

FLOOD CONTROL PERMIT NO. FC-30

Name of Applicant: City of Sioux Falls

Address: 224 W 9th St, Sioux Falls SD 57102

Phone: 605 367-7048

Amount of Water Claimed: NA

Total Acres: NA

Source of Water Supply: Big Sioux River – Skunk Creek

Water to be used for: flood control project

County: Minnehaha

Type of Waste Disposal System:

Location:

PRIORITY

Date Received: 4-19-2001

Fee: \$150

Corrected Application Received::

Period of Annual Use: January 1- December 31

Remarks:

Diversion Point:

Land to be Irrigated: NA

Depth of Well: NA

Well Driller: :

Remarks:

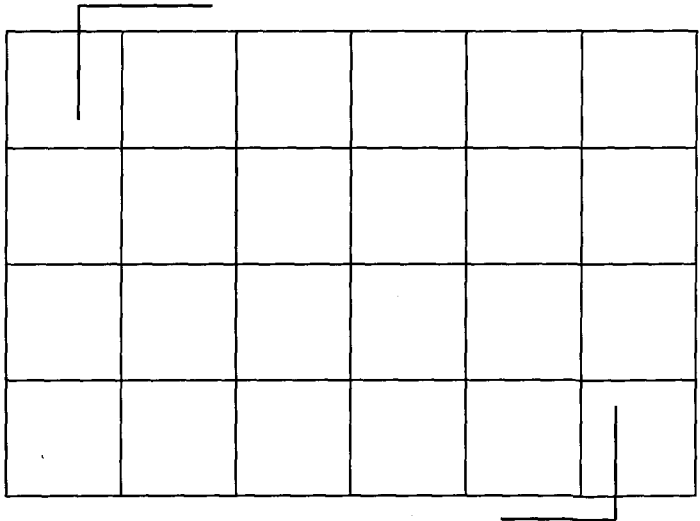
Type of Map:

Prepared by:

Reviewed and the Number Assigned on: 4-19-2001

By: **Karen Schlaak**

Notice of Hearing - date to intervene: _____



FORM 2: Application for flood control permit

(type or print)

Mail to: Water Rights Program Joe Foss Building 523 E. Capitol Pierre, SD 57501-3181 (605) 773-3352	(office use only)	
	No. <u>FC 30</u>	Hydrologic Unit <u>10170203</u>
	Basin <u>Sioux River</u>	
	Newspaper <u>Argus Leader, Sioux Falls</u>	

RECEIVED
MAY - 8 2003
WATER RIGHTS
PROGRAM

Application For Flood Control Permit Within The State Of South Dakota1. Name of Applicant City of Sioux FallsAddress 224 W 9th Street

(Street, RR or Box)

Sioux Falls, South Dakota 57104Phone No. 367-8600

(City)

(State)

(Zip Code)

2. Name of watercourse Big Sioux River and Skunk Creek3. Location of project (e.g. SW $\frac{1}{4}$ NE $\frac{1}{4}$ section 2-T89N-R58W) Township 101 North Range 49 West, Township 101 North Range 50 West, and Township 102 North Range 49 West4. County or counties where project is located Minnehaha County

5. Give a brief description of the proposed project including the type of project (Dam, Dikes, Channel Modifications, etc.) and purpose for the project. When available include any preliminary engineering reports or other information that will help explain the project. (Attach sheet if more space is needed.)

The project includes the raising of the city's existing levee system to provide continued protection for the 100-year flood events on the Big Sioux River and Skunk Creek. Using several additional years of flow information after the original design and construction of the city's levee system, including record flood events, the United States Army Corps of Engineers recalculated the flow events for the Big Sioux River and Skunk Creek. The recalculations showed that the 100-year flood events were greater than previously thought and that the existing system did not provide for protection from the 100-year events on the channels. In order to meet Federal Emergency Management Administration requirements to provide for continued protection of properties along the Big Sioux River and Skunk Creek, the City of Sioux Falls and the federal government through the United States Army Corps of Engineers are working together to improve the flood control system.

Attachments: Project Description

Location Map

Seepage Analysis Report

100 Year Flood Plain Boundary Maps

Memorandum for Files, May 9, 2002

Memorandum for Files, February 3, 2003

STATE OF SOUTH DAKOTA)

County of Minnehaha) SS

I, Dave Munson the applicant, certify that I have read this application, have examined the attached map and that the matters are true and that I intend, and am able to complete the necessary construction.

Signed Dave Munson, MayorSubscribed and sworn to before me this 18th day of April 20 03

Notary Public

4-2000

SOUTH DAKOTA
FLOOD CONTROL PERMIT NO. FC-30

Date of first receipt of application May 8, 2003.

The Water Management Board approved Flood Control Permit No. FC-30 on July 10, 2003 for the City of Sioux Falls, 224 W 9th St, Sioux Falls SD 57102 subject to the following limitations, conditions and qualifications:

1. Flood Control Permit No. FC-30 authorizes improvements to the existing flood control system located within the corporate limits of Sioux Falls in Minnehaha County. The flood control system will be designed to provide protection for the 100-year flood event as defined by the US Corps of Engineer. The legal description of the project area includes sections within T101N, R49W; T101N, R50W and T102N, R49W. The project is to be completed in 3 phases (see public notice and report on No. FC-30 for a full description of project).
2. The date from which applicant may claim right is May 8, 2003.
3. All construction is to be completed on or before July 10, 2008.

QUALIFICATIONS

1. The City of Sioux Falls is responsible for operation and maintenance of the flood control works.
2. Flood Control Permit No. FC-30 is subject to securing easements and/or land acquisitions on any areas, other than city property, where construction activities will take place or additional lands are flooded. These documents shall be held by the city of Sioux Falls and be available for review by the Water Rights Program.
3. Prior to construction of Phase II and III, final designs for that phase shall be submitted to the Chief Engineer of the Water Rights Program for review and approval.
4. Engineering change notices, software calibrations or other calculations that effect water surface elevations or seepage analysis data previously submitted are subject to review and approval by the Chief Engineer.
5. Design of all levees in Phases II and III shall include measures to reduce uplift pressures to result in an exit gradient not to exceed 0.8 at the landward levee toe, to satisfy criteria in EM 1110-2-1901, Seepage Analysis and Control for Dams.
6. The Operation and Maintenance (O & M) Manual for the system shall be completed by the US Army Corps of Engineers upon completion of construction. The manual shall set forth criteria for operation of the diversion dam in various flood events. The manual shall provide guidelines for the controlled breach of the levee system if a breach is needed to prevent a catastrophic, random failure. The operating manual is subject to review and approval by the Chief Engineer.
7. The Water Management Board retains jurisdiction of Flood Control Permit No. FC-30 in the event that additional information shows this project causes an increase in the severity of flood damages in areas other than the project area.

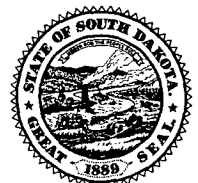
WATER MANAGEMENT BOARD

By: Garland Erbele

Garland Erbele, Chief Engineer
Water Rights Program
Department of Environment and Natural Resources

AUG 28 2003

date



RECEIPT

Water Rights Program

South Dakota Department of Environment and Natural Resources

416825

Pierre, April 19, 2001

RECEIVED OF City of Sioux Falls, 224 West Ninth St., Sioux Falls, SD 57104
the following amount in fees for services rendered as provided for by law:

Fee for Application for Permit No. _____ to Appropriate Water, to construct and to put water to beneficial use _____	150	00
Fee for Application for Permit No. _____ to Appropriate Water, for Future Use _____		
Fee to retain Future Use Permit No. _____ after period of seven years.		
Fee for Inspecting Constructed Works, confirming beneficial use and issuing Water License No. _____	50	00
Fee for Filing Transfer Form _____		
Fee for Filing Extension Request _____		
Fee for _____		

(Any Other Work Provided by Law)	Total	200 00

By

Darland Erbe

Chief Engineer

gm

**BIG SIOUX RIVER and SKUNK CREEK
FLOOD CONTROL PROJECT FC-30
City of Sioux Falls
224 W. 9th Street
Sioux Falls, SD 57102**

Flood Control Application FC-30, City of Sioux Falls, SD, proposes to improve and extend the existing flood control system that reroutes and contains within levees, Big Sioux River and Skunk Creek flood level flows. The existing flood control system is located within the corporate limits of Sioux Falls, Minnehaha County, SD and includes a Diversion Dam, Diversion Channel, weir, spillway chute, stilling basin, levee overflow (fuse) plug, and levees along the Big Sioux River natural channel, Skunk Creek, and the Diversion Channel (Plate 1).

The project constructing the existing flood control system was authorized by the 83rd Congress in Public Law 780 dated September 3, 1954. Funds for the completed Feasibility Report and Environmental Assessment, *Local Flood Protection Big Sioux River and Skunk Creek at Sioux Falls, SD (1993)*, and this proposed project are cost shared from federal, City of Sioux Falls, and State of South Dakota appropriations.

There was no State of South Dakota statute requiring a flood control permit at the time the existing flood control system was designed and constructed between 1956 and 1965. Since 1983, a flood control permit has been required pursuant to South Dakota Codified Law (SDCL) 46-2A-11 and 46-5-47 for facilities constructed on a watercourse, other than a dry draw, to control flooding. According to these statutes, a flood control permit may only be issued if the project will reduce the damage from flooding or erosion in the area proposed to be benefited, the project will not increase the likelihood or the severity for flood damages in areas other than the project area or the area proposed to be benefited, the project will not endanger human life or property and the project will not impair existing rights, except to the extent that such rights are extinguished or compensated through agreement or exercise of the power of eminent domain.

The Water Rights Program Chief Engineer's evaluation of this application's modifications to the existing Sioux Falls, SD flood control system is based solely on this project's future impacts on those conditions outlined in SDCL 46-2A-11. Impacts from projects completed and in place before the flood control permitting statute was in effect were not evaluated in this permitting process.

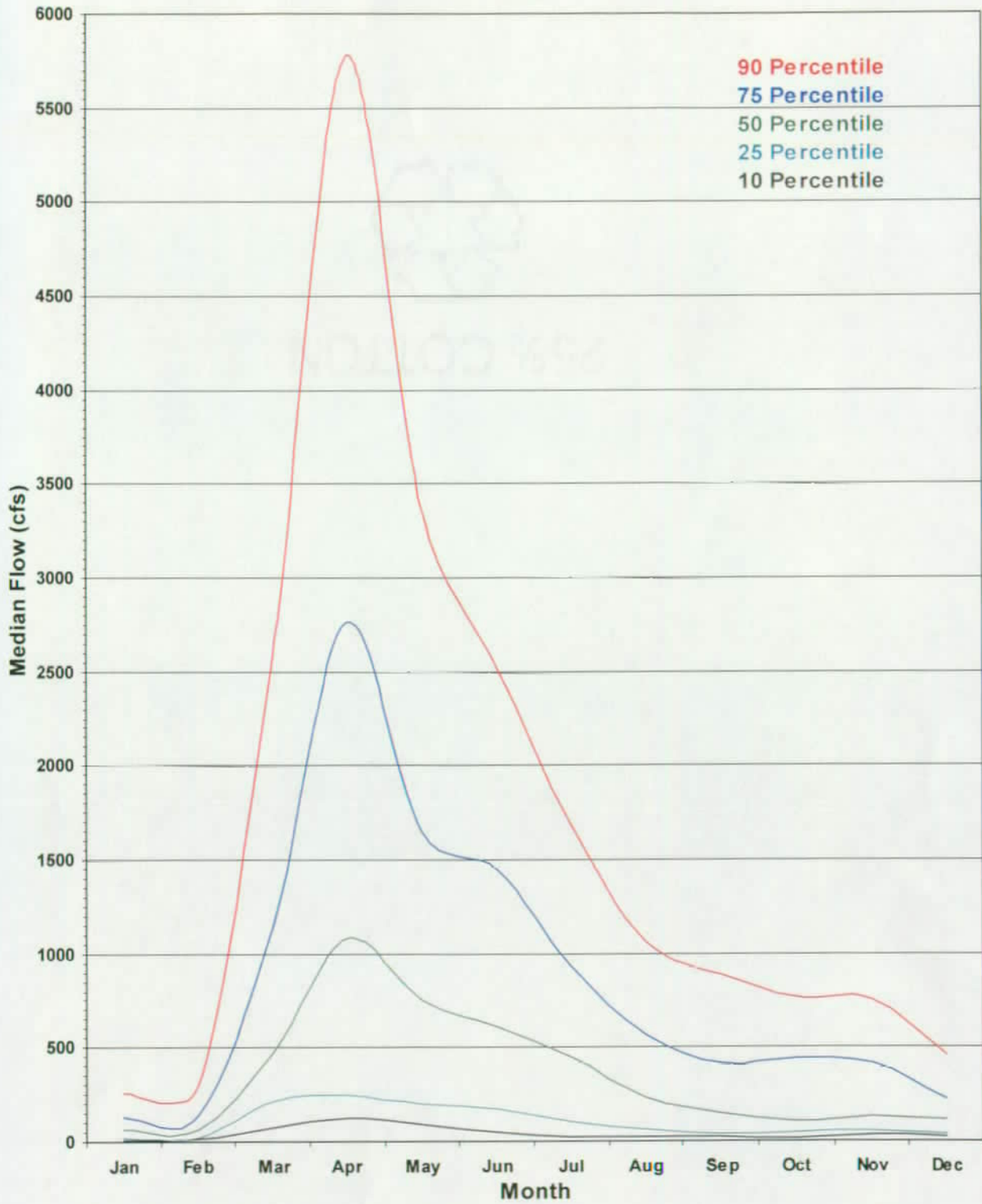
Review of Existing Flood Control System

The Big Sioux River originates north of Watertown, SD and flows south to the Missouri River near Sioux City, IA. Upstream from Sioux Falls the Big Sioux River drains approximately 5,216 square miles in South Dakota and Minnesota. The Big Sioux River meanders from Watertown, SD to Sioux Falls, SD with an average river gradient of 1.5-feet per mile. In the City of Sioux Falls, the river's flood plain is highly developed for industrial, commercial, residential, and recreational purposes. Upstream and downstream of Sioux Falls the flood plain is mostly used for agricultural purposes. Flood level flows in the Big Sioux River normally originate from heavy snow pack melt coinciding with heavy spring rains within the river's watershed. (Duration Hydrograph 1)

Skunk Creek originates near Madison, SD and meanders to the Big Sioux River confluence at Sioux Falls, SD draining an area of approximately 622 square miles entirely within the state. Upstream from Sioux Falls the creek's flood plain is used mainly for agricultural purposes. Within Sioux Falls, the creek's flood plain is mostly residential with some commercial uses. Skunk Creek's highest recorded flows at Sioux Falls have occurred in the month of June from severe rainstorms within the stream's watershed. Skunk Creek also experiences high flows from snow pack melt and spring rains. (Duration Hydrograph 2)

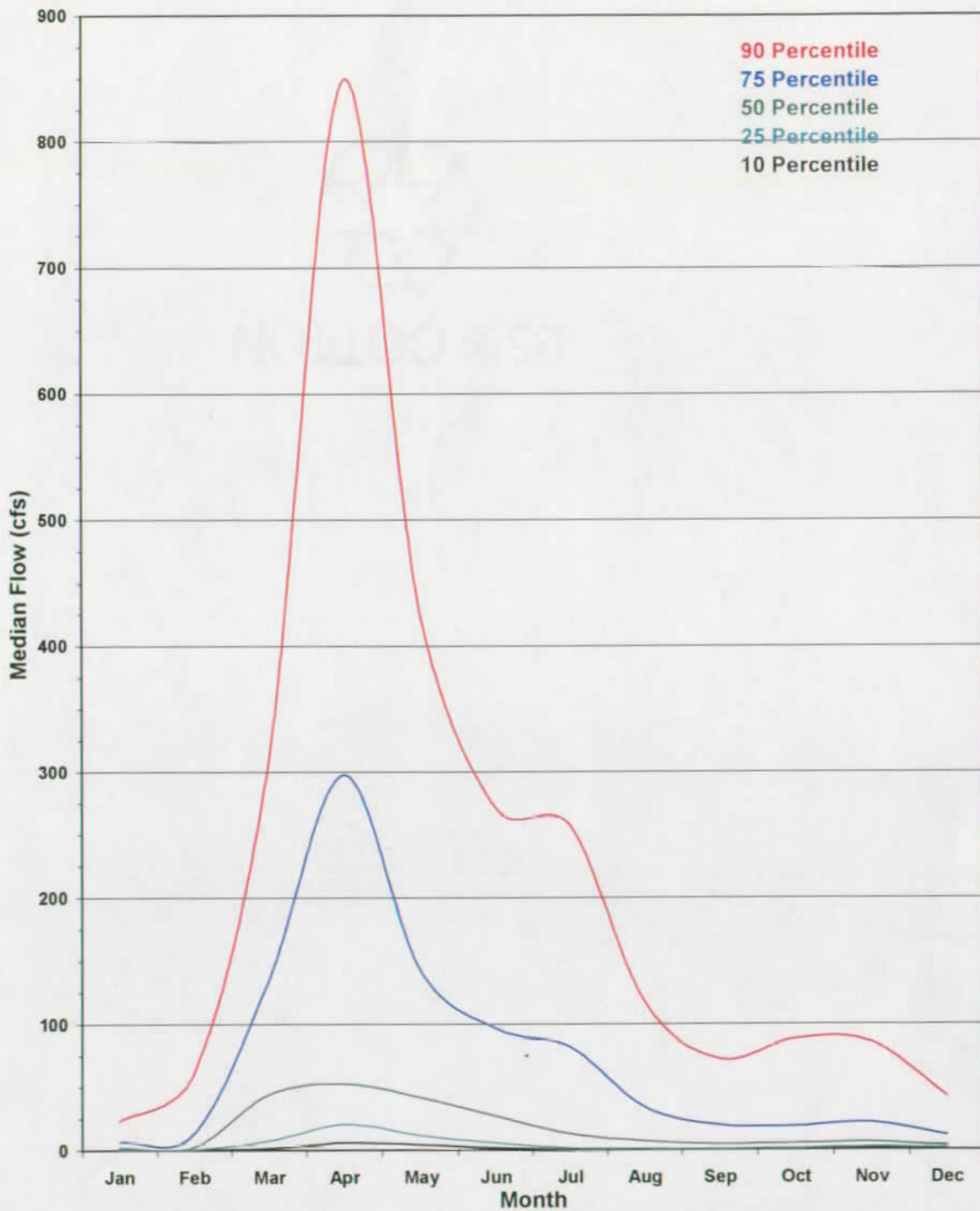
Duration Hydrograph 1. Big Sioux River Median Flows

Big Sioux River
Sioux Falls Cliff Ave
1971-2001



Duration Hydrograph 2. Skunk Creek Median Flows

Skunk Creek
Sioux Falls 1948-2001



The major portion of the City of Sioux Falls, including the main business district, lies within a horseshoe bend of the Big Sioux River's natural channel at the Skunk Creek confluence in southern Minnehaha County,

SD (Plate 1). This is a region of low relief prone to flooding from snowmelt, high rainfall, or a combination of these two events.

Plate 1. Sioux Falls



The City of Sioux Falls and the United States Army Corps of Engineers (USACE) completed an analysis of flood control measures in mid 1950 and initiated construction in 1956 of the existing flood control system on the Big Sioux River and Skunk Creek. By agreement with the USACE, the City of Sioux Falls is responsible for the operation and maintenance of the existing flood control system.

The existing flood control system was designed and constructed between 1956 and 1965 for flows of 24,400 cubic feet per second (cfs) in the Big Sioux River and 9,350 cfs in Skunk Creek based on the limited 6 to 10 years of hydrological data available at that time from the United States Geological Service (USGS). For the Big Sioux River, the existing flood control system was designed to divert 17,100 cfs into the Diversion Channel and pass 7,300 cfs through the Diversion Dam gates to flow in the river's natural channel around Sioux Falls. The design discharge of 24,400 cfs in the Big Sioux River was about 75-percent greater than the maximum flood of record (approximately 13,500 cfs) at that time, the flood in the spring of 1952. At the time of construction, the design discharge of 24,400 cfs in the Big Sioux River indicated the flood control system would provide protection well over a 100-year event.

Several Big Sioux River flooding episodes have occurred since construction of the existing Sioux Falls flood control system, with the highest ever-recorded flow in the spring of 1969. The USACE estimates that the Big Sioux River flow for the 1969 flood event was 40,000 cfs with 30,000 cfs routed through the Diversion Channel and 10,000 cfs passed through the Diversion Dam to flow in the Big Sioux River's natural channel

around Sioux Falls. Historical data from the USGS stage gages at Dell Rapids, SD, approximately 20 miles upstream of Sioux Falls, and Brandon, SD, approximately 6.5 miles downstream of Sioux Falls, recorded the peak flows for the 1969 flood event at 41,300 cfs on April 9, 1969 and 36,800 cfs on April 10, 1969 respectively. There was no USGS gaging station installed on the Big Sioux River at Sioux Falls during the 1969 flood, although a peak discharge of 40,700 cfs on April 10, 1969 is recorded in USGS peak flow data for North Cliff Avenue, Sioux Falls, SD. These recorded flows exceeded the existing flood control system design discharge of 24,400 cfs by about 68-percent. Extensive emergency measures were used in 1969 that prevented major flooding in Sioux Falls.

The Federal Emergency Management Agency (FEMA) administers the National Flood Insurance Program and is responsible for ensuring the Flood Insurance Rate Map (FIRM) for Sioux Falls reflects current flood hazard conditions. The 1979 Flood Insurance Study (FIS) for Sioux Falls and vicinity reported that the existing flood control system protected the city from floods in excess of the 100-year event (24,400 cfs) on the Big Sioux River and the 25-year event (9,350 cfs) on Skunk Creek. In 1982, FEMA released the FIRM for the Sioux Falls area. In 1987, FEMA was notified of the USACE study that determined the existing flood control system does not provide adequate protection for Sioux Falls. At that time, FEMA decided not to re-evaluate the Sioux Falls area until either the existing flood control system had been modified or a decision for no modification was made.

FEMA later prepared a draft FIRM based on data taken from USACE 1993 and 1997 publications. The City of Sioux Falls feels this draft FIRM does not accurately reflect the most up-to-date nor the post project conditions based on present and forecasted infrastructure, and updated Geographic Information System (GIS) and hydrological data. Recommendations were made to FEMA by the City of Sioux Falls to update the FIRM base mapping consistent with the city's GIS database and to delay formal implementation of the FIRM until completion of this proposed project. These recommendations have been accepted by FEMA.

Feasibility Report and Design Optimization Study

The USACE Feasibility Report and Environmental Assessment, *Local Flood Protection Big Sioux River and Skunk Creek at Sioux Falls, SD (1993)*, determined that major portions of the highly developed areas of Sioux Falls are vulnerable to flooding and a 100-year flood event in the Big Sioux River could cause \$111 million estimated damage in the city. A 100-year flood event in Skunk Creek could cause \$75 million estimated damage in the city. This report also found the most economically feasible flood control solution at Sioux Falls, SD to be modification of the existing flood control structures on the Big Sioux River and Skunk Creek.

Table 1 presents the revised 100 and 500-year flood event flow rates for the Big Sioux River and Skunk Creek as determined by the USACE from updated stream flow data and model simulation.

Table 1. USACE Defined Flood Event Flow Rates

Event	Location	Flow (cfs)
100-Year	Big Sioux River – Diversion Dam	35,000
100-Year	Big Sioux River – North Cliff Ave.	36,300
100-Year	Skunk Creek – Sioux Falls, SD	23,500
500-Year	Big Sioux River – Diversion Dam	57,500
500-Year	Skunk Creek – Sioux Falls, SD	43,500

The USACE commissioned HDR Engineering Inc. to conduct a Design Optimization Study to obtain the least cost alternative and prepare a Design Documentation Report (DDR) that provides the technical basis for the proposed project. The design area studied extends upstream from the Diversion Channel spillway chute to near SD Highway 38 on the Big Sioux River and from the Big Sioux River to Marion Road on Skunk

Creek. The hydrologic study area ended approximately 5 miles upstream of the Diversion Dam on the Big Sioux River and to 12th Street on Skunk Creek. The DDR was released in March 2000 and established three phases for the proposed project.

Except for the overflow plug, most major modifications suggested in the *Feasibility Report and Design Optimization Study* are included in the final project. The modified flood control system will be designed to provide protection for the USACE defined 100-year flood event for the Big Sioux River and Skunk Creek within the City of Sioux Falls, SD. Water surface elevations for pre and post conditions of each phase of the project were modeled at the 100 and 500-year event flows (Table 1).

Hydrologic & Geotechnical Analyses

The USACE HEC-RAS computer software system calculates one-dimensional water surface cross-sectional profiles for steady and unsteady, gradually varied, flow for a full network of natural and constructed channels. HEC-RAS modeling is being used by the USACE, Omaha District to determine water surface elevations for pre and post conditions of each phase of the project. Models are calibrated using observed levels from previous flooding episodes and analyses are subjected to the USACE Quality Assurance system.

USACE used 2-foot contours available from the City of Sioux Falls and USGS as the basis for stream flow modeling. The 2-foot contours are available for all land within the city and limited areas outside city limits. To provide current data for the design of the required levee modifications, USACE retained Merrick and Company to provide updated topographic data. In May 1998, Merrick and Company performed an aerial survey of the area encompassed by the flood control system. This survey provided 1-foot contour data for the existing levees and adjacent areas included in the expansion of these levees.

Increased hydrostatic pressure on a levee embankment during high-water events will result from the larger volume of water levees will contain after height increases. An increase in hydrostatic pressure could result in unacceptable seepage rates through permeable strata beneath a levee or high uplift pressure at the landward toe of the levee. There were undocumented verbal reports of excessive levee under-seepage sand boils during the 1969 flood event.

Using geotechnical information and soil boring data compiled from 1956 through 2001 for relevant projects in the areas of interest, the USACE, Omaha District completed seepage analyses following Engineering Manuals EM 1110-2-1913, *Design and Construction of Levees*, and EM 1110-2-1901, *Seepage Analysis and Control for Dams*.

A two-dimensional, finite element, computer software program, SEEP2D, developed by the U.S. Army Engineer Waterways Experiment Station (WES) was used to model levee seepage. Modeling results, areas of concern, and corrective recommendations are reported in the final *Seepage Analysis Report, February 2003*, prepared by the USACE, Omaha District for the City of Sioux Falls Department of Public Works.

The USACE HEC-RAS and WES SEEP2D computer software programs are recognized and accepted in the public and private sectors for hydrologic and geotechnical analyses.

Project Phases

Phase IA

Phase IA has been completed and consisted of raising the Diversion Channel spillway chute walls, the stilling basin walls, and the approach walls in varying heights from 2.5 to 10 feet. Buttresses were added to the chute walls, the backfill was raised behind the chute walls, and the slab drainage system was modified. (Plate 1)

The height of the spillway chute walls increased, but the width and depth of the chute did not, therefore no change in upstream or downstream water surface elevations should take place because of this modification. Addition of buttresses, back filling, and slab drainage modifications were all on the landward side of the spillway chute and will not impact upstream or downstream water surface elevations from present conditions.

Phase IB

Phase IB has also been completed and consisted of setting back approximately 100 feet of the existing stilling basin right bank levee downstream of the spillway chute and raising a portion of this levee adding more protective riprap. This work created a channel with a smoother transition curve and wider bottom, improving flow through the stilling basin and reducing water surface elevations for a given upstream discharge from the spillway chute to the Big Sioux River falls. (Plate 1)

HEC-RAS calculations showed that for a 500-year or less flood event, upstream and downstream water surface elevations are slightly lower after completion of Phase IB.

Phase II

Phase II encompasses both banks of the Big Sioux River from south of the Interstate 29 Bridge to Russell Street and both banks of Skunk Creek from Marion Road east to the Big Sioux River. Work will consist of elevating and strengthening levees and adding floodwalls as required along Skunk Creek and the Big Sioux River (Plate 1). Levee heights along Skunk Creek and the Big Sioux River are to be elevated approximately 2 to 6 feet to contain 100-year event flows. Work on this phase will include elevating and lengthening the Marion Road Bridge and elevating the 41st Street Bridge, plus levee seepage corrective measures.

The final *Seepage Analysis Report, February 2003*, prepared by USACE, Omaha District identified four (4) areas of potential seepage within the Phase II area. The calculated rates of seepage for these areas are considered negligible by the USACE, but three (3) areas have calculated exit gradients exceeding 0.8 (unitless number denoting uplift pressure) that according to EM 1110-2-1901 criteria require corrective measures. Landward seepage berms are to be used to reduce uplift pressures in these areas to acceptable levels (≤ 0.8 exit gradient). The location, thickness, and material type will be determined during Phase II final design.

Water surface elevations calculated by the USACE, Omaha District for Phase II show that for a 100-year flood event (Table 1), the water surface elevations for the proposed project are lower than the current profiles upstream of Marion Road on Skunk Creek. The lowering of the water surface elevations upstream of Marion Road will be accomplished through the elevation and lengthening of the Marion Road Bridge. Water surface elevations will be greater within the levee system since flow will not be allowed to overtop the modified levees.

In any levee system, a rate of flow is reached where a levee cannot handle the volume of water and becomes a bottleneck, resulting in expanded water surface elevations. HEC-RAS analysis shows this is true in the Phase II area for a 500-year flood event (Table 1), especially along Skunk Creek between Marion Road and the Big Sioux River. The areas forecasted to flood at the USACE defined 500-year flood flow are within the corporate limits of the City of Sioux Falls, the project, and the areas proposed to be benefited by the project. There can be no guarantee that catastrophic failure will not occur during extreme flood events, including a 500-year event.

It is not economically justifiable to attempt to provide protection against the largest flood that could possibly occur. Such protection would be too costly for such a rare event. Governmental and private institutions have agreed that the most infrequent event to protect against is the one-percent flood (100-year event). Although the levees and other structures in the proposed modifications to the flood control system are expected to avoid catastrophic failure up to the USACE defined 500-year flood event in the Big Sioux River and Skunk Creek, overall the modifications are to be designed to provide flood protection for a 100-year event (Table 1).

Phase III

Phase III is to encompass both banks of the Diversion Channel from the spillway chute to Silver Creek on the east side and the Big Sioux River on the west side, the levee on the east side of Silver Creek north of the Diversion Channel to just west of North Cliff Avenue, and the levees on the west bank of the Big Sioux River from the Diversion Dam to just south of Interstate 90 (Plate 1). Work will consist of elevating and strengthening levees, adding floodwalls as required, and levee seepage corrective measures. Levees are to be elevated approximately 1 to 4-feet to contain slightly greater than 200-year event flows (43,900 cfs). Originally, the overflow (fuse) plug on the levee just upstream of the Diversion Dam was to be modified during this phase of the project.

The overflow plug is located upstream of the Diversion Dam on the right levee. The existing flood control system was designed for a capacity of 24,400 cfs, passing 17,100 cfs into the Diversion Channel and 7,300 cfs through the Diversion Dam into the Big Sioux River's natural channel around the City of Sioux Falls. The overflow plug was originally designed to breach and pass flows exceeding 24,400 cfs onto the area between the right levee on the natural channel of the Big Sioux River and Interstate 29. This overflow was to return to the Big Sioux River's natural channel at the Skunk Creek-Big Sioux River confluence. Since construction of the existing flood control system at Sioux Falls, the overflow plug has been reinforced with riprap and sandbags during flooding episodes so that breaching would not occur. Presently the overflow plug is heavily fortified with riprap.

Elevating and increasing the extent of the Skunk Creek and Big Sioux River levees in Phase II of this project will prevent any overflow water in the area between Interstate 29 and the right levee of the Big Sioux River's natural channel from re-entering the river. If during catastrophic flood flows in the Big Sioux River or Skunk Creek, the need arises to divert any flow from the flood control system to protect human life or property, the City of Sioux Falls will, after safety, engineering, and economical risk assessments, perform a controlled breach at the most favorable location in lieu of using an overflow plug. Again, there can be no guarantee that catastrophic failure will not occur during extreme flood events, including a 500-year event. Phase III design will be for slightly over a 200-year event (43,900 cfs).

The *Seepage Analysis Report* prepared by the USACE, Omaha District identified four (4) areas with calculated exit gradients exceeding 0.8 (unit-less number correlated with uplift pressure) that according to EM 1110-2-1901 criteria require corrective measures. Landward seepage berms are to be used to reduce uplift pressures in those areas to acceptable levels (≤ 0.8 exit gradient). The location, thickness, and material type will be determined during Phase III final design.

Water surface elevations calculated by the USACE, Omaha District for Phase III show that for 100 and 500-year flood events (Table 1), the water surface elevations remain essentially the same as the existing flood control system profiles.

Flood Control System Operation

The City of Sioux Falls will be responsible for the operation and maintenance of the modified flood control system. The Operation and Maintenance (O&M) Manual presently in place will be completely revised, especially to add sections for the operation of the Diversion Dam gates and controlled levee breaching.

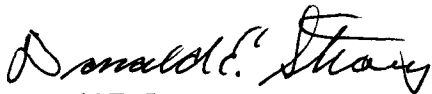
The USACE, Omaha District is developing upstream pool elevation-gate opening versus flow curves for the Diversion Dam gates that will be incorporated into the new O&M Manual for safe control of water elevations during periods of increased flows in the Big Sioux River.

The methods and responsibilities for completing the safety, engineering, and economical risk assessments before performing a controlled levee breach during catastrophic flood flows will also be incorporated into the new O&M Manual.

The City of Sioux Falls will initiate interim procedures covering controlled levee breaching and operation of the Diversion Dam gates until complete revision of the O&M Manual is accomplished.

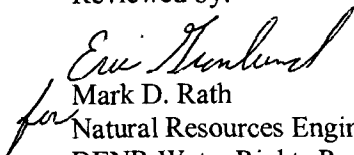
Conclusions

1. Consideration of this Flood Control Permit for modifications to the existing Sioux Falls, SD flood control system is evaluated on criteria pertaining to this proposed project's future impacts on the conditions outlined in SDCL 46-2A-11 and not how the existing flood control system impacts these same conditions.
2. The USACE and their contractors used software programs, analyses procedures, and quality assurance procedures recognized and accepted in the public and private sectors to produce geotechnical and hydrologic data for the design of this project.
3. Design data show the project will reduce the damage from flooding or erosion in the area proposed to be benefited, the project will not increase the likelihood or the severity for flood damages in areas other than the project area or the area proposed to be benefited, the project will not endanger human life or property, nor impair existing rights.
4. When finalized, the designs for Phases II and III, any design engineering change notices (ECN), water surface elevation or other calculations and software calibration data pertaining to these Phases or ECNs should be reviewed by the Chief Engineer or his representative before the work is implemented.



Donald E. Stroup
Natural Resources Project Engineer
DENR Water Rights Program

Reviewed by:



Mark D. Rath
Natural Resources Engineering Specialist
DENR Water Rights Program

References

South Dakota Department of Environment and Natural Resources, Water Rights Program Records

Feasibility Report and Environmental Assessment Local Flood Protection Big Sioux River and Skunk Creek at Sioux Falls, SD, US Army Corps of Engineers, November 1993

Sioux Falls Flood Control Project Design Optimization Study Big Sioux River, Skunk Creek and Diversion Channel, Sioux Falls, SD, HDR Engineering Inc. for US Army Corps of Engineers, March 2000

U.S. Geological Survey Surface Water Data retrieved from USGS Water Resources of South Dakota Internet Site

US Army Corps of Engineers, City of Sioux Falls, SD, and Water Rights Program Correspondence

Civil Engineering Reference Manual, Michael R. Lindeburg, P.E., Professional Publications, Inc.



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182
www.state.sd.us/denr

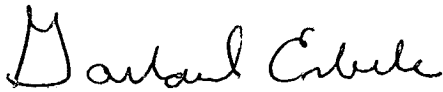
**RECOMMENDATION OF CHIEF ENGINEER FOR FLOOD CONTROL PERMIT
APPLICATION NO. FC-30, City of Sioux Falls**

Pursuant to SDCL 46-2A-2, the following is the recommendation of the Chief Engineer, Water Rights Program, Department of Environment and Natural Resources concerning Flood Control Permit Application No. FC-30, City of Sioux Falls, c/o Mayor Dave Munson, 224 West 9th Street, Sioux Falls SD 57102.

The Chief Engineer is recommending APPROVAL of Application No. FC-30 with qualifications because 1) the project will not increase the likelihood or severity of flood damages, 2) will not endanger human life or property, 3) will not impair existing water rights, 4) necessary land and /or easements will be obtained prior to construction on that phase of the project, and 5) it is in the public interest to provide flood control within the highly developed areas of Sioux Falls with the following qualifications:

1. The City of Sioux Falls is responsible for operation and maintenance of the flood control works.
2. Flood Control Permit No. FC-30 is subject to securing easements and/or land acquisitions on any areas, other than city property, where construction activities will take place or additional lands are flooded. These documents shall be held by the city of Sioux Falls and be available for review by the Water Rights Program.
3. Prior to construction of Phase II and III, final designs for that phase shall be submitted to the Chief Engineer of the Water Rights Program for review and approval.
4. Engineering change notices, software calibrations or other calculations that effect water surface elevations or seepage analysis data previously submitted are subject to review and approval by the Chief Engineer.
5. Design of all levees in Phases II and III shall include measures to reduce uplift pressures to result in an exit gradient not to exceed 0.8 at the landward levee toe, to satisfy criteria in EM 1110-2-1901, Seepage Analysis and Control for Dams.

6. The Operation and Maintenance (O & M) Manual for the system shall be completed by the US Army Corps of Engineers upon completion of construction. The manual shall set forth criteria for operation of the diversion dam in various flood events. The manual shall provide guidelines for the controlled breach of the levee system if a breach is needed to prevent a catastrophic, random failure. The operating manual is subject to review and approval by the Chief Engineer.
7. The Water Management Board retains jurisdiction of Flood Control Permit No. FC-30 in the event that additional information shows this project causes an increase in the severity of flood damages in areas other than the project area.



Garland Erbele, Chief Engineer
May 29, 2003

Don Stroup
Department of Environment and Natural Resources
Foss Bldg
523 E Capitol Ave
Pierre SD 57501-3182

RECEIVED
MAY - 6 2003
WATER RIGHTS
PROGRAM

Dear Don:

Re: Permit for Big Sioux River/Skunk Creek Flood Control Project

Enclosed are the permit application, the permit fee and three copies of supporting documents for our permit application. Please process for the July meeting of the permitting board.

Sincerely,

Thomas O. Berkland



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

PMB 2020
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182
www.state.sd.us/denr

May 9, 2003

Tom Berkland
City Engineer's Office
City of Sioux Falls
224 West Ninth Street
Sioux Falls, SD 57104-6407

Dear Mr. Berkland:

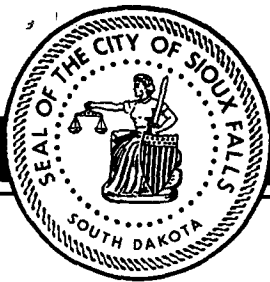
Please find enclosed the check for \$200 that the city submitted for the flood control permit application. As I mentioned on the voice mail I left for you, we discovered that the city paid the filing fee with its first submittal of the application back in 2001. Please give this check to the appropriate person within the city.

If you have any questions, please feel free to contact me.

Sincerely,

Eric Gronlund
Water Rights Program, DENR
(605) 773-3352

enclosure



PUBLIC WORKS

CITY OF SIOUX FALLS

AN EQUAL OPPORTUNITY EMPLOYER

224 West Ninth Street, Sioux Falls, SD 57104-6407
Hearing Impaired (605) 367-7039

June 27, 2001

Mr. Garland Erbele, Chief Engineer
Water Rights Program
South Dakota Department of Environment & Natural Resources
523 E. Capitol
Pierre, SD 57501

Dear Mr. Erbele:

Subject: Big Sioux River & Skunk Creek Flood Control Improvement Project
Permit for Flood Control Works

The City of Sioux Falls has submitted to your office an application for permit for flood control according to the requirements of SDCL 46-2A. Included in that package were the November 1993 Feasibility Report for Local Flood Protection Big Sioux River and Skunk Creek (Corps of Engineers) and the March 2000 Sioux Falls Flood Control Project Design Optimization Study (HDR/Corps). In addition, I believe we had transmitted a July 2000 Briefing Report (City of Sioux Falls) on the project and the November 1997 Flood Evaluation Study of the Big Sioux River and Skunk Creek (HDR/CSF).

Having discussed this application with your staff and reviewed SDCL 46-2A, I would request that you evaluate the necessity of pursuing the flood control permit based on the following factors:

- 1) The existing flood control system was authorized under Public Law 780 in the 83rd Congress, September of 1954. The specific intent of the project as dictated by Congress was flood control. The State of South Dakota has recognized both the project and project intent under the session laws of 1992, Chapter 254, Section 17. Both of these actions would lead me to conclude that permissive approval has already been granted or grandfathered. The permit application could introduce an adverse action. Denial of the permit would in affect negate the congressional authorization and previous action by the Legislature of South Dakota, and illegally challenge the existing flood control system.

Public Works Administration

(605) 367-7143
FAX (605) 367-4605

Water Reclamation

(605) 367-7088
FAX (605) 367-8484

Lights

(605) 367-7150
FAX (605) 367-8306

Streets

(605) 367-7051 or 367-7008
FAX (605) 367-7010

Billing

(605) 367-7031
FAX (605) 367-7341

Engineering

(605) 367-7048
FAX (605) 367-4310

Water Purification

(605) 367-7025
FAX (605) 367-8475

Water Meters/Utility Maintenance

(605) 367-7020
FAX (605) 367-7883

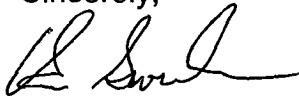


- 2) The project submitted is within the scope and intent of the original authorization. The project scope, limits and parameters have not changed. The original intent of the project was to provide flood protection for the 100-year design event and flood damage mitigation for the 500-year design event. Only the design discharge for the 100-year flood event is being addressed with the project. This project in effect brings the existing flood control system into conformance with the original intent of the flood control system. I would submit that the project would only provide that benefit originally authorized. Therefore, I would again conclude the permit application is not necessary.
- 3) The intent of SDCL 46-2A-11 has been met as it relates to the current project. The Feasibility Report indicates that the project, within the confines of the original project authorization, reduces flood damage and erosion in the area to be benefited. The project, within the confines of the original authorization and as noted in the Optimization Study, Flood Evaluation Study and attached correspondence from the Corps of Engineers, does not increase the likelihood or the severity of flood damage in adjacent areas. The project, by complying with the original authorization, does not endanger human life or property or impair water rights.

The project does not place material in or restrict the existing channel thereby impacting upstream water profiles. The weir elevation on the diversion channel will remain unchanged. The number and size of the flood control gates will remain unaffected. As the attached letter from the Corps of Engineers and previous transmittals indicate, the project will address a raise in the levees or floodwall structures above and/or to the landward side of the existing channels. The project will increase the height of spillway structure, improve the structural stability of the spillway structure and stilling basin, and complete identified system maintenance and protection features (sealing of spillway joints, rip rap protection in vulnerable areas, etc.). These items all fall within the original authorization of the flood control system.

I would ask that you review this request in light of the intent of SDCL 46-2A. I would like to meet with you to discuss any issues or concerns you may have. Thank you for your consideration.

Sincerely,



Ken Swedeen
City Engineer-City of Sioux Falls

Cc: Lyle Johnson, Public Works Director
Rod Liesinger, Assistant Engineer-Project Development (PW/E)
Project File
Attachments



DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, OMAHA DISTRICT
106 SOUTH 15TH STREET
OMAHA, NEBRASKA 68102-1618
OFFICIAL BUSINESS

RECEIVED
JUN 27 2001
ENGINEER'S OFFICE

June 20, 2001

Hydrologic Engineering Branch

Mr. Rodney A. Liesinger, P. E.
Assistant Engineer -- Design
City of Sioux Falls
224 West Ninth Street
Sioux Falls, South Dakota 57104-6407

Dear Mr. Liesinger:

We are transmitting collected data for your use in the Floodplain Permit application process for the City of Sioux Falls and the Big Sioux River Flood Protection project. This data and the following supporting documentation use the same phase designation as the overall project. Enclosure 1 shows project Phase IA, IB, II, and III. As you are aware, each phase is at a different point in the design/construction process and thus the design data available for each phase is also at a different point in the process. The design of Phases IA and IB is complete, the design of Phase II has just begun, and Phase III is still in the Feasibility stage.

Phase IA consists of raising the chute walls, the stilling basin walls, and the approach walls by varying amounts ranging from 2.5 to 10 feet. The project also includes adding counterforts, raising the backfill behind the chute walls, and modifying the slab drainage system. Neither the invert profile nor width of the chute is affected by this work and therefore this project has no impact to the water surface profile. Plan and profile sheets for the chute work in Phase IA are included for your use as Enclosure 2. The rest of the work is on the landside of the chute and has no impact on the water surface profile.

Phase IB will realign a portion of the existing right bank levee immediately downstream of the chute by setting it back approximately 100 feet. A portion of the levee will be raised and additional riprap protection will be added. Enclosure 3 is a plan view of the general work under this contract. A "bottleneck" in the channel that previously restricted flows will be removed by the realignment creating a smoother curve with a wider bottom width in the channel. This realignment actually reduces the water surface for a given discharge upstream from the chute to the falls as can be seen in Enclosure 4. Pre- and post-project HEC-RAS models were used to compute the water surface profiles in the design. These models are available on request. Also

enclosed are typical sections for work on the levee. The typical sections show the realignment and additional fill on the levee. Similar to Phase IA, the work is outside the channel proper and therefore the additional fill on the levee has no impact to the water surface in the channel.

Final design on Phase II has just begun and final design on Phase III is still several months away. Most of the information available for Phases II and III is presented in the November 1993 Feasibility Report for Local Flood Protection Big Sioux River and Skunk Creek and the March 2000 Sioux Falls Flood Control Project Design Optimization Study.

Phase II consists of a combination of raising the levees and adding flood walls. The levee heights will be raised approximately 4 feet along Skunk Creek and approximately 3.5 feet along a portion of the Big Sioux River. Work may also include modifications to the Marion Road Bridge and the 41st Street Bridge. HEC-RAS models will be constructed with new survey data to calculate pre- and post-project conditions. However, these models are still several months away from completion.

Phase II levee raises will be constructed up and landward from the levee following the same construction pattern as Phase IB. Typical sections for the levee raise are included as Enclosure 5. This type of modification to the levees will not reduce the conveyance capacity of the existing system and will not impact water surfaces confined to the existing levee system.

Phase II presents a very complex situation. The design discharge has increased since the original project construction and is reflected in the Feasibility Study and the Optimization Study. The current project was authorized based on the inability of the existing levee system to provide protection from the revised design discharge. The proposed modifications to the existing levee system will subsequently increase the water surface upstream under those flow conditions that would have previously overtopped the existing levees. Modifications to the bridges will increase conveyance capacity and likely help reduce upstream water surfaces. The alignment of the left bank levee near Marion Road has not been finalized. A complete analysis of upstream impacts cannot be completed until this alignment is finalized as well as roughness values, encroachment location, and other variables used in the models to determine water surface elevations.

The Feasibility Study computed an increased water surface of approximately 2 feet near Marion Road gradually decreasing to no increase approximately 1.5 miles upstream of Marion Road. The Optimization Study indicated less than 0.1 feet increase in the water surface elevation for the with project conditions upstream of Marion Road and slightly greater increases downstream of Marion Road. The Optimization Study provides the most recent HEC-2 models

and analysis. These HEC-2 models are available. New HEC-RAS models will be prepared using new survey data in the design process.

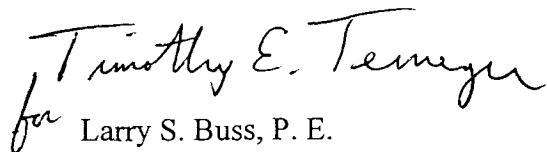
Phase III consists of raising the levees along the diversion channel approximately 2.2 feet and modifying the diversion dam. The levees will be modified to provide protection similar to Phase II. The Optimization Study indicated no increase in the water surface elevation for the with project conditions upstream of Interstate 90 for the 100-year frequency event. Again, flows that will remain in the existing channel will not be impacted by the new project. The with-project and existing conditions HEC-2 models used in the Optimization Study are available.

The Feasibility Study addressed numerous conditions that included flow and no-flow through the diversion dam, flow and no-flow over the fuseplug spillway, and debris blockage of the bridges. There are no plans to raise the fuseplug spillway elevation and previous studies did not include any fuseplug elevation raise alternatives. The design function of the fuseplug will limit or possibly eliminate upstream water surface impacts. However, the fuseplug will be analyzed in more detail in the Phase III design and some modifications are possible. Flows that would have previously overtopped the levees that will now be confined may increase the upstream water surfaces under those events depending on the function of the fuseplug spillway.

The Feasibility Study does indicate a slight increase in the water surface for the with project conditions upstream from the diversion dam. The most recent models remain the ones used in the Optimization Study and indicate no adverse upstream impacts with the project. New HEC-RAS models will be constructed with new survey data to calculate pre- and post-project conditions. Enclosure 6 is the rating curves for the headwater and tailwater at the diversion dam as requested in our June 7 meeting.

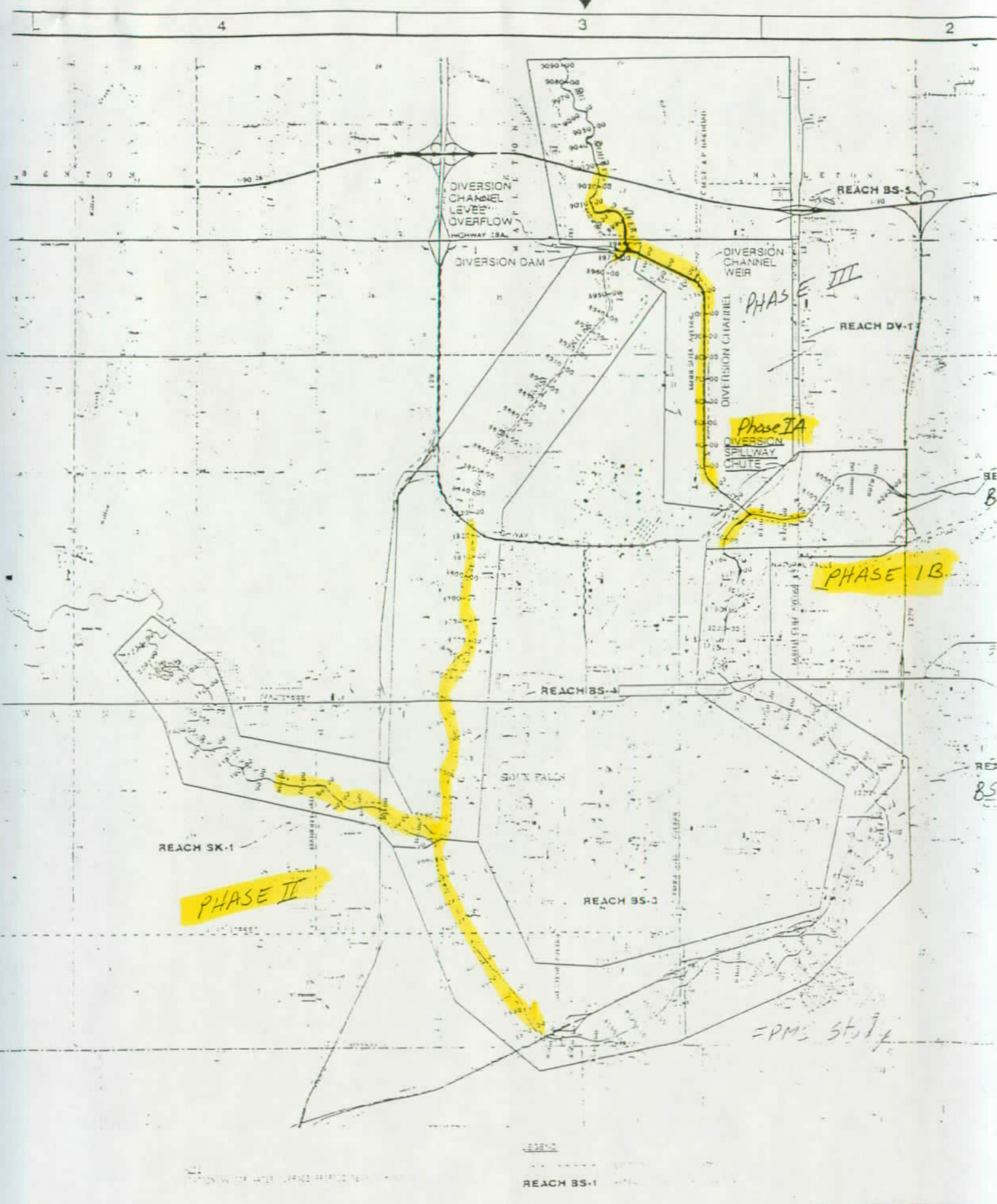
If you have any questions please contact Kevin Adams at (402) 221-4120. He is also available to meet with you or floodplain permitting personnel to discuss these issues.

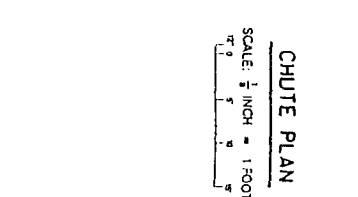
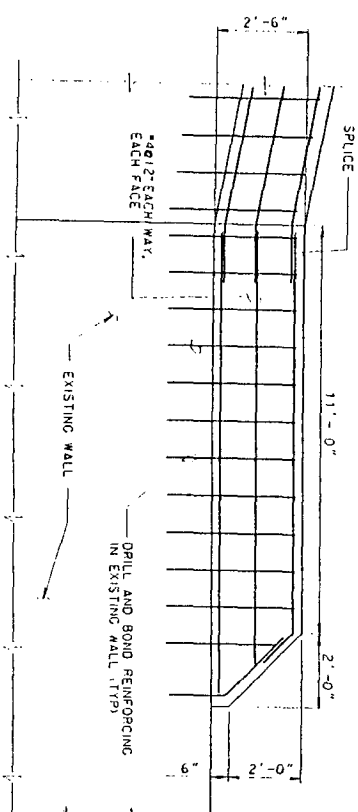
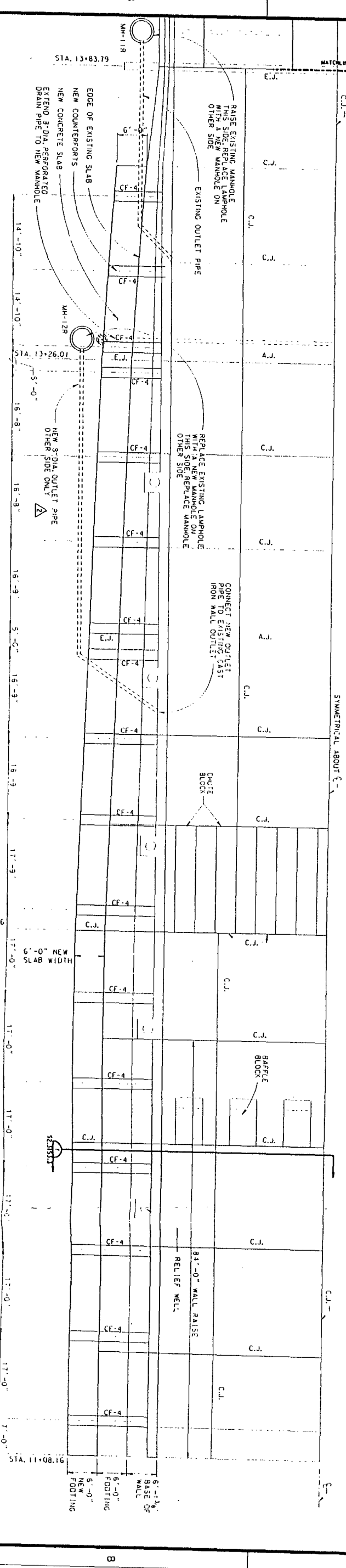
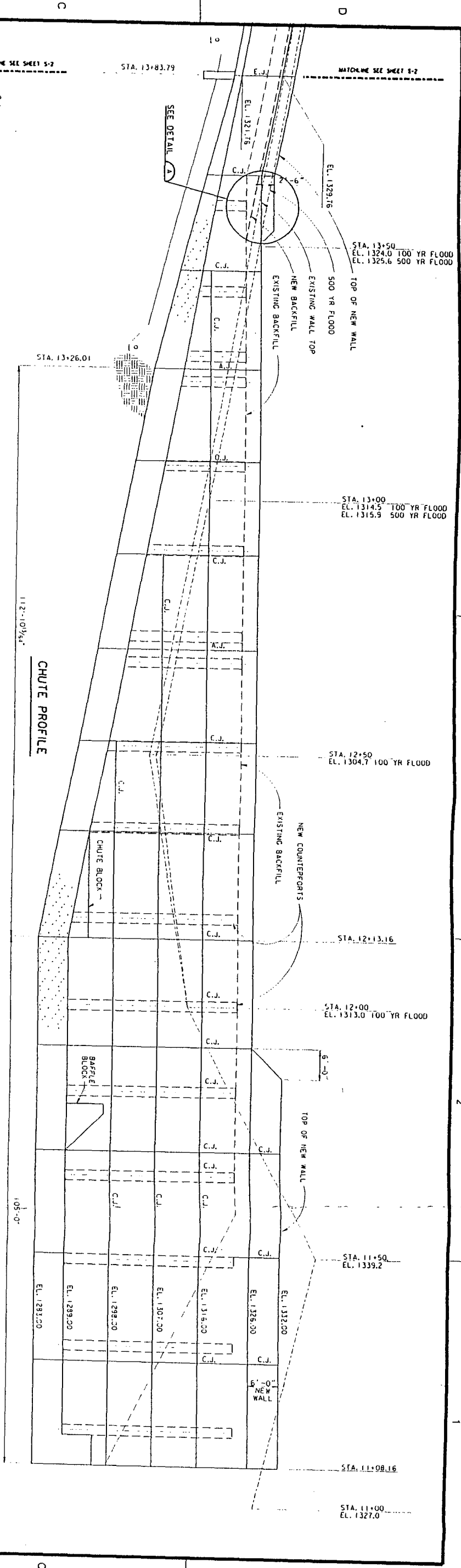
Sincerely,

 Timothy E. Temeyer

for Larry S. Buss, P. E.
Chief, Hydrologic Engineering Branch
Engineering Division

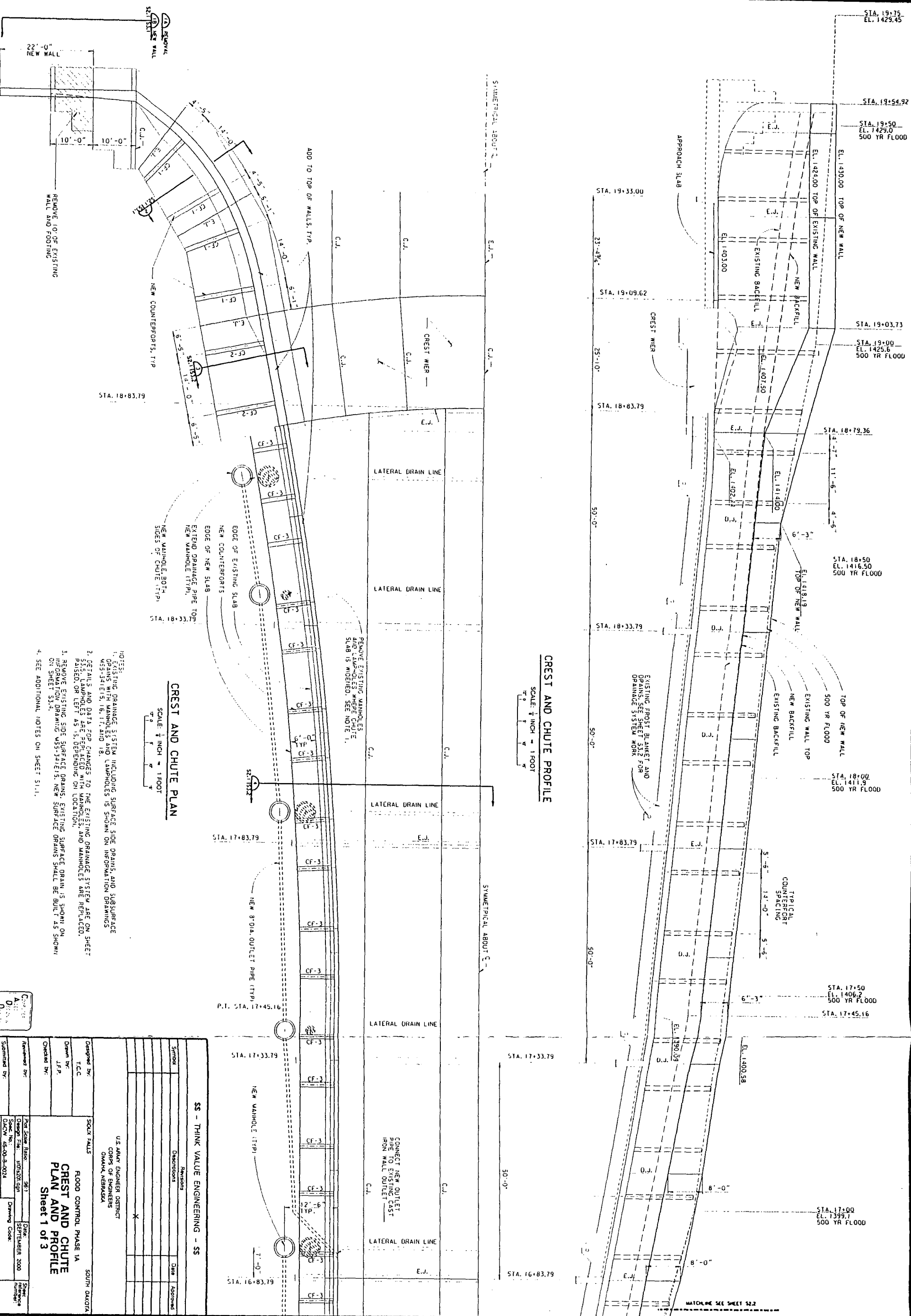
Enclosures





NOTES:
1. SEE NOTES ON SHEET S2.1.
2. NOTES ON SHEET S2.1.
3. NOTES ON SHEET S2.1.

SS - THINK VALUE ENGINEERING - SS			
Symbol	Dimensions	Date	Approved
Δ	REVISION IN ACCORDANCE WITH AM #0002	10-2-00	
U.S. ARMY ENGINEER DISTRICT OMAHA, NEBRASKA			
SOUTH DAKOTA			
FLOOD CONTROL PHASE 1A STILLING BASIN PLAN & PROFILE Sheet 3 of 3			
Designed by:	TCC	SOX FALLS	
Drawn by:	JATTC		
Checked by:			
Reviewed by:			
Design No.:	45-00-B-0024	Design Date:	SEPTEMBER 2000
Submitted by:		Drawing Code:	MB51 - 220E18
Chief Structural Section:		Sheet Number:	S2.3



CREST AND CHUTE PROFILE

SCALE: $\frac{1}{8}$ INCH = 1 FOOT

SOME THINGS ABOUT

SYMMETRICAL ABOUT $\xi = 0$.

CREST AND CHUTE PLAN

SCALE: $\frac{1}{8}$ INCH = 1 FOOT

1997

1. EXISTING DRAINAGE SYSTEM INCLUDING SURFACE SIDE DRAINS, AND SUBSURFACE DRAINS WITH MANHOLES, AND AMPHOLES IS SHOWN ON INFORMATION DRAWINGS VSS-341E13, 16, 17, AND 18.
 2. DETAILS AND DATA FOR CHANGES TO THE EXISTING DRAINAGE SYSTEM ARE ON SHEET 3341E13.
 3. REMOVE EXISTING SIDE SURFACE DRAINS, EXISTING SURFACE DRAIN IS SHOWN ON SHEET 3341E13.
 4. NEW SURFACE DRAINS SHALL BE BUILT AS SHOWN ON SHEET 3341E13.
- SEE ADDITIONAL NOTES ON SHEET 331.1.

[illegible]

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
OMAHA, NEBRASKA

OX FALLS

SOUTH DAKOTA

FLOOD CONTROL PHASE 1A
CREST AND CHUTE
PLAN AND PROFILE

of 3



Reviewed by:	Part Scale Ratio: 96:1	Date: SEPTEMBER 2000	Sheet reference number:
Design File: 3103201.dgn			
Spec No.: DACW 45-00-B-0074	Drawing Code: MBS1 - 220E16		52.1
Submitted by: Chief, Structural Section	Contract No.: DACW 45-00-C-0002		

HEC-RAS River: big sioux Reach: phase 1b

Reach	River Sta	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
phase 1b	821895	exist clomr	7000.00	1378.00	1389.71		1390.01	0.000850	4.38	1597.55	217.02	0.28
phase 1b	821895	design clomr	7000.00	1378.00	1389.72		1390.02	0.000848	4.38	1599.06	217.14	0.28
phase 1b	821895	exist clomr	15600.00	1378.00	1395.21		1395.67	0.000684	5.44	2868.62	233.00	0.27
phase 1b	821895	design clomr	15600.00	1378.00	1395.21		1395.67	0.000684	5.44	2867.85	233.00	0.27
phase 1b	821895	exist clomr	20800.00	1378.00	1397.69		1398.25	0.000676	6.04	3461.04	391.69	0.28
phase 1b	821895	design clomr	20800.00	1378.00	1397.69		1398.26	0.000676	6.03	3462.39	394.58	0.28
phase 1b	821895	exist clomr	36800.00	1378.00	1401.21		1402.13	0.000923	7.99	7709.10	1812.23	0.33
phase 1b	821895	design clomr	36800.00	1378.00	1401.20		1402.13	0.000924	8.00	7698.71	1810.11	0.33
phase 1b	821845	exist clomr	7000.00	1378.90	1389.50		1389.93	0.000954	5.23	1339.46	160.72	0.32
phase 1b	821845	design clomr	7000.00	1378.90	1389.51		1389.93	0.000951	5.22	1340.65	160.76	0.32
phase 1b	821845	exist clomr	15600.00	1378.90	1394.79		1395.54	0.000995	6.94	2255.11	202.47	0.35
phase 1b	821845	design clomr	15600.00	1378.90	1394.79		1395.54	0.000996	6.94	2254.39	202.35	0.35
phase 1b	821845	exist clomr	20800.00	1378.90	1397.41		1398.16	0.000853	7.16	5066.12	1998.27	0.33
phase 1b	821845	design clomr	20800.00	1378.90	1397.42		1398.16	0.000852	7.16	5075.14	1998.91	0.33
phase 1b	821845	exist clomr	36800.00	1378.90	1401.33		1401.93	0.000668	7.42	13306.33	2125.74	0.30
phase 1b	821845	design clomr	36800.00	1378.90	1401.32		1401.93	0.000669	7.43	13294.14	2125.39	0.30
phase 1b	821475	exist clomr	7000.00	1378.90	1389.06		1389.53	0.001117	5.52	1268.79	158.04	0.34
phase 1b	821475	design clomr	7000.00	1378.90	1389.07		1389.54	0.001113	5.51	1270.18	158.10	0.34
phase 1b	821475	exist clomr	15600.00	1378.90	1394.33		1395.14	0.001120	7.21	2165.50	186.56	0.37
phase 1b	821475	design clomr	15600.00	1378.90	1394.32		1395.13	0.001124	7.21	2163.29	186.15	0.37
phase 1b	821475	exist clomr	20800.00	1378.90	1396.96		1397.81	0.000980	7.54	4234.53	1706.05	0.35
phase 1b	821475	design clomr	20800.00	1378.90	1396.95		1397.80	0.000983	7.55	4218.53	1698.00	0.35
phase 1b	821475	exist clomr	36800.00	1378.90	1401.02		1401.68	0.000739	7.72	12642.04	2120.35	0.32
phase 1b	821475	design clomr	36800.00	1378.90	1401.00		1401.67	0.000742	7.73	12616.93	2120.20	0.32
phase 1b	821427	exist clomr	7000.00	1378.70	1389.11		1389.40	0.000669	4.38	1703.65	263.81	0.27
phase 1b	821427	design clomr	7000.00	1378.70	1389.11		1389.41	0.000667	4.37	1705.97	264.03	0.27
phase 1b	821427	exist clomr	15600.00	1378.70	1394.46		1394.93	0.000623	5.61	3479.93	405.62	0.27
phase 1b	821427	design clomr	15600.00	1378.70	1394.45		1394.92	0.000625	5.62	3475.23	405.15	0.27
phase 1b	821427	exist clomr	20800.00	1378.70	1397.09		1397.61	0.000568	6.00	5680.88	1665.74	0.27
phase 1b	821427	design clomr	20800.00	1378.70	1397.09		1397.60	0.000569	6.01	5666.27	1658.33	0.27
phase 1b	821427	exist clomr	36800.00	1378.70	1401.07		1401.57	0.000526	6.89	14662.64	2607.86	0.27
phase 1b	821427	design clomr	36800.00	1378.70	1401.05		1401.56	0.000528	6.70	14632.41	2606.15	0.27
phase 1b	821426	exist clomr	7000.00	1378.70	1389.06	1384.20	1389.39	0.000995	4.66	1550.32	231.51	0.29
phase 1b	821426	design clomr	7000.00	1378.70	1389.06	1384.20	1389.40	0.000994	4.66	1550.91	231.57	0.29
phase 1b	821426	exist clomr	15600.00	1378.70	1394.38	1386.83	1394.91	0.001038	5.95	3143.04	376.50	0.30
phase 1b	821426	design clomr	15600.00	1378.70	1394.37	1386.83	1394.90	0.001041	5.96	3139.92	376.22	0.30
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phase 1b	821426	design clomr	20800.00	1378.70	1397.01	1388.25	1397.58	0.000915	6.31	4760.33	1411.12	0.29
phase 1b	821426	exist clomr	36800.00	1378.70	1401.05	1391.95	1401.57	0.000784	6.82	13595.37	2581.74	0.27
phase 1b	821426	design clomr	36800.00	1378.70	1401.04	1391.96	1401.56	0.000787	6.83	13563.86	2580.74	0.28
phase 1b	821414	Bridge										
phase 1b	821404	exist clomr	7000.00	1378.70	1388.99		1389.33	0.001019	4.70	1535.45	229.88	0.29
phase 1b	821404	design clomr	7000.00	1378.70	1388.99		1389.33	0.001021	4.70	1534.49	229.78	0.29
phase 1b	821404	exist clomr	15600.00	1378.70	1393.52		1394.15	0.001259	6.44	2835.77	343.94	0.33
phase 1b	821404	design clomr	15600.00	1378.70	1393.52		1394.14	0.001260	6.45	2834.59	343.85	0.33
phase 1b	821404	exist clomr	20800.00	1378.70	1395.71		1396.44	0.001288	7.07	3671.18	421.68	0.34
phase 1b	821404	design clomr	20800.00	1378.70	1395.70		1396.43	0.001292	7.07	3666.51	419.99	0.34
phase 1b	821404	exist clomr	36800.00	1378.70	1400.63		1401.23	0.000907	7.22	12516.91	2547.30	0.29
phase 1b	821404	design clomr	36800.00	1378.70	1400.62		1401.23	0.000908	7.23	12509.44	2547.06	0.29
phase 1b	821403	exist clomr	7000.00	1378.70	1389.01		1389.31	0.000694	4.43	1678.87	261.44	0.27
phase 1b	821403	design clomr	7000.00	1378.70	1389.01		1389.31	0.000695	4.43	1677.79	261.33	0.27
phase 1b	821403	exist clomr	15600.00	1378.70	1393.56		1394.11	0.000793	6.08	3130.22	378.03	0.31
phase 1b	821403	design clomr	15600.00	1378.70	1393.56		1394.11	0.000795	6.08	3127.01	375.82	0.31
phase 1b	821403	exist clomr	20800.00	1378.70	1395.74		1396.40	0.000796	6.72	4146.01	775.00	0.31
phase 1b	821403	design clomr	20800.00	1378.70	1395.73		1396.39	0.000798	6.73	4137.42	771.07	0.31
phase 1b	821403	exist clomr	36800.00	1378.70	1400.64		1401.21	0.000599	7.03	13565.09	2552.24	0.28
phase 1b	821403	design clomr	36800.00	1378.70	1400.64		1401.21	0.000599	7.03	13557.61	2551.85	0.28
phase 1b	821353	exist clomr	7000.00	1378.90	1388.68		1389.20	0.001285	5.79	1209.38	155.76	0.37
phase 1b	821353	design clomr	7000.00	1378.90	1388.68		1389.20	0.001287	5.79	1208.66	155.73	0.37
phase 1b	821353	exist clomr	15600.00	1378.90	1392.86		1393.90	0.001650	8.20	1903.47	174.58	0.44
phase 1b	821353	design clomr	15600.00	1378.90	1392.86		1393.90	0.001651	8.20	1903.17	174.58	0.44
phase 1b	821353	exist clomr	20800.00	1378.90	1394.81		1396.13	0.001763	9.24	2257.93	202.95	0.46
phase 1b	821353	design clomr	20800.00	1378.90	1394.80		1396.13	0.001765	9.25	2257.09	202.81	0.46
phase 1b	821353	exist clomr	36800.00	1378.90	1400.29		1401.10	0.000919	8.38	11950.52	2514.41	0.35
phase 1b	821353	design clomr	36800.00	1378.90	1400.28		1401.10	0.000920	8.38	11941.31	2514.40	0.35
phase 1b	820953	exist clomr	7000.00	1378.90	1387.94		1388.57	0.001719	6.39	1095.15	151.26	0.42
phase 1b	820953	design clomr	7000.00	1378.90	1387.94		1388.57	0.001720	6.39	1095.13	151.26	0.42
phase 1b	820953	exist clomr	15600.00	1378.90	1391.79		1393.07	0.002240	9.08	1718.64	170.36	0.50
phase 1b	820953	design clomr	15600.00	1378.90	1391.79		1393.07	0.002242	9.08	1718.18	170.35	0.50
phase 1b	820953	exist clomr	20800.00	1378.90	1393.60		1395.23	0.002408	10.23	2033.87	177.50	0.53

ENCLOSURE 4

HFC-BAS River: big Sioux Reach: phase 1b (Continued)

Reach	River Sta	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
phase 1b	820953	design clomr	20800.00	1378.90	1393.60		1395.22	0.002412	10.23	2032.70	177.48	0.53
phase 1b	820953	exist clomr	36800.00	1378.90	1399.70	1393.10	1400.72	0.001144	9.14	10482.18	2513.31	0.39
phase 1b	820953	design clomr	36800.00	1378.90	1399.70	1393.09	1400.72	0.001147	9.15	10466.82	2513.30	0.39
phase 1b	820593	exist clomr	7000.00	1378.90	1386.86		1387.73	0.002734	7.48	936.12	144.78	0.52
phase 1b	820593	design clomr	7000.00	1378.90	1386.86		1387.73	0.002735	7.48	936.09	144.78	0.52
phase 1b	820593	exist clomr	15600.00	1378.90	1389.86		1391.79	0.004189	11.17	1396.85	162.74	0.67
phase 1b	820593	design clomr	15600.00	1378.90	1389.85		1391.79	0.004203	11.18	1395.34	162.71	0.67
phase 1b	820593	exist clomr	20800.00	1378.90	1391.15		1393.74	0.004849	12.92	1609.76	167.82	0.74
phase 1b	820593	design clomr	20800.00	1378.90	1391.14		1393.73	0.004863	12.93	1608.23	167.78	0.74
phase 1b	820593	exist clomr	36800.00	1378.90	1395.28	1393.10	1399.13	0.004909	15.75	2382.37	393.21	0.77
phase 1b	820593	design clomr	36800.00	1378.90	1395.27	1393.09	1399.13	0.004916	15.76	2379.94	387.88	0.77
phase 1b	820545	exist clomr	7000.00	1373.50	1387.14		1387.36	0.000492	3.74	1870.15	229.00	0.23
phase 1b	820545	design clomr	7000.00	1373.50	1387.14		1387.36	0.000493	3.74	1870.09	229.00	0.23
phase 1b	820545	exist clomr	15600.00	1373.50	1390.47		1391.01	0.000812	5.92	2632.93	229.00	0.31
phase 1b	820545	design clomr	15600.00	1373.50	1390.47		1391.01	0.000812	5.93	2632.80	229.00	0.31
phase 1b	820545	exist clomr	20800.00	1373.50	1391.97		1392.73	0.000974	6.99	2976.57	229.00	0.34
phase 1b	820545	design clomr	20800.00	1373.50	1391.96		1392.72	0.000975	6.99	2974.89	229.00	0.34
phase 1b	820545	exist clomr	36800.00	1373.50	1396.56		1397.65	0.001005	8.64	6966.27	2258.95	0.36
phase 1b	820545	design clomr	36800.00	1373.50	1396.55		1397.65	0.001007	8.64	6954.42	2257.68	0.36
phase 1b	820544	exist clomr	7000.00	1373.50	1387.12	1380.95	1387.35	0.000715	3.87	1808.31	223.00	0.24
phase 1b	820544	design clomr	7000.00	1373.50	1387.12	1380.96	1387.35	0.000715	3.87	1808.25	223.00	0.24
phase 1b	820544	exist clomr	15600.00	1373.50	1390.42	1384.24	1391.00	0.001279	6.13	2544.19	223.00	0.32
phase 1b	820544	design clomr	15600.00	1373.50	1390.42	1384.26	1391.00	0.001279	6.13	2543.86	223.00	0.32
phase 1b	820544	exist clomr	20800.00	1373.50	1391.90	1385.44	1392.71	0.001591	7.24	2874.01	223.00	0.36
phase 1b	820544	design clomr	20800.00	1373.50	1391.89	1385.46	1392.70	0.001593	7.24	2872.40	223.00	0.36
phase 1b	820544	exist clomr	36800.00	1373.50	1396.55	1388.41	1397.65	0.001594	8.71	6866.13	2257.91	0.37
phase 1b	820544	design clomr	36800.00	1373.50	1396.55	1388.41	1397.65	0.001597	8.71	6853.45	2256.55	0.37
phase 1b	820517	Bridge										
phase 1b	820492	exist clomr	7000.00	1373.50	1387.08		1387.31	0.000725	3.89	1799.40	223.00	0.24
phase 1b	820492	design clomr	7000.00	1373.50	1387.08		1387.31	0.000725	3.89	1799.43	223.00	0.24
phase 1b	820492	exist clomr	15600.00	1373.50	1390.34		1390.93	0.001305	6.17	2526.90	223.00	0.32
phase 1b	820492	design clomr	15600.00	1373.50	1390.34		1390.93	0.001305	6.17	2526.58	223.00	0.32
phase 1b	820492	exist clomr	20800.00	1373.50	1391.80		1392.62	0.001627	7.29	2851.63	223.00	0.36
phase 1b	820492	design clomr	20800.00	1373.50	1391.79		1392.62	0.001630	7.30	2850.00	223.00	0.36
phase 1b	820492	exist clomr	36800.00	1373.50	1395.43		1396.86	0.002173	9.72	4868.12	1272.55	0.43
phase 1b	820492	design clomr	36800.00	1373.50	1395.42		1396.85	0.002181	9.73	4848.94	1262.43	0.43
phase 1b	820491	exist clomr	7000.00	1373.50	1387.09		1387.31	0.000502	3.77	1858.72	229.00	0.23
phase 1b	820491	design clomr	7000.00	1373.50	1387.08		1387.30	0.000503	3.77	1857.93	229.00	0.23
phase 1b	820491	exist clomr	15600.00	1373.50	1390.36		1390.91	0.000837	5.98	2607.33	229.00	0.31
phase 1b	820491	design clomr	15600.00	1373.50	1390.36		1390.91	0.000838	5.98	2606.99	229.00	0.31
phase 1b	820491	exist clomr	20800.00	1373.50	1391.81		1392.59	0.001013	7.07	2940.48	229.00	0.35
phase 1b	820491	design clomr	20800.00	1373.50	1391.81		1392.59	0.001013	7.07	2940.68	229.00	0.35
phase 1b	820491	exist clomr	36800.00	1373.50	1395.45		1396.83	0.001336	9.53	4978.27	1282.82	0.41
phase 1b	820491	design clomr	36800.00	1373.50	1395.44		1396.82	0.001339	9.54	4968.12	1277.52	0.41
phase 1b	820441	exist clomr	7000.00	1379.40	1386.65		1387.17	0.001862	5.82	1202.39	207.98	0.43
phase 1b	820441	design clomr	7000.00	1379.40	1386.64		1387.17	0.001866	5.83	1201.51	207.96	0.43
phase 1b	820441	exist clomr	15600.00	1379.40	1389.55		1390.67	0.002527	8.52	1830.65	226.25	0.53
phase 1b	820441	design clomr	15600.00	1379.40	1389.54		1390.67	0.002528	8.53	1830.24	226.23	0.53
phase 1b	820441	exist clomr	20800.00	1379.40	1390.79		1392.29	0.002850	9.85	2144.85	301.89	0.57
phase 1b	820441	design clomr	20800.00	1379.40	1390.79		1392.29	0.002849	9.85	2145.21	301.93	0.57
phase 1b	820441	exist clomr	36800.00	1379.40	1394.87	1390.93	1396.62	0.002388	11.05	5298.88	1400.92	0.55
phase 1b	820441	design clomr	36800.00	1379.40	1394.87	1390.94	1396.62	0.002387	11.05	5300.25	1401.86	0.55
phase 1b	820316	exist clomr	7000.00	1379.40	1386.30		1386.89	0.002265	6.20	1129.78	206.40	0.47
phase 1b	820316	design clomr	7000.00	1379.40	1386.30		1386.89	0.002265	6.20	1129.81	206.40	0.47
phase 1b	820316	exist clomr	15600.00	1379.40	1388.95		1390.26	0.003210	9.19	1697.49	222.24	0.59
phase 1b	820316	design clomr	15600.00	1379.40	1388.95		1390.26	0.003213	9.19	1696.89	222.22	0.59
phase 1b	820316	exist clomr	20800.00	1379.40	1389.99		1391.79	0.003795	10.78	1931.23	229.24	0.65
phase 1b	820316	design clomr	20800.00	1379.40	1389.99		1391.79	0.003793	10.78	1931.60	229.25	0.65
phase 1b	820316	exist clomr	36800.00	1379.40	1391.95	1390.94	1395.60	0.006060	15.40	2555.47	439.12	0.85
phase 1b	820316	design clomr	36800.00	1379.40	1391.94	1390.94	1395.60	0.006071	15.41	2552.95	437.98	0.85
phase 1b	819762	exist clomr	7000.00	1379.40	1385.46		1385.73	0.001470	4.25	1839.70	443.01	0.36
phase 1b	819762	design clomr	7000.00	1379.40	1385.46		1385.73	0.001470	4.25	1839.81	443.02	0.36
phase 1b	819762	exist clomr	15600.00	1379.40	1388.15		1388.63	0.001589	5.65	3479.78	1068.15	0.40
phase 1b	819762	design clomr	15600.00	1379.40	1388.15		1388.63	0.001587	5.65	3481.99	1068.52	0.40
phase 1b	819762	exist clomr	20800.00	1379.40	1389.32		1389.83	0.001508	6.02	4914.28	1407.21	0.41
phase 1b	819762	design clomr	20800.00	1379.40	1389.33		1389.84	0.001597	6.01	4931.32	1412.60	0.41
phase 1b	819762	exist clomr	36800.00	1379.40	1392.18		1392.72	0.001267	6.50	10185.76	2077.15	0.38
phase 1b	819762	design clomr	36800.00	1379.40	1392.18		1392.71	0.001271	6.51	10169.02	2076.29	0.38
phase 1b	819312	exist clomr	7000.00	1379.40	1383.83		1384.50	0.004782	6.67	1171.52	362.80	0.63

