4.1 Summary of Infrastructure Protection Investigation for Feature 1: Churchs Ferry

4.1.0 Flood Protection Strategy

The flood protection strategy that was analyzed for Churchs Ferry was relocation of the affected structures.

4.1.1 General Information

Feature Type: Community

Location: Churchs Ferry is located approximately 23 miles northwest of Devils Lake, ND on US Highway 2. The accompanying Figure 4.1-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Churchs Ferry was a community of approximately 77 people (based on 2000 census) prior to the FEMA buyout. Based on an October 2002 phone conversation with the mayor of Churchs Ferry (Paul Christenson), the current population of Churchs Ferry is 7 (after the FEMA buyout program).

Significance: Churchs Ferry is important because of its proximity along Burlington Northern Railroad and adjacent grain elevators. The rising lake level has affected Churchs Ferry over the last few years, and more structures could be affected by rising lake levels. The businesses remaining in Churchs Ferry provide services to the surrounding rural community.

Damages: The Economic Analyses identified only the loss of three homes, the grain elevator and church. Recent discussions with the mayor of Churchs Ferry indicated that there are several additional buildings that should be included. The grain elevator will be relocated during 2003. The flooding of Churchs Ferry would result in the following damages:

- loss of 3 homes
- loss of a church, firehall, City Hall, post office, automobile repair shop, bar, school buildings, Masonic Lodge, a City shop, a railroad maintenance building, and 3 other miscellaneous buildings
- sewage lagoons

Owner/Sponsor: Churchs Ferry city council is responsible for managing and maintaining Churchs Ferry.

Lead Federal Agency: The Corps of Engineers would take the lead for Churchs Ferry for any flood protection work that may take place. The Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

4.1.2 Feature Protection

History of Flood Protection: In the past, flood protection for Churchs Ferry has consisted of constructing a temporary levee to elevation 1451.5 and conducting a buyout program that was implemented in 2000. Only three residents decided to forego the buyout offer, all of which are located between 1456 and 1464. The other remaining buildings evaluated in this study were not part of the buyout program. It was assumed that the existing temporary levee would not be raised because the cost of raising it would exceed the value of the structures that it would protect.

Based on a phone conversation with BTR Farmers Coop staff on October 24, 2002, the grain elevator in Churchs Ferry is scheduled to be relocated. The new elevator is currently under construction and will be completed during the summer of 2003. The elevator will be located along the Burlington Northern Sante Fe (BNSF) mainline about 6 miles west of the current elevator. Grain operation will be moved during 2003 when the new elevator is completed.

General Protection Strategy: The Infrastructure Protection Study's analysis for Churchs Ferry considered one incremental flood protection strategy. At the first action level, relocation was the only strategy that was feasible both from an economic and a constructability standpoint. The strategy involved relocation of 3 residences, a church, firehall, City Hall, post office, repair shop, bar, school buildings, Masonic Lodge, a City shop, and a railroad maintenance building.

The existing sewage lagoons serve the 3 residences and the remaining buildings. The cost to protect or relocate the sewage lagoons or abandon the sewage lagoons and construct individual septic systems was not analyzed as part of this study.

Protection Strategy by Action Level: The single flood protection strategy analyzed for Churchs Ferry (relocation of structures) would require action before the water rises to 1452 and overtops the sewage ponds. This strategy is highlighted on the accompanying Figure 4.1-2.

The pertinent reference elevations for this flood protection strategy are given below:

Reference Elevations for Structure Relocations (AL1)		
Elevation	**Name**	**Significance**
1452	Low Structure Elevation	Top of berm at sewage lagoon
1451	Lake Damage Elevation	Lake elevation at which damage to sewage lagoon begins (assume 1-foot freeboard)

Reference Elevations for Structure Relocations (AL1)		
Elevation	**Name**	**Significance**
1451	Project Completion Elevation	Lake elevation at which structure relocation must be complete
NA	Construction Initiation Elevation	Lake elevation at which structure relocation must begin
NA	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

4.1.3 Design Considerations

Figure 4.1-1 shows the location of the Churchs Ferry structures.

4.1.3.0 General Design

Not applicable because there is no levee construction strategy.

4.1.3.1 Site Geology

No geologic concerns would be associated with the incremental strategy for this feature.

4.1.3.2 Hydrology/Interior Drainage issues

No interior drainage concerns would be associated with the incremental strategy for this feature.

4.1.3.3 Real Estate Requirements

No real estate concerns would be associated with the incremental strategy for this feature.

4.1.3.4 Environmental/Cultural issues

The potential environmental and cultural issues in Churchs Ferry were not analyzed in detail. The costs related to relocation of structures were incorporated into the relocation costs. The report for Feature 11: Burlington Northern Railroad (Along US Highway 2) discusses local environmental and cultural issues.

4.1.3.5 Effects on Existing Infrastructure and Utilities

Not applicable because there is no levee construction strategy.

4.1.3.6 Interdependencies

The protection of Churchs Ferry is related to the protection of the highways and railroads that serve it. These features include:

- Feature 11: Burlington Northern Railroad (Along US Highway 2)

- Feature 12: Burlington Northern Railroad (Churchs Ferry to Cando)
- Feature 13: US Highway 2
- Feature 16: US Highway 281 (South of US Highway 2)
- Feature 17: US Highway 281 (North of US Highway 2)

These highways and rail lines are critical for Churchs Ferry in that they provide the main transportation routes in and out of the community.

Table 4.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

4.1.3.7 O&M

No O&M is necessary for the incremental strategy for this feature.

4.1.3.8 Lead Time Required

Current FEMA policies make relocations unlikely until damage to the structures actually occurs (assumed to be 1 foot below the low structure elevation). Relocations would be done on an as-needed basis, with no lead time provided.

4.1.3.9 Potential Problems and Risks

- Utilities may need to be abandoned or relocated as part of the relocations.
- Abandonment of the sewage lagoon will require immediate relocation of all structures unless other means are provided to handle sewage.

4.1.3.10 Data Deficiencies

The following data should be collected or verified prior to proceeding with the relocations:

- Verify location, number, and elevation of structures that would need relocating.
- Precise locations of above ground and buried utilities.
- Verify environmental and cultural issues.
- The cost to protect or relocate the sewage lagoons or abandon the sewage lagoons and construct individual septic systems was not analyzed as part of this study. As the lake rises, it may be desirable to construct new sewage lagoons or install individual septic systems to maintain sewer service to the bar, post office, City Hall, the firehall, and other buildings at higher elevations.

- A detailed wave analysis was not performed for Churchs Ferry. The land adjacent to the sewage lagoon appears relatively flat, which will minimize wave action. A 1-foot freeboard was assumed for the Churchs Ferry Sewage Lagoon. Therefore it was assumed that damage to the sewage lagoons would occur after the lake reaches 1451. Maintenance may be required to protect the lagoon during operation at this level.

4.1.4 Economics of Flood Protection

Damages: For the Infrastructure Protection Study's analysis, the flood damage estimates for Churchs Ferry were reassessed in order to update and more accurately characterize the nature of the damages. The updated damage computations for Churchs Ferry are summarized in the accompanying Table 4.1-1. All damages were estimated up to the maximum lake level (1463) at the first action level.

The feature damages include the structures described in Section 4.1.1. Unit prices for all the damage computations were listed in Section 4.0, and are detailed in Table 4.0-2. An updated (as of 2002) list of assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Churchs Ferry are listed in the Churchs Ferry Infrastructure Protection Study Assumptions listing, attached to this Section 4.1.

Costs: The updated costs of providing flood protection for Churchs Ferry are detailed in the accompanying Table 4.1-2 for Churchs Ferry. Unit prices, data sources, and relevant assumptions are listed. All costs are given in 2002 dollars.

The flood protection costs for Churchs Ferry include relocation of all structures described in Section 4.1.1. Unit prices for all the cost computations were discussed previously in Section 4.0, and are detailed in Table 4.0-1. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Churchs Ferry are listed in the Churchs Ferry Infrastructure Protection Study Assumptions listing, attached to this Section 4.1.

Contingencies: For relocation of structures, a contingency percentage of 30% was used for all structures (Table 4.1-2).

4.1.5 Economic Results

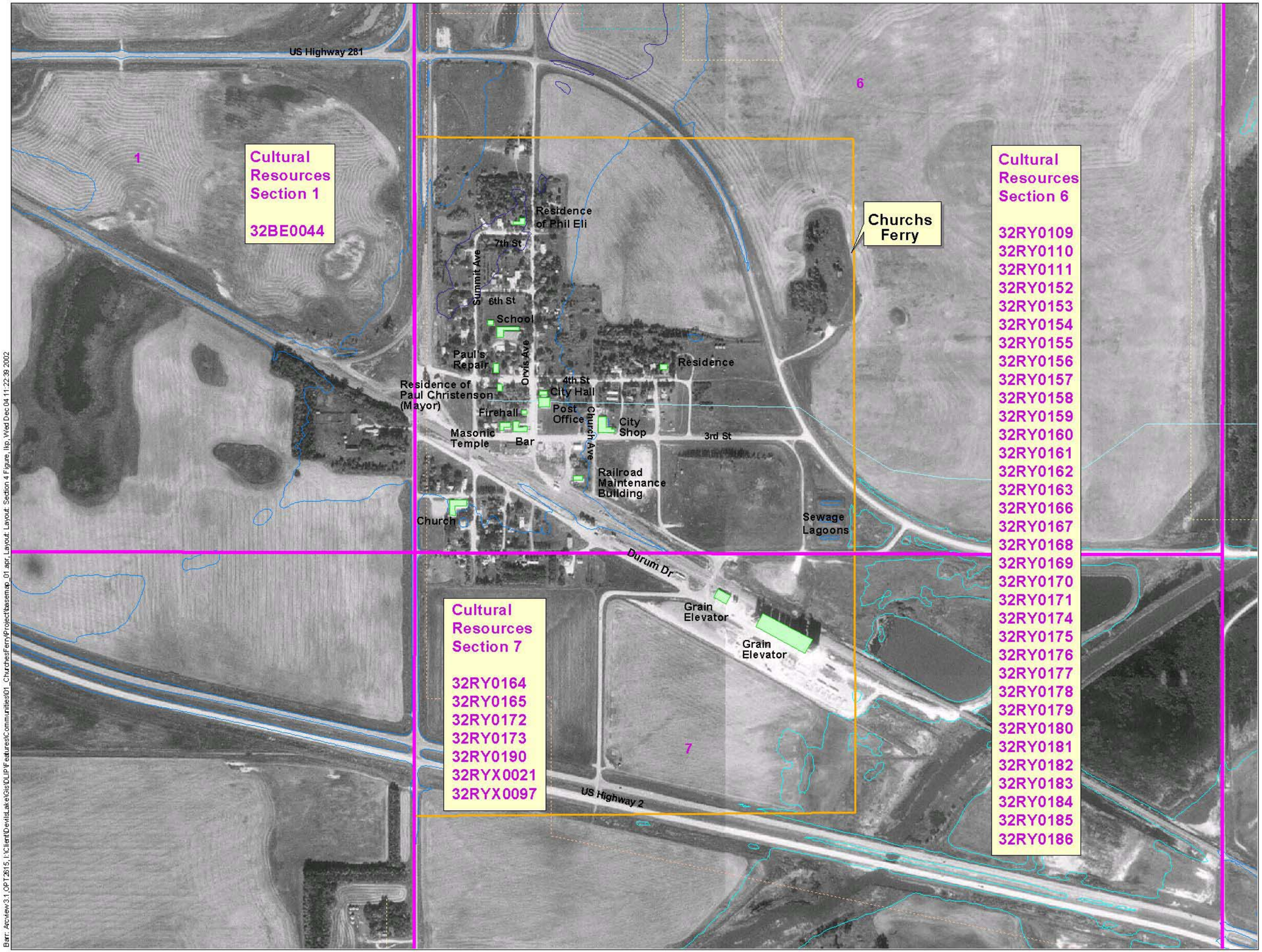
The results of the Infrastructure Protection Study for Churchs Ferry are listed in Table 4.1-3. Since there is only one action level for this feature, this table represents the results for both the first action level and for all action levels.

Stochastic Analysis Results: Using the stochastic analysis along with the updated damage and cost estimates for Churchs Ferry, the Infrastructure Protection Study's analysis provided relevant economic indices for relocation of structures at the first action level. The relocation of structures

at the first action level strategy is highlighted on the decision tree (Figure 4.1-2). The annual net benefits for this approach were less than zero ($-6,100). The BCR for this approach was less than one (0.76). These results show that this strategy is not economically justified. The annual damages prevented by this relocation strategy are $19,300. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: Relocation of structures at the first action level was also analyzed under each of three specific climate futures. For Churchs Ferry, the economic indices for each of the three climate futures are as follows:

- Wet Future – Under the wet future climate scenario, the net benefits of relocation of structures at the first action level were -$22,400, and the BCR was 0.76, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $70,900.
- First Moderate Future – Under the first moderate future climate scenario, lake levels do not reach first damage levels.
- Second Moderate Future – Under the second moderate future climate scenario, the net benefits of relocation of structures at the first action level were -$14,800, and the BCR was 0.76, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $46,800.



Data: 1997 USGS Digital Ortho Quad

N
W E
S

300 0 300 600 900 Feet

Reference Lake Contours

1447

1454

1463

Identified Structures

Cultural Resources Sites

Corporate Boundary

Pump Station

Utilities

Electric

Overhead

Underground

Unknown

Water

Watermain

Watermain, Abandoned

Sewer

Sewer

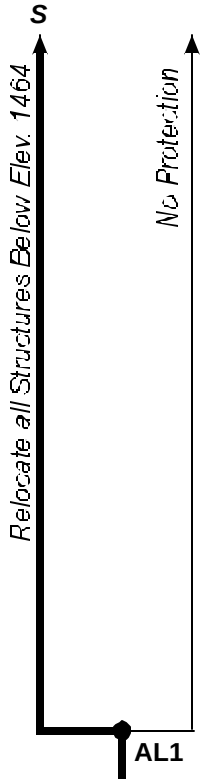
Sewer, Abandoned

Gas

Figure 4.1-1

LOCATION MAP
FEATURE 1: CHURCHS FERRY
Devils Lake Infrastructure Protection Study

Barr: Arcview 3.1, OPT2615, I:\Client\DevilsLake\Gis\DLIP\Features\Communities\01_ChurchesFerry\Projectbasemap_01.apr, Layout: Layout: Section 4 Figure, Ltp, Wed Dec 04 11:22:39 2002



▬▬▬	FloodProtectionStrategy
●	Decisionrequiredatthispoint
⊙	Triggerpointforaction,nodecisionneeded
AL1	Decision/Action Level
L(1)	Incrementalleveeraise(numberoftimes)
L	LeveeraisetoElev.1468
S(1)	Structurerelocation(numberoftimes)
S	RelocateallstructuresbelowElev.1464

Figure4.1-2

DECISION TREE
FEATURE 1:CHURCHSFERRY
DevilsLakeInfrastructure ProtectionStudy

P:\1360\020\DECISIONTREES\2002FIGURES\FIGURE4_01.CDR RLG 01-06-03

Table 4.1-1

Flood Damages
Feature 1: Churchs Ferry
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Structure Elevation Range	Structures and Infrastructure
	(MSL)	(THOUSANDS)
AL1	1453-1463	$1,479

DAMAGE BREAKDOWN

Structure Elevation 1453-1463				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	3	EA	$62,000	$186
Bar	1	EA	$17,100	$17
Church	1	EA	$104,000	$104
Pauls Repair	1	EA	$15,600	$16
School Building	1	EA	$550,000	$550
Misc Buildings	3	EA	$2,100	$6
RR Maintenance Building	1	EA	$55,000	$55
Firehall	1	EA	$109,000	$109
City Hall	1	EA	$109,000	$109
City Shop	1	EA	$109,000	$109
Masonic Lodge	1	EA	$109,000	$109
Post Office	1	EA	$109,000	$109
Total				**$1,479**

Table 4.1-2

Flood Protection Costs
Feature 1: Churchs Ferry
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	S
Action Level	Cost to Relocate Structures at AL1
	(THOUSANDS)
AL1	$1,946

COST BREAKDOWN

Strategy	S AT AL1					
	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)
Incremental Relocation	Residence	3	EA	$68,000	30%	$265
	Bar	1	EA	$17,100	30%	$22
	Church	1	EA	$104,000	30%	$135
	Pauls Repair	1	EA	$15,600	30%	$20
	School Building	1	EA	$550,000	30%	$715
	Misc Buildings	3	EA	$2,100	30%	$8
	RR Maintenance Building	1	EA	$55,000	30%	$72
	Firehall	1	EA	$109,000	30%	$142
	City Hall	1	EA	$109,000	30%	$142
	City Shop	1	EA	$109,000	30%	$142
	Masonic Lodge	1	EA	$109,000	30%	$142
	Post Office	1	EA	$109,000	30%	$142
	Total Relocation					**$1,946**

Table 4.1 - 3

Economics Results
Feature 1: Churchs Ferry
Devils Lake Infrastructure Protection Study

Stochastic Analysis (ST-9)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$19,300	$19,300	$0	$0	--
S(1)	Relocation of Structures at AL1	$0	$0	$25,400	$25,400	$0	$0	$19,300	-$6,100	0.76

Wet Future Scenario (WF-9)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$70,900	$70,900	$0	$0	--
S(1)	Relocation of Structures at AL1	$0	$0	$93,300	$93,300	$0	$0	$70,900	-$22,400	0.76

Moderate Future 1 Scenario (M1-4)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$0	$0	$0	$0	--
S(1)	Relocation of Structures at AL1	$0	$0	$0	$0	$0	$0	$0	$0	--

Moderate Future 2 Scenario (M2-4)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$46,800	$46,800	$0	$0	--
S(1)	Relocation of Structures at AL1	$0	$0	$61,600	$61,600	$0	$0	$46,800	-$14,800	0.76

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.125% and rounded to the nearest $100.
*Total benefits are calculated as the total damages incurred for the "No Protection" strategy minus the total damages for the strategy implemented (F(S)).

Attachment to 4.1:
Churchs Ferry Economic Analysis Assumptions

A. General Assumptions

1. Farmland losses were not included in this feature. These losses were included in Feature 8.1: Devils Lake Rural Areas.

B. Levees

1. It was assumed that the existing levee would not be raised because the cost of raising it would greatly exceed the value of the few structures that it would protect.

2. The top of the existing levee is at elevation 1451.5.

C. Residential And Commercial Property

1. The average value of a house in Churchs Ferry was estimated to be $62,000. This figure was obtained from the Federal Emergency Management Agency (FEMA) and represents the average value of a house located on the Spirit Lake Nation Reservation. The value for each house was determined for FEMA by certified flood insurance adjusters and was based on total habitable square footage of the buildings and standardized real estate appraisals (*FEMA*, personal communication, March, 2001). These values did not include the value of land on which the houses were located.

2. The average relocation cost for a house is $68,000. This cost was obtained from the North Dakota - North Central Planning Council and represents the average cost to relocate a residence during the buyout program conducted in Churchs Ferry in 2000. The $68,000 includes the following costs: demolition of the existing house, purchase of an equivalent house in a nearby community, purchase of a lot, and legal, appraisal, and management fees. Only 3 residents decided to forego the buyout offer, all of which are located between 1456 and 1464.

3. The cost for relocation/rebuilding of commercial and public facilities was assumed to be 100% of the value of the structure and property.

4. Based on a phone conversation with BTR Farmers Coop on October 24, 2002, the grain elevator in Churchs Ferry was scheduled to be relocated. The new elevator is currently under construction and will be completed during the summer of 2003. The elevator will be located along the Burlington Northern Sante Fe (BNSF) mainline about 6 miles west of the current elevator. Grain operation will be moved during 2003 when the new elevator is completed. The costs from the Economic Analysis were not included as part of the Infrastructure Protection Study

5. In 1998, the value of the church was estimated to be $100,000, including the value of the parcel. This value was updated for inflation by multiplying it by the ENR Building Cost Index of 1.042. This

accounts for 4.2% inflation during the period from 1998 to February 2001. The updated value is $104,000.

6. The existing sewage lagoons serve the 3 residences and the remaining buildings. The cost to protect or relocate the sewage lagoons or abandon the sewage lagoons and construct individual septic systems was not analyzed as part of this study.

7. Based on a phone conversation with the Jerry Ratzlaff, Ramsey County Assessor on October 25, 2002, the 2002 assessed values were used as relocation costs for the following buildings:

   - Bar: $17,100
   - Paul's Repair Shop: $15,600
   - 3 miscellaneous buildings: $6,300

8. The cost of relocating the school buildings was assumed to be $550,000. This was based on the Economic Analysis cost to relocate the school building at Minnewaukan.

9. The cost to relocate the firehall, City Hall, the City shop, Masonic lodge, and the post office was assumed to be $109,000 each. This was based on the average cost for government/public structures for Minnewaukan from the FEMA infrastructure database provided by Paul Seeley, FEMA, October 2002.

10. The cost to relocate the railroad maintenance building was assumed to be $55,000 (one half the above referenced cost for government/public structures at Minnewaukan).

11. The list of existing structures in Churchs Ferry was based on an October 2002 phone conversation with the mayor of Churchs Ferry (Paul Christenson).

4.2 Summary of Infrastructure Protection Investigation for Feature 2: City of Devils Lake

4.2.0 Flood Protection Strategy

The Economics Analysis indicated that the flood protection strategy with the largest net benefits for the City of Devils Lake was incremental raise of the existing levee. This strategy was evaluated in the Infrastructure Protection Study. Detailed plans for the first levee raise are currently being completed, and therefore more detailed information was available for this feature, as discussed below.

4.2.1 General Information

Feature Type: Community

Location: The City of Devils Lake is located in north central North Dakota 89 miles west of Grand Forks and 121 miles east of Minot on US Highway 2. It is the county seat for Ramsey County. The city is located along a portion of the north shore of Devils Lake and is currently protected by a levee that was constructed by the Corps. The accompanying Figure 4.2-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: The City of Devils Lake is a community of 7,222 people (based on 2000 census).

Significance: The City of Devils Lake is important because it is the largest city between Grand Forks and Minot and ranks as the 11th largest city in North Dakota.

Damages: The flooding of the City of Devils Lake would result in the following damages:

- loss of homes
- loss of historical buildings
- loss of commercial properties
- loss of public property including parks and land owned by Ramsey County and City of Devils Lake
- loss of Devils Lake Cemetery
- loss of schools including Minnie H Elementary School; Sweetwater Elementary; Prairieview Elementary School, Central Middle School, Harmony House, Lake Area Vo-Tech Center, North Dakota School for the Deaf

- loss of churches including Assembly of God Church, Christ Free Lutheran Church, St. Joseph Catholic Church, Lakewood Bible Camp Assembly of God
- loss of tax revenues
- loss of Devils Lake Airport
- loss of sewage treatment ponds serving the City of Devils Lake

Owner/Sponsor: The Devils Lake City Commission is responsible for managing and maintaining the City of Devils Lake.

Lead Federal Agency: The Corps of Engineers would take the lead for any flood protection work that may take place for the City of Devils Lake. The Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

4.2.2 Feature Protection

History of Flood Protection: In the past, flood protection for the City of Devils Lake has consisted of levee construction and incremental levee raises, road raises, and relocations. The rising water level has caused flooding of roadways and other infrastructure adjacent to the lake. Levees have been raised on several occasions to protect the City of Devils Lake from flooding because of the rising lake levels. Levees were most recently raised in 1998, with a design lake level of 1450. More recent evaluations indicate that the design level of protection for the existing levee is 1452.

The *Alternative Alignment Study* (Barr, January 2002) summarizes an analysis of extensions that are required for the Devils Lake levee system to provide continued protection against flooding of the city, and several alternatives for these extensions. That report should be referred to for the detailed analysis of these extensions. The analysis assumed the levees will be raised to 1460 to provide flood protection for the lake to 1454.

The following discussion of the City of Devils Lake feature was primarily excerpted from the *Alternative Alignment Study*, 2002. A preliminary MCASES cost estimate was also prepared for inclusion in this report. However, the analysis was completed after economics modeling had been conducted. Therefore, the economics model uses information from the *Alternative Alignment Study*, 2002 for the first action level.

General Protection Strategy: For the incremental levee raise strategy, the existing Stage 1A and Stage 2A levees need to be raised to provide continued protection of the City of Devils Lake against flooding. There are several locations where it will also be necessary to build smaller levees to connect high ground and maintain the integrity of the levee that protects the City of

Devils Lake. The minimum levee additions that will provide such protection at the first action level, designated the baseline alignments, are:

- Lakewood Segment 2
- Acorn Ridge Segments 2 and 3
- Highway 2 Segment 1
- Six tieback levees (three at the Golf Course, North Creel Bay, Highway 2, and Acorn Ridge)

The *Alternative Alignment Study* analyzed the levee tiebacks and various alternative levee alignments to raise the level of protection for the City of Devils Lake to a design lake elevation 1454, or top of levee (TOL) elevation 1460. These levee sections would be constructed concurrently with any future raises of the Stage 1A and Stage 2A levees. Plans and specifications for the levee raises of the Stage 1A, Stage 2A, tiebacks, and baseline alignments are currently under way. Figure 4.2-1 shows the Devils Lake region and identifies the levee alignment areas.

Protection Strategy by Action Level: The flood protection strategy that was analyzed in detail for the City of Devils Lake was for one incremental levee raise to a top of levee at 1460 (AL1). However, the Features Analysis Model was also used to determine the net benefits based on action levels to full height (AL1, AL2, and AL3).

The pertinent reference elevations for the flood protection strategy are given below:

Reference Elevations for Levee Raises				
Elevation				
AL1	**AL2**	**AL3**	**Name**	**Significance**
1457	1460	1465	Low Structure Elevation	Low point on top of levee
1454.5	1457	1462	Lake Damage Elevation	Lake elevation at which damage to levee begins (based on existing 5-foot freeboard as provided by Corps)[1] (assumed to be ½ height of freeboard)
1452	1454	1459	Project Completion Elevation	Lake elevation at which levee raise construction must be complete
1448	1450	1456	Construction Initiation Elevation	Lake elevation at which levee raise construction must begin (assume 2-year construction, elevation provided by Corps)
Current	1448	1455	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

[1] Freeboard will be increased to 6 feet for future raises.

4.2.3 Design Considerations

Sections 4.2.3.0 through 4.2.3.10 describe the analysis of the levee raise design, as well as other considerations (geotechnical, environmental, etc.) necessary to compute the cost estimates for the first action level. Section 4.2.3.11 describes the abbreviated cost estimating method for subsequent action levels.

4.2.3.0 General Design

The existing levee segments Stage 1A and Stage 2A were designed with a top width that would support a raise to 1460 without widening the base. Therefore, raising the existing levee sections for Action Level 1 (AL) will require an additional 3-foot raise on top of the existing levee.

The Infrastructure Protection Study also incorporated the baseline levee segment locations, which are described in detail below. All of the alternatives are based on a design lake level at elevation 1454. A Corps study on the effect of wind on the water elevations of Devils Lake indicates that the tops of levees should be approximately 6 feet above the design lake level. Therefore, the levee construction was designed with the top at elevation 1460. A detailed description of the levee construction is provided in the *Alternative Alignment Study*. Figure 4.2-3 shows typical cross-sections of the proposed baseline levees. Profiles for each levee segment are shown on Figure 4.2-4.

The following descriptions of the additional baseline levee sections are from the *Alternative Alignment Study* (updated with more current information) for AL1. These levee tiebacks and segments maintain the integrity of the existing City of Devils Lake levee system, there are no additional areas that would be protected with these levees. No internal flood control systems are required for these levees, since all areas will continue to drain in the same manner as they do under existing conditions. The alternatives that were analyzed for the baseline conditions are noted in each segment, although none of the alternatives were selected for construction.

Lakewood Segment 2

The Segment 2 levee will connect high ground across a relatively narrow gap between 1460 contours and is considered part of the baseline alternative. The north end of the levee will start east of Fair Road approximately 350 feet north of Samuelson Street and it will extend southeast to the south side of Samuelson Street (approximately 650 feet east of Fair Road). The alignment may impact two homes. The total length of levee for this segment would be about 700 feet, with a maximum height of about 3 feet.

Several alternative alignments were analyzed in the *Alternative Alignment Study*, some of which were economically justified. However the community selected the baseline alignment due to other reasons.

Golf Course Tieback Segments A, B, and C

Tieback levee Segments A, B, and C at the south end of the existing Stage 1A levee would extend the existing levee south to a hill near the golf course club house, south from the south side of that same hill to the most southerly portion of the existing levee, and south from the most southerly portion of the existing levee to Ramsey County Highway 1. Levee Segment A is within the golf course and Segment B is near the golf course entrance. It was assumed that the Segment C levee would be placed west of Fair Road, approximately midway between the cleared area and the existing homes. This location avoids the existing residences that are on the lakeshore and provides adequate land east of the levee for these residences to relocate on their property.

The total length of these levee segments would be about 170 feet, 20 feet, and 670 feet, respectively, with maximum heights of about 3 feet for Segments A and B, and about 5 feet for Segment C.

Acorn Ridge Tieback Segment

The Acorn Ridge tieback levee segment extends westerly from the existing Stage 2A levee to the nearest 1460 contour. The levee is about 80 feet in length and has a maximum height of about 3 feet. This levee extension is located in a heavily wooded area.

Acorn Ridge Segment 2

The Acorn Ridge Segment 2 levee connects the 1460 contours along the ridge near the Peterson Farm and is considered part of the baseline alternative for the Acorn Ridge Area. The north end of the levee starts at the Quiet Acres development east of 80th Avenue and extends southwest across a farm field. The length of this alignment is about 1,700 feet, with a maximum height of about 3 feet.

Several alternative alignments were analyzed in the *Alternative Alignment Study*, none of which were economically justified. This levee alignment is less desirable among the community because it does not protect a large field that could be developed with residential homes in the near future. Therefore, one additional alternative alignment is still under consideration for this closure.

Acorn Ridge Segment 3

The Acorn Ridge Segment 3 levee connects a narrow gap between 1460 contours in a heavily wooded area southwest of the water tower. The total length of the levee is about 170 feet, with a maximum height of about 1 foot. The alignment of this levee was designed to be just east of the existing water supply pipeline (the pipeline alignment to the watertower appears as an opening in the trees).

North Creel Bay Area

There is one area that requires levee closure in the North Creel Bay area: tieback of the north end of the existing Stage 1A levee. Only the baseline alignment was analyzed for this extension of the existing levee: extending the levee along the existing alignment to high ground. The existing levee is located underneath a gravel roadway (extending north from Highway 19). It was assumed for this analysis that this levee tieback would extend north along the roadway and that the roadway would be maintained as part of the levee construction. The total length that is required for this tieback levee would be about 500 feet, with a maximum height of about 3 feet.

Highway 2 Tieback Segment

This levee extends from the east end of the existing levee to the 1460 contour, a total length of about 270 feet and a maximum height of about 3 feet. The levee will extend generally straight out from the existing alignment.

Highway 2 Segment 1

The Highway 2 levee Segment 1 connects high ground in a low area east of the City of Devils Lake. The lake will encroach on the Highway 2 roadway embankment at 1454 (although it does not overtop the road). There is one culvert underneath Highway 2 in this area that would act as a conduit for flows. Closure of this area with a top of levee at 1460 is required to maintain the integrity of the Devils Lake levee system. One alternative levee is still being considered for this closure, however it would require construction of the levee within the existing ND DOT right-of-way for ND Highway 2.

