Table 4.4-1

Flood Damages
Feature 4: City of Minnewaukan
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Elevation Range	Relocation Strategies	Levee Strategies[1]
	(MSL)	(THOUSANDS)	
AL1	1451-1458	$9,348	$10,493
AL2	1458-1466	$15,694	$16,930

DAMAGE BREAKDOWN

	Structure Elevation 1451-1458					Structure Elevation 1458-1466				
	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Relocation Strategies	Residence	50	EA	$88,000	$4,400	Residence	88	EA	$88,000	$7,744
	Apartment Complexes	2	EA	$402,000	$804	Apartment Complexes	0	EA	$402,000	$0
	Trailer Court	2	EA	$275,000	$550	Trailer Court	0	EA	$275,000	$0
	Agricultural Silos	1	EA	$26,500	$27	Agricultural Silos	0	EA	$26,500	$0
	Commercial Properties	4	EA	$148,000	$592	Commercial Properties	17	EA	$148,000	$2,516
	Telephone Switching Fac.	0	EA	$1,000,000	$0	Telephone Switching Fac.	1	EA	$1,000,000	$1,000
	Grain Elevator	0	EA	$704,000	$0	Grain Elevator	1	EA	$704,000	$704
	Church	2	EA	$322,000	$644	Church	2	EA	$322,000	$644
	School	1	EA	$1,022,000	$1,022	School	0	EA	$1,022,000	$0
	Museum	1	EA	$332,000	$332	Museum	0	EA	$332,000	$0
	Library	0	EA	$432,000	$0	Library	1	EA	$432,000	$432
	Courthouse	0	EA	$2,000,000	$0	Courthouse	1	EA	$2,000,000	$2,000
	Government/Public	5	EA	$109,000	$545	Government/Public	6	EA	$109,000	$654
	Barns	6	EA	$72,000	$432					
	Total				**$9,348**	**Total**				**$15,694**
Levee Strategies	Residence	50	EA	$88,000	$4,400	Residence	88	EA	$88,000	$7,744
	Apartment Complexes	2	EA	$402,000	$804	Apartment Complexes	0	EA	$402,000	$0
	Trailer Court	2	EA	$275,000	$550	Trailer Court	0	EA	$275,000	$0
	Agricultural Silos	1	EA	$26,500	$27	Agricultural Silos	0	EA	$26,500	$0
	Commercial Properties	4	EA	$148,000	$592	Commercial Properties	17	EA	$148,000	$2,516
	Telephone Switching Fac.	0	EA	$1,000,000	$0	Telephone Switching Fac.	1	EA	$1,000,000	$1,000
	Grain Elevator	0	EA	$704,000	$0	Grain Elevator	1	EA	$704,000	$704
	Church	2	EA	$322,000	$644	Church	2	EA	$322,000	$644
	School	1	EA	$1,022,000	$1,022	School	0	EA	$1,022,000	$0
	Museum	1	EA	$332,000	$332	Museum	0	EA	$332,000	$0
	Library	0	EA	$432,000	$0	Library	1	EA	$432,000	$432
	Courthouse	0	EA	$2,000,000	$0	Courthouse	1	EA	$2,000,000	$2,000
	Government/Public	5	EA	$109,000	$545	Government/Public	6	EA	$109,000	$654
	Barns	6	EA	$72,000	$432					
	Lots	120	EA	$313	$38	Lots	352	EA	$313	$110
	Land	83	EA	$400	$33	Land	128	EA	$400	$51
	Utility Improvements	1	LS	$900,000	$900	Utility Improvements	1	LS	$900,000	$900
	Street Improvements	1	LS	$175,000	$175	Street Improvements	1	LS	$175,000	$175
	Total				**$10,493**	**Total**				**$16,930**

1 Damages for levee strategies is listed here for information only. Due to limitations of the economics model, damages cannot vary based on the strategy analyzed.

Table 4.4-2

Flood Protection Costs
Feature 4: City of Minnewaukan
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	S (2)	S	L	L(1)S	L(2)
Action Level	Cost to Relocate Structures at AL1 and AL2	Cost to Relocate All Structures at AL1	Cost to Raise at AL1	Cost to Incrementally Raise at AL1, Relocate All Remaining Structures at AL2	Cost to Incrementally Raise at AL1, AL3
	(THOUSANDS)				
AL1	$12,206	$55,194	$17,605	$11,298	$11,298
AL2	$21,668	$0	$0	$55,194	$6,307

COST BREAKDOWN

Strategy	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)
	S AT AL1											
Relocation of Entire City	Residence	138	EA	$94,000	30%	$16,864						
	Apartment Complexes	2	EA	$402,000	30%	$1,045						
	Trailer Court	2	EA	$335,000	30%	$871						
	Agricultural Silos	0	EA	$26,500	30%	$0						
	Commercial Properties	18	EA	$154,000	30%	$3,604						
	Telephone Switching Fac.	1	EA	$1,000,000	30%	$1,300						
	Grain Elevator	1	EA	$704,000	30%	$915						
	Church	3	EA	$322,000	30%	$1,256						
	School	1	EA	$1,022,000	30%	$1,329						
	Museum	1	EA	$332,000	30%	$432						
	Library	1	EA	$432,000	30%	$562						
	Courthouse	1	EA	$2,000,000	50%	$3,000						
	Government/Public	7	EA	$115,000	30%	$1,047						
	Incremental Relocation Subtotal					$32,223						
	Performance/Payment Bond	1	JB	$127,014	10%	$140						
Municipal Construction	Electric Infrastructure	1	LS	$400,000	50%	$600						
	Stripping	254.5	AC	$6,510	50%	$2,485						
	Grading	254.5	AC	$510	50%	$195						
	Site Restoration	254.5	AC	$15,000	50%	$5,726						
	Curb and Gutter	82,000	LF	$7.25	50%	$892						
	30' W Bituminous Roadway	34,000	LF	$54	50%	$2,754						
	45' W Bituminous Roadway	7,000	LF	$81	50%	$851						
	Sanitary Forcemain	4,500	LF	$62	50%	$419						
	Sanitary Lift Station	1	EA	$200,000	50%	$300						
	Sanitary Sewer	19,000	LF	$53	50%	$1,511						
	Water Tower	1	EA	$110,000	50%	$165						
	Supply from Water Plant	1,500	LF	$50	50%	$113						
	Water main	17,000	LF	$50	50%	$1,275						
	Utility Trench	41,000	LF	$14	50%	$861						
	Environmental Impacts											
	Mitigation	1	LS			$49						
	HTRW	1	LS			$117						
	Cultural Resources Investigation	1	LS			$104						
	Incremental Municipal Construction Subtotal					$18,554						
	Engineering and Design			15%		$2,783						
	Supervision and Administration			8%		$1,484						
	Real Estate Acquisition for ROW	1	LS			$150						
	Total Relocation of Entire City					**$55,194**						
	S(1) AT AL1						**S(2) AT AL2**					
Incremental Relocation	Residence	50	EA	$94,000	30%	$6,110	Residence	88	EA	$94,000	30%	$10,754
	Apartment Complexes	2	EA	$402,000	30%	$1,045	Apartment Complexes	0	EA	$402,000	30%	$0
	Trailer Court	2	EA	$335,000	30%	$871	Trailer Court	0	EA	$335,000	30%	$0
	Agricultural Silos	1	EA	$26,500	30%	$34	Agricultural Silos	0	EA	$26,500	30%	$0
	Commercial Properties	4	EA	$154,000	30%	$801	Commercial Properties	17	EA	$154,000	30%	$3,403
	Telephone Switching Fac.	0	EA	$1,000,000	30%	$0	Telephone Switching Fac.	1	EA	$1,000,000	30%	$1,300
	Grain Elevator	0	EA	$704,000	30%	$0	Grain Elevator	1	EA	$704,000	30%	$915
	Church	2	EA	$322,000	30%	$837	Church	2	EA	$322,000	30%	$837
	School	1	EA	$1,022,000	30%	$1,329	School	0	EA	$1,022,000	30%	$0
	Museum	1	EA	$332,000	30%	$432	Museum	0	EA	$332,000	30%	$0
	Library	0	EA	$432,000	30%	$0	Library	1	EA	$432,000	30%	$562
	Courthouse	0	EA	$2,000,000	50%	$0	Courthouse	1	EA	$2,000,000	50%	$3,000
	Government/Public	5	EA	$115,000	30%	$748	Government/Public	6	EA	$115,000	30%	$897
	Total Incremental Relocation					**$12,206**						**$21,668**
Incremental Levee Raise	**L(2) AT AL1**						**L(2) AT AL2**					
	L(1)S AT AL1											
	L AT AL1											
	Raise Top of Levee for AL1						**Raise Top of Levee for AL2**					
	Performance/Payment Bond	1	JB	$55,484	10%	$61	Performance/Payment Bond	1	JB	$35,247	10%	$39
	General Relocation	2	EA	$8,500	30%	$22	Residence Relocation	0	EA	$94,000	30%	$0
	Government/Public	1	EA	$115,000	30%	$150						
	Barns	3	EA	$72,000	50%	$324						
	Levee Construction						**Levee Construction**					
	Clearing and Grubbing	16.0	AC	$3,000	30%	$62	Clearing and Grubbing	18.0	AC	$3,000	30%	$70
	Stripping (1')	26,100	CY	$1.50	30%	$51	Stripping (1')	28,900	CY	$1.50	30%	$56
	Inspection Trench	10,300	LF	$4.00	30%	$54	Inspection Trench	11,400	LF	$4.00	30%	$59
	Levee Fill	95,900	CY	$5.00	30%	$623	Levee Fill	266,500	CY	$5.00	30%	$1,732
	Bedding	16,100	CY	$35	30%	$733	Bedding	20,800	CY	$35	30%	$946
	Riprap	22,700	CY	$40	40%	$1,271	Riprap	29,400	CY	$40	40%	$1,646
	Sand Drain	23,800	CY	$22	30%	$681	Sand Drain	16,700	CY	$22	30%	$478
	Topsoil (4")	4,200	CY	$2.50	30%	$14	Topsoil (4")	7,200	CY	$2.50	30%	$23
	Seed	16.0	AC	$1,000	30%	$21	Seed	18.0	AC	$1,000	30%	$23
	Interior Drainage/Pump Station						**Interior Drainage/Pump Station**					
	Culverts	11,850	LF	$50	50%	$889	Culverts	0	LF	$50	50%	$0
	Channel	4,640	LF	$40	50%	$278	Channel	0	LF	$40	50%	$0
	Pump Station	1	EA	$2,500,000	30%	$3,250	Pump Station	0	EA	$0	50%	$0
	Geotechnical						**Geotechnical**					
	Slurry Wall	24,000	SF	$6.00	50%	$216	Slurry Wall	0	SF	$6.00	50%	$0
	Borings	15	EA	$1,000	50%	$23	Borings	0	EA	$1,000	50%	$0
	Excavation of Unsuitable Material	14,500	CY	$8.50	50%	$185	Excavation of Unsuitable Material	0	CY	$8.50	50%	$0
	Environmental Impacts						**Environmental Impacts**					
	Mitigation	1	LS			$17	Mitigation	1	LS			$4
	HTRW	1	LS			$44	HTRW	1	LS			$1
	Cultural Resources Investigation	1	LS			$104	Cultural Resources Investigation	1	LS			$0
	Subtotal					$9,071	Subtotal					$5,079
	Engineering and Design			15%		$1,361	Engineering and Design			15%		$762
	Supervision and Administration			8%		$726	Supervision and Administration			8%		$406
	Real Estate Acquisition for ROW	1	LS			$140	Real Estate Acquisition for ROW	1	LS			$60
	Total Raise					**$11,298**	**Total Raise**					**$6,307**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Levee Maintenance	Pump O&M	Total Operation and Maintenance Cost
	(THOUSANDS)		
AL1	$35	$53	$88
AL2	$85	$53	$138

Notes:
1. The cost for S(2) at AL1 includes relocating structures to lots within the existing city,
2. The cost for S(2) at AL2 includes relocating the entire city.
3. Levee maintenance costs shown are the cumulative totals for each respective level.

Table 4.4 - 3a

Economics Results: All Action Levels -- to Lake Level 1463
Feature 4: City of Minnewauken
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	$186,600	$186,600	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$719,300	$719,300	$18,500	$18,500	$168,100	-$551,200	0.23
L	Raise Top of Levee to 1468	$229,400	$28,100	$0	$257,600	$0	$0	$186,600	-$71,000	0.72
L(1)S	1 Incremental Levee Raise: Relocae All Structures Below 1464	$147,200	$8,100	$376,300	$531,700	$18,500	$18,500	$168,100	-$363,600	0.32
L(2)	2 Levee Raises	$190,200	$21,700	$0	$211,900	$0	$0	$186,600	-$25,300	0.88
S(2)	2 Incremental Relocations	$0	$0	$222,900	$222,900	$18,500	$18,500	$168,100	-$54,800	0.75

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	$1,038,700	$1,038,700	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$2,646,800	$2,646,800	$94,000	$94,000	$944,700	-$1,702,100	0.36
L	Raise Top of Levee to 1468	$844,200	$107,200	$0	$951,500	$0	$0	$1,038,700	$87,200	1.09
L(1)S	1 Incremental Levee Raise: Relocae All Structures Below 1464	$541,800	$11,200	$2,214,500	$2,767,600	$94,000	$94,000	$944,700	-$1,822,900	0.34
L(2)	2 Levee Raises	$794,900	$94,200	$0	$889,000	$0	$0	$1,038,700	$149,700	1.17
S(2)	2 Incremental Relocations	$0	$0	$1,270,700	$1,270,700	$94,000	$94,000	$944,700	-$326,000	0.74

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	Relocation of All Structures below 1468	$0	$0	$0	$0	$0	$0	$0	$0	--
L	Raise Top of Levee to 1468	$0	$0	$0	$0	$0	$0	$0	$0	--
L(1)S	1 Incremental Levee Raise: Relocae All Structures Below 1464	$0	$0	$0	$0	$0	$0	$0	$0	--
L(2)	2 Levee Raises	$0	$0	$0	$0	$0	$0	$0	$0	--
S(2)	2 Incremental Relocations	$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	$331,900	$331,900	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$1,745,900	$1,745,900	$36,200	$36,200	$295,700	-$1,450,200	0.17
L	Raise Top of Levee to 1468	$556,900	$68,200	$0	$625,000	$0	$0	$331,900	-$293,100	0.53
L(1)S	1 Incremental Levee Raise: Relocae All Structures Below 1464	$357,400	$2,600	$1,645,100	$2,005,000	$36,200	$36,200	$295,700	-$1,709,300	0.15
L(2)	2 Levee Raises	$545,400	$62,400	$0	$607,600	$0	$0	$331,900	-$275,800	0.55
S(2)	2 Incremental Relocations	$0	$0	$386,100	$386,100	$36,200	$36,200	$295,700	-$90,400	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)).

Table 4.4 - 3b

Economics Results: First Action Level
Feature 4: City of Minnewauken
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	$136,700	$136,700	$0	$0	--
L(1)	1 Levee Raise	$147,200	$13,100	$0	$160,400	$0	$0	$136,700	-$23,600	0.85

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	$503,200	$503,200	$0	$0	--
L(1)	1 Levee Raise	$541,800	$23,400	$0	$565,200	$0	$0	$503,200	-$62,000	0.89

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	$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	$331,900	$331,900	$0	$0	--
L(1)	1 Levee Raise	$357,400	$40,700	$0	$398,000	$0	$0	$331,900	-$66,200	0.83

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 4.4:
City of Minnewaukan Economic Analysis Assumptions

A. General Assumptions

1. Structure elevation data was obtained from the 2000 FEMA LIDAR 1-foot topography, and associated structure database (referred to hereafter as the FEMA database). When this information conflicted with assumptions from the Economic Analysis of Devils Lake Alternatives, the FEMA information was used.

2. Certain structures in the city have been moved, or it was reported that they would be moved within 12 months. The new locations of these structures are unknown, but it is assumed that they will remain within the city limits. These include Trinity Lutheran Church and associated garage (FEMA structures 678 and 679), two homes and a garage west of West Avenue on "D" Street (FEMA structures 693, 697 and 702), and the residence and garage at 330 "B" Avenue (FEMA structures 691 and 700).

3. The Economic Analysis of Devils Lake Alternatives assumed that the low structure in the city lies at elevation 1448, based on maps supplied by the city staff showing curb and gutter elevations, selected survey points, and personal conversations with the County Assessor. The current evaluation used the elevation information from the FEMA database. The database column containing ground elevations at the structures was used as the elevation when a structure would be impacted.

4. For levee and relocation strategies, it was assumed that the five residences below 1454 will be temporarily protected until levee construction or relocation.

B. Levees

1. 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.)

2. For levee protection, it was assumed that 3 feet of freeboard would be required for levees 4A and 4F, and 4 feet for levees 4B, 4C, 4D, and 4E at all action levels. The assumed freeboard was based on calculated wave heights for this area plus 1 foot.

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

4. A 50% contingency was applied to the interior pump station.

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

6. 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).

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

8. 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.

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

10. 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.

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

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

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

14. 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).

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

16. It was assumed that construction of levee sections 4D, 4E, and 4F would provide flood protection along an unnamed coulee along the northwest city limits during runoff events.

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

18. For levee strategies, each lot was assumed to be $313. According to the city assessor during the economic analysis, each lot had an assessment value of $300. The updated value is $313.

19. For levee strategies, land value was assumed to be $400/acre. This value was provided by the Corps of Engineers (personal communication April 2001) and is an estimate of the average value of land surrounding Devils Lake.

20. For levee strategies, utility improvements were assumed to be $1,800,000 based on November 2002 phone conversation with Minnewaukan city council member (George Howard).

21. For levee strategies, street improvements were assumed to be $350,000 based on November 2002 phone conversation with Minnewaukan city council member (George Howard).

C. Residential and Commercial Buildings

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 Minnewaukan is estimated to be $88,000. This figure was obtained from the Federal Emergency Management Agency (FEMA) and represents the average value of rural houses located around Devils Lake, excluding houses 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 the land on which the houses were located. The $88,000 average was based on rural houses only, therefore houses in the Cities of Minnewaukan and Devils Lake were not included in the analysis. However, the analysis did include many houses in the area surrounding Minnewaukan. Therefore, it was assumed that the average value of a residence in Minnewaukan was same as in the surrounding area.

3. Relocation costs for residences were estimated to be $94,000. This cost includes the average value of a house in Minnewaukan ($88,000) and the estimated cost for demolition and site restoration ($6,000). Damages for each residence was $88,000.

4. The values and relocation costs for the structures and properties described below were obtained from the FEMA infrastructure database as provided by Paul Seeley, FEMA, October 2002:

   a. The value of each apartment complex was $402,000 based on the average of all apartments,

   b. The value of each trailer court was $275,000 based on the average of all trailer courts. For relocation strategies, costs were increased by $60,000 (estimated 10 units at $6,000) to $335,000 to include demolition and site restoration. Damages for each trailer court was $275,000.

   c. The value of each barn was $72,000 based on the average of all barns.

   d. The value of each agricultural silo was $26,500.

   e. The value of each commercial property was $148,000 based on the average value of all commercial properties. For relocation strategies, costs were increased by $6,000 to $154,000 to include demolition and site restoration. Damages for each commercial property was $148,000.

   f. The value of the grain elevator was $704,000.

g. The value of each church was $322,000, based on the average value of all churches.

h. The value of the school was $1,022,000.

i. The value of the museum was $332,000.

j. The value of the library was $432,000.

k. The value of the courthouse was $2,000,000.

l. The value of each governmental/public structure was $109,000, based on the average value of all churches Governmental/Public structures. For relocation strategies, costs were increased by $6,000 to $115,000 to include demolition and site restoration. Damages for each governmental/ public building was $109,000.

5. For relocation strategies, it was assumed that the pool and park were not relocated. The pool is in very poor condition, and has not been used in recent years because of its poor condition.

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

D. Relocation Strategies

1. At Action Level 1 (AL1), it was assumed that all structures in the city would need to be moved to an adjacent site. Infrastructure would be required for the municipal construction. It was also assumed based on conversation with the Corps of Engineers that the relocation strategy at the ultimate lake level (1463) would include moving all structures, even those above elevation 1463, to prevent structures from being isolated or surrounded by water. An incremental relocation strategy was also analyzed. The incremental relocation assumed that structures would be moved to other towns. This strategy would not require new municipal construction and could result in the abandonment of the City of Minnewaukan.

2. The Economic Analysis of Devils Lake Alternatives did not include a detailed estimate of the cost of infrastructure that would be required in a relocation strategy. In order to more accurately reflect the actual cost of the relocation strategy, the following infrastructure assumptions and costs were used:

   a. In the absence of specific information, it was assumed that the relocated city would include similar quantities and sizes of infrastructure as the existing city, including surface area, length of roadway, curb and gutter, sewer pipes, water piping, and hookup of utilities at each structure moved. Unit prices for new construction from similar projects or from Means 2002 *Heavy Construction Cost Data* (Means) were used for estimating costs. The multiplier given in Means is 0.807 for Devil's Lake

b. The relocation site was chosen because it lies close to the existing city, is close to the proposed reroute of US Highway 281, is owned by one party, is contiguous and currently not developed except for agriculture, and has relatively few delineated wetland areas. The relocation site provides slightly more surface area than the current City of Minnewaukan. Costs of the relocation include stripping, grading, and site restoration based on the total area of the relocation site.

- Topsoil stripping was assumed to be $2.50/CY based on unit prices from the Pump Station MCACES and 2 feet of topsoil to strip. The cost for "stripping" was calculated to be $6510/acre.

- Grading was based on Means Section 02300 for "finish grading, gentle slopes" at $0.13/SY. The cost for "grading" was converted to $510/acre.

- Restoration was based on Means Section 02300 for "spreading top soil" amount per acre calculated above to rough finish ($4.14/CY) and top dressing with an additional 1CY/600 SF. Seeding of turf mix was assumed to be by hydroseeding, mulch and fertilizer and cost was taken from Section 02920. The cost for the combined restoration items was calculated to be $15,000/acre.

c. The approximate length of roadway within the City of Minnewaukan was scaled off maps supplied by KMJ Engineering of Devils Lake, ND. It was assumed that all roads were bituminous with concrete curb and gutter on each side. Based on the maps, it appeared that major thoroughfares were 45 feet curb-to-curb, and other roads were 30 feet curb-to-curb. The total length of each type of road was determined, and it was assumed the relocated city would have the same length of each type of roadway. It was further assumed that the total length of curb and gutter was twice the total length of roadway (curb and gutter on both sides of every street).

- Curb and Gutter was based on Means Section 02770 for machine-formed 24-inch-wide curb and gutter. The cost of $7.25/LF was not adjusted by the City of Devils Lake multiplier.

- Bituminous Roadway costs were calculated per linear feet (LF) based on Means Section 02700. An 8-inch compacted gravel base was assumed with 2-inch base course and 2.5-inch wear course. Grading was previously included. The cost for 30-foot-wide roads was $54/LF. The cost for 45-foot-wide roads was $81/LF.

d. At the suggestion of the North Dakota Telephone Company, it was assumed that a utility trench would be included along with road construction to allow for underground installation of multiple utilities in the same trench. The length of utility trench was assumed to be the same as the calculated length of roadway.

- Utility Trench was based on Means Section 01030 and assumed to be 6 feet deep. The cost for utility trench was $14/LF.

e. It was assumed that storm drainage would mainly consist of grading within the relocated city; therefore, no cost was included for storm sewer.

f. It was assumed that a new water tower would be constructed at the relocation site, and a new supply line would be run from the existing water plant directly to the relocation site. The length and size of water supply piping was computed from maps supplied by KLJ Engineering of Devils Lake, ND. The major distribution piping was 8-inch PVC pipe, with some 6-inch pipe used in branches of the system. Typical service to the residents was through 1-inch copper lines to individual properties. For the relocation strategy, it was assumed that the total length of pipe was the same as the existing system, but that all new pipes would be 8-inch PVC. A 1-inch copper line was assumed for each structure relocated, with an average length of 80 feet.

- The water tower was assumed to have a 100,000 gal capacity. The cost of $229,000 was based on Means and was not adjusted by the Devils Lake multiplier.

- Supply from the Water Plant and Water Main were assumed to be 10-inch PVC and were estimated per linear feet (LF). Costs for the trenching and pipe bedding were based on Means Section 01030 using 10-foot-deep trenches 2 feet wide and 1 to 1 slope. Pipe material was based on Means Section 02500. The cost for supply from the water plant was $50/LF. The cost for water main was $50/LF.

g. It was assumed that a new sanitary lift station would be required at the relocation site, and a new forcemain would be run to the existing water plant directly from the relocation site. The length and size of sewer piping was computed from maps supplied by KLJ Engineering of Devils Lake, ND. The major piping was 8-inch DIP, with some 6-inch DIP used in branches of the system. Service to properties was not shown on the map, but 3-inch DIP service was assumed. For the relocation strategy, it was assumed that the total length of pipe was the same as the existing system, but that the new forcemain would be 12-inch DIP. A 3-inch DIP line was assumed for each structure relocated, with an average length of 80 feet.

- The Sanitary Lift Station was based on recent submersible lift stations bid in the Twin Cities and on estimates provided by Sioux Utilities for City of St. Michael. The cost for sanitary lift station was $200,000. Associated piping/forcemain was estimated separately.

- Sanitary Forcemain was assumed to be 12-inch diameter DIP at an 8-foot bury and was estimated per linear feet (LF). Costs for the trenching and pipe bedding were based on Means Section 01030 using 10-foot-deep trenches 2 feet wide and 1 to 1 slope. Pipe material was based on Means Section 02500. The cost for sanitary forcemain was $62/LF.

- Sanitary Sewer was assumed to be 8-inch diameter DIP at an 8-foot bury and was estimated per linear feet (LF). Costs for the trenching and pipe bedding were based on Means Section 01030 using 10-foot-deep trenches 2 feet wide and 1 to 1 slope. Pipe material was based on Means Section 02500. The cost for sanitary sewer was $53/LF.

h. It was assumed that in addition to proving electrical hookup for new service at each relocated structure (cable from distribution system, grounding rod, and hookup to panel inside structure), some major infrastructure would be needed including a new distribution system and substation near the relocation site. Based on conversations with Ottertail Power during preparation of the economic analysis for the City of Devils Lake, a substation was assumed to be $100,000 and the distribution system to provide electricity to the new city was assumed to be $1,500 per user. The electrical infrastructure was assumed to be $400,000.

i. It was assumed that moving the telephone switching facility was the major cost for telephone infrastructure, but hookup for service to each relocated structure was also included. The cost of relocating the switching station was taken from a conversation with Tom Hunter at North Dakota Telephone Company, and was assumed to be $1,000,000.

j. There is currently no gas service in the city, therefore no cost was included for gas service infrastructure.

4.5 Summary of Infrastructure Protection Investigation for Feature 5: St. Michael

4.5.0 Flood Protection Strategy

The Infrastructure Protection Study indicates that the flood protection strategy with the largest net benefits for St. Michael was relocation of all structures (residences and sewage lagoons).

4.5.1 General Information

Feature Type: Community

Location: St. Michael is located along the south side of Devils Lake in Benson County. The majority of the town is adjacent to BIA Highway 1 just north of the intersection of BIA Highway 1 and BIA Highway 6. The accompanying Figure 4.5-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: St. Michael is an unincorporated town.

Significance: St. Michael is important because of the density of infrastructure in this primarily rural community. Although St. Michael has not been significantly affected by the rising lake level to date, several homes and a sewage lagoon could be affected by rising lake levels. St. Michael is a primary community for the Spirit Lake Nation.

Damages: The flooding of St. Michael would result in the following damages:

- Loss of residences
- Loss of access for 16 residences at 1460
- Loss of two sewage lagoons (the north sewage lagoon at 1451 and the south sewage lagoon at 1455)

Owner/Sponsor: The Spirit Lake Nation is responsible for managing and maintaining St. Michael.

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

4.5.2 Feature Protection

History of Flood Protection: St. Michael is located in the area that is currently being protected by roads that are acting as dams. Therefore, the flood level at St. Michael is much lower than the level of Devils Lake. In the past, flood protection for St. Michael has consisted of raising berms around the sewage lagoons.

General Protection Strategy: The Infrastructure Protection Study's analysis for St. Michael allowed for reconsideration of flood mitigation options at each of several action levels. In general, at each of these levels, a choice would be made as to whether to protect the feature or abandon it. Flood protection options for St. Michael included:

- Construction of a levee to protect the most vulnerable (north) part of town. The levee would protect 10 residences and access to 16 other homes. The sewage lagoons would still need to be relocated along with construction of a lift station (for the north sewage lagoon) to maintain service to the existing homes.
- Relocation of the town's sewage lagoons and the affected residences.

Protection Strategy by Action Level: A variety of flood protection strategies were analyzed for St. Michael. These strategies are represented on Figure 4.5-2 as separate branches of the decision tree. Further investigations showed that the original decision tree for St. Michael needed to be updated. These updates have been included on Figure 4.5-2. The updates included: adding multiple levee raises and relocating the two sewage lagoons.

The stepwise approach to flood protection for the St. Michael consisted of the following:

1. At Action Level 1 (AL1), the North Sewage Lagoons would be relocated. A decision would also be made as to whether a levee would be constructed to protect the residences that are located at higher elevations.
2. At Action Level 2 (AL2), the South Sewage Lagoons would be relocated. 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.
3. If a levee were constructed at AL2, at Action Level 3 (AL3), a decision would be made as to whether to raise the levee or relocate all structures.

