MOWER COUNTY SOIL AND WATER CONSERVATION DISTRICT
DOBBINS CREEK WATERSHED PROJECT
STREAMBANK INVENTORY, 1993

by
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PREFACE

The following document deals with Dobbins Creek, whose watershed spans the west half of Mower County (MN). Evidence shows that East Side Lake, a small artificial lake located at the watershed outlet, is suffering considerable sedimentation due to materials delivered via the stream. Consequently, concern for the lake's well-being—both in environmental and recreational terms—has prompted the Mower County SWCD to explore options for remedying the situation. One option they chose to explore is the reduction of sediment loading in the stream due to streambank erosion. Thus, in late June of 1993, I was hired by the SWCD to inventory streambank erosion along Dobbins Creek and prepare a report for their use in formulating an erosion reduction strategy.

For the first five months of the project—when not delayed by high water (due to unusually frequent and abundant spring and summer rainfall) or equipment problems—I walked the entire length of the creek, documenting erosion, riparian gullies and other pertinent information. I then spent the next three months processing and analyzing the field data and identifying erosion-related trends. This report is the culmination of those efforts. I hope that the enclosed information, which includes my personal insights, will prove helpful to the SWCD in its quest to improve the quality of both Dobbins Creek and East Side Lake.

ACKNOWLEDGEMENTS

When I accepted this internship in the summer of 1993, it seemed a valuable scientific, educational and vocational opportunity. Although that assessment has proved undeniably true, the project, due to frequent weather- and equipment-related delays, was also an eight-month exercise in patience and persistence. The end product of my perseverance is the ensuing report. I am especially grateful to the following people, without whose aid and support I could not have completed this project.

Ms. Bev Nordby, District Manager, Mower County Soil and Water Conservation District (SWCD), for her unfailing support and direction as my project supervisor.

Mower County SWCD staff, who shared freely both their knowledge and their equipment.

Mr. Phil Splett, Career Opportunities Coordinator, College of Natural Resources, and **Dr. Jay Bell**, Department of Soil Science, College of Agriculture, University of Minnesota, St. Paul, for their support and counsel.

Mr. Mark Hunstiger, Software Engineer, Imaginet, whose advice transformed a computer crisis into a moderate delay

Mower County Highway Department, for the loan of important equipment.

Thanks to all of the above, and to any others that I may have missed, for donating their time and resources to make this report complete and accurate.

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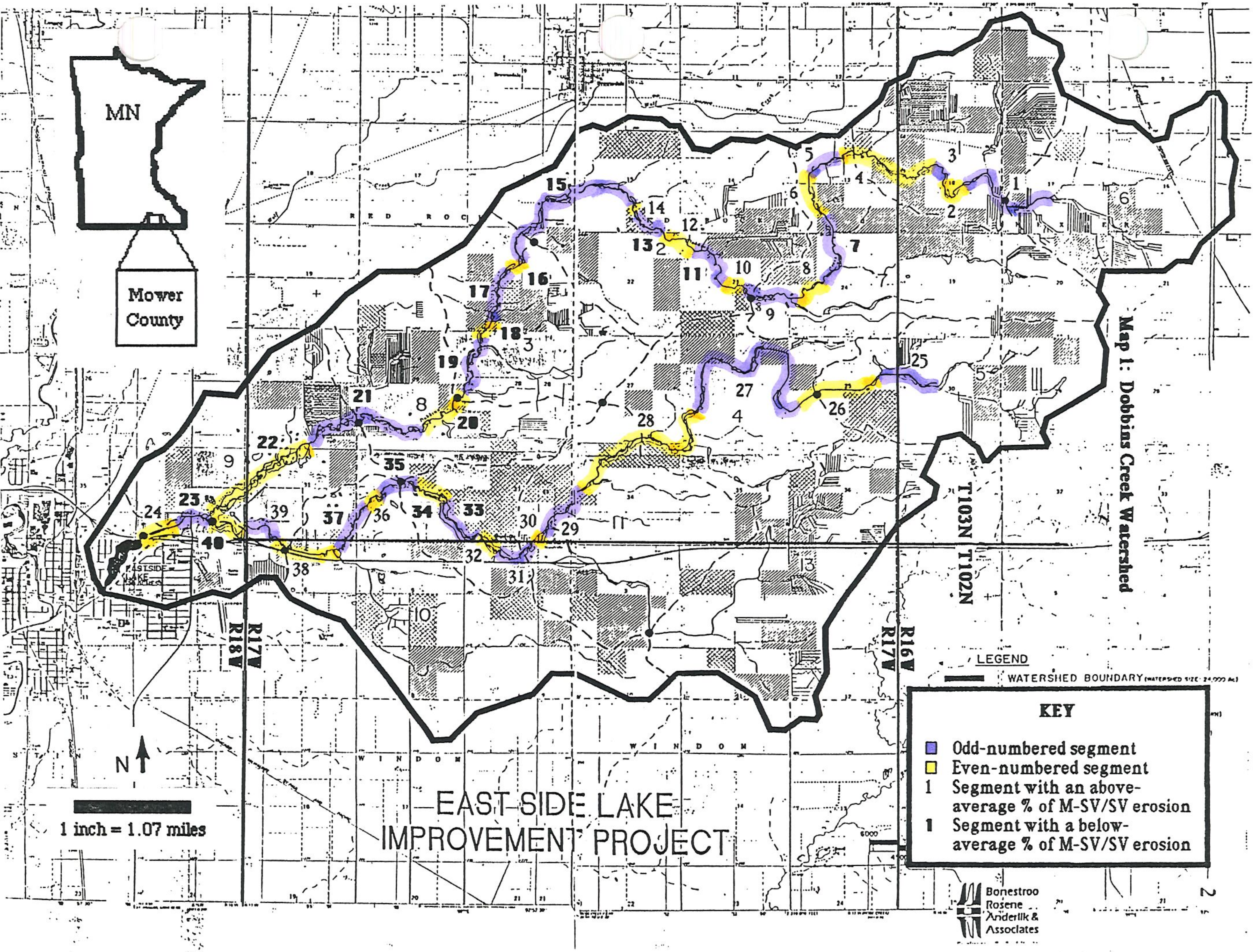
INTRODUCTION

PURPOSE

The purpose of the Dobbins Creek Watershed streambank inventory was to ascertain and document, through meticulous field research, the extent of erosion in the stream's banks and riparian areas. The data collected, summarized herein, will be used to develop a streambank erosion reduction and gully control strategy for the watershed (Map 1, page 2), with the ultimate objective of reducing sediment deposition and increasing water quality in East Side Lake, located at the watershed outlet.

SCOPE

Field work for this project was performed as prescribed in Richard Rippley's 1991 *Whitewater Watershed Project Stream Survey* and its related instructions, compiled by Bill Thompson of the Minnesota Pollution Control Agency's Division of Water Quality. The area studied lies entirely in the western half of Mower County (MN) and encompasses all of Dobbins Creek. The streambank inventoried, however, includes only the stream's three main reaches—the North Branch, South Branch and Main Flow—and not its smaller tributaries.


Map 1: Dobbins Creek Watershed
MN
Mower County
N
1 inch = 1.07 miles
EAST SIDE LAKE IMPROVEMENT PROJECT
T103N
T102N
R16W
R17W
R17W
R18W
LEGEND
WATERSHED BOUNDARY
KEY
Odd-numbered segment
Even-numbered segment
1 Segment with an above-average % of M-SV/SV erosion
1 Segment with a below-average % of M-SV/SV erosion
Bonestroo Rosene Anderlik & Associates

OVERVIEW OF DOBBINS CREEK WATERSHED

Dobbins Creek, a frequently meandering stream, tends to be quite narrow and shallow (three feet deep or less), especially in its easternmost stretches. As it flows west, however, its channel becomes considerably wider but, in general, only a foot or two deeper. For the numerical values of these stream width generalizations, see the Results section (pages 13-28). The stream's roughly 26.2-mile length is divided as follows: North Branch, 15.62 miles; South Branch, 10.09 miles, and Main Flow, 0.50 miles. The North and South Branches, which begin about 8 and 6.5 miles, respectively, northeast of the City of Austin, wind southwest into the city and form a confluence in the J.C. Hormel Nature Center. From there, the considerably wider Main Flow travels a relatively short distance before emptying into East Side Lake. A brief description of the Dobbins Creek Watershed's basic characteristics follows.

RELIEF

The relief of the watershed, and of Mower County in general, is the product of glacial melting in which the resultant deposited materials formed extensive, nearly-level outwash plains. Consequently, slopes within the area inventoried are long and uniform and rarely exceed 6 percent (USDA, 1989). Consistent with this information,. slope measurements taken from Minnesota quadrangles indicate that the watershed consists almost exclusively of Class-A (0- to 2-percent) and -B (2- to 6-percent) relief. Sparse instances of Class-C (6- to 12-percent) slopes were found, but are likely attributable to imprecise measurement methods.

GEOLOGY

According to the *Soil Survey of Mower County* (USDA, 1989), bedrock (Devonian-age dolomitic limestone) is near the surface in only a few places in Mower County. It is primarily overlain by Pleistocene sediments: glacial till, outwash, alluvium and loess. Furthermore, Dobbins Creek has more recently, and with regularity, covered its flood plain with silty, loamy or sandy alluvium—the foundations of the stream's primary adjacent soils.

SOILS

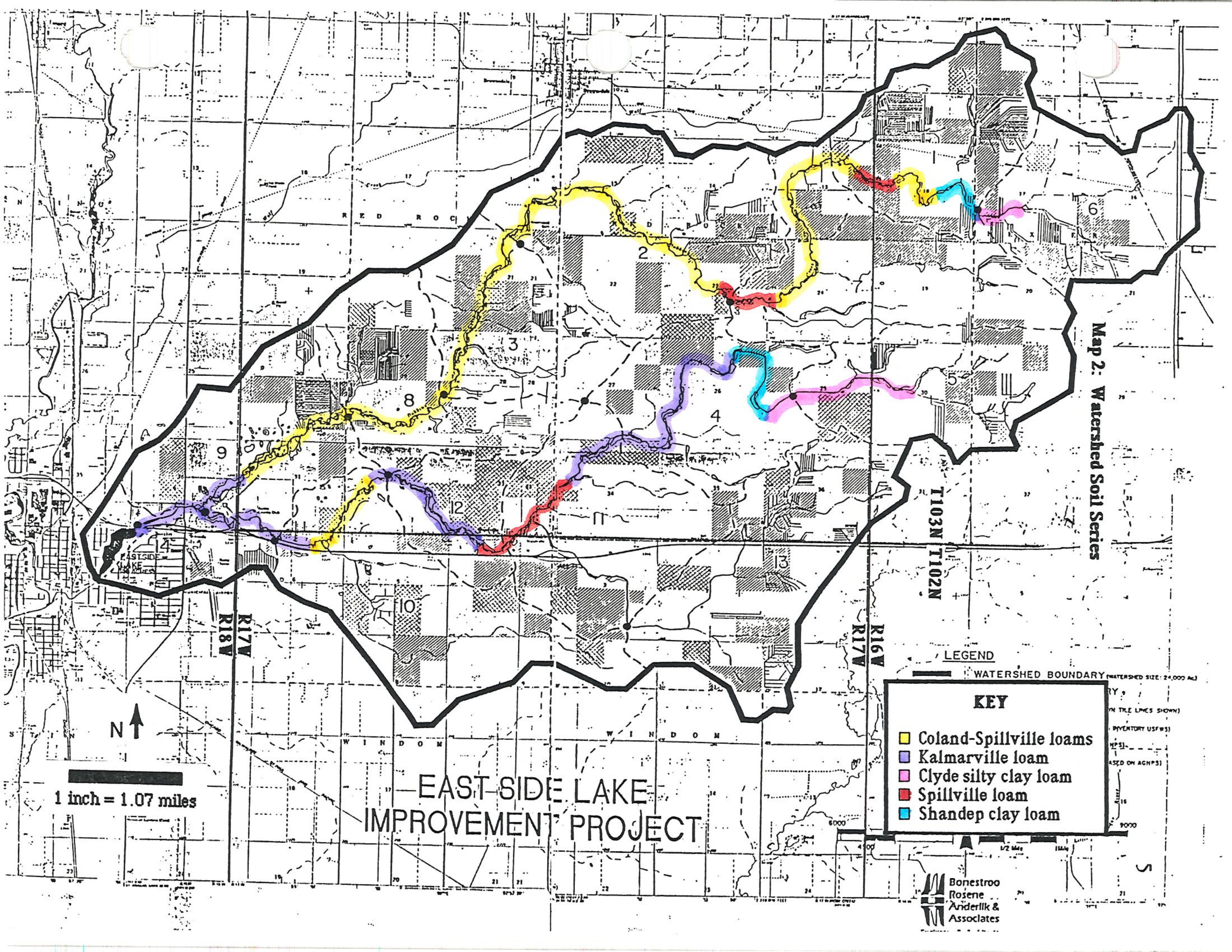
The Dobbins Creek's primary riparian soils, according to the *Soil Survey of Mower County* (USDA, 1989), come from the following soil series (Map 2, page 5), listed in order of decreasing quantity: Coland-Spillville loams, Kalmarville loam, Spillville loam, Clyde silty clay loam and Shandep clay loam. The last two series, higher in clay, flank only the easternmost stretches of the North and South Branches. In general, however, soils from all five series tend to occupy long and relatively narrow stretches associated with the stream's floodplain. In addition, most or all of them have the following characteristics in common (USDA, 1989):

- They are generally poorly drained and/or frequently flooded—conditions which could make revegetation of eroded streambanks and riparian areas difficult;
- Their surface layers consist of dark, friable loams and loam variants that are only slightly to moderately erodible, and
- Their underlying material, sampled at a depth of 60 inches, consists of sandy loams, loamy sands and, in some instances, loose sand. These materials' high silt and sand contents make them highly to extremely erodible.

Moreover, in sporadic instances these soils tend to be unstable due to their high clay contents (greater than 40 percent) coupled with their subjection to frequent freezing and thawing (Troeh et al., 1991). The above characteristics tend to promote erosion and, especially the first and the third, to hinder erosion control efforts.

