FINAL TECHNICAL MEMORANDUM
AWD-00002 – FLOWS THROUGH FLOOD DAMAGE REDUCTION AREA

July 16, 2012

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The purpose of this study is to evaluate options for increasing the flow and resultant residual Red River of the North flood stage through the flood damage reduction area as an alternative environmental mitigation project to the proposed fish passages on the Red and Wild Rice River control structures. This study evaluates River Stages (RS) beyond the approximately RS 31 feet planned for in the Integrated Final Feasibility Report and the Final Environmental Impact Statement (FR/FEIS) dated July 2011. This plan is now known as the Federally Recommended Plan (FRP).

The following table presents a summary of the FR/FEIS existing and proposed flood stage levels at the Red River of the North Fargo Gage.

Existing and Phase 4 Proposed Flood Stages

Event	Existing Flood Stage at Fargo Gage (13th Ave South)	Proposed Flood Stage at Fargo Gage (FR/FEIS - LPP) (13th Ave South)
10-Year	34.7 feet±	30-31 feet±
100-Year	42.4 feet±	30.8 feet±
500-Year	46.7 feet±	40.8 feet±

In addition to the FRP of RS 31 feet, seven additional residual flood stage options were evaluated between RS 30 feet and RS 37 feet using the US Army Corps of Engineers' Unsteady HEC-RAS Model, Phase 5. This evaluation is intended to provide an initial estimate of capital and operation/maintenance costs that would result from these higher stages. The following table presents the resultant 100-year peak discharge and corresponding existing condition frequency of this peak discharge.

Residual Peak 100-yr Flood Stage, Discharge, and Approximate Existing Frequency Conditions

Residual 100-yr Flood Stage	Residual 100-yr Peak Discharge (cfs)	Approximate Existing Condition Frequency (yr)
RS30	10,700	3.6
RS31	11,900	4.8
RS32	13,300	6.0
RS33	14,600	7.1
RS34	15,900	8.4
RS35	17,500	10.2
RS36	19,200	11.4
RS37	21,000	12.9

As a secondary benefit, if proposed mitigation measures to allow more flow through the flood damage reduction area are completed early in the construction phase, they will help to mitigate flood risk during flood events prior to completion of the diversion channel by lessening the extent of required temporary flood fighting measures. Increasing flow (and residual flood stage) will also reduce the frequency, depth and duration of staging water in the storage and staging areas.

The information in this report, along with the evaluation of mitigation credits and parallel studies being performed on the Red and Wild Rice River control structure locations and use of a variable gate on the Diversion Channel inlet, will need to be considered prior to selecting the desired residual flood stage.

1 OBJECTIVE

The objective of this study is to evaluate options for increasing the flow and resultant residual Red River of the North flood stage through the flood damage reduction area beyond the approximately RS 31 feet planned for and presented for the Locally Preferred Plan (LPP, aka North Dakota Diversion) in the Integrated Final Feasibility Report and the Final Environmental Impact Statement (FR/FEIS) dated July 2011. This plan is now known as the Federally Recommended Plan (FRP). This is being evaluated to determine the potential for providing an alternative environmental mitigation project to the proposed fish passages on the Red and Wild Rice River control structures. This evaluation is intended to provide an initial estimate of capital and operational/maintenance costs that would result from these higher stages.

Table 1 presents a summary of the FR/FEIS existing and proposed flood stage levels at the Red River of the North Fargo Gage.

Table 1: Existing and Phase 4 Proposed Flood Stages

Event	Existing Flood Stage at Fargo Gage (13th Ave South)	Proposed Flood Stage at Fargo Gage (FR/FEIS - LPP) (13th Ave South)
10-Year	34.7 feet±	30-31 feet±
100-Year	42.4 feet±	30.8 feet±
500-Year	46.7 feet±	40.8 feet±

If a change in flow and river stage is selected, environmental review and documentation of project changes will be required.

2 STUDY APPROACH

The FRP was designed to reduce the 100-year flood level at the Fargo Gage from RS 42.4 feet to approximately RS 31 feet as shown in Table 1. This plan serves as the base plan in this evaluation for comparison purposes.

In addition to the FRP RS 31 feet, seven additional residual flood stage options were evaluated between RS 30 feet and RS 37 feet using the US Army Corps of Engineers' Unsteady HEC-RAS (River Analysis System) Model, Phase 5. Table 2 presents the resultant 100-year peak discharge and corresponding existing condition frequency of this peak discharge.

