NORTH CENTRAL MINNESOTA SWCD's JOINT POWERS BOARD

ENGINEERING STUDY & PRELIMINARY DESIGN FOR THE STABILIZATION OF JUDICIAL DITCH 28

FOR

LAKE OF THE WOODS COUNTY

AND THE

LAKE OF THE WOODS SOIL & WATER CONSERVATION DISTRICT

ENGINEERING STUDY & PRELIMINARY DESIGN FOR

THE STABILIZATION OF JUDICIAL DITCH 28

For

LAKE OF THE WOODS COUNTY

GENERAL: Judicial Ditch 28 is located on the north side of Sections 31 & 32 of Wheeler Township, Lake of the Woods County, Minnesota. At the request of the county, HDR Engineering, Inc. of Thief River Falls, MN completed a sediment reduction study encompassing the Bostick Creek Watershed in June of 2005. That study identified this section of JD 28 as generally unstable, citing mainly ditch bank sloughing.

The recommendation in the HDR study is to further evaluate this problem area and implement practices to provide stability in this reach of the ditch. This report focuses on that goal.

CAUSES OF INSTABILITY: It is likely that a number of variables are involved in the erosion of this ditch section. There is no record of maintenance work being done on this section for many years, if ever. The areas adjacent to the ditch have been grazed at times with the cattle having unrestricted access to the channel. There are differing soil types and textures within this reach, with some being more susceptible to erosion than others. This section of channel has a slope that is three times steeper than that of the areas upstream and downstream of it. The existing channel cross sectional area is small relative to the high flow volume this system experiences during the large runoff events. This results in high channel velocities. This was the case during the extreme flood event of June 2002 when the ditch experienced a large amount of damage in this section. The existing condition of the channel is particularly unstable do to numerous obstructions and irregularities created by the bank sloughing. This tends to create areas of high velocity flow resulting in severe erosion.

DESIGN APPROACH: Two-Stage Ditch Design

Natural stream systems tend to include not only a main channel but also a floodplain. The floodplains of high quality streams are characterized by frequent, extensive over-bank flow. Channels, sized by stable fluvial processes, just convey the effective (bankfull) discharge and larger flows widen out onto the floodplain. In equilibrium, a stream system depends on both the ability of the floodplain to dissipate high flow energy, and also concentrate the energy of low flow - effectively creating a balance in sediment transport, storage and supply.

Ditch channels are often oversized for small flows and provide no floodplain for large flows. In response to this imbalance, fluvial processes create a small main channel by building a floodplain or bench within the confines of the ditches. If conditions allow, these benches can reach a stable size, and become thickly vegetated with primarily grasses. The small main channel will often meander slightly within the ditch and is sized by nature to carry the effective discharge.

A two-stage ditch attempts to restore some of the functions of a natural stream. A main channel is constructed to convey the effective (bankfull) discharge. At the bankfull elevation, a level bench is constructed to act as a floodplain.

Benefits of a two-stage ditch over a conventional ditch include both improved drainage and ecological functions. Drainage benefits can include increased ditch stability and reduced maintenance.

Channel stability may be improved by a reduction in the erosive potential of larger flows as they are shallower and spread out across the bench. Stability of the ditch bank may also be improved because the toe of the ditch bank meets the bench rather than the ditch bottom.

Judicial Ditch 28
Layout Map
T.162 R.32 Sec 31N, 32N

Legend

A = Jct of Co. Rd. #4 and JD 28
B = Start of any major visible sloughing
C = Jct of JD 28 and Bostic Creek

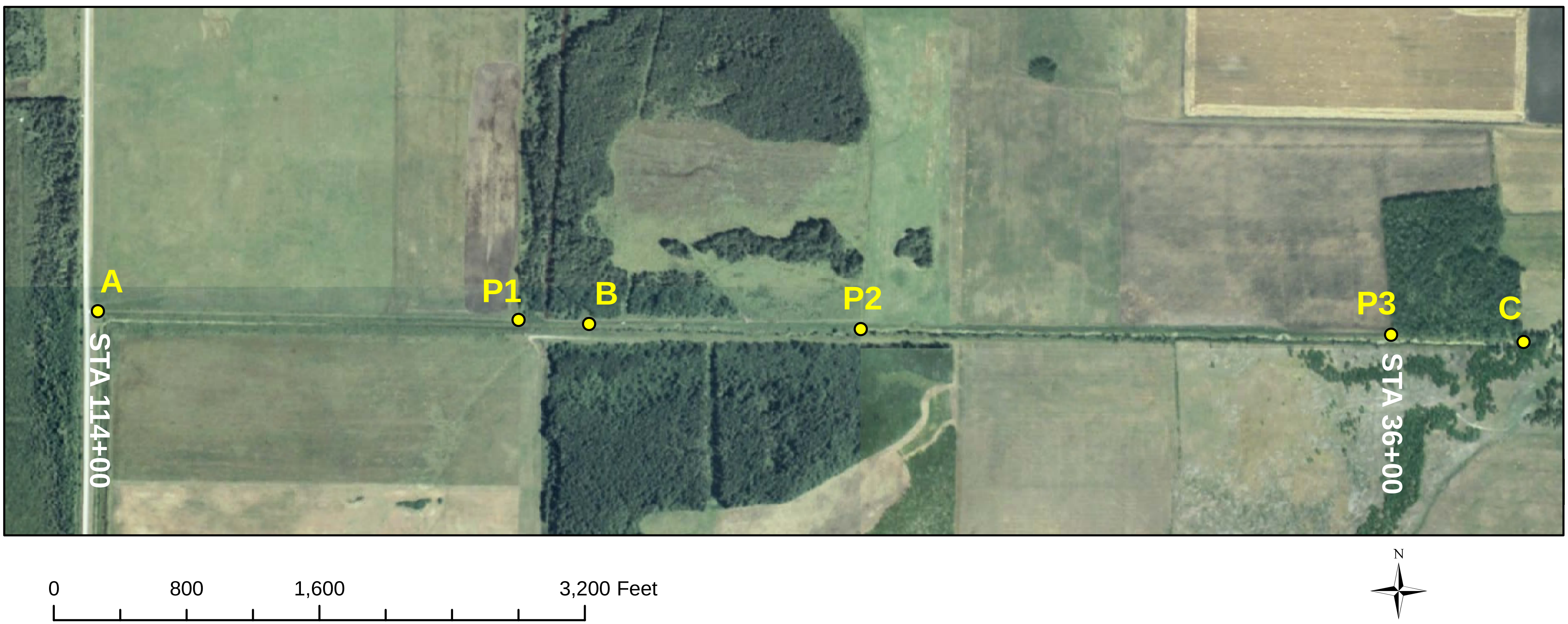
P1 = Property boundary
P2 = Fenced heading north
P3 = Fenced heading north

Distances

A to B = 2, 965 ft.
B to C = 5,625 ft.

