BROWNS VALLEY DIKE
BROWNS VALLEY, MINNESOTA
Lake Traverse Project

HISTORY AND POTENTIAL FOR INTERBASIN FLOW

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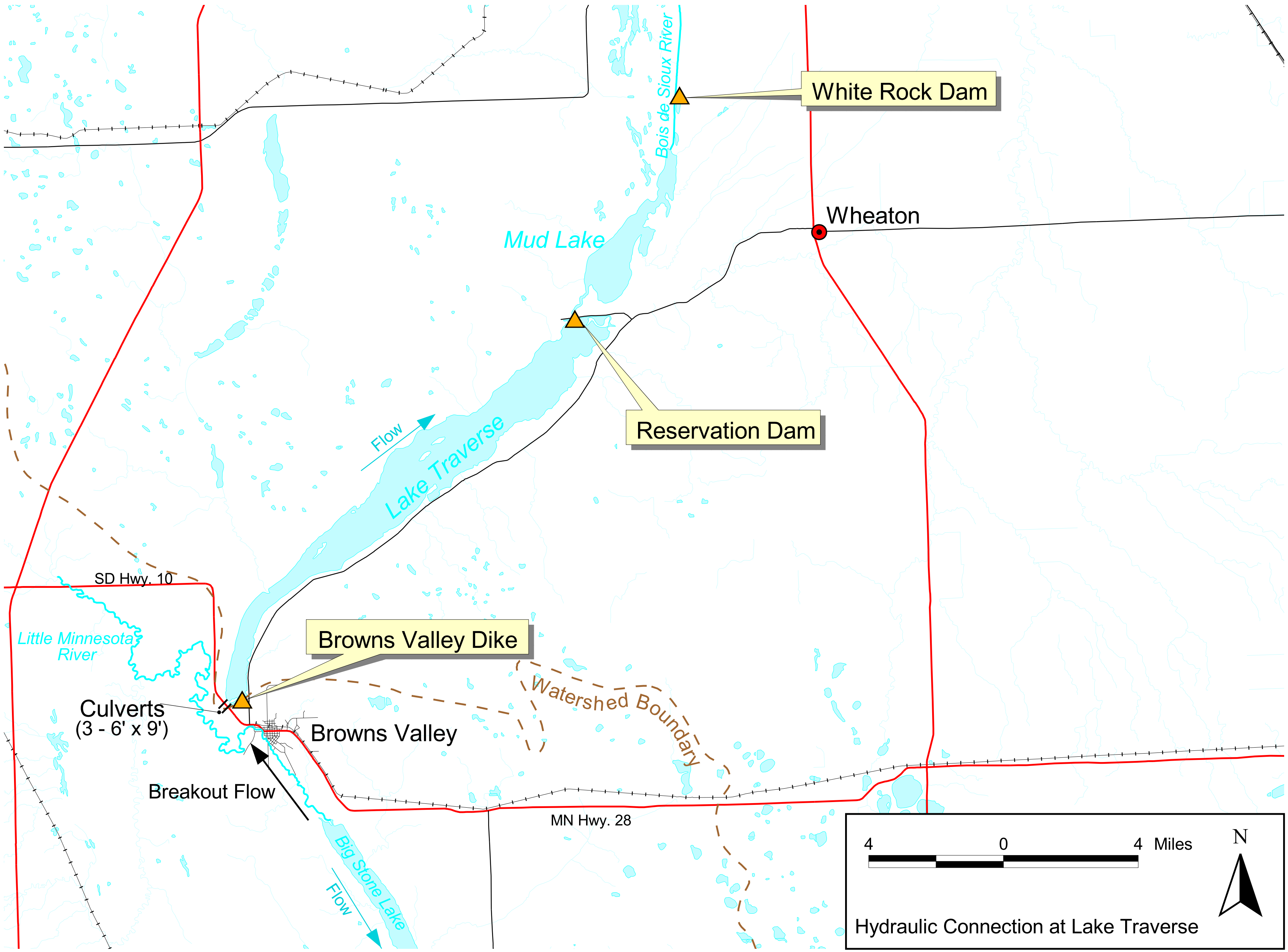
White Rock Dam
Bois de Sioux River
Wheaton
Mud Lake
Reservation Dam
Flow
Lake Traverse
SD Hwy. 10
Little Minnesota River
Browns Valley Dike
Watershed Boundary
Culverts
(3 - 6' x 9')
Browns Valley
Breakout Flow
MN Hwy. 28
Big Stone Lake
Flow
4
0
4 Miles
N
Hydraulic Connection at Lake Traverse

1.1 INTRODUCTION

The Brown's Valley Dike is a part of the Lake Traverse Flood Control Project. The Lake Traverse Project was completed in 1941 and includes, in addition to the Brown's Valley Dike, Reservation Dam and White Rock Dam. The dike is situated near the continental divide which separates the Little Minnesota River (Minnesota River Basin) from the Red River of the North watershed. See **Plate No. 1-1** (the water from White Rock Dam flows north)**.**

The Little Minnesota River forms the headwaters of the Minnesota River and flows into Big Stone Lake which is controlled by Big Stone Dam. The Little Minnesota River passes within approximately 800 yards of Lake Traverse. The Bois de Sioux River flows out of Lake Traverse and, along with the Ottertail River, forms the headwaters for the Red River of the North. The outlet of Big Stone Reservoir is the beginning of the Minnesota River.

Prior to the construction of the Brown's Valley Dike, floodwaters from the Little Minnesota River could overflow the continental divide and spill northwest into Lake Traverse. **Plate Nos. 1-2 and Plate No. 1-3** show topographic data for both after (1971, **Plate 1-2**) and before (1916, **Plate 1-3**) the dike was constructed. Shortly after the Lake Traverse Project (including the Brown's Valley Dike) was completed, three concrete box culverts were installed through the dike in order to allow this natural overflow to continue. This overflow is a concern due to the fact that it provides a path for exotic biota (Zebra Mussels, Millfoil etc.) to pass between the Minnesota River basin (Upper Mississippi River watershed) and the Red River of the North watershed (or visa versa). Waterborne exotic biota have infiltrated various reaches of the Upper Mississippi River basin to the mouth of the Minnesota River and points north.

This report will examine the potential for interbasin flow between the Minnesota River basin and the Red River of the North watershed in the vicinity of Brown's Valley, Minnesota.

1.2 Vertical Datum. There are primarily two vertical datums in use in the Big Stone Lake/Lake Traverse area. They are the 1912 Mean Sea Level (MSL) adjustment and the 1929 National Geodetic Vertical Datum (NGVD). At Browns Valley, Minnesota the 1912 MSL datum can be adjusted to the 1929 datum by the addition of approximately 0.40 feet. At Big Stone Dam the adjustment is approximately +2.31 feet. The 1912 MSL adjustment is used by the Corps of Engineers at the Lake Traverse Project. In the interest of consistency, and the fact that Lake Traverse is a focus of this study, all elevations in this report will be referenced to the 1912 MSL datum.

2.1 LAKE TRAVERSE RESERVOIR PROJECT

2.1.1 General. The Lake Traverse Project consists of the Brown's Valley Dike and two pools or reservoirs; each of which have a dam/control structure. The control structures are White Rock Dam, which controls the northern most pool, and Reservation Dam, which controls the southern most pool. See **Plate No. 1-1.** White Rock Dam operates under normal conditions to regulate the level of Mud Lake. Reservation Dam regulates the level of Lake Traverse. However, during flood control operation, Reservation Dam is inundated by the Mud Lake pool and the outlet control is at White Rock Dam. The entire reservoir is then called Lake Traverse. See **Plate No. 2-1.** The dams straddle the South Dakota--Minnesota state border. Brown's Valley Dike is located at the southern end of Lake Traverse. The construction of the Lake Traverse Project began in the later part of 1939 and was for the most part complete by 31 December 1941. The U.S. Army Corps of Engineers owns and operates the project. See **Reference No. 1.**

2.1.2 White Rock Dam and Control Structure. White Rock Dam is a 14,400-foot-long rolled-earth fill embankment. This length includes the concrete control structure (with 3 Tainter gates) which is 47 feet long. The embankment has a top elevation of 986.0 feet (1912 M.S.L. datum). See **Plate No. 2-1.** The normal summer pool elevation is 972.0 feet. Water can be stored in the reservoir to elevation 982.0 feet in order to provide flood control protection for areas downstream.

2.1.3 Reservation Dam and Control Structure. Reservation dam is a rolled-earth fill embankment. The section of the embankment on the South Dakota side is about 1,100 feet long and has a top elevation of 983.0 feet. The embankment on the Minnesota side is about 9,100 feet long and has a top elevation of 981.0 feet ($\pm$ 0.5 foot). The lower top elevation on the Minnesota side provides additional spillway capacity during floods when the reservoir elevation exceeds approximately 981.0 feet ($\pm$ 0.5 foot). See **Plate No. 2-1.** The normal summer pool elevation is 976.0 feet. Water can be stored to elevation 982.0 feet when the control switches to White Rock Dam.

The Reservation Dam outlet structure is a grouted riprap weir with a spillway crest (sill) elevation of 974.0 feet. There are 17 stop log/bulkhead sections (bays) across the top of the spillway.

2.1.4 Browns Valley Dike and Culverts. The Browns Valley Dike is located at the south end of Lake Traverse. The dike is approximately 16.5 miles south of Reservation Dam near Browns Valley, Minnesota. See **Plate No. 1-1.** The main dike extends for a distance of 3,700 feet between South Dakota State Trunk Highway 10 (which is also Minnesota State Trunk

Highway 28) and Minnesota Highway 27. Portions of Highway 10 and Highway 27 are incorporated into the dike. Culverts pass through the dike under Highway 10. See **Plate Nos. 1-**

2 and 2-2. The dike is constructed of rolled earth fill and has a top width of 10 feet and a top elevation of 987.0 feet (1912 M.S.L. datum). A general plan and cross sections are shown on **Plate No. 2-3.**

The culverts, which pass through the dike under South Dakota Highway 10, are comprised of three, 6-foot high by 9-foot wide openings. The culverts are 68 feet 9 inches long. The invert elevation on the east side (lake side) is elevation 973.9 feet. The invert on the west side (Little Minnesota River side) is at elevation 974.0 feet.

The culvert structure allows overbank flows from the Little Minnesota River to flow into Lake Traverse to reduce flooding pressure in the village of Brown's Valley, Minnesota. Conversely, when Lake Traverse is high, water from the reservoir could flow south into the Little Minnesota River. This could only occur, however, if wind, wave setup, a large flood or other factors were to force the pool higher than the low point of the continental divide which has a minimum elevation of approximately 983.9 feet (see lower right corner of **Plate No. 2-2**). The gates at White Rock Dam must be wide open when Lake Traverse reaches elevation 982.0 feet. The pool can go higher than 982.0 feet, however, if the inflow volume exceeds the outflow capacity of the dam. White Rock Dam does not have an emergency spillway (top of dam = 986.0 ft.).

For additional information on this area see **Paragraph 6.1.5.**

3.1 Little Minnesota River and Big Stone Lake

3.1.1 Little Minnesota River. The Little Minnesota River originates in South Dakota. It flows into Minnesota at the south end of Lake Traverse near the town of Browns Valley, Minnesota. There are approximately 447 square miles of drainage area upstream of the city. The river eventually flows into Big Stone Lake reservoir which is about 8 miles downstream of Browns Valley. The outlet of Big Stone Lake at Ortonville, Minnesota forms the Minnesota River. See **Plate No. 1-1.**

3.1.2 Big Stone Lake Dam. The water level of Big Stone Lake is regulated by Big Stone Dam. The conservation (summer) pool elevation of Big Stone Lake is 967.01 feet (1912 M.S.L. datum) which is approximately 9 feet below the summer pool elevation of Lake Traverse. This pool elevation corresponds to the crest elevation of the silt barrier at the mouth

of Big Stone Lake upstream of the dam. The top of the flood control pool is at elevation 968.01 feet. At this elevation the gates must be fully open. The lake reached a peak elevation of 975.51 feet during the 1997 flood which is the flood of record at Big Stone Lake. During the 1997 flood there were problems with the gate operation machinery switches and the gates were partially plugged with debris.

4.1 Available Gage Records.

The gage records pertinent to this report are listed in **Table 4.1.** Selected annual peak flows, and the corresponding mean daily flows, for the Little Minnesota River near Brown's Valley, Minnesota (USGS gage No. 05290000) are shown in **Table 4-2.**

Table 4-1
Gages in the vicinity of Browns Valley, Minnesota

Name/Location	Owner/Gage Number	Record Length
Lake Traverse, Reservation Dam	Corps of Engineers	1941 -- 1999 (1)
Little MN Nr Browns Valley, MN (4.25 mi. DS from 05290000) Little MN River Nr Peever, SD Drainage Area = 447 square miles	 USGS No. 05290000	1937, 1939 Misc records only Oct. 1939 -- Sept. 1981 Oct. 1989 -- 1999 (2)
Big Stone Lake Nr Big Stone City, SD Big Stone Lake Nr Big Stone City, SD	USGS No. 05291500 Upper MN River Watershed District	1937 -- 1993 (3) 1994 -- 1999

1. Miscellaneous records prior to 1941 are available (see **Reference Nos. 2 and 3**).
2. The gage is located 2 miles NW of Browns Valley. See **Plate 1-2.** An estimate of the 1919 mean daily peak is available (2,970 cfs, see Table No. 10, **Reference No. 4**).
3. Miscellaneous records prior to 1937 are available (see Page No. 13, **Reference No. 4**).

Table 4-2
Selected Annual Peak Flows, Little Minnesota River near Browns Valley, Minnesota
U.S.G.S. Gage No. 05290000

Date	Peak Flow, cfs	Mean Daily Peak, cfs	Was the Peak River Stage affected by ice? (1)	Notes
July 25, 1993	8,900	5,400	No	Breakout Flow to Lake Traverse
April 8, 1952	4,730	4,400	No	
March 25, 1943	4,320	------	Yes	Breakout Flow, Brown's Valley Dike Breached
Spring 1916	See Note No. 2	------	NA	Breakout flow probably occurred
March 28, 1997	3,590	3,420	Yes	Breakout flow probably occurred
April 6, 1969	3,270	2,100	No	
May 23, 1962	3,140	2,440	No	
June 22, 1919	NA	2,970	No	Estimated Peak Mean Daily Flow, see Note No. 3
March 21, 1976	2,960	2,260	No	
June 7, 1942	2,960	1,810	No	Peak Discharge Equal to 1976
June 2, 1965	2,920	1,740	Yes	
April 11, 1947	2,780	2,550	No	
March 13, 1995	2,700	1,500	No	
May 27, 1954	2,300	201	No	
March 16, 1972	2,180	1,910	No	
March 28, 1978	2,140	1,920	Yes	

1. Peak stages in 22 of the 59 years of record (1940-1998) were affected by ice. This is not necessarily indicative of ice effects downstream at the breakout reach (at Browns Valley, MN). Also, peak flows are not affected by ice jams (only stages).
2. **Reference No. 4, Page 47** suggests the 1916 flood approximated the 1943 flood in regards to the volume of breakout flow into Lake Traverse.
3. Estimate from **Reference No. 4, Page 19**.

5.1 BROWNS VALLEY DIKE.

5.1.1 History. The Browns Valley Dike was constructed between May 1941 and October 1941 as part of the Corps of Engineers' Lake Traverse Project. The dike was constructed to a top elevation of 987.0 feet (1912 M.S.L. datum) to act as a tie-back levee on the south end of Lake Traverse. This was done to prevent any possibility of water from the reservoir spilling into the Little Minnesota River during an extremely high pool level (see **Reference No. 5, p. 9**) or, presumably, as the result of wind setup or wave run up. No mention is made in the early reports (e.g. **Reference No. 5**) in regards to the dike serving to keep water from the Little Minnesota River from reaching Lake Traverse. When the dike was completed in 1941 it did not contain a means (e.g. culverts) for water to flow between the Minnesota and Red River of the North basins.

In late March and early April of 1943 a large flood occurred on the Little Minnesota River. According to **Reference No. 4,** this flood resulted from the rapid melting of snow which had a very high water content.. **Reference 4, Paragraph 25** goes on to say:

> "On the Little Minnesota River, ice jams immediately upstream from Browns Valley were apparently responsible for a large portion of the flood waters overflowing the channel banks"................"Water overflowing the left bank of the [Little Minnesota] river upstream from Browns Valley, flowed toward the north, overtopping the low natural divide between the river and Lake Traverse, and eventually overtopping Minnesota Highway No. 28 [see **Plate Nos. 1-1 and 2-2**]. After crossing this highway the water was prevented from flowing into Lake Traverse by the Browns Valley Dike, but was ponded, instead, in the area south of the dike and overtopped Minnesota Highway 27 to the east. From here the water flowed over low areas in the north and east part of Browns Valley where it was ponded by the grades of the Great Northern Railway and Minnesota Highway No. 28................."Approximately 40 families were forced to seek temporary shelter elsewhere when the heating systems in their homes were rendered useless by the floodwaters."

Reference No. 4 Paragraph 26 continues:

> "The Browns Valley Dike, which prevented the Little Minnesota River overflow from entering Lake Traverse, was constructed by the Federal Government in 1941 as a part of the Lake Traverse and Bois de Sioux River Flood Control and Water Conservation Project. The purpose of this dike is to prevent flooding of Browns Valley when Lake

> Traverse is at a high level. In attempting to alleviate flood conditions at Browns Valley, local interests, after receiving permission from this Department, breached the dike [see **Plate 2-2** for breach location]. An opening approximately 7 feet deep and 2 feet wide at the bottom was made in the dike, but due to difficulties encountered in the work no attempt was made to widen the cut. A maximum flow of about 10 second-feet was diverted into Lake Traverse through the breach in the dike."............"it is apparent that provision should be made to take care of emergency overflow along the left bank upstream from the village, which overflow in the state of nature could pass into Lake Traverse. The present Browns Valley Dike effectively blocks this overflow."

Over the course of the next couple of years various alternatives were considered to either restore the natural flow path from the Little Minnesota River into Lake Traverse or in lieu of that, construct a project to prevent flooding in the City of Browns Valley.

In the end it was determined that culverts would be placed through the dike to restore the natural flow path. Construction of the culverts was done in 1945. The 1946 Annual Report to the Chief of Engineers for the fiscal year ended June 30, 1946 (see **Reference No. 6**) states:

> "Construction of the culvert on South Dakota Highway No. 10 and repair of breach in Browns Valley Dike were accomplished by contract."

5.2 HISTORIC HYDROMETEOROLOGICAL INFORMATION, PRIOR TO MAY 1941

5.2.1 Introduction. A literature search was conducted to search for references to river flow conditions (not necessarily breakout flow) in the Browns Valley area prior May 1941 (prior to dike construction). An attempt was made to quote these historical sources verbatim. Speculation on whether or not breakout flow was occurring during some of the events is left to the reader.

It should be noted that channel capacities can vary greatly as time passes. A comparison of the present channel capacity to, for example, conditions in the early 1900's, would need to consider:

1. Unknown overbank and channel roughness variables.
2. Changes in the alignment of the channel compared to present conditions (old oxbows along the river are evidence of a meandering channel).
3. Agricultural users have artificially raised the bank of the river in some places very near the

breakout area. The height of these levees can be variable year to year.

5.2.2 Spring 1820. After grass hoppers destroyed the crops of the Selkirk Colony in Manitoba, Canada in 1818 and 1819, farm manager William Laidlow and others snowshoed to Prairie du Chien, Wisconsin in early 1820 in hopes of returning by planting time with seed and supplies. Apparently water levels were high enough in the spring of 1820 to allow boat traffic between the Little Minnesota River and Lake Traverse. **Reference No. 7**, Page 4 states:

"Loading three Mackinac boats with wheat, oats a few peas and some chickens, all purchased from [Mr.] Rolette, they embarked on April 15 and headed back up the Mississippi And Minnesota Rivers. Water levels were high in the early spring and they were able to reach Big Stone Lake by boat. From there they dragged and floated the craft across the marshy divide to Lake Traverse . It may have been the first and last time the entire journey was made by boat."

5.2.3 Spring and Summer, 1916. **Reference No. 8**, Page 18 states, in reference to the design of the Lake Traverse Project, "The flood of 1916 caused the level of Lake Traverse to rise to elevation 981.0 feet....". If this statement is true it would indicate that a very large flood may have occurred in the Lake Traverse/Browns Valley area which could have resulted in flow across the continental divide. This would have been an extremely high lake level considering the fact that Reservation Dam and White Rock Dam did not exist. It is likely that the above statement is in reference to the use of the 1916 flood as a pattern flood for design of the reservoir. Research for this study into the design documents for the Lake Traverse Project has determined the following with regards to the 1916 flood (see **Reference Nos. 2, 3 and 9**). **Reference No. 3, Paragraph 17.c.** states in reference to Lake Traverse:

> "The 1916 flood occurred during the spring of the year and attained the highest natural lake level, about elevation 977.3, during the period covered by this study."

The referenced study of natural lake levels covered the period 1907 to the fall of 1939. Records with some degree of continuity began in 1907. Data is also available for 1882 and 1897.

It is possible that water may have flowed from the Little Minnesota River into Lake Traverse in 1916 (depending on ice conditions in the channel). **Reference 4**, Page 47, Paragraph 59 states:

> "As described previously, the volume of the 1943 flood on the Little Minnesota River was exceptionally large. During the spring of 1916, the runoff may have been comparable to that of 1943 with respect to the total volume which could have been diverted from the Little Minnesota River [into Lake Traverse]."

Plate No. 1-3 shows topography for the Browns Valley area circa 1916. Note the wetland in the area now occupied by the Browns Valley Dike as shown on **Plate No. 1-2**).

5.2.4 June 1919. **Reference No. 4** states:

> "One of the largest floods since 1890 was that resulting from the heavy precipitation of 21 and 22 June 1919, when approximately 3 inches of rain fell over the Minnesota River basin above Marsh Lake. A majority of this precipitation fell in a period of less than 24 hours."

The basin upstream of Marsh Lake includes the Little Minnesota River. Table 10 of **Reference No. 4** estimates the maximum mean daily discharge of the 1919 flood at the USGS gage site near Peever, SD to be 2,970 cfs.

5.2.5 July 6-7, 1930. Eric Sevareid and Walter C. Port paddled and portaged a canoe from Minneapolis, Minnesota to Hudson Bay in the summer of 1930 (see **Reference No. 10**). On July 6 they reached Browns Valley. The following quote from **Reference 10, Pages 36-37** provides a snapshot of conditions for a short period in 1930.

> "Darkness found us laboring along in the narrow, weed-choked channel which leads into Browns Valley"........"We faced a two-mile portage in the morning, right through the center of town. We loaded each other with pack sacks, realizing we had things very badly arranged for portaging."

5.3 RECORDED HYDROMETEOROLOGICAL DATA

5.3.1 Basin Characteristics. U.S.G.S. gage No. 0529000, Little Minnesota River at Peever, South Dakota (for location see **Plate 1-2**) is located 2 miles northwest of Browns Valley, Minnesota and has a drainage area of 447 square miles. The drainage area where the breakout flows occur is 452 square miles. The Little Minnesota River has a slope of 3.2 feet per mile and an average annual runoff of 2.0 inches (see **Reference No. 11**). **Table 4-2** contains a comparison of peak flows to mean daily flows for both spring and summer events. Additional data can be found in **Table 6-2.**

5.3.2 1937 and 1939. The USGS made some miscellaneous discharge measurements in 1937 and 1939 on the Little Minnesota River at a site 4.25 miles downstream from the current USGS gage location (see **Table 4-1 and Reference Nos. 12 and 13**). Two measurements were made in Water Year (WY) 1937 and eight were made in WY 1939. These records are not complete enough to draw any conclusions about overbank flooding during those periods.

5.3.3 October 1939 to October 1941. This covers the period between the establishment of the USGS gage on the Little Minnesota River (see **Table 4-1**) and the construction of the dike. An examination of the USGS records for the 1940 and 1941 Water Years (WY) (Oct. 1939 thru Sept. 1941) (see **Reference Nos. 14 and 15**) indicated that the flows in the river were relatively low both years. The highest recorded flow in WY 1940 was 420 cfs (Mar. 30) and the highest flow in WY 1941 was 714 cfs (June 23). These flows are well within the channel capacity of the river. The record contains some mention of ice and debris jams. However, it is doubtful that ice or debris jams in the vicinity of Browns Valley could have been severe enough to cause overbank flooding of a magnitude large enough to spill water from the Little Minnesota River over into Lake Traverse.

5.3.4 November 1941 to Present. Selected annual peak flows for this period are shown in **Table 4-2.** Some of the largest floods are discussed below.

5.3.4.1 March-April 1943 Flood. Ice jams in the channel of the Little Minnesota River caused the river to overflow its banks on approximately March 31, 1943. River stages during this event were apparently elevated due to ice problems in the vicinity of the city. The flood waters pooled south of the recently completed Browns Valley Dike. The dike was breached to allow the water to flow into Lake Traverse (see **Paragraph 5.1.1**).

5.3.4.2 July 1993 Flood. Rainfall amounts as high as 10 inches were reported in the Little Minnesota River basin prior to this flood. The peak flow at the U.S.G.S. gage at Peever, SD occurred on July 25 (8,900 cfs). Corps of Engineers personnel from the Lake Traverse Project observed water running northward into Lake Traverse through the Browns Valley Dike on July 25th (see **Reference No. 16**.). A direct observation of the Little Minnesota River was not made. However, given the channel capacity of the Little Minnesota River in the breakout reach, (approx. 3,000 cfs, see **Paragraph 6.1.1**) the water was undoubtably from the Little Minnesota River. The elevation of the Lake Traverse pool on July 25 was 978.33 feet (1912 M.S.L. datum).

On August 6, 1993 water was observed to be flowing south from Lake Traverse in the direction of the Little Minnesota River (see **Reference 16**). The level of Lake Traverse on August 6 was 979.89 feet which is not high enough for water to flow over the Continental divide. A northwest wind on August 6th may have been causing a seiche effect on the lake creating the appearance of a small flow of water to the south through the dike.

5.3.4.3 April 1997 Flood. The peak flow (3,590 cfs) at the U.S.G.S. gage at Peever, SD occurred on March 28, 1997 (see **Table 4-2**). The elevation of the Lake Traverse pool on March 28 was 974.59 feet (pool drawdown for flood control). During this time, flooding associated with ice jams occurred in the City of Browns Valley. The following accounts indicate that there is a high probability that breakout flow occurred from the Little Minnesota River to Lake Traverse in late March due in part to elevated water surface elevations from ice jams.

The April 1, 1997 edition of the Browns Valley newspaper (**Reference No. 16.a.**) includes a picture of water flowing north through the Browns Valley Dike culverts into Lake Traverse. An interview with the editor of the Valley News (**Reference No. 16.b.**) indicated that the picture was taken on March 27 or 28, 1997. The following text accompanies the picture:

> "Normally water from the Little Minnesota River doesn't flow into Lake Traverse, but apparently an ice jam has diverted the water and a substantial flow is going into the lake from [under] the bridge located on the Continental Divide on the South Dakota - Minnesota border about a mile west of Browns Valley where Hwy. 28 changes to Hwy. 10 (below the "Sisseton Hill"). The diversion, no doubt, has alleviated some of the flooding in Browns Valley."

Ice jams were occurring in Browns Valley during the period of March 27th - 31st. The Corps of Engineers Spring Flood 1997 After Action Report (**Reference No. 16.c., Page No. 5**) states:

> "On 27 March, flooding began in the City of Browns Valley, MN on the Little Minnesota River. A contract was initiated for removal of ice and debris at bridges and constrictions. The contractor also excavated snow from ditches. The Corps also supplied sand bags."

In addition, the Corps of Engineers Emergency Operations Center Situation Report (**Reference No. 16.d.**) for the period March 27 to March 28, 1997 states

> "Breakage of ice jams on upstream portion of Little Minnesota River causing flooding in Browns Valley; Corps of Engineers contractor in place to insure that no ice/debris jams downstream increase severity of flooding" [similar comments can be found in the reports dated March 29 and 31]

Two Corps of Engineers flood reconnaissance engineers (Scott Jutilia and Jim Murphy), visited the Browns Valley Dike on April 11, 1997. They made observations at both the Browns Valley culvert and the smaller culvert at the road crossing to the south (see **Plate 2-2**). The water was observed to be stagnant at that time. On that day the pool level of Lake Traverse was 981.73 feet and rising. The pool peaked at 982.21 feet on April 16. The stagnant water that was observed was primarily from the Lake Traverse pool which had backwatered through the Browns Valley culverts. The mean daily flow on the Little Minnesota River on April 11 was 935 cfs (well below channel capacity). The Corps team did not make a direct observation of the Little Minnesota River breakout reach and did not directly observe any breakout flow during their visits to the area on these particular dates.

Two photos of the Browns Valley area taken during the 1997 flood are included with this report as **Plate Nos. 5-1 and 5-2.** **Plate 5-1** is an aerial photo taken on April 13, 1997 (**Reference No. 17**). The pool level of Lake Traverse on April 13 was 982.0 feet (the pool is ice covered).

Plate 1-2 can be used to reference the breakout area and the dike. Note that the small road south of the Browns Valley culverts is inundated. The mean daily flow in the Little Minnesota River on April 13 was 955 cfs (channel capacity is approx. 3,000 cfs, see **Paragraph 6.1.1**). **Plate 5-2** is a low-level color oblique photo taken on April 16, 1997 (**Reference No. 18**). The pool level of Lake Traverse on April 16 was 982.21 feet which is the highest pool level in recorded history (the pool is still ice covered). The breakout area is in the lower center foreground. The southern edge of the Lake Traverse pool can be seen in the upper left hand corner. The mean daily flow in the Little Minnesota River on April 16 was 1,210 cfs.

6.1 BREAKOUT FLOW FROM THE LITTLE MINNESOTA RIVER TO LAKE TRAVERSE.

6.1.1 Discharge-Frequency. The frequency with which breakout flow occurs from the left bank of the Little Minnesota River to Lake Traverse was studied as part of the Flood Insurance Study (FIS) for the City of Browns Valley (see **Reference No. 19**). The study used the HEC-2 computer model (**Reference No. 20**) to compute water surface profiles. Information from that study is reproduced here in **Table 6-1.** A review of the HEC-2 breakout flow model (**Reference No. 20a**) revealed that the breakout begins between a discharge of approximately 3,000 and 6,000 cfs (between a 10- and 50-yr. event) during open-water conditions. More surveys would be needed to fine tune the analysis; however, the many uncertainties involved (e.g. impacts of ice jams) complicate the matter considerably. For purposes of this study, the breakout flow will be assumed to begin at 3,000 cfs (10-yr. event). The breakout flow reach is shown on **Plate Nos. 1-2 and 2-2.**

The initial breakout flow (assumed to be 3,000 cfs) has a recurrence interval of approximately 10 years (commonly termed a 10-year flood). A 10-year flood has a 10 percent chance of being equaled or exceeded in any given year. The recurrence interval reflects the long-term average period between floods of a specific magnitude. Floods of a given recurrence interval can occur in shorter intervals or even within the same year. The risk of experiencing a particular flood increases when overall periods greater than one year are considered. For example, the risk of having a flood that equals or exceeds a 10-year flood (10-percent chance of annual recurrence) in any 10-year period is 65 percent (see **Reference No. 21, Page 10-4** for more information).

The photos on **Plates 5-1 and 5-2** were taken at a time when the river was not of sufficient height to allow breakout flow over the left bank and hence into Lake Traverse (see **Paragraph 5.3.4.3**). However, the two photos appear to indicate that some water escapes from the right bank where it flows overland until it reenters the Little Minnesota River further downstream. The water appears to flow overland to Dakota Avenue (see **Plate 2-2**). It then crosses Dakota Avenue and reenters the Little Minnesota River downstream. The HEC-2 model used to model the left bank breakout flow did not account for any overland flow from the right bank. The available surveys are not of sufficient detail to permit this level of study. However, if the flow which leaves and then reenters the channel is a small percentage of the total flow, it would have little impact on the water surface profile in the breakout reach.

Table 6-1
Discharge-Frequency, Little Minnesota River, In the Vicinity of Browns Valley, MN
Source: Browns Valley, Minnesota Flood Insurance Study, Reference No. 19.

Location	**Drainage Area Sq. Mi.**	**Recurrence Interval and Peak Discharge (cfs) (1)**			
		10-Yr	**50-Yr**	**100-Yr**	**500-Yr**
Little MN River Nr Peever, SD U.S.G.S. Gage No. 05290000	447				
Little MN River at MN-SD State Boundary (at the breakout point) See **Plate Nos. 1-2 and 2-2**	452	2,970	5,870 (2)	6,970(3)	9,260 (4)

1. Stage-Frequency should be considered because of ice jams. Due to ice jams, breakout flows will occur more frequently than indicated by discharge-frequency.
2. This flow (50-yr) has been reduced by a breakout flow to Lake Traverse of 350 cfs.
3. This flow (100-yr) has been reduced by a breakout flow to Lake Traverse of 1,020 cfs.
4. This flow (500-yr) has been reduced by a breakout flow of 3,830 cfs of which 1,600 enters Lake Traverse. The remainder flows north around the city and reenters the Little MN River.

6.1.2. Stage-Frequency, Ice Jams. A review of the HEC-2 breakout flow model (see above) revealed that the breakout begins at a discharge equal to or greater than 3,000 cfs during open-water conditions (no ice jams).

However, the City of Browns Valley, Minnesota has a history of ice jam problems. When ice jams occur, breakout flows will happen at discharges much less than those required to overtop the river banks during ice-free periods. As a result, discharge-frequency alone does not indicate the true frequency of breakouts and the resulting chance of biota transfer. Ice jams do not affect the magnitude of peak flows. However, the damming effect of the ice jam elevates river levels/stages. Ice jams can occur during both high and low flow years. For example, ice jams have affected the peak stages in 22 out of the 59 years of record at the Peever gage (see **Table 4-2**). Although, an ice jam at the Peever gage does not necessarily indicate that an ice jam occurred in the City of Browns Valley.

A stage-frequency analysis that considers the effects of ice would be required to accurately predict the frequency with which breakout flows would occur. The lack of recorded river stages in the city would hamper a stage-frequency analysis. The frequency of breakout flow would have to be combined with the probability of an exotic species being present, when the breakout flow occurs, to get a true probability related to exotic biota transfer.

6.1.3. Frequency of Biota Transfer. The frequency of breakout flows is only one indicator of the probability of nonindigenous species traveling between the Minnesota River basin and the Red River of the North watershed. Biota transfer can also occur between, for example, the Missouri River and the Red River or the Missouri River and the Minnesota River from sources other than water transfer routes (see **Paragraph 7.1)**. **Reference No. 22** discusses this along with the issue of breakout flow at Browns Valley. It also addresses the issue of the frequency of biota transfer from many different sources.

When breakout flows are occurring into Lake Traverse, there is a very high probability that water is also discharging out of the lake and into Mud Lake and eventually into the Red River of the North. When flooding conditions exist and the lake levels are rising, the outlet structures at Lake Traverse and Mud Lake are opened in an effort to maintain normal pool levels.

6.1.4 Volume of Breakout Flow. **Table 6-2** provides an estimate of the volume of breakout flow to Lake Traverse from the Little Minnesota River for selected flood events. For purposes of this analysis, breakout flows are assumed to occur at discharges above 3,000 cfs. However, this is not meant to be an exhaustive list of all the breakout flow events. As noted previously, ice jams can cause breakout flows at discharges much less than 3,000 cfs. The duration and size of the ice jam will affect the volume of breakout flow. The following statements apply to **Table 6-2**:

1. Discharges at the U.S.G.S. gage (No. 05290000) are assumed to be indicative of flows at the break out point. Actual discharges at the breakout point should be somewhat larger due to the slight increase in drainage area.

2. A table containing mean daily flows (one value per 24 hours) was used to estimate durations and volumes. As such, the durations and volumes are approximate. The effects of ice jams on stage increases were not considered.

3. Breakout flows are assumed to occur when the discharge at the U.S.G.S. gage is above 3,000 cfs. This study only found references to direct observations of breakout flows for the years 1943 and 1993.

Table 6-2
Analysis of Discharges
U.S.G.S. Gage No. 05290000, Little MN River Near Peever, SD

Date (1)	Peak Discharge cfs	Approx. Time Above 3,000 cfs, hrs. (2)	Approx. Breakout Volume ac-ft (3)	Notes
July 25, 1993	8,900	Approx. 48 hrs.	14,000	Breakout flow observed
April 8, 1952	4,730	Approx. 48 hrs.	3,000	
March 25, 1943	4,320	(4)		Gage affected by ice.
March 28, 1997	3,590	Approx. 24 hrs.	2,000	Gage affected by ice.
April 6, 1969	3,270	Approx. 3 days	2,000	Large snow melt flood
May 23, 1962	3,140	Approx. 16-24 hrs.	500	

1. Breakout flows are assumed to have occurred on these dates.
2. Based on a plot of mean daily flows. Breakout flows are assumed to begin at 3,000 cfs (see **Paragraph 6.1.1)**
3. Based on a plot of mean daily flows. Does not consider the effects of ice jams on stage increases.
4. The Browns Valley dike prevented a majority of the breakout flow from entering Lake Traverse. After the dike was breached, a flow of approximately 10 cfs was passed (duration unknown) into the lake (see **Paragraph 5.1.1**) .

6.1.5. Topography Along the Continental Divide. The left bank of the Little Minnesota River in the area of the breakout reach forms the continental divide between the Minnesota River basin and the Red River of the North watershed. The lowest elevation of the left bank in the breakout area is an elevation of approximately 983.9 feet (see **Plate No. 2-2**). The gates at White Rock Dam must be wide open when Lake Traverse reaches elevation 982.0 feet. The pool can go higher than 982.0 feet, however, if the inflow volume exceeds the outflow capacity of the dam or if wind, wave setup or other factors occur. No data was found for this study to suggest that wind and wave setup have ever raised the pool high enough to overflow the continental divide.

Breakout flows have to pass through a 4 by 6 foot box culvert under a road before reaching the Browns Valley culverts. This road is directly south of the Browns Valley culverts and intersects with Minnesota Highway No. 28 (see **Plate Nos. 1-2 and 2-2**). However, this road is overtopped when the water level in Lake Traverse is high (see **Plate No. 5-1**). The breakout flow into Lake Traverse is not significantly affected by this culvert or the road.

7.1 AQUATIC BIOTA TRANSFER.

The culverts through the Browns Valley Dike are not the only mechanism by which nonindigenous species can travel between the Minnesota and the Red River of the North watersheds. The activities of anglers, bait suppliers, aquaculturists and even public fishery managers may in the future, or may have already contributed, to the movement of aquatic organisms between the watersheds (see **Reference 22, Page v**). **Reference 22** discusses breakout flow at Browns Valley and lists 17 mechanisms or pathways by which aquatic organisms (e.g. animals and plants) can move between watersheds. The pathways can be either naturally occurring (e.g. Little MN River breakout flows) or anthropogenic (caused by the activity of man).

Some other factors to consider in this discussion include:

I. The recent priority given to controlling invasive species by President Clinton's Executive Order 13112 issued February 3, 1999.

ii. The legislative requirements of the Aquatic Nuisance Species Act (ANS) of 1996.

iii. And the joint US-Canada initiatives of the Western Regional Panel established in 1997 under ANS. (The Western Regional Panel is comprised of representatives of the 17 western states and four western provinces.).

8.1 MITIGATION COSTS IF BROWNS VALLEY CULVERTS WERE TO BE REMOVED.

If the opportunity for interbasin flow were to be essentially eliminated by removal of the culverts at the Browns Valley dike, further investigation would be required to determine all associated impacts that would have to be mitigated. At a minimum, some flood control features would most likely have to be provided to the village of Browns Valley. Based on a Section 205 Flood Control Reconnaissance Report that was prepared for the Little Minnesota River at Browns Valley, Minnesota, in February 1972 (**Reference No. 24**), the cost of levees and portable pumps at Browns Valley were estimated to be approximately $225,000 (in April 1999 costs). A more recent study of flood damage reduction at Browns Valley was completed by a consulting engineering firm,Widseth Smith Nolting & Associates, in December 1991**(Reference No. 25).** One feasible approach identified involved a diversion of a significant portion of the Little Minnesota River flows around Browns Valley. The current costs of implementing that alternative is approximately $1.5 million.

9.1 SUMMARY.

Water does break out from the Little Minnesota River and flow across the continental divide into Lake Traverse (see **Plates 1-2 and 2-2**). This study assumes that during open-river conditions (no ice jams), the break out flow occurs at a discharge of approximately 3,000 cfs and has a 10-percent chance (10-year flood) of being equaled or exceeded in any given year. The risk increases when periods longer than one year are considered (see **Section 6.1**). Breakout flows, however, probably occur more frequently than indicated by a 10-year flood (based on open-river conditions). This is due to the fact that ice jams in Browns Valley often cause artificially elevated water surface elevations during flood events with peaks smaller than 3,000 cfs.

The breakout flow provides a pathway for the transfer of aquatic biota (e.g. exotic species) from the Minnesota River basin and the Red River of the North watershed. Some aquatic species can move both upstream (against the flow) and downstream (with the flow). As a result, biota transfer could occur from Lake Traverse into the Little Minnesota River when water from the Little Minnesota River is flowing northward into Lake Traverse.

Interbasin flow is not the only mechanism providing a pathway for biota transfer between river basins. Other mechanisms include activities associated with sport fishing, construction projects and animal transport. Eliminating a single pathway (e.g. culvert removal), without addressing other biota transfer mechanisms may be ineffective in reducing the overall potential for interbasin transfer of exotic species.

In addition to restoring a pathway for flow between the Minnesota River and the Red River, the installation of culverts through the Browns Valley Dike also provided a means for interbasin flow across international basins. The St. Paul District investigated whether or not the Canadian government was notified of the breaching of the Browns Valley Dike and the installation of culverts (see **Reference No. 23**). That limited research effort did not confirm or deny the issue of international notification.

References:

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16b. Editor, Valley News, Browns Valley, Minnesota, Personal Contact on December 30, 1999.

16c. U.S. Army Corps of Engineers, St. Paul, District, Spring Flood '97, Red River of the North, Minnesota River and Mississippi River, After Action Report, April 1998.

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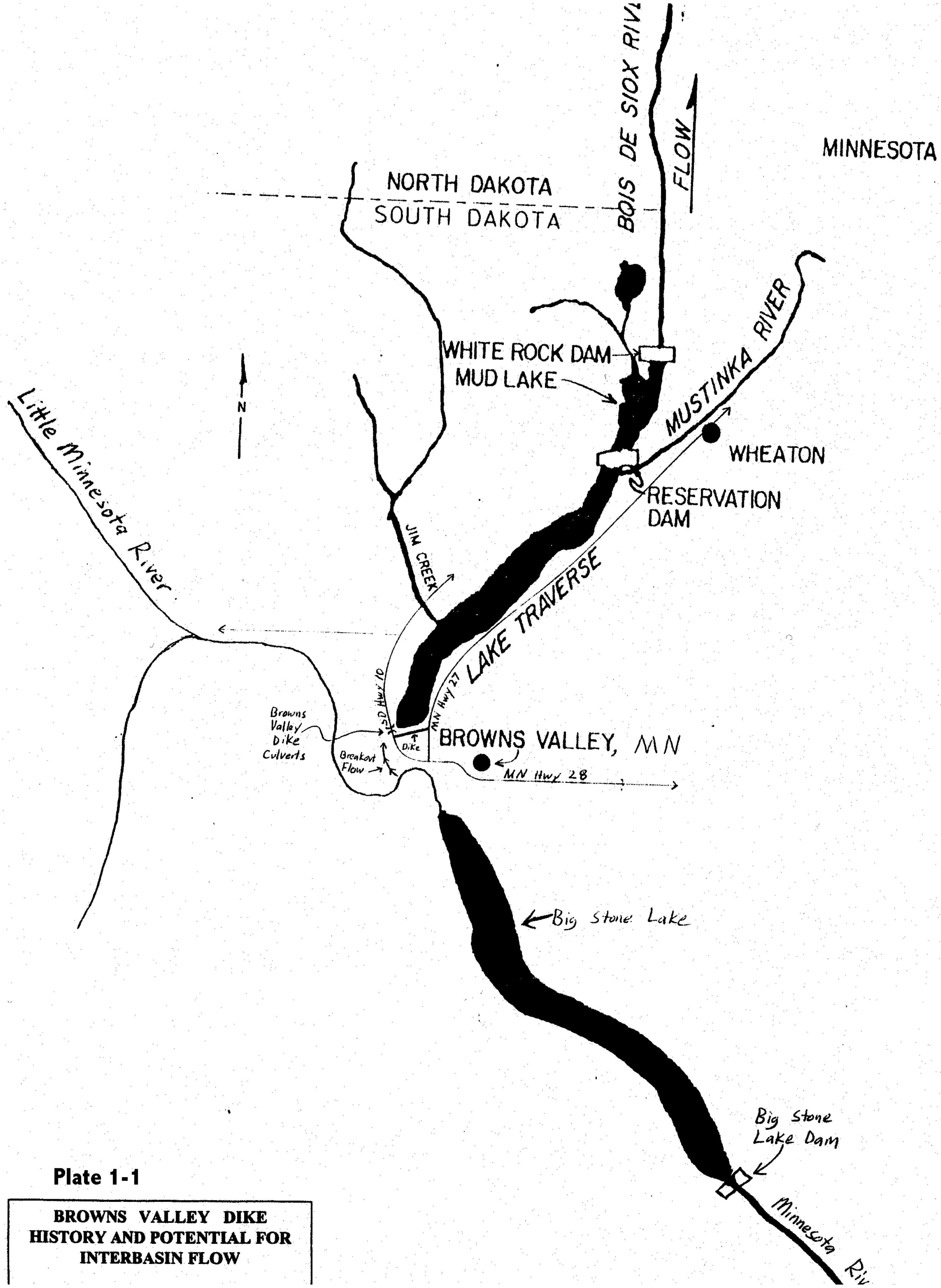
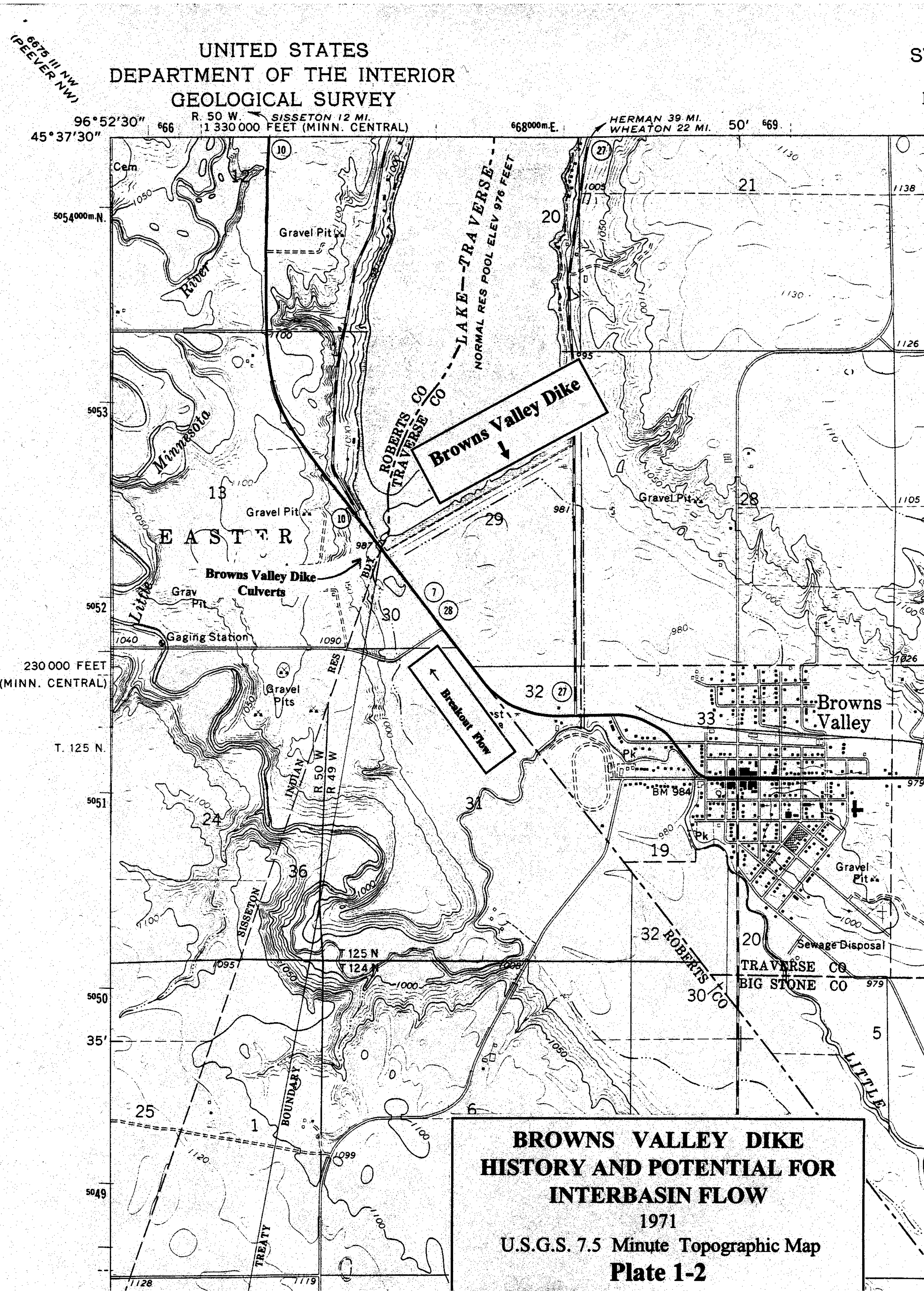
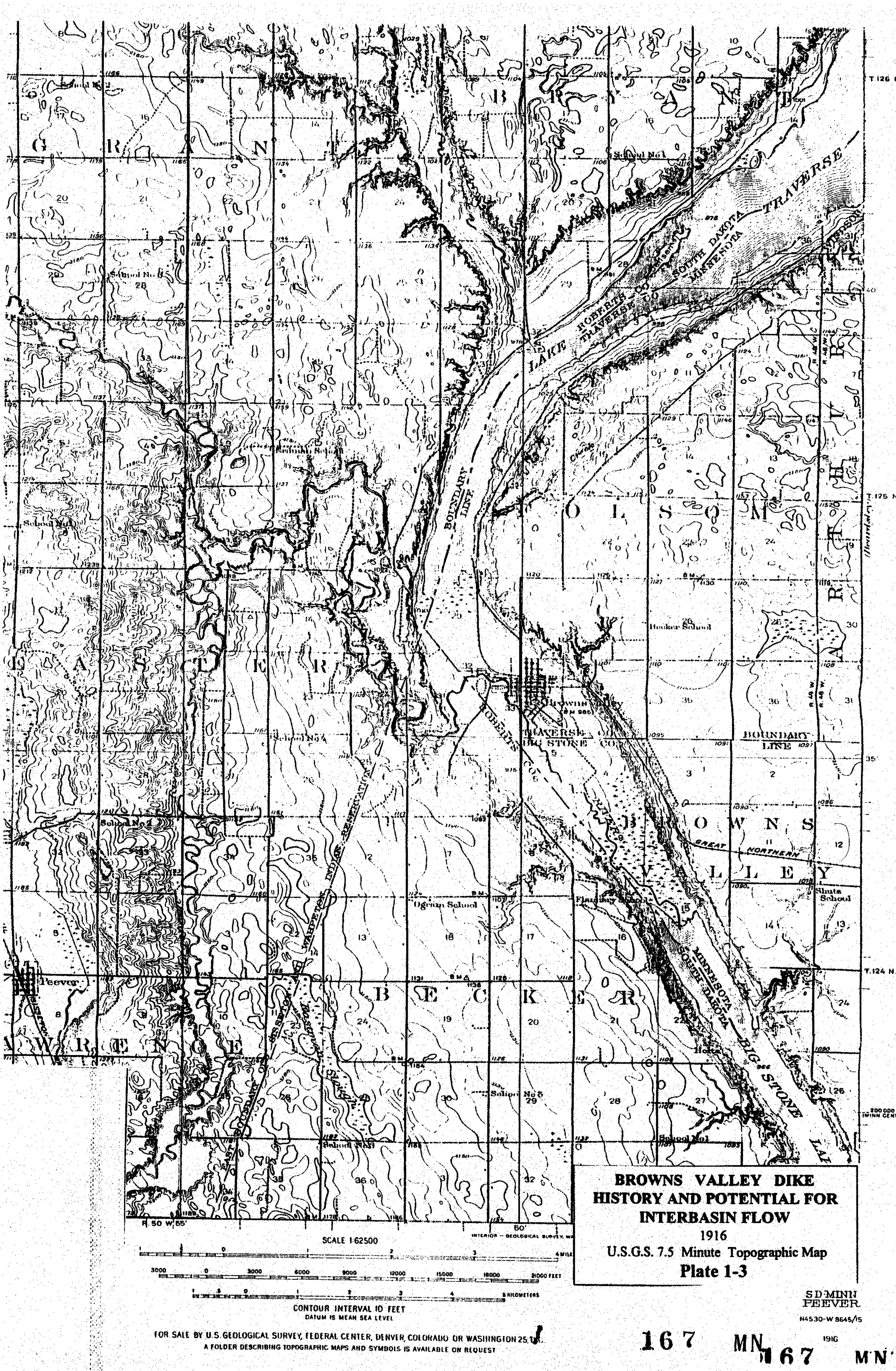


Plate 1-1

BROWNS VALLEY DIKE HISTORY AND POTENTIAL FOR INTERBASIN FLOW



BROWNS VALLEY DIKE
HISTORY AND POTENTIAL FOR INTERBASIN FLOW
1971
U.S.G.S. 7.5 Minute Topographic Map
Plate 1-2

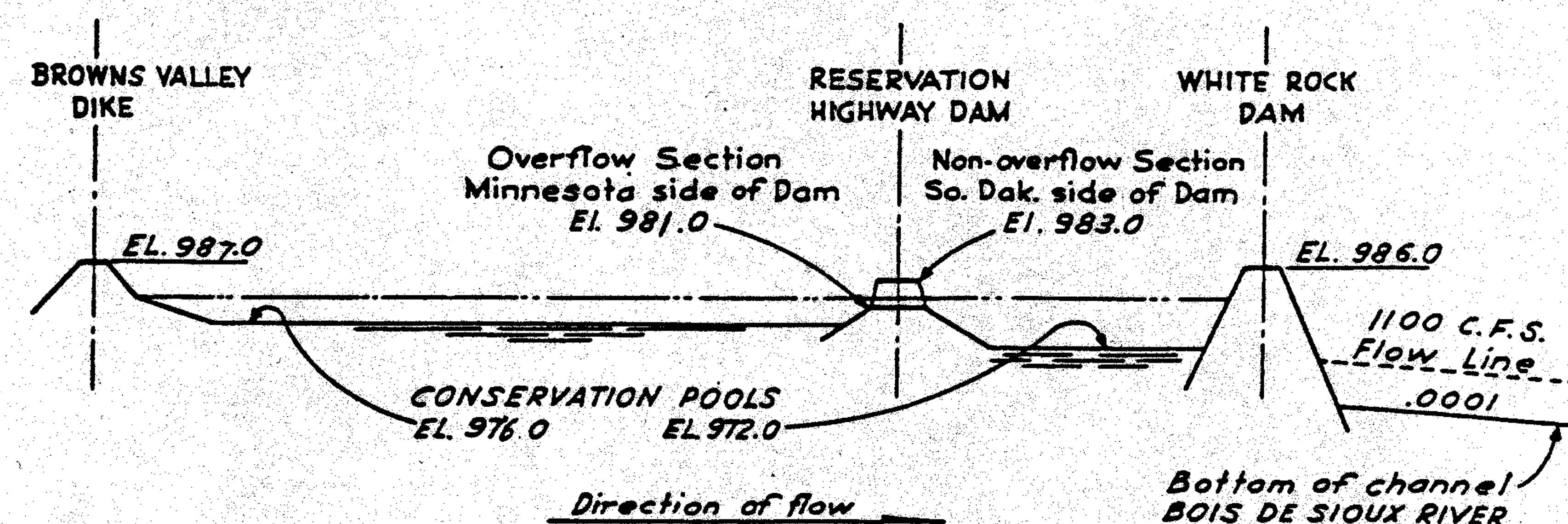


BROWNS VALLEY DIKE
HISTORY AND POTENTIAL FOR INTERBASIN FLOW

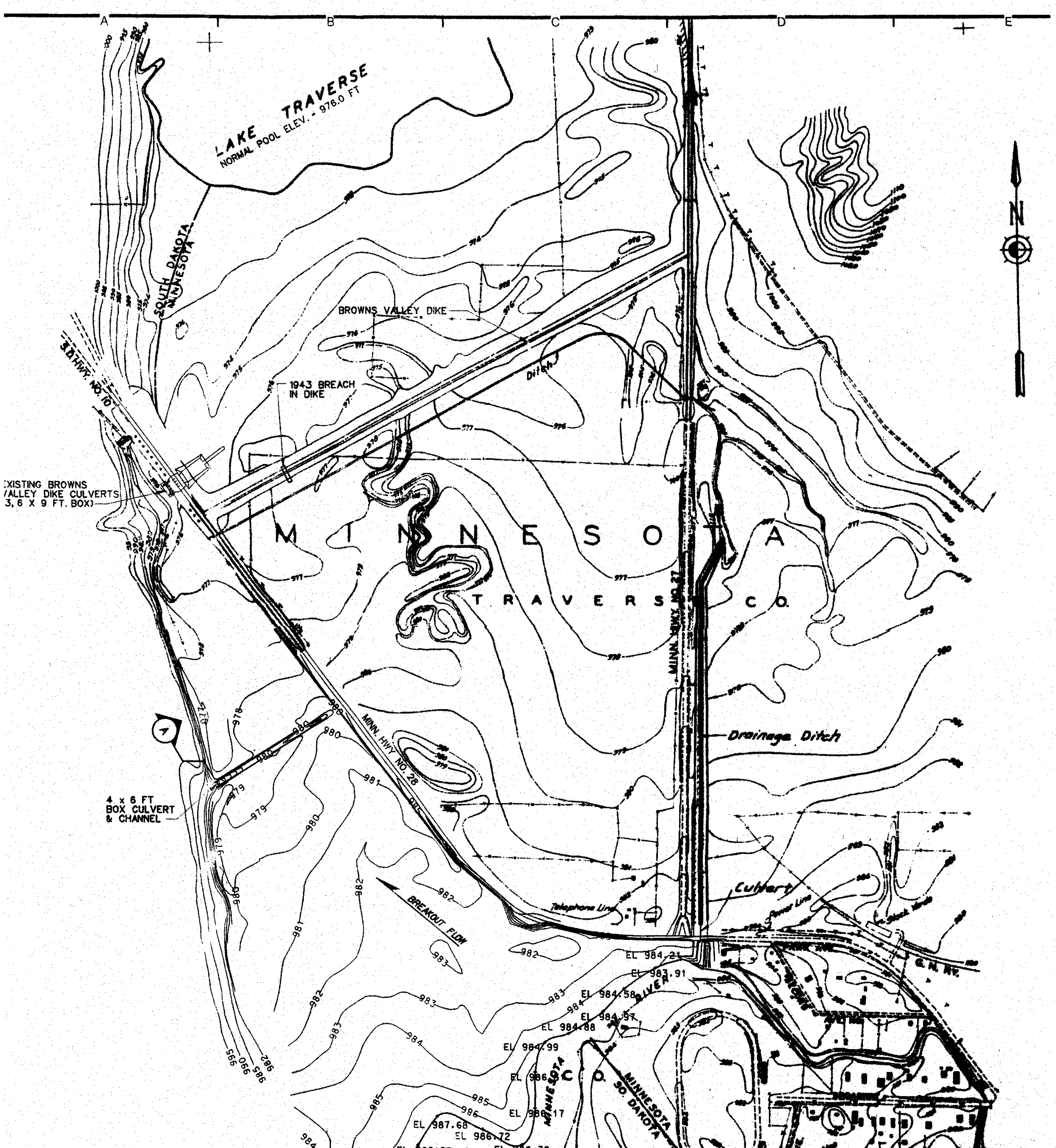
1916

U.S.G.S. 7.5 Minute Topographic Map

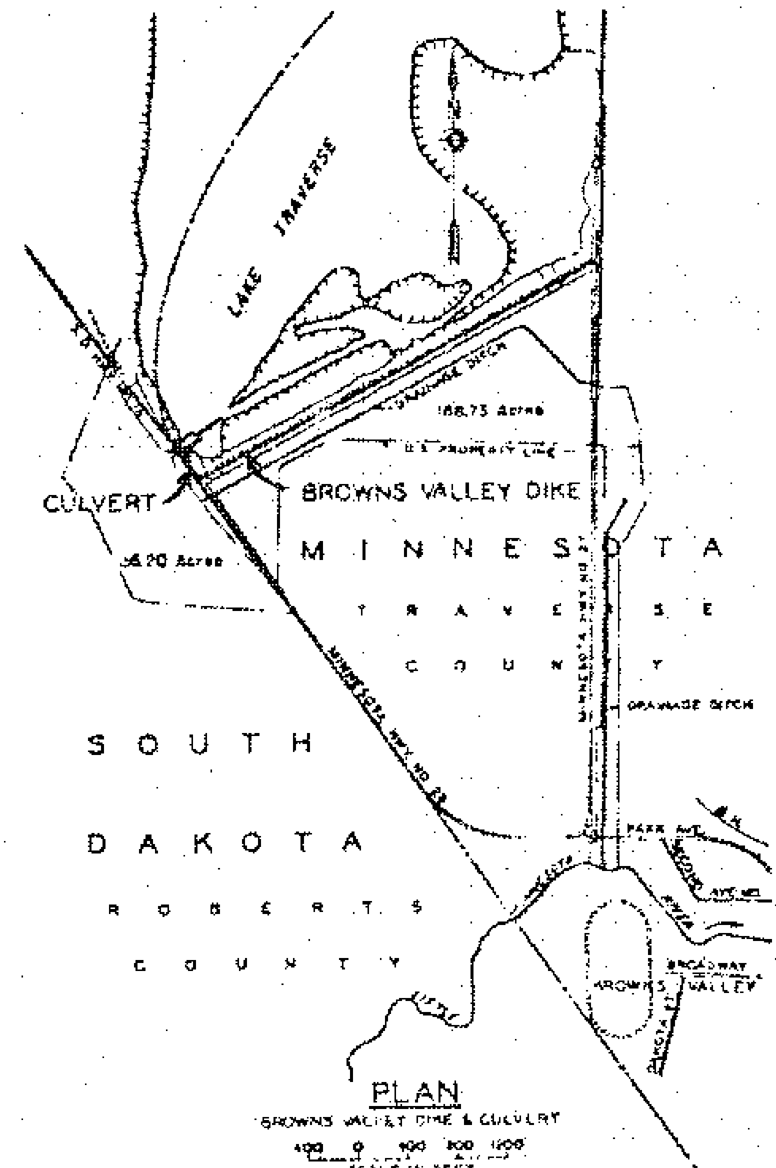
Plate 1-3



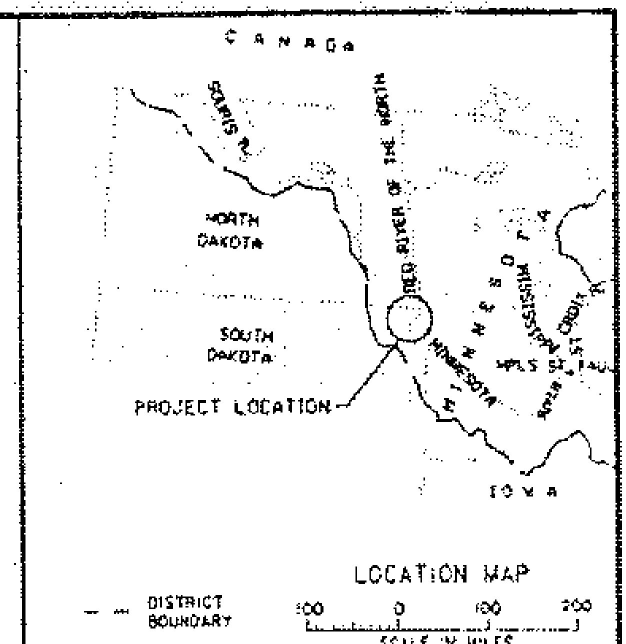
BROWNS VALLEY DIKE
HISTORY AND POTENTIAL FOR INTERBASIN FLOW
Lake Traverse Profile
Plate 2-1



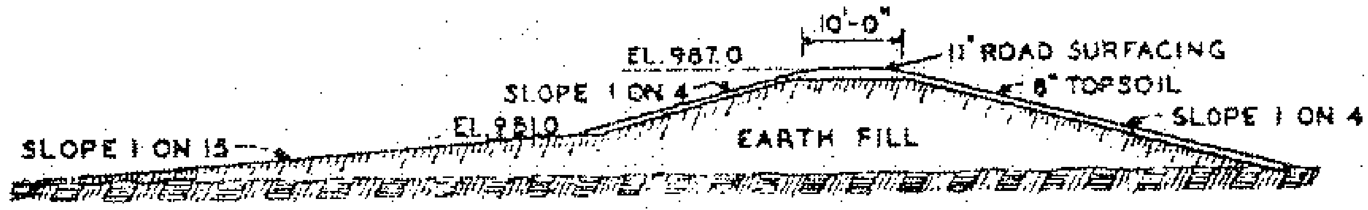
BROWNS VALLEY DIKE
HISTORY AND POTENTIAL FOR INTERBASIN FLOW
1-Foot Contour Topography
Drawing No. R30-S-10/029
Plate 2-2



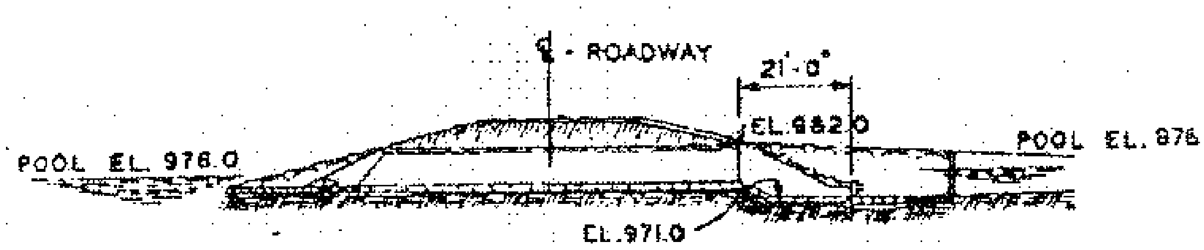
PLAN
BROWNS VALLEY DIKE & CULVERT
400 0 400 800 1200
SCALE IN FEET



LOCATION MAP



EARTH DIKE SECTION
BROWNS VALLEY
0 10
SCALE IN FEET



CULVERT SECTION
BROWNS VALLEY
0 20
SCALE IN FEET

ELEVATIONS ARE REFERENCED TO 1912 M.S.L.

LAKE TRAVERSE PROJECT
BOIS DE SIOUX RIVER

WATER CONTROL MANUAL
BROWNS VALLEY DIKE AND CULVERT

GENERAL PLAN AND CROSS SECTIONS

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL ENGINEERING DISTRICT
ST. PAUL, MINNESOTA

BROWNS VALLEY DIKE
HISTORY AND POTENTIAL FOR INTERBASIN FLOW

Aerial Photograph, Contact Print, April 13, 1997
Browns Valley, MN and Lake Traverse Reservoir

Plate 5-1

BROWNS VALLEY DIKE
HISTORY AND POTENTIAL FOR INTERBASIN FLOW

Aerial Photograph, Color Oblique, April 16, 1997
Browns Valley, MN and Lake Traverse Reservoir

Plate 5-2