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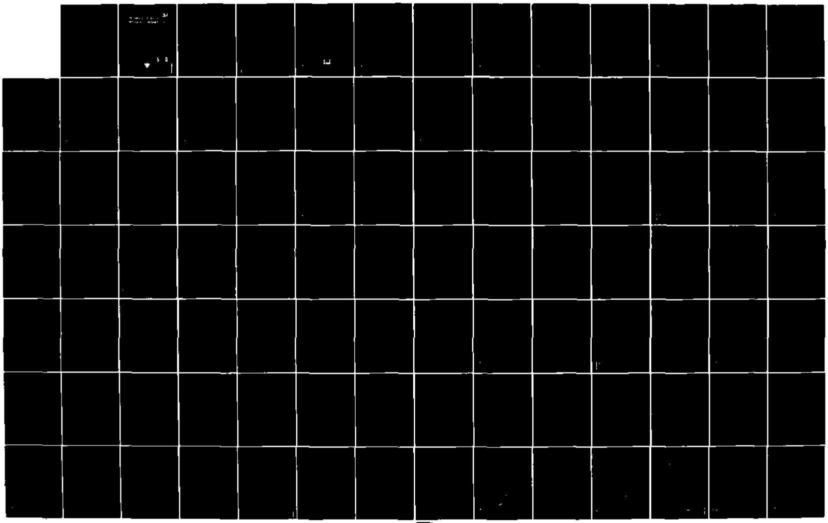

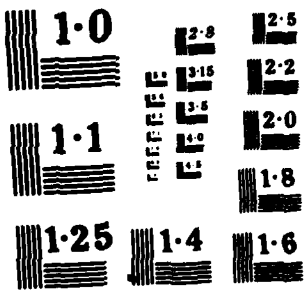
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REDWOOD RIVER at MARSHALL, MINNESOTA

FEASIBILITY REPORT FOR FLOOD CONTROL

JUNE 1979

Channel

Diversion

Redwood River

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT,
CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

UNCLASSIFIED

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this study was to investigate alternative measures and select a plan for insuring effective operation on the existing flood control project and providing flood protection to new unprotected development. Recurrent flooding of the Redwood River together with damaging overflows into the adjoining Cottonwood River basin has resulted in flood damages and the need for local emergency flood ~~fights~~ evacuation.
The selected plan consists of channel widening, straightening, bank reshaping, levees, an overflow diversion structure with appurtenant control and outlet

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) works, interior drainage works, aesthetic measures, recreational facilities, and required relocations. The plan also includes revegetation of all disturbed areas. A 133-year degree of flood protection for the City of Marshall and adjacent urbanized areas would be provided.

This report consists of a main report and two appendices.

FEASIBILITY REPORT FOR FLOOD CONTROL

REDWOOD RIVER AT MARSHALL, MINNESOTA

UNDER SECTION 216 OF THE FLOOD CONTROL ACT OF 1970, AS AMENDED

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

SYLLABUS

The purpose of this study was to investigate alternative measures and select a plan for insuring effective operation of the existing flood control project and providing flood protection to new unprotected development. Recurrent flooding of the Redwood River together with damaging overflows into the adjoining Cottonwood River basin has resulted in flood damages and the need for local emergency flood fights.

The selected plan of improvement consists of channel widening, straightening, and bank reshaping measures; levees; an overflow diversion structure with appurtenant control and outlet works, interior drainage works; aesthetic measures; recreational facilities; and required relocations. The plan also includes revegation of all disturbed areas. The plan would provide a 133-year degree of flood protection for the City of Marshall and adjacent urbanized areas.

Adverse environmental effects resulting from plan implementation would be minimized where possible. Opportunities for environmental enhancement in some areas would be realized. The economic stability and effects of the flood damage reduction benefits resulting from the plan will have favorable impacts on the regional and national economies.

The District Engineer recommends Federal participation in the construction of the additional flood protection and recreational measures at Marshall in accordance with the President's cost sharing policy.

The estimated cost to the Federal Government would be $1,745,100. The estimated combined non-Federal first cost is $758,900. The benefit-cost ratio for the proposed overall project is 1.8.

PREFACE

In reviewing this document, it should be specifically noted that completion of this study and report has undergone several years' delay in order to reflect numerous changes in Federal policy, regulations, and procedures. It should be further noted that during this time the city of Marshall has experienced vibrant growth and development, and this high growth rate is anticipated to continue for some time into the future based on currently announced industrial plant and employment expansion plans and new housing expansion trends (averaging about 160 housing units per year over the past 5 years). Information on this vibrant rate of growth in urban development is contained in Appendix I, Section J (See Development Under Existing Conditions).

Since the background information contained in this report on the resources and economy of the study area was developed early in the 1970's prior to this vibrant growth rate at Marshall, the future population and projected urban growth rates presented in the main report and various appendixes are now conservative and outdated estimates. Modifying this report to properly reflect existing and future growth rates would not alter the selected flood damage reduction plan or its scale of development. Phase I preconstruction planning will reflect any changed condition. Thus, further delay in completing this study to reflect more appropriate existing and projected future growth rates is not believed warranted at this time or in the best public interest. Proceeding with project authorization, postauthorization planning, and timely construction would best serve the needs of the citizens of Marshall and alleviate the threat, potential for loss of life, and human suffering associated with flooding.

REDWOOD RIVER AT

MARSHALL, MINNESOTA

FEASIBILITY REPORT

FOR FLOOD CONTROL

THE STUDY AND REPORT

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REDWOOD RIVER AT

MARSHALL, MINNESOTA

FEASIBILITY REPORT

FOR FLOOD CONTROL

THE STUDY AND REPORT

Marshall, Minnesota, the county seat of Lyon County, is located in southwestern Minnesota near the center of the Redwood River Basin. The community occupies both banks of the Redwood River for a distance of about 4.8 miles at a point approximately 68 miles upstream of the river's confluence with the Minnesota River, as shown on plate 1. A federally-constructed flood control project was completed at Marshall in 1963. This project was originally designed for a peak flood flow of 6,500 cfs which had a 114-year frequency of occurrence. After the occurrence of two major floods in a short time span (1957 and 1969), discharge-frequency relationships at Marshall have been revised. Based on the revised discharge-frequency curve, what was originally a 114-year recurrence interval is now a 59-year interval. Because of flood problems experienced during the record April 1969 flood due to inadequate channel capacity both upstream and downstream of the existing project, the City and County have requested a study to determine if corrective action is advisable. A discussion of background information, problems and needs, alternative measures considered, and recommended action are discussed in the following report sections.

PURPOSE AND AUTHORITY

Authority for this study is provided for in section 216 of the 1970 River and Harbor Act. This section of the Act states:

> "The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."

By resolutions of 6 June 1972 and 3 July 1972 respectively, the Lyon County Board of Commissioners and the City of Marshall requested that the Corps of Engineers review the operation of the existing project to determine the advisability of corrective measures required to upgrade the project and provide protection to unprotected development at Marshall. By letter of December 3, 1975, the City of Marshall requested additional studies of the advisability of locally desired recreational facilities in conjunction with the existing and proposed flood control measures.

SCOPE OF THE STUDY

The flood control portion of this study principally concerns the adequacy of the existing Corps of Engineers project in providing flood damage reduction in the City of Marshall and adjacent urbanized areas both upstream and downstream of the city. The study area applicable to flood damage reduction and recreational needs includes these reaches in addition to the natural river reach through the city. Any required recreational lands would be limited to lands acquired for the existing and proposed flood control project or immediately adjacent lands purchased entirely at local expense to provide access to considered developments. Investigations were made in sufficient detail to permit selection of the best overall plan from a series of alternatives and establish final project designs and cost estimates. Selection of the recommended plan was made after considering various effects, water and related land resource planning objectives, current planning policies and criteria, and the views of interested agencies and public. Coordination was maintained through the study with the City of Marshall and interested state and Federal agencies.

STUDY PARTICIPANTS AND COORDINATION

To assure the acceptability of a plan to the local public, close coordination between Federal, State and local interests has been an important element in this study. Several meetings were held with the City of Marshall to identify the nature and extent of the flood problem and needed recreation facilities and to determine alternative solutions thereto. Coordination was maintained with the following state and Federal agencies during the study:

* Minnesota Department of Natural Resources
* Minnesota Pollution Control Central Agency
* Minnesota Department of Highways
* U.S. Department of the Interior - Fish and Wildlife Service
  - Bureau of Outdoor Recreation
  - National Park Service
* U.S. Department of Agriculture - Soil Conservation Service
* U.S. Environmental Protection Agency

Meetings open to and attended by the public were held with the Marshall City Council on 3 March 1975 and 20 October 1975 to obtain local views on proposed upstream and downstream reach improvements respectively. Pertinent correspondence regarding this coordination effort is attached in Appendix II. On February 1977 a public meeting was held at Marshall to discuss the proposed plan of improvement. A copy of the meeting transcript together with subsequent correspondence received is also contained in Appendix II.

A meeting was held with City officials in Marshall on 2 March 1978 to review revised study recommendations based on a review of the draft report by higher Corps authority. On 2 April 1979, a meeting was held with City officials and other interested persons to discuss additional studies of alternative flood barrier alignments made in response to Executive Orders 11988 and 11990. At this same meeting, the City adopted two resolutions indicating its willingness and intent to provide required assurances of local cooperation when and as required for the proposed flood plain management and recreation measures. Copies of these resolutions are also contained in Appendix 2.

THE REPORT

Results of this study are presented in a main report with two appendices. The main report is a brief non-technical presentation with recommendations concerning proposed improvements to alleviate the flood problem at Marshall. Appendix I is a detailed technical report following the same general outline as the main report, but providing greater detail on natural and economic resources, plan formulation, and division of responsibilities for implementing the selected plan. Appendix II contains all pertinent correspondence associated with the study.

PRIOR STUDIES AND REPORTS

House Document No. 230, 74th Congress, 1st Session, includes a report submitted by the St. Paul District Engineer on 24 November 1934 concerning water and related land resource problems in the Minnesota River Basin. However, this report did not specifically consider flooding and related problems at Marshall.

House Document 417, 86th Congress, 2nd Session, includes a 25 March 1960 report from the St. Paul District Engineer recommending flood control improvements at Marshall to include clearing and snagging of a 3.1 mile reach of the Redwood River, construction of 2,135 feet of levee, and a floodwater diversion channel at Federal and Non-Federal first costs of $2,252,000 and $701,000 respectively, and subject to certain assurances of local cooperation.

A flood plain information report on the Redwood River at Marshall was prepared by Wehrman, Chapman Associates, Inc., Minneapolis, Minnesota under contract to the Corps of Engineers in December, 1974. This report, prepared at the request of the City of Marshall with the endorsement of the Minnesota Department of Natural Resources contains maps, profiles, and cross sections which indicate the extent of flooding which has been experienced and which could occur in the future at Marshall.

A flood insurance report has been prepared for the city by the St. Paul District, Corps of Engineers under contract to the Federal Insurance Administration. This report was completed in August 1976.

RESOURCES AND ECONOMY OF THE STUDY AREA

The City of Marshall (1970 population 9,886) is located in southwestern Minnesota and along the Redwood River at mile 68.1 as shown on plates 1 and 2. It is the county seat of Lyon County and also serves as the retail trade and service center for the surrounding rich agricultural region.

ENVIRONMENTAL SETTING AND NATURAL RESOURCES

Marshall is located along the Redwood River between river miles 66.0 and 70.8. The town lies on the topographic divide between the Redwood and Cottonwood River basins, the Cottonwood River located about 6 miles to the south at its nearest point.

Land use in the study area outside the urbanized area is predominantly agricultural with scattered rural residential and recreation uses. A narrow intermittent fringe of bottomland forest along both river banks provides food, water, and sanctuary for area wildlife. The agricultural lands, which extend to these wooded areas are slowly being lost to expanding residential and other development. Public land use along the flood plain consists of a state roadside park, city-owned right-of-way along the existing floodwater diversion channel, and the Southwest State College at Marshall and three city parks.

The Redwood River rises in Pipestone County and extends downstream along an elongated drainage area of approximately 743 square miles of which 251 square miles are located upstream of Marshall. The river at Marshall is generally less than 40 feet wide with numerous areas of steep, eroding banks and is flanked on both sides by an intermittent but fairly dense strip of tree and understory cover.

The general topography of the basin is that of a rolling upland area. The river drops from an elevation of about 1,850 feet above sea level to an elevation of 1,200 feet at Marshall for an average rate of about 18 feet per mile. The river slope then flattens to an average of about 4 feet per mile between Marshall and Redwood Falls (mile 8.5[1]). Between Redwood Falls and its confluence with the Minnesota River, the river slope increases sharply to an average of 24 feet per mile.

Soil patterns in the Marshall area are complex due to the nature of the glacial deposits and mixing action of wind, water, and stream flow. Soils are of recent and glacial origin and consist of alluvial silt, clay, and sand underlain by clayey glacial till or sandy outwash material. The inherent soil fertility is quite high, reflected in high annual agricultural yields during non-drought periods.

The climate of the study area is characteristically continental with wide seasonal variations in temperature. Average mean daily temperatures range from 74° in July to 13° in January, the coldest month. A ..rage annual temperature is about 45° with recorded extremes of -36° F and 107° F. Normal yearly precipitation is about 27 inches with the annual snowfall averaging about 40 inches. High intensity rains of 4 to 5 inches in 24 hours are not uncommon during the spring and summer.

Vegetation in the study area consists of the thin strip of forest and understory cover along the river banks, small isolated plots of native prairie, grasslands on previously tilled cropland, and domesticated plant communities on agricultural and residential areas. Reed canary grass is by far the most abundant grass species found on the river banks. Aquatic vegetation generally consists of several species of attached algae and a few species of aquatic weeds.

[1] All Redwood River mileages referenced to mile 0.0 at the confluence with the Minnesota River.

The river woodlands provide habitat and a source of food and water for a variety of wildlife. Red fox (Vulpes fulva), raccon (Procyn lotor), mink (Mustela vison), muckrat (Ondatra zibethica), and beaver (Castor canadensis) are common in the area. The woodlands along the river just downstream of Marshall are uniquely important to the local bird population as many species of wading birds are attracted to the sewage disposal ponds located north of Marshall. No significant sport fishery is present in the river at Marshall due to the high turbidity levels and very shallow depths or dry areas during low-flow periods.

Although the Marshall area has experienced substantial Indian and early white settler activity, no evidence of historic Indian, or sites of other historical or archeological interest have been identified in the study area. This finding is supported by a check of the National Register of Historic Places, research done by the State of Minnesota, and an environmental assessment for the Marshall municipal airport by the City Engineer.

Major recreational resources in Marshall include four municipal parks and a private golf course. Developed public use areas in the immediate study area include the state roadside park located southwest of the community as shown on plate 1, and three city parks as shown on plate 2. Some walking trails are found in the river woodlands but are not publicly owned. Fishing and canoeing activity is minimal due to the very shallow areas and fallen trees and snags in the channel. The City is presently making a study of a bicycle trail system around the city. A portion of this system would utilize existing city-owned diversion channel right-of-way and provide connections to the college and downtown areas.

Two County ditches are located within the study area. These ditches No. 70 and No. 62 are maintained by Lyon County in accordance with

State law. The Redwood River downstream of the State Highway 23 crossing is classified as a judicial ditch.

The existing flood control project at Marshall is located mostly within the City limits and operated and maintained by the City in accordance with local assurances of cooperation previously furnished to the Secretary of the Army. The City has recently adopted a flood plain management program based on the completed flood plain information report. Management of unincorporated flood plain areas adjacent to the city are subject to an existing agreement between the City and Lyon County.

HUMAN RESOURCES

The present site of Marshall was settled in 1869. Railroad transportation to the town was initiated in 1872. The city's population has steadily increased to a 1970 population of 9,886, an increase of 48 percent over the 1960 census. Much of this increase was due to annexation by the City and the opening of the Southwest State College at Marshall. The City's population is expected to grow over the next 25 years but at a decreasing rate.

DEVELOPMENT AND ECONOMY

Marshall, the county seat of Lyon County, serves as an important regional government, trade and service center. The State college provides various educational and cultural opportunities for area residents. Much of the agricultural activity around Marshall is based on the marketing of annual products with three of the largest employers involved in food processing. Farming in the area continues to become more specialized with a decrease in cash crops and an increase in livestock and dairy operations. Median family income for Marshall residents in 1970 was $9,856 with a per capita income of $2,840. The Marshall area is served by one major U.S. highway, three State highways, rail freight service, two truck freight lines, bus service, and a charter airplane service.

PROBLEMS AND NEEDS

The existing federally-constructed flood control project provides protection to much of Marshall during the frequent smaller floods. However, a large portion of the city remains subject to severe damage during major flood periods. The following paragraphs discuss the status of existing improvements, the flood problem and improvements desired by local interests. Additional discussion of study area resource management problems and needs is given in Section C of Appendix I to this report.

STATUS OF EXISTING PLANS AND IMPROVEMENTS

In 1952 the City completed a 1,100-foot long channel cutoff on the Redwood River at mile 67.0. This cutoff together with channel clearing and straightening works by the Corps of Engineers in 1953 reduced flood stages about a foot in the downstream portion of the town. The City was provided additional protection with the completion of the existing diversion project in 1963. This project, constructed by the Corps of Engineers, included channel clearing and snagging, a levee, a 2.4-mile long floodwater diversion channel,

channel enlargement along two river reaches, flanking spoil dikes along improved channel reaches, drop structures in the diversion and natural channels, and necessary road, rail and bridge alterations. The project was designed to pass a flow of 6,500 cubic feet per second (cfs) around and through the city with no significant flood damage.

The City presently has a flood plain management program in effect with floodway recently having been designated for the area. Adjacent flood plain reaches upstream and downstream of the City limits are subject to Lyon County flood plain management regulations for unincorporated areas.

THE FLOOD PROBLEM

The City of Marshall remains subject to severe flood damage during major flood periods. The existing project was designed to pass a peak flood flow of 6,500 cfs around and through the City without any significant flood damages. Updated frequency-discharge relationships indicate that the 114-year frequency of occurrence originally associated with this discharge is now a 59-year recurrence interval. Based on these updated relationships, a 100-year recurrence interval corresponds to a peak discharge of 8,200 cfs or a discharge close to the 8,090 cfs which occurred during the April 1969 flood.

The existing diversion channel has sufficient capacity to pass the original design discharged of 6,500 cfs without any problems. However, the existing channels upstream and downstream of the project have insufficient capacity to pass the design flood into or away from the project. Channel capacity along both reaches is limited by extensive debris, vegetative growth, inadequate flow area, and numerous sharp meanders. Thus, as evidenced during the April 1969, the actual level of protection afforded the City is against a flood having a recurrence interval of about once in 16 years (point at which flood flows would overtop CSAH 7 and flow into Marshall).

Overbank flows along the upstream reach commence at the wayside park at a flow of about 2,500 cfs. At a discharge of 6,500 cfs most of the land area upstream of County State Aid Highway 7 (CSAH 7) (plate 1) would be flooded. At a discharge greater than 3,500 cfs, floodwaters would cross over CSAH 7 and re-enter the river after passing through the western part of the town. At the peak Redwood River discharge of 8,090 cfs at the Highway 23 wayside park during the 1969 flood, approximately 1,400 cfs initially overtopped Highway 23 and flowed into the Cottonwood basin. The construction of an emergency levee along CSAH 7 during the flood to prevent overflows into the town resulted in inundation damages to upstream farmlands. Subsequent breaching of Highway 23 to relieve pressure on the emergency levee and remove the retained floodwaters allowed an additional 1,106 cfs to flow into the Cottonwood causing inundation and erosion damages to two farm properties located south of the highway. At the height of the flood only 5,590 cfs reached the existing diversion structure. Without the emergency raise of CSAH 7, approximately 1,090 cfs would have flowed over CSAH 7 into the City causing extensive damage.

Insufficient downstream reach channel capacity was also demonstrated during the 1969 flood when extensive emergency measures were required to protect downstream development against a peak downstream discharge of 5,590 cfs (8090 - 2500). It is expected that a much greater damage potential would occur in the event of the revised downstream 100-year discharge of 6,700 cfs.

Based on a review of the existing project's performance during the 1969 flood, it is obvious that without additional measures upstream and downstream of the project, the project cannot function as intended. These additional improvements are needed to pass the design flood both into and away from the diversion project without damaging overbank flows.

RECREATIONAL AND OTHER RELATED RESOURCE NEEDS

During the course of this study, the City has indicated a growing need for a city-wide recreational trail system. A recent survey by the City indicates that local residents place a high priority on the need for such a system. A perimeter trail system utilizing city owned diversion channel right-of-way is in the initial planning stage by the City. Local interests also desired improvements to a generally undeveloped softball complex on the diversion channel right-of-way, cross-country ski facilities, river bank improvements in the interest of public safety at two city parks, expanded picnicking facilities at a third park, an off-road vehicle track, and nature education and quiet areas.

IMPROVEMENTS DESIRED

The primary improvements sought by the City are the additional measures to insure effective operation of the existing project and protect presently unprotected development immediately downstream of the existing project. By a resolution of 6 June 1972, Lyon County requested that the Corps review the operation of the existing project and required modifications be made thereto to insure that Marshall will be provided an adequate degree of protection. By a resolution of 3 July 1972, the City requested that a study be made to determine what improvements can be made to provide for additional protection and efficiency of the study project. The City has also indicated a desire for a study to include consideration of the advisability of a recreational trail system and other facilities in conjunction with any proposed flood control improvements.

FORMULATING A PLAN

The actual damages and problems experienced during the April 1969 flood and the present potential for even greater flood damages emphasize the need for additional flood control measures at Marshall.

The purpose of these formulation studies is to review the operation of the existing flood control project at Marshall with the intent of identifying solutions that meet the study objectives identified early in this study. These specific objectives are:

o Reduce damages from flooding along the Redwood River at Marshall during the period 1980 to 2030.

o Contribute to water and winter recreation needs for Marshall during the period 1980 to 2030.

o Contribute to the riverine woodland and wetland areas within the City of Marshall for ecological, diversity, and aesthetic purposes during the period 1980 to 2030.

A detailed discussion of planning objectives and criteria is given in Section D of Appendix I to this report.

In formulating a plan, consideration must be given to both structural and non-structural solutions giving due consideration to economic, environmental and social well-being factors. Preservation and enhancement of study area natural, cultural and recreational resources are also considered.

FORMULATION AND EVALUATION CRITERIA

In the formulation of alternative plans, two major objectives relating to Federal participation in water and related land resource programs have been considered.

* Enhance national economic development by increasing the value of the Nation's output of goods and services and improving economic efficiency.

* Enhance the quality of the environment by the management, conservation, preservation, creation, restoration or improvement of the quality of natural and cultural resources.

To meet these objectives, each alternative is analyzed on a "with" or "without" project basis and is developed using a variety of technical, economic, and environmental criteria. Consideration is also given to the effects of all plans considered on regional development and social well-being of the affected people.

TECHNICAL CRITERIA

Technical data such as hydraulic and soils parameters, design requirements, and results of other studies made for project designs and cost estimates are prepared and evaluated according to Corps of Engineers regulations and accepted professional practice. Both general criteria applicable to any project and criteria specific to the Marshall area were considered in formulating a plan.

General Technical Criteria require that the degree of protection be the maximum practical level of protection, or the Standard project flood level, if feasible. The plan must be complete within itself, technically feasible, and be generally in concert with water and related land resource programs of other interested agencies.

Specific Technical Criteria require that controlled overflow into the Cottonwood River basin commence at a Redwood River discharge of approximately 6,500 cfs. Approximately 50 percent of the Redwood River flow in excess of 6,500 cfs would be diverted into the Cottonwood River basin. For interior drainage designs, these criteria require that any ponding or pumping facilities be designed to minimize adverse economic, environmental, and social well-being effects in affected areas.

ECONOMIC CRITERIA

The selected plan to insure effective operation of the existing project must be economically justified with a benefit to cost ratio greater than unity. Annual costs and benefits are based on a 50-year economic life, and interest rate of 6 7/8 percent and price levels and conditions existing in October 1977.

ENVIRONMENTAL AND OTHER CONSIDERATIONS

Environmental, recreational, and other planning criteria involve consideration of the public health and safety, social well-being, and quality of life of the local residents, as well as general public acceptance of the project. Environmental planning criteria require that preservation or enhancement of area environmental resources be given equal consideration with economic efficiency in developing and evaluating alternative solutions.

Social well-being factors considered in this study include: possible loss of life and hazards to health and safety of area residents; preservation and enhancement of social, cultural, historical, and aesthetic values in the area; air, noise, and water pollution; injurious displacement of people and businesses; adverse employment effects; and disruption of desirable community and regional growth.

The plan must fit integrally into an overall plan for water and related land resources management and development for the Upper Mississippi River basin.

POSSIBLE SOLUTIONS

Flood damage reduction solutions considered in this study pertain only to additional measures needed to assure effective operation of the existing project and to providing flood protection to downstream development not presently protected by the existing project. Both structural and non-structural solutions and combinations of both were considered in selecting a plan of improvement. In addition to these solutions, the consequences of doing nothing to alleviate the recurring flood problem is considered as a base from which to measure the impacts of positive alternative solutions.

No Public Action - Plan 1

This alternative represents the "without" project or base condition and provides for continuance of the existing situation at Marshall without any further local, State or Federal action to provide additional measures to assure effective operation of the existing project. The existing situation relating to flooding at Marshall is represented by the existing federally-constructed project, flood warnings by the National Weather Service Forecast office in Minneapolis of impending Redwood River flood occurrences, related emergency flood fight and supporting disaster relief activities by the City and other government agencies, the required purchase of flood insurance to obtain federally-supported financing for building in flood prone areas, and flood plain management regulations recently adopted by the City of Marshall. It is recognized that flood warnings, if timely and accurate, tend to mitigate flood losses and are essential to public safety.

With this alternative (see table 1), a large portion of the highly developed central part of the city and agricultural lands adjacent to the city would remain vulnerable to extensive flood damages during major floods without major flood fighting efforts. No further public action would thus perpetuate the continued burden on the City in terms of human suffering, hazards to public health and safety and the required inefficient commitment of local financial and manpower resources. This course of action does little in terms of permanent flood damage reduction and is clearly unacceptable to the City. Therefore, this alternative was not considered further except as the base condition against which the other alternatives are compared. Only the continuance of flood warnings, the enforcement of local flood plain management, and flood insurance programs will be considered further but as supplements to other alternatives. With this alternative, average annual flood damages of $352,685 could be expected to periodically recur.

Permanent Evacuation - Plan 2

Permanent evacuation would solve the residual flood problem at Marshall but would require the relocation of most developments in the city including over 1,100 residences, over 200 businesses, and several churches and schools. Roadways and utilities would remain as needed to serve adjacent flood-free areas and the evacuated areas which would be converted to open-space recreational and other public use areas. The displacement of existing development in addition to being totally uneconomic is considered impractical and totally unacceptable to local interests and therefore is not considered further.

Permanent evacuation of the downstream reach was considered not as an alternative to the existing project, but rather as a complement to it relative to evacuation of new unprotected development. Evacuation of this new development would involve the removal and relocation of eight new residences, 32 mobile homes, three apartment buildings of 33 units each, four apartment buildings with eight basement level units affected in each, and seven large buildings on the college campus. Total first costs for this alternative are estimated at $20,000,000. Comparison of average annual costs and benefits of $1,526,300 and $379,900 respectively indicate an unfavorable 0.3 benefit-cost ratio as shown on table 1.

Movement of the apartment and college buildings would be physically impossible, leaving razing the only alternative. Even the temporary loss of the buildings from the State Regional College campus would place a severe and adverse economic, educational, and social impact on the community, region, and state. Permanent evacuation of the new development is totally unacceptable to all concerned interests and therefore not considered further.

Partial Evacuation and Flood Proofing - Plan 3

This alternative (table 1) would involve partial evacuation of selected downstream reach flood prone structures together with flood proofing measures to remaining residential, commercial, and public structures in both reaches. Evacuated areas would be managed as flood damage-free areas in accordance with local flood plain management regulations that are in effect for the City.

Partial evacuation measures would involve the relocation of all residential structures subject to flood depths greater than 3 feet and any structure not considered suitable for flood proofing. With this alternative, 30 residences, 5 commercial structures, and the trailer court in the downstream reach would be relocated out of the 100-year flood plain.

Floodproofing measures would include structural changes and landscaping measures. Structural changes to the basement level apartment units would include sealing of doorways, windows, and other openings, sealing and bracing of basements, and in some cases, provision of floor drain standpipes. Structural changes to the college buildings would include these same measures plus the construction of bulkheads in interconnecting equipment tunnels and placement of valve closures in drain pipes running between and from the buildings. Sealing of the ground level windows and other openings could probably be accomplished but only with the remaining threat of extensive damage and possible health and safety hazards in the event of failure of any one closure. Seepage into these units would likely be a problem during major flood periods. Assuming effective bulkhead and valve closures, water damage to the college buildings would be minimized. However, extensive electrical failures would still be possible due to electrical shorting of cables, switches and connections in the cableways.

This plan would significantly reduce potential flood damages but only at excessive economic and social well-being costs as shown on table 1. The removal of the much needed residential and apartment housing from areas presently zoned and developed for this purpose would have a major adverse long-term effect on regional educational opportunities and established community patterns. Local interests clearly do not favor a major rearrangement of area housing and indicate a preference for a more positive method of flood protection for the college campus. Further, it is accepted State policy that permanently habitable space below the regulatory flood elevation should not be flood proofed. Similarly, evacuation and floodproofing in the upstream reach would be totally infeasible since nearly all of the core city would be affected.

Upstream Reservoir Storage - Plan 4

Reservoir storage was also considered as a possible solution to Marshall's flood problem. The only practical site from a technical standpoint is located in Camden State Park, about 8 miles upstream of Marshall. Earlier studies made in support of the existing project and recent preliminary review studies show that a single large reservoir would probably have sufficient storage capacity but would be economically infeasible and environmentally unacceptable. Estimated average annual costs and benefits of $1,523,500 and $339,900 respectively indicate an unfavorable benefit-cost ratio of 0.2 as shown on table 1. A reservoir in this regionally important park would result in extensive forest resource losses, the loss of several miles of canoe stream and stream fishery and major aesthetic alterations.

A system of small reservoirs on headwater tributary streams presently under consideration to solve agricultural flooding would be located too far upstream and have too little storage volume to provide the desired level of flood protection for the City of Marshall. Thus, for these reasons, upstream storage via a single large reservoir or a system of small tributary reservoirs is dropped from further consideration.

FLOOD BARRIER AND CHANNEL WORK ALTERNATIVES - UPSTREAM REACH

Both flood barriers and channel works were considered as additional upstream reach measures to permit efficient operation of the existing project as designed. It became clear very early in the study that because of inadequate channel capacity and topographic and other constraints, neither levees or channel works alone would achieve the desired solutions. As described in the earlier report paragraphs on technical criteria, overflows of the Redwood River occur naturally during major flood periods in the vicinity of the Highway 23 wayside park. Hydraulic studies subsequent to the 1969 flood indicate that approximately 50 percent of these overflows would have entered the Cottonwood River basin under natural (pre-existing project) conditions. To avoid any major hydraulic changes to the existing flood flow pattern at Marshall, all upstream structural alternatives provide for continuance of these overflows via diversion works at the wayside park.

COMBINED LEVEE - CHANNEL WORKS - PLAN 5U

This alternative would enable operation of the existing project to provide a 100-year degree of protection with the construction of levees, channel widening, bank protection, and clearing and snagging measures along the Redwood River between the existing diversion structure (mile 70.2) and the upstream study limit (mile 73.8). An overflow structure with attendant outlet channel and culvert works would be located at the wayside park. The 540-foot long overflow structure would divert approximately 50 percent of flood overflows in excess of the present design discharge of 6,500 cfs, or a maximum

Another modification (SU-mod. 3) including a 700-foot long cut-off along with the 600-foot long cut-off would further reduce the channel length and provide a slight reduction in levee heights. As the increased total project first costs of about $250,000 would clearly not be commensurate with the minor benefits gained, this modification is not considered further.

Modification (SU-mod. 4 or Executive Order 11988 Plan) would eliminate all right bank levees downstream of those required to maintain proper operation of the overflow structure. This modification would also require that State Highway 23 and CSAH 7 be raised to suitable elevations such that they would act as flood barriers. This would create an approximately 80 acre triangular ponding area which would keep flood flows from bypassing the diversion structure and flooding Marshall. Due to the additional costs that would be incurred due to the purchase of necessary lands and costs of required road raises, this modification would be economically infeasible and thus was not considered further. Detailed discussion of this alternative including analysis of substitute levees in lieu of the road raises is given in Section J of Appendix I to this report.

Two alternatives were considered to the proposed overflow structure along the right channel bank at the wayside park. The first would involve lowering of State Highway 23 in the vicinity of the wayside park to permit unimpeded overflow into the Cottonwood River basin. Downstream channel improvements would be limited to insure required river stages at the park (overflow area). However, limiting the channel measures would likely result in severe downstream bank erosion and potential levee damages. In view of these adverse effects along with possible damage to the highway, traffic disruptions, and potential overflow inundation damages to farm properties, this modification was not considered further.

The second alternative to the proposed river bank overflow structure would involve using the existing Highway 23 embankment as a of 850 cfs at the 100-year Redwood River flow of 8,200 cfs.

The plan would also provide for minor interior drainage measures, relocation of two structures, and utility relocations. Plan impacts and total first costs of about $1.7 million are shown on table 1. The plan would accomplish the desired improvement generally in accordance with the desires of local interests. Thus, it is carried forward for further impact analysis and possible combination with downstream improvements to develop a total plan for the area.

Several minor modifications to plan 5U were considered with a view towards modifying the effects of the considered levees and overflow structure. One modification (5U-mod.1) suggested by local interests would involve realignment of the right bank levee to permit flood-free use of a 10-acre river meander area located just upstream of CSAH 7. Although this modification would increase total plan 5U first costs by about $160,000, it is carried forward for further impact and trade-off analysis at the request of local interests.

Another modification (5U-mod.2) would substitute a 600-foot long cut-off channel in lieu of a 4-foot high levee across the river meander. This cut-off channel would reduce the natural channel length by 1,900 feet and result in a slight lowering of the levees. This modification, with reduced main channel works and bank protection needs, would provide a net saving of about $50,000 in total first costs, exclusive of financial losses to the property owner and a flood-free access. Utilization of the 10-acre area would be hindered as access across the channel would be affected by backwater in the cut-off channel every one to two years. As this modification is of questionable economic merit and lacks local support, it is not considered further.

controlled overflow wier together with raising of a driveway east of the park to confine overflows to the park area. This plan, together with considered downstream channel improvements would actually result in lesser overflows into the Cottonwood Basin and corresponding increased downstream flows through Marshall. Further, any changed downstream channel conditions with related back water stage effects at the park overflow area would make overflow control questionable. In view of these problems, potential highway embankment damages, and traffic disruptions, this modification was not considered further.

FLOODWATER DIVERSION CHANNEL - PLAN 6U

Consideration was given at the request of local officials to a flood-water diversion channel between the CSAH 7 bridge and the Burlington Northern Railroad Bridge. This 4,200 foot-long channel with a 200-foot top width would pass about 60 percent of the design 100-year flood flow. In addition to extensive realigning and widening of the natural channel at the downstream confluence, extensive bank protection and levee works would still be required. Seven acres of forested land would be required for this plan. Greatly increased total first costs of about $3.4 million and other plan impacts are shown on table 1. This plan would accomplish the desired flood damage reduction along the upstream reach but at a substantially higher economic and environmental costs than plan 5U. However, it is carried forward for further impact and trade-off analysis at the request of local interests. A modification of this plan providing additional by-pass channel capacity was also considered but dropped as added benefits did not compare favorably with increased project first costs.

STRUCTURAL ALTERNATIVES - DOWNSTREAM REACH

Alternative downstream reach structural measures considered as possible solutions together with the previously discussed upstream works include channel works, levees, combined levee-channel works, and combined levee-highway works as discussed in the following paragraphs. An itemized breakdown of economic, social, and environmental impacts for these alternatives is shown on table 1.

CHANNEL IMPROVEMENTS ONLY - PLAN 7D

Downstream reach channel improvements to provide a 100-year degree of protection to bottom land cropland and scattered rural farmsteads was quickly found to be both technically and economically infeasible. Thus, channel improvements were considered only in the context of improving the operation of the existing project and reducing flood damages to unprotected urban development.

Considered channel improvements would include channel widening between river miles 64.63 and 66.3 and a 1,300-foot long channel cutoff between 65.47 and 65.94. Clearing and snagging would be accomplished along the entire reach downstream to the State Highway 23 bridge (mile 58.3). Riprap bank protection would be provided at two bends to prevent erosion of channel banks and possible damage to County Road 67. Estimated total first costs would be $303,000.

These channel works would provide only a minor reduction in flood damages to flood-prone urban development. The upstream portion of these works would, however, mitigate the slightly increased river stages due to increased flows from the upstream reach works. In view of the limited benefits, and the potential adverse environmental effects, particularly in regard to transient birdlife, occasionally utilizing the nearby river bottom woods, channel improvements were not considered further except in combination with downstream levee works.

HIGHWAY ALIGHMENT LEVEE - PLAN 8D

This alternative would include a 7,600-foot long levee extending a considered highway alignment (approved system route FAS 6072) from high ground near 5th Street and Hudson Avenue to high ground near the Highway 23 embankment. Also included would be a 450-foot long levee along the right channel bank upstream of the downstream confluence with the diversion channel and a low 200-foot long levee to bridge another low right channel bank area. Other works would include a 7-acre interior drainage ponding area with attendant ditch and outlet works and a temporary sandbag closure across 4th Street (County 67). These plan measures would result in more efficient operation of the existing project and provide a adequate degree of protection to presently unprotected downstream reach development.

Estimated total first costs of $347,600 and other plan impacts are shown on table 1. Since this plan provides the desired degree of flood damage reduction, is incrementally feasible as indicated by a 2.5 benefit-cost ratio, and is generally acceptable to local interests, it is carried forward for detailed impact and trade-off analysis.

COMBINED HIGHWAY-LEVEE - PLAN 9D

This alternative was considered at the request of the City, which in conjunction with Lyon County, is considering a possible highway by-pass around the northern part of the city. This by-pass around the west and north sides of Marshall would include approved routes FAU 5764 and FAS 6072. Route FAS 6072 would extend from the vicinity of the junction of the diversion channel and natural river (mile 66.1) easterly to U.S. Highway 23 as shown on plate 1. This plan would include a combined highway-levee embankment along much the same alignment as for plan 8D. Required flood control measures would be similar to those of plan 8D but excluding the 200-foot long levee and sandbag closure. The Federal first costs for flood control would be limited to the equivalent levee cross-section required together with the 400-foot levee and needed interior drainage works. As this alternative is favor e to the City, it is also carried forward for additional impact and trade-off analysis.

COMBINED LEVEE-CHANNEL WORKS - PLAN 10D

Consideration was given to combined levee-channel measures to further reduce flood stages and required embankment heights. This plan would include channel works (Plan 7D) together with the highway alignment levee (Plan 8D) and reduce required levee heights by about one-half foot. Interior drainage requirements would be the same as for plan 8D. Construction of the channel widening measures would require removal of an existing right bank levee and replacement of the 200-foot long levee with an 850-foot long levee of slightly higher height. Total plan first costs of $580,800 and other plan impacts are shown on table 1. Average annual incremental first costs for the channel works of $22,000 when compared with incremental average annual benefits of $11,400 indicates that addition of the channel work is not economically feasible. Further, this alternative would have a greater adverse effect in terms of vegetative and habitat losses due to channel bank clearing and reshaping.

EXECUTIVE ORDER 11988 AND EXECUTIVE ORDER 11990 ALTERNATIVES

Additional alternatives prepared in response to Executive Orders 11988 and 11990 are presented in Section J of Appendix I to this report.

TABLE [illegible] COMPARISON OF ALTERNATIVE PLANS CONSIDERED

[illegible] PARAMETERS	ENTIRE STUDY AREA PLAN 1 No Public Action	PLAN 2 Permanent Evacuation 1/	PLAN 3 Partial Evacuation and Floodproofing 1/	PLAN 4 Upstream Storage	STRUCTURAL UPSTREAM REACH ONLY PLAN 5U Combined Levee-Channel Works	PLAN 6U Floodwater Diversion Channel	STRUCTURAL DOWNSTREAM REACH ONLY Plan 7D Channel Improvements	Plan 8D Highway Alignment Levee	PLAN 9D Combined Highway Levee	Plan 10D Combined Levee-Channel Works
NED										
[illegible] First Cost ($1,000)	0	$19,800.0	$10,361.6	19[illegible]	$1,554.8	$7,240.0	$297.[illegible]	$501.[illegible]	$50[illegible] 2/	$516.[illegible]
[illegible] First Cost ($1,000)	0	200.0	2,590.4	1[illegible]	17[illegible].4	178.[illegible]	5.[illegible]	46.[illegible]	46.6	64.[illegible]
[illegible] ($1,000)		20,000.0	12,952.2	20[illegible]	[illegible].8	7,418.[illegible]	303.0	547.[illegible]	54[illegible].6	580.6
[illegible] ($1,000)		1,412.0	738.0	1[illegible]	110.9	231.[illegible]	21.[illegible]	31.[illegible]	41.[illegible]	36.9
[illegible] Maintenance ($1,000)	0	200.0	[illegible].2		[illegible].3	4.5	[illegible].3	[illegible]	[illegible]	[illegible].5
[illegible] ($1,000)		314.3	196.[illegible]		[illegible]8.5	21.2	[illegible]	4.4	4.4	6.[illegible]
[illegible] ($1,000)	0	1,526.3	935.[illegible]	[illegible]	130.4	252.3	22.9	25.3	25.[illegible]	43.[illegible]
[illegible] Damage Reduction ([illegible])	0	95.0	4[illegible].0	[illegible]	90.0	60.0	18.0	65.[illegible]	85.[illegible]	87.[illegible]
Average Annual Benefits ($1,000)		370.9	358.5	[illegible]	[illegible]	190.[illegible]	13.5	40.[illegible]	96.[illegible]	65.[illegible]
Benefit-Cost Ratio 3/		0.2	[illegible].4		[illegible]	0.8	0.6	[illegible].5	[illegible].5	[illegible]
Tax Revenues	No effect	Major long-term adverse effect due to business not replaced with a forced permanent evacuation	Moderate long-term adverse effect due to total losses on structures not replaced	No significant effect in either reservoir area or immediate Marshall area	Increased tax revenues from protected structures and developments on newly protected lands	Expected slight increase from protected structures and newly protected lands	No significant effect due to limited extent of flood damage reduction	Increased local tax revenues from protected lands and developments	Same as Plan 8D	Same as Plan 9D
[illegible] Values	Continued increase in study area croplands due to general increase in farm land prices and [illegible] developmental potential	Major decrease in property values on evacuated lands. Major increase newly developed flood free lands	Major decrease in property values on evacuated lands. Some increase for flood proofed structures	No significant effect as considered [illegible] area is presently [illegible] lands (Camden State Park)	Increased property values for protected lands and structures	Increased property values for protected structures and lands	No significant effect due to limited extent of flood damage reduction	Increased property values for protected lands and developments. [illegible] protected lands would experience a 200% acre increase in present market value	Same as Plan 8D	Same as Plan 8D
[illegible]	No effect	Major long-term adverse effect due to relocation of public buildings and other facilities from downtown area	Major short-term adverse effects due to relocation and modification of existing public buildings in flooded area	Major long-term adverse effect due to [illegible] of a major portion of Camden State Park	Major reduction in flood induced losses to public buildings, outdoor facilities and grounds. Approximate [illegible] reduction in flood losses to public facilities	Same as Plan 5U	No significant effect due to limited extent of flood damage reduction	Major long term reduction in flood losses [illegible] State College facilities. Approximate [illegible] reduction in public damages under existing conditions	Same as Plan 8D	Same as Plan 8D
[illegible]	[illegible] disrupted for several [illegible] during flooding [illegible]	Adverse short term effect due to relocation of facilities	[illegible] adverse effect due to relocation and [illegible] activities	Major long-term [illegible] of park services [illegible] Camden State Park	Major long term beneficial effect from maintenance of public services during both flood emergencies and [illegible] periods	Same as Plan 5U	No significant effect due to limited extent of flood damage reduction	Major reduction in [illegible] to services provided at the college	Same as Plan 8D	Same as Plan 8D
[illegible]	[illegible] employment [illegible] damaged [illegible] and loss of access to flooded buildings during flood [illegible]	Major temporary losses in business employment. Major temporary increase in local construction work force	Temporary [illegible] construction labor force [illegible] due to relocation and flood proofing activities	Temporary [illegible] reservoir construction	Temporary [illegible] increase in local labor force due to construction of local flood control measures	Same as Plan 5U	Slight temporary increase in local labor force due to channel excavation works	Temporary [illegible] increase in local labor force due to construction of considered levee and other works	Same as Plan 8D	Same as Plan 8D
[illegible] Industrial [illegible]	[illegible] short term adverse effect due to damaged structures, facilities and [illegible] and lost [illegible] of major flooding up to [illegible] would be affected with a 100-year or greater flood occurrence	Major long-term adverse disruptions to existing business activities	Moderate mid-term adverse effect due to reduced activity during partial evacuation and flood proofing activities	Reduced business losses due to major reduction in frequency and severity of flooding	Major long-term beneficial effect to reduced flood losses. Existing condition business losses would be reduced about 55%	Same as Plan 5U	Minor [illegible] reduction in flood losses	Major long term beneficial effect [illegible] existing condition business losses	Same as Plan 8D	Same as Plan 8D
[illegible] of Farms	Approximately 100 acres of crop land in the study area [illegible] for single and multi family residential development under continuing local developmental conditions	Permanent loss of flood free cropland to accommodate relocated structures. Approximately 300 acres of farm land would be affected	Permanent loss of a lesser amount of flood free crop land to accommodate displaced structures	No effect except storage in Camden State Park. Probable loss of croplands with alternative storage on tributary streams	Protection of 120 acres of cropland would probably speed up planned development on these lands	Same as Plan 5U	No effect	Flood protection for [illegible] acres of cropland would probably speed [illegible] development on these lands	Same as Plan 8D	Same as Plan 8D
[illegible]										
Residences Relocated	[illegible]	159	40	[illegible]	[illegible]	2	0	0	0	0
Businesses Relocated	0	[illegible]	[illegible]	[illegible]	50	50	0	0	0	0
Structures Relocated	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	1	1
Farm Units Affected	3	[illegible]	[illegible]	[illegible]	[illegible]	3	1	0	0	1
Structures [illegible] (feet)	3	[illegible]	[illegible]	[illegible]	[illegible],000	2,700	400	0	0	90[illegible]
Community Cohesion	Disruptions during major flood periods	Major long-term disruption to established community patterns. Permanent loss of established social, transportation and trade patterns	Moderate long-term disruption to established community trades, transportation and social patterns	No significant effect at Marshall	Major long-term beneficial effect due to markedly reduced disruptions during major flood periods.	Same as Plan 5U	Minor beneficial effect due to reduced disruptions during flooding with minor level of protection.	Major beneficial long-term effect due to reduced incidence and severity of disruptions during major flood periods	Same as Plan 8D	Same as Plan 9D
Community Growth	Expanding urbanization on farmland adjacent to the city	Major adverse disruption of community growth patterns. Established business and commercial center would be relocated to the outskirts of the city	Moderate adverse effect due to a lesser degree of disruption than for Plan 2. Most businesses and residences would be flood proofed and remain at the same locations.	No significant effect at Marshall	Protection of 120 acre cropland area probably will speed development of this land to a residential area. Other areas would remain largely unaffected.	Same as Plan 5U	No significant effect	Protect on of [illegible] acres of cropland will probably speed conversion of this area to single and multi family residential development.	Inclusion of feeder highway may affect community growth patterns in the immediate area, i.e. some farm or commercial or other development may be induced on present cropland along the proposed highway right-of-way	Same as Plan 8D
Environmental										
Lands Required for project										
Agricultural acres	0	Unknown amount of development of another site.		[illegible]	3.8	14.4	2.0	18.[illegible]	34.[illegible]	21.0
Forest acres	0			[illegible]	6.1	7.0	0.1	0	0	0.1
Park acres	0			[illegible]	0.6	0.0	0	0	0	0
Other acres	0			[illegible]	14.0	13.1	1.0	0.0	4.4	2.4
Archeological Sites Affected	None	Possibly some at new development site	Possibly some at new development site	[illegible]	No known sites affected					
Historical Sites Affected	None	Possibly some at new development site	Possibly some at new development site	[illegible]	No known sites affected					
Natural Sites Affected	None	State College	State College	[illegible]	No known sites affected					
Effect on Local and Regional Growth Patterns	Continued development in flood plain only in accordance with existing flood plain regulations	Severe long-term adverse effect on local community pattern. Loss of regional educational facility	Severe short-term adverse effect during relocation of 46 family units.		Preservation of established community developments, social and cultural patterns due to increased security against flooding.		Minor beneficial effect due to slight reduction in flood damages.	Major beneficial effect due to near elimination of flood damages along downstream reach.		
Biological Resources	Long term benefits to stream and riparian habitat due to restricted development with flood plain regulation	Long-term benefits to biological communities within the project area. Undetermined permanent losses in other areas where residents relocate		Conversion of terrestrial to aquatic communities due to habitat changes.	Temporary reduction in biotic populations along reshaped channel and levee reaches, along with minor long-term losses. Temporary sedimentation effects on benthic fauna.		Minor long-term adverse effects on aquatic and riparian habitat due to channel modification.	Reduced habitat for upland game birds and small mammals. Most of the required area is presently tilled farmland.	Minor long-term adverse effects to aquatic and riparian habitat due to channel modifications. Reduced habitat for upland game birds and small mammals. Most of the required area for levees is tilled farmland	

1/ Entire Study Area
2/ Federal first cost for flood control needs same as for plan 7D.
3/ Incremental benefit-cost ratio except for plans 1, 3, and 4

TABLE 1 -- COMPARISON OF ALTERNATIVE PLANS CONSIDERED (contin

PLANNING OBJECTIVE PARAMETER	ENTIRE STUDY AREA				UPSTR
	PLAN 1	PLAN 2	PLAN 3	PLAN 4	PLAN 2U
	No Public Action	Permanent Evacuation	Partial Evacuation and Floodproofing	Upstream Storage	Combined Levee-Channel Works
(1) ENVIRONMENTAL (continued)					
Ecosystem effect					
Vegetation	Some continued conversion of cropland and vacant space to residential development over a long period of time and in accordance with existing flood plain management regulations.	Continued use of lands for agri. purposes. Potential for the loss of up to 200 ac. of cropland & native vegetation if residential develop. occurs at another site. Substantial gain in open-space area.	Possible loss of up to 420 acres of presently tilled cropland or vacant lands. Increased open-space areas.	Permanent loss of several acres of forest and understory cover. Change to aquatic vegetation in and around reservoir in State Park.	Permanent loss of acres of mixed for and understory cov Loss of terrestial aquatic vegetation long riprapped cha bank
Fish and Wildlife	Preservation of existing aquatic and riparian habitat due to flood plain regulations.	-- Preservation and enhancement of existing wildlife habitat. Undetermined loss of wildlife habitat at redeveloped areas.		Likely conversion of present limited stream fishery to lake fishery. Loss of valuable game and other small mammal habitat.	-- Minor long-te habitat. Short due to increas struction. Per habitat. Perm cropland.
Aesthetics	Somewhat improved over time.	Major gain in open space, park, and green belt area.	Moderate gain in open-space, park, and green-belt area.	Major visual and other changes in existing State Park with creation of a large lake.	--- Permanent visu impaired acces where levees p lots.
Threatened & Endangered Species	No Effect	No Known Effect	No Known Effect	Not Evaluated	---------- No kno
Air Quality	No Effect	----Temporarily reduced air quality during -- relocation and reconstruction period.		Short-term (4-5 yr) increase in smoke, dust, and combustion products during reservoir clearing & project construction.	--- Short-term (2 and combustion project constr
Water Quality	Continued decrease due to unchecked channel bank erosion.	---------------- No effect ----------------		Possible slow degradation of lake water quality over project life. Beneficial effect at Marshall due to reduced sediment loads.	--Major increase ing and shortly term improvemen stabilization.
Noise Level Effect	No Effect	Major short-term increase in noise levels during demolition, relocation, and reconstruction period.		----- Temporary increase during constru	
Irreversible Commitments of Resources to Future Use	None	Fuel, materials, and land for demolition and reconstruction at new site.	Fuel, materials, and land for floodproofing measures and reconstruction at new site.	Several acres of forested state park land and fast flowing stream lost to reservoir development. Materials for construction of embankment, access road and maintenance facilities.	----------Energy during
Man-made resources	No significant effect	Permanent removal of hundreds of resident. and business structures	Partial removal of most severely flood prone structures.	Permanent loss of state park facilities in the reservoir area.	One house woul located a shor Four other wou somewhat affec the close prox considered fl. Other flood pr would be signi susceptible to flood damage.
Natural resources	Continued streambank erosion, high turbidity	Some portion of evacuated area could revert to a near natural state. Some natural grass could be adversely affected by relocated development.	Possibly adverse effects to natural resources vegetation wildlife - in new flood free development area.	Permanent loss of miles of free-flowing stream due to inundation by reservoir.	Permanent loss about 4.2 acre of woodland.

1/ Federal first cost for flood control works same as for plan 7D.
2/ To new unprotected development only.

[illegible]ION OF ALTERNATIVE PL[illegible] [illegible] (Continued)

	UPSTREAM REACH ONLY			DOWNSTREAM REACH ONLY			
	PLAN 4	[illegible]AN	PLAN 6U	Plan 7D	Plan 8D	PLAN 9D	Plan 10D
	Upstream Storage	[illegible] Levee [illegible]	Floodwater Diversion Channel	Channel Improvements	Highway Alignment Levee	Combined Highway Levee	Combined Levee-Channel Works
	Permanent loss of several acres of forest [illegible] understory cover. Change to aquatic vegetation and around reservoir State Park	[illegible] loss of [illegible] [illegible] and forest [illegible] cover [illegible] terrestrial and [illegible] vegetation a [illegible] riprapped channel [illegible]	Permanent loss of 7 acres of forest cover. Temporary loss of ground cover along levees until reseeding is established.	Temporary loss (4 to 5 years) of ground cover, shrubs along 2 miles of river bank. Permanent loss of mature trees along river in the vicinity of channel modifications.	Temporary loss of about 3.5 acres of upland grasses, forms, shrubs and a few mature trees	Temporary loss of about 4.4 acres of native grasses, shrubs and a few scattered trees	Temporary vegetative ground cover losses along levee areas. Permanent loss along riprapped channel bank areas
	Likely conversion of present limited stream fishery to lake fishery. Loss of valuable game and other small mammal habitat.	[illegible] long term adverse effect on riparian habitat. Short term (2 season) adverse effect due to increased stream turbidity during construction. Permanent loss of wooded wild life habitat. Permanent loss of 15.8 acres of tilled cropland.		Temporary and long term term disruption of small mammal habitat along reworked river banks and channel cutoff. Short term adverse effect on limited area fishery due to increased turbidity. Temporary adverse effect to transient birdlife utilizing woods along river as a resting place.	--- Temporary disruption of small mammal habitat. Permanent loss of 19 acres of tilled cropland.		Short-term adverse effect to stream fishery and other aquatic life due to increased turbidity and sedimentations. Long-term loss of small mammal habitat in the vicinity of channel modifications.
	Major visual and other changes in existing State Park with creation of a large lake.	Permanent visual changes and slightly --- impaired access to river at 7 locations where levees pass through residential [illegible]		Long-term changes in areas where channelization takes place.	------ Moderate visual change to natural setting with completion --- of levee and 7.0 acre ponding area.		
	Not Evaluated	------ No known effect		No Effect	No effect	No effect	No effect
	Short term (4-5 yrs.) increase in smoke, dust, and combustion products during reservoir clearing & project construction.	Short term (2 yrs.) increase in dust --- and combustion product levels during project construction.		------Slight increase in dust and combustion products during and for a short time after ----- two-season construction period.			
	Possible slow degradation of lake water quality over project life. Beneficial effect at Marshall due to reduced sediment loads.	---Major increase in stream turbidity during and shortly after construction. Long term improvement due to channel bank stabilization.		Major increase in stream turbidity levels during construction period.	No effect	No effect	Significant increase in stream turbidity and sedimentation during and shortly after channel construction work
[illegible]ing [illegible]riod	----- Temporary increase during construction period ----------			----------------- Temporary increase during construction period -------------------------			
	Several acres of forested state park land and fast flowing stream lost to reservoir development. Materials for construction of embankment, access road and maintenance facilities.	------Energy resources expended ---------- during construction.		Energy resources used for construction.	---- Energy resources and reinforced concrete used for ------------ project construction.		
[illegible]t	Permanent loss of state park facilities in the reservoir area	One house would be relocated a short distance. Four other would be somewhat affected by the close proximity of considered flood barriers. Other flood prone structures would be significantly less susceptible to recurring flood damage.	Same as Plan 5U	No significant effect other than raising and widening one bridge.	Major beneficial effect to college complex with increased level of flood protection.	A considered feeder highway could be efficiently integrated with the considered levee embankment.	Same as Plan 8D
[illegible]	Permanent loss of miles of free-flowing stream due to inundation by reservoir.	Permanent loss of about 4.2 acres of woodland.	Permanent loss of about 7 acres of forested area.	Permanent loss of about 0.10 acres of channel bank woodlands.	No significant effect to natural resources.	Same as Plan 8D	Same as Plan 8D

ALTERNATIVES CONSIDERED FURTHER

Of the upstream reach alternatives considered, only the combined-levee channel works plan (5U) and the floodwater diversion channel plan were considered for detailed impact analysis. A minor modification of plan 5U to include protection of an additional 10-acre area via realignment of the project levee was also carried forward. This impact analysis clearly showed that of the two basic plans (plans 5U and 6U), plan 5U provides the most cost effective solution and is the least aesthetically and environmentally disruptive. Further analysis also indicates that protection of the 10-acre meander area would be technically feasible, locally acceptable but economically unjustified.

Of the downstream reach alternatives considered, the highway alignment levee (plan 8D) and the combined highway-levee (plan 9D) were examined further. In addition, limited channel widening measures are also considered with both plans. Both plans would be technically and economically feasible from a flood damage reduction standpoint. The combined highway-levee plan would require about 20 more acres of cropland and result in slightly higher vegetative and habitat losses. Although initially suggested by the City as a possible efficient combination of projects, it is believed that the required planning and designs for the highway would not be completed in time to achieve a combined project assuming approval and normal Federal funding of any recommended flood control works. Since the proposed levee follows the proposed highway alignment, it could later be incorporated into the proposed highway without major modifications of the flood control project features.