The following table summarizes the levee lengths and heights to raise the top of levee to 1460 for AL1 (existing Stage 1 and Stage 2 levees are not shown):

AL1			
Area	**Segment**	**Length of Levee (feet)**	**Maximum Levee Height (feet)**
Lakewood	2	700	3
	Tieback A	170	3
	Tieback B	20	3
	Tieback C	667	5

AL1			
Area	Segment	Length of Levee (feet)	Maximum Levee Height (feet)
Acorn Ridge	2	1,700	3
	3	170	1
	Tieback	80	3
North Creel Bay	Tieback	500	3
Highway 2	1	1,800	9
	Tieback	270	3

4.2.3.1 Site Geology

Refer to the *Alternative Alignment Study* (Barr, January 2002).

4.2.3.2 Hydrology/Interior Drainage issues

Refer to the *Alternative Alignment Study* (Barr, January 2002).

4.2.3.3 Real Estate Requirements

Refer to the *Alternative Alignment Study* (Barr, January 2002).

4.2.3.4 Environmental/Cultural issues

This section summarizes the environmental issues related to the City of Devils Lake based upon summary of *Alternative Alignment Study*.

HTRW

Current land uses surrounding the tieback and closure levee alignments in Devils Lake were studied in 2001 and summarized in the following report by Barr Engineering: *HTRW Assessment, Devils Lake, North Dakota*, prepared for the Corps of Engineers, September 2001. These alignment areas appear to be mixed residential/commercial in the Lakewood and Acorn Ridge areas and rural in the Highway 2 and North Creel Bay areas. Land uses have not changed significantly since the 1960s. Several structures or land uses were identified as potential environmental risks. The risk of encountering a widespread release requiring major environmental remediation is minimal. Minor releases, resulting in isolated areas of contaminated soil, will likely be encountered during levee construction. It is recommended that a contingency plan for managing petroleum-contaminated soil and releases from transformers be in place prior to construction.

The following is a list of notable observations and findings that may present an environmental risk at each study area:

- **Lakewood Area**
  - Septic holding tanks, transformers, private water supply wells, and ASTs or potentially USTs for fuel oil are or may be present at the private residences.
  - A residence formerly occupied by an auto mechanic may have been used for auto repair. The parcel appears to have a gasoline AST and is currently used for carpentry.
  - The Chautauqua and railroad may have been sources of releases.
  - Stressed vegetation and disturbed soil were observed.
  - Housekeeping issues, including debris piles, were observed at many residences.
  - Abandoned lots may have formerly used private water supply wells, septic tanks, fuel oil tanks, and transformers.
- **Acorn Ridge Area**
  - Septic holding tanks, transformers, private water supply wells, and ASTs or potentially USTs for fuel oil are or may be present at private residences.
  - Abandoned debris, including automobiles, a pile of miscellaneous tires, metal docks, and scrap metal, were observed along the alignment.
  - Vegetative stress and stained soil near an area with abandoned automobiles.
  - A yellow AST with unknown contents was observed near the bin of snowmobile signs.
  - Abandoned drums with antifreeze and unknown contents and nearby stressed vegetation were observed along the proposed alignment.
- **Highway 2 Area**
  - Potential presence of septic tanks, private water supply wells, and AST or potentially UST fuel oil tanks is likely at the park and nearby farms.
  - Mertens farm appears to have chemical storage, anhydrous ammonia tank, abandoned tanks, grain elevator, large machinery maintenance, farm machinery debris, and potential presence of transformers.
  - Gasoline AST was observed at Shelvers Grove park.

- **North Creel Bay Area**
  - No environmental concerns were identified in this study area. The site is located in close proximity to the airport, which is the only adjacent property with the potential for significant releases. A potential release at the airport is not expected to affect the proposed alignment area.

Cultural Resources

A cultural resources analysis was not conducted for this feature because it was completed before as part of the *Alternative Alignment Study*. The following paragraphs summarize the cultural resources results of that investigation.

A Phase 1 Cultural Resources survey of the original levee alignments was conducted in 2001. In the *Alternative Alignment Study*, the tieback and closure segments and their alternatives were analyzed. Known cultural resources sites were identified within these corridors. Shovel testing was then performed in selected areas to determine the presence of sites. No cultural sites were identified during shovel testing along these alignments. However, the survey did identify approximately 20 structures that appear to have been constructed over 50 years ago, and may qualify for inclusion in the National Register of Historic Places. These structures are all located in the Chautauqua area within the Lakewood alignments, however none of those alternative alignments are included in the baseline segments that are being constructed. The Chautauqua area has much historical significance for the City of Devils Lake.

Environmental

The following information on environmental impacts was taken from the Corps Environmental Assessment for the Devils Lake Levee Raise Project.

Levee construction would primarily affect urban land. Some areas of grasslands, oak forest land and wetlands would also be affected. These areas have limited wildlife value due to their proximity to residential areas or from being subjected to grazing. Temporary work areas would be restored to their pre-project condition. In areas that would not be protected with riprap, the levees would be seeded with native species of grasses resulting in a small gain in grassland area. The locally preferred alignment for Acorn Ridge (Segment 4a) would require the removal of approximately 5 acres of trees. Other alignments, evaluated during the study, would require only minor amounts of tree removal. Trees would be replaced on a two-for-one basis.

There are about 33 acres of wetlands in the project area. Of approximately 2.2 acres that would be affected, about 1.2 acres of wetlands would be permanently filled by levee

construction. Mitigation would replace the lost wetland values. The local sponsor (City of Devils Lake) and the Devils Lake office of the FWS have agreed to develop a wetland restoration/enhancement plan for the wetland impacts in conjunction with the levee project. This could involve the inclusion of wetland features in a 5.3-acre interior drainage ponding area, restoration of degraded wetlands in the vicinity, or some other mutually acceptable plan. The project is not expected to affect the FWS wetland easements. Based on a recommendation from the FWS, if the interior drainage ponding areas were designed with wetland features, several culverts would be placed upright and designed to provide nesting habitat for waterfowl.

The potential borrow areas are upland sites. Most sites have already been used as sources of borrow material. If a site were not an active source of material, it would be surveyed for natural and cultural resources before being approved for use. The topsoil would be stripped and replaced following excavation. Depending on the final disposition of the site, the areas would be reseeded or returned to pre-project conditions.

The project would not affect the biodiversity of the area or fragmentation of the habitat. The project is located in a primarily residential environment. The project follows the alignment of the existing levee to a large degree. Impacts would be minimized through good project design and the mitigation of adverse effects on wetlands.

No critical habitat is located in the project area, and none of the threatened or endangered species are known to nest near the project site. The levee raise/extension would have no effects on any listed threatened or endangered species.

4.2.3.5 Effects on Existing Infrastructure and Utilities

Refer to the *Alternative Alignment Study* (Barr, January 2002).

4.2.3.6 Interdependencies

The City of Devils Lake is the primary center of activity for the Devils Lake area, providing much of the necessary services for the entire surrounding rural community. Therefore, it is interdependent with the entire surrounding community. The protection of the City of Devils Lake is related to the protection of the highways and railroads that serve it. These features include:

- Feature 10: Canadian Pacific Railroad
- Feature 11: Burlington Northern Railroad (Along US Highway 2)
- Feature 13: US Highway 2

- Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281)
- Feature 18: ND Highway 19
- Feature 20: ND Highway 20 (North of the City of Devils Lake)
- Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57)
- Feature 22: ND Highway 20 (ND Highway 57 to Tokio)

These highways are critical for Devils Lake in that they provide the main transportation routes in and out of the community.

Table 4.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

4.2.3.7 O&M

Refer to the *Alternative Alignment Study* (Barr, January 2002).

4.2.3.8 Lead Time Required

Planning and implementation of flood protection measures must begin well in advance of the time when lake water would actually be causing damage to the feature. The lead time will depend on the time needed to plan and implement the flood protection measure. For the City of Devils Lake, estimates of required times for the levee construction are as follows:

- Time required for planning and design – a lead time of about twelve months would be necessary for final design, preparation of construction documents and bidding. Planning and design will be completed by the spring of 2003.
- Time required for construction – it was assumed that raising the existing City of Devils Lake Stage 1A and 2A levees could be completed in one construction season, and the remaining tiebacks and closures could be completed in the second consecutive construction season.
- The total time between initiation of final design and substantial completion of construction was assumed to be in the range of 30 to 36 months.

Lead time estimates were provided by the Corps.

4.2.3.9 Potential Problems and Risks

Refer to the *Alternative Alignment Study* (Barr, January 2002).

4.2.3.10 Data Deficiencies

Refer to the *Alternative Alignment Study* (Barr, January 2002).

4.2.3.11 Abbreviated Cost Estimating for Feature Subsequent Action Levels

As was mentioned previously, for Feature 2, an abbreviated method was necessary for examining the costs of infrastructure protection at action levels above the first. The estimated costs at action levels subsequent to the first were taken directly from the Economic Analysis, and are presented in Table 4.2-2b. No additional analyses were completed and no changes were made to the unit costs. Levee raise costs for the subsequent action levels do not include any geological/geotechnical considerations, environmental quantities and costs, or real estate.

Estimates of benefits—damages prevented—for subsequent action levels were also obtained from the Economic Analysis, no further analyses were completed. The damage estimates for all action levels are shown in Table 4.2-1.

4.2.4 Economics of Flood Protection

Damages: For the Infrastructure Protection Study's analysis of the first action level, the flood damage estimates for the City of Devils Lake were reassessed in order to update and more accurately characterize the nature of the damages. Damages estimates for subsequent action levels were obtained directly from the Economic Analysis. The updated damage computations for the City of Devils Lake are summarized in the accompanying Table 4.2-1.

The damages that would occur if no flood protection were provided include damages to structures, utilities, city property, cemeteries, and the airport that are currently protected by the existing levees.

Unit prices for all the damage computations were listed in Section 4.0, and are detailed in Table 4.0-2. An updated (as of 2002) list of assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for the City of Devils Lake is listed in the City of Devils Lake Infrastructure Protection Study Assumptions listing, attached to this Section 4.2.

Costs: The updated costs of providing the first action level of flood protection to the City of Devils Lake are detailed in the accompanying Table 4.2-2a (based on data from the *Alternative Alignment Study*, 2002). Unit prices, data sources, and relevant assumptions are listed. All costs for the first action level are given in 2002 dollars. The costs for subsequent action levels are listed in Table 4.2-2b (based on data from the Economic Analysis).

The total estimated cost for raising the City of Devils Lake levees to provide flood protection to Lake Elevation 1454 was $6.3 million in the economics evaluation for the Infrastructure Protection Study. These costs include environmental impacts (HTRW and natural resources) and utility modifications. A detailed feasibility cost estimate was also prepared in MCACES using existing available information. These project costs and contingencies were priced at December 2002 price levels. This estimate resulted in a total estimated cost of $7.2 million. A summary table from the MCACES estimate is provide in Table 4.2-2c. Note that the MCACES total cost differs from the cost used in the Infrastructure Protection Analysis. However, this difference is not expected to change the economic justification for this feature. A more detailed write-up is provided in the Cost Data section of the supporting documentation for this report.

The construction costs for levee tiebacks and closure sections for the first action level are listed by levee segment in Table 4.2-2a. These costs also include environmental impacts (HTRW and natural resources) and utility modifications.

Unit prices for the cost computations at the first action level were discussed previously in Section 4.0, and are detailed in Table 4.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for the City of Devils Lake are listed in the City of Devils Lake Infrastructure Protection Study Assumptions listing, attached to this Section 4.2.

Contingencies: The contingency percentages used for construction materials ranged from 30 to 50% (Table 4.2-2). Contingencies for riprap, removals, and seed were estimated at the higher end of the range because of the potential variability in the quantities and unit prices.

4.2.5 Economic Results

The flood protection strategy that was analyzed was incremental levee raises, which is highlighted on the decision tree (Figure 4.2-2). The results of the Infrastructure Protection Study for the City of Devils Lake are listed in Table 4.2-3a for the analysis of all action levels and in Table 4.2-3b for the analysis of the first action level.

Multiple Action Level Stochastic Analysis Results: Using the stochastic analysis along with the updated damage and cost estimates for the City of Devils Lake, the Infrastructure Protection Study's analysis provided relevant economic indices for three incremental levee raises. The results for all action levels are shown on the Economic Results table (Table 4.2-3a). The annual net benefits for this approach were greater than zero ($365,200). The BCR for this approach was greater than one (1.30). These results indicate that this strategy is economically justified. The stochastic results are averages over 10,000 traces.

The net benefits computed in the Infrastructure Protection Study are significantly less than those computed in the Economic Analysis. The primary reason for the reduction in net benefits is the

increase in the damage elevation, so that damages are incurred later than the construction costs. In some traces, the costs are incurred and the lake level never reaches the damage level.

Multiple Action Level Results for Specific Scenarios: Three incremental levee raises were also analyzed under each of three specific climate futures. For the City of Devils Lake, the economic indices for each of the three climate futures are as follows:

- Wet Future – Under the wet future climate scenario, the net benefits of three incremental levee raises were $6,972,700, and the BCR was 2.84, indicating that this strategy was economically justified.
- First Moderate Future – Under the first moderate future climate scenario, the net benefits of three incremental levee raises were -$1,485,800, indicating that this strategy was not economically justified. Under this future, levee raises were implemented, however, the lake level never reached the first damage level.
- Second Moderate Future – Under the second moderate future climate scenario, the net benefits of three incremental levee raises were $3,814,700, and the BCR was 2.55, indicating that this strategy was economically justified.

First Action Level Stochastic Analysis Results: Using the stochastic analysis along with the updated damage and cost estimates for the City of Devils Lake, the Infrastructure Protection Study's analysis also provided relevant economic indices for one incremental levee raise. These results are shown on the Economic Results table (Table 4.2-3b).

The annual net benefits for this approach were greater than zero ($1,294,000). The BCR for this approach was greater than one (5.74). These results show that this strategy is economically justified. The stochastic results are averages over 10,000 traces.

The results for the first action level indicate economic justification for this feature, similar to the results computed for all action levels for this feature, but indicate higher net benefits. The higher net benefits are attributable to the first action level damages that are very high compared to subsequent action levels and the costs that are relatively minor at the first action level (because the base does not need to be expanded).

First Action Level Results for Specific Scenarios: One incremental levee raise was also analyzed under each of three specific climate futures. For the City of Devils Lake, the economic indices for each of the three climate futures are as follows:

- Wet Future – Under the wet future climate scenario, the net benefits of one incremental levee raise were $10,392,400, and the BCR was 29.46, indicating that this strategy was economically justified.

- First Moderate Future – Under the first moderate future climate scenario, the net benefits of one incremental levee raise were -$180,100, indicating that this strategy was not economically justified. The levee raise was implemented, however, the lake level never reached the first damage level.

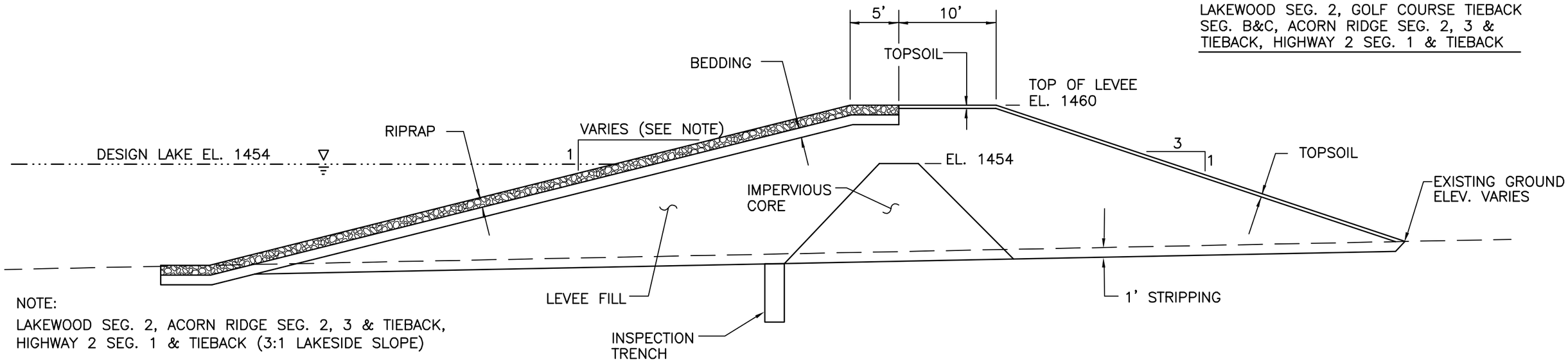
- Second Moderate Future – Under the second moderate future climate scenario, the net benefits of one incremental levee raise were $5,915,500, and the BCR was 17.07, indicating that this strategy was economically justified.

Figure 4.2-1

LOCATION MAP
FEATURE 2: CITY OF DEVILS LAKE
Devils Lake Infrastructure
Protection Study

Barr: Arcview 3.1, PIII/AF, I:\Client\DevilsLake\Gis\DLIP\Features\Communities\02_DevilsLake\Project\devilslake_02.apr, Layout: Section 4 figure, llp, Tue Nov 12 11:57:35 2002

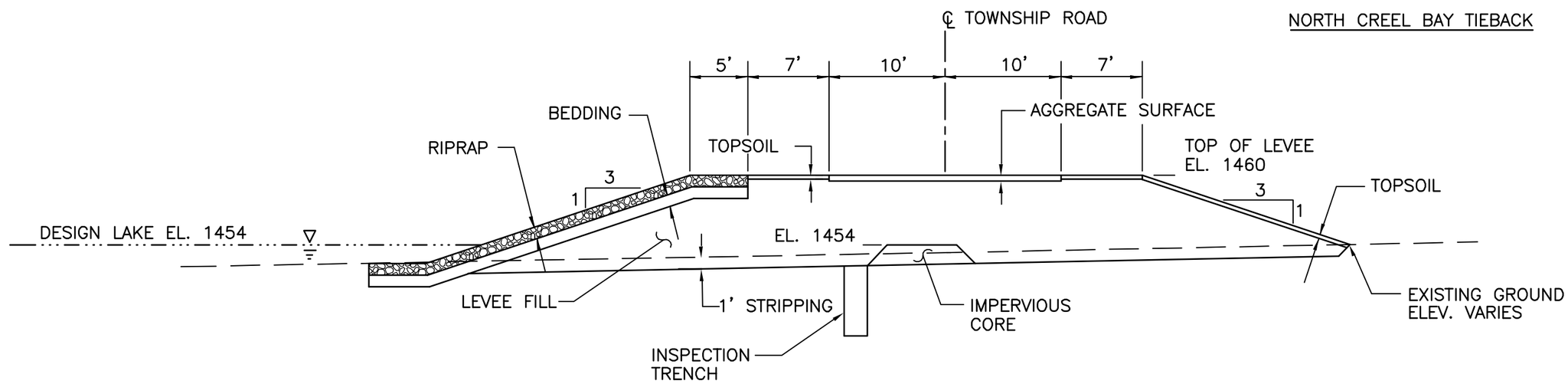
Data: 1997 USGS Digital Ortho Quad

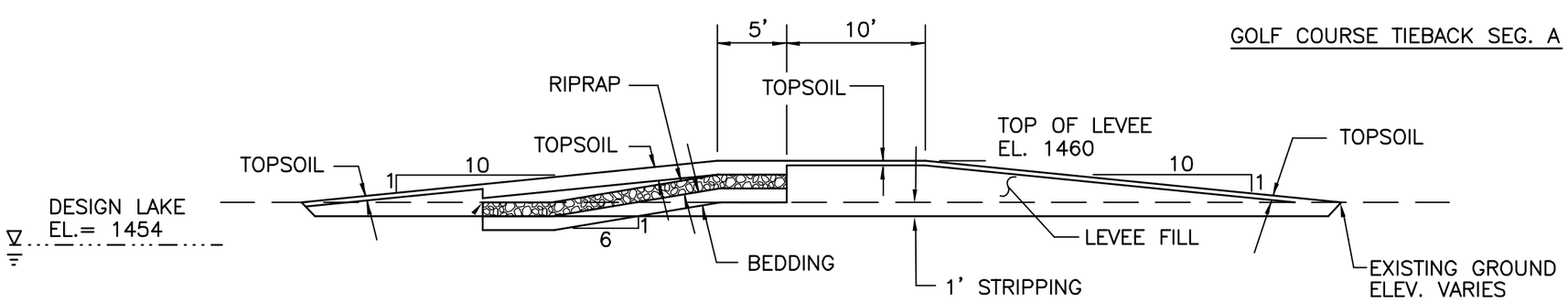


NOTE:

LAKEWOOD SEG. 2, ACORN RIDGE SEG. 2, 3 & TIEBACK, HIGHWAY 2 SEG. 1 & TIEBACK (3:1 LAKESIDE SLOPE)

GOLF COURSE TIEBACK SEG. B&C (4:1 LAKESIDE SLOPE)





0 10 20

SCALE IN FEET

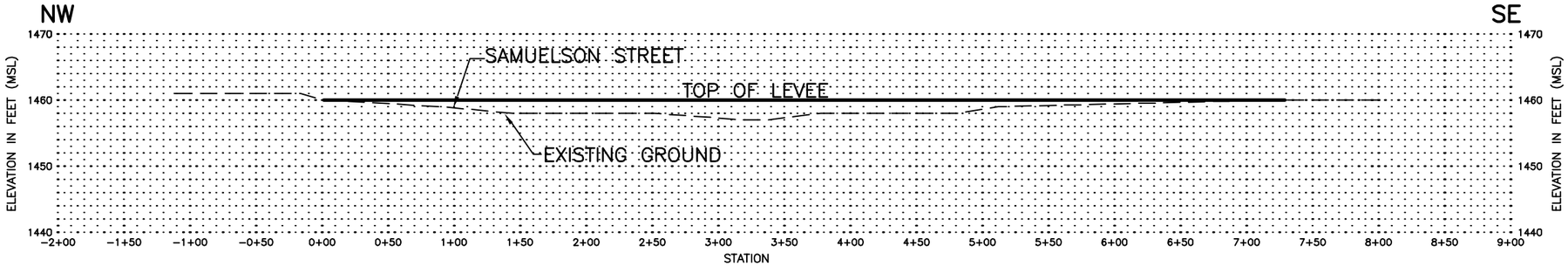
Figure 4.2–3

TYPICAL LEVEE CROSS–SECTIONS

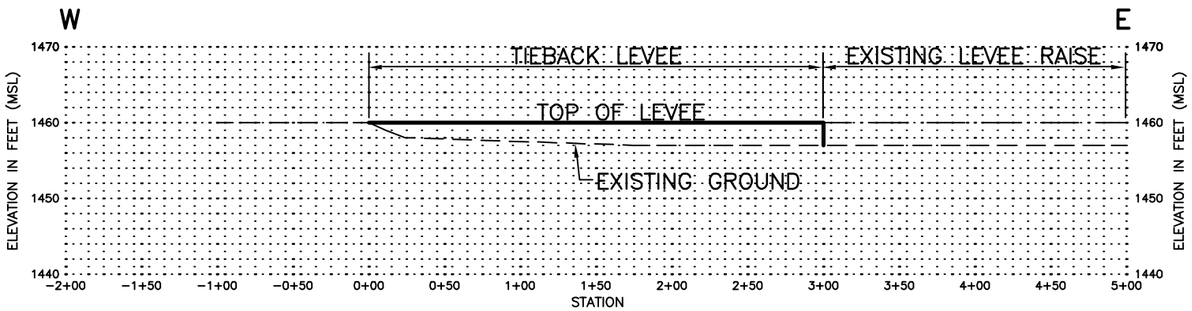
FEATURE 2:
CITY OF DEVILS LAKE

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

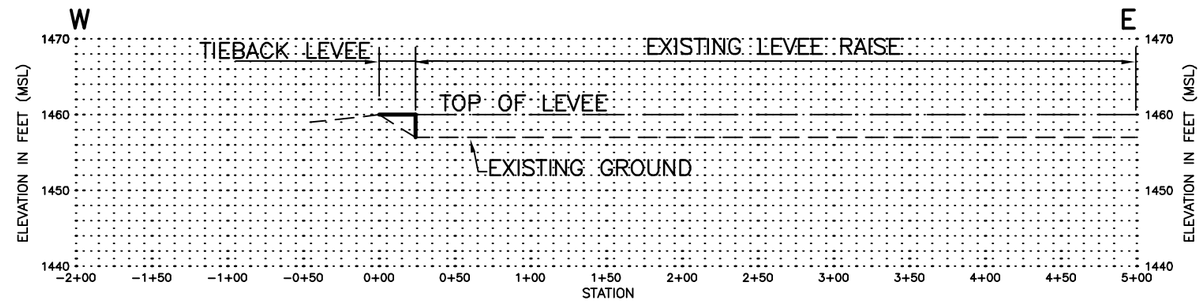
NRD M:\CAD\3436020\17268_2.DWG Plot at 10 11/05/2002 12:49:52



LAKEWOOD SEG 2



GOLF COURSE TIEBACK A



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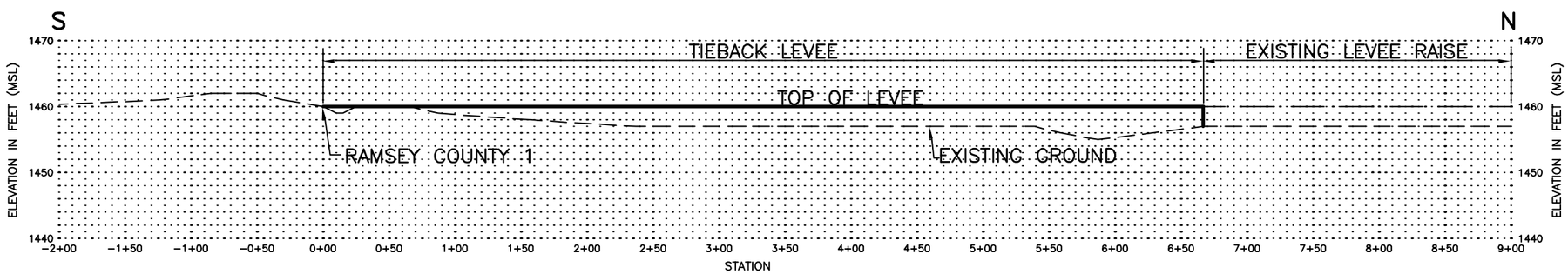
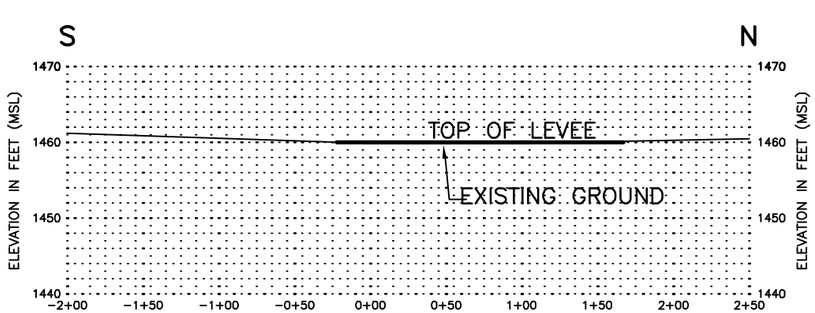
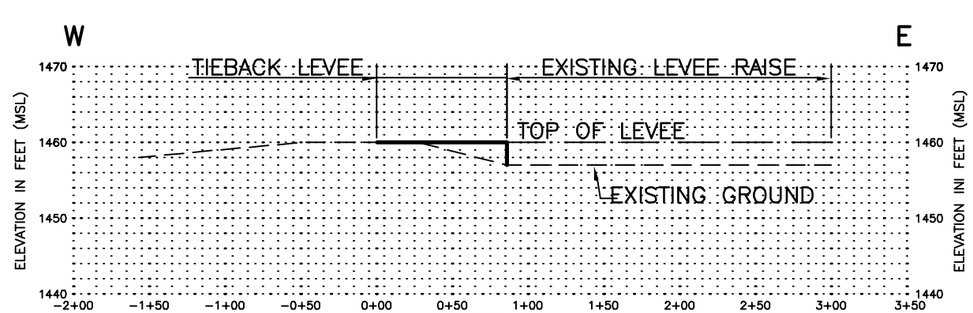


GOLF COURSE TIEBACK C



ACORN RIDGE SEG 3



ACORN RIDGE TIEBACK

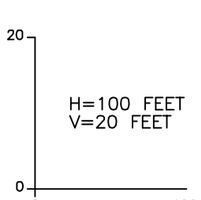


Figure 4.2–4a

LEVEE PROFILES

FEATURE 2:
CITY OF DEVILS LAKE

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

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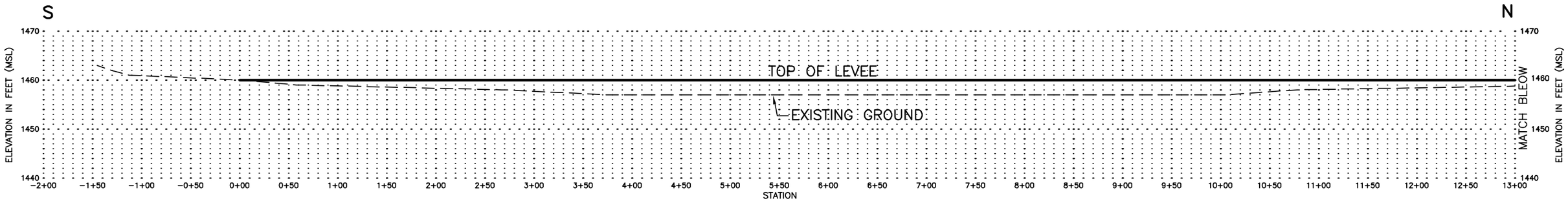
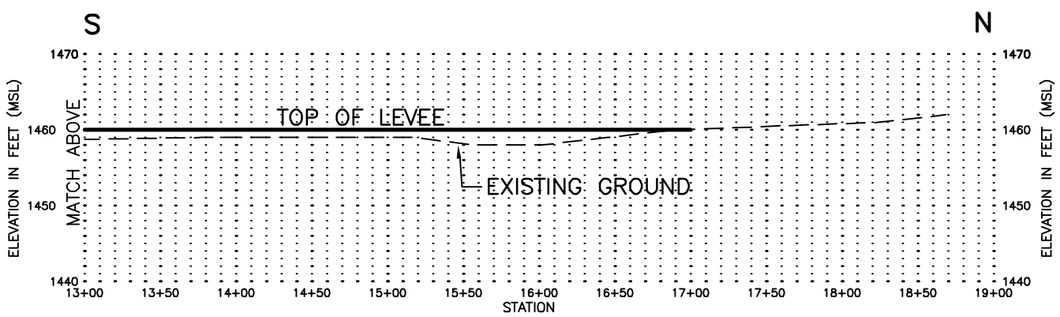
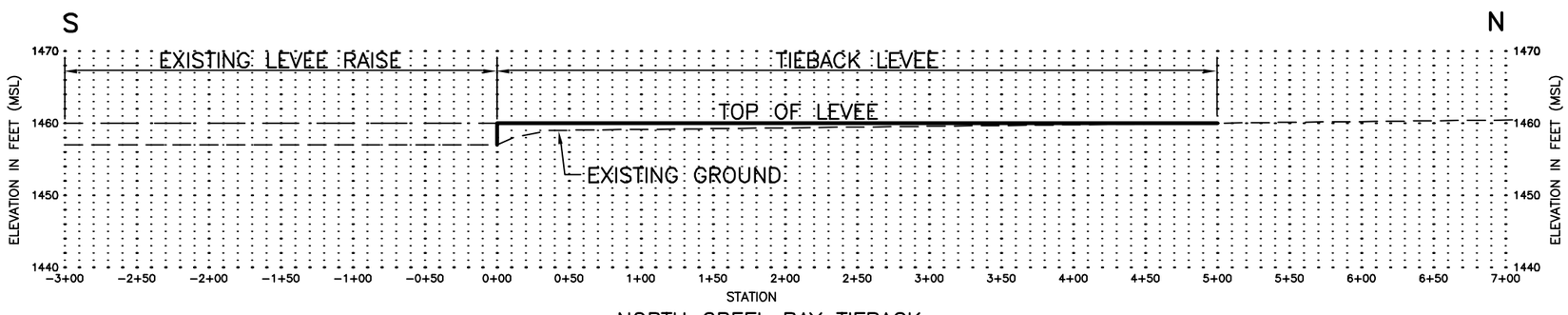