A to P1 = 2,550 ft.
A to P2 = 4,600 ft.
A to P3 = 7,800 ft.

*Note: P1 is the reportedly the location where the 1970's/80's reshaping stopped.



Here the bank height is effectively reduced and the shear stress (erosive force) on the toe of the bank is less. Also, this bank material will be dryer, not being in contact with low flow.

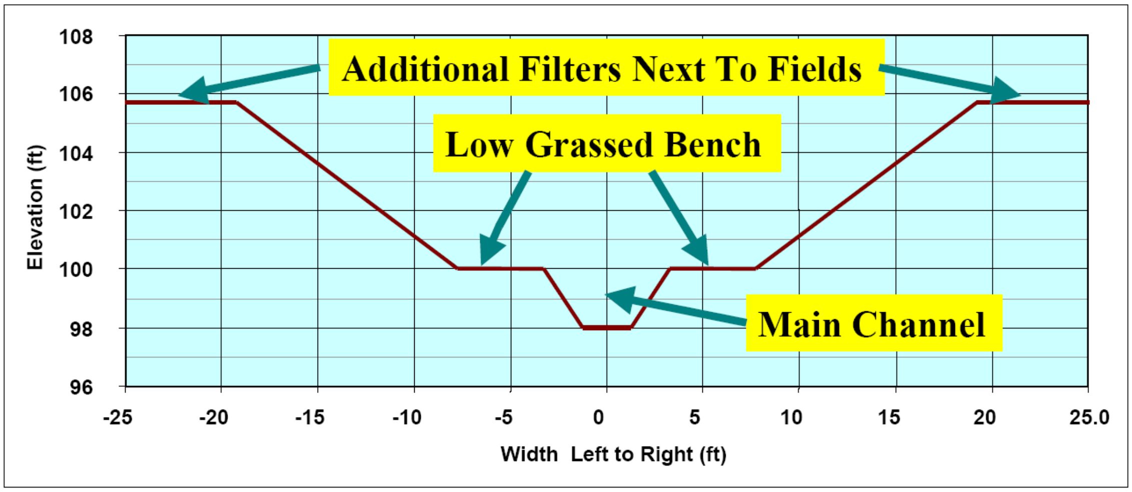


Figure 1. A two-stage ditch with a small main channel and low grassed bench.

The two-stage ditch has the potential to create and maintain better habitat. The narrow deep main channel provides greater water depth during periods of low flow. Grass on the benches provide quality cover and shade. The substrate in the main channel is improved since the two-stage form increases sediment conveyance and also sorting, with fines deposited on the benches and courser material forming the bed. Two-stage ditches might also improve nutrient assimilation, and therefore water quality.

Initial costs of two-stage ditches are higher because of increased width and more earthwork. Creating a low bench typically requires a greater top width. Assuming a two-stage ditch is approximately 10-20 feet wider than a conventional ditch, then the loss of potentially farmable land might be 1 to 3 acres per mile of ditch, depending the size of the watershed and existing ditch. The increased width however, will usually increase the capacity (amount of flow it can carry) by 25%-100%.

HYDRAULIC MODELING OF THE EXISTING CHANNEL: Cross sections of approximately 5 miles of JD 28 were surveyed in May of 2007 using survey grade GPS equipment. This data was used to model approximately 7,600 feet of the channel using the US Army Corps of Engineers HEC-RAS software. The focus area is from where JD 28 turns to the east and away from County Road 4 to where the ditch joins into the meandering channel of Bostick Creek.

Peak flows used in the modeling of the channel were taken from the June 2005 HDR Engineering Sediment Reduction Study. The flows used are as shown below:

2 Year	10 Year	50 Year	100 Year
219 cfs	588 cfs	1020 cfs	1230 cfs

HDR calculated these discharges using the USGS regional regression equations.

The upstream 2,800 feet of this area appears to be fairly stable. The banks are well vegetated with grasses and also substantial willow growth in the lower bank areas. Corresponding modeled velocities range from 3 ft/sec to 8 ft/sec depending on flow volume. The next 4,800 feet of channel is eroding and the modeled velocities range from 4 ft/sec to 11 ft/sec. This is shown graphically in figure 2. Figure 3 illustrates the channel cross-sectional areas for the four modeled flow rates. As expected, the highest velocities are in the locations with the smallest cross sectional areas. This is also the area of steepest channel grade (Figure 4).

SOILS: Seven different soil types are present in this study area. Textures range from silty sand (SM) to heavy clay (CH). Maximum allowable velocity for the SM textured soil is 2.5 ft/sec and for the CH soils it is 5.0 ft/sec. This information is taken from Table 6-1 in the MN Drainage Guide.

Soils in the most severely eroded areas of the ditch vary from SM to CH. There does not appear to be a direct link between erodibility of the soil and the severity of erosion in the channel. A separate soil resource report providing detailed information is included as an attachment.

Three of the soil types in the study area are wetland soils.

HYDRAULIC MODELING OF DESIGN CROSS SECTIONS:

Generally the effective discharge is between the 1.3 year and the 1.7 year recurrence interval. A slightly higher discharge, the 2 year recurrence interval, was used to size the main channel for this project.

Based on modeling of the existing channel, the 2 yr discharge (219 cfs) was contained in a cross-sectional area ranging from 25 sq. ft. in the high velocity area to 80 sq. ft. in the lower velocity sections. In hopes of attaining manageable velocities in the main channel, the 80 sq. ft. area was selected for design. This is achieved by a configuration with an 8 ft. bottom width and 3:1 side slopes with 4 ft. of depth.

Bench widths of 8 ft. and 10 ft. were both evaluated. The 10 ft. bench width is more favorable in terms of constructability and added capacity. Side slopes of 3:1 are planned for the upper bank area as well.

Modeling of this design cross section (10 ft. bench width) produces main channel velocities ranging from 2.5 ft/sec at the 2 yr flow rate to almost 7 ft/sec during the 100 yr flows. In general, the 2 yr and 10 yr flow rates have velocities that would be considered acceptable in a well vegetated channel (less than 5 ft/sec). The larger flow rates (50 yr and 100 yr) produce velocities in the range of 6 to 7 ft/sec. Grassed channels are considered only marginally stabile at these velocities during prolonged flow events. See Figure 5 for a plot of modeled velocities.