Table 2: Residual Peak 100-yr Flood Stage, Discharge, and Approximate Existing Frequency

Residual 100-yr Flood Stage	Residual 100-yr Peak Discharge (cfs)	Approximate Existing Condition Frequency (yr)
RS30	10,700	3.6
RS31	11,900	4.8
RS32	13,300	6.0
RS33	14,600	7.1
RS34	15,900	8.4
RS35	17,500	10.2
RS36	19,200	11.4
RS37	21,000	12.9

2.1 OPTIONAL RESIDUAL FLOOD STAGE IMPACTS

Using the water surface elevations from the HEC-RAS modeling for the FRP, the resultant inundation area was mapped through the flood damage reduction area at each optional residual flood stage. For illustration purposes, this mapping only took into account the protection that had previously been accredited by FEMA (e.g., 4th Street Levee, Fargo). Protection that is provided by other permanent projects (i.e., Horn Park in Moorhead, North Oaks Levee in Fargo) that have been constructed but not yet accredited by FEMA were excluded for this mapping in order to better illustrate floodplain impacts that would occur without accreditation. The extents of the projects requiring accreditation will be dependent on the final selected residual 100-year flood stage allowed through the flood damage reduction area. Additional information on the reaches requiring accreditation is included in Section 3 – Additional Mitigation Measures.

Maps showing the resultant 100-year inundation within the flood damage reduction areas under each optional residual flood stage between RS 30 feet and RS 37 feet are included in Appendix A – Residual Flood Stage Inundation Maps. A summary of the hydraulic model results including the frequency, resultant stages and discharges for each option is included in Appendix B – Hydraulic Evaluation Results.

2.2 EXISTING AND EMERGENCY PROTECTION MEASURES

Currently, during times of impending flooding, most developed areas in and adjacent to both cities are currently protected using a combination of emergency measures and permanent flood protection projects (both FEMA accredited

Typical sandbag truck — 2009

and non-accredited). These emergency measures vary in scale and type depending on the predicted flood stages.

The alignments of past emergency flood fight measures (i.e., 2009, 2010) were obtained from Fargo and Moorhead. Using this information, along with the inundation mapping, the estimated length of emergency and permanent protection measures requiring preparation, construction, operation and/or maintenance was determined for each optional flood stage. Note that since operation and maintenance of these measures may be required anytime the flood water reaches the base of them, the length of flood control measures included at each stage generally extends beyond the lengths that might be needed for actual protection.

The flood related efforts associated with these protection measures include advance preparations, flood alert actions, flooding period inspections and monitoring, and post-flood recovery.

Advance preparations for emergency operations start well in advance of flood threats. These include activities such as O&M manual reviews, assembling sufficient personnel for surveillance, pre-flood inspections, performing any necessary maintenance to ensure operation, and inventorying emergency equipment and supplies (sandbags, clay, polyethylene film, etc.).

Flood alert actions include such activities as closure of structures, construction of emergency protection measures (levees, sandbag dikes, etc.), testing of pump stations, examining ponding areas and drainage pipes, and securing backup power supplies and portable pumps to control seepage and interior runoff.

Flooding period inspections and monitoring include such activities as continuous patrols of levees, closures, and pumping stations during the flood. Continuous levee patrols typically begin once the river reaches the toe of the levee. Periodic inspection of the ponding areas, drainage pipes, and backup power supplies and portable pumps are also completed.

As soon as practical following a flood, general cleanup of the flood control measures are completed. This post-flood recovery includes activities such as removal of emergency measures, repair of erosion on permanent levees, opening closure structures, inspection and repair of damage to pipes, gates, operating mechanisms, pumps, ditches, etc.

The estimated annual operation and maintenance (O&M) cost for the existing and emergency protection measures under each residual flood stage was estimated and is presented in Table 3. The column listed as “100-yr Event Based Cost” indicates the cost that would be incurred as a result of a single 100-yr event inundation. The “Expected Annual Cost” provides probability weighted annual cost for the total O&M costs.

Table 3: Estimated O&M Cost for Existing and Emergency Flood Protection Measures under Current Conditions

Residual Flood Stage	100-yr Event Based Cost	Expected Annual Cost
RS30	$31,000	$25,000
RS31	$156,000	$100,000
RS32	$284,000	$178,000
RS33	$528,000	$284,000
RS34	$913,000	$397,000
RS35	$1,634,000	$513,000
RS36	$2,321,000	$533,000
RS37	$2,950,000	$543,000

Additional detail on how these estimates were calculated is included in Appendix C – Operation and Maintenance Background Data.

