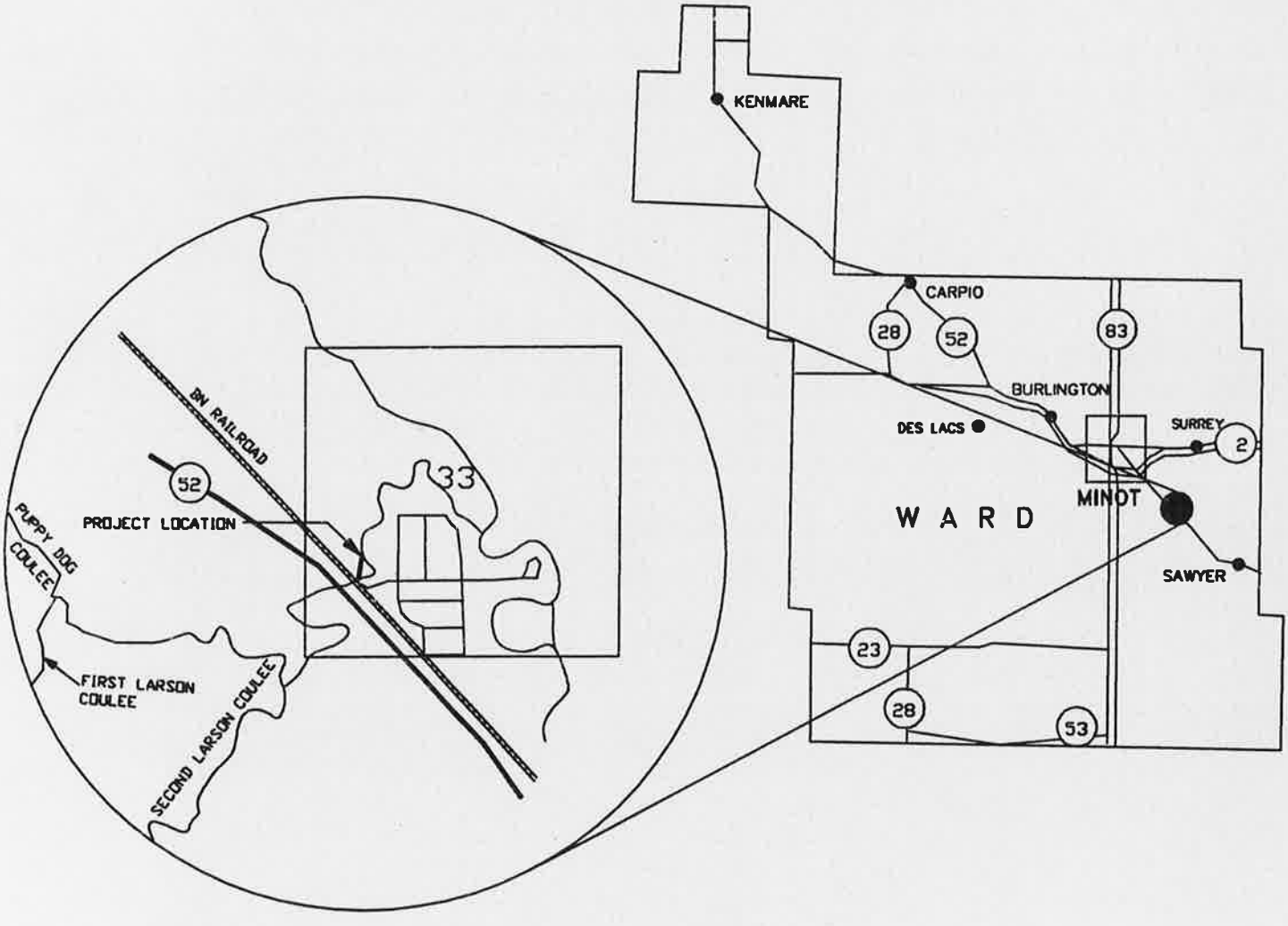
PRELIMINARY ENGINEERING REPORT

PUPPY DOG and LARSON COULEE FLOOD CONTROL

SWC NO. 1313
WARD COUNTY



NORTH DAKOTA
STATE WATER COMMISSION

November 1992

PRELIMINARY ENGINEERING REPORT

Puppy Dog and Larson Coulee
Flood Control Project
SWC Project #1313

November, 1992

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

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I. INTRODUCTION

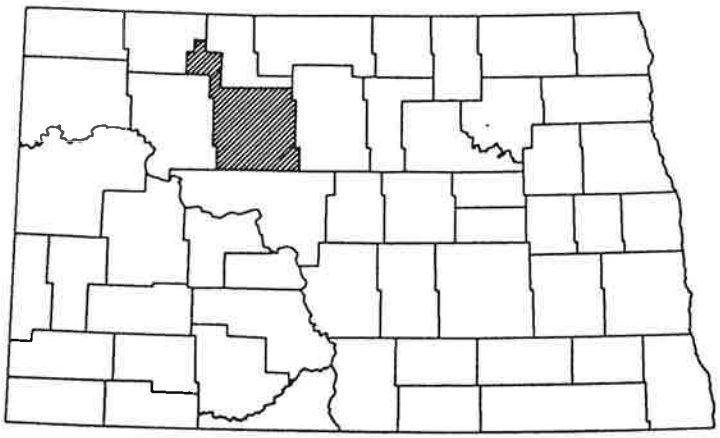
Study Objectives:

In November of 1991, the North Dakota State Water Commission and the Ward County Water Resource District entered into an agreement to investigate the feasibility of a flood control project below the confluence of Puppy Dog, First Larson, and Second Larson Coulees near Minot, North Dakota. The agreement called for the State Water Commission to conduct a field survey to obtain cross-sectional data; conduct a hydraulic analysis to determine water surface elevations for various frequency precipitation events; perform an evaluation of alternatives for flood control; prepare a preliminary cost estimate for viable alternatives; and prepare a written report documenting the findings of the investigation.

Project Location and Purpose:

The project is located below the confluence of Puppy Dog, First Larson, and Second Larson Coulees, southeast of the city of Minot, North Dakota. Figure 1 shows the location of the project within the state of North Dakota.

Presently, flooding occurs in the Eastside Estates Housing Development located downstream of the confluence of the three coulees, northeast of Highway 52. In the fall of 1988, a channelization project was constructed on the Puppy Dog and Larson Coulee channel near the development that involved blocking the upstream end of a meander and constructing a bypass channel (see