The higher than desired velocities during the large flow events are due to the steeper channel grade in this area of the channel. Options to deal with the high velocities include reducing the channel grade through the use of a drop structure or multiple drop structures, or line the main channel with material that will remain stable in the anticipated velocities. Only the option of channel lining is explored in this study.

A base flow exists in this ditch system. This prevents the bottom of the channel from becoming vegetated. The proposed two-stage ditch design was modeled with the main channel having an earth bottom and grassed side slopes. The Manning's roughness coefficient, n value, for this channel is a relatively low 0.027. A low n value in addition to a steeper grade is what is producing slightly higher than desired velocities in this channel.

The option of lining the high velocity section with loose rock riprap was modeled using HEC-RAS. The results are favorable in terms of stability. The riprap has a Manning's n value of 0.038 which in itself results in lower channel velocities. Also, the riprap is capable of withstanding prolonged velocities of over 8 ft/sec. Figure 6 is a plot of velocities with a rip rapped main channel.

COST COMPARISON:

The following are estimates of costs to reconstruct the ditch channel. The estimates are based on the two-state design as described above and illustrated in Figure 7. The second estimate includes riprap lining 3,200 linear feet of the channel.

Judicial Ditch 28
Channel Reconstruction
Lake of the Woods County
Preliminary Cost Estimate

Item				
	unit	Quantity	Unit Cost	Item Cost
Clear & Grub	acre	3.5	$1,500.00	$ 5,250.00
Seed & Mulch	acre	13.5	$700.00	$ 9,450.00
Excavation	cu. yds.	40,400	$2.75	$ 111,100.00
Salvage & Spread Topsoil	acre	13.5	$350.00	$ 4,725.00
Side Inlet Structures	each	6	$2,500.00	$ 15,000.00
			Sub-total	$ 145,525.00
Taxes, Contingencies, etc.				$ 14,552.50
			Total	$ 160,077.50
			Use	**$ 160,000.00**

Judicial Ditch 28
Channel Reconstruction
Lake of the Woods County
Preliminary Cost Estimate
3,200' of Channel Riprap

Item	unit	Quantity	Unit Cost	Item Cost
Clear & Grub	acre	3.5	$1,500.00	$ 5,250.00
Seed & Mulch	acre	13.5	$700.00	$ 9,450.00
Excavation	cu. yds.	40,400	$2.75	$ 111,100.00
Salvage & Spread Topsoil	acre	13.5	$350.00	$ 4,725.00
Side Inlet Structures	each	6	$2,500.00	$ 15,000.00
Rock Riprap	cu. yds.	4,800	$40.00	$ 192,000.00
Geotextile Fabric	sq. yds.	11,520	$2.50	$ 28,800.00
			Sub-total	$ 366,325.00
Taxes, Contingencies, etc.				$ 36,632.50
			Total	$ 402,957.50
			Use	**$ 400,000.00**

SUMMARY AND RECOMMENDATIONS:

The addition of the riprap lining will more than double the cost of the project. A decision is needed on whether or not the increased level of protection is worth the dramatic increase in project cost.

Further evaluation of the stabile reach of channel in the study area is helpful in making this decision. This upstream reach (from Sta 114+00 to Sta 86+00) is in good condition with dense grass cover on the banks and fairly heavy willow growth in the low bank area. It evidently came through the flood event during June of 2002 with very little damage. The results of the modeling show fairly high velocities in this reach when evaluating the 50 yr and 100 yr flow events. These velocities range from 5.5 ft/sec to 8 ft/sec, similar to and even slightly higher than those expected in the reconstructed or design channel reach. The conclusion that can be drawn from these facts is that a newly constructed channel with similar vegetative cover will be equally as stable.

For this reason, the riprap lining is not recommended. The dramatic cost increase is difficult to justify when there is good reason to believe that an acceptable level of stability can be achieved in this channel without it.

The willow brush in the upstream, stabile portion of the study area is likely providing erosion control benefits. It increases the channel roughness which helps to slow the velocity. The root mass of the brush also helps to hold bank soils in place. However, there is a fine line concerning woody vegetation growing on the ditch banks. The small diameter, dense brush is beneficial, but for long term maintenance of the channel, larger woody species are not recommended due to significant flow obstruction and causing isolated areas of high velocity. One of the main goals of channel maintenance should be to achieve a very uniform flow condition.

Consideration can be given to achieving a better level of protection in the main channel through methods other than rip rap lining. Planting of brush-type woody vegetation would likely have stability and habitat improvement benefits. Periodic maintenance is recommended to ensure a dense stand of small diameter material. Permanent erosion control blanket or turf reinforcement mat may also be a viable option. The benefits of these applications would also need to be weighed against the available project funding.

Additional easement area beyond the 66 feet currently available for this drainageway will be needed to reconstruct the channel as recommended. The new top width will be approximately 90 feet. A 100 foot easement width may be appropriate.

Over 40,000 cubic yards of excavation work be involved with reconstructing this ditch section. Consideration will need to be given to the configuration and location of this excavated material. It is anticipated that it will be placed in spoil banks adjacent to the channel.

The proposed project length is 4,800 feet. Lateral flows enter the ditch in several areas along this reach. Design consideration will need to be given to these areas in order to convey these flows to the channel in a stabile manner. Rock lined chutes, or pipe structures are the likely methods to be used.

The concluding recommendation is that final design and drawings be prepared to reconstruct approximately 4,800 linear feet of badly eroded Judicial Ditch 28 channel. The final design will address the issues of lateral flow conveyance, spoil bank location and configuration, main channel lining (if any), and new easement area and location. Construction should take place at low flow conditions during mid to late summer. A maintenance plan should be developed and implemented for the newly constructed channel.

_____________________________ Date_______________

Jon D. Hodgson, P.E.

