Master Original

Tolna Dam

REINSPECTED
DATE 10-12-83
SEE APPENDIX F

Tolna Coulee
Trib. Of The Sheyenne River
Red River of The North Basin
Nelson County
North Dakota
Fed. ID No. ND 00027
SWC proj No. 266

Phase 1 Inspection Report
National Dam Safety Program

Owned By
Nelson County W. M. D.
Inspected: October 21, 1980

REINSPECTED
DATE 9-25-86
SEE APPENDIX E

REINSPECTED
DATE 8-8-89
SEE APPENDIX E

REINSPECTED
DATE 8-5-92
SEE APPENDIX E

REINSPECTED
DATE 7-11-95
SEE APPENDIX E

DAM SAFETY INSPECTION
N D STATE WATER COMMISSION
BISMARCK, NORTH DAKOTA

North Dakota State Water Commission

900 EAST BOULEVARD • BISMARCK, ND 58505-0850 • 701-224-2750 • FAX 701-224-3696

WATER DEVELOPMENT DIVISION
(701) 224-2752

December 21, 1993

Ben Varnson, Chr.
Nelson County WRD
Courthouse
Lakota, ND 58344

RE: Tolna Dam

Dear Ben:

Tolna Dam was reinspected on August 5, 1992, as a follow-up inspection to the Phase I Inspection Report done on October 21, 1980, and the annual inspections thereafter. The observations, comments, and recommendations are contained in the enclosed Appendix F. These sheets are planned to be inserted as an additional appendix into the orange-covered 1980 Phase I Inspection Report you previously received.

A sticker for the front cover is furnished to indicate that this dam has been reinspected and an update appendix has been added.

If you should have any questions, please feel free to call.

Sincerely,

Dale L Frink

Dale L. Frink, P.E.
Director of Water Development

DLF:BB:dm/266/1579
Encl.
Copy to: Game and Fish

TOLNA DAM #1

Tolna Coulee

Sheyenne River

Red River Basin

Nelson County

North Dakota

Federal Inventory I.D. No. ND 00027

SWC Project No. 266

Inspection, Report Preparation, and Submittal By:

Edgar W Schmidt

Edgar W. Schmidt, P.E.
Dam Safety Engineer

James T. Fay

James T. Fay
Assistant Dam Safety Engineer

Robert N Bucholz

Robert N. Bucholz
Dam Safety Technician

Under the Direction of

David A Sprynczynatyk

David A. Sprynczynatyk, P.E.
Director, Engineering Division
North Dakota State Water Commission

TABLE OF CONTENTS

SUMMARY OF ASSESSMENTS AND RECOMMENDATIONS

TOLNA DAM NO. 1

On Tolna Coulee

Tributary of the Sheyenne River

Tributary of the Red River Basin

Nelson County, North Dakota

Federal Inventory Number ND 00027

State Water Commission Project Number 266

The investigation of Tolna Dam No. 1 revealed conditions which could constitute a hazard to the project. It is recommended that the following repair and maintenance items be corrected:

1. The concrete of the principal outlet is in a deteriorated condition and the channel below the outlet is highly eroded, endangering the concrete outlet structure. It is recommended that the outlet structure be subjected to large scale repair or replacement, including the addition of an energy dissipating structure and channel stabilization.

2. Tolna Dam No. 1, at the design elevations, is capable of passing about 39 percent of the Probable Maximum Flood without overtopping. This capacity is considered inadequate. This condition could be corrected by increasing the capacity of the principal outlet or by adding an emergency spillway with sufficient capacity.

3. The trees growing on the embankment should be removed and treated to prevent the regrowth since decaying tree roots can provide passageways for water through the embankment.

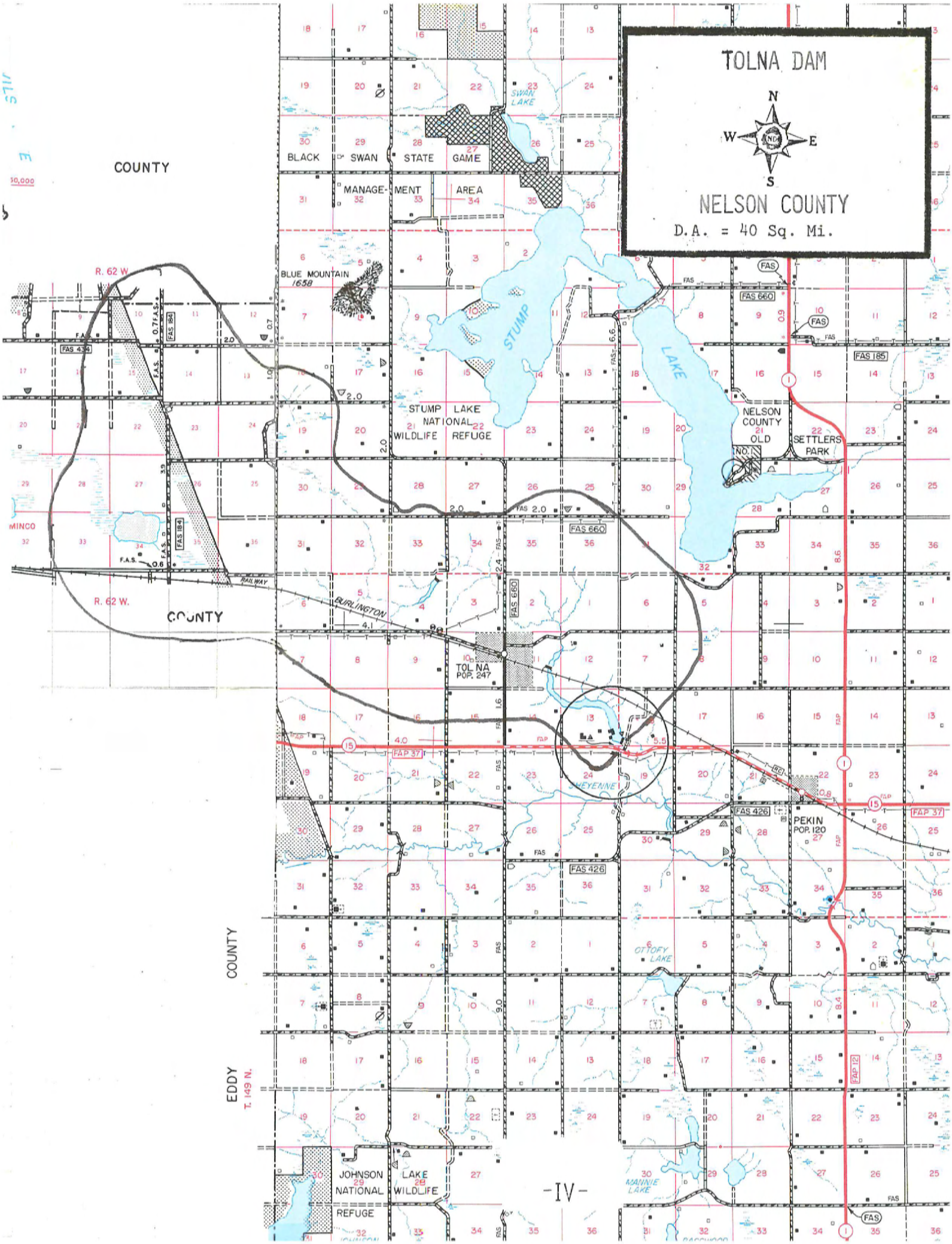
4. The approach to the principal outlet weir should be kept clear of weed growth to permit the free discharge of excess flows.