2.3 FLOOD DAMAGE REDUCTION AREA IMPACTED PRIVATE PROPERTY

In addition to impacting the existing and emergency protection measures, variation in the residual flood stage through the Flood Damage Reduction Area will also impact private property. Property is impacted in different ways depending on the type, location, and elevation of the property. These impacts may be by direct flooding of property, hindering or eliminating accessibility, and/or requiring cleanup and repair. Because all residual flood stages being considered would reduce the flood levels post-project compared to pre-project, no costs associated with the variation in these damages were calculated. However, in Section 3 of this report, proposed mitigation activities, such as property acquisitions and access improvements, were included in an effort to assist local decision makers in comparing the optional residual stages.

Hackberry Drive, Fargo (2009) showing typical private protection

On the following page, Table 4 provides a summary of the existing land use impacted at each optional residual flood stage within the protected area.

Table 4: Flood Damage Reduction Area Land Use Impacts

Residual Flood Stage	Land Use Class (NLCD) (acres)			Total Acres Impacted
	Agricultural	Developed	Other (Water, Wetland, Forest, Grass, etc.)	
RS30	14,764	2,229	5,483	22,476
RS31	14,920	2,311	5,581	22,812
RS32	15,266	2,409	5,681	23,356
RS33	15,881	2,524	5,781	24,186
RS34	16,722	2,656	5,894	25,272
RS35	17,998	2,858	6,062	26,918
RS36	19,658	3,191	6,222	29,071
RS37	21,773	3,556	6,386	31,715

2.4 FLOOD DAMAGE REDUCTION AREA IMPACTED INFRASTRUCTURE AND OPEN SPACES

The amount of public infrastructure (e.g., roads, bridges, drainage ditches, park facilities) also varies depending on the residual flood stage within the flood damage reduction area. Prior to flooding events, these facilities often require pre-flood preparations, such as culvert inspections and signing for potential closures. During flooding events, roadways require periodic inspections to look for damages/washouts that may pose threats to the traveling public. Following flooding events many of these facilities require cleanup, such as sediment and debris removal. Roadways that have overtopped also often require erosion repair and replacement of surfacing that was washed away during the flooding.

The estimated annual operation and maintenance cost for the impacted public infrastructure under each residual flood stage was estimated and is presented in Table 5.

Table 5: Estimated O&M Cost for Infrastructure and Open Spaces

Residual Flood Stage	100-yr Event Based Cost	Expected Annual Cost
RS30	$50,000	$41,000
RS31	$52,000	$42,000
RS32	$52,000	$42,000
RS33	$76,000	$53,000
RS34	$91,000	$57,000
RS35	$95,000	$57,000
RS36	$111,000	$58,000
RS37	$116,000	$58,000

Additional detail regarding how these estimates were calculated is included in Appendix C – Operation and Maintenance Background Data.

2.5 STAGING/STORAGE AREA AND DIVERSION CHANNEL IMPACTED PROPERTY AND INFRASTRUCTURE

The variation in residual flood stage through the flood damage reduction area also results in changes in the stage and frequency of flooding depth within the proposed Upstream Staging Area and also within Storage Area 1. Table 6 summarizes the resultant stages and frequency in each of these facilities. Note that there is no appreciable change in the 100-year flood stage because of the proposed gate operation; however, variation does occur for events more frequent than the 1% flood. This is because of the configuration of Storage Area 1. Additional details on the assumed operation are included in Appendix B – Hydraulic Evaluation Results.

Table 6: Variation in Stage and Frequency within Staging Area and Storage Area 1

Residual Flood Stage	Staging Area and Storage Area 1 Elevation		
	10-year – Staging Area	10-year – Storage Area 1	100-year – Both
RS30	916.7	915.2	923.2
RS31	916.6	915.1	923.2
RS32	916.6	915.1	923.2
RS33	909.1	910.3	923.2
RS34	N/A	N/A	923.2
RS35	N/A	N/A	923.2
RS36	N/A	N/A	923.2
RS37	N/A	N/A	923.2

It was assumed the property rights impacted within the Staging Area, Storage Area 1, and the along the Diversion Channel would be acquired based on the maximum design flood level. The change in frequency of inundation may affect the required acquisition costs for these property rights; however determining the amount of this change was beyond the scope of this evaluation.

The variable costs associated with operation, maintenance, cleanup, and repair of project components (e.g., tie-back levees, channels) and public infrastructure (e.g., roads, bridges, ditches) within the Staging Area, Storage Area 1, and along the Diversion Channel are presented in Table 7 for each residual flood stage.