JPB Engineer

Existing Channel Velocity

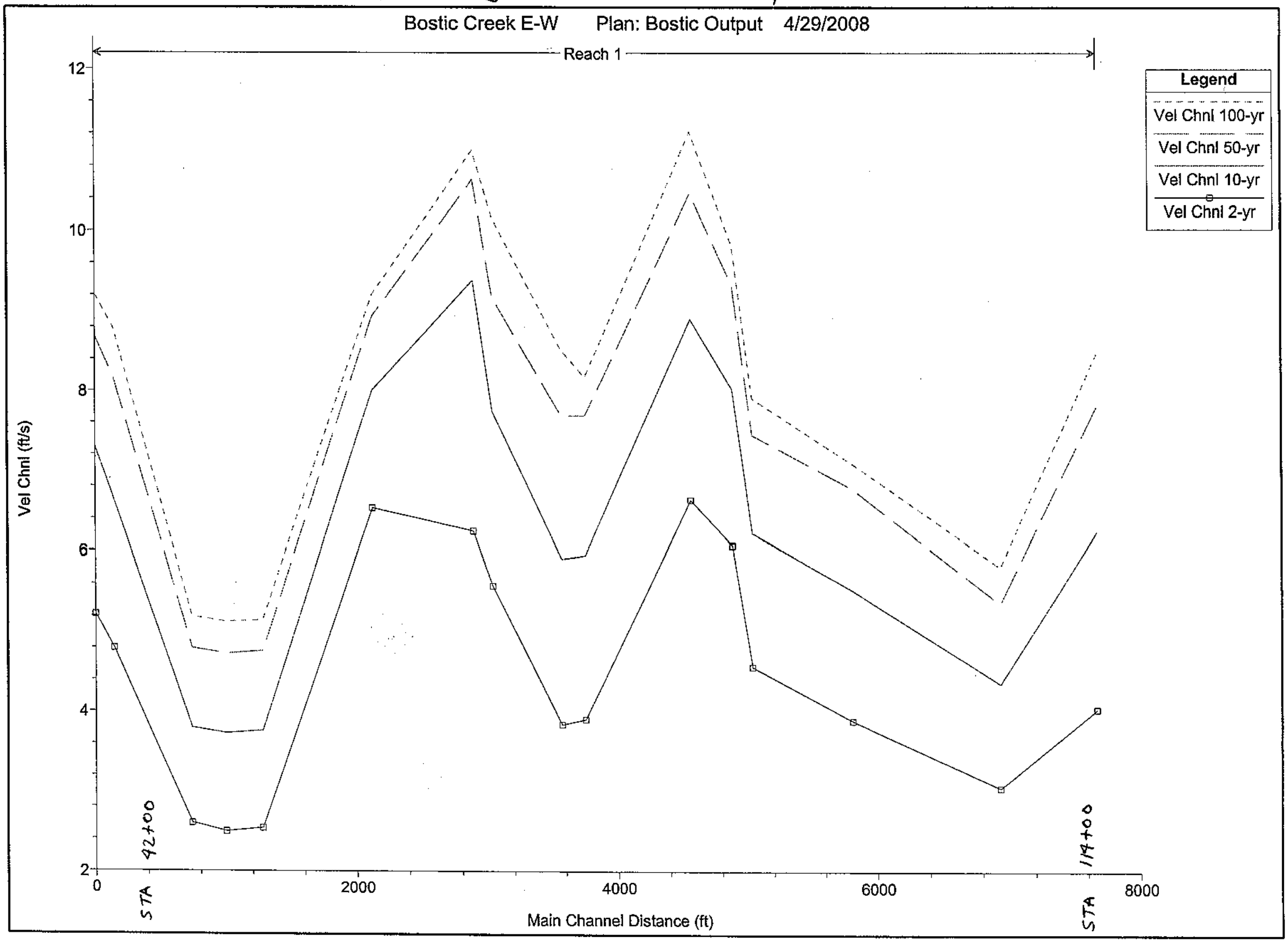


Figure 2

Existing Channel Area

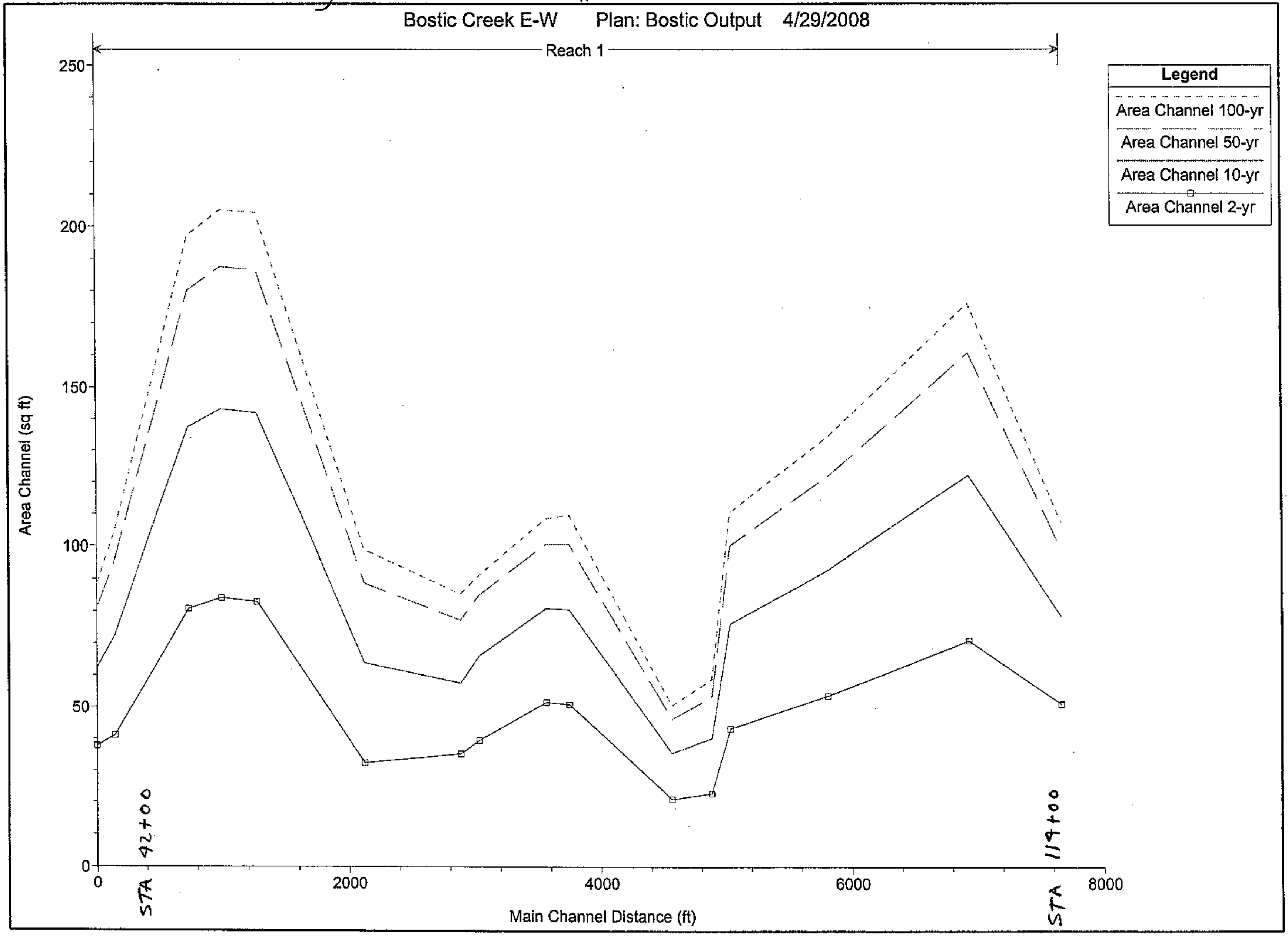


Figure 3

Existing Channel Slope

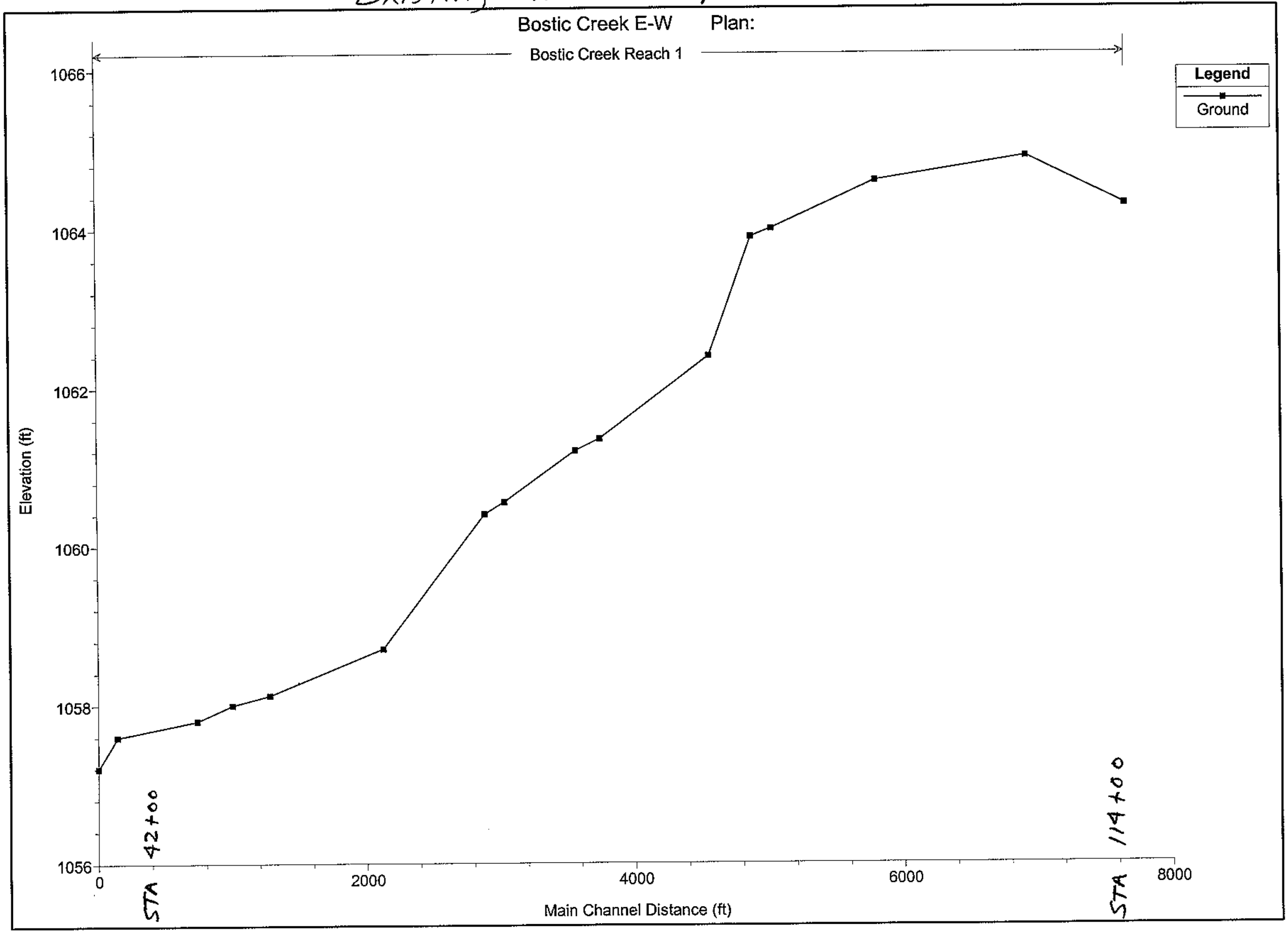