LAND USE

According to the *Soil Survey of Mower County* (USDA, 1989), the county's main industry is farming, including livestock and dairy farming. Consequently, of the county's 449,920 total acres, 366,945 acres (81.6 percent) are used for cropland and 23,055 acres (5.1 percent) are used for pasture. Although this trend is reflected in actual riparian land use along Dobbins Creek, the proportions change slightly: approximately 50 percent of the stream is bordered by (i. e. within 300 feet of) cropland and nearly 24 percent is abutted by pasture. Most of the cropland, however, is separated from the creek by grass buffer strips and/or forested strips.


Map 2: Watershed Soil Series
EAST SIDE LAKE IMPROVEMENT PROJECT
LEGEND
WATERSHED BOUNDARY (WATERSHED SIZE: 24,000 Ac)
KEY
Coland-Spillville loams
Kalmarville loam
Clyde silty clay loam
Spillville loam
Shandep clay loam
T103N T102N
R16W
R17W
R17W
R18W
1 inch = 1.07 miles
N
EASTSIDE LAKE
Bonestroo Rosene Anderlik & Associates
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This disparity between riparian and overall land use is primarily explained by the land-use capacities of the area's soils. For instance, riparian soils, as described in the previous section, tend to be absolutely or relatively unsuited to cropping due to their poor drainage and/or frequent subjection to flooding. Consequently, they are best left idle or used for pasture (USDA, 1989). This is reflected by the field data, which shows riparian areas being used primarily as grassland, forest and pasture. In contrast, soils bordering these areas are generally well-suited for agriculture and, accordingly, tend to be cropped. A summary of riparian land use is provided below in Table 1. Please note that within land-use categories (e. g. Forest/Grassland), the individual land uses are listed in order of decreasing proximity to the stream.

Table 1: Riparian Land Use

Land Use	Streambank Length (mi)	Portion of Total Streambank (% by length)
Forest	3.64	6.94
Forest/Grassland	0.54	1.03
Forest/Grassland/Cropland	1.60	3.05
Forest/Residential	0.58	1.11
Grassland	2.84	5.42
Grassland/Cropland	17.58	33.54
Grassland/Forest	5.32	10.15
Grassland/Forest/Cropland	5.66	10.80
Other (Golf Course)	0.76	1.45
Pasture	7.80	14.88
Pasture/ Cropland	4.90	9.35
Residential	1.20	2.29

The above land uses occur in a fairly similar pattern over both creek branches. For each branch, land use along the easternmost stretch is primarily grassland—either alone or in combination with cropland and/or scattered forested land. As the branches flow west, riparian land use alternates between pasture and grassland, with the latter commonly accompanied by forested areas. Yet while the North Branch commonly runs through cropland, the South Branch generally does not. The South Branch then winds through the southwest portion of the Austin Country Club's golf course before joining the North Branch in the forests of the J.C Hormel Nature Center. The Main Flow, on the other hand, runs primarily through residential Austin before reaching East Side Lake.

COVER
Not surprisingly, riparian cover generally corresponds to riparian land use, with the most extensive land-use types also representing the most extensive cover types. Thus, the extensive grasslands of the North and South Branches are dominated by tall grasses along their easternmost stretches and medium-height grasses farther west. In contrast, the considerable pasture land of both branches consists of shorter grasses. Similarly, the golf course and the residential areas possess short or very short grasses. Finally, the forested areas include various combinations of short and medium grasses, bushes and assorted-sized trees, with the most mature trees generally located in the Nature Center.

METHODS

REASONS FOR STREAMBANK EROSION ASSESSMENT
Streambank erosion, although a fairly isolated phenomenon, can have surprisingly extensive and severe effects on a watershed (Hudson, 1981). First, it often affects highly productive soils that, once eroded, become completely and irretrievably lost to their original locales. Moreover, streambank erosion sometimes damages expensive engineering structures such as roads and bridges. Finally, the deposition of eroded sediments may have any of a number of deleterious effects: burying productive soils with unproductive sediments, damaging vegetation, causing siltation of streams, altering aquatic environments or reducing channel capacity, thus increasing flood potential. Siltation and its detrimental effects on East Side Lake are of primary concern to the Mower County SWCD. Therefore, the SWCD's main objective is to formulate an erosion reduction plan in order to slow the siltation of the lake. Thus, the goal of this streambank inventory was threefold:

1. To identify the main source of sediment loading in the watershed, if such a source exists, so that ameliorative actions may be taken;
2. To assess the extent of streambank erosion so that remedial priorities may be set, and
3. To identify the predominant fundamental cause or causes of the erosion so that an abatement strategy may be formulated and executed.

Ideally, if all of these goals have been met, the SWCD will be able to formulate an efficient and effective plan to meet its objectives.

FIELD EQUIPMENT
The equipment utilized in conducting this inventory was similar to that recommended in the Rippley report. Included were the following items:

1. Field data forms (Appendix A, page 38), based largely on those used by Rippley, for notetaking;

2. Topographicmaps, photocopied from Minnesota quadrangles, for locating and mapping erosion sites. Aerial photos and/or other detailed maps also proved helpful;
3. A fieldbook or clipboard for holding data forms and maps and protecting them from moisture and mud;
4. A 35mm camera and slide film for photographing sites;
5. A four- or five-foot Jacob staff or the like, pointed on one end and calibrated into one-foot sections. This versatile item proved useful in several ways: making erosion site length and bank height measurements, aiding one's balance and probing for unseen rocks and debris when walking in the stream, clearing away vegetation and debris and, finally, providing perspective and scale to photographs;
6. A carpenter's tape measure, for making relatively short measurements (i. e. those of six feet or less). Longer measurements required use of the Jacob staff, although a party of two or more could use a 100-foot surveyor's tape instead;
7. A tile spade for sampling streambank and bed materials to ascertain their composition and structure, and
8. Waders—hip waders in shallower water (three feet deep or less) and/or warmer weather, chest waders in deeper water and/or cooler weather—for comfort and protection when working in the stream.

DATACOLLECTION

Field Data Acquired

The field data collected was of two basic types: that detailing stream and streambank characteristics and that describing riparian conditions. Variables of first type included the following:

- Side of creek, oriented downstream, containing the erosion site;
- Bank erosion classification (Figures 1-4, pages 9-10);
- Length, height and, when significant, width of erosion;
- Estimated erosion severity;
- Presence of point sources, either pipes or gullies, of present or potential water flow into the stream;
- Bank and bed composition, and
- Stream width.

Variables describing riparian conditions, on the other hand, were as follows:

- Presence of bank seeps;
- Presence of cultural features;
- Cover type;
- Presence of cattle access into the stream;

- Riparian land use;
- Riparian slope, and
- Presence of gullies.

In addition, I subdivided stretches of fairly uniform riparian land use into 40 separate land-use segments (Map 1, page 2).

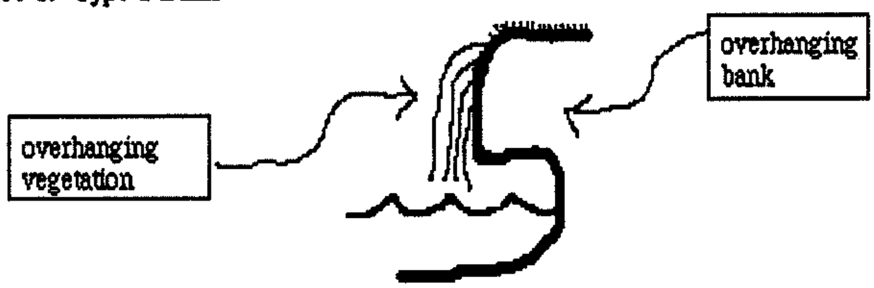
Field Data Acquisition

For best results when collecting field data, I walked directly in the stream whenever possible. This provided a good view of both banks, generally offered less obstructions to walking and allowed the clearing of vegetation and debris away from banks to reveal hidden erosion, pipes and gullies.

When describing an eroded bank, I first measured and documented bank height, erosion length and height and, when significant, erosion width. Then I noted the erosion class. The five main erosion classes I encountered are described below (Rippley, 1991):

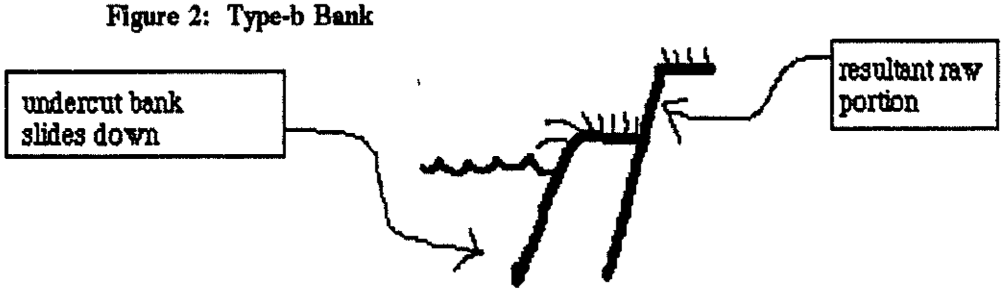
1. Type a: undercutting. This condition occurs when streamflow erodes away the bottom portion of the bank, creating a concave cavity that in many instances is hidden by overhanging vegetation.

Figure 1: Type-a Bank



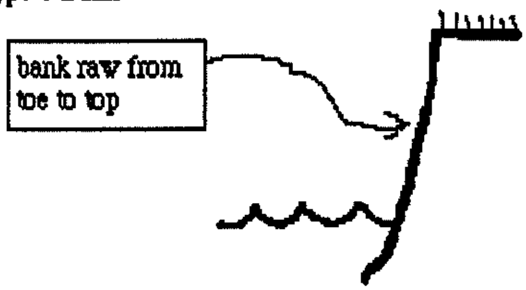
2. Type b: undercutting with upper bank sliding to waterline. Such banks, raw at the top, are relatively straight and steep.

Figure 2: Type-b Bank



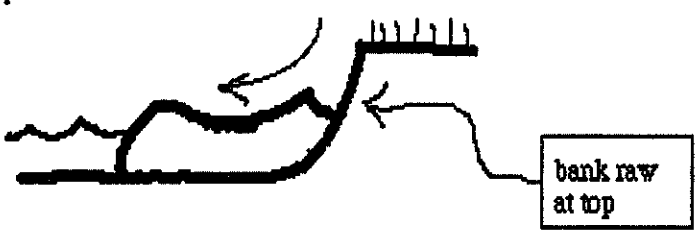
3. Type c: toe-to-top-of-bank erosion. This erosion type affects deflection banks, which accept the force of streamflow directly or nearly directly. Such banks are relatively steep and either straight or slightly concave.

Figure 3: Type-c Bank



4. Type d: rotational slide. This condition results in the "internal failure" of the bank. As with Type-b erosion, the subsequent sliding of bank materials to the toe causes these banks to be raw at the top. This sliding, typically quite severe, also pushes the bank and bed materials at the toe up and out. Concave banks generally, but not always, at relatively low angles are the result.

Figure 4: Type-d Bank



5. Type e: sliding caused and/or exacerbated by livestock trampling. Usually caused by cattle, this is frequently the most destructive form of streambank erosion. Typical Type-e banks are raw from top to toe and pummeled to concavity and to relatively low angles. Furthermore, because they are highly exposed to overland flow, they often develop rills or gullies.

In addition, I occasionally encountered banks simultaneously exhibiting two of the above classes of erosion (e. g. Types a and c) and classified them as combination banks (e. g. Type a/c)

I also subjectively categorized each eroded bank according to its degree of erosion using the followingclassifications:

1. Slight (SL);
2. Slight to Moderate (SL-M);
3. Moderate(M);
4. Moderate to Severe (M-SV), or
5. Severe (SV).

Moreover, I evaluated each site for the remaining characteristics listed on pages 8-9. Finally, at the request of the Mower County Environmental Health Office, I noted and evaluated all pipes that I encountered, documenting them along with and in the same manner as erosion sites.

DATADOCUMENTATION

I documented all erosion site data on field data sheets, later transferring the information to computer. I also photographed each site, either in part or in whole, for the production of a comprehensive series of slides. In field notes and on field topographic maps (Appendix B, pages 39-46), I catalogued erosion sites under exclusive and consecutive site numbers assigned in downstream order. Moreover, I tagged all field data with the numbers of the sites in which they occurred and listed them on the computer-generated data sheets that accompany this report. Finally, I numbered all land-use segments sequentially and in downstream order.

RESULTS

GENERAL FORMAT OF REPORT RESULTS

Although this study included all of Dobbins Creek, time restrictions arising from numerous delays—weather-related and otherwise—limited the inventory to only the severe and moderate-to-severe sites along the South Branch, the final reach completed. Otherwise, I inventoried the entire stream in a comprehensive and consistent manner. The topographic maps in Appendix B show erosion site locations; field data is included in a separate volume.

Inventory results appear in 40 separate sections, presented in downstream order, corresponding to the 40 land-use segments encountered. Result-section headings contain the following information:

1. Land-usesegmentnumber;
2. Stream reach (North Branch, South Branch or Main Flow);
3. Township (T) and range (R);
4. Section(s);

5. Sites;
6. Mappage(s);
7. Photograph and film roll numbers, and
8. Traversedate(s).

A general description of the segment—land use; cover; common erosion types, severities, dimensions and locations; bank and bed materials; slope, and other noteworthy features—follows each heading. Furthermore, because the extent of combined M-SV and SV (M-SV/SV) erosion in each segment is of special interest, this quantity, expressed as a percentage of bank length, is presented for each segment along with its land use and length in Table 2 (pages 12-13).

SUMMARY OF RESULTS

Please note that the figures used in this section represent either averages or strong trends and are by no means definitive. For a review of erosion classifications and severity abbreviations, see pages 9-11. Slope classifications are described on page 3.

