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# *FLOOD PLAIN MANAGEMENT STUDY*



## *LOWER WOOD RIVER*

*Buffalo and Hall Counties, Nebraska*

prepared by:  
United States  
Department of  
Agriculture  
  
Soil  
Conservation  
Service  
Lincoln, Nebraska  
  
Nebraska Natural  
Resources Commission  
Lincoln, Nebraska

for:  
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Natural Resources  
District  
Grand Island, Nebraska

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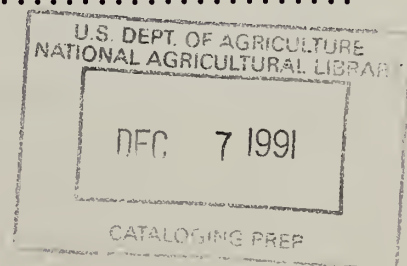
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LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
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FLOOD PLAIN MANAGEMENT STUDY  
LOWER WOOD RIVER  
BUFFALO AND HALL COUNTIES  
NEBRASKA

INTRODUCTION

The floodplains of rivers and streams have been formed by nature to provide for the conveyance of flood flows resulting from large amounts of snowmelt or rainfall. Floods are acts of nature which cannot be wholly prevented by man. Floodplains are as important to the stream system as the actual creek channel.

The long-term solution to reducing flood damage and loss of life is to keep the floodplain free of development which could be damaged or which could obstruct the conveyance of flood waters. Some basic public actions which can be used to keep floodplain areas free of development are:

1. Provide public information to make lending institutions and prospective property buyers aware of the flood hazards.
2. Initiate floodplain regulations to prevent the development of the floodplain in a manner which would be hazardous during floods.
3. Acquisition of flood prone areas for use as parks, open space, wildlife habitat, and other public uses.

Potential users of the floodplain should base their decisions upon the advantages and disadvantages of such a location. Knowledge of flood hazards is not widespread, and consequently the managers, potential users, and occupants cannot always accurately assess the risks. In order for flood plain management to effectively play its role in the planning, development, and use of floodplains, it is necessary to:

1. Develop appropriate technical information and interpretations for use in flood plain management by state and local units of government.
2. Provide technical services to managers of floodplain property for community, industrial, and agricultural uses.
3. Improve basic technical knowledge about flood hazards.

A joint coordination agreement was executed between the Nebraska Natural Resources Commission (NNRC) and the U.S. Department of Agriculture, Soil Conservation Service (SCS) on November 20, 1981 to furnish technical assistance in carrying out flood plain management studies (FPMS). Authority for carrying out this study is provided by Section 6 of Public Law 83-566, Watershed Protection and Flood Prevention Act (Reference 1). This authorizes the SCS to cooperate with other federal, state, and local agencies to make investigations of the watersheds of rivers and other waterways as a basis for coordinated programs. In carrying out this study, the SCS is directed by Executive Order No. 11988, dated May 24, 1977 (Reference 2), which instructs federal agencies to provide leadership to avoid the risk of flood loss,

minimize impacts of floods on people, and to restore and preserve the natural and beneficial values served by floodplains.

To reduce the degree of flooding, resulting in loss of lives and property, the NNRC has been given responsibility for determining the floodway encroachment lines in conjunction with watercourses and drainageways throughout the state. The establishment of regulations to control the development in defined floodways will also be necessary. This responsibility is designated through the 1983 Legislative Bill 35 Flood Plain Management Act (Reference 3). The NNRC is also the coordinator between the state and the National Flood Insurance Program.

Also the 1983 Legislative Bill 35 Flood Plain Management Act (Reference 3) directs the Nebraska Natural Resources Commission to initiate a program for the delineation of all the floodplain areas of the state which drain one square mile or more of area.

The study is conducted in accordance with the April 1983 Plan of Work developed and endorsed by the SCS, NNRC, and Central Platte Natural Resources District (NRD). The technical information in this FPMS was prepared by the SCS. This study shows high water profiles and areas subject to flooding based on analyses of existing stream hydraulics and current watershed and floodplain land use and cover.

Special appreciation is extended to the individuals who contributed information for the study. Appreciation is also extended to the landowners who permitted access to their property for surveys, photographs, and reconnaissance.

## STUDY AREA

The Lower Wood River Watershed contains approximately 196,500 acres (307 sq. mi.). The watershed is located in Buffalo and Hall Counties, Nebraska. The study area is located in United States Geological Survey Hydrologic Unit Number 10200102.

### Streams

The watershed includes Lower Wood River, North Channel Platte River, Boxelder Creek, Buckeye Valley, Dry Creek, and several unnamed tributaries all intermittent streams. The study of the Lower Wood River begins at stream gauge 06771000 located at latitude 40° 47' 56", longitude 99° 11' 48", in NW $\frac{1}{4}$ , NW $\frac{1}{4}$ , Section 31, Township 10 North, Range 16 West, Buffalo County on State Highway 40, 1.5 miles north-west of Riverdale. The study area includes the Lower Wood River from the gauge to its intersection with State Highway 30 in the NE $\frac{1}{4}$ , NW $\frac{1}{4}$ , Section 14, Township 10 North, Range 11 West, 3 $\frac{1}{2}$  miles northeast of the City of Wood River.

The North Channel Platte River is a tributary to the Lower Wood River. It begins in Section 7, Township 8 North, Range 17 West, at the Platte River and flows northeast. The study of the North Channel Platte River terminates in W $\frac{1}{2}$ , Section 26, Township 10 North, Range 11 West, 3 $\frac{1}{2}$  miles east of the City of Wood River.

Boxelder Creek was analyzed with the dam in Section 18, Township 10 North, Range 13 West in place and the outflow from this dam being routed into

Prairie Creek. Boxelder Creek was evaluated from north edge of Section 29, Township 10 North, Range 13 West. From this point it flows southeast to its union with Lower Wood River at the SW $\frac{1}{4}$ , SE $\frac{1}{4}$ , Section 29, Township 10 North, Range 12 West, two miles northeast of the Village of Shelton. Buckeye Valley is a creek that begins in the NE $\frac{1}{4}$ , NW $\frac{1}{4}$ , Section 7, Township 10 North, Range 14 West. Buckeye Valley then heads southeast to its meeting with Lower Wood River in SE $\frac{1}{4}$ , Section 12, Township 9 North, Range 14 West, one-half mile north of the City of Gibbon. Dry Creek has its beginning in NE $\frac{1}{4}$ , NW $\frac{1}{4}$ , Section 35, Township 11 North, Range 16 West, five miles south of the Village of Pleasanton. Dry Creek then flows south to the SE $\frac{1}{4}$ , SE $\frac{1}{4}$ , Section 2, Township 9 North, Range 16 West at which time it swings to the east until it converges with the Lower Wood River in the SE $\frac{1}{4}$ , SW $\frac{1}{4}$ , Section 10, Township 9 North, Range 15 West, two miles northeast of Kearney's Municipal Airport.

TABLE 1  
DETAILED STUDY AREA

Stream	Length in Miles	Drainage Area in Square Miles
Lower Wood River	77	182.4
Dry Creek	35	18.0
Buckeye Valley	11	12.6
Boxelder Creek	40	2.5
North Channel Platte River	20	91.5
TOTAL	183	307.0

## Soils and Topography

The Lower Wood River watershed lies between the South Loup River and the Platte River. The watershed is in the Central Nebraska Loess Hills Major Land Resource Area (MLRA). Bedrock consists of semi-consolidated sands and silts of the Ogallala Formation. Unconsolidated Pleistocene sands and gravels are present in the valleys, overlain throughout much of the watershed by wind deposited loess.

The bottom land consists of moderately well drained to poorly drained soils that range from fine textured to coarse textured. The stream terraces and adjacent foot slopes include a few small areas of undulating to rolling sandy soils but mainly consist of nearly level to gently sloping silty soils. The uplands consists of moderately fine textured to medium textured soils that are somewhat excessively drained or well drained. (References 4,5)

TABLE 2  
Soil Series in Lower Wood River

Soil Series	Acres	Percent
Hord	49,120	25
Hall	23,580	12
Holdrege	21,630	11
Coly	21,610	11
Alluvial Land	9,850	5
Breaks	9,830	5
Cozad	9,820	5
Uly	9,820	5
Wood River	9,800	5
Wann	5,900	3
Hobbs	3,940	2
Leshara	3,930	2
O'Neil	3,930	2
Platte	3,910	2
Alda	2,000	1
Cass	1,970	1
Gibbon	1,960	1
Lamoure	1,960	1
Scott	1,940	1

Hord soils are formed in alluvium and colluvium on foot slopes, in loess and alluvium on stream terraces, and in loess on uplands. They are deep, well drained soils that are nearly level to gently sloping.

Hall soils formed in loess on uplands and a mixture of loess and alluvium on stream terraces. They consist of deep, well drained and moderately well drained soils that are nearly level and very gently sloping.

Holdrege soils are formed in loess on uplands. They consist of deep, well drained soils that are nearly level to strongly sloping.

Coly soils are weakly developed and formed in loess on uplands. This series consists of deep, well drained and somewhat excessively drained soils that are strongly sloping to very steep.

Loamy alluvial land is formed along the Platte River in abandoned river channels and other low areas. It is a shallow land type that consists of less than 10 inches of soil material over mixed sand and gravel.

Breaks consist of short, steep side slopes. The side slopes range from 11 to 30 percent. The surface layer is loam or silt loam 8 to 12 inches thick. Depth to calcium carbonate is variable, but usually greater than 18 inches.

Cozad soils are formed in loess and alluvium on stream terraces and foot slopes. It consists of deep, well drained and moderately well drained soils that are nearly level to steep.

Uly soils are formed in loess on uplands. It consists of deep, well drained and somewhat excessively drained silty soils that are strongly sloping to steep.

Wood River soils are formed in loess and silty alluvium. They are deep, moderately well drained soils that have a claypan and are on stream terraces along the Platte and Wood Rivers.

Wann soils are formed in loamy alluvium. They consist of deep, somewhat poorly drained soils on the bottom lands of the Platte River.

Hobbs soils are formed in alluvium on narrow bottoms and on foot slopes of upland drainageways. It consists of deep, well drained soils that are nearly level to gently sloping.

Leshara soils formed in silty and loamy alluvium. They consist of deep, somewhat poorly drained, nearly level soils on bottom lands bordering the Platte River. A few areas are dissected by abandoned river channels.

O'Neill soils developed in loamy to sandy stream deposited materials. They are excessively drained and have a low water holding capacity.

Platte soils formed in silty to sandy alluvium that is 10 to 20 inches thick over mixed sand and gravel. It consists of somewhat poorly drained nearly level soils on bottom lands of the Platte River.



Alda soils are moderately deep, somewhat poorly drained, nearly level soils on bottom lands in the valley along the Platte River. Some areas are dissected by shallow abandoned channels.

Cass soils are formed in recent sandy alluvium. It consists of somewhat excessively drained, deep and moderately deep bottom land soils that have a sandy subsoil.

Gibbon soils formed in nearly level soils in silty alluvium on bottom lands and low stream terraces along the Platte River. It is deep and somewhat poorly drained.

Lamoure soils developed in stream deposited materials. They consist of deep soils of the bottom land. These soils are well distributed throughout the bottom lands.

Scott soils consist of deep, poorly drained, soils that have a claypan and are in upland depressions. Roots cannot penetrate the subsoil when it is dry.

The measure used to determine the suitability of land for use without permanent damage is by land capability. The SCS classifies land capability into 8 classes:

Class I - Soils have few limitations that restrict their use.

Class II - Soils have moderate limitations that reduce the choice of plants or require easily applied conservation practices.

Class III - Soils have severe limitations that require special conservation measures or reduce the choice of plants.

Class IV - Soils have very severe limitations, require intensive conservation measures and very careful management, if occasionally cultivated.

Class V - Soils have no erosion hazard but have other limitations, impractical to remove, that limit their use.

Class VI - Soils have some limitations that make them generally unsuited for cultivation.

Class VII - Soils have very severe limitations that make them unsuitable for cultivation.

Class VIII - Soils are not suited to agricultural production. They have value for wildlife and recreation.

Land capability classes are further subdivided into subclasses by principal problem:

E - Risks of erosion

W - Water limitation such as wetness, drainage or over flow

S - Soil or root limitations

C - Climatic limitations

The following table shows acreage amounts for each Land Capability Class in the Lower Wood River study area.

Table 3  
Acres in Lower Wood River Study Area by Land Capability Class

Land Capability Class	Acres
1	66,569
2E	18,005
2C	12,529
2S	17,139
2W	18,803
3E	4,714
3S	366
3W	2,395
4E	29,643
4S	1,509
4W	110
6E	13,828
6W	2,920
7E	629
7S	1,975
8S	100
Other *	5,266
Total	196,500

\* Water, Quarry, Cut & Fill, Ect.

Source: USDA-SCS  
NNRC-Natural Resources Data Bank

## Climate

The climate of the watershed is typical of the plains region with wide and often abrupt variations in precipitation and temperature. Chinook winds on the eastern side of the Rocky Mountains bring warm air for occasional sudden rises in temperature during the cold season.

About 80 percent of the annual precipitation occurs from April through September. The origin of most of the precipitation is the Gulf of Mexico and the Caribbean Sea. When these wind currents hold a more easterly direction, drought can develop. The driest year on record was 1952 with 12.8 inches. The wettest year on record occurred in 1915 with 37.3 inches.

Usually slow, steady, and well distributed showers occur in the early spring. Progressing into the summer, more rainfall occurs but the distribution is irregular and erratic. The storms at times are severe and accompanied by local downpours, hail, and damaging wind. Fall and late summer the precipitation becomes lighter and less frequent. Cool nights, mild days, and abundant sunshine are characteristic of the fall weather.

Winter frequently has one or more periods of freezing rain. Generally precipitation is light and nearly all of it falls as snow. Northerly winds commonly accompanies the snow. Average annual snowfall is 28 inches. Ground is covered by snow 45 days during an average winter. Frequently snow melts between subsequent snowfalls.

A temperature of 33 degrees below zero was the lowest record and it occurred February 11, 1899. The highest temperature recorded was 116 degrees on July 11, 1954. Subzero temperatures are a norm during winter months and temperatures exceeding 100 degrees happen nearly every summer.

The last freeze of the year usually occurs by May 6. The average time of the first freeze of the year is October 3.

The normal annual precipitation is 24 inches. The average monthly precipitation in inches by month is:

January	0.6	July	3.2
February	0.8	August	2.7
March	1.3	September	2.4
April	2.4	October	1.5
May	3.7	November	0.9
June	3.8	December	0.7

### Economy

The principal enterprise of the watershed is livestock/grain farming and farm related industries. Two of the farm related industries are the production of hybrid corn for seed and the production of dehydrated alfalfa. The main crops are corn, grain sorghum, soybeans, wheat, and alfalfa. A large part of the forage and grain crops grown in the area is fed to livestock.

The largest municipality in the watershed is the City of Kearney with a population of 21,158 according to the 1980 Census of Population and Housing (Reference 6). Gibbon has a population of 1,531. The City of Wood River follows close with a population of 1,328. Next is the Village of Shelton with a population of 1,046. The smallest community in the watershed is the Village of Riverside with a population of 198.

Most of the study area is intensively farmed as 76% of its acres are in cropland. Of this cropland, 86% is irrigated. The next largest land use is range and pastureland making up 18%. Forestland is a very minor resource, as it includes less than 1% of the total area. Other land, water, roads, farmsteads, etc. make up the remaining land uses.

Table 4  
Land Use Acres By Land Capability Class

Land Capability Class	Cropland		Range & Pastureland	Forest-land	Other	Total
	Dry	Irrigated				
1	20	66,385	160	-	4	66,569
2E	4,123	9,897	2,495	60	1,430	18,005
2C	4,800	-	2,180	288	5,261	12,529
2S	166	16,028	192	14	739	17,139
2W	1,895	13,580	2,860	56	412	18,803
3E	850	2,812	876	8	168	4,714
3S	-	366	-	-	-	366
3W	84	2,129	145	2	35	2,395
4E	6,877	9,263	12,326	6	1,171	29,643
4S	29	1,470	-	-	10	1,509
4W	45	-	63	-	2	110
6E	2,107	-	10,852	176	693	13,828
6W	174	-	2,009	161	576	2,920
7E	48	-	537	-	44	629
7S	135	-	1,542	92	206	1,975
8S	-	-	63	7	30	100
**		5,194	42	-	30	5,266
Total	21,353	127,124	36,342	870	10,811	196,500

\*\* Water, Quarry, Cut & Fill, Ect.

Source: USDA-SCS  
NNRC-Natural Resources Data Bank

In most areas of the Platte River Valley, the severity of erosion is not extensive. Lower Wood River is no exception. Eighty-eight percent of the study area is adequately treated, soil losses do not exceed tolerance levels. Only 12% is in need of conservation treatment where soil losses exceed acceptable tolerance levels. The tolerable soil loss limit (T) is the maximum average annual rate of soil erosion that can occur without affecting crop productivity over a sustained period.

Table 5  
Land Treatment By Land Use

	Total Acres	Adequately Treated T	Not Adequately Treated T - 2T	Not Adequately Treated 2T
Dry Cropland	21,353	11,940	740	8,673
Irr. Cropland	127,124	112,704	2,830	11,590
Range & Pastureland	36,342	36,342	-	-
Forestland	870	858	12	-
Other land	10,811	10,811	-	-
Total	<u>196,500</u>	<u>172,655</u>	<u>3,582</u>	<u>20,263</u>

Source: USDA-SCS  
NNRC-Natural Resources Data Bank

#### Historical and Archaeological

There are no known historical or archaeological sites in the watershed, according to the National Register of Historical Places (Reference 7). There is a possibility that unknown cultural resource sites may be present in the study area. Although no structural plan has been recommended for this watershed, land treatment practices may affect unknown sites.

## NATURAL VALUES

Floodplains, in their natural or relatively undisturbed state, provide numerous beneficial natural resource values. These values include; natural moderation of floods, water quality maintenance and ground water recharge. The physical characteristics of the floodplain regulate or modify flood flows.

The Lower Wood River floodplain generally provides area for the spreading and temporary storing of flood waters. This, in turn, reduces flood peaks and velocities, lessening the potential for erosion in the floodplain.

Floodplains serve important functions in protecting the physical, biological and chemical integrity of water. Vegetation slows the surface runoff, causing it to drop most of its sediment on the floodplain. Pathogens and toxic substances entering the main water body through surface runoff and the accompanying sediments are then decreased. The surface conditions favor local ponding and detention, while subsurface conditions are conducive to infiltration and storage. This slowing of runoff provides additional time for the infiltration and natural purification of water while recharging available ground water aquifers.



TABLE 6

## LAND USE AND CONSERVATION TREATMENT

County/Acres	Nonirrigated Cropland		Irrigated Cropland		Range and Pastureland		Woodland		Other Land		Total Land		
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	
Buffalo/139,330	27,880	6,770	67,020	16,290	11,060	1,950	1,180	210	5,920	1,050	113,060	26,270	
Hall/57,170	2,330	4,140	13,920	24,770	7,780	1,370	490	80	1,950	340	26,470	30,700	
Total:	196,500	30,210	10,910	80,940	41,060	18,840	3,320	1,670	290	7,870	1,390	139,530	56,970

TABLE 7  
FLOODPLAIN AND UPLAND ACRES BY LAND USE

Present Land Use	100 Year Floodplain (Acres)	Upland (Acres)	Total (Acres)
Cropland, Non-Irrigated	3,960	17,393	21,353
Cropland, Irrigated	15,860	111,264	127,124
Pasture Land and Rangeland	2,600	33,742	36,342
Other Land	<u>1,180</u>	<u>10,501</u>	<u>11,681</u>
Totals	23,600	172,900	196,500

Source: NRD and Field Office records

Date: 5/86

Prime Farmland

Prime farmland is that land best suited for producing food, feed, forage, and oil seed crops. It has the soil quality, growing season, and moisture supply needed to produce sustained high yields economically when treated and managed, according to modern farm methods.

Within the study area as much as 66% of the area could possibly be considered prime farmland. Characteristically, prime farmlands are those soils not flooded frequently during the growing season. Average frequency of flooding is considered to be less often than once in two years. Those soils not considered prime are predominantly included in the Uly-Coly soil association and located primarily on the uplands adjacent to the floodplain.

## Rangeland

This watershed in its natural state was mixed prairie. The mixed prairie is comprised largely of mid and short grass plant species. Together, they form a plant community, which could survive drought and grazing pressure over several years, and still provide adequate amounts of forage for livestock and wildlife. Examples of mixed prairie grasses include: little bluestem, sideoats grama, wheatgrasses, needlegrasses, wildryes, dropseeds, buffalograss and blue grama. Presently rangeland has taken on lesser importance as the predominate land use is now cropland. Eighteen percent or 36,342 acres of the watershed are rangeland and pastureland. The pastures that remain are generally small and usually overgrazed, resulting in a conversion to a weedy, Kentucky bluegrass-dominant pasture composition.

## Forestry

The watershed contains only 870 acres (.4%) of woodland. Wooded areas occur mainly on the bottomlands and along stream channels. Hackberry-Ash-Cottonwood stands are the predominant tree species. Eastern red cedar is scattered in wooded areas, pastures, and along fence rows and windbreaks.

## Wildlife

The abundance and variety of both game and non-game wildlife reflect the diverse natural resources that exist within the study area. Three distinct habitat types exist in Lower Wood River; grasslands, confined mainly to the upland area; croplands, located within and adjacent to the floodplain; woodlands, limited to the channel areas of Lower Wood River and various tributaries.

Generally, in the cropland areas, spring tillage is used allowing crop residues to be present over winter. These residues provide food and cover for wildlife but are generally not effective for winter protection. Only 18% of the watershed is rangeland and pastureland, which provides the nesting cover for ground nesting birds and cottontail rabbits. Woody vegetation provides the most effective winter protection but only occupies less than 1% of the watershed and is found along creek bottoms, drainageways, and farmstead windbreaks. Consequently, winter cover is scarce and is generally not available near cropped fields. This lack of cover is a primary factor, limiting production of wildlife in this watershed.

Population densities for the predominant wildlife species are shown in the following:

Pheasant - low to moderate - 10-200 per section

Deer - low to scarce - less than 1-3 per section

Cottontail rabbit - low - 10-100 per section

Bobwhite quail\* - scarce to low - less than 10-100 per section

Mourning dove - high density - numbers not available

\* moderate populations 100/300 exist in Wood River channel

Lower Wood River, with its proximity to significant river systems, rainwater basins and impoundments, lies within the most important migration corridor of the central fly way. Numerous migratory ducks, geese, swans, and shore birds pass through the area.

No significant wetlands exist within this watershed.

## Threatened and Endangered Species

No known threatened or endangered species of wildlife is a permanent resident of this area. However, the following list identifies those species whose range may possibly include Lower Wood River:

### Endangered Species

<u>Birds</u>	Artic peregrine falcon Whooping crane Eskimo curlew	<u>Falco peregrinus tundrius</u> <u>Grus americana</u> <u>Numenius borealis</u>
<u>Mammals</u>	Black-footed ferret Swift fox	<u>Mustela nigripes</u> <u>Vulpes velox</u>

### Threatened Species

<u>Birds</u>	Interior least tern Mountain plover	<u>Sterna albifrons athalassos</u> <u>Charadrius montanus</u>
<u>Mammals</u>	Southern flying squirrel	<u>Glaucomys volans</u>

## Water Quality

The Nebraska Department of Environmental Control (NDEC) has classified the surface water in Lower Wood River Watershed as Warmwater Aquatic Life Class B and Agricultural Class A. Warmwater Aquatic Life Class B are waters where the potential variety of life forms is presently limited by degraded water quality (natural or irretrievable human-induced conditions) or habitat conditions. These waters will support fish population consisting of nonsensitive forage species. Agricultural Class A are waters used for general agricultural purposes without treatment.

As is the case throughout the Central Platte Valley, adverse groundwater quality is a potential concern. The NDEC groups groundwater quality problems into four groups: nitrate-nitrogen, synthetic organic compounds, hydrocarbons, and other contaminants. Primarily, non-point agricultural sources of pollution including excessive nitrates and agriculture chemicals are the major threats for this area. Nitrate concentrations in groundwater have steadily risen in certain areas and pesticides are being detected with increasing frequency.

Wood River and Gibbon both have public water supplies with greater than 10 milligrams per liter nitrate-nitrogen. The towns are under Health Department Order and must provide bottled water for infants and monitor wells monthly.

## PROBLEMS AND OPPORTUNITIES

### Flooding

Records of floods on the Lower Wood River date back to 1899. There are no complete records of floods on the Lower Wood River between 1949 and 1967. The reasons for apparent freedom from severe floods during that span is not entirely clear. It is known that drought conditions existed in the watershed during the decade of the 1950's. Records of average annual rainfall in the Lower Wood River watershed verify that the amount of moisture received during the 1950's was less than during the previous decade.

