Lead Federal Agency: The Corps of Engineers would most likely take the lead for the Canadian Pacific Railroad for any flood protection work that may take place.

4.10.2 Feature Protection

History of Flood Protection: In the past, flood protection for the Canadian Pacific Railroad between Devils Lake and Harlowe has consisted of abandoning the rail line until funding is received to raise the rail line for future use.

General Protection Strategy: The Infrastructure Protection Study's analysis for the Canadian Pacific Railroad considered the only available incremental flood protection strategy, apart from abandonment. That flood protection strategy involved incremental raises of the rail line. The current low rail elevation is 1450; however, the railroad is currently out of service due to damage that has already occurred.

Protection Strategy by Lake Level: Figure 4.10-2 shows the decision tree for Canadian Pacific Railroad. As shown on Figure 4.10-2, the stepwise approach to flood protection for Canadian Pacific Railroad consists of the following:

1. At Action Level 1 (AL1), a decision would be made as to whether the rail line would be raised to 1458, or whether the rail line would be temporarily abandoned.

2. If the rail line were raised at AL1, a decision would be made at Action Level 2 (AL2) whether to raise the rail line to 1467, or whether to temporarily close the rail line.

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

Reference Elevations for Feature 10 Rail Raises			
Elevation			
AL1	**AL2**	**Name**	**Significance**
1450	1458	Low Structure Elevation	Low sill on lowest building or minimum railroad elevation
Current	1454	Lake Damage Elevation	Lake elevation at which damage to railway occurs (a 4-foot wave runup was calculated for this feature)
Current	N/A	Project Completion Elevation	Lake elevation at which railway construction must be complete
Current	1454	Construction Initiation Elevation	Lake elevation at which railway raise construction must begin.
Current	1452	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

4.10.3 Design Considerations

Sections 4.10.3.0 through 4.10.3.10 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 4.10.3.11 describes the abbreviated cost estimating method for a subsequent action level.

4.10.3.0 General Design

Alignment & Profile

Figure 4.10-1 shows the alignment of the existing Canadian Pacific Railroad. The raised rail line will follow the same alignment. The overall length of this segment of the rail line is approximately 18 miles, with approximately 7.4 miles of the rail to be raised. The current low rail elevation is 1450. Figure 4.10-4 shows the existing rail profile and raised rail profile. The proposed rail profile is at 1458.

Cross-section

Figure 4.10-3 shows a typical cross-section of the proposed rail raise. The raise will be accomplished by removing the existing rails, filling over the existing rail centerline with compacted embankment fill, placing riprap on both slopes, and installing new rails including ballast, subballast, ties and rails. The embankment crest will be 20 feet wide with 2H:1V side slopes.

Materials

It was assumed that the fill would be constructed from readily available native soils that are suitable for use as compacted embankment fill. The ballast and subballast would be constructed using commercially available coarse aggregates suitable for rail line embankment construction. The riprap would be constructed from commercially available stones of appropriate size for erosion protection as described below.

Erosion Protection

It was assumed that riprap would be placed on both slopes of the raised rail line embankment. The riprap is to be placed directly over the compacted fill material along the entire length of the slope from the crest down to the natural ground surface. No topsoil or seeding was assumed for the raised rail.

Riprap sizing and thickness was evaluated using COE methods and the COE *Shore Protection Manual,* with wave height calculated from the report titled, *Devils Lake, North Dakota, Wind-Induced Impacts to Water Elevations,* COE, 1998 revised edition. A summary of the riprap design, based on fetch, depth of water, and the side slope, follows:

Wind-Induced Wave Height (ft.)	Additional Freeboard (ft.)	Riprap size (D_{50})	Riprap Thickness (ft.)
3.0	1.0	42 inches	5

The riprap analysis appears to overestimate the size, based on typical rail line details. Discussions with BNSF staff and the report *Preliminary Evaluation of Joint Raise of BNSF Mainline Tracks and US Highway 2 in the Vicinity of Devils Lake, North Dakota* (Barr, March 2002), indicate a 4-foot freeboard and a 2-foot thickness of riprap is appropriate. It was recognized that some wave run-up or splashing along the top of the rails would be acceptable. Therefore, based on the referenced report (Barr, March 2002), the following parameters were assumed to provide erosion protection for the Canadian Pacific Railroad cross-section:

Freeboard (ft.)	Riprap size (D_{50})	Riprap Thickness (ft.)
4.0	16 inches	2

Construction Considerations

It was assumed that construction would take place under dry conditions where possible, and the planning and design would be complete prior to the rail line being impacted by wave action. Several miles of the track have recently been damaged due to wave action, but the tracks are not submerged; construction would need to be completed in partially wet conditions in these areas. Staging for the work would be within the 15-foot buffer zone from the toe slopes assumed for easements and would progress from one end along the length of the rail or from both ends and working towards the center. Crossings and culverts would be raised or extended as necessary prior to raising the rail adjacent to these facilities. It is assumed that construction would be completed with the necessary effort to complete in one season, as extended closures are extremely costly.

4.10.3.1 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 belong to formations of the Coleharbor Group.

The proposed improvement sections for the Canadian Pacific Railroad are underlain by bouldery clay till in a low-relief stagnation moraine of the Coleharbor Group. 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. Boring logs and cross-section information show that some sand and gravel outwash units may be present at depth. The uppermost bedrock is Cretaceous Pierre Shale.

As indicated principally 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 from Station 0 to Station 7. Some areas of the alignment (approximately from Station 7 to 18) have deposits associated with glacial pothole lakes and outwash deposits. Currently flooded areas may also have accumulated recent lake sediments, typically in areas overlying prehistoric Lake Minnewaukan.

As detailed in Figure 4.10-4, the proposed feature enhancements cross several soil types. The soil type descriptions are taken from the Soil Survey of Ramsey County (ref.), with a general description of each soil type's properties regarding road construction, (applicable to railroad bed improvement and levee construction). In the descriptions, "Slight" means soil properties and site characteristics are generally favorable for this use. "Severe" means special design may be required. Wetness and flooding are a given, since much of the area is currently inundated. Generally, soils belong to one of the following groups:

- Till – typically ML and CL to CL-ML loams. Typically these deposits are described as "Slight to "Moderate," primarily based on low strength and frost action. As such they usually are acceptable subgrade materials. In some localized areas, the soil materials are described as "Severe" alternately due to low strength, frost action, shrink-swell, flooding and wetness and may need soil correction measures. The majority of deposits underlying the alignment are till.

- Lake deposits – typically clay and silt loams, ML and CL to CL-ML with CH and organic clay OL areas. All of these lake deposits are generally described as "Severe" based on low strength, frost action, shrink-sell and wetness. Lake deposit materials typically require soil correction efforts. Lake bed deposits underlie approximately 48% of the alignments.

- Beach deposits or Outwash – typically sand and sandy loams, SP, SM-SP and SM with some quite gravelly areas (GM and GP-GM). These deposits are typically described as "Good" to "Slight" with frost action and wetness cited as concerns. These materials typically are suitable subgrade materials for road construction.

- Esker/Kame deposits – These deposits are similar in description to beach and outwash deposits but are typically much more coarse sand and gravelly with boulders and cobbles.

Characterizing the planned improvement portions of the alignment will require 12 soil borings.

4.10.3.2 Hydrology/Interior Drainage issues

It is assumed that the existing culverts will be maintained or extended through the raised rail embankment to allow for water level equalization on both sides of the rail line. These existing culverts will be extended as necessary to extend through the new embankment. Therefore, hydrology and drainage are not a concern for this feature other than maintaining the proper size culverts to maintain flows at the Mauvais Coulee crossing and Six Mile Bay crossing.

4.10.3.3 Real Estate Requirements

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

4.10.3.4 Environmental/Cultural issues

HTRW

Current land uses, surrounding the Canadian Pacific Railroad, appear to be predominantly agricultural with scattered rural residences and farms from Tilden to the City of Devils Lake limits. The rail line crosses through two small towns with less than 10 homes or buildings, Ramsey and Darby. These towns appear to be generally made up of rural residences but may potentially have other land uses including commercial or industrial. Land use does not appear to have changed significantly since the 1950s.

Regulatory record reviews for zip code 58301, which includes the City of Devils Lake, were obtained from FirstSearch on October 15, 2002. None of the properties listed in the FirstSearch report appear to be adjacent to the Canadian Pacific Railway.

One potential HTRW site identified along the alignment is listed below and shown on Figure 4.10-1:

HTRW Site Costs			
Site #	**Action Level Affected**	**HTRW Category**	**HTRW Costs**
10-1-1	1	Pipeline Crossings	$500

The site does not cross the portion of the alignment of concern; however, it is close enough to note. Site inspection visit to verify pipeline location with respect to impact area should be completed. An investigation is not anticipated, unless the feature construction should end up affecting this area in the future. A description of environmental concerns associated with these categories is in Section 4.0. A more detailed description of site history and a breakdown of costs are in Appendix C.

Cultural

This project has the potential to impact two known sites and three site leads/isolated finds as shown on Figure 4.10-1. The two known sites are both architectural properties: the Anderson House (32RY0192) and Grand Harbor Townsite 1 (32RY0403). Grand Harbor Townsite 1 has been recommended as potentially eligible for listing on the NRHP. The Anderson House, which is actually an historical farmstead, was studied during an evaluative survey and was recommended as eligible for listing on the NRHP, both individually and as part of a potential historic district.

The site leads that may fall within the Canadian Pacific Railroad area of potential effect include two historical archaeological site leads: 32BEX0053 (Spaulding Ferry) and 32RYX0027 (Darby Station). Isolated find 32RYX0105 is prehistoric archaeological in nature.

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

Feature 10 Canadian Pacific Railroad: 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	2	0
Architectural Site Leads/Isolated Finds	0	0	0
Archaeological Site Leads/Isolated Finds	0	0	3
Total	0	2	3

The estimated cost to conduct Phase 1 Surveys for each of the 3 sites is presented in the following table. The total cost for all surveys is $36,000. As noted in Section 4.0, these

costs are believed representative of the cultural resources investigations needed for the next stage of study.

Feature 10 Canadian Pacific Railroad: Phase 1 Survey Costs		
Site Number	**Investigation Type**	**Estimated Cost**
32BEX0053	Phase I Archaeological	$14,000
32RYX0027	Phase I Archaeological	$14,000
32RYX0105	Phase I Archaeological	$8,000

Environmental

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 natural resources within the right-of-way of Canadian Pacific Railroad include wetlands, oak forest/woodlands, and grasslands. The acres of habitat impacted by land use category are shown on Figure 4.10-1. A total of 0.35 acres of wetland easement areas and 10.24 acres of other 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. These environmental impacts are more fully detailed in the general impacts discussion Section 4.0. This loss of wetland would require 20.83 acres of mitigation wetlands as set forth in the project mitigation policy developed through consultation with the Corps and FWS.

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. These environmental impacts are more fully detailed in the general impacts discussion Section 4.0. A total of 0.83 acres of oak forest/oak woodland with 0.17 of those acres under easement, 6.48 acres of grasslands under easements, 26.56 acres of other grassland habitat and 1.31 acres of cover crop under easements would be impacted 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 1.49 acres of oak forest/oak

woodland, 59.6 acres of grasslands habitat and 1.31 acres of cover crop like upland habitat areas for these impacts.

4.10.3.5 Effects on Existing Infrastructure and Utilities

The existing infrastructure and utilities affected by raising the Canadian Pacific Railroad are road crossings, culverts, and crossing signals. There are several uncontrolled local road crossings that must be raised and one gated vehicle crossing that must be raised. Also, as mentioned above, existing culverts will have to be extended through the new embankment. There are no other known utilities or facilities affected by raising the Canadian Pacific Railroad.

4.10.3.6 Interdependencies

The protection of the Canadian Pacific Railroad is related to the protection of the following other features:

- Feature 2: City of Devils Lake – Collection of grain in the City of Devils Lake may increase truck traffic in the city during any closures of this rail line
- Feature 13: US Highway 2 – Shipments of grain will increase truck traffic on US Highway 2 during any closures of this rail line
- Feature 16: US Highway 281 (South of US Highway 2) – Shipments of grain will increase truck traffic on US Highway 281 during any closures of this rail line
- Feature 18: ND Highway 19 – Shipments of grain will increase truck traffic on ND Highway 19 during any closures of this rail line

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

4.10.3.7 O&M

Operation and maintenance requirements for the raised rail line would be similar to the unimpacted rail line with respect to rails, ties, and shoulder maintenance. Additional maintenance requirements for the raised rail sections would include maintenance of the riprap on the slopes. 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.

4.10.3.8 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 Canadian Pacific Railroad, estimates of required times for the rail line raise 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 – raising of the Canadian Pacific Railroad 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.

4.10.3.9 Potential Problems and Risks

The greatest risk associated with the raising of the Canadian Pacific Railroad is the uncertainty with the rate of the lake level changes. If the lake level rises faster than anticipated the lead time necessary to implement the raise may be inadequate, requiring portions of the construction to be completed in wet conditions.

4.10.3.10 Data Deficiencies

The following data should be collected or verified prior to proceeding with raising the Canadian Pacific Railroad:

- Locate above ground and buried utilities, if any
- Perform soil borings as necessary prior to raising the rail
- Locate and evaluate nearby cultural resources that were identified
- Review Canadian Pacific Railroad property holdings along the rail line and the proposed right-of-way requirements

4.10.3.11 Abbreviated Cost Estimating for Feature Subsequent Action Levels

As was mentioned previously, for Feature 10, an abbreviated method was necessary for examining the costs of infrastructure protection at the second action level. The estimated costs at action levels subsequent to the first are presented in Table 4.10-2b. 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 4.10-1.

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

Design Assumptions

- Raise elevation

  Action Level 2: 9-foot raise to 1467

- Cross-section

  Action Level 2: 20-foot top width, 2H:1V side slopes, centerline-aligned raise

- Length

  Action Level 2: Total length of raised railroad- 74,450 feet

- Impacted Area

  Action Level 2: Incremental area impacted by raised railroad- 110 acres

Construction material quantities were calculated in accordance with design assumptions discussed previously, and are listed in Table 4.10-2b. 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 proportional to the impacted area of the raise.

4.10.4 Economics of Flood Protection

Damages: For the Infrastructure Protection Study's analysis, the flood damage estimates for the Canadian Pacific Railroad were reassessed in order to update and more accurately characterize the nature of the damages. The updated damage computations for the Canadian Pacific Railroad are summarized in the accompanying Table 4.10-1.

The top portion of table 4.10-1 gives a summary of the annual detour damages that would occur during the years when the rail line is flooded. It also shows railroad restoration damages that can be expected once the lake recedes.

The lower portion of the table shows the breakdown of these summary values. It gives quoted costs from the rail line for detour damages and cost per lineal foot of rail for restoration damages. The restoration units include excavation and rail removal per lineal foot and installation of new rail per lineal foot. Restoration damages are assumed necessary when water reaches the rail elevation and then recedes.

Unit prices for all the damage computations were listed in Section 4.0, and are detailed in Table 4.0-2. A list of assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for Canadian Pacific Railroad are listed in the Canadian Pacific Railroad Infrastructure Protection Study Assumptions listing, attached to this Section 4.10.

Costs: The updated costs of providing flood protection for the Canadian Pacific Railroad are detailed in the accompanying Table 4.10-2a for the first action level and in Table 4.10-2b for the second action level. Unit prices, data sources, and relevant assumptions are listed. All costs are given in 2002 dollars.

The top portion of the table gives the cost of providing flood protection as presented in the Infrastructure Protection Study. The lower portion of the table provides a cost breakdown of the quantities and costs by line item: fill, riprap, crossings, gated crossings, bridge raise, culverts, mainline train traffic control signals, and track installation. Also included in this portion of the table are geotechnical, environmental, engineering, and real estate right-of-way costs.

Unit prices for all the cost computations were discussed previously in Section 4.0, and are detailed in Table 4.0. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for the Canadian Pacific Railroad are listed in the Canadian Pacific Railroad Assumptions listing, appended to this Section 4.10.

Contingencies: The contingency percentages used for construction materials ranged from 30 to 50% (Table 4.10-2). Contingencies for riprap, fill material, culverts, and geotechnical items were estimated at the higher end of the range because of the potential variability in the quantities and unit prices.

4.10.5 Economic Results

The flood protection strategy that was analyzed was incremental rail raises, which is highlighted on the decision tree (Figure 4.10-2). The results of the Infrastructure Protection Study for

Canadian Pacific Railroad are listed in Table 4.10-3a for the analysis of all action levels and in Table 4.10-3b 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 Canadian Pacific Railroad, the Infrastructure Protection Study analysis provided relevant economic indices for raising the rail line. The annual net benefits for this approach were less than zero (-$895,900). The BCR for this approach was less than one (0.48). These results show that this strategy is not economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $212,700. The stochastic results are averages over 10,000 traces.

Multiple Action Level Results for Specific Scenarios: Raising the rail line was also analyzed under each of three specific climate futures. For Canadian Pacific Railroad, 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 rail line were –$2,646,700, and the BCR was 0.17, indicating that this strategy was not economically justified. No restoration damages are listed under this scenario, indicating that the water level never recedes below the first action level. For this future, the present worth annualized detour damages that would be prevented were computed at $219,700.

- First Moderate Future – Under the first moderate future climate scenario, the annual net benefits of raising the rail line were $272,500, and the BCR was 1.19, indicating that this strategy was economically justified. The positive net benefits reflect that the high costs for the second action level were never reached, but the first action level appears to be economically justified under this future; there are also high restoration damages that are prevented under this future. For this future, the present worth annualized detour damages that would be prevented were computed at $212,900.

- Second Moderate Future – Under the second moderate future climate scenario, the annual net benefits of raising the rail line were -$2,135,100, and the BCR was 0.22, indicating that this strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $384,600.

First Action Level Stochastic Analysis Results: Using the stochastic analysis along with the updated damage and cost estimates for Canadian Pacific Railroad, the Infrastructure Protection Study analysis also provided relevant economic indices for the first raise of the rail line. The annual net benefits for this approach were less than zero (-$654,500). The BCR for this approach was less than one (0.54). These results show that this strategy is not economically justified. The

present worth annualized detour damages that would be prevented by this strategy were computed to be $212,700. The stochastic results are averages over 10,000 traces.

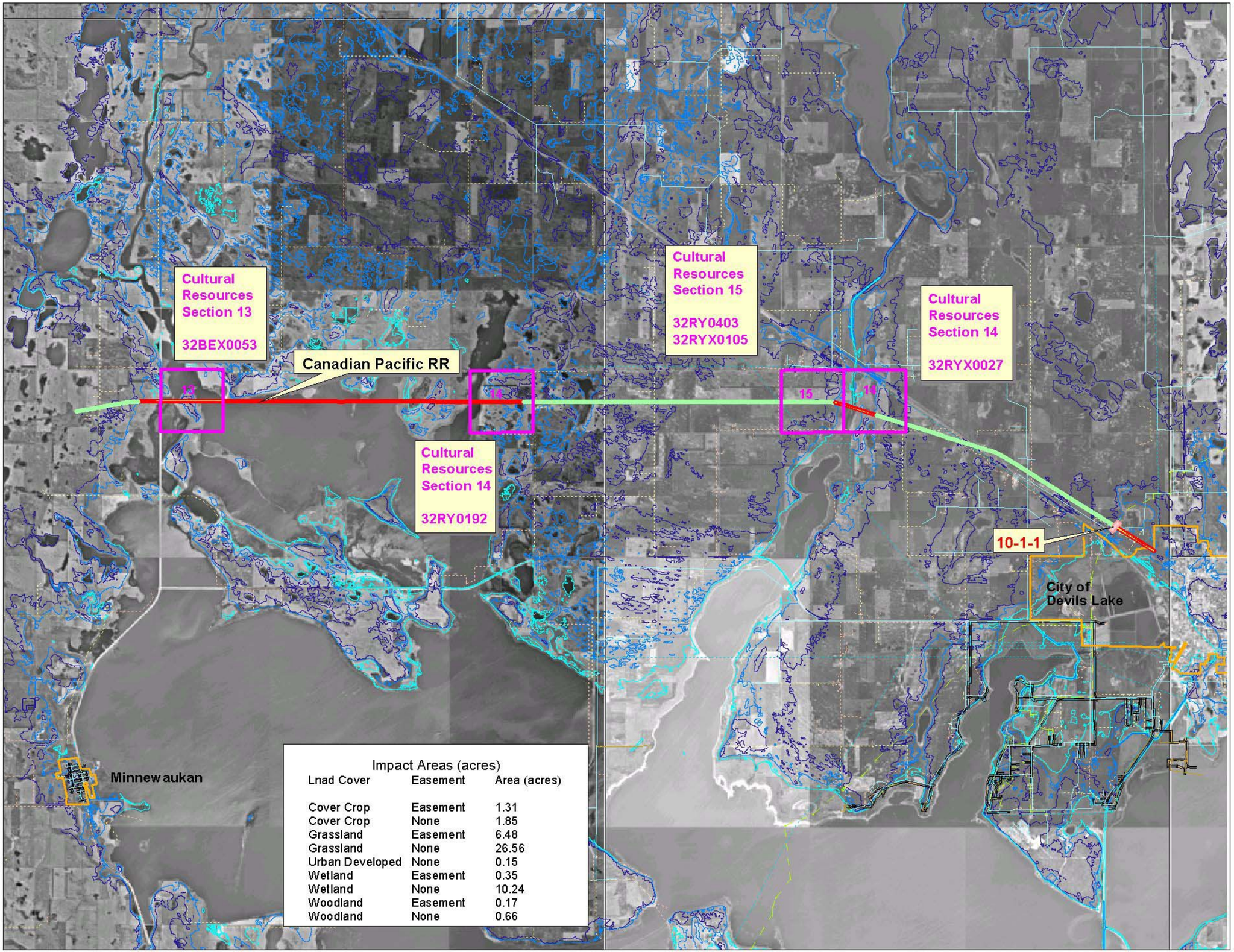
First Action Level Results for Specific Scenarios: Raising the rail line was also analyzed under each of three specific climate futures. For Canadian Pacific Railroad, the economic indices for each of the three climate futures are as follows:

- Wet Future – Under the wet future climate scenario, the annual net benefits of raising the rail line were -$1,193,600, and the BCR was 0.16, indicating that this strategy was not economically justified. No restoration damages are listed under this scenario, indicating that the water level never recedes below the first action level. For this future, the present worth annualized detour damages that would be prevented were computed at $219,700.

- First Moderate Future – Under the first moderate future climate scenario, the annual net benefits of raising the rail line were $272,500, and the BCR was 1.19. The positive net benefits reflect that the first action level appears to be economically justified under this future; there are also high restoration damages that are prevented under this future. For this future, the present worth annualized detour damages that would be prevented were computed at $212,900.

- Second Moderate Future – Under the second moderate future climate scenario, the annual net benefits of raising the rail line were -$1,028,700, and the BCR was 0.27, indicating that this strategy was not economically justified. No restoration damages are listed under this scenario; the lake level exceeds the second action level, and restoration damages would be a function of the subsequent action levels[1]. For this future, the present worth annualized detour damages that would be prevented were computed at $384,600.

[1] For analysis of the first action level, it was assumed that restoration damages would be attributable to the first action level only if the lake level never reached the subsequent action levels. See Section 3.2.2.1 for further discussion of this assumption.