HEC-RAS River: big Sioux Reach: phase 1b (Continued)

Reach	River Sta	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
phase 1b	819312	design clomr	7000.00	1379.40	1383.84		1384.50	0.004776	6.66	1172.23	363.00	0.63
phase 1b	819312	exist clomr	15600.00	1379.40	1384.80	1384.80	1386.66	0.011748	11.21	1554.44	418.15	1.01
phase 1b	819312	design clomr	15600.00	1379.40	1384.79	1384.79	1386.66	0.011784	11.22	1552.75	418.01	1.01
phase 1b	819312	exist clomr	20800.00	1379.40	1385.67	1385.67	1387.80	0.011322	12.03	1931.50	451.22	1.02
phase 1b	819312	design clomr	20800.00	1379.40	1385.65	1385.65	1387.80	0.011424	12.07	1925.34	450.67	1.02
phase 1b	819312	exist clomr	36800.00	1379.40	1387.56	1387.56	1390.64	0.011505	14.50	2919.75	762.06	1.07
phase 1b	819312	design clomr	36800.00	1379.40	1387.56	1387.56	1390.64	0.011463	14.48	2925.06	764.41	1.07
phase 1b	819262	exist clomr	7000.00	1379.10	1383.20	1383.20	1384.04	0.015821	7.41	977.79	595.64	1.02
phase 1b	819262	design clomr	7000.00	1379.10	1383.20	1383.20	1384.05	0.015880	7.41	976.70	595.63	1.02
phase 1b	819262	exist clomr	15600.00	1379.10	1384.39	1384.39	1385.80	0.012952	9.61	1684.78	600.74	1.01
phase 1b	819262	design clomr	15600.00	1379.10	1384.38	1384.38	1385.80	0.012993	9.62	1683.17	600.73	1.01
phase 1b	819262	exist clomr	20800.00	1379.10	1384.96	1384.96	1386.70	0.012438	10.64	2030.16	603.21	1.02
phase 1b	819262	design clomr	20800.00	1379.10	1384.97	1384.97	1386.70	0.012326	10.61	2035.75	603.25	1.01
phase 1b	819262	exist clomr	36800.00	1379.10	1386.56	1386.56	1389.07	0.010740	12.78	3003.03	610.13	1.01
phase 1b	819262	design clomr	36800.00	1379.10	1386.57	1386.57	1389.07	0.010686	12.76	3007.65	610.16	1.01
phase 1b	818957	exist clomr	7000.00	1365.80	1371.32	1371.32	1372.80	0.012587	9.90	773.07	279.86	1.00
phase 1b	818957	design clomr	7000.00	1365.80	1371.32	1371.32	1372.80	0.012670	9.92	771.43	279.77	1.00
phase 1b	818957	exist clomr	15600.00	1365.80	1373.51	1373.51	1375.85	0.009827	12.57	1477.34	357.00	0.97
phase 1b	818957	design clomr	15600.00	1365.80	1373.51	1373.51	1375.85	0.009839	12.57	1476.73	356.93	0.97
phase 1b	818957	exist clomr	20800.00	1365.80	1374.35	1374.35	1377.31	0.010353	14.24	1789.79	389.32	1.02
phase 1b	818957	design clomr	20800.00	1365.80	1374.35	1374.35	1377.31	0.010310	14.22	1792.60	389.57	1.02
phase 1b	818957	exist clomr	36800.00	1365.80	1377.42	1377.42	1381.06	0.007635	16.07	3145.61	483.66	0.94
phase 1b	818957	design clomr	36800.00	1365.80	1377.43	1377.43	1381.06	0.007599	16.05	3151.22	483.72	0.94
phase 1b	818877	exist clomr	7000.00	1363.00	1369.51		1369.96	0.002209	5.35	1309.45	296.63	0.45
phase 1b	818877	design clomr	7000.00	1363.00	1369.52		1369.96	0.002199	5.34	1311.41	296.70	0.45
phase 1b	818877	exist clomr	15600.00	1363.00	1372.49		1373.21	0.002276	6.82	2287.65	365.62	0.48
phase 1b	818877	design clomr	15600.00	1363.00	1372.48		1373.20	0.002286	6.83	2284.21	365.53	0.48
phase 1b	818877	exist clomr	20800.00	1363.00	1373.91		1374.75	0.002228	7.38	2819.14	391.79	0.48
phase 1b	818877	design clomr	20800.00	1363.00	1373.83		1374.69	0.002274	7.46	2788.71	387.18	0.49
phase 1b	818877	exist clomr	36800.00	1363.00	1377.41		1378.44	0.002224	8.16	4512.27	538.05	0.50
phase 1b	818877	design clomr	36800.00	1363.00	1377.41		1378.44	0.002225	8.16	4512.14	538.05	0.50
phase 1b	818827	exist clomr	7000.00	1363.00	1369.35		1369.83	0.002486	5.55	1260.86	294.87	0.47
phase 1b	818827	design clomr	7000.00	1363.00	1369.36		1369.83	0.002472	5.54	1263.13	294.96	0.47
phase 1b	818827	exist clomr	15600.00	1363.00	1372.30		1373.07	0.002491	7.02	2221.35	363.86	0.50
phase 1b	818827	design clomr	15600.00	1363.00	1372.30		1373.07	0.002493	7.02	2220.73	363.84	0.50
phase 1b	818827	exist clomr	20800.00	1363.00	1373.73		1374.62	0.002349	7.56	2751.20	383.62	0.50
phase 1b	818827	design clomr	20800.00	1363.00	1373.66		1374.56	0.002414	7.64	2722.43	381.54	0.50
phase 1b	818827	exist clomr	36800.00	1363.00	1377.24		1378.32	0.002369	8.32	4420.63	534.06	0.51
phase 1b	818827	design clomr	36800.00	1363.00	1377.24		1378.32	0.002369	8.32	4420.56	534.06	0.51
phase 1b	818826	exist clomr	7000.00	1363.00	1368.93		1369.73	0.005785	7.17	976.62	253.00	0.64
phase 1b	818826	design clomr	7000.00	1363.00	1368.94		1369.73	0.005734	7.15	979.62	253.14	0.64
phase 1b	818826	exist clomr	15600.00	1363.00	1371.64		1372.91	0.006283	9.07	1720.39	316.23	0.69
phase 1b	818826	design clomr	15600.00	1363.00	1371.63		1372.91	0.006293	9.07	1719.42	316.21	0.69
phase 1b	818826	exist clomr	20800.00	1363.00	1373.01		1374.45	0.005735	9.63	2160.70	324.90	0.66
phase 1b	818826	design clomr	20800.00	1363.00	1372.89		1374.38	0.006044	9.80	2121.95	324.15	0.68
phase 1b	818826	exist clomr	36800.00	1363.00	1376.36		1378.11	0.006098	10.63	3463.36	461.44	0.68
phase 1b	818826	design clomr	36800.00	1363.00	1376.36		1378.11	0.006099	10.63	3463.19	461.43	0.68
phase 1b	818806	exist clomr	7000.00	1363.00	1367.75	1367.75	1369.33	0.014651	10.09	694.00	222.52	1.01
phase 1b	818806	design clomr	7000.00	1363.00	1367.75	1367.75	1369.33	0.014605	10.07	694.81	222.63	1.00
phase 1b	818806	exist clomr	15600.00	1363.00	1370.02	1370.02	1372.40	0.013719	12.38	1259.65	266.39	1.00
phase 1b	818806	design clomr	15600.00	1363.00	1370.02	1370.02	1372.40	0.013747	12.39	1258.77	266.35	1.00
phase 1b	818806	exist clomr	20800.00	1363.00	1371.11	1371.11	1373.88	0.013283	13.35	1558.06	279.83	1.00
phase 1b	818806	design clomr	20800.00	1363.00	1371.28	1371.28	1373.88	0.013688	12.94	1607.52	314.44	1.01
phase 1b	818806	exist clomr	36800.00	1363.00	1373.80	1373.80	1377.39	0.013209	15.20	2421.79	337.28	1.00
phase 1b	818806	design clomr	36800.00	1363.00	1373.80	1373.80	1377.39	0.013206	15.19	2422.03	337.32	1.00
phase 1b	818805	exist clomr	7000.00	1363.00	1367.34	1367.34	1368.84	0.012707	9.84	711.29	239.83	1.01
phase 1b	818805	design clomr	7000.00	1363.00	1367.34	1367.34	1368.84	0.012645	9.82	712.55	240.01	1.00
phase 1b	818805	exist clomr	15600.00	1363.00	1369.48	1369.48	1371.72	0.011201	11.99	1300.77	296.31	1.01
phase 1b	818805	design clomr	15600.00	1363.00	1369.49	1369.49	1371.72	0.011108	11.96	1304.28	296.44	1.00
phase 1b	818805	exist clomr	20800.00	1363.00	1370.46	1370.46	1373.10	0.010596	13.05	1594.10	306.69	1.01
phase 1b	818805	design clomr	20800.00	1363.00	1370.46	1370.46	1373.10	0.010544	13.03	1596.64	306.78	1.01
phase 1b	818805	exist clomr	36800.00	1363.00	1373.05	1373.05	1376.43	0.009682	14.74	2496.97	371.13	1.00
phase 1b	818805	design clomr	36800.00	1363.00	1373.05	1373.05	1376.43	0.009690	14.74	2496.29	371.11	1.00
phase 1b	818595	exist clomr	7000.00	1353.00	1357.43	1357.43	1358.95	0.012182	9.92	716.65	248.70	0.99
phase 1b	818595	design clomr	7000.00	1353.00	1357.42	1357.42	1358.95	0.012308	9.96	714.29	248.52	1.00
phase 1b	818595	exist clomr	15600.00	1353.00	1359.63	1359.63	1362.13	0.009879	12.78	1315.33	298.92	0.98
phase 1b	818595	design clomr	15600.00	1353.00	1359.63	1359.63	1362.13	0.009879	12.78	1315.33	298.92	0.98
phase 1b	818595	exist clomr	20800.00	1353.00	1360.79	1360.79	1363.70	0.008884	13.84	1690.49	340.24	0.96
phase 1b	818595	design clomr	20800.00	1353.00	1360.79	1360.79	1363.70	0.008896	13.84	1689.62	340.22	0.96
phase 1b	818595	exist clomr	36800.00	1353.00	1363.37	1363.37	1367.66	0.008613	17.03	2641.88	406.43	1.00
phase 1b	818595	design clomr	36800.00	1353.00	1363.37	1363.37	1367.66	0.008597	17.02	2643.77	406.57	1.00

HEC-RAS River: big Sioux Reach: phase 1b (Continued)

Reach	River Sta	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
phase 1b	818265	exist clomr	7000.00	1323.50	1331.00	1331.00	1333.45	0.010989	12.57	556.75	114.44	1.00
phase 1b	818265	design clomr	7000.00	1323.50	1331.00	1331.00	1333.45	0.010982	12.57	556.89	114.46	1.00
phase 1b	818265	exist clomr	15600.00	1323.50	1334.72	1334.72	1337.96	0.008227	14.60	1212.58	235.57	0.94
phase 1b	818265	design clomr	15600.00	1323.50	1334.72	1334.72	1337.96	0.008237	14.60	1211.95	235.56	0.94
phase 1b	818265	exist clomr	20800.00	1323.50	1336.17	1336.17	1339.96	0.008005	15.94	1557.29	239.66	0.95
phase 1b	818265	design clomr	20800.00	1323.50	1336.18	1336.18	1339.96	0.007980	15.93	1559.25	239.69	0.94
phase 1b	818265	exist clomr	36800.00	1323.50	1339.89	1339.89	1344.91	0.007431	18.76	2539.85	289.89	0.96
phase 1b	818265	design clomr	36800.00	1323.50	1339.88	1339.88	1344.91	0.007459	18.79	2535.96	289.68	0.96
phase 1b	817805	exist clomr	7000.00	1313.70	1322.05	1322.05	1325.35	0.010498	14.57	480.31	73.11	1.00
phase 1b	817805	design clomr	7000.00	1313.70	1322.04	1322.04	1325.35	0.010526	14.59	479.87	73.09	1.00
phase 1b	817805	exist clomr	15600.00	1313.70	1326.90	1326.90	1331.83	0.009370	17.82	879.40	105.93	1.00
phase 1b	817805	design clomr	15600.00	1313.70	1326.91	1326.91	1331.83	0.009334	17.80	880.69	106.36	1.00
phase 1b	817805	exist clomr	20800.00	1313.70	1330.00	1330.00	1334.58	0.006788	17.44	1462.87	258.42	0.88
phase 1b	817805	design clomr	20800.00	1313.70	1330.00	1330.00	1334.58	0.006777	17.43	1464.36	258.56	0.88
phase 1b	817805	exist clomr	36800.00	1313.70	1335.30	1335.30	1340.03	0.005219	18.76	3304.22	480.95	0.81
phase 1b	817805	design clomr	36800.00	1313.70	1335.28	1335.28	1340.03	0.005252	18.80	3292.60	480.39	0.81
phase 1b	817190	exist clomr	7000.00	1304.00	1319.21		1319.65	0.000680	5.33	1313.05	100.00	0.26
phase 1b	817190	design clomr	7000.00	1304.00	1318.78		1319.25	0.000753	5.51	1270.12	100.00	0.27
phase 1b	817190	exist clomr	15600.00	1304.00	1324.99		1325.78	0.000895	7.48	3846.23	1090.98	0.30
phase 1b	817190	design clomr	15600.00	1304.00	1324.51		1325.40	0.001025	7.87	3343.27	986.29	0.32
phase 1b	817190	exist clomr	20800.00	1304.00	1327.63		1328.26	0.000714	7.29	6933.31	1216.82	0.28
phase 1b	817190	design clomr	20800.00	1304.00	1326.33		1327.27	0.001062	8.53	5377.89	1173.43	0.33
phase 1b	817190	exist clomr	36800.00	1304.00	1334.38		1334.74	0.000401	6.55	15393.54	1255.90	0.22
phase 1b	817190	design clomr	36800.00	1304.00	1332.59		1333.11	0.000594	7.64	13147.28	1255.90	0.26
phase 1b	817140	exist clomr	7000.00	1304.00	1319.17	1311.41	1319.61	0.000686	5.35	1309.30	100.00	0.26
phase 1b	817140	design clomr	7000.00	1304.00	1318.74	1311.41	1319.21	0.000750	5.53	1265.92	100.00	0.27
phase 1b	817140	exist clomr	15600.00	1304.00	1324.93	1315.17	1325.73	0.000911	7.53	3778.80	1077.50	0.31
phase 1b	817140	design clomr	15600.00	1304.00	1324.44	1315.18	1325.35	0.001045	7.93	3271.85	970.51	0.33
phase 1b	817140	exist clomr	20800.00	1304.00	1327.59	1317.09	1328.22	0.000723	7.33	6884.76	1215.49	0.28
phase 1b	817140	design clomr	20800.00	1304.00	1326.24	1317.09	1327.21	0.001091	8.62	5275.68	1170.53	0.34
phase 1b	817140	exist clomr	36800.00	1304.00	1334.36	1326.00	1334.72	0.000403	6.56	15367.48	1255.90	0.22
phase 1b	817140	design clomr	36800.00	1304.00	1332.56	1326.01	1333.08	0.000599	7.66	13107.26	1255.90	0.26
phase 1b	817122.5	Bridge										
phase 1b	16123.40	exist clomr	7000.00	1308.00	1319.24	1312.82	1319.50	0.000499	4.05	1726.34	190.96	0.24
phase 1b	16123.40	design clomr	7000.00	1308.00	1318.81	1312.82	1319.09	0.000579	4.26	1643.78	189.08	0.25
phase 1b	16123.40	exist clomr	15600.00	1308.00	1324.86	1315.81	1325.28	0.000471	5.25	3804.29	615.59	0.25
phase 1b	16123.40	design clomr	15600.00	1308.00	1323.90	1315.81	1324.40	0.000620	5.74	3228.39	549.63	0.28
phase 1b	16123.40	exist clomr	20800.00	1308.00	1327.52	1317.19	1327.96	0.000417	5.55	5640.55	779.77	0.24
phase 1b	16123.40	design clomr	20800.00	1308.00	1326.28	1317.19	1326.84	0.000574	6.18	4717.75	706.90	0.28
phase 1b	16123.40	exist clomr	36800.00	1308.00	1334.08	1320.77	1334.50	0.000301	5.89	12784.69	1351.96	0.22
phase 1b	16123.40	design clomr	36800.00	1308.00	1332.18	1320.76	1332.76	0.000449	6.79	10344.70	1228.57	0.26
phase 1b	15991.58	exist clomr	7000.00	1307.70	1319.19	1312.65	1319.42	0.000448	3.83	1829.45	200.69	0.22
phase 1b	15991.58	design clomr	7000.00	1307.70	1318.75	1312.64	1319.00	0.000519	4.02	1741.03	198.28	0.24
phase 1b	15991.58	exist clomr	15600.00	1307.70	1324.82	1315.43	1325.22	0.000441	5.12	3425.53	435.53	0.24
phase 1b	15991.58	design clomr	15600.00	1307.70	1323.84	1315.43	1324.31	0.000565	5.53	3029.63	333.45	0.27
phase 1b	15991.58	exist clomr	20800.00	1307.70	1327.43	1316.79	1327.89	0.000422	5.60	5127.07	930.10	0.24
phase 1b	15991.58	design clomr	20800.00	1307.70	1326.18	1316.78	1326.76	0.000564	6.15	4109.58	678.51	0.27
phase 1b	15991.58	exist clomr	36800.00	1307.70	1334.06	1320.29	1334.44	0.000274	5.63	13891.43	1518.94	0.20
phase 1b	15991.58	design clomr	36800.00	1307.70	1332.15	1320.30	1332.69	0.000414	6.54	11142.73	1403.27	0.25
phase 1b	15167.48	exist clomr	7000.00	1307.50	1318.83	1312.46	1319.04	0.000435	3.67	1907.65	219.05	0.22
phase 1b	15167.48	design clomr	7000.00	1307.50	1318.33	1312.45	1318.57	0.000520	3.89	1798.03	215.93	0.24
phase 1b	15167.48	exist clomr	15600.00	1307.50	1324.46	1315.13	1324.82	0.000468	4.78	3265.77	266.50	0.24
phase 1b	15167.48	design clomr	15600.00	1307.50	1323.38	1315.12	1323.81	0.000601	5.23	2982.67	256.36	0.27
phase 1b	15167.48	exist clomr	20800.00	1307.50	1327.09	1316.40	1327.51	0.000471	5.21	3995.02	288.04	0.25
phase 1b	15167.48	design clomr	20800.00	1307.50	1325.72	1316.41	1326.24	0.000631	5.76	3608.19	278.16	0.28
phase 1b	15167.48	exist clomr	36800.00	1307.50	1333.48	1319.75	1334.09	0.000429	6.28	5896.60	303.58	0.25
phase 1b	15167.48	design clomr	36800.00	1307.50	1331.46	1319.74	1332.22	0.000605	6.98	5288.54	299.93	0.29
phase 1b	14174.06	exist clomr	7000.00	1307.00	1318.46	1311.72	1318.61	0.000375	3.13	2236.33	297.89	0.20
phase 1b	14174.06	design clomr	7000.00	1307.00	1317.86	1311.73	1318.04	0.000482	3.40	2058.44	292.75	0.23
phase 1b	14174.06	exist clomr	15600.00	1307.00	1324.16	1314.63	1324.39	0.000302	3.87	4026.96	329.88	0.20
phase 1b	14174.06	design clomr	15600.00	1307.00	1322.96	1314.64	1323.25	0.000413	4.29	3636.38	323.58	0.23
phase 1b	14174.06	exist clomr	20800.00	1307.00	1326.79	1315.85	1327.07	0.000296	4.23	4924.79	352.56	0.20
phase 1b	14174.06	design clomr	20800.00	1307.00	1325.31	1315.85	1325.65	0.000410	4.71	4411.89	339.13	0.23
phase 1b	14174.06	exist clomr	36800.00	1307.00	1333.25	1318.74	1333.66	0.000263	5.11	7352.41	386.93	0.20
phase 1b	14174.06	design clomr	36800.00	1307.00	1331.12	1318.75	1331.62	0.000380	5.71	6534.32	379.54	0.23
phase 1b	12494.08	exist clomr	7000.00	1306.00	1317.90	1311.26	1318.06	0.000293	3.22	2174.17	255.45	0.19
phase 1b	12494.08	design clomr	7000.00	1306.00	1317.12	1311.27	1317.32	0.000384	3.54	1979.76	247.05	0.22
phase 1b	12494.08	exist clomr	15600.00	1306.00	1323.63	1313.67	1323.88	0.000293	4.06	3840.25	323.09	0.21
phase 1b	12494.08	design clomr	15600.00	1306.00	1322.21	1313.66	1322.54	0.000417	4.60	3389.74	312.12	0.25

HEC-RAS River: big Sioux Reach: phase 1b (Continued)

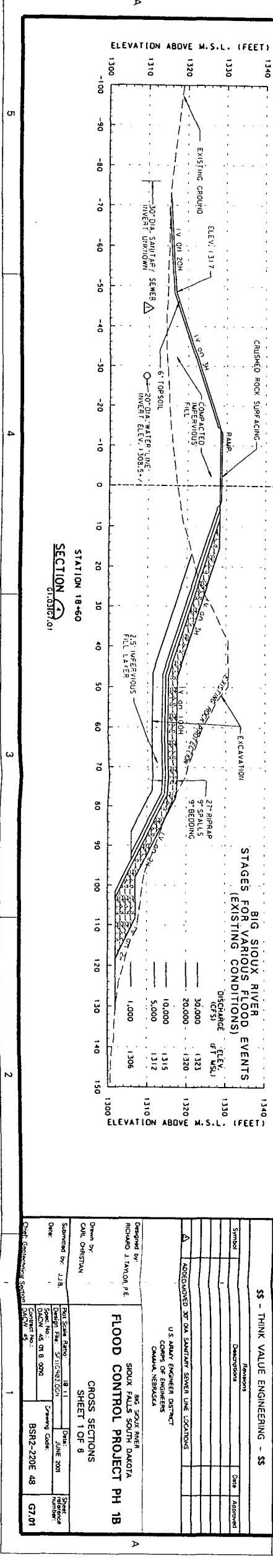
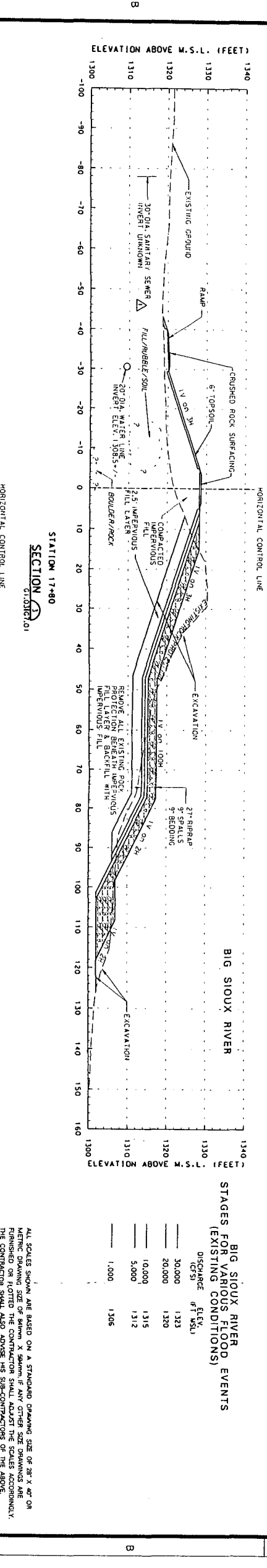
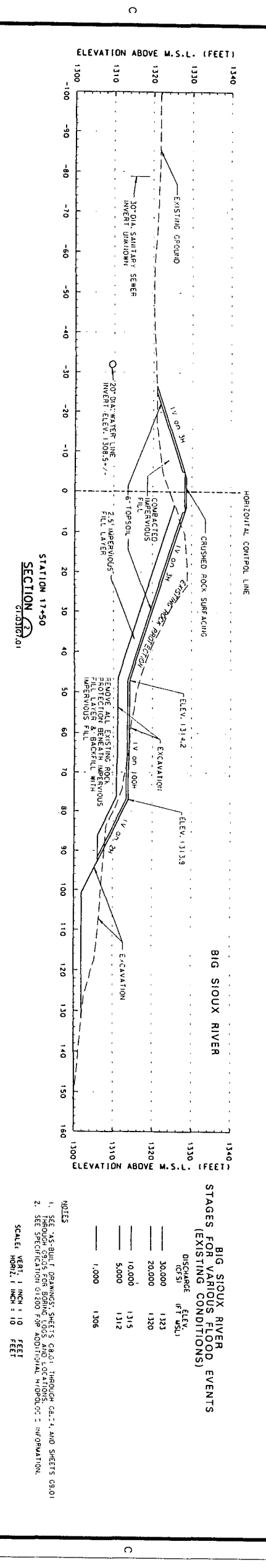
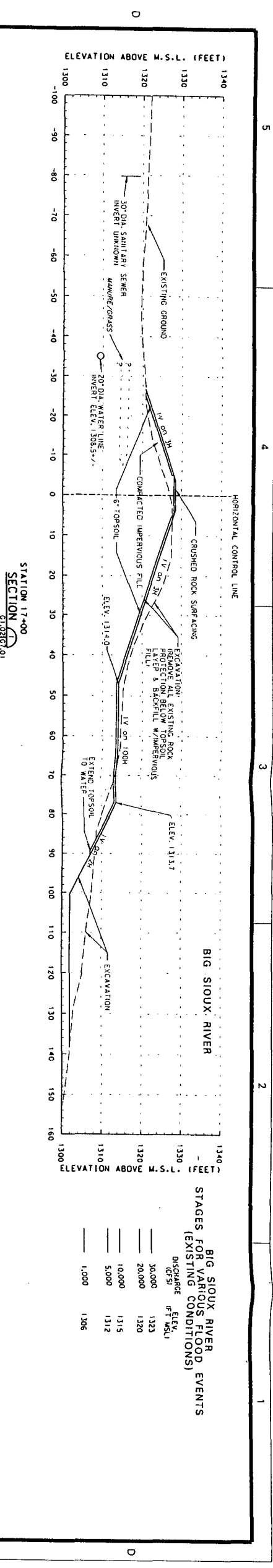
Reach	River Sta	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
phase 1b	12494.08	exist clomr	20800.00	1306.00	1326.27	1314.88	1326.57	0.000290	4.41	4722.84	353.49	0.21
phase 1b	12494.08	design clomr	20800.00	1306.00	1324.55	1314.86	1324.94	0.000420	5.02	4142.26	330.39	0.25
phase 1b	12494.08	exist clomr	36800.00	1306.00	1332.81	1318.00	1333.22	0.000261	5.16	7874.22	558.10	0.20
phase 1b	12494.08	design clomr	36800.00	1306.00	1330.42	1318.01	1330.96	0.000397	5.92	6572.25	531.71	0.25
phase 1b	12078.65	exist clomr	12100.00	1303.91	1316.79	1310.68	1317.59	0.001285	7.20	1681.63	146.93	0.37
phase 1b	12078.65	design clomr	12100.00	1303.91	1316.77	1309.04	1317.09	0.000530	4.53	2672.94	258.98	0.25
phase 1b	12078.65	exist clomr	25100.00	1303.91	1321.46	1314.74	1323.14	0.001965	10.39	2416.88	167.70	0.48
phase 1b	12078.65	design clomr	25100.00	1303.91	1321.60	1312.12	1322.22	0.000682	6.31	3978.66	281.54	0.30
phase 1b	12078.65	exist clomr	32500.00	1303.91	1323.59	1316.81	1325.70	0.002209	11.68	2783.03	176.89	0.52
phase 1b	12078.65	design clomr	32500.00	1303.91	1323.82	1313.60	1324.59	0.000734	7.04	4614.59	292.19	0.31
phase 1b	12078.65	exist clomr	54700.00	1303.91	1328.71	1321.99	1332.03	0.002587	14.61	3753.82	211.68	0.59
phase 1b	12078.65	design clomr	54700.00	1303.91	1329.35	1317.61	1330.51	0.000881	8.67	6326.37	349.33	0.35
phase 1b	11967.96	exist clomr	12100.00	1302.50	1316.79	1309.51	1317.36	0.000871	6.05	1999.37	173.45	0.31
phase 1b	11967.96	design clomr	12100.00	1302.50	1316.75	1307.60	1317.00	0.000375	3.99	3030.87	273.11	0.21
phase 1b	11967.96	exist clomr	25100.00	1302.50	1321.53	1313.52	1322.71	0.001311	8.73	2873.74	195.36	0.40
phase 1b	11967.96	design clomr	25100.00	1302.50	1321.59	1310.83	1322.09	0.000523	5.69	4413.56	298.44	0.26
phase 1b	11967.96	exist clomr	32500.00	1302.50	1323.69	1315.38	1325.19	0.001485	9.82	3308.28	207.20	0.43
phase 1b	11967.96	design clomr	32500.00	1302.50	1323.81	1312.28	1324.44	0.000574	6.39	5089.02	310.06	0.28
phase 1b	11967.96	exist clomr	54700.00	1302.50	1330.14	1320.04	1330.38	0.000481	5.46	24709.10	3004.66	0.22
phase 1b	11967.96	design clomr	54700.00	1302.50	1329.35	1316.35	1330.33	0.000706	7.91	6916.09	354.41	0.32
phase 1b	10795.88	exist clomr	12100.00	1302.00	1316.05	1309.21	1316.42	0.000594	4.85	2493.39	272.96	0.28
phase 1b	10795.88	design clomr	12100.00	1302.00	1316.05	1309.21	1316.42	0.000594	4.85	2492.49	272.94	0.28
phase 1b	10795.88	exist clomr	25100.00	1302.00	1320.63	1312.72	1321.30	0.000765	6.59	3810.55	302.37	0.33
phase 1b	10795.88	design clomr	25100.00	1302.00	1320.63	1312.73	1321.31	0.000764	6.58	3812.36	302.41	0.33
phase 1b	10795.88	exist clomr	32500.00	1302.00	1322.78	1314.33	1323.60	0.000809	7.26	4474.23	316.07	0.34
phase 1b	10795.88	design clomr	32500.00	1302.00	1322.78	1314.33	1323.60	0.000809	7.26	4474.19	316.07	0.34
phase 1b	10795.88	exist clomr	54700.00	1302.00	1328.19	1317.77	1329.37	0.000848	8.72	6317.49	360.73	0.36
phase 1b	10795.88	design clomr	54700.00	1302.00	1328.17	1317.77	1329.36	0.000850	8.73	6313.09	360.73	0.36
phase 1b	10239.09	exist clomr	12100.00	1302.00	1315.67	1307.91	1316.08	0.000588	5.11	2367.93	207.04	0.27
phase 1b	10239.09	design clomr	12100.00	1302.00	1315.67	1307.90	1316.08	0.000589	5.11	2367.18	207.03	0.27
phase 1b	10239.09	exist clomr	25100.00	1302.00	1319.82	1311.54	1320.75	0.000968	7.71	3254.89	221.33	0.35
phase 1b	10239.09	design clomr	25100.00	1302.00	1319.83	1311.52	1320.75	0.000967	7.71	3256.45	221.36	0.35
phase 1b	10239.09	exist clomr	32500.00	1302.00	1321.74	1313.19	1322.95	0.001132	8.81	3687.30	230.37	0.39
phase 1b	10239.09	design clomr	32500.00	1302.00	1321.74	1313.17	1322.95	0.001131	8.81	3688.42	230.39	0.39
phase 1b	10239.09	exist clomr	54700.00	1302.00	1326.54	1317.24	1328.52	0.001464	11.28	4870.25	300.03	0.45
phase 1b	10239.09	design clomr	54700.00	1302.00	1326.53	1317.23	1328.51	0.001467	11.29	4865.49	299.98	0.45
phase 1b	10193.20	exist clomr	12100.00	1302.00	1315.60	1308.46	1316.04	0.000688	5.33	2269.67	208.49	0.28
phase 1b	10193.20	design clomr	12100.00	1302.00	1315.59	1308.47	1316.04	0.000689	5.33	2268.91	208.48	0.28
phase 1b	10193.20	exist clomr	25100.00	1302.00	1319.71	1311.95	1320.69	0.001092	7.95	3158.45	223.96	0.37
phase 1b	10193.20	design clomr	25100.00	1302.00	1319.71	1311.94	1320.69	0.001091	7.95	3159.03	223.97	0.37
phase 1b	10193.20	exist clomr	32500.00	1302.00	1321.60	1313.63	1322.87	0.001256	9.05	3589.52	232.11	0.41
phase 1b	10193.20	design clomr	32500.00	1302.00	1321.61	1313.63	1322.88	0.001255	9.05	3590.68	232.13	0.41
phase 1b	10193.20	exist clomr	54700.00	1302.00	1326.36	1317.69	1328.42	0.001599	11.51	4751.02	256.05	0.47
phase 1b	10193.20	design clomr	54700.00	1302.00	1326.35	1317.70	1328.41	0.001601	11.52	4748.40	256.00	0.47
phase 1b	10144	Bridge										
phase 1b	10096.03	exist clomr	12100.00	1302.00	1315.36	1308.72	1315.88	0.000883	5.76	2099.75	204.32	0.32
phase 1b	10096.03	design clomr	12100.00	1302.00	1315.36	1308.73	1315.88	0.000883	5.76	2099.82	204.32	0.32
phase 1b	10096.03	exist clomr	25100.00	1302.00	1319.25	1312.39	1320.39	0.001403	8.58	2926.80	221.29	0.42
phase 1b	10096.03	design clomr	25100.00	1302.00	1319.25	1312.40	1320.39	0.001402	8.57	2927.42	221.30	0.42
phase 1b	10096.03	exist clomr	32500.00	1302.00	1321.02	1314.18	1322.50	0.001612	9.77	3327.27	229.41	0.45
phase 1b	10096.03	design clomr	32500.00	1302.00	1321.02	1314.19	1322.50	0.001613	9.77	3326.65	229.40	0.45
phase 1b	10096.03	exist clomr	54700.00	1302.00	1324.62	1318.26	1327.27	0.002401	13.06	4188.05	251.74	0.56
phase 1b	10096.03	design clomr	54700.00	1302.00	1324.61	1318.27	1327.26	0.002404	13.07	4185.53	251.65	0.56
phase 1b	10040.86	exist clomr	12100.00	1301.00	1315.36	1307.91	1315.79	0.000726	5.27	2293.84	218.63	0.29
phase 1b	10040.86	design clomr	12100.00	1301.00	1315.36	1307.90	1315.79	0.000726	5.27	2293.92	218.63	0.29
phase 1b	10040.86	exist clomr	25100.00	1301.00	1319.26	1311.51	1320.23	0.001171	7.87	3188.55	238.32	0.38
phase 1b	10040.86	design clomr	25100.00	1301.00	1319.27	1311.52	1320.23	0.001171	7.87	3189.22	238.33	0.38
phase 1b	10040.86	exist clomr	32500.00	1301.00	1321.06	1313.41	1322.31	0.001343	8.97	3622.57	246.30	0.41
phase 1b	10040.86	design clomr	32500.00	1301.00	1321.05	1313.41	1322.30	0.001344	8.97	3621.94	246.29	0.41
phase 1b	10040.86	exist clomr	54700.00	1301.00	1324.71	1317.49	1326.94	0.001970	12.00	4558.20	267.07	0.51
phase 1b	10040.86	design clomr	54700.00	1301.00	1324.70	1317.48	1326.94	0.001974	12.01	4555.53	267.01	0.51
phase 1b	9360.739	exist clomr	12100.00	1301.00	1314.98	1307.37	1315.34	0.000519	4.81	2515.80	268.12	0.28
phase 1b	9360.739	design clomr	12100.00	1301.00	1314.98	1307.35	1315.34	0.000519	4.81	2515.97	268.13	0.28
phase 1b	9360.739	exist clomr	25100.00	1301.00	1318.68	1311.01	1319.45	0.000859	7.06	3556.65	294.44	0.36
phase 1b	9360.739	design clomr	25100.00	1301.00	1318.68	1311.01	1319.46	0.000858	7.06	3557.62	294.47	0.36
phase 1b	9360.739	exist clomr	32500.00	1301.00	1320.41	1312.90	1321.40	0.000982	7.97	4077.15	306.88	0.39
phase 1b	9360.739	design clomr	32500.00	1301.00	1320.41	1312.90	1321.40	0.000982	7.97	4076.21	306.85	0.39
phase 1b	9360.739	exist clomr	54700.00	1301.00	1325.09	1316.57	1325.53	0.000476	6.45	16224.59	1357.93	0.27
phase 1b	9360.739	design clomr	54700.00	1301.00	1325.08	1316.58	1325.52	0.000477	6.46	16210.99	1357.74	0.27

HEC-RAS River: big Sioux Reach: phase 1b (Continued)

Reach	River Sta	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
phase 1b	7781.610	exist clomr	12100.00	1301.00	1314.34	1306.16	1314.61	0.000367	4.11	2944.94	294.82	0.23
phase 1b	7781.610	design clomr	12100.00	1301.00	1314.34	1306.14	1314.61	0.000367	4.11	2945.16	294.85	0.23
phase 1b	7781.610	exist clomr	25100.00	1301.00	1317.59	1309.23	1318.16	0.000671	6.09	4119.91	397.77	0.33
phase 1b	7781.610	design clomr	25100.00	1301.00	1317.59	1309.23	1318.17	0.000670	6.09	4121.66	397.80	0.33
phase 1b	7781.610	exist clomr	32500.00	1301.00	1319.18	1310.72	1319.90	0.000758	6.82	4762.77	410.08	0.35
phase 1b	7781.610	design clomr	32500.00	1301.00	1319.17	1310.72	1319.90	0.000758	6.83	4761.07	410.05	0.35
phase 1b	7781.610	exist clomr	54700.00	1301.00	1323.21	1314.70	1324.31	0.000931	8.44	6489.36	456.91	0.39
phase 1b	7781.610	design clomr	54700.00	1301.00	1323.20	1314.70	1324.31	0.000932	8.45	6486.46	456.78	0.39
phase 1b	7696.877	exist clomr	12100.00	1300.00	1314.32	1305.17	1314.56	0.000394	3.96	3078.79	398.15	0.21
phase 1b	7696.877	design clomr	12100.00	1300.00	1314.32	1305.17	1314.56	0.000394	3.96	3079.07	398.26	0.21
phase 1b	7696.877	exist clomr	25100.00	1300.00	1317.54	1308.44	1318.10	0.000687	6.11	4525.02	573.48	0.30
phase 1b	7696.877	design clomr	25100.00	1300.00	1317.54	1308.43	1318.10	0.000687	6.11	4525.02	573.48	0.30
phase 1b	7696.877	exist clomr	32500.00	1300.00	1319.11	1310.54	1319.83	0.000785	6.96	5261.25	586.60	0.32
phase 1b	7696.877	design clomr	32500.00	1300.00	1319.11	1310.53	1319.83	0.000785	6.96	5261.36	586.60	0.32
phase 1b	7696.877	exist clomr	54700.00	1300.00	1323.08	1314.13	1324.22	0.000945	8.88	7154.86	1493.80	0.36
phase 1b	7696.877	design clomr	54700.00	1300.00	1323.07	1314.14	1324.22	0.000946	8.88	7151.87	1493.66	0.37
phase 1b	6152.494	exist clomr	12100.00	1299.00	1313.15	1305.04	1313.67	0.000745	5.76	2102.36	169.87	0.29
phase 1b	6152.494	design clomr	12100.00	1299.00	1313.15	1305.04	1313.67	0.000745	5.75	2102.53	169.88	0.29
phase 1b	6152.494	exist clomr	25100.00	1299.00	1316.65	1308.94	1317.04	0.000678	6.07	7980.54	1681.51	0.28
phase 1b	6152.494	design clomr	25100.00	1299.00	1316.65	1308.91	1317.04	0.000678	6.07	7980.54	1681.51	0.28
phase 1b	6152.494	exist clomr	32500.00	1299.00	1318.28	1310.87	1318.68	0.000638	6.33	10007.64	1737.32	0.28
phase 1b	6152.494	design clomr	32500.00	1299.00	1318.28	1310.86	1318.68	0.000638	6.33	10007.80	1737.32	0.28
phase 1b	6152.494	exist clomr	54700.00	1299.00	1322.47	1316.01	1322.88	0.000562	6.94	15196.81	1822.70	0.27
phase 1b	6152.494	design clomr	54700.00	1299.00	1322.46	1316.01	1322.88	0.000563	6.95	15187.28	1822.60	0.27
phase 1b	5127.379	exist clomr	12100.00	1299.00	1312.18	1306.41	1312.77	0.000978	6.17	1987.06	376.54	0.37
phase 1b	5127.379	design clomr	12100.00	1299.00	1312.18	1306.40	1312.77	0.000977	6.17	1987.47	376.64	0.37
phase 1b	5127.379	exist clomr	25100.00	1299.00	1316.20	1309.97	1316.45	0.000483	5.12	10395.74	2257.37	0.26
phase 1b	5127.379	design clomr	25100.00	1299.00	1316.20	1309.97	1316.45	0.000483	5.12	10395.74	2257.37	0.26
phase 1b	5127.379	exist clomr	32500.00	1299.00	1317.91	1312.39	1318.14	0.000420	5.11	13384.11	2315.41	0.24
phase 1b	5127.379	design clomr	32500.00	1299.00	1317.91	1312.39	1318.14	0.000420	5.11	13384.33	2315.42	0.24
phase 1b	5127.379	exist clomr	54700.00	1299.00	1322.20	1314.94	1322.41	0.000334	5.31	20893.39	2410.06	0.22
phase 1b	5127.379	design clomr	54700.00	1299.00	1322.19	1314.92	1322.41	0.000335	5.31	20878.87	2409.92	0.22
phase 1b	4273.776	exist clomr	12100.00	1299.00	1311.59	1306.84	1311.94	0.000715	4.77	2763.25	526.19	0.30
phase 1b	4273.776	design clomr	12100.00	1299.00	1311.59	1306.85	1311.94	0.000714	4.77	2764.02	526.25	0.30
phase 1b	4273.776	exist clomr	25100.00	1299.00	1315.21	1309.38	1315.79	0.000839	6.32	4836.67	1479.16	0.33
phase 1b	4273.776	design clomr	25100.00	1299.00	1315.21	1309.39	1315.79	0.000839	6.32	4836.67	1479.16	0.33
phase 1b	4273.776	exist clomr	32500.00	1299.00	1316.76	1310.82	1317.46	0.000892	7.02	5735.06	1541.80	0.34
phase 1b	4273.776	design clomr	32500.00	1299.00	1316.76	1310.80	1317.46	0.000892	7.02	5735.13	1541.80	0.34
phase 1b	4273.776	exist clomr	54700.00	1299.00	1320.67	1313.75	1321.68	0.000979	8.64	8002.31	1641.34	0.37
phase 1b	4273.776	design clomr	54700.00	1299.00	1320.66	1313.76	1321.67	0.000981	8.65	7995.73	1641.02	0.37
phase 1b	4164.614	exist clomr	12100.00	1299.00	1311.40	1306.55	1311.83	0.000902	5.25	2302.60	324.79	0.35
phase 1b	4164.614	design clomr	12100.00	1299.00	1311.40	1306.56	1311.83	0.000901	5.25	2303.11	324.81	0.35
phase 1b	4164.614	exist clomr	25100.00	1299.00	1314.78	1309.82	1315.60	0.001263	7.28	3447.33	349.27	0.41
phase 1b	4164.614	design clomr	25100.00	1299.00	1314.78	1309.83	1315.60	0.001263	7.28	3447.33	349.27	0.41
phase 1b	4164.614	exist clomr	32500.00	1299.00	1316.17	1311.02	1317.22	0.001443	8.25	3937.99	358.28	0.44
phase 1b	4164.614	design clomr	32500.00	1299.00	1316.17	1311.03	1317.22	0.001443	8.25	3938.03	358.28	0.44
phase 1b	4164.614	exist clomr	54700.00	1299.00	1319.61	1313.95	1321.32	0.001797	10.51	5205.92	376.78	0.50
phase 1b	4164.614	design clomr	54700.00	1299.00	1319.61	1313.96	1321.32	0.001798	10.51	5204.58	376.77	0.50
phase 1b	4117	Bridge										
phase 1b	4069.033	exist clomr	12100.00	1299.00	1311.19	1306.82	1311.62	0.000937	5.30	2284.85	324.65	0.35
phase 1b	4069.033	design clomr	12100.00	1299.00	1311.19	1306.82	1311.63	0.000936	5.29	2285.37	324.66	0.35
phase 1b	4069.033	exist clomr	25100.00	1299.00	1314.42	1309.55	1315.28	0.001353	7.43	3380.22	351.69	0.42
phase 1b	4069.033	design clomr	25100.00	1299.00	1314.42	1309.54	1315.28	0.001353	7.43	3380.22	351.69	0.42
phase 1b	4069.033	exist clomr	32500.00	1299.00	1315.72	1310.88	1316.83	0.001563	8.46	3842.88	359.37	0.46
phase 1b	4069.033	design clomr	32500.00	1299.00	1315.72	1310.89	1316.83	0.001563	8.46	3842.93	359.37	0.46
phase 1b	4069.033	exist clomr	54700.00	1299.00	1318.93	1313.82	1320.77	0.002013	10.89	5024.50	377.79	0.53
phase 1b	4069.033	design clomr	54700.00	1299.00	1318.92	1313.82	1320.77	0.002014	10.89	5023.07	377.77	0.53
phase 1b	3926.410	exist clomr	12100.00	1299.00	1311.03	1305.76	1311.48	0.001098	5.38	2247.80	443.47	0.41
phase 1b	3926.410	design clomr	12100.00	1299.00	1311.03	1305.77	1311.48	0.001098	5.38	2248.58	443.50	0.41
phase 1b	3926.410	exist clomr	25100.00	1299.00	1314.29	1310.50	1315.03	0.001297	6.87	3651.73	781.38	0.42
phase 1b	3926.410	design clomr	25100.00	1299.00	1314.29	1310.49	1315.03	0.001297	6.87	3651.73	781.38	0.42
phase 1b	3926.410	exist clomr	32500.00	1299.00	1315.60	1311.40	1316.53	0.001421	7.71	4215.05	903.43	0.43
phase 1b	3926.410	design clomr	32500.00	1299.00	1315.60	1311.39	1316.53	0.001420	7.71	4215.10	903.45	0.43
phase 1b	3926.410	exist clomr	54700.00	1299.00	1318.85	1313.71	1320.32	0.001664	9.75	5609.40	1463.95	0.48
phase 1b	3926.410	design clomr	54700.00	1299.00	1318.85	1313.73	1320.32	0.001664	9.75	5609.35	1463.94	0.48
phase 1b	3209.207	exist clomr	12100.00	1299.00	1309.92	1306.74	1310.52	0.001503	6.20	1956.78	408.54	0.47
phase 1b	3209.207	design clomr	12100.00	1299.00	1309.93	1306.74	1310.52	0.001501	6.19	1958.18	409.72	0.47
phase 1b	3209.207	exist clomr	25100.00	1299.00	1313.22	1310.01	1314.01	0.001502	7.40	4312.24	1624.95	0.44
phase 1b	3209.207	design clomr	25100.00	1299.00	1313.22	1310.00	1314.01	0.001502	7.40	4312.24	1624.95	0.44
phase 1b	3209.207	exist clomr	32500.00	1299.00	1314.58	1311.01	1315.46	0.001501	7.96	5383.64	1719.45	0.44

HEC-RAS River: big sioux Reach: phase 1b (Continued)

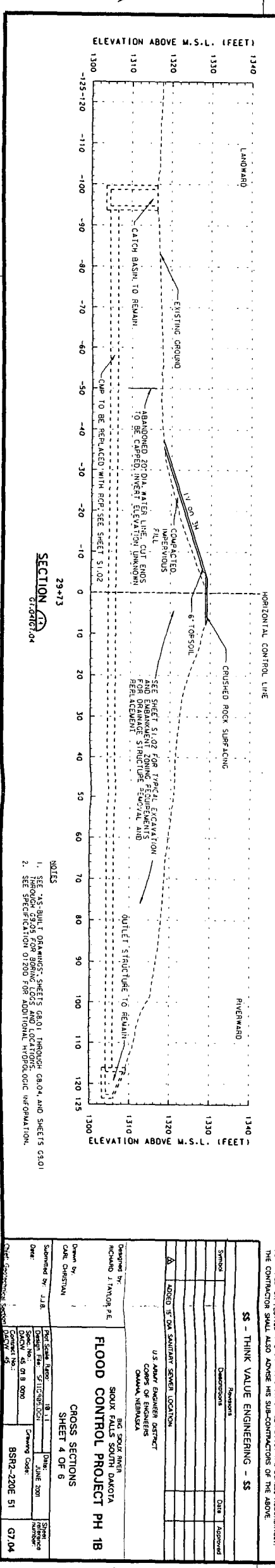
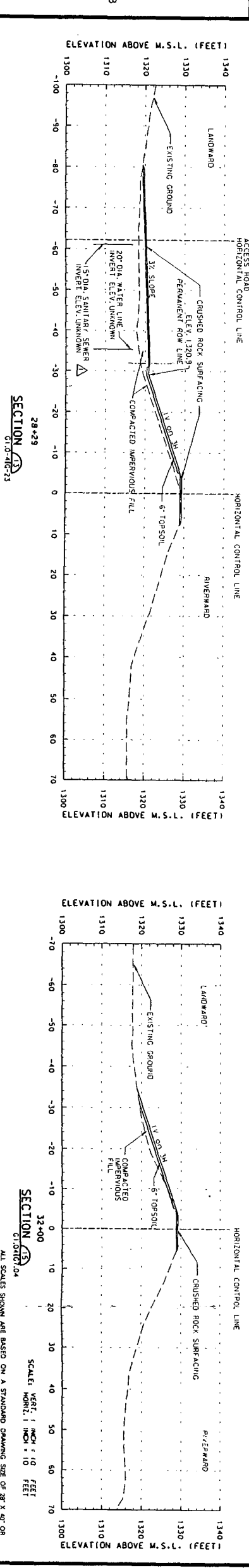
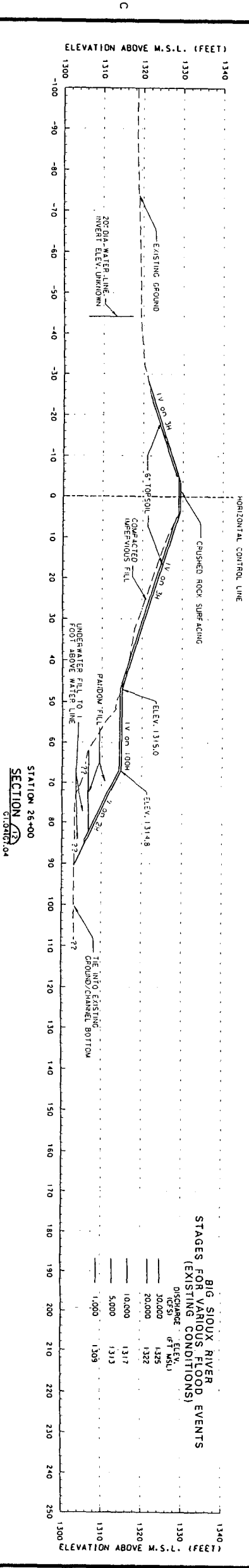
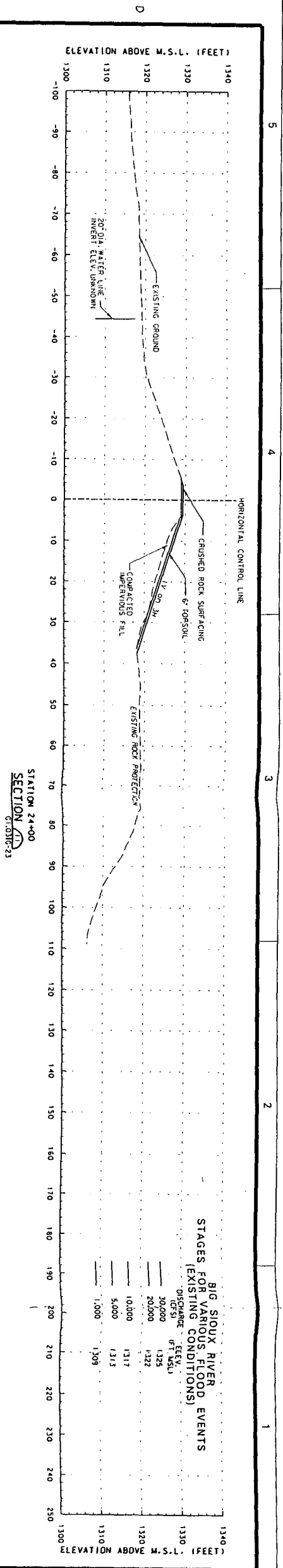
Reach	River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
phase 1b	3209.207	design clomr	32500.00	1299.00	1314.58	1311.01	1315.46	0.001501	7.96	5383.64	1719.45	0.44
phase 1b	3209.207	exist clomr	54700.00	1299.00	1317.88	1313.88	1319.02	0.001501	9.34	7994.64	1910.41	0.45
phase 1b	3209.207	design clomr	54700.00	1299.00	1317.88	1313.65	1319.02	0.001501	9.34	7994.73	1910.41	0.45



STAGES FOR VARIOUS FLOOD EVENTS (EXISTING CONDITIONS)			
DISCHARGE (CFS)	ELEV. (FT MSL)	DATE	APPROVED
30,000	1323		
20,000	1320		
10,000	1315		
5,000	1312		
1,000	1306		

STAGES FOR VARIOUS FLOOD EVENTS (EXISTING CONDITIONS)			
DISCHARGE (CFS)	ELEV. (FT MSL)	DATE	APPROVED
30,000	1323		
20,000	1320		
10,000	1315		
5,000	1312		
1,000	1306		

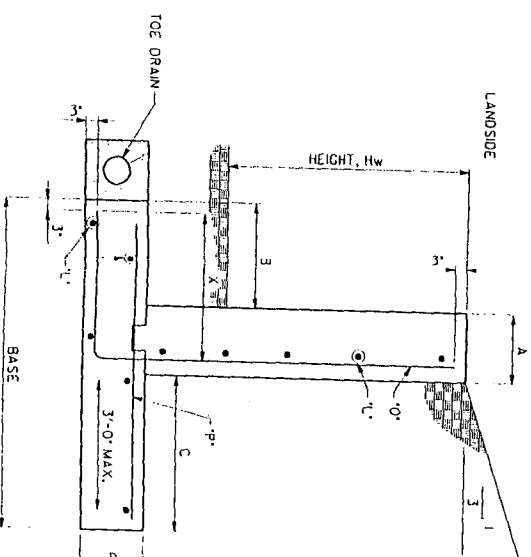
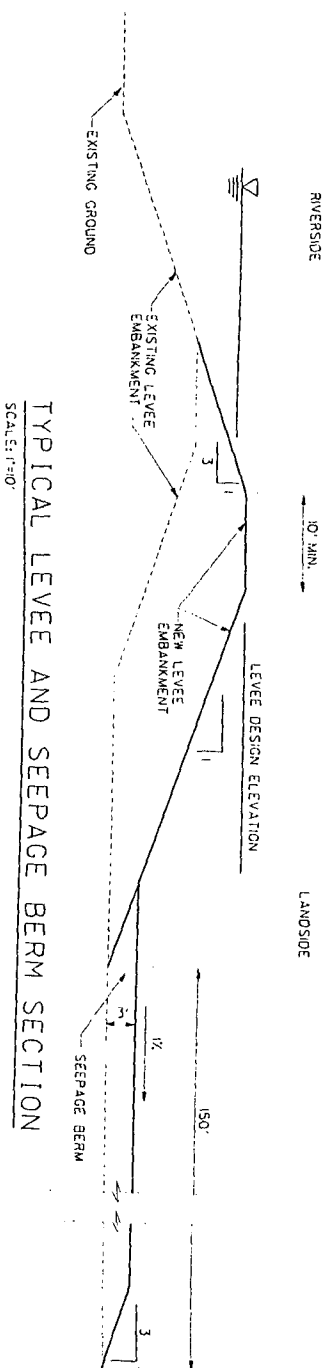
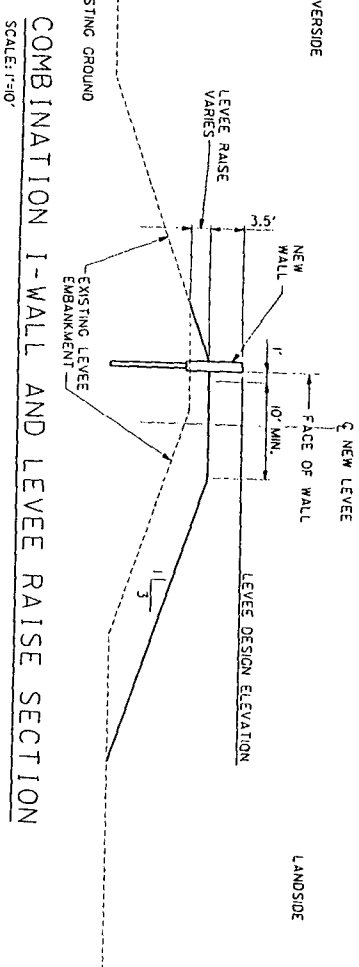
ENCLOSURE 5



DESIGNED BY: RICHARD J. TAYLOR, P.E.
U.S. ARMY DISTRICT ENGINEER
OMAHA, NEBRASKA

PROJECT: SIOUX FALLS SOUTH DAKOTA
FLOOD CONTROL PROJECT PH 1B
CROSS SECTIONS
SHEET 4 OF 8

DATE: JUNE 2001
DRAWING CODE: BSRD-220E 51
SCALE: 1" = 10' HORIZ. 1" = 10' VERT.



I - WALL DETAIL
SCALE: 1/2" = 1'-0"

FDR

TYPICAL SECTIONS

HDR Engineering, Inc.



DESIGN OPTIMIZATION STUDY
SIOUX FALLS FLOOD CONTROL PROJECT
SIOUX FALLS, SOUTH DAKOTA
USACE CONTRACT DACA45-57

Big Sioux River, Sioux Falls, SD Diversion Dam Tailwater Rating Curve

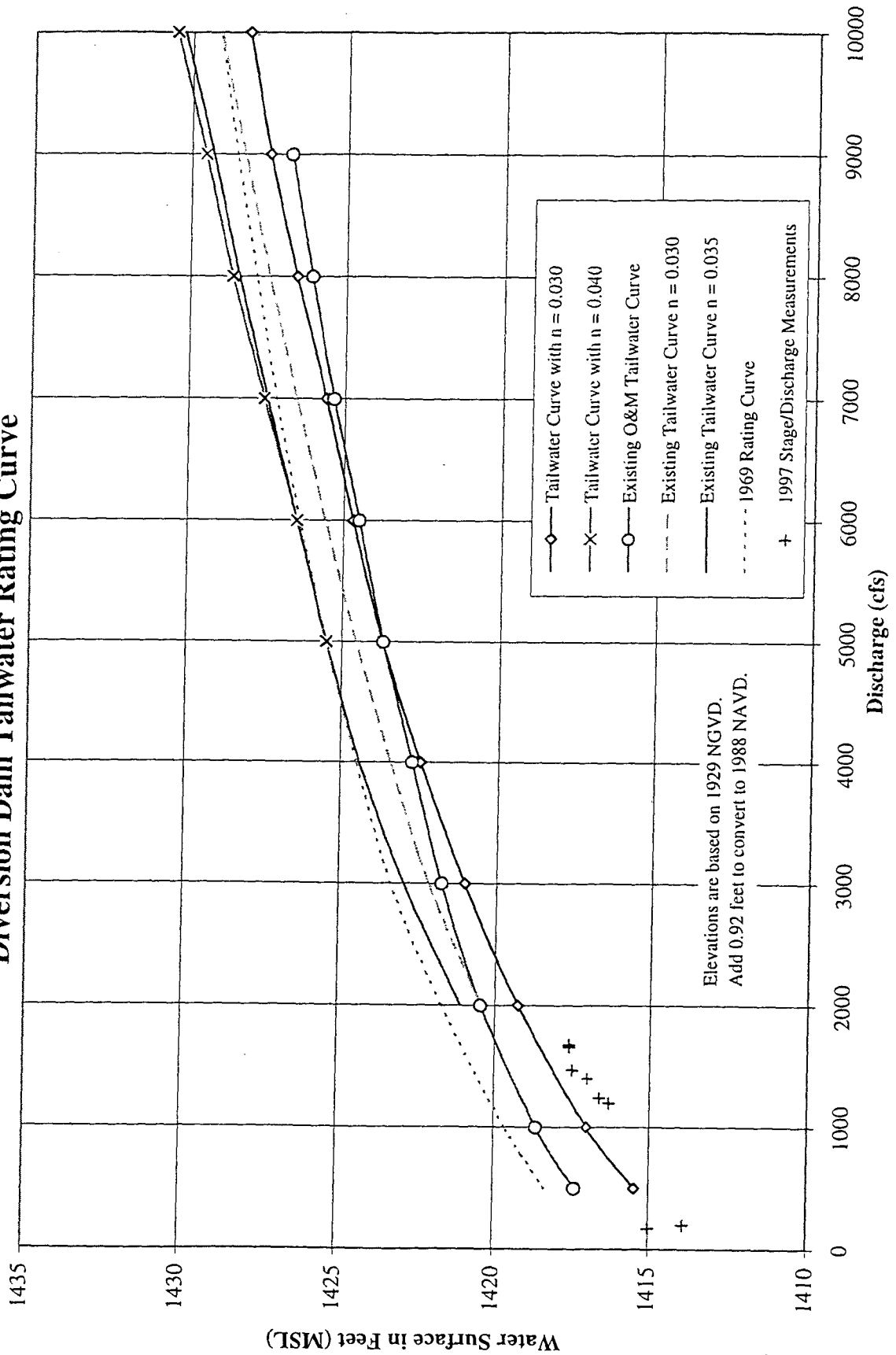


Figure A-9

Big Sioux River, Sioux Falls, SD Diversion Dam Headwater Rating Curve

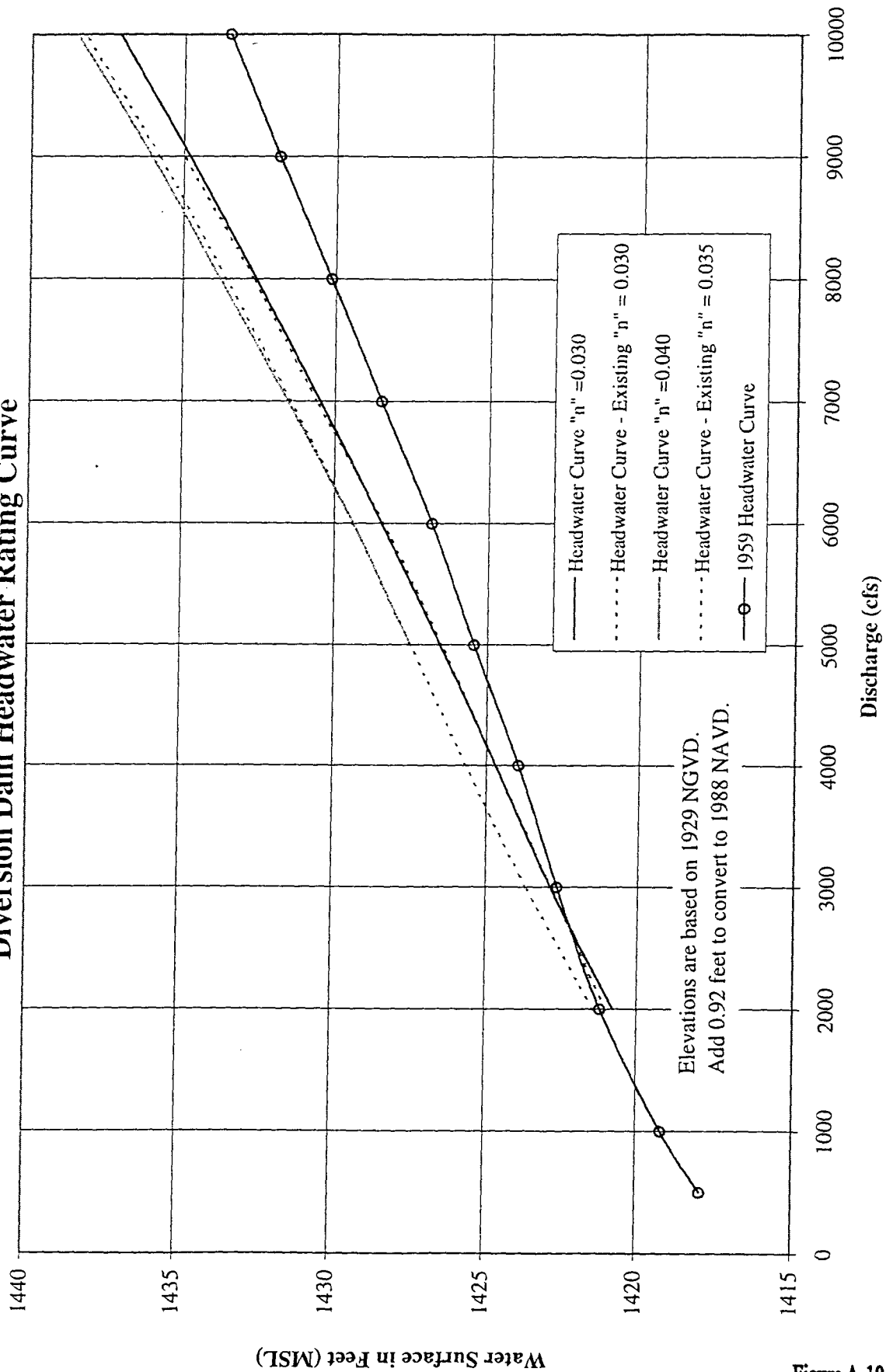


Figure A-10

MEMORANDUM FOR FILES

SUBJECT: Meeting on 29 April 2002 with DENR & City of Sioux Falls and discussion of various discharges used throughout the study.

1. Initial Levee/Flood Control Project completed in 1965. Design Memorandum for project dated October 1956.

The initial project was designed to pass 40-45% of the Standard Project Flood (SPF) due to the limited available hydrologic data. The design discharges were 24,400 cfs for the Big Sioux River and 9,350 cfs for Skunk Creek. Available period of record for determining hydrologic frequency data approximately:

a. Big Sioux River	
near Dell Rapids	1948 - 1954
@ Sioux Falls	1944 - 1954
North Cliff @ Sioux Falls	N/A
near Brandon	N/A
b. Skunk Creek	
@Sioux Falls	1948 - 1954

2. Feasibility Study completed November 1993.

Available period of record for determining hydrologic frequency data:

a. Big Sioux River	
near Dell Rapids	1948 - 1987
@ Sioux Falls	1944 - 1960
North Cliff @ Sioux Falls	1962 - 1987
near Brandon	1959 - 1972
b. Skunk Creek	
@ Sioux Falls	1948 - 1987

Considerably more available data for the feasibility study analysis than the original project design memorandum including, floods in 1957, 1960, 1962, 1969, and 1984.

Therefore, there would be a considerable change in frequency computed discharges between the two analyses regardless of the method of analysis.

3. Based on Feasibility Study.

Existing Flood Control System inadequate for 100-year protection.

New frequency discharges computed (cfs)

a. Big Sioux River	10-yr	50-yr	100-yr	500-yr
near Dell Rapids	12,700	27,100	35,000	57,500
@ Diversion Structure	12,700	27,100	35,000	57,500
@ North Cliff	12,500	27,300	36,300	66,300
b. Skunk Creek				
@ Sioux Falls	7,300	18,000	23,500	43,500

4. COE vs FEMA Frequency Discharge Computation

- **COE** uses a w/ expected probability in its statistical analysis to compute frequency discharges. This is an adjustment made in the analysis to compensate for limited available data based on years of record. The fewer the available years of record, the greater the adjustment.
- **FEMA** uses a w/o expected probability in its statistical analysis to compute frequency discharges. No adjustment is made regardless of the available years of record data.
- **FEMA** regards the w/ expected probability analysis as reflecting a future condition and therefore uses the w/o expected probability analysis for their work.
- **COE** uses the w/ expected probability for design as a matter of policy.

5. Consideration of Debris on Bridges

- **FEMA** does not include debris on bridge impacts in their analysis. Water surface profiles are computed w/o debris.
- **COE** generally considers impacts of debris when computing water surface profiles.

6. Methods of setting levee heights

Several methods of setting levee heights may be used for a project. **FEMA** and **COE** generally will use different methods to set a levee height.

- **FEMA** generally would use their 100-year discharge, w/o debris on bridges, to compute a water surface profile. The profile would be increased by 3' (or some other amount) to provide needed freeboard to set the levee height.
- **COE** for Sioux Falls Phase I and Phase II used an equivalent discharge greater than the design discharge w/ debris on bridges to set the levee height. Additional freeboard was not added to this computed water surface. The freeboard was provided by the increased equivalent discharge. The equivalent discharge is determined by comparing rating curves for two different Manning's "n" values--one for design conditions and one for an increased roughness condition to capture the uncertainties inherent in hydraulic modeling.
- The two methods provide similar levee heights, although the **COE** method provides a more conservative (higher) levee height.
- The **COE** feels this method provides a better levee profile through structures such as bridges than a set, constant freeboard height.
- Since the completion of the feasibility study, the **COE** now uses a risk and uncertainty analysis to determine levee heights. There is also now in place a Memorandum of Understanding between the **COE** and **FEMA** that addresses **FEMA** freeboard requirements and/or reliability of a designed levee.
- A 500-year discharge with flow through the diversion dam and through an overflow (fuseplug) spillway was used to set levee heights for Sioux Falls Phase III. However, during the Phase III design, it became apparent that the contour of the land will not allow the designed discharge to exit through the fuseplug. New criteria was developed and agreed to during the Phase III design process. (A maximum levee capacity system, slightly larger than a 200-yr event protection level will be used).

7. Design Discharges

Based on the equivalent discharge method the following design Qs were used:

	1993 Feasibility Study	2002 Plans & Specs
Phase I	41,000 cfs	41,000 cfs
Phase II		
Skunk Creek	28,500 cfs *	29,000 cfs *
Big Sioux River u/s of confluence	backwater effect only	backwater effect only
Big Sioux River d/s of confluence	27,000 cfs *	29,000 cfs *

*The equivalent discharge used changed slightly based on new rating curves from new surveyed cross section and geometry data.

Based on a 500-year level of protection:

* revised during the Phase III design to slightly greater than a 200-yr level of protection:

	1993 Feasibility Study	2003 Plans & Specs
Phase III		
U/s of Highway 38A	57,500 cfs	*45,800 cfs
Diversion Channel	37,300 cfs	37,300 cfs
Through the Diversion Dam	8,500 cfs	8,500 cfs
Overflow (fuseplug)	11,700 cfs	11,700 cfs

8. FEMA - Applications

COE discharges are used to set levee heights.

- Levee heights are compared against FEMA condition profiles to ensure FEMA freeboard requirements are met.
- Conditional Letters of Map Revision (CLOMR) are submitted by COE to FEMA for their review and approval.
- Upstream and downstream impacts are addressed in the CLOMR application.

9. Adverse Impacts

- Frequency, depth, durations tables are computed for any area where the w/ project condition adversely impacts property owners.
- Real Estate and Legal departments for COE address easement and compensation requirements.

MEMORANDUM FOR FILES

SUBJECT: Meeting on 29 January 2003 with DENR & City of Sioux Falls and discussion of upstream water surface impacts associated with the operation of the diversion dam.

1. Diversion Dam Operation.

During the subject meeting, discussion occurred regarding the upstream impacts due to the operation of the diversion dam gates. The current design and RAS models include flow through the diversion dam and thus removed from the diversion channel flow. Under current design conditions, 4900 cfs is released through the diversion dam under a 10-year event, 7300 cfs is released through the diversion dam under both a 50-year and 100-year, and 8500 cfs is released through the diversion dam under maximum system capacity conditions. The channel capacity downstream of the diversion dam is limited to 8500 cfs.

2. Current Operations and Maintenance Manual.

The current O&M Manual is vague and provides little specific guidance as to actual operating criteria of the gate(s) at the diversion dam. The city currently operates the dam to maximize upstream storage for recharge of the well field.

3. Additional Upstream Cross Sections.

The RAS models used for the levee improvement design and pre- and post-project conditions do not extend far enough upstream to determine the extent of upstream sensitivity to the operation of the diversion dam. Therefore, cross sections from an existing HEC-2 file were added to the RAS models to extend further upstream.

4. Computed Water Surfaces.

Discharge adjustments were made in the design RAS models to compute water surfaces for varying conditions. The following tables summarize those results.

For the 100-yr event 31,300 cfs, w/o expected probability, w/o debris:

	CWS WITH VARIABLE DISCHARGE THROUGH DIVERSION DAM				
Location	Discharge through diversion dam in cfs				
	7300	6000	4000	2000	0
x-section 19855 (~ u/s of I-90)	1435.39	1435.67	1436.11	1436.56	1437.08
x-section 23579 (~ 3,800' u/s of I-90)	1437.47	1437.55	1437.69	1437.86	1437.95
x-section 918285 (~ 15,800' u/s of I-90)	1438.74	1438.78	1438.84	1438.92	1439.03

For the 50-yr event 27,100 cfs, w/ expected probability, w/o debris:

	CWS WITH VARIABLE DISCHARGE THROUGH DIVERSION DAM				
Location	Discharge through diversion dam in cfs				
	7300	6000	4000	2000	0
x-section 19855 (~ u/s of I-90)	1434.12	1434.36	1434.76	1435.21	1435.67
x-section 23579 (~ 3,800' u/s of I-90)	1436.57	1436.64	1436.78	1436.93	1437.09
x-section 918285 (~ 15,800' u/s of I-90)	1438.17	1438.2	1438.25	1438.30	1438.35

For the 10-yr event 12,700 cfs, w/ expected probability, w/o debris:

	CWS WITH VARIABLE DISCHARGE THROUGH DIVERSION DAM				
Location	Discharge through diversion dam in cfs				
		4900	4000	2000	0
x-section 19855 (~ u/s of I-90)		1431.42	1431.43	1431.48	1431.60
x-section 23579 (~ 3,800' u/s of I-90)		1432.82	1432.83	1432.87	1432.93
x-section 918285 (~ 15,800' u/s of I-90)		1436.29	1436.29	1436.29	1436.29

5. Summary and Conclusions.

As shown in the previous tables, operation of the diversion dam gates impacts the upstream water surface. With the gates completely closed, the computed water surface for the 100-yr event increases approximately 1.7' immediately upstream of I-90 and gradually decreases in severity to approximately 0.3', 3 miles upstream of the I-90 bridge. The impacts will "daylight" at some point further upstream. Also with the gates completely closed, the computed water surface for the 50-yr event increases approximately 1.6' immediately upstream of I-90 gradually decreasing in severity to approximately 0.2', 3 miles upstream of the I-90 bridge. The 10-yr event computed water surface is approximately 0.2' higher immediately upstream of I-90 and gradually decreases in severity until no increase is computed approximately 2 miles upstream.

During the 1997 flood fight, gates were operated to minimize downstream flooding in the parks along the Big Sioux River in the south part of town. The gates cannot be operated in a manner that minimizes both upstream impacts and downstream impacts. There are currently plans to conduct a Section 22 study that connects Phases I and II of the levee improvements. This study would clarify impacts and flood boundaries of the area of the parks.

6. Recommendations.

A revised diversion dam operating plan will be part of the new O&M Manual written at the completion of the Sioux Falls Levee Improvement project. Until then, it is recommended that the gates be operated to convey the design discharge under the 50- and 100-yr events of 7300 cfs for Big Sioux River floods. No special operating criteria is required for 10-year and lower events on the Big Sioux River. Skunk Creek flood flows are not coincidental with Big Sioux River flooding and flood events from Skunk Creek are considerably greater than the 7300 cfs allowed to pass through the diversion dam. The area downstream of Phase II is designed to handle the flows through the diversion dam. .

Water Rights Program - DENR
Conversation File Documentation

NAME OF PERSON OR FILE: Sioux Falls Flood Control Application No. FC-30

ADDRESS: COUNTY: Minnehaha

DATE: May 28, 2003 TELEPHONE: 367-8611

RE: Call to Tom Berkland regarding interpretation of maps for Phase III

COMMENTS:

I contacted Mr. Berkland regarding the maps provided with the application for a flood control permit. Particularly, I asked about the maps for Phase III of the project. I stated that 46-2A-11 requires that we review that the project will not increase the likelihood or the severity of flood damages. In looking at the maps you can not see any line differentiating between the 100 year event – existing conditions and the 100 year event – with project in place. Mr. Berkland responded that if there is no change in flood boundaries that only the dashed white line is present. This represents that there is no change in the flood boundaries during the 100 year event with this project in place. If you look at the 500 year event the lines between the existing and w/project can be seen in places.

Mr. Berkland said the levees are being fortified in this area due to Corps of Engineer requirements and not to meet additional FEMA protection levels.

NAME: *Eric Hamlund*

City of Sioux Falls

Big Sioux River Flood Control

Flood Control System Improvements



Prepared by: Public Works-Engineering
April 15, 2003

RECEIVED

MAY 28 2003

WATER RIGHTS
PROGRAM

Flood Control System

The Big Sioux River encompasses a drainage basin of roughly 9,565 square miles. The Big Sioux River Basin upstream from Sioux Falls contains approximately 5,718 square miles of the total basin. Skunk Creek drains an area of 560 square miles. The City of Sioux Falls is located within a horseshoe bend of the Big Sioux River. It is also located at the confluence of the Big Sioux River and Skunk Creek. Therefore, flood events from these two watersheds imperil the City of Sioux Falls. Flood events can be due to high rainfall events (common for Skunk Creek), snowmelt (typical of the Big Sioux River), or a combination of the two events. Due to the damage caused by flooding, the City of Sioux Falls and the Army Corps of Engineers initiated an analysis of possible flood control measures in the mid-1950's. This analysis triggered the construction of the flood control system on the Big Sioux River and Skunk Creek upstream and through the City.

The existing flood control system on the Big Sioux River was constructed between 1956 and 1961. This system includes a system of levee protection and floodwall along the historic channel (including a portion of Skunk Creek above the confluence of the Big Sioux River), a Diversion Dam, Diversion Channel and Spillway. The system includes approximately 29.2 miles of levees adjacent to the Big Sioux River, Big Sioux River Diversion Channel, Silver Creek, and Skunk Creek. The Diversion Channel traverses approximately 2.8 miles from the Diversion Dam structure to a 118-foot vertical drop back down to the historic channel at the base of the Spillway.

The intent of the system is to reroute flood flows in and around the City of Sioux Falls and contain these flows within the levee system. The system was designed based on a technical analysis completed in 1954. The initial project planned for design discharges of 24,400 cubic feet per second (cfs) on the Big Sioux River. The Skunk Creek system used a design discharge of 9,305 cfs.

The analysis, design, and construction of this system were coordinated under the United States Army Corps of Engineers (USACE) with involvement from the local and state levels. The City of Sioux Falls (City) by agreement is responsible for maintenance and operation of this system.

The system begins on the right bank of the Big Sioux River directly south of Interstate 90. The left bank levee begins north of Interstate 90 just west of SD Highway 115. The diversion dam and headwaters of the diversion channel are located in this area. Levee structures extend downstream on the Big Sioux River channel to South Western Avenue in the area of Interstate 229 and 57th Street. Topography and flood plane protection via zoning restrictions exist from Western Avenue downstream to Falls Park Drive. Levee protection was constructed from Falls Park Drive through the area of the confluence of the diversion channel outfall or spillway. The spillway outfall and stilling basin are located in the general area directly north of Rice Street and Weber Avenue encompassing the river frontage of the John Morrell Plant. The levee system extends downstream to a point between North Cliff Avenue and Interstate 229. A map is attached outlining the general features of the flood control system.

The existing flood control system design capacity (24,400 cfs for the Big Sioux River and 9,305 cfs for Skunk Creek) translates to protection for a 30-year flood event for the Big Sioux River and a 20-year flood event for the Skunk Creek reach.¹ Emergency flood fighting measures, such as those mobilized following the winter of 1996-97, provide additional protection. These measures include temporarily raising the headwalls of the diversion channel spillway, selective temporary dikes, sandbagging, and structure protection including erosion control or armor at drainage structures. Sections of the existing levee system are also raised one to three feet by placement of temporary embankment during these measures.

In the early 1990's the USACE at the City's request, initiated a Feasibility Study to analyze this system based on better-defined hydrologic data for the Big Sioux River and Skunk Creek basins. This study was also initiated due to the continued development in the southwestern area of the City that accentuated the benefits derived from the flood control system. Major retail and residential development in the area outlined by Maple Street to the north, 57th Street to the south, Kiwanis Avenue to the east, and Marion Road to the west, was a prime focal point for the improvements. The feasibility study was completed in 1994 and the City and the USACE proceeded to pursue funding for the *Big Sioux River and Skunk Creek Flood Control Project*.

The feasibility study identified the limitations of the existing flood control system based on eight major flood events chronicled since 1950. One of these events, the flood of 1969, was considered the 100-year event and therefore to be the standard against which the flood control improvements would be measured. The estimated discharge on the Big Sioux River for the 1969 flood event was approximately 40,000 cfs. Approximately 30,000 cfs was diverted into the diversion channel and discharged through the spillway chute. The remaining 10,000 cfs passed through the diversion dam and continued down the Big Sioux River channel.

