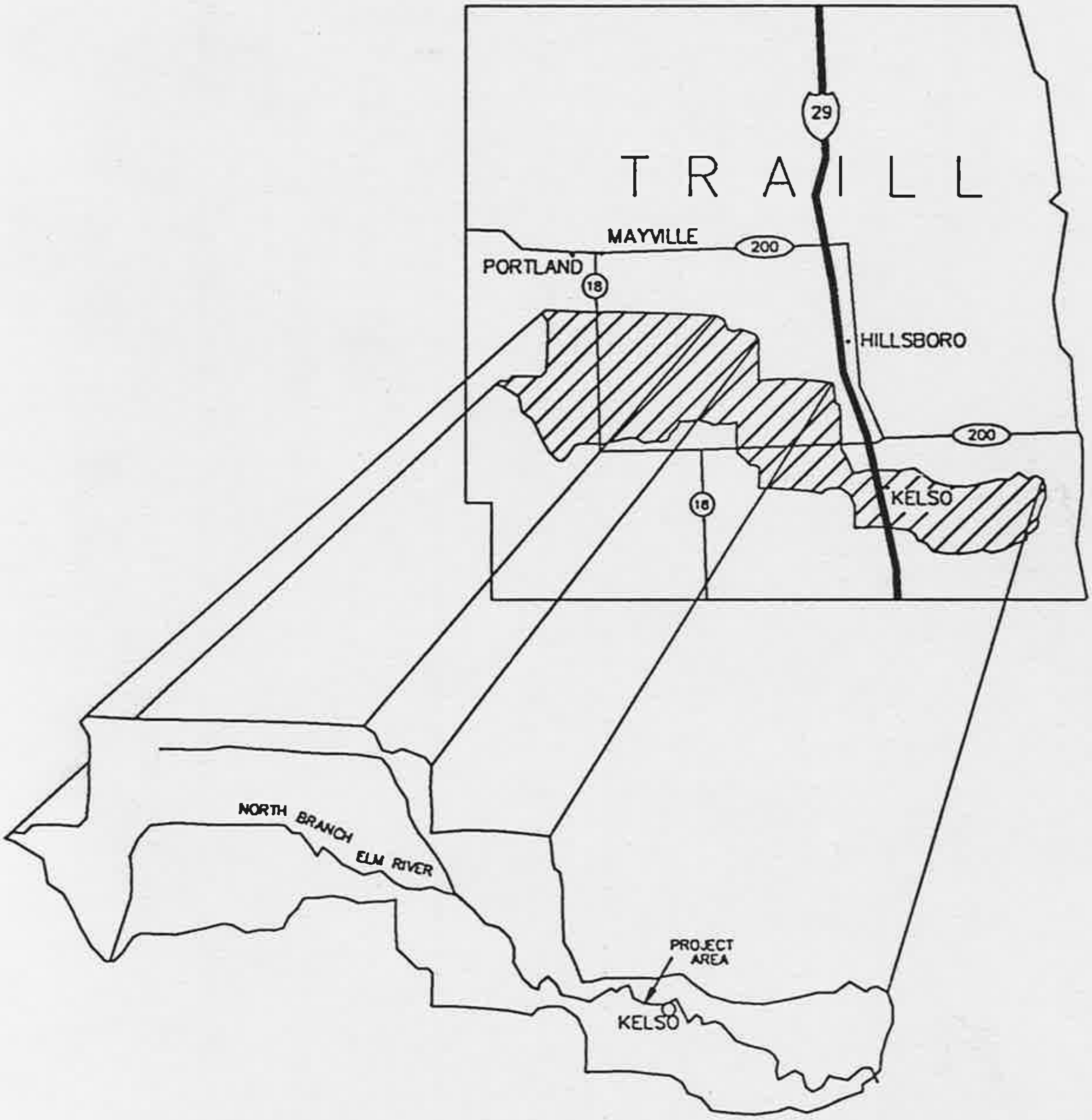
PRELIMINARY ENGINEERING REPORT
NORTH BRANCH OF THE ELM RIVER
FLOOD CONTROL PROJECT
SWC # 1311
TRAILL COUNTY



NORTH DAKOTA
STATE WATER COMMISSION

MARCH 1991

PRELIMINARY ENGINEERING REPORT

North Branch of the Elm River
Flood Control Project
SWC Project #1311

March 1991

North Dakota State Water Commission
900 East Boulevard
Bismarck, North Dakota 58505-0850

Prepared by:

C. Gregg Thielman

C. Gregg Thielman
Water Resource Engineer

Submitted by:

Dale L. Frink

Dale L. Frink, Director
Water Development Division

Approved by:

David A. Sprynczynatyk

David A. Sprynczynatyk, P.E.
State Engineer

TABLE OF CONTENTS

TABLES

TABLE OF CONTENTS (CONT.)

I. INTRODUCTION

Study Objectives:

In August of 1990, the North Dakota State Water Commission and the Traill County Water Resource District entered into an agreement to investigate the feasibility of a flood control project on the North Branch of the Elm River in Traill County. The agreement called for the State Water Commission to conduct a survey of the area to obtain cross-sectional data, conduct a hydraulic analysis on the river to determine water surface elevations for various frequency precipitation events, evaluate alternatives for flood control, prepare a written report documenting the findings of the investigation, and prepare cost estimates for viable alternatives. A copy of the agreement is contained in Appendix A.

This report contains a description of the geology and climate of the site, a summary of the hydrologic and hydraulic analysis performed on the river, a summary of the alternatives considered in the investigation, and a statement of conclusions and recommendations regarding the project.

Basin Location and Description:

The project is located on the North Branch of the Elm River, which is located in the southern one-half of Traill County. The North Branch of the Elm River originates near the city of Clifford, North Dakota. The river flows in a southeasterly direction, eventually entering the main branch of the Elm River

southeast of the city of Kelso, North Dakota. The main branch of the Elm River also flows in a southeasterly direction, eventually entering the Red River of the North. The drainage area for the North Branch of the Elm River is approximately 100 square miles. Figure 1 shows the location of the North Branch of the Elm River within the state of North Dakota and its drainage basin.

Historical Background:

The flooding occurs on the North Branch of the Elm River near the city of Kelso, North Dakota. During high flows, the river breaks out of its channel in a low spot in the SW1/4 of Section 33, Township 145 North, Range 50 West. The channel in this area is generally very shallow, with the bank elevations higher than the surrounding ground. This prevents the breakout flows from returning to the channel. After leaving the channel, the water spreads out towards the north, eventually crossing the railroad tracks and Highway 81 near the center of the section. The water then flows to the northeast corner of Section 33 where it enters a drain adjacent to the section road. This drain eventually joins Nelson Legal Drain (Traill County Drain #28) in Section 36. The recurrence interval of the breakout is approximately every five years. Figure 2 shows the location of the breakout and the path the water follows.