Table 2: Summary of M-SV/SV Erosion

Segment	Length (mi)	Land Use	Portion of Segment M-SV/SV Eroded (% by length)
1	1.03	Grassland/Cropland	3.53
2	0.51	Grassland	0
3	0.21	Grassland/Forest	4.50
4	1.40	Grassland/Cropland	3.42
5	0.23	Grassland/Forest/Cropland	0
6	0.29	Grassland/Cropland	1.02
7	0.88	Pasture/Cropland	6.54
8	0.37	Grassland/Cropland	0.77
9	0.69	Pasture/Cropland	5.45
10	0.17	Grassland/Cropland	2.55
11	0.61	Pasture/Cropland	9.08
12	0.20	Grassland/Forest	2.76
13	0.27	Pasture/Cropland	21.33
14	0.24	Forest/Grassland/Cropland	0
15	2.11	Grassland/Cropland	5.54
16	0.15	Pasture	13.12

Table 2 (continued)

17	0.56	Forest/Grassland/Cropland	12.69
18	0.27	Forest/Grassland	6.82
19	0.94	Pasture	20.17
20	1.34	Grassland/Forest/Cropland	12.35
21	1.79	Pasture	6.70
22	1.36	Forest	7.66
23	0.29	Forest/Residential	8.21
24	0.21	Residential	0
25	0.46	Grassland/Forest	0
26	0.94	Grassland/Forest/Cropland	0
27	3.42	Grassland/Cropland	0.31
28	0.47	Pasture	2.80
29	0.38	Grassland	5.10
30	0.24	Residential	0.90
31	0.46	Grassland/Forest	4.22
32	0.27	Pasture	3.72
33	0.57	Grassland/Forest	8.63
34	0.32	Grassland/Forest/Cropland	8.98
35	0.53	Grassland	10.98
36	0.15	Residential	0
37	0.28	Pasture	20.85
38	0.76	Grassland/Forest	5.37
39	0.38	Other (Golf Course)	1.24
40	0.46	Forest	4.06

Segment 1, North Branch, T103NR16W

section(s): 17, 18 sites: 1 to 82 map page(s): 1, 2

photo numbers/roll numbers: 2/1 to 30/3 traverse date(s): 7/15/93 to 7/29/93

This segment consists of cropland separated from the stream on either side by a 50- to 100-foot tall-grass buffer strip. SL and SL-M Type-a erosion predominate, forming one-foot-high sites in the four- to five-foot-tall banks of Section 17 and the three-foot-tall banks of Section 18. SL and SL-M Type-b and -c erosion also exist. Moreover, the high water brought on by this year's heavy spring and summer rains has left the tops of many banks slightly raw in the segment's eastern half. Streambanks in general, typically moderately sloping, consist primarily of silt mixed with smaller amounts of sand, fine sand and, oftentimes, clay. In the channel, six feet wide on average, sand and silt dominate the widely-varied bed material. Significant amounts of clay and gravel and less significant amounts cobbles and boulders are also present. The riparian slope is generally Class B.

Segment 2, North Branch, T103NR16W

section(s): 18 sites: 83 to 98 map page(s): 2

photo numbers/roll numbers: 31/3 to 13/4 traverse date(s): 7/29/93 to 7/30/93

This very lightly eroded segment has been left to tall grass. The vast majority of its erosion is SL-M Type a, forming 1.5-foot-high erosion sites in three- to four-foot-tall banks. These sites also contain occasional SL-M Type-b or -c erosion. No M-SV or SV spots exist. Silt mixed with lesser amounts of fine sand makes up the streambanks, now more sharply sloping; combinations of silt, sand and gravel compose the stream bed. Clay and boulders are also frequently present in the often-hard bottom material. The channel remains six feet wide. Class-A and -B slopes predominate on the creek's right and left sides (facing downstream), respectively.

Segment 3, North Branch, T103NR16W

section(s): 18 sites: 99 to 109 map page(s): 2

photo numbers/roll numbers: 14/4 to 24/4 traverse date(s): 7/30/93

Tall-grass grasslands, along with scattered forested stretches set back about 25 feet from the channel, make up this section. SL-M Type-c erosion predominates, forming three-foot-high sites that correspond to a series of fairly sharp deflection bends. Significant SL-M Type-a erosion—scattered throughout the segment, but more prevalent toward the downstream end—is also present. Note, however, that a series of beaver dams spread throughout Segment 3 and the eastern half of Segment 4 has backed up water along this stretch, thus making erosion appear less severe than it would at normal stream depths. The streambanks, three to four feet tall, are composed of silt and scant fine sand. Sand and silt—along with frequent instances of clay, gravel and cobbles—make up the stream bed. The nine-foot-wide channel winds through a riparian area possessing mostly Class-B slopes, with intermittent Class-A slopes present on the left side.

Segment 4, North Branch, T103NR16W-T103NR17W

section(s): 18 (R16W); 13 (R17W) sites: 110 to 165 map page(s): 2
photo numbers/roll numbers: 25/4 to 10/6 traverse date(s): 7/30/93 to 8/12/93

Cropland, separated from the stream by 15- to 250-foot-wide tall-grass buffer strips, dominates this segment. The majority of the erosion is Type c, ranging from SL to M in severity and forming 3.5-foot-high sites along the segment's abundant deflection bends. Some deflection banks, however, exhibit M-SV Type-c erosion, and a few—especially in the downstream half of the segment—are severely eroded. Furthermore, significant SL-M and M Type-a and -b erosion also exists. Banks typically three to four feet tall, but often exceeding six feet, flank the frequently-meandering ten-foot-wide channel. Seeps occur in these banks—composed of silt, fine sand and, sometimes, clay—at Sites 110, 130 and 132. The bed consists predominantly of sand and silt, with frequent instances of gravel and less frequent instances of clay and cobbles. Slopes are Class B.

Segment 5, North Branch, T103NR17W

section(s): 13 sites: 166 to 173 map page(s): 2
photo numbers/roll numbers: 11/6 to 18/6 traverse date(s): 8/12/93

Cropland also dominates this segment, but is kept 100 to 300 feet from the stream by an abutting strip of forest and a subsequent tall-grass buffer strip. The relatively sparse overall erosion is almost exclusively Type c. Four-foot-high sites of SL-M severity are typical; M-SV and SV sites are nonexistent. Silt and fine sand are the predominant bank materials. Similarly, silt and sand—and often gravel—make up the stream bed. A ten-foot-wide channel runs through riparian areas with Class-B slopes.

Segment 6, North Branch, T103NR17W

section(s): 13 sites: 174 to 188 map page(s): 2
photo numbers/roll numbers: 19/6 to 34/6 traverse date(s): 8/12/93

This segment consists mostly of cropland separated from the stream by a 60- to 80-foot-wide tall-grass buffer strip. Type-a erosion—alternately SL, SL-M or M—predominates, cutting 1.5-foot-high holes into four-foot-tall banks. Relatively little M-SV or SV erosion has occurred, however. Banks of silt mixed with fine sand and, occasionally, clay contain seeps at Site 188. Sand, silt and gravel compose the stream bed. Class B riparian slopes flank the eight-foot-wide channel.

Segment 7, North Branch, T103NR17W

section(s): 13, 24 sites: 189 to 230 map page(s): 2
photo numbers/roll numbers: 35/6 to 5/8 traverse date(s): 8/12/93 to 8/26/93

The main riparian land use is pasture, which keeps adjacent cropland 30 to 200 feet from the stream on either side. Short and medium-height pasture grasses cover a soggy and uneven land surface. Type-a and -e erosion predominate in banks ranging from three to five feet high. The Type-a spots, generally SL or SL-M in severity, are typically 1.5 feet high. In contrast, the Type-e banks, three feet high and 15 feet (horizontally) wide on average, are M-SV and SV due to pummelling by cattle. Still, compared with other pastured segments, such sites occur sporadically. Streambanks consist of silt and scant fine sand. Sand, silt, gravel and occasional cobbles make up the stream bed. Riparian areas with Class-B slopes surround a typically 10-foot-wide channel.

Segment 8, North Branch, T103NR17W

section(s): 24 sites: 231 to 239 map page(s): 2
photo numbers/roll numbers: 6/8 to 14/8 traverse date(s): 8/26/93

This lightly eroded segment consists of cropland separated from the stream on either side by a 30- to 150-foot-wide buffer strip of medium-height grass. The sparse erosion sites generally consist of combinations of SL-M and M Type-a, -b and -c spots. The Type-a and -b stretches are typically two feet high in the three- to four-foot-tall banks, while the Type-c stretches tend to be three feet high. Banks composed of silt and fine sand flank the 12-foot-wide channel. Sand, silt and gravel make up the stream bed. Slopes are Class B.

Segment 9, North Branch, T103NR17W

section(s): 23 sites: 240 to 271 map page(s): 2, 3
photo numbers/roll numbers: 15/8 to 10/9 traverse date(s): 8/27/93 to 9/2/93

In this segment, 10- to 250-foot-wide strips of pasture separate cropland from the eleven-foot-wide channel. Cover consists of short and short-to-medium-height grasses and scattered trees. All five erosion classes are present, but Type c is most abundant: this reflects the frequent tight meanders and subsequent numerous deflection banks characteristic of this stretch of stream. Type-a, -b and -c spots—which in combination compose most of the sites—tend to be SL-M or M in severity, although the latter two types are sometimes M-SV. In contrast, the relatively sparse Type-e spots are generally M-SV or SV. Stretches of Type-a and -b erosion have formed two-foot-high erosion spots in banks typically three to four foot tall, but frequently exceeding six feet. These banks, as do those in Segments 10 and 11, tend to be taller and steeper than those in previous segments. Type-c and -e erosion, on the other hand, have formed four- and three-foot-high spots, respectively. Furthermore, the Type-e spots range average 15 feet in width. Banks are composed of silt, fine sand and, occasionally, clay and contain seeps at Site 251. Sand, silt and, frequently, gravel form the stream bed. Slopes are Class B.

Segment 10, North Branch, T103NR17W

section(s): 23 sites: 272 to 276 map page(s): 3
photo numbers/roll numbers: 11/9 to 15/9 traverse date(s): 9/2/93

This segment consists of cropland bordered by a buffer strip of medium-height grass. In addition, short strips of forest lie behind the buffer strips at either end of the segment. Very sporadic instances of M-SV Type-b and -c erosion and SV Type-d erosion affect the left- and right-side banks, which are typically three and five feet tall, respectively, but range up to 13 feet. The Type-b and Type-c spots, which are often contiguous, are four and five feet high, respectively. In contrast, the sole Type-d site is 13 feet high and 12 feet wide. The banks consist primarily of silt and scant fine sand, while the bed contains sand, silt, gravel and occasional cobbles. A 12-foot-wide channel winds through riparian areas with Class-B slopes.

Segment 11, North Branch, T103NR17W

section(s): 23 sites: 277 to 302 map page(s): 3
photo numbers/roll numbers: 16/9 to 6/10 traverse date(s): 9/2/93 to 9/7/93

In this segment, 15- to 160-foot wide strips of pasture lie between cropland and the stream. Pasture grasses are short or short-to-medium in height. Various combinations of contiguous spots from all five erosion classes make up the erosion sites present along the four- to six-foot-tall banks. Type-a, -b and -c erosion tend to be SL-M or M, while Types d and e are generally M-SV or SV. Erosion spots corresponding to Type-a, -b, -c, -d and -e erosion are typically 1.5 and two feet high, respectively, for the former two classes and four feet high for the latter three. In addition, the Type-d and -e spots average about 14 feet in width. The banks consist of silt mixed with significant amounts of fine sand. Sand, silt and gravel compose the bed, with sparse instances of clay, cobbles and boulders also evident. The channel averages 11 feet wide. Riparian areas generally possess Class-B slopes, with a few Class-A slopes present on the left side.

Segment 12, North Branch, T103NR17W

section(s): 22 sites: 303 to 309 map page(s): 3
photo numbers/roll numbers: 7/10 to 13/10 traverse date(s): 9/7/93

The stream flows through a combination of grassland and forest, sometimes running near cropland as well. Grasses are of medium height and trees are scattered throughout the segment. Erosion, generally Types a and c, is sparse and most often SL or SL-M in severity, although frequent M and M-SV sites exist. The Type-a and -c spots are generally one foot and four feet high, respectively.

The banks, 2.5 to 5 feet tall, consist mostly of silt and scant sand or fine sand. The 15-foot-wide channel, on the other hand, possesses a bed of silt, sand, clay and gravel. Slopes are Class B.

Segment 13, North Branch, T103NR17W

section(s): 15 sites: 310 to 322 map page(s): 3

photo numbers/roll numbers: 14/10 to 27/10 traverse date(s): 9/7/93 to 9/8/93

A 20- to 200-foot-wide strip of short-grassed pasture lies between cropland and the stream. Overall, erosion is extensive and, relatively speaking, extremely severe. Sites are composed primarily of combinations of Type-a and -e spots interspersed with lesser amounts of Type-b and -c erosion. The Type-a, -b and -c spots are generally SL-M or M in severity. Furthermore, they tend to be one, 2.5 and five feet tall, respectively. The frequent Type-e spots, however, along with occasional Type-b and -c spots, are generally M-SV or SV. The former areas are, on average, four feet tall and 12 feet wide. Banks composed of silt and fine sand and typically three to five feet tall flank the 10-foot-wide channel. Sand, silt and gravel make up the stream bed. Slopes are primarily Class B, with some Class-A slopes present on the right.

Segment 14, North Branch, T103NR17W

section(s): 15 sites: 323 to 328 map page(s): 3

photo numbers/roll numbers: 28/10 to 33/10 traverse date(s): 9/8/93

Adjacent forest and a subsequent strip of medium-height grass separate the stream from cropland on both sides. The grassed strip lies 30 to 50 feet and the cropland 70 to 300 feet from the channel. Very sparse SL-M and M Type-a and -c erosion spots—1.5 and three feet high, respectively—mar banks three feet tall on average. In general, the banks are composed of silt and fine sand, while the bed consists of coarser sand and silt. Both the banks and the bed also contain sporadic instances of clay, gravel and cobbles. Riparian areas with Class-B slopes surround a 15-foot-wide channel.