Mathematical modeling was performed to recreate the 1969 event within the design criteria for the improvements. In addition, a scale hydraulic model was created at the USACE Waterways Experimentation Station in Vicksburg, Mississippi to review several improvement options. The results of these studies were included in the feasibility study. For design purposes on the Big Sioux River, the current 100-year event is determined to be 35,000 cfs at the diversion dam and 36,300 cfs at North Cliff Avenue. The 500-year event is determined to be 57,500 cfs at the diversion dam and 66,300 cfs at North Cliff Avenue. The flood of record in 1969 was determined to be 30,000 cfs.

The damage in the Sioux Falls area created by a 100-year event with the existing flood control system was estimated at \$186 million in 1992 dollars and with 1992 infrastructure.² Considerable development has occurred post-1992 including the Meadows on the River Development bounded by Skunk Creek, the Big Sioux River, 26th Street/Louise Avenue and 41st Street. In addition, continued development has occurred in the 41st Street Corridor including the area bounded by Western Avenue, I-29, I-229 and 41st Street. It could be conservatively estimated that the damage figure would be significantly increased when calculated in 2000 dollars and development.

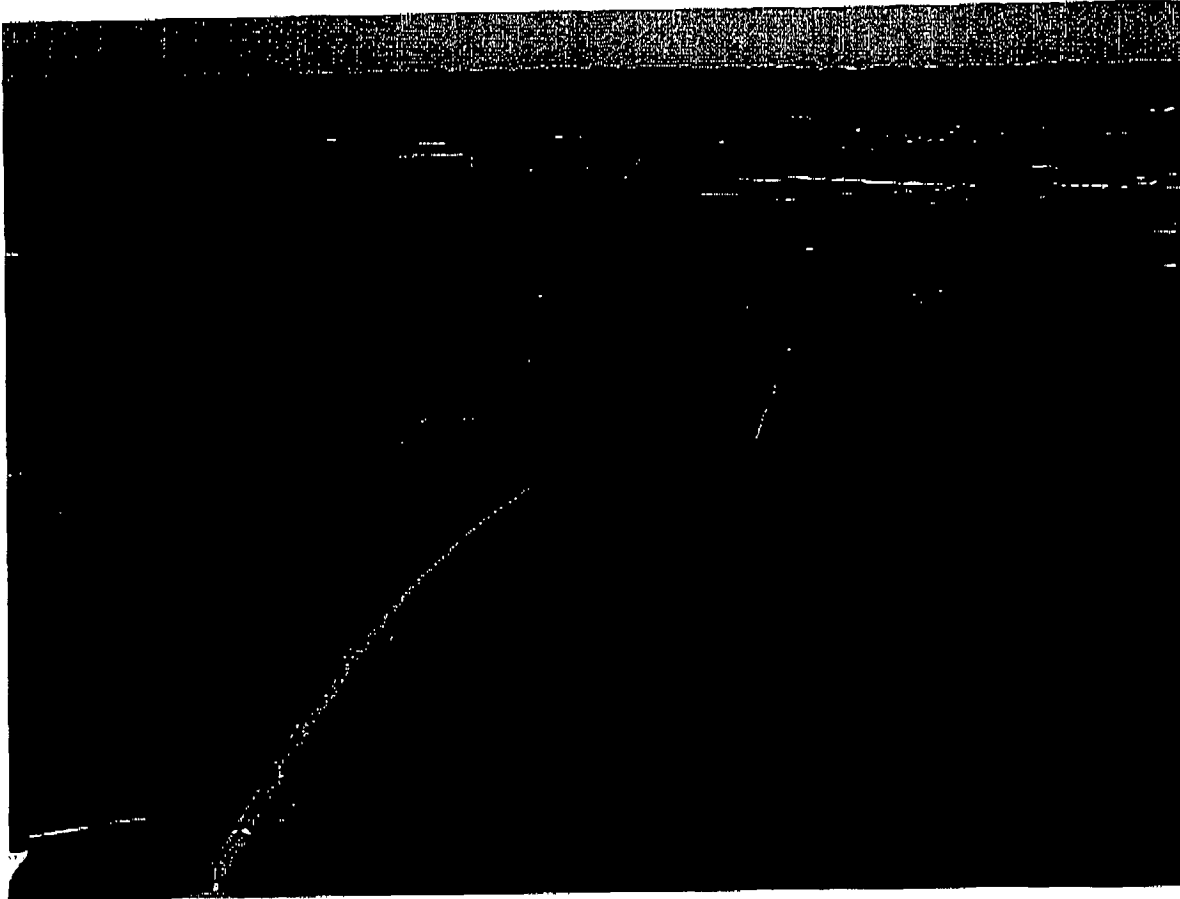
¹ Local Flood Protection, Big Sioux River and Skunk Creek at Sioux Falls, SD, November 1993.

² Op. Cit.

Flood Control Project

The Big Sioux River and Skunk Creek Flood Control Project consists of a series of levee improvements and flood control structure modifications identified in the 1994 Feasibility Study completed by the USACE. The USACE, soon after the completion of the Feasibility Study, initiated a contract to provide preliminary engineering including right-of-way impacts based on the issues identified within the Feasibility Study. This report, *Sioux Falls Flood Control Project Design Optimization Study—Big Sioux River, Skunk Creek and Diversion Channel*, was completed in March 2000 by HDR Engineering, Inc. The preliminary engineering included providing "10% Design Complete" drawings to aid in pursuing design and construction sequencing. The USACE and the City of Sioux Falls have completed review of this document.

As proposed in the Design Optimization Study, the project has been broken into three phases. Phases II and III were reversed at the request of the City. A map is attached that illustrates the proposed phasing of the flood control project.



Phase I

Phase I included improvements to the diversion channel spillway of raising the height of sidewalls, increasing capacity, and strengthening the structure by buttressing the sidewalls. Associated geotechnical work was also completed in and around the structure. The stilling

basin or the outfall of the spillway into the Big Sioux River channel was modified. Long-term maintenance on the existing spillway headwalls and floor were included as a part of this phase.

The right bank levee opposite of the spillway, adjacent to John Morrell & Co., was modified also. This levee was relocated approximately 100 feet southeast to improve the hydraulics of the stilling basin. Measures to preclude seepage under the right bank were also included in this phase.

Construction of improvements on Phase I were started in October 2000, and will be completed by December 2003. The costs of improvements completed under Phase I are \$6,100,000.

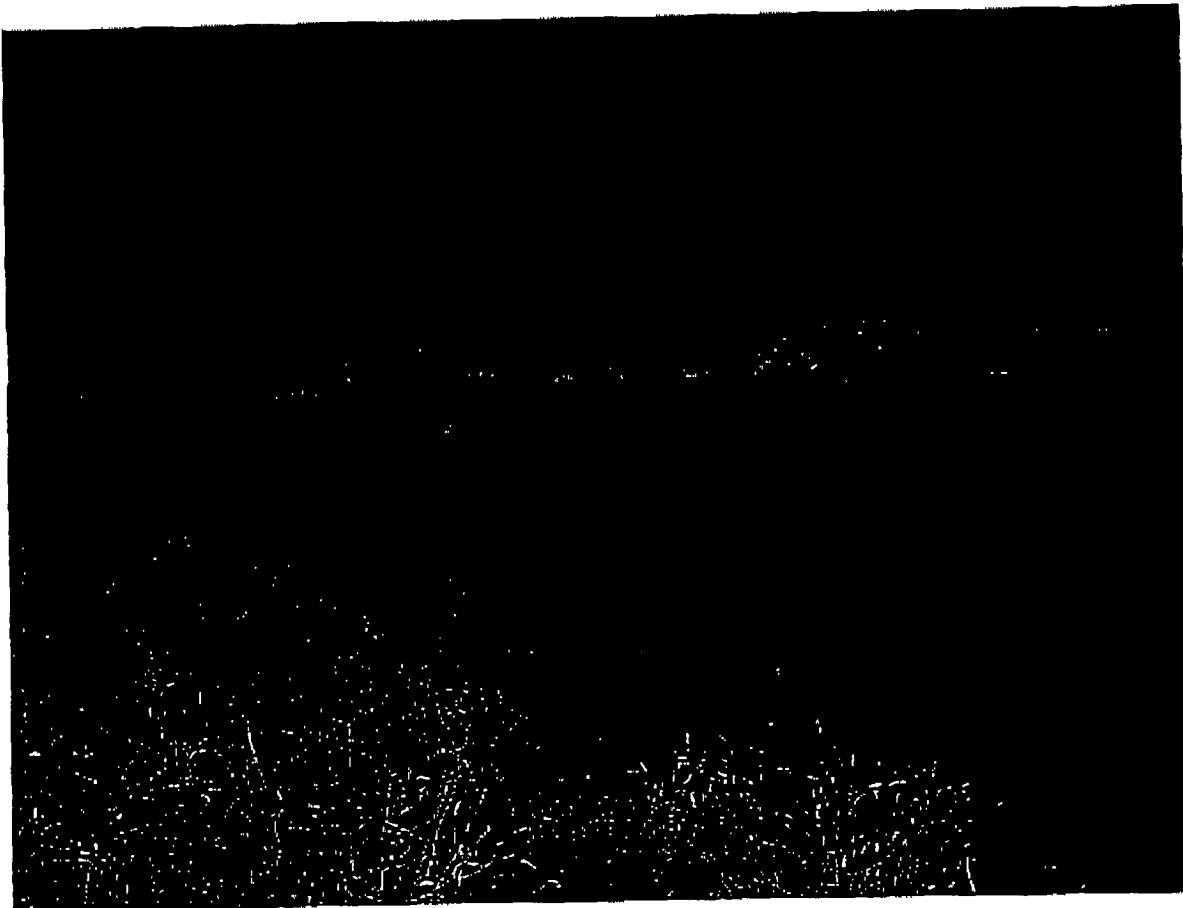


Phase II

Phase II includes levee improvements from Russell Street to Interstate 229 on the Big Sioux River and from Marion Road to the confluence of the Big Sioux River on Skunk Creek. Under seepage measures and surface drainage structure improvements are included with the project as well as modifications to the 41st Street and Marion Road bridges. The levee height in this area will require a rise of anywhere from 2 ft. to 6 ft. varying throughout both reaches addressed by this phase.

Areas of concern for under seepage in Phase II have been identified along the left bank just south of Russell Street and along the right bank about one half mile south of 12th Street in the area of Westward Ho Country Club and River Run Addition.

Construction of Phase II is scheduled for bidding in late 2003 with a completion in 2006. The current estimate of probable costs for Phase II is \$16,000,000.



Phase III

Phase III includes improvements to the levees on the Big Sioux River north of the diversion dam and on the diversion channel from the Big Sioux River to the spillway. Associated surface drainage structure modifications are included in this phase.

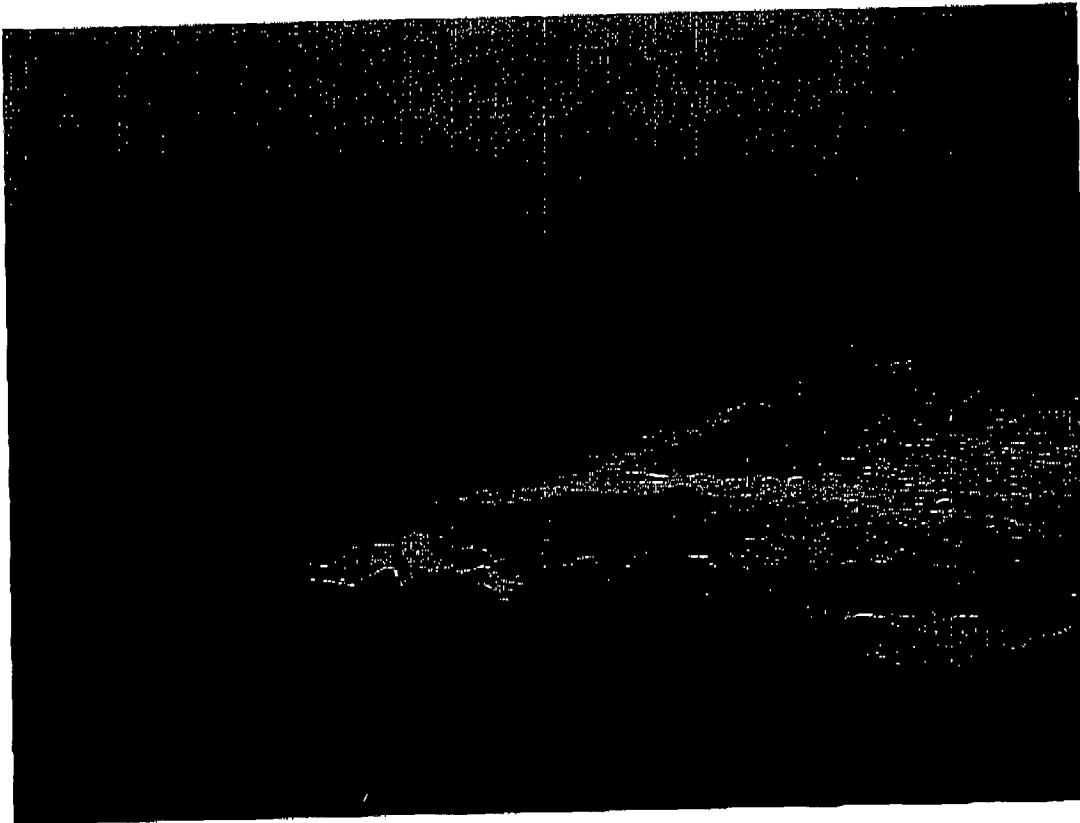
Under seepage studies are not completed for Phase III at this time. Any areas of concern will be addressed with the design of this phase.

With the construction of the original levee system, a segment of the left bank levee just north of the diversion dam was constructed as a designed overflow area (fuse plug). In the design of the system improvements, it has been determined that fuse plugs do not adequately address their designed intent. The original function of a fuse plug was to allow excess flow in an event greater than the system design to be diverted to an area where it would not do great damage to the inundated land. In the history of the USACE conduct of flood fights through the years, where fuse plugs have existed they have been armored to

prevent their designed function. With the improvements being made on Phase III, the fuse plug will be removed.

The estimated cost of Phase III is \$7,500,000. It is anticipated that the design will be complete in 2005 with construction being completed by mid 2006.

As each phase of the project is constructed, all land and/or easements required for that phase will be acquired prior to the bid letting for that phase. This is a requirement for the USACE and is a standard for the City. All land acquisition will follow federal standards for notification, appraisal and acquisition.



Operations and Maintenance

The proposed Big Sioux River Flood Control Project improvements would provide 100-year event protection on the Big Sioux River and Skunk Creek. At the completion of the project, the USACE will submit a Conditional Letter of Map Revision to the Federal Emergency Management Agency for the revision of the flood plane boundaries encompassed by the project. Also, the USACE will provide a new operation manual for the system. The operation manual will address the proper settings of the diversion dam in various flood events to minimize flooding of areas upstream of the system and the area along the Big Sioux River between Western Avenue and Falls Park Drive. The manual will give guidelines for the breach of the levee system if, during a flood event greater than the capacity of the system, the decision is made that a breach is needed to prevent a catastrophic, random failure.

The operation of the diversion dam gates has been of concern to the city and to upstream property owners since the original construction of the system. The current operations manual does not properly address the impacts of upstream flood elevations with regard to the operation of the gates. Only the requirement for river freeze conditions are addressed in the manual. The USACE has analyzed the impacts of the operation of the diversion dam gates on the flood elevation of the Big Sioux River upstream of the diversion dam. The results of the study were presented in their February 3, 2003 Memorandum to Files (see attached), and shows negligible impact in the 10-year event. However, the operation of the gates does impact upstream flood elevations in the 50-year and 100-year events. To minimize the upstream impacts, the city will follow the memorandum's recommendations and open the gates during floods at or greater than the 50-year event to allow 7,300 cubic feet per second flow through the dam. For gate operation during floods between the 10-year and 50-year events, the city will attempt to allow a proportional amount to flow through the dam.

Proper maintenance of the levee system will also be included in the manual. Required maintenance procedures will include mowing and maintenance of proper ground cover, undesirable vegetation control, burrowing animal control and periodic inspection procedures along with other prescribed maintenance procedures.

Flood Authorization and Funding

The existing flood control project was authorized under the Public Law 780, 83rd Congress, dated September 3, 1954. The feasibility study for the flood control project improvements was authorized by an August 1, 1963 resolution of the Committee on Environment and Public Works of the U.S. Senate and by a May 8, 1964 resolution of the Committee on Public Works and Transportation of the U.S. House of Representatives. The feasibility study was funded by both Federal and non-Federal sources in accordance with the provisions of the Water Resources Development Act of 1986. The non-Federal sponsors of the project are the City of Sioux Falls and the State of South Dakota.

The acceptance of the feasibility study initiated requests for funding under the Flood Control Act of 1970, as amended under Public Law 91-611 and the Water Resources Development Act of 1986, as amended under Public Law 99-662. Section 902 of Public Law 99-662 established the maximum amount of costs and cost sharing and established the **Big Sioux River and Skunk Creek Flood Control Project**. The maximum amount was subsequently amended to \$40,600,000 with the non-Federal sponsor contributing a minimum of 25% or \$10,300,000. The State of South Dakota committed to the non-Federal cost share with the City of Sioux Falls by obligating \$4,550,000 under the Session Laws of 1992, Chapter 254, Section 17. A new start appropriation of \$2,200,000 was approved by U.S. Congressional action in FY 2000. The House Appropriations Subcommittee on Energy and Water Development approved the fiscal year 2001 Energy and Water Appropriations Act in June 2000. This action, following release of the legislation, appropriates an additional \$1.5 million of federal funding to the Big Sioux River and Skunk Creek Flood Control Project.

The appropriations received recently enable the City of Sioux Falls to release the obligational authority it has been budgeting since 1994. Work is nearing completion for Phase I. Design is proceeding on Phases II and III. Further appropriations will be required to pursue construction of these phases.

Federal Emergency Management Agency and Flood Insurance Rate Map

The March 1979 Flood Insurance Study for Sioux Falls and vicinity reported that the existing project protected Sioux Falls from floods in excess of the 100-year event on the Big Sioux River and at approximately the 25-year level on Skunk Creek. In 1982, the Federal Emergency Management Agency (FEMA) released its Flood Insurance Rate Maps (FIRM) for Sioux Falls.

During September 1987, FEMA was notified of the Corps' study results stating that the existing project provides inadequate flood protection for Sioux Falls. Because FEMA administers the National Flood Insurance Program, it is FEMA's responsibility to ensure that the FIRM for Sioux Falls reflects the current flood hazard. At that time, FEMA decided not to reevaluate the Sioux Falls area until the existing project had been modified or a decision was made not to modify the existing project.

The City of Sioux Falls met with Dr. John Liou of FEMA in March 2000. FEMA had prepared a draft FIRM map under the 1992 base city map utilizing the data from the Feasibility Report and Engineering Appendices for **Local Flood Protection, Big Sioux River and Skunk Creek at Sioux Falls, South Dakota** dated November 1993, the **Big Sioux River Model Study CHL-97-18** dated July 1997 and the **USACE Hydraulic Design Criteria**.

Several problems and issues are inherent in the draft FIRM as presented. Base mapping does not reflect the more accurate elevation and infrastructure data currently available with the City of Sioux Falls Geographic Information System (GIS) database including updated aerial photography and base mapping. Elevation datum based on the hydrologic model dictates actual FIRM application and administration within the City. This has and continues to be the policy of the City. The mapping provided within FIRM serves as the reference for the public and systematic land use planning. However, with the problems inherent with the "dated" base mapping, as well as the accuracy of the mapping with respect to infrastructure and elevation datum, the FIRM map as presented provides an inaccurate "picture" of flood hazard. In addition, with the initiation of the Big Sioux River Flood Control Project, it is likely the FIRM would be in a state of flux as improvements are constructed during the phased implementation of the project. Basically, FEMA proposed initiation of the FIRM as if a decision had been made "not to modify the existing project."

Administratively, reissuance and continual updating of the FIRM would be expensive and confusing. Therefore, recommendations were made and accepted by FEMA to explore the option of updating the base mapping consistent with the City of Sioux Falls GIS database. Recommendations also included the delay of formal implementation of the FIRM until completion of Big Sioux River Flood Control Project. Implementation of the FIRM could be reevaluated on an annual basis as the status of funding and phase completion dates become more accurate. Under this scenario, elevation control would still apply for application of flood rates but revised FIRM distribution would be delayed until the Big Sioux River and Skunk Creek Flood Control Project improvements are in place. It is critical, however, for the City of Sioux Falls to disclose the basis for administration of the FEMA mapping and to hold public hearings in conjunction with FEMA outlining the program.

At the completion of all work on the flood control system, it is the city's intent to work with the USACE to provide all required information to FEMA and apply for a LOMR for the entire area encompassed by the system as well as the area along the Big Sioux River from Interstate 229 at the end of Phase II to Falls Park Drive where the levee system resumes. It is anticipated that at that time, the city will have an up to date and accurate FIRM.

Enclosed with this application are a location map, Seepage Analysis Report, 100-Year Flood Boundaries Maps and associated tables, the May 9, 2002 US Army Corps of Engineers Memorandum for Files as revised January 2003, and the February 3, 2003 US Army Corps of Engineers Memorandum for Files.



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

PMB 2020
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182
www.state.sd.us/denr

June 4, 2003

Mike Williams
5901 Ditch Road
Sioux Falls SD 57104

Paul Evenson
47482 258th St.
Renner SD 57055

Lloyd Siemonsma
6200 N. Kiwanis
Sioux Falls SD 57107

Harlan Wehde
27641 476th Ave.
Garretson SD 57030

Gentlemen:

The city of Sioux Falls has applied for a flood control permit for improvements to the existing flood control system. I am providing information on this application to Mr. Williams who in the past has expressed concerns over the project. Mr. William also gave me your names as members of the Mapleton Township Board who may be interested in this application. Specifically, enclosed is a copy of the report, recommendation and public notice prepared on the application.

The notice of hearing will be published in the Argus Leader on June 11 and 18, 2003. The notice schedules a hearing before the Water Management Board at their July 10, 2003 meeting. Petitions to intervene from anyone desiring to participate in the hearing must be submitted by June 30, 2003.

If you have any questions, please feel free to Don Stroup or myself.

Sincerely,


Eric Gronlund
Water Rights Program, DENR
(605) 773-3352
eric.gronlund@state.sd.us

enclosures



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

PMB 2020
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June 4, 2003

Leslie Petersen
SD Dept. of Game, Fish and Parks
523 E. Capitol Avenue
Pierre SD 57501

Dear Leslie:

The city of Sioux Falls has applied for a flood control permit for improvements to the existing flood control system. Enclosed is a copy of the report, recommendation and public notice prepared on the application.

The notice of hearing will be published in the Argus Leader on June 11 and 18, 2003. The notice schedules a hearing before the Water Management Board at their July 10, 2003 meeting. If GF&P desires to participate in the hearing, petitions to intervene must be submitted by June 30, 2003.

This information is being sent to you to keep GF&P apprised of this project that involves the Big Sioux River. If you have any questions, please feel free to Don Stroup or myself.

Sincerely,

Eric Gronlund
Water Rights Program, DENR
(605) 773-3352
eric.gronlund@state.sd.us

enclosures

AFFIDAVIT OF PUBLICATION-
Customer Number: 078340
Invoice Number: 17620

Dept of Environment

Argus Leader AFFIDAVIT OF PUBLICATION

STATE OF SOUTH DAKOTA

COUNTY OF MINNEHAHA } ss

Vicki Kiel being duly sworn, says: That The Argus Leader is, and during all the times hereinafter mentioned was, a daily legal newspaper as defined by SDCL 17-2-21, as amended published at Sioux Falls, Minnehaha County, South Dakota; that affiant is and during all of said times, was an employee of the publisher of such newspaper and has personal knowledge of the facts stated in this affidavit; that the notice, order or advertisement, a printed copy of which is hereto attached, was published in said newspaper upon

Wednesday, the 11 day of June 2003

Wednesday, the 18 day of June 2003

_____, the _____ day of _____ 2003

_____, the _____ day of _____ 2003

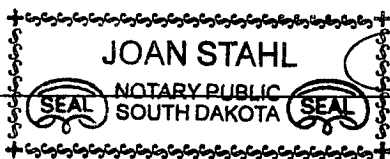
_____, the _____ day of _____ 2003

_____, the _____ day of _____ 2003

_____, the _____ day of _____ 2003

and that \$245.49 was charged for publishing the said including A \$5.00 affidavit fee,

Vicki Kiel
Subscribed and sworn to before 6/18/2003



Joan Stahl
Notary Public, So

My Commission expires June 30th, 2005

chute walls, the still basing walls, the approach walls and providing buttressing to the chute walls. This phase also includes setting bank of the existing stilling basin right bank levee downstream of the spillway chute and raising a portion of the levee in order to provide a smoother transition curve to improve flow. This phase is located in Section 9, T101N, R49W.

Phase II involves both banks of the Big Sioux River from south of the I-229 bridge to Russell Street and both banks of Skunk Creek from Marion Road east to the Big Sioux River. Work will consist of elevating and strengthening levees and adding flood walls plus levee seepage corrective measures. Work also includes elevating and lengthening the Marion Road Bridge and elevating the 41st Street Bridge.

Phase III involves both banks of the diversion channel, the levee on the east side of Silver Creek north of the diversion channel to just west of North Cliff Ave, and levees on the west bank of the Big Sioux River from the diversion dam to just south of I-90. Work will consist of elevating and strengthening levees, adding flood walls and levee seepage corrective measures.

NOTICE OF HEARING on Application No. FC-30 for a Flood Control Permit

Notice is given that the city of Sioux Falls, c/o Mayor Dave Munson, 224 West 9th Street, Sioux Falls, SD 57104 has filed an application for a permit for improvements to the existing flood control system located within the corporate limits of Sioux Falls in Minnehaha County. The system reroutes and contains within levees the Big Sioux River and Skunk Creek flood flows. The existing system was designed and constructed between 1956 and 1965 to provide protection in excess of the 100-year storm event along the Big Sioux River and Skunk Creek based on the limited hydrological data available at the time. The flood control system consists of a diversion dam, diversion channel, weir, spillway chute, stilling basin, levee overflow plug, and levees along the Big Sioux River natural channel, Skunk Creek and the diversion channel. The original project was constructed prior to the state of South Dakota having a flood control permitting process. Sioux Falls has applied for a flood control permit for improvements to the system to again provide protection in excess of 100-year flood event. The modified flood control system is to be designed to provide protection for the 100-year flood event as defined by the US Corps of Engineers. The 100-year flood event has been redefined based on more complete hydrologic data since more years of record are available than were used during original design. The updated 100-year flood event for the Big Sioux River is 36,300 cubic feet of water per second (cfs) at North Cliff Avenue and 23,500 cfs for Skunk Creek.

Pursuant to SDCL 46-2A-2, the Chief Engineer recommends APPROVAL of Application No. FC-30 with qualifications because 1) the project will not increase the likelihood or severity of flood damages, 2) will not endanger human life or property, 3) will not impair existing water rights, and 4) is in the public interest to provide flood control within the highly developed areas of Sioux Falls.

Any person interested in opposing or supporting this application must file a written petition with BOTH the applicant and Chief Engineer. The applicant must also file a petition opposed to the Chief Engineer's recommendations. The Chief Engineer's address is given above. A petition filed by either an interested person or the applicant must be filed by June 30, 2003. The petition may be informal, but must include a statement described the petitioner's interest in the application, the petitioner's reasons for opposing or supporting the application, and the signature and mailing address of the petitioner or the petitioner's legal counsel, if legal counsel is obtained.

The Water Management Board will consider this application at 1:30 PM, July 10, 2003 in the Matthew Training Center, Foss Building, 523 E. Capitol Ave., Pierre, SD. The agenda time is an estimate. The Chief Engineer's recommendation is not final or binding upon the Board. The Board is authorized to 1) approve all or portions of application, 2) approve with qualifications, 3) defer, or 4)

deny this application based on the facts presented at the public hearing. The July 10, 2003 hearing date will be automatically delayed for at least 20 days upon written request to the Chief Engineer from the applicant or any interested person opposing the application. The request for an automatic delay must be filed by June 30, 2003.

Any hearing may be an adversarial proceeding. Any person filing a petition and/or the applicant have the right to be represented by a lawyer and may present evidence or cross-examine witnesses according to SDCL 1-26. This and other due process rights will be forfeited if not exercised. Decisions of the Board may be appealed to the Circuit Court and State Supreme Court as provided by law. Contact Eric Gronlund by June 30, 2003, at the above Water Rights Program address to request copies of information pertaining to this application, to assure access to the hearing by the handicapped or to obtain an interpreter for the hearing impaired.

Since this application does not involve a momentary controversy in excess of \$2,500.00 or termination of a property right in accordance with SDCL 1-26-18.3, the Chief Engineer has determined this contested case may not be referred to the Office of Hearing Examiners. If any party disagrees with this determination, the Chief Engineer shall be notified by June 30, 2003.

This application is made pursuant to SDCL 46-1-1 thru 46-1-9, 46-1-12 thru 46-1-16; 46-2-3.1, 46-2-9, 46-2-11, 46-2-13, 46-2-17; 46-2A-1 thru 46-2A-12, 46-2A-14, 46-2A-15, 46-2A-20, 46-2A-21; 46-5-1 thru 46-5-11, 46-5-13 thru 46-5-15, 46-5-24, 46-5-25, 46-5-30.2, 46-5-30.4, 46-5-31, 46-5-47, 46-5-48 and Board Rules ARSD 74:02:01:01 thru 74:02:01:15. Steven Pirner, Department of Environment and Natural Resources. 17620 June 11, 18, 2003

RECEIVED

JUN 23 2003

WATER RIGHTS
PROGRAM

Instruction to Newspaper - Publish first Notice on June 11, 2003 with the second publication 7 days later. The applicant is responsible for payment.

NOTICE OF HEARING on Application No. FC - 30 for a Flood Control Permit

Notice is given that the city of Sioux Falls, c/o Mayor Dave Munson, 224 West 9th Street, Sioux Falls SD 57104 has filed an application for a permit for improvements to the existing flood control system located within the corporate limits of Sioux Falls in Minnehaha County. The system reroutes and contains within levees the Big Sioux River and Skunk Creek flood flows. The existing system was designed and constructed between 1956 and 1965 to provide protection in excess of the 100-year storm event along the Big Sioux River and Skunk Creek based on the limited hydrological data available at the time. The flood control system consists of a diversion dam, diversion channel, weir, spillway chute, stilling basin, levee overflow plug, and levees along the Big Sioux River natural channel, Skunk Creek and the diversion channel. The original project was constructed prior to the state of South Dakota having a flood control permitting process.

Sioux Falls has applied for a flood control permit for improvements to the system to again provide protection in excess of the 100-year flood event. The modified flood control system is to be designed to provide protection for the 100-year flood event as defined by the US Corps of Engineer. The 100-year flood event has been redefined based on more complete hydrologic data since more years of record are available than were used during original design. The updated 100-year flood event for the Big Sioux River is 36,300 cubic feet of water per second (cfs) at North Cliff Avenue and 23,500 cfs for Skunk Creek.

The legal description of the project area includes sections within T101N, R49W; T101N, R50W and T102N, R49W. The project is to be completed in 3 phases.

Phase I includes raising the diversion channel spillway chute walls, the still basing walls, the approach walls and providing buttressing to the chute walls. This phase also includes setting back of the existing stilling basin right bank levee downstream of the spillway chute and raising a portion of the levee in order to provide a smoother transition curve to improve flow. This phase is located in Section 9, T101N, R49W.

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A copy of the application or the Water Rights Program's staff report which more completely describes the project may be obtained by contacting the Water Rights Program, Department of Environment and Natural Resources, 523 E. Capitol Avenue, Pierre SD 57501 (605 773-3352).

(continued)

Pursuant to SDCL 46-2A-2, the Chief Engineer recommends APPROVAL of Application No. FC - 30 with qualifications because 1) the project will not increase the likelihood or severity of flood damages, 2) will not endanger human life or property, 3) will not impair existing water rights, and 4) is in the public interest to provide flood control within the highly developed areas of Sioux Falls.

Any person interested in opposing or supporting this application must file a written petition with BOTH the applicant and Chief Engineer. The applicant must also file a petition if opposed to the Chief Engineer's recommendations. The Chief Engineer's address is "Water Rights Program, Foss Building, 523 E Capitol, Pierre SD 57501 (605 773-3352)" and the applicant's mailing address is given above. A petition filed by either an interested person or the applicant must be filed by June 30, 2003. The petition may be informal, but must include a statement describing the petitioner's interest in the application, the petitioner's reasons for opposing or supporting the application, and the signature and mailing address of the petitioner or the petitioner's legal counsel, if legal counsel is obtained.

The Water Management Board will consider this application at 1:30 PM., July 10, 2003 in the Matthew Training Center, Foss Building, 523 E Capitol Ave., Pierre, SD. The agenda time is an estimate. The Chief Engineer's recommendation is not final or binding upon the Board. The Board is authorized to 1) approve all or portions of application, 2) approve with qualifications, 3) defer, or 4) deny this application based on the facts presented at the public hearing. The July 10, 2003 hearing date will be automatically delayed for at least 20 days upon written request to the Chief Engineer from the applicant or any interested person opposing the application. The request for an automatic delay must be filed by June 30, 2003.

Any hearing may be an adversarial proceeding. Any person filing a petition and/or the applicant have the right to be represented by a lawyer and may present evidence or cross-examine witnesses according to SDCL 1-26. This and other due process rights will be forfeited if not exercised. Decisions of the Board may be appealed to the Circuit Court and State Supreme Court as provided by law. Contact Eric Gronlund by June 30, 2003, at the above Water Rights Program address to request copies of information pertaining to this application, to assure access to the hearing by the handicapped or to obtain an interpreter for the hearing impaired.

Since this application does not involve a monetary controversy in excess of \$2,500.00 or termination of a property right in accordance with SDCL 1-26-18.3, the Chief Engineer has determined this contested case may not be referred to the Office of Hearing Examiners. If any party disagrees with this determination, the Chief Engineer shall be notified by June 30, 2003.

This application is made pursuant to SDCL 46-1-1 thru 46-1-9, 46-1-12 thru 46-1-16; 46-2-3.1, 46-2-9, 46-2-11, 46-2-13, 46-2-17; 46-2A-1 thru 46-2A-12, 46-2A-14, 46-2A-15, 46-2A-20, 46-2A-21; 46-5-1 thru 46-5-11, 46-5-13 thru 46-5-15, 46-5-24, 46-5-25, 46-5-30.2, 46-5-30.4, 46-5-31, 46-5-47, 46-5-48 and Board Rules ARSD 74:02:01:01 thru 74:02:01:15. Steven Pirner, Secretary, Department of Environment and Natural Resources.



DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES

PMB 2020
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182
www.state.sd.us/denr

June 3, 2003

Argus Leader
PO Box 5034
Sioux Falls SD 57117-5034

ATTENTION: Legal Public Notice

Enclosed is a Notice of Hearing on Application No. FC-30 to Appropriate Water to be published twice. Please publish the first notice on June 11, 2003 with the second publication 7 days later.

The applicant must verify to you that the notice is to be published, before you make the first publication. **Please BILL the APPLICANT for the cost of publication.** The APPLICANT is City of Sioux Falls, % Tom Berkland, 224 W. 9th St., Sioux Falls SD 57102 (Ph # 605-367-7048).

Please send the Water Rights Program the first publication immediately. The publication is checked for accuracy so any corrections can be made in the second publication. You may use the form below or fax a copy of the first publication. Any fax should be sent to the attention of Karen Schlaak at (605) 773-4068. Publication errors can invalidate the public notice.

After the second publication, **please send us an affidavit or use the enclosed Proof of Publication form.** The applicant pays the cost of publication, but the Water Rights Program records require an affidavit or Proof of Publication. Delays in receiving the affidavit can be costly to the applicant.

Sincerely,

Eric Gronlund
Natural Resources Engineer
605 773-3352

enclosures

-----CUT HERE-----

No. FC-30

TO: Eric Gronlund
Water Rights Program
Joe Foss Building
Pierre SD 57501-3181

Date _____

We are in receipt of your letter of June 3, 2003 enclosing Notice of Hearing to Appropriate Water by Application No. FC-30 which was first published in our issue of _____. **ENCLOSED IS A COPY OF THIS FIRST PUBLICATION.**

Name

Newspaper



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

PMB 2020
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182

www.state.sd.us/denr

**NOTE: TO BE SURE OF PUBLICATION ON
THE CORRECT DATES, CONTACT
THE NEWSPAPER RIGHT AWAY.**

June 3, 2003

City of Sioux Falls
% Tom Berkland
224 W 9th St
Sioux Falls SD 57102

Dear Mr. Berkland:

Water Permit Application No. FC-30 for flood control project use has been examined and found to comply with the South Dakota Water Laws and applicable rules. A notice of hearing has been sent to the Publisher of the Argus Leader printed at Sioux Falls, SD (Ph # 605-331-2200). You will need to contact the newspaper and authorize publication of this notice. For your information, a copy of the notice, the recommendation of the Chief Engineer and a report on the application are enclosed. Please review the notice prior to publication and notify this office, if you have any corrections or questions.

Be sure to contact the above newspaper to authorize publication of your Notice of Hearing and to arrange for payment. Early contact with the paper can eliminate delays. Upon receiving authorization, the publisher has been instructed to publish your notice once each week for two consecutive weeks with the last publication to occur twenty days before the board meeting. The newspaper has also been instructed to send us the Proof of Publication. We must receive Proof of Publication before action can be taken on the application.

Sincerely,


Eric Gronlund
Natural Resources Engineer
(605) 773-3352

enclosures

NOTE: If you plan to contest any part of the Chief Engineer's recommendation, you must file a petition pursuant to the procedures outlined in the attached notice of hearing. The Water Management Board will then consider your concerns during a hearing on the application.



AUG 28 2003

**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

PMB 2020
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182
www.state.sd.us/denr

City of Sioux Falls
% Tom Berkland
224 W 9th St.
Sioux Falls SD 57102

Dear Mr. Berkland:

Enclosed is Flood Control Permit No. FC-30 as approved by the Water Management Board. Please note that the city has five (5) years to complete construction of the flood control works. However, with a project of this magnitude there are provisions in law to request an extension of time if works are not completed by July 10, 2008. If you have any questions pertaining to the permit, please contact this office.

Sincerely,

Garland Erbele, Chief Engineer
Water Rights Program
(605) 773-3352

Enclosure

November 25, 2003

Planning, Programs and Project Management Division

Mr. Tim Tollefsrud
South Dakota Department of Environment and
Natural Resources
Division of Environmental Services
523 East Capitol Avenue
Joe Foss Building
Pierre, South Dakota 57501

Dear Mr. Tollefsrud :

In November of 1993, the U.S. Army Corps of Engineers (Corps) completed an integrated Feasibility Study (FS) and Environmental Assessment (EA) for the purpose of evaluating the feasibility of raising the level of flood protection and recommending a project for construction that is economically feasible, environmentally acceptable, and technically adequate for Sioux Falls, South Dakota. The project was developed in partnership with the City of Sioux Falls and was split into three phases (I, II, and III). Phases I and II are in various stages of design and construction.

As part of Phase II of the existing flood protection project, the Corps is preparing a supplemental Environmental Impacts Analysis (EIA) to the integrated FS and EA completed in 1993. Phase II of the project was divided into Phase IIA and IIB because of realty acquisition, funding, and execution schedules. Phase IIA begins upstream of the Skunk Creek confluence and continues to Russell Street on the Big Sioux River. Phase IIB includes a portion on Skunk Creek from Marion Road to the confluence with the Big Sioux River and continues downstream on the Big Sioux River to Western Avenue. The supplemental EIA would describe the replacement of the 41st Street Bridge and the construction of an inflatable dam just above the confluence of Skunk Creek and the Big Sioux River, and account for the environmental effects caused by the changes to the original plan. A map of the Big Sioux River & Skunk Creek Flood Control Project is enclosed.

The 41st Street Bridge is part of an east-west thoroughfare located approximately 20 blocks south of the Big Sioux River and Skunk Creek confluence in southeast Sioux Falls. The original plan for the 41st Street Bridge was to have it remain at its existing height, build closure structures, and raise levees upstream to provide the necessary flood protection. Recent detailed structural analysis of the bridge revealed that hydraulic conditions make it necessary to raise or replace the 41st Street Bridge to allow the flood protection project to function properly. The City of Sioux Falls proposes to completely replace the 41st Street Bridge at a higher elevation with the same number of piers. Replacement of the piers would require work within the channel of the Big Sioux River. Although the Corps would not be replacing the bridge, the Corps flood

protection project necessitates replacement of the bridge. Therefore, the Corps has decided to include it in the EIA.

A railroad bridge is located upstream of the confluence with Skunk Creek, approximately $\frac{1}{4}$ mile upstream from 12th Street. New surveys were obtained in early spring of 2003 to determine exact low chord and high chord elevations of the railroad bridge. Water surface depths were computed using Hydrologic Engineering Center – River Analysis System (HEC-RAS). A depth-duration analysis was completed to determine the amount of time that water would be at, on, or above the railroad bridge. Under the new with project conditions, water would be against but not overtopping the railroad bridge for approximately 7.8 hours for the 100-year event. Without the new project conditions, water would be against but not overtopping the railroad for approximately 6.0 hours for the 100-year event. There is an increase of approximately 0.37 feet in the water surface and an increase of approximately 1.8 hours in duration at the bridge for the 100-year event with the new project in place.

The Corps has considered various alternatives to rectify the situation. A structure to prevent backflow into the Big Sioux River just upstream from the confluence with Skunk Creek provides the best overall solution. It eliminates the need for Phase IIA design, construction, and realty acquisition. The structure would also eliminate impacts to the railroad, and eliminate the need for special grading at Westward Ho Country Club and Minnehaha Country Club. Construction cost savings realized from the elimination of levee work and right-of-way acquisition upstream of the structure, especially if a new railroad bridge would be required, would offset additional construction costs for a new structure.

We request that your agency provide us with comments and/or suggestions regarding the potential environmental impacts and their minimization, permit and/or approval requirements, and potential design parameters. We also request your office give special consideration to any resources or actions particularly pertaining to your agency's authority or expertise. Please provide your comments no later than December 22, 2003.

If you have any questions or require additional information, please contact Ms. Lauren Deane at (402) 221-3803.

Sincerely,

Candace M. Gorton
Chief, Environmental, Economics and
Cultural Resources Section
Planning Branch



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182
www.state.sd.us/denr

July 27, 2004

Candace M. Gorton
Planning, Programs and Project Management Division
US Army Corps of Engineers, Omaha District
106 South 15th Street
Omaha NE 68102

Dear Ms. Gorton:

I am in writing in response to your letter regarding the upgrade to the Sioux Falls Flood Control Project addressed to Tim Tollefsrud on November 25, 2003. Lauren Deane with your office contacted DENR inquiring whether a response was sent. To my knowledge DENR never received your letter until it was faxed to us on July 16, 2004.

The City of Sioux Falls in partnership with the Corps of Engineers is undertaking an upgrade of the existing flood protection project. DENR has reviewed the proposed project and provides the following comments and recommendations:

1. The City of Sioux Falls applied for and obtained South Dakota Flood Control Permit No. FC-30 in 2003 authorizing improvements to the existing flood control system. DENR conducted a thorough review of the hydrologic and geotechnical analyses performed and found the project will not increase the likelihood or the severity for flood damages in areas other than the project area or the area proposed to be benefited, that the project will not endanger human life or property, nor impair existing rights. A copy of Permit No. FC-30 is enclosed.

Your letter describes an inflatable dam to prevent backflow under certain conditions. This component of the project was not part of the application that was approved. Therefore, the impacts of the inflatable dam were not analyzed and it is not part of the approved permit. DENR requests that hydrologic analyses be conducted and submitted for review which includes the inflatable dam component. Engineering change notices may be allowed under the existing permit if the appropriate updated analysis is provided for review and approval by the Chief Engineer.

2. This segment of the Big Sioux River is classified by the South Dakota Surface Water Quality Standards and Uses Assigned to Streams for the following beneficial uses:

- (1) Domestic water supply waters;
- (5) Warmwater semipermanent fish life propagation waters;
- (7) Immersion recreation waters;
- (8) Limited contact recreation waters;
- (9) Fish and wildlife propagation, recreation, and stock watering waters; and
- (10) Irrigation waters.

Because of these beneficial uses, special construction measures may have to be taken to ensure that the total suspended solids standard of 90 mg/L is not violated.

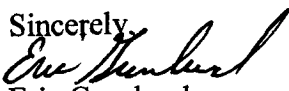
Skunk Creek is classified by the South Dakota Surface Water Quality Standards and Uses Assigned to Streams for the following beneficial uses:

- (6) Warmwater marginal fish life propagation waters;
- (8) Limited contact recreation waters;
- (9) Fish and wildlife propagation, recreation, and stock watering waters; and
- (10) Irrigation waters.

Because of these beneficial uses, special construction measures may have to be taken to ensure that the total suspended solids standard of 150 mg/L is not violated.

3. Wetlands may be impacted by the project. Wetlands are considered water of the state and are protected under the South Dakota Surface Water Quality Standards. The discharge of pollutants from any source, including indiscriminate use of fill material, may not cause destruction or impairment to water of the state except where authorized under Sections 402 and 404 of the Federal Water Pollution Control Act.
4. Coverage under the General Permit for Storm Water Discharges Associated with Construction Activities must be obtained for this project since more than one acre of land will be disturbed during construction. The permit request development and implementation of a storm water pollution prevention plan prior to the start of activities. For more information on storm water permitting, please contact Stacy Reed at 1-800-SDSTORM (737 8676) or visit www.state.sd.us/stormwater.

Thank you for contacting DENR to ensure that environmental issues are addressed. If you have any questions, feel free to contact me at (605) 773-3352.

Sincerely,

Eric Gronlund
Water Rights Program, DENR
(605) 773-3352

enclosure

**SOUTH DAKOTA
FLOOD CONTROL PERMIT NO. FC-30**

Date of first receipt of application May 8, 2003.

The Water Management Board approved Flood Control Permit No. FC-30 on July 10, 2003 for the City of Sioux Falls, 224 W 9th St, Sioux Falls SD 57102 subject to the following limitations, conditions and qualifications:

1. Flood Control Permit No. FC-30 authorizes improvements to the existing flood control system located within the corporate limits of Sioux Falls in Minnehaha County. The flood control system will be designed to provide protection for the 100-year flood event as defined by the US Corps of Engineer. The legal description of the project area includes sections within T101N, R49W; T101N, R50W and T102N, R49W. The project is to be completed in 3 phases (see public notice and report on No. FC-30 for a full description of project).
2. The date from which applicant may claim right is May 8, 2003.
3. All construction is to be completed on or before July 10, 2008.

QUALIFICATIONS

1. The City of Sioux Falls is responsible for operation and maintenance of the flood control works.
2. Flood Control Permit No. FC-30 is subject to securing easements and/or land acquisitions on any areas, other than city property, where construction activities will take place or additional lands are flooded. These documents shall be held by the city of Sioux Falls and be available for review by the Water Rights Program.
3. Prior to construction of Phase II and III, final designs for that phase shall be submitted to the Chief Engineer of the Water Rights Program for review and approval.
4. Engineering change notices, software calibrations or other calculations that effect water surface elevations or seepage analysis data previously submitted are subject to review and approval by the Chief Engineer.
5. Design of all levees in Phases II and III shall include measures to reduce uplift pressures to result in an exit gradient not to exceed 0.8 at the landward levee toe, to satisfy criteria in EM 1110-2-1901, Seepage Analysis and Control for Dams.
6. The Operation and Maintenance (O & M) Manual for the system shall be completed by the US Army Corps of Engineers upon completion of construction. The manual shall set forth criteria for operation of the diversion dam in various flood events. The manual shall provide guidelines for the controlled breach of the levee system if a breach is needed to prevent a catastrophic, random failure. The operating manual is subject to review and approval by the Chief Engineer.
7. The Water Management Board retains jurisdiction of Flood Control Permit No. FC-30 in the event that additional information shows this project causes an increase in the severity of flood damages in areas other than the project area.

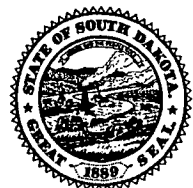
WATER MANAGEMENT BOARD

By: Garland Erbele

Garland Erbele, Chief Engineer
Water Rights Program
Department of Environment and Natural Resources

AUG 28 2003

date



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4. Engineering change notices, software calibrations or other calculations that effect water surface elevations or seepage analysis data previously submitted are subject to review and approval by the Chief Engineer.
5. Design of all levees in Phases II and III shall include measures to reduce uplift pressures to result in an exit gradient not to exceed 0.8 at the landward levee toe, to satisfy criteria in EM 1110-2-1901, Seepage Analysis and Control for Dams.
6. The Operation and Maintenance (O & M) Manual for the system shall be completed by the US Army Corps of Engineers upon completion of construction. The manual shall set forth criteria for operation of the diversion dam in various flood events. The manual shall provide guidelines for the controlled breach of the levee system if a breach is needed to prevent a catastrophic, random failure. The operating manual is subject to review and approval by the Chief Engineer.
7. The Water Management Board retains jurisdiction of Flood Control Permit No. FC-30 in the event that additional information shows this project causes an increase in the severity of flood damages in areas other than the project area.

WATER MANAGEMENT BOARD

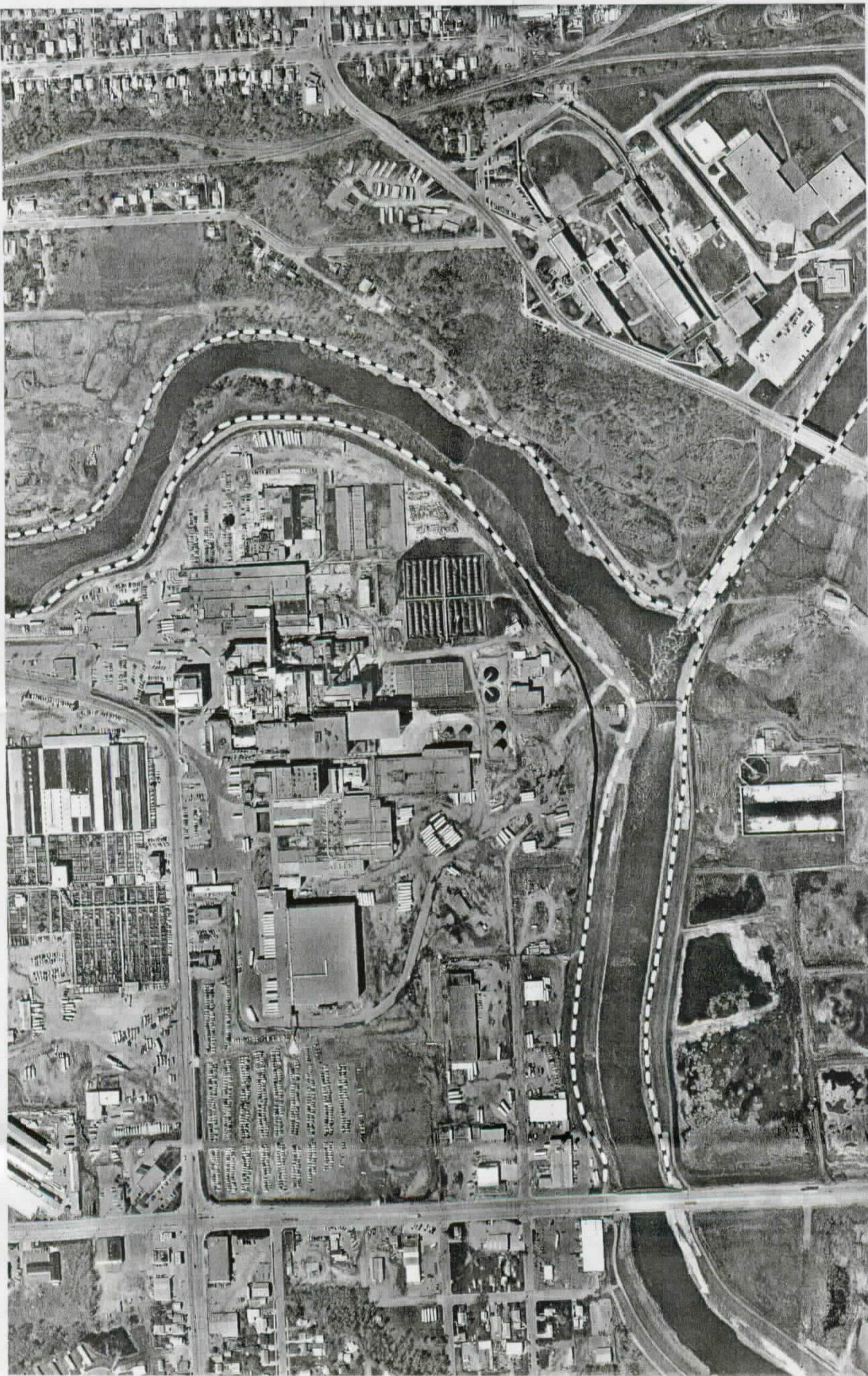
By: Garland Erbele

Garland Erbele, Chief Engineer
Water Rights Program
Department of Environment and Natural Resources

AUG 28 2003

date



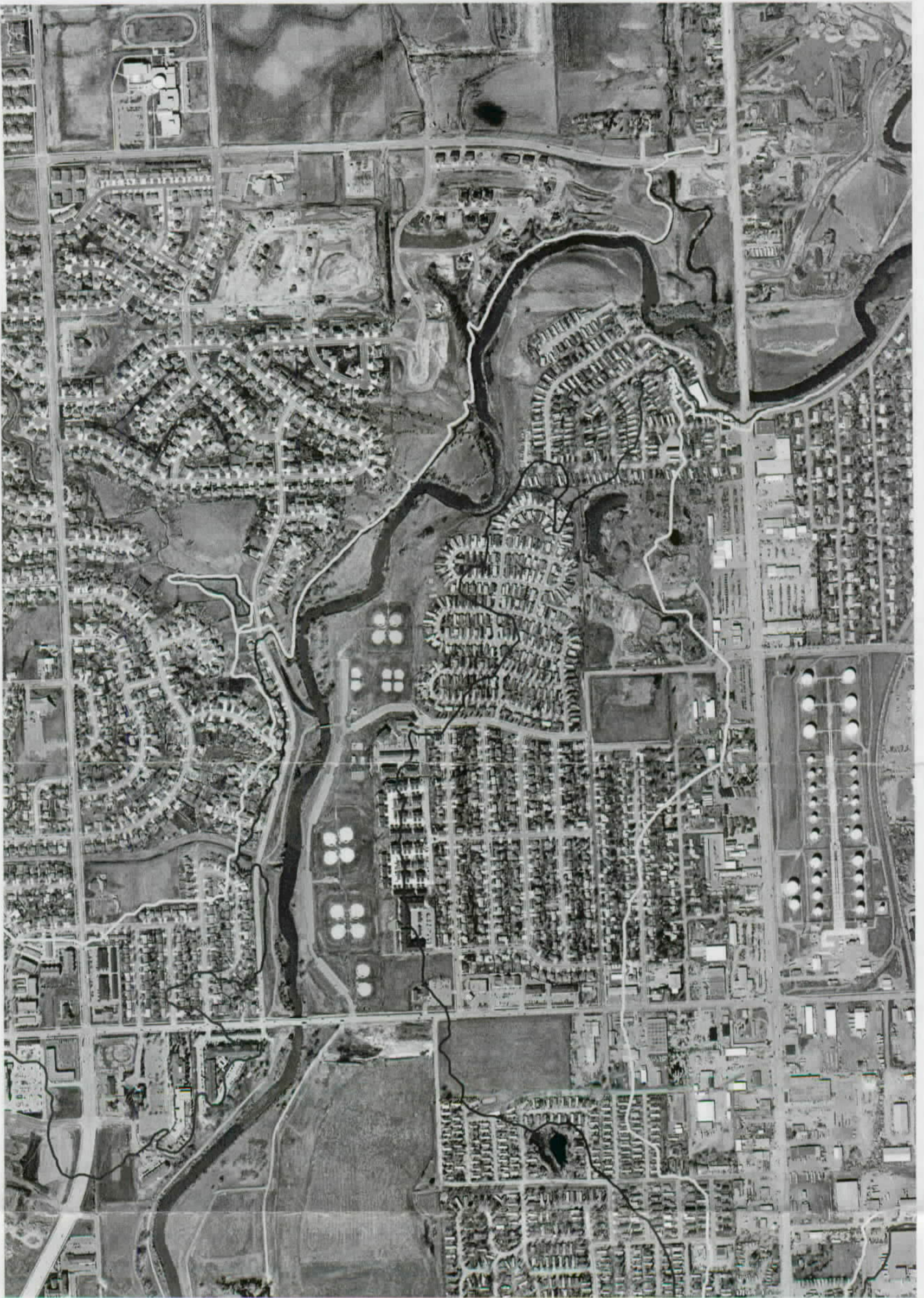


100-yr Existing Flood Boundary
100-yr w/ Project Flood Boundary

400 0 400 Feet



Plate No. PH1B-1	Date: June 2002 Computer File: arcview Plot Scale: 1:4800	Phase 1B Sheet 1 of 1	Big Sioux River Sioux Falls, SD Sioux Falls Phase 1B Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Designed by: K.K.A. Drawn by: M.A.L. Reviewed by: K.K.A.
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Ph II 500-yr Existing

Ph II 500-yr w/ Project New Marion Road & 41st

800 0 800 Feet

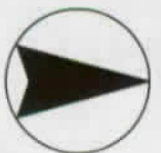
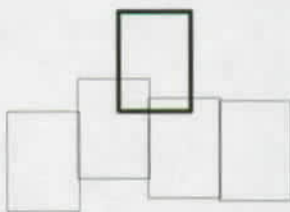
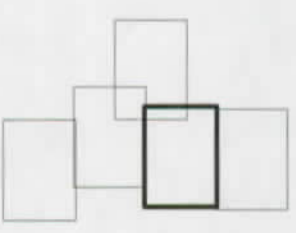
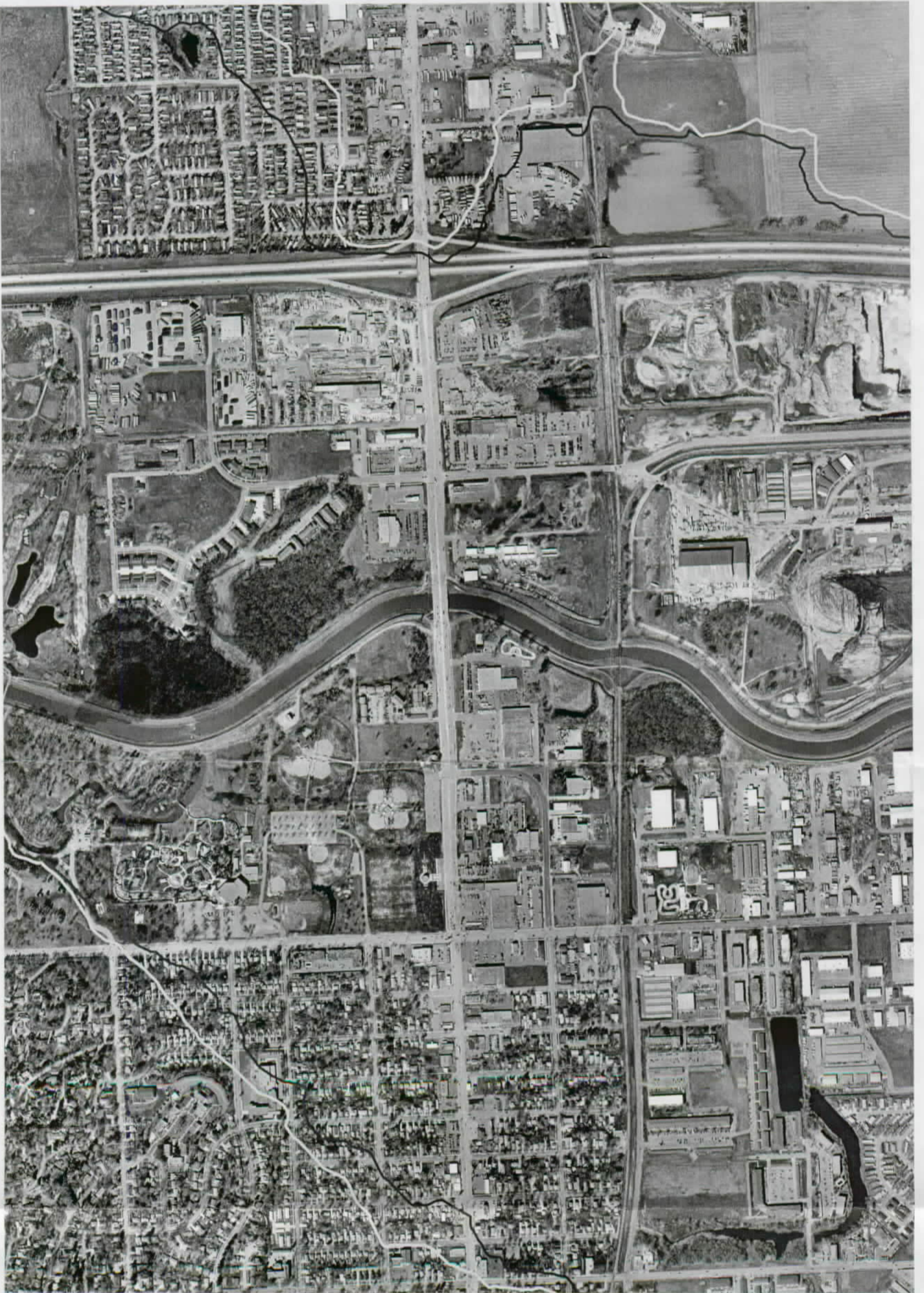


Plate No. PH2-1A	Date: Sept. 2002	Skunk Creek and Big Sioux River Sheet 1 of 5	Big Sioux River Sioux Falls, SD Sioux Falls Phase II Levee Improvements 500-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
	Computer File:					Designed by: M.A.I.
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Ph II 500-yr Existing
Ph II 500-yr w/ Project New Marion Road & 41st

Plate No: PH2-2A	Date: Sept. 2002	Skunk Creek and Big Sioux River Sheet 2 of 5	Big Sioux River	Sioux Falls, SD		US Army Corps of Engineers Omaha District	Submitted by:	Drawn by: K.K.A.
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			Sioux Falls Phase II Levee Improvements 500-yr Flood Boundaries					



800 0 800 Feet

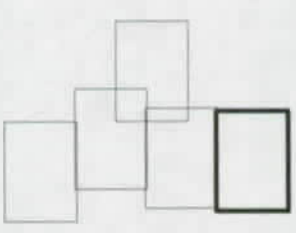
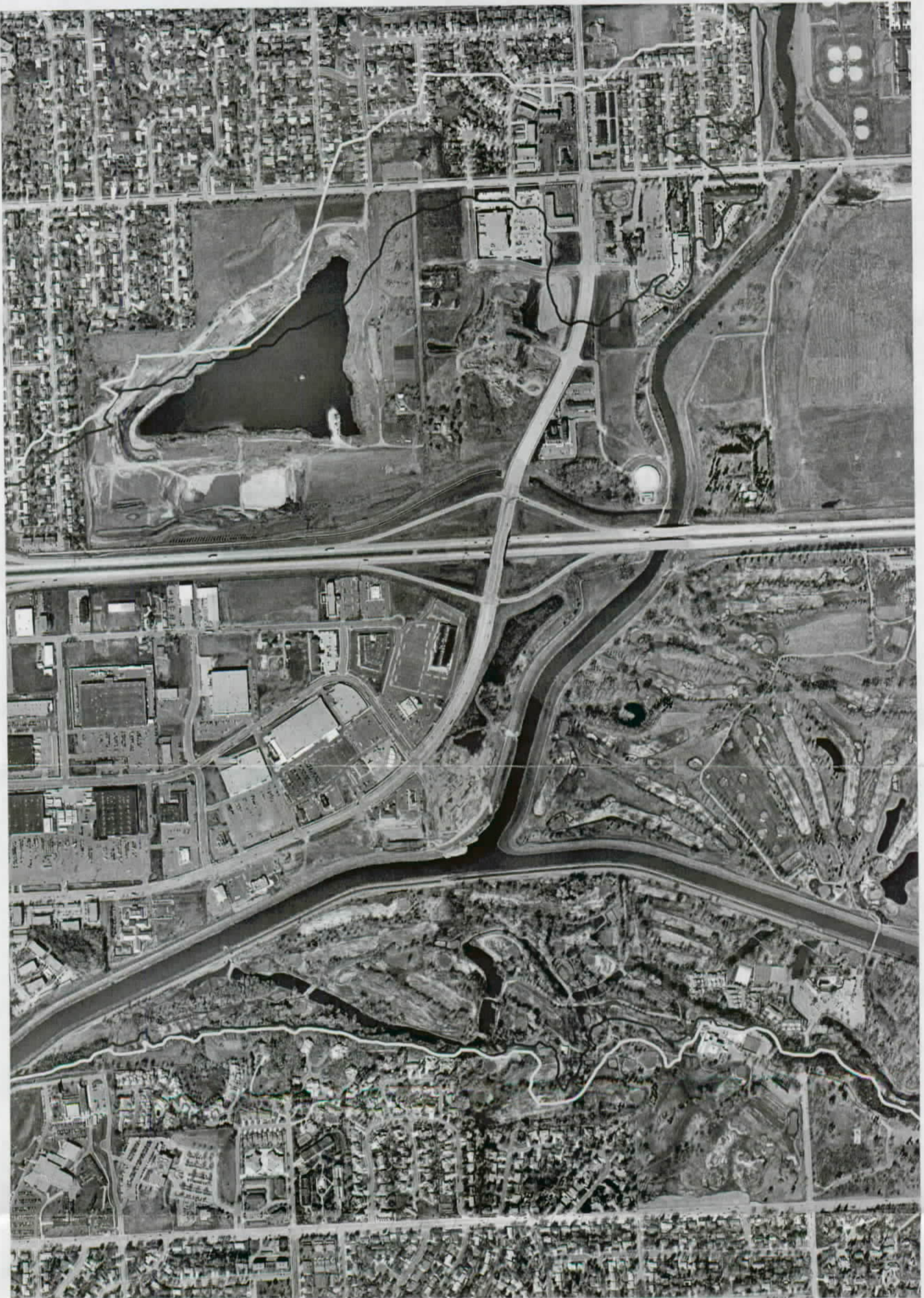


Plate No. PH2-3A	Date: Sept. 2002	Skunk Creek and Big Sioux River Sheet 3 of 5	Big Sioux River Sioux Falls, SD Sioux Falls Phase II Levee Improvements 500-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
	Computer File:					Designed by: M.A.I.
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Ph II 500-yr Existing
Ph II 500-yr w/ Project New Marion Road & 41st

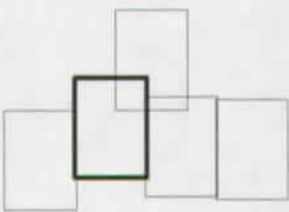


Plate No. PH2-4A	Date: Sept. 2002	Skunk Creek and Big Sioux River Sheet 4 of 5	Big Sioux River Sioux Falls, SD Sioux Falls Phase II Levee Improvements 500-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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Ph II 500-yr Existing
Ph II 500-yr w/ Project New Marion Road & 41st

800 0 800 Feet

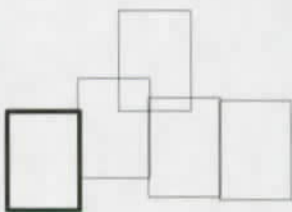
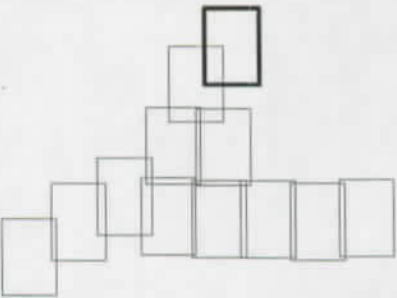


Plate No. PH2-5A	Date: Sept. 2002	Skunk Creek and Big Sioux River Sheet 5 of 5	Big Sioux River Sioux Falls, SD Sioux Falls Phase II Levee Improvements 500-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
	Computer File:					Designed by: M.A.I.
	Plot Scale: 1:9600					Reviewed by: K.K.A.



Ph II 100-yr Existing

Ph II 100-yr w/ Project New Marion Road & 41st

400 0 400 Feet

Plate No. PH2-1	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 1 of 12	Big Sioux River Sioux Falls, SD Sioux Falls Phase II Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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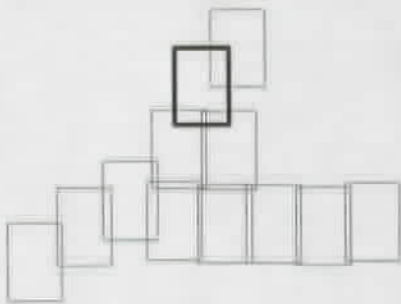


Plate No. PH2-2	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 2 of 12	Big Sioux River Sioux Falls, SD	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: KKA
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400
0
400 Feet

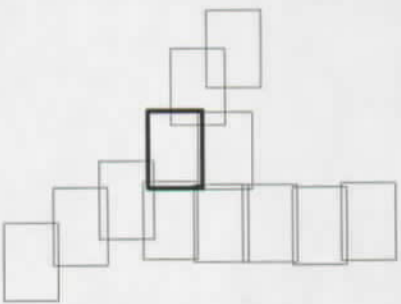
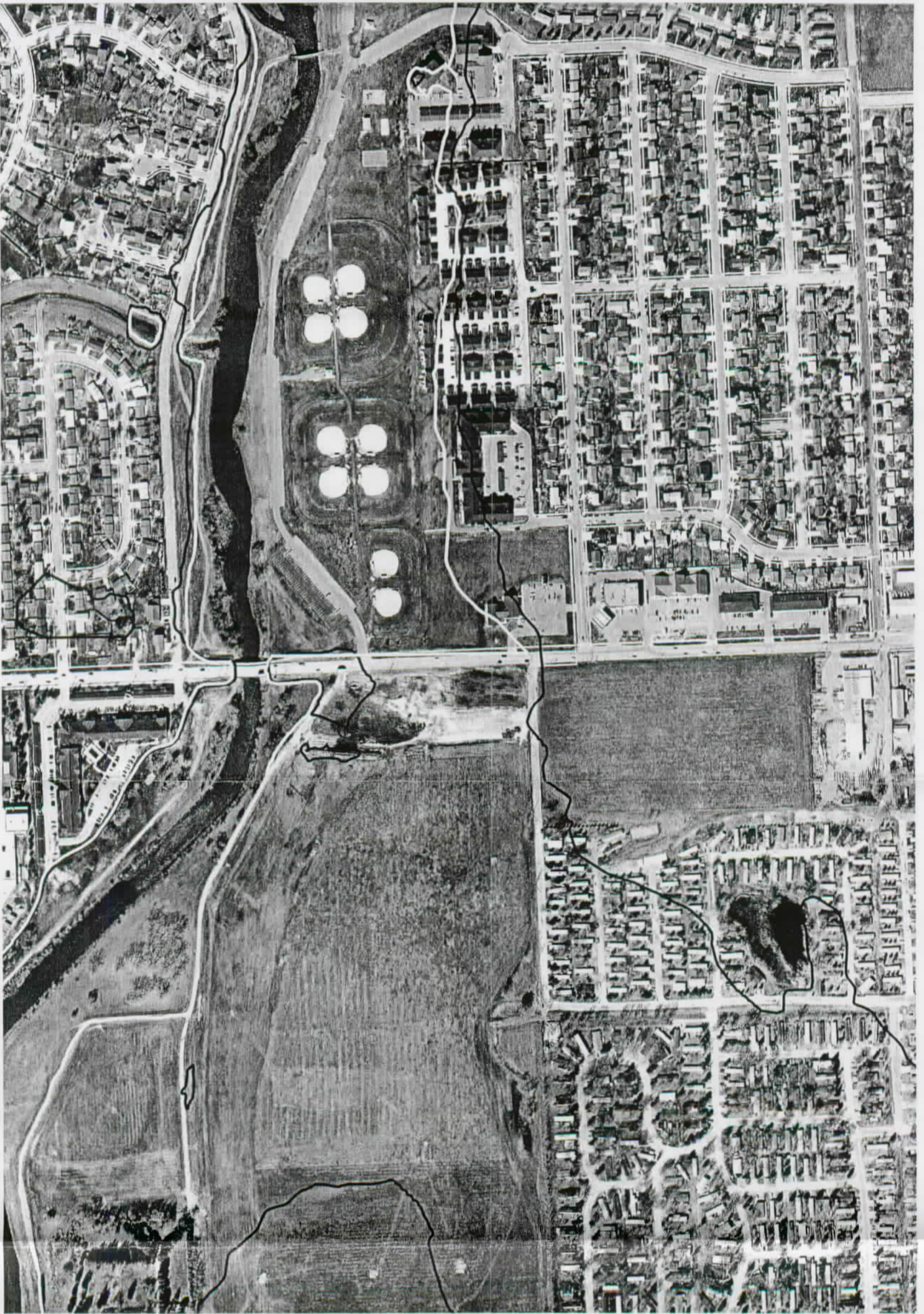


Plate No. PH2-3	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 3 of 12	Big Sioux River Sioux Falls, SD Sioux Falls Phase II Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
	Computer File:					Designed by: M.A.I.
	Plot Scale: 1:4800					Reviewed by: K.K.A.



Ph II 100-yr Existing

Ph II 100-yr w/ Project New Marion Road & 41st

400 0 400 Feet

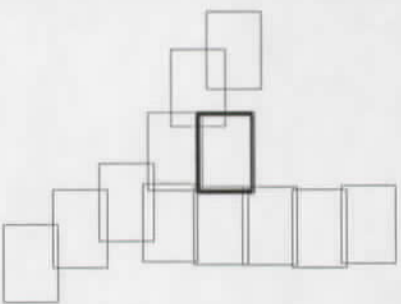
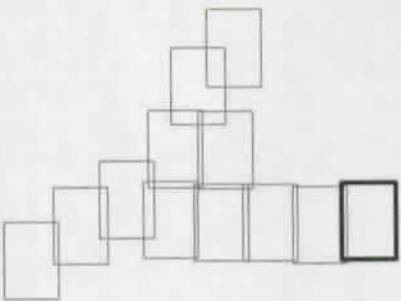


Plate No. PH2-4	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 4 of 12	Big Sioux River Sioux Falls, SD Sioux Falls Phase II Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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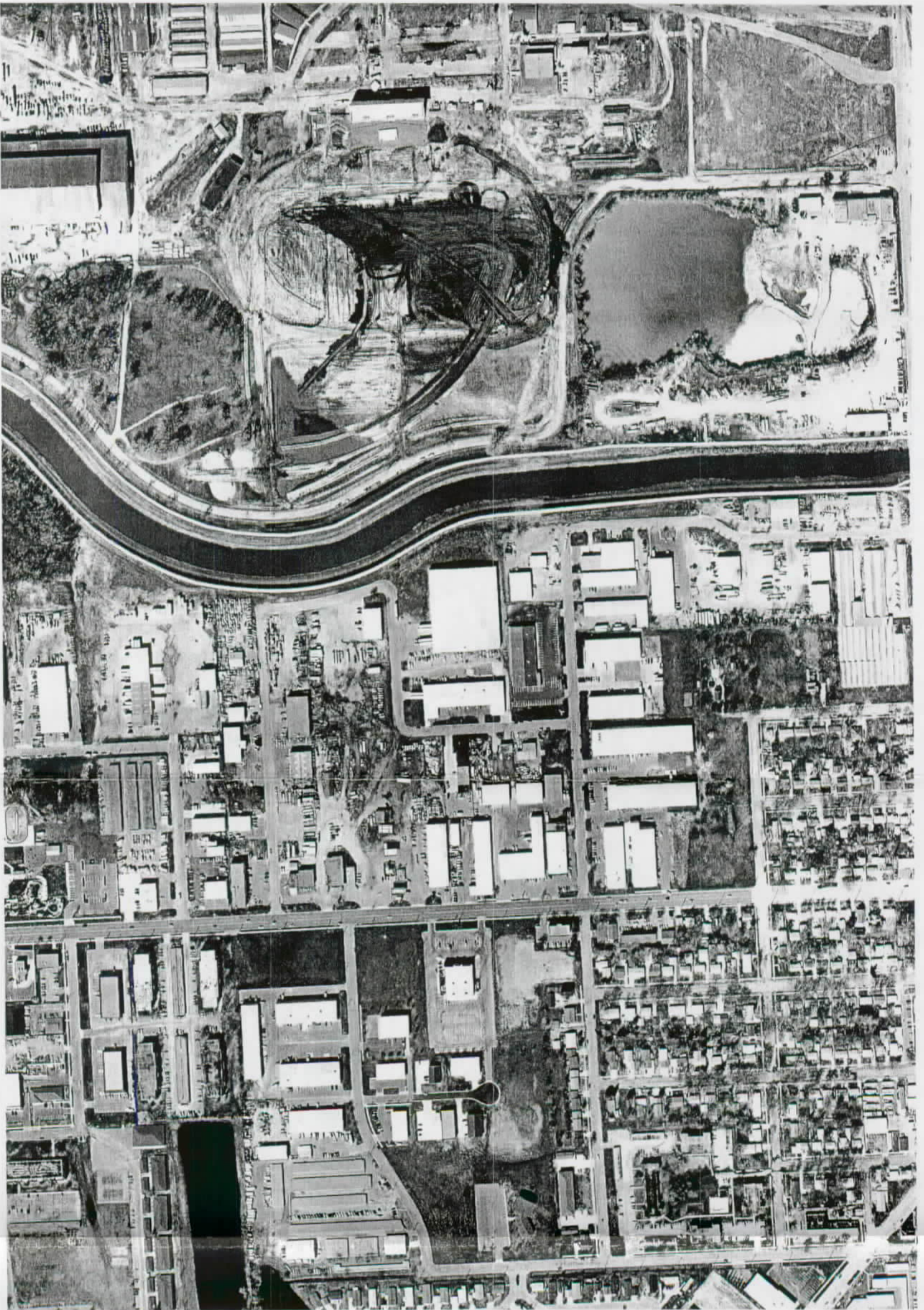
Ph II 100-yr Existing

Ph II 100-yr w/ Project New Marion Road & 41st

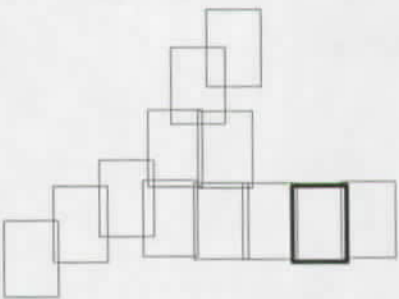


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Plate No. PH2-5	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 5 of 12	Big Sioux River Sioux Falls, SD	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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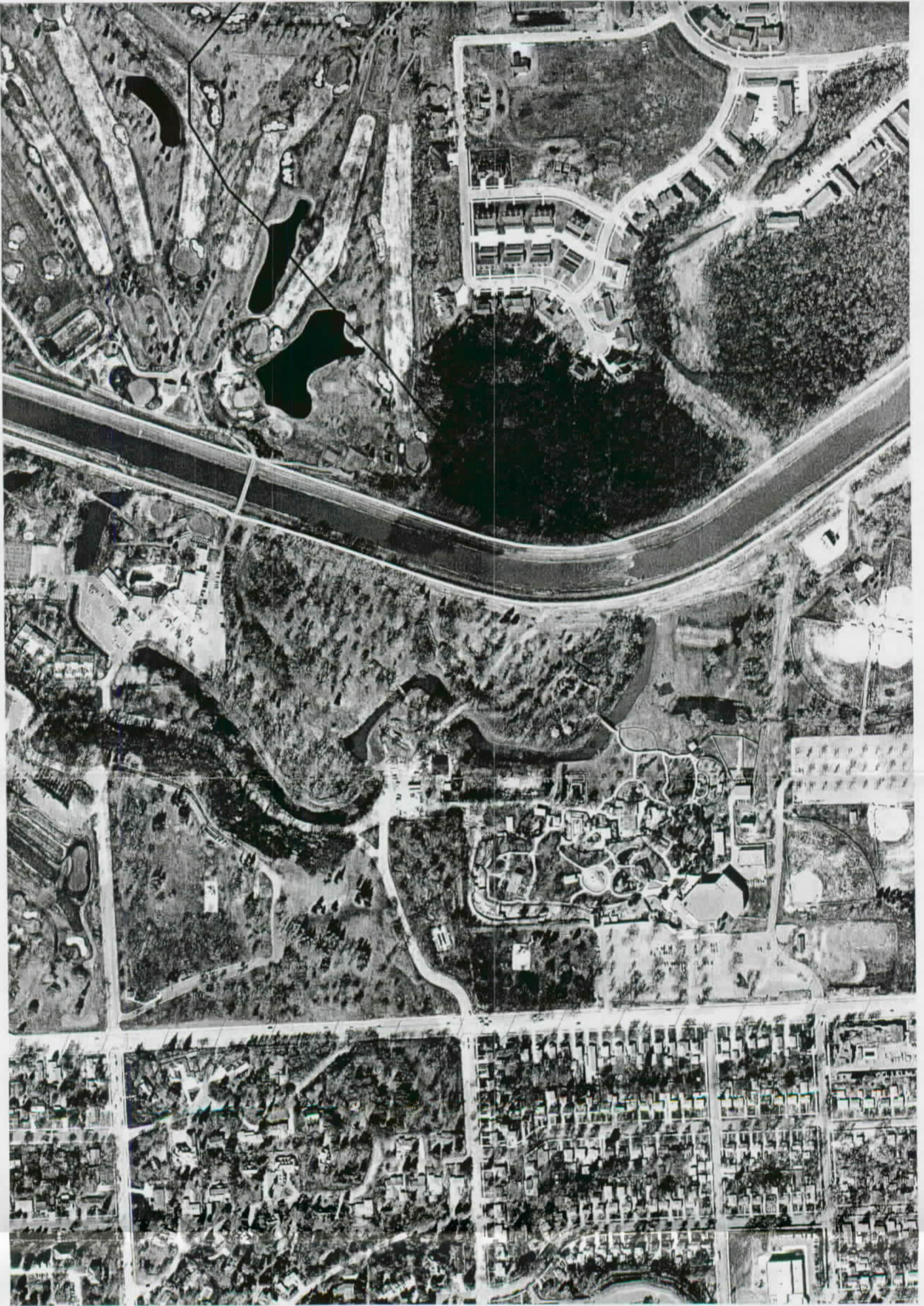


Ph II 100-yr Existing
Ph II 100-yr w/ Project New Marion Road & 41st



400 0 400 Feet

Plate No. PH2-6	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 6 of 12	Big Sioux River Sioux Falls, SD	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
	Computer File:					Designed by: M.A.I.
	Plot Scale: 1:4800					Reviewed by: K.K.A.
Sioux Falls Phase II Levee Improvements 100-yr Flood Boundaries						



Ph II 100-yr Existing
Ph II 100-yr w/ Project New Marion Road & 41st

400 0 400 Feet

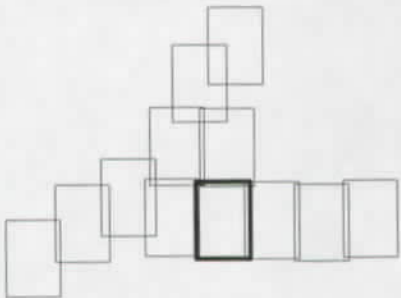
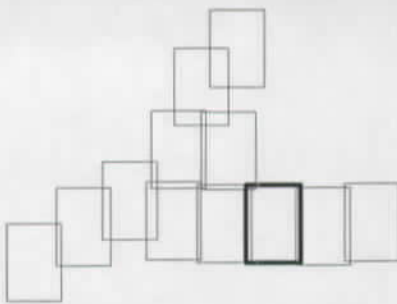


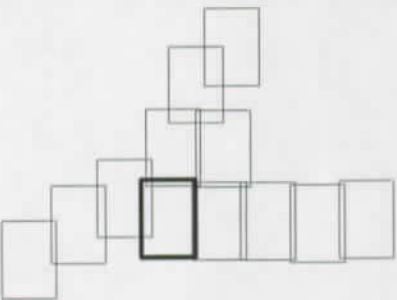
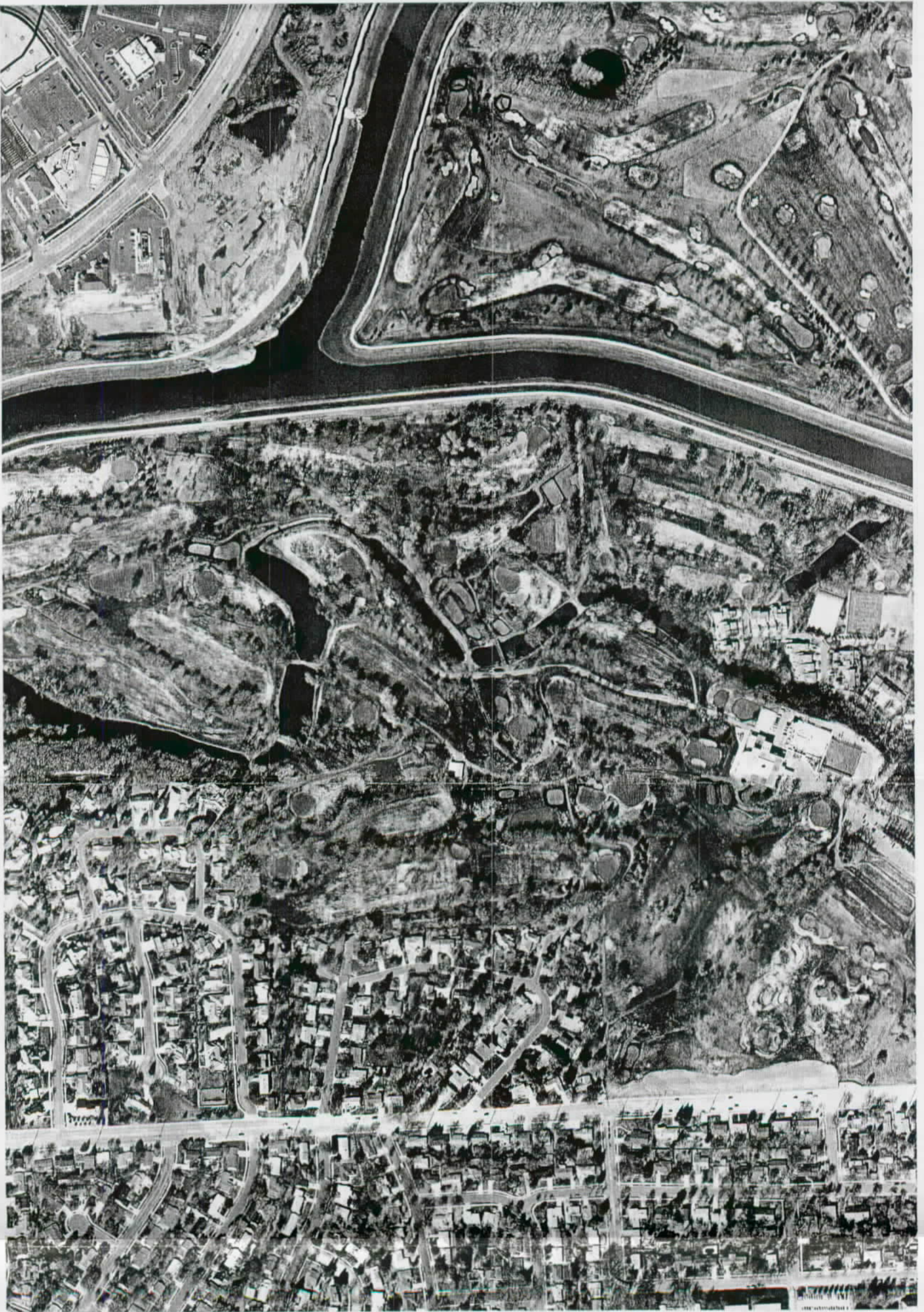
Plate No. PH2-8	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 8 of 12	Big Sioux River Sioux Falls, SD Sioux Falls Phase II Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
	Computer File:					Designed by: M.A.I.
	Plot Scale: 1:4800					Reviewed by: K.K.A.