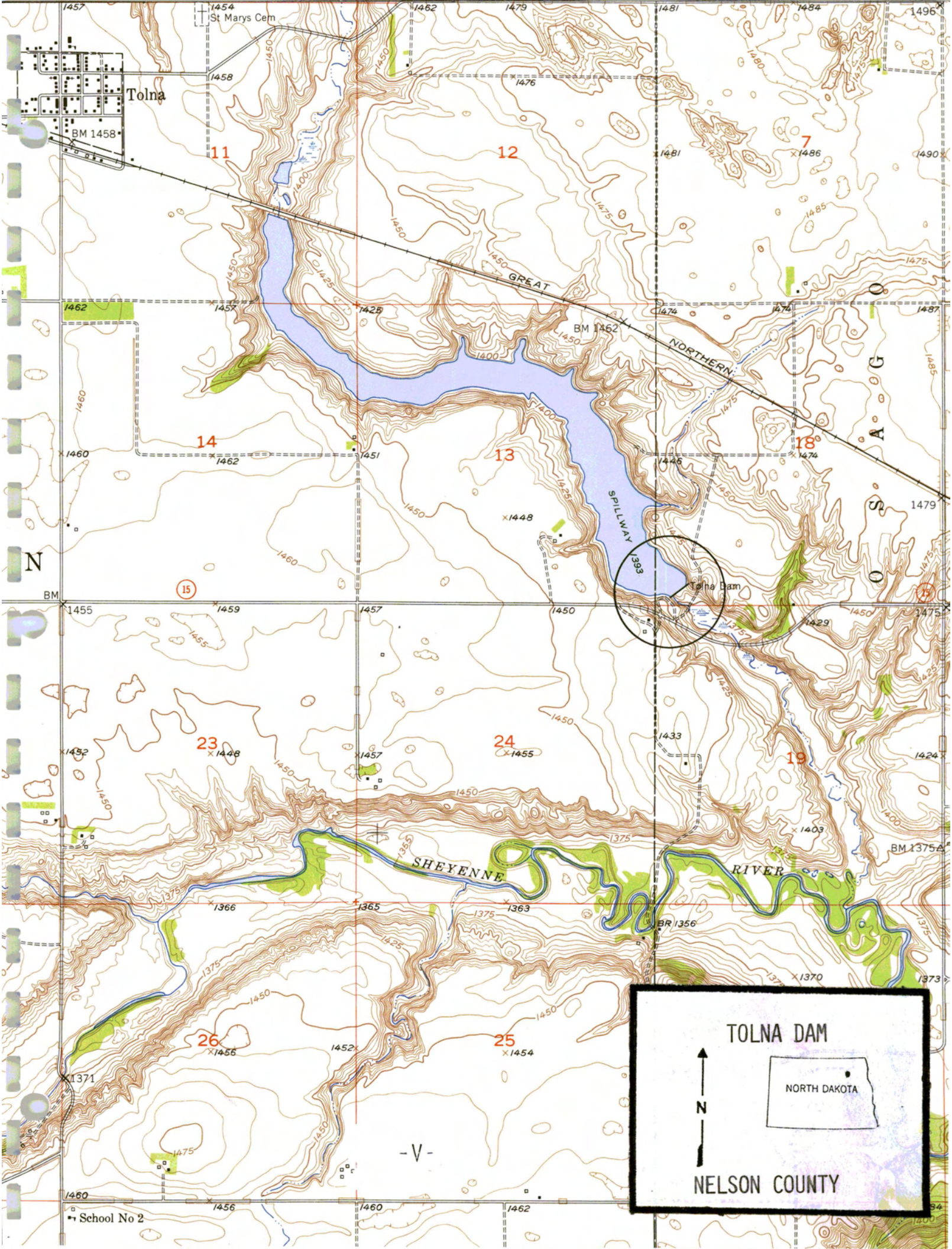
It is also recommended that the following items be monitored for the possible development of hazardous conditions.

1. The scarped area at the downstream toe and the marsh immediately below the dam should be monitored for signs of active seepage.

2. The large animal hole in the downstream toe and the area should be monitored for signs of animal activity and the animals removed or eradicated.

3. The seepage from the spillway structure itself should be checked for any increase in seepage or if fines are coming through with the flow.


TOLNA DAM
N
W
E
S
NELSON COUNTY
D.A. = 40 Sq. Mi.
COUNTY
R. 62 W.
BLACK SWAN STATE GAME MANAGE- MENT AREA
SWAN LAKE
BLUE MOUNTAIN
1658
STUMP LAKE
STUMP LAKE NATIONAL WILDLIFE REFUGE
NELSON COUNTY OLD NO. 1
SETTLERS PARK
FAS 660
FAS 185
FAS 434
FAS 184
MINCO
RAILWAY
BURLINGTON
TOLNA
POP. 247
FAP 37
FAS 426
PEKIN
POP. 120
OTTOFY LAKE
MANNIE LAKE
JOHNSON NATIONAL WILDLIFE REFUGE
COUNTY
EDDY
T. 149 N.
-IV-


St Marys Cem
Tolna
BM 1458
GREAT NORTHERN
BM 1462
SPILLWAY
1393
Tolna Dam
SHEYENNE RIVER
BM 1375
BR 1356
School No 2
TOLNA DAM
NORTH DAKOTA
N
NELSON COUNTY

PERTINENT DATA

A. GENERAL

Name of Dam	Tolna Dam No. 1
Federal Inventory Number	ND 00027
State Water Commission Project Number	266
County	Nelson
State	North Dakota
Stream	Tolna Coulee
River	Sheyenne River
Basin	Red River Basin
Owner	Nelson County Water Management District
Hazard Potential Classification	2 (Significant)
Size Classification	Intermediate
Built	1936
Location (Legal Description)	SW 1/4 SW 1/4,S-18,T-150N,R-60W
Inspection Date	October 21, 1980

B. EMBANKMENT

Type	Zoned, Rolled Earth
Top Length	355 Feet
Top Width	11 Feet
Top Elevation	1399 MSL
Structural Height	36 Feet
Height Above Streambed	30 Feet
Volume of Fill (Total)	25,000 Cu. Yd. (Estimated)

C. OUTLET WORKS

Type	Uncontrolled Chute Spillway
Crest Elevation	1393.9 MSL
Weir Crest Length	75 Feet
Chute Width	75 Feet
Chute Slope	1H:1V
Drop	25 Feet