Segment 15, North Branch, T103NR17W

section(s): 15, 16, 21 sites: 329 to 375 map page(s): 3, 5

photo numbers/roll numbers: 34/10 to 10/12 traverse date(s): 9/8/93 to 9/27/93

Cropland is separated from the stream on both sides by either 25- to 200-foot-wide tall-grass buffer strips or, toward the downstream end of the segment, forest. Erosion is relatively heavy, with individual sites comprised of series of Type-a and -c and, less frequently, -b erosion. This erosion is predominantly SL-M or M, although several M-SV and SV Type-b and -c spots exist in the upstream two-thirds of the segment. Type-a, -b and -c spots are typically 1.5-, two- and three-feet-high, respectively. Note, however, that a beaver dam in the western half of the section has manipulated stream levels. Thus, sites upstream and, more significantly, downstream appear less and more severe, respectively, than they would at typical water levels. Streambanks—3.5 feet tall on average, but sometimes exceeding six feet—are comprised of silt and fine sand and contain seeps at Sites 337 and 375. In the 18-foot-wide channel, bed materials include sand, silt and, occasionally, gravel. Riparian slopes are generally Class B, with infrequent Class-A slopes present on the left.

Segment 16, North Branch, T103NR17W

section(s): 21 sites: 376 to 382 map page(s): 5
photo numbers/roll numbers: 11/12 to 17/12 traverse date(s): 9/27/93

Land use in this segment is predominantly heavily eroded pasture. The grasses of the pasture's upstream and downstream portions are medium and short in height, respectively. Erosion sites are comprised of contiguous combinations of Type-a, -c and, most frequently, -e erosion. The erosion spots of the former two classes tend to be SL-M or M. In contrast, those of the latter type are generally M, M-SV or, toward the middle of the segment, SV. Spots tend to be 1.5-, 2.5- and three-feet-high for Type-a, -e and -c erosion, respectively. Furthermore, Type-e spots are generally 12 feet wide. The relatively short banks, typically less than three feet tall, consist primarily of silt and scant fine sand. Sand and silt, with occasional instances of gravel and cobbles, also make up the stream bed. Riparian areas with Class-B slopes surround the 17-foot-wide channel.

Note: The erosion in Segments 17 through 21 is relatively frequent and heavy. Erosion sites in these segments are comprised of long (up to 1,000 feet) series of assorted erosion classes affecting both banks.

Segment 17, North Branch, T103NR16W

section(s): 21 sites: 383 to 393 map page(s): 5
photo numbers/roll numbers: 18/12 to 28/12 traverse date(s): 9/27/93 to 9/29/93

In this heavily-eroded segment, both forested strips and, less often, medium-height grassed strips form an 80- to 200-foot buffer between cropland and the stream. Erosion sites consist almost exclusively of long series of Type-c and -a sites characterized by 1.5- and four-foot-high erosion spots, respectively. Both the Type-a and -c spots display SL-M and M erosion. The Type-c spots, however, are often M-SV and occasionally SV. Four-foot-tall banks composed of silt and fine sand flank the 14-foot-wide channel. The stream bed is comprised primarily of sand and silt, with occasional gravel and cobbles also present. Class-B slopes predominate in the riparian areas.

Segment 18, North Branch, T103NR17W

section(s): 21, 28 sites: 394 to 398 map page(s): 5
photo numbers/roll numbers: 29/12 to 33/12 traverse date(s): 9/29/93 to 9/30/93

Forest lies between grassland and the stream in this segment. Tall grasses predominate toward the segment's upstream end, but are gradually replaced by medium-height grasses. Sites consist of series of SL-M and M Type-a, -c and, sometimes, -b erosion. Erosion spots corresponding to these respective classes average one, four and 2.5 feet high. Occasionally, these spots are produced by streamflow deflected by large uprooted or otherwise fallen trees. The four- to six-foot-tall banks—relatively high for this stretch of stream—are comprised of silt and fine sand, while coarser sand and silt make up the stream bed. Riparian areas with Class-B slopes surround the 13-foot-wide channel.

Segment 19, North Branch, T103NR17W

section(s): 28 sites: 399 to 410 map page(s): 5
photo numbers/roll numbers: 34/12 to 9/13 traverse date(s): 9/30/93 to 10/2/93

Land use is predominantly pasture blanketed by short and short-medium height grasses. This pasture's streambanks have suffered extensive and, in relative terms, extremely severe erosion. Sites consist of long series of Type-a, -c and -e spots and occasionally include Type-b and -d spots. The Type-a erosion is generally SL-M or M and has formed one-foot-high holes in banks typically four to five feet tall, but ranging up to 12 feet. Type-b, -c, -d and -e spots in these banks, however, range from M to SV and average 1.5, four, and 12 and four feet high, respectively. Furthermore, the latter two classes of erosion spots are typically 18 feet wide. Of special interest, the presence of tracks at the bases of the segment's two Type-d banks strongly suggests that cattle traffic played a major role in their formation. In general, streambanks are high in silt and fine sand and flank an 11-foot-wide channel. Sand, silt and gravel compose the stream bed. While the riparian slopes are generally Class B, intermittent Class-A slopes are present on the right.

Segment 20, North Branch, T103NR17W

section(s): 28, 29 sites: 411 to 429 map page(s): 5
photo numbers/roll numbers: 10/13 to 5/14 traverse date(s): 10/2/93 to 10/5/93

Medium-height grass buffer strips separate adjacent forested strips and, subsequently, cropland from the stream. Erosion, both extensive and relatively heavy, consists almost exclusively of Type a and c spots averaging one and 3.5 feet in height, respectively. Severity generally ranges from SL-M to M-SV, although some SV Type-c spots exist in the segment's upstream half. Periodically, where mature forest abuts the stream, significant erosion occurs around the occasional downed tree. Also of interest, a 48-foot-long stretch of washed-out barbed-wire fence on the right side of Site 421 reflects considerable and presumably rapid bank recession. Although this situation is hardly unique, in this particular case it is unusually extensive. Silt and fine sand, along with sporadic instances of clay, make up the three- to four-foot-tall banks; sand, silt and gravel, along with lesser instances of clay and cobbles, form the stream bed. Riparian areas possessing Class-B and, more sporadically, Class-A slopes flank the 13-foot-wide channel.

Segment 21, North Branch, T103NR17W

section(s): 29, 30 sites: 430 to 453 map page(s): 5, 7
photo numbers/roll numbers: 6/14 to 32/14 traverse date(s): 10/5/93 to 10/11/93

Two separate pastures dominate this segment. The first pasture, relatively lightly eroded, is located east of Mower County Road 24 and contains horses. Its short-to-medium-height grasses cover an uneven and swampy land surface. The second, more heavily eroded pasture—located west of the county road—contains cattle and grasses cropped short by heavy grazing. Sites in both pastures contain combinations of all five erosion classes, but Type-c, -e and, especially, -a spots predominate. Erosion is typically SL-M or M, although Type-d, -e and, less frequently, -c spots tend to be M-SV or SV. Type-a and -c spots tend to be one and 3.5 feet high, respectively; Type-e spots, the worst of which lie in the west pasture, are typically 3.5 feet high and 15 feet wide. In addition, the west pasture contains three Type-d banks that are, on average, nine feet high and 21 feet wide. In both pastures, banks composed of silt and fine sand, sometimes mixed with clay and gravel, flank a 13-foot-wide channel. These banks are 3.5 feet high on average, but often exceed six feet, especially in the west pasture. Sand, silt, gravel and occasional clay and cobbles compose the steam bed throughout. Riparian slopes are primarily Class B, with sparse instances of Class-A slopes on either side. Of special note, a horse corral at the segment's far east end raises additional water quality concerns: it lies as close as ten feet to the stream and, moreover, contains a small gully that, judging by the foul water at its mouth, carries horse wastes directly into the stream.

Segment 22, North Branch, T103NR17W-T103NR18W

section(s): 31 (R17W), 36 (R18W) sites: 454 to 480 map page(s): 7, 8
photo numbers/roll numbers: 33/14 to 27/15 traverse date(s): 10/12/93 to 10/18/93

As the the stream enters the J.C Hormel Nature Center, land use becomes exclusively forest. Cover includes mature trees, frequently-thick underbrush and grasses short to medium in height. A series of beaver dams significantly manipulates water levels, concealing most of the erosion in the upstream portion of the segment while revealing it in the downstream portion. SL-M and M Type-a and -c spots, generally contiguous over long stretches, predominate. Still, M-SV Type-a and -c erosion are common in the segment's downstream and upstream halves, respectively. In sporadic cases, such erosion occurs around fallen trees. Furthermore, SV Type-d erosion is present in the middle of the segment. Typical Type-a, -c and -d spots are, respectively, 1.5, four and eight feet high. The banks—generally three to five feet tall, but frequently topping six feet—are comprised of silt and fine sand, sometimes mixed with gravel and clay. In addition, the high, steep banks and the stream bed below Gerard School—located toward the segment's downstream end—are lined with a light layer of riprap. Sand, silt, gravel and, occasionally, cobbles and clay compose the bed. The 18-foot-wide channel, which ends in a confluence with the South Branch, flows through riparian areas with Class-B and, periodically, -A slopes.

Segment 23, Main Flow, T103NR18W

section(s): 36 sites: 481 to 485 map page(s): 8
photo numbers/roll numbers: 28/15 to 32/15 traverse date(s): 10/18/93

Forest on the left side and tall, steep banks on the right separate residential land from the stream. Left-bank cover consists of trees and bushes; right-bank cover is scattered trees and mowed lawns. SL-M and M Type-a erosion sites, occasionally accompanied by Type-c spots, predominate. Although usually M in severity, the Type-c erosion, especially in the middle of the segment, is sometimes M-SV. Type-a spots are generally 1.5 feet high, while Type-c spots are four feet high on average and 12 feet high maximum. The banks tend to be either relatively short (two to four feet) or, along much of the right side, exceptionally tall (12 to 15 feet). Composed of silt, fine sand and occasional instances of gravel and clay, they flank a 64- to 125-foot-wide channel. Sand, silt, gravel and cobbles make up the stream bed. Riparian slopes are primarily Class-B, with some Class-A slopes on the right.

Segment 24, Main Flow, T103NR18W

section(s): 36 sites: 486 to 490 map page(s): 8
photo numbers/roll numbers: 33/15 to 36/15 traverse date(s): 10/18/93

Residential land covered by scattered trees and either short-to-medium-height grass or mowed lawns dominates the right side. On the left, however, a city street runs along the top of a tall, steep bank covered by scattered trees and shrubs. Erosion is exclusively SL and SL-M Type-a and -c. The former erosion class typically forms 1.5-foot-high spots in four-foot-tall banks. In contrast, the latter forms spots 10 feet high on average. The banks—two to four feet tall on the left, up to 12 feet tall on the right—are composed of silt and fine sand. Sand, silt and gravel form the upstream portion of the stream bed. In the downstream portion, however, the funnelling of streamflow through a comparatively narrow culvert and into East Side Lake has caused the deposition of vast amounts of sand upstream of that point. Consequently, while the stream is relatively deep (greater than six feet) in the upstream portion, it is exceptionally shallow (less than two feet) downstream. Riparian areas with Class-B, and occasionally Class-A, slopes surround the 48- to 88-foot-wide channel.

Note: Due to time restrictions, I inventoried only pipes and M-SV or SV erosion sites and gullies in Segments 25 through 40.

Segment 25, South Branch, T103NR16W-T103NR17W

section(s): 30 (R16W), 25 (R17W) sites: 491 to 493 map page(s): 2
photo numbers/roll numbers: 1/16 to 3/16 traverse date(s): 11/2/93

Other than an isolated gully, this segment is devoid of M-SV and SV erosion. Tall-grass grassland separates thin strips of forest from the eight-foot-wide stream. The four- to five-foot-tall banks are composed primarily of silt and fine sand, while the stream bed is made up of sand, silt and gravel. Class B riparian slopes predominate.

Segment 26, South Branch, T103NR17W

section(s): 25 sites: 494 to 497 map page(s): 2
photo numbers/roll numbers: 4/16 to 7/16 traverse date(s): 11/2/93

This segment, whose sites are all gullies or pipes, has no M-SV or SV erosion. Narrow strips of grassland and forest keep cropland 33 to 64 feet from the stream. The grassed strips, which abut the stream, are composed of both tall and medium-height grasses. The six-foot banks, relatively tall for this stretch of stream, are composed of silt, fine sand and clay and flank an eight-foot-wide channel. Sand, silt, clay and gravel make up the stream bed. Riparian slopes are typically Class B, with intermittent Class-A slopes on the left side.

Segment 27, South Branch, T103NR17W

section(s): 26 sites: 498 to 503 map page(s): 2, 3
photo numbers/roll numbers: 8/16 to 13/16 traverse date(s): 11/2/93

In this segment, a 24- to 60-foot-wide grass buffer strip lies between cropland and the stream. The strip consists of medium-height and tall grasses. The erosion sites documented, predominantly M-SV and widely scattered, are typically 3.5-foot-high Type-c spots. Also noteworthy, however, is extensive M Type-a and -b erosion. Of particular interest is Site 498, marked on either bank by SV, 3.5-foot-high Type-c erosion. This site is unusual not only because it occurs in a fairly straight stretch of stream, but also because its severely gouged banks and bed are almost entirely clay—proof of clay's destabilizing effect when present in large amounts. In contrast, the rest of the banks, typically two to four feet high, possess more silt and fine sand and relatively little clay. The stream bed, on the other hand, consists of sand, silt, gravel and sporadic instances of clay. Riparian lands possessing Class-B slopes surround the seven-foot-wide channel.

Segment 28, South Branch, T103NR17W

section(s): 34 sites: 504 to 509 map page(s): 4
photo numbers/roll numbers: 14/16 to 19/16 traverse date(s): 11/4/93

Pasture covered by short-to-medium-height grasses makes up this segment. Compared to other pastures, this one is very lightly eroded. Scattered M-SV and SV Type-e sites predominate, with M-SV Type-b and -c sites less common. The latter two classes of sites tend to be 2.5 and four feet high, respectively. The Type-e sites, on the other hand, are typically four feet high and 15 feet wide. Furthermore, although not inventoried, M Type-a and -b erosion, along with scattered M Type-e spots, are also prevalent. Four-foot-tall banks of silt and fine sand surround the 10-foot-wide channel. The stream bed is composed of sand, silt, gravel and, less frequently, clay and cobbles. Riparian slopes are primarily Class B.

