed to the levee breach. Due to the location of some structures near the rivers, there are some areas that do show some loss of life regardless of the double-warning time.

When analyzing the loss of life results from the HEC-FIA simulations, it is important to know that the total life loss is a sum of all of the fatalities for the entire structure inventory. Many times, the values for life loss for an individual structure are very small, say 0.00001 people. This is due to the algorithms that calculate the life loss based on depth of water at the structure, warning time, and so on. When looking at the plates that show where the loss of life occurred, it is important to know that the number of structures that experience life loss greater than 0 will be larger than the totals shown in Table 2 in this report. The percentages shown on the plates represent the percentage of people at risk in each individual structure. The plates showing the location of the life loss are important, because they represent the areas that are most prone to life loss during the individual flooding events.

Table 2 shows the life loss results from the HEC-FIA simulations. The 10yr and 100yr non-breach runs were not simulated since the LPP is designed for these events. Population at Risk (PAR) is the number of

people that are potentially at risk from the flood inundation. In general, Life Loss represents the total number of fatalities from people who choose not to leave, have not been warned to leave in time, or are caught evacuating and cannot reach high ground before the floodwaters arrive. The results are also broken down into Day/Night. This is important when dealing with a mixture of occupancy types. Industrial/Commercial buildings tend to have a higher population during the day, while Residential buildings tend to have a higher population during the night.

Results from the HEC-FIA modeling for the 100yr Levee Breach can be seen in the plates following this report.

Plate 1 shows the depth grid that was generated by HEC-RAS. The range of depths was chosen to give a general sense of the threshold depths required to cause life loss in a one story.

Plates 2 and 3 show the results for the Life Loss simulation for the 100yr Breach run with the Extreme Lower Bounds warning scenario. Plate 2 shows the results overlaid on the depth grid, while Plate 3 shows the results overlaid on the double-warning polygon. The areas in pink were warned at the start of the simulation, while the areas in green were warned 24 hours prior to the levee breach.

Plates 4 and 5 show the results for the Life Loss simulation for the 100yr Breach run with the Base Estimate warning scenario. Plate 4 shows the results overlaid on the depth grid, while Plate 5 shows the results overlaid on the double-warning polygon. The areas in pink were warned at the start of the simulation, while the areas in green were warned at the start of the levee breach.

Plates 6 and 7 show the results for the Life Loss simulation for the 100yr Breach run with the Extreme Upper Bounds warning scenario. Plate 6 shows the results overlaid on the depth grid, while Plate 7 shows the results overlaid on the double-warning polygon. The areas in pink were warned at the start of the simulation, while the areas in green were warned 4 hours after the start of the levee breach.

Table 2 – Loss of Life Results for LPP from HEC-FIA

| Plan | Warning Scenario | Day | | Night | |
|---|---|---|---|---|---|
| | | PAR | Life Loss | PAR | Life Loss |
| 10yr Breach | Extreme Lower | 863 | 0 | 686 | 0 |
| | Base Estimate | 863 | 0 | 686 | 0 |
| | Extreme Upper | 863 | 0 | 686 | 0 |
| 100yr Breach | Extreme Lower | 18976 | 2 | 24596 | 0 |
| | Base Estimate | 18976 | 2 | 24596 | 1 |
| | Extreme Upper | 18976 | 31 | 24596 | 9 |
| 500x2 | Extreme Lower | 20877 | 0 | 25040 | 0 |
| | Base Estimate | 20877 | 0 | 25040 | 0 |
| | Extreme Upper | 20877 | 9 | 25040 | 6 |
| 500x2 Breach | Extreme Lower | 74694 | 5 | 76523 | 3 |
| | Base Estimate | 74694 | 7 | 76523 | 4 |
| | Extreme Upper | 74694 | 350 | 76523 | 241 |

Existing conditions are also being analyzed as part of this study, but the results are not available at the time of this draft report. An earlier Loss of Life analysis performed in 2009 for existing conditions estimated life loss at 1, 4, and 12 for the 10yr, 100yr, and 500yr events, respectively. These numbers are based on assumptions similar to the Base Estimate warning scenario.