CONTRIBUTIONS OF ALTERNATIVES TO NATIONAL OBJECTIVES

To achieve a balanced plan for flood control while maintaining and enhancing the natural environment, separate plans were developed. The first optimizes national economic efficiency while the second provides for achieving the principal flood damage reduction objective while emphasizing the environmental quality objective. These separate plans were then analyzed via a trade-off analysis of plan impacts to achieve a compromise or selected plan.

National Economic Development (NED) Plan - The NED plan, from a national viewpoint, must reflect the best return on any investment of economic resources. From the foregoing analysis, the NED plan for the upstream reach would be plan 5U incorporating levees, overflow diversion works and channel improvement measures. Similarly for the downstream reach, plan 8D together with limited channel widening measures provides the most economical method of obtaining effective operation of the existing project and providing a 100-year degree of protection to unprotected urban development. Thus, for the entire project area, the overall NED plan would include plan 5U together with plan 8D and accompanying channel works.

Environmental Quality (EQ) Plan - Since all the alternatives considered were formulated based on satisfying the specific flood damage reduction objective, and the EQ plan must also satisfy this objective, the EQ plan will, with relatively minor alteration, be among the alternatives considered. Working within the context of a framework environmental quality objective plan, which was initially least disruptive to the environment, measures were added incrementally to develop the most acceptable and environmentally beneficial plan.

From an analysis of the alternatives considered further for flood damage reduction, it was determined that the overall EQ plan would include:

For the upstream reach -- Plan 5U incorporating added measures including relocation and reshaping of the flood barriers at nearby residences to minimize adverse aesthetic effects, tree and shrub plantings at selected locations along the levees and surface treatment of the overflow weir to blend it into the park setting. Also included would be the controlled disposal of waste excavation, trees, brush and debris, deletion of clearing and snagging measures other than at riprapped or widened channel areas; and management of residual flood plain areas.

For the downstream reach - Plan 8D together with channel widening measures, tree and shrub plantings, and flood plain management measures for residual unprotected areas is selected as the EQ plan as well as the NED plan for the downstream reach since it would have no significant adverse effect on the natural and cultural setting while still satisfying the flood damage reduction alternatives.

Both the NED and EQ plans would also include a recreational trail system and related facilities along the rights-of-way needed for flood control measures. The proposed trail and other facilities are desired by local interests no matter what type of flood control measures are considered.

SELECTING A PLAN

Of the alternatives considered, all but one total plan for Marshall have been eliminated. The selected plan reflects only minor tradeoffs from the NED plans and in this instance, is also the EQ plan.

In summary, the Selected Plan includes: upstream reach plan 5U without the major clearing and snagging measures but including the levee reshaping, relocations, aesthetic measures, and management of residual flood plain areas; downstream reach plan 8D with accompanying channel widening and flood plain management measures and recreational measures along both reaches. The characteristics of the selected plan have been evaluated according to the Federal Water Resource Council's planning objectives. A summary of selected characteristics for the selected and EQ plan, along with similar ones for the NED plan is given in table 2. A detailed account of plan characteristics for the selected plan is given in table D-4 of Section D of Appendix 1.

The selected plan provides the most cost-effective solution for assuring effective operation of the existing project and provides the most feasible means of flood protection to unprotected downstream reach urbanized development. Of the viable solutions considered in terms of flood control, the selected plan would result in the least adverse environmental impact in terms of required lands, vegetative losses and related effects on fish and wildlife habitat. Minimal (one family) displacement of people would occur. In this one instance, a house would be moved only a short distance on the same property. Thus, the environmental quality and social well-being objectives are best satisfied with this plan. Local interests have indicated at various meetings that the selected plan is acceptable. For these reasons, a total area plan incorporating the modified upstream reach plan 5U as described in the preceeding paragraph together with downstream reach plan 8D (also described in preceeding paragraph) and various recreational facilities is selected for detailed designs and recommendation.

Table 2 - System of Accounts

Summary Comparison of Alternatives

	NED Plan	EQ and Selected Plan
1. Plan Data		
Structures	Levees, channel works, overflow weir, culvert works, ponding area.	Levee, channel works, overflow weir, culvert works, ponding area, aesthetic measures.
Additional land	119.8 acres	119.8 acres
Non-structural components	Management of residual flood plain areas.	Management of residual flood plain areas.
2. NED[1/]		
Beneficial (Ann.Benefits)	$260,800	$260,800
Adverse (Ann.Costs) [2/]	156,300	160,600[3/]
Net (Benefits)	106,300	100,200
3. EQ		
Water quality	Temporary increase in turbidity long-term decrease.	Temporary increase in turbidity. Long-term decrease.
Recreation and open space	Added recreational opportunities with trail system and other facilities.	Additional recreational opportunities with trail system and other facilities.
4. R.D.		
Project area	Beneficial effect with protection of regional State College facilities and improved prospects for Marshall's standings as regional trade and service center	Same as NED plan.

Table 2 - System of Accounts (continued)

Summary Comparison of Alternatives

	NED Plan	EQ and Selected Plan
5. SWB		
Reduced flood risk	Reduced flood damages to public, commercial, and residential development.	Same as NED Plan

1/ Present condition flood damage reduction benefits only.

2/ Excludes annual costs for purchase of floodway lands as purchase would be common to all upstream reach structural alternatives.

3/ Increased costs for levee widening and landscaping measures.

SCALE OF DEVELOPMENT

To determine the optimum level of protection, annual costs and benefits were evaluated for the 50-year, 100-year, 150-year, 200-year, and 500-year flood levels. An optimum relationship between average annual costs and benefits exists for a 133-year level of protection. A sensitivity analysis of interest rates varying over time versus benefit-cost ratios for various levels of protection was made to determine the limits of economic feasibility. This analysis (see Section D of Appendix I) indicated that the maximum feasible level of protection or benefit-cost ratio greater than 1.0 would be about the 150-year level at an 8 3/8 percent interest rate. Provision of the added increment of protection between the 133-year and 150-year flood levels would result in significantly increased total Federal and non-Federal first costs of $1,040,000.

Provision of a standard project level of protection would require major additional works including road and driveway raises and the relocation of numerous residents and businesses in the downtown area to accommodate needed flood barriers and interior drainage works. An SPF level of protection is clearly infeasible as indicated by a 0.7 benefit-cost ratio.

With an assumed levee failure at the SPF flow, several hundred commercial and residential structures would be adversely affected in the city. However, as nearly all proposed levees along both study reaches would be relatively low (4 to 5 feet average height) and overbank velocities would be less than one foot per second, the potential for loss of life is not considered great. To assure that no SPF level flows would overtop flood barriers and enter the city, two feet of freeboard above the SPF flood level would be provided along the right bank levee between the existing diversion structure (mile 70.5) and proposed overflow works at the State Highway 23 wayside park.

After review of the draft feasibility report, the City has stated (See April 1978 letter from City in Appendix 2) that a SPF level of protection would be unrealistic and unacceptable. By letter of 21 February 1979 (See Appendix 2) the City also indicates that "the ... 133-year level of protection would still be a most acceptable level of protection" and that"... the additional work and cost involved do not warrant the relatively small degree of additional protection..." between the 133-year and 150-year flood levels. Thus, based on the optimization and sensitivity analysis, consideration of the impact of a SPF levee failure, and views of the City, a 133-year degree of protection is selected as the appropriate level for project designs and estimates.

THE SELECTED PLAN

This section of the report describes the plan of improvement as selected in the previous section on plan formulation. In addition to the basic plan description, all meaningful effects, both beneficial and adverse, are identified and discussed. Pertinent information concerning design, construction, and operation and maintenance is also presented to provide the reader with a broader understanding of the technical aspects involved in plan implementation.

PLAN DESCRIPTION

The plan of improvement to provide additional measures to assure effective operation of the existing project and to provide protection to unprotected downstream reach urbanized development are discussed separately for the upstream and downstream study reaches. Also discussed briefly are the proposed recreational facilities. The general plan of improvement is shown on plates 1 and 2.

Upstream reach improvements would consist of levees, channel improvements, a gabion channel drop structure, an overflow diversion structure with attendant outlet channel and culvert works, road raises, two temporary sandbag closures, minor interior drainage works, relocation of structures and utilities, aesthetic treatment measures, and management of residual flood plain areas in accordance with adopted flood plain management regulations. Preservation of the 71.1 acre area upstream of CSAH 7 as project floodway is required to prevent encroachments in the area which would increase flood stages with possible adverse effects to the right bank levee and impaired operation of the overflow works.

Upstream reach levees would include a 2,260-foot long levee extending along the left bank from the existing diversion structure to the Burlington Northern Railroad embankment. Levee heights would range from 4 to 7 feet for an average of 5 feet. A 1,660-foot long levee with an average height of 4 feet would extend along the left overbank from the proposed gabion control upstream to high ground as shown on plate 1. The left bank levee would have a 10-foot top width and 1 on 3 side slopes except at the riverside residences located just upstream of CSAH 7. At this location the landward levee slope would be variable or warped as needed to blend it into the adjacent setting.

Right bank levees would include a 6,350-foot long levee with an average height of 5.5 feet extending from the existing diversion structure upstream to the State Highway 23 embankment at the wayside park. This levee would provide 2 feet of freeboard over the SPF flood level to preclude overtopping of the levee during flows exceeding the design flood level. Right bank levee works would also include a short levee and road raise extending from the proposed overflow diversion to high ground as shown on plate 1.
A 45-foot long temporary sandbag closure at the upstream terminus of this levee would provide free-board to contain the 133-year flood with 3 feet of freeboard. A 100-foot long temporary sandbag closure would be provided as needed across Highway 23 at the east end of the wayside park to prevent SPF level flows from leaving the park area. Proposed channel improvements would include realignment of the channel for a distance of about 500 feet to alleviate the sharp river bend just upstream

of the CSAH 7 bridge. Other channel works would include about 3,300 feet of channel widening along three river reaches to obtain bottom widths ranging from 45 to 55 feet as required. Reshaping and riprapping of channel bends would be accomplished as shown on plate 1. Reshaped channel banks not riprapped would be topsoiled and seeded. Abandoned car bodies and other large debris would be removed from the channel. Riprap would be placed over the entire channel cross-section at the CSAH 7 bridge to protect the bridge piers.

The proposed 540-foot long overflow diversion structure would divert approximately one-half the Redwood River flood flows in excess of 6,500 cfs (about 850 cfs at 100-year flood flow) into the Cottonwood River basin via the diversion overflow channel. A 6-foot high gabion channel control structure would be located immediately downstream of the overflow structure as shown on plate 1. This structure, together with the 1,000-foot continuing left overbank levee would insure proper river stage control over the overflow weir.

The proposed 2,140-foot long overflow channel with required culvert works through the Highway 23 embankment would carry the excess Redwood River overflows into the Cottonwood basin. This channel, with a 20-foot bottom width and side slopes ranging from 1 on 4 to 1 on 6 would accommodate up to 50 percent of the excess river flow over 6,500 cfs or a peak flow of 1260 cfs at the design 133-year Redwood River flood flow.

Required upstream reach interior drainage works would include the flap-gating of two double culverts through the Burlington Northern Railroad embankment, extension of a 36-inch highway roadside drainage system through the right bank levee works, the placement of one gated and one ungated culvert through two driveways, and the relocation of one driveway culvert. In addition, minor landscaping measures would be accomplished at one right bank levee location to eliminate a small natural ponding area.

The proposed channel works would involve the excavation of about 61,125 cubic yards of material. Of this amount, 44,590 cubic yards would be utilized as levee fill. Two small left bank spoil areas (.7 acres total) would accommodate about 4,520 cubic yards. The remaining 12,015 cubic yards would be placed on the city-owned spoil disposal area adjacent to the existing diversion channel for later re-use.

The proposed upstream reach flood control improvements would require the acquisition of an estimated 99.5 acres of land and temporary construction easements at selected locations. Of these lands 71.1 acres would be flood plain lands located upstream of CSAH 7 and acquired for project floodway purposes. Necessary relocations would include the relocation of one house a short distance on the same property, five utility poles, 550 feet of farm fencing and the temporary relocation and replacement of 700 feet of buried utility cable. A temporary by-pass would be constructed across the median to permit two-way traffic on State Highway 23 during placement of the overflow channel culverts.

Proposed downstream reach improvements would include levee works, channel widening, interior drainage measures, and proposed management of residual flood plain areas as shown on plate 1. Required levee works would include a 7,670-foot long levee with an average height of about 5 feet extending from high ground near Highway 23 upstream to high ground near 5th Street and Hudson Avenue as shown on plate 2. A 100-foot long temporary sandbag closure would be required at the County 67 levee crossing to provide a 3-foot freeboard over the 135 year flood level. Also included would be a 450-foot long levee of 4 foot average height along the natural channel right bank upstream of the downstream confluence with the existing diversion channel. An 860 foot long levee with an average height of 5 feet would replace an existing right channel bank spoil levee removed by the needed channel widening as shown on plate 1.

Proposed channel works would include widening of the channel of the right bank only to a minimum bottom width of 55 feet for a distance of 1,550 feet extending downstream from the downstream confluence of the existing diversion channel (mile 60.1) as shown on plate 1. The reshaped channel bank would have a 1 on 5 side slope and be riprapped its entire length to insure protection of the adjacent levee.

Proposed downstream interior drainage works would consist of a 7-acre ponding area, a 5,280-foot long collector ditch along the toe of the levee, and a 24-inch diameter drainage pipe together with needed outlet control works at its junction with County ditch 62.

Of the 54,100 cubic yards of material excavated from the ponding area and channel works, 34,100 cubic yards would be used for levee fill. An additional 9,400 cubic yards would be used to regrade a low area long the levee as shown on plate 1. The remaining spoil would be placed on vacant municipal property for later reuse by local interests.

The proposed downstream measures would require an estimated 20.3 acres of land and temporary access easements to construction areas. The channel and adjacent levee works would require relocation of six utility poles.

All levee crowns and levee and channel side slopes, and other disturbed areas would be reseeded with grass species such as sweet clover that provides cover for area wildlife. Trees and shrubs would be planted at selected locations to enhance the project area aesthetic setting. These plantings, together with the irregular or warped landward levee slopes would help blend the levees into the natural setting.

Proposed recreational improvements would include approximately 5.2 miles of combined walking-biking trail with rest areas and trail head facilities, and about 5.7 miles of cross-country ski trail. Local interest would provide at their expense a total of 0.9 miles of connecting trails prior to or concurrent with the construction of any authorized trail improvements. Other measures would also include limited picnicking facilities on project lands near Justice Park and the softball complex north of State Highway 19. Other facilities to be provided by local interests at their own expense would include development of a quiet area with trails in the wooded area upstream of CSAH 7 and an improved canoe access at the Highway 23 roadside park. Detailed discussion regarding lands, management and cost-sharing responsibilities is given on page 3 of this report and pages G-2, G-3, and G-34 in Section G of Appendix I. The proposed recreational facilities are shown on plate 2.

EVALUATED ACCOMPLISHMENTS

The principal accomplishment resulting from the selected plan of improvement would be the enhanced operation of the existing flood control project and the protection of unprotected downstream reach development located immediately adjacent to the presently protected area. The selected plan would provide a 133-year degree of flood protection to the Marshall area. The proposed works would result in an

85 percent reduction in average annual flood damages to new development and significantly reduce the need for the present and periodic inefficient commitment of local material, financial and manpower resources during major flood occurrences. The alleviation of flood damages would not only enhance the area economy but would improve the safety and well-being of the affected people and preserve intact long established community patterns. The proposed recreational facilities would partially satisfy present and projected facility needs in the Marshall area. Thus, the selected plan accomplishes the study purpose and the desired improvement as expressed by local interests.

EFFECT ON THE ENVIRONMENT

The proposed downstream reach works would provide protection to about 85 acres of agricultural land adjacent to the city. Protection from flooding would likely facilitate the eventual conversion of this land to residential development as this area is presently zoned.A total of 119.8 acres of land would be converted to flood control uses. An additional 120 acres of vacant or agricultural land in the reach upstream of the City would also be afforded protection. Protection of these undeveloped lands is soley due to the selection of the most cost-efficient flood barrier alignments. Under existing conditions, the 205 acres of undeveloped flood plain lands can be developed in accordance with State flood plain management criteria by placement of fill to an elevation of one foot above the 100-year flood level. The selected project would not require fill for the development of this area. However, it is recognized that the proposed alignment may accelerate future development of this area.

Construction of the proposed channel works would have adverse short-term effects on stream water quality, fish, and aquatic biota via increases in turbidity and sedimentation during and for a short time after construction. However, the stabilization of presently eroding channel bank areas would in the long-term reduce turbidity and sedimentation resulting in improved water quality.

The permanent loss of 4.2 acres of woodland would result in associated population losses of small mammals and song birds. Increased noise levels during construction would have unsettling effects on area wildlife. The loss of about 30 mature shade trees at four residences would result in adverse aesthetic impacts to the affected residences and loss of cover to area song birds. The loss of grassy vegetation along the reworked channel banks would also contribute to the permanent loss of small mammal and song bird habitat. The acquisition and designation of 71.1 acres of flood plain lands upstream of CSAH 7 as project floodway would preserve the natural characteristics of that area and maintain wildlife habitat in its current state.

The revegetation of all disturbed areas with cover species would mitigate the ground cover losses. Tree and shrub plantings and sculptured levee sections in the vicinity of affected residences would aid in blending the levees into the adjoining topography and setting. The proposed levee and overflow structure in the park would result in marked aesthetic changes including a slightly impaired view of the natural river setting. In effect, no park area would be lost as the project features would be open to park pedestrian traffic.

OTHER EFFECTS

Placement of the culverts throughout the State Highway 23 embankment would inconvenience vehicular traffic for about a month. Picnicking and other uses of the wayside park would effectively be eliminated for about one summer season, due to increased noise levels and movement of machinery. Similarly, two driveways would be temporarily affected by road raises and movement of construction equipment. Access to two farm properties would be permanently affected by the levee and channel works.

The proposed works would require the relocation of one permanent residence a short distance on the same property. Noise, dust and pollutant levels would be noticeable during the construction period. The proposed works would not require the displacement of any businesses. In turn, they would enhance community cohesion, likely increase protected property values and related tax benefits to the community. Preservation of established community patterns would help maintain Marshall's position as a regionally important trade and farm service center.

DESIGN

Design of the remedial measures necessary to obtain effective operation of the existing project is based on the need for the maximum practical degree of protection and compatibility with State and local flood plain management regulations.

The existing project is designed to pass a peak discharge of 6,500 cubic feet per second (cfs) which originally had a recurrence interval of about once in 114 years. However, revised frequency-discharge relationships indicate that a flow of 6,500 cfs now has an expected recurrence interval of about once in 59 years. Similarly, a flood with a 1% chance of occurring in any given year (100 year flood) is estimated to have a peak discharge of 8,200 cfs. The hydraulic design of the selected plan is based on providing protection against the 133-year Redwood River flood flow.

Although the existing project was designed to pass a flood flow of 6,500 cfs, it was evident during the April 1969 flood (peak discharge of 8,090 cfs) that the design flow was not able to reach the existing project. Studies also indicate that, without the April 1969 emergency works, overflows over CSAH 7 that commence at a Redwood River flow of about 3,500 cfs would have re-entered the natural channel downstream of the existing diversion structure and caused extensive damage. This zero damage discharge corresponds to a flood frequency of once in about 16 years. Hydraulic studies indicate that of the 8,200 cfs 1% chance flood flow, approximately 1,500 cfs would overflow the State Highway 23 embankment in the vicinity of the wayside park. Approximately 1,090 cfs would flow over CSAH 7 and re-enter the Redwood River downstream of the existing diversion structure. The remaining 5,610 cfs reaching the existing diversion project would combine downstream of Marshall with the re-entering 1,090 cfs overbank flow to give a peak 100-year downstream reach discharge of 6,700 cfs.

Hydraulic studies indicate that approximately one-half of the April 1969 flood overflows would have entered the Cottonwood basin were it not for the flood emergency measures undertaken. Thus, to not aggravate either the Cottonwood basin flood problems or downstream Redwood River flood problems over those presently experienced, the design of the proposed overflow diversion structure is based on a near-equal division of overflows for a peak 133-year overflow discharge of approximately 1,260 cfs into the Cottonwood River basin.

Design of the re-shaped channel slopes and levee side slopes is based on the need to prevent slope failure under both peak flood and sudden draw-down conditions. Riprap bank and pier protection is designed in accordance with Corps standards to withstand shear forces created by peak channel velocities.

Structural designs were made in accordance with Corps design criteria. Structural items include the culvert headwalls and gate well for the ponding area discharge conduit.

CONSTRUCTION

Construction of the project would be accomplished in two construction seasons Required levee fill would be obtained from the channel and ponding area excavation Topsoil, stripped from channel bank, ponding area, and levee foundations would be stockpiled for later replacement over disturbed areas Additional topsoil needs would be met from local sources Riprap would be obtained from the established quarry at Granite Falls, Minnesota Bedding and other aggregate would be obtained from local suppliers Concrete and other culvert needs can easily be met from regional sources. Culvert flapgates and associated hardware would likely be obtained through suppliers in the Minneapolis-St. Paul area

The construction works would be closely monitored to minimize stream, air, and noise pollution Applicable guide specifications on environmental protection would be incorporated in any project plans and specifications to minimize pollution These provisions would include landscape protection, debris burning, erosion control, dust and noise control, and discharges into streams Plans and specifications will also include the specific type, size, and mix of ground cover, trees, and shrubs required for the project Also included will be the identification and proper disposition of any buried artifacts uncovered during construction. Government inspectors would be present to monitor construction, and adherence to environmental protection and other project specifications

OPERATION AND MAINTENANCE

Operation of the project during a flood emergency would include erection of two temporary sandbag closures (three for an SPF level flood) and operation of the gated control structure at the outlet of the ponding area. Maintenance of the project would include mowing of designated levee, ditch, and channel areas; riprap adjustments or replacements; repair of any severely eroded channel bank areas; periodic inspection of culverts and flapgates; and periodic removal of collected sediment, debris, etc. from the overflow channel, collector ditch and ponding area. Also included would be the maintenance of the proposed recreational facilities. Required mowing would be timed so that the ground cover would be of maximum benefit to wildlife.

ECONOMICS OF THE SELECTED PLAN

This section of the report presents the economic aspects of the selected plan for the City of Marshall. Included are pertinent details of the flood damage evaluation, benefit analysis, cost estimates and project justification.

METHODOLOGY

To determine the economic justification of the proposed project, the merits of the upstream remedial measures and downstream reach measures to protect new development were evaluated separately. Proposed upstream and downstream reach measures were justified on the basis of related annual benefits exceeding annual project costs. For the proposed development, a comparison of incremental average annual costs (interest, amortization, operation and maintenance) with estimated average annual benefits is made over the project life of the project. Project benefits are discounted using a 6 7/8 percent interest rate and a 50-year economic life. All costs and benefits are based on October 1977 price levels. The base year used since the beginning of this feasibility study is 1980. A more realistic base year would now be about 1985. However, use of 1985 as the base year would not result in a change sufficient to warrant reformulation or revised scale of development studies.

FLOOD DAMAGES

The areas subject to flooding include scattered residential, agricultural, and vacant lands in the upstream reach, nearly 300 acres of the highly developed central portion of the city, and agricultural, residential, public (mostly Southwest State College), and commercial property. Principal flood damages incurred include innundation damage to single and multiple family residential structures; the college buildings, equipment and grounds; damages to sewers, streets, and other utilities; and emergency flood fight, supporting disaster relief, and cleanup costs. Intangible damages include hazards to public health and safety, community disruption, and human suffering and insecurity during major flood periods. Remaining present condition flood damages with the existing project are estimated at $352,685 at October 1977 price levels.

BENEFITS

The principal benefits from flood damage reduction were evaluated as the reduction in flood damages due to obtaining a 133-year degree of protection from the existing project together with needed remedial measures and the difference in flood damages to unprotected development with and without the proposed project. Residential, public, and commercial benefits were computed based on 1980 base year conditions with appropriate discounted allowances for future damage growth. In addition to the flood damage reduction benefits, significant flood proofing cost savings benefits would be obtained with the conversion of 68 acres of agricultural land with more intensive single and multiple-family residential development. Also, substantial benefits attributable to expected use of the proposed recreation facilities would be realized. Average annual project benefits attributable to protection of new unprotected development and increased locational advantages are summarized in the following table.

Table 3 - Average Annual Benefits

Benefit Category	Amount
Flood damage reduction -- Remedial measures	$ 204,570
-- Downstream reach	58,610
Future growth to 2030	24,410
Flood Proofing Cost Savings Benefits	11,110
Recreation benefits	43,130
Total	$ 341,830

FIRST COSTS

The total estimated first cost of $2,504,000 for the project is based on October 1977 price levels for similar work in the area and is summarized in the following table.

Table 4 - Estimated Project Costs

Item	Cost
Channel works	$ 738,600
Levees	171,800
Overflow works	418,200
Interior drainage	184,000
Relocations	52,400
Lands and damages	211,600
Recreation facilities	385,600
Engineering and Design	195,000
Supervision and Administration	146,800
TOTAL FIRST COST	$2,504,000

ANNUAL COSTS

The annual costs of the interest, amortization, operation, and maintenance for the proposed project are $187,590 as shown in the following table.

Table 5 - Annual Costs

Item	Cost
Interest and Amortization	$ 178,590
Operation and Maintenance	9,000
Total Annual Costs	$ 187,590

JUSTIFICATION

The proposed remedial measures to insure effective operation of the existing project to provide a 133-year degree of protection are justified in that the average annual flood damage reduction benefits exceed related average annual costs. Similarly, proposed downstream works to protect recent unprotected development are incrementally justified as shown in table 6 below. The figures given in the table represent direct tangible values only and are displayed for the National Economic Development (NED) account.

Table 6 - Summary of Economic Analyses

Item		Amount
Average annual benefits	- upstream reach remedial works	$ 221,730
	- downstream reach -	76,970
	- recreational facilities	43,130
Average annual costs	- remedial works	124,620
	- downstream reach	28,680
	- recreational facilities	34,290
Incremental benefit-cost ratio	- remedial works	1.8
	- downstream reach	2.7
	- recreation	1.3
Benefit-cost ratio	- total flood control[1/]	1.9

[1/] Excluding recreation costs and benefits.

DIVISION OF PLAN RESPONSIBILITIES

The purpose of this section is to present pertinent information regarding cost apportionment between Federal and non-Federal interests.

COST ALLOCATION AND APPORTIONMENT

Cost allocation among project purposes is not considered warranted for the proposed project since the proposed recreation works are limited in scope and represent a relatively small portion of the project costs and benefits. Project costs are apportioned between Federal and non-Federal interests under both existing legislation and the President's proposed cost-sharing policies as shown in Table 7.

FEDERAL RESPONSIBILITIES

The Federal Government will design and construct the various features of the proposed works. The work charged as a Federal cost includes that for levees, channel works, the overflow diversion works, interior drainage works, aesthetic mitigation measures, and one-half the construction cost of the proposed recreation facilities. The Federal Government also assumes the cost of this study. The total Federal first cost, excluding costs of this study, is estimated at $2,008,800 based on existing cost-sharing legislation. However, applying the President's proposed cost-sharing policies would result in a total Federal first cost of $1,745,100.

NON-FEDERAL RESPONSIBILITIES

Non-Federal interests must meet all elements of local cooperation which includes the assurance that they will:

a. Provide, without cost to the United States all lands, easements, and rights-of-way including suitable areas for borrow and disposal of excavated material as determined by the Chief of Engineers for construction, operation and maintenance of the project.

b. Hold and save the United States free from damages that may result from construction and maintenance of the project, not including damages which are due to the fault or negligence of the United States or its contractors.

c. Maintain and operate the project after completion in accordance with regulations prescribed by the Chief of Engineers

d. Accomplish without cost to the United States all relocations and alterations of buildings (except nonstructural measures), transportation facilities, storm and sanitary sewer systems, public and private utilities, local betterments, drainage facilities, and other structures and improvements made necessary by construction of the recommended plan, as determined by the Chief of Engineers, excluding facilities necessary for the normal interception and disposal of local interior drainage at the line of protection.

e. Prescribe and enforce regulations to prevent obstructions or encroachment on channels, floodway areas, and ponding areas which would reduce their flood-carrying capacity or hinder maintenance and operation.

f. Provide a cash contribution for recreation equal to 50 percent of the final separable cost allocated to this function less a credit for the value of lands, easements, rights-of-way, alterations, and relocations furnished therefor.

g. Publicize floodplain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the floodplain and in adopting such regulations as may be necessary to insure compatibility between future development and protection levels provided by the project

h. In acquiring lands, easements, and rights-of-way for construction of the project, the local sponsor will comply with the applicable provisions of the "Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970," Public Lar 91-646, approved 2 January 1971.

i. At least annually inform affected interests regarding the limitations of the protection afforded by the project.

Under existing cost-sharing legislation, the total non-Federal first cost is estimated at $495,200 (see local cooperation items a, d, and f above and table 7.) Applying the President's proposed cost-sharing policy would require non-Federal interests to contribute 20 percent of the project first costs assigned to flood damage prevention and 50 percent of the separable cost for construction of recreational facilities (see item f above) plus require the State of Minnesota to contribute 5 percent of the total first costs of construction. Thus, the President's cost-sharing policy would result in total combined non-Federal first costs estimated at $758,900 (see table 7). Under both existing cost-sharing legislation and the President's cost-sharing policy, non-Federal interests would be required to satisfy local cooperation items b and c above, with item c estimated to result in $9,000 annual operation and maintenance cost.

Table 7 - Apportionment of first costs among interests

Item	Federal	Non-Federal State	Non-Federal City	Total
Based on existing cost-sharing legislation:				
Lands	-	-	$211,600	$211,600
Relocations	-	-	52,400	52,400
Channels	$738,600	-	-	738,600
Levees	171,800	-	-	171,800
Overflow works	418,200	-	-	418,200
Interior drainage	184,000	-	-	184,000
Recreation facilities	192,800	-	192,800	385,600
Engineering, administration	303,400	-	38,400 (1)	341,800
Total (existing legislation)	2,008,800	-	495,200	2,504,000
Based on President's proposed cost-sharing policy:				
Flood damage prevention	$1,332,500	$88,800	$355,300	$1,776,600
Recreational facilities	173,500	19,300	192,800	385,600
Engineering, administration	239,100	17,100 (2)	85,600 (3)	341,800
Total (President's Policy)	1,745,100	125,200	633,700	2,504,000

(1) Includes 50 percent of the separable Engineering, Administration (E,A) cost ($28,800) and 100 percent separable E,A relocations cost ($9,600).
(2) Includes 5 percent of total E,A.
(3) Includes 20 percent of flood damage prevention E,A, cost ($56,800) and 50 percent of recreational facility E,A cost ($28,800).

PLAN IMPLEMENTATION

Once a plan of improvement under the Section 216 authority has been found feasible and acceptable to local interests, the procedure necessary for its implementation involves the following steps:

- The feasibility report on the plan and accompanying environment impact statement would be reviewed by such higher authorities as the Division Engineer, North Central, the Board of Engineers for Rivers and Harbors and the Office of the Chief of Engineers.
- The Chief of Engineers would seek formal review and comment by the Governor of Minnesota and interested Federal agencies.
- Upon approval by the Chief of Engineers, the report is transmitted through the Secretary of the Army to the Congress for final review, authorization and appropriation of needed funding.
- Upon receipt of project funding, the District Engineer is directed to commence detailed planning studies and an estimate of cost.
- Upon completion of the detailed planning studies and subsequent review and approval by higher Corps authority, the District Engineer would be directed to prepare detailed designs and specifications and an estimate of project costs.
- Concurrently with this detailed planning, the City of Marshall would proceed with acquisition of needed rights-of-way. The City also would enter into a local cooperation agreement with the Federal government.

- Upon completion of plans and specifications, the project would be advertised for competitive bidding by private contractors.
- After award of the contract to the lowest capable bidder, it is estimated that the project could be completed in two construction seasons.
- Upon completion of the project, local interests would commence project operation and maintenance

VIEWS OF NON-FEDERAL INTERESTS

Non-Federal interests coordinated with in the formulation of the selected plan included:

- The City of Marshall
- Lyon County Highway Department
- Lyon County Historical Society
- Minnesota Department of Natural Resources
- Minnesota Pollution Control Agency
- Minnesota Highway Department
- State Historic Preservation Officer
- Minnesota State Historical Society
- Lyon County Board of Commissioners
- Burlington Northern Railroad

Statements or resolutions expressing the views and recommendations of these interests are contained in Appendix II.

The proposed upstream and downstream reach flood control improvements were considered by Marshall City Council at meetings held at

Marshall on 3 March and 20 October 1975 respectively. These meetings were open to and attended by the interested public. A public meeting was held at Marshall on 2 February 1977 to discuss the proposed plan of improvement and receive the public's views and comments related to the plan. A copy of the meeting transcript and related correspondence is contained in Appendix II, Pertinent Correspondence.

A meeting was held with City officials on 2 March 1978 to review revised study findings based on a review of the draft report by higher Corps authority. On 2 April 1979, a meeting was held with City officials and interested members of the public to discuss additional studies of alternative flood barrier alignments made in response to the President's Executive Orders 11988 and 11990. Upon conclusion of these discussions, the Marshall City Council adopted resolutions supporting the proposed flood plain management and recreation measures and indicating the City's willingness and intent to provide needed assurances of local cooperation when and as required.

REVIEW BY OTHER FEDERAL AGENCIES

Federal agencies involved either in the formulation or review of the selected plan were:

- Department of Agriculture - Soil Conservation Service
- U.S. Environmental Protection Agency
- Department of the Interior - National Park Service
  - Fish and Wildlife Service
  - Bureau of Outdoor Recreation.

The draft report with accompanying environmental impact statement was circulated for comment among the various Federal agencies. Statements received from these agencies are included in Appendix II.

SUMMARY

The City of Marshall and immediately adjacent flood plain reaches are subject to recurrent flooding of the Redwood River and related property damages even with the existing flood control project. The April 1979 flood clearly showed that natural conditions immediately upstream and downstream of the project were such that the design floodwaters could not be conveyed into or away from the project. This same flood also showed that substantial flood plain development in the downstream reach remains unprotected under existing conditions.

In addition to a "no further public action plan", nine possible solutions to the flood problem were analyzed. From this analysis and the demonstrated interest by the City of Marshall, it is concluded that the only feasible and acceptable plan for obtaining effective operation of the existing project and reducing flood damages to unprotected downstream reach development is the selected plan. This plan provides for channel works, levees, and overflow-diversion works to permit controlled passage of excess Redwood River flood overflows into the Cottonwood River basin. The project works would provide a 133-year degree of protection with generally three feet of allowable levee freeboard. Two feet of freeboard over the SPF flood level would be provided along the right bank levee upstream of the existing diversion structure to prevent SPF flows from overtopping the levee and entering the city.

The selected plan also provides locally desired recreational facilities, including bicycling and cross-country ski trails and limited picnicking facilities. Local interests would provide 0.9 miles of connecting trails at their expense prior to or concurrent with construction of any authorized improvements. Other recreational works, if desired by local interests and constructed at their expense,

would include nature, educational and quiet areas upstream of CSAH 7 and canoe access at the Highway 23 wayside park.

Natural resources to be committed in construction of the project would include approximately 119.8 acres of land including 71.1 acres of land for project floodway purposes. Of the 48.7 acres of land required for project construction, 4.2 acres are forested, 16.3 acres are in agricultural use, with the remainder as open space or vacant land.

Social and economic benefits of the project would include an increased and expanded level of flood protection, the enhancement of former flood plain lands, enhanced public security and well-being, the preservation of desirable community patterns, and the near elimination of the need for inefficient commitment of local resources for flood emergency activities. The proposed recreation works would partially satisfy unmet demands for recreational opportunities in the Marshall area.

The remedial measures required to obtain effective operation of the existing project are economically justified. The total project first cost is estimated at $2,504,000. Protection of unprotected downstream reach development is incrementally justified with a benefit-cost ratio of 2.7 to 1. The upstream reach remedial measures are also justified as indicated by a 1.8 benefit-cost-ratio.

The non-Federal first cost under existing cost-sharing legislation is estimated at $495,200. Construction of the project could be completed by the United States in two construction seasons dependent upon the availability of necessary funds, completion of plans and specifications, and receipt of non-Federal assurances of participation. Following construction, operation and maintenance of the project would be the responsibility of the City of Marshall.

EXECUTIVE ORDERS 11988 and 11990

Additional alternatives providing flood protection to the City of Marshall were prepared in response to E.O. 11988 and 11990 concerning flood plain development and the protection of wetlands. Analysis of the alternatives determined that they did not constitute "practicable" alternatives (as defined by the Executive Orders), nor do they preclude development in the flood plain. In addition, the selected plan generally meets the requirements in the President's 1980 budget criteria pertaining to flood plain development and wetland protection. A detailed description and evaluation of the alternatives is presented in Appendix 1, Section J.

SECTION 404 REQUIREMENTS

A public notice outlining the proposed flood control plans involving dredging and filling, in the Redwood River at Marshall was issued on 28 February. The notice summarized the expected significant environmental effects and offered any interested person opportunity to request a public hearing in accordance with Section 404(b) of the Federal Water Pollution Control Act Amendments of 1972. Comments on the public notice are attached to Appendix 2. ______________ comments opposing the Corps of Engineers project and ______________ requests for a public hearing were received. The proposed project would comply with the requirements of Section 404 as described in this report and the accompanying revised draft EIS.

STATEMENT OF FINDINGS

I have reviewed and evaluated, in light of the overall public interest, the documents concerning the proposed action and the stated views of other interested agencies and the concerned public, relative to the various practical alternatives considered to insure effective operation of the existing flood control project and protect additional flood-prone development at Marshall, Minnesota.

The possible consequences of these alternatives have been studied for environmental, social well-being, and economic effects (including regional and national economic development as appropriate) and engineering feasibility.

BACKGROUND

Authority for the proposed plan is provided in section 216 of the 1970 River and Harbor Act.

Marshall, Minnesota, with a 1970 population of 9,886 persons, is subject to flood damages from overflows of the Redwood River. Marshall and Lyon County, of which Marshall is the county seat, requested in letters dated 3 July 1972 and 6 June 1972, respectively, that a study be made to determine what improvements can be made to increase the efficiency of the existing flood control project and provide additional protection.

The existing flood control project at Marshall was constructed by the Federal Government in 1963 at an estimated first cost of $2,953,000 (1963 dollars). The project was designed to provide protection against a flood with an expected recurrence interval of once in about 114 years (0.88 - percent chance flood). However, as experienced during the April 1969 flood, this original level of protection now represents only a 59-year degree of protection (1.69-percent chance flood). This reduced level of protection is mainly caused by inadequate flow capacity of the natural channel upstream and downstream of Marshall. Only a major local flood fight during the April 1969 flood prevented extensive damages to the city. However, Redwood River overflows into the Cottonwood River basin and the emergency flood fight activities resulted in moderate damages to some area farms, local highways, and other property.

Since the existing project was completed in 1963, considerable development has occurred on the flood plain immediately downstream of the project. The majority of this development, generally consisting of the Southwest State College at Marshall and student and other local housing, is not protected by the existing project. Without emergency flood barriers, this development would have been extensively damaged during the April 1969 flood.

Several meetings in support of this study were held in the city to obtain local views on city flood problems and needs. Two meetings, open to and attended by the public, were held on 3 March 1975 and 20 October 1975 to obtain the city's views on upstream and downstream reach alternatives, respectively. A late-stage meeting was held at Marshall in February 1977 to obtain local views on the selected plan. On 2 March 1978 a meeting was held with City officials to discuss revised study findings. On 2 April 1979, another meeting was held with City officials and interested members of the public to discuss additional studies of alternative flood barrier alignments made in response to Executive Orders 11988 and 11990.

ALTERNATIVES

Alternatives considered included no further public action, permanent evacuation of the flood plain, partial evacuation and flood proofing, upstream reservoir storage, channel modifications, levee works, and combinations of non-structural measures. The no further public action alternative represents the "without" project condition against which the impacts of all other alternatives are compared.

Except for flood plain management measures in conjunction with structural measures, none of the non-structural alternatives provide a viable, economically justified, or locally acceptable solution. Permanent flood plain evacuation would reduce most damages to unprotected development but would result in severe dislocations of established community patterns and severe adverse long-term effects to the State college. Partial evacuation and flood proofing would minimize the adverse effects to the college but still result in the locally unacceptable rearrangement of area housing patterns and other dislocations of established transportation and development.

Adequate upstream reservoir storage capacity is severely limited. One possible site exists in Camden State Park about 8 miles upstream of Marshall. A reservoir in the park would cause severe environmental losses and significantly change the use of the park. It would also be unacceptable to the State and local interests and is not economically justified. Tributary storage would, in total, result in probable major environmental losses and be technically and economically infeasible.

Several combination of levees were considered. A combination of upstream and downstream levees with channel modifications, overflow diversion, interior drainage works, aesthetic measures, and necessary relocations would insure the effective operation of the existing project and provide protection to additional areas. A comparison of estimated average annual benefits of $157,500 with average annual costs of $148,500 results in a benefit-cost ratio of 1.1.

Other measures for the upstream reach were considered including a perimeter levee around a 10-acre river meander area, an alternative channel cutoff across the meander area to improve flow efficiency, a floodwater bypass channel, and raising of CSAH 7 and Highway 23 to provide temporary floodwater storage. None of these variations were recommended as they proved to be either impractical, uneconomical, or locally unacceptable or would cause unacceptable adverse environmental effects.

Of the other downstream reach structural measures considered, a combined highway-levee plan would be practical, feasible, and have only slightly more adverse environmental impacts than the other plans considered. However, the uncertainty as to the timing of local completion of required designs and availability of local funding precluded recommendation of the plan at this time. If these problems could be resolved before construction of the flood control works, the Chief of Engineers could permit construction of a joint highway-levee project. In any case, the selected plan would not foreclose the future and efficient combination of a highway with the downstream reach levee.

Various combinations of channel measures including widening, bank protection, and a channel cutoff were considered for the downstream reach. Other than 1,500 feet of channel widening to reduce slight upstream stage increases resulting from the upstream works and selected widening at bends and along a 1,000-foot reach upstream of the proposed overflow diversion structure, none of these measures had sufficient merit to warrant incorporation in the selected plan.

THE SELECTED PLAN

The selected plan consists of structural flood plain management measures along the river reaches upstream and downstream of the existing flood control project at Marshall. Upstream works would generally consist of a 2,260-foot long levee along the north (left) bank and a 6,350-foot long levee with a temporary sandbag closure along the south (right) bank. The north and south bank levees would start at the upstream end of the existing project (existing diversion structure at river mile 70.2) and extend to high ground at the Burlington Northern Railroad and State Highway 23 embankments, resepctively. Other upstream improvements would include channel widening, riprap pier protection at the CSAH (County State Aid Highway) 7 bridge, an overflow diversion at the State Highway 23 wayside park with attendant 2,140-foot long overflow channel to control flood overflows into the Cottonwood River basin, interior drainage works, aesthetic measures, and necessary relocations.

Required downstream improvements would consist of a 7,670-foot long levee extending from high ground near the State Highway 23 embankment east of the city upstream to high ground in the vicinity of North 5th Street and Kossuth Avenue. For the most part, this levee would follow the alignment of a proposed highway under joint consideration by the city and Lyon County. If later desired, the highway could incorporate the levee embankment or be constructed adjacent to it. Other downstream reach levee works would include a temporary sandbag closure, a 450-foot foot long levee along the natural channel south bank just upstream of the downstream confluence of the natural channel and existing project diversion channel. An 860-foot long levee about 2 feet high would bridge a low channel bank reach along the natural channel. The river channel immediately downstream of the downstream confluence would be widened to a 35-foot bottom width (an additional 5 feet) for a distance of about 1,500 feet.

Riprap bank protection would protect the widened channel bank and adjacent levee from erosion and possible damage. Related downstream interior drainage works would include a 7-acre ponding area with attendant collector ditch and outlet works. Six utility poles would be relocated along the 860-foot levee alignment.

The residual flood plain along both project reaches would be managed in accordance with existing city flood plain management regulations. Principal areas to be managed include the 71.1-acre floodway area upstream of CSAH 7, an 18-acre area along the north channel bank immediately upstream of the downstream confluence of the existing diversion channel, and the entire remaining flood plain riverward of the proposed downstream reach levee.

The proposed project would also provide for much needed recreation facilities. Initial facilities would include a 5.2-mile bike-walking trail and a 5.7-mile cross-country ski trail, trail head improvements, a rest stop at the existing softball complex, and limited picnicking facilities at Justice Park. Additional improvements that would be provided by local interests include a nature education and quiet areas in the wooded river corridor upstream of CSAH 7 and a canoe access at the State Highway 23 wayside park.

The proposed structural flood plain management measures would insure effective operation of the existing project and provide protection to presently unprotected downstream reach developments against a Redwood River flood having a 0.75-percent chance of occurring in any given year (133-year flood). The project would be constructed by the Federal Government at an estimated Federal first cost of $2,008,800 and a non-Federal first cost of $495,200. The project would then be turned over to the City of Marshall for operation and maintenance in accordance with the required assurances of local cooperation. Annual coperation, maintenance and equipment costs are estimated at $9,000.

EVALUATION OF THE SELECTED PLAN

Engineering Considerations Of the alternatives considered for the upstream reach, the combined levee-channel plan has proved to be the best method of solving the problem. The overflow structure and attendant outlet channel in particular are considerd effective in controlling the damaging overflows into the adjacent Cottonwood River basin. The proposed plan represents the most logical solution evaluated on the basis of obtaining effective operation of the existing inefficient project, engineering feasibility, local acceptablility, and environmental effects. Total Federal and non-Federal first costs under existing cost-sharing legislation are estimated at $2,008,800 and $495,200 respectively. A comparison of estimated average annual benefits of $341,830 with average annual costs of $187,590 results in a benefit-cost ratio of 1.8.

Similarly, of the plans considered for the downstream reach, the selected plan proves to be the most effective method for improving the operation of the existing project and protecting additional development. The plan provides effective protection from the 0.75-percent chance (133-year) flood and maintains the possiblity of a combined levee-highway during or at any time after construction. Thus, this portion of the overall plan also represents the most efficient plan in terms of economic benefits, technical feasibility and environmental effects.

Environmental Considerations An estimated 119.8 acres of land, including 41.0 acres of wooded land and 32.0 acres of tilled cropland, would be required for the project. The conversion of 4.2 acres of wooded land and 28.2 acres of undeveloped lands is expected to have adverse effects on small mammal communities in the area. The channel widening and bank protection measures would have at least short-term adverse effects on project areas, small mammals, amphibians, the limited area stream fishery, and other aquatic fauna. Many of these biological communities can be expected to begin repopulating the area once the construction activity ceases. The regular maintenance of the project, such as mowing of levees, will permanently suppress species that formerly occupied such areas. Although channel excavation and bank protection works would markedly affect stream water quality during and shortly after construction, the long-term impact of these works is expected to be beneficial in terms of reduced erosion, sedimentation, and turbidity. The loss of mature shade trees and impairment of the river view at riverside residences would be a long-term adverse effect. Recreational trail use would result in a long-term change in the physical setting and increased noise levels during the summer at one riverside residence adjacent to the trail.

The proposed acquisition of 71.1 acres of flood plain lands for floodway purposes would provide a long-term beneficial impact in preserving the natural area from future encroachments. Aesthetic and wildlife habitat losses would be minimized by reseeding all disturbed areas with selected grass species and replacing lost residential trees with similar but smaller species at selected locations. The proposed works are considered to provide a balance between adverse environmental impacts and need for effective flood damage reduction at Marshall.

EXECUTIVE ORDERS 11988 and 11990 CONSIDERATIONS

The selected levee alignments make use of existing high ground, are economical and engineeringly efficient levee alignments. However, the selected levee alignments protect 205 acres of flood plain presently in agricultural use. In response to Executive Orders 11988 and 11990 concerning flood plain development and wetlands protection, alternate levee alignments were developed for both the upstream and downstream reaches of the project. Analysis of the alternate levee alignments determined that they did not constitute "practicable" alternatives (as defined by the Executive Orders) nor did they preclude development in the flood plain. In addition, the selected levee alignment generally fulfills the requirements from the President's 1980 budget criteria concerning flood plain development.

The selected and alternative levee alignments would have similar effects on the natural and beneficial values of the flood plain. The selected levee alignments may however, accelerate future development in the flood plain by eliminating fill requirements needed under existing conditions to meet State flood plain management criteria. The alternate levee alignments would approximately double the fill requirements necessar; for development under existing conditions, which may discourage or retard future flood plain development.

OTHER

Two feet of freeboard over the SPF flood levee would be provided along the right bank levee upstream of the existing diversion structure to confine flood flows exceeding the 133-year design level between the levee and the Burlington Northern Railroad embankment. Thus, the impact of floods on human safety with the proposed project would not be a major concern.

The overall study, draft report, Environmental Impact Statement, and public notices were coordinated with Federal, State, regional and local interests and groups. Appendix II of this report and Section 9.0 of the Revised Draft Environmental Impact Statement contain correspondence from the various concerned groups and interests, as well as the responses to their comments.

CONCLUSION

I find that:

a. The action proposed in the recommendations section of this report is based on a thorough analysis and evaluation of various practicable alternative courses of action for achieving the stated objectives.

b. Wherever unavoidable adverse effects are found to be involved, they cannot be avoided by reasonable alternative courses of action which would achieve the congressionally specified project purpose.

c. Where the proposed action results in an adverse effect, this effect is either minimized or substantially outweighed by other considerations of national policy.

d. The fill sites for the Marshall project have been evaluated and found in compliance with the Section 404(b)(1) Guidelines.

e. The selected project is in compliance with Executive Orders 11988 and 11990.

f. The selected alignment was coordinated and reviewed by the Minnesota Department of Natural Resources and found to be acceptable.

Accordingly, it is my decision that the public interest would be best served by implementation of the recommended action. Also, this plan is acceptable to the city of Marshall and the other agencies and interests associated with this study.

RECOMMENDATION

I recommend that the United States provide additional flood damage reduction measures and related recreational improvements at Marshall, Minnesota, generally in accordance with the plan proposed herein, with such modifications thereof as in the discretion of the Chief of Engineers may be advisable. The President in his June 1978 water policy message to Congress, proposed several changes in cost-sharing for water resources projects to allow States to participate more actively in project implementation decisions and to equalize cost-sharing between structural and nonstructural flood damage prevention projects. These changes include a cash contribution from benefiting States of 5 percent of the first costs of construction assigned to nonvendible project purposes. Application of this policy to the Marshall project would require the State of Minnesota to contribute an estimated $125,200 in cash (5 percent of $2,504,000 total estimated project first costs of construction assigned to nonvendible project purposes based on October 1977 price levels).

The president also proposed that the present cost-sharing requirements for flood damage prevention projects be modified to require a cash or in-kind contribution equal to 20 percent of the project first costs assigned to flood damage prevention benefits. Application of this policy to the Marshall project would require that non-Federal interests make, in addition to the State contribution, as a cash or in-kind contribution of an estimated $412,100 (20 percent of the total project first costs of construction - separable costs assigned to recreation). Also, non-Federal interests will be required to pay, contribute in kind or repay, with interest, 50 percent of the separable cost for construction of recreational facilities, in accordance with the Federal Water Project Recreation Act of 1965. The amount involved is presently estimated at $221,600. In addition, non-Federal interests will be required to provide assurances satisfactory to the Secretary of the Army that they will:

a. Hold and save the United States free from damages that may result from construction and maintenance of the project, not including damages which are due to the fault or negligence of the United States or its contractors.

b. Maintain and operate the project after completion in accordance with regulations prescribed by the Chief of Engineers.

The combined non-Federal share of project costs is currently estimated to be $758,900 of total first cost and $9,000 annual operation and maintenance cost. I recommend construction authorization for the Marshall project in accordance with the President's proposed cost-sharing policy.

WILLIAM W. BADGER
Colonel, Corps of Engineers
District Engineer

15 OCT 1979

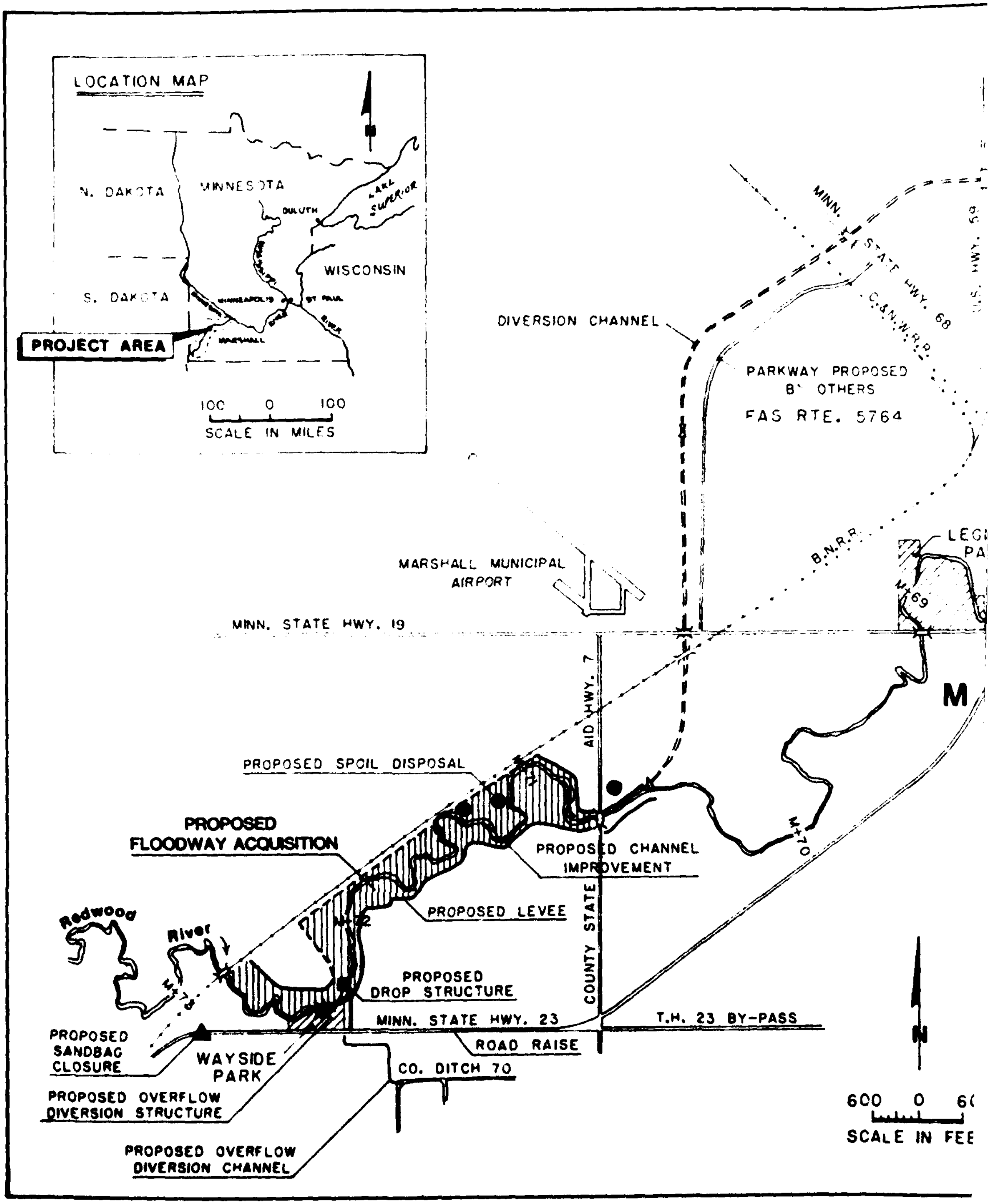
NCDPD-FF (June 1979) 1st Ind
SUBJECT: Redwood River at Marshall, Minnesota, Feasibility Report for Flood Control

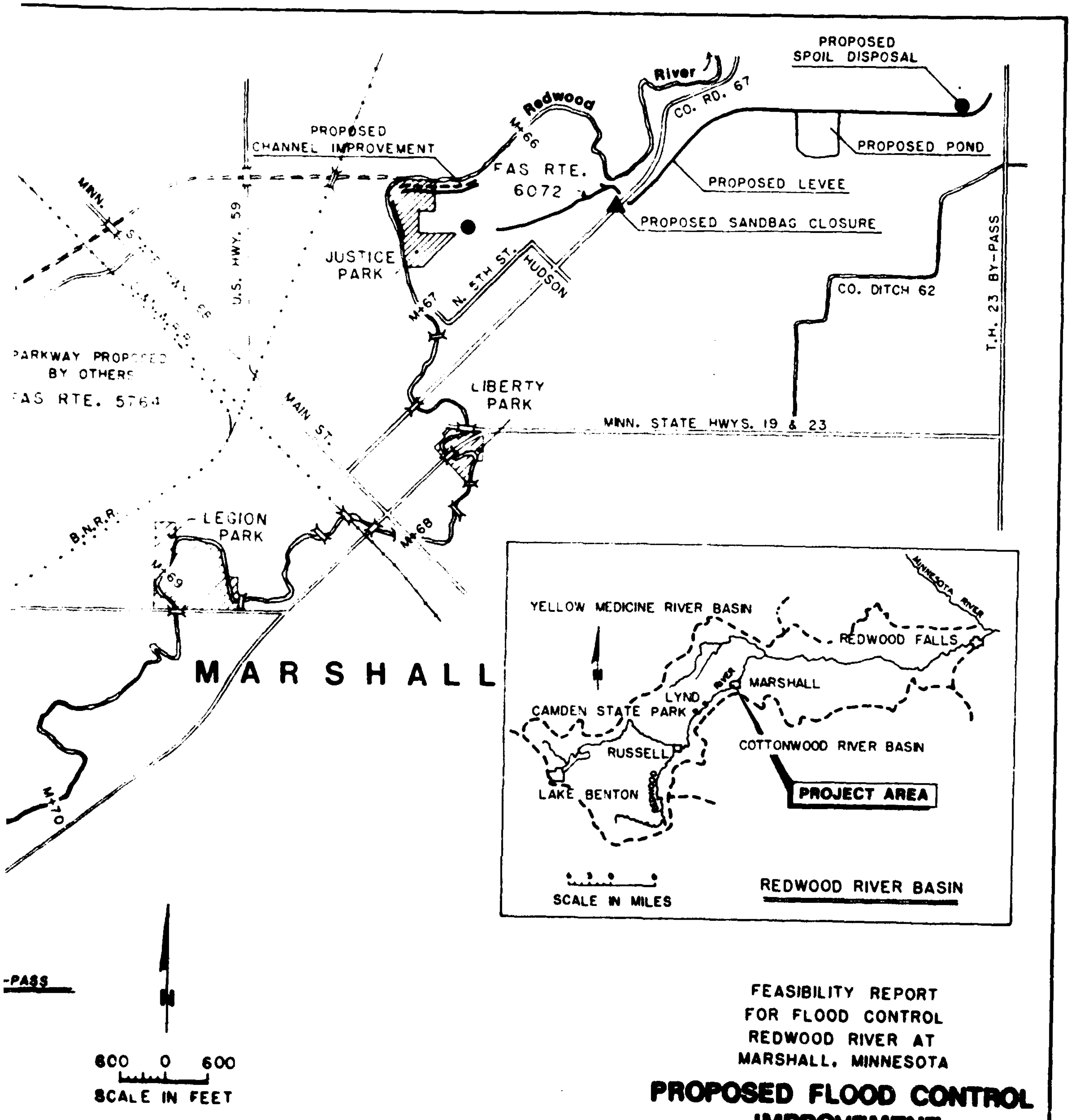
DA, North Central Division, Corps of Engineers, 536 S. Clark St., Chicago, Illinois 60605

TO: HQDA (DAEN-CWP-C), WASH DC 20314

I concur in the analysis and recommendations of the District Engineer.