Impact Areas (acres)

Lnad Cover	Easement	Area (acres)
Cover Crop	Easement	1.31
Cover Crop	None	1.85
Grassland	Easement	6.48
Grassland	None	26.56
Urban Developed	None	0.15
Wetland	Easement	0.35
Wetland	None	10.24
Woodland	Easement	0.17
Woodland	None	0.66

N
W E
S

0.5 0 0.5 1 1.5 2 Miles

Reference Lake Contours
- 1447
- 1454
- 1463

Railroads
- Raised
- No Action

ROW

HTRW Sites

Cultural Resources Sites

Corporate Boundary

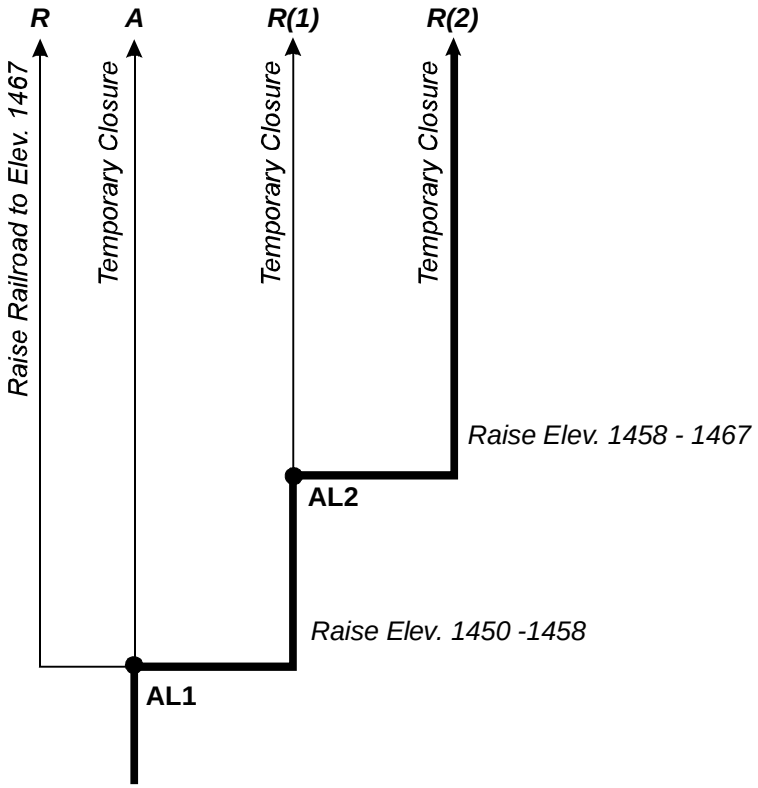
Utilities
- Electric
  - Overhead
  - Underground
  - Unknown
- Water
  - Watermain
  - Watermain, Abandoned
- Sewer
  - Sewer
  - Sewer, Abandoned
- Gas

Figure 4.10-1

LOCATION MAP
FEATURE 10: CANADIAN PACIFIC RAILROAD
Devils Lake Infrastructure Protection Study

Data: 1997 USGS Digital Ortho Quad

Barr: Arcview 3.1, OPT2615, i:\client\devilslake\gis\dlip\features\roadandrails\rails\10_cpr\project\basemap_10.apr, Layout: Layout: Section 4 Figure, lkp, Tue Nov 19 13:42:06 2002



Lowest Rail Elevation: 1450

P:\34\36\020\DECISIONTREES\2002FIGURES\FIGURE4_10.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 railroad raise (number of times)
R	Railroad raise to 1467
A	Temporary closure of railroad

Figure 4.10-2

DECISION TREE
FEATURE 10: CANADIAN PACIFIC RAILROAD
Devils Lake Infrastructure Protection Study

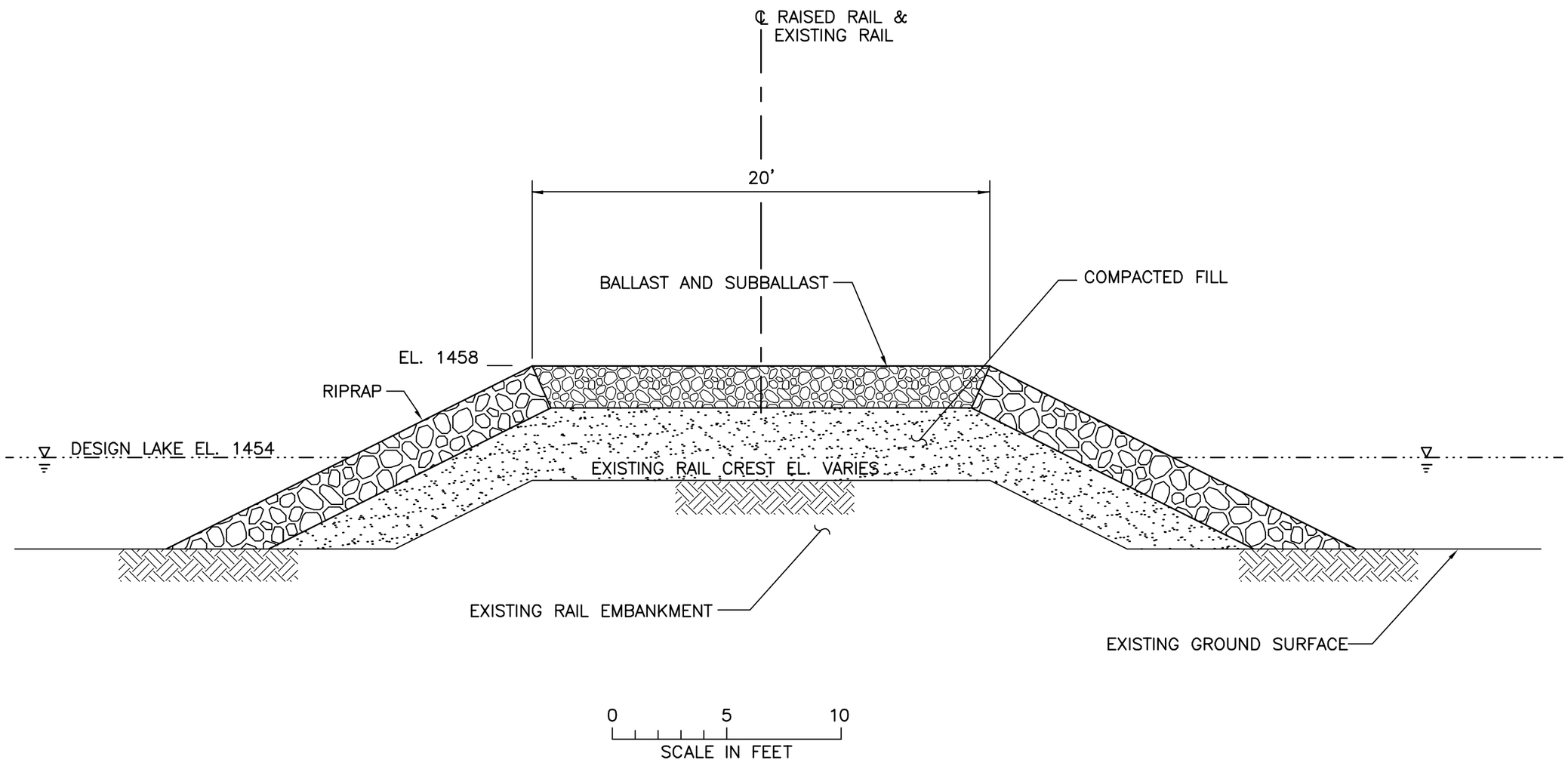


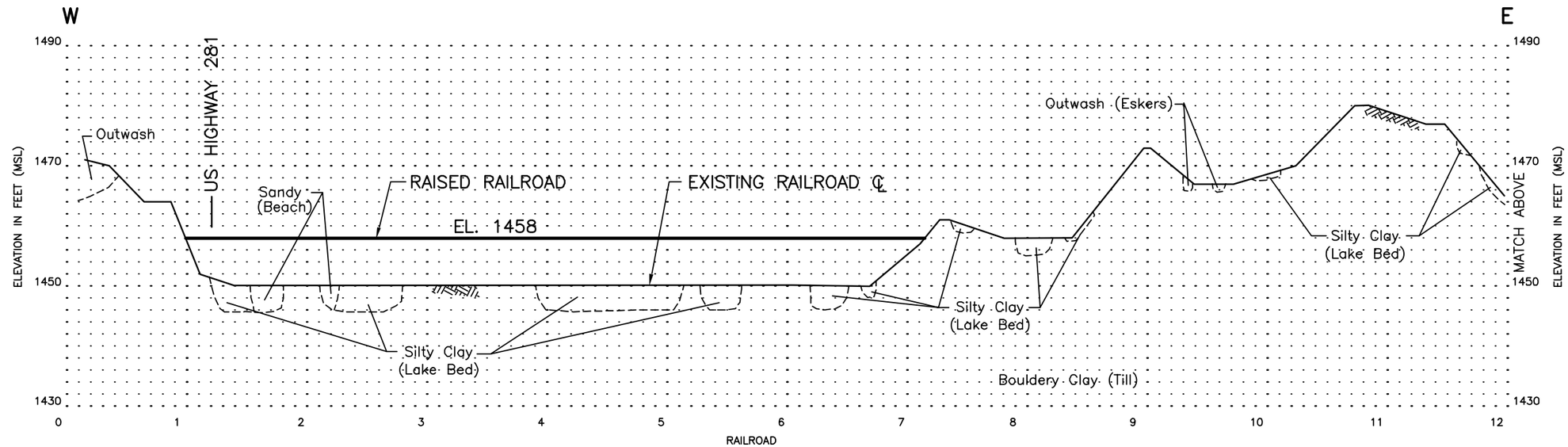
Figure 4.10–3

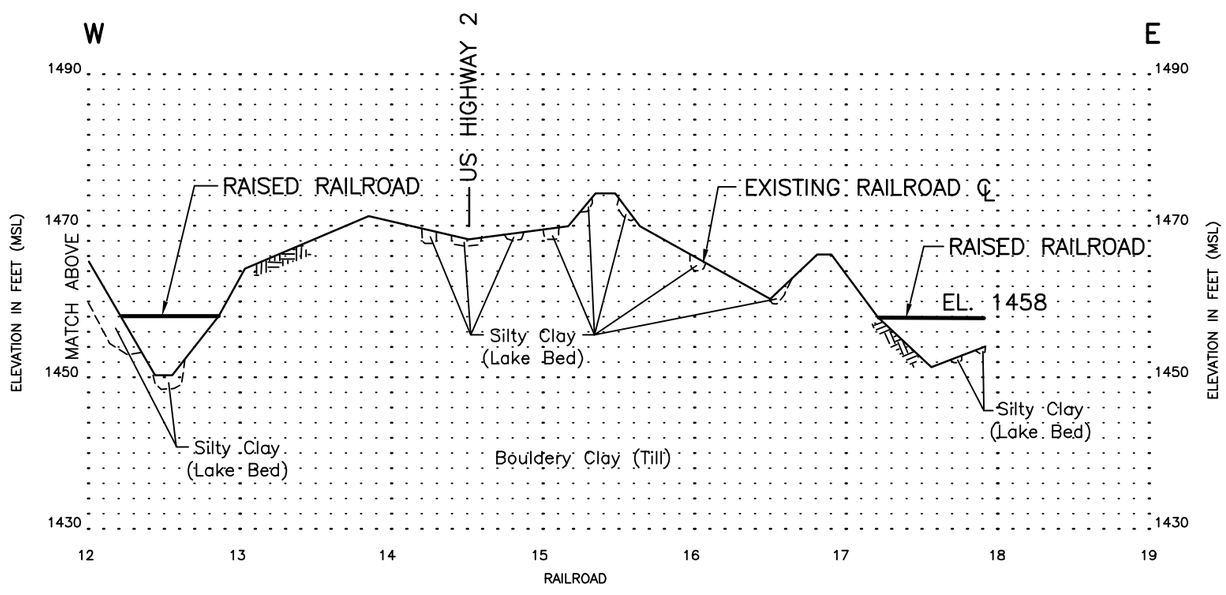
TYPICAL RAILROAD CROSS–SECTION

FEATURE 10:
CANADIAN PACIFIC RAILROAD

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

NRD M:\CAD\3436020\17208_1.dwg Plot at 5 11/06/2002 14:07:21





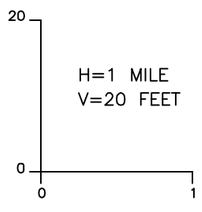


Figure 4.10–4

RAILROAD PROFILE

FEATURE 10:
CANADIAN PACIFIC RAILROAD

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

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Table 4.10-1

Flood Damages
Feature 10: Canadian Pacific Railroad
Devils Lake Infrastructure Protection Study

DAMAGES

	Annual Detour Damages	Restoration Damages	
Lake Elevation (MSL)	**Damage Value (THOUSANDS)**	**Impacted Railroad Length (FEET)**	**Damage Value (THOUSANDS)**
1447	$533	25,000	$8,586
1448	$533	26,000	$8,807
1449	$533	27,000	$9,028
1450	$533	28,510	$9,362
1451	$533	28,510	$9,362
1452	$533	29,730	$9,632
1453	$533	31,730	$10,074
1454	$533	33,060	$10,368
1455	$533	36,490	$11,126
1456	$533	37,610	$11,373
1457	$533	38,620	$11,596
1458	$533	39,560	$11,804
1459	$533	40,410	$11,992
1460	$533	41,260	$12,180
1461	$533	42,040	$12,352
1462	$533	47,560	$13,572
1463	$533	49,630	$14,030
1464	$533	50,920	$14,315
1465	$533	53,240	$14,827

DAMAGE BREAKDOWN

Annual Detour Damages	**Description**	**Quantity**	**Units**	**Unit Cost**	**Value (THOUSANDS)**
	Detour Damages	1	LS	$533	$533
	Total				**$533**

Restoration Damages	**Item**	**Description**	**Quantity per LF of Railroad**		**Unit Cost**	**Contingency**	**Value per LF of Railroad**
	Excavation/Rail Removal	Removal of existing rail, ballast, and subballast	1.35	CY/LF	$7.41	30%	$13.00
	Install New Rail	Install new rails, ballast, subballast, and ties	1.00	LF	$160.00	30%	$208.00
	Total						**$221**
	Item	**Description**	**Quantity per LF of Railroad**		**Unit Cost**	**Contingency**	**Total Value for Railroad**
	Riprap	Place riprap from road surface elevation to bottom of embankment replacement for	1.89	CY/LF	$40.00	30%	$2,801,963
	Geotextile Fabric	For use under riprap restoration	3.5	SY/LF	$2.00	30%	$259,441
	Total						**$3,061,404**

Table 4.10-2a

Flood Protection Costs
Feature 10: Canadian Pacific Railroad
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	R(1)
Action Level	Incremental Raise at AL1
	(THOUSANDS)
AL1	$23,234

COST BREAKDOWN

Strategy	R(1)					
	Description	Quantity	Units	Unit Cost	Contingency	Value (THOUSANDS)
Rail Raise	**Raise Rail to Elevation 1458**					
	Performance/Payment Bond	1	JB	$129,731	10%	$143
	Fill Material	305,700	CY	$5.00	50%	$2,293
	Riprap	129,000	CY	$40	40%	$7,224
	Crossings (concrete structure)	3	EA	$32,000	30%	$125
	Vehicle Crossing Signals (gated)	1	EA	$140,000	30%	$182
	Culverts	2	EA	$25,000	50%	$75
	Track Installation	39,070	LF	$170	30%	$8,634
	Geotechnical					
	Slurry Wall	0	SF	$6.00	50%	$0
	Borings	12	EA	$1,000	50%	$18
	Environmental Impacts					
	Mitigation	1	LS			$30
	HTRW	1	LS			$1
	Cultural Resources Investigation	1	LS			$36
		Subtotal				$18,761
	Engineering and Design		15%			$2,814
	Supervision and Administration		8%			$1,501
	Real Estate Acquisition for ROW	1	LS			$158
	Total Rail Raise					**$23,234**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Rail Maintenance Costs
	(THOUSANDS)
AL1	$93

Table 4.10-2b

Flood Protection Costs
Feature 10: Canadian Pacific Railroad
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	R(2)
Action Level	Incremental Raise at AL2
	(THOUSANDS)
AL2	$44,027

COST BREAKDOWN

Strategy	R(2)					
	Description	Quantity	Units	Unit Cost	Contingency	Value (THOUSANDS)
Rail Raise	**Raise Rail from 1458 to Elevation 1467**					
	Performance/Payment Bond	1	JB	$247,179	10%	$272
	Fill Material	928,700	CY	$5.00	50%	$6,965
	Riprap	303,500	CY	$40	40%	$16,996
	Crossings (concrete structure)	3	EA	$32,000	30%	$125
	Vehicle Crossing Signals (gated)	1	EA	$140,000	30%	$182
	Culverts	2	EA	$25,000	50%	$75
	Track Installation	49,630	LF	$170	30%	$10,968
	Geotechnical					
	Slurry Wall	0	SF	$6.00	50%	$0
	Borings	4	EA	$1,000	50%	$6
	Environmental Impacts					
	Mitigation	1	LS			$39
	HTRW	1	LS			$0
	Cultural Resources Investigation	1	LS			$0
	Subtotal					$35,628
	Engineering and Design		15%			$5,344
	Supervision and Administration		8%			$2,850
	Real Estate Acquisition for ROW	1	LS			$204
	Total Rail Raise					**$44,027**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Rail Maintenance Costs
	(THOUSANDS)
AL2	$177

Table 4.10 - 3a

Economics Results: All Action Levels -- to Lake Level 1463
Feature 10: Canadian Pacific Railroad
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
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$571,600	$212,700	$784,300	$0	$0	--
R(3)	3 Incr. Rail Raises	$1,708,600	$1,708,600	$0	$0	$0	$812,700	-$895,900	0.48

Wet Future Scenario (WF-9)
(Annual)

Strategy		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$219,700	$219,700	$0	$0	--
R(3)	3 Incr. Rail Raises	$3,179,700	$3,179,700	$0	$0	$0	$533,000	-$2,646,700	0.17

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

Strategy		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$1,472,900	$212,900	$1,685,800	$0	$0	--
R(3)	3 Incr. Rail Raises	$1,413,300	$1,413,300	$0	$0	$0	$1,685,800	$272,500	1.19

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

Strategy		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$135,000	$384,600	$519,600	$0	$0	--
R(3)	3 Incr. Rail Raises	$2,725,500	$2,725,500	$0	$0	$0	$590,400	-$2,135,100	0.22

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 "Temporary Closure" strategy minus the total damages for the strategy implemented (E(S)).

Table 4.10 - 3b

Economics Results: First Action Level
Feature 10: Canadian Pacific Railroad
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
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$541,200	$212,700	$753,900	$0	$0	--
R(1)	1 Incremental Rail Raise	$1,408,400	$1,408,400	$0	$0	$0	$753,900	-$654,500	0.54

Wet Future Scenario (WF-9)
(Annual)

Strategy		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$219,700	$219,700	$0	$0	--
R(1)	1 Incremental Rail Raise	$1,413,300	$1,413,300	$0	$0	$0	$219,700	-$1,193,600	0.16

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

Strategy		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$1,472,900	$212,900	$1,685,800	$0	$0	--
R(1)	1 Incremental Rail Raise	$1,413,300	$1,413,300	$0	$0	$0	$1,685,800	$272,500	1.19

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

Strategy		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
		Raise	Total	Restoration	Detour	Total	To Strategy (Damages Prevented)	To Strategy	(BCR)
Designation	Description	A	B = A	C	D	E = C + D	F = E(A) - E(S) *	G = F - B	I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$384,600	$384,600	$0	$0	--
R(1)	1 Incremental Rail Raise	$1,413,300	$1,413,300	$0	$0	$0	$384,600	-$1,028,700	0.27

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 "temporary closure strategy" minus the total damages for the strategy implemented (E(S)).

Attachment to 4.10:
Canadian Pacific Railroad Economic Analysis Assumptions

A. General Assumptions

1. The following assumptions were used in developing the 2002 costs for raising or restoring the Canadian Pacific Railroad. The assumptions are based on two reports and discussions with representatives of the railroad. The reports referenced include, "Technical Appendix; Economic Analysis of Devils Lake Alternatives," by Barr Engineering, November 2001 and "Preliminary Evaluation of Joint Raise of BNSF Mainline Tracks and US Highway 2, in the Vicinity of Devils Lake, North Dakota," by Barr Engineering, March 2002.

2. Centerline profile was established using 2000 FEMA Lidar topography.

3. Based on conversation with Greg Haug of Northern Plains Railroad, lessee of Canadian Pacific Railroad (CPR) tracks, CPR would not reroute rails to higher ground. Rerouting the track would be extremely costly. Even rebuilding a portion of the track within the railroad's right-of-way has proven to be an expensive effort. The railroad would likely raise the tracks to keep the line open as the lake level rises.

4. It was assumed that 4 feet of freeboard would be required for all railroads. The assumed freeboard was based on the referenced March 2002 report.

5. The railroad has been closed since 1998. The current lake level (1447) is 3 feet below the lowest elevation of the tracks (1450); however, wave action has caused erosion damage along the non-protected sides of the rail bed. A portion of the railroad has failed, making the railroad too dangerous to use.

6. The bridges along this railroad stretch have been removed and replaced with culverts according to Greg Haug of CPR.

7. Olson Engineering (a consultant for CPR) previously estimated that raising 8.5 miles of this track to 1460 would cost $20M dollars.

B. Railroad Raise

1. Based on conclusions reached in the referenced March 2002 report, it would be cost prohibitive to raise a railroad in increments due to the down time necessary to raise the track. Therefore, it was assumed that the railroad would be raised to 1458 in one step rather than multiple raises.

2. Side slopes for raises and repair of rail beds were assumed to be 2H:1V.

3. Filter fabric will not be used under riprap for railroad raises.

4. Crest width was assumed to be 20'-0".

5. The cost to install rails (including removal of old rails, and placement of new rails, ties, ballast, and subballast) was estimated to be $170 per lineal foot. The Economic Analysis previously assumed the cost to be $135 per lineal foot. This cost was increased to include $10 for removal of existing rails, $20 for subballast, and inflation.

6. The cost for rail restoration was estimated to be $170 per lineal foot. The cost assumes that after the rail is flooded and water recedes, the top 20 inches of the rail must be restored. Restoring the top 20 inches includes replacing the ballast, subballast, ties and rail.

7. The cost for fill material is $5 per cubic yard based on available data for this area.

8. The cost of riprap material $40 per cubic yard based on available data for this area.

9. The costs for crossing raises, culverts, signals, and bridge raises obtained from Table D-1 of the referenced March 2002 report:

   - Crossings (concrete structure): $20,000 each plus $11,800 for aggregate subbase is approximately $32,000 per crossing.

   - Vehicle Crossing Signals (gated): Each $140,000.

   - Culverts: For 5 culverts the total cost was $137,800 or approximately $27,560 per culvert. However, the cost varied greatly from $6,300 to $57,000 depending on type. Thus, a slightly skewed average of $25,000 versus $27,560 was used for estimating purposes. There is also a contingency used within the cost table.

10. The annual maintenance cost for the railroad was assumed to be 0.5% of the construction costs.

C. Detours

1. The tracks between the City of Devils Lake and Harlowe were predominantly used for grain shipments. Grain is now trucked to a BNSF line instead of being shipped by rail. This increases shipment costs by approximately $480,000 per year (based on conversations with Greg Haug-Northern Plains Railroad, lessee of CPR tracks). Mr. Haug recommended increasing the shipment costs provided in the Economic Analysis to account for inflation. Therefore, it was assume detour damages are $533,000.

4.11 Summary of Infrastructure Protection Investigation for Feature 11: Burlington Northern Railroad (Along US Highway 2)

4.11.0 Flood Protection Strategy

The flood protection strategy that was analyzed for Burlington Northern Railroad (Along US Highway 2) was a raise to 1467.

4.11.1 General Information

Feature Type: Rail Line

Location: Feature 11 is the portion of the Burlington Northern Railroad (along US Highway 2) from the City of Devils Lake northwest to Churchs Ferry. The accompanying Figure 4.11-1 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. Two concrete bridges are located along this stretch of rail. One bridge is spans Channel "A" and a second bridge spans the Mauvais Coulee near Churchs Ferry.

Significance: The Burlington Northern Railroad (along US Highway 2) is important because the track is a transcontinental freight route that extends from the State of New York to the State of Washington (through Devils Lake). Amtrak passenger routes use the track and many other companies use the track for shipping a variety of products across the country.

Damages: The flooding of the Burlington Northern Railroad (along US Highway 2) 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: The Burlington Northern and Sante Fe Railway Company (BNSF) is responsible for managing and maintaining Feature 11.

Lead Federal Agency: The Corps of Engineers would most likely take the lead for the Burlington Northern Railroad (along US Highway 2) for any flood protection work that may take place.

4.11.2 Feature Protection

History of Flood Protection: Flood protection for the Burlington Northern Railroad (along US Highway 2) between Devils Lake and Churchs Ferry consisted of a track raise in the vicinity of the Mauvais Coulee near Churchs Ferry. BNSF raised the track up 3 feet at various reaches of the track to maintain the track at 1456 or higher.

General Protection Strategy: The Infrastructure Protection Study's analysis for the Burlington Northern Railroad (along US Highway 2) considered one flood protection strategy. That flood protection strategy was the only strategy that was feasible both from an economic and a constructability standpoint. The strategy involved raising the rail line to 1467. This would allow for a maximum lake elevation of 1463 with 4 feet of freeboard. Incremental raises of this rail line were not feasible due to the high cost of raising the two bridges and the impacts of repeated closures of this line.

Protection Strategy by Lake Level: Figure 4.11-2 shows the decision tree for Burlington Northern Railroad (along US Highway 2). As shown on Figure 4.11-2, the stepwise approach to flood protection for Burlington Northern Railroad (along US Highway 2) consists of the following:

1. At Action Level 1 (AL1), a decision would be made as to whether the rail line would be raised to 1467, or whether the rail line would be temporarily abandoned.

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

Reference Elevations for Rail Raise (AL1)		
Elevation	**Name**	**Significance**
1456	Low Structure Elevation	Low point on top of rail line
1452	Lake Damage Elevation	Lake elevation at which rail line becomes unusable (assume 4-foot freeboard)
1452	Project Completion Elevation	Lake elevation at which rail line raise construction must be complete
1452	Construction Initiation Elevation	Lake elevation at which rail line raise construction must begin
1450	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

4.11.3 Design Considerations

4.11.3.0 General Design

Alignment & Profile

Figure 4.11-1 shows the alignment of the existing Burlington Northern Railroad (along US Highway 2). The raised railroad will follow the same alignment. The overall length of this segment of the railroad is approximately 28 miles, with approximately 19 miles of the railroad to be raised. The current low rail elevation is 1456. Figure 4.11-4 shows the existing rail profile and raised rail profile.

Cross-section

Figure 4.11-3 shows a typical cross-section of the proposed railroad raise. The raise will be accomplished by removing the existing rails, placing compacted embankment fill over the existing rail centerline, placing riprap on both slopes, and installing ballast, subballast, ties and rails. The embankment crest will be 16 feet wide with 2H:1V side slopes.

Materials

It was assumed that the fill would be constructed from readily available native soils that are suitable for use as compacted embankment fill. The ballast and subballast would be constructed using commercially available coarse aggregates suitable for rail line embankment construction. The riprap would be constructed from commercially available stones of appropriate size for erosion protection as described below.

Erosion Protection

It was assumed that riprap would be placed on both slopes of the raised rail embankment. The riprap is to be placed directly over the compacted fill material along the entire length of the slope from the crest down to the natural ground surface. No topsoil or seeding was assumed for the raised rail.

Riprap sizing and thickness was determined using COE methods and the COE *Shore Protection Manual*, with wave height calculated from the report titled, *Devils Lake, North Dakota, Wind-Induced Impacts to Water Elevations*, COE, 1998 revised edition. A summary of the riprap design, based on fetch, depth of water, and the side slope, follows:

Wind-Induced Wave Height (ft.)	Additional Freeboard (ft.)	Riprap size (D_{50})	Riprap Thickness (ft.)
4.9	1.0	66 inches	8.4

The riprap analysis appears to overestimate the size, based on typical rail line details. Discussions with BNSF staff and the report *Preliminary Evaluation of Joint Raise of BNSF Mainline Tracks and US Highway 2 in the Vicinity of Devils Lake, North Dakota* (Barr, March 2002), indicate a 4-foot freeboard and a 2-foot thickness of riprap is appropriate. It was recognized that some wave run-up or splashing along the top of the rail line would be acceptable. Therefore, based on the referenced report (Barr, March 2002), the following parameters were assumed to provide erosion protection for the typical rail line cross-section:

Freeboard (ft.)	**Riprap size (D_{50})**	**Riprap Thickness (ft.)**
4.0	16 inches	2

Construction Considerations

It was assumed that construction would take place under dry conditions where possible. Several miles of the track are currently being affected by wave action (although the tracks are not submerged) and construction may need to be completed in partially wet conditions in these areas. Staging for the work would be within the 15-foot buffer zone from the toe slopes assumed for easements and would progress from one end along the length of the track or from both ends and working towards the center. Crossings and culverts would be raised or extended as necessary prior to raising the track adjacent to these facilities and bridges would be raised independently from other work and be completed in the early stages of construction. It is assumed that construction would be completed with the necessary effort to complete in one season, as extended closures are extremely costly and Burlington Northern expressed their desire that all work be completed in one year.

4.11.3.1 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 and associated beach deposits from both current lakes and prehistoric lakes Cando and Minnewaukan are also present in the Devils Lake basin. All the glacial deposits in this area belong to formations of the Coleharbor Group.

The proposed improvement sections for the Burlington Northern Railroad (along Highway 2) are underlain by bouldery clay till in a low-relief stagnation moraine of the Coleharbor Group. The till is generally composed of silty clay with sand, pebbles, cobbles, and boulders. This till 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. Boring logs (from the County hydrogeologic report) and cross-section (from the County geologic report) indicate that some sand and gravel outwash units are likely present at depth. The uppermost bedrock is Cretaceous Pierre Shale.

As indicated principally 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 (the southern portion of prehistoric Lake Cando) – may be present in the low areas from Station 0 to Station 7. Some areas of the alignment (approximately from Station 7 to 22) have deposits associated with glacial pothole lakes and outwash deposits. Currently flooded areas may also have accumulated recent lake sediments, typically in areas overlying prehistoric Lake Minnewaukan.