The Features Analysis Model was then used to determine which of the paths through the branches of the decision tree—which strategy—had the largest net benefits. That strategy is highlighted on Figure 4.5-2, and consists of the following:

1. At Action Level 1 (AL1), relocation of the North Sewage Lagoon
2. At Action Level 2 (AL2), relocation of the South Sewage Lagoon
3. At Action Level 3 (AL3), 10 residences would need to be relocated and an access road would need to be constructed for the remaining 16 residences

Therefore, the first increment of protection would include the relocation of the North Sewage Lagoon. The pertinent reference elevations for the flood protection strategy are given below:

Reference Elevations for North Sewage Lagoon Relocation (AL1)		
Elevation	**Name**	**Significance**
1451	Low Structure Elevation	Top berm of north sewage lagoon
1447	Lake Damage Elevation (currently protected by Roads as Dams)	Lake elevation at which damage begins (assume 4-foot freeboard)
1447	Project Completion Elevation	Lake elevation at which relocation must be complete
Current	Construction Initiation Elevation	Lake elevation at which relocation must begin
Current	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

Reference Elevations for South Sewage Lagoon Relocation (AL2)		
Elevation	**Name**	**Significance**
1455	Low Structure Elevation	Top berm of south sewage lagoon
1451	Lake Damage Elevation	Lake elevation at which damage begins (assume 4-foot freeboard)
1451	Project Completion Elevation	Lake elevation at which relocation must be complete
1448	Construction Initiation Elevation	Lake elevation at which relocation must begin
Current	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

Reference Elevations for Structure Relocations (AL3)		
Elevation	**Name**	**Significance**
1461	Low Structure Elevation	Ground elevation at structure
1460	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**
1461	Low Structure Elevation	Ground elevation at structure
1460	Lake Damage Elevation	Lake elevation at which damage to lowest structure occurs
1450	Project Completion Elevation	Lake elevation at which levee construction must be complete (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
1453	Lake Damage Elevation	Lake elevation at which damage to levee begins (assumed to be ½ height of freeboard)
1451	Project Completion Elevation	Lake elevation at which levee raise construction must be complete
1448	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
1458	Lake Damage Elevation	Lake elevation at which damage to levee begins (assumed to be ½ height of freeboard)
1456	Project Completion Elevation	Lake elevation at which levee raise construction must be complete
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

4.5.3 Design Considerations

4.5.3.0 General Design

Alignment

The general plan for flood protection at St. Michael includes the construction of a levee, as shown on Figure 4.5-1.

The levee would be constructed along the north side of St. Michael, north of BIA Highway 1. The levee would protect 10 residences below 1464 and the access road to these residences, in addition to the access to 16 other homes that are above 1464.

The table below provides a summary of the levees for St. Michael:

	Total Levee Lengths (Feet)		
Levee	**AL1**	**AL2**	**AL3**
5	630	1720	2550

Cross-section

Figure 4.5-3 shows a typical cross-section of the proposed levee.

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 for St. Michael are 6H:1V (as shown on Figure 4.5-4). 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 4.5-4 shows the profile of the proposed levee. Three levee raises were designed for St. Michael, 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 (1447-1451)	AL2 PL (1451-1458)	AL3 PL (1458-1464)
5	2.9	4	1455	1460	1467

[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 12 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 St. Michael 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. An inspection trench will 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 this levee 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 St. Michael cost estimate.

As an alternative, foundation work including the inspection trench and other associated grading could be constructed at low water elevations. The remaining levee could be constructed in the wet, at high water, when the levee is required. This would minimize construction of a levee that may not be needed. However, greater risks exist due to construction in the wet.

4.5.3.1 Site Geology

General

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.

The levee alignment proposed for St. Michael is underlain with boulder clay till in a low-relief stagnation moraine of the Coleharbor Formation. The 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 glacial deposits range from about 70 to 150 feet in thickness. It is likely that some sand and gravel outwash units are present at depth. The bedrock is Cretaceous Pierre Shale.

Although not indicated by the soils map, thin layers of the silt and clay facies lake bed deposits and sand beach deposits, both from past high stands of the lake (prehistoric Lake Minnewaukan), may be present in the low areas.

Foundations

The proposed levee crosses the following soil types, which have the indicated comments with respect to road construction, which is similar to levee construction. "Severe" means special design may be required. Wetness and flooding are a given, since much of the area is already inundated.

- 110&113 Bottineau loam; CL, CL-ML; till; Severe: low strength
- 12B Barnes-Svea loams, CL, CL-ML, till; Moderate: frost action, low strength

Need for Borings/Additional Information

Borings need to be completed in the area under the alignment of this levee. It is assumed three soil borings will be sufficient to characterize this alignment. Based on the soil survey, there are no apparent conditions that require mitigation.

4.5.3.2 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 2000 FEMA LIDAR 1-foot topography. The tributary area inside the flood barrier is about 97 acres and was divided into two subwatersheds. Land use in the tributary area is mainly grassland and woodland, with smaller portions of urban developments and cropland. The hydrologic soil group of the area is C. A curve number of 70 was assumed for all subwatersheds.

Ponding will occur in two locations along the St. Michael levee. The total ponding area was calculated to be 2.7 acres. One 24-inch RCP pipe, 950 feet in length, will be used to convey runoff from the higher elevation pond to the pump station location.

Pumping Requirements

The interior drainage system was designed to provide a minimum of 1-foot freeboard during the 10-day 100-year storm event. Two pumps will be utilized, with operation

beginning at different water levels. The capacities of the pumps are listed in the following table:

Pumps	Flow (cfs)	Elevation Top of Levee	Minimum Pond Water Level	Total Design Head (ft)	Power (hp)
1	10	1467	1451	16	27
2	10	1467	1452	15	25

4.5.3.3 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.

4.5.3.4 Environmental/Cultural issues

HTRW

Current land uses surrounding the levees associated with St. Michael appear to be mixed residential/commercial and potential industrial within St. Michael, and rural residential outside of the city. Land use does not appear to have changed significantly over time. In 1931, St. Michael was called Mission and consisted of less than five residences. By 1951, the town had its current name and consisted of about 16 structures, including some nonresidential properties. Development of St. Michael has increased in small increments since the 1950s. St. Michael was essentially at its current size by 1981. 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 was obtained from FirstSearch on September 24, 2002. Seven properties within the St. Michael's zip code (58370) were identified in the regulatory databases. Exact locations of six sites were not determined due to limited location information; however, none of the sites are suspected to be located within the areas affected by the feature protection strategies. The St. Michael lagoons, a CERCLIS site, are located next to the proposed levees. The lagoons are downgradient of the site and listed as stabilized and, therefore, are not suspected to be a concern. No buildings observed along the feature actions levels resemble a structure typical of a hospital, and therefore, the St. Michael hospital CERCLIS site is not a concern. The location of four UST sites and one ERNS (reportable spill site) site were not determined. Properties with retail petroleum UST's pose an environmental threat due their high potential for a release. Based on the aerial photograph review and the descriptions provided in FirstSearch, it is

not likely that a petroleum retail facility is located within the footprint of the proposed levees. The ERNs site, although not located, listed in the report that no remediation was necessary; therefore, this site is not suspected to present an environmental risk.

Two potential HTRW sites were identified within the levee action levels as shown on Figure 4.5-1. 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**
05-3-1	3	Nonresidential Properties	$500
05-1-2	1	Rural Residences & Farmsteads	$500

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

Cultural

This feature has the potential to affect two known sites and one site lead as shown on Figure 4.5-1. One of the known sites, St. Michael's Cemetery (32BE0087), is an architectural site and was studied as part of a larger survey of wrought iron crosses as grave markers in North Dakota. Though many cemeteries containing such markers have been recommended as eligible for listing on the NRHP, this cemetery was recommended as not eligible because its two wrought iron crosses "are not representative of any coherent tradition of local artistry" (NDCRS Form, 32BE0087, on file at the SHSND). The second known site, 32BE0410 (Mission Hill), is listed in the 1997 database as a prehistoric archaeological mound group. An artifact scatter is likely associated with the site since surface collection was conducted there. The eligibility of this site for listing on the NRHP has not been determined.

The site lead that may fall within the St. Michael area of potential effect is 32BEX0022 (St. Michael Mission). The historical context for this site lead was recorded as Irrigation and Conservation.

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

Feature 5 St. Michael: 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	0
Archaeological	0	0	1
Architectural Site Leads/Isolated Finds	0	0	0
Archaeological Site Leads/Isolated Finds	0	0	1
Total	0	1	2

The estimated cost to conduct Phase 1 Surveys for each of the 2 sites is presented in the following table. The total cost for all surveys is $22,000. As noted in Section 4.0, these costs are believed representative of the cultural resources investigations needed for the next stage of study.

Feature 5 St. Michael: Phase 1 Survey Costs		
Site Number	**Investigation Type**	**Estimated Cost**
32BE0410	Phase I Archaeological	$8,000
32BEX0022	Phase I Archaeological	$14,000

Environmental

Fill used in the construction of the St. Michael levees could cause environmental impacts due to encroachment upon wetlands and upland plant communities. The natural resources within the St. Michael levees impact area include wetlands and upland areas. The acres of habitat impacted by land use category are shown on Figure 4.5-1. Impacts to the wetland communities represent the most important environmental impact to the 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 would 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 and grassland areas would 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 1.42 acres of potential oak forest/oak woodland impacts and 0.38 acres of grassland habitat impacts are expected from the proposed infrastructure protection measures 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 0.76 acres of like upland grassland habitat areas and 2.84 acres of like woodland habitat areas for these impacts.

At Action Level 2 (AL2), a total of 2.31 acres of potential oak forest/oak woodland impacts and 0.12 acres of grassland habitat impacts are expected from the proposed infrastructure protection measures 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 4.62 acres of like upland grassland habitat areas and 0.24 acres of like woodland habitat areas for these impacts.

At Action Level 3 (AL3), a total of 6.92 acres of potential oak forest/oak woodland impacts are expected from the proposed infrastructure protection measures 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 13.84 acres of like woodland habitat areas for these impacts.

4.5.3.5 Effects on Existing Infrastructure and Utilities

- Utilities in the vicinity of the proposed levee should be reviewed in detail during final design

4.5.3.6 Interdependencies

St. Michael is one of the few communities on the Spirit Lake Nation Reservation. Therefore, it is interdependent with the entire Spirit Lake Nation Reservation. The protection of St. Michael 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 23: BIA Highway 1
- Feature 24: BIA Highway 6

These highways are critical for St. Michael in that they provide the main transportation routes in and out of the community. ND Highway 57 is also a main transportation route to the Spirit Lake Casino and Resort.

Roads Acting as Dams (Feature 25) has an effect on St. Michael. If lake levels rise and the water levels on each side of any nearby roads acting as dams are allowed to equalize, the protection of St. Michael would be necessary. However, if appropriate levee protection along the roads currently acting as dams is provided, St, Michael would be protected by those levees.

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

4.5.3.7 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 interior pump station was assumed to be 1.5% of the pump station construction costs plus $4,000 for electricity.

4.5.3.8 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 St. Michael, 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 St. Michael levee 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 residential relocations, no estimate of lead time was needed. Current policies of local agencies make residential relocations unlikely until damage to the structures actually occurs. Relocations would be done on an as-needed basis, with no lead time provided. Relocation of the sewage lagoons could likely be completed within several months.

4.5.3.9 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 to construct levees in the dry
- Utilities may need to be abandoned or relocated as part of the sewage lagoon relocations or levee construction
- Foundation soils may be too soft to provide adequate foundation for levees and pump stations

4.5.3.10 Data Deficiencies

The following data should be collected or verified prior to proceeding with constructing the St. Michael protection strategies:

- Verify location, number, and elevation of homes that would need relocating
- Conduct soil borings along proposed levee alignment
- Define lift station and piping required when relocating the sewage lagoons

- Determine precise locations of above ground and buried utilities
- Confirm low home elevation
- Locate and evaluate nearby cultural resources that were identified

4.5.4 Economics of Flood Protection

Damages: For the Infrastructure Protection Study's analysis, the flood damage estimates for St. Michael were reassessed in order to update and more accurately characterize the nature of the damages. The updated damage computations for St. Michael are summarized in the accompanying Table 4.5-1. All damages were estimated up to the maximum lake level (1463).

- Loss of ten (10) residences at 1463.
- Loss of access to 16 residences at 1463.
- Loss of two sewage lagoons (the north sewage lagoon at 1451 and the south sewage lagoon at 1455). The north sewage lagoon includes 3 cells and the south sewage lagoon includes one cell.

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 St. Michael are listed in the St. Michael Infrastructure Protection Study Assumptions listing, attached to this Section 4.5.

Costs: The updated costs of providing flood protection for St. Michael are detailed in the accompanying Table 4.5-2 for St. Michael. 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 at the first Action Level (AL1) include relocation of the North Sewage Lagoon at $159,000 (for all protection strategies along with construction of a lift station). This cost was taken from the *Devils Lake Spirit Lake Nation Reservation Alternatives Assessment*, Barr Engineering Company, October 1997. The cost of a lift station would be approximately $250,000 which would include associated piping. This cost was based on a phone conversation with Carolyn Greene (Sioux Utilities) on October 23, 2002.

The costs at the second Action Level (AL2) include relocation of the south Sewage Lagoon (for all protection strategies).

The relocation costs at the third Action Level (AL3) includes all affected structures between 1461 and 1464 and construction of an access road for 16 residences.

Unit prices for all the cost computations were discussed previously in Section 4.0, and are detailed in Table 4.0-5. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for St. Michael are listed in the St. Michael Infrastructure Protection Study Assumptions listing, attached to this Section 4.5.

Contingencies: The contingency percentages used for construction materials ranged from 30 to 50% (Table 4.5-2). 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 North Sewage Lagoon lift station and piping were estimated at the higher end of the range because of the limited data.

4.5.5 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 St. Michael are listed in Table 4.5-3a for the analysis of all action levels and in Table 4.5-3b 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 4.5-2). The annual net benefits for this approach were less than zero (-$11,700). The BCR for this approach was less than one (0.71). These results show that this strategy is not economically justified. The annual damages prevented by this relocation strategy are $28,100. 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 St. Michael, 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 -$21,200, and the BCR was 0.71, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $52,400.

- First Moderate Future – For the first moderate future, the strategy with the largest net benefits was incremental relocation. The annual net benefits were -$10,500, and the BCR was 0.70,

indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $24,900.

- Second Moderate Future – For the second moderate future, the strategy with the largest net benefits was incremental relocation. The net benefits were -$11,900, and the BCR was 0.71, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $29,600.

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

The annual net benefits for this approach were less than zero (-$10,500). The BCR for this approach was less than one (0.70). These results show that this strategy is not economically justified. The annual damages prevented by this relocation strategy are $24,800. The stochastic results are averages over 10,000 traces.

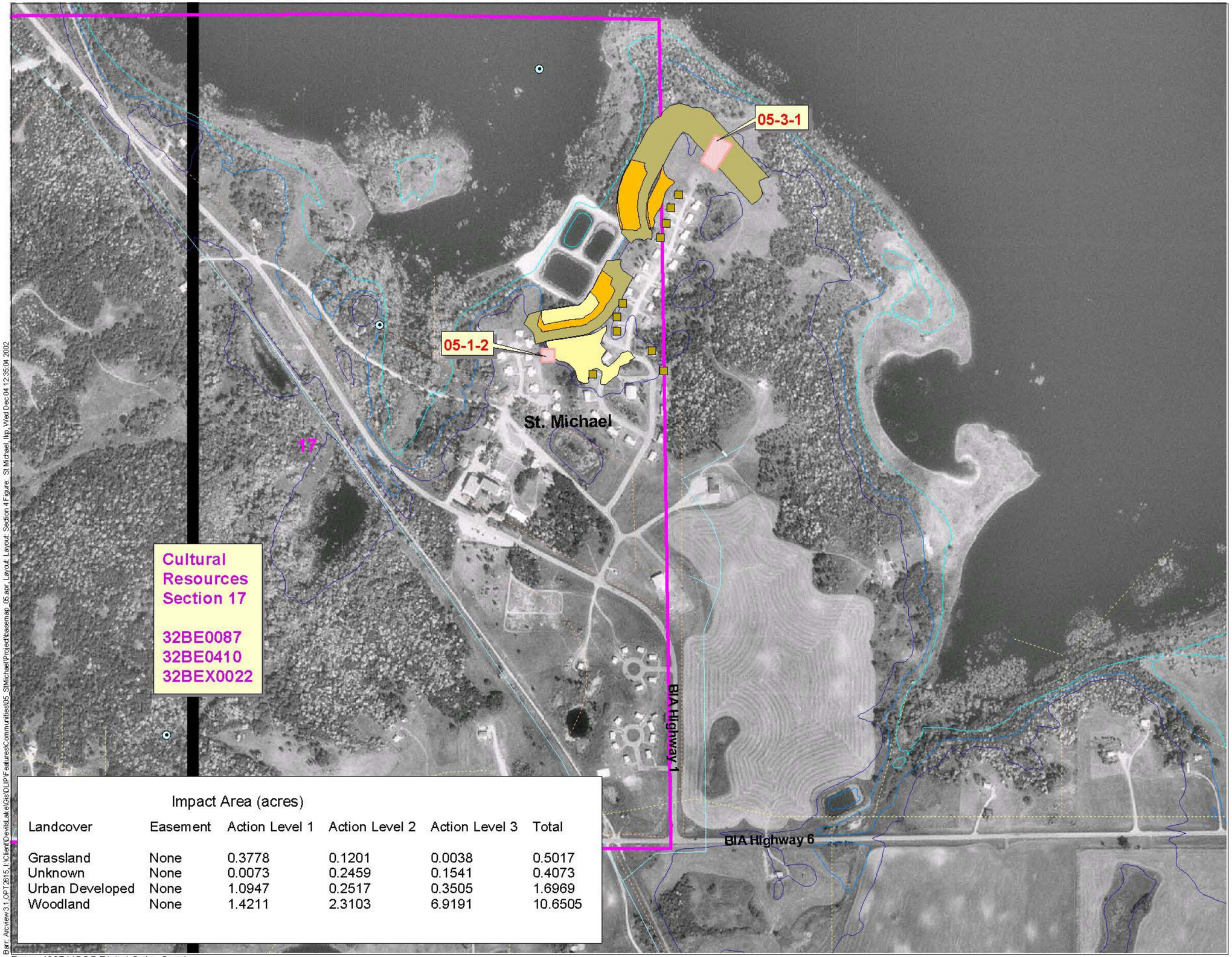
The results for the first action level are similar to the results computed for all action levels for this feature. It is interesting to note that the results of the first action level analysis are exactly the same for the stochastic analysis and the specific scenarios. This is a result of the first action level costs and damages both being incurred immediately under all futures (because it is currently protected by roads that are acting as dams).

First Action Level Results for Specific Scenarios: One incremental relocation was also analyzed under each of three specific climate futures. For St. Michael, 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 relocation were -$10,500, and the BCR was 0.70, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $24,900.

- First Moderate Future – Under the first moderate future climate scenario, the net benefits of one incremental relocation were -$10,500, and the BCR was 0.70, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $24,900.

- Second Moderate Future – Under the second moderate future climate scenario, the net benefits of one incremental relocation were -$10,500, and the BCR was 0.70, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $24,900.



Impact Area (acres)

Landcover	Easement	Action Level 1	Action Level 2	Action Level 3	Total
Grassland	None	0.3778	0.1201	0.0038	0.5017
Unknown	None	0.0073	0.2459	0.1541	0.4073
Urban Developed	None	1.0947	0.2517	0.3505	1.6969
Woodland	None	1.4211	2.3103	6.9191	10.6505

Data: 1997 USGS Digital Ortho Quad

Barr: Arcview 3.1, OPT2615, I:\Client\DevilsLake\Gis\DLIP\Features\Communities\05_StMichael\Project\basemap_05.apr, Layout: Layout: Section 4 Figure: St Michael, llp, Wed Dec 04 12:35:04 2002

N
W E
S

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
- Cultural Resources Sites
- Pump Station

Utilities

Electric
- Overhead
- Underground
- Unknown

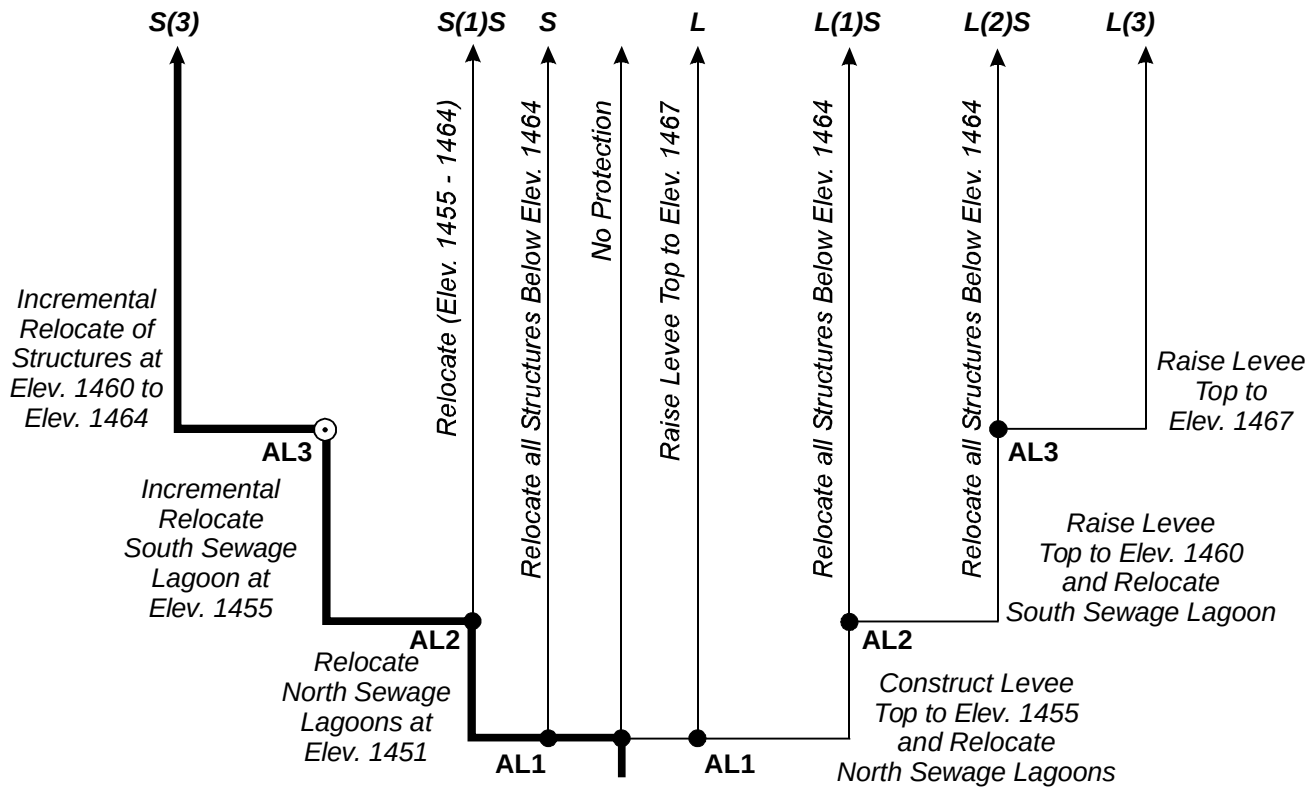
Water
- Watermain
- Watermain, Abandoned

Sewer
- Sewer
- Sewer, Abandoned

- Gas
- Well

Figure 4.5-1

LOCATION MAP
FEATURE 5: ST. MICHAEL
Devils Lake Infrastructure Protection Study



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. 1467

S(1) Structure relocation (number of times)

S Relocate all structures below Elev. 1464

— — — Strategy not Analyzed

Figure 4.5-2

DECISION TREE
FEATURE 5: ST. MICHAEL
Devils Lake Infrastructure Protection Study

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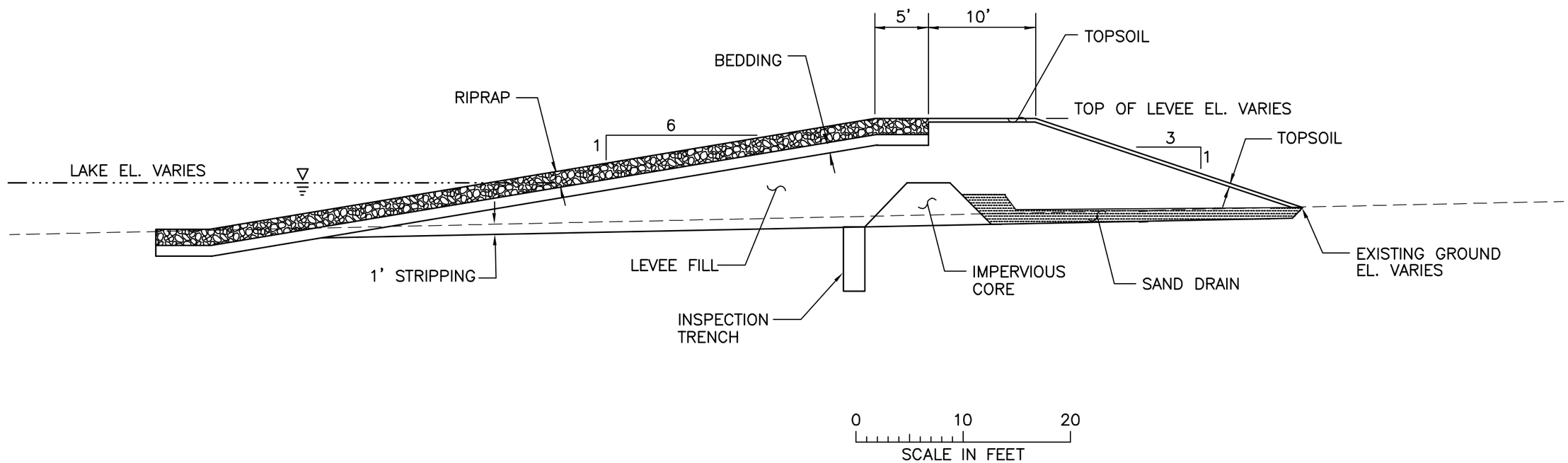


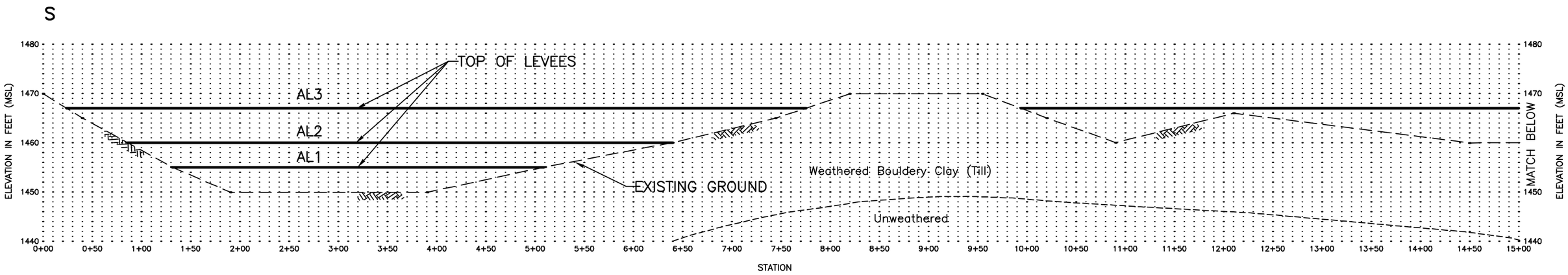
Figure 4.5–3

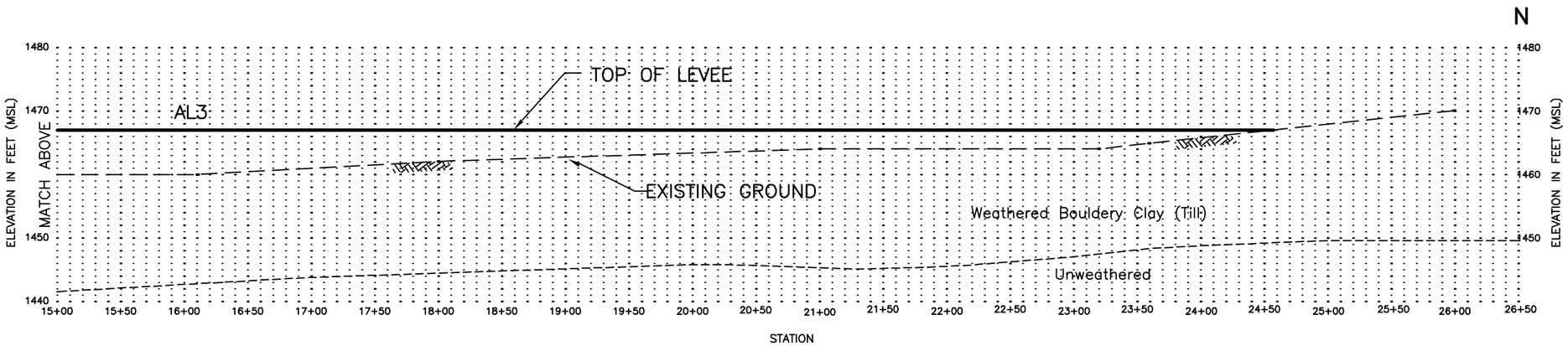
TYPICAL LEVEE CROSS–SECTION

FEATURE 5:
ST. MICHAEL

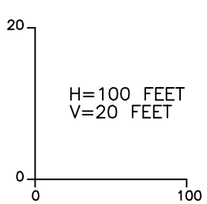
DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