RICHARD L. HARRIS
Major General, USA
Division Engineer

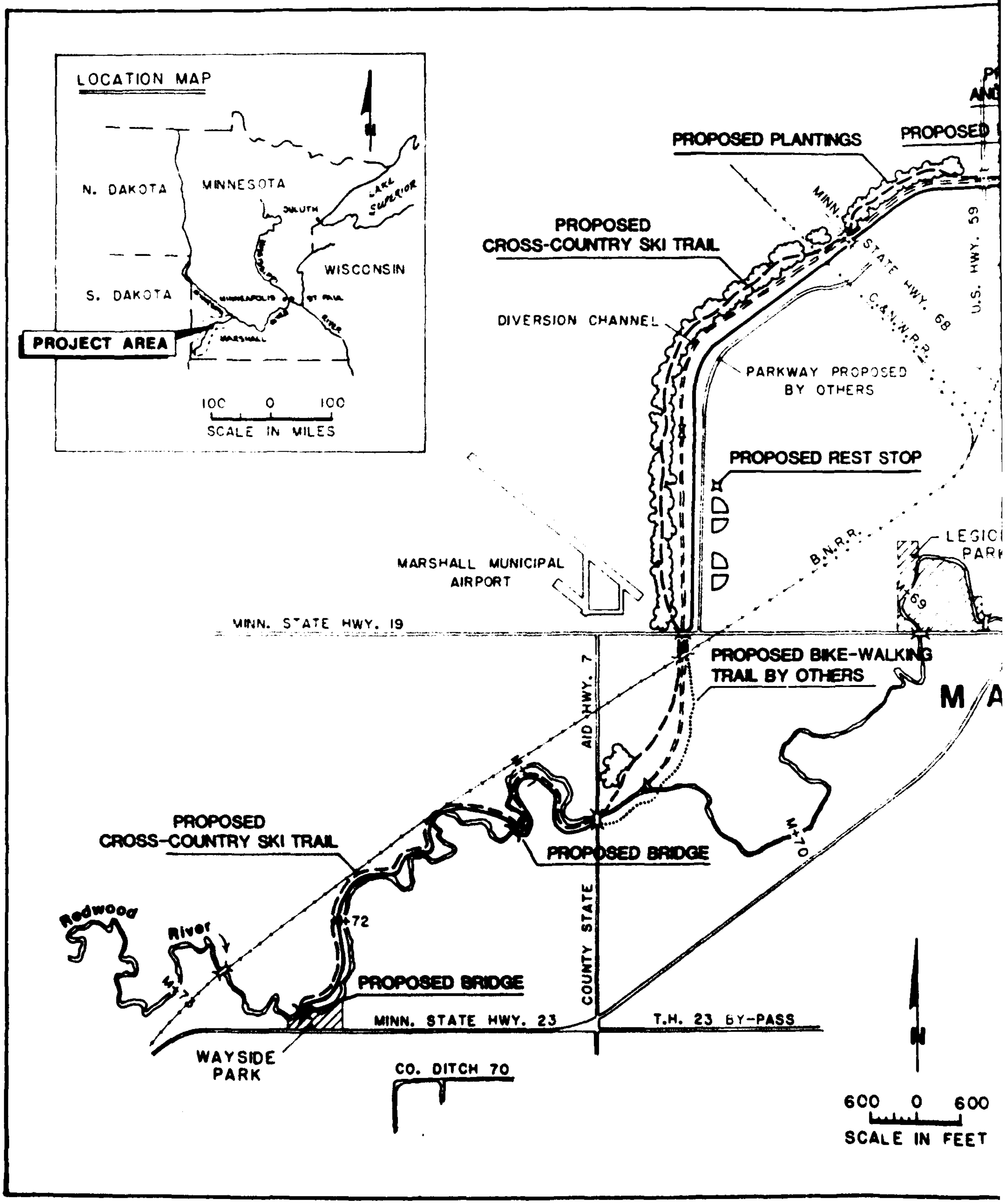

LOCATION MAP
N. DAKOTA
MINNESOTA
LAKE SUPERIOR
DULUTH
WISCONSIN
S. DAKOTA
MINNEAPOLIS
ST PAUL
MARSHALL
PROJECT AREA
100 0 100
SCALE IN MILES
DIVERSION CHANNEL
MINN. STATE HWY. 68
C.&N.W.R.R.
PARKWAY PROPOSED BY OTHERS
FAS RTE. 5764
MARSHALL MUNICIPAL AIRPORT
B.N.R.R.
M+69
MINN. STATE HWY. 19
COUNTY STATE AID HWY. 7
M
PROPOSED SPOIL DISPOSAL
PROPOSED FLOODWAY ACQUISITION
PROPOSED CHANNEL IMPROVEMENT
M+70
PROPOSED LEVEE
Redwood River
M+72
PROPOSED DROP STRUCTURE
MINN. STATE HWY. 23
T.H. 23 BY-PASS
PROPOSED SANDBAG CLOSURE
WAYSIDE PARK
ROAD RAISE
CO. DITCH 70
PROPOSED OVERFLOW DIVERSION STRUCTURE
PROPOSED OVERFLOW DIVERSION CHANNEL
SCALE IN FEE



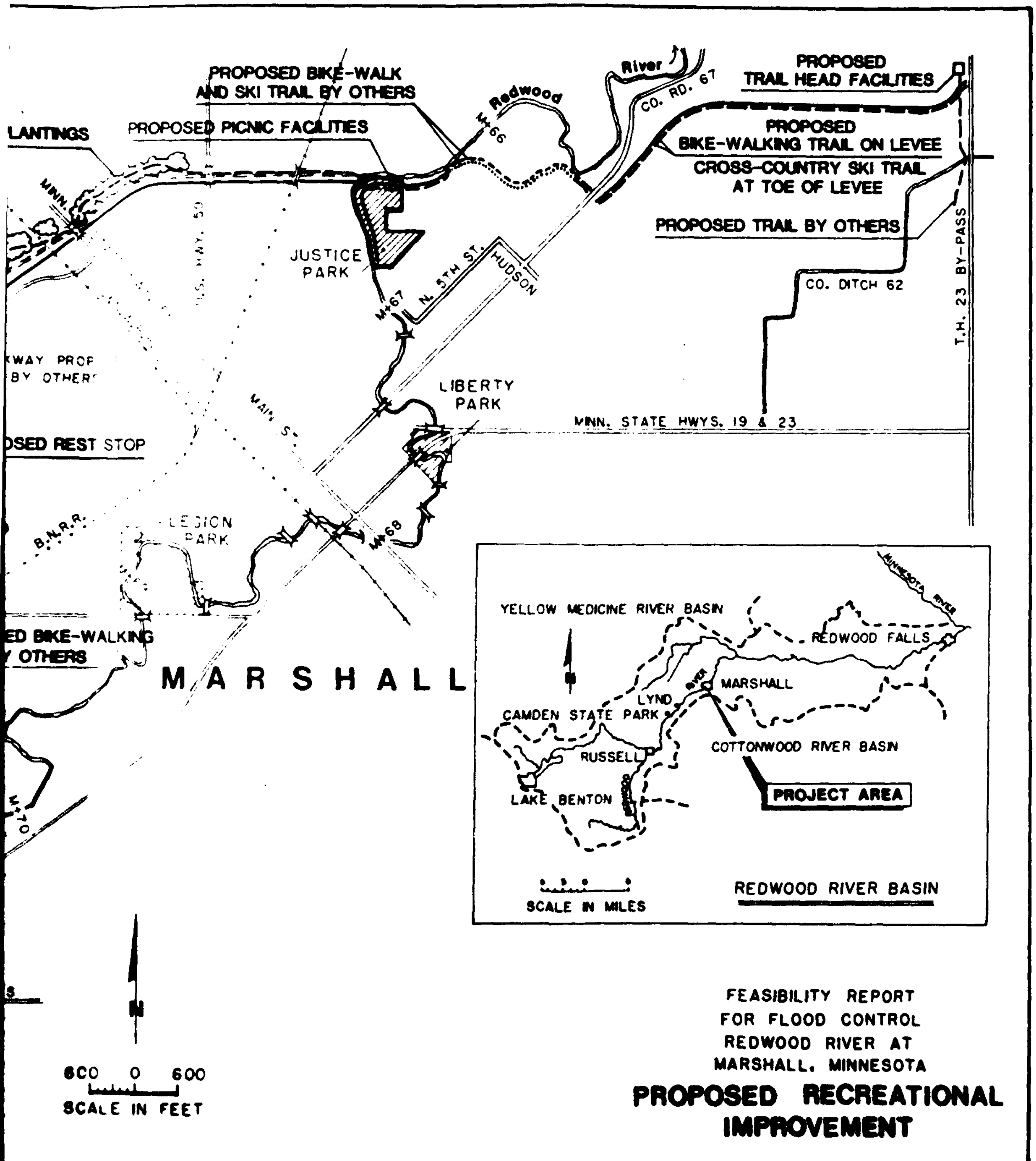
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

PROPOSED FLOOD CONTROL IMPROVEMENT

PLATE 1



LOCATION MAP
N. DAKOTA
MINNESOTA
S. DAKOTA
WISCONSIN
LAKE SUPERIOR
DULUTH
MINNEAPOLIS
ST PAUL
MARSHALL
PROJECT AREA
100 0 100
SCALE IN MILES
PROPOSED PLANTINGS
PROPOSED
PROPOSED CROSS-COUNTRY SKI TRAIL
DIVERSION CHANNEL
MINN. STATE HWY. 68
C.&N.W.R.R.
U.S. HWY. 59
PARKWAY PROPOSED BY OTHERS
PROPOSED REST STOP
B.N.R.R.
MARSHALL MUNICIPAL AIRPORT
MINN. STATE HWY. 19
PROPOSED BIKE-WALKING TRAIL BY OTHERS
COUNTY STATE AID HWY. 7
PROPOSED CROSS-COUNTRY SKI TRAIL
PROPOSED BRIDGE
Redwood River
PROPOSED BRIDGE
MINN. STATE HWY. 23
T.H. 23 BY-PASS
WAYSIDE PARK
CO. DITCH 70
600 0 600
SCALE IN FEET



FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

PROPOSED RECREATIONAL IMPROVEMENT

PLATE 2

FEASIBILITY REPORT FOR FLOOD CONTROL

REDWOOD RIVER AT MARSHALL, MINNESOTA

TECHNICAL REPORT

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SECTION C.	PROBLEMS AND NEEDS
SECTION D.	FORMULATING A PLAN
SECTION E.	THE SELECTED PLAN
SECTION F.	ECONOMICS OF SELECTED PLAN
SECTION G.	RECREATION RESOURCES
SECTION H.	DESIGN CONSIDERATIONS
SECTION I.	DIVISION OF PLAN RESPONSIBILITIES
SECTION J.	EXECUTIVE ORDERS 11988 AND 11990

APPENDIX 1

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

SECTION A

THE STUDY AND REPORT

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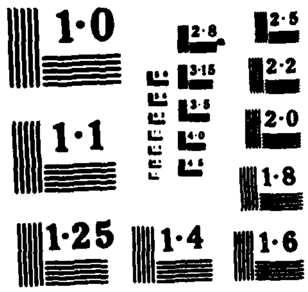
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2·8
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3·15
2·2
3·5
2·0
4·0
4·5
1·1
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1·25
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1·6

SECTION A

THE STUDY AND REPORT

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SECTION A

THE STUDY AND REPORT

1. This section presents a discussion of study purpose and authority, scope of study, study participants and coordination and prior studies and reports on the same subject. It also includes a short discussion on the relationship of this technical report to the main report.

PURPOSE AND AUTHORITY

2. Flooding of the Redwood River at Marshall has been a severe burden on the community. In 1963, permanent flood control works including channel improvements, levee works, and a channel diversion were constructed by the Federal government to reduce the recurring flood damages. The subsequent 1969 flood, however, demonstrated very clearly that the project would not convey the design flood through Marshall in the manner prescribed in the original project document and design memorandum.

3. Authority for this study is provided for in section 216 of the River and Harbor Act of 1970. This section of the Act states:

> "The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the

construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions and to report thereon to Congress with recommendations on the advisability of modifying the structures of their operation, and for improving the quality of the environment in the overall public interest."

SCOPE OF STUDY

4. This investigation concerns the adequacy of the existing Corps of Engineers project in providing flood damage reduction in the city of Marshall and adjacent urbanized area both upstream and downstream of the city. Investigations were made in sufficient detail to permit selection of the best overall plan from a series of alternatives and establish final project designs and cost estimates. Field surveys were made to obtain needed topographic information. Borings were taken at certain locations to establish foundation conditions. Field investigations were also made to identify critical erosion areas and other channel characteristics, and to determine the impact of the alternatives considered on the environment. Selection of the recommended plan was made after considering various effects, current planning policies and criteria, and views of the affected public. Coordination was maintained throughout the study with the City of Marshall and interested State and Federal agencies.

STUDY PARTICIPANTS AND COORDINATION

5. The principal objective during the formulation phase of this study was to devise an effective plan that is acceptable to the local public. Plan formulation, plan selection, final designs and estimates and preparation of the draft report were accomplished by Wehrman, Chapman Associates, Inc. - Minneapolis, Minnesota under contract to the St. Paul District Corps of Engineers. The St. Paul District had principal responsibility for the study including contract supervision, coordination with the public and interested local, State and Federal agencies, and preparation of the final report and environmental statement.

6. Several meetings were held with the City of Marshall to enable selection of the best plan. Formulation stage meetings with the Marshall City Council to discuss upstream and downstream improvements were held on 3 March, 1975 and 20 October 1975, respectively. Comments concerning the possible effects of a project action on area environmental, historical, and cultural values were requested from the following agencies:

* Minnesota Department of Natural Resources
* Minnesota Pollution Control Agency
* Minnesota Department of Highways
* Fish and Wildlife Service - Department of the Interior
* Bureau of Outdoor Recreation - Department of the Interior
* National Park Service - Department of the Interior
* Soil Conservation Service - Department of Agriculture
* U.S. Environmental Protection Agency

7. A late stage public meeting was held in Marshall during February 1977 to receive comments and any suggested modifications to the proposed plan of improvement. On 2 March 1978, a meeting was held with city officials to review revised study recommendations based on a review of the draft report by higher Corps authority. On 2 April 1979 a meeting was held with city officials and interested public to discuss additional studies of proposed flood barrier alignments in response to the President's Executive Orders 11988 and 11990. The city also adopted at this meeting, resolutions indicating its willingness and interest to meet local assurances of cooperation for the proposed flood plain management and recreation measures when and as required. Copies of these resolutions and transmitting correspondence are included in Appendix 2.

THE REPORT

8. This report consists of three parts: the main report and two appendices. The main report is a non-technical presentation concerning problems and needs alternative plans and their effects, and a recommended course of action to solve the flood problems at Marshall. The main report provides a broad view of the overall study for the benefit of both general and technical readers. It also provides emphasis on study items, such as plan implementation, report review by others, and study recommendations.

9. Appendix I is a detailed technical version of the main report. Although it follows the same general outline as the main report, it examines the problems, needs, and alternative solutions in depth for the benefit of technical review.

10. Appendix II contains all pertinent correspondence affecting coordination among Federal and State agencies and local interests and a summary of public involvement activities conducted during the study.

PRIOR STUDIES AND REPORTS

11. House Document No. 230, 74th Congress, 1st session, includes a report submitted by the St. Paul District Engineer on 24 November, 1934, concerning water and related land resource problems in the Minnesota River Basin. However, this report did not specifically consider flooding and related problems in the Redwood River Basin.

12. House Document 417, 86th Congress, 2nd session, includes a 25 March, 1960 report from the St. Paul District Engineer recommending flood control improvements at Marshall to include clearing and snagging of a 3.1 mile reach of the Redwood River, construction of 2,135 feet of levee, and a floodwater diversion channel at a Federal first cost of $2,252,000 and subject to certain assurances of local cooperation.

13. A General Design Memorandum on authorized improvements on the Redwood River at Marshall was completed by the St. Paul District, U.S. Army Corps of Engineers in November 1961. This report provided the detailed designs and cost estimates for the existing Corps flood control project.

14. A flood plain information report on the Redwood River at Marshall was completed by Wehrman, Chapman Associates, Inc. Minneapolis, Minnesota under contract to the Corps of Engineers in March, 1975. This report, prepared at the request of the City of Marshall with the endorsement of the Minnesota Department of Natural Resources, contains maps, profiles, and cross-sections which indicate the extent of flooding which has been experienced and which could occur in the future at Marshall.

15. Other related reports include the Comprehensive Plan for the City of Marshall dated December 1962 with subsequent supporting updates and addendums and the State Comprehensive Outdoor Recreation Plan (SCORP).

16. A final draft Flood Insurance Study Report dated August 1976 for the City of Marshall was prepared by the St. Paul District under contract with the Federal Insurance Administration of the U.S. Department of Housing and Urban Development.

17. Flood plain management regulations adopted by the City of Marshall on 21 February 1978. These regulations designate (and regulate development in) the Floodway and Flood Fringe Districts as shown on the incorporated official zoning map.

18. A report entitled "Archeological Survey of a Proposed Flood Control Project in Marshall, Minnesota" was prepared in 1978 by the St. Paul District, U.S. Army Corps of Engineers. This report documents the results of archeological field surveys to identify the presence and location of any archeological sites that may be affected by proposed flood control measures.

SECTION B

RESOURCES AND ECONOMY OF THE AREA

SECTION B

RESOURCES AND ECONOMY OF THE AREA

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SECTION B

RESOURCES AND ECONOMY OF THE AREA

1. This section of the report discusses the natural and human resources and state of development and economy at Marshall.

2. The City of Marshall (1970 population of 9,886) is located in southwestern Minnesota near the center of the Redwood River Basin as shown on plate B-1. It is located at mile 68[1/] on the Redwood River, which rises near the Minnesota - South Dakota boundary and flows northeasterly to a point about seven miles northeast of Marshall, where it turns and then flows generally eastward to its confluence with the Minnesota River. Marshall is a farm service center in a relatively wealthy agricultural region. Rich prairie soils in the surrounding area provide for high crop production except during drought periods.

ENVIRONMENTAL SETTING AND NATURAL RESOURCES

3. Marshall is located on the Redwood River, between approximate river miles 66.0 and 70.8 as shown on plates B-1 and B-2. The town

[1/] All Redwood River mileages referenced to mile 0 at the confluence of the Redwood and Minnesota Rivers.

lies on the divide between the Redwood River Basin and Cottonwood River Basin, the Cottonwood River being about six miles to the south at its nearest point. The study area (plates B-1 and B-2) considered in this study is comprised of two separate Redwood River reaches. The lower reach extends from State Highway 23 (mile 58.3) to the downstream confluence of the river channel and diversion channel (mile 66.3). The upstream reach covers the remainder of the river upstream through the city to the upstream end of the existing left bank levee at river mile 73.8 located immediately upstream of the Burlington Northern Railroad bridge.

LAND USE

4. Land use outside the urbanized area is predominantly agricultural with scattered rural residential and recreation uses. Typical agricultural land use along the upstream reach is shown on the following photograph. In most instances, this land use extends up to the narrow fringe of forest which borders the river channel. The Comprehensive Guide Plan[1/] for Marshall indicates that by 1980, and with adequate protection against flooding, much of the agricultural (mainly crop) land in and adjacent to the city and the river corridor will be developed in about the same proportions of land use mix presently experienced. Public land use adjacent to the river corridor principally consists of a State wayside park at approximately river mile 72.5 as shown on plate B-1 and the Southwest State College at Marshall on the opposite side of town, shown on plate B-2. The only industrial use along either study reach is limited to that of the Burlington Northern Railroad at the upstream study area limit.

[1/] The Comprehensive Plan, City of Marshall, Minnesota December, 1962

Agricultural Land Use-Upstream Reach

GEOLOGY, TOPOGRAPHY AND SOILS

5. The underlying rock formations in Lyon County date from Precambrian, Cretaceous, Pleistocene and recent times. Granite and quartziet comprise the Precambrian rocks. The Cretaceous strata overlie this and are composed of thick sections of soft shale and thin beds of sandstone. Glacial drift deposited in the Late Wisconsin glaciation of the Pleistocene period overlies the Precambrian and Cretaceous rocks, forming the surface of the area. Recent deposits of alluvium overlie the glacial drift in valleys and stream channels.

6. In the project area, the Redwood River flows in a shallow channel across the Lowland Plain of the county. It is a slow-moving, meandering stream with a gradient of less than seven feet per mile. The river bottom is silted and relatively free of rocks and other obstructions to the water flow. Erosion can be a major problem along the riverbank as heavy rainfall and flooding wash away the topsoil along the river.

7. The Redwood River originates southwest of Marshall on an elevated till plain and flows northeastward in a well-defined, shallow valley less than 1/4 mile wide. From its origin, the river descends about 500 feet across a prominent regional slope onto an undulating till plain that slopes gently to the northeast. The river, on this lower plain, occupies a shallow channel that meanders across the plain in a meander belt 1,000 to 1,500 feet wide with no well-defined valley or flood plain for several miles northeast of the base of the regional slope. The lack of a confining valley and reduction in gradient on the lower plain contribute significantly to overland flooding in the Marshall area.

8. The city of Marshall is located about two miles northeast of the base of the regional slope. The upstream study reach is on a belt of alluvium that parallels the base of the slope. Borings in this area showed from 10 to more than 32 feet of mixed alluvial silt, clay and sand of recent origin resting on glacial sediments consisting of clayey till with some outwash sand. Some of the deeper sand identified as recent alluvium may actually be glacial outwash material. Borings for the downstream study reach showed only 2 to 12 feet of alluvial clay, silt and sand overlying glacial till. The topography along both study reaches consists of a river channel 30 to 60 feet wide and 6 to 8 feet deep meandering across nearly level

terrain, as shown on the plates in section E of this report. The depths to water recorded for the project borings were in most cases determined before static water-level conditions were reached and vary from 5-1/2 to 28 feet. The more reliable measurements, however, indicate that a water table under the proposed levee alignments should be expected at a depth of 5 to 7 feet. Well records in the area show that glacial sediments extend to a depth of 60 to 100 feet and are underlain by Cretaceous shale with some sandstone.

GROUND WATER - CITY WATER SUPPLY

9. The municipal water supply is pumped from eleven wells which penetrate to the deeper artesian sandstones. Present storage capacity is 3.1 million gallons. The pumping capacity of these wells is 2,500 gallons per minute with an average demand of 1,500 gallons per minute. Peak demand is 2,300 gallons per minute. Fluoride is added to city water as required by state law. The water from the main artesian sandstone is quite hard with 513 ppm, containing large amounts of sodium, sulphates and chlorine.

10. Meltwater deposits associated with the Marshall moraine may have lateral subsurface extents of a mile or more beyond the limits of the surficial channels. These may have value as sources of ground water although in the lowland plain around Marshall, the glacial drift is too thin for these to be important sources of ground water. The pockets and layers of sand and gravel afford generally reliable sources of water.

11. The water table fluctuates seasonally, reflected in most wells in the area. When annual precipitation is normal, water levels rise in the spring due to heavy rainfall, snowmelt and frostmelt. This

is followed by a gradual decline from late spring until the first killing frost. The rate of decline in fall and winter gradually decreases until it is almost non-existent. Recharge to the ground water supply is effected by precipitation and discharge is accomplished through evapotranspiration and the flow of ground water into effluent streams. Minor fluctuations of the water level may be due to atmospheric pressure changes or pumping of nearby wells.

THE STREAM AND ITS VALLEY

12. The Redwood River rises in Pipestone County and is a major tributary of the Minnesota River. It has an elongated drainage area of approximately 743 square miles of which about 307 square miles are drained above Marshall. In both reaches the river is generally less than 40 feet wide with numerous areas of steep, eroding banks and is flanked on both sides by a fairly dense tree and understory cover as shown on the following photograph.

Typical Riverbank Vegetation

SURFACE WATER QUALITY

13. The waters of the Redwood River within the project area are classified as 2B, 3C, 4A and B, 5 and 6 by the State of Minnesota. Surface water quality data for the Redwood River is presented in Table B-1. Applicable water quality standards are given in Table B-2.

Table B-8 - Water Quality Data for Redwood River at Marshall

Sampling Station	pH	Specific Conductance μmho/cm	Total Alkalinity meq/liter	Diss. O_2 ppm[1]	Chl 4 ppb[1]	Tot-P ppb	PO_4-P ppb	NO_3-N ppb	Na+ ppm	CA++ ppm	Mg++ ppm	K+ ppm	Cl- ppm	SiO_4^{-4} ppm
Station #1[2] (Mile 72.1)														
Aug. 25, 1974	8.7	1050	5.8	9.4	1.6	88	28	6	38	97	60	7.1	25	19.4
Sept. 22, 1974	8.1	1288	5.1	9.4	1.7	55	37	19	41	99	58	7.1	23	16.4
Oct. 24, 1974	8.0	1274	5.9	10.2	0.7	61	41	3	38	106	58	6.5	25	17.7
Station #2 (Mile 65.1)														
Aug.25,1974	8.6	1069	4.3	11.3	3.6	157	74	33	70	87	84	7.8	109	14.3
Sept.22,1974[3]	8.0	1745	4.8	9.9	10.3	111	43	6	117	93	63	9.3	281	7.3
Oct.24, 1974	8.0	1330	5.9	9.5	1.3	103	50	4	60	114	64	8.5	87	17.6
Station #3 (Mile 58.3)														
Aug.25,1974	8.0	1104	4.1	10.8	5.7	154	47	5	89	88	84	9.1	151	15.5
Sept.22,1974[4]	8.1	1911	4.7	11.9	20.8	83	17	3	138	100	69	10.5	296	13.5
Oct.24,1974	8.3	1454	6.0	11.3	1.5	108	47	3	72	110	74	9.9	146	15.9

[1] ppm - milligrams/liter; ppb - micrograms/liter

[2] Sampling stations located upstream of Marshall, immediately downstream of Marshall, and at downstream study limit respectively.

[3] River was dry upstream of Station #2 in September, but was flowing past the sample station.

[4] River was dry upstream as well as downstream of Station #3 in September. ONly a stagnant pool left.

Table B-2 - Existing Water Quality Standard Applicable to Redwood River at Marshall

Limit or Range by Class

Substance or Characteristic	2B	3C	4A	4B	5	6
Dissolved Oxygen	- 6 ppm (1 Apr.-31 May) - 5 ppm (other times)	-	-	-	-	-
Temperature	$5^{o}F$ above natural (Max. of $86^{o}F$)	-	-	-	-	-
Ammonia (N)	1 ppm	-	-	-	-	-
Chromium (Cr)	0.05 ppm	-	-	-	-	-
Copper (Cu)	0.01 ppm or - 1/10 the 96 hour TLM valve	-	-	-	-	-
Cyanides (CN)	0.02 ppm	-	-	-	-	-
Oil	0.05 ppm	-	-	-	-	-
PH Valve	6.5 - 9.0	6.0-9.0	6.0-8.5	6.0-9.0	6.0-9.0	-
Phenols	0.01 ppm and none that could impart odor or taste to fish flesh or other freshwater edible products.	-	-	-	-	-
Turbitity Valve	25					
Fecal coliform organisms	200 most probable number per 100 ml. as a monthly geometric mean based on not less than 5 samples a month or 2000 most probable number per 1000 ml. in more than 10% of all samples during any month.	200 most probably number over 100 ml.	Same as 3C	Same as 3C	Same as 3C	-

Table B-2

Substance or Characteristic	2B	3C	4A	4B	5	6[1/]
			Limit or Range by Class			
Chlorides (CI)	-	250 ppm	-	-	-	-
Hardness	-	500 ppm	-	-	-	-
Bicarbonates (HCO_3)	-	-	5 ppm	-	-	-
Boron (B)	-	-	0.5 ppm	-	-	-
Specific conductance	-	-	700 ppm	-	-	-
Total dissolved salts	-	-	60% of total cations as ppm	-	-	-
Sodium (Na)	-	-	10 ppm	-	-	-
Sulfate (SO_4)	-	-	-	None at	-	-
Unspecified toxic substance	-	-	-	*levels harmful either* directly or indirectly		-
Hydrogen Sulfide	-	-	-	-	0.02 ppm	-
Other	-	-	-	-	-	-

[1/] The uses to be protected in this class may be under other juridictions and in other areas to which the intrastate waters of the state are tributary and may include any or all of the uses listed in the foregoing categories, plus any other possible beneficial uses. The Agency therefore reserves the right to impose any standards necessary for the protection of this class, consistent with legal limitations.

14. From its source to a few miles southwest of Marshall, the Redwood River slopes at a rate of about 18 feet per mile. From this point to Redwood Falls, the slope is approximately four feet per mile. From Redwood Falls to the river's mouth at the Minnesota River, the average slope increases to about 24 feet per mile.

15. The general topography of the basin is that of rolling upland area. From the source of the river at an elevation of about 1,850 feet above sea level, the land slopes down to an elevation of 1,200 feet near Marshall. From this point, the river flows southeastward to Redwood Falls where the elevation is 1,000 feet. The relatively short distance from the City of Redwood River to the Redwood River's confluence with the Minnesota River is characterized by a drop in elevation of about 150 feet.

CLIMATE

16. Marshall's climate is characteristically continental as it lies in the western portion of the Interior Lowlands. Wide seasonal variations in temperature are the norm for this area. The average July mean daily temperature is 74° F. while January, the coldest month, has a mean temperature of 13° F. The highest temperature recorded in Marshall prior to 1960 was 107° F; the lowest was -36°F. The average annual temperature is about 45° F. The average date of the last spring freeze is May 8th while the first fall frost is generally about September 26th. The average annual growing season is approximately 150 days.

17. The average annual precipitation is 27 inches, 42 percent of this occurring during the June - August period. The average growing

season (May - September) precipitation is 14 inches. The monthly average is only 2.2 inches, although high-intensity rains of four or five inches in 24 hours are not uncommon during the spring and summer. The maximum precipitation in a 24-hour period in Marshall was the 8.07 inches recorded on June 17, 1975. The recorded maximum annual precipitation is 36.83 inches recorded in 1957. In 1976, only 12.05 inches of precipitation fell, the minimum recorded at Marshall. Annual snowfall averages 40 inches while the average annual number of days with snow cover of one inch or more is 90.

VEGETATION

18 . Continued development over the years has left only a few small plots of native or virgin prairie and to a certain extent, the narrow river woodlands as the only original plant communities in the vicinity of Marshall. These communities can best be described as: natural prairie, grasslands inhabiting previously tilled crop land, domesticated agricultural or residential lands, and the woodlands near the river. The wooded river corridor along the upstream study reach is an extension of the coulee ravine woods protruding from the slopes of the Coteau des Prairie, these woods known locally as the Lynn Woods. Reed canary grass is by far the most abundant grass species along this reach and is found both on the river banks and in the river. Major tree species include American Elm, Green Ash, Cottonwood, Willows and Bur Oak. Sugar Maple and Quaking Aspen are present in limited numbers. The understory along the river is extremely dense and includes Wild Plum, Choke Cherry, High Bush Cranberry, June Berry, Sand Bar Willow, etc.

19 . Most common tree species in the downstream study reach are the Box Elders. Reed canary grass is most dominant of all species along

this reach. Little evidence of shrub communities are found except near the city of Marshall. The only resemblance to native prairie vegetation can be found on two small floodway tracts enclosed by ox-bows. A typical example of vegetation along the downstream reach is shown on the following photograph.

Typical Flood Plain Vegetation - Downstream Reach

Aquatic vegetation along both reaches generally consists of a large number of species of peri-phyton (attached algae) and a few species of macro-phytes (aquatic weeds). Phyto-plankton comprised mainly of green algae and diatoms are also present.

FISH AND WILDLIFE

20 . Several wildlife management areas are located within ten miles of the study area, but none are in or adjacent to the project area. The river woodlands provide habitat, protection from predators, and a source of food and water for a variety of wildlife. The most common species of furbearing animals found in the area include the red fox, raccoon, mink, muskrat, and beaver. The woodlands along the river just downstream of Marshall are uniquely important to the local bird population as many species of wading birds are attracted to the sewage disposal ponds located north of Marshall. Species which utilize the river woodlands as roasting areas include the snowy egret (Leucophoyx Thula Thula), least tern (Sterna albatrass), piping plover (Charadrus melodus), and the buff-breasted sandpiper (Tryngites subruficallis), along with about 30 common species of birds. Game birds in the area include the ring-necked pheasant (Phasianus colchicus), redheads (ducks (Athya americana) and various species of migrant waterfowl.

21. No significant fishery exists in the Redwood River at Marshall due to 21. No significant fishery exists in the Redwood River at Marshall due to the high turbidity and intermittent periods of little or no discharge. The State area fisheries manager indicates that the stream fishery in the study area consists of common minnow (Cyprinus sp.) species, fathead (Pimephales notatus), and sucker (Catostomus sp.), minnows rough fish such as carp (Cyprinus carplo), suckers (Catostomus sp.), and bullheads (Ictalurus sp.); and possibly a few green sunfish (Lepomis cyanellus) and orange spotted sunfish (Lepomis humilis). A few northern pike (Esox lucius) may utilize the stream during spring high water to reach spawning areas.

THREATENED AND ENDANGERED SPECIES

22. A review of the 26 Septembor 1975 and 16 June 1976 Federal Registers and all updates indicate that no threatened or endangered animal or plan species are found in the project area or would be affected by the project. Artic peregrive faleou are reportedly an infrequent visitor to the area. However no adverse effect on this species is considered likely.

ARCHEOLOGICAL - HISTORICAL

23. In compliance with Section 106 of the National Historic Preservation Act of 1966 and Executive Order 11593, the National Register of Historic Places has been consulted and as of 9 December 1975, no sites in the proposed project area have been designated as important historical and/or cultural sites.

24. A cultural resources literature and records search was conducted to determine the presence of known historic and/or prehistoric sites and to estimate the potential for the existence of additional sites. The search disclosed that there are no recorded prehistoric sites in the proposed project area, but that immediately upstream of the area there are recorded burial mounds. Prehistoric cultural material has been collected in the vicinity of the mounds, suggesting the presence of sites, yet unrecorded.

RECREATION

25. Marshall has four municipal parks - Legion Field, Liberty Park, and Freedom Park, and the generally undeveloped Justice Park. These parks provide facilities for swimming, ice skating, tennis and softball. In conjunction with this, the area schools make all of their facilities available to community residents for recreation. One private 18-hole golf course is located in Marshall. The State maintains a wayside rest area southwest of the community on State Highway 23. The Redwood River at Marshall is occasionally used for wading and swimming. The natural area along the river has walking trails outside of the city, but they are not publicly owned. Some horseback riding is also done along the river near the wayside rest area. Fishing along the river is negligible as is canoeing, due to the very shallow areas, fallen trees, etc. The City is presently making a study of a perimeter bicycle trail system around the city. This trail system would utilize existing city-owned diversion channel right-of-way and would provide connections to the college and downtown areas.

AESTHETICS

26. The wooded riverine corridor provides an attractive setting for the City of Marshall, otherwise located in an area of mostly open and monotonous agricultural land. However, in certain areas, this natural setting is interrupted by rural residential development near or on the riverbank and scarred by areas of severe erosion, mud and silt deposits, and piles of junk and debris placed on the river banks.

INSTITUTIONAL SETTING

27. In accordance with Federal criteria, the Redwood River at Marshall is classified as a navigable stream. The Minnesota Trust Doctrine provides that, on all navigable streams, the State owns absolutely the bed of a watercourse and that the riparian owner owns that shore property up to the high water mark. Chapter 105.38 of the Minnesota Statutes provides that its State policy to control and supervise, insofar as practical, the construction, reconstruction, repair, removal or abandonment of dams, reservoirs, and all control structures in any public waters of the State. This control and supervision is accomplished by the issuance of water use permits as provided in Chapters 105.37 to 105.77.

28. The Federal interest in water resource management, and more specifically, flood control at Marshall, is embodied in the specific legislation authorizing the existing project, Section 205 of the 1960 River and Harbor Act, as amended, and Section 216 of the 1970 River and Harbor Act. Section 205 provides for the construction

of small flood control projects with a Federal first cost less than $1,000,000[1/] without specific legislation, and which are complete within themselves. Section 216 provides for the review of completed project with a view towards correcting project deficiencies due to significantly changed physical or economic conditions.

29. Two county ditches are located within the study area. These ditches, No. 70 and No. 62, are located as shown on plates B-1 and B-2, respectively, are maintained by Lyon County in accordance with State law. The Redwood River is classified as a judicial ditch along a reach commencing at the State Highway 23 crossing (mile 58.3) and extending downstream into Redwood County.

30. The existing flood control project at Marshall is entirely within the city limits. The City maintains and operates the project in accordance with local assurances of cooperation previously furnished by the City to the Secretary of the Army. Under present State law, communities generally do not have the expressed right to enter into cooperative agreements with Federal agencies but must seek and obtain specific enabling legislation for any such agreements. However, the City did furnish the required assurances for the existing project and very likely has the capability to provide required assurances for any additional related work. The City would also be responsible for providing any required local cash contributions. These contributions could possibly include State or County contributions towards project-related highway and other improvements of State and/or County interest

31. Under present State law, local communities are required to promulgate and enforce flood plain management regulations or be subject

[1/] This amount is increased to $2,000,000 if the area has been designated a Federally-declared disaster area within the past 5 years.

to such regulations imposed by the State in the absence of local regulations. The City of Marshall presently has a flood plain management program in effect based on a recently completed flood plain information study by the Corps of Engineers. The unincorporated flood plain reaches upstream and downstream of the city are subject to flood plain management regulations currently in effect for Lyon County.

HUMAN RESOURCES

32. Minnesota was organized as a territory in 1849 and Lyon County saw its first permanent settlers in 1867. The present site of Marshall was settled in 1869 by C.H. Whitney and C.H. Upton. The only advantages of the site at that time were its proximity to the river, the close location to an Indian trail between Lynd and Redwood Falls and its good farmland.

33. 1872 was a momentuous year for Marshall. In July of that year, the town was named in honor of a former governor of Minnesota. October 12th was the date on which the railroad was completed as far as Marshall. The village was platted in October and the Atlantic Hotel was opened in that month. In 1873, the State Legislature passed a bill changing the county seat from Lynd to Marshall, which was ratified by the voters in November, 1873.

34. By 1874, Marshall had a population of 300 and in 1876 it became an incorporated village. The population was 961 in 1880 and it grew to 1,203 by 1890. The 1890s witnessed the major growth of Marshall

as the population grew to 2,088 in 1900. The city grew steadily although the Depression years were hard and by 1950, population was placed at 5,923. The growth between 1950 and 1960 was 758 persons, increasing the population to 6,681. The 1970 census places the population at 9,886, an increase of 48 percent over the 1960 population figures. This increase is attributable both to annexation by the city and the fact that the Southwest Minnesota State College was established in 1967. The college enrollment accounted for approximately 2,985 persons in 1971. The increase in Marshall's population between 1960 and 1970 would have been approximately 1,100 had the college not been established, an increase of 16 percent.

35. College enrollment has decreased since 1970 and is expected to stabilize at approximately 1,900 students in the future. Marshall will continue to grow, but at a decreasing rate over the next 25 years as indicated by the projections in table B-1, unless unforeseen circumstances arise. Projections of city populations for 1980 and 1990 are 11,856 and 13,730 respectively, while the population is expected to reach approximately 15,000 by the year 2000. Developments that might change the pattern of growth are the introduction of new industries, creating new jobs, and the possiblity of war or natural disaster.

Table B-3 -- Present and Projected Populations for Marshall[1/]

Year	Population: Marshall[1/]	Population: OBE Subarea 0701	Percent Change (Marshall)
1900	2,088	---	--
1910	2,152	---	3.1
1920	3,092	---	43.7
1930	3,250	---	5.1
1940	4,590	---	41.2
1950	5,923	486,028	29.0
1960	6,681	495,709[2/]	12.8
1970	9,886	495,730	48.0[3/]
1980 *	11,856	499,800	19.9
1990 *	13,730	524,800	15.8
2000 *	15,436	540,700	14.4

*Projected

1/ From Comprehensive Land Use Plan for Marshall, dated December 1962

2/ Data for 1962

3/ Due to establishment of Southwest Minnesota State College

DEVELOPMENT AND ECONOMY

36. Marshall is the county seat of Lyon County, a part of the rich agricultural area of southwestern Minnesota and thus serves as an important regional government, trade and service center. Southwest State College at Marshall, a four-year liberal arts college, provides numerous educational opportunities for area residents and provides a resource base for stimulated research of area socioeconomic

needs. The agricultural base of the Marshall area has great dependence upon the marketing of animal products. This is quite evident with three of the major employers involved in food processing and employing over a total of 1,000 persons. Farming has undergone noticeable changes in recent years as cash crops have diminished, livestock and dairy farming have increased, and farms have become more specialized. More than 90 percent of the land area in Lyon County is in farms.

37 . Early in its history, Marshall became the retail center for the surrounding farming area. The railroad and Marshall's importance as the county seat increased its possibilities as an employment center. Total employment is growing at present, as indicated in Table B-2.

Table B-4 -- Comparative Employment Figures By Industry

Category	April 1960	July 1973	July 1974	Percent Change 1973 - 1974
Trade	769	1,354	1,485	9
Service	286	276	243	-11
Manufacturing	544	1,193	1,399	17
Construction	109	226	113	-50
Transportation	134	213	253	18
Government (includes city, county, state and federal)	414	1,220	1,291	5
Finance, Insurance, Real Estate and other Activities	142	166	163	- 1
TOTAL:	2,398	4,648	4,947	6

38. The income of the community is reflected both in the strength of its farm markets and its relationship to competition. The lack of nearby retail competition has helped Marshall become economically strong. The retail strength of Marshall is very good, especially to the west where there is very little competition. Median family income for Marshall area residents in 1970 was $9,856 with a per-capita income of $2,840.

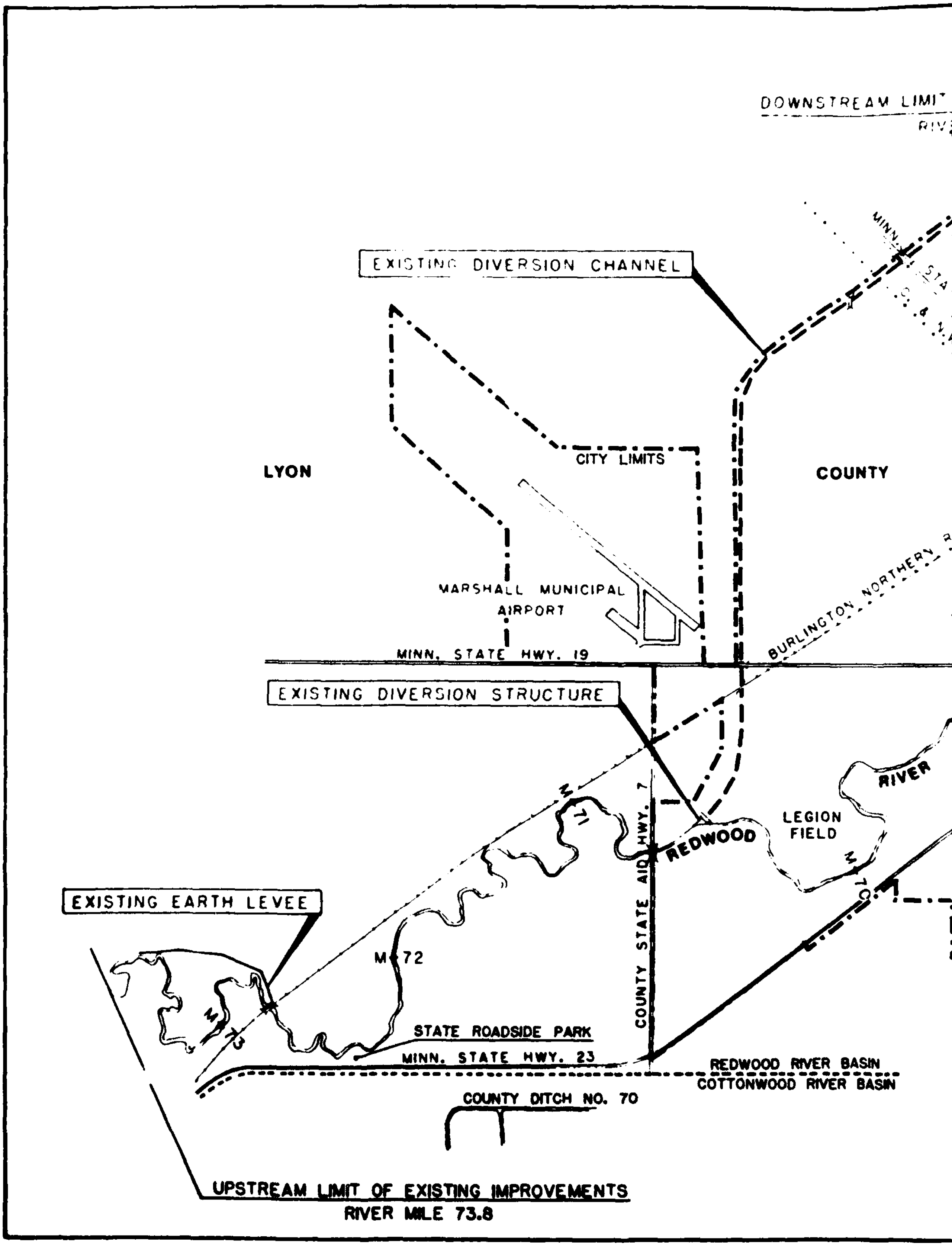
TRANSPORTATION

39. During the early settlement of the region, the Indian trails across the prairie provided the major means of ingress and egress from the site of Marshall. Presently there are 14 bridges across the Redwood River in Marshall and seven across the diversion channel. The major highways serving Marshall are U.S. Highway 59 and State Trunk Highways 19, 23, and 68. Interstate 29 is 63 miles west of Marshall. Rail service is provided by two companies which provide overnight service to the Twin Cities. Inter-city bus service is available. Marshall has its own airport with a charter service available. The nearest major airport is at Sioux Falls, South Dakota.

DESCRIPTIVE PUBLICATIONS

40. In addition to the maps of the study area, plates B-1 and B-2 of this section, available descriptive information includes aerial photography, scale 1 inch = 100 feet by the Corps of Engineers, a general highway map of Lyon County, scale 1 inch = 1 mile (5,280 feet), mapping of the City of Marshall, scale 1 inch = 500 feet, and

U.S. Geological Survey quadrangle maps, scale 1 inch = 2,000 feet and a contour interval of 10 feet. Other materials include the Comprehensive Land Use Plan for the City of Marshall, with supporting documents, an environmental inventory report made in support of this study, 1969 flood photographs in the files of the City and various local newspapers, aerial photographs taken by the Soil Conservation Service in 1967, and the flood plain information report prepared for the City by the Corps of Engineers.


DOWNSTREAM LIMIT
EXISTING DIVERSION CHANNEL
CITY LIMITS
LYON
COUNTY
MARSHALL MUNICIPAL
AIRPORT
MINN. STATE HWY. 19
BURLINGTON NORTHERN
EXISTING DIVERSION STRUCTURE
RIVER
LEGION
FIELD
REDWOOD
M 71
M 70
COUNTY STATE AID HWY. 7
EXISTING EARTH LEVEE
M 72
M 73
STATE ROADSIDE PARK
MINN. STATE HWY. 23
REDWOOD RIVER BASIN
COTTONWOOD RIVER BASIN
COUNTY DITCH NO. 70
UPSTREAM LIMIT OF EXISTING IMPROVEMENTS
RIVER MILE 73.8

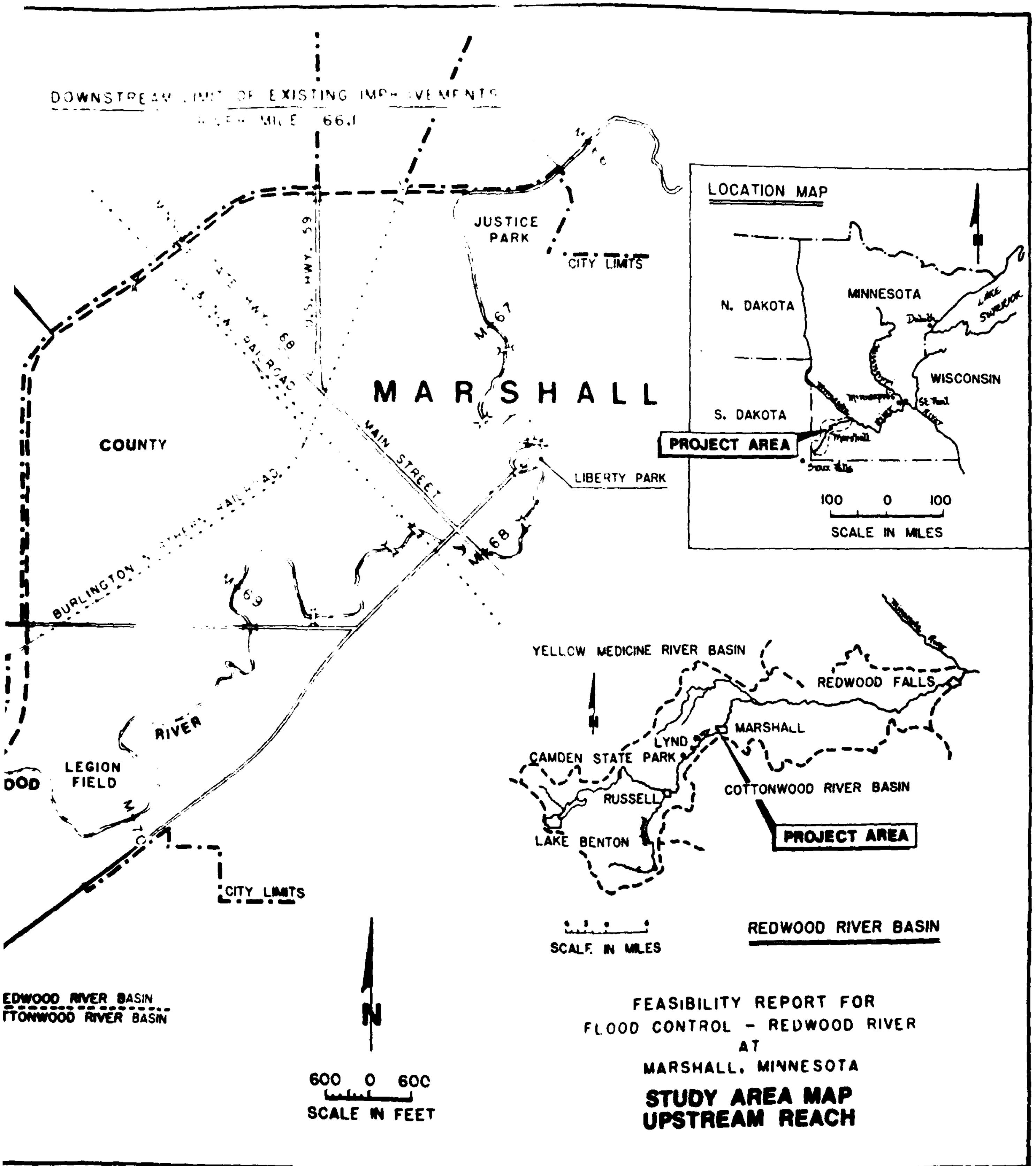
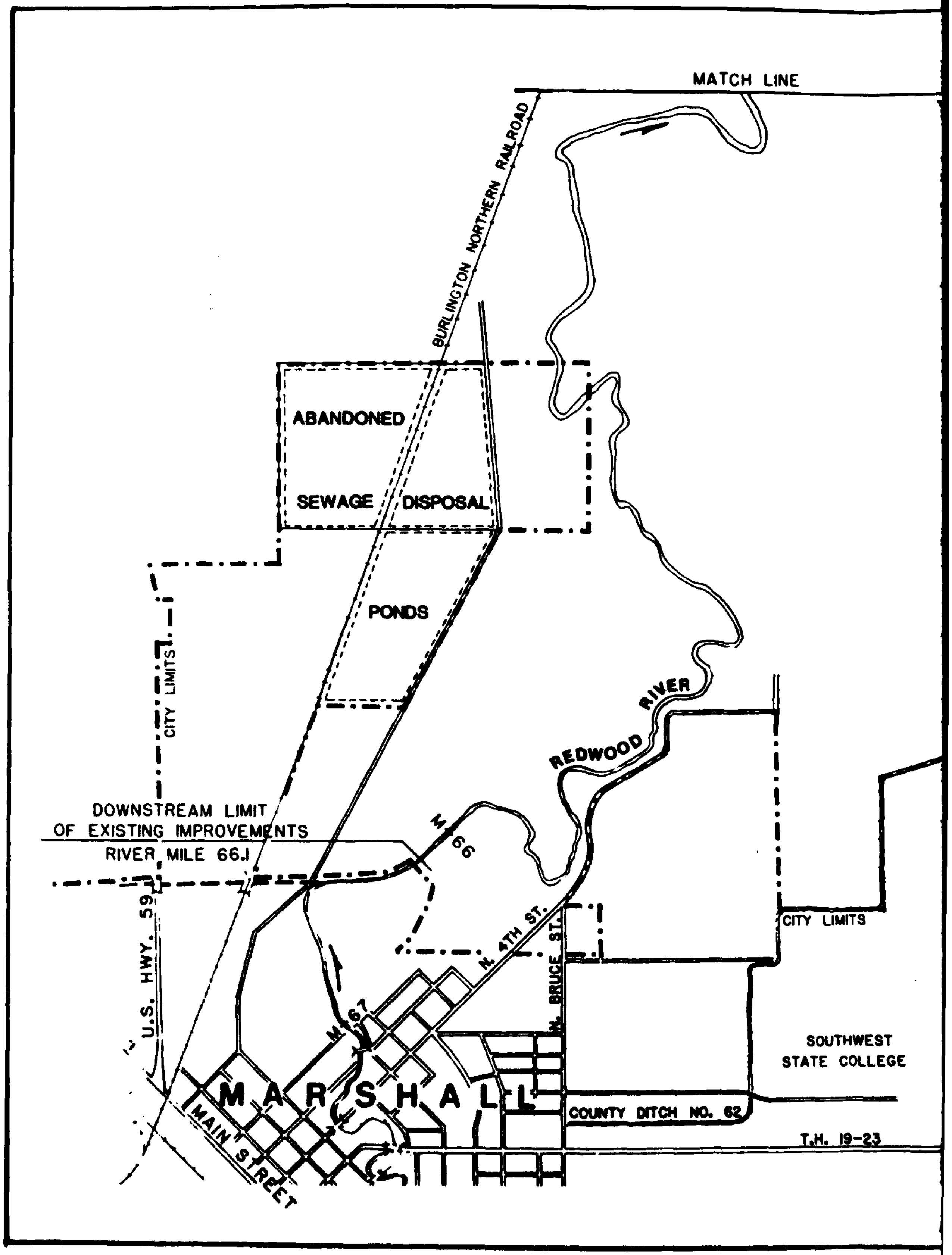
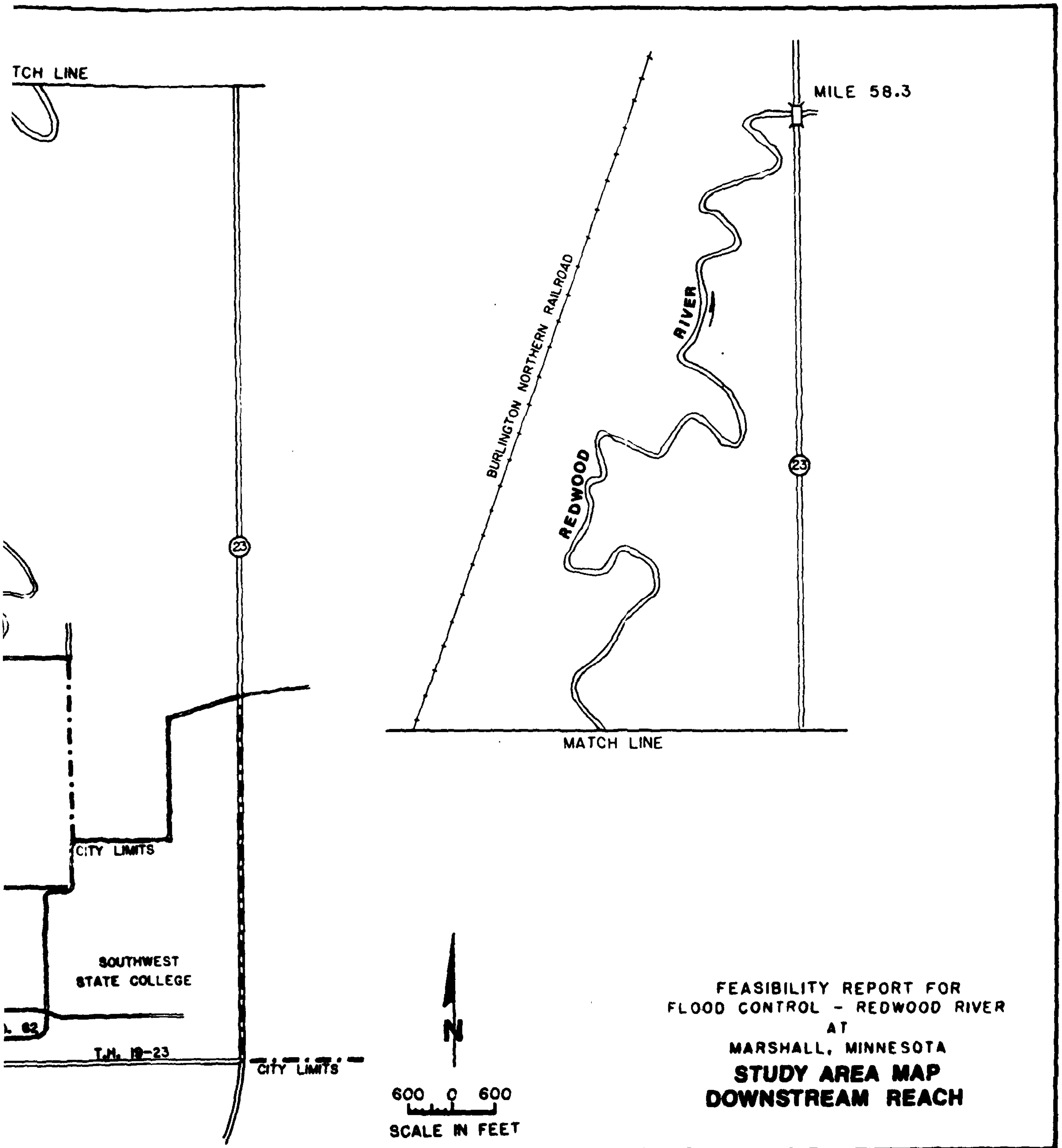

MARSHALL
JUSTICE PARK
CITY LIMITS
COUNTY
MAIN STREET
LIBERTY PARK
RIVER
LEGION FIELD
CITY LIMITS
LOCATION MAP
N. DAKOTA
MINNESOTA
WISCONSIN
S. DAKOTA
PROJECT AREA
100 0 100
SCALE IN MILES
YELLOW MEDICINE RIVER BASIN
REDWOOD FALLS
MARSHALL
LYND
CAMDEN STATE PARK
RUSSELL
COTTONWOOD RIVER BASIN
LAKE BENTON
PROJECT AREA
SCALE IN MILES
REDWOOD RIVER BASIN
600 0 600
SCALE IN FEET
FEASIBILITY REPORT FOR
FLOOD CONTROL - REDWOOD RIVER
AT
MARSHALL, MINNESOTA
STUDY AREA MAP
UPSTREAM REACH

PLATE B-1


MATCH LINE
BURLINGTON NORTHERN RAILROAD
ABANDONED
SEWAGE DISPOSAL
PONDS
CITY LIMITS
REDWOOD RIVER
DOWNSTREAM LIMIT
OF EXISTING IMPROVEMENTS
RIVER MILE 66.1
M 66
U.S. HWY. 59
N. 4TH ST.
N. BRUCE ST.
CITY LIMITS
M 67
SOUTHWEST
STATE COLLEGE
MARSHALL
MAIN STREET
COUNTY DITCH NO. 62
T.H. 19-23



FEASIBILITY REPORT FOR
FLOOD CONTROL - REDWOOD RIVER
AT
MARSHALL, MINNESOTA

STUDY AREA MAP
DOWNSTREAM REACH

PLATE B-2

SECTION C

PROBLEMS AND NEEDS

SECTION C

PROBLEMS AND NEEDS

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SECTION C

PROBLEMS AND NEEDS

1. Flooding of the Redwood River at Marshall remains the principal water resource problem in the area. This section of the technical report discusses this problem, the status of the existing Federally-constructed flood control project, and improvements desired by the City of Marshall.

