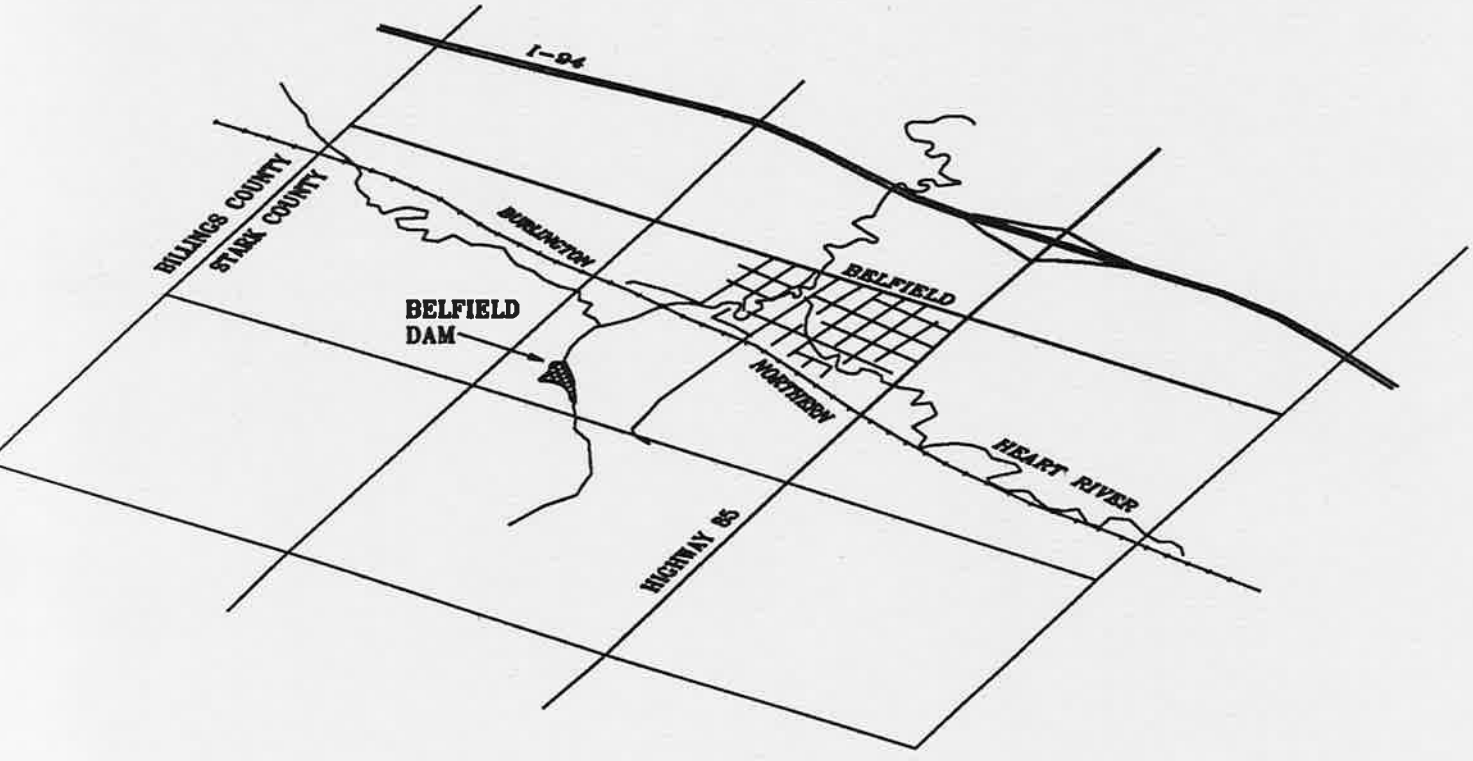
PRELIMINARY ENGINEERING REPORT

BELFIELD DAM

SWC #1307

STARK COUNTY



NORTH DAKOTA
STATE WATER COMMISSION
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PRELIMINARY ENGINEERING REPORT

Belfield Dam
SWC Project #1307
Stark County

November 1990

North Dakota State Water Commission
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Appendix A - Copy of Agreement

I. INTRODUCTION

Study Objectives:

In June of 1990, the North Dakota State Water Commission and the Stark County Water Resource District entered into an agreement to investigate the feasibility of reconstructing and/or rehabilitating Belfield Dam. The purpose of the agreement was to conduct a topographic survey of the dam site, conduct a study of the hydrology of the watershed upstream of the dam, design the outlet works necessary to safely and efficiently pass the design flood through the dam, design a low-level outlet works for drawdown capabilities, and design modifications to reduce seepage losses through the embankment. A copy of the agreement is contained in Appendix A.

This report contains a description of the geology of the site, a hydrologic and hydraulic analysis of the drainage basin, a summary of the preliminary design, a cost estimate based on the preliminary design, a description of land rights, and a statement of conclusions and recommendations regarding the project.

Location:

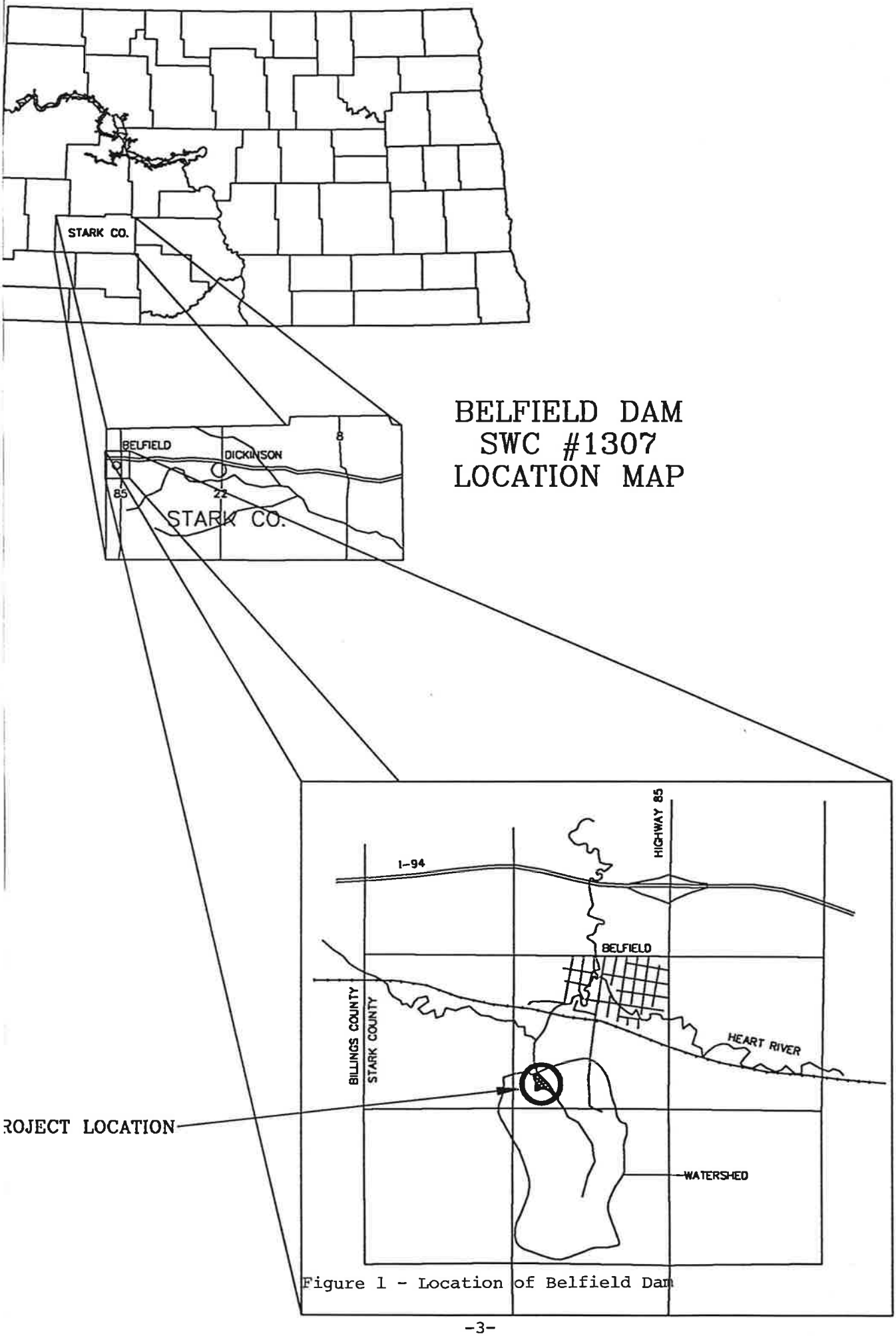
Belfield Dam is located in the SW1/4 Section 5, Township 139 North, Range 99 West, near Belfield, North Dakota. The proposed modifications will aid in the development of a much needed and improved recreational facility for the city of Belfield and the surrounding area. The facility would give residents oppor-

tunities for fishing, camping, and other recreational purposes. Figure 1 shows the location of Belfield Dam.