As detailed in Figure 4.11-4, the proposed feature enhancements cross several soil types. The soil type descriptions are taken from the Soil Survey of Ramsey County (ref.), with a general description of each soil type's properties regarding road construction, (applicable to railroad bed improvement and levee construction). In the descriptions, "Slight" means soil properties and site characteristics are generally favorable for this use. "Severe" means special design may be required. Wetness and flooding are a given, since much of the area is currently inundated. Generally, soils belong to one of the following groups:

- Till – typically ML and CL to CL-ML loams. Typically these deposits are described as "Slight to "Moderate", primarily based on low strength and frost action. As such they usually are acceptable subgrade materials. In some localized areas the soil materials are described as "Severe" alternately due to low strength, frost action, shrink-swell, flooding and wetness and may need soil correction measures. The majority of deposits underlying the alignment are till.

- Lake deposits – typically clay and silt loams, ML and CL to CL-ML with CH and organic clay OL areas. All of these lake deposits are generally described as "Severe" based on low strength, frost action, shrink-sell and wetness. Lake deposit materials typically require soil correction efforts. Lake bed deposits underlie slightly approximately 48% of the alignments.

- Beach deposits or Outwash – typically sand and sandy loams, SP, SM-SP and SM with some quite gravelly areas (GM and GP-GM). These deposits are typically described as "Good" to "Slight" with frost action and wetness cited as concerns. These materials typically are suitable subgrade materials for road construction.

- Esker/Kame deposits– These deposits are similar in description to beach and outwash deposits but are typically much more coarse sand and gravelly with boulders and cobbles.

Characterizing the planned improvement portions of the alignment will require 65 soil borings.

4.11.3.2 Hydrology/Interior Drainage issues

It is assumed that the existing culverts will be maintained or extended through the raised railroad embankment and bridges raised to allow for water level equalization on both sides of the railroad. Any existing culverts will be extended as necessary to extend through the new embankment. Therefore, hydrology and drainage are not a concern for this feature other than maintaining the proper sizes to maintain flows at the Mauvais Coulee crossing and Channel "A" crossing.

4.11.3.3 Real Estate Requirements

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

- A 16-inch crude oil pipeline, owned and operated by Enbridge Pipeline North Dakota, runs parallel to and along the south side of the railroad mainline track. The pipeline is located on railroad rights-of-way. See section: *Effects on Existing Infrastructure and Utilities*.

- A telephone conversation with Mark Gjevre, BNSF, indicated that BNSF's existing right-of-way along the railroad varies between 75 and 400 feet.

4.11.3.4 Environmental/Cultural issues

HTRW

Current land uses, surrounding the Burlington Northern Railroad, appear to be predominantly agricultural with scattered rural residences and farms between towns. The railroad crosses through four towns: Churchs Ferry, Penn, Grand Harbor, and the City of Devils Lake. These towns appear to be have mixed residential, commercial, and industrial uses. Land use along the rail line outside of the towns does not appear to have changed significantly since the 1950s for the entire extent and since the 1930s for the area from Penn to the City of Devils Lake. One exception is that the town of Grand

Harbor had significantly decreased in size from the early 1930s to the 1950s. In addition, the City of Devils Lake has increased in size since the 1950s.

Regulatory record reviews for zip codes 58346, 58325, 58362 and 58301 were obtained from FirstSearch on October 15, 2002. All of the sites listed in zip codes 58346 appear to be near the town of Leeds. One UST facility was listed in Churchs Ferry (58325) and one was listed in Penn (58362). The locations of these facilities are probably on US Highway 2, but the exact locations were not identified from the available data. Of the 7 facilities listed as located on US Highway 2 without an address one is a RCRA small quantity generator, four facilities have USTs, and two facilities are listed as LUSTs of which one is closed. The United Parcel Facility is listed as a RCRA generator, and a closed UST and LUST site. It is unlikely that any of the sites are within the footprint of the impact area.

Fourteen potential HTRW sites identified along the railroad alignment are listed below and shown on Figure 4.11.1:

HTRW Site Costs			
Site #	**Action Level Affected**	**HTRW Category**	**HTRW Costs**
1-11-1	1	Pipeline Crossings	$8,500
11-1-2	1	Pipeline Crossings	$8,500
11-1-3	1	Nonresidential Properties	$9,000
11-1-4	1	Nonresidential Properties	$9,000
11-1-5	1	Artificial Pond	$9,000
11-1-6	1	Railroad Related Land Uses	$500
11-1-7	1	Nonresidential Properties	$9,000
11-1-8	1	Nonresidential Properties	$9,000
11-1-9	1	Nonresidential Properties	$9,000
11-1-10	1	Nonresidential Properties	$500
11-1-11	1	Rural Residences & Farmsteads	$1,500
11-1-12	1	Railroad Related Land Uses	$500
11-1-13	1	Railroad Related Land Uses	$5,500
11-1-14	1	Former Communities	$9,000

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.

Cultural

This project has the potential to affect 46 known sites and four site leads/isolated finds as shown on Figure 4.11-1. Forty-one of the known sites (32RY0101, 32RY0108-32RY0112, 32RY0152-32RY0186) are architectural properties in the city of Churchs Ferry. For six of these properties, including Penn Gymnasium (32RY0101), Immaculate Conception Church (32RY0108), Zion Lutheran Church (32RY0109), Methodist Church (32RY0110), City Hall (32RY0111), and Auditorium (32RY0112), a recommendation of eligibility has not been made. Twenty-three of these properties were recommended as eligible for listing on the NRHP, including the school (32RY0152), Charles and Jessie Diem House (32RY0153), school/Modern Woodmen of America building (32RY0155), Christ Braaten House (32RY0156), John Thomson House (32RY0157), Adolph Wellen House (32RY0159), Chester Whitney House (32RY0160), Joseph Nichol House (32RY0161), James and Cynthia McCormick House (32RY0162), Emma and John Solberg House (32RY0163), Dr. Anton Flath House (32RY0165), Lewis and Ellen Bond House (32RY0170), John Overland House (32RY0176), Farmers Home (32RY0178), Methodist Episcopal Parsonage (32RY0179), Ole Moe House (32RY0180), Thomas Hillerman House (32RY0181), Jacob Erickson House (32RY0182), Mary Mowbray and David Giles House (32RY0185), Zion Lutheran Parsonage (32RY0186), both Charles Studness Houses (32RY0175 and 32RY0183) and one John and Lena Anderson House (32RY0172). Twelve properties, including an unnamed house (32RY0154), Albert Nelson House (32RY0158), Joseph Nichol/Charles Harding House (32RY0163), one John and Lena Anderson House (32RY0166), John Jacobson House (32RY0167), Robert Wynn House (32RY0168), Mary Barber Rental House (32RY0169), Nels Backstrom House (32RY0171), Henry Marcoe House (32RY0173), K. M. Nybo House (32RY0174), John Cashman House (32RY0177), and Wm Hausmann House (32RY0184), were recommended as not eligible for listing on the NRHP.

In addition to the Churchs Ferry architectural properties, the Burlington Northern Railroad Bridge (32BE0044) and 32RY0364, which is listed as a grain storage, commercial feature in the 1997 database, are architectural properties that may be impacted by the Burlington Northern Railroad (Along US Highway 2) project. The remaining three known sites that may fall within this project area are historical archaeological sites. Sites 32RY0087 and 32RY0404 (Grand Harbor Townsite II) were identified through surface collection, but inconclusive recommendations of eligibility were drawn. Site 32RY0190, a sparse scatter of ceramic, glass, and metal items, was surface collected, but no subsurface testing was conducted at the site. The site was recommended as not eligible for listing on the NRHP based on a lack of subsurface cultural deposits (NDCRS Form, 32RY0190, on file at the SHSND). However, because

the investigator did not conduct subsurface testing, it is unclear how this determination was made. Therefore, this site may require additional Phase I survey if it is to be impacted by the Burlington Northern Railroad (Along US Highway 2) project.

Two of the three site leads that may fall within this features area of potential effect are historical archaeological. These include 32RYX0027 (Darby Station) and 32RYX0097. The third site lead, 32RYX0114, is a house that, according to the 1997 database, is associated with the historical context of "Colonization." A biface of Knife River Flint (32RYX0021) is the only isolated find within the possible area to date.

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

Feature 11 Burlington Northern Railroad (Along US Highway 2): 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	35	8
Archaeological	0	0	3
Architectural Site Leads/Isolated Finds	0	0	1
Archaeological Site Leads/Isolated Finds	0	0	3
Total	0	35	15

The estimated cost to conduct Phase 1 Surveys for each of the 15 sites is presented in the following table. The total cost for all surveys is $121,800. As noted in Section 4.0, these costs are believed representative of the cultural resources investigations needed for the next stage of study. (Note: Many residents in Churchs Ferry were relocated by FEMA in 2000. Therefore, some of the structures listed for Phase I surveys may no longer exist.)

Feature 11 Burlington Northern Railroad (Along US Highway 2): Phase 1 Survey Costs		
Site Number	**Investigation Type**	**Estimated Cost**
32BE0044	Phase I Architectural	$6,200
32RY0101	Phase I Architectural	$6,200
32RY0108	Phase I Architectural	$6,200
32RY0109	Phase I Architectural	$6,200
32RY0110	Phase I Architectural	$6,200

Feature 11 Burlington Northern Railroad (Along US Highway 2): Phase 1 Survey Costs		
Site Number	**Investigation Type**	**Estimated Cost**
32RY0111	Phase I Architectural	$6,200
32RY0112	Phase I Architectural	$6,200
32RY0364	Phase I Architectural	$6,200
32RYX0114	Phase I Architectural	$6,200
32RY0087	Phase I Archaeological	$8,000
32RY0190	Phase I Archaeological	$8,000
32RY0404	Phase I Archaeological	$14,000
32RYX0021	Phase I Archaeological	$8,000
32RYX0027	Phase I Archaeological	$14,000
32RYX0097	Phase I Archaeological	$14,000

Environmental

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 natural resources within the right-of-way of Burlington Northern Railroad (Along US Highway 2) include wetlands, oak forest/woodlands, and grasslands. The acres of habitat impacted by land use category are shown on Figure 4.11-1. Impact is expected for 2.45 acres of wetland and an additional 0.03 acres of wetlands with easements 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. These environmental impacts are more fully detailed in the general impacts discussion Section 4.0. This loss of wetland would require 4.93 acres of mitigation wetlands as set forth in the project mitigation policy developed through consultation with the Corps and FWS.

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. These environmental impacts are more fully detailed in the general impacts discussion Section 4.0. A total of 7.64 acres of oak forest/oak woodland with 1.03 of those acres under easement, 15.27 acres of grasslands under easements, 107.25

acres of other grassland habitat and 1.73 acres of cover crop under easements would be impacted from the proposed infrastructure protection measures in this location. 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 and loss. Mitigation activities would require the acquisition of 14.25 acres of oak forest/oak woodland, 229.27 acres of grasslands habitat and 1.73 acres of cover crop in like upland habitat areas for these impacts.

4.11.3.5 Effects on Existing Infrastructure and Utilities

The existing infrastructure and utilities affected by raising Feature 11 are road crossings, culverts, bridges, traffic control signals, and an oil pipeline. These include:

- A total of 27 crossings along this reach, 17 public and 10 private. Of the 27 crossings, 16 crossings have a top-of-rail elevation lower than 1466. The future need for each individual crossing depends in large part on the area covered by water with Devils Lake at higher levels. Based on an assessment of the area covered by Devils Lake at an elevation of 1460, 11 of the crossings would likely be abandoned due to lack of need for the crossing.
- Five of the existing culverts would need to be extended through the new embankment.
- One mainline train traffic control signal would need to be raised.
- Two bridges would need to be raised.
- A 16-inch crude oil pipeline, owned and operated by Enbridge Pipeline North Dakota, runs parallel to and along the south side of the BNSF mainline track. The pipeline is located on BNSF rights-of-way and according to the easement agreement between BNSF and Enbridge Pipeline, any modifications required to the pipeline to accommodate the operation of BNSF would be the responsibility of the Enbridge Pipeline.

4.11.3.6 Interdependencies

The protection of the Burlington Northern Railroad (along US Highway 2) is related to the protection of the following other features:

- Feature 1: Churchs Ferry – The rail line currently provides service to the grain elevator in Churchs Ferry

- Feature 2: City of Devils Lake – Collection of grain in the City of Devils Lake may increase truck traffic in the city during any closures of this rail line
- Feature 13: US Highway 2 – Shipments of grain would increase truck traffic on US Highway 2 during any closures of this rail line

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

4.11.3.7 O&M

Operation and maintenance requirements for the raised rail line would be similar to the unimpacted rail with respect to rails, ties, and shoulder maintenance. Additional maintenance requirements for the raised rail sections would include maintenance of the riprap on the slopes. 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.

4.11.3.8 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 Burlington Northern Railroad (along Highway 2). The amount of lead time will depend on the amount of time needed to plan and implement the flood protection measure. For Burlington Northern Railroad (along Highway 2), estimates of required times for the raise are as follows:

- Time required for planning and design – A lead time of about 12 months would be necessary for final design, preparation of documents, and bidding
- Time required for construction – The raising of the Burlington Northern Railroad (along US Highway 2) could be completed in one construction season
- The total time between initiation of final design and 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.

4.11.3.9 Potential Problems and Risks

The greatest risk associated with the raising of the Burlington Northern Railroad (along US Highway 2) is the uncertainty with the rate of the lake level changes. If the lake level rises faster than anticipated the lead time necessary to implement the raise may be

inadequate, requiring portions of the construction to be completed in wet conditions. Conversely, if the lake does not continue to rise or drops, the effort to implement the raise may be expended unnecessarily.

4.11.3.10 Data Deficiencies

The following data should be collected or verified prior to proceeding with raising the Burlington Northern Railroad (along US Highway 2):

- Locate above ground and buried utilities
- Coordinate with Enbridge Pipeline North Dakota regarding buried oil pipeline
- Perform soil borings, as necessary, prior to raising rail
- Locate and evaluate nearby cultural resources that were identified
- Review BNSF property holdings along the railroad and the proposed right-of-way requirements

4.11.4 Economics of Flood Protection

Damages: For the Infrastructure Protection Study's analysis, the flood damage estimates for the Burlington Northern Railroad (along US Highway 2) were reassessed in order to update and more accurately characterize the nature of the damages. The updated damage computations for the Burlington Northern Railroad (along US Highway 2) are summarized in the accompanying Table 4.11-1.

The top portion of Table 4.11-1 gives a summary of the annual detour damages that would occur during the years when the rail line is flooded. It also shows restoration damages that can be expected if the lake recedes.

The lower portion of the table shows the breakdown of these summary values. It gives costs for detour damages and cost per lineal foot of railroad for restoration damages. The restoration units include excavation and rail removal per lineal foot and installation of new rail per lineal foot. Restoration damages are assumed necessary when water reaches the rail elevation and then recedes.

Unit prices for all the damage computations were listed in Section 4.0, and are detailed in Table 4.0-2. A list of assumptions regarding the damage computations, data sources, and other aspects of the economic analysis for the Burlington Northern Railroad (along US Highway 2) are listed in the Burlington Northern Railroad (along US Highway 2) Infrastructure Protection Study Assumptions listing, attached to this Section 4.11.

Costs: The updated costs of providing flood protection for the Burlington Northern Railroad (along US Highway 2) are detailed in the accompanying Table 4.11-2 for the Burlington Northern Railroad. Unit prices, data sources, and relevant assumptions are listed. All costs are given in 2002 dollars.

The top portion of the table gives the cost of providing flood protection as presented in the Infrastructure Protection Study analysis. The lower portion of the table provides a cost breakdown of the quantities and costs by line item: fill, riprap, crossings, gated crossings, bridge raise, culverts, mainline train traffic control signals, and track installation. Also included in this portion of the table are geotechnical, environmental, engineering, and real estate right-of-way costs.

Unit prices for all the cost computations were discussed previously in Section 4.0, and are detailed in Table 4.0-2. Assumptions regarding the cost computations, data sources, and other aspects of the economic analysis for the Burlington Northern Railroad (along US Highway 2) are listed in the Burlington Northern Railroad Assumptions listing, appended to this Section 4.11.

Contingencies: The contingency percentages used for construction materials ranged from 30 to 50% (Table 4.11-2). Contingencies for riprap, fill material, culverts, and geotechnical items were estimated at the higher end of the range because of the potential variability in the quantities and unit prices.

4.11.5 Economic Results

The flood protection strategy that was analyzed was one rail raise, which is highlighted on the decision tree (Figure 4.11-2). The results of the Infrastructure Protection Study for Burlington Northern Railroad (along US Highway 2) are listed in Table 4.11-3.

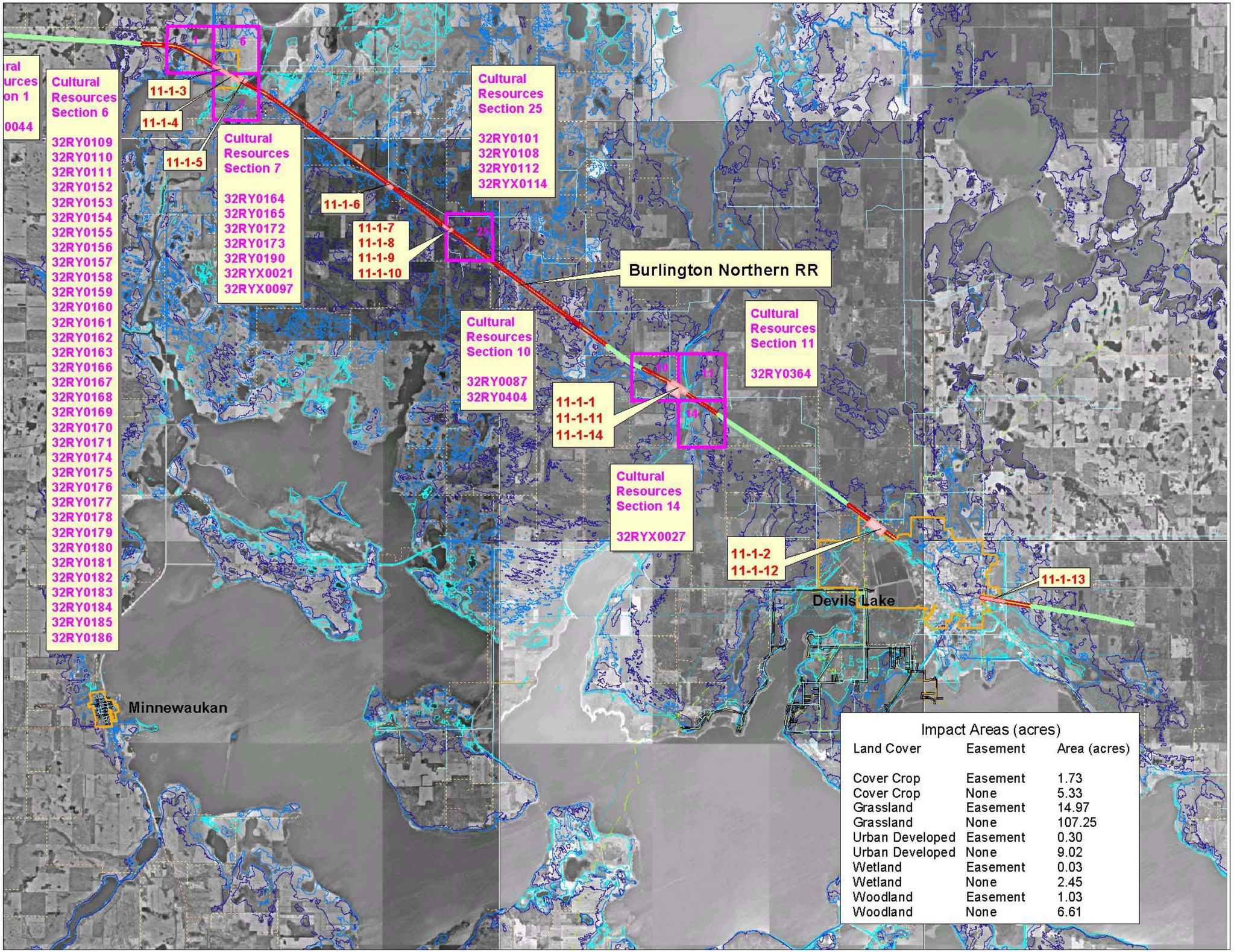
Stochastic Analysis Results: Using the stochastic analysis along with the updated damage and cost estimates for Burlington Northern Railroad (along US Highway 2), the Infrastructure Protection Study analysis provided relevant economic indices for raising the rail line. The annual net benefits for this approach were less than zero (-$62,600). The BCR for this approach was less than one (0.87). These results show that this strategy is not economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $367,100. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: Raising the rail line was also analyzed under each of three specific climate futures. For Burlington Northern Railroad (along US Highway 2), 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 rail line were $1,060,300, and the BCR was 1.48, indicating that this strategy was economically justified. The high net benefits indicate that this flood protection measure is economically justified when the high detour damages extend for long periods of time. For this future, the present worth annualized detour damages that would be prevented were computed at $3,082,300.

- First Moderate Future – Under the first moderate future climate scenario, the lake level does not reach the first damage level.

- Second Moderate Future – Under the second moderate future climate scenario, the annual net benefits of raising the rail line were -$584,100, and the BCR was 0.60, indicating that this strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $671,300.

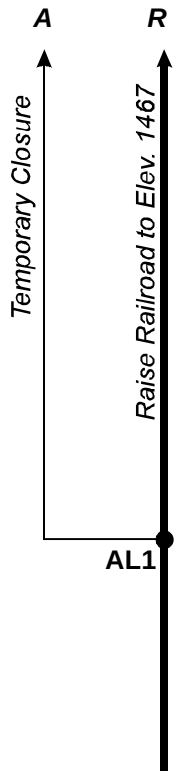


Data: 1997 USGS Digital Ortho Quad

Figure 4.11-1

LOCATION MAP
FEATURE 11: BURLINGTON NORTHERN RAILROAD (ALONG US HIGHWAY 2)
Devils Lake Infrastructure Protection Study

Barr: Arcview 3.1, OPT2615, I:\clients\devilslake\gis\dlip\features\roads\rails\rails\t11_bn_hwy2\project\basemap_11.apr, Layout: Layout: Section 4 Figure BN Railroad along hwy 2, lkp, Tue Nov 19 13:44:13 2002



Lowest Rail Elevation: 1456

P:\34\36\020\DECISIONTREES\2002FIGURES\FIGURE4_11.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 railroad raise (number of times)
R	Railroad raise to 1467
A	Temporary Closure

Figure 4.11-2

DECISION TREE
FEATURE 11: BURLINGTON NORTHERN RAILROAD
(Along U.S. Highway 2)
Devils Lake Infrastructure Protection Study

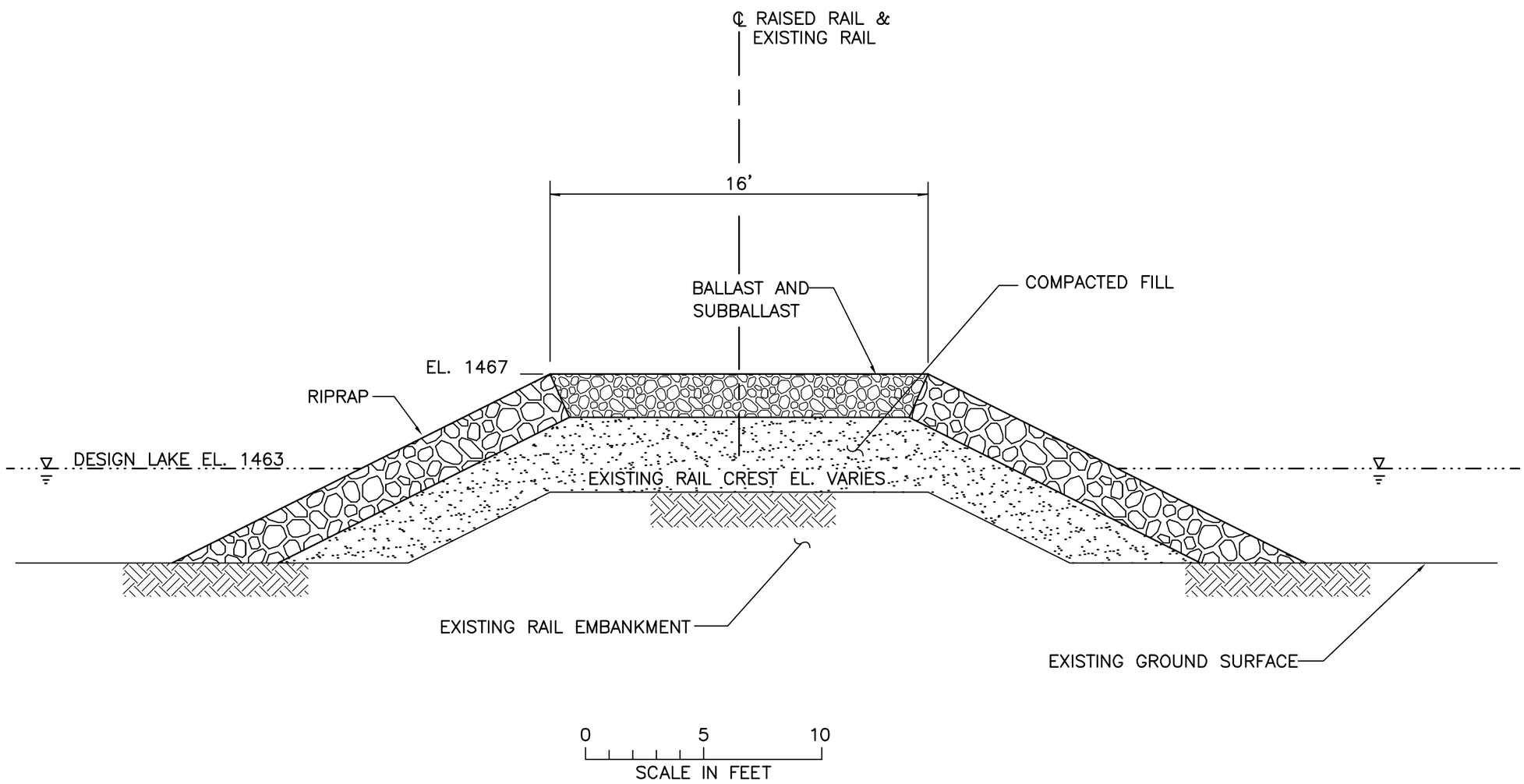


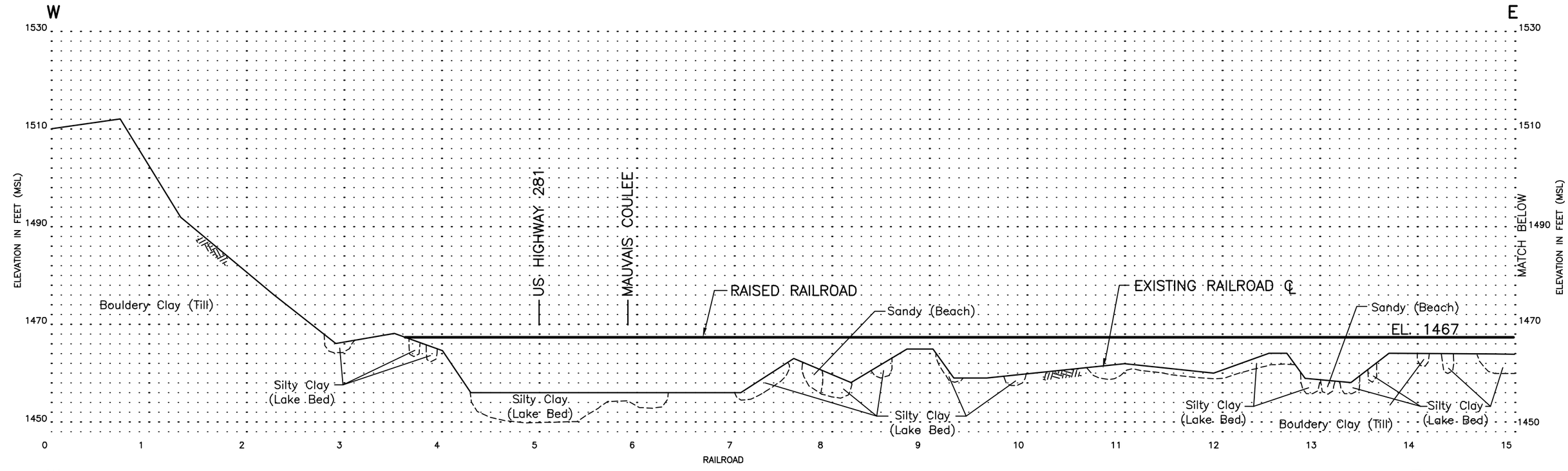
Figure 4.11–3

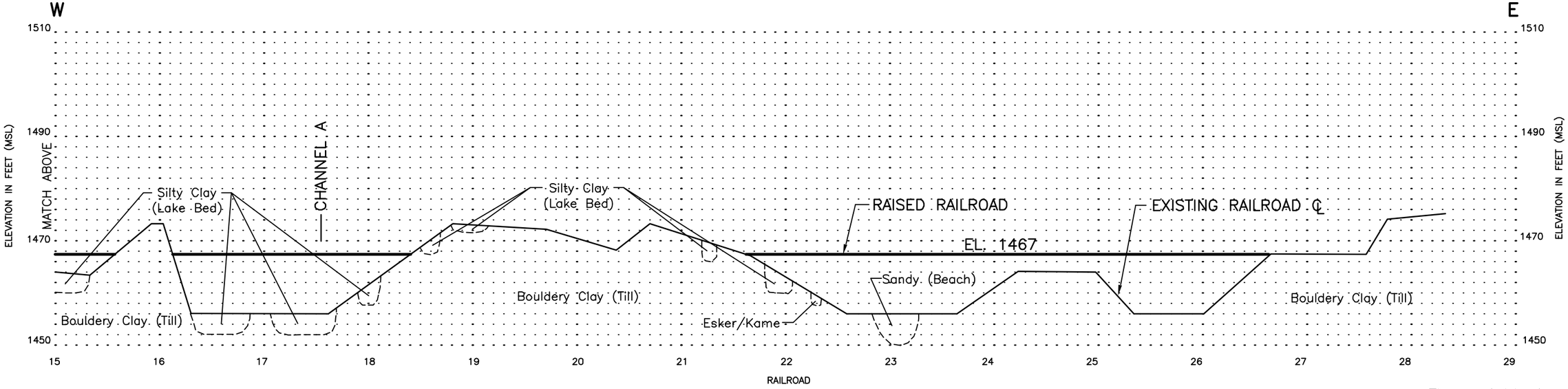
TYPICAL RAILROAD CROSS–SECTION

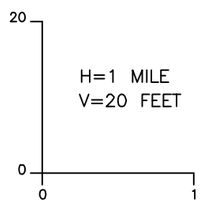
FEATURE 11:
BURLINGTON NORTHERN RAILROAD
(ALONG US HIGHWAY 2)