STATUS OF EXISTING PLANS AND IMPROVEMENTS

2. The City of Marshall is provided a limited amount of protection against flooding by both Federally and non-Federally constructed projects. In 1952 the City completed a 1,100-foot long cut-off on the Redwood River at about mile 67.0 (plate C-1). This cut-off reduced the channel length by about 1,000 feet and together with 1953 channel works by the Corps of Engineers provided about a one-foot reduction in flood stages in the downstream portion of the town. In 1953 the Corps of Engineers completed a channel clearing and straightening project from mile 56.3 to the downstream limit of Marshall (mile 66.8). This project provided for removal of trees and snags and construction of 900-foot long cut-off of a river loop having an original length of about a mile. The project was turned over to the City of Marshall, which has provided necessary maintenance to date.

3. The City was provided further protection by the Corps of Engineers in 1963 as a direct result of the 1957 flood experience. This project as constructed includes channel clearing and snagging on the Redwood River between river miles 70.7 and 73.08, construction of a 1,840-foot long levee on the left bank of the river at the upstream end of the project (mile 73.8), a new 2.4 mile long floodwater diversion channel between miles 66.6 to 70.5, enlargement of the river channel between the upstream diversion structure (mile 70.5) and the CSAH 7 Bridge (mile 70.7) channel enlargement and a channel cut-off between miles 66.1 and 66.6, and spoil bank dikes flanking the river channel between miles 70.5 and 70.7. Other project works include new highway and railway bridges over the diversion channel, drop structures in the diversion and natural river channels, a circulation culvert in the cut-off closure embankment, and relocation of a township road. Basic project features are shown on plate C-1. The project was designed to pass a discharge of 6,500 cfs around and through the city (1,500 cfs through natural river channel) with no significant flood damage.

4. The project was turned over the the city of Marshall for operation and maintenance in accordance with the prescribed assurances of local cooperation and an Operation Manual prepared by the St. Paul District, Corps of Engineers. This operation and maintenance has been performed satisfactorily as evidenced by periodic inspections by the District Engineer.

5. The City of Marshall currently has flood plain management regulations in effect. The flood plain reach upstream of CSAH 7 (plate B-1) and the reach downstream of the confluence of the diversion channel and natural river channel (plate B-2) are both outside the city limits and thus subject to County flood plain management regulations for unincorporated areas.

6. Emergency works constructed during the April 1969 flood included a levee along the left channel bank upstream of CSAH 7, levees near the college area and a levee on top of CSAH 7. Only the left bank levee upstream of CSAH 7 remains in place at this time.

THE FLOOD PROBLEM

RECENT FLOODS

7. Marshall is subject to flooding on the Redwood River caused by rapid spring snowmelt and related runoff or summer thunderstorm activity. Recent large floods have occurred in June 1947, April 1951, April 1952, June 1957 and April 1969. The June 1957 flood was by far the most damaging, having occurred before completion of the existing project. This flood, which had a peak discharge of 6,170 cfs, covered a major part of the business and residential portions of the city and flooded wide areas of farm land on the level flood plains. Total damages including emergency flood fight costs resulting from the 1957 flood were approximately $5,920,000 in January 1975 dollars. The next largest flood in recent years occurred in April 1969 as a result of rapid snowmelt runoff. The flood crested immediately upstream of Marshall at a peak discharge of 8,090 cfs which corresponds to an estimated frequency of occurrence of once in about 100 years, based on current flood frequency analysis. Actual flood damages incurred during this flood amounted to $87,000 based on January 1975 price levels. Without the emergency flood fight, these damages would have increased to $1,866,000.

REVISED HYDROLOGIC ANALYSES

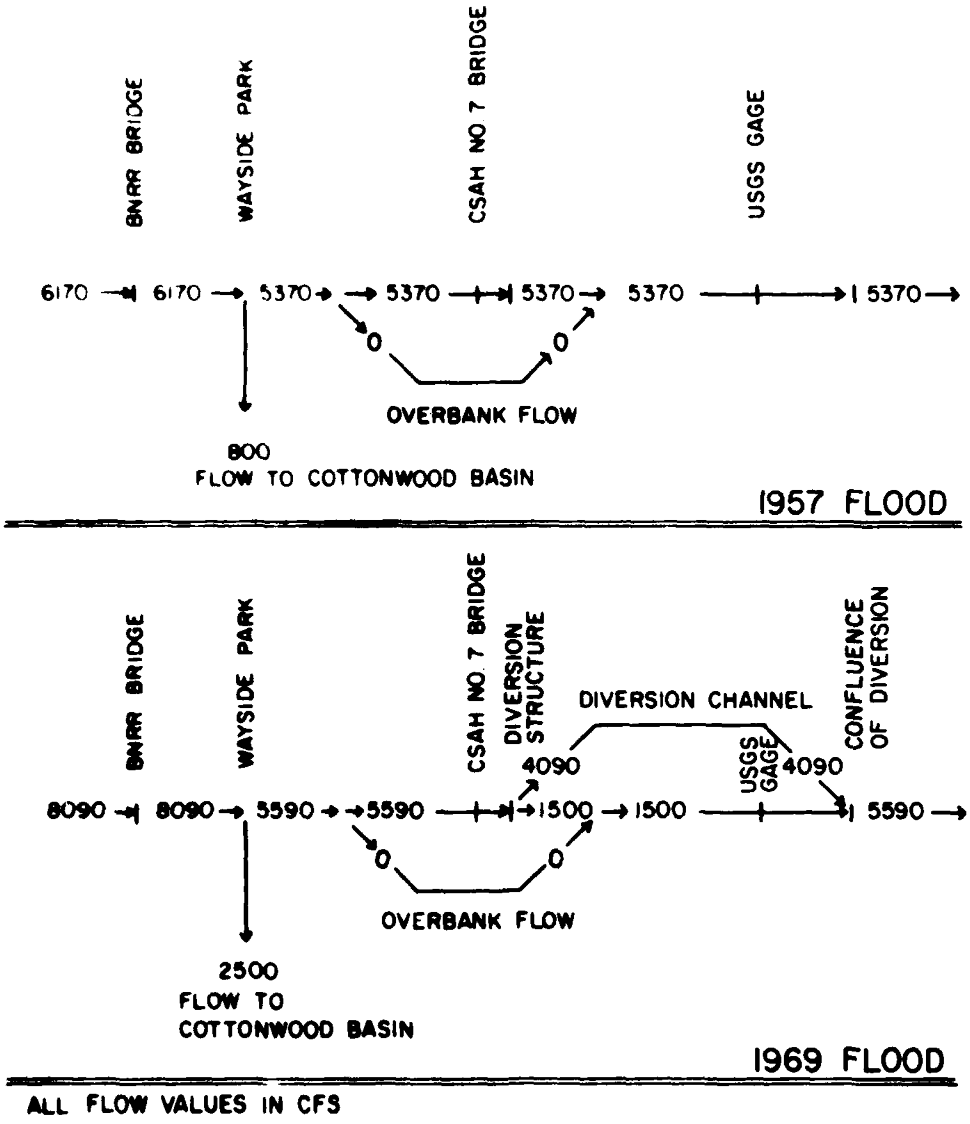
8. A coordinated restudy of hydrologic conditions in the Redwood River Basin above Marshall by the Corps of Engineers, Soil Conservation Service and the U.S. Geological Survey indicate a substantial revision in basin frequency-discharge relationships. This change is principally due to the occurrence of two major floods within a relatively short time span. As an example, the previously determined recurrence interval of 114 years for the project design flood of 6,500 cfs has been revised to a recurrence interval of about once in 59 years. Both the project document and revised frequency-discharge relationships are shown for comparison on plate H-3 of Section H.

INADEQUATE CHANNEL CAPACITY UPSTREAM AND DOWNSTREAM OF EXISTING PROJECT

9. The existing project was designed to pass a peak flood flow of 6,500 cfs around and through the city without flooding and related damages. Of this discharge, 5,000 cfs was designed to go through the diversion and 1,500 through the natural channel. As it happened, significant overflows of the channel occurred during the 1969 flood in the vicinity of the State Wayside park (see plate C-1). At the peak of the flood, overbank flows of more than 2,500 cfs proceeded southeastward to the State Highway 23 and CSAH 7 embankments. Portions of these floodwaters crossed low points along Highway 23 near the park and then proceeded to flow southeastward into the Cottonwood River basin. An emergency levee or fill was constructed on CSAH 7 to prevent overbank flows from crossing over CSAH 7 and reentering the city at a point along the natural river downstream of the existing diversion structure. This action resulted in

additional flows passing over Highway 23 near its intersection with CSAH 7. Ultimately Highway 23 was breached by the city to prevent overtopping of the raised CSAH 7 and subsequent flooding of developments in Marshall. This action also increased flows into the Cottonwood basin resulting in flooding and erosion damage to farms located south of Highway 23. Other farms were also affected as a result of construction of the CSAH 7 levee and increased flood stages and durations west of CSAH 7 and north of Highway 23. The distribution of flood flows and attendant overflows at Marshall during the 1957 and 1969 floods is illustrated on Figure C-1.

10. Thus, from the conditions experienced during the 1969 flood, it is evident that the natural channel capacity both upstream and downstream of the existing project is inadequate. This is illustrated by the fact that, without the emergency works, damages would have been sustained at Marshall at an upstream reach flow of about 3,500 cfs over CSAH 7 (3,570 cfs corresponds to a 16 percent flood frequency).



HISTORIC FLOW DISTRIBUTIONS
REDWOOD RIVER
MARSHALL, MINNESOTA

FIGURE C-1

THE EXISTING FLOOD PROBLEM

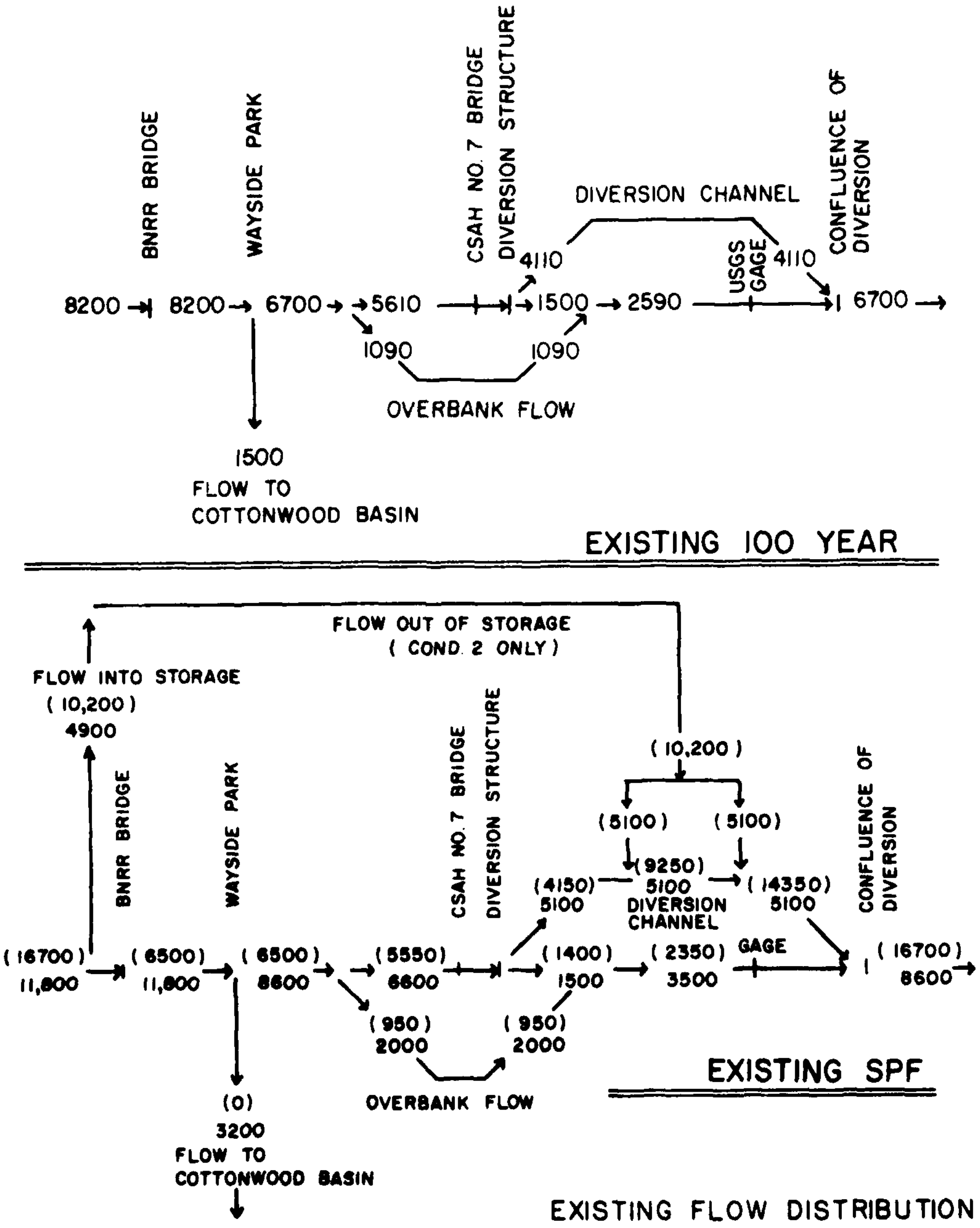
11. Although designed for a flow of 5,000 cfs, the existing floodwater diversion channel has sufficient capacity to pass the standard project flood discharge. Similarly, the upstream diversion structure (plate C-1) would provide adequate control of flows entering the natural channel at Redwood River flood flows approaching the standard project flood discharge. However, existing flood problems are concentrated in both the upstream and downstream reaches as described in the following paragraphs. A detailed discussion of the standard project flood is given in section H.

12. The principal reason for flood problems in the upstream reach (miles 66.3 - 73.8) is that overflows resulting from the inadequate capacity of the natural river channel do not reach the existing diversion channel and without emergency measures would cause overland flooding of Marshall. Channel capacity is limited by the extensive debris and vegetative growth in the channel, inadequate channel cross-section or flow area, and numerous sharp meanders. Buildup of ice in the natural channel is considered to result in increased flood stages at relatively low flows only. Of the peak 1969 flood discharge of 8,090 cfs, only 5,590 cfs reached the upstream limits of the existing project. The remaining 2,500 cfs overflowed the right bank at the state wayside park and subsequently entered the Cottonwood River basin. Overbank flow commences in the vicinity of the wayside park at a flow of about 2,500 cfs. At the original project design discharge of 6,500 cfs, most of the land area upstream of CSAH 7 would be flooded. For the revised 100-year discharge of 8,200 cfs, floodwaters commencing at a river flow of about 3,500 cfs would cross over CSAH 7 and enter the western portions of the city before re-entering the natural river channel further downstream. Beginning at the approximate 6,500 cfs discharge level, some of the

overflows would cross over State Highway 23 and flow into the Cottonwood River basin via flow over farmland before entering County Ditch No. 70, the location of which is also shown on plate C-1.

13. No flows entering the County ditch 70 would re-cross highway 23 east of CSAH 7 and re-enter Marshall at the 100-year flood level. At the SPF level, the ditch flows could cross northward through Highway via culverts located just east of the intersection with CSAH 7. These floodwaters would innundate low areas east of CSAH 7 and north of Highway 23. The temporary retention of floodwaters over the area west of CSAH 7 during the 1969 flood adversely affected one farm operation north of Highway 23. The subsequent breaching of State Highway 23 and sudden release of retained water adversely affected two farm properties south of Highway 23.

14. Similarly the downstream channel reach does not have sufficient capacity to pass even the original design flow of 6,500 cfs. This condition was evidenced during the 1969 flood when, with a peak downstream discharge of 5,590 cfs (8,090 cfs - 2,500 cfs), extensive emergency diking was needed to prevent damages to Southwest State College facilities and other developments. Thus, it is quite obvious that without emergency protective measures, significant damages would occur with the revised 100-year discharge of 6,700 cfs (8,200 - 1,500) at mile 66.1. (Approximately 1,500 cfs would leave the Redwood River basin at the Highway 23 wayside park and pass into the Cottonwood River basin). The distribution of flood flows at the existing 100-year (1% chance of occurrence) and standard project flood levels is illustrated on Figure C-2.



NOTE:
ALL FLOW VALUES IN CFS
VALUES W/O PARENTHESES - SPF CONDITION 1
VALUES W/ PARENTHESES - SPF CONDITION 2

EXISTING FLOW DISTRIBUTION
REDWOOD RIVER
MARSHALL, MINNESOTA

FIGURE C-2

15. Based on a review of the existing project's performance during the 1969 flood, it is obvious that the project cannot function as intended without additional improvements along both the upstream and downstream reaches at Marshall. As previously discussed, these improvements are needed to pass the design floodwaters both into and away from the diversion project without causing damaging overbank flows.

16. The city of Marshall has indicated that in view of the increasing interest in cross-country skiing, a growing need for a recreational trail system and other facilities in and adjacent to the city exists. A questionnaire sent to area residents by the City Parks and Recreation Department reveals that recreation trail needs rank near the top in terms of the residents' own priorities.

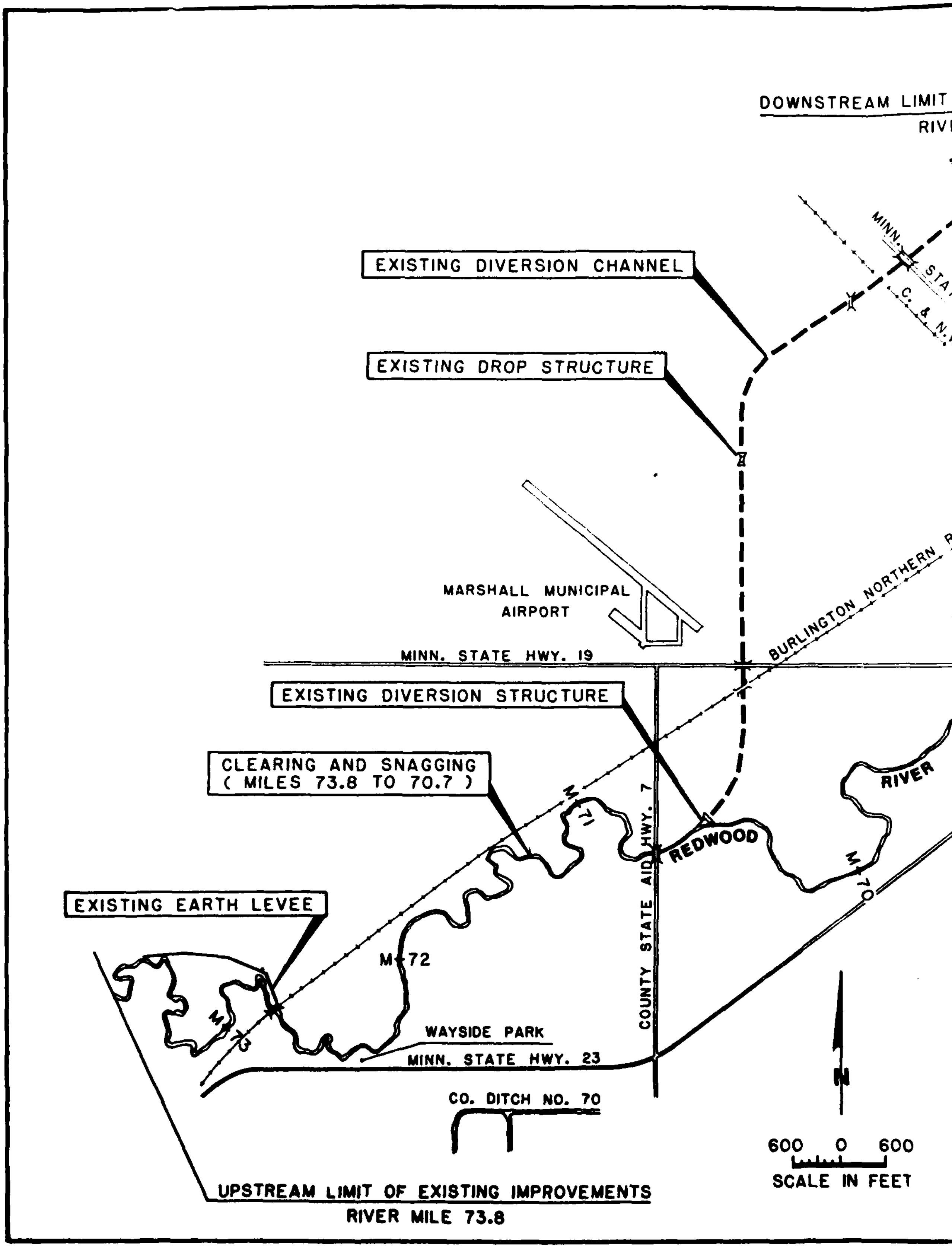
17. Woodlands of any type are in relatively short supply in the Marshall area. The only remaining contiguous tract is located along the river corridor upstream of County Highway 7. These woodlands provide valuable habitat, cover, and food supply to small mammals and song bird populations. In most areas, these woodlands provide an attractive background to the residences and wayside park located along the river. Reduction in the extent of these woodlands or any other adverse effects should be minimized.

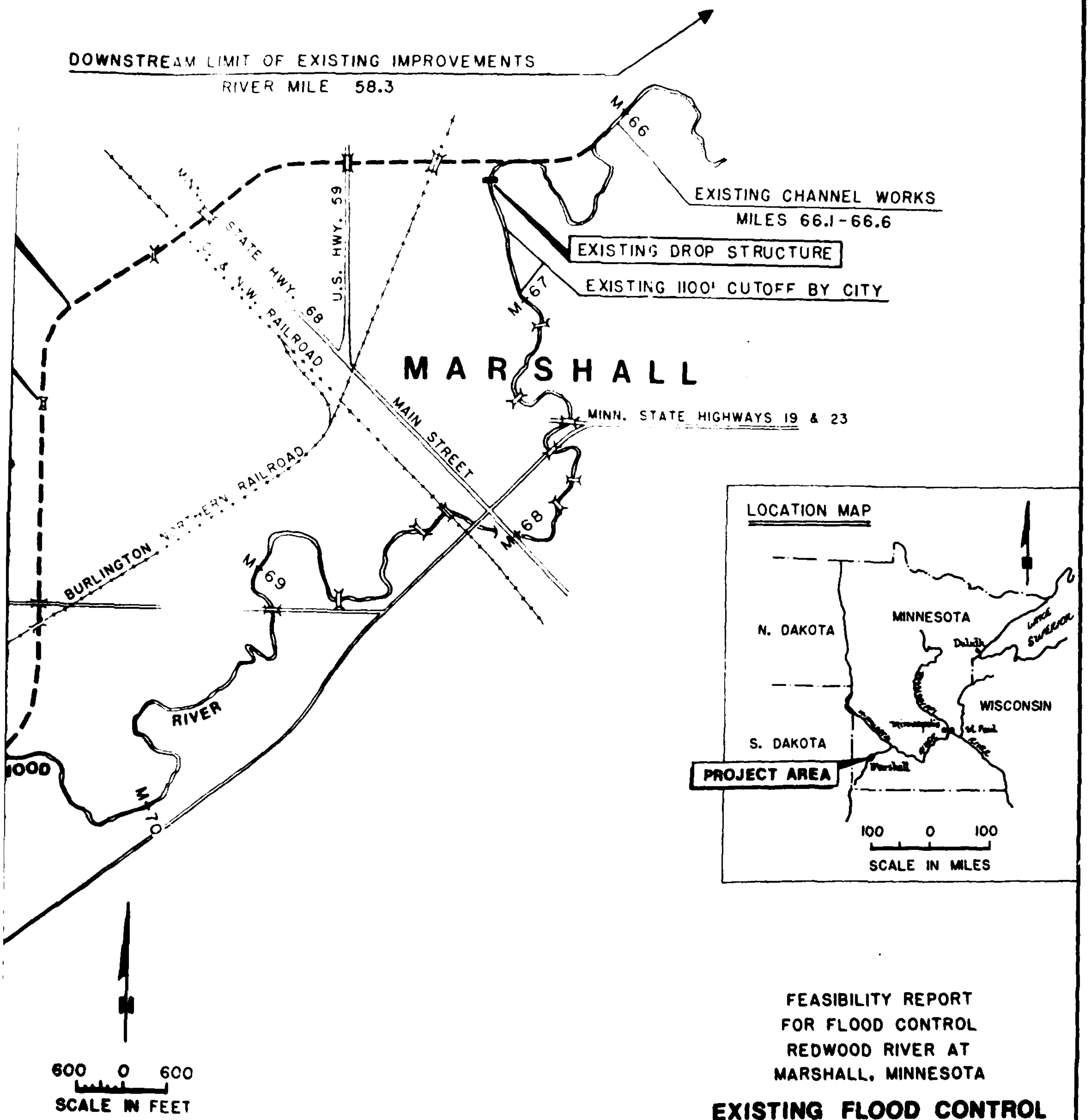
18. Productive agricultural lands are located on the floodplain both upstream and downstream of the City of Marshall. As agricultural activity contributes significantly to the economic base, many are concerned about the continuing loss of valuable cropland to expanding urbanization. All of the immediately adjacent cropland has been zoned for single or multi-family residential development. Consideration should be given to minimizing adverse effects to these croplands commensurate with the economic development needs of the community.

IMPROVEMENTS DESIRED

19. The city of Marshall incurred substantial financial losses during the April 1969 flood as a result of direct property damage, emergency floodfight activities, and court awarded damages to adversely affected farmers. In view of these losses and the potential for similar or greater recurring losses, the Lyon County Board of Commissioners requested by formal resolution adopted 6 June 1972 that the Corps of Engineers review the operation of the existing project and make modifications as necessary to insure that the project will operate at least as originally designed. By a resolution of 3 July 1972, and other written and verbal communications, the city of Marshall has also requested "...that a study be made to determine what improvements can be made to provide for additional protection and efficiency of the Redwood River Diversion Channel Project...". A copy of this resolution is contained Appendix II, Pertinent Correspondence.

20. A letter from the City requests a study of the advisability of a trail system, improvements to a softball complex on the existing diversion channel right-of-way, a riverbank improvement program at three locations to improve aesthetics and public safety, picniking facilites, and the development of quiet and nature education areas.


DOWNSTREAM LIMIT
RIV
MINN. STA
C. & N.
EXISTING DIVERSION CHANNEL
EXISTING DROP STRUCTURE
MARSHALL MUNICIPAL AIRPORT
BURLINGTON NORTHERN R
MINN. STATE HWY. 19
EXISTING DIVERSION STRUCTURE
CLEARING AND SNAGGING (MILES 73.8 TO 70.7)
M-71
COUNTY STATE AID HWY. 7
REDWOOD
RIVER
M-70
EXISTING EARTH LEVEE
M-72
M-73
WAYSIDE PARK
MINN. STATE HWY. 23
CO. DITCH NO. 70
N
600 0 600
SCALE IN FEET
UPSTREAM LIMIT OF EXISTING IMPROVEMENTS
RIVER MILE 73.8



FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

EXISTING FLOOD CONTROL IMPROVEMENTS

PLATE C-1

SECTION D

FORMULATING A PLAN

SECTION D

FORMULATING A PLAN

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SECTION D

FORMULATING A PLAN

1. The objective of the formulation portion of this study is to review the operation of the existing flood control project at Marshall with the intent of identifying solutions that will meet the study objectives identified early in the study. The following planning objectives have been identified in coordination with local and other interests:

o Reduce damages from flooding along the Redwood River at Marshall during the period 1980 to 2030.

o Contribute to water and winter recreation needs for Marshall during the period 1980 to 2030.

o Contribute to the riverine woodland and wetland areas within the City of Marshall for ecological, diversity, and aesthetic purposes during the period 1980 to 2030.

FORMULATION AND EVALUATION CRITERIA

2. In developing a plan to insure effective operation of the existing project and to reduce flood damages in the recently developed downstream river reach not protected by the existing project, standards and procedures which have been set forth in various flood control acts and policies and related regulations established by the Corps of Engineers have been followed. All alternatives were evaluated in accordance with the following specified criteria.

TECHNICAL CRITERIA

- The degree of protection afforded by any proposed plan will be at least equivalent to the degree of protection intended for the original project, or the maximum practical level of protection. The degree of protection must also be in consonance with established State flood plain management regulations and the desires of local interests.

- All flood barriers will provide adequate freeboard over the adopted flood level. Also appropriate freeboard will be provided between the design water surface and low member of any channel crossings. Generally, three feet of freeboard is considered appropriate, however, greater or lesser freeboard may be required in some areas depending upon risk and design uncertainties.

- The plan must insure completeness of the existing project and insure effective operations as designed without additional future improvements.

- The plan must be technically feasible to implement.

ECONOMIC CRITERIA

- The selected plan must represent the most cost-effective solution and be economically feasible to implement with projected annual benefits exceeding projected annual costs. However, a more costly plan can be recommended if appropriate gains in environmental quality and social well-being can be shown provided that the overall plan is economically feasible with benefits at least equal to the related costs.

- Annaul costs and benefits are based on a 50-year economic life, an interest rate of 6-7/8 percent and price levels and conditions existing in October 1977.

ENVIRONMENTAL AND OTHER CRITERIA

- The public health, safety, well-being and quality of life of affected residents are the principal considerations in the development of a project.

- The loss of area environment and aesthetic values will be minimized to the extent practicable.

- Public acceptability of proposed improvements and the project-sponsor's ability and willingness to meet local cooperation requirements are essential considerations.

- Specific social well-being factors considered in this study included: possible loss of life and possible hazards to the health and safety of affected area residents; preservation of aesthetic, cultural, and historic values in the area; leisure time enjoyment; injurious displacement of people and businesses; and the disrup' on of desirable community and regional growth.

POSSIBLE SOLUTIONS

3. Solutions considered in this study pertain strictly to provision of additional measures required to insure effective operation of the existing project and to providing flood protection to downstream development not protected by the existing project. Area flood problems principally originate in the upstream reach where modest new development has occurred. Possible solutions considered include both non-structural measures and structural solutions such as reservoir storage, flood barriers, channels or combinations of these measures. In addition to these solutions, the consequences of doing nothing at all about recurring flood problems in Marshall is considered as a base from which to measure the impacts of positive alternative solutions.

ALTERNATIVE PLANS ANALYZED

4. The following discussion is a detailed description of the alternative plans considered. Since the "no-public action" alternative, non-structural alternatives and reservoir storage alternatives apply to the entire Marshall study area, they are discussed first. A discussion of local structural alternatives (flood barriers and channel improvements) by respective reach, upstream and downstream, then follows. Non-structural alternatives considered include no public action, permanent evacuation, and combined partial evacuation and flood proofing. Plan costs and other impacts are shown on table D-1 found later in this section.

PLAN 1 - NO PUBLIC ACTION

5. This alternative represents the "without" project or base conditions and would provide for continuation of the existing situation at Marshall without any further local, State or Federal action to provide additional measures to permit effective operation of the existing project. The base economic, social, and environmental setting of the study area is described in detail in section B of this report. The existing situation relating to flooding at Marshall is represented by warnings by the National Weather Service of impending Redwood River flood occurrences, related emergency flood fight and supporting disaster relief activities by the City and other government agencies, the required purchase of flood insurance to obtain federally-supported financing for building in flood-prone areas, and flood plain management regulations currently being developed by the City of Marshall.

6. Urban development continues to expand on the agricultural flood plain adjacent to Marshall, particularly along the downstream reach, where the development consists of municipal maintenance buildings, residential and limited commercial development, and the Southwest State College. Development in the upstream flood plain reach includes residential development along the right immediately downstream of CSAH 7, a motel, a few scattered rural residences and farmsteads, and a wayside park.

7. Under present conditions, the National Weather Service at Kansas City, Missouri with supporting elements at Minneapolis provides warning of potentially damaging flood occurrences on the Redwood River at Marshall. If the warnings indicate that flooding is imminent, emergency action will be taken by the City, and if requested by local officials, the Corps of Engineers, and other agencies. Such emergency

action may include the provision of temporary flood barriers, temporary interior drainage pumping, and flood proofing of various structures as needed.

Supporting disaster relief services provided during the April 1969 flood included temporary food and housing, evacuation of threatened areas, and other supporting services. Follow-up disaster relief efforts including removal of temporary works, replacement or repair of damaged public facilities, and post-flood cleanup are administered by the Federal Disaster Assistance Administration with the support of other Federal and State agencies. Reliance on emergency protective measures at Marshall is impractical in view of the limited time available to construct temporary flood barriers, possible inclement weather conditions, and the availability of funds.

8. Flood insurance is presently required for Federal financial assistance to any new developments constructed on the 100-year flood plain. The city became enrolled in the regular phase of the flood insurance program on 30 September 1977. Thus flood insurance is available for existing structures under subsidized rates and for new (post 30 Setember 1977) structures based on actuarial rates. Determination of flood plain property eligible for flood insurance is presently based on flooded area maps furnished to the city and county by the U.S. Department of Housing and Urban Development. Total maximum coverage obtainable at subsidized rates for existing single family residential and other residential buildings is $35,000 and $100,000 respectively. Non-residential structures are covered under regular rates up to $100,000. On a regional basis, a flood insurance program would at least partially compensate individual flood losses by spreading premium costs over a wider area. However, such a program would not reduce flood damages and, at Marshall, would result in remaining average annual flood damages of over $75,000 to unprotected downstream developments alone. It would also do little to reduce the anxiety, human misery, and community disruption currently experienced during major flood periods.

9. The City of Marshall presently has a flood plain management program in effect. These flood plain management regulations have been developed on the basis of a recently completed flood plain information study by the Corps of Engineers. The flood plain information study report established the 100-year frequency flood outline and average depths of flooding at selected locations. A program limits the location, type and extent of new development on the 100-year flood plain and limits substantial expansions to existing flood plain developments.

10. Enforcement of flood plain regulations would do little to reduce flood damages to existing development but would be very effective in reducing future growth of flood damages due to curtailment of new flood plain growth. Although flood plain regulations alone would not substantially reduce potential flood damage in the developed flood plain, it would serve as an effective supplement to other structural or non-structural measures to arrive at a total plan of protection.

11. With the no-public action alternative, a large portion, or nearly 300 acres, of the highly developed central part of the city and developments adjacent to the city would remain vulnerable to extensive flood damages during major flood occurrences without major emergency flood fighting efforts. Planned and temporarily halted developments in fringe flood plain areas would not be accomplished until measures were provided to permit the operation of the existing project as originally designed. No further public action would perpetuate the continued burden on the city in terms of human suffering, hazards to public health and safety, and the required inefficient commitment of local financial and manpower resources. This course of action would do

little to permanently reduce flood damages and is clearly unacceptable to the city. For these reasons, this alternative was not considered further except as the base condition against which the other alternatives are compared. However, the continuation of flood warning services and the expansion of local flood plain management and flood insurance programs will be considered as integral parts of other structural or non-structural plans developed.

PLAN 2 - PERMANENT EVACUATION

12. Permanent evacuation would solve the residual flood problem at Marshall but would require the relocation of most developments in the city including over 1100 residences, over 200 businesses and several churches and schools. The displacement of these upstream reach developments in addition to being totally uneconomical is considered impractical and wholly unacceptable to local interests and thus, is not considered further.

13. Permanent evacuation of the recently developed 100-year downstream flood plain (see table D-1) was not considered as an alternative to the existing project, but rather as a supplement to it. Total evacuation along the downstream study reach would involve the removal of an estimated 8 new residences, a trailer court with approximately 32 mobile homes, at least 3 apartment buildings at 33 units each, 4 apartments with 8 basement level apartments in each, and seven large buildings on the college campus. Evacuated residential areas would be converted to and managed as flood-free open space, park, or recreational uses. Evacuated campus areas could be converted to relatively damage-free outdoor recreation facilities. Evacuation of the college buildings, residences, and apartments could

be accomplished with available equipment but at great economic, social and environmental costs.

14. Movement of the large apartment complexes and college buildings would be physically impossible, leaving razing the buildings the only alternative. Immediately adjacent undeveloped and flood-free sites for the college structures do exist.

However, the removal and replacement of any of the major structures from the relatively new State College campus would place a severe economic, educational, and social impact on the community, region, and the State.

15. Although total evacuation of the presently unprotected development in the downstream reach would reduce area flood damages, the economic costs, and adverse short and long term social and environmental impacts make this plan unacceptable to all concerned interests. Thus, total evacuation of unprotected residential and public property is not considered further either in the total study reach or in the downstream reach alone.

PLAN 3 - PARTIAL EVACUATION AND FLOOD PROOFING

16. Instead of total evacuation of the flood plain, consideration was given to partial evacuation of selected downstream reach flood-prone structures together with flood proofing measures to remaining residential, commercial, and public structures in both reaches. Evacuated areas would be managed in accordance with local flood plain management regulations.

17. Partial evacuation measures would involve the relocation of all residential structures subject to flood depths greater than 3 feet and any structure not considered suitable for flood proofing. With this alternative, 30 residences, 5 commercial structures, and the downstream reach trailer court would be relocated out of the 100-year flood plain

18. Flood proofing measures would include structural changes and other adjustments to structures, and landscaping measures. Structural changes would include sealing of doorways, windows, and other openings, sealing and bracing of basements, and in some cases, provision of flood drain standpipes and landscaping around raised structures to help offset adverse aesthetic impacts. Approximately 65 residential uni[illegible]f the eight downstream reach apartment buildings have flood levels about 4 feet below ground level. Sealing of ground level window openings of these occupied units could probably be accomplished but only with the remaining threat of extensive damage and possible health and safety hazards in the event of failure of any one closure. Seepage into these units would likely be a major problem during major flood periods. Only the college buildings, commercial structures, and residential structures subject to less than 3 feet of innundation appear to lend themselves to flood proofing techniques.

19. Seven college buildings, 31 commercial structures, and 280 residences were evaluated for possible flood proofing measures. Flood proofing measures for the college buildings would include the construction of bulk heads and gate valves in underground equipment tunnels and placement of gate valves in drainage pipes running between and from the buildings. Assuming effective valve closures, this plan would prevent water damage to the buildings but could still result in extensive electrical failures due to possible electrical short circuiting of cables, switches and connections in the cable ways.

20. Evacuation of the residences, commercial structures, and trailer homes is estimated to cost about $4,200,000 including appropriate allowances for relocation expenses. Flood proofing of the remaining residences, apartments, commercial buildings, and college buildings would cost another $8,752,000 as shown on table D-1. Total Federal first costs at an assumed 80 percent cost share would be $10,361,600 as shown on table D-1. Minnesota State flood proofing regulations indicate that flood proofing of habitable basement space is usually not permitted. This plan would result in the near elimination of potential flood damages, but only at excessive economic and social well-being costs. Environmental losses would probably not be major as the required new development sites would very likely be on presently tilled cropland outside of Marshall.

21. The removal and relocation of the much needed residential housing from areas near the college and presently zoned and developed for this activity to productive agricultural areas would have a decided adverse effect on established community patterns, educational opportunities and general cohesiveness of the area. Present occupants, most of whom are in some way associated with the school, depend on this nearby housing. Local interests object to this considered gross rearrangement of area residential housing and the related effects, and indicate a preference for a more positive method of flood protection for the college campus. Since this alternative lacks local support in all aspects, it is not considered further.

PLAN 4 - UPSTREAM RESERVOIR STORAGE

22. Reservoir storage was investigated as a possible means of flood damage reduction at Marshall during the earlier feasibility scope studies made in support of the existing project. During those studies, only one site could be identified as having sufficient storage capacity to reduce flooding at Marshall, but the site would require floodwater storage in Camden State Park located about eight miles upstream of Marshall. Increased channel flow capatity via the existing diversion channel in combination with levees in the upstream reach would increase the effectiveness of upstream reservoir storage but not enough to eliminate the threat of longer floods nor make it feasible justifying the reservoir economically. In addition, a reservoir in the park would clearly have substantial and unacceptable adverse environmental effects on natural ecosystems as provided in the park and presently in relatively short supply in this agricultural region (see table D-1).

23. A system of small reservoirs on headwater tributary streams presently under consideration by the U.S. Soil Conservation Service to solve localized agricultural flooding would have too little storage volume to have any appreciable effect at Marshall. Although a system of three small reservoirs would influence control over 58% of the total drainage area, their combined storage capacity would only control 0.4 inches of run-off. This represents 9% of the average annual run-off, 6% of the 100-year run-off, and 3% of the SPF run-off. Thus, for these reasons, upstream reservoir storage via a single large reservoir or a system of small tributary reservoirs is not considered further in this analysis as a viable solution to Marshall's flood problems.

FLOOD BARRIERS AND CHANNEL WORKS - UPSTREAM REACH

24. Both flood barriers and channel works were considered separately as additional measures required to permit efficient operation of the existing project. Early in the supporting hydraulic studies, it became evident that, because of inadequate channel flow area and channel obstructions, neither levees nor channel works alone would achieve the desired flood damage reduction. Thus, all upstream alternatives include a combination of levee and channel works and are essentially variations in the location and extent of such works. Since Redwood River overflows into the adjoining Cottonwood River basin occurred under natural conditions prior to the construction of the existing project and presently occur with the project, all considered levee-channel alternatives in the upstream reach provide for the continuation of such overflows in some manner.

PLAN 5U - COMBINED LEVEE - CHANNEL WORKS

25. This plan would provide protection against the 100-year frequency flood with the construction of levees, channel widening measures, and clearing and snagging along 2 miles of channel between the existing diversion structure (mile 70.2) and the Burlington Northern Railroad (BNRR) bridge at Mile 72.6 (plate D-1). Approximately 2,260 feet of levee ranging in height from 3 to 6 feet would be required along the left or north bank commencing at

the CSAH 7 bridge and extending to the BN railroad embankment. Along the remainder of the left bank reach, the railroad embankment would serve as a barrier to prevent floods from escaping to the north and flooding city developments further downstream. Flap gates would be installed on four culverts passing through the railroad embankment. About 6,300 lineal feet of levee from 3 to 12 feet high would be required on the right or south bank as shown on Plate D-1. The existing right and left bank levees between the existing diversion structure and the CSAH 7 bridge would be raised an average of one and six feet, respectively. Clearing and snagging would be accomplished at scattered locations along the entire reach to remove fallen trees, debris, and other obstructions to flow in the channel.

26. This alternative would also provide for an overflow weir with attendant outlet channel that would be located in the vicinity of the wayside park (mile 72.1). The proposed 540-foot long weir would divert up to approximately 50 percent of overflows in excess of the present project design discharge of 6,500 cfs, or a maximum of about 850 cfs at the 100-year Redwood River flood flow of 8,200 cfs. Overflows would be conveyed by a natural ditch on the east side of the park and would pass through proposed multiple culverts are required to prevent overtopping of State Highway 23 and possible overland flooding of Marshall.

27. This plan would also provide for riprap bank protection measures, minor interior drainage measures, relocation of one house and utility relocations. Plan effects and estimated total first costs of about $1.7 million are shown on table D-1. The plan would accomplish the desired flood damage reduction generally in accordance with the desires of local interests. Thus, it is carried forward for detailed impact analysis and possible combination with downstream reach improvements to develop a total plan for the Marshall area.

28. A minor modification to this plan (5U-Mod. 1) was suggested by local interests. This modification would permit flood-free use of a 10-acre parcel of land within a large river meander (miles 70.45 to 70.88) with realignment of the levee as shown on plate D-1. Local interests would be responsible for additional costs of $160,000 over the most cost effective alignment (plan 5U). This plan modification is also carried forward for detailed impact and trade-off analysis. Estimated total first costs with this modification would be about $1,860,000.

29. Another possible modification to this plan (5U-Mod. 2) would provide the same principal features as plan 5U but would include a 600-foot long channel cut-off across the river meander between river miles 70.75 and 70.86, as shown on plate D-1. This cut-off channel would reduce the required channel works and riprap bank protection around the river bend for a net savings of about $50,000 excluding financial losses to the property owner. Utilization of the unprotected 10-acre area slated for industrial development in the future would be adversely affected as access would be hindered by back water in the cut-off channel every one to two years. Local interests do not favor this modification. Therefore, it is dropped from further consideration.

30. An additional modification of this plan (5U-Mod. 3) would include both the 600-foot long cut-off and a 700-foot long channel cut-off between river miles 71.2 and 71.7 as shown on plate D-1. This cut-off would further reduce the length of the natural channel by 2,800 feet and would pass flood flows in excess of 3,600 cfs (the capacity of the natural channel at the upstream end of the cutoff). This alternative would result in a slight reduction in levee height from those levees considered in plan 5U but at an additional total first cost of about $250,000. Since the additional benefits gained are clearly not commensurate with added first costs, this modification was not considered further.

31. A fourth modification of this plan (SU-Mod. 4 or E011988 Plan) would eliminate the proposed right bank levee works between the gabion control structure and CSAH #7. In addition, State Trunk Highway 23 and CSAH 7 would be raised to a 100-year design elevation of 1183.0 feet including 3 feet of freeboard (1185.0 SPF). Flood flows in this upstream reach would then be contained between the river, CSAH 7, Highway 23, and right bank levees in the vicinity of the overflow and gabion control structures forming a flood water storage reservoir as shown on plate D-1. Analysis, however, of this triangular area shows little storage capacity and that flood flows would flow back into the river channel (200 feet upstream of CSAH 7) as quickly as they leave the channel (downstream of the gabion control structure). This modification was investigated for both the 100-year and SPF design levels. Additional discussion of this alternative is given in Section J of this appendix.

32. At the 100-year design level, this modification would reduce channel modification costs by about $491,000 (66 percent) and total Federal first costs by $451,000 or 23 percent. However, approximately 127 acres of productive farm land and vacant land would have to be either acquired in fee or flood easements paid. As acquisition of these lands would appear the most probably course of action based on discussions with local interests, non-Federal first costs would increase by about $460,000. Additional raising of the roadways together with a new CSAH 7 bridge to achieve a Standard Project Flood level of protection would further increase total Federal and Non-Federal First Costs by $745,000 and $153,000 respectively. Since this modification would be more costly at either the 100-year or SPF flood levels than the considered levee plan at no additional benefit it was not considered further. Substituting levess (Plate D-1) in lieu of the considered road raises would significantly reduce the increase in plan first costs as discussed in Section J.

33. Two alternatives were considered to the proposed overflow structure along the right channel bank at the wayside park. The first alternative would involve lowering of State Highway 23 in the vicinity of the wayside park to permit unimpeded Redwood River overflows into the Cottonwood River basin. With the lowered highway, maintenance of required river stages at the park to assure passage of river overflows would require limited channel improvements downstream of the park. Conversely, the limited channel widening measures would result in expected severe erosion problems and possible damage to required river bank levees without extensive and costly riprap. In view of this effect, the frequency and duration of flooding of the highway, and potentially increased damages from higher overflows (1,250 cfs vs. 850 cfs with plan 5U) to farm property south of the highway, this modification was not considered further.

34. The second overflow alternative would involve using the existing westbound Highway 23 embankment as the overflow weir, together with raising of a driveway east of the park to confine overflows to the park area. This plan, together with downstream channel widening measures would actually result in lesser overflows into the Cottonwood basin than under plan 5U and corresponding increased downstream discharges through Marshall. Any future changed channel conditions downstream of the park or related backwater stage fluctuations at the park would make control of overflows over the highway extremely difficult. In view of these problems, the potential damages to the highway itself, and traffic disruptions during major floods, this alternate overflow concept was also dropped from further consideration.

PLAN 6U - FLOODWATER DIVERSION CHANNEL

35. In response to suggestions by city officials, consideration was also given to a floodwater diversion channel between river miles 70.4 and 72.5 as shown on plate D-1. This channel would be about 4,200 feet long, 18 feet deep, have a top width of about 200 feet and

would pass a flow of 4,850 cfs, which in combination with the 2,500 cfs capacity of the natural channel would be capable of safely passing the 100-year flood flow of 7,350 cfs. A combination sheet-pile diversion and drop structure would be located at the upstream end. Another drop structure, about 4 feet high, would be required in the diversion channel to reduce erosive velocities. Other required improvements would include realigning and widening of the natural channel between river miles 70.2 and 70.4, riprap bank protection at critical erosion areas, clearing and snagging of approximately 1.8 miles of river channel, 1,300 feet of levee about 5 feet high on the left bank and 4,800 feet about 2 feet high on the right bank. These levees would be along the diversion channel cut-off and would not negate the need for levees along the natural channel. Levee heights along the natural channel with this plan would be reduced an average of 3 feet from those given in plan 5U. This plan would also require relocation of one house, a house trailer, five utility poles, and would require a total of 35.3 acres of land, 7 acres of which would be forested. Estimated total plan first costs of $3,418,500 and significant plan impacts are displayed on table D-1. This plan would accomplish the same result as other levee-channel alternatives in the upstream reach but at substantially higher economic and environmental costs. However, it is considered further for detailed impact and trade-off analysis at the request of local interests.

36. A considered modification to plan 6U (6U-Mod.1) would include an increased diversion channel capacity of 5,850 cfs with a slight increase in channel depth and width. This design would reduce the right bank levee along the natural channel by about 800 feet with an additional reduction in levee height of about 0.5 feet. As this modification would result in only minor added flood damage reduction benefits at moderately higher economic and environmental costs, it was not considered further.

FLOOD BARRIERS AND CHANNEL WORKS - DOWNSTREAM REACH

37. All downstream reach structural alternatiyes were formulated on the basis of their capability to permit operation of the existing project to at least a 100-year degree of protection and to provide at least a similar level protection to unprotected flood plain development. Alternatives considered included channel works, levees, combined levee-channel works, and combined levee-highway works as discussed in the following paragraphs. An itemized breakdown of plan first costs and other impacts is also shown on table D-1.

PLAN 7D - CHANNEL WORKS

38. Considered channel improvements as shown on plate D-2 to reduce downstream reach flood stages would include widening of the river channel bottom to a minimum of 35 feet by excavation of the right bank only between river miles 64.6 and 65.5 and 65.9 to 66.3. This plan would also include excavation of a channel cut-off to eliminate a sharp river bend between river miles 65.2 and 65.9. This 1,300-foot long cut-off would have a 35-foot bottom width, 1 on 3 side slopes, and an approximately 100-foot top width. Clearing and snagging would be accomplished over the river reach between the State Highway 23 bridge (mile 58.3) and river mile 66.3 to remove all fallen trees, stumps, and debris from the river channel. Riprap slope protection would be placed on the outside of sharp channel bends between river miles 65.0 to 65.1 and 65.4 to 65.6 to prevent erosion of channel banks and possible damage to County Road 67 and a residence. Total plan first costs would be $303,000 as shown on Table D-1.

39. Hydraulic and economic studies indicate that these channel works alone would provide at most an 18 percent reduction in flood

damages to downstream reach development. These improvements would result in a moderate loss of tree, brush and other bank cover, and would result in temporary increases in stream turbidity. In view of the very minor flood damage reduction benefits (0.6 benefit-cost ratio) and possible adverse environmental effects, channel improvements will not be considered further except in combination with downstream levee works.

PLAN 8D - HIGHWAY ALIGNMENT LEVEE

40. This alternative would include a 7,670-foot long levee extending from high ground at 5th Street and Hudson Avenue (see plate D-2) eastward to high ground near the State Highway 23 embankment and contiguous with a proposed Federal-aid highway (FAS6072) alignment presently under joint consideration by the City and County. A levee along this alignment would principally protect development not protected by the existing project as intended in the original design would include a 450-foot long levee along the right channel bank immediately upstream of the downstream confluence with the diversion channel (mile 66.3). A 200-foot long levee would be required on the right channel bank to bridge a low channel bank area at river mile 66.1. The levees would have a 10-foot top width and average heights from 2 to 10 feet.

41. Other works required with this plan would include a 7-acre interior drainage ponding area with attendant outlet works to County Ditch No. 62, a collector ditch along the landward toe of the levee, a temporary 100-foot long sand bag closure, and limited clearing and grubbing. A total of 18.1 acres of land would be required including 8.5 acres for the levee works and 2.1 acres for the collector

ditch. Estimated total first costs (table D-1) for this flood damage reduction plan would be about $348,000. In addition to upgrading the existing project, Plan 8D would provide 100-year flood protection to presently unprotected residential and college property along the downstream reach. Protection of unprotected downstream reach property would be economically feasible with a resultant incremental benefit-cost ratio of about 2.5. Since this plan provides the desired downstream reach flood protection, is incrementally economically feasible as it relates to the new development, and is generally acceptable to local interests, it is carried forward for detailed impact and trade-off analysis.

PLAN 9D - COMBINED HIGHWAY - LEVEE

42. This alternative would involve a combined highway-levee embankment along the same alignment shown for plan 8D, as shown on plate D-2. This plan would include the 450-foot long river bank levee (mile 66.3) as in plan 8D but would not require the 200-foot long channel-bank levee. Interior drainage needs would be similar to those for plan 8D. Real estate requirements would increase by about 20 acres to 38 acres.

43. Plan 9D provides for incorporation of the required levee cross-section into the proposed highway embankment. Raising of the two-lane embankment to provide the required three feet of freeboard would increase local road fill costs by about $45,000. A modified plan placing the proposed roadway on the inside or protected side of the considered levee would eliminate the added $45,000 fill cost but would require off-setting increased local rights-of-way costs

of about $50,000. With either variation, the Federal costs would be limited to the equivalent levee cross-section required for flood control together with needed interior drainage works. Thus, project first costs for flood control would remain the same as for plan 8D. As this alternative is favored by the City, it is carried forward for further impact analysis.

PLAN 10D - COMBINED LEVEE - CHANNEL WORKS

44. Consideration was given to a combined levee-channel plan to further reduce flood stages in the downstream reach. This alternative would include the channel works described in alternative 7D together with the highway alignment levee, plan 8D. This plan would reduce downstream water levels slightly for an average levee height of about 3.5 feet. Interior drainage requirements would be essentially the same as for plan 8D. Construction of the channel widening measures would require replacement of the 200-foot levee with an 850-foot long levee (mile 66.1) of slightly higher average height. Total plan first costs are estimated at $580,800 as shown on table D-1. Incremental average annual first costs of $22,000 for the channel works portion when compared with incremental average annual benefits of $11,400 indicates that addition of the channel work is not economically feasible. Further, this alternative would have a greater adverse environmental effect in terms of channel bank clearing,bank reshaping, and increased turbidity levels. Accordingly, plan 10D is not considered further.