Background and Description:

Belfield Dam was constructed on a tributary to the Heart River, by the Northern Pacific Railroad, between the years of 1900 and 1910. The depth of the reservoir was increased through the use of a dragline shortly after completion. The maximum depth at the time was about 16 feet. The depth has decreased since then due to sediment deposition and the drought.

The embankment is a rolled earthfill structure. The embankment is approximately 300 feet long, 12 feet high, and 10-20 feet wide at the crest. The crest of the embankment ranges from 2601 msl to 2601.8 msl, and has an alignment of east to west, with the right abutment on the east side. The reservoir is controlled at an elevation of 2599 msl by the use of a notched channel in the right abutment. At this level, the reservoir contains 39 acre-feet of water, has an average depth of 6.5 feet, and a maximum depth of 10.5 feet. Presently, the water surface is about 3 feet below the control elevation. The reservoir is supplied by a drainage area of 0.75 square miles and is supplemented with spring discharges. The spring-fed area is located about 300 feet upstream of the dam near the left shore.



BELFIELD DAM
SWC #1307
LOCATION MAP

Figure 1 - Location of Belfield Dam

II. GEOLOGY AND CLIMATE

Belfield Dam is located in the unglaciated Missouri Plateau section of the Great Plains physiologic province. This area is characterized by a rolling plateau surface that is highly dissected by erosion. Scattered buttes, capped by resistant sandstone, limestone, or scoria beds are remnants of sedimentary strata that once covered the area more extensively.

The Sentinel Butte Formation, the uppermost formation of the Fort Union Group, forms the land surface in most of Stark County. The formation consists of silty fine- to medium-grained sandstone, carbonaceous and bentonite claystone, and lignite.

The climate for the basin is characteristic of the interior of the continent and latitude. Relatively large extremes in the weather occur rapidly. Most precipitation falls in summer thunderstorms, which can be intense and accompanied by hail.

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 discharges and flow volumes of various frequency storms. It formulates a mathematical hydrologic model of the watershed based on the following data: the amount of rainfall, the rainfall 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 model was developed to determine the hydrologic response of the Belfield watershed. The results obtained through the use of the model include: (1) inflow hydrographs, (2) reservoir stage hydrographs, and (3) outflow hydrographs.

IV. PRELIMINARY DESIGN

Introduction:

Belfield Dam site is a suitable location for a small reservoir. The size of reservoir that is attainable is limited by the topography of the area and the fact that the watershed does not consistently yield reliable volumes of water to offset evaporation. Springs located in the area appear to compensate for a portion of the evaporation. Three alternatives were considered as part of the preliminary investigation: The first alternative is to modify the existing embankment to meet North Dakota Dam Safety Standards. The second alternative is to remove the old embankment and install a new one at the location of the old embankment. The third alternative is to remove the old embankment and install a new one further downstream. The following sections describe these alternatives in detail.

Dam Classification:

A dam should be classified in order to design the outlet works. Design criteria are based on hazard classification and the height of the dam. Hazards are potential loss of human life or property damage downstream of a dam from floodwaters released from a dam or waters released by partial or complete failure of the dam. The following hazard categories of dams and a brief description are contained in the "North Dakota Dam Design Handbook."

Low - Dams located in rural or agricultural areas where there is little possibility of future development. Failure of low hazard dams may result in damage to agricultural land, township and county roads, and farm building other than residences. No loss of life is expected if the dam fails.

Medium - Dams located in predominantly rural or agricultural areas where failure may damage isolated homes, main highways, railroads, or cause interruption of minor public utilities. The potential for the loss of a few lives may be expected if the dam fails.

High - Dams located upstream of developed and urban areas where failure may cause serious damage to homes, industrial and commercial buildings and major public utilities. There is a potential for the loss of more than a few lives if the dam fails.

Belfield Dam is classified as a medium hazard dam. This classification is due to the low height of the dam and the fact that there are no occupied houses located immediately downstream of the embankment. Failure of the dam would not cause serious damage to property and/or the loss of a large number of lives.

After a dam has been given a hazard category, it can be classified according to its height. The following table was listed in the "North Dakota Dam Design Handbook":

Table 1 - Dam Design Classification

Height (Feet)	Hazard Categories		
	Low	Medium	High
Less than 10	I	II	IV
10 to 24	II	III	IV
25 to 39	III	III	IV
40 to 55	III	IV	V
Over 55	III	IV	V

Belfield Dam has a medium hazard classification and falls in the 10- to 24-foot height range. Based on this, it is given a class III classification for design purposes.

For a class III dam, the principal spillway must pass the flow due to a 25-year precipitation event without the use of an emergency spillway. The entire spillway system (i.e. emergency and principal spillway) must pass the flow resulting from 30 percent of a probable maximum precipitation value without over-topping the dam. The emergency spillway must also pass the flow due to a 100-year precipitation event without exceeding the allowable velocity of 7 feet per second.

Hydrology:

The watershed above Belfield Dam was defined using USGS 7.5 minute quadrangle maps of the area. The drainage area for the existing Belfield Dam site was calculated to be 0.75 square miles. Figure 2 shows the drainage basin above Belfield Dam.

Considering the relatively small drainage area, it was necessary to perform a yield analysis to determine the potential for maintaining a suitable reservoir level. Stream gage data from the Heart River was used to determine yield. The data gives a median yield of 48.3 acre-feet per square mile. This indicates an average runoff of 36.2 acre-feet per year can be expected from the Belfield Dam drainage basin, since it is a tributary to the Heart River.