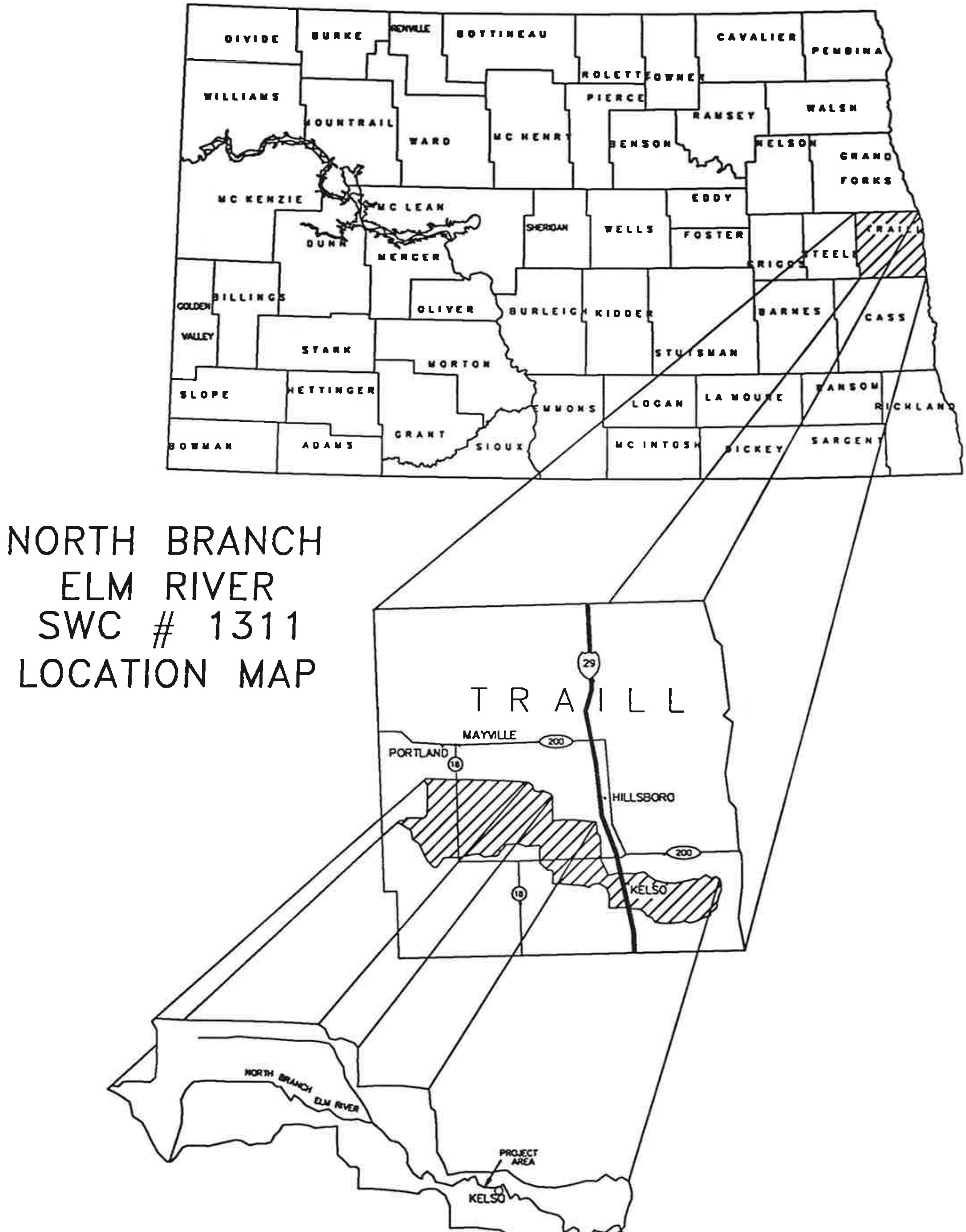


Figure 1 - Location of
The North Branch of the Elm River

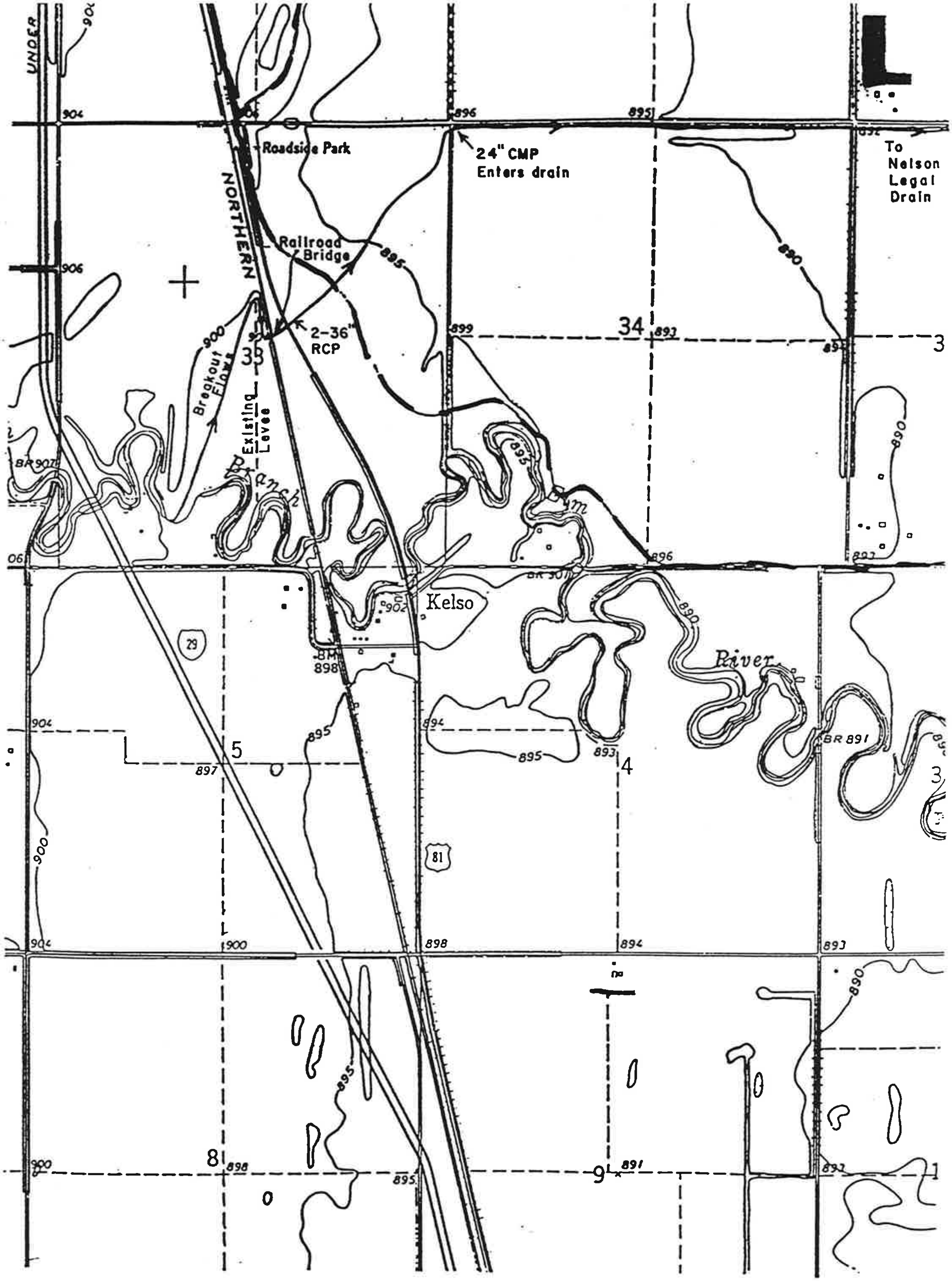


Figure 2
Location of the breakout

II. GEOLOGY AND CLIMATE

The North Branch of the Elm River Basin lies in the Red River Valley lake plain, once occupied by glacial Lake Agassiz. The soils in the basin consist mainly of silt and clay. These soils were most likely deposited in early post-glacial time, during the pluvial period, when greatly increased precipitation resulted in extensive runoff and erosion of areas adjacent to Lake Agassiz and correspondingly rapid deposition of the silts.

