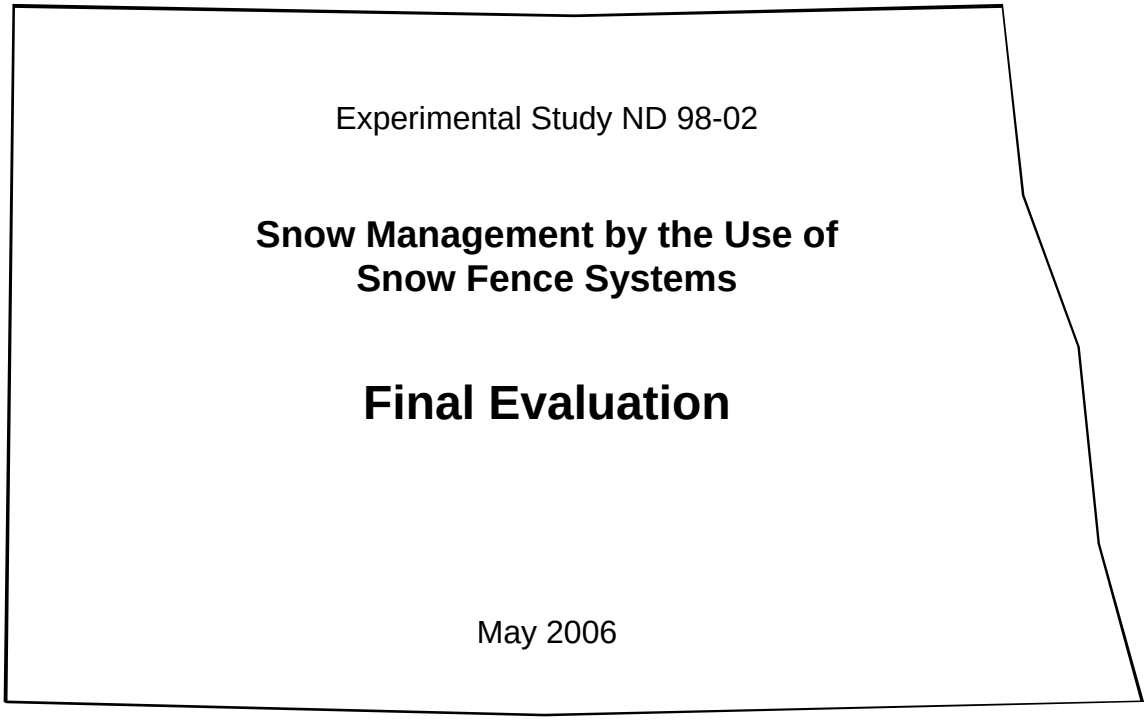
NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION



Experimental Study ND 98-02

Snow Management by the Use of Snow Fence Systems

Final Evaluation

May 2006

Prepared by

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
BISMARCK, NORTH DAKOTA
www.dot.nd.gov

DIRECTOR
David A. Sprynczynatyk, P.E.

MATERIALS AND RESEARCH DIVISION
Ron Horner, P.E.

RCS HHO-30-19

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT

EXPERIMENTAL PROJECT NO. (1)
STATE: ND | YEAR: 98 | - | NUMBER: 02 | SURF:

CONSTRUCTION PROJ NO (8):

LOCATION: Burleigh & Cass 28 Counties

EVALUATION FUNDING (48)
1 X HP&R
2 CONSTRUCTION
3 DEMONSTRATION
4 IMPLEMENTATION

NEEP NO. (49):

PROPRIETARY FEATURE? (51)
X Yes
No

SHORT TITLE

TITLE (52): Snow Management by the Use of Snow Fence Systems

THIS FORM

DATE (140): MO. 05 -- YR. 2006

REPORTING: 1 INITIAL 2 ANNUAL 3 X FINAL

KEY WORDS

KEY WORD 1 (145): MAINTENANCE
KEY WORD 2 (167): SNOWCONTROL
KEY WORD 3 (189): SNOW FENCE
KEY WORD 4 (211):
UNIQUE WORD (233):
PROPRIETARY FEATURE NAME (255):

CHRONOLOGY

Date Work Plan Approved	Date Feature Constructed:	Evaluation Scheduled Until:	Evaluation Extended Until:	Date Evaluation Terminated:
10-1997	12-1997	12-2002	05-2006	05-2006
277	281	285	289	293

QUANTITY AND COST

QUANTITY OF UNITS (ROUNDED TO WHOLE NUMBERS)	UNITS		UNIT COST (*Dollars, Cents*)
(297)	1 LIN. FT 2 SY 3 SY-IN 4 CY (305)	5 TON 6 LBS 7 EACH 8 X LUMP SUM	55270.00 (306)

AVAILABLE EVALUATION REPORTS

CONSTRUCTION	PERFORMANCE	FINAL
X (315)	X	X

EVALUATION

CONSTRUCTION PROBLEMS (318)
1 X NONE
2 SLIGHT
3 MODERATE
4 SIGNIFICANT
5 SEVERE

PERFORMANCE (319)
1 EXCELLENT
2 GOOD
3 X SATISFACTORY
4 MARGINAL
5 UNSATISFACTORY

APPLICATION (320)

1 ADOPTED AS PRIMARY STD.
2 PERMITTED ALTERNATIVE
3 X ADOPTED CONDITIONALLY
4 PENDING
5 REJECTED
6 NOT CONSTRUCTED

(Explain in remarks if 3, 4, 5, or 6 is checked)

REMARKS

321 Installation of the snow fence systems went well. The structural snow fences are in good condition but do require maintenance to keep the polymer straps tensioned and to reattach the loose brackets.