Figure 4

Design Channel Velocity - Unlined Channel

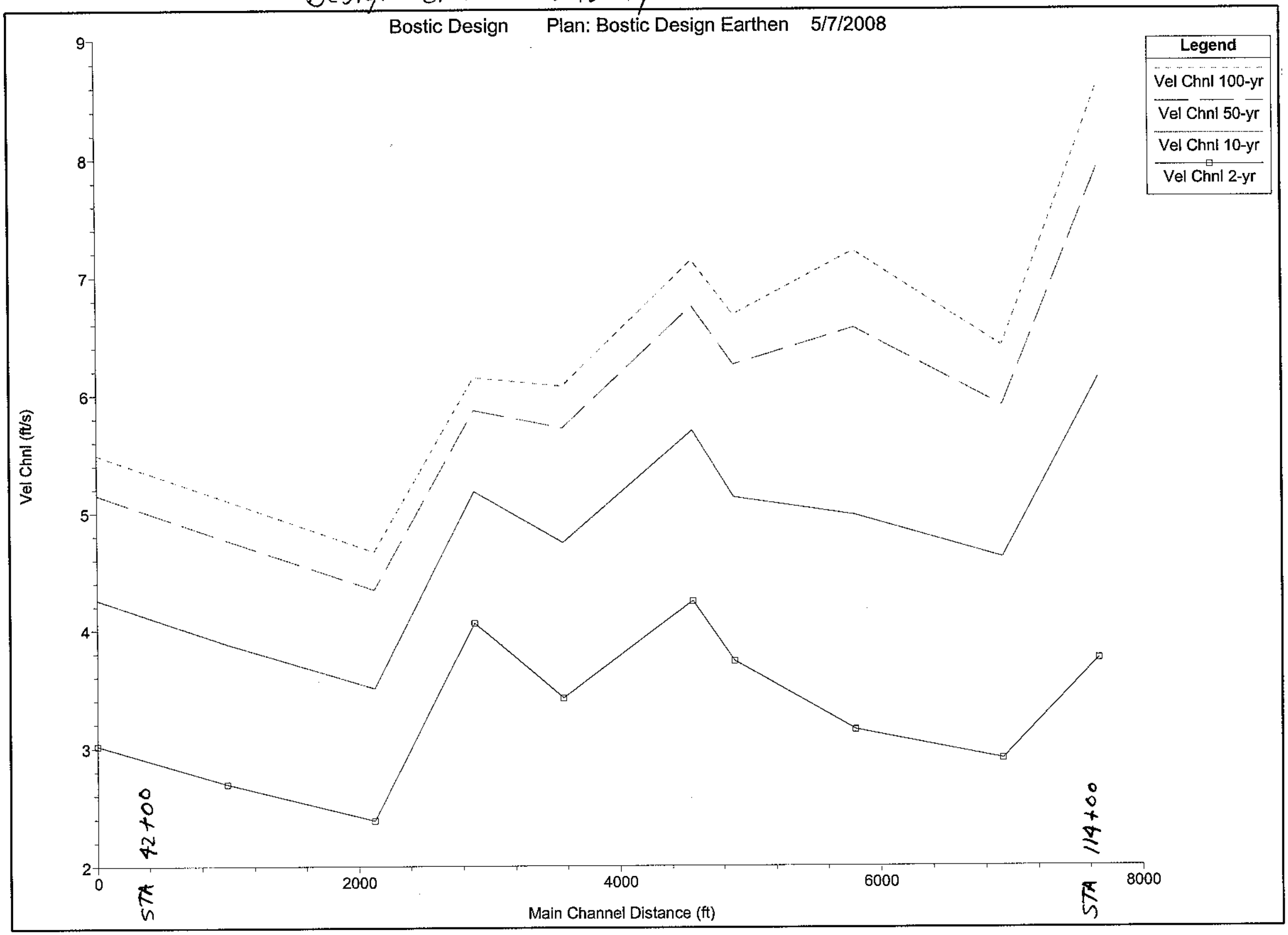
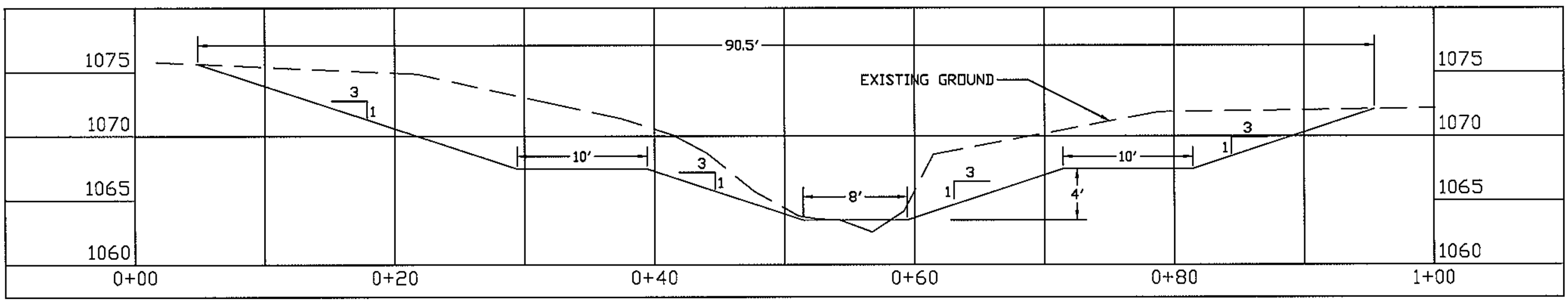


Figure 5

Design Channel Velocity - Riprap Lined Channel

Figure 6

LAKE OF THE WOODS COUNTY