The flat topography and nutrient rich soils of the basin make it ideal for agriculture, which is the primary land use in the area. The primary crops grown include wheat, barley, sugar beets, sunflowers, and beans.

The area has a subhumid, continental climate that is characterized by cold winters and warm summers. The average annual precipitation recorded by the U.S. Weather Bureau at nearby Hillsboro, North Dakota is 20.05 inches. The mean annual temperature is +39.0 degrees Fahrenheit.

III. HYDROLOGY

A hydrologic analysis of the watershed was performed using the HEC-1 computer model, developed by the U.S. Army Corps of Engineers. The model was used to determine the peak flows in the North Branch of the Elm River for various frequency precipitation events. HEC-1 formulates a mathematical hydrologic model of the watershed based on the following data: the amount of precipitation, the precipitation distribution, soil type, land use, and the hydraulic characteristics of the channels and drainage areas. The HEC-1 model is designed to calculate the surface runoff of the watershed in relation to precipitation by representing the basin as an interconnected system of hydrologic and hydraulic components. Each component of the model represents an aspect of the precipitation-runoff process within a portion of the subbasin. These components were put into the model to determine the magnitude and duration of runoff from hydrologic events with a range of frequencies.

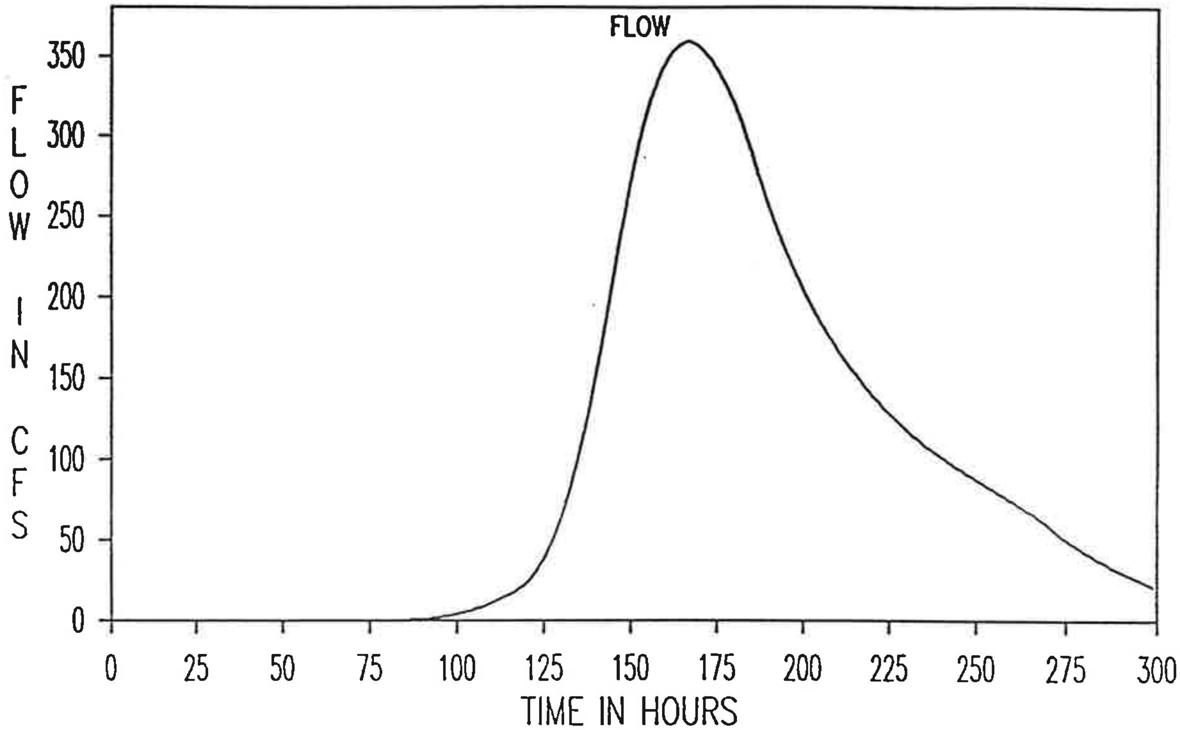
The HEC-1 computer model was used to determine the runoff for the North Branch of the Elm River basin upstream of Section 4. The watershed above this point was defined using USGS 7.5 minute quadrangle maps of the area. The drainage area used for this investigation was calculated to be 84 square miles, of which 83 square miles is contributing. The peak flow was determined for the 10-day snowmelt precipitation event for different recurrence intervals. The 10-day snowmelt was analyzed because the flooding occurs primarily during spring runoff. Table 1 shows the intensity and peak flows for the various events analyzed. Figures 3 and 4 show the flow hydrographs for the various events analyzed.

Table 1 - Intensity and Peak Flows for Snowmelt Events

Event	Intensity (in/interval)	Peak Flow (cfs)
25-year 10-day snowmelt	3.43	1928
10-year 10-day snowmelt	2.40	1287
5-year 10-day snowmelt	1.70	851
2-year 10-day snowmelt	0.90	359