NRD M:\CAD\3436020\17234_1.DWG Plot at 10 11/05/2002 11:04:5





LEVEE 5



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

Figure 4.5–4

LEVEE PROFILE

FEATURE 5:
ST. MICHAEL

DEVILS LAKE
INFRASTRUCTURE PROTECTIONSTUDY

NRD M:\CAD\3436020\17233_1.DWG Plot at 1 11/05/2002 11:55:35

Table 4.5-1

Flood Damages
Feature 5: St. Michael
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Structure Elevation Range (MSL)	Structures and Infrastructure (THOUSANDS)
AL1	1451-1455	$409
AL2	1455-1460	$159
AL3	1460-1464	$656

DAMAGE BREAKDOWN

Structure Elevation (1451-1455)					Structure Elevation (1455-1460)					Structure Elevation (1460-1464)				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	0	EA	$62,000	$0	Residence	0	EA	$62,000	$0	Residence	10	EA	$62,000	$620
North Sewage Lagoon	1	EA	$159,000	$159	South Sewage Lagoon	1	EA	$159,000	$159	Access Road	1,100	LF	$33	$36
North Sewage Lagoon Lift Station and Piping	1	EA	$250,000	$250										
Total				**$409**	**Total**				**$159**	**Total**				**$656**

Table 4.5-2

Flood Protection Costs
Feature 5: St. Michael
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	$582	$582	$1,720	$4,407	$2,201	$2,201	$2,201
AL2	$207	$1,138	$0	$0	$1,720	$863	$863
AL3	$931	$0	$0	$0	$0	$1,720	$1,343

COST BREAKDOWN

Strategy	Description	Quantity	Units	Unit Cost	Contingency	Value (THOUSANDS)
	S AT AL1					
	S(1) S AT AL1					
	S(3) AT AL1					
Incremental Relocation	Residence	0	EA	$68,000	30%	$0
	North Sewage Lagoon	1	EA	$159,000	30%	$207
	North Sewage Lagoon Lift Station and Piping	1	EA	$250,000	50%	$375
	Subtotal					$582
	Total Relocation					**$582**
	L(3) AT AL1					
	L(2)S AT AL1					
	L(1)S AT AL1					
	L AT AL1					
Incremental Levee Raise	**Raise Top of Levee to El. 1455**					
	Performance/Payment Bond	1	JB	$8,108	10%	$9
	North Sewage Lagoon	1	EA	$159,000	30%	$207
	North Sewage Lagoon Lift Station and Piping	1	EA	$250,000	50%	$375
	Levee Construction					
	Clearing and Grubbing	0.9	AC	$3,000	30%	$4
	Stripping (1')	1,400	CY	$1.50	30%	$3
	Inspection Trench	630	LF	$4.00	30%	$3
	Levee Fill	2,400	CY	$5.00	30%	$16
	Bedding	900	CY	$35	30%	$41
	Riprap	1,400	CY	$40	40%	$78
	Sand Drain	1,100	CY	$22	30%	$31
	Topsoil (4")	200	CY	$2.50	30%	$1
	Seed	0.4	AC	$1,000	30%	$1
	Interior Drainage/Pump Station					
	Culverts	950	LF	$50	50%	$71
	Pump Station	1	EA	$700,000	30%	$910
	Geotechnical					
	Slurry Wall	0	SF	$6.00	50%	$0
	Borings	3	EA	$1,000	50%	$5
	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			$22
		Subtotal				$1,777
	Engineering and Design			15%		$267
	Supervision and Administration			8%		$142
	Real Estate Acquisition for ROW	1	LS			$15
	Total Levee					**$2,201**

Strategy	Description	Quantity	Units	Unit Cost	Contingency	Value (THOUSANDS)
	S AT AL1					
	S(1)S AT AL2					
	S(3) AT AL2					
Incremental Relocation	Residence	0	EA	$68,000	30%	$0
	South Sewage Lagoon	1	EA	$159,000	30%	$207
	Subtotal					$207
	Total Relocation					**$207**
	L(3) AT AL2					
	L(2)S AT AL2					
	L(1)S AT AL2					
	L AT AL1					
Incremental Levee Raise	**Raise Top of Levee to El. 1460**					
	Performance/Payment Bond	1	JB	$3,355	10%	$4
	South Sewage Lagoon	1	EA	$159,000	30%	$207
	Levee Construction					
	Clearing and Grubbing	2.2	AC	$3,000	30%	$9
	Stripping (1')	3,500	CY	$1.50	30%	$7
	Inspection Trench	1,090	LF	$4.00	30%	$6
	Levee Fill	12,200	CY	$5.00	30%	$79
	Bedding	2,300	CY	$35	30%	$105
	Riprap	3,500	CY	$40	40%	$196
	Sand Drain	2,600	CY	$22	30%	$74
	Topsoil (4")	700	CY	$2.50	30%	$2
	Seed	1.2	AC	$1,000	30%	$2
	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			$0
	Cultural Resources Investigation	1	LS			$0
		Subtotal				$691
	Engineering and Design			15%		$104
	Supervision and Administration			8%		$55
	Real Estate Acquisition for ROW	1	LS			$13
	Total Levee					**$863**

Strategy	Description	Quantity	Units	Unit Cost	Contingency	Value (THOUSANDS)
	S(3) AT AL3					
Incremental Relocation	Residence	10	EA	$68,000	30%	$884
	Access Road	1,100	LF	$33	30%	$47
	Subtotal					$931
	Total Relocation					**$931**
	L(3) AT AL3					
Incremental Levee Raise	**Raise Top of Levee to El. 1467**					
	Performance/Payment Bond	1	JB	$7,324	10%	$8
	Levee Construction					
	Clearing and Grubbing	4	AC	$3,000	30%	$16
	Stripping (1')	6,400	CY	$1.50	30%	$12
	Inspection Trench	830	LF	$4.00	30%	$4
	Levee Fill	48,800	CY	$5.00	30%	$317
	Bedding	4,300	CY	$35	30%	$196
	Riprap	6,500	CY	$40	40%	$364
	Sand Drain	4,500	CY	$22	30%	$129
	Topsoil (4")	1,500	CY	$2.50	30%	$5
	Seed	2.7	AC	$1,000	30%	$4
	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			$3
	HTRW	1	LS			$1
	Cultural Resources Investigation	1	LS			$0
		Subtotal				$1,058
	Engineering and Design			15%		$159
	Supervision and Administration			8%		$85
	Real Estate Acquisition for ROW	1	LS			$41
	Total Levee					**$1,343**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Levee Maintenance	Pump O&M	Total Operation and Maintenance Cost
	(THOUSANDS)		
AL1	$2	$15	$16
AL2	$7	$15	$21
AL3	$17	$15	$32

Notes:
1. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.
2. Levee maintenance costs shown are the cumulative totals for each respective level.

Table 4.5 - 3a

Economics Results: All Action Levels -- to Lake Level 1463
Feature 5: St. Michael
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	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	$28,100	$28,100	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$104,300	$104,300	$0	$0	$28,100	-$76,200	0.27
L	Raise Levee Top to 1467	$267,100	$31,900	$0	$299,000	$0	$0	$28,100	-$271,000	0.09
L(1)S	1 Levee Raise: Then Relocate	$133,400	$4,600	$73,300	$211,200	$0	$0	$28,100	-$183,200	0.13
L(2)S	2 Levee Raises: Then Relocate	$170,200	$16,100	$11,700	$198,100	$0	$0	$28,100	-$170,000	0.14
L(3)	3 Levee Raises	$179,300	$19,300	$0	$198,600	$0	$0	$28,100	-$170,600	0.14
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$44,800	$44,800	$0	$0	$28,100	-$16,700	0.63
S(3)	3 Incremental Relocations	$0	$0	$39,800	$39,800	$0	$0	$28,100	-$11,700	0.71

Wet Future Scenario (WF-9)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	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	$52,400	$52,400	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$104,600	$104,600	$0	$0	$52,400	-$52,200	0.50
L	Raise Levee Top to 1467	$268,100	$32,000	$0	$300,100	$0	$0	$52,400	-$247,700	0.17
L(1)S	1 Levee Raise: Then Relocate	$133,900	$900	$98,600	$233,400	$0	$0	$52,400	-$181,000	0.22
L(2)S	2 Levee Raises: Then Relocate	$183,300	$6,800	$69,000	$259,200	$0	$0	$52,400	-$206,800	0.20
L(3)	3 Levee Raises	$237,200	$26,100	$0	$263,300	$0	$0	$52,400	-$210,900	0.20
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$83,900	$83,900	$0	$0	$52,400	-$31,400	0.62
S(3)	3 Incremental Relocations	$0	$0	$73,700	$73,700	$0	$0	$52,400	-$21,200	0.71

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

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	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	$24,900	$24,900	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$104,600	$104,600	$0	$0	$24,900	-$79,700	0.24
L	Raise Levee Top to 1467	$268,100	$32,000	$0	$300,100	$0	$0	$24,900	-$275,200	0.08
L(1)S	1 Levee Raise: Then Relocate	$133,900	$8,500	$48,300	$190,800	$0	$0	$24,900	-$165,800	0.13
L(2)S	2 Levee Raises: Then Relocate	$158,100	$17,000	$0	$175,200	$0	$0	$24,900	-$150,300	0.14
L(3)	3 Levee Raises	$158,100	$17,000	$0	$175,200	$0	$0	$24,900	-$150,300	0.14
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$35,400	$35,400	$0	$0	$24,900	-$10,500	0.70
S(3)	3 Incremental Relocations	$0	$0	$35,400	$35,400	$0	$0	$24,900	-$10,500	0.70

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

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	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	$29,600	$29,600	$0	$0	--
S	Relocation of All Structures below 1468	$0	$0	$104,600	$104,600	$0	$0	$29,600	-$75,000	0.28
L	Raise Levee Top to 1467	$268,100	$32,000	$0	$300,100	$0	$0	$29,600	-$270,500	0.10
L(1)S	1 Levee Raise: Then Relocate	$133,900	$900	$98,600	$233,400	$0	$0	$29,600	-$203,800	0.13
L(2)S	2 Levee Raises: Then Relocate	$183,300	$10,300	$51,300	$245,000	$0	$0	$29,600	-$215,400	0.12
L(3)	3 Levee Raises	$223,400	$24,200	$0	$247,600	$0	$0	$29,600	-$217,900	0.12
S(1)S	1 Incremental Relocation: Then Relocate All Remaining	$0	$0	$69,300	$69,300	$0	$0	$29,600	-$39,700	0.43
S(3)	3 Incremental Relocations	$0	$0	$41,600	$41,600	$0	$0	$29,600	-$11,900	0.71

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 4.5 - 3b

Economics Results: First Action Level
Feature 5: St. Michael
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	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	$24,800	$24,800	$0	$0	--
S(1)	1 Incremental Relocation	$0	$0	$35,300	$35,300	$0	$0	$24,800	-$10,500	0.70

Wet Future Scenario (WF-9)
(Annual)

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	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	$24,900	$24,900	$0	$0	--
S(1)	1 Incremental Relocation	$0	$0	$35,400	$35,400	$0	$0	$24,900	-$10,500	0.70

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

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	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	$24,900	$24,900	$0	$0	--
S(1)	1 Incremental Relocation	$0	$0	$35,400	$35,400	$0	$0	$24,900	-$10,500	0.70

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

Strategy		COSTS				DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	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	$24,900	$24,900	$0	$0	--
S(1)	1 Incremental Relocation	$0	$0	$35,400	$35,400	$0	$0	$24,900	-$10,500	0.70

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 4.5:
St. Michael Economic Analysis Assumptions

A. General Assumptions

1. Estimated damages included only the homes in the immediate area of St. Michael. 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. Levees

1. For levee protection, it was assumed that 4 feet of freeboard would be required for levee 5 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 station were calculated for the maximum levee elevation only.

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

6. 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).

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

8. 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.

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

10. The annual operation and maintenance cost for the interior pump station was assumed to be 1.5% of the pump station construction costs plus $4,000 for electricity.

11. It was assumed that any levee constructed for the community would **not** protect the sewage lagoons. The top of the existing north sewage lagoons is at elevation 1451 and the top of the existing south

sewage lagoon is at elevation 1455. The lagoons were assumed to be affected at AL1 and AL2 because of potential wave damage. It was assumed that the lagoons require the same 4-foot freeboard as the levees.

12. The inspection trench was assumed at each action level, because the levee gets significantly longer at each levee raise.

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 4.5-1 shows 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 the contingency 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 St. Michael 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 costs for homes were 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 the approximately the same in St. Michael 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. For relocation strategies, the advanced replacement of the north sewage lagoon was estimated at $150,000 (*Devils Lake Spirit Lake Nation Reservation Alternatives Assessment*, Barr Engineering Company, October, 1997). This cost is in 1998 dollars, therefore, for the Economic Analysis, it was updated for inflation by multiplying it by the ENR Construction Cost Index of 1.06. The updated relocation cost for the sewage lagoon is $159,000. This is the same cost that is being used for the Infrastructure Protection Study.

6. It was assumed that the relocation of the north sewage lagoon to higher ground at AL1 would require construction of a lift station to maintain service to the existing homes. The cost of a lift station was estimated to be approximately $250,000 including associated piping. This cost was based on a phone conversation with Carolyn Greene (Sioux Utilities) on October 23, 2002.

7. A 50% contingency was applied to the North Sewage Lagoon Lift Station and piping in the cost tables.

8. It was assumed that the south sewage lagoon at AL2 could be relocated to an area lower than the houses that it services. Therefore, a lift station would not be necessary.

9. For relocation strategies, it was assumed that at AL3, ten houses would be relocated. The access road to the remaining sixteen houses would need to be raised slightly. The cost for this was estimated using the 2002 unit prices for construction of a township road.

4.6 Summary of Infrastructure Protection Investigation for Feature 6: Gilbert C. Grafton Military Reserve

4.6.0 Flood Protection Strategy

The flood protection that was analyzed for Gilbert C. Grafton Military Reservation (Camp Grafton) was to relocate the munitions training facility.

4.6.1 General Information

Feature Type: State Facility

Location: Gilbert C. Grafton Military Reservation is located approximately 6 miles south southwest of the City of Devils Lake along the west side of ND Highway 20. The accompanying Figure 4.6-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Gilbert C. Grafton Military Reservation (Camp Grafton) is the main training site for the North Dakota Army National Guard. It is a 1,600-acre camp, accommodating up to 3,000 soldiers with housing, dining hall facilities, field, and classroom training facilities. This main camp facility is also associated with the 10,000 acre Camp Grafton South training area, located 35 miles to the south.

Significance: Camp Grafton is important because it is the major training facility for the North Dakota Army National Guard, and its operation has a major economic impact on the community.

Damages: The flooding of Camp Grafton would result in the following damages:

- loss of access to this important training facility
- loss of training facilities
- loss of commerce associated with Camp operation, visitors

Owner/Sponsor: The State of North Dakota, or North Dakota Army National Guard is responsible for managing and maintaining Camp Grafton.

Lead Federal Agency: The State of North Dakota would take the lead for Camp Grafton for any flood protection work that may take place.

4.6.2 Feature Protection

History of Flood Protection: The northeastern portion of Camp Grafton lands are located in the area that is currently being protected by roads that are acting as dams (ND Highway 20 – See

Feature 25 description). Therefore, the flood level at the munitions facility is much lower than the level of Devils Lake. In the past, flood protection for Camp Grafton has consisted of:

- Access road raises, with the top currently at 1455
- Pumping seepage water from the munitions training area located in the northeast corner of the facility, adjacent to Highway 20
- Converting the sewer system to Ramsey County Rural Utility Service
- Initial construction of the Avenue A levee to a top of 1460

The camp does have plans to relocate the munitions storage area, instead of the previous plan to protect this area with a levee.

General Protection Strategy: The Economic Analysis identified and evaluated several different approaches for protecting Camp Grafton. This strategy has changed since the Economic Analysis was completed. The current strategy includes:

- ND Highway 20 is assumed to be raised to provide access to the camp
- Camp Grafton will not close, even if water surfaces reach maximum level, because a significant portion of the facility property is above Elevation 1475
- The main access road is likely to be raised by staff at the facility at the same time (or immediately after) ND Highway 20 is raised
- The main gate is the only gate that will be maintained and raised
- The existing levee along Avenue A will be raised by staff at the facility to provide protection to ultimate lake level
- The only buildings to be moved will be those associated with the munitions storage area

Protection Strategy by Action Level: Figure 4.6-2 shows the decision tree for Camp Grafton. As shown on Figure 4.6-2, the stepwise approach to flood protection for Camp Grafton consists of the following:

1. At Action Level 1 (AL1), the munitions facility would be relocated.

The Infrastructure Protection Study analysis considered the flood protection strategy for relocation of the munitions facility. It was assumed that all higher action level flood protection work would be completed by staff at the facility, as has been done in the past. Therefore, the economics results include only one action level.

Reference Elevations for Structure Relocation (AL1)		
Elevation	**Name**	**Significance**
1444	Low Structure Elevation	Ground at lowest building in the group
Current	Lake Damage Elevation	Lake elevation at which damage to lowest building begins
NA	Project Completion Elevation	Lake elevation at which building relocation must be complete
NA	Construction Initiation Elevation	Lake elevation at which building relocation must begin
NA	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

4.6.3 Design Considerations

4.6.3.0 General Design

The first incremental action for flood protection at Camp Grafton includes relocation of the munitions storage area buildings. These buildings will be moved to higher ground to the west.

4.6.3.1 Site Geology

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

4.6.3.2 Hydrology/Interior Drainage Issues

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

4.6.3.3 Real Estate Requirements

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

4.6.3.4 Environmental/Cultural issues

HTRW

Gilbert C. Grafton Military Reserve has been listed in the same location since the 1930s. Quantity of military buildings and nearby residences has increased over the years; however, land use does not appear to have changed significantly over time. Surrounding land use is mostly forested and agricultural land with scattered rural residences in the central areas and more extensive residential developments along the shores of Devils Lake, including the nearby Lakewood area.

At the Gilbert C. Grafton Military Reserve the only structure that needs to be relocated is the Ammunition Supply Point. This structure and the surrounding area contain two non-standard above ground magazines of permanent masonry type construction; three standard earth covered magazines, and an inspection building of permanent masonry type construction. Considering the land use and the building construction, these buildings are not considered to be RECs.

The regulatory record review for zip code 58301 was obtained from FirstSearch on October 15, 2002. Two buildings area listed as being RCRA generators and the North Dakota Army National Guard facility is listed as having USTs and as a closed LUST site. None of these facilities are located within Feature 6.

Cultural

The Gilbert C. Grafton Military Reservation contains 48 known cultural resources sites and 5 site leads/isolated finds. However, this feature only requires relocating a cluster of above and below ground munitions magazine storage facilities and an associated munitions inspection building in a small area of the overall facility. These relocations have the potential to affect only one known prehistoric archaeological site as shown on Figure 4.6-1. Site 32RY0147 contains buried artifact scatters that were identified through shovel tests and auger probes. The site was recommended as potentially eligible for listing on the NHRP. A Phase 1 survey will need to be performed for this site prior to implementation of this feature in order to determine eligibility to the National Register of Historic Places. The cost of this survey is estimated to be $14,000. As noted in Section 4.0, these costs are believed representative of the cultural resources investigations required for the next stage of study.

Environmental

The natural resources within the areas impacted by protection measures Gilbert C. Grafton Military Reservation will be minimal and confined to those areas directly impacted by the relocating of structures. Fill used for the relocations could cause environmental impacts due to the subsequent re-vegetation of fill or borrow locations. Revegetation and soil compaction may allow for the introduction of weedy, non-native species. Any impact to woodland, wetland and grassland areas would result in minimal impacts to songbird nesting and small mammal populations, as well as impacting reptile and amphibian populations due to habitat fragmentation.

4.6.3.5 Effects on Existing Infrastructure & Utilities

There are no anticipated effects on existing infrastructure and utilities.

4.6.3.6 Interdependencies

Camp Grafton is not directly interdependent with other features, although the Camp is dependent on these other features (roads for access, communities for normal daily activities, hospitals, etc). The primary roadways that are critical for Camp Grafton include:

- Feature 13: US Highway 2 – US Highway 2 provides a major transportation route into and out of the Camp.
- Feature 16: US Highway 281 (South of US Highway 2) – US Highway 281 provides a major transportation route into and out of the Camp.
- Feature 21: ND Highway 20 – The protection of Camp Grafton is related to the protection of ND Highway 20. Without a road raise on ND Highway 20, there is no access to Camp Grafton.
- Feature 22: ND Highway 20 – The south Camp Grafton site is accessed via ND Highway 20.
- Feature 25: Roads Acting as Dams – If lake levels rise and the water levels on each side of ND Highway 20 that is acting as a dam are allowed to equalize, the flood protection measures may be necessary to allow its continued use.

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

4.6.3.7 O&M

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

4.6.3.8 Lead Time Required

A lead time estimate was not completed for the incremental strategy for this feature.

4.6.3.9 Potential Problems and Risks

There are no known potential problems and risks associated with the incremental strategy for this feature.

4.6.3.10 Data deficiencies

There are no known data deficiencies with the incremental strategy for this feature.

4.6.4 Economics of Flood Protection

Damages: For the Infrastructure Protection Study, the flood damage estimates for Camp Grafton were reassessed in order to update and more accurately characterize the nature of the damages. The updated damage computations for Camp Grafton are summarized in the accompanying Table 4.6-1.

Table 4.6-1 lists damages to buildings that would be inundated by rising waters. These damages are based on capitalized values of the buildings impacted, as provided by camp operations staff. Inundated land values are also listed, using a standard assessed value per acre.

Unit prices for all the damage computations were discussed previously in Section 3.0, and are detailed in Table 4.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Camp Grafton are listed in the Feature 6 Assumptions listing, appended to this Section 4.6.

Costs: Updated costs of providing flood protection for Camp Grafton are detailed in the accompanying Table 4.6-2. Unit prices, data sources, and relevant assumptions are listed.

Table 4.6-2 lists the expected costs for relocating the munitions storage facility.

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 Camp Grafton are listed in the Feature 6 Assumptions listing, appended to this Section 4.6.

Contingencies: A contingency percentages of 5% was used for the relocation of the munitions facility. This contingency is lower than the typical range used in this study because the costs were based on more detailed analyses completed by Camp Grafton.

4.6.5 Economic Results

The results of the Infrastructure Protection Study for Camp Grafton are listed in Table 4.6-3. 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 the Camp Grafton, the Infrastructure Protection Study's analysis provided relevant economic indices for relocation of the munitions facility. The relocation of the munitions facility strategy is highlighted on the decision tree (Figure 4.6-2). The annual net benefits for this approach were less than zero (-$33,000). The BCR for this approach was less than one (0.64). These results show that this strategy is not economically justified. The annual

damages prevented by this relocation strategy are $58,800. The stochastic results are averages over 10,000 traces.

As noted below, the results of the analysis are the same for the stochastic analysis and the specific scenarios. This is a result of the first action level costs and damages both being incurred immediately under all futures (because it is currently protected by roads that are acting as dams).

Results for Specific Scenarios: Relocation of the munitions facility was also analyzed under each of three specific climate futures. For Camp Grafton, 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 relocation of the munitions facility were -$33,100, and the BCR was 0.64, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $59,000.
- First Moderate Future – Under the first moderate future climate scenario, the net benefits of relocation of the munitions facility were -$33,100, and the BCR was 0.64, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $59,000.
- Second Moderate Future – Under the second moderate future climate scenario, the net benefits of relocation of the munitions facility were -$33,100, and the BCR was 0.64, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $59,000.

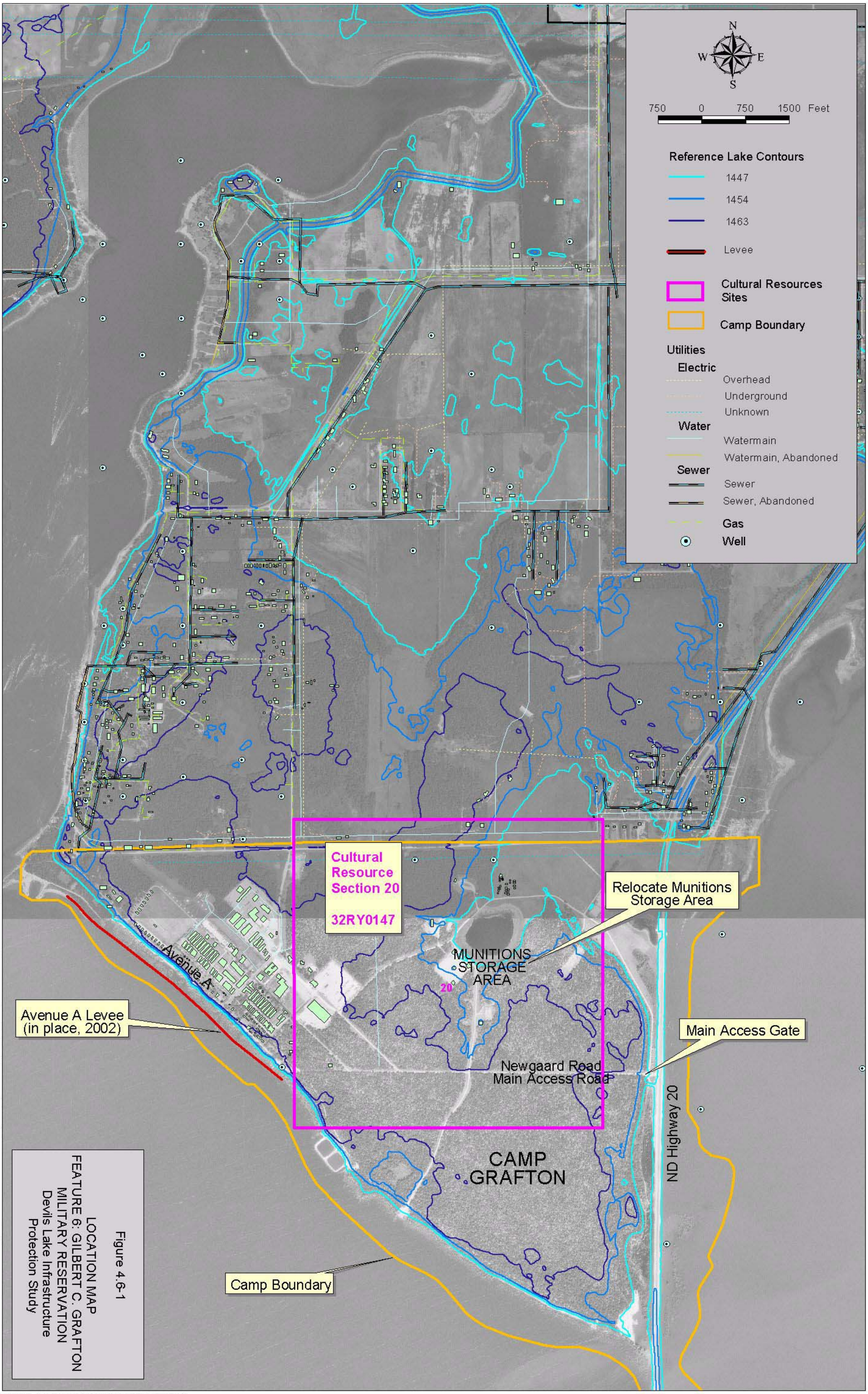
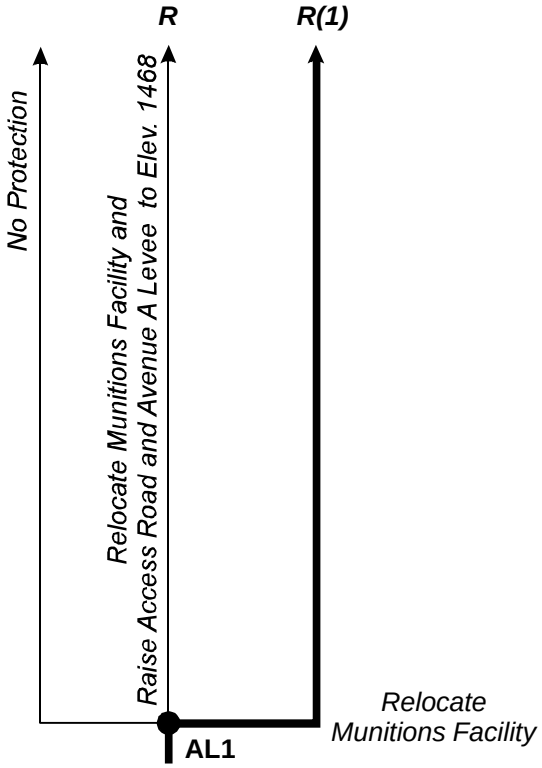


Figure 4.6-1
LOCATION MAP
FEATURE 6: GILBERT C. GRAFTON MILITARY RESERVATION
Devils Lake Infrastructure Protection Study

Barr: Arcview 3.1,OPT2615, i:\client\devilslake\gis\dlip\features\staterurallfeatures\06_grafton\project\basemap_06.apr, Layout: Layout: Section 4 Figure Fort Grafton, lkp, Tue Nov 19 13:21:19 2002

DATA: 1997 USGS Digital Ortho Quad



Lowest Access Road Elevation: 1455

P:\34\36\020\DECISIONTREES\2002FIGURES\FIGURE4_06.CDR RLG 01-06-03

▬	Flood Protection Strategy
●	Decision required at this point
⊙	Trigger point for action, no decision needed
AL1	Decision/Action Level
R(1)	Incremental road raise(number of times)

Figure 4.6-2

DECISION TREE
FEATURE 6:GILBERT C. GRAFTON
MILITARY RESERVATION
Devils Lake Infrastructure Protection Study

Table 4.6-1

Flood Damages
Feature 6: Gilbert C. Grafton Military Reservation
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Structure Elevation Range (MSL)	Structures and Infrastructure (THOUSANDS)
AL1	Below 1447	$970

DAMAGE BREAKDOWN

Structure Elevation - Immediate				
Description	**Quantity**	**Units**	**Unit Cost**	**Value (THOUSANDS)**
Munitions Area Buildings Includes Ammo Storage Office and 4 Ammo Storage Bunkers	1	EA	$970,000	$970
Total				**$970**

Notes:
1. The munitions facility is currently being protected by feature 25: RAAD.