JUDICIAL DITCH 28



PROPOSED CHANNEL CROSS SECTION

FIGURE 7

United States Department of Agriculture

NRCS

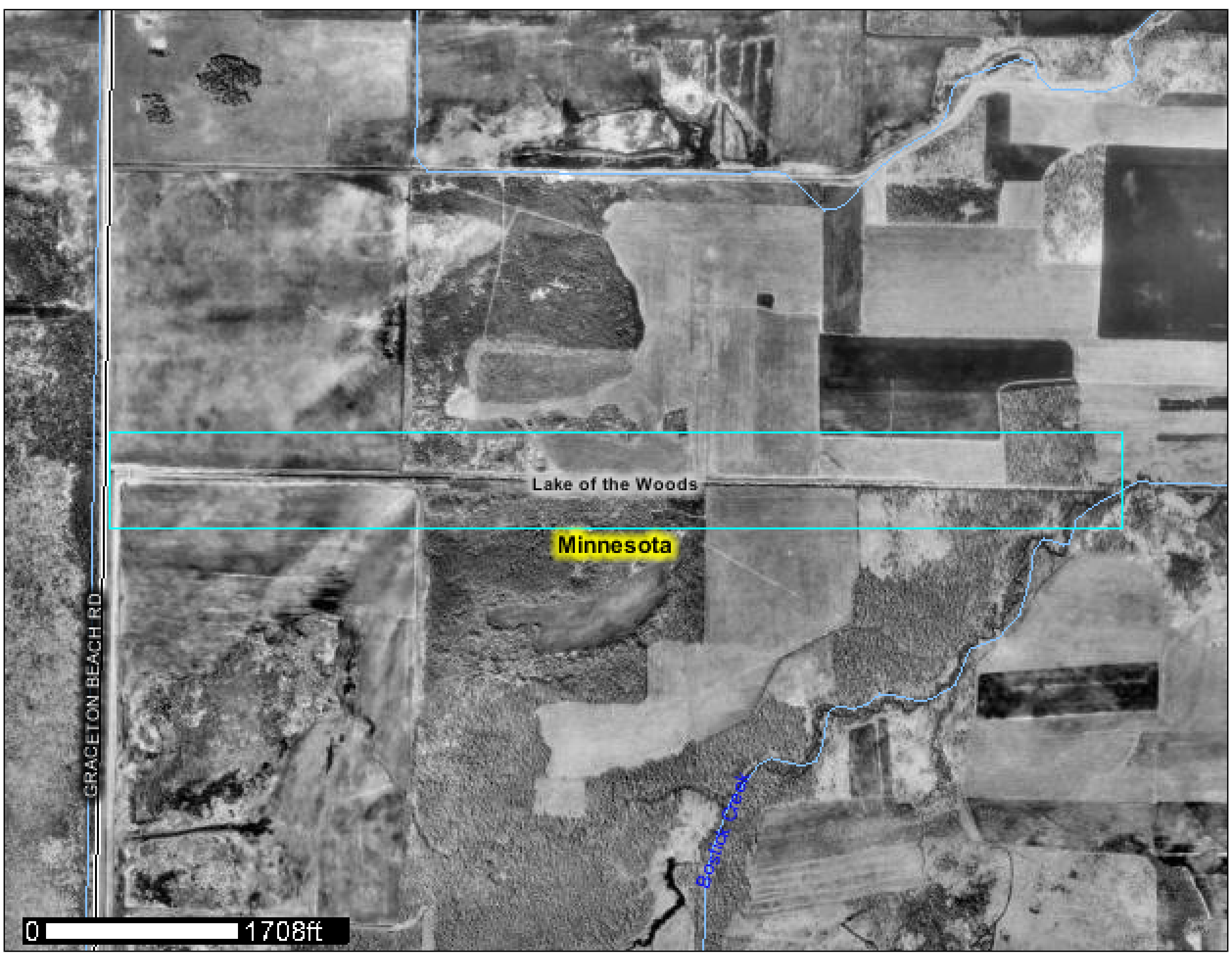
Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Lake of the Woods County, Minnesota