TABLE D-1 -- COMPARISON OF ALTERNATIVE P

PLANNING OBJECTIVE PARAMETERS	ENTIRE STUDY AREA: PLAN 1 No Public Action	PLAN 2 Permanent Evacuation 1/	PLAN 3 Partial Evacuation and Floodproofing 1/	PLAN 4 Upstream Storage	STRUCTURAL ALTE: PLAN 5A Combined Leve Channel Work
I. ECONOMIC					
Federal first cost (x $1,000)	0	$ 10,000.0	$10,361.6	10,000.0	$1,564.8
Non-Federal first cost (x $1,000)	0	200.0	2,500.4	1,000.0	171.8
TOTAL first cost (x $1,000)	0	20,000.0	12,952.0	20,000.0	1,726.4
Federal Ave. Ann. Cost (x $1,000)	0	1,411.0	730.0	1,355.1	110.9
Operation & Maintenance (x $1,000)	0	100.0	12.0	60.0	7.3
Non-Federal Ave. Ann. Cost (x $1,000)	0	114.5	190.7	160.4	18.5
TOTAL Ave. Ann. Cost (x $1,000)	0	1,526.5	955.7	1,525.5	130.4
Flood damage reduction (%)	?	95.0	90.0	85.0	60.0
Average Annual Benefits (x $1,000)		379.0	350.1	330.9	100.7
Benefit-Cost Ratio 2/		0.2	0.4	0.2	1.5
Tax revenues	No effect	Major long-term adverse effect due to business not replaced with a forced permanent evacuation	Moderate long-term adverse effect due total losses on structures not replaced	No significant effect in either reservoir area or immediate Marshall area.	Increased tax reve protected structu developments on n protected lands
Property values	Continued increase in study area croplands due to general increase in farm land prices and excellent developmental potential.	Major decrease in property values on evacuated lands. Major increase newly developed flood free lands.	Major decrease in property values on evacuated lands. Some increase for flood proofed structures	No significant effect as considered reservoir area is presently public lands (Camden State Park).	Increased property for protected lan structures.
Public facilities	No effect	Major long-term adverse effect due to relocation of public buildings and other facilities from downtown area.	Major short-term adverse effects due to relocation and modification of existing public buildings in flooded area	Major long-term adverse effect due to inundation of a major portion of Camden State Park.	Major reduction induced losses to buildings, outdoc and grounds. App reduction in floo to public faciliti
Public services	Normal public services disrupted for several days during flooding in city	Adverse short-term effect due to relocation of facilities	Moderate short-term adverse effects due to relocation and reconstruction activities	Major long-term losses of park services at Camden State Park.	Major long-term be effect from mainte of public services both flood emerge floodfree periods.
Employment/Labor Force	Temporary loss of business employment due to damaged facilities and loss of access to flooded buildings during flood periods.	Major temporary losses in business employment. Major temporary increase in local construction work force.	Temporary increase in construction work force (3-5 yrs.) due to relocation and flood-proofing activities.	Temporary increase for reservoir construction	Temporary (2-year in local labor fo to construction of flood control mea
Business and Industrial Activity	Major short-term adverse effect due to damaged structures, facilities, and inventory and shut-down during periods of major flooding up to 300 businesses could be affected with a 100-year or greater flood occurrence.	Major long-term adverse disruptions to existing business activities	Moderate mid-term adverse effect due to reduced activity during partial evacuation and flood-proofing activities.	Reduced business losses due to major reduction in frequency and severity of flooding.	Major long-term be effect to reduced losses. Existing business losses w reduced about 65
Displacement of Farms	Approximately 300 acres of cropland in the study area is slated for single and multi-family residential development under continuing local developmental conditions	Permanent loss of flood free cropland to accommodate relocated structures. Approximately 300 acres of farm land would be affected	Permanent loss of a lesser amount of flood free crop land to accommodate displaced structures	No effect with storage in Camden State Park. Probable loss of croplands with alternative storage on tributary streams.	Protection of 120 cropland would pr speed up planned d on these lands.
II. SOCIAL					
Residences Relocated	0	130	40	0	2
Roads Relocated (feet)	0	?	?	?	50
Structures Relocated	0	?	0	?	2
Storm Sewers Affected	0	?	?	0	0
Utilities Relocated (feet)	0	?	?	?	2,000
Community Cohesion	Disruptions during major flood periods.	Major long-term disruption to established community patterns. Permanent loss of established social, transportation and trade patterns.	Moderate long-term disruption to established community trades, transportation and social patterns	No significant effect at Marshall	Major long-term be effect due to mar reduced disruptio major flood perio
Community Growth	Expanding urbanization on farmland adjacent to the city.	Major adverse disruption of community growth patterns. Established business and commercial center would be relocated to the outskirts of the city.	Moderate adverse effect due to a lesser degree of disruption than for Plan 2. Most businesses and residences would be flood proofed and remain at the same locations.	No significant effect at Marshall	Protection of 120 cropland area prob will speed develop this land to a re area. Other areas remain largely un
III. Environmental					
Lands Required for project					
Agricultural (acres)	0	Unknown amount of development of another site.		?	3.8
Forest (acres)	0			?	4.1
Park (acres)	0			?	0.0
Others (acres)	0			?	14.0
Archaeological Sites Affected	None	Possibly some at new development site	Possible some at new development site	?	----------
Historical Sites Affected	None	Possible some at new development site	Possibly some at new development site	?	----------
Cultural Sites Affected	None	State College	State College	?	----------
Effect on Local and Regional Growth Patterns	Continued development in flood plain only in accordance with existing flood plain regulations.	Severe long-term adverse effect on local community pattern. Loss of regional educational facility	Severe short-term adverse effect during relocation of 40 family units.	----	Preservation of established com and cultural patterns due to in flooding.
Biological resources	Long term benefits to stream and riparian habitat due to restricted development with flood plain regulation.	Long-term benefits to biological communities within the project area. Undetermined permanent losses in other areas where residents relocate.		---- Conversion of terrestrial to aquatic communities due to habitat changes.	--- Temporary ... tions a ... reaches, ... losses. ... on benef

1/ Entire Study Area.
2/ Federal first cost for flood control works same as for plan 7B.
3/ Incremental benefit-cost ratio change for plans 2, 3, and 4.

TABLE [illegible] ALTERNATIVE PLANS CONSIDERED

	PLAN 3 Flood Evacuation & Floodproofing 1/	PLAN [illegible] [illegible]	STRUCTURAL UPSTREAM REACH ONLY: PLAN 5U [illegible] Levee [illegible] Works	PLAN 6U Floodwater Diversion Channel	STRUCTURAL DOWNSTREAM REACH ONLY: Plan 7D Channel Improvements	Plan 8D Highway [illegible] Levee	PLAN 9D Combined Highway Levee	Plan 10D Combined Levee-Channel Works
	$10,361.4	[illegible]	$ [illegible]	$ 1,260.0	$ 297.8	$301.[illegible]	$ 881.0 2/	$516.7
	2,500.4	[illegible]	[illegible]	178.5	5.5	[illegible]	46.6	66.1
	12,862.0	[illegible]	[illegible]	1,418.5	303.0	347.0	587.6	580.1
	700.0	[illegible]	[illegible]	232.[illegible]	21.[illegible]	[illegible]	21.5	36.0
	12.0	[illegible]	[illegible]	8.5	1.1	[illegible]	1.1	1.6
	100.[illegible]	[illegible]	18.5	21.2	[illegible]	[illegible]	6.6	6.2
	865.[illegible]	[illegible]	[illegible]	252.5	22.9	75.0	25.0	43.1
	98.8	[illegible]	[illegible]	60.0	18.0	[illegible]	85.0	47.0
	350.5	[illegible]	[illegible]	186.[illegible]	13.5	66.[illegible]	66.1	66.7
	0.4	[illegible]	[illegible]	9.0	0.6	[illegible]	2.5	1.5
	[illegible] long-term adverse [illegible] tax losses as [illegible] not replaced.	No significant effect [illegible] either reserve [illegible] immediate [illegible] area	Increased tax revenues from protected structures and developments on newly protected lands	Expected slight increase from protected structures and newly protected lands	No significant effect due to limited extent of flood damage reduction	Increased [illegible] tax revenues from protected lands and developments	Same as Plan 8D	Same as Plan 8D
	[illegible] in property [illegible] evacuated lands. [illegible] for flood [illegible] structures	No significant effect [illegible] considered [illegible] area [illegible] lands (Camden [illegible])	Increased property values for protected lands and structures	Increased property values for protected structures and lands	No significant effect due to limited extent of flood damage reduction	Increased property values for protected lands and developments. Newly protected lands would experience a [illegible]/acre increase [illegible] present market value	Same as Plan 8D	Same as Plan 8D
	[illegible]-term adverse due to relocation [illegible] of existing [illegible] buildings in flooded [illegible]	Major long-term adverse effect [illegible] Major [illegible] State Park	[illegible] reduction in flood [illegible] to public buildings [illegible] facilities and grounds. Approximate [illegible] reduction in flood losses [illegible] facilities	Same as Plan 5U	No significant effect due to limited extent of flood damage reduction	Major long-term reduction in flood losses to south [illegible] village facilities. Approximate [illegible] reduction in public damages under existing conditions	Same as Plan 8D	Same as Plan 8D
	[illegible] short-term effects [illegible] relocation [illegible] construction [illegible]	Major [illegible] of park [illegible] State Park	[illegible] long-term beneficial effect from [illegible] services during [illegible] emergencies and [illegible]	Same as Plan 5U	No significant effect due to limited extent of flood damage reduction	[illegible] reduction in disruption [illegible] as provided [illegible] village	Same as Plan 8D	Same as Plan 8D
	[illegible] increase in [illegible] work force [illegible] due to [illegible] and flood-[illegible] activities.	Temporary [illegible]	Temporary [illegible] increase in local labor force due to construction of [illegible] flood control measures	Same as Plan 5U	Slight temporary increase in local labor force due to channel excavation works	Temporary [illegible] increase in local labor force due to construction of [illegible] levee and other works	Same as Plan 8D	Same as Plan 8D
	[illegible]-term adverse [illegible] to reduced [illegible] during partial [illegible] and flood [illegible] activities	Reduced [illegible] due to [illegible] Frequent [illegible] flooding	[illegible] long-term beneficial effect to [illegible] of flood [illegible] existing condition [illegible] would be reduced about [illegible]	Same as Plan 5U	Minor. Approx. [illegible] reduction in flood losses	[illegible] long-term beneficial effect due to [illegible] reduction in existing [illegible] business losses	Same as Plan 8D	Same as Plan 8D
	[illegible] loss of a [illegible] of flood [illegible] and to unconfined [illegible] structures	No effect [illegible] Camden [illegible] Probable [illegible] with alternative [illegible] on tributary [illegible]	Protection of 20 acres of [illegible] and would probably speed up planned development on these lands	Same as Plan 5U	No effect	Flood protection for 81 acres of cropland would probably speed up planned development on these lands	Same as Plan 8D	Same as Plan 8D
	90		[illegible]	2	3	4	6	4
	[illegible]		[illegible]	50	0	[illegible]	3	0
	0		[illegible]	2	4	3	[illegible]	1
	0		[illegible]	0	1	2	0	[illegible]
	0		[illegible]	2,000	900		4	900
	[illegible] long-term disruption [illegible] established [illegible] trades, [illegible] and socio[illegible].	No significant [illegible] effect at Marsh[illegible]	[illegible] long-term beneficial effect due to marked[illegible] reduced disruptions during [illegible] flood periods	Same as Plan 5U	Minor beneficial effect due to reduced disruptions during flooding with minor level of protection	Major beneficial long-term effect due to reduced incidence and severity of disruption during major flood periods	Same as Plan 8D	Same as Plan 8D
	[illegible] adverse effect due [illegible] degree of [illegible] than for Plan 2. [illegible] would be flood [illegible] remain at the [illegible]	No significant [illegible] effect at Marsh[illegible]	Protection of 120 acre cropland area probably will speed development of this land to a residential area. Other areas would remain largely unaffected	Same as Plan 5U	No significant effect	Protection of 81 acres of cropland will probably speed conversion of this area to single and multi-family residential development	Inclusion of fender highway may affect community growth patterns in the immediate area, i.e. some form of commercial or other development may be induced on present cropland along the proposed highway right-of-way	Same as Plan 8D
			3.0	14.4	2.8	18	34.1	22.0
			[illegible]	7.5	0.1	[illegible]	0	0.1
			0.0	0.8	0	[illegible]	0	0
			14.0	13.1	1.0	0.[illegible]	4.4	2.4
[illegible] same as [illegible] [illegible] site			No known sites affected					
[illegible] same as [illegible] [illegible] site			No known sites affected					
[illegible]			No known sites affected					
[illegible]-term adverse [illegible] during [illegible] of [illegible] family		Preservation of established community development, social and cultural patterns due to increased security against flooding			Minor beneficial effect due to slight reduction in flood damages	Major beneficial effect due to near elimination of flood damages along downstream reach.		
[illegible]		Conversion of terrestrial to aquatic communities due to habitat changes	Temporary reduction in biotic populations along reshaped channel and levee reaches, along with minor long-term losses. Temporary sedimentation-effects on benthic fauna		Minor long-term adverse effects on aquatic and riparian habitat due to channel modification	Reduced habitat for upland game birds and small mammals. Most of the required area is presently tilled farmland	Minor long-term adverse effects to aquatic and riparian habitat due to channel modifications. Reduced habitat for upland game birds and small mammals. Most of the required area for levees is tilled farmland.	

IVE PLANS CONSIDERED (continued)

	UPSTREAM REACH ONLY		DOWNSTREAM REACH ONLY			
	PLAN 5U	PLAN 6U	Plan 7D	Plan 8D	PLAN 9D	Plan 10D
	Combined Levee-Channel Works	Floodwater Diversion Channel	Channel Improvements	Highway Alignment Levee	Combined Highway Levee	Combined Levee-Channel Works
of sev- forest and er. Change etat.on in servoir in	Permanent loss of 4.1 acres of mixed forest and understory cover. Loss of terrestial and aquatic vegetation along riprapped channel bank	Permanent loss of 7 acres of forest cover. Temporary loss of ground cover along levees until reseeding is established.	Temporary loss(4 to 5) years) of ground cover, shrubs along 2 miles of river bank. Permanent loss of mature trees along river in the vicinity of channel modifications.	Temporary loss of about 0.5 acres of upland grasses, forms, shrubs and a few mature trees.	Temporary loss of about 4.4 acres of native grasses, shrubs and a few scattered trees.	Temporary vegetative ground cover losses along levee areas. Permanent loss along riprapped channel bank areas.
ion of d stream e fishery. le game l mammal	--- Minor long-term adverse effect on riparian habitat. Short-term (2-season) adverse effect due to increased stream turbidity during construction. Permanent loss of wooded wild life habitat. Permanent loss of 15.8 acres of tilled cropland.		Temporary and long term term disruption of small mammal habitat along reworked river banks and channel cutoff. Short term adverse effect on limited area fishery due to increased turbidity. Temporary adverse effect to transient birdlife utilizing woods along river as a resting place.	---- Temporary disruption of small mammal habitat. Permanent loss of 19 acres of tilled cropland.		Short-term adverse effect to stream fishery and other aquatic life due to increased turbidity and sedimentations. Long-term loss of small mammal habitat in the vicinity of channel modifications.
nd other sting h crea- e lake.	--- Permanent visual changes and slightly --- impaired access to river at 7 locations where levees pass through residential lots		Long-term changes in areas where channelization takes place.	------ Moderate visual change to natural setting with completion ---- of levee and 7.0 acre ponding area.		
	-------- No known effect		No Effect	No effect	No effect	No effect
-5 yr) in- e, dust, n products ir clear- construction.	--- Short term (2 yrs.) increase in dust --- and combustion product levels during project construction.		------Slight increase in dust and combustion products during and for a short time after ----- two-season construction period.			
degrada- water qual- ect life. fect at Mar- reduced sedi loads.	---Major increase in stream turbidity during and shortly after construction. Long term improvement due to channel bank stabilization.		Major increase in stream turbidity levels during construction period.	No effect	No effect	Significant increase in stream turbidity and sedimentation during and shortly after channel construction work.
orary increase during construction period	---------------		------------------ Temporary increase during construction period	-------------------------		
of forest- land and stream lost development. r construction of access road and facilities.	------- Energy resources expended ---------- during construction.		Energy resources used for construction.	----- Energy resources and reinforced concrete used for ------------- project construction.		
ss of facilities rvoir area.	One house would be relocated a short distance. Four other would be somewhat affected by the close proximity of considered flood barriers. Other flood prone structures would be significantly less susceptible to recurring flood damage.	Same as Plan 5U	No significant effect other than raising and widening one bridge.	Major beneficial effect to college complex with increased level of flood protection.	A considered feeder highway could be efficiently integrated with the considered levee embankment.	Same as Plan 8D
ss of e-flowing o inunda- rvoir.	Permanent loss of about 4.2 acres of woodland.	Permanent loss of about 7 acres of forested area.	Permanent loss of about 0.10 acres of channel bank woodlands.	No significant effect to natural resources.	Same as Plan 8D	Same as Plan 8D

ALTERNATIVES CONSIDERED FURTHER

UPSTREAM REACH

45. To provide increased flood protection at Marshall, the principal resource management problem in the study area, the formulation analysis considered both non-structural and structural alternatives. Present programs, such as flood plain regulation and flood insurance, under the no further public action alternative, although effective flood plain management tools, would not provide a comprehensive solution to the study area flood problems. Non-structural alternatives involving permanent evacuation or partial evacuation and flood proofing could provide a 100-year level of flood damage reduction but were found to be uneconomic and socially unacceptable. Of the structural alternatives, reservoir storage was found to be technically and economically infeasible due to lack of needed storage capacity and unacceptable due to the adverse social and environmental impacts. Thus, localized improvements including levees and channel works together with flood plain regulation and flood insurance are left as the only feasible and practical means of providing needed additional flood damage reduction.

46. The selection of upstream reach alternatives for further analysis was based on the need for providing locally acceptable and viable measures for insuring effective operation of the existing diversion project. The alternatives carried forward were then subjected to an in-depth impact and trade-off analysis to provide a technically and economically viable plan commensurate with the equal needs of preservation and/or enhancement of area environment, social, and cultural values. To make this analysis, all selected alternatives were evaluated on the basis of criteria outlined earlier in this section.

47. Of the upstream reach structural alternatives considerd, only the combined levee-channel plan (plan 5U) and the flood water diversion channel plan (plan 6U) would meet study area flood plain management needs and are considered further. Plan 5U provides the least costly plan in terms of both first costs and subsequent operation and maintenance costs to the city. This plan would enable potentially damaging flood flows to reach and pass through the existing project without problems and the expense of local resources similar to those incurred during the 1969 flood. The considered works would have temporary adverse effects in terms of impaired water quality, increased noise and air pollution levels, and channel bank habitat changes. Marked increases in stream turbidity and sedimentation would occur during construction but diminish to below current levels after a short period due to protection of presently eroding river banks. Increased noise, dust, combustion product levels, and smoke from the controlled burning of debris and trees would cease almost immediately after construction. Revegetation of disturbed channel bank areas would reduce small mammal habitat losses. Relatively permanent effects would include the loss of about 4.2 acres of woodlands and related small mammal and bird habitat, and aesthetic changes where the proposed level is in close proximity to seven residences.

48. Plan 5U would provide substantial beneficial effects in terms of added flood protection for the City of Marshall, which in turn would maintain desirable community growth patterns and assure Marshall's status as a vigorous regional trade, service and educational center.

49. Modification of plan 5U to include protection to the 10-acre river meander area (plan 5U-mod. 1) would be technically feasible but economically unjustified since the entire area could be filled an average of about one foot to the 100-year flood level. Estimated fill costs are about $28,700 as compared to the perimeter levee costs of approximately $172,000. Levee construction around the river loop would also result in considerable fringe woodland loss as compared to no loss with the basic plan 5U levee across the open farm land. Although a slight inconvenience to area access, the proposed levee would be ramped and surfaced for unimpeded access to the unprotected meander area. This proposed modification would also result in the loss over Plan 5U of an additional two acres of fringe woodland and understory cover already in relatively short supply.

50. The flood water diversion channel (plan 6U) would also provide Marshall an adequate level of flood protection, but at twice the costs of plan 5U. A lower and shorter right bank levee with this plan would have lesser adverse aesthetic effects to affected residences. However, increased woodland and understory cover losses of about 1.8 acres would result with further adverse effects on floodway wildlife. However, plan 6U clearly lacks economic feasibility as indicated by the 0.8 benefit-cost ratio (table D-1).

DOWNSTREAM REACH

51. Of the downstream reach structural alternatives considered, both the highway alignment levee (plan 8D) and the combined highway-levee plan (plan 9D) are discussed further. In addition, limited channel measures immediately below the downstream confluence of the river and diversion channel are considered with both plans. Plan 8D with limited channel widening, would, in combination with upstream reach plan 5U, provide the most cost-effective additional measures to achieve a 100-year degree of protection for the city and adjacent downstream developments. Plan 8D would result in minimal environmental losses as the proposed levee would traverse presently tilled cropland with essentially no native grass or tree losses. The required channel widening works would occur entirely on reworked channel bank areas presently covered with scattered weed growth. This plan would result in the immediate loss of about 15 acres of cropland and likely facilitate the eventual conversion of another 80 acres to urban development.

52. The combined levee-highway plan (plan 9D) would accomplish the same degree and extent of protection as plan 8D and at nearly the same Federal first cost for flood damage reduction. This plan would result in the immediate conversion of about 50 acres of cropland to flood control purposes. Except for slightly increased vegetative ground cover losses in the vicinity of an old river oxbow, plan environmental effects would be similar to those with plan 8D. Although plan 9D was initially suggested by the City, it is now considered unlikely that local plans for the proposed highway would be ready in time to permit combined construction assuming normal Federal approval and funding of any recommended flood control works.

CONTRIBUTIONS OF ALTERNATIVES TO NATIONAL OBJECTIVES

GENERAL

53. The selected water resource plan for added measures to assure operation of the existing project as designed and protecting downstream reach developments at Marshall must not only satisfy specific objectives for the study area but provide positive contributions to the national economic development and environmental quality objectives. To achieve a balanced plan reflecting the area's dual concern for improved flood plain management while maintaining and enhancing the natural environment, separate plans -- one optimizing economic efficiency, the other emphasizing the environmental quality objective -- were developed. Through a series of trade-offs among public preferences and beneficial and adverse plan impacts, the plan

which contributed most to the local and national planning objectives was developed and further refined. Table D-2 gives a comparison of beneficial and adverse plan impacts for the selected plan, NED Plan and EQ Plan in accordance with the system of accounts established by the Water Resources Council.

NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

54. The NED Plan must, from the national point of view, represent the best return on the investment of economic resources, including capital, labor, and irreplaceable natural resources needed for construction. For upstream reach measures to assure effective operation of the existing project, plan 5U incorporating levees, an overflow weir with attendant outlet works, channel widening and bank stabilization measures represents the most economically feasible plan that would provide the desired degree of flood damage reduction. Similarly, and as shown on table D-2, the proposed downstream reach levee along the considered highway alignment (plan 8D) together with minor channel widening measures (part of plan 7D) provides the most economical method of improving the operation of the existing project and providing a minimum 100-year degree of protection to presently unprotected downstream reach flood plain development.

ENVIRONMENTAL QUALITY (EQ) PLAN

55. The EQ plan is the alternative which enhances the quality of the environment through the preservation or enhancement of important natural and cultural resources and ecological systems, and which

minimizes adverse effects on environmental quality. The alternatives chosen for further analysis were formulated principally on the basis of the flood damage reduction objective. An evaluation of these alternatives in the context of enhanced environmental quality was made to develop the environmental quality plan. Since all alternatives were formulated based on satisfying the specific flood damage reduction objective and the EQ plan must also satisfy this objective, the EQ alternative was with relatively minor alteration, among the alternatives considered for further analysis.

56. The selected framework environmental quality alternative was that which is initially least environmentally disruptive to the existing project area. After selection of the framework EQ alternative, measures to better fulfill specific study objectives were added incrementally to develop the most acceptable and environmentally beneficial plan. From such an analysis of alternatives considered further for principally flood damage reduction, it was determined that the EQ plan would include:

Upstream Reach -- Plan 5U incorporating added measures such as reshaping and relocation of certain portions of the flood barrier at nearby residential structures; addition of a recreational trail and other facilities on or near the levee crown to enhance local recreation opportunities; modification of the overflow weir to better blend into the existing roadside park setting; and tree and shrub plantings to minimize the visual impact on the levee works. Clearing and snagging measures would be deleted with only a slight adverse effect on channel hydraulic capacity but with significant gains in environmental quality. This alternative would have long term beneficial environmental effect in terms of assured flood protection for Marshall, reduced river bank erosion and improved water quality. Short-term adverse effects would include loss of natural habitat and associated temporary losses in benthic organisms and small mammal populations. Reseeded channel bank, levee, and spoil areas would return to a near-native state within a few years after construction.

Downstream Reach -- Plan 8 D. together with limited channel widening, aesthetic tree and shrub plantings, and a recreational trail system on or near the levee, and flood plain management measures for residual unprotected flood plain areas, was selected as the EQ plan as well as the NED plan since it would have the least adverse effect on the natural and cultural setting while still satisfying the flood damage reduction objective. This alternative would require no wooded areas and very limited grassed areas as the proposed levee alignment would be along presently tilled cropland. Small mammals frequenting the area would only be temporarily displaced by the construction activities.

PLAN SELECTION

57. Selecting the best plan of improvement for the City of Marshall involved the comparison of alternatives which satisfy established water resource planning objectives and formulation and evaluation criteria. Of the upstream reach alternatives considered further, plan 5U, with continued flood warning services and flood plain management of the residual 10-acre river meander area and addition of environmental enhancement measures, is considered in balance the best possible plan. As local highway plans are not expected to be completed in time to permit a combined project, plan 8D together with minor channel widening and management of residual flood plain areas is the best downstream reach plan.

58. Together, these plans provide an effective and locally acceptable combined plan of improvement for resolving the residual flood problem at Marshall. Thus, the combined plan is selected for detailed design and cost estimates. At several meetings held at Marshall, the city, county, and Minnesota Department of Highways have provided substantial input to the plan formulation process and all generally concur with the selected plan. Table D-4 displays the system of accounts for the selected plan.

SCALE OF DEVELOPMENT

GENERAL

59. To permit selection of the optimum economic level of flood damage reduction for the City of Marshall, costs and benefits were evaluated for five degrees of flood protection that would be provided by varying the design flood discharge for the flood control project. Results of the plan optimization studies are discussed separately in the following paragraphs.

60. To determine the optimum level of protection, annual costs and benefits were determined for the 50-year (6100 cfs), 100-year (8200cfs), 150-year (9500), 200-year (10,500 cfs), and 250-year (11,500 cfs) flood levels. Although the SPF flood flow upstream of the BN Railroad bridge at mile 72.6 is 16,700 cfs, only 11,800 cfs can enter the project area through the Burlington Northern Railroad bridge at mile 72.6. Thus, this flow, equivalent to a 270-year flood frequency flow, is considered to represent Standard Project Flood conditions in the upstream reach as the remaining 4900 cfs which would flow north eastward through the airport grounds and re-enter the existing diversion channel does not significantly contribute to the damage potential within the heavily developed areas of Marshall (Reaches B, C & D). The SPF level flow of 16,700 cfs was used to reflect annual costs and benefits for related downstream reach flood damage reduction measures.

61. From an analysis of annual costs and benefits for these five levels of protection an optimum relationship between average annual costs and benefits for the entire project exists when flood protection is provided against a flood having a recurrence interval of once in about 133 years. Plan optimization data are given in table D-2 and shown graphically on Plate D-3.

Table D-2 Plan Optimization Data (6 7/8% Interest Rate)

Level of Protection	Annual Cost	Annual Benefits	Net Benefits	Benfit-Cost Ratio
50-year	$113,330	$146,800	$ 33,470	1.30
100-year	142,240	260,800	118,560	1.83
150-year	218,070	309,100	91,030	1.42
200-year	430,640	334,610	-96,030	0.78
250-year	483,320	350,220	-133,100	0.72

62. As a higher level of protection would be justified by a benefit-cost ratio greater than unity but at reduced net benefits as indicated in table D-2, a sensitivity analysis of interest rates varying over time versus benefit-cost ratios was made to determine the limits of economic feasibility. Interest rates selected to provide a broad range of rates were the 6 7/8, 7 5/8, 8 3/8, and 12 percent rates. These rates were assumed to increase one-fourth of one percent per year until fixed by assumed authorization of the project. The analysis indicated that the earliest the rates would be fixed would be in year 1985 at a rate of 8 3/8 percent. A tabulation of benefit-cost ratios versus interest rates for the 50-year through 200-year levels of protection is given in table D-3. Similar data for the 250-year flood level was not derived as a benefit-cost ratio less than unity is indicated at the current 6 7/8 percent interest rate.

Table D-3 Sensitivity Analysis-Comparison of Benefit-Cost Ratios with Varying Interest Rates

	Level of Protection				
Interest Rate %	50-year	100-year	133-year	150-year	200-year
6 7/8	1.3	1.8	1.8	1.4	0.78
7 5/8	1.2	1.7	1.6	1.3	0.71
8 3/8	1.1	1.5	1.5	1.2	0.65
12	0.8	1.1	1.04	0.83	0.46

63. From Table D-3 it is evident that the maximum feasible level of protection would be about the 150-year flood level at the 8 3/8% interest rate. Increasing the level of protection from the 133-year level to the 150-year flood level (12.8% increase) would result in a 29.6 percent reduction in net benefits or $38,300. The analysis also indicated that up to about the 133-year flood level, total first costs generally increase proportionately with respect to increased flood barrier heights. However, once this level is exceeded, added costly measures would sharply increase total project first costs as generally indicated by the flattened upper portion of the optimization curve shown on Plate D-3. Principal added measures to assure an effective 150-year level of protection would include raising of the CSAH 7 bridge with related grade transitions, raising of the BN railroad subgrade adding an impervious clay blanket along the innerward side of the railroad embankment upstream of County Highway 7, added channel works, and additional flood barrier works upstream of the downstream confluence river and existing diversion channel.

64. Provision of this added increment of protection would result in increased Federal and Non-Federal first costs by about $680,000 and $360,000 respectively for a total increase in project first costs of about $1,040,000.

65. Provision of a standard project flood level of protection would require further extension of the service drive road raise upstream of the Highway 23 wayside park. The resultant 6 to 7 foot raise would result in severe and unacceptable driveway grades at several residences. Provision of a SPF level of protection would also result in severe dislocations of established residential areas with the required relocations of 5 houses upstream of CSAH 7 and numerous residences and businesses in the developed downtown area (1.2 mile backwater flood barrier reach). As indicated in Table D-2, a 250-year level of protection, which is close (11,500 cfs v.s. 11,800 cfs) to the SPF flow downstream of the BN railroad bridge at mile 72.6 is clearly infeasible as indicated by the 0.72 benefit-cost ratio.

66. Assuming a levee failure at the SPF flow, approximately 3500 cfs would enter the densely urbanized portion of the city. Of this amount, 2000 cfs would represent overland flow over County Highway 7 and which would re-enter the river channel downstream of the existing diversion structure. The total flow of 3500 cfs would result in a flooded area along the river with an average width of about 1200 feet and average water depths of 2 to 4 feet. Overbank velocities would be less than 0.8 feet per second. Several hundred commercial and residential structures would be adversely affected by either basement or first floor flooding.

67. However, as nearly all of the proposed levees along both study reaches would be relatively low (4 to 5 feet average height) the potential for loss of life is not considered great. To assure that no flows would overtop flood barriers upstream of the existing diversion structure, two feet of freeboard above the SPF flood level would be provided along the right bank levee between the existing diversion structure and the proposed overflow works at the wayside park.

68. After review of the draft feasibility report, the City of Marshall stated (See April 1978 letter from City of Marshall in Appendix 2) that provision of a SPF level of protection would be unrealistic and unacceptable to the City. They further advised that the design 133-year plan of protection would be acceptable subject to a few minor modifications. Subsequent to this correspondence, additional study effort was made to establish the maximum practical but still feasible level of protection. As discussed in earlier paragraphs, this level is about the 150-year flood level. This reanalysis was presented to the City for their review. By letter of 21 February, 1979 (See Appendix 2) the City advised that the "... proposed 133-year level of protection would still be a most acceptable level of protection" and that "... the additional work and cost involved do not warrant the relatively small degree of additional protection...". Thus, based on the foregoing optimation and sensitivity analyses, consideration of the impact of a SPF levee failure, and views of the City, a 133-year degree of protection was selected as the appropriate level for project designs and estimates.

69. At several coordination meetings subsequent to the basic formulation studies of upstream reach flood damage reduction alternatives, the City has indicated a perceived need for acquiring the flood plain lands upstream of CSAH 7 and lying between the right bank flood barriers and the Burlington Northern Railroad right-of-way. About 71.1 acres of flood plain land would be affected at the 133-year design flood level. The City believes that local developmental conditions would force either outright purchase of these lands or equally costly flood easements. Acquisition of these lands by local interests is part of the proposed project is considered advisable as any significant developments (encroachments) in the floodway may adversely affect design flood levels and operation of the proposed project. Inclusion of the additonal estimated cost of $101,000 for these lands in the completed plan formulation estimates would

not significantly influence the conclusions reached. Thus, acquisition by local interests of the additional 71.1 acres of flood plain lands for project floodway purposes is incorporated as a feature of the selected plan.

AD A146 926 REDWOOD RIVER AT MARSHALL MINNESOTA; FEASIBILITY REPORT FOR FLOOD CONTROL(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT JUN 79

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SYSTEM OF ACCOUNTS

Table D-4 - Selected Plan

Effects	Timing	Marshall	Regional Development Southwest Minnesota	Rest of Nation	Totals	The Nation: A Summary Income Classes Resi-dential	Comm. Indust.	Public
1. National Economic Development								
Beneficial (x $1000)								
Increased output								
Flood Control (Av. Ann.)	III	260.8 A,b	0	0	260.8 A,b	29.2	0.5	70.3
Floodproof Cost Savings Benefits	III	9.8 A,b	0	0	9.8 A,b	100.0	0	0
Recreation	III	43.1 A,b	0	0	43.1 A,b	-	-	-
External Economics	----------None----------							
TOTAL BENEFICIAL		313.7	0	0	313.7	34.6	0.5	64.9
Adverse (x $1000)								
Value of resources for project construction (Av. Ann.)	I	26.7 A,b	0	139.9	166.6 A,b	-----	----	----
External diseconomies 1/	I	1.0 A,c	0	0	1.0 A,c	-----	----	----
O & M (Av. Ann.)	I	8.4 A,b	0	0	8.4	-----	----	----
TOTAL ADVERSE		36.1	0	139.9	176.0	34.6	0.5	64.9
2. Environmental Quality								
Wild & Scenic Rivers	----------None----------					-----	----	----
Lakes	----------None----------					-----	----	----
Archeological	-------Buried archeological sites possible -- Effects unknown-------							
Historical	----------No known effects----------					-----	-----	----

Table D-4 - Selected Plan (continued)

Effects	Timing	Marshall	Regional Development Southwest Minnesota	Rest of Nation	Totals	The Nation: A Summary Income Classes: Residential	Comm. Indust.	Public
Ecological Systems	I	Project would convert about 9.1 acres of cropland to intermittently wet ditches and ponding area. Some shift of terrestial floral and faunal species to semi-aquatic species expected. Approximately 4.2 acres of forest and understory cover would be converted to grassed areas. Acquisition of approximately 70 acres of flood plain lands upstream of CSAH 7 would preserve these lands in their current natural state. Reseeding of disturbed areas would limit most losses to one or two growing seasons. A,b	-------	------	Same as for Marshall	-----	-----	-----
Irreversible Effects	I, III	Commitment of material and energy resources for project construction. Loss of 4.2 acres of mature forest cover. Conversion of 119.8 acres to flood control uses. A,c,F,	-------	------	Same as for Marshall	-----	-----	-----
3. Regional Development								
Income - Summary National Accounts	III	175.0 F = Ave. ann. cost + O & M - 1,000	0	139.9 +	35.1	34.6	0.5	64.9
*Employment Stability	II	Likely increase, not quantified. A,B	-------	------	-------	-----	-----	-----
Population Distribution	III	--------------Increased residential population in protected area------------				-----	-----	-----
*Desirable Regional Growth	III	Enhanced community growth pattern. A,b,F	-------	------	-------	-----	-----	-----
*Local Tax Revenues	III	Increase, not quantified. A,b	-------	0	0	-----	-----	-----
*Property Values	III	Likely increase in some areas to reduced flood risk. A,b,P	-------	0	0	-----	-----	-----

SYSTEM OF ACCOUNTS

Table D-4 - Selected Plan (continued)

Effects	Timing	Marshall	Regional Development Southwest Minnesota	Rest of Nation	Totals	The Nation: A Summary Income Classes: Resi-dential	Comm. Indust.	Public
Land Quality	I, III	Permanent loss of 4.2 acres of forest cover. Conversion of 16.3 acres of cropland to flood control uses. Preservation of an additional 70 acres of flood plain land in its natural state due to acquisition for project floodway purposes. A,c	Loss of 4.2 acres of wood lands out of a limited regional supply.	------	Same as for Marshall	-----	-----	-----
*Air Quality and Noise	I	Temporary increase in smoke, dust and fuel combustion products in air and increased noise levels during 2-season construction period. A,b	----------	------	Same as for Marshall	-----	-----	-----
Streambank erosions	I, III	Temporary increase during and shortly after construction. Long-term decrease due to bank stabilization. A,c	----------	------	Same as for Marshall	-----	-----	-----
*Water Quality	I, III	Temporary marked increase in stream turbidity during and for a short time after construction. Long-term improvement due to channel bank stabilization. A,b	----------	------	Same as for Marshall	-----	-----	-----
Biological Resources	I	Initial loss of benthic fauna due to channel works. Temporary destruction of other small mammal habitat. Some re-population of species expected within a few years after construction. A,b	----------	------	Same as for Marshall	-----	-----	-----
Rare and endangered species	-----------	-----No known effect-----	-----------	-----------	-----------	-----	-----	-----

SYSTEM OF ACCOUNTS

Table D-4 -- Selected Plan (continued)

Effects	Timing	Marshall	Regional Development Southwest Minnesota	Rest of Nation	Totals	The Nation: A Summary Income Classes: Resi-dential	Comm. Indust.	Public
4. Social Well-being								
Reduced Flood Risk	I	Reduced damages to all categories of development. A,c,F.	-----	-----	Reduced threat to all categories. A,c,F	---	---	---
Loss of Agricultural Lands	I	Approximately 16.3 acres of cropland lost with construction of levee and interior drainage works.	No appreciable effect.	Insignificant effect.	Same as for Marshall	---	---	---
Recreation		Added opportunities for leisure time enjoyment. A,c,F	No appreciable effect.	No effect.	Same as for Marshall	---	---	---

NOTATION: Actual and Potential Effects

A - No Government action needed other than implementing agencies.

B - Government action needed and likely to produce beneficial effect; adverse effect can and likely will be prevented by Government action.

C - Government action needed but not assured to produce beneficial effect; Government action can prevent adverse effect but such action not assured.

Uncertainty

a - 50% or more

b - 10-50%

c - less than 50%

Non-Exclusivity

F - Overlapping entry with NED; fully monetarized in NED account.

P - Overlapping entry with NED; partially monetarized in NED account.

Timing

I - Construction or within a few years of construction.

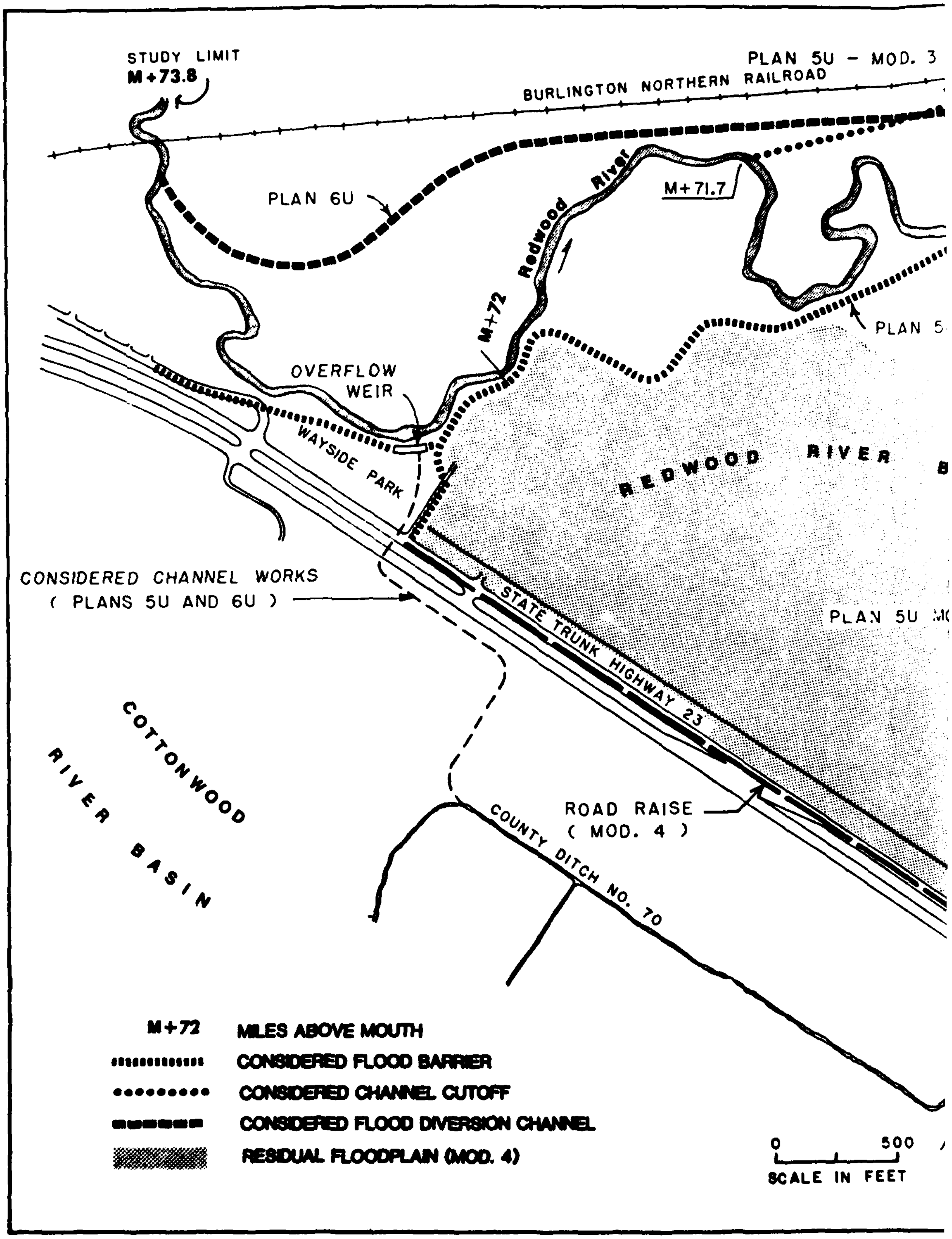
II - Over project life, main impact by year 10.

III - Over project life, main impact by 10-15 years.

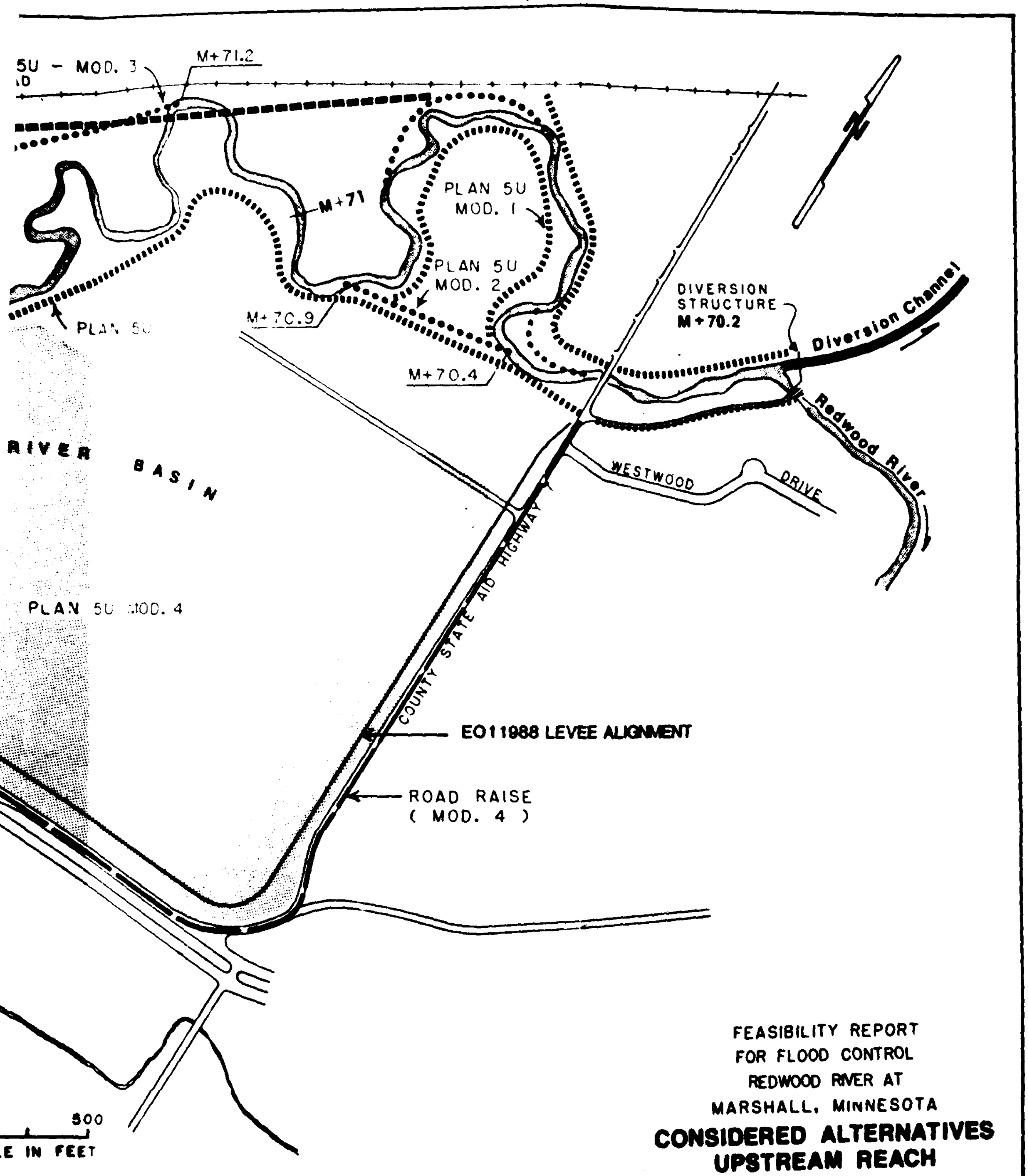
IV - Over project life main impact by 20-25 years.

V - Over project life, main impact by 50 years.

1/ Annual loss of production on 15.8 acres of cropland lost to levees and interior drainage works.



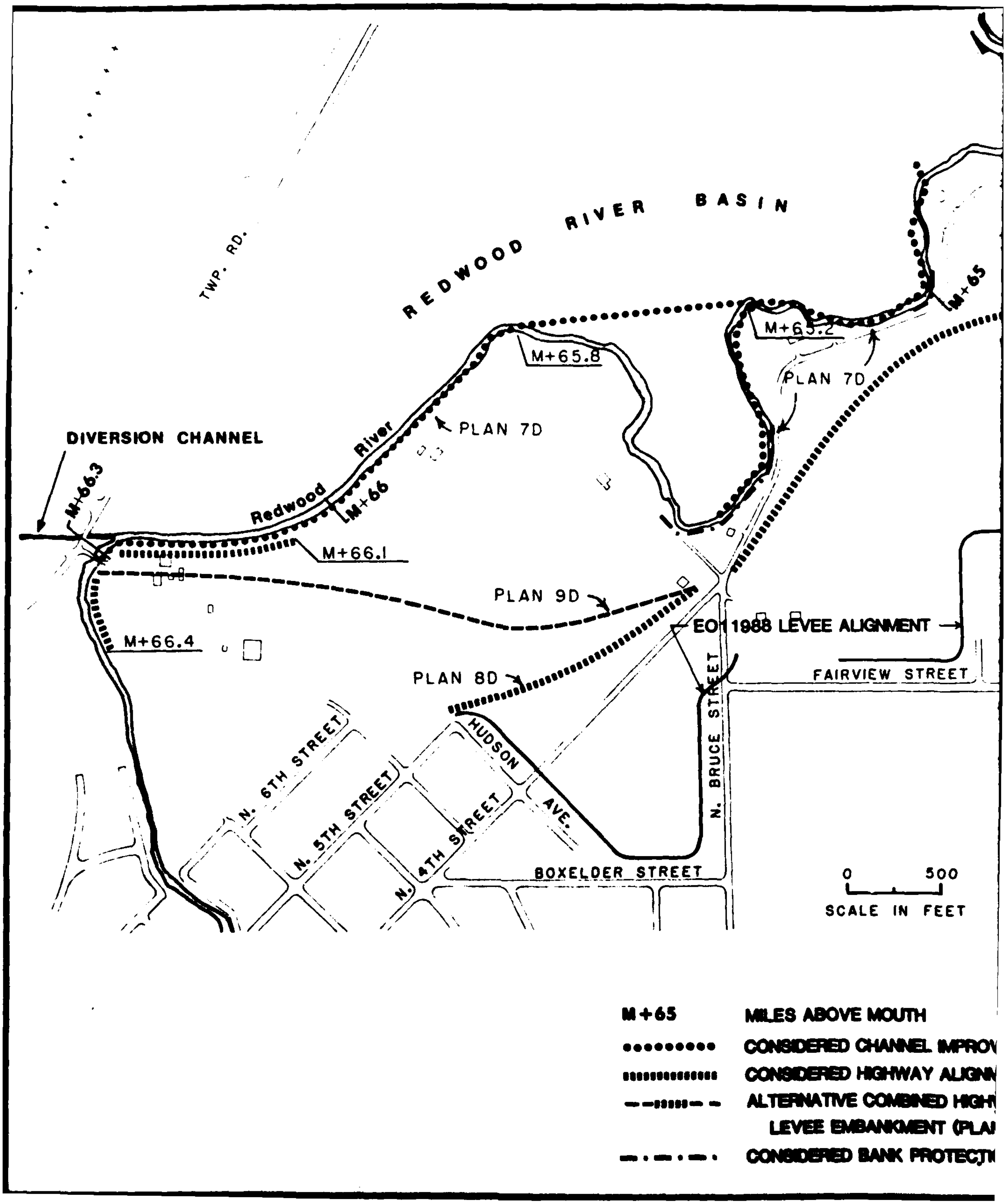
STUDY LIMIT
M+73.8
PLAN 5U - MOD. 3
BURLINGTON NORTHERN RAILROAD
PLAN 6U
Redwood River
M+71.7
M+72
PLAN 5
OVERFLOW
WEIR
WAYSIDE PARK
REDWOOD RIVER
CONSIDERED CHANNEL WORKS
(PLANS 5U AND 6U)
STATE TRUNK HIGHWAY 23
PLAN 5U
COTTONWOOD
RIVER BASIN
ROAD RAISE
(MOD. 4)
COUNTY DITCH NO. 70
M+72 MILES ABOVE MOUTH
CONSIDERED FLOOD BARRIER
CONSIDERED CHANNEL CUTOFF
CONSIDERED FLOOD DIVERSION CHANNEL
RESIDUAL FLOODPLAIN (MOD. 4)
0 500
SCALE IN FEET

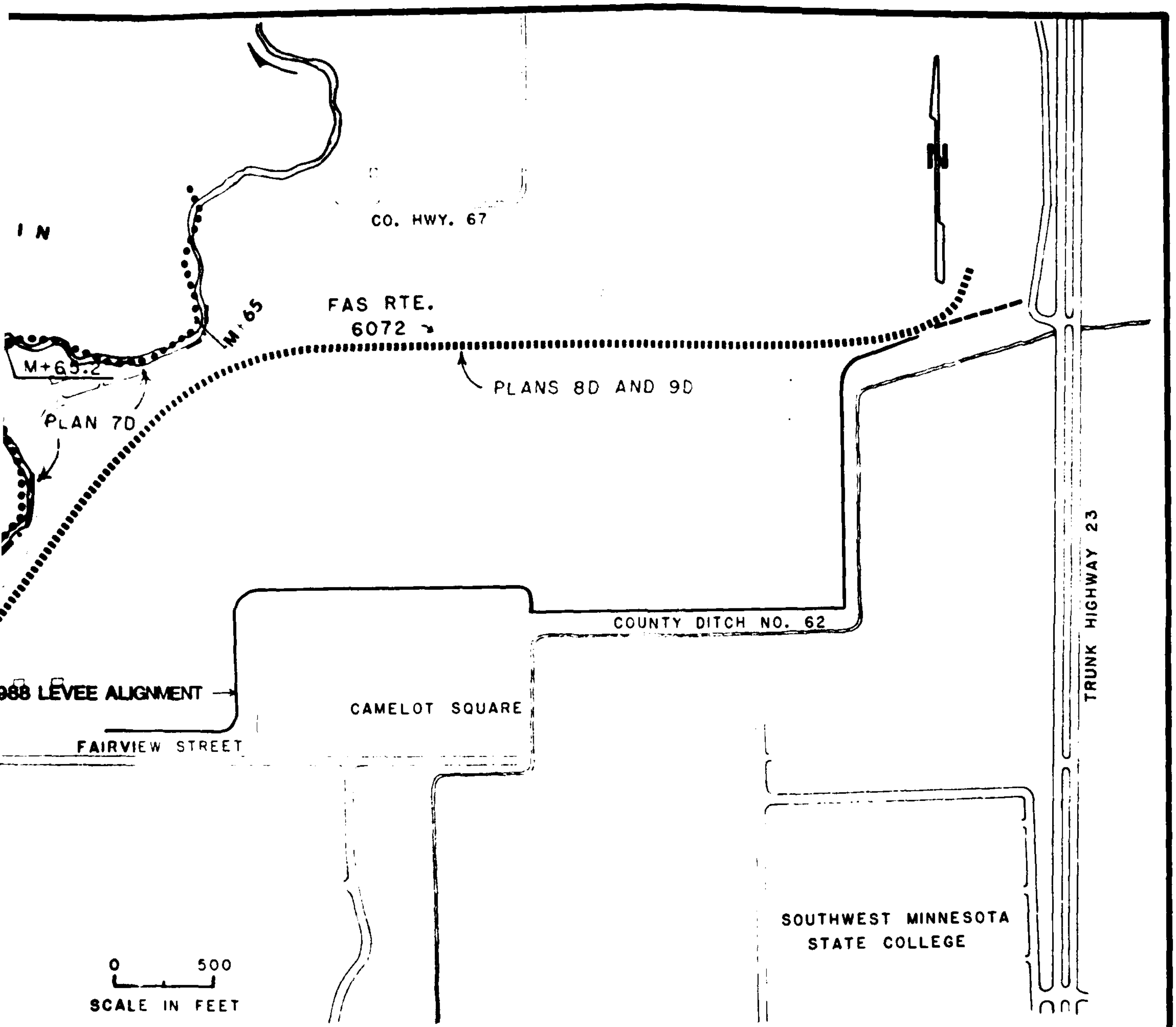


FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

CONSIDERED ALTERNATIVES
UPSTREAM REACH

PLATE D-1


REDWOOD RIVER BASIN
TWP. RD.
DIVERSION CHANNEL
M+66.3
Redwood River
M+66
M+66.1
M+66.4
M+65.8
PLAN 7D
M+65.2
M+65
PLAN 9D
PLAN 8D
EO 1988 LEVEE ALIGNMENT
FAIRVIEW STREET
N. BRUCE STREET
HUDSON AVE.
N. 6TH STREET
N. 5TH STREET
N. 4TH STREET
BOXELDER STREET
0 500
SCALE IN FEET
M+65 MILES ABOVE MOUTH
CONSIDERED CHANNEL IMPROV
CONSIDERED HIGHWAY ALIGNN
ALTERNATIVE COMBINED HIGH
LEVEE EMBANKMENT (PLA
CONSIDERED BANK PROTECTI

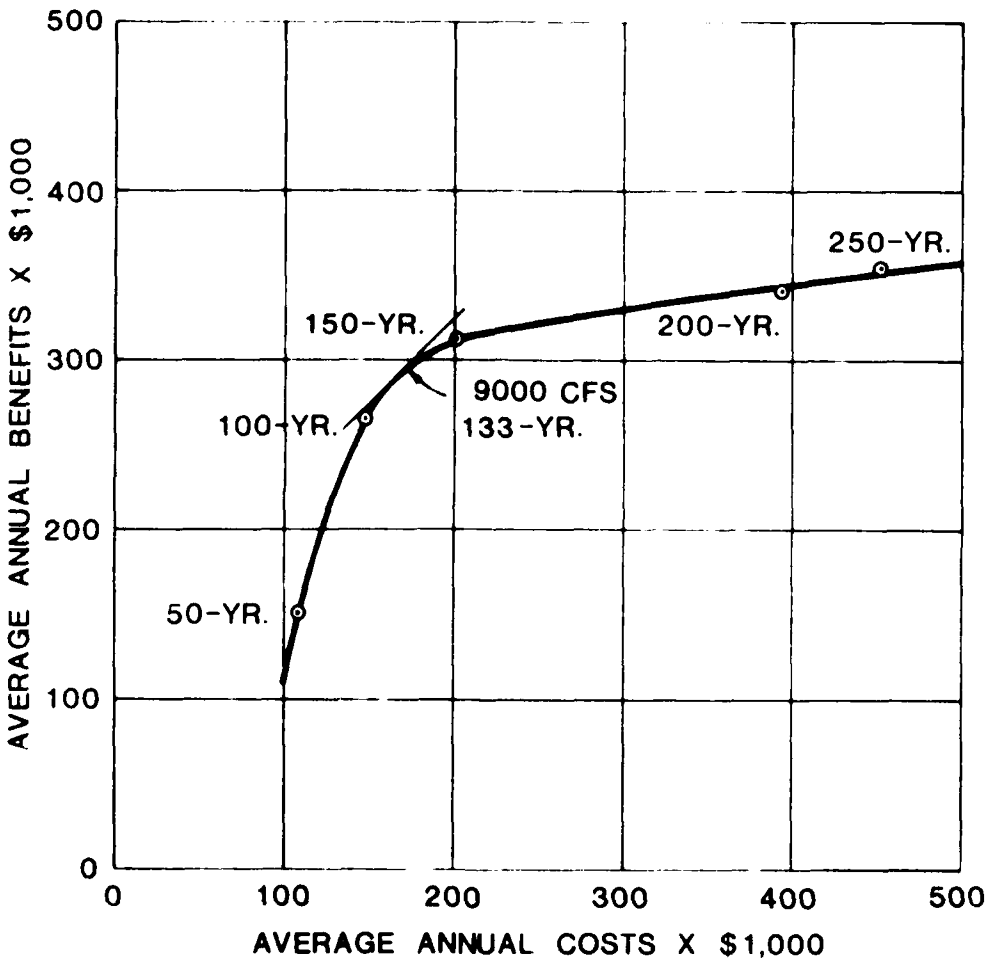


MILES ABOVE MOUTH
CONSIDERED CHANNEL IMPROVEMENTS (PLAN 7D)
CONSIDERED HIGHWAY ALIGNMENT LEVEE (PLAN 8D)
ALTERNATIVE COMBINED HIGHWAY -
LEVEE EMBANKMENT (PLAN 9D)
CONSIDERED BANK PROTECTION

FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

CONSIDERED ALTERNATIVES
DOWNSTREAM REACH

PLATE D-2



FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

MAXIMIZATION OF NET TANGIBLE BENEFITS

SECTION E

THE SELECTED PLAN

SECTION E

THE SELECTED PLAN

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF PLATES

SECTION E

THE SELECTED PLAN

1. This section of the report describes the plan of improvement as selected in the previous section on formulation. In addition to the basic description, all meaningful effects, both beneficial and adverse, are identified and discussed. Pertinent information concerning design, construction, and operation and maintenance of the plan is also represented to provide the reader with a broader understanding of the technical aspects involved for implementation. Plates E-1 through E-12 show the important features of the selected plan.