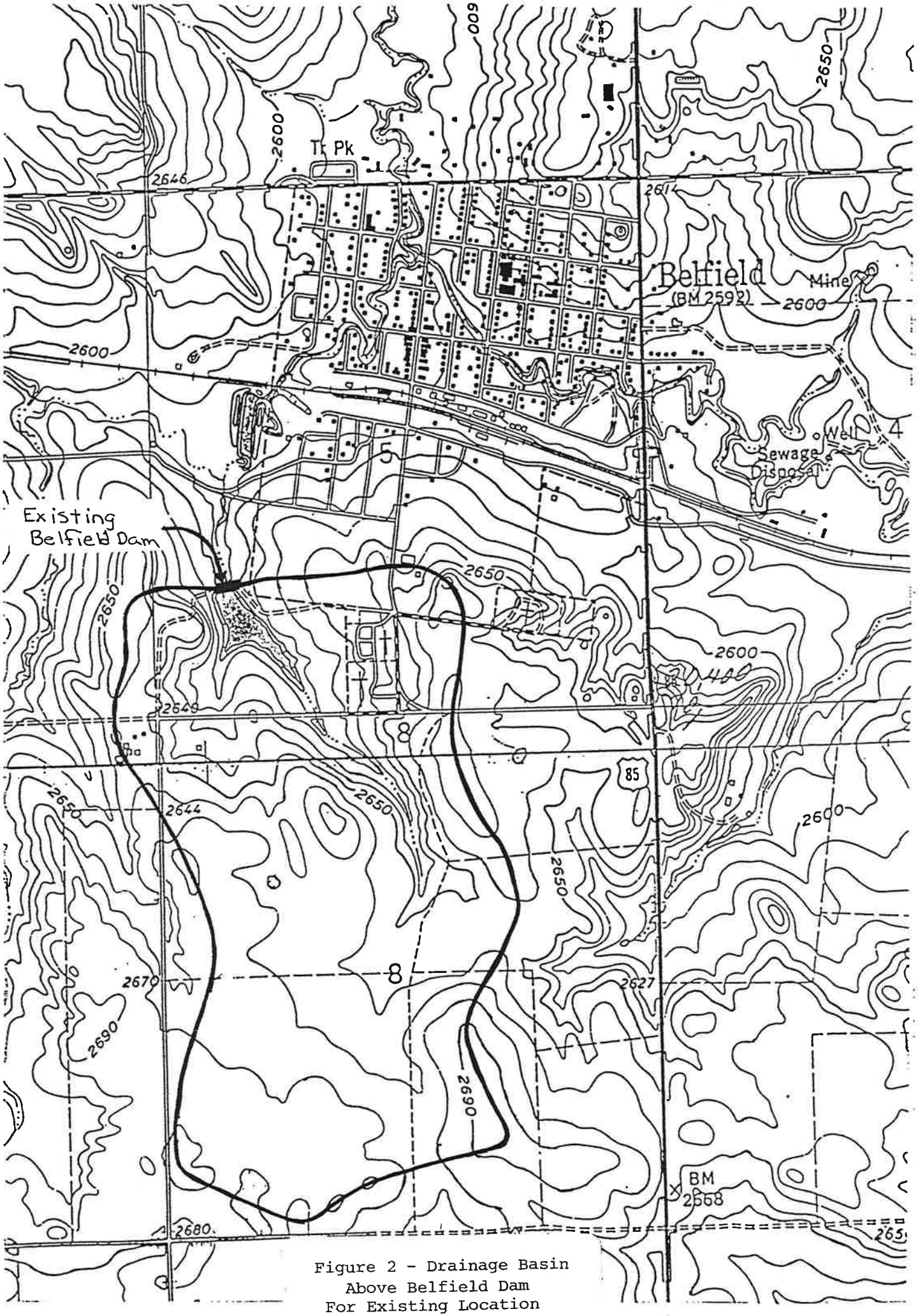


Figure 2 - Drainage Basin
Above Belfield Dam
For Existing Location

Following the expected yield calculations, the evaporation losses were examined. A value of 36.5 inches of evaporation per year was calculated. This value was obtained through the use of the Hydrology Manual for North Dakota.

The sustainable water surface elevation was determined using the Rezfill computer program, developed by the North Dakota State Water Commission. The Rezfill program calculates the elevation reached by a reservoir water surface given inputs of evaporation, runoff, the percent runoff which is snowmelt, the basin area, and an elevation versus area curve. The Rezfill program indicated that a water surface elevation of 2603 msl could be reached in five years, starting with an empty reservoir and receiving average runoff. Considering this, a water surface elevation of 2603 msl was selected. At this level, the reservoir would contain 63.4 acre-feet of water, have an average depth of 7.2 feet, and have a maximum depth of 14.5 feet. It does not appear that the watershed and the topography of the reservoir site will allow for the creation of a deeper reservoir unless the reservoir bottom is dredged.

The proposed downstream dam site has a drainage area of 0.80 square miles. Figure 3 shows the proposed downstream location and its drainage basin. The sustainable water surface elevation for the downstream site is 2594 msl, based on the Rezfill computer program. At this level, the reservoir would contain 33 acre-feet of water, have an average depth of 4.2 feet, and have a

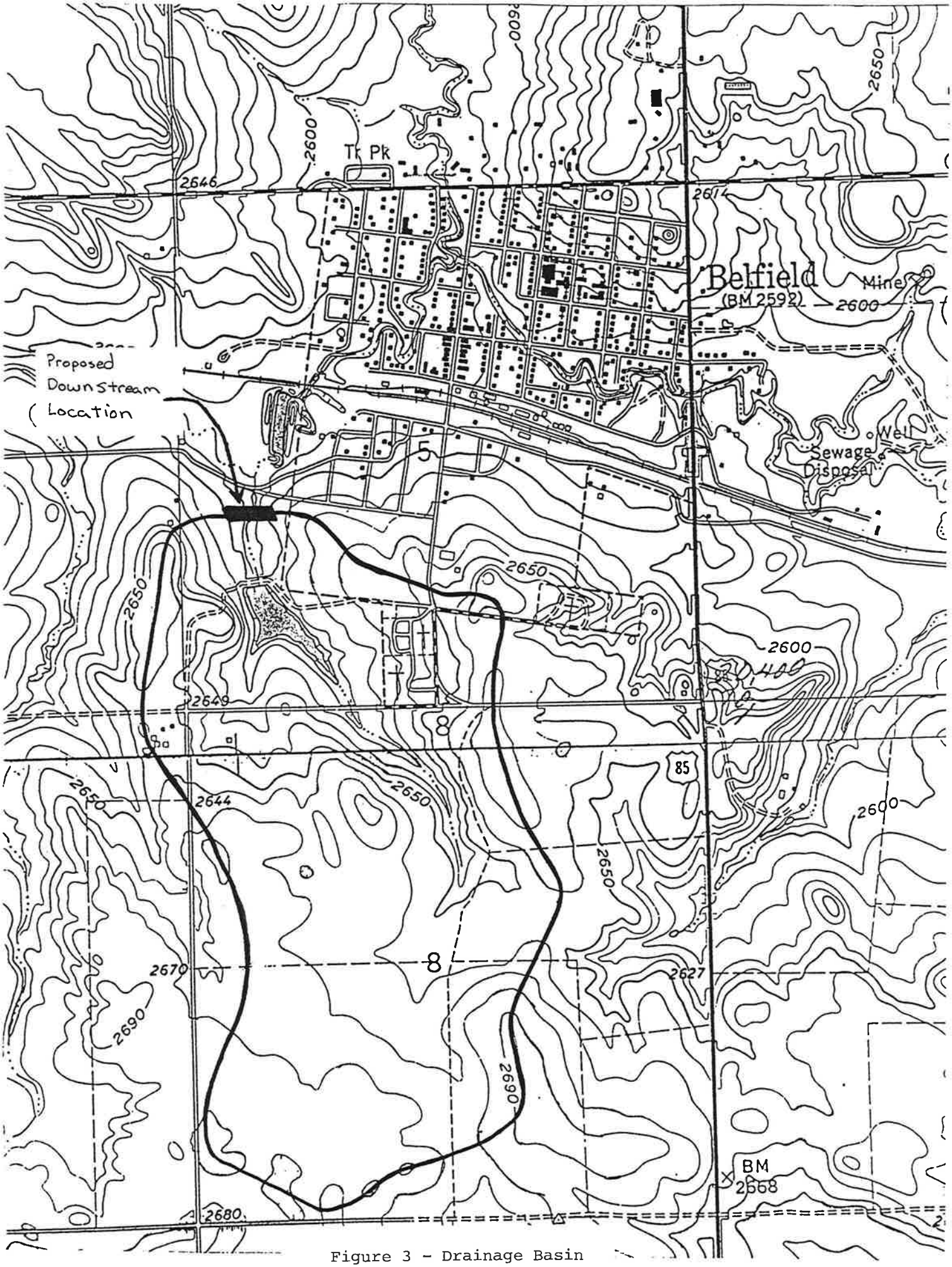


Figure 3 - Drainage Basin
For Proposed
Downstream Location

maximum depth of 12 feet. The low average depth of the reservoir at the downstream site makes it impractical to relocate.

Precipitation Design:

Precipitation design amounts were determined once the dam was classified. Outlet works of a dam are required to have flow capacities capable of passing runoff from precipitation events as suggested by its classification.

Based on the North Dakota Dam Design Handbook, the requirements for a class III dam are: 1) The principal spillway is to pass the flows due to a 25-year precipitation event without the use of a non-structural emergency spillway, 2) The emergency spillway is to pass the flows of a 100-year precipitation event within acceptable velocity limits, and 3) The dam is to withstand the 0.3 PMP event without overtopping. A 10-day rainfall, 24-hour rainfall, and 10-day snowmelt precipitation tables were used for the 25-year and 100-year events, and a 6-hour extreme rainfall table developed from Hydrometeorological Report Number 51, was used for the 0.3 PMP event. Table 2 shows the resulting peak inflows and total volumes for these events.