Table 4.6-2

Flood Protection Costs
Feature 6: Gilbert C. Grafton Military Reservation
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	S (1)
Action Level	Relocate All Structures at AL1
	(THOUSANDS)
AL1	$1,514

COST BREAKDOWN

Strategy	S (1)					
	Description	Quantity	Units	Unit Cost	Contingency	Value (THOUSANDS)
Incremental Relocations	Above Ground Magazine	2	EA	$225,000	5%	$473
	Earth Covered Magazine	3	EA	$117,000	5%	$369
	Inspection Building	1	EA	$180,000	5%	$189
	Clearing and Grubbing	1	LS	$60,000	5%	$63
	Sitework	1	LS	$150,000	5%	$158
	Bituminous Pavement	1,440	TON	$50	5%	$76
	Utilities	1	LS	$74,000	5%	$78
	Security Lighting	1	LS	$15,000	5%	$16
	Fencing	2870	LF	$12	5%	$36
	Environmental Impacts					
	Mitigation	1	LS			$0
	HTRW	1	LS			$0
	Cultural Resources Investigation	1	LS			$14
	Subtotal					$1,470
	Engineering and Design		2%			$22
	Supervision and Administration		2%			$22
	Real Estate Acquisition for ROW	1	LS			$0
	Total Road Raise					**$1,514**

Table 4.6 - 3

Economics Results
Feature 6: Gilbert C. Grafton Military Reservation
Devils Lake Infrastructure Protection Study

Strategy		Stochastic Analysis (ST-9) Mean Value over 10,000 Traces (Annual)							
		COST			DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Relocation A	Levee & Riprap B	Total C = A + B	Damages D	Total E=D	To Strategy (Damages Prevented) F = E(No Protection) - E(S) *	To Strategy G = F - C	(BCR) I = F / C
No Protection	No Protection or Relocation	$0	$0	$0	$58,800	$58,800	$0	$0	--
R(1)	1 Road Raise	$91,800	$0	$91,800	$0	$0	$58,800	-$33,000	0.64

Strategy		Wet Future Scenario (WF-9) (Annual)							
		COST			DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Relocation A	Levee & Riprap B	Total C = A + B	Damages D	Total E=D	To Strategy (Damages Prevented) F = E(No Protection) - E(S) *	To Strategy G = F - C	(BCR) I = F / C
No Protection	No Protection or Relocation	$0	$0	$0	$59,000	$59,000	$0	$0	--
R(1)	1 Road Raise	$92,100	$0	$92,100	$0	$0	$59,000	-$33,100	0.64

Strategy		Moderate Future 1 Scenario (M1-4) (Annual)							
		COST			DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Relocation A	Levee & Riprap B	Total C = A + B	Damages D	Total E=D	To Strategy (Damages Prevented) F = E(No Protection) - E(S) *	To Strategy G = F - C	(BCR) I = F / C
No Protection	No Protection or Relocation	$0	$0	$0	$59,000	$59,000	$0	$0	--
R(1)	1 Road Raise	$92,100	$0	$92,100	$0	$0	$59,000	-$33,100	0.64

Strategy		Moderate Future 2 Scenario (M2-4) (Annual)							
		COST			DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Relocation A	Levee & Riprap B	Total C = A + B	Damages D	Total E=D	To Strategy (Damages Prevented) F = E(No Protection) - E(S) *	To Strategy G = F - C	(BCR) I = F / C
No Protection	No Protection or Relocation	$0	$0	$0	$59,000	$59,000	$0	$0	--
R(1)	1 Road Raise	$92,100	$0	$92,100	$0	$0	$59,000	-$33,100	0.64

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 (E(S)).

Attachment to 4.6:
Gilbert C. Grafton State Military Reservation Economic Analysis Assumptions

A. General Assumptions

1. It was assumed that Highway 20 access would be kept open to provide access to the Camp roads. These costs are not included in this feature and are analyzed separately in Feature 21: Highway 20 from the City of Devils Lake Levee to Highway 57.

2. Camp Grafton is valued at approximately $35 million, not including land. These capitalized costs were provided by Captain Clark Johnson, Civil Engineer, Camp Grafton.

3. It was assumed that during high water conditions, the main gate (Gate #6 with access from Highway 20) would be the only access route that would be maintained and raised (based on conversations with Captain Clark Johnson).

4. It was assumed that the Camp would not close, even if the lake reaches its maximum level. A significant portion of the land area and all of the structures are above elevation 1463. Camp Grafton South (30 miles south) would be unaffected and could be used for maneuvers and activities that require a larger area.

5. It was assumed that the sewer system would be fully converted to the Ramsey County Rural Sewer system before lagoons were inundated (State Flood Coordination Center, Staff meeting, November 18, 1997).

6. There are currently no open culverts located under Highway 20 near Camp Grafton, and the area west of Highway 20 has been kept dry in recent years with pumping. It was assumed that culverts would be installed under Highway 20 to relieve pressure, resulting in flooding of the low areas west of Highway 20. It was assumed this would occur in the near future and, thereafter, all lands west of Highway 20 would be inundated by lake levels higher than the elevations of those lands.

B. Levees and Roads

1. A flood protection levee has been constructed along Avenue A, with top elevation of 1460. It was assumed that this levee would be raised to provide protection above this elevation if necessary (conversation with Captain Clark Johnson, Civil Engineer, Camp Grafton, and copies of levee plans provided by Camp staff).

C. Structures

1. It was assumed that the munitions storage area buildings would be relocated (based on conversations and correspondence with Captain Clark Johnson, Civil Engineer, Camp Grafton). Estimated cost for these relocations is $1.499 million (estimate provided by LTC Tabor).

2. The assumed damages for the munitions storage area buildings were developed from the replacement estimate provided by camp staff (LTC Tabor, provided via fax; estimate dated 20 Feb 2002). The replacement facility includes expansion from the existing munitions storage facility size. The estimated value of existing buildings was therefore developed by adjusting the estimated replacement cost for buildings and site work ($1,386k), and reducing this by 30 percent to reflect the amount of expansion space planned for the replacement facility.

3. Other buildings on the Camp facility were assumed to remain in place, because most buildings are above elevation 1464 (based on conversations with Lieutenant Colonel Gary Doll, Camp Grafton).

4. Building values were based on the capitalized cost, which was computed as the original cost plus improvements. This is probably a low estimate, as some buildings were constructed in the 1940s and the replacement value would be much higher (based on conversations with Captain Clark Johnson, Civil Engineer, Camp Grafton).

5. The land value for Camp Grafton is estimated to be $400/acre. This value was provided by the Corps of Engineers (personal communication, April, 2001) and is an estimate of the average value of all land surrounding Devils Lake.

4.7 Summary of Infrastructure Protection Investigation for Feature 7: Grahams Island State Park

4.7.0 Flood Protection Strategy

The incremental flood protection that was analyzed for Grahams Island State Park (Grahams Island) was incremental raises of the access road.

4.7.1 General Information

Feature Type: State Facility

Location: Grahams Island State Park is located 10 miles west of the City of Devils Lake, 5 miles south of ND Highway 19 along the border between Benson and Ramsey counties. The accompanying Figure 4.7-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: Grahams Island State Park is the largest and most developed state park facility on Devils Lake, with campground, beach, harbor, ranger and manager facilities, activity center, and trails. The campground covers 1,100 acres, and has space for 100 campers, as well as 4 sleeping cabins. The park has potable water and sewer lines, with an on-site treatment facility.

In addition to the State Park facility, there are several farmsteads located on Grahams Island that would be stranded if access to the island were lost. The Infrastructure Protection Study evaluation included these farmsteads in the damage assessment of the Grahams Island feature.

Significance: Grahams Island is important because it is considered a major tourist attraction in the area. It is the largest and most used state park facility around Devils Lake. Park staff estimate that a total of 72,800 visitors used the park in 1995. Access to the park is affected by rising water levels; the Park was closed in 1997 when the access road was under water. During 1997, approximately $2.2 million was invested in raising the access road to the park. In 1999, the Park had 73,770 visitors.

Damages: The flooding of Grahams Island would result in the following damages:

- Loss to utility infrastructure
- Loss of residential buildings
- Loss of recreational buildings and facilities
- Loss of facility access
- Loss of user fees

- Loss of usable land
- Loss of farmstead and farm operations buildings

Owner/Sponsor: The North Dakota Parks and Recreation Department, is responsible for operating and maintaining the Grahams Island State Park.

Lead Federal Agency: The State of North Dakota would take the lead for Feature 7 for any flood protection work that may take place.

4.7.2 Feature Protection

History of Flood Protection: In the past, flood protection for Grahams Island has consisted of raising the access road from ND Highway 19 to the park and relocating buildings and other facilities to higher ground.

General Protection Strategy: The Infrastructure Protection Study analysis re-evaluated the Economic Analysis Alternatives approach, and also considered an additional option not considered in the previous effort. Strategies considered in this 2002 evaluation included:

- Relocation of buildings
- Relocation / replacement of comfort station and lift station
- Relocation / replacement of a picnic area
- Road raise on access road from ND Highway 19

The other option considered included developing an alternate access road to the south of Grahams Island across Ziebach Pass. However, the costs of this option were far greater than raising the existing access from Highway 19, and were therefore not considered further.

Protection Strategy by Action Level: Figure 4.7-2 shows the decision tree for Grahams Island. As shown on Figure 4.7-2, the stepwise approach to flood protection for Grahams Island consists of the following:

1. At Action Level 1 (AL1), a decision would be made as to whether the access road would be raised to 1456.3 or whether the road would be temporarily abandoned.
2. If the access road was raised at AL1, a decision would be made at Action Level 2 (AL2) whether to raise the access road to 1461.3 and relocate structures between 1451 and 1456.3, or to temporarily close the access road and relocate all structures above 1451.

3. If the access road was raised at AL2, a decision would be made at Action Level 3 (AL3) whether to raise the access road to 1465 and relocate structures above 1456.3, or to temporarily close the access road and relocate all structures above 1456.3.

The pertinent reference elevations for implementing each increment of flood protection strategy are given below:

Reference Elevations for Feature 7 Road Raises				
Elevation				
AL1	**AL2**	**AL3**	**Name**	**Significance**
1451.3	1456.3	1461.3	Low Structure Elevation	Low point on top of road surface
Current	1451.3	1456.3	Lake Damage Elevation	Lake elevation at which road becomes unusable due to wave action[1] (a 5-foot wave runup was calculated for this feature)
Current	N/A	N/A	Project Completion Elevation	Lake elevation at which levee construction must be complete
Current	1453.3	1458.3	Construction Initiation Elevation	Lake elevation at which road raise construction must begin. (The current trigger for release of emergency highway funds for road raises is when the lake level reaches within 3 feet of the minimum road surface.)
Current	1450	1456	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

The low structure foundation on Grahams Island is 1451. If the access road is not raised the entire island would be severed and lose access, and all structures and land would be considered damaged.

Reference Elevations for Feature 7 Structure Relocations				
Elevation				
AL1	**AL2**	**AL3**	**Name**	**Significance**
Current	1451.3	1456.3	Low Structure Elevation	Ground at lowest structure in the group
Current	1451.3	1456.3	Lake Damage Elevation	Lake elevation at which damage to lowest structure begins or loss of access

[1] Although damages to this feature were computed to begin 5 feet below the top of road, it was assumed that temporary emergency measures would be implemented to protect the road until the lake reaches the 3-foot trigger that is currently used by the ND DOT. The damage elevations listed in this table reflect the 5-foot damage elevation.

Reference Elevations for Feature 7 Structure Relocations				
Elevation				
AL1	AL2	AL3	Name	Significance
NA	1451.3	1456.3	Project Completion Elevation	Lake elevation at which structure relocation must be complete
NA	NA	NA	Construction Initiation Elevation	Lake elevation at which structure relocation must begin
NA	NA	NA	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

4.7.3 Design Considerations

Sections 4.7.3.0 through 4.7.3.10 describe the analysis of the design of flood protection measures, as well as other considerations (geotechnical, environmental, etc.) necessary to make the cost estimates for the first action level. Section 4.7.3.11 describes the abbreviated cost estimating method for subsequent action levels.

4.7.3.0 General Design

The maximum wind-induced wave height along this feature based on fetch, depth of water, and the side slope was calculated to be approximately 5 feet above lake elevation. This wave height is used to compute the lake elevation at which damage will occur to the roadway due to wave action. However, for this feature, the damage elevation was set to 3 feet above the lake elevation to correspond with current ND DOT policy regarding road raises. Temporary emergency measures (such as placing a riprap berm on the lake side) can be taken to minimize disruption to the road during this period.

Alignment

Figure 4.7-1 shows the alignment of the existing Grahams Island access road. The current low road subgrade elevation of 1450.5 (top at 1451.3) does not provide adequate protection for design wave run-up. This first action would raise the access road 5 feet to a subgrade elevation of 1455.5 (top at 1456.3), providing protection to lake level of 1453.3. The raised roadway will follow the same alignment. The length of the raised section is approximately 1,650 feet. Figure 4.7-4 shows the existing road profile and the raised road profile.

Cross-Section

Figure 4.7-3 shows a typical cross-section of the proposed road raise. The raise will be accomplished by filling on the west side of the existing roadway to minimize fill placement in water. This section is based on the typical section constructed during the

1997 road raise, when the access road was raised to provide a minimum road subgrade at 1450.5. The road top width was assumed to be 30 feet with a 28-foot asphalt surface and paved shoulders. The side slopes are 4H:1V on both sides of the road. The minimum raised road subgrade elevation is assumed to be 1455.5, a 5-foot raise from the current minimum elevation. It was assumed that unsuitable fill foundation material, averaging 1 foot in depth, would be stripped along the west side roadway toe prior to placement of road fill.

Materials

It was assumed that the roadway fill would be constructed from readily available native silty clay and clay loam. These materials are suitable for road embankment construction. The top 6 inches of the roadway section will be constructed of commercially available aggregate surface course material.

Erosion Protection

On the east slope, riprap was assumed to be placed over geotextile (no additional bedding material) from the existing top edge of riprap all the way to the roadway crest. On the west slope, riprap was assumed to be placed from 1 foot below the water surface up to the raised road crest, equaling a total slope length of 31 feet. No topsoil or seeding was assumed for the raised roadbed. 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 design, based on the fetch, depth of water, and the side slope, is summarized in the table below.

Location	Wind-Induced Height (ft.)	Additional Freeboard (ft.)	Riprap size (D_{50})	Riprap Thickness (ft.)
West Side	5.2	0.0	12”	2.0
East Side	5.1	0.0	Use same as west side	

4.7.3.1 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.

This highway alignment is underlain by (1) boulder clay till in a low-relief stagnation moraine and (2) silt and clay facies representing lake bed deposits. All of these deposits are in the Coleharbor Formation. The 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 glacial deposits range from about 60 to 120 feet in thickness. It is likely that some sand and gravel outwash units are present at depth. The bedrock is Cretaceous Pierre Shale.

The impacted section of highway crosses the following:

- Lake bed deposits from prehistoric Lake Minnewaukan. These typically soft, silty clays (CL, CL-ML, CH, OL, ML) underlie over 50 percent of the alignment. These are likely thickest in the deepest portion of the basin (Station 12500 to 16500). In places, these may include saline soil, highly organic soil, fat clays, and/or marls (very soft calcium carbonate mud).
- Glacial till (CL, CL-ML) as described above.
- Sand beach deposits consisting of fine to coarse sand (SP, SP-SM) which may be over 5 feet thick (example between station 16600 and 18500). These may be related to outcrops of outwash in the area.

Geotechnical concerns are primarily related to the soft lake bed soils, which may also experience moderate to severe frost action.

It is assumed 12 soil borings will be sufficient to characterize this alignment. The impacted alignment crosses approximately 18,000 feet of lake bed deposits, which may be inadequate subgrade.

4.7.3.2 Hydrology/Interior Drainage Issues

It is assumed that culverts will be placed through the raised roadway embankment to allow for water level equalization on both sides of the roadway. It is assumed that existing culverts through the roadway will be filled and abandoned in place.

4.7.3.3 Real Estate Requirements

Right-of-way requirements for the road raise are assumed to extend 15 feet beyond the west side toe of the raised embankment. The 15-foot buffer will provide sufficient room for temporary construction activities and long-term maintenance access.

4.7.3.4 Environmental/Cultural issues

HTRW

Current land uses surrounding the levees associated with Grahams Island State Park appear to be mostly forested and agricultural land with scattered rural residences. Land use does not appear to have changed significantly over time.

Regulatory record review for zip code 58301 and 58357 were obtained from FirstSearch on October 15, 2002. No facilities were listed as being located in or adjacent to Grahams Island State Park.

Three potential HTRW sites identified within the levee action levels are listed below and shown on Figure 4.7-1:

HTRW Site Costs			
Site #	**Action Level Affected**	**HTRW Category**	**HTRW Costs**
07-1-1	1	Nonresidential Properties	$500
07-1-2	1	Cylindrical Structures	$9,000
07-1-3	1	Rural Residences & Farmsteads	$500

A more detailed description of site history and a breakdown of costs are in Appendix C. A description of environmental concerns associated with these categories is in Section 4.0.

Five relocations are expected for the feature. These include two barns, a garage, a sanitary lift station, and a comfort station.

Relocation HTRW Costs			
Number	**Type of Items Relocated**	**HTRW Category**	**HTRW Costs**
2	Barns	Rural Residences & Farmsteads	Covered under a separate relocation cost estimate.
1	Garage	Rural Residences & Farmsteads	
1	Sanitary List Station	Nonresidential Properties	$10,000
1	Comfort Station	Nonresidential Properties	

Cultural

This project has the potential to impact three known sites and one site lead as shown on Figure 4.7-1. Recommendations of eligibility for listing on the NRHP have not been made for any of the known sites, which include 32BE0025, a prehistoric archaeological

site, presumably an artifact scatter, given that surface collection and subsurface testing were performed there; 32BE0053, a historical archaeological site, the historical context of which is listed as "Farming" in the 1997 database; and Hulst Cabin Site (32BE0420), a site that is listed as architectural in the 1997 database, but at which surface collection was conducted.

The site lead that may fall within the Grahams Island State Park APE is 32BEX0038a (LaRose Post Office). It is listed in the 1997 database as historical archaeological.

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

Feature 7 Grahams Island State Park: 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	0	0
Archaeological	0	0	3
Architectural Site Leads/Isolated Finds	0	0	0
Archaeological Site Leads/Isolated Finds	0	0	1
Total	0	0	4

The estimated cost to conduct Phase 1 Surveys for each of the 4 sites is presented in the following table.

Grahams Island State Park: Known Cultural Resources—Estimated Costs		
Site Number	**Investigation Type**	**Estimated Cost**
32BE0420	Phase I Architectural	$6,200
32BE0025	Phase I Archaeological	$8,000
32BE0053	Phase I Archaeological	$8,000
32BEX0038a	Phase I Archaeological	$14,000

In addition to the access road raise to the park, this feature also requires relocation of a sanitary lift station and comfort station, and relocation of a garage and two barns. One barn located on the southern end of the island is a large well-maintained, classic style curved roof structure over 50 years old. Barns of this style and condition are rapidly disappearing from the rural landscape due to the decline of the family farm tradition. It is likely eligible for the National Register of Historic Places and will require a Phase 1

survey and Phase II site evaluation prior to relocation. The cost of this survey is estimated to be $6,200. The total cost for all surveys for this feature is $42,400. As noted in Section 4.0, these costs are believed representative of the cultural resources investigations needed for the next stage of study.

Environmental

The natural resources within the road corridor of Grahams Island State Park include wetlands, oak forest/woodlands, and grasslands. Fill used for the construction of the road raise and relocation 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 4.7-1. A total of 1.58 acres of wetland impacts are expected from the proposed infrastructure protection measures. 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 would impact waterfowl, marsh bird and songbird-nesting areas, as well bring about impacts to reptile and amphibian populations due to habitat fragmentation. This loss of wetland would require 3.16 acres of mitigation wetlands as set forth in the project mitigation policy developed through consultation with the Corps and FWS. 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 re-vegetation of fill or borrow locations may allow for the introduction of weedy, non-native species. These environmental impacts are more fully detailed in the general impacts discussion section 4.0. 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. A total of 5.98 acres oak forest/oak woodland and 34.81 acres grassland impacts would be expected from the proposed infrastructure protection measures 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 69.62 acres of like upland grassland habitat areas and 11.96 acres of like woodland habitat areas for these impacts.

4.7.3.5 Effects on Existing Infrastructure & Utilities

Replacement of local driveway access to adjacent properties was not considered as a separate cost item, but is considered incidental to the other construction items. With the

exception of drainage culverts discussed above, no other infrastructure or utilities are expected to be impacted.

4.7.3.6 Interdependencies

Access to Grahams Island is not directly interdependent with other features, although the Island is dependent on these other features (roads for access, communities for normal daily activities, hospitals, etc). The primary roadways that are critical for Grahams Island include:

- Feature 13: US Highway 2 – US Highway 2 provides a major transportation route into and out of the region for park visitors.
- Feature 16: US Highway 281 (South of US Highway 2) – US Highway 281 provides a major transportation route into and out of the region for park visitors.
- Feature 18: ND Highway 19 – Access to Grahams Island is from the north on ND Highway 19. Without continuing road raises along ND Highway 19, there is no access to Grahams Island.

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

4.7.3.7 O&M

Operation and maintenance requirements for the raised roadway would be similar to the unimpacted roadway with respect to road surface maintenance and shoulder and slope mowing. Additional maintenance requirements for the raised roadway sections would include maintenance of the riprap on both the east and west sides. Annual maintenance costs for the riprap have been estimated at 0.5 percent of the initial construction cost. The O&M costs were not included in the economic analysis due to limitations of the Feature Analysis Model.

4.7.3.8 Lead Time Required

The raising of the Grahams Island access road could be completed in one construction season. A lead time of about twelve months would be necessary for final design, preparation of construction documents and bidding. Total time between initiation of final design and substantial completion of construction would be in the range of 18 to 24 months.

4.7.3.9 Potential Problems and Risks

The potential problems and risks associated with the road raise include:

- Road embankment fill into water will make compaction and quality control difficult
- Foundation conditions will be difficult to assess prior to actual construction
- Adjacent utilities may need to be relocated

4.7.3.10 Data Deficiencies

The following data should be collected or verified prior to proceeding with raising the access road:

- Locations of buried utilities, if any
- Soil borings along toe of existing road embankment
- Precise location and evaluation of nearby cultural resources

4.7.3.11 Abbreviated Cost Estimating for Feature Subsequent Action Levels

As was mentioned previously, for Feature 7, 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 are presented in Table 4.7-2b. Estimates of benefits—damages prevented—for subsequent action levels were made in the same manner as for the first action level. The damage estimates for all action levels are shown in Table 4.7-1.

The same general approach to calculate costs was used for the subsequent action levels. Unit prices were not changed. However, some of the cost items were simply extrapolated for the higher action levels, rather than being calculated in detail. The relevant design and cost assumptions for the abbreviated method are listed below.

Design Assumptions

The costs associated with infrastructure protection at the second and third action levels at Grahams Island are associated with raising the access road to provide continued access to the park.

- Raise elevations

  Action Level 2: 5-foot raise to 1461.3

  Action Level 3: 3.5-foot raise to 1465

- Cross-section

  Action Level 2: 30-foot top width, 4H: 1V side slopes, centerline-offset raise

  Action Level 3: 30-foot top width, 4H: 1V side slopes, centerline-offset raise

- Length

  Action Level 2: Total length of raised roadway- 23,350 feet

  Action Level 3: Total length of raised roadway- 23,950 feet

- Impacted Area

  Action Level 2: Incremental area impacted by raised roadway- 20.0 acres

  Action Level 3: Incremental area impacted by raised roadway- 16.3 acres

Construction material quantities were calculated in accordance with design assumptions discussed previously, and are listed in Table 4.7-2b. The geological/geotechnical and environmental quantities and costs were estimated in proportion to the Action Level 1 costs as described in Section 3.2.13. Real Estate costs were assumed to be the same for each raise.

4.7.4 Economics of Flood Protection

Damages: For the Infrastructure Protection Study, the flood damage estimates for Grahams Island were reassessed to update and more accurately characterize the nature of the damages. The updated damage computations for Grahams Island are summarized in the accompanying Table 4.7-1.

Table 4.7-1 lists damages to buildings that would be inundated by rising waters. These damages are based on capitalized values of the buildings impacted, as provided by camp operations staff. Inundated land values are also listed, using a standard assessed value per acre. Damages for this feature also include lost revenue for the park facility and temporary closure of the access road.

Unit prices for all the damage computations were discussed previously in Section 2.0, and are detailed in Table 4.0-1. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Grahams Island are listed in the Feature 7 Assumptions listing, appended to this Section 4.7.

Costs: The updated costs of providing flood protection for Grahams Island are detailed in the accompanying Table 4.7-2a for the first action level and in Table 4.7-2b for the subsequent action levels. Unit prices, data sources, and relevant assumptions are listed.

Table 4.7-2a lists costs for the first raise of the access road to 1456.3 and the costs for relocation of structures up to elevation 1451.3.

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 Grahams Island are listed in the Feature 7 Assumptions listing, appended to this Section 4.7.

Contingencies: The contingency percentages used for construction materials ranged from 30 to 50% (Table 4.7-2). Contingencies for riprap, fill material, and geotechnical items were estimated at the higher end of the range because of the potential variability in the quantities and unit prices. Contingency percentages for relocations ranged from 30 to 100%.

4.7.5 Economic Results

The flood protection strategy that was analyzed was incremental road raises, which is highlighted on the decision tree (Figure 4.7-2). The results of the Infrastructure Protection Study for Grahams Island are listed in Table 4.1-3a for the analysis of all action levels and in Table 4.7-3b 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 Grahams Island, the Infrastructure Protection Study analysis provided relevant economic indices for raising the access road. The access road raises and relocation of structures strategy is highlighted on the decision tree (Figure 4.7-2). The annual net benefits for this approach were less than zero (-$66,400). The BCR for this approach was less than one (0.86). These results show that this strategy is not economically justified. The present worth annualized lost business damages that would be prevented by this strategy were computed to be $146,700. The stochastic results are averages over 10,000 traces.

The economic justification of this feature appears to be dependent on the duration of lost business damages in relation to the number of action levels and timing of the costs that are incurred.

Multiple Action Level Results for Specific Scenarios: Raising the access road was also analyzed under each of three specific climate futures. For Grahams Island, 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 raising the access road were -$414,400, and the BCR was 0.59, indicating that this strategy was not economically justified. For this future, the present worth annualized lost business damages that would be prevented were computed at $516,000. No restoration damages are listed under this scenario, indicating that the water level never recedes below the first action level.

- First Moderate Future – Under the first moderate future climate scenario, the annual net benefits of raising the access road were $18,600, and the BCR was 1.05, indicating that this strategy was not economically justified. For this future, the present worth annualized lost business damages that would be prevented were computed at $60,900.

- Second Moderate Future – Under the second moderate future climate scenario, the annual net benefits of raising the access road were $13,400, and the BCR was 1.02, indicating that this strategy was economically justified. For this future, the present worth annualized lost business damages that would be prevented were computed at $440,900.