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

NRD M:\CAD\3436020\17209_1.dwg Plot at 1 10/31/2002 08:32:42







1. Adjacent ground elevations obtained from 2000 FEMA LIDAR topography.
2. Existing road surface elevations from the following construction drawings:
   BIA Aberdeen Area Ft. Totten Indeian Reservation Plans No's 1–A,1–10(5),6–10(4),21–10(2).
3. Raised road surface elevation based on assumed incremental raise height.
4. Stationing assigned as part of this analysis with stationing increasing from north to south.

Figure 4.11–4

RAILROAD PROFILE

FEATURE 11:
BURLINGTON NORTHERN RAILROAD
(ALONG US HIGHWAY 2)

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

NRD M:\cad\3436020\17231_2.DWG Plot at 1 11/01/2002 13:48:09

Table 4.11-1

Flood Damages
Feature 11: Burlington Northern Railroad (Along US Highway 2)
Devils Lake Infrastructure Protection Study

DAMAGES

	Annual Detour Damages	Restoration Damages	
Lake Elevation (MSL)	**Damage Value (THOUSANDS)**	**Impacted Railroad Length (FEET)**	**Damage Value (THOUSANDS)**
1452	$4,333	20,000	$7,414
1453	$4,333	22,000	$7,856
1454	$4,333	24,000	$8,298
1455	$4,333	26,000	$8,740
1456	$4,333	27,880	$9,155
1457	$4,333	30,570	$9,750
1458	$4,333	33,260	$10,344
1459	$4,333	36,430	$11,045
1460	$4,333	44,350	$12,795
1461	$4,333	58,080	$15,829
1462	$4,333	68,110	$18,046
1463	$4,333	74,450	$19,447
1464	$4,333	86,160	$22,035
1465	$4,333	93,240	$23,600

DAMAGE BREAKDOWN

Annual Detour Damages	**Description**	**Quantity**	**Units**	**Unit Cost**	**Value (THOUSANDS)**
	BNSF - Grain Trains	1	LS	$113,201	$113
	BNSF - Merchandise Trains	1	LS	$298,928	$299
	AMTRACK	1	LS	$3,494,500	$3,495
	Subtotal				$3,907
	2001 Total				$4,141
	2002 Total (add inflation)				$4,333
	Total				**$4,333**

Restoration Damages	**Item**	**Description**	**Quantity per LF of Railroad**	**Unit Cost**	**Contingency**	**Value per LF of Railroad**
	Excavation/Rail Removal	Removal of existing rail, ballast, and subballast	1.35 CY/LF	$7.41	30%	$13.00
	Install New Rail	Install new rails, ballast, subballast, and ties	1.00 LF	$160.00	30%	$208.00
	Total					**$221**
	Item	**Description**	**Quantity per LF of Railroad**	**Unit Cost**	**Contingency**	**Total Value for Railroad**
	Riprap	Place riprap from rail surface elevation to bottom of embankment replacement for	1.89 CY/LF	$40.00	30%	$2,740,046
	Geotextile Fabric	For use under riprap restoration	3.5 SY/LF	$2.00	30%	$253,708
	Total					**$2,993,754**

Table 4.11-2

Flood Protection Costs
Feature 11: Burlington Northern Railroad (Along US Highway 2)
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	R(1)
Action Level	Maximum Raise at AL1
	(THOUSANDS)
AL1	$48,583

COST BREAKDOWN

Strategy	R(1)					
	Description	Quantity	Units	Unit Cost	Contingency	Value (THOUSANDS)
Rail Raise	**Raise Rail to Elevation 1467**					
	Performance/Payment Bond	1	JB	$268,770	10%	$296
	Fill Material	518,700	CY	$5.00	50%	$3,890
	Riprap	182,200	CY	$40	40%	$10,203
	Crossings (concrete structure)	5	EA	$32,000	30%	$208
	Vehicle Crossing Signals (gated)	0	EA	$140,000	30%	$0
	Bridge Raise	2	EA	$1,400,000	50%	$4,200
	Culverts	5	EA	$25,000	50%	$188
	Mainline Train Traffic Control Signals	8	EA	$20,000	30%	$208
	Track Installation	88,230	LF	$170	30%	$19,499
	Geotechnical					
	Slurry Wall	29,830	SF	$6.00	50%	$268
	Borings	65	EA	$1,000	50%	$98
	Environmental Impacts					
	Mitigation	1	LS			$78
	HTRW	1	LS			$89
	Cultural Resources Investigation	1	LS			$122
	Subtotal					$39,345
	Engineering and Design		15%			$5,902
	Supervision and Administration		8%			$3,148
	Real Estate Acquisition for ROW	1	LS			$188
	Total Rail Raise					**$48,583**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Rail Maintenance Costs
	(THOUSANDS)
AL1	$192

Table 4.11 - 3

Economics Results
Feature 11: Burlington Northern Railroad (Along US Highway 2)
Devils Lake Infrastructure Protection Study

Strategy		Stochastic Analysis (ST-9) Mean Value over 10,000 Traces (Annual)							
		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Total B = A	Restoration C	Detour D	Total E = C + D	To Strategy (Damages Prevented) F = E(A) - E(S) *	To Strategy G = F - B	(BCR) I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$68,100	$367,100	$435,200	$0	$0	--
R(1)	Rail Raise to 1468	$497,800	$497,800	$0	$0	$0	$435,200	-$62,600	0.87

Strategy		Wet Future Scenario (WF-9) (Annual)							
		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Total B = A	Restoration C	Detour D	Total E = C + D	To Strategy (Damages Prevented) F = E(A) - E(S) *	To Strategy G = F - B	(BCR) I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$173,400	$3,082,300	$3,255,700	$0	$0	--
R(1)	Rail Raise to 1468	$2,195,400	$2,195,400	$0	$0	$0	$3,255,700	$1,060,300	1.48

Strategy		Moderate Future 1 Scenario (M1-4) (Annual)							
		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Total B = A	Restoration C	Detour D	Total E = C + D	To Strategy (Damages Prevented) F = E(A) - E(S) *	To Strategy G = F - B	(BCR) I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$0	$0	$0	$0	--
R(1)	Rail Raise to 1468	$0	$0	$0	$0	$0	$0	$0	--

Strategy		Moderate Future 2 Scenario (M2-4) (Annual)							
		COSTS		DAMAGES			Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Total B = A	Restoration C	Detour D	Total E = C + D	To Strategy (Damages Prevented) F = E(A) - E(S) *	To Strategy G = F - B	(BCR) I = F / B
A	Temporary Closure During Floods at First Action Level	$0	$0	$192,600	$671,300	$863,900	$0	$0	--
R(1)	Rail Raise to 1468	$1,448,000	$1,448,000	$0	$0	$0	$863,900	-$584,100	0.60

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 "Temporary Closure" strategy minus the total damages for the strategy implemented (E(S)).

Attachment to 4.11:
Burlington Northern Railroad (along US Highway 2):
Economic Analysis Assumptions

A. General Assumptions

1. The following assumptions were used in developing the 2002 costs for raising or restoring the Burlington Northern Railroad (along US Highway 2). The assumptions are based on two reports and discussions with representatives of the railroad. The reports referenced include, "Technical Appendix; Economic Analysis of Devils Lake Alternatives," by Barr Engineering, November 2001 and "Preliminary Evaluation of Joint Raise of BNSF Mainline Tracks and US Highway 2, in the Vicinity of Devils Lake, North Dakota," by Barr Engineering, March 2002.

2. Centerline profile was established using 2000 FEMA Lidar topography.

3. It was assumed that 4 feet of freeboard would be required for all railroads. The assumed freeboard was based on the referenced March 2002 report.

4. Quantities for milepost 3.7 to 18.3 were obtained from the referenced March 2002 report. The quantities were modified to account for an increased elevation from 1466 (March 2002 report) to 1467 (Infrastructure Protection Study). Quantities for milepost 21.7 to 26.5 were calculated based on the profile established using the 2000 FEMA Lidar topography.

B. Railroad Raise

1. Based on conclusions reached in the referenced March 2002 report, it would be cost prohibitive to raise a railroad in increments due to the down time necessary to raise the track. Therefore, it was assumed that the railroad would be raised to 1467 in one step rather than multiple raises.

2. Side slopes for raises and repair of rail beds were assumed to be 2H:1V.

3. Filter fabric will not be used under riprap for railroad raises.

4. Crest width was assumed to be 16'-0".

5. The cost to install rails (including removal of old rails, and placement of new rails, ties, ballast, and subballast) was estimated to be $170 per lineal foot. The Economic Analysis previously assumed the cost to be $135 per lineal foot. This cost was increased to include $10 for removal of existing rails, $20 for subballast, and inflation.

6. The cost for rail restoration was estimated to be $170 per lineal foot. The cost assumes that after the rail is flooded and water recedes, the top 20 inches of the rail must be restored. Restoring the top 20 inches includes replacing the ballast, subballast, ties and rail.

7. The cost for fill material is $5 per cubic yard based on available data for this area.

8. The cost of riprap material $40 per cubic yard based on available data for this area.

9. The costs for crossing raises, culverts, signals, and bridge raises obtained from Table D-1 of the referenced March 2002 report:

   - Crossings (concrete structure): $20,000 each plus $11,800 for aggregate subbase is approximately $32,000 per crossing.
   - Vehicle Crossing Signals (gated): $140,000
   - Mainline Train Traffic Control Signals: $20,000
   - Culverts: For 5 culverts the total cost was $137,800 or approximately $27,560 per culvert. However, the cost varied greatly from $6,300 to $57,000 depending on type. Thus, a slightly skewed average of $25,000 versus $27,560 was used for estimating purposes. There is also a contingency used within the cost table.
   - Bridges: two bridges were identified, the cost for Channel "A" Bridge was $1,674,960 and the cost for Mauvais Coulee Bridge was $1,125,000. The cost for "Bridge Raise" was assumed to be the average cost of the two bridges: $1,400,000.

10. The annual maintenance cost for the railroad was assumed to be 0.5% of the construction costs.

C. Detours

The estimated detour damages are based on the referenced Economic Analysis of Devils Lake Alternatives. The damages have been adjusted for inflation. The assumptions include:

a. In general, the train traffic that runs through Devils Lake along U.S. Highway 2 consists of two Amtrak trains per day; two merchandise trains per day, six times per week (100 cars per train); and four grain trains per week (104 cars per train). The merchandise and grain trains make stops in Devils Lake to pick up/drop off cargo and then continue on in the same direction.

b. The detour costs for Amtrak trains were based on a conversation with Gary Erford, Produce Line Director, Amtrak. If the rail line along U.S. Highway 2 were closed, Amtrak trains would be rerouted from Fargo, northwest to Minot (along Highway 52... hereafter called the lower track). Consequently, there would be no Amtrak service for Grand Forks, Devils Lake and Rugby.

c. The lost service to the three cities for Amtrak was estimated to result in approximately $100,000 per year revenue to Amtrak. Although bus service could be used to transport passengers from Grand Forks, Devils Lake, and Rugby to Minot or Fargo at a cost of $365,000 per year, it was

assumed that service would be stopped to these three cities. The updated value for lost train service is $106,000.

d. The other Amtrak damage involved in abandoning the track along U.S. Highway 2 is the lost time due to congestion on the Fargo-Minot line (the lower track). When Amtrak first switched over to the lower track during the 1997 floods, their trains had delays of 1 to 2 hours per trip. However, after the fleeting was better organized, the delay was down to 30 minutes. This is considered a better estimate of a typical Amtrak delay along this line. This delay does not take into account those times that bad weather or mechanical failure cause extreme hold-ups along the line. The cost associated with delay is $155 per minute, based on Amtrak computations. This 30-minute delay at $155 per minute was assumed for this study, and incorporates passenger time, crewover time and fuel. The updated cost associated with the delay is $164 per minute.

e. Data for the grain and merchandise train detour costs are based on conversation with Doug Chapel, Train Master of North Dakota in Fargo—in charge of the Burlington Northern line between Minot and Grand Forks and with Chuck Wendt, Superintendent of Operations in Fargo.

f. Doug Chapel stressed the issue of congestion on the would-be detour line from Fargo to Minot (the lower track). Amtrak trains are on the upper Devils Lake line because of the difficulties of congestion on the lower line, not because Amtrak business is booming in Devils Lake. Routing trains on the lower line would be more of a short-term fix rather than an easy solution to an abandoned track through Devils Lake.

g. John Quiltey, the BNR Head of the Locomotive Engineers in Forth Worth, TX and Skip Trader, also of the BNR Fort Worth Office, were contacted regarding detour costs.

h. The detour costs for merchandise and grain trains were based on fuel costs and crew overtime using Amtrak's 30-minute delay and assuming the detoured trains travel at 70 mph. An equivalent detour mileage for the time delay is then 35 miles.

i. Fuel costs for 1997 of $0.684/gal were assumed, based on conversations with Mr. Skip Trader (BNSF Fort Worth). Fuel efficiency is based on a Gross Ton Mile/Gal figure, at 711 ton mile/gal for 1997. In other words, 711 gross tons (material plus car weight) were transported 1 mile using 1 gallon of diesel fuel. The updated fuel cost is $0.725/gal.

j. The average capacity of grain and merchandise cars was obtained from the BNSF Railroad web site—an average agricultural car capacity of 134 gross tons and an average boxcar capacity of 120 gross tons.

k. The average crew required to operate a train was assumed to be three, plus one more person for switch operation. Dennis Mead (BNSF Payroll) stated that the crew members get paid on a

mileage basis until a certain limit is reached. After that, a lot of other add-ons occur and that no general assumptions could be made for the 30 additional minutes of crew delay time. Therefore, the crew was assumed to be paid at an average hourly rate of $25/hr/person and that delays would be paid at 1.5 the normal rate. The updated average hourly rate is $26.50/hr/person.

l. The detour costs do not account for trucking of merchandise and grain to/from Devils Lake. However, if the track along U.S. Highway 2 is under water, the viability of commerce in Devils Lake is questionable and there may not be as great a need for merchandise and grain shipment to/from Devils Lake.

m. The detour costs also do not address the possibility of additional delays that other existing trains would experience due to the additional traffic from the upper track. However, five more trains per day on the lower track may not make much difference to the trains already there, especially if fleeting is well coordinated.

n. Recent surveys (2001) indicate that this segment of the BNR has three signaling stations that would need to be replaced if the railroad is raised. The replacement cost for the signaling network (i.e., all three signaling stations) is estimated to be $850,000. The signaling network would need to be replaced for each incremental railroad raise.

o. Recent surveys (2001) indicate that railroad raises would affect three road crossings. The cost to rebuild each crossing is estimated to be $1,000 per track-foot and the typical track-foot length is 30 feet; therefore, the total estimated rebuild cost would be $30,000.

These assumptions equated to annual detour costs in 2001 as follows; BNSF Grain Train detour costs were $113,201 per year, BNSF Merchandise Train detour costs were $298,928 per year, and AMTRACK passenger detour costs were $3,494,500 per year. These numbers were adjusted to 2002 dollars for inflation.

4.16 Summary of Infrastructure Protection Investigation for Feature 16: US Highway 281 (South of US Highway 2)

4.16.0 Flood Protection Strategy

The flood protection strategy evaluated for US Highway 281 (South of US Highway 2) was realignment with a minimum road surface elevation of 1465. The ND DOT has indicated that this strategy will most likely occur, so this Infrastructure Protection Study did not analyze various flood protection strategies to define the largest net benefits for US Highway 281 (South of US Highway 2).

4.16.1 General Information

Feature Type: Road

Location: Feature 16 is the 25.5-mile portion of US Highway 281 extending from just south of its intersection with ND Highway 57 at the south end to its intersection with US Highway 2 near Churchs Ferry at the north end. US Highway 281 (South of US Highway 2) passes through the City of Minnewaukan, and the Townships of Normania, Riggin, West Bay, Oberon, and Lallie in Benson County. The accompanying Figure 4.16-1 shows the feature's current and realigned locations and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: US Highway 281 (South of US Highway 2) is a two-lane bituminous National Highway. The entire highway route spans the United States from Canada to Texas. It is classified as a principal arterial highway and National Highway System route. Average daily traffic counts for this feature were 659 in 1994 and 946 in 2002.

Significance: This portion of US Highway 281 is important because it is a major traffic route in the area, including the main route between Minnewaukan and Churchs Ferry. It is vital to serving local transportation, agricultural needs, and moving products through the area.

Damages: The flooding of Feature 16 would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when US Highway 281 (South of US Highway 2) is closed and traffic is detoured
- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation

Owner/Sponsor: The North Dakota Department of Transportation is responsible for managing and maintaining US Highway 281 (South of US Highway 2).

Lead Federal Agency: The Federal Highway Administration would take the lead for US Highway 281 (South of US Highway 2) for any flood protection work that may take place.

4.16.2 Feature Protection

History of Flood Protection: Flood protection for US Highway 281 (South of US Highway 2) has thus far consisted of road raises. The most recent raise occurred in 2001, with 0.37 miles being raised to elevation 1452. This segment is located 2 miles south of US Highway 2. Other raises occurred in 1997 and 1998, raising a total of 9.2 miles of Highway to elevation 1452.

General Protection Strategy: The ND DOT is currently planning to realign US Highway 281 (South of US Highway 2) to provide protection to this feature up to lake level 1463. The realignment will place most of US Highway 281 (South of US Highway 2) outside of the maximum flood extents of the lake. In the areas where the existing ground is below 1465, the highway will be constructed to a minimum elevation of 1465.

Protection Strategy by Lake Level: Figure 4.16-2 shows the decision tree for US Highway 281 (South of US Highway 2). As shown on Figure 4.16-2, the only approach to flood protection for US Highway 281 (South of US Highway 2) consists of the following:

1. At Action Level 1 (AL1), a decision would be made as to whether the road would be relocated or whether the road would be temporarily abandoned.

The intent of the ND DOT is to construct the planned road realignment to prevent any future problems with the rising lake. Therefore, the incremental protection strategy of road raises was not analyzed in the Infrastructure Protection Study. The reference elevation that the ND DOT will use, if any, to implement the planned realignment is not known.

The Infrastructure Protection Study analysis considered the flood protection strategy, relocating the road. The pertinent reference elevations for implementing this flood protection strategy based on the wave height are given below:

Reference Elevations for Relocation (AL1)		
Elevation	**Name**	**Significance**
1452	Low Structure Elevation	Low point on top of road surface (existing alignment)
Current	Lake Damage Elevation	Lake elevation at which road becomes unusable due to wave action
Current	Project Completion Elevation	Lake elevation at which road relocation construction must be complete

Reference Elevations for Relocation (AL1)		
Elevation	**Name**	**Significance**
Current	Construction Initiation Elevation	Lake elevation at which road relocation construction must begin
Current	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

This relocation protection will be sufficient up to the maximum lake level (1463).

4.16.3 Design Considerations

4.16.3.0 General Design

This section summarizes the preliminary design information provided by NDDOT and its consulting engineers, Kadrmas, Lee, and Jackson. This information is preliminary, but after discussions with the ND DOT, Kadrmas, Lee, and Jackson, and the federal transportation board, this is the option most likely to be completed. The maximum wind-induced wave height along the current alignment of 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, which is below the current lake elevation. A temporary riprap berm was constructed along the lake side to protect the road from wave action.

Alignment

Figure 4.16-1 shows the alignment of the existing US Highway 281 (South of US Highway 2) and the realignment of US Highway 281 (South of US Highway 2). The realigned roadway, starting at US Highway 2, will follow a route due south at a distance of 3 miles to the west of the existing alignment, for 12.8 miles. The realigned route will then angle southeast past Minnewaukan for 3.8 miles, then due south for 1.5 miles, and finally southeast for 2 miles where it will connect back with the existing alignment. The length of US Highway 281 (South of US Highway 2) being considered is approximately 30 miles. Figure 4.16-4 shows the realigned road profile.

With the realignment of US Highway 281(South of US Highway 2), ND Highway 19 would need to be extended to the west to meet US Highway 281 (South of US Highway 2) as it currently does. This extension of ND Highway 19 was included in the cost analysis for the realignment of US Highway 281 (South of US Highway 2). ND Highway 19 would be extended approximately 3 miles to the west of its current intersection with US Highway 281 to meet the realigned roadway.

Cross-section

Figure 4.16-3 shows a typical cross-section of the proposed road. This section is based on US Highway 281 Typical Section from the Preliminary Construction Report for US Highway 281, prepared for the NDDOT by Kadrmas, Lee, and Jackson. The road top width was assumed to be 64 feet. Bituminous surfacing will be 40 feet in width, and will be 5 inches in depth. The shoulder side slopes at 6H:1V on both the sides. The minimum raised road elevation is assumed to be 1465 at the top of pavement. This is being done so the road is protected up to lake elevation of 1463, and no further work will be required. It was assumed that unsuitable fill foundation material, averaging 1 foot in depth, would be stripped along the realignment width.

The typical cross-section for ND Highway 19 extension was taken from ND DOT project SER-3-019(016)138. It was assumed that the top of pavement would be constructed to 1465. The road top width was assumed to be 52 feet. The shoulder side slopes were assumed to be 6H:1V for the first 10 feet, and then 3H:1V until the side slope meets the adjacent ground.

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 aggregate surface course and bituminous surfacing will be constructed from commercially available material.

Erosion Protection

For US Highway 281 (South of US Highway 2), on both sides of the road, riprap was assumed to be placed over geotextile (no additional bedding material) only when the adjacent ground elevation was below 1463. Riprap was placed over the slope length of the road. Topsoil and seeding was assumed for the raised roadbed when riprap was not required.

For ND Highway 19, riprap was assumed to be placed over geotextile (no additional bedding material) only when the road elevation was below 1455. Riprap was assumed to be placed over the 3H:1V side slope. Topsoil and seeding was assumed for 6H:1V side slope length.

4.16.3.1 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 and associated beach deposits from both current lakes and prehistoric lakes

Cando and Minnewaukan are also present in the Devils Lake basin. All the glacial deposits in this area belong to formations of the Coleharbor Group.

The proposed improvement sections and re-route sections of US Highway 281 (South of US Highway 2) are underlain by bouldery clay till in a low-relief stagnation moraine (specifically the boulder clay facies) of the Coleharbor Group. The till is generally composed of silty clay with sand, pebbles, cobbles, and boulders. This till 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 80 to 200 feet in thickness. Boring logs (from the County hydrogeologic report) and cross-section (from the County geologic report) indicate that some sand and gravel outwash units are likely present at depth. In some areas, glacial deposits bury narrow pre-glacial bedrock valleys. The uppermost bedrock is Cretaceous Pierre Shale.

As indicated principally by the soils map, thin layers of silt and clay lakebed deposits are scattered across the entire alignment, associated with smaller glacial margin and glacial pothole lakes. These deposits are typically found in topographic low areas. Localized areas of very coarse, gravelly ice-contact deposits may be present associated with hummocky till and pothole lakes. Mappable areas of associated beach, alluvium and outwash deposits are present primarily at Road Mile 7 through 9, Road Mile 12 through 15 and Road Mile 17.5. As noted, currently flooded areas may also have accumulated additional lake sediments.