NORTH BRANCH ELM RIVER HYDROGRAPH

2 YEAR 10-DAY SNOWMELT



5 YEAR 10-DAY SNOWMELT

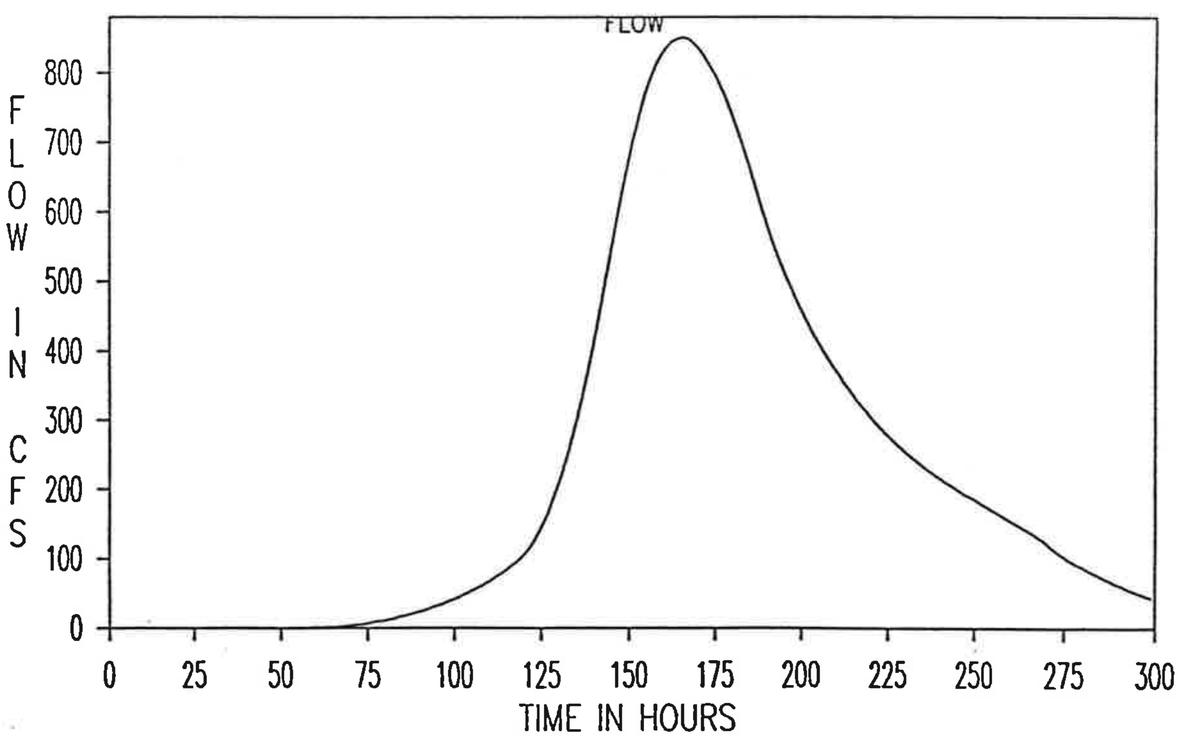
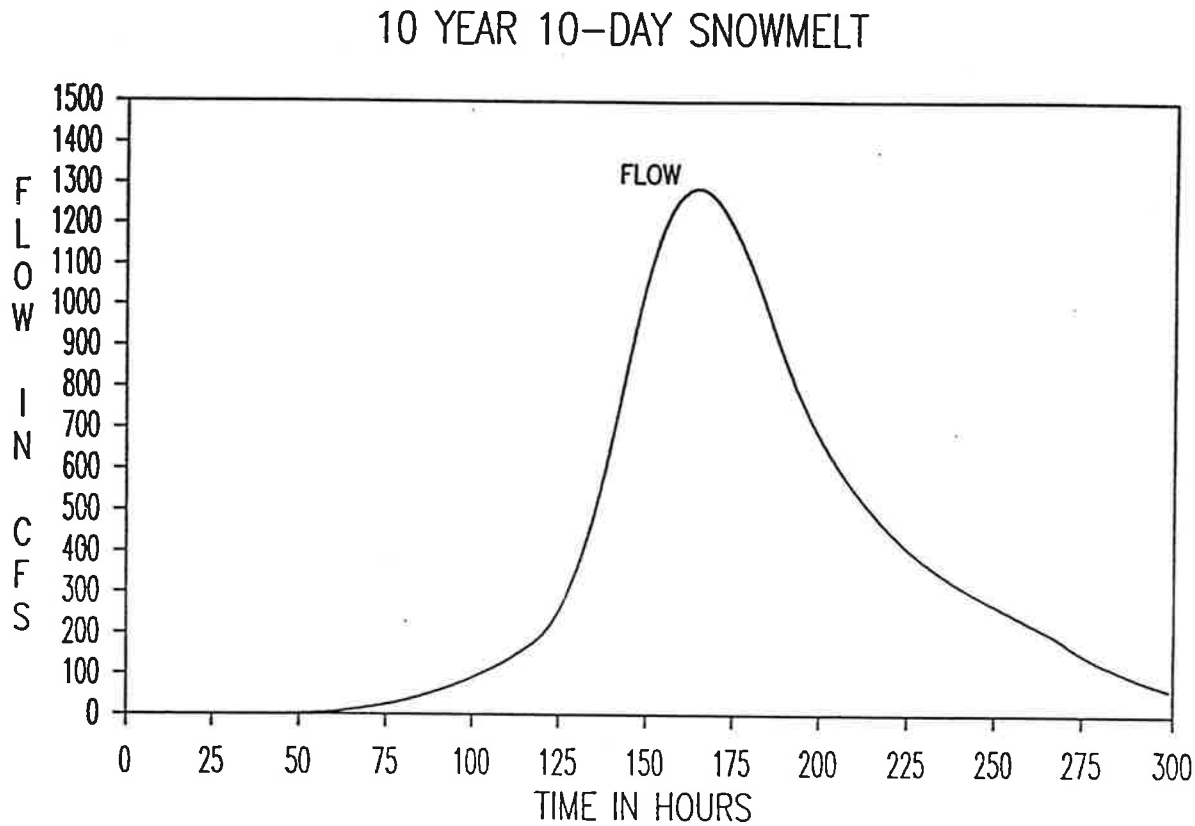


Figure 3 - North Branch of the Elm River Hydrographs

NORTH BRANCH ELM RIVER HYDROGRAPH



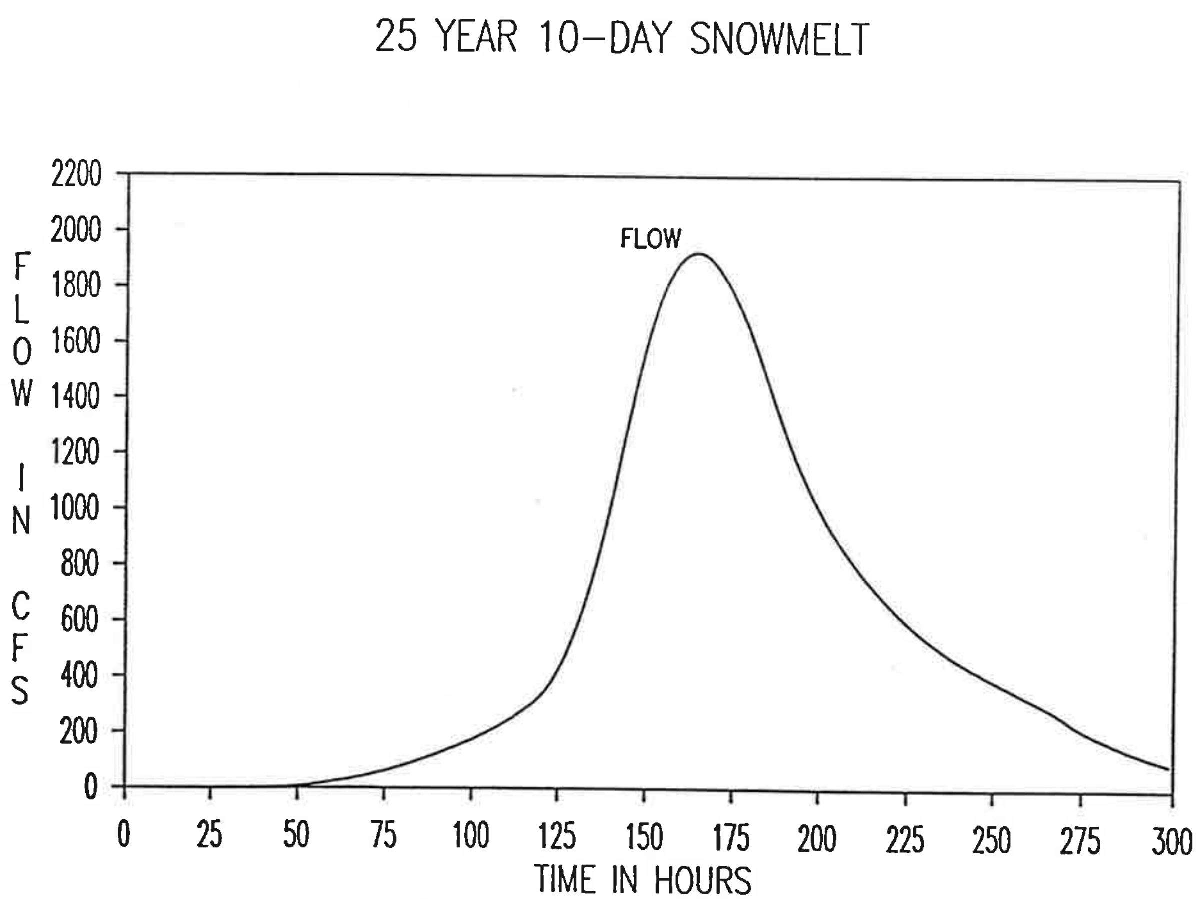


Figure 4 - North Branch of the Elm River Hydrographs

IV. HYDRAULICS

A hydraulic analysis of the North Branch of the Elm River was performed using the HEC-2 computer model, developed by the U.S. Army Corps of Engineers. HEC-2 calculates water surface profiles for steady, gradually varied flow in natural or man-made channels for flows due to various precipitation events. The data needed to perform these computations includes: flow regime, starting water surface elevation, discharge, loss coefficients, cross section geometry, and reach lengths. The computational procedure used by the model is based on the solution of the one-dimensional energy equation with energy loss due to friction evaluated with Manning's equation. This computation is generally known as the Standard Step Method.