The structural snow fence systems are recommended for use in areas that have a history of drifting snow on the roadway and have adequate land area for a properly designed structural snow fence. The living snow fences are also recommended. However, they don't appear to be as effective as the structural snow fence systems and they take some time to grow to an effective size and thickness.

Form FHWA 1461

Experimental Study ND 98-02

Snow Management by the Use of Snow Fence Systems

Final Evaluation

May 2006

Written by
Curt Dunn/Steven Henrichs

Disclaimer

The contents of this report reflect the views of the author or authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not reflect the official views of the North Dakota Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

TABLE OF CONTENTS

Snow Management by the Use Of Snow Fence Systems

Purpose and Need

North Dakota winters, due to high winds and open prairies, have a potential for drifting snow on our roadways. Proper road design can be effective in preventing snowdrifts and poor visibility. However, there are isolated areas along our highway system that have a tendency to accumulate snow and exhibit poor driving conditions. Many of these areas are due to grade separations at intersections and structures.

During the 1996/97 winter season, the interstate system was forced to close on many more occasions due to blowing snow and snow accumulation than in past winters. After the snowstorms ceased, the interstate system remained closed while maintenance crews worked to open the roadways. The closures may be minimized if proper management and control of blowing snow could be attained. Snow management may be attained in these highly vulnerable areas through carefully designed living and structural snow fences. Addressing these problem areas is critical to ensure our roadways stay safe for the traveling public.

Objective

The objectives are to collect snow in drifts before it reaches the highway or highway structure, improve visibility by reducing the concentration of snow in the air, and reduce snow removal and highway maintenance costs.

Scope

The North Dakota Department of Transportation (NDDOT) had installed demonstration structural snow fence systems at four sites located on the interstate system. These four sites were problem areas due to poor visibility and snow accumulation on the roadway. One of the sites had an existing living snow fence, consisting of a young shelterbelt of Ash and Pine trees. Photo 1 shows a six feet tall structural snow fence with the living snow fence in February 1998.

The structural sites and the living snow fence were evaluated to determine if snow fence systems can be utilized on a larger scale on North Dakota roadways.

Photo 1 - Structural snow fence and living snow fence in February 1998.

Location

Two test sites were located in the Fargo District and two test sites were located in the Bismarck District. The sites were strategically located in the vicinity of either a grade separation or an interchange along Interstates I-29 and I-94. Refer to Figure 1 for the project location.

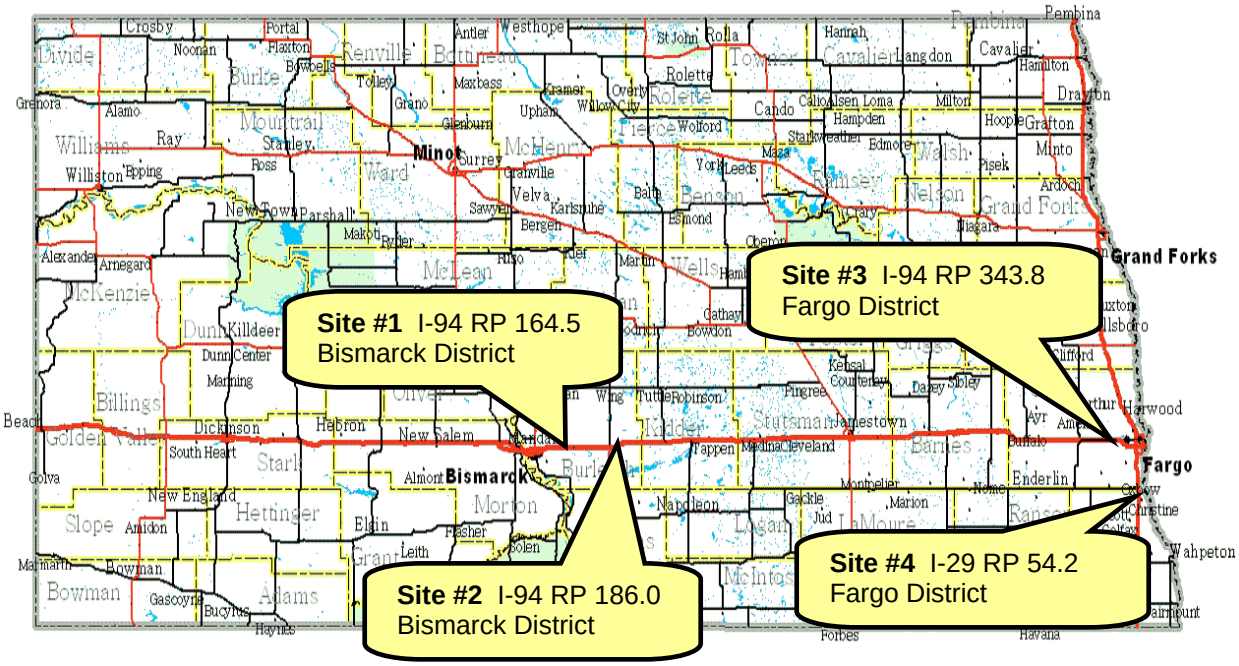


Figure 1 - Project Location.