✓ Ph II 100-yr Existing
Ph II 100-yr w/ Project New Marion Road & 41st

400 0 400 Feet

PH2-7	Plate No.	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 7 of 12	Big Sioux River	Sioux Falls, SD		US Army Corps of Engineers Omaha District	Submitted by:	Drawn by: K.K.A.
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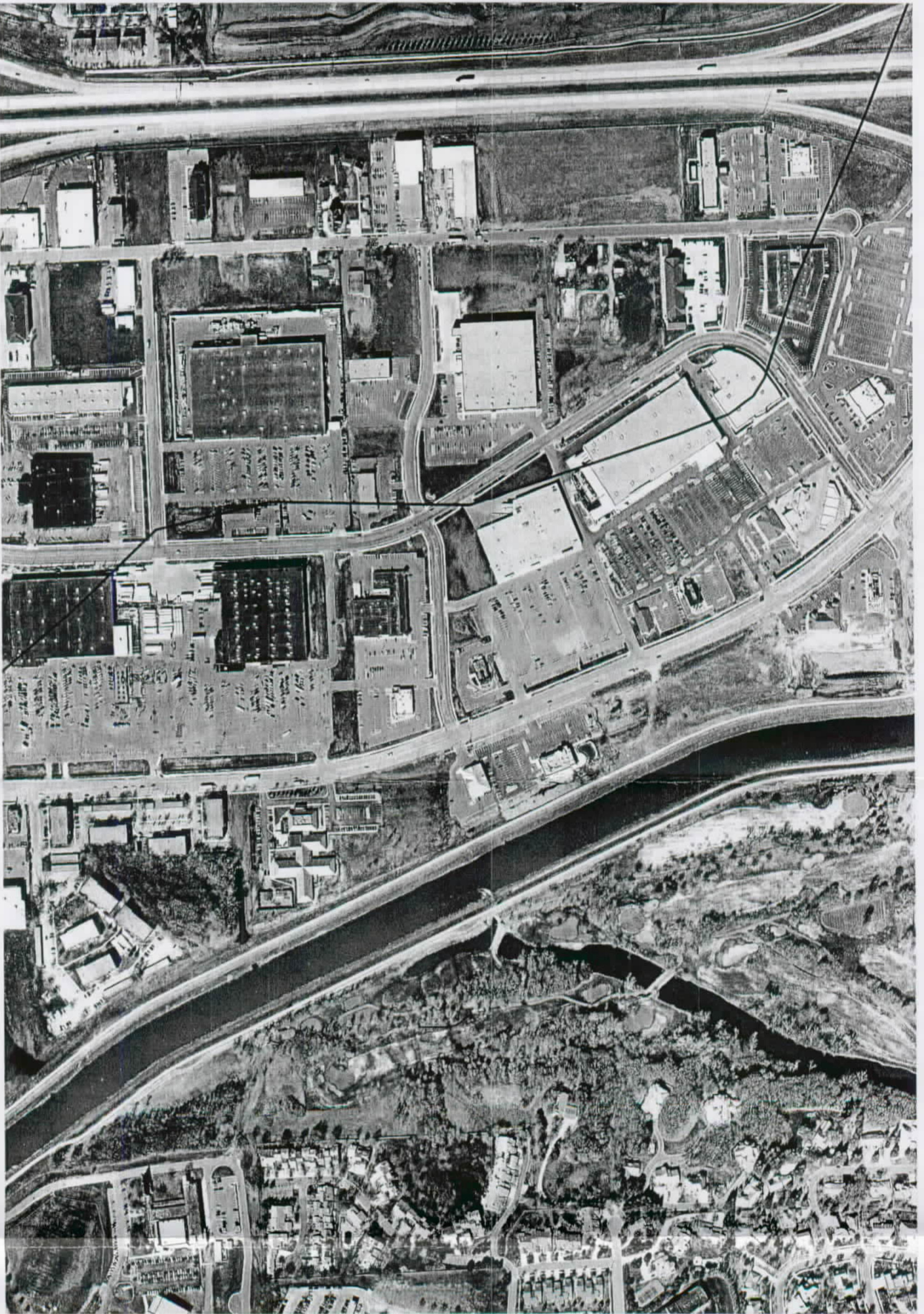


400 0 400 Feet

Ph II 100-yr Existing

Ph II 100-yr w/ Project New Marion Road & 41st

Plate No. PH2-9	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 9 of 12	Big Sioux River Sioux Falls, SD Sioux Falls Phase II Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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Ph II 100-yr Existing

Ph II 100-yr w/ Project New Marion Road & 41st

400 0 400 Feet

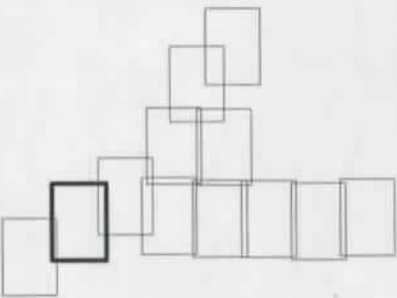


Plate No. PH2-10	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 10 of 12	Big Sioux River Sioux Falls, SD	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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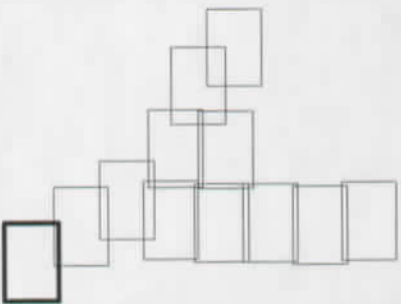
Ph II 100-yr Existing

Ph II 100-yr w/ Project New Marion Road & 41st



400 0 400 Feet

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	Plot Scale: 1:4800	Reviewed by:						M.A.I.	
									K.K.A.



400 0 400 Feet

Ph II 100-yr Existing

Ph II 100-yr w/ Project New Marion Road & 41st

Plate No. PH2-12	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 12 of 12	Big Sioux River Sioux Falls, SD Sioux Falls Phase II Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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Ph II 100-yr Existing
Ph II 100-yr w/ Project New Marion Road & 41st

400 0 400 Feet

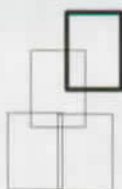


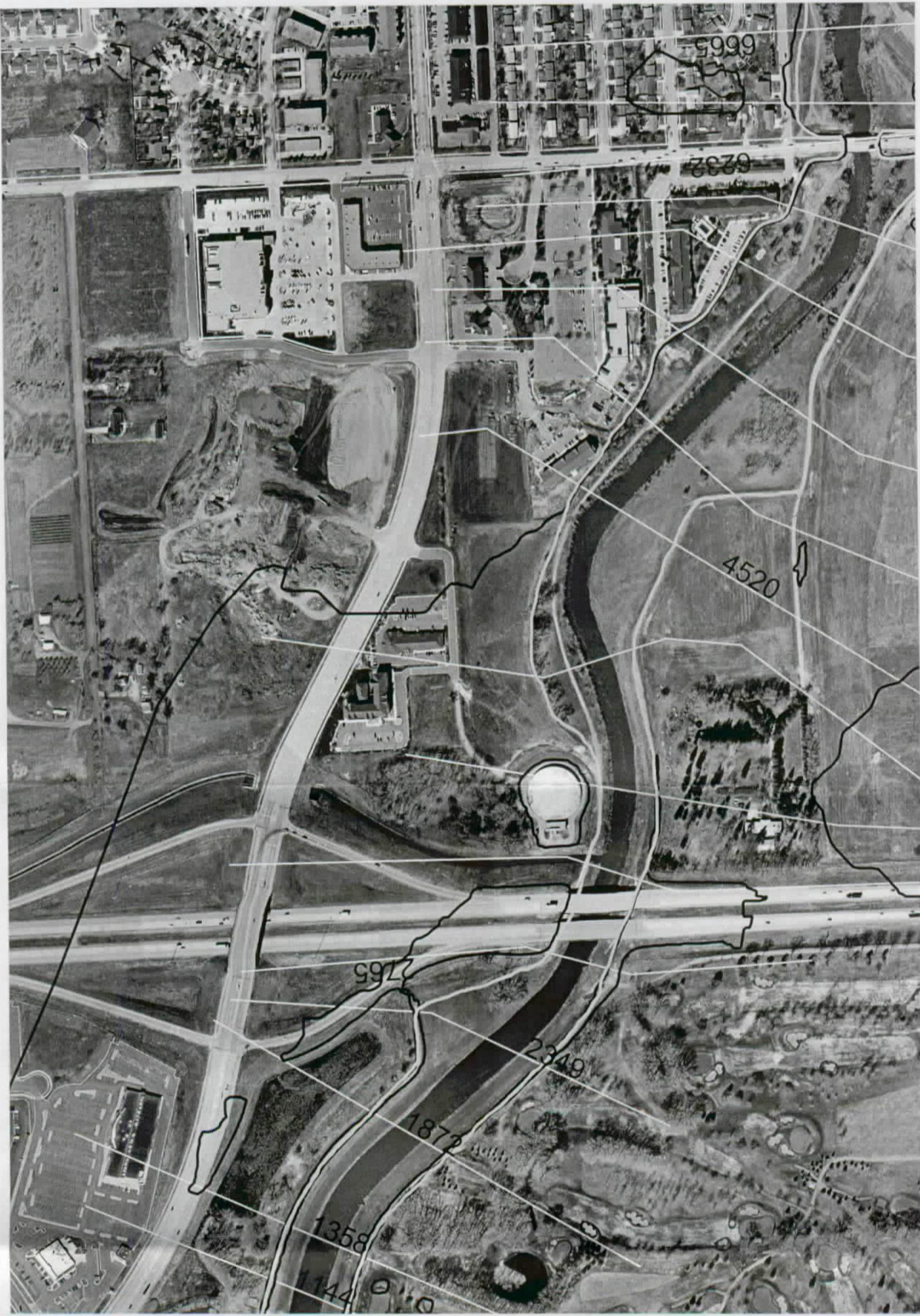
Plate No. PH2-1B	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 1 of 4	Big Sioux River Sioux Falls, SD	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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Ph II 100-yr Existing
Ph II 100-yr w/ Project New Marion Road & 41st

400 0 400 Feet

Plate No. PH2-2B	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 2 of 4	Big Sioux River Sioux Falls, SD Sioux Falls Phase II Levee Improvements Skunk Creek X-Sections	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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Ph II 100-yr Existing
Ph II 100-yr w/ Project New Marion Road & 41st

400 0 400 Feet



Plate No. PH2-3B	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 3 of 4	Big Sioux River Sioux Falls, SD	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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Ph II 100-yr Existing
Ph II 100-yr w/ Project New Marion Road & 41st



Plate No. PH2-4B	Date: Dec 2002	Skunk Creek and Big Sioux River Sheet 4 of 4	Big Sioux River Sioux Falls, SD Sioux Falls Phase II Levee Improvements Skunk Creek X-Sections	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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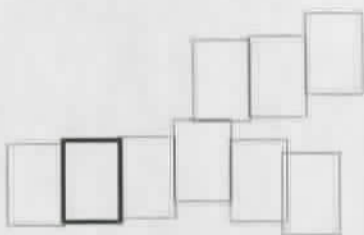


Ph III 100-yr Existing
Ph III 100-yr w/ Project



400 0 400 Feet

Plate No. PH3-1	Date: Jan 2003	Big Sioux River Sheet 1 of 9	Big Sioux River Sioux Falls Phase III Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A. Designed by: M.A.L. Reviewed by: K.K.A.
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Ph III 100-yr Existing
Ph III 100-yr w/ Project

400 0 400 Feet

Plate No. PH3-2	Date: Oct. 2002	Big Sioux River Sheet 2 of 9	Big Sioux River Sioux Falls Phase III Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A. Designed by: M.A.L. Reviewed by: K.K.A.
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Ph III 100-yr Existing
Ph III 100-yr w/ Project

400 0 400 Feet

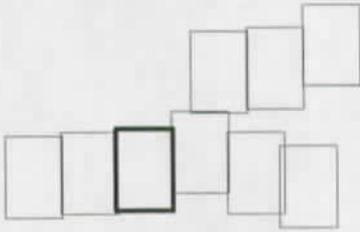
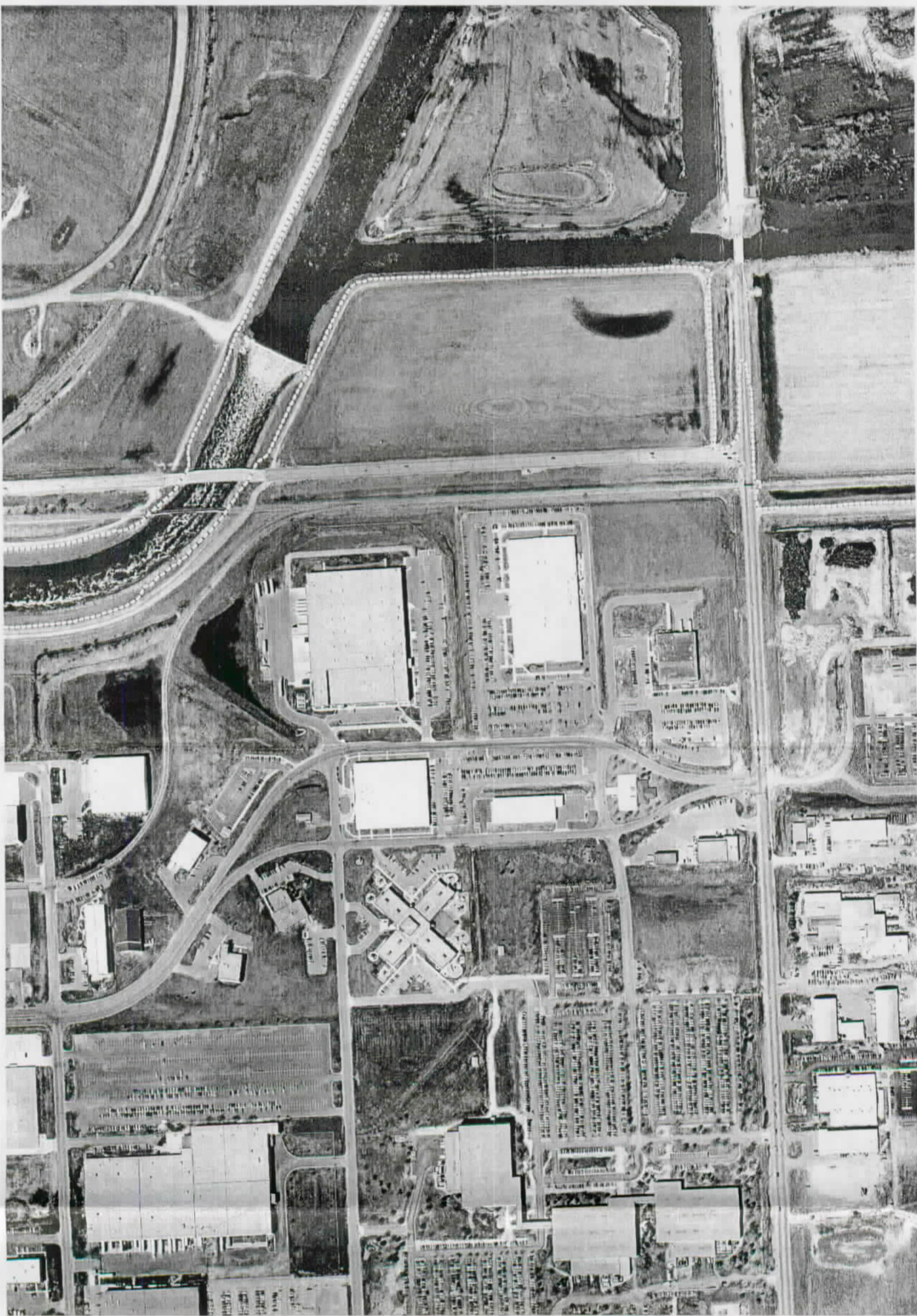


Plate No. PH3-3	Date: Oct. 2002	Big Sioux River Sheet 3 of 9	Big Sioux River Sioux Falls Phase III Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A. Designed by: M.A.L. Reviewed by: K.K.A.
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Ph III 100-yr Existing
Ph III 100-yr w/ Project

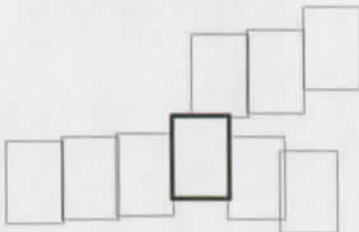
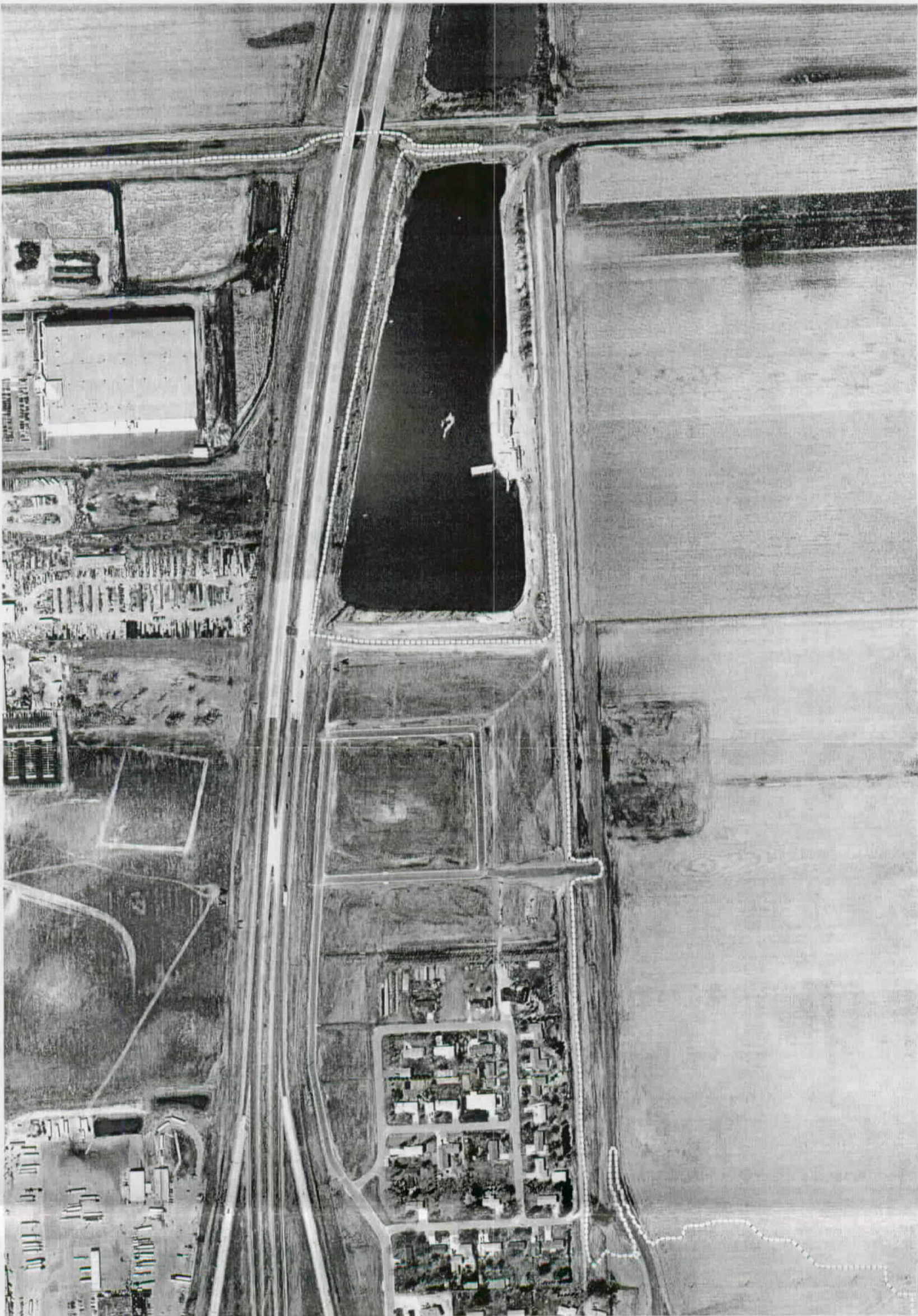
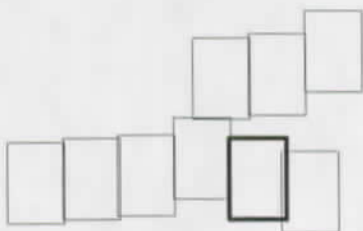


Plate No. PH3-4	Date: Oct. 2002	Big Sioux River Sheet 4 of 9	Big Sioux River Sioux Falls Phase III Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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	Plot Scale: 1:4800					Reviewed by: K.K.A.



Ph III 100-yr Existing
Ph III 100-yr w/ Project

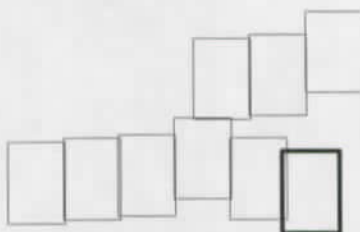


400 0 400 Feet

Plate No. PH3-5	Date: Oct. 2002	Big Sioux River Sioux Falls Phase III Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by:	Drawn by: K.K.A.
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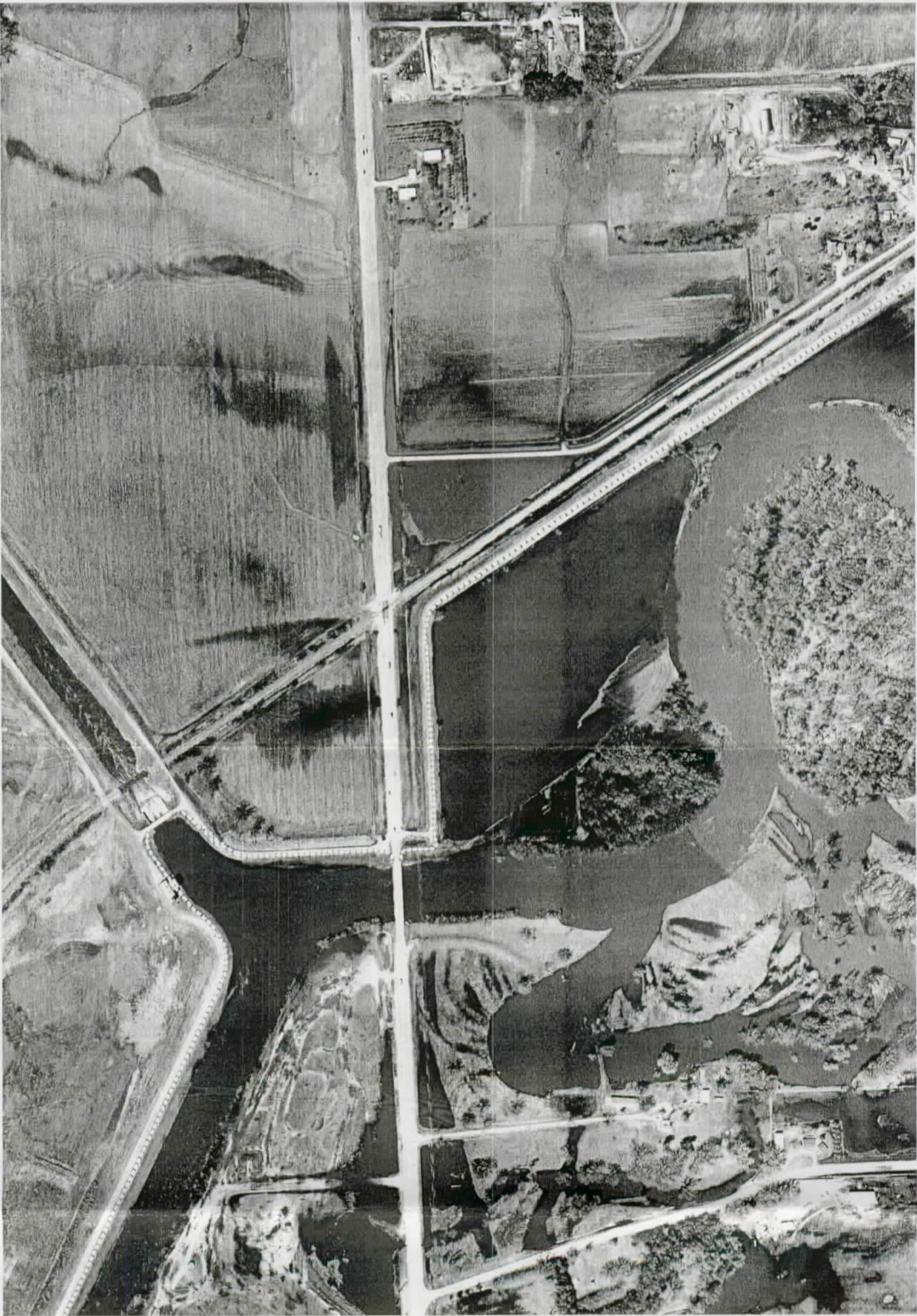


Ph III 100-yr Existing
Ph III 100-yr w/ Project

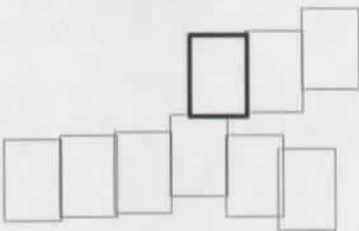


400
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400 Feet

Plate No. PH3-6	Date: Oct. 2002	Big Sioux River Sheet 6 of 9	Big Sioux River Sioux Falls, SD Sioux Falls Phase III Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
	Computer File:					Designed by: M.A.L.
	Plot Scale: 1:4800					Reviewed by: K.K.A.



Ph III 100-yr Existing
Ph III 100-yr w/ Project

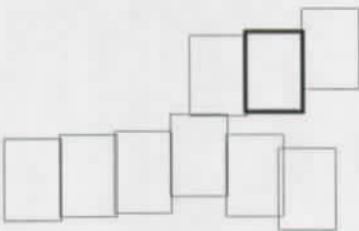


400 0 400 Feet

Plate No. PH3-7	Date: Oct. 2002	Big Sioux River Sioux Falls Phase III Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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Ph III 100-yr Existing
Ph III 100-yr w/ Project

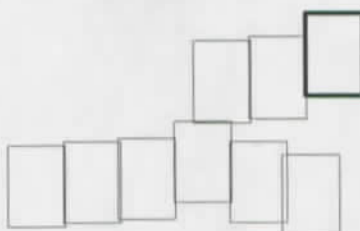


400 0 400 Feet

Plate No. PH3-8	Date: Oct. 2002	Big Sioux River Sheet 8 of 9	Big Sioux River Sioux Falls, SD Sioux Falls Phase III Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
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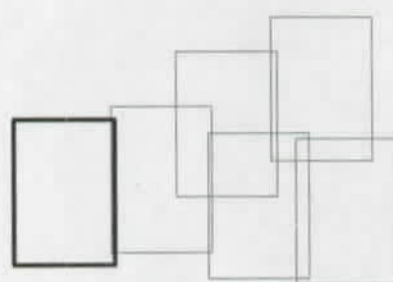
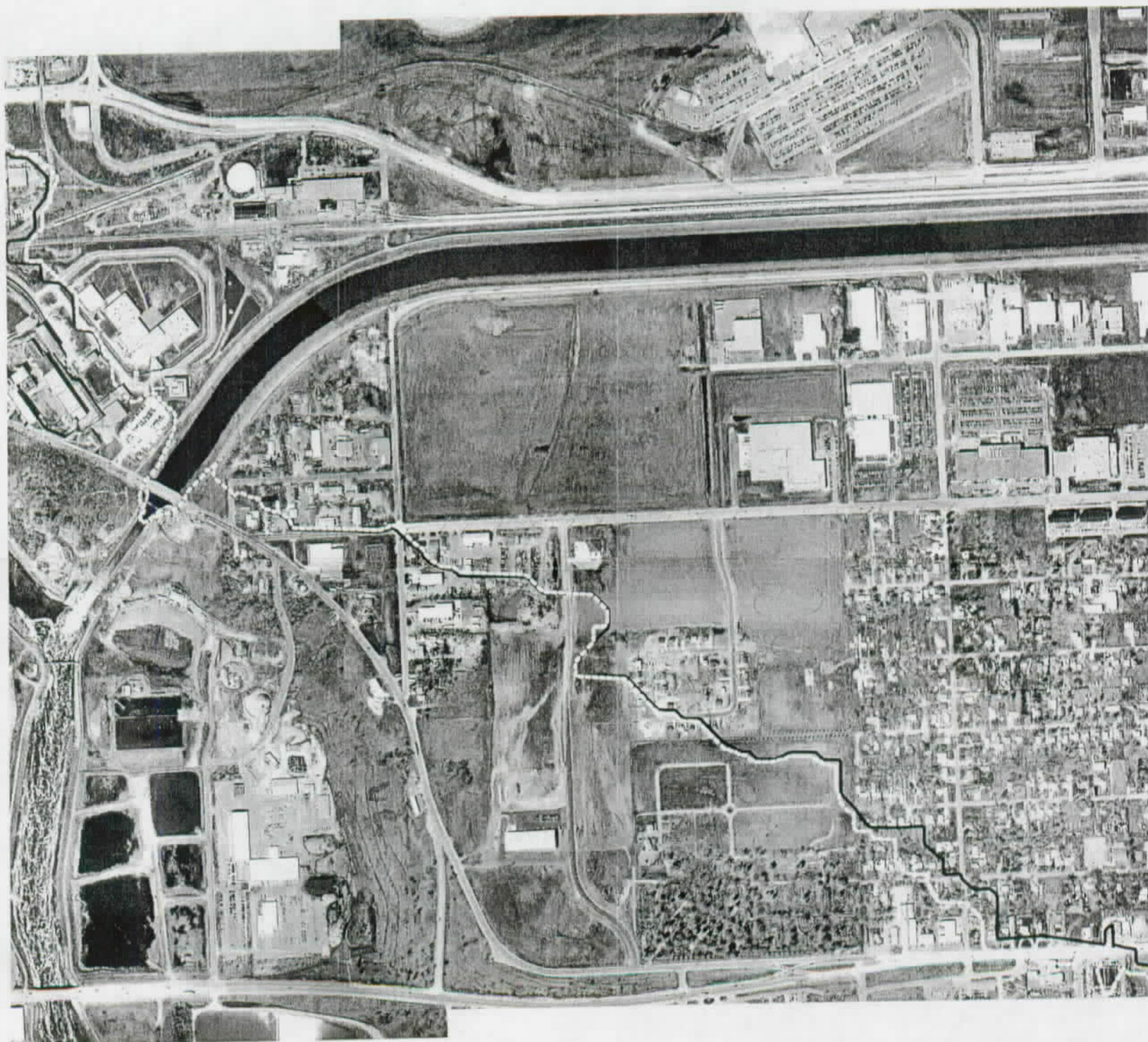
Ph III 100-yr Existing
Ph III 100-yr w/ Project



400 0 400 Feet

Plate No. PH3-9	Date: Oct. 2002	Big Sioux River Sheet 9 of 9	Big Sioux River Sioux Falls, SD Sioux Falls Phase III Levee Improvements 100-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
	Computer File:					Designed by: M.A.L.
	Plot Scale: 1:4800					Reviewed by: K.K.A.

✓ Ph III 500-yr w/ Project



800 0 800 Feet

Plate No. PH3-1A	Date: Jan 2003
	Computer File:
	Plot Scale: 1:4800

Big Sioux River
Sheet 1 of 6

Big Sioux River Sioux Falls, SD
Sioux Falls Phase III
Levee Improvements
500-yr Flood Boundaries



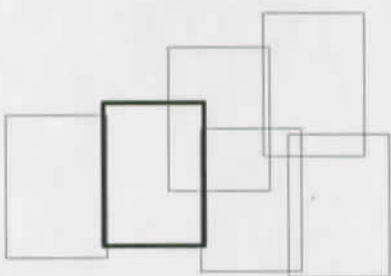
US Army Corps
of Engineers
Omaha District

Submitted by:
Jeff McClenathan
Chief
Hydraulics Section

Drawn by:	K.K.A.
Designed by:	M.A.L.
Reviewed by:	K.K.A.



Ph III 500-yr Existing
Ph III 500-yr w/ Project



800 0 800 Feet

Plate No. PH3-2A	Date: Jan 2003	Big Sioux River Sioux Falls Phase III Levee Improvements 500-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A. Designed by: M.A.L. Reviewed by: K.K.A.
	Computer File:				
	Plot Scale: 1:4800				

Big Sioux River
Sheet 2 of 6

Big Sioux River Sioux Falls, SD
Sioux Falls Phase III
Levee Improvements
500-yr Flood Boundaries



US Army Corps
of Engineers
Omaha District

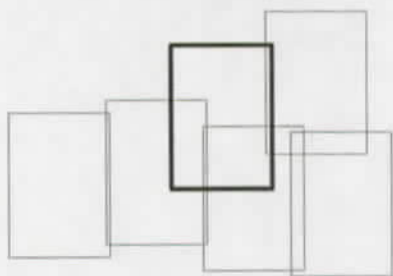
Submitted by:
Jeff McClenathan
Chief
Hydraulics Section

Drawn by: K.K.A.
Designed by: M.A.L.
Reviewed by: K.K.A.



Ph III 500-yr Existing

Ph III 500-yr w/ Project



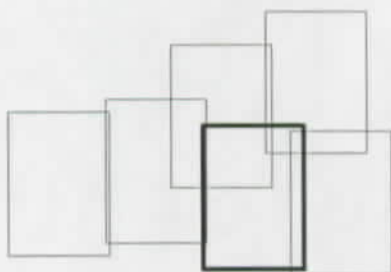
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Plate No. PH3-3A	Date: Jan 2003	Big Sioux River Sheet 3 of 6	Big Sioux River Sioux Falls Phase III Levee Improvements 500-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
	Computer File:					Designed by: M.A.L.
	Plot Scale: 1:4800					Reviewed by: K.K.A.



Ph III 500-yr Existing

Ph III 500-yr w/ Project



800
0
800 Feet

Plate No. PH3-4A	Date: Jan 2003	Big Sioux River Sheet 4 of 6	Big Sioux River Sioux Falls, SD Sioux Falls Phase III Levee Improvements 500-yr Flood Boundaries		US Army Corps of Engineers Omaha District	Submitted by:	Drawn by: K.K.A.
	Computer File:					Jeff McClenathan Chief Hydraulics Section	Designed by: M.A.L.
	Plot Scale: 1:4800						Reviewed by: K.K.A.



Ph III 500-yr Existing
Ph III 500-yr w/ Project

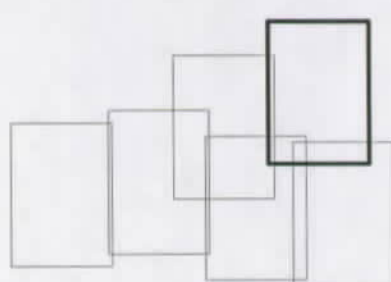


Plate No. PH3-5A	Date: Jan 2003	Big Sioux River Sheet 5 of 6	Big Sioux River Sioux Falls, SD Sioux Falls Phase III Levee Improvements 500-yr Flood Boundaries	 US Army Corps of Engineers Omaha District	Submitted by: Jeff McClenathan Chief Hydraulics Section	Drawn by: K.K.A.
	Computer File:					Designed by: M.A.L.
	Plot Scale: 1:4800					Reviewed by: K.K.A.

Big Sioux River Flood Control

Flood Control System Improvements & Flood Mapping



Prepared by: Public Works -Engineering
Ken Swedeen, City Engineer
July 1, 2000

Flood Control System

The Big Sioux River encompasses a drainage basin of roughly 9,565 square miles. The Big Sioux River Basin upstream from Sioux Falls contains approximately 5,718 square miles of the total basin. Skunk Creek drains an area of 560 square miles. The City of Sioux Falls is located within a horseshoe bend of the Big Sioux River. It is also located at the confluence of the Big Sioux River and Skunk Creek. Therefore, flood events from these two watersheds imperil the City of Sioux Falls. Flood events can be due to high rainfall events (common for Skunk Creek), snowmelt (typical of the Big Sioux River), or a combination of the two events. Due to the damage caused by flooding, the City of Sioux Falls and the Army Corps of Engineers initiated an analysis of possible flood control measures in the mid-1950's. This analysis triggered the construction of the flood control system on the Big Sioux River and Skunk Creek upstream and through the City.

The existing flood control system on the Big Sioux River (BSR) was constructed between 1956 and 1961. This system includes a system of levee protection and flood wall along the historic channel (including a portion of Skunk Creek above the confluence of the BSR), a Diversion Dam, Diversion Channel and Spillway. The system includes approximately 29.2 miles of levees adjacent to the Big Sioux River, Big Sioux River Diversion Channel, Silver Creek and Skunk Creek. The Diversion Channel traverses approximately 15,000 ft. from the Diversion Dam structure to a 118-foot vertical drop back down to the historic channel at the Spillway.

The intent of the system is to reroute flood flows in and around the City of Sioux Falls and contain these flows within the levee system. The system was designed based on a technical analysis completed in 1954. The initial project planned for design discharges (cubic feet per second, cfs) of 24,400 cfs on the Big Sioux River. The Skunk Creek system used a design discharge of 9,305 cfs.

The analysis, design and construction of this system were coordinated under the Department of Defense-Army Corps of Engineers (COE) with involvement from the local and state levels. The City of Sioux Falls (CSF) by agreement is responsible for maintenance and operation of this system.

The system begins directly south of 60th Street North (SD Highway 38) and west of North Minnesota Avenue. The diversion dam and headwaters of the diversion channel are located in this area. Levee structures extend downstream on the Big Sioux Falls channel to South Western Avenue in the area of I-229 and 57th Street. Topography and flood plain protection via zoning restrictions exist from Western Avenue downstream to Falls Park Drive. Levee protection was constructed from Falls Park Drive through the area of the confluence of the diversion channel outfall or spillway. The spillway outfall and stilling basin are located in the general area directly north of Rice Street and Weber Avenue encompassing the river frontage of the John Morrell Plant. The levee system extends downstream to a point between North Cliff Avenue and Interstate 229. A map is attached outlining the general features of the flood control system.

The existing flood control system design capacity of 24,400 cfs translates to protection for a 30-year flood event for the Big Sioux River and a 20-year flood event for the Skunk Creek reach¹. Emergency flood fighting measures, such as those mobilized following the winter of 1996-97, provide additional protection. These measures include temporarily raising the headwalls of the diversion channel spillway, selective temporary dikes, sandbagging, and structure protection including erosion control or armor at drainage structures. Sections of the existing levee system are raised 1 to 3 feet by placement of temporary embankment during these measures, also.



Exhibit 1-Spillway/Stilling Basin (1969 Flood)

In the early 1990's, the COE at the CSF's request, initiated a Feasibility Study to analyze this system based on better defined hydrologic data for the Big Sioux River and Skunk Creek basins. This study was also initiated due to the continued development in the southwestern area of the City that accentuated the benefits derived from the flood control system. Major retail and residential development in the area outlined by Maple Street to the north, 57th Street to the south, Kiwanis Avenue to the east, and Marion Road to the west, was a prime focal point for the improvements. The feasibility study was completed in 1994 and the CSF and COE proceeded to pursue funding for the *Big Sioux River and Skunk Creek Flood Control Project (BSR FCP)*.

The feasibility study identified the limitations of the existing flood control system based on eight major flood events chronicled since 1950. One of these events, the flood of 1969,

¹ Local Flood Protection, Big Sioux River and Skunk Creek at Sioux Falls, SD, November 1993.

was considered the 100-year event and therefore to be the standard against which the flood control improvements would be measured. The estimated discharge on the Big Sioux River for the 1969 flood event was approximately 40,000 cfs. Approximately 30,000 cfs was diverted into the diversion channel and discharged through the spillway chute. The remaining 10,000 cfs passed through the diversion dam and continued down the Big Sioux River channel.

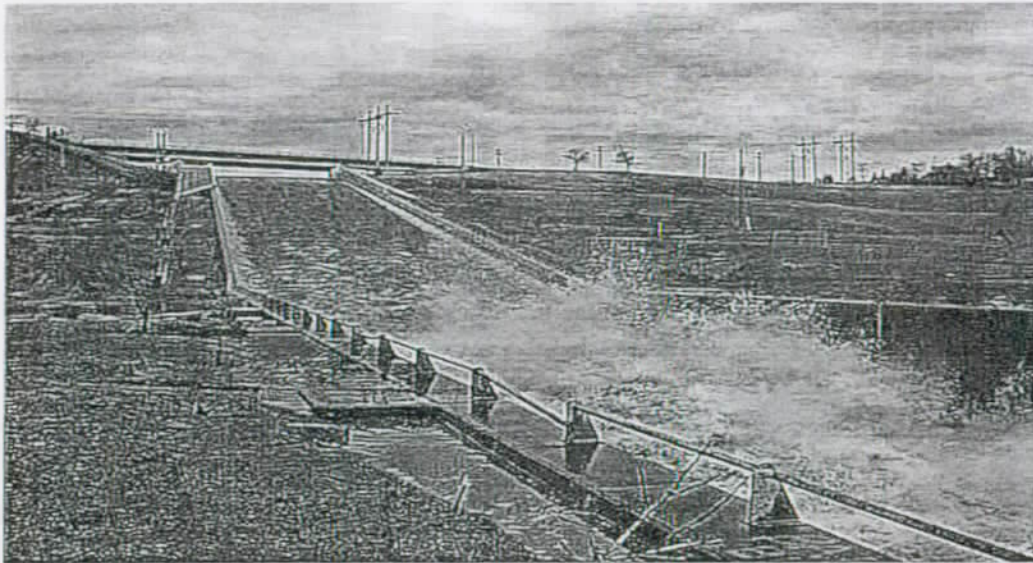


Exhibit 2 – Diversion Spillway (1997 Flood Fight)

Mathematical modeling was performed to recreate the 1969 event within the design criteria for the improvements. In addition, a scale hydraulic model was created at the COE Waterways Experimentation Station in Vicksburg, Mississippi to review several improvement options. The results of these studies were included in the feasibility study. For design purposes on the Big Sioux River, the 100-year event was determined to be 29,000 cfs, the 500-year event was determined to be 36,300 cfs, and the flood of record in 1969 determined to be 30,000 cfs.



Exhibit 3 – North of Sioux Falls (1997 Flood)

The damage in the Sioux Falls area created by a 100-year event with the existing flood control system was estimated at \$186 million in 1992 dollars and with 1992 infrastructure.² Considerable development has occurred post-1992 including the Meadows on the River Development bounded by Skunk Creek, the Big Sioux River, 26th Street/Louise and 41st Street. In addition, continued development has occurred in the 41st Street Corridor including the area bounded by Western Ave., I-29, I-229 and 41st Street. It could be conservatively estimated that the damage figure would be significantly increased when calculated in 2000 dollars and development.



Exhibit 4 – Stilling Basin (1997 Flood)

² Op. Cit.

Flood Control Project

The Big Sioux River and Skunk Creek Flood Control project consists of a series of levee improvements and flood control structure modifications identified in the 1994 Feasibility Study (FS) completed by the COE. The COE, soon after the completion of FS, initiated a contract to provide preliminary engineering including right-of-way impacts based on the issues identified within the Feasibility Study. This report, *Sioux Falls Flood Control Project Design Optimization Study (DOS)-Big Sioux River, Skunk Creek and Diversion Channel*, was completed in March 2000 by HDR Engineering, Inc. The preliminary engineering included providing "10% Design Complete" drawings to aid in pursuing design and construction sequencing. The COE and the City of Sioux Falls have completed review of this document.

As proposed in the DOS, the project has been broken into three phases. Phases II and III were reversed at the request of the CSF. Phase I was broken into two sub-phases to better pursue the design objectives within the construction constraints. A map is attached that illustrates the proposed phasing of the BSR FCP.

Phase IA includes improvements to the diversion channel spillway including raising the height of sidewalls, increasing capacity and strengthening the structure by buttressing the sidewalls. Associated geotechnical work will also be pursued in and around the structure. Phase IA also includes modification and improvements to the stilling basin or the outfall of the spillway into the Big Sioux River channel. Long-term maintenance on the existing spillway headwalls and floor will also be included as a part of this Phase.

Phase IB incorporates levee improvements, channel modifications and revetment and measures to preclude seepage on the reach of the Big Sioux River from near Falls Park Drive to Cliff Avenue. The stilling basin and spillway outfall are located in this reach. Associated surface drainage structure modifications are included in this Phase, also.

Phase II includes levee improvements from near West Maple Street on the Big Sioux River to Western Avenue and from Marion Road on Skunk Creek to the confluence of the BSR. Seepage measures and surface drainage structure improvements are included with the project as well as probable infrastructure modifications including the 41st and 49th Street bridges. The levee height in this area will require a rise of anywhere from 2 ft. to 6-ft. varying throughout both reaches addressed by this Phase.

Phase III includes modifications and structural improvements to the diversion dam and flood gate structures and levee improvements including the I-90 tieback (Silver Creek), north levee (north of I-90), and diversion channel from the diversion dam to the spillway. Associated surface drainage structure modifications and modifications to railroad and Minnesota Avenue bridges are included in this Phase.

The estimated total cost of improvements is \$40,600,000. The schedule for completion of all phases is September of 2006. The tables below break cost and schedule out by Phase of construction.

Table 1 – Cost Estimates by Phase

Phase	Estimated Cost (\$1,000)
IA	\$ 4,000
IB	\$ 5,900
II	\$18,400
III	\$12,300
Total	\$40,600



Exhibit 5 – Diversion Channel Weir (1997 Flood)

Table 2 – Construction Schedule (Tentative)

Phase	Dates
IA	Fall 2000-Winter 2002
IB	Spring 2001-Spring 2002
II	Summer 2002-Fall 2003
III	Spring 2004-Fall 2006

The proposed Big Sioux River Flood Control Project improvements would provide 100-year event protection on the Big Sioux River and Skunk Creek. They would also provide relief from any possible catastrophic failure of the spillway and diversion structures in a 500-year event. Spillway and diversion channel improvements accommodate a design discharge of 29,000 cfs. Headwall improvements on the spillway increase its capacity to 37,300 cfs. The proposed improvements based on the 100-year flood event provide a Benefit/Cost ratio of 1.2:1 for the Big Sioux River reach and 1.3:1 for the Skunk Creek Reach.³

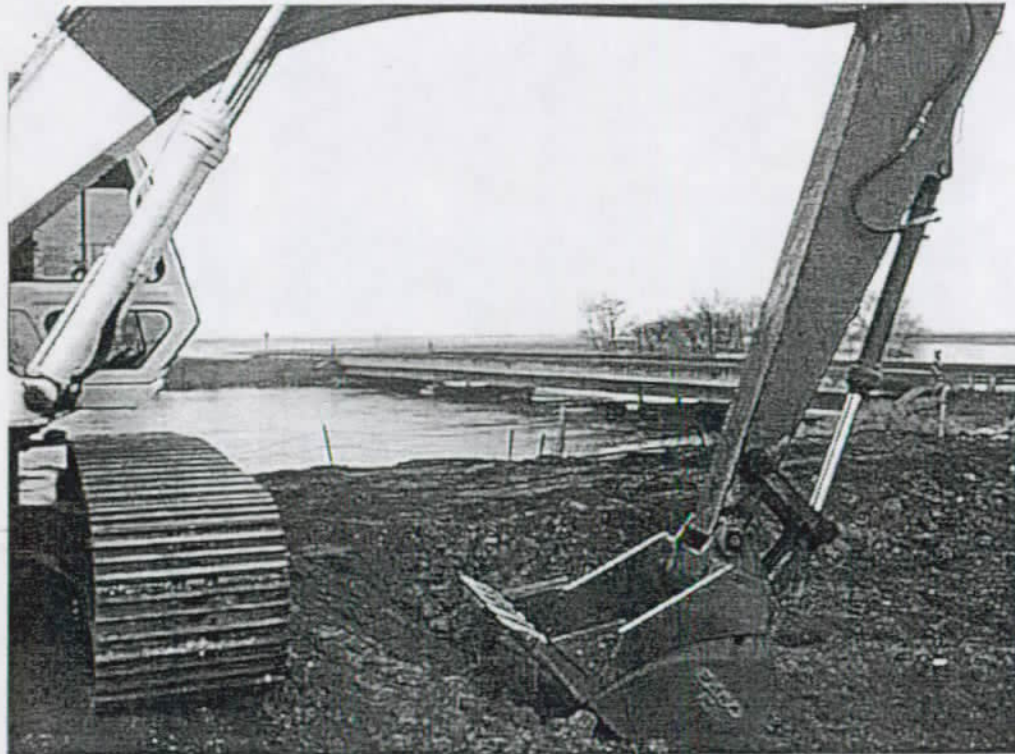


Exhibit 6 – Flood Control Measures, 60th St. N. (1997 Flood)

Project Authorization & Funding

The existing flood control project was authorized under the Public Law 780, 83rd Congress, dated 3 September 1954. The feasibility study for the flood control project improvements was authorized by a 1 August 1963 resolution of the Committee on Environment and Public Works of the U.S. Senate and by an 8 May 1964 resolution of the Committee on Public Works and Transportation of the U.S. House of Representatives. The feasibility study was funded by both Federal and non-Federal sources in accordance with the provisions of the Water Resources Development Act of 1986. The non-Federal sponsors of the project are the City of Sioux Falls and the State of South Dakota.



Exhibit 7 – 49th Street (1997 Flood)

The acceptance of the feasibility study initiated requests for funding under the Flood Control Act of 1970, as amended under Public Law 91-611, and the Water Resources Development Act of 1986, as amended under Public Law 99-662. Section 902 of Public Law 99-662 established the maximum amount of costs and cost sharing and established the *Big Sioux River and Skunk Creek Flood Control Project*. The maximum amount was subsequently amended to \$40,600,000 with the non-Federal sponsor contributing a minimum of 25% or \$10,300,000. The State of South Dakota committed to the non-Federal cost share with the City of Sioux Falls by obligating \$4,550,000 under the session Laws of 1992, Chapter 254, Section 17. A new start appropriation of \$2,200,000 was approved by U.S. Congressional action in FY 2000. The House Appropriations Subcommittee on Energy and Water Development approved the fiscal year 2001 Energy and Water Appropriations Act in June 2000. This action, following release of the

legislation, appropriates an additional \$1.5 million of federal funding to the Big Sioux River and Skunk Creek Flood Control Project.

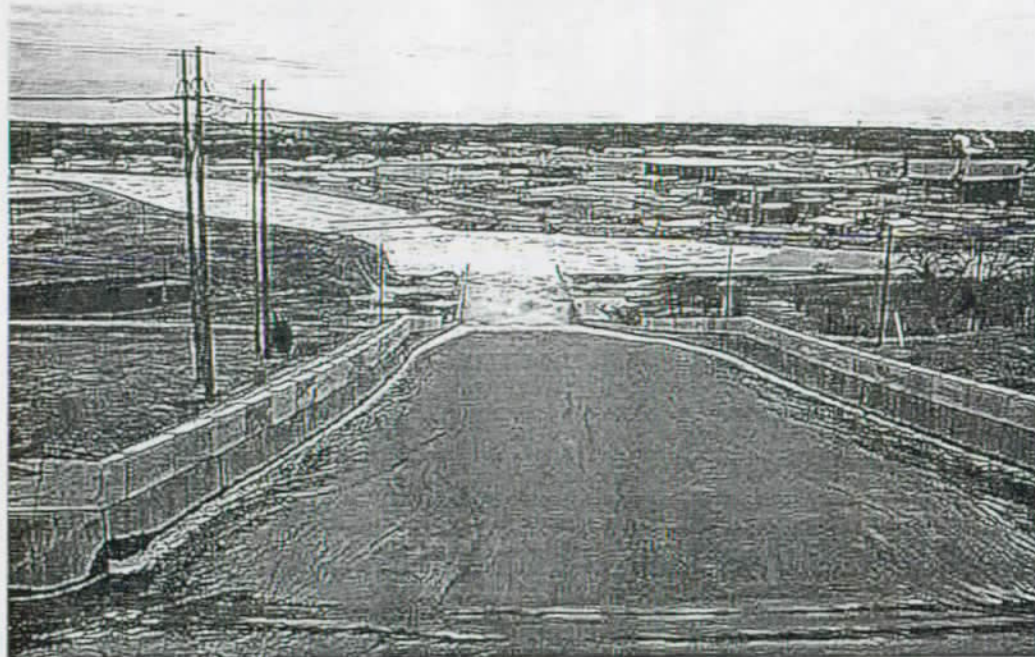


Exhibit 8 – Spillway/Stilling Basin (1997 Flood)

The appropriations received recently enable the City of Sioux Falls to release the obligational authority it has been budgeting since 1994. Design is nearing completion for Phases IA and IB and contract lettings scheduled for October 1, 2000 and April 1, 2001, respectively. Preliminary design is also proceeding on Phases II and III. Further appropriations will be required to pursue construction of these phases.

Federal Emergency Management Agency & Flood Insurance Rate Map

The March 1979 Flood Insurance Study (FIS) for Sioux Falls and vicinity reported that the existing project protected Sioux Falls from floods in excess of the 100-year event on the Big Sioux River and at approximately the 25-year level on Skunk Creek. In 1982, the Federal Emergency Management Agency (FEMA) released its Flood Insurance Rate Maps (FIRM) for Sioux Falls.

During September 1987, FEMA was notified of the Corps' study results stating that the existing project provides inadequate flood protection for Sioux Falls. Because FEMA administers the National Flood Insurance Program (NFIP), it is FEMA's responsibility to ensure that the FIRM for Sioux Falls reflects the current flood hazard. At that time, FEMA decided not to reevaluate the Sioux Falls area until the existing project had been modified or a decision was made not to modify the existing project.



Exhibit 9 -Diversion Channel (circa 1909)

The City of Sioux Falls met with Dr. John Liou of FEMA in March 2000. FEMA had prepared a draft FIRM map under the 1992 base City map utilizing the data from the Feasibility Report and Engineering Appendices for *Local Flood Protection, Big Sioux River and Skunk Creek at Sioux Falls, South Dakota* dated November 1993, the *Big Sioux River Model Study CHL-97-18* dated July 1997 and the Corps of Engineers *Hydraulic Design Criteria*.

Several problems and issues are inherent in the draft FIRM as presented. Base mapping does not reflect the more accurate elevation and infrastructure data currently available with the City of Sioux Falls' Geographic Information System (GIS) database including updated aerial photography and base mapping. Elevation datum based on the hydrologic model dictates actual FIRM application and administration within the City. This has and continues to be the policy of the City. The mapping provided within FIRM serves as the reference for the public and systematic land use planning. However, with the problems inherent with the "dated" base mapping, as well as the accuracy of the mapping with respect to infrastructure and elevation datum, the FIRM map as presented provides an inaccurate "picture" of flood hazard. In addition, with the initiation of the Big Sioux River Flood Control Project, it is likely the FIRM would be in a state of flux as improvements are constructed during the phased implementation of the project. Basically, FEMA proposed initiation of the FIRM as if a decision had been made "not to modify the existing project".

Administratively, reissuance and continual updating of the FIRM would be expensive and confusing. Therefore, recommendations were made and accepted by FEMA to explore the option of updating the base mapping consistent with the City of Sioux Falls GIS database. Recommendations also included the delay of formal implementation of the FIRM until completion of Big Sioux River Flood Control Project. Implementation of the FIRM could be reevaluated on an annual basis as the status of funding and Phase Completion dates become more accurate. Under this scenario, elevation control would still apply for application of flood rates but revised FIRM distribution would be delayed until the Big Sioux River & Skunk Creek Flood Control Project improvements are in place. It is critical, however, for the City of Sioux Falls to disclose the basis for administration of the FEMA mapping and to hold public hearings in conjunction with FEMA outlining the program.

Big Sioux River & Skunk Creek and Flood Control Project



Phase 1A.....Spillway Chute and Silling Basin
Improvements.

Fall 2000 - Winter 2002



Phase 1B.....Levee Raise on Big Sioux River
From Falls Park Dr to Cliff Ave.

Spring 2001 - Spring 2002



Phase 2.....Levee Raise on Big Sioux River
From Russell St to Western Ave
and on Skunk Creek
From Marion Rd to Confluence
With Big Sioux River.

Summer 2002 - Fall 2003



Phase 3.....Levee Raise on Big Sioux River
From I-90 to Diversion Dam
and on Diversion Channel
From Diversion Dam and
Spaders Rogers Addition to
North Drive/Spillway.

Spring 2004 - Fall 2006

- Streets
- Levee
- Rails
- River
- City Limits

Appendix A-
Corps of Engineers
Schedule & Cost Estimate

	Thru 2000	2001	2002	2003	2004	2005	2006	Project Total
Federal Costs	\$2,338,000	\$5,991,000	\$4,000,000	\$8,440,000	\$4,826,000	\$4,300,000	\$2,555,000	\$30,450,000
Sioux Falls Costs	\$146,000	\$1,217,000	\$6,169,000	\$386,000	\$806,000	\$777,000	\$649,000	\$10,150,000
Yearly Total Costs	\$2,484,000	\$7,208,000	\$10,169,000	\$6,826,000	\$5,632,000	\$5,077,000	\$3,204,000	\$40,600,000

Page 1

Appendix B-
Corps of Engineers
Progress Review Meeting Minutes



city interoffice

MEMORANDUM

Date: June 6, 2000
To: All Attendees
From: Rod Liesinger, Assistant Engineer—Design *Rod Liesinger*
Subject: May 2, 2000, Coordination Meeting with Corps of Engineers on City of Sioux Falls Flood Control Project and Review of the 10 Percent Plan Submittal for Phases II and III

A coordination meeting was held on May 2, 2000, in the Corps of Engineers office in Omaha, Nebraska, to discuss the City of Sioux Falls Flood Control Project. The following were in attendance:

Name and Title	Area of Responsibility	Phone No.
John Osman, Drainage Engineer	City of Sioux Falls	(605) 367-8640
Bob Worden, Civil Engineer	Corps of Engineers	(402) 221-4707
Tom Berkland, Assistant Engineer Support Services	City of Sioux Falls	(605) 367-8611
Mike Barnes, Project Manager	Corps of Engineers	(402) 221-4605
Tim Campbell, Structural Engineer	Corps of Engineers	(402) 221-4650
Bob Reed, Real Estate Specialist	Corps of Engineers	(402) 221-4339
Jerry Smith, Real Estate Specialist	Corps of Engineers	(402) 221-4319
Rod Liesinger, Assistant Engineer Project Development	City of Sioux Falls	(605) 367-8637
Ken Swedeen, City Engineer	City of Sioux Falls	(605) 367-8651
Kevin Adams, Hydraulic Engineer	Corps of Engineers	(402) 221-4120
Mark Adel, Project Manager	Corps of Engineers	(402) 221-4479

Agenda items discussed included:

- ◆ Design update Phase I.
- ◆ Design update Phases II and III.
- ◆ Review of 10 percent plan submittal.
- ◆ Discussion on financial statement.
- ◆ Survey update.

Tim Campbell indicated Phase IA: Raising of the spillway chute and stilling basin area plans will be ready for review by June 1, 2000. The Corps of Engineers is uncertain at this time how many days will be required to complete the project. As this project is funded in fiscal year 2001, no work can commence until after October 1, 2000.

Plans for Phase IB of the project: Raising the levies downstream of the spillway should be complete in early 2000 for construction during the 2001 construction season.

There was discussion on coordination of utilities adjacent to the project. The City understands we are responsible for relocating our own utilities; however, there needs to be some assertive coordination effort with the private utility companies. The City will make the initial contact with utility companies regarding advising them of the scope and schedule of the project. We will discuss not only Phases IA and IB, but also Phases II and III.

The project is to be constructed in four phases as follows:

- ◆ Phase IA: Spillway chute and stilling basin area.
- ◆ Phase IB: Levies adjacent to Morrells downstream to Cliff Avenue.
- ◆ Phase II: Levies along Skunk Creek from Marion Road to the confluence with the Big Sioux River and the Big Sioux River upstream to near Madison Street and downstream to the tieback levies near Western Avenue.
- ◆ Phase III: Diversion channel levies.

The Corps of Engineers staff indicated a concern regarding underseepage along the entire stretch of Phase IB. They are in the process of doing an underseepage analysis. They are especially concerned about the area along the old sanitary sewer lagoons.

The City of Sioux Falls had an underseepage analysis done in conjunction with a proposed detention pond near the John Morrell & Company by GSI. A copy of this underseepage analysis was provided to the Corps.

There was discussion regarding the originally proposed detention pond on the Morrell property. Due to the extensive amount of work required to provide underseepage protection, it appears it would be more cost-effective to install a double installation 4 x 6 box culvert at this location rather than construct a detention pond. The City's consultant will be instructed to complete the design and include the design with the flood control project Phase IB as a nonparticipating item. The Corps

of Engineers staff indicated they will include sealing the joints on the spillway in conjunction with the Phase IA project.

Tom Berkland discussed the survey that is currently being done to identify the existing right-of-way adjacent to the entire flood control system. The survey adjacent to Phases IA and IB of the project is to be complete by the end of May 2000. The surveys for Phases II and III are scheduled to be complete by October of 2000. This information will be provided to the Corps of Engineers as soon as it is available. Tom mentioned the City has acquired the property needed for the project adjacent to John Morrell & Company. A copy of the plat for this property will be forwarded to the Corps of Engineers.

The design schedule for Phases IA and IB were discussed.

Phase IA

Schedule

Plans to City for review	Mid-June 2000
City review complete	July 1, 2000
Advertise	August 1, 2000
Award	October 1, 2000

Phase IB

Schedule

Advertise	Spring of 2000
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Kevin Adams indicated they are considering fully opening eight of the ten gates on the diversion structure to allow a maximum of 7,300 cfs to flow down the main river channel minimizing the impact on the Phase IA project. There was discussion regarding the scheduled completion date to determine if work within the spillway area could be complete before freeze-up in the late fall. This would allow the gates to be closed for the spring 2000 runoff. Further coordination in this area will be required.

Another issue which needs to be considered is maintaining a sufficient level of water upstream of the Weir structure to allow the City to continue pumping water to the Water Plant. The minimum level typically maintained is to the top of the Weir structure.

The 10 percent submittal plans were reviewed. The City's comments and concerns are attached to this document for reference. These issues were also discussed during the meeting.

HDR Engineering had previously completed an interior drainage study which identifies all locations runoff enters the river through drainage structures. Their work included a condition survey of the existing drainage pipes through the dike. A number of the existing structures are corrugated metal pipe. The Corps of Engineers 10 percent submittal plans indicate these will be extended if HDR Engineers' report indicated they were in good repair. City staff expressed a concern about leaving CMP pipe in place. Corps of Engineers staff indicated they would be looked at further as the design for each phase of the project progresses.

The issue of considering extending the project along Skunk Creek upstream of Marion Road was discussed. The Corps of Engineers staff felt they did not want to amend the current project to extend upstream of Marion Road as it may cause a delay in the completion of the project. They suggested the City request this area be considered within their Section 205 program. City staff will take this under advisement.

The 10 percent complete plans were prepared based on the Merek survey which was conducted in 1993. Therefore, a significant amount of changes have occurred adjacent to the flood control system. City staff will submit as-built information, contoured aerial information, and any other information available to supplement this survey data. The areas noted as being modified are detailed on the attached memorandum dated May 1, 2000, addressed to Mike Barnes.

The City will provide the Corps of Engineers with the following documents:

- ◆ 57th Street from Western Avenue to Louise Avenue as-built plans.
- ◆ Prairie View diversion channel as-built plans.
- ◆ DOT project West 12th Street over the Big Sioux River structure plans.
- ◆ DOT project Benson Road structure over the diversion channel plans.
- ◆ Development plans for the area at the confluence of Skunk Creek and the Big Sioux River.
- ◆ As-built documentation of the drainage structure along I-90 entering Catfish Bay.
- ◆ Aerial photography showing Sweetman quarry area.
- ◆ DOT project 26th Street and I-29 interchange plans which would include borrow area/detention pond adjacent to Skunk Creek.
- ◆ DOT project I-229 and Western Avenue interchange as-built plans.

All Attendees
Page 5
June 6, 2000

Documentation/plans for the following detention ponds:

- ◆ Pond adjacent to the post office along diversion channel.
- ◆ Pond adjacent to the West 12th Street Kmart and Sertoma Park Oxbow area south of 49th Street.

The impact on the golf course property near Station 86 30 + 00 on the left bank was discussed. Coordination will be necessary with the golf course to minimize the effects. The issue of underseepage through this area was also discussed. This will be addressed with the design of Phase II.

The Corps of Engineers requested the City investigate locations for borrow sources for the project. City staff requested they provide us with the quantity of borrow needed and the type soils needed.

The Corps of Engineers requested the City assist in identifying the locations of wetlands adjacent to the project. The City will need to provide potential mitigation sites if needed to mitigate for impacted wetlands. The Corps will schedule a site visit to investigate the wetland sites and possible mitigation locations.

Corps of Engineers staff indicated the walls on the diversion channel structure will be raised approximately three feet and low-flow gates within the existing gates will be added.

The Corps is investigating further how to address providing adequate area at the 41st Street crossing of the Big Sioux River to pass the 100-year flow. This will be addressed in conjunction with the Phase II design.

Ken Swedeen returned the financial agreement to the Corps with the City's recommended modifications. The Corps will review the City's request and resubmit it back to the City.

Mike Barnes will notify the City when the next review meeting will be scheduled. The City proposes to attend coordination meetings to assist the Corps with information needed from our staff to keep the project on schedule.

c All Attendees
Enclosures

city interoffice
MEMORANDUM

Date: June 20, 2000
To: All Attendees
From: Ken Swedeen, City Engineer
Subject: June 1, 2000, Coordination Meeting with Corps of Engineers (COE) on City of Sioux Falls (CSF) Flood Control Project

A progress review meeting was held on June 1, 2000, in the COE office in Omaha, NE to discuss the design of the Big Sioux River Flood Control Project (BSR FCP). The following persons were in attendance:

Name and Title	Area of Responsibility	Phone No.
Mike Barnes	COE-Omaha; PM	402-221-4605
Tom Berkland	CSF-AE	605-367-8611
Mike Roth	CSF-Zoning & BS Dir.	605-367-8670
Steve Van Aartsen	CSF-GIS Mgr.	605-367-8653
Ken Swedeen	CSF-City Engineer	605-367-8651
Tim Campbell	COE-Omaha; Design	402-221-4650
Randy Sellers	COE-Omaha; Environ.	402-221-3054
Bob Reed	COE-Omaha; RE	402-221-4339
Jerry Smith	COE-Omaha; RE	402-221-4319
Kevin Adams	COE-Omaha; Hyd.	402-221-4120
Mark Adel	COE-Omaha; Const.	402-221-4470
Dick Taylor	COE-Omaha; Geotech.	402-221-3772

Flood Plain Management Issues

Prior to the design review meeting, a meeting was held with Larry Buss of the COE-Flood Plain Management Group concerning flood mapping (FIRM) and FEMA implementation schedule of new flood insurance rates and zones. New contour mapping and revised location mapping had been submitted to the FEMA and the COE to upgrade the existing database for creation of the necessary documents. "As-constructed" plans had also been submitted for improvements within the flood plain not accounted for in the existing mapping. These include 57th Street improvements, I-229 improvements, I-29 and 26th Street Interchange improvements and Western Avenue and I-229 improvements. It was agreed that the COE would develop a scope of work and cost estimate to revise the flood mapping based on the new base mapping and revised flood plain features. The CSF would review this information and broker a cost share proposal to complete the mapping. Timing and scheduling of FEMA implementation would be dependent on BSR FCP progress and FEMA recommendations.

Mapping data available including FTP site and ArcView, ArcInfo, and AUTOCADD data transfer were discussed.

Discussion included flood plain management and mapping of the area downstream from Western Avenue currently outside the Flood Control System and upstream on Skunk Creek from Marion Road to LaMesa.

Agenda items for the progress review meeting included:

- Phase IA Plan Status
- Phase IA Design Issues
- Phase II & III Environmental Clearance
- Financial Certification Statement
- Schedule and Cost Estimate

Phase IA Plan Status

Tim Campbell indicated the COE was currently running interference checks on the Phase IA Plans. Internal review of the design package is expected to begin June 16, 2000. The bike path crossing on the spillway appears to not be feasible due to counterfort and spillway foundation design. Mark Adel submitted the Utility Drawings for Phase IA and IB. The CSF will review and set up locate and relocation meetings with private contractors. Ken Swedeen again reiterated the necessity to prepare a Protection of Utilities Special Provision for the CSF Sanitary Sewer Trunk line crossing under the spillway. This is the main trunk to the Water Reclamation Plant. Current plans call for the facility not to be disturbed or require relocation with the spillway modifications.

ROW issues for Phase IA were discussed and Tom Berkland will provide the plats for area below Falls Park Drive. ROW is in place for Phase IA and Phase IB. Jerry Smith indicated the COE would require Title evidence and appraisals would be required to determine the value of the ROW involved. Tom Berkland will send the Exhibits and Plats. He will also work with the CSF Attorney's Office-ROW on providing a list of local appraisers. The COE needs legal descriptions prior to appraisals and whole ownership plus takings listing.

It is expected the COE will mail or provide Plans & Specifications the end of June.

Phase IA Design Issues

Staging areas and construction access were discussed and the CSF will provide layouts and aerial photographs of these. Borrow material specifications and sites were discussed and the CSF will provide material location and testing for the borrow needed for Phase IA. It was indicated that this would be non-structural fill.

The condition of relief wells for the spillway area was discussed and the COE will be investigating. The COE will be making a field review in the near future to explore this in conjunction with Environmental Assessment issues on Phases II and III.

Phase II & III Environmental Clearance

Randy Sellars will be on-site in late June to review wetland sites and the mitigation plan. Other EA issues will be reviewed during this field reconnaissance. The CSF will coordinate and Rod Liesinger is the City contact.

Financial Certification Statement

The FCS as provided is acceptable for issuance. The signing ceremony for the Project Cooperative Agreement between the COE and CSF was discussed. An August date is anticipated.

Schedule and Cost Estimate

The COE is working on federal funds portion for the 2002 budget. Phase IA is still projected at an October 1, 2000 bid date at the initiation of the Federal Fiscal Year 2001 program. CSF review of the P&S is anticipated beginning July 1, 2000.

Miscellaneous

Recent development in the area to the north and east of the diversion structure on the levee structure north of I-90 (E. Dike Place & 7th Ave.) had been submitted by the CSF and reviewed by the COE. The COE recommendations for

acceptance included scarification of the roadway surface and removal of gravel surfacing with impermeable material at the levee crest. There should also be a restriction of travel east to west on the levee crest.



city interoffice

MEMORANDUM

Date: June 28, 2000
To: All Attendees
From: Rodney A. Liesinger, P.E., Assistant Engineer—Design *Rod Liesinger*
Subject: Site Inspection of Big Sioux River Flood Control Project

A site review meeting was held June 23, 2000, in the City Engineer's Office. The following were in attendance: Dick Taylor, Randy Sellers, and Bob Worden, all with the Corps of Engineers, and Ken Swedeen, Tom Berkland, John Osman, and Rod Liesinger with the City of Sioux Falls. The following issues were discussed.

The City coordinated a design locate meeting with the utility companies for Phases IA and IB. A survey and plan was done following field locates by the utilities. A survey identifying the locations of the utilities, along with plans, was prepared following the field locate. A copy of this information was provided to the Corps of Engineers' staff. This information will be reviewed in relation to the design to identify any potential conflicts with the utilities.

The City staff specifically pointed out the location of the City's central sanitary sewer main. The Corps of Engineers' staff indicated special attention will be listed on the plans relating to protecting this sewer line.

The 404 Wetlands Permit was received this past week. A copy was provided to the Corps staff. The work on Phase IA is covered under a nationwide permit.

Ken Swedeen discussed the dirt borrow sources. The City has material available from cleaning the river channel. This material will be tested for soil characteristics as well as undesirables. The Corps of Engineers' staff will provide us with a quantity of fill material required for the project. The plans for Phase IA are scheduled to be available for review by July 14, 2000.

JSA Engineers are under contract by the City to design a box culvert adjacent to the John Morrell Company plant. The construction of this box culvert will be coordinated with the Phase IB project. The plans are to be completed by August 30, 2000. City staff will forward them to the Corps of Engineers when they are available. Bob Worden and Dick Taylor requested that we provide the invert elevation of the box culvert and our grading plan for the area adjacent to the dike as soon as this information is available.

Dick Taylor requested a copy of the 1997 Advance Measures plans so they could identify areas the dikes were raised with that project. City staff will forward these plans.

The operation of the diversion structure gates was discussed. The City would prefer the diversion gates be operated to maintain the water level in the diversion channel to the top of the weir structure. This would provide for the most efficient operation of the City's water pump station. The Corps of Engineers will develop a plan for operating the diversion structure to minimize impact on the Phase IA project and to address the City's needs. In discussion with Corps staff, the Phase IA project is projected to take six months. Thus, construction may get into the time of year when spring runoff is likely.

Corps of Engineers' staff asked how much water the City pumps daily from the river. City staff will provide this information.

Again, sealing joints on the spillway were discussed. This work will be coordinated with the Phase IA project.

During the field visit, the staging area was observed. It will be on the north side of the spillway-stilling basin. Access will be from Chambers Avenue.

Project mitigation issues as they related to the 1993 Reconnaissance Report were discussed. These include the woodlot south of 12th Street on the right bank of the river. A strip of woodlot approximately 3,000 feet long will be impacted with a total area of .34 acres. The City is required to provide 1.03 acres of woodlot mitigation site. During inspection of the project, it appears there are locations along the river which could be used to mitigate this 1.03 acres. This will be coordinated with the project. A memorandum from Randy Sellers dated June 26, 2000, summarizing this and other environmental issues, is attached for reference.

Attachment

c Mike Barnes, Corps of Engineers

Liesinger, Rod

From: Sellers, Randy P NWO [Randy.P.Sellers@nwo02.usace.army.mil]

Sent: Monday, June 26, 2000 2:20 PM

To: Barnes, Micheal J NWO; Taylor, Richard J NWO; Anderson, Paul F NWO; Cisar, Bryan R NWO; Gorton, Candace M NWO; Oehlerking, M J NWO; Naylor, Steven E NWO; Iske, Kathy L NWO; 'rliesinger@SIOUX-FALLS.org'

Subject: Sioux Falls flood control project

Trip Report:

Rod, Ken, John, Tom, Thanks for the meeting and the escort, it was very helpful.

Last weekend Bob Worden, Dick Taylor, and I made a trip to Sioux Falls to view various segments of the Sioux Falls Flood control project. My primary objective was to view the wetlands which the Feasibility report of 1993 identified as potentially being impacted by Phase 2 of the project. I also was interested in viewing potential mitigation sites. In doing so, we also viewed the woodlot to be impacted as well as both golf courses. To follow is a summary of our findings.

WOODLOT.

-feasibility study on target, it appears as though a 10' corridor will be impacted along 3000 feet of levee, requiring either replacement or purchase of 1.03 acres of existing trees for protection in perpetuity.

WETLANDS.

-feasibility study not so on target. It appears as though the project will impact more than the estimated .81 acres of wetland identified in the FS. Impacts to as many as >5 acres may occur. This could include impacts directly along the toe of the levee as well as potential impacts further into the wetlands depending upon seepage concerns.

-I will need to look at the 10% design drawings in conjunction with the NWI and aerial photo's. I will then estimate a new acreage.

-Geotech will need to define any seepage concerns so that associated impacts may also be accounted for.

-Once I have a reasonable project description and estimated impact I will coordinate with Regulatory, Sioux Falls, and other agencies.

-It does appear as though plenty of opportunity for creation of mitigation wetlands exists. There are a number of areas along the levee as well as some other areas close by which the city has identified. The city plans to look into mitigation sites further once I have further defined impacts and needs.

-It still appears as though the bulk of the quality wetlands are occurring between 49th St and 57th St. There is one area however located north of 41st, outside the left bank levee and within the golf course. This is a good size piece, but definitely of low quality and probably of a function and value solely related to golf course aesthetics. I am guessing the golf course will want this back somewhere on the golf course. It is basically a shallow lake with turf grass surrounding it.

GOLF COURSE.

-FS right on target--a few ornamentals to replace.

-other golf course issues noticed by Worden include; trees planted on the levee, tee box on levee, and greens, fairways, tee-boxes potentially within new levee right of way. All issues which will come to the design and public involvement portions of phase 2.

MISCELLANEOUS.

-Need supplement to EA for levee portions on Skunk, upstream of I-29. This will require definition of affected environment during separate site visit.

RELIEF WELLS.