Table 7: Estimated O&M Cost for Staging Area, Storage Area 1, and Diversion Channel

Residual Flood Stage	100-yr Event Based Cost	Expected Annual Cost
RS30	$481,000	$209,000
RS31	$526,000	$237,000
RS32	$540,000	$244,000
RS33	$480,000	$174,000
RS34	$487,000	$157,000
RS35	$504,000	$159,000
RS36	$525,000	$160,000
RS37	$530,000	$159,000

Additional detail on how these estimates were calculated is included in Appendix C – Operation and Maintenance Background Data.

2.6 GENERAL LOSS OF SERVICE

In additional to the costs in the previous sections, variations in the residual flood stage within the flood damage reduction area also result in loss of service/revenue in some areas that are flooded. For the range of elevations under consideration, these were limited to loss of service on public golf courses.

Table 8 on the following page presents the annualized estimated loss-of-service cost for each residual flood stage option.

Table 8: Estimated Loss-of-Service Costs within Flood Damage Reduction Area

Residual Flood Stage	100-yr Event Based Cost	Expected Annual Cost
RS30	$73,000	$59,000
RS31	$367,000	$236,000
RS32	$367,000	$236,000
RS33	$367,000	$236,000
RS34	$367,000	$236,000
RS35	$367,000	$236,000
RS36	$342,000	$235,000
RS37	$342,000	$235,000

Additional detail on how these estimates were calculated is included in Appendix C – Operation and Maintenance Background Data.

3 POTENTIAL MITIGATION MEASURES

Section 2 quantifies impacts as well as operation and maintenance costs associated with varying the residual flood stages through the flood damage reduction area. This section identifies potential mitigation measures that could be implemented to reduce the operation and maintenance costs, while providing added protection for impacted property within the flood damage reduction area.

Example permanent mitigation project - Timberline Area Floodwall, Fargo— 2011

These measures generally involve the following categories of potential mitigation efforts:

- Urban property and infrastructure flood risk management measures
- Rural property flood risk management measures
- Transportation mitigation measures

It should be noted that, because of the large geographic extents of this review, the scope of the study was only intended to be to a conceptual level of design. As a result, additional detailed design (survey, hydraulics, soil borings, etc.) will be required prior to implementing any of the proposed projects.

3.1 URBAN PROPERTY AND INFRASTRUCTURE FLOOD RISK MANAGEMENT MEASURES

Urban property and infrastructure flood risk management measures generally involve the implementation of FEMA-accredited permanent flood protection projects. This will involve the certification/accreditation of several existing projects and the construction of additional projects to eliminate the requirement for emergency levee and/or sandbag construction.

To be recognized as providing a 1-percent-annual-chance level of flood protection on NFIP maps, protection systems must meet and continue to meet the minimum standards set forth in Title 44 of the Code of Federal Regulations (CFR) Section 65.10 for the following three categories:

- Design
- Operation
- Maintenance

If appropriate documentation is certified by a registered Professional Engineer to show that a levee system meets these three categories, FEMA will "accredit" the levee system and will revise the affected FIRM panel to show the impacted area — landward of the levee system — as having a moderate flood risk.

According to CFR Section 65.10, riverine levees must provide a minimum freeboard of three feet above the water-surface level of the base flood. However, exceptions to the minimum riverine freeboard requirement may be approved by FEMA. The additional level of protection provided by the Diversion Channel may allow for a reduction in the freeboard requirement from the normal 3 feet; however, a future Risk and Uncertainty Analysis would be required to document this. For this analysis, three feet of freeboard was assumed and used. As such, the final top of permanent protection levees and tie-in elevations were set at the residual flood stage elevation plus 3 feet. The calculated quantities were increased to account for estimated overbuild volume that would likely be required to account for settlement and topsoil depths. Floodwall segments were developed with 4 feet of freeboard because of the difficulty in raising them during emergency events. The tie-in location for floodwall segments however were set at the residual flood stage elevation plus 3 feet, similar to the levee segments.