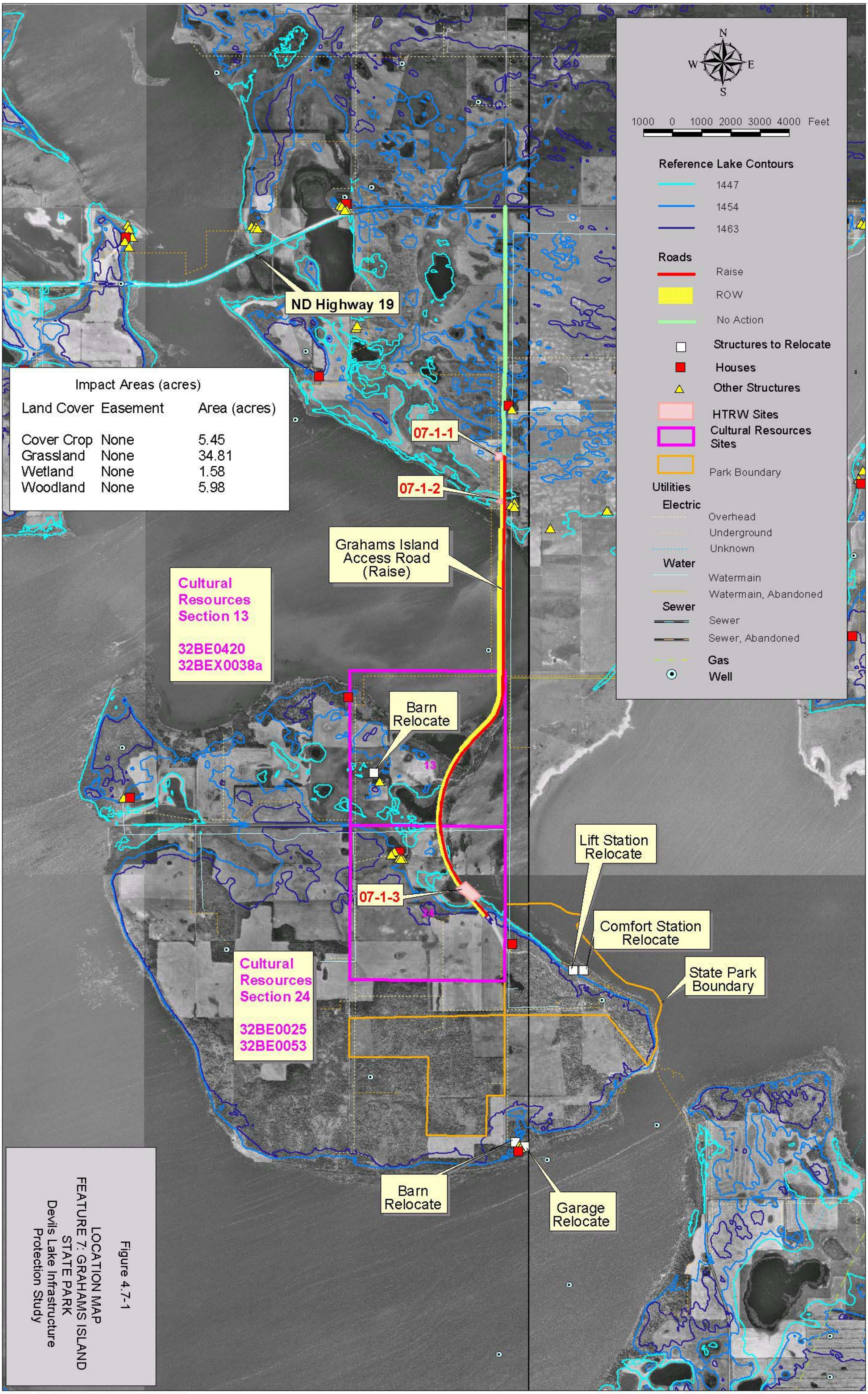
First Action Level Stochastic Analysis Results: Using the stochastic analysis along with the updated damage and cost estimates for Grahams Island, the Infrastructure Protection Study analysis also provided relevant economic indices for the first action level. The annual net benefits for this approach were less than zero (-$67,500). The BCR for this approach was less than one (0.80). These results show that this strategy is not economically justified. The present worth annualized lost business damages that would be prevented by this strategy were computed to be $146,700. The stochastic results are averages over 10,000 traces.

First Action Level Results for Specific Scenarios: The first raise of the access road was also analyzed under each of three specific climate futures. For Grahams Island, 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 raising the access road were $173,000, and the BCR was 1.50, indicating that this strategy was economically justified. For this future, the present worth annualized lost business damages that would be prevented were computed at $516,000. No restoration damages are listed under this scenario, indicating that the water level never recedes below the first action level.

- First Moderate Future – Under the first moderate future climate scenario, the annual net benefits of raising the access road were -$118,300, and the BCR was 0.66, indicating that this strategy was not economically justified. For this future, the present worth annualized lost business damages that would be prevented were computed at $60,900.

- Second Moderate Future – Under the second moderate future climate scenario, the annual net benefits of raising the access road were $97,900, and the BCR was 1.29, indicating that this strategy was economically justified. For this future, the present worth annualized lost business damages that would be prevented were computed at $440,900.



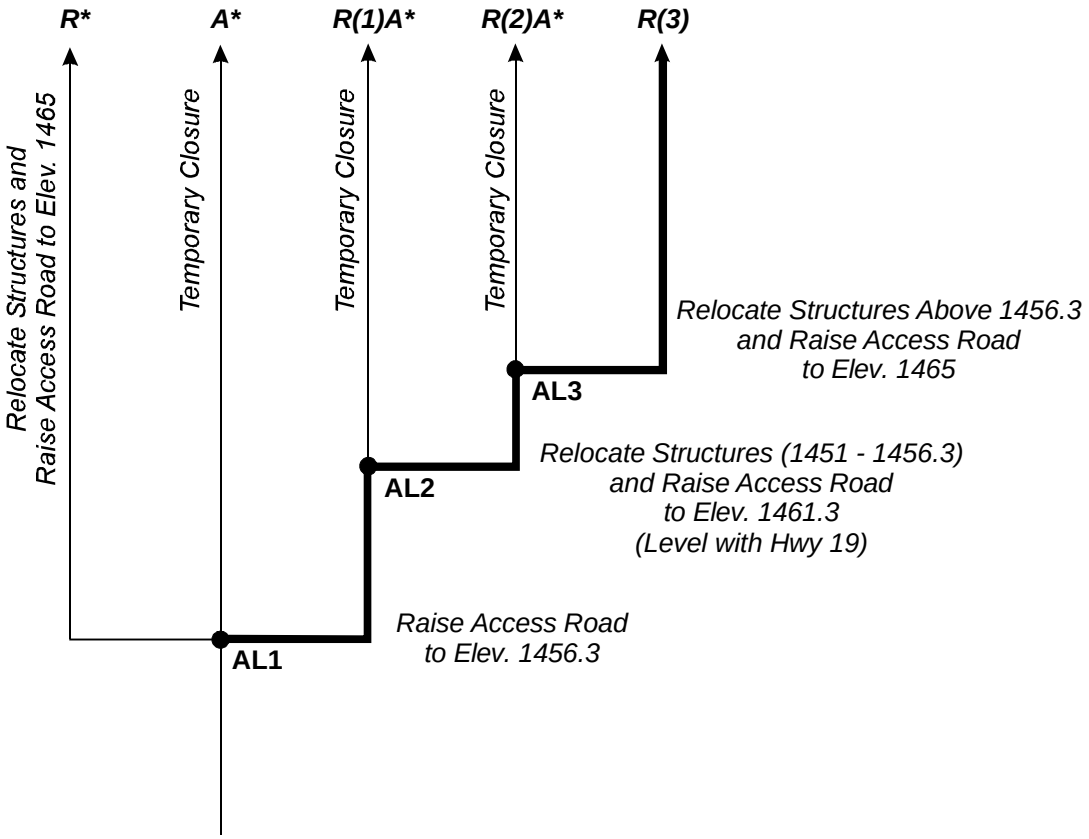
Impact Areas (acres)

Land Cover	Easement	Area (acres)
Cover Crop	None	5.45
Grassland	None	34.81
Wetland	None	1.58
Woodland	None	5.98

Figure 4.7-1
LOCATION MAP
FEATURE 7: GRAHAMS ISLAND
STATE PARK
Devils Lake Infrastructure
Protection Study

Barr: Arcview 3.3, P1V02, I:\Client\DevilsLake\Gis\DLIP\Features\StateRuralFeatures\07_GrahamsIsland\Project\basemap_07.apr, Layout: Layout: Section 4 Grahams Island, lkp, Tue Dec 31 11:42:43 2002

DATA: 1997 USGS Digital Ortho Quad



Lowest Access Road Elevation: 1451.3

P:\34\36\020\DECISIONTREES\2002FIGURES\FIGURE4_07.CDR RLG 01-06-03

━━━	Flood Protection Strategy
●	Decision required at this point
⊙	Trigger point for action, no decision needed
AL1	Decision/Action Level
A	Temporary closure of park
R(1)	Incremental road raise(number of times)
*****	In addition to road raises or temporary closure there are also structure relocations

Figure 4.7-2

DECISION TREE
FEATURE 7: GRAHAMS ISLAND STATE PARK
Devils Lake Infrastructure Protection Study

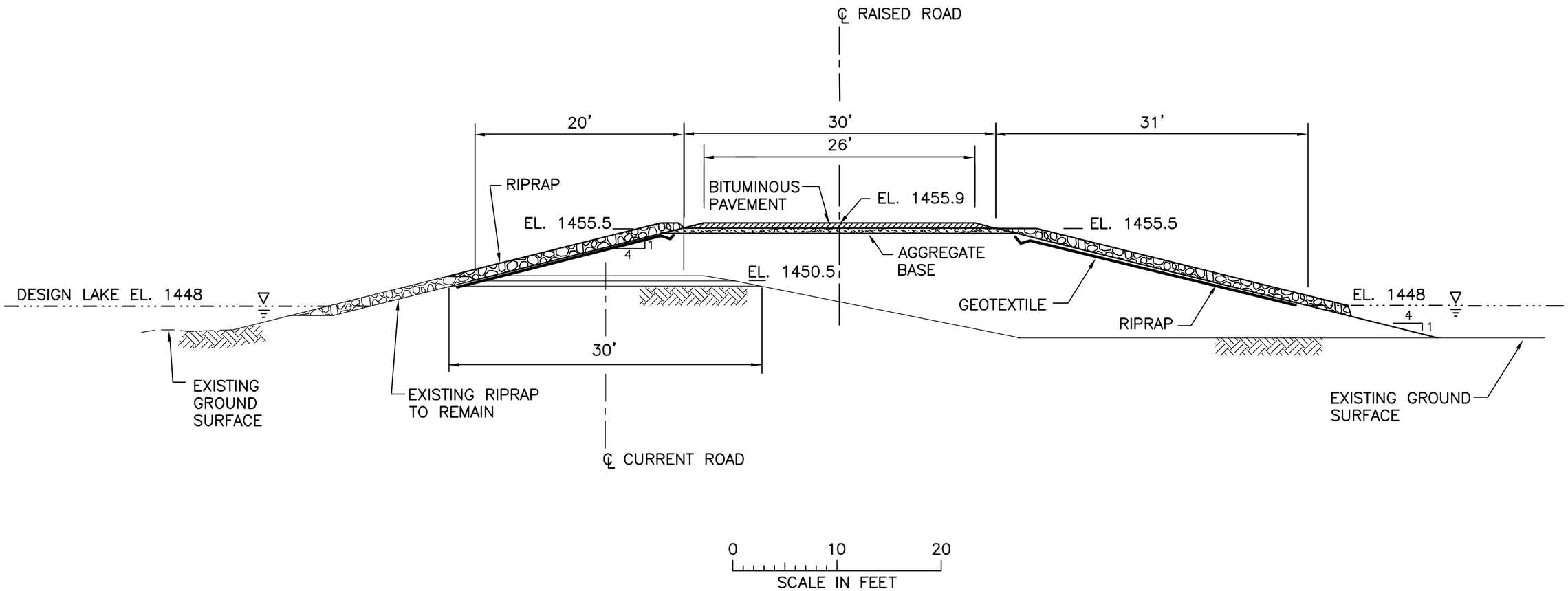


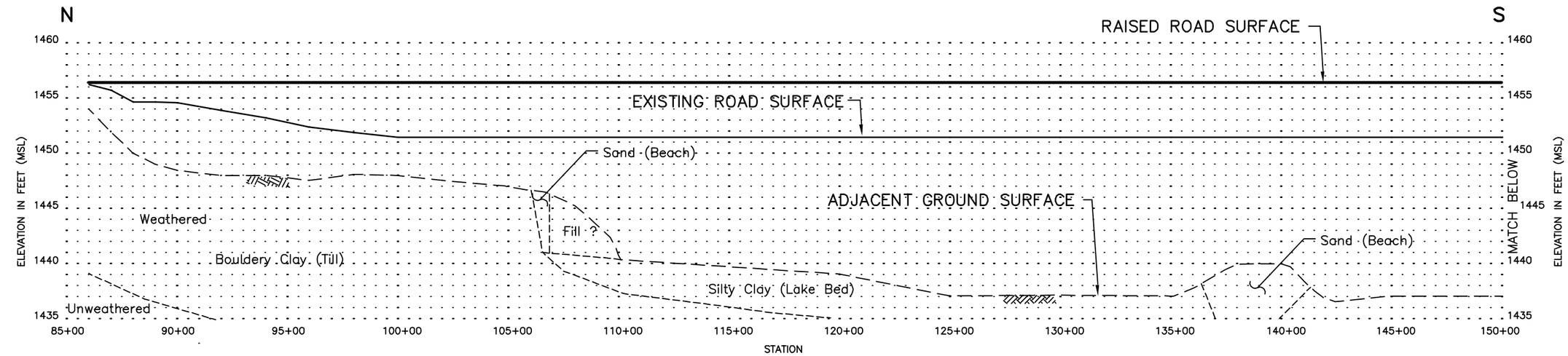
Figure 4.7–3

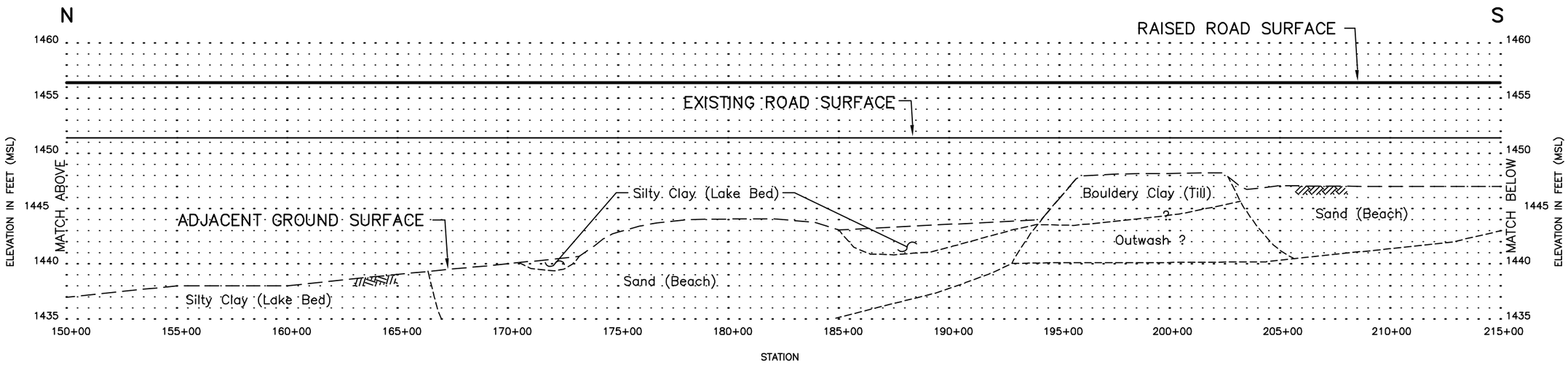
TYPICAL ROAD CROSS–SECTION

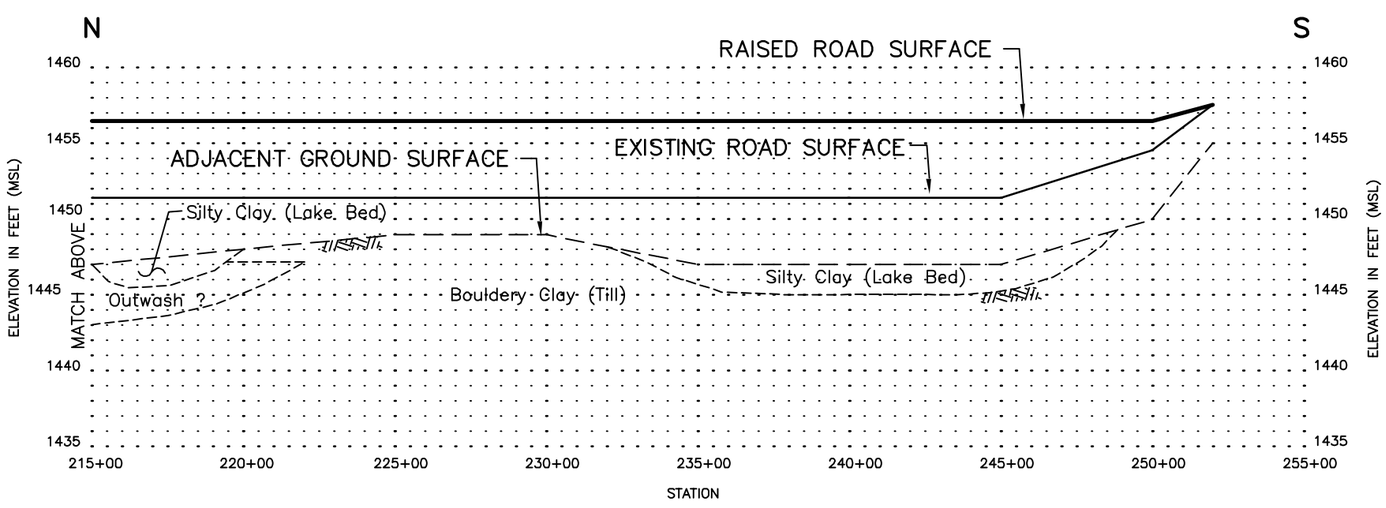
FEATURE 7:
GRAHAMS ISLAND STATE PARK

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

NRD M:\CAD\3436020\17276_1.DWG Plot at 10 11/06/2002 12:31:11







1. Adjacent ground elevation obtained from 2000 FEMA LIDAR topography.
2. Ground surfaces that are currently under water were obtained from an
3. outdated Grahams Island Topo Quad on Topozone.com
4. Existing road surface elevations from the following construction drawings:
   Benson/Ramsey County, ND Plans: Federal Aid Project CER-3607(56)
   Raised road surface elevations based on assumed incremental raise height.
5. Stationing assigned as part of this analysis with stationing increasing from north to south.

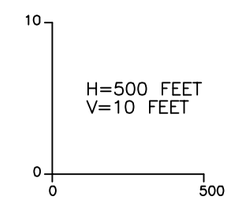


Figure 4.7-4

ROAD PROFILE

FEATURE 7:
GRAHAMS ISLAND STATE PARK

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

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Table 4.7-1

Flood Damages
Feature 7: Grahams Island State Park
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Structure Elevation Range (MSL)	Structures and Infrastructure (THOUSANDS)	Land (THOUSANDS)	Revenue (THOUSANDS)
AL1	Below 1451.3	$63	$468	$516
AL2	1451.3 - 1456.3	$489	$248	$516
AL3	Above 1456.3	$461	$988	$516

Lake Elevation (MSL)	Restoration Damages: Impacted Roadway Length (FEET)	Restoration Damages: Damage Value (THOUSANDS)
1449	15,252	$2,858
1450	15,669	$2,896
1451	16,225	$2,946
1452	16,392	$2,961
1453	16,560	$2,976
1454	16,600	$2,980
1455	17,950	$3,101
1456	19,300	$3,223
1457	20,650	$3,345
1458	22,000	$3,466
1459	23,350	$3,588
1460	23,450	$3,597
1461	23,550	$3,606
1462	23,650	$3,615
1463	23,750	$3,624
1464	23,850	$3,633
1465	23,950	$3,642

DAMAGE BREAKDOWN

Structural Damages

Structure Elevation (Below 1451.3)					Structure Elevation 1451.3 - 1456.3					Structure Elevation Above 1456.3				
Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	0	EA	$62,000	$0	Residence	2	EA	$62,000	$124	Residence	3	EA	$62,000	$186
Barn	0	EA	$72,000	$0	Barn	3	EA	$72,000	$216	Barn	0	EA	$72,000	$0
Shed	0	EA	$43,200	$0	Shed	2	EA	$43,200	$86	Shed	2	EA	$43,200	$86
Commercial/Industrial	1	EA	$63,000	$63	Commercial/Industrial	1	EA	$63,000	$63	Commercial/Industrial	3	EA	$63,000	$189
Total				**$63**	**Total**				**$489**	**Total**				**$461**

Land Damages

Lake Elevations (Below 1451.3)					Lake Elevations 1451.3 - 1456.3					Lake Elevations Above 1456.3				
Description	Quantity	Unit	Unit Cost	Value (THOUSANDS)	Description	Quantity	Unit	Unit Cost	Value (THOUSANDS)	Description	Quantity	Unit	Unit Cost	Value (THOUSANDS)
Land	1,170	AC	$400.00	$468	Land	620	AC	$400.00	$248	Land	2,470	AC	$400.00	$988
Total				**$468**	**Total**				**$248**	**Total**				**$988**

Revenue Damages

Lake Elevations (Above 1451.3)				
Description	Quantity	Unit	Unit Cost	Value (THOUSANDS)
Annual Revenue	1	LS	$516,000	$516
Total				**$516**

Restoration Damages

Item	Description	Quantity per LF of Road		Unit Cost	Contingency	Value per LF of Road
Excavation	Removal of existing bituminous (30'x4' - includes shoulder), existing aggregate (30'x0.5') and top 1.5' of existing road embankment fill	2.88	CY/LF	$3.50	30%	$13
Fill Material	Replace top 1.5' of roadway embankment	2.00	CY/LF	$5.00	30%	$13
Geotextile Fabric	Place geotextile beneath new aggregate base	3.78	SY/LF	$2.00	30%	$10
Aggregate Base Course	Replace 0.5' of subgrade	0.56	CY/LF	$20.00	30%	$15
Bituminous	Replace 0.3' of bituminous pavement	0.61	Tons/LF	$50.00	30%	$40
		Total				**$90**
Item	**Description**	**Quantity per LF of Road**		**Unit Cost**	**Contingency**	**Total Value for Road**
Riprap	Place riprap from road surface elevation to bottom of embankment replacemnt for lowest impacted roadway length	1.43	CY/LF	$40.00	30%	$1,134,171
Geotextile Fabric	For use under riprap restoration	8.8	SY/LF	$2.00	30%	$348,976
		Total				**$1,483,147**

Table 4.7-2a

Flood Protection Costs
Feature 7: Grahams Island State Park
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	A	R(1)
Action Level	Cost to Temporarily Close Access Roads and to Relocate all Structures	Cost to Incrementally Raise at AL1 and Incrementally Relocate Structures
	(THOUSANDS)	
AL1	$1,763	$5,668

COST BREAKDOWN

Strategy	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)
	A AT AL1					
Incremental Relocation	Residence	5	EA	$68,000	30%	$442
	Barn	3	EA	$72,000	100%	$432
	Shed	4	EA	$43,200	50%	$259
	Commercial/Industrial	5	EA	$63,000	100%	$630
	Total Relocation					**$1,763**
	R(1) AT AL1					
Road Raise	**Raise Road to Elevation 1456.3**					
	Residence	0	EA	$68,000	30%	$0
	Barn	0	EA	$72,000	100%	$0
	Shed	0	EA	$43,200	50%	$0
	Commercial/Industrial	1	EA	$63,000	100%	$126
	Performance/Payment Bond	1	JB	$29,703	10%	$33
	Clearing and Grubbing	0.0	AC	$3,000	30%	$0
	Stripping	23,000	CY	$1.50	30%	$45
	Geotextile Fabric	84,000	SY	$2.00	30%	$218
	Aggregate Base Course	9,000	CY	$20	30%	$234
	Fill Material	329,000	CY	$5.00	40%	$2,303
	Bedding	0	CY	$35	30%	$0
	Riprap	14,000	CY	$40	40%	$784
	Bituminous Pavement	10,000	TON	$50	30%	$650
	Culverts	140	LF	$50	30%	$9
	Topsoil	0	CY	$2.50	30%	$0
	Seed	0.0	AC	$1,000	30%	$0
	Geotechnical					
	Slurry Wall	0	SF	$6.00	50%	$0
	Borings	18	EA	$1,000	50%	$27
	Environmental Impacts					
	Mitigation	1	LS			$26
	HTRW	1	LS			$20
	Cultural Resources Investigation	1	LS			$42
		Subtotal				$4,517
	Engineering and Design			15%		$678
	Supervision and Administration			8%		$361
	Real Estate Acquisition for ROW	1	LS			$112
	Total Raise					**$5,668**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Road Maintenance	Pump O&M	Total Operation and Maintenance Cost
	(THOUSANDS)		
AL1	$21	$0	$21

Table 4.7-2b

Flood Protection Costs
Feature 7: Grahams Island State Park
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	R(2)	R(3)
Action Level	Cost to Incrementally Raise at AL2	Cost to Incrementally Raise at AL3
	(THOUSANDS)	
AL2	$9,507	$0
AL3	$0	$8,589

COST BREAKDOWN

Strategy	R(2) AT AL2						R(3) AT AL3					
	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)
Road Raise	**Raise Road to Elevation 1461.3**						**Raise Road to Elevation 1465**					
	Residence	2	EA	$68,000	30%	$177	Residence	3	EA	$68,000	30%	$265
	Barn	3	EA	$72,000	100%	$432	Barn	0	EA	$72,000	100%	$0
	Shed	2	EA	$43,200	50%	$130	Shed	2	EA	$43,200	50%	$130
	Commercial/Industrial	1	EA	$63,000	100%	$126	Commercial/Industrial	3	EA	$63,000	100%	$378
	Performance/Payment Bond	1	JB	$46,078	10%	$51	Performance/Payment Bond	1	JB	$41,764	10%	$46
	Clearing and Grubbing	20.0	AC	$3,000	30%	$78	Clearing and Grubbing	16.3	AC	$3,000	30%	$64
	Stripping	34,500	CY	$1.50	30%	$67	Stripping	26,500	CY	$1.50	30%	$52
	Geotextile Fabric	118,000	SY	$2.00	30%	$307	Geotextile Fabric	116,000	SY	$2.00	30%	$302
	Aggregate Base Course	12,500	CY	$20	30%	$325	Aggregate Base Course	13,500	CY	$20	30%	$351
	Fill Material	540,000	CY	$5.00	40%	$3,780	Fill Material	512,000	CY	$5.00	40%	$3,584
	Bedding	0	CY	$35	30%	$0	Bedding	0	CY	$35	30%	$0
	Riprap	20,500	CY	$40	40%	$1,148	Riprap	12,000	CY	$40	40%	$672
	Bituminous Pavement	13,500	TON	$50	30%	$878	Bituminous Pavement	14,500	TON	$50	30%	$943
	Culverts	0	LF	$50	30%	$0	Culverts	0	LF	$50	30%	$0
	Topsoil	0	CY	$2.50	30%	$0	Topsoil	0	CY	$2.50	30%	$0
	Seed	0.0	AC	$1,000	30%	$0	Seed	0.0	AC	$1,000	30%	$0
	Geotechnical						**Geotechnical**					
	Slurry Wall	0	SF	$6.00	50%	$0	Slurry Wall	0	SF	$6.00	50%	$0
	Borings	7	EA	$1,000	50%	$11	Borings	1	EA	$1,000	50%	$2
	Environmental Impacts						**Environmental Impacts**					
	Mitigation	1	LS			$38	Mitigation	1	LS			$31
	HTRW	1	LS			$30	HTRW	1	LS			$24
	Cultural Resources Investigation	1	LS			$62	Cultural Resources Investigation	1	LS			$50
		Subtotal				$7,638		Subtotal				$6,892
	Engineering and Design			15%		$1,146	Engineering and Design			15%		$1,034
	Supervision and Administration			8%		$611	Supervision and Administration			8%		$551
	Real Estate Acquisition for ROW	1	LS			$112	Real Estate Acquisition for ROW	1	LS			$112
	Total Raise					**$9,507**	**Total Raise**					**$8,589**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Road Maintenance	Pump O&M	Total Operation and Maintenance Cost
	(THOUSANDS)		
AL2	$33	$0	$33
AL3	$30	$0	$30

Table 4.7 - 3a

Economics Results: All Action Levels -- to Lake Level 1463
Feature 7: Grahams Island State Park
Devils Lake Infrastructure Protection Study

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

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Structure Relocation	Total	Restoration	Land and Structure	Lost Business	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(No Protection) - G(S)**	I = H - C	I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$134,000	$164,700	$146,700	$445,500	$0	$0	--
R(4)*	Relocation of Structure at First, Second, and Fifth Action Levels:4 Road Raises	$468,700	$7,600	$476,300	$0	$35,600	$0	$35,600	$409,900	-$66,400	0.86

Wet Future Scenario (WF-9)
(Annual)

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Structure Relocation	Total	Restoration	Land and Structure	Lost Business	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(No Protection) - G(S)**	I = H - C	I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$0	$165,300	$516,000	$681,200	$0	$0	--
R(4)*	Relocation of Structure at First, Second, and Fifth Action Levels:4 Road Raises	$1,012,400	$7,700	$1,020,100	$0	$75,500	$0	$75,500	$605,700	-$414,400	0.59

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

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Structure Relocation	Total	Restoration	Land and Structure	Lost Business	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(No Protection) - G(S)**	I = H - C	I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$163,800	$165,300	$60,900	$390,000	$0	$0	--
R(4)*	Relocation of Structure at First, Second, and Fifth Action Levels:4 Road Raises	$335,400	$7,700	$343,000	$0	$28,500	$0	$28,500	$361,600	$18,600	1.05

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

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Structure Relocation	Total	Restoration	Land and Structure	Lost Business	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(No Protection) - G(S)**	I = H - C	I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$37,800	$165,300	$440,900	$643,900	$0	$0	--
R(4)*	Relocation of Structure at First, Second, and Fifth Action Levels:4 Road Raises	$587,100	$7,700	$594,700	$0	$35,800	$0	$35,800	$608,000	$13,400	1.02

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.
* In addition to a road raise or temporary closure, there are also structure relocations.
**Total benefits are calculated as the total damages incurred for the "No Protection" strategy minus the total damages for the strategy implemented (G(S)).