Table 2 - Peak Inflows and Volumes for Design Frequency

Event	Intensity (in/interval)	Peak Inflow (cfs)	Total Inflow Volume (acre-feet)
25-year 24-hour rainfall	3.50	137	55
25-year 10-day rainfall	5.90	100	69
25-year 10-day snowmelt	2.40	74	70
100-year 24-hour rainfall	4.50	229	86
0.3 PMP	6.15	1008	143

Hydraulic Design:

The HEC-1 computer model was used to simulate the precipitation versus runoff response for the basin and to route the flows through the reservoir. The area-capacity curve for the reservoir and the rating curve for the spillway were needed in order to use the HEC-1 computer model. An area-capacity curve for Belfield Dam was developed using a topographical map obtained from survey data. Figure 4 shows the area capacity curve. The rating curve for the principal spillway was calculated based on the equations for pipe flow. The rating curve for the emergency spillway was calculated using the Rater computer program developed by the North Dakota State Water Commission. Rater develops a rating curve for an open channel using Manning's equation. The rating curve for the proposed spillway system is contained in Table 3.

Table 3 - Rating Curve for Proposed 24-inch Diameter CMP

Elevation	Q-Principal (cfs)	Q-Emergency (cfs)	Q-Total (cfs)
2603	-	-	-
2604	29	-	29
2605	39	-	39
2606	41	102	143
2607	42	393	435
2608	43	782	825
2609	45	1368	1413
2610	46	2017	2063
2611	47	2786	2833

BELFIELD DAM

AREA-CAPACITY CURVE

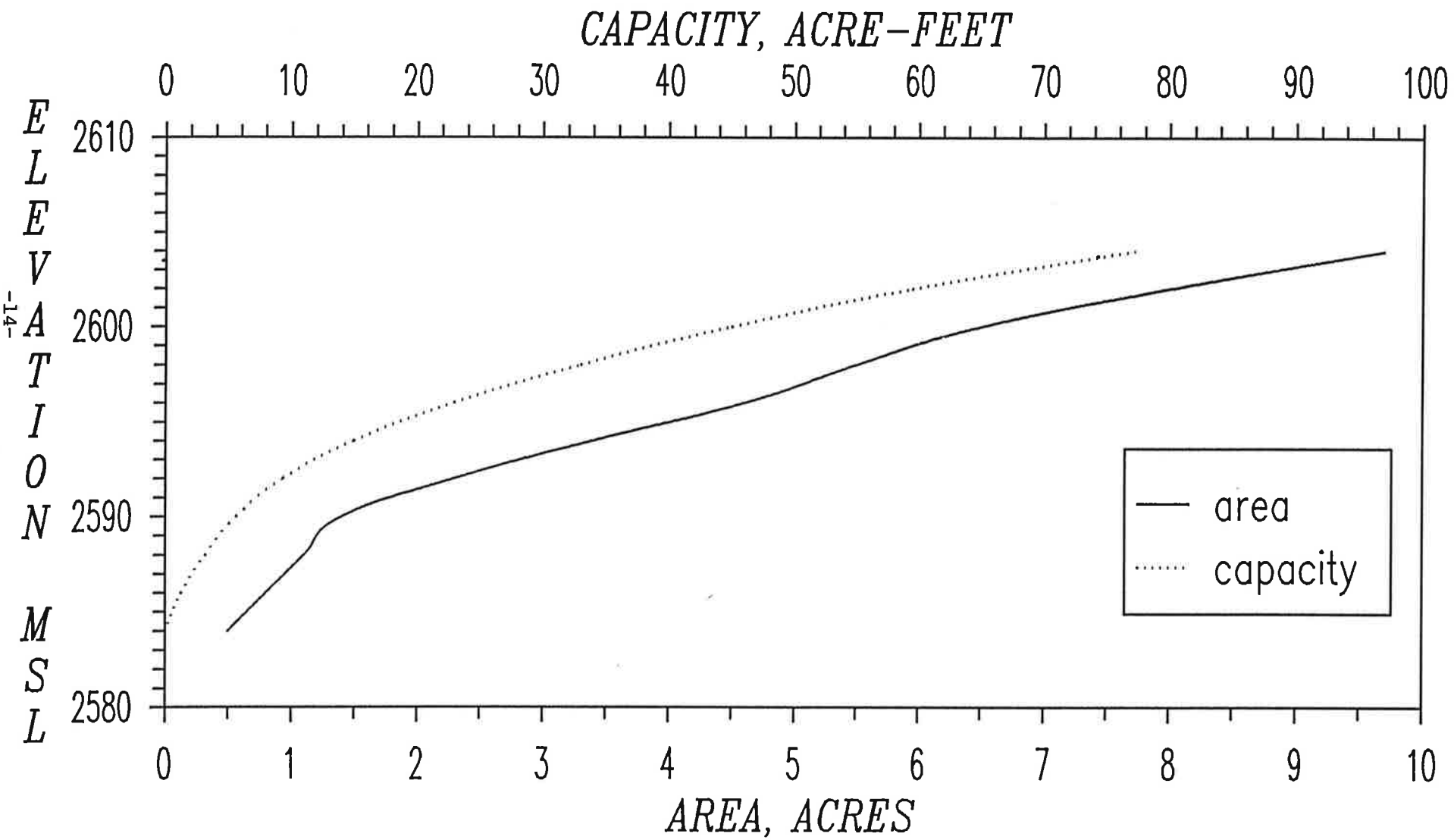


Figure 4 - Area-Capacity Curve

Principal Spillway Works:

Presently, Belfield Dam does not have a separate principal spillway. A class III dam is required to have a separate principal spillway that is capable of passing flows due to a 25-year precipitation event without using the emergency spillway. A number of alternatives were evaluated as potential outlet works for Belfield Dam. Analysis indicated that a 24-inch diameter corrugated metal pipe (CMP) with a 36-inch diameter drop inlet most effectively passes design flows, as suggested by North Dakota Dam Safety Standards. The inlet of the 36-inch diameter CMP drop inlet should be set at 2603 msl, as indicated by the yield analysis. Table 4 gives the inflow, outflow, and stage for the different precipitation events for the proposed new outlet obtained from the HEC-1 model. Figures 5-7 show the various inflow outflow relationships for the proposed new outlet.

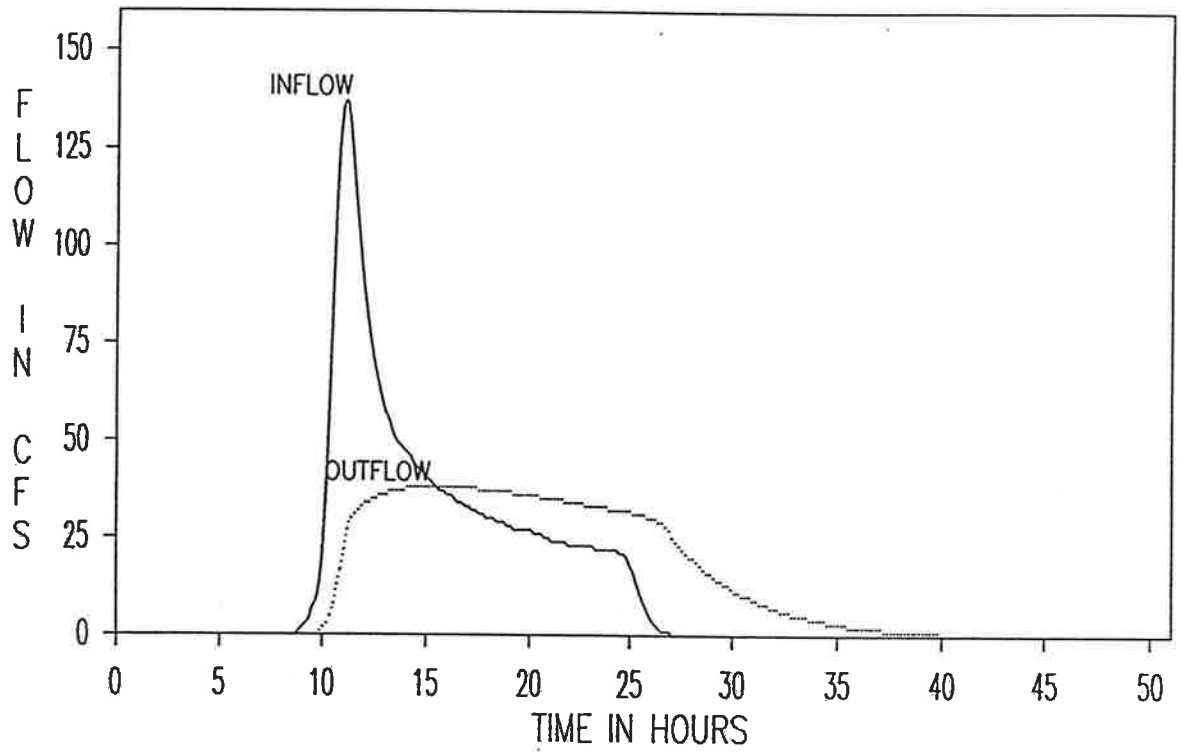
Table 4 - Hydrologic Results for the Proposed 24-inch Diameter CMP