3.1.1 EXISTING URBAN FLOOD RISK MANAGEMENT PROJECT CERTIFICATION/ ACCREDITATION

Both Fargo and Moorhead have a number of existing and ongoing flood mitigation projects that have been or are being constructed

Existing Ridgewood Flood Control Project that would require certification / accreditation

to provide additional interim protection. Many of these projects were constructed since the record flood of 2009. Although none of these projects are currently FEMA certified/accredited according to City staff, the designs of most of the projects were completed consistent with the minimum standards set forth in the Code of Federal Regulations (CFR) Section 65.10 based on the current FEMA Preliminary 100-year Floodplain of approximately RS 39.4 feet. As a result, it was assumed in this evaluation that these projects could be certified/accredited, if necessary, for the optional residual flood stages of RS 30 feet to RS 37 feet being considered in this analysis.

Table 9 below presents a listing of the number of properties protected from the residual floodplain at each river stage by project. This table was developed based on the number of primary structures that would be touched by the residual 100-year floodplain at each elevation. Certification of the Ridgewood/VA project is currently in the process of undergoing certification/accreditation. No effort for certification/accreditation has begun on the other four projects.

Table 9: Estimated Number of Properties Protected From Residual Floodplain

Project	Estimated Number of Properties Protected from Residual Floodplain							
	RS30	RS31	RS32	RS33	RS34	RS35	RS36	RS37
Ridgewood/VA*	1	2	3	3	4	11	16	26
Project F1 Moorhead	0	0	0	0	0	1	3	3
Mickelson	0	0	0	1	3	6	8	8
Woodlawn	0	0	0	0	0	2	4	10
Horn	0	0	0	0	0	4	12	40

* Certification/accreditation of the Ridgewood/VA Project is currently pending.

The location of the existing projects that would require certification/accreditation are shown on the maps included in Appendix E – Conceptual Mitigation Plans.

Because these projects were recently designed and constructed, it is assumed that the certification/accreditation process would primarily be limited to review of the project plans, geotechnical evaluations, and other documents. As such, the estimated cost was based on the assumption that only limited additional analysis would likely be needed to complete and provide the necessary documentation.

Table 10 below presents the estimated cost of certification/accreditation for each residual flood stage.

Table 10: Estimated Cost of Certification/Accreditation

Residual Flood Stage	Estimated Cost of Certification/Accreditation
RS30	$0
RS31	$0
RS32	$0
RS33	$50,000
RS34	$50,000
RS35	$200,000
RS36	$200,000
RS37	$200,000

* Certification/accreditation of the Ridgewood/VA Project is currently pending – costs not included.

3.1.2 ADDITIONAL URBAN FLOOD RISK MITIGATION PROJECTS

Depending on the residual flood stage level, a number of properties and storm/sanitary lift stations become impacted. Wherever feasible, urban flood risk management projects were developed to provide protection for the impacted property and lift stations. Up to five urban areas were identified for additional urban flood risk management projects. The five potential areas are:

- El Zagal
- Mickelson Levee Extension
- 2nd Street/Downtown – North
- 2nd Street/Downtown – South
- Belmont Park, Fargo

Example permanent mitigation project - Meadow Creek Flood Risk Management Project — 2011

Wherever practical, two project options for each area were developed to provide the variation in potential projects that could be selected. Generally, the initial intent was to have one option that was more focused on structural protection (e.g. levees, floodwalls,…) and the other option focused more on floodplain abandonment (e.g. acquisitions,…). However, the overall scope of the project options vary considerably depending on the location and residual flood under consideration. In some areas (e.g., El Zagal, Mickelson) current uncertified protection exists that provides for “real” protection to a specific elevation. In these areas, urban flood risk management projects were not proposed to have a top elevation less than the existing “real” protection level. As a result, the same top elevation was proposed for multiple residual flood stages on the El Zagal and Mickelson Levee Extension projects. Maps showing the location/details of proposed projects at each residual flood stage are shown in Appendix E – Conceptual Mitigation Plans.

Below, Table 11 presents a listing of the number of properties protected from the residual floodplain at each river stage by each proposed mitigation project. This table was developed based on the number of primary structures that would be touched by the residual 100-year floodplain at each elevation.

Table 11: Estimated Number of Properties Protected From Residual Floodplain – Option 1

Project	Estimated Number of Properties Protected from Residual Floodplain							
	RS30	RS31	RS32	RS33	RS34	RS35	RS36	RS37
El Zagal	0	1	1	1	1	1	1	1
Mickelson Levee Extension	0	0	0	1	2	5	6	6
2nd Street/Downtown – North	0	0	0	0	0	0	4	4
2nd Street/Downtown – South	0	0	0	0	1	1	1	1
Belmont Park, Fargo	0	0	0	0	0	1	2	12

In addition to removing property from the residual floodplain, the proposed measures generally involve the implementation permanent levees or floodwalls that will eliminate the requirement for emergency levees and/or sandbag construction. This results in an overall reduction in the expected future operation and maintenance costs.