*Conclusions*

The results from the Loss of Life simulation performed with the HEC-FIA software package gives the public an idea of the potential danger zones during a levee breach. It is important to remember that, while the software shows a life loss of 31 people during the day for the 100yr Breach, Extreme Upper warning scenario, those fatalities are spread across approximately 2700 structures in the study area. The results are useful to both the agencies responsible for emergency response during a flood event and the public living and working in the area.

0 ft - 2 ft

2 ft - 15 ft

15 ft - 24 ft

> 24 ft

# HEC-RAS Modeling
# 100yr Breach - Depth Grid

N

0 10,000 20,000 Feet

Plate 1

# Loss of Life Results
# 100yr Breach - Lower Bounds

**100yr Breach Lower Bounds Loss of Life**

- 0% - 0.5%
- 0.5% - 1%
- 1% - 3%
- 3% - 5%
- 5% - 10%
- 10% - 50%
- 50% - 100%

**LPP 100yr Levee Breach Depths**

- 0 ft - 2 ft
- 2 ft - 15 ft
- 15 ft - 24 ft
- > 24 ft

as a percentage of population in each individual structure

N

0 5,000 10,000 Feet

Plate 2

# Loss of Life Results
# 100yr Breach - Lower Bounds

as a percentage of population in each individual structure

**100yr Breach Lower Bounds Loss of Life**

- 0% - 0.5%
- 0.5% - 1%
- 1% - 3%
- 3% - 5%
- 5% - 10%
- 10% - 50%
- 50% - 100%

**LPP 100yr Warning Times**

- 24 Hours Prior to Time of Breach
- Early Warning

N

0 5,000 10,000 Feet

Plate 3

# Loss of Life Results
# 100yr Breach - Base Estimate

**100yr Breach Base Estimate Loss of Life**

- 0% - 0.5%
- 0.5% - 1%
- 1% - 3%
- 3% - 5%
- 5% - 10%
- 10% - 50%
- 50% - 100%

**LPP 100yr Levee Breach Depths**

- 0 ft - 2 ft
- 2 ft - 15 ft
- 15 ft - 24 ft
- > 24 ft

as a percentage of population in each individual structure

N

0 5,000 10,000 Feet

Plate 4

# Loss of Life Results
# 100yr Breach - Base Estimate

as a percentage of population in each individual structure

**100yr Breach Base Estimate Loss of Life**

- 0% - 0.5%
- 0.5% - 1%
- 1% - 3%
- 3% - 5%
- 5% - 10%
- 10% - 50%
- 50% - 100%

**LPP 100yr Warning Times**

- At Time of Breach
- Early Warning

N

0 5,000 10,000 Feet

Plate 5

# Loss of Life Results
# 100yr Breach - Upper Bounds

as a percentage of population in each individual structure

**100yr Breach Upper Bounds Loss of Life**

- 0% - 0.5%
- 0.5% - 1%
- 1% - 3%
- 3% - 5%
- 5% - 10%
- 10% - 50%
- 50% - 100%

**LPP 100yr Levee Breach Depths**

- 0 ft - 2 ft
- 2 ft - 15 ft
- 15 ft - 24 ft
- > 24 ft

N

0 5,000 10,000 Feet

Plate 6

# Loss of Life Results
# 100yr Breach - Upper Bounds

as a percentage of population in each individual structure

**100yr Breach Upper Bounds Loss of Life**

- 0% - 0.5%
- 0.5% - 1%
- 1% - 3%
- 3% - 5%
- 5% - 10%
- 10% - 50%
- 50% - 100%

**LPP 100yr Warning Times**

- 4 Hours After Time of Breach
- Early Warning

N

0 5,000 10,000 Feet

Plate 7