JD 28 Soils



Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

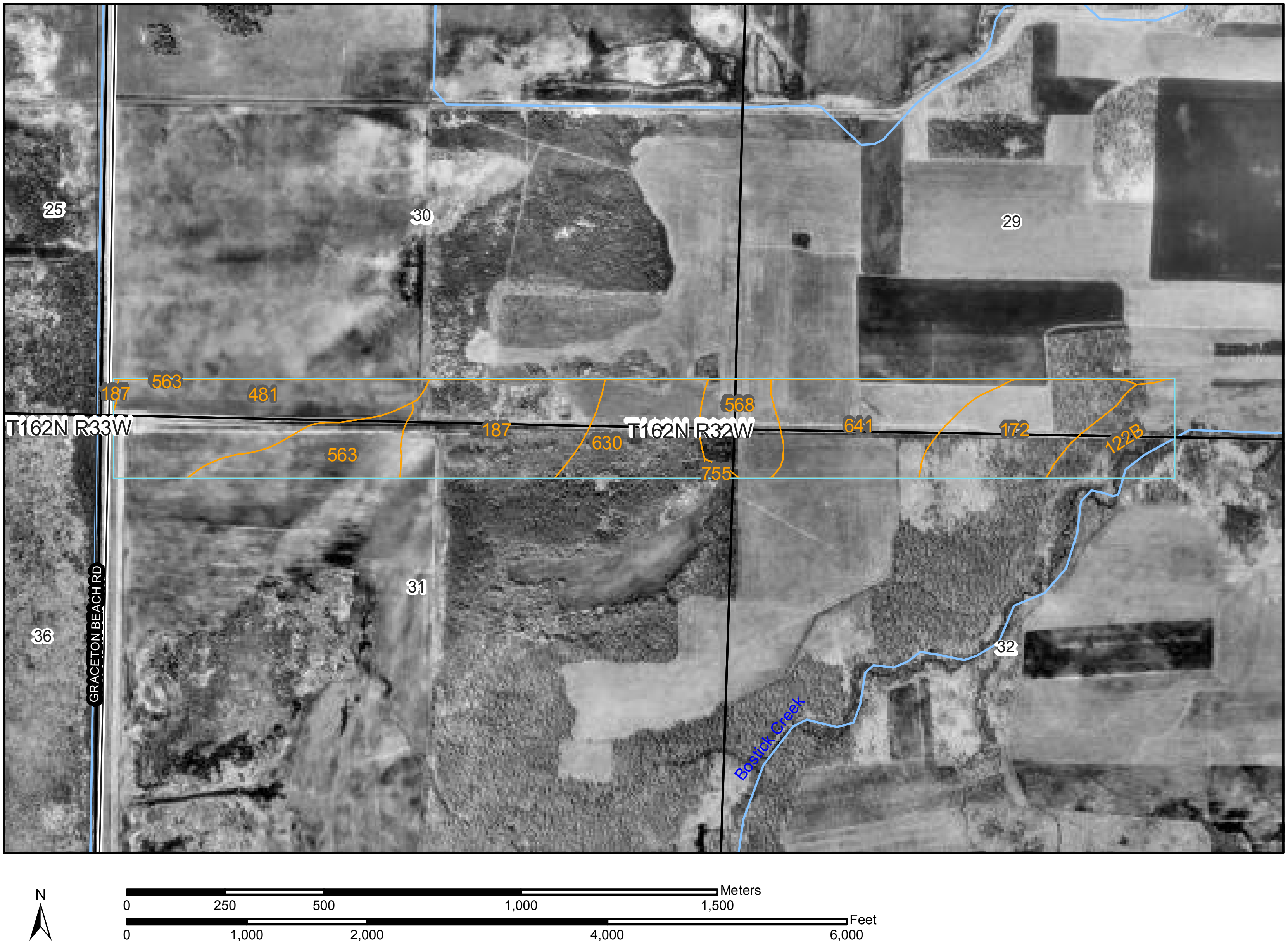
Information about soils is updated periodically. Updated information is available through the NRCS Soil Data Mart Web site or the NRCS Web Soil Survey. The Soil Data Mart is the data storage site for the official soil survey information.

Contents

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



25
30
29
187
563
481
568
T162N R33W
187
T162N R32W
641
172
122B
630
563
755
31
GRACETON BEACH RD
36
32
Bostick Creek
N
Meters
0
250
500
1,000
1,500
Feet
0
1,000
2,000
4,000
6,000

Legend

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features

- Gully
- Short Steep Slope
- Other

Political Features

Public Land Survey

- Township and Range
- Section

Municipalities

- Cities
- Urban Areas

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails

Roads

- Interstate Highways
- US Routes
- State Highways
- Local Roads
- Other Roads

MAP INFORMATION

Original soil survey map sheets were prepared at publication scale. Viewing scale and printing scale, however, may vary from the original. Please rely on the bar scale on each map sheet for proper map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 15N

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Lake of the Woods County, Minnesota
Survey Area Data: Version 4, Nov 2, 2006

Date(s) aerial images were photographed: 1991

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Lake of the Woods County, Minnesota (MN077)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
122B	Taylor loam, 1 to 8 percent slopes	13.1	7.9%
172	Indus clay loam	22.0	13.2%
187	Haug muck	28.2	16.8%
481	Kratka fine sandy loam	32.3	19.3%
563	Northwood muck	14.1	8.4%
568	Zippel very fine sandy loam	11.2	6.7%
630	Wildwood mucky peat	18.4	11.0%
641	Clearwater clay	27.4	16.4%
755	Woodslake clay	0.6	0.4%
Totals for Area of Interest (AOI)		167.3	100.0%