Segment 29, South Branch, T103NR17W

section(s): 33 sites: 510 to 518 map page(s): 4
photo numbers/roll numbers: 20/16 to 29/16 traverse date(s): 11/4/93

This segment, exclusively grassland, is covered entirely with short-to-medium- and medium-height grasses. M-SV Type-c erosion predominates, having laid bare four-foot-tall deflection banks. Silt and fine sand compose these banks; sand, silt and gravel make up the stream bed. Riparian areas with Class-B slopes surround the eight-foot-wide channel.

Segment 30, South Branch, T103NR17W

section(s): 33 sites: 519 to 520 map page(s): 4, 6
photo numbers/roll numbers: 30/16 to 31/16 traverse date(s): 11/4/93

Land use is residential, with cover consisting of medium-height grass and mowed lawns. The only erosion noted, sporadic but SV Type-b, exists as 3.5-foot-high sites in four-foot-tall banks. These banks are composed of silt and scant fine sand, while the bed consists of sand, silt, gravel and cobbles. Riparian slopes on either side of the 10-foot-wide channel are Class B.

Segment 31, South Branch, T102NR17W

section(s): 4 sites: 521 to 527 map page(s): 6
photo numbers/roll numbers: 32/16 to 2/17 traverse date(s): 11/10/93

Grassland consisting of medium-height grasses and mixed with scattered forested patches is the primary land use. M-SV Type-a -b and -c erosion form infrequent two-, three- and four-foot-high spots, respectively, in four-foot-tall banks composed of silt and fine sand. Sand, silt, gravel and occasional cobbles make up the stream bed. Riparian areas with Class-B slopes throughout and scattered Class-A slopes on the left surround the 13-foot-wide channel.

Segment 32, South Branch, T103NR17W

section(s): 33 sites: 528 to 532 map page(s): 6
photo numbers/roll numbers: 3/17 to 7/17 traverse date(s): 11/10/93

Horse pasture dominates segment. Its grasses, mixed with scattered trees, are short or short-to-medium in height. Comparatively, this pasture is very lightly eroded. Erosion consists exclusively of M-SV and SV Type-e and -c sites typically three and four feet high, respectively, in banks the same height. The Type-e spots are, on average, 12 feet wide. Also present, but undocumented, are sporadic M Type-e sites. Banks possessing silt, fine sand and occasional gravel flank the ten-foot-wide channel. Sand, silt and gravel compose the bed. Riparian slopes are Class B.

Segment 33, South Branch, T103NR17W

section(s): 32 sites: 533 to 541 map page(s): 6
photo numbers/roll numbers: 8/17 to 16/17 traverse date(s): 11/10/93 to 11/17/93

This segment is covered primarily by mixed grassland and forest, although a barnyard lies 20 to 30 feet to the right of the stream at the downstream end. Grasses are generally of medium height. M-SV Type-b and -c erosion predominates along this tightly-meandering stretch of stream, forming 2.5- and 3.5-foot-high spots, respectively, in the three- to four-foot-tall banks. Undocumented M Type-a erosion is also common. Bank materials consist primarily of silt and either sand or fine sand. Sand, silt and, usually, gravel compose the bed of the 10-foot-wide channel. Riparian slopes are generally Class B, although some Class-A slopes exist on the right.

Segment 34, South Branch, T103NR17W

section(s): 32 sites: 542 to 546 map page(s): 6
photo numbers/roll numbers: 17/17 to 21/17 traverse date(s): 11/17/93

Strips of grassland, which abut the stream, and forest form a buffer of 20 feet minimum width between cropland and the 10-foot-wide channel in this relatively heavily eroded segment. The grasses are of medium height. Located primarily below a large beaver dam, inventoried sites consist primarily of contiguous series of M-SV, and occasionally SV, Type-b and -c erosion. These Type-b and -c spots, typically 2.5 and 3.5 feet high, respectively, are largely the products of tight stream meandering. Also noteworthy, but undocumented, are frequent M Type-b and -c sites. Silt and fine sand make up the four- to five-foot-tall banks; sand, silt, gravel and, occasionally, clay compose the stream bed. Riparian slopes are Class B.

Segment 35, South Branch, T103NR17W

section(s): 32 sites: 547 to 559 map page(s): 6

photo numbers/roll numbers: 22/17 to 36/17 traverse date(s): 11/17/93

This segment's riparian areas are covered exclusively by medium grass and widely scattered trees. Relatively heavily eroded, the segment contains several SV Type-b and -c spots in its upstream two-thirds, while M-SV spots of both types are scattered throughout. The Type-b and -c spots are typically 2.5 and four feet high, respectively. Also, though undocumented, M Type-b and -c erosion are also common. Four- to five-foot-tall banks composed of silt and fine sand flank the 10-foot-wide channel. Sand, silt and gravel, along with less frequent instances of clay, make up the stream bed. Riparian slopes are generally Class A, although Class-B slopes are scattered along both sides.

Segment 36, South Branch, T103NR17W

section(s): 32 sites: 560 to 561 map page(s): 6

photo numbers/roll numbers: 1/18 to 2/18 traverse date(s): 11/17/93

This lightly eroded segment, composed of medium-height grasses lying between mowed residential lawns and the stream, contains no M-SV or SV erosion: the above site numbers correspond to a pipe and a gully, respectively. This apparent lack of erosion is largely due to the backup of streamflow by a beaver dam at the segment's extreme downstream end. Banks typically four feet tall are composed of silt and sand; the stream bed consists of sand, silt, gravel and, occasionally, cobbles. Riparian areas with Class-B slopes surround the 18-foot-wide channel.

Segment 37, South Branch, T103NR17W-T102NR17W

section(s): 31 (T103N), 6 (T102N) sites: 562 to 571 map page(s): 7

photo numbers/roll numbers: 3/18 to 12/18 traverse date(s): 11/17/93 to 11/18/93

This segment, one of the most heavily eroded of the watershed, contains a horse pasture covered by short-to-medium-height grasses. The erosion inventoried—located just below the beaver dam of Segment 36 and thus especially visible—is generally M-SV, but occasionally SV. Type-b and -c erosion predominate, with infrequent Type-d and -e spots scattered throughout the segment. Sporadic instances of M Type-e erosion, left undocumented, also exist. The Type-b, -c, -d and -e spots are typically 2.5, four, five and 3.5 feet high, respectively. Moreover, the Type-e spots tend to be 10 feet wide. Silt and fine sand, occasionally mixed with clay, make up the four- to five-foot-tall banks, while sand (both fine and coarse), silt and gravel compose the stream bed. The 13-foot-wide channel winds through riparian areas with Class-B slopes.

Segment 38, South Branch, T102NR17W

section(s): 6 sites: 572 to 582 map page(s): 7

photo numbers/roll numbers: 13/18 to 24/18 traverse date(s): 11/18/93

Mixed grassland and forest predominate. The former possesses short-to-medium-height grasses. Along the right bank, this combination frequently separates mowed residential land from the stream. At the segment's left, upstream end, however, it lies before what may be pasture. Of the erosion documented, M-SV Type-b and, especially, -c spots are most common. Solitary M-SV Type-a and SV Type-d and -e spots also exist. The Type-a, -b, -c, -d and -e spots are typically one, 2.5, four, eight and four feet high, respectively. Furthermore, the Type-d spot is 16 feet wide, while the Type-e spot is 19 feet wide. Silt, fine sand and, sometimes, gravel make up banks ranging from four to eight feet in height. The 13-foot-wide channel possesses a bed of silt, gravel and, alternately, fine and coarser sand. Riparian slopes are Class B.

Segment 39, South Branch, T103NR17W

section(s): 31 sites: 583 to 593 map page(s): 7

photo numbers/roll numbers: 25/18 to 35/18 traverse date(s): 11/18/93 to 11/19/93

In this segment, the 24-foot-wide channel winds through the southwest corner of the Austin Country Club's golf course. Predictably, very short grass blankets most of the riparian land, although grasses of short-to-medium height and scattered trees are often present in the segment's downstream half. Most of the generally three- to five-foot-tall streambank, often heavily riprapped, contains no M-SV or SV erosion: the majority of the segment's sites correspond to pipes. On the right side at the segment's downstream end, however, SV, 9-foot-high Type-c spots exist in the 13-foot-tall banks. These banks are composed of silt, sand, clay and gravel, while the preceding banks are made up primarily of silt and either fine or coarser sand. Furthermore, the stream bed associated with the eroded banks is comprised of clay and cobbles along with sand and silt, while the preceding bed is composed primarily of sand and silt. Riparian slopes are Class B.

Segment 40, South Branch, T103NR18W

section(s): 36 sites: 594 to 598 map page(s): 8

photo numbers/roll numbers: 36/18 to 4/19 traverse date(s): 11/19/93

This segment consists of forested land in the J.C Hormel Nature Center. Cover is comprised of relatively mature trees and heavy undergrowth, including grasses short-to-medium in height. Erosion in this segment is sparse and generally M-SV. Most prevalent are Type-c spots, generally five feet high. In contrast, a solitary SV Type-d bank is nine feet high and 15 feet wide. Interestingly, judging by cracks at the base of its raw upper portion, this steep bank's materials are in the process of sliding for a second time. In general, banks range from four to 15 feet in height and are composed of silt and fine sand, although the Type-d bank also contains clay and gravel. Sand, silt, clay, gravel and cobbles make up the stream bed. Riparian lands with Class-B slopes surround the 21-foot-wide channel.

CONCLUSIONS

PROJECT SUMMARY

In the course of collecting, processing and analyzing the data for this project, I arrived at a number of conclusions regarding streambank erosion in Dobbins Creek Watershed. The most noteworthy of these are listed below. Please note that because I measured only M-SV and SV erosion along the South Branch, I generally utilized data related only to these degrees of erosion in assessing erosion trends and computing statistics for the stream as a whole.

1. All of Dobbins Creek's streambank is eroded to some degree, although comparatively little of that erosion—only 6 percent of the total streambank—is M-SV or SV. Yet this evident lack of severity fails to reflect the considerable cumulative contributions of streambank erosion to the sedimentation of East Side Lake. In other words, the bulk of streambank material entering Dobbins Creek is likely attributable to extensive moderate erosion rather than intermittent severe erosion.

2. On a watershed scale, both the comprehensiveness and the high cumulative rate of streambank erosion are primarily attributable to the high erodibility of streambank soils. In general, the soils' high sand and silt contents—especially in their subsurface layers—and occasional clay deposits (e. g. the severely eroded Site 498 in Segment 27) tend to inhibit the formation of stable aggregates, thus making them highly susceptible to erosion. Erosion severity, however, appears closely related to the specific soil series present (Map 2, page 9). For example, loam-based series flank seven-eighths of the stream, yet they predominate in a disproportionately high number—the top 23 and 31 of the top 32—of the its most severely eroded segments. Most noteworthy are loams of the Coland-Spillville series, which are present in the eight most severely eroded segments. In contrast, the higher clay contents of the clay loams, which flank the remaining one-eighth of the stream, apparently make these soils much more stable. To illustrate, of the only four segments possessing clay loams—Segments 1, 25, 26 and 27—the latter three rank among the top eight least severely eroded segments and all four rank among the top 17. In short, specific soil type—or more accurately, its characteristic composition—is apparently among the most significant factors in overall erosion severity.

3. Although streambank erosion severity is determined by many related factors, such as soil type and riparian cover, the most significant is undoubtably land use. In particular, streambanks in pastures, because of cattle or horse trampling (i. e. Type-e erosion), tend to be the most severely eroded. Moreover, cattle pastures, due primarily to larger herd sizes and heavier animals, are generally more severely eroded than horse pastures, such as those in Segments 21 and 32. Type-e spots accounts for approximately 25 percent, by length, of M-SV/SV erosion and, more importantly, over 54 percent of all SV erosion. But erosion in pastures is not limited to Type e: pasture streambanks also contain disproportionately high amounts of Type-b and -d erosion, as well as the majority of erosion sites deemed extremely SV. In the latter two cases, livestock traffic has often played a significant role. As is suggested by conditions in the middle of the North Branch—where the heavily eroded pasture of Segment 13 is flanked by unpastured segments with similar characteristics, but much less severely eroded—improved land management practices (e. g. reducing grazing pressure, restricting cattle access to the stream) may help significantly reduce erosion severity in pastures. Priority, however, should be given to the most severely eroded of these segments: Specifically, Segments 11, 19 and 21 (along with the forested Segment 22) contain inordinately high instances of both Type-d spots, which are typically SV, and exceptionally SV spots in general. Furthermore, in terms of overall erosion severity, Segments 13, 16, 19 and 37 are far and away the worst of the watershed.

4. Next to land use, cover is apparently the most important determining factor in erosion severity. Specifically, inventory results reveal two important trends involving grass height and density, respectively. In the first, erosion severity apparently decreases with increasing grass height. Presumably, the presence of taller grasses along streambanks decreases the volume (due to increased infiltration) and velocity—and thus the erosiveness—of precipitation runoff as it flows down the banks and into the stream. To illustrate, of the 11 segments covered primarily by tall grass, nine exhibit percentages of M-SV/SV erosion, by length, lower than the watershed average. Furthermore, four such segments—2, 5, 25 and 26—are among seven overall possessing no M-SV or SV spots. In contrast, seven of the eleven segments blanketed mainly by short grass exhibit above-average percentages of M-SV/SV erosion. Because short grass is primarily correlated to pasture, this last trend may seem questionable. Yet I also found a positive correlation between relative abundance of taller grasses and decreased M-SV/SV erosion percentage in pastures. Moreover, M-SV/SV erosion percentages are also above average for the majority of segments containing short-to-medium-height grasses. Thus, in areas prone to serious erosion, the establishment of tall-grass buffer strips along streambanks is likely a simple and effective remedial measure. Exceptions to the grass height trend include residential segments—24, 30 and 36—and Segment 39, which runs through the Austin Country Club golf course.