Design

The North Dakota Department of Transportation consulted with Tabler & Associates from Longmont, Colorado for the design of the structural snow fence test sections. Tabler & Associates specialize in engineering for snow, sand, dust, and wind control. The procedures that Tabler & Associates used to determine the required height and placement of fences are those recommended in the Strategic Highway Research Program Report SHRP-H-381, *"Design Guidelines for the Control of Blowing and Drifting Snow,"* 1994 (364 pages). Tabler & Associates' plans are provided in Appendix A.

The structural snow fences were constructed with a post and rail design. The rail is a composite polymer strap in which three 10.5-gauge wires are embedded. This product, marketed as Centaur HTP fencing, is five inches wide and comes in lengths up to 660 feet. Because 40% to 50% fence porosity is considered ideal, the straps are spaced five inches apart. The straps are mounted to the posts by brackets that allow the straps to freely slide along the length of the strap and the straps are tensioned with a ratchet system permanently attached to a post on one end of the fence. Photo 2 shows the polymer straps being tensioned with the ratchet system during construction.

Photo 2 - Polymer straps are tensioned with a ratchet system.

Construction

State maintenance forces constructed the snow fence systems. Construction went well and maintenance forces were very efficient in installing the fences. Crews of approximately four to six workers were assigned to each site. The Fargo District used salvaged power poles as fence posts. The Bismarck District purchased new wooden posts.

The plans for site 1 (I-94 RP 164.5) are shown in Appendix A. The six-foot and four-foot fences along the right-of-way were constructed in mid-December 1997. The plans show three ten-foot fences that are outside the right-of-way, but these fences were not constructed. Instead, a single ten-foot fence was constructed in 1998. This fence is approximately 200’ north of the right-of-way and is parallel to the 6’ fence constructed in 1997. The approximate location of this fence is shown in blue in Appendix A. Site 1 had an existing living snow fence that was planted in 1994. The living snow fence was planted along the right-of-way and consists of two rows of trees planted 12’ apart. One row is Green Ash and the other row is Pine.

The plans for site 2 are shown in Appendix A. The snow fences between Interstate 94 and the frontage roads were constructed in December 1997. The plans show a long ten-foot fence that is to north and west of a communications tower. This fence was never constructed.

Appendix A shows the plans for site 3 and site 4. Both sites were built according to the plans. Site 3 was constructed in December of 1997 and site 4 was constructed in 1998.

Evaluation

First Evaluation

The snow fence systems were visually inspected in the summer of 2002 for structural integrity and for signs of deterioration. The living snow fence was inspected for survival and growth of the trees.

Sites 2, 3, and 4 were inspected on June 12, 2002 and site 1 was inspected on August 12, 2002. The overall condition of the snow fences was good. The ratchet hardware showed signs of corrosion but appeared to be operable. The polymer strap material showed no signs of deterioration but on most of the snow fences the polymer straps needed to be adjusted by tensioning the straps. Photo 3 shows a fence with polymer straps that need tensioning.

Photo 3 - Loose polymer straps.

It was typical to see, that one or two brackets per fence had become loose. These brackets hold the polymer straps in position and are attached to the posts by screws. The brackets had become loose because the screws had pulled out of the posts. It appeared the screws had pulled out because the posts had cracked. The salvage posts had more cracks and loose brackets than the purchased posts. This problem could probably be addressed by using longer screws. The loose brackets didn't appear to be a problem. Photo 4 shows a bracket that had become loose.

Photo 4 - Bracket that has become loose.

At site 4, a fence post had tilted and had caused some of the polymer straps to become loose and other straps to bind. Photo 5 shows the tilted post. This post was near the north end of an eight-foot fence that is located between Interstate 29 and the southbound exit ramp. This end of the fence is in an area that appeared to collect water and the ground at the base of the fence post was wet and quite soft.

Photo 5 - A tilted fence post at Site 4.

Site 1 also had a fence post that had tilted. This post was the eastern-most post of the six-foot fence that runs along the right-of-way. The post was loose in the ground and could be rocked by hand. It was in standing water and the ground was very soft.

The living snow fences at site 1 appeared to be thriving and no trees appeared to have died. The Green Ash trees are approximately 12'-16' tall and the Pine trees are approximately 8'-10' tall. The condition of the living snow fence is shown in photos 6 and 7. The height of the living snow fence in 1998 is shown in photo 1.

Photo 6 - A view of the living snow fence in 2002.

Photo 7 - Another view of the living snow fence in 2002.