-See Bob Worden, Dick Taylor. -

Feel Free to contact me. 402 221 3054,
Randy



City of Sioux Falls

MEMORANDUM

Date: July 26, 2000
To: All Attendees
From: Rod Liesinger, Assistant Engineer—Design
Subject: July 14, 2000, Review Meeting on City of Sioux Falls Flood Control Project with the Corps of Engineers Office in Omaha, Nebraska

A meeting was held July 14, 2000, in the Corps of Engineers Office in Omaha, Nebraska, to review the current status of the City of Sioux Falls flood control project. The following staff personnel were in attendance:

Mike Barnes	Corps of Engineers	Project Management	(402) 221-4605
Bob Reed	Corps of Engineers	Real Estate	(402) 221-4339
Jerry Smith	Corps of Engineers	Real Estate	(402) 221-4319
Kevin Adams	Corps of Engineers	Hydraulics Engineer	(402) 221-4120
Mark Adel	Corps of Engineers	Civil Division	(402) 221-4479
Bob Worden	Corps of Engineers	Geotech Division	(402) 221-4707
Ken Swedeen	City of Sioux Falls	City Engineer	(605) 367-8651
Rod Liesinger	City of Sioux Falls	City Engineering	(605) 367-8637
John Osman	City of Sioux Falls	City Engineering	(605) 367-8640
Tim Campbell	Corps of Engineers	Structural Division	(402) 221-4650
Dave Ray	Corps of Engineers	Geotech Division	(402) 221-4493
Steve Graf	Corps of Engineers	Construction Division	(402) 221-4158
John Palensky	Corps of Engineers		(402) 221-7177
Greg Johnson	Corps of Engineers		(402) 221-4408

John Palensky provided City staff with information regarding the Corps of Engineers Section 205 program, Flood Damage Reduction Projects. The purpose of the program is to construct projects to reduce damage caused by flooding. This program focuses on solving local flooding problems in urban areas. A copy of an outline of the program is attached for reference.

Mr. Palensky also provided City staff a copy of the scope of work for a Flood Warning System on Skunk Creek. This project qualifies for federal funding under the Section 22

All Attendees
Page 2
July 26, 2000

program, Planning Assistance to States and Tribes. He was inquiring whether the City wanted to pursue this project. City staff will review the scope of work and get back to Mr. Palensky's office. A copy of the scope of work is attached for reference.

Rod Liesinger provided information to Kevin Adams and Mike Barnes on the amount of water the City of Sioux Falls pumps from the Big Sioux River via the City's pumping station. This information is as follows. In 1999, the City used a total of 3,069 million gallons of water from the Big Sioux River. The City currently has water rights for 3,250 million gallons of surface water per year. We are currently applying for additional water rights to increase our surface water usage to 6,516 million gallons per year. The pumping station has the capacity to pump 45 million gallons per day. Our 1999 daily pumping average was 13.3 million gallons per day. There are times in the early spring when the station is not on line for a period of several weeks due to runoff which may cause taste and odor occurrences.

Tim Campbell distributed five sets of preliminary design plans for the Phase IA project for City of Sioux Falls review. City staff will review the plans and have our comments back to the Corps of Engineers by August 4, 2000. The project is scheduled for advertising near the end of August, 2000.

Jerry Smith advised that all right-of-way must be secured before the project is awarded. City of Sioux Falls staff is currently working with the South Dakota Department of Corrections to secure right of entry on Department of Corrections property. This information will be provided to the Corps when available.

Jerry Smith advised the Corps of Engineers needs a copy of the title certificate for the John Morrell and Company property. They also need copies of County plats for subdivisions along the Phase IB project to acquire these properties. By Federal regulation, projects cannot be let until ROW is cleared through the Corps of Engineers.

Ken Swedeen advised the City has established a location for staging the project. This area is just north and east of the stilling basin. The Corps of Engineers' real estate staff indicated the City can receive a credit for lease value for the time the staging area and also for the time the construction zones are needed. City of Sioux Falls will provide a survey of these properties to include in the plans and also for computing a lease rate. The lease rate must be based on fair market value and for a term of two years.

Jerry Smith also advised the City can receive sponsor credit for the value of all properties which the flood control system occupies if the properties were either originally donated or purchased by the City of Sioux Falls. No credit can be claimed for properties purchased with Federal funds. This includes the existing system and new properties

needed for the upgrade of the flood control system. The City will need to pursue appraisals of these properties.

Kevin Adams discussed the verbiage they have proposed in the contract for operation of the diversion structure. He indicated the diversion structure will allow 1,900 cfs to pass down the main river channel before runoff overtops the weir structure at elevation 1421. Thus, their proposal is to advise the contractor that 1,900 cfs can be diverted down the river channel with all diversion gates open. The runoff in excess of 1,900 cfs will overtop the weir structure and will need to be managed downstream. City of Sioux Falls staff reiterated their desire to have the flow maintained at the level of the weir structure to maximize efficiency for the pumping station. Corps staff indicated in the event of low flow (before 1,900 cfs) this will need to be coordinated with the contractor.

Ken Swedeen indicated materials tests for nonstructural backfill will be forthcoming. Tests are currently being done and will be forwarded to Bob Worden when available. Mr. Worden indicated approximately 5,000 cy of nonstructural borrow has been estimated for the Phase IA project adjacent to the spillway and stilling basin. He also advised if the contractor elects to build a cofferdam out of borrow material, 7,000 cy will be required. The material for the cofferdam will be set up in a contract to be furnished by the contractor.

Jerry Smith advised at this point if the City buys/furnishes borrow material, we need to certify the quantity for sponsor credit.

Bob Worden discussed the results of the relief well inspection which was conducted June 23, 2000. He indicated Relief Wells 3 and 5 on the left bank as referenced in their report are full of debris and need to be cleaned for inspection. Also, they were unable to access Well No. 2 on the right bank due to debris. He indicated the other seven wells are in reasonably good repair.

There was discussion regarding cleaning the contaminated relief wells so they could be inspected. City of Sioux Falls staff will work with Bob Worden to develop specifications to have a local well driller clean these relief wells as soon as possible so they can be inspected. The Corps of Engineers would like to be present for the work.

Steve Graf with the construction division indicated Don Stolz who is located in the Corps of Engineers Rapid City office will administer the construction of the Phase IA project. He indicated the Corps of Engineers will do their own quality control/quality assurance testing for the project.

Dave Ray with the geotechnical division discussed proceeding with the soils investigation on Phases II and III of the project. Their goals is to have all the field work

done by November 2000. This work will include underseepage analyses and pump testing. They requested names of local testing firms to assist with the field work. City staff will forward this information through Mike Barnes.

There was discussion regarding the need to do further geotechnical work on Phase IB. This work will be coordinated through Dick Taylor.

Ken Swedeen indicated the City of Sioux Falls will be making a presentation to the South Dakota Board of Water and Natural Resources during their July meeting July 27 and 28. The Board will be considering the City of Sioux Falls for a grant under the State Water Resource Management System.

He inquired whether an updated schedule and revised estimate was available. Mike Barnes said he would update the project schedule and forward it to the City. Also, he will revise the cost estimates and get this information to the City. Mike indicated the revised cost estimate for Phase IA is \$4.0 million.

The design for Phase IB has been started. It is scheduled for a March 2001 bid date.

A copy of the Section 404 permit was provided to the Corps of Engineers staff. Also, a copy of the asbestos survey conducted on the abandoned lift station near John Morrell and Company was provided to the Corps for their information. A copy is attached for reference.

In conversation with Dick Taylor earlier in the week, he advised the Corps of Engineers environmental staff would be available to do further environmental assessments of the lift station. He will proceed with scheduling this work.

There was discussion regarding breaking the Phase II project into two phases. There are extensive right-of-way issues and wetlands issues along this phase of the project.

Ken Swedeen advised the Corps staff the City has established a committee to review the flood wall issue. City staff will keep the Corps apprised of the discussion within this committee.

There was also discussion relating to passing the 100-year storm event under the 41st Street bridge. The Corps of Engineers are in the process of reviewing the proposal presented in HDR Engineering's 10 percent design plans. Further consideration will be given to raising the 41st Street bridge.

Two issues relating to development adjacent to the river were discussed. R. F. Sayre and Associates have proposed an excavated retention area adjacent to the river dike in conjunction with expansion of the W. H. Lyons Fairgrounds. The City has requested

All Attendees
Page 5
July 26, 2000

Corps staff review underseepage issues relating to this proposal. A copy of a contoured plan sheet was provided to the Corps outlining the location of the proposed retention basin.

Also, the City Parks Department is proposing to construct a bike path connecting the Falls Park area to the northern part of the city. In conjunction with this project, they have requested consideration for extending the bike trail under the Falls Park Drive bridge. City staff provided the Corps with photographs of the area. A copy of the cross-section of the bridge area will be forwarded for their use in analyzing the impact on the flow.

Kevin Adams requested a copy of the cross-sections for the North Cliff Avenue structure over the Big Sioux River and the I-229 structure over the Big Sioux River. City staff will forward this information promptly.

There was discussion with Kevin Adams and Greg Johnson regarding proceeding with the flood insurance study for Phase I of the project. They are proposing to use the City's aerial photography with the two-foot contours. There was also discussion about providing the data exclusively in the 88 datum rather than the 29 datum and integrating the current five reaches for the river analysis into the HEC-RAZ model. The 29 datum was used to design the Phase IA and IB projects. The City is very supportive of this and City staff will discuss whether it is acceptable to simply use an adjustment of 0.91 feet to convert from the 29 datum to the 88 datum.

The next meeting is scheduled for August 14, 2000, in the City of Sioux Falls Engineer's Office. The cooperative agreement between the City of Sioux Falls and Corps of Engineers is scheduled to be signed on that date. It was requested by the City that Corps of Engineers financial representatives be available if possible to review cost accounting, standards, and audit procedures for the project.

c Lyle Johnson
Tom Berkland

FLOOD-DAMAGE REDUCTION PROJECTS

(Section 205)

PURPOSE: To construct projects (structural or nonstructural) to reduce damages caused by flooding. This program focuses on solving local flood problems in urban areas, towns, and villages.

DESCRIPTION: Examples of structural projects are levees, channels, small dams, and floodwalls. Examples of nonstructural projects include flood plain parks, flood warning systems, flood proofing, and relocation of flood-prone development. The Corps works with the project sponsor to (1) define the flood problem, (2) evaluate solutions, (3) select a plan, (4) develop the design, and (5) construct a project.

PROCESS:

FEASIBILITY STUDY

The Corps, along with a non-Federal sponsor, conducts a feasibility study to identify potentially feasible projects and to determine whether the Federal Government and the non-Federal sponsor should construct a structural or a nonstructural project. The first \$100,000 of the feasibility study cost is 100 percent Federal; any costs over \$100,000 are cost-shared 50-50 with the sponsor--in the form of cash and in-kind services.

CONSTRUCTION

If it is decided to proceed with construction, the non-Federal sponsor provides 5 percent of the project cost in cash and also provides any needed lands, easements, rights-of-way, relocations, and disposal. If these items equal less than 35 percent of the total project cost, the cash contribution must be increased to make up the difference. The contribution of the non-Federal sponsor is currently limited to a maximum of 50 percent of the total project cost. After construction is complete, operation and maintenance is the responsibility of the non-Federal sponsor.

Some States have programs to help local communities provide their share of cost-shared studies and construction costs. The Federal investment in the solution is limited to a maximum of \$5 million per project.

AUTHORITY: Section 205 of the Flood Control Act of 1948, as amended.

SCOPE OF WORK
SECTION 22 STUDY
FLOOD WARNING SYSTEM
SIOUX FALLS, SOUTH DAKOTA

1. GENERAL: During recent floods, high water has occurred on Skunk Creek in Sioux Falls with minimal warning. Development continues in the Skunk Creek basin, west of Sioux Falls. Additionally, when the Big Sioux River is high, rapid stage increases have been noticed on Silver Creek. Skunk Creek is a significant right bank tributary with headwaters originating in the prairie northwest of Sioux Falls. Silver Creek is a small left bank tributary, which can carry significant overflows from the Big Sioux River, during basin-wide floods. Both streams represent a hazard to people and property in their flood plains. Timely evacuation could reduce the hazard. Flood warning is necessary to permit detection of the flood threat and timely evacuation.

2. BACKGROUND: During a meeting held in August 1997, the flood threat was reviewed by Corps and city personnel. It was decided that it will be desirable to define the flood threat, determine suitable flood detection sites and implement a limited manual flood warning system by early in 1998. That effort would be followed with an automated flood warning system design for Skunk and Silver Creeks, which would be built as funds permit.

3. NEEDED WORK: It is proposed that the work proceed in three phases as follows:

A. Determine the nature of flood threats from Skunk and Silver Creeks. Both the nature of the flood threat and the amount of warning time needed to mitigate the threat will be defined in this phase. Existing flood reports, city records, recommendations from local officials and a site reconnaissance would be needed to complete this task.

B. Define flood monitoring points at upstream locations in both basins. Initial flood warning points will be determined from USGS quadrangle maps and a site visit. The warning times from those points to locations in Sioux Falls, where a flood threat exists, will be estimated using a calibrated hydrologic model and hydraulic data for historical storms and a range of flood frequencies. Warning times estimated using the model will be compared to the required warning times identified in the first phase. Flood warning gage site locations will be adjusted based upon the model results. Technical assistance will be provided to Sioux Falls in establishing manual flood warning stage gages by late Winter 1998.

C. Evaluate automated flood detection alternatives. Three flood warning system alternatives will be evaluated, based upon flood warning time provided, cost and serviceability. The systems to be evaluated include high stage detection with automatic phone dialers, combined rainfall and stage detection using DCPs with a computer base station and an ALERT flood warning system. Concept designs will be provided for each flood warning alternative. Estimates of costs, flood warning times and annual maintenance costs for each option will be provided as a study product.

4. DETAILED WORK ITEMS

Item No. Task or Work Item

1 Flood Threat Identification

- 1.1 Obtain Quad maps and Corps reports
- 1.2 Obtain City flood threat information
- 1.3 Coordination with City
- 1.4 Site Reconnaissance
- 1.5 Define hazards and required warning times

2 Define Flood Monitoring Points

- 2.1 Define potential gage sites on maps
- 2.2 Site Recon (combine with item 1.4)
- 2.3 Develop & Calibr. HEC-1 Model of Skunk Cr.
- 2.4 Model hypothetical & historical floods
- 2.5 Estimate Warning Times for Skunk Creek
- 2.6 Estimate flood warning times on Silver Cr.
- 2.7 Determine Final Flood Warning Gage Sites
- 2.8 Determine Threshold Warning Discharges
- 2.9 Site Visit to establish manual warning syst.

3 Evaluate Flood Detection Options

- 3.1 Determine relative warning times
- 3.2 Determine Equipment Requirements
- 3.3 Installation cost estimates via ED-CC
- 3.4 Develop annual operation cost estimates
- 3.5 Write Section 22 Report
- 3.6 Incorporate Review Comments

SOWest

Scope of Work Schedule and Costs							
Assume 15 November Start Date							
No.	Task or Work Item	M Hrs	Hrly\$	Labor \$	Other \$	Item \$	Compl. Date
1	Flood Threat Identification						
1.1	Obtain Quad maps and Corps reports	6	74	444	50	494	25-Nov-97
1.2	Obtain City flood threat information	8	74	592		592	25-Nov-97
1.3	Coordination with City	4	74	296		296	5-Dec-97
1.4	Site Visit	12	74	888	100	988	5-Dec-97
1.5	Define hazards and required warning times	16	74	1184		1184	15-Dec-97
	Subtotal					3554	
2	Define Flood Monitoring Points						
2.1	Define potential gage sites on maps	4	74	296		296	30-Dec-97
2.2	Site Recon (combine with item 1.4)	12	74	888	100	988	5-Dec-97
2.3	Develop & Calibr. HEC-1 Model of Skunk Cr.	48	74	3552		3552	5-Jan-98
2.4	Model floods of frequencies and history	24	76	1824		1824	12-Jan-98
2.5	Model Warning Times for Skunk Creek	8	76	608		608	19-Jan-98
2.6	Estimate flood warning times on Silver Cr.	8	76	608		608	19-Jan-98
2.7	Determine Final Flood Warning Gage Sites	8	76	608		608	26-Jan-98
2.8	Determine Threshold Warning Discharges	16	76	1216		1216	2-Feb-98
2.9	Site Visit to establish manual warning syst.	24	76	1824	100	1924	6-Mar-98
	Subtotal					11624	
3	Evaluate Flood Detection Options						
3.1	Determine relative warning times	4	76	304		304	9-Feb-98
3.2	Determine Equipment Requirements	16	76	1216		1216	23-Feb-98
3.3	Installation cost estimates via ED-CC	4	76	304	3000	3304	20-Mar-98
3.4	Develop annual operation cost estimates	16	76	1216		1216	20-Mar-98
3.5	Write Section 22 Report	40	76	3040		3040	18-Apr-98
3.6	Incorporate Review Comments	32	76	2432		2432	8-May-98
	Subtotal					11512	
	SUBTOTAL					26690	
4	Supervision & Overhead						
4.1	Supervision at 10%				2669	2669	8-May-98
4.2	CEFMS Work	16	76	1216	0	1216	8-May-98
	Subtotal					3885	
	TOTAL COST					30575	

ASBESTOS SURVEY

LIFT STATION, NORTH OF MORRELLS

April 12, 1996

City of Sioux Falls
Attn: John Osman
224 West 9th Street
Sioux Falls, SD 57102

RECEIVED
JUL 12 2000
ENGINEER'S OFFICE

6610 95-503

INTRODUCTION:

This report presents the results of our recent testing a sample obtained by our laboratory on March 28, 1996. The scope of our services was limited to a survey of materials present in the lift station to determine if asbestos was present. We were given authorization on March 14, 1996. The purchase order for this work is #49460.

SUMMARY:

Our survey of the building indicated that no asbestos-containing materials are present inside or outside the building.

TEST METHOD:

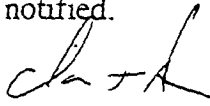
The examination for the presence and the identification of asbestos fibers in bulk samples is performed in this laboratory using crossed polarized light microscopy and dispersion staining particle identification technique. This analysis was performed using a Leitz Laborlux 12 POL Microscope at 100X magnification in accordance with EPA 600/M4-82-020, 1987.

RESULTS:

The results are summarized in Tables #1.

REMARKS:

Our testing was performed on samples submitted for analysis and does not document the level of asbestos which may be contained in the work space air. These samples will be retained by our laboratory for thirty days from the date of this report and then discarded unless otherwise notified.


Dan T. Hanson
Chemistry Manager
Cert. #1549R

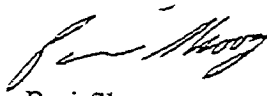

Pari Skoog
Industrial Hygienist

TABLE 1

MICROSCOPIC RESULTS
CITY OF SIOUX FALLS, LIFT STATION
SIOUX FALLS, SOUTH DAKOTA
#6610 95-503

<u>Sample Number</u>	<u>Sample Identification</u>	<u>Asbestos Type Approximate Percent</u>	<u>Balance of Material Approximate Percent</u>
96-3898	Roof Sample	ND	Nonfibrous 80% Synthetic Fibers 2%

ND-No asbestos present in the sample portion tested

Appendix C-
Corps of Engineers
Project Cooperation Agreement

PROJECT COOPERATION AGREEMENT
BETWEEN
THE DEPARTMENT OF THE ARMY
AND
CITY OF SIOUX FALLS, South Dakota
FOR CONSTRUCTION OF THE
BIG SIOUX RIVER AND SKUNK CREEK FLOOD CONTROL PROJECT

THIS AGREEMENT is entered into this _____ day of _____, by and between the DEPARTMENT OF THE ARMY (hereinafter the "Government"), represented by the Assistant Secretary of the Army (Civil Works), and CITY OF SIOUX FALLS, South Dakota (hereinafter the "Non-Federal Sponsor") represented by the MAYOR.

WITNESSETH, THAT:

WHEREAS, construction of the **BIG SIOUX RIVER AND SKUNK CREEK FLOOD CONTROL PROJECT** at SIOUX FALLS, SOUTH DAKOTA was authorized by;

WHEREAS, the Government and the Non-Federal Sponsor desire to enter into a Project Cooperation Agreement for construction of the **BIG SIOUX RIVER AND SKUNK CREEK FLOOD CONTROL PROJECT** (hereinafter the "Project," as defined in Article I.A. of this Agreement);

WHEREAS, Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, specifies the cost-sharing requirements applicable to the Project;

WHEREAS, Section 221 of the Flood Control Act of 1970, Public Law 91-611, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, provide that the Secretary of the Army shall not commence construction of any water resources project, or separable element thereof, until each non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

WHEREAS, the Non-Federal Sponsor does not qualify for a reduction of the maximum non-Federal cost share pursuant to the guidelines that implement Section 103(m) of the Water Resources Development Act of 1986, Public Law 99-662, as amended;

WHEREAS, Section 902 of Public Law 99-662 establishes the maximum amount of costs for the **BIG SIOUX RIVER AND SKUNK CREEK FLOOD CONTROL PROJECT** and sets forth procedures for adjusting such maximum amount; and

WHEREAS, the Government and Non-Federal Sponsor have the full authority and capability to perform as hereinafter set forth and intend to cooperate in cost-sharing and financing of the construction of the Project in accordance with the terms of this Agreement.

NOW, THEREFORE, the Government and the Non-Federal Sponsor agree as follows:

ARTICLE I—DEFINITIONS AND GENERAL PROVISIONS

For purposes of this Agreement:

A. The term "Project" shall mean raising of the existing levees, modifying the chute and stilling basin, and associated construction as generally described in the feasibility report entitled *Local Flood Protection, Big Sioux River and Skunk Creek at Sioux Falls, South Dakota*, dated November 1993 and approved by Chief of Engineers on June 17, 1994.

B. The term "total project costs" shall mean all costs incurred by the Non-Federal Sponsor and the Government in accordance with the terms of this Agreement directly related to construction of the Project. Subject to the provisions of this Agreement, the term shall include, but is not necessarily limited to: continuing planning and engineering costs incurred after October 1, 1985; advanced engineering and design costs; preconstruction engineering and design costs; engineering and design costs during construction; the costs of investigations to identify the existence and extent of hazardous substances in accordance with Article XV.A. of this Agreement; costs of historic preservation activities in accordance with Article XVIII.A. of this Agreement; actual construction costs, including the costs of alteration, lowering, raising, or replacement and attendant removal of existing railroad bridges and approaches thereto; supervision and administration costs; costs of participation in the Project Coordination Team in accordance with Article V of this Agreement; costs of contract dispute settlements or awards; the value of lands, easements, rights-of-way, relocations, and suitable borrow and dredged or excavated material disposal areas for which the Government affords credit in accordance with Article IV of this Agreement; and costs of audit in accordance with Article X of this Agreement. The term does not include any costs for operation, maintenance, repair, replacement, or rehabilitation; any costs due to betterments; or any costs of dispute resolution under Article VII of this Agreement.

C. The term "financial obligation for construction" shall mean a financial obligation of the Government other than an obligation pertaining to the provision of lands, easements, rights-of-way, relocations, and borrow and dredged or excavated material disposal areas, that results or would result in a cost that is or would be included in total project costs.

D. The term "non-Federal proportionate share" shall mean the ratio of the Non-Federal Sponsor's total cash contribution required in accordance with Articles II.D.1.

and II.D.3. of this Agreement to total financial obligations for construction, as projected by the Government.

E. The term "period of construction" shall mean the time from the date the Government first notifies the Non-Federal Sponsor in writing, in accordance with Article VI.B. of this Agreement, of the scheduled date for issuance of the solicitation for the first construction contract to the date that the U.S. Army Engineer for the Omaha District (hereinafter the "District Engineer") notifies the Non-Federal Sponsor in writing of the Government's determination that construction of the Project is complete.

F. The term "highway" shall mean any public highway, roadway, street, or way, including any bridge thereof.

G. The term "relocation" shall mean providing a functionally equivalent facility to the owner of an existing utility, cemetery, highway or other public facility, or railroad (excluding existing railroad bridges and approaches thereto) when such action is authorized in accordance with applicable legal principles of just compensation or as otherwise provided in the authorizing legislation for the Project or any report referenced therein. Providing a functionally equivalent facility may take the form of alteration, lowering, raising, or replacement and attendant removal of the affected facility or part thereof.

H. The term "fiscal year" shall mean one fiscal year of the Government. The Government fiscal year begins on October 1 and ends on September 30.

I. The term "functional portion of the Project" shall mean a portion of the Project that is suitable for tender to the Non-Federal Sponsor to operate and maintain in advance of completion of the entire Project. For a portion of the Project to be suitable for tender, the District Engineer must notify the Non-Federal Sponsor in writing of the Government's determination that the portion of the Project is complete and can function independently and for a useful purpose, although the balance of the Project is not complete.

J. The term "betterment" shall mean a change in the design and construction of an element of the Project resulting from the application of standards that the Government determines exceed those that the Government would otherwise apply for accomplishing the design and construction of that element.

ARTICLE II—OBLIGATIONS OF THE GOVERNMENT AND THE NON-FEDERAL SPONSOR

A. The Government, subject to receiving funds appropriated by the Congress of the United States (hereinafter, the "Congress") and using those funds and funds provided by the Non-Federal Sponsor, shall expeditiously construct the Project (including alteration, lowering, raising, or replacement and attendant removal of existing

railroad bridges and approaches thereto), applying those procedures usually applied to Federal projects, pursuant to Federal laws, regulations, and policies.

1. The Government shall afford the Non-Federal Sponsor the opportunity to review and comment on the solicitations for all contracts, including relevant plans and specifications, prior to the Government's issuance of such solicitations. The Government shall not issue the solicitation for the first construction contract until the Non-Federal Sponsor has confirmed in writing its willingness to proceed with the Project. To the extent possible, the Government shall afford the Non-Federal Sponsor the opportunity to review and comment on all contract modifications, including change orders, prior to the issuance to the contractor of a Notice to Proceed. In any instance where providing the Non-Federal Sponsor with notification of a contract modification or change order is not possible prior to issuance of the Notice to Proceed, the Government shall provide such notification in writing at the earliest date possible. To the extent possible, the Government also shall afford the Non-Federal Sponsor the opportunity to review and comment on all contract claims prior to resolution thereof. The Government shall consider in good faith the comments of the Non-Federal Sponsor, but the contents of solicitations, award of contracts, execution of contract modifications, issuance of change orders, resolution of contract claims, and performance of all work on the Project (whether the work is performed under contract or by Government personnel), shall be exclusively within the control of the Government.

2. Throughout the period of construction, the District Engineer shall furnish the Non-Federal Sponsor with a copy of the Government's Written Notice of Acceptance of Completed Work for each contract for the Project.

B. The Non-Federal Sponsor may request the Government to accomplish betterments. Such requests shall be in writing and shall describe the betterments requested to be accomplished. If the Government in its sole discretion elects to accomplish the requested betterments or any portion thereof, it shall so notify the Non-Federal Sponsor in a writing that sets forth any applicable terms and conditions, which must be consistent with this Agreement. In the event of conflict between such writing and this Agreement, this Agreement shall control. The Non-Federal Sponsor shall be solely responsible for all costs due to the requested betterments and shall pay all such costs in accordance with Article VI.C. of this Agreement.

C. When the District Engineer determines that the entire Project is complete or that a portion of the Project has become a functional portion of the Project, the District Engineer shall so notify the Non-Federal Sponsor in writing and furnish the Non-Federal Sponsor with an Operation, Maintenance, Repair, Replacement, and Rehabilitation Manual (hereinafter the "OMRR&R Manual") and with copies of all of the Government's Written Notices of Acceptance of Completed Work for all contracts for the Project or the functional portion of the Project that have not been provided previously. Upon such notification, the Non-Federal Sponsor shall operate, maintain, repair, replace, and rehabilitate the entire Project or the functional portion of the Project in accordance with Article VIII of this Agreement.

D. The Non-Federal Sponsor shall contribute a minimum of 25 percent, but not to exceed 50 percent, of total project costs in accordance with the provisions of this paragraph.

1. The Non-Federal Sponsor shall provide a cash contribution equal to 5 percent of total project costs in accordance with Article VI.B. of this Agreement.

2. In accordance with Article III of this Agreement, the Non-Federal Sponsor shall provide all lands, easements, rights-of-way, and suitable borrow and dredged or excavated material disposal areas that the Government determines the Non-Federal Sponsor must provide for the construction, operation, and maintenance of the Project, and shall perform or ensure performance of all relocations that the Government determines to be necessary for the construction, operation, and maintenance of the Project.

3. If the Government projects that the value of the Non-Federal Sponsor's contributions under paragraphs D.1. and D.2. of this Article and Articles V, X, and XV.A. of this Agreement will be less than 25 percent of total project costs, the Non-Federal Sponsor shall provide an additional cash contribution, in accordance with Article VI.B. of this Agreement, in the amount necessary to make the Non-Federal Sponsor's total contribution equal to 25 percent of total project costs.

4. If the Government determines that the value of the Non-Federal Sponsor's contributions provided under paragraphs D.2. and D.3. of this Article and Articles V, X, and XV.A. of this Agreement has exceeded 45 percent of total project costs, the Government, subject to the availability of funds, shall reimburse the Non-Federal Sponsor for any such value in excess of 45 percent of total project costs. After such a determination, the Government, in its sole discretion, may provide any remaining Project lands, easements, rights-of-way, and suitable borrow and dredged or excavated material disposal areas and perform any remaining Project relocations on behalf of the Non-Federal Sponsor.

E. The Non-Federal Sponsor may request the Government to provide lands, easements, rights-of-way, and suitable borrow and dredged or excavated material disposal areas or perform relocations on behalf of the Non-Federal Sponsor. Such requests shall be in writing and shall describe the services requested to be performed. If in its sole discretion the Government elects to perform the requested services or any portion thereof, it shall so notify the Non-Federal Sponsor in a writing that sets forth any applicable terms and conditions, which must be consistent with this Agreement. In the event of conflict between such a writing and this Agreement, this Agreement shall control. The Non-Federal Sponsor shall be solely responsible for all costs of the requested services and shall pay all such costs in accordance with Article VI.C. of this Agreement. Notwithstanding the provision of lands, easements, rights-of-way, and suitable borrow and dredged or excavated material disposal areas or performance of relocations by the Government, the Non-Federal Sponsor shall be responsible, as

between the Government and the Non-Federal Sponsor, for the costs of cleanup and response in accordance with Article XV.C. of this Agreement.

F. The Government shall perform a final accounting in accordance with Article VI.D. of this Agreement to determine the contributions provided by the Non-Federal Sponsor in accordance with paragraphs B., D., and E. of this Article and Articles V, X, and XV.A. of this Agreement and to determine whether the Non-Federal Sponsor has met its obligations under paragraphs B., D., and E. of this Article.

G. The Non-Federal Sponsor shall not use Federal funds to meet the Non-Federal Sponsor's share of total project costs under this Agreement unless the Federal granting agency verifies in writing that the expenditure of such funds is expressly authorized by statute.

H. The Non-Federal Sponsor agrees to participate in and comply with applicable Federal floodplain management and flood insurance programs.

I. Not less than once each year the Non-Federal Sponsor shall inform affected interests of the extent of protection afforded by the Project.

J. The Non-Federal Sponsor shall publicize flood plain information in the area concerned and shall provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the Project.

K. Maintain a prescribed cross-sectional area in the Big Sioux River, the Diversion Channel, and Skunk Creek to ensure the design level of protection is not jeopardized.

L. Maintain the prescribed minimum flow through the Diversion Dam.

M. Prevent encroachment upon project works that would adversely affect the proper functioning of efficient operating and maintenance of the project.

ARTICLE III—LANDS, RELOCATIONS, DISPOSAL AREAS, AND PUBLIC LAW 91-646 COMPLIANCE

A. The Government, after consultation with the Non-Federal Sponsor, shall determine the lands, easements, and rights-of-way required for the construction, operation, and maintenance of the Project, including those required for relocations, borrow materials, and dredged or excavated material disposal. The Government in a timely manner shall provide the Non-Federal Sponsor with general written descriptions, including maps as appropriate, of the lands, easements, and rights-of-way that the Government determines the Non-Federal Sponsor must provide, in detail sufficient to enable the Non-Federal Sponsor to fulfill its obligations under this paragraph, and shall

provide the Non-Federal Sponsor with a written notice to proceed with acquisition of such lands, easements, and rights-of-way. Prior to the end of the period of construction, the Non-Federal Sponsor shall acquire all lands, easements, and rights-of-way set forth in such descriptions. Furthermore, prior to issuance of the solicitation for each construction contract, the Non-Federal Sponsor shall provide the Government with authorization for entry to all lands, easements, and rights-of-way the Government determines the Non-Federal Sponsor must provide for that contract. For so long as the Project remains authorized, the Non-Federal Sponsor shall ensure that lands, easements, and rights-of-way that the Government determines to be required for the operation and maintenance of the Project and that were provided by the Non-Federal Sponsor are retained in public ownership for uses compatible with the authorized purposes of the Project.

B. The Government, after consultation with the Non-Federal Sponsor, shall determine the improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the construction, operation, and maintenance of the Project. Such improvements may include, but are not necessarily limited to, retaining dikes, wasteweirs, bulkheads, embankments, monitoring features, stilling basins, and de-watering pumps and pipes. The Government in a timely manner shall provide the Non-Federal Sponsor with general written descriptions of such improvements in detail sufficient to enable the Non-Federal Sponsor to fulfill its obligations under this paragraph, and shall provide the Non-Federal Sponsor with a written notice to proceed with construction of such improvements. Prior to the end of the period of construction, the Non-Federal Sponsor shall provide all improvements set forth in such descriptions. Furthermore, prior to issuance of the solicitation for each Government construction contract, the Non-Federal Sponsor shall prepare plans and specifications for all improvements the Government determines to be required for the proper disposal of dredged or excavated material under that contract, submit such plans and specifications to the Government for approval, and provide such improvements in accordance with the approved plans and specifications.

C. The Government, after consultation with the Non-Federal Sponsor, shall determine the relocations necessary for the construction, operation, and maintenance of the Project, including those necessary to enable the removal of borrow materials and the proper disposal of dredged or excavated material. The Government in a timely manner shall provide the Non-Federal Sponsor with general written descriptions, including maps as appropriate, of such relocations in detail sufficient to enable the Non-Federal Sponsor to fulfill its obligations under this paragraph, and shall provide the Non-Federal Sponsor with a written notice to proceed with such relocations. Prior to the end of the period of construction, the Non-Federal Sponsor shall perform or ensure the performance of all relocations as set forth in such descriptions. Furthermore, prior to issuance of the solicitation for each Government construction contract, the Non-Federal Sponsor shall prepare or ensure the preparation of plans and specifications for, and perform or ensure the performance of, all relocations the Government determines to be necessary for that contract.

D. The Non-Federal Sponsor in a timely manner shall provide the Government with such documents as are sufficient to enable the Government to determine the value of any contribution provided pursuant to paragraphs A., B., or C. of this Article. Upon receipt of such documents the Government, in accordance with Article IV of this Agreement and in a timely manner, shall determine the value of such contribution, include such value in total project costs, and afford credit for such value toward the Non-Federal Sponsor's share of total project costs.

E. The Non-Federal Sponsor shall comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 C.F.R. Part 24, in acquiring lands, easements, and rights-of-way required for the construction, operation, and maintenance of the Project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and shall inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

ARTICLE IV—CREDIT FOR VALUE OF LANDS, RELOCATIONS, AND DISPOSAL AREAS

A. The Non-Federal Sponsor shall receive credit toward its share of total project costs for the value of the lands, easements, rights-of-way, and suitable borrow and dredged or excavated material disposal areas that the Non-Federal Sponsor must provide pursuant to Article III of this Agreement, and for the value of the relocations that the Non-Federal Sponsor must perform or for which it must ensure performance, pursuant to Article III of this Agreement. However, the Non-Federal Sponsor shall not receive credit for the value of any lands, easements, rights-of-way, relocations, or borrow and dredged or excavated material disposal areas that have been provided previously as an item of cooperation for another Federal project. The Non-Federal Sponsor also shall not receive credit for the value of lands, easements, rights-of-way, relocations, or borrow and dredged or excavated material disposal areas to the extent that such items are provided using Federal funds unless the Federal granting agency verifies in writing that such credit is expressly authorized by statute.

B. For the sole purpose of affording credit in accordance with this Agreement, the value of lands, easements, and rights-of-way, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, shall be the fair market value of the real property interests, plus certain incidental costs of acquiring those interests, as determined in accordance with the provisions of this paragraph.

1. **Date of Valuation.** The fair market value of lands, easements, or rights-of-way owned by the Non-Federal Sponsor on the effective date of this Agreement shall be the fair market value of such real property interests as of the date the Non-Federal Sponsor provides the Government with authorization for entry thereto. The fair market value of lands, easements, or rights-of-way acquired by the Non-

Federal Sponsor after the effective date of this Agreement shall be the fair market value of such real property interests at the time the interests are acquired.

2. General Valuation Procedure. Except as provided in paragraph B.3. of this Article, the fair market value of lands, easements, or rights-of-way shall be determined in accordance with paragraph B.2.a. of this Article, unless thereafter a different amount is determined to represent fair market value in accordance with paragraph B.2.b. of this Article.

a. The Non-Federal Sponsor shall obtain, for each real property interest, an appraisal that is prepared by a qualified appraiser who is acceptable to the Non-Federal Sponsor and the Government. The appraisal must be prepared in accordance with the applicable rules of just compensation, as specified by the Government. The fair market value shall be the amount set forth in the Non-Federal Sponsor's appraisal, if such appraisal is approved by the Government. In the event the Government does not approve the Non-Federal Sponsor's appraisal, the Non-Federal Sponsor may obtain a second appraisal, and the fair market value shall be the amount set forth in the Non-Federal Sponsor's second appraisal, if such appraisal is approved by the Government. In the event the Government does not approve the Non-Federal Sponsor's second appraisal, or the Non-Federal Sponsor chooses not to obtain a second appraisal, the Government shall obtain an appraisal, and the fair market value shall be the amount set forth in the Government's appraisal, if such appraisal is approved by the Non-Federal Sponsor. In the event the Non-Federal Sponsor does not approve the Government's appraisal, the Government, after consultation with the Non-Federal Sponsor, shall consider the Government's and the Non-Federal Sponsor's appraisals and determine an amount based thereon, which shall be deemed to be the fair market value.

b. Where the amount paid or proposed to be paid by the Non-Federal Sponsor for the real property interest exceeds the amount determined pursuant to paragraph B.2.a. of this Article, the Government, at the request of the Non-Federal Sponsor, shall consider all factors relevant to determining fair market value and, in its sole discretion, after consultation with the Non-Federal Sponsor, may approve in writing an amount greater than the amount determined pursuant to paragraph B.2.a. of this Article, but not to exceed the amount actually paid or proposed to be paid. If the Government approves such an amount, the fair market value shall be the lesser of the approved amount or the amount paid by the Non-Federal Sponsor, but no less than the amount determined pursuant to paragraph B.2.a. of this Article.

3. Eminent Domain Valuation Procedure. For lands, easements, or rights-of-way acquired by eminent domain proceedings instituted after the effective date of this Agreement, the Non-Federal Sponsor shall, prior to instituting such proceedings, submit to the Government notification in writing of its intent to institute such proceedings and an appraisal of the specific real property interests to be acquired in such proceedings. The Government shall have 60 days after receipt of such a notice

and appraisal within which to review the appraisal, if not previously approved by the Government in writing.

a. If the Government previously has approved the appraisal in writing, or if the Government provides written approval of, or takes no action on, the appraisal within such 60-day period, the Non-Federal Sponsor shall use the amount set forth in such appraisal as the estimate of just compensation for the purpose of instituting the eminent domain proceeding.

b. If the Government provides written disapproval of the appraisal, including the reasons for disapproval, within such 60-day period, the Government and the Non-Federal Sponsor shall consult in good faith to promptly resolve the issues or areas of disagreement that are identified in the Government's written disapproval. If, after such good faith consultation, the Government and the Non-Federal Sponsor agree as to an appropriate amount, then the Non-Federal Sponsor shall use that amount as the estimate of just compensation for the purpose of instituting the eminent domain proceeding. If, after such good faith consultation, the Government and the Non-Federal Sponsor cannot agree as to an appropriate amount, then the Non-Federal Sponsor may use the amount set forth in its appraisal as the estimate of just compensation for the purpose of instituting the eminent domain proceeding.

c. For lands, easements, or rights-of-way acquired by eminent domain proceedings instituted in accordance with sub-paragraph B.3. of this Article, fair market value shall be either the amount of the court award for the real property interests taken, to the extent the Government determined such interests are required for the construction, operation, and maintenance of the Project, or the amount of any stipulated settlement or portion thereof that the Government approves in writing.

4. Incidental Costs. For lands, easements, or rights-of-way acquired by the Non-Federal Sponsor within a five-year period preceding the effective date of this Agreement, or at any time after the effective date of this Agreement, the value of the interest shall include the documented incidental costs of acquiring the interest, as determined by the Government, subject to an audit in accordance with Article X.C. of this Agreement to determine reasonableness, allocability, and allowability of costs. Such incidental costs shall include, but not necessarily be limited to, closing and title costs, appraisal costs, survey costs, attorney's fees, plat maps, and mapping costs, as well as the actual amounts expended for payment of any Public Law 91-646 relocation assistance benefits provided in accordance with Article III.E. of this Agreement.

C. After consultation with the Non-Federal Sponsor, the Government shall determine the value of relocations in accordance with the provisions of this paragraph.

1. For a relocation other than a highway, the value shall be only that portion of relocation costs that the Government determines is necessary to provide a functionally equivalent facility, reduced by depreciation, as applicable, and by the salvage value of any removed items.

2. For a relocation of a highway, the value shall be only that portion of relocation costs that would be necessary to accomplish the relocation in accordance with the design standard that the State of South Dakota would apply under similar conditions of geography and traffic load, reduced by the salvage value of any removed items.

3. Relocation costs shall include, but not necessarily be limited to, actual costs of performing the relocation; planning, engineering and design costs; supervision and administration costs; and documented incidental costs associated with performance of the relocation, but shall not include any costs due to betterments, as determined by the Government, nor any additional cost of using new material when suitable used material is available. Relocation costs shall be subject to an audit in accordance with Article X.C. of this Agreement to determine reasonableness, allocability, and allowability of costs.

D. The value of the improvements made to lands, easements, and rights-of-way for the proper disposal of dredged or excavated material shall be the costs of the improvements, as determined by the Government, subject to an audit in accordance with Article X.C. of this Agreement to determine reasonableness, allocability, and allowability of costs. Such costs shall include, but not necessarily be limited to, actual costs of providing the improvements; planning, engineering and design costs; supervision and administration costs; and documented incidental costs associated with providing the improvements, but shall not include any costs due to betterments, as determined by the Government.

ARTICLE V—PROJECT COORDINATION TEAM

A. To provide for consistent and effective communication, the Non-Federal Sponsor and the Government, not later than 30 days after the effective date of this Agreement, shall appoint named senior representatives to a Project Coordination Team. Thereafter, the Project Coordination Team shall meet regularly until the end of the period of construction. The Government's Project Manager and a counterpart named by the Non-Federal Sponsor shall co-chair the Project Coordination Team.

B. The Government's Project Manager and the Non-Federal Sponsor's counterpart shall keep the Project Coordination Team informed of the progress of construction and of significant pending issues and actions, and shall seek the views of the Project Coordination Team on matters that the Project Coordination Team generally oversees.

C. Until the end of the period of construction, the Project Coordination Team shall generally oversee the Project, including issues related to design; plans and specifications; scheduling; real property and relocation requirements; real property acquisition; contract awards and modifications; contract costs; the Government's cost projections; final inspection of the entire Project or functional portions of the Project;

preparation of the proposed OMRR&R Manual; anticipated requirements and needed capabilities for performance of operation, maintenance, repair, replacement, and rehabilitation of the Project; and other related matters. This oversight shall be consistent with a project management plan developed by the Government after consultation with the Non-Federal Sponsor.

D. The Project Coordination Team may make recommendations that it deems warranted to the District Engineer on matters that the Project Coordination Team generally oversees, including suggestions to avoid potential sources of dispute. The Government in good faith shall consider the recommendations of the Project Coordination Team. The Government, having the legal authority and responsibility for construction of the Project, has the discretion to accept, reject, or modify the Project Coordination Team's recommendations.

E. The costs of participation in the Project Coordination Team shall be included in total project costs and cost shared in accordance with the provisions of this Agreement.

ARTICLE VI—METHOD OF PAYMENT

A. The Government shall maintain current records of contributions provided by the parties and current projections of total project costs and costs due to betterments. By July 30 of each year and at least quarterly thereafter, the Government shall provide the Non-Federal Sponsor with a report setting forth all contributions provided to date and the current projections of total project costs, of total costs due to betterments, of the maximum amount of total project costs determined in accordance with Article XIX of this Agreement, of the components of total project costs, of each party's share of total project costs, of the Non-Federal Sponsor's total cash contributions required in accordance with Articles II.B., II.D., and II.E. of this Agreement, of the non-Federal proportionate share, and of the funds the Government projects to be required from the Non-Federal Sponsor for the upcoming fiscal year. On the effective date of this Agreement, total project costs are projected to be \$40,600,000, and the Non-Federal Sponsor's cash contribution required under Article II.D. of this Agreement is projected to be \$2,215,000. Such amounts are estimates subject to adjustment by the Government and are not to be construed as the total financial responsibilities of the Government and the Non-Federal Sponsor.

B. The Non-Federal Sponsor shall provide the cash contribution required under Articles II.D.1. and II.D.3. of this Agreement in accordance with the provisions of this paragraph.

1. Not less than 30 calendar days prior to the scheduled date for issuance of the solicitation for the first construction contract, the Government shall notify the Non-Federal Sponsor in writing of such scheduled date and the funds the Government determines to be required from the Non-Federal Sponsor to meet the non-Federal proportionate share of projected financial obligations for construction through

the first fiscal year of construction, including the non-Federal proportionate share of financial obligations for construction incurred prior to the commencement of the period of construction. Not later than such scheduled date, the Non-Federal Sponsor shall verify to the satisfaction of the Government that the Non-Federal Sponsor has deposited the required funds in an escrow or other account acceptable to the Government, with interest accruing to the Non-Federal Sponsor.

2. For the second and subsequent fiscal years of construction, the Government shall notify the Non-Federal Sponsor in writing, no later than 60 calendar days prior to the beginning of that fiscal year, of the funds the Government determines to be required from the Non-Federal Sponsor to meet the non-Federal proportionate share of projected financial obligations for construction for that fiscal year. No later than 30 calendar days prior to the beginning of the fiscal year, the Non-Federal Sponsor shall make the full amount of the required funds for that fiscal year available to the Government through the funding mechanism specified in Article VI.B.1. of this Agreement.

3. The Government shall draw from the funds provided by the Non-Federal Sponsor such sums as the Government deems necessary to cover: (a) the non-Federal proportionate share of financial obligations for construction incurred prior to the commencement of the period of construction; and (b) the non-Federal proportionate share of financial obligations for construction as they are incurred during the period of construction.

4. If at any time during the period of construction the Government determines that additional funds will be needed from the Non-Federal Sponsor to cover the non-Federal proportionate share of projected financial obligations for construction for the current fiscal year, the Government shall notify the Non-Federal Sponsor in writing of the additional funds required, and the Non-Federal Sponsor, no later than 60 calendar days from receipt of such notice, shall make the additional required funds available through the payment mechanism specified in Article VI.B.1. of this Agreement.

C. In advance of the Government incurring any financial obligation associated with additional work under Article II.B. or II.E. of this Agreement, the Non-Federal Sponsor shall verify to the satisfaction of the Government that the Non-Federal Sponsor has deposited the full amount of the funds required to pay for such additional work in an escrow or other account acceptable to the Government, with interest accruing to the Non-Federal Sponsor. The Government shall draw from the funds provided by the Non-Federal Sponsor such sums as the Government deems necessary to cover the Government's financial obligations for such additional work as they are incurred. In the event the Government determines that the Non-Federal Sponsor must provide additional funds to meet its cash contribution, the Government shall notify the Non-Federal Sponsor in writing of the additional funds required. Within 30 calendar days thereafter, the Non-Federal Sponsor shall provide the Government with a check for the full amount of the additional required funds.

D. Upon completion of the Project or termination of this Agreement, and upon resolution of all relevant claims and appeals, the Government shall conduct a final accounting and furnish the Non-Federal Sponsor with the results of the final accounting. The final accounting shall determine total project costs, each party's contribution provided thereto, and each party's required share thereof. The final accounting also shall determine costs due to betterments and the Non-Federal Sponsor's cash contribution provided pursuant to Article II.B. of this Agreement.

1. In the event the final accounting shows that the total contribution provided by the Non-Federal Sponsor is less than its required share of total project costs plus costs due to any betterments provided in accordance with Article II.B. of this Agreement, the Non-Federal Sponsor shall, no later than 90 calendar days after receipt of written notice, make a cash payment to the Government of whatever sum is required to meet the Non-Federal Sponsor's required share of total project costs plus costs due to any betterments provided in accordance with Article II.B. of this Agreement.

2. In the event the final accounting shows that the total contribution provided by the Non-Federal Sponsor exceeds its required share of total project costs plus costs due to any betterments provided in accordance with Article II.B. of this Agreement, the Government shall, subject to the availability of funds, refund the excess to the Non-Federal Sponsor no later than 90 calendar days after the final accounting is complete; however, the Non-Federal Sponsor shall not be entitled to any refund of the 5 percent cash contribution required pursuant to Article II.D.1. of this Agreement. In the event existing funds are not available to refund the excess to the Non-Federal Sponsor, the Government shall seek such appropriations as are necessary to make the refund.

ARTICLE VII—DISPUTE RESOLUTION

As a condition precedent to a party bringing any suit for breach of this Agreement, that party must first notify the other party in writing of the nature of the purported breach and seek in good faith to resolve the dispute through negotiation. If the parties cannot resolve the dispute through negotiation, they may agree to a mutually acceptable method of non-binding alternative dispute resolution with a qualified third party acceptable to both parties. The parties shall each pay 50 percent of any costs for the services provided by such a third party as such costs are incurred. The existence of a dispute shall not excuse the parties from performance pursuant to this Agreement.

ARTICLE VIII—OPERATION, MAINTENANCE, REPAIR, REPLACEMENT, AND REHABILITATION (OMRR&R)

A. Upon notification in accordance with Article II.C. of this Agreement and for so long as the Project remains authorized, the Non-Federal Sponsor shall operate, maintain, repair, replace, and rehabilitate the entire Project or the functional portion of the Project, at no cost to the Government, in a manner compatible with the Project's authorized purposes and in accordance with applicable Federal and State laws as

provided in Article XI of this Agreement and specific directions prescribed by the Government in the OMRR&R Manual and any subsequent amendments thereto.

B. The Non-Federal Sponsor hereby gives the Government a right to enter, at reasonable times and in a reasonable manner, upon property that the Non-Federal Sponsor owns or controls for access to the Project for the purpose of inspection and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project. If an inspection shows that the Non-Federal Sponsor for any reason is failing to perform its obligations under this Agreement, the Government shall send a written notice describing the non-performance to the Non-Federal Sponsor. If, after 30 calendar days from receipt of notice, the Non-Federal Sponsor continues to fail to perform, then the Government shall have the right to enter, at reasonable times and in a reasonable manner, upon property that the Non-Federal Sponsor owns or controls for access to the Project for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Government shall operate to relieve the Non-Federal Sponsor of responsibility to meet the Non-Federal Sponsor's obligations as set forth in this Agreement, or to preclude the Government from pursuing any other remedy at law or equity to ensure faithful performance pursuant to this Agreement.

ARTICLE IX—INDEMNIFICATION

The Non-Federal Sponsor shall hold and save the Government free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the Project and any Project-related betterments, except for damages due to the fault or negligence of the Government or its contractors.

ARTICLE X—MAINTENANCE OF RECORDS AND AUDIT

A. Not later than 60 calendar days after the effective date of this Agreement, the Government and the Non-Federal Sponsor shall develop procedures for keeping books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to this Agreement. These procedures shall incorporate, and apply as appropriate, the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 C.F.R. Section 33.20. The Government and the Non-Federal Sponsor shall maintain such books, records, documents, and other evidence in accordance with these procedures and for a minimum of three years after the period of construction and resolution of all relevant claims arising therefrom. To the extent permitted under applicable Federal laws and regulations, the Government and the Non-Federal Sponsor shall each allow the other to inspect such books, documents, records, and other evidence.

B. Pursuant to 32 C.F.R. Section 33.26, the Non-Federal Sponsor is responsible for complying with the Single Audit Act of 1984, 31 U.S.C. Sections 7501-7507, as

implemented by Office of Management and Budget (OMB) Circular No. A-128 and Department of Defense Directive 7600.10. Upon request of the Non-Federal Sponsor and to the extent permitted under applicable Federal laws and regulations, the Government shall provide to the Non-Federal Sponsor and independent auditors any information necessary to enable an audit of the Non-Federal Sponsor's activities under this Agreement. The costs of any non-Federal audits performed in accordance with this paragraph shall be allocated in accordance with the provisions of OMB Circulars A-87 and A-128, and such costs as are allocated to the Project shall be included in total project costs and cost shared in accordance with the provisions of this Agreement.

C. In accordance with 31 U.S.C. Section 7503, the Government may conduct audits in addition to any audit that the Non-Federal Sponsor is required to conduct under the Single Audit Act. Any such Government audits shall be conducted in accordance with Government Auditing Standards and the cost principles in OMB Circular No. A-87 and other applicable cost principles and regulations. The costs of Government audits performed in accordance with this paragraph shall be included in total project costs and cost shared in accordance with the provisions of this Agreement.

ARTICLE XI—FEDERAL AND STATE LAWS

In the exercise of their respective rights and obligations under this Agreement, the Non-Federal Sponsor and the Government agree to comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulations 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army" and Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701 b-12), requiring non-Federal preparation and implementation of flood plain management plans.

ARTICLE XII—RELATIONSHIP OF PARTIES

A. In the exercise of their respective rights and obligations under this Agreement, the Government and the Non-Federal Sponsor each act in an independent capacity, and neither is to be considered the officer, agent, or employee of the other.

B. In the exercise of its rights and obligations under this Agreement, neither party shall provide, without the consent of the other party, any contractor with a release that waives or purports to waive any rights such other party may have to seek relief or redress against such contractor either pursuant to any cause of action that such other party may have or for violation of any law.

ARTICLE XIII—OFFICIALS NOT TO BENEFIT

No member of or delegate to the Congress, nor any resident commissioner, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom.

ARTICLE XIV—TERMINATION OR SUSPENSION

A. If at any time the Non-Federal Sponsor fails to fulfill its obligations under Article II.B., II.D., II.E., VI, or XVIII.C. of this Agreement, the Assistant Secretary of the Army (Civil Works) shall terminate this Agreement or suspend future performance under this Agreement unless he determines that continuation of work on the Project is in the interest of the United States or is necessary in order to satisfy agreements with any other non-Federal interests in connection with the Project.

B. If the Government fails to receive annual appropriations in amounts sufficient to meet Project expenditures for the then-current or upcoming fiscal year, the Government shall so notify the Non-Federal Sponsor in writing, and 60 calendar days thereafter either party may elect without penalty to terminate this Agreement or to suspend future performance under this Agreement. In the event that either party elects to suspend future performance under this Agreement pursuant to this paragraph, such suspension shall remain in effect until such time as the Government receives sufficient appropriations or until either the Government or the Non-Federal Sponsor elects to terminate this Agreement.

C. In the event that either party elects to terminate this Agreement pursuant to this Article or Article XV of this Agreement, both parties shall conclude their activities relating to the Project and proceed to a final accounting in accordance with Article VI.D. of this Agreement.

D. Any termination of this Agreement or suspension of future performance under this Agreement in accordance with this Article or Article XV of this Agreement shall not relieve the parties of liability for any obligation previously incurred. Any delinquent payment shall be charged interest at a rate, to be determined by the Secretary of the Treasury, equal to 150 per centum of the average bond equivalent rate of the 13-week Treasury bills auctioned immediately prior to the date on which such payment became delinquent, or auctioned immediately prior to the beginning of each additional 3-month period if the period of delinquency exceeds 3 months.

ARTICLE XV—HAZARDOUS SUBSTANCES

A. After execution of this Agreement and upon direction by the District Engineer, the Non-Federal Sponsor shall perform, or cause to be performed, any investigations for hazardous substances that the Government or the Non-Federal Sponsor determines to be necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and

Liability Act (hereinafter "CERCLA"), 42 U.S.C. Sections 9601-9675, that may exist in, on, or under lands, easements, and rights-of-way that the Government determines, pursuant to Article III of this Agreement, to be required for the construction, operation, and maintenance of the Project. However, for lands that the Government determines to be subject to the navigation servitude, only the Government shall perform such investigations unless the District Engineer provides the Non-Federal Sponsor with prior specific written direction, in which case the Non-Federal Sponsor shall perform such investigations in accordance with such written direction. All actual costs incurred by the Non-Federal Sponsor for such investigations for hazardous substances shall be included in total project costs and cost shared in accordance with the provisions of this Agreement, subject to an audit in accordance with Article X.C. of this Agreement to determine reasonableness, allocability, and allowability of costs.

B. In the event it is discovered through any investigation for hazardous substances or other means that hazardous substances regulated under CERCLA exist in, on, or under any lands, easements, or rights-of-way that the Government determines, pursuant to Article III of this Agreement, to be required for the construction, operation, and maintenance of the Project, the Non-Federal Sponsor and the Government shall provide prompt written notice to each other, and the Non-Federal Sponsor shall not proceed with the acquisition of the real property interests until both parties agree that the Non-Federal Sponsor should proceed.

C. The Government and the Non-Federal Sponsor shall determine whether to initiate construction of the Project, or, if already in construction, whether to continue with work on the Project, suspend future performance under this Agreement, or terminate this Agreement for the convenience of the Government, in any case where hazardous substances regulated under CERCLA are found to exist in, on, or under any lands, easements, or rights-of-way that the Government determines, pursuant to Article III of this Agreement, to be required for the construction, operation, and maintenance of the Project. Should the Government and the Non-Federal Sponsor determine to initiate or continue with construction after considering any liability that may arise under CERCLA, the Non-Federal Sponsor shall be responsible, as between the Government and the Non-Federal Sponsor, for the costs of clean-up and response, to include the costs of any studies and investigations necessary to determine an appropriate response to the contamination. Such costs shall not be considered a part of total project costs. In the event the Non-Federal Sponsor fails to provide any funds necessary to pay for clean up and response costs or to otherwise discharge the Non-Federal Sponsor's responsibilities under this paragraph upon direction by the Government, the Government may, in its sole discretion, either terminate this Agreement for the convenience of the Government, suspend future performance under this Agreement, or continue work on the Project.

D. The Non-Federal Sponsor and the Government shall consult with each other in accordance with Article V of this Agreement in an effort to ensure that responsible parties bear any necessary clean up and response costs as defined in CERCLA. Any

decision made pursuant to paragraph C. of this Article shall not relieve any third-party from any liability that may arise under CERCLA.

E. As between the Government and the Non-Federal Sponsor, the Non-Federal Sponsor shall be considered the operator of the Project for purposes of CERCLA liability. To the maximum extent practicable, the Non-Federal Sponsor shall operate, maintain, repair, replace, and rehabilitate the Project in a manner that will not cause liability to arise under CERCLA.

ARTICLE XVI—NOTICES

A. Any notice, request, demand, or other communication required or permitted to be given under this Agreement shall be deemed to have been duly given if in writing and either delivered personally or by telegram or mailed by first-class, registered, or certified mail, as follows:

If to the Non-Federal Sponsor:

City of Sioux Falls
224 West Ninth Street
Sioux Falls, South Dakota 57104

If to the Government:

District Engineer
Omaha District, Corps of Engineers
215 North 17th Street
Omaha, Nebraska 68102-4978

B. A party may change the address to which such communications are to be directed by giving written notice to the other party in the manner provided in this Article.

C. Any notice, request, demand, or other communication made pursuant to this Article shall be deemed to have been received by the addressee at the earlier of such time as it is actually received or seven calendar days after it is mailed.

ARTICLE XVII—CONFIDENTIALITY

To the extent permitted by the laws governing each party, the parties agree to maintain the confidentiality of exchanged information when requested to do so by the providing party.

ARTICLE XVIII—HISTORIC-PRESERVATION

A. The costs of identification, survey, and evaluation of historic properties shall be included in total project costs and cost shared in accordance with the provisions of this Agreement.

B. As specified in Section 7(a) of Public Law 93-291 (16 U.S.C. Section 469c(a)), the costs of mitigation and data recovery activities associated with historic preservation shall be borne entirely by the Government and shall not be included in total project costs, up to the statutory limit of one percent of the total amount authorized to be appropriated for the Project.

C. The Government shall not incur costs for mitigation and data recovery that exceed the statutory one percent limit specified in paragraph B. of this Article unless and until the Assistant Secretary of the Army (Civil Works) has waived that limit in accordance with Section 208(3) of Public Law 96-515 (16 U.S.C. Section 469c-2(3)). Any costs of mitigation and data recovery that exceed the one percent limit shall not be included in total project costs but shall be cost shared between the Non-Federal Sponsor and the Government consistent with the minimum non-Federal cost sharing requirements for the underlying flood control purpose, as follows: 25 percent borne by the Non-Federal Sponsor, and 75 percent borne by the Government.

ARTICLE XIX—SECTION 902 PROJECT COST LIMITS

The Non-Federal Sponsor has reviewed the provisions set forth in Section 902 of Public Law 99-662, as amended, and understands that Section 902 establishes the maximum amount of total project costs for the Big Sioux River and Skunk Creek Flood Control Project. Notwithstanding any other provision of this Agreement, the Government shall not make a new Project financial obligation, make a Project expenditure, or afford credit toward total project costs for the value of any contribution provided by the Non-Federal Sponsor, if such obligation, expenditure, or credit would result in total project costs exceeding this maximum amount, unless otherwise authorized by law. On the effective date of this Agreement, this maximum amount is estimated to be \$48,720,000, as calculated in accordance with ER 1105-2-100 using October 1, 1995, price levels and allowances for projected future inflation. The Government shall adjust this maximum amount in accordance with Section 902.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement, which shall become effective upon the date it is signed by the Assistant Secretary of the Army (Civil Works).

THE DEPARTMENT OF THE ARMY THE CITY OF SIOUX FALLS, South Dakota

BY: _____

Mark E. Tillotson
Colonel, Corps of Engineers
District Engineer
Omaha District

BY: _____

Jack White
Mayor, City of Sioux Falls

DATE: _____

DATE: _____

CERTIFICATE OF AUTHORITY

I, _____, do hereby certify that I am the principal legal officer of the City of Sioux Falls, South Dakota, that the City of Sioux Falls, South Dakota, is a legally constituted public body with full authority and legal capability to perform the terms of the Agreement between the Department of the Army and the City of Sioux Falls, South Dakota, in connection with the Big Sioux River and Skunk Creek Flood Control Project, and to pay damages in accordance with the terms of this Agreement, if necessary, in the event of the failure to perform, as required by Section 221 of Public Law 91-611 (42 U.S.C. Section 1962d-5b), and that the persons who have executed this Agreement on behalf of the City of Sioux Falls, South Dakota, have acted within their statutory authority.

IN WITNESS WHEREOF, I have made and executed this certification this

_____ day of _____ 19____.

CERTIFICATION REGARDING LOBBYING

The undersigned certifies, to the best of his or her knowledge and belief that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

DATE: _____

CERTIFICATION OF LEGAL REVIEW

The final Project Cooperation Agreement for the Big Sioux River and Skunk Creek Flood Control Project has been fully reviewed by the Office of Counsel, USAED, Omaha, and is legally sufficient.

District Counsel

Appendix D-
Miscellaneous

SOUTH DAKOTA CONGRESSMAN

JOHN THUNE

Aberdeen 605-622-7988

Rapid City 605-342-5135

Sioux Falls 605-331-1010

Washington, D.C. 202-225-2801

For Immediate Release
Tuesday, June 13, 2000

Contact: Jennifer Hayes
202-225-2801

**Sioux Falls, Pierre Flood Control Projects
In Line to Receive Another Wave of Funding**

Washington, D.C. – Congressman John Thune announced today he has secured funding to safeguard against floods in Sioux Falls, to purchase flood-prone areas in Pierre, and to provide safe drinking water to residents in the Huron area and the Pine Ridge, Rosebud, Lower Brule, and Crow Creek Indian reservations.

The House Appropriations Subcommittee on Energy and Water Development approved the fiscal year 2001 Energy and Water Appropriations Act. The bill includes more than \$50 million of funding for a number of water and flood control projects significant to South Dakota.

"Flood control and water development are two of the most important issues that South Dakota faces. I am pleased the House subcommittee realizes our needs. I see this funding as progress toward achieving South Dakota's water goals," Thune said.

The legislation will now go to the full House Appropriations Committee. Funding levels may fluctuate as the process continues. The House bill contains \$800 million less in total funding than the Senate bill. The Senate has yet to mark up its bill.

"Although I am disappointed the levels are not as high as we hoped and worked for, we will continue to work throughout the process to try to increase funding for the projects that need it most," Thune said. "The House helped pick up the numbers last year in conference to ensure South Dakota projects could move forward. With a budget of about \$800 million less than the Senate's bill, it is tough to stretch the dollars any farther. I am pleased we were able to secure \$50 million toward South Dakota's needs," Thune said.

Big Sioux River Flood Control, Sioux Falls

House Bill	President's Budget
\$1.5 million	\$1.5 million

The Big Sioux River Flood Control project would provide protection against a 100-year flood event. Funds will be used to upgrade flood control structures on the Big Sioux River and Skunk Creek. The current flood control structures provide a 30-year flood protection level on the Big Sioux River and 20-year protection on Skunk Creek. Eight major flood events on the Big Sioux River have occurred since 1950, and existing flood control plans have proven inadequate in protecting the highly developed areas of Sioux Falls, which lie in the flood plain.

-MORE-

Pierre/Ft. Pierre Flood Mitigation

House Bill	President's Budget
\$4 million	\$4 million -

Funding will help efforts to acquire property threatened by flooding in the Pierre/Ft. Pierre area. The U.S. Army Corps of Engineers will continue to work with local officials and residents on flood proofing and relocating homes with the funds allocated. Homes, private, and public property have been endangered by flooding caused by wintertime releases at the Oahe Dam upstream from the Pierre and Fort Pierre communities.

Mid-Dakota Rural Water System

House Bill	President's Budget
\$11 million	\$6 million

The Mid-Dakota Rural Water System is designed to provide water from the Oahe Reservoir on the Missouri River to 30,000 South Dakotans in the east-central region of the state. The project is more than 50 percent complete.

Mni Wiconi Rural Water Project

House Bill	President's Budget
\$27.57 million	\$23.57 million

The Mni Wiconi Rural Water Project is designed to serve three American Indian tribal water systems and one non-tribal system in south-central, western, and southwestern South Dakota. The system will serve more than 50,000 residents in this region when the project is completed.

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SIOUX FALLS FLOOD PROTECTION PROJECT

PHASE IB

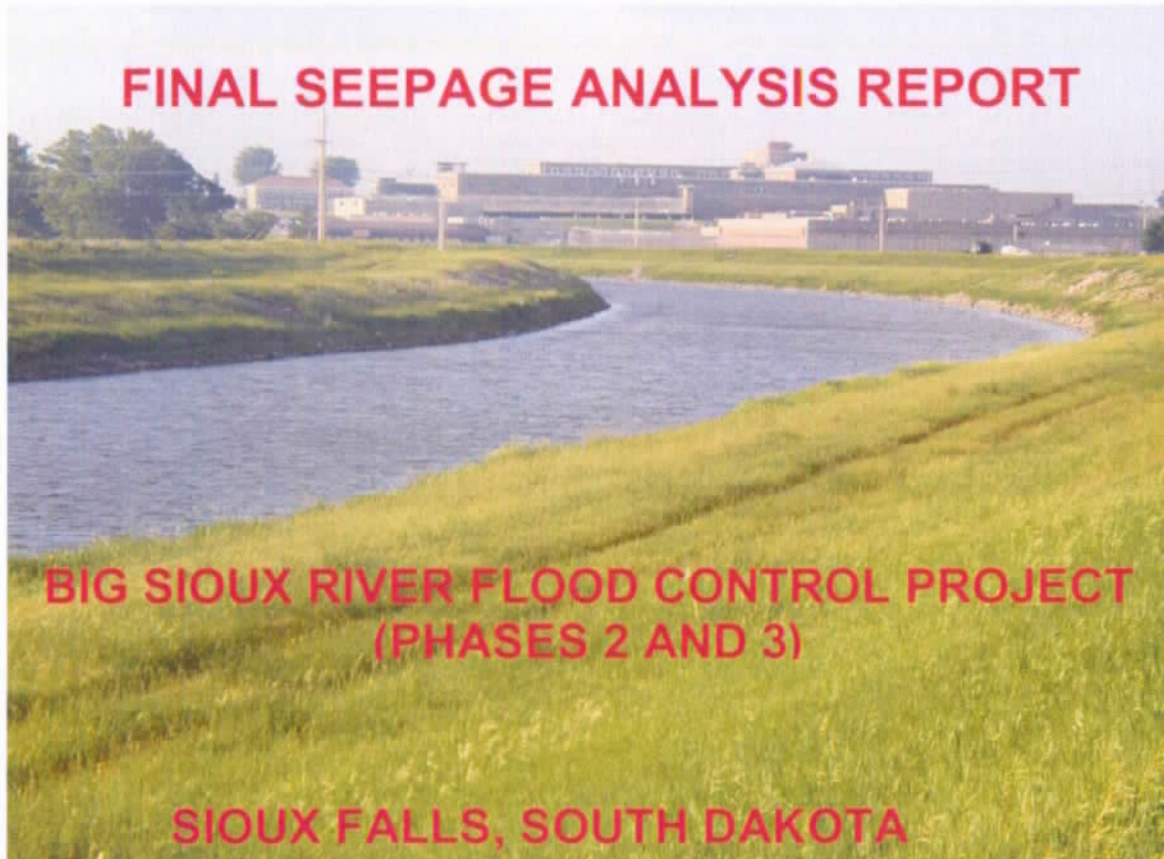
DRAFT

<u>Item</u>	<u>Date</u>
Start Work	12 July 2000
Initiate Geotechnical Field Work	21 Aug 2000
Preliminary Seepage Analysis Complete	8 Sep 2000
A/E Culvert Plans Received	30 Aug 2000
Complete Geotechnical Field Work	15 Sep 2000
Geotechnical Lab Analysis Complete	30 Sep 2000
Revised Water Surface Profile Complete (Final profile for levee and flood wall design)	2 Oct 2000
Refined Seepage Analysis Complete	20 Oct 2000
Peer Review Complete	27 Oct 2000
Interdisciplinary Check I (Drawings)	30 Oct 2000
Interdisciplinary Check II (Drawings, Specs, and DDR)	20 Nov 2000
DDR to P&S	1 Dec 2000
Specs to P&S	5 Dec 2000
Drawings to P&S	5 Dec 2000
DDR, Drawings, & Specs to DAPS	8 Dec 2000
Quality Control Review (QCR)	13 Dec 2000
QCR Comments to Design Team	15 Dec 2000
Revised DDR and Specs to P&S	29 Dec 2000
Revised Drawing Plots to P&S	4 Jan 2001
DDR, DWGS, Specs to DAPS	10 Jan 2001
Mail Final Documents to Sioux Falls for Review	15 Jan 2001
Meeting with City of Sioux Falls	2 Feb 2001
Revised DDR & Specs to P&S	19 Feb 2001
QAR Plot Corrections to CADD/Spec Section	21 Feb 2001
DDR, DWGS, and Specs Complete to DAPS (Adv)	26 Feb 2001
Advertise	5 Mar 2001



**US Army Corps
of Engineers®**

FINAL SEEPAGE ANALYSIS REPORT



BIG SIOUX RIVER FLOOD CONTROL PROJECT (PHASES 2 AND 3)

SIOUX FALLS, SOUTH DAKOTA

**Prepared for: City of Sioux Falls - Department of Public Works,
Engineering Division**

Prepared by: U.S. Army Corps of Engineers, Omaha District

February 2003

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2. Seepage Considerations
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 - 5.b. Soil Borings Location Plans
 - 5.c. Seepage Analysis Cross Sections
 - 5.d. SEEP2D Output Files
 - 5.e. Calculations

1. General Project Description

The project involves raising the existing levee system to provide 100-year flood protection along the Big Sioux River and Skunk Creek. In general, the project consists of placing and compacting fill to raise existing earthen levees. In order to provide 100-year flood protection, the existing levee system will be raised approximately 2 to 6 feet in the Phase 2 project area, and approximately 1 to 4 feet in the Phase 3 project area.

Floodwalls will be constructed in areas where it is not feasible to place and compact fill.

The Phase 2 project extends along both banks of the Big Sioux River from just south of the Interstate 229 (I-229) Bridge to Russell Street, and along both banks of the Skunk Creek from Marion Road east to the confluence with the Big Sioux River.

The Phase 3 project extends along both banks of the Big Sioux River from the diversion chute spillway located south of the North Drive Bridge to approximately one-half mile north of East 60th Street (South Dakota Highway 38). In addition, the Phase 3 project includes both banks of the Big Sioux River along the diversion channel, the levee on the east side of Silver Creek north of the diversion channel and south of East 60th Street, and levees north of East 60th Street along the north side of Interstate 90. A map of the Phase 1, 2 and 3 flood control projects is included in Appendix 5.a.

2. Seepage Considerations

Increasing the levee height to provide 100-year flood protection results in the potential for increased hydrostatic pressure to act against the levee embankment during high-water events. The increase in hydrostatic pressure may result in unacceptable rates of seepage

through permeable stratum beneath the levee or high uplift pressures at the landward toe of the levee, necessitating remedial measures to control these conditions. The potential for seepage or high uplift pressures to occur depends primarily on geologic conditions beneath the levee embankment.

Geologic conditions conducive to seepage are thick deposits of permeable sands and gravels that extend beneath the levee foundation and contact the ground surface on the landward side of the levee. High uplift pressures may occur when permeable deposits beneath the levee rise in elevation to near the ground surface on the landward side where they are overlain by a thin layer of less permeable material. Seepage may result in the formation of “boils”, visible pools of water that typically occur near the landward toe of the levee. When seepage velocities reach a critical value, fine-grained soil can be transported from beneath the levee foundation by seepage forces. When this occurs, water exiting along the landward side of the levee appears cloudy due to the presence of fine-grained soil. This phenomena known as “piping” can lead to instability of the levee foundation, and in extreme cases failure of the levee embankment.

A seepage analysis was performed for the Phase 2 and Phase 3 projects in order to assess the potential for seepage to occur in permeable stratum beneath the levee embankment when levee elevations have been raised to provide 100-year flood protection. The analysis was performed to determine the stability of the levee system during high-water events, and to estimate the volume of seepage expected to pass through permeable zones known to exist beneath the levee embankment in some areas. Levee stability was assessed by calculating the exit gradient, a measure of the uplift pressure exerted by

seepage through permeable stratum underlying the levee. The seepage analysis was based on Engineering Manual EM 1110-2-1913, *Design and Construction of Levees* (March 1978), and EM 1110-2-1901, *Seepage Analysis and Control for Dams* (September 1986). EM 1110-2-1913 recommends a seepage analysis be performed when levee systems are located on pervious foundation zones. EM 1110-2-1913 also states seepage problems are most acute when pervious stratum extend both landward and riverward of the levee, overlain by a relatively thin impervious stratum on the landward side of the levee. Based on subsurface information to support design of the original levee system and subsequent levee alterations, thick deposits of pervious soil overlain by thin layers of impervious soil are known to exist in areas within the Phase 2 and 3 project boundaries.

Uncontrolled seepage may result in one or more of the following undesirable conditions:

- Excessive hydrostatic pressure beneath an impervious top stratum on the landside of the levee;
- Sand boils on the landside of the levee, typically near the levee toe;
- Piping of fine-grained soil from beneath the levee foundation. In severe cases this can lead to failure of the levee embankment.

Unacceptable rates of seepage may dictate relief measures such as cutoff walls, seepage berms, toe drains, or relief wells. Measures to control seepage are discussed in section 4, *Design Recommendations*.

3. Method of Seepage Analysis

SEEP2D, a two-dimensional finite element groundwater model developed by the U.S.

Army Engineer Waterways Experiment Station (WES), was used to model seepage

beneath the levee embankment. SEEP2D was developed for use on profile models such

as cross-sections of earthen dams or levees, and can be used to model confined or unconfined steady state flow conditions. Confined conditions result when groundwater is “confined” between two impermeable layers. Unconfined conditions result when groundwater is confined by a single impermeable layer or is not confined by impermeable layers either above or below. Unconfined conditions are most representative of subsurface strata at Sioux Falls.

SEEP2D assumes the levee embankment has reached a “steady state” or equilibrium condition. High-water events that last for brief periods, such as two to four days, are unlikely to result in complete saturation of the embankment and therefore do not result in steady-state conditions. If the levee has not reached a saturated condition, SEEP2D would overestimate the volume of seepage predicted to pass beneath the levee. Past flood events at Sioux Falls have typically resulted in high water against the levee for not more than four days. Based on engineering judgment, a minimum high-water period of seven days would be required to result in complete saturation of the levee embankment, resulting in steady-state conditions.

Post-processing of SEEP2D results were performed using the Groundwater Modeling System (GMS), a graphical pre and post-processor for SEEP2D developed by the Brigham Young University Environmental Modeling Research Laboratory in cooperation with WES. In a typical modeling situation, a series of tasks are required to use the SEEP2D software. These tasks are briefly described below.

Mesh Construction – The first task in preparing to use the software is development of a finite element mesh representing the region to be modeled. The mesh depicts the cross section of the levee embankment, boundary conditions and location and thickness of pervious and impervious stratum beneath the levee embankment.

Boundary Conditions – Once the mesh is constructed, boundary conditions are applied to the mesh to represent actual flow conditions. Boundary conditions are typically entered as constant head at a node, head equals elevation (exit face) at a node, or as an incoming flux at a node or along an element edge. Boundary conditions also require selection of an appropriate hydraulic conductivity entered to represent flow velocities in the X and Y direction for each soil type used in the model.

Execution – Once the mesh is constructed, the SEEP2D program can be executed to calculate head, flow, discharge or Darcian velocity, and pore pressure at every node in the mesh. Output files consist of a flow net showing calculated seepage quantity or lines of constant total head. Output files are found in Appendix 5.d.

Documentation explaining use of SEEP2D software, known as the SEEP2D Primer, is available in electronic or hard copy format upon request.

3.a. Input to the Seepage Model

In order to incorporate all known existing soil borings in the analysis, a database was created to include borings from design of the original levee system in 1956 through the Phase 2 and 3 geotechnical investigations drilled in the winter and spring of 2001, respectively. In addition, geophysical survey information obtained during the Phase 2 investigation was used to correlate information from soil borings. Subsurface information from each investigation is summarized below.

- 1956 Levee and Channel Alterations – soil borings were drilled to define subsurface conditions for the original levee system along the Big Sioux River from Benson Road south to the I-229 bridge, and along the Skunk Creek from Marion Road east to the confluence with the Big Sioux River. The investigation covered the entire Phase 2 reach of the Big Sioux River and Skunk Creek, consisting of 144 soil borings drilled to depths of 3 to 16 feet below grade.

- 1959 Levee and Channel Alterations – soil borings were drilled to define subsurface conditions for the original levee system along the Big Sioux River, extending north of Interstate 90 along Catfish Bay, extending along the east side of the Sioux Falls Airport (Joe Foss Field) to east of Cliff Avenue. The investigation covered the entire Phase 3 reach of the Big Sioux River with the exception of the Big Sioux River north of the Diversion Dam, consisting of 10 soil borings drilled to depths of 10 to 16 feet below grade.
- 1990 North Bank Diversion Channel Alteration – Five soil borings were drilled to obtain subsurface information for levee improvements along the north bank of the Big Sioux River from the Diversion Dam south to the Diversion Weir. This project is located within the Phase 3 project area. Soil borings were drilled to a depth of 10 feet below grade.
- 1996 Detention Pond – Three soil borings were drilled to determine subsurface conditions for a new detention area to be constructed adjacent to the east side of the Big Sioux River between 12th and 18th Streets. Borings were drilled to depths of 26 to 65 feet below grade. The depth of these borings suggests an analysis was performed to assess the potential for seepage and hydraulic connection between the Big Sioux River and the proposed detention area.
- 1996 Prairie View By-Pass Channel – 21 soil borings were drilled to determine subsurface conditions for the proposed by-pass channel located just north of the I-229 bridge along the Big Sioux River. The investigation is located within the Phase 2 project reach. Soil boring depths ranged from 12 to 67 feet below grade.
- 1997 Airport Runway Project – 14 soil borings were drilled to determine subsurface conditions necessary to relocate a section of the levee along the Big Sioux River around the north end of the new cross-wind (northwest-southeast) runway at Joe Foss Field. The investigation extended from West Benson Road north to the Diversion Dam, along the Big Sioux River. All soil borings were drilled to a depth of 25 feet below grade.
- 1989 Lower Riverside Trunk Sewer Project – 17 soil borings were drilled to determine subsurface conditions for the lower riverside trunk sewer project. The project extended from Diversion Chute to east of Cliff Avenue along the Big Sioux River. Soil boring depths ranged from 2 to 30 feet below grade.
- 2001 Phase 2 Geotechnical Investigation – 116 soil borings were drilled to determine subsurface information to raise the existing levee along the Big Sioux River and Skunk Creek to provide 100-year flood protection. As such, the project extends from West Russell Street south to the I-229 Bridge along the Big Sioux River, and along Skunk Creek from Marion Road east to the

confluence with the Big Sioux River. Soil borings were drilled to depths ranging from 11 to 111 feet below grade.

- 2001 Phase 2 Geotechnical Investigation – Direct current (DC) electrical resistivity profiling, commonly referred to as Electrical Imaging (EI), was performed in 11 areas along the Phase 2 alignment. Geoelectric cross sections were developed that depict bedrock boundaries, areas of high resistivity interpreted to be relatively permeable coarse-grained materials, and areas of low resistivity interpreted to be relatively fine-grained, low hydraulic conductivity materials. EI information was correlated against subsurface data obtained from soil borings.
- 2001 Phase 3 Geotechnical Investigation – 45 soil borings were drilled to obtain subsurface information to raise the existing levee along the Big Sioux River to provide 100-year flood protection. The Phase 3 project extends north of Interstate 90 along Catfish Bay to immediately north of the Diversion Chute on the Big Sioux River. Soil borings were drilled to depths ranging from 65 to 80 feet below grade.

A database of soil borings from the above investigations is not included in this report but is available in electronic or hard copy format upon request.

Based on review of subsurface data, four areas of potential seepage within the Phase 2 project and two areas within the Phase 3 project were identified, and are discussed below.

Phase 2

The first area of seepage concern is along both banks of the Skunk Creek from Marion Road east to the confluence with the Big Sioux River, extending approximately 1,000 feet south of the confluence on both banks of the Big Sioux River. Permeable sand and gravel deposits approximately 70 feet in thickness are present beneath the levee in this area. Geophysical survey line L-9 is located within this area for correlation with soil boring data.

The second area of seepage concern is along both banks of the Big Sioux River from 12th Street north to approximately 1,000 feet south of Madison Street, and along the left bank of the Big Sioux River from Russell Street south approximately 1,000 feet. As with the first area of concern, permeable sand and gravel deposits approximately 70 feet in thickness are present beneath the levee in this area. Geophysical survey lines L-1 and L-2 are located within this area for correlation with soil boring data.