In June, 1968, 12 inches of rain fell in a five hour period. Several smaller rains fell later which compounded the flooding. Damage occurred to the agricultural lands along the Wood River and its tributaries in Buffalo County and in the town of Shelton, Nebraska.

A 1967 flood occurred in the watershed as a result of a two week period of rains which created wet conditions and then a rain of approximately five inches during a six hour period fell. The peak discharge at the Riverdale stream gauge was 5,280 CFS. Many miles of fences were lost, bridge and road damage was heavy and the crop loss was high. Severe flooding and extremely high losses occurred in several of the towns and cities.

On June 1949, a flood of 1,200 cubic feet per second was recorded at the Riverdale stream gauge. The gauge height was recorded at 10.97 feet which was almost nine feet less than the flood stage reached in June of 1947. Overbank flooding occurred generally from Gibbon, Nebraska, downstream to the mouth of Lower Wood River. The period of overbank flooding lasted about 20 hours.

The flood of June 1947 produced flood stages higher than any flood in the memory of the oldest residents, and caused the most extensive flooding and greatest damage to highway facilities. Virtually the entire length of the stream experienced overbank flooding, during this flood. The width of overbank flooding exceeded one fourth mile in some reaches, with flood widths increasing to widths exceeding one mile in the lower reaches and up to two miles at Shelton, Nebraska. A peak discharge of 20,000 cubic feet per second was recorded at stream gauge 06771000, located at Riverdale, Nebraska. This discharge exceeds the discharge that would have a one percent recurrence interval.

Communities located along Lower Wood River are Riverdale, Gibbon, Shelton, and Wood River. Negligible flooding is experienced in Gibbon and Wood River. Shelton experiences the most flooding of all the communities.

Land use in the one percent recurrence interval floodplain consists of 19,820 acres of cropland, 2,600 acres of pastureland, 20 acres of urban land, and 1,160 acres of other land. Current cropland use in the floodplain is 14,070 acres of corn, 990 acres of sorghum, 2,080 acres of alfalfa, 1,290 acres of soybeans, and 1,390 acres of wheat. Crop and pasture damages are estimated to average \$123,530 annually. Crop and pasture damages occur beginning with the 100 percent recurrence event. (Table 8)



TABLE 8 1/

## Average Annual Cropland and Pastureland Flood Damages

Evaluation: Reach 2/	100 Year:	Value of Crop		Damage			
	Flood Plain (AC)	and Pasture Production	Flood Free 3/	Flooded 4/	Average Annual Total 5/	Per Acre 6/	Percent of Flood Free 7/
	A	B	C	D	E	F	
1	6,790	1,291,190	1,245,790	45,330	7	4	
2	11,530	1,939,740	1,886,870	52,870	5	3	
3	4,380	786,600	771,170	15,430	4	2	
4	900	152,790	142,890	9,900	11	6	
Total	23,600	4,170,250	4,046,720	123,530	5	3	

1/ Price Base - 1987

2/ Evaluation reaches are shown on the Evaluation Reach Map, (Figure 1).

3/ Composite acre value X acres in floodplain (yield X price X % in floodplain X acres in floodplain)

4/ Col. B minus Col. D

5/ Crop and pasture damages occurring in the flood plain as determined by ECON-2.

6/ Col. D divided by Col. A

7/ Col. D divided by Col. B

Other agricultural properties located in the one percent floodplain include 54 farmsteads, an estimated 4 miles of private roads and 103 miles of fences. Total average annual damage to other agricultural property is \$12,400. (Table 9)

Nonagricultural property subject to damage consists of 4 miles of federal and state roads and 43 miles of county and township roads. There are 38 road crossings subject to damage. In addition, there are 1.2 miles of railroads in the floodplain. Damages to both roads and railroads include the replacement of surface materials and the cost of sediment and debris cleanout. Damages are estimated to be \$18,500 annually. (Table 9)

The total average annual damages for present floodwater problems are estimated to be \$154,400, as shown in the following table:

TABLE 9  
ESTIMATED AVERAGE ANNUAL FLOOD DAMAGES  
(Without Project)

Damages	⋮	Dollars <u>1/</u>
Crop and Pasture	⋮	123,500
Other Agricultural	⋮	12,400
Roads, Bridges & Utilities	⋮	<u>18,500</u>
Total		154,400

1/Price Base 1987

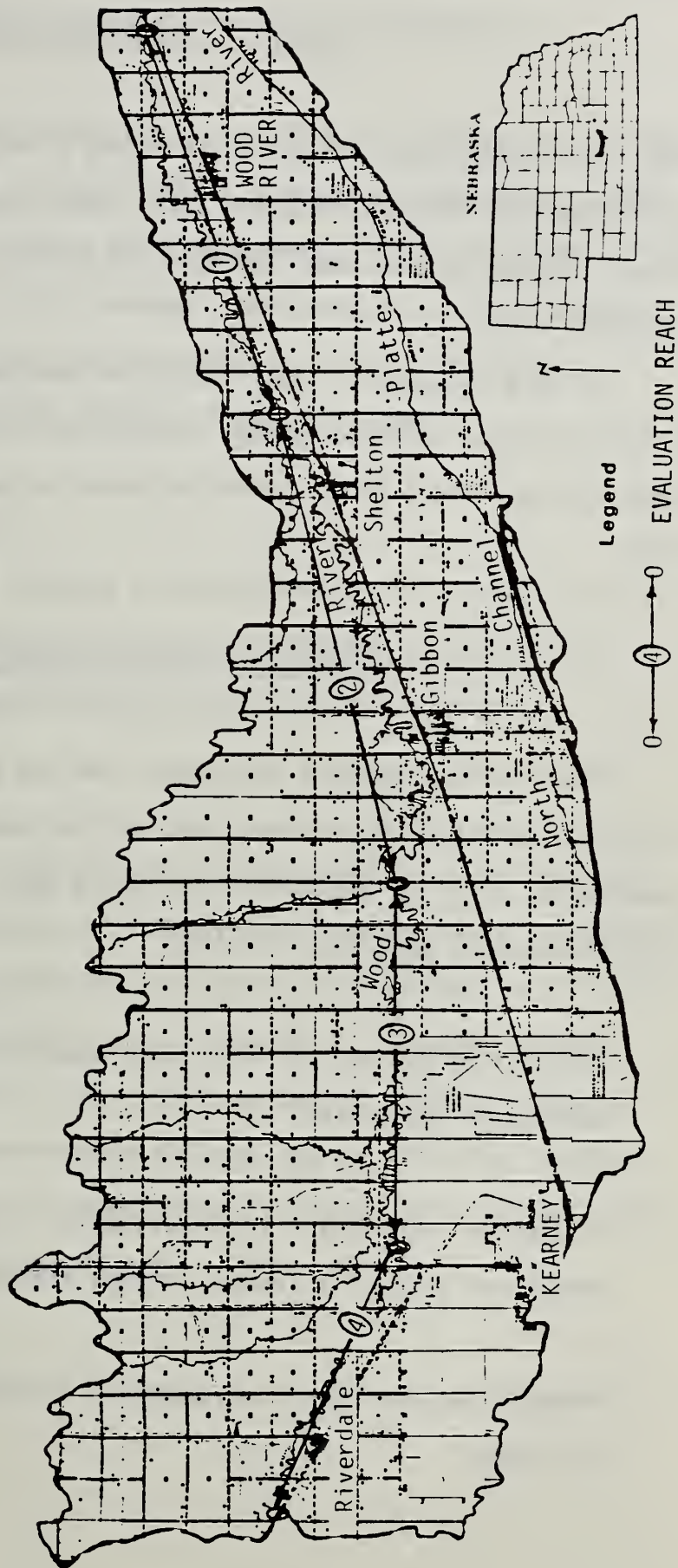
Erosion and Sediment

Erosion in channel sources such as gullies and streambanks is minimal. Although some gullies are present in upland slope positions, they are not significant contributors of sediment.

Present sheet and rill erosion for the watershed on untreated cropland can exceed 20 tons per acre on some Class VI land.

The major stream channels have a large flow capacity, which in turn means that overbank deposition of sediment and scour is not a major floodplain problem. The overall rate of degradation in channel bottoms is low, and the channel banks are generally stable and well vegetated.

Figure 1  
**EVALUATION REACH MAP**  
**LOWER WOOD RIVER**  
**WATERSHED**  
 Buffalo and Hall Counties  
 Nebraska



## EXISTING FLOOD PLAIN MANAGEMENT

The City of Wood River, Nebraska (Reference 8) entered the regular National Flood Insurance Program, December 1978. Hall County (Reference 9) entered the regular program August 1980, and the City of Gibbon (Reference 10) entered September 1985.

The data included in this flood plain management study is comparable to a detailed flood insurance study. Except the floodplain delineation of the North Channel Platte River, which was based on the historical flood of May 1973.

## ALTERNATIVES FOR FLOOD PLAIN MANAGEMENT

Flood plain management encourages land use and development which minimizes potential flood damage and, at the same time permits floodplain development which is compatible with nature and the local area needs. Flood plain management objectives include:

1. Restricting building or other development which may cause increased flood heights or velocities.
2. Protecting individuals from investments located in flood hazard areas which are subject to frequent damage and flooding.
3. Prohibiting uses which are dangerous to public health or safety in times of flood.

4. Requiring that public or private facilities that are vulnerable to floods be protected against flood damage at the time of construction.

The achievement of these objectives is possible by implementing a flood plain management program. A program ordinarily requires community or group action for implementation. A flood plain management program or system can be composed of a combination of land treatment, nonstructural, and structural measures. Figure 2, illustrates the relationship of these measures.

A discussion of these measures or courses of action follows:

#### Present Condition (No Action)

Existing problems would continue or become worse. The property owners presently subject to flooding could relocate or continue accepting flood damage. Limited flood insurance coverage would remain available.

#### Land Treatment

Land treatment provides opportunities to reduce upland runoff and soil erosion. The traditional approach of conservation land treatment, by working with landowners to install conservation practices, will minimize soil erosion and reduce flooding. Installation of such measures as terraces, grassed waterways or underground outlets, diversions, permanent vegetative cover, improved range management, conservation tillage, and on site water storage will reduce runoff, erosion, and sedimentation. However, this approach will have minimal effects on the larger floods.

## Preservation and/or Restoration of Natural Values

Since the primary value of the Lower Wood River floodplain is its ability to transport floodwaters, encroachment onto the floodplain with obstacles which interfere with the movement of floodwater should be avoided to preserve its present carrying capacity. Less than one percent of the floodplain is in urban areas. In these areas, floodplain parks could serve as nature study centers and laboratories for outdoor learning experiences, as well as baseball fields and other traditional park facilities. These parks would insure an open floodplain which would not interfere with floodwater movement.

The floodplain is biologically important because it is the place where land and water meet, and the elements of both terrestrial and aquatic ecosystems mix. Shading of the stream by floodplain vegetation moderates water temperature; roots and fallen trees provide instream habitat; and near stream vegetation filters runoff, removing harmful sediments and buffering pollutants to further enhance instream environments.

Preserve open space areas, especially in the undeveloped areas. Their preservation, in accordance with soil limitation and good land use management, will reduce development hazards, and prevent additional future flood damages.

Soils with high water tables should be retained in natural vegetation. The Soil Conservation Service has completed soil surveys for Buffalo and Hall Counties (References 4 & 5). Copies of the material, including maps and interpretations, are available for reference in the local Soil Conservation Service District Office. This information can be used to determine the kind of soils in a given area and their limitations for various uses.

## Nonstructural Measures

Nonstructural measures such as land use and control regulations (zoning), building codes, flood insurance, post flood recovery are primarily administrative actions. These actions may be needed to reduce the impact of flooding, especially in areas which may be subjected to future development pressures.

Nonstructural measures to reduce the susceptibility to flooding include 1) relocation of existing floodplain properties, 2) flood warning system, and 3) flood proofing.

Zoning is a legal method used to implement and enforce the details of the flood plain management program, to preserve property values, and to achieve the most appropriate and beneficial use of available land. Clear, concise, and thorough zoning bylaws with enforcement of the bylaws are essential to making zoning effective.

Building codes are developed to set up minimum standards for controlling the design, construction, and quality of materials used in buildings and structures within a given area to provide safety for life, health, property and public welfare. Building codes can be used to minimize structural and subsequent damages resulting from inundation.

Flood insurance was established by the National Flood Insurance Act of 1968 (Public Law 90-448, as amended) (Reference 11) to make limited amounts of flood insurance, which were previously unavailable from private insurers,

available to property owners and occupiers. The Flood Disaster Protection Act of 1973, Public Law 93-234, as amended, (Reference 12) was a major expansion of the National Flood Insurance Program.

Flood insurance is available through local insurance agents and brokers only after a local governing body applies and is declared eligible for the program by the Federal Insurance and Hazard Mitigation Division of the Federal Emergency Management Agency (FEMA). Adoption and enforcement of a local flood prevention ordinance which meets FEMA minimum flood plain management criteria is necessary to qualify and maintain eligibility.

In those communities participating in the FEMA program, owners and occupiers of all buildings and mobile homes in the entire community are eligible to obtain flood insurance coverage. Where flood insurance is available, it is recommended that buildings and mobile homes within or adjacent to the delineated flood hazard areas carry flood insurance on the structure and contents.

Development policies which are designed to prevent construction of streets and utility systems in flood prone areas, limits development of the floodplains.

Emergency preparedness consists of a plan by local officials to be put into effect in the event of flooding. Procedures are worked out and personnel designated to implement the plan. The emergency preparedness plan will describe methods and procedures to alert and warn the populous of possible flooding are developed. High risk areas, handicapped, elderly or others known to need help during evacuation are located and identified. Plans are made for their evacuation or rescue. Shelters are provided for evacuees.



Relocation of existing floodplain properties is intended to reposition residential, commercial, industrial, and farm buildings on flood free land. Land that is evacuated for relocation should have a restriction in the deed or other recorded restrictions to prohibit rebuilding on that land. Such lands could be used for parks or other purposes that would not be subject to large flood damages and would not interfere with flood flows.

Flood Warning Systems used to notify floodplain occupants of potential flooding in time to protect property from damage, to evacuate the area, or both. These warnings can be initiated by: 1) The National Weather Services issue frequent warnings of potential flood producing storms. 2) Staff gauges set at key locations and monitored to give advance warnings. 3) A float-activated electronic signal connected to the local police or fire station for monitoring. An effective forecasting and warning system to be effective must be supported by an emergency action plan.

Flood Proofing consists of work on individual buildings such as blocking of low level entrances and windows, installing one way valves in drains, strengthening walls and foundations, installing protective walls, and elevating the building or contents above the base flood (1% recurrence interval) elevation to minimize flood losses.

#### Structural Measures

Structural measures are installed and maintained to reduce flood water, sediment, and erosion damages. Structural measures may include, but are not limited to 1) floodwater retarding dams, 2) dikes, 3) diversions, 4) floodways, and 5) channel work. All of these measures were considered for Lower Wood River.

## Combinations of Alternatives

Some future flood plain management programs which appear applicable for Lower Wood River Watershed, Nebraska follows:

### Alternative 1 - No Action

Components: This alternative would consist of continuing the existing limited flood insurance coverage.

Effects: Existing problems would continue to become worse. Property owners presently subject to flooding could relocate or continue to accept flood damages.

### Alternative 2 - Land Treatment and Nonstructural Measures

Components: This alternative consists of land treatment measures, floodplain zoning, building codes, a flood warning system, and an emergency action plan.

Effects: Land treatment would reduce erosion and sediment from upland areas. Adoption of floodplain regulations would permit Shelton to be included in the regular flood insurance program. The economic impact of flooding would be reduced.

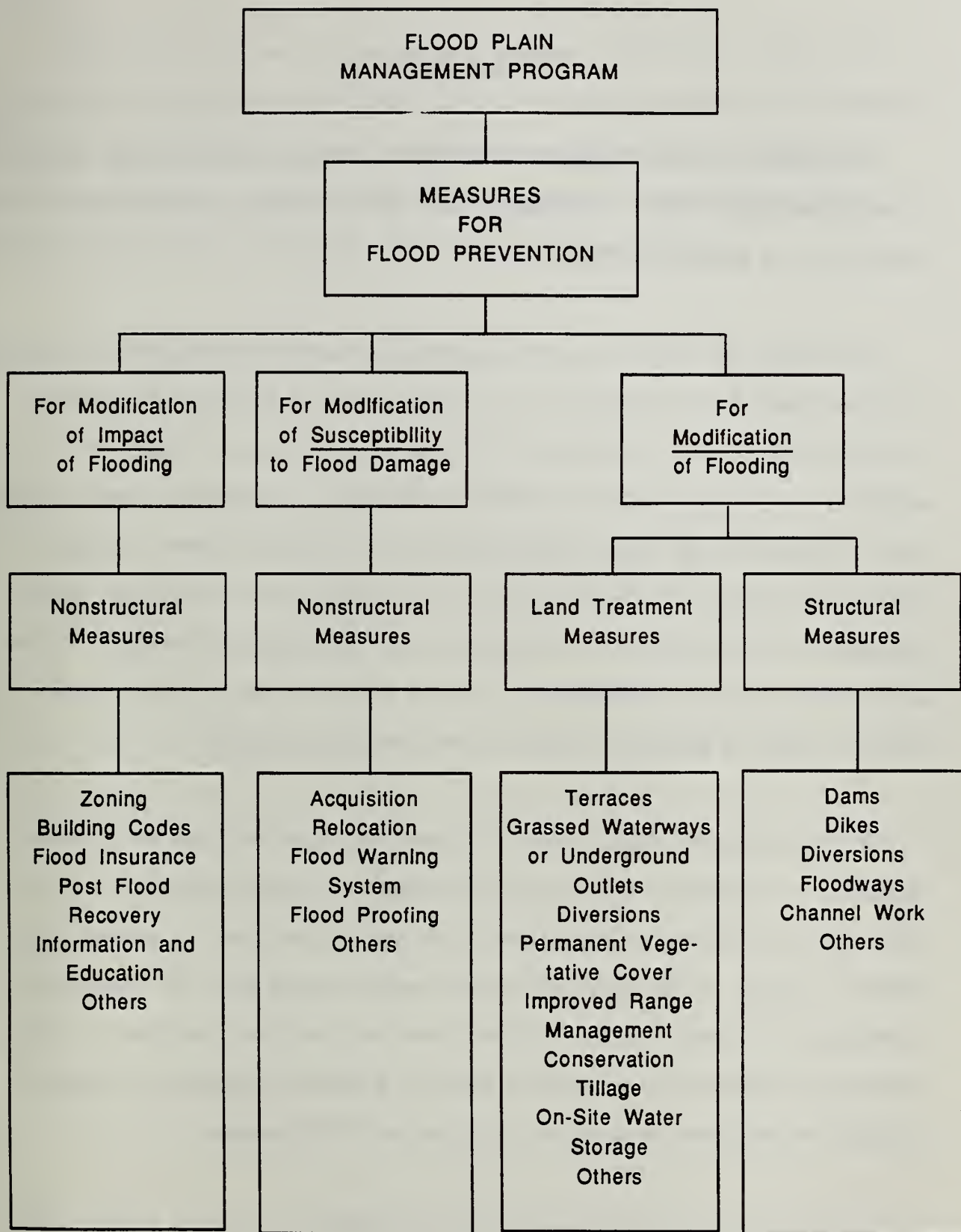


Figure 2

## FLOOD HAZARD MAPS

The Sheet Index Map (Appendix A) shows the stream reach covered by each of the Flood Hazard Maps. The Sheet Index Map also shows the watershed boundaries and stream reaches studied.

The limits of the 0.2% and 1% recurrence interval floods were delineated on Flood Hazard Maps (Appendix A) to indicate the extent of area inundated. The flood lines shown are based on field surveys of roads, bridges, valley sections, and interpretation of aerial photographs. These maps should only be used to determine the approximate boundaries of the flood areas. Actual dimensions measured on the ground may vary slightly from those shown on the photomaps of this report due to map scale and reproduction limitations. The water surface profiles (Appendix B) for the 0.2%, 1%, 2%, and 10% floods should be used to determine actual on the ground dimensions.

To determine expected flood levels at a specific location, use Sheet Index (Appendix A). Refer to the appropriate Flood Hazard Maps (Appendix A) to determine the location of the nearest surveyed section and the general area affected. Refer to the adjacent plotted water surface profiles (Appendix B) to determine the mean sea level flood elevations for that location. Profile elevations (Appendix C) may also be used to determine the extent or depth of flooding in any given area by use of detailed field surveys.

In cases where the 0.2% and 1% flood boundaries are close together only the 1% boundary has been shown.

Flood elevations in this report are minimum elevations. Debris may collect at bridges and culverts and clog the channels during major floods and increase the depth of flooding. Analyses were made without showing the effects of potential obstructions. Also, extremely rare events such as catastrophic storms, beyond the 0.2% storm, were not analyzed.



## GLOSSARY

Backwater -- The resulting highwater surface upstream from a dam, bridge or other obstruction in a floodplain.

Basin -- An area which has its runoff collect at a common point.

Channel -- A natural stream that conveys water; a ditch or trench excavated for the flow of water.

Channel Bottom -- The elevation of the deepest part of a stream channel, the thalweg, at a particular cross section.

Confluence -- A flowing together or place of junction of two or more streams.

Cross section or valley section -- A graph showing the shape of the streambed, banks and adjacent land on either side made by plotting elevations at measured distances along a line perpendicular to the flow of the stream.

Datum -- An assumed reference plan from which elevations and depths are measured such as from sea level.

Elevation-Discharge Relationship -- The relationship between water surface elevation and rate of flow at a specified location for a range of flow rates.

Encroachment -- Obstruction in part of a floodplain which reduces floodwater carrying capacity, therefore increasing flood stages.

Flood -- An overflow of water on to land not normally covered by water. This inundation of land is temporary, and the land is normally adjacent to a river or stream, lake, or other body of water. Normally, a "flood" is considered as any temporary rise in stream flow or stage that causes a significant adverse effect. Adverse effects would be damage to property, sewer backup, creation of unsanitary conditions, sedimentation, accumulation of debris, or other problems.

Flood Peak -- The maximum instantaneous discharge of flow in cubic feet per second passing a given location. It usually occurs at or near the time of the flood crest.

Floodplain -- The relatively flat area or low lands covered by flood waters originating with the adjoining channel of a water course such as a river or stream.

Flood Routing -- The process of determining progressively the timing and shape of a flood wave at successive points along a stream. This procedure is used to derive a downstream hydrograph from an upstream hydrograph. Local inflow and tributary hydrographs are considered.

Floodway -- The portion of the floodplain including the channel of the stream that is required for the conveyance of flood flow. The limits of the floodway are those limits where the extent of permitted encroachment would not raise the level of the 1% recurring flood more than one foot.

Floodway Fringe -- The area of the 1% recurring floodplain lying outside of the floodway.



Head Loss -- The effect of obstructions, such as narrow bridge openings, dams or buildings that limit the area through which water must flow, raising the water surface upstream from the obstruction.

Headwater -- The tributaries and upper reaches which are the sources of the stream.

High Water Mark (HWM) -- The maximum observed and recorded height or elevation that floodwater reaches during a storm, usually associated with the flood peak. The high water mark may be referenced to a particular building, bridge, or other landmark, or based on debris deposits on bridges, fences, or other evidence of the flood.

Hydraulics -- The science of the laws governing the motion of water and their practical applications.

Hydrograph -- A graph denoting the discharge or stage of flow over a period of time.

Hydrology -- The science dealing with the occurrence and movement of water upon and beneath the land areas of the earth.

Inundation -- The flooding or overflow of an area with water.

Left Bank -- The bank of the left side of a river, stream or water course, when oriented downstream.

Low Bank -- The highest elevation of a specific channel cross section at which the water will be contained without overflowing onto adjacent floodplain areas.

Low Ground -- The highest elevation at a specific stream channel cross section at which the flow in the stream can be contained in the channel without overflowing into adjacent overbank areas.

Manning's "n" -- A coefficient of channel and overbank roughness used in Manning's open channel flow formula, commonly called a retardance factor.

Reach Length -- A longitudinal length of stream channel selected for use in hydraulic or other computations.

Recurrence Interval -- The average interval of time within which the given flood will be equaled or exceeded once. A flood having a recurrence interval of 10 years is one that has a 10 percent chance of recurring in any year. Likewise, a 50 year flood has a 2 percent chance, and a 100 year flood has a 1 percent chance, of recurring in any year.

Right Bank -- The bank on the right side of the river, stream or water course, when oriented downstream.

Runoff -- That portion of the precipitation on a drainage area that is discharged from the area in stream channels; types include surface runoff, groundwater runoff, or seepage.

Surcharge -- Increase in depth of floodwaters in floodway.

Time of Concentration -- Time required for water to flow from the most remote point of a watershed to the outlet or other point of reference.

Water Surface Profile -- A graph showing the relationship of water surface elevation to stream channel location for a specific flood event.