The snow fences were evaluated for snow collection on January 29, 2003. There was two to five inches of snow on the ground and there was not enough snow to determine if the snow fences prevented drifting onto the roadway.

All of the snow fences had collected a drift on the downwind side of the fence and most snow fences had also collected a drift upwind of the fence. Downwind of some snow fences there was an obvious area where less snow had accumulated on the ground than in the surrounding area. Photo 8 shows a snow fence with an area of less snow accumulation at site 2.

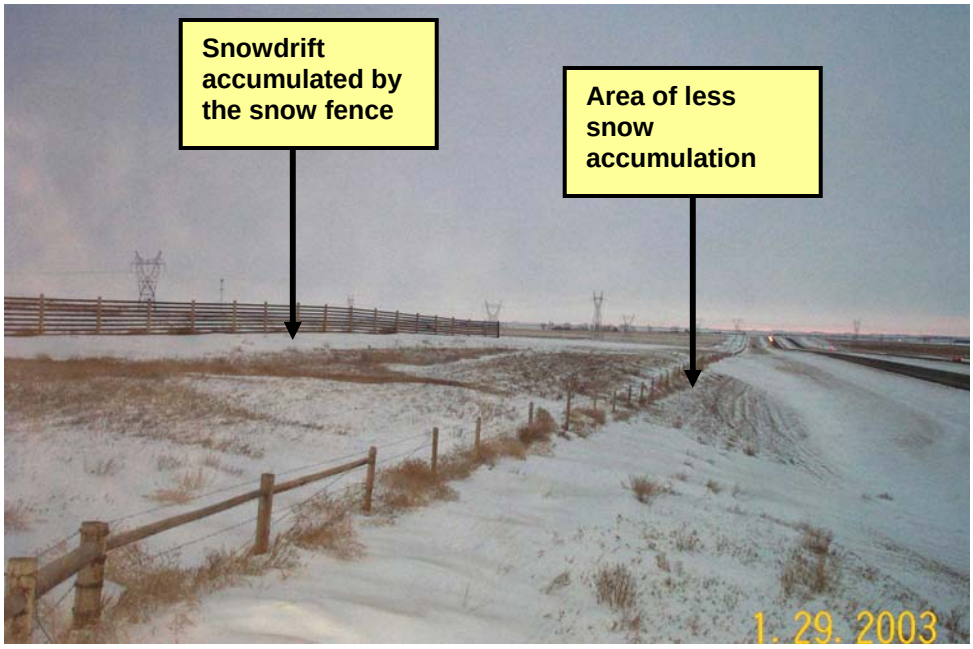


Photo 8 - A snow fence at site 2 in January 2003.

Snow fences at higher locations than surrounding areas appeared to collect more snow than fences in low areas. Photo 9 shows a large drift along a snow fence in a high location on the west side of site 3. Photo 10 shows the relatively small amount of snow collected by a snow fence in a low location at site 3.

Photo 9 - A large drift accumulated by a snow fence at a relatively high location at site 3.

Photo 10 - A snow fence in at a low elevation at site 3 with relatively little snow accumulation.

Second Evaluation

The condition of the snow fence systems were evaluated in the summer of 2003. There was little change from the previous summer's evaluation. The structural snow fences remained serviceable. The straps showed almost no deterioration. Approximately, the same number of brackets that hold the strap to the posts remained loose as the previous summer. Posts that were found to be tilted in the previous evaluation remained in the same position and remained effective. The loose post at Site 1 remained upright but tilted. The living snow fence continued to thrive and no trees appeared to have died.

Sites 1 and 2 were evaluated on February 13, 2004 for their ability to collect snow in drifts. There had been recent snow fall and there was 6-10" of snow on the ground. The roadway had already been plowed so that there was no snow on the pavement. It appeared that the snow fences were functioning according to design. Typically, the downwind side of the snow fences had drifts 1 1/2 ft to 3 ft deep. From the shape of the drifts it appeared that the prevailing winds are from approximately the same direction as used for the design of the snow fences. Photo 11 shows a snow fence at Site 2 and the drift it created. Photo 11 was taken facing southwest.

Photo 11 – Snow drift created by a fence at Site 2.

The living snow fence at Site 1 had collected snow also. The snow was mostly collected within the two rows of trees and did not appear to develop a downwind drift like the structural snow fences. This may be because the snow collected between the two rows of trees was collected by the Pine trees and the Ash trees collected little snow. The snow was approximately 1' to 2' deep within the two rows of trees. The structural snow fence that ran along the living snow fence collected drifts the same size as other snow fences and the amount of snow it collected wasn't obviously affected by its proximity to the living snow fence. Photo 12 shows the snow collected within the living snow fence.

Photo 12 – Snow collected within the living snow fence.

Third Evaluation

The condition of the snow fence systems were evaluated in the winter of 2005 and spring of 2006. The snow fences generally showed little change from the previous evaluation and the living snow fences continue to thrive.

At Site 1, the easternmost 4' fence had sustained some damage from a grass fire in the ditch. The two lowest polymeric straps had been burned through but the internal wires remained intact and continuity of the straps wasn't compromised. The damaged area of the fence is shown in Photo 13.