D. RESERVOIR

Top of Storage	Elevation	Surface Area	Storage Volume
Normal Pool (Outlet Crest)	1393.9 MSL	166.3 Acres	2027 Acre-Feet
Maximum Pool(Top of Dam)	1399 MSL	229 Acres	3080 Acre-Feet

E. DRAINAGE BASIN

Total Drainage Area	40 Square Miles
Channel Length	9.5 Miles
Channel Slope	14 Feet Per Mile

DAM INFORMATION SHEET
(Dams larger than 50 ac ft) (White)

State Co. No. 32

Fed. I.D. No. ND 00 027 Hazard Cl. 2 (Significant) Water Permit No. None

Name Tolna Dam No. 1 Latitude 47 48.1 Const. Permit No. None

Popular N. _____ Longitude 98 23.6 Project No. 266

Name of Impoundment _____ Private Dams on Fed. Lands No

Fed. Div. MRD CE Dist. NCS Fed Region 09 Fed Basin 02 Fed. Co. # 063

Ownership: Non-Fed X Fed Gov't Agencies _____ COE _____; Fed Regulated No

SCS Assistance: None X Technical _____ Financial _____ Both Tech & Finan Assist _____

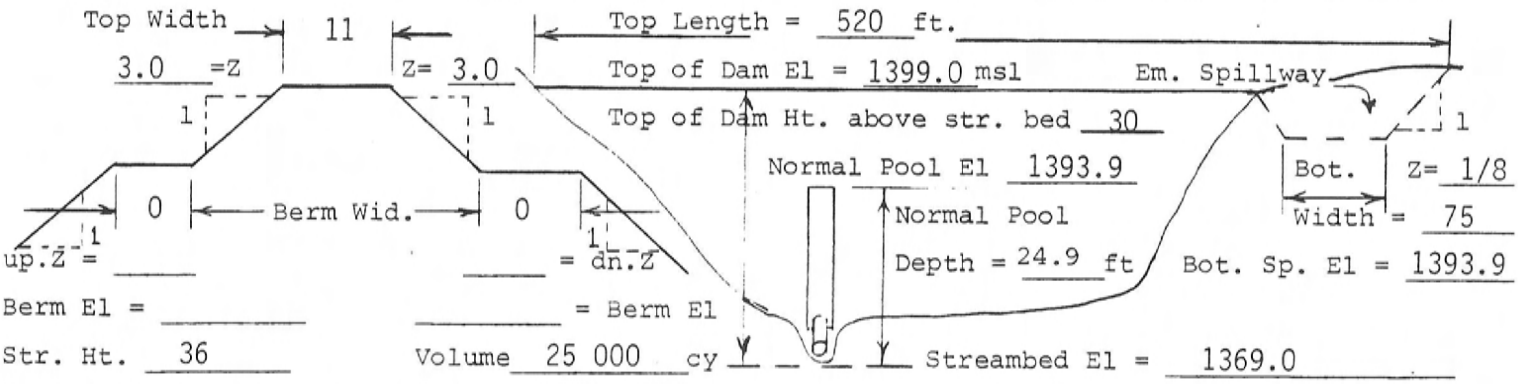
Basin SHY Sub-Basin 035 Section 18 CC Township 150 Range 60

County Nelson Coulee _____ Stream Tolna Coulee

River Sheyenne River River Basin Red River Basin

Drain A. Tot. 40 Non-contribute _____ Contribute _____ Uncontrolled _____

Dam-Type: Zoned Rolled Earth Purpose Recreation



Outlet Works, Areas, Capacities. Location: Lt. Abut., Center, Rt. Abut.

First Stage-Type Chute Spillway (Both) (Service) (Emergency)

Crest Elevation 1393.9 MSL Acres 166.3 Acre-feet 2027

Conduit Size - Type - Length - ft

Outlet Elev. _____ MSL Width 75 Ft.; Side Slope 1H:8V

Controlled un Capacity _____ cfs @ _____ ft/head

Second Stage-Type _____ (Serv. or Emerg.) (Lt,Cen,Rt.)

Crest Elevation _____ MSL Acres _____ Acre-feet _____

Conduit Size _____ Type _____ Length _____ ft

Outlet Elev. _____ MSL Width _____ Ft.; Side Slope _____

Controlled _____ Capacity _____ cfs @ _____ ft/head

Third Stage-Type _____ (Serv. or Emerg.) (Lt,Cen,Rt.)

Crest Elevation _____ MSL Acres _____ Acre-feet _____

Conduit Size _____ Type _____ Length _____ ft

Outlet Elev. _____ MSL Width _____ Ft.; Side Slope _____

Controlled _____ Capacity _____ cfs @ _____ ft/head

Fourth Elev _____ MSL _____ Acres _____ acre-feet

Top of Dam 1399.0 MSL 229 Acres 3080 acre-feet

Form No. 94 12/84

Auxiliary Outlet Works:

Low Level Riparian Drain: Size N Type Pipe _____ El:In _____ Out _____

Cold Water Return: N Crest El. _____ Size _____ Type _____ Controlled By _____

Toe Drain: # of Outlets 0 , _____

Owner (emb) Nelson Co. WRD Engineered By _____

Owner (Lake) Same Constructed By _____

Year Completed 1936 1984 Maintenance Respon. Nelson Co. WRD

Miles of Shoreline _____ Nearest Downstream Towns _____

Health D. Lake Cl. 2C G&F Lake Cl 15 Distance to that town _____

Hyd-Residence Time _____ Mon. Photos Yes X No ____ Quad Tolna

Date Last Inspected _____ Info Date 3-1985

Design Flood: _____year _____cfs; _____year _____cfs; _____year _____cfs.

Topographic Survey Date _____ Soils Survey Date _____

Cost Sharing: Yr	1936	1941(a)	1947(b)	1956(c)	1985(d)	
1. WPA	?	3,741.00				
2. SWC		324.17	342.99	1,834.45	15,466	
3. Nelson Co. WRD		0	70.46	1,600.00	15,466	
4. Game & Fish		400.00	250.00			
5. Village of Tolna		1,030.83	70.46			
6.						
7.						
8.						
TOTALS	?	5,496.00	733.91	3,434.45	30,932	

Comments (a) Apron and training walls were added

(b) A second apron was installed below 1941 section

(c) Spillway was gunited in 1956

(d) Coffer dam, gunite spillway, riprap

Source	have Info	no Info
Corr.	X	
Micro		
WPA	X	
CCC		
Blu Bk	X	
SCS		
Plans		
Quad	X	
F.Insp	X	

TOLNA DAM NO. 1

NELSON COUNTY, NORTH DAKOTA

1. GENERAL

1.1. Purpose. The purpose of this report is to present the findings of the Phase I investigation under the National Program of Inspection of Non-federal dams.

1.2. Scope. This Phase I investigation develops an assessment of the general condition of the project with respect to safety based on the available data and a visual inspection. The investigation also determines if there is need for emergency measures, and concludes if additional studies, investigations, and analyses are warranted.