The third area of seepage concern is along both banks of the Big Sioux River beginning approximately 1,000 feet north of the confluence with Skunk Creek, extending approximately 1,000 feet north of the bridge near the north boundary of Westward Ho Country Club bridge (golf cart bridge). Permeable deposits of sand and gravel as much

as 27 feet in thickness are present beneath the levee in this area. The southern portion of geophysical survey line L-6 is located within this area for correlation with soil boring data.

The fourth area of seepage concern is along both banks of the Big Sioux River beginning approximately 500 feet north of 49th Street to approximately 1,500 feet north of 49th Street. Permeable sand deposits as much as 16 feet in thickness are present beneath the levee in this area. Geophysical survey lines L-5 and L-11 are located within this area for correlation with soil boring data.

Phase 3

The first area of seepage concern is along the Diversion Channel, beginning approximately 1,000 feet north of North Drive (State Highway 38A), extending approximately one-half mile to Benson Road. Deposits of permeable sand and gravel as much as 36 feet in thickness are present beneath the levee in this area.

Based on a request from the City of Sioux Falls Engineering Division, the east levee along Catfish Bay was also analyzed for potential seepage due to its location adjacent to an area of new residential development. Pervious deposits of sand approximately 30 feet in thickness are present beneath the levee in this area.

In general, the levee embankment is founded on 2 to 6 feet of clay soil overlying permeable deposits of sand and gravel summarized above. Soil layers were categorized as "pervious", "impervious", or "mixed" for the seepage analysis, based on the percentage of soil by weight passing the U.S. standard number 200 sieve. Soil containing in excess of 15% passing the No. 200 sieve was considered to be impervious, while soil containing 15% or less passing the No. 200 sieve was considered to be pervious. Thin layers of pervious and impervious soil were designated as mixed layers. Hydraulic conductivities were assigned to layers based on established correlations with grain-size, such as Hazen's equation for pervious soils with a correction for the soil fraction passing the No. 200 sieve, according to Figure 2-12 of EM 1110-2-1901.

Hazen's equation calculates the hydraulic conductivity as 100 multiplied by the square of the soil fraction at which 10 percent of the sample is smaller by weight, referred to as the D_{10} size. Hazen's equation can be written as $K = 100 \times D_{10}^2$, where K is the hydraulic conductivity in centimeters per second, and D_{10} is expressed in centimeters. Hazen's equation is an empirical equation based on clean sands with a uniform (well graded) grain-size. Weighted average hydraulic conductivities for mixed layers were calculated based on the relative thickness of each layer in relation to the total thickness of the mixed layer. A hydraulic conductivity of 5×10^{-6} cm/sec (5 ft/year) was assumed for the levee embankment and all clay foundations layers beneath the levee.

Uplift pressure is often expressed in terms of gradient at the landward levee toe, typically referred to as the exit gradient. The exit gradient is a dimensionless measure of head loss per foot through the upper impervious stratum. In equation form, the exit gradient is calculated as $I_e = \Delta h/l$, where I_e is the exit gradient, Δh is the head loss through the upper impervious strata, and l is the impervious strata thickness. Based on criteria in EM 1110-2-1901, satisfactory uplift pressures are associated with an exit gradient not to exceed 0.8. Exit gradients in excess of 0.8 typically require remedial measures to reduce the uplift pressure at the landward toe to an acceptable value. Remedial measures are discussed in section 4, *Design Recommendations*.

Soil borings from projects identified above were used to create a two dimensional file in MicroStation CAD illustrating soil boring locations in relation to Phase 2 and Phase 3 levee alignments. Three-dimensional surfaces of distinct soil types (pervious,

impervious, and mixed) were created using MicroStation InRoads software. The levee alignment, soil boring locations, and soil type surfaces were used to develop cross sections for input to the SEEP2D modeling software. Soil boring location plans used to construct the Phase 2 and Phase 3 alignments are included in Appendix 5.b.

In order to evaluate seepage and uplift pressures at the landward toe, representative cross sections were developed in each area of seepage concern using MicroStation CAD.

Typical cross sections used in the analysis are included in Appendix 5.c. Results of the analysis are discussed in section 3.b, *Results of the Seepage Model*.

3.b. Results of the Seepage Model

Cross sections of the river showing the existing levee embankment and topography, and proposed new levee embankment, were developed within potential seepage areas identified in Section 3.a, *Input to the Seepage Model*. Top of levee elevations required to provide 100-year flood protection were determined from Hydrologic Engineering Center River Analysis System modeling (HEC-RAS), performed by the Hydrology Branch of the Omaha District Corps of Engineers.

Calculated seepage rates using SEEP2D are expressed per foot of levee length. In general, geologic conditions within the six potential seepage areas are variable and discontinuous. As a result, calculation of a total volume of seepage within each area would be subjective and difficult to perform. Calculated seepage and uplift pressures (exit gradients) for potential seepage areas within Phase 2 and 3 are discussed below. SEEP2D output files are included in Appendix 5.d. Variables entered as input to

SEEP2D modeling such as soil type, thickness, and hydraulic conductivity (K) are summarized in Appendix 5.e.

Design of the levee system will include remedial measures to reduce uplift pressures to result in an exit gradient not to exceed 0.8 at the landward levee toe, to satisfy criteria in EM 1110-2-1901, *Seepage Analysis and Control for Dams*. Remedial measures are discussed in section 4, *Design Recommendations*.

Phase 2

Rates of seepage from potential seepage areas one through four range from a low of 320 to a high of 1,400 cubic feet per year per foot of levee. The maximum seepage rate of 1,400 cubic feet per year per foot (29 gallons per day per foot) of levee was calculated near station 215+65, along the left bank of the Big Sioux River. In addition to seepage rates, exit gradients at the landward toe of the levee were calculated for potential seepage areas one through four. Exit gradients range from 0.4 to 1.3. The maximum exit gradient of 1.3 was calculated in two areas, station 8+00 in potential seepage area two, and station 215+65 in potential seepage area four.

Potential Seepage Area No. 1

Soil borings SFP200-37, SFP200-40, and SFP200-59 were used to develop stations 165+00 and 195+00 along the Skunk Creek, and station 159+25 along the Big Sioux River. The Westward Ho Country Club golf course is adjacent to the left bank of Skunk Creek from the confluence with the Big Sioux River to Interstate 29. The west water storage reservoir for the City of Sioux Falls is located west of Interstate 29, along the

right bank of the Skunk Creek. Calculated rates of seepage and exit gradients were acceptable for all stations analyzed in this area.

Potential Seepage Area No. 2

Soil boring SFP200-104 was used to develop station 8+00 which is located approximately 900 feet south of Russell Street along the left bank of the Big Sioux River. The area extends along the left bank of the Big Sioux River from Russell Street south to the approximate location of a 65-inch by 39-inch corrugated metal pipe arch (CMPA). The area is characterized by a heavy stand of large trees, extending east from the existing levee toe approximately 300 feet. The calculated seepage rate in this area is negligible, equivalent to about 23 gallons per day per foot of levee length. A maximum exit gradient of 1.3 was also calculated for this area.

Potential Seepage Area No. 3

Soil boring SFP200-73 was used to develop station 112+25, located approximately 2,600 feet south of 12th Street (about 1,000 feet north of the Westward Ho Country Club golf cart bridge), along the right bank of the Big Sioux River. The area contains a dense growth of trees extending at least 300 feet west of the existing levee toe, beginning immediately north of the 11th green on the Westward Ho Country Club golf course. The calculated seepage rate in this area is negligible, equivalent to about 27 gallons per day per foot of levee length. A maximum exit gradient of 0.9 was calculated for this area.

Potential Seepage Area No. 4

Station 215+65 is located about half way between 41st and 49th Streets, in potential seepage area four. Subsurface information from soil boring SFP200-18 was used to develop station 215+65. This area is surrounded by an ox bow that begins east of Kinko's, located along the left bank of the Big Sioux River approximately 400 feet south

of 41st Street. From Kinko's, the ox bow extends south/southeast, rejoining the left bank of the Big Sioux River approximately 550 feet north of 49th Street through a 36-inch diameter reinforced concrete pipe (RCP). The calculated seepage rate in this area is negligible, equivalent to about 29 gallons per day per foot of levee length. A maximum exit gradient of 1.3 was calculated for this area.

Phase 3

A maximum seepage rate of 2,300 cubic feet per year per foot of levee length was calculated for the Phase 3 project near station 106+15. Soil boring SFP301-08 was used to develop station 106+15, located along the right bank of the Big Sioux River Diversion Channel, approximately 3,800 feet south of Benson Street. Based on available subsurface information, it is unclear if the thin impervious layer underlying the riverside toe remains continuous, extending into the Big Sioux River. As a result of this uncertainty, two scenarios were considered for station 106+15. The first assumes the impervious layer is continuous into the river, thereby acting as an impervious riverside seepage blanket. The predicted rate of seepage under this scenario is about 690 cubic feet per year per foot of levee. The second scenario assumes the impervious layer does not extend into the river or extends only a very short distance. The calculated seepage rate under this scenario is much higher, about 2,300 cubic feet per year per foot of levee, as previously stated. Based on discussions with the City of Sioux Falls Engineering Division, areas of major seepage have not been observed during past high-water events, such as the floods of 1969, 1983 and 1984. Because significant seepage areas have not been observed in the Phase 2 or 3 project areas during past flood events, the impervious

layer was assumed to extend into the river. Additional study should be performed to verify the presence or absence of this impervious layer during the design phase.

Calculated exit gradients for seepage areas one and two range from 0.2 to 2.1. All exit gradients are in excess of 1.4 with the exception of station 106+15, assuming the thin impervious layer underlying the right bank levee is not continuous into the Big Sioux River. In general, these exit gradients indicate remedial measures will need to be incorporated into design of the Phase 3 project to minimize uplift pressures.

At the request of the City of Sioux Falls Engineering Division, the east levee of Catfish Bay was analyzed to assess the effect of seepage on the new residential housing area east of Catfish Bay. Since Catfish Bay is surrounded by levee on the north, west, and east sides, and is protected by the Interstate 90 embankment to the south, the analysis assumed the levee to the north or west failed, was overtopped, or experienced significant seepage resulting in the water level within Catfish Bay reaching the 100-year flood elevation. The seepage rate through the east levee under this scenario was 2,900 cubic feet per year per foot of levee (59 gallons per day per foot), with an exit gradient of 0.8 at the landward levee toe. While this represents a significant increase in the rate of seepage, this scenario would likely be associated with a precipitation event far in excess of a 100-year storm. Subsurface soil information is not available for the north and west levee surrounding Catfish Bay. As a result, the calculation was based on subsurface conditions along the east levee obtained from soil borings SFP301-36 and SFP301-37. The time for the water surface in Catfish Bay to increase from elevation 1423.3 (April 2001 topographic survey)

to elevation 1441.9, the 100-year water surface elevation, was calculated to be 2.3 years. The calculation assumed the only method of filling was seepage beneath the east, west, and north levee surrounding Catfish Bay resulting from a constant water surface elevation of 1441.9 against the landward side of the levee (i.e., water elevation at the top of the levee). Based on the calculation, the potential for excessive seepage beneath the east levee surrounding Catfish Bay does not pose a serious risk to the new residential development east of Catfish Bay. Additional study should be performed, however, to determine the feasibility of constructing basements in the new development due to permeable subsurface soils in the area of the east levee.

Seepage rates and uplift pressures are summarized in Tables 1 and 2.

Table 1
Seepage Rates and Exit Gradients
Phase 2 Project

Station	Typical Soil Boring	Seepage Rate		Exit Gradient	Comments
		Ft ³ /year/ft	Gal/day/ft		
Seepage Area No. 1					
(Skunk Creek-South from Marion Road to approx. 1,000 feet south of confluence with BSR)					
(Big Sioux River-Approximately 1,000 feet south of confluence with Skunk Creek)					
SKC 165+00, LB	SFP200-59	320	6.6	0.5	Seepage rate and exit gradient - okay
SKC 195+00, RB	SFP200-40	740	15	0.8	Seepage rate and exit gradient - okay
BSR 159+25, LB	SFP200-37	530	11	0.4	Seepage rate and exit gradient - okay
Seepage Area No. 2					
(Big Sioux River-12 th Street north to approximately 1,000 feet south of Madison Street, and Russell Street south approximately 1,000 feet)					
BSR 8+00, LB	SFP200-104	1,100	23	1.3	Seepage rate okay, exit gradient > 0.8
BSR 57+50, LB	SFP200-87/92	910	19	0.7	Seepage rate and exit gradient - okay
BSR 67+15, RB	SFP200-87/92	470	9.6	0.4	Seepage rate and exit gradient - okay
BSR 79+10, LB	SFP200-90	1,000	21	0.7	Seepage rate and exit gradient - okay
Seepage Area No. 3					
(Big Sioux River-Beginning approximately 1,000 feet north of confluence with Skunk Creek, extending approximately 1,000 feet north of Westward Ho CC golf cart bridge)					
BSR 112+25, RB	SFP200-73	1,300	27	0.9	Seepage rate okay, exit gradient > 0.8
BSR 128+50, LB	SFP200-70/71	690	14	0.7	Seepage rate and exit gradient - okay
BSR 144+50, LB	SFP200-64/66	950	19	0.6	Seepage rate and exit gradient - okay
Seepage Area No. 4					
(Big Sioux River-Approximately 500 to 1,500 feet north of 49 th Street)					
BSR 215+65, LB	SFP200-18	1,400	29	1.3	Seepage rate okay, exit gradient > 0.8
BSR 215+65, RB	SFP2GS-111	610	13	0.4	Seepage rate and exit gradient - okay

Table 2
Seepage Rates and Exit Gradients
Phase 3 Project

Station	Typical Soil Boring	Seepage Rate		Exit Gradient	Comments
		Ft ³ /year/ft	Gal/day/ft		
Seepage Area No. 5 (Big Sioux River along Diversion Channel)					
BSR 42+45, RB	SFP301-28	750	15	1.4	Seepage rate okay, exit gradient > 0.8
BSR 42+45, RB ⁽¹⁾	SFP301-28	1,100	23	2.1	Seepage rate okay, exit gradient > 0.8
BSR 106+15, RB	SFP301-08	690	14	1.5	Seepage rate okay, exit gradient > 0.8
BSR 106+15, RB ⁽¹⁾	SFP301-08	2,300	46	0.2	Seepage rate marginal, exit gradient okay
BSR 129+50, RB	SFP301-02	570	12	1.9	Seepage rate okay, exit gradient > 0.8
Seepage Area No. 6 (Levee along east side of Catfish Bay Lake)					
Catfish Bay, East Levee, 4+60	SFP301-37	2,900	59	0.8	Seepage rate marginal, exit gradient okay

Notes for Tables 1 and 2:

BSR = Big Sioux River

SKC = Skunk Creek

LB = Left Bank

RB = Right Bank

⁽¹⁾ – Assumes impervious layer underlying riverside toe is not continuous

0.8 = Maximum permissible exit gradient at landward levee toe per EM1110-2-1901, *Seepage Analysis and Control for Dams*

4. Design Recommendations

Several methods of controlling seepage are available to the design engineer if unacceptable rates of seepage are anticipated. Primary methods for controlling seepage include the following:

- Cutoff trench
- Riverside impervious blanket
- Landside seepage berm
- Pervious toe trench
- Relief wells

Cutoff Trench – Seepage through pervious stratum beneath a levee embankment can be blocked by an impervious trench or by sheet piling, usually constructed near the riverside toe. Clay, bentonite, or grout may be used as impervious trench fill. Steel or vinyl sheet piling are not watertight due to leakage at the interlocking joints. However, sheet piling can significantly reduce seepage and the potential for piping fine-grained material from the embankment foundation. Based on EM 1110-2-1913, cutoff trenches should be installed to penetrate at least 95 percent of the pervious stratum in order to be effective against seepage. As a result, cutoff trenches are rarely economical if the required depth of cutoff exceeds about 40 feet.

Based on the Phase 2 geotechnical investigation, pervious stratum extend to a depth of about 70 feet in some areas of the Phase 2 project, resulting in a required cutoff trench depth of about 67 feet to effectively control seepage. In addition, installation of a cutoff trench would require room for large construction equipment such as a crane with sheet pile driving head or a deep soil excavator. In many areas of the Phase 2 project, adequate space for large construction equipment does not exist to install a cutoff trench. Due to

the required depth of cutoff and inadequate space for large construction equipment to operate, a cutoff trench is not an economically feasible measure for controlling seepage in Phase 2 or 3 project areas.

Riverside Impervious Blanket – If an impervious blanket or stratum is known to exist above pervious stratum, the impervious blanket may effectively reduce seepage flow and seepage pressures landside of the levee if riverside blankets are continuous and extend riverward for a considerable distance. If riverside blankets are not continuous, impervious fill can be placed to extend the naturally occurring blanket.

In order to rely on a riverside impervious blanket to control seepage, subsurface information should be available to confirm the presence of the blanket a significant distance from the riverside toe of the levee. Given the complex geology that exists in the Sioux Falls area, and lacking information to verify presence of the impervious blanket into the river, a riverside impervious blanket will not be counted on to control or reduce seepage in Phase 2 or 3 project areas.

Landside Seepage Berm – Landside berms can be an effective method for controlling seepage. Uplift pressure in pervious deposits underlying an impervious top stratum can breach the impervious top stratum when the uplift pressure exceeds the effective weight of the top stratum, resulting in boils that typically occur near the landside levee toe. Landside berms can be used to counteract uplift pressures by providing additional weight to counteract upward seepage forces at the levee toe. Landside berms can be constructed of impervious material, semi-pervious material, or free-draining material, depending on

availability and cost of material, and available real estate for constructing the seepage berm. Seepage berms are easy to construct and require minimal maintenance. Berm thickness should be designed to provide an appropriate factor of safety against seepage forces, typically 1.5 at the landward levee toe.

The potential need to acquire real estate or obtain legal easements is the primary downside to landside seepage berms. In order to offset large seepage forces, landside berms may need to extend a considerable distance from the landside levee toe. Real estate implications may not be an issue for agricultural levees, but are an important consideration for levees located in an urban setting such as the Phase 2 project.

Pervious Toe Trench – When a levee system is located on pervious deposits with little or no overlying impervious material, a pervious toe trench can be used to improve seepage conditions at or near the landside levee toe. Pervious toe trenches are typically installed at the landward toe of the levee, but may also be installed beneath the landward back slope of the levee. Trench width and depth can be variable, however, a width of two to six feet and a depth not to exceed 10 feet are typical.

Toe trenches are effective only when thin deposits of pervious material are present beneath the levee embankment. When thick deposits of pervious material are present beneath the embankment, toe trenches are effective in collecting only shallow seepage from near-surface pervious material. Toe trenches are not effective in collecting seepage that occurs at depths greater than the bottom of the toe trench. When thick deposits of

pervious material are present beneath the levee embankment, a significant fraction of the total seepage can bypass the shallow toe trench. When seepage through deep deposits of pervious material is anticipated, relief wells may be used in conjunction with a pervious toe trench. In this application, relief wells would collect deep seepage and the toe trench would collect shallow seepage.

In urban settings, a perforated collection pipe is typically installed in a toe trench in order to convey seepage water to a convenient location for collection and discharge. Given the poor interior drainage conditions known to exist along the Westward Ho and Minnehaha Country Clubs, collection and discharge of seepage water will likely worsen already poor interior drainage conditions.

Relief Wells – A system of relief wells may be installed near the landside levee toe to reduce uplift pressure that could otherwise result in boils and in extreme cases, piping of fine-grained foundation soils. Relief wells reduce uplift pressure by intercepting and providing a controlled outlet for seepage that would otherwise emerge on the landward side of the levee. Relief wells are typically used when pervious strata extend to depths below which seepage can be effectively controlled using a cutoff trench or pervious toe trench. To be effective, relief wells must be spaced sufficiently close to maintain a safe hydrostatic pressure between relief wells and outside their zone of influence.

In contrast to landside seepage berms, a system of relief wells typically requires minimal real estate to install and operate. A system of relief wells can usually be expanded with minimal effort if the initial installation fails to provide adequate seepage control.

To be effective, relief wells must be designed to provide resistance to corrosion and bacterial clogging during their service life. A properly designed system will require periodic maintenance of well screens, filter packs, and other critical components to maintain operational efficiency of the system. Relief well systems, even those that have been well maintained, have been documented to lose efficiency over time due to corrosion and bacterial clogging. Relief well design must include a means for disposal of seepage water collected. Collection and discharge of seepage water along many areas of the Phase 2 and 3 projects will be difficult due to the likelihood of worsening already poor interior drainage conditions.

Phase 2 Design Conclusions

Based on the analysis, measures to control uplift pressures at the landward levee toe will be required in three areas within the Phase 2 project. Measures to control uplift pressures are necessary when the calculated exit gradient at the landward levee toe exceeds 0.8, based on criteria in EM1110-2-1901. Based on existing site conditions, landward seepage berms are believed to be the most economical method for controlling seepage and uplift pressures. Seepage berm thickness and width (distance from the landward levee toe) were calculated according to requirements in EM 1110-2-1913. The seepage analysis indicates excessive seepage will not occur as a result of raising the levee elevation to provide 100-year flood protection, in any of the areas analyzed. Exit gradients, however, exceed 0.8 in isolated regions within potential seepage areas two, three, and four, necessitating measures to control uplift pressures in these areas. The ensuing paragraphs summarize design recommendations for each area of concern. A

complete set of design parameters to include berm length and material properties will be determined during the final design phase.

The first area requiring uplift control measures is along the right bank of the Big Sioux River near station 112+25. The area begins approximately 500 feet north of the Westward Ho Country Club golf cart bridge, extending for a length of approximately 500 feet. The area contains a dense growth of large trees, extending at least 400 feet from the landward levee toe. Preliminary information indicates a seepage berm approximately 5.5 feet in thickness and approximately 90 feet in width will be required to control uplift pressures in this area.

The second area of concern is along the left bank of the Big Sioux River beginning approximately 1,200 feet north of 49th Street, extending north a distance of approximately 400 feet. The southern portion of this area has been cleared of trees while the northern portion contains a dense growth of large trees. Preliminary information indicates a seepage berm approximately 3.5 feet in thickness with a width of approximately 35 feet will be required to control uplift pressures in this area.

The third area of concern is along the left bank of the Big Sioux River beginning at Russell Street, extending approximately 1,000 feet south. The area contains a heavy stand of large trees extending west from near the existing levee toe. Preliminary information indicates a seepage berm approximately 3.5 feet in thickness with a width of approximately 30 feet will be required to control uplift pressures in this area.

Phase 3 Design Conclusions

In addition, some areas along the right bank of the Phase 3 project where low areas exist adjacent to the levee will require measures to control uplift pressures, since calculated exit gradients are well in excess of 0.8. Based on the preceding discussion of remedial control measures, landward seepage berms will be used to reduce uplift pressures to acceptable values if sufficient real estate is available to construct seepage berms. Design requirements to reduce uplift pressures for Phase 3 project areas will be determined during the Phase 3 design phase.

APPENDIX 5.a.

FLOOD CONTROL PROJECT MAP

Big Sioux River & Skunk Creek and Flood Control Project

**Phase 1A.....Spillway Chute and Stilling Basin
Improvements.**

Fall 2000 - Winter 2002

**Phase 1B.....Levee Raise on Big Sioux River
From Falls Park Dr to Cliff Ave.**

Spring 2001 - Spring 2002

**Phase 2.....Levee Raise on Big Sioux River
From Russell St to Western Ave
and on Skunk Creek
From Marion Rd to Confluence
With Big Sioux River.**

Summer 2002 - Fall 2003

**Phase 3.....Levee Raise on Big Sioux River
From I-90 to Diversion Dam
and on Diversion Channel
From Diversion Dam and
Spaders Rogers Addition to
North Drive/Spillway.**

Spring 2004 - Fall 2006

- Streets
- Levee
- Rails
- River
- City Limits



APPENDIX 5.b.

SOIL BORINGS LOCATION PLANS

POTENTIAL SEEPAGE AREA NO. 1 -
SKUNK CREEK EAST OF MARION ROAD
TO APPROXIMATELY 1,000 FEET SOUTH OF
THE CONFLUENCE WITH THE BIG SIOUX RIVER.

POTENTIAL SEEPAGE AREA NO. 2 -
BIG SIOUX RIVER NORTH OF 12TH STREET
TO APPROXIMATELY 1,000 FEET SOUTH OF
MADISON STREET.

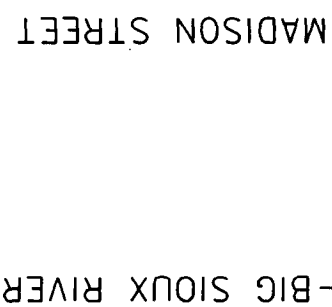
POTENTIAL SEEPAGE AREA NO. 3 - BIG SIOUX RIVER BEGINNING APPROXIMATELY 1,000 FEET NORTH OF THE CONFLUENCE WITH SKUNK CREEK, EXTENDING APPROXIMATELY 1,000 FEET NORTH OF THE WESTWARD HO COUNTRY CLUB BRIDGE (GOLF CART BRIDGE).

POTENTIAL SEEPAGE AREA NO. 4 -
BIG SIOUX RIVER BEGINNING APPROXIMATELY
500 FEET NORTH OF 49TH STREET,
EXTENDING APPROXIMATELY 1,500 FEET
NORTH OF 49TH STREET.



SCALE: 1 INCH = 800 FEET

ELLIS & EASTERN RAILROAD BRIDGE



\$\$ - THINK VALUE ENGINEERING - \$\$

[illegible]

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
OMAHA, NEBRASKA

Designed by:
BRAD N. JONES, PA
14021-221-4488

SEEPAGE ANALYSIS REPORT

Drawn by

SOIL BORINGS LOCATION PLAN - PHASE 2

SHEET 1 OF 2

Submitted by:
DAVID P. RAY, PE
Date JANUARY 200

Figure 7

Contract No
DACW 45

MR447-082E)

61

LEGEND

POTENTIAL SEEPAGE AREA NO. 1 -
SKUNK CREEK EAST OF MARION ROAD
TO APPROXIMATELY 1,000 FEET SOUTH OF
THE CONFLUENCE WITH THE BIG SIOUX RIVER.

POTENTIAL SEEPAGE AREA NO. 2 -
BIG SIOUX RIVER NORTH OF 12TH STREET
TO APPROXIMATELY 1,000 FEET SOUTH OF
MADISON STREET.

POTENTIAL SEEPAGE AREA NO. 3 -
BIG SIOUX RIVER BEGINNING
APPROXIMATELY 1,000 FEET NORTH
OF THE CONFLUENCE WITH SKUNK
CREEK, EXTENDING APPROXIMATELY
1,000 FEET NORTH OF THE WESTWARD
HO COUNTRY CLUB BRIDGE (GOLF CART
BRIDGE).

POTENTIAL SEEPAGE AREA NO. 4 -
BIG SIOUX RIVER BEGINNING APPROXIMATELY
500 FEET NORTH OF 49TH STREET,
EXTENDING APPROXIMATELY 1,500 FEET
NORTH OF 49TH STREET.

A - MATCHLINE - A

12TH STREET

WESTWARD HO COUNTRY CLUB
GOLF CART BRIDGE

BIG SIOUX RIVER

INTERSTATE 29

MARION ROAD

SKUNK CREEK

SCALE: 1 INCH = 800 FEET



DESIGNED BY BRAD N. JONES, PE 1407-201-4488		BIG SIOUX RIVER FLOOD CONTROL PROJECT SOIL BORINGS LOCATION PLAN - PHASE 2 SHEET 2 OF 3	
U.S. ARMY ENGINEER DISTRICT OMAHA, NEBRASKA		DRAWING CODE MR447-082E X	
CHECKED BY DATE APPROVED BY DATE		DATE JANUARY 2003	
PROJECT NO. 1407-201-4488		SHEET NO. 2 OF 3	
CONTRACT NO. MR447-082E X		G2	

POTENTIAL SEEPAGE AREA NO. 1 -
SKUNK CREEK EAST OF MARION ROAD
TO APPROXIMATELY 1,000 FEET SOUTH OF
THE CONFLUENCE WITH THE BIG SIOUX RIVER.

POTENTIAL SEEPAGE AREA NO.2 -
BIG SIOUX RIVER NORTH OF 12TH STREET
TO APPROXIMATELY 1,000 FEET SOUTH OF
MADISON STREET.

POTENTIAL SEEPAGE AREA NO. 3 - BIG SIOUX RIVER BEGINNING APPROXIMATELY 1,000 FEET NORTH OF THE CONFLUENCE WITH SKUNK CREEK, EXTENDING APPROXIMATELY 1,000 FEET NORTH OF THE WESTWARD HO COUNTRY CLUB BRIDGE (GOLF CART BRIDGE).

POTENTIAL SEEPAGE AREA NO. 4 - BIG SIOUX RIVER BEGINNING APPROXIMATELY 500 FEET NORTH OF 49TH STREET, EXTENDING APPROXIMATELY 1,500 FEET NORTH OF 49TH STREET.



B - MATCHLINE - B

INTERSTATE 1-229

49TH STREET

-41ST STREET

SCALE: 1 INCH = 800 FEET

800'	0	800'
------	---	------

[illegible]

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
OMAHA, NEBRASKA

BIG SIOUX RIVER
SIOUX FALLS, SOUTH DAKOTA
FLOOD CONTROL PROJECT

SEEPAGE ANALYSIS REPORT

SHEET 3 OF 3

Submitted by: DAVID P RAY PE Date JANUARY 2003	Post Scale Ratio 9/16/1000	Date: JANUARY 2003	Sheet reference Number
Spec. No.:			
Drawing Code:			

Contract No.:	MR447-082E X
DATE:	G3

SCALE: 1 INCH = 200 FEET
200'
0'
200'



SURGE 1 TRACTS

SURGE 2 TRACTS

STATE HIGHWAY 38A

BURLINGTON NORTHERN STANLEY FE RAILROAD

BIG SIOUX RIVER

BIG SIOUX RIVER

E 60TH ST N

N DITCH ROAD

SPT300-48

SPT301-46

SPT301-42

SPT301-41

DIVERSION CHANNEL

ALL SCALES SHOWN ARE BASED ON A STANDARD DRAWING SIZE OF 28" X 40" OR METRIC DRAWING SIZE OF 1016mm X 711.2mm. IF ANY OTHER SIZE DRAWINGS ARE FURNISHED OR PLOTTED THE CONTRACTOR SHALL ADJUST THE SCALES ACCORDINGLY. THE CONTRACTOR SHALL ALSO ADVISE SUB-CONTRACTORS OF THE ABOVE.

MATCHLINE 1 - SEE SHEET G2

Sheet
reference
number:
G1

BIG SIOUX RIVER AND DIVERSION CANAL
SIOUX FALLS, SOUTH DAKOTA
FLOOD PROTECTION PROJECT - PHASE 3
BOREHOLE LOCATION PLAN
SHEET 1 OF 4

Designed by:
Michael E. Barne, PE
(402) 221-4329
Submitted by: David P. Ray, PE
Date: Jan. 2003
Chief: Soils A Section Geotechnical Branch

Drawn by:
Michael E. Barne, PE
(402) 221-4329
Date: July 31, 2002
Design File Name:
200PHASE3 1.DGN
Plot Scale Ratio:
200:1
Drawing Code: **SDBS1-220**

Date	Rev.
July 31, 2002	
Design File Name	Spec. No.
200PHASE3 1.DGN	DACW45-02-B-0020
Plot Scale Ratio	Contract No.
200:1	DACW45-03
Drawing Code	
SDBS1-220	



[illegible]

ALL SCALES SHOWN ARE BASED ON A STANDARD DRAWING SIZE OF 28" X 40" OR METRIC DRAWING SIZE OF 1016mm X 712mm. IF ANY OTHER SIZE DRAWINGS ARE FURNISHED OR PLOTTED THE CONTRACTOR SHALL ADJUST THE SCALES ACCORDINGLY. THE CONTRACTOR SHALL ALSO ADJUST THE CONTRACTORS OF THE ABOVE.

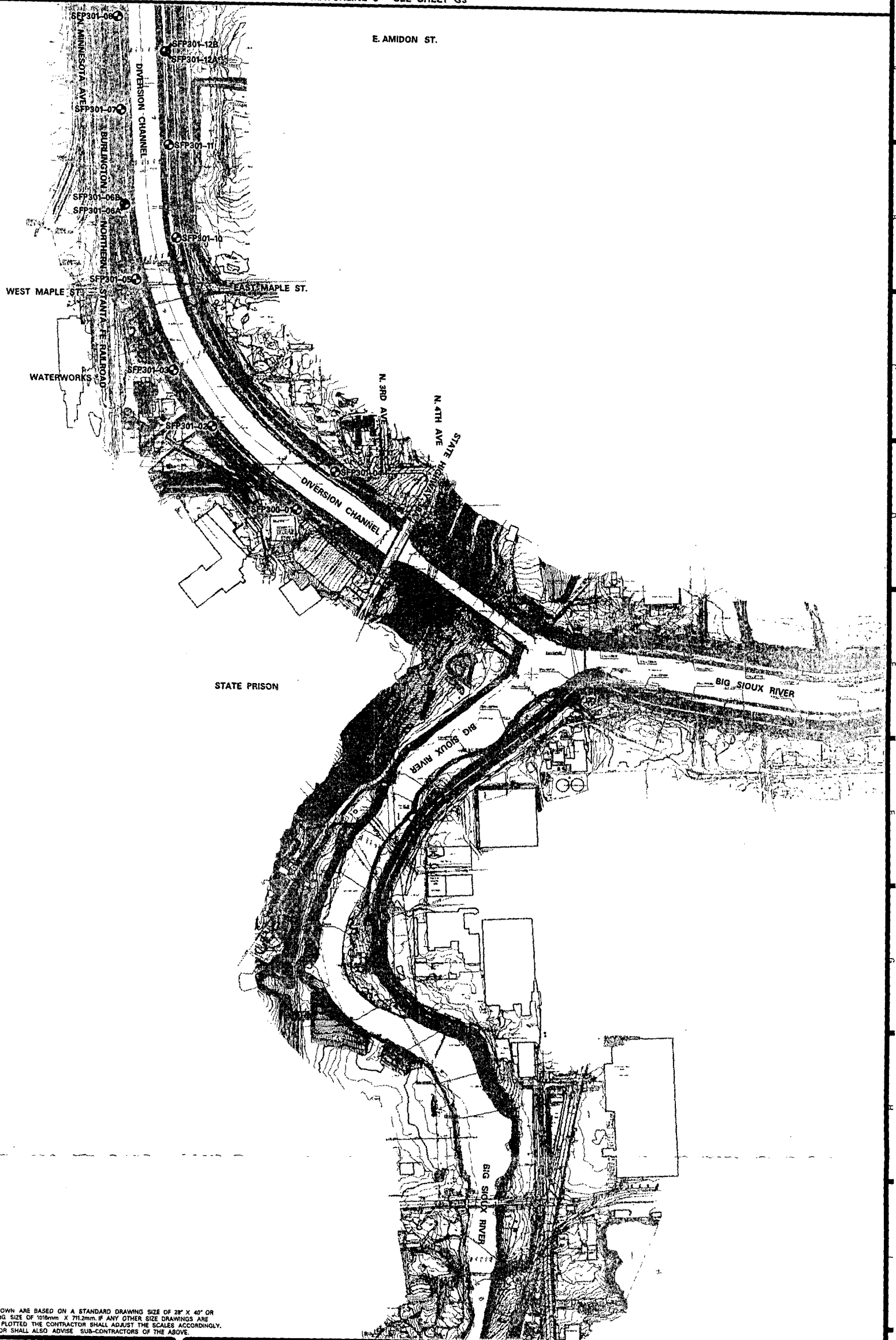
SIoux FALLS, SOUTH DAKOTA
FLOOD PROTECTION PROJECT - PHASE 3
BOREHOLE LOCATION PLAN
SHEET 2 OF 4

Date: July 31, 2002	Rev.
Design File Name 200PHASE3 2.DGN	Spec. No. DACW45-02-B-0020
Plot Scale Ratio: 200:1	Contract No. DACW45-03-
Drawing Code: SDPS1-220	



US Army Corps
of Engineers
Omaha District

MATCHLINE 3 - SEE SHEET G3



SCALE: 1 INCH = 200 FEET
0 100 200

ALL SCALES SHOWN ARE BASED ON A STANDARD DRAWING SIZE OF 36" X 48" OR METRIC DRAWING SIZE OF 1016mm X 712mm. IF ANY OTHER SIZE DRAWINGS ARE FURNISHED OR PLOTTED THE CONTRACTOR SHALL ADJUST THE SCALES ACCORDINGLY. THE CONTRACTOR SHALL ALSO ADVISE SUB-CONTRACTORS OF THE ABOVE.

Sheet
reference
number:
G4

BIG SIOUX RIVER AND DIVERSION CANAL
SIOUX FALLS, SOUTH DAKOTA
FLOOD PROTECTION PROJECT - PHASE 3
BOREHOLE LOCATION PLAN
SHEET 4 OF 4

Designed by:
Michael E. Barne, PE
(402) 221-4329
Submitted by: David P. Rey, PE
Date: Jan. 2003
Chief: Sols A. Section Geotechnical Branch

Drawn by:
Michael E. Barne, PE
(402) 221-4329

Date: July 31, 2002
Design File Name:
200PHASE3 4.DGN

Plot Scale Ratio:
200:1
Drawing Code: SDBS1-220

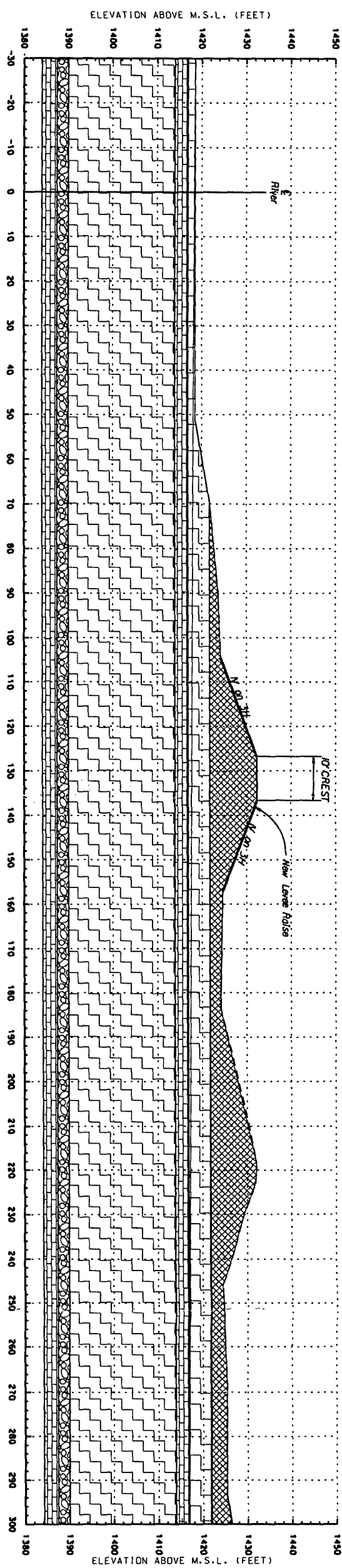
Rev.
Spec. No.
DACW45-02-B-0020

Contract No.
DACW45-03-

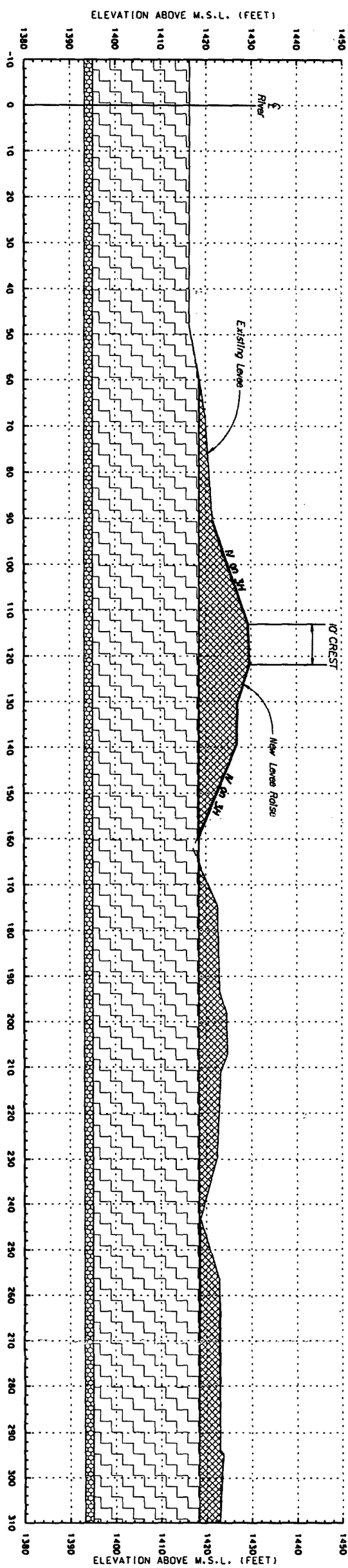


APPENDIX 5.c.

SEEPAGE ANALYSIS CROSS SECTIONS



PROPOSED CROSS SECTION, BIG SIOUX RIVER RIGHT BANK STATION 42+45



PROPOSED CROSS SECTION, BIG SIOUX RIVER, RIGHT BANK, STATION 106+15

LEGEND

CLAY

GP

SP

SP with GRAVEL

SP-5

ALL SCALES SHOWN ARE BASED ON A STANDARD DRAWING SIZE OF 28" X 40"
IF ANY OTHER SIZE DRAWINGS ARE FURNISHED OR PLOTTED THE CONTRACTOR
SHALL ALSO ADVISE HIS SUB-CONTRACTORS OF THE ABOVE.

BIG SIOUX RIVER AND SKUNK CREEK
SIOUX FALLS, SOUTH DAKOTA
FLOOD PROTECTION PROJECT
BIG SIOUX RIVER AT SIOUX FALLS - PHASE 3
CROSS SECTIONS

Designed by:
J.M. Conroy
1-800-270-4100

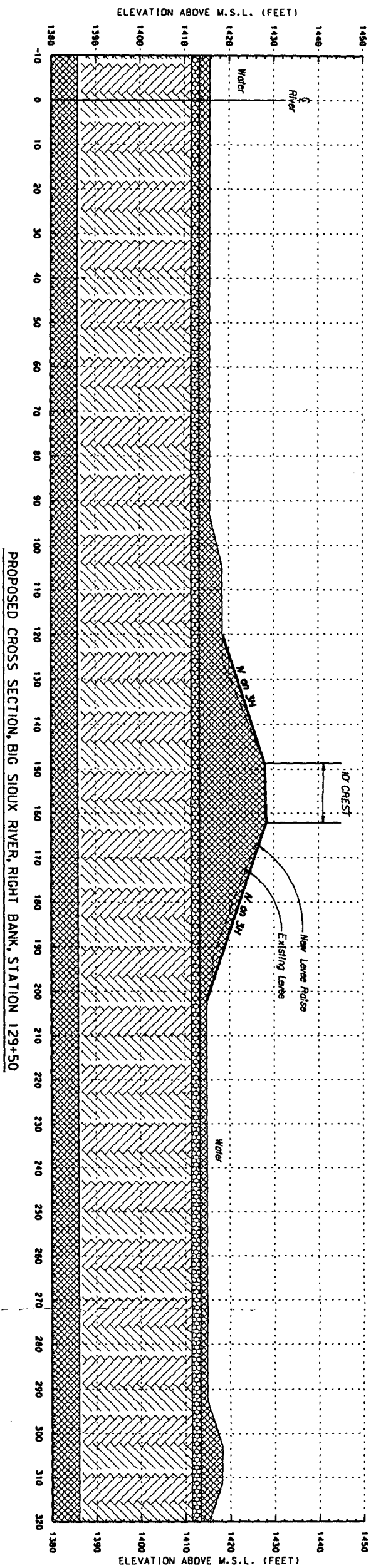
Submitted by
David F. Ray, PE
Date:
Chief:
SOLAS & (Spec)

Drawn by:
J.A. Hampson

Date: AUGUST 2002
 Design file name: SF13G903.DGN
 Plot Scale Ratio: 1:1
 Drawing code: MSB5-220

Now,
Spec. No.
DACA 45
Contract No.
DACA 45

Sheet
reference
number:
G9.03



PROPOSED CROSS SECTION, BIG SIOUX RIVER, RIGHT BANK, STATION 129+50

LEGEND

CLAY
SP-SW
SW-SP

ALL SCALES SHOWN ARE BASED ON A STANDARD DRAWING SIZE OF 28" X 40"
IF ANY OTHER SIZE DRAWINGS ARE FURNISHED OR PLOTTED THE CONTRACTOR
SHALL ALSO ADVISE HIS SUB-CONTRACTORS OF THE ABOVE.

BIG SIOUX RIVER AND SKUNK CREEK
SIOUX FALLS, SOUTH DAKOTA
FLOOD PROTECTION PROJECT
BIG SIOUX RIVER AT SIOUX FALLS - PHASE 3
CROSS SECTIONS

Designed by:
J.M. Coffey
(605) 721-5381

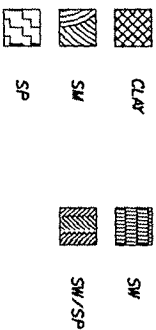
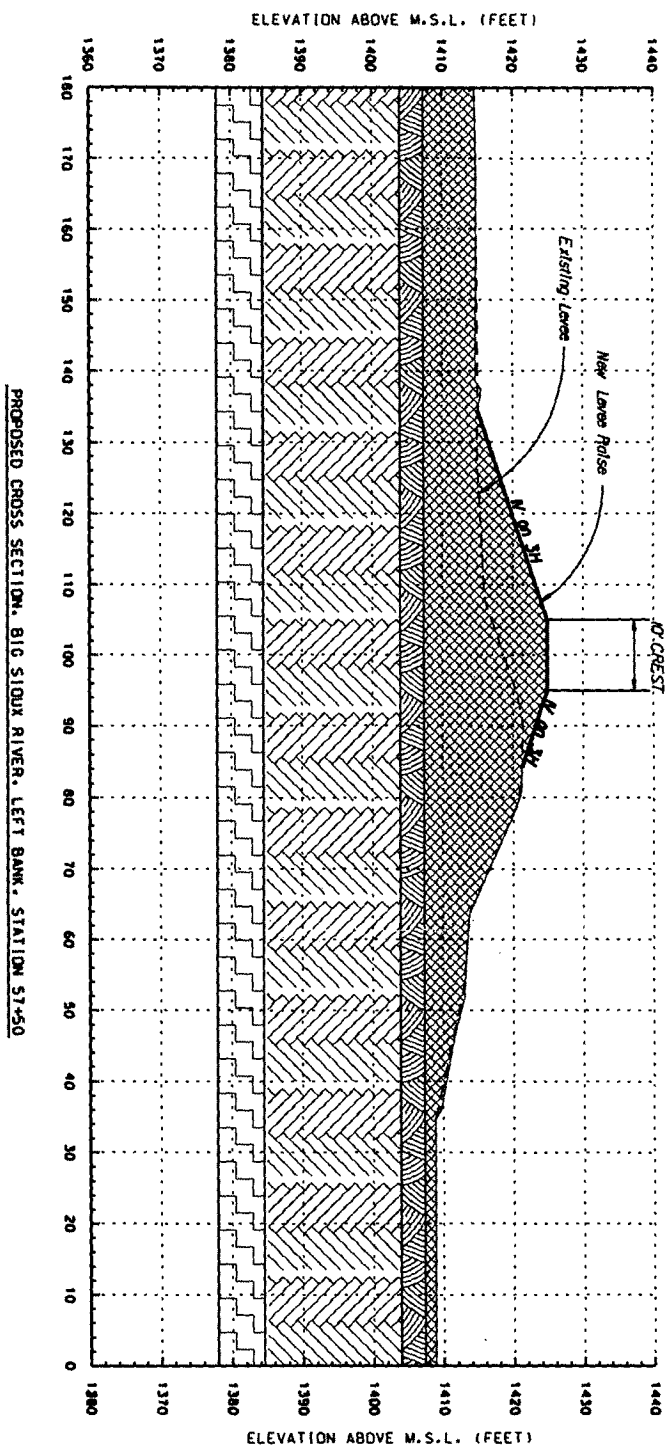
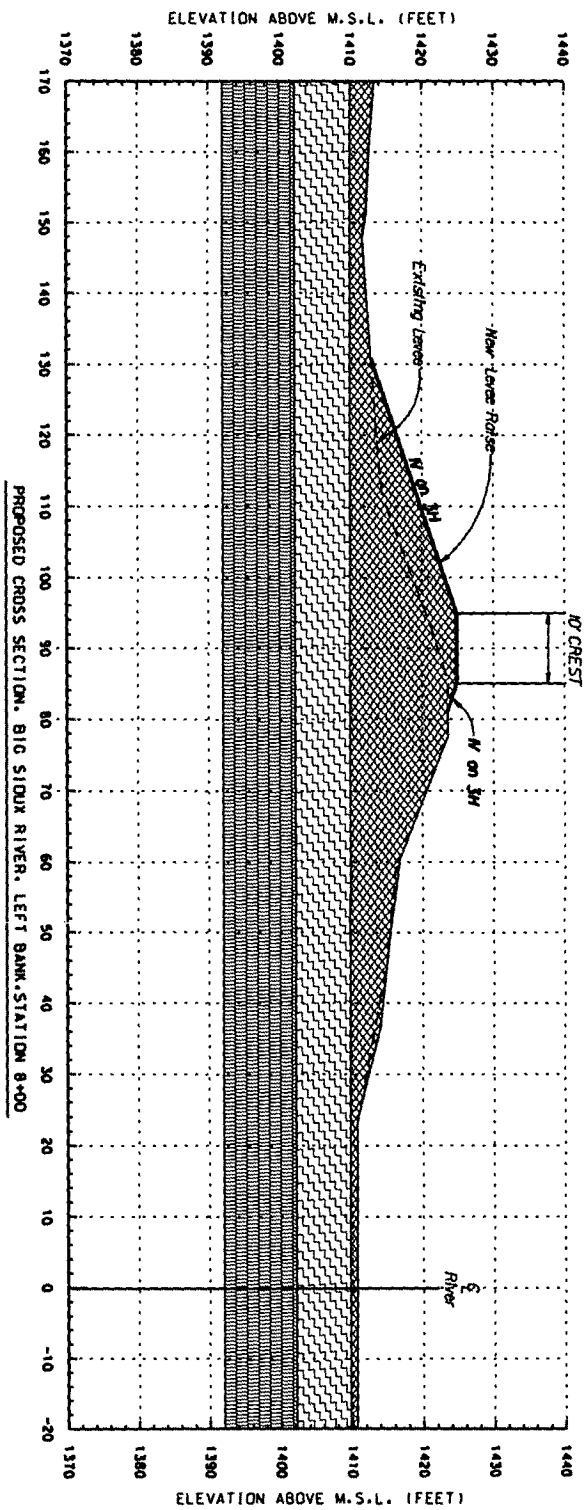
Drawn by:
J.A. Hengel

Date:
AUGUST 2002
Project No.:
SF136985.DCN
Sheet No.:
011
Drawing code:
MSB5-220

Check by:
DACA #5
Contract No.:
DACA #5

Sheet
reference
number:
G9.04

US Army Corps
of Engineers
Civilian Engineer



ALL SCALES SHOWN ARE BASED ON A STANDARD DRAWING SIZE OF 28" X 40"
IF ANY OTHER SIZE DRAWINGS ARE FURNISHED OR PLOTTED THE CONTRACTOR
SHALL ALSO ADVISE HIS SUB-CONTRACTORS OF THE ABOVE.

BIG SIOUX RIVER AND SKUNK CREEK
SIOUX FALLS, SOUTH DAKOTA
FLOOD PROTECTION PROJECT
BIG SIOUX RIVER AT SIOUX FALLS - PHASE 2
CROSS SECTIONS

Designed by:
J.M. Gentry
600-221-4361

Drawn by:
J.A. Hensel

Submitted by:
David P. Ray, PE
Date:
Sheet:
SIOUX A. Section

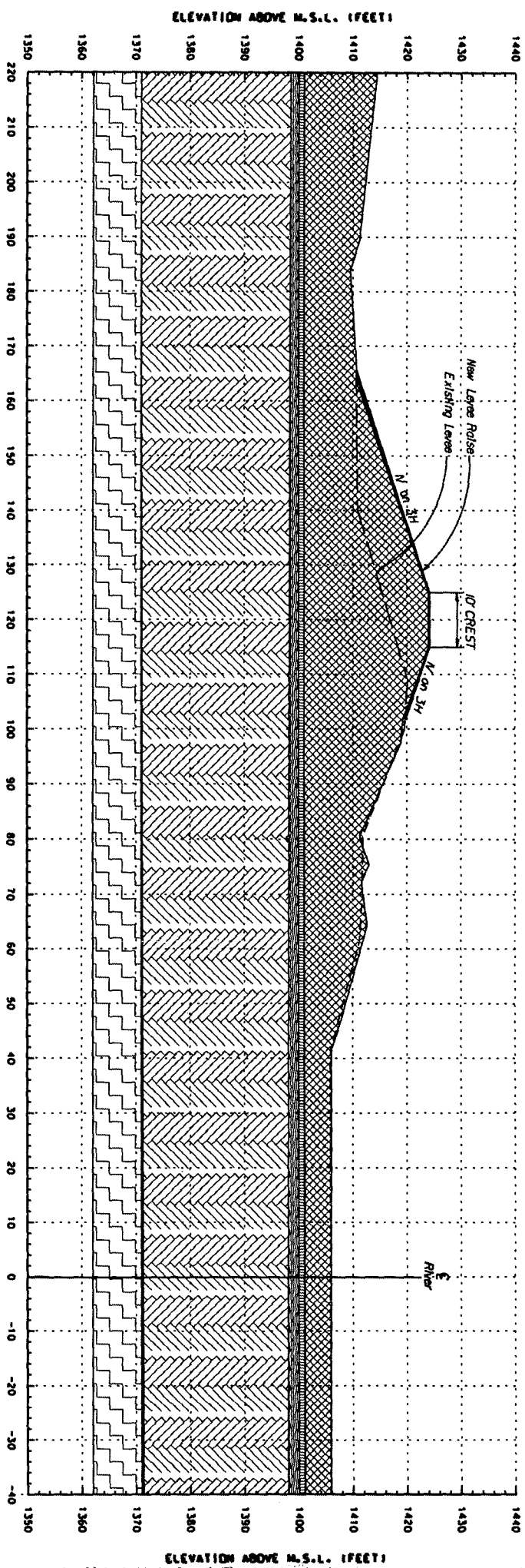
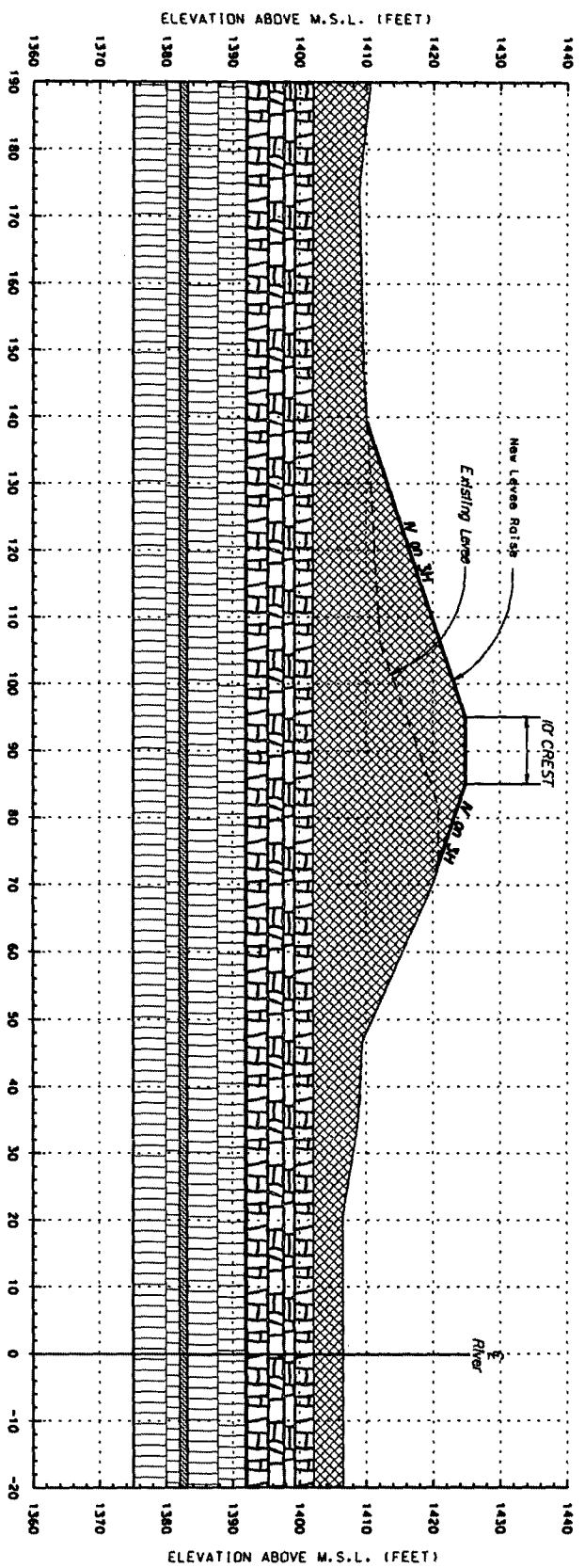
Date:
AUGUST 2002
Project No.:
SF13C987.00N
Not Scale Rep:
0:1
Drawing code:
MSB5-220

Rev. No.
DACA 45

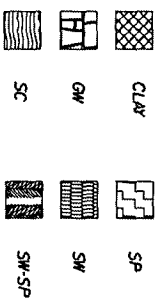
Contract No.
DACA 45

US Army Corps
of Engineers
Omaha District

Sheet
reference
number:
G9.07



LEGEND



ALL SCALES SHOWN ARE BASED ON A STANDARD DRAWING SIZE OF 28" X 40"
IF ANY OTHER SIZE DRAWINGS ARE FURNISHED OR PLOTTED THE CONTRACTOR
SHALL ALSO ADVISE HIS SUB-CONTRACTORS OF THE ABOVE.

BIG SIOUX RIVER AND SKUNK CREEK
SIOUX FALLS, SOUTH DAKOTA
FLOOD PROTECTION PROJECT
BIG SIOUX RIVER AT SIOUX FALLS - PHASE 2
CROSS SECTIONS

Sheet
reference
number:
G9.09

assigned by:
J.M. Connor
(402)-221-4261

Drawn by:
J.A. Humpal

Date: **AUGUST 2002**
 CRIMINAL JUSTICE SYSTEMS

SF13C909.DCN
Viol Scale Entry
10:1

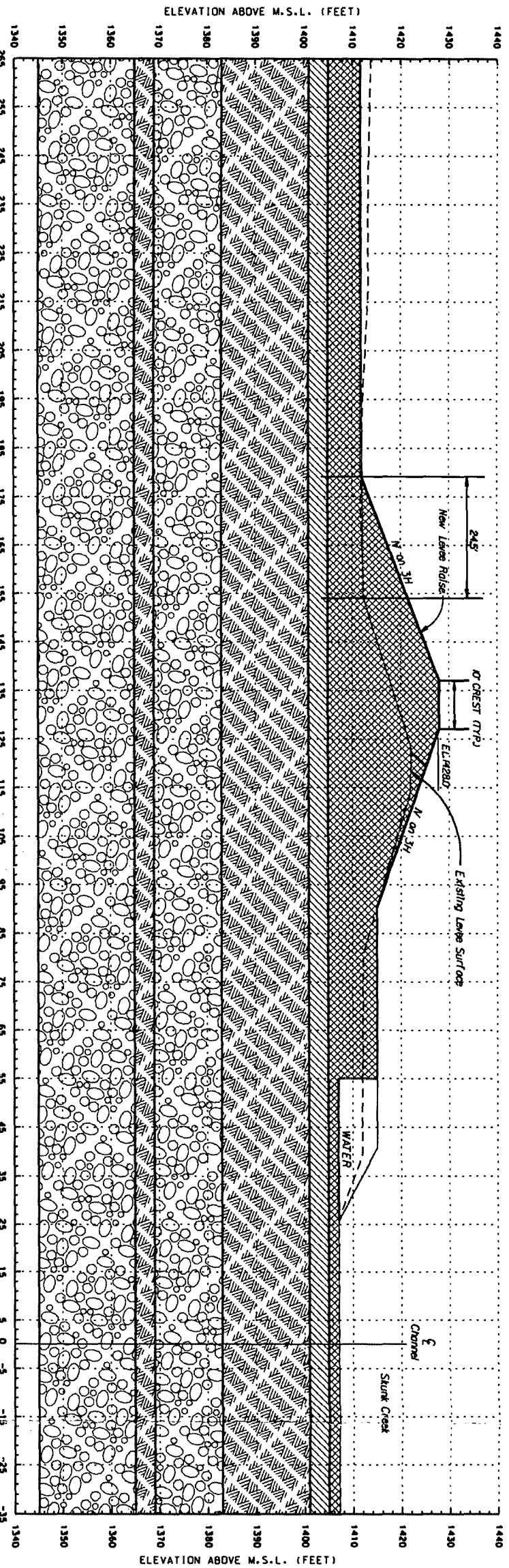
Drawing code:
MSB5-220

14

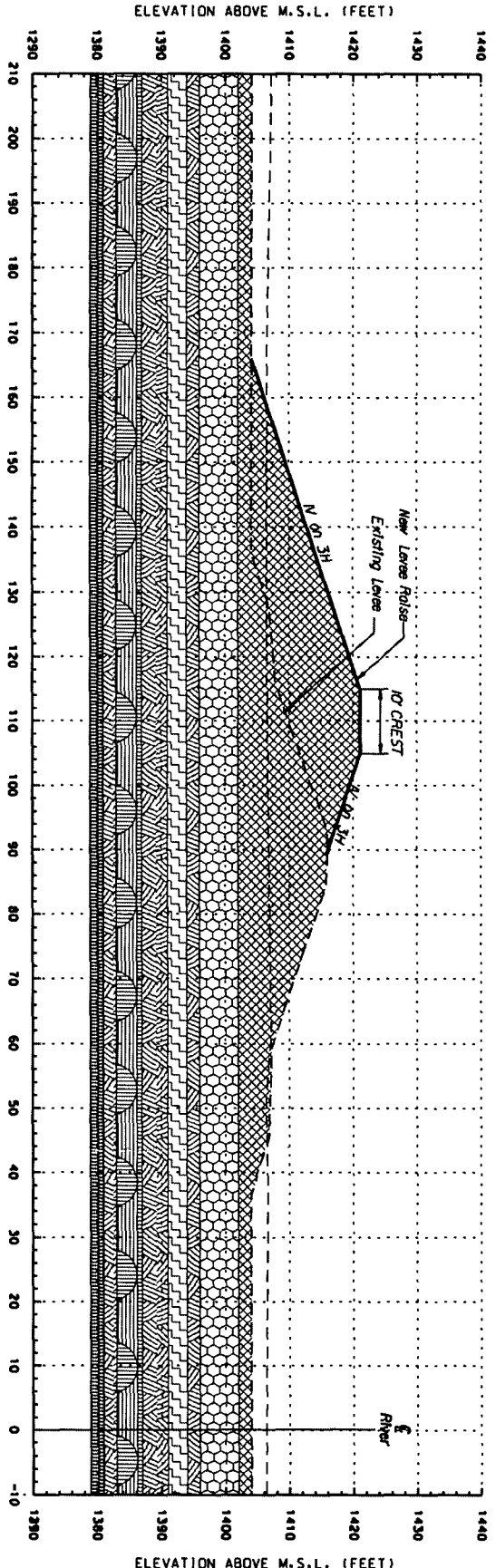
DACA 45

DACA 45





PROPOSED CROSS SECTION, SKUNK CREEK, LEFT BANK, STATION 165+00



PROPOSED CROSS SECTION, BIG SIOUX RIVER, LEFT BANK, STATION 215+65

	CLAY		SP
	SAND 1		SP-SW
	SAND/SILT		SW
	SAND 2		SW-SW
	SW		

LEGEND

ALL SCALES SHOWN ARE BASED ON A STANDARD DRAWING SIZE OF 28" X 40"
IF ANY OTHER SIZE DRAWINGS ARE FURNISHED OR PLOTTED THE CONTRACTOR
SHALL ALSO ADVISE HIS SUB-CONTRACTORS OF THE ABOVE.

BIG SIOUX RIVER AND SKUNK CREEK
SIOUX FALLS, SOUTH DAKOTA
FLOOD PROTECTION PROJECT
BIG SIOUX RIVER AT SIOUX FALLS - PHASE 2
CROSS SECTIONS

Designed by L.M. Conroy 407-251-4348	Drawn by J.A. Hamper	Date AUGUST 2002	Scale AS SHOWN
Submitted by David P. Roy, P.E. Date	Checked by CHUB A. Sorenson	Drawing code MSB5-220	Contract No. DACA 45

No.	Description	Rev.	Appr.



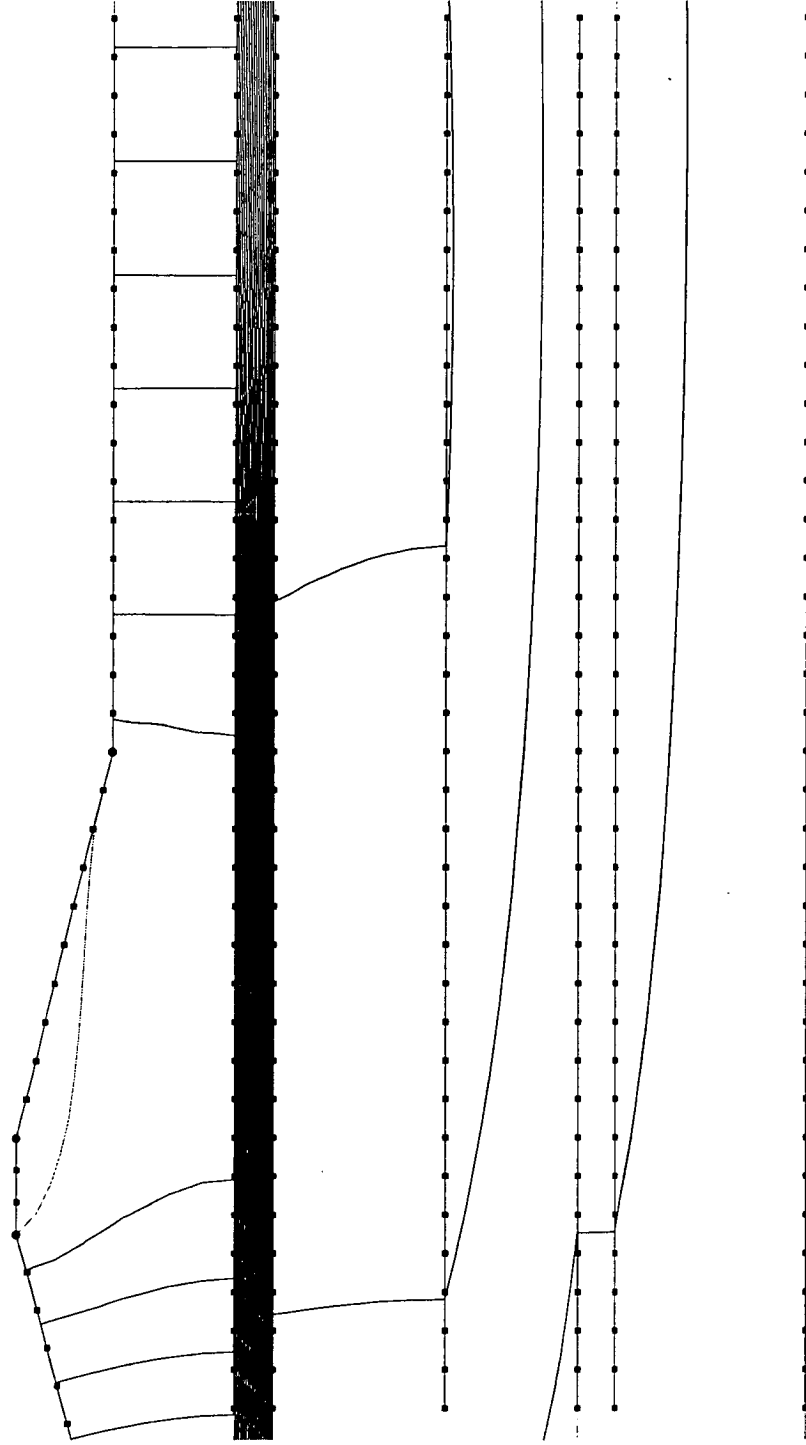
Sheet
Reference
Number:
G9.10

APPENDIX 5.d.

SEEP2D OUTPUT FILES

SKUNK CREEK, LEFT BANK, STATION 165+00 (With project levee)

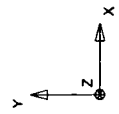
Total Flowrate = 322.7628(ft³/yr)/(ft)



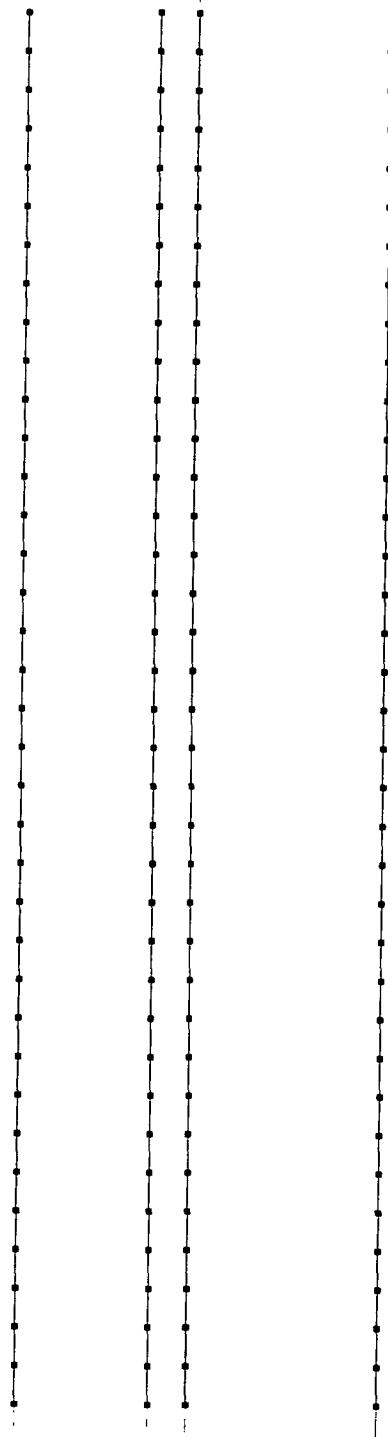
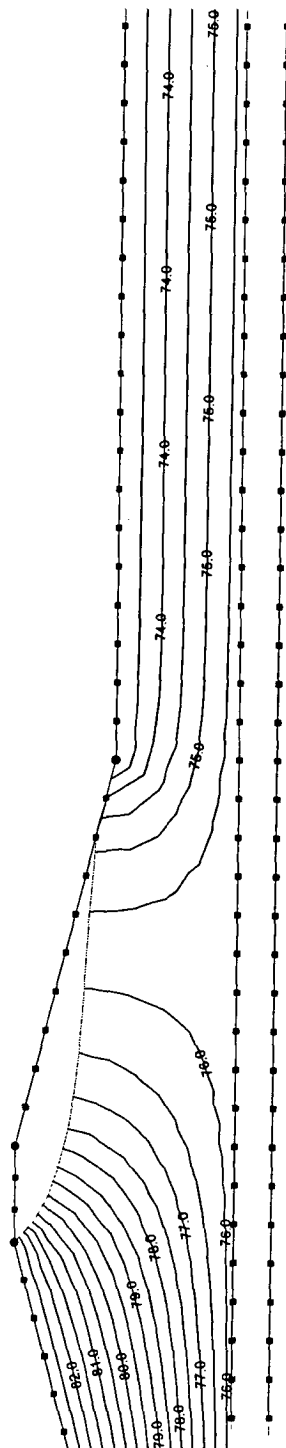
FLOWLINES

Materials

Clay_1	
Sand_1	
Sand_Silt_1	
Sand_2	
Sand_Silt_2	

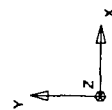


Total Flowrate = $322.7628(\text{ft}^3/\text{yr})/(\text{ft})$



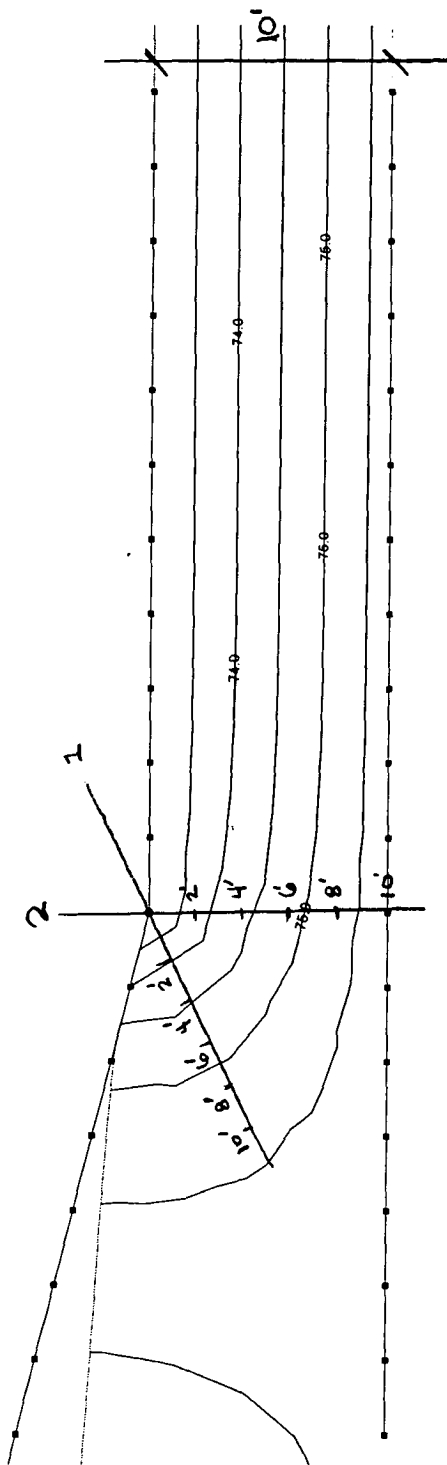
EQUIPOTENTIAL HEAD LINES

Materials
Clay_1
Sand_1
Sand_Silt_1
Sand_2
Sand_Silt_2



SKUNK CREEK, LEFT BANK, STATION 165+00 (With project levee)

Total Flowrate = 322.7628 (ft³/yr)/(ft)



$$L = \Delta H / L_c = 0.8 \text{ (EM 1110-2-1913)}$$

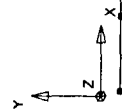
$$L_1 = \frac{74-73}{2} = 0.5$$

$$L_2 = \frac{75.7-73}{10} = 0.27$$

$$\text{OR } \frac{74-73}{2.5-1} = 0.40$$

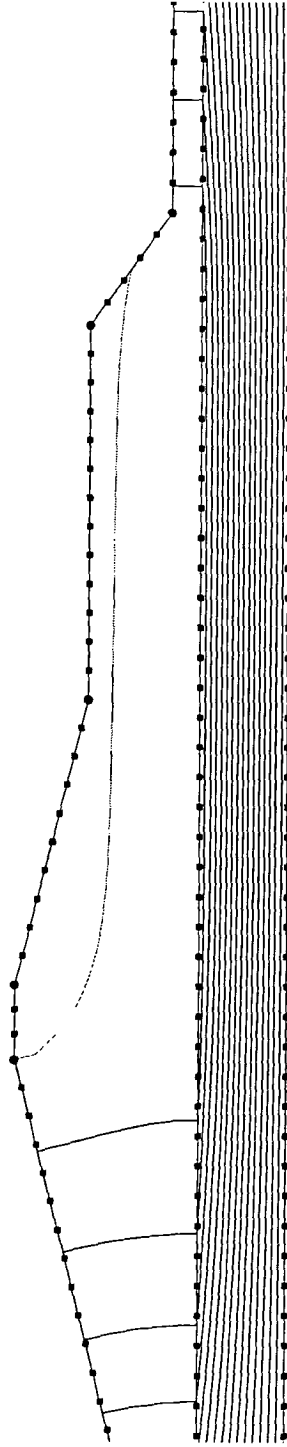
EQUIPOTENTIAL HEAD LINES

Materials				
	Clay_1			
	Sand_1			
	Sand_Silt_1			
	Sand_2			
	Sand_Silt_2			

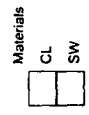
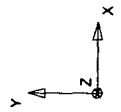


SKUNK CREEK, RIGHT BANK, STATION 195+00, (With levee raise)

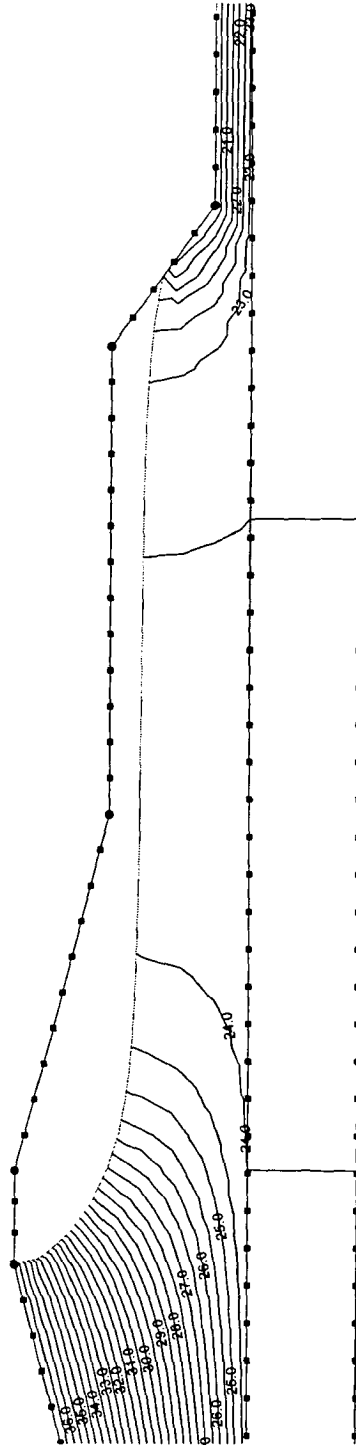
Total Flowrate = $735.2149(\text{ft}^3/\text{yr})/(\text{ft})$



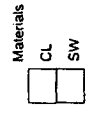
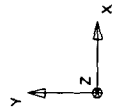
FLOWLINES



SKUNK CREEK, RIGHT BANK, STATION 195+00, (With levee raise)
 Total Flowrate = 735.2149(ft³/yr)/(ft)



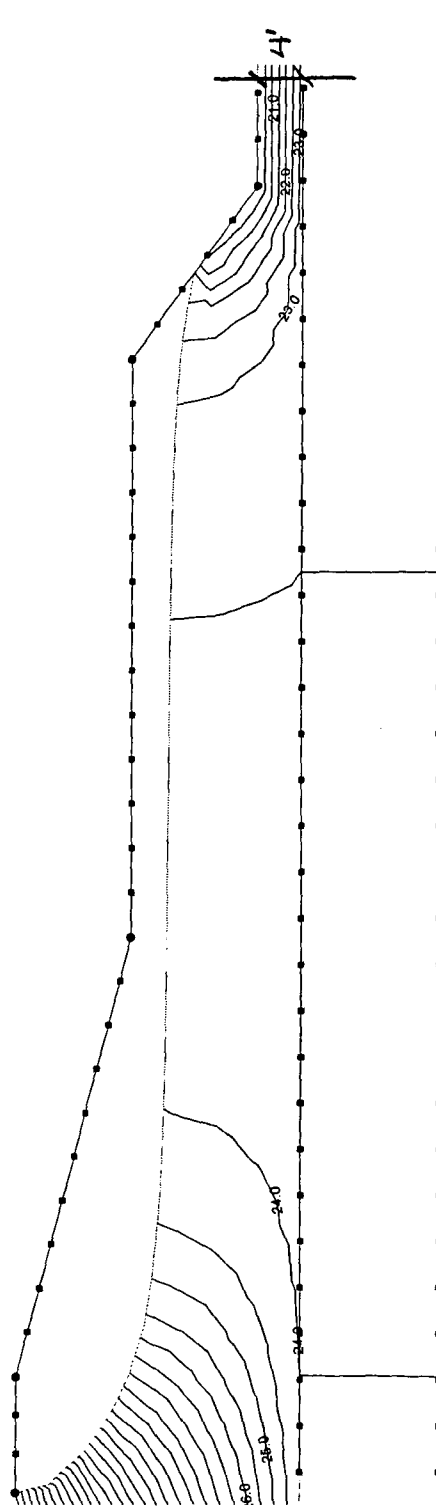
EQUIPOTENTIAL HEAD LINES



SKUNK CREEK, RIGHT BANK, STATION 195+00, (With levee raise)

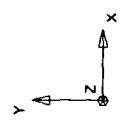
Total Flowrate = 735.2149 (ft³/yr)/(ft)

EQUIPOTENTIAL HEAD LINES



$$i = \Delta H / L \quad i_c = 0.8 \text{ (EM 1110-2-1913)}$$

$$i = \frac{73.5 - 20}{41} = 0.75$$

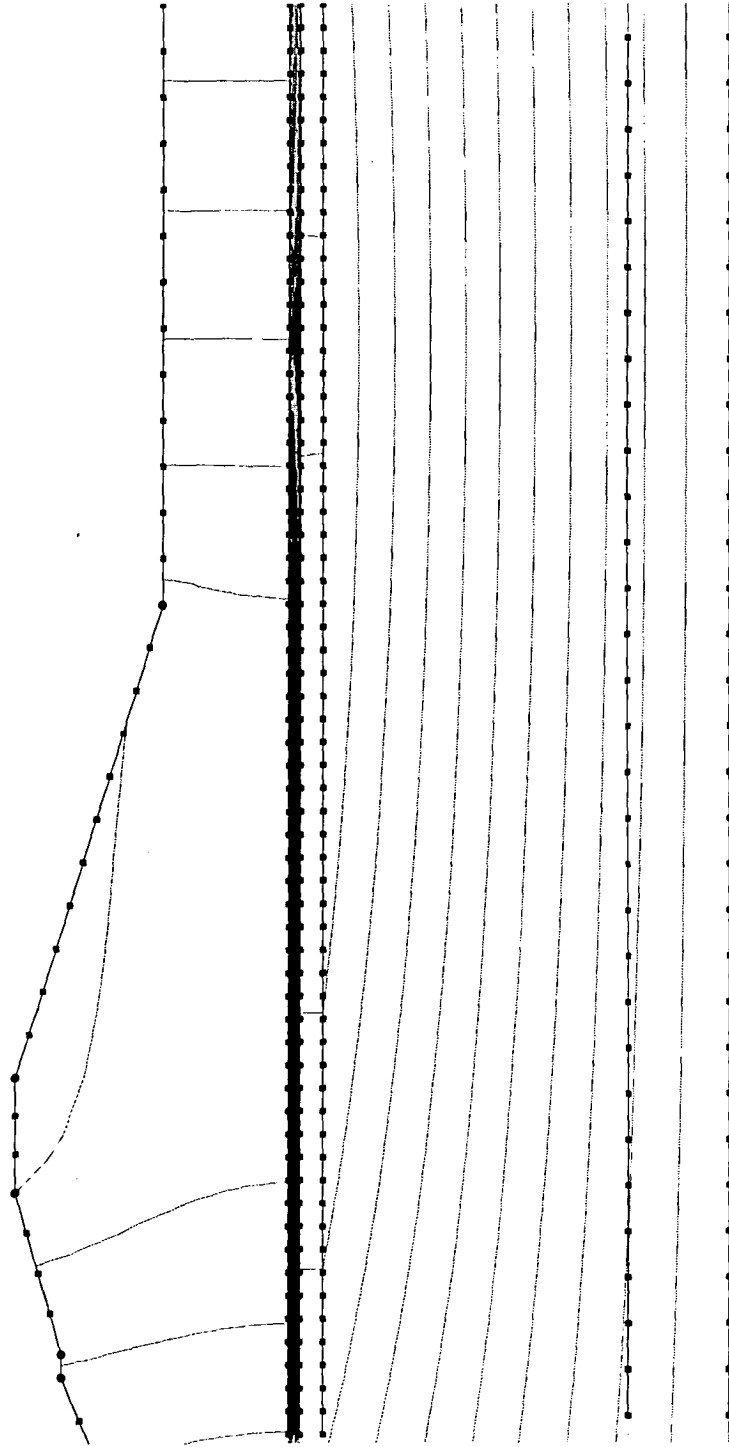


Materials

CL	SW
----	----

BIG SIOUX RIVER, LEFT BANK, STATION 159+25 (With levee raise)

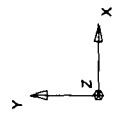
Total Flowrate = 533.4514 (ft³/yr)/(ft)



FLOWLINES

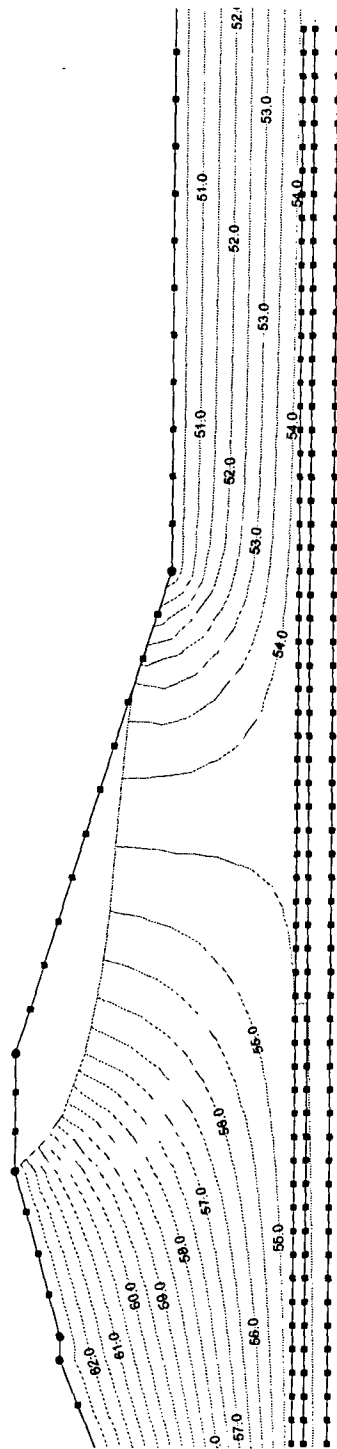
Materials

Clay	SW	SC	SP1	SP2



BIG SIOUX RIVER, LEFT BANK, STATION 159+25 (With levee raise)

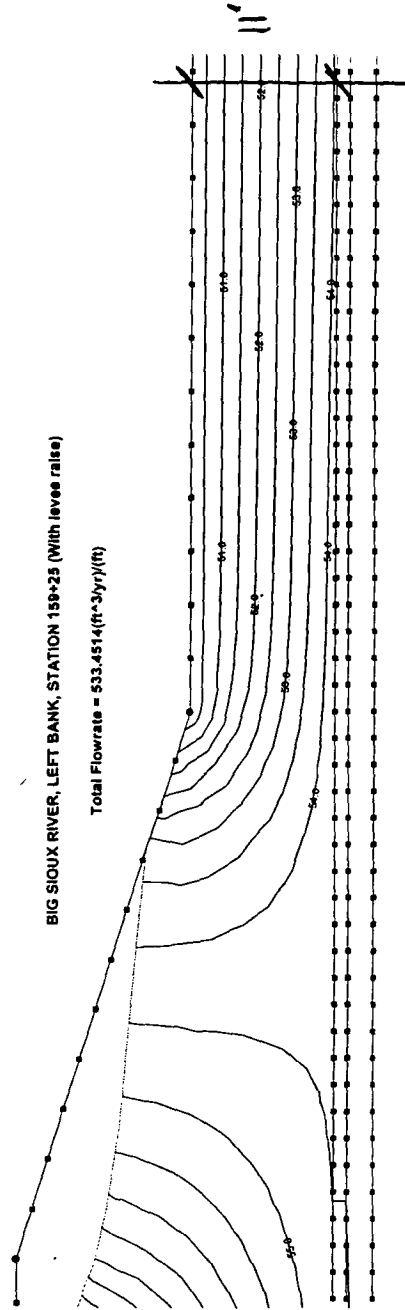
Total Flowrate = 533.4514 (ft³/yr)/(ft)



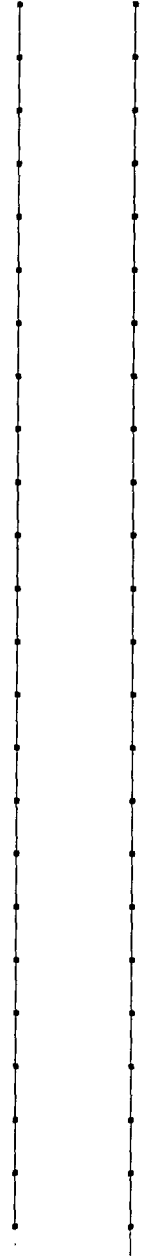
EQUIPOTENTIAL HEADLINES

Materials

Clay	
SW	
SC	
SP1	
SP2	



EQUIPOTENTIAL HEADLINES



Materials					
	Clay				
	SW				
	SC				
	SPL				
	SP2				

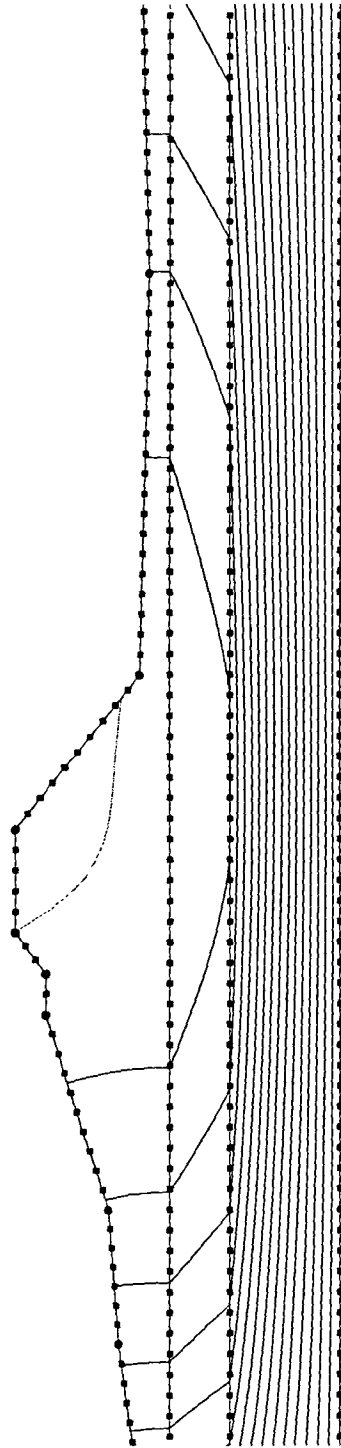
$$L = \Delta H / L$$

$$L_c = 0.8 \text{ (EM 110-2-1913)}$$

$$L = \frac{54' - 50'}{11'} = 0.36$$

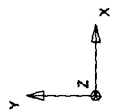
BIG SIOUX RIVER, LEFT BANK, STATION 8+00 (With Levee Raise)

Total Flowrate = 1143.8722(ft³/yr)/(ft)



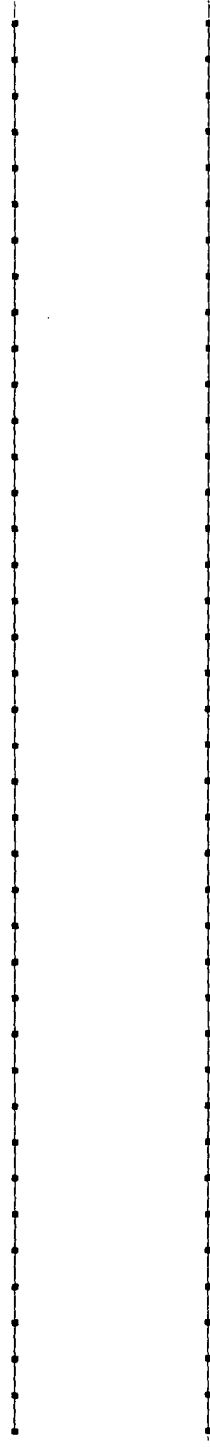
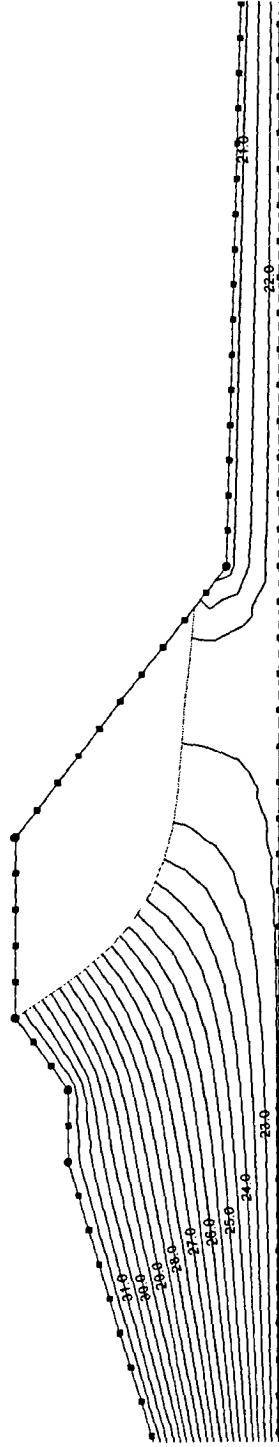
FLOWLINES

Materials
Clay
SP
SW

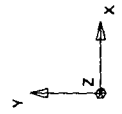


BIG SIOUX RIVER, LEFT BANK, STATION 8+00 (With Levee Raise)

Total Flowrate = 1143.8722(ft³/yr)/(ft)

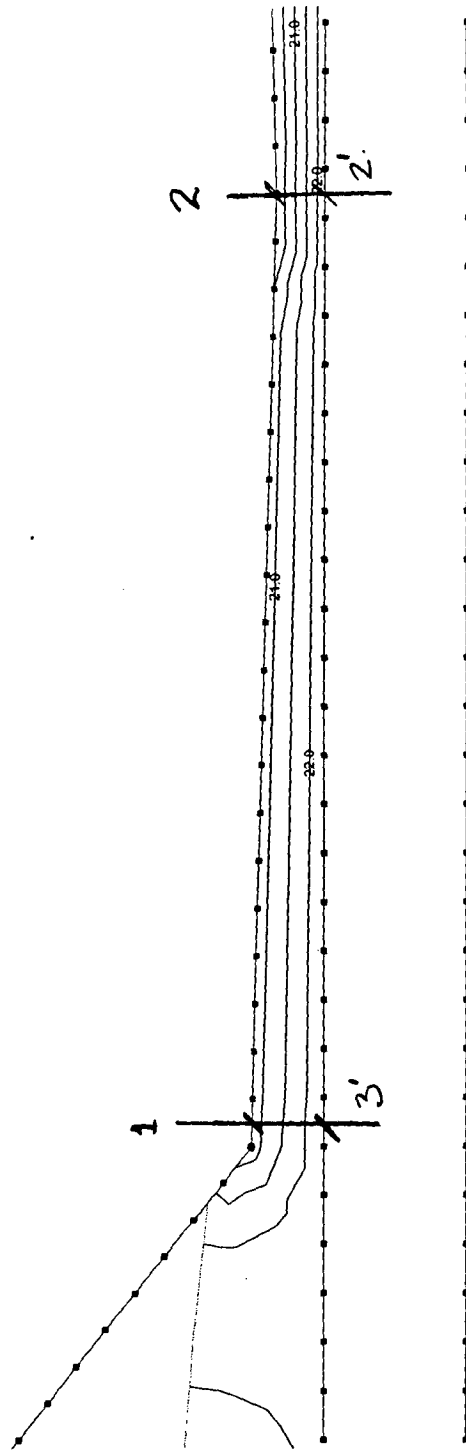


EQUIPOTENTIAL HEAD LINES



BIG SIOUX RIVER, LEFT BANK, STATION 8+00 (With Levee Raise)

Total Flowrate = 1143.8722 (ft³/yr)/(ft)

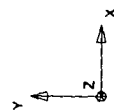
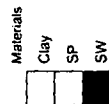


EQUIPOTENTIAL HEAD LINES

$$\bar{l} = \Delta H / L \quad l_1 = 0.8 \quad (EM 110-2-1913)$$

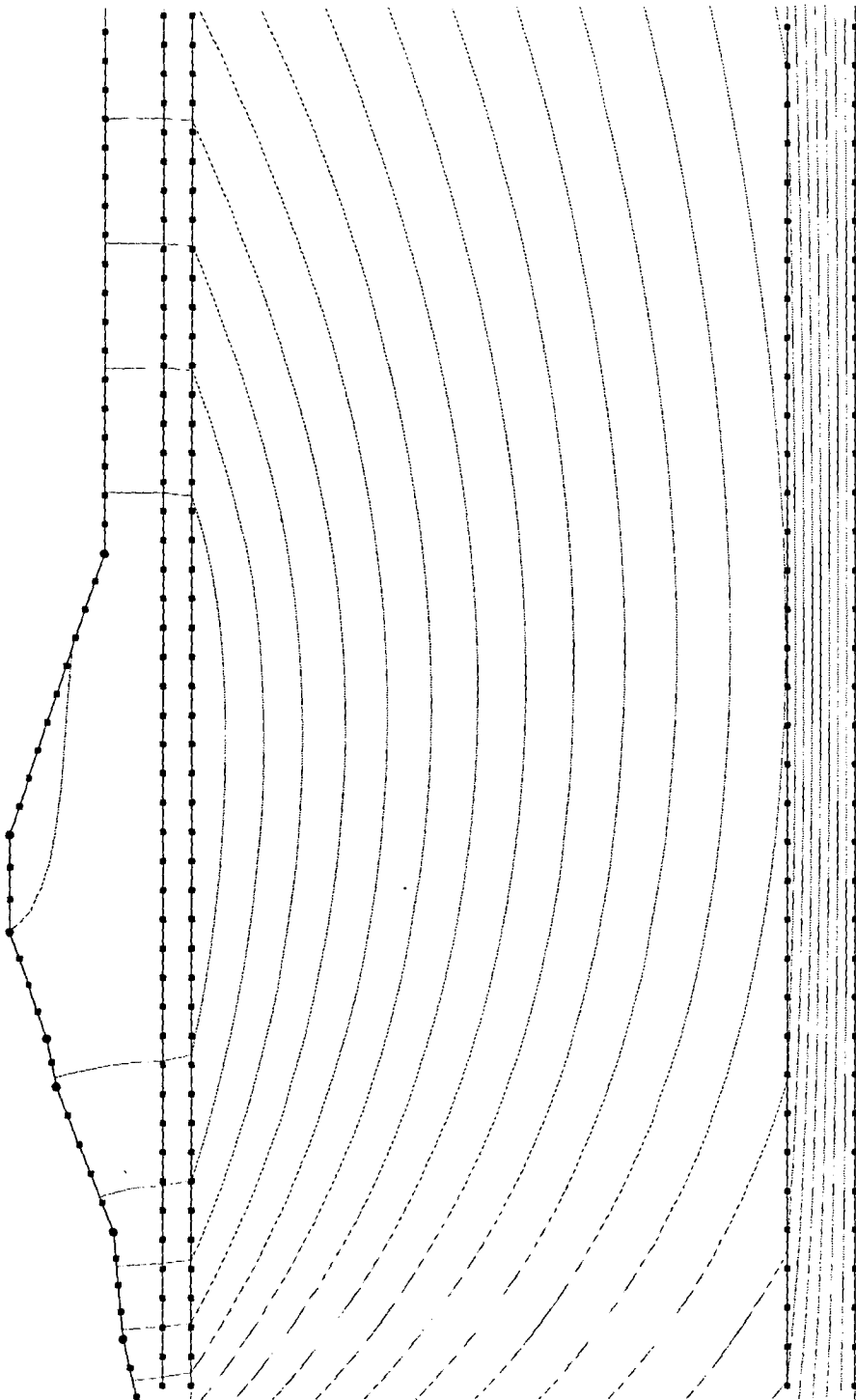
$$l_2 = \frac{22.5 - 21.5}{3.1} = 0.33$$

$$l_2 = \frac{22.5 - 20}{2} = 1.25 \quad *$$



BIG SIOUX RIVER, LEFT BANK, STATION 57+50 (With levee raise)

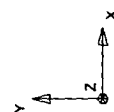
Total Flowrate = 908.3282 (ft³/yr)/(ft)



Materials

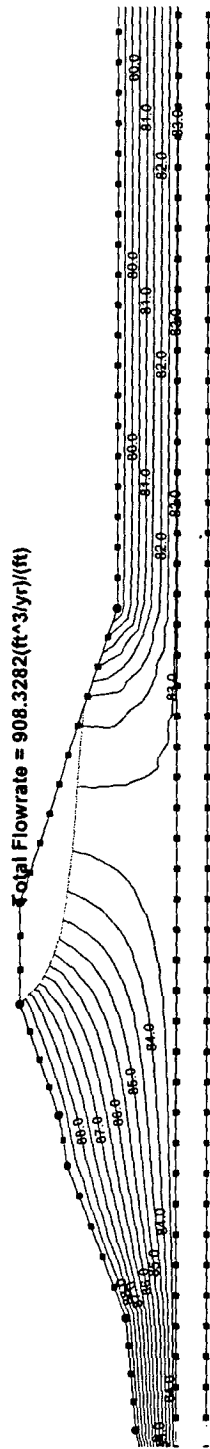
CL	SM	SW/SP	SP
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FLOWLINES



BIG SIOUX RIVER, LEFT BANK, STATION 57+50 (With levee raise)

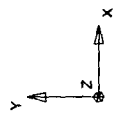
Total Flowrate = 908.3282 (ft³/yr)/(ft)



EQUIPOTENTIAL HEAD LINES

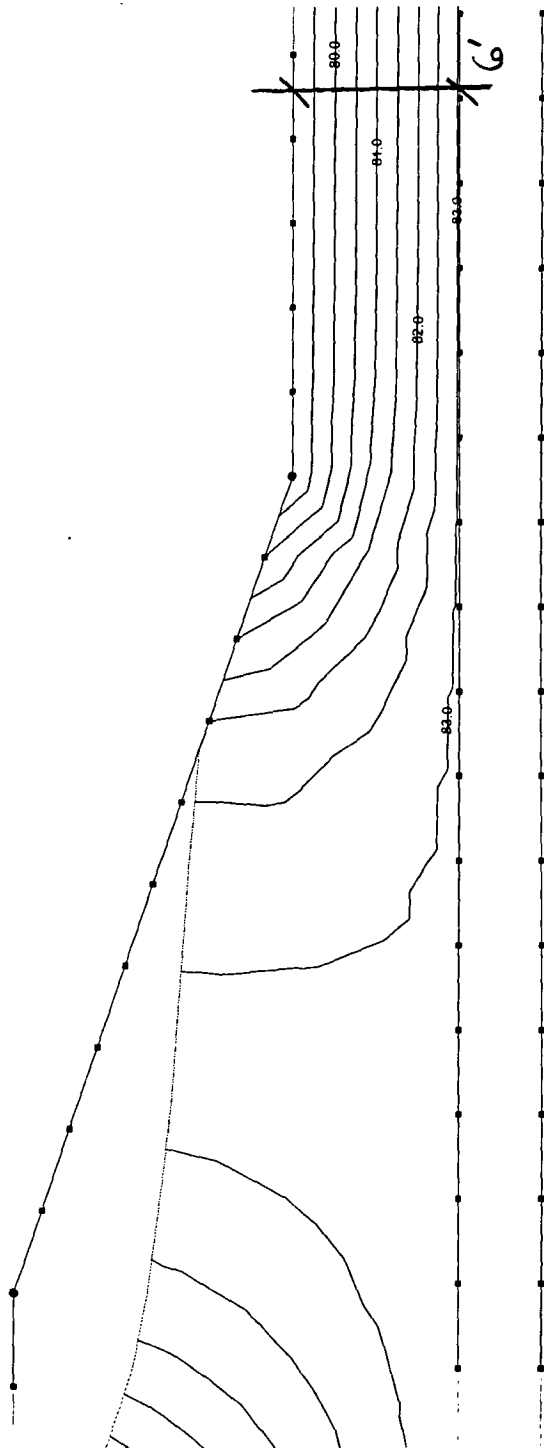
Materials

CL	SM	SW/SP	SP
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BIG SIOUX RIVER, LEFT BANK, STATION 57+50 (With levee raise)

Total Flowrate = 908.3282 (ft³/yr)/(ft)

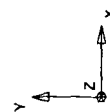


EQUIPOTENTIAL HEADLINES

$$i = \Delta H / L \quad L_c = 0.8 \quad (EM \ 1110-2-1913)$$

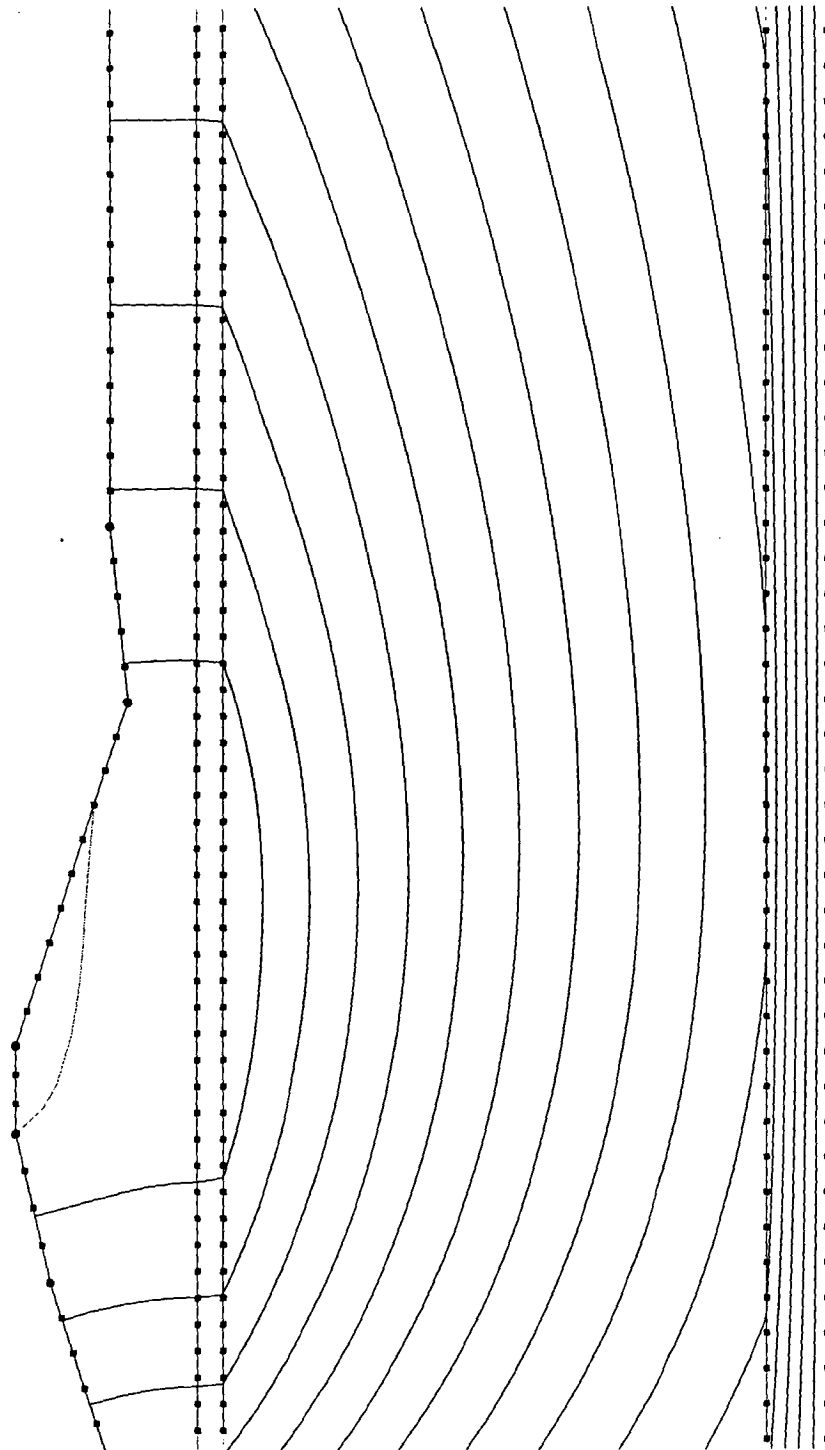
$$i = \frac{83' - 79'}{6'} = 0.67$$

Materials				
CL				
SM				
SW/SP				
SP				



BIG SIOUX RIVER, RIGHT BANK, STATION 67+15, (with project levee)

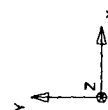
Total Flowrate = 486.7022 (ft³/yr)/(ft)



Materials

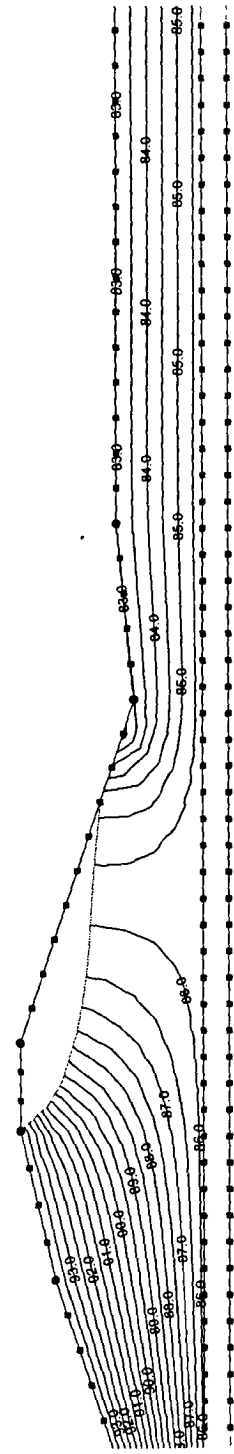
Clay	SM	SW/SP	SP
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FLOWLINES



BIG SIOUX RIVER, RIGHT BANK, STATION 67+15, (with project levee)

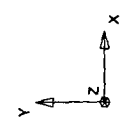
Total Flowrate = 466.7022(ft³/yr)/(ft)



EQUIPOTENTIAL HEAD LINES

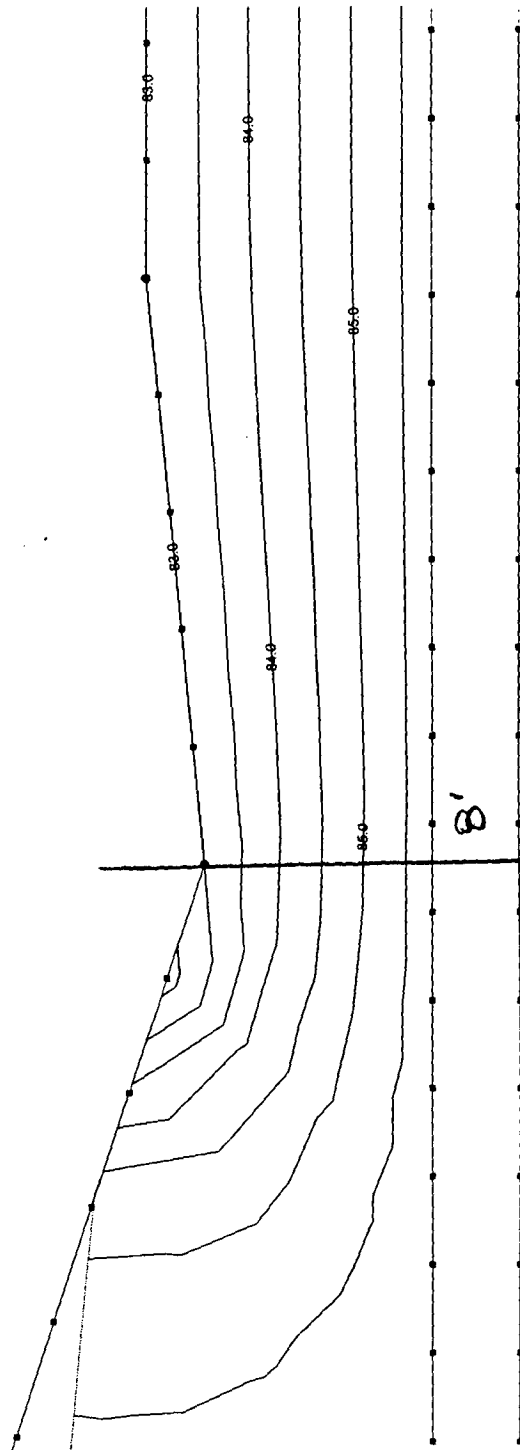
Materials

Clay	
SM	
SW/SP	
SP	



BIG SIOUX RIVER, RIGHT BANK, STATION 67+15, (with project levee)

Total Flowrate = 466.7022 (ft³/yr)/(ft)

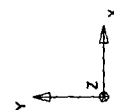


EQUIPOTENTIAL HEAD LINES

$$i = \Delta H / L \quad i_c = 0.8 \quad (EM 1110-2-1913)$$

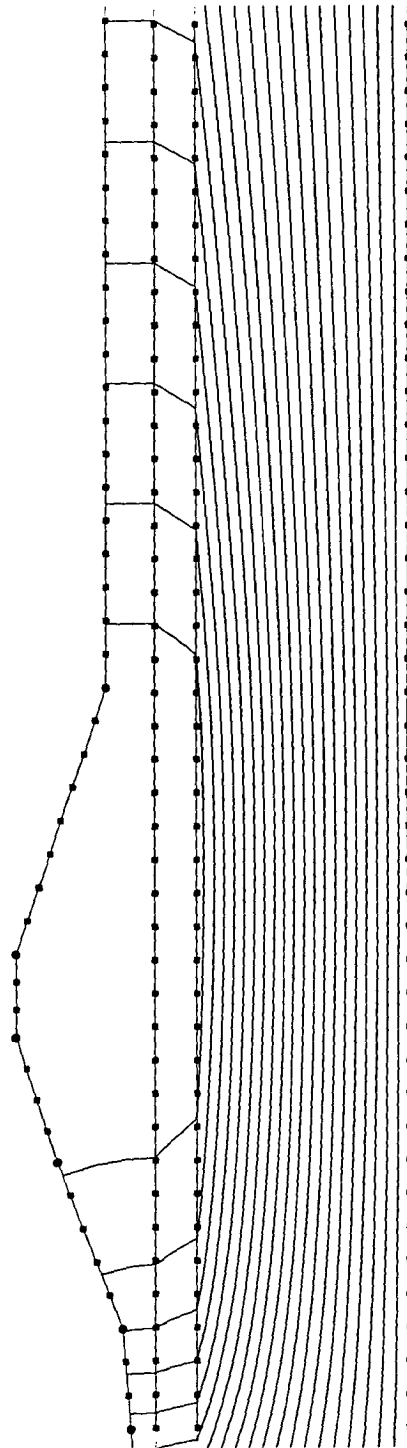
$$i = \frac{86' - 83'}{8'} = 0.38$$

Materials				
Clay				
SM				
SW/SP				
SP				



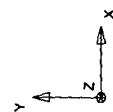
BIG SIOUX RIVER LEFT BANK, STATION 79+10 (With levee raise)

Total Flowrate = 1031.7834(ft³/yr)/(ft)



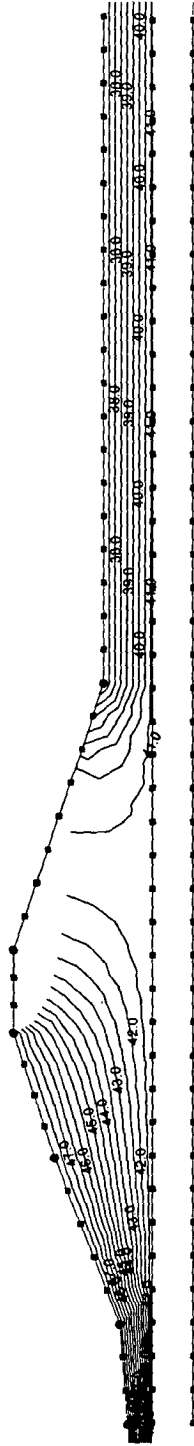
FLOWLINES

Materials			
CL	SP-SM	SP	



BIG SIOUX RIVER LEFT BANK, STATION 79+10 (With levee raise)

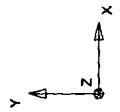
Total Flowrate = 1031.7834(ft³/yr)/(ft)



EQUIPOTENTIAL HEAD LINES

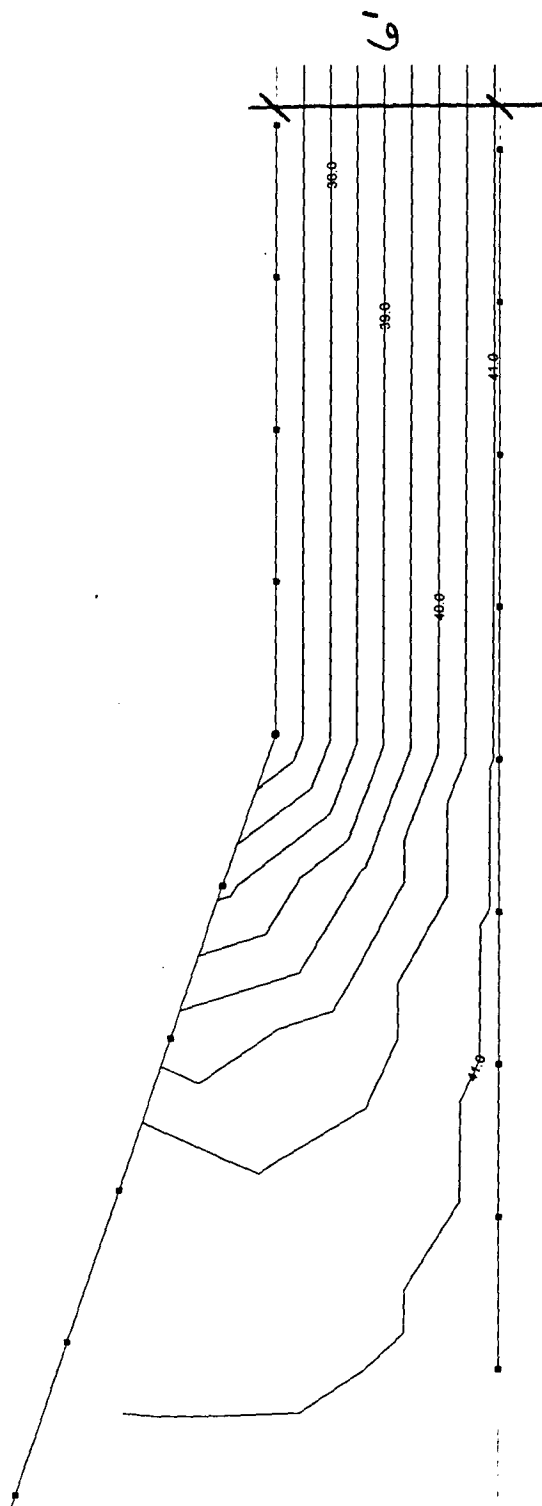
Materials

CL	SP-SM	SP
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BIG SIOUX RIVER LEFT BANK, STATION 79+10 (With levee raise)

Total Flowrate = 1031.7834 (ft³/yr)/(ft)

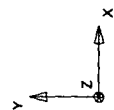


EQUIPOTENTIAL HEAD LINES

$$i = \Delta H / L \quad i_c = 0.8 \quad (EM 1110-2-19.13)$$

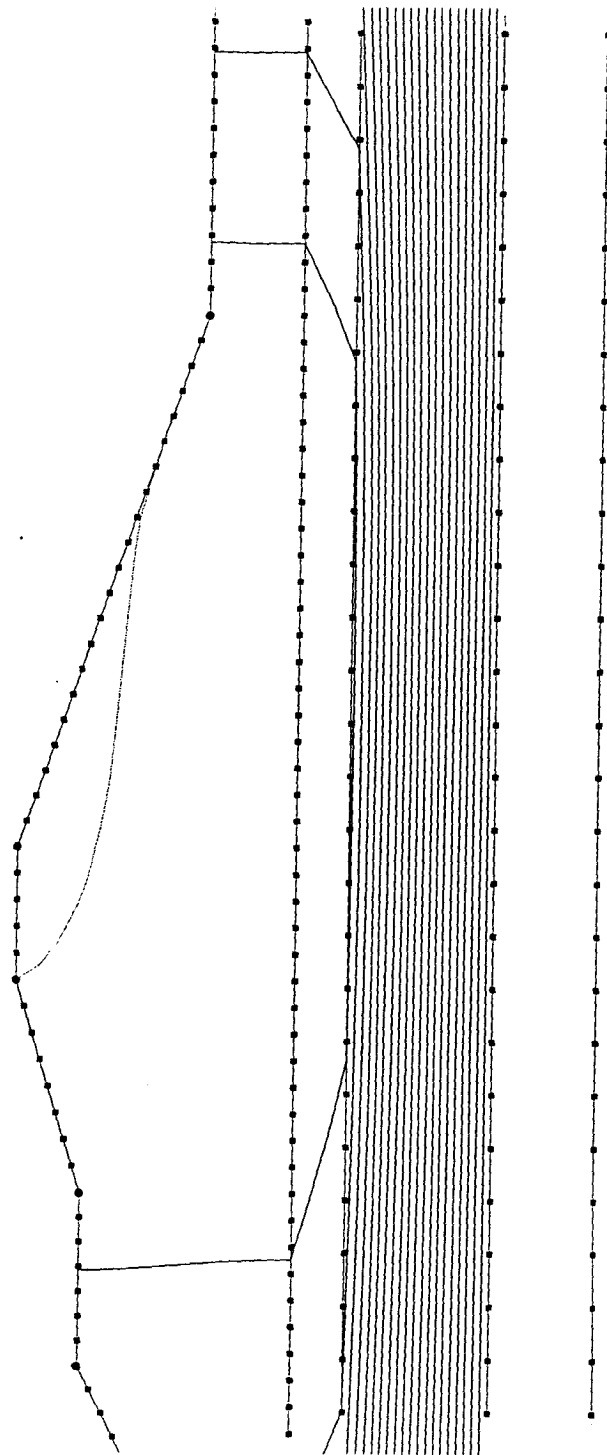
$$i = \frac{41' - 37'}{6'} = 0.67$$

Materials			
CL	SP-SM	SP	



BIG SIOUX RIVER, RIGHT BANK Station 112+25 (with levee raise)

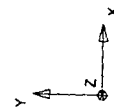
Total Flowrate = 1296.6588(ft³/yr)/(ft)



FLOWLINES

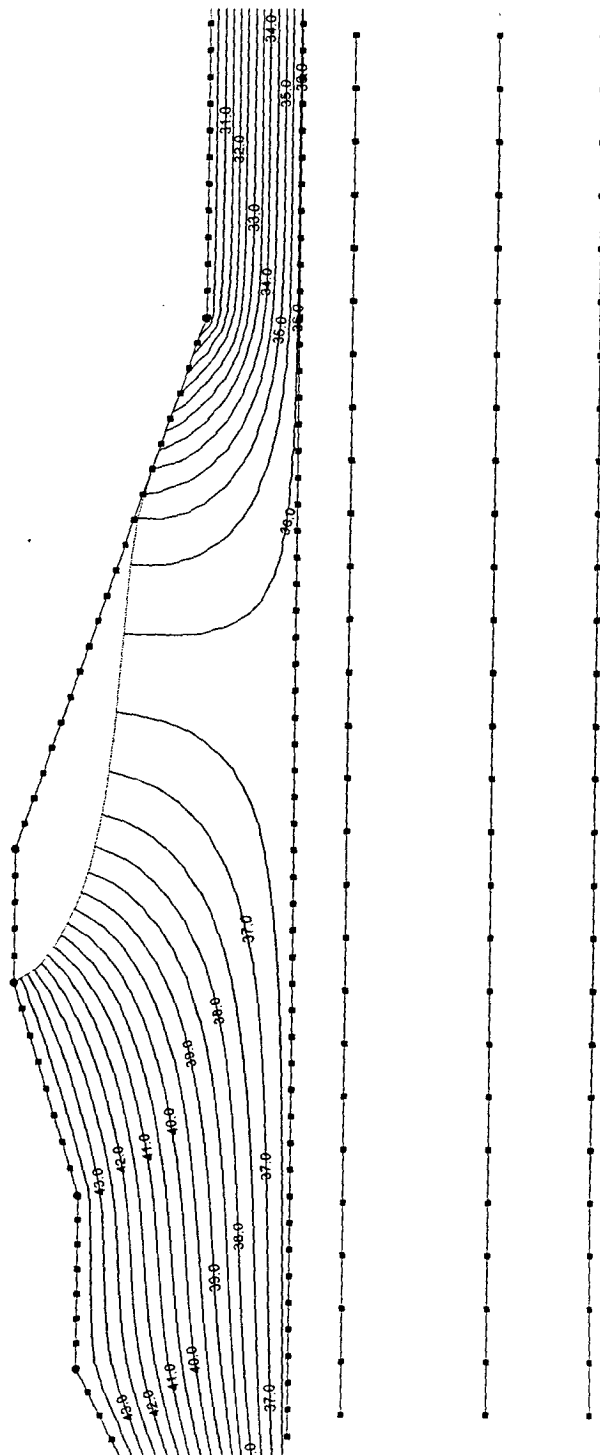
Materials

	Clay
	Sand, Poorly Graded (SP)
	Sand, Well Graded (SW)



BIG SIOUX RIVER, RIGHT BANK Station 112+25 (with levee raise)

Total Flowrate = 1296.6588(ft³/yr)/(ft)



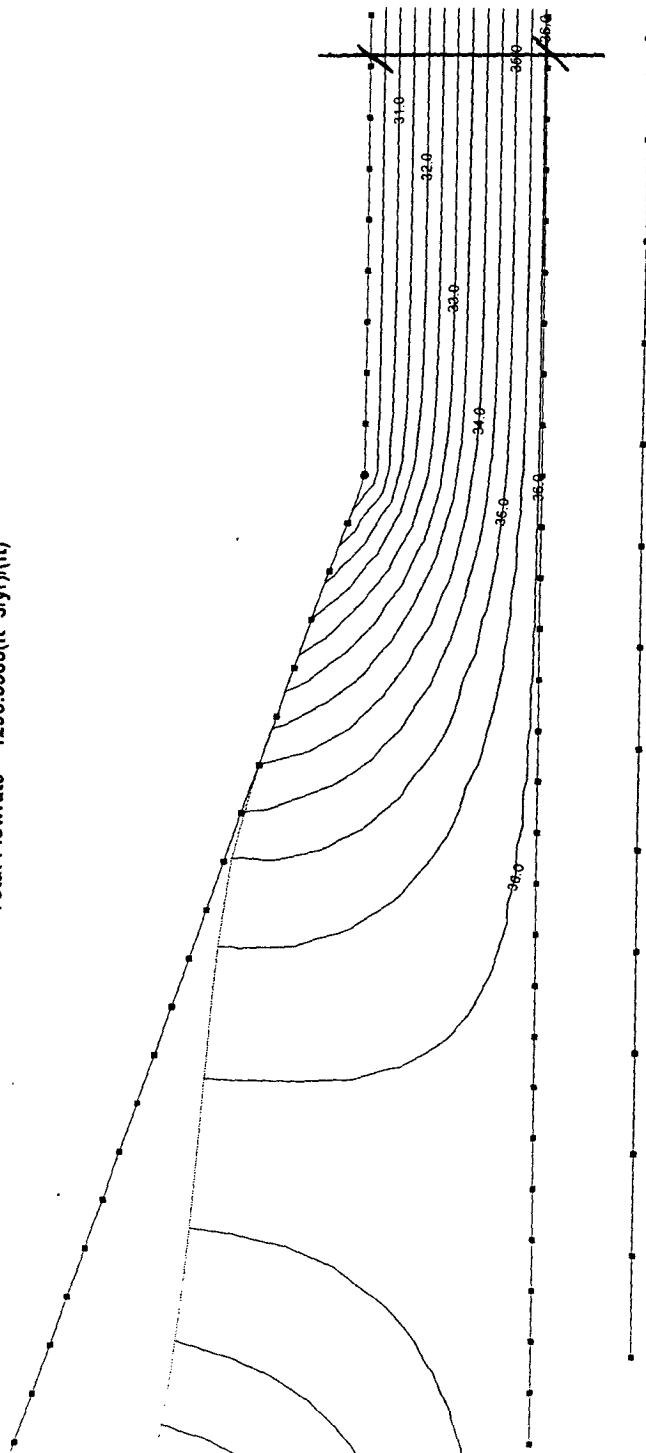
EQUIPOTENTIAL HEAD LINES

Materials

	Clay
	Sand, Poorly Graded (SP)
	Sand, Well Graded (SW)

BIG SIOUX RIVER, RIGHT BANK Station 112+25 (with levee raise)

Total Flowrate = 1296.6588 (ft³/yr)/(ft)



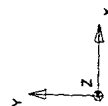
EQUIPOTENTIAL HEAD LINES

$$i = \Delta H / L \quad i_c = 0.8 \quad (EM \ 110-2-1913)$$

$$i = (36' - 30') / 7' = 0.9 \quad *$$

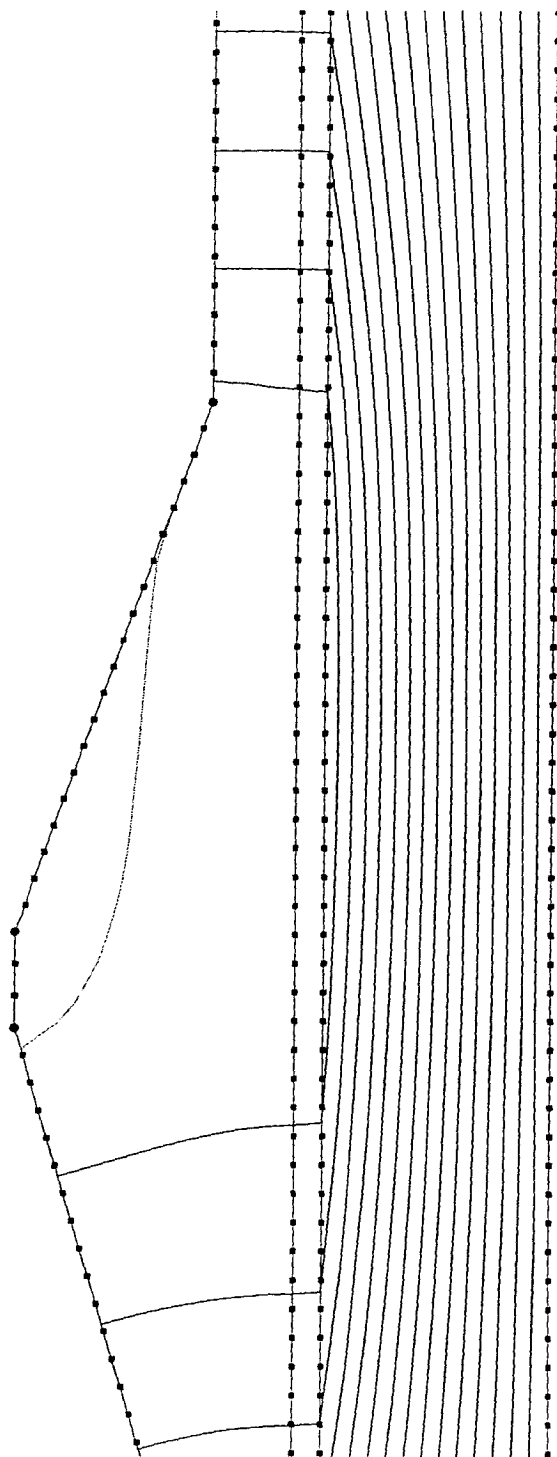
Materials

	Clay
	Sand, Poorly Graded (SP)
	Sand, Well Graded (SW)



BIG SIOUX RIVER, LEFT BANK, STATION 128+50, (With levee raise)

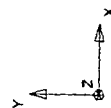
Total Flowrate = 691.2026(ft³/yr)/(ft)



FLOWLINES

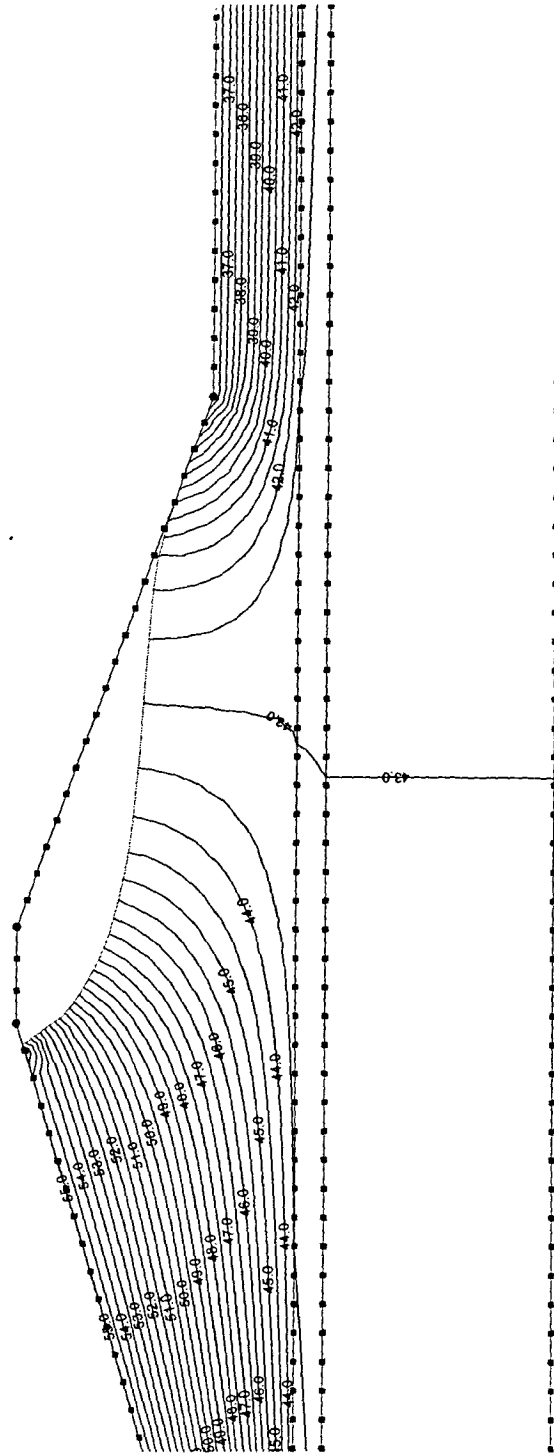
Materials

Clay
SP-SC
Sand



BIG SIOUX RIVER, LEFT BANK, STATION 128+50, (With levee raise)

Total Flowrate = 691.2026(ft³/yr)/(ft)

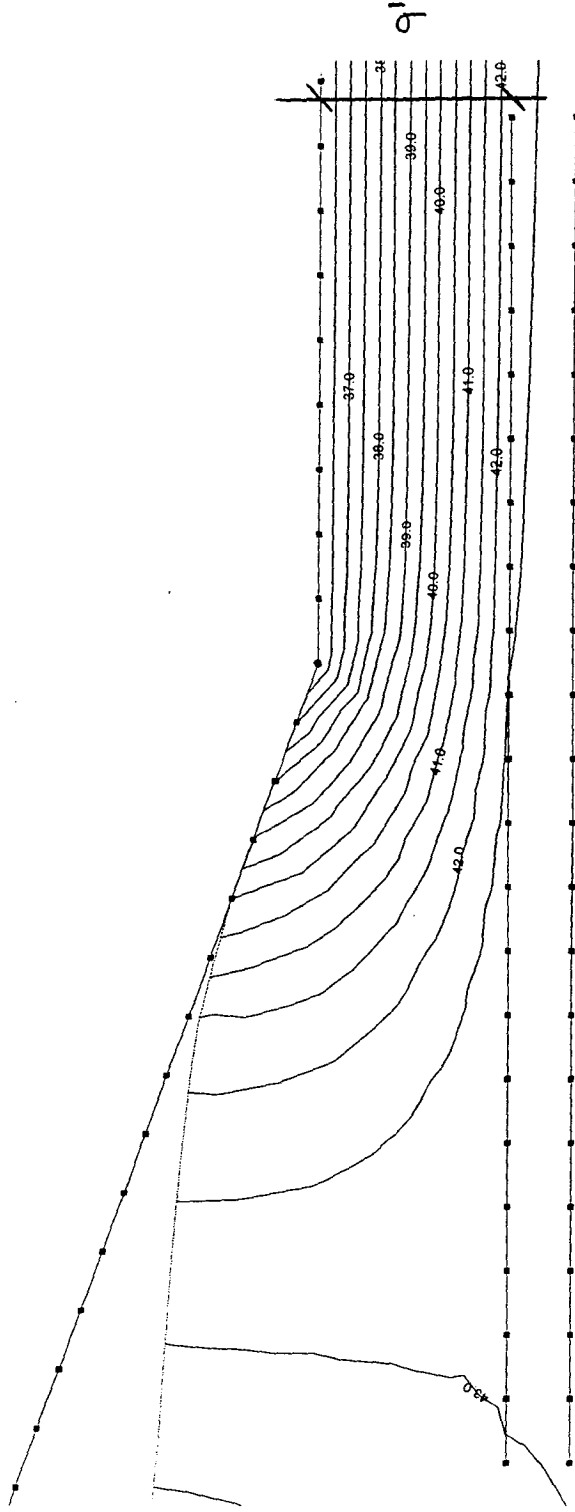


Materials			
	Clay		SP-SC
	Sand		

EQUIPOTENTIAL HEAD LINES

BIG SIOUX RIVER, LEFT BANK, STATION 128+50, (With levee raise)

Total Flowrate = 691.2026 (ft³/yr)/(ft)

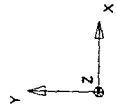


EQUIPOTENTIAL HEAD LINES

$$i = \Delta H / L \quad i_c = 0.8 \quad (EM 1110-2-1913)$$

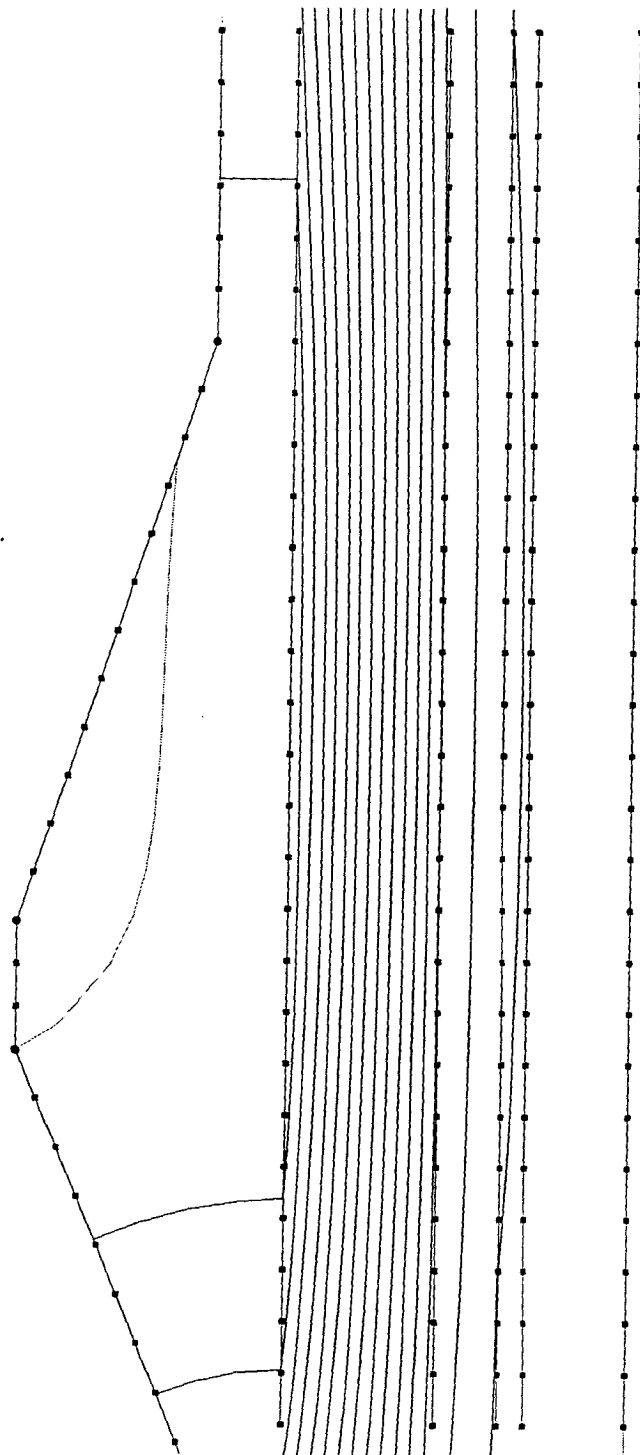
$$i = (42.5' - 36') / 9' = 0.7$$

Materials			
☐	Clay	☐	SP-SC
☐	SP-SC	☐	Sand

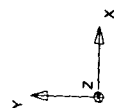


BIG SIOUX RIVER, LEFT BANK, Station 144+50, (with project levee)

Total Flowrate = 947.6682(ft³/yr)/(ft)

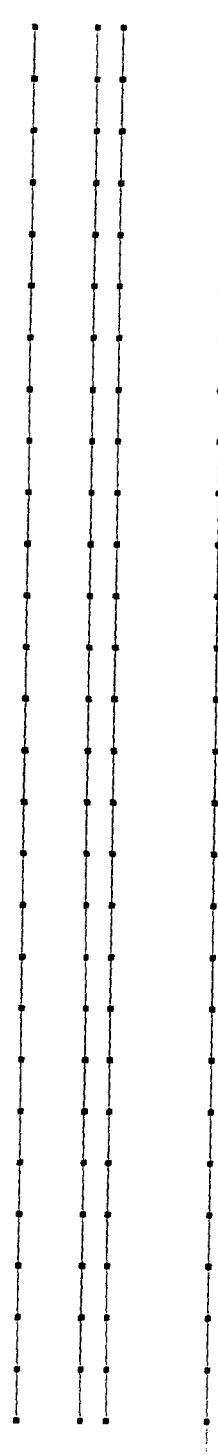
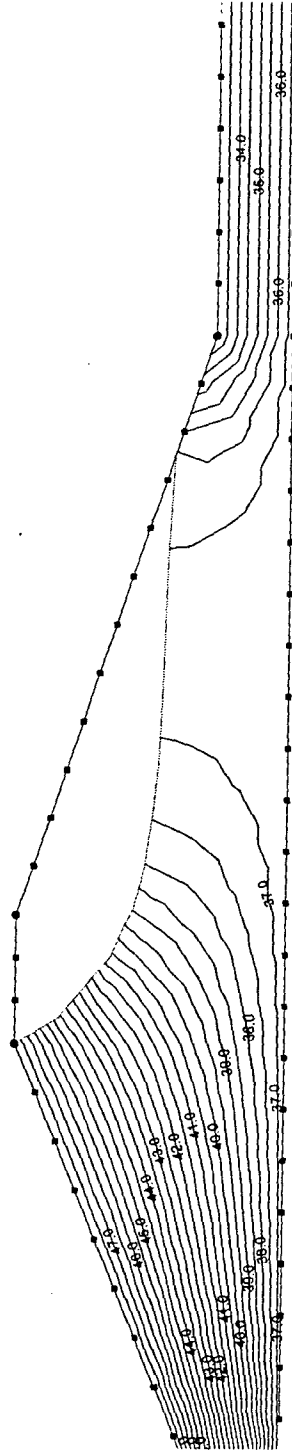


FLOWLINES

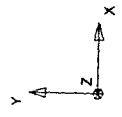
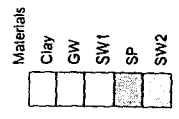


BIG SIOUX RIVER, LEFT BANK, Station 144+50, (with project levee)

Total Flowrate = 947.6682(ft³/yr)/(ft)

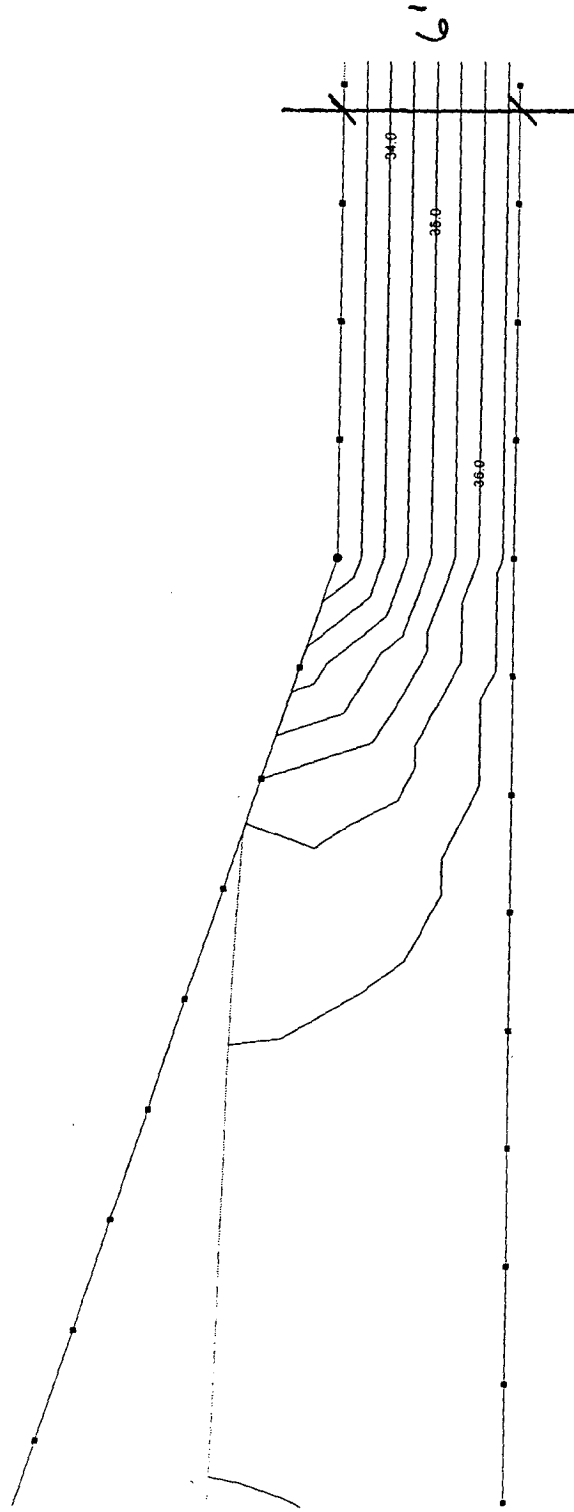


EQUIPOTENTIAL HEAD LINES



BIG SIOUX RIVER, LEFT BANK, Station 144+50, (with project levee)

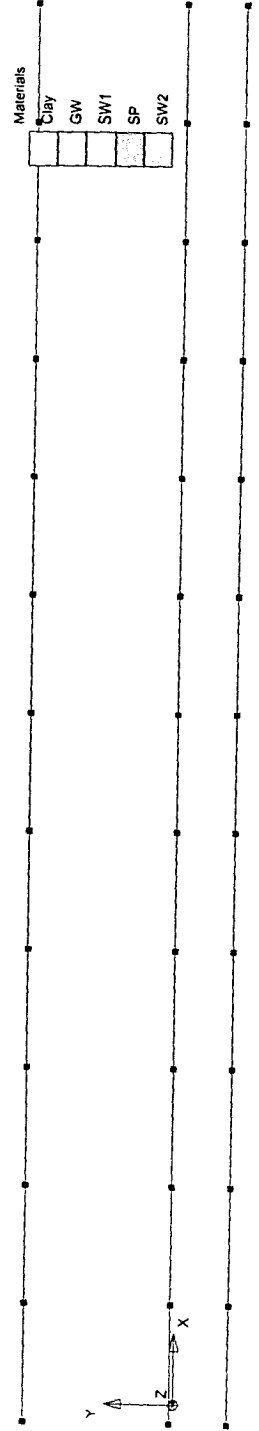
Total Flowrate = $947.6682(\text{ft}^3/\text{yr})/(\text{ft})$



EQUIPOTENTIAL HEAD LINES

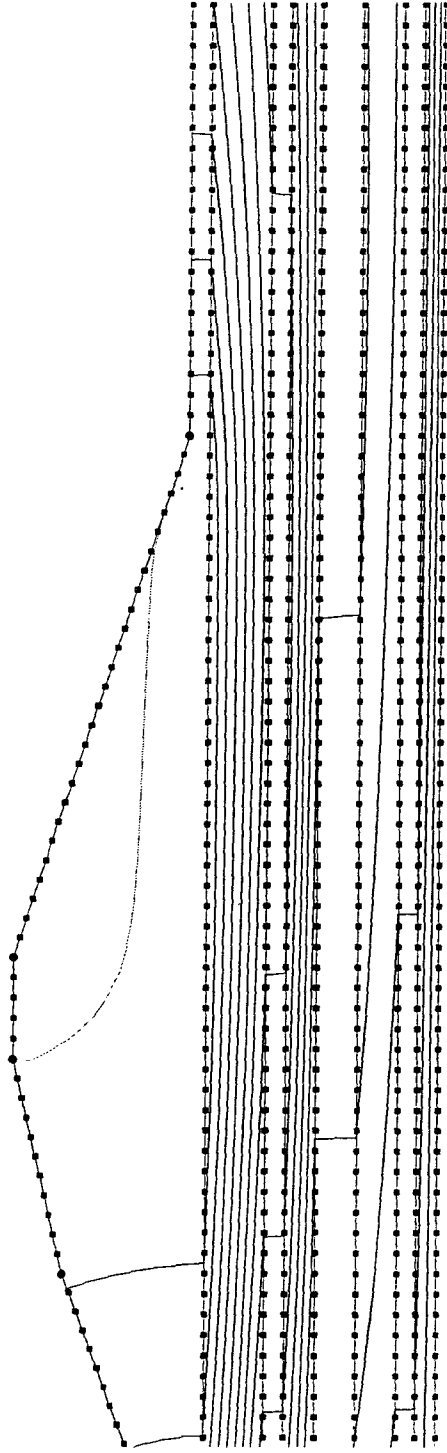
$$i = \Delta H / L \quad i_c = 0.8 \quad (EM \ 110-2-1913)$$

$$i = (36.5' - 33') / 6' = 0.6$$



BIG SIOUX RIVER, LEFT BANK, STATION 215+65 (with project levee)

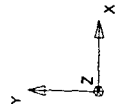
Total Flowrate = $1394.6493(\text{ft}^3/\text{yr})/(\text{ft})$



FLOWLINES

Materials

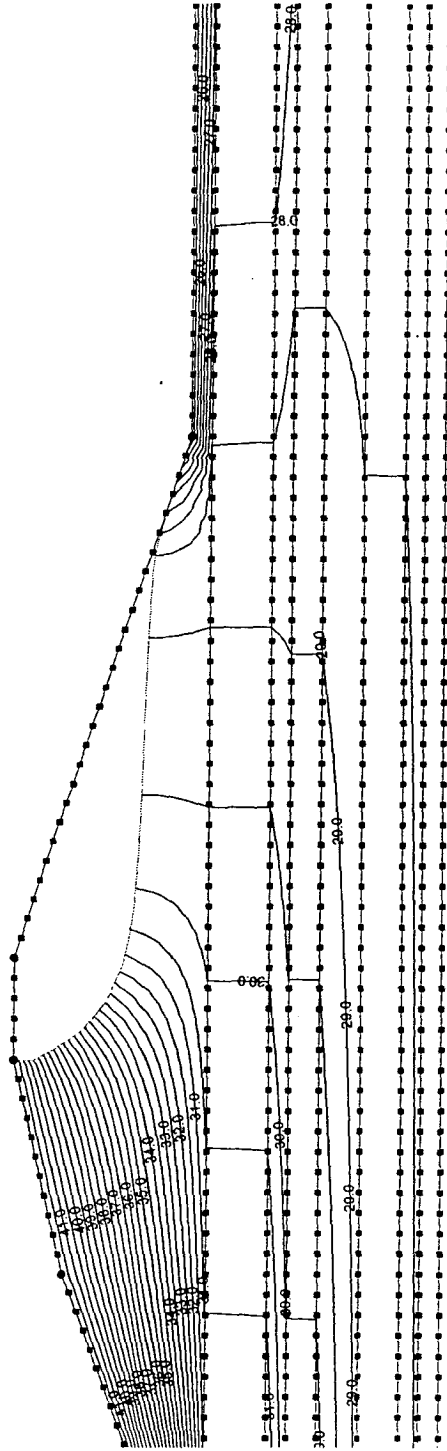
Clay	SP-SM	SM	SP	SW-SM	SW
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Top Layer, Clay, $K = 5 \text{ ft/year}$

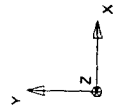
BIG SIOUX RIVER, LEFT BANK, STATION 215+65 (with project levee)

Total Flowrate = 1394.6493 (ft³/yr)/(ft)



EQUIPOTENTIAL HEAD LINES

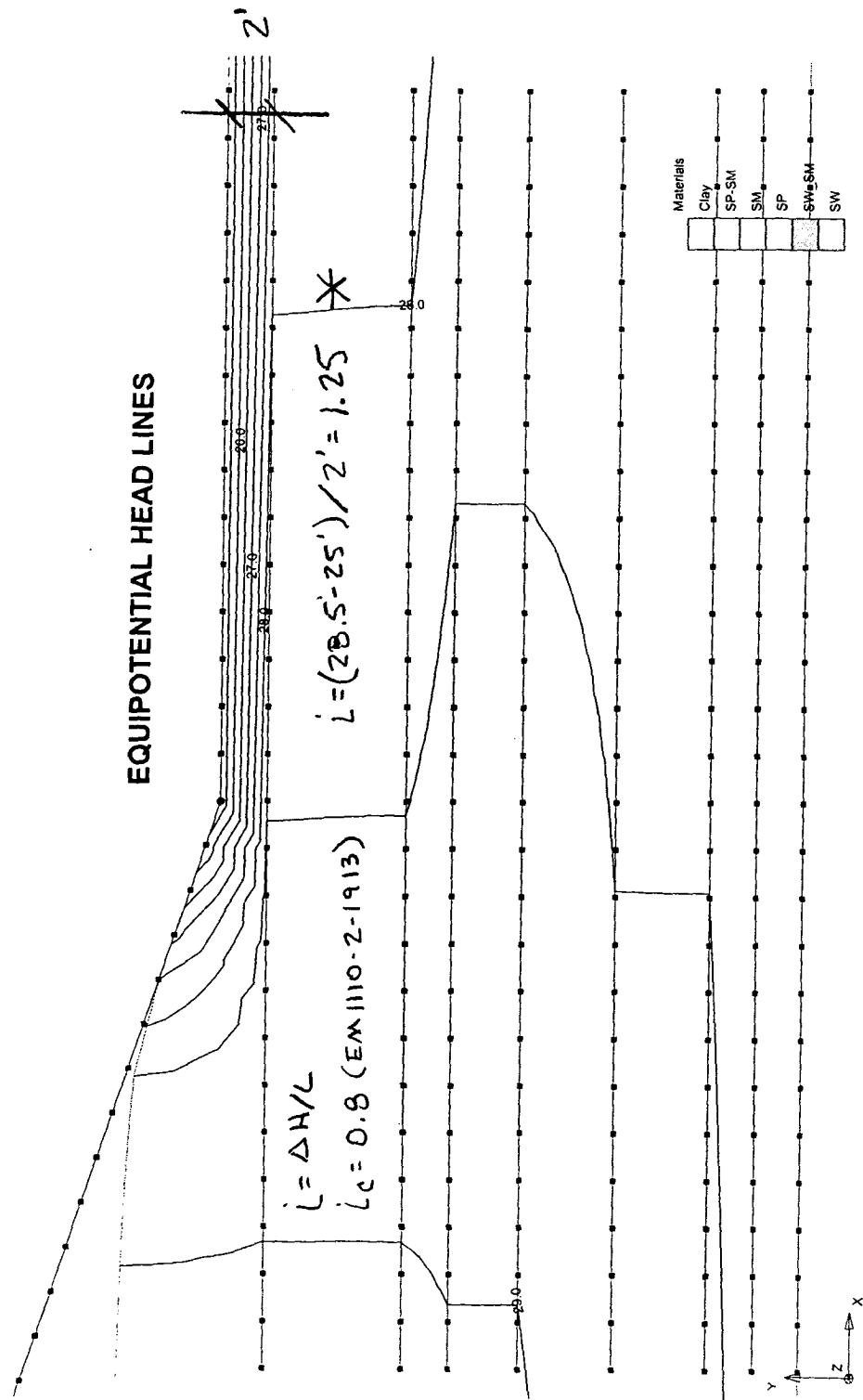
Materials					
Clay	SP-SM	SM	SP	SW_SM	SW



Top Layer, Clay, K = 5 ft/year

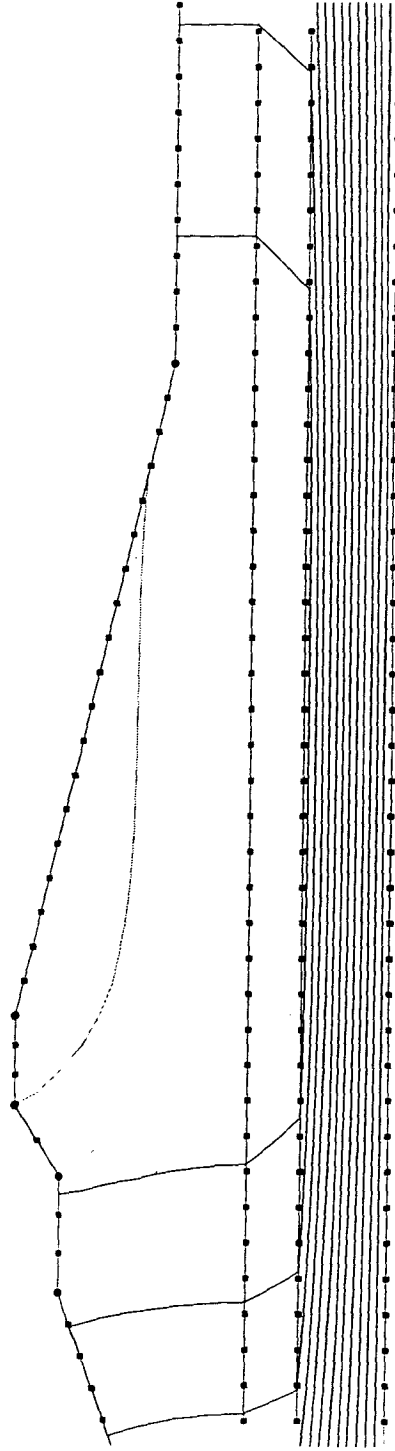
BIG SIOUX RIVER, LEFT BANK, STATION 215+65 (with project levee)

Total Flowrate = $1394.6493 \text{ (ft}^3\text{/yr)}/(\text{ft})$

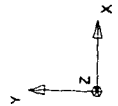


BIG SIOUX RIVER, RIGHT BANK, STATION 215+65 (with project levee)

Total Flowrate = $614.1062(\text{ft}^3/\text{yr})/(\text{ft})$



Materials
 Clay
 SW-SM
 SW

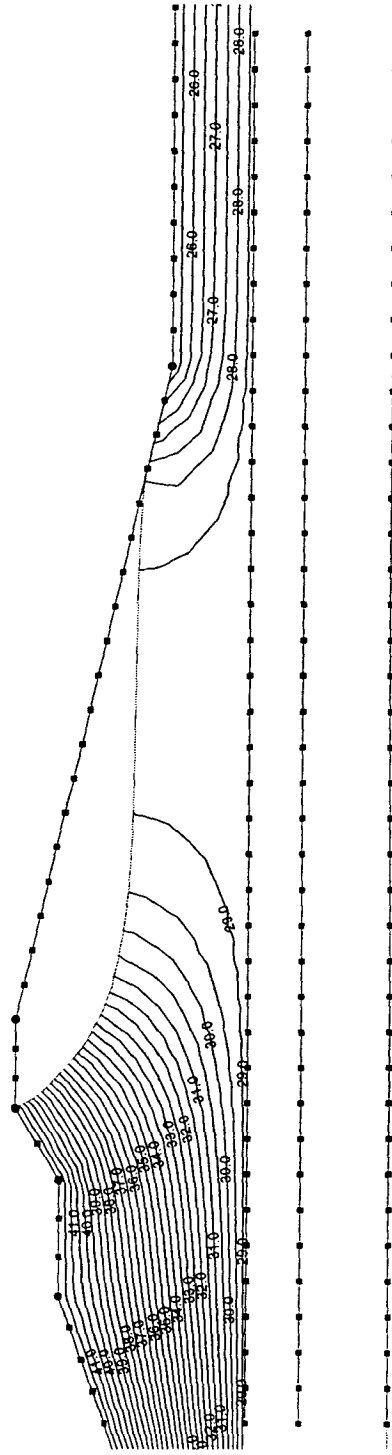


FLOWLINES

Top Layer, Clay, $K = 5 \text{ ft/year}$

BIG SIOUX RIVER, RIGHT BANK, STATION 215+65 (with project levee)

Total Flowrate = 614,1062(ft³/yr)/(ft)



EQUIPOTENTIAL HEAD LINES

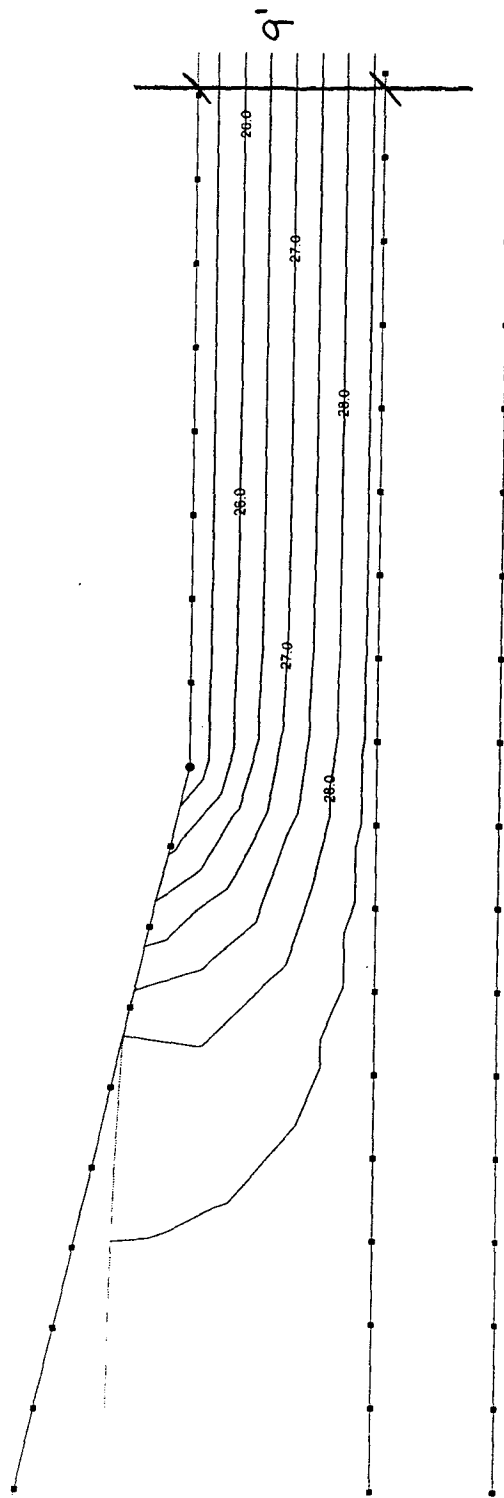
Materials

Clay
SW-SM
SW

Top Layer, Clay, K = 5 ft/year

BIG SIOUX RIVER, RIGHT BANK, STATION 215+65 (with project levee)

Total Flowrate = 614.1062(ft³/yr)/(ft)