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Lake of the Woods County, Minnesota Version date: 11/2/2006 1:47:37 PM

122B—Taylor loam, 1 to 8 percent slopes

Map Unit Setting

Elevation: 1,000 to 1,600 feet
Mean annual precipitation: 21 to 28 inches
Mean annual air temperature: 36 to 43 degrees F
Frost-free period: 90 to 145 days

Map Unit Composition

Taylor and similar soils: 85 percent

Description of Taylor

Setting

Landform: Rises on lake plains, flats on lake plains
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Glaciolacustrine

Properties and qualities

Slope: 1 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 22 to 49 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Available water capacity: High (about 9.7 inches)

Interpretive groups

Land capability (nonirrigated): 2e

Typical profile

0 to 12 inches: Loam
12 to 29 inches: Clay
29 to 60 inches: Clay

172—Indus clay loam

Map Unit Setting

Elevation: 1,000 to 1,600 feet
Mean annual precipitation: 22 to 28 inches
Mean annual air temperature: 36 to 39 degrees F
Frost-free period: 90 to 120 days

Map Unit Composition

Indus and similar soils: 85 percent

Description of Indus

Setting

Landform: Swales on lake plains, flats on lake plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Glaciolacustrine

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: About 0 to 30 inches
Frequency of flooding: None
Frequency of ponding: Occasional
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.8 inches)

Interpretive groups

Land capability (nonirrigated): 3w

Typical profile

0 to 2 inches: Clay loam
2 to 4 inches: Clay loam
4 to 18 inches: Clay
18 to 60 inches: Clay

187—Haug muck

Map Unit Setting

Elevation: 800 to 1,600 feet
Mean annual precipitation: 19 to 28 inches
Mean annual air temperature: 36 to 45 degrees F
Frost-free period: 90 to 140 days

Map Unit Composition

Haug and similar soils: 85 percent

Description of Haug

Setting

Landform: Depressions on lake plains
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Organic over till

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None

Frequency of ponding: Frequent
Calcium carbonate, maximum content: 30 percent
Available water capacity: Very high (about 13.1 inches)

Interpretive groups
Land capability (nonirrigated): 6w

Typical profile
0 to 15 inches: Muck
15 to 18 inches: Fine sandy loam
18 to 60 inches: Sandy loam

481—Kratka fine sandy loam

Map Unit Setting
Elevation: 700 to 1,500 feet
Mean annual precipitation: 19 to 33 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 90 to 150 days

Map Unit Composition
Kratka and similar soils: 85 percent

Description of Kratka

Setting
Landform: Swales on lake plains, flats on lake plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Glaciolacustrine over till

Properties and qualities
Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 1.98 in/hr)
Depth to water table: About 0 to 30 inches
Frequency of flooding: None
Frequency of ponding: Occasional
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 8.1 inches)

Interpretive groups
Land capability (nonirrigated): 3w

Typical profile
0 to 9 inches: Fine sandy loam
9 to 25 inches: Loamy fine sand
25 to 60 inches: Loam

563—Northwood muck

Map Unit Setting
Elevation: 800 to 1,400 feet
Mean annual precipitation: 20 to 27 inches

Mean annual air temperature: 36 to 39 degrees F
Frost-free period: 90 to 140 days

Map Unit Composition

Northwood and similar soils: 85 percent

Description of Northwood

Setting

Landform: Depressions on lake plains
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Organic over glaciolacustrine

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 10.9 inches)

Interpretive groups

Land capability (nonirrigated): 6w

Typical profile

0 to 9 inches: Muck
9 to 12 inches: Loamy sand
12 to 27 inches: Fine sand
27 to 60 inches: Clay loam

568—Zippel very fine sandy loam

Map Unit Setting

Elevation: 800 to 1,400 feet
Mean annual precipitation: 19 to 28 inches
Mean annual air temperature: 36 to 45 degrees F
Frost-free period: 90 to 140 days

Map Unit Composition

Zippel and similar soils: 85 percent

Description of Zippel

Setting

Landform: Swales on lake plains, flats on lake plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Glaciolacustrine

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches

Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 0 to 30 inches
Frequency of flooding: None
Frequency of ponding: Occasional
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 10.8 inches)

Interpretive groups
Land capability (nonirrigated): 2w

Typical profile
0 to 7 inches: Very fine sandy loam
7 to 12 inches: Very fine sandy loam
12 to 60 inches: Stratified very fine sand to silt loam

630—Wildwood mucky peat

Map Unit Setting
Elevation: 600 to 1,600 feet
Mean annual precipitation: 22 to 30 inches
Mean annual air temperature: 36 to 43 degrees F
Frost-free period: 88 to 135 days

Map Unit Composition
Wildwood and similar soils: 85 percent

Description of Wildwood

Setting
Landform: Depressions on lake plains
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Organic over glaciolacustrine

Properties and qualities
Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 30 percent
Available water capacity: Low (about 5.9 inches)

Interpretive groups
Land capability (nonirrigated): 6w

Typical profile
0 to 10 inches: Mucky peat
10 to 18 inches: Clay
18 to 60 inches: Clay

641—Clearwater clay

Map Unit Setting

Elevation: 800 to 1,300 feet
Mean annual precipitation: 18 to 28 inches
Mean annual air temperature: 36 to 43 degrees F
Frost-free period: 88 to 140 days

Map Unit Composition

Clearwater and similar soils: 85 percent

Description of Clearwater

Setting

Landform: Swales on lake plains, flats on lake plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Glaciolacustrine

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Occasional
Calcium carbonate, maximum content: 25 percent
Available water capacity: High (about 10.0 inches)

Interpretive groups

Land capability (nonirrigated): 2w

Typical profile

0 to 9 inches: Clay
9 to 18 inches: Clay
18 to 60 inches: Clay

755—Woodslake clay

Map Unit Setting

Elevation: 800 to 1,300 feet
Mean annual precipitation: 20 to 28 inches
Mean annual air temperature: 36 to 41 degrees F
Frost-free period: 90 to 125 days

Map Unit Composition

Woodslake and similar soils: 85 percent

Description of Woodslake

Setting

Landform: Swales on lake plains, flats on lake plains
Down-slope shape: Linear

Across-slope shape: Linear
Parent material: Glaciolacustrine

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 6.7 inches)

Interpretive groups

Land capability (nonirrigated): 3w

Typical profile

0 to 7 inches: Clay
7 to 19 inches: Clay
19 to 60 inches: Clay