PUPPY DOG & LARSON COULEE FLOOD CONTROL

SWC # 1313

LOCATION MAP

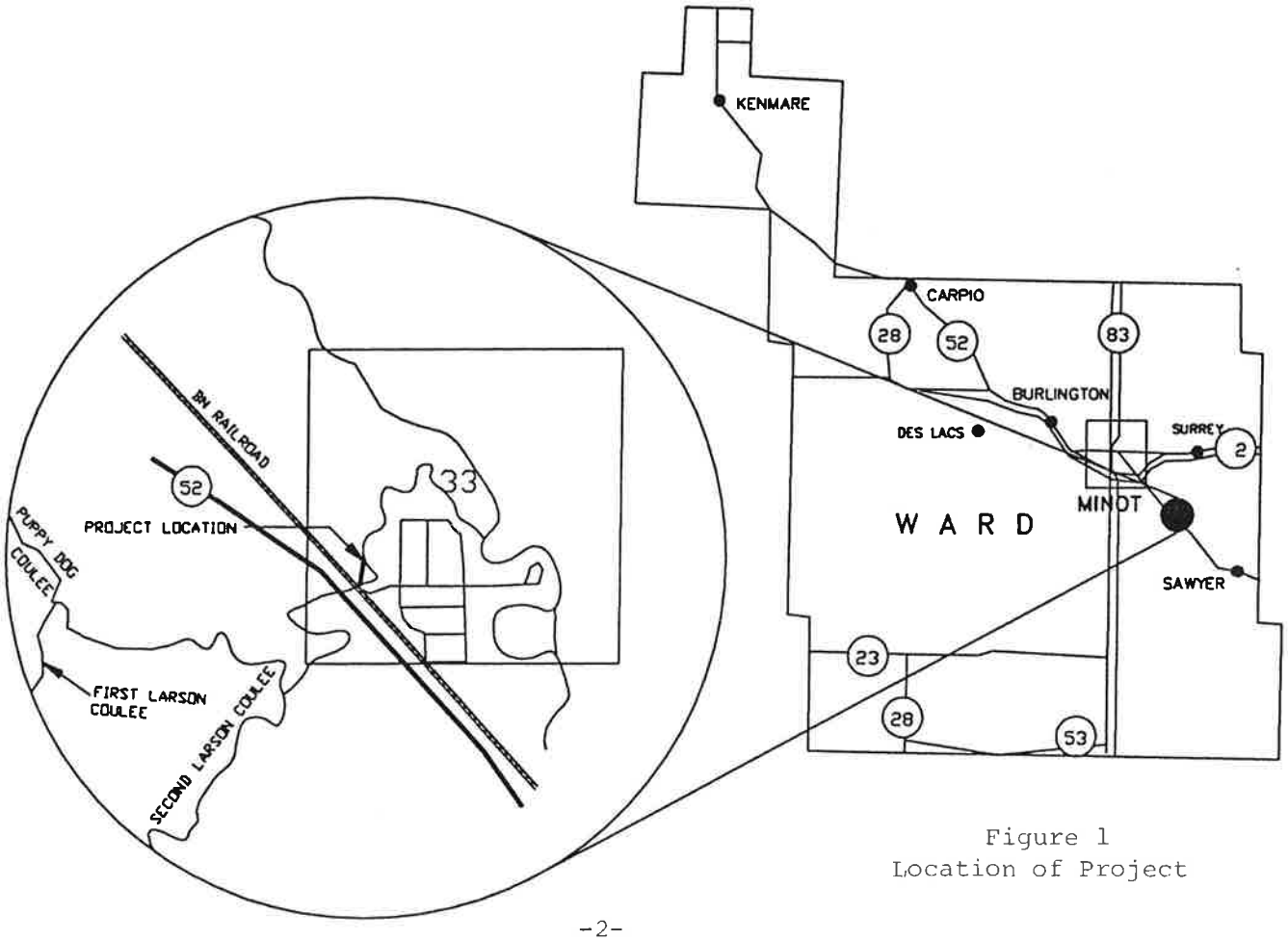


Figure 1
Location of Project

Figure 6). The downstream end of the meander was left open. During high flows, backwater enters through the open meander and leaves the channel through low spots in the bank. This causes flooding to low-lying houses located in the development. Local residents feel that the flooding has increased in recent years due to the increased urban development that has occurred in the Puppy Dog Coulee basin.

II. GEOLOGY AND CLIMATE

The Puppy Dog, First Larson, and Second Larson Coulee drainage basins are part of the Souris River drainage basin. They extend from their origin southwest of Minot to their confluence with the Souris River east of Minot. The western portion of the basins lies in the glaciated Missouri Plateau Section of the Great Plains Physiographic Province, while the eastern portion lies in the Western Lake Section of the Central Lowlands Physiographic Province.

The topography of the basins is relatively flat in the western reaches and steep in the east. Land use in the western portion of the basins is primarily agricultural, while the eastern portion of the basins consists of agricultural land, grassland, and areas of urban development.

The northern continental climate for the basins is characterized by a wide temperature range, rigorous winters, a summer rainy season, and strong northwesterly winds. The average annual precipitation is 15 inches, a majority of which falls in the period from May through September. The mean annual temperature for the basins is +39 degrees Fahrenheit.

III. HYDROLOGY

A hydrologic analysis of the Puppy Dog, First Larson, and Second Larson Coulee watersheds 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 stream due to 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 watershed above the project site was defined using USGS 7.5-minute quadrangle maps of the area. Puppy Dog Coulee is supplied by a drainage area of 16.3 square miles. It originates southwest of Minot and flows in a northeasterly direction through southern Minot, at which point it joins First Larson Coulee. First Larson Coulee also originates southwest of Minot. It is supplied by a drainage area of 18.1 square miles. It flows in a northeasterly direction parallel to Puppy Dog Coulee. After First Larson Coulee joins Puppy Dog Coulee, they are supplemented by an

additional 0.7 square miles of drainage area prior to joining Second Larson Coulee. Second Larson Coulee originates southwest of Minot and flows in a northeasterly direction parallel to Puppy Dog Coulee and First Larson Coulee. It is supplied by a drainage area of 14.9 square miles. After Second Larson Coulee joins First Larson and Puppy Dog Coulees, they are supplemented by an additional 1.3 square miles of drainage area prior to the project site. The total drainage area upstream of the project site is 51.3 square miles. Figure 2 shows the drainage basins for Puppy Dog, First Larson, and Second Larson Coulees.

The downstream portion of the Puppy Dog Coulee drainage basin contains a significant amount of urban development. This area was divided into smaller subbasins in the HEC-1 model to account for this increased urbanization.

Precipitation events for various recurrence intervals were modelled to determine the peak flow at the project site. Precipitation events that were modelled include the 24-hour rainfall, 10-day rainfall, and 10-day snowmelt. Analysis indicated that the 24-hour rainfall event caused the highest flow at the project site and was used to determine the design flow. Table 1 shows the intensity and peak flows for the various 24-hour rainfall events that were analyzed.