PLAN DESCRIPTION - UPSTREAM REACH

2. The plan of improvement, selected for assuring effective operation of the existing project and protection of new development along the reach below the confluence of the Redwood River and the diversion channel, is comprised of two parts - that for the upstream reach (river mile 66.3 to 73.8) and that for the downstream reach (river mile 58.3 to 66.3), respectively. Flood barriers for the selected plan are designed (with one exception as discussed in Paragraph 5) to accommodate the 133-year flood with 3 feet of freeboard along both reaches.

GENERAL

3. The proposed plan of improvement for the upstream reach consists of levees; channel widening and reshaping; an overflow diversion structure with attendant overflow channel and other works; channel and levee slope protection; minor interior drainage facilities; and utility and building relocations. The plan would also include a recreational trail system, and limited picnicking facilities. Aesthetic and environmental mitigation measures are also provided to offset vegetation and aesthetic losses and help blend the proposed project into the natural setting. Flood plain management measures are proposed for residual flood plain areas. In addition, river and flood forecasting by the National Weather Service, an integral part of the design and operation of levees and other flood control systems and essential for multi-purpose water resource management will continue to be needed.

LEVEES

4. The proposed upstream works provide for a 2,260-foot long levee along the left or north bank commencing at the existing diversion structure (mile 70.2) and extending to the Burlington Northern Railroad embankment at the upstream end as shown on plate E-1. The existing left bank levee between stations 0 + 00 and 8 + 60 would require a raise of about seven feet. Levee heights between stations 8 + 60 and 22 + 60 would range from 4 to 7 feet with an average height of 5 feet. The entire levee would have a 10-foot top width except at the widened or warped section between

station 9 + 00 and 14 + 00. Landward and riverward side slopes would both be 1 on 3 except along the warped levee section. Typical cross-sections for the left bank levee are shown on plate E-6. Also included would be a 1,660-foot long levee between the proposed gabion drop structure and high ground north of the wayside park. Average height would be 4 feet. Pertinent features of this levee are shown on plates E-2 and E-3.

5. The proposed upstream work would also include a 6,350-foot long levee extending along the right bank from the existing diversion structure upstream to high ground at the State Highway 23 embankment in the vicinity of the State wayside park, as shown on plates E-1, E-2 and E-3. Except for a required 3-foot raise of the existing levee between stations 0 + 00 and 9 + 00, and a 3 foot raise of a private driveway between stations 60 + 00 and 63 + 50, levee heights providing three feet of freeboard over the 133-year design flood level would range from 4 to 13 feet with the maximum height over an old channel crossing between stations 48 + 00 and 52 + 00. However, the right bank levee between station 0 + 00 and 60 + 00 would be raised to provide two feet of freeboard over the SPF flood level. Both the landward and riverward levee side slopes would be 1 on 3 except along a short reach of residential property immediately upstream of CSAH 7 (station 9 + 40 to 13 + 00), at the access ramp to the area within the large river meander (station 17 + 00) and at two residences between stations 53 + 20 and 58 + 00). The short levee reaches near the three residences would have 1 on 3 riverward slope and an irregular and flattened landward slope to provide for plantings to mitigate tree and other aesthetic losses. The access ramp at station 17 + 00 (section F-F, plate E-7), would have 1 on 6 side slopes and a 10-foot wide compacted gravel surface course to provide easier vehicular movement.

6. Two temporary sandbag closures would tie the right bank levee into high ground. A 100-foot long closure would tie the road raise at station 63 + 50 into the Highway 23 embankment to divert standard project flood flows into the Cottonwood River basin. A 45-foot

long closure at the upstream end of the road raise west of the way-side park would provide sufficient freeboard to contain the 133-year flood.

7. The top width of the right bank levee would be 10 feet except along the existing service drive between stations 0 + 00 and 9 + 00 and the driveway between stations 60 + 00 and 63 + 50. Along the service drive, the levee would have 20-foot top width with a 10-foot wide gravel surface course. The raised driveway would have a 12-foot top width with an 8-foot wide gravel surface course. Typical cross-sections showing the standard levee sections, irregular sections, and raised road sections are shown on plates E-1, E-6 and E-7.

8. The riverward toe of both the left and right bank levees would be located at least 10 feet from the top of the channel bank except along reaches where the channel bank is to be riprapped and at five areas where existing structures are located close to the river channel. Along these latter areas, the riverward levee slope would represent an upward extension of the riprapped channel side slope. Typical cross-sections illustrating this condition are shown on plate E-6.

CHANNEL IMPROVEMENTS

9. Proposed channel improvements would include realignment of the river channel between river stations 9 + 40 and 14 + 40 to alleviate a sharp channel bend. The bottom width of the realigned channel would vary from 80 feet at the County State Aid Highway 7 (CSAH 7) bridge to 50 feet at a point approximately 500 feet upstream of the bridge. Other channel works would include widening by excavation

of one bank only between stations 48 + 00 to 55 + 00 and 106 + 00 to 119 + 60, and channel realignment between stations 97 + 00 to 106 + 00. The channel widening between stations 97 + 00 to 119 + 60 would lower the water surface to that of the existing conditions. Minimum channel bottom widths along these widened reaches would be 50, 45, and 55 feet respectively. Also included would be reshaping and riprapping of 6 channel bends as shown on plates E-1, E-2 and E-3. Typical channel cross-sections are shown on plates E-6 and E-7.

10. The proposed 540-foot long overflow diversion structure would commence at right bank levee station 58 + 90 and extend westward along the Redwood River as shown on plate E-3. This structure would consist of a gabion embankment with a 10-foot top width and 1 vertical on 2.5 horizontal side slopes. The 540-foot long overflow portion of this embankment would have a crest of constant slope with elevations of 1192.64 at the downstream end and 1192.94 at the upstream end. The existing ditch located at the east side of the park would be slopes in the direction of the overflow culverts to pass flood overflows through the State Highway 23 embankment. The overflow structure would commence operation at a river flow of 6,500 cfs and would accommodate up to 50 percent of the excess river flow over 6,500 cfs or a peak flow of 1,260 cfs at the design 133-year Redwood River discharge.

11. The proposed gabion drop structure would be located at river station 97 + 45 (river mile 72.04). The structure would consist of a gabion embankment with a 9-foot grouted crest and 1 vertical on 4 horizontal and 1 vertical on 6 horizontal upstream and downstream side slopes. There would be four 36" R C P culverts to pass low flows. The drop structure would be overtopped at a discharge of 300 cfs, or about every other year on the average.

12. The proposed 2,140-foot long overflow channel would have a 20-foot bottom width and a channel bottom slope of 0.2 percent between stations 0 + 00 and 12 + 00 and 0.25 percent between stations 12 + 00 and 21 + 40. Channel side slopes would be 1 on 6 and 1 on 4 respectively for the left and right banks for the channel reach along the State Highway 23 right-of-way. Channel slopes downstream of the Highway 23 right-of-way would be 1 on 6 on both sides to permit movement of farm equipment. The overflow channel would join County Ditch No. 70 which ultimately drains into Cottonwood River. Three 115-inch by 72-inch concrete arch culverts would pass the peak design discharge of 1,260 cfs through the State Trunk Highway 23 (T.H. 23) embankment. Typical overflow structure, overflow channel and culvert details are shown on plates E-3 and E-4.

BRIDGE PROTECTION

13. Riprap bank and pier protection would be provided at the CSAH 7 bridge. Riprap would be placed over the entire channel section and extend 30 feet upstream and 50 feet downstream of the bridge. Typical cross-sections at this location are shown on plate E-6.

INTERIOR DRAINAGE

14. Required upstream interior drainage works would include modification of the State Highway 23 drainage system at the wayside park, installation of flap gates on two double 30-inch railroad culverts,

an 18-inch flap-gated culvert at station 10 + 00 of the left bank levee, installation of a flap-gate on an existing driveway culvert at station 63 + 50, and installation of a 12-inch C M P culvert through a driveway at right bank levee station 11 + 20. Modification of the State Highway 23 drainage system would include installation of a 10-foot wide parabolic channel leading to the overflow structure, and a flap-gated 36-inch reinforced concrete culvert through the structure.

The land area drained by the culverts is, in all instances, very small (less than 2.5 acres) or the land slopes away from the levees. Thus, installation of the flap gates would not create any adverse effects. Minor landscaping measures would also be accomplished at right bank levee station 27 + 00 to fill a low area adjacent to the proposed levee. Typical details for the upstream reach interior drainage facilities are shown on plates E-4 and E-8.

SPOIL DISPOSAL

15. The proposed upstream channel works would require the excavation of approximately 61,125 cubic yards of material. Of this amount, 44,590 cubic yards would be used as embankment fill. Two small disposal areas would be located on the left channel bank at station 30 + 00 and 48 + 00 to accommodate waste material not easily accessible to the levee works. The 0.2-acre and 0.5-acre areas would contain a total of 4,520 cubic yards of spoil material to a maximum depth of about 4 feet. Spoil bank levees would be bulldozed at each location to prevent return of the excavated material to the channel. The remaining 12,015 cubic yards of material obtained from the channel works would be trucked from the area to the existing

spoil area on the left bank of the existing diversion channel. Surface material stripped from the levee alignment and accessible channel bank areas would be stockpiled and re-used as topsoil.

16. Of the 26,775 cubic yards of material to be excavated from the overflow channel, approximately 6,180 cubic yards would be used as random backfill or fill for the overflow structure. An additional 16,735 cubic yards of waste material would also be stockpiled for subsequent city re-use at the existing diversion channel spoil bank area.

RELOCATIONS

17. The proposed upstream levee overflow works, and channel improvements would require the acquisition of an estimated 22.8 acres of land, temporary construction easements along two private driveways and one other property, relocation of one house, 500 lineal feet of overhead line, temporary relocation of 700 feet of buried utility cable, and relocation of about 550 feet of farm fencing. Placement of the culverts through the four-lane T.H. 23 would require construction of a temporary by-pass across the median to permit two-way traffic during project construction. The extent and locations of required relocations are shown on plates E-1 and E-3.

AESTHETIC TREATMENT MEASURES

18. Aesthetic treatment measures would be provided at various locations along the left and right bank levees to lessen the adverse

effects of levee construction near residential structures. Excluding riprapped areas, all disturbed areas would be reseeded with native vegetation or other ground cover such as wheat grass or sweet clover. Other measures would include tree and shrub planting and warped or enlarged levee sections with irregular landward slopes to blend the levees into the natural topography. The plantings on or near the enlarged landward slope would partially offset the loss of existing tree and shrub growth and soften the visual effects of the flood barriers at affected residences.

19. In addition to the proposed structural measures, flood plain management measures (principally zoning) would be utilized in managing residual flood plain areas riverward of the levees to preclude flood prone development in these areas. An additional 71.1 acres of flood plain lands located between the proposed right bank levee and the Burlington Northern (BN) Railroad embankment and extending from CSAH 7 upstream to the BN railroad bridge (mile 72.6) would be purchased to insure preservation of the area as a floodway.

DOWNSTREAM REACH

GENERAL

20. Proposed flood control improvements along the downstream river reach would include levees, channel improvements, channel slope protection, interior drainage facilities, flood plain management measures, and beautification measures.

LEVEES

21. The proposed downstream works would provide for a 7,670-foot long levee commencing at high ground near the State Highway 23 embankment and extending to high ground at 5th Street and Hudson Avenue as shown on plates E-9, E-10, and E-11. The levee would have a 10-foot top width and 1 on 3 riverward and landward side slopes. Levee heights would range from 3 to 10 feet with an average height of 5 feet. A 450-foot long levee would also be required along the right bank of the river just upstream of its confluence with the diversion channel as shown on plate E-11. With the same typical cross-section as the longer levee, average levee height would be 2.0 feet. A low 2.0-foot high levee would be required to bridge a low channel bank reach between river stations 0 + 00 and 9 + 00. A 2-foot high by 100-foot long temporary sandbag closure across County Highway 67 would be required to maintain a continuous 3-foot freeboard allowance over the design 133-year flood. Typical cross-sections for these levees are shown on plate E-12.

CHANNEL IMPROVEMENTS

22. Proposed downstream channel improvements would include widening of the river channel bottom to approximately 35 feet by excavation of only the right bank between river stations 0 + 00 and 13 + 50. Riprap slope protection would be provided along the entire widened bank. Riprapped side slopes would be 1 on 3. Typical channel cross-sections are also shown on plate E-12.

INTERIOR DRAINAGE

23. Required downstream interior drainage facilities would include a 7-acre ponding area at station 27 + 00, a collector ditch along the levee toe, and a 24-inch diameter drainage conduit with appurtenant works leading to County Ditch No. 62. Two 24-inch diameter R C P culverts would pass collector ditch flows through the County Highway 67 embankment. The ponding area would be excavated to elevation 1134.0 for an average depth of about 4 feet. Removal of ponded peak design runoff is estimated to take about 2 days. A plan view and typical section for required downstream interior drainage works are shown on plates E-9 and E-12. The contributing interior drainage area is shown on plates E-9 and E-10.

SPOIL DISPOSAL

24. The proposed downstream channel works would require the excavation of 6,390 cubic yards of material. Of this material, approximately 1,700 cubic yards would be used as channel bank levee fill, the remaining material to be placed on available City-owned property

on the right channel bank near river station 10 + 00. Of the 47,700 cubic yards of material excavated from the ponding area and collector ditches, 34,100 cubic yards would be used as levee fill. The remaining material would be used to fill a low area along the collector ditch, a partially filled oxbow on municipal property, and two low areas adjacent to the ponding area as shown on plates E-9 and E-11. Topsoil stripped from the ponding area and ditches would be stockpiled for replacement on disturbed areas.

RELOCATIONS

25. Relocations would be limited to the relocation of 900 lineal feet of overhead utility line along the channel bank levee alignment.

26. Alternative alignments to the proposed flood barrier alignments were evaluated to minimize impacts on study area wetlands. These alternative are discussed in Section J of this Appendix.

RECREATIONAL FACILITIES

27. Proposed recreational facilities would include a 5.7 mile long multi-use recreational trail system with rest and observation areas extending from State Highway 23 at the downstream end of the proposed project upstream to the Highway 23 wayside park and limited picnic facilities in conjunction with the levee works at Justice Park and the existing softball complex north of State Highway 19. A 0.6-mile section of the trail system between State Highway 19 and CSAH 7 is expected to be completed by the City prior to any construction of proposed project features.

A 0.3-mile section of trail upstream of County Highway 67 (Plate G-2) would be completed by the City concurrent with the construction of any authorized recreational trail facilities. Future development to be provided by the City might include the development of a quiet and nature educational area in the wooded flood plain area upstream of CSAH 7, an improved canoe access at or near the State Highway 23 wayside park, and additional facilities at Justice Park. Plan views and pertinent area sections for the proposed recreational facilities are shown on Plates G-1, G-2, and G-3.

AESTHETIC TREATMENT MEASURES

28. Downstream reach aesthetic treatment measures would consist of reseeding all disturbed areas with suitable ground cover species. Actual grass mixes would be determined during preparation of final project plans and specifications.

PLAN ACCOMPLISHMENTS

29. The major accomplishments resulting from the selected plan of improvement would be the improved operation of the existing flood control project and protection of downstream reach development not protected by the existing project. The proposed improvements would eliminate damaging overbank flows up to the 133-year design discharge. Flood flows in excess of the existing design discharge of 6,500 cfs would be equally passed downstream through the existing project and through the upstream overflow diversion works into the Cottonwood River basin. The overflow works would reduce the frequency and magnitude of floodwaters into the Cottonwood River basin resulting from cross flow from the Redwood River about 43 percent at the 133-year design flood level and 26 percent at the standard project flood discharge.

30. The elimination of most present and future flood damages at Marshall would not only enhance the economic development and stability of the City, but would also enhance the social well-being

of the affected people. Specifically, the plan would provide for efficient operation of the existing project to provide protection against a flood with a 0.75 percent chance of occurring in any given year and provide flood protection and related security to most of the unprotected downstream development, including the facilities of the Southwest State College at Marshall. The plan would also significantly satisfy the demand for new, expanded or improved outdoor recreational facilities. Thus, the proposed plan accomplishes the study purpose and desired improvements as expressed by the City of Marshall and Lyon County.

EFFECT ON THE ENVIRONMENT

31. The selected plan would likely facilitate on-going changes in land use in the flood plain. Approximately 120 acres of tilled agricultural land and over 100 acres of undeveloped and partially developed vacant land in the upstream reach would probably be developed as single family or multiple family dwelling units. Similarly, and in accordance with established zoning classifications, a large portion of the vacant land along the downstream reach may be developed into an expanded trailer park and residential dwelling units. Protected flood plain property owned by the College would likely be developed by the College as the need for additional building and outdoor facilities arose.

32. The selected plan of improvement would have both temporary and permanent effects on the natural environment. Temporary adverse effects would include: increased turbidity and sedimentation during and for a short time after construction with association effects on the very limited area fishery, benthos populations; the minor

long-term loss of native ground cover on disturbed levee and channel bank areas with associated losses and shifts in small mammal habitat; increased noise levels during construction and slightly reduced air quality during construction due to increased levels of dust and fuel combustion products. Stream water quality would be temporarily worsened due to increased turbidity and sediment levels, particularly as a result of the channel works.

33. Provisions would be made in final designs and specifications for appropriate spoil disposal, debris burning, runoff and other pollution control measures and construction inspection procedures to minimize adverse effects. Construction would be scheduled to provide the least impact on nesting waterfowl and other bird life. Mitigation of temporary vegetative losses would be accomplished by reseeding of disturbed areas with grass species native to the area.

34. Relatively permanent environmental effects would include the loss of a total of about 4.2 acres of trees and brush cover along principally the upstream reach, including about 80 mature trees along the upstream reach, the commitment of an additional 119.8 acres of land in the Marshall area for flood control purposes, and the commitment of materials, primarily earth fill, rock riprap, and fuel for project construction. Of the mature trees removed near widely separated upstream residences, few could be replaced in size or location over the 50-year project life. These trees serve as shade trees, landscaping enhancements and provide valuable shelter and resting areas for area bird life. This tree loss would be partially offset with replanting of similar but much smaller trees and shrubs on warped levee sections or as near as possible to the levee while still providing access for project maintenance.

35. Other tree and understory cover loss represents a relatively minor extension of a large expanse of woodlands located a short distance upstream. Species of trees lost, primarily elm, green ash, cottonwood, willow, and bur oak, are commonly found in the adjacent flood plain areas and in the protected woodland of Camden State Park located about 8 miles upstream of the project area. Water quality would probably be improved in the long-term due to the proposed bank stabilization measures. The purchase of 71.1 acres of flood plain lands upstream of CSAH 7 for floodway purposes would maintain the natural characteristics of the area.

36. Research at local libraries, the Marshall and Lyon County historical centers, and the Southwest State College at Marshall indicate that no known architecturally, historically or archeologically significant resources are present in the project area. Unknown buried resources may be present in the project area, and if uncovered during project construction, would be preserved, relocated or otherwise disposed of in an acceptable manner. Recent contacts with the State Historical Preservation Officer indicate that no sites on or eligible for the National Register of Historical Places are evident in the project area.

OTHER EFFECTS

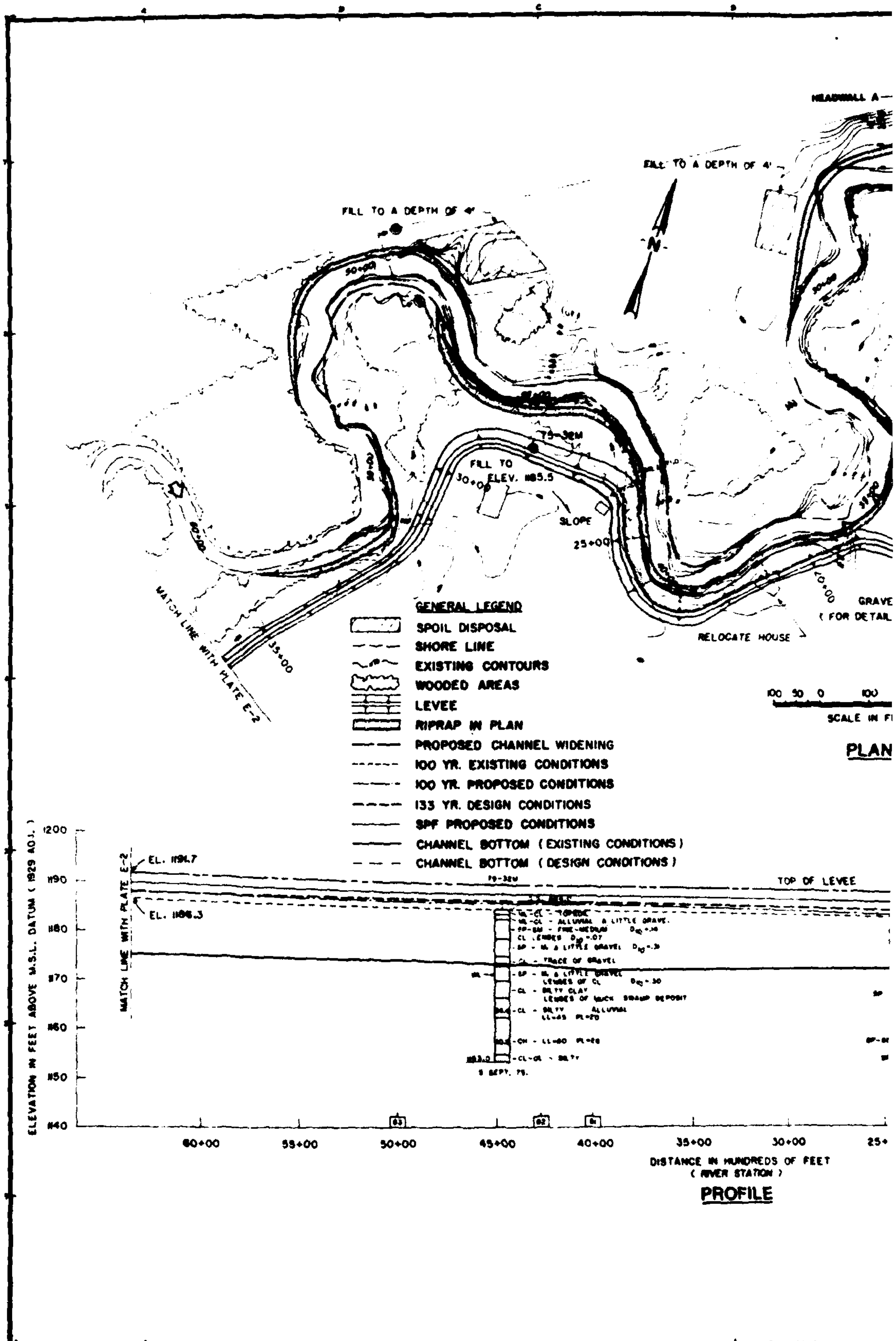
37. The selected plan, without appropriate mitigation measures, would have permanent adverse aesthetic effects due to tree and shrub losses at localized areas, particularly just upstream of CSAH 7. In a few instances, the levees would either block or detract from the present view of the river. These effects would be

at least partially offset by the proposed landscaping, tree and shrub planting and reseeding measures.

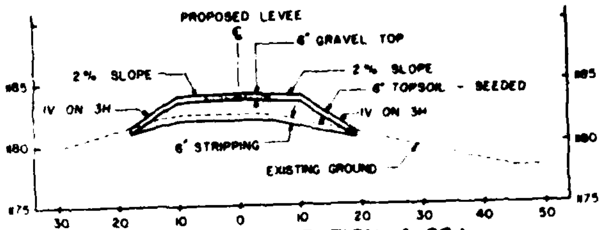
38. Vehicular traffic on T.H. 23 would be inconvenienced for a period of about one month due to placement of the overflow channel culverts. Traffic on CSAH 67 and No. Bruce Street would be inconvenienced for a few days during placement of the collector ditch culverts. Similarly, agricultural activities along both the project reaches would be affected for two seasons due to the levee construction.

39. The selected plan would reduce future flood damages at Marshall, thus stabilizing, preserving, and enhancing the economic stability of the area, community development patterns, and the general security and social well-being of the affected people. The plan, if implemented, would nearly negate the need, as in 1969, for the periodic and inefficient commitment of local financial, manpower, and material resources for emergency flood fight activities.

40. The completed overflow diversion structure and channel would provide an attractive extension of the wayside park. Structure slopes would be gradual enough to permit free pedestrian access.

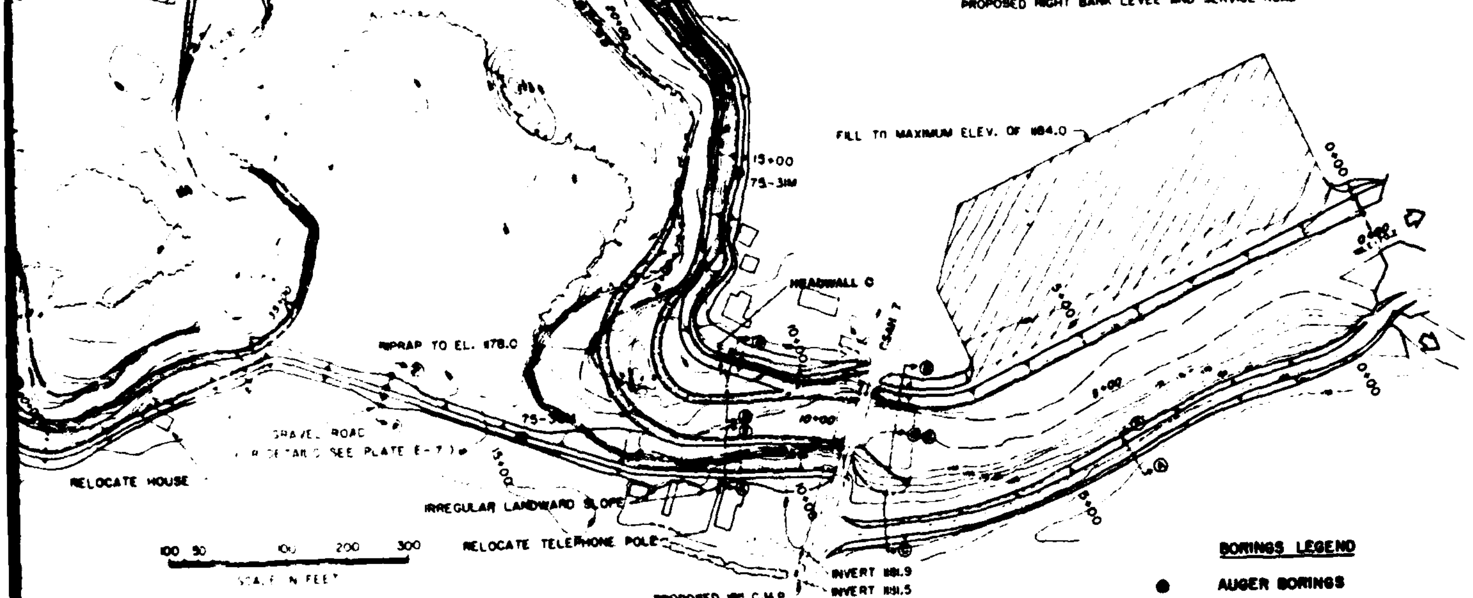


HEADWALL A
FILL TO A DEPTH OF 4'
FILL TO A DEPTH OF 4'
N
FILL TO ELEV. 1185.5
SLOPE
RELOCATE HOUSE
MATCH LINE WITH PLATE E-2
GRAVE
(FOR DETAIL
GENERAL LEGEND
SPOIL DISPOSAL
SHORE LINE
EXISTING CONTOURS
WOODED AREAS
LEVEE
RIPRAP IN PLAN
PROPOSED CHANNEL WIDENING
100 YR. EXISTING CONDITIONS
100 YR. PROPOSED CONDITIONS
133 YR. DESIGN CONDITIONS
SPF PROPOSED CONDITIONS
CHANNEL BOTTOM (EXISTING CONDITIONS)
CHANNEL BOTTOM (DESIGN CONDITIONS)
SCALE IN FI
PLAN
ELEVATION IN FEET ABOVE M.S.L. DATUM (1929 ADJ.)
MATCH LINE WITH PLATE E-2
EL. 1191.7
EL. 1186.3
TOP OF LEVEE
5 SEPT. 79.
60+00
55+00
50+00
45+00
40+00
35+00
30+00
DISTANCE IN HUNDREDS OF FEET
(RIVER STATION)
PROFILE

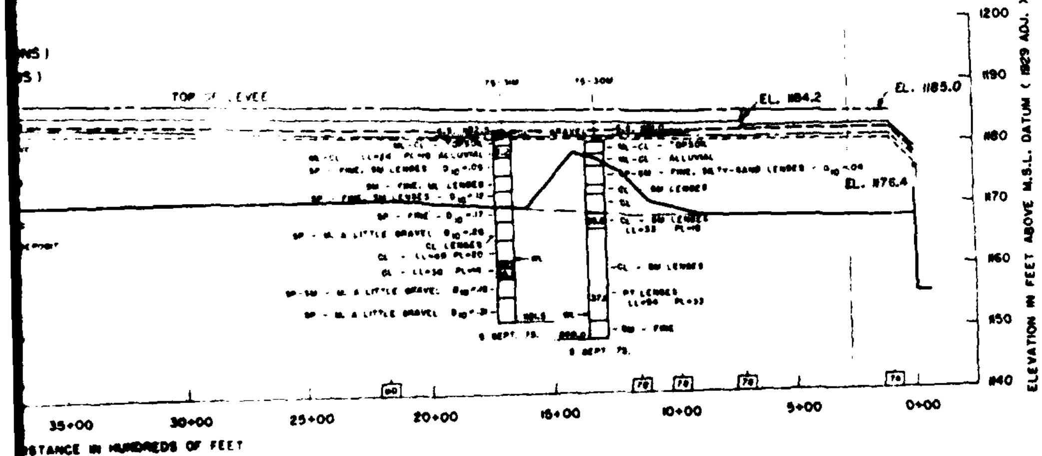


SECTION A-A (STATION 4+00)

PROPOSED RIGHT BANK LEVEE AND SERVICE ROAD



PLAN



PROFILE

BORINGS LEGEND

●	AUGER BORINGS
SP	SAND, FINE GRAINED
SM	SILTY SAND
SC	CLAYEY SAND
ML	SILT
CL	SANDY CLAY
ML-SM	SANDY SILT
ML-CL	CLAYEY SILT
OL	ORGANIC SILTS, ORG. SILTY CLAYS
MH-CL	SILTY CLAY
CH	FAT CLAY
CL-CH	MEDIUM FAT CLAY
OH	ORGANIC CLAYS
WL	WATER LEVEL
PT	PEAT
LL	LIQUID LIMIT
PL	PLASTIC LIMIT
G.S.	GROUND SURFACE ELEV. (EST.)

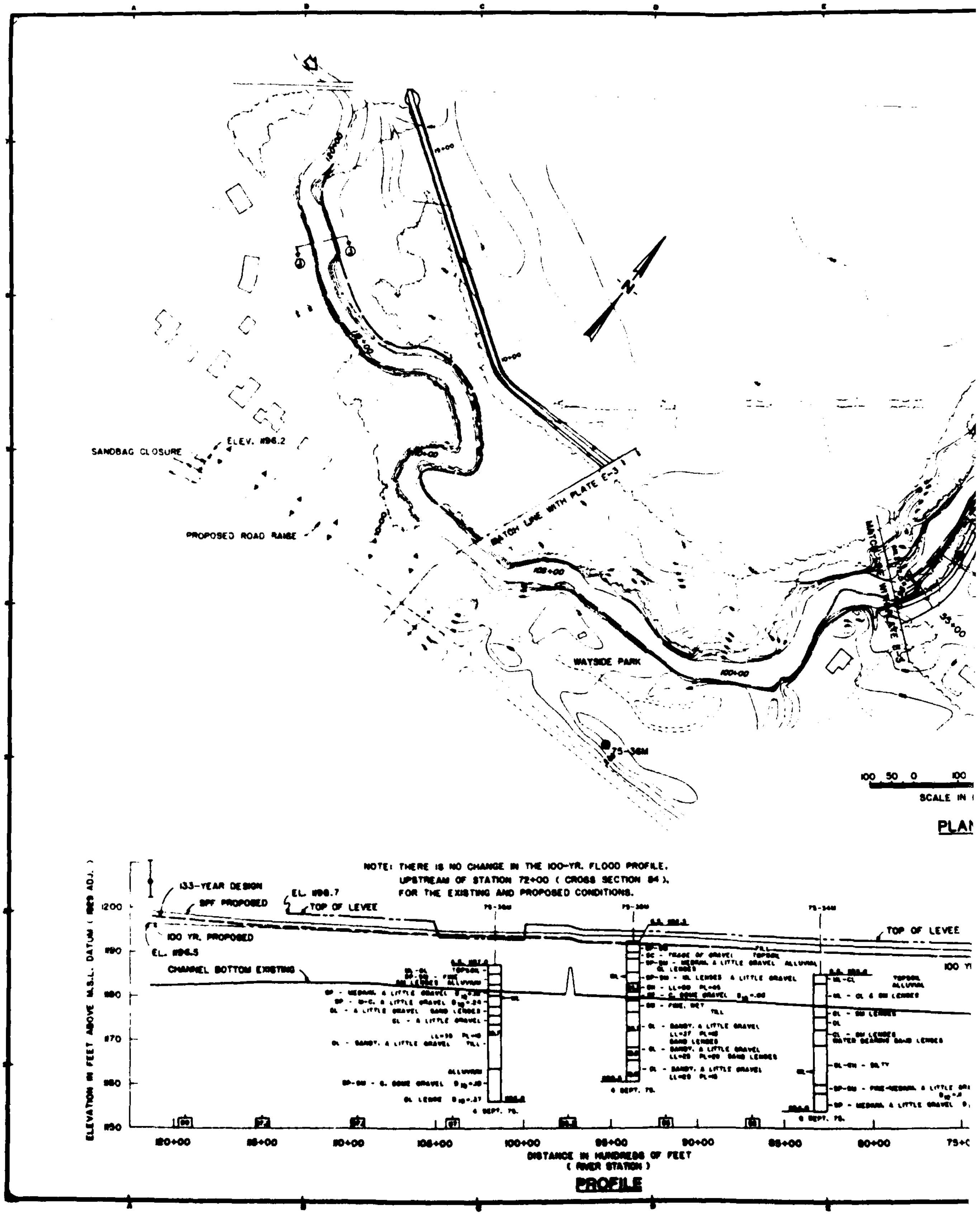
DEPARTMENT OF THE ARMY

FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

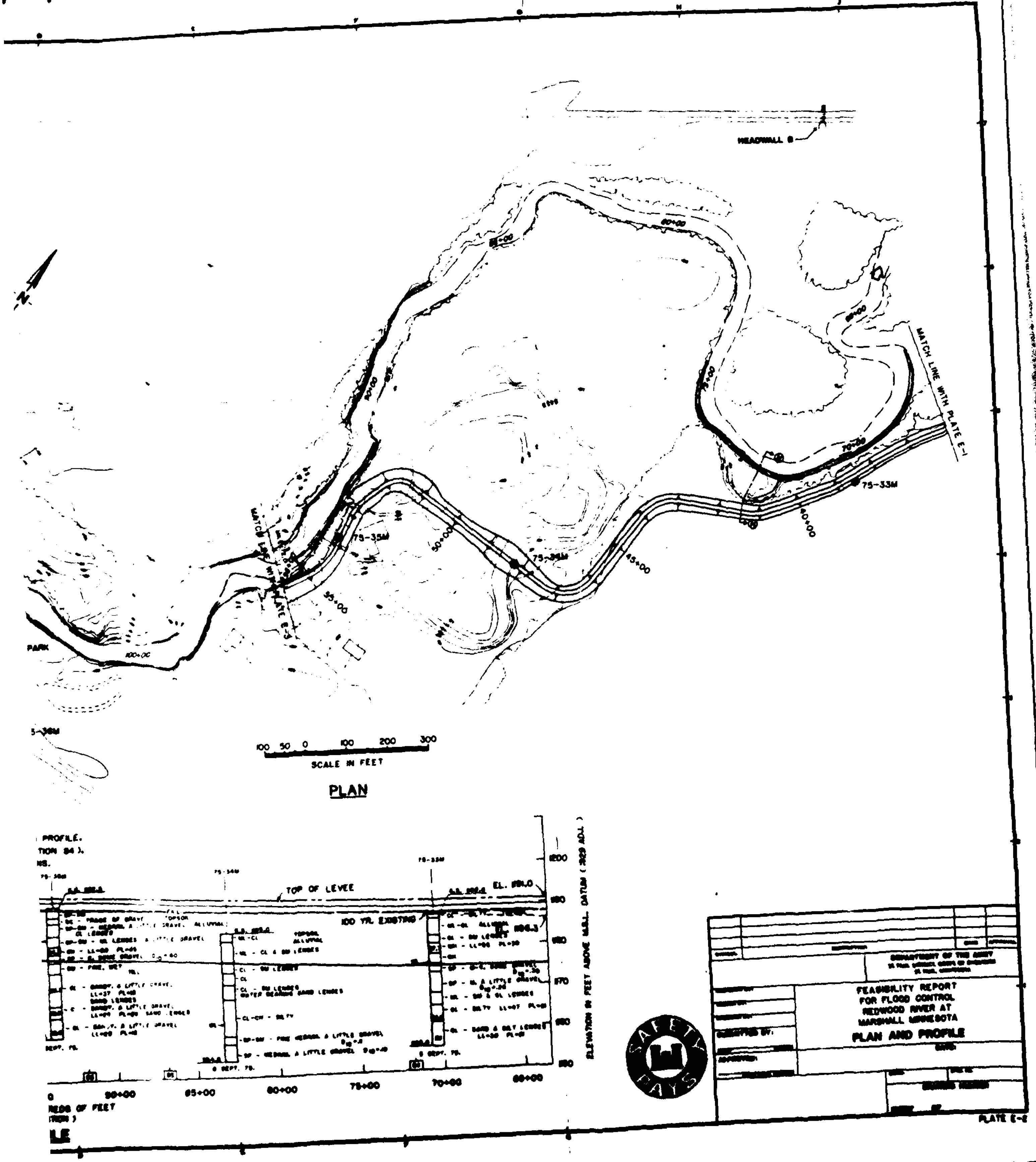
PLAN AND PROFILE

SAFETY PAYS

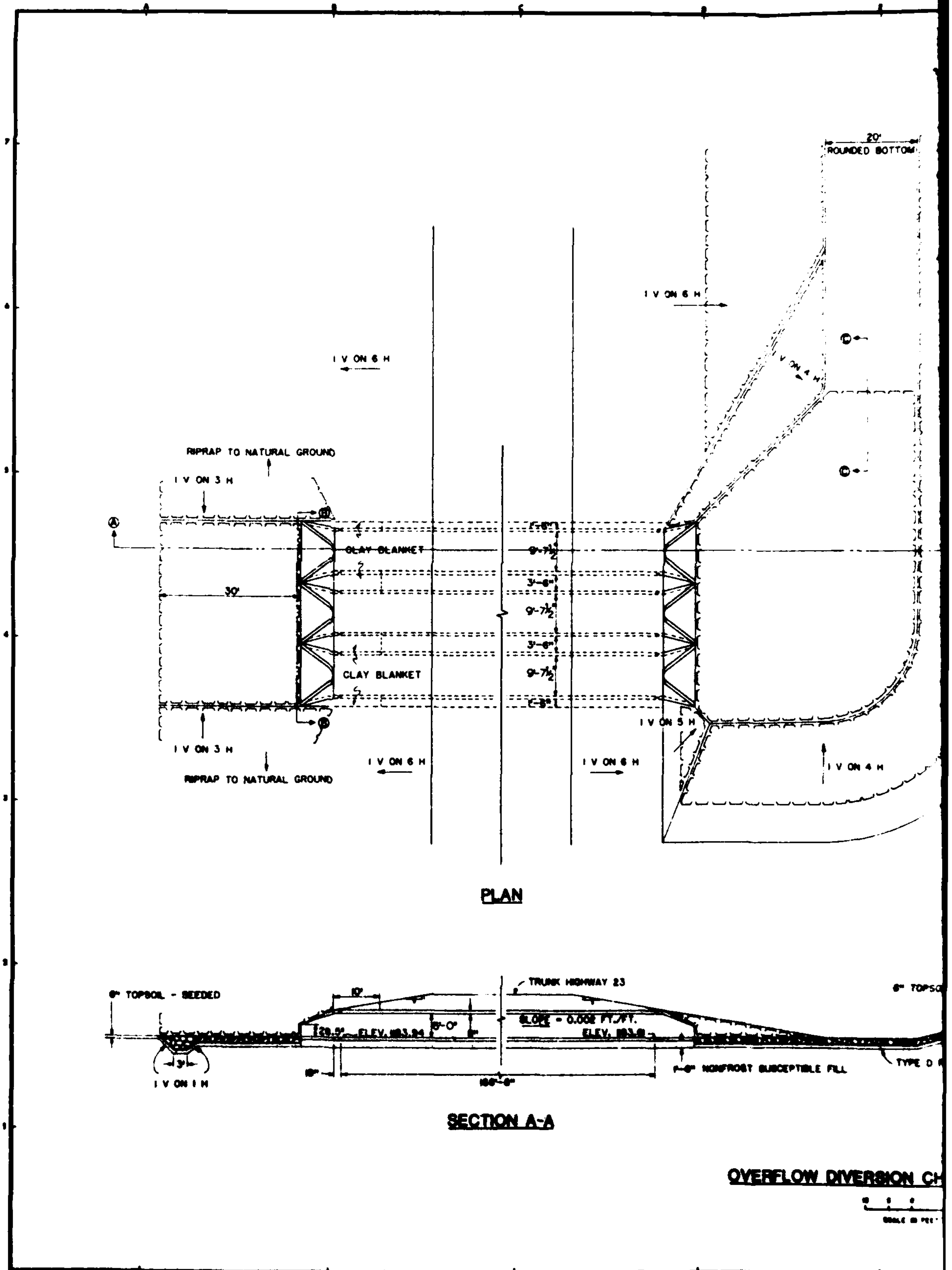
PLATE E-1

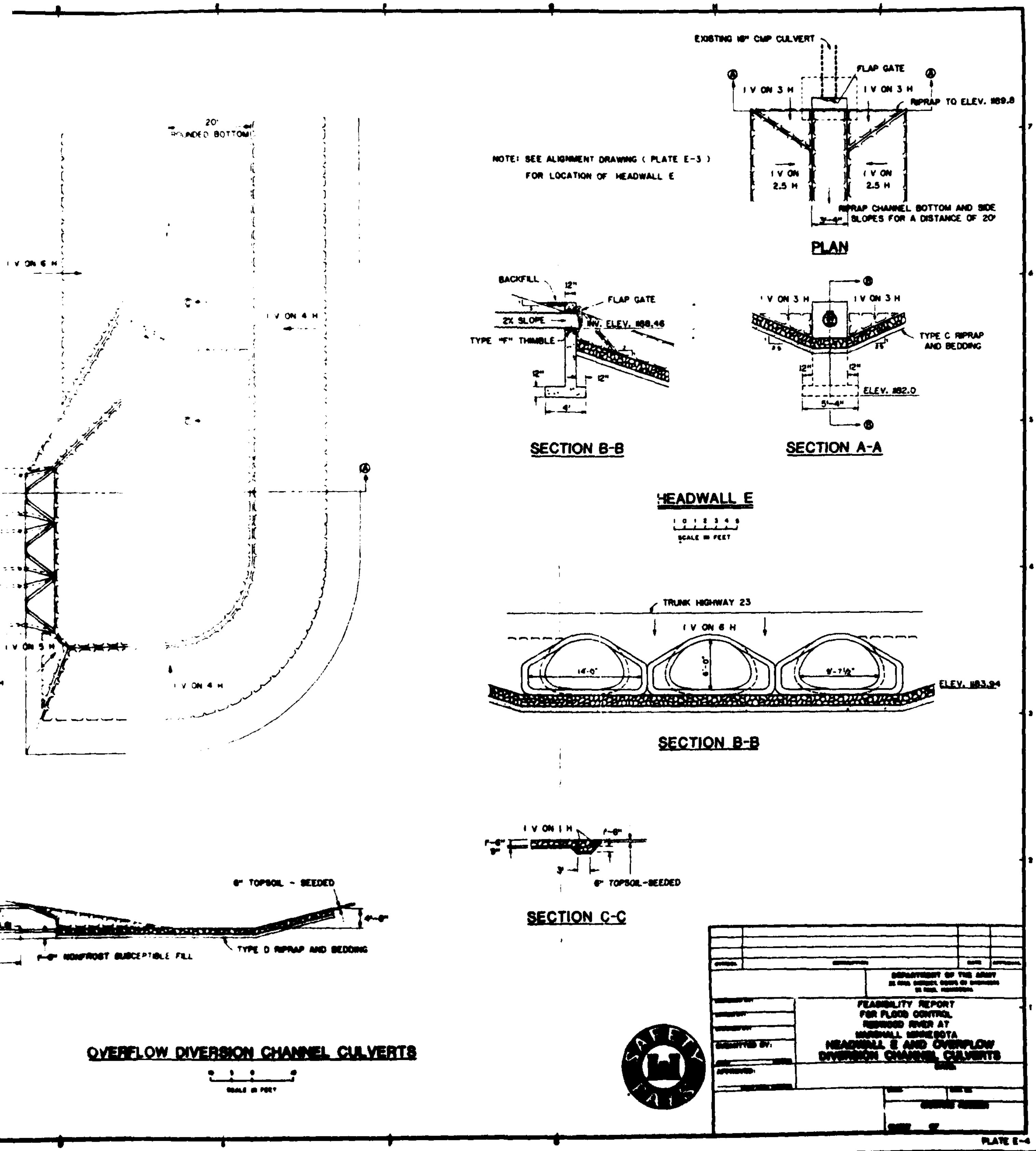


SANDBAG CLOSURE
ELEV. 1196.2
PROPOSED ROAD RAISE
MATCH LINE WITH PLATE E-3
WAYSIDE PARK
75-36M
100 50 0 100
SCALE IN
PLAN
NOTE: THERE IS NO CHANGE IN THE 100-YR. FLOOD PROFILE, UPSTREAM OF STATION 72+00 (CROSS SECTION 84), FOR THE EXISTING AND PROPOSED CONDITIONS.
133-YEAR DESIGN
SPF PROPOSED
EL. 1198.7
TOP OF LEVEE
100 YR. PROPOSED
EL. 1196.5
CHANNEL BOTTOM EXISTING
TOP OF LEVEE
ELEVATION IN FEET ABOVE M.S.L. DATUM (1929 ADJ.)
DISTANCE IN HUNDREDS OF FEET (RIVER STATION)
PROFILE



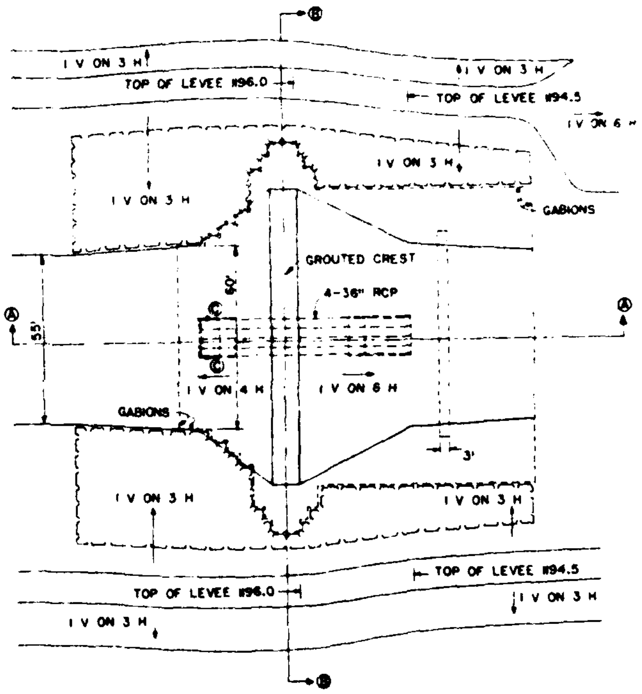
HEADWALL B
MATCH LINE WITH PLATE E-1
MATCH LINE WITH PLATE E-3
75-35M
75-33M
50+00
55+00
60+00
65+00
70+00
80+00
90+00
100+00
PARK
100 50 0 100 200 300
SCALE IN FEET
PLAN
PROFILE
TOP OF LEVEE
EL. 1190
100 YR. EXISTING
ELEVATION IN FEET ABOVE M.S.L. DATUM (1929 ADJ.)
1200
1190
1180
1170
1160
1150
90+00
85+00
80+00
75+00
70+00
65+00
DEPARTMENT OF THE ARMY
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL MINNESOTA
PLAN AND PROFILE
SAFETY PAYS
PLATE E-2


20'
ROUNDED BOTTOM
1 V ON 6 H
1 V ON 4 H
1 V ON 6 H
RIPRAP TO NATURAL GROUND
1 V ON 3 H
CLAY BLANKET
30'
3'-6"
9'-7½"
CLAY BLANKET
1 V ON 5 H
1 V ON 3 H
1 V ON 6 H
1 V ON 6 H
1 V ON 4 H
RIPRAP TO NATURAL GROUND
PLAN
TRUNK HIGHWAY 23
6" TOPSOIL - SEEDED
10'
SLOPE = 0.002 FT./FT.
ELEV. 183.94
ELEV. 183.61
8'-0"
3'
1 V ON 1 H
1'-6" NONFROST SUSCEPTIBLE FILL
SECTION A-A
OVERFLOW DIVERSION CH

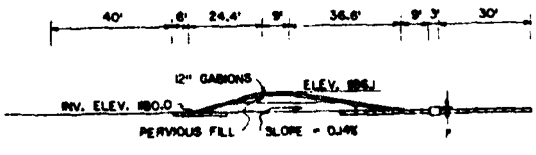


EXISTING 18" CMP CULVERT
FLAP GATE
1 V ON 3 H
1 V ON 3 H
RIPRAP TO ELEV. 869.8
1 V ON 2.5 H
1 V ON 2.5 H
RIPRAP CHANNEL BOTTOM AND SIDE SLOPES FOR A DISTANCE OF 20'
3'-4"
PLAN
NOTE: SEE ALIGNMENT DRAWING (PLATE E-3) FOR LOCATION OF HEADWALL E
BACKFILL
12"
FLAP GATE
2% SLOPE
INV. ELEV. 868.46
TYPE "F" THIMBLE
12"
12"
4'
SECTION B-B
1 V ON 3 H
1 V ON 3 H
TYPE C RIPRAP AND BEDDING
12"
12"
ELEV. 862.0
5'-4"
SECTION A-A
HEADWALL E
SCALE IN FEET
TRUNK HIGHWAY 23
1 V ON 6 H
14'-0"
9'-7½"
ELEV. 863.94
SECTION B-B
1 V ON 1 H
1'-6"
9"
3'
6" TOPSOIL-SEEDED
SECTION C-C
20'
ROUNDED BOTTOM
1 V ON 6 H
1 V ON 4 H
1 V ON 5 H
1 V ON 4 H
6" TOPSOIL - SEEDED
4'-0"
1'-0" NONFROST SUSCEPTIBLE FILL
TYPE D RIPRAP AND BEDDING
OVERFLOW DIVERSION CHANNEL CULVERTS
SCALE IN FEET
SAFETY PAYS
DEPARTMENT OF THE ARMY
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA
HEADWALL E AND OVERFLOW
DIVERSION CHANNEL CULVERTS
SUBMITTED BY:
APPROVED:

PLATE E-4

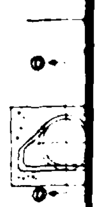


PLAN



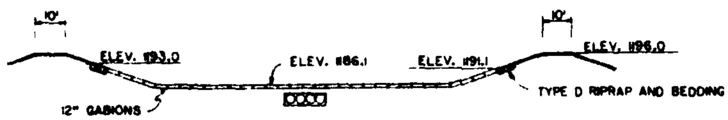
SECTION A-A

SCALE IN FEET



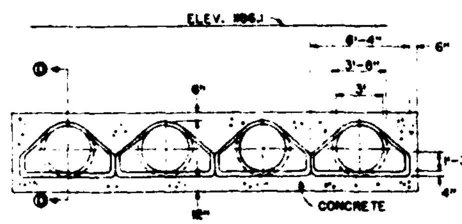
NOTE: OUTL

GABION DROP STRUCTU



SECTION B-B

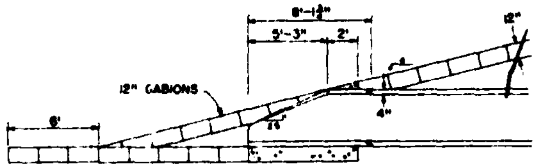
SCALE IN FEET



SECTION C-C

NOTE: OUTLET WOULD BE SIMILAR TO SECTION C-C

SCALE IN FEET



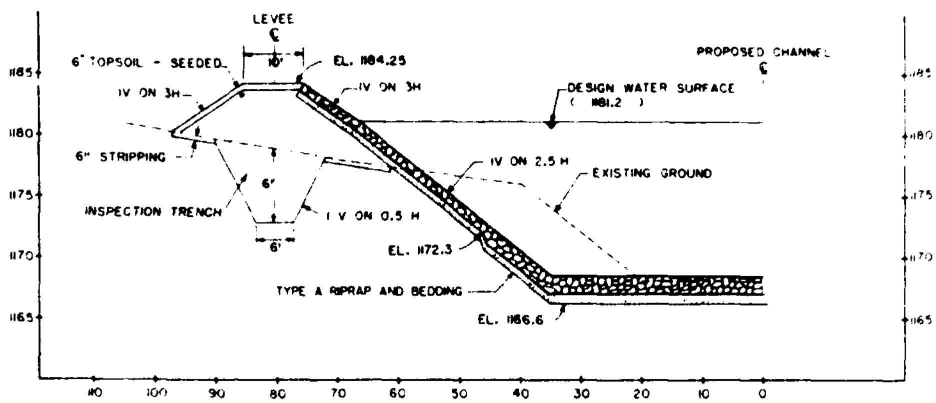
SECTION D-D

GABION DROP STRUCTURE

DEPARTMENT OF THE ARMY

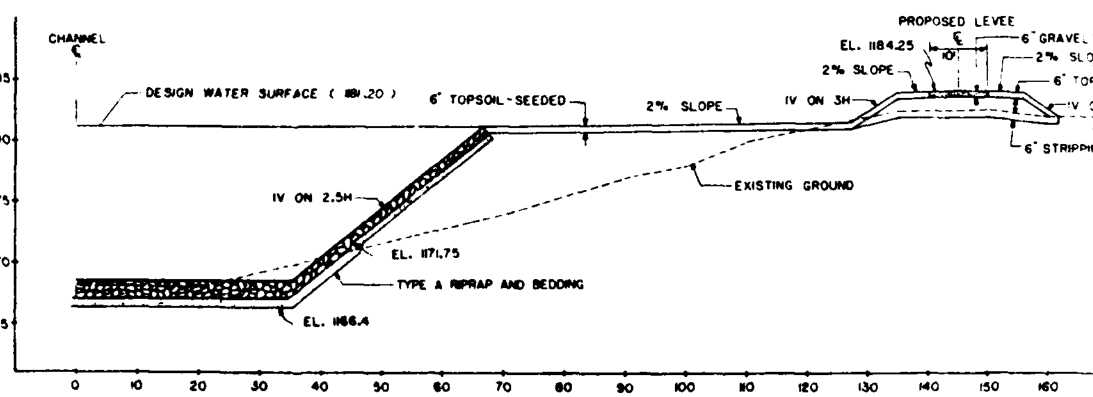
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL MINNESOTA
GABION DROP STRUCTURE

PLATE E-5



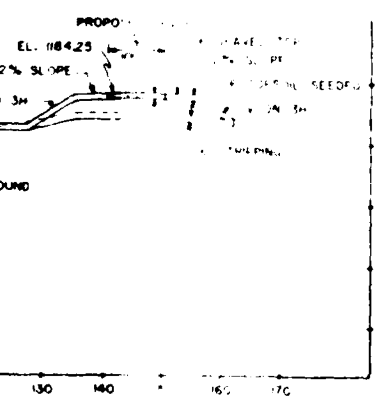
SECTION B-B (RIVER STATION 8+70)

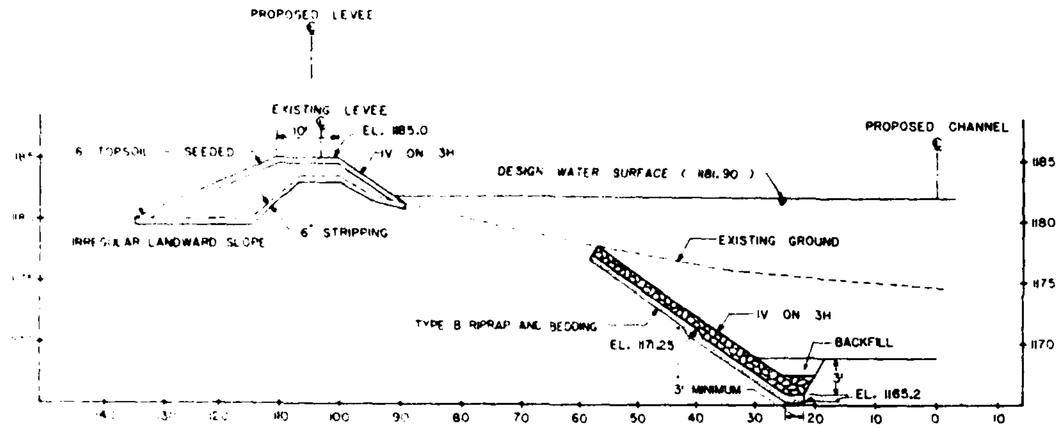
PROPOSED CHANNEL AND LEFT BANK LEVEE



SECTION C-C (RIVER STATION 8+70)

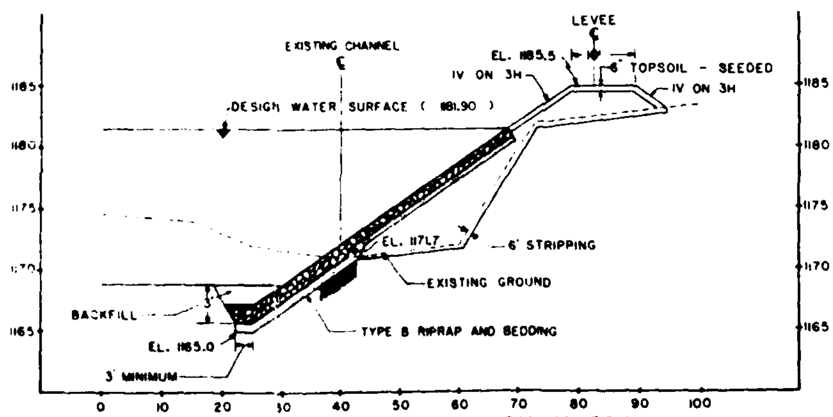
PROPOSED CHANNEL AND RIGHT BANK LEVEE AND SERVICE ROAD