Although covered primarily by mowed lawns, these segments possess low M-SV/SV erosion percentages that are presumably attributable to comparatively intensive streambank monitoring and maintenance.

In the second trend, grass density and erosion severity are seemingly inversely correlated. In particular, streambanks flanked by forest, found primarily along the North Branch, generally exhibit above-average erosion severity percentages—probably due to the relatively sparse grass cover beneath the forest canopy. In short, it appears that grass is the most effective form of cover for anchoring stabilizing streambank soils. There are likely no practical means, however, for remedying the above condition.

5. Two other noteworthy sources of heavy streambank erosion are tight stream meanders and natural dams. Dobbins Creek's extensive meandering is especially significant. In general, wherever the stream bends, erosion intensifies. Yet many segments, such as Segment 9, exhibit stretches where exceptionally tight meandering produces several heavily eroded deflection banks over a relatively short distance. The resulting erosion is generally Type c, which by length makes up approximately 50 percent of the stream's M-SV erosion and nearly 40 percent of its combined M-SV and SV erosion. Such erosion may be, and sometimes already is, combatted via riprapping or other means. In contrast to deflection bends, natural dams are a relatively small-scale and isolated erosion factor. Occurring exclusively where forests flank the stream, and especially common in Segments 18 and 20, these dams consist of uprooted (via undercutting) or otherwise fallen trees, often accompanied by loose branches. Erosion, often severe, occurs at a dam's ends and underside—the spots where streamflow is directed against bank and bed materials. Of particular concern is the likelihood that over time the erosion from these dams will likely uproot more trees, creating more dams and thus perpetuating a vicious cycle. The cycle can be broken by periodically clearing the channel of all trees, brush, stumps and other debris. Such cycles, however, are not characteristic of beaver dams which, by significantly slowing and backing up streamflow, actually seem to cause a cumulative erosion reduction.

6. There are several other streambank characteristics that, while not significant on a watershed scale, affect erosion severity in certain instances. The most noteworthy of these site-specific characteristics are bank and bed composition and bank height. For example, there are clear ties between a particular site's bank and bed materials and its bank stability. Most significantly, nearly all M-SV and SV erosion spots have bank materials high in either fine or coarser sand. In addition, though much less consistent, there is a positive correlation between excessive (greater than 40 percent) bank clay content and erosion severity, especially with Type-d and exceptionally

eroded banks. Moreover, there is a positive but weak correlation between stream bed gravel content and erosion severity: a relatively hard bottom evidently enhances current velocity, cattle footing or both. Surprisingly, however, the presence of clay in bed materials appears to slightly decrease erosion severity. Furthermore, M-SV and SV banks are often, but not always, relatively tall. For example, although the average bank is three to five feet tall, Type-d bank heights routinely exceed six feet, and often 10 feet. While none of the above characteristics suggest possible erosion remedies, they may be useful in identifying and prioritizing both current and potential problem banks.

7. Dobbins Creek's three main reaches vary significantly in erosion severity. In particular, the North Branch's percentage of M-SV/SV erosion is roughly 1.5 times that of the Main Flow and over twice that of the South Branch. It also holds the vast majority of all Type-d and exceptionally eroded spots. These disparities are primarily due to two factors. First, the North Branch possesses an inordinate amount—nearly 84 percent—of the watershed's pastured streambank. Accordingly, it contains over 90 percent, by length, of all Type-e erosion and large amounts of other erosion types. Second, its banks are composed primarily of Coland-Spillville loams—seemingly the most erodible soil series. Also worth noting, over three-fourths of all segments exhibiting above-average percentages of M-SV/SV erosion are located in the watershed's western half (i. e. west of State Highway 56). Not surprisingly, the eastern half possesses an inordinately high proportion of the least-erodible soils, including all of the clay loams. Thus, remedial efforts should focus primarily on the portion of the North Branch in the western half of the watershed. A detailed discussion of remedial measures follows.

REMEDIAL MEASURES

According to Troeh et al., streambank erosion—whether perceived as geologic or anthropic—is a natural process that cannot be halted, but only slowed (1991). Moreover, while abatement measures may reduce overall erosion rates, they also tend to shift erosion-related problems from one area to another—usually downstream. Nevertheless, when used correctly, such measures can be effective erosion deterrents.

Remedial practices for streambank erosion are of two basic types: those that divert streamflow away from and those that reduce the erodibility of vulnerable areas (Schwab et al., 1993). Each type is described here in detail.

Streamflow Diversion Measures

Methods of this type are exclusively mechanical. Besides diverting streamflow, they also slow it so that suspended sediments precipitate out—a phenomenon desirable in many, but not all, cases. Furthermore, when spread regularly throughout a stream, they may help slow streamflow momentum gained—as in the case of Dobbins Creek—over long, smooth slopes. Common examples of these measures, taken from various sources, include the following (Hudson, 1981; Schwab et al., 1993; Troeh et al., 1991).

A dike, in the case of erosion reduction, is a wall composed of loose, heavy stones. With one end touching the bank, this wall projects out into the channel at a slight angle downstream. Its top, generally tapering downward farther from the bank, may range from three feet above the low-flow water level to full bank height. When placed before and slightly upstream of an eroded bank, a dike protects the site by diverting streamflow away from it.

Like a dike, a jetty (or groin) extends out from the streambank and is oriented either perpendicular or at a slight downstream angle to streamflow. Constructed from various combinations of vertical timber piling, stone, reinforced concrete blocks and steel or iron framing, jetties are placed upstream of problem banks, protecting them by deflecting away erosive currents. In addition, when placed parallel to each other on opposite banks, jetties funnel water to the center of the stream, creating a deeper main channel

A variation of the jetty is the permeable spur, or retard. Extending into the stream like jetties, spurs are composed of either timber or prefabricated metal frames and are anchored to the bank by wire cables. But unlike jetties, which deflect streamflow, permeable spurs allow it to pass through, thus slowing it to a less-erosive velocity and, consequently, causing deposition of sediments along the vulnerable bank.

Finally, a weir is a concrete barrier that spans the stream and is oriented roughly perpendicular to streamflow. Located upstream of the vulnerable area, it slows flow by constricting it and forcing it over a crest, or notch. Different streamflow effects may be achieved by using different crest shapes—rectangular, triangular or trapezoidal are most common—to create various head-discharge relationships.

Of special interest is an apparent abatement structure, which I was unable to identify, located in the J. C. Hormel Nature Center at Site 459. It is basically a concrete wall approximately five feet tall and 10 feet long—a total less than the channel width—and possessing at bottom center a square opening roughly three feet on a side. Oriented perpendicular to streamflow and located on a short bank just downstream of a taller, lightly riprapped one, the structure is presumably meant to restrict flow along the bank while funnelling it through the opening. Seemingly possessing qualities of both weirs and jetties, its effectiveness is implied by the large amount of alluvial sand on its downstream side.

While generally very effective for erosion reduction, streamflow diversion measures also have certain drawbacks. First, they tend to be quite expensive. Furthermore, in deflecting streamflow away from a problem bank—especially in a narrow stream stretch—they may consequently direct it against, and thus increase erosion of, the opposite bank. Finally, they may cause unwanted sediment deposition.

Streambank Fortification Measures

The second class of remedial measures—those that reduce bank erodibility—may be either mechanical or vegetative. Unlike diversion structures, bank fortifying measures do not manipulate streamflow, but merely shield vulnerable banks or anchor bank materials. On the other hand, they are generally less expensive—though they may still involve considerable cost—and simpler to apply. Below are some common examples (Hudson, 1981; Troeh et al., 1991).

Riprapping involves lining the entire eroded bank with loose, undressed stones (i. e. riprap)—generally cobbles or boulders. Still, materials such as concrete chunks, while not technically riprap, will also suffice. Strong evidence of riprapping's effectiveness exists at Site 398, where a large pile of fine alluvial sand has been deposited at the downstream end of a riprapped deflection bank. Where banks are too steep for true riprapping, however, one may use such variations as toe protection and hardpoint protection. Toe protection involves spreading protective materials, either by hand or machine, over just the toe and the lower portion of the bank. In contrast, hardpoint protection is even less intensive: the material is simply dumped over the edge of the bank, protecting only the toe.

Similar to riprapping, but more complex, are methods using gabions and revetments. Gabions are prefabricated, heavy-wire baskets filled with stones or the like. With its materials held steady by the confining basket, which can be stood vertically against a steep bank, a gabion is a more stable and versatile, yet more expensive, substitute for riprap. Moreover, gabions may be used in jetties or revetments—retaining walls or protective facings placed over and anchored to an eroded bank. When cemented or otherwise linked together, rocks, old auto tires and flattened car bodies also make effective revetment facings. Generally more erosion resistant than other bank fortifying methods, revetments also tend to be more expensive.

Revegetation of eroded banks is yet another erosion abatement option. When established on eroded banks, fast-growing and extensive-rooting plant species such as willows both shield and anchor bank materials. Yet revegetation, when done alone, is seldom successful. In short, many heavily eroded banks are too steep and/or too frequently scoured for adequate vegetation establishment. Moreover, livestock traffic prevents the revegetation of Type-e banks. Thus, successful revegetation is generally accomplished in combination with other abatement efforts, especially those involving streamflow deflection or, in pastures, livestock traffic restriction.

In summary, any of the above measures, when used correctly, will adequately protect a vulnerable bank under most or all conditions. Yet because the characteristics of problem banks often vary from site to site, matching remedial measures to specific banks, though not always feasible, is probably the most effective abatement strategy.

RECOMMENDATIONS

Because streambank erosion is fundamentally unstoppable and because Dobbins Creek Watershed's basic characteristics, especially its soils, make its streambanks highly vulnerable to erosion, the rapid sedimentation of East Side Lake will likely continue regardless of remedial measures. Still, I feel that certain measures will help reduce erosion rates more than others. In particular, I believe that the most efficient, effective and economically feasible remedial (and preventative) measure would be to halt livestock access to the stream. Ideally, one would restrict livestock traffic, presumably with fences, while fortifying the pummeled banks via mechanical measures (e. g. riprapping). Yet in some cases, because Type-e banks are typically gently sloping, revegetation may possibly afford adequate protection at less cost. At the very least, erosion severity may be diminished by reducing the number of animals grazing in a certain area. Such endeavors, however, might receive strong opposition from pasture owners.

Of the remaining remedial options, riprapping is among the simplest, least expensive and most effective. For any measure chosen, however, the associated planning and cost will likely be considerable. To illustrate, Dobbins Creek contains over 300 M-SV or SV spots, including over 100 SV spots alone—many more than can be feasibly remedied. Furthermore, especially when excluding Type-e banks, narrowing them down is no easy task. Therefore, I suggest that planning and costs be minimized by limiting treatment to one or both of the following:

1. The very worst-eroded individual spots,
2. Sites containing relatively high concentrations of M-SV and SV erosion.

These locations are highlighted in the field notes accompanying this report.

Ultimately, it's questionable that any practical erosion reduction program can satisfactorily slow the sedimentation of East Side Lake. For as with any dammed body of water, stream-borne sediments will steadily and inevitably continue to fill the lake basin, and the investments of both labor and funds necessary to, in the long run, significantly slow this process will likely be prohibitive. Thus, periodic dredging may be the only way to keep East Side Lake at a long-term chosen standard of quality.

NOTES TO FUTURE INTERNS

I offer the following suggestions to future interns undertaking similar projects in hopes that they may benefit from my experience.

1. Be sure to obtain a four- or five-foot Jacob staff, or the like, before beginning the project. I am convinced that this versatile tool, whose many uses are described on page 3, is truly indispensable.

2. Become adequately familiar with your project area and project procedures before commencing field work. By first studying relevant maps, such as topographic and aerial maps, and reading reports and instructions from similar projects, you will likely proceed much more capably and confidently in the field.

3. If stream depth permits, choose a number of water level checkpoints along the entire stream length. These will allow you to check relative stream level fluctuations after rainfall, allowing you to better determine when to delay field work and, if delayed, when to restart it. For comparison purposes, be sure to make initial measurements of stream at levels suitable for working. Potential checkpoint sites must have hard bottoms—road culverts are ideal.

4. Instead of just recording site locations on topographic and aerial maps, document other noteworthy points as well. For example, note interesting or unusual stream features. Or emphasize instances of erosion that are relatively scarce, such as Type-d or exceptionally severe spots. Marking such spots will allow you to more easily recall them and their locations when writing the report.

5. Carry an accurate compass. Oftentimes when locating and documenting sites on field maps, high banks or thick vegetation make it impossible to exit the stream and locate

landmarks. Moreover, heavy cloud cover or thick forest canopies may make you unable to orient yourself using the sun. In such cases, a compass is invaluable for determining your approximate position.

6. Make field data processing and report writing on-going endeavors. This is important for several reasons: First, by having the data fresh in your mind, you can write more accurate field descriptions. Second, you can break up the monotony of the field work. Third, you can simplify the final computation of statistics and identification of trends by keeping running totals of such data as erosion length, both by type and severity. Finally, by spreading the cumulatively large component tasks of report writing—data analysis and interpretation, outside research, field description, summary and conclusion formulation—over a longer time period, you can manage them much more easily. In the end, working continuously makes report writing both easier and more accurate.

REFERENCES

Hudson, N. (1981). Soil Conservation. 2nd ed. Ithaca, NY: Cornell University Press.

Rippley, R. (1991). Whitewater Watershed Project: Stream Survey, 1991. Paper presented to Winona State University Geology Internship Program.

Schwab, G.O., Fangmeier, D.D., Elliot, W.J., & Frevert, R.K. (1993). Soil and Water Conservation Engineering. 4th ed. New York: John Wiley & Sons, Inc.

Troeh, F.R., Hobbs, J.A, & Donahue, R.L. (1991). Soil and Water Conservation. 2nd ed. Englewood Cliffs, NJ: Prentice Hall.

United States Department of Agriculture. (1989). Soil Survey of Mower County, Minnesota. Washington, DC: U. S. Government Printing Office.