As detailed in Figures 4.16-4a and 4.16-4b, the proposed feature enhancements cross several soil types. The soil type descriptions are taken from the Soil Survey of Benson County (ref.), with a general description of each soil type's properties regarding road construction, (applicable to railroad bed improvement and levee construction). In the descriptions, "Slight" means soil properties and site characteristics are generally favorable for this use. "Severe" means special design may be required. Generally, soils belong to one of the following groups:

- Till, typically ML and CL to CL-ML loams, underlie more than 90 percent of the alignment. Typically these deposits are described as "Slight to "Moderate", primarily based on low strength and frost action. As such they usually are acceptable subgrade materials. In some localized areas the soil materials are described as "Severe" alternately due to low strength, frost action, shrink-swell, flooding and wetness and may need soil correction measures.

- Lake deposits, typically clay and silt loams, ML and CL to CL-ML with CH and organic clay OL areas, underlie about 4 percent of the alignment. All of these lake

deposits are generally described as "Severe" based on low strength, frost action, shrink-sell and wetness. Lake deposit materials typically require soil correction efforts.

- Beach deposits, alluvium, and outwash, typically sand and sandy loams, SP, SM-SP and SM with some quite gravelly areas (GM and GP-GM), underlie a small fraction of the alignment. These deposits are typically described as "Good" to "Slight" with frost action and wetness cited as concerns. These materials typically are suitable subgrade materials for road construction.

Characterizing the planned improvement portions of the alignment will require 160 soil borings, based on a maximum spacing of one boring every 1,000 feet of road length.

4.16.3.2 Hydrology/Interior Drainage issues

It is assumed that culverts will be placed through the realigned roadway embankment to allow for drainage across the roadway. New RCP culverts were assumed to have been placed through the roadway embankment at nine low spots along the road.

4.16.3.3 Real Estate Requirements

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

4.16.3.4 Environmental/Cultural issues

HTRW

Current land uses, surrounding US Highway 281 South (South of US Highway 2), appear to be predominantly agricultural with scattered rural residences and farms. Land use does not appear to have changed significantly since the 1950s.

Regulatory record reviews for zip codes 58346, 58320, 58351 and 58357 were obtained from First Search between September 25, 2002 and October 15, 2002. All of the sites listed in zip code 58346 appear to be in or near the town of Leeds, which is several miles from US Highway 281. No regulated facilities were listed in the database search for zip code 58320, and no facilities listed in zip code area 58357 are located on Highway 281. Multiple properties are listed in zip code 58651, but most of the facilities are in the town of Minnewaukan. One facility is listed as a closed leaking UST site with a closed UST at Grady's Auto Service. The address for this facility is Highway 281 North. If Grady's Auto Service is located within the impact area, it is not expected to be a REC since the site is closed.

Twelve potential HTRW sites identified along the feature alignment are listed below and shown on Figure 4.16-1:

HTRW Site Costs			
Site #	**Action Level Affected**	**HTRW Category**	**HTRW Costs**
16-1-1	1	Rural Residences & Farmsteads	$1,500
16-1-2	1	Rural Residences & Farmsteads	$500
16-1-3	1	Rural Residences & Farmsteads	$500
16-1-4	1	Rural Residences & Farmsteads	$1,500
16-1-5	1	Rural Residences & Farmsteads	$500
16-1-6	1	Railroad Related Land-Uses	$5,500
16-1-7	1	Railroad Related Land-Uses	$5,500
16-1-8	1	Substation	$5,000
16-1-9	1	Rural Residences & Farmsteads	$500
16-1-10	1	Cylindrical Structures	$9,000
16-1-11	1	Rural Residences & Farmsteads	$1,500
16-1-12	1	Rural Residences & Farmsteads	$500

The substation was identified in the *Environmental Site Assessment Devils Lake Outlet, Benson County, North Dakota June 14, 2002*.

HRTW sites and associated costs for this feature have changed since the draft report due to the inclusion of additional historic information originally not available. The initial HTRW cost of $14,500 determined for the final review report is still presented in the final cost estimate for this feature and was used in the economic model since the new HTRW cost of $32,000 shown in this table was not available when the model runs were conducted. Even if included, this slight increase in cost will not affect the economic outcome or recommendations for this feature. 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.

Cultural

This project has the potential to impact eight known sites and fifteen site leads/isolated finds as shown on Figure 4.16-1, which include the six known sites and 12 site leads that may be impacted by Feature 4: City of Minnewaukan discussed previously. The remaining two known sites, 32BE0116 and 32BE0117, are historical archaeological in nature. Site 32BE0116 is an artifact scatter that included 47 ceramic, glass, and metal items. The site was recommended as not eligible for listing on the NRHP based on a lack

of structures and features; however, subsurface testing, which may have revealed foundations or other features, was not conducted. This site, therefore, may require additional Phase I survey if it is to be impacted by the US Highway 281 (South of US Highway 2) project. Site 32BE0117 is an abandoned farmstead and associated scatter of over 1,000 artifacts. This site was recommended as not eligible for listing on the NRHP because it could not conclusively meet NRHP Criterion A, and it did not meet the remaining NRHP criteria.

The two site leads not previously discussed in Feature 4, include two farmsteads, 32BEX0135 and 32BEX0139, that could only be examined at a distance from the road, thus their age and potential eligibility could not be assessed. A biface of Knife River Flint (32BEX0134) is the only isolated find within the possible area to date.

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

Feature 16 US Highway 281 (South of US Highway 2): Evaluation Status of Known Cultural Resources

Resource Type	Resources Listed on or Nominated for the NRHP	Resources with Recommendations (Phase I Survey Completed)	Resources with Inconclusive or No Recommendations (Require Phase I Survey)
Architectural	2	2	1
Archaeological	0	2	1
Architectural Site Leads/Isolated Finds	0	0	11
Archaeological Site Leads/Isolated Finds	0	0	4
Total	2	4	17

The estimated cost to conduct Phase 1 Surveys for each of the 17 sites is presented in the following table. The total cost for all surveys is $115,600. As noted in Section 4.0, these costs are believed representative of the cultural resources investigations needed for the next stage of study.

Feature 16 US Highway 281 (South of US Highway 2): Phase 1 Survey Costs

Site Number	Investigation Type	Estimated Cost
32BE0035	Phase I Architectural	$6,200
32BEX0017	Phase I Architectural	$6,200
32BEX0025	Phase I Architectural	$6,200
32BEX0041	Phase I Architectural	$6,200

Feature 16 US Highway 281 (South of US Highway 2): Phase 1 Survey Costs		
Site Number	**Investigation Type**	**Estimated Cost**
32BEX0055	Phase I Architectural	$6,200
32BEX0066	Phase I Architectural	$6,200
32BEX0079	Phase I Architectural	$6,200
32BEX0104	Phase I Architectural	$6,200
32BEX0105	Phase I Architectural	$6,200
32BEX0106	Phase I Architectural	$6,200
32BEX0135	Phase I Architectural	$6,200
32BEX0139	Phase I Architectural	$6,200
32BE0116	Phase I Archaeological	$8,000
32BEX0039	Phase I Archaeological	$14,000
32BEX0040	Phase I Archaeological	$14,000
32BEX0042	Phase I Archaeological	$14,000
32BEX0134	Phase I Archaeological	$8,000

Environmental

The natural resources within the right-of-way of Highway 281 (south of US Highway 2) 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 4.16-1. A total of 10.4 acres of wetland impacts are expected from the proposed infrastructure protection measures, with 1.61acres of those wetlands having easements on them. 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. These environmental impacts are more fully detailed in the general impacts discussion Section 4.0. 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 loss and fragmentation. This loss of wetland would require 19.21 acres of mitigation wetlands as set forth in the project mitigation policy developed through consultation with the Corps and FWS.

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. A total of 3.27 acres of oak forest/oak woodland with 1.03 of those acres under easement, 29.65 acres of grasslands under easements, 77.99 acres of other grassland habitat and 25.02 acres of cover crop under easements would be impacted 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 loss and fragmentation. These environmental impacts are more fully detailed in the general impacts discussion Section 4.0. Mitigation activities would require the acquisition of 5.51 acres of oak forest/oak woodland, 185.63 acres of grasslands habitat and 25.02 acres of cover crop like upland habitat areas for these impacts.

4.16.3.5 Effects on Existing Infrastructure and Utilities

Utilities located along the existing right-of-way limits were assumed not to be impacted by the relocation. With the exception of drainage culverts discussed above, no other infrastructure or utilities are expected to be impacted.

4.16.3.6 Interdependencies

The protection of US Highway 281 (South of US Highway 2) is related to the protection of several other features, as it provides primary access to the region from the south. The following features are functionally dependent on US Highway 281 (South of US Highway 2), and would be affected if it were temporarily closed:

- Feature 1: Churchs Ferry
- Feature 2: City of Devils Lake
- Feature 3: Fort Totten
- Feature 4: City of Minnewaukan – The City of Minnewaukan is located along Feature 16. The protection strategy chosen for either, particularly if the strategy involves relocation, will have an impact on the other feature.
- Feature 5: St. Michael
- Feature 6: Gilbert C. Grafton Military Reservation
- Feature 7: Graham's Island State Park
- Feature 8: Rural Areas

If US Highway 281 (South of US Highway 2) were temporarily closed, the following roads would either experience increased traffic as a detour routes or decreased traffic as travel is routed to other roadways:

- Feature 13: US Highway 2 – The north end of Feature 16 is at its intersection of Feature 13
- Feature 14: ND Highway 57 (ND Highway 20 to BIA Highway 1)
- Feature 15: ND Highway 57 (BIA Highway 1 to US Highway 281)
- Feature 18: ND Highway 19 – Feature 18
- Feature 21: ND Highway 20 (North of the City of Devils Lake)
- Feature 22: ND Highway 20 (ND Highway 57 to Tokio)
- Feature 24: BIA Highway 6

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

4.16.3.7 O&M

Operation and maintenance requirements for the relocated roadway would be similar to the existing roadway with respect to road surface maintenance and shoulder and slope mowing. The increase in O&M on the adjacent routes that are used as detours would be approximately equal to O&M on the temporarily closed road. 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.

4.16.3.8 Lead Time Required

The realignment of US Highway 281 (South of US Highway 2) would likely be completed in two construction seasons. A lead time of about 18 to 24 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 3 to 4 years.

4.16.3.9 Potential Problems and Risks

Potential problems and risks associated with the road realignment include:

- New route will require purchase of land

4.16.3.10 Data deficiencies

The following data should be collected or verified prior to proceeding with raising US Highway 281 (South of US Highway 2):

- Locations of utilities, if any
- Soil data along route of proposed road realignment
- Precise location and evaluation of nearby cultural resources

4.16.4 Economics of Flood Protection

Damages: For US Highway 281 (South of US Highway 2), the damages resulting from flooding were estimated up to the maximum lake level (1463). The damages were calculated for the existing roadway alignment. The damage computations for US Highway 281 (South of US Highway 2) are summarized in the accompanying Table 4.16-1.

The top portion of Table 4.16-1 gives a summary of the annual detour damages that would occur during the years when the highway was flooded. It also shows road restoration damages that can be expected when the lake recedes.

The lower portion of the table shows the breakdown of these summary values. It gives quantities in terms of miles per year (of extra miles traveled as a result of detours) and hours per year (of additional travel time resulting from detours) for the detour damages. Also shown are quantities and line-item damages for excavation, geotextile fabric, aggregate base course, fill, bituminous pavement, and riprap for road restoration work when waters recede.

The 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 US Highway 281 (South of US Highway 2) are listed in the Feature 16 Assumptions listing, appended to this Section 4.16.

Costs: The costs of providing flood protection for US Highway 281 (South of US Highway 2) are detailed in the accompanying Table 4.16-2. Quantities and line-item totals are listed.

The top portion of the table gives the estimated total cost of relocating this road. The lower portion of the table gives a breakdown of the quantities and costs by line item.

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 US Highway 281 (South of US Highway 2) are listed in the Feature 16 Assumptions listing, appended to this Section 4.16.

Kadrmas, Lee, and Jackson have also prepared a cost estimate for the realignment of US Highway 281 (South of US Highway 2), at an estimated cost of approximately $30 million. This number was obtained from *SER-3-281(071)156 & SER-3-281(072)160 US Highway 281 Project Concept Report,* July 2002. The difference between their cost estimate and the cost estimate prepared for this study can be attributed to different contingency and unit price assumptions. The estimated quantities for both were similar.

Contingencies: The contingency percentages used for construction materials ranged from 30 to 50% (Table 4.16-2). Contingencies for riprap, fill material, culverts, and geotechnical items were estimated at the higher end of the range because of the potential variability in the quantities and unit prices.

4.16.5 Economic Results

The flood protection strategy that was analyzed was relocation, which is highlighted on the decision tree (Figure 4.16-2). The results of the Infrastructure Protection Study for US Highway 281 (South of US Highway 2) are listed in Table 4.17-3. 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.

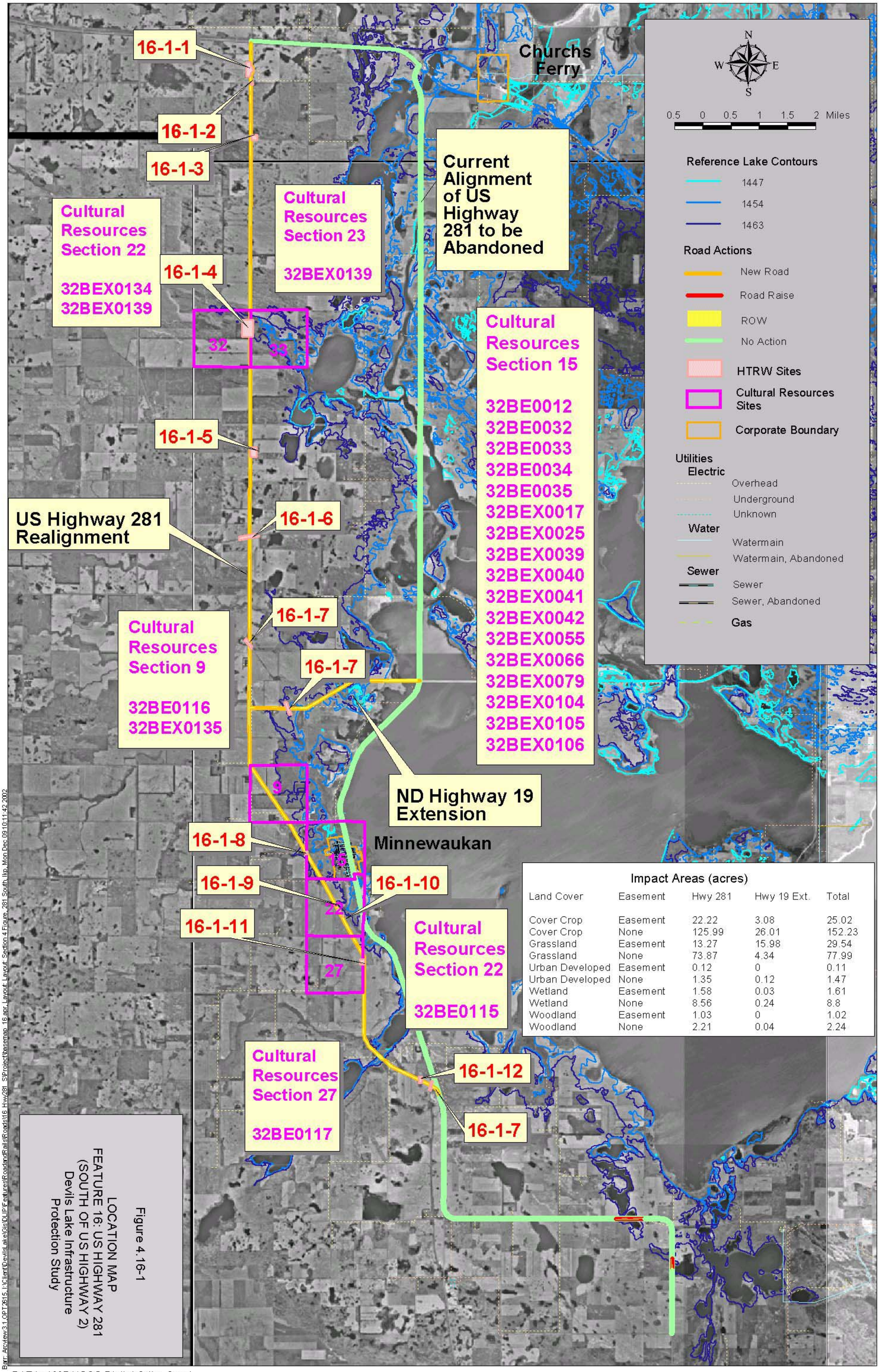
Stochastic Analysis Results: Using the stochastic analysis along with the updated damage and cost estimates for US Highway 281 (South of US Highway 2), the Infrastructure Protection Study analysis provided relevant economic indices for relocating the road. The annual net benefits for this approach were greater than zero ($315,600). The BCR for this approach was greater than one (1.11), indicating that this strategy was economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $2,503,100. The stochastic results are averages over 10,000 traces.

Results for Specific Scenarios: Raising the road was also analyzed under each of three specific climate futures. For US Highway 281 (South of US Highway 2), the economic indices for each of the three climate futures are as follows:

- Wet Future – Under the wet future climate scenario, the average net benefits of relocating the road were $2,733,000, and the BCR was 1.98, indicating that this strategy was economically justified. No restoration damages are listed under this scenario, indicating that the water level never recedes below the first action level. For this future, the present worth annualized detour damages that would be prevented were computed at $5,533,000.

- First Moderate Future – Under the first moderate future climate scenario, the average net benefits of relocating the road were $965,200, and the BCR was 1.34, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $2,210,200.

- Second Moderate Future – Under the second moderate future climate scenario, the average net benefits of relocating the road were $2,076,200, and the BCR was 1.74, indicating that this strategy was economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $4,727,700.



Impact Areas (acres)

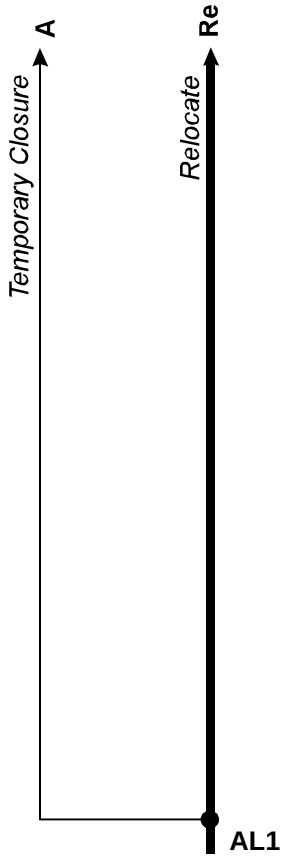
Land Cover	Easement	Hwy 281	Hwy 19 Ext.	Total
Cover Crop	Easement	22.22	3.08	25.02
Cover Crop	None	125.99	26.01	152.23
Grassland	Easement	13.27	15.98	29.54
Grassland	None	73.87	4.34	77.99
Urban Developed	Easement	0.12	0	0.11
Urban Developed	None	1.35	0.12	1.47
Wetland	Easement	1.58	0.03	1.61
Wetland	None	8.56	0.24	8.8
Woodland	Easement	1.03	0	1.02
Woodland	None	2.21	0.04	2.24

Figure 4.16-1

LOCATION MAP
FEATURE 16: US HIGHWAY 281
(SOUTH OF US HIGHWAY 2)
Devils Lake Infrastructure
Protection Study

Barr: ArcView 3.1, OPT2615, I:\Client\DevilsLake\Gis\DLIP\Features\RoadandRails\Roads\16_Hwy281_SVProject\basemap_16.apr, Layout: Layout: Section 4 Figure, 281 South, lkp, Mon Dec 09 10:11:42 2002

DATA: 1997 USGS Digital Ortho Quad



Lowest Road Elevation: 1452

▬▬▬	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)
A	Temporary closure of road
Re	Relocate

Figure 4.16-2

DECISION TREE
FEATURE 16: U.S. HIGHWAY 281
(South of U.S. Highway 2)
Devils Lake Infrastructure Protection Study

P:\34\36\020\DECISIONTREES\2002FIGURES\FIGURE4_16.CDR RLG 01-06-03

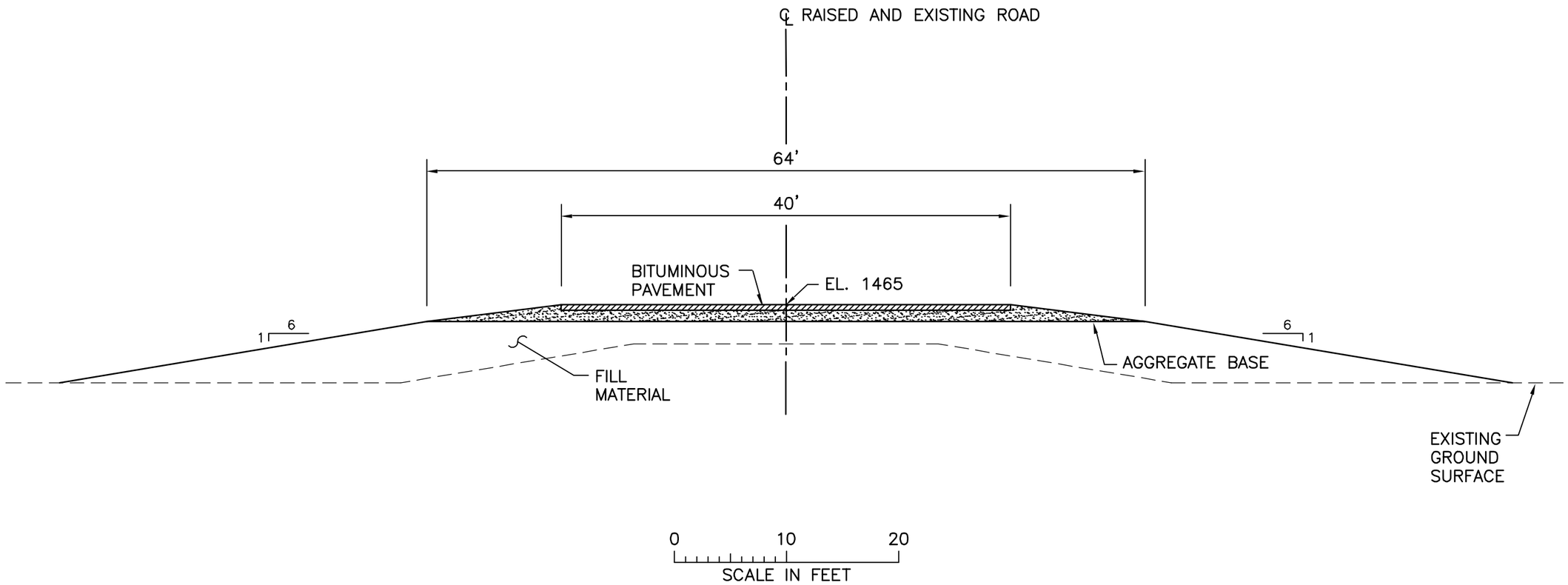


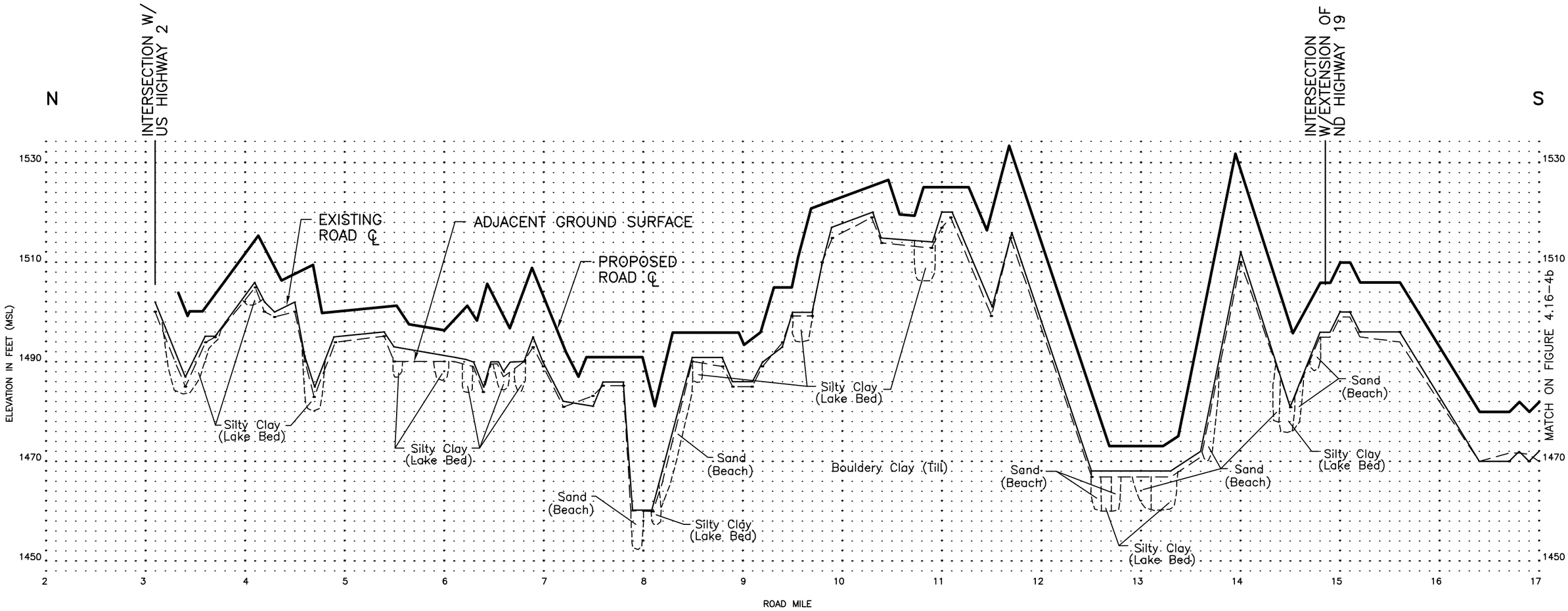
Figure 4.16–3

TYPICAL ROAD CROSS–SECTION

FEATURE 16:
US HIGHWAY 281
(SOUTH OF US HIGHWAY 2)

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

NRD M:\CAD\3436020\17167_1.DWG Plot at 10 11/06/2002 13:59:12



1. Adjacent ground and existing surface elevations obtained from 2000 FEMA LIDAR topography.
2. Relocated road alignment and road surface elevation based on ND DOT report, "us 281 from South of Minnewaukan to Maza, North Dakota Federal Aid Project No. SER-3-281(071)156, South of Minnewaukan SER-3-281(072)160, North of Minnewaukan".
3. Stationing assigned as part of this analysis with stationing increasing from north ot south.

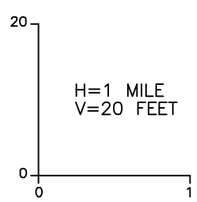


Figure 4.16-4a

ROAD PROFILE

FEATURE 16:
US HIGHWAY 281
(SOUTH OF US HIGHWAY 2)

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

NRD M:\cad\3436020\17177_1.DWG Plot at 1 11/01/2002 13:24:41

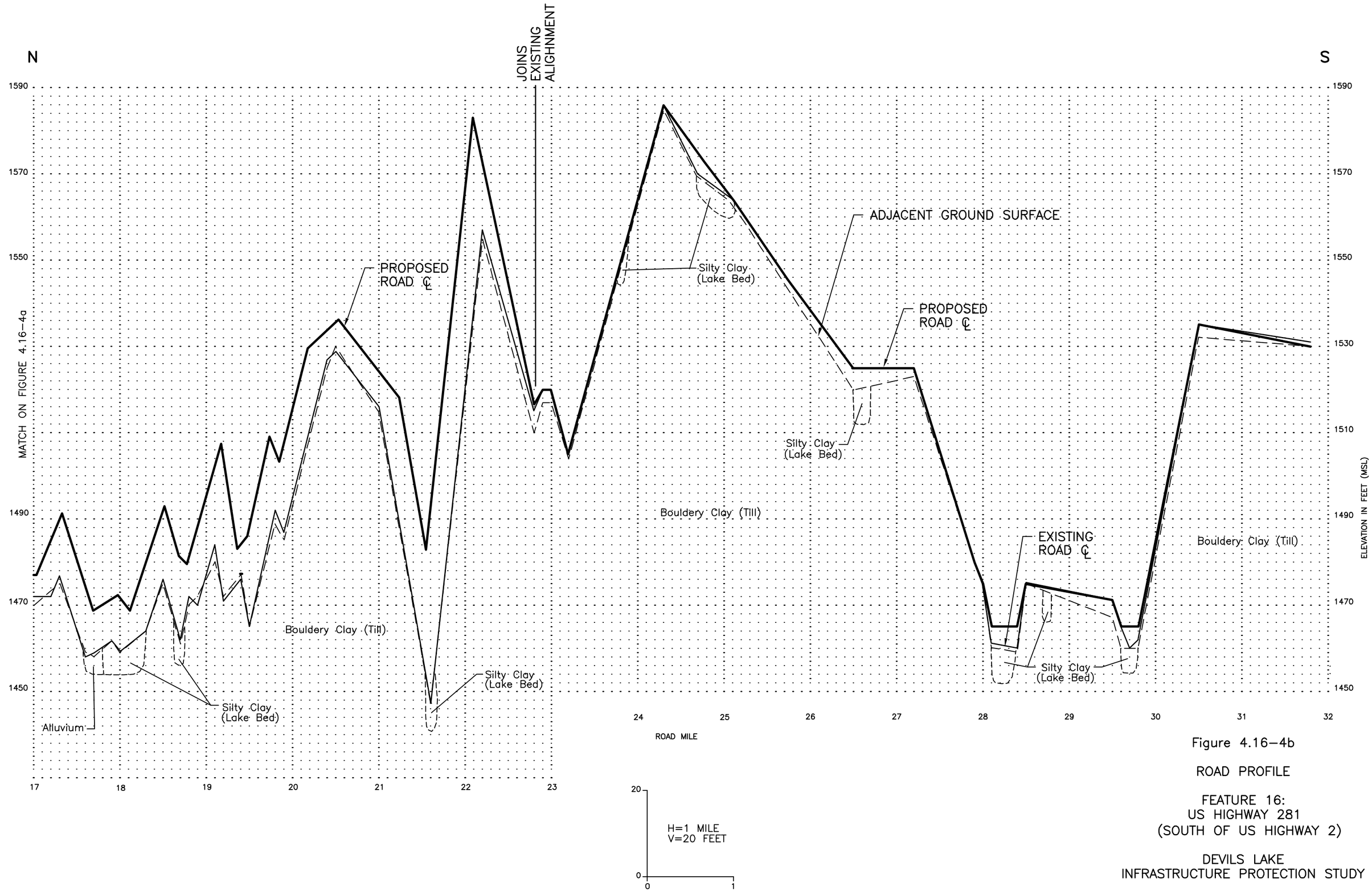


Figure 4.16-4b

ROAD PROFILE

FEATURE 16:
US HIGHWAY 281
(SOUTH OF US HIGHWAY 2)

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

NRD M:\CAD\3436020\17206_1.DWG Plot at 1 11/05/2002 08:33:35

Table 4.16-1

Flood Damages
Feature 16: US Highway 281 (South of US Highway 2)
Devils Lake Infrastructure Protection Study

DAMAGES

Lake Elevation (MSL)	Annual Relocation Detour Damages: Damage Value (THOUSANDS)	Annual Detour Damages: Damage Value (THOUSANDS)	Restoration Damages: Impacted Roadway Length (FEET)	Restoration Damages: Damage Value (THOUSANDS)
1447	$1,671	$5,533	40,000	$9,141
1448	$1,671	$5,533	41,000	$9,257
1449	$1,671	$5,533	42,000	$9,373
1450	$1,671	$5,533	45,580	$9,787
1451	$1,671	$5,533	48,380	$10,111
1452	$1,671	$5,533	50,680	$10,378
1453	$1,671	$5,533	52,540	$10,593
1454	$1,671	$5,533	54,540	$10,824
1455	$1,671	$5,533	67,300	$12,302
1456	$1,671	$5,533	69,900	$12,603
1457	$1,671	$5,533	71,270	$12,761
1458	$1,671	$5,533	72,820	$12,941
1459	$1,671	$5,533	74,400	$13,124
1460	$1,671	$5,533	82,860	$14,103
1461	$1,671	$5,533	85,230	$14,378
1462	$1,671	$5,533	86,630	$14,540
1463	$1,671	$5,533	87,720	$14,666
1464	$1,671	$5,533	88,500	$14,756
1465	$1,671	$5,533	89,000	$14,814

DAMAGE BREAKDOWN

	Description	Quantity	Unit	Unit Cost	Value (THOUSANDS)
Annual Detour Damages	Hours/Year	211,940	HR	$7.13	$1,511
	Miles/Year	11,656,390	MILE	$0.35	$4,021
	Total				**$5,533**
Annual Relocation Detour Damages	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Value (THOUSANDS)**
	Hours/Year	64,025	HR	$7.13	$456
	Miles/Year	3,521,410	MILE	$0.35	$1,215
	Total				**$1,671**

	Item	Description	Quantity per LF of Road		Unit Cost	Contingency	Value per LF of Road
Restoration Damages	Excavation	Removal of existing bituminous (24' X 0.5'), existing shoulder (3' X 0.5' ea. side), existing aggregate base (41' X 0.5'), and top 1.5' of existing road embankment fill	4.06	CY/LF	$3.50	30%	$18
	Fill Material	Replace top 1.5' of roadway embankment	2.69	CY/LF	$5.00	30%	$17
	Geotextile Fabric	Place geotextile beneath new aggregate base	5.00	SY/LF	$2.00	30%	$13
	Aggregate Base Course	Replace 0.5' of subgrade and shoulders (3' X 0.5' ea. side)	0.92	CY/LF	$20.00	30%	$24
	Bituminous	Replace 0.5' of bituminous pavement	0.66	Tons/LF	$50.00	30%	$43
			Total				**$116**
	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 replacement for lowest impacted roadway length	1.89	CY/LF	$40.00	30%	$4,127,760
	Geotextile Fabric	For use under riprap restoration	3.5	SY/LF	$2.00	30%	$382,200
			Total				**$4,509,960**

Table 4.16-2

Flood Protection Costs
Feature 16: US Highway 281 (South of US Highway 2)
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	Re (1)
Action Level	**Relocation at AL1**
	(THOUSANDS)
AL1	$46,031

COST BREAKDOWN

	Re(1)					
Strategy	**Description**	**Quantity**	**Units**	**Unit Cost**	**Contingency**	**Value (THOUSANDS)**
Road Relocation	Performance/Payment Bond	1	JB	$254,606	10%	$280
	Clearing and Grubbing	3.9	AC	$3,000	30%	$15
	Stripping	538,700	CY	$1.50	30%	$1,050
	Geotextile Fabric	57,800	SY	$2.00	30%	$150
	Aggregate Base Course	249,900	CY	$20	30%	$6,497
	Fill Material	2,643,300	CY	$5.00	35%	$17,842
	Bedding	0	CY	$35	30%	$0
	Riprap	25,000	CY	$40	40%	$1,400
	Bituminous Pavement	135,400	TON	$50	30%	$8,801
	Culverts	3,000	LF	$50	50%	$225
	Topsoil	87,400	CY	$2.50	30%	$284
	Seed	82.0	AC	$1,000	30%	$107
	Geotechnical					
	Slurry Wall	0	SF	$6.00	50%	$0
	Borings	160	EA	$1,000	50%	$240
	Environmental Impacts					
	Mitigation	1	LS			$82
	HTRW	1	LS			$15
	Cultural Resources Investigation	1	LS			$116
	Subtotal					$37,104
	Engineering and Design		15%			$5,566
	Supervision and Administration		8%			$2,968
	Real Estate Acquisition for ROW	1	LS			$393
	Total Road Relocation					**$46,031**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Road Maintenance Costs
	(THOUSANDS)
AL1	$182

Table 4.16 - 3a

Economics Results: All Action Levels -- to Lake Level 1463
Feature 16: US Highway 281 (South of US Highway 2)
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	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$602,800	$2,503,100	$0	$3,105,900	$0	$0	--
Re(1)	Relocation of Road at AL1	$0	$2,790,300	$2,790,300	$0	$0	$1,665,000	$1,665,000	$3,105,900	$315,600	1.11

Wet Future Scenario (WF-9)
(Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$0	$5,533,000	$0	$5,533,000	$0	$0	--
Re(1)	Relocation of Road at AL1	$0	$2,800,000	$2,800,000	$0	$0	$1,671,000	$1,671,000	$5,533,000	$2,733,000	1.98

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

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$1,555,000	$2,210,200	$0	$3,765,200	$0	$0	--
Re(1)	Relocation of Road at AL1	$0	$2,800,000	$2,800,000	$0	$0	$1,671,000	$1,671,000	$3,765,200	$965,200	1.34

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

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$148,500	$4,727,700	$0	$4,876,200	$0	$0	--
Re(1)	Relocation of Road at AL1	$0	$2,800,000	$2,800,000	$0	$0	$1,671,000	$1,671,000	$4,876,200	$2,076,200	1.74

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 "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.
The top action level (1463) is never reached in the 10,000 traces, rendering some of the costs and damages equal between different strategies.

Table 4.16 - 3b

Economics Results: First Action Level
Feature 16: US Highway 281 (South of US Highway 2)
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	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$602,800	$2,503,100	$0	$3,105,900	$0	$0	--
Re(1)	Relocation of Road at AL1	$0	$2,790,300	$2,790,300	$0	$0	$1,665,000	$1,665,000	$3,105,900	$315,600	1.11

Wet Future Scenario (WF-9)
(Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$0	$5,533,000	$0	$5,533,000	$0	$0	--
Re(1)	Relocation of Road at AL1	$0	$2,800,000	$2,800,000	$0	$0	$1,671,000	$1,671,000	$5,533,000	$2,733,000	1.98

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

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$1,555,000	$2,210,200	$0	$3,765,200	$0	$0	--
Re(1)	Relocation of Road at AL1	$0	$2,800,000	$2,800,000	$0	$0	$1,671,000	$1,671,000	$3,765,200	$965,200	1.34

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

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$148,500	$4,727,700	$0	$4,876,200	$0	$0	--
Re(1)	Relocation of Road at AL1	$0	$2,800,000	$2,800,000	$0	$0	$1,671,000	$1,671,000	$4,876,200	$2,076,200	1.74

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 "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.
The top action level (1463) is never reached in the 10,000 traces, rendering some of the costs and damages equal between different strategies.

Attachment to 4.16:
US Highway 281 (South of US Highway 2) Infrastructure Protection Study Assumptions

A. Existing Road Information

1. Existing road elevations for the feature were obtained through contact with North Dakota Department of Transportation (ND DOT) representatives, Brad Darr, and the consulting engineers for the ND DOT, Kadrmas, Lee, and Jackson, primarily Charlotte Brett.

2. Existing road cross-section for the feature were based on construction drawing typical sections obtained from Kadrmas, Lee, and Jackson, including:

   - Project SER-3-281(071)156 & SER-3-281(072)160 US Highway 281 Project Concept Report
   - ND DOT Project SER-3-019-(016)138

3. Existing road centerline profiles for the features evaluated were obtained from the 2000 FEMA LIDAR topography.

B. Road Realignment

1. The road realignment was assumed from discussions with ND DOT representatives, primarily Brad Darr, the consulting engineers for the ND DOT, Kadrmas, Lee, and Jackson, primarily Charlotte Brett, and the Federal Transportation Board. The plans referenced include:

   - Project SER-3-281(071)156 & SER-3-281(072)160US Highway 281 Project Concept Report
   - ND DOT Project SER-3-019-(016)138

2. The road realignment either removed the road from the flood extents of the lake or set the road elevation at 1465, so future raises would not be required.

3. Topsoil and seeding was assumed for the road realignment where riprap was not placed to prevent erosion. Topsoil was assumed to be 4 inches deep.

C. Geotechnical

1. The scope and cost of geotechnical mitigation are related to: (1) number of borings and soil tests, and (2) soft soils that may require excavation and/or additional construction material,

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 of road length. Additional borings will be completed in areas of critical soils. Each soil boring and associated observation and testing will cost $2,000.

5. Cut off walls are estimated to be $6/square foot based on past work at Devils Lake.

6. 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.

   The subgrade conditions along the alignment of this feature are based upon review of:

   - 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

D. Road Restoration

1. For damage calculations it was assumed that if the feature were temporarily closed, it would be restored after the lake level has receded to the minimum road surface elevation less the assumed wave runup (the "Lake Damage Elevation").

2. Restoration damages were calculated assuming 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. It was assumed riprap would be placed on the lake side slope over geotextile from the road surface elevation to the bottom of the embankment replacement. The riprap would be placed along the length of roadway lying below the receded lake

damage elevation. The receded lake damage elevation is defined as the receded lake elevation plus the calculated wind-induced wave height.

E. Detours

1. Detour damages were included for every year that the feature is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

2. Restoration of a road would only occur after the lake has receded to 2 feet below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no water on any part of the road and there would be only minor potential for wave action damage on the road.

3. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report,* Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

4. There is more commitment on the part of the North Dakota Department of Transportation (NDDOT) to the Highway 57 causeway than to the Highway 20 causeway through The Narrows. Therefore, Highway 57 was assumed to be the detour route for the Highway 20 causeway. If the Highway 57 causeway was temporarily closed during flooding, it was assumed that the Highway 20 causeway would also be temporarily closed.

5. The detour route for Highway 57 is around the lake to the west via Highway 281 and Highway 19. Woods-Rutten Road was considered as a detour route for Highway 57, but it was not retained as a viable alternative, because it would have to be significantly raised and improved to carry the traffic of Highway 57.

6. Detour paths were determined assuming that all other featured roads would be open (with three exceptions: the Highway 57 detour assumes that Highway 20 across The Narrows is closed and both the BIA 1 and the BIA 6 detours assume that Highway 20 from Highway 57 to Tokio is closed). No effort was made to link detour routes with lake level. However, if a featured road was presented as a detour route, an "interdependency" was noted.

7. The analysis of Features 23 (BIA 1 between Highway 57 and BIA 6) and Feature 24 (BIA 6 between Highway 20 and Fort Totten) assumed that Feature 22 (Highway 20 between Highway 57 and Tokio) is temporarily closed during high lake levels. BIA 1 and BIA 6 are part of the north-south detour for Highway 20 and the preliminary analysis indicated that Feature 22 would likely be temporarily closed during high lake levels.

8. Two features can have mutually interdependent detour routes if they are the most reasonable detours. In these cases, it was assumed that either the analyzed feature or the other feature would be raised or rerouted. In these cases, the interdependency was noted.

4.17 Summary of Infrastructure Protection Investigation for Feature 17: US Highway 281 (North of US Highway 2)

4.17.0 Flood Protection Strategy

The incremental flood protection that was analyzed for US Highway 281 (North of US Highway 2) was an incremental road raise. The ND DOT has indicated that this strategy will most likely occur, so this Infrastructure Protection Study did not analyze other flood protection strategies for US Highway 281 (North of US Highway 2).

4.17.1 General Information

Feature Type: Road

Location: Feature 17 is the portion of US Highway 281 north of US Highway 2 located in Towner County and along the borders of Ramsey and Benson Counties. It extends16.5 miles from its intersection with US Highway 2 outside of Churchs Ferry at the south to Cando at the north. Feature 17 passes through the Townships of Olson, Cando, Atkins, Maza, Irvine, Chain Lakes, Normania, and Coulee. The accompanying Figure 4.17-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: US Highway 281 north of US Highway 2 is a two-lane bituminous National Highway. The entire highway route spans the United States from Canada to Texas. It is classified as a principal arterial highway and National Highway System route. Average daily traffic counts for this feature were 1,250 in 1994 and 1,075 in 2002.

Significance: This portion of US Highway 281 is important because it is a major traffic route in the area, including the main route between Cando and Churchs Ferry. It is vital to serving local transportation, agricultural needs, and moving products through the area.

Damages: The flooding of Feature 17 would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when US Highway 281 (North of US Highway 2) is closed and traffic is detoured
- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation

Owner/Sponsor: The North Dakota Department of Transportation is responsible for managing and maintaining US Highway 281 (North of US Highway 2).

Lead Federal Agency: The Federal Highway Administration would take the lead for US Highway 281 (North of US Highway 2) for any flood protection work that may take place.

4.17.2 Feature Protection

History of Flood Protection: Flood protection for US Highway 281 (North of US Highway 2) has not been an issue to date. Currently all of this section of road has been above the level of the rising water.

General Protection Strategy: The ND DOT plans to raise US Highway 281 north of US Highway 2 and south of Cando to a minimum road surface elevation of 1457.4. The roadway embankment will also be widened along the entire length (below 1465) to accommodate potential future raises up to road surface elevation 1465 without requiring fill placement below water.

Protection Strategy by Lake Level: Figure 4.17-2 shows the decision tree for US Highway 281 (North of US Highway 2). As shown on Figure 4.17-2, the stepwise approach to flood protection for US Highway 281 (North of US Highway 2) consists of the following:

1. At Action Level 1 (AL1), a decision would be made as to whether the road would be raised to 1457.4, whether the road would be relocated, or whether the road would be temporarily abandoned.

2. If the road were raised at AL1, a decision would be made at Action Level 2 (AL2) whether to raise the road to 1462, whether the road would be relocated, or whether to temporarily close the road.

3. If the road were raised at AL2, a decision would be made at Action Level 3 (AL3) whether to raise the road to 1465, whether the road would be relocated, or whether to temporarily close the road.

The intent of the ND DOT is to construct the planned road raise to 1457.4 and embankment widening to minimize the work performed in water. The reference elevations the ND DOT will use, if any, to implement the planned raise and any subsequent raise(s) are not known.

The pertinent reference elevations for implementing each planned action level for the flood protection strategy are given below:

Reference Elevations for Feature 17 Road Raises				
Elevation				
AL1	AL2	AL3	Name	Significance
1454	1457.4	1462	Low Structure Elevation	Low sill on lowest building or minimum road elevation
1451[1]	1454.4[1]	1459[1]	Lake Damage Elevation	Lake elevation at which damage to roadway occurs[1]
N/A	N/A	N/A	Project Completion Elevation	Lake elevation at which levee construction must be complete
1451	1454.4	1459	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.)
1448	1452	1457	Planning and Design Initiation Elevation	Lake elevation at which planning and design process must begin

4.17.3 Design Considerations

Sections 4.17.3.0 through 4.17.3.10 describe the analysis of the road raise design, as well as other considerations (geotechnical, environmental, etc.) necessary to compute the cost estimates for the first action level. Section 4.17.3.11 describes the abbreviated cost estimating method for subsequent action levels.

4.17.3.0 General Design

This section summarizes the preliminary design information provided by NDDOT and its consulting engineers, Kadrmas, Lee, and Jackson. This information is preliminary, but based on discussions in October 2002 with the ND DOT, Kadrmas, Lee, and Jackson, and the federal transportation board, this is the option most likely to be completed. 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.

[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 elevations listed in this table reflect the 3-foot trigger elevation.

Alignment

Figure 4.17-1 shows the alignment of the existing US Highway 281 (North of US Highway 2). The raised roadway will follow the same alignment. The length of US Highway 281 between US Highway 2 and Cando is approximately 16.5 miles. Four segments of the highway are currently below the planned raise to 1457.4. The segments are located:

- Along the border of Section 6 in Chain Lakes Township, Ramsey County and Section 1, Irvine Township, Benson County, and is approximately 0.1 miles long
- Along the border of Section 7 in Chain Lakes Township, Ramsey County and Section 12 in Irvine Township, Benson County, and is approximately 0.3 miles long
- Along the border of Sections 19 and 30 in Chain Lakes Township, Ramsey County and Sections 24 and 25 in Irvine Township, Benson County, and is approximately 1.2 miles long
- Along the border of Section 31 in Chain Lakes Township, Ramsey County and Section 36 in Irvine Township, Benson County, and is approximately 1.5 miles long

All of US Highway 281 (North of US Highway 2) is planned to be widened, except in the following areas:

- From US Highway 2 to ½ mile North of US Highway 2
- From Cando to 1.5 miles south of Cando
- From 1.75 miles south of Cando to 5 miles south of Cando

Figure 4.17-4 shows the existing road profile and the raised road profile.

Cross-Section

Figure 4.17-3 shows a typical cross-section of the proposed road raise. The raise will maintain the existing road centerline. Fill will be placed on each side of the existing embankment wide enough to provide a base width to accommodate potential future raises to an ultimate road surface at 1465. This section is based on US Highway 281 Staged Grade Raise Typical Section from the *Preliminary Construction Report for US Highway 281*, July 2002, by Kadrmas, Lee, and Jackson.

The minimum raised road elevation is assumed to be 1457.4 top of pavement. The road top width was assumed to be 64 feet. The shoulder side slopes are broken up into three different slopes. The first side slope runs 12 feet horizontally and is at 6H:1V on both the sides. The second side slope is only for when the current road elevation is below 1465.

At this point the side slope is 24H:1V on both sides, and varies in length depending upon the elevation of the road. The final side slope is 4H:1V, and runs to the surrounding ground elevation. This is being done so that if the lake continues to rise, all future raises can be done above water. It was assumed that unsuitable foundation soils, averaging 1 foot in depth, will be stripped along the existing embankment 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 12 inches of the roadway section will be constructed of commercially available aggregate surface course material. Bituminous surfacing will be 40 feet in width, and will be 5 inches in depth.

Erosion Protection

On both sides of the road, riprap was assumed to be placed over geotextile (no additional bedding material) between 1452 and 2 feet below the water surface. No topsoil or seeding was assumed for the raised roadbed.

4.17.3.1 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.

Most of US Highway 281 North lies on the silt and clay facies of the Coleharbor Formation. This facies represents lacustrine deposits formed on the bed of former higher stands of Devils Lake, known as Lake Minnewaukan and Lake Cando. The lacustrine deposits include soft lake bottom silt and clay, and lie on the easily recognized lake plain, most of which is now beneath the current lake.

There are a few other deposits of note at the scale of the county geologic maps. In Towner County (T157N, R66W, sec. 20) there is a more recent lake bed deposit, mapped as part of the Oahe Formation. This deposit is generally described as up to 20 feet of tough black silty clay with up to a few percent of organic content. In that same section there the road follows the edge of collapsed lake bed deposits. This was deposited in lakes formed on ice, and the deposits collapsed and distorted as the ice melted. The collapsed lake deposits are similar to other lake deposits, but tend to contain more sand.

In Benson and Ramsey Counties (T156N, R67W, sec. 24 and T156N, R66W, sec. 19 and 30), there is a sand and gravel beach deposit extending westward from Lake Irvine. In Benson County, it is mapped as the sand and gravel facies of the Coleharbor Formation, and in Ramsey County it is mapped as part of the Oahe Formation.

The lake and glacial deposits are just over 100 feet thick on the southern end of Highway 281 North, and thicken to over 300 feet thick in the area of Cando in Towner County. The bedrock is Cretaceous Pierre Shale.

The impacted highway crosses the following soil types, which have the indicated comments with respect to road construction:

- Towner County, near Cando sewage treatment ponds
  - 450 Colvin silt loam; CL, CL-ML; lake bed – Severe: wetness
  - 2293 Colvin silt loam; CL, CL-ML; alluvial deposit – Severe: wetness, flooding
- Towner County southern segment
  - 2196 Colvin silt loam, saline; CL, CL-ML; lake bed – Severe: excess salt, wetness
  - 1221 Maddock loamy fine sand; SM, SC-SM; beach; Slight
  - 1782 Swenoda fine sandy loam; SM, SC-SM; beach; Moderate: frost action
  - 450 Colvin silt loam; CL, CL-ML; lake bed – Severe: wetness
  - 2048 Wyndmere fine loamy sand; SM, ML, SC-SM; beach; Severe: frost action, droughty
  - 846 Great Bend-Overly silt loam; Cl, CL-ML; lake bed; Severe: low strength, frost action
  - 2286 Beardon silt loam; CL-ML, CL; lake bed; Moderate: wetness
- Benson County
  - 119 Aberdeen silty clay loam; CL, CH, ML; lake bed; Severe: shrink-swell, low strength
  - 45 Bearden silt loam, CL-ML, CL; lake bed; Severe: frost action, low strength
  - 4 Fargo silty clay loam; CL, CH; lake bed; Severe: wetness, low strength

- 19 Tonka silt loam; CL, CL-ML; lake bed; Severe: wetness, floods, low strength
- 42&42B Gardena silt loam; ML; Severe: frost action
- 68B Arvilla sandy loam; SM, SC, SM-SC; beach; Slight
- 89&145 Grano silty clay; CH; lake bed; Severe: wetness, floods, low strength
- 41 Overly silty clay loam; CL; lake bed; Severe: frost action, low strength
- 5 Hegne silty clay; CH; lake bed; Severe: wetness, shrink-swell, low strength
- 90 Lallie loam; Ml, CL; lake bed; Severe: wetness, floods, low strength
- 3 Parnell silty clay loam; CL, CH; lake bed; Severe: wetness, floods, low strength

- Ramsey County
  - 34 Aberdeen silt loam; CL, ML; lake bed; Severe: low strength, shrink-swell
  - 36 Bearden silt loam, CL, CH; lake bed; Severe: low strength, frost action
  - 7 Fargo silty clay; CH; lake bed; Severe: low strength, wetness, frost action
  - 30 Emden loam; ML, ML-CL; lake bed; Moderate: frost action
  - 54B Arvilla sandy loam; SM, SC, SM-SC; beach; Slight
  - 5 Grano silty clay; CH; lake bed; Severe: low strength, ponding, frost action
  - 35 Overly silty clay loam; CL, CL-ML; lake bed; Severe: low strength, frost action
  - 45 Hegne silty clay; CH; lake bed; Severe: low strength, shrink-swell
  - 44 Hegne silty clay; OH, CH; lake bed; Severe: low strength, ponding, shrink-swell

"Slight" means soil properties and site characteristics are generally favorable for this use. "Severe" means special design may be required. Wetness and flooding are a given, since much of the area is already inundated.

It is assumed that 15 borings need to be completed in order to determine the strength of the lake bed deposits. The entire impacted road overlies lake bed deposits; approximately 1.8 miles of the impacted road overlies fat clay.

4.17.3.2 Hydrology/Interior Drainage issues

It is assumed that culverts would be placed through the raised roadway embankment to allow for water level equalization on both sides of the roadway. Any existing culverts through the raised roadway were assumed to be filled and abandoned in place. New RCP culverts were assumed to have been placed through the roadway embankment at six low spots along the road.

4.17.3.3 Real Estate Requirements

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

4.17.3.4 Environmental/Cultural issues

HTRW

Current land uses, surrounding US Highway 281 North (North of US Highway 2), appear to be predominantly agricultural with scattered rural residences and farms. One formerly more extensive town, the village of Maza, intercepted by this feature may have had commercial or industrial uses. Land use does not appear to have changed significantly since the 1950's, with the exception of the diminishment of the village of Maza.

Regulatory record reviews for zip codes 58346, 58325, and 58324 were obtained from FirstSearch on October 15, 2002. All of the sites listed in zip codes 58346 and 58324 appear to be in or near the towns of Leeds and Cando, respectively. These two towns are several miles from US Highway 281. One UST facility was listed in Churchs Ferry (58325) but the location was not identified. Based on the name of the facility, Crossroads Service, this UST facility maybe located adjacent to the impact area and site designated as 17-1-5.

Five potential HTRW sites identified along the feature alignment are listed below and shown on Figure 4.17-1:

HTRW Site Costs			
Site #	**Action Level Affected**	**HTRW Category**	**HTRW Costs**
17-1-1	1	Former Communities	$9,000
17-1-2	1	Rural Residences & Farmsteads	$500
17-1-3	1	Rural Residences & Farmsteads	$500
17-1-4	1	Rural Residences & Farmsteads	$500
17-1-5	1	Railroad Related Land Uses	$5,500

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.

Cultural

This project has the potential to affect four known sites and one site lead as shown on Figure 4.17-1. The four known sites are all architectural properties, and they include the Burlington Northern Railroad Bridge (32BE0044), Bennington House (32RY0193), Maza Steeple (32TO0017), and Maza School (32TO0029). Recommendations of eligibility have not been made for the Burlington Northern Railroad Bridge or Maza Steeple. An evaluative survey of Bennington House determined that it was not eligible for listing on the NRHP due to poor integrity. The Maza School, however, was surveyed and was recommended as eligible for listing on the NRHP for its association with the incorporation of the town of Maza.

The site lead that may fall within the US Highway 281 (North of US Highway 2) area of potential effect is 32TOX0004 (Maza Townsite/Post Office), a historical archaeological site lead.

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

Feature 17 US Highway 281 (North of US Highway 2) 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	2	2
Archaeological	0	0	0
Architectural Site Leads/Isolated Finds	0	0	0
Archaeological Site Leads/Isolated Finds	0	0	1
Total	0	2	3

The estimated cost to conduct Phase 1 Surveys for each of the 3 sites is presented in the following table. The total cost for all surveys is $18,600. As noted in Section 4.0, these costs are believed representative of the cultural resources investigations needed for the next stage of study.

Feature 17 US Highway 281 (North of US Highway 2) Phase 1 Survey Costs		
Site Number	**Investigation Type**	**Estimated Cost**
32BE0044	Phase I Architectural	$6,200
32TO0017	Phase I Architectural	$6,200
32TO0029	Phase I Architectural	$6,200

Environmental

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 natural resources within the right-of-way of US Highway 281 (North of US Highway 2) to be raised include wetlands, oak forest/woodlands, and grasslands. The acres of habitat impacted by land use category are shown in Figure 4.22-1. A total of 2.13 acres of wetland impacts would be expected from the proposed infrastructure protection measures, with 0.08 acres of those wetlands having easements on them. 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 loss and fragmentation. These environmental impacts are more fully detailed in the general impacts discussion Section 4.0. This loss of wetland would require 4.18 acres of mitigation wetlands as set forth in the project mitigation policy developed through consultation with the Corps and FWS.

In the upland areas a loss of native species due to grading and filling could be expected. 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. A total of 0.79 acres of oak forest/oak woodland, 0.86 acres of grasslands under easements, 84.60 acres of other grassland habitat and 2.42 acres of cover crop under easements would be impacted from the proposed infrastructure protection measures in this location. The loss of woodland and grassland habitat 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. Mitigation activities would require the acquisition of 1.58 acres of oak forest/oak woodland, 170.06 acres of grasslands habitat and 2.42 acres of cover crop like upland habitat areas for these impacts.

4.17.3.5 Effects on Existing Infrastructure and Utilities

Utilities located along the existing right-of-way limits are assumed not to be impacted by the raise. With the exception of drainage culverts discussed above, no other infrastructure or utilities are expected to be impacted.

4.17.3.6 Interdependencies

The protection of US Highway 281 (North of US Highway 2) is related to the protection of several other features:

- Feature 1: Churchs Ferry – Feature 1 is located at the south end of Feature 17. The protection strategy chosen for either, particularly if the strategy involves relocation, will have an impact on the other feature.
- Feature 13: US Highway 2 – If Feature 17 is closed Feature 13 would experience decreased traffic as other local roads are used to go north to Cando.
- Feature 20: ND Highway 20 (North of the City of Devils Lake) – If Feature 17 is closed Feature 20 would experience increased traffic as a detour route.

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

4.17.3.7 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. The increase in O&M on the adjacent routes that are used as detours would be approximately equal to O&M on the temporarily closed road. Additional maintenance requirements for the raised roadway sections would include maintenance of the riprap on both the lake and land 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.

4.17.3.8 Lead Time Required

The raising of US Highway 281 (North of US Highway 2) 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.

4.17.3.9 Potential Problems and Risks

Potential problems and risks associated with the road raise include:

- Road embankment fill into water in some low areas, or if the lake level encroaches on the roadway, will make compaction and quality control difficult
- Foundation conditions may require additional excavation and/or fill in low areas adjacent to the roadway

4.17.3.10 Data deficiencies

The following data should be collected or verified prior to proceeding with raising US Highway 281 (North of US Highway 2):

- Locations of utilities
- Soil borings along toe of existing road embankment in low areas
- Precise location and evaluation of nearby cultural resources

4.17.3.11 Abbreviated Cost Estimating for Feature Subsequent Action Levels

As was mentioned previously, for Feature 17, 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 4.17-2b. 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 4.17-1.

The same general approach to calculate road raise 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

- Raise elevations

  Action Level 2: 4.6-foot raise to 1462

  Action Level 3: 3-foot raise to 1465

- Cross-section

  Action Level 2: 64-foot top width, 4H:1V side slopes, centerline-aligned raise

  Action Level 3: 64-foot top width, 4H:1V side slopes, centerline-aligned raise

- Length

  Action Level 2: Total length of raised roadway- 6.5 miles

  Action Level 3: Total length of raised roadway- 10.0 miles

- Impacted Area

  The sections raised at the first action level impact no additional land area because the roadway was assumed to be widened to accommodate the subsequent raises. However, additional area is impacted in subsequent raises in those sections that were not previously raised.

Construction material quantities were calculated in accordance with design assumptions discussed previously, and are listed in Table 4.17-2b. 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.

4.17.4 Economics of Flood Protection

Damages: For US Highway 281 (North of US Highway 2), the damages resulting from flooding were estimated up to the maximum lake level (1463). The damage computations for US Highway 281 (North of US Highway 2) are summarized in the accompanying Table 4.17-1.

The top portion of Table 4.17-1 gives a summary of the annual detour damages that would occur during the years when the highway was flooded. It also shows road restoration damages that can be expected when the lake recedes.

The lower portion of the table shows the breakdown of these summary values. It gives quantities in terms of miles per year (of extra miles traveled as a result of detours) and hours per year (of additional travel time resulting from detours) for the detour damages. Also shown are quantities and line-item damages for excavation, geotextile fabric, aggregate base course, fill, bituminous pavement, and riprap for road restoration work when waters recede.

The 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 US Highway 281 (North of US Highway 2) are listed in the Feature 17 Assumptions listing, appended to this Section 4.17.

Costs: The costs of providing flood protection for US Highway 281 (North of US Highway 2) are detailed in the accompanying Table 4.17-2a for the first action level and Table 4.17-2b for the subsequent action levels. Quantities and line-item totals are listed.

The top portion of the tables gives the costs of providing flood protection (as represented in the analysis) by action level. The lower portion of the tables gives a breakdown of the quantities and costs by line item.

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 US Highway 281 (North of US Highway 2) are listed in the Feature 17 Assumptions listing, appended to this Section 4.17.

Kadrmas, Lee, and Jackson prepared a cost estimate for the raising and widening of US Highway 281 (North of US Highway 2), with an estimated cost of $5.2 million. This number was obtained from *SER-3-281(071)156 & SER-3-281(072)160 US Highway 281 Project Concept Report*, July 2002. The difference between their cost estimate and the cost estimate of the first action level that was prepared for this study can be attributed to different assumptions for contingencies and unit prices. The estimated quantities for both were similar.

Contingencies: The contingency percentages used for construction materials ranged from 30 to 50 percent (Table 4.17-2). 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.

4.17.5 Economic Results

The flood protection strategy that was analyzed was incremental road raises, which is highlighted on the decision tree (Figure 4.17-2). The results of the Infrastructure Protection Study for US Highway 281 (North of US Highway 2) are listed in Table 4.17-3a for the analysis of all action levels and in Table 4.17-3b 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 US Highway 281 (North of US Highway 2), the Infrastructure Protection Study analysis provided relevant economic indices for raising the road. The annual net benefits for this approach were less than zero (-$35,200). The BCR for this approach was less than one (0.85). These results show that this strategy is not economically justified. The present worth annualized detour damages that would be prevented by this strategy were computed to be $151,900. The stochastic results are averages over 10,000 traces.

Multiple Action Level Results for Specific Scenarios: Raising the road was also analyzed under each of three specific climate futures. For US Highway 281 (North of US Highway 2), the economic indices for each of the three climate futures are as follows:

- Wet Future – Under the wet future climate scenario, the average net benefits of raising the road were -$198,300, and the BCR was 0.86, indicating that this strategy was not

economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $1,090,100.

- First Moderate Future – Under the first moderate future climate scenario, the first action level is not reached.

- Second Moderate Future – Under the second moderate future climate scenario, the average net benefits of raising the road were -$215,500, and the BCR was 0.67, indicating that this strategy was not economically justified. For this future, the present worth annualized detour damages that would be prevented were computed at $291,000.

First Action Level Stochastic Analysis Results: Using the stochastic analysis along with the updated damage and cost estimates for US Highway 281 (North of US Highway 2), the Infrastructure Protection Study analysis also provided relevant economic indices for the first raise of the road independently. The annual net benefits for this approach were less than zero (-$15,300). The BCR for this approach was less than one (0.88). These results show that this strategy is not economically justified; the results are similar to the results based on all action levels. The present worth annualized detour damages that would be prevented by this strategy were computed to be $84,100. The stochastic results are averages over 10,000 traces.

First Action Level Results for Specific Scenarios: The first raise of the road was also analyzed under each of three specific climate futures. For US Highway 281 (North of US Highway 2), the economic indices for each of the three climate futures are as follows:

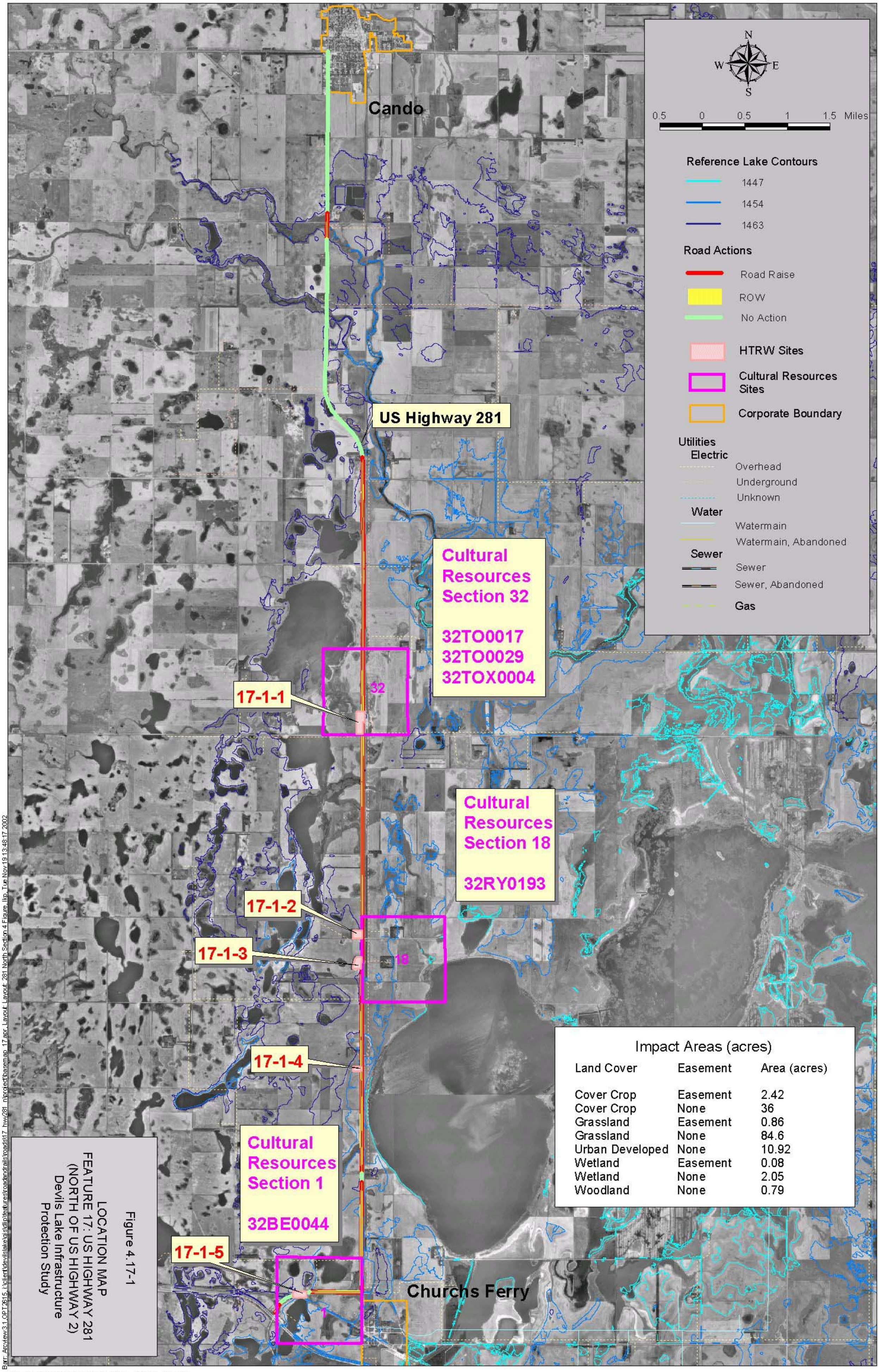
- Wet Future – Under the wet future climate scenario, the average net benefits of the first raise of the road were -$207,000, and the BCR was 0.57, indicating that this strategy was not economically justified. No restoration damages are listed under this scenario; the lake level exceeds the second action level, and restoration damages would be a function of the subsequent action levels[2]. For this future, the present worth annualized detour damages that would be prevented were computed at $270,300.

- First Moderate Future – Under the first moderate future climate scenario, the lake levels do not reach the first damage level.

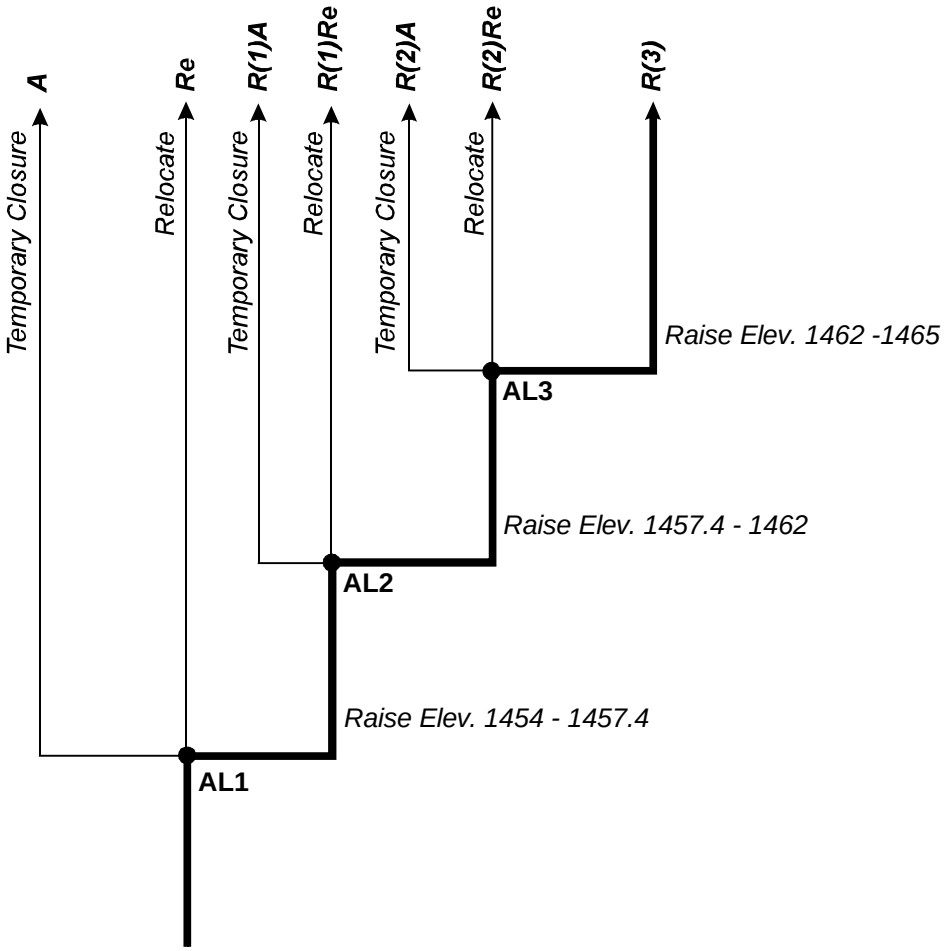
- Second Moderate Future – Under the second moderate future climate scenario, the average net benefits of raising the road were -$135,300, and the BCR was 0.57, indicating that this strategy was economically justified. No restoration damages are listed under this scenario; the

[2] For analysis of the first action level, it was assumed that restoration damages would be attributable to the first action level only if the lake level never reached the subsequent action levels. See Section 3.2.2.1 for further discussion of this assumption.

lake level exceeds the second action level, and restoration damages would be a function of the subsequent action levels[2]. For this future, the present worth annualized detour damages that would be prevented were computed at $179,500.



DATA: 1997 USGS Digital Ortho Quad



Lowest Road Elevation: 1454

━━━	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)
A	Temporary closure of road
Re	Relocate

Figure 4.17-2

DECISION TREE
FEATURE 17: U.S. HIGHWAY 281
(North of U.S. Highway 2)
Devils Lake Infrastructure Protection Study

P:\34\36\020\DECISIONTREES\2002FIGURES\FIGURE4_17.CDR RLG 01-06-03

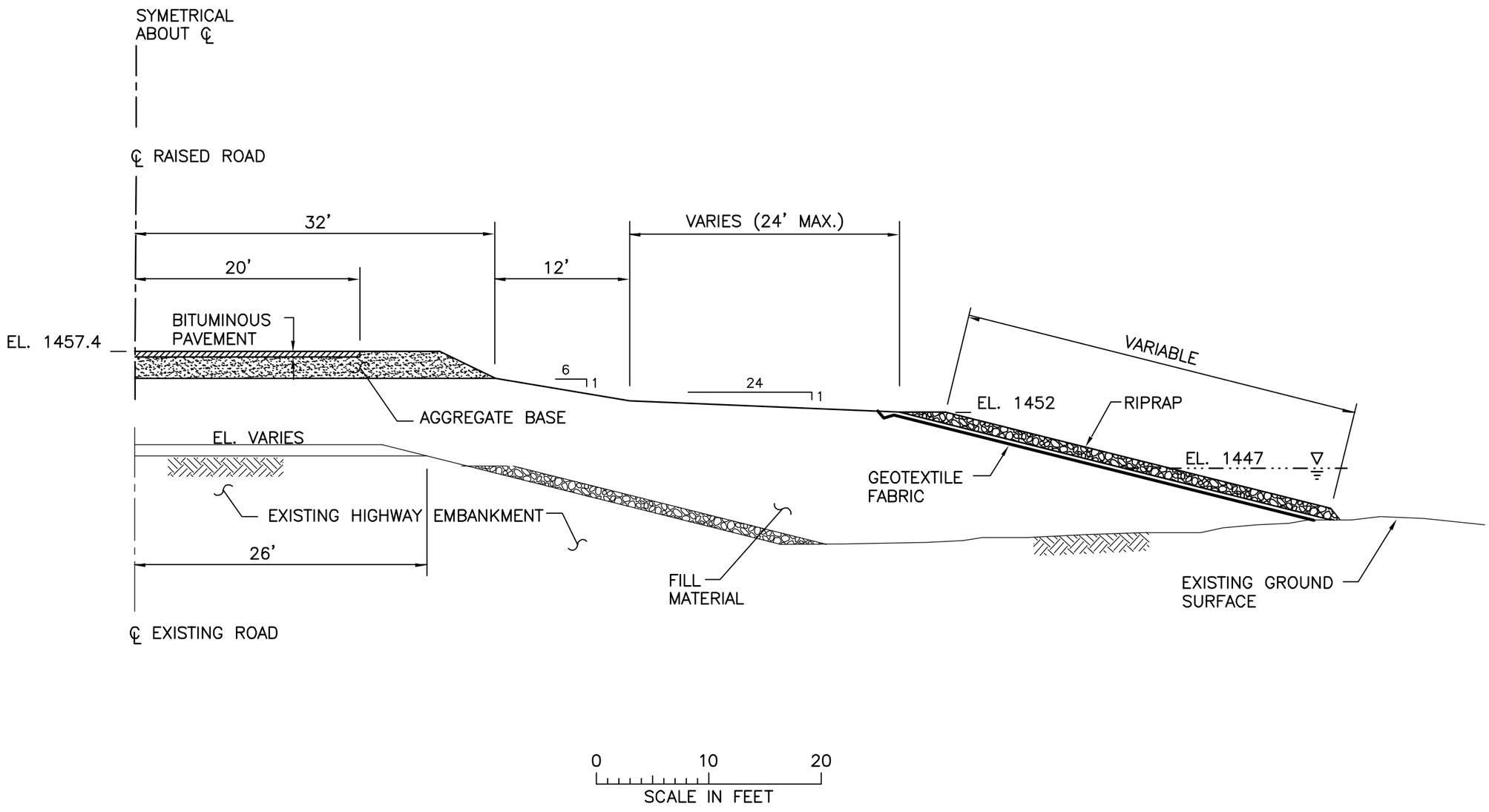


Figure 4.17–3

TYPICAL ROAD CROSS–SECTION

FEATURE 17:
US HIGHWAY 281
(NORTH OF US HIGHWAY 2)

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

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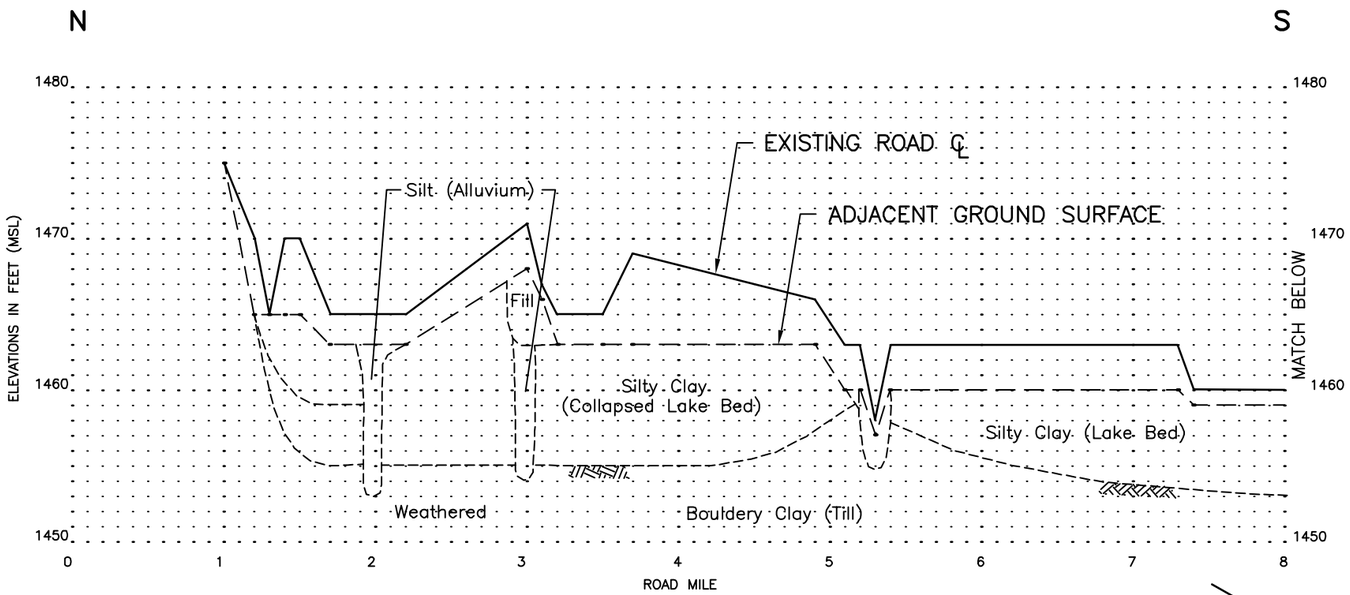

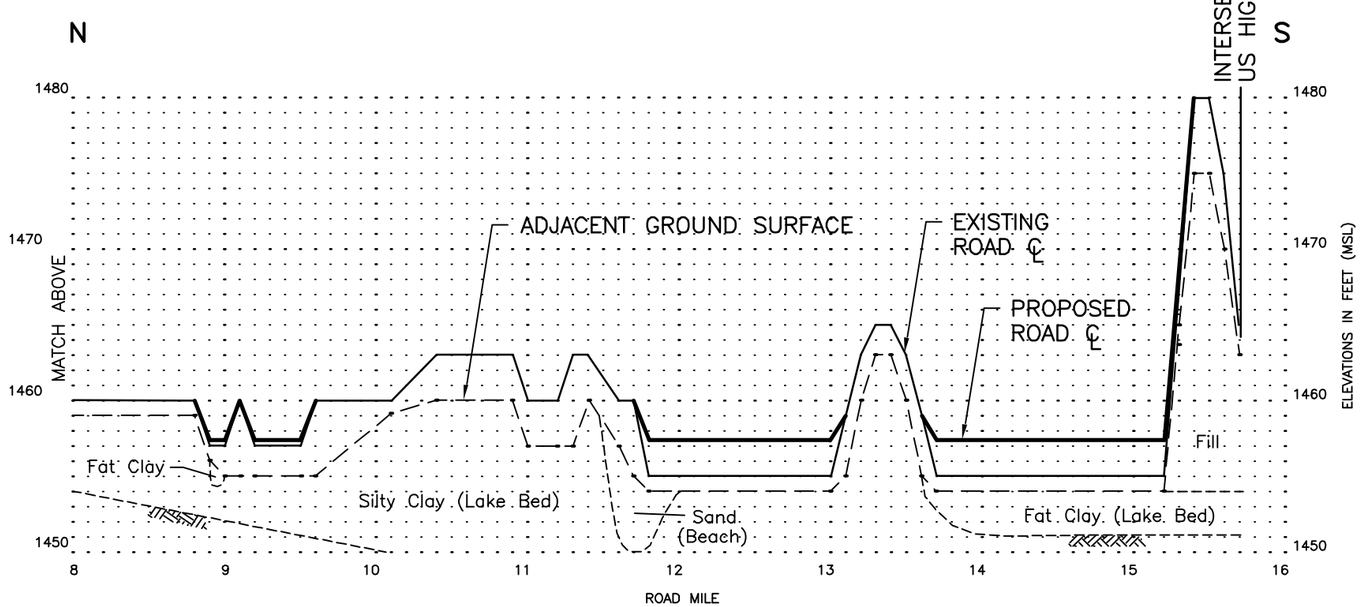

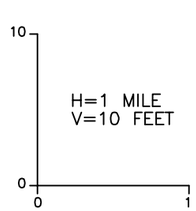

1. Adjacent ground and existing surface elevations obtained from 2000 FEMA LIDAR topography.
2. Road alignment and road surface elevation based on ND DOT report, "US 281 from South of Minnewaukan to Maza, North Dakota Federal Aid Project No. SER–3–281(071)156, South of Minnewaukan SER–3–281(072)160, North of Minnewaukan".
3. Stationing assigned as part of this analysis with stationing increasing from north ot south.

Figure 4.17–4

ROAD PROFILE

FEATURE 17:
US HIGHWAY 281
(NORTH OF US HIGHWAY 2)

DEVILS LAKE
INFRASTRUCTURE PROTECTION STUDY

NRD M:\CAD\3436020\17176_1.DWG Plot at 1 11/01/2002 13:31:45

Table 4.17-1

Flood Damages
Feature 17: US Highway 281 (North of US Highway 2)
Devils Lake Infrastructure Protection Study

DAMAGES

Lake Elevation (MSL)	Annual Detour Damages	Restoration Damages	
	Damage Value (THOUSANDS)	Impacted Roadway Length (FEET)	Damage Value (THOUSANDS)
1448	$0	0	$0
1449	$1,403	14000	$3,552
1450	$1,403	14,430	$3,626
1451	$1,403	14,850	$3,697
1452	$1,403	17,720	$4,187
1453	$1,403	18,840	$4,378
1454	$1,403	20,170	$4,605
1455	$1,403	33,990	$6,965
1456	$1,403	36,360	$7,370
1457	$1,403	39,360	$7,882
1458	$1,403	53,170	$10,240
1459	$1,403	55,280	$10,600
1460	$1,403	59,510	$11,322
1461	$1,403	61,090	$11,592
1462	$1,403	62,150	$11,773
1463	$1,403	62,670	$11,862
1464	$1,403	63,200	$11,952
1465	$1,403	63,700	$12,037

DAMAGE BREAKDOWN

Annual Detour Damages	Description	Quantity	Unit	Unit Cost	Value (THOUSANDS)
	Hours/Year	53,740	HR	$7.13	$383
	Miles/Year	2,955,560	MILE	$0.35	$1,020
	Total				**$1,403**

Restoration Damages	Item	Description	Quantity per LF of Road		Unit Cost	Contingency	Value per LF of Road
	Excavation	Removal of existing bituminous (26' X 0.5'), existing shoulder (10' X 0.5' ea. side), existing aggregate base (52' X 0.5'), and top 1.5' of existing road embankment fill	5.94	CY/LF	$3.50	30%	$27
	Fill Material	Replace top 1.5' of roadway embankment	3.14	CY/LF	$5.00	30%	$20
	Geotextile Fabric	Place geotextile beneath new aggregate base	6.22	SY/LF	$2.00	30%	$16
	Aggregate Base Course	Replace 0.5' of subgrade and shoulders (10' X 0.5' ea. side)	2.32	CY/LF	$20.00	30%	$60
	Bituminous	Replace 0.5' of bituminous pavement	0.72	Tons/LF	$50.00	30%	$47
	Total						**$171**
	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 replacement for lowest impacted roadway length	1.41	CY/LF	$40.00	30%	$1,058,008
	Geotextile Fabric	For use under riprap restoration	2.77	SY/LF	$2.00	30%	$103,925
	Total						**$1,161,932**

Table 4.17-2a

Flood Protection Costs
Feature 17: US Highway 281 (North of US Highway 2)
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	R (1)
Action Level	Incremental Raise at AL1
	(THOUSANDS)
AL1	$9,953

COST BREAKDOWN

Strategy	R(1) Description	Quantity	Units	Unit Cost	Contingency	Value (THOUSANDS)
Road Raise	**Raise Road to Elevation 1457.4**					
	Performance/Payment Bond	1	JB	$54,429	10%	$60
	Clearing and Grubbing	5.5	AC	$3,000	30%	$21
	Stripping	167,000	CY	$1.50	30%	$326
	Geotextile Fabric	1,200	SY	$2.00	30%	$3
	Aggregate Base Course	43,800	CY	$20	30%	$1,139
	Fill Material	670,000	CY	$5.00	35%	$4,523
	Bedding	0	CY	$35	30%	$0
	Riprap	300	CY	$40	40%	$17
	Bituminous Pavement	23,100	TON	$50	30%	$1,502
	Culverts	810	LF	$50	30%	$53
	Topsoil	34,200	CY	$2.50	30%	$111
	Seed	63.0	AC	$1,000	30%	$82
	Geotechnical					
	Slurry Wall	0	SF	$6.00	50%	$0
	Borings	15	EA	$1,000	50%	$23
	Environmental Impacts					
	Mitigation	1	LS			$56
	HTRW	1	LS			$16
	Cultural Resources Investigation	1	LS			$19
	Subtotal					$7,949
	Engineering and Design		15%			$1,192
	Supervision and Administration		8%			$636
	Real Estate Acquisition for ROW	1	LS			$176
	Total Road Raise					**$9,953**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Road Maintenance Costs
	(THOUSANDS)
AL1	$39

Table 4.17-2b

Flood Protection Costs
Feature 17: US Highway 281 (North of US Highway 2)
Devils Lake Infrastructure Protection Study

STRATEGY COSTS BY ACTION LEVEL

Strategy:	R (2)	R (3)
Action Level	Incremental Raise at AL2	Incremental Raise at AL3
	(THOUSANDS)	
AL2	$11,824	$0
AL3	$0	$16,682

COST BREAKDOWN

	R(2)						R(3)					
Strategy	Description	Quantity	Units	Unit Cost	Contingency	Value (THOUSANDS)	Description	Quantity	Units	Unit Cost	Contingency	Value (THOUSANDS)
Road Raise	**Raise Road to Elevation 14xx**						**Raise Road to Elevation 14xx**					
	Performance/Payment Bond	1	JB	$65,782	10%	$72	Performance/Payment Bond	1	JB	$93,220	10%	$103
	Clearing and Grubbing	0.0	AC	$3,000	30%	$0	Clearing and Grubbing	0.0	AC	$3,000	30%	$0
	Stripping	0	CY	$1.50	30%	$0	Stripping	0	CY	$1.50	30%	$0
	Geotextile Fabric	119,000	SY	$2.00	30%	$309	Geotextile Fabric	153,000	SY	$2.00	30%	$398
	Aggregate Base Course	85,000	CY	$20	30%	$2,210	Aggregate Base Course	129,000	CY	$20	30%	$3,354
	Fill Material	311,000	CY	$5.00	35%	$2,099	Fill Material	429,000	CY	$5.00	35%	$2,896
	Bedding	0	CY	$35	30%	$0	Bedding	0	CY	$35	30%	$0
	Riprap	32,000	CY	$40	40%	$1,792	Riprap	38,500	CY	$40	40%	$2,156
	Bituminous Pavement	45,000	TON	$50	30%	$2,925	Bituminous Pavement	68,000	TON	$50	30%	$4,420
	Culverts	0	LF	$50	30%	$0	Culverts	0	LF	$50	30%	$0
	Topsoil	11,000	CY	$2.50	30%	$36	Topsoil	16,000	CY	$2.50	30%	$52
	Seed	20.0	AC	$1,000	30%	$26	Seed	32.0	AC	$1,000	30%	$42
	Geotechnical						**Geotechnical**					
	Slurry Wall	0	SF	$6.00	50%	$0	Slurry Wall	0	SF	$6.00	50%	$0
	Borings	0	EA	$1,000	50%	$0	Borings	0	EA	$1,000	50%	$0
	Environmental Impacts						**Environmental Impacts**					
	Mitigation	0	LS			$0	Mitigation	0	LS			$0
	HTRW	0	LS			$0	HTRW	0	LS			$0
	Cultural Resources Investigation	0	LS			$0	Cultural Resources Investigation	0	LS			$0
	Subtotal					$9,470	Subtotal					$13,420
	Engineering and Design		15%			$1,420	Engineering and Design		15%			$2,013
	Supervision and Administration		8%			$758	Supervision and Administration		8%			$1,074
	Real Estate Acquisition for ROW	1	LS			$176	Real Estate Acquisition for ROW	1	LS			$176
	Total Road Raise					**$11,824**	**Total Road Raise**					**$16,682**

ANNUAL OPERATION AND MAINTENANCE COSTS

Action Level	Road Maintenance Costs
	(THOUSANDS)
AL2	$47
AL3	$67

Table 4.17 - 3a

Economics Results: All Action Levels -- to Lake Level 1463
Feature 17: US Highway 281 (North of US Highway 2)
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	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$54,900	$151,900	$0	$206,800	$0	$0	--
R(3)	3 Incr. Road Raises	$242,000	$0	$242,000	$0	$0	$0	$0	$206,800	-$35,200	0.85

Wet Future Scenario (WF-9)
(Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$131,800	$1,090,100	$0	$1,221,900	$0	$0	--
R(3)	3 Incr. Road Raises	$1,420,200	$0	$1,420,200	$0	$0	$0	$0	$1,221,900	-$198,300	0.86

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

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(3)	3 Incr. Road Raises	$0	$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	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$140,400	$291,000	$0	$431,400	$0	$0	--
R(3)	3 Incr. Road Raises	$646,900	$0	$646,900	$0	$0	$0	$0	$431,400	-$215,500	0.67

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 "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.

Table 4.17 - 3b

Economics Results: First Action Level
Feature 17: US Highway 281 (North of US Highway 2)
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	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$30,300	$84,100	$0	$114,400	$0	$0	--
R(1)	1 Incremental Road Raise	$129,700	$0	$129,700	$0	$0	$0	$0	$114,400	-$15,300	0.88

Wet Future Scenario (WF-9)
(Annual)

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$0	$270,300	$0	$270,300	$0	$0	--
R(1)	1 Incremental Road Raise	$477,300	$0	$477,300	$0	$0	$0	$0	$270,300	-$207,000	0.57

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

Strategy		COSTS			DAMAGES				Total Benefits	Net Benefits	Benefit- Cost Ratio
Designation	Description	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$0	$0	$0	$0	$0	$0	--
R(1)	1 Incremental Road Raise	$0	$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	Raise A	Relocation B	Total C = A + B	Restoration D	Detour E	Relocation Detour F	Total G = D + E + F	To Strategy (Damages Prevented) H = G(A) - G(S) *	To Strategy I = H - C	(BCR) I = H / C
A	Temporary Closure During Floods at First Action Level	$0	$0	$0	$0	$179,500	$0	$179,500	$0	$0	--
R(1)	1 Incremental Road Raise	$314,800	$0	$314,800	$0	$0	$0	$0	$179,500	-$135,300	0.57

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 "temporary closure strategy" minus the total damages for the strategy implemented (G(S)).
The "No Protection" strategy for roads has been defined as temporary closure during floods at the first action level with restoration when the lake recedes.

Attachment to 4.17:
US Highway 281 (North of US Highway 2) Infrastructure Protection Study Assumptions

A. Existing Road Information

1. Existing road elevations for the feature were obtained through contact with North Dakota Department of Transportation (ND DOT) representatives, Brad Darr, and the consulting engineers for the ND DOT, Kadrmas, Lee, and Jackson, primarily Charlotte Brett.

2. Existing road cross-section for the feature were based on preliminary typical sections obtained from Kadrmas, Lee, and Jackson, including:

   - Project SER-3-281(071)156 & SER-3-281(072)160 US Highway 281 Project Concept Report

3. Existing road centerline profiles for the features evaluated were obtained from the 2000 FEMA LIDAR topography.

B. Road Raise

1. The road raise was assumed to be to elevation 1457.4. The raise height varied over the length of the highway, depending on the current elevation.

2. The future road raise cross-section was based discussions with North Dakota Department of Transportation (ND DOT) representatives, Brad Darr, and the consulting engineers for the ND DOT, Kadrmas, Lee, and Jackson, primarily Charlotte Brett. The plans referenced included:

   - Project SER-3-281(071)156 & SER-3-281(072)160 US Highway 281 Project Concept Report

3. In the areas where the base was extended to accommodate future road raises, 4 inches of topsoil was assumed. Seeding in that area was also assumed.

C. Geotechnical

1. The scope and cost of geotechnical mitigation are related to: (1) number of borings and soil tests, and (2) soft soils that may require excavation and/or additional construction material,

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 of road length. Additional borings will be completed in areas of critical soils. Each soil boring and associated observation and testing will cost $2,000.

5. Cut off walls are estimated to be $6/square foot based on past work at Devils Lake.

6. 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.

The subgrade conditions along the alignment of this feature are based upon review of:

- 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

- Hobbs, Howard C. and J.P. Bluemle, 1987. Geology of Ramsey County, North Dakota. North Dakota Geological Survey Bulletin 71 – Part I (also North Dakota State Water Commission County Groundwater Studies 26 – Part I)

- 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/
- Bluemle, John P., 1984. Geology of Towner County, North Dakota. North Dakota Geological Survey Bulletin 79 – Part I (also North Dakota State Water Commission County Groundwater Studies 36 – Part I)
- Kuzniar, R.L. and P.G. Randich, 1983. Groundwater Data for of Towner County, North Dakota. North Dakota Geological Survey Bulletin 79 – Part II (also North Dakota State Water Commission County Groundwater Studies 36 – Part II)
- Randich, P.G. and R.L. Kuzniar, 1984. Groundwater Resources of Towner County, North Dakota. North Dakota Geological Survey Bulletin 79 – Part III (also North Dakota State Water Commission County Groundwater Studies 36 – Part III)
- USDA Soil Conservation Service, 1992, Soil Survey of Towner County, North Dakota. Hardcopy and electronically from http://nasis.nrcs.usda.gov/

D. Road Restoration

1. For damage calculations it was assumed that if the feature were temporarily closed, it would be restored after the lake level has receded to the minimum road surface elevation less the assumed wave runup (the "Lake Damage Elevation").

2. Restoration damages were calculated assuming 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. It was assumed riprap would be placed on the lake side slope over geotextile from the road surface elevation to the bottom of the embankment replacement. The riprap would be placed along the length of roadway lying below the receded lake damage elevation. The receded lake damage elevation is defined as the receded lake elevation plus the calculated wind-induced wave height.

E. Detours

1. Detour damages were included for every year that the feature is temporarily closed, as well as for the first year that the lake has receded. It was assumed that during the first year after the lake has receded, the road would be under restoration. During this first year, there would be both a detour damage and restoration damage. After this first year, there would be no further detour or restoration damages unless the lake rises to within 1 foot of the road again.

2. Restoration of a road would only occur after the lake has receded to 2 feet below the lowest elevation in that road. This was based on the assumption that restoration would only occur when there is no

water on any part of the road and there would be only minor potential for wave action damage on the road.

3. Detour damages were calculated using a cost of $7 per hour of additional travel time, 1.5 people per vehicle, and $0.32 per mile for additional travel distance (Corps of Engineers, March, 2001). Additional time and miles traveled were taken from the results of the QRS II model used in *Devils Lake Flood Control: Economics Database Update: Transportation Report*, Barr Engineering Company, January 1998. The QRS II model determines the overall effect of a closed road on an entire network of traffic, incorporating the fact that traffic consists of trips having different origins and destinations.

4. There is more commitment on the part of the North Dakota Department of Transportation (NDDOT) to the Highway 57 causeway than to the Highway 20 causeway through The Narrows. Therefore, Highway 57 was assumed to be the detour route for the Highway 20 causeway. If the Highway 57 causeway was temporarily closed during flooding, it was assumed that the Highway 20 causeway would also be temporarily closed.

5. The detour route for Highway 57 is around the lake to the west via Highway 281 and Highway 19. Woods-Rutten Road was considered as a detour route for Highway 57, but it was not retained as a viable alternative, because it would have to be significantly raised and improved to carry the traffic of Highway 57.

6. Detour paths were determined assuming that all other featured roads would be open (with three exceptions: the Highway 57 detour assumes that Highway 20 across The Narrows is closed and both the BIA 1 and the BIA 6 detours assume that Highway 20 from Highway 57 to Tokio is closed). No effort was made to link detour routes with lake level. However, if a featured road was presented as a detour route, an "interdependency" was noted.

7. The analysis of Features 23 (BIA 1 between Highway 57 and BIA 6) and Feature 24 (BIA 6 between Highway 20 and Fort Totten) assumed that Feature 22 (Highway 20 between Highway 57 and Tokio) is temporarily closed during high lake levels. BIA 1 and BIA 6 are part of the north-south detour for Highway 20 and the preliminary analysis indicated that Feature 22 would likely be temporarily closed during high lake levels.

8. Two features can have mutually interdependent detour routes if they are the most reasonable detours. In these cases, it was assumed that either the analyzed feature or the other feature would be raised or rerouted. In these cases, the interdependency was noted.

4.19 Summary of Infrastructure Protection Investigation for Feature 19: ND Highway 1

4.19.0 Flood Protection Strategy

The flood protection strategy evaluated for ND Highway 1 was relocation of one reach of the highway. The ND DOT has already implemented this strategy, so this Infrastructure Protection Study did not analyze the flood protection strategy with the largest net benefits for this feature.

4.19.1 General Information

Location: Feature 19 is the portion of ND Highway 1 in Nelson County that begins at the southern ends of Sections 15 and 16 in Wamduska Township, and continues south to the southern end of the border between Sections 34 and 35. It extends approximately 3.4 miles across this stretch. The accompanying Figure 4.19-1 shows the feature's location and approximate extents, and the inundation extents at the three reference lake levels (1447, 1454, and 1463).

Description: ND Highway 1 in Wamduska Township is a two-lane bituminous-surfaced state highway. The centerline elevation varies from a minimum of 1465 just east of the easternmost part of Stump Lake, to 1503 approximately 3 miles south of Stump Lake. Average daily traffic counts for this feature were 638 in 1994 and 469 in 2002.

Significance: This portion of ND Highway 1 is important because it is a major north-south traffic route for the area east of Devils Lake and Stump Lake. It is vital to serving local transportation, agricultural needs, and moving products through the area.

Damages: The flooding of Feature 19 would result in the following damages:

- Detour damages resulting from the added travel time and miles traveled when ND Highway 1 is closed and traffic is detoured
- Restoration damages resulting from repairs that would be necessary to bring the highway back to a useable condition after a period of inundation

Owner/Sponsor: The North Dakota Department of Transportation is responsible for managing and maintaining ND Highway 1.

Lead Federal Agency: The Federal Highway Administration would take the lead for ND Highway 1 for any flood protection work that may take place.

4.19.2 Feature Protection

History of Flood Protection: The ND DOT completed the realignment of 2.4 miles of ND Highway 1 in fall of 2002. The realignment involved abandoning a segment of the road inundated by the rising level of Stump Lake and relocating of that section of the road east of Stump Lake.

General Protection Strategy: The general protection strategy for this feature—already implemented—consists of road relocation.

Protection Strategy by Action Level: As can be seen on the decision tree for Feature 19, the protection strategy is the same regardless of the lake level.

4.19.3 Design Considerations

4.19.3.0 General Design

This section summarizes the design information of the completed road realignment provided by NDDOT. This information is based on the following plans:

- ND DOT Road Realignment in Nelson County. Project No. SER-3-001(010)150, dated 9/13/2001
- ND DOT Hot Bituminous Pavement in Nelson County. Project No. SER-3-001(008)150, dated 9/13/2001

Alignment

Figure 4.19-1 shows the alignment of the relocated ND Highway 1. The relocated roadway does not follow the original road alignment, but was moved farther to the east.

Cross-Section

Figure 4.19-3 shows a typical cross-section of the realignment. This section is based on the ND DOT road realignment plans listed above. The road width is 58 feet and has a paved width of 40 feet. The shoulder side slopes are 6H:1V, while the embankment slopes vary from 2H:1V at the road's highest section, to 6H:1V at its lowest section.

Materials

The relocated roadway fill was constructed from soils obtained from borrow areas adjacent to the realigned roadway.

4.19.3.1 Site Geology

No analysis of site geology was completed for ND Highway 1 because the realignment described has already been implemented.

4.19.3.2 Hydrology/Interior Drainage Issues

No hydrology/interior drainage issues were examined for ND Highway 1 because the realignment has already been completed.

4.19.3.3 Real Estate Requirements

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

4.19.3.4 Environmental/Cultural issues

No environmental/cultural analysis was completed for ND Highway 1 because the road raise and realignment described has already been implemented.

4.19.3.5 Effects on Existing Infrastructure and Utilities

No analysis of effects on existing infrastructure and utilities was completed for ND Highway 1 because the road raise described has already been implemented.

4.19.3.6 Interdependencies

The protection of ND Highway 1, by virtue of it already being implemented, is not interdependent to the protection of any other features.

4.19.3.7 O&M

Operation and maintenance requirements were not examined for ND Highway 1 because the above-mentioned realignment has already been completed.

4.19.3 Economics of Flood Protection

Damages: No damages analysis was completed for ND Highway 1 because the road relocation described has already been implemented.

Costs: The construction cost of providing flood protection for ND Highway 1 by realigning a segment of the road was $2.58 million for the grading and $395,000 for the pavement. This was based on information provided by Brad Darr at the ND DOT.

4.19.4 Economic Analysis Results

No economic analysis was completed for ND Highway 1 because the road relocation described has already been implemented.

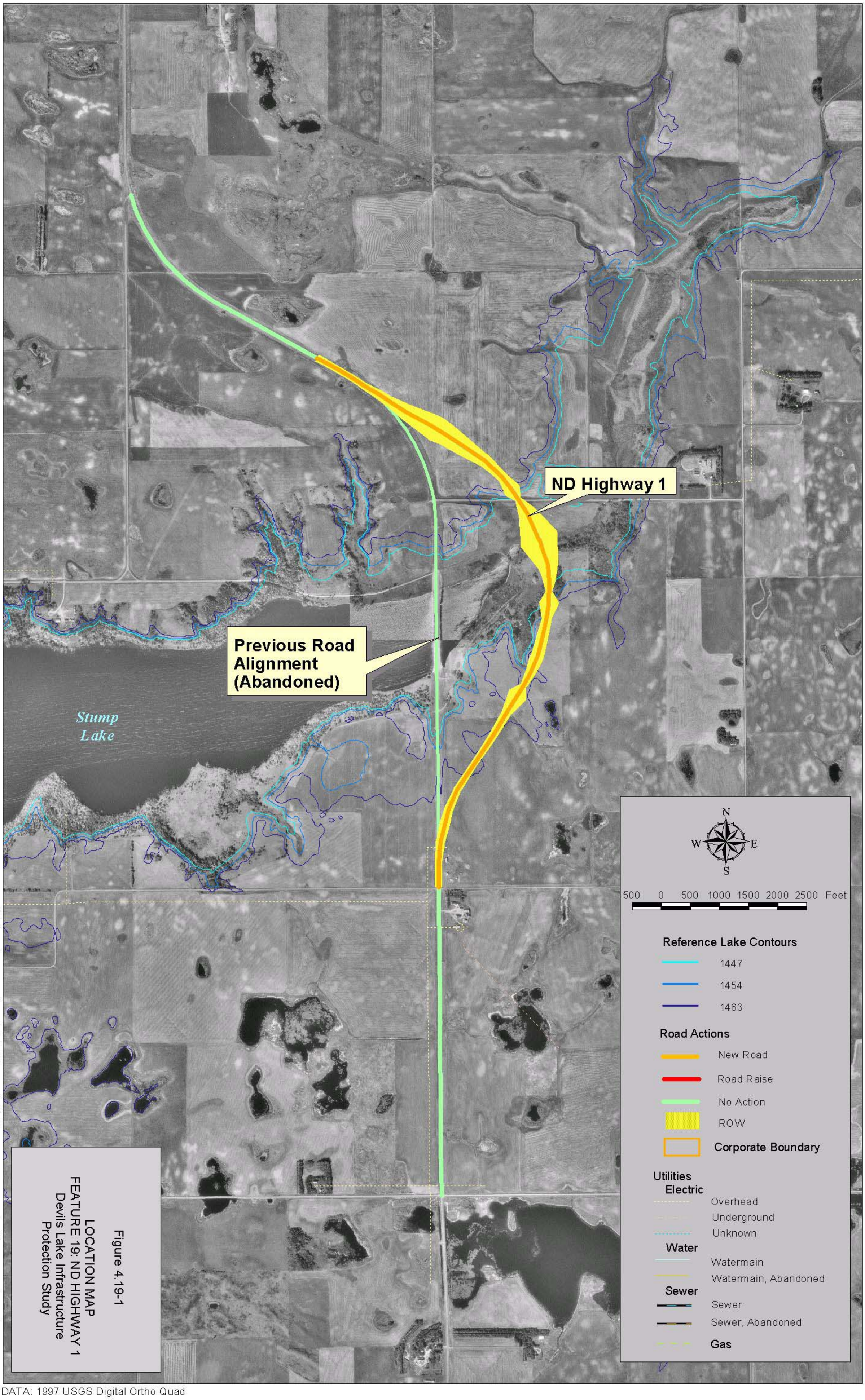

Figure 4.19-1
LOCATION MAP
FEATURE 19: ND HIGHWAY 1
Devils Lake Infrastructure
Protection Study

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