SECTION D-D (RIVER STATION *11+50*)

PROPOSED CHANNEL AND LEFT BANK



SECTION E-E (RIVER STATION *11+22*)

PROPOSED CHANNEL AND RIGHT BANK

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

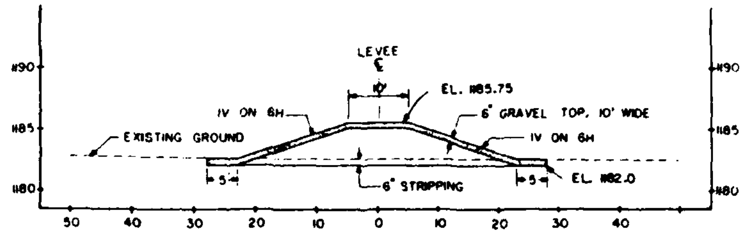
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL MINNESOTA

TYPICAL CROSS-SECTIONS

SUBMITTED BY:

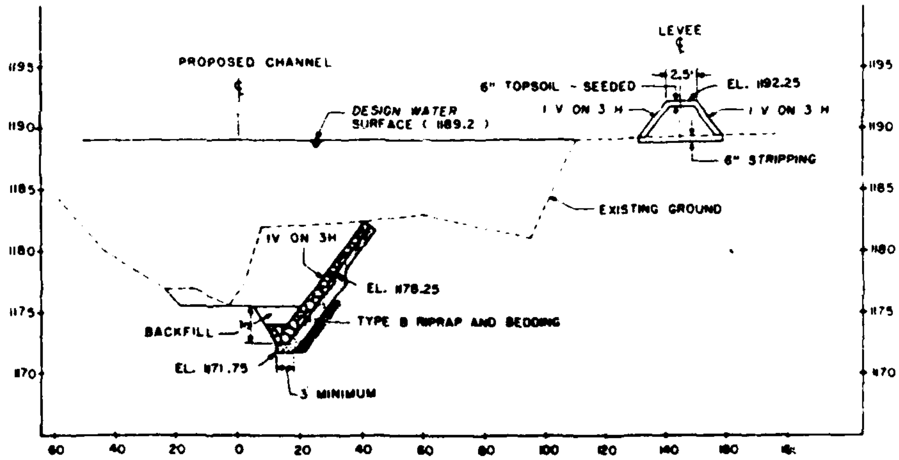
APPROVED:

PLATE E-6



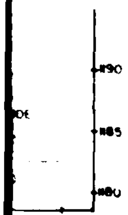
SECTION F-F (STATION 17+00)

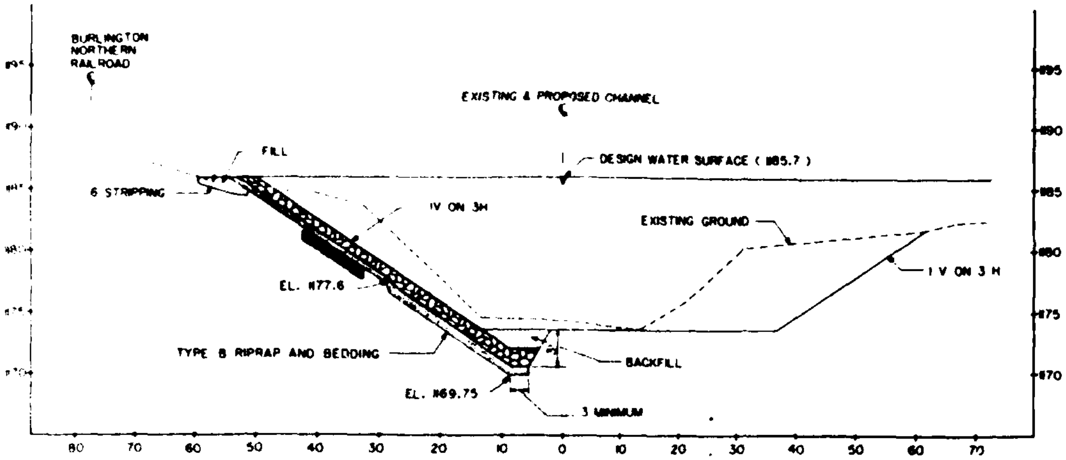
PROPOSED ROADWAY ACROSS RIGHT BANK LEVEE



SECTION H-H (RIVER STATION 72+50)

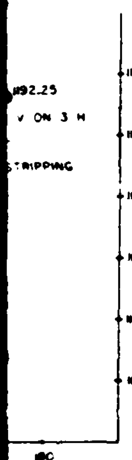
PROPOSED CHANNEL AND RIGHT BANK LEVEE

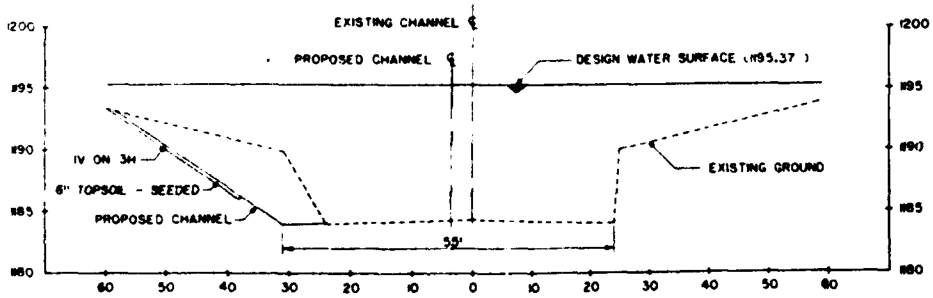




SECTION G-G (RIVER STATION 49+35)

PROPOSED CHANNEL





SECTION J-J (RIVER STATION 117+50)

PROPOSED CHANNEL

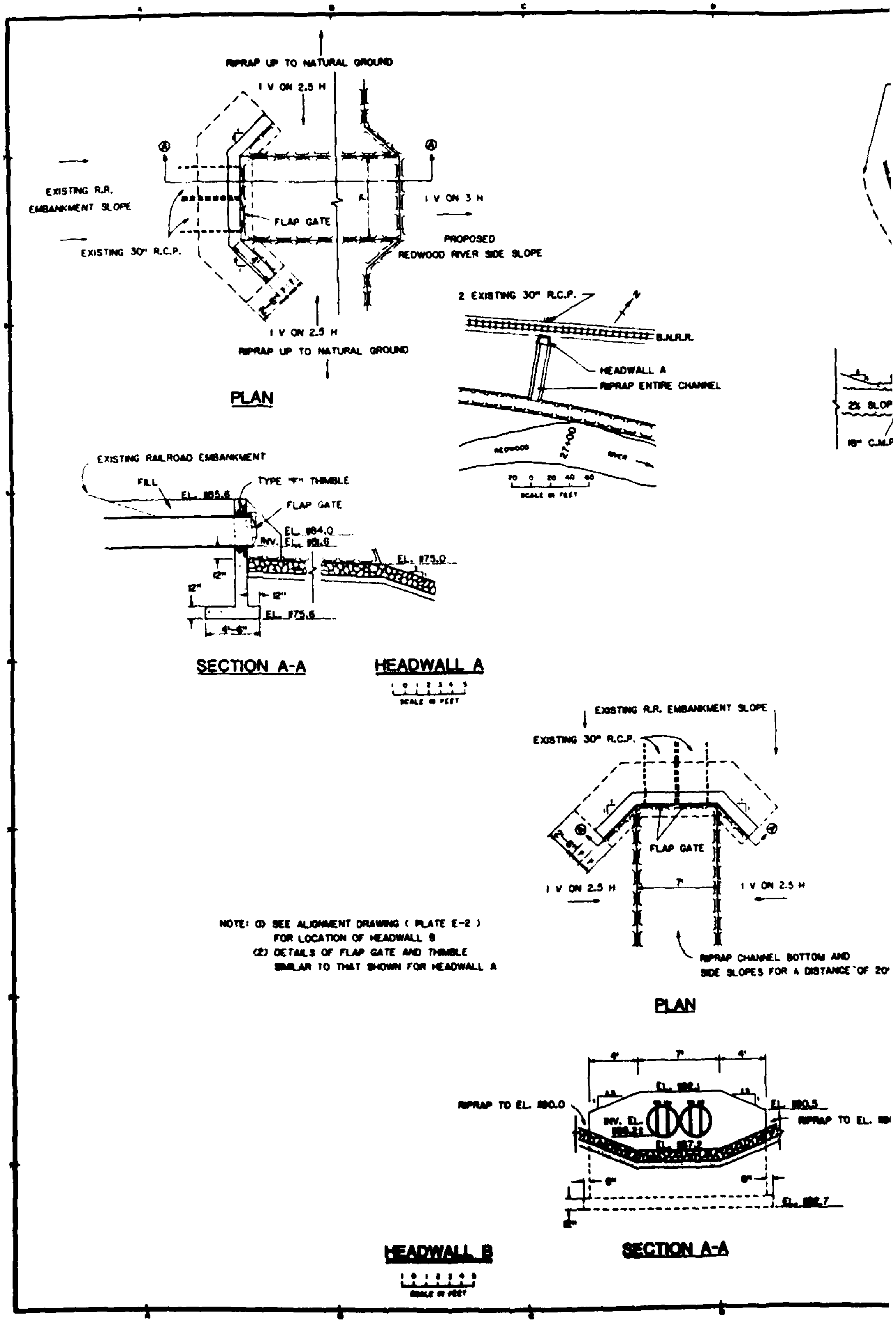
DEPARTMENT OF THE ARMY

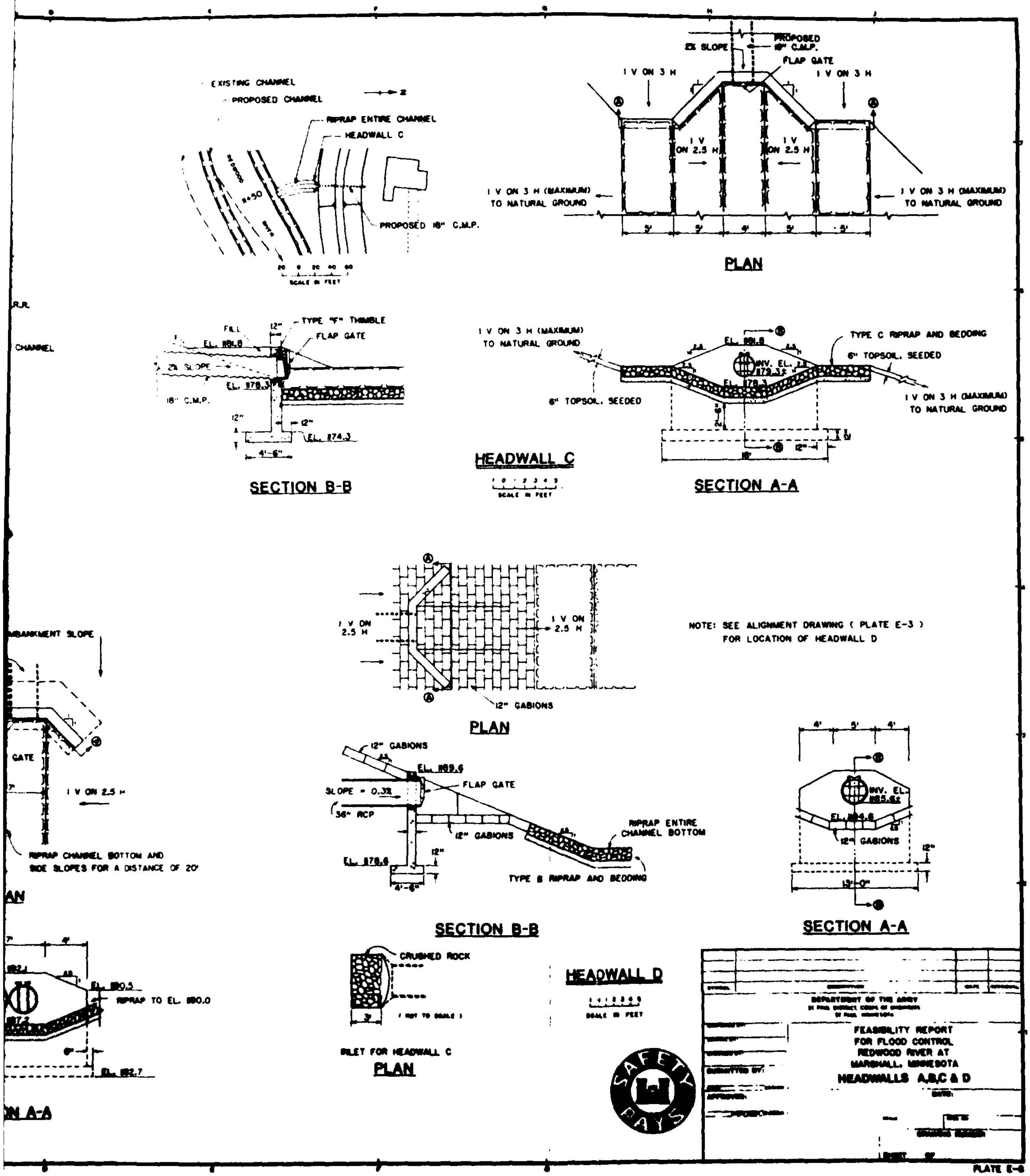
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL MINNESOTA

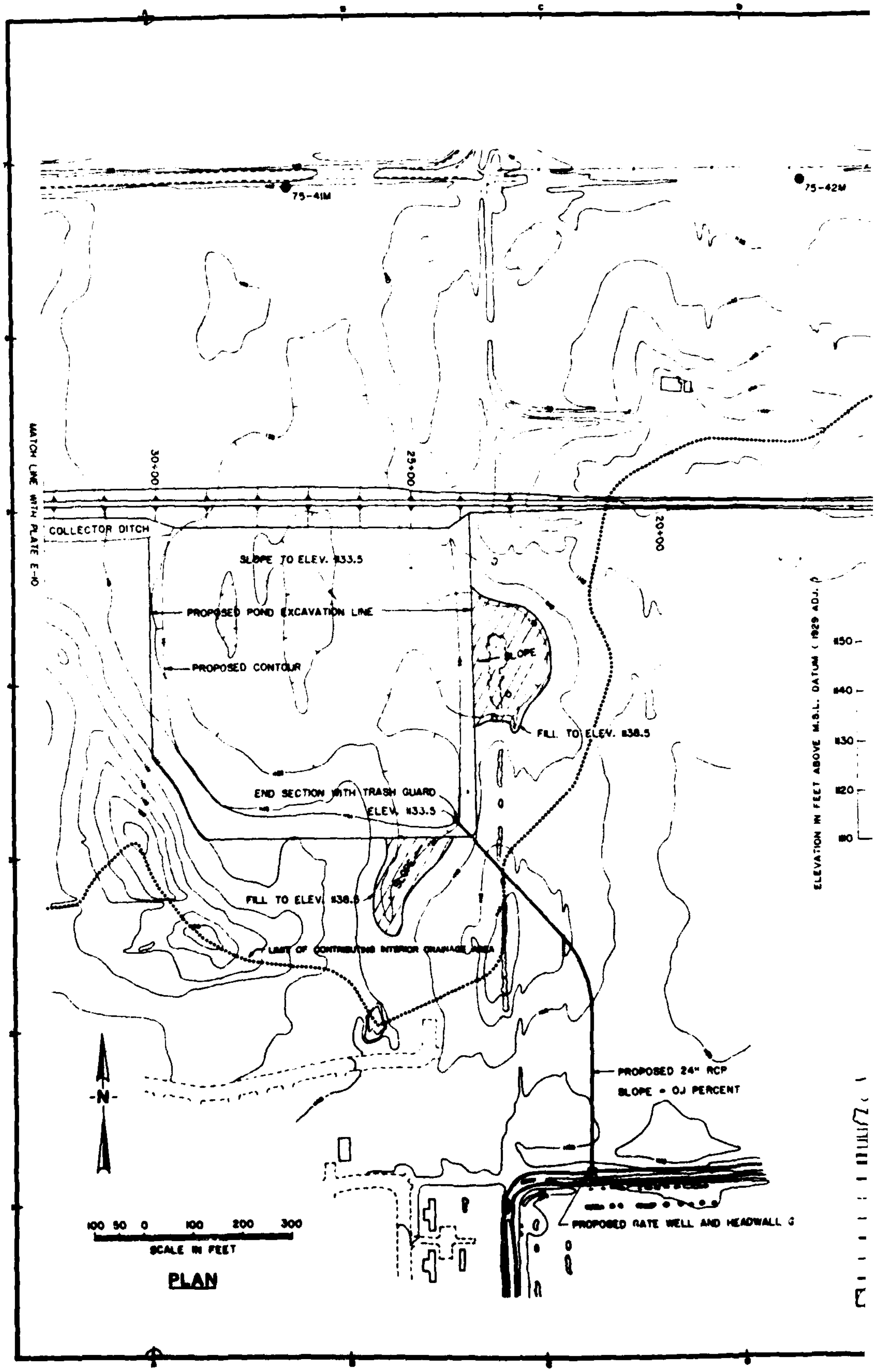
TYPICAL CROSS-SECTIONS

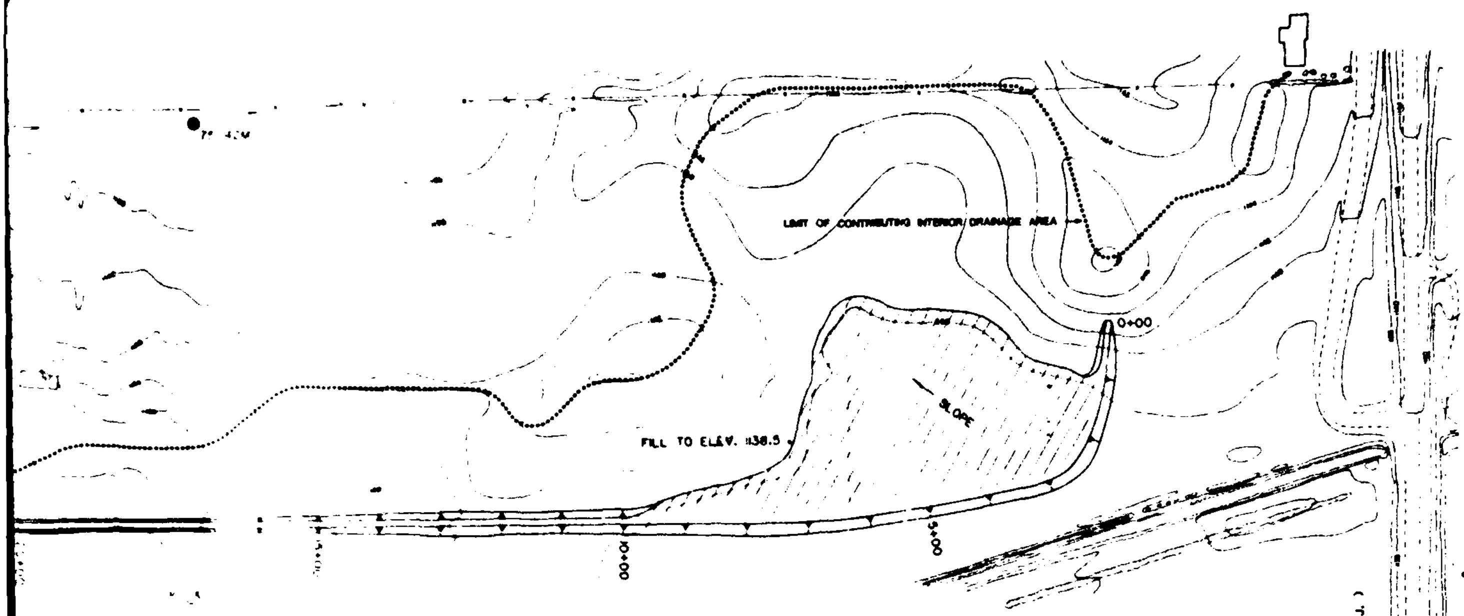
SAFETY PAYS

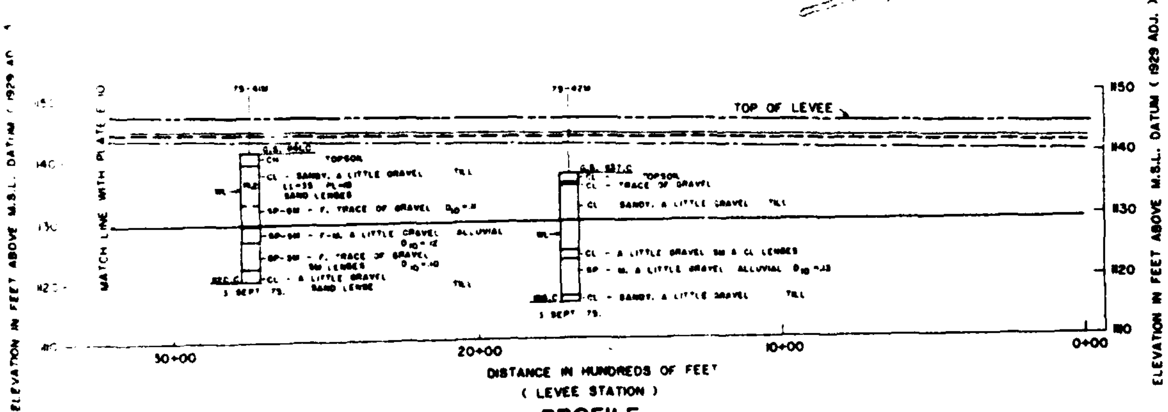
PLATE E-7


RIPRAP UP TO NATURAL GROUND
1 V ON 2.5 H
EXISTING R.R. EMBANKMENT SLOPE
FLAP GATE
1 V ON 3 H
EXISTING 30" R.C.P.
PROPOSED REDWOOD RIVER SIDE SLOPE
1 V ON 2.5 H
RIPRAP UP TO NATURAL GROUND
PLAN
2 EXISTING 30" R.C.P.
B.N.R.R.
HEADWALL A
RIPRAP ENTIRE CHANNEL
REDWOOD
RIVER
27+00
SCALE IN FEET
EXISTING RAILROAD EMBANKMENT
FILL
EL. 885.6
TYPE "F" THIMBLE
FLAP GATE
EL. 884.0
INV. EL. 881.6
EL. 875.0
12"
12"
12"
EL. 875.6
4'-6"
SECTION A-A
HEADWALL A
SCALE IN FEET
EXISTING R.R. EMBANKMENT SLOPE
EXISTING 30" R.C.P.
FLAP GATE
1 V ON 2.5 H
7'
1 V ON 2.5 H
RIPRAP CHANNEL BOTTOM AND SIDE SLOPES FOR A DISTANCE OF 20'
PLAN
NOTE: (1) SEE ALIGNMENT DRAWING (PLATE E-2) FOR LOCATION OF HEADWALL B
(2) DETAILS OF FLAP GATE AND THIMBLE SIMILAR TO THAT SHOWN FOR HEADWALL A
4'
7'
4'
RIPRAP TO EL. 890.0
INV. EL.
EL. 890.5
6"
6"
HEADWALL B
SCALE IN FEET
SECTION A-A
2% SLOP
18" C.M.P


EXISTING CHANNEL
PROPOSED CHANNEL
RIPRAP ENTIRE CHANNEL
HEADWALL C
PROPOSED 18" C.M.P.
SCALE IN FEET
2% SLOPE
PROPOSED 18" C.M.P.
FLAP GATE
1 V ON 3 H
1 V ON 2.5 H
1 V ON 3 H (MAXIMUM) TO NATURAL GROUND
PLAN
R.R.
CHANNEL
FILL
TYPE "F" THIMBLE
FLAP GATE
EL. 881.6
2% SLOPE
EL. 879.3
18" C.M.P.
EL. 874.3
4'-6"
SECTION B-B
HEADWALL C
SCALE IN FEET
TYPE C RIPRAP AND BEDDING
6" TOPSOIL, SEEDED
INV. EL. 879.32
EL. 878.3
SECTION A-A
EMBANKMENT SLOPE
GATE
1 V ON 2.5 H
RIPRAP CHANNEL BOTTOM AND SIDE SLOPES FOR A DISTANCE OF 20'
AN
EL. 890.5
RIPRAP TO EL. 890.0
EL. 882.7
ON A-A
12" GABIONS
PLAN
NOTE: SEE ALIGNMENT DRAWING (PLATE E-3) FOR LOCATION OF HEADWALL D
12" GABIONS
EL. 889.6
FLAP GATE
SLOPE = 0.3%
36" RCP
RIPRAP ENTIRE CHANNEL BOTTOM
EL. 878.6
4'-6"
TYPE B RIPRAP AND BEDDING
SECTION B-B
INV. EL. 885.62
EL. 884.6
12" GABIONS
13'-0"
SECTION A-A
CRUSHED ROCK
(NOT TO SCALE)
INLET FOR HEADWALL C
PLAN
HEADWALL D
SCALE IN FEET
SAFETY PAYS
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA
HEADWALLS A,B,C & D
SUBMITTED BY:
APPROVED:
DRAWING NUMBER
SHEET OF
PLATE E-6


75-41M
75-42M
MATCH LINE WITH PLATE E-10
30+00
25+00
20+00
COLLECTOR DITCH
SLOPE TO ELEV. 33.5
PROPOSED POND EXCAVATION LINE
PROPOSED CONTOUR
SLOPE
FILL TO ELEV. 38.5
END SECTION WITH TRASH GUARD
ELEV. 33.5
FILL TO ELEV. 38.5
LIMIT OF CONTRIBUTING INTERIOR DRAINAGE AREA
PROPOSED 24" RCP
SLOPE = 0.1 PERCENT
PROPOSED GATE WELL AND HEADWALL
-N-
100 50 0 100 200 300
SCALE IN FEET
PLAN
ELEVATION IN FEET ABOVE M.S.L. DATUM (1929 ADJ.)
50
40
30
20
10
0





PROFILE

BORINGS LEGEND

●	AUGER BORINGS
SP	SAND, FINE GRAINED
SM	SILTY SAND
SC	CLAYEY SAND
ML	SILT
CL	SANDY CLAY
ML-SM	SANDY SILT
ML-CL	CLAYEY SILT
OL	ORGANIC SILTS, ORG. SILTY CLAYS
MH-CL	SILTY CLAY
CH	FAT CLAY
CL-CH	MEDIUM FAT CLAY
OH	ORGANIC CLAYS
WL	WATER LEVEL
PT	PEAT
LL	LIQUID LIMIT
PL	PLASTIC LIMIT
G.S.	GROUND SURFACE ELEV. (EST.)

GENERAL LEGEND

- SHORE LINE
- EXISTING CONTOURS
- WOODED AREAS
- LEVEE
- RIPRAP IN PLAN
- PROPOSED CHANNEL WIDENING
- 100 YR. EXISTING CONDITIONS
- 100 YR. PROPOSED CONDITIONS
- 133 YR. DESIGN CONDITIONS
- SPF PROPOSED CONDITIONS
- CHANNEL BOTTOM
- SPOIL DISPOSAL

ED 24" RCP
- 0.1 PERCENT
WELL AND HEADWALL 6

SAFETY PAYS

DEPARTMENT OF THE ARMY

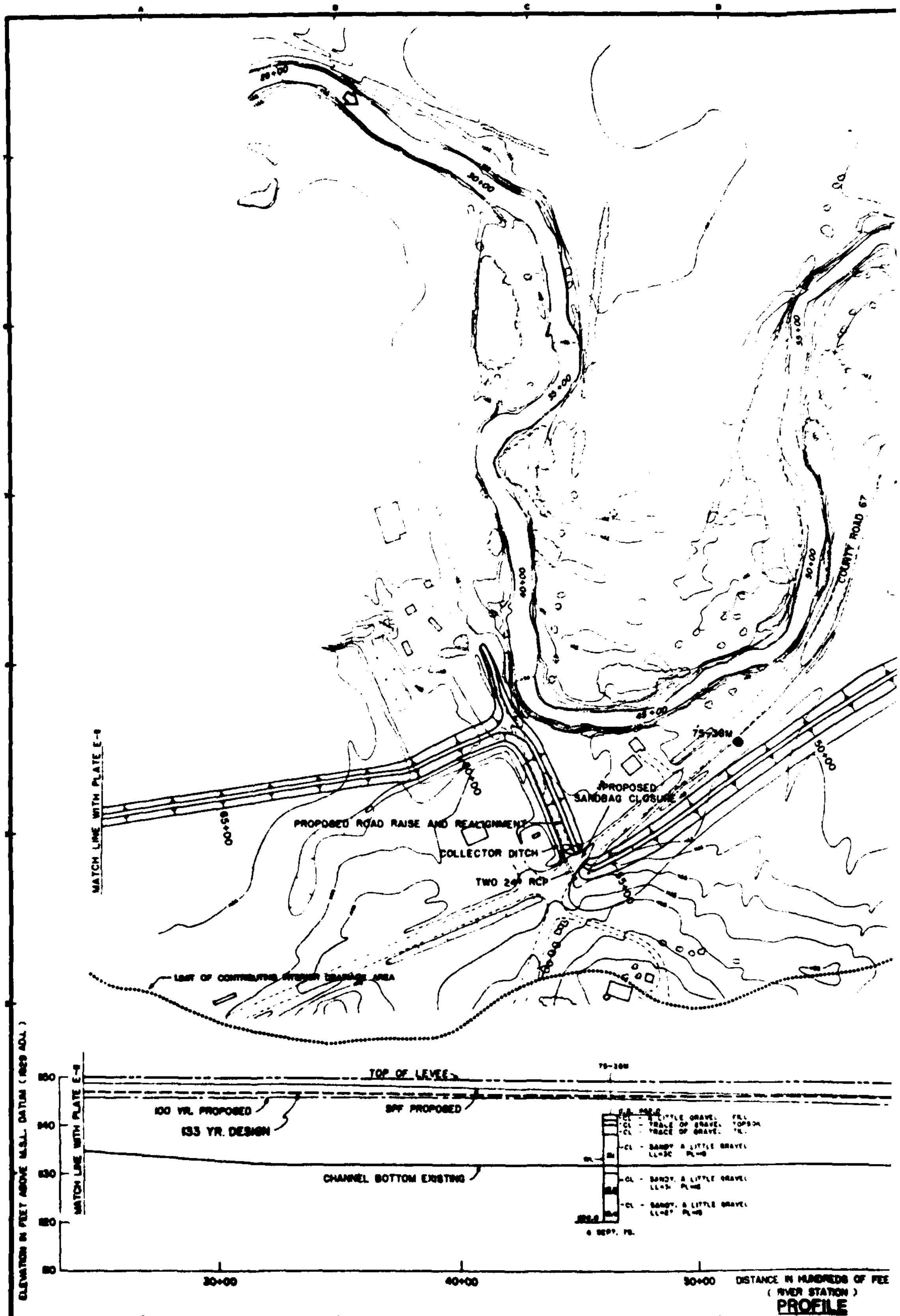
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

PLAN AND PROFILE

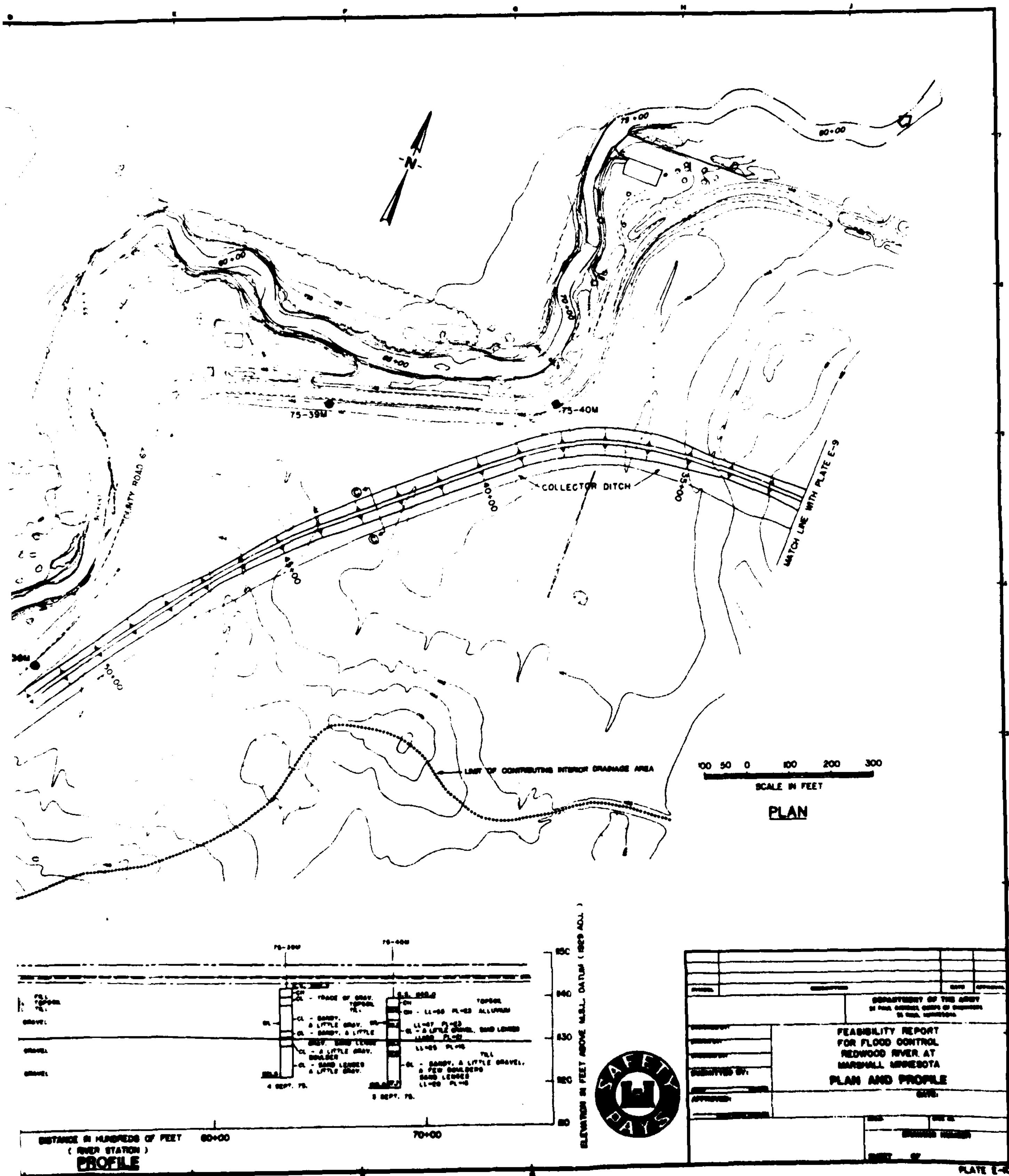
SUBMITTED BY:

APPROVED:

PLATE E-9

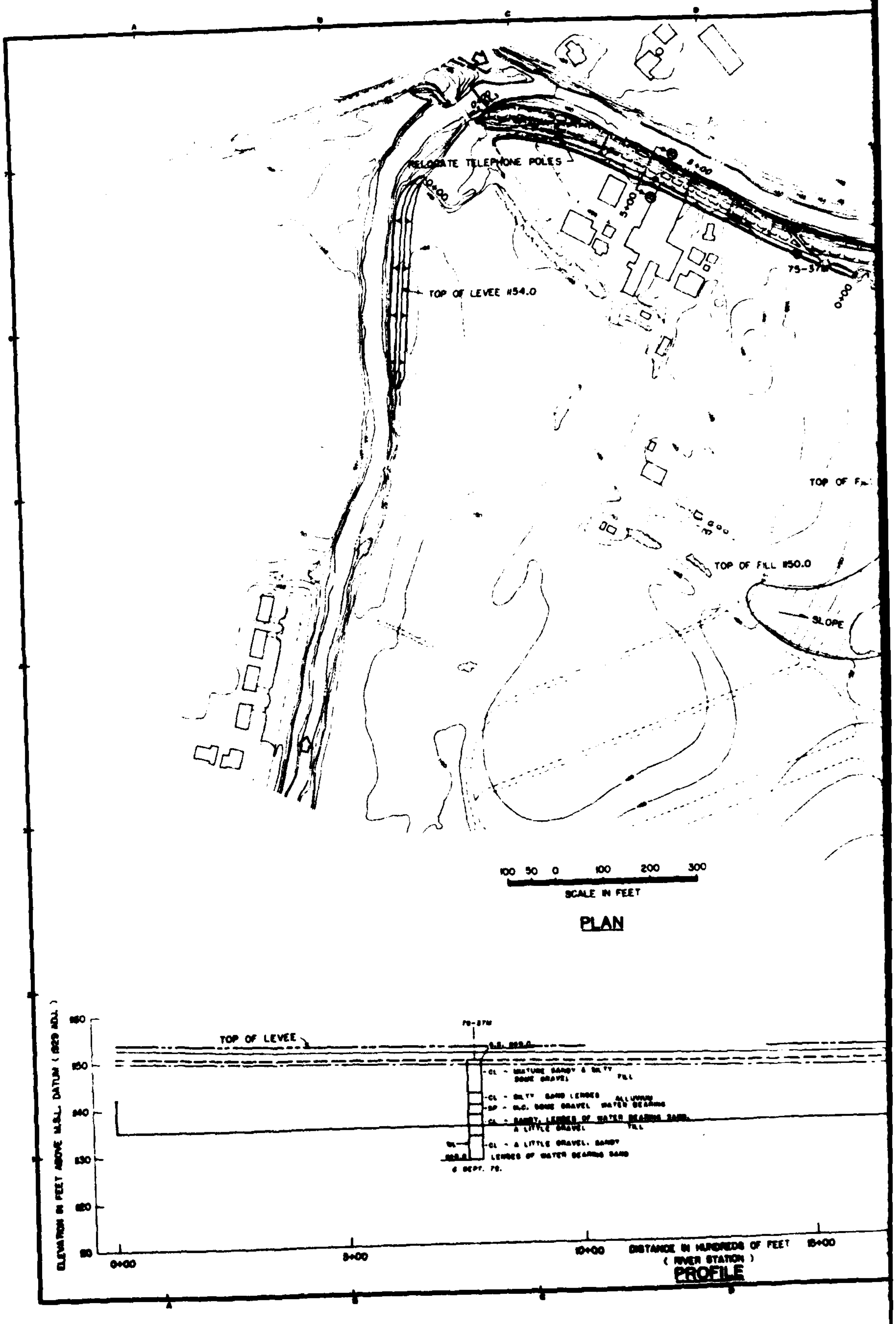


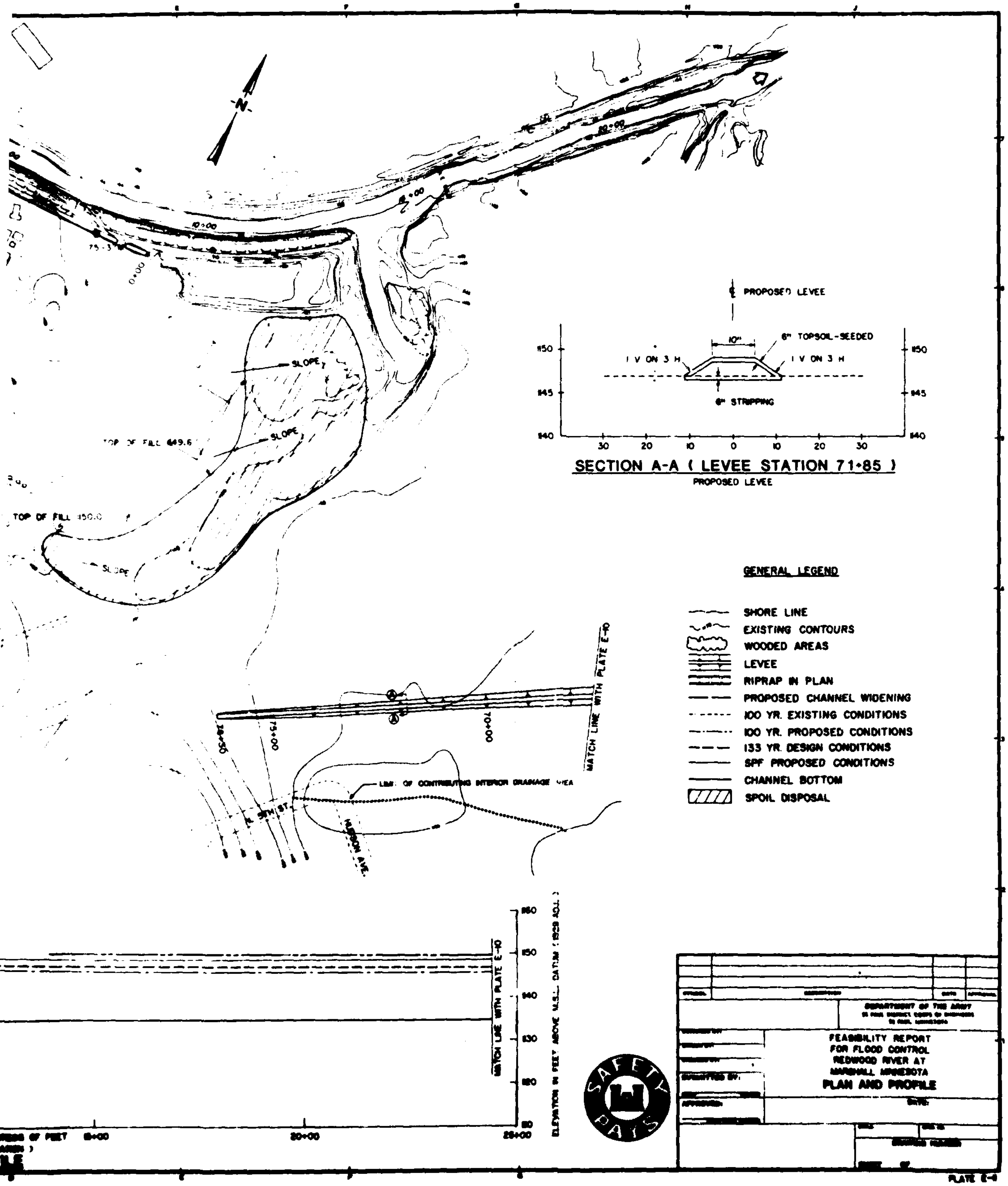
MATCH LINE WITH PLATE E-8
COUNTY ROAD 67
PROPOSED SANDBAG CLOSURE
PROPOSED ROAD RAISE AND REALIGNMENT
COLLECTOR DITCH
TWO 24" RCP
LIMIT OF CONTRIBUTING INTERIOR DRAINAGE AREA
TOP OF LEVEE
100 YR. PROPOSED
133 YR. DESIGN
SPF PROPOSED
CHANNEL BOTTOM EXISTING
ELEVATION IN FEET ABOVE M.S.L. DATUM (1929 ADJ.)
30+00
40+00
50+00
DISTANCE IN HUNDREDS OF FEE
(RIVER STATION)
PROFILE



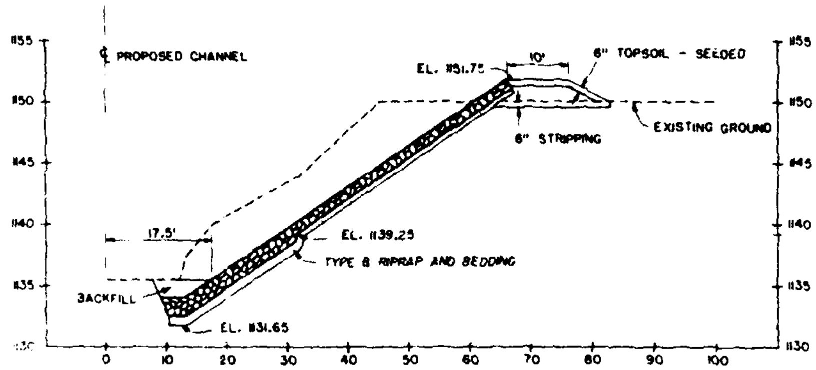
N
75+00
80+00
85+00
90+00
75-39M
75-40M
COUNTY ROAD 67
COLLECTOR DITCH
35+00
40+00
45+00
50+00
MATCH LINE WITH PLATE E-9
LIMIT OF CONTRIBUTING INTERIOR DRAINAGE AREA
100 50 0 100 200 300
SCALE IN FEET
PLAN
75-39M
75-40M
850
840
830
820
810
4 SEPT. 75.
5 SEPT. 75.
ELEVATION IN FEET ABOVE M.S.L. DATUM (1929 ADJ.)
DISTANCE IN HUNDREDS OF FEET 60+00 70+00
(RIVER STATION)
PROFILE
SAFETY PAYS
DEPARTMENT OF THE ARMY
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL MINNESOTA
PLAN AND PROFILE
SUBMITTED BY:

PLATE E-10


RELOCATE TELEPHONE POLES
TOP OF LEVEE #54.0
75-37M
TOP OF FILL #50.0
SLOPE
100 50 0 100 200 300
SCALE IN FEET
PLAN
ELEVATION IN FEET ABOVE M.S.L. DATUM (1929 ADJ.)
TOP OF LEVEE
CL - A LITTLE GRAVEL, SANDY
LENSES OF WATER BEARING SAND
0+00
5+00
10+00
15+00
DISTANCE IN HUNDREDS OF FEET
(RIVER STATION)
PROFILE

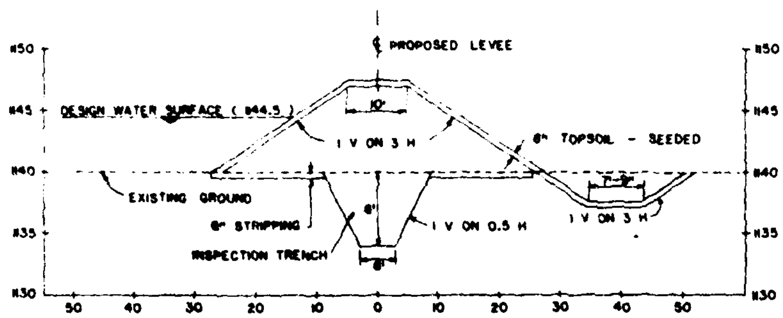


N
TOP OF FILL 849.6
SLOPE
TOP OF FILL 850.0
PROPOSED LEVEE
10'
6" TOPSOIL-SEEDED
1 V ON 3 H
1 V ON 3 H
6" STRIPPING
850
845
840
30
20
10
0
10
20
30
SECTION A-A (LEVEE STATION 71+85)
PROPOSED LEVEE
GENERAL LEGEND
SHORE LINE
EXISTING CONTOURS
WOODED AREAS
LEVEE
RIPRAP IN PLAN
PROPOSED CHANNEL WIDENING
100 YR. EXISTING CONDITIONS
100 YR. PROPOSED CONDITIONS
133 YR. DESIGN CONDITIONS
SPF PROPOSED CONDITIONS
CHANNEL BOTTOM
SPOIL DISPOSAL
MATCH LINE WITH PLATE E-10
75+00
70+00
HUDSON AVE.
MATCH LINE WITH PLATE E-10
ELEVATION IN FEET ABOVE M.S.L. DATUM (1929 ADJ.)
20+00
25+00
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL MINNESOTA
PLAN AND PROFILE



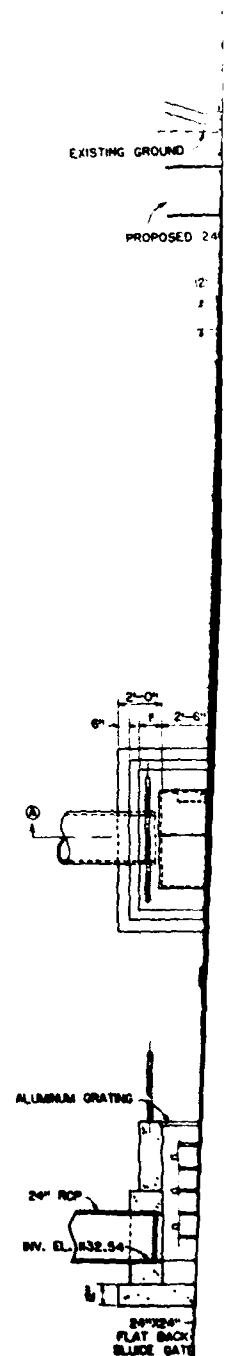
SECTION B-B (RIVER STATION 4+00)

PROPOSED CHANNEL WIDENING

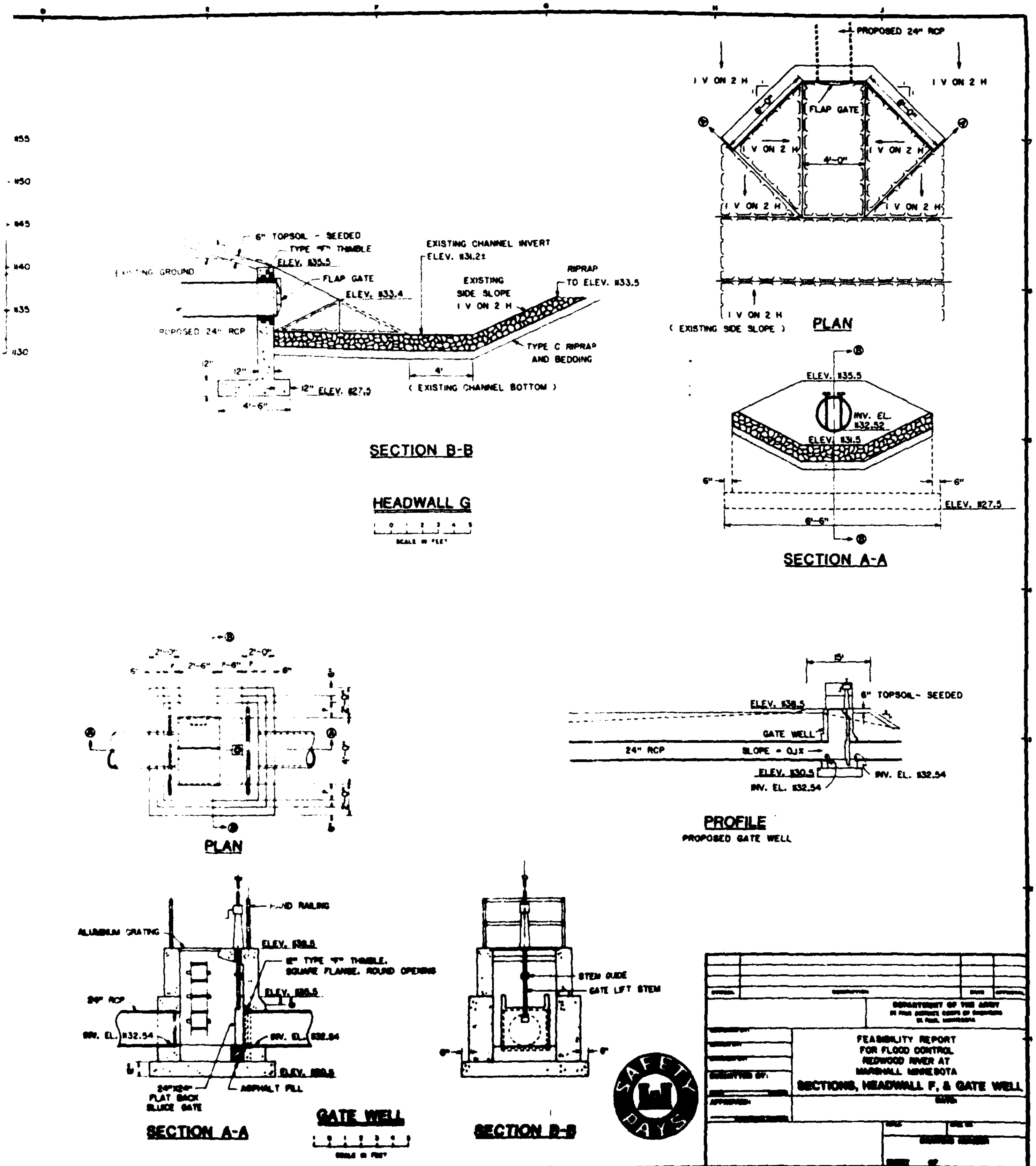


SECTION C-C (LEVEE STATION 42+60)

PROPOSED LEVEE AND COLLECTOR DITCH



SECTIO



PROPOSED 24" RCP
1 V ON 2 H
FLAP GATE
4'-0"
(EXISTING SIDE SLOPE)
PLAN
6" TOPSOIL - SEEDED
TYPE "F" THIMBLE
ELEV. 835.5
EXISTING GROUND
FLAP GATE
ELEV. 833.4
EXISTING CHANNEL INVERT
ELEV. 831.2±
EXISTING
SIDE SLOPE
1 V ON 2 H
RIPRAP
TO ELEV. 833.5
PROPOSED 24" RCP
TYPE C RIPRAP
AND BEDDING
12" ELEV. 827.5
4'-6"
(EXISTING CHANNEL BOTTOM)
SECTION B-B
HEADWALL G
SCALE IN FEET
ELEV. 835.5
INV. EL.
832.52
ELEV. 831.5
6"
ELEV. 827.5
6'-6"
SECTION A-A
PLAN
15'
6" TOPSOIL - SEEDED
ELEV. 838.5
GATE WELL
24" RCP
SLOPE = 0.1%
ELEV. 830.5
INV. EL. 832.54
INV. EL. 832.54
PROFILE
PROPOSED GATE WELL
HAND RAILING
ALUMINUM GRATING
ELEV. 838.5
8" TYPE "F" THIMBLE,
SQUARE FLANGE, ROUND OPENING
24" RCP
ELEV. 835.5
INV. EL. 832.54
INV. EL. 832.54
ELEV. 830.5
24"X24"
FLAT BACK
SLUICE GATE
ASPHALT FILL
SECTION A-A
GATE WELL
SCALE IN FEET
STEM GUIDE
GATE LIFT STEM
SECTION B-B
SAFETY PAYS
DEPARTMENT OF THE ARMY
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL MINNESOTA
SECTIONS, HEADWALL F, & GATE WELL

PLATE E-12

SECTION F

ECONOMICS OF SELECTED PLAN

SECTION F

ECONOMICS OF SELECTED PLAN

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SECTION F

ECONOMICS OF SELECTED PLAN

1. The purpose of this section is to present the procedures used in determining the benefits and costs of the selected plan. Included are pertinent discussions on flood damage evaluation, determination of project benefits in accordance with ER 1105-2-351, estimated project costs, project justification and optimization.

METHODOLOGY

2. The evaluation of project benefits and costs were accomplished separately for the upstream and downstream reaches. These reaches were identified early in the study to aid in the evaluation of remedial measures required to insure effective operation of the existing project and measures needed to protect downstream reach development not protected by the existing project. The upstream reach extends from the downstream confluence of the natural river and existing project diversion channel (mile 66.1) upstream to the Burlington Northern Railroad bridge at mile 73.8 as shown on plate F-3. The downstream study reach extends downstream from mile 66.1 to the U.S. Highway 23 bridge at mile 58.3. Justification of needed upstream improvements was based on the need for additional measures to assure effective operation of the existing project as originally designed. Selection of the plan for the upstream reach is based on a comparison of net benefits attributable to the most physically feasible and implementable alternatives, environmental impacts, and desires of local interests.

3. The determination of plan benefits, justification, and optimization of required downstream works was based on the need for upgrading the existing project, mitigating any adverse effects from the proposed upstream improvements, and providing protection to downstream reach flood plain growth not protected by the existing project.

4. Agricultural flood damages along the 270-acre agricultural area downstream of the city between river miles 65 and 58.3 were not evaluated since this area is outside the limits of the existing project and would not be substantially benefitted by works needed to upgrade the existing project. Further, protection of this relatively long and narrow reach would be incrementally unjustified by itself.

5. Information developed in support of plan formulation studies was updated and expanded upon to develop a detailed economic analysis for the selected plan. Project costs and benefits were estimated for a 50-year project life and a 6-7/8 percent interest rate. Price levels are based on October, 1977 prices for similar work done in the area. The base year used in this economic analysis since the beginning of this feasibility study was 1980. A more realistic base year would now be about 1985. However, projection of interim damage growth and reduction of future damage growth to base year 1985 would not affect the analysis contained herein enough to warrant a change in plan formulation or scale of development analyses.

CHARACTER OF FLOODED AREA

6. Without additional measures, substantial flooding would occur in the highly developed or central portion of the city. Approximately 293 acres of mixed open-space recreational, single and multiple-family dwelling, commercial, and light industrial property remains subject to flood damage due to floodwaters entering the area principally from the upstream reach. Of the total upstream area subject to flooding, about 120 acres are in agricultural use, slightly over 40 acres are committed to existing or planned residential use, and the remaining acreage occupied by the river corridor or utilized for transportation and other uses as shown on Plate F10, Existing and Proposed Land Use. Without the existing project deficiency, all of this land should have been protected during the April 1969 flood.

7. The downstream reach area subject to flooding generally includes the flood plain area between River Mile 66.1 and State Highway 23 in an east-west direction and between State Highway 19 and the Highway 23 bridge (river mile 58.3) in a south-north direction. (See plate B-2 for area map.) Approximately 215 acres (or 24 percent) of this approximately 880-acre area is occupied by the Southwest State College campus. About 356 acres (or 60 percent) are in agricultural use. Single and multiple-family dwelling units occupy another 85 acres. Commercial land use is generally confined to a 40-acre narrow strip of land along State Highwa 19 between North Bruce St. and State Highway 23. The remaining flood plain land is either vacant, used for County Ditch No. 62, or is in transportation use. The existing 100-year and SPF flooded area outlines for both the upstream and downstream reaches were determined in the Flood Plain Information Study for Marshall and are shown on plate F-1.

TYPES OF FLOOD DAMAGE

8. Tangible flood damages determined through field surveys and research of flood records consist of the following categories: residential; commercial; damages to buildings, equipment and grounds at Southwest State College; damages to streets, sewers, and other utilities; and emergency flood fight and cleanup costs. Minor agricultural damages would occur within or immediately adjacent to the developed area with a 100-year flood under present conditions. However, most of the agricultural land use and related damage potential along the upstream reach (immediately upstream of CSAH 7) is expected to be converted to residential development shortly after completion of the proposed project (see Plate F-10 for map of proposed land use). A total of 80 acres of agricultural land along the downstream reach would be protected from flooding with the project.

Intangible damages, such as hazards to public health and safety, community disruption and human suffering and insecurity are not evaluated herein in monetary units but are discussed later in this report as appropriate.

EVALUATION OF FLOOD DAMAGES

9. This evaluation of flood damages includes an analysis of upstream reach flood damages that would occur under existing project and developmental conditions and the associated benefits attributed to a maximum practical level of protection to reduce these damages. It also includes an analysis of downstream reach flood damages to determine the feasibility of measures to protect existing development not protected by the existing flood control project.