Watershed -- A drainage basin or area which collects runoff and transmits it usually by means of streams and tributaries to the outlet of the basin.

Watershed Boundary - The divide separating one drainage basin from another.

0.2 Percent Chance of Flood -- A flood that has a 0.2% probability of occurring in any given year. This storm is classified as an extreme event, but it is not impossible. It is often referred to as the 500 year flood. It has an average frequency of occurrence in the order of once in 500 years, although the flood may occur in any given year or even in successive years.

1 Percent Chance Flood -- This event is often referred to as the 100 year flood. Contrary to popular belief, the 100 year flood is not defined as "a flood occurring once every 100 years". The 100 year flood is properly defined as, "a flood having a 1% probability of occurring in any given year". Thus, it is more properly referred to as a "1% frequency flood", although the term "100 year flood", is more popular. Statistically the 1% flood has an average frequency of occurrence in the order of once in 100 years, although the flood may occur in any given year or even in successive years. The 1% flood magnitude is based on statistical analysis of stream flow records available for the watershed and analysis of rainfall and runoff characteristics in a general region of the watershed. For these reasons, the magnitude of the 1% flood is different for each different watershed and even different areas of the same watershed.

2 Percent Chance Flood -- This event is often referred to as the 50 year flood. A flood that has a 2% probability of occurring in any given year. It is more properly referred to as a "2% frequency flood", although the term "50 year flood" is more popular. Statistically the 2% flood has an average frequency of occurrence in the order of once in 50 years, although the flood may occur in any given year or even in successive years.

10 Percent Chance Flood -- This event is often referred to as the 10 year flood. This flood has a 10% probability of occurring in any given year. It is more properly referred to as a "10% frequency flood", although the term "10 year flood" is more popular. Statistically the 10% flood has an average frequency of occurrence in the order of once in 10 years, although the flood may occur in any given year or even in successive years.

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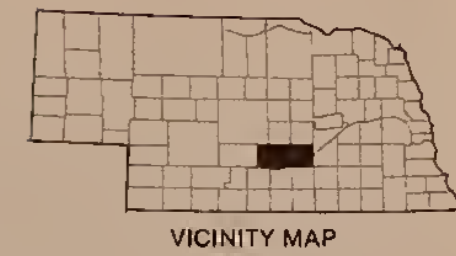
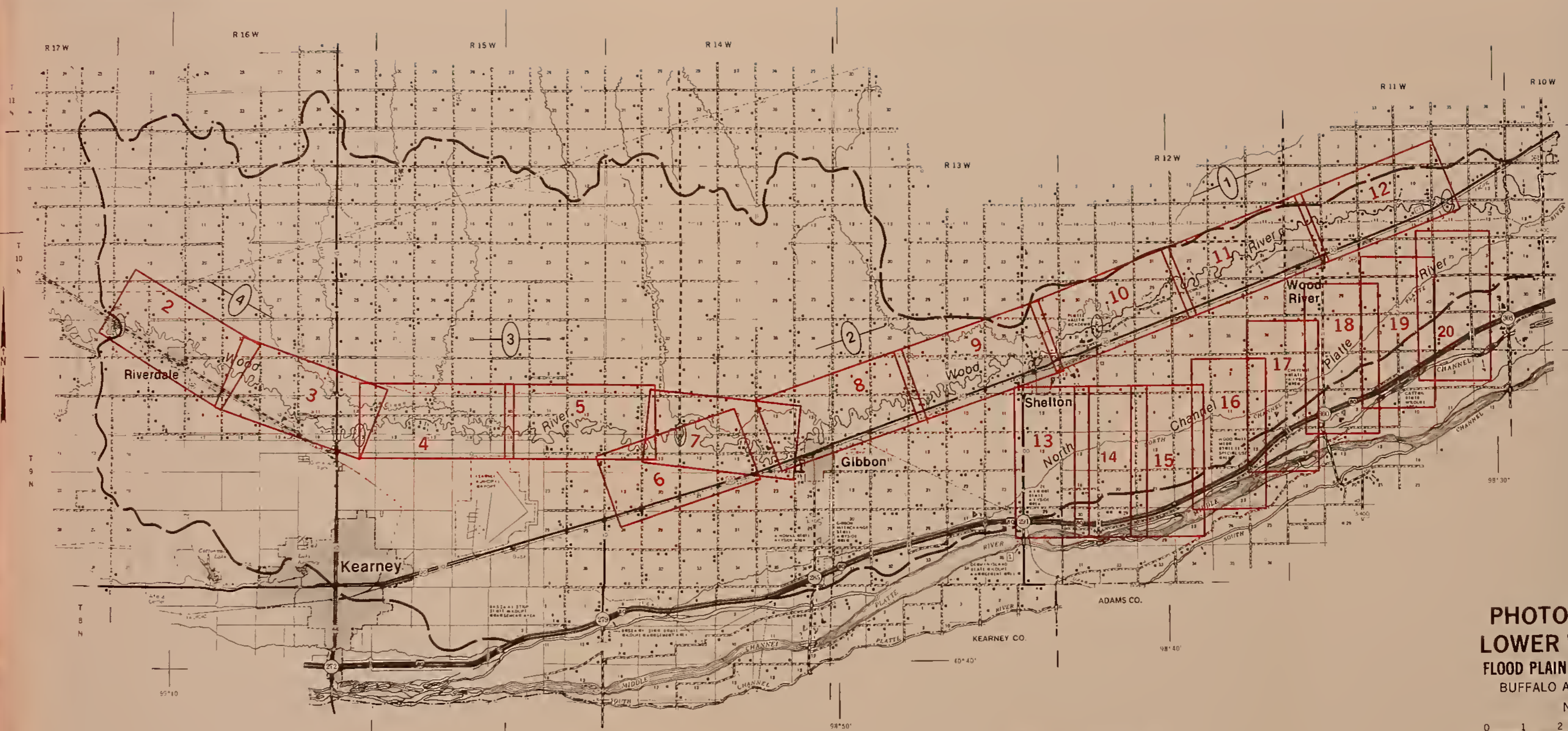




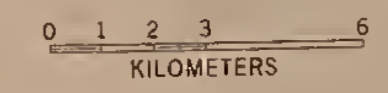
# **APPENDIX A**

## **FLOOD HAZARD MAPS**





**PHOTO MAP INDEX**  
**LOWER WOOD RIVER**  
**FLOOD PLAIN MANAGEMENT STUDY**  
 BUFFALO AND HALL COUNTIES  
 NEBRASKA



**20** Sheet Location

**4** Evaluation Reach

**SHEET**  
**1 OF 20**

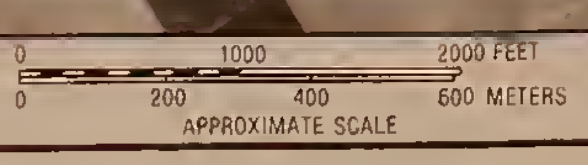
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NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.

Nebraska Natural Resources  
Commission-1985 Photography



**LEGEND**

- 100 Year Flood Hazard Area
- 500 Year Flood Hazard Area
- ~2175~ 100 Year Flood Elevation
- ⊗(4)⊗ Evaluation Reach
- ⬮(140) Cross Section
- Limit of Study

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SOIL CONSERVATION SERVICE

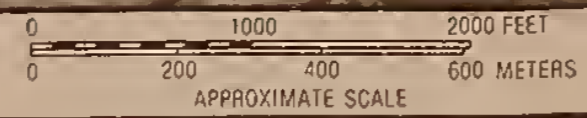
**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**





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Nebraska Natural Resources  
Commission-1985 Photography



**LEGEND**

- 100 Year Flood Hazard Area
- - - 500 Year Flood Hazard Area
- ⊗ 4 ⊗ Evaluation Reach
- ⊗ 140 ⊗ Cross Section
- Limit of Study

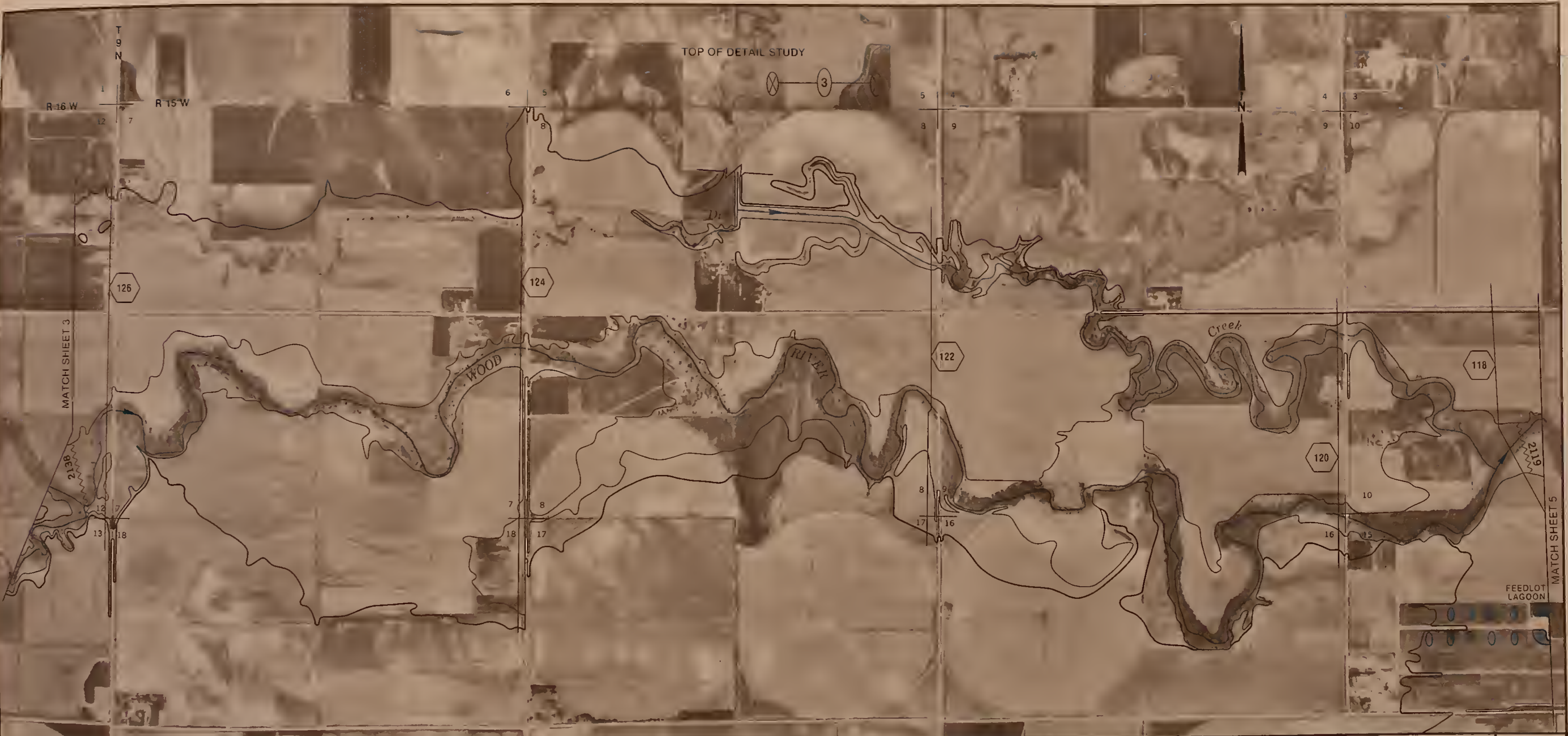
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**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

**SHEET  
3 OF 20**







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**LEGEND**

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- 500 Year Flood Hazard Area
- ⊗ ④ ⊗ Evaluation Reach
- ⊡ ① ⊡ Cross Section
- Limit of Study

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**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

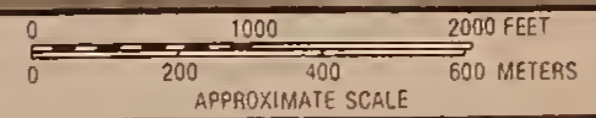
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Nebraska Natural Resources  
Commission-1985 Photography



**LEGEND**

- 100 Year Flood Hazard Area
- 500 Year Flood Hazard Area
- ~ 2175 ~ 100 Year Flood Elevation
- ⊗ 4 ⊗ Evaluation Reach
- ① 140 Cross Section
- Limit of Study

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**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

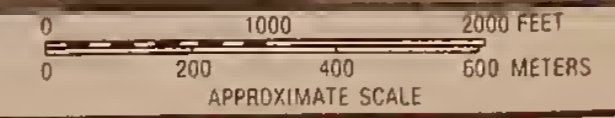
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Nebraska Natural Resources  
Commission-1985 Photography



**LEGEND**

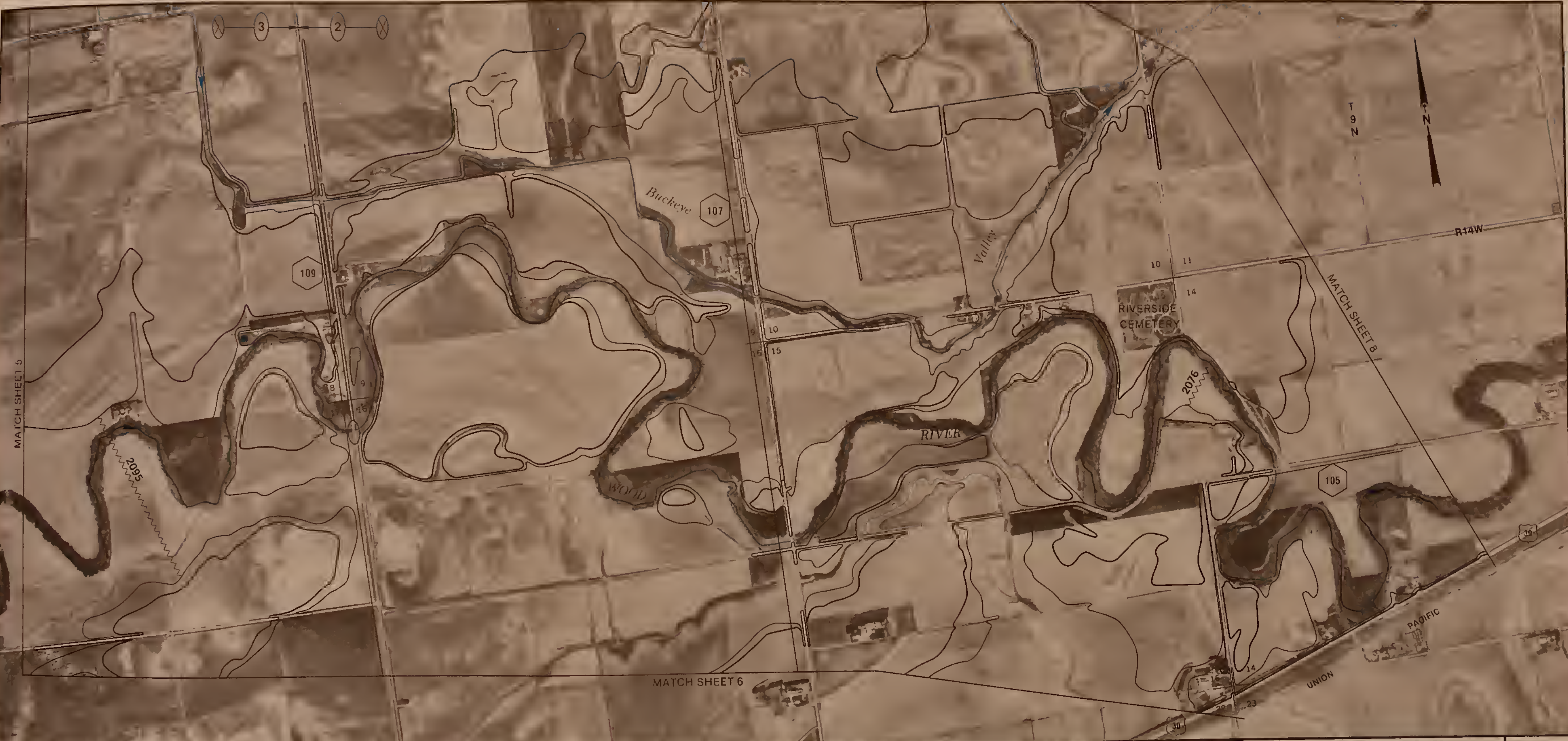
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- - - 500 Year Flood Hazard Area
- ~ 2175 ~ 100 Year Flood Elevation
- ⊗ ④ ⊗ Evaluation Reach
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- Limit of Study

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SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

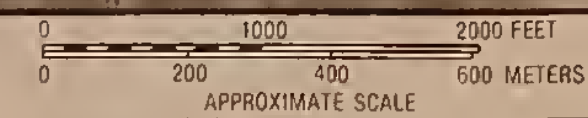
**SHEET  
6 OF 20**





NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
Commission-1985 Photography



**LEGEND**

- 100 Year Flood Hazard Area
- 500 Year Flood Hazard Area
- ~2175~ 100 Year Flood Elevation
- ⊗-4-⊗ Evaluation Reach
- ⬮ Cross Section
- Limit of Study

U.S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

**SHEET  
7 OF 20**

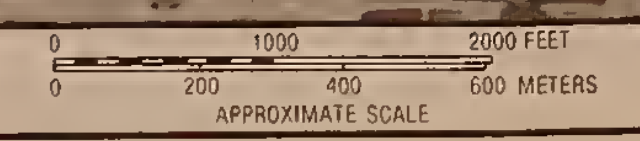






NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.

Nebraska Natural Resources  
Commission-1985 Photography



**LEGEND**

- 100 Year Flood Hazard Area
- 500 Year Flood Hazard Area
- ~2175~ 100 Year Flood Elevation
- ⊗(4)⊗ Evaluation Reach
- ①②③④⑤⑥⑦⑧⑨⑩⑪⑫⑬⑭⑮⑯⑰⑱⑲ Cross Section
- Limit of Study

U.S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

**SHEET  
8 OF 20**



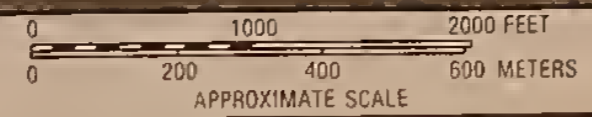


MATCH SHEET 8

MATCH SHEET 10

NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
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**LEGEND**

- 100 Year Flood Hazard Area
- 500 Year Flood Hazard Area
- 2175' 100 Year Flood Elevation
- Evaluation Reach
- Cross Section
- Limit of Study

U.S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

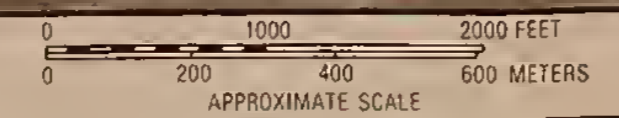
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9 OF 20**





NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
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**LEGEND**

- 100 Year Flood Hazard Area
- 500 Year Flood Hazard Area
- ~ 2175 ~ 100 Year Flood Elevation
- ⊗ 4 ⊗ Evaluation Reach
- ⊠ 140 ⊠ Cross Section
- Limit of Study

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SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

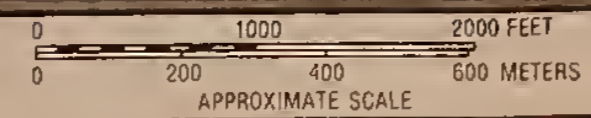
**SHEET  
10 OF 20**





NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
Commission-1985 Photography



**LEGEND**

- 100 Year Flood Hazard Area
- 500 Year Flood Hazard Area
- 2175' 100 Year Flood Elevation
- ⊗—④—⊗ Evaluation Reach
- ⑭— Cross Section
- Limit of Study

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SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

**SHEET  
11 OF 20**

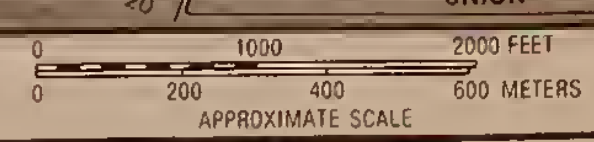






NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT SERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
Commission-1985 Photography



**LEGEND**

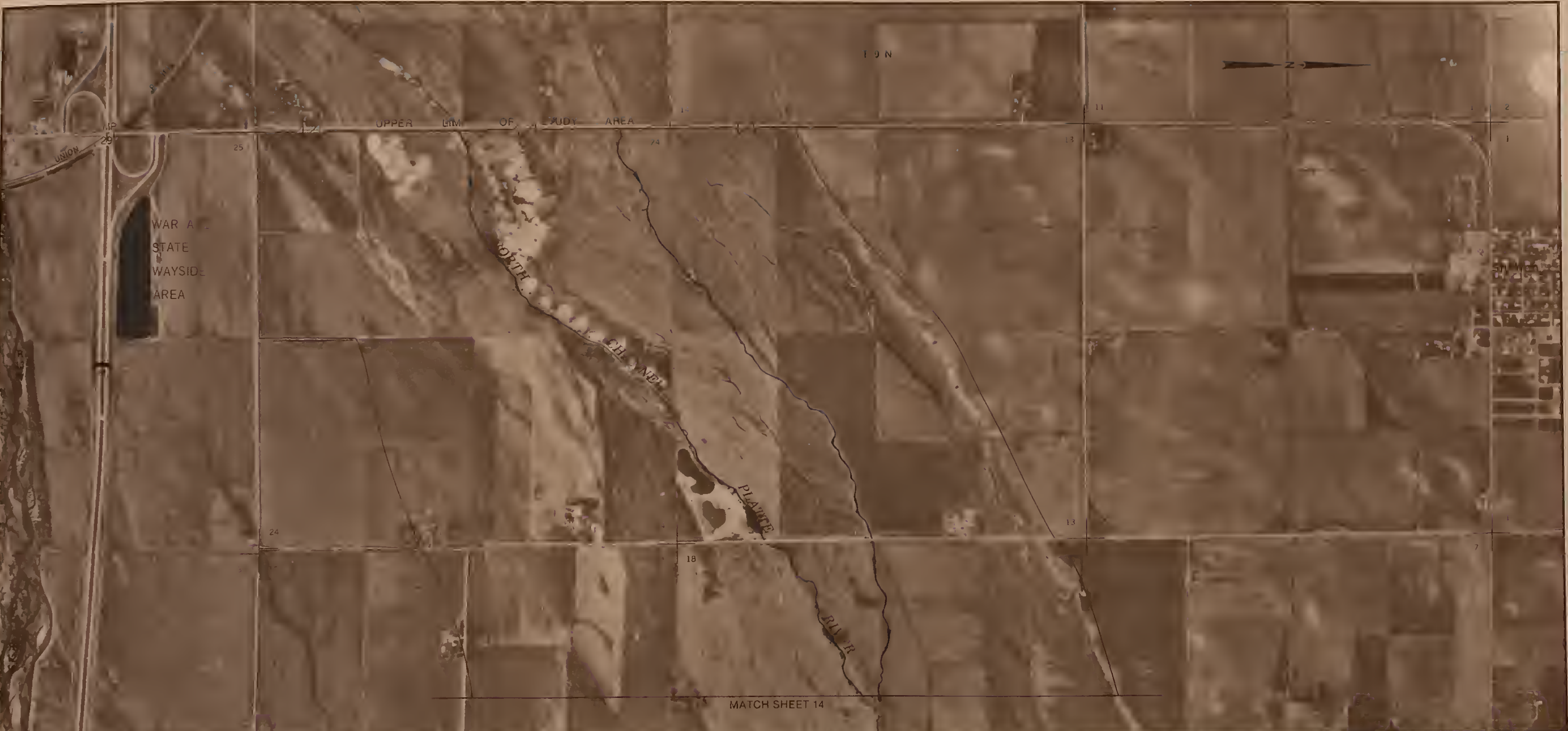
- 100 Year Flood Hazard Area
- 500 Year Flood Hazard Area
- ~2175~ 100 Year Flood Elevation
- ⊗④⊗ Evaluation Reach
- ①④⑤ Cross Section
- Limit of Study

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SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

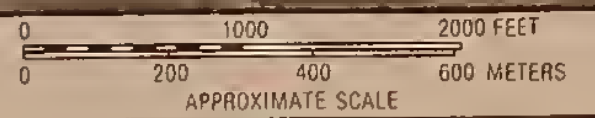
**SHEET  
12 OF 20**





NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

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**LEGEND**  
 - - - - - Limit of Study  
 ——— Flood Prone Area

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**LOWER WOOD RIVER  
 FLOOD PLAIN MANAGEMENT STUDY  
 BUFFALO AND HALL COUNTIES, NEBRASKA**

**SHEET  
 13 OF 20**



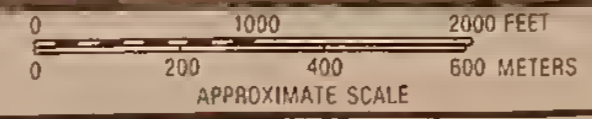
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NORTH  
CHA  
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PLATT  
RIVER

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NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

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**LEGEND**  
— Limit of Study  
— Flood Prone Area

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SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

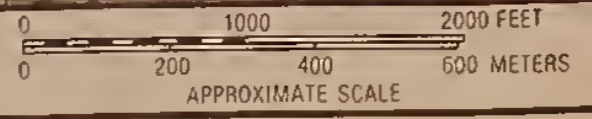
**SHEET  
14 OF 20**





NOTE: AREAS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
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**LEGEND**  
 Limit of Study  
 Flood Prone Area

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 SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
 FLOOD PLAIN MANAGEMENT STUDY  
 BUFFALO AND HALL COUNTIES, NEBRASKA**

**SHEET  
 15 OF 20**

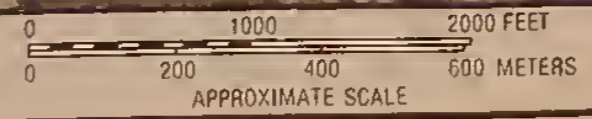






NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT SERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.