The analysis performed on the North Branch of the Elm River started southeast of Kelso in Section 4, and proceeded upstream to the Interstate 29 bridge. This allowed for the computation of water surface elevations at the location of the breakout. The cross sectional data and bridge geometries were obtained from field survey data. The reach lengths were approximated using USGS 7.5 minute quadrangle maps of the area. The loss coefficients were approximated using guidelines in the North Dakota Hydrology Manual and visual data from the area.

The flow rates used to develop the water surface elevations, as mentioned in the hydrology section, were obtained using the HEC-1 computer model. The flow through the breakout was approximated by developing a rating curve for the two 36-inch diameter reinforced concrete pipe (RCP) culverts under Highway 81. These culverts limit the passage of flow through the breakout. Table 2 shows the water surface elevations at the breakout obtained from the HEC-2 computer model. The computer model developed for the basin does not take into account the storage of water that takes place over the area the breakout inundates.

Table 2 - Water Surface Elevations at Breakout

Event	Total Flow (cfs)	Channel Flow (cfs)	Breakout Flow (cfs)	Water Surface Elevation (msl)
25-year 10-day snowmelt	1928	1793	135	901.9
10-year 10-day snowmelt	1287	1164	123	900.7
5-year 10-day snowmelt	851	751	100	899.6
2-year 10-day snowmelt	359	359	-	897.8

V. ALTERNATIVES

Several alternatives were considered as part of the preliminary investigation: The first alternative is to return the breakout flows to the channel through the Highway 81 ditch. The second alternative is to retain the flows in the channel by the use of a dike along the breakout. The third alternative is to enlarge the culverts in the drain west of Nelson Legal Drain. The fourth alternative is to perform a snagging and clearing project to increase the channel capacity. Several other alternatives were also considered. The following sections describe these alternatives in detail.

Alternative 1:

The first alternative that was considered as part of this investigation is to reroute the breakout flows through the Highway 81 ditch. This alternative would entail the construction of a dike along the ditch on the east side of Highway 81. The breakout flow that passes through the two 36-inch diameter RCP under the highway would be contained within the dike and rerouted south back into the river. This alternative would require that further excavation of the ditch be performed. Figure 5 shows this alternative as proposed.

The Highway 81 ditch slopes upward as you proceed north from the river to a peak elevation of approximately 898.1 msl. This high area serves as the drainage divide between the North Branch of the Elm River and the areas to the north. It then slopes

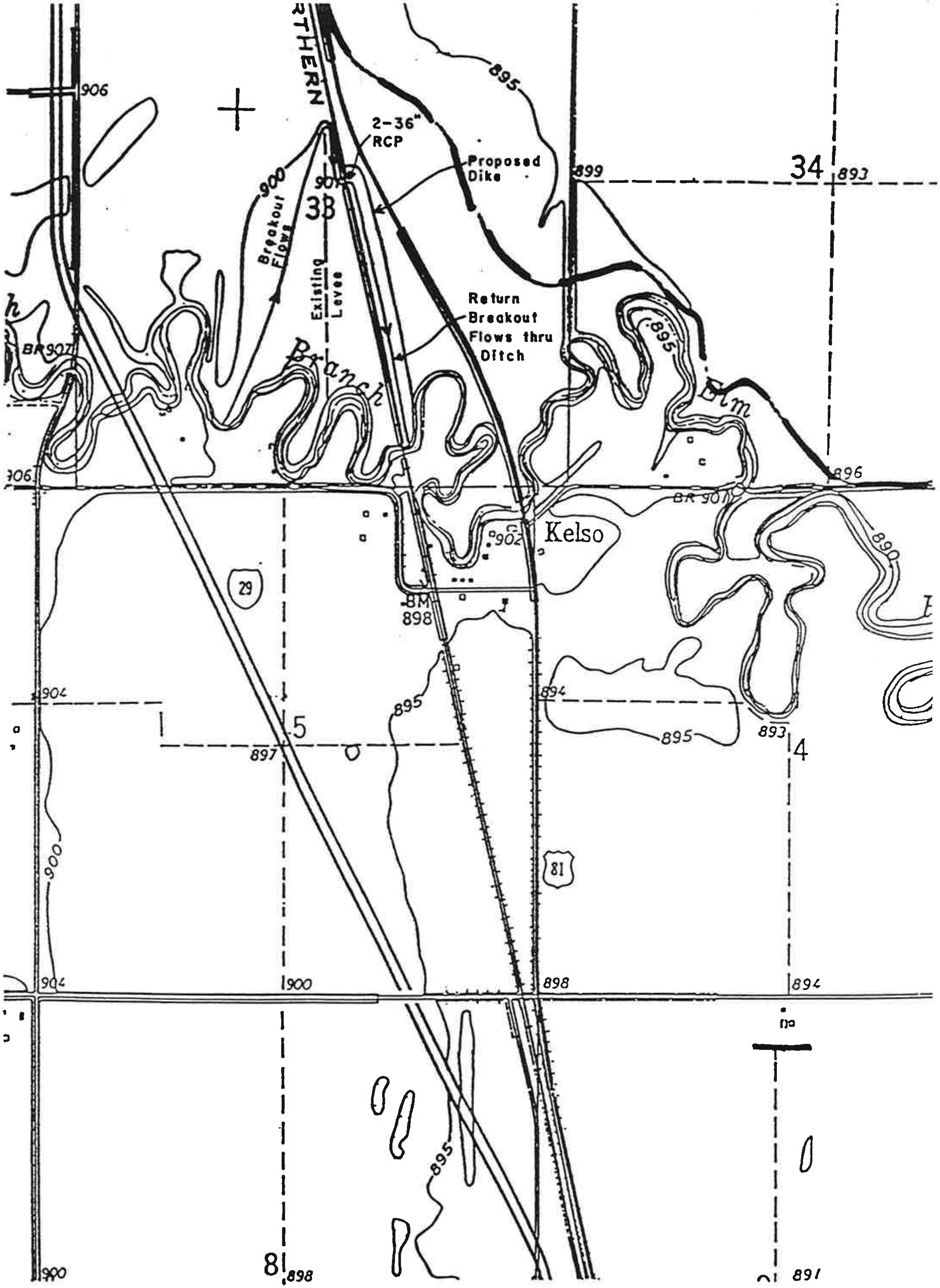


Figure 5

Alternative I

downward to a minimum elevation of approximately 894.3 msl, which is at the outlet of the two 36-inch diameter RCP. To reroute the breakout flows through the Highway 81 ditch would require that the bottom of the ditch be excavated approximately five feet at the high point. Table 3 shows the water surface elevations in the North Branch of the Elm River at its junction with the Highway 81 ditch, as determined using the HEC-2 computer model.

Table 3 - Water Surface Elevations at Highway 81 Ditch

Event	Total Flow (cfs)	Channel Flow (cfs)	Breakout Flow (cfs)	Water Surface Elevation (msl)
25-year 10-day snowmelt	1928	1793	135	898.0
10-year 10-day snowmelt	1287	1164	123	896.8
5-year 10-day snowmelt	851	751	100	895.6
2-year 10-day snowmelt	359	359	-	893.8

These water surface elevations indicate that water from the North Branch of the Elm River would flow north in the new ditch during flood periods and potentially cause additional damage. Therefore, this alternative is not recommended and a preliminary cost estimate was not prepared.