Event	Inflow (cfs)	Outflow (cfs)	Stage (msl)
25-year 24-hour rainfall	137	39	2604.9
25-year 10-day rainfall	100	35	2604.7
25-year 10-day snowmelt	74	38	2604.9
100-year 24-hour rainfall	229	97	2605.6
0.3 PMP	1008	765	2607.8

The use of a 24-inch diameter CMP principal spillway requires that the emergency spillway be set at an elevation of 2605 msl. The principal spillway will be approximately 100 feet in length, with the inlet invert set at an elevation of 2592 msl

BELFIELD DAM HYDROGRAPH

25 YEAR 24-HOUR RAINFALL



25 YEAR 10-DAY RAINFALL

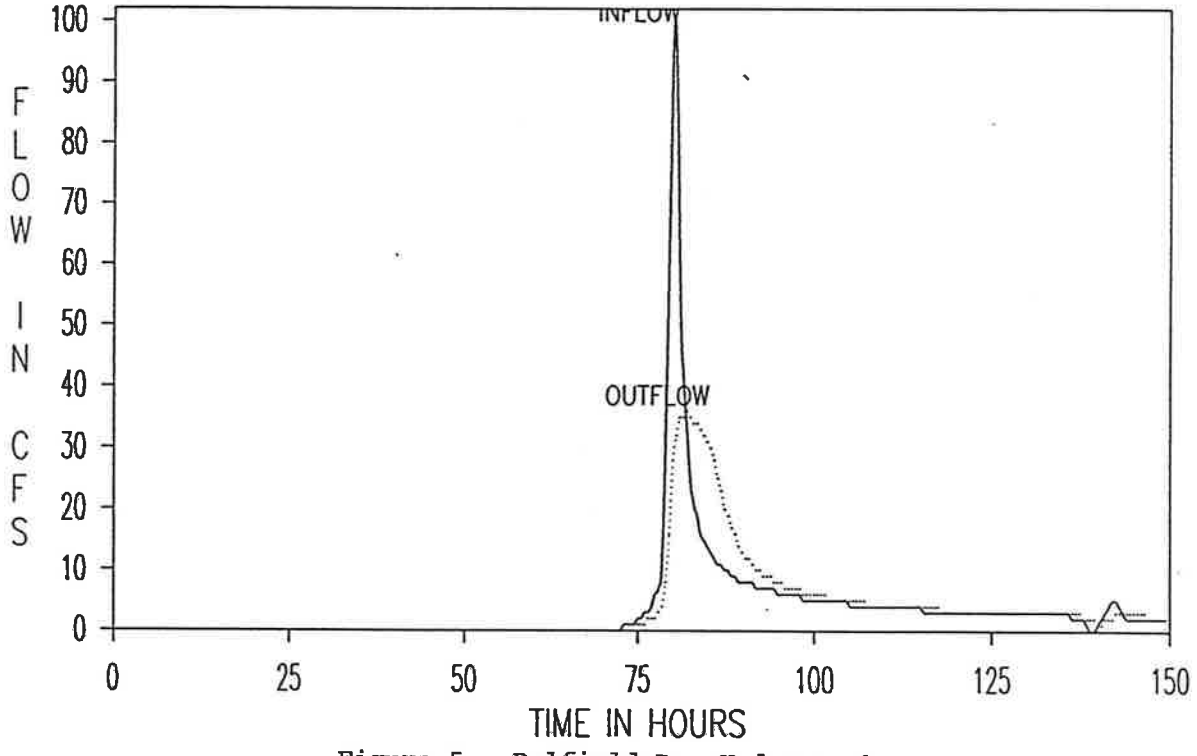


Figure 5 - Belfield Dam Hydrograph

BELFIELD DAM HYDROGRAPH

25 YEAR 10-DAY SNOWMELT

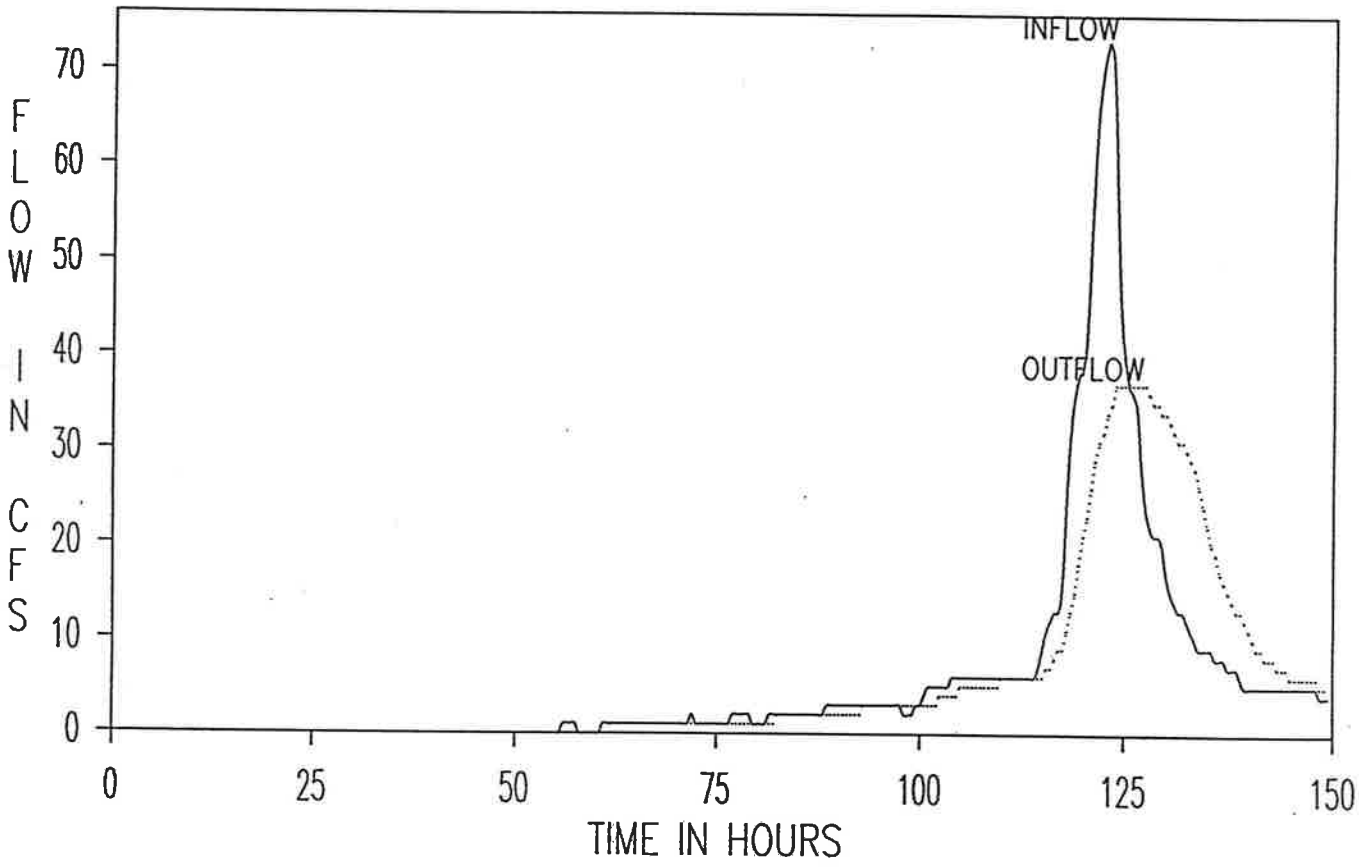
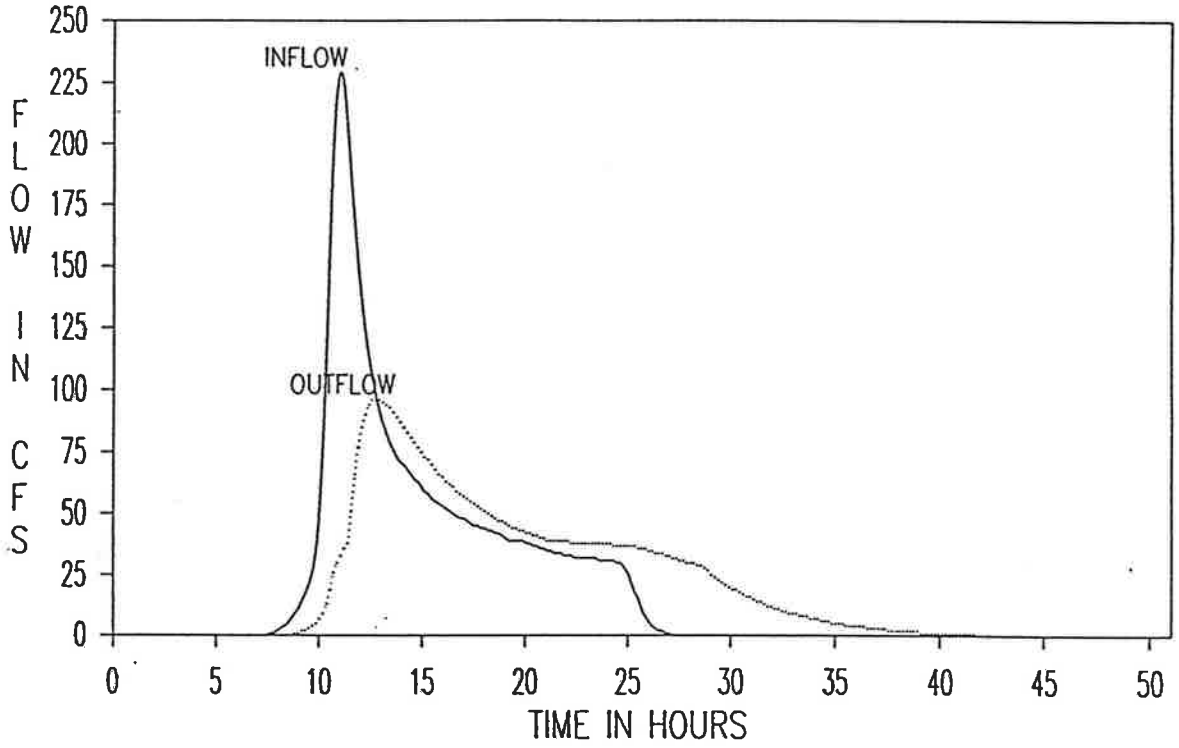