1.3. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. North Dakota Century Code 61-02-01 declares that the general welfare and protection of the people require the conservation, control of waters, and exercise of the sovereign powers of this State in investigating, constructing, maintaining, regulating, supervising, and controlling any system of works.

An inspection of Tolna Dam No. 1 was conducted on October 21, 1980. The inspection team consisted of:

Edgar W. Schmidt	State Water Commission
James T. Fay	State Water Commission
Robert N. Bucholz	State Water Commission

2. PROJECT LOCATION

Tolna Dam No. 1 is located in the southwest 1/4 of the Southwest 1/4 of Section 18, Township 150 North, Range 60 West. The site is about 1 1/2 miles south and 2 miles east from the City of Tolna in Nelson County, North Dakota. The embankment lies across Tolna Coulee about 1 mile above its confluence with the Sheyenne River.

3. PROJECT DESCRIPTION

3.1. Purpose of Dam. Tolna Dam No. 1 was built to impound water for recreation and for fish and wildlife habitat.

3.2. Size Classification. Tolna Dam No. 1 has a height above the streambed of 30 feet and a maximum storage capacity of 3080 acre-feet. This classifies it as an intermediate sized dam. An intermediate sized dam has a height greater than or equal to 40 feet but less than 100 feet and a maximum storage capacity greater than or equal to 1,000 acre-feet, but less than 50,000 acre-feet. The size classification is based on either the height or the storage capacity, whichever gives the larger classification.

3.3. Hazard Potential Classification. There are three possible hazard classifications to which a dam can be assigned. They are as follows:

Low Hazard (3)	-No permanent or nonpermanent structures for human habitation located in the danger zone and the economic loss must be minimal. Loss of life is limited to unexpected victims such as a sportsman, farmer, or other outdoorsman.
Significant Hazard (2)	-A few permanent type living quarters are permitted in the danger zone, provided there is accessible high ground for safety exit. Also if there is a chance for appreciable economic loss.
High Hazard (1)	-Lives of several people are endangered and/or the potential damage to property is excessive.

One occupied dwelling is located about 3 1/2 miles below Tolna Dam No. 1. This home can be seen in Photo No.'s 15 and 16. Although high ground is accessible to the south for safety exit, the home is located at riverbank elevation. Due to danger to the occupants of this home, Tolna Dam No. 1 is classified in the 2, or significant hazard category.

3.4. Basin Description. Tolna Dam No. 1 is located on Tolna Coulee, a tributary of the Sheyenne River, which is a tributary of the Red River Basin. The drainage basin above the dam encompasses 40 square miles. The length of the channel within this basin is 9.5 miles with an average slope of 14 feet per mile.

Upstream from Tolna Dam No. 1 were four dams. A brief description of each will be given:
Snortland Dam was located in the northwest 1/4 of Section 4, Township 150 North, Range 61 West. This dam was originally constructed in 1935 and was washed out in 1948 due to failure in the spillway. It never was repaired.

There is a small dam in the southeast 1/4 of Section 11, Township 150 North, Range 61 West just above the Burlington Northern Railroad tracks, which is on the main stem of Tolna Coulee. The name of this small low dam is unknown and it holds back very little water. The hydrologic capability of this dam, particularly on a large runoff, is basically insignificant in retaining or retarding these runoffs. Therefore, this dam will not be flood routed.

There is another small dam located on a tributary to Tolna Coulee. This coulee drains only one or two square miles of drainage area. The height of this dam is about 15 or 20 feet. The coulee is deep and has a steep slope, and, therefore, the body of water behind the structure is very small. This

dam is considered basically insignificant as far as it affects the hydrologic capacity of Tolna Dam No. 1.

The quadrangle map shows another dam up in the southwest 1/4 of Section 29, Township 151 North, Range 61 West. This one is named Haas Dam. It appears to be in natural low area according to maps. This dam is near the upper reaches of the drainage area, and would have an effect on the system. The inspection team did not know about this dam at the time of inspection and, therefore, it was not inspected. There is no information available in any of our files on this dam. The spillway width or even the condition of structure is unknown.

With all of the above unknowns, it was decided to adjust Snyders unit hydrograph constants to reflect these conditions. C_p was chosen at .32 or nearly a low as it could go and T_p was lengthened from 5.6 hours up to 7.5 hours. In addition, the infiltration rate used in the Probable Maximum Flood computations for Tolna Dam No. 1 was increased from 1.3 to 1.35 inches per hour.

3.5. General Geology. Tolna Dam is located in the Drift Prairie District of the Central Lowland Physiographic Province. The surficial deposits in the vicinity of the dam site are materials washed out from the glacier by meltwater. These deposits consist mainly of sandy gravel, some gravel and gravelly sand. The material has horizontal bedding, poor sorting, and a high percentage of shale.

The bedrock at the site is the Pierre Formation. This formation consists of gray to black marine shales with gray marl and numerous beds of bentonite, noncalcareous to calcareous. Slumping has been observed in places.

3.6. Embankment. The embankment is a zoned rolled earth structure with a top length of 355 feet containing an estimated 25,000 cubic yards of fill. The elevation of the top is 1399 MSL. The structural height of the embankment is 36 feet and its height above the streambed is 30 feet. The top width is 11 feet and both upstream and downstream faces have slopes of 3H:1V. The alignment is generally northeast to southwest with the right abutment to the southwest. Details can be seen on Plates C-1 and C-2. The plans on Plate C-2 show a 6-foot berm and downstream riprap. The W.P.A. often made field changes and seldom made notes on the plans. The 6-foot berm and the riprap on the toe were never built.

3.7. Principal Outlet. The principal outlet is a reinforced concrete chute controlled by a weir 77'-6" in length. Details of this structure are shown on Plates C-1 and C-2. The total drop is 25 feet. There is no stilling basin. This structure is located on natural ground beyond the right abutment.

4. CONSTRUCTION HISTORY

Tolna Dam No. 1 was built in about 1936 under the Work Projects Administration. No construction records are available for this project, so the construction sequence and details are unknown.

5. OPERATION AND MAINTENANCE HISTORY

For a history of floods, the U.S. Geological Survey Water Supply papers were checked for runoff for Tolna Coulee, but none were found. Therefore,

we checked the closest gaging station on the Sheyenne River to find which years would have high peaks. This gaging station is upstream from Tolna Coulee and near the town of Warwick, ND. The records start in 1950 and continue through 1979 (29 years). The highest year of record was in 1969, and the second in 1956. Other years which had high record flows were 1950, 1966, 1979, and 1971, and 1974.