Photo 13 – Damage to polymer straps caused by a grass fire. Note that the internal steel wires remained intact.

The 6’ fence on the west side of Site 1 had several posts tilting and one post being pulled out. This was in an area on the fence’s east end that often has wet soil. The posts are shown in Photo 14.

Photo 14 – A fence with tilted posts in wet soil at Site 1.

In the spring of 2006, Site 4 was observed to be partially flooded. This was during a period of widespread spring flooding in the Red River Valley. The fences didn't appear to be affected by the flooding. Photo 15 shows Site 4 during flooding in 2006.

Photo 15 – Fence at Site 4 during spring flooding in 2006.

Summary

Installation of the snow fence systems went well. The structural snow fences were in good condition but do require maintenance to keep the polymer straps tensioned and to reattach the loose brackets. The living snow fence is thriving and has grown significantly.

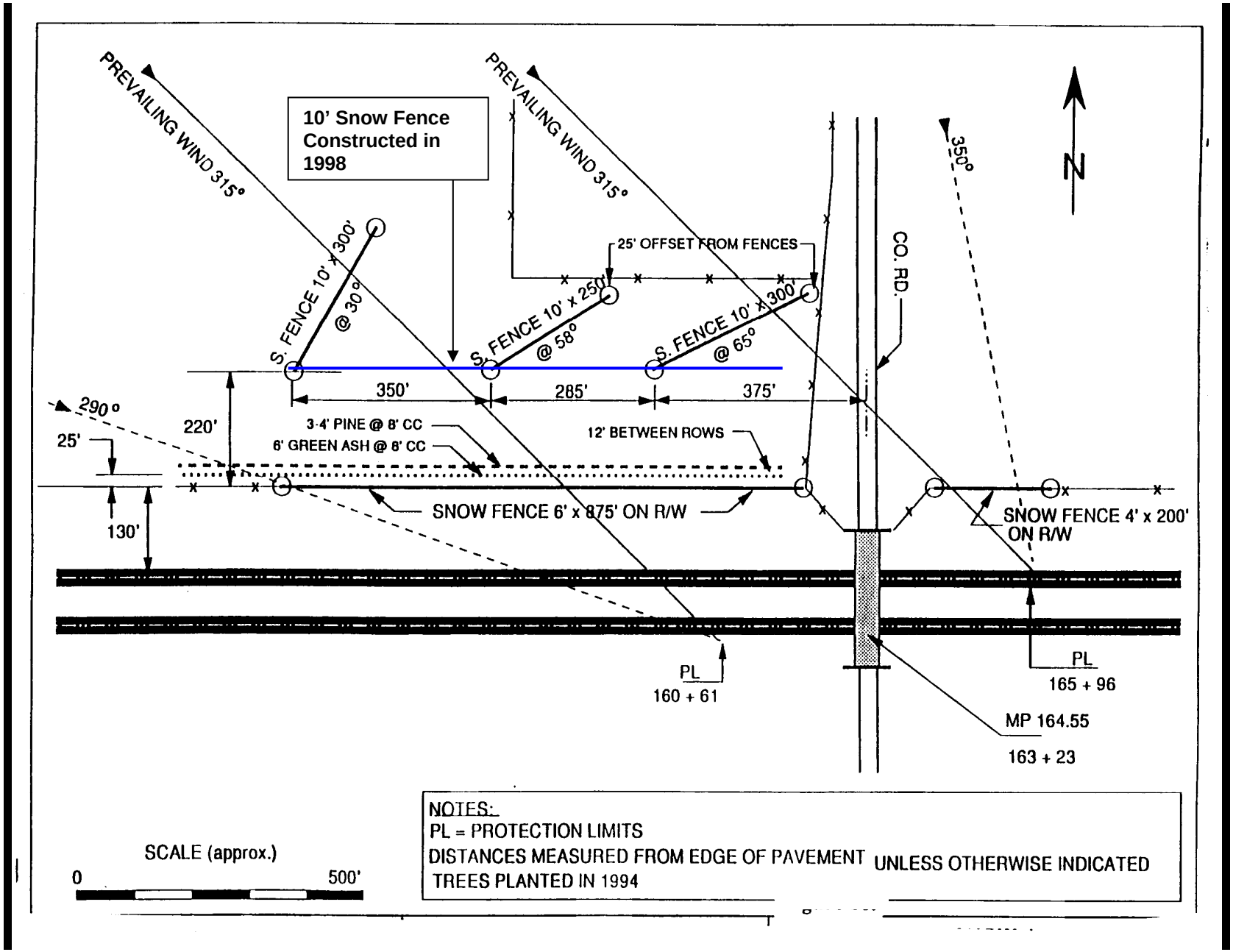
The snow fences have shown the capability to collect snow in drifts. The structural snow fences appear to collect more snow than the living snow fences. There has not been enough snow to evaluate if the snow fences have an effect on roadway conditions.

Recommendation

The structural snow fence systems are recommended for use in areas that have a history of drifting snow on the roadway and have adequate land area for a properly designed structural snow fence.