Tables 12 and 13 present the expected change in O&M costs and the estimated project implementation costs for the projects. They are listed as Option 1 and Option 2, respectively.

Table 12: Estimated Change in O&M Cost and Estimated Project Cost – Option 1

Residual Flood Stage	100-yr Event Based Cost Change	Expected Annual Cost Change	Estimated Project Cost
RS30	-$6,000	-$4,000	$0
RS31	-$64,000	-$40,000	$318,800
RS32	-$129,000	-$79,000	$18,445,160
RS33	-$292,000	-$151,000	$19,775,441
RS34	-$555,000	-$227,000	$28,294,811
RS35	-$1,059,000	-$310,000	$29,209,905
RS36	-$1,604,000	-$334,000	$33,959,435
RS37	-$2,069,000	-$346,000	$41,985,293

Table 13: Estimated Change in O&M Cost and Estimated Project Cost – Option 2

Residual Flood Stage	100-yr Event Based Cost Change	Expected Annual Cost Change	Estimated Project Cost
RS30	-$6,000	-$4,000	$0
RS31	-$66,000	-$40,000	$1,067,858
RS32	-$133,000	-$79,000	$12,376,026
RS33	-$297,000	-$151,000	$13,664,507
RS34	-$560,000	-$227,000	$22,327,277
RS35	-$1,064,000	-$310,000	$23,643,471
RS36	-$1,611,000	-$334,000	$28,518,101
RS37	-$2,084,000	-$346,000	$33,401,766

Details on how these estimates were calculated are included in Appendix C – Operation and Maintenance Background Data, Appendix D – HTRW Review, and Appendix F – Conceptual Mitigation Option of Probable Costs. The estimated project costs developed for each project were based on estimated quantities from the conceptual flood mitigation plans. These construction estimates were based on unit prices from recent similar flood mitigation projects constructed by the Cities of Fargo and Moorhead. Land acquisition estimates were also included and were based on comparable projects.

For lift station impacts that were not included within the five proposed urban flood risk management projects, it was assumed that elevation and/or relocation would be done to eliminate the impacts. No detailed lift station modification plans were developed; however, an estimated cost for each modification was included.

Similarly, for isolated private properties outside of the proposed urban flood risk management projects proposed, it was assumed that the properties would be reviewed in the future to determine if non-structural measures such as those identified in FR/FEIS Non-Structural Report could be used. However, these measures are very site building/site specific. As a result, each structure will need to be inspected by a team consisting of a floodplain engineer, structural engineer, cost engineer, civil engineer, and real estate specialist in order to determine the specifics relative to each type of measure employed. This level of review was beyond the scope of this evaluation.

As a result, for cost estimating purposes, it was assumed that each of the isolated urban properties would be acquired and removed if impacted by the residual floodplain. This should provide a relatively conservative estimate in the sense that any other non-structure

Typical Emergency Protection — 2009

measure found to be feasible would likely be less expensive. The isolated urban properties that should be reviewed for non-structural mitigation measures at each residual flood stage are identified on the maps included in Appendix E – Conceptual Mitigation Plans.

Table 14 presents the number of proposed isolated urban properties requiring mitigation measures and the estimated cost for the measures by residual flood stage.

Table 14: Estimated Number and Costs of Isolated Urban Property Mitigation

Residual Flood Stage	Number of Isolated Urban Property Requiring Additional Mitigation Measures	Estimated Mitigation Cost
RS30	0	0
RS31	0	0
RS32	0	0
RS33	0	0
RS34	0	0
RS35	1	$137,277
RS36	3	$798,162
RS37	5	$1,272,713

Additional detail on how these estimates were calculated is included in Appendix D – HTRW Review, and Appendix F – Conceptual Mitigation Option of Probable Costs.

3.2 RURAL PROPERTY FLOOD RISK MANAGEMENT MEASURES

Variation in the residual flood stage through the flood damage reduction area will also impact rural private property. Property is impacted in different ways depending on the type, location and elevation of the property. These impacts may be by direct flooding of property, hindering or eliminating accessibility, and/or requiring cleanup and repair.