ACORN RIDGE SEG 2



ACORN RIDGE SEG 2 (CONT)



NORTH CREEL BAY TIEBACK

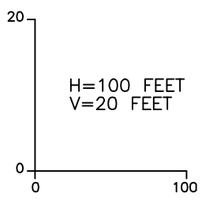


Figure 4.2–4b

LEVEE PROFILES

FEATURE 2:
CITY OF DEVILS LAKE

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

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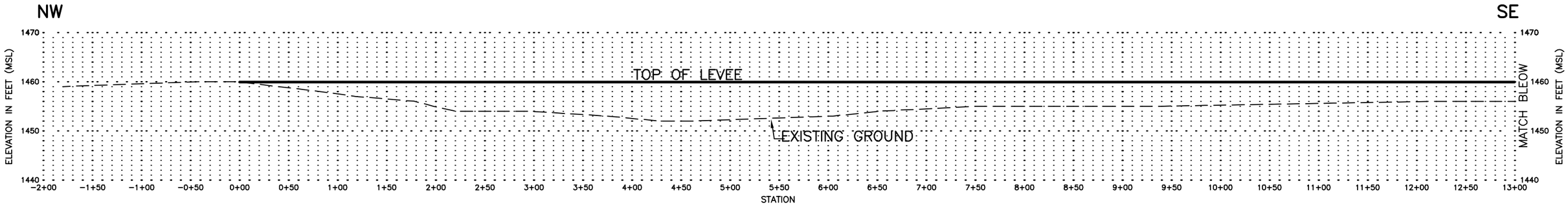
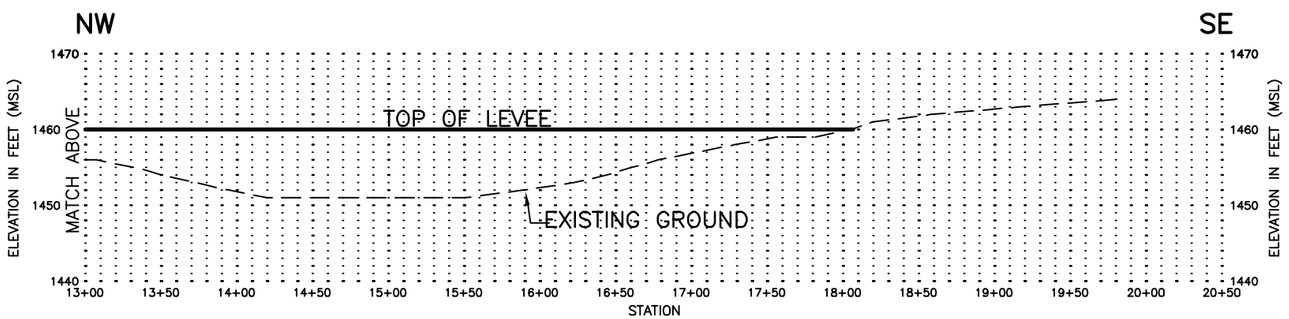


HIGHWAY 2 SEG 1



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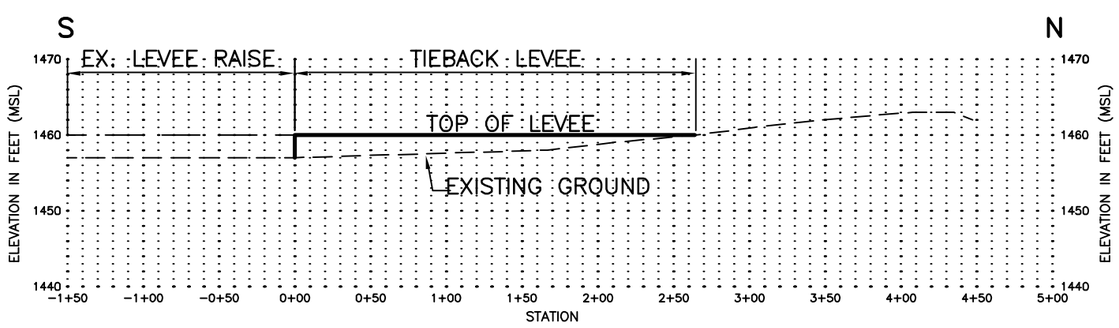

HIGHWAY 2 TIEBACK

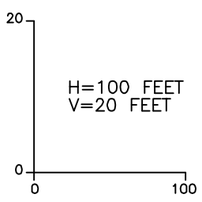

Figure 4.2–4c

LEVEE PROFILES

FEATURE 2:
CITY OF DEVILS LAKE

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

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Table 4.2-1

Flood Damages

Feature 2: City of Devils Lake

Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Structure Elevation Range (MSL)	Structures and Infrastructure (THOUSANDS)
AL1	Below 1457	$223,729
AL2	1457-1462	$56,311
AL3	1462-1464	$25,340

DAMAGE BREAKDOWN

Structure Elevation Below 1457					Structure Elevation 1457-1462					Structure Elevation 1462-1464				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Assessed Residential and Commercial	1	LS	$160,120,000	$160,120	Assessed Residential and Commercial	1	LS	$45,104,000	$45,104	Assessed Residential and Commercial	1	LS	$20,297,000	$20,297
Churches and Schools	1	LS	$7,540,000	$7,540	Churches and Schools	1	LS	$0	$0	Churches and Schools	1	LS	$0	$0
Utilities	1	LS	$36,715,000	$36,715	Utilities	1	LS	$10,342,000	$10,342	Utilities	1	LS	$4,654,000	$4,654
Airport	1	LS	$11,837,000	$11,837	Airport	1	LS	$0	$0	Airport	1	LS	$0	$0
City Property	1	LS	$3,069,000	$3,069	City Property	1	LS	$865,000	$865	City Property	1	LS	$389,000	$389
Cemetary	1	LS	$4,448,000	$4,448	Cemetary	1	LS	$0	$0	Cemetary	1	LS	$0	$0
Total				**$223,729**	**Total**				**$56,311**	**Total**				**$25,340**

Table 4.2-2a

Flood Protection Costs
Feature 2: City of Devils Lake
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	L(1)
Action Level	Cost to Incrementally Raise Levee at L(1)
	(THOUSANDS)
AL1	$6,327

COST BREAKDOWN

Strategy	L(1) AT AL1 Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)
Incremental Levee Raise	**Lakewood Segment 2 - Raise Top of Levee to El. 1460**					
	Performance/Payment Bond	1	JB	$291	10%	$0
	Levee Construction					
	Clearing and Grubbing	1.0	AC	$3,000	30%	$4
	Stripping (1')	584	CY	$1.50	30%	$1
	Removals	1	JB	$2,000.00	50%	$3
	Inspection Trench	0	LF	$4.00	30%	$0
	Levee Fill	886	CY	$5.00	30%	$6
	Bedding	238	CY	$35	30%	$11
	Riprap	238	CY	$40	40%	$13
	Sand Drain	0	CY	$22	30%	$0
	Topsoil (4")	598	CY	$2.50	30%	$2
	Seed	1.1	AC	$1,000	50%	$2
	Subtotal Levee Construction					$42
	Golf Course Tieback Segment A - Raise Top of Levee to El. 1460					
	Performance/Payment Bond	1	JB	$154	10%	$0
	Levee Construction					
	Clearing and Grubbing	0.3	AC	$3,000	30%	$1
	Stripping (1')	227	CY	$1.50	30%	$0
	Removals	1	JB	$1,000.00	50%	$2
	Inspection Trench	0	LF	$4.00	30%	$0
	Levee Fill	597	CY	$5.00	30%	$4
	Bedding	121	CY	$35	30%	$6
	Riprap	121	CY	$40	40%	$7
	Sand Drain	0	CY	$22	30%	$0
	Topsoil (4")	440	CY	$2.50	30%	$1
	Seed	0.8	AC	$1,000	50%	$1
	Subtotal Levee Construction					$22
	Golf Course Tieback Segment B - Raise Top of Levee to El. 1460					
	Performance/Payment Bond	1	JB	$11	10%	$0
	Levee Construction					
	Clearing and Grubbing	0.0	AC	$3,000	30%	$0
	Stripping (1')	22	CY	$1.50	30%	$0
	Removals	1	JB	$100.00	50%	$0
	Inspection Trench	0	LF	$4.00	30%	$0
	Levee Fill	20	CY	$5.00	30%	$0
	Bedding	10	CY	$35	30%	$0
	Riprap	10	CY	$40	40%	$1
	Sand Drain	0	CY	$22	30%	$0
	Topsoil (4")	21	CY	$2.50	30%	$0
	Seed	0	AC	$1,000	50%	$0
	Subtotal Levee Construction					$2
	Golf Course Tieback Segment C - Raise Top of Levee to El. 1460					
	Performance/Payment Bond	1	JB	$430	10%	$0
	Levee Construction					
	Clearing and Grubbing	0.4	AC	$3,000	30%	$2
	Stripping (1')	791	CY	$1.50	30%	$2
	Removals	1	JB	$900.00	50%	$1
	Inspection Trench	667	LF	$4.00	30%	$3
	Levee Fill	1,734	CY	$5.00	30%	$11
	Bedding	380	CY	$35	30%	$17
	Riprap	380	CY	$40	40%	$21
	Sand Drain	0	CY	$22	30%	$0
	Topsoil (4")	599	CY	$2.50	30%	$2
	Seed	1.1	AC	$1,000	50%	$2
	Subtotal Levee Construction					$62
	Acorn Ridge Segment 2 - Raise Top of Levee to El. 1460					
	Performance/Payment Bond	1	JB	$938	10%	$1
	Levee Construction					
	Clearing and Grubbing	2.3	AC	$3,000	30%	$9
	Stripping (1')	1,813	CY	$1.50	30%	$4
	Removals	1	JB	$5,000.00	50%	$8
	Inspection Trench	0	LF	$4.00	30%	$0
	Levee Fill	3,191	CY	$5.00	30%	$21
	Bedding	830	CY	$35	30%	$38
	Riprap	830	CY	$40	40%	$46
	Sand Drain	0	CY	$22	30%	$0
	Topsoil (4")	1,494	CY	$2.50	30%	$5
	Seed	2.8	AC	$1,000	50%	$4
	Subtotal Levee Construction					$135
	Acorn Ridge Segment 3 - Raise Top of Levee to El. 1460					
	Performance/Payment Bond	1	JB	$35	10%	$0
	Levee Construction					
	Clearing and Grubbing	0.2	AC	$3,000	30%	$1
	Stripping (1')	57	CY	$1.50	30%	$0
	Removals	1	JB	$500.00	50%	$1
	Inspection Trench	0	LF	$4.00	30%	$0
	Levee Fill	41	CY	$5.00	30%	$0
	Bedding	21	CY	$35	30%	$1
	Riprap	21	CY	$40	40%	$1
	Sand Drain	0	CY	$22	30%	$0
	Topsoil (4")	138	CY	$2.50	30%	$0
	Seed	0.3	AC	$1,000	50%	$0
	Subtotal Levee Construction					$5
	Acorn Ridge Tieback - Raise Top of Levee to El. 1460					
	Performance/Payment Bond	1	JB	$38	10%	$0
	Levee Construction					
	Clearing and Grubbing	0.1	AC	$3,000	30%	$0
	Stripping (1')	30	CY	$1.50	30%	$0
	Removals	1	JB	$300.00	50%	$0
	Inspection Trench	0	LF	$4.00	30%	$0
	Key Trench Subcut	236	CY	$2.75	30%	$1
	Levee Fill	47	CY	$5.00	30%	$0
	Key Trench Impervious Core	236	CY	$5.85	30%	$2
	Bedding	12	CY	$35	30%	$1
	Riprap	12	CY	$40	40%	$1
	Sand Drain	0	CY	$22	30%	$0
	Topsoil (4")	69	CY	$2.50	30%	$0
	Seed	0.1	AC	$1,000	50%	$0
	Subtotal Levee Construction					$5
	North Creel Bay Tieback - Raise Top of Levee to El. 1460					
	Performance/Payment Bond	1	JB	$202	10%	$0
	Levee Construction					
	Clearing and Grubbing	0.7	AC	$3,000	30%	$3
	Stripping (1')	740	CY	$1.50	30%	$1
	Removals	1	JB	$1,500.00	50%	$2
	Inspection Trench	0	LF	$4.00	30%	$0
	Levee Fill	1,070	CY	$5.00	30%	$7
	Bedding	128	CY	$35	30%	$6
	Riprap	128	CY	$40	40%	$7
	Sand Drain	0	CY	$22	30%	$0
	Topsoil (4")	442	CY	$2.50	30%	$1
	Seed	0.8	AC	$1,000	50%	$1
	Aggregate Base Course	187	CY	$20	30%	$5
	Subtotal Levee Construction					$34
	Highway 2 Segment 1 - Raise Top of Levee to El. 1460					
	Performance/Payment Bond	1	JB	$2,141	10%	$2
	Levee Construction					
	Clearing and Grubbing	2.3	AC	$3,000	30%	$9
	Stripping (1')	3,164	CY	$1.50	30%	$6
	Removals	1	JB	$5,000.00	50%	$8
	Inspection Trench	1,800	LF	$4.00	30%	$9
	Levee Fill	12,065	CY	$5.00	30%	$78
	Impervious Core	490	CY	$5.85	30%	$4
	Bedding	1,477	CY	$35	30%	$67
	Riprap	1,477	CY	$40	40%	$83
	Sand Drain	0	CY	$22	30%	$0
	Topsoil (4")	1,809	CY	$2.50	30%	$6
	Seed	3.4	AC	$1,000	50%	$5
	Culverts	410	LF	$50	50%	$31
	Subtotal Levee Construction					$308
	Highway 2 Tieback - Raise Top of Levee to El. 1460					
	Performance/Payment Bond	1	JB	$187	10%	$0
	Levee Construction					
	Clearing and Grubbing	0.3	AC	$3,000	30%	$1
	Stripping (1')	260	CY	$1.50	30%	$1
	Removals	1	JB	$800.00	50%	$1
	Inspection Trench	0	LF	$4.00	30%	$0
	Key Trench Subcut	750	CY	$2.75	30%	$3
	Levee Fill	437	CY	$5.00	30%	$3
	Key Trench Impervious Core	750	CY	$5.85	30%	$6
	Bedding	110	CY	$35	30%	$5
	Riprap	110	CY	$40	40%	$6
	Sand Drain	0	CY	$22	30%	$0
	Topsoil (4")	239	CY	$2.50	30%	$1
	Seed	0.4	AC	$1,000	50%	$1
	Subtotal Levee Construction					$27
	Environmental Impacts					
	HTRW	1	LS			$62
	Cultural Resources	1	LS			$0
	Natural Resources	1	LS			$2
	Utility Modifications	1	LS			$131
	Subtotal					$838
	Engineering and Design			15%		$126
	Supervision and Administration			8%		$67
	Real Estate Acquisition for ROW	1	LS			$183
	Raise Existing Levee					$5,114
	Total Levee					**$6,327**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Levee Maintenance	Pump O&M	Total Operation and Maintenance Cost
	(THOUSANDS)		
AL1	$6	$0	$6

Table 4.2-2b

Flood Protection Costs
Feature 2: City of Devils Lake
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Action Level	L(3) Raise Levee at AL2, AL3
	(THOUSANDS)
AL2	$46,476
AL3	$25,371

COST BREAKDOWN

Strategy		L(2) Description	L(2) Quantity	L(2) Units	L(2) Unit Cost	L(2) Value (THOUSANDS)	L(3) Description	L(3) Quantity	L(3) Units	L(3) Unit Cost	L(3) Value (THOUSANDS)
Incremental Levee Raise											
	Levee	Performance/Payment Bond	1	JB	$142,935	$143	Performance/Payment	1	JB	$89,802	$90
		Clearing & Grubbing	20	AC	$1,925	$39	Clearing & Grubbing	10	AC	$1,925	$19
		Removals	20	AC	$825.00	$17	Removals	10	AC	$825.00	$8
		Stripping	106,000	CY	$1.25	$133	Stripping	16,000	CY	$1.25	$20
		Inspection Trench	8,500	LF	$3.75	$32	Inspection Trench	8,500	LF	$3.75	$32
		Impervious Fill	3,199,751	CY	$4.40	$14,079	Impervious Fill	456,940	CY	$4.40	$2,011
		Bedding	86,051	CY	$35.00	$3,012	Bedding	98,826	CY	$35.00	$3,459
		Riprap	161,362	CY	$45.00	$7,261	Riprap	185,299	CY	$45.00	$8,338
		Sand Drain	185,000	CY	$20.00	$3,700	Sand Drain	0	CY	$20.00	$0
		Topsoil (4")	107,852	CY	$1.25	$135	Topsoil (4")	25,029	CY	$1.25	$31
		Seed	201	AC	$900	$181	Seed	47	AC	$900	$42
		Pump Station	0	EA	$1,000,000	$0	Pump Station	0	EA	$1,000,000	$0
		Subtotal				$28,730	Subtotal				$14,051
		Contingency (30%)				$8,619	Contingency (30%)				$4,215
		Subtotal w/ Contingency				$37,349	Subtotal w/ Contingency				$18,266
		Engineering and Design (6%)				$2,241	Engineering and Design (6%)				$1,096
		Supervision and Administration (10%)				$3,735	Supervision and Administration (10%)				$1,827
		1998 Total				$43,325	1998 Total				$21,188
		2001 Total (add inflation)				$45,924	2001 Total (add inflation)				$22,460
		2001 Adjusted Total				$45,925	2001 Adjusted Total				$22,427
		Pump Modifications	I JB			$21	Pump Modifications	1	JB	$2,944,000	$2,944
		Runway Extensions	I JB			$530					
		Total				**$46,476**	**Total**				**$25,371**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Levee Maintenance
	(THOUSANDS)
AL2	$7
AL3	$11

Table 4.2-2c

Flood Protection Costs -- Devils Lake Levee Raise
(MCACES Construction Cost Estimate Summary)

Feature 2: City of Devils Lake
Devils Lake Infrastructure Protection Study

Date: 1/10/03 12:30 PM
Prepared By: Carrie Ryan, Barr Engineering Co.
File Name: P:\34\36\021\Costest\[MCASES_OUTPUT_12_20_02.xls]Table 4.2-2c

Reference No.	CWBS No.	Description		Units	Quantity	Unit Cost	Total Cost	Contingencies Percent	Contingencies Amount	Estimated Total Cost
100		**Reach 1**		**LS**	**1**	**$2,120,289.39**	**$2,120,289**	**27%**	**$573,018**	**$2,693,308**
100900	01	Real Estate		LS	1	$2,400.00	$2,400	0%	$0	$2,400
100850	02	Utility Relocations		LS	1	$78,000.00	$78,000	0%	$0	$78,000
100100	11	Clearing and Grubbing		JOB	1	$5,329.03	$5,329	35%	$1,865	$7,194
100150	11	Removals		JOB	1	$4,337.59	$4,338	50%	$2,169	$6,506
100200	11	Stripping		CY	1,780	$2.81	$5,006	25%	$1,252	$6,258
100250	11	Impervious Fill		CY	57,111	$4.98	$284,664	30%	$85,399	$370,063
100350	11	Geotextile Fabric		SY	17,454	$1.98	$34,532	30%	$10,359	$44,891
100400	11	Bedding		CY	12,936	$29.66	$383,736	30%	$115,121	$498,857
100450	11	Riprap		CY	23,579	$36.63	$863,726	30%	$259,118	$1,122,844
100600	11	Topsoil		CY	7,792	$3.01	$23,420	30%	$7,026	$30,446
100650	11	Seeding		AC	15.0	$1,293.73	$19,406	30%	$5,822	$25,228
100700	11	Aggregate Surfacing		CY	1,187	$24.78	$29,412	30%	$8,824	$38,236
		Subtotal Construction Cost					$1,653,569		$496,954	$2,150,523
100950	30	Planning, Engineering, and Design	15%	LS	1	$248,035.29	$248,035	20%	$49,607	$297,642
100960	31	Construction Management	8%	LS	1	$132,285.49	$132,285	20%	$26,457	$158,743
100800	32	HTRW Mitigation		LS	1	$4,200.00	$4,200	0%	$0	$4,200
100750	33	Natural Resources Mitigation		LS	1	$1,800.00	$1,800	0%	$0	$1,800
200		**Reach 2**		**LS**	**1**	**$2,895,900.77**	**$2,895,901**	**28%**	**$813,153**	**$3,709,054**
200900	01	Real Estate		LS	1	$1,200.00	$1,200	0%	$0	$1,200
200100	1	Clearing and Grubbing		JOB	1	$1,611.10	$1,611	35%	$564	$2,175
200150	11	Removals		JOB	1	$1,363.24	$1,363	50%	$682	$2,045
200200	11	Stripping		CY	290	$2.81	$816	25%	$204	$1,020
200230	11	Key Trench Subcut		CY	986	$1.84	$1,814	25%	$453	$2,267
200250	11	Impervious Fill		CY	54,597	$4.98	$272,133	30%	$81,640	$353,773
200280	11	Key Trench Impervious Core		CY	986	$10.21	$10,072	30%	$3,021	$13,093
200350	11	Geotextile Fabric		SY	50,000	$1.98	$98,922	30%	$29,677	$128,598
200400	11	Bedding		CY	19,697	$29.66	$584,296	30%	$175,289	$759,584
200450	11	Riprap		CY	36,481	$36.63	$1,336,341	30%	$400,902	$1,737,244
200600	11	Topsoil		CY	7,781	$3.01	$23,387	30%	$7,016	$30,403
200650	11	Seeding		AC	14.5	$1,293.73	$18,759	30%	$5,628	$24,387
		Subtotal Construction Cost					$2,349,513		$705,076	$3,054,588
200950	30	Planning, Engineering, and Design	15%	LS	1	$352,426.92	$352,427	20%	$70,485	$422,912
200960	31	Construction Management	8%	LS	1	$187,961.03	$187,961	20%	$37,592	$225,553
200800	32	HTRW Mitigation		LS	1	$4,200.00	$4,200	0%	$0	$4,200
200750	33	Natural Resources Mitigation		LS	1	$600.00	$600	0%	$0	$600
300		**Lakewood Levee**		**LS**	**1**	**$242,642.39**	**$242,642**	**5%**	**$11,413**	**$254,056**
300900	01	Real Estate		LS	1	$131,200.00	$131,200	0%	$0	$131,200
300850	02	Utility Relocations		LS	1	$23,000.00	$23,000	0%	$0	$23,000
300100	11	Clearing and Grubbing		JOB	1	$3,717.93	$3,718	35%	$1,301	$5,019
300150	11	Removals		JOB	1	$2,478.62	$2,479	50%	$1,239	$3,718
300200	11	Stripping		CY	584	$2.81	$1,642	25%	$411	$2,053
300250	11	Impervious Fill		CY	886	$4.98	$4,416	30%	$1,325	$5,741
300400	11	Bedding		CY	238	$29.66	$7,060	30%	$2,118	$9,178
300450	11	Riprap		CY	238	$36.63	$8,718	30%	$2,615	$11,334
300600	11	Topsoil		CY	598	$3.01	$1,797	30%	$539	$2,337
300650	11	Seeding		AC	1.1	$1,293.74	$1,423	30%	$427	$1,850
		Subtotal Construction Cost					$31,254		$9,976	$41,230
200950	30	Planning, Engineering, and Design	15%	LS	1	$4,688.10	$4,688	20%	$938	$5,626
200960	31	Construction Management	8%	LS	1	$2,500.32	$2,500	20%	$500	$3,000
300800	32	HTRW Mitigation		LS	1	$50,000.00	$50,000	0%	$0	$50,000
400		**Acorn Ridge A Levee**		**LS**	**1**	**$155,987.14**	**$155,987**	**23%**	**$35,677**	**$191,664**
400900	01	Real Estate		LS	1	$32,400.00	$32,400	0%	$0	$32,400
400100	11	Clearing and Grubbing		JOB	1	$8,675.17	$8,675	35%	$3,036	$11,711
400150	11	Removals		JOB	1	$6,196.55	$6,197	50%	$3,098	$9,295
400200	11	Stripping		CY	1,813	$2.81	$5,099	25%	$1,275	$6,374
400250	11	Impervious Fill		CY	3,191	$4.98	$15,905	30%	$4,772	$20,677
400400	11	Bedding		CY	830	$29.66	$24,621	30%	$7,386	$32,008
400450	11	Riprap		CY	830	$36.63	$30,404	30%	$9,121	$39,525
400600	11	Topsoil		CY	1,494	$3.01	$4,490	30%	$1,347	$5,838
400650	11	Seeding		AC	2.8	$1,293.73	$3,622	30%	$1,087	$4,709
		Subtotal Construction Cost					$99,014		$31,122	$130,136
400950	30	Engineering and Design	15%	LS	1	$14,852.09	$14,852	20%	$2,970	$17,823

Table 4.2-2c

Flood Protection Costs -- Devils Lake Levee Raise
(MCACES Construction Cost Estimate Summary)

Feature 2: City of Devils Lake
Devils Lake Infrastructure Protection Study

Date: 1/10/03 12:30 PM
Prepared By: Carrie Ryan, Barr Engineering Co.
File Name: P:\34\36\021\Costest\[MCASES_OUTPUT_12_20_02.xls]Table 4.2-2c

Reference No.	CWBS No.	Description		Units	Quantity	Unit Cost	Total Cost	Contingencies Percent	Contingencies Amount	Estimated Total Cost
400960	31	Construction Management	8%	LS	1	$7,921.11	$7,921	20%	$1,584	$9,505
400800	32	HTRW Mitigation		LS	1	$1,200.00	$1,200	0%	$0	$1,200
400750	33	Natural Resources Mitigation		LS	1	$600.00	$600	0%	$0	$600
500		**Acorn Ridge B Levee**		**LS**	**1**	**$36,777.81**	**$36,778**	**4%**	**$1,560**	**$38,337**
500900	01	Real Estate		LS	1	$600.00	$600	0%	$0	$600
500850	02	Utility Relocations		LS	1	$30,000.00	$30,000	0%	$0	$30,000
500100	11	Clearing and Grubbing		JOB	1	$867.52	$868	35%	$304	$1,171
500150	11	Removals		JOB	1	$619.66	$620	50%	$310	$929
500200	11	Stripping		CY	57	$2.81	$160	25%	$40	$200
500250	11	Impervious Fill		CY	41	$4.99	$204	30%	$61	$266
500400	11	Bedding		CY	21	$29.66	$623	30%	$187	$810
500450	11	Riprap		CY	21	$36.63	$769	30%	$231	$1,000
500600	11	Topsoil		CY	138	$3.01	$415	30%	$124	$539
500650	11	Seeding		AC	0.3	$1,293.73	$388	30%	$116	$505
		Subtotal Construction Cost					$4,047		$1,373	$5,420
500950	30	Engineering and Design	15%	LS	1	$607.05	$607	20%	$121	$728
500960	31	Construction Management	8%	LS	1	$323.76	$324	20%	$65	$389
500800	32	HTRW Mitigation		LS	1	$1,200.00	$1,200	0%	$0	$1,200
600		**Highway 2 Levee**		**LS**	**1**	**$245,232.19**	**$245,232**	**28%**	**$68,524**	**$313,757**
600900	01	Real Estate		LS	1	$3,600.00	$3,600	0%	$0	$3,600
600100	11	Clearing and Grubbing		JOB	1	$8,675.17	$8,675	35%	$3,036	$11,711
600150	11	Removals		JOB	1	$6,196.55	$6,197	50%	$3,098	$9,295
600200	11	Stripping		CY	3,164	$2.81	$8,899	25%	$2,225	$11,123
600250	11	Impervious Fill		CY	12,065	$4.98	$60,137	30%	$18,041	$78,178
600300	11	Impervious Core		CY	490	$5.79	$2,837	30%	$851	$3,688
600400	11	Bedding		CY	1,477	$29.66	$43,814	30%	$13,144	$56,958
600450	11	Riprap		CY	1,477	$36.63	$54,104	30%	$16,231	$70,335
600600	11	Topsoil		CY	1,809	$3.01	$5,437	30%	$1,631	$7,068
600650	11	Seeding		AC	3.4	$1,293.73	$4,399	30%	$1,320	$5,718
		Subtotal Construction Cost					$194,498		$59,577	$254,075
600950	30	Engineering and Design	15%	LS	1	$29,174.66	$29,175	20%	$5,835	$35,010
600960	31	Construction Management	8%	LS	1	$15,559.82	$15,560	20%	$3,112	$18,672
600800	32	HTRW Mitigation		LS	1	$1,200.00	$1,200	0%	$0	$1,200
600750	33	Natural Resources Mitigation		LS	1	$1,200.00	$1,200	0%	$0	$1,200
		2002 Preliminary DL Levee Raise		**LS**	**1**	**$5,696,829.69**	**$5,696,830**	**26%**	**$1,503,346**	**$7,200,175**

Notes:
1. The quantities are a culmination of Reach 1A and Reach 2A quantities provided by the Corps as well as some levee segments and tiebacks developed in Barr's 2002 Alignment Study.
2. Natural Reources and HTRW Mitigation and Real Estate costs were developed from the 2002 Alignment Study. Contingencies have already been included in the lump sum costs.
3. Utility relocations include water, sewer, electric utility, telephone, and gas lines. Information and costs for the utility modifications was used from the 2002 Alignment Study.
4. The quantities obtained from the Corps of Engineers for Reach 1A and 2A do not include costs for removal of existing features of work such as bedding, riprap, topsoil, aggregate surface course or any other features of work. It is assumed that these features of work have not yet been constructed.
5. The cost of the items for which quantities were not developed is anticipated to be less than 5% of the total project cost and do not need to be itemized separately.

Table 4.2 - 3a

Economics Results: All Action Levels -- to Lake Level 1463
Feature 2: City of Devils Lake
Devils Lake Infrastructure Protection Study

Stochastic Analysis (ST-9)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$1,581,700	$1,581,700	$0	$0	--
L(3)	3 Levee Raises	$1,212,100	$4,500	$0	$1,216,500	$0	$0	$1,581,700	$365,200	1.30

Wet Future Scenario (WF-9)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$10,757,600	$10,757,600	$0	$0	--
L(3)	3 Levee Raises	$3,776,600	$8,200	$0	$3,784,900	$0	$0	$10,757,600	$6,972,700	2.84

Moderate Future 1 Scenario (M1-4)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$0	$0	$0	$0	--
L(3)	3 Levee Raises	$1,483,000	$2,800	$0	$1,485,800	$0	$0	$0	-$1,485,800	--

Moderate Future 2 Scenario (M2-4)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$6,283,400	$6,283,400	$0	$0	--
L(3)	3 Levee Raises	$2,462,800	$6,000	$0	$2,468,700	$0	$0	$6,283,400	$3,814,700	2.55

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.125% and rounded to the nearest $100.
*Total benefits are calculated as the total damages incurred for the "No Protection" strategy minus the total damages for the strategy implemented (F(S)).