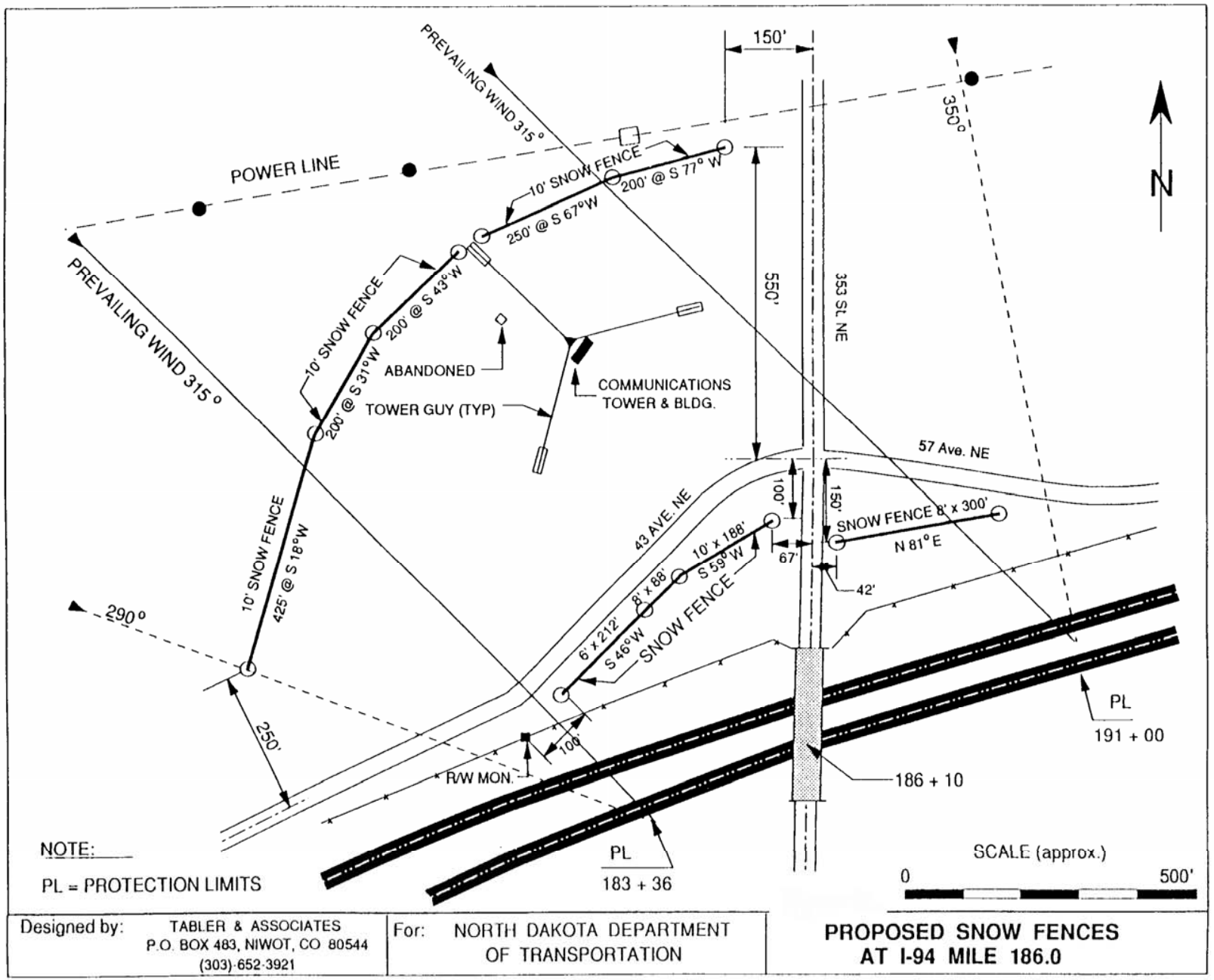
The living snow fences are also recommended. However, they don't appear to be as effective as the structural snow fence systems and they take some time to grow to an effective size and thickness.