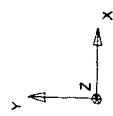


EQUIPOTENTIAL HEAD LINES

$$i = \Delta H/L \quad i_c = 0.8 \quad (EM 110-2.1913)$$

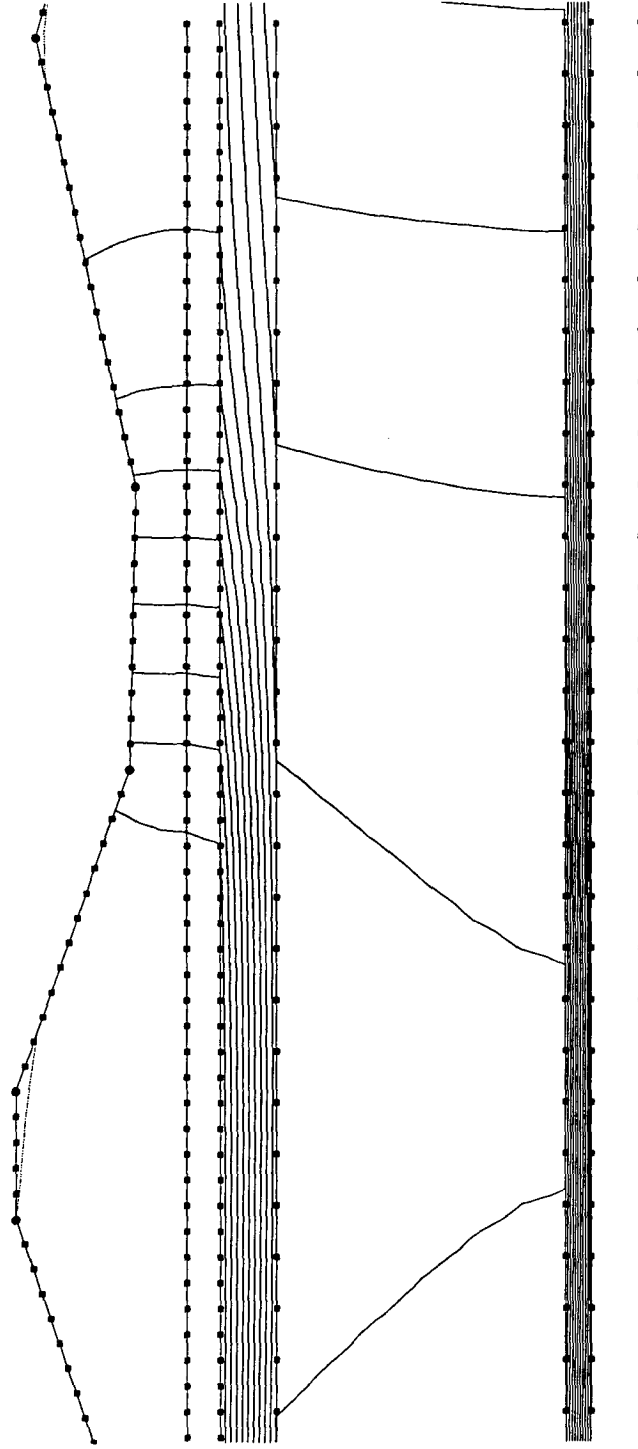
$$i = (28.75' - 25') / 9' = 0.4$$

Materials			



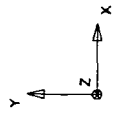
BIG SIOUX RIVER, RIGHT BANK, STATION 42+25, (with levee raise)

Total Flowrate = 1138.5874(ft³/yr)/(ft)



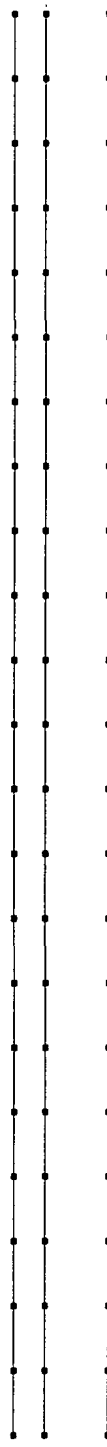
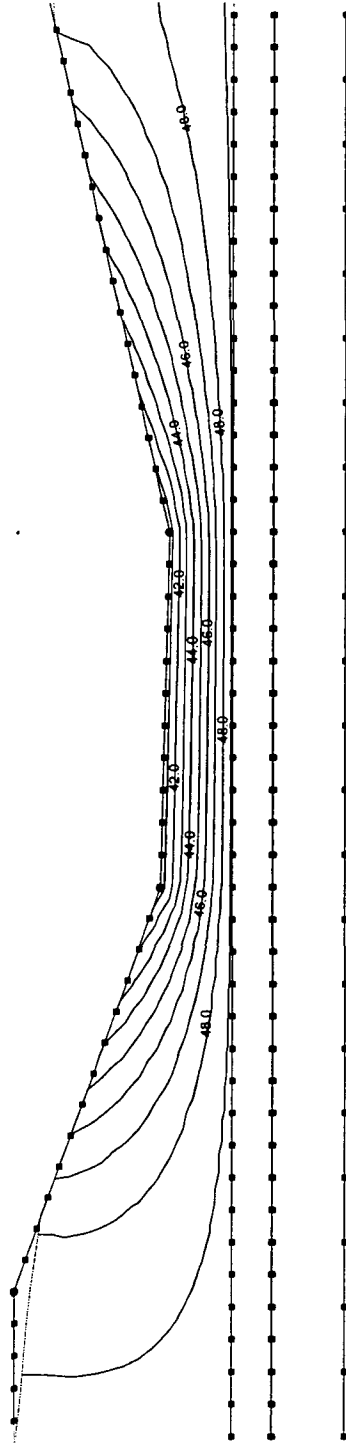
FLOWLINES

Materials	
CH	
SP	
SP w/gravel	
GP	



BIG SIOUX RIVER, RIGHT BANK, STATION 42+25, (with levee raise)

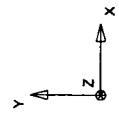
Total Flowrate = 1138.5874(ft³/yr)/(ft)



EQUIPOTENTIAL HEAD LINES

Materials

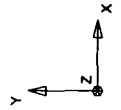
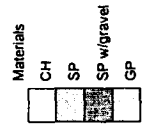
CH
SP
SP w/gravel
GP



Total Flowrate = 1138.5874(ft^3/yr)/(ft)

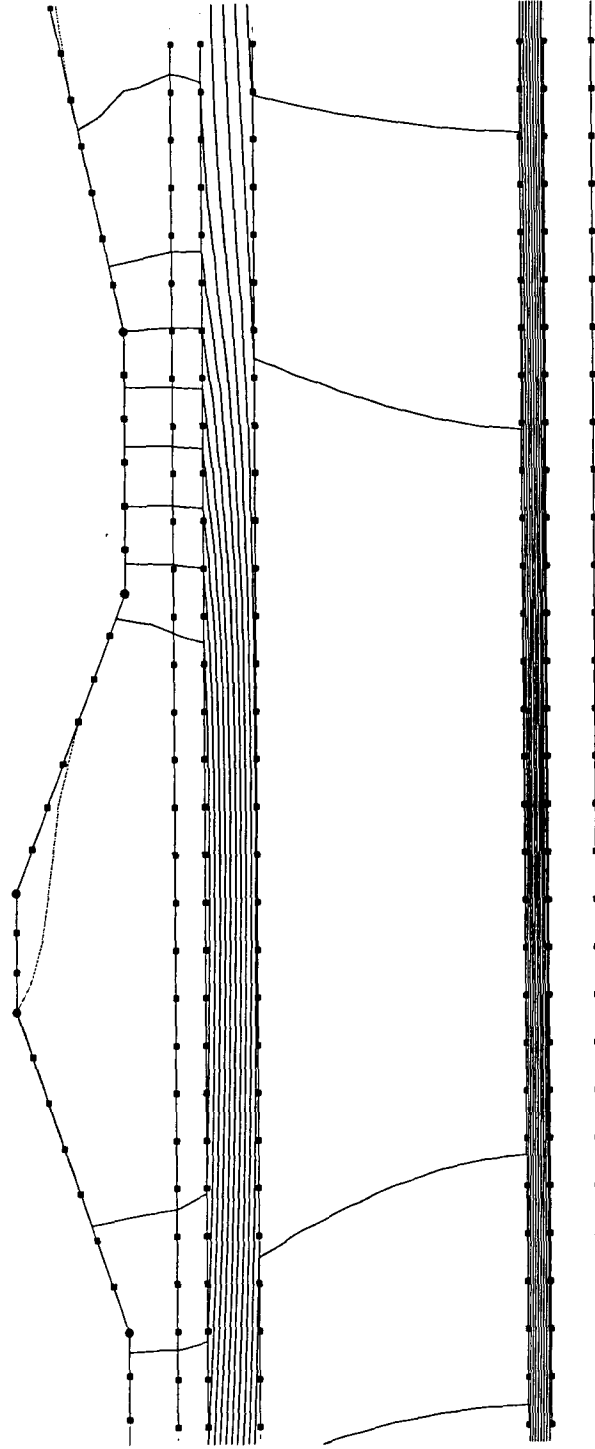
1 - 02 (EX 110-2-1913)

$$\begin{aligned} i &= \Delta H / L & i_c &= 0.8 \text{ (EM 1110-2-19)} \\ i &= (49' - 40.5') / 4' & &= 2.1 \quad * \end{aligned}$$



BIG SIOUX RIVER PHASE 3, STATION 42+25 RIGHT BANK (With levee raise)

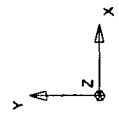
Total Flowrate = 747.4212(ft³/yr)/(ft)



FLOWLINES

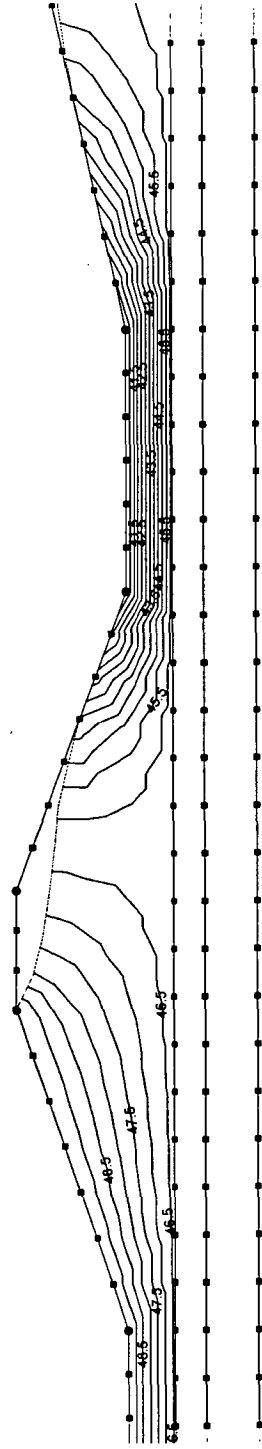
Materials

CH
SP
SP w/gravel
GP



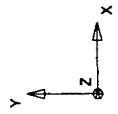
BIG SIOUX RIVER PHASE 3, STATION 42+25 RIGHT BANK (With levee raise)

Total Flowrate = 747.4212(ft³/yr)/(ft)



EQUIPOTENTIAL HEAD LINES

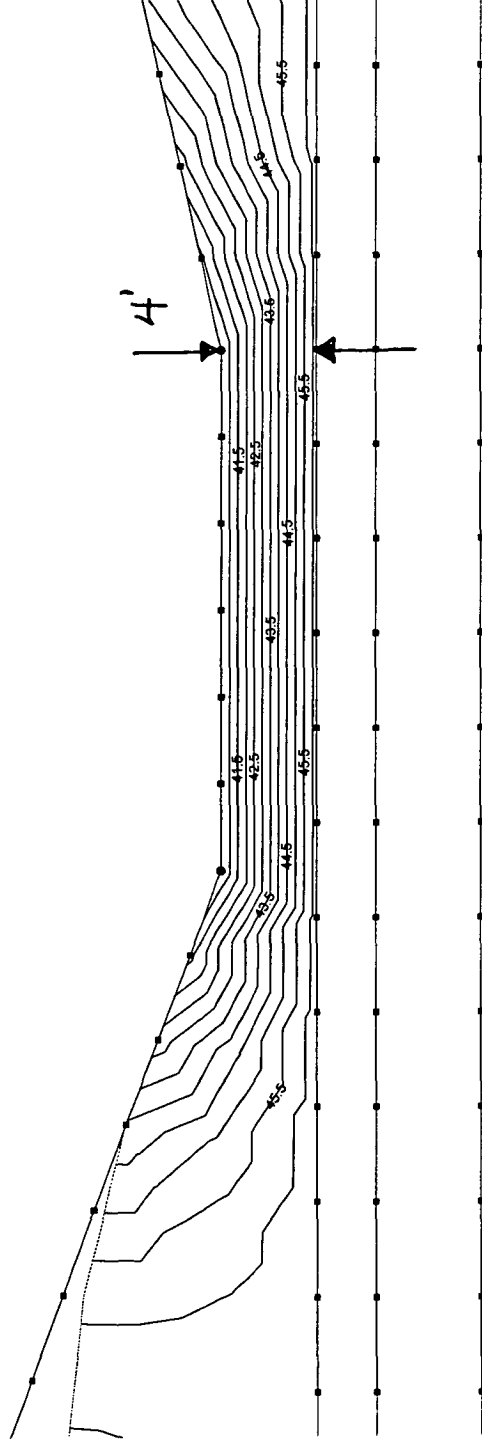
Materials				
	CH	SP	SP w/gravel	GP



BIG SIOUX RIVER PHASE 3, STATION 42+25 RIGHT BANK (With levee raise)

Total Flowrate = $747.4212(\text{ft}^3/\text{yr})/(\text{ft})$

(Assumes thin (1') clay layer present on river side)

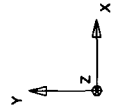


EQUIPOTENTIAL HEAD LINES

$$i = \Delta H / L \quad i_c = 0.8 \quad (\text{EM 110-2-1913})$$

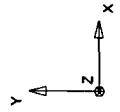
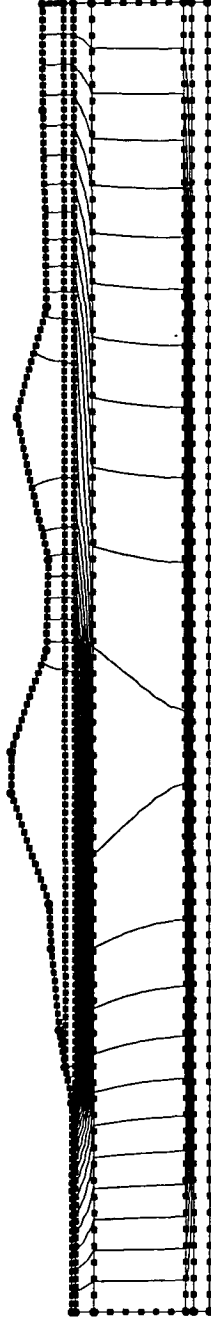
$$i = (46 - 40.5) / 4' = 1.4 \quad *$$

Materials			
CH			
SP			
SP w/gravel			
GP			



BIG SIOUX RIVER, RIGHT BANK, STATION 42+25, (with levee raise)

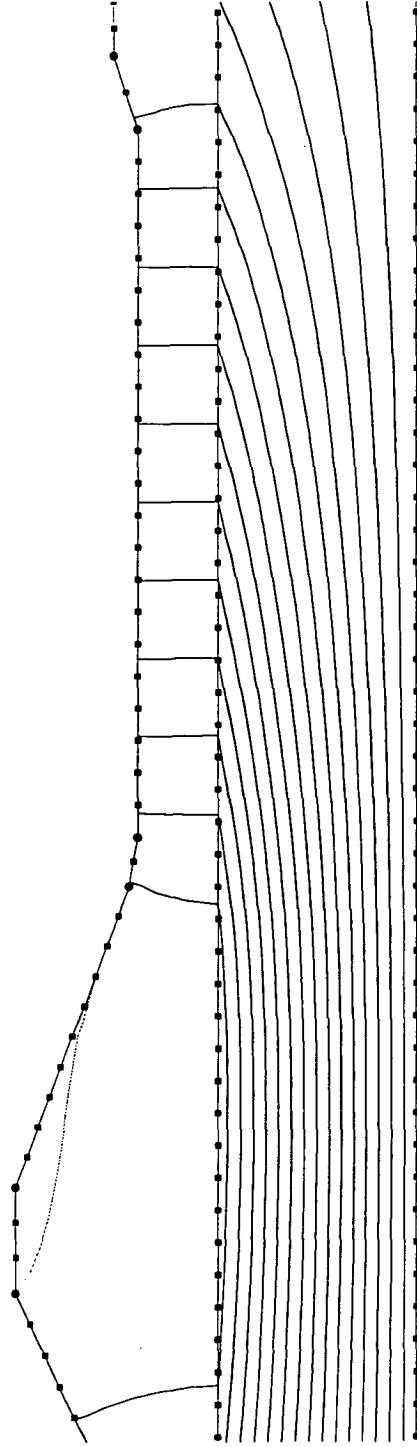
Total Flowrate = 1138.5874(ft³/yr)/(ft)



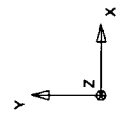
Materials			
☐	CH	☐	SP
☐	SP	☐	SP w/gravel
☐		☐	GP

BIG SIOUX RIVER, PHASE 3, STATION 129+50, RIGHT BANK (With levee raise)

Total Flowrate = 570.1728(ft³/yr)/(ft)



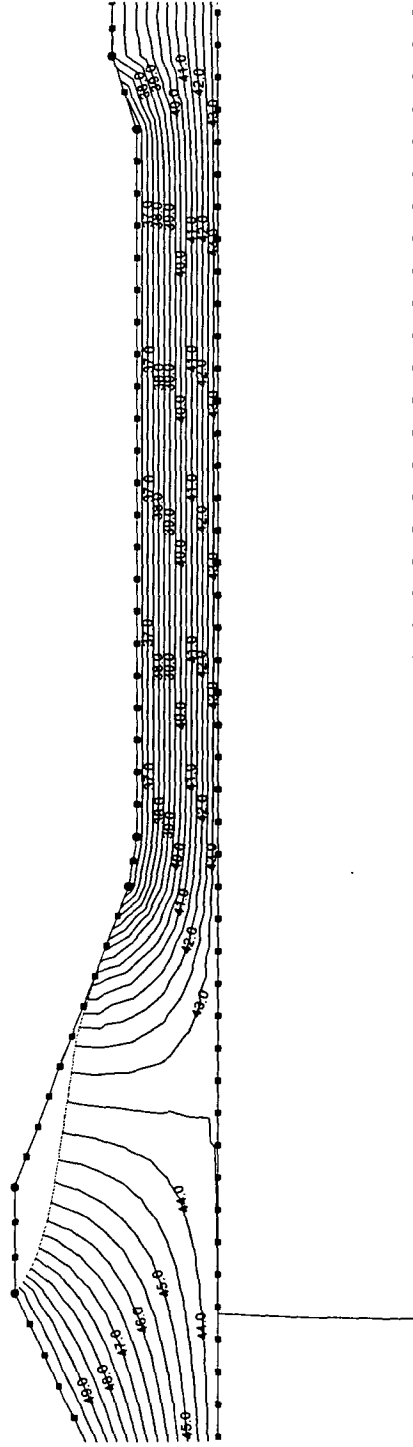
FLOWLINES



Materials	
CL	SW/SP

BIG SIOUX RIVER, PHASE 3, STATION 129+50, RIGHT BANK (With levee raise)

Total Flowrate = 570.1728(ft³/yr)/(ft)

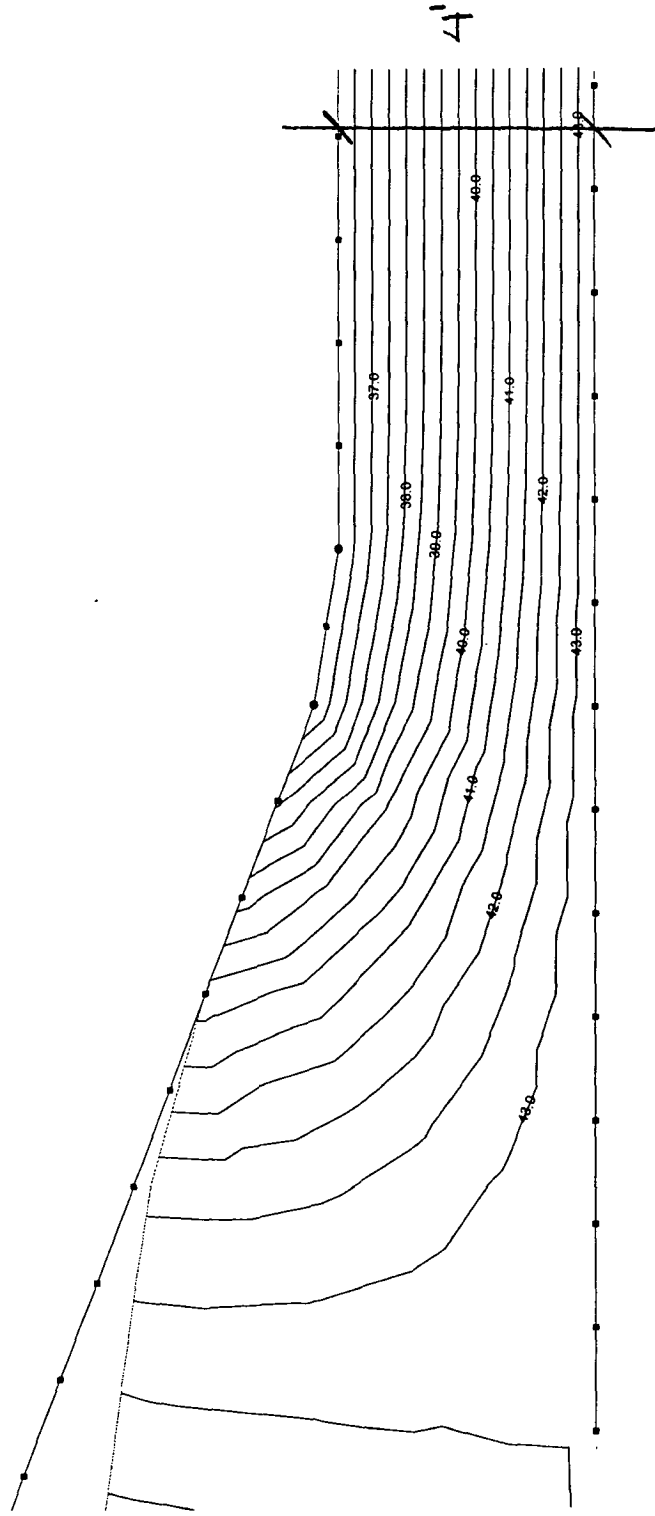


EQUIPOTENTIAL HEAD LINES

Materials
CL
SW/SP

BIG SIOUX RIVER, PHASE 3, STATION 129+50, RIGHT BANK (With levee raise)

Total Flowrate = 570.1728(ft³/yr)/(ft)



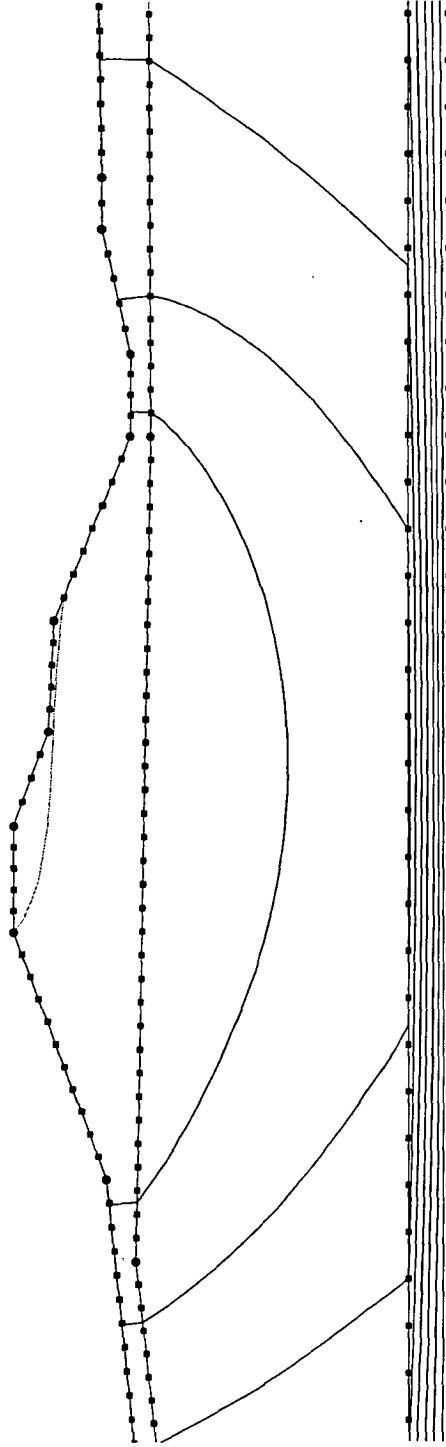
EQUIPOTENTIAL HEAD LINES

$$i = \Delta H / L \quad i_c = 0.8 \quad (EM. 1110-2-1913)$$

$$i = (43.5' - 36') / 4' = 1.9 \quad *$$

BIG SIOUX RIVER, STATION 106+15, RIGHT BANK, (With levee raise)

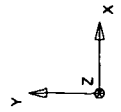
Total Flowrate = $686.8135(\text{ft}^3/\text{yr})/(\text{ft})$
(Assumes 2' clay layer present
at river and landward
depression.)



FLOWLINES

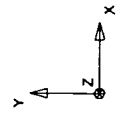
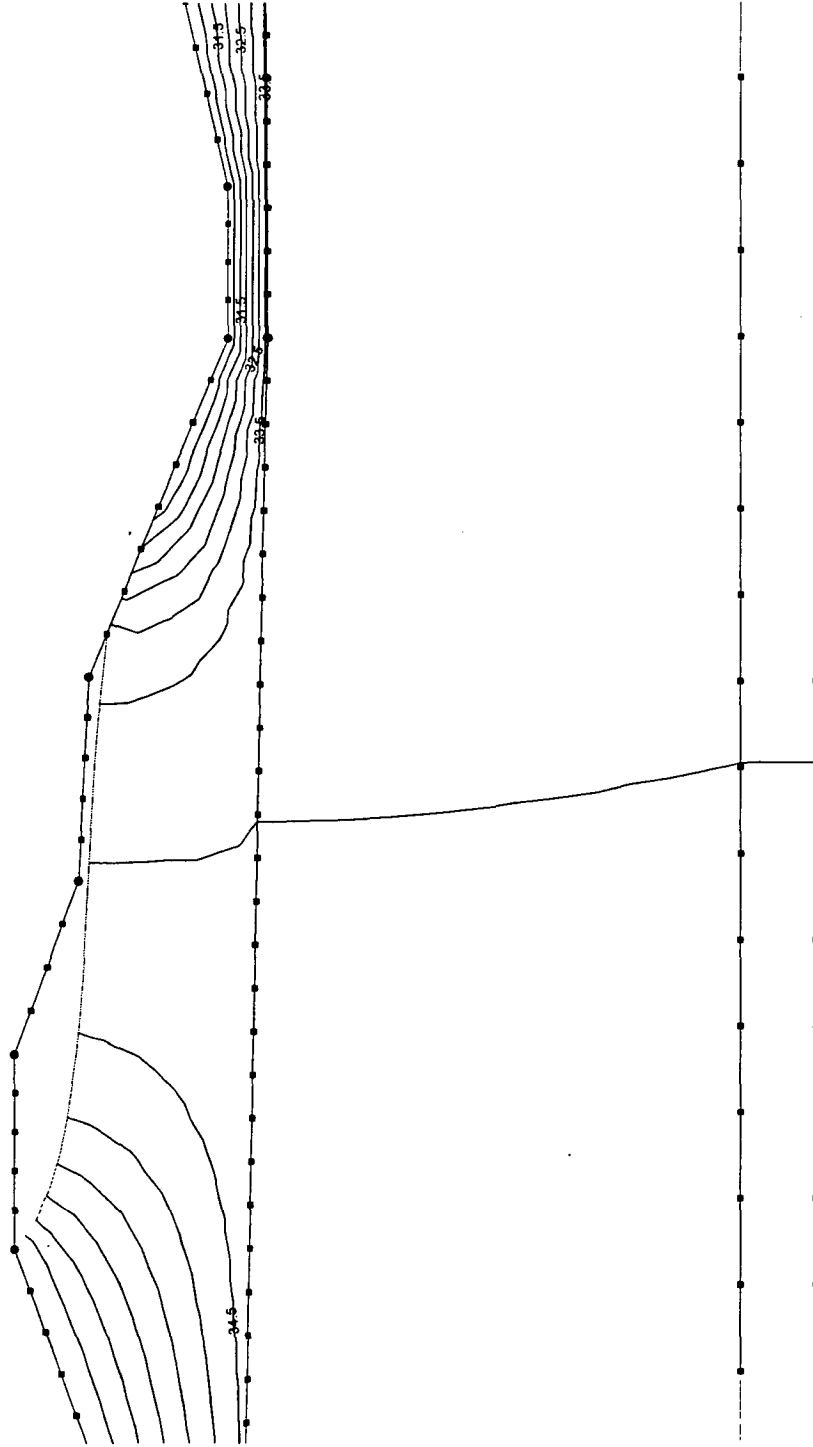
Materials

CL
SP
SP-SM



BIG SIOUX RIVER, STATION 106+15, RIGHT BANK, (With levee raise)

Total Flowrate = 686.8135(ft³/yr)/(ft)



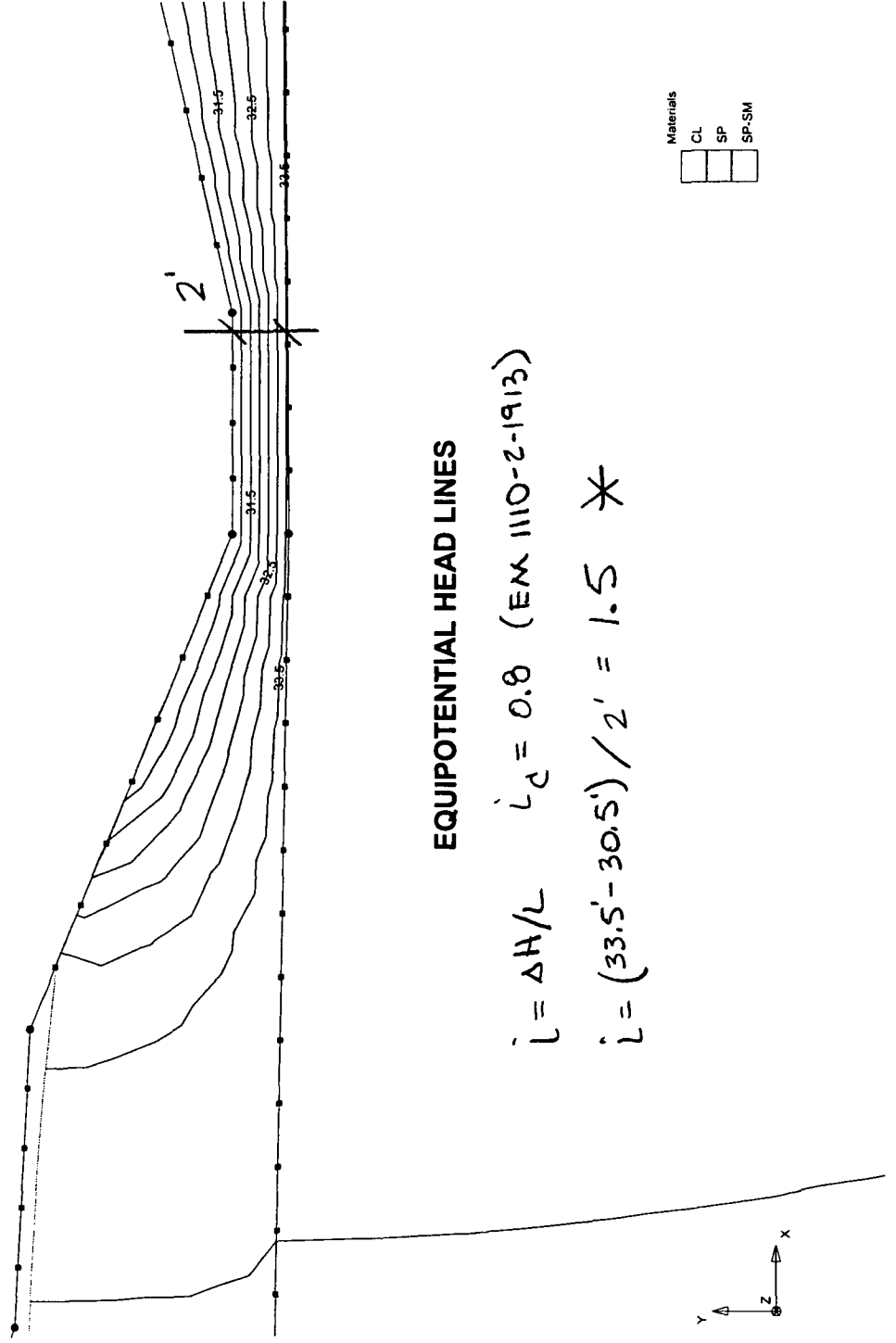
Materials

CL	SP	SP-SM
----	----	-------

EQUIPOTENTIAL HEAD LINES

BIG SIOUX RIVER, STATION 106+15, RIGHT BANK, (With levee raise)

Total Flowrate = 686.8135(ft³/yr)/(ft)



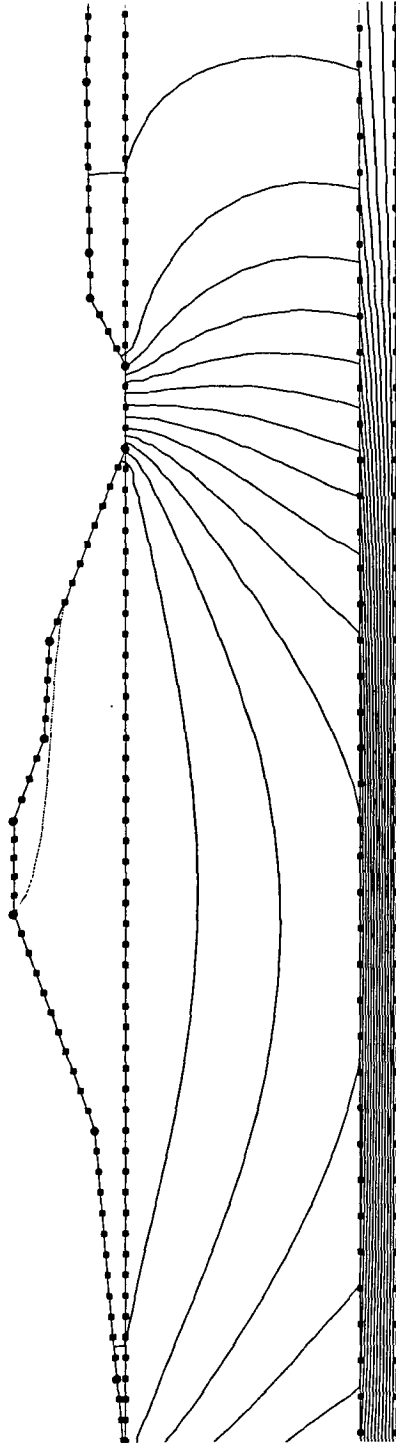
EQUIPOTENTIAL HEAD LINES

$$i = \Delta H / L \quad i_d = 0.8 \quad (EM \ 1110-2-1913)$$

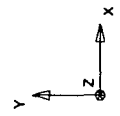
$$i = (33.5' - 30.5') / 2' = 1.5 \quad *$$

BIG SIOUX RIVER, STATION 106+15, RIGHT BANK (With levee raise)

Total Flowrate = 2258.3230(ft³/yr)/(ft)



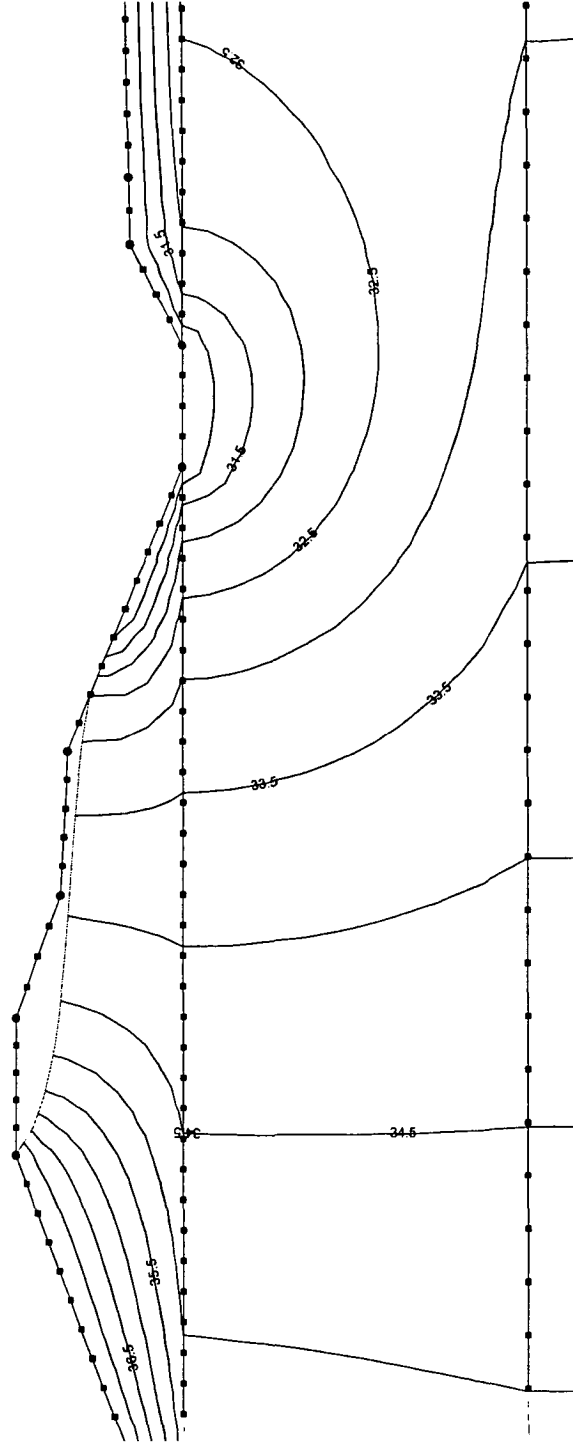
FLOWLINES



Materials			
CL	SP	SP-SM	

BIG SIOUX RIVER, STATION 106+15, RIGHT BANK (With levee raise)

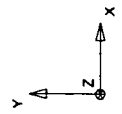
Total Flowrate = 2258.3230(ft³/yr)/(ft)



Materials

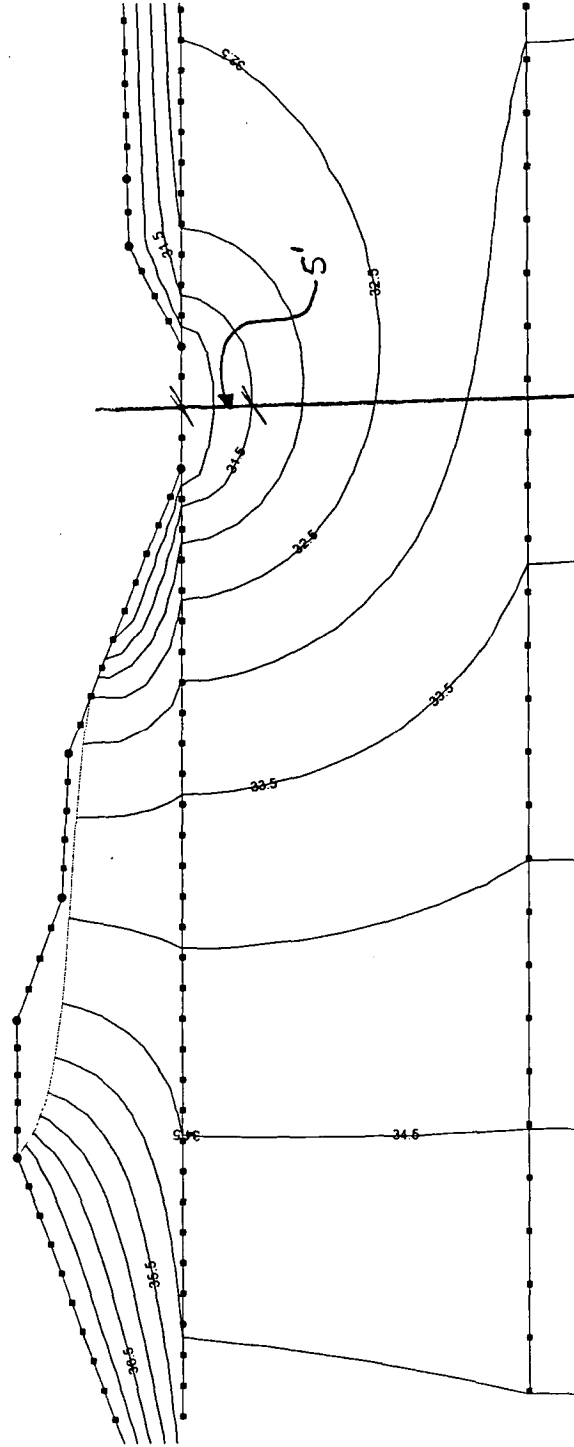
CL	SP	SP-SM

EQUIPOTENTIAL HEAD LINES



BIG SIOUX RIVER, STATION 106+15, RIGHT BANK (With levee raise)

Total Flowrate = 2258.3230(ft³/yr)/(ft)



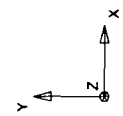
EQUIPOTENTIAL HEAD LINES

$$i = \Delta H / L \quad i_0 = 0.8 \quad (EM \ 1110-2-1913)$$

$$i = (31.5' - 30.5') / 5' = 0.2$$

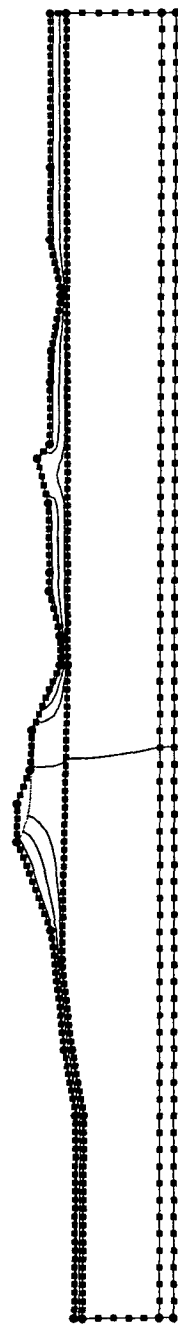
Materials

CL	SP	SP-SM

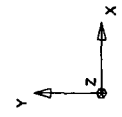


BIG SIOUX RIVER, STATION 106+15, RIGHT BANK, (With levee raise)

Total Flowrate = $686.8135(\text{ft}^3/\text{yr})/(\text{ft})$



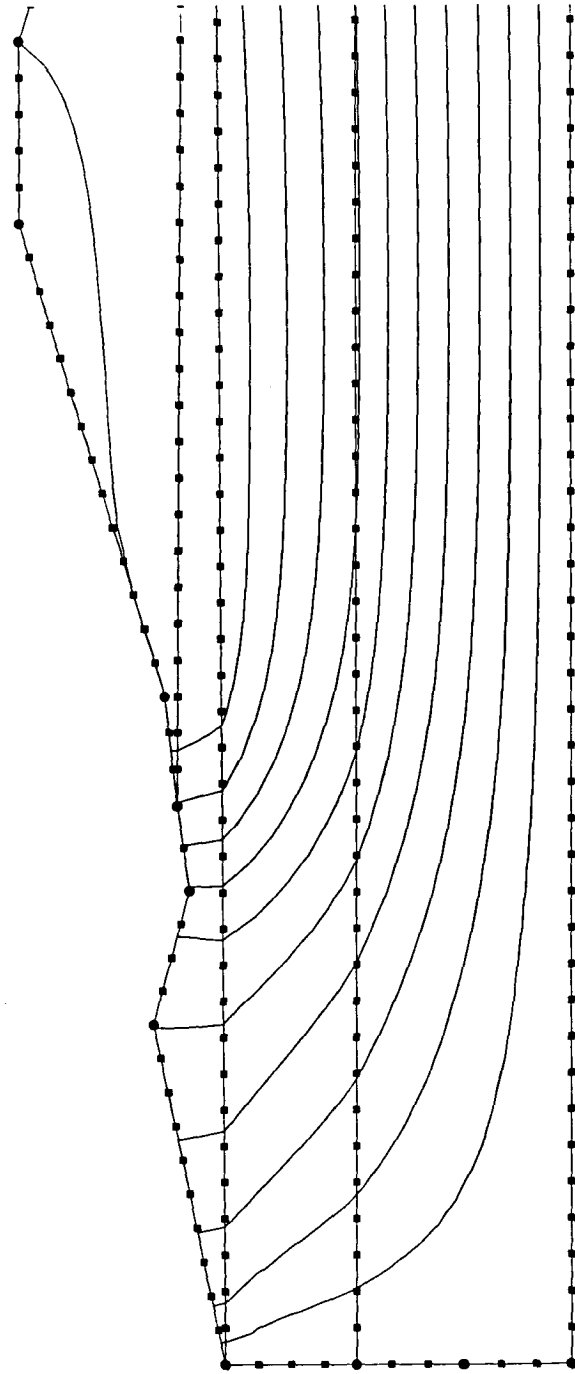
EQUIPOTENTIAL HEAD LINES



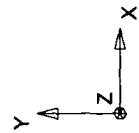
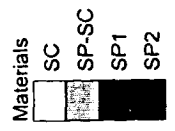
Materials

CL	SP	SP-SM
----	----	-------

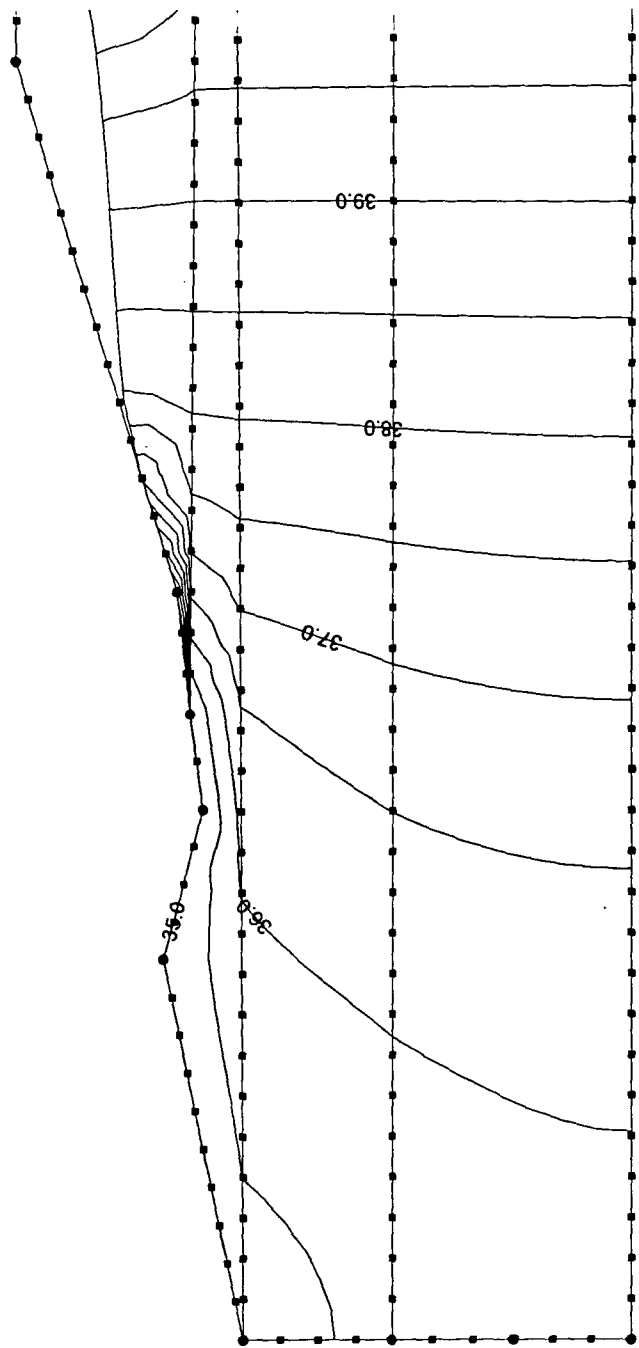
BIG SIOUX RIVER, CATFISH BAY EAST LEVEE, STATION 4+60 (Lake El @ top of new levee)
 Total Flowrate = 2863.6017(ft³/yr)/(ft)



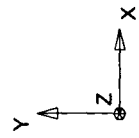
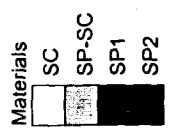
FLOW LINES



BIG SIOUX RIVER, CATFISH BAY EAST LEVEE, STATION 4+60 (Lake El @ top of new levee)
 Total Flowrate = 2863.6017 (ft³/yr)/(ft)

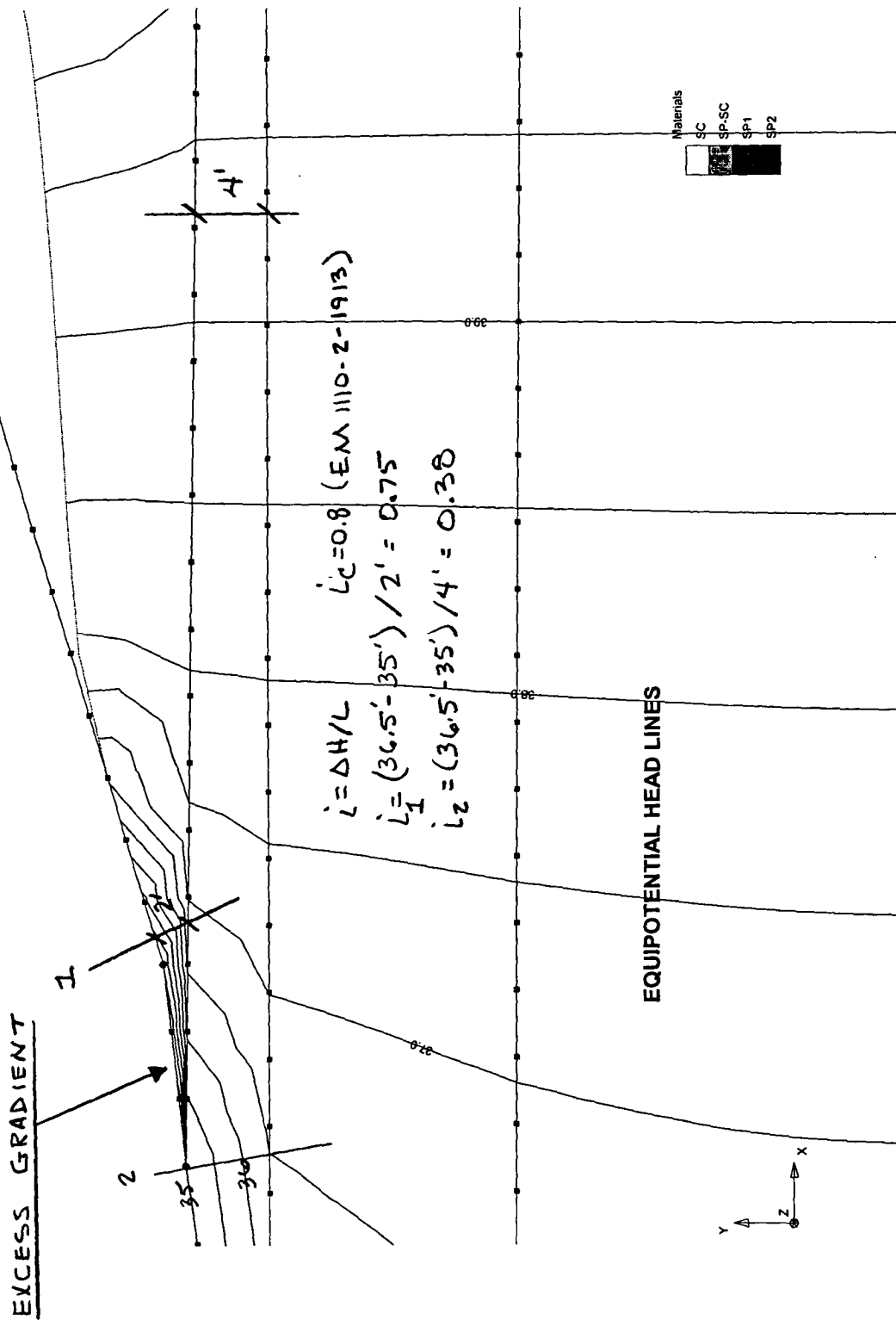


EQUIPOTENTIAL HEADLINES



BIG SIOUX RIVER, CATFISH BAY EAST LEVEE, STATION 4+60 (Lake El @ top of new levee)

Total Flowrate = 2863.6017 (ft³/yr)/(ft)



APPENDIX 5.e.

CALCULATIONS

SIOUX FALLS PHASE 2 SEEPAGE ANALYSIS**POTENTIAL SEEPAGE AREA - ONE****STATION** 165+00, LEFT BANK**BORING(S)** SFP-200-59

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CL/SC	10			
SW	4	0.59	2	
SP-SM	18	0.086	2	
SP	14.5	0.31	1	
SP	4	0.19	5.5	
SP	20	0.4	1	

HYDRAULIC CONDUCTIVITY CALCULATIONS**Hazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{-1.2} \text{ (cm}^2\text{)}$** Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CL/SC			5	
SW	0.35	0.33	120,000	
SP-SM	0.0074	0.01	80	
SP	0.096	0.67	66,640	
SP	0.036	0.01	375	
SP	0.16	0.67	111,000	

Multiply cm/sec by 1,035,000 to convert to ft/year.

REDUCTION FACTORS,**Figure 12.a, EM 1110-2-1901,****Seepage Analysis and Control for Dams**

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

SIOUX FALLS PHASE 2 SEEPAGE ANALYSIS**POTENTIAL SEEPAGE AREA - ONE****STATION** 195+00, RIGHT BANK**BORING(S)** SFP-200-40

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CL	6			
SW	12	0.5	5	
CL	8			Clay layer is thick enough to cut off seepage to lower layers. It will be used as bottom of pervious layer for seepage analysis.
SP	11			

HYDRAULIC CONDUCTIVITY CALCULATIONS**Hazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{.2} \text{ (cm}^2\text{)}$** Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CL			5	
SW	0.25	0.033	8500	
CL			5	
SP				

Multiply cm/sec by 1,035,000 to convert to ft/year.

REDUCTION FACTORS,**Figure 12.a, EM 1110-2-1901,****Seepage Analysis and Control for Dams**

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

SIOUX FALLS PHASE 2 SEEPAGE ANALYSIS**POTENTIAL SEEPAGE AREA - ONE****STATION** 159+25, LEFT BANK**BORING(S)** SFP-200-37

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CL	12			
SW	1	0.4	2	
SC	2		25	PI = 4
SP	14	0.43	1.5	Weighted average
SP	13	0.32	1	
SP	9	0.18	4.5	
CL/SM/CL	19			Top of clay taken as bottom of pervious layer.

HYDRAULIC CONDUCTIVITY CALCULATIONS**Hazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{.2} \text{ (cm}^2\text{)}$** Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CL			5	
SW	0.16	0.33	55,000	
SC			5	
SP	0.43	0.185	96,000	
SP	0.102	0.67	71,000	Combine with the layer above and model as 27' thick layer, K = 83,500 ft/yr.
SP			3,100	

Multiply cm/sec by 1,035,000 to convert to ft/year.

REDUCTION FACTORS,
Figure 12.a, EM 1110-2-1901,
Seepage Analysis and Control for Dams

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

SIOUX FALLS PHASE 2 SEEPAGE ANALYSIS**POTENTIAL SEEPAGE AREA - TWO****STATION** 8+00, LEFT BANK**BORING(S)** SFP-200-104

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CL	6			
SP	6	0.26	3.5	
SW	11	0.36	1.6	
SANDSTONE BEDROCK				

HYDRAULIC CONDUCTIVITY CALCULATIONS**Hazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{-2} \text{ (cm}^2\text{)}$** Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CL			5	
SP	0.068	0.1	7,000	
SW	0.13	0.5	67,000	

Multiply cm/sec by 1,035,000 to convert to ft/year.

REDUCTION FACTORS,**Figure 12.a, EM 1110-2-1901,****Seepage Analysis and Control for Dams**

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

SIOUX FALLS PHASE 2 SEEPAGE ANALYSIS**POTENTIAL SEEPAGE AREA - TWO****STATION** 57+50, LEFT BANK**BORING(S)** SFP-200-87, 92

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CH	5			
SM	3	0.25	9	
SW/SP	63	0.24	2.75	Weighted average.
SP	7	0.4	2.75	Weighted average.
Bedrock				

HYDRAULIC CONDUCTIVITY CALCULATIONS**Hazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{.5} \text{ (cm}^2\text{)}$** Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CH			5	
SM		0.005	500	
SW/SP		0.25	15,000	Weighted average.
SP		0.25	103,000	Weighted average.
Bedrock				

Multiply cm/sec by 1,035,000 to convert to ft/year.

REDUCTION FACTORS,**Figure 12.a, EM 1110-2-1901,****Seepage Analysis and Control for Dams**

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

SIOUX FALLS PHASE 2 SEEPAGE ANALYSIS**POTENTIAL SEEPAGE AREA - TWO****STATION** STATION 67+15, RIGHT BANK**BORING(S)** SFP-200-87, 92

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CH	5			
SM	3	0.25	9	
SW/SP	63	0.24	2.75	Weighted average.
SP	7	0.4	2.75	Weighted average.
Bedrock				

HYDRAULIC CONDUCTIVITY CALCULATIONS**Hazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{.5} \text{ (cm}^2\text{)}$** Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CH			5	
SM		0.005	500	
SW/SP		0.25	15,000	Weighted average.
SP		0.25	103,000	Weighted average.
Bedrock				

Multiply cm/sec by 1,035,000 to convert to ft/year.

REDUCTION FACTORS,**Figure 12.a, EM 1110-2-1901,****Seepage Analysis and Control for Dams**

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

SIOUX FALLS PHASE 2 SEEPAGE ANALYSIS**POTENTIAL SEEPAGE AREA - TWO****STATION** STATION 79+10, LEFT BANK**BORING(S)** SFP-200-90

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CL	5			
SP-SM	5	0.25	5.5	
SP	26	0.4	2	Weighted average.
CL	8			

HYDRAULIC CONDUCTIVITY CALCULATIONS**Hazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{1.5} \text{ (cm}^2\text{)}$** Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CL			5	
SP-SM	0.06	0.05	3,300	
SP	0.16	0.33	55,000	
CL				Top of clay taken as bottom of pervious layer.

Multiply cm/sec by 1,035,000 to convert to ft/year.

**REDUCTION FACTORS,
Figure 12.a, EM 1110-2-1901,
Seepage Analysis and Control for Dams**

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

SIOUX FALLS PHASE 2 SEEPAGE ANALYSIS**POTENTIAL SEEPAGE AREA - THREE****STATION** 112+25, RIGHT BANK**BORING(S)** SFP-200-73

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CL	3.8			
SP	3.8	0.27	4.5	
GW	0.5	0.63	0.5	
SW	11.4	0.42	3	
CH	8.5			
Quartzite Bedrock				

HYDRAULIC CONDUCTIVITY CALCULATIONS**Hazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{.85} \text{ (cm}^2\text{)}$** Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CL				
SP	0.07	0.05	3,800	
GW	0.4	2	820,000	
SW	0.18	0.1	18,000	
CH				

Multiply cm/sec by 1,035,000 to convert to ft/year.

**REDUCTION FACTORS,
Figure 12.a, EM 1110-2-1901,
Seepage Analysis and Control for Dams**

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

SIOUX FALLS PHASE 2 SEEPAGE ANALYSIS**POTENTIAL SEEPAGE AREA - THREE****STATION** 128+50, LEFT BANK**BORING(S)** SFP-200-70, 71

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CL	12			
SP-SC	3	0.09	9	
SP/SW	24	0.028	4	
CL	15			Bottom of pervious layer.

HYDRAULIC CONDUCTIVITY CALCULATIONS**Hazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{1.25} \text{ (cm}^2\text{)}$** Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CL			5	
SP-SC	0.0081	0.003	26	
SP/SW	0.0784	0.085	7,000	

Multiply cm/sec by 1,035,000 to convert to ft/year.

**REDUCTION FACTORS,
Figure 12.a, EM 1110-2-1901,
Seepage Analysis and Control for Dams**

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

SIOUX FALLS PHASE 2 SEEPAGE ANALYSIS**POTENTIAL SEEPAGE AREA - THREE****STATION**

144+50, LEFT BANK

BORING(S)

SFP-200-64, 66, 67

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CL	2.9			SFP200-67 was used as worst case.
GW	11.8	0.42	1.5	Gravel with sand. SFP200-64, sample D-8.
SW	5.1	0.32	5	SFP200-60, sample D-12.
SP	2.2	0.22	2.5	SFP200-61, sample D-7.
SW	7.6	0.28	2.5	SFP200-60, sample D-14.
CL	6.4			This layer is sufficiently thick to block seepage from a flood event. Top of this layer will be taken as the bottom of the pervious stratum for the seepage analysis.
SP	23'			

HYDRAULIC CONDUCTIVITY CALCULATIONSHazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{1/2} \text{ (cm}^2\text{)}$ Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CL			5	
GW	0.18	1	180,000	
SW	0.1	0.4	64,000	
SP	0.05	0.25	13,000	
SW	0.08	0.25	20,000	

Multiply cm/sec by 1,035,000 to convert to ft/year.

REDUCTION FACTORS,

Figure 12.a, EM 1110-2-1901,

Seepage Analysis and Control for Dams

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

SIOUX FALLS PHASE 2 SEEPAGE ANALYSIS**POTENTIAL SEEPAGE AREA - FOUR****STATION** 215+65, LEFT BANK**BORING(S)** SFP-200-18

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CH	6			
SP-SM	6	0.23	5.5	Weighted average.
SM	2	0.01	28	
SP	3	0.5	4	
SM	4	0.013	18	
SW-SM	4	0.5	4	
SM	2	0.01	19	
SW	2	0.5	0.5	

HYDRAULIC CONDUCTIVITY CALCULATIONSHazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{-2} \text{ (cm}^2\text{)}$ Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CH			5	
SP-SM	0.053	0.06	3,350	
SM			10	Hazen's not used.
SP	0.25	0.033	8,500	
SM			10	Hazen's not used.
SW-SM	0.25	0.033	8,500	
SM			10	Hazen's not used.
SW	0.25	0.85	220,000	

Multiply cm/sec by 1,035,000 to convert to ft/year.

**REDUCTION FACTORS,
Figure 12.a, EM 1110-2-1901,
Seepage Analysis and Control for Dams**

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

SIOUX FALLS PHASE 2 SEEPAGE ANALYSIS**POTENTIAL SEEPAGE AREA - FOUR**

STATION 215+65, RIGHT BANK

BORING(S) SFP-2GS-111

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CH/SW-SM	11			
SW/SP	6	0.29	9.5	Weighted average.
SW	10	0.56	2	Weighted average.
GC-GM				Silty, Clayey, gravel with sand. Clay lenses, finely bedded.

HYDRAULIC CONDUCTIVITY CALCULATIONSHazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{-2} \text{ (cm}^2\text{)}$ Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CL			5	
SW-SM	0.084	0.04	3,600	
SW	0.314	0.33	107,000	

Multiply cm/sec by 1,035,000 to convert to ft/year.

REDUCTION FACTORS,

Figure 12.a, EM 1110-2-1901,

Seepage Analysis and Control for Dams

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

**SIOUX FALLS PHASE 3 SEEPAGE ANALYSIS
POTENTIAL SEEPAGE AREA ONE - (DIVERSION
CHANNEL)**

STATION 129+50, RIGHT BANK
BORING(S) SFP301-02

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CH	4			
SP-SM	2	0.07	11	
SW/SP	19	0.26	2	Weighted average
SW	6	0.47	3	
CL				

HYDRAULIC CONDUCTIVITY CALCULATIONS

Hazen's Formula; $K \text{ (cm/sec)} = 100 \cdot D_{10}^{.42} \text{ (cm}^2\text{)}$

Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CH			5	
SP-SM				Combine with layer above and model as 6' with K = 5
SW/SP	0.0676	0.33	23,100	
SW	0.221	0.1	22,900	Combine with layer above and model as 25' with K = 23,000

Multiply cm/sec by 1,035,000 to convert to ft/year.

**REDUCTION FACTORS,
Figure 12.a, EM 1110-2-1901,
Seepage Analysis and Control for Dams**

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

**SIOUX FALLS PHASE 3 SEEPAGE ANALYSIS
POTENTIAL SEEPAGE AREA ONE - (DIVERSION
CHANNEL)**

STATION 106+15, RIGHT BANK
BORING(S) SFP301-08

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CH	2			
SP	23	0.12	5	
SP-SM	4	0.42	3	

HYDRAULIC CONDUCTIVITY CALCULATIONS

Hazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{1.5} \text{ (cm}^2\text{)}$

Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CH			5	
SP	0.0144	0.033	500	
SP-SM	0.1764	0.1	18,300	

Multiply cm/sec by 1,035,000 to convert to ft/year.

**REDUCTION FACTORS,
Figure 12.a, EM 1110-2-1901,
Seepage Analysis and Control for Dams**

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

**SIOUX FALLS PHASE 3 SEEPAGE ANALYSIS
POTENTIAL SEEPAGE AREA ONE - (DIVERSION
CHANNEL)**

STATION 42+45

BORING(S) SFP301-28, RIGHT BANK

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
CH	3			
SP	3	0.12	4.5	From adjacent boring.
SP w/Gravel	4.5	0.6	2	
SP	23	0.12	4.5	From adjacent boring.
GP	2	1.8	1	
SP w/Gravel	4	0.6	5	
SM			15	Taken as bottom of permeable layer.

HYDRAULIC CONDUCTIVITY CALCULATIONS

Hazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{.42} \text{ (cm}^2\text{)}$

Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
CH			5	
SP	0.0144	0.05	750	
SP w/Gravel	0.36	0.15	56,000	
SP	3.24	0.67	2,250,000	
GP	0.0144	0.05	750	
SP w/Gravel	0.36	0.15	56,000	

Multiply cm/sec by 1,035,000 to convert to ft/year.

REDUCTION FACTORS,

Figure 12.a, EM 1110-2-1901,

Seepage Analysis and Control for Dams

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

SIOUX FALLS PHASE 3 SEEPAGE ANALYSIS
POTENTIAL SEEPAGE AREA TWO
STATION CATFISH BAY LEVEE
BORING(S) SFP301-37

STRATA	THICKNESS (ft)	D ₁₀ (mm)	P ₂₀₀ (%)	Comments
SC	2.2			
SP-SC	3.4	0.13	10	
SP	28.9	0.13	3	
CL				

HYDRAULIC CONDUCTIVITY CALCULATIONS

Hazen's Formula; $K \text{ (cm/sec)} = 100 * D_{10}^{.42} \text{ (cm}^2\text{)}$

Note: Hazen's formula uses the D₁₀ in cm.

STRATA	K (cm/sec)	R _f	K _(reduced) ft/year	Comments
SC			10	
SP-SC	0.017	0.01	175	
SP	0.017	0.1	1,750	

Multiply cm/sec by 1,035,000 to convert to ft/year.

REDUCTION FACTORS,
Figure 12.a, EM 1110-2-1901,
Seepage Analysis and Control for Dams

P ₂₀₀ (%)	Reduction Factor (R _f)
1/2	0.85
1	0.67
1 1/2	0.5
2	0.33
2 1/2	0.15
3	0.1
4 1/2	0.05
6	0.01
9	0.005
12	0.0025
<15	0.001

City of Sioux Falls

Big Sioux River Flood Control

Flood Control System Improvements



Prepared by: Public Works-Engineering
April 15, 2003

Flood Control System

The Big Sioux River encompasses a drainage basin of roughly 9,565 square miles. The Big Sioux River Basin upstream from Sioux Falls contains approximately 5,718 square miles of the total basin. Skunk Creek drains an area of 560 square miles. The City of Sioux Falls is located within a horseshoe bend of the Big Sioux River. It is also located at the confluence of the Big Sioux River and Skunk Creek. Therefore, flood events from these two watersheds imperil the City of Sioux Falls. Flood events can be due to high rainfall events (common for Skunk Creek), snowmelt (typical of the Big Sioux River), or a combination of the two events. Due to the damage caused by flooding, the City of Sioux Falls and the Army Corps of Engineers initiated an analysis of possible flood control measures in the mid-1950's. This analysis triggered the construction of the flood control system on the Big Sioux River and Skunk Creek upstream and through the City.

The existing flood control system on the Big Sioux River was constructed between 1956 and 1961. This system includes a system of levee protection and floodwall along the historic channel (including a portion of Skunk Creek above the confluence of the Big Sioux River), a Diversion Dam, Diversion Channel and Spillway. The system includes approximately 29.2 miles of levees adjacent to the Big Sioux River, Big Sioux River Diversion Channel, Silver Creek, and Skunk Creek. The Diversion Channel traverses approximately 2.8 miles from the Diversion Dam structure to a 118-foot vertical drop back down to the historic channel at the base of the Spillway.

The intent of the system is to reroute flood flows in and around the City of Sioux Falls and contain these flows within the levee system. The system was designed based on a technical analysis completed in 1954. The initial project planned for design discharges of 24,400 cubic feet per second (cfs) on the Big Sioux River. The Skunk Creek system used a design discharge of 9,305 cfs.

The analysis, design, and construction of this system were coordinated under the United States Army Corps of Engineers (USACE) with involvement from the local and state levels. The City of Sioux Falls (City) by agreement is responsible for maintenance and operation of this system.

The system begins on the right bank of the Big Sioux River directly south of Interstate 90. The left bank levee begins north of Interstate 90 just west of SD Highway 115. The diversion dam and headwaters of the diversion channel are located in this area. Levee structures extend downstream on the Big Sioux River channel to South Western Avenue in the area of Interstate 229 and 57th Street. Topography and flood plane protection via zoning restrictions exist from Western Avenue downstream to Falls Park Drive. Levee protection was constructed from Falls Park Drive through the area of the confluence of the diversion channel outfall or spillway. The spillway outfall and stilling basin are located in the general area directly north of Rice Street and Weber Avenue encompassing the river frontage of the John Morrell Plant. The levee system extends downstream to a point between North Cliff Avenue and Interstate 229. A map is attached outlining the general features of the flood control system.

The existing flood control system design capacity (24,400 cfs for the Big Sioux River and 9,305 cfs for Skunk Creek) translates to protection for a 30-year flood event for the Big Sioux River and a 20-year flood event for the Skunk Creek reach.¹ Emergency flood fighting measures, such as those mobilized following the winter of 1996-97, provide additional protection. These measures include temporarily raising the headwalls of the diversion channel spillway, selective temporary dikes, sandbagging, and structure protection including erosion control or armor at drainage structures. Sections of the existing levee system are also raised one to three feet by placement of temporary embankment during these measures.

In the early 1990's the USACE at the City's request, initiated a Feasibility Study to analyze this system based on better-defined hydrologic data for the Big Sioux River and Skunk Creek basins. This study was also initiated due to the continued development in the southwestern area of the City that accentuated the benefits derived from the flood control system. Major retail and residential development in the area outlined by Maple Street to the north, 57th Street to the south, Kiwanis Avenue to the east, and Marion Road to the west, was a prime focal point for the improvements. The feasibility study was completed in 1994 and the City and the USACE proceeded to pursue funding for the Big Sioux River and Skunk Creek Flood Control Project.

The feasibility study identified the limitations of the existing flood control system based on eight major flood events chronicled since 1950. One of these events, the flood of 1969, was considered the 100-year event and therefore to be the standard against which the flood control improvements would be measured. The estimated discharge on the Big Sioux River for the 1969 flood event was approximately 40,000 cfs. Approximately 30,000 cfs was diverted into the diversion channel and discharged through the spillway chute. The remaining 10,000 cfs passed through the diversion dam and continued down the Big Sioux River channel.

Mathematical modeling was performed to recreate the 1969 event within the design criteria for the improvements. In addition, a scale hydraulic model was created at the USACE Waterways Experimentation Station in Vicksburg, Mississippi to review several improvement options. The results of these studies were included in the feasibility study. For design purposes on the Big Sioux River, the 100-year event was determined to be 29,000 cfs, the 500-year event was determined to be 36,300 cfs, and the flood of record in 1969 determined to be 30,000 cfs.

The damage in the Sioux Falls area created by a 100-year event with the existing flood control system was estimated at \$186 million in 1992 dollars and with 1992 infrastructure.² Considerable development has occurred post-1992 including the Meadows on the River Development bounded by Skunk Creek, the Big Sioux River, 26th Street/Louise Avenue and 41st Street. In addition, continued development has occurred in the 41st Street Corridor including the area bounded by Western Avenue, I-29, I-229 and 41st Street. It could be conservatively estimated that the damage figure would be significantly increased when calculated in 2000 dollars and development.

¹ Local Flood Protection, Big Sioux River and Skunk Creek at Sioux Falls, SD, November 1993.

² Op. Cit.

Flood Control Project

The Big Sioux River and Skunk Creek Flood Control Project consists of a series of levee improvements and flood control structure modifications identified in the 1994 Feasibility Study completed by the USACE. The USACE, soon after the completion of the Feasibility Study, initiated a contract to provide preliminary engineering including right-of-way impacts based on the issues identified within the Feasibility Study. This report, *Sioux Falls Flood Control Project Design Optimization Study—Big Sioux River, Skunk Creek and Diversion Channel*, was completed in March 2000 by HDR Engineering, Inc. The preliminary engineering included providing "10% Design Complete" drawings to aid in pursuing design and construction sequencing. The USACE and the City of Sioux Falls have completed review of this document.

As proposed in the Design Optimization Study, the project has been broken into three phases. Phases II and III were reversed at the request of the City. A map is attached that illustrates the proposed phasing of the flood control project.



Phase I

Phase I included improvements to the diversion channel spillway of raising the height of sidewalls, increasing capacity, and strengthening the structure by buttressing the sidewalls. Associated geotechnical work was also completed in and around the structure. The stilling

basin or the outfall of the spillway into the Big Sioux River channel was modified. Long-term maintenance on the existing spillway headwalls and floor were included as a part of this phase.

The right bank levee opposite of the spillway, adjacent to John Morrell & Co., was modified also. This levee was relocated approximately 100 feet southeast to improve the hydraulics of the stilling basin. Measures to preclude seepage under the right bank were also included in this phase.

Construction of improvements on Phase I were started in October 2000, and will be completed by December 2003. The costs of improvements completed under Phase I are \$6,100,000.



Phase II

Phase II includes levee improvements from Russell Street to Interstate 229 on the Big Sioux River and from Marion Road to the confluence of the Big Sioux River on Skunk Creek. Under seepage measures and surface drainage structure improvements are included with the project as well as modifications to the 41st Street and Marion Road bridges. The levee height in this area will require a rise of anywhere from 2 ft. to 6 ft. varying throughout both reaches addressed by this phase.

Areas of concern for under seepage in Phase II have been identified along the left bank just south of Russell Street and along the right bank about one half mile south of 12th Street in the area of Westward Ho Country Club and River Run Addition.

Construction of Phase II is scheduled for bidding in late 2003 with a completion in 2006. The current estimate of probable costs for Phase II is \$16,000,000.



Phase III

Phase III includes improvements to the levees on the Big Sioux River north of the diversion dam and on the diversion channel from the Big Sioux River to the spillway. Associated surface drainage structure modifications are included in this phase.

Under seepage studies are not completed for Phase III at this time. Any areas of concern will be addressed with the design of this phase.

With the construction of the original levee system, a segment of the left bank levee just north of the diversion dam was constructed as a designed overflow area (fuse plug). In the design of the system improvements, it has been determined that fuse plugs do not adequately address their designed intent. The original function of a fuse plug was to allow excess flow in an event greater than the system design to be diverted to an area where it would not do great damage to the inundated land. In the history of the USACE conduct of flood fights through the years, where fuse plugs have existed they have been armored to

prevent their designed function. With the improvements being made on Phase III, the fuse plug will be removed.

The estimated cost of Phase III is \$7,500,000. It is anticipated that the design will be complete in 2005 with construction being completed by mid 2006.

As each phase of the project is constructed, all land and/or easements required for that phase will be acquired prior to the bid letting for that phase. This is a requirement for the USACE and is a standard for the City. All land acquisition will follow federal standards for notification, appraisal and acquisition.



Operations and Maintenance

The proposed Big Sioux River Flood Control Project improvements would provide 100-year event protection on the Big Sioux River and Skunk Creek. At the completion of the project, the USACE will submit a Conditional Letter of Map Revision to the Federal Emergency Management Agency for the revision of the flood plane boundaries encompassed by the project. Also, the USACE will provide a new operation manual for the system. The operation manual will address the proper settings of the diversion dam in various flood events to minimize flooding of areas upstream of the system and the area along the Big Sioux River between Western Avenue and Falls Park Drive. The manual will give guidelines for the breach of the levee system if, during a flood event greater than the capacity of the system, the decision is made that a breach is needed to prevent a catastrophic, random failure.

The operation of the diversion dam gates has been of concern to the city and to upstream property owners since the original construction of the system. The current operations manual does not properly address the impacts of upstream flood elevations with regard to the operation of the gates. Only the requirement for river freeze conditions are addressed in the manual. The USACE has analyzed the impacts of the operation of the diversion dam gates on the flood elevation of the Big Sioux River upstream of the diversion dam. The results of the study were presented in their February 3, 2003 Memorandum to Files (see attached), and shows negligible impact in the 10-year event. However, the operation of the gates does impact upstream flood elevations in the 50-year and 100-year events. To minimize the upstream impacts, the city will follow the memorandum's recommendations and open the gates during floods at or greater than the 50-year event to allow 7,300 cubic feet per second flow through the dam. For gate operation during floods between the 10-year and 50-year events, the city will attempt to allow a proportional amount to flow through the dam.

Proper maintenance of the levee system will also be included in the manual. Required maintenance procedures will include mowing and maintenance of proper ground cover, undesirable vegetation control, burrowing animal control and periodic inspection procedures along with other prescribed maintenance procedures.

Flood Authorization and Funding

The existing flood control project was authorized under the Public Law 780, 83rd Congress, dated September 3, 1954. The feasibility study for the flood control project improvements was authorized by an August 1, 1963 resolution of the Committee on Environment and Public Works of the U.S. Senate and by a May 8, 1964 resolution of the Committee on Public Works and Transportation of the U.S. House of Representatives. The feasibility study was funded by both Federal and non-Federal sources in accordance with the provisions of the Water Resources Development Act of 1986. The non-Federal sponsors of the project are the City of Sioux Falls and the State of South Dakota.

The acceptance of the feasibility study initiated requests for funding under the Flood Control Act of 1970, as amended under Public Law 91-611 and the Water Resources Development Act of 1986, as amended under Public Law 99-662. Section 902 of Public Law 99-662 established the maximum amount of costs and cost sharing and established the **Big Sioux River and Skunk Creek Flood Control Project**. The maximum amount was subsequently amended to \$40,600,000 with the non-Federal sponsor contributing a minimum of 25% or \$10,300,000. The State of South Dakota committed to the non-Federal cost share with the City of Sioux Falls by obligating \$4,550,000 under the Session Laws of 1992, Chapter 254, Section 17. A new start appropriation of \$2,200,000 was approved by U.S. Congressional action in FY 2000. The House Appropriations Subcommittee on Energy and Water Development approved the fiscal year 2001 Energy and Water Appropriations Act in June 2000. This action, following release of the legislation, appropriates an additional \$1.5 million of federal funding to the Big Sioux River and Skunk Creek Flood Control Project.

The appropriations received recently enable the City of Sioux Falls to release the obligational authority it has been budgeting since 1994. Work is nearing completion for Phase I. Design is proceeding on Phases II and III. Further appropriations will be required to pursue construction of these phases.

Federal Emergency Management Agency and Flood Insurance Rate Map

The March 1979 Flood Insurance Study for Sioux Falls and vicinity reported that the existing project protected Sioux Falls from floods in excess of the 100-year event on the Big Sioux River and at approximately the 25-year level on Skunk Creek. In 1982, the Federal Emergency Management Agency (FEMA) released its Flood Insurance Rate Maps (FIRM) for Sioux Falls.

During September 1987, FEMA was notified of the Corps' study results stating that the existing project provides inadequate flood protection for Sioux Falls. Because FEMA administers the National Flood Insurance Program, it is FEMA's responsibility to ensure that the FIRM for Sioux Falls reflects the current flood hazard. At that time, FEMA decided not to reevaluate the Sioux Falls area until the existing project had been modified or a decision was made not to modify the existing project.

The City of Sioux Falls met with Dr. John Liou of FEMA in March 2000. FEMA had prepared a draft FIRM map under the 1992 base city map utilizing the data from the Feasibility Report and Engineering Appendices for **Local Flood Protection, Big Sioux River and Skunk Creek at Sioux Falls, South Dakota** dated November 1993, the **Big Sioux River Model Study CHL-97-18** dated July 1997 and the USACE **Hydraulic Design Criteria**.

Several problems and issues are inherent in the draft FIRM as presented. Base mapping does not reflect the more accurate elevation and infrastructure data currently available with the City of Sioux Falls Geographic Information System (GIS) database including updated aerial photography and base mapping. Elevation datum based on the hydrologic model dictates actual FIRM application and administration within the City. This has and continues to be the policy of the City. The mapping provided within FIRM serves as the reference for the public and systematic land use planning. However, with the problems inherent with the "dated" base mapping, as well as the accuracy of the mapping with respect to infrastructure and elevation datum, the FIRM map as presented provides an inaccurate "picture" of flood hazard. In addition, with the initiation of the Big Sioux River Flood Control Project, it is likely the FIRM would be in a state of flux as improvements are constructed during the phased implementation of the project. Basically, FEMA proposed initiation of the FIRM as if a decision had been made "not to modify the existing project."

Administratively, reissuance and continual updating of the FIRM would be expensive and confusing. Therefore, recommendations were made and accepted by FEMA to explore the option of updating the base mapping consistent with the City of Sioux Falls GIS database. Recommendations also included the delay of formal implementation of the FIRM until completion of Big Sioux River Flood Control Project. Implementation of the FIRM could be reevaluated on an annual basis as the status of funding and phase completion dates become more accurate. Under this scenario, elevation control would still apply for application of flood rates but revised FIRM distribution would be delayed until the Big Sioux River and Skunk Creek Flood Control Project improvements are in place. It is critical, however, for the City of Sioux Falls to disclose the basis for administration of the FEMA mapping and to hold public hearings in conjunction with FEMA outlining the program.

At the completion of all work on the flood control system, it is the city's intent to work with the USACE to provide all required information to FEMA and apply for a LOMR for the entire area encompassed by the system as well as the area along the Big Sioux River from Interstate 229 at the end of Phase II to Falls Park Drive where the levee system resumes. It is anticipated that at that time, the city will have an up to date and accurate FIRM.

Enclosed with this application are a location map, Seepage Analysis Report, 100-Year Flood Boundaries Maps and associated tables, the May 9, 2002 US Army Corps of Engineers Memorandum for Files as revised January 2003, and the February 3, 2003 US Army Corps of Engineers Memorandum for Files.