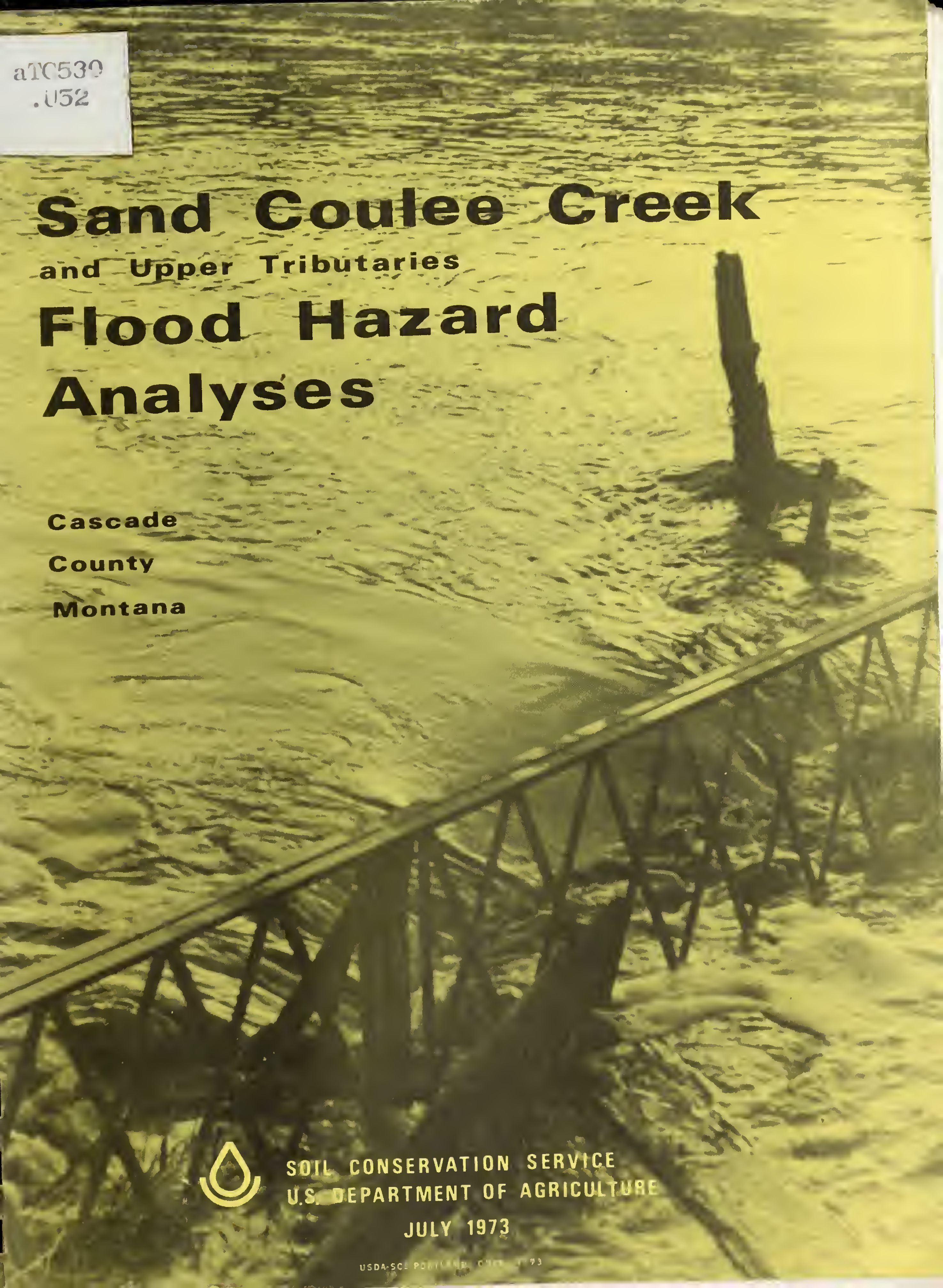

Sand Coulee Creek
and Upper Tributaries
Flood Hazard Analyses

Cascade County Montana

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

JULY 1973

USDA-SCS PORTLAND, OREG. 1973

UNITED STATES
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Bozeman, Montana

REPORT OF
SAND COULEE CREEK AND UPPER TRIBUTARIES FLOOD HAZARD ANALYSES
CASCADE COUNTY, MONTANA

Prepared in cooperation with
Montana Department of Natural Resources and Conservation
Cascade County Conservation District
Cascade County

July 1973

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INTRODUCTION

The Cascade County Commissioners, Cascade County Conservation District, and the Montana Department of Natural Resources and Conservation requested this flood hazard study to help solve local flood problems and to determine the best use of land subject to overflow.

This flood hazard report is on Sand Coulee Creek and two of its tributaries. The tributaries studied were Sand Coulee Fork, which flows through the town of Sand Coulee, and Cottonwood Creek. Other towns in the study area are Tracy, Centerville, Stockett, Brown (Number Seven), and the communities of Donovan Park, Gibson Flats, and Fields. See map following page 2.

Flood hazard analyses are carried out by the Soil Conservation Service as an outgrowth of the recommendations in A Report by the Task Force on Federal Flood Control Policy, House Document No. 465, (89th Congress--August 10, 1966), especially Recommendation 9(c), "Regulation of Land Use," which recommended the preparation of preliminary reports for guidance in those areas where assistance is needed before a full flood hazard information report can be prepared or where a full report is not scheduled.

Authority for funding flood hazard analyses is provided by Section 6 of P. L. 83-566, which authorizes USDA to cooperate with other federal, state, and local agencies to make investigations and surveys of the watersheds of rivers and other waterways as a basis for the development of coordinated programs.

In carrying out flood hazard analyses, the Soil Conservation Service is being responsive to Executive Order 11296, dated August 10, 1966, especially to Section 1(4), which directs that "all executive agencies responsible for programs which entail land use planning shall take flood hazards into account when evaluating plans and shall encourage land use appropriate to the degree of hazard involved."

Priorities regarding scheduling, location, and intensity of flood hazard studies are set in cooperation with the Montana Department of Natural Resources and Conservation.

In 1971 the Montana Legislature passed legislation to ease the increasing problem of flood loss and damage in Montana. This act was revised by the 1973 Legislature. The Montana Floodway Management and Regulation Act, title 89, chapter 35, Revised Code of Montana, authorizes the Montana Department of Natural Resources and Conservation to initiate a comprehensive program of floodway delineation and regulation for the entire state. The purpose of this state-wide flood plain policy is two-fold:

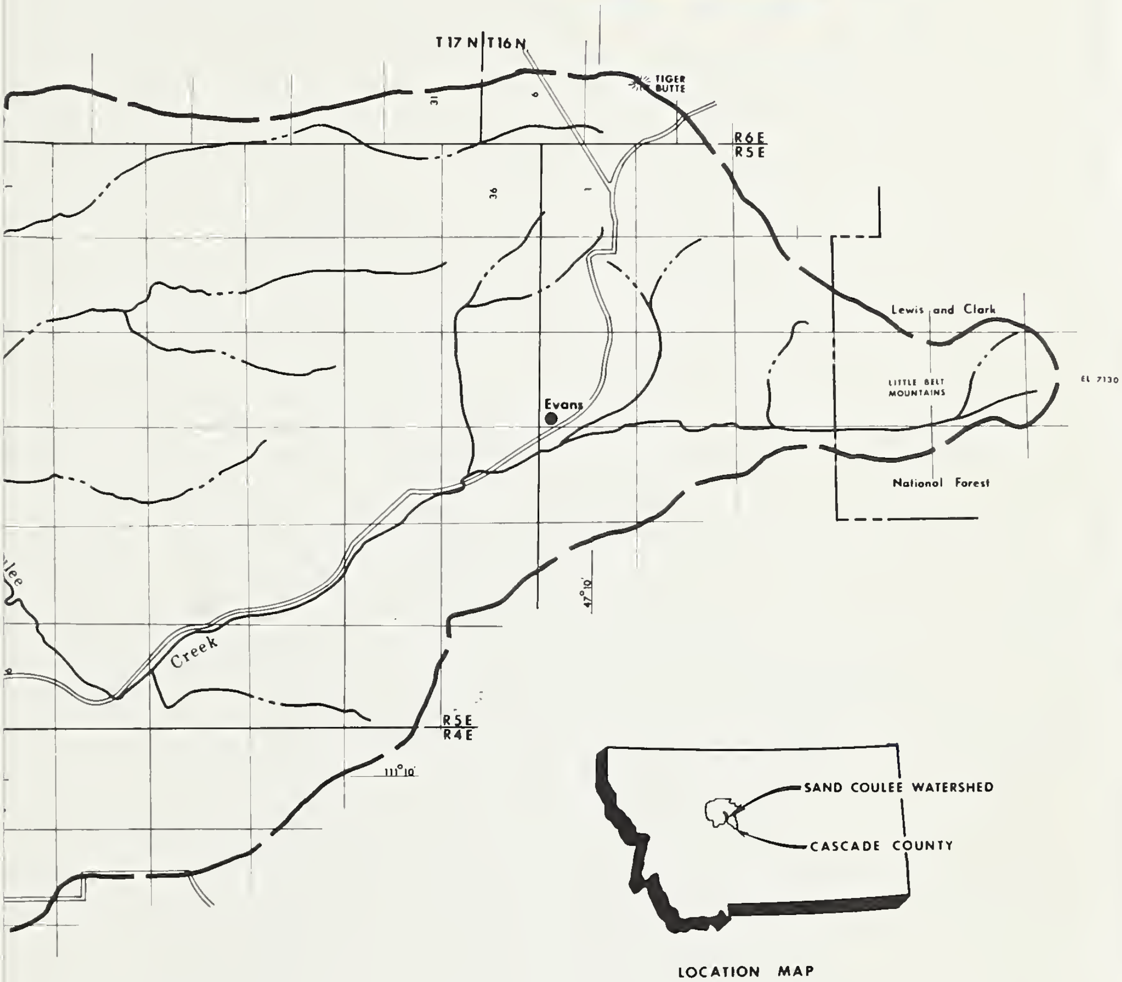


Figure 1

STUDY AREA MAP

SAND COULEE FLDDD HAZARD ANALYSES
CASCAOE COUNTY, MONTANA

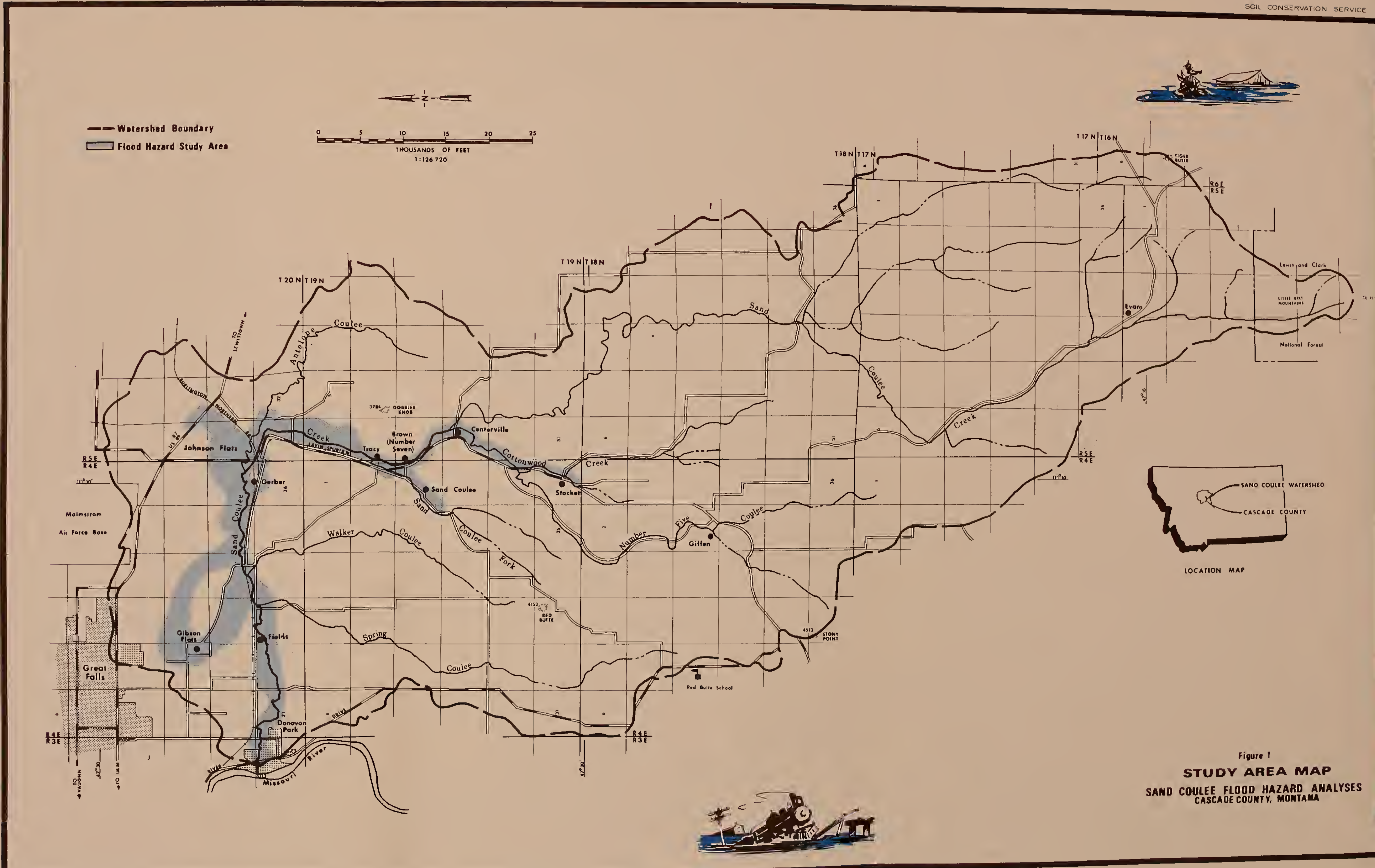


Figure 1
STUDY AREA MAP
SAND COULEE FLOOD HAZARD ANALYSES
CASCADE COUNTY, MONTANA

1. To eliminate or minimize loss of life, personal suffering, and physical hardships which are immediate consequences of serious floods.

2. To achieve the optimum beneficial use of our flood plains for both private and public benefits.

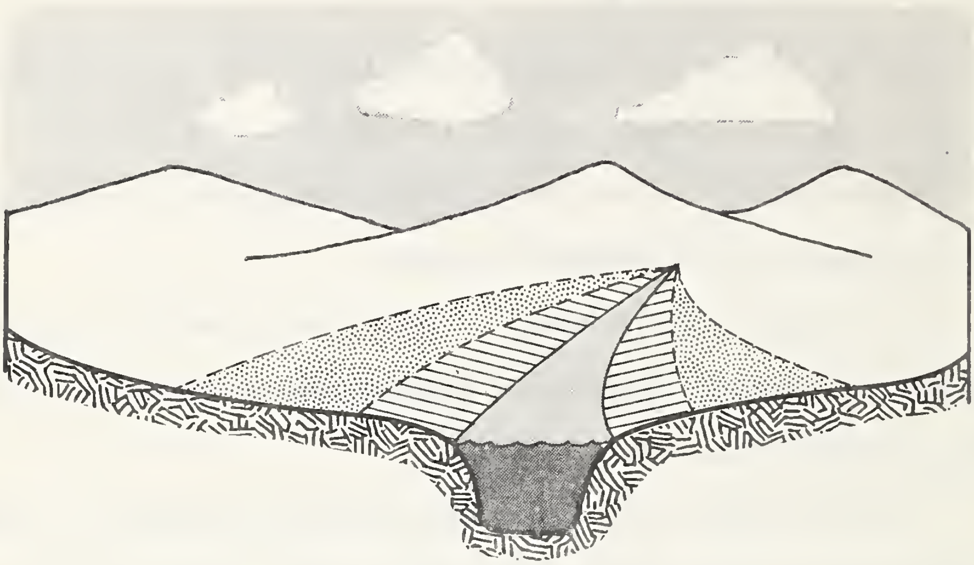
Implementation of the State Floodway Management and Regulation Act proceeds in three successive phases.

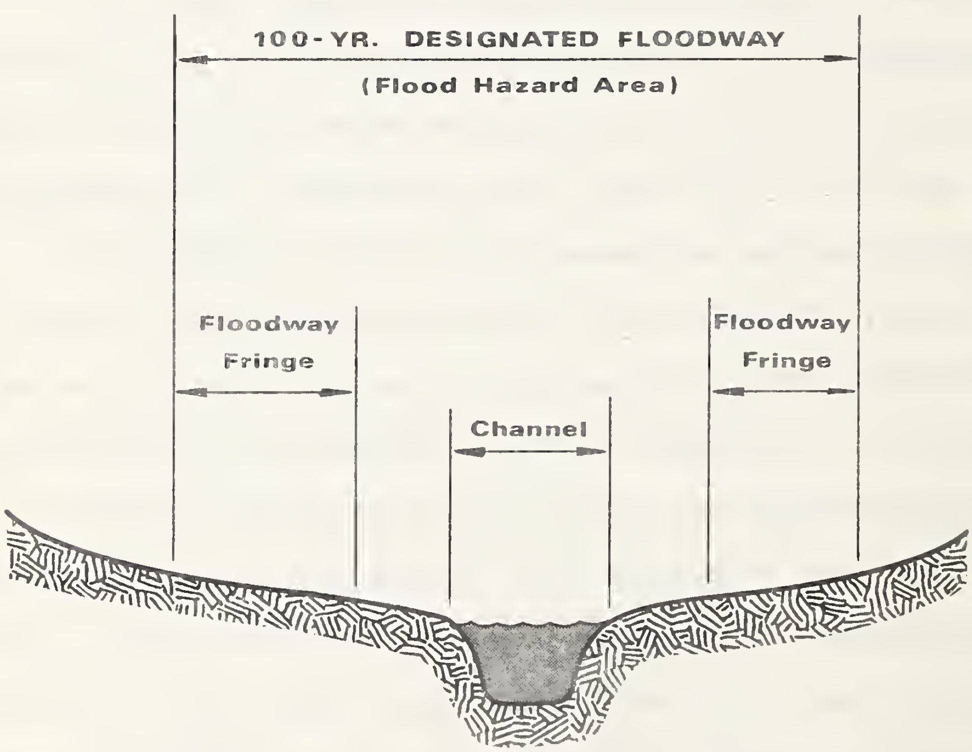
(1) First, areas adjacent to watercourses subject to flooding must be delineated. This report supplies the necessary technical data to fulfill the first requirement.

(2) The second step in the implementation process is a public presentation of the floodway delineation lines. This is accomplished at a public hearing where the boundary lines of the 100-year frequency flood are presented and discussed. See page 4. Following the public hearing, the 100-year designated flood lines are recorded in the office of the County Clerk and Recorder. The Department of Natural Resources and Conservation provides the officials of the political subdivision with floodway delineation data, a copy of the State Floodway Management and Regulation Act, rules and regulations of the Department of Natural Resources and Conservation, and minimum standards for land use within the 100-year floodway.

(3) The third phase in the implementation process is primarily local action. As specified in the state law, the political subdivision must adopt land use regulations which meet or exceed the minimum standards of the Department within one year after receiving

FLOOD HAZARD AREAS





the flood plain delineation data from the Department of Natural Resources and Conservation. If land use regulations are not adopted on the local level, the designated or 100-year floodway can be enforced by the Department of Natural Resources and Conservation.

Many land uses are compatible with periodic flooding and are permitted within the designated floodway to the extent that they are not prohibited by any other statute. Some "open space" uses specifically allowed within the designated floodway are agricultural uses, industrial and commercial uses such as loading areas or parking areas, and open-type public and private recreation areas. In addition, other land uses, including buildings for living purposes or commercial structures and excavations, may be allowed on the floodway fringe provided they are adequately floodproofed.

Specific recommendations on acceptable flood plain land uses and State standards for flood plain development will be furnished to the Cascade County Conservation District and the Cascade County Commissioners by the Montana Department of Natural Resources and Conservation.

Flood hazards increase in developing areas. Urbanization means new homes, schools, businesses, streets, etc. This results in less exposed soil to absorb precipitation and, therefore, more storm runoff. Pavements, roofs, compacted soil, and storm sewers all increase and speed up the runoff, increasing the flood hazard locally and downstream. See Plate 9.

Various land uses in a developing area compete for each parcel of land. Flood plain lands are no exception. Encroachments into the flood plain by land filling, railroads, highways, channel modification, and other developments can constrict the flow of floodwater. These constrictions can increase floodwater depths and velocities.

Managers and users of flood plain land should base their use upon the advantages and disadvantages of locating within flood hazard areas. Knowledge of the hazards involved is not widespread and, consequently, managers, potential users, and occupants cannot always accurately assess the risks. In order for flood plain management to effectively play its role in the development of flood plains, it is necessary to:

1. Provide state and local units of government with appropriate technical information and interpretations for use in flood plain management.
2. Provide technical services to managers of flood plain property to better coordinate planning for development and appropriate land use.
3. Improve basic technical knowledge about flood plain hazards in cooperation with other agencies and groups.

This report contains nine (9) aerial photomaps showing the 100-year frequency flood lines along portions of Sand Coulee Fork, Cottonwood Creek, and Sand Coulee Creek. The photomaps also show soils information. Additional information in the form of valley cross sections, water surface profiles, soils interpretations, photographs, and other related flood plain data are also included.

The 10-, 50-, 100-, and 500-year frequency floods were analyzed. A 50-year frequency flood has an average occurrence of once in 50 years or a two percent chance of occurring in any given year. A 100-year flood occurs once in 100 years on the average or has a one percent chance of occurring in any given year. Only the 100-year natural flood lines are shown on the aerial photomaps, valley cross sections, and water surface profiles. Information for the 10-, 50-, 100-, and 500-year floods are shown in flood plain reference tables. Elevations for other frequency storms can be determined from the basic support data on file with the Soil Conservation Service.

This report can be used as a technical tool to help develop local flood plain land use and development regulations. It is intended to serve as a technical basis for determining needed action to minimize flood damages and as a basis for further study and planning on the part of Cascade County, the City of Great Falls, Cascade County Conservation District, and the Montana Department of Natural Resources and Conservation. Future action could include local planning programs to guide developments by controlling the permitted uses of flood plains through zoning and subdivision regulations, the construction of flood protection works, and combinations of the two approaches. Such solutions could include the following nonstructural or preventive measures:

Land Use Planning
Flood Plain Control Regulations
Flood Plain Development Policies
Flood Plain Filling Regulations

Flood Plain Acquisition
Flood Plain Zoning
Upstream Land Treatment Program
Flood Warning System
Flood Insurance
Tax Adjustments
Health Regulations
Building Codes

Corrective or structural measures which would complement the preceding include:

Floodwater Retarding Reservoirs
Channel Improvement
Levees and Dikes
Pumps
Floodproofing
Watershed Treatment
Urban Relocation

The Montana Department of Natural Resources and Conservation and the Soil Conservation Service will, upon request, provide technical assistance to federal, state, and local agencies and organizations in the interpretation and use of the information developed in this study.

DESCRIPTION OF THE WATERSHED

The Sand Coulee Creek Watershed is located in the southcentral section of Cascade County. The drainage area lies within Cascade County and encompasses 195 square miles.

Sand Coulee Creek heads near the north flank of the Little Belt Mountains, approximately 28 miles south of Great Falls, Sand Coulee Creek flows generally north to near the south edge of Great

Falls and then west into the Missouri River. It flows into the Missouri River approximately three miles upstream from the Great Falls water treatment plant. Sand Coulee Creek enters an ancient channel of the Missouri River approximately two and one-half miles downstream from Tracy and continues to flow within this channel to the present Missouri River. This old channel has a fairly flat downstream slope, approximately five feet per mile, and varies from one-half mile to three-fourths mile in width. Maximum elevation of the watershed is 7,130 feet mean sea level (msl) in the Little Belt Mountains. The minimum elevation is 3,313 feet msl at the Missouri River.

Land use in the watershed is primarily rangeland and dry cropland, and a small portion of the upper watershed is timber land.

Major tributaries of Sand Coulee Creek are Spring Coulee, Walker Coulee, Number Five Coulee, Cottonwood Creek, Antelope Coulee, and Sand Coulee Fork. See map following page 2.

Spring Coulee, with 16.9 square miles drainage area, heads near Red Butte School, flows generally north and runs into Sand Coulee Creek near Fields.

Walker Coulee, with a 6.5 square miles drainage area, heads at Red Butte and flows into Sand Coulee Creek approximately one mile upstream from the mouth of Spring Coulee.

Sand Coulee Fork has a drainage area of 6.4 square miles, also heads near Red Butte and flows generally northwest through Sand Coulee (town) and joins Sand Coulee Creek at Tracy.

Number Five Coulee, with a 26.9 square miles drainage area, joins Cottonwood Creek between Stockett and Centerville.

Cottonwood Creek has a 10.4 square miles drainage area, upstream from Stockett, flows through Stockett and joins Sand Coulee Creek at Centerville.

Antelope Coulee, with 9.3 square miles of drainage area, is the easternmost tributary. It flows generally northwest through the lower portion of Johnson Flats and joins Sand Coulee Creek at Gerber.

Average annual precipitation for the area varies from 30 inches in the Little Belt Mountains to 14 inches near Great Falls.

The area is commonly swept by high westerly winds. These winds often create a "chinook" condition in March and April which rapidly melts the winter snow and causes flooding while the ground is still frozen. Major flooding occurs when rainstorms are combined with the heaviest snowmelt in May and June. Flooding is also caused by high intensity rainstorms later in the summer. Floods that damage crops have occurred one year in three. Cropland along the narrow valley bottoms of the upper watershed and in the broad floodplain of the lower watershed receive flooding from even minor storms.

Major floods in the watershed have occurred in 1894, 1899, 1908, 1927, 1936, 1953, 1958, 1964, 1965, 1966, and 1969. Some floods have affected particular parts of the watershed more than others.

There are no known streamflow gaging stations on Sand Coulee Creek or its tributaries.

Streamflow usually follows a seasonal pattern with high discharges in the spring and low flows during fall and winter months. It is not unusual for surface flow in the main channel between Tracy and the Missouri River to be nonexistent during late fall and winter.

GEOLOGY

The Sand Coulee Creek Watershed is underlain by a thick sequence of sedimentary rocks. Many of these rocks are porous and will store and transmit ground water. The sedimentary rocks dip gently northward except in the upper watershed where they are folded upward and exposed in the foothills and flanks of the Little Belt Mountains. The high precipitation in this area serves as recharge for much of the ground water that is present in bedrock aquifers in the Sand Coulee Creek Watershed. The oldest formation exposed in the drainage is the Mission Canyon. It consists of thick layers of limestone and dolomite that outcrop near Stockett and south of Centerville. The upper layers of the Mission Canyon contain cavernous zones which store and transmit large quantities of ground water.

Overlaying the Mission Canyon formation is a massive sandstone known as the Swift Sandstone. This formation is exposed in Number Five Coulee, Cottonwood Creek, and Sand Coulee Creek near Centerville. The Swift varies in thickness from a few feet to 30-40 feet and will store and transmit small to moderate amounts of ground water.

The Morrison Formation consists of 120 to 180 feet of claystone, sandstone, and siltstone, and overlays the Swift Formation. The

Morrison outcrops along all major drainages in the area and, due to its low resistance to erosion, forms gentle slopes. Bituminous coal deposits in the Stockett-Sand Coulee area are found in the upper part of the Morrison Formation and are overlain by sandstone bedrock layers. These deposits have been extensively mined. The coal deposits in the watershed contain small pyrite (Ferric sulfide) nodules which oxidize and form sulfuric acid when exposed to oxygen and water. The coal seams, ranging from four to seven feet in thickness, were the principal producing horizons in the coal mines. The coal-bearing portion of the Morrison has a low permeability and acts as a barrier to ground water movement.

The Kootenai Formation overlays the Morrison. It consists of various alternate layers of sandstone, siltstone, mudstone, claystone, and limestone. In the Sand Coulee Creek drainage, the Kootenai has undergone considerable erosion and varies in thickness from zero to about 250 feet. These sandstone layers store and transmit large quantities of ground water. This formation is present at the ground surface in much of the drainage.

The deeply incised drainage system in the watershed has cut through and exposed several high-yielding ground water aquifers, leaving the water free to escape as springs. These springs furnish most of the base flow in Sand Coulee Creek and its major tributaries.

The presence of large amounts of ground water and extensive coal mine tunnels have resulted in a water quality problem in the lower Sand Coulee Creek Watershed. The sandstone strata that overlie the coal deposits emit ground water into mine workings where metallic sulfides are exposed to atmospheric oxygen. Sulfuric acid that has been produced is then leached out of the coal and is expelled from the mine as toxic acid mine water.

MINING HISTORY

There is evidence of over 100 coal mines in the area. The Nelson mine east of the town of Sand Coulee opened about 1880. It was the first mine in the area. The railroad to Sand Coulee was completed in 1888. The major portion of the coal was used for railroad locomotive fuel. Subsequently, a few major mines and many small mines were developed. The Cottonwood and Giffen were the largest mines in the area with reported productions of 1,800 and 6,000 tons per day, respectively. Shortly after World War II, all of the mines had closed, although some individuals mined coal for domestic use. At present, coal mining in the study area is not evident.

ACID MINE WATER

Approximately 25 miles of Sand Coulee Creek and its tributaries are seriously affected by acid mine drainage. Major streams in the study area show a yellow deposit or suspension. Such a stream passes through or near each community in the drainage area. Although acid flows from many sources in the watershed, Sand Coulee Fork contributes 75 percent of the acid load to Sand Coulee Creek, and Cottonwood Creek, 16 percent. The water quality of Sand Coulee

Creek deteriorates as it flows downstream. Acid stains appear along the channel all the way to the Missouri River.

Plant growth appears to be normal along the stream banks, but is not evident in many reaches of the stream bottom. Sediment deposits along the stream often contain acid in sufficient concentrations to cause burns on humans and animals.

During spring runoff, Sand Coulee Creek and Sand Coulee Fork often overflow low banks. Such areas are between the towns of Sand Coulee and Tracy. Where acid has been transported in quantities into flood plain areas, plant growth has been reduced or eliminated.

Water in Sand Coulee Creek downstream from Centerville is too toxic to be used for irrigation or stock water. Some benefit to cropland occurs during flooding when acid water is sufficiently diluted.

SOILS

The soils information in this report is confined to the flood plain and the adjacent terraces and alluvial fans. The soils of this survey area are mainly silty clay loam and clay loam in the surface layers; however, significant areas in the Johnson and Gibson Flats portion of the study area are silty clays. Most of these soils are underlain by deep valley fill of relatively slow permeability. The soils are mostly well drained and runoff is slow due to the broad areas of nearly level land. See Plates 3 and 5. Small areas along Sand Coulee Creek are moderately well drained. Slopes are nearly level to strongly sloping within the study area.

Soil boundaries and symbols are printed in red on the photomaps. Eighteen mapping units have been identified and detailed descriptions and interpretations are found in Appendix A.

SOURCES OF DATA

Basic data used in this study include U. S. Geological Survey (USGS) topographic maps, bench marks (BM), and streamflow records outside the watershed; U. S. Forest Service (USFS) maps; Cascade County road maps and plat maps; Cascade County Conservation District map; report to Montana Board of Health, "Acid Mine Waste Pollution Abatement, Sand Coulee Creek, Montana," by G. M. McArthur; and the Great Falls "Tribune." The photomaps are 1972 aerial photographs taken by the Montana State Highway Department. Soil data are taken from "Soil Survey of Cascade County Area, Montana."

Other physical data were obtained from locally available maps and engineering field surveys. Water surface profile determinations were made using available SCS Automatic Data Processing programs to establish elevation-discharge relationships. Flows for various frequency events were determined from a synthetic hydrologic analysis and correlated with a regional analysis of streamflow records available from gages outside the watershed.

The water surface profile elevation-discharge relationships were used to establish flood elevations for the various events at each surveyed cross section.

Engineering field surveys were made by SCS field crews. Flood lines were located between valley cross sections by stereoscopic interpretations, additional field surveys, and historical records of high water marks.

Water surface profile computations at bridges are based on present normal bridge openings. Consideration was not given to possible blockage of bridge openings by ice, sediment, or other debris nor any future enlargement. Flood plain filling and other encroachments also can affect the computed water surface profiles. Computations for this study considered only conditions in the flood plain at the time field surveys were made. Future flood plain and watershed development and modification will require revised water surface profile computations.

GIBSON FLATS

Gibson Flats is located in a depression on the flood plain and has a history of flooding problems. See Plates 5, 8, 11, 13, and 14. This floodwater comes from three sources: (1) local runoff, (2) overflow from Sand Coulee Creek near junction of Lyman Cutoff Road and Gibson Flats Road, and (3) "backup" from Sand Coulee Creek.

The local runoff problem is due to the lack of a drainage channel through the area. The area acts as a retarding reservoir discharging only when the runoff is sufficient to cause ponding to a depth that will force water to flow southward over a slight rise to Sand Coulee Creek. The contributing drainage area for Gibson Flats is 5,120 acres, of which 200 acres are urban development within the city limits of Great Falls. Runoff from developed areas discharges more storm water per acre than does farmland and grassland. See storm sewer outlet, Plate 9. At present, this area is less than five percent of the total drainage area. The frequency of flooding and the amount of runoff could increase with the continued construction of suburban homes, roads, highways, and additional subdivisions to the city of Great Falls.

The second source of flooding is high water from Sand Coulee Creek, which can enter Gibson Flats from the east. See Figure 1. Floodwater can overtop the Gibson Flats Road (E 1/2, Sec 27, T20, R4E) and reach levels which are sufficient to cause flows around the north side of the hill (SE 1/4, Sec 22, T20N, R4E) that is directly east of Gibson Flats. A low divide that exists on the flood plain east of the hill is only 0.5 feet above the low point on Gibson Flats Road. See page 37. County bridge No. 317 on the Gibson Flats Road consists of two 6-foot-diameter culverts. These culverts have an approximate capacity of 500 cubic feet per second. A storm of 10-year frequency or greater would exceed the capacity of these culverts.

The third source of flooding for Gibson Flats is backup water from Sand Coulee Creek. Most of the floodwater coming down Sand Coulee Creek remains on the north side of the railroad track after it flows over the Gibson Flats Road. Some of this water is then forced onto Gibson Flats because of the inadequate bridge capacity under the railroad and the channel restriction between the railroad and the hills to the north below the Gibson Flats outlet. Water normally flows out of Gibson Flats into Sand Coulee Creek. However, because of the extremely flat topography and bridge and channel restriction, water is "backed up" during high flood stages. See page 37. The lack of an adequate outlet in Gibson Flats has caused floodwater to remain ponded for several weeks in the past.

A combination of all three sources of flooding during a 100-year storm would cause water to reach depths of six feet in the Gibson Flats community.

Possible structural measures or combinations of measures that could alleviate flood problems for Gibson Flats include: (1) diking, (2) channeling, (3) pumping, (4) enlargement of culverts and bridges, or (5) urban relocation. Future development should be restricted pending the solution of flooding problems in this area.

PLATE 1

GREAT FALLS TRIBUNE PHOTO 4-6-66

Water levels are checked frequently as floodwaters threaten Tracy.

GREAT FALLS TRIBUNE PHOTO

GREAT FALLS TRIBUNE PHOTO

People stand helplessly by as Sand Coulee Creek becomes a small river separating them from homes and livestock. Rapid runoff from warm chinook winds created widespread flooding conditions.

PLATE 2

U. S. AIR FORCE PHOTO

Flooding at Fields--March 1969. New construction is occurring in many floodprone areas such as this one. Floodplain management is essential to reduce flood losses and unwise land use in hazardous areas.