Appendix A

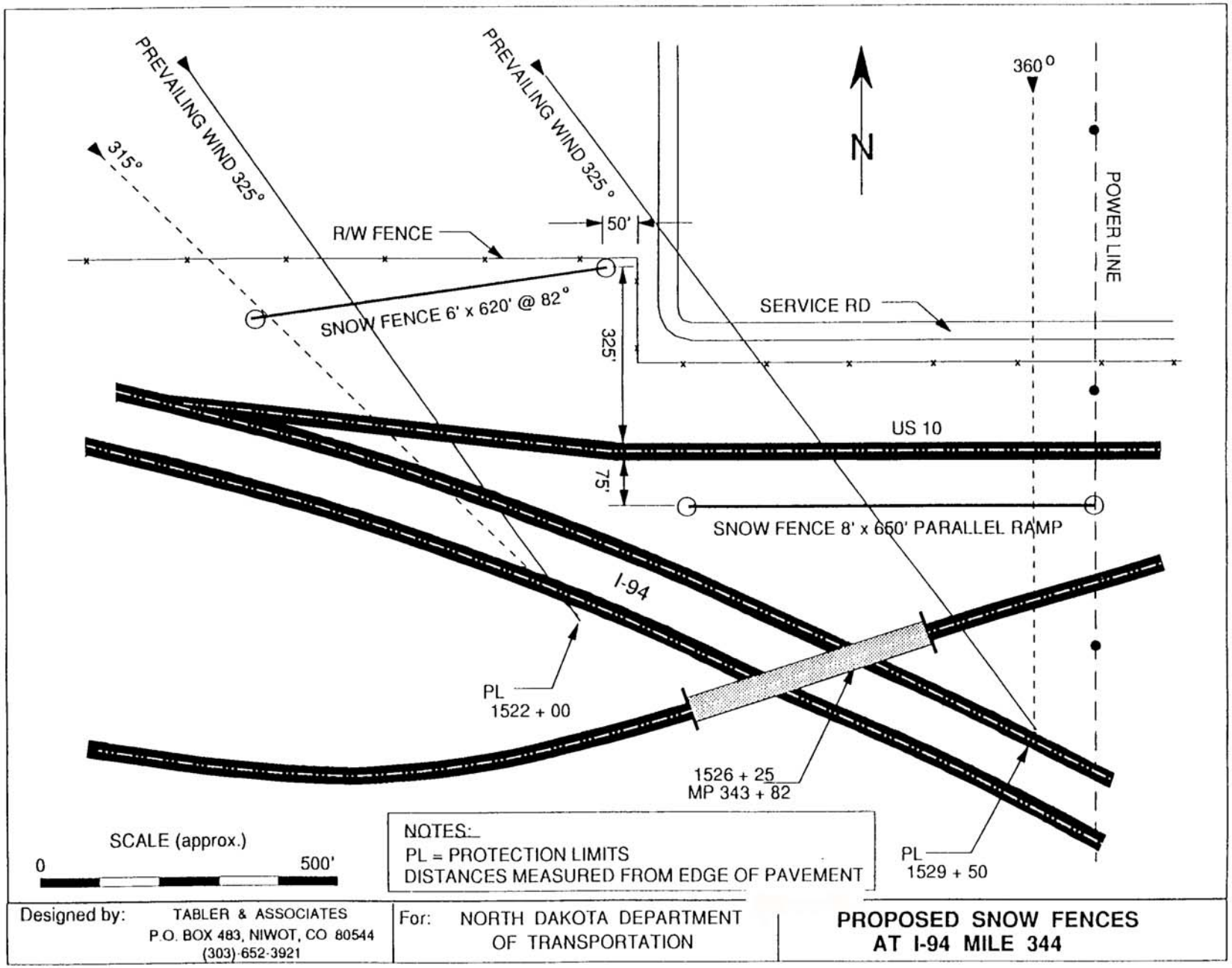

10' Snow Fence Constructed in 1998
PREVAILING WIND 315°
PREVAILING WIND 315°
350°
N
25' OFFSET FROM FENCES
CO. RD.
S. FENCE 10' x 300' @ 30°
S. FENCE 10' x 250' @ 58°
S. FENCE 10' x 300' @ 65°
350'
285'
375'
290°
220'
25'
130'
3-4' PINE @ 8' CC
6' GREEN ASH @ 8' CC
12' BETWEEN ROWS
SNOW FENCE 6' x 875' ON R/W
SNOW FENCE 4' x 200' ON R/W
PL
160 + 61
PL
165 + 96
MP 164.55
163 + 23
SCALE (approx.)
0
500'
NOTES:
PL = PROTECTION LIMITS
DISTANCES MEASURED FROM EDGE OF PAVEMENT UNLESS OTHERWISE INDICATED
TREES PLANTED IN 1994