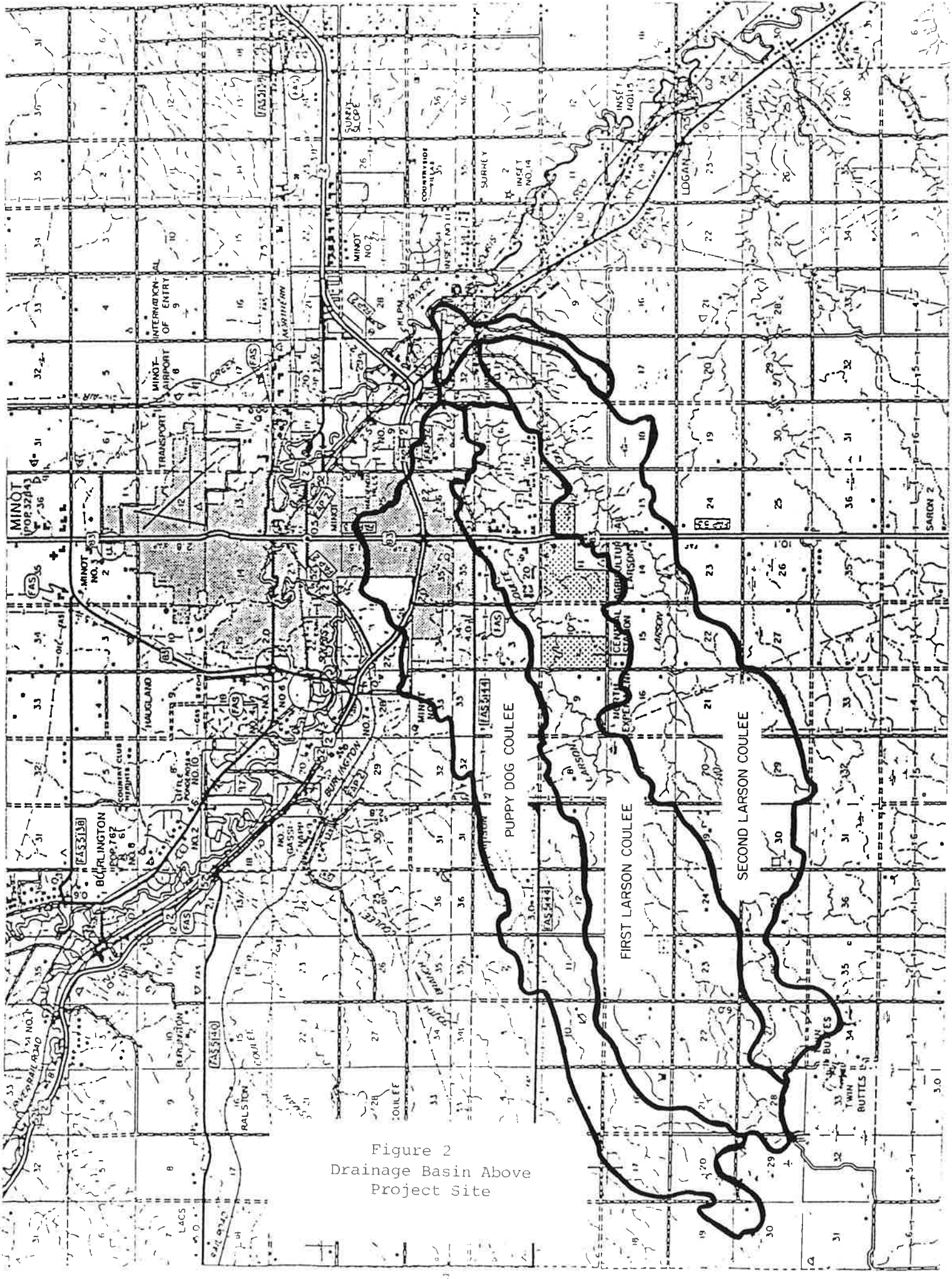
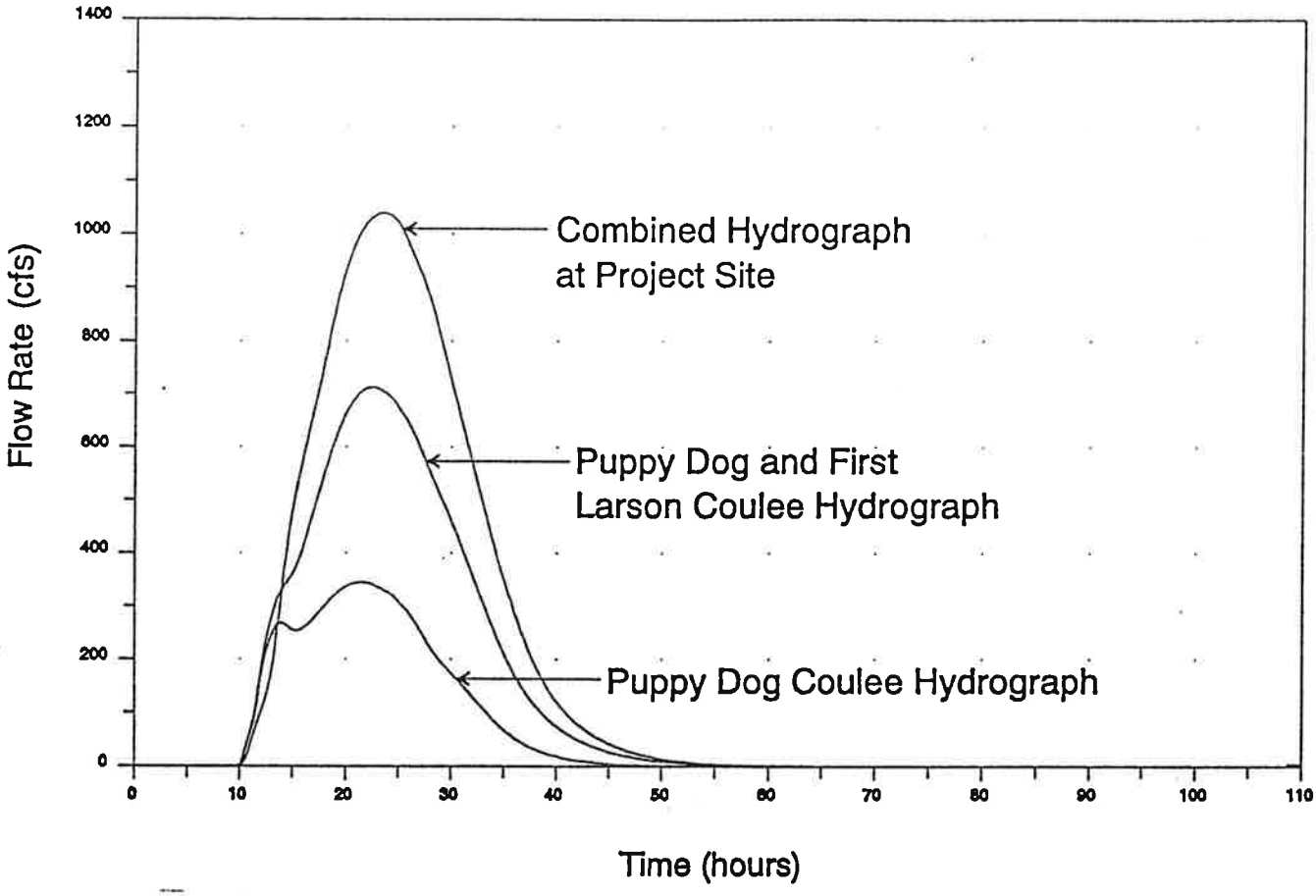


Figure 2
Drainage Basin Above
Project Site

Table 1 - Intensity and Peak Flows
for Rainfall Events

Event	Intensity (in/interval)	Peak Flow (cfs)
100-year 24-hour rainfall	4.64	3640
50-year 24-hour rainfall	4.12	2901
25-year 24-hour rainfall	3.62	2236
10-year 24-hour rainfall	3.09	1594
5-year 24-hour rainfall	2.57	1040

Figures 3, 4, and 5 show the flow hydrographs for the rainfall events listed in Table 1. The hydrographs show the flow at three locations: at the downstream end of Puppy Dog Coulee; at the confluence of Puppy Dog and First Larson Coulee; and at the project site. The flow hydrographs indicate that the similarity in the size and orientation of the Puppy Dog, First Larson, and Second Larson Coulee drainage basins results in the peak flow for each basin occurring at virtually the same time. This results in the high flow that occurs when they combine.