Because all residual flood stages being considered would reduce the flood levels post-project compared to pre-project, coupled with the relatively low likelihood of growing season flooding, no specific mitigation was identified for agricultural production land. However, to better define the resultant impacts of varying the residual flood stage for rural structures, a cursory review of each property was completed to determine the individual impacts. Similar to the isolated urban structures discussed in the previous section, each of these rural properties should be reviewed in detail to determine if similar nonstructural mitigation measures to those identified in FR/FEIS Non-Structural Report could be used. This level of review was beyond the scope of this evaluation.

For this reason, in order to estimate the relative variation in resultant costs, a simplified approach was used in this evaluation. In this approach rural homesteads inside the protected area with the primary structure located within 450 feet of an adjacent river and touching the residual 100-year floodplain were assumed to require mitigative measures under each optional residual flood level. Since the appropriate type of mitigation would only be determined following a detailed non-structural assessment, the simplified approach assumed the method would be acquisition and removal for the purpose of costs estimating. The properties requiring mitigation are identified on the maps included in Appendix E – Conceptual Mitigation Plans.

Table 15 presents the resultant number of proposed rural properties requiring mitigation and estimated cost for these properties by residual flood stage.

Table 15: Estimated Number and Costs of Rural Property Mitigation Measures

Residual Flood Stage	Estimated Number of Rural Properties Requiring Mitigation Measures	Estimated Mitigation Cost
RS30	7	$1,918,000
RS31	7	$1,918,000
RS32	7	$1,918,000
RS33	8	$2,286,000
RS34	8	$2,286,000
RS35	11	$3,241,000
RS36	12	$3,340,000
RS37	17	$4,637,000

Additional detail on how these estimates were calculated is included in Appendix D – HTRW Review and Appendix F – Conceptual Mitigation Opinion of Probable Costs.

3.3 TRANSPORTATION MITIGATION MEASURES

Variation in the residual flood stage through the flood damage reduction area will also result in differing levels of impact on the rural transportation system. The higher the residual flood level, the more roads that become inundated. This results in difficulty and — in some cases — eliminates accessibility to certain property. In addition, increased O&M costs result from necessary pre-flood planning, monitoring, and restoration of roads following overtopping or inundation.

To mitigate for these impacts, the rural roads within the flood damage reduction area were reviewed and evaluated to determine the appropriate mitigation method for areas that were inundated. In general four different classifications were determined.

First, wherever considered practical, the roadway was proposed to be raised to a level of 1 foot above the residual flood stage where it would otherwise be inundated. In these areas, a cursory hydraulic review was completed to determine the approximate additional culvert capacity required to minimize adjacent stage impacts.

Second, in areas of substantial overtopping or Red River breakouts, the roadways were proposed to be unchanged because raising these areas would likely cause substantial hydraulic impact to the current river flows.

Third, in areas where the existing roadway is a limited maintenance or trail, no improvements were proposed.

Finally, in areas where the roadway was no longer serving a necessary use because of previous or proposed acquisitions of flood-prone property, the roadway was identified for abandonment.

The classification of the inundation sections of rural roadway by residual flood stage are identified on the maps included in Appendix E – Conceptual Mitigation Plans.

Table 16 presents the estimated change in O&M cost and the total cost of proposed transportation improvements by residual flood stage.

Table 16: Estimated Reduction in Annual O&M Cost and Project Cost

Residual Flood Stage	Event Based Cost Change	Expected Annual Cost Change	Estimated Transportation Improvement Cost
RS30	-$2,000	-$2,000	$2,895,501
RS31	-$2,000	-$2,000	$2,917,718
RS32	-$2,000	-$2,000	$3,038,745
RS33	-$2,000	-$2,000	$3,154,157
RS34	-$2,000	-$2,000	$3,344,944
RS35	-$2,000	-$2,000	$3,686,885
RS36	-$3,000	-$2,000	$4,466,899
RS37	-$4,000	-$2,000	$5,553,910

Additional detail on how these estimates were calculated is included in Appendix C – Operation and Maintenance Background Data and Appendix F – Conceptual Mitigation Opinion of Probable Costs.

3.4 SUMMARY OF ATTAINABLE FLOOD RISK MANAGEMENT MEASURES

Sandbagging effort — 2009

The purpose of this analysis was to evaluate options for varying the residual Red River of the North flood stage through the flood damage reduction area beyond the approximately RS 31 feet planned for the FRP. The potential mitigation measures included in Section 4 could be implemented to reduce the O&M costs while providing added protection for impacted property within the protected area. To accurately determine the benefit of each plan, a detailed economic analysis would need to be completed. This level of analysis was beyond the scope of this analysis. However, to get a general sense of the mitigation benefits provided at each flood stage, Tables 17 and 18 were developed to summarize some of the key findings. Local decision makers will also need to consider other values, such as the changes in required environmental mitigation, interim flood management benefits, changes in frequency of staging and use of the diversion channel, and other socioeconomic factors.