Table 4.2 - 3b

Economics Results: First Action Level
Feature 2: City of Devils Lake
Devils Lake Infrastructure Protection Study

Stochastic Analysis (ST-9)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$1,567,100	$1,567,100	$0	$0	--
L(1)	1 Levee Raise	$269,500	$3,600	$0	$273,100	$0	$0	$1,567,100	$1,294,000	5.74

Wet Future Scenario (WF-9)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$10,757,600	$10,757,600	$0	$0	--
L(1)	1 Levee Raise	$362,700	$2,500	$0	$365,200	$0	$0	$10,757,600	$10,392,400	29.46

Moderate Future 1 Scenario (M1-4)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$0	$0	$0	$0	--
L(1)	1 Levee Raise	$177,700	$2,500	$0	$180,100	$0	$0	$0	-$180,100	0.00

Moderate Future 2 Scenario (M2-4)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit - Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I= G/D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$6,283,400	$6,283,400	$0	$0	--
L(1)	1 Levee Raise	$362,700	$5,300	$0	$368,000	$0	$0	$6,283,400	$5,915,500	17.07

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.125% and rounded to the nearest $100.
*Total benefits are calculated as the total damages incurred for the "No Protection" strategy minus the total damages for the strategy implemented (F(S)).

Attachment to 4.2:
City of Devils Lake Economic Analysis Assumptions

A. General Assumptions

1. The area included in the City of Devils Lake feature is the land currently protected by the levees and the area within the Devils Lake city limits.

2. Existing levees have been built to elevation 1457. Plans and specifications for the construction of the levee raises to 1460 have been prepared during 2002.

3. The value of land outside of the Devils Lake city limits was estimated to be $400 per acre (*Corps of Engineers*, April, 2001).

4. The values of the properties described below were determined in 1998. These values were updated for inflation by multiplying them by 1.09, which accounts for an inflation rate of 3% per year from 1998 to February 2001. This inflation rate was obtained from the Devils Lake City Assessor.

   a. The value of land for airport relocation was estimated at $500 per acre in 1998. The updated value is $545 per acre.

   b. The estimated value of commercial property within the Devils Lake city limits was $10,000 per acre in 1998. The updated value is $10,900 per acre.

   c. The estimated value of parkland within the Devils Lake city limits was $5,000 per acre in 1998. The updated value is $5,450.

5. The costs for HTRW, Cultural Resources, Natural Resources, and Utility Modifications were taken directly from the Alternative Alignment Study (Barr, January 2002).

6. Costs for Real Estate ROW ($183,000) were based on information from the Corps of Engineers. The data from the Alternative Alignment Study was not used.

7. Feature 2 generally describes AL1 levee raise to 1460.

B. Levees

1. It was assumed that the existing levees are built with adequate base to raise the levee to elevation 1460. The parameters used to design the existing levees allow for a 15-foot top width at elevation 1460.

2. The freeboard for the existing levee is 5 to 6 feet with the top of levee at 1457. The freeboard for the levee raise to 1460 will be 6 feet.

3. This report only analyzed detailed levee raises to 1460 for AL1. Costs and damages for AL2 and AL3 were obtained from the Economic Analysis of Devils Lake Alternatives. The features analysis model and benefit cost ratios were based on action levels to full height (AL1, AL2, and AL3).

4. The quantities for the levee raises on Table 4.2-2 were taken directly from the Alternative Alignment Study, Barr, January 2002, with the unit prices for the Infrastructure Protection Study applied to these quantities. Some of the levees from the Alternative Alignment Study included items that have not been included in the levees for the Infrastructure Protection Study. These items include quantities for removals, impervious core, key trench subcut, and key trench impervious core. In these cases, the unit prices from the Alternative Alignment Study were used.

5. The quantities for clearing and grubbing were adjusted so the quantity multiplied by the Infrastructure Protection Study unit price ($3,000) would equal the clearing and grubbing total price (per job) from the Alternative Alignment Study.

6. The cost of stripping additional topsoil between each levee raise was considered to be incidental. The cost of stripping topsoil to extend the levee on undisturbed ground was included.

7. Seed quantity assumed to be the same as the topsoiled area.

8. Levee quantities assume total volume of new topsoil added at each levee raise (new topsoil may include topsoil salvaged from previous levee construction—the unit price of any salvaged topsoil assumed to be the same as for new topsoil).

9. Levee quantities assume the 5 feet of riprap along the top of the levee would be salvaged and reused at each levee raise.

10. For levee raises, the lake damage elevation was assumed to be one-half the height of its freeboard.

C. Residential and Commercial Properties

1. Damages were taken from the Alternative Alignment Study (Barr, January 2002) and from the Economic Analysis of Devils Lake Alternatives. Damages were redistributed based on the revised structure elevations shown for AL1, AL2, and AL3 in Table 4.2-1.

2. In 1998, the assessed values of residential and commercial structures were obtained from the municipal GIS database. These values were increased based on data from the City of Devils Lake Assessor for the period from 1998 to February 2001. Values were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a factor of 1.09 (to account for inflation of 3% per year).

3. On the 1994 USGS quadrangle map, small buildings outside the Devils Lake city limits were assumed to denote single residential dwellings. Each square was counted as a single residence, unless

field investigation indicated otherwise (i.e., structure was already gone or abandoned or the structure was a garage instead of residential dwelling). Additional residences that were not indicated on the quadrangle map were counted based on visits to the city.

4. Subdivision boundaries in the Creel Township area were identified based on visits to the city (*Devils Lake Creel Township Levee Assessment*, Barr Engineering Company, August 20, 1997). Average values of residences within these boundaries were obtained from the 1997 report. These values were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a factor of 1.09 (to account for inflation of 3% per year) for the increase during the period from 1998 to February 2001.

5. The value of residences outside of the Devils Lake city limits (described in item number 3 above) were estimated based on the 1998 residential average within the city (from the municipal GIS database). These values were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a factor of 1.09 (to account for inflation of 3% per year) for the increase during the period from 1998 to February 2001. Specific assumptions for the 1998 values included:

   a. If a residence was part of "small tracts of land" in the Midland Atlas, the average value used for the residential dwelling was $41,950 (lot value and improvement value). The updated value is $49,950.

   b. If a residence was on land with an identified owner in the Midland Atlas, the lot value was estimated by multiplying the parcel size shown in the Midland Atlas by $300 per acre (the agricultural land value). This lot value was added to $34,664 per residential dwelling, the estimated average improvement value, to give a total value for lot and improvements. The updated values are $400 per acre for lots and $40,620 for improvements.

   c. In the absence of flood protection measures, damages were assumed to occur at the lowest elevation at which a residential structure was affected by rising lake levels. Land could be affected at lower elevation but this land loss was not included until the dwelling was affected. Seepage into basements was not considered.

6. On the 1994 quadrangle map, larger plain rectangles (not small squares) outside the Devils Lake city limits were assumed to denote commercial buildings. Each rectangle was counted as a single commercial building.

7. Commercial buildings outside of the Devils Lake city limits were assumed to have average values based on the 1998 commercial average within the city (from the municipal GIS database). These values were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a factor of 1.09 (to account for inflation of 3% per year) for the increase during the period from 1998 to February 2001. Specific assumptions for the 1998 values included:

a. If a commercial building was part of "small tracts of land" in the Midland Atlas, the average value of the commercial building used was $94,785 (lot value plus improvement value). The updated value is $111,060.

b. If a commercial building was on land with an identified owner in the Midland Atlas, the lot value was estimated by multiplying the parcel size shown in the Midland Atlas by $300 per acre (the agricultural land value). This lot value was added to $74,743 per commercial building (the estimated average improvement value) to give an estimated total value of lot and improvement. The updated values are $400 per acre for lots and $87,580 for improvements.

c. In the absence of flood protection measures, damages were assumed to occur at the lowest elevation at which a structure was affected by rising lake levels. Land could be affected at lower elevations but these losses were only included at the elevation at which the structure began to be affected.

8. The area identified as "Bible Camp" on the 1994 quadrangle map was outlined based on field observation (Lakewood Bible Camp). The structures within the Lakewood Bible Camp boundaries were not included in the above residential or commercial values.

   a. All but one small building (small square on topographical map) was at an elevation greater than 1465. Although the buildings in the Camp are on high ground, the Bible Camp would be surrounded by the lake without the existing levee and it would not have access.

   b. The replacement cost of the Bible Camp was assumed to be the insured value of the structures. In 1998, the insured value was $2,462,000. This value was multiplied by a factor of 1.09, to account for inflation of 3% per year, during the period from 1998 to February 2001. The updated value is $2,683,580.

9. The value of the golf course was assumed to be $2,300,000 (*Devils Lake Creel Township Levee Assessment*, Barr Engineering Company, August 20, 1997). This value is in 1998 dollars; therefore it was multiplied by a factor of 1.09, to account for inflation of 3% per year, during the period from 1998 to February 2001. The updated value is $2,500,000.

10. Land in the Midland Atlas that had a total acreage, but did not have structures noted on the quadrangle map, was valued at $400 per acre (the agricultural land value as stated above).

11. In the absence of flood protection measures, damages to structures were assumed to occur at the lowest elevation at which structures were affected, except as follows:

    a. Damages to the golf course were assumed to occur at the first action level where the levee is not raised. The golf course is protected by the city levee and damages would only happen if the levee was abandoned.

b. Damages to land that contains no structures or improvements were estimated to occur at the lowest elevation at which the land was affected. Damages to land were grouped between action levels, and were assumed to occur when the water surface is 1 foot below the action level. This may 'front-end load' the damages; however, only small parcels of land were analyzed for this feature, and the effects of this assumption are not expected to be significant. Conversely, wave action could affect land several feet above the lake's level and, therefore, actual damages might occur before the lake reaches the parcel's lowest elevation.

c. The Bible Camp is excepted as noted above.

12. Land outside the city limits that is within the assumed levee alignment and above the maximum lake level would become isolated and inaccessible if the levee is not raised and the lake rises to 1463. The values for the land and structures in these isolated areas were calculated and included as damages for relocation strategies. Conversely, for strategies where levees remain in place, these amounts were included as damages prevented.

13. In the absence of the existing levee, the subdivision located southwest of the intersection of Highway 20 and Ramsey County 1 would become isolated and surrounded by the lake above elevation 1440. However, the access road is relatively short and the costs of raising the access would be minimal compared to the costs of relocating the subdivision. Because Highway 20 within the levee is assumed to remain open with or without the levee in place, the area was assumed to have access even if the existing levee was removed. For levee strategies, damages prevented for this area were assumed to occur at the elevation of the structures.

14. All structures and property below elevation 1450 were grouped to compute damages in the absence of flood protection measures.

15. In the absence of flood protection measures, damages to structures and property were assumed to be equal to the depreciated replacement values discussed above. Conversely, if protection is provided, all or a portion of the potential damages would be treated as damages prevented.

D. Public Properties

1. The values and costs for the public property described below in items 2 – 6, were determined in 1998. These 1998 dollars were multiplied by a factor of 1.09 to account for inflation of 3% per year during the period from 1998 to February 2001. This inflation rate was obtained in conversations with the Ramsey County Assessor and the City of Devils Lake Assessor.

2. Estimated values for property owned by Ramsey County were based on telephone conversations with staff at the County Assessor's office.

3. Estimated values for properties owned by the City of Devils Lake were based on telephone conversations with Gary Martinson, City Assessor.

4. The value of public properties was based on the estimated insured replacement values of the structures.

5. In the absence of flood protection measures, damages to the cemetery included 80 acres at $1,000 per acre and 8,000 burials at $500 each. The updated values are $1,090 per acre for land and $545 per burial for relocating.

E. School and Churches

1. All costs and values described below in items 2 – 6 were determined in 1998. These 1998 dollars were multiplied by a factor of 1.075 (to account for new development of 2.5% per year) and a factor of 1.09 (to account for inflation of 3% per year) for the increase during the period from 1998 to February 2001. These inflation rates were obtained in conversations with the City of Devils Lake Assessor.

2. For schools and churches, insured values of the structure were used when available. According to the City Assessor, insured replacement values are typically much greater than assessed values. Therefore, land values were not added to determine the total value. Insured values for several schools were obtained from telephone conversations with the Devils Lake school administrator. Insured values for several churches were obtained from telephone conversations with church administrators. All other school and church values were estimated using *RS Means Building Construction Cost Data, 56th Annual Edition*, 1998. If only total insured values were provided, the structure was assumed to have a value of 75% of the total insured value.

3. Insured values included the value of only the structures. The insured value of contents was not included in the insured value.

4. In the absence of flood protection measures, damages were assumed to be 100% of insured value of the structure.

F. Utilities

1. The costs of relocating utilities described below in items 2 – 9 were obtained in 1998. These 1998 dollars were updated for inflation by multiplying it by the ENR Construction Cost Index of 1.06. This accounts for 6% inflation during the period from 1998 to February 2001.

2. Individual utility service connections were included with assessed lot values. However, the cost to replace utility infrastructure was calculated separately for relocation strategies and to determine the benefit provided for flood protection measures.

3. Gas main costs associated with relocation strategies were based on discussions with Montana Dakota Utilities (MDU) staff. In the absence of flood protection measures, damages were assumed to equal the relocation or rebuild cost. Costs were distributed on a per-user basis.

4. Relocation costs for electrical infrastructure were based on conversations with Otter Tail Power staff. In the absence of flood protection measures, damages were assumed to equal the relocation cost.

5. Relocation costs for telephone infrastructure were based on conversations with North Dakota Telephone Company staff. In the absence of flood protection measures, damages were assumed to equal the relocation cost. The costs did not include the cost of fiber optic cables. Costs were distributed on a per-user basis.

6. For relocation strategies, costs for the wastewater treatment system were based on conversations with the City Engineer and the City Assessor and on Environmental Protection Agency (EPA) construction costs. The cost includes construction of a new wastewater treatment plant and distribution system and the closing of the existing lagoons. In the absence of flood protection measures, damages were assumed to be 75% of the rebuild cost, due to depreciation of the existing system. Although land application disposal was assumed in this study, the City Engineer indicated that a lagoon system may be required.

7. For strategies that include levee protection, it was assumed that the lagoons would continue to function as the lake continues to rise. A brief analysis of groundwater in the area indicates that it would not affect the operation of lagoons in the area *(Hydrogeology of the Shallow Water Table at the City of Devils Lake, North Dakota*, North Dakota State Water Commission, 1998).

8. For relocation strategies, costs for the water treatment system were based on conversations with the City Engineer and the City Assessor and on EPA construction costs. The cost includes construction of a new plant, a 500,000-gallon water tower, a 3,000,000-gallon reservoir, four supply wells, and a distribution system. The actual system may include tapping into and treating surface water. However, the scope of the study did not include review of specific treatment system alternatives. In the absence of flood protection measures, advance replacement of infrastructure was assumed to be 75% of the rebuild cost to factor in the effects of depreciation.

9. For relocation strategies, costs for the storm sewer system were based on a conversation with the City Engineer. The cost was based on converting the $7,000,000 upgrade performed in 1978 to 1998 costs using historical cost indexes (*RS Means Building Construction Cost Data, 56th Annual Edition,* 1998). The estimated cost to rebuild the system was $14,968,000. The updated cost is $15,866,080. In the absence of flood protection measures, damages were assumed to be 75% of the rebuild cost due to depreciation. The costs were distributed on a per-user basis.

G. Devils Lake Airport

1. The costs to relocate the airport and build a runway extension, described below in items 2 – 6, were determined in 1998. These costs were updated for inflation by multiplying the airport by a factor of 1.09 (to account for an inflation rate of 3% per year) and the runway extension was multiplied by the ENR Construction Cost Index of 1.06 (to account for 6% inflation from 1998 to February 2001). The inflation rate was obtained from the City of Devils Lake Assessor.

2. Airport relocation costs were developed based on telephone conversations with the Airport District Engineer and the airport consultant at the firm of Kadrmis, Lee & Jackson.

3. Airport relocation costs included 15% for various engineering, administrative, and environmental review costs. In addition to engineering design, the relocation of the new airport would require detailed studies including preparation of an Environmental Impact Statement (EIS) to assess the social, economic and environmental effects of the project.

4. Due to depreciation, the value of the existing airport ("damages prevented") was assumed to be 75% of the value to relocate/rebuild.

4.3 Summary of Infrastructure Protection Investigation for Feature 3: Fort Totten

4.3.0 Flood Protection Strategy

The Infrastructure Protection Study indicates that the flood protection strategy with the largest net benefits for Fort Totten would be incremental relocations.

4.3.1 General Information

Feature Type: Community

Location: Fort Totten is located along the south side of Devils Lake on the Spirit Lake Nation Reservation in Benson County. The majority of the town is adjacent to Highway 57 just northeast of the intersection of Highway 57 and BIA Highway 1. The accompanying Figure 4.3-1 shows the feature's location, location of structures, approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Fort Totten is an unincorporated community of 952 people (based on 2000 census).

Significance: The value of all communities is high because of the density of infrastructure in this primarily rural section of North Dakota. Although Fort Totten has not been significantly affected by the rising lake level to date, it is a relatively large community and a major center of activity for the Spirit Lake Nation.

Damages: The flooding of Fort Totten would result in the following damages:

- Loss of the Siaka Pump (sanitary lift) Station.
- Loss of the Veterans Memorial.
- Loss of seven (7) residences.
- Access to the Sullys Hill National Game Preserve (Sullys Hill) facility located immediately east of Fort Totten. Flooding would result in loss of the access road to the facility and the loss of several structures including the visitor center, maintenance shops and houses.

Owner/Sponsor: The Spirit Lake Nation is responsible for managing and maintaining Fort Totten.

Lead Federal Agency: The Corps of Engineers would take the lead for any flood protection work that may take place to protect Fort Totten. The Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

4.3.2 Feature Protection

History of Flood Protection:

- Sewage Lagoons: In the past, flood protection for Fort Totten has consisted of relocating the sewage lagoons. Sioux Utility operates two sewage lagoons consisting of seven cells. The west sewage lagoon, consisting of four new cells, was constructed on higher ground west of Fort Totten. The east sewage lagoon, consisting of three cells near the lake, had a majority of the wastewater removed by pumping into the new west sewage lagoon, according to Neil Austin of the Spirit Lake Nation Indian Health Service. A direct pipeline still exists from the east sewage lagoon to the new west sewage lagoon. The pipeline serves two purposes:

  1. To pump the remaining wastewater from the old east lagoons to the new west lagoons

  2. To be used in case of an emergency where the new west lagoons would be unusable

  Carolyn Greene of the Sioux Utility confirmed that the large cell (eastern lagoon) is currently used for emergency operation about two to three times per year. The two smaller cells have been out of service for three years. Therefore, it was assumed that the east sewage lagoon will not be needed during flooding events and can be abandoned if necessary.

- Sullys Hill National Game Preserve (Sullys Hill): According to Joe Maxwell, Refuge Manager, two structures located near Sweetwater Lake have been abandoned or relocated. One of these buildings was moved to higher ground during October 2002. The FWS pumps Sweetwater Lake to minimize potential flooding. Sweetwater Lake, located immediately north of the visitor center, is important for managing the elk and bison herd. Some of the FWS maintenance facilities have been moved from Sullys Hill to Lake Alice National Wildlife Refuge. According to Roger Hollevoet, FWS, the current dike/access road at Sullys Hill has been raised on two different occasions for a total of 13 feet of vertical rise. Their engineers recommended that the FWS no longer raise the Sullys Hill dike, as it would become a high hazard dam versus a dike. As a result, it was recommended that the FWS relocate the entrance to the Sullys Hill facilities and all of the structures.

General Protection Strategy: The Infrastructure Protection Study's analysis for Fort Totten allowed for reconsideration of flood mitigation options at each of several action levels. Flood protection options for Fort Totten included:

- Construction of levees to protect structures along the northeast side of Fort Totten. Construction of the levees would also include relocation of one isolated structure. Extending the levee to protect this house would require an additional 500 feet of levee.

- Relocation of the affected residences.

- Relocation of the Sullys Hill National Game Preserve structures. Constructing a levee to protect the Sullys Hill National Game Preserve facility would require 2,500 feet of levee, a new access road, and an internal pump station. The FWS determined that an additional raise to the existing levee/access road to protect the existing facility was not feasible, therefore the levee option was not pursued further at this location. The proposed master plan includes relocating the facility approximately 0.5 miles north and constructing a new access road off of ND Highway 57. In addition, some of the maintenance building will be relocated to the Lake Alice National Wildlife Refuge. The FWS has not obtained funding for the master plan. Initial funds, for a portion of the project, were diverted to fighting wildfires in the western United States during the summer of 2002.

Protection Strategy by Action Level: A variety of flood protection strategies were analyzed for Fort Totten. These strategies are represented on Figure 4.3-2 as separate branches of the decision tree. As shown on Figure 4.3-2, the stepwise approach to flood protection for Fort Totten consisted of the following:

1. At Action Level 1 (AL1), a decision would be made as to whether the structures between 1449 and 1454 should be relocated or a levee constructed to protect these structures. One residence, all of the Sullys Hill facilities and Sullys Hill access road would be relocated under either strategy.

2. If a levee were constructed at AL1, at Action Level 2 (AL2), a decision would be made as to whether to raise the levee or relocate all structures below 1459. Under the relocation strategy, the Siaka Pump (lift) Station would need to be relocated at AL2.

3. If a levee were raised at AL2, at Action Level 3 (AL3), a decision would be made as to whether to raise the levee or relocate all structures below 1464. Under the relocation strategy, the four residences between 1459 and 1464 would need to be relocated.

The Features Analysis Model was then used to determine which of the flood protection paths through the branches of the decision tree—which incremental flood protection strategy—had the largest net benefits. That strategy is highlighted on Figure 4.3-2, and consists of the following:

1. At Action Level 1 (AL1), the structures impacted between 1449 and 1454 would be relocated. This includes one residence, all of the Sullys Hill facilities and relocating the access road.

2. At Action Level 2 (AL2), the Siaka Pump (lift) Station would need to be relocated.

3. At Action Level 3 (AL3), four residences would need to be relocated.

Therefore, the first increment of protection would include the relocation of structures between 1449 and 1454. The pertinent reference elevations for the flood protection strategies are given below:

Reference Elevations for Structure Relocations (AL1)		
Elevation	**Name**	**Significance**
1449	Low Structure Elevation	Ground elevation at isolated structure
1448	Lake Damage Elevation	Lake elevation at which damage to lowest structure begins
NA	Project Completion Elevation	Lake elevation at which structure relocation must be complete
NA	Construction Initiation Elevation	Lake elevation at which structure relocation must begin
NA	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

Reference Elevations for Siaka Pump (Lift) Station Relocation (AL2)		
Elevation	**Name**	**Significance**
1454	Low Structure Elevation	Ground elevation at structure
1454	Lake Damage Elevation	Lake elevation at which damage to lowest structure begins
1454	Project Completion Elevation	Lake elevation at which structure relocation must be complete
1453	Construction Initiation Elevation	Lake elevation at which structure relocation must begin
1453	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

Reference Elevations for Structure Relocations (AL3)		
Elevation	**Name**	**Significance**
1460	Low Structure Elevation	Ground elevation at lowest structure
1459	Lake Damage Elevation	Lake elevation at which damage to lowest structure begins
NA	Project Completion Elevation	Lake elevation at which structure relocation must be complete
NA	Construction Initiation Elevation	Lake elevation at which structure relocation must begin
NA	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

Reference Elevations for Levee Construction (AL1)		
Elevation	**Name**	**Significance**
1451	Low Structure Elevation	Ground elevation at lowest structure protected by levee
1450	Lake Damage Elevation	Lake elevation at which damage to lowest structure would occur
1448	Project Completion Elevation	Lake elevation at which levee construction must be complete (ground elevation to construct in dry)
Current	Construction Initiation Elevation	Lake elevation at which levee construction must begin
Current	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

Reference Elevations for Levee Raise (AL2)		
Elevation	**Name**	**Significance**
1455	Low Structure Elevation	Low point on top of levee
1454	Lake Damage Elevation	Lake elevation at which damage to levee begins (assumed to be ½ height of freeboard)
1452	Project Completion Elevation	Lake elevation at which levee raise construction must be complete
1450	Construction Initiation Elevation	Lake elevation at which levee raise construction must begin
Current	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

Reference Elevations for Levee Raise (AL3)		
Elevation	**Name**	**Significance**
1460	Low Structure Elevation	Low point on top of levee
1459	Lake Damage Elevation	Lake elevation at which damage to levee begins (assumed to be ½ height of freeboard)
1457	Project Completion Elevation	Lake elevation at which levee raise construction must be complete
1456	Construction Initiation Elevation	Lake elevation at which levee raise construction must begin
1454	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

4.3.3 Design Considerations

4.3.3.0 General Design

Alignment

The general plan for flood protection at Fort Totten would include the construction of a levee that is divided at Highway 57, as shown on Figure 4.3-1.

Levee 3A-North would be constructed along the east side of the Fort Totten north of Highway 57. Levee 3A-South would be constructed along the east side of the Fort Totten south of Highway 57. Levee 3A would protect 6 structures located in a low area along Highway 57. Levee 3A would also protect the Veterans Memorial and the Siaka pump station. One isolated structure located immediately north of the proposed levee will need to be relocated.

The table below provides a summary of the levees for Fort Totten:

	Levee Lengths (Feet)		
Levee	**(AL1)**	**(AL2)**	**(AL3)**
3A-North	750	750	750
3A-South	750	900	950

Cross-section

Figure 4.3-3 shows a typical cross-section of the proposed levees.

The top widths for the levees were assumed to be 15 feet (10 feet of compacted fill and 5 feet of riprap tie-in). The side slopes are 3H:1V on the interior (land side) of the levee. The side slopes on the lake side of the levee vary depending on the location and depth of water: 4H:1V and 6H:1V (as noted on Figure 4.3-4). The elevations of the tops of the two levees vary depending on wave height and required freeboard. The top and interior side of the levees would be covered with 4 inches of topsoil and seeded.

An impervious core was designed for all levees. Sand drains were assumed to be included for all levees with a height of 9 feet or greater at the maximum levee height (sand drains would need to be constructed during initial levee construction even though initial levee heights would be less than 9 feet). The top of the sand drain layer would be 4 feet wide. The sand drain would then slope down at a 1H:1V slope and be 2 feet thick along the rest of its length (depending on the height of the levee). The actual sand drain elevations should be reviewed during final design and during construction of each levee addition.

Profile

Figure 4.3-4 shows the profile of the proposed levees. Levee 3A-North is 1 foot higher than Levee 3A-South due to additional wave protection provided by ND Highway 57. Three levee raises were designed for Fort Totten, based on the action levels and protection levels.

The general design parameters are presented in the following table:

Levee	Wind Induced Wave Height (Ft.)	Freeboard [1] (Ft.)	Top of Levee Elevations[2]		
			[3]AL1 [4]PL (1449-1454)	AL2 PL (1454-1459)	AL3 PL (1459-1464)
3A-North	2.4	4	1456	1461	1467
3A-South	1.4	3	1455	1460	1466

[1] Freeboard calculated by adding 1 foot to the wind-induced wave height (rounded up to the nearest whole foot).
[2] Top of levee elevations were determined by adding the freeboard to the maximum protection level elevation.
[3] Action Level (AL)
[4] Protection Level (PL): Number in ( ) refers to elevation range for relocating structures.

Materials

It was assumed that the levees would be constructed from readily available native silty clay and clay loam. These materials are relatively impermeable, and are suitable for levee construction. An impervious core was also assumed for all levees.

Erosion Protection

The exterior side slopes of all levees will require erosion protection due to wave action. Riprap sizing and thickness was determined using COE methods described in EM1110-2-1601, with wave height based on a COE Report titled *Devils Lake, North Dakota, Wind-Induced Changes in Water Elevations*, revised September 1998. The riprap sizing was evaluated for various side slopes to determine the cost-effective exterior side slope for each alternative. The average size of the riprap (D_{50}) is 9 inches based on the fetch, depth of water, and the side slope. Riprap thickness was designed to be 1.5 feet (18 inches) for the levees protecting this feature. A 12-inch granular filter was assumed for bedding under the riprap for each of the levees. The exterior (lake side) slopes are protected with riprap to the top of the levee, with a 5-foot tie-in. The interior side slopes would not be protected with riprap.

Construction Considerations

All levees constructed to protect Fort Totten would be constructed as dams. The top 12 inches of ground surface would be stripped prior to construction for better adhesion between the ground and the levee. A portion of the levee will require removal of

bituminous and subgrade material along 74th Avenue and across ND Highway 57. An inspection trench would also be constructed for all levees to permit observation of the top 6 feet of foundation materials.

The alignment of the levees would require modification if the lake level rises prior to construction. Constructions along alignments that are inundated are more difficult and costly to construct. It is also not feasible to examine the foundation when it is under water, there is less control over the placement of material under the water, and quality control verification is limited. Therefore, it was assumed that the levees would be constructed in the dry. Construction of Levee 3A-North and 3A-South may require a cofferdam along the upstream toe during initial levee construction to ensure construction in the dry if decisions are delayed or the lake rises faster. After construction of the cofferdam, the interior water behind the cofferdam can be pumped out to facilitate examination of the foundation, stripping of the top layer of ground and construction of the inspection trench. Cofferdam costs were not included in the Fort Totten cost estimate.

4.3.3.1 Site Geology

General

In the area of Devils Lake, Late Wisconsin age glacial deposits of varying thickness overlay deposits of earlier glaciation or Cretaceous age bedrock. Thin lacustrine deposits from prehistoric lake levels are also present in the Devils Lake basin. All the glacial deposits in this area are part of the Coleharbor Formation.

In the area of Fort Totten, the lacustrine deposits include soft lake bottom silt and clay and coarse sand to fine silty sand beach deposits. The lake bottom deposits lie on the easily recognized lake plain. These are mapped as the silt and clay facies of the Coleharbor Formation. The beach deposits, where present, are along the slope break surrounding the lake plain. These deposits tend to be too small of an area to be shown on the county geologic map, but are apparent in the county soil maps. The predominant glacial till deposits are generally composed of silty clay with sand, pebbles, cobbles, and boulders. The till is yellowish brown in the oxidized zone in the uppermost 10 to 25 feet near the ground surface, and olive gray at depth. The uneven surface, including closed basins, poorly developed drainage, and rounded hills are indications that the till is an ice margin and/or stagnation deposit. West of Fort Totten, the till deposit is described as a low-relief stagnation moraine. East and south of Fort Totten, the till is part of the North Viking end moraine. Well logs in the area of Fort Totten indicate that the glacial deposits

are 80 to over 300 feet thick. Typical well logs include sections of sand and gravel within the clay till. The bedrock is Cretaceous Pierre Shale.