Table 4.7 - 3b

Economics Results: First Action Level
Feature 7: Grahams Island State Park
Devils Lake Infrastructure Protection Study

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

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Structure Relocation	Total	Restoration	Land and Structure	Lost Business	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(No Protection) - G(S)**	I = H - C	I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$127,600	$32,200	$146,700	$306,600	$0	$0	--
R(1)	Incremental Road Raise at AL1	$334,200	$7,600	$341,800	$0	$32,200	$0	$32,200	$274,400	-$67,500	0.80

Wet Future Scenario (WF-9)
(Annual)

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Structure Relocation	Total	Restoration	Land and Structure	Lost Business	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(No Protection) - G(S)**	I = H - C	I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$0	$32,300	$516,000	$548,300	$0	$0	--
R(1)	Incremental Road Raise at AL1	$335,400	$7,700	$343,000	$0	$32,300	$0	$32,300	$516,000	$173,000	1.50

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

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Structure Relocation	Total	Restoration	Land and Structure	Lost Business	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(No Protection) - G(S)**	I = H - C	I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$163,800	$32,300	$60,900	$257,100	$0	$0	--
R(1)	Incremental Road Raise at AL1	$335,400	$7,700	$343,000	$0	$32,300	$0	$32,300	$224,800	-$118,300	0.66

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

Strategy		COST			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Structure Relocation	Total	Restoration	Land and Structure	Lost Business	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B	C = A + B	D	E	F	G = D + E + F	H = G(No Protection) - G(S)**	I = H - C	I = H / C
No Protection	Temporary Closure of Road During Floods, No Relocation of Structures	$0	$0	$0	$0	$32,300	$440,900	$473,200	$0	$0	--
R(1)	Incremental Road Raise at AL1	$335,400	$7,700	$343,000	$0	$32,300	$0	$32,300	$440,900	$97,900	1.29

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.
* In addition to a road raise or temporary closure, there are also structure relocations.
** Total benefits are calculated as the total damages incurred for "No Protection strategy" minus the total damages for the strategy implemented (G(S)).

Attachment to 4.7:
Grahams Island State Park Economic Analysis Assumptions

A. General Assumptions

1. Access to Grahams Island State Park is dependent on Highway 19 remaining open. It was assumed that Highway 19 access would be kept open to provide access to the park road. The costs for Highway 19 are not included in this feature and are analyzed separately in Feature 18: Highway 19 from the City of Devils Lake Levee to Highway 281. Costs for the park access road from Highway 19 to the park were included in the costs of protection for this feature.

2. Grahams Island is defined as the entire island area, including farm, resident, and land area located outside of the state park boundaries.

B. Roads

- **Existing Road Information**

    1. Existing road elevations for the feature were obtained through contact with Wold Engineering in Bottineau, ND, primarily Donald Indvik.

    2. Existing road cross-section for the feature were based on construction drawing typical sections obtained from BIA/ND DOT/or their consultants including: Benson/Ramsey County North Dakota Plans for Federal Aid Project CER-3607(56) Inslope Repair and Inslope Protection (Wold Engineering).

    3. Existing road centerline profiles for the features evaluated were obtained from the plans listed above. Plan elevation data was assessed for reasonableness by comparing to the 2000 FEMA LIDAR topography. Where necessary road plan elevation information was supplemented with the LIDAR information.

- **Road Raise Information**

    1. For the incremental road raise strategies, it was assumed that the access road would be raised when the lake level is within 1 foot of the low road elevation.

    2. It was assumed that the offset centerline raise method would be implemented on the next raise, and therefore is the basis of the raised road cross-section. Pavement and subgrade design was based on the existing drawings mentioned above.

    3. No topsoil or seeding was assumed for the road raise because of the width of the road shoulder and the height of riprap placement.

4. It was assumed that two culverts would be placed in two individual low areas in need of flow equalization. It was assumed that any existing culverts were left in place, and that the two new culverts would be located at an elevation equal to the existing road surface elevation.

5. For the incremental road raise strategies, it was assumed that county roads being used as park access would be raised to the same elevation as Highway 19, starting with the first raise at elevation 1449.5 (1 foot below the existing road elevation).

6. The estimated maximum road elevation was elevation 1468, based on a 5-foot freeboard above the maximum lake level of 1463.

7. Road raises within the park boundary were not included because roads within the park are, for the most part, above elevation 1468.

- **Road Restoration/Detours**

1. If the selected strategy is temporary closure during flooding, restoration costs for the access road were included when the lake drops 1 foot below the lowest point on the access road.

2. If the county access road is not raised and access to the park is temporarily lost, the value lost was assumed to equal the unit day value of time lost. The unit day value of time lost was computed as $7 per day (Corps of Engineers, personal communication, March, 2001) times the average annual number of park visitors. In 1999 the park had 73,770 visitors, which is representative of a typical year (based on conversations with Dick Horner, Park Superintendent). This number was used to compute the unit day value of time lost, for a total of $516,000 per year.

3. Restoration damages were calculated assuming that that the bituminous surfacing, shoulder and aggregate subgrade would be removed along with an additional 1.5 feet of embankment material. Those materials would then be replaced in kind over a geotextile.

C. Geotechnical Assumptions

1. The scope and cost of geotechnical mitigation are related to three issues: (1) number of borings and soil tests, (2) soft soils that may require excavation and/or additional construction material, and (3) sand deposits which may require excavation or other mitigation such as cut-off walls if such occurs in the alignments of levees.

2. While the county soil surveys have similar descriptions of the subgrade characteristics of glacial till and lake bed deposits (Severe: low strength), experience in the Devils Lake area has indicated that most till deposits are better subgrade than lake. The potential thickness of soft-soil deposits

has been estimated based on descriptions of the lake bed deposits in the geologic and soils reports.

3. The potential extents of sand deposits have been estimated based on descriptions in the soils reports. It is likely that in some locations, the surficial sand deposits, typically assumed herein to beach deposits, may be continuous with subsurface sand and gravel deposits (glacial outwash). As such, some of the sand deposits may be of much greater extent vertically and laterally (buried) than has been assumed herein.

4. It is assumed that a soil boring will be completed approximately every 1,000 feet. Additional borings will be completed in areas of critical soils. Each soil boring and associated observation and testing will cost $2,000.

5. In instances where construction may be completed in the wet, it is assumed that soft soil will not be excavated, but instead may be displaced by new fill. In those instances, additional fill contingency is added based on the percentage of the feature alignment that is underlain by potentially soft soil – for 50 percent of the alignment, the contingency is increased by 10 percent, and thereafter the amount is pro-rated.

6. The alignment subgrades of these features are based on:

   - Carlson, C.G. and T.F. Freers, 1975. Geology of Benson and Pierce Counties, North Dakota. North Dakota Geological Survey, Bulletin 59 – Part 1 (also North Dakota State Water Commission County Groundwater Studies 18 – Part 1)

   - Randich, P.G., 1971. Groundwater Basic Data of Benson and Pierce Counties, North Dakota. North Dakota Geological Survey Bulletin 59 – Part II (also North Dakota State Water Commission County Groundwater Studies 18 – Part II)

   - Randich, P.G., 1977. Groundwater Resources of Benson and Pierce Counties, North Dakota. North Dakota Geological Survey Bulletin 59 – Part III (also North Dakota State Water Commission County Groundwater Studies 18 – Part III)

   - USDA Soil Conservation Service, 1977, Soil Survey of Benson County Area, North Dakota

   - Downey, J.S., 1973. Groundwater Resources. Nelson and Walsh Counties, North Dakota. North Dakota Geological Survey Bulletin 57 – Part III (also North Dakota State Water Commission County Groundwater Studies 17 – Part III)

   - Hutchinson, R.D., 1977. Groundwater Basic Data for Ramsey County, North Dakota. North Dakota Geological Survey Bulletin 71 – Part II (also North Dakota State Water Commission County Groundwater Studies 26 – Part II)

- Hutchinson, R.D. and Robert L. Klausing, 1980. Groundwater Resources of Ramsey County, North Dakota. North Dakota Geological Survey Bulletin 71 – Part III (also North Dakota State Water Commission County Groundwater Studies 26 – Part III)

- USDA Soil Conservation Service, 1986, Soil Survey of Ramsey County, North Dakota. Hardcopy and electronically from http://nasis.nrcs.usda.gov/

D. Structures

1. If the county access road is inundated and access to the island is lost, all land and structures located on Grahams Island are considered impacted.

2. It was assumed that if access was maintained to the island, structures on the island that would be affected by the lake would be moved to high ground (above elevation 1464.) Structures were assumed to be moved when the lake level was within 1 foot of the structure.

3. The estimated value of State Park structures was full replacement value, since all structures have been built since 1989 (based on conversations with Dick Horner, Park Superintendent).

4. The estimated value for houses outside the State Park on Grahams Island was $88,000. This figure was obtained from the Federal Emergency Management Agency (FEMA). This average value was determined based on valuation of 1,219 houses in the area. 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. These values did not include the value of land on which the houses were located. FEMA has been using these average values for planning purposes only (*FEMA*, March, 2001). The number of houses and their elevations was developed from the FEMA database.

5. The FEMA database did not provide an adequate data set of values for barns, sheds, or silos. The FEMA database did include estimated values for three barn structures, ranging from $100,000 to $200,000. Limited market research resulted in estimated costs for pre-fabricated metal structures at between $10 and $30 per square foot. At $30 per square foot, a 30-foot by 80-foot pole barn would result in $72,000 value. This was used as the assumed value for a barn. Sheds were assumed to be 24 feet by 60 feet, resulting in an assumed value of $43,200. Values for silos were developed by using data provided by the North Dakota State Water Commission (Michael Hove, 10/11/2002 phone call and follow-up data). While not comprehensive, this data provided a reasonable data set for silos included in the FEMA inventory, matched a subset of these with field observation, and placed values to each of these structures based on field dimensions and estimated structure cost per bushel storage. This analysis resulted in an average value of $20,453, and was used as the estimated average value for silos. Based on the uncertainty in the database

counts for these structures, and the unit prices assumed, the contingency for these structures was assumed to be 100 percent.

6. If the park was temporarily closed because of lack of access, buildings at elevations greater than the maximum lake level were assumed to be unaffected. The buildings are primarily used by park staff, and could be temporarily closed while access is unavailable.

7. The land value for Grahams Island State Park is estimated to be $400/acre. This value was provided by the Corps of Engineers (personal communication, April, 2001) and is an estimate of the average value of all land surrounding Devils Lake.

8. Structure relocation costs were estimated to be 75% of the structure value for residential and farm structures (including garages, barns, etc.) and 100% for commercial structures (lift stations, comfort stations, etc.).

9. If the park was temporarily closed because of lack of access, damages to land and structures were assumed to occur as they are affected by the rising lake level.

4.8 Summary of Infrastructure Protection Investigation for Feature 8: Rural Areas

4.8.0 Flood Protection Strategy

Relocation is the only protection strategy considered for rural structures.

4.8.1 General Information

Feature Type: Rural Areas

Location: Rural structures are located throughout Ramsey, Benson, Nelson, and Towner counties surrounding Devils Lake and Stump Lake. The accompanying Figure 4.8-1 shows the overall coverage of the rural areas. Figures 4.8-1a, 4.8-1b, 4.8-1c, 4.8-1d, and 4.8-1e show more detailed areas.

Description: The Rural feature consists of land and rural structures adjacent to the lake, including farmsteads and farmland, residences, state and regional parks, and communities not already covered as separate features. The Rural Areas were divided into two areas for the Infrastructure Protection study, as follows:

1. Devils Lake Rural Areas, including Ramsey, Benson, and Towner counties (except the communities of Devils Lake, Churchs Ferry, Minnewaukan, Fort Totten; and state features Camp Grafton and Grahams Island)

2. Stump Lake Rural Areas, including Nelson County

Significance: Although the cost of individual infrastructure and land components in these rural areas is not high, the total impact of rising lake levels on rural areas is significant.

Damages: The flooding of Rural Areas would result in the following damages:

- Loss of homes and farmstead buildings and structures
- Loss of crop and pasture land
- Loss of parks, park buildings, and park infrastructure
- Loss or relocation of utilities

Owner/Sponsor: Counties and communities would likely be responsible for managing and maintaining the structures in these Rural Areas.

Lead Federal Agency: The Federal Emergency Management Agency (FEMA) would coordinate relocation of structures.

4.8.2 Feature Protection

History of Flood Protection: Flood protection for Rural Areas has generally consisted of relocation of homes and structures. Some of the Rural Areas have benefited from protection by roads acting as dams in the Mission Township area and the area west of ND Highway 20 near Acorn Ridge in combination with temporary levees built by the Corps in the Mission Township area.

General Protection Strategy: The only strategy considered in this Infrastructure Protection Study evaluation included relocation of structures. Structures included in the analysis included:

- Houses (on-reservation)
- Houses (off-reservation)
- Barns (including larger prefabricated metal buildings as well as timber barns)
- Sheds (including machine and tractor storage buildings and smaller pre-fabricated structures)
- Silos (including grain storage bins and silos)
- Churches
- Commercial and Industrial buildings (stores, commercial, and public buildings)

In addition, land damages were evaluated in this investigation (although rural lands cannot be protected, and were therefore not included in the Economic Analysis).

Protection Strategy by Action Level: Figure 4.8.1-2 shows the decision tree for Devils Lake Rural Areas. As shown on Figure 4.8.1-2, the approach to flood protection for the Devils Lake Rural Areas consisted of the following:

1. At Action Level 1 (AL1), the structures below 1449 would be relocated
2. At Action Level 2 (AL2), the structures between 1449 and 1451 would be relocated
3. At Action Level 3 (AL3), the structures between 1451 and 1452.5 would be relocated
4. At Action Level 4 (AL4), the structures between 1452.5 and 1454 would be relocated
5. At Action Level 5 (AL5), the structures between 1454 and 1455.5 would be relocated
6. At Action Level 6 (AL6), the structures between 14455.5 and 1457 would be relocated
7. At Action Level 7 (AL7), the structures between 1457 and 1459 would be relocated
8. At Action Level 8 (AL8), the structures between 1459 and 1461 would be relocated

9. At Action Level 9 (AL9), the structures between 1461 and 1464 would be relocated

Figure 4.8.2-2 shows the decision tree for Stump Lake Rural Areas. As shown on Figure 4.8.2-2, the approach to flood protection for the Stump Lake Rural Areas consisted of the following:

1. At Action Level 1 (AL1), the structures below 1414 would be relocated
2. At Action Level 2 (AL2), the structures between 1414 and 1419 would be relocated
3. At Action Level 3 (AL3), the structures between 1419 and 1424 would be relocated
4. At Action Level 4 (AL4), the structures between 1424 and 1429 would be relocated
5. At Action Level 5 (AL5), the structures between 1429 and 1434 would be relocated
6. At Action Level 6 (AL6), the structures between 1434 and 1439 would be relocated
7. At Action Level 7 (AL7), the structures between 1439 and 1444 would be relocated
8. At Action Level 8 (AL8), the structures between 1444 and 1449 would be relocated
9. At Action Level 9 (AL9), the structures between 1449 and 1454 would be relocated
10. At Action Level 10 (AL10), the structures between 1454 and 1459 would be relocated
11. At Action Level 11 (AL11), the structures between 1459 and 1464 would be relocated

For the Rural Areas, the Infrastructure Protection Study analysis considered all of the incremental flood protection action levels below 1454 as the "first action level" analysis. All action levels were evaluated at the same level of detail.

4.8.3 Design Considerations

4.8.3.0 General Design

No design issues were associated with this feature.

4.8.3.1 Site Geology

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

4.8.3.2 Hydrology/Interior Drainage Issues

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

4.8.3.3 Real Estate Requirements

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

4.8.3.4 Environmental/Cultural issues

HTRW

The rural areas near Devils Lake and Stump Lake have numerous rural residences and farmsteads. The area has been developed since the early 1900s. An HTRW review including review of aerial photographs, topographic maps, and regulatory databases was not performed for this feature. The information presented below is a summary of the typical facilities to be relocated that were identified in the FEMA report.

Current land uses, in the Devils Lake and Sump Lake Rural areas are predominantly agricultural. The structures in the Devils Lake rural area include numerous rural residents and farms, five churches and 18 commercial buildings. In the Stump Lake Rural area there are numerous rural residences and farms. Most of the structures in this area were built during a time when asbestos was used in building materials.

As presented in Section 4.0, a site inspection to locate wells, fuel tanks, and septic systems and a nondestructive asbestos survey would be needed for each rural residence or facility. Cost estimates for relocation of rural residences, farmsteads and other facilities in the Devils Lake and Stump Lake rural areas are included in the relocation cost estimates.

Cultural

Since this feature only involves relocating numerous individual farmsteads and scattered residences and structures as the lake level rises, a cultural resources literature search was not deemed practical or necessary at this level of study. However, prior to implementation, a Phase 1 survey would need to be conducted to determine the locations of any cultural resources sites in the project area. In particular, any houses or standing structures over 50 years old that would be affected would need to have their eligibility to the National Register of Historic Places evaluated prior to relocation or demolition. A cost of $6,000 per site was included in the relocation costs to conduct a Phase 1 survey.

Environmental

The natural resources within the areas impacted by relocations would be minimal and confined to those areas directly impacted by the moving of structures. Fill used for the relocations could cause environmental impacts due to the subsequent revegetation of fill or borrow locations. Revegetation and soil compaction may allow for the introduction of weedy, non-native species. Any impact to woodland, wetland and grassland areas would impact songbird nesting and small mammal populations, as well impacting reptile and amphibian populations due to habitat fragmentation. Impacts to these species would be minimal.

4.8.3.5 Effects on existing infrastructure & utilities

Effects on existing infrastructure and utilities were not evaluated throughout the Devils Lake basin.

4.8.3.6 Interdependencies

The Rural Areas are not directly interdependent with other features, although the entire rural community is heavily dependent on these other features (roads for access, communities for normal daily activities, hospitals, etc). The primary roadways that are critical for the Rural Areas include:

- Feature 13: US Highway 2
- Feature 16: US Highway 281 (South of US Highway 2)
- Feature 18: ND Highway 19
- Feature 19: ND Highway 1
- Feature 21: ND Highway 20 (City of Devils Lake Levee to ND Highway 57)

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

4.8.3.7 O&M

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

4.8.3.8 Lead Time Required

A lead time estimate was not completed for the incremental strategy for this feature.

4.8.3.9 Potential Problems and Risks

There are no known potential problems and risks associated with the incremental strategy for this feature.

4.8.3.10 Data Deficiencies

There are no known data deficiencies with the incremental strategy for this feature.

4.8.4 Economics of Flood Protection

Damages: For the Infrastructure Protection Study's analysis, the flood damage estimates for Rural Areas were reassessed to consider damages of additional structures affected by the rising water. The updated damage computations for Rural Areas are summarized in the accompanying Table 4.8.1-1 (for Devils Lake Rural) and Table 4.8.2-1 (for Stump Lake Rural).

Tables 4.8.1-1 and 4.8.2-1 list damages to structures and other infrastructure that would be inundated by rising waters. These damages are based on available figures from FEMA, and from estimates of average values for barns, shed, and silos associated with rural farm operations. Damages for non-structural infrastructure, including utilities, parks and recreation facilities, and boat ramps were not included in the damage tables because there was no readily available source for inventory and values for these entities. Damages to land are also listed on these tables.

Creel Township 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 in Creel Township would be done on an as-needed basis, with lead time based on the National Weather Service's spring prediction of expected water levels. In all other rural locations, structure relocations would be completed when the structure is actually damaged. The economic analysis assumes that all structures are damaged at one foot below the structure elevation.

Unit prices for all the damage computations were discussed previously in Section 4.0, and are detailed in Table 4.0-2. Assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Rural Areas are listed in the Feature 8 Assumptions listing, appended to this Section 4.8.

Costs: Updated costs of providing flood protection for Rural Areas are detailed in the accompanying Table 4.8.1-2 (for Devils Lake Rural) and Table 4.8.2-2 (for Stump Lake Rural). Unit prices, data sources, and relevant assumptions are listed. These tables list the costs for relocating rural structures.

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 Rural Areas are listed in the Feature 8 Assumptions listing, appended to this Section 4.8.

Contingencies: The contingency percentages used for relocations ranged from 30 to 100% (Tables 4.8.1-2 and 4.8.2-2). Contingencies for structures other than residences were estimated at the higher end of the range because of the potential variability and unknowns.

4.8.5 Economic Results

The results of the Infrastructure Protection Study for Rural Areas up to the maximum lake level are listed in Table 4.8.1-3a (Devils Lake Rural) and Table 4.8.2-3 (Stump Lake Rural). The economic results for the Devils Lake Rural Areas up to elevation 1454 are listed in Table 4.8.1-3b (Devils Lake Rural). There is only one action level for relocation strategy within the Stump Lake

Rural Areas, therefore the Economic Results are only presented up to the maximum lake level of 1463.

The Economic Results do not include the damages to land; these rural land damages cannot be prevented through the relocation protection strategy.

Devils Lake Rural Areas

Multiple Action Level Stochastic Analysis Results (up to 1463): Using the stochastic analysis along with the updated damage and cost estimates for Devils Lake Rural Areas, the analysis provided relevant economic indices for relocation of structures up to a lake level of 1463. This incremental relocation strategy is highlighted on the decision tree (Figure 4.8.1-2). The annual net benefits for this approach were less than zero (-$273,700). The BCR for this approach was less than one (0.72). These results show that this strategy is not economically justified. The annual damages prevented by this relocation strategy are $706,700. The stochastic results are averages over 10,000 traces.

Multiple Action Level Results for Specific Scenarios (up to 1463): Relocation of structures up to 1463 was also analyzed under each of three specific climate futures. For Devils Lake Rural Areas, 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 Devils Lake Rural structures up to 1463 were -$831,300, and the BCR was 0.73, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $2,262,600.

- First Moderate Future – Under the first moderate future climate scenario, the net benefits of relocation of Devils Lake Rural structures up to 1463 were -$213,700, and the BCR was 0.71, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $514,300.

- Second Moderate Future – Under the second moderate future climate scenario, the net benefits of relocation of Devils Lake Rural structures up to 1463 were -$394,900, and the BCR was 0.72, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $1,013,900.

First Action Level Stochastic Analysis Results (up to 1454): Using the stochastic analysis along with the updated damage and cost estimates for Devils Lake Rural Areas, the analysis provided relevant economic indices for relocation of structures up to elevation 1454. The annual net benefits for this approach were less than zero (-$218,500). The BCR for this approach was less than one (0.72). These results show that this strategy is not economically justified. The

annual damages prevented by this relocation strategy are $555,700. The stochastic results are averages over 10,000 traces.

First Action Level Results for Specific Scenarios (up to 1454): Relocation of structures up to 1454 was also analyzed under each of three specific climate futures. For Devils Lake Rural Areas, 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 Devils Lake Rural structures up to 1454 were -$359,500, and the BCR was 0.72, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $939,500.

- First Moderate Future – Under the first moderate future climate scenario, the net benefits of relocation of Devils Lake Rural structures up to 1454 were -$213,700, and the BCR was 0.71, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $514,300.

- Second Moderate Future – Under the second moderate future climate scenario, the net benefits of relocation of Devils Lake Rural structures up to 1454 were -$304,600, and the BCR was 0.72, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $777,900.

Stump Lake Rural Areas

Multiple Action Level Stochastic Analysis Results (up to 1463): Using the stochastic analysis along with the updated damage and cost estimates for Stump Lake Rural Areas, the analysis provided relevant economic indices for relocation of structures up to elevation 1463. This incremental relocation strategy is highlighted on the decision tree (Figure 4.8.2-2). The annual net benefits for this approach were less than zero (-$28,700). The BCR for this approach was less than one (0.65). These results show that this strategy is not economically justified. The annual damages prevented by this relocation strategy are $53,100. The stochastic results are averages over 10,000 traces.

Multiple Action Level Results for Specific Scenarios (up to 1463): Relocation of structures up to 1463 was also analyzed under each of three specific climate futures. For Stump Lake Rural features, 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 Stump Lake Rural structures up to 1463 were -$87,700, and the BCR was 0.65, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $161,600.

- First Moderate Future – Under the first moderate future climate scenario, the net benefits of relocation of Stump Lake Rural structures up to 1463 were -$18,800, and the BCR was 0.66, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $37,400.

- Second Moderate Future – Under the second moderate future climate scenario, the net benefits of relocation of Stump Lake Rural structures up to 1463 were -$61,300, and the BCR was 0.64, indicating that this strategy was not economically justified. The annual damages prevented by this relocation strategy are $108,100.

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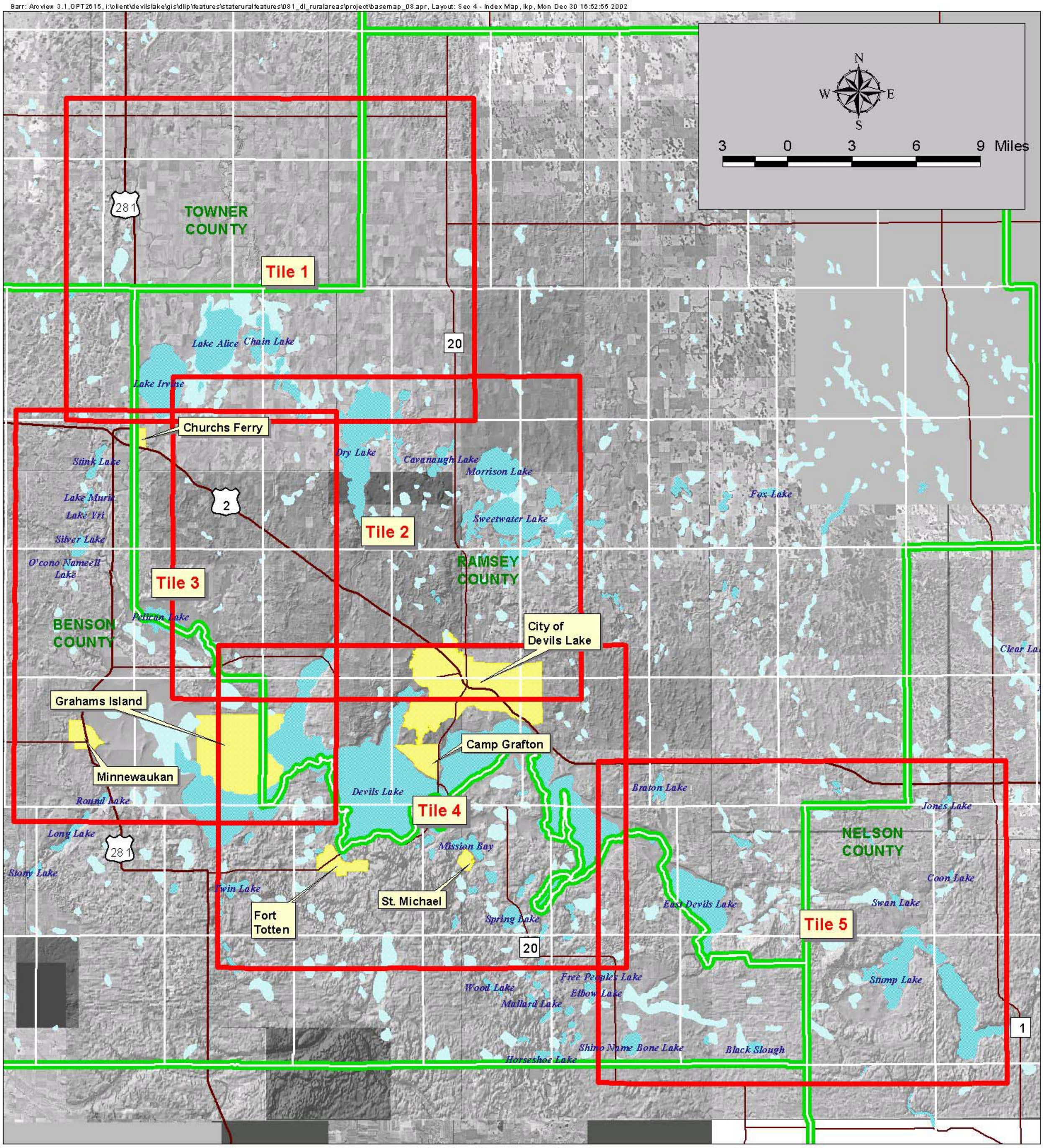
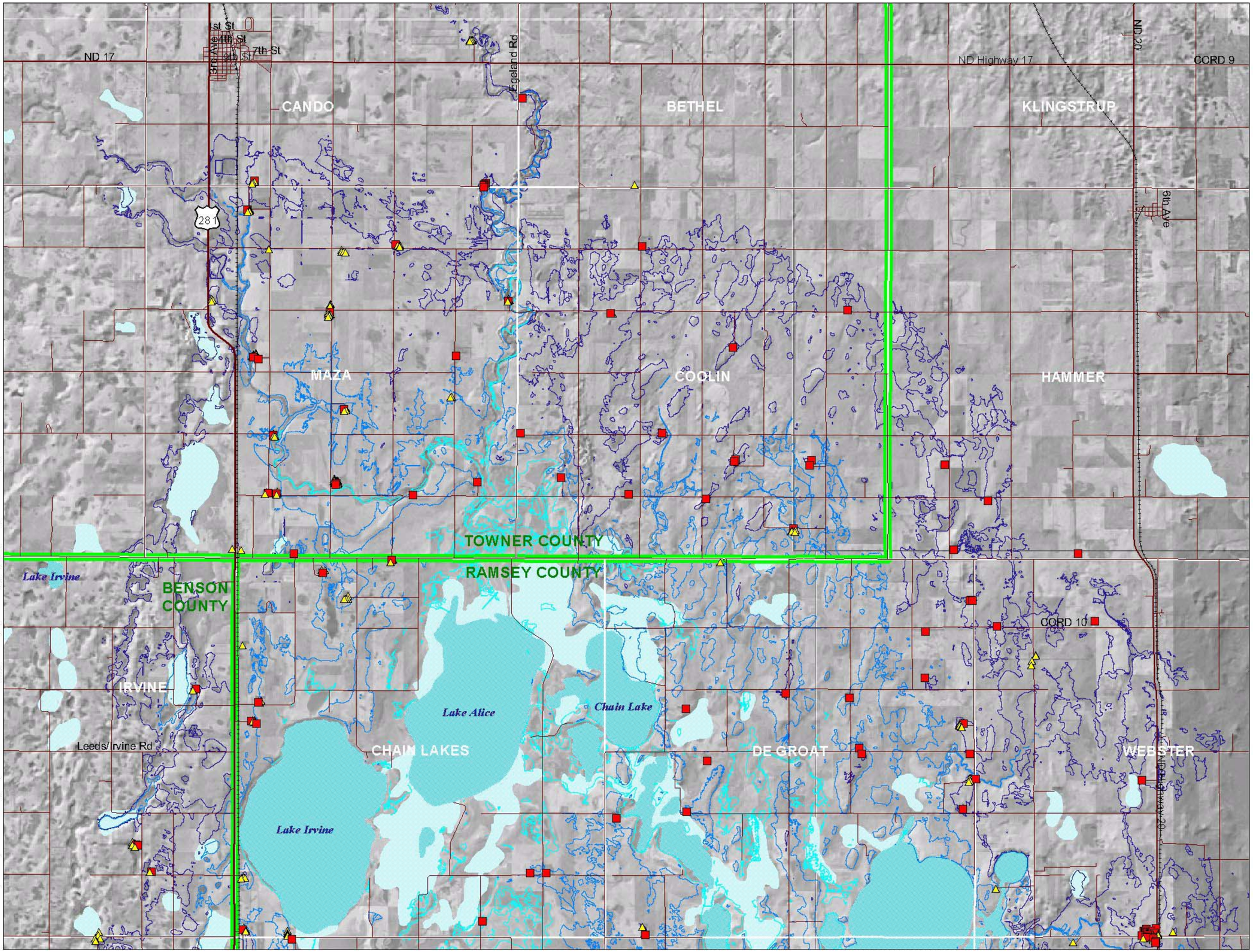