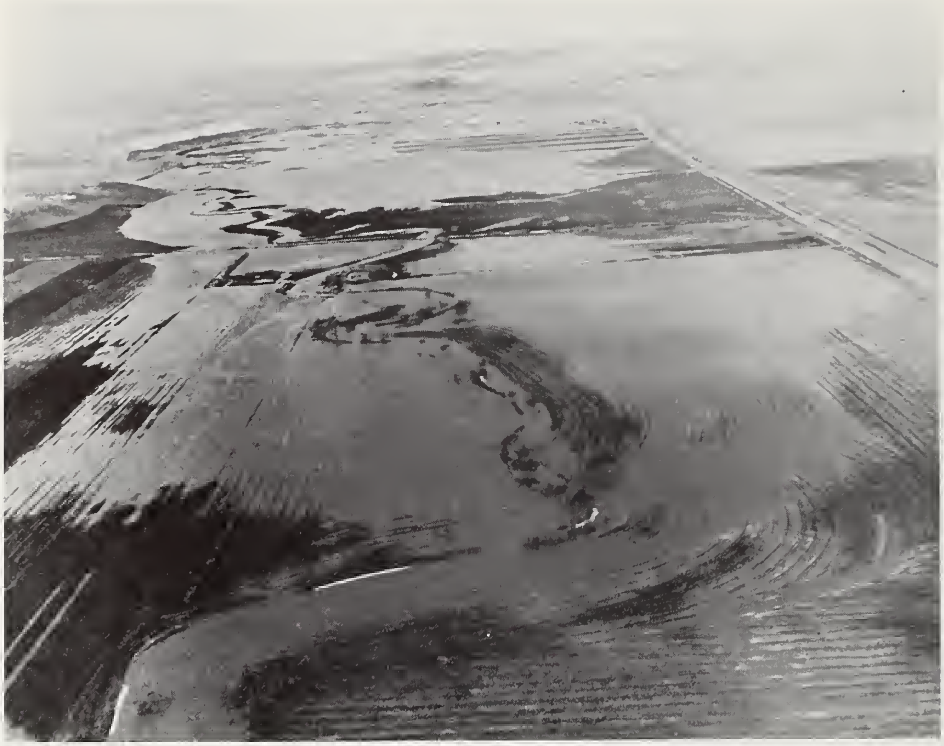
PLATE 3

U. S. AIR FORCE PHOTO - MARCH 11, 1966

Sand Coulee Creek spreads over bottom land east of Donovan Park and the lower reaches of the flood plain. This flooding was caused by warm chinook winds which rapidly melted the snow. This is the most common cause of flooding in the area.

U. S. AIR FORCE PHOTO - MARCH 11, 1966

PLATE 4



U. S. AIR FORCE PHOTO - MARCH 11, 1966

Top picture shows flooding west of Fields. Donovan Park is in the background. Note farm headquarters in center of photo. A closeup of this farmstead is shown below.

U. S. AIR FORCE PHOTO - MARCH 11, 1966

PLATE 5

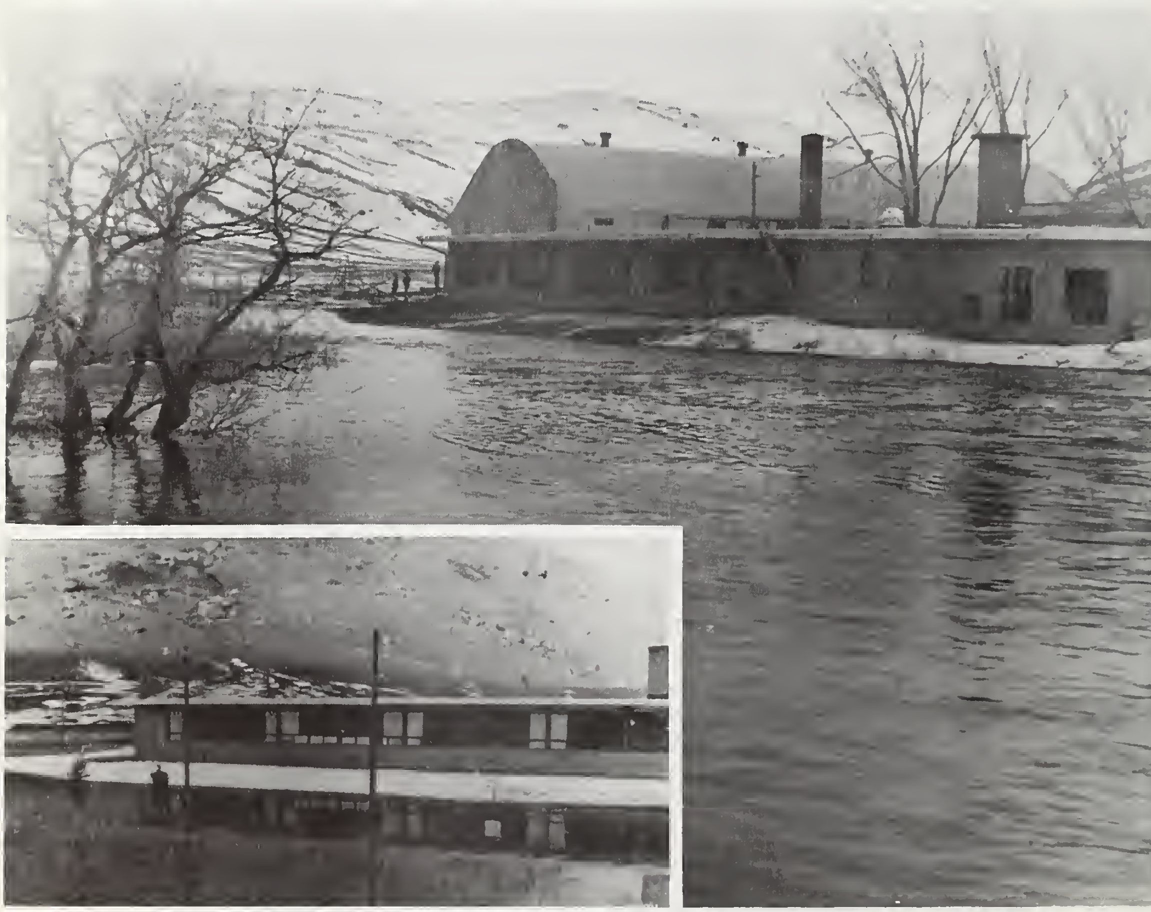
DE MIER PHOTO

Looking southwest at the community of Gibson Flats, March 18, 1969. The lake formed by melting snow had forced the evacuation of approximately one dozen families. This area remained inundated for more than six weeks. A need exists for urban flood protection measures as well as preventing future development in such hazardous areas.

PLATE 6

GREAT FALLS TRIBUNE PHOTO

Floodwater often threatens the Centerville School on Sand Coulee Creek as shown in April 1966. Water covered the football field and almost reached the school walls. All gullies gushed water as snow melted in the nearby Sand Coulee and Stockett areas.



GREAT FALLS TRIBUNE PHOTOS

PLATE 7

GREAT FALLS TRIBUNE PHOTO

The limp body of a cat hangs on a fence--a victim of the floodwaters that cascaded down Sand Coulee Creek from snowmelt March 18, 1969.

GREAT FALLS TRIBUNE PHOTO - 1969

Trash hangs in trees at Centerville as a reminder of high flood flows. Debris often plugs bridges and culverts, increasing flood damages.

GREAT FALLS TRIBUNE PHOTO - 1969

Floods create many problems and expenses to owners trying to protect and save property.

PLATE 9

Storm sewer discharging onto Gibson Flats from a residential area of Great Falls. Continued urban buildup could increase flood problems. Note the erosion and source of sediment.

SCS PHOTO

SCS PHOTO Mt-P1098-5

Several bridges and culverts are in need of maintenance to improve hydraulic capacity.

SCS PHOTO Mt-P1089-3

PLATE 10

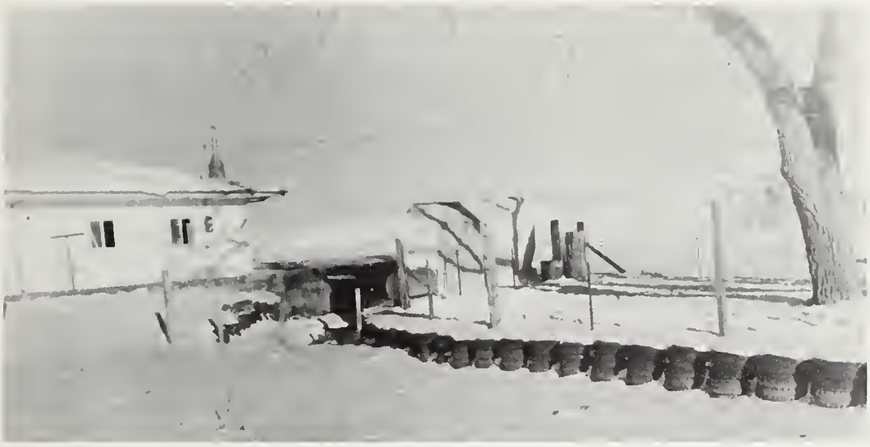
SCS PHOTO

Debris, filth, and pollution in the stream channel in the town of Sand Coulee. Sewage effluent from several homes in the residential area also discharges directly into the stream.

SCS PHOTO

Acid water flows from the entrance of an abandoned mine in the Giffen area. There are about 40 mines that discharge various amounts of acid water into Sand Coulee Creek.

PLATE 11



SCS PHOTO Mt-P1097-14

Floodproofing measures such as dikes and walls are not only expensive, but are often inadequate for large storms.

SCS PHOTO Mt-P1098-15

SCS PHOTO

STUDY RESULTS AND APPLICATION

This flood hazard study focused on developing information about the 100-year flood plain area in the Sand Coulee Creek Watershed. Much of the information is interrelated and specific data often may be obtained from this report in several ways. The data developed, including water surface profiles and delineated flood lines, are based on existing watershed cover, present flood plain use, and existing channel conditions.

Plates 12 to 15 show visually the depth of the 100-year frequency flood at specific locations. Following the plates are the Flood Hazard Area photomaps showing the area affected by the 100-year flood, the location of flood plain cross sections, and the soils delineations. Channel Bottom and Water Surface Profiles sheets and Typical Valley Cross Section sheets follow the photomaps. These sheets show the profile of the 100-year flood and shape of selected valley cross sections. See pages 26-39.

Appendix A contains descriptions and interpretations for the soils symbols shown on the aerial photomaps. Soils data correlate with flood plain information and can be used for land use planning.

Appendix B provides supplemental data and tables for: flood frequency discharges, elevations of various frequency floods, bridges and culverts, increased depth-remaining floodway widths, and information on bench marks.

For information about the estimated floodwater elevation at a specific location, refer to the aerial photomaps to determine where this location is relative to the nearest upstream and downstream surveyed cross sections. Interpolation is necessary between cross sections to arrive at an estimated floodwater elevation from flood plain reference data tables, Appendix B.

Another method to determine a floodwater elevation at a specific location is to estimate the channel station near the location in question from the stations shown on the maps. Next, find the location of that station on the profile sheets. Read the flood elevation directly from the sheet by going vertically from the station scale to the plotted floodwater line and then horizontally to read the elevation.

The preceding methods will give flood elevations on the flood plain for all sections except those footnoted in the flood plain reference data tables. The flood plain at the footnoted cross sections is lower than the main channel bank and is therefore subject to overland flow of varying depths. As Sand Coulee Creek flows beyond Tracy, the flood plain widens and becomes less definable. There are many old channels and meanders in the valley floor caused by natural and man-made channel changes. When the flow reaches flood stage, waters from the main channel overflow into these old side channels. This overflow water may run in these old side channels for a considerable distance before it rejoins the main channel. This flow causes "islands" or isolated areas in the flood plain.

The delineated areas subject to inundation on the photomaps are general in nature and may include small areas that do not flood or vice versa. See Plates 3 and 4.

Flooding conditions in Tracy, Sand Coulee, and Donovan Park differ from flooding in the open areas. The 100-year frequency flood profile, as shown on the channel bottom and water surface profiles and flood plain reference data, is based on computed data. These high water elevations are considered to be representative of flow levels near the stream channel and are estimated for flow levels one or more city blocks from the channel. As floodwater leaves the channel, it is divided and diverted by buildings, fences, and other obstacles. Because of shallow depths that prevail, these out-of-channel flows will generally follow along roads and streets. The water surfaces in these instances will vary from the published data for the cross section.

CONSIDERATIONS FOR LOCAL REGULATIONS

Flood damage prevention can only be achieved through proper recognition of the hazards associated with flood plain development. County commissioners and other responsible local officials should take the steps necessary to regulate and control structural development in the Sand Coulee Area. Zoning and subdivision regulations are two regulatory tools available to local officials to control and prevent unwise developments in flood prone areas. Comprehensive planning is a necessary prerequisite for zoning, and flood plain limitations are an important consideration for land use planning in the Sand Coulee area.

Land use regulation for the flood prone areas along Sand Coulee Creek should include the following provisions:

1. The 100-year flood area should be reserved for agricultural and other essentially open-space uses.
2. Residential and commercial uses should be located outside the 100-year flood area.
3. Minor structures, if permitted in flood prone areas, should be suitably anchored to prevent flotation.
4. No use should be allowed that increases the elevation of the 100-year flood more than 0.5 foot.

Table 12 indicates the amount the total flood area must be constricted to cause a 0.5-foot or 1.0-foot increase in flood elevation and can be used to estimate the effect of individual developments. This reduction in floodway width is based on equal reduction in the floodway conveyance factors on both sides of the channel.

A two-zone floodway-flood plain approach may be a desirable way to meet arguments that severe restrictions on the use of private property within the floodway "take" such property. A flood plain zoning approach which restricts the entire 100-year flood plain to only open space uses is vulnerable to such attack, particularly in urban areas with high land values. A two-zone approach which permits some flood-protected development in the outer fringe of the flood plain area, but severely restricts development only in inner floodway areas, is more likely to withstand such an attack.

If the designated flood plain is narrowed, adequate structural measures should be required. Narrowing of the designated flood plain will increase flood depths and damages to existing property within the remaining floodway area.

An alternate to be considered would be the acquisition of flowage easements along each bank of the stream. This procedure would allow the area to pursue a long-range program of channel improvements. Nonconforming uses would be eliminated, future encroachments prevented, and channel maintenance assumed as a county and town responsibility.

The impact of the acid mine water problem should be given special consideration in any land use regulations that are established for the flood plain. The presence of high concentrations of acid mine water in the stream would impose a severe limitation on the use of the land that would ordinarily be compatible with flood plain development.

The Montana Department of Natural Resources and Conservation will provide assistance to local officials considering zoning and/or subdivisions regulations to prevent flood damage.

CONTINUED OBSERVATIONS

The data presented in this report have been derived from a limited history of past flood events. Observation of future flood heights and flood quantities should be continued and the computed values checked and refined by these observations. The assistance of individuals in the flood plain is required in this future observation program. Local residents should be encouraged to make accurate observations, including photographs of flood heights on their properties. These data should be collected and reported to the local government units.

PLATE 12

SCS PHOTO 11-022-B-10

Depth of 100-year frequency flood over bridge 326 in Sand Coulee. (Valley Cross Section No. 95)

SCS PHOTO 11-022-B-9

Depth of 100-year frequency flood one block south of the Sand Coulee Post Office. (Valley Cross Section No. 90)

PLATE 13

SCS PHOTO 11-022-B-13

Depth of 100-year frequency flood at the road intersection of the Sand Coulee Road and Tracy Road near Tracy. (Valley Cross Section No. 45)

SCS PHOTO 11-022-B-6

Depth of 100-year frequency flood along Gibson Flats Road and Eaton Avenue-looking southeast.

PLATE 14

SCS PHOTO 11-022-B-7

Depth of 100-year frequency flood in Gibson Flats-looking north on Eaton Avenue.

SCS PHOTO 11-022-B-14

Depth of 100-year frequency flood at the first bridge east of Fields on Fields Road. (Valley Cross Section No. 18)

PLATE 15

SCS PHOTO 11-022-7

Depth of 100-year frequency flood at the bridge over Sand Coulee Creek on Ayrshire Dairy Road. (Valley Cross Section No.8)

SCS PHOTO 11-022-5

Depth of 100-year frequency flood at bridge on River Drive Road over Sand Coulee Creek. (Valley Cross Section No. 2)

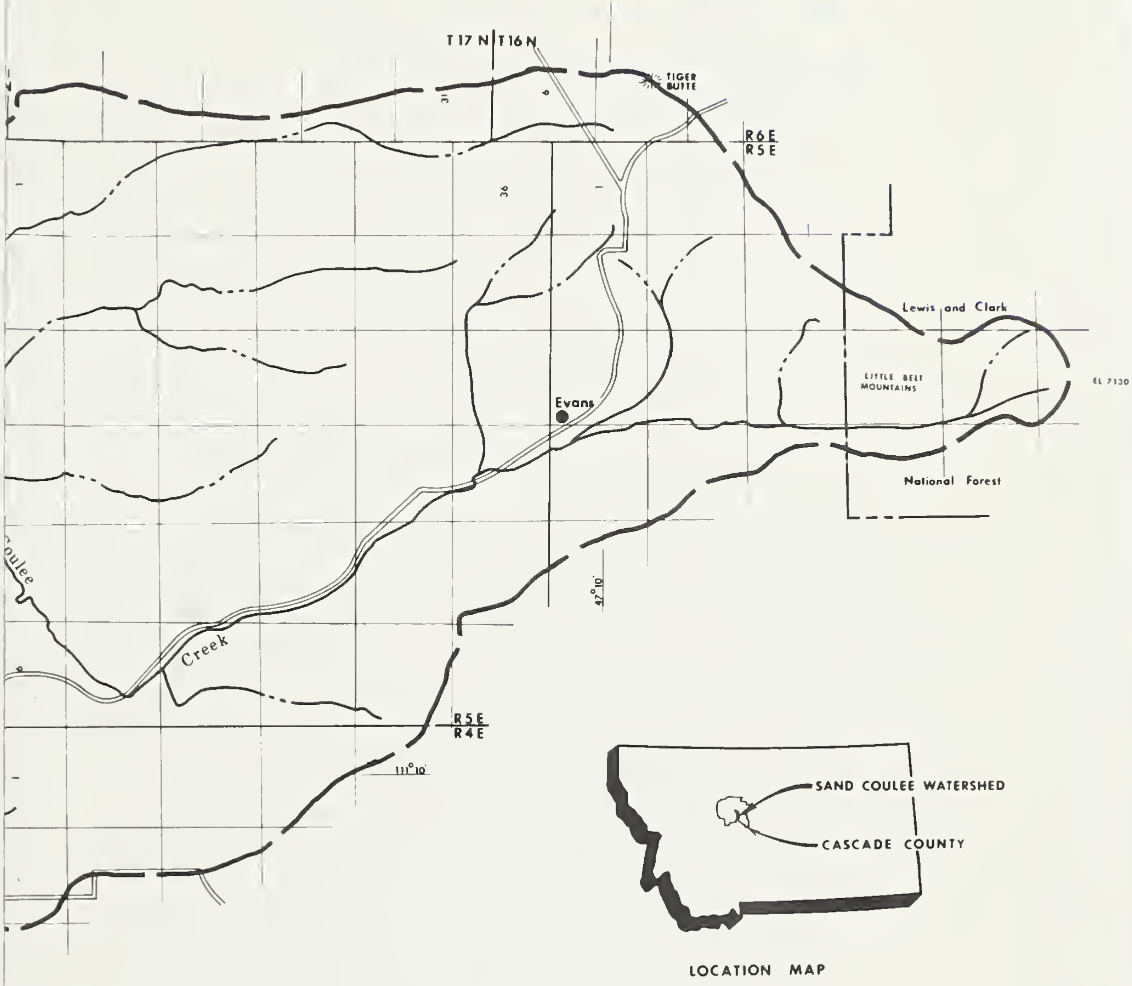


Figure 2

PHOTOMAP INDEX

SAND COULEE FLOOD HAZARD ANALYSES
CASCADE COUNTY, MONTANA

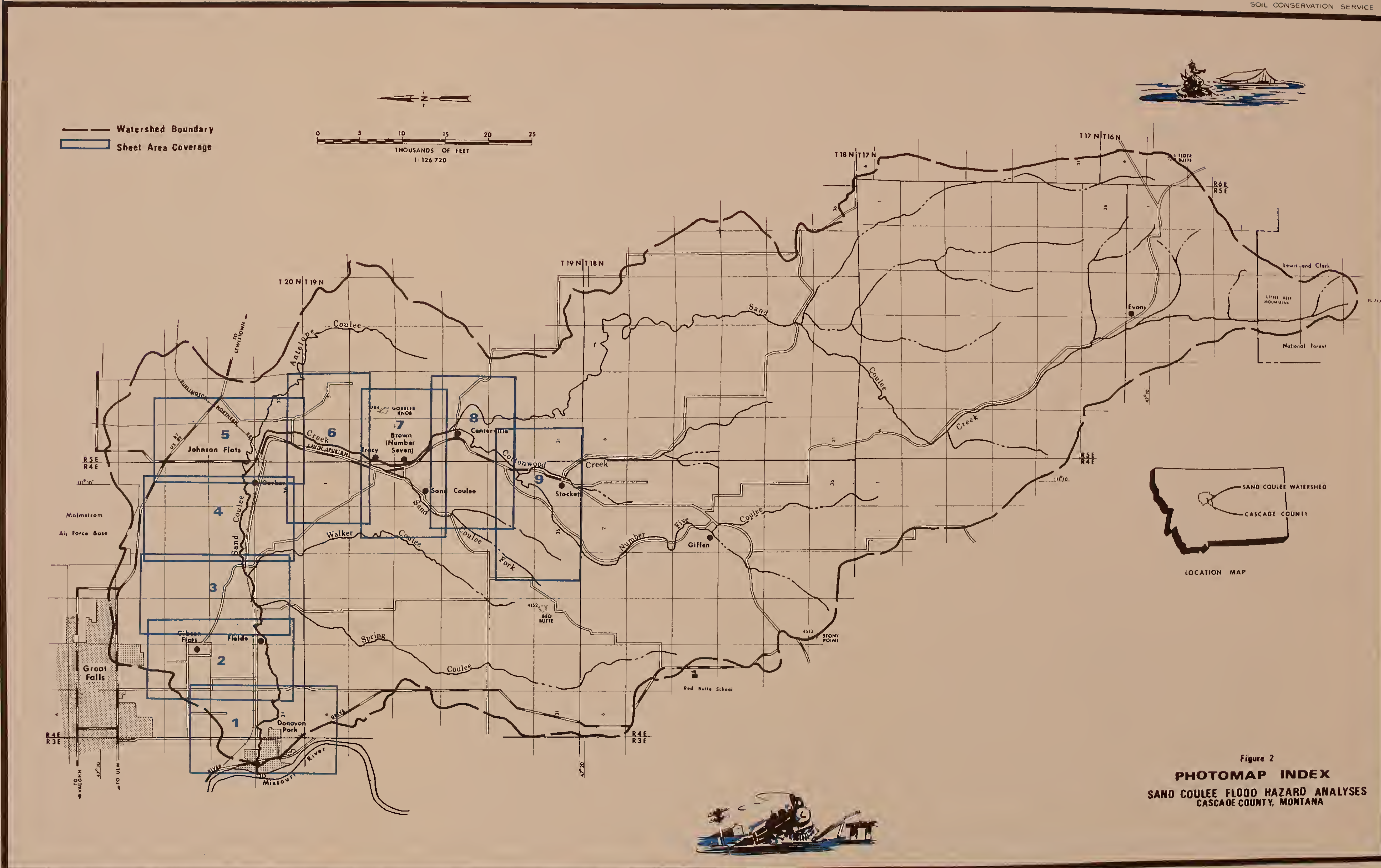
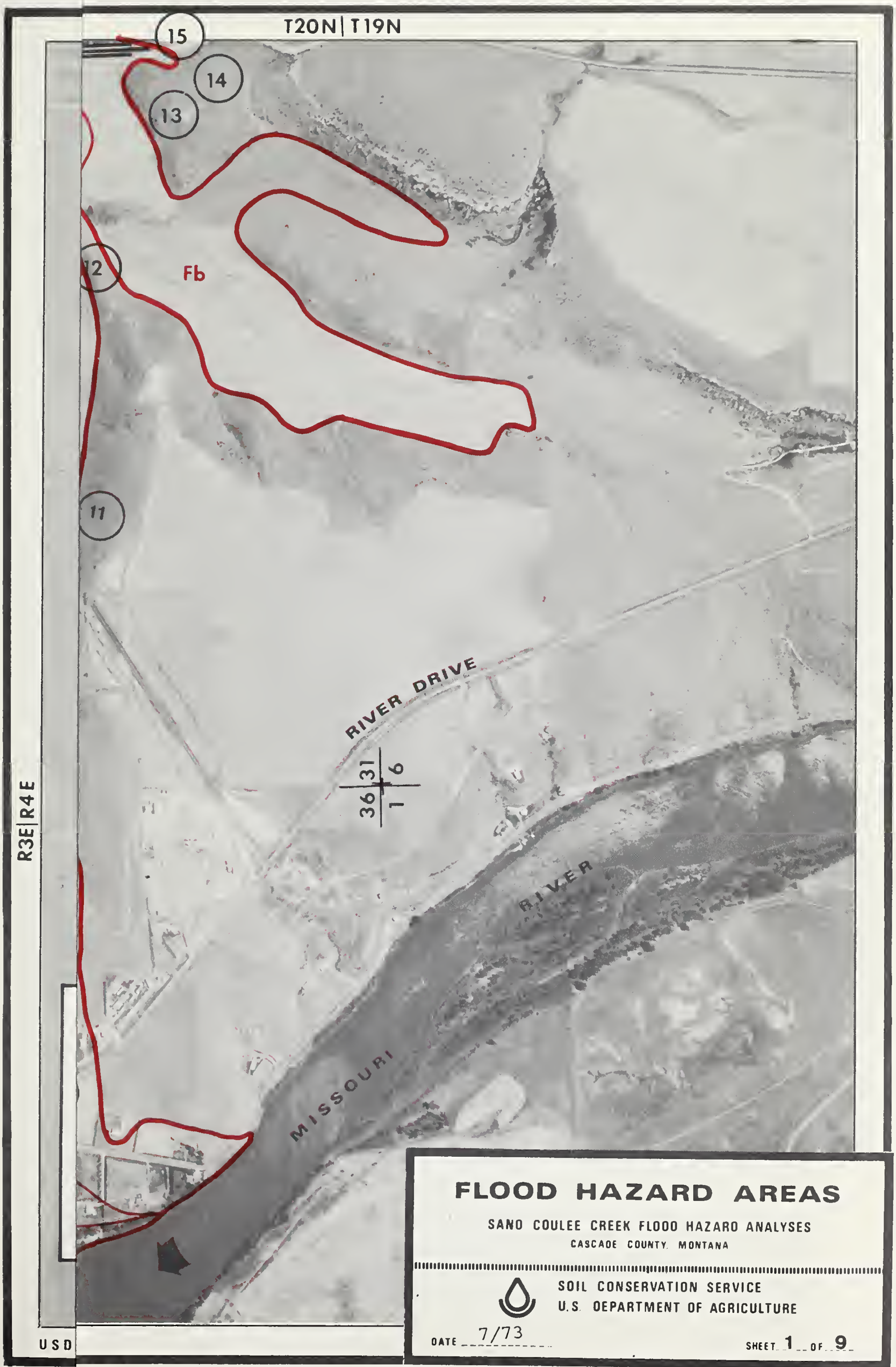


Figure 2
PHOTOMAP INDEX
SAND COULEE FLOOD HAZARD ANALYSES
CASCADE COUNTY, MONTANA



FLOOD HAZARD AREAS

SAND COULEE CREEK FLOOD HAZARD ANALYSES

CASCADE COUNTY, MONTANA

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

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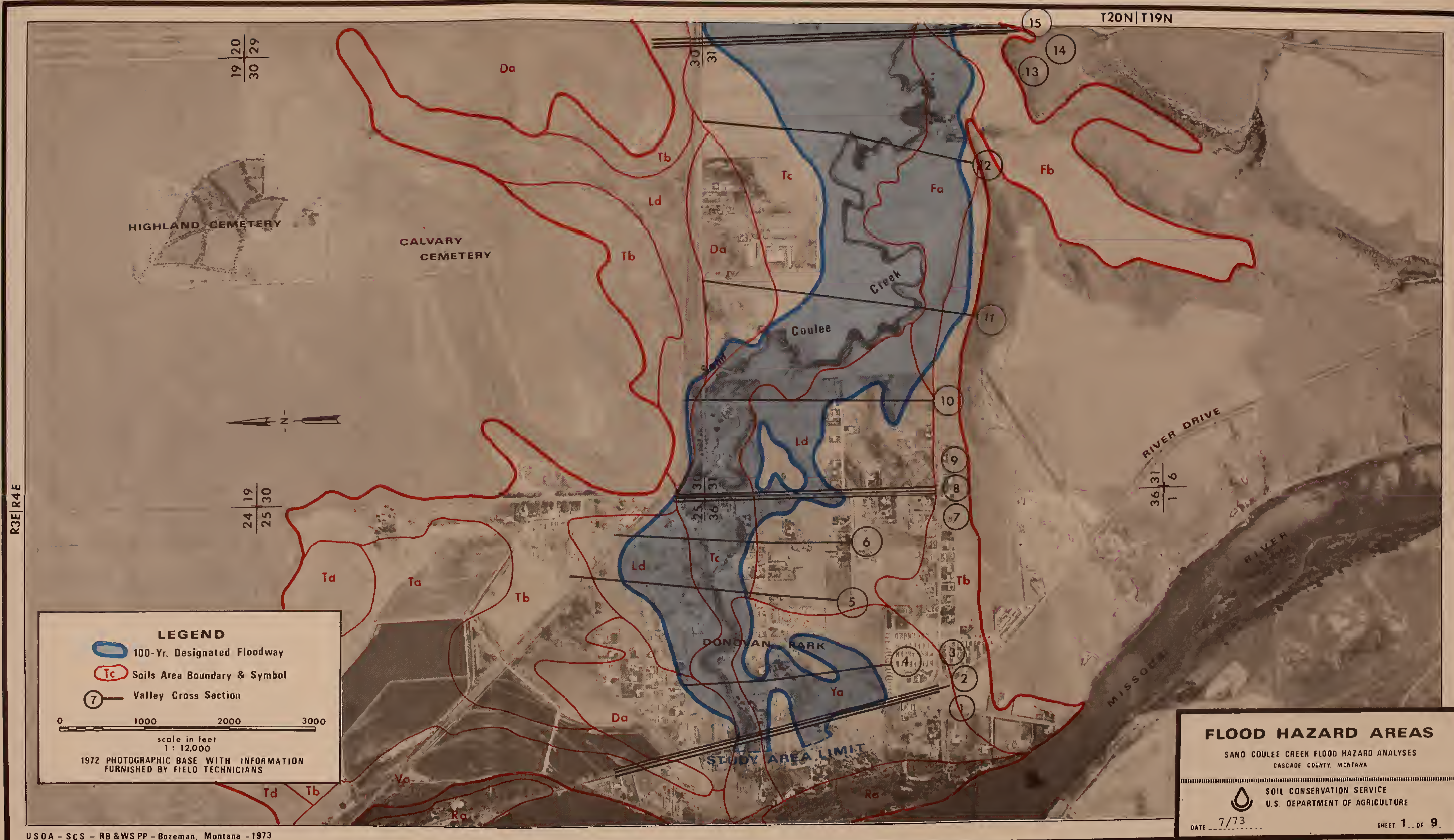
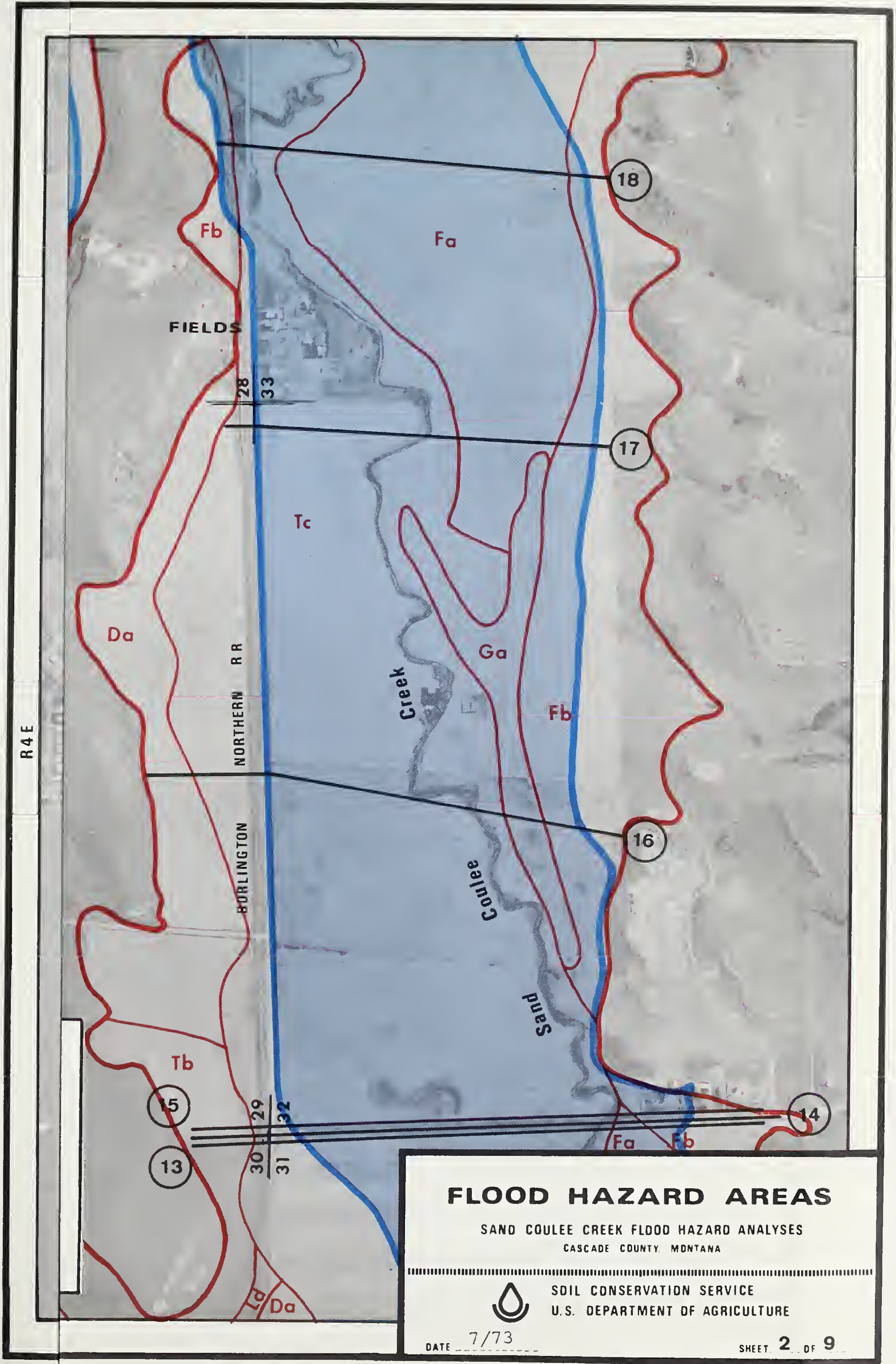

T20N | T19N
R3E | R4E
HIGHLAND CEMETERY
CALVARY CEMETERY
Sand Coulee Creek
DONOVAN PARK
STUDY AREA LIMIT
RIVER DRIVE
MISSOURI RIVER
Da
Tb
Ld
Tc
Fa
Fb
Ta
Td
Ya
Ra
LEGEND
100-Yr. Designated Floodway
Tc Soils Area Boundary & Symbol
7 Valley Cross Section
0 1000 2000 3000
scale in feet
1 : 12,000
1972 PHOTOGRAPHIC BASE WITH INFORMATION FURNISHED BY FIELD TECHNICIANS
FLOOD HAZARD AREAS
SAND COULEE CREEK FLOOD HAZARD ANALYSES
CASCADE COUNTY, MONTANA
SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE
DATE 7/73
SHEET 1 OF 9
USDA - SCS - RB & WS PP - Bozeman, Montana - 1973



FLOOD HAZARD AREAS

SAND COULEE CREEK FLOOD HAZARD ANALYSES
CASCADE COUNTY, MONTANA

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U.S. DEPARTMENT OF AGRICULTURE