Erosion below the principal outlet has been a recurring problem at Tolna Dam No. 1. The original chute terminated at the toe of the slope (see Plates C-1 and C-2). The first apron and training walls were added in 1941 in an attempt to correct the erosion and channel degradation. Photograph No. 1 shows the construction of these facilities. By 1945 erosion was undercutting the 1941 addition, as can be seen in Photograph No. 2 and 3. In 1947 another apron was installed below the 1941 addition. Photograph No. 4, 5, 6, and 7 show the construction of this apron. By 1953 erosion was again evident (see Photograph No. 8). It is not known what, if any, measures were taken at this time. The concrete chute was resurfaced with pneumatically applied mortar in 1956. Investigations were made in 1958 regarding desires to raise the top elevation, however the foundation conditions made this unfeasible. Reports in 1969 indicated holes in the spillway and a large willow tree growing through the concrete near the top of the chute. Erosion at that time had progressed to the point where concern was expressed about lack of support on the entire downstream end of the structure. One x-section sheet shows that the dam was proposed to be raised. It has a 2:1 dn stm slope no perm which matches present conditions. no da

note:

6. OPERATION AND MAINTENANCE PROCEDURES

There is no water control, emergency or flood warning procedure for the project. The operation of Tolna Dam No. 1 is limited to a minimum of personnel. The principal outlet is designed to discharge freely whenever the reservoir elevation exceeds 1393.9 MSL, which is the elevation of the outlet weir crest.

7. INSPECTION

7.1. Embankment.

7.1.1. Top of Dam. The top of the dam is shown in Photograph No. 11. Several trees were found growing in this area. No cracks, settlements, or misalignments were noted.

7.1.2. Upstream Face. The upstream face of Tolna Dam No. 1 is shown in Photograph No. 10 and 11. Trees were also found in this area. Scarping was noted along the waterline, although the riprap appeared sound. A hole approximately 1 1/2' deep and 10" in diameter was found in the riprap approximately 130' left of the spillway on the upstream face of the embankment.

7.1.3. Downstream Face. This area was well protected by grass. Small willows and brush were found growing along the lower portions. The toe of the embankment was scarped approximately 1-foot high along the valley floor. A large animal hole was found in this scarped area. This area is shown in Photograph No. 12.

7.2. Downstream Area. A large marsh extends from abutment to abutment for approximately 200 feet downstream. Although no boils were found, this water is considered to be the result of pool-related seepage. See Photograph No. 12, 14, and 22.

7.3. Principal Outlet. The principal outlet can be seen in Photograph No. 17 and 18. The approach to the weir was found to contain heavy weed growth (cattails). The willow tree growing near the weir crest (reported in 1969) was still present, as can be seen in Photograph No. 17. The surface of the weir, which was applied in 1956, was found to be deteriorated, having come loose in places. Numerous cracks were found in the concrete, some exposing the reinforcing steel. The joint between the original chute toe and the 1941 apron was seeping at an estimated rate of 12 to 18 gallons per minute. This seepage can be seen in Photograph No. 19, 20, 21, and 22, and apparently has been a problem for a long time. The historic problem of channel degradation and erosion has not been solved. As can be seen in Photograph No. 19, 21, and 22, the channel has been eroded to a depth of 7 to 8 feet below the last apron, exposing much of the downstream end of the outlet. The parent channel bottom and sides in this area appear to be composed almost exclusively of weathered shale. The concrete at the downstream end of the outlet was severely deteriorated, with many clumps of grass and weeds growing through these cracks.

8. HYDROLOGIC AND HYDRAULIC EVALUATION

8.1. Hydrologic Evaluation. From the standpoint of dam safety, the hydrologic design of a dam aims at avoiding overtopping unless the dam is designed to withstand overtopping. Overtopping is especially dangerous to an earth dam because the downrush of waters will erode the dam face and, if continued long enough, will breach the embankment releasing all the stored waters suddenly into the downstream floodplain. The safe hydrologic design of a dam calls for an outlet capacity, in combination with an embankment height, that can pass a very large and exceedingly rare flood without overtopping.

The Corps of Engineers designs its dams to safely pass the Probable Maximum Flood that is estimated could be generated from the upstream watershed without overtopping. This is the generally accepted standard criterion for major dams throughout the world, and is the standard for dam safety where overtopping would pose any threat to human life. Although dams that do not fully meet this Corps standard will not be evaluated as "unsafe", a significant hazard potential, intermediate sized dam is considered inadequate if it cannot pass one-half of the Probable Maximum Flood without overtopping.

The technical hydrologic analysis for Tolna Dam No. 1 is shown on Plates D-6 through D-12 of Appendix D. Plate D-6 gives a brief explanation of the information shown on Plates D-7 through D-12. As shown on the reservoir routing summary on Plate D-12, Tolna Dam No. 1 is capable of passing an event equal to about 39 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood overtops Tolna Dam No. 1 by 2.2 feet with a duration of embankment overflow of about 30 hours. Information on Plate D-12 also indicates that an event equivalent to one-half of the Probable Maximum Flood would overtop the embankment by about 0.5 feet with a duration of embankment overflow of about 9.2 hours. This would very likely result in a failure of the embankment with the release of about 3080 acre-feet of stored water. The hydrologic capacity is considered inadequate for a significant hazard, intermediate sized dam.

8.2. Hydraulic Evaluation. The original elevation-capacity relationship for Tolna Dam No. 1 is not available. The 1958 investigation on raising the dam, however, included developing that relationship for points

above the present outlet crest. These points were tabulated on Plate D-1 and the curve was plotted on Plate D-2. The principal outlet was treated as a trapezoidal weir with 1H:1V side slopes. This rating is tabulated on Plate D-3. The top of the dam was also treated as a weir, and this rating is calculated on Plate D-4. Both the principal outlet rating and the top of dam rating are shown graphically on Plate D-5.

9. STRUCTURAL AND GEOTECHNICAL EVALUATION

9.1. General. The evaluation of this project is based on the available design and construction data, operating records, conversations with people familiar with the project, and the visual inspection. Review of the available data indicates that the construction of the outlet on shale without a stilling basin has resulted in recurring channel degradation and erosion problems which may now result in a threat to the project.

9.2. Embankment. No stability analyses are available for the embankment, therefore, the margins of safety are unknown. The embankment has been in place since 1936, withstanding several major flows, as discussed in Paragraph 5. No signs of embankment instability were observed. The embankment should be monitored, and if signs of instability are observed, stability analyses should be performed. The riprap on the upstream slope appeared to have been added recently, probably since the development of the scarp mentioned in Section 7.1.2. This area should be monitored to determine if the slope is now adequately protected against wave erosion. If the scarping progresses further, addition of more riprap may be necessary.

The scarping at the toe of the dam is considered to be the result of long exposure to the large marsh directly below the dam. This area should be monitored closely for progression of the erosion and seepage. No signs of active seepage were discovered during the inspection, however the marsh below the dam is considered to be the result of pool-related seepage. This area should be visually monitored for changes.