Figure 6 - Belfield Dam Hydrograph

BELFIELD DAM HYDROGRAPH

100 YEAR 24-HOUR RAINFALL



30% OF PROBABLE MAXIMUM PRECIPITATION

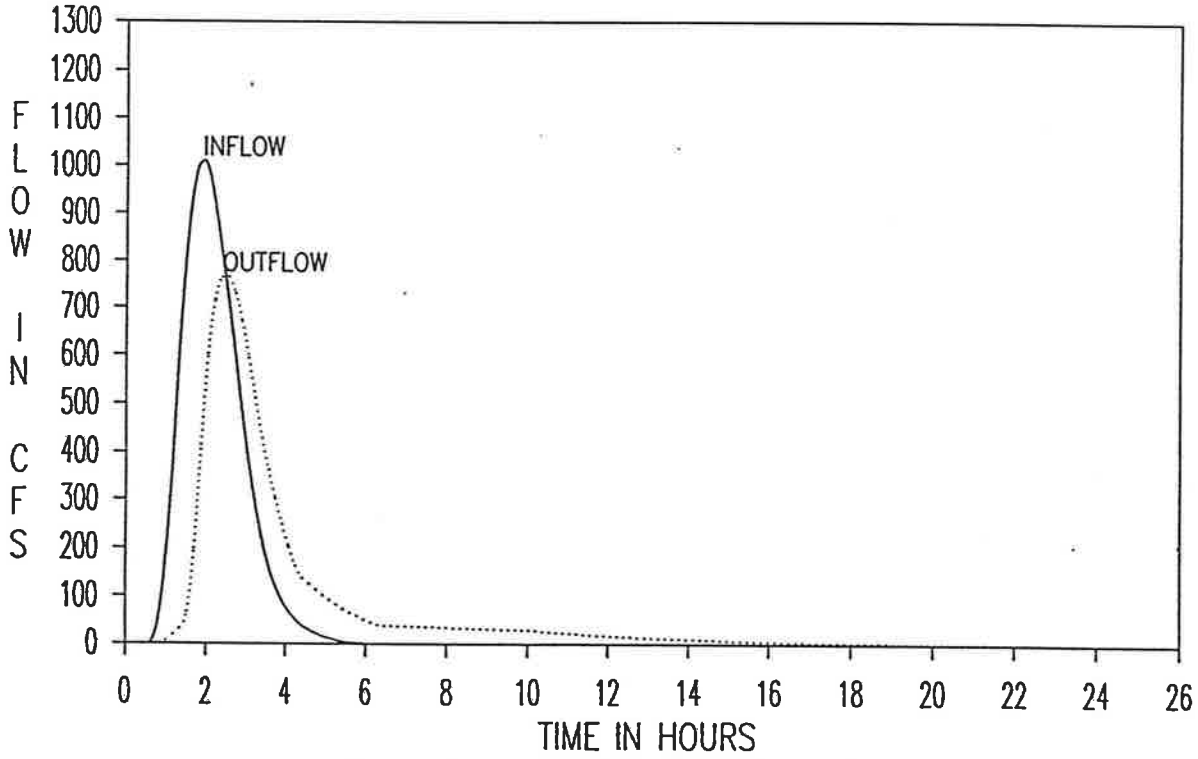


Figure 7 - Belfield Dam Hydrograph

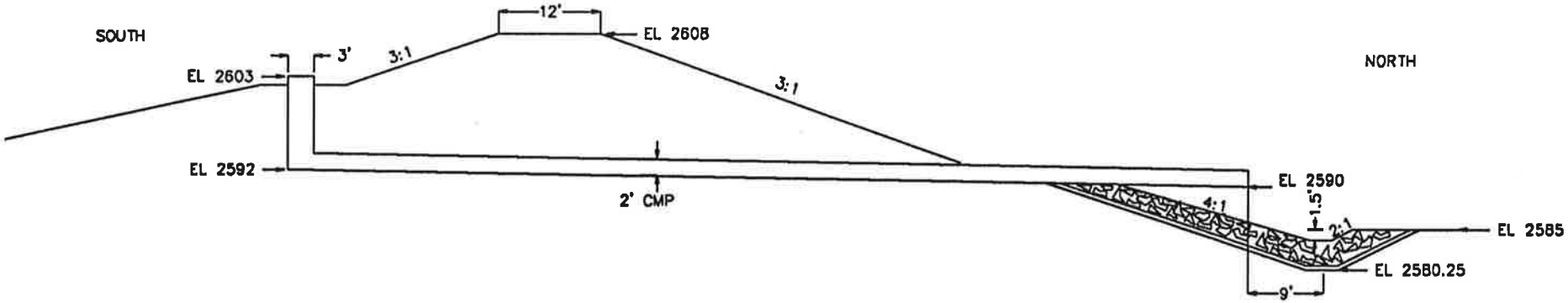
and the outlet invert set at an elevation of 2590 msl. The slope of the spillway will be 2.0 percent. Within the length of the spillway there will be two anti-seep collars. Figure 8 shows a typical cross section of the dam at the principal spillway.