APPENDIX A: FIELD DATA FORM

STREAMBANK INVENTORY DATA FORM--DOBBINS CREEK (JUNE 1993)

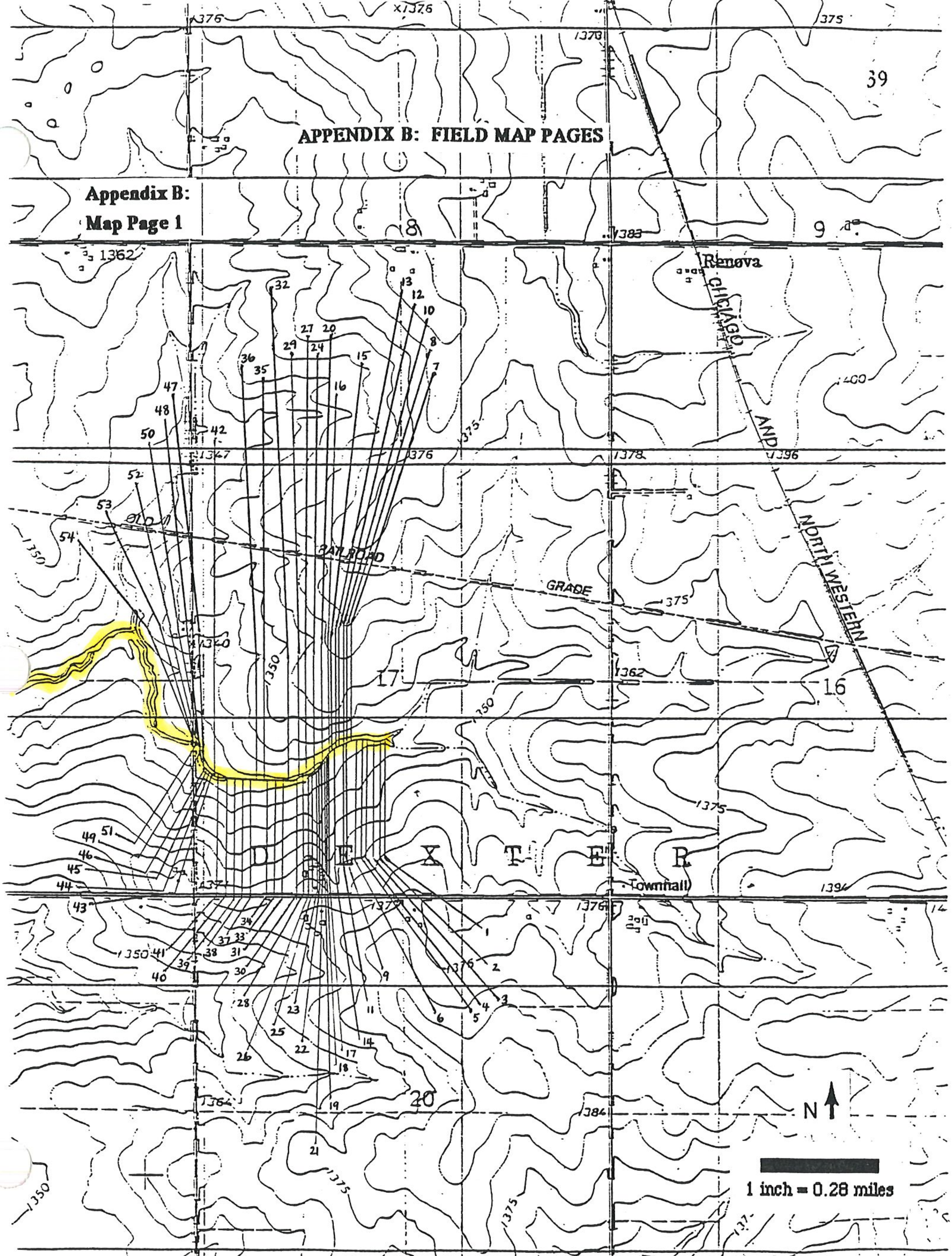
	SITE #	MAP #	TN	R	S	1/4S	PIC.#/ ROLL#	SEG. #	LRB	BANK CLASS	L	H	PS	SV
1.														
2.														
3.														
4.														
5.														

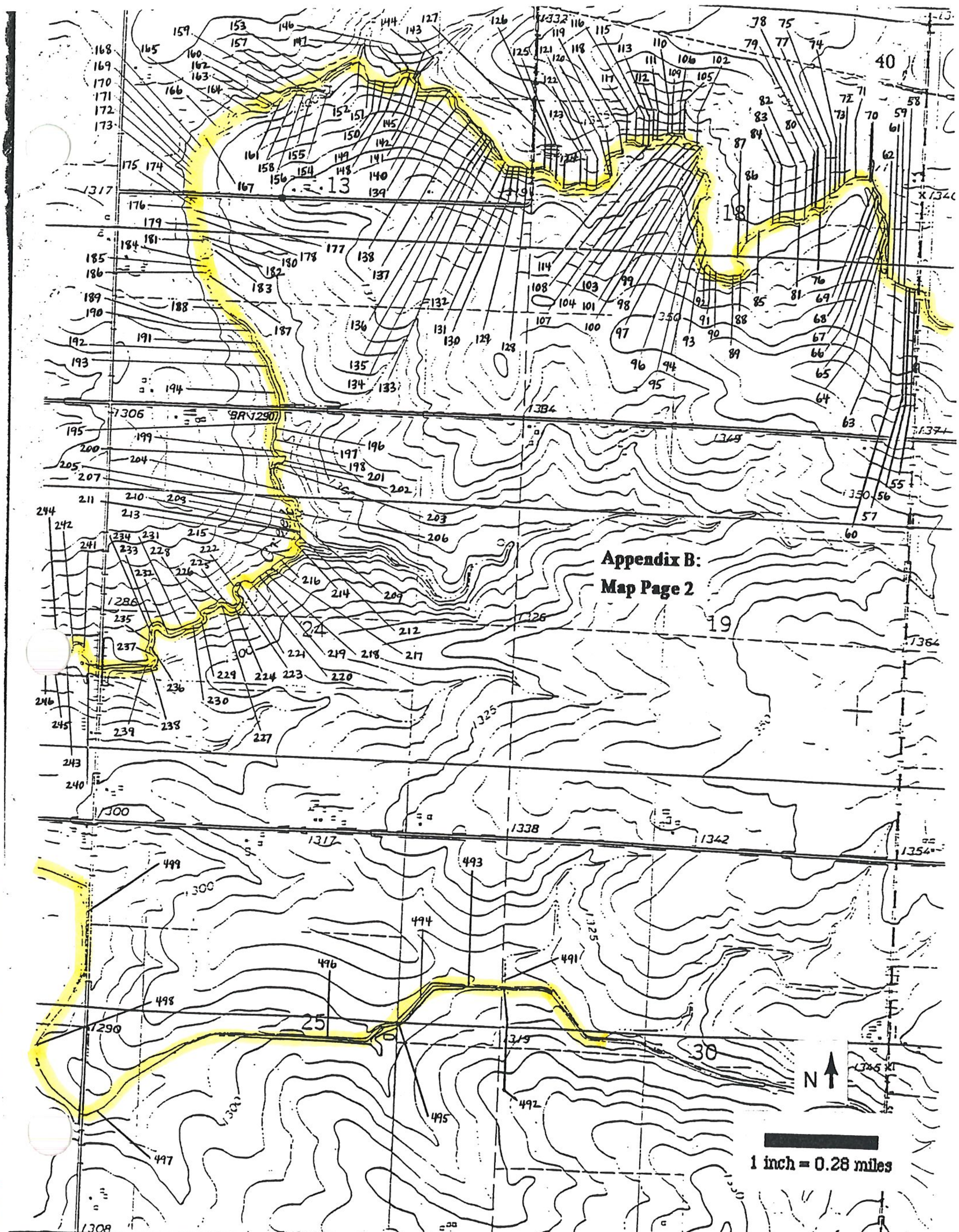
RIPARIAN CONDITIONS ------------------------------->

	BA/BE MAT.	STREAM WIDTH	SEEPS	CULT. FEAT.	COVER	CATTLE ACCESS	LAND USE	SLOPE	GULLIES
1.									
2.									
3.									
4.									
5.									