Alternative 2:

The second alternative that was analyzed is the construction of a dike along the breakout to retain flows in the channel. The elevation of the dike would correspond to the level of protection desired. The installation of a dike would prevent the flows from breaking out during smaller precipitation events. During larger precipitation events, the dikes would be overtopped and the water would proceed as it did before. Analysis with the HEC-2 computer model indicates that the smallest precipitation event from which the breakout occurs is the 5-year 10-day snowmelt.

The increased downstream flood potential associated with this alternative makes it questionable. Presently, the water leaves the main channel, passes through the railroad bridge and the two 36-inch diameter RCP under Highway 81, eventually entering Nelson Legal Drain, and ultimately the Red River of the North. This water bypasses the city of Kelso. If a dike is constructed to retain the flows in the channel, the potential for flooding in Kelso may be increased. The dike would also increase the potential for additional breakouts to occur farther downstream. A particular area of concern regarding downstream flooding is at the center of Section 4, southeast of Kelso. The elevation of the south bank of the river in this area is relatively low and the potential for breakouts to the southeast exists. In fact, breakouts have occurred here in the past. Another area of concern is the southwest corner of Section 34, where the potential for breakouts to the northeast exists. Due to the infeasibility of this alternative, a preliminary cost estimate was not prepared.

Alternative 3:

The third alternative that was analyzed is the enlargement of the culverts in the drain west of Nelson Legal Drain. Presently, the breakout flow passes through the railroad bridge and the two 36-inch diameter RCP under Highway 81, before proceeding to the northeast corner of Section 33. It then enters a drain adjacent to the section road, eventually joining Nelson Legal Drain in Section 36. There are several roads and field approaches that cross this drain. Figure 6 shows the culverts through these crossings as obtained from the Traill County culvert inventory.

The first crossing is located in the northeast corner of Section 33 and consists of a field approach with a 24-inch diameter corrugated metal pipe (CMP) culvert. The next crossing is a field approach with an 18-inch diameter CMP culvert located in the center of Section 34. This is followed by a section road with two 24-inch diameter CMP culverts located in the northeast corner of Section 34. The crossing in the northeast corner of Section 35 consists of a section road with two 36-inch diameter CMP culverts. The crossing in the center of Section 36 consists of a field approach with two 36-inch diameter CMP culverts. The crossings farther downstream in Nelson Legal Drain consist of bridges of various dimensions.

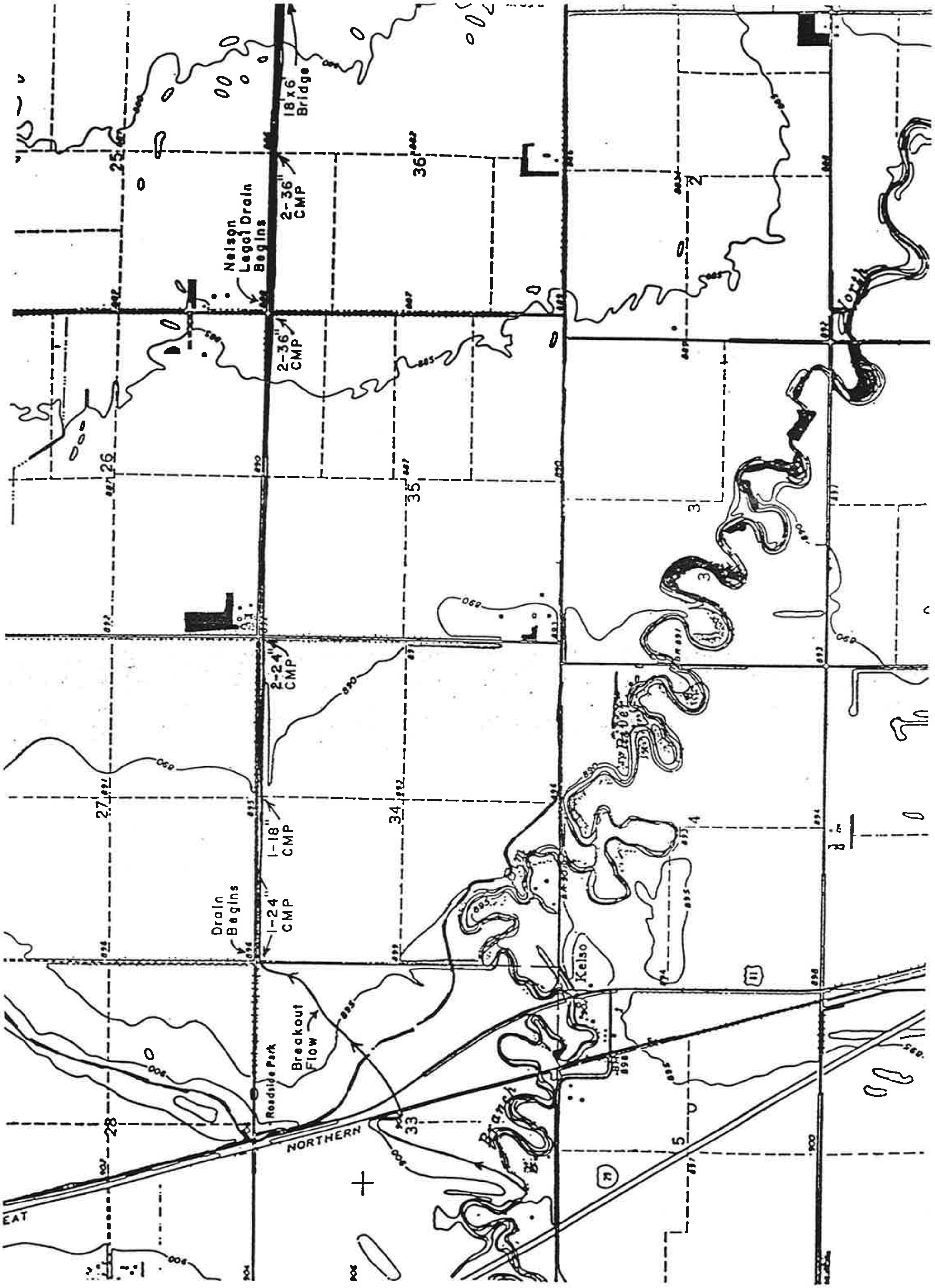


Figure 6 - Culvert Inventory in Drain

Analysis with the HEC-2 computer model and the equations for pipe flow indicates that the maximum flow that can be passed through the 24-inch diameter CMP in the northeast corner of Section 33 is 15 cfs. The capacity of this culvert is limited by tailwater effects from the 18-inch diameter CMP located in the center of Section 34. The limited flow causes water to back up into Section 33. The proposed solution to this problem is to replace the 18-inch diameter CMP in the center of Section 34 with two 24-inch diameter CMP and to add an additional 24-inch diameter CMP in the northeast corner of Section 33. This will increase the flow capacity of the crossing from 15 cfs to 40 cfs. This will decrease the length of time that the farm land in Section 33 is flooded.

A concern associated with this alternative is that the increased flow through the drain due to the enlargement of the culverts will cause additional flooding adjacent to the drain. It does not appear that enlarging these culverts will cause additional flooding, since the maximum amount of flow that will be added to the drain is only 25 cfs. A precaution that can be taken is to install a slide gate on one or both of the 24-inch diameter CMP's proposed for the northeast corner of Section 33. These gates could be closed during periods of high flow. As the breakout flows decrease, the gates can be opened, allowing greater flows to pass.