9.3. Principal Outlet. The concrete of the principal outlet is in a deteriorated condition. Numerous cracks were noted, some exposing the reinforcing steel. The pneumatically applied mortar has broken loose in several places, and vegetation is growing in the cracks in numerous places. The channel erosion at the downstream end of the outlet chute is considered a serious threat to the project. This erosion has progressed to the point where there is little, if any, horizontal support for the structure. Seepage in the order of 12 to 18 gallons per minute was observed emerging from the cracks near the base of the structure. Although this water did not appear to be carrying any soil materials, it should be visually monitored to detect possible piping beneath the concrete chute. Consideration should be given to large scale repair or replacement of the entire spillway structure.

10. ASSESSMENT AND RECOMMENDATIONS

10.1. General. This section is an assessment of the general condition of the dam with respect to safety based on this visual inspection, the hydrologic and hydraulic evaluation, and the structural and geotechnical evaluation. This section also includes recommendations considered necessary to

correct possible hazardous conditions and monitor areas that could become hazardous.

10.2. Hydrologic Requirements. Tolna Dam No. 1, at design elevations, is capable of passing an event equal to about 39 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood overtops the embankment by 2.2 feet with a duration of embankment overflow of about 30 hours. In addition, one-half the Probable Maximum Flood would overtop the embankment by 0.5 feet with a duration of embankment overflow for our 5.2 hours. This hydrolgic capacity is considered inadequate for a significant hazard potential, intermediate sized dam. This condition could be corrected by increasing the capacity of the principal outlet or adding an emergency spillway of sufficient capacity. Raising the embankment was investigated in the past and found to be unfeasible.

10.3. Embankment. No conditions were found during the inspection that adversely effect the safety of the embankment. The scarped area at the toe of the dam and the marsh should be monitored closely for signs of active seepage. The embankment should also be monitored, particularly during times of high reservoir levels, for signs of slope movement. If this occurs, then these items should be reevaluated as to their effect on the safety of the embankment.

10.4. Principal Outlet. The concrete of the principal outlet is in a deteriorated condition. Consideration should be given to large scale repair or replacement of this structure. The recurring erosion of the channel immediately below the outlet is considered to be the result of too steep a slope on the outlet channel which has resulted in channel degradation.

The parent soil is basically shale which is somewhat resistant to erosion, however, it does weather, and erodes faster than normal without the aid of a stilling basin. This erosion has progressed to the point where it presents a serious threat to the project. Some type of energy dissipating structure should be added and means of stabilizing the channel should be investigated.

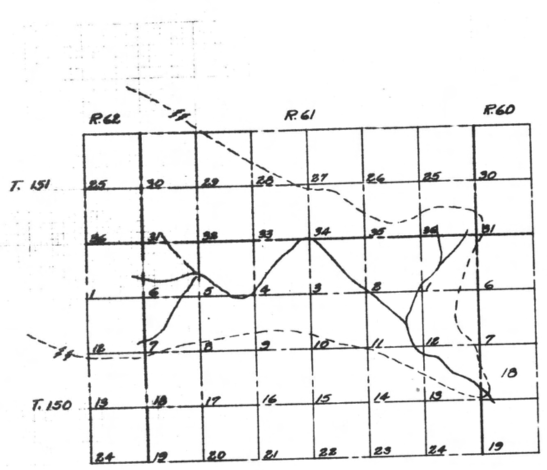
The seepage seen in Photo No. 19, 20, 21, and 22 apparently has been there a long time. It should be monitored to see if it increases or if fines are coming through with the flow.

10.5. Maintenance. The trees should be removed from the embankment and treated periodically to prevent regrowth, since decaying tree roots can provide passageways for water through the embankment. The scarp on the upstream face should be monitored. If the wave erosion progresses, the addition of more rock riprap may be required. The animal holes at the downstream toe of the embankment should be filled and the area should be monitored for future signs of animal activity. The approach to the outlet weir could be kept clear of weed growth to permit the free passage of excess flows.

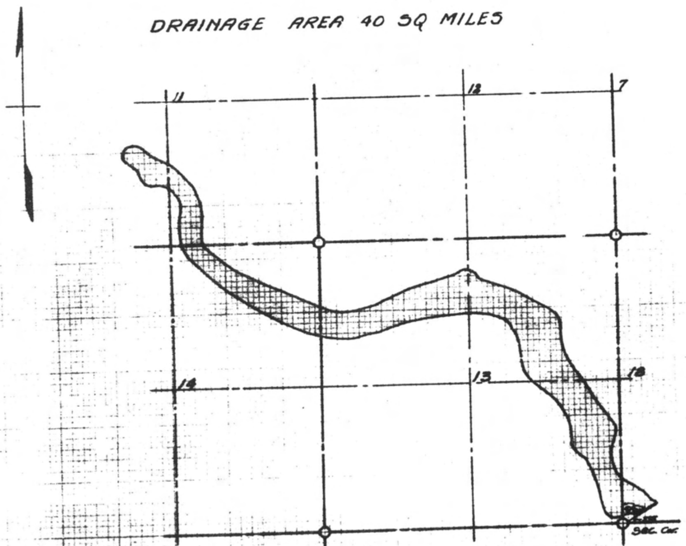
APPENDIX C

Plans

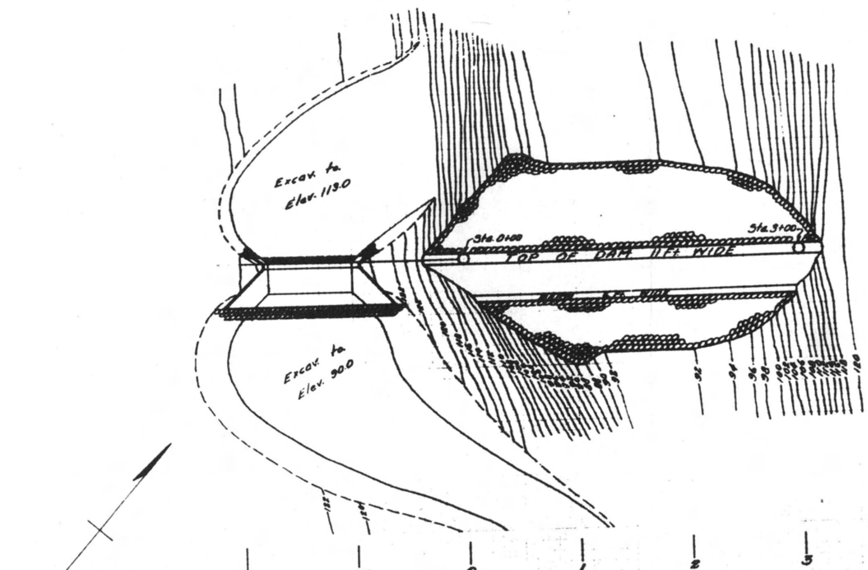
PLATE NO.	TITLE
C-1	Top View of Dam and Spillway plus Profile of Dam and Spillway
C-2	Cross-Section of Dam plus Details of Rubble Masonry Spillway



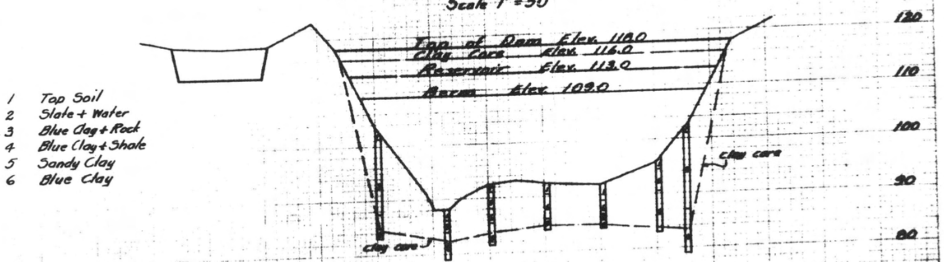
DRAINAGE AREA 40 SQ MILES



PLAT OF RESERVOIR
AREA 143.4 ACRES
CAPACITY 1369.4 ACRE.Ft
Scale 1" = 1000'



TOP VIEW OF DAM & SPILLWAY
Scale 1" = 50'

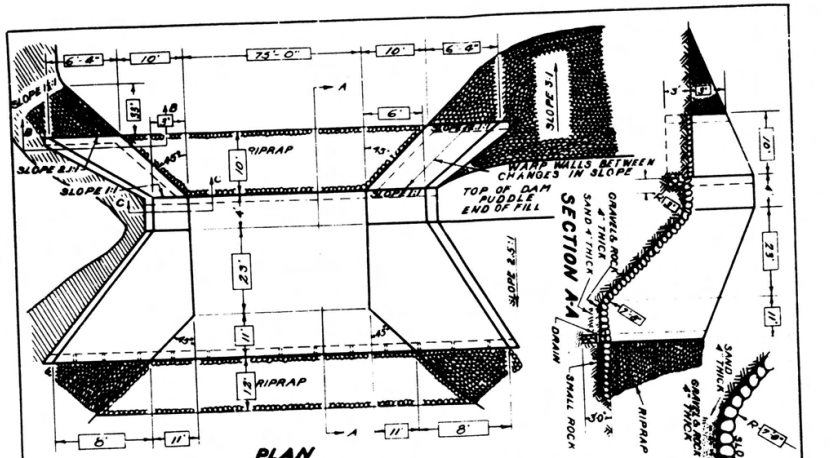


PROFILE OF DAM & SPILLWAY
Scale 1" = 10' Vert. 50' Horiz.

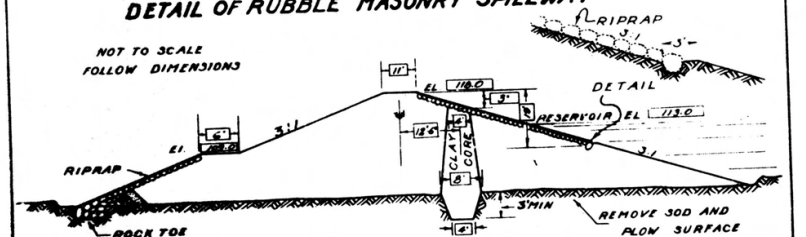
W.P.A. ENGINEERING DEPT.
FOR NORTH DAKOTA
TOLNA DAM
NELSON COUNTY
Sec. 18-150-60

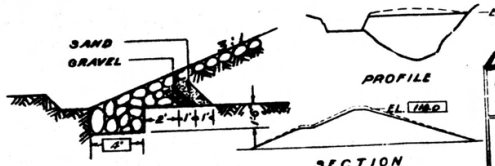
-1366-866-11

Plate C-1



DETAIL OF RUBBLE MASONRY SPILLWAY





DS4-4381-268-2
W.P.A. ENGINEERING DEPT.
FOR NORTH DAKOTA
TOLNA DAM
NELSON COUNTY
SEC. 18-150-60
DATE 10-3-38 MAP

JHS

Proj. 266-4301-1

Plate C-2

APPENDIX D

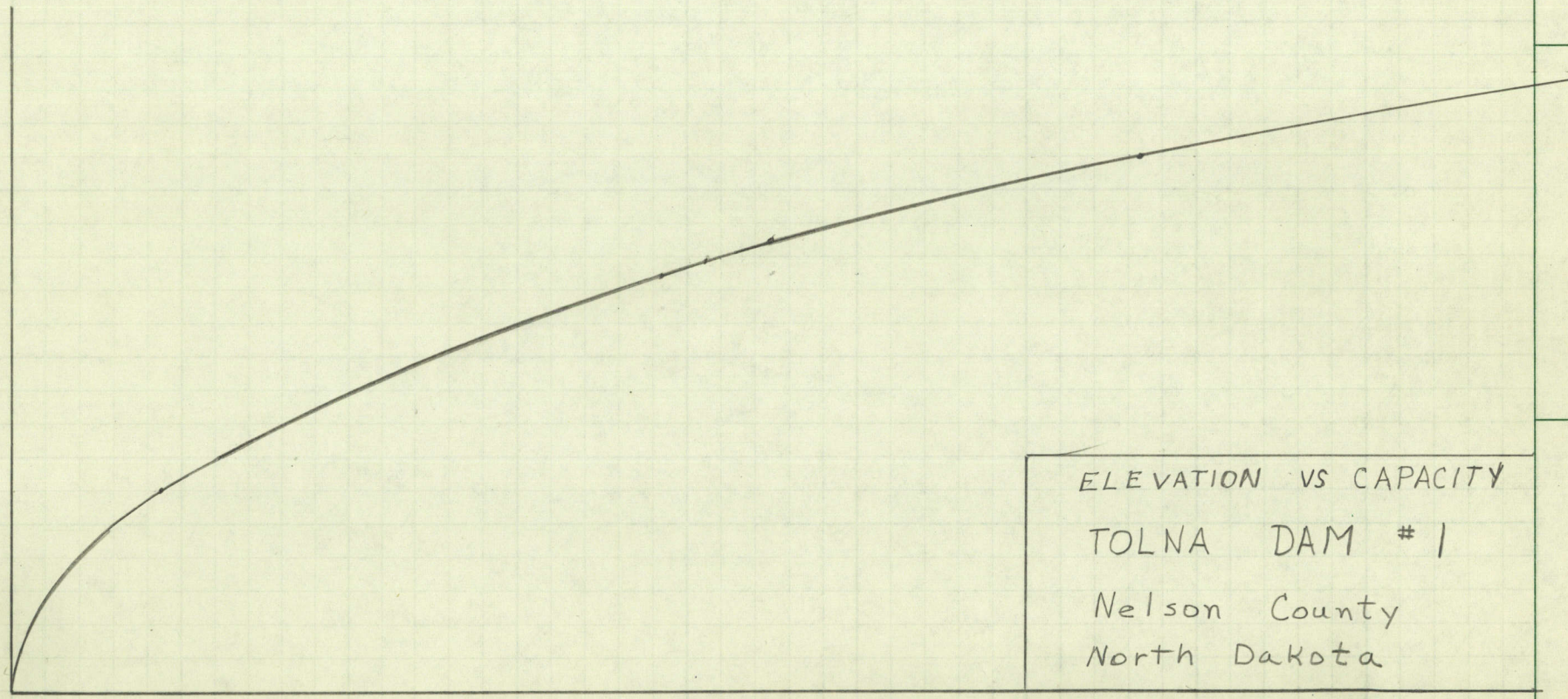
Hydraulics and Hydrology

PLATE NO.	TITLE
D-1	Elevation-Capacity Table
D-2	Elevation-Capacity Curve
D-3	Outlet Rating Calculations
D-4	Top of Dam Rating Calculations
D-5	Outlet and Top of Dam Rating Curves
D-6	Explanation of Data Shown on Plates D-7 to D-12
D-7	Computer Input Data
D-8	Unit Hydrograph
D-9	Printout of Unit Hydrograph Ordinates, Probable Maximum Precipitation, Loss, and Excesses
D-10	Elevation-Storage and Rating Table
D-11	Lake Inflow Hydrograph
D-12	Information Summary and Reservoir Routing Results

TOLNA DAM #1

Elevation Area Capacity Table

Elev	Acres	ΔE	Incremental Volume	Volume
1369	0	0	0	0
1380	70	11	385	385
1393.9	166.3	13.9	1642.3	2027
1395	189.2	1.1	195.5	2223
1400	239.4	5	1071.5	3294
1405	314.9	5	1385.8	4680



ELEVATION VS CAPACITY

TOLNA DAM #1

Nelson County

North Dakota

Plate D-2

TOLNA DAM NO. 1

Outlet Rating

$$Q = C\left[LH^{1.5} + .8Z^{-1.5}(ZH)^{2.5}\right] \quad C=2.9,\ L=77.5',\ Z=1$$

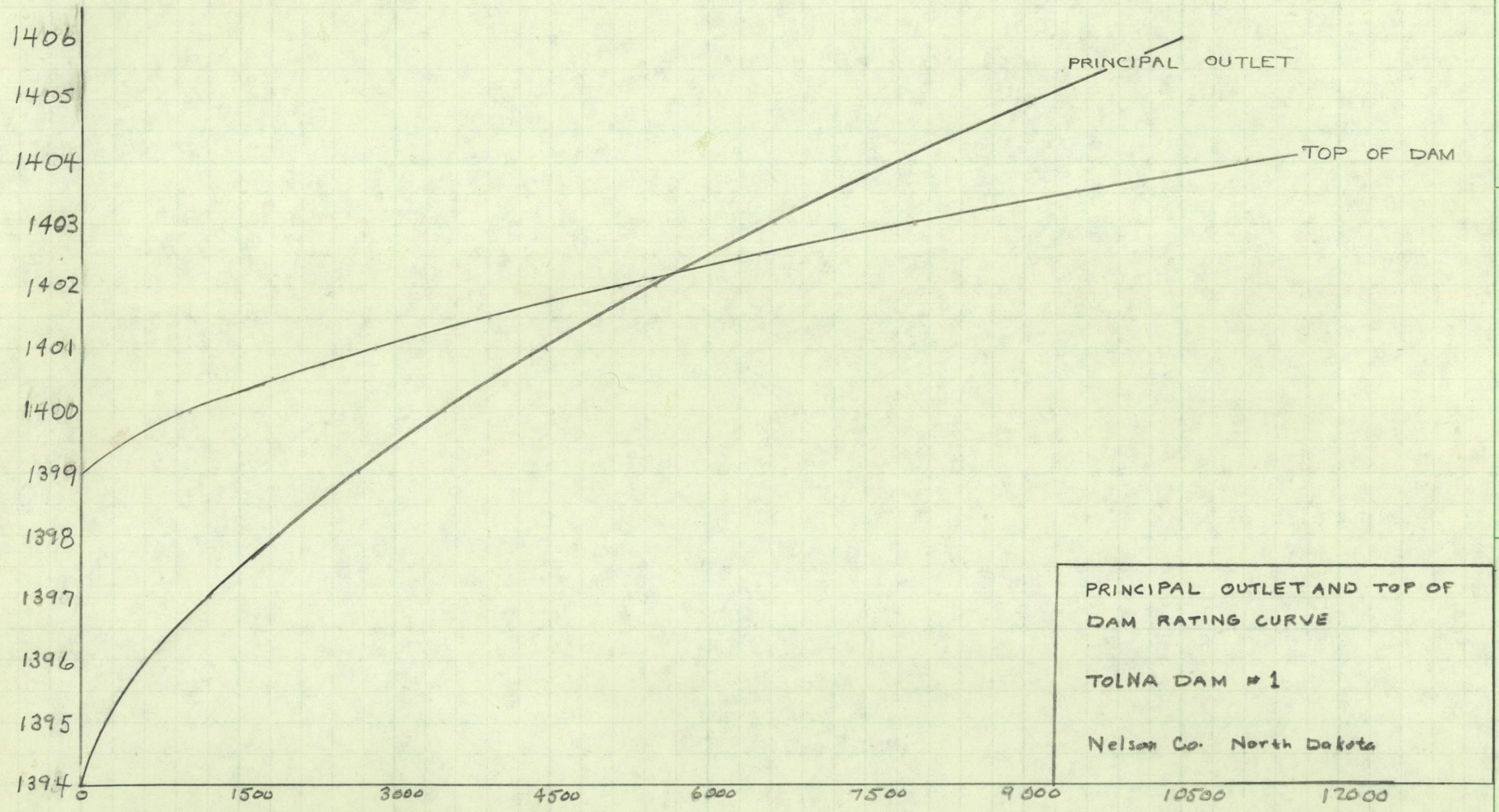
W.S. Elev. (MSL)	H	Q (cfs)
1394	0	0
1395	1	227
1396	2	649
1397	3	1204
1398	4	1872
1399	5	2642
1400	6	3508
1401	7	4463
1402	8	5505
1403	9	6632
1404	10	7841

TOLNA DAM NO. 1

Top of Dam Rating

$Q=CLH^{3/2}$ L=355', C=2.8

W.S. Elev.	H	Q
1399	0	0
1399.5	0.5	351
1400.0	1.0	994
1400.5	1.5	1826
1401.0	2.0	2811
1401.5	2.5	3929
1402.0	3.0	5165
1402.5	3.5	6509
1403.0	4.0	7952
1403.5	4.5	9489
1404.0	5.0	11113



PRINCIPAL OUTLET AND TOP OF DAM RATING CURVE

TOLNA DAM # 1

Nelson Co. North Dakota

Plate D-5

TOLNA DAM #1

Elevation Area Capacity Table

Elev	Acres	ΔE	Incremental Volume	Volume
1369	0	0	0	0
1380	70	11	385	385
1393.9	166.3	13.9	1642.3	2027
1395	189.2	1.1	195.5	2223
1400	239.4	5	1071.5	3294
1405	314.9	5	1385.8	4680

Normal Pool 1393.9 166.3 2027

Top of Dam 1399 229 3080

Plate D-1