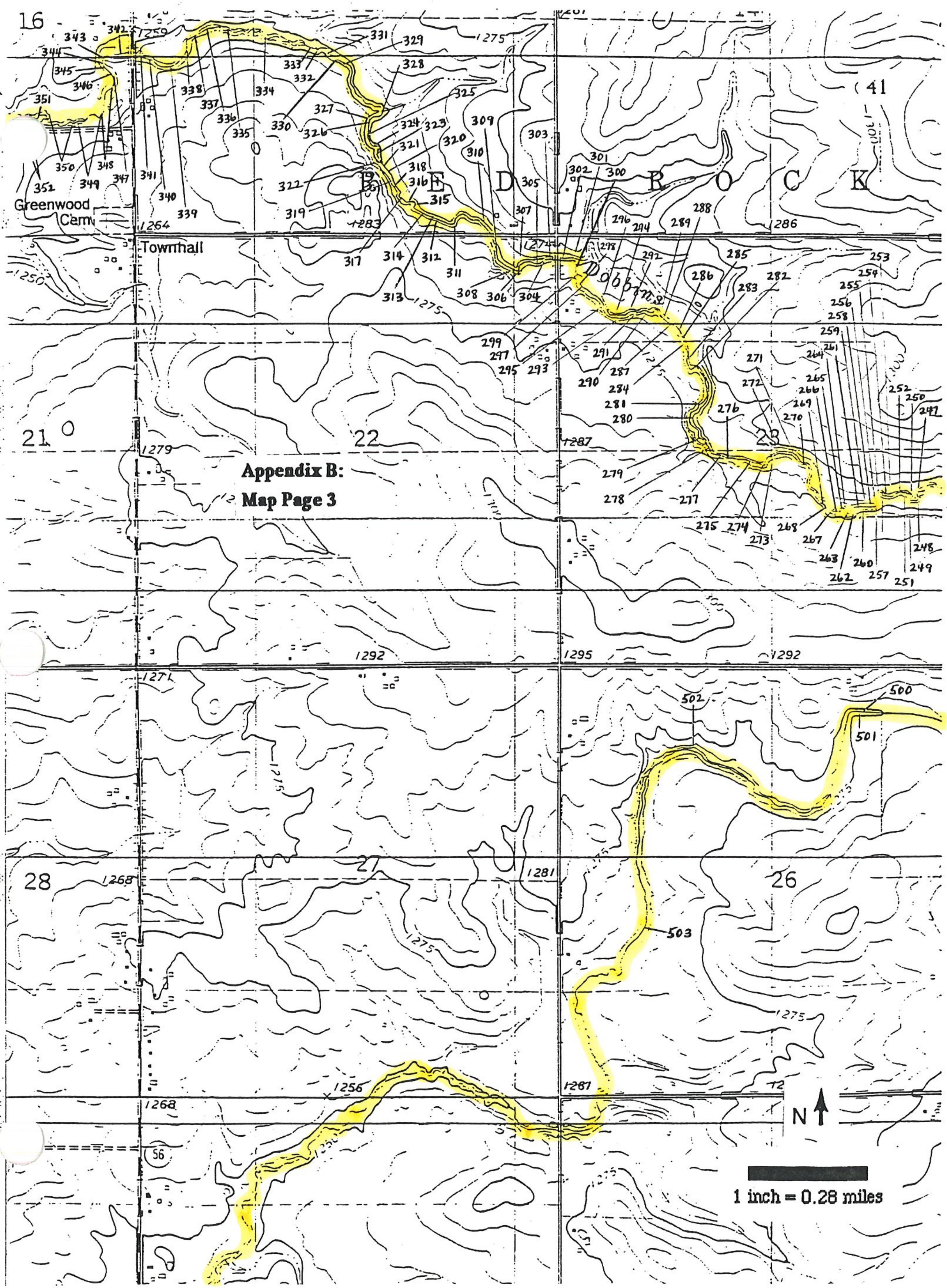
APPENDIX B: FIELD MAP PAGES

Appendix B:
Map Page 1





Appendix B:
Map Page 2
N
1 inch = 0.28 miles



Appendix B:
Map Page 3
Greenwood Cem
Townhall
B E D R O C K
Dobbins
16
21
22
23
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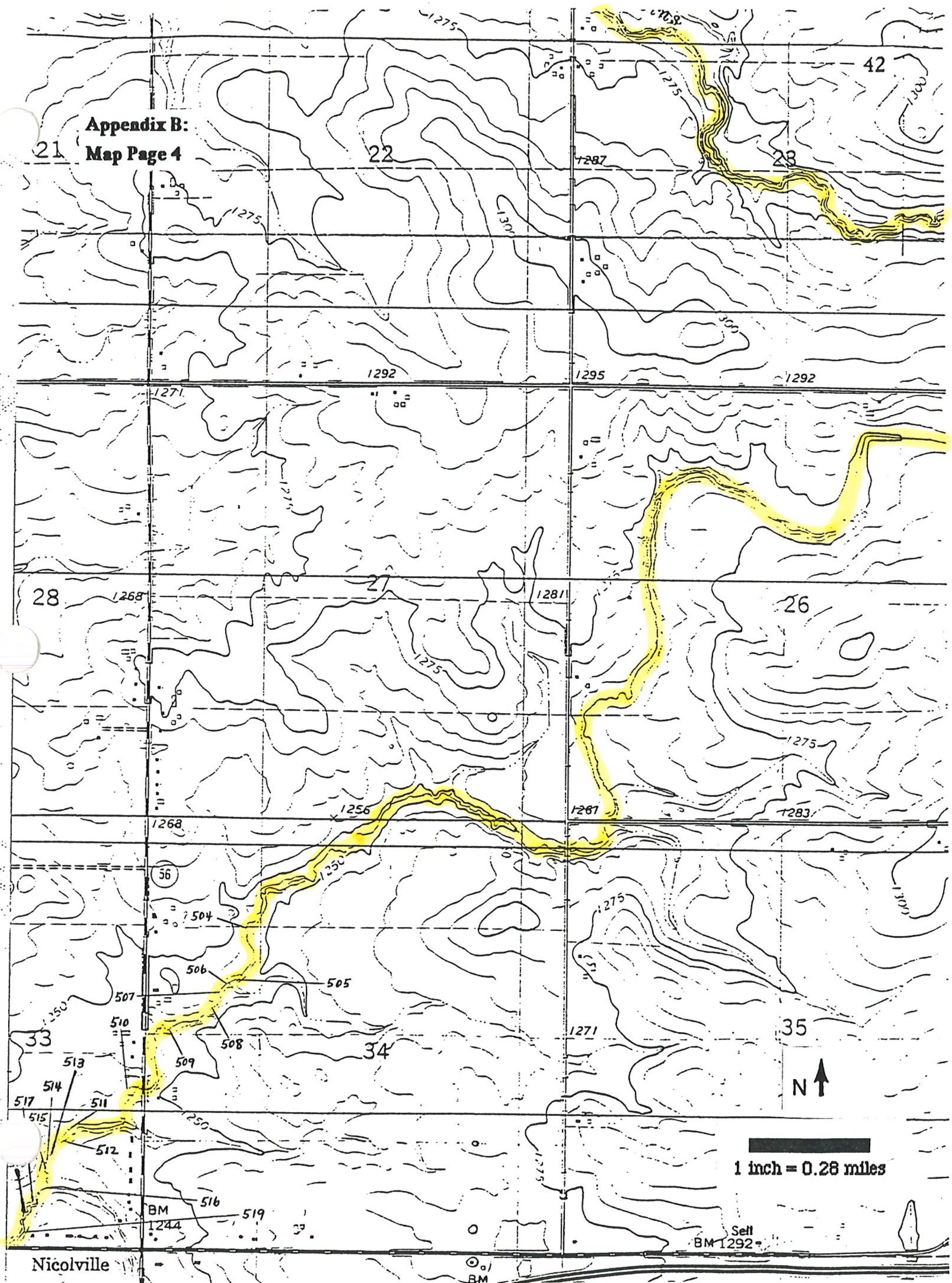
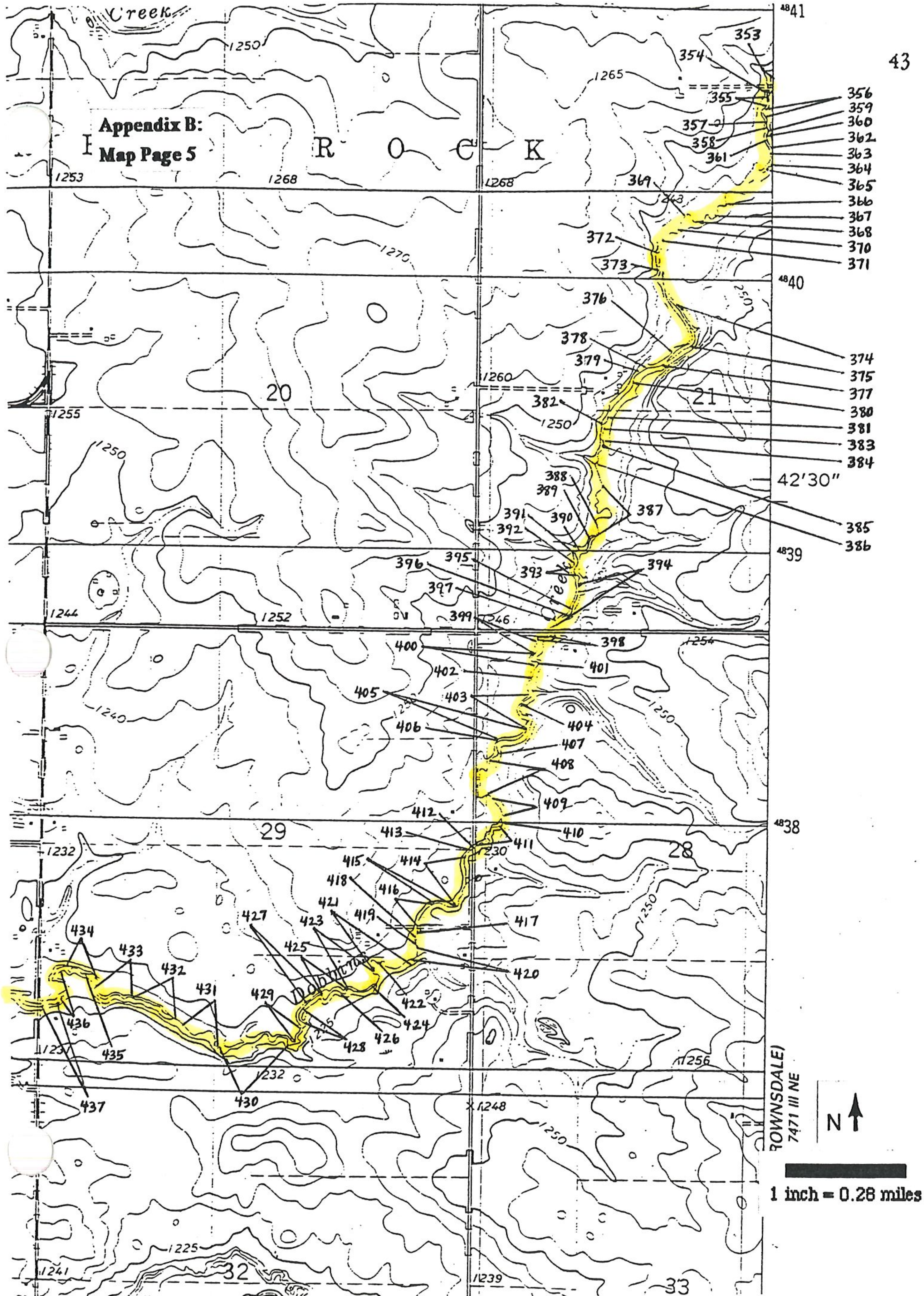
27
26
41
N
1 inch = 0.28 miles

Appendix B:
Map Page 4




Appendix B:
Map Page 5
Creek
R O C K
20
21
29
28
32
33
Dobbins
Creek
1250
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1232
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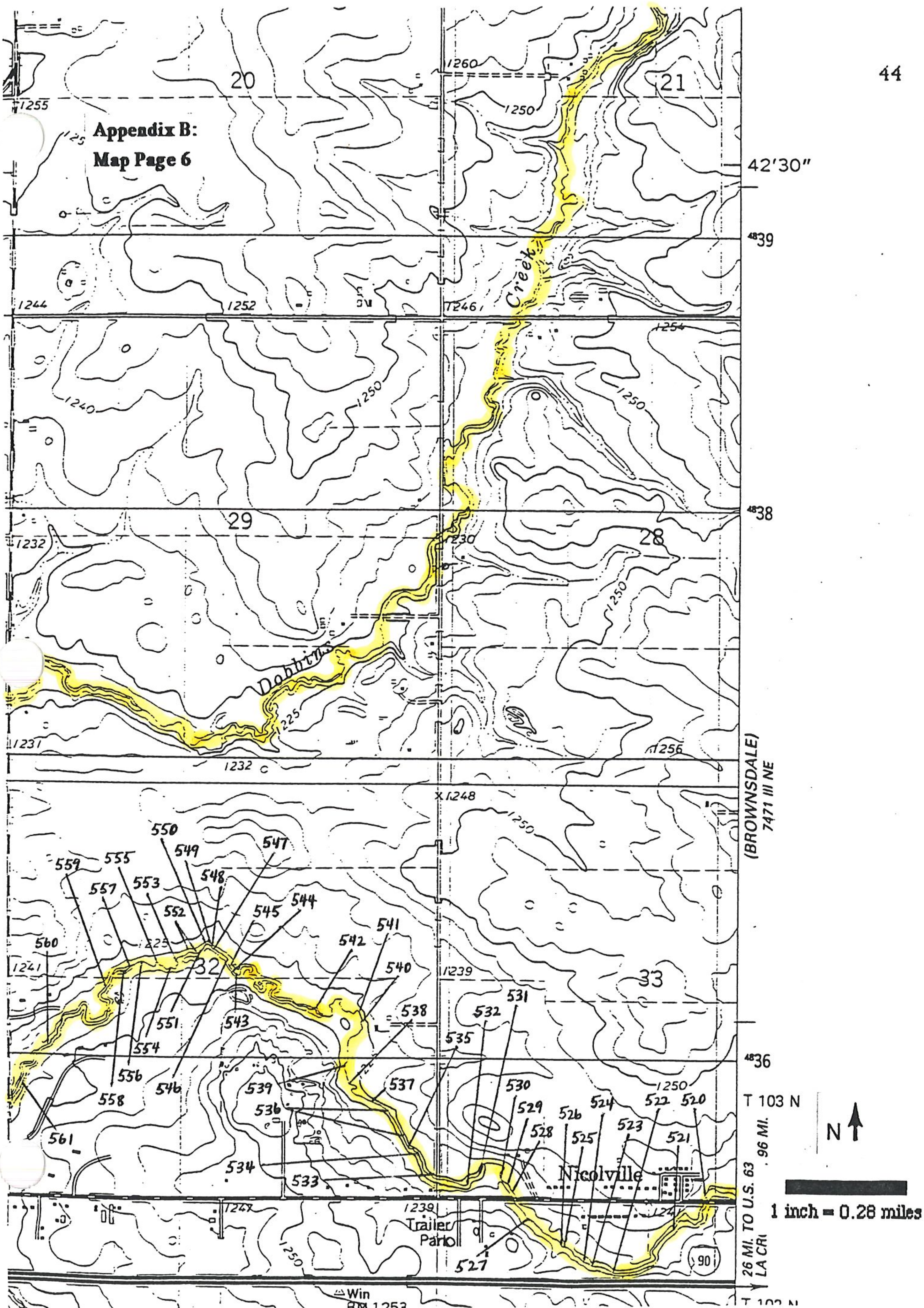
Appendix B:
Map Page 6
20
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42'30"
4839
4838
4836
Dobbins
Creek
Nicolville
Trailer Park
(BROWNSDALE)
7471 III NE
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26 MI. TO U.S. 63
.96 MI.
90
N
1 inch = 0.28 miles
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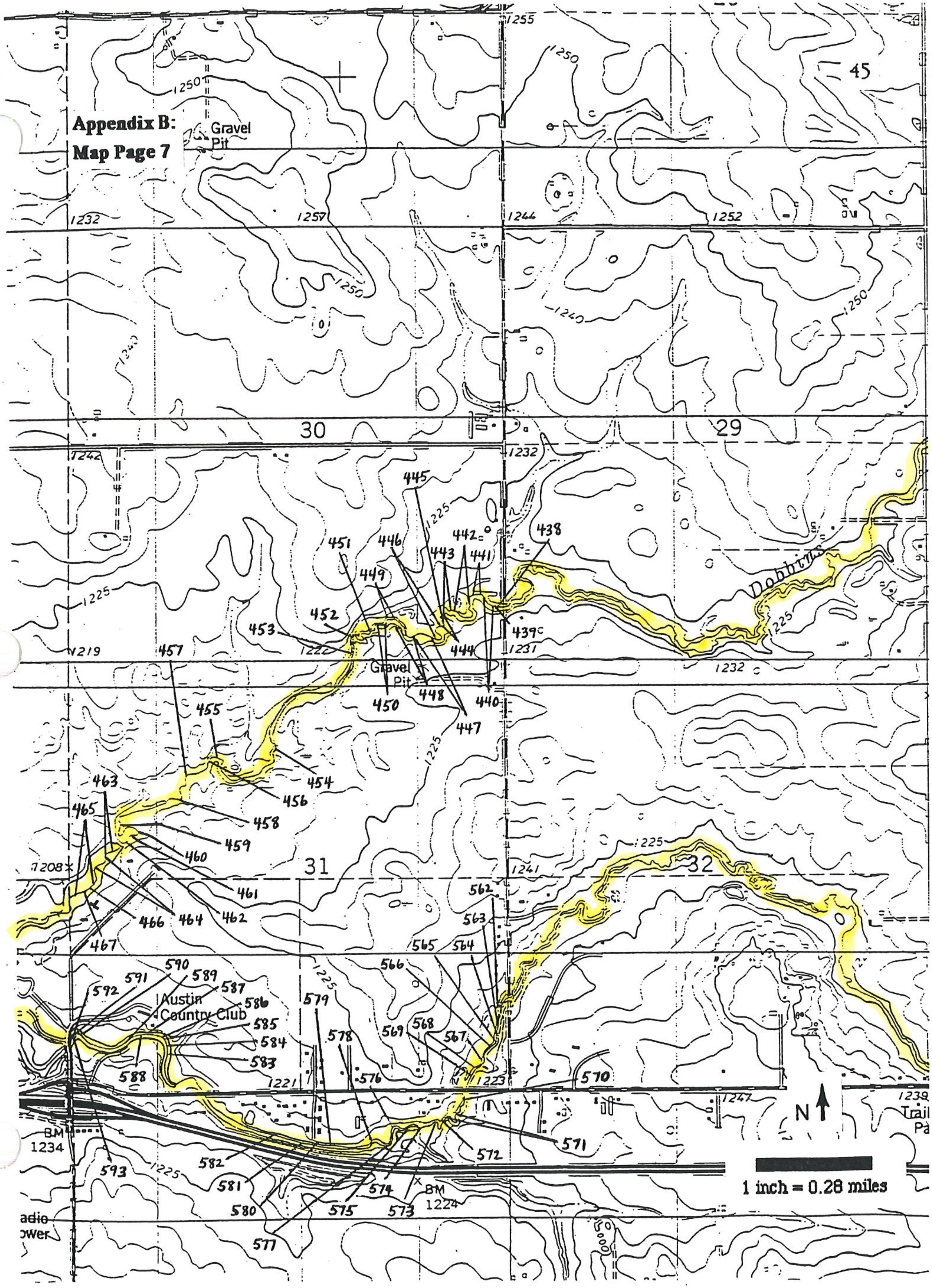
Appendix B: Map Page 7



Appendix B:
Map Page 8