The preliminary cost estimate for this alternative is $4,800. This cost estimate assumes a local contractor can perform the project. Table 4 shows a breakdown of the preliminary cost estimate.

Table 4 - Preliminary Cost Estimate for Alternative 3

	Item	Quantity	Unit	Unit Price	Total
1.	Mobilization	1	LS	$ 500.00	$ 500
2.	24-inch Diameter CMP	90	LF	17.28	1,555
3.	Labor	1	LS	1,000.00	1,000
4.	Equipment	1	LS	600.00	600
	Subtotal				$3,655
	Contingencies			(+/- 10%)	381
	Contract Administration			(+/- 10%)	382
	Engineering			(+/- 10%)	382
	Total			(+/- 30%)	$4,800

The installation of slide gates on the 24-inch diameter CMP culverts in the northeast corner of Section 33 will represent an increase of $1,100 per slide gate to the total cost.

<u>Alternative 4</u>:

The fourth alternative that was analyzed is to perform a snagging and clearing project on the channel to remove debris which can cause increased upstream water surface elevations. The North Branch of the Elm River is surrounded by a large number of trees in the vicinity of Kelso. In some locations, the trees have fallen into the channel. These trees have collected other debris which can restrict the flow in the channel, causing increased upstream water surface elevations. During spring runoff, this problem can be compounded when snow becomes caught in the debris.

A snagging and clearing project involves the removal of trees, brush, stumps, and other debris in the channel which can inhibit flow. This helps convey the water downstream more rapidly, which decreases the occurrence of floods due to breakouts.

A snagging and clearing project on the North Branch of the Elm River will lower the water surface elevation at the breakout. Table 5 shows the water surface elevations at the breakout, as determined by the HEC-2 computer model, for existing channel conditions and improved channel conditions.

Table 5 - Water Surface Elevations at Breakout

	Water Surface Elevation for Existing Conditions (msl)	Water Surface Elevation for Improved Conditions (msl)
25-year 10-day snowmelt	897.8	897.0
10-year 10-day snowmelt	899.6	899.2
5-year 10-day snowmelt	900.7	900.1
2-year 10-day snowmelt	901.9	901.3

The data in Table 5 shows that a snagging and clearing project will lower the water surface elevation at the breakout by 0.8 feet for a 25-year 10-day snowmelt. In determining these water surface elevations, the channel improvements mentioned include the removal of debris along the channel. This does not include blockages by this debris. It is not possible to determine the water surface elevations if the debris is blocking the channel.

It is recommended that the reach of the North Branch of the Elm River located downstream of the Interstate 29 bridge be surveyed for the need for snagging and clearing. One concern with only looking at a short reach is that the problem could be moved downstream. Snagging and clearing is also a short-term solution and in all likelihood, the channel will require further work in the future.

In order to prepare a cost estimate for a snagging and clearing project, an inventory of obstructions in the channel needs to be taken. This will require that a separate agreement between the State Water Commission and the Traill County Water Resource District be initiated. The distance to be inventoried is approximately eighteen river miles, beginning at the Interstate 29 bridge west of Kelso and continuing to the junction of the North Branch of the Elm River and the Main Branch of the Elm River. The river along this reach has areas that are heavily wooded. In many of these areas, debris has accumulated which can inhibit flow. Figure 7 shows the reach length that will need to be inventoried.

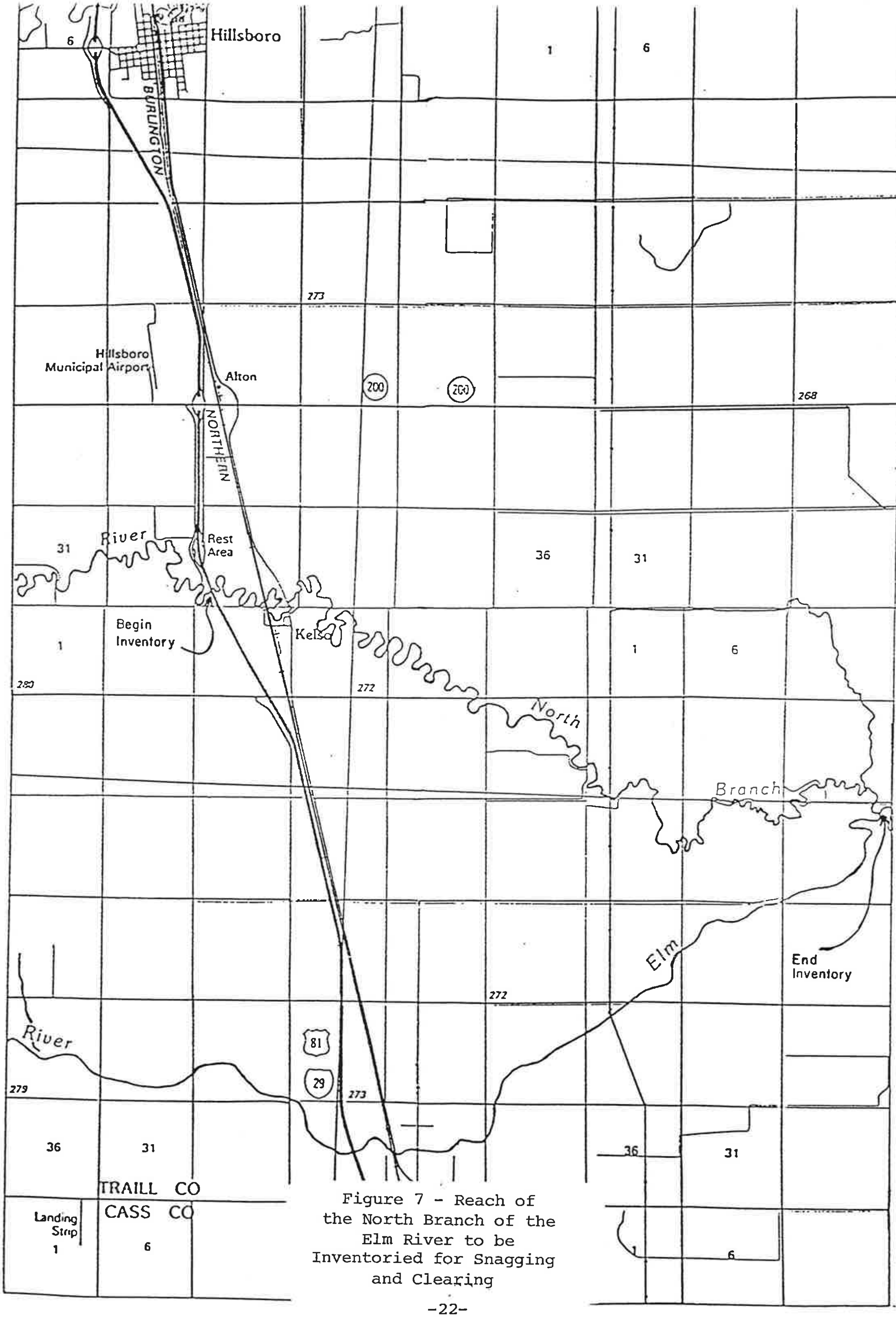


Figure 7 - Reach of the North Branch of the Elm River to be Inventoried for Snagging and Clearing

After the inventory is taken, a cost estimate to perform the project will be prepared and submitted in a written report. The cost to perform this inventory is estimated to be $2,300, of which $1,150 will be covered by the State Water Commission.

<u>Other Alternatives</u>:

Another alternative that should be considered is the construction of an upstream flood detention dam. This would involve the construction of a dam to retain water during periods of high flow, protecting downstream interests. This water would be released from the dam at a later date when flows are lower. The design of a flood detention dam is beyond the scope of this investigation.