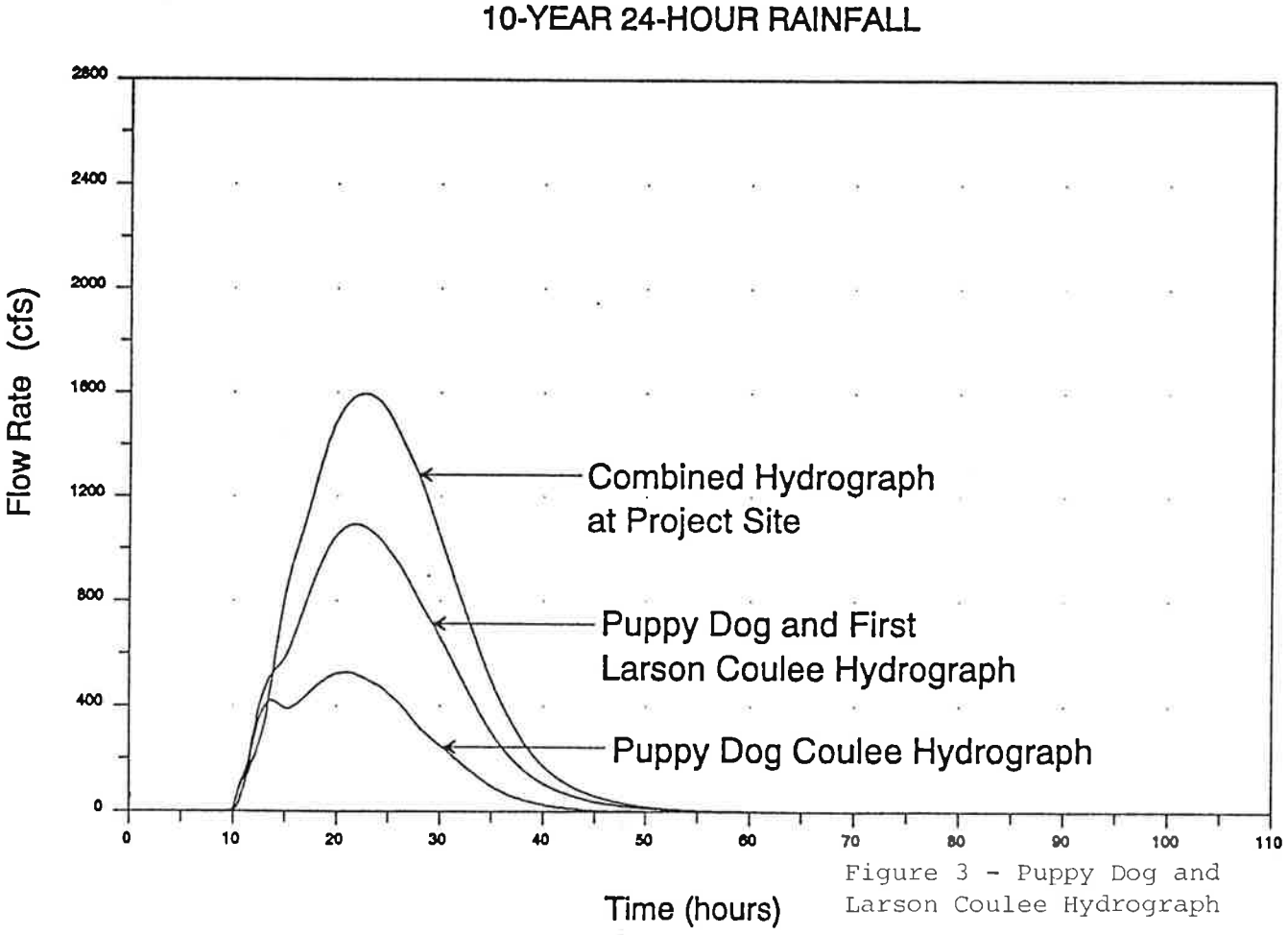
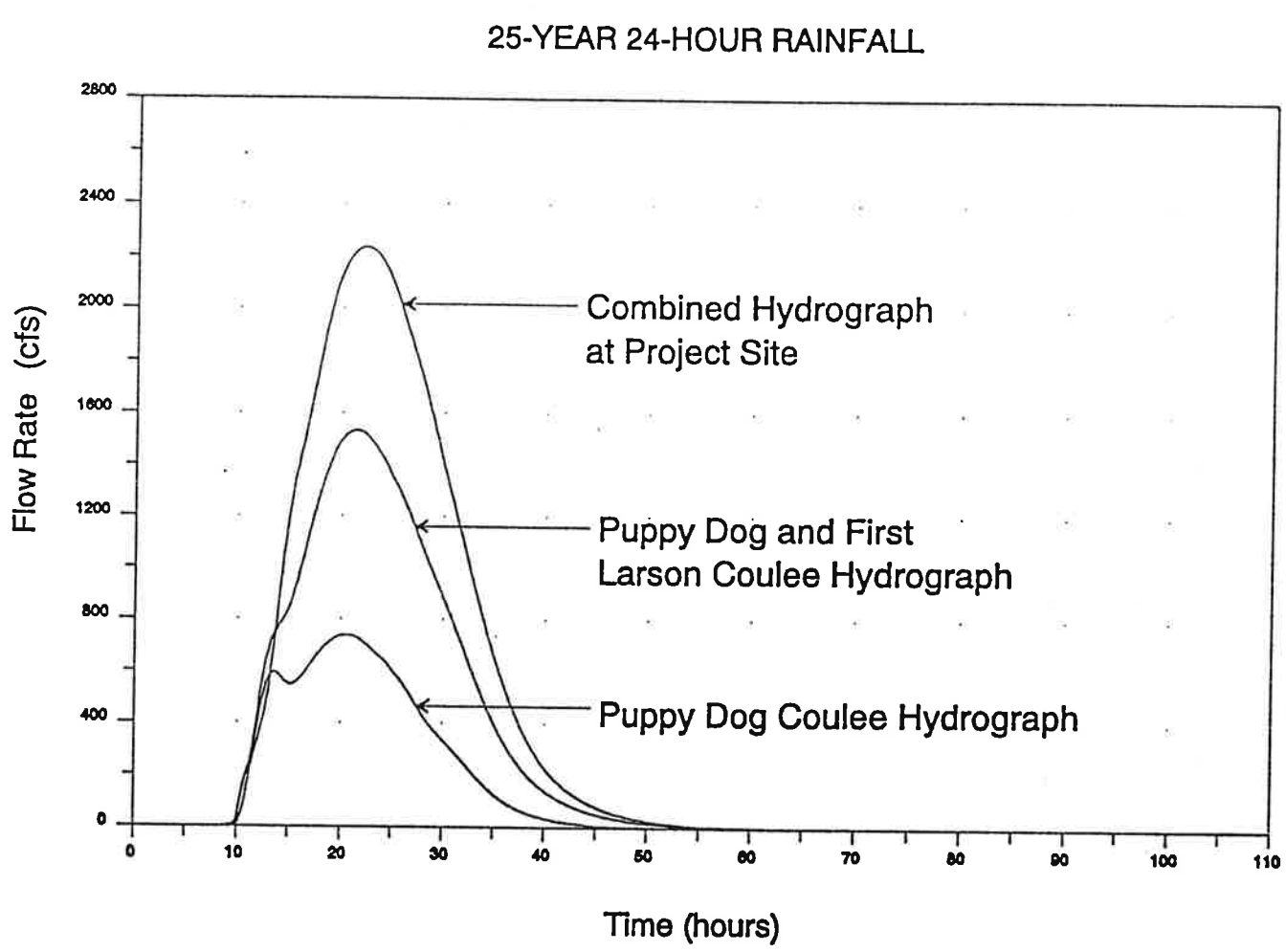


Figure 3 - Puppy Dog and Larson Coulee Hydrograph



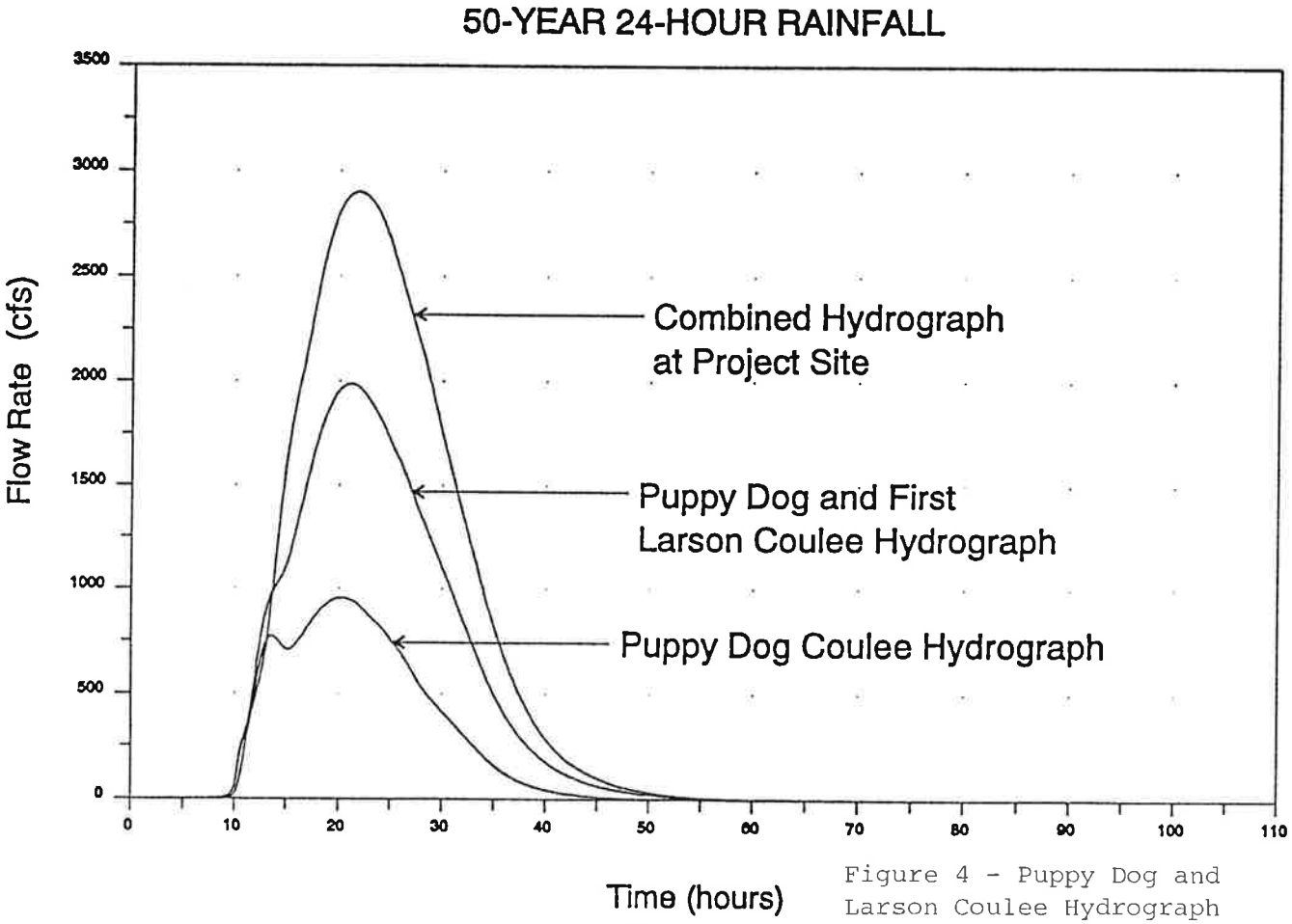


Figure 4 - Puppy Dog and Larson Coulee Hydrograph

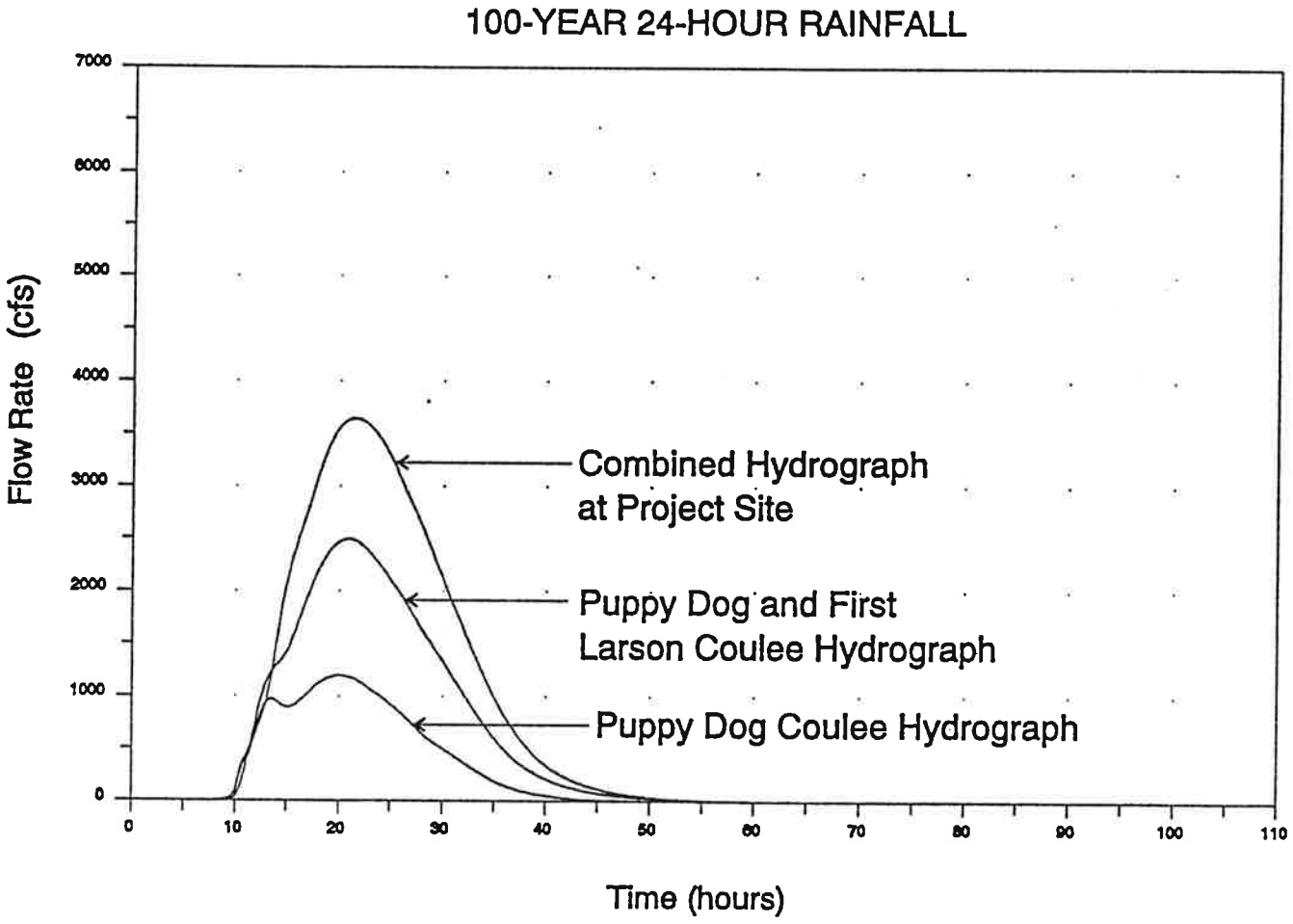


Figure 5 - Puppy Dog and
Larson Coulee Hydrograph

IV. HYDRAULICS

A hydraulic analysis of the Puppy Dog and Larson Coulee channel near the project site 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, 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 stream channel began at its confluence with the Souris River and proceeded upstream past the Highway 52 bridge. The cross sectional data and bridge geometries used in the HEC-2 model 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.

When the water surface in the channel reaches an elevation of 1546.3 msl at its intersection with the Highway 52 ditch, a portion of the flow is diverted into the Highway 52 ditch, eventually

reentering the Souris River farther downstream. Figure 6 shows the path of the water that is diverted through the Highway 52 ditch. The split-flow capability of the HEC-2 computer model was used to account for this diverted flow. The amount of flow that is diverted is limited by two 24-inch diameter Corrugated Metal Pipe (CMP) culverts located beneath a roadway that crosses the ditch. Table 2 shows the flow that is diverted through the Highway 52 ditch, the remaining channel flow, and the water surface elevations for the stream channel at the downstream end of the bypass channel for various precipitation events, as computed using the HEC-2 computer model.

Table 2 - Water Surface Elevations at Bypass Channel for Existing Conditions

Event	Total Flow (cfs)	Channel Flow (cfs)	Highway 52 Ditch Flow (cfs)	Water Surface Elevation (msl)
25-year rainfall	2236	2167	69	1551.6
10-year rainfall	1594	1536	58	1550.2
5-year rainfall	1040	1000	40	1548.6

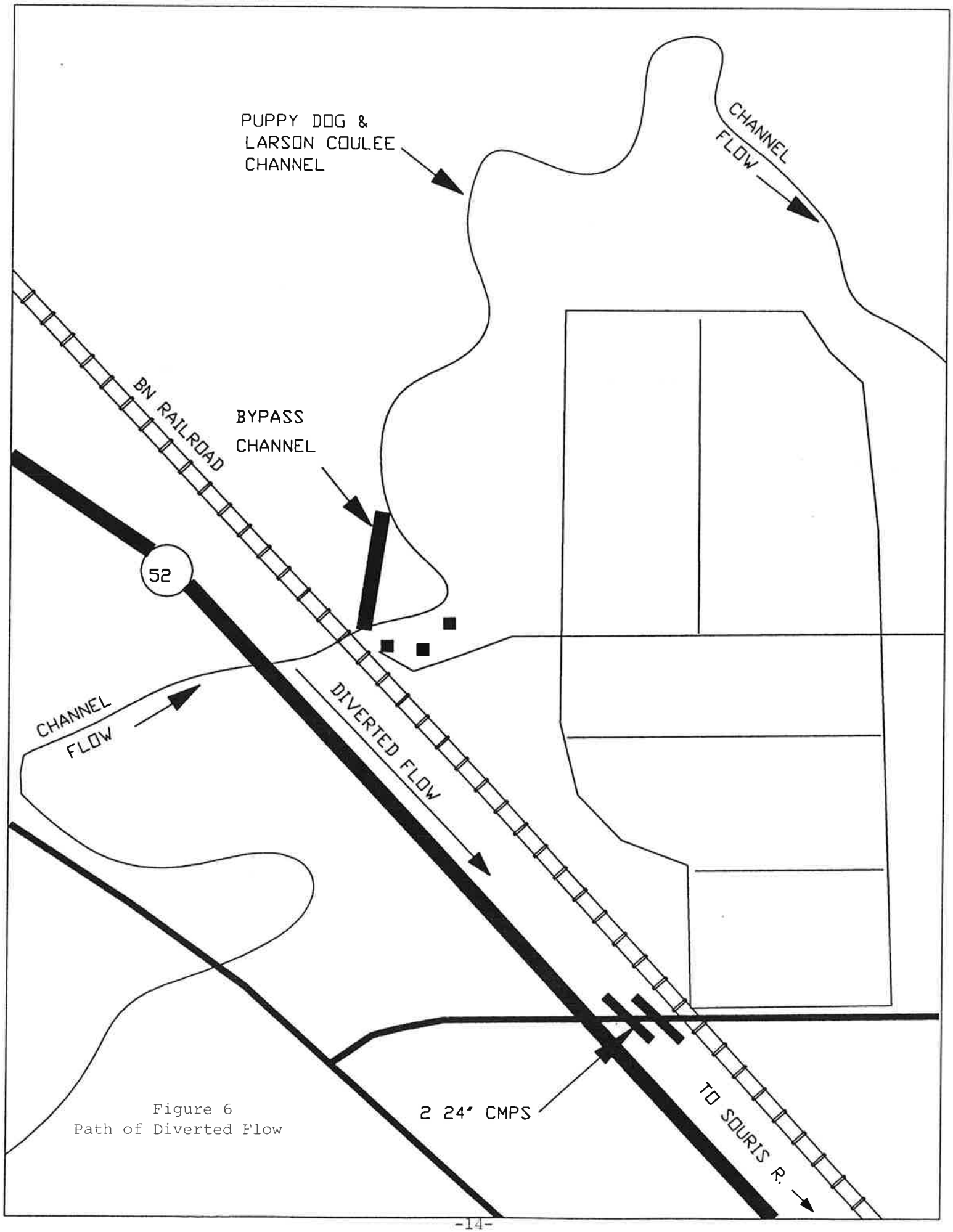


Figure 6
Path of Diverted Flow

V. ALTERNATIVES

Several alternatives were considered as part of this investigation. The first alternative involved blocking the downstream end of the meander that was bypassed as part of the channelization project. The second alternative consisted of diverting additional flow through the Highway 52 ditch. The third alternative involved the construction of flood detention dams (dry dams) to reduce the peak flow at the project site. The fourth alternative consisted of relocating or raising the houses that experience flooding. The following sections describe these alternatives in detail.

Alternative One:

This alternative involves blocking the downstream end of the meander that was bypassed as part of the channelization project. This will reduce the occurrence of water leaving the channel. Based on survey data obtained for this investigation, water will leave the channel when the water surface elevation exceeds 1548.5 msl in the meander that was bypassed. Analysis with the HEC-2 computer model indicates that under current conditions, the water level exceeds this elevation during a 5-year precipitation event.

The topography of the area will allow for the construction of a channel block at an elevation of 1550.5 msl. A channel block at this level will retain the flows due to a 10-year precipitation event within the channel. No additional benefit will be gained by constructing a channel block above this level since its elevation

will exceed the elevation of the adjacent stream bank. A single 24-inch diameter CMP culvert with a flap gate will be placed through the channel block to prevent water from accumulating in the old channel. Figure 7 shows Alternative One as proposed. Table 3 gives a cost estimate for Alternative One.

Table 3 - Preliminary Cost Estimate for Alternative One

Item	Quantity	Unit	Unit Price	Total
Mobilization	1	LS	$1,000.00	$1,000
Clearing and Grubbing	1	LS	1,000.00	1,000
Stripping and Spreading Topsoil	700	SY	0.25	175
24-inch Diameter CMP	70	LF	25.00	1,750
24-inch Diameter Flap Gate	1	Ea.	250.00	250
Fill	900	CY	1.20	1,080
Seeding	0.5	Ac.	300.00	150
Subtotal				$5,405
Contingencies			(+/- 10%)	531
Contract Administration			(+/- 10%)	532
Engineering			(+/- 10%)	532
Total				$7,000

Alternative Two:

The second alternative consists of diverting additional flow through the Highway 52 ditch. Currently, when the water level in the Puppy Dog and Larson Coulee channel reaches an elevation of 1546.3 msl at its intersection with the Highway 52 ditch, water flows through the ditch, eventually reentering the Souris River farther downstream. The amount of flow that can be diverted through the Highway 52 ditch is limited by two 24-inch diameter CMP culverts that pass through a roadway that crosses the ditch between Section 33, Township 155 North, Range 82 West and Section 4, Township 154 North, Range 82 West.

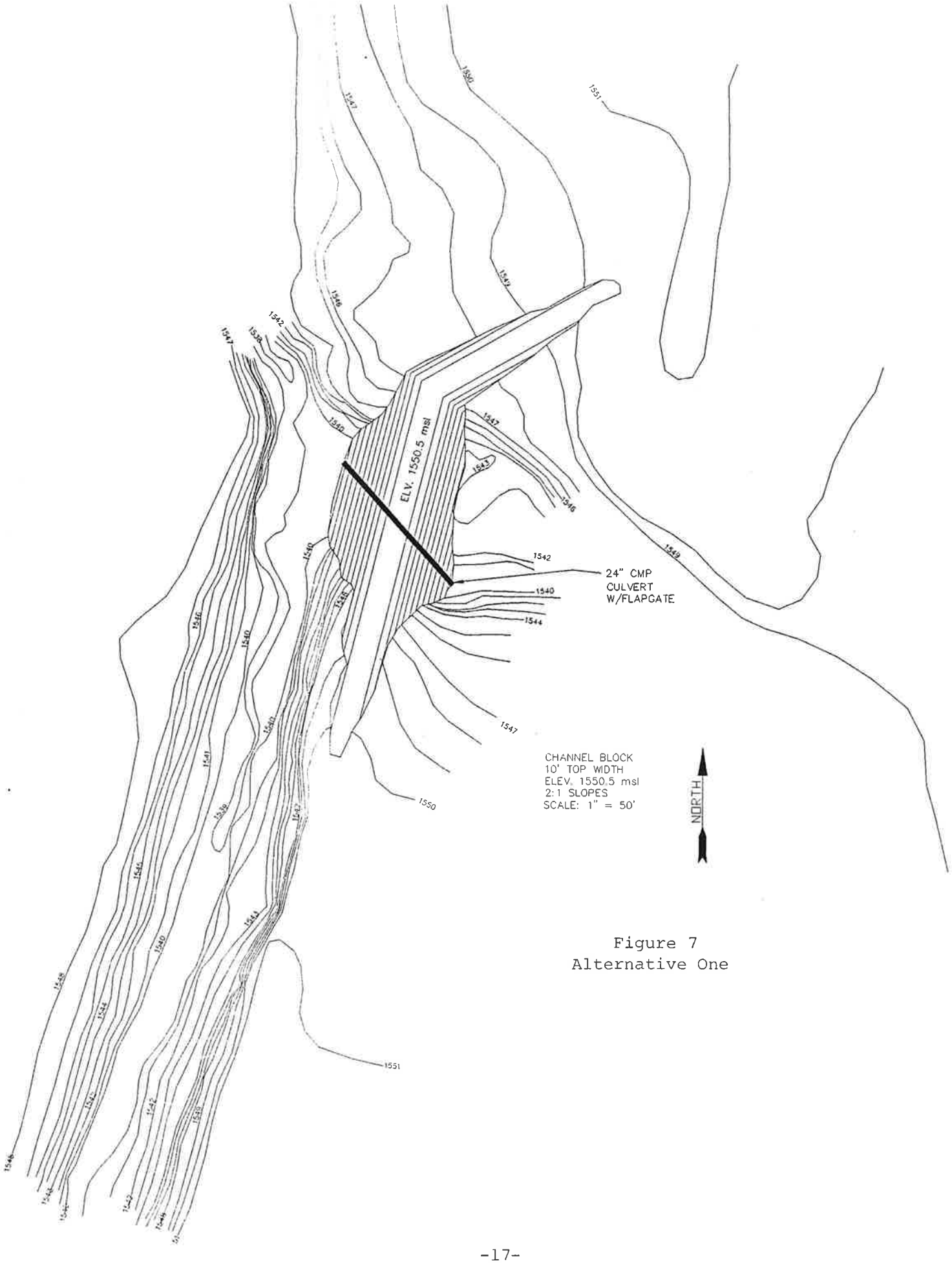


Figure 7
Alternative One

Analysis with the HEC-2 computer model indicates that the diversion of 400 cfs of flow through the Highway 52 ditch will reduce the water surface elevation in the channel by 1-foot during a 10-year precipitation event. Modifications to the Highway 52 ditch and the roadway that crosses it will be necessary in order to divert this additional flow. These modifications include excavating a 15-foot wide channel with 4H:1V side slopes through the ditch and installing two 60-inch diameter CMP culverts through the roadway that crosses it. The invert of the channel will be at an elevation of 1543 msl at its intersection with the Puppy Dog and Larson Coulee channel. Table 4 shows the flow that escapes through the modified Highway 52 ditch, the remaining channel flow, and the water surface elevation for the stream channel at the downstream end of the bypass channel for various precipitation events, as computed using the HEC-2 computer model.

Table 4 - Water Surface Elevations at Bypass Channel for Modified Highway 52 Ditch

Event	Total Flow (cfs)	Channel Flow (cfs)	Highway 52 Ditch Flow (cfs)	Water Surface Elevation (msl)
25-year rainfall	2236	1784	452	1550.8
10-year rainfall	1594	1193	401	1549.2
5-year rainfall	1040	760	280	1547.5

Analysis of these water levels indicates that despite the 1-foot reduction in water level that the ditch modifications produce, water will still leave the channel through the low-spot in the bank during a 10-year precipitation event. Therefore, the

diversion of additional water through the Highway 52 ditch, alone, will not significantly reduce the occurrence of flooding. This alternative may want to be considered in combination with the construction of a channel block and dike mentioned in Alternative One to give added flood protection.

A concern associated with this alternative is the effect that the increased flow will have on downstream structures. The water that is diverted through the ditch enters a series of oxbows formed by the meandering Souris River channel. This water eventually enters the Souris River farther downstream. There are several houses located adjacent to these oxbows. The diversion of additional water through the Highway 52 ditch may cause flooding to these houses. A detailed hydraulic analysis will need to be performed on this area before this alternative can be recommended. Therefore, a detailed cost estimate has not been prepared.

Alternative Three:

The third alternative involves constructing dry dams to reduce the peak flow at the project site. A dry dam consists of a dam with an ungated outlet positioned so that essentially all stored water will be drained from the reservoir by gravity. The reservoir will normally be nearly dry. During precipitation events, the flow is retained upstream of the dam. This reduces the downstream flow to that which is released through the ungated outlet. Following the precipitation event, the flood pool is slowly released through the ungated outlet, reducing the peak flow downstream.

Currently, the peak flow from Puppy Dog, First Larson, and Second Larson Coulees occurs at virtually the same time, resulting in a higher flow at the project site. The construction of dry dams on one or more of the coulees will attenuate the peak flow for that basin, resulting in a reduced flow at the project site.

A preliminary analysis of potential dam sites resulted in the selection of two sites. The first site is located on Puppy Dog Coulee in Section 31, Township 155 North, Range 82 West, approximately 3,000 feet upstream of its confluence with First Larson Coulee. The second site is located on First Larson Coulee in Section 31, Township 155 North, Range 82 West, approximately 400 feet upstream of its confluence with Puppy Dog Coulee. Figure 8 shows the location of these dam sites.

A preliminary hydraulic analysis of these dam sites indicates that the construction of dry dams at both sites will reduce the 100-year flow at the project site from 3,640 cfs to 1,525 cfs. If this is done in combination with Alternative One, the Eastside Estates Housing Development will be provided with 100-year flood protection. The goal of most urban flood control projects is to provide 100-year flood protection to the area that experiences flooding. This will eliminate the need for flood insurance on the buildings located in the flood plain.

A problem associated with the installation of dry dams on Puppy Dog and First Larson Coulees is the high cost. The dams

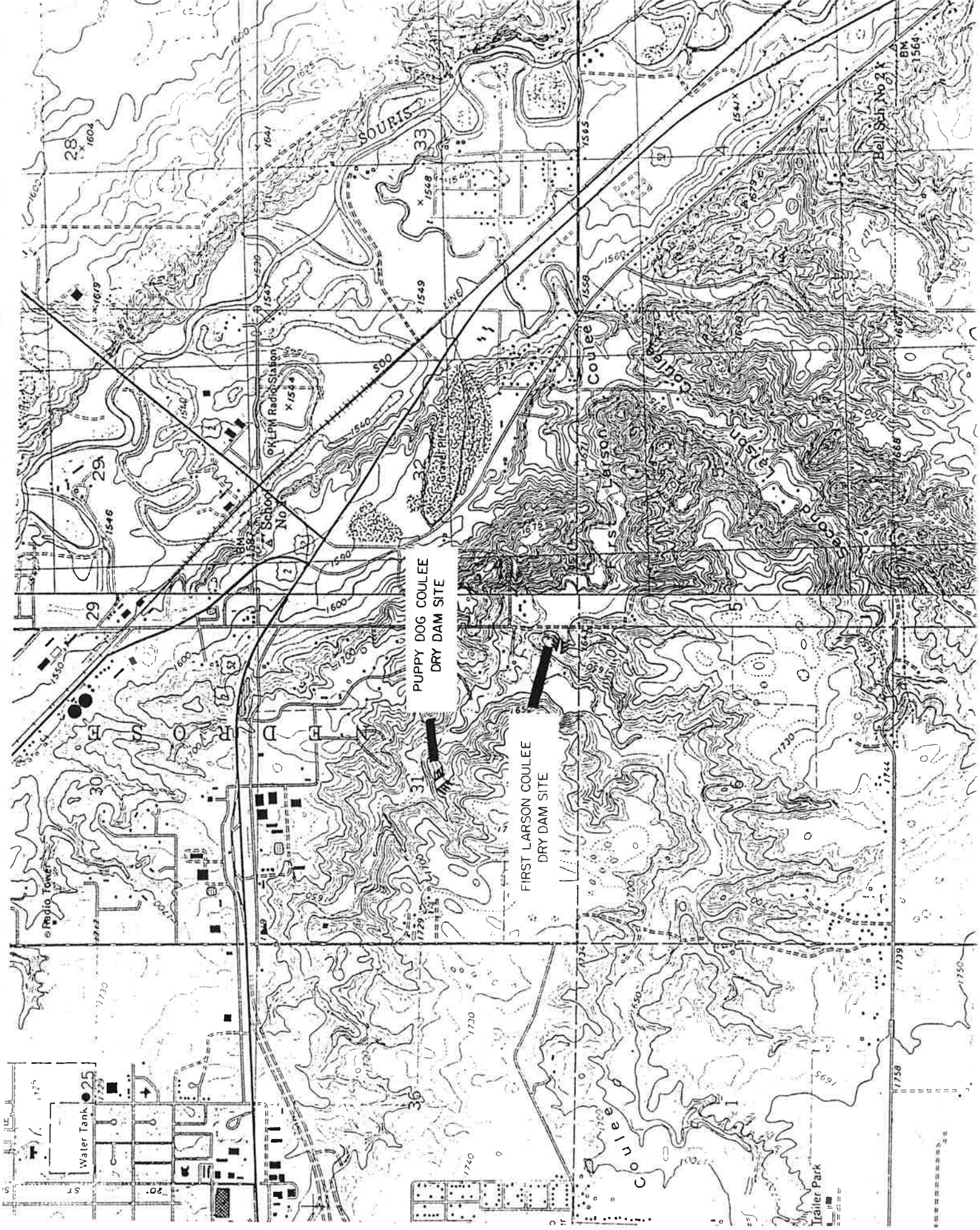


Figure 8
Location of Dry Dam Sites

will be given a high hazard classification due to the housing development located downstream. Therefore, it will be necessary to design the dams to pass a Probable Maximum Flood (PMF) without overtopping. This will require a high embankment with a large emergency spillway. Several houses and roadways that will be inundated by the flood pool will also need to be relocated or raised. Based on 1988 aerial photos, approximately three houses located upstream of the Puppy Dog Coulee dry dam site and one farm located upstream of the First Larson Coulee dry dam site will need to be relocated or raised. A field survey will be necessary to determine the exact number of houses that will need to be raised or relocated.

The analysis that was performed on these dam sites is very preliminary in nature. The dam sites were selected based on information gained from USGS 7.5-minute quadrangle maps of the area and aerial photos. Additional information, including a detailed field survey and a geotechnical exploration, will be needed in order to further study these sites. This information will be necessary to prepare cost estimates for the proposed dry dams. Public input into this alternative is also important, since it may involve relocating or raising several houses and roadways located upstream of the dry dams. Residents living in these houses may oppose the relocation of their homes to protect homes located farther downstream.

Alternative Four:

The fourth alternative involves relocating or raising the houses that experience flooding. Based on USGS 7.5-minute quadrangle maps, it appears that there are approximately 50 houses located in the Eastside Estates Housing Development. It also appears that all of these houses lie below the 100-year flood level for the Puppy Dog and Larson Coulee channel. Relocating or raising these houses above the 100-year flood level will eliminate the need for flood insurance by the homeowners. Problems associated with this alternative include high cost and potential opposition from residents living in the development. If the decision is made to pursue this alternative farther, it will be necessary to perform a field survey to more accurately determine the number of houses that will need to be relocated or raised and the associated cost.

VI. SUMMARY

The feasibility of a flood control project below the confluence of Puppy Dog, First Larson, and Second Larson Coulees, has been examined. The flooding occurs in the Eastside Estates Housing Development located downstream of the three coulees, northeast of Highway 52 near Minot, North Dakota. A channelization project that was performed in this area involved blocking the upstream end of a meander and constructing a bypass channel. The downstream end of the meander remains open. During high flows, backwater enters through the meander and leaves the channel through low spots in the bank. This causes flooding to low-lying houses located in the development.

Several alternatives were considered as potential solutions to the flooding problem. The first alternative involved constructing a channel block at the downstream end of the meander that was bypassed. The top of the proposed channel block is set at an elevation of 1550.5 msl. A channel block constructed at this level retains the flow due to a 10-year precipitation event within the channel. The cost to construct this alternative is estimated to be $7,000.

The second alternative consists of diverting additional flow through the Highway 52 ditch. Analysis indicated that the diversion of additional flow through the ditch, alone, does not significantly reduce the occurrence of water leaving the channel through the low spots in the bank. If this alternative is pursued,

it should be done in combination with Alternative One to provide additional flood protection. A hydraulic analysis of the impact the diverted water will have farther downstream should be performed before this alternative is considered further.

The third alternative involved the construction of dry dams upstream of the project site to reduce the peak flow. An evaluation of potential dam sites resulted in the selection of two sites. The first site is located on Puppy Dog Coulee, approximately 3,000 feet upstream of its confluence with First Larson Coulee. The second site is located on Second Larson Coulee, approximately 400 feet upstream of its confluence with Puppy Dog Coulee. A preliminary analysis of these sites indicated that the construction of dry dams at both sites reduces the flow due to a 100-year 24-hour rainfall from 3,640 cfs to 1,525 cfs at the project site. If this were done in combination with Alternative One, the houses located in the development would be provided with 100-year flood protection. A more detailed analysis of these sites was beyond the scope of this investigation.

The fourth alternative consists of relocating or raising the houses that experience flooding. Additional information will need to be obtained to perform a detailed analysis of this alternative.

VII. RECOMMENDATIONS

Four alternatives were considered as part of this investigation. The four alternatives will all provide flood protection of some level for the residents living in the Eastside Estates Housing Development. Alternative One will provide 10-year flood protection. Alternative Three will provide 100-year flood protection if it is done in combination with Alternative One. Alternative 4 will also provide 100-year flood protection. The goal of most urban flood control projects is to provide 100-year flood protection to the area that experiences flooding. This will eliminate the need for flood insurance on the buildings located in the flood plain. Therefore, it is recommended that either Alternative Three or Alternative Four be pursued further.

Regardless of the alternative selected, the city and county should pursue a flood plain study on Puppy Dog and Larson Coulee. This will allow the city to more accurately zone and control future development in flood plain areas. The decision to proceed with this project is the responsibility of the Ward County Water Resource Board.

Appendix A - Copy of Agreement

SWC Project #1313
November 1, 1991

A G R E E M E N T

Investigation of a Flood
Control Project on Puppy Dog
and Larson Coulees

I. PARTIES

THIS AGREEMENT is between the North Dakota State Water Commission, hereinafter Commission, through its Secretary, David A. Sprynczynatyk; and the Ward County Water Resource District, hereinafter District, through its Chairman, Arden Haner.

II. PROJECT, LOCATION, AND PURPOSE

The District has requested the Commission to investigate the feasibility of a flood control project below the confluence of Puppy Dog Coulee and the First and Second Larson Coulees in Ward County. The Project is located in Section 33, Township 155 North, Range 82 West.

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 $800.00 with the Commission to help defray the field 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 agrees to indemnify and hold harmless the State of North Dakota, the Commission, its Secretary, their employees and agents, from all claims, suits or actions of whatsoever nature resulting out of the design, construction, operation, or maintenance of the project. In the event a suit is initiated or judgment is entered against the State of North Dakota, the Commission, its Secretary, their employees or their agents, the District shall indemnify any or all of them for all costs and expenses, including legal fees, and any judgment arrived at or satisfied or settlement entered.

VII. MERGER CLAUSE

This agreement constitutes the entire agreement between the parties. No waiver, consent, modification or change of terms of this agreement shall bind either party unless in writing, signed by the parties, and attached hereto. Such waiver, consent, modification or change, if made, shall be effective only in the specific instance and for the specific purpose given. There are no understandings, agreements, or representations, oral or written, not specified herein regarding this agreement.

NORTH DAKOTA STATE WATER COMMISSION
By: David A. Sprynczynatyk
DAVID A. SPRYNCZYNATYK
Secretary

WITNESS: Dale L Frink

DATE: 4 Nov 91

WARD COUNTY WATER RESOURCE DISTRICT
By: Arden Haner
ARDEN HANER
Chairman

WITNESS: Nancy Ali

DATE: January 13, 1992

Appendix B - Symbols and Abbreviations

SYMBOLS AND ABBREVIATIONS

CMP - Corrugated Metal Pipe

HEC - The Hydrologic Engineering Center

msl - mean sea level

cfs - cubic feet per second

USGS - United States Geological Survey

SWC - State Water Commission