Table 17: Summary of Attainable Flood Risk Mitigation Measures – Option 1

Residual Flood Stage	Total 100-yr Event Based O&M Cost	Total Expected Annual O&M Cost	Total Proposed Mitigation Cost	Total Number of Properties Protected/ Removed from Residual Floodplain	Total 100-yr Event Based O&M Cost Change	Total Expected Annual O&M Cost Change
RS30	$635,000	$334,000	$4,813,501	8	-$8,000	-$6,000
RS31	$1,101,000	$615,000	$5,154,518	10	-$66,000	-$42,000
RS32	$1,243,000	$700,000	$23,401,905	11	-$131,000	-$81,000
RS33	$1,451,000	$747,000	$25,265,598	14	-$294,000	-$151,000
RS34	$1,858,000	$847,000	$33,975,755	19	-$557,000	-$227,000
RS35	$2,600,000	$965,000	$36,337,790	44	-$1,061,000	-$310,000
RS36	$3,299,000	$986,000	$41,966,334	72	-$1,607,000	-$334,000
RS37	$3,938,000	$995,000	$52,376,203	133	-$2,073,000	-$346,000

Table 18: Summary of Attainable Flood Risk Mitigation Measures – Option 2

Residual Flood Stage	Total 100-yr Event Based O&M Cost	Total Expected Annual O&M Cost	Total Proposed Mitigation Cost	Total Number of Properties Protected/ Removed from Residual Floodplain	Total 100-yr Event Based O&M Cost Change	Total Expected Annual O&M Cost Change
RS30	$635,000	$334,000	$4,813,501	8	-$8,000	-$6,000
RS31	$1,101,000	$615,000	$5,903,576	10	-$68,000	-$42,000
RS32	$1,243,000	$700,000	$17,332,771	11	-$135,000	-$81,000
RS33	$1,451,000	$747,000	$19,154,664	14	-$299,000	-$153,000
RS34	$1,858,000	$847,000	$28,008,221	19	-$562,000	-$229,000
RS35	$2,600,000	$965,000	$30,771,356	44	-$1,066,000	-$312,000
RS36	$3,299,000	$986,000	$36,525,000	72	-$1,614,000	-$336,000
RS37	$3,938,000	$995,000	$43,792,676	133	-$2,088,000	-$348,000

It should be noted that this analysis was based only on available existing data (i.e. LiDAR, previous soil borings, aerial photography, etc.). No new field data collection was completed as part of this analysis. Consequently, the conceptual mitigation plans and conceptual mitigation option of probable costs included in this report should be used with care to avoid misrepresenting the level of accuracy.

4 IMPLEMENTATION CONSIDERATIONS

The primary benefit of the potential modifications would be to reduce the required environmental mitigation (number and cost of fish passageways) as a result of reducing the frequency of operation of the diversion channel.

However, if the proposed mitigation measures to allow more flow through the flood damage reduction area are completed early in the construction phasing, they will also help to mitigate flood risk during events prior to completion of the diversion channel by lessening the extent of required temporary flood fighting measures. The proposed measures will also assist to mitigate the risk for floods that exceed the 100-year event after completion of the diversion channel.

Typical emergency in area of 4th Street Levee in downtown Fargo — 2009

For these reasons, during the implementation of the proposed mitigation measures, local decision makers should consider enhancements (e.g., added elevation, length) that could be added locally to allow the projects to meet both the long-term mitigation requirements and improved interim flood protection. For example, consideration should be given to constructing the proposed levees and floodwalls to a level consistent with the ongoing flood mitigation projects within the cities. In addition, rural flood prone properties that are selected for long-term mitigation review should be offered such mitigation in the short-term to eliminate existing flood risk.

A proposed schedule of potential mitigation activities is included in Appendix H – Project Schedule.

APPENDIX A – RESIDUAL FLOOD STAGE INUNDATION MAPS

APPENDIX B – HYDRAULIC EVALUATION RESULTS

APPENDIX C – OPERATION AND MAINTENACE BACKGROUND DATA

APPENDIX D – HTRW REVIEW

APPENDIX E – CONCEPTUAL MITIGATION PLANS

APPENDIX F – CONCEPTUAL MITIGATION OPINION OF PROBABLE COSTS

APPENDIX G – PROJECT SCHEDULE