The enlargement of the Highway 81 bridge was considered as another alternative. There is some local feeling that the bridge on Highway 81 is too small and causes water to back up. Analysis with the HEC-2 computer model indicates that the increase in the water surface elevation through the Highway 81 bridge is negligible. Therefore, the enlargement of the bridge would not be necessary.

The final alternative is taking no action. The breakout acts as a natural means of flood control for the city of Kelso and other downstream interests. When the water leaves the channel it inundates farm land without damaging homes. If the water is retained in the channel, the potential for flooding in

Kelso or for downstream breakouts to occur is increased. A positive result of the flooding of farm land is that it acts as a means of flood irrigation during certain years. This moisture is beneficial for crops during the growing season.

VI. SUMMARY

The feasibility of a flood control project on the North Branch of the Elm River in Traill County has been examined. The flooding occurs when the water leaves the river channel near the city of Kelso, North Dakota. The river breaks out of its channel in a low spot in the SW1/4 of Section 33, Township 145 North, Range 50 West. After leaving the channel, the water spreads out towards the north, eventually crossing the railroad tracks and Highway 81 near the center of the section. The water then proceeds to the northeast corner of Section 33 where it enters a drain adjacent to the section road. This drain joins Nelson Legal Drain in Section 36. Crossings in the drain cause the water to back up into Section 33, flooding farm land. This flooding occurs approximately every five years.

Several alternatives were analyzed as potential solutions to the flooding problem. The first alternative is to construct a dike along the ditch on the east side of Highway 81. The break-out flows that pass through the two 36-inch diameter RCP under the highway would be contained within the dike and rerouted south back into the river. However, this alternative would require that the ditch be excavated and, as a result, water from the North Branch of the Elm River could flow north in this channel during flood periods and cause additional flooding problems. Therefore, this alternative is not recommended.

The second alternative that was analyzed includes the construction of a dike along the breakout to retain flows in the channel. The dike would retain flows in the channel during smaller precipitation events and would be overtopped during larger events, allowing the water to proceed as before. By retaining the flows in the channel, the problem could possibly be moved farther downstream. As a result, the dike could increase the chance of flooding in Kelso, and could also increase the occurrence of breakouts farther downstream.

The third alternative that was analyzed involves the enlargement of the culverts in the drain west of Nelson Legal Drain. This would include placing an additional 24-inch diameter CMP culvert through the field approach in the northeast corner of Section 33 and replacing the 18-inch diameter CMP culvert through the field approach in the center of Section 34 with two 24-inch diameter CMP culverts. This would increase the flow capacity of the crossings from 15 cfs to 40 cfs. This will allow larger flows to pass through the drain, decreasing the time that the farm land is flooded. It does not appear that enlarging these culverts will cause increased flooding to the east. The amount of flow that will be added to the drain is only 25 cfs. This, and the fact that the crossing sizes increase as you progress east, should prevent additional flooding from occurring. A precaution that can be taken to prevent any additional flooding that may be encountered by the enlargement of these crossings is the installation of a slide gate on one or both of the 24-inch diameter CMP culverts proposed for the crossing in the northeast corner of Section 33. During high flows, these gates could be closed. As the breakout flows recede, these gates could be opened to allow increased flows to pass. The cost of this alternative is estimated to be $4,800. The installation of slide gates will represent an increase of $1,100 per gate to the total cost.

The fourth alternative that was analyzed is to perform a snagging and clearing project on the channel to remove debris that can cause increased upstream water surface elevations. This alternative would require that an inventory of obstructions in the channel be taken. A cost estimate and report would be prepared summarizing the results of this inventory. A problem associated with this alternative is that snagging and clearing is a short-term solution and in all likelihood the channel will require further work in the future. The cost to prepare the snagging and clearing inventory is estimated to be $2,300, of which $1,150 would be covered by the State Water Commission.

Other alternatives that were considered as part of this investigation include the installation of an upstream flood detention dam (dry dam), enlarging the Highway 81 bridge, and the alternative of taking no action.

VII. RECOMMENDATIONS

Several alternatives were analyzed as part of this investigation. The investigation culminated in the selection of Alternative 3 as the most feasible. The estimated construction cost for this alternative, including administration, engineering, and contingencies is $4,800. This alternative involves the enlargement of the culverts in the drain west of Nelson Legal Drain. This will allow greater flows to pass through the drain, reducing the length of time that the fields in Section 33 are flooded. If slide gates are installed on these culverts, the total cost will increase by $1,100 for each gate installed. Another alternative that should be considered is to conduct a snagging and clearing study along the North Branch of the Elm River to determine whether debris may be causing increased upstream water surface elevations. The decision to proceed with this project is the responsibility of the Traill County Water Resource Board.

APPENDIX A - COPY OF AGREEMENT

SWC Project #1311
August 9, 1990

A G R E E M E N T

Investigation of a Flood Control Project on the North Branch of the Elm River in Traill County

I. PARTIES

THIS AGREEMENT is between the North Dakota State Water Commission, hereinafter Commission, through its Secretary, David Sprynczynatyk, hereinafter Secretary; and the Traill County Water Resource District, hereinafter District, through its Chairman, Gary L. Peterson.

II. PROJECT, LOCATION, AND PURPOSE

The District has requested the Commission to investigate and determine the feasibility of a flood control project on the North Branch of the Elm River in Traill County. The purpose of the investigation is to conduct a preliminary engineering study and prepare a report giving alternatives and cost estimates to prevent flooding on the North Branch of the Elm River. The problem area is located in Section 33, Township 145 North, Range 50 West, near Kelso, North Dakota.

III. PRELIMINARY INVESTIGATION

The parties agree that further information is necessary concerning the proposed project. Therefore, the Commission shall conduct the following:

1. A survey to obtain cross-sectional data.
2. A hydraulic analysis to determine water surface elevations for various frequency events.
3. An evaluation of alternatives for flood control.
4. A written report documenting the findings of the investigation.
5. A cost estimate for viable alternatives.

IV. DEPOSIT

The District shall deposit a total of $2,000 with the Commission to help defray the costs associated with this investigation.

V. RIGHTS-OF-ENTRY

The District agrees to obtain written permission from any affected landowners for field investigations by the Commission, which are required for the preliminary investigation.

VI. INDEMNIFICATION

The District hereby accepts responsibility for, and holds the Commission, its employees, its agents, and the State Engineer free from all claims and damages to public or private property, rights, or persons arising out of this agreement. In the event a suit is initiated or judgment entered against the Commission, its employees, or agents, the District shall indemnify it for any settlement arrived at or judgment satisfied.

VII. CHANGES TO THE AGREEMENT

Changes to any contractual provisions herein will not be effective or binding unless such changes are made in writing, signed by both parties and attached hereto.

NORTH DAKOTA STATE WATER COMMISSION	TRAILL COUNTY WATER RESOURCE DISTRICT
By: David A. Sprynczynatyk	By: Gary L. Peterson
DAVID A. SPRYNCZYNATYK	GARY L. PETERSON
Secretary	Chairman
DATE:	DATE:
August 16, 1990	Sept 4, 1990
WITNESS:	WITNESS:
Dale L. Frink	Donald VonRuden V.Ch.

BIBLIOGRAPHY

1. Soil Conservation Service, U.S.D.A., Bismarck, North Dakota, Hydrology Manual for North Dakota

2. U.S. Army Corps of Engineers, HEC-1 Flood Hydrograph Package, September, 1981.

3. U.S. Army Corps of Engineers, HEC-2 Water Surface Profiles September, 1982.