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**LEGEND**  
 - - - - - Limit of Study  
 ■■■■■ Flood Prone Area

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 SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
 FLOOD PLAIN MANAGEMENT STUDY  
 BUFFALO AND HALL COUNTIES, NEBRASKA**

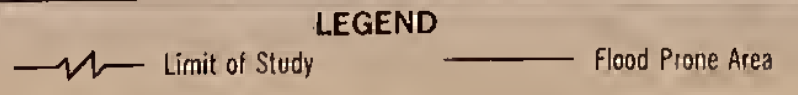
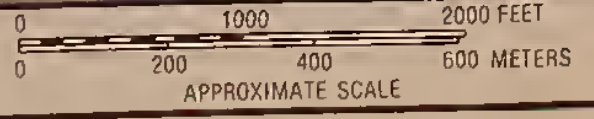
SHEET  
 16 OF 20





NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL  
 SITUATION ON THE GROUND AND DUE TO INHERENT  
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 GRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
 Commission-1985 Photography

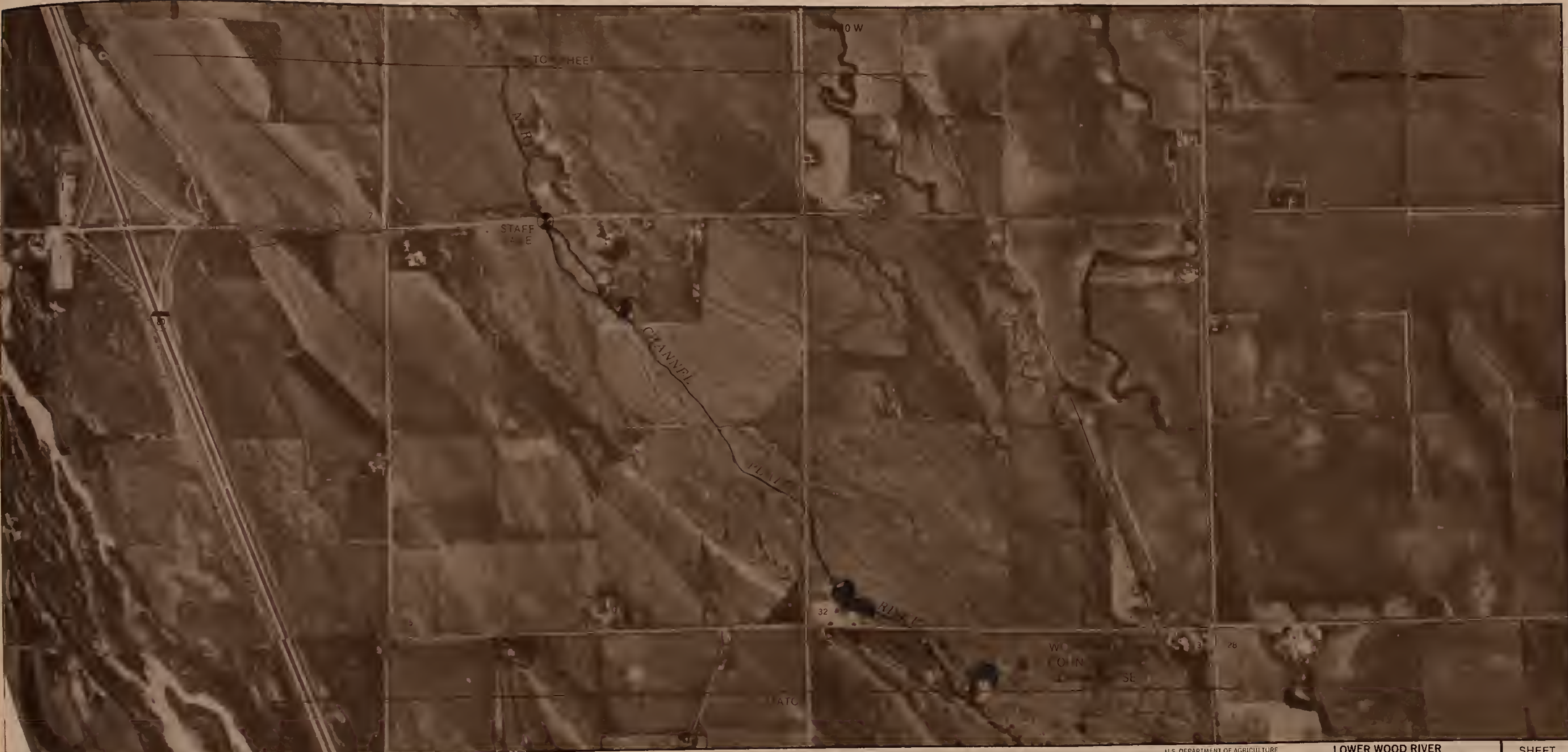


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 SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
 FLOOD PLAIN MANAGEMENT STUDY  
 BUFFALO AND HALL COUNTIES, NEBRASKA**

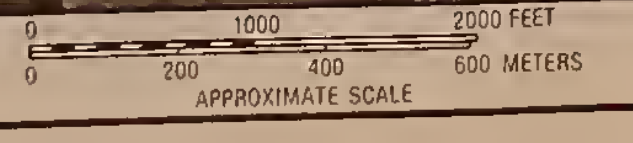
**SHEET  
 17 OF 20**





NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT ERRORS, PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHY MADE MAY VARY FROM TRUE GROUND LOCATION

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Commission-1985 Photography



**LEGEND**  
 ~~~~~ Limit of Study  
 \_\_\_\_\_ Flood Prone Area

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 SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
 FLOOD PLAIN MANAGEMENT STUDY  
 BUFFALO AND HALL COUNTIES, NEBRASKA**

**SHEET  
 18 OF 20**

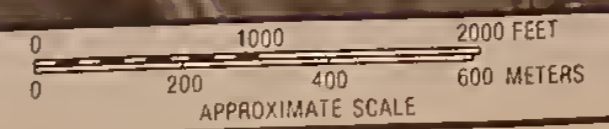
AUGUST 1983 1002444





NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL CONDITIONS ON THE GROUND AND DUE TO INHERENT ERRORS IN PHOTOGRAPHY. DISPLACEMENT OF PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.

Nebraska Natural Resources  
Commission-1985 Photography

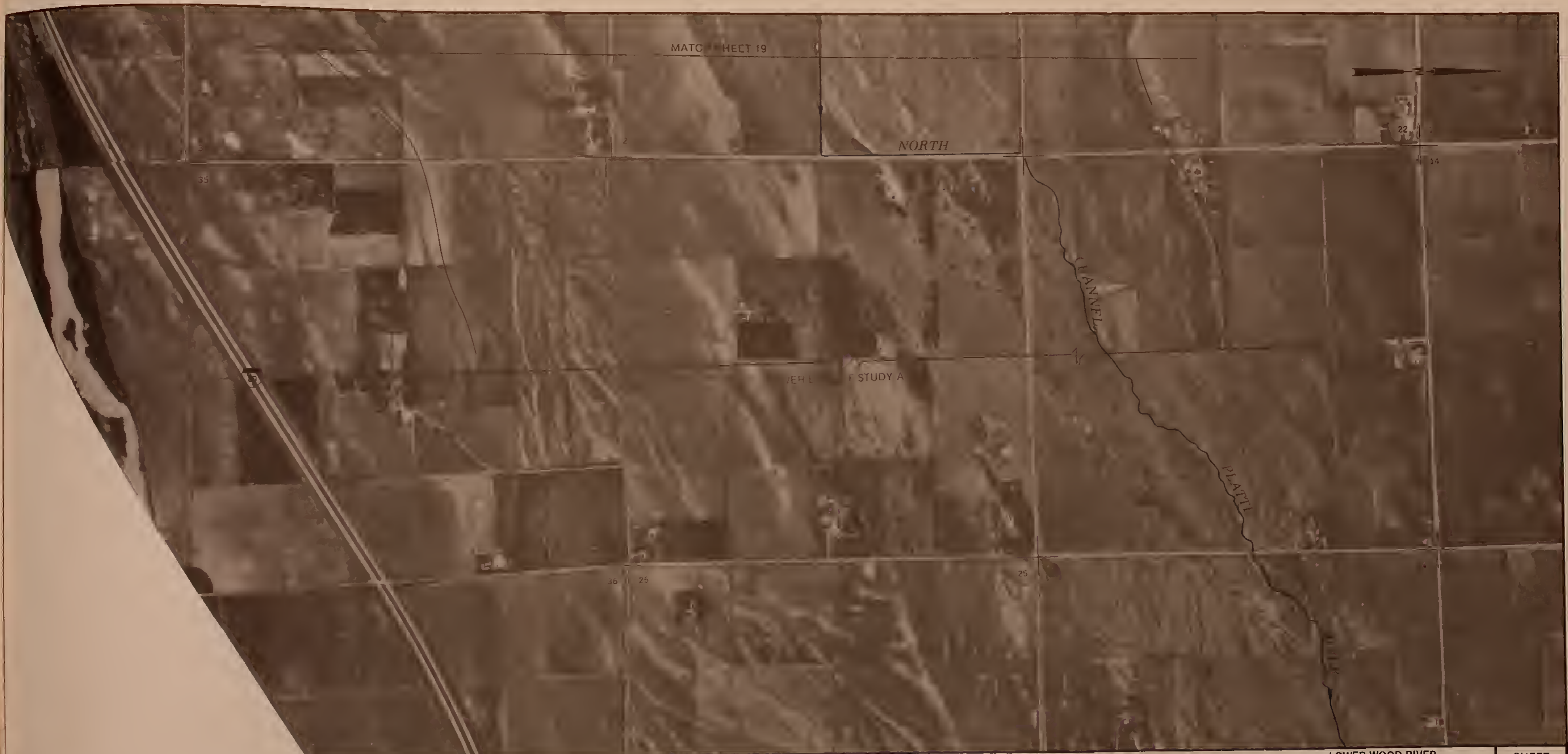


**LEGEND**  
 Limit of Study  
 Flood Prone Area

U.S. DEPARTMENT OF AGRICULTURE  
  
 SOIL CONSERVATION SERVICE

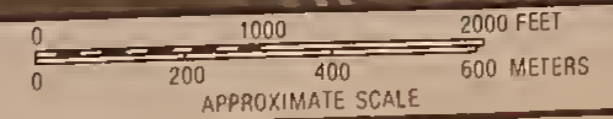
**LOWER WOOD RIVER  
 FLOOD PLAIN MANAGEMENT STUDY  
 BUFFALO AND HALL COUNTIES, NEBRASKA**

**SHEET  
 19 OF 20**



NOTE: FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT Aerial PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
Commission-1985 Photography



**LEGEND**  
 ⚡ Limit of Study  
 — Flood Prone Area

U.S. DEPARTMENT OF AGRICULTURE  
 SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
 FLOOD PLAIN MANAGEMENT STUDY  
 BUFFALO AND HALL COUNTIES, NEBRASKA**

**SHEET  
 20 OF 20**

AUGUST 1989 1002444

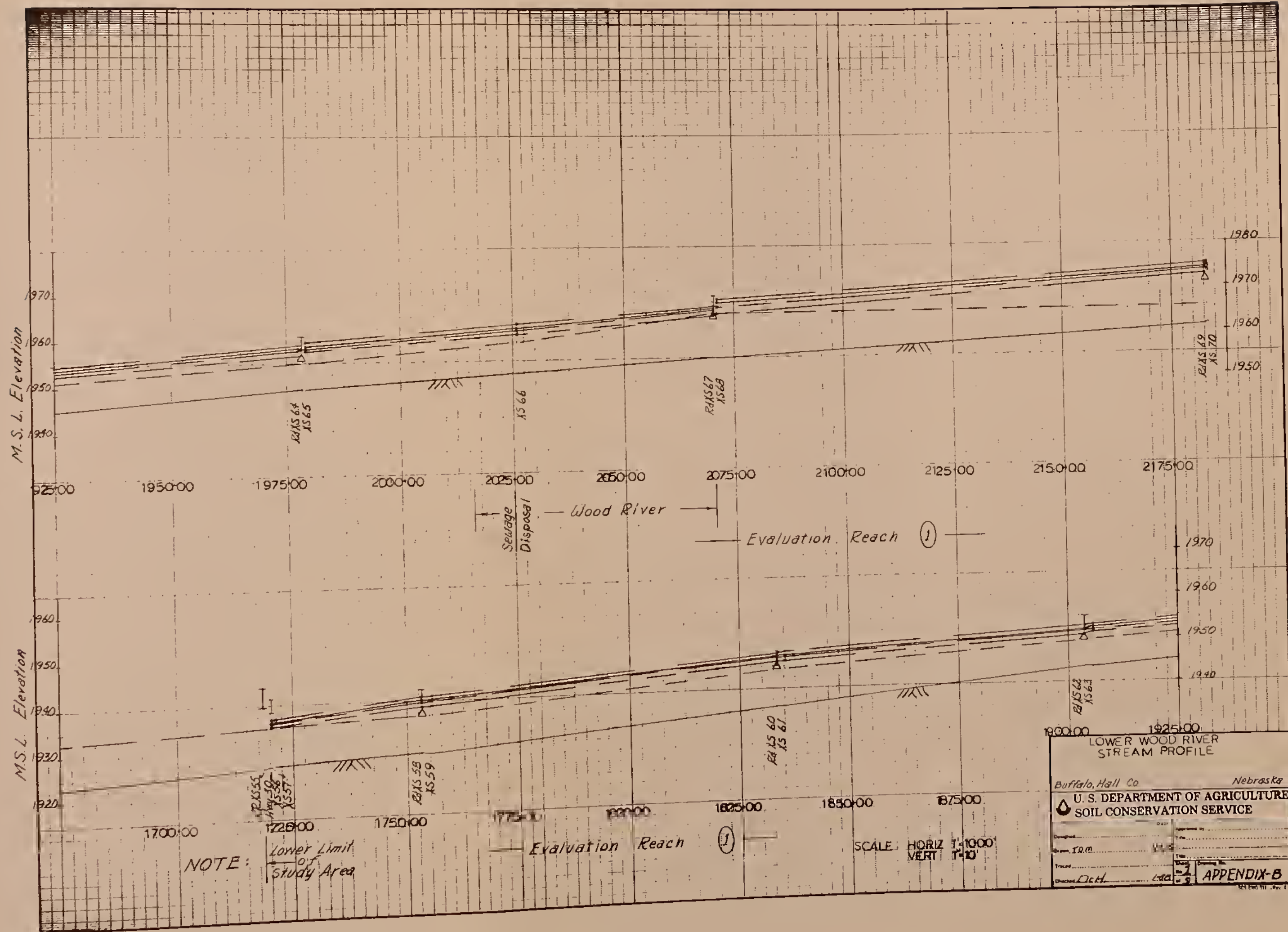


# **APPENDIX B**

## **FLOOD PROFILES**



- LEGEND
- Year
  - 500 \_\_\_\_\_
  - 100 \_\_\_\_\_
  - 50 \_\_\_\_\_
  - 10 \_\_\_\_\_
  - Low Bank \_\_\_\_\_
  - Channel Bottom \_\_\_\_\_
  - Bridge I
  - Low Point In Roadway  $\Delta$
  - Evaluation Reach (A)



**LOWER WOOD RIVER  
STREAM PROFILE**



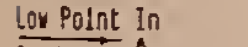

Buffalo, Hall Co Nebraska

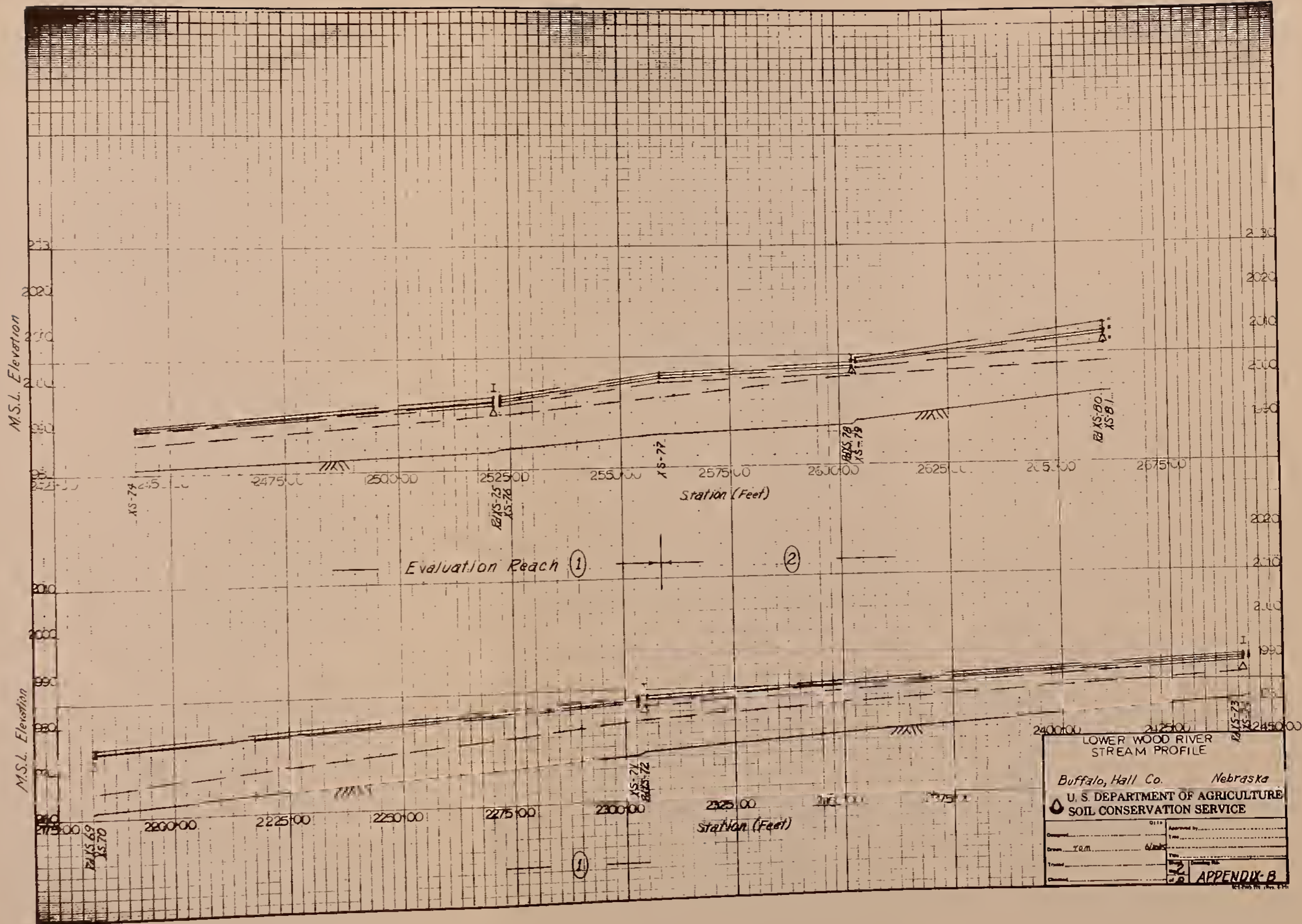
**U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE**

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|-------------------|-------------------|
| Designed by _____ | Checked by _____  |
| Drawn by T.R.M.   | Plotted by W.L.S. |
| Traced by _____   | Reviewed by _____ |
| Checked by D.E.H. | Approved by _____ |

**APPENDIX-B**



- LEGEND
- Year
  - 500 \_\_\_\_\_
  - 100 \_\_\_\_\_
  - 50 \_\_\_\_\_
  - 10 \_\_\_\_\_
  - Low Bank \_\_\_\_\_
  - Channel Bottom 
  - Bridge 
  - Low Point In Roadway 
  - Evaluation Reach 



LOWER WOOD RIVER  
STREAM PROFILE

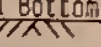


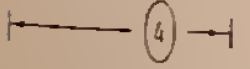
Buffalo, Hall Co. Nebraska

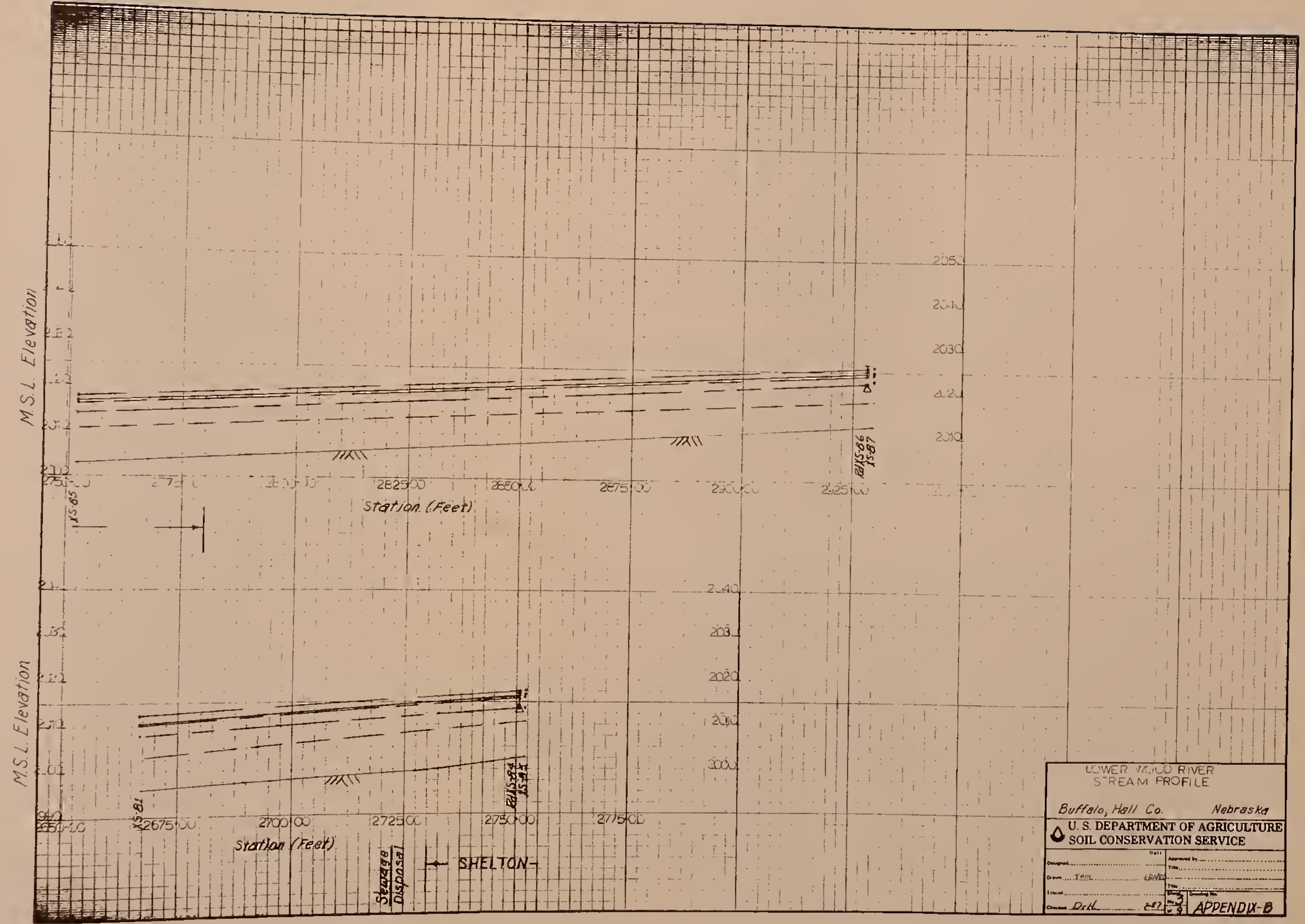
U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

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| Designed     | Approved by |
| Drawn Y.E.M. | Checked     |
| Treated      | Scale       |
| Channel      | Sheet No. 2 |

APPENDIX-B



- LEGEND
- Year
  - 500 \_\_\_\_\_
  - 100 \_\_\_\_\_
  - 50 \_\_\_\_\_
  - 10 \_\_\_\_\_
  - Low Bank \_\_\_\_\_
  - Channel Bottom 
  - Bridge 
  - Low Point In Roadway 
  - Evaluation Reach 



LOWER NIANGUA RIVER  
STREAM PROFILE

Buffalo, Hall Co. Nebraska

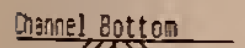


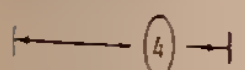
U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

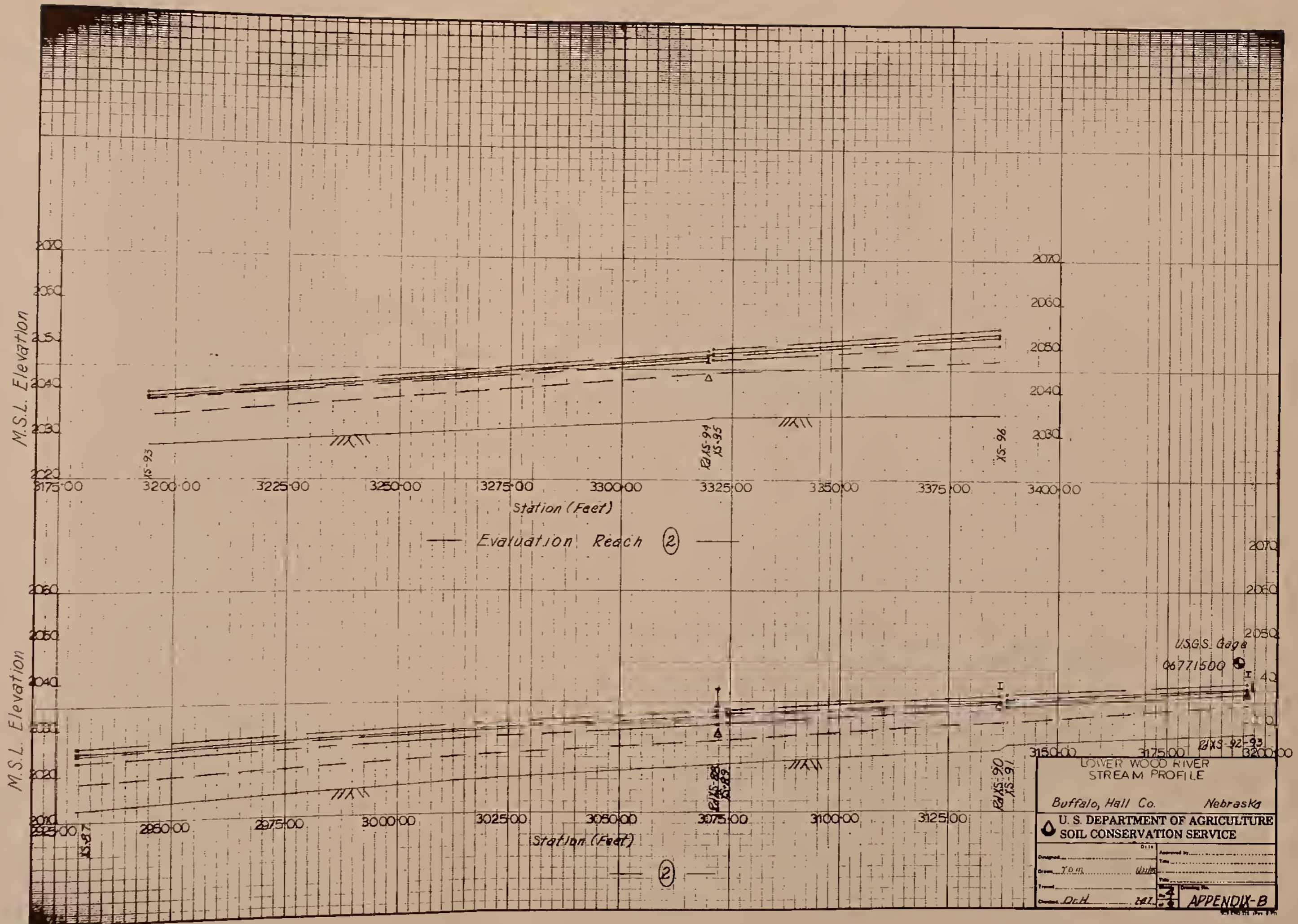
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| Drawn by Tom _____     | Date _____ | Checked by _____  | Date _____  |
| Checked by Detl. _____ |            | Date _____        |             |

APPENDIX-B





- LEGEND
- Year
  - 500 \_\_\_\_\_
  - 100 \_\_\_\_\_
  - 50 \_\_\_\_\_
  - 10 \_\_\_\_\_
  - Low Bank \_\_\_\_\_
  - Channel Bottom 
  - Bridge 
  - Low Point In Roadway 
  - Evaluation Reach 



**LOWER WOOD RIVER  
STREAM PROFILE**

Buffalo, Hall Co. Nebraska

**U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE**

|                                  |                                  |
|----------------------------------|----------------------------------|
| <small>Designed by</small>       | <small>Approved by</small>       |
| <small>Drawn by</small> T.O.M.   | <small>Checked by</small> W.H.S. |
| <small>Typed by</small>          | <small>Checked by</small>        |
| <small>Checked by</small> D.C.H. | <b>APPENDIX-B</b>                |



**LEGEND**

Year

500 \_\_\_\_\_

100 \_\_\_\_\_

50 \_\_\_\_\_

10 \_\_\_\_\_

Low Bank \_\_\_\_\_

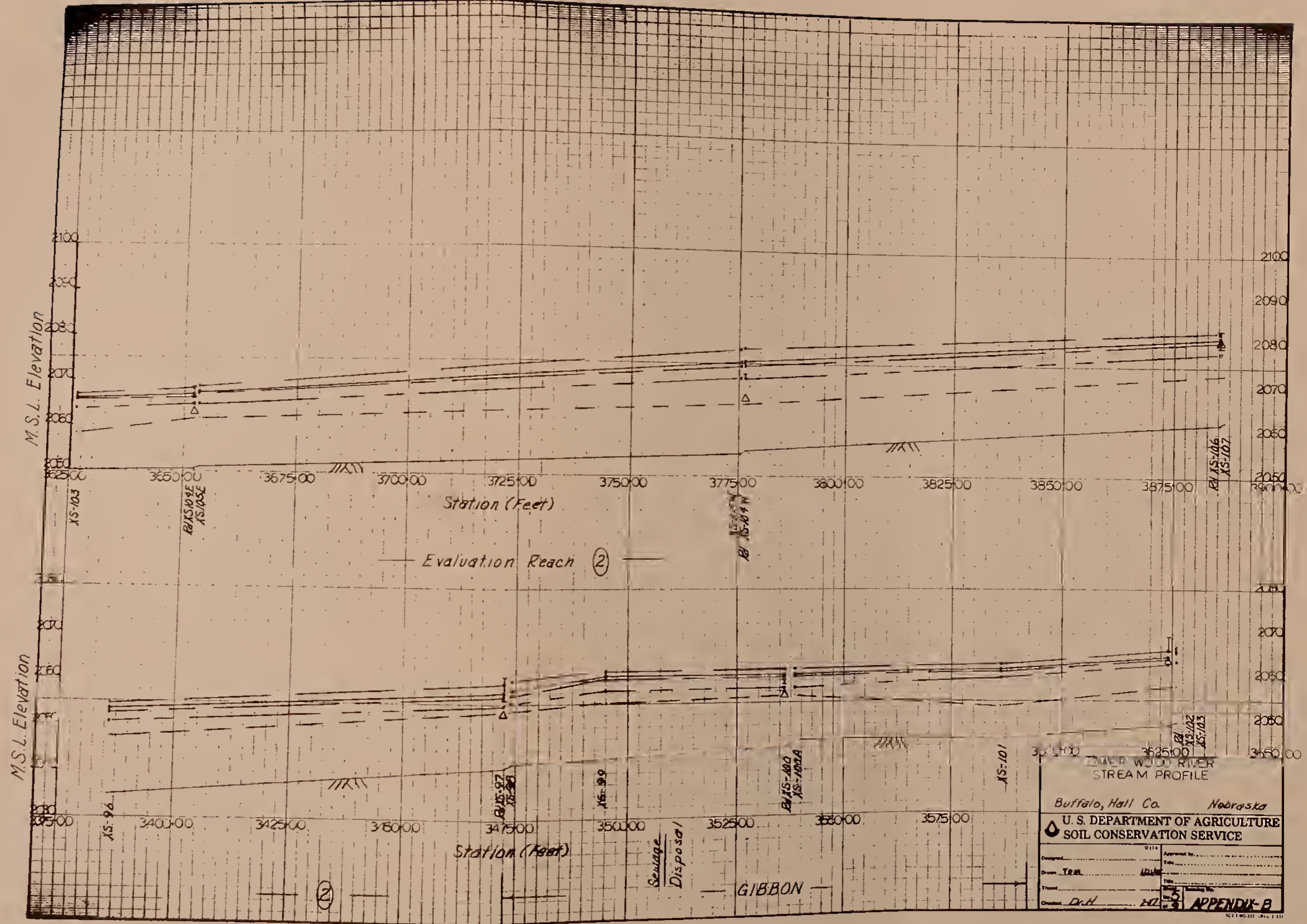
Channel Bottom \_\_\_\_\_

Bridge I

Low Point In Roadway  $\Delta$

Evaluation Reach

(4)



Buffalo, Hall Co. Nebraska

U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

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Designed: \_\_\_\_\_ Title: \_\_\_\_\_

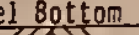



Drawn: T.M. Date: 10/1/51

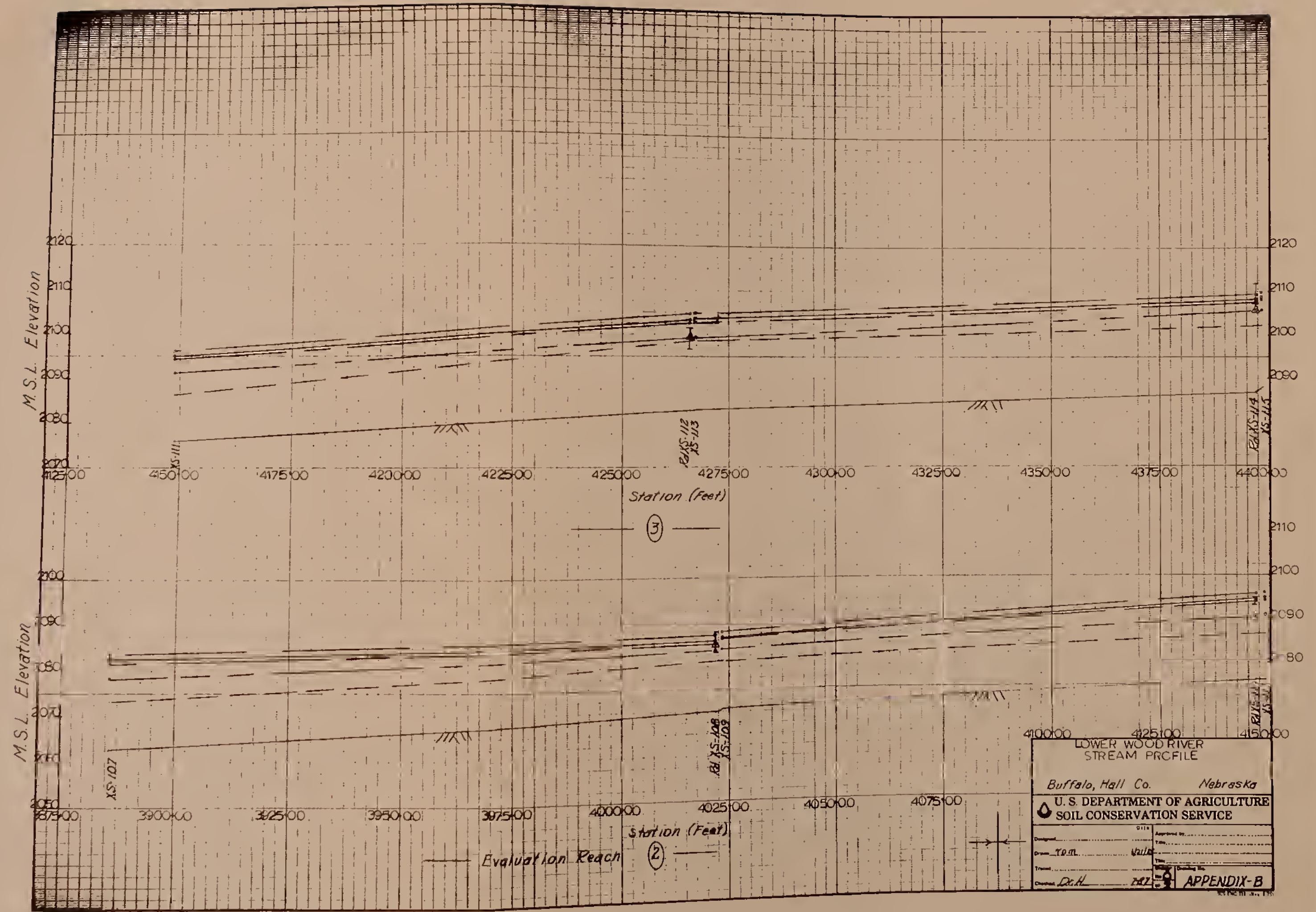
Checked: Dr.H. Date: 2/1/52

Approved By: \_\_\_\_\_ Title: \_\_\_\_\_

APPENDIX-B



- LEGEND**
- Year
  - 500 \_\_\_\_\_
  - 100 \_\_\_\_\_
  - 50 \_\_\_\_\_
  - 10 \_\_\_\_\_
  - Low Bank \_\_\_\_\_
  - Channel Bottom 
  - Bridge 
  - Low Point In Roadway 
  - Evaluation Reach 



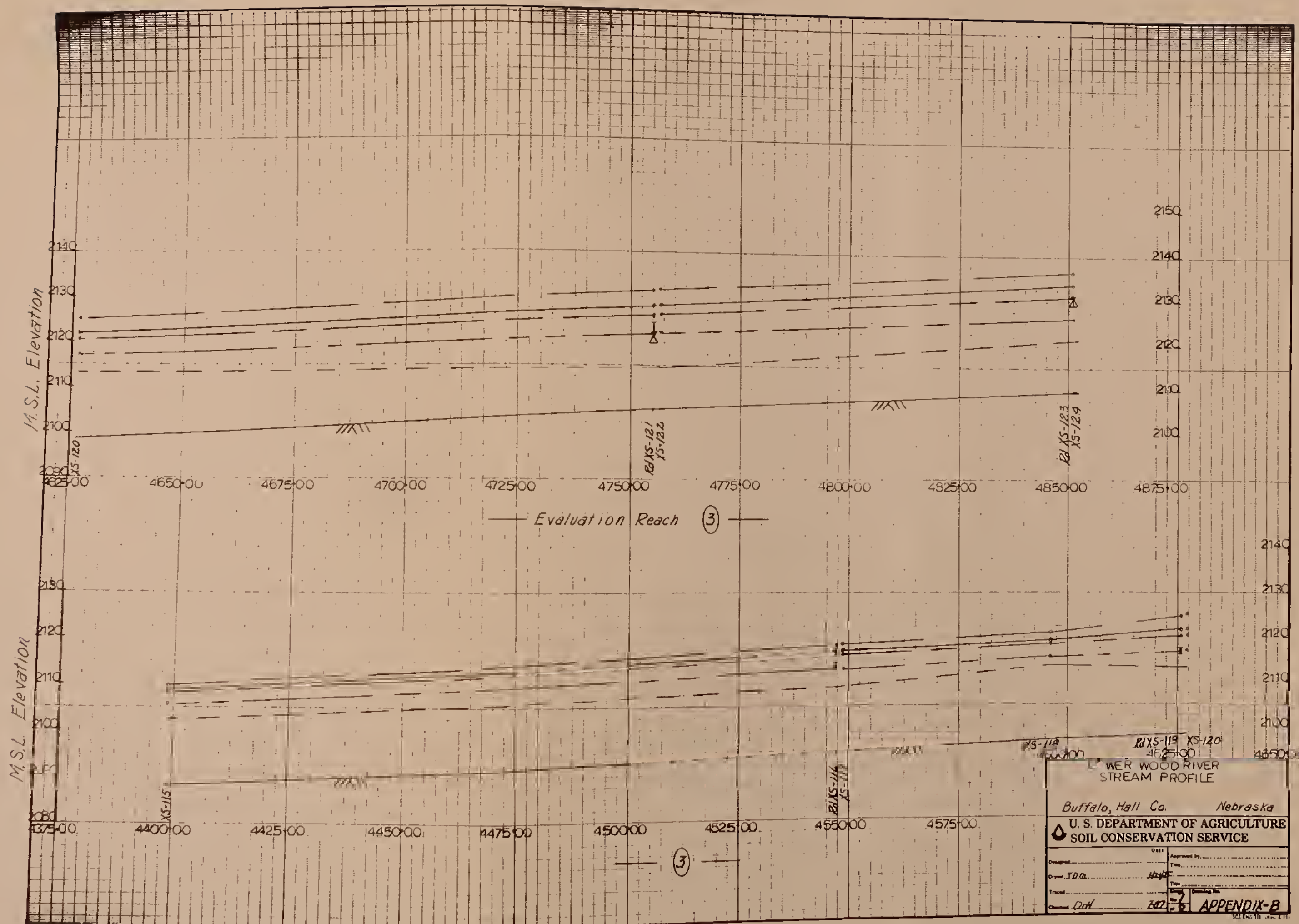
**LOWER WOOD RIVER  
STREAM PROFILE**

Buffalo, Hall Co. Nebraska

**U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE**

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| Drawn <i>T.P.M.</i> | Scale <i>Vertical</i> |
| Traced _____        | Checked <i>D.C.H.</i> |
| <b>APPENDIX-B</b>   |                       |





**LEGEND**

Year

500 \_\_\_\_\_

100 \_\_\_\_\_

50 \_\_\_\_\_

10 \_\_\_\_\_

Low Bank

Channel Bottom

Bridge

Low Point In Roadway

Evaluation Reach

**LOWER WOOD RIVER  
STREAM PROFILE**

Buffalo, Hall Co. Nebraska

U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

|                |             |
|----------------|-------------|
| Date           | Approved by |
| Designed       | Time        |
| Drawn J.D.M.   | Checked     |
| Traced         | Time        |
| Checked D.H.H. | 7/27/56     |

**APPENDIX-B**









**LEGEND**

Year


500 \_\_\_\_\_


100 \_\_\_\_\_


50 \_\_\_\_\_


10 \_\_\_\_\_

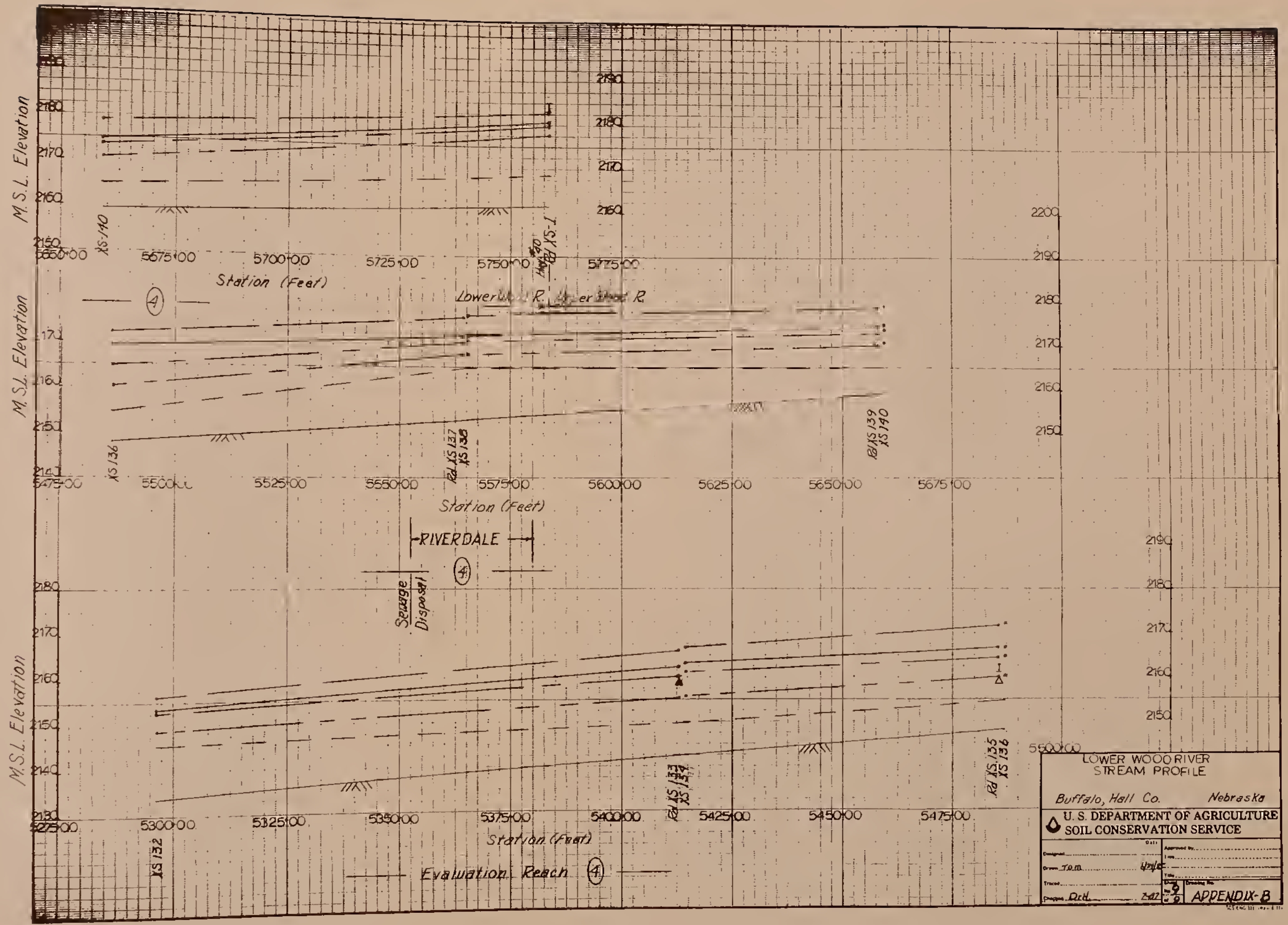
Low Bank \_\_\_\_\_

Channel Bottom 

Bridge 

Low Point In Roadway 

Evaluation Reach 



**LOWER WOOD RIVER  
STREAM PROFILE**

Buffalo, Hall Co. Nebraska

U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

|          |        |             |         |
|----------|--------|-------------|---------|
| Designed | 0/11   | Approved By |         |
| Drawn    | J.D.M. | Date        | 4/21/60 |
| Traced   |        | Scale       |         |
| Checked  |        | Sheet No.   | 2 of 2  |
| Project  | Drd.   | Project No. | 742     |

**APPENDIX-B**



# **APPENDIX C**

## **TECHNICAL TABLES**



APPENDIX C  
DISCHARGE, ELEVATION BY FREQUENCY  
LOWER WOOD RIVER.

| Cross Section Number | 10 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet | 50 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet | 100 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet | 500 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet |
|----------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|---------------------------------|----------------------------------|---------------------------------|
| -REACH 1-            |                                 |                                 |                                 |                                 |                                  |                                 |                                  |                                 |
| 56 RD                | 1950                            | 1935.2                          | 4870                            | 1935.9                          | 7060                             | 1936.2                          | 13470                            | 1936.9                          |
| 56 Upstream          |                                 | 1935.2                          |                                 | 1935.9                          |                                  | 1936.2                          |                                  | 1937.0                          |
| 57                   | 1950                            | 1935.2                          | 4870                            | 1935.9                          | 7060                             | 1936.2                          | 13470                            | 1937.0                          |
| 58 RD                | 1950                            | 1938.7                          | 4860                            | 1939.7                          | 7050                             | 1940.2                          | 13460                            | 1941.1                          |
| 58 Upstream          |                                 | 1938.8                          |                                 | 1939.8                          |                                  | 1940.2                          |                                  | 1941.2                          |
| 59                   | 1950                            | 1938.8                          | 4860                            | 1939.9                          | 7050                             | 1940.3                          | 13460                            | 1941.3                          |
| 60 RD                | 1940                            | 1945.5                          | 4840                            | 1946.7                          | 7020                             | 1947.1                          | 13400                            | 1948.0                          |
| 60 Upstream          |                                 | 1946.1                          |                                 | 1947.0                          |                                  | 1947.4                          |                                  | 1948.2                          |
| 61                   | 1940                            | 1946.1                          | 4840                            | 1947.1                          | 7020                             | 1947.5                          | 13400                            | 1948.4                          |
| 62 RD                | 1930                            | 1950.6                          | 4820                            | 1951.5                          | 6990                             | 1951.9                          | 13340                            | 1952.8                          |
| 62 Upstream          |                                 | 1951.3                          |                                 | 1951.9                          |                                  | 1952.2                          |                                  | 1953.0                          |
| 63                   | 1930                            | 1951.3                          | 4820                            | 1952.0                          | 6990                             | 1952.4                          | 13340                            | 1953.1                          |
| 64 RD                | 1920                            | 1956.7                          | 4800                            | 1957.8                          | 6960                             | 1958.3                          | 13270                            | 1959.3                          |
| 64 Upstream          |                                 | 1957.6                          |                                 | 1958.1                          |                                  | 1958.4                          |                                  | 1959.5                          |
| 65                   | 1920                            | 1957.7                          | 4800                            | 1958.2                          | 6960                             | 1958.6                          | 13270                            | 1959.6                          |
| 66                   | 1920                            | 1960.7                          | 4780                            | 1961.7                          | 6940                             | 1962.2                          | 13240                            | 1963.2                          |
| 67 RD                | 1910                            | 1964.3                          | 4770                            | 1965.6                          | 6920                             | 1966.0                          | 13210                            | 1966.5                          |
| 67 Upstream          |                                 | 1964.3                          |                                 | 1965.9                          |                                  | 1966.7                          |                                  | 1967.3                          |
| 68                   | 1910                            | 1964.9                          | 4770                            | 1966.7                          | 6920                             | 1967.3                          | 13210                            | 1968.0                          |
| 69 RD                | 1900                            | 1972.7                          | 4750                            | 1973.7                          | 6890                             | 1974.2                          | 13150                            | 1975.0                          |
| 69 Upstream          |                                 | 1973.3                          |                                 | 1974.0                          |                                  | 1974.4                          |                                  | 1975.1                          |
| 70                   | 1900                            | 1973.3                          | 4750                            | 1974.1                          | 6890                             | 1974.4                          | 13150                            | 1975.2                          |
| 71                   | 1900                            | 1981.2                          | 4740                            | 1982.1                          | 6870                             | 1982.6                          | 13120                            | 1983.1                          |
| 72 RD                | 1900                            | 1981.3                          | 4740                            | 1982.2                          | 6870                             | 1982.7                          | 13120                            | 1983.3                          |
| 72 Upstream          |                                 | 1981.3                          |                                 | 1982.6                          |                                  | 1983.0                          |                                  | 1983.5                          |
| 73 RD                | 1890                            | 1989.1                          | 4720                            | 1989.8                          | 6850                             | 1990.1                          | 13070                            | 1990.6                          |
| 73 Upstream          |                                 | 1989.5                          |                                 | 1989.8                          |                                  | 1990.2                          |                                  | 1990.6                          |
| 74                   | 1890                            | 1989.6                          | 4720                            | 1989.9                          | 6850                             | 1990.3                          | 13070                            | 1990.8                          |
| 75 RD                | 1890                            | 1994.2                          | 4710                            | 1995.1                          | 6820                             | 1995.4                          | 13030                            | 1996.3                          |
| 75 Upstream          |                                 | 1994.5                          |                                 | 1995.3                          |                                  | 1995.7                          |                                  | 1996.5                          |
| 76                   | 1890                            | 1994.5                          | 4710                            | 1995.4                          | 6820                             | 1995.8                          | 13030                            | 1996.6                          |
| 77                   | 2170                            | 1999.1                          | 5750                            | 2000.2                          | 8110                             | 2000.6                          | 16890                            | 2001.4                          |
| -REACH 2-            |                                 |                                 |                                 |                                 |                                  |                                 |                                  |                                 |
| 78 RD                | 2360                            | 2001.0                          | 5950                            | 2002.1                          | 8380                             | 2002.5                          | 18040                            | 2003.5                          |
| 78 Upstream          |                                 | 2001.6                          |                                 | 2003.2                          |                                  | 2003.5                          |                                  | 2004.1                          |
| 79                   | 2360                            | 2001.6                          | 5950                            | 2003.2                          | 8380                             | 2003.5                          | 18040                            | 2004.2                          |
| 80 RD                | 2360                            | 2006.9                          | 5930                            | 2009.0                          | 8350                             | 2009.8                          | 17970                            | 2011.9                          |
| 80 Upstream          |                                 | 2007.9                          |                                 | 2010.0                          |                                  | 2010.4                          |                                  | 2011.9                          |
| 81                   | 2360                            | 2007.9                          | 5930                            | 2010.1                          | 8350                             | 2010.4                          | 17970                            | 2012.1                          |
| 84 RD                | 2350                            | 2013.2                          | 5920                            | 2015.7                          | 8330                             | 2016.4                          | 17950                            | 2017.4                          |

APPENDIX C  
DISCHARGE, ELEVATION BY FREQUENCY  
LOWER WOOD RIVER

| Cross Section Number | 10 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet | 50 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet | 100 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet | 500 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet |
|----------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|---------------------------------|----------------------------------|---------------------------------|
| 84 Upstream          |                                 | 2013.8                          |                                 | 2016.0                          |                                  | 2016.6                          |                                  | 2017.5                          |
| 85                   | 2350                            | 2013.8                          | 5920                            | 2016.0                          | 8330                             | 2016.6                          | 17950                            | 2017.6                          |
| 86 RO                | 2330                            | 2022.4                          | 5860                            | 2024.1                          | 8260                             | 2024.6                          | 17780                            | 2025.8                          |
| 86 Upstream          |                                 | 2022.8                          |                                 | 2024.1                          |                                  | 2024.7                          |                                  | 2025.9                          |
| 87                   | 2330                            | 2022.9                          | 5860                            | 2024.2                          | 8260                             | 2024.8                          | 17780                            | 2026.0                          |
| 88 RD                | 2330                            | 2029.8                          | 5850                            | 2031.5                          | 8240                             | 2031.8                          | 17750                            | 2032.8                          |
| 88 Upstream          |                                 | 2029.9                          |                                 | 2031.6                          |                                  | 2031.9                          |                                  | 2033.0                          |
| 89                   | 2330                            | 2030.0                          | 5850                            | 2031.7                          | 8240                             | 2032.1                          | 17750                            | 2033.1                          |
| 90 RO                | 2320                            | 2033.4                          | 5850                            | 2034.5                          | 8240                             | 2034.9                          | 17740                            | 2036.0                          |
| 90 Upstream          |                                 | 2033.4                          |                                 | 2034.5                          |                                  | 2035.0                          |                                  | 2036.1                          |
| 91                   | 2320                            | 2033.6                          | 5850                            | 2034.8                          | 8240                             | 2035.3                          | 17740                            | 2036.4                          |
| 92 RO                | 2320                            | 2036.8                          | 5850                            | 2037.6                          | 8230                             | 2037.9                          | 17730                            | 2039.0                          |
| 92 Upstream          |                                 | 2037.9                          |                                 | 2038.3                          |                                  | 2038.5                          |                                  | 2039.2                          |
| 93                   | 2320                            | 2037.9                          | 5850                            | 2038.3                          | 8230                             | 2038.5                          | 17730                            | 2039.3                          |
| 94 RO                | 2320                            | 2046.8                          | 5840                            | 2047.8                          | 8220                             | 2048.3                          | 17700                            | 2049.1                          |
| 94 Upstream          |                                 | 2046.9                          |                                 | 2048.0                          |                                  | 2048.6                          |                                  | 2049.5                          |
| 95                   | 2320                            | 2047.1                          | 5840                            | 2048.2                          | 8220                             | 2048.7                          | 17700                            | 2049.7                          |
| 96                   | 2320                            | 2050.7                          | 5830                            | 2052.5                          | 8210                             | 2053.2                          | 17690                            | 2054.5                          |
| 97 RO                | 2320                            | 2054.7                          | 5830                            | 2056.5                          | 8200                             | 2057.4                          | 17670                            | 2059.4                          |
| 97 Upstream          |                                 | 2055.0                          |                                 | 2056.7                          |                                  | 2057.6                          |                                  | 2059.8                          |
| 98                   | 2320                            | 2055.1                          | 5830                            | 2056.8                          | 8200                             | 2057.8                          | 17670                            | 2060.0                          |
| 99                   | 2320                            | 2057.8                          | 5820                            | 2060.5                          | 8200                             | 2061.1                          | 17660                            | 2062.2                          |
| 100 RO               | 2310                            | 2058.2                          | 5820                            | 2060.7                          | 8200                             | 2061.2                          | 17660                            | 2062.3                          |
| 100 Upstream         |                                 | 2058.2                          |                                 | 2060.7                          |                                  | 2061.2                          |                                  | 2062.3                          |
| 100A                 | 2310                            | 2058.2                          | 5820                            | 2060.7                          | 8200                             | 2061.3                          | 17660                            | 2062.4                          |
| 101                  | 2310                            | 2060.1                          | 5820                            | 2061.6                          | 8200                             | 2062.1                          | 17650                            | 2063.3                          |
| 102 RO               | 2310                            | 2063.1                          | 5810                            | 2064.4                          | 8190                             | 2064.8                          | 17630                            | 2066.2                          |
| 102 Upstream         |                                 | 2063.6                          |                                 | 2065.7                          |                                  | 2066.0                          |                                  | 2066.7                          |
| 103                  | 2310                            | 2063.6                          | 5810                            | 2065.7                          | 8190                             | 2066.0                          | 17630                            | 2066.8                          |
| 104 ERO              | 2310                            | 2064.8                          | 5810                            | 2066.5                          | 8190                             | 2066.9                          | 17630                            | 2068.3                          |
| 104 E Upstream       |                                 | 2064.8                          |                                 | 2066.5                          |                                  | 2067.1                          |                                  | 2068.5                          |
| 105 E                | 2310                            | 2064.9                          | 5810                            | 2067.0                          | 8190                             | 2067.6                          | 17630                            | 2068.9                          |
| 105 W                | 2310                            | 2071.8                          | 5810                            | 2074.4                          | 8190                             | 2075.4                          | 17620                            | 2078.2                          |
| 104 WRO              | 2310                            | 2071.8                          | 5810                            | 2074.5                          | 8180                             | 2075.5                          | 17620                            | 2078.4                          |
| 104 W Upstream       |                                 | 2071.8                          |                                 | 2074.5                          |                                  | 2075.6                          |                                  | 2078.5                          |
| 106 RO               | 2480                            | 2078.2                          | 6270                            | 2080.8                          | 8940                             | 2081.4                          | 18850                            | 2083.0                          |
| 106 Upstream         |                                 | 2078.2                          |                                 | 2081.4                          |                                  | 2082.6                          |                                  | 2083.6                          |
| 107                  | 2480                            | 2078.3                          | 6270                            | 2081.5                          | 8940                             | 2082.6                          | 18850                            | 2083.6                          |
| 108 RO               | 2470                            | 2083.6                          | 6260                            | 2085.2                          | 8920                             | 2085.8                          | 18810                            | 2087.2                          |
| 108 Upstream         |                                 | 2084.0                          |                                 | 2086.4                          |                                  | 2086.8                          |                                  | 2087.8                          |
| 109                  | 2470                            | 2084.0                          | 6260                            | 2086.4                          | 8920                             | 2086.9                          | 18810                            | 2087.9                          |



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| Cross Section Number | 10 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet | 50 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet | 100 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet | 500 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet |
|----------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|---------------------------------|----------------------------------|---------------------------------|
| -REACH 3-            |                                 |                                 |                                 |                                 |                                  |                                 |                                  |                                 |
| 110 RD               | 2500                            | 2091.0                          | 6410                            | 2094.0                          | 9260                             | 2094.7                          | 19360                            | 2095.8                          |
| 110 Upstream         |                                 | 2091.0                          |                                 | 2094.2                          |                                  | 2094.9                          |                                  | 2096.0                          |
| 111                  | 2500                            | 2091.2                          | 6410                            | 2094.3                          | 9260                             | 2095.0                          | 19360                            | 2096.1                          |
| 112 RD               | 2480                            | 2099.2                          | 6350                            | 2102.6                          | 9170                             | 2103.3                          | 19160                            | 2104.6                          |
| 112 Upstream         |                                 | 2099.2                          |                                 | 2102.8                          |                                  | 2103.5                          |                                  | 2104.8                          |
| 113                  | 2480                            | 2099.3                          | 6350                            | 2102.8                          | 9170                             | 2103.6                          | 19160                            | 2104.9                          |
| 114 RD               | 2550                            | 2105.5                          | 6580                            | 2107.6                          | 9620                             | 2108.2                          | 20170                            | 2109.3                          |
| 114 Upstream         |                                 | 2105.6                          |                                 | 2108.2                          |                                  | 2108.8                          |                                  | 2109.7                          |
| 115                  | 2550                            | 2105.7                          | 6580                            | 2108.3                          | 9620                             | 2108.8                          | 20170                            | 2109.8                          |
| 116 RD               | 2490                            | 2113.0                          | 6440                            | 2116.2                          | 9400                             | 2116.9                          | 19710                            | 2118.3                          |
| 116 Upstream         |                                 | 2113.1                          |                                 | 2116.4                          |                                  | 2117.1                          |                                  | 2118.5                          |
| 117                  | 2490                            | 2113.2                          | 6440                            | 2116.4                          | 9400                             | 2117.2                          | 19710                            | 2118.6                          |
| 118                  | 2430                            | 2115.7                          | 6270                            | 2118.5                          | 9160                             | 2119.3                          | 19200                            | 2121.0                          |
| 119 RD               | 2470                            | 2116.8                          | 6510                            | 2120.1                          | 9590                             | 2121.4                          | 20520                            | 2124.6                          |
| 119 Upstream         |                                 | 2116.9                          |                                 | 2120.3                          |                                  | 2121.7                          |                                  | 2125.0                          |
| 120                  | 2470                            | 2117.0                          | 6510                            | 2120.4                          | 9590                             | 2121.8                          | 20520                            | 2125.1                          |
| 121 RD               | 2470                            | 2121.9                          | 6500                            | 2126.1                          | 9570                             | 2128.0                          | 20490                            | 2131.5                          |
| 121 Upstream         |                                 | 2122.2                          |                                 | 2126.2                          |                                  | 2126.2                          |                                  | 2131.8                          |
| 122                  | 2470                            | 2127.2                          | 6500                            | 2126.3                          | 9570                             | 2128.2                          | 20490                            | 2131.9                          |
| 123 RD               | 2460                            | 2126.1                          | 6480                            | 2131.1                          | 9550                             | 2133.7                          | 20440                            | 2136.5                          |
| 123 Upstream         |                                 | 2126.1                          |                                 | 2132.0                          |                                  | 2134.3                          |                                  | 2136.9                          |
| 124                  | 2460                            | 2126.2                          | 6480                            | 2132.0                          | 9550                             | 2134.4                          | 20440                            | 2136.9                          |
| 125 RD               | 2460                            | 2129.8                          | 6470                            | 2135.2                          | 9530                             | 2137.6                          | 20400                            | 2140.3                          |
| 125 Upstream         |                                 | 2129.8                          |                                 | 2135.6                          |                                  | 2137.8                          |                                  | 2140.6                          |
| 126                  | 2460                            | 2129.9                          | 6470                            | 2135.7                          | 9530                             | 2137.9                          | 20400                            | 2140.7                          |
| -REACH 4-            |                                 |                                 |                                 |                                 |                                  |                                 |                                  |                                 |
| 127 RD               | 2420                            | 2135.9                          | 6370                            | 2139.8                          | 9390                             | 2141.8                          | 20100                            | 2145.0                          |
| 127 Upstream         |                                 | 2135.9                          |                                 | 2140.3                          |                                  | 2143.2                          |                                  | 2145.9                          |
| 128                  | 2420                            | 2136.0                          | 6370                            | 2140.4                          | 9390                             | 2143.2                          | 20100                            | 2145.9                          |
| 129 RD               | 2410                            | 2141.5                          | 6340                            | 2144.9                          | 9340                             | 2146.8                          | 20000                            | 2150.4                          |
| 129 Upstream         |                                 | 2141.7                          |                                 | 2145.2                          |                                  | 2147.1                          |                                  | 2150.7                          |
| 130                  | 2410                            | 2141.7                          | 6340                            | 2145.3                          | 9340                             | 2147.2                          | 20000                            | 2150.8                          |
| 131 RD               | 2420                            | 2147.8                          | 6660                            | 2151.4                          | 9670                             | 2152.7                          | 20780                            | 2155.6                          |
| 131 Upstream         |                                 | 2148.6                          |                                 | 2152.6                          |                                  | 2153.5                          |                                  | 2156.1                          |
| 132                  | 2420                            | 2148.7                          | 6660                            | 2152.7                          | 9670                             | 2153.5                          | 20780                            | 2156.2                          |
| 133 RD               | 2300                            | 2155.3                          | 6350                            | 2160.1                          | 9210                             | 2162.4                          | 19790                            | 2166.0                          |
| 133 Upstream         |                                 | 2155.5                          |                                 | 2161.1                          |                                  | 2163.0                          |                                  | 2166.7                          |
| 134                  | 2300                            | 2155.6                          | 6350                            | 2161.2                          | 9210                             | 2163.1                          | 19790                            | 2166.8                          |
| 135 RD               | 2300                            | 2160.0                          | 6340                            | 2164.3                          | 9190                             | 2166.2                          | 19760                            | 2171.6                          |
| 135 Upstream         |                                 | 2160.1                          |                                 | 2164.6                          |                                  | 2166.5                          |                                  | 2172.0                          |

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| Cross Section Number | 10 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet | 50 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet | 100 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet | 500 Year Frequency Discharge CFS | Frequency Elevation M.S.L. Feet |
|----------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|---------------------------------|----------------------------------|---------------------------------|
| 136                  | 2300                            | 2160.2                          | 6340                            | 2164.7                          | 9190                             | 2166.6                          | 19760                            | 2172.1                          |
| 137 RD               | 2260                            | 2167.6                          | 6240                            | 2170.3                          | 9060                             | 2171.8                          | 19470                            | 2176.1                          |
| 137 Upstream         |                                 | 2167.8                          |                                 | 2170.6                          |                                  | 2172.1                          |                                  | 2176.6                          |
| 138                  | 2260                            | 2167.9                          | 6240                            | 2170.7                          | 9060                             | 2172.2                          | 19470                            | 2176.6                          |
| 139 RO               | 2210                            | 2169.9                          | 6100                            | 2172.7                          | 8850                             | 2174.1                          | 19030                            | 2178.5                          |
| 139 Upstream         |                                 | 2170.7                          |                                 | 2173.4                          |                                  | 2174.6                          |                                  | 2178.9                          |
| 140                  | 2210                            | 2170.7                          | 6100                            | 2173.5                          | 8850                             | 2174.7                          | 19030                            | 2178.9                          |

# **APPENDIX D**

**INVESTIGATIONS AND ANALYSES**



## INVESTIGATION AND ANALYSES

Encroachment of floodplains, such as artificial barriers, reduces the water carrying capacity and increases flood heights, thus increasing flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from the floodplain development against the resulting increased flood hazard.

For purposes of the flood insurance program the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 1% recurring floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of the stream plus any adjacent floodplain areas that must be kept free of encroachment in order that the 1% recurring flood can be carried without a substantial increase in flood heights. In Nebraska the minimum standard used to define the 1% floodway is described in the Nebraska Revised Statutes of 1943 under Sections 31-1001 through 31-1031 (Reference 13). In this standard the encroachment in the floodplain is limited to that which will cause only an insignificant increase in flood heights. The Nebraska Department of Water Resources has defined that the floodway be determined using no more than a 1 foot surcharge. The 1 foot surcharge floodway proposed for this study was computed by equal conveyance reduction from each side of the floodplain.

As shown in the Supplement of Floodway Maps, the floodway boundaries were determined at individual cross sections. Between the cross sections the boundaries are interpolated.

The area between the floodway and boundary of 1% recurring flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the floodplain that could be completely obstructed without increasing the water surface elevations of the 1% flood more than 1 foot at any point. The typical relationship between the floodway fringe and the floodway are shown in the floodway schematic (Figure 3).

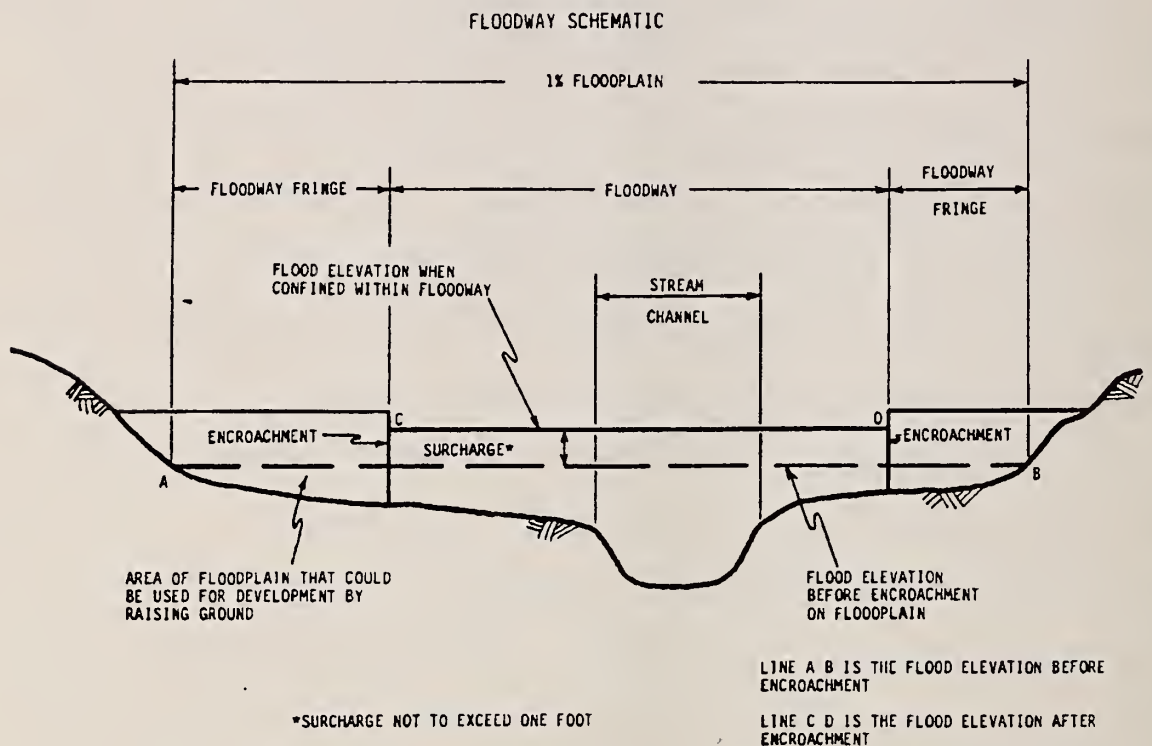


Figure 3

Uses of the floodway are allowable providing they do not restrict flow in any way causing an increase in flow depths. Also no structure for human habitation is permitted in the floodway. Any use of the fringe area is permissible, provided any structure in the fringe area must have its first floor elevation one foot above the 1% recurrence interval flood elevation.

Field surveys were made of bridges, roads, structures, and the channel and floodplain within the study area to represent the hydraulic characteristics of the stream system in 1983. Surveys were made using third order accuracy. To be classed as third order accuracy, the error of closure should not be more than the product of 0.05 times the square root of the length surveyed in miles.

For the Lower Wood River, 54 valley and channel cross-sections plus 54 roads, bridges, and structures were surveyed by the NNRC. Twenty-five valley and channel cross sections plus seven road and bridge sections were provided by Kirkham, Michael and Associates (Reference 14). Aerial photography flown May 1985 (Reference 15) was used as a base for the Flood Hazard Maps used to delineate the floodplain.

Physical data was obtained from USGS topographic maps (Reference 16), soil survey maps (Reference 4, 5), local topographic maps, and aerial photographs (Reference 15), as well as on-site field inspections. The watershed boundary was determined from both map studies and field checks. The watershed was divided into 55 sub-areas. Drainage areas for the sub-areas were measured. Times of concentration were calculated for each of the sub-watersheds.

Channel flood routings to establish peak discharge-frequency relationships were made using the Computer Program for Project Formulation Hydrology, Technical Release 20 (TR20), dated September 1, 1983 (Reference 17), and U.S. Department of Agriculture computer facilities. The Modified Attenuation-Kinematic (Att-Kin) method of routing through stream channels is used by this program.

This method is derived from inflow-outflow hydrograph relationships. Several types of data were used in developing this watershed model. Drainage area, hydrologic soil groups, and land use and cover were used to develop runoff hydrographs.

Temporary flood water storage at several of the road culverts and bridges was recognized as a potential to modify downstream peak discharges. Data was gathered and evaluated. Opening sizes and type, head available from the top of opening to top of road fill, and storage shapes were determined.

The watershed model was calibrated using three stream gauges. Stream gauge 06771000 is located at the outlet of the Upper Wood River watershed, 1.5 miles northwest of Riverdale. Another stream gauge, 06771500, is located 2.5 miles northeast of Gibbon, downstream from bridge on County Highway. The third stream gauge used is 06772000, located 1.2 miles south of Alda. These gauges were evaluated using Bulletin 17B Guidelines for Determining Flood Flow Frequency (Reference 18). Other studies of Hall County and the City of Wood River by Kirkham, Michael and Associates (References 8, 9) were used in the calibration.

An analysis of the hydraulic characteristics of the creeks was carried out to provide stage estimates for floods of selected recurrence intervals along each of the streams. The water surface elevations (stage) were established based upon the physical elements present such as the channel size and shape, the floodplain size and shape, the bridge sizes and shapes, and the Manning's roughness coefficients (Reference 19). The hydraulic computations were made using the SCS Hydraulic Model WSP-2, Technical Release 61 (TR61)



(Reference 20). This model employs the standard step method for backwater profiles. The method involves a computational procedure which estimates total energy at each stream cross section and accounts for friction losses between sections. The bridge effects on stream hydraulics were accounted for in TR61 using the Bureau of Public Roads (BPR) Method (Reference 21). The bridge method has been formulated by the principle of conservation of energy between the point of maximum backwater upstream from the bridge and a point downstream from the bridge at which normal stage has been established. The culverts were evaluated by the principle of conservation of energy and consideration of the depth of headwater and tailwater, the barrel shape and cross-sectional areas, the type of inlet, and shape of headwall.

Economic analysis was performed by the use of the ECON-2 computer program (Reference 22). This includes the determination of crop and pasture, other-agriculture and non-agricultural damages. Basically, three types of input data are required: economic, hydraulic and hydrologic related data.

The ECON-2 program is designed to use hydraulic and hydrologic data from flood routing as part of the input data. It can be used, therefore, to appraise floodwater damages when the acres flooded have been determined. The program computes the average annual damages to crops and pasture where floodwater damages can be related to flood depths or elevations. Some types of damage such as damage to the land from voiding through gully encroachment or bank caving, and deposition of sediment have not been included in the program. These types of damages often are not correlated directly with flood peaks and their causal factors are not subject to hydrologic analysis.

For the economic input section of ECON-2, several processes need to be completed. The major tasks are determining the crop distribution, crop yields, and the composite acre value of land use for each reach in the flood plain.

The method used for determining crop distribution in each reach of the floodplain was to secure recent aerial photographs and make a detailed inspection of the photographs. With the use of the aerial photographs an estimation was made of the acres of pasture, cropland and miscellaneous land uses in each one half section that the creek ran through. The percentages of crops irrigated and the kinds and percentages of crops grown were determined by field inspection and by using Nebraska Agricultural Statistics county data (Reference 23).

After the crop distribution is determined it is displayed by reach for the ECON-2 program. There are certain economic factors that are considered in determining the length of a reach to be studied and the number of cross-sections within this reach. Some of the economic factors are the uniformity of the crop distribution, the fertility and width of floodplain, and the total value of a floodplain acre. Ordinarily, if crops and values subject to damage do not differ significantly and there is no localized effect of a structural measure, such as channel improvement, several cross-sections can be combined into one evaluation reach for damage analysis. The reaches that were chosen are shown in Figure 1.

Crop yields were determined by using two general sources: 1) Nebraska Agricultural Statistics data (Reference 23); 2) SCS published soil surveys (Reference 4, 5). Specific soils in the floodplains were identified. Crop yields were weighted according to the percentage of those soils in Buffalo, and Hall Counties.

A five year county average yield was calculated from Nebraska Agricultural Statistics. These county average yields were then adjusted for floodplain yields by applying a ratio derived from the differences between floodplain soil yields and whole county average soil yields in the SCS published soil surveys.

Crop prices for ECON-2 are obtained from the United States Department of Agriculture. The crop prices are derived by using information obtained from a structural econometric model of the agricultural sector as well as inputs from commodity specialists in the Economic Research Service. The simulation model procedure was used to minimize short-run distortions in market prices caused by such factors as abnormal weather patterns and short-term fluctuations in the foreign demand for agricultural products. Commodity specialists then used the model results to derive consistent commodity prices and indices for those commodities not included in the simulation model.

Considering the crop distribution in the floodplain, the average yields of the crops, and current normalized prices, a composite damageable value per acre of floodplain was determined. This value for reach 1 is \$190.29 per acre (Table 10).

TABLE 10

Composite Value Per Acre of Flooded Area for Reach 1

| Crop in Flooded Area | Yield Per Acre (Flood Free) | Value Per 1/ Unit | Value Per Acre | Percent of Crop in Area | Crop Composite Value |
|----------------------|-----------------------------|-------------------|----------------|-------------------------|----------------------|
|                      |                             | (\$)              | (\$/acre)      |                         | (\$/acre)            |
| Corn                 | 97 bu.                      | 1.71              | 165.87         | 1.9                     | 3.15                 |
| Corn(Irr.)           | 151 bu.                     | 1.71              | 258.21         | 61.3                    | 158.28               |
| Grain Sorg.          | 83 bu.                      | 1.58              | 131.14         | 2.7                     | 3.54                 |
| Grain Sorg.(Irr)     | 94 bu.                      | 1.58              | 148.52         | 0.5                     | 0.74                 |
| Soybeans             | 31 bu.                      | 4.12              | 127.72         | 0.9                     | 1.15                 |
| Soybeans (Irr.)      | 50 bu.                      | 4.12              | 206.00         | 3.8                     | 7.83                 |
| Alfalfa              | 4.4 tons                    | 29.40             | 129.36         | 3.0                     | 3.88                 |
| Alfalfa (Irr.)       | 6.3 tons                    | 29.40             | 185.22         | 1.7                     | 3.15                 |
| Wheat                | 46 bu.                      | 2.16              | 99.36          | 2.8                     | 2.78                 |
| Wheat (Irr.)         | 59 bu.                      | 2.16              | 127.44         | 0.4                     | 0.51                 |
| Pasture              | 3.0 A.U.M. <u>2/</u>        | 10.35             | 31.05          | 17.0                    | 5.28                 |
| Misc.                | 0                           | 0                 | 0              | 4.0                     |                      |
| Total                |                             |                   |                | 100                     | 190.29               |

1/ Price Base - 1987 current normalized prices2/ Animal Unit Month

Damage factors for ECON-2 are derived for each crop. The month of the growing season and the depth of flooding are both considered in deriving the factors. The depth of water is given in these ranges: 0-1 feet, 1-3 feet, and any depth greater than 3 feet. The percent damage to a given crop at each depth increment of flooding during a given month is used by the computer.

The damage factors used allow for normal duration of flooding, but in some cases additional duration of flooding should be considered. Where this is the case, an adjustment in the basic damage factor to account for the added duration can be made.

The crop damage factors are given by month because at different times of the year the crops are more susceptible to damage from flooding than during other months. For example, six inches of water in May or June causes more damage to corn than six inches in August when the corn is more mature.

The damage is expressed as a percentage of the gross value (price times yield) of the crop if it were undamaged. Included in the damage calculation is the physical loss in yield together with any reduction in value per unit, plus additional production costs incurred, minus expenses saved, such as harvesting, hauling, and storing. The theoretical basis for this approach is that when a farmer reserves part of his land for a given crop, he has done so with the expectation of obtaining a certain return based upon yield, price, and normal production expenses. A flood which affects any of these factors unfavorably will reduce his net income.

Included in the ECON-2 input data is the percent chance of floods and the storm series. The data should list the percent chance of occurrence of the largest storm first and other evaluated storms will be listed in descending order.

The seasonal distribution of floods is also taken into account when making economic evaluations. This is necessary because of the difference in flood damage resulting from given flood stages during different periods of plant growth. The flood distribution refers to the percent of the total number of floods for a given year that occur in the months the soil is not frozen.

# APPENDIX E

ELEVATION BENCH MARKS





U.S.G.S. BENCHES  
used in  
LOWER WOOD RIVER  
Hall and Buffalo Counties

| Bench Mark Number | Elevation MSL | Bench Mark Description                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| B 5               | 2026.010      | About 1.4 miles SW along PRR from Shelton, Buffalo County, about 1464' SW of milepost 171, 120' W of semaphores, 171.3 & 171.2 at county road crossing, 58' E of center line of road, about 174' S of center line of US #30, 43.1' S of S rail of S main track, 20' E of E ROW fence of road and 5' N of S RR ROW fence. A standard disk stamped "2026.010 B5 1933." Set in top of conc. post projecting 3" above ground. Gibbon North Quad. |
| B 293 Reset 1958  | 2192.079      | 0.6 miles NW along State Highway #40 from UPRR station at Riverdale, between the highway and tracks, 47.5' NE of NE rail of tracks, 40' SW of center line of highway, 45' SW of telephone pole, 134' NW of a telephone pole, 101' NE of SW RR ROW fence, 2' SW of white wooden witness post, set in top of a conc. post projecting 0.2' above ground. Riverdale Quad.                                                                        |
| C 287             | 2012.171      | 0.35 mile SW along UPRR from station at Shelton, thence 2.5 miles S along a graveled road, 83' W of N-S road, 32' S of center line of T-road leading W, 45' W of center of wire gate, 34' NW of center line of private road leading SW through a pasture, 2' S of fence, 2.8' E of reference post, set in top of conc. post projecting 0.8' above ground. Denman Quad.                                                                       |
| C 293             | 2175.888      | 1.1 mile SE along State Highway #40 from UPRR station at Riverdale, between highway and tracks, 79' NW of center line of gate, 43' NE of NE rail of tracks, 39' SW of center line of highway, 5' SW of Fence, 3' SE of milepost 9, 1.5' NW of reference post, set in top of conc. post projecting 0.2' above ground. Riverdale Quad.                                                                                                         |
| D 5               | 2060.327      | At Gibbon, Buffalo County, 186' NE of SE corner of UPRR station, 190' NE of milepost 176, 102' W of center line of road, 44' E of semaphore, 58' S of center line of US #30 and 17.6' N of N rail of N main track. Standard disk stamped "2060.371 D5 1933" and set in top of conc. post projecting 4" above ground. Gibbon North Quad.                                                                                                      |

| <u>Bench Mark Number</u> | <u>Elevation MSL</u> | <u>Bench Mark Description</u>                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------------|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| E 5                      | 2075.042             | About 1.7 miles SW along UPRR from Gibbon, Buffalo County, about 0.6 mile NE of milepost 178, 640' W of semaphores 177.5 and 177.6 at county road crossing, 75' S of center line of US #30, 45' N of N rail of N main track, 35' E of center line of road, 5' E of E ROW fence of road, 4.4' S of N RR ROW fence. Standard disk stamped "2075.042 E5 1933" and set in top of a conc. post projecting 1" above ground. Gibbon South Quad. |
| G 5                      | 2095.248             | About 8.2 miles NE along UPRR from station at Kearney, Buffalo County, 0.2 miles NE of milepost 181, at county road crossing, 55' W of center line of road, 80' S of center line of US #30, 43.4' N of N rail of N main track, 13.4' W of W ROW fence of road, and 4' S of N RR ROW fence. A standard disk stamped "2095.248 G5 1933" and set up in top of a conc. post projecting 2" above ground. Newark Quad.                         |
| H 5                      | 2115.229             | About 6.1 miles NE along UPRR from station at Kearney, Buffalo County, 742' NE of milepost 183, at county road crossing, 85' S of center line of US #30, 44.8' N of N rail of N main track, 41' E of center line of the road, 5.2' E of E ROW fence of road, 4.4' S of N RR fence. A standard disk stamped "2115.229 H5 1933" and set in conc. post projecting 3" above ground. Newark Quad.                                             |
| J 279                    | 1926.653             | 1.85 miles SW along UPRR from station at Alda, 97' N of center line of private road leading E, 54' E of center line of N-S road, 46' SE of SE rail of SE set of tracks, 25' NE of a fenc corner post, 1.6' NW of ROW fence, 1.7' SW of reference post, set in top of conc. post projecting 0.3' above ground. Wood River Quad.                                                                                                           |
| J 285                    | 2015.678             | At Shelton, 0.4 mile N along county road from post office, 160' SW of center line of county road with tangents leading S and NW, 53' N of center line of E-W road, 42' E of NE corner of garage, 12' SE of SW corner of Ralph Urwiller home 0.6' W of W edge of conc. sidewalk, set in top of conc. post and projecting 0.2' above ground. Shelton Quad.                                                                                 |
| K 287                    | 1959.766             | 0.7 mile NE along UPRR from station at Wood River at road crossing, 86' W of center line of N-S road, 68' SW of W end of 24" CMP 46' SE of SE rail of SE set of tracks, 1.6' NW of ROW fence, 2.4' SW of reference post, set in conc. post projecting 0.6' above ground. Wood River Quad.                                                                                                                                                |

| Bench Mark Number | Elevation MSL | Bench Mark Description                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| M 279             | 1942.850      | 3.5 miles SW along UPRR from station at Alda, set in SE end of SW abutment of Bridge #158.00 over Wood River, 30' NE of center line of private road to farmhouse, 4.7' SE of SE rail of SE set of tracks, 2.0' W of SW end of SW girder of the bridge and 1.5' below top of rail. Wood River Quad.                                                                                                                   |
| N 279             | 1945.997      | 3.5 miles NE along UPRR from station at Wood River, 9 rails NE of private road crossing, 47' SE of SE rail of SE set of tracks, 13' SW of mile post, 159', 1' NW of ROW fence, 2' NE of reference post, and set in top of conc. post projecting 1.0' above ground. Wood River Quad.                                                                                                                                  |
| P 279             | 1948.388      | 2.35 miles NE along UPRR from station at Wood River, 5 rails NE of Wood River 1 Mile sign post, 1 pole SW of mile post 160, 46' SE of SE rail of SE set of tracks, 1.0' NW of ROW fence, 2.0' NE of reference post and set in top of conc. post projecting 0.5' above ground. Wood River Quad.                                                                                                                       |
| P 295 Reset       | 2179.557      | At Riverdale, at SE edge of town, between Highway #40 and UPRR tracks, about 470' S of public school, 65' W of center line of N-S road, 40' SW of center line of highway, 47.5' NE of NE rail of tracks, 43' W of SW corner of conc. headwall of culvert, 25.5' East of telephone pole, 52.5' NW of power pole, 154' S of SW corner of house, set in top of conc. post projecting 0.2' above ground. Riverdale Quad. |
| Q 279             | 1955.301      | 1.35 mile NE along UPRR from station at Wood River, at private road crossing, 109' E of center line of crossing, 47' SE of SE rail of SE set of tracks, 43' SW of milepost 161, 1.2' NW of ROW fence, 1.7' NE of reference post, set in top of conc. post projecting 0.5' above ground. Wood River Quad.                                                                                                             |
| R 279             | 1989.727      | 3.6 miles SW along UPRR from station at Wood River, at road crossing, 3 poles NE of mile post 166, 126' N of extended center line of road leading F from T-junction road, 57' W of center line of N-S road, 46' SE of SE rail of SE track, 28' SW of fence corner post, 2.0 SW of reference post, 1.5' NW of ROW fence and set in top of conc. post projecting 0.5' above ground. Shelton Quad.                      |

| <u>Bench Mark Number</u> | <u>Elevation MSL</u> | <u>Bench Mark Description</u>                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| S 287                    | 1959.934             | 0.7 mile NE along UPRR from station at Wood River, thence 3.65 miles S along gravel road, at farm of S. J. Abbot and occupied by Elmer Gosda, 142' N of center line of private drive, 104' E of center line of N-S road, 84' NW of NW corner of house, 2.0' S of reference post, set in top of conc. post projecting 0.5' above ground. Wood River Quad.                                              |
| T 291                    | 2017.352             | 1.5 miles N along county road from post office at Shelton, at SW corner of Sec. 25-10N-13W, in NW $\frac{1}{4}$ of public road crossing, 37' N of center line of E-W road, 36' E of center line of N-S road, 1.3' NE of power pole, 2' W of reference post, set in top of conc. post projecting 0.2' above ground. Shelton Quad.                                                                      |
| U 287                    | 1962.588             | 0.7 mile NE along UPRR from station at Wood River, thence 1.5 miles S along graveled road at farm of M. J. McDermott, set between two most Easterly trees in row of evergreens on S side of drive, 98' SE of SE corner of house, 60' W of center line of N-S road, 17' S of center line of private driveway, 8.0' N of fence, set in top of conc. post projecting 0.5' above ground. Wood River Quad. |
| V 287                    | 1975.213             | 1.5 miles SW along UPRR from station at Wood River, 99' W of center line of N-S road, 78' SW of fence corner post, 46' SE of SE rail of SE set of tracks. 1.0' NW of ROW fence, 2.8' W of reference post, set in top of conc. post projecting 0.5' above ground. Shelton Quad.                                                                                                                        |
| Z 4                      | 1977.752             | 4.7 miles SW along UPRR from Wood River, Hall County, about 925' NE of semaphores 167.1 & 167.2, about 24' E of mile post 167 at county road crossing, 189' S of center line of US #30, 46' E of center line of road, 43.4' S of S rail of S main track, 4' N of S row fence. A standard disk stamped "1977.752 Z4 1933" and set in top of conc. post projecting 3" above ground. Shelton Quad.       |
| Z 292 Reset              | 2200.388             | 1.6 miles NW along State Highway #40 from UPRR station at Riverdale, about 0.3 mile SE of a large 2-story farm house on NE side of highway, between highway and RR tracks, on top of cut bank, 47' NE of NE rail of track, 42' SW of center line of highway, 1.0' SW of fence, 1.6' NW of a reference post, set in top of conc. post projecting 0.2' above ground. Riverdale Quad.                    |

Other bench marks and temporary bench marks were established by the Nebraska Natural Resources Commission in 1984. For a complete listing of these bench marks, contact the Nebraska Natural Resources Commission or the Soil Conservation Service State Office in Lincoln, Nebraska.



# **APPENDIX F**

## **FLOODWAY MAPS**





The floodway maps are distributed under a separate cover. This is to avoid the rescinding of the flood plain management study should a community or land owner choose to realign the floodway. The floodway is selected by an equal reduction in conveyance from both sides of the floodplain. As long as the depth in flow is not increased by more than a foot, the reduction in flow area can be taken from either side of the floodplain. Therefore, an adjustment in alignment of the floodway is possible.

For a copy of Appendix F - Floodway Maps, contact the local Soil Conservation Service Office.



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Appendix

# Appendix F - Floodway Maps

## FLOOD PLAIN

## MANAGEMENT

## STUDY



# LOWER WOOD RIVER

Buffalo and Hall Counties, Nebraska

prepared by:

United States  
Department of  
Agriculture

Soil Conservation  
Service  
Lincoln, Nebraska

Nebraska Natural  
Resources Commission  
Lincoln, Nebraska

for:

Central Platte Natural Resources District

April 1990

AD-33 Bookplate  
(1-68)

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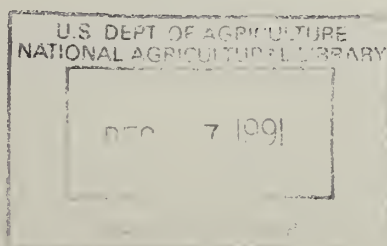
**LIBRARY**

## FLOODWAY MAPS

This is Appendix F of the Lower Wood River Flood Plain Management Study (FPMS). For detailed information about the watershed, information about the procedure used to perform the study, or more about the hydrology and hydraulics of the area see the Lower Wood River Flood Plain Management Study dated February 1990. This is the proposed floodway based on an equal reduction in conveyance on both sides of the floodplain. This floodway is subject to change by communities and landowners in the watershed, thus it is being distributed separately.

Encroachment of floodplains, such as artificial barriers, reduces the water carrying capacity and increases flood heights, thus increasing flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from the floodplain development against the resulting increased flood hazard.

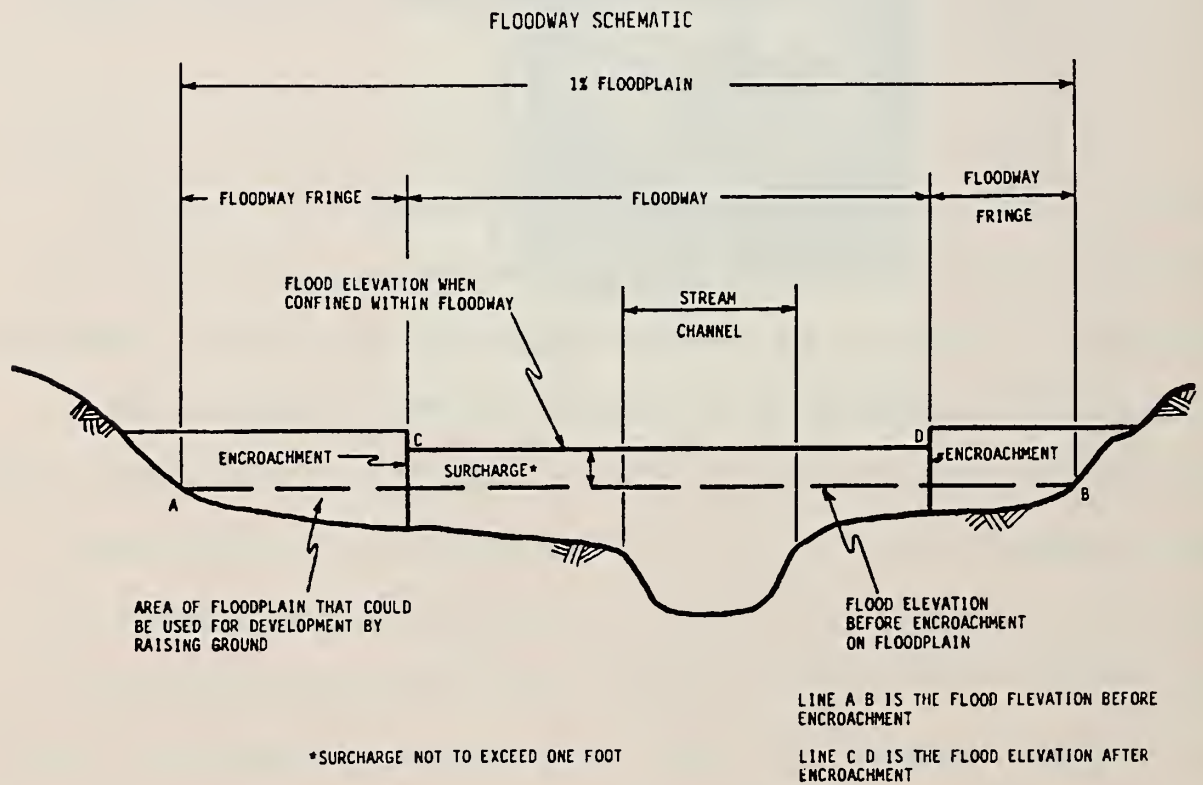
For purposes of the flood insurance program the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 1% recurring floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of the stream plus any adjacent floodplain areas that must be kept free of encroachment in order that the 1% recurring flood can be carried without a substantial increase in flood heights. In Nebraska the minimum standard used to define the 1% floodway is described in the Nebraska Revised Statutes of 1943 under Sections 31-1001 through 31-1031. In this standard the encroachment in the floodplain is limited to that which will cause only an insignificant increase



in flood heights. The Nebraska Department of Water Resources has defined that the floodway be determined using no more than a 1 foot surcharge. The 1 foot surcharge floodway proposed for this study was computed by equal conveyance reduction from each side of the floodplain.

The floodway boundaries were determined at individual cross sections. Between the cross sections the boundaries are interpolated.

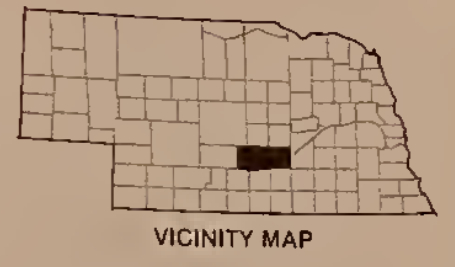
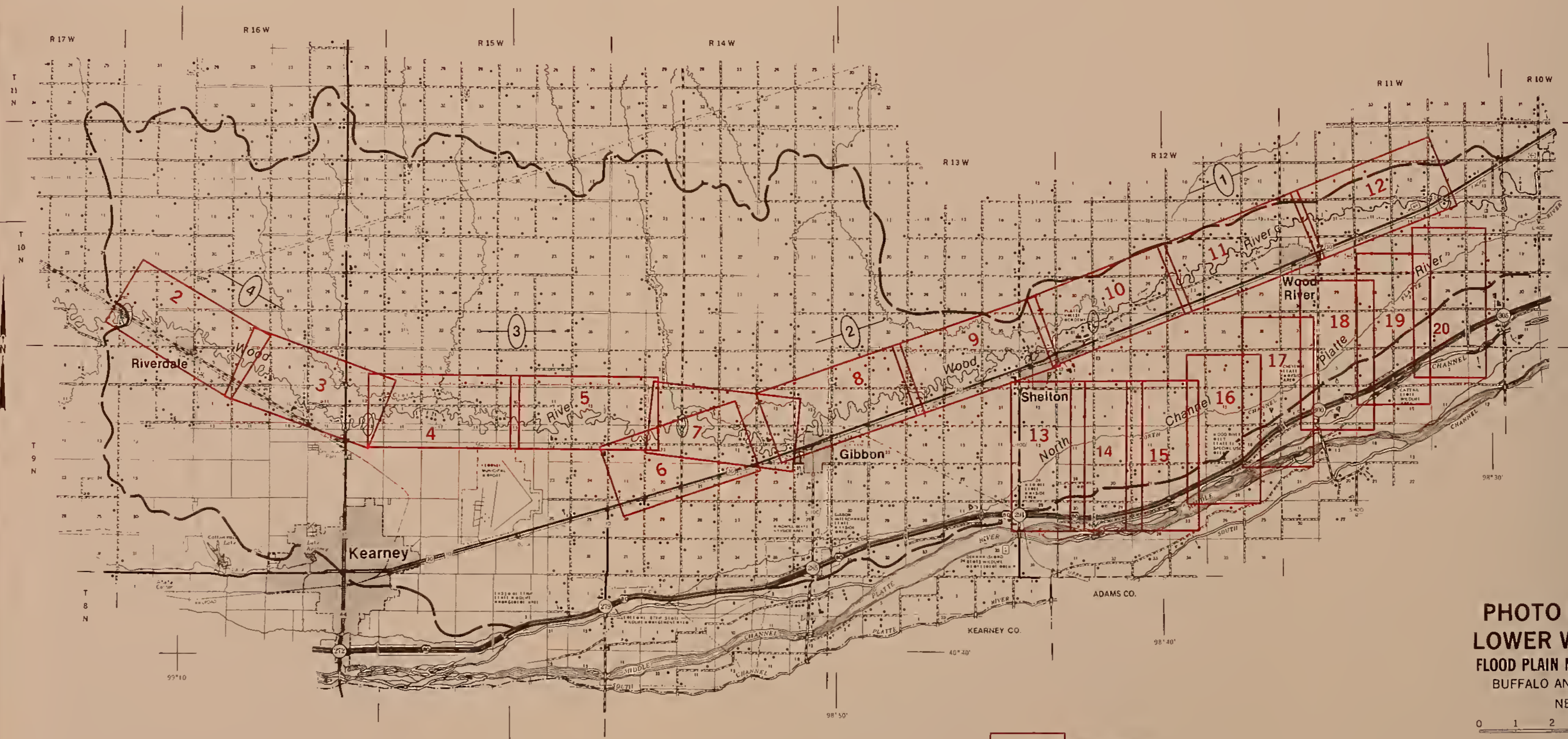
The area between the floodway and boundary of 1% recurring flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the floodplain that could be completely obstructed without increasing the water surface elevations of the 1% flood more than 1 foot at any point. The typical relationship between the floodway fringe and the floodway are shown in the following schematic.





Uses of the floodway are allowable providing they do not restrict flow in any way causing an increase in flow depths. Also no structure for human habitation is permitted in the floodway. Any use of the fringe area is permissible, provided any structure in the fringe area must have its first floor elevation one foot above the 1% recurrence interval flood elevation.





**PHOTO MAP INDEX  
LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES  
NEBRASKA**



**20** Sheet Location

**4** Evaluation Reach

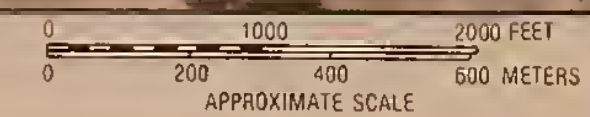
SOURCE  
1976 COUNTY HIGHWAY MAPS AND  
INFORMATION FROM SCS FIELD PERSONNEL  
LAMBERT CONFORMAL CONIC PROJECTION





NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
Commission-1985 Photography



**LEGEND**  
 Floodway

--- 100 Year Flood Hazard Area  
 — 500 Year Flood Hazard Area

~2175~ 100 Year Flood Elevation  
 ⊗(4)⊗ Evaluation Reach

①④① Cross Section  
 — Limit of Study

U.S. DEPARTMENT OF AGRICULTURE  
 SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
 FLOOD PLAIN MANAGEMENT STUDY  
 BUFFALO AND HALL COUNTIES, NEBRASKA**

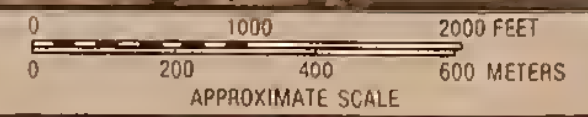
**SHEET  
 2 OF 20**





NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
Commission-1985 Photography



**LEGEND**  
Floodway

100 Year Flood Hazard Area  
500 Year Flood Hazard Area  
2175 100 Year Flood Elevation  
④ Evaluation Reach

140 Cross Section  
Limit of Study

U.S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

SHEET  
3 OF 20

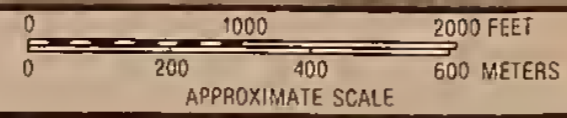






NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
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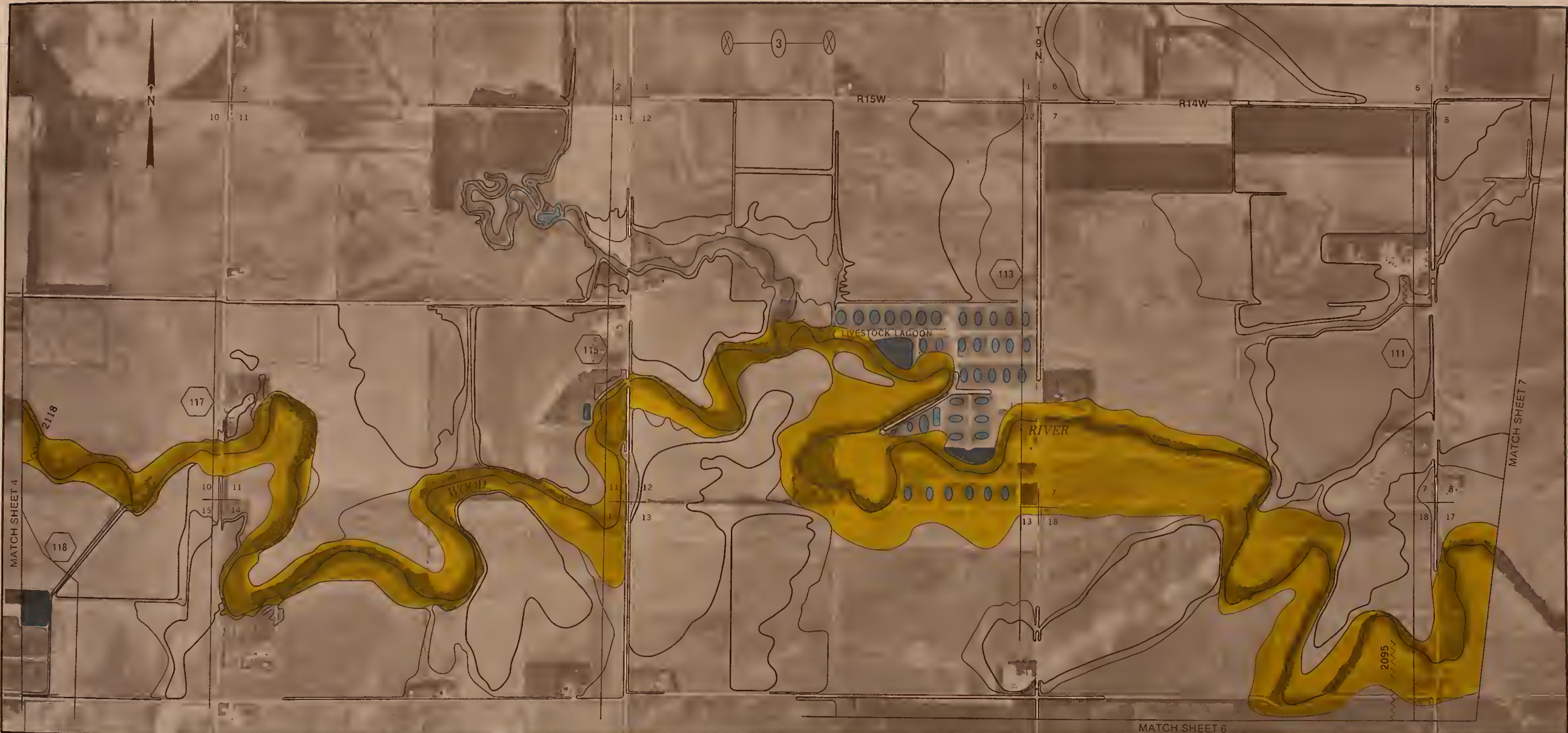
| LEGEND |                            |
|--------|----------------------------|
|        | Floodway                   |
|        | 100 Year Flood Hazard Area |
|        | 500 Year Flood Hazard Area |
|        | 100 Year Flood Elevation   |
|        | Evaluation Reach           |
|        | Cross Section              |
|        | Limit of Study             |

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SOIL CONSERVATION SERVICE

LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA

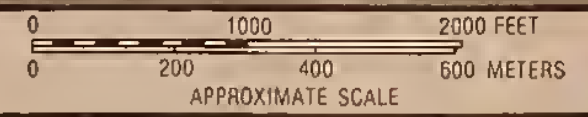
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4 OF 20





NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
Commission-1985 Photography



**LEGEND**

- Floodway
- 100 Year Flood Hazard Area
- 500 Year Flood Hazard Area
- 100 Year Flood Elevation
- 4 Evaluation Reach
- Cross Section
- Limit of Study

U.S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

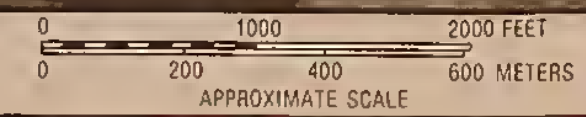
**SHEET  
5 OF 20**





NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
Commission-1985 Photography



| LEGEND |                            |
|--------|----------------------------|
|        | Floodway                   |
|        | 100 Year Flood Hazard Area |
|        | 500 Year Flood Hazard Area |
|        | 100 Year Flood Elevation   |
|        | Evaluation Reach           |

|  |                |
|--|----------------|
|  | Cross Section  |
|  | Limit of Study |

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SOIL CONSERVATION SERVICE

LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA

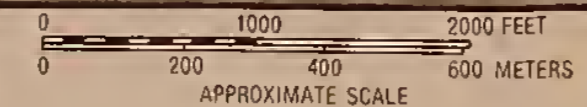
SHEET  
6 OF 20





NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.

Nebraska Natural Resources  
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**LEGEND**

- Floodway
- 100 Year Flood Hazard Area
- 500 Year Flood Hazard Area
- 100 Year Flood Elevation
- Evaluation Reach
- Cross Section
- Limit of Study

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SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

SHEET  
7 OF 20

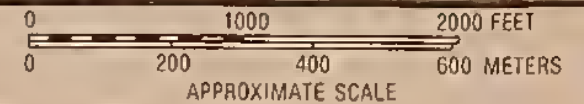






NOTE: LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

Nebraska Natural Resources  
Commission 1985 Photography



**LEGEND**

- Floodway
- 100 Year Flood Hazard Area
- 500 Year Flood Hazard Area
- 100 Year Flood Elevation
- Evaluation Reach

- Cross Section
- Limit of Study

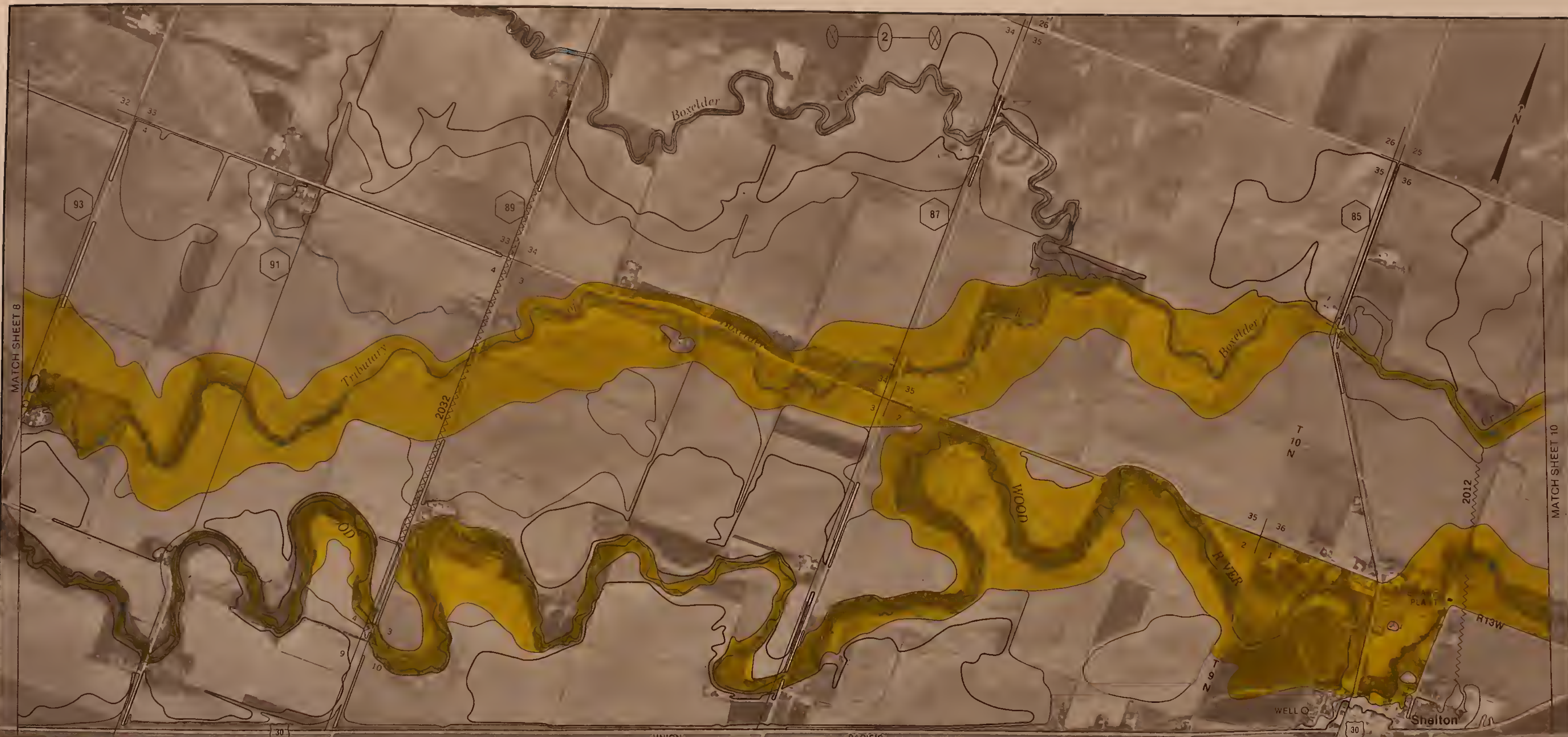
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SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

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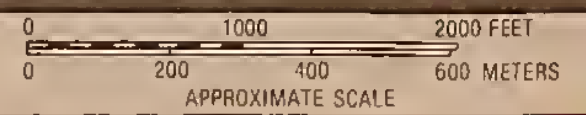
VTLA 2025 NATIONAL CARTOGRAPHIC CENTER, FT. WORTH, TX, 1985





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**LEGEND**  
Floodway

100 Year Flood Hazard Area  
500 Year Flood Hazard Area

2175 100 Year Flood Elevation  
Evaluation Reach

140 Cross Section  
Limit of Study

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SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

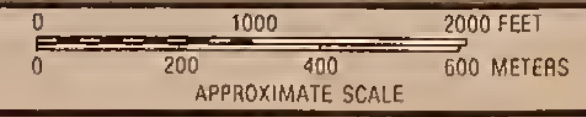
**SHEET  
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| LEGEND |                            |
|--------|----------------------------|
|        | Floodway                   |
|        | 100 Year Flood Hazard Area |
|        | 500 Year Flood Hazard Area |
|        | 100 Year Flood Elevation   |
|        | Evaluation Reach           |

|  |                |
|--|----------------|
|  | Cross Section  |
|  | Limit of Study |

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**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY**  
BUFFALO AND HALL COUNTIES, NEBRASKA

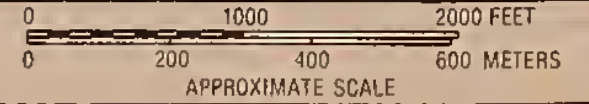
SHEET  
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**LEGEND**  
Floodway

100 Year Flood Hazard Area  
500 Year Flood Hazard Area

2175 100 Year Flood Elevation  
Evaluation Reach

140 Cross Section  
Limit of Study

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SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

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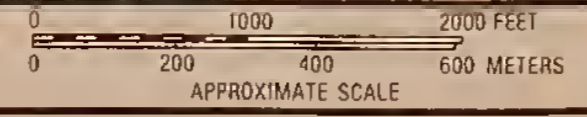






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**LEGEND**  
Floodway

100 Year Flood Hazard Area  
500 Year Flood Hazard Area

2175' 100 Year Flood Elevation  
Evaluation Reach

140 Cross Section  
Limit of Study

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SOIL CONSERVATION SERVICE

**LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA**

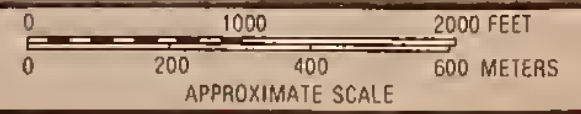
SHEET  
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**LEGEND**  
 ~~~~~ Limit of Study  
 \_\_\_\_\_ Flood Prone Area

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**LOWER WOOD RIVER  
 FLDOD PLAIN MANAGEMENT STUDY  
 BUFFALO AND HALL COUNTIES, NEBRASKA**

**SHEET  
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T 9 R  
MATCH SHEET 13

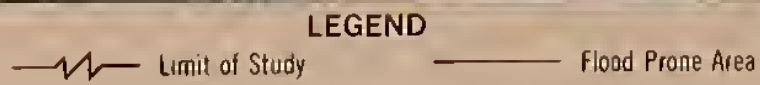
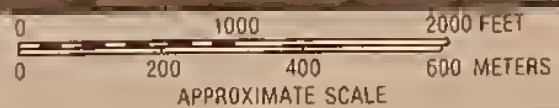
NORTH  
CHINNEL

PLATE  
RIVER

MATCH SHEET 15

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LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA

SHEET  
14 OF 20

AUGUST 1989 1002444



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MATCH SHEET 4

29 20  
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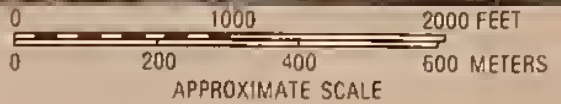
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16  
15

MATCH SHEET 16

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LEGEND

Limit of Study

Flood Prone Area

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SOIL CONSERVATION SERVICE

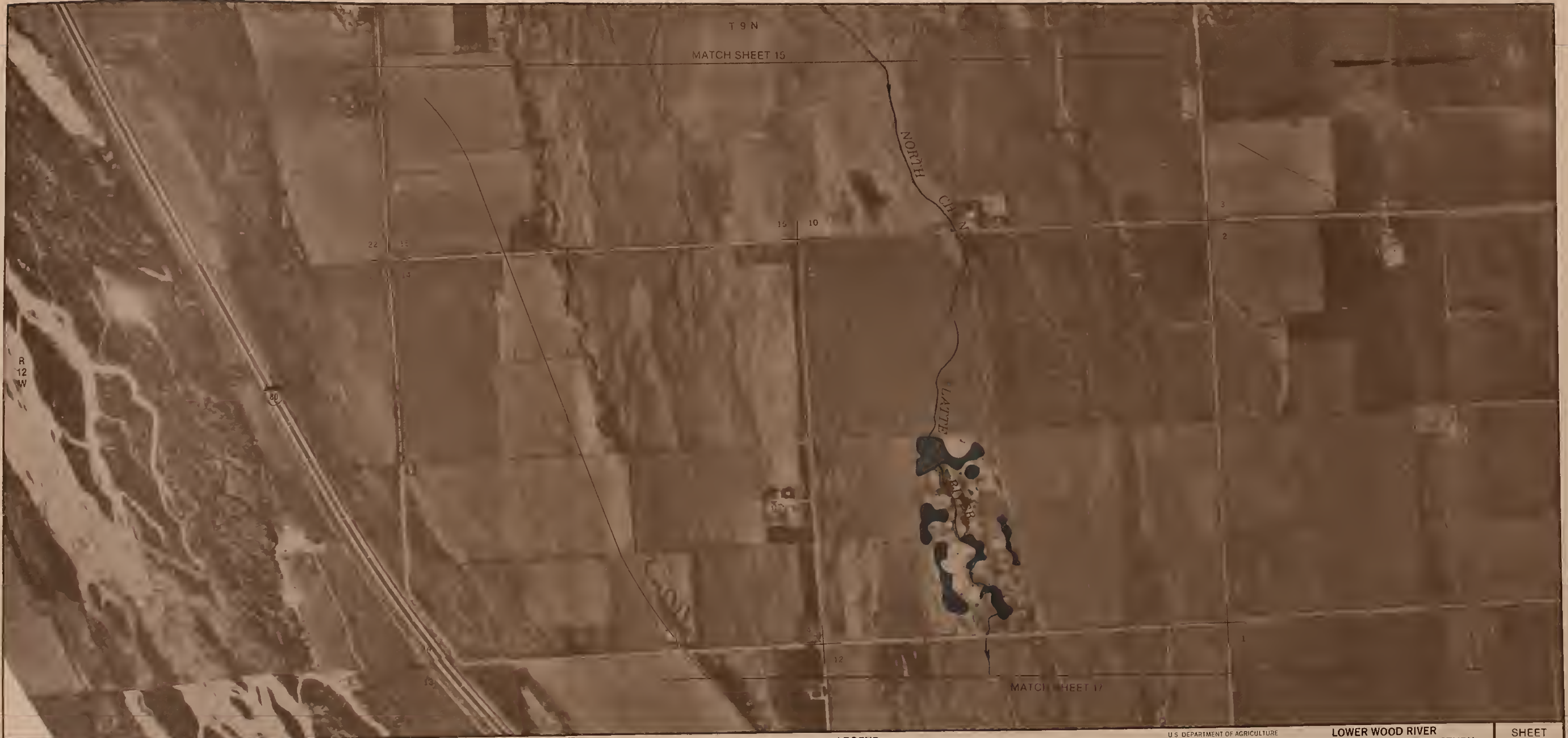
LOWER WOOD RIVER  
FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA

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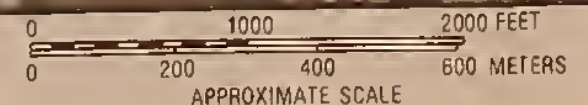






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**LEGEND**  
 - - - - - Limit of Study  
 \_\_\_\_\_ Flood Prone Area

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**LOWER WOOD RIVER  
 FLOOD PLAIN MANAGEMENT STUDY  
 BUFFALO AND HALL COUNTIES, NEBRASKA**

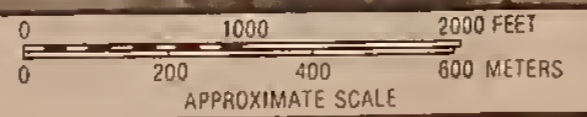
**SHEET  
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FLOOD PLAIN MANAGEMENT STUDY  
BUFFALO AND HALL COUNTIES, NEBRASKA

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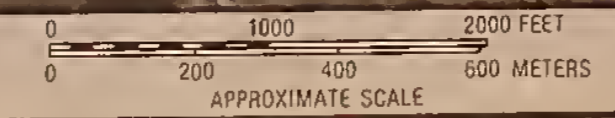






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**LEGEND**  
 - - - - - Limit of Study  
 \_\_\_\_\_ Flood Prone Area

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 FLOOD PLAIN MANAGEMENT STUDY  
 BUFFALO AND HALL COUNTIES, NEBRASKA**

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PHOTOGRAPHIC CENTER, ST. PETERS, MO. 1989

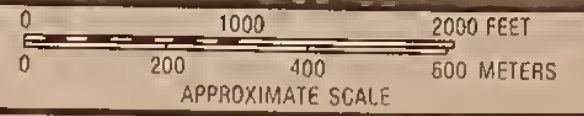






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**LEGEND**  
 Limit of Study  
 Flood Prone Area

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 FLOOD PLAIN MANAGEMENT STUDY  
 BUFFALO AND HALL COUNTIES, NEBRASKA**

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