Foundations

Based on past experience, the clay till is a good base for the levees. The lakebed deposits may be too soft to provide adequate foundation for levees and pump stations, and the sand beach deposits would allow for water to flow beneath the levees. Following is a summary of the soils beneath proposed Levee 3A:

- 12B, 13C Barnes Svea loam; CL, CL-ML; till – Moderate to Severe: low strength, frost action
- 18E Buse loam; ML, CL, CL-ML; till – Severe: low strength, slope
- 101 Lallie loam; ML, CL; lake bed – Severe: wetness, floods, low strength
- 107 Minnewaukan loamy fine sand; SM, SM-SP; beach – Severe: wetness, flooding

It is likely that some of the potentially problematic soil can be excavated and replaced with new fill. It is possible that a cut-off trench (or equivalent element) may be needed to mitigate the sand deposits. The cost estimate includes stripping the top foot of soil to remove potential problematic soil. It was assumed that a 1,740 square-foot slurry wall would be required to prevent seepage under the sand beach deposits, and was included in the cost estimate.

Need for Borings/Additional Information

Borings need to be completed in the areas of the sand beach deposits under both Fort Totten levees to determine their thickness. A boring will need to be completed in the low point of Fort Totten Levee 3A to determine the thickness and nature of the lake bed deposit.

Borrow Areas

Any upland soil south and west of Fort Totten is likely to supply adequate material for impervious core and impervious fill. If not already inundated, the coarse sand beach deposit near Sullys Hill National Game Preserve may be a source for sand borrow material.

4.3.3.2 Hydrology/Interior Drainage issues

Hydrology

An analysis of the internal drainage system was completed to assist with the sizing of an interior pump station to remove the accumulation of water from the interior area behind the levee. The analysis investigated the amount of water expected from precipitation, seepage through the levees, and groundwater seepage underneath the levees.

The interior drainage tributary watersheds were delineated using the USGS quadrangle maps and 1-foot LIDAR contours. The tributary area inside the flood barrier is about 800 acres and was divided into five subwatersheds. The total ponding area was calculated to be 5 acres. Land use in the tributary area is mainly grassland, with smaller portions of urban developments, woodland and cropland. The hydrologic soil group of the area is C. A curve number of 70 was assumed for all subwatersheds.

Two alternatives were analyzed to protect Fort Totten against internal flooding: (1) a pump station near the levee to pump out the runoff due to the entire drainage area, and (2) a smaller pump station designed near the levee to pump the runoff from the northern subwatersheds and rerouting the drainage from the southern subwatershed (south of 39th Street) directly into Devils Lake. The drainage diversion consists of one 24-inch RCP pipe, 2,200 feet in length and would route the runoff east, directly into the lake. The addition of the drainage pipes reduces the peak inflow from 88 to 68 cfs.

Pumping Requirements

The interior drainage system was designed to provide a minimum of 1-foot freeboard during the 10-day 100-year event. The design of the pump station was based on alternative 1, described above. For this alternative, three pumps will be utilized, with operation starting at different water levels. The capacities of the pumps are listed in the following table.

- Pump Characteristics – Fort Totten

Pumps	Flow (cfs)	Elevation Top of Levee	Minimum Pond Water Level	Total Design Head (ft)	Power (hp)
1	20	1466	1445.5	20.5	69
2	20	1466	1446	20	67
3	25	1466	1446.5	19.5	82

4.3.3.3 Real Estate Requirements

Right-of-way requirements for the levees are assumed to extend 15 feet beyond the toes of the embankments. The 15-foot buffer will provide sufficient room for temporary construction activities and long-term maintenance access.

4.3.3.4 Environmental/Cultural issues

HTRW

Current land uses surrounding the levees at Fort Totten appear to be mixed residential, commercial, and potentially industrial within Fort Totten, and rural residential outside of the community limits. Land use does not appear to have changed significantly over time. From 1931 to 1951, the town had increased slightly with some additional buildings and roads. In the 1950s and through 1967, the town still consisted of only a few buildings. By 1975, the town had doubled in size and has continued to grow slowly since. Surrounding land use is generally made of scattered rural residences, tree-covered land, and agricultural fields and has not significantly changed since the 1930s.

The regulatory record review for Fort Totten (58370) was obtained from FirstSearch on September 25, 2002. Five properties within the Fort Totten area were identified in the regulatory databases searched by FirstSearch, but none of the properties appear to be within the impact area. One property located within the area of concern is the Sullys Hill National Wildlife Preserve. The FWS has one registered underground storage tank. Although the exact location was not determined due to limited data, the UST is likely located in the relocation area.

Six potential HTRW sites were identified within the levee action levels as shown on Figure 4.3-1. A description of environmental concerns associated with these categories is in Section 4.0.

HTRW Site Costs			
Site #	**Action Level Affected**	**HTRW Category**	**HTRW Costs**
03-1-1	1	Rural Residences & Farmsteads	$1,500
03-1-2	1	Rural Residences & Farmsteads	$1,500
03-1-3	1	Rural Residences & Farmsteads	$500
03-2-4	2	Rural Residences & Farmsteads	$500
03-3-5	3	Rural Residences & Farmsteads	$500
03-1-6	1	Excavation or Fill Areas	$4,500

A more detailed description of site history and a breakdown of costs are in Appendix C.

A few structural relocations were evaluated for Fort Totten: seven residences; one sanitary lift station; and the Sullys Hill Facility, which includes a visitor center, a few gas tanks, a couple residences, and few maintenance buildings. Each home would be placed into the Rural Residences & Farmsteads category and would have the same environmental concerns and costs associated with that category. Determination of the location and removal of fuel tanks, septic systems, wells, and transformers is already included in the cost estimate for the relocation. Sanitary lift stations have the potential for release of nitrates and other substances disposed of into the sanitary sewer system. The UST referred to in the First Search report is likely located with one of the maintenance buildings at Sully Hill. A site investigation should be completed at the lift station and would cost $8,500. The soil and groundwater quality surrounding the UST should be investigated prior to removal as part of the Phase II if the tank is greater than 500 gallons or has been in the ground for greater than 10 years. Otherwise the risk of a release is similar to the risk associated with home heating fuel USTs and the tank basin can be inspected when the tank is removed.

Removal of the Sullys Hill Facility would fall under the Nonresidential Properties category and would have the same environmental concerns and costs as the Nonresidential Properties with a high potential for a release. Determination of the location and removal of fuel tanks, septic systems, wells, and transformers is already included in the cost estimate for residential relocation. A site investigation should be completed at the UST registered to the Sully Hill Facility and at the lift station. The total cost is estimated to be $18,500.

Relocation HTRW Costs				
Action Level Affected	**Number**	**Type of Items Relocated**	**HTRW Category**	**HTRW Costs**
1	3	Residences	Rural Residences & Farmsteads	none
	1	Sully Hill Facility	Nonresidential Properties – Registered UST	$10,000
2	1	Sanitary Lift Station	Nonresidential Properties	$8,500
3	4	Residences	Rural Residences & Farmsteads	none

Cultural

This project has the potential to affect nine known sites and three site leads/isolated finds as shown on Figure 4.3-1. Three of the nine known sites are archaeological sites related to the Fort Totten Historic Site and include the NRHP-listed Fort Totten Historic District

(32BE0011), the NRHP-listed Fort Totten historic archaeological site (32BE0011a), and the Fort Totten prehistoric archaeological site (32BE0011b), the NRHP-eligibility of which has not yet been determined. Site 32BE0011b consists of an artifact scatter that may not have been formally investigated as no investigation type is listed for this site in the 1997 database. A fourth archaeological site, 32BE0208, is a prehistoric archaeological site that was surface collected. The eligibility of this site for listing on the NRHP has not been evaluated.

The remaining five known sites that may be affected by the Fort Totten levee are architectural sites. These include St. Thomas Episcopal Church (32BE0099), Seven Dolors Catholic Church (32BE0100), Dakota Baptist Church (32BE0102), Cavalry Worship Center (32BE0104), and Sullys Hill Gate (32BE0114). According to the site files for the four churches, these properties were recorded as part of the "Picture North Dakota Churches" project sponsored by the State Historical Society of North Dakota, but they were not evaluated for their potential eligibility for listing on the NRHP. Site 32BE0114 (Sullys Hill Gate), the gate to the Sullys Hill Game Preserve, was recorded during a Phase I cultural resources survey by the FWS. This site was recommended as eligible to the NRHP for its association with the establishment of the preserve and for its unique construction (NDCRS Form, 32BE0114, on file at the SHSND).

Three site leads/isolated finds may fall within the Fort Totten cultural resources area of potential effect. The first of these, 32BEX0024 (Hunt Monument), is listed in the 1997 database as a historical archaeological site lead, with feature/structure type as "Clinic, Animal/Veterinarian," and historical context as "Irrigation and Conservation." The second, 32BEX0123, is an isolated find, consisting of a single .45 caliber lead bullet. Site lead 32RYX0094 is a reported mound site that was excavated in 1889, but no details on the site were reported by the excavator (University of North Dakota Archaeology Survey Sheet, 32RYX0094, on file at the SHSND).

A summary of the evaluation status of known cultural resources is presented in the following table.

Feature 3 Fort Totten: Evaluation Status of Known Cultural Resources			
Resource Type	**Resources Listed on or Nominated for the NRHP**	**Resources with Recommendations (Phase I Survey Completed)**	**Resources with Inconclusive or No Recommendations (Require Phase I Survey)**
Architectural	0	1	4
Archaeological	2	0	2
Architectural Site Leads/Isolated Finds	0	0	0
Archaeological Site Leads/Isolated Finds	0	0	3
Total	2	1	9

The estimated cost to conduct Phase 1 Surveys for each of the nine sites is presented in the following table. The total cost for all surveys is $76,800. As noted in Section 4.0, these costs are believed representative of the cultural resources investigations needed for the next stage of study.

Feature 3 Fort Totten: Phase 1 Cultural Survey Costs		
Site Number	**Investigation Type**	**Estimated Cost**
32BE0099	Phase I Architectural	$6,200
32BE0100	Phase I Architectural	$6,200
32BE0102	Phase I Architectural	$6,200
32BE0104	Phase I Architectural	$6,200
32BE0011b	Phase I Archaeological	$8,000
32BE0208	Phase I Archaeological	$8,000
32BEX0024	Phase I Archaeological	$14,000
32BEX0123	Phase I Archaeological	$8,000
32RYX0094	Phase I Archaeological	$14,000

Environmental

Fill used in the construction of the Fort Totten levees could cause environmental impacts due to encroachment upon upland plant communities, primarily to oak forest/woodlands and grasslands. The acres of habitat impacted by land use category are shown on Figure 4.3-1. In these upland areas a loss of native plant species due to grading and filling could be expected to occur. Subsequent revegetation of fill or borrow locations may allow for the introduction of weedy, non-native species. A loss of native tree species due to grading and filling, as well as the introduction of weedy, non-native under-story species

could also be expected in these areas. These environmental impacts are more fully detailed in the general impacts discussion Section 4.0.

At Action Level 1 (AL1), a total of 2.72 acres of potential oak forest/woodland and 4.01 acres of grasslands impacts are expected from the proposed levee construction. The loss of woodland and grassland areas would impact songbird nesting and small mammal populations, as well impacting reptile and amphibian populations due to habitat fragmentation. Mitigation for the upland would require the acquisition of 5.45 acres of like woodland habitat and 8.02 acres of like grassland habitat.

At Action Level 2 (AL2), a total of 0.67 acres of potential oak forest/woodland and 0.50 acres of grasslands impacts are expected from the proposed levee construction. The loss of woodland and grassland areas would impact songbird nesting and small mammal populations, as well impacting reptile and amphibian populations due to habitat fragmentation. Mitigation for the upland would require the acquisition of 1.35 acres of like woodland habitat and 1.01 acres of like grassland habitat.

At Action Level 3 (AL3), a total of 0.45 acres of potential oak forest/woodland and 0.87 acres of grasslands impacts are expected from the proposed levee construction. The loss of woodland and grassland areas would impact songbird nesting and small mammal populations, as well impacting reptile and amphibian populations due to habitat fragmentation. Mitigation for the upland would require the acquisition of 0.90 acres of like woodland habitat and 1.74 acres of like grassland habitat.

4.3.3.5 Effects on Existing Infrastructure and Utilities

- Levee 3A will cross Highway 57 (Highway 57 divides Levee 3A-North and Levee 3A-South. Highway 57 will need to be raised to provide protection.
- Levee 3A-South will result in closing/abandoning a part of 74th Avenue N.E. immediately south of Highway 57.
- Levee 3A will provide protection for 40th Street N.E.
- Levee 3A will provide protection for the Siaka Pump (lift) Station.
- Levee 3A will provide protection for the Veterans Memorial.
- 40th Street N.E. provides convenient access to structures located north and south of ND Highway 57. In the event that Levee 3 is not constructed, 40th Street N.E. would be flooded at 1454. Although, alternate routes would allow travel between structures

north and south of ND Highway 57, it may be desirable to raise 40th Street N.E. to maintain this route.

- Utilities in the vicinity of Levee 3A North and 3A South should be reviewed in detail during final design.

4.3.3.6 Interdependencies

Fort Totten is the primary center of activity for the Spirit Lake Nation, providing much of the necessary services for the tribe. Therefore, it is interdependent with the entire Spirit Lake Nation Reservation. Flood protection for Fort Totten is related to the protection of the highways that serve it. These highways include:

- Feature 13: US Highway 2
- Feature 14: ND Highway 57 (between ND Highway 20 and BIA Highway 1)
- Feature 15: ND Highway 57 (between BIA Highway 1 and US Highway 281)
- Feature 16: US Highway 281 (South of US Highway 2)
- Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57)
- Feature 22: ND Highway 20 (ND Highway 57 to Tokio)
- Feature 24: BIA Highway 6

These highways are critical for Fort Totten in that they provide the main transportation routes in and out of the community. Closing these highways would mean that Fort Totten would have to be relocated. Conversely, if Fort Totten were relocated, the need to protect these highways would be reduced.

The access to Sullys Hill National Game Preserve will be interdependent with access from ND Highway 57.

Table 4.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

4.3.3.7 O&M

The annual costs for operation and maintenance of the pumps and levees were estimated using data from the City of Devils Lake levees and pumping stations obtained from the Corps.

The annual maintenance costs for the levees were assumed to be 1% of the initial construction cost. The annual operation and maintenance cost for the pump station was assumed to be 1.5% of the pump station construction costs plus $13,000 for electricity.

4.3.3.8 Lead Time Required

Planning and implementation of flood protection measures must begin well in advance of the time when lake water would actually be causing damage to the feature. The amount of lead time will depend on the amount of time needed to plan and implement the flood protection measure. For Fort Totten, estimates of required times for the levee construction are as follows:

- Time required for planning and design – a lead time of about twelve months would be necessary for final design, preparation of construction documents and bidding
- Time required for construction – constructing the Fort Totten levees could be completed in one construction season
- The total time between initiation of final design and substantial completion of construction would be in the range of 18 to 24 months

Lead time estimates were used along with the Corps-provided probability-based projection of the rate of rise of Devils Lake to produce the tables of critical lake levels presented in Section 4.0.

However, for the relocations required for Fort Totten, no estimate of lead time was needed. Current FEMA policies make relocations unlikely until damage to the structures actually occurs. Relocations would be done on an as-needed basis, with no lead time provided, as presented in Section 4.3.2.

4.3.3.9 Potential Problems and Risks

Potential problems and risks associated with the levees and structure relocations include:

- Lake level: delayed decisions or faster rising lake levels may require the construction of cofferdams in order to construct levees in the dry
- Utilities may need to be abandoned or relocated as part of the house relocations, Sullys Hill relocation, or levee construction
- Foundation soils may be too soft to provide adequate foundation for levees and pump stations

4.3.3.10 Data Deficiencies

The following data should be collected or verified prior to proceeding with constructing the Fort Totten levees:

- Verify location, number, and elevation of homes that would need relocating.
- Collect soil borings along proposed levee alignment.
- Determine precise locations of above ground and buried utilities.
- Confirm low home: a group of three footprints existed on 2000 FEMA LIDAR topography in vicinity of Levee 3A. One of these footprints, located at 1448, did not appear to be an existing structure based on LIDAR notes. This structure was not included in the Infrastructure Protection Study.
- Coordinate with FWS and its plan regarding Sullys Hill National Game Preserve.
- Locate and evaluate nearby cultural resources that were identified.
- Structures were assumed to be relocated when damages begin to occur to the structure (when lake level approaches ground elevation at structure). Each structure to be relocated should be reviewed to confirm estimated ground elevation and to document when damages actually occur due to potential utilities, basements, low house openings, etc.

4.3.4 Economics of Flood Protection

Damages: For the Infrastructure Protection Study's analysis, the flood damage estimates for Fort Totten were reassessed in order to update and more accurately characterize the nature of the damages. The updated damage computations for Fort Totten are summarized in the accompanying Table 4.3-1. All damages were estimated up to the maximum lake level (elevation 1463).

The damages at AL1 include three residences and the Sullys Hill facility. Discussions with Joe Maxwell, Refuge Manager and Roger Hollevoet, FWS indicate that facilities which will be lost or made inaccessible due to rising water include the Sullys Hill shop and visitor center, two Regional Environmental Learning Center classrooms, a carpenter shop, a cold storage building, a seed shed, the duck hospital/storage building, quarters #2 and #28, the Sullys Hill entrance road and access to the auto tour route, the lower loop of the auto tour route which surrounds Sweetwater Lake, three vault toilets, a comfort station storage building, a grain bin, bulk fuel and diesel tanks, the fire cache/storage building, the nature trail, fee station, handicapped accessible trail and the amphitheater.

The damages at AL2 would be related to the Siaka sanitary lift station.

The damages at AL3 would occur to four residences. Damages to the Veterans Memorial would also occur at AL3, however these costs were not evaluated for this study.

Unit prices for all the damage computations were listed in Section 4.0, and are detailed in Table 4.0-2. An updated (as of 2002) list of assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Fort Totten are listed in the Fort Totten Infrastructure Protection Study Assumptions listing, attached to this Section 4.3.

Costs: The updated costs of providing flood protection for Fort Totten are detailed in the accompanying Table 4.3-2 for Fort Totten. Unit prices, data sources, and relevant assumptions are listed. All costs are given in 2002 dollars.

The costs for the levee include the levee construction, geotechnical items, environmental issues, and an interior drainage system. Pump costs were estimated from previous Devils Lake pumping stations and verified with other typical pumping station cost curves. Costs for the levee strategy includes the relocation of structures at Sullys Hill (since they are outside the levee protection area).

The costs for the relocation strategies include relocation of all structures.

Unit prices for all the cost computations were discussed previously in Section 4.0, and are detailed in Table 4.0-3. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for Fort Totten are listed in the Fort Totten Infrastructure Protection Study Assumptions listing, attached to this Section 4.3.

Contingencies: The contingency percentages used for construction materials ranged from 30 to 50% (Table 4.3-2). Contingencies for riprap and geotechnical items were estimated at the higher end of the range because of the potential variability in the quantities and unit prices.

4.3.5 Economic Results

Two flood protection strategies were analyzed for this feature for all action levels: incremental levee raise and incremental relocation. The results of the Infrastructure Protection Study for Fort Totten are listed in Table 4.3-3a for the analysis of all action levels and in Table 4.3-3b for the analysis of the first action level.

Multiple Action Level Stochastic Analysis Results: The stochastic analysis indicated that incremental relocation was the flood protection strategy that showed the largest net benefits. This strategy is highlighted on the decision tree (Figure 4.3-2). The average net benefits for this approach were less than zero (-$20,500). The BCR for this approach was less than one (0.76).

These results show that this strategy is not economically justified. The annual damages prevented by this relocation strategy are $66,700. The stochastic results are averages over 10,000 traces.

Multiple Action Level Results for Specific Scenarios: All of the flood protection strategies were also analyzed under three specific climate futures. For Fort Totten, the resulting economic indices for each of the three specific climate futures are as follows:

- Wet Future – For the wet future, the annual net benefits were -$65,600, and the BCR was 0.76, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $211,500.
- First Moderate Future – For the first moderate future, the annual net benefits were –$31,300, and the BCR was 0.77, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $102,200.
- Second Moderate Future – For the second moderate future, the annual net benefits were -$52,200, and the BCR was 0.77, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $170,400.

First Action Level Stochastic Analysis Results: Using the stochastic analysis along with the updated damage and cost estimates for Fort Totten, the Infrastructure Protection Study's analysis also provided relevant economic indices for one incremental relocation of structures.

The annual net benefits for this approach were less than zero (-$19,900). The BCR for this approach was less than one (0.77). These results show that this strategy is not economically justified. The annual damages prevented by this relocation strategy are $64,800. The stochastic results are averages over 10,000 traces.

The results for the first action level are similar to the results computed for all action levels for this feature.

First Action Level Results for Specific Scenarios: One incremental relocation of structures was also analyzed under each of three specific climate futures. For Fort Totten, the economic indices for each of the three climate futures are as follows:

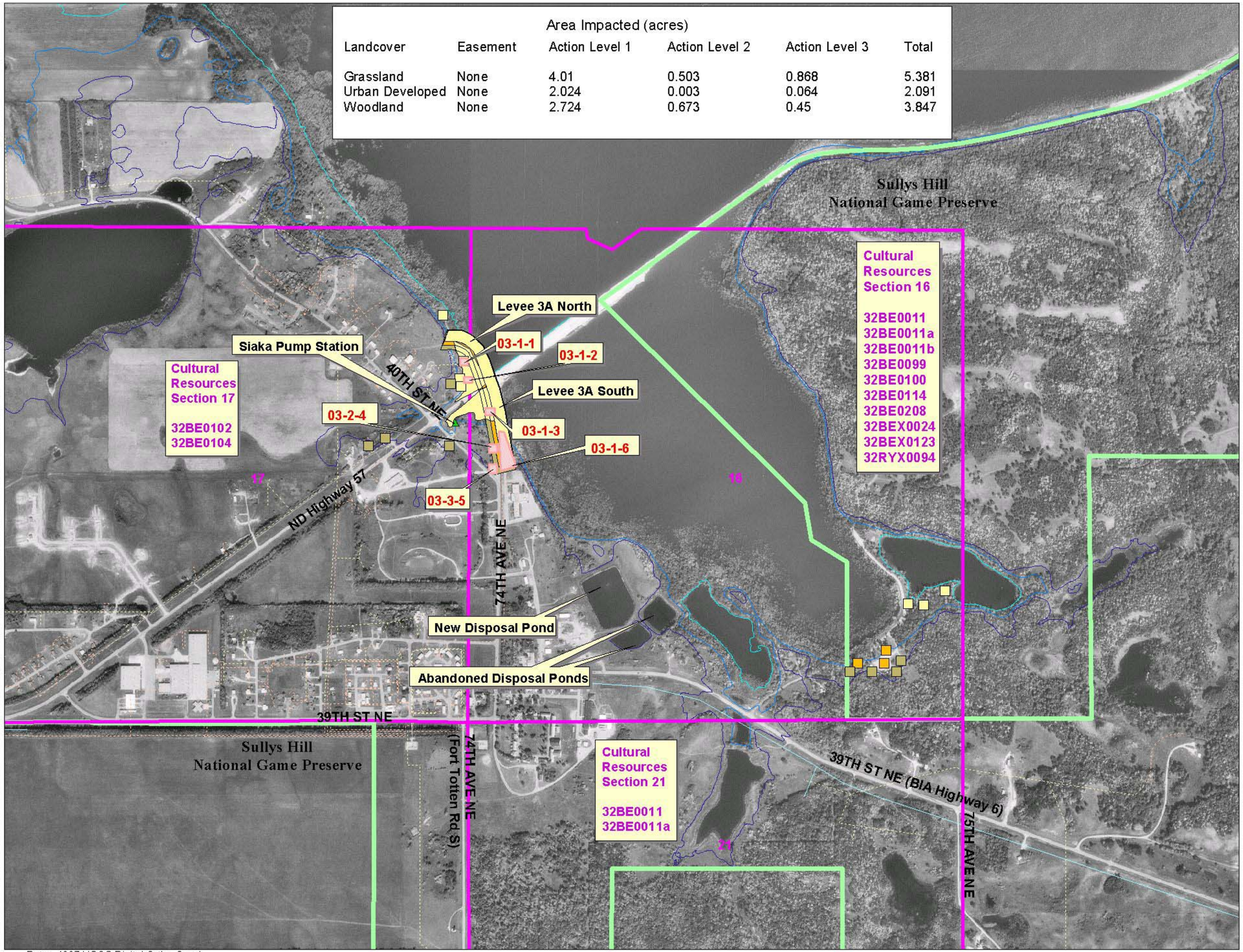
- Wet Future – Under the wet future climate scenario, the annual net benefits of one incremental relocation of structures were -$60,200, and the BCR was 0.77, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $196,500.
- First Moderate Future – Under the first moderate future climate scenario, the annual net benefits of one incremental relocation of structures were -$31,300, and the BCR was 0.77,

indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $102,200.

- Second Moderate Future – Under the second moderate future climate scenario, the annual net benefits of one incremental relocation of structures were -$50,400, and the BCR was 0.77, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $164,400.

Area Impacted (acres)

Landcover	Easement	Action Level 1	Action Level 2	Action Level 3	Total
Grassland	None	4.01	0.503	0.868	5.381
Urban Developed	None	2.024	0.003	0.064	2.091
Woodland	None	2.724	0.673	0.45	3.847



Data: 1997 USGS Digital Ortho Quad

N
W E
S

500 0 500 1000 Feet

Reference Lake Contours
- 1447
- 1454
- 1463

Impact Areas
- Action Level 1
- Action Level 2
- Action Level 3

Structure Relocation
- Action Level 1
- Action Level 2
- Action Level 3
- Other Structures

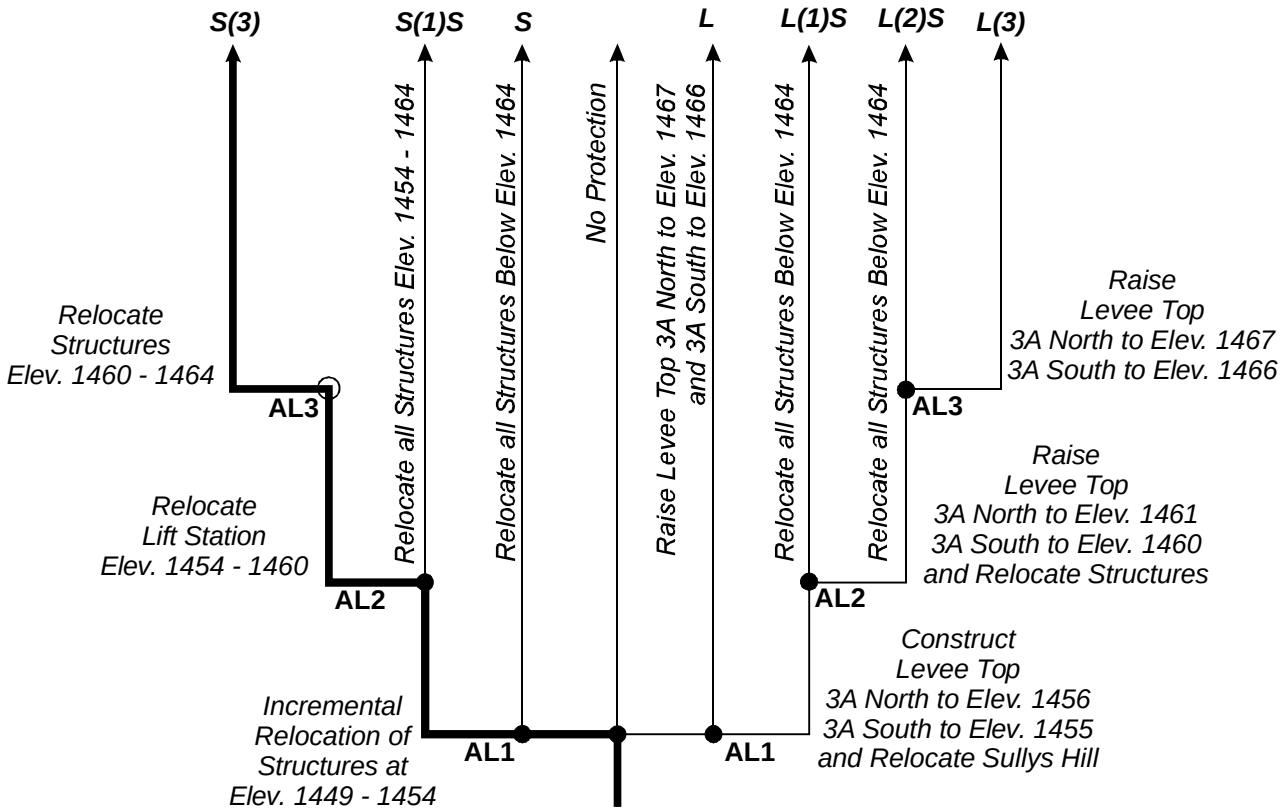
- HTRW Sites
- National Game Preserve
- Cultural Resources Sites
- Pump Station

Utilities
- Electric
  - Overhead
  - Underground
  - Unknown
- Water
  - Watermain
  - Watermain, Abandoned
- Sewer
  - Sewer
  - Sewer, Abandoned
- Gas

Figure 4.3-1

LOCATION MAP
FEATURE 3: FORT TOTTEN
Devils Lake Infrastructure
Protection Study

Barr: Arcview 3.1, OPT2615, I:\Client\DevilsLake\Gis\DLIP\Features\Communities\03_FortTotten\Project\basemap_03.apr, Layout: Layout: Section 4 Figure, lkp, Tue Nov 19 13:16:12 2002

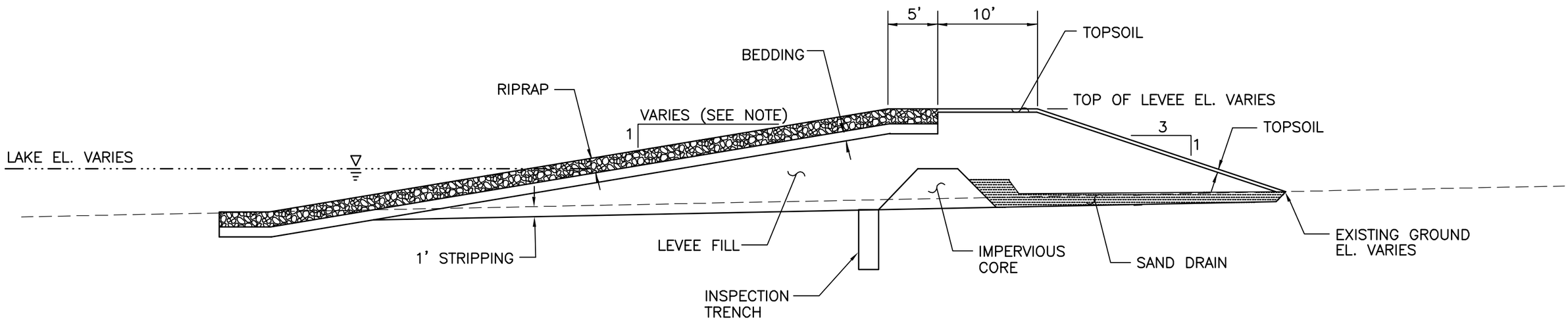


P:\34\36\020\DECISIONTREES\2002FIGURES\FIGURE4_03.CDR RLG 01-06-03

━━━	Flood Protection Strategy
●	Decision required at this point
⊙	Trigger point for action, no decision needed
AL1	Decision/Action level
L(1)	Incremental levee raise (number of times)
L	Levee raise to Elev. 1466/1467
S(1)	Structure relocation (number of times)
S	Relocate all structures below Elev. 1464

Figure 4.3-2

DECISION TREE
FEATURE 3: FORT TOTTEN
Devils Lake Infrastructure Protection Study



NOTE: LEVEE 3A NORTH 6:1 LAKESIDE SLOPE
LEVEE 3A SOUTH 4:1 LAKESIDE SLOPE

0 10 20
SCALE IN FEET

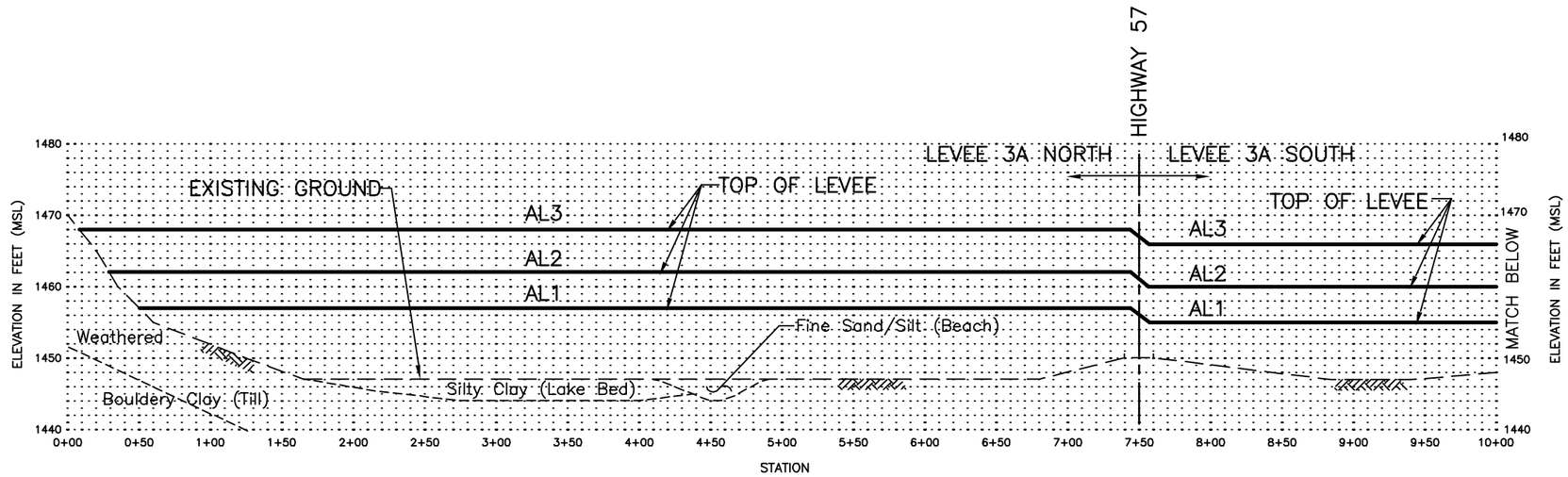
Figure 4.3–3

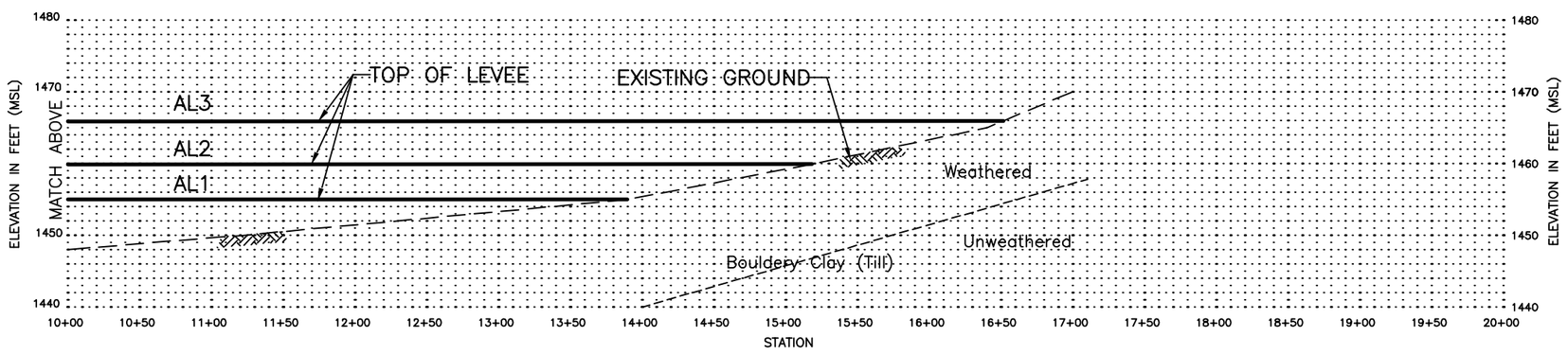
TYPICAL LEVEE CROSS–SECTION

FEATURE 3:
FORT TOTTEN

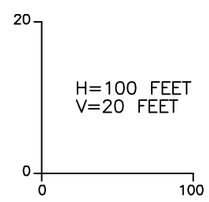
DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

NRD M:\CAD\3436020\17124_1.DWG Plot at 10 11/05/2002 11:09:39





LEVEES 3A NORTH AND 3A SOUTH



Notes:
1. Adjacent ground elevation obtained from 2000 FEMA LIDAR topography.
2. Stationing increases along levee from north to south.

Figure 4.3–4

LEVEE PROFILE

FEATURE 3:
FORT TOTTEN

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

NRD M:\cad\3436020\17125_2.DWG Plot at 100 11/05/2002 11:50:10

Table 4.3-1

Flood Damages
Feature 3: Fort Totten
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Structure Elevation Range (MSL)	Structures and Infrastructure (THOUSANDS)
AL1	1449-1454	$3,638
AL2	1454-1459	$200
AL3	1459-1464	$248

DAMAGE BREAKDOWN

Structure Elevation 1449-1454					Structure Elevation 1454-1459					Structure Elevation 1459-1464				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	3	EA	$62,000	$186	Residence	0	EA	$62,000	$0	Residence	4	EA	$62,000	$248
Sullys Hill NGP - Access Road	1	LS	$1,514,000	$1,514	Siaka Pump Station	1	EA	$200,000	$200					
Sullys Hill NGP - Buildings	1	LS	$1,938,000	$1,938										
Total				**$3,638**	**Total**				**$200**	**Total**				**$248**

Table 4.3-2

Flood Protection Costs
Feature 3: Fort Totten
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	S(3)	S(1)S	S	L	L(1)S	L(2)S	L(3)
Action Level	Cost to Incrementally Relocate Structures at AL1, AL2, AL3	Cost to Incrementally Relocate at AL1, Relocate All Remaining Structures at AL2	Cost to Relocate All Structures at AL1	Cost to Raise Levee at AL1	Cost to Incrementally Raise Levee at AL1, Relocate All Remaining Structures at AL2	Cost to Incrementally Raise Levee at AL1, AL2, Relocate All Remaining Structures at AL3	Cost to incrementally Raise Levee at AL1, AL2, AL3
	(THOUSANDS)						
AL1	$4,753	$4,753	$5,367	$9,983	$8,978	$8,978	$8,978
AL2	$260	$614	$0	$0	$5,366	$367	$367
AL3	$354	$0	$0	$0	$0	$5,366	$638

COST BREAKDOWN

Strategy	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)
	S AT AL1					
	S(1) S AT AL1					
	S(3) AT AL1					
Incremental Relocation	Residence	3	EA	$68,000	30%	$265
	Sullys Hill NGP - Access Road	1	LS	$1,514,000	30%	$1,968
	Sullys Hill NGP - Buildings	1	LS	$1,938,000	30%	$2,519
	Total Relocation					**$4,753**
	L(3) AT AL1					
	L(2)S AT AL1					
	L(1)S AT AL1					
	L AT AL1					
Incremental Levee Raise	**Sully Hill National Game Preserve**					
	Sullys Hill NGP - Access Road	1	LS	$1,514,000	30%	$1,968
	Sullys Hill NGP - Buildings	1	LS	$1,938,000	30%	$2,519
	3A North - Raise Top of Levee to El. 1456					
	Performance/Payment Bond	1	JB	$2,143	10%	$2
	Residence Relocation	1	EA	$68,000	30%	$88
	Levee Construction					
	Clearing and Grubbing	1.4	AC	$3,000	30%	$5
	Stripping (1')	2,300	CY	$1.50	30%	$4
	Inspection Trench	750	LF	$4.00	30%	$4
	Levee Fill	6,900	CY	$5.00	30%	$45
	Bedding	1,500	CY	$35	30%	$68
	Riprap	2,300	CY	$40	40%	$129
	Sand Drain	1,700	CY	$22	30%	$49
	Topsoil (4")	300	CY	$2.50	30%	$1
	Seed	0.6	AC	$1,000	30%	$1
	Subtotal Levee 3A North Construction					$4,884
	3A South - Raise Top of Levee to El. 1455					
	Performance/Payment Bond	1	JB	$21,411	10%	$24
	Residence Relocation	0	EA	$68,000	30%	$0
	Levee Construction					
	Clearing and Grubbing	1.0	AC	$3,000	30%	$4
	Stripping (1')	1,500	CY	$1.50	30%	$3
	Inspection Trench	750	LF	$4.00	30%	$4
	Levee Fill	3,700	CY	$5.00	30%	$24
	Bedding	900	CY	$35	30%	$41
	Riprap	1,400	CY	$40	40%	$78
	Sand Drain	1,500	CY	$22	30%	$43
	Topsoil (4")	300	CY	$2.50	30%	$1
	Seed	0.5	AC	$1,000	30%	$1
	Subtotal Levee 3A South Construction					$222
	Interior Drainage/Pump Station					
	Culverts	0	LF	$50	50%	$0
	Pump Station	1	EA	$2,200,000	30%	$2,860
	Geotechnical					
	Slurry Wall	1,740	SF	$6.00	50%	$16
	Borings	5	EA	$1,000	50%	$8
	Excavation of Unsuitable Material	500	CY	$8.50	50%	$6
	Environmental Impacts					
	Mitigation	1	LS			$4
	HTRW	1	LS			$18
	Cultural Resources Investigation	1	LS			$77
	Subtotal					$8,095
	Engineering and Design			15%		$541
	Supervision and Administration			8%		$289
	Real Estate Acquisition for ROW	1	LS			$54
	Total Levee					**$8,978**

Strategy	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)
	S(1)S AT AL2					
	S(3) AT AL2					
Incremental Relocation	Residence	0	EA	$68,000	30%	$0
	Siaka Pump Station	1	EA	$200,000	30%	$260
	Total Relocation					**$260**
	L(3) AT AL2					
	L(2)S AT AL2					
	L(1)S AT AL2					
Incremental Levee Raise	**3A North - Raise Top of Levee to El. 1461**					
	Performance/Payment Bond	1	JB	$1,017	10%	$1
	Residence Relocation	0	EA	$68,000	30%	$0
	Levee Construction					
	Clearing and Grubbing	0.5	AC	$3,000	30%	$2
	Stripping (1')	700	CY	$1.50	30%	$1
	Inspection Trench	0	LF	$4.00	30%	$0
	Levee Fill	8,900	CY	$5.00	30%	$58
	Bedding	500	CY	$35	30%	$23
	Riprap	800	CY	$40	40%	$45
	Sand Drain	500	CY	$22	30%	$14
	Topsoil (4")	400	CY	$2.50	30%	$1
	Seed	0.7	AC	$1,000	30%	$1
	Subtotal Levee 3A North					$146
	3A South - Raise Top of Levee to El. 1460					
	Performance/Payment Bond	1	JB	$956	10%	$1
	Residence Relocation	0	EA	$68,000	30%	$0
	Levee Construction					
	Clearing and Grubbing	0.6	AC	$3,000	30%	$2
	Stripping (1')	900	CY	$1.50	30%	$2
	Inspection Trench	0	LF	$4.00	30%	$0
	Levee Fill	6,100	CY	$5.00	30%	$40
	Bedding	500	CY	$35	30%	$23
	Riprap	800	CY	$40	40%	$45
	Sand Drain	800	CY	$22	30%	$23
	Topsoil (4")	400	CY	$2.50	30%	$1
	Seed	0.8	AC	$1,000	30%	$1
	Subtotal Levee 3A South					$138
	Interior Drainage/Pump Station					
	Culverts	0	LF	$50	50%	$0
	Pump Station	0	EA	$0	50%	$0
	Geotechnical					
	Slurry Wall	0	SF	$6.00	50%	$0
	Borings	0	EA	$1,000	50%	$0
	Excavation of Unsuitable Material	0	CY	$8.50	50%	$0
	Environmental Impacts					
	Mitigation	1	LS			$1
	HTRW	1	LS			$9
	Cultural Resources Investigation	1	LS			$0
	Subtotal					$294
	Engineering and Design			15%		$44
	Supervision and Administration			8%		$23
	Real Estate Acquisition for ROW	1	LS			$6
	Total Levee					**$367**

Strategy	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)
	S(3) AT AL3					
Incremental Relocation	Residence	4	EA	$68,000	30%	$354
	Total Relocation					**$354**
	L(3) AT AL3					
Incremental Levee Raise	**3A North - Raise Top of Levee to El. 1467**					
	Performance/Payment Bond	1	JB	$2,099	10%	$2
	Residence Relocation	0	EA	$68,000	30%	$0
	Levee Construction					
	Clearing and Grubbing	0.9	AC	$3,000	30%	$4
	Stripping (1')	1,500	CY	$1.50	30%	$3
	Inspection Trench	0	LF	$4.00	30%	$0
	Levee Fill	20,300	CY	$5.00	30%	$132
	Bedding	1,000	CY	$35	30%	$46
	Riprap	1,500	CY	$40	40%	$84
	Sand Drain	1,000	CY	$22	30%	$29
	Topsoil (4")	600	CY	$2.50	30%	$2
	Seed	1.1	AC	$1,000	30%	$1
	Subtotal Levee 3A North					$302
	3A South - Raise Top of Levee to El. 1466					
	Performance/Payment Bond	1	JB	$1,446	10%	$2
	Residence Relocation	0	EA	$68,000	30%	$0
	Levee Construction					
	Clearing and Grubbing	0.7	AC	$3,000	30%	$3
	Stripping (1')	1,100	CY	$1.50	30%	$2
	Inspection Trench	0	LF	$4.00	30%	$0
	Levee Fill	12,600	CY	$5.00	30%	$82
	Bedding	700	CY	$35	30%	$32
	Riprap	1,000	CY	$40	40%	$56
	Sand Drain	1,000	CY	$22	30%	$29
	Topsoil (4")	600	CY	$2.50	30%	$2
	Seed	1.1	AC	$1,000	30%	$1
	Subtotal Levee 3A South					$208
	Interior Drainage/Pump Station					
	Culverts	0	LF	$50	50%	$0
	Pump Station	0	EA	$0	50%	$0
	Geotechnical					
	Slurry Wall	0	SF	$6.00	50%	$0
	Borings	0	EA	$1,000	50%	$0
	Excavation of Unsuitable Material	0	CY	$8.50	50%	$0
	Environmental Impacts					
	Mitigation	1	LS			$1
	HTRW	1	LS			$1
	Cultural Resources Investigation	1	LS			$0
	Subtotal					$512
	Engineering and Design			15%		$77
	Supervision and Administration			8%		$41
	Real Estate Acquisition for ROW	1	LS			$8
	Total Levee					**$638**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Levee Maintenance	Pump O&M	Total Operation and Maintenance Cost
	(THOUSANDS)		
AL1	$5	$46	$51
AL2	$8	$46	$54
AL3	$13	$46	$59

Notes:
1. The costs for the Relocate All Structures strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.
2. Incremental levee raise for 3A North includes relocation of 1 residence and the Sully Hill Facility during AL1.
3. Levee maintenance costs shown are the cumulative totals for each respective level.

Table 4.3 - 3a

Economics Results: All Action Levels -- to Lake Level 1463

Feature 3: Fort Totten

Devils Lake Infrastructure Protection Study

Stochastic Analysis (ST-9)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$66,700	$66,700	$0	$0	--
S	Relocation of All Structures below 1464	$0	$0	$95,600	$95,600	$0	$0	$66,700	-$28,900	0.70
L	Raise Levee Top to 1464	$605,100	$58,800	$0	$663,900	$0	$0	$66,700	-$597,200	0.10
L(1)S	1 Levee Raise: Then Relocate	$544,300	$34,300	$95,500	$674,100	$0	$0	$66,700	-$607,300	0.10
L(2)S	2 Levee Raises: Then Relocate	$550,800	$45,000	$24,300	$620,100	$0	$0	$66,700	-$553,400	0.11
L(3)	3 Levee Raise	$553,700	$48,900	$0	$602,500	$0	$0	$66,700	-$535,700	0.11
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$88,800	$88,800	$0	$0	$66,700	-$22,100	0.75
S(3)	3 Incremental Relocations	$0	$0	$87,200	$87,200	$0	$0	$66,700	-$20,500	0.76

Wet Future Scenario (WF-9)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$211,500	$211,500	$0	$0	--
S	Relocation of All Structures below 1464	$0	$0	$289,800	$289,800	$0	$0	$211,500	-$78,400	0.73
L	Raise Levee Top to 1464	$607,200	$59,000	$0	$666,200	$0	$0	$211,500	-$454,800	0.32
L(1)S	1 Levee Raise: Then Relocate	$546,100	$5,700	$289,800	$841,600	$0	$0	$211,500	-$630,100	0.25
L(2)S	2 Levee Raises: Then Relocate	$565,900	$21,900	$191,100	$779,000	$0	$0	$211,500	-$567,500	0.27
L(3)	3 Levee Raise	$588,700	$53,000	$0	$641,700	$0	$0	$211,500	-$430,200	0.33
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$281,300	$281,300	$0	$0	$211,500	-$69,800	0.75
S(3)	3 Incremental Relocations	$0	$0	$277,100	$277,100	$0	$0	$211,500	-$65,600	0.76

Moderate Future 1 Scenario (M1-4)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$102,200	$102,200	$0	$0	--
S	Relocation of All Structures below 1464	$0	$0	$150,700	$150,700	$0	$0	$102,200	-$48,500	0.68
L	Raise Levee Top to 1464	$607,200	$59,000	$0	$666,200	$0	$0	$102,200	-$564,100	0.15
L(1)S	1 Levee Raise: Then Relocate	$546,100	$27,200	$150,700	$724,100	$0	$0	$102,200	-$621,900	0.14
L(2)S	2 Levee Raises: Then Relocate	$556,500	$49,100	$0	$605,500	$0	$0	$102,200	-$503,400	0.17
L(3)	3 Levee Raise	$556,500	$49,100	$0	$605,500	$0	$0	$102,200	-$503,400	0.17
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$133,500	$133,500	$0	$0	$102,200	-$31,300	0.77
S(3)	3 Incremental Relocations	$0	$0	$133,500	$133,500	$0	$0	$102,200	-$31,300	0.77

Moderate Future 2 Scenario (M2-4)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$170,400	$170,400	$0	$0	--
S	Relocation of All Structures below 1464	$0	$0	$242,500	$242,500	$0	$0	$170,400	-$72,200	0.70
L	Raise Levee Top to 1464	$607,200	$59,000	$0	$666,200	$0	$0	$170,400	-$495,900	0.26
L(1)S	1 Levee Raise: Then Relocate	$546,100	$13,000	$242,500	$801,600	$0	$0	$170,400	-$631,300	0.21
L(2)S	2 Levee Raises: Then Relocate	$562,700	$50,000	$0	$612,600	$0	$0	$170,400	-$442,300	0.28
L(3)	3 Levee Raise	$562,700	$50,000	$0	$612,600	$0	$0	$170,400	-$442,300	0.28
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$233,100	$233,100	$0	$0	$170,400	-$62,700	0.73
S(3)	3 Incremental Relocations	$0	$0	$222,500	$222,500	$0	$0	$170,400	-$52,200	0.77

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.125% and rounded to the nearest $100.
*Total benefits are calculated as the total damages incurred for the "No Protection" strategy minus the total damages for the strategy implemented (F(S)).

Table 4.3 - 3b

Economics Results: First Action Level
Feature 3: Fort Totten
Devils Lake Infrastructure Protection Study

Stochastic Analysis (ST-9)
Mean Value over 10,000 Traces (Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$64,800	$64,800	$0	$0	--
S(1)	1 Incremental Relocation	$0	$0	$84,600	$84,600	$0	$0	$64,800	-$19,900	0.77

Wet Future Scenario (WF-9)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$196,500	$196,500	$0	$0	--
S(1)	1 Incremental Relocation	$0	$0	$256,700	$256,700	$0	$0	$196,500	-$60,200	0.77

Moderate Future 1 Scenario (M1-4)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$102,200	$102,200	$0	$0	--
S(1)	1 Incremental Relocation	$0	$0	$133,500	$133,500	$0	$0	$102,200	-$31,300	0.77

Moderate Future 2 Scenario (M2-4)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Levee Raise A	O&M B	Relocation C	Total D = A + B + C	Damages E	Total F = E	To Strategy (Damages Prevented) G = F(No Protection) - F(S) *	To Strategy H = G - D	(BCR) I = G / D
No Protection	No Protection or Relocation	$0	$0	$0	$0	$164,400	$164,400	$0	$0	--
S(1)	1 Incremental Relocation	$0	$0	$214,800	$214,800	$0	$0	$164,400	-$50,400	0.77

All dollar values are present worth values annualized over a 50-year period at an interest rate of 6.125% and rounded to the nearest $100.
* Total benefits are calculated as the total damages incurred for the "No Protection" strategy minus the total damages for the strategy implemented (F(S)).

Attachment to 4.3:
Fort Totten Economic Analysis Assumptions

A. General Assumptions

1. Estimated damages included only the homes in the immediate area of Fort Totten. According to the League of Cities office in Bismarck, the area is not incorporated. The few homes outside of the immediate area were included in computations for Feature 8.1: Devils Lake Rural Areas.

2. Structure elevation data was obtained from the 2000 FEMA LIDAR 1-foot topography.

B. Levee

1. For levee protection, it was assumed that 4 feet of freeboard would be required for levee 3A North and 3 feet for levee 3A South at all action levels. The assumed freeboard was based on calculated wave heights for this area plus 1 foot.

2. A decision was assumed to be made when the lake is at the Planning and Design Initiation Elevation (i.e., elevation when planning must begin due to lead time required to complete planning, design and construction to maintain desired protection levels.)

3. A 40% contingency was applied to all riprap costs.

4. Interior pond areas and volumes used for sizing of interior pump stations were calculated for the maximum levee elevation only.

5. A 50% contingency was applied to the interior pump stations.

6. The cost of relocating the Siaka Pump Station was obtained from a phone conversation with Sioux Utilities (Carolyn Greene) on October 16, 2002. The ground elevation of the lift station was assumed to be at 1454.

7. Sand drains were assumed to be included for all levees with a height of 9 feet or greater at the maximum levee height (sand drains would need to be constructed during initial levee construction even though initial levee heights would be less than 9 feet).

8. It was assumed that the impervious fill materials for levees would come from nearby clay borrow areas.

9. Although, it was recognized that special handling, placement and compaction methods would be required for construction of impervious core, it was assumed that the unit price for impervious core would be similar to levee fill. Impervious core was includes in the levee fill quantity.

10. The annual maintenance cost for the levees was assumed to be 1% of the construction costs.

11. The annual operation and maintenance cost for the pump station was assumed to be 1.5% of the pump station construction costs plus $13,000 for electricity.

12. The inspection trench was assumed for the initial levee construction (AL1) only.

13. Seed quantity assumed to be the same as the topsoil area.

14. Stripping of topsoil between levee raises was considered incidental.

15. Levee quantities assume total volume of new topsoil added at each levee raise (new topsoil may include topsoil salvaged from previous levee construction—the unit price of any salvaged topsoil was assumed to be the same as for new topsoil).

16. Levee quantities assume the 5 feet of riprap along the top of the levee would be salvaged and reused at each levee raise.

17. Figure 4.3-1 shows two residences near the AL1 ponding area. It was assumed that the ponds and minor grading around structures would be adjusted as necessary to prevent impacts to these residences. Incidental costs were assumed to be included in contingencies for interior drainage/pump station.

18. For levee raises, the lake damage elevation was assumed to be one-half the height of its freeboard.

C. Residential and Commercial Properties

1. For relocation strategies, structures were assumed to be relocated when the lake level approached the ground elevation at each structure and damages would occur. Damages were assumed to begin when the lake elevation was 1 foot below the structure ground elevation to account for potential wave action.

2. The average value of a house in Fort Totten was estimated to be $62,000. This figure was obtained from the Federal Emergency Management Agency (FEMA) and represents the average value of a house located on the Spirit Lake Nation Reservation. The value for each house was determined for FEMA by certified flood insurance adjusters and was based on total habitable square footage of the buildings and standardized real estate appraisals (*FEMA*, personal communication, March, 2001). These values did not include the value of land on which the houses were located.

3. Relocation cost for a house was estimated to be $68,000. This cost was obtained from the North Dakota-North Central Planning Council and represents the average cost to relocate a residence during the buyout program conducted in Churchs Ferry (2000). The $68,000 includes the following costs: demolition of the existing house, purchase of an equivalent house in a nearby community, purchase of a lot, and legal, appraisal, and management fees. It was assumed relocation costs would be approximately the same in Fort Totten as they were in Churchs Ferry.

4. The cost for relocation/rebuilding of commercial and public facilities was assumed to be 100% of the value of the structure and property.

5. Sewage Lagoons: a new sewage lagoon was constructed on higher ground west of Fort Totten. The east sewage lagoon, near the lake, had a majority of the wastewater removed by pumping into the new sewage lagoon, according to Neil Austin of the Spirit Lake Nation Indian Health Service. A direct pipeline still exists from the east sewage lagoon (consisting of three cells) to the new west sewage lagoon (consisting of four cells). The pipeline serves two purposes:

   a. To pump the remaining wastewater from the old eastern lagoon to the new western lagoon.

   b. To be used in case of an emergency where the new western lagoon would be unusable.

   Carolyn Greene of the Sioux Utility confirmed that the large cell (eastern lagoon) is currently used for emergency operation about two to three times per year. The two smaller cells have been out of service for three years. Therefore, it was assumed that the eastern sewage lagoon will not be needed during flooding events and can be abandoned if necessary.

D. Sullys Hill National Game Preserve (Sullys Hill)

1. According to Joe Maxwell, Sullys Hill Refuge Manager, two structures located near Sweetwater Lake have been abandoned or relocated. One of these buildings was moved to higher ground during October 2002. The FWS pumps Sweetwater Lake to minimize potential flooding. Sweetwater Lake, located immediately north of the visitor center, is important for managing the elk and bison herd. Some of the FWS maintenance facilities have been moved from Sullys Hill to Lake Alice National Wildlife Refuge. According to Roger Hollevoet, FWS, the current dike/access road at Sullys Hill has been raised on two different occasions for a total of 13 feet of vertical rise. Their engineers recommended that the FWS no longer raise the Sullys Hill dike, as it would become a high hazard dam versus a dike. As a result it was recommended that the FWS relocate the structures at Sullys Hill. Therefore, only relocation strategy was reviewed for Sullys Hill.

2. According to Joe Maxwell, Sullys Hill Refuge Manager, revenue for the facility include a $2 auto tour user fee and income from sale of books and other educational materials. The total annual revenue was only $2,000 to $3,000. Therefore, revenue was considered negligible and was not included in the Infrastructure Protection Study.

3. According to Joe Maxwell, Sullys Hill Refuge Manager, approximately 40,000 individuals visit Sullys Hill each year.

4. The following estimated costs were provided by the FWS. All costs include Engineering and Administration:

- $1,514,000: Construction of new access road from ND Highway 57
- $8,000: Move classroom to Lake Alice National Wildlife Refuge
- $495,000: New shop at Lake Alice (replaces existing building at Sullys Hill)
- $280,000: New manager's residence
- $162,000: Relocate Sullys Hill Amphitheater
- $17,000: Reconstruct trailer pads for visitor center hosts
- $61,000: Cap wells and replace drainfield at existing headquarters
- $360,000: New shop at Sullys Hill
- $10,000: Relocate gas/diesel tanks
- $225,000: New cold storage building at Lake Alice NWR (replaces existing building at Sullys Hill)
- $320,000: Reconstruct volunteer residence

5. Sullys Hill costs include Engineering & Design (E&D) and Supervision & Administration (S&A), therefore, they were subtracted out of the total that the E&D and S&A were applied to in the cost table.

4.4 Summary of Infrastructure Protection Investigation for Feature 4: City of Minnewaukan

4.4.0 Flood Protection Strategy

The Infrastructure Protection Study indicates that the flood protection strategy with the largest net benefits for the City of Minnewaukan would be incremental levee raises.

4.4.1 General Information

Feature Type: Community

Location: The City of Minnewaukan is located on the west side Devils Lake in Benson County, ND, Section 15, Township 153N, Range 67W. Currently, US Highway 281 (South of US Highway 2) passes through the city limits. The accompanying Figure 4.4-1 shows the feature's location and approximate extents, and the inundation extents at the reference lake levels (1447, 1454, 1463).

Description: Minnewaukan is a city with a current population of 318, and is the county seat of Benson County. The city covers approximately 250 acres and includes residential and commercial development, municipal facilities (public library, courthouse, fairgrounds, etc.), utility infrastructure (roads, sewers, electrical, telephone, etc.), and transportation infrastructure (US Hwy 281 [South of US Highway 2]).

Significance: The value of all communities is high because of the density of infrastructure in this primarily rural section of North Dakota. Minnewaukan is important because it is a densely populated area that contains property of value and historical significance. The surrounding infrastructure includes major transportation routes for population and industry. The city contains county seat facilities including the county fairgrounds and courthouse.

Damages: There are numerous commercial and residential properties that would be affected by rising lake levels, particularly for lake levels above 1455. The flooding of the City of Minnewaukan would result in the following damages:

- Loss of residences – The majority of the property at risk in the city is located between 1456 and 1463. Approximately 13 residences exist below 1455. Approximately 5 residences exist below 1454. The lowest residence is 1452. The lowest garage is 1451.
- Loss of historical buildings – The Benson County Courthouse and Grace Episcopal Church are listed in the National Register of Historic Places.
- Loss of commercial and municipal properties – As with homes in the city, the majority of commercial and municipal properties at risk are between elevations 1456 and 1463. Two

commercial structures were identified below 1455. The lowest commercial structure is at 1454.

- Loss of other structures – Several other agricultural, institutional, governmental, and other structures would be damaged. The lowest structure is one of the 4-H barns located at the fairgrounds. Its ground elevation is approximately 1450.
- There are also several structures above 1463 that would be severed from the main land during high lake levels.
- Loss of access to the City.

Owner/Sponsor: The City of Minnewaukan City Council is responsible for managing and maintaining day-to-day administration of the city.

Lead Federal Agency: The Corps of Engineers would take the lead for the City of Minnewaukan for any flood protection work that may take place. The Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

4.4.2 Feature Protection

History of Flood Protection: In the past, flood protection for the City of Minnewaukan has consisted of the following:

- Moving the sewage treatment ponds to higher ground (in 1995). The top of the dike around the sewage treatment ponds is believed to be above 1463.
- Installation of a back-up water supply line from the water plant north of town, extending south from the water plant to the west of the city, then extending east through the city to the water tower.
- Installation of drainage features to prevent flooding from the unnamed coulee on the northwest side of the city, including enlarging culverts under the railroad and highways on the north end of town.
- Abandoning certain portions of the county fairgrounds, and abandoning parts of the park and athletic fields on the east side of the school. Currently, the football field is not useable because part of the field is under water.
- Moving structures to higher ground, or plans to move structures within the next year. According to information provided during the site reconnaissance trip, this year structures planned for relocation include Trinity Church, and structures west of West Avenue on D Street.

- The Red River Valley and Western Railroad that previously passed through town was abandoned.

- The report *Devils Lake City of Minnewaukan Assessment* (Barr, April 1998) was prepared to identify potential flooding concerns and discuss alternatives for protecting infrastructure adjacent to the Coulee located north of the city.

- The *Devils Lake Minnewaukan Federal Interest Study* (Barr, September 1998) was prepared to identify potential flood mitigation alternatives to protect the city from the rising lake.

General Protection Strategy: The Infrastructure Protection Study's analysis for the City of Minnewaukan allowed for reconsideration of flood mitigation options at each of several action levels. Flood protection options for the City of Minnewaukan included:

- Construction of levees to protect the City of Minnewaukan. The levees would tie into high ground near the reroute location for US Highway 281 (South of US Highway 2), and would allow access to the city through the existing roadway system. Construction of the levees would also include relocation of isolated structures, such as the county fairground buildings and a few isolated structures in the levee footprint.

- Relocation of all affected structures (including the homes severed from the main land).

Protection Strategy by Action Level: A variety of flood protection strategies were analyzed for the City of Minnewaukan. As shown on Figure 4.3-2, the stepwise approach to flood protection for the City of Minnewaukan consisted of the following:

1. At Action Level 1 (AL1), a decision would be made as to whether the entire city should be relocated or a levee constructed to protect these structures (top of levee at 1459/1460). An incremental relocation strategy was also analyzed that assumed the structures below 1458 would be moved to other towns. This strategy could result in the abandonment of the City of Minnewaukan.

2. If a levee were constructed at AL1, at Action Level 2 (AL2), a decision would be made to relocate the city or raise the levee to a top of 1466/1467. If incremental relocation were conducted at AL1, relocation of structures above 1458 would be required at AL2 (including those severed).

The Features Analysis Model was then used to determine which of the paths through the branches of the decision tree - which flood protection strategy - had the largest net benefits. That strategy is highlighted on Figure 4.4-2, and consists of the following:

1. At Action Level 1 (AL1), construction of the initial levee raise to a top of 1459/1460

2. At Action Level 2 (AL2), raise the levee to a top of 1466/1467

Therefore, the first action level of protection would include the construction of the levee to 1459/1460. It was assumed that

The pertinent reference elevations for the flood protection strategies are given below:

Reference Elevations for Relocation of Entire City (AL1)		
Elevation	**Name**	**Significance**
1452	Low Structure Elevation	Ground elevation at structure
1451	Lake Damage Elevation	Lake elevation at which damage to lowest structure begins
1454	Project Completion Elevation	Lake elevation at which relocation of entire city must be complete (the 5 residences below 1454 will be temporarily protected until relocation)
1451	Construction Initiation Elevation	Lake elevation at which relocation of entire city must begin
Current	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

Reference Elevations for Incremental Relocations			
Elevation			
AL1	**AL2**	**Name**	**Significance**
1452	1458	Low Structure Elevation	Ground elevation at structure
1451	1457	Lake Damage Elevation	Lake elevation at which damage to lowest structure begins
1451	1457	Project Completion Elevation	Lake elevation at which relocation must be complete
NA	NA	Construction Initiation Elevation	Lake elevation at which relocations must begin
NA	NA	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

Reference Elevations for Levee Construction (AL1)		
Elevation	**Name**	**Significance**
1452	Low Structure Elevation	Ground elevation at structure (protected by levee)
1451	Lake Damage Elevation	Lake elevation at which damage to lowest structure occurs
1453	Project Completion Elevation	Lake elevation at which levee construction must be complete (the 5 residences below 1454 will be temporarily protected until levee is completed)
1451	Construction Initiation Elevation, assumes initial levee investigations completed in the dry prior to construction	Lake elevation at which levee construction must begin
Current	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

Reference Elevations for Levee Raise (AL2)		
Elevation	**Name**	**Significance**
1459	Low Structure Elevation	Low point on top of levee
1458	Lake Damage Elevation	Lake elevation at which damage to levee begins (assumed to be 1/2 height of freeboard)
1456	Project Completion Elevation	Lake elevation at which levee raise construction must be complete (at freeboard)
1454	Construction Initiation Elevation	Lake elevation at which levee raise construction must begin
1452	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

4.4.3 Design Considerations

4.4.3.0 General Design

Alignment

The general plan for flood protection at the City of Minnewaukan would be the construction of a levee. The levee was analyzed in six reaches, referred to hereafter as levees 4A-4F. The resulting plan view is a large "U" shaped levee around the city, as shown on Figure 4.4-1. This levee alignment varies significantly from the alignment presented in the Economic Analysis of Devils Lake Alternatives, which was a ring-

shaped levee completely circling the city, with US Highway 281 as part of the levee. The difference is due to a change in plans for US Highway 281 (re-routing of the highway outside the city limits is likely), and to minimize levee cost based on updated contours provided by LIDAR mapping of the area. The updated mapping information and subsequent cost comparison of various alignments show a significant savings in levee construction cost by tying into high ground rather than completely encircling the city in a ring-shaped levee.

Levee 4A would extend from high ground south of the city and would protect the current intersection of US Highway 281 ("C" Avenue within the city) and US Highway 19, providing access to the city from the west. Levee 4B skirts the east edge of the city. Levees 4C and 4D skirt the northeast end of the city. Levee 4E is located between existing structures and the unnamed coulee north of the city, and prevents coulee flows from entering the area protected by the levee system, thus minimizing interior drainage requirements. The final segment, Levee 4F ties into high ground northwest of the city.

Some structures or properties are outside the alignment, or lie in the footprint of the proposed levees. These include the county fairgrounds (and three fairgrounds structures), the athletic fields east of the school, and a stable or barn east of the county maintenance garage.

The table below provides a summary of the levees for the City of Minnewaukan:

	Levee Lengths (Feet)	
Levee	**AL1**	**AL2**
4A	1680	2350
4B	2600	2600
4C	1720	1720
4D	1125	1125
4E	1645	1645
4F	1500	1970

Cross-section

Figure 4.4-3 shows a typical cross-section of the proposed levees.

The top widths for the levees were assumed to be 15 feet (10 feet of compacted fill and 5 feet of riprap tie-in). The side slopes are 3H:1V on the interior (land side) of the levee. The side slopes on the lake side of the levee vary depending on the location and depth of water: 5H:1V and 6H:1V (as noted on Figure 4.4-4). The elevations of the tops of the

levees vary depending on wave height and required freeboard. The top and interior side of the levees would be covered with 4 inches of topsoil and seeded.

An impervious core was designed for all levees. Sand drains were assumed to be included for all levees with a height of 9 feet or greater at the maximum levee height (sand drains would need to be constructed during initial levee construction even though initial levee heights would be less than 9 feet). The top of the sand drain layer would be 4 feet wide. The sand drain would then slope down at a 1H:1V slope and be 2 feet thick along the rest of its length (depending on the height of the levee). The actual sand drain elevations should be reviewed during final design and during construction of each levee addition.

Profile

Figure 4.4-4 shows the profile of the proposed levees. Levees 4B, 4C, 4D, and 4E are one foot higher than Levees 4A and 4F due to different wind-induced wave heights and corresponding requirements for erosion protection. Two levee raises were designed for the City of Minnewaukan, based on the action levels and protection levels.

The general design parameters are presented in the following table:

Levee	Wind Induced Wave Height (Ft.)	Freeboard [1] (Ft.)	Top of Levee Elevations[2]	
			[3]AL1 [4]PL (1451-1458)	AL2 PL (1458-1466)
4A	2.0	3	1459	1466
4B	2.9	4	1460	1467
4C	3.0	4	1460	1467
4D	2.2	4	1460	1467
4E	3.0	4	1460	1467
4F	2.0	3	1459	1466

[1] Freeboard calculated by adding 1 foot to the wind-induced wave height (rounded up to the nearest whole foot).
[2] Top of levee elevations were determined by adding the freeboard to the maximum protection level elevation.
[3] Action Level (AL)
[4] Protection Level (PL): Number in ( ) refers to elevation range for relocating structures.

Materials

It was assumed that the levees would be constructed from readily available native silty clay and clay loam. These materials are relatively impermeable, and are suitable for levee construction. An impervious core was also assumed for all levees.

Erosion Protection

The exterior side slopes of all levees will require erosion protection due to wave action. Riprap sizing and thickness was determined using COE methods described in EM1110-2-1601, with wave height based on a COE Report titled *Devils Lake, North Dakota, Wind-Induced Changes in Water Elevations*, revised September 1998. The riprap sizing was evaluated for various side slopes to determine the most cost-effective exterior side slope for each alternative. The average size of the riprap (D_{50}) is 9 inches based on the fetch, depth of water, and the side slope. Riprap thickness varies depending on erosion control calculations for each segment of the levee, and varies from 1 foot to 1.5 feet thick. A 12-inch granular filter was assumed for bedding under the riprap for each of the levees. The exterior (lake side) slopes are protected with riprap to the top of the levee, with a 5-foot tie-in. The interior side slopes would not be protected with riprap.

Construction Considerations

All levees constructed to protect Minnewaukan will be constructed as dams. The top 12 inches of ground surface will be stripped prior to construction for better adhesion between the ground and the levee. A portion of the levee will require removal of bituminous and subgrade material along E Avenue and across US Highway 281 and other local streets. An inspection trench will also be constructed for all levees to permit observation of the top 6 feet of foundation materials.

Prior to the lake rising above the ground level along the levee alignment, it was assumed that the following pre-construction activities would be conducted in the dry: an inspection trench, stripping of the top layer of ground, and geotechnical investigations to examine the foundation. Although constructions along alignments that are inundated are more difficult and costly to construct, the alignment footprint would only be inundated by a few feet and the initial investigations would have been completed. Construction of the Minnewaukan levees may require a small cofferdam along the upstream toe during initial levee construction if decisions are delayed or the lake rises faster. After construction of the cofferdam, the interior water behind the cofferdam can be pumped out. Cofferdam costs were not included in the Minnewaukan cost estimate.

4.4.3.1 Site Geology

In the area of Devils Lake, Late Wisconsin age glacial deposits of varying thickness overly deposits of earlier glaciations and/or Cretaceous age bedrock. Thin lacustrine deposits from the current and prehistoric Lake Minnewaukan are also present in the Devils Lake basin. All the glacial deposits in this area are part of the Coleharbor Formation.

In the area of the City of Minnewaukan, the lacustrine deposits and the glacial deposits are present, as is an alluvial deposit along the stream on the north edge of town. The alluvial deposit roughly parallels the proposed levee segments 4E and 4F, and is primarily a silt. This deposit is relatively small, and is not mapped in the county geologic report, but is apparent in the county soil survey. The lacustrine deposits include soft lake bottom silt and clay and coarse sand to fine silty sand beach deposits. The lake bottom deposits lie on the easily recognized lake plain, most of which is now beneath the lake. These are mapped as the silt and clay facies of the Coleharbor Formation, and this is the predominant deposit north and east of Minnewaukan. The beach deposits, where present, are along the slope break surrounding the lake plain. These deposits tend to be too small in area to be shown on the county geologic map, but are apparent in the county soil maps.

The predominant glacial till is generally composed of silty clay with sand, pebbles, cobbles, and boulders. This deposit is yellowish brown in the oxidized zone in the uppermost 10 to 25 feet near the ground surface, and olive gray at depth. The till is mapped as part of the boulder clay facies of the Coleharbor Formation. It is described as a low-relief stagnation moraine, typified by an uneven and low-relief surface, including closed basins, poorly developed drainage, and rounded hills. Well logs in the area of Minnewaukan indicate that the glacial deposits are 25 to 56 feet thick, with clay till in the uppermost 17 to 41 feet, and sand and gravel with some till layers at depth. The bedrock is Cretaceous Pierre Shale.

The proposed levee alignments cross the following soil types, which have the indicated comments with respect to levee construction. "Slight" means soil properties and site characteristics are generally favorable for this use. "Severe" means special design may be required. Wetness and flooding are a given, since much of the area is already inundated. The concern is the low strength.

- Segment 4A
  - 140B Svea loam; CL, CL-ML; glacial till – Severe: low strength
  - 41 Overly silty clay loam: CL, CL-ML; glacial till – Severe: frost action, low strength
  - 129 Colvin silt loam, saline; CL; lake bed – Severe: wetness, floods, low strength
  - 45 Beardon silt loam; CL-ML, CL; lake bed – Severe: frost action, low strength
- Segment 4B
  - 45 Beardon silt loam; CL-ML, CL; lake bed – Severe: frost action, low strength

- 50B Great Bend silt loam; CL, ML; lake bed – Severe: frost action, low strength
- 75 Ryan silty clay; CH; lake bed – Severe: wetness, floods, low strength

- Segment 4C
  - 75 Ryan silty clay; CH; lake bed – Severe: wetness, floods, low strength
  - 99C Claire loamy coarse sand; SP, SP-SM; beach – Slight
  - 101 Lallie loam; ML, CL; lake bed – Severe: wetness, floods, low strength
  - 107 Minnewaukan loamy fine sand; SM, SM-SP; beach – Severe: wetness, floods

- Segment 4D
  - 107 Minnewaukan loamy fine sand; SM, SM-SP; beach – Severe: wetness, flooding
  - 101 Lallie loam; ML, CL; lake bed – Severe: wetness, floods, low strength
  - 7 Colvin silt loam; CL; alluvium – Severe: low strength, wetness, floods
  - 50B Great Bend silt loam; CL, ML; lake bed – Severe: frost action, low strength

- Segment 4E
  - 7 Colvin silt loam; CL; alluvium – Severe: low strength, wetness, floods
  - 41 Overly silty clay loam: CL, CL-ML; glacial till – Severe: frost action, low strength
  - 50B Great Bend silt loam; CL, ML; lake bed – Severe: frost action, low strength

- Segment 4F
  - 41 Overly silty clay loam: CL, CL-ML; glacial till – Severe: frost action, low strength
  - 45 Beardon silt loam; CL-ML, CL; lake bed – Severe: frost action, low strength
  - 7 Colvin silt loam; CL; alluvium – Severe: low strength, wetness, floods
  - 13C Barnes loam; CL, CL-ML; glacial till – Moderate: frost action, low strength

Borings need to be completed in the areas of the lake bed and till deposits to determine the strength. Borings will need to be completed in the areas of the beach and alluvial

deposits to determine the need for and extent of remedial features (i.e., cutoff walls). A total of 15 borings are recommended. It was assumed that approximately 1,200 feet of levee alignment would require a cut-off wall or excavation of permeable sub-soil. Approximately 5,200 feet of the levee alignment overlies lake bed deposits, which may need to be excavated.

4.4.3.2 Hydrology/Interior Drainage issues

Hydrology

An analysis of the internal drainage system was completed to assist with the sizing of an interior pump station to remove the accumulation of water from the interior area behind the levees. The analysis investigated the amount of water expected from precipitation, seepage through the levees, and groundwater seepage underneath the levees.

The interior drainage tributary watersheds were delineated using the USGS quadrangle maps and the 2000 FEMA LIDAR 1-foot topography. The tributary area inside the flood barrier is about 900 acres and was divided into eight subwatersheds. Land use in the tributary area is mainly cropland and urban developments, with smaller portions of grassland. The hydrologic soil group of the area is C. A curve number of 70 was assumed for all subwatersheds.

Two alternatives were considered for routing the flood water to the Minnewaukan pump station: (1) interior drainage routed through the current drainage system to the pump station, and (2) rerouting a portion of the interior drainage through town directly to the pump station and the remaining drainage routed through current drainage system. The first alternative was determined to be more economically feasible, and was used in the design of the pump station. Under both scenarios, runoff from higher ground was channeled outside of the levee to the west and directly into the lake through a 2,400 feet long, 5 feet wide, grass lined channel.

The Minnewaukan pump station would be located in the northeastern corner of the levee. Ponding would occur at four different locations near the Minnewaukan Levee. The total ponding area was calculated to be 20.3 acres. The following drainage channels and pipes were necessary to route the runoff to the pump station:

- A 2,240 feet channel, with side slopes 3H:1V and a bottom width of 5 feet
- One 24-inch concrete drainage pipe, 600 feet long
- Three 24-inch concrete drainage pipes, 3,750 feet long

Pumping Requirements

The interior drainage system was designed to provide a minimum of 1-foot freeboard during the 10-day 100-year event. Three pumps will be utilized, with operation starting at different water elevations. The capacities of the pumps are listed in the following table.

Minnewaukan Pump Station

Pumps	Flow (cfs)	Elevation Top of Levee	Minimum Pond Water Level	Total Design Head (ft)	Power (hp)
1	35	1467	1447	20	117
2	20	1467	1447.5	19.5	65
3	20	1467	1448	19	64

4.4.3.3 Real Estate Requirements

Right-of-way requirements for the levees are assumed to extend 15 feet beyond the toes of the embankments. The 15-foot buffer will provide sufficient room for temporary construction activities and long-term maintenance access.

4.4.3.4 Environmental/Cultural issues

HTRW

Current land uses surrounding the levees at Minnewaukan appear to be mixed residential, commercial, and potentially industrial within the City of Minnewaukan, and rural residential and agricultural outside of the city. Land use does not appear to have changed significantly over time. Minnewaukan has been essentially the same size since the 1950s, with the exception of a few additional residences and nonresidential properties. Surrounding land use is generally made of scattered rural residences, tree-covered land, and agricultural fields and has not significantly changed since the 1950s.

The regulatory record review for Minnewaukan (58351) was obtained from FirstSearch on October 1, 2002. Six of the seven facilities located within the Minnewaukan area appear to be located within the relocation area. The six facilities have registered USTs and two of the UST facilities are listed as closed leaking underground storage tank sites. These properties do no appear to be within the footprint of the impact areas. Exact locations of most of the sites were not able to be determined. Due to the risk of leakage from USTs each of these properties are suspected to be RECs that will need to be investigated if the City of Minnewaukan is moved.

Thirteen potential HTRW sites identified within the levee action levels are listed below and shown on Figure 4.4-1. A general description of environmental concerns associated with these categories is in Section 4.0.

HTRW Site Costs			
Site #	**Action Level Affected**	**HTRW Category**	**HTRW Costs**
04-R-1	Relocate	Rural Residences & Farmsteads	$1,500
04-1-2	1	Excavation or Fill Areas	$4,500
04-1-3	1	Rural Residences & Farmsteads	$1,500
04-1-4	1	Rural Residences & Farmsteads	$500
04-1-5	1	Excavation or Fill Areas	$4,500
04-1-6	1	Nonresidential Properties	$10,000
04-1-7	1	Rural Residences & Farmsteads	$1,500
04-1-8	1	Nonresidential Properties	$10,000
04-1-9	1	Excavation or Fill Areas	$4,500
04-2-10	2	Rural Residences & Farmsteads	$500
04-1-11	1	Former Recreation Facility	$500
04-1-12	1	Potential Dumps	$500
04-1-13	1	Railroad Related Land Uses	$5,500

A more detailed description of site history and a breakdown of costs are in Appendix C.

If the City of Minnewaukan is relocated west of the current location the following table shows the number of structures by category and the HTRW costs that maybe associated with each structure. Each residence would be placed into the Rural Residences & Farmsteads category and would have the same environmental concerns and costs associated with that category. Determination of the location and removal of fuel tanks, septic systems, wells, asbestos and transformers is already included in the cost estimate for the relocation. Site investigations are needed for commercial structures used for petroleum retail or pesticide storage and sale, the grain elevator, and the government garages. Based on the FirstSearch regulatory database, two of the commercial properties used retail petroleum services and two of the government buildings have USTs.

Relocation HTRW Costs			
Number	**Type of Items Relocated**	**HTRW Category**	**HTRW Costs**
129	Res. House	Rural Residences & Farmsteads	Included as part of the relocation cost estimate.
9	Res. Mfg. Str.	Rural Residences & Farmsteads	
7	Apartments	Rural Residences & Farmsteads	

Relocation HTRW Costs			
Number	**Type of Items Relocated**	**HTRW Category**	**HTRW Costs**
62	Garages	Nonresidential Properties	$1,500
4	Barn/Silo	Nonresidential Properties	$1,500
24	Commercial	Nonresidential Properties	$46,000*
2	Commercial Petroleum	Nonresidential Properties	$20,000
1	Grain Elevator	Nonresidential Properties	$10,000
3	Church	Nonresidential Properties	$4,500
1	School	Nonresidential Properties	$1,500
1	Govt. Museum	Nonresidential Properties	$1,500
1	Govt. Library	Nonresidential Properties	$1,500
1	Govt. Courthouse	Nonresidential Properties	$1,500
4	Govt. General	Nonresidential Properties	$6,000
2	Govt. Garages	Nonresidential Properties	$20,000

* Of the 24 commercial properties one property is expected to require a field investigation.

Cultural

The levee construction and the relocation of structures have the potential to affect six known sites and 12 site leads as shown on Figure 4.4-1. Two of the known architectural sites, the Benson County Courthouse (32BE0012) and the Episcopal Church (32BE0032) are listed on the NRHP. Of the four remaining known sites, three are architectural sites: the Lutheran Church (32BE0033), the Harriman House (32BE0034), and the Cubbison House (32BE0035). The Lutheran Church was previously recommended as potentially eligible for listing on the NRHP, the Harriman House was recommended as eligible, and no recommendation of eligibility has been made for the Cubbison House. The final known site, 32BE0115, consists of a scatter of historical-period cultural materials, including ceramics, glass, and metal. This site was recommended as not eligible for listing on the NRHP.

Nine of the site leads that may fall within the City of Minnewaukan potential effects are houses: the Mike Haman House (32BEX0017), the Chris Teigan House (32BEX0025), the Norma Schmidt House (32BEX0041), the Hermin Jorgenson House (32BEX0055), the Pat Stensby House (32BEX0066), the Lavern Butts House (32BEX0079), the Harold Johnson House (32BEX0104), the Hazel Schmid House (32BEX0105), and the Anthony Charboneass House (32BEX0106). The remaining site leads are categorized as historical

archaeological site leads and include the locations of the Minnewaukan Presbyterian Church (32BEX0039), the Minnewaukan Townsite (32BEX0040), and the Plummer Hardware Store (32BEX0042).

A summary of the evaluation status of known cultural resources is presented in the following table.

Feature 4 City of Minnewaukan: Evaluation Status of Known Cultural Resources			
Resource Type	**Resources Listed on or Nominated for the NRHP**	**Resources with Recommendations (Phase I Survey Completed)**	**Resources with Inconclusive or No Recommendations (Require Phase I Survey)**
Architectural	2	2	1
Archaeological	0	1	0
Architectural Site Leads/Isolated Finds	0	0	9
Archaeological Site Leads/Isolated Finds	0	0	3
Total	2	3	13

While there is a potential to impact all of these cultural resources for any of the action levels proposed for this feature, the impacts would be most severe for total relocation of the community. The estimated cost to conduct Phase 1 Surveys for each of 13 sites is presented in the table below. The total cost for all surveys is $104,000. As noted in Section 4.0, these costs are believed representative of the cultural resources investigations needed for the next stage of study.

Feature 4 City of Minnewaukan: Estimated Cost For Phase 1 Surveys of Known Sites		
Site Number	**Investigation Type**	**Estimated Cost**
32BE0035	Phase I Architectural	$6,200
32BEX0017	Phase I Architectural	$6,200
32BEX0025	Phase I Architectural	$6,200
32BEX0041	Phase I Architectural	$6,200
32BEX0055	Phase I Architectural	$6,200
32BEX0066	Phase I Architectural	$6,200
32BEX0079	Phase I Architectural	$6,200
32BEX0104	Phase I Architectural	$6,200
32BEX0105	Phase I Architectural	$6,200
32BEX0106	Phase I Architectural	$6,200
32BEX0039	Phase I Archaeological	$14,000

Feature 4 City of Minnewaukan: Estimated Cost For Phase 1 Surveys of Known Sites		
Site Number	**Investigation Type**	**Estimated Cost**
32BEX0040	Phase I Archaeological	$14,000
32BEX0042	Phase I Archaeological	$14,000
Total Cost for Phase 1 Surveys		$104,000

Environmental

The natural resources within the City of Minnewaukan levees and relocation impact area include wetlands and upland areas. Fill used in the construction of the City of Minnewaukan levees could cause environmental impacts due to encroachment upon wetlands and upland plant communities. The acres of habitat impacted by land use category are shown on Figure 4.4-1. Impacts to the wetland communities represent an important environmental impact to these natural resources. Complete or partial loss of wetland functions and conversion to upland due to filling is possible in some locations. In areas where some hydrology is maintained and wetland conditions remain, changes in plant community and hydrology could lead to a wetland type change. The loss of wetland area will impact waterfowl, marsh bird and songbird-nesting areas, as well bring about impacts to reptile and amphibian populations due to habitat fragmentation. These environmental impacts are more fully detailed in the general impacts discussion Section 4.0.

In the upland areas a loss of native species due to grading and filling could be expected to occur. Subsequent revegetation of fill or borrow locations may allow for the introduction of weedy, non-native species. A loss of native tree species due to grading and filling, as well as the introduction of weedy, non-native under-story species could also be expected in these areas. The loss of woodland areas will impact songbird nesting and small mammal populations, as well impacting reptile and amphibian populations due to habitat fragmentation. These environmental impacts are more fully detailed in the general impacts discussion Section 4.0.

At Action Level 1 (AL1), a total of 4.36 acres of potential oak forest/oak woodland, 4.60 acres of wetlands, 3.31 acres of grasslands under easements, 12.97 acres of other grassland habitat and 2.82 acres of cover crop under easements would be impacted from the proposed levee construction in this location. The loss of woodland areas would impact songbird nesting and small mammal populations, as well impacting reptile and amphibian populations due to habitat fragmentation. Mitigation activities would require the acquisition of 8.72 acres of potential oak forest/oak woodland, 29.25 acres of

grasslands habitat and 2.82 acres of cover crop like upland habitat areas for these impacts. This loss of wetland would require 9.20 acres of mitigation wetlands as set forth in the project mitigation policy developed through consultation with the Corps and FWS.

At Action Level 2 (AL2), a total of 1.04 acres of oak forest/oak woodland, 0.34 acres of wetlands, 1.44 acres of grasslands under easements, 4.58 acres of other grassland habitat and 1.18 acres of cover crop under easements would be impacted from the proposed levee construction in this location. The loss of woodland areas would impact songbird nesting and small mammal populations, as well impacting reptile and amphibian populations due to habitat fragmentation. Mitigation activities would require the acquisition of 8.72 acres of oak forest/oak woodland, 10.6 acres of grasslands habitat and 1.18 acres of cover crop like upland habitat areas for these impacts. This loss of wetland would require 0.68 acres of mitigation wetlands as set forth in the project mitigation policy developed through consultation with the Corps and FWS.

At the action level requiring relocation of the City of Minnewaukan, a total 6.21 acres of potential oak forest/oak woodland, 6.09 acres of wetland and 63.7 acres of grasslands habitat would be impacted within the proposed relocation area. The loss of woodland areas would impact songbird nesting and small mammal populations, as well impacting reptile and amphibian populations due to habitat fragmentation. Mitigation activities would require the acquisition of 12.42 acres of potential oak forest/oak woodland and 127.4 acres of grasslands in like upland habitat areas for these impacts. This loss of wetland would require 12.18 acres of mitigation wetlands as set forth in the project mitigation policy developed through consultation with the Corps and FWS.

4.4.3.5 Effects on Existing Infrastructure and Utilities

- Levee 4F would tie into the embankment of the proposed relocated US Highway 281. Levee 4F is not currently planned to be constructed as a combined road/levee, but could provide a second means of egress from the city should such an improvement be desired in future design considerations. The alignment of levee 4F crosses 45 ½ Street NE west of the city and the levee could be designed to carry traffic to US Highway 281 via 45 ½ Street NE.

- Construction of levee 4B would result in closing/abandoning “E” Avenue and portions of other local streets.

- Utilities in the vicinity of all levees should be reviewed in detail during final design. Currently, most major utilities such as water, sanitary, telephone, and others are routed underground. The city water supply and sanitary forcemain to the water treatment plant would both pass under levee 4C.

- The North Dakota Telephone Company (NDTC) has a central switching station in the City of Minnewaukan that serves the city as well as the surrounding rural area. Any relocation strategy that includes moving the telephone switching station would require rerouting service to the rural communities as well. Relocation of this station was included in the costs for this feature.

4.4.3.6 Interdependencies

The City of Minnewaukan is a center of activity for Benson County, providing much of the necessary services for the rural community. Therefore, it is interdependent with the entire surrounding rural community. The protection of Minnewaukan is related to the following features:

- Feature 8: Rural Areas – the North Dakota Telephone Company (NDTC) has a central switching station in the City of Minnewaukan that serves the city as well as the surrounding rural area. Any relocation strategy that includes moving the telephone switching station would require rerouting service to the rural communities as well.

- Feature 13: US Highway 2 – US Highway 2 provides a main transportation route in and out of the city.

- Feature 16: US Highway 281 (South of US Highway 2) – Highway 281 passes through the city limits and is the major thoroughfare for traffic. Relocation or raise of Highway 281 will affect access to the city and will also affect the location of the city in any relocation alternatives.

- Feature 18: ND Highway 19 – ND Highway 19 provides a main transportation route in and out of the city.

Table 4.0-1, mentioned earlier in this report, provides a summary of the interdependencies among the features.

4.4.3.7 O&M

The annual costs for operation and maintenance of the pumps and levees were estimated using data from the City of Devils Lake levees and pumping stations obtained from the Corps.

The annual maintenance costs for the levees were assumed to be 1% of the initial construction cost. The annual operation and maintenance cost for the pump station was assumed to be 1.5% of the pump station construction costs plus $15,000 for electricity.

4.4.3.8 Lead Time Required

Planning and implementation of flood protection measures must begin well in advance of the time when lake water would actually begin causing damage to the feature. The amount of lead time will depend on the amount of time needed to plan and implement the flood protection measure. For the City of Minnewaukan, estimates of required times for the levee construction follows:

- Time required for planning and design – a lead time of about twelve months would be necessary for final design, preparation of construction documents and bidding.
- Time required for construction – constructing the Minnewaukan levees could be completed in one construction season. The total time between initiation of final design and substantial completion of construction would be in the range of 18 to 24 months.

Lead time estimates were used along with the Corps-provided probability-based projection of the rate of rise of Devils Lake to produce the tables of critical lake levels presented in Section 4.0.

For incremental relocation of structures within the City of Minnewaukan, no estimate of lead time was needed. The City of Minnewaukan signed the FEMA waiver to their typical flood disaster policy that allows structures to be eligible for buyouts prior to the structures being damaged. Incremental relocations would be done on an as-needed basis, with lead time based on the National Weather Service's spring prediction of expected water levels. An exception would be if relocation of the entire city were implemented. Adequate lead time would be necessary for planning, property acquisition, development of infrastructure, and relocation of structures. It was assumed that a total of two years may be necessary for planning the relocation. An additional two years would likely be required to construct the infrastructure and conduct the relocation of the entire city.

4.4.3.9 Potential Problems and Risks

Potential problems and risks associated with the levees and structure relocations include:

- Lake level: delayed decisions or faster rising lake levels may require the construction of cofferdams.
- The construction of a levee around the City of Minnewaukan may reduce the aesthetic value of the city; therefore, the value of structures may depreciate under the levee strategy.

- Utilities may need to be abandoned or relocated as part of the house relocations or levee construction.

- Approximately 5,200 feet of the levee alignment overlies lake bed deposits, which may need to be excavated. It is assumed that approximately 1,200 feet of levee alignment will require cut-off wall or excavation of permeable sub-soil.

- Relocation of the entire city would require detailed coordination with utility companies. The existing telephone switching facility in the city is essential for telephone service to the city and surrounding community and a detailed cost estimate for relocation was not available. According to an engineer at North Dakota Telephone Company, relocation of the facility would cost "at least one million dollars," but a more precise figure was not available without a detailed plan for the new city. The extent of electrical infrastructure changes for various protection strategies is also unclear. For example, it is unclear if a new substation, new transmission lines, or other electrical infrastructure would be needed for the relocation strategy.

- Topography east of the city is such that current lake levels are already encroaching on the levee alignment, particularly in the area around US Highway 281 as it enters the north end of the city. Because structures in that area are scheduled for relocation, the levee may need to be realigned during final design to allow for initial investigations in dry conditions.

4.4.3.10 Data Deficiencies

- Borings will need to be completed in the areas of the beach and alluvial deposits to determine the need for and extent of remedial features (i.e., cutoff walls). A total of 15 borings were assumed.

- Verify location, number, and elevation of homes that would need relocating.

- Determine precise locations of above ground and buried utilities.

- Locate and evaluate nearby cultural resources that were identified.

- Although new sewage treatment ponds have been constructed at high ground, the elevations of manholes, sanitary sewers, and sewage lift stations must be reviewed in detail to determine actual impacts.

- Structures were assumed to be relocated when damages begin to occur to the structure (when lake level approaches ground elevation at structure). Each structure

to be relocated must be reviewed to confirm estimated ground elevation and to document elevation damages actually occur due to potential utilities, basements, low house openings, etc.

4.4.4 Economics of Flood Protection

Damages: For the Infrastructure Protection Study's analysis, the flood damage estimates for the City of Minnewaukan were reassessed in order to update and more accurately characterize the nature of the damages. The updated damage computations for the City of Minnewaukan are summarized in the accompanying Table 4.4-1. All damages were estimated up to the maximum lake level (1463).

- Loss of homes – There are 24 residences and a few other structures located between 1451 and 1455. The number and combined value of homes increases significantly at about elevation 1455. Approximately 90% of the single-family homes in the city lie above 1455. The majority of the property at risk in the city is located between 1456 and 1463. Structures above 1463 that would be severed from the main land were assumed to be damaged due to safety concerns.

- Loss of historical buildings – The Benson County Courthouse and Grace Episcopal Church are listed in the National Register of Historic Places. Existing damage estimates include the assessed value of the property. The Benson County Courthouse has an estimated value around $2,000,000, making it the most valuable single property in the city, and accounting for about 8% of the total estimated value of all property within the city.

- Loss of commercial and municipal properties – As with homes in the city, the majority of commercial and municipal properties at risk are between elevations 1456 and 1463. Significant properties in the city include the public school, the grain elevator, the museum, and four churches. These items taken together account for over 10% of the total value of all property within the city.

- Loss of the telephone switching station that serves the entire surrounding area.

- Loss of access on major highways and rail lines.

- Damages to streets, utilities, lots and land are listed under levee strategies. These damages can only be protected by the levee strategy, therefore levee strategies prevent more damages.

Unit prices for all the damage computations were listed in Section 4.0, and are detailed in Table 4.0-2. An updated (as of 2002) list of assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for the City of Minnewaukan are listed in the

City of Minnewaukan Infrastructure Protection Study Assumptions listing, attached to this Section 4.4.

Costs: The updated costs of providing flood protection for the City of Minnewaukan are detailed in the accompanying Table 4.4-2 for the City of Minnewaukan. Unit prices, data sources, and relevant assumptions are listed. All costs are given in 2002 dollars.

The costs for the levee include the levee construction, geotechnical items, environmental issues, and an interior drainage system. Pump costs were estimated from previous Devils Lake pumping stations and verified with other typical pumping station cost curves.

The costs for relocation of the entire city at the Action Level 1 (AL1) assume that the majority of the relocations would start when the lake affects the large concentration of structures above 1454. These costs also include construction of new utilities and infrastructure, which would need to be developed before relocation of structures could begin. The lowest structures would be moved first, as the new infrastructure is constructed. Relocation costs included structures above 1463 that would be severed from the main land. Incremental relocations included only the costs to relocate structures at each action level, including the structures that would be severed.

Unit prices for all the cost computations were discussed previously in Section 4.0, and are detailed in Table 4.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for the City of Minnewaukan are listed in the City of Minnewaukan Infrastructure Protection Study Assumptions listing, attached to this Section 4.4.

Contingencies: The contingency percentages used for construction materials ranged from 30 to 50% (Table 4.4-2). Contingencies for riprap, geotechnical items, and the interior drainage system were estimated at the higher end of the range because of the potential variability in the quantities and unit prices. Under the incremental relocation strategy, the contingencies for relocation of the county courthouse, barns, and utilities were estimated at the higher end of the range because of the potential variability in the expected costs.

4.4.5 Economic Results

Three flood protection strategies were analyzed for this feature for all action levels: incremental levee raise, incremental relocation, and relocation of the entire city. The results of the Infrastructure Protection Study for City of Minnewaukan are listed in Table 4.4-3a for the analysis of all action levels and in Table 4.4-3b for the analysis of the first action level.

Multiple Action Level Stochastic Analysis Results: The stochastic analysis indicated that incremental levee raises were the flood protection strategy that showed the largest net benefits. This strategy is highlighted on the decision tree (Figure 4.4-2).

The annual net benefits for this approach were less than zero (-$25,300). The BCR for this approach was less than one (0.88). These results show that this strategy is not economically justified. The annual damages prevented by this levee raise strategy are $186,600. The stochastic results are averages over 10,000 traces.

A sensitivity analysis was conducted on the without-project (no action) condition for this feature, assuming that the most likely strategy of incremental relocations was used as the without-project condition. By revising the without-project condition, the annual average net benefits for the incremental levee raises would be $29,500. The positive net benefits indicate that this flood protection strategy is economically justified, assuming that incremental relocations are the without-project condition.

Multiple Action Level Results for Specific Scenarios: All of the flood protection strategies were also analyzed under three specific climate futures. For the City of Minnewaukan, the resulting economic indices for each of the three specific climate futures are as follows:

- Wet Future – For the wet future, the strategy with the largest net benefits was incremental levee raises. The annual net benefits were $149,700, and the BCR was 1.17, indicating that this strategy was economically justified. The annual damages prevented by this levee raise strategy are $1,038,700. Under the wet future scenario, the costs and benefits for both action levels are incurred within the first ten years, indicating that if the lake is going to rise to the second damage level very quickly, protection with a levee is feasible economically.

- First Moderate Future – For the first moderate future, the lake levels do not reach the elevation of the first damages or costs that are incurred for this feature.

- Second Moderate Future – For the second moderate future, the strategy with the largest net benefits was incremental relocations. The net benefits were -$90,400 and the BCR was 0.77. The net benefits for incremental levee raises were -$275,800, and the BCR was 0.55, indicating that neither strategy was economically justified. The annual damages prevented by this levee raise strategy are $331,900. For this future, incremental relocation showed larger net benefits because damages are only incurred at the first action level, and levee costs are incurred for both action levels. There is a high initial investment for the levee raises for the few homes that are protected by the first levee raise (because the lake level drops prior to reaching the second level of damages).

First Action Level Stochastic Analysis Results: Using the stochastic analysis along with the updated damage and cost estimates for the City of Minnewaukan, the Infrastructure Protection Study's analysis also provided relevant economic indices for one incremental levee raise. The annual net benefits for this approach were less than zero (-$23,600). The BCR for this approach

was less than one (0.85). These results show that this strategy is not economically justified. The annual damages prevented by this levee raise strategy are $136,700. The stochastic results are averages over 10,000 traces.

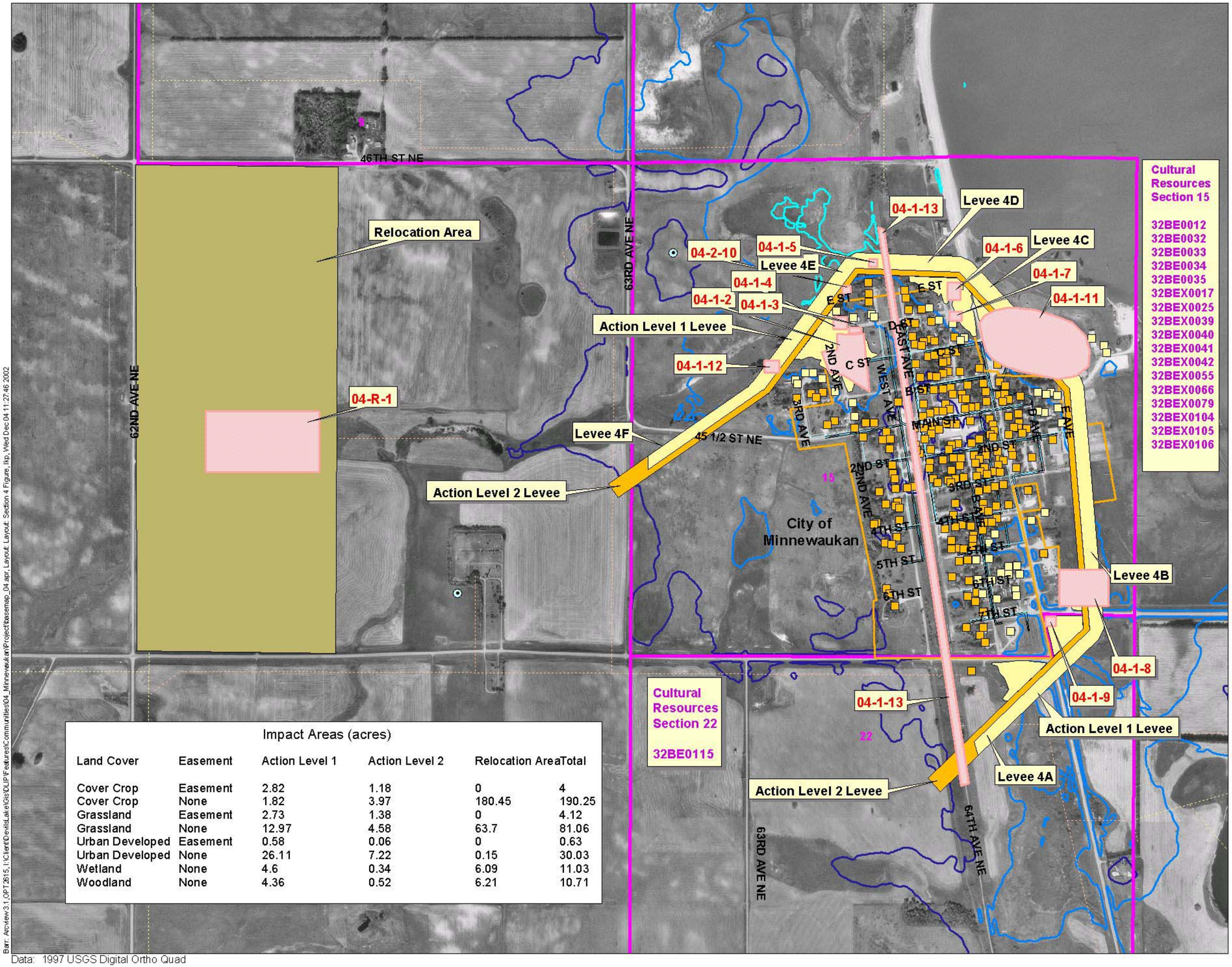
The results for the first action level are similar to the results computed for all action levels for this feature. No sensitivity analysis could be conducted for the first action level analysis, since the incremental levee strategy was the only strategy that was analyzed. However, the costs indicate that the first levee raise is less expensive than the first relocations. Therefore, if the without-project condition were revised to reflect incremental relocations, the net benefits for the first incremental levee raise would be positive.

First Action Level Results for Specific Scenarios: One incremental levee raise was also analyzed under each of three specific climate futures. For the City of Minnewaukan, the economic indices for each of the three climate futures are as follows:

- Wet Future – Under the wet future climate scenario, the annual net benefits of one incremental levee raise were -$62,000, and the BCR was 0.89, indicating that this strategy was not economically justified. The annual damages prevented by this levee raise strategy are $503,200. The negative net benefits emphasize the fact that the incremental levee raise strategy is not economically feasible unless the lake rises to the second damage level (which were not considered in this analysis of the first action level).

- First Moderate Future – Under the first moderate future climate scenario, the lake levels do not reach the elevation of the first damages or costs that are incurred for this feature.

- Second Moderate Future – Under the second moderate future climate scenario, the annual net benefits of one incremental levee raise were -$66,200, and the BCR was 0.83, indicating that this strategy was not economically justified. The annual damages prevented by this levee raise strategy are $331,900.



Impact Areas (acres)

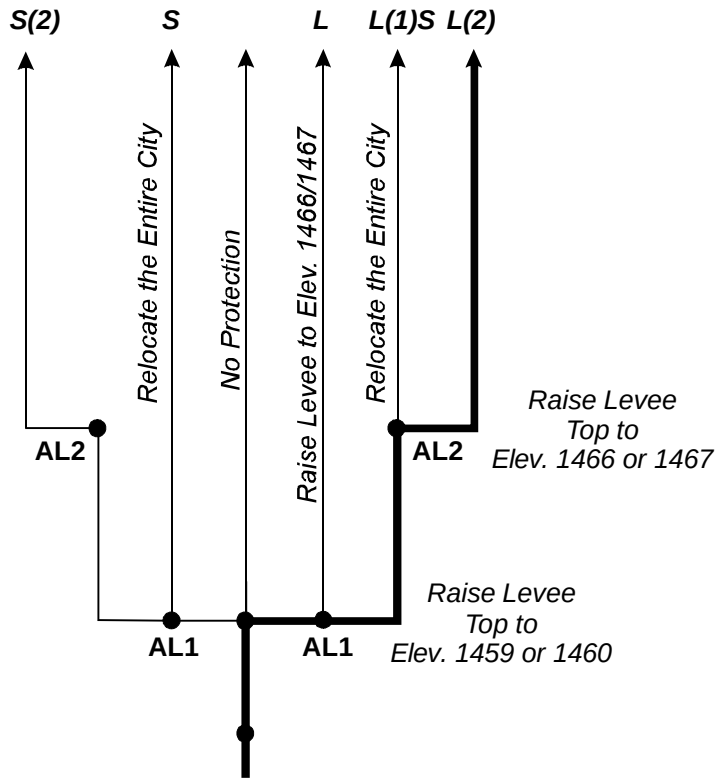
Land Cover	Easement	Action Level 1	Action Level 2	Relocation Area	Total
Cover Crop	Easement	2.82	1.18	0	4
Cover Crop	None	1.82	3.97	180.45	190.25
Grassland	Easement	2.73	1.38	0	4.12
Grassland	None	12.97	4.58	63.7	81.06
Urban Developed	Easement	0.58	0.06	0	0.63
Urban Developed	None	26.11	7.22	0.15	30.03
Wetland	None	4.6	0.34	6.09	11.03
Woodland	None	4.36	0.52	6.21	10.71

Figure 4.4-1

LOCATION MAP
FEATURE 4:
CITY OF MINNEWAUKAN
Devils Lake Infrastructure Protection Study

Data: 1997 USGS Digital Ortho Quad

Barr: Arcview 3.1, OPT2615, I:\Client\DevilsLake\Gis\DLIP\Features\Communities\04_Minnewaukan\Project\basemap_04.apr, Layout: Layout: Section 4 Figure, lkp, Wed Dec 04 11:27:46 2002



▬	Flood Protection Strategy
●	Decision required at this point
⊙	Trigger point for action, no decision needed
AL1	Decision/Action Level
L(1)	Incremental levee raise (number of times)
L	Levee raise to Elev. 1466/1467
S(1)	Structure relocation (number of times)
S	Relocate all structures below Elev. 1464

Figure 4.4-2

DECISION TREE
FEATURE 4: CITY OF MINNEWAUKAN
Devils Lake Infrastructure Protection Study

P:\34\36\020\DECISIONTREES\2002FIGURES\FIGURE2_04.CDR RLG 01-06-03

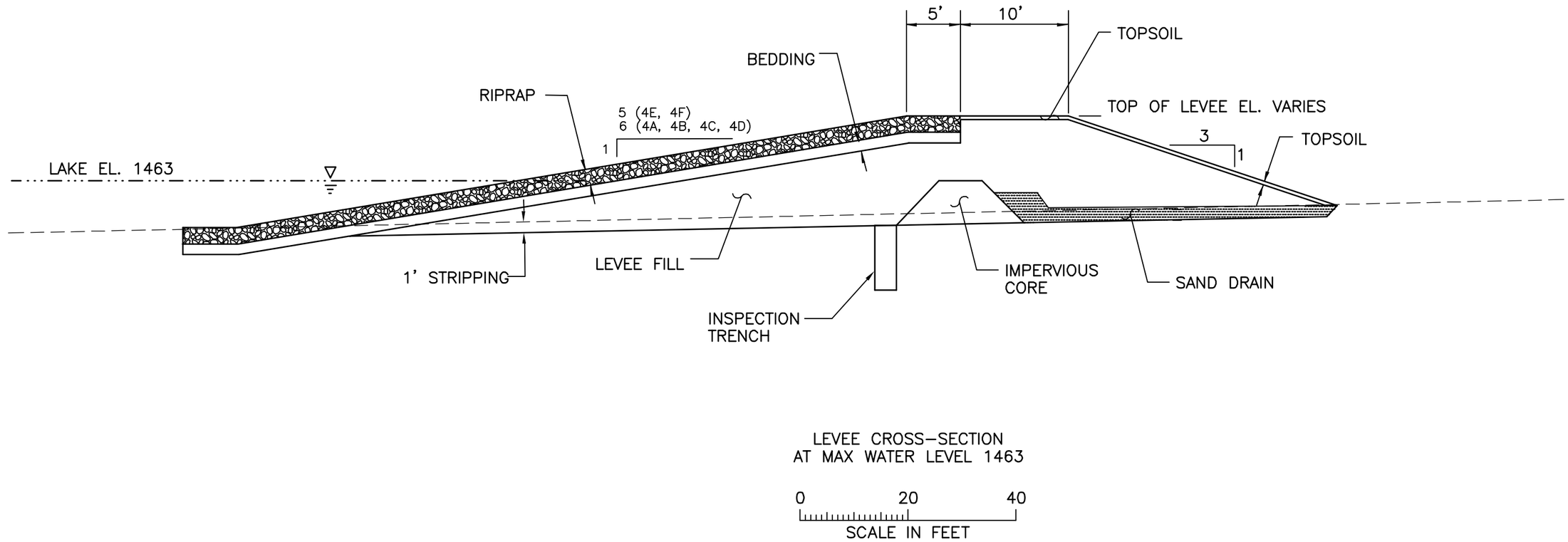


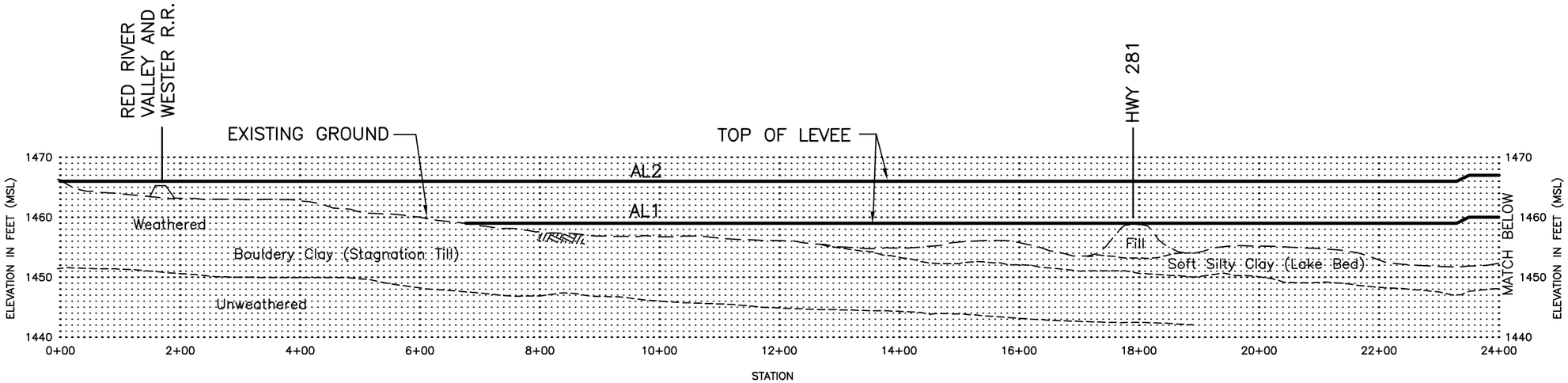
Figure 4.4-3

TYPICAL LEVEE CROSS-SECTION

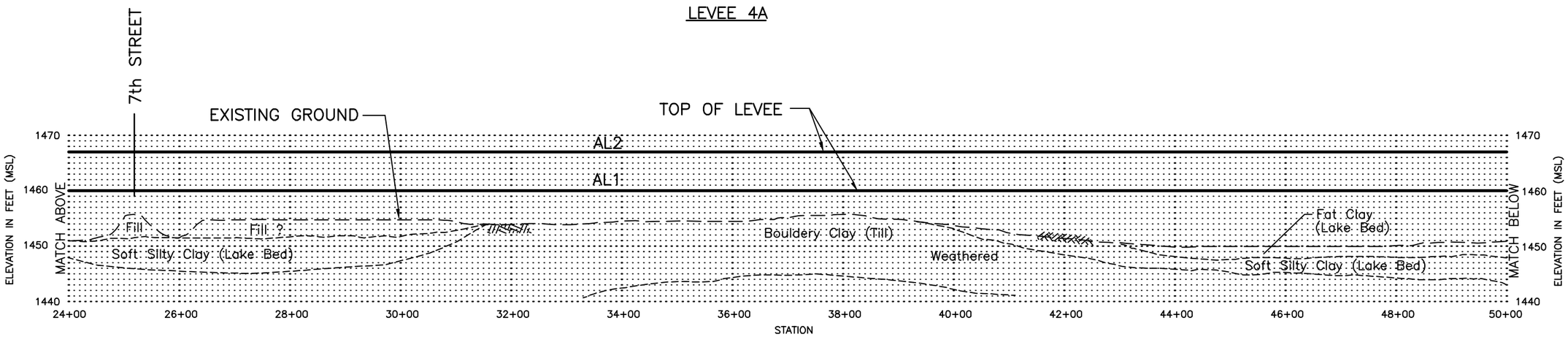
FEATURE 4:
CITY OF MINNEWAUKAN

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

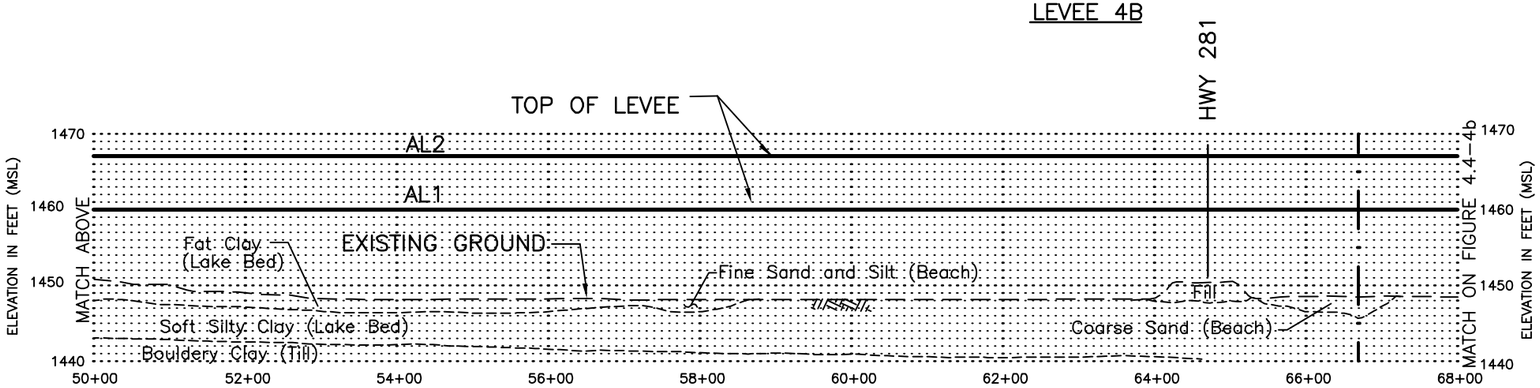
NRD M:\CAD\3436020\17243_2.DWG Plot at 10 11/05/2002 11:08:12



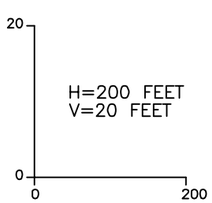
LEVEE 4A



LEVEE 4B



LEVEE 4C



Notes:
1. Adjacent ground elevation obtained from 2000 FEMA LIDAR topography.
2. Stationing increases clockwise along levee beginning at northwest end of levee.

Figure 4.4–4a

PROFILE

FEATURE 4:
CITY OF MINNEWAUKAN

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

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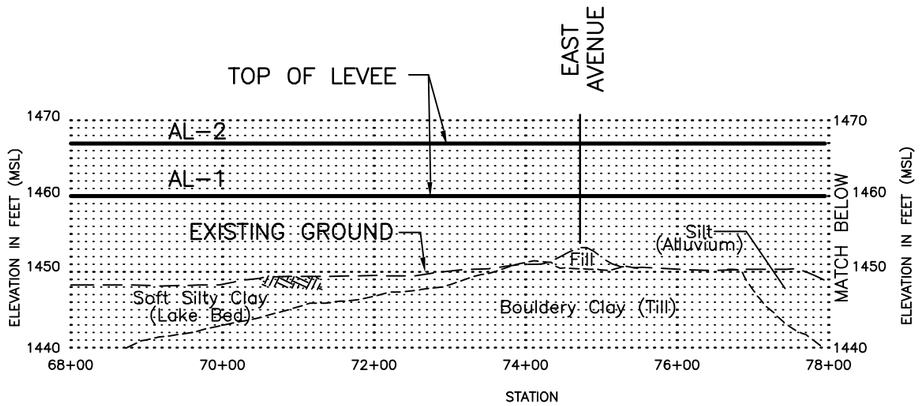
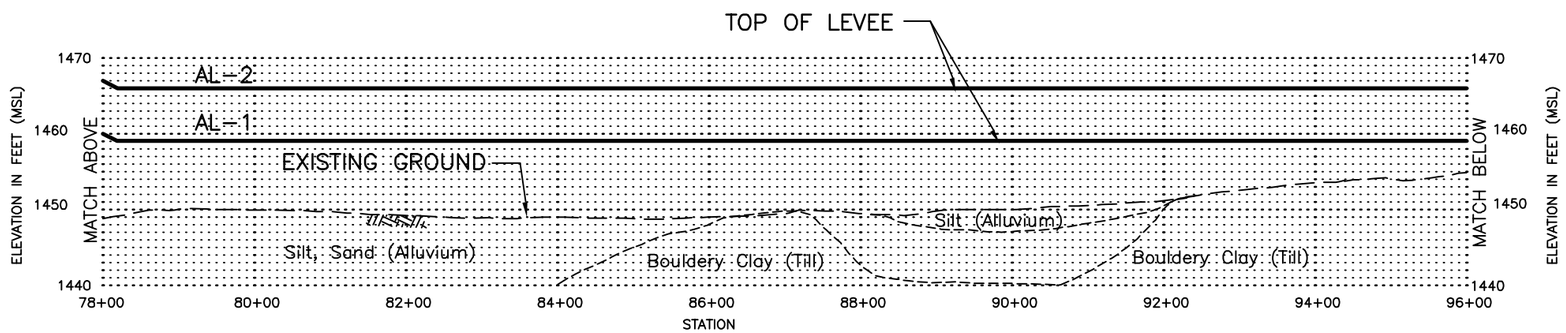


LEVEE 4D



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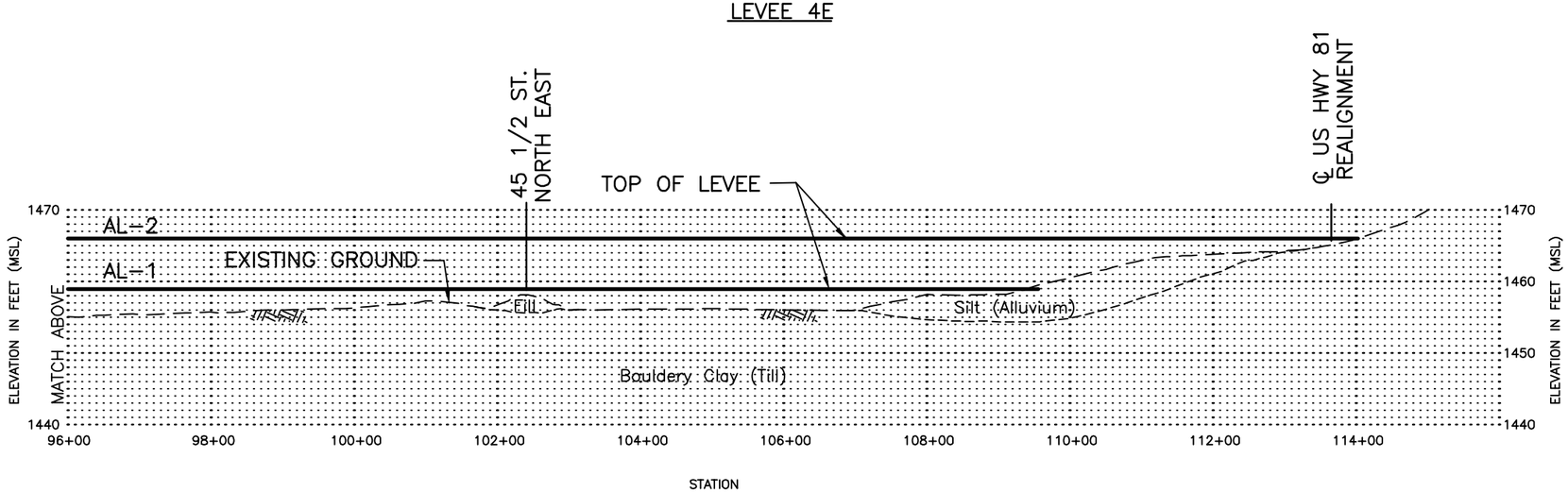

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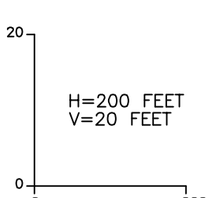

Figure 4.4–4

LEVEE PROFILE

FEATURE 4:
MINNEWAUKAN

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

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