Figure 4.8-1

LOCATION MAP
FEATURE 8: RURAL AREAS
FIGURE INDEX MAP
Devils Lake Infrastructure
Protection Study



N
W E
S

0 0.75 1.5 2.25 3 Miles

Reference Lake Contours

1447

1454

1463

Buildings

House

Other Structure

Townships

Counties

Figure 4.8-1a

LOCATION MAP
FEATURE 8: RURAL AREAS
(TILE 1)
Devils Lake Infrastructure
Protection Study

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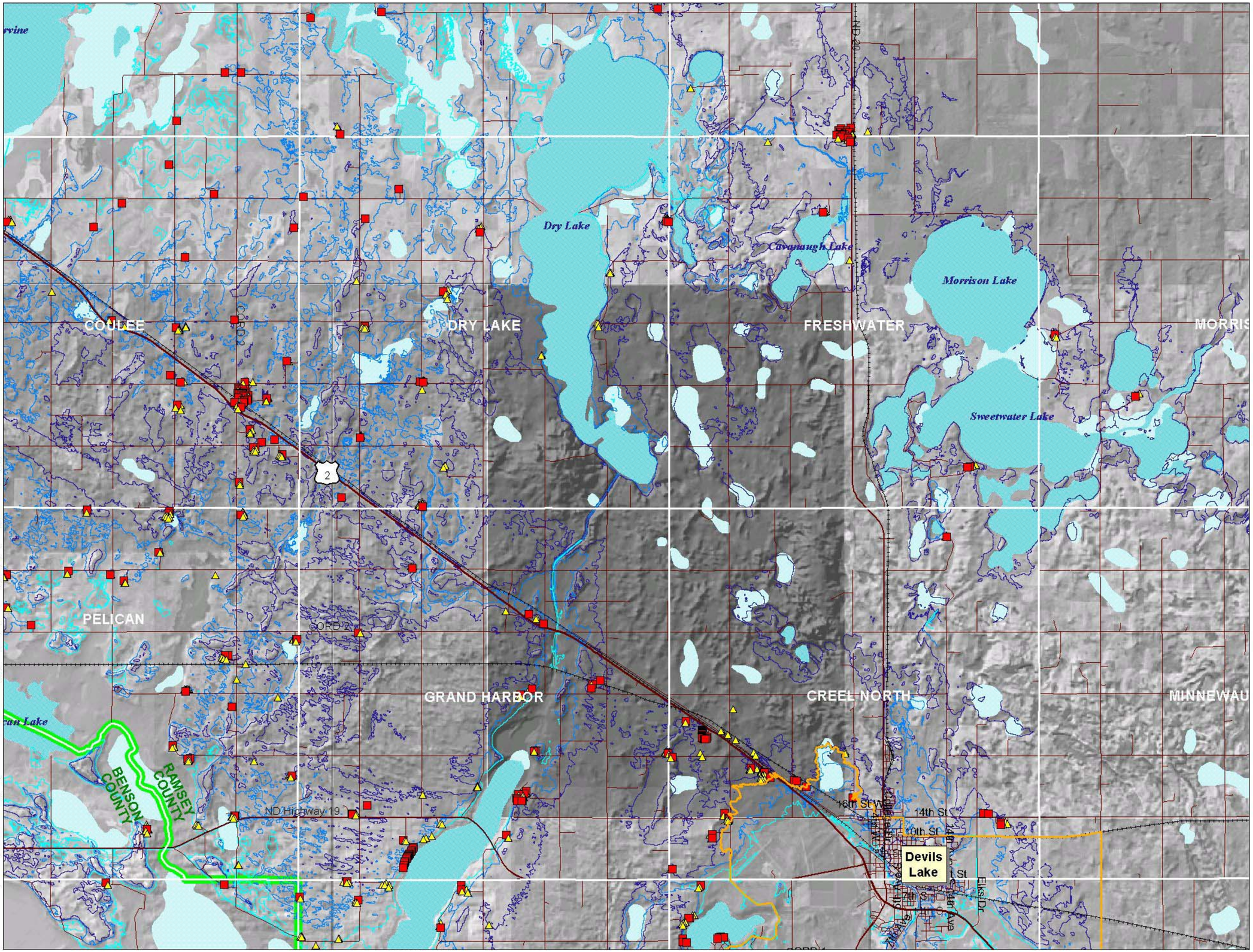

N
W E
S

0 0.75 1.5 2.25 3 Miles

Reference Lake Contours

1447

1454

1463

Buildings

House

Other Structure

Townships

Counties

State and Community Features (Structures in These Areas Not Included in Rural Feature Inventory)

Figure 4.8-1b

LOCATION MAP
FEATURE 8: RURAL AREAS
(TILE 2)
Devils Lake Infrastructure Protection Study

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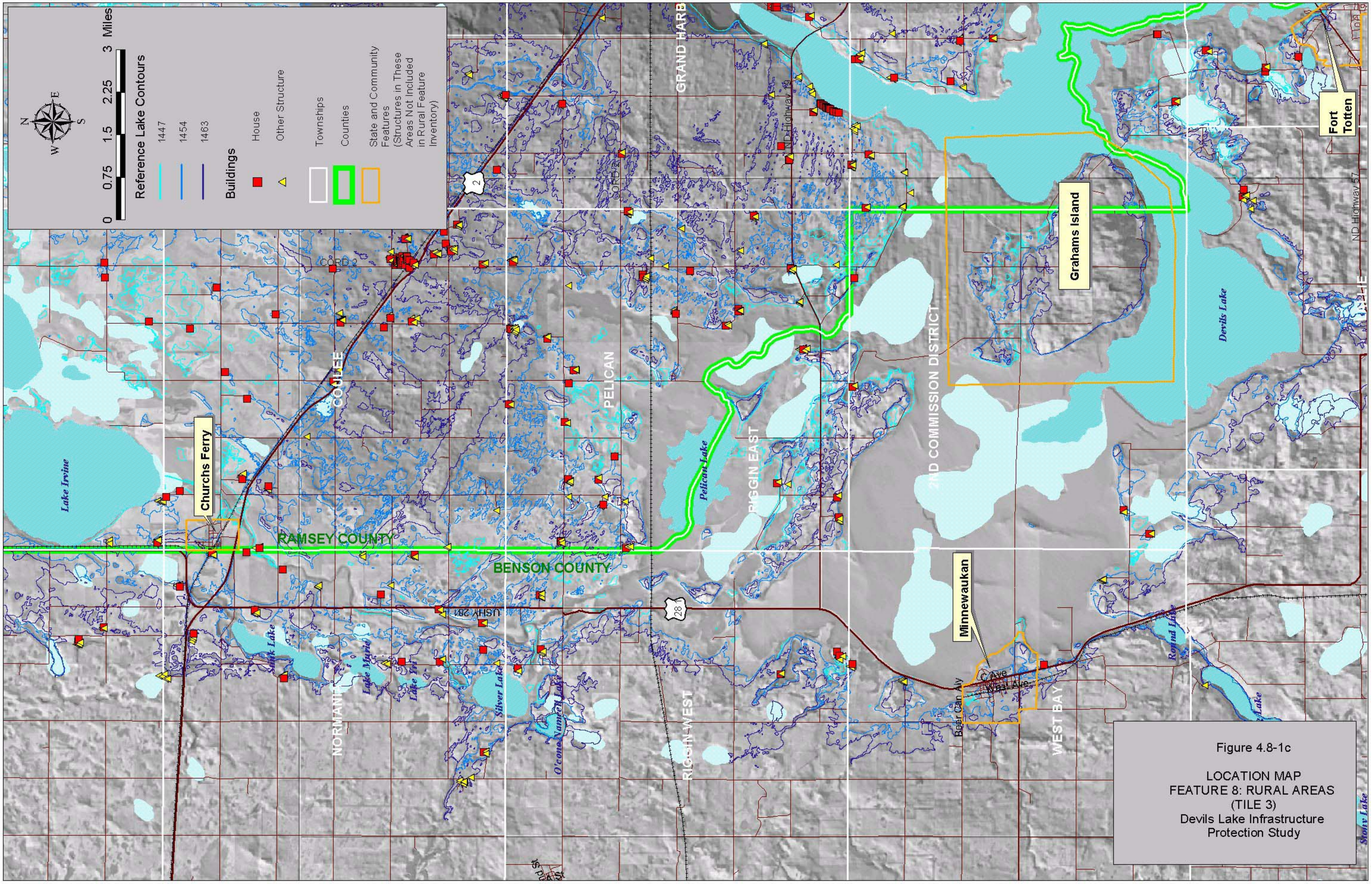

Figure 4.8-1c

LOCATION MAP
FEATURE 8: RURAL AREAS
(TILE 3)
Devils Lake Infrastructure
Protection Study

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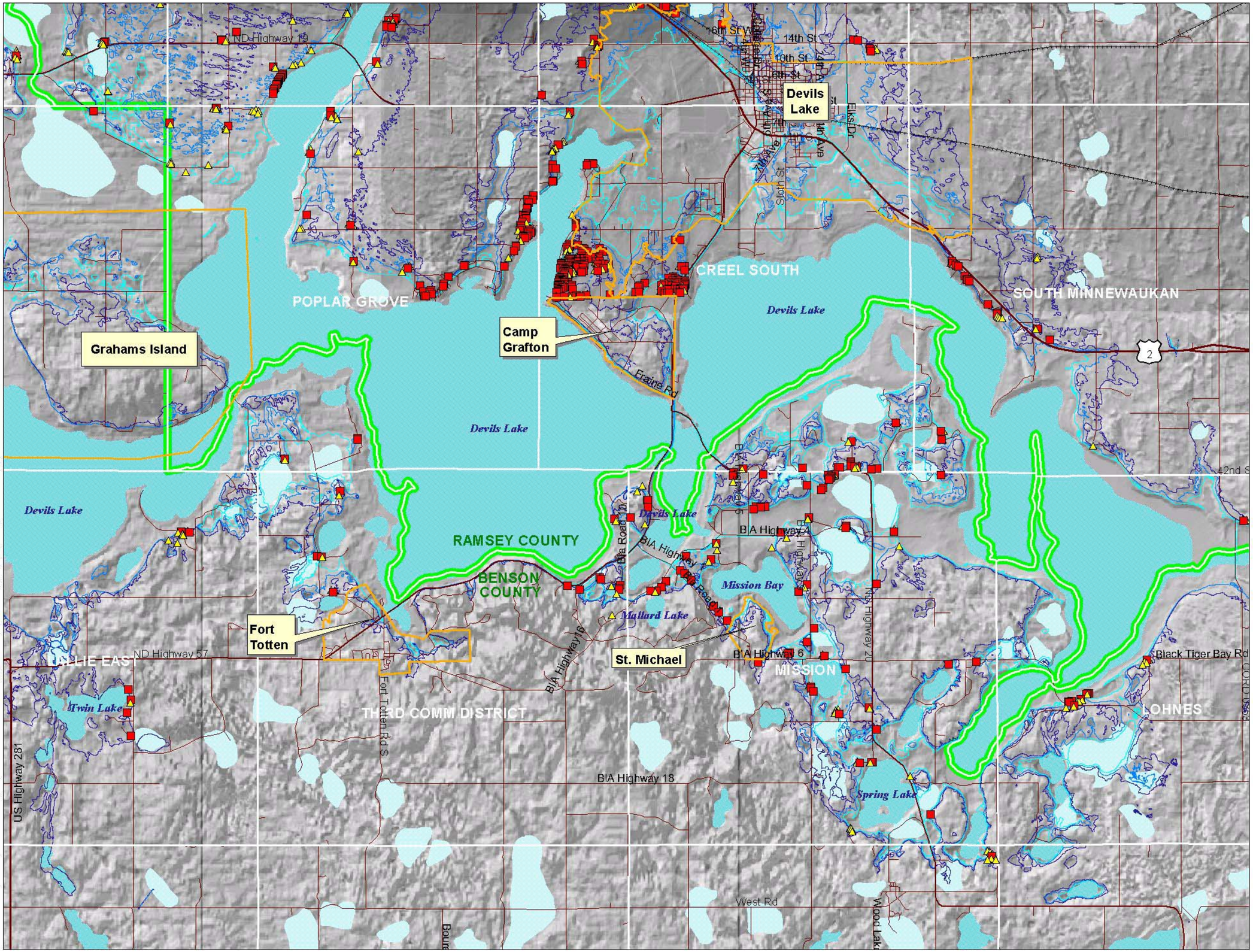


Figure 4.8-1d

LOCATION MAP
FEATURE 8: RURAL AREAS
(TILE 4)
Devils Lake Infrastructure Protection Study

Barr: Arcview 3.1,OPT2515, I:\client\devilslake\gis\dlip\features\statarural\features\081_dl_ruralareas\project\basemap_08.apr, Layout: Layout: Sec 4 Tile 4, lkp, Mon Dec 30 16:56:25 2002

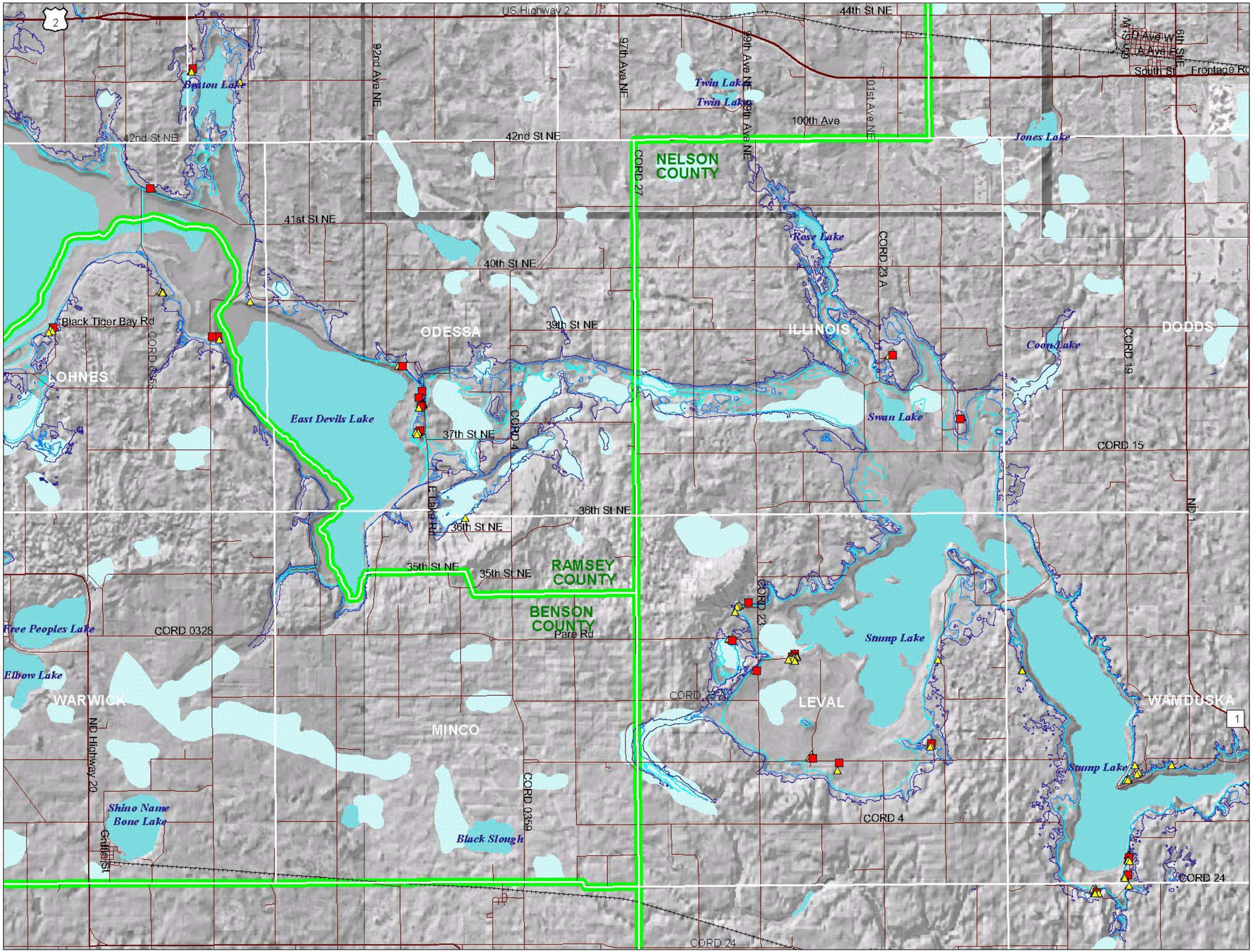
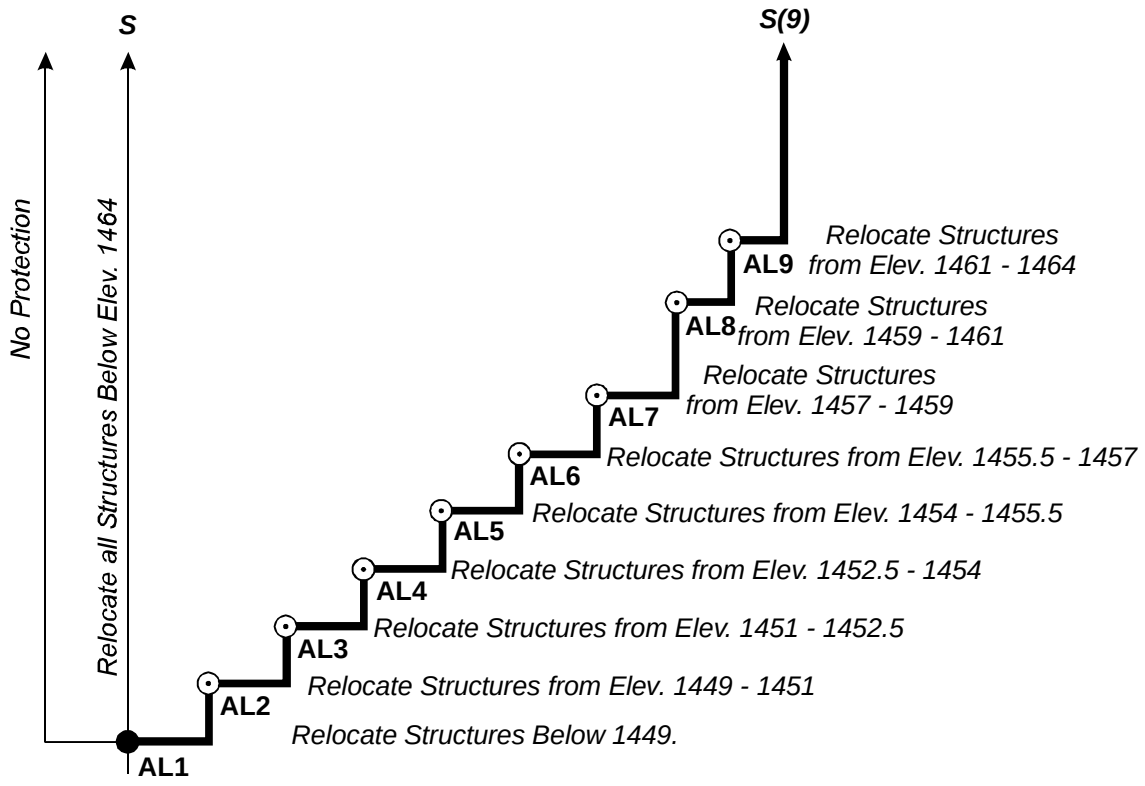


Figure 4.8-1e

LOCATION MAP
FEATURE 8: RURAL AREAS
(TILE 5)
Devils Lake Infrastructure
Protection Study

Barr: Arcview 3.1,OPT2615, i:\client\devilslake\gis\dlip\features\staterurralfeatures\081_dl_ruralareas\projects\basemap_08.apr, Layout: Layout: Sec 4 Tile 5, lkp, Mon Dec 30 16:57:10 2002



━━━	Flood Protection Strategy
●	Decision required at this point
⊙	Trigger point for action, no decision needed
AL1	Decision/Action Level
S(1)	Incremental structure relocation (number of times)
S	Relocate all structures below Elev. 1464

Figure 4.8.1-2

DECISION TREE
FEATURE 8.1: RURAL AREAS (DEVILS LAKE)
Devils Lake Infrastructure Protection Study

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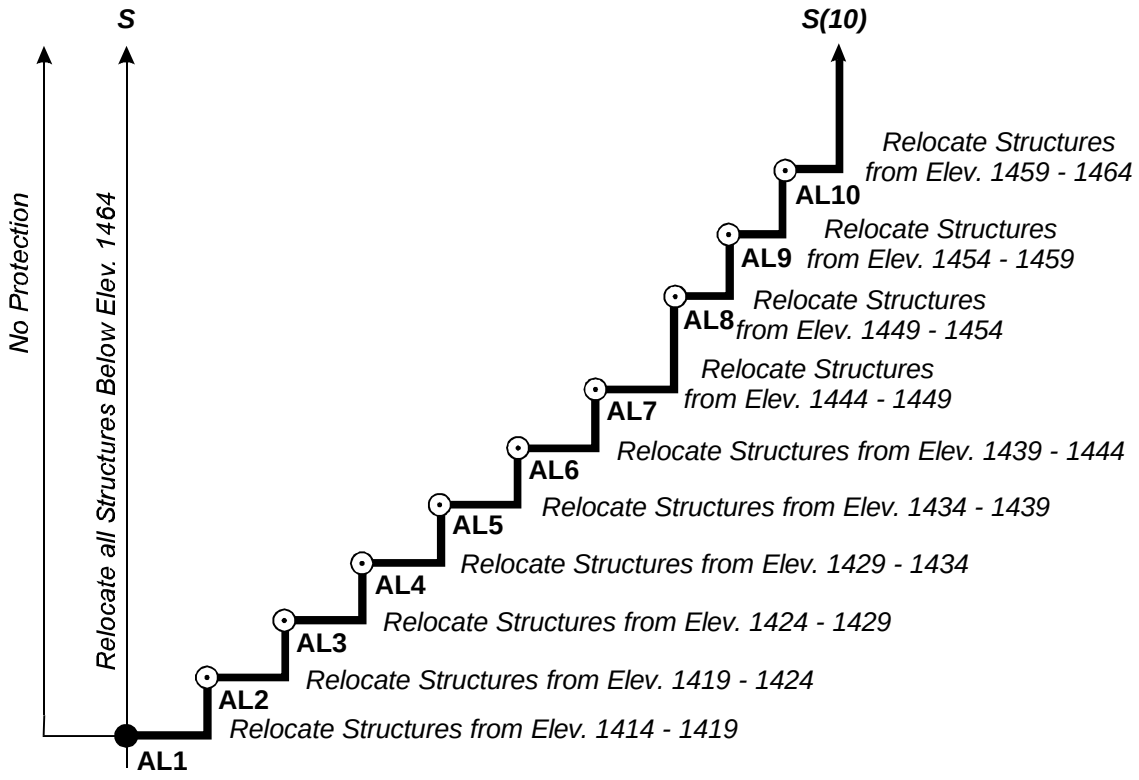

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━━━	Flood Protection Strategy
●	Decision required at this point
⊙	Trigger point for action, no decision needed
AL1	Decision/Action Level
S(1)	Incremental structure relocation (number of times)
S	Relocate all structures below Elev. 1464

Figure 4.8.2-2

DECISION TREE
FEATURE 8.2: RURAL AREAS(STUMP LAKE)
Devils Lake Infrastructure Protection Study

Table 4.8.1-1

Flood Damages
Feature 8.1: Devils Lake Rural Areas
Devils Lake Infrastructure Protection Study

DAMAGES

Action Level	Structure Elevation Range (MSL)	Structures and Infrastructure (THOUSANDS)	Land (THOUSANDS)
AL1	Below 1449.5	$5,285	$7,471
AL2	1449.6-1451.0	$3,649	$5,218
AL3	1451.1-1452.5	$3,217	$5,968
AL4	1452.6-1454.0	$4,904	$6,622
AL5	1454.1-1455.5	$3,871	$7,502
AL6	1455.6-1457.0	$4,295	$8,252
AL7	1457.1-1459.0	$8,563	$12,454
AL8	1459.1-1461.0	$8,990	$14,115
AL9	1461.1-1464.0	$15,897	$23,733

DAMAGE BREAKDOWN

Structure Elevation (Below 1449.5)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residence (On-Res)	24	EA	$62,000	$1,488
Residence (Off-Res)	20	EA	$88,000	$1,760
Barn	13	EA	$72,000	$936
Shed	25	EA	$43,200	$1,080
Silo	1	EA	$20,500	$21
Church	0	EA	$265,000	$0
Commercial	0	EA	$63,000	$0
Subtotal				$0
Total Relocation				**$5,285**
Land				
Land	18,677	AC	$400	$7,471
Total Land				**$7,471**

Structure Elevation (1449.6-1451.0)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residence (On-Res)	6	EA	$62,000	$372
Residence (Off-Res)	20	EA	$88,000	$1,760
Barn	10	EA	$72,000	$720
Shed	17	EA	$43,200	$734
Silo	0	EA	$20,500	$0
Church	0	EA	$265,000	$0
Commercial	1	EA	$63,000	$63
Subtotal				$0
Total Relocation				**$3,649**
Land				
Land	13,045	AC	$400	$5,218
Total Land				**$5,218**

Structure Elevation (1451.1-1452.5)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residence (On-Res)	4	EA	$62,000	$248
Residence (Off-Res)	12	EA	$88,000	$1,056
Barn	13	EA	$72,000	$936
Shed	16	EA	$43,200	$691
Silo	1	EA	$20,500	$21
Church	1	EA	$265,000	$265
Commercial	0	EA	$63,000	$0
Subtotal				$0
Total Relocation				**$3,217**
Land				
Land	14,921	AC	$400	$5,968
Total Land				**$5,968**

Structure Elevation (1452.6-1454.0)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residence (On-Res)	4	EA	$62,000	$248
Residence (Off-Res)	33	EA	$88,000	$2,904
Barn	10	EA	$72,000	$720
Shed	22	EA	$43,200	$950
Silo	4	EA	$20,500	$82
Church	0	EA	$265,000	$0
Commercial	0	EA	$63,000	$0
Subtotal				$0
Total Relocation				**$4,904**
Land				
Land	16,554	AC	$400	$6,622
Total Land				**$6,622**

ure Elevation (1454.1-1455.5)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residence (On-Res)	3	EA	$62,000	$186
Residence (Off-Res)	21	EA	$88,000	$1,848
Barn	7	EA	$72,000	$504
Shed	16	EA	$43,200	$691
Silo	3	EA	$20,500	$62
Church	1	EA	$265,000	$265
Commercial	5	EA	$63,000	$315
Subtotal				$0
Total Relocation				**$3,871**
Land				
Land	18,754	AC	$400	$7,502
Total Land				**$7,502**

Structure Elevation (1455.6-1457.0)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residence (On-Res)	6	EA	$62,000	$372
Residence (Off-Res)	25	EA	$88,000	$2,200
Barn	15	EA	$72,000	$1,080
Shed	12	EA	$43,200	$518
Silo	3	EA	$20,500	$62
Church	0	EA	$265,000	$0
Commercial	1	EA	$63,000	$63
Subtotal				$0
Total Relocation				**$4,295**
Land				
Land	20,629	AC	$400	$8,252
Total Land				**$8,252**

Structure Elevation (1457.1-1459.0)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residence (On-Res)	12	EA	$62,000	$744
Residence (Off-Res)	45	EA	$88,000	$3,960
Barn	24	EA	$72,000	$1,728
Shed	36	EA	$43,200	$1,555
Silo	9	EA	$20,500	$185
Church	1	EA	$265,000	$265
Commercial	2	EA	$63,000	$126
Subtotal				$0
Total Relocation				**$8,563**
Land				
Land	31,136	AC	$400	$12,454
Total Land				**$12,454**

Structure Elevation (1459.1-1461.0)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residence (On-Res)	11	EA	$62,000	$682
Residence (Off-Res)	55	EA	$88,000	$4,840
Barn	24	EA	$72,000	$1,728
Shed	26	EA	$43,200	$1,123
Silo	11	EA	$20,500	$226
Church	1	EA	$265,000	$265
Commercial	2	EA	$63,000	$126
Subtotal				$0
Total Relocation				**$8,990**
Land				
Land	35,288	AC	$400	$14,115
Total Land				**$14,115**

Structure Elevation (1461.1-1464.0)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Structures and Infrastructure				
Residence (On-Res)	14	EA	$62,000	$868
Residence (Off-Res)	98	EA	$88,000	$8,624
Barn	36	EA	$72,000	$2,592
Shed	61	EA	$43,200	$2,635
Silo	23	EA	$20,500	$472
Church	1	EA	$265,000	$265
Commercial	7	EA	$63,000	$441
Subtotal				$0
Total Relocation				**$15,897**
Land				
Land	59,333	AC	$400	$23,733
Total Land				**$23,733**

Notes
1. Land damages are not included in the economic analysis as damages, since it is not feasible to protect.

Table 4.8.1-2

Flood Protection Costs
Feature 8.1: Devils Lake Rural Areas
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	S	S(9)
Action Level	Cost to Relocate All Structures at AL1	Cost to Incrementally Relocate Structures at AL1, AL2, AL3,
	(THOUSANDS)	
AL1	$79,764	$7,423
AL2	$0	$4,966
AL3	$0	$4,880
AL4	$0	$6,243
AL5	$0	$5,406
AL6	$0	$5,884
AL7	$0	$11,849
AL8	$0	$12,050
AL9	$0	$21,063

COST BREAKDOWN

S AT AL1

Strategy	S(9) AT AL1; Below 1449.5						S(9) AT AL2; 1449.6-1451.0						S(9) AT AL3; 1451.1-1452.5						S(9) AT AL4; 1452.6-1454.0					
	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)
Incremental Relocation	Residence (On-Res)	24	EA	$68,000	30%	$2,122	Residence (On-Res)	6	EA	$68,000	30%	$530	Residence (On-Res)	4	EA	$68,000	30%	$354	Residence (On-Res)	4	EA	$68,000	30%	$354
	Residence (Off-Res)	20	EA	$68,000	30%	$1,768	Residence (Off-Res)	20	EA	$68,000	30%	$1,768	Residence (Off-Res)	12	EA	$68,000	30%	$1,061	Residence (Off-Res)	33	EA	$68,000	30%	$2,917
	Barn	13	EA	$72,000	100%	$1,872	Barn	10	EA	$72,000	100%	$1,440	Barn	13	EA	$72,000	100%	$1,872	Barn	10	EA	$72,000	100%	$1,440
	Shed	25	EA	$43,200	50%	$1,620	Shed	17	EA	$43,200	50%	$1,102	Shed	16	EA	$43,200	50%	$1,037	Shed	22	EA	$43,200	50%	$1,426
	Silo	1	EA	$20,500	100%	$41	Silo	0	EA	$20,500	30%	$0	Silo	1	EA	$20,500	30%	$27	Silo	4	EA	$20,500	30%	$107
	Church	0	EA	$265,000	100%	$0	Church	0	EA	$265,000	100%	$0	Church	1	EA	$265,000	100%	$530	Church	0	EA	$265,000	100%	$0
	Commercial	0	EA	$63,000	100%	$0	Commercial	1	EA	$63,000	100%	$126	Commercial	0	EA	$63,000	100%	$0	Commercial	0	EA	$63,000	100%	$0
	Total Relocation					**$7,423**	**Total Relocation**					**$4,966**	**Total Relocation**					**$4,880**	**Total Relocation**					**$6,243**

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S AT AL1

Strategy	S(9) AT AL5; 1454.1-1455.5						S(9) AT AL6; 1455.6-1457.0						S(9) AT AL7; 1457.1-1459.0						S(9) AT AL8; 1459.1-1461.0						S(9) AT AL9; 1461.1-1464.0					
	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)
Incremental Relocation	Residence (On-Res)	3	EA	$68,000	30%	$265	Residence (On-Res)	6	EA	$68,000	30%	$530	Residence (On-Res)	12	EA	$68,000	30%	$1,061	Residence (On-Res)	11	EA	$68,000	30%	$972	Residence (On-Res)	14	EA	$68,000	30%	$1,238
	Residence (Off-Res)	21	EA	$68,000	30%	$1,856	Residence (Off-Res)	25	EA	$68,000	30%	$2,210	Residence (Off-Res)	45	EA	$68,000	30%	$3,978	Residence (Off-Res)	55	EA	$68,000	30%	$4,862	Residence (Off-Res)	98	EA	$68,000	30%	$8,663
	Barn	7	EA	$72,000	100%	$1,008	Barn	15	EA	$72,000	100%	$2,160	Barn	24	EA	$72,000	100%	$3,456	Barn	24	EA	$72,000	100%	$3,456	Barn	36	EA	$72,000	100%	$5,184
	Shed	16	EA	$43,200	50%	$1,037	Shed	12	EA	$43,200	50%	$778	Shed	36	EA	$43,200	50%	$2,333	Shed	26	EA	$43,200	50%	$1,685	Shed	61	EA	$43,200	50%	$3,953
	Silo	3	EA	$20,500	30%	$80	Silo	3	EA	$20,500	30%	$80	Silo	9	EA	$20,500	30%	$240	Silo	11	EA	$20,500	30%	$293	Silo	23	EA	$20,500	30%	$613
	Church	1	EA	$265,000	100%	$530	Church	0	EA	$265,000	100%	$0	Church	1	EA	$265,000	100%	$530	Church	1	EA	$265,000	100%	$530	Church	1	EA	$265,000	100%	$530
	Commercial	5	EA	$63,000	100%	$630	Commercial	1	EA	$63,000	100%	$126	Commercial	2	EA	$63,000	100%	$252	Commercial	2	EA	$63,000	100%	$252	Commercial	7	EA	$63,000	100%	$882
	Total Relocation					**$5,406**	**Total Relocation**					**$5,884**	**Total Relocation**					**$11,849**	**Total Relocation**					**$12,050**	**Total Relocation**					**$21,063**

Notes:
1. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.

Table 4.8.1 - 3a

Economics Results: All Action Levels -- to Lake Level 1463
Feature 8.1: Devils Lake Rural Areas
Devils Lake Infrastructure Protection Study

Strategy		Stochastic Analysis (ST-9) Mean Value over 10,000 Traces (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / A
No Protection	No Protection or Relocation	$0	$0	$706,700	$706,700	$0	$0	--
S(9)	9 Incremental Relocations	$980,400	$980,400	$0	$0	$706,700	-$273,700	0.72

Strategy		Wet Future Scenario (WF-9) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / A
No Protection	No Protection or Relocation	$0	$0	$2,262,600	$2,262,600	$0	$0	--
S(9)	9 Incremental Relocations	$3,093,800	$3,093,800	$0	$0	$2,262,600	-$831,300	0.73

Strategy		Moderate Future 1 Scenario (M1-4) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / A
No Protection	No Protection or Relocation	$0	$0	$514,300	$514,300	$0	$0	--
S(9)	9 Incremental Relocations	$728,000	$728,000	$0	$0	$514,300	-$213,700	0.71

Strategy		Moderate Future 2 Scenario (M2-4) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / A
No Protection	No Protection or Relocation	$0	$0	$1,013,900	$1,013,900	$0	$0	--
S(9)	9 Incremental Relocations	$1,408,800	$1,408,800	$0	$0	$1,013,900	-$394,900	0.72

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 (D(S)).

Table 4.8.1 - 3b

Economics Results: Action Levels Up to 1454
Feature 8.1: Devils Lake Rural Areas
Devils Lake Infrastructure Protection Study

Strategy		Stochastic Analysis (ST-9) Mean Value over 10,000 Traces (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Relocation A	Total B = A	Damages C	Total D = C	To Strategy (Damages Prevented) E = D(No Protection) - D(S) *	To Strategy F = E - B	(BCR) I = E / A
No Protection	No Protection or Relocation	$0	$0	$555,700	$555,700	$0	$0	--
S(5)	5 Incremental Relocations	$774,100	$774,100	$0	$0	$555,700	-$218,500	0.72

Strategy		Wet Future Scenario (WF-9) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Relocation A	Total B = A	Damages C	Total D = C	To Strategy (Damages Prevented) E = D(No Protection) - D(S) *	To Strategy F = E - B	(BCR) I = E / A
No Protection	No Protection or Relocation	$0	$0	$939,500	$939,500	$0	$0	--
S(5)	5 Incremental Relocations	$1,299,100	$1,299,100	$0	$0	$939,500	-$359,500	0.72

Strategy		Moderate Future 1 Scenario (M1-4) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Relocation A	Total B = A	Damages C	Total D = C	To Strategy (Damages Prevented) E = D(No Protection) - D(S) *	To Strategy F = E - B	(BCR) I = E / A
No Protection	No Protection or Relocation	$0	$0	$514,300	$514,300	$0	$0	--
S(5)	5 Incremental Relocations	$728,000	$728,000	$0	$0	$514,300	-$213,700	0.71

Strategy		Moderate Future 2 Scenario (M2-4) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Relocation A	Total B = A	Damages C	Total D = C	To Strategy (Damages Prevented) E = D(No Protection) - D(S) *	To Strategy F = E - B	(BCR) I = E / A
No Protection	No Protection or Relocation	$0	$0	$777,900	$777,900	$0	$0	--
S(5)	5 Incremental Relocations	$1,082,400	$1,082,400	$0	$0	$777,900	-$304,600	0.72

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 "No Protection strategy" minus the total damages for the strategy implemented (D(S)).

Table 4.8.2-1

Flood Damages
Feature 8.2: Stump Lake Rural Areas
Devils Lake Infrastructure Protection Study

DAMAGES

Strategy	Structure Elevation Range (MSL)	Structure and Infrastructure (THOUSANDS)	Land (THOUSANDS)
AL1	1414-1419	$0	$221
AL2	1419-1424	$0	$260
AL3	1424-1429	$21	$327
AL4	1429-1434	$202	$412
AL5	1434-1439	$926	$507
AL6	1439-1444	$253	$607
AL7	1444-1449	$275	$703
AL8	1449-1454	$284	$791
AL9	1454-1459	$804	$864
AL10	1459-1464	$783	$911

DAMAGE BREAKDOWN

Structure Elevation (1414-1419)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	0	EA	$88,000	$0
Barn	0	EA	$72,000	$0
Shed	0	EA	$43,200	$0
Silo	0	EA	$20,500	$0
Government/Public	0	EA	$63,000	$0
Total Relocation				**$0**
Land				
Land	553	AC	$400	$221
Total Land				**$221**

Structure Elevation (1419-1424)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	0	EA	$88,000	$0
Barn	0	EA	$72,000	$0
Shed	0	EA	$43,200	$0
Silo	0	EA	$20,500	$0
Government/Public	0	EA	$63,000	$0
Total Relocation				**$0**
Land				
Land	651	AC	$400	$260
Total Land				**$260**

Structure Elevation (1424-1429)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	0	EA	$88,000	$0
Barn	0	EA	$72,000	$0
Shed	0	EA	$43,200	$0
Silo	1	EA	$20,500	$21
Government/Public	0	EA	$63,000	$0
Total Relocation				**$21**
Land				
Land	817	AC	$400	$327
Total Land				**$327**

Structure Elevation (1429-1434)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	0	EA	$88,000	$0
Barn	1	EA	$72,000	$72
Shed	3	EA	$43,200	$130
Silo	0	EA	$20,500	$0
Government/Public	0	EA	$63,000	$0
Total Relocation				**$202**
Land				
Land	1,030	AC	$400	$412
Total Land				**$412**

Structure Elevation (1434-1439)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	4	EA	$88,000	$352
Barn	2	EA	$72,000	$144
Shed	9	EA	$43,200	$389
Silo	2	EA	$20,500	$41
Government/Public	0	EA	$63,000	$0
Total Relocation				**$926**
Land				
Land	1,268	AC	$400	$507
Total Land				**$507**

Structure Elevation (1439-1444)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	1	EA	$88,000	$88
Barn	2	EA	$72,000	$144
Shed	0	EA	$43,200	$0
Silo	1	EA	$20,500	$21
Government/Public	0	EA	$63,000	$0
Total Relocation				**$253**
Land				
Land	1,517	AC	$400	$607
Total Land				**$607**

Structure Elevation (1444-1449)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	1	EA	$88,000	$88
Barn	2	EA	$72,000	$144
Shed	1	EA	$43,200	$43
Silo	0	EA	$20,500	$0
Government/Public	0	EA	$63,000	$0
Total Relocation				**$275**
Land				
Land	1,758	AC	$400	$703
Total Land				**$703**

Structure Elevation (1449-1454)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	0	EA	$88,000	$0
Barn	1	EA	$72,000	$72
Shed	2	EA	$43,200	$86
Silo	0	EA	$20,500	$0
Government/Public	2	EA	$63,000	$126
Total Relocation				**$284**
Land				
Land	1,978	AC	$400	$791
Total Land				**$791**

Structure Elevation (1454-1459)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	1	EA	$88,000	$88
Barn	7	EA	$72,000	$504
Shed	2	EA	$43,200	$86
Silo	0	EA	$20,500	$0
Government/Public	2	EA	$63,000	$126
Total Relocation				**$804**
Land				
Land	2,160	AC	$400	$864
Total Land				**$864**

Structure Elevation (1459-1464)

Description	Quantity	Units	Unit Cost	Value (THOUSANDS)
Residence	2	EA	$88,000	$176
Barn	1	EA	$72,000	$72
Shed	8	EA	$43,200	$346
Silo	0	EA	$20,500	$0
Government/Public	3	EA	$63,000	$189
Total Relocation				**$783**
Land				
Land	2,278	AC	$400	$911
Total Land				**$911**

Table 4.8.2-2

Flood Protection Costs
Feature 8.2: Stump Lake Rural Areas
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	S	S(10)
Action Level	Cost to Relocate All Structures at AL1	Cost to Incrementally Relocate Structures at AL1, AL2, AL3,
	(THOUSANDS)	
AL1	$5,457	$0
AL2	$0	$0
AL3	$0	$41
AL4	$0	$338
AL5	$0	$1,307
AL6	$0	$417
AL7	$0	$441
AL8	$0	$437
AL9	$0	$1,390
AL10	$0	$1,085

COST BREAKDOWN

S AT AL1

Strategy	S(10) AT AL1; 1414-1419						S(10) AT AL2; 1419-1424						S(10) AT AL3; 1424-29						S(10) AT AL4; 1429-34						S(10) AT AL5; 1434-39					
	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)
Incremental Relocation	Residence	0	EA	$68,000	30%	$0	Residence	0	EA	$68,000	30%	$0	Residence	0	EA	$68,000	30%	$0	Residence	0	EA	$68,000	40%	$0	Residence	4	EA	$68,000	30%	$354
	Barn	0	EA	$72,000	100%	$0	Barn	0	EA	$72,000	100%	$0	Barn	0	EA	$72,000	100%	$0	Barn	1	EA	$72,000	100%	$144	Barn	2	EA	$72,000	100%	$288
	Shed	0	EA	$43,200	50%	$0	Shed	0	EA	$43,200	50%	$0	Shed	0	EA	$43,200	50%	$0	Shed	3	EA	$43,200	50%	$194	Shed	9	EA	$43,200	50%	$583
	Silo	0	EA	$20,500	100%	$0	Silo	0	EA	$20,500	100%	$0	Silo	1	EA	$20,500	100%	$41	Silo	0	EA	$20,500	100%	$0	Silo	2	EA	$20,500	100%	$82
	Government/Public	0	EA	$63,000	30%	$0	Government/Public	0	EA	$63,000	30%	$0	Government/Public	0	EA	$63,000	30%	$0	Government/Public	0	EA	$63,000	30%	$0	Government/Public	0	EA	$63,000	30%	$0
	Total Relocation					**$0**	**Total Relocation**					**$0**	**Total Relocation**					**$41**	**Total Relocation**					**$338**	**Total Relocation**					**$1,307**

S AT AL1

Strategy	S(10) AT AL6; 1439-44						S(10) AT AL7; 1444-49						S(10) AT AL8; 1449-54						S(10) AT AL9; 1454-59						S(10) AT AL10; 1459-64					
	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contin.	Value (THOUSANDS)
Incremental Relocation	Residence	1	EA	$68,000	30%	$88	Residence	1	EA	$68,000	30%	$88	Residence	0	EA	$68,000	30%	$0	Residence	1	EA	$68,000	30%	$88	Residence	2	EA	$68,000	30%	$177
	Barn	2	EA	$72,000	100%	$288	Barn	2	EA	$72,000	100%	$288	Barn	1	EA	$72,000	100%	$144	Barn	7	EA	$72,000	100%	$1,008	Barn	1	EA	$72,000	100%	$144
	Shed	0	EA	$43,200	50%	$0	Shed	1	EA	$43,200	50%	$65	Shed	2	EA	$43,200	50%	$130	Shed	2	EA	$43,200	50%	$130	Shed	8	EA	$43,200	50%	$518
	Silo	1	EA	$20,500	100%	$41	Silo	0	EA	$20,500	100%	$0	Silo	0	EA	$20,500	100%	$0	Silo	0	EA	$20,500	100%	$0	Silo	0	EA	$20,500	100%	$0
	Government/Public	0	EA	$63,000	30%	$0	Government/Public	0	EA	$63,000	30%	$0	Government/Public	2	EA	$63,000	30%	$164	Government/Public	2	EA	$63,000	30%	$164	Government/Public	3	EA	$63,000	30%	$246
	Total Relocation					**$417**	**Total Relocation**					**$441**	**Total Relocation**					**$437**	**Total Relocation**					**$1,390**	**Total Relocation**					**$1,085**

Notes:
1. The costs for the Relocate All Structures at AL1 strategy (S) is equal to the sum of all relocations that have not been included in incremental relocations.

Table 4.8.2 - 3a

Economics Results: All Action Levels -- to Lake Level 1463
Feature 8.2: Stump Lake Rural Areas
Devils Lake Infrastructure Protection Study

Strategy		Stochastic Analysis (ST-9) Mean Value over 10,000 Traces (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / B
No Protection	No Protection or Relocation	$0	$0	$53,100	$53,100	$0	$0	--
S(10)	10 Incremental Relocations	$81,700	$81,700	$0	$0	$53,100	-$28,700	0.65

Strategy		Wet Future Scenario (WF-9) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / B
No Protection	No Protection or Relocation	$0	$0	$161,600	$161,600	$0	$0	--
S(10)	10 Incremental Relocations	$249,200	$249,200	$0	$0	$161,600	-$87,700	0.65

Strategy		Moderate Future 1 Scenario (M1-4) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / B
No Protection	No Protection or Relocation	$0	$0	$37,400	$37,400	$0	$0	--
S(10)	10 Incremental Relocations	$56,300	$56,300	$0	$0	$37,400	-$18,800	0.66

Strategy		Moderate Future 2 Scenario (M2-4) (Annual)						
		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / B
No Protection	No Protection or Relocation	$0	$0	$108,100	$108,100	$0	$0	--
S(10)	10 Incremental Relocations	$169,300	$169,300	$0	$0	$108,100	-$61,300	0.64

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 (D(S)).

Table 4.8.2 - 3b

Economics Results: Action Levels Up to 1454
Feature 8.2: Stump Lake Rural Areas
Devils Lake Infrastructure Protection Study

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

Strategy		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / B
No Protection	No Protection or Relocation	$0	$0	$44,200	$44,200	$0	$0	--
S(8)	8 Incremental Relocations	$67,100	$67,100	$0	$0	$44,200	-$22,900	0.66

Wet Future Scenario (WF-9)
(Annual)

Strategy		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / B
No Protection	No Protection or Relocation	$0	$0	$102,600	$102,600	$0	$0	--
S(8)	8 Incremental Relocations	$155,700	$155,700	$0	$0	$102,600	-$53,100	0.66

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

Strategy		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / B
No Protection	No Protection or Relocation	$0	$0	$37,400	$37,400	$0	$0	--
S(8)	8 Incremental Relocations	$56,300	$56,300	$0	$0	$37,400	-$18,800	0.66

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

Strategy		COST		DAMAGES		Total Benefits	Net Benefits	Benefit- Cost Ratio
		Relocation	Total	Damages	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D = C	E = D(No Protection) - D(S) *	F = E - B	I = E / B
No Protection	No Protection or Relocation	$0	$0	$118,300	$118,300	$0	$0	--
S(8)	8 Incremental Relocations	$179,800	$179,800	$0	$0	$118,300	-$61,500	0.66

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 "No Protection strategy" minus the total damages for the strategy implemented (D(S)).

Attachment 4.8:
Rural Areas Economic Analysis Assumptions

A. General Assumptions

1. The only viable strategy for the rural areas was to relocate residences, abandon public and private property, and relocate public utilities. The density of structures does not justify the cost for protection by a levee, and access is a potential problem if the structures were somehow protected.

2. The cost of road raises or road restoration was not considered for the rural areas in this report. Major roads in the region were analyzed as separate features, Features 13 through 24.

3. Areas that are protected by levees were not considered in the value of rural areas—these were included in the feature for the respective community or city.

4. A GIS database of structures was provided by FEMA and was used to inventory rural structures. This data included building descriptions, elevations, and for most of the structures, estimates of structure values. Rural structures were sorted using GIS tools to drop those structures that fall within the analytical boundaries of communities included in this study, including Devils Lake, Camp Grafton, St. Michael, Fort Totten, Minnewaukan, Churchs Ferry, and Grahams Island. From this inventory of rural structures, the data was further sorted by county, feature, and elevation range. Spirit Lake Nation reservation boundaries were also used to discern on-reservation v. off-reservation houses.

5. Average values for Feature 8.1 houses were obtained from FEMA values provided in 2001. The average value of rural houses located around Devils Lake, but not on the reservation, was $88,000. The average value for rural houses located on the Spirit Lake Nation Reservation was $62,000. These figures were obtained from the Federal Emergency Management Agency (FEMA). The average values for off-reservation and on-reservation houses were based upon 1,219 and 88 houses, respectively. 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. These values did not include the value of land on which the houses were located. FEMA has been using these average values for planning purposes only (*FEMA*, March, 2001). Contingency for houses was assumed to be 30 percent, to reflect the large database of costs, and therefore the relative certainty in quantity and unit price.

6. Average values for Feature 8.2: Stump Lake Rural Areas houses were assumed to be the values presented in the 1997 Depreciated Replacement Cost (*Economics Database Update for the Lands and Developments Feasibility Study, Devils Lake,* Watts & Associates, Inc., October, 1997). FEMA data was for the Stump Lake area was not available in time for this study. These values were updated for inflation by multiplying them by 1.09 to account for inflation of 3% per year during the period from

1998 to February 2001. Contingency for houses was assumed to be 30 percent, to reflect the large database of costs, and therefore the relative certainty in quantity and unit price.

7. The FEMA database did not provide an adequate data set of values for barns, sheds, or silos. The FEMA database did include estimated values for three barn structures, ranging from $100,000 to $200,000. Limited market research resulted in estimated costs for pre-fabricated metal structures at between $10 and $30 per square foot. At $30 per square foot, a 30-foot by 80-foot pole barn would result in $72,000 value. This was used as the assumed value for a barn. Sheds were assumed to be 24 feet by 60 feet, resulting in an assumed value of $43,200. Values for silos were developed by using data provided by the North Dakota State Water Commission (Michael Hove, 10/11/2002 phone call and follow-up data). While not comprehensive, this data provided a reasonable data set for silos included in the FEMA inventory, matched a subset of these with field observation, and placed values to each of these structures based on field dimensions and estimated structure cost per bushel storage. This analysis resulted in an average value of $20,453, and was used as the estimated average value for silos. Based on the uncertainty in the database counts for these structures, and the unit prices assumed, the contingency for these structures was assumed to be 100 percent.

8. The average value for churches located around Devils Lake was $265,000. This is based on a data set of six churches in the FEMA database. Based on the limited data set, a contingency of 100% was used in the cost analysis for relocations.

9. The average value for commercial buildings was $63,000. This was based on the average value throughout the Devils Lake are as included in the FEMA database (data set included 59 commercial buildings). Based on the range of building costs, a contingency of 100% was used in the cost analysis for relocations.

10. For Feature 8.1, within each increment it was assumed that structures would be relocated and land would be damaged when the water surface reached the ground elevation listed for each structure. For each action level, it was assumed that land and structures would be damaged when the water surface reaches the lower limit of the range. This assumption front-end loads the costs and damages for each increment. However, wave action could affect land and structures several feet above the lake's level and, therefore, actual damages might occur well before the lake reaches the land or structure elevation.

11. For Feature 8.2, there are only 4 structures that are located between the current lake elevation and 1464. Ten action levels were selected for this feature to compute the damages to land. Within these elevation increments, it was assumed that land and structures would be damaged when the water surface reaches the lower limit of the range, as in Feature 8.1.

12. Land value in rural areas was assumed to be $400/acre. This value was provided by the Corps of Engineers (personal communication, April, 2001) and is an estimate of the average value of all land surrounding Devils Lake.

13. The majority of Spirit Lake Nation Reservation residences are in Fort Totten and St. Michael and were considered separately in those features.

14. All structures and land in Nelson County are part of the Stump Lake watershed and would not be affected until Devils Lake overflows at elevation 1446.6. Therefore, the Stump Lake rural areas were analyzed separately from the Devils Lake rural areas. The relocation costs and damages for the Stump Lake rural areas were calculated with reference to Stump Lake water surface elevations, not Devils Lake water surface elevations.

15. In the 1998 study, costs for relocating rural utilities and damages to rural parks and boat ramps were included in the total damage values for structures and infrastructure. The total damage values were obtained from the *Economics Database Update for the Lands and Developments Feasibility Study, Devils Lake* by Watts & Associates, Inc. (October, 1997). However, relocation costs for utilities and damages to rural parks and boat ramps were not itemized in the Watts study and these data were not available elsewhere. Therefore, for this analysis these additional costs were not included in the total damages.

16. Land areas adjacent to Devils Lake and Stump Lake that would be affected by rising lake levels were obtained from the USGS (5-Box Model) elevation-volume-area relationships. Areas above elevation 1463 were extrapolated to elevation 1465.

4.10 Summary of Infrastructure Protection Investigation for Feature 10: Canadian Pacific Railroad

4.10.0 Flood Protection Strategy

The incremental flood protection that was analyzed for the Canadian Pacific Railroad was incremental rail raises.

4.10.1 General Information

Feature Type: Rail Line

Location: Feature 10 is the portion of the Canadian Pacific Railroad from the City of Devils Lake west to US Highway 281 near Harlowe. It extends approximately 18 miles from the City of Devils Lake to US Highway 281. The accompanying Figure 4.10-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: The rail line was constructed on raised embankments. It currently has approximately 3 miles near the west end of the line that is damaged, but not submerged, by a portion of Devils Lake at its current lake level. There are culverts under the rail line for water passage at Mauvais Coulee and Six Mile Bay.

Significance: The tracks between the City of Devils Lake and Harlowe were predominantly used for grain shipments. This rail line has been temporarily closed since 1998 due to erosion of the embankment. The current lake level (1447) is about 3 feet below the lowest elevation of the tracks (1450); however, wave action has caused erosion damage to the sides of the rail bed, making the rail line too dangerous to use. Grain is now trucked to a BNSF line instead of being shipped by rail. Northern Plains Railroad, lessee of Canadian Pacific Railroad tracks, does not consider the railroad "abandoned" because they intend to reopen the tracks if they receive funding from the US Congress for repair and raises. Instead the railroad is considered "embargoed."

Damages: The flooding of the Canadian Pacific Railroad would result in the following damages:

- Restoration damages resulting from repairs that would be necessary to bring the rail line back to a useable condition after a period of inundation
- Alternate shipping/detour damages when the rail line is closed

Owner/Sponsor: Canadian Pacific Railroad is responsible for managing and maintaining Feature 10: Canadian Pacific Railroad.