A cantilever outlet and plunge pool will be sufficient to dissipate the energy of the water going through the principal spillway. The invert of the cantilever outlet is to be at least one-foot above the tailwater elevation at maximum discharge.

Emergency Spillway:

The existing spillway at Belfield Dam serves as both a principal and an emergency spillway. It consists of a 50-foot wide by one-foot deep grass-lined channel located in the right abutment. The control elevation of the spillway is set at 2599 msl.

The proposed emergency spillway for Belfield Dam is a 50-foot wide grass-lined channel with 4:1 side slopes located in the left abutment. The rating curve for the emergency spillway was developed using the rater computer program. The rating curve was used to route the velocity and freeboard hydrographs. The velocity hydrograph consists of a 100-year precipitation event and the freeboard hydrograph consists of 30 percent of the probable maximum precipitation.



BELFIELD DAM

DAM CROSS SECTION
&
PRINCIPAL SPILLWAY

Figure 8 - Transverse Profile of
Dam at Principal Spillway

The 100-year 24-hour rainfall inflow is 229 cfs. The routing of the 100-year 24-hour rainfall yielded a 97 cfs outflow. The event caused the reservoir to rise to an elevation of 2605.6 msl. The principal spillway passes 40 cfs while the emergency spillway passes 57 cfs of total outflow. The velocity corresponding to this outflow is 2 feet per second. The criteria from the North Dakota Dam Design Handbook allows a velocity of 7 feet per second for a group one cover on erosion resistant soils at a slope under 5 percent. This shows that the proposed emergency spillway is acceptable based on the velocity hydrograph.

The 0.3 PMP inflow is 1008 cfs. The routing of the 0.3 PMP event yielded a 765 cfs outflow. The event caused the reservoir to rise to an elevation of 2607.8 msl. The North Dakota Dam Design Handbook requires a class III dam to pass a 0.3 PMP event without overtopping the dam. The maximum reservoir elevation of 2607.8 msl indicates that the top of dam elevation should be 2608 msl in order for the dam to be acceptable based on the freeboard hydrograph.

Embankment:

The existing embankment does not meet North Dakota Dam Safety requirements for the proposed outlet works. The alternative of moving the embankment downstream is not considered to be feasible due to the topography of the downstream area. A reservoir located at the downstream site would have a larger surface area, but the average depth and capacity would be less.

The depth would not satisfy the requirements for fish propagation. This means the existing embankment should be modified or replaced. The ability to modify the existing embankment is dependent on the subsurface conditions. If the subsurface conditions are adequate, the vegetation and topsoil should be stripped from the existing embankment and a clay cap placed over it. If the subsurface conditions do not allow the embankment to be modified, it should be removed and a new embankment constructed.

The new or modified embankment would have a crest elevation of 2608 msl. The proposed embankment would be 12 feet wide at the crest, and have an upstream and downstream slope of 3:1. The embankment would have a 50-foot wide emergency spillway located in the left abutment. The proposed water surface elevation of 2603 msl will require that the slope of the bank east of the reservoir be lowered. The slope should be lowered to 3:1. This slope will help prevent erosion due to wave action.

Low-Level Drawdown:

The proposed modifications to Belfield Dam include the installation of a low-level drawdown structure. The low-level drawdown structure, also known as a cold water return or hypolimnetic discharge structure, is designed to counteract accelerated aging in reservoirs. The low-level drawdown structure removes nutrient-rich water from the bottom of a thermally stratified reservoir, leaving the better quality water behind,

and thus increasing the usefulness and life span of the reservoir. Improved water quality conditions result in a positive benefit to the fishery and to all other recreational uses.

A rule of thumb used in the design of low-level drawdown structures is that they should pass 10 percent of the reservoir volume in a 14-day time period. For Belfield Dam, a 4-inch PVC pipe is sufficient to act as a low-level drawdown. The pipe will extend into the reservoir for a distance of about 150 feet.

Downstream Modifications:

The channel downstream of Belfield Dam is sufficient to convey any flows going through the proposed spillway system, although the roadway downstream of the dam will have to be modified. Presently, the roadway has a 30-inch diameter CMP to pass flows. There is a dip in the road to the west of the culvert, and during high flow periods water passes over the top of the road. A Bureau of Public Roads nomograph based on inlet control was used to determine the size of the crossing that would be necessary to prevent overtopping of the road. The roadway will be designed to pass a 25-year precipitation event without overtopping. The maximum flow through the principal spillway due to a 25-year precipitation event is 39 cfs. A 30-inch diameter CMP culvert and a 24-inch diameter CMP culvert will pass a flow of 52 cfs. This is sufficient to pass flows from the principal spillway, as well as flows due to local runoff. The roadway will need to be raised to a minimum elevation of 2586.3 msl, in order

to obtain this type of flow through the crossing without overtopping and to allow for sufficient cover on the culverts. This will require that the roadway be raised for a distance of approximately 220 feet. At its lowest point, the roadway will have to be raised approximately 1.4 feet. If the condition of the existing 30-inch diameter CMP is satisfactory, it can be relocated at the new crossing.

Water Control:

The water that is presently in Belfield Dam will have to be contained or removed in order to perform the proposed modifications. The small size of the reservoir and the fact that an established fishery is not located in it make retaining the water impractical. The proposed alternative for water control is to notch the embankment and drain the reservoir.

V. GEOTECHNICAL

The subsurface condition of the existing embankment is unknown. If the decision is made to proceed with this project, it will be necessary to perform soil borings to determine if the existing embankment can be modified. Two penetrometer borings should be sufficient to determine subsurface conditions. The estimated cost to perform two test borings is about $1500. This cost is not included in the preliminary cost estimate.

VI. LAND RIGHTS

Belfield Dam and the adjoining land are presently owned by Burlington Northern Railroad. The ability to proceed with the reconstruction and/or rehabilitation of Belfield Dam is dependent on land acquisition or easements which need to be obtained.

VII. PRELIMINARY COST ESTIMATE

Cost estimates were prepared for the rehabilitation of the dam and for the replacement of the dam at or near its present location. Both alternatives have the same characteristics for height, reservoir area, and storage. The cost to rehabilitate Belfield Dam is estimated to cost $58,900. This does not include the cost of land acquisition. Table 5 shows the cost breakdown for the modifications.

Table 5 - Belfield Dam Rehabilitation Cost Estimate

	Item	Quantity	Units	Unit Price	Total
1.	Mobilization	1	LS	$5,000.00	$ 5,000
2.	Drain Existing Embankment	1	LS	3,000.00	3,000
3.	Clearing and Grubbing	1	LS.	2,000.00	2,000
4.	Stripping and Spreading Topsoil	1,500	SY	.25	375
5.	Fill	10,674	CY	1.10	11,741
6.	Spillway				
	(a) 36-inch CMP	11	LF	75.00	825
	(b) 24-inch CMP	100	LF	50.00	5,000
	(c) Trash Rack	1	LS	90.00	90
	(d) Joints	2	Ea.	100.00	200
	(e) Anti-Seep Collars	2	Ea.	225.00	450
	(f) Concrete	1	CY	275.00	275
	(g) Reinforcing Steel	130	Lbs	.50	65
7.	Plunge Pool				
	(a) Riprap	33	CY	25.00	825
	(b) Filter Material	13	CY	15.00	195
	(c) Excavation	33	CY	1.50	50
8.	Downstream Roadway Mod.				
	(a) 24-inch CMP	30	LF	35.00	1,050
	(b) Move 30-inch CMP	1	LS	200.00	200
	(c) Gravel or Scoria	47	CY	15.00	705
	(d) Fill to Raise Roadway	125	CY	1.10	138
9.	Riprap	225	CY	25.00	5,625
10.	Excavation	2,075	CY	2.20	4,565
11.	Seeding	2	Ac.	200.00	400
12.	Low-Level Outlet	1	LS	2,500.00	2,500
	Subtotal				$45,274
	Contingencies (+/- 10%)				4,542
	Contract Administration (+/-10%)				4,542
	Engineering (+/-10%)				4,542
	Total (+/- 30%)				$58,900

The cost to replace Belfield Dam is estimated to cost $81,700. This does not include the cost of land acquisition. Table 6 shows the cost breakdown for the replacement.