REDUCTION IN FLOOD DAMAGES DUE TO UPGRADING OF EXISTING PROJECT

10. To facilitate the evaluation of upstream reach flood damages, the total upstream reach extending from river mile 66.1 to 73.8 is seperated into four seperate sub-reaches as shown on Plate F-3 and described in Table F-1. These sub-reaches correspond to those used in the original economic studies for the existing project and permit an accurate comparison of existing conditions (with existing project) and proposed project conditions.

Table F-1 Description of Sub-Reaches

Sub-Reach	River Mile	Type of Development[1/]
A	70.7 - 73.8	Agricultural, Public, Residential
B	69.1 - 70.7	Public, Residential, Commercial
C	67.9 - 69.1	Commercial, Residential, Public
D	66.1 - 67.9	Residential, Commercial, Public

[1/] Listed in order of dominant type of development and related flood damage potential. See plate F-10 for map of existing land use.

11. Under present conditions the City of Marshall is subject to flood damages when flood flows upstream of CSAH 7 reach about 3,500 cfs (16-year frequency). At this river flow, floodwater overflows would cross over CSAH 7 south of the CSAH 7 bridge and pass through sub-reaches B and C before re-entering the natural river channel in Marshall about 2,500 feet downstream of the existing diversion structure. At the 100-year and SPF (11,800 cfs) flood flows, the overflows into Marshall would be 1,090 and 2,000 cfs respectively. At the SPF flow the existing diversion channel has sufficient capacity to pass the remaining 8,300 cfs flood flow without adverse effects.

12. In addition to these potential damages within the highly developed area of Marshall from the overflows over CSAH 7, the flood plain area upstream of CSAH 7 (reach A) is also subject to flood damage. Overland flow commences at a river flow of about 2,500 cfs and inunndates park property, agricultural lands west of CSAH 7 and north of State Highway 23, and limited commercial development along Highway 23.

Another factor contributing to increased flood damages in Marshall are the increased flood stages along the natural channel (Reach D) as a result of backwater from high river stages immediately downstream of the downstream confluence of the existing diversion channel and river at river mile 66.3. At the 100-year flood flow, the backwater effect would extend up the natural channel to north 6th St. At the SPF flood flow, the backwater effect would extend further upstream to the vicinity of East College Drive (see plate D-2 for street locations).

13. The extent of flood damage reduction with the proposed works is measured as the difference in remaining flood damages with and without the proposed project. To evaluate these damages in accordance with ER 1105-351, the project document damages were updated to present conditions reflecting interim flood plain growth and October 1977 price levels. These damage estimates were further modified to reflect the conversion of some agricultural lands (primarily in Reach B) to commercial and residential development since completion of the existing project. In addition, the proportionate increase in the value of residential contents over the approximately 15 year interim (1961-1976) was evaluated. A summary of total updated potential flood damages for the upstream study reach at Marshall is given in Table F-2.

TABLE F-2

SUMMARY OF TOTAL UPSTREAM REACH FLOOD DAMAGES[1/]

REACH A

	Apr. 51 (2740 cfs)	June 57 (5370 cfs)	7900 cfs
Res.	$ 930	$ 2,740	$ 5,580
Public	930	13,160	19,850
Ag. and Comm.	14,180	142,500	160,420
	$ 16,040	$158,400	$ 185,850

REACH B

	Apr. 51 (2740 cfs)	June 57 (5370 cfs)	7900 cfs
Res.	$ 9,170	$ 24,710	$ 50,220
Public	8,980	103,750	162,240
Ag. and Comm.	5,470	9,340	10,260
	$ 23,620	$137,800	$ 222,720

REACH C

	Apr. 51 (2740 cfs)	June 57 (5370 cfs)	7900 cfs
Res.	$543,070	$ 2,038,030	$ 2,193,260
Public	365,980	1,416,770	1,832,910
Ag. and Comm.	568,820	3,646,780	5,512,130
	$ 1,477,870	$ 7,101,580	$ 9,538,300

REACH D

	Apr. 51 (2740 cfs)	June 57 (5370 cfs)	7900 cfs
Res.	$ 199,780	$ 572,560	$ 629,820
Pub.	119,970	343,370	440,420
Ag. and Comm.	187,350	213,580	458,490
	$ 507,100	$ 1,129,510	$ 1,528,730

1/ Updated for price level changes from October 1959 to October 1977

14. To analyze the remaining flood damage potential along the upstream study reach at Marshall, elevation-damage and frequency-damage relationships were developed for each sub-reach and are displayed on Plates F-4 through F-7. From these relationships, total remaining average annual upstream reach flood damages with the existing project are estimated at $286,285. Present condition (October 1977) average annual residential, public and agricultural and commercial flood damages are estimated at $78,890, $63,435, and $143,960 respectively as shown in Table F-3.

Table F-3 - Estimated Average Annual Damages[1] - Upstream Reach

Damage Reach	Residential	Public	Agricultural[2] and Commercial	Total
A	$ 230	$ 810	$ 8520	$ 9560
B	970	3640	280	4890
C	59900	45125	123800	228825
D	17790	13860	11360	43010
	$ 78890	$ 63435	$ 143960	$ 286285

[1] October 1977 prices and conditions

[2] Agricultural damages in Reach A only

15. Flood damages attributable to future developmental growth would be limited to conforming flood plain use, development above the 100-year flood level or flood-proofed improvements. The estimated number of future structures expected to be located within the 100-year flood plain is tabulated by decade in table F-4. No increase in number of structures is projected for residential or commercial structures. Agricultural land use in reach A is expected to decline and eventually be converted to multi-family residential development as shown on plate F-10.

Table F-4 - Estimated Future Development[1/]

Project Type	Existing 1977	Future 1980	1990	2000	2010	2020	2030
	Number of Structures						
Residential	1084	1084	1084	1084	1084	1084	1084
Public	17[2/]	18	19	21	22	23	25
Commercial	200[2/]	200	200	200	200	200	200

[1/] Upstream reach and developed downtown area flood plain extending downstream to mile 66.1.

[2/] Estimated from extension of June 1957 flood data.

16. Future residential damages -- In accordance with ER 1105-2-351 only the growth in damages to contents is evaluated. Although the value of contents may by regulations equal 75 percent of the structure value the future maximum value of contents in this area is estimated at 60 percent of the structure value based on field surveys of existing structural conditions of area housing. With an existing total residential property valuation of $32,791,000 and an existing contents value of 25 percent of the structural value or $8,197,800, the limiting damage growth factor is 2.4. An inspection of Series E per capita income projections for OBE Area 099, within which Marshall is located, indicates a growth factor of 4.179 for the 50-year period between 1980 and 2030. A 50-year (1980-2030) Series E per capita growth factor of 4.179 indicates a compound growth rate of 2-7/8 percent. With a limiting factor of 2.4, future growth of contents will cease in year 31. With a base year average annual total residential damage of $81,730 and estimating that contents incur 40 percent of flood losses, the 1980 base year average annual damage to contents is $32,690. Adjusted unit flood damages reflecting the effects of the affluence factor are shown by decade in Table F-5. Future growth of average annual damages at a 2.4 limiting growth factor is $78,460. With 31 years of growth,

and no growth over the next 19 years, the average annual equivalent value of this future growth is $78,460 - $32,690 x 0.3676 or $16,825 as shown on table F-6. Total average annual residential damages would thus be $98,555.

Table F-5 - Adjusted Unit Flood Damages - Upstream Reach

Property Type	Ave. Ann. Damages Under Existing Conditions 1/	Projected Unit Flood Damages including Effects of Affluence Factor					
	1977	1980	1990	2000	2010	2020	2030
Residential:							
Structure	$ 44	$ 44	$ 44	$ 44	$ 44	$ 44	$ 44
Contents	29	32	42	56	74	74	74
	$ 73	$ 76	$ 86	$100	$118	$118	$118

1/ Remaining upstream reach flood damages with existing project.

17. Remaining flood damages to public property along the upstream study reach and located within the 100-year floodplain are expected to grow in accordance with increasing area population. At a 0.74 percent straight line growth rate over the 50-year project life (from State Demographer), future growth of the 1980 base year damage of $64,830 is estimated at $24,050. Discounted over the 50-year project life, the average annual equivalent value of this future damage growth would be $6,580 as shown on Table F-6.

18. No future growth of upstream reach commercial property damages is forecast beyond year 1980, as nearly all available lands are presently developed or are unsuitable. The minor amount of agricultural activity in the area is expected to cease in a few years. Total average annual

remaining flood damages within the present project area (upstream reach) reflecting both existing conditions, future growth, and effects of the affluence factor are shown in Table F-6.

19. The reduction of flood damages along the upstream reach (upstream of mile 66.1) with the provision of upstream works alone would result in a slight increase in downstream reach damages. An increase of 1260 cfs into the downstream reach with the 133-year design flood flow would raise the corresponding downstream water surface about one-half foot at the confluence of the natural channel and diversion channel and along the agricultural area east of the County 67 river crossing. However, the proposed channel widening measures immediately downstream of the confluence would reduce this rise in the vicinity of the confluence to existing condition water levels. As no additional measures are proposed along the agricultural reach downstream of mile 65.0, this one-half foot rise would result in increased average annual damages of about $1,310, as illustrated on Plate F-9.

EVALUATION OF DOWNSTREAM REACH DAMAGES

20. Downstream reach (downstream of mile 66.1) flood damages were determined for three theoretical peak flood levels to adequately reflect the relationship of damages to river flood stages. Flood damage data were obtained for each category of development for the 100-year, 100-year minus one foot, and 100-year plus one foot levels as shown in table F-7. The hypothetical flood levels correspond to river flood stages of 1143.0, 1142.0, and 1144.0[1/], as shown on the rating curve given in Plate F-8. Corresponding recurrence intervals for these three peak flood stages are once in about 100 years, 20 years, and 227 years respectively.

21. Emergency flood fight, cleanup, and disaster relief costs are also reflected in the damage figures given in table F-7. All

[1/] River stages referenced to rating curve location at river mile 65.16.

Table F-6 -- Existing and Future Flood Upstream Reach Damages Including Effects of Affluence Factor

Physical Flood Losses Reported By Property Type	Ave.Ann.[1/] Damage Under Existing Conditions 1977	Projected Total Future Flood Damages Including Effects of Affluence Factor						In-crease over 1980	Ave. Ann. Equiva-lent In-crease Over 50-Year Project Life	Total Ave. Ann. Damages
		1980 5/	1990	2000	2010	2020	2030			
Residential	$ 78,890	$ 81,730[2/]	$ 93,220	$108,400	$127,500	$127,500	$127,500	$45,770	$16,825	$ 98,555
Public	63,435	64,830[3/]	69,630	74,440	79,230	84,020	88,880	24,050	6,580	71,410
Agricultural and Commercial	143,960	152,740[4/]	152,740	152,740	152,740	152,740	152,740	0	0	152,740
	$286,285	$299,300	$315,590	$335,580	$359,470	$364,260	$369,120	$69,820	$23,405	$322,705

1/ Total average annual damages for sub-reaches A,B, C and D = $9560, 4890, 228,825 and 43,010 respectively. See Table F-3 for break-down by developmental category.

2/ 2-7/8% Compound growth

3/ 0.74% Straight line growth (Factor = 1.022)

4/ 2% Straight line growth (Factor = 1.061)

5/ See paragraph 5 for discussion of base year damages shown in table F-7 are present condition damages to property not measurably protected by the existing diversion channel or earlier local and Federal downstream channel improvements.

22. Residential flood damages along the downstream reach under present conditions commence at a river stage elevation of 1137.5 at mile 65.16 with a corresponding discharge of 725 cfs as indicated by the rating curve shown on plate F-8. First floor flooding up to about one foot deep would occur to some single family dwellings with the occurrence of the 100-year flood and no emergency flood fight. Home values in this area are approximately $45,000 based on October 1977 price levels. A few permanent residences would be subject to basement flooding via seepage and sewer backup. Thirty-four single and double unit trailer homes would be similarly affected. The basement levels of two large apartment complexes would incur severe damage at the 100-year flood level.

23. Field inspections and interviews with home and property owners provided data for determining physical damages and values of residences. Evaluation of residential damages as derived from depth-flooded-damage tables considered the value of the home and depth of flooding above basement or first floor levels. Results of damage surveys indicate that total residential damages at the 100-year flood level would be $355,000 based on October 1977 price levels.

24. Business damage would consist of loss of or damage to goods and property by water, loss of income by employers and employees due to shutdown, and cost of repairs and cleanup necessary for a

return to normal business operation. Of the businesses inspected and interviewed, the most affected by flooding include a nursery and a few other small businesses located on the north side of State Highway 19. Total damages that would be caused by the occurrence of the 100-year flood without emergency protective measures is estimated at $990 based on October 1977 price levels.

25. Flood damage to downstream reach public property at Marshall consists of damages to public streets, sewers, and other utilities, and damages to buildings, grounds, & equipment at the S.W. State College at Marshall. Public street, sewer, and utility damage is minimal at the 100-year flood level. Extensive damage to low-level electrical and mechanical equipment would occur and extensive cleanup efforts required at the college in the event of a recurrence of the 100-year level without the construction of effective emergency flood barriers. Flooding of electrical and mechanical equipment would render them inoperative with a likely closing of the campus. A four to five day temporary closure of the college would result in increased annual operating expenses of approximately $50,000. Total public damages resulting from a flood similar to the 100-year flood level and without effective emergency flood barriers would be $198,000 as shown in table F-7.

Table F-7 -- Flood Damage Data - Downstream Reach

Flood	Frequency Percent	Peak Flood Stage[1/] Feet	Discharge cfs	Residential Damage	Business Damage	Public Damage
100-yr.-1'	4.90	1142.0	4000	$ 63,800	$ 0	$185,000
100-yr.	1.00	1143.0	6700	355,000	900	198,000
100-yr.+1'	0.44	1144.0	9100	807,900	35,400	226,000

[1/] Rating curve location at mile 65.16 (existing conditions)

Derivation Of Average Annual Damage

26. Field studies were made to establish high water marks for the April 1969 flood, flood damage areas and zero damage elevations. Initial damage along the downstream reach occurs at a river stage of about 1137.5 (above mean sea level, 1929 adj.) at mile 65.16. Significant flood damage commences at a river stage of about 1143 with a corresponding discharge of 5500 cfs. This elevation corr- esponds to a discharge of about 725 cfs and an expected frequency of occurrence of one in about 2.1 years. Damage surveys made in November 1974 and May 1975 for the downstream reach determined the depth of flooding and pertinent damage elevations at residences and other structures. Residential damages were determined from flooded-depth-damage relationships. Commercial damages were de- termined through local inspection and interviews with affected pro- perty owners and/or managers. Estimates of public damages were obtained through research of records and/or interviews with City and Southwest State College officials.

27. Using this basic information and previously determined stage- discharge and frequency-discharge relationships, discharge-damage and frequency-damage relationships for both present and 1980 base year conditions for each damage category were developed. Discharge- damage and frequency-damage curves are shown on plate F-9. As determined in this manner for existing conditions, average annual residential, commercial (business), and public damages are estimated at $13,450, $375, and $52,575 respectively.

Future Flood Damage

28. Future flood plain development is expected to occur in accor- dance with flood plain regulations that have recently been adopted by the City.

Thus, damages to new development would be limited to conforming flood plain use, development above the 100-year flood level or flood-proofed improvements. The estimated future numbers of downstream reach flood plain structures is tabulated by decade in table F-8.

Table F-8 -- Estimated Future Development - Downstream Reach

	Number						
	Existing	Future					
Property Type	1977	1980	1990	2000	2010	2020	2030
Residential:							
Single-Family	44	44	44	44	44	44	44
Multiple-Family	66	66	66	66	66	66	66
Commercial	3	3	3	3	3	3	3
Public	7	7	8	9	9	10	10

29. Residential -- Present condition average annual flood damages were increased as appropriate to reflect new damage growth over the 50-year project life. In projecting future residential flood damages, and in accordance with ER 1105-2-351, only the growth in damages to contents is evaluated. Further, the future value of the contents is not expected to exceed 60% of the structural value. The existing value of damage-prone residential structures in the downstream reach is approximately $1,560,000. With a current contents value of 25 percent of the structural value, the limiting growth factor is 2.4. An inspection of Series E per capita income projections for OBE area 099, within which Marshall is located, indicates a growth factor of 4.179 for the 50-year period between 1980 and 2030. This growth factor indicates a compound growth rate of approximately 2-7/8 percent. A limiting factor of 2.4 thus indicates that future

growth of contents will cease in year 31. With a base year average annual total residential damage of $14,660, and assuming that contents incur 40 percent of flood losses, the 1980 base year average annual damage to contents is $5,860. Adjusted unit flood damages reflecting the effects of the affluence factor are shown by decade in table F-9. Future growth of average annual damage to contents at a 2.4 limiting growth factor is $14,060. With a 31-year growth period and no growth thereafter over the 50-year project life, the average annual equivalent value of the net future growth is $8,200 x 0.3676 or $3,015, as shown on table F-10. Thus, total average annual residential damages are estimated at $17,675.

Table F-9 -- Adjusted Unit Flood Damages - Downstream Reach

Physical Flood Losses by Property Type	Ave.Ann.Damages under Existing Conditions	Projected Unit Flood Damages Including Effects of Affluence Factor					
	1977	1980	1990	2000	2010	2020	2030
Residential:							
Structure	$ 73	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80
Contents	49	53	70	93	128	128	128
	$122	$133	$150	$173	$208	$208	$208

30. Flood damages to public facilities are expected to grow generally in accordance with the growth in such facilities needed to meet the needs of an increasing area population. Although the population of the southwest region of the state is expected to decline, both the OBERS series E and State demographer's projections indicate a rising population for Lyon County. The city of Marshall is a growing regional educational trade and farm service center for the region and is expected to continue growing over the next 50

years. The projections by the State Demographer are considered to best represent this local growth situation with a 50-year growth increase of 37.1 percent, or an annual straight line growth rate of 0.7 percent simple growth rate over the 50-year project life is estimated at $19,920. Discounted, this future growth would be $5,450 on an average annual basis as shown on Table F-10.

31. No future growth of damages to commercial establishments is anticipated beyond base year 1980. Expansion of a flood-prone nursery will be accomplished outside the flood plain. No further expansion of other small establishments was indicated in interviews with building owners and operators.

32. Total average annual downstream reach flood damages of $77,235 flecting both existing conditions and future growth and including effects of the affluence factor are shown in table F-10.

Table F-10-- Existing and Future Downstream Reach Flood Damages Including Effects of Affluence Factor

Physical Flood Losses Reported by Property Type	Av. Ann. Damage Under Existing Conditions 1977	Projected Total Future Flood Damages Including Effects of Affluence Factors 1980 3/	1990	2000	2010	2020	2030	Increase Over 1980	Av. Ann. Equivalent Increase Over 50-yr. Project Life	Total Average Annual Damages
Residential	$ 13,450	$ 14,660	$ 16,530	$ 19,070	$ 22,860	$ 22,860	$ 22,860	$ 8,200	$ 3,015 1/	$17,675
Commercial	375	430	430	430	430	430	430	0	0	430
Public	52,575	53,680	57,665	61,650	65,635	69,620	73,600	19,920	5,450 2/	59,130
TOTALS	$ 66,400	$ 68,770	$ 74,625	$ 81,150	$ 88,925	$ 92,910	$ 96,890	$ 28,120	8,465	77,235

1/ Ave. ann. equivalent factor, compound growth for 31 years = 0.3676

2/ Ave. ann. equivalent factor, straight line growth for 50 years = 0.2736

3/ See paragraph 5 of text for discussion of base year used.

BENEFITS

33. Project benefits include the benefits attributable to reduction of flood damages in the upstream and downstream study reaches. They also include location benefits attributable to the incidental protection of present agricultural property which would likely be converted to more intensive development with protection from flooding. Recreation benefits that would be realized from proposed facilities attendant to the proposed flood damage reduction measures are determined in Section G of Appendix I and included in the summary of benefits given later in this section. Similar to the prior discussion of flood damages, the discussion of related flood damage reduction benefits is presented seperately for the upstream and downstream study reaches.

FLOOD DAMAGE REDUCTION BENEFITS

34. Flood damage reduction benefits considered in this analysis consist of both benefits attributable to additional measures required to assure effective operation of the existing project and protection of presently unprotected downstream property. These benefits were derived in accordance with the following rationale. Flood control benefits represent the difference in flood damages with and without the selected plan (133-year degree of protection). First, benefits from improving the operation of the existing project were determined from revised frequency-damage relationships as the reduction in remaining flood damages with and without the proposed remedial measures. Then, increased downstream reach flood damages caused by the approximate one-half foot raise in water levels along the unprotected agricultural reach downstream of mile 65.0 were subtracted to obtain net benefits. Benefits attributable to protection of presently unprotected downstream reach property were also evaluated based on an analysis of discharge-damage and frequency-damage relationships shown on plates F-4 through F-7 and F-9. Average annual flood damage reduction benefits under present conditions were computed as the difference in areas (converted to equivalent dollar damages) under the "with" and "without" project frequency-damage curves as shown on plates F-4 through F-7 and F-9. Present (1977) condition average annual benefits attributable to obtaining effective operation of the existing project (upstream study reach) and protection of unprotected downstream development are estimated at $195,710 and $56,600 respectively.

35. To determine benefits resulting from the reduction in future flood damages, present condition residential and public benefits are considered to increase in the same proportion as future flood damages. The development of total average annual flood damage reduction benefits of $221,730 attributable to assuring effective operation of the existing project and benefits of $65,860 attributable to protection of downstream developments not protected by the existing project is shown in tables F-11 and F-12 respectively.

Table F-11 -- Derivation of Flood Damage Reductions Benefits Due To Improving the Operation of the Existing Project

Benefit Category	Present Condition Remaining Damages	Remaining Ave. Ann. Damages with 133-yr. Remedial Measures	Remaining Ave. Ann. Damages with SPF level of Protection	Present Condition Ave. Ann Benefits 1/	1980 Base Year Ave. Ann Benefits 2/	Net Change 2030-1980	Ave. Ann. Equivalent of Future Growth	TOTAL Average Annual Benefits
Residential								
Structural	$78,890	$22,095	$11,005	$34,080	$34,080	-	-	$34,080
Contents				22,715	24,760	34,660	12,740	37,500
Public	63,435	20,815	9,880	42,620	43,560	16,160	4,420	47,980
Commercial & Agricultural	143,960	47,665	24,310	96,295	102,170	0	0	102,170
	$286,285	$90,575	$45,195	$195,710	$204,570	$50,820	$17,160	$221,730

1/ Total average annual present-condition benefits for sub-reaches A, B, C and D are $7,070, $3,150, $154,880 and $28,140 respectively.

2/ See paragraph 5, page F-2 for discussion of base year

Table F-12-- Derivation of Downstream Reach Flood Damage Reduction Benefits

Benefit Category	Present Condition Ave. Ann. Damages	Remaining Ave. Ann. Damages With Project	Benefits Under Existing Conditions	1980 Base Year 1/ Conditions	Future Growth 1980-2030	Av. Ann. Eq. of Future Growth	TOTAL Average Annual Benefits
Residential	$ 13,450	$ 1,730					
Structural			$ 7,030	$ 7,660	$ 0	$ 0	$ 7,660
Contents			4,690	5,110	7,150	2,630	7,740
Public	52,575	8,015	44,560	45,500	16,880	4,620	50,120
Commercial	375	55	320	340	0	0	340
	$ 66,400	$ 9,800	$56,600	$58,610	$24,030	$ 7,250	$65,860

1/ See paragraph 5, page F-2 for discussion of base year

DOWNSTREAM REACH LAND USE CHANGES

36. Approximately 85 acres of downstream reach flood plain land presently in crop use would be protected by the project levee. This area is presently zoned for single family and multiple-family development as shown on Plate F-10. Local interests indicate that this area would be developed even without a project due to its close proximity to existing thoroughfares and utilities and the downtown service area. The "without-project" condition represents development of these areas. This development is expected to commence immediately after completion of the project. Of the 85 acres available for development, 65 acres could reasonably be developed. Of this acreage, 56 acres would be developed with residential dwellings, the remaining 12 acres to be used for streets, utilities and open space areas. No change in land use and intensity of development is anticipated with the project. The current value of this land reflects agricultural use with appreciation due to eminent urbanization. The difference in value between agricultural land under urbanization pressure and agricultural use sustained into the future is about $2,000 per acre. A market value increase is anticipated with the project equal to the capitalized costs savings of not incurring flood proofing development costs. However, these project benefits are evaluated as an innundation reduction cost savings benefit.

REDUCED FLOOD PROOFING COST SAVINGS BENEFIT

37. In accordance with ER 1105-351, reduced flood proofing costs were calculated as an innundation reduction benefit for the downstream reach under proposed project conditions. In the absence of providing levee protection to the net 56 developable acres, an average of 3.2 feet of earthen fill would be required to bring the area up to the 133-year design water surface elevation. Of the required 244,000 cubic yards of fill, approximately 40 percent would be hauled in from other areas and could consist of demolition debris, excavated material from area building projects or new borrow. Estimated total first costs of $155,800 capitalized at a 6-7/8 percent rate of return give a net savings or benefit of $11,110.

A very limited number of present land owners would receive benefits from flood proofing cost savings with protection of their property against flooding. Protection of the 56 developable acres is incidental to the selection of the most cost effecitve levee alignment. Local interests indicate that adjustment of the levee alignment to exclude this property would require their probable payment of flood easements equal or greater in value to any flood proof cost savings.

OTHER BENEFITS

38. The proposed project would provide in addition to the eavluated monetary benefits, intangible benefits including reduced apprehension and anxiety of area residents, reduced hazards to health and safety, and reduced disruptions to established community growth patterns. Construction of the recreational trail system and picnic facilities would provide substantial benefits in terms of increased leisure time opportunities and direct monetary benefits in terms of

local expenditures for enjoyment of recreational biking, cross-country skiing, walking, picnicking, and other activities. These benefits are presently estimated at $43,130.

39. Estimated downstream reach flood damage reduction benefits of $76,970 including flood proof cost savings are summarized in Table F-14.

Table F-13 - Summary of Benefits

Flood damage reduction	
Improvement of existing project (upstream reach)	
1980 Base year conditions	$ 204,570
Future growth	17,160
Downstream reach	
1980 Base year conditions	58,610
Future growth	7,250
Reduced Flood Proofing Cost Savings Benefit	11,110
Recreation benefits (entire study area)	43,130
	$341,830

DETAILED COST ESTIMATE

40. A detailed estimate of project costs based on October 1977 price levels and reflecting similar work done by the St. Paul District in the area is given in Table F-4. Estimated land costs are based on recent market transactions in the area.

Table F-14 - Detailed Estimate of First Costs

Item	Unit	Quantity	Unit Cost	Total Cost
Federal First Costs				
Channels				
Main Channel				
Clear and grub	ac.	3.6	$1,000.00	$ 3,600
Excavation	c.y.	67,515	1.50	101,300
Spoil wasted on river bank	c.y.	10,910	0.40	4,400
Spoil trucked to disposal area	c.y.	1,905	0.80	1,500
Spoil hauled for levee and random channel fill	c.y.	54,700	.35	19,100
Channel fill				
Random	c.y.	10,100	0.75	7,600
Pervious	c.y.	8,850	2.00	17,700
Riprap	c.y.	17,755	20.50	364,000
Bedding	c.y.	10,585	9.00	95,300
Seeding	ac.	1.4	700.00	1,000
Contingencies (20%)				123,100
Total Channels				$738,600
Levees				
Stripping	c.y.	15,930	$ 1.10	$ 17,500
Levee fill	c.y.	77,660	0.80	62,100
Topsoil	c.y.	14,935	1.75	26,100
Seeding	ac.	13.6	650.00	8,800
Clear and grub	ac.	1.6	1,000.00	1,600

Table F-14 - Detailed Estimate of First Costs (continued)

Item	Unit	Quantity	Unit Cost	Total Cost
Federal First Costs (continued)				
Levees (continued)				
Remove existing pavement	s.y.	1,550	$ 1.75	$ 2,700
Remove and replace base course	c.y.	350	2.50	900
Bit. wear course	ton	180	15.00	2,700
Bit. Binder course	ton	180	10.00	1,800
Bit. material	ton	15	100.00	1,500
Plantings	job	sum	--	17,500
Contingencies (20%)				28,600
Total Levees				$ 171,800
Floodway Control and Diversion Structures				
(Overflow structure)				
Stripping	c.y.	2,810	$ 1.10	$ 3,100
Embankment fill	c.y.	4,035	0.90	3,600
Channel excavation	c.y.	19,465	0.60	11,700
Spoil hauled away	c.y.	17,320	.75	13,000
Riprap	c.y.	2,370	20.50	48,600
Bedding	c.y.	1,185	9.00	10,700
Channel fill	c.y.	250	2.00	500
Topsoil from channel stripping	c.y.	1,775	1.25	2,200
Seeding	ac.	3.4	650.00	2,200
Gabion slope and crest protection	c.y.	1,000	65.00	65,000
Concrete weir key	c.y.	90	125.00	11,200

Table F-14 - Detailed Estimate of First Costs (continued)

Item	Unit	Quantity	Unit Cost	Total Cost
Federal First Costs (continued)				
Floodway Control and Diversion Structures (continued)				
(Overflow Structure) (continued)				
115x72" R C P arch cul.	l.f.	501	$ 215.00	$ 107,700
115x72" R C P aprons	ea.	6	1,000.00	6,000
Asphaltic concrete	ton	85	23.00	2,000
Class 5 gravel	c.y.	85	5.50	500
Class 3 gravel	c.y.	210	4.50	900
Frost free fill	c.y.	490	8.50	4,200
Temporary Hwy. 23 bypass	job	sum	--	12,000
Contingencies (20%)				61,000
Sub-total Overflow Structure				$ 366,100
(Channel Drop Structure)				
Gabion slope protection (1' deep)	c.y.	530	$ 65.00	$ 34,400
Gabion end sill (3' deep)	c.y.	22	44.00	1,000
Mass concrete	c.y.	30	65.00	1,900
Grout	c.y.	6.4	40.00	300
24" R C P - CL III	l.f.	152	30.00	4,600
End section for 24" pipe	ea.	8	150.00	1,200
Contingencies (20%)				8,700
Sub-total Drop Structure				$ 52,100
Total Floodway Control Diversion Structure				$ 418,200

Table F-14 - Detailed Estimate of First Costs (continued)

Item	Unit	Quantity	Unit Cost	Total Cost
Federal First Costs (continued)				
Interior Drainage				
Headwall A				
Concrete headwall	job	sum	--	$ 1,100
Riprap	c.y.	20	$ 20.00	400
Bedding	c.y.	9	10.00	100
30" Flap gate with Type F thimble	ea.	2	2,000.00	4,000
Headwall B				
Concrete headwall with riprap	job	sum	--	1,800
30" Flap gate with Type F thimble	ea.	2	2,000.00	4,000
Headwall C				
Concrete headwall	job	sum	--	1,300
18" C M P with end section	l.f.	55	28.00	1,500
Riprap	c.y.	46	20.50	1,000
Bedding	c.y.	23	9.00	200
18" Flap gate with Type F thimble	ea.	1	1,400.00	1,400
Headwall D				
Concrete headwall	job	sum	--	1,200
16" Flap gate with Type F thimble	ea.	1	1,200.00	1,200

Table F-14 - Detailed Estimate of First Costs (continued)

Item	Unit	Quantity	Unit Cost	Total Cost
Federal First Costs (continued)				
Interior Drainage (continued)				
Headwall F				
Excavation (headwall and 210-foot channel)	c.y.	170	$ 5.50	$ 900
Concrete headwall	job	sum	--	500
36" Flap gate with Type F thimble	ea.	1	2,400.00	2,400
Driveway Culvert				
(Rt. bank sta. 9+50)				
18" C M P	l.f.	30	1[illegible].50	600
Ponding Area and Collector Ditch				
Ponding area excavation	c.y.	41,940	.75	31,400
Collector ditch excavation	c.y.	6,180	3.00	18,500
Spoil trucked to disposal area	c.y.	5,300	0.75	4,000
Stripping	c.y.	7,400	1.10	8,100
Topsoil from stripping	c.y.	7,450	1.40	10,400
Seeding	ac.	10.0	650.00	6,500
24" R C P ditch culverts	l.f.	130	24.00	3,100
End sections for 24" R C P	ea.	4	150.00	600

Table F-14 - Detailed Estimate of First Costs (continued)

Item	Unit	Quantity	Unit Cost	Total Cost
Federal First Costs (continued)				
Interior Drainage (continued)				
Gate Well				
Reinforced concrete	c.y.	9	$ 175.00	$ 1,600
Manhole frame, cover and steps	job	sum	--	600
24" sluice gate	ea.	1	2,700.00	2,700
Headwall G				
Concrete headwall	job	sum	--	1,600
24" R C P CL III	l.f.	808	24.00	19,400
End section with grate for 24" pipe	ea.	1	400.00	400
24" Flap gate with Type F thimble	ea.	1	1,800.00	1,800
Contingencies (20%)				30,700
Total Interior Drainage				$ 184,000
Recreational Facilities1/				
Recreational Bike Trail	(From Section G est.)			$ 279,600
Cross Country Ski Trail		"		2,900
Beautification Plantings		"		36,000
Picnic Facilities		"		2,800
Contingencies		"		64,300
Total Recreational Facilities2/				$ 385,600

Table F-14 - Detailed Estimate of First Costs (continued)

Item	Unit	Quantity	Unit Cost	Total Cost
Federal First Costs (continued)				
Engineering and Design[3/]				$ 189,800
Supervision and Administration[3/]				
Inspection				94,900
Overhead				47,500
Total Engineering, Design, Supv. and Admin.				$ 332,200
Total Cost (Federal First Costs plus Non-Federal Contributions)				$2,230,400
Less Non-Federal Contribution				221,600
Total Federal First Costs				$2,008,800
Non-Federal First Costs				
Lands and damages				
Flood Control - fee purchase	ac.	119.8	$ 1,400,00	$ 167,700
Acquisition and easements	job	sum	--	8,600
Contingencies (20%)				35,300
Total Lands and Damages				$ 211,600
Relocations				
Remove and replace				
(6' x 50') foot bridge	job	sum	--	$ 16,000
Relocate dwelling	job	sum	--	8,000

Table F-14 - Detailed Estimate of First Costs (continued)

Item	Unit	Quantity	Unit Cost	Total Cost
Non-Federal First Costs (continued)				
Relocations (continued)				
Overhead power lines	l.f.	1,400.0	$ 11.00	$ 15,400
Underground utility cable	l.f.	550	6.60	3,600
Farm fence	l.f.	700.0	0.90	630
Contingencies (20%)				8,800
Total Relocations				$ 52,400
Engineering and Design				$ 5,200
Supervision and Administration				
Insepction				$ 2,800
Overhead				1,600
Non-Federal Contributions				
Recreation facilities (50% of est. cost)				$ 192,800
Indirect Costs				28,800
Total Non-Federal Contributions				$221,600
Non-Federal First Costs				$495,200
Total Project First Costs[5/]				$2,504,000

Table F-14 - Detailed Estimate of First Costs (continued)

1/ See Section G for detailed estimate.

2/ Includes 50 percent Non-Federal contribution.

3/ Includes Non-Federal contribution for indirect costs on recreational facilities.

4/ Includes items 2 and 3 above.

5/ Exclusive of pre-authorization study costs.

ANNUAL COSTS

41. Annual costs are computed on the basis of a 50-year economic life and an interest rate of 6-7/8 percent. Included in the total estimated annual charges shown below are the costs of non-Federal operation and maintenance of the proposed project. Since the project would be completed in two construction seasons or less, no charges are included for interest during construction.

<u>FEDERAL</u>	
Estimated first cost	$ 2,008,800
Interest during construction	0
Total Federal investment	$ 2,008,800
Federal Annual Charges	
Interest and amortization	$ 143,270
Total Federal Annual Charges	$ 143,270
<u>NON-FEDERAL</u>	
Estimated first cost	$ 495,200
Interest during construction	0
Total Non-Federal investment	$ 495,200
Non-Federal Annual Charges	
Interest and amortization ($495,200 @ 0.07132)	$ 35,320
Operation and maintenance	9,000
Total Non-Federal Annual Charges	$ 44,320
TOTAL ANNUAL CHARGES	$ 187,590

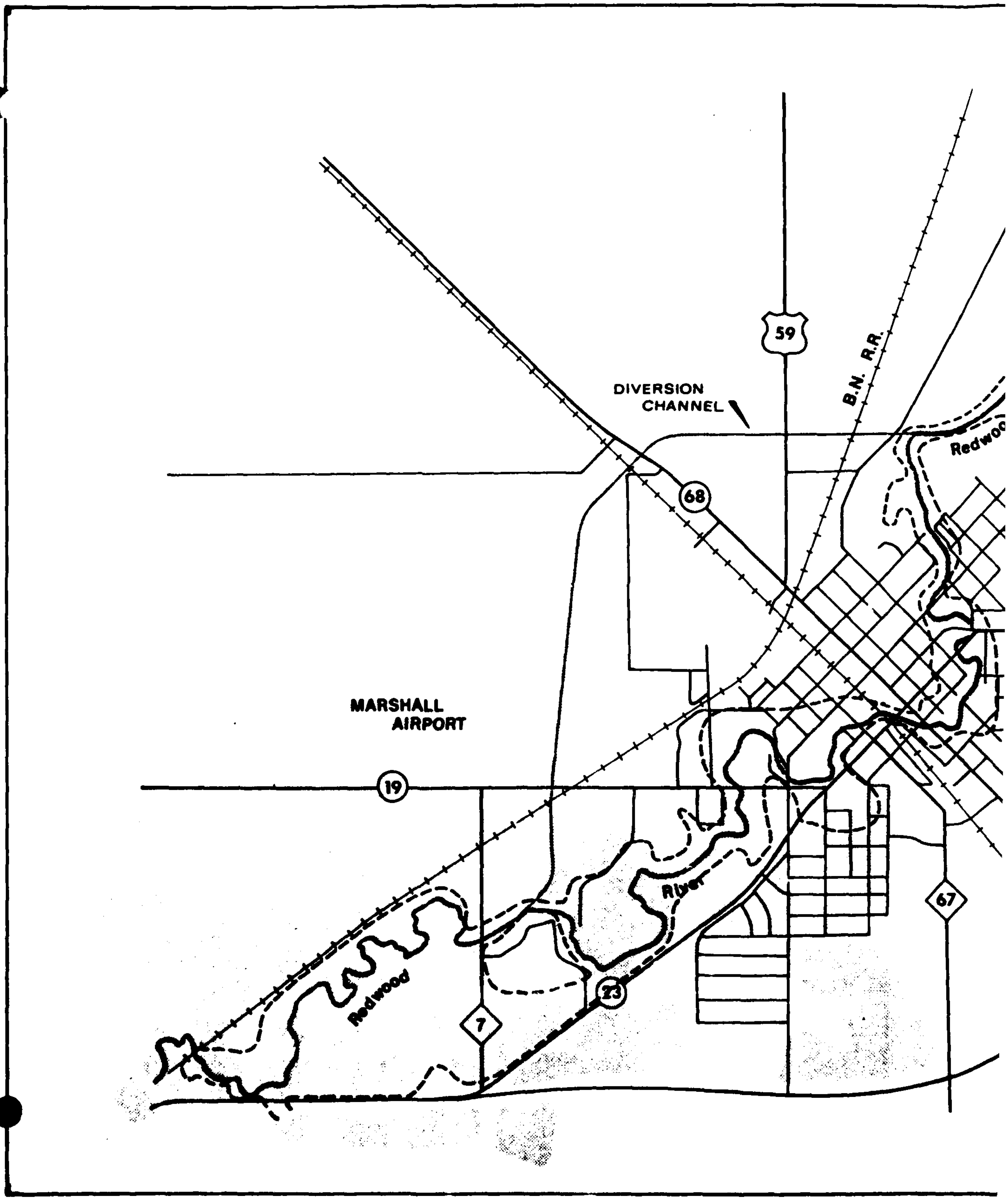
PROJECT JUSTIFICATION

42. In accordance with established procedures, both the remedial measures and protection of downstream reach development are economically justified. A comparison of incremental annual costs versus annual benefits for the remedial measures indicates an incremental benefit-cost ratio of 1.8. A similar comparison for the downstream reach improvements indicates a favorable 2.7 benefit-cost ratio. Average annual charges of $22,300 versus related average annual benefits of $54,160 indicates that the proposed recreational facilities are justified. A comparison of all project costs together with related benefits indicates that the entire project as a whole is also justified as shown in Table F-15. A comparison of average annual benefits and costs indicates an internal rate of return of about 12 percent and that annual project benefits would exceed annual project costs immediately upon completion of the project.

Table F-15 - Comparison of Average Annual Costs and Benefits

Feature	Total First Costs	Average Annual Costs	Average Annual Benefits	Benefit Cost Ratio
Upstream Reach	$1,674,800	$124,620	$221,730	1.8
Downstream Reach protection	386,000	28,680	76,970[1/]	2.7
Recreational facilities	443,200	34,290	43,130	1.3
Total Project	$2,504,000	$187,590	$341,830	1.8

1/ Includes $11,110, flood proof cost savings benefit



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River
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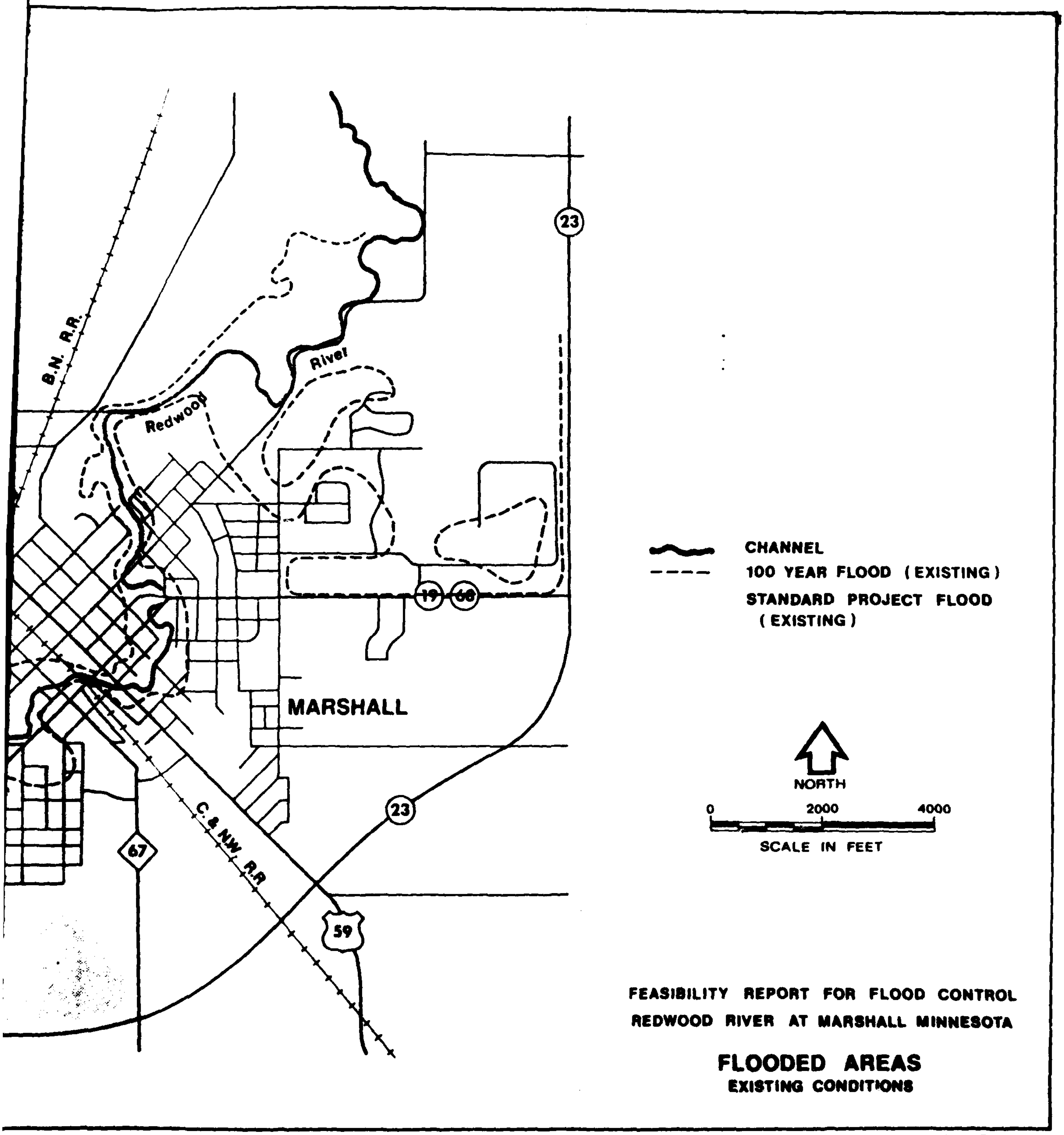
Redwood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Redwood
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MARSHALL
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C. & NW. R.R.
59
CHANNEL
100 YEAR FLOOD (EXISTING)
STANDARD PROJECT FLOOD (EXISTING)
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0
2000
4000
SCALE IN FEET
FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA
FLOODED AREAS
EXISTING CONDITIONS

AD A146 926 REDWOOD RIVER AT MARSHALL MINNESOTA; FEASIBILITY REPORT FOR FLOOD CONTROL(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT JUN 79 4/7

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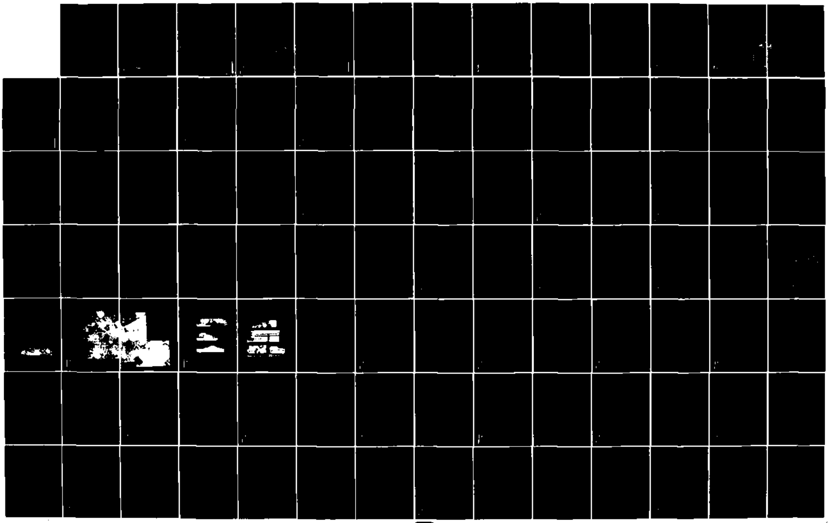

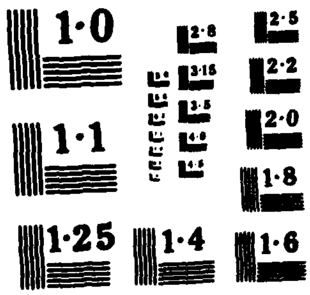
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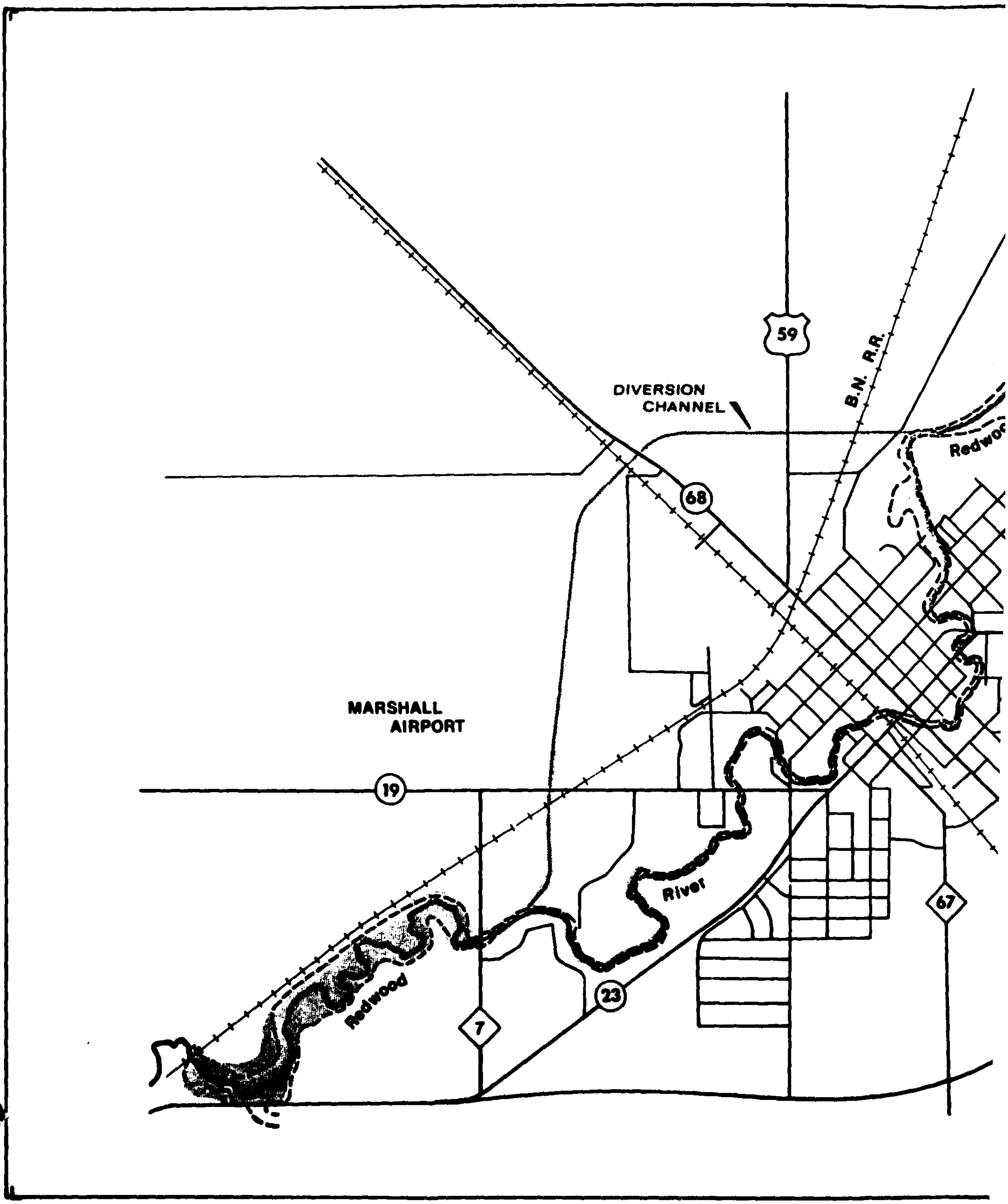

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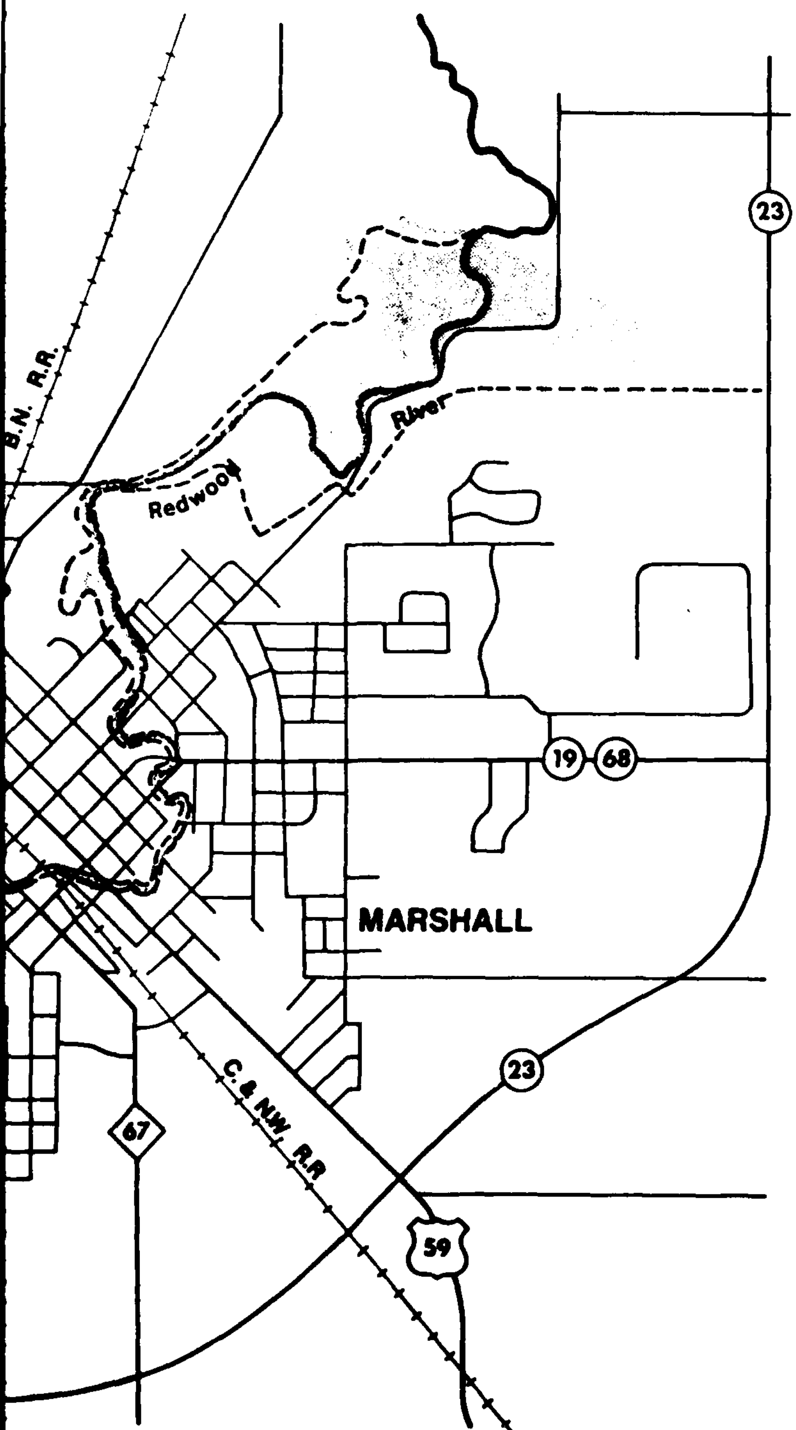


CHANNEL

133 YEAR DESIGN FLOOD
(PROPOSED)

STANDARD PROJECT FLOOD
(PROPOSED- CONDITION 1)

SEE FIGURE H-4 AND PLATE F-I FOR SPF CONDITION 2 FLOW DISTRIBUTION IN AIRPORT AREA

NORTH

0 2000 4000

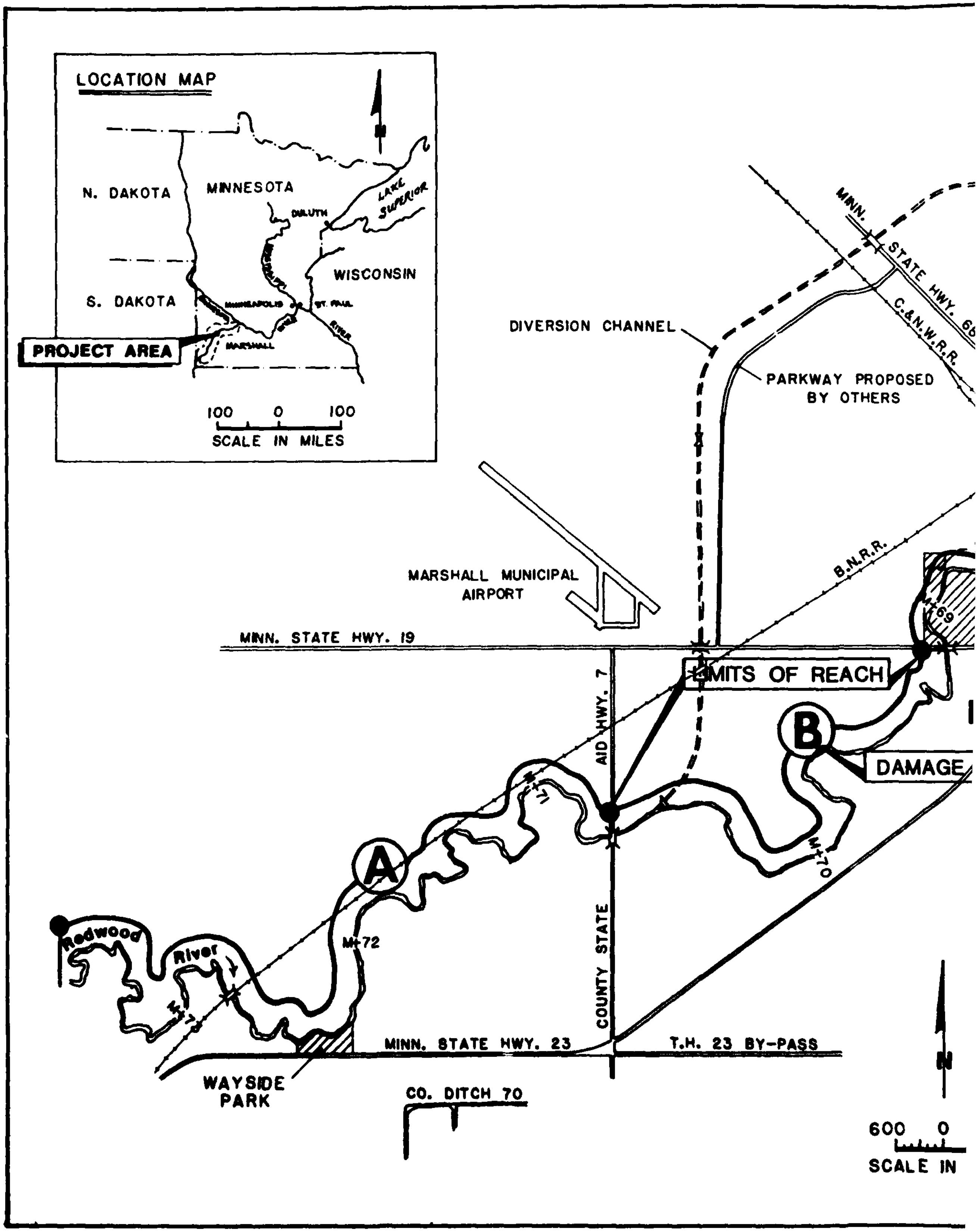
SCALE IN FEET

FEASIBILITY REPORT FOR FLOOD CONTROL