A-1

Site 1

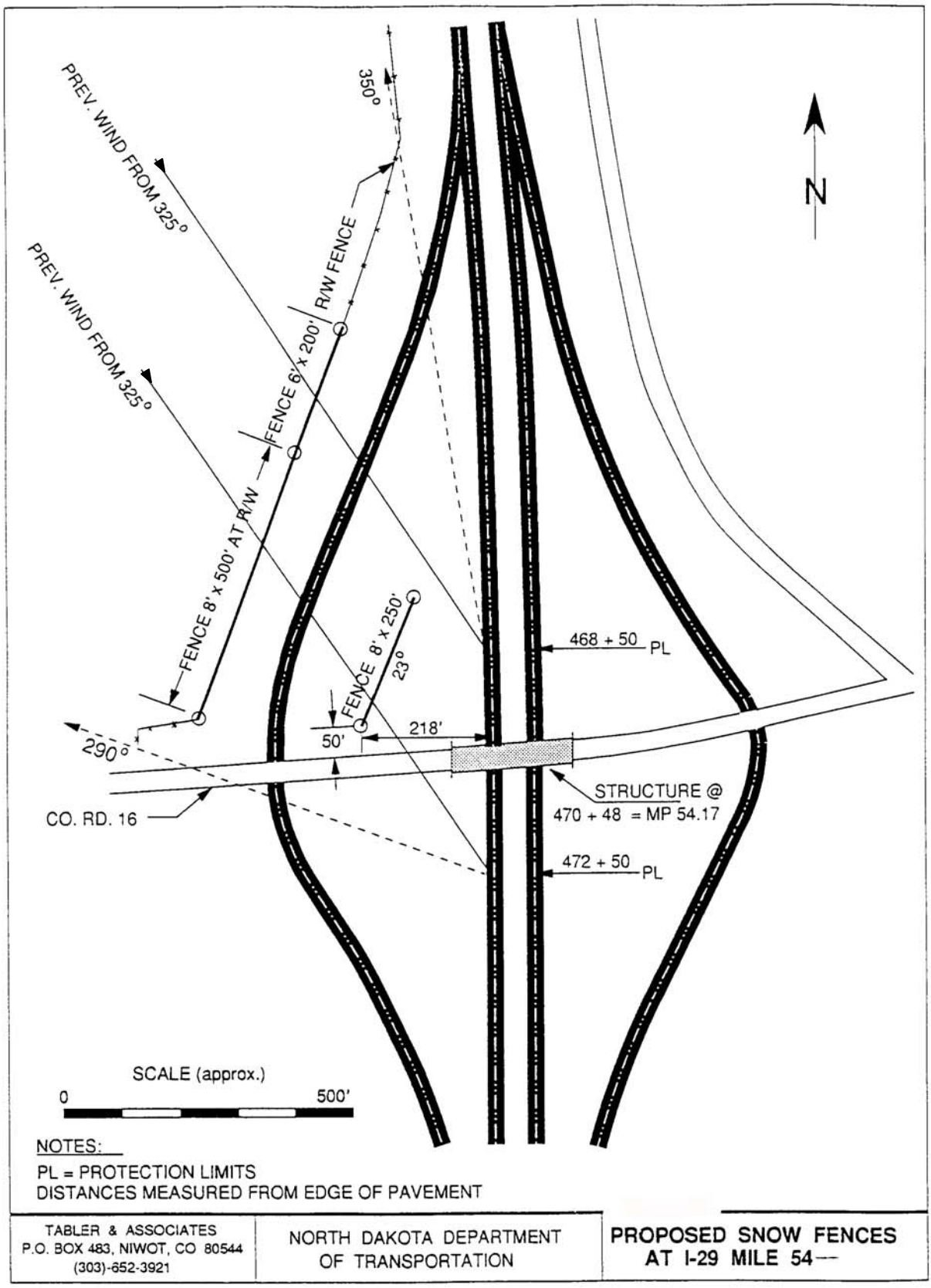

PREVAILING WIND 315°
150'
350°
N
POWER LINE
10' SNOW FENCE
200' @ S 77° W
250' @ S 67°W
PREVAILING WIND 315°
10' SNOW FENCE
200' @ S 43°W
200' @ S 31°W
ABANDONED
TOWER GUY (TYP)
COMMUNICATIONS TOWER & BLDG.
550'
353 St NE
57 Ave. NE
100'
150'
SNOW FENCE 8' x 300'
N 81° E
43 AVE. NE
10' x 188'
S 59° W
67'
42'
8' x 88'
6' x 212'
S 46°W
SNOW FENCE
10' SNOW FENCE
425' @ S 18°W
290°
250'
100'
R/W MON.
PL
191 + 00
186 + 10
PL
183 + 36
NOTE:
PL = PROTECTION LIMITS
SCALE (approx.)
0
500'
Designed by: TABLER & ASSOCIATES
P.O. BOX 483, NIWOT, CO 80544
(303)-652-3921
For: NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
PROPOSED SNOW FENCES
AT I-94 MILE 186.0

Site 2


PREVAILING WIND 325°
PREVAILING WIND 325°
315°
360°
N
POWER LINE
R/W FENCE
50'
SNOW FENCE 6' x 620' @ 82°
SERVICE RD
325'
US 10
75'
SNOW FENCE 8' x 660' PARALLEL RAMP
I-94
PL
1522 + 00
1526 + 25
MP 343 + 82
PL
1529 + 50
SCALE (approx.)
0
500'
NOTES:
PL = PROTECTION LIMITS
DISTANCES MEASURED FROM EDGE OF PAVEMENT
Designed by: TABLER & ASSOCIATES
P.O. BOX 483, NIWOT, CO 80544
(303)-652-3921
For: NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
PROPOSED SNOW FENCES
AT I-94 MILE 344

A-3

Site 3


PREV. WIND FROM 325°
PREV. WIND FROM 325°
350°
R/W FENCE
FENCE 6' x 200'
FENCE 8' x 500' AT R/W
FENCE 8' x 250'
23°
290°
50'
218'
468 + 50 PL
472 + 50 PL
STRUCTURE @
470 + 48 = MP 54.17
CO. RD. 16
N
SCALE (approx.)
0
500'
NOTES:
PL = PROTECTION LIMITS
DISTANCES MEASURED FROM EDGE OF PAVEMENT
TABLER & ASSOCIATES
P.O. BOX 483, NIWOT, CO 80544
(303)-652-3921
NORTH DAKOTA DEPARTMENT
OF TRANSPORTATION
PROPOSED SNOW FENCES
AT I-29 MILE 54--

Site 4