Table 6 - Belfield Dam Replacement Cost Estimate

	Item	Quantity	Units	Unit Price	Total
1.	Mobilization	1	LS	$5,000.00	$ 5,000
2.	Drain Existing Embankment	1	LS	3,000.00	3,000
3.	Clearing and Grubbing	1	LS.	2,000.00	2,000
4.	Stripping and Spreading Topsoil	1,500	SY	.25	375
5.	Excavation	7,320	CY	2.20	16,104
6.	Fill	16,140	CY	1.10	17,754
7.	Spillway				
	(a) 36-inch CMP	11	LF	75.00	825
	(b) 24-inch CMP	100	LF	50.00	5,000
	(c) Trash Rack	1	LS	90.00	90
	(d) Joints	2	Ea.	100.00	200
	(e) Anti-Seep Collars	2	Ea.	225.00	450
	(f) Concrete	1	CY	275.00	275
	(g) Reinforcing Steel	130	Lbs	.50	65
8.	Plunge Pool				
	(a) Riprap	33	CY	25.00	825
	(b) Filter Material	13	CY	15.00	195
	(c) Excavation	33	CY	1.50	50
9.	Downstream Roadway Mod.				
	(a) 24-inch CMP	30	LF	35.00	1,050
	(b) Move 30-inch CMP	1	LS	200.00	200
	(c) Gravel or Scoria	47	CY	15.00	705
	(d) Fill to Raise Roadway	125	CY	1.10	138
10.	Riprap	225	CY	25.00	5,625
11.	Seeding	2	Ac.	200.00	400
12.	Low-Level Outlet	1	LS	2,500.00	2,500
	Subtotal				$62,826
	Contingencies (+/- 10%)				6,291
	Contract Administration (+/-10%)				6,291
	Engineering (+/-10%)				6,292
	Total (+/- 30%)				$81,700

VIII. SUMMARY

The feasibility of rehabilitating or reconstructing Belfield Dam has been examined. The dam site and reservoir is located on a tributary to the Heart River in the SW1/4 Section 5, Township 139 North, Range 99 West, near the city of Belfield, North Dakota. The dam was built by the Northern Pacific Railroad.

Failure of Belfield Dam will not cause serious damage to property and/or the loss of lives, therefore, it is given a medium hazard classification. Based on a 10- to 24-foot embankment height and a medium hazard classification, Belfield Dam is classified as a class III dam for design purposes.

Design events for the various hydraulic structures are as follows: 1) the principal spillway must be capable of passing flows due to a 25-year 24-hour rainfall event, a 25-year 10-day rainfall event, and a 25-year 10-day snowmelt without the use of a non-structural emergency spillway; 2) the emergency spillway is required to pass the flows from a 100-year precipitation event within acceptable velocity limits; and 3) the dam is required to pass the flows of a 0.3 PMP extreme rainfall event without overtopping.

Analysis with the HEC-1 computer model indicated that the existing embankment does not satisfy North Dakota Dam Safety Standards. Three alternatives to improve the embankment were analyzed. Alternative number one is to modify the existing

embankment so that it meets North Dakota Dam Safety Standards. This would consist of raising the embankment to a crest elevation of 2608 msl. The water surface would be controlled at an elevation of 2603 msl through the use of a drop inlet. At this level, the reservoir would contain 63.4 acre-feet of water, have an average depth of 7.2 feet, and have a maximum depth of 14.5 feet. The ability to proceed with this alternative is dependent on the subsurface conditions of the existing embankment. The second alternative consists of removing the existing embankment and placing a new one in its place. The new embankment should have a crest elevation of 2608 msl. The reservoir and embankment characteristics for this alternative are the same as for alternative one. The third alternative is to remove the old embankment and replace it with a new one further downstream. This alternative is not considered feasible due to the topography of the downstream area. A reservoir located at the downstream site would contain 33 acre-feet of water, have an average depth of 4.2 feet, and have a maximum depth of 12 feet. The depth would not satisfy requirements for fish propagation.

The resulting hydraulic structure from the analysis of the basin can be described as follows: The principal spillway consists of a 36-inch diameter CMP drop inlet that will control the reservoir elevation at 2603 msl. A 24-inch diameter CMP spillway extends through the embankment to convey flows. The length of the spillway is approximately 100 feet and extends into a cantilever outlet with a plunge pool to dissipate the energy of

the water. A low-level drawdown structure has also been designed to allow for the removal of stagnant water from the bottom of the reservoir. An emergency spillway consisting of a 50-foot wide channel with 4:1 side slopes located in the left abutment will be used to convey high flows.

The roadway downstream of the dam should be modified to prevent overtopping. The existing 30-inch diameter CMP culvert should be relocated at the center of the channel and an additional 24-inch diameter CMP culvert installed. The installation of the proposed roadway crossing will require that the roadway be raised for a length of approximately 220 feet. If the downstream modifications were handled by local entities, the project cost could be reduced by a total of $2,700.

The cost to modify the existing embankment is estimated to be $58,900. The cost to replace the embankment at its present location is estimated to be $81,700.

IX. RECOMMENDATIONS

The proposed modifications to Belfield Dam will enable it to safely pass the design flood. The modifications will also help reduce seepage through the embankment. The ability to modify the existing embankment is dependent on the subsurface conditions. If the decision is made to proceed with this project, it is recommended that a soils investigation be performed. The soils investigation will indicate if the existing embankment can be modified. If the subsurface conditions are such that the existing embankment can be modified, this alternative is recommended. Otherwise, the existing embankment should be removed and a new embankment should be constructed. The decision to proceed with this project is the responsibility of the Stark County Water Resource Board.

APPENDIX A - Copy of Agreement

SWC Project #1307
May 31, 1990

A G R E E M E N T

Investigation of Rehabilitation of Belfield Dam Near Belfield, North Dakota

I. PARTIES

THIS AGREEMENT is between the North Dakota State Water Commission, hereinafter Commission, through its Secretary, David Sprynczynatyk, hereinafter Secretary; and the Stark County Water Resource District, hereinafter District, through its Chairman, Nick Kessel.

II. PROJECT, LOCATION, AND PURPOSE

The District wishes to investigate the feasibility for the reconstruction and/or rehabilitation of Belfield Dam. The dam is located in the SW1/4 Section 5, Township 139 North, Range 99 West, near Belfield, North Dakota. The dam is currently used for fishing and recreation purposes.

III. PRELIMINARY INVESTIGATION

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

1. Conduct a topographic survey of the dam site,
2. Conduct a study of the hydrology of the watershed upstream of the dam,
3. Design the outlet works necessary to safely and efficiently pass the design flood through the dam,

4. Design low-level outlet works for drawdown capabilities, and

5. Design modifications to reduce seepage losses through the embankment.

IV. DEPOSIT - REFUND

The District shall deposit a total of $500.00 with the Commission to partially defray the cost of the field work necessary to conduct the investigation. Upon receipt of a request from the District to terminate proceeding further with the preliminary investigation or upon a breach of this agreement by any of the parties, the Commission shall provide the District with a statement of all expenses incurred in the investigation and shall refund to the District any remaining funds.

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 state of North Dakota, the Commission, the State Engineer, and their employees and agents, 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 state of North Dakota, the Commission, the State Engineer, or their employees or agents, the District agrees

to indemnify it for any settlement arrived at or judgment satisfied.

VII. MERGER

This agreement constitutes the entire agreement between the parties. No waiver, consent, or changes to any contractual provisions herein will be binding unless such changes are made in writing, signed by both parties, and attached hereto.

NORTH DAKOTA STATE WATER COMMISSION
By:

DAVID A. SPRYNCZYNATYK
Secretary

DATE: July 2, 1990

WITNESS: Dale L Frink

STARK COUNTY WATER RESOURCE DISTRICT
By:

NICK KESSEL
Chairman

DATE: June 19 1990

WITNESS: Russell L Nelson

BIBLIOGRAPHY

1. Moum, R. A., D. L. Frink, and E. J. Pope, North Dakota Dam Design Handbook, Office of the North Dakota State Engineer, Second Printing, June 1985.

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

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

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