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SHEET 2 OF 9

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FIELDS
Fb
Fa
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17
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Da
Ga
Fb
16
NORTHERN RR
BURLINGTON
Sand Coulee Creek
Tb
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LEGEND
100-Yr. Designated Floodway
Soils Area Boundary & Symbol
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scale in feet
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1972 PHOTOGRAPHIC BASE WITH INFORMATION FURNISHED BY FIELD TECHNICIANS
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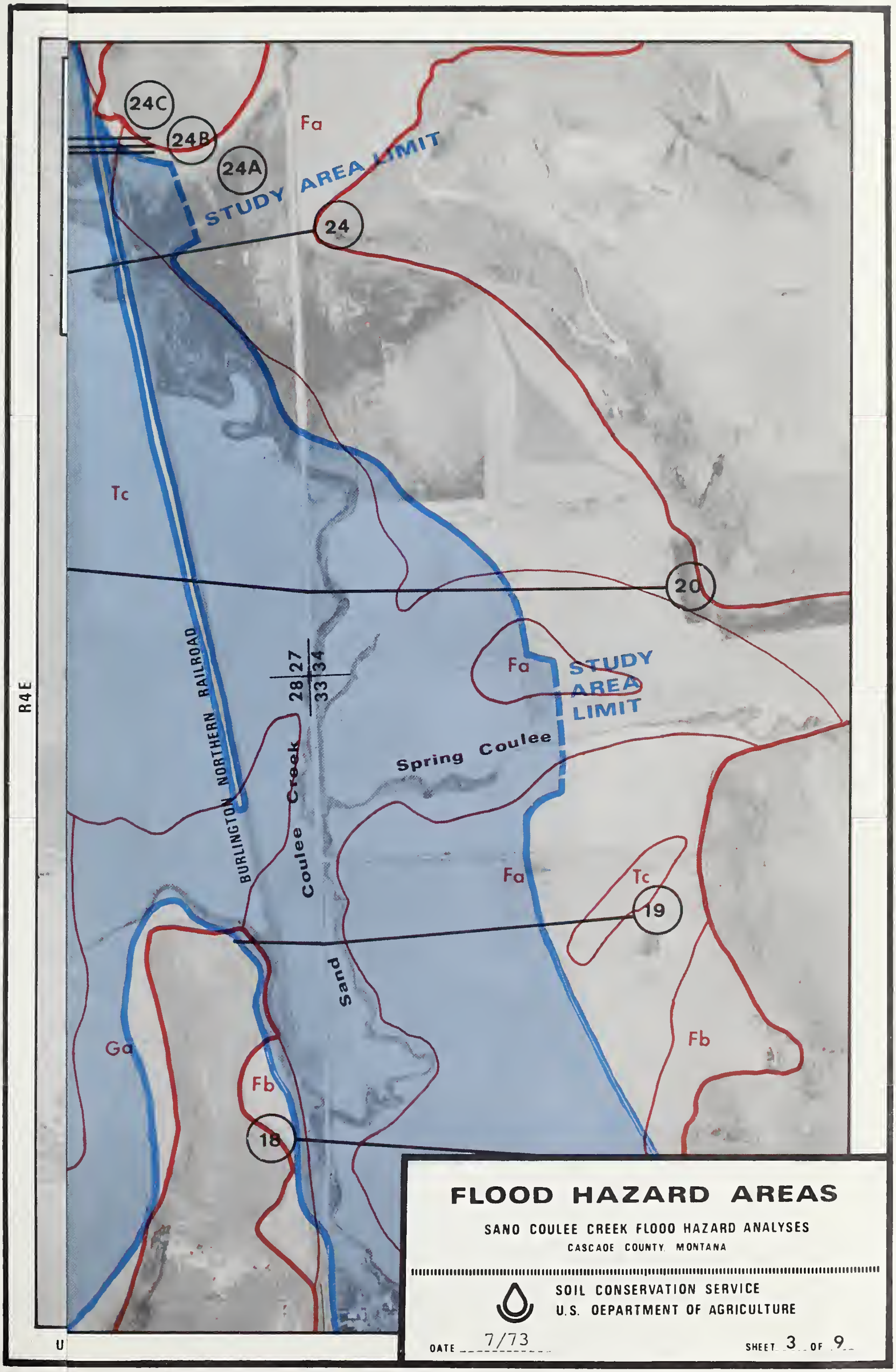
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Sand Coulee Creek
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FLOOD HAZARD AREAS
SANO COULEE CREEK FLOOO HAZARD ANALYSES
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T20N
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100-Yr. Designated Floodway
Fa Soils Area Boundary & Symbol
7 Valley Cross Section
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scale in feet
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1972 PHOTOGRAPHIC BASE WITH INFORMATION
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STUDY AREA LIMIT
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Spring Coulee
Sand Coulee Creek
BURLINGTON NORTHERN RAILROAD
Gibson Flats
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28 27 33 34
USDA - SCS - RB&WSPP - Bozeman, Montana - 1973
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CASCADE COUNTY, MONTANA
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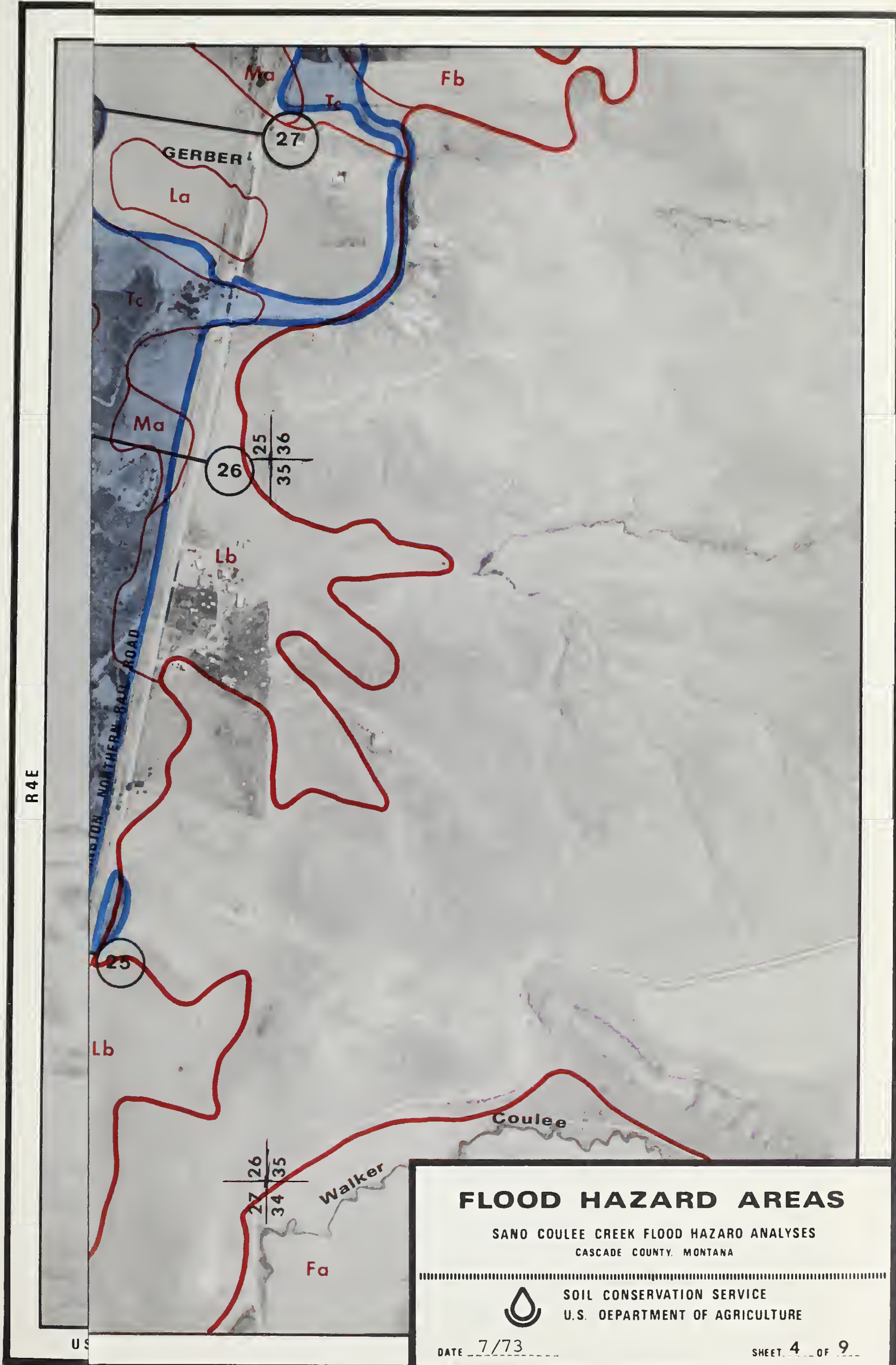

FLOOD HAZARD AREAS

SAND COULEE CREEK FLOOD HAZARD ANALYSES

CASCADE COUNTY, MONTANA

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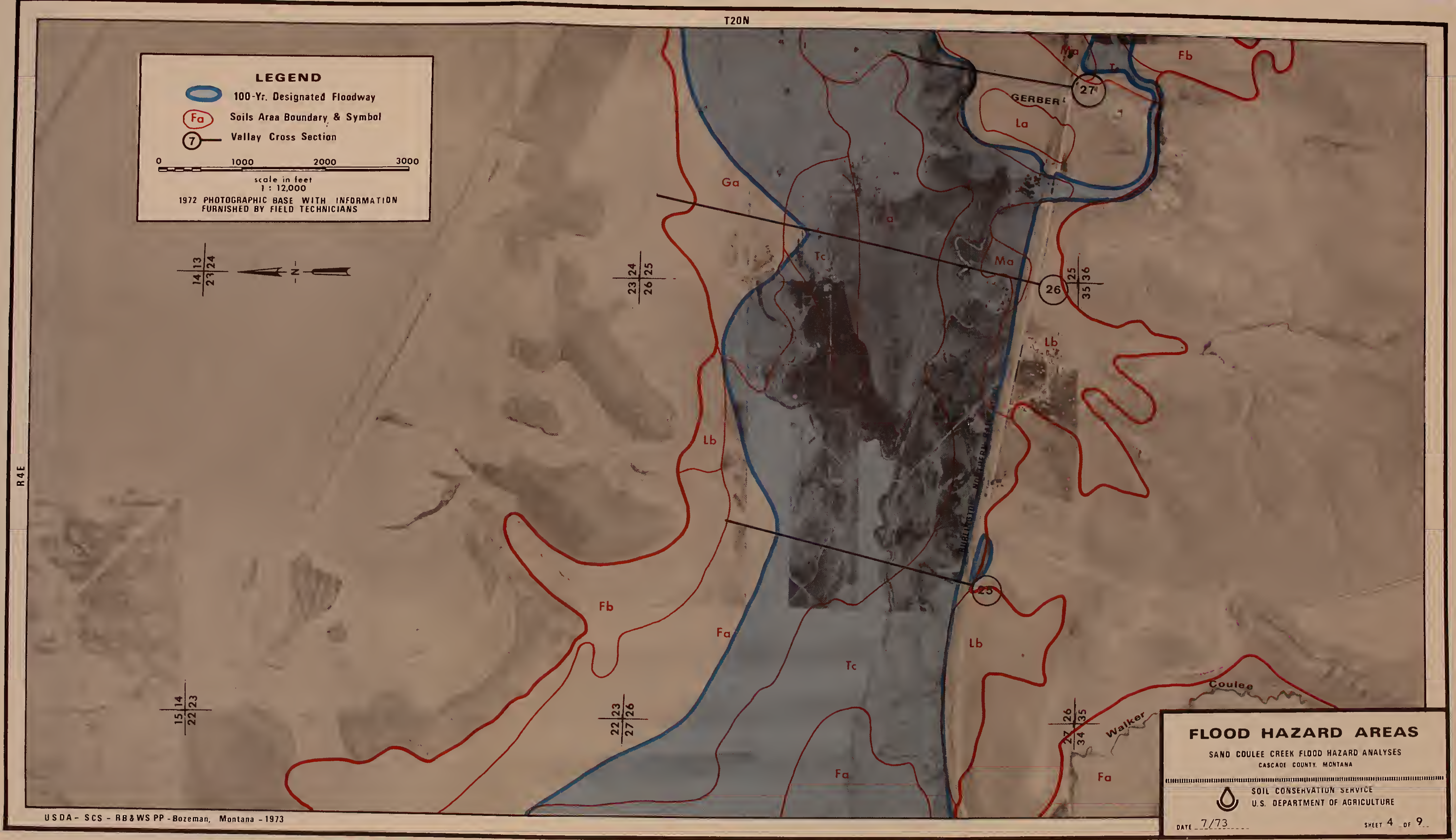
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scale in feet
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FLOOD HAZARD AREAS
SAND COULEE CREEK FLOOD HAZARD ANALYSES
CASCADE COUNTY, MONTANA
SOIL CONSERVATION SERVICE
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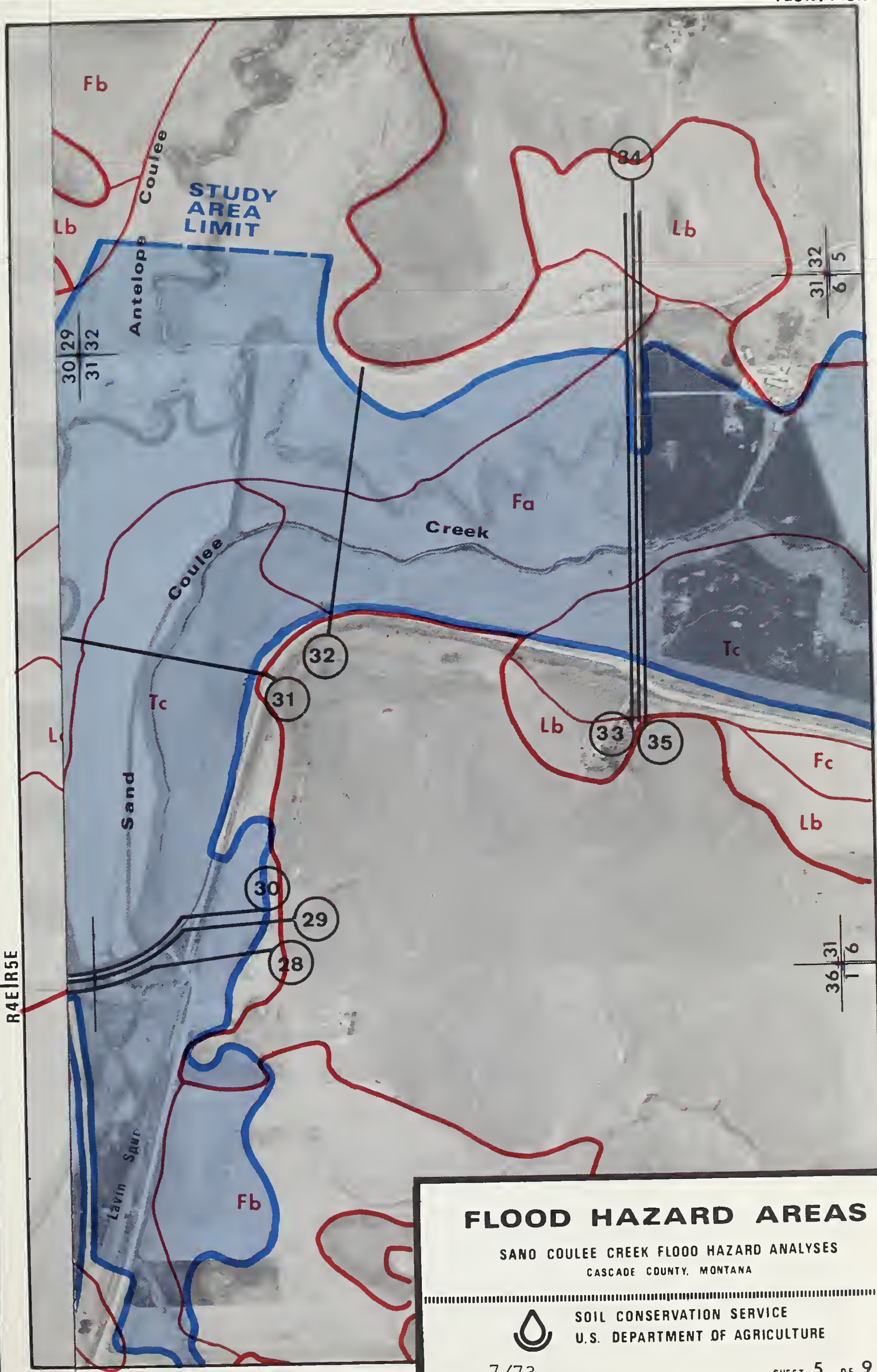

FLOOD HAZARD AREAS

SAND COULEE CREEK FLOOD HAZARD ANALYSES

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LEGEND
100-Yr. Designated Floodway
Soils Area Boundary & Symbol
Valley Cross Section
0 1000 2000 3000
scale in feet
1 : 12,000
1972 PHOTOGRAPHIC BASE WITH INFORMATION FURNISHED BY FIELD TECHNICIANS
USDA - SCS - RB&WS PP - Bozeman, Montana - 1973
T20N | T19N
R4E | R5E
STUDY AREA LIMIT
Burlington Northern Railroad
U.S. Highway 87-89
Johnson Flats
Antelope Coulee
Sand Coulee Creek
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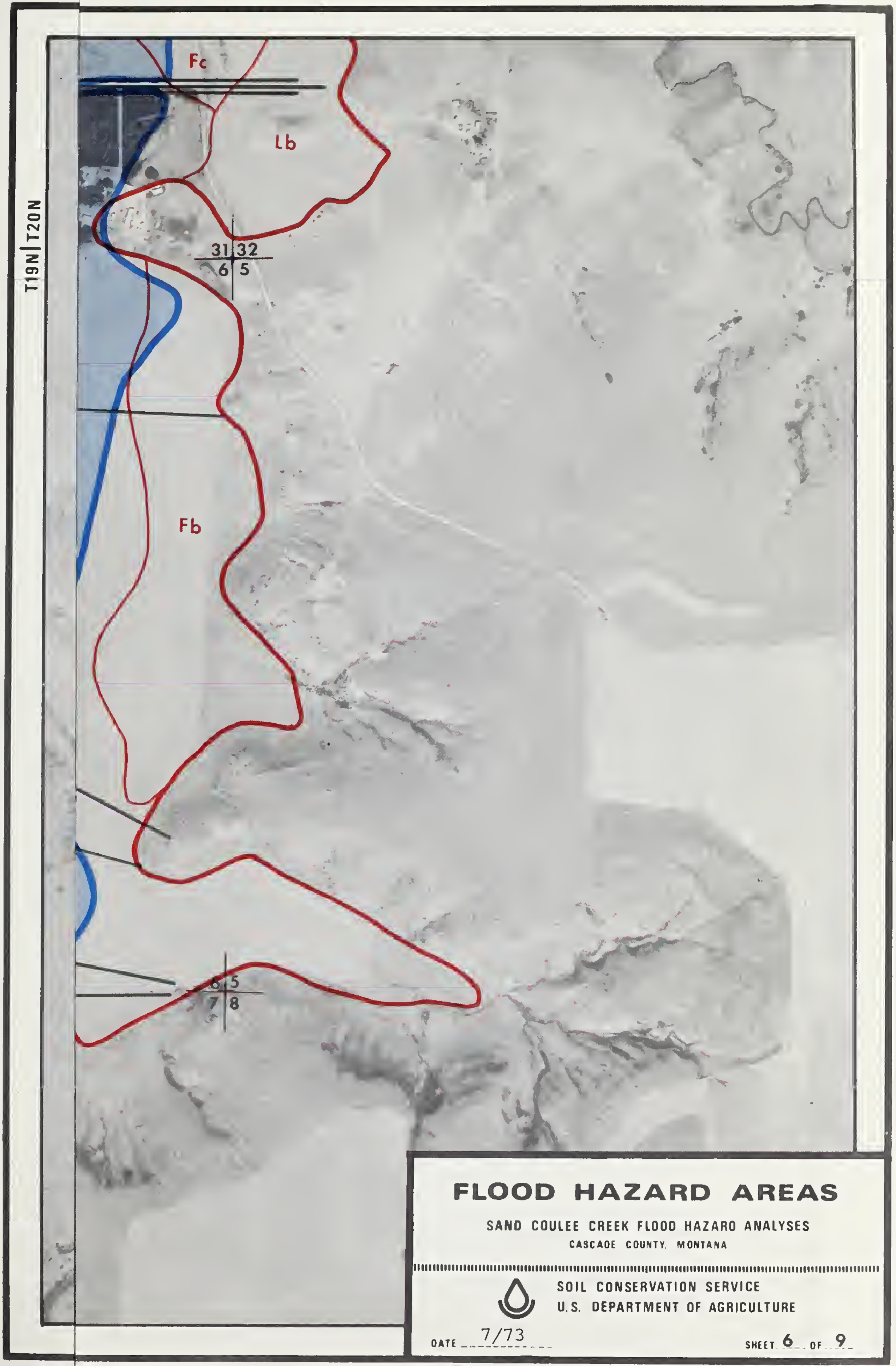

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R4E|R5E
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FLOOD HAZARD AREAS
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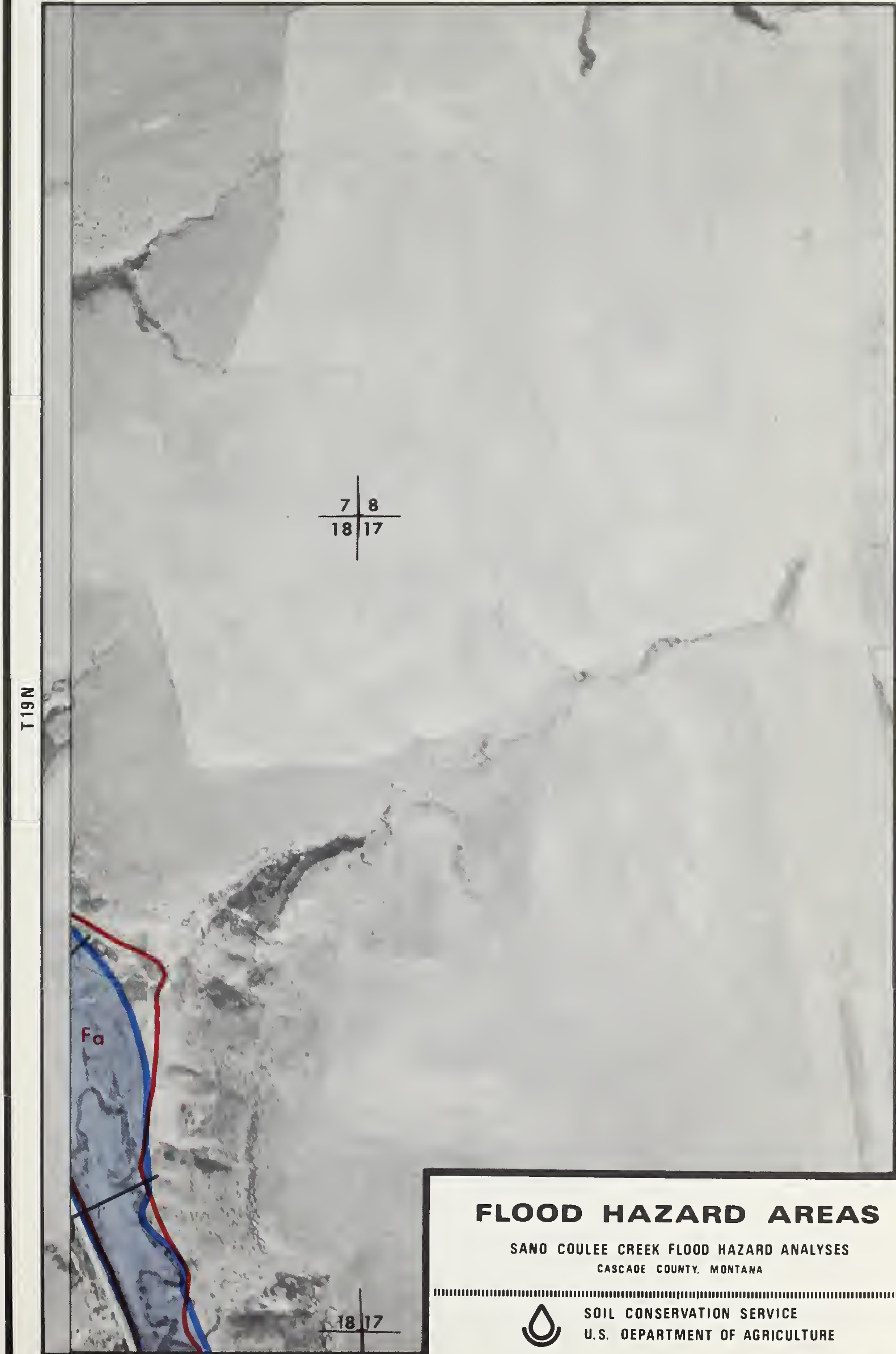

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SAND COULEE CREEK FLOOD HAZARD ANALYSES

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R4E | R5E
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100-Yr. Designated Floodway
Soils Area Boundary & Symbol
Valley Cross Section
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scale in feet
1 : 12,000
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NUMBER SEVEN
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Sand Coulee Fork
Sand Coulee Creek
T19N
STUDY AREA LIMIT
FLOOD HAZARD AREAS
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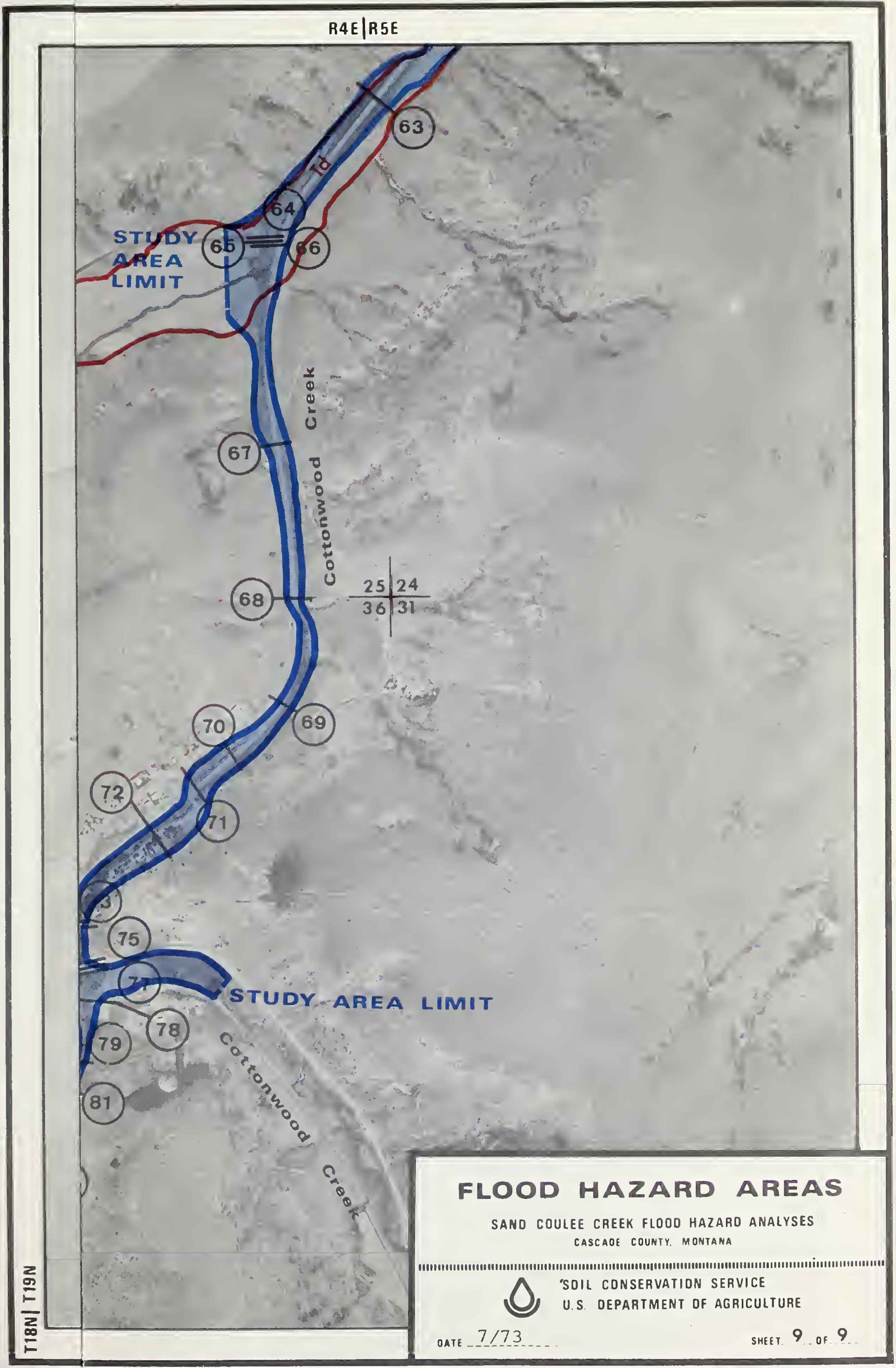

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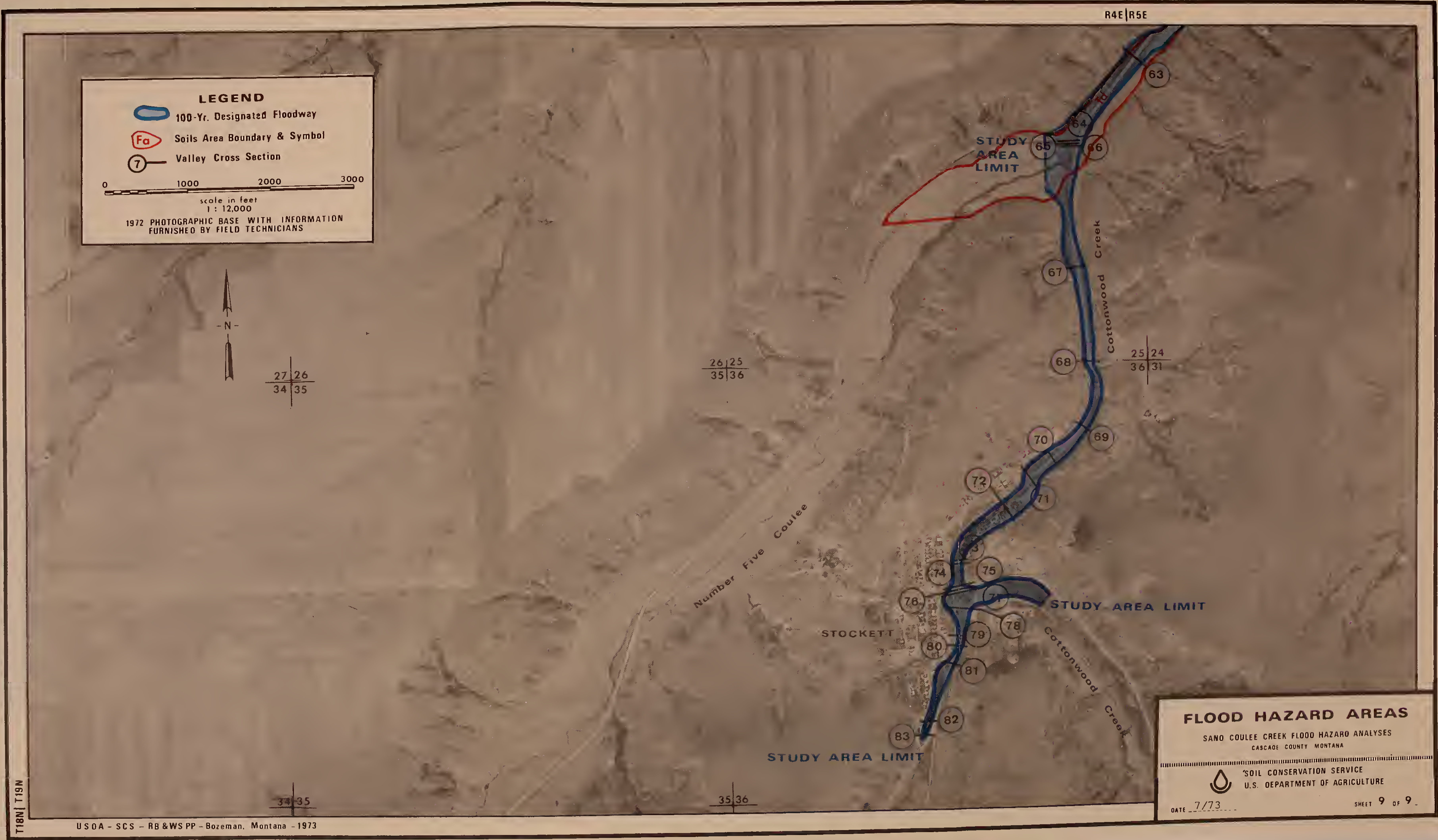

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Soils Area Boundary & Symbol
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scale in feet
1 : 12,000
1972 PHOTOGRAPHIC BASE WITH INFORMATION FURNISHED BY FIELD TECHNICIANS
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34|35
26|25
35|36
25|24
36|31
STUDY AREA LIMIT
Cottonwood Creek
Number Five Coulee
STOCKETT
STUDY AREA LIMIT
STUDY AREA LIMIT
63
64
65
66
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72
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80
81
82
83
34|35
35|36
T18N|T19N
FLOOD HAZARD AREAS
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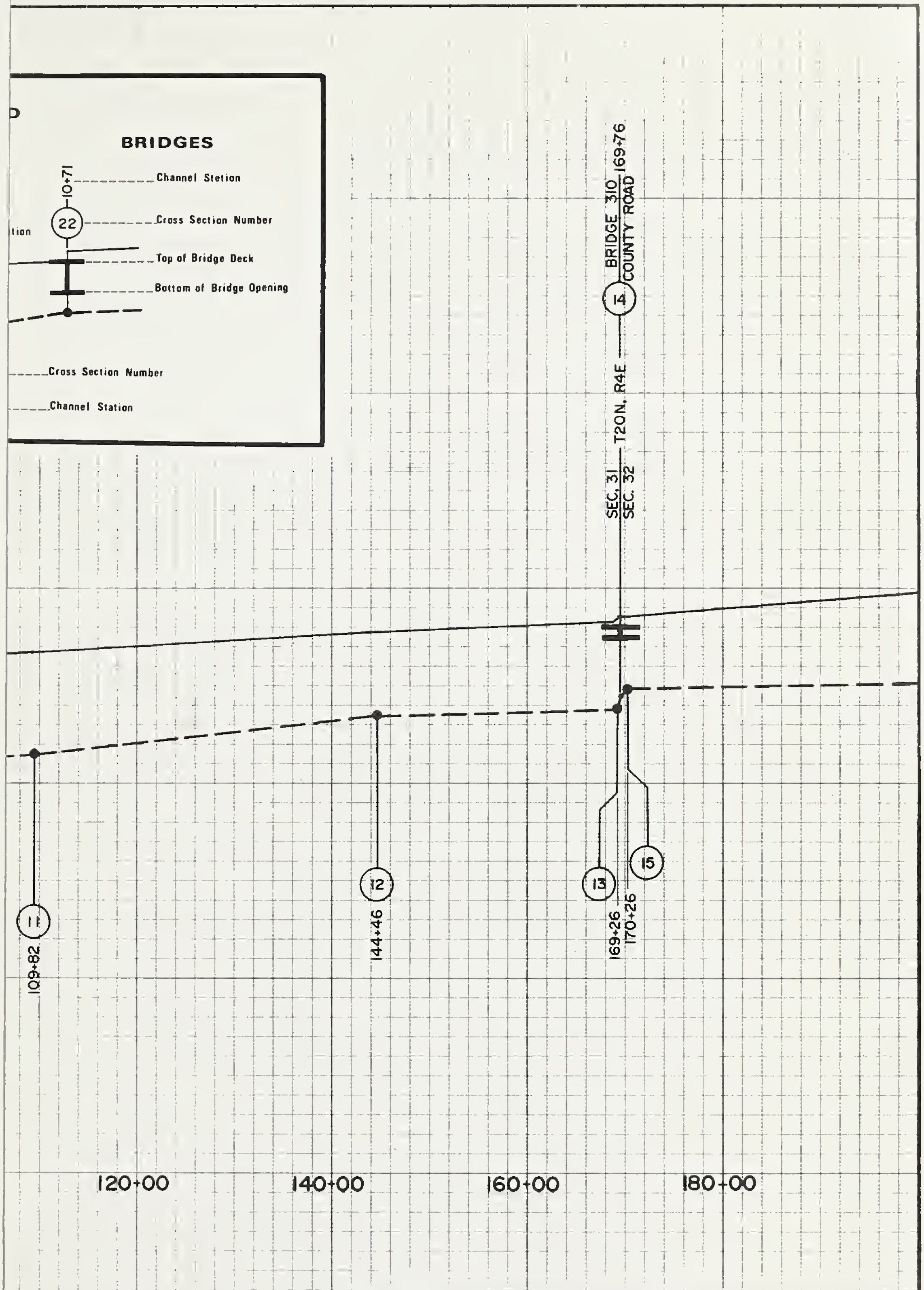
---ERRATA---

Channel Bottom and Water Surface Profile Sheets, Pages 26 - 36

Change Legend, Bridges, from "Bottom of Bridge Opening" to "Bottom of Bridge Deck."



CHANNEL BOTTOM AND WATER SURFACE PROFILE

SAND COULEE CREEK

SANO COULEE CREEK FLOOO HAZARO ANALYSES

CASCAOE COUNTY, MONTANA

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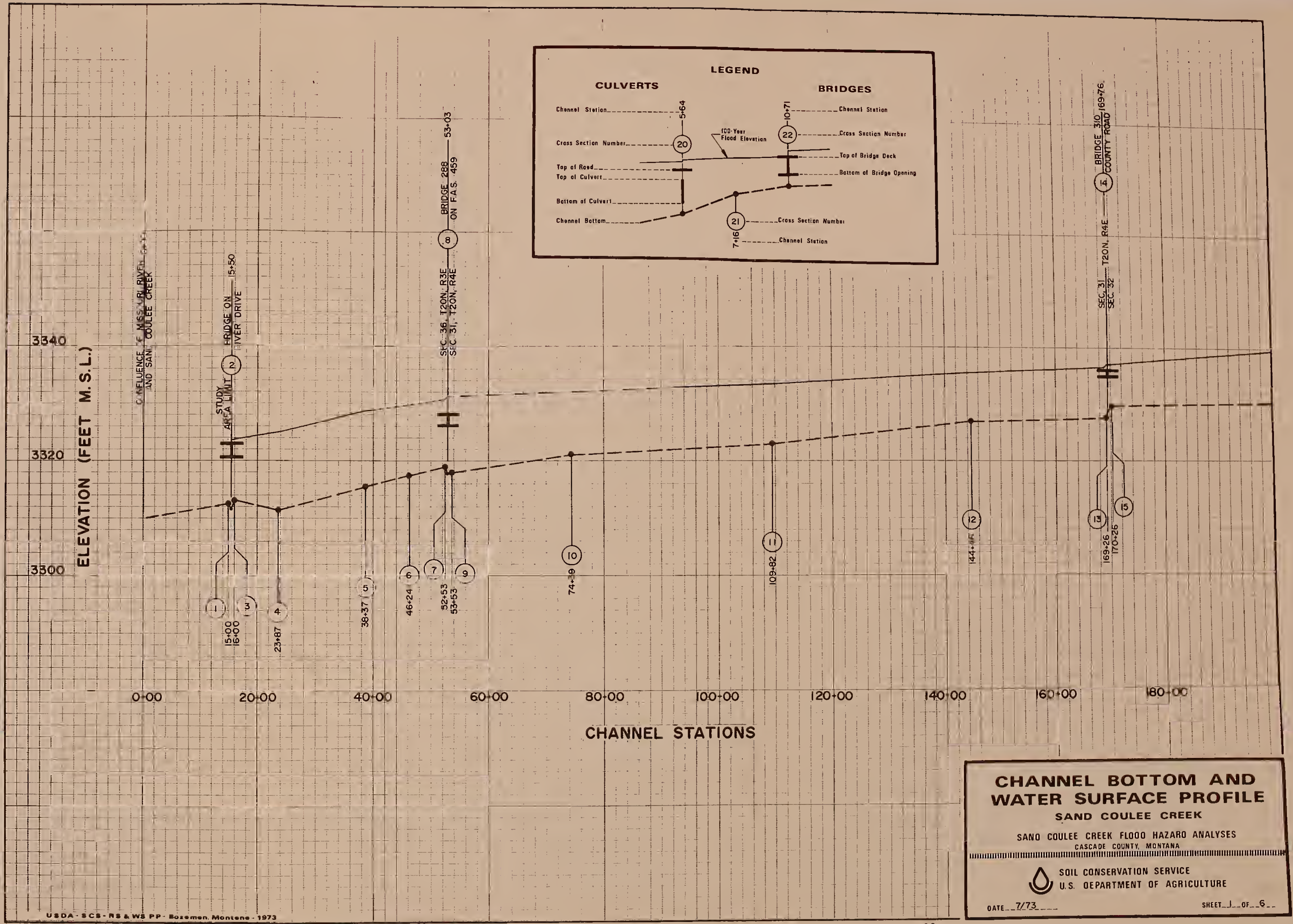
LEGEND
CULVERTS
BRIDGES
Channel Station
Cross Section Number
Top of Road
Top of Culvert
Bottom of Culvert
Channel Bottom
100-Year Flood Elevation
Top of Bridge Deck
Bottom of Bridge Opening
5+64
10+71
7+16
ELEVATION (FEET M.S.L.)
3340
3320
3300
CHANNEL STATIONS
0+00
20+00
40+00
60+00
80+00
100+00
120+00
140+00
160+00
180+00
STUDY AREA LIMIT
BRIDGE ON RIVER DRIVE
15+50
BRIDGE 288 ON F.A.S. 459
53+03
SEC. 36, T20N, R3E
SEC. 31, T20N, R4E
BRIDGE 310 COUNTY ROAD
169+76
SEC. 31
SEC. 32
T20N, R4E
15+00
16+00
23+87
38+37
46+24
52+53
53+53
74+39
109+82
169+26
170+26
CHANNEL BOTTOM AND WATER SURFACE PROFILE
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SAND COULEE CREEK FLOOD HAZARD ANALYSES
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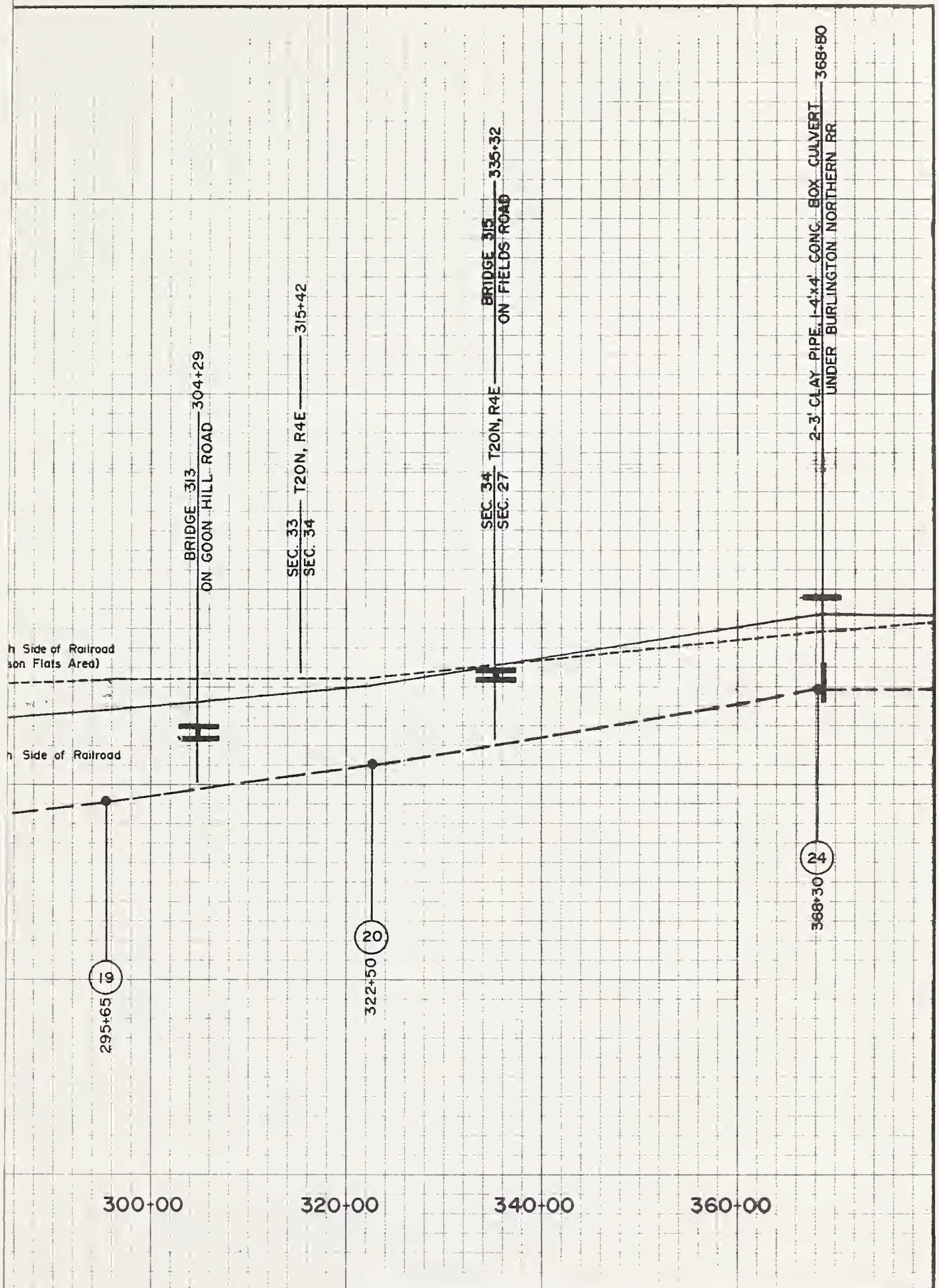

CHANNEL BOTTOM AND WATER SURFACE PROFILE

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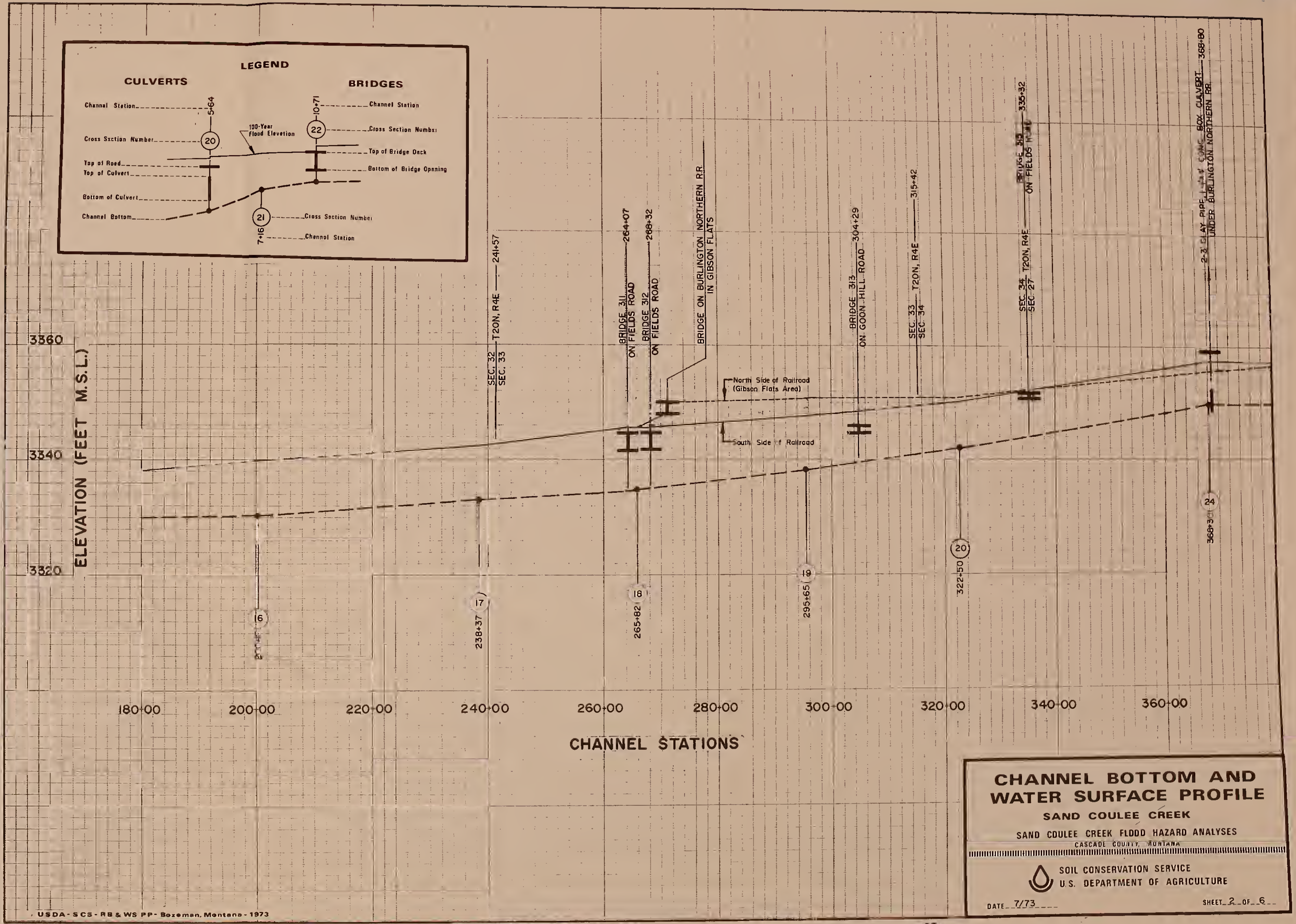
LEGEND
CULVERTS
BRIDGES
Channel Station
Cross Section Number
100-Year Flood Elevation
Top of Road
Top of Culvert
Bottom of Culvert
Channel Bottom
Top of Bridge Deck
Bottom of Bridge Opening
5+64
10+71
7+16
SEC. 32 SEC. 33 T20N, R4E 241+57
BRIDGE 311 ON FIELDS ROAD 264+07
BRIDGE 312 ON FIELDS ROAD 268+32
BRIDGE ON BURLINGTON NORTHERN R.R. IN GIBSON FLATS
North Side of Railroad (Gibson Flats Area)
South Side of Railroad
BRIDGE 313 ON GOON-HILL ROAD 304+29
SEC. 33 SEC. 34 T20N, R4E 315+42
SEC. 34 SEC. 27 T20N, R4E
ON FIELDS ROAD 335+32
UNDER BURLINGTON NORTHERN RR
BOX CULVERT 368+80
3360
3340
3320
ELEVATION (FEET M.S.L.)
238+37
265+82
295+65
322+50
368+30
180+00
200+00
220+00
240+00
260+00
280+00
300+00
320+00
340+00
360+00
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CHANNEL BOTTOM AND WATER SURFACE PROFILE
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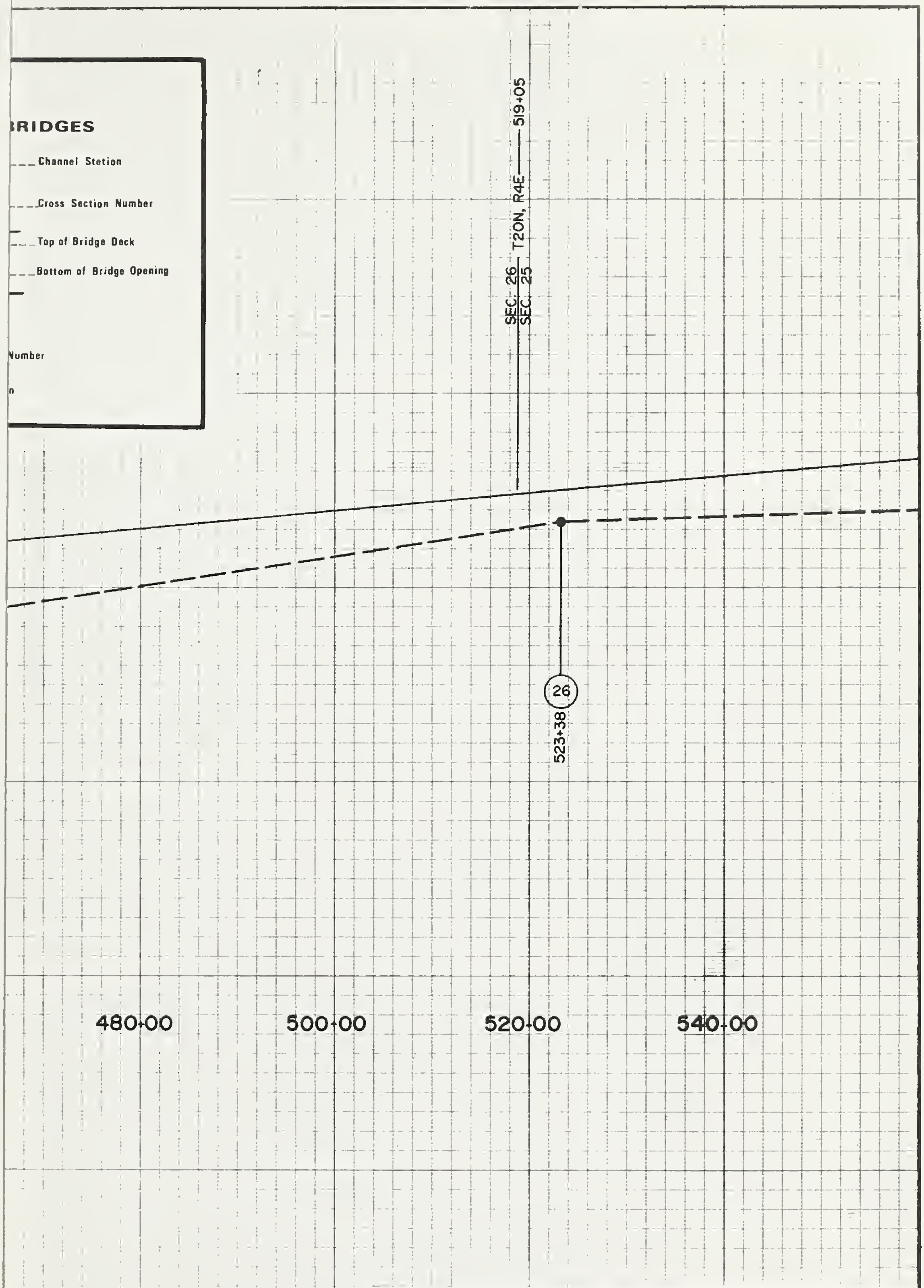

CHANNEL BOTTOM AND WATER SURFACE PROFILE

SAND COULEE CREEK

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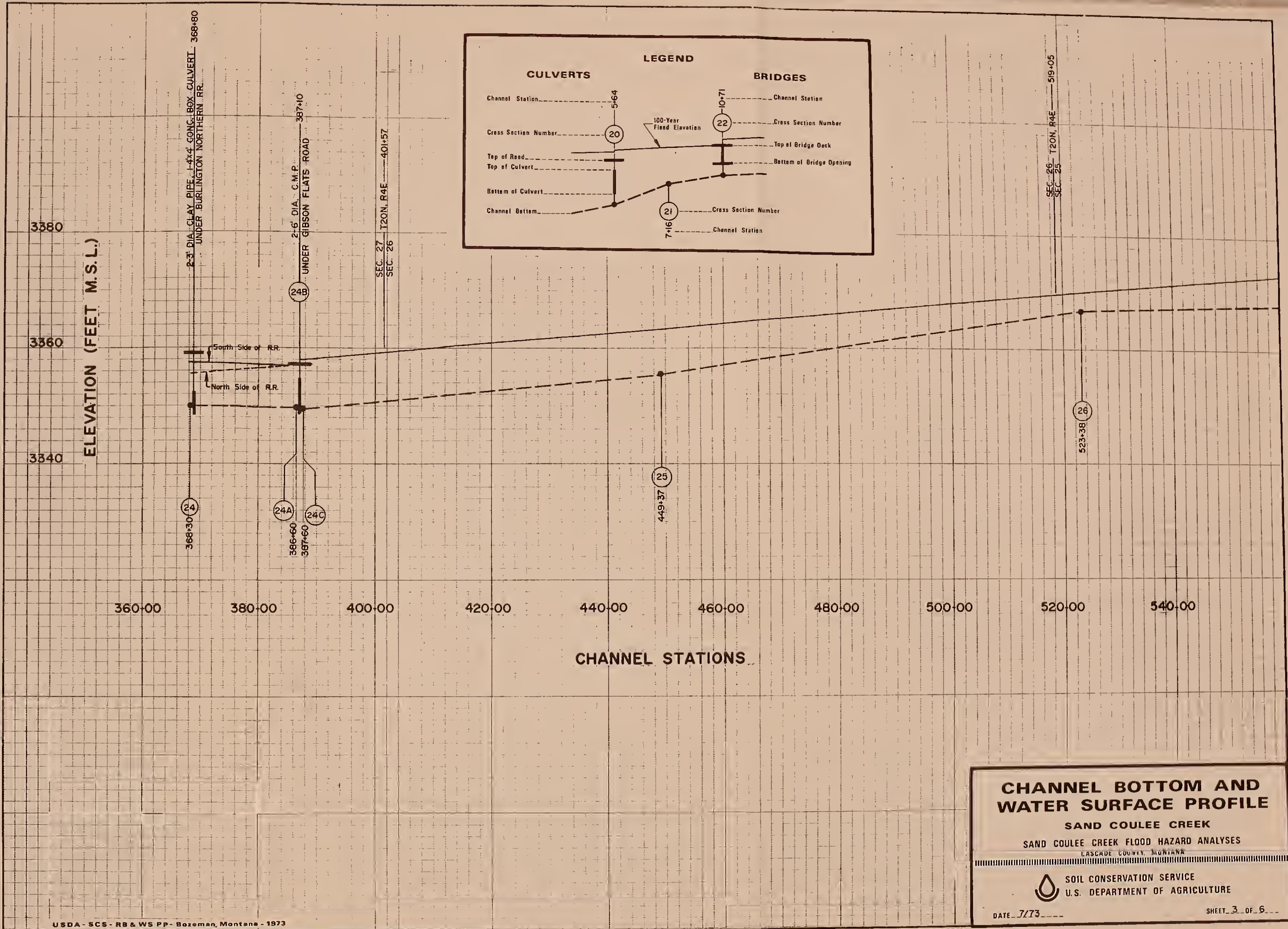

CHANNEL BOTTOM AND WATER SURFACE PROFILE

SAND COULEE CREEK

SAND COULEE CREEK FLOOD HAZARD ANALYSES

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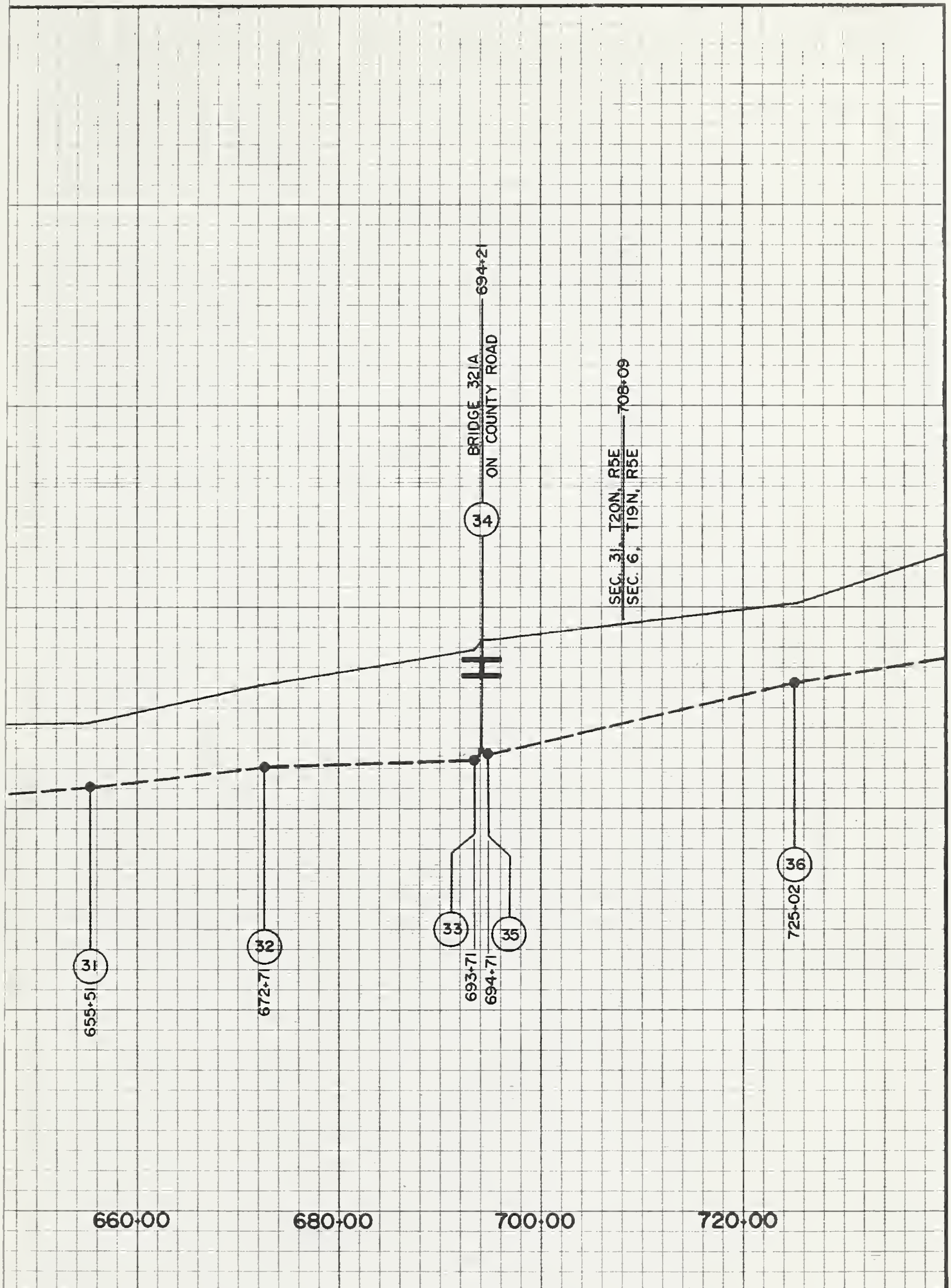

CHANNEL BOTTOM AND WATER SURFACE PROFILE

SAND COULEE CREEK

SANO COULEE CREEK FLOOO HAZARO ANALYSES

CASCADE COUNTY, MONTANA

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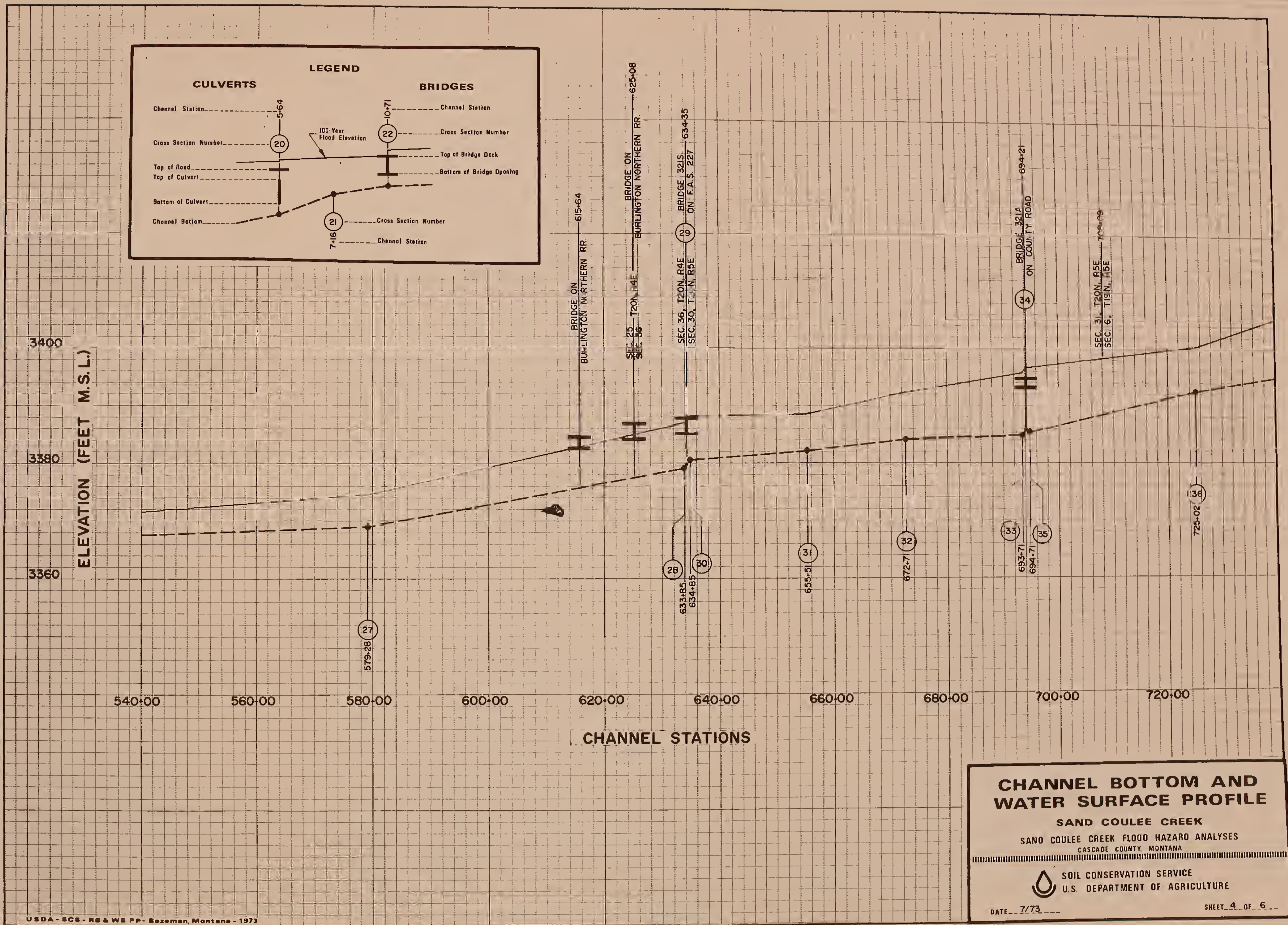
LEGEND
CULVERTS
BRIDGES
Channel Station
5+64
10+71
Cross Section Number
100-Year Flood Elevation
Top of Bridge Deck
Top of Road
Top of Culvert
Bottom of Bridge Opening
Bottom of Culvert
Channel Bottom
7+16
BRIDGE ON BURLINGTON NORTHERN RR.
615+64
625+08
SEC. 25, T20N, R4E
SEC. 36
BRIDGE 321S. ON F.A.S. 227
634+35
SEC. 36, T20N, R4E
SEC. 30, T20N, R5E
BRIDGE 321A ON COUNTY ROAD
694+21
SEC. 31, T20N, R5E
SEC. 6, T19N, R5E
3400
3380
3360
ELEVATION (FEET M.S.L.)
579+28
633+85
634+85
655+51
672+71
693+71
694+71
725+02
540+00
560+00
580+00
600+00
620+00
640+00
660+00
680+00
700+00
720+00
CHANNEL STATIONS
CHANNEL BOTTOM AND WATER SURFACE PROFILE
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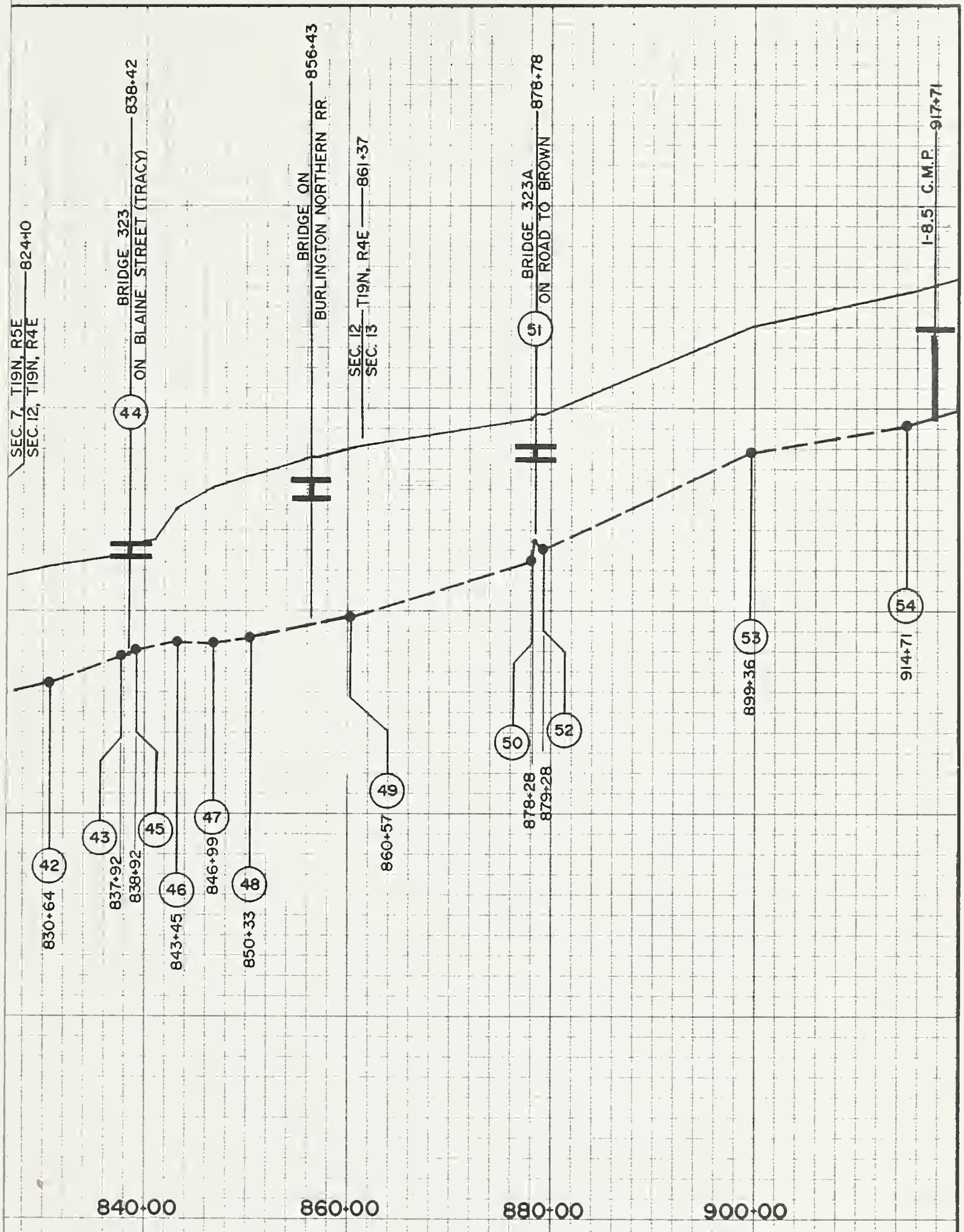

CHANNEL BOTTOM AND WATER SURFACE PROFILE

SAND COULEE CREEK

SAND COULEE CREEK FLOOD HAZARD ANALYSES

CASCADE COUNTY, MONTANA

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U.S. DEPARTMENT OF AGRICULTURE

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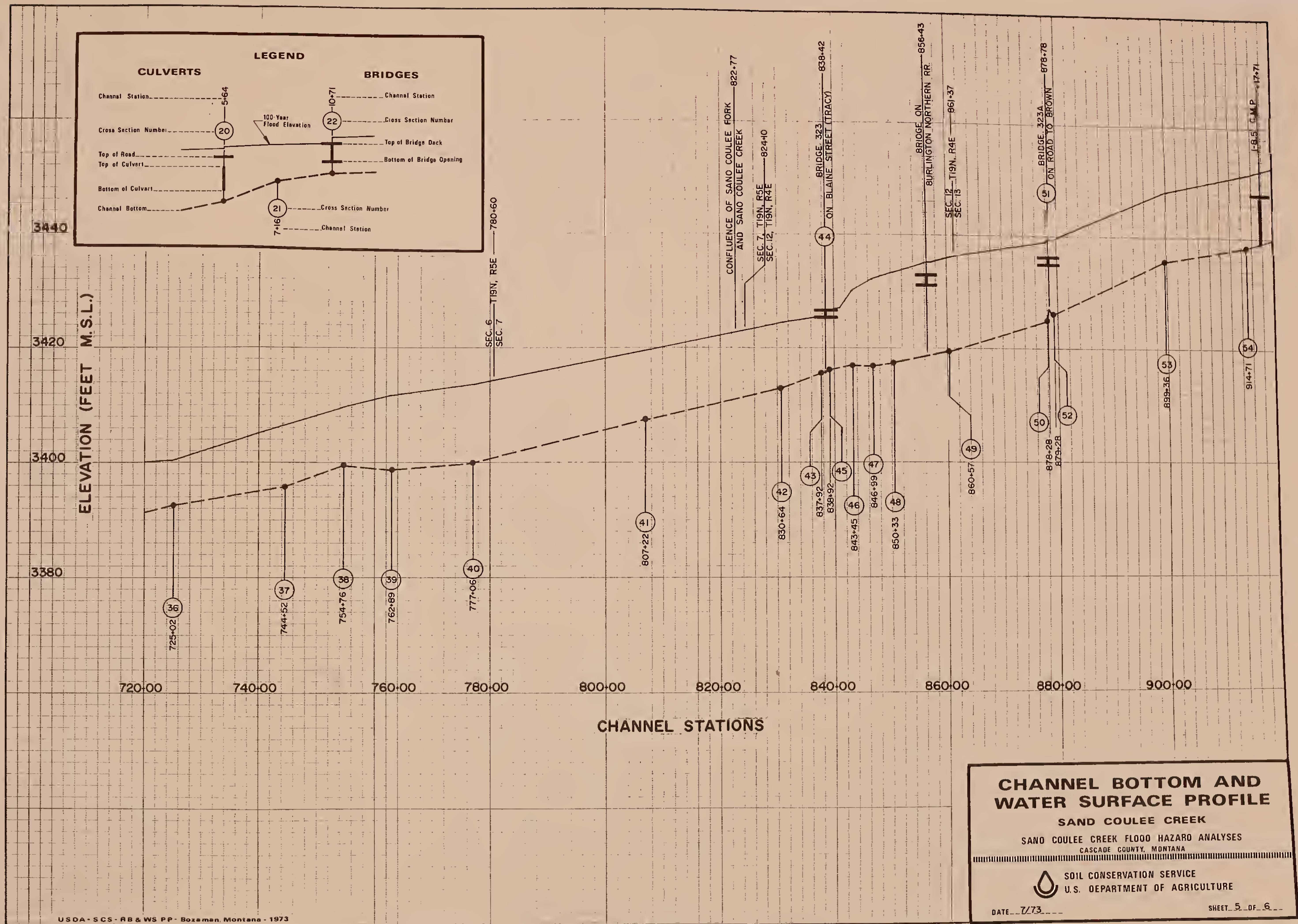

LEGEND
CULVERTS
BRIDGES
Channel Station
Cross Section Number
Top of Road
Top of Culvert
Bottom of Culvert
Channel Bottom
100-Year Flood Elevation
Top of Bridge Deck
Bottom of Bridge Opening
5+64
20
21
7+16
10+71
22
ELEVATION (FEET M.S.L.)
3440
3420
3400
3380
CHANNEL STATIONS
720+00
740+00
760+00
780+00
800+00
820+00
840+00
860+00
880+00
900+00
36 725+02
37 744+52
38 754+76
39 762+89
40 777+06
41 807+22
42 830+64
43 837+92
44 838+42
45 838+92
46 843+45
47 846+99
48 850+33
49 860+57
50 878+28
51 878+78
52 879+28
53 899+36
54 914+71
SEC. 6 SEC. 7 T19N, R5E 780+60
CONFLUENCE OF SAND COULEE FORK AND SAND COULEE CREEK 822+77
SEC. 7, T19N, R5E SEC. 12, T19N, R4E 824+10
BRIDGE 323 ON BLAINE STREET (TRACY) 838+42
BRIDGE ON BURLINGTON NORTHERN RR. 856+43
SEC. 12 SEC. 13 T19N, R4E 861+37
BRIDGE 323A ON ROAD TO BROWN 878+78
1-8.5 C.M.P. 917+71
CHANNEL BOTTOM AND WATER SURFACE PROFILE
SAND COULEE CREEK
SAND COULEE CREEK FLOOD HAZARD ANALYSES
CASCADE COUNTY, MONTANA
SOIL CONSERVATION SERVICE
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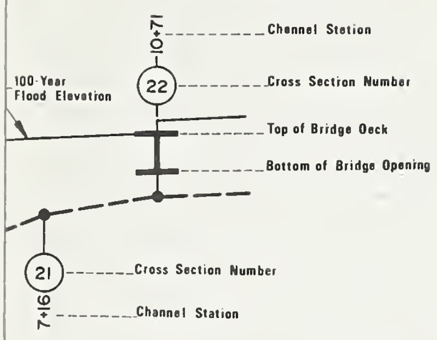
EGEND

BRIDGES



CHANNEL BOTTOM AND WATER SURFACE PROFILE

SAND COULEE CREEK

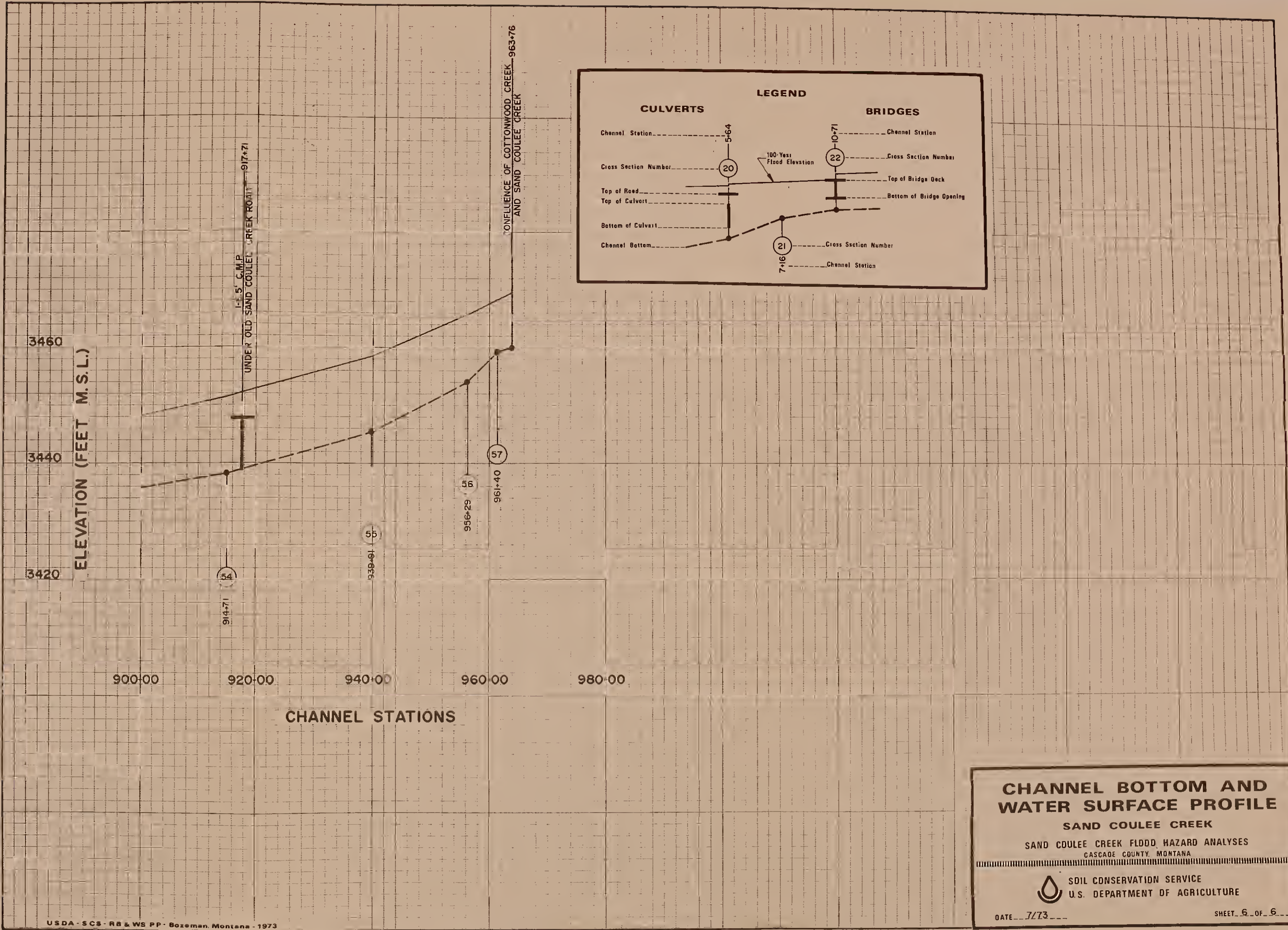
SANO COULEE CREEK FLOOO HAZARD ANALYSES

CASCAOE COUNTY, MONTANA

SOIL CONSERVATION SERVICE

U.S. OEPARTMENT OF AGRICULTURE

OATE 7/73 SHEET 6 OF 6



CHANNEL BOTTOM AND WATER SURFACE PROFILE

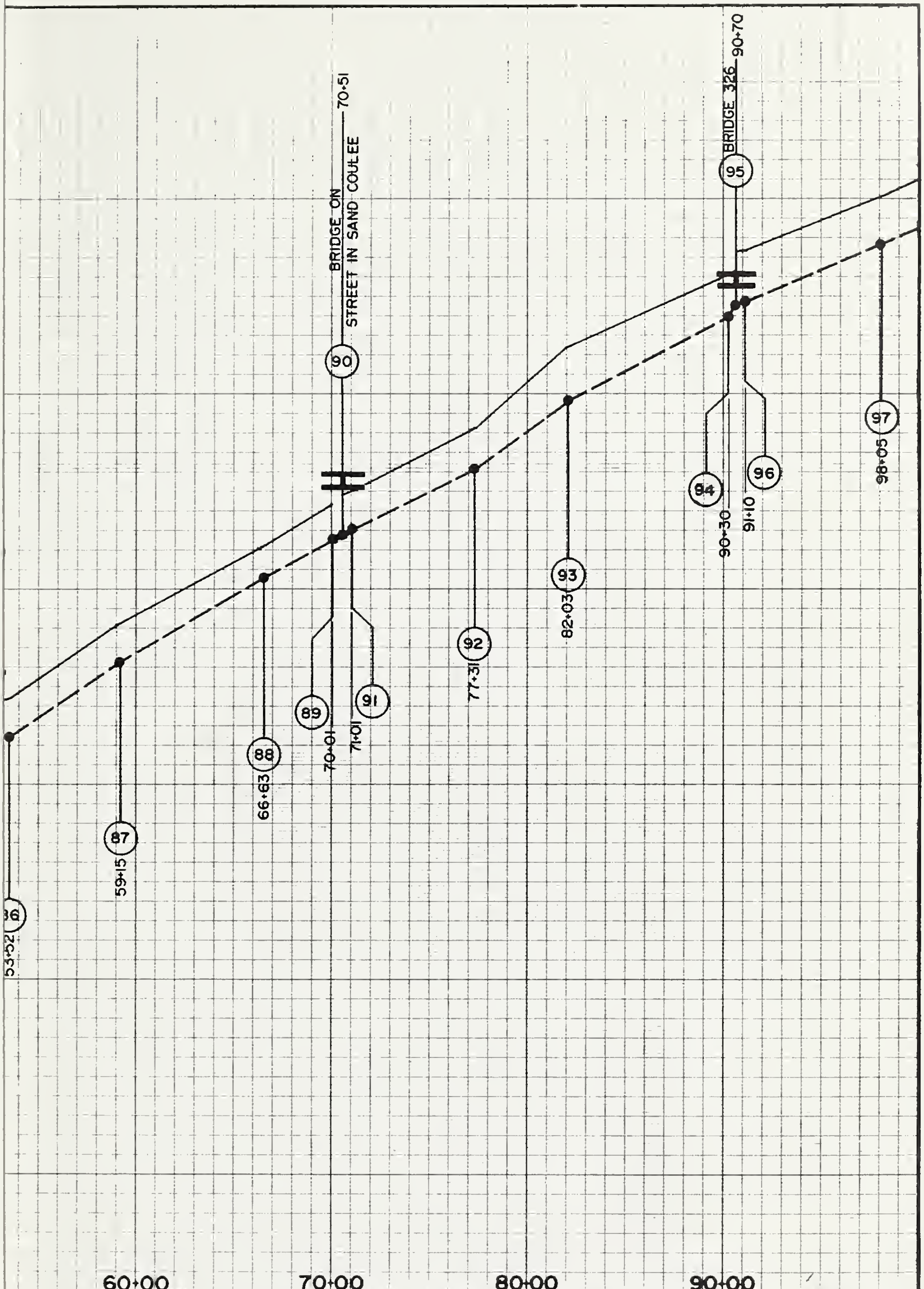
SAND COULEE CREEK

SAND COULEE CREEK FLOOD HAZARD ANALYSES

CASCADE COUNTY, MONTANA

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

DATE 7/73 SHEET 6 OF 6



CHANNEL BOTTOM AND WATER SURFACE PROFILE

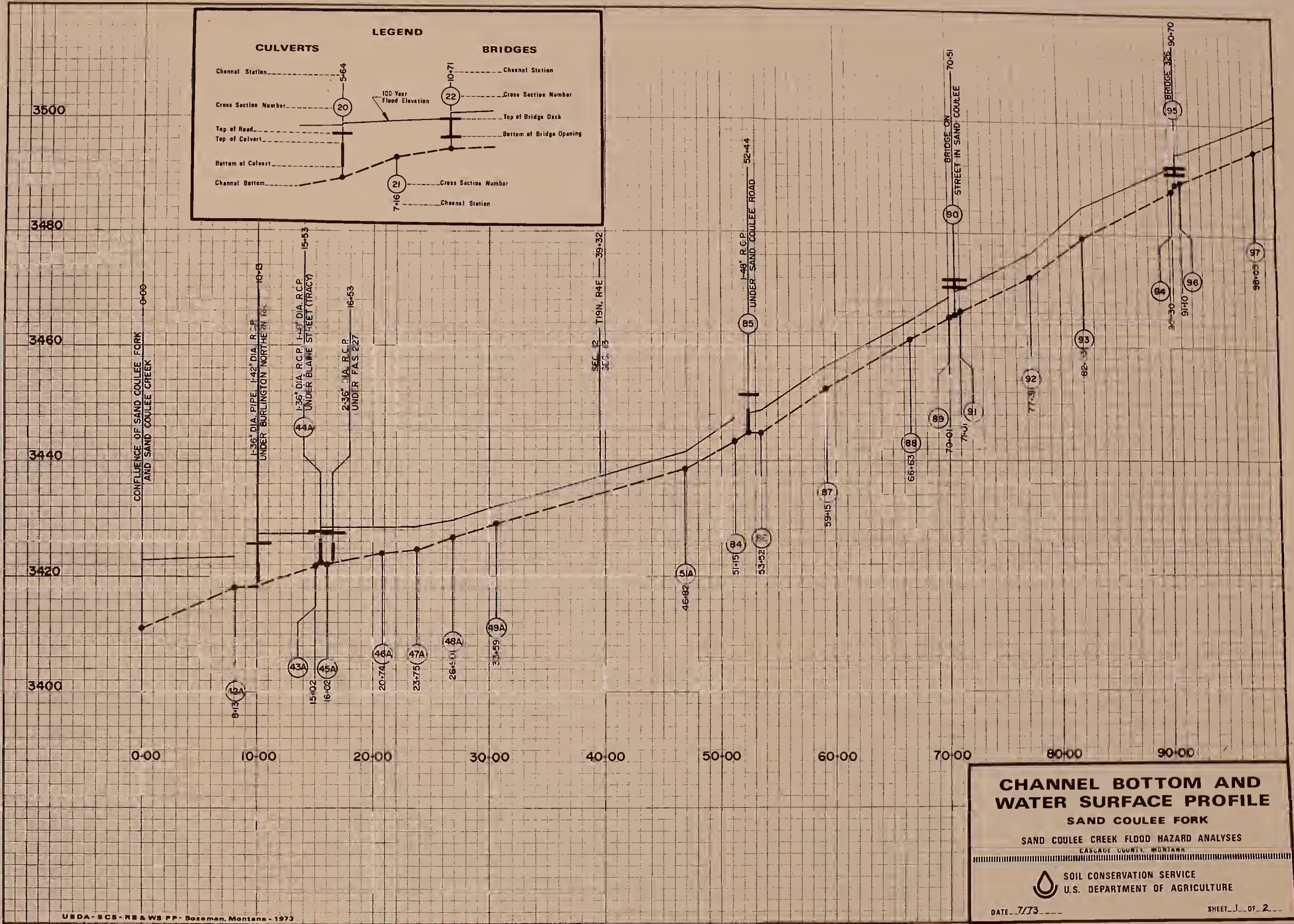
SAND COULEE FORK

SANO COULEE CREEK FLOOO HAZARO ANALYSES

CASCAOE COUNTY, MONTANA

SOIL CONSERVATION SERVICE
U.S. OEPARTMENT OF AGRICULTURE

OATE 7/73 SHEET 1 OF 2



CHANNEL BOTTOM AND WATER SURFACE PROFILE

SAND COULEE FORK

SAND COULEE CREEK FLOOD HAZARD ANALYSES

CASCADE COUNTY, MONTANA

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

DATE 7/73 SHEET 1 OF 2

GES

nel Station

Section Number

f Bridge Deck

m of Bridge Opening

CHANNEL BOTTOM AND WATER SURFACE PROFILE

SAND COULEE FORK

SANO COULEE CREEK FLOOO HAZARD ANALYSES

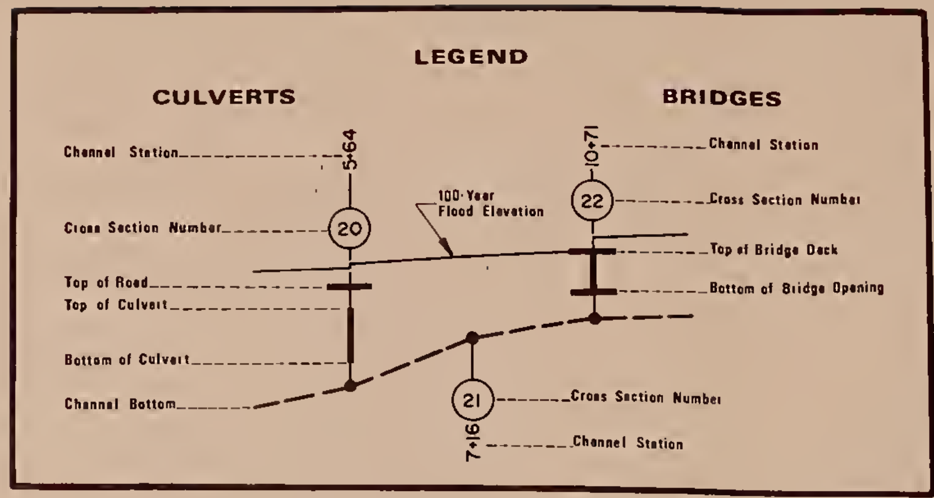
CASCADE COUNTY, MONTANA

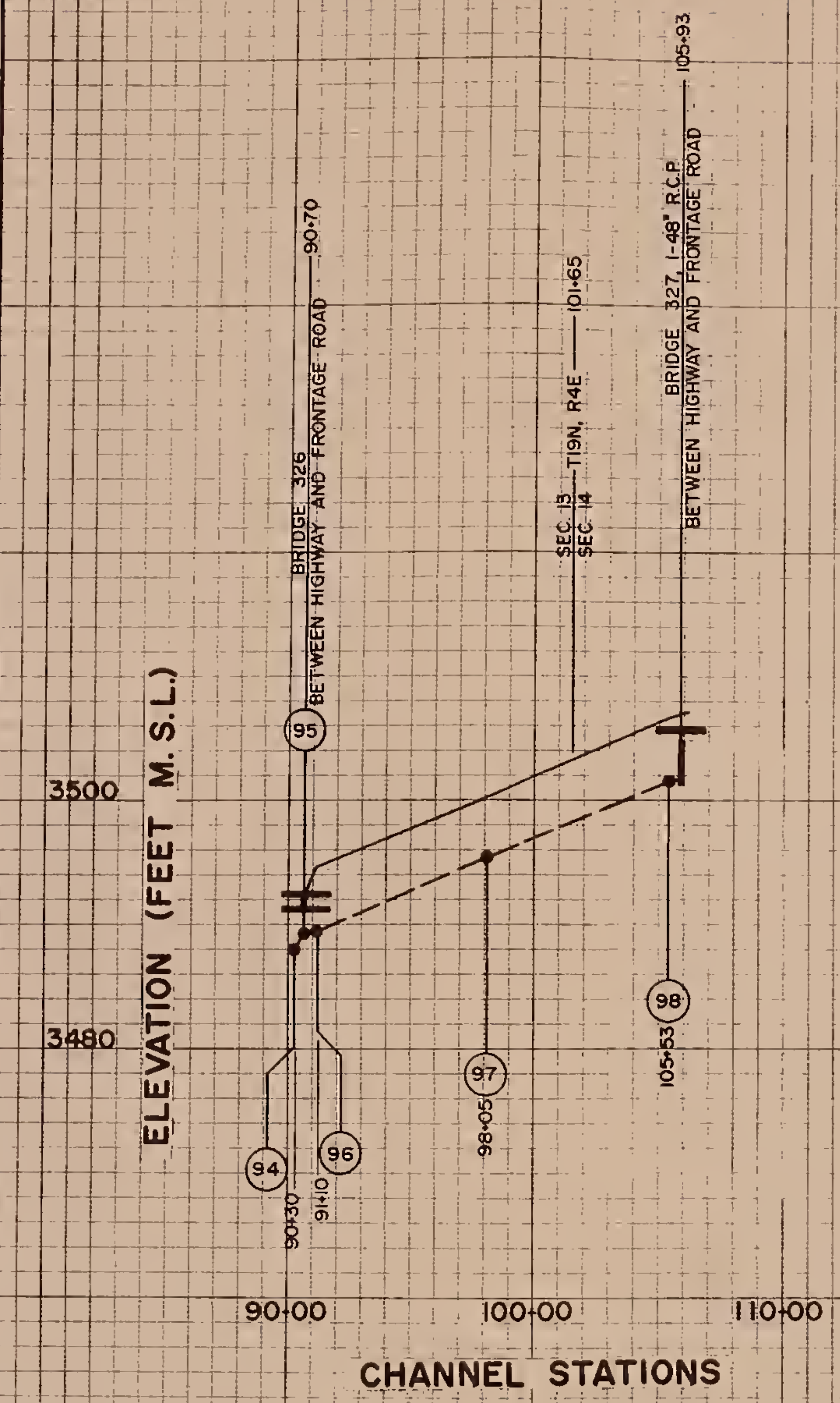
SOIL CONSERVATION SERVICE

U.S. OEPARTMENT OF AGRICULTURE

DATE 7/73

SHEET 2 OF 2





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CHANNEL BOTTOM AND WATER SURFACE PROFILE

SAND COULEE FORK

SANO COULEE CREEK FLOOO HAZARO ANALYSES

CASCADE COUNTY, MONTANA

SOIL CONSERVATION SERVICE

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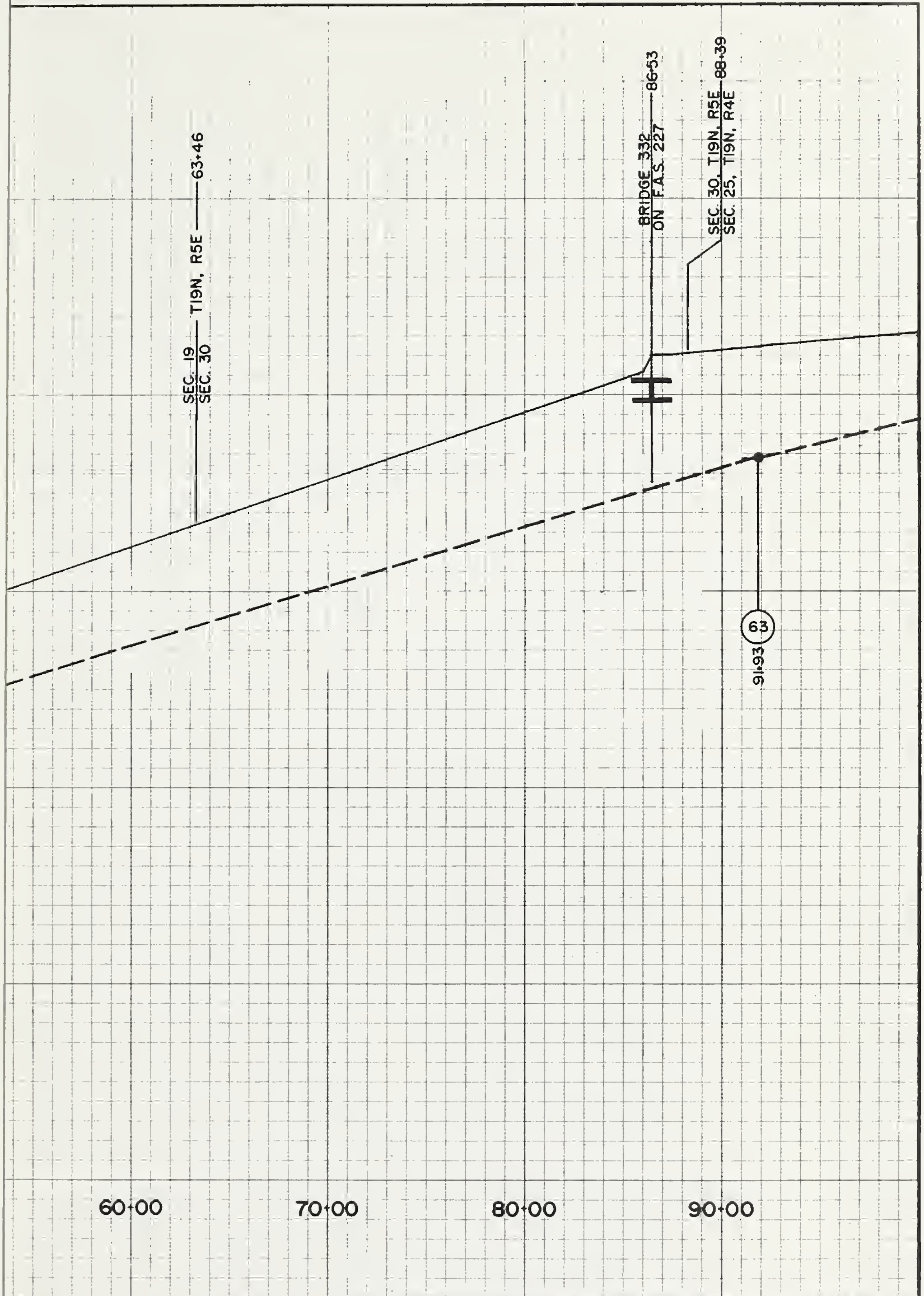

CHANNEL BOTTOM AND WATER SURFACE PROFILE

COTTONWOOD CREEK

SANO COULEE CREEK FLOOO HAZARO ANALYSES

CASCADE COUNTY, MONTANA

SOIL CONSERVATION SERVICE

U.S. DEPARTMENT OF AGRICULTURE

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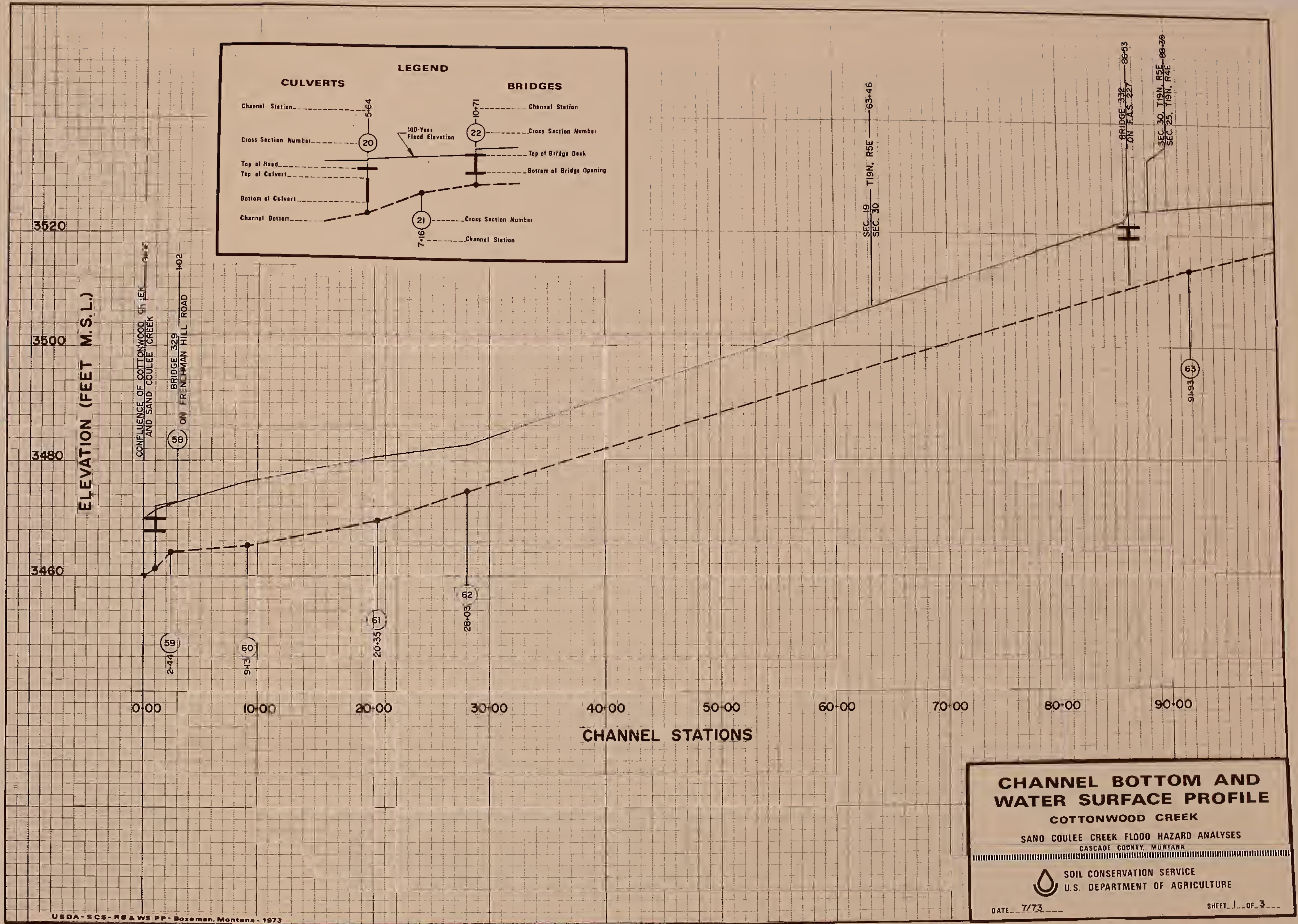

LEGEND
CULVERTS
BRIDGES
Channel Station
Cross Section Number
100-Year Flood Elevation
Top of Road
Top of Culvert
Bottom of Culvert
Channel Bottom
Top of Bridge Deck
Bottom of Bridge Opening
5+64
10+71
7+16
ELEVATION (FEET M.S.L.)
3460
3480
3500
3520
CONFLUENCE OF COTTONWOOD CREEK AND SAND COULEE CREEK
BRIDGE 329 ON FRENCHMAN HILL ROAD
1+02
2+44
9+13
20+35
28+03
SEC. 19 SEC. 30 T19N, R5E
63+46
BRIDGE 332 ON F.A.S. 227
86+53
SEC. 30, T19N, R5E SEC. 25, T19N, R4E
88+39
91+93
0+00
10+00
20+00
30+00
40+00
50+00
60+00
70+00
80+00
90+00
CHANNEL STATIONS
CHANNEL BOTTOM AND WATER SURFACE PROFILE
COTTONWOOD CREEK
SAND COULEE CREEK FLOOD HAZARD ANALYSES
CASCADE COUNTY, MONTANA
SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE
DATE 7/73
SHEET 1 OF 3
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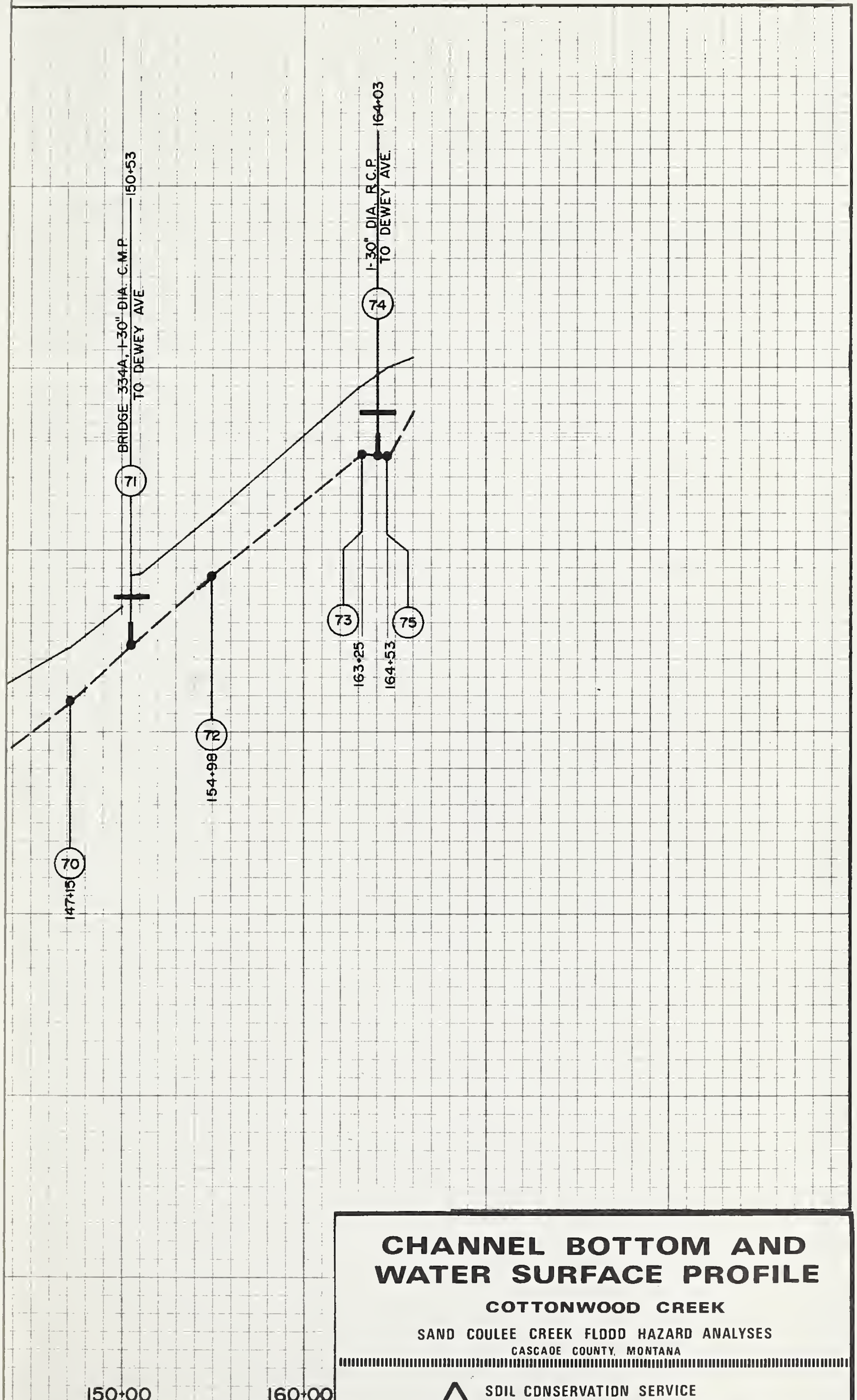


CHANNEL BOTTOM AND WATER SURFACE PROFILE

COTTONWOOD CREEK

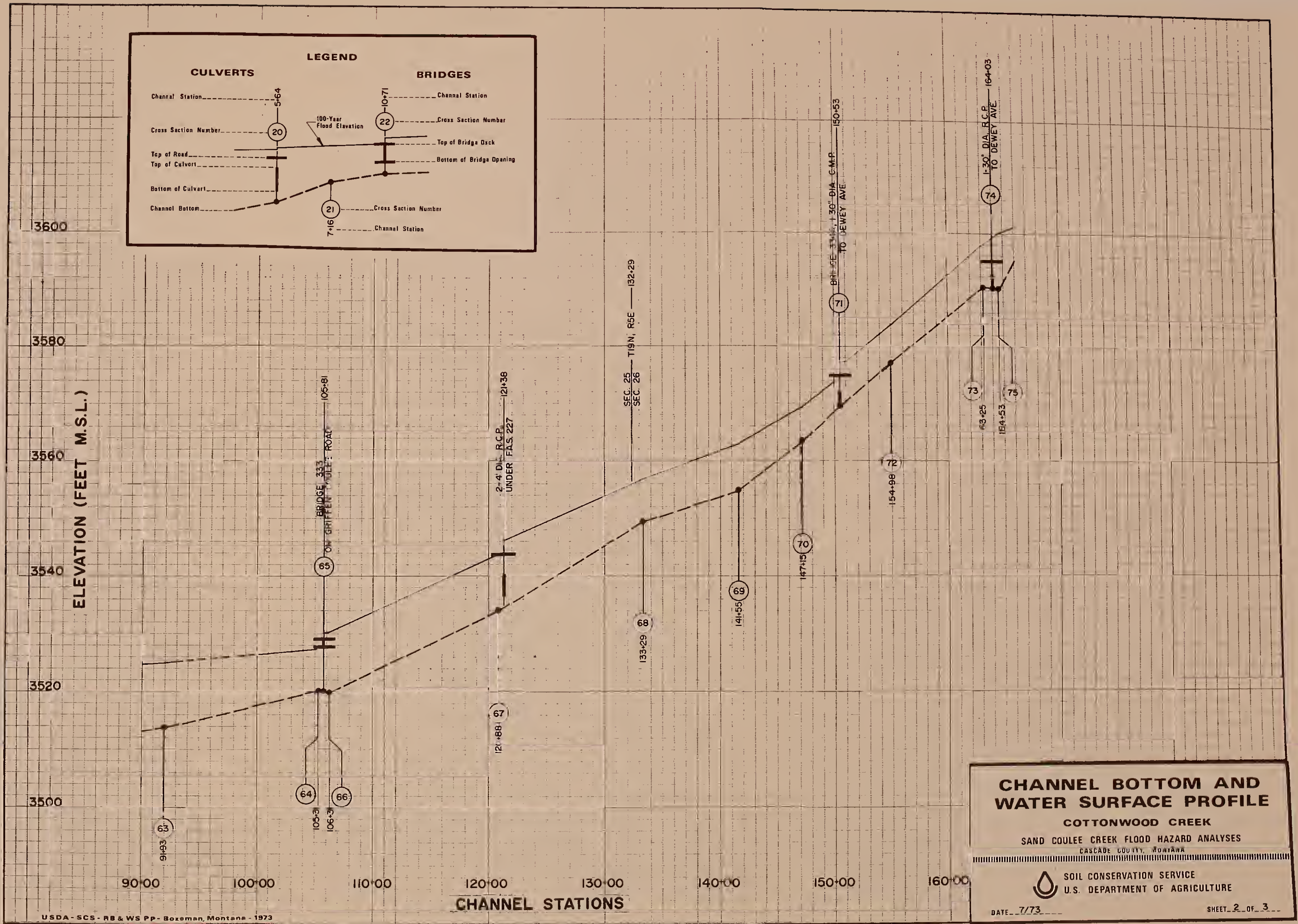
SAND COULEE CREEK FLOOD HAZARD ANALYSES

CASCADE COUNTY, MONTANA

SOIL CONSERVATION SERVICE

U.S. DEPARTMENT OF AGRICULTURE

DATE 7/73 SHEET 2 OF 3


LEGEND
CULVERTS
BRIDGES
Channel Station
Cross Section Number
100-Year Flood Elevation
Top of Road
Top of Culvert
Bottom of Culvert
Channel Bottom
Top of Bridge Deck
Bottom of Bridge Opening
5+64
20
10+71
22
21
7+16
ELEVATION (FEET M.S.L.)
3600
3580
3560
3540
3520
3500
105+81
121+38
UNDER F.A.S. 227
SEC. 25
SEC. 26
T19N, R5E
132+29
150+53
TO DEWEY AVE
164+03
1-30" DIA. R.C.P.
TO DEWEY AVE.
63
91+93
64
105+31
65
66
106+31
67
68
133+29
69
141+55
70
147+15
71
72
154+98
73
163+25
74
75
164+53
90+00
100+00
110+00
120+00
130+00
140+00
150+00
160+00
CHANNEL STATIONS
CHANNEL BOTTOM AND WATER SURFACE PROFILE
COTTONWOOD CREEK
SAND COULEE CREEK FLOOD HAZARD ANALYSES
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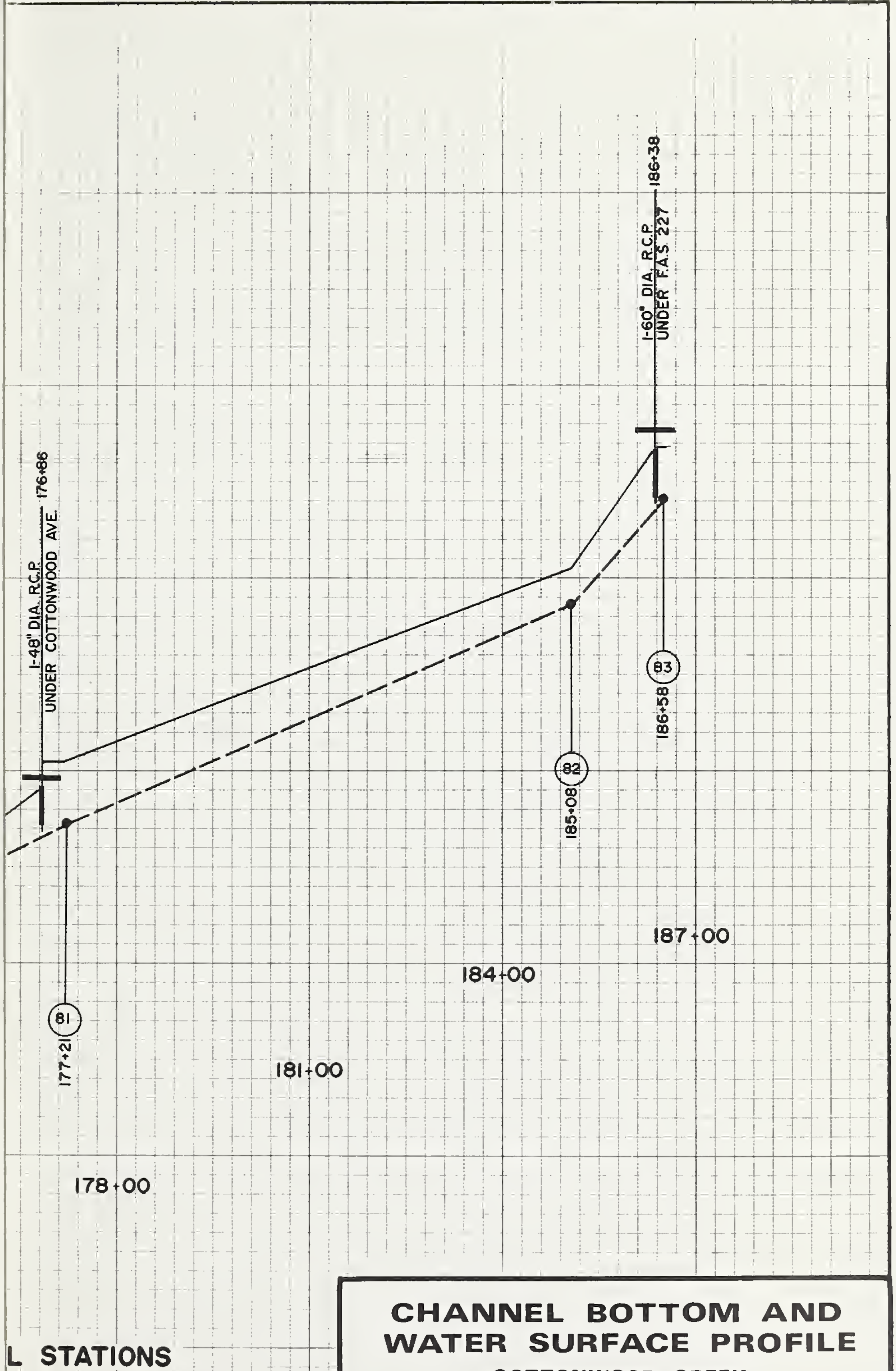
SHEET 2 OF 3
USDA-SCS-RB & WS PP- Bozeman, Montana - 1973



CS - RB & WS PP - Bozeman, Montana - 1973

CHANNEL BOTTOM AND WATER SURFACE PROFILE

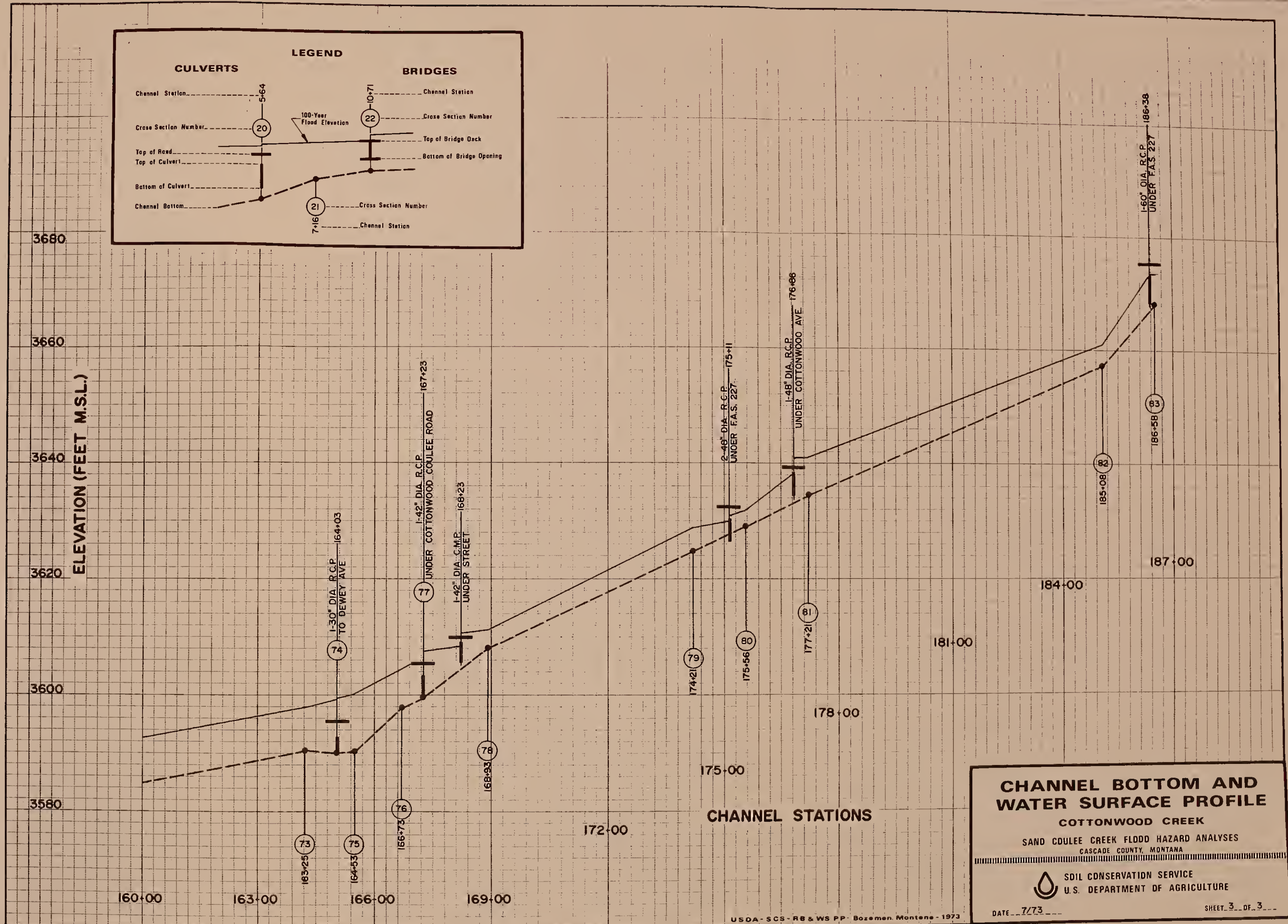
COTTONWOOD CREEK

SAND COULEE CREEK FLOOD HAZARD ANALYSES

CASCADE COUNTY, MONTANA

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

DATE 7/73 SHEET 3 OF 3



CHANNEL BOTTOM AND WATER SURFACE PROFILE

COTTONWOOD CREEK

SAND COULEE CREEK FLOOD HAZARD ANALYSES

CASCADE COUNTY, MONTANA

SOIL CONSERVATION SERVICE

U.S. DEPARTMENT OF AGRICULTURE

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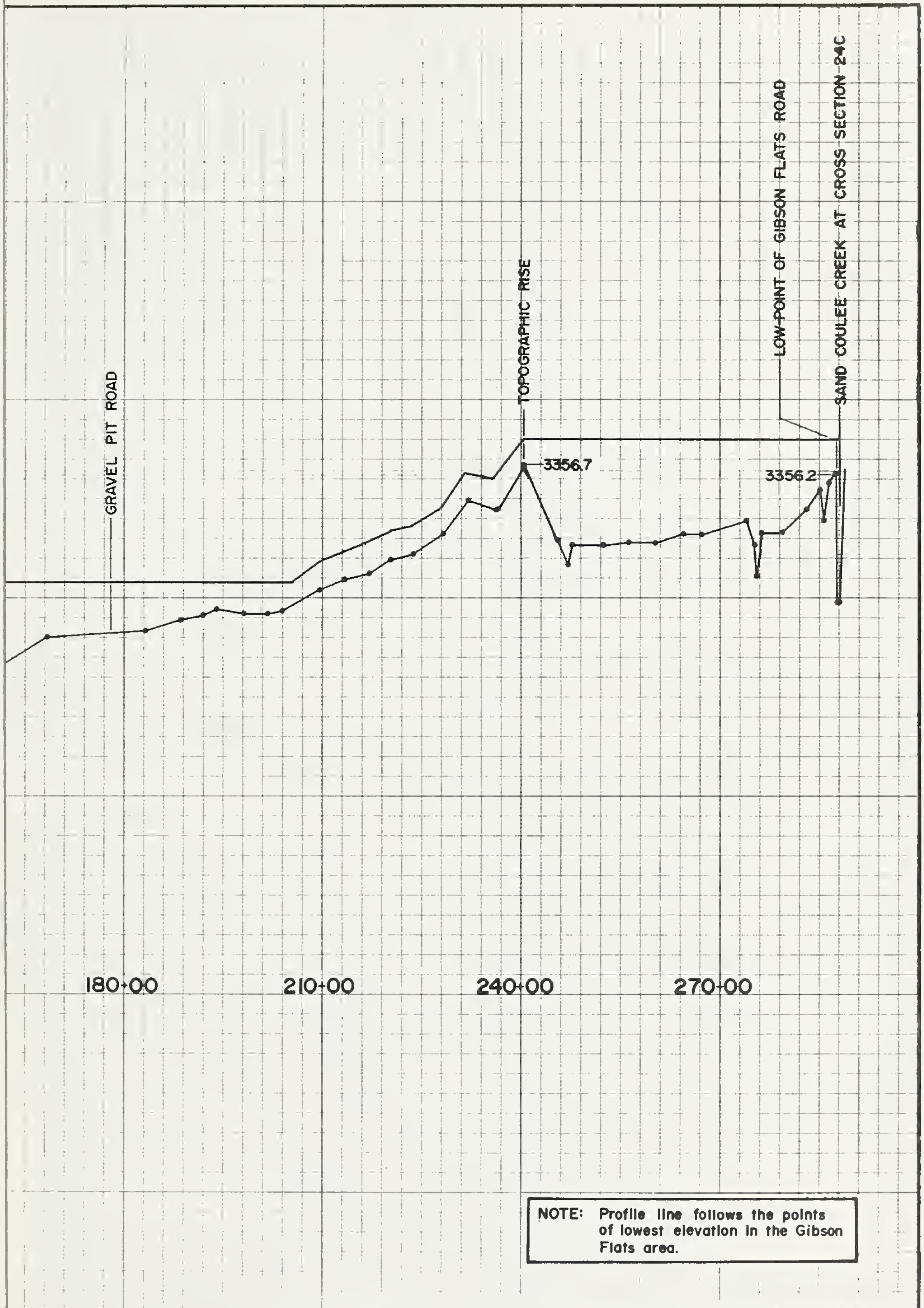
SHEET 3 OF 3

USDA-SCS-RB & WS PP. Bozeman, Montana - 1973



GROUND SURFACE AND WATER SURFACE PROFILE

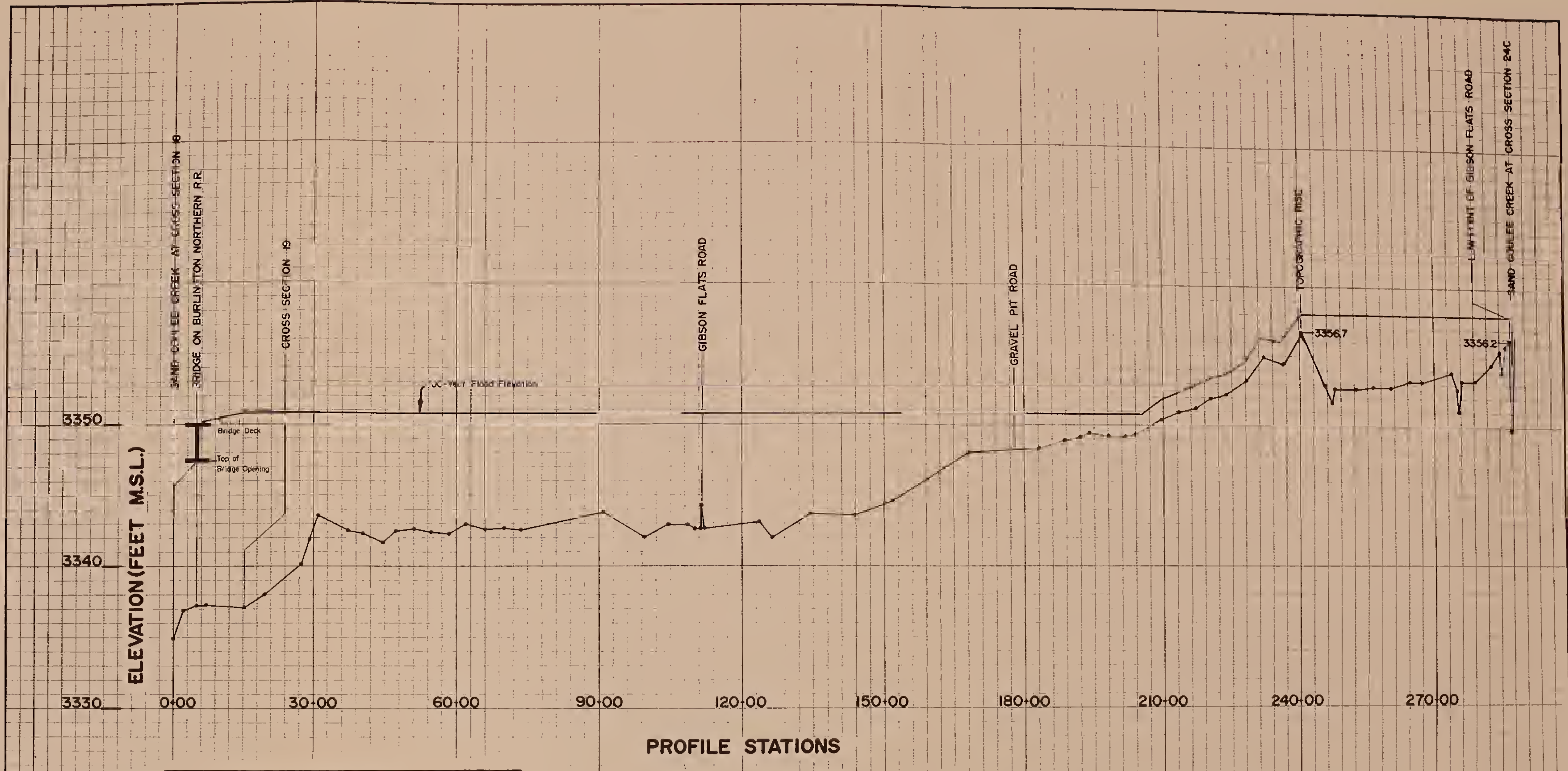
GIBSON FLATS AREA

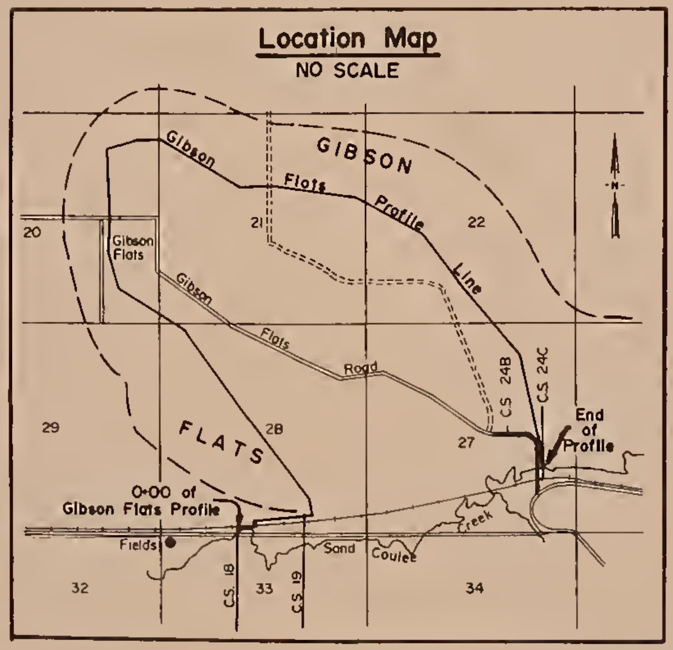
SAND COULEE CREEK FLOOD HAZARD ANALYSES

CASCADE COUNTY, MONTANA

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

DATE 7/73 SHEET 1 OF 1





NOTE: Profile line follows the points of lowest elevation in the Gibson Flats area.

GROUND SURFACE AND WATER SURFACE PROFILE

GIBSON FLATS AREA

SAND COULEE CREEK FLOOD HAZARD ANALYSES

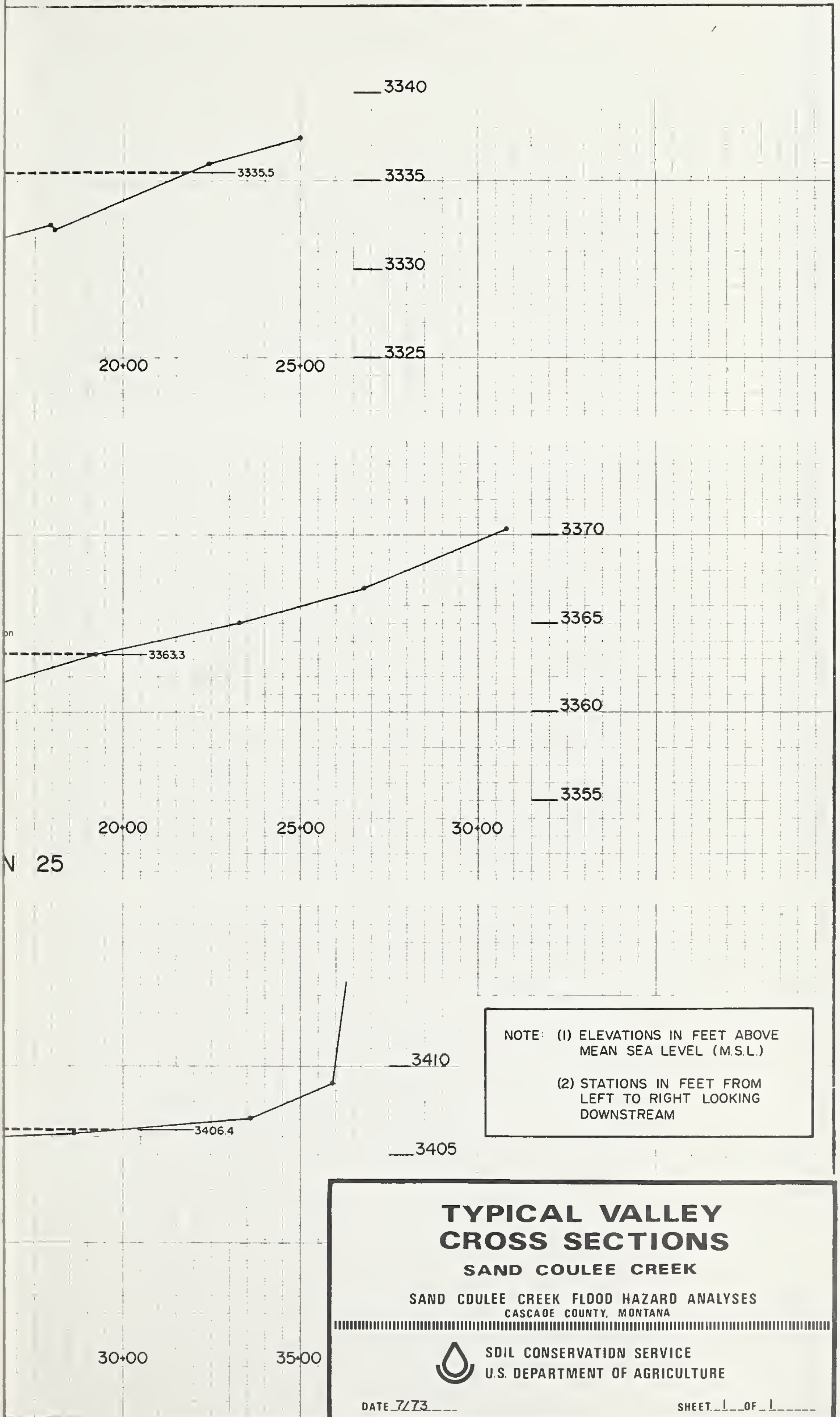
CASCADE COUNTY, MONTANA

SOIL CONSERVATION SERVICE

U.S. DEPARTMENT OF AGRICULTURE

DATE 7/73 SHEET 1 OF 1

USDA - SCS - RB & WS PP - Bozeman, Montana - 1973



NOTE: (1) ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL (M.S.L.)

(2) STATIONS IN FEET FROM LEFT TO RIGHT LOOKING DOWNSTREAM

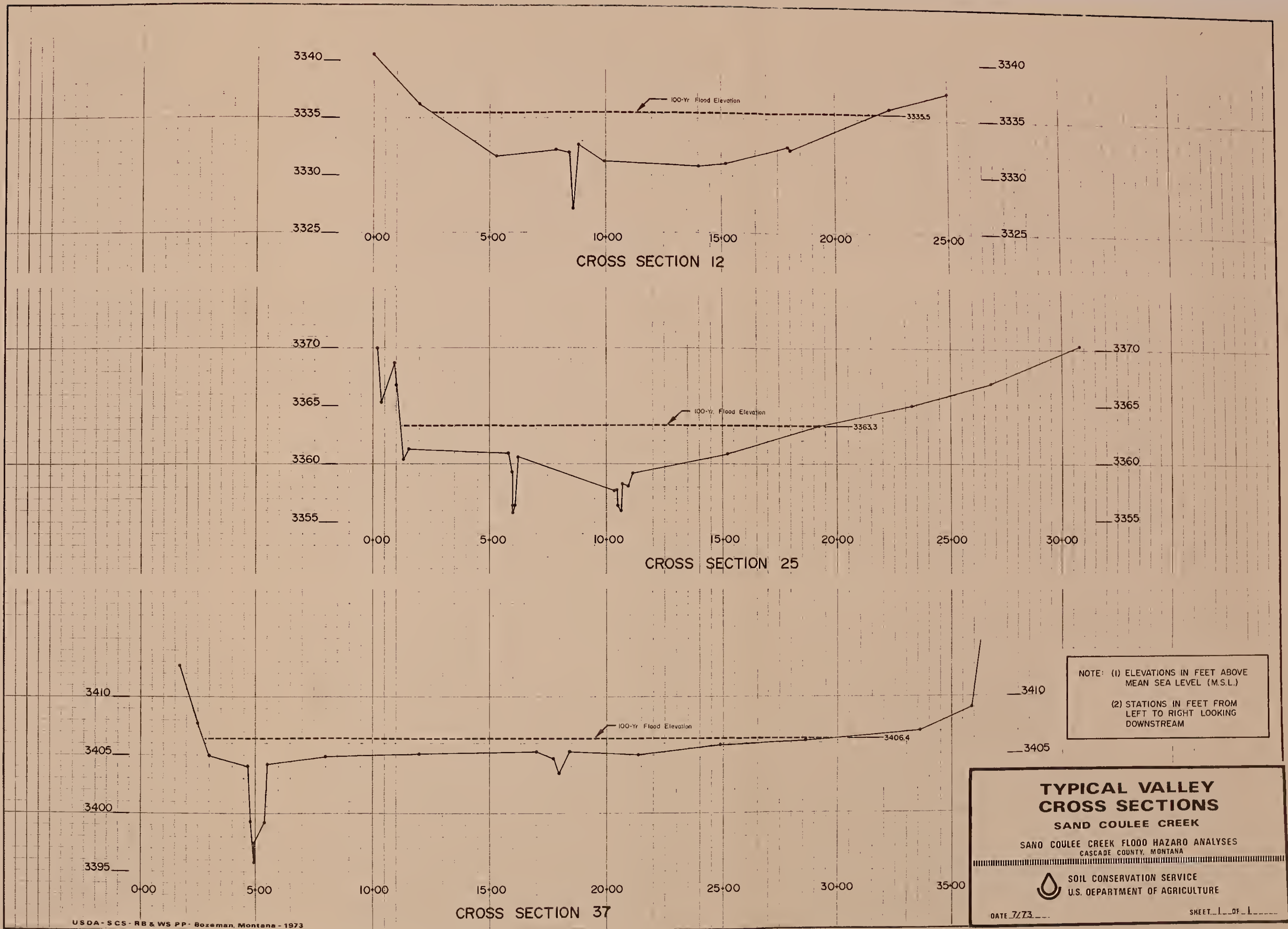
TYPICAL VALLEY CROSS SECTIONS

SAND COULEE CREEK

SAND COULEE CREEK FLOOD HAZARD ANALYSES
CASCADE COUNTY, MONTANA

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

DATE 7/73 SHEET 1 OF 1


3340
3335
3330
3325
100-Yr Flood Elevation
3335.5
0+00
5+00
10+00
15+00
20+00
25+00
CROSS SECTION 12
3370
3365
3360
3355
100-Yr. Flood Elevation
3363.3
0+00
5+00
10+00
15+00
20+00
25+00
30+00
CROSS SECTION 25
3410
3405
3400
3395
100-Yr Flood Elevation
3406.4
0+00
5+00
10+00
15+00
20+00
25+00
30+00
35+00
CROSS SECTION 37
NOTE: (1) ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL (M.S.L.)
(2) STATIONS IN FEET FROM LEFT TO RIGHT LOOKING DOWNSTREAM
TYPICAL VALLEY CROSS SECTIONS
SAND COULEE CREEK
SAND COULEE CREEK FLOOD HAZARD ANALYSES
CASCADE COUNTY, MONTANA
SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE
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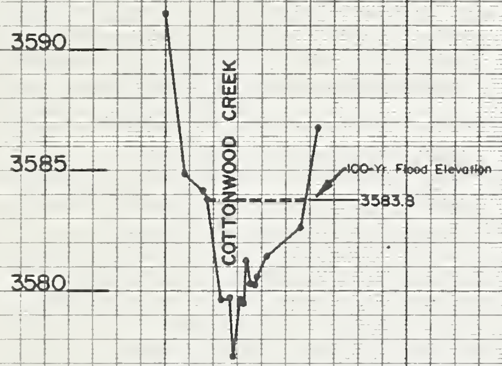

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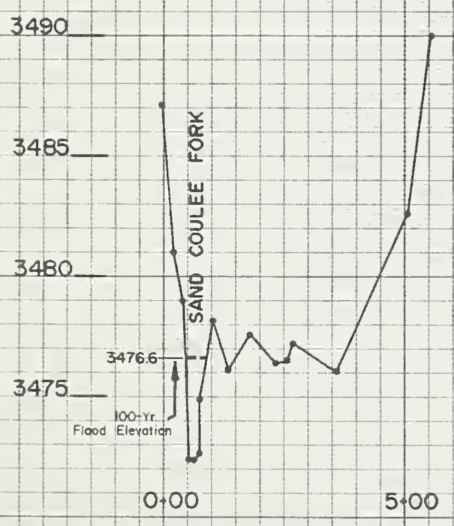

CROSS SECTION 92

NOTE: (1) ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL (M.S.L.)

(2) STATIONS IN FEET FROM LEFT TO RIGHT LOOKING DOWNSTREAM

TYPICAL VALLEY CROSS SECTIONS

SAND COULEE CREEK FLOOD HAZARD ANALYSES
CASCADE COUNTY, MONTANA

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

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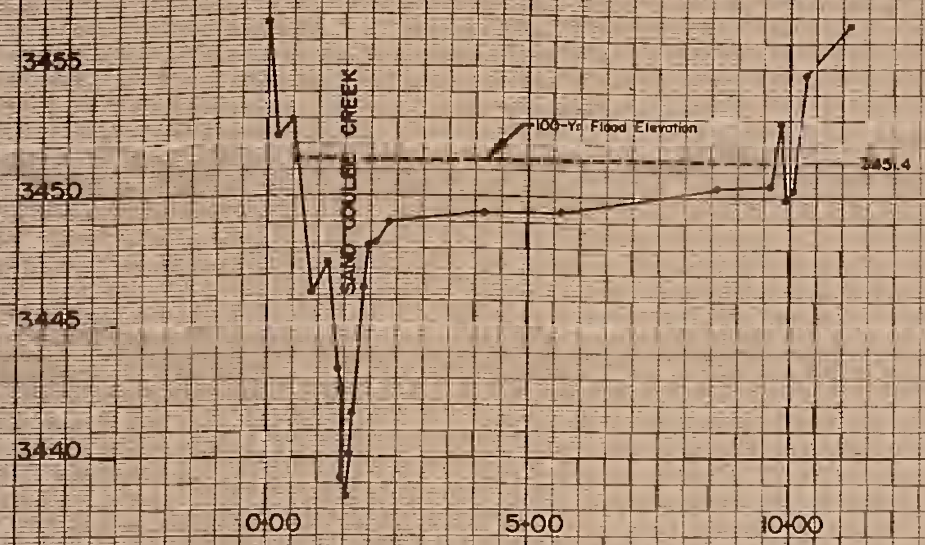

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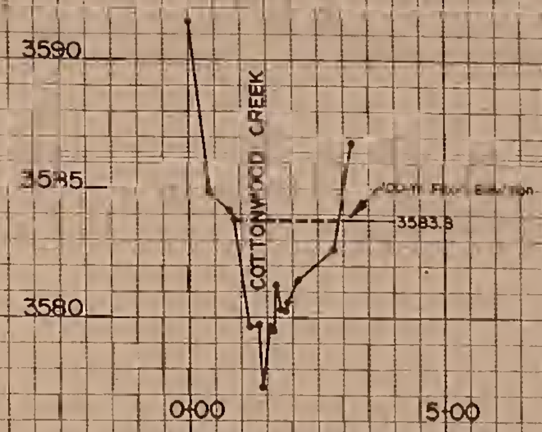
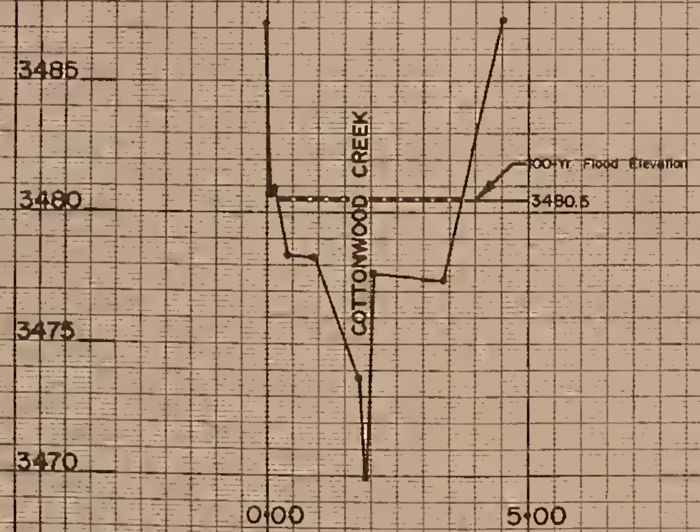
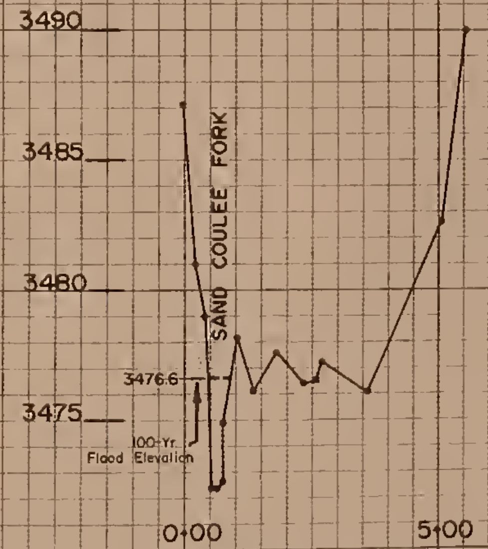


CROSS SECTION 72



CROSS SECTION 61



CROSS SECTION 92

NOTE: (1) ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL (M.S.L.)

(2) STATIONS IN FEET FROM LEFT TO RIGHT LOOKING DOWNSTREAM

TYPICAL VALLEY CROSS SECTIONS

SAND COULEE CREEK FLOOD HAZARD ANALYSES
CASCADE COUNTY, MONTANA

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

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USDA-SCS-RS&WS PP-Bozeman, Montana-1973

APPENDIX A

SOILS

APPENDIX A

SOILS

Following are descriptions, explanation of interpretations, and Table of Interpretations of the 12 series and the 18 soil mapping units used in this report. These units have been designated as Da, Fa, Fb, Fc, Ga, Gb, La, Lb, Lc, Ld, Ma, Ra, Ta, Tb, Tc, Td, Va, and Ya. Soil area boundaries and symbols are shown on the aerial maps.

DESCRIPTIONS OF SERIES AND MAPPING UNITS

ABSHER SERIES (Fc)

The Absher series consists of deep, moderately well drained, nearly level soils on terraces along Sand Coulee Creek. Typically, Absher soils have a light brownish gray loam surface layer less than four inches thick; silty clay or clay subsoils and clay loam, silty clay loam, or silty clay underlying material. A thin hard crust forms on this soil in cropland areas when the surface layer dries.

Permeability is very slow. The available water capacity is moderate. Soil reaction is mildly alkaline to about four inches and moderately to strongly alkaline below that depth. Areas adjacent to Sand Coulee Creek have a seasonal fluctuating water table and are predicted to be subject to flooding by 100-year frequency flood.

These soils are used for nonirrigated crops such as small grain and hay.

The mapping unit with about 20 percent Absher soil included is:

(Fc) Fergus-Absher silty clay loams, 0 to 2 percent slopes.

The Absher soil areas in this mapping unit occupy the slight concave micro-depressions in an irregular pattern in areas less than one acre in size.

DOOLEY SERIES (Da)

The Dooley series consists of deep, well drained, nearly level to gently rolling soils on terraces. Typically, Dooley soils have dark grayish brown sandy loam surface layers; brown, sandy clay loam subsoils over grayish brown clay loam underlying material.

Permeability is moderate to about two feet and moderately slow to slow below that depth. The available water capacity is moderate. Soil reaction is neutral to moderately alkaline to about two feet and moderate to strongly alkaline in the underlying material.

The 100-year flood frequency prediction affects all or only a portion of Dooley sandy loam, 1 to 8 percent slopes (Da).

These soils are used for small grain, hay, and pasture.

The mapping unit of the Dooley series recognized within the area is:

(Da) Dooley sandy loam, 1 to 8 percent slopes.

FERGUS SERIES (Fa, Fb, Fc)

The Fergus series consists of deep, well drained, nearly level to moderately sloping soils on terraces and fans. Typically, Fergus soils have brown clay loam surface layers; reddish brown heavy silty clay loam subsoils; and silty clay loam underlying material.

Permeability is moderately slow. The available water capacity is high. Soil reaction is neutral to mildly alkaline to about 14 inches and moderately to strongly alkaline below that depth. Many nearly level areas are subject to flooding.

Mapping units Fergus silty clay loam, 0 to 2 percent slopes (Fa) and Fergus-Absher silty clay loam, 0 to 2 percent slopes (Fc) are predicted to be mostly all subject to flooding during a 100-year frequency flood. Parts of mapping unit Fergus clay loam, 2 to 8 percent slopes (Fb) are predicted to be subject to flooding during a 100-year frequency flood.

These soils are mainly used for nonirrigated crops such as small grain and hay.

Mapping units of the Fergus series recognized are:

(Fa) Fergus silty clay loam, 0 to 2 percent slopes

(Fb) Fergus clay loam, 2 to 8 percent slopes

(Fc) Fergus-Absher silty clay loam, 0 to 2 percent slopes

The (Fc) mapping unit includes areas of Absher silty clay loam soils comprising about 20 percent of the unit. The Absher soils differ in being moderate to strongly alkaline within about eight inches of the soil surface.

GERBER SERIES (Ga, Gb)

The Gerber series consists of deep, well drained, nearly level soils on terraces. Typically, Gerber soils have a dark grayish brown, granular silty clay loam surface layer about seven inches thick; a prismatic-blocky, noncalcareous, silty clay subsoil; and calcareous, grayish brown to light brownish gray, silty clay loam underlying material.

Permeability is slow. The available water capacity is high. Soil reaction is mildly alkaline in the surface layer and moderate to strongly alkaline in the subsoil and underlying material.

Mapping unit Gerber silty clay loam, 0 to 2 percent slopes (Ga) is predicted to be mostly all subject to flooding during a 100-year frequency flood. Mapping unit Gerber silty clay, 0 to 2 percent slopes (Gb) is predicted to be subject to flooding during a 100-year frequency flood.

These soils are used for nonirrigated crops such as small grain and hay.

Mapping units of the Gerber series recognized within the area are:

(Ga) Gerber silty clay loam, 0 to 2 percent slopes

(Gb) Gerber silty clay, 0 to 2 percent slopes

LAWTHER SERIES (La, Lb, Lc)

The Lawther series consists of deep, well drained, nearly level to moderately sloping soils on terraces and foot slopes. Typically, Lawther soils have a grayish brown, granular, silty clay surface layer; a calcareous, blocky-structured silty clay subsoil and underlying material.

Permeability is slow. The available water capacity is high. Soil reaction is moderately alkaline.

Parts of mapping unit Lawther silty clay, 0 to 2 percent slopes (La) are predicted to be subject to flooding during a 100-year frequency flood. Parts of, or mostly all of, Lawther silty clay, 2 to 8 percent slopes (Lb) are predicted to be subject to flooding during a 100-year frequency flood. The Lawther clay, overflowed (Lc), is predicted to be completely flooded during a 100-year frequency flood.

These soils are used for nonirrigated crops such as small grain and hay.

Mapping units of the Lawther series recognized within the area are:

(La) Lawther silty clay, 0 to 2 percent slopes

(Lb) Lawther silty clay, 2 to 8 percent slopes

(Lc) Lawther clay, overflowed

LIHEN SERIES (Ld)

The Lihen series consists of deep, well drained, nearly level and gently rolling soils on terraces. Typically, Lihen soils have a dark grayish brown loamy sand surface layer about 20 inches thick. It is underlain by light brownish gray loamy sand or loamy fine sand underlying material.

Permeability is rapid. The available water capacity is low. Soil reaction is neutral to mildly alkaline to about 20 inches and moderately alkaline in the underlying material. Runoff is slow and soils have severe wind erosion hazard.

Parts of mapping unit Lihen loamy fine sand, 2 to 8 percent slopes (Ld), is predicted to be subject to flooding during a 100-year frequency flood.

These soils are used mainly for hay, pasture, and residential developments.

The mapping unit of the Lihen series recognized within the area is:

(Ld) Lihen loamy sand, 2 to 8 percent slopes

MCKENZIE SERIES (Ma)

The McKenzie series consists of deep, poorly drained, nearly level soils on flood plains and in depressions. Typically, McKenzie soils have a gray clay surface layer over olive gray and gray clay underlying material.

Permeability is very slow. The available water capacity is high. Soil reaction is moderate to strongly alkaline. Runoff from higher lying land floods these soils for several days or weeks following heavy rains or snowmelt.

This soil is used mainly for the production of small grain.

The mapping unit of the McKenzie series recognized within this area is:

(Ma) McKenzie clay

RIVRA SERIES (Ra)

The Rivra series consists of somewhat excessively drained, nearly level soils on low terraces and flood plains. Typically, Rivra soils have a brown fine sandy loam or gravelly loam surface layer and very gravelly and cobbly loamy sand underlying material.

Permeability is very rapid. The available water capacity is very low. Soil reaction is mildly alkaline to moderately alkaline. These soils are subject to occasional flooding and have a water table above three feet at some period during most years.

These soils are used mainly for range or pasture.

The mapping unit of the Rivra series recognized within the area is:

(Ra) Rivra loam

TALLY SERIES (Ta, Tb)

The Tally series consists of deep, well drained, nearly level to strongly sloping soils on terraces and foot slopes. Typically, Tally soils have a grayish brown, fine sandy loam surface layer; a brown, fine sandy loam subsoil; and light gray, calcareous, sandy loam underlying material.

Permeability is moderately rapid. The available water capacity is low. Soil reaction is neutral to mildly alkaline to about 15 inches and moderately alkaline below that depth. Runoff is slow and soils have severe wind erosion hazard.

These soils are used for small grains, hay, and pasture and for residential developments.

Parts of mapping units Tally fine sandy loam, 0 to 2 percent slopes (Ta), and Tally fine sandy loam, 2 to 15 percent slopes (Tb), are predicted to be subject to flooding during a 100-year frequency flood.

Mapping units of the Tally series recognized within the area are:

(Ta) Tally fine sandy loam, 0 to 2 percent slopes

(Tb) Tally fine sandy loam, 2 to 15 percent slopes

TWIN CREEK (Tc, Td)

The Twin Creek series consists of deep, well drained, nearly level to moderately sloping soils on terraces and foot slopes. Typically, Twin Creek soils have a dark brown loam surface layer; a reddish brown, prismatic-blocky, loam subsoil layer; and a calcareous, reddish brown, stratified, loam and silt loam underlying material.

Permeability is moderate. The available water capacity is high. Soil reaction is neutral to mildly alkaline to about 15 inches and moderately alkaline below that depth.

These soils are used for nonirrigated crops such as small grain and hay. They are also used for residential developments.

Mapping unit Twin Creek silty clay loam, 0 to 2 percent slopes (Tc), is predicted to be mostly all subject to flooding during a 100-year frequency flood. Mapping unit Twin Creek loam, 2 to 8 percent slopes (Td) in narrow drainageways, is predicted to be mostly all subject to flooding during a 100-year frequency flood.

Mapping units of the Twin Creek series recognized within the area are:

(Tc) Twin Creek silty clay loam, 0 to 2 percent slopes

(Td) Twin Creek loam, 2 to 8 percent slopes

VELVA SERIES (Va)

The Velva series consists of deep, well drained, nearly level soils on stream terraces. Typically, Velva soils have a dark, grayish brown, fine sandy loam surface layer and a calcareous, light brownish gray, stratified fine sandy loam, loamy fine sand, or loam-textured underlying material.

Permeability is moderate. The available water capacity is low. Soil reaction is mildly alkaline to moderately alkaline. Areas are subject to flooding during periods of high water runoff or when ice jam occurs in river.

These soils are used for small grain, hay, and pasture. It is also used for residential developments.

The mapping unit of the Velva series recognized within the area is:

(Va) Velva fine sandy loam, 0 to 2 percent slopes

YETULL SERIES (Ya)

The Yetull series consists of deep, well drained, gently rolling and strongly rolling soils on terraces. Typically, Yetull soils have grayish brown, calcareous, loamy sand surface layers, and light brownish gray, calcareous, loamy coarse sand underlying material.

Permeability is rapid. The available water capacity is low. Soil reaction is mildly alkaline in the surface layer and moderately alkaline in the underlying material. Runoff is very slow and soils have very severe wind erosion hazard.

Parts of mapping unit Yetull loamy sand, 4 to 15 percent slopes (Ya), are predicted to be subject to flooding during a 100-year frequency flood.

These soils are used mainly for hay, pasture, and residential developments.

The mapping unit of the Yetull series in this area is:

(Ya) Yetull loamy sand, 4 to 15 percent slopes

INTERPRETATIONS OF SOILS

Interpretations are given in Table I for a number of uses. The ratings do not apply to small areas of highly contrasting soils within a mapping unit. For this reason the interpretations will not eliminate the need for on-site investigations and testing for specific design and construction. The interpretations can, however, be useful in general land use planning, in assessing hazards and development problems, in comparing different areas for a specific use, and in planning more detailed investigations at selected sites. Interpretations are based on the upper five feet of soil material in its natural state unless otherwise rated.

For some of the interpretations in Table I, soil limitations are indicated by the ratings slight, moderate, and severe. Slight means soil properties generally are favorable for the use or limitations are minor and easily overcome. Moderate means that some soil properties are limiting, but can be overcome or modified by special planning and design.

Severe means soil properties are so limiting that to correct or overcome them requires major soil reclamation or special design. For other uses, such as topsoil, suitability is rated by the terms good, fair, and poor, which have meanings approximately parallel to the terms slight, moderate, and severe. For other uses, no rating is given, but important soil features to be considered in planning, installation, or maintenance are listed. Where ratings such as moderate, severe, fair, or poor are used, the main limiting features are given by number (some are in percent slope). Definition of limiting soil features indicated by numbers are listed on page 56.

Following are explanations of the selected uses listed in the interpretation table:

Cropland--The limitations of soils for cropland are based on the capacity of the soil to produce, without excessive soil deterioration, economically acceptable yields of crops commonly grown in the area. Droughtiness, wetness, erosion hazard, workability, slope, and soil patterns are items considered in evaluating the soils for cropland.

Septic Tank Absorption Fields--Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 24 inches to five feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope is a soil property that affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage Lagoons--Sewage lagoons are shallow ponds constructed to hold sewage within a depth of two to five feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor. The sides, or embankments, are of soil material compacted to medium density. The pond is protected from flooding. Soil properties are considered that affect the pond floor and the embankment. Those that affect the pond floor are permeability, organic matter, depth to gravel, and slope. The soil properties that affect the embankment are the engineering properties of the embankment material that influence the ease of excavation and compaction.

Shallow Excavations--Shallow excavations are those that require digging or trenching to a depth of less than six feet; for example, excavations for pipelines, sewer lines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Dwellings--Dwellings, for which the soils are given limitation ratings are those not more than three stories high and that are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for such dwellings are those that relate to capacity to support load and resist settlement under load. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, frost action potential, and shrink-swell potential. Those that affect excavation are wetness, slope, and content of stones and rocks. (On-site investigations are needed for interpretations relevant to detailed design of foundations and to specific placement of buildings.)

Local Roads and Streets--Local roads and streets for which soil ratings are given have an all-weather surface expected to carry automobile traffic. Roads and streets should have a subgrade consisting of gravel, crushed rock, or compacted soil material with a surface of gravel, asphalt, or concrete. They are graded to shed water and have provisions for drainage.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity, stability of the subgrade, and the workability and quantity of cut-and-fill material available. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut-and-fill needed to reach an even grade.

Playgrounds--Playgrounds are areas to be used intensively for baseball, football, badminton, and for other similar organized games. These areas are subject to intensive foot traffic. A nearly level surface, good drainage, and a soil texture and consistency that gives a firm surface generally are required. Soil suitability for growing vegetation is an important consideration.

Paths and Trails--Paths and trails include local and cross-country footpaths, trails, and bridle paths. It is assumed that these areas will be used as they occur in nature and that little or no soil will be moved (excavated or filled). Soil features that affect trafficability, dust, design, and maintenance are given special emphasis. These include soil texture, wetness, slope, and coarse fragments.

Picnic Areas and Campgrounds--Picnic areas and campgrounds are areas used for tents and small trailers and the accompanying activities of outdoor living or for picnicking. Foot traffic and vehicle traffic are usually more intense on campgrounds than on picnic areas, but the two require about the same kind of soil. Well-drained, moderately permeable to rapidly permeable, nearly level soils with texture that provides a firm surface are ideal for picnic areas and campgrounds. Soils that have a high clay content, those that are very slowly permeable to water, those that have a water table within 20 inches of the surface during the season of use, or those that are on slopes of more than 15 percent are rated as severe. It is assumed that little site preparation will be done other than shaping or leveling for tents and parking areas. Soils should be suitable for heavy foot traffic and limited vehicular traffic. Suitability for growing vegetation is an important consideration.

Road Fill--The suitability ratings reflect (1) the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and (2) the relative ease of excavating the material at borrow areas.

Topsoil--Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments are characteristics that affect suitability, but also considered in the ratings is the damage that will result at the area from which topsoil is taken.

Dikes, Levees, and Embankments--Dikes, levees, and other embankments for retention of water require soil material resistant to seepage and piping and of favorable stability; shrink-swell potential; shear strength; and compactibility. Presence of stones or organic material in a soil are among factors that are unfavorable.

Drainage--Drainage is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope, stability in ditch banks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation--Irrigation of a soil is affected by such features as slope, susceptibility to stream overflow, water erosion or soil blowing, soil texture, contents of stones, accumulations of salts and alkali, depth of root zone, rate of water intake at the surface, permeability of soil layers below the surface layer, amount of water held available to plants, and need for drainage or depth to water table or bedrock.

LIMITING SOIL FEATURES INDICATED BY NUMBER IN TABLE 1

1. Flooding or ponding hazard
2. Seasonally high water table 2 to 4 feet below the surface
3. Gently sloping to strongly sloping
4. Permeability is more than 2.0 inches/hr.
5. Moderate permeability (0.60 to 2.0 inches/hr.)
6. Moderately slow permeability (0.20 to 0.60 inches/hr.)
7. Slow permeability (less than 0.20 inches/hr.)
8. Erosion hazard
9. High potential frost action
10. Moderate shrink-swell potential
11. High shrink-swell potential
12. Unfavorable clay content
13. Slippery and sticky when wet and slow to dry
14. Seepage and piping hazards
15. Salinity and alkalinity limitations
16. Sandy soil textures
17. Coarse fragments (gravels, cobbles, or stones)

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Soil Features Affecting:		
Dikes, Levees, Embankments	Drainage	Irrigation
Poor stability; highly erosive	Permeability less than .06 in/hr.	Permeability less than .06 in/hr; moderate or strong alkalinity
Piping hazard in materials in upper two feet	Permeability less than .6 in/hr below 24 inches	Undulating topography; potential salinity and alkalinity build-up
Medium to low shear strength; fair to good compaction characteristics	Permeability 0.2-.6 in/hr	Permeability 0.2-.6 in/hr
Medium to low shear strength; fair to good compaction characteristics	Permeability 0.2-.6 in/hr	Permeability 0.2-.6 in/hr; 2-8% slopes
Low shear strength; moderate or high shrink-swell potential	Permeability .06-.2 in/hr	Permeability .06-.2 in/hr
Low shear strength; moderate or high shrink-swell potential	Permeability .06-.2 in/hr	Permeability .06-.2 in/hr
High shrink-swell; poor compaction; low shear strength	Permeability less than .20 in/hr	Permeability less than .20 in/hr
High shrink-swell; poor compaction; low shear strength	Permeability less than .20 in/hr	Permeability less than .20 in/hr
High shrink-swell; poor compaction; low shear strength	Permeability less than .20 in/hr	Permeability less than .20 in/hr
Poor resistance to piping	Permeability 6.0-20 in/hr	Permeability 6.0-20 in/hr
High shrink-swell; poor compaction	Permeability less than .06 in/hr; outlets difficult to establish	Permeability less than .06 in/hr
Permeability more than 20 in/hr; high susceptibility to piping	Flooding hazard	Permeability more than 20 in/hr; flooding hazard
Low resistance to piping	All features favorable	Permeability 2.0-6.0 in/hr
Low resistance to piping	All features favorable	Permeability 2.0-6.0 in/hr
Low resistance to piping	Permeability 0.6-2.0 in/hr	All features favorable
Low resistance to piping	Permeability 0.6-2.0 in/hr	All features favorable on less than 4% slopes; erosion hazard over 4% slopes
Low resistance to piping	All features favorable	Permeability 0.6-2.0 in/hr
High susceptibility to piping	All features favorable	Low available water capacity; severe wind erosion hazard

TABLE I

SAND COULEE CREEK FLOOD HAZARD ANALYSIS

CASCADE COUNTY, MONTANA

TABLE OF SOIL INTERPRETATIONS FOR SELECTED USES

	Degree and Kind 2/ of Limitation For:										Suitability As a Source Of:		Soil Features Affecting:		
Soil Series and Map Symbols	Cropland	Septic Tank Absorption Fields	Sewage Lagoons	Shallow Excavations	Dwellings With Basements	Dwellings Without Basements	Local Roads Streets and Parking Areas	Playgrounds	Paths and Trails	Picnic Areas and Campgrounds	Road Fill	Topsoil	Dikes, Levees, Embankments	Drainage	Irrigation
Absher Fc	Severe 1, 11, 12, 15	Severe 1, 7, 12	Severe 1	Severe 1, 12	Severe 1, 9	Severe 1, 9	Severe 1, 9	Severe 12, 7	Severe 12	Severe 7, 12	Poor 9	Poor 12, 15	Poor stability; highly erosive	Permeability less than .06 in/hr.	Permeability less than .06 in/hr; moderate or strong alkalinity
Dooley 2/ Da	Moderate 8, 16	Severe 6	Slight	Moderate 12	Moderate 9, 10	Moderate 9, 10	Severe 9	Slight	Slight	Slight	Poor 9	Good	Piping hazard in materials in upper two feet	Permeability less than .6 in/hr below 24 inches	Undulating topography; potential salinity and alkalinity build-up
Fergus Fa, Fc	Moderate 1	Severe 1, 6	Severe 1	Severe 1, 12	Severe 1, 9	Severe 1, 9	Severe 1, 9	Moderate 12, 6	Moderate	Moderate 6, 12	Poor 9	Fair 12	Medium to low shear strength; fair to good compaction characteristics	Permeability 0.2-.6 in/hr	Permeability 0.2-.6 in/hr
Fergus 3/ Fb	Moderate 3	Severe 6	Slight	Severe 12	Severe 9	Severe 9	Severe 9	Moderate 6, 12	Moderate 12	Moderate 1, 12	Poor 9	Fair 12	Medium to low shear strength; fair to good compaction characteristics	Permeability 0.2-.6 in/hr	Permeability 0.2-.6 in/hr; 2-8% slopes
Gerber Ca	Moderate 1	Severe 1, 7	Severe 1	Severe 1, 12	Severe 1, 9	Severe 1, 9	Severe 9, 10	Moderate 7, 12	Moderate 12	Moderate 7, 12	Poor 11	Poor 12	Low shear strength; moderate or high shrink-swell potential	Permeability .06-.2 in/hr	Permeability .06-.2 in/hr
Gerber 3/ Cb	Moderate 12	Severe 7	Slight	Severe 12	Severe 9	Severe 9	Severe 11	Moderate 7, 12	Moderate 12	Moderate 7, 12	Poor 11	Poor 12	Low shear strength; moderate or high shrink-swell potential	Permeability .06-.2 in/hr	Permeability .06-.2 in/hr
Lawther 3/ La	Moderate 12	Severe 7	Slight	Severe 12	Severe 11,	Severe 11,	Severe 11	Severe 7, 12, 13	Severe 12	Severe 7, 12, 13	Poor 11	Poor 12, 13	High shrink-swell; poor compaction; low shear strength	Permeability less than .20 in/hr	Permeability less than .20 in/hr
Lawther 2/ Lb	Moderate or Severe 12, 3	Severe 7	Slight, 2% slopes; Moderate, 2-7% slopes; Severe, 7% slopes	Severe 12	Severe 11,	Severe 11	Severe 11	Severe 7, 12, 13	Severe 12, 13	Severe 7, 12, 13	Poor 11	Poor 12, 13	High shrink-swell; poor compaction; low shear strength	Permeability less than .20 in/hr	Permeability less than .20 in/hr
Lawther Lc	Moderate 1, 12	Severe 1, 7	Severe 1	Severe 1, 12	Severe 1, 11	Severe 1, 11	Severe 1, 11	Severe 7, 12, 13	Severe 12, 13	Severe 7, 12, 13	Poor 11	Poor 12, 13	High shrink-swell; poor compaction; low shear strength	Permeability less than .20 in/hr	Permeability less than .20 in/hr
Lihen 3/ Ld	Severe 8	Slight 1/	Severe 1/ 4	Severe 16	Slight	Slight	Slight	Moderate 16	Moderate 16	Moderate 16	Good	Poor 16	Poor resistance to piping	Permeability 6.0-20 in/hr	Permeability 6.0-20 in/hr
McKenzie Ma	Severe 1, 12	Severe 1, 7	Severe 1	Severe 1, 12	Severe 1, 11	Severe 1, 11	Severe 1, 9, 11	Severe 1, 12, 13	Severe 1, 12, 13	Severe 12, 13	Poor 11	Poor 12, 13	High shrink-swell; poor compaction	Permeability less than .06 in/hr; outlets difficult to establish	Permeability less than .06 in/hr
Rivra Ra	Severe 1, 2	Severe 1, 2, 14	Severe 1, 4, 14	Severe 1, 2, 16	Severe 1, 2	Severe 1, 2	Severe 1	Moderate 1, 17	Moderate 1	Severe 1	Good	Poor 16, 17	Permeability more than 20 in/hr; high susceptibility to piping	Flooding hazard	Permeability more than 20 in/hr; flooding hazard
Tally 3/ Ta	Moderate 16, 8	Slight 1/	Severe 1/ 4, 14	Slight	Severe 9	Severe 9	Severe 9	Slight	Slight	Slight	Poor 9	Good	Low resistance to piping	All features favorable	Permeability 2.0-6.0 in/hr
Tally 3/ Tb	Moderate 3, 16, 8	Slight, 0-8% slopes; Moderate, 8-15% slopes	Severe 4, 14	Slight, 0-8% slopes; Moderate, 8-15% slopes	Severe 9	Severe 9	Severe 9	Moderate, 2-6 % slopes; Severe, 6%+ slopes	Slight	Slight 0-8% slopes; Moderate, 8-15% slopes	Poor 9	Good	Low resistance to piping	All features favorable	Permeability 2.0-6.0 in/hr
Twin Creek Tc	Moderate 1	Severe 1	Severe 1	Severe 1	Severe 1, 9	Severe 1, 9	Severe 1, 9	Slight	Slight	Slight	Poor 9	Good	Low resistance to piping	Permeability 0.6-2.0 in/hr	All features favorable
Twin Creek Td	Moderate 1, 3	Severe 1	Severe 1	Severe 1	Severe 1, 9	Severe 1, 9	Severe 1, 9	Moderate, 2-6% slopes; Severe, 6%+ slopes	Slight	Slight, 0-8% slopes	Poor 9	Good, 0-8% slopes	Low resistance to piping	Permeability 0.6-2.0 in/hr	All features favorable on less than 4% slopes; erosion hazard over 4% slopes
Velva Va	Moderate 8, 16	Severe 1	Severe 1, 4, 14	Moderate 1	Severe 1, 9	Severe 1, 9	Severe 9	Slight	Slight	Slight	Poor 9	Good	Low resistance to piping	All features favorable	Permeability 0.6-2.0 in/hr
Yetull 3/ Ya	Severe 8, 16	Slight 1/ 14	Severe 1/4, 14, 16	Severe 16	Slight	Slight	Slight	Moderate 16	Moderate 16	Moderate 16	Good	Poor 16	High susceptibility to piping	All features favorable	Low available water capacity; severe wind erosion hazard

1/ Potential ground water pollution hazard.

2/ The 100-year flood frequency prediction affects all or only a portion of these soils. These flooded areas have a severe degree of limitation for most urban-related land uses.

3/ The 100-year flood frequency prediction affects some parts of these soils. These flooded areas have a severe degree of limitation for most urban-related land uses.

GLOSSARY

Available water capacity--Available water capacity is the amount of water held in the soil for plant growth after all free water has drained away. It is expressed in inches of water held per five-foot depth of soil.

Inches/60-inch Profile	Class
0 to 3	Very low
3 to 6	Low
6 to 9	Moderate
9+	High

Calcareous Soil--Soil containing sufficient calcium carbonate to effervesce visibly when treated with 0.1 normal hydrochloric acid.

Clay--As a soil separate, the mineral soil particles less than .002 millimeters in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay loam--A soil textural class; soil material that has 27 to 40 percent clay and 20 to 45 percent sand.

Erosion hazard--Relative susceptibility of the soil to the prevailing erosion agents of water and wind.

Fine sandy loam--A soil textural class; soil material that contains either 20 percent clay or less and the percentage of silt plus twice the percentage of clay exceeds 30, and 52 percent or more sand; or less than 7 percent clay, less than 50 percent silt, and between 43 and 52 percent sand.

Interpretation, Soil--The art and science of explaining the meaning or significance of basic soil information for alternative uses.

Loam--A soil textural class having 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

Loamy sand--A soil textural class having 25 percent or more very coarse, coarse and medium sand, and less than 50 percent fine or very fine sand.

Mapping Unit--It is composed of one or more soils having defined properties. Included are areas of other soils.

Permeability--The rate at which water will move downward through a saturated soil. Terms used to describe relative classes of soil permeability are as follows:

Class	Rate of Measurement Through Soil (Inches per hr.)
Very slow	Less than 0.06
Slow	0.06 to 0.20
Moderately slow	0.20 to 0.6
Moderate	0.6 to 2.0
Moderately rapid	2.0 to 6.0
Rapid	6.0 to 20
Very rapid	More than 20

Potential for Frost Action--Potential for frost action refers to the heaving of soils upon freezing as a result of the formation of ice crystals or lenses in the soil. This is verv noticeable in the spring when the freezing and thawing is the most intense. The intensity of the problem is associated with soil and drainage characteristics. Values of high, moderate, and low are used to rate this soil hazard for soils with a potential for frost action.

Reaction--The degree of acidity or alkalinity of the soil, usually expressed as a pH value. The following reaction classes are recognized:

Slightly acid	pH 6.1 to 6.5
Neutral	pH 6.6 to 7.3
Mildly alkaline	pH 7.4 to 7.8
Moderately alkaline	pH 7.9 to 8.4
Strongly alkaline	pH 8.5 to 9.0

Runoff--The removal of water by flow over the surface of the soil. The amount and rapidity of surface runoff are affected by the texture, structure, and porosity of the surface layer, by the vegetative covering, by the prevailing climate, and by the slope. The rate of surface runoff is expressed as follows: ponded, very slow, slow, medium, rapid, and very rapid.

Sand--Individual rock or mineral fragments having diameters ranging from 0.05 millimeters to 2.0 millimeters. Sand grains consist chiefly of quartz, but they may be of any mineral composition. As a textural class, soil that is 85 percent or more sand and not more than 10 percent clay.

Series, soil--A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface soil, are similar in differentiating characteristics and in arrangement in the profile.

Shrink-swell potential--Shrink-swell potential is the potential volume change of a wet soil compared to the same soil when dry. The volume change behavior of soils is influenced by the amount and kind of clay present in the soil. In general, soils of clay texture have a high shrink-swell potential, whereas soils having high sand and gravel content with small amounts of clay and silt have a low shrink-swell potential.

Silt loam--A soil textural class; soil material that has 50 percent or more silt and 12 to 27 percent of clay.

Slope--The rise or fall of the land surface measured in feet per hundred feet distance and expressed in percent.

Soil Series and Map Symbols--Each kind of soil is listed separately by series. The map symbol (such as Da) designates the mapping unit in which a given series occurs.

Subsoil--Technically, the B horizon; roughly, the part of the profile below plow depth.

Substratum--Any layer beneath the solum or true soil.

Surface Layer--The soil ordinarily moved in tillage or its equivalent in uncultivated soil (about 5 to 8 inches in thickness).

Terrace (Geologic)--An old alluvial plain, ordinarily nearly level or undulating, bordering a river or stream.

Texture, Soil--The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes used in this survey in order of increasing proportion of fine particles are loamy sand, loamy fine sand, sandy loam, fine sandy loam, loam, silt loam, sandy clay loam, clay loam, silty clay loam, silty clay and clay.

APPENDIX B

SUPPLEMENTARY TABLES
AND
BENCH MARK DOCUMENTATION

TABLE 2

FLOOD FREQUENCY DISCHARGE
FOR
SELECTED CROSS SECTIONS

Cross Section Number	10-Year (cfs)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)
SAND COULEE CREEK				
2	2970	6310	8170	13182
14	3051	6424	8286	13213
19	3161	6503	8318	13214
24	2842	5812	7440	11773
30	2697	5482	7029	11076
31	2472	5122	6579	10352
32	2260	4757	6114	9535
42	2257	4793	6160	9530
45	2215	4717	6068	9394
57	2057	4364	5611	8629
COTTONWOOD CREEK				
60	1266	2727	3527	5496
64	1252	2694	3500	5446
67	670	1383	1773	2687
77	656	1355	1725	2620
78	103	221	285	453
83	103	221	285	453
SAND COULEE FORK				
46A	239	560	730	1215
86	260	620	800	1290
98	260	620	800	1290

TABLE 3

ELEVATIONS OF VARIOUS FREQUENCY FLOODS

SAND COULEE CREEK

Surveyed Cross Section Number	Channel Distance Stationing	Stream Bed Elevation ft. M.S.L.	10-Year Flood Elevation ft. M.S.L.	50-Year Flood Elevation ft. M.S.L.	100-Year Flood Elevation ft. M.S.L.	500-Year Flood Elevation ft. M.S.L.
Missouri R.	0+00					
1	15+00	3312.5	Out of study area.			
2	15+50	3311.5	3320.5	3322.9	3323.6	3324.6
*3	16+00	3313.4	3321.1	3323.2	3323.8	3324.5
*4	23+87	3311.5	3322.2	3324.9	3325.1	3326.0
*5	38+37	3315.8	3326.5	3328.0	3328.7	3330.0
*6	46+24	3317.5	3327.2	3329.0	3329.7	3331.2
7	52+53	3319.1	3328.4	3330.1	3330.8	3525.7
8	53+03	3317.7	3328.8	3330.4	3331.2	3332.8
*9	53+53	3318.1	3328.8	3330.4	3331.2	3332.9
10	74+39	3321.4	3330.0	3331.4	3332.0	3333.6
11	109+82	3322.9	3330.6	3332.8	3333.4	3334.8
12	144+46	3327.0	3333.6	3335.0	3335.5	3336.8
13	169+26	3327.7	3335.1	3336.2	3336.6	3337.6
14	169+76	3329.0	3335.6	3336.6	3337.1	3338.0
15	170+26	3329.8	3335.6	3336.4	3337.1	3338.0
16	200+18	3330.4	3338.3	3339.2	3339.8	3340.8
17	238+37	3333.1	3341.0	3342.0	3342.6	3343.5
18	265+82	3334.9	3344.1	3345.2	3345.7	3346.7
*19 (S)**	295+65	3338.4	3346.6	3347.3	3347.6	3348.2
(N)**			3348.7	3349.8	3350.8	3351.3
20 (S)**	322+50	3342.2	3349.6	3350.2	3350.2	3350.8
(N)**			3349.6	3350.4	3350.9	3351.6

* Flood elevations shown for this section pertain only to streamflow in the main channel.
** (S) = south side of railroad; (N) = north side of railroad.

TABLE 3 (Continued)

ELEVATIONS OF VARIOUS FREQUENCY FLOODS FOR SAND COULEE CREEK

Surveyed Cross Section Number	Channel Distance Stationing	Stream Bed Elevation ft. M.S.L.	10-Year Flood Elevation ft. M.S.L.	50-Year Flood Elevation ft. M.S.L.	100-Year Flood Elevation ft. M.S.L.	500-Year Flood Elevation ft. M.S.L.
24 (S)**	368+30	3350.0	3357.0	3357.4	3357.5	3357.8
(N)**			3354.3	3355.2	3355.6	3356.3
24A	386+60	3349.7	3355.6	3356.7	3357.2	3358.0
24B	387+10	3348.8	3357.4	3357.8	3358.0	3358.6
24C	387+60	3349.7	3357.4	3357.8	3358.0	3358.6
25	449+37	3355.8	3361.8	3363.0	3363.3	3364.4
*26	523+38	3367.1	3369.2	3369.9	3370.1	3370.8
*27	579+28	3369.1	3373.3	3374.1	3374.6	3375.4
*28	633+85	3379.1	3385.3	3386.6	3386.9	3387.8
29	634+35	3379.9	3386.6	3387.8	3388.2	3389.0
30	634+85	3380.6	3386.2	3387.9	3388.2	3388.9
*31	655+52	3382.2	3387.0	3388.4	3388.7	3389.5
*32	672+71	3384.2	3391.0	3392.0	3392.3	3393.2
33	693+71	3384.8	3394.7	3395.6	3395.8	3396.6
34	694+21	3385.6	3395.7	3396.4	3396.8	3397.4
35	694+71	3385.4	3396.0	3396.5	3396.8	3397.3
*36	725+02	3392.6	3399.4	3400.3	3400.4	3401.2
37	744+52	3395.8	3405.4	3406.1	3406.4	3407.0
*38	754+76	3399.5	3408.8	3409.4	3409.6	3410.0
*39	762+89	3398.9	3411.1	3411.6	3411.7	3412.1
*40	777+06	3400.0	3412.7	3413.5	3413.6	3414.0
*41	807+22	3407.6	3418.4	3419.2	3419.4	3420.0
*42	830+64	3413.0	3423.3	3424.0	3424.4	3425.3
*43	837+92	3415.6	3423.6	3424.8	3425.3	3426.1
44	838+42	3415.8	3424.7	3426.0	3426.4	3427.2
*45	838+92	3416.3	3424.9	3426.4	3426.9	3427.6
*46	843+45	3417.0	3428.0	3429.6	3430.0	3431.6
*47	846+99	3417.0	3429.2	3431.2	3432.0	3433.6
*48	850+33	3417.5	3431.0	3432.8	3433.4	3434.4

* Flood elevations shown for this section pertain only to streamflow in the main channel.
** (S) = south side of railroad; (N) = north side of railroad.

TABLE 3 (Continued)
ELEVATIONS OF VARIOUS FREQUENCY FLOODS FOR SAND COULEE CREEK

Surveyed Cross Section Number	Channel Distance Stationing	Stream Bed Elevation ft. M.S.L.	10-Year Flood Elevation ft. M.S.L.	50-Year Flood Elevation ft. M.S.L.	100-Year Flood Elevation ft. M.S.L.	500-Year Flood Elevation ft. M.S.L.
*49	860+57	3419.7	3433.0	3435.4	3436.0	3437.2
50	878+28	3424.9	3437.5	3438.6	3439.0	3440.1
51	878+78	3426.8	3438.0	3439.0	3439.4	3440.7
*52	879+28	3426.1	3437.8	3438.8	3439.4	3440.7
*53	899+36	3435.6	3448.2	3448.2	3448.2	3449.0
54	914+71	3438.3	3449.8	3451.1	3451.4	3452.3
*55	939+91	3445.4	3457.2	3458.0	3458.3	3460.0
*56	956+29	3454.1	3463.6	3465.2	3465.7	3466.6
*57	961+40	3459.3	3467.0	3468.0	3468.3	3469.2
Confluence with Cottonwood Creek	963+76 = 0+00 of Cottonwood Creek					

* Flood elevations shown for this section pertain only to streamflow in the main channel.

TABLE 4

ELEVATIONS OF VARIOUS FREQUENCY FLOODS

SAND COULEE FORK

Surveyed Cross Section Number	Channel Distance Stationing	Stream Bed Elevation ft. M.S.L.	10-Year Flood Elevation ft. M.S.L.	50-Year Flood Elevation ft. M.S.L.	100-Year Flood Elevation ft. M.S.L.	500-Year Flood Elevation ft. M.S.L.
Confluence with Sand Coulee Cr.	0+00 = 822+77 of Sand Coulee Creek					
42A	8+13	3418.1	3422.4	3423.2	3423.4	3423.9
*43A	15+02	3421.7	3426.7	3427.2	3427.4	3427.8
44A	15+53	3422.3	3427.6	3428.3	3428.5	3428.7
*45A	16+02	3422.0	3427.6	3428.3	3428.5	3428.7
*46A	20+74	3424.0	3427.6	3428.3	3428.5	3428.7
*47A	23+75	3424.7	3427.9	3428.4	3428.6	3429.0
*48A	26+90	3426.7	3429.1	3429.6	3429.8	3430.2
*49A	33+59	3429.1	3431.3	3432.1	3432.2	3432.7
51A	46+82	3438.3	3441.0	3441.4	3441.5	3441.9
*84	51+15	3443.5	3446.4	3447.0	3447.3	3447.8
85	52+44	3444.9	3447.4	3448.1	3448.3	3448.7
*86	53+52	3444.9	3447.8	3448.6	3448.9	3449.5
*87	59+15	3452.7	3455.2	3456.3	3456.5	3456.9
*88	66+63	3461.4	3463.5	3464.2	3464.4	3465.0
*89	70+01	3465.2	3467.5	3468.4	3468.8	3469.4
*90	70+51	3465.6	3469.0	3469.6	3469.7	3470.3
*91	71+01	3466.4	3469.2	3469.8	3470.1	3470.6
*92	77+31	3472.4	3474.8	3476.1	3476.6	3477.6
*93	82+03	3479.5	3483.4	3484.4	3484.7	3485.4
*94	90+30	3488.0	3490.6	3491.6	3492.0	3492.6
95	90+70	3489.2	3493.3	3494.4	3494.6	3495.3
*96	91+10	3489.6	3493.4	3494.4	3494.7	3495.4
*97	98+05	3495.5	3499.2	3499.9	3500.2	3500.7
*98	105+53	3501.5	3505.3	3506.2	3506.5	3507.3

* Flood elevations shown for this section pertain only to streamflow in the main channel.

TABLE 5

ELEVATIONS OF VARIOUS FREQUENCY FLOODS

COTTONWOOD CREEK

Surveyed Cross Section Number	Channel Distance Stationing	Stream Bed Elevation ft. M.S.L.	10-Year Flood Elevation ft. M.S.L.	50-Year Flood Elevation ft. M.S.L.	100-Year Flood Elevation ft. M.S.L.	500-Year Flood Elevation ft. M.S.L.
Confluence with Sand Coulee Cr.	0+00 = 963+76 of Sand Coulee Creek					
58	1+02	3461.4	3470.4	3471.0	3471.3	3472.0
*59	2+44	3464.2	3470.8	3472.0	3472.4	3473.0
*60	9+13	3465.3	3474.4	3475.9	3476.3	3477.0
61	20+35	3469.8	3478.8	3480.0	3480.5	3481.5
62	28+03	3474.7	3481.1	3482.4	3482.9	3483.8
*63	91+93	3513.7	3521.4	3524.0	3524.9	3525.7
*64	105+31	3520.2	3525.2	3526.7	3527.3	3528.3
65	105+81	3520.0	3527.0	3529.1	3530.0	3531.2
*66	106+31	3519.8	3527.5	3529.5	3530.2	3531.1
*67	120+88	3534.2	3541.0	3542.9	3543.6	3544.7
*68	133+29	3549.5	3555.0	3556.3	3556.8	3558.0
*69	141+55	3555.0	3560.8	3562.4	3562.8	3564.0
*70	147+15	3563.4	3567.6	3568.8	3569.3	3570.2
71	150+03	3569.5	3576.1	3576.9	3577.2	3577.8
72	154+98	3577.3	3582.4	3583.4	3583.8	3584.5
73	163+25	3590.5	3596.1	3597.4	3597.8	3598.9
74	164+03	3590.2	3597.4	3598.8	3599.2	3600.3
75	164+53	3590.3	3598.2	3599.5	3600.0	3601.1
76	166+73	3598.0	3602.8	3604.0	3604.4	3605.2
77	167+23	3599.9	3606.5	3607.3	3607.6	3608.3
78	168+93	3608.1	3610.4	3611.0	3611.2	3611.7
79	174+21	3624.8	3627.7	3628.6	3628.8	3629.2
80	175+56	3629.2	3630.8	3631.6	3631.8	3632.4
81	177+21	3634.5	3639.0	3640.3	3641.0	3641.4
82	185+08	3657.2	3659.6	3660.6	3661.0	3662.0
83	186+58	3668.3	3672.2	3673.2	3673.6	3674.3

*Flood elevations shown for this section pertain only to streamflow in the main channel.

TABLE 6

BRIDGE DATA AND FLOOD ELEVATION FOR SAND COULEE CREEK

Cross Section Number	Creek Channel Stationing	Identification	Stream Bed Elev. (ft.) M.S.L.	Bridge Deck Elev. (ft.) M.S.L.	100-Year Flood Crest Elev. (ft.) M.S.L.	Bridge Underclearance Relation 100-Year Flood: Elev. (ft.) M.S.L.	Above	Below
2	15+50	River Drive	3311.5	3322.9	3323.6	3320.6		3.0
8	53+03	F.A.S. 459	3317.7	3328.0	3331.2	3326.2		5.0
14	169+76	Bridge 310 County Road	3329.0	3335.9	3337.1	3334.8		2.3
	264+07	Bridge 311 Fields Road	3334.7	3344.5	3345.7	3341.5		4.2
	268+32	Bridge 312 Fields Road	3335.2	3344.7	3345.7	3341.7		4.0
	304+29	Bridge 313 Goon Hill Rd.	3340.0	3345.9	3348.4	3344.7		3.7
	335+32	Bridge 315 Fields Road	3343.9	3351.6	3352.0	3350.9		1.1
	615+64	Burlington Northern R.R. Bridge	3376.0	3384.4	3383.6	3382.6		1.0
	625+08	Burlington Northern R.R. Bridge	3378.8	3386.9	3384.8	3384.0		.8

TABLE 6--BRIDGE DATA AND FLOOD ELEVATION FOR SAND COULEE CREEK (Continued)

Cross Section Number	Creek Channel Stationing	Identification	Stream Bed Elev. (ft.) M.S.L.	Bridge Deck Elev. (ft.) M.S.L.	100-Year Flood Crest Elev. (ft.) M.S.L.	Bridge Underclearance Relation 100-Year Flood Elev. (ft.) M.S.L.	Above	Below
29	634+35	Bridge 321 S. Highway F.A.S. 227	3379.9	3388.0	3388.2	3385.2		3.0
34	694+21	Bridge 321 A County Road	3385.6	3394.8	3396.8	3393.4		3.4
44	838+42	Bridge 323 Blaine St. (Tracy)	3415.8	3426.7	3426.4	3425.3		1.1
	856+43	Burlington Northern R. R. (Tracy)	3418.6	3432.8	3435.2	3431.0		4.2
51	878+78	Bridge 323 A Road to Brown	3426.8	3436.1	3439.4	3434.8		4.6

TABLE 7

CULVERT DATA AND FLOOD ELEVATION FOR SAND COULEE CREEK

Cross Section Number	Channel Stationing	Identification	Size (feet)		Number of Pipes & Type	Invert Elevations M.S.L.		Road Surface Elevations M.S.L.	100-Year Flood Crest Elevations M.S.L.
			dia.	length		Inlet	Outlet		
	368+80	Burlington Northern R.R.	3.0	46	2 CP	3349.7	3350.1	3359.1	3357.2
	368+80	Burlington Northern R.R.	4x4	46	1 RCP	3348.4	3348.5	3359.1	3357.2
24B	387+10	Gibson Flats Road	6.0	33	2 CMP	3348.8	3348.5	3357.2	3358.0
	917+71	Old Sand Coulee Cr. Road	8.5	60	1 CMP	3438.8	3435.9	3447.8	3452.2

CP=Clay Pipe
RCP=Reinforced Concrete Pipe
CMP=Corrugated Steel Pipe

TABLE 8

BRIDGE DATA AND FLOOD ELEVATION FOR SAND COULEE FORK

Cross Section Number	Creek Channel Stationing	Identification	Stream Bed Elev. (ft.) M.S.L.	Bridge Deck Elev. (ft.) M.S.L.	100-Year Flood Crest Elev. (ft.) M.S.L.	Bridge Underclearance Relation 100-Year Flood Elev. (ft.) M.S.L.	Above	Below
90	70+51	Bridge to private land	3465.6	3471.8	3469.7	3470.5	0.8	
95	90+70	Bridge 326 to Frontage Road	3489.2	3492.4	3494.6	3491.2		3.4

TABLE 9

CULVERT DATA AND FLOOD ELEVATION FOR SAND COULEE FORK

Cross Section Number	Channel Stationing	Identification	Size (feet) dia.	Size (feet) length	Number of Pipes & Type	Invert Elevations M.S.L. Inlet	Invert Elevations M.S.L. Outlet	Road Surface Elevations M.S.L.	100-Year Flood Crest Elevations M.S.L.
	10+13	Burlington Northern R.R.	3.0	40	1 RSP	3418.9	3418.4	3425.7	3427.4
	10+13	Burlington Northern R.R.	3.5	40	1 RCP	3419.6	3418.6	3425.7	3427.4
44A	15+53	Blaine Street	3.0	40	1 RCP	3422.7	3422.3	3427.9	3428.5
44A	15+53	Blaine Street	4.0	40	1 RCP	3422.3	3421.7	3427.9	3428.5
	16+53	Highway F.A.S. 227	3.0	40	2 RCP	3422.7	3422.4	3427.7	3428.5
85	52+44	Highway to Sand Coulee	4.0	122	1 RCP	3444.9	3443.0	3451.5	3448.3
	105+93	Street to Frontage Road	4.0	32	1 RCP	3501.2	3500.8	3505.6	3507.1

RSP=Riveted Steel Pipe
RCP=Reinforced Concrete Pipe

TABLE 10

BRIDGE DATA AND FLOOD ELEVATION FOR COTTONWOOD CREEK

Cross Section Number	Creek Channel Stationing	Identification	Stream Bed Elev. (ft.) M.S.L.	Bridge Deck Elev. (ft.) M.S.L.	100-Year Flood Crest Elev. (ft.) M.S.L.	Bridge Underclearance Relation 100-Year Flood Elev. (ft.) M.S.L.	Above	Below
58	1+02	Bridge 329 Frenchman Hill Rd.	3461.4	3470.0	3471.3	3467.8		3.5
	86+53	Bridge 332 Highway F.A.S. 227	3512.1	3521.3	3524.0	3519.3		4.7
65	105+81	Bridge 333 Giffen Coulee Rd.	3520.0	3529.0	3530.0	3527.7		2.3

CULVERT DATA AND FLOOD ELEVATION FOR COTTONWOOD CREEK

Cross Section Number	Channel Stationing	Identification	Size (feet) dia.	Size (feet) length	Number of Pipes & Type	Invert Elevations M.S.L. Inlet	Invert Elevations M.S.L. Outlet	Road Surface Elevations M.S.L.	100-Year Flood Crest Elevations M.S.L.
	120+88	Highway F.A.S. 227	4.0	60	2 RCP	3536.3	3535.4	3543.8	3546.1
71	150+53	Dewey Ave.	2.5	24	1 CMP	3569.4	3569.5	3574.8	3577.2
74	164+03	Dewey Ave.	2.5	26	1 RCP	3590.2	3589.0	3595.1	3599.2
77	167+23	Cottonwood Coulee Rd.	3.5	60	1 RCP	3599.9	3598.6	3605.4	3607.6
	168+23	Street	3.5	30	1 CMP	3605.6	3605.4	3610.1	3610.5
	175+11	Highway F.A.S. 227	4.0	32	2 RCP	3626.4	3625.4	3632.5	3630.8
	176+86	Cottonwood Avenue	4.0	40	1 RCP	3634.5	3633.6	3639.2	3640.7
	186+38	Highway F.A.S.	5.0	140	1 RCP	3668.3	3657.2	3675.3	3673.4

RCP=Reinforced Concrete Pipe
CMP=Corrugated Metal Pipe

TABLE 12

INCREASED DEPTH-REMAINING FLOODWAY WIDTH VALUES

Valley Cross Section Number	Stream Channel Width	100-Yr. Designated Floodway Width			0.5 ft. Increased Depth Remaining Width			1.0 ft. Increased Depth Remaining Width		
		Left[1/]	Right	Total	Left	Right	Total	Left	Right	Total
				SAND COULEE CREEK						
3	112	1611	143	1866	1030	26	1168	961	3	1076
4	190	1592	338	2120	807	203	1200	753	98	1041
5	130	336	1099	1565	160	435	725	120	380	630
6	105	114	1183	1402	28	869	1002	15	530	650
7	48	970	464	1482	702	253	1003	515	216	779
9	90	1530	365	1985	1294	269	1653	809	224	1123
10	43	2236	127	2406	897	94	1034	765	77	885
11	30	399	1230	1659	232	931	1193	187	707	924
12	35	589	1305	1929	314	743	1092	262	628	925
13	105	435	2456	2996	222	1402	1729	177	1081	1363
15	120	636	2457	3213	176	1576	1872	120	1207	1447
16	45	1067	1124	2236	668	737	1450	559	593	1197
17	140	1240	1113	2493	819	686	1645	673	519	1332
18	116	2432	30	2578	1536	0	1652	1213	0	1329
19	123	1400	844	2367	444	844	1411	344	844	1311
20	110	1259	3877	5246	551	3064	3725	398	2542	3050
24	184	397	1316	1897	111	1094	1389	89	934	1207
24A	17	158	783	958	68	783	868	46	783	846
25	70	934	833	1837	597	317	984	427	244	741
26	24	698	1876	2598	386	1389	1799	275	1093	1392
28	30	837	5535	6402	----------	----------	Not	Computed	----------	----------
30	39	885	5706	6630						
31	20	635	1820	2475	410	1523	1953	339	1316	1675
32	35	497	1056	1588	369	536	940	310	441	786
33	50	840	1495	2385	326	652	1028	271	458	779

TABLE 12--INCREASED DEPTH-REMAINING FLOODWAY WIDTH VALUES (Continued)

Valley Cross Section Number	Stream Channel Width	100-Yr. Designated Floodway Width			0.5 ft. Increased Depth Remaining Width			1.0 ft. Increased Depth Remaining Width		
		Left 1/	Right	Total	Left	Right	Total	Left	Right	Total
35	48	944	1293	2285	708	576	1332	596	440	1084
36	82	542	2062	2686	- - - - - - - Not Computed - - - - - - - - - -					
37	80	196	2432	2708	94	947	1121	63	589	732
38	38	4	2891	2933	0	1499	1537	0	769	807
39	127	0	2994	3121	- - - - - - - Not Computed - - - - - - - - - -					
40	85	403	2531	3019	51	1765	1901	0	1333	1418
41	65	333	982	1380	221	685	971	155	543	763
42	62	195	910	1167	0	679	741	0	574	636
43	90	273	946	1309	121	647	858	0	461	551
45	77	284	983	1344	62	728	867	0	599	676
46	60	122	558	740	81	430	571	61	349	470
47	86	396	308	790	322	203	611	269	154	509
48	53	350	282	685	287	226	566	238	199	490
49	85	945	5	1035	718	0	803	613	0	698
50	140	520	384	1044	337	53	530	263	10	413
52	44	1120	372	1536	792	84	920	672	57	773
53	80	1153	8	1241	- - - - - - - Not Computed - - - - - - - - - -					
54	76	57	822	955	27	386	489	16	272	364
55	190	410	0	600	223	0	413	163	0	353
56	120	72	320	512	0	192	312	0	146	266
57	105	664	0	769	515	0	620	483	0	588
COTTONWOOD CREEK										
59	91	477	15	573	44	0	135	15	0	106
60	53	87	314	454	74	197	324	67	155	275
61	26	146	166	338	65	108	199	49	85	160
62	23	69	236	328	41	107	171	32	79	134

TABLE 12--INCREASED DEPTH-REMAINING FLOODWAY WIDTH VALUES (Continued)

Valley Cross Section Number	Stream Channel Width	100-Yr. Designated Floodway Width			0.5 ft. Increased Depth Remaining Width			1.0 ft. Increased Depth Remaining Width		
		Left[1/]	Right	Total	Left	Right	Total	Left	Right	Total
63	35	82	164	281	56	114	205	49	102	186
64	50	252	153	455	139	0	189	110	0	160
66	105	377	157	639	147	112	364	114	53	272
67	88	0	80	168	0	0	88	0	0	88
68	50	80	0	130	53	0	103	31	0	81
69	70	50	0	120	29	0	99	8	0	78
70	41	102	0	143	72	0	113	56	0	97
72	75	0	123	198	0	24	99	0	0	75
73	36	61	37	134	20	19	75	14	13	63
75	38	35	17	90	9	7	54	3	0	41
76	87	87	45	219	7	35	129	0	26	113
78	30	165	0	195	0	0	30	0	0	30
79	28	41	32	101	0	15	43	0	5	33
80	45	0	0	45	0	0	45	0	0	45
81	18	22	93	133	0	0	18	0	0	18
82	19	0	0	19	0	0	19	0	0	19
83	33	98	0	131	75	0	108	0	0	33
SAND COULEE FORK										
42A	39	45	297	381	0	53	92	0	25	64
43A	105	805	196	1106	315	106	526	262	18	385
45A	129	818	279	1226	498	179	806	337	111	577
46A	105	835	0	940	- - - - - - - - Not Computed - - - - - - - - -					
47A	83	610	0	693	257	0	340	99	0	182
48A	30	633	0	663	278	0	308	188	0	218
49A	21	386	0	407	185	0	206	139	0	160
51A	47	93	684	824	0	428	475	0	261	308
84	48	0	395	443	0	216	264	0	0	48

TABLE 12--INCREASED DEPTH-REMAINING FLOODWAY WIDTH VALUES (Continued)

Valley Cross Section Number	Stream Channel Width	100-Yr. Designated Floodway			0.5 ft. Increased Depth			1.0 ft. Increased Depth		
		Width			Remaining Width			Remaining Width		
		Left 1/	Right	Total	Left	Right	Total	Left	Right	Total
86	33	0	505	538	0	271	304	0	230	263
87	27	38	321	386	0	66	93	0	0	27
88	46	0	424	470	0	50	96	0	0	46
89	33	0	394	427	0	265	298	0	167	200
91	38	0	406	444	0	251	289	0	0	38
92	60	0	268	328	0	0	60	0	0	60
93	44	3	292	339	- - - - - - - - -Not Computed - - - - - - - - - -					
94	32	85	83	200	22	0	54	0	0	32
96	30	56	114	200	20	43	93	13	19	62
97	33	43	139	215	19	6	58	6	0	39
98	17	15	92	124	0	43	60	0	25	42

1/ The distances to the left and right are measured from the respective edges of the stream channel.

Note: This table indicates the amount the total flood area must be constricted to cause a 0.5' and 1.0' increase in flood elevation. This reduction in floodway width is based on equal reduction in the floodway conveyance factors on both sides of the channel.

SAND COULEE CREEK FLOOD HAZARD STUDY
COAST AND GEODETIC SURVEY BENCH MARKS
(USED FOR THIS SURVEY)

Bench Mark No. C-165
Elevation 3,329.862
Description:

About 4.6 miles southeast along the Burlington Northern Railway from the station at Great Falls, in section 25, T20N, R3E, 0.1 mile southwest of the Ayshire Dairy Barns, at a private road crossing and 11 poles southeast of milepost 220, 46 feet northeast of the north-east rail, 21 feet northwest of the center line of the private road, 11 feet west of a power pole braced by a guy wire, 1-1/2 feet south-west of a fence, 1.4 feet northwest of a metal witness post, about level with the road, about 5 feet below the level of the rail, and set in the top of a concrete post projecting 4 inches.

Bench Mark No. D-165
Elevation 3,338.930
Description:

About 5.0 miles west along the Burlington Northern Railway from the station sign at Gerber, or 6.5 miles southeast along the Burlington Northern Railway from the station at Great Falls, in section 29, T20N, R4E, at a road crossing and 6 poles east of milepost 218, 46 feet north of the north rail, 53 feet west of the center line of a road leading north, 34 feet southeast of a steel tower for a power line, 14-1/2 feet northwest of a telephone pole, 1-1/2 feet south of a fence, 1.4 feet west of a metal witness post, about 1 foot below the level of the track, and set in the top of a concrete post projecting 2 inches.

Bench Mark No. D-40
Elevation 3,336.023
Description:

About 5.7 miles southeast along the Burlington Northern Railway from the station at Great Falls, or 5.8 miles west along the Burlington Northern Railway from the station sign at Gerber, in section 30, T20N, R4E, 13 poles east of milepost 219, about 150 feet north-northwest of and across a private road from the northwest corner of a farmhouse, 41 feet south of the south rail, 49 feet southwest of the center of a private road crossing, 50 feet north of the center line of a graveled road that parallels the track, 1.2 feet north of a metal witness post, about 4 feet above the level of the road, about 2 feet below the level of the track, and set in the top of a concrete post flush with the ground.

Bench Mark E-40
Elevation 3,349.039
Description:

About 4.0 miles west along the Burlington Northern Railway from the station sign at Gerber, in section 28, T20N, R4E, 4 poles west of the railroad siding which was formerly Fields, 37-1/2 feet northeast of the 6th pole east of milepost 217, 53 feet north of the north rail of the main track, set in the top of a rock ledge, 37-1/2 feet north of the north rail of a side track, 21 feet north of a fence, about 2 feet above the level of the track, and flush with the ground.

Bench Mark E-165
Elevation 3,350.102
Description:

About 3.0 miles west along the Burlington Northern Railway from the station sign at Gerber, in section 27, T20N, R4E, 7 poles east of milepost 216, 42 feet north of the north rail, 11-1/2 feet north of a telephone pole, 1-1/2 feet south of a fence, 1.8 feet west of a metal witness post, about 5 feet below the level of the track, and set in the top of a concrete post projecting 4 inches.

Bench Mark G-40
Elevation 3,383,320
Description:

About 0.1 mile east along the Burlington Northern Railway from the station sign at Gerber, in section 25, T20N, R4E, 9-1/2 poles east of milepost 213, 5-1/2 feet north of the north rail, set in the top of the north end of the west concrete abutment of a bridge over Gerber Creek, and about 1-1/2 feet below the level of the track.

Bench Mark TCB-8-1953
Elevation 3,426.033
Description:

Centerville, 2.2 mi. N. of high school along Gerber Branch of the Burlington Northern Railway (or asphalt county road); near NE corner Sec. 12, T19N, R4E; 112 ft. W and 0.9 ft. higher than W rail of railway; 46 ft. W and 4.5 ft. lower than asphalt county road; 115 ft. S of farm entrance; 17 ft. S of fence corner; 2 ft. E of fence; in concrete post projecting 5 in. above ground; standard tablet stamped, "TCB 8 1953 3426".

Bench Mark TCB 7 1953
Elevation 3,473.805
Description:

Centerville, at schoolhouse; near NE corner of Sec. 19, T19N, R5E; 200 ft. NW OF NW corner of school building; 39 ft. W and 0.3 ft. higher than W rail of Gerber Branch of the Burlington Northern Railway; 44 ft. E and 2.4 ft. lower than center line of asphalt Stockett-Sand Coulee road; 303 ft. S of gravel Spring Creek road; in concrete post 6 in. above ground; standard tablet stamped, "TCB 7 1953 3474".

Bench Mark TCB 11 1953
Elevation 3,670.881
Description:

Stockett, southern edge; near S 1/4 cor. Sec. 36, T19N, R4E, where road S begins upgrade; 31 ft. E and 2.7 ft. higher than road; 67 ft. N of shallow drain; 84 ft. SE of fence corner; in large rock; standard tablet stamped, "TCB 11 1953 3671".

SAND COULEE CREEK FLOOD HAZARD ANALYSIS

TBM DESCRIPTIONS

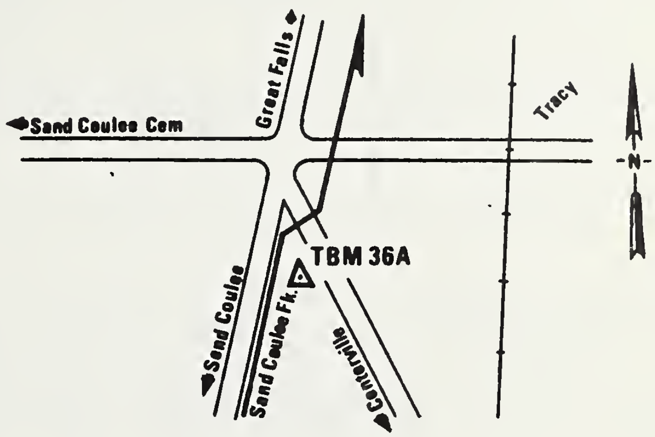
TBM [1] Number	MSL [2] Elevation	Description
1	3327.01	On top of pier painted red on NW corner of Sand Coulee Creek bridge. First bridge south of Ayrshire Dairy.
2	3330.01	On top of iron anchor post for corner post on NW corner of first intersection south of first bridge south of Ayrshire Dairy.
3	3321.67	On point of large white rock on SW corner of bridge over Sand Coulee Creek on River Drive, Sec. 36, T20N, R3E.
4	3326.40	On 2x2 hub by brown corner post on SE corner of bridge to Christenson house.
5	3333.17	On 2x2 hub set by R/W fence 21' north of cross section 11 and 120' west of fence running south from highway.
20-A	3344.71	On SE corner of bridge deck, first bridge east of Fields.
21-A	3345.31	On 1x2 hub on south side of county road, 3,250' east of Fields, or 30' west of power pole west of white bridge, Sec. 33, T20N, R4E.
22-A	3345.64	On NW wing of white bridge across Sand Coulee Creek on first road south off county road east of Fields (known as Goon Grade).
23-A	3350.54	On end of bottom bolt in power pole that has brace anchor pole on north side of road, first one east of TBM 22-A.
24-A	3350.54	On end of SW wing wall on 3rd bridge east of Fields.

TBM DESCRIPTIONS FOR SAND COULEE CREEK

TBM 1/ Number	MSL 2/ Elevation	Description
25-A	3358.65	On point of large rock in NE corner of road intersection 165' south of south RR rail in SE ¼ Sec. 27, T20N, R4E.
26-A	3361.81	On top of south end of pipe under RR; first pipe east of point of hill ½ mile west of Lyman Ranch feedlot.
27-A	3372.29	On top of east end of 12" metal pipe under entrance drive to power station about 500 feet east of Lyman Ranch house on east line of Sec. 26, T20N, R4E.
30-A	3385.54	On SW wing of 2nd RR bridge east of Gerber, 1,300' west of section corner 25|30 / 36|31 T20N, R4E-R5E.
31-A	3388.56	On south side of concrete footing for RR signal on south side of main line of BN RR at crossing on Stockett-Sand Coulee Road; ½ mile east of Gerber, 200' north of section corner 25|30 / 36|31 T20N, R4E-R5E.
32-A	3390.23	On large boulder on west side of highway to Tracy. On south end of first highway curve east of Gerber. Center, N½ Sec. 31, T20N, R5E.
33-A	3396.01	On NE corner of concrete box in NW corner of hayfield on SE corner of road intersection and RR crossing approximately 2 miles north of Tracy. SW¼, Sec. 31, T20N, R5E.
34-A	3398.29	On point of large sandstone rock on west side of highway 50' north of driveway, 2nd set of buildings south of RR crossing, NW¼, Sec. 6, T19N, R5E.
35-A	3412.77	On top of highway R/W marker on west side of highway north of driveway to multi-colored house one mile north of Tracy. Center, W½, Sec. 6, T19N, R5E.

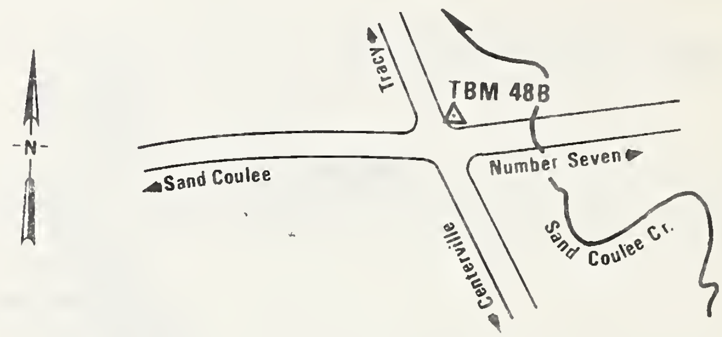
TBM DESCRIPTIONS FOR SAND COULEE CREEK

TBM [1/] Number	MSL [2/] Elevation	Description
36-A	3425.48	On top of R/W marker in center of "Y" of highways at Tracy--Sec. 12, T19N, R4E



42-B	3409.04	On west end of culvert under RR 30' south of cross section 39, SW¼, Sec. 6, T19N, R5E.
43-B	3415.65	On bolt head of east rail splice on BN RR on cross section 40, SW¼, Sec. 6, T19N, R5E.
44-B	3420.25	On bolt head on west rail splice, on BN RR 20' east of cross section 41, NE¼, Sec. 12, T19N, R4E
45-B	3425.81	On large flat rock by old round post, 40' west of RR track, 100' north of white house with pink trim at north edge of Tracy, Sec. 12, T19N, R4E.
46-B	3428.19	On nut on first rail splice on east rail of track on south side of crossing on Blaine Street in Tracy, Sec. 7, T19N, R5E.
47-B	3432.38	On top of NW end of abutment beam under RR bridge, 1st bridge south of Tracy on Sand Coulee Cr.

	MSL 2/ Elevation	Description
48-B	3437.79	On point of large sandstone rock by base of power pole in NW corner of highway intersection 1 mile south of Tracy--E½, Sec. 13, T19N, R4E.



49-B	3442.91	On R/W marker on south side of pavement, 18' east of telephone pole. Also, south of a green house with red trim that is on north side of pavement. W½, Sec. 18, T19N, R5E.
50-B	3448.46	On highway R/W marker on south side of highway where highway starts around hill. NE¼, SW¼, Sec. 18, T19N, R5E.
51-B	3467.91	On top of west end of 2' corrugated metal pipe under highway, 95' south of white house with brown trim and white picket fence at north end of Centerville on N. sec. line, Sec. 19, T19N, R5E.
52-B	3480.01	On white rock, 2' south of fence south of old RR grade at point of hill approximately 1,000' SW of Centerville School, SW¼, NE¼, Sec. 19, T19N, R5E.
53-B	3485.75	On point of large sandstone rock on north side of RR grade 4 inches high. 200' west of cross section 61.
54-B	3518.57	On large flat rock between RR grade and highway 1.5 miles SW of Centerville or 550' SW of first highway bridge across creek SW of Centerville.
55-B	3540.69	On top of inlet end of east RCP under highway across road from green bldg. 1 mi. north of Stockett.

TBM DESCRIPTIONS FOR SAND COULEE CREEK

TBM [1/] Number	MSL [2/] Elevation	Description
58-B	3576.55	On R/W marker on south side of highway across from old machinery on SE corner of intersection on north edge of Stockett.
60-B	3638.14	On outlet end of 4' RCP, 100' E of red board fence on old road through Stockett, south end of town near cross section 83.
70-S	3449.32	On top of inlet end of RCP under highway, 700' north of town of Sand Coulee.
71-S	3453.62	Top of west end of CMP under highway at street-highway intersection, north edge of the town of Sand Coulee.
73S	3470.28	On NW corner of sidewalk in front of Sand Coulee Post Office.
74-S	3477.81	RR spike in telephone pole in NE corner of intersection where highway and street intersect, south end of business district in Sand Coulee.
75-S	3483.64	On top inlet end of RCP in center of "S" curve in highway, south end of business district in Sand Coulee.
76-S	3492.55	On large rock on NE wing of white bridge, 1st bridge south of business district in Sand Coulee.

1/ Temporary Bench Mark (TBM)

2/ Mean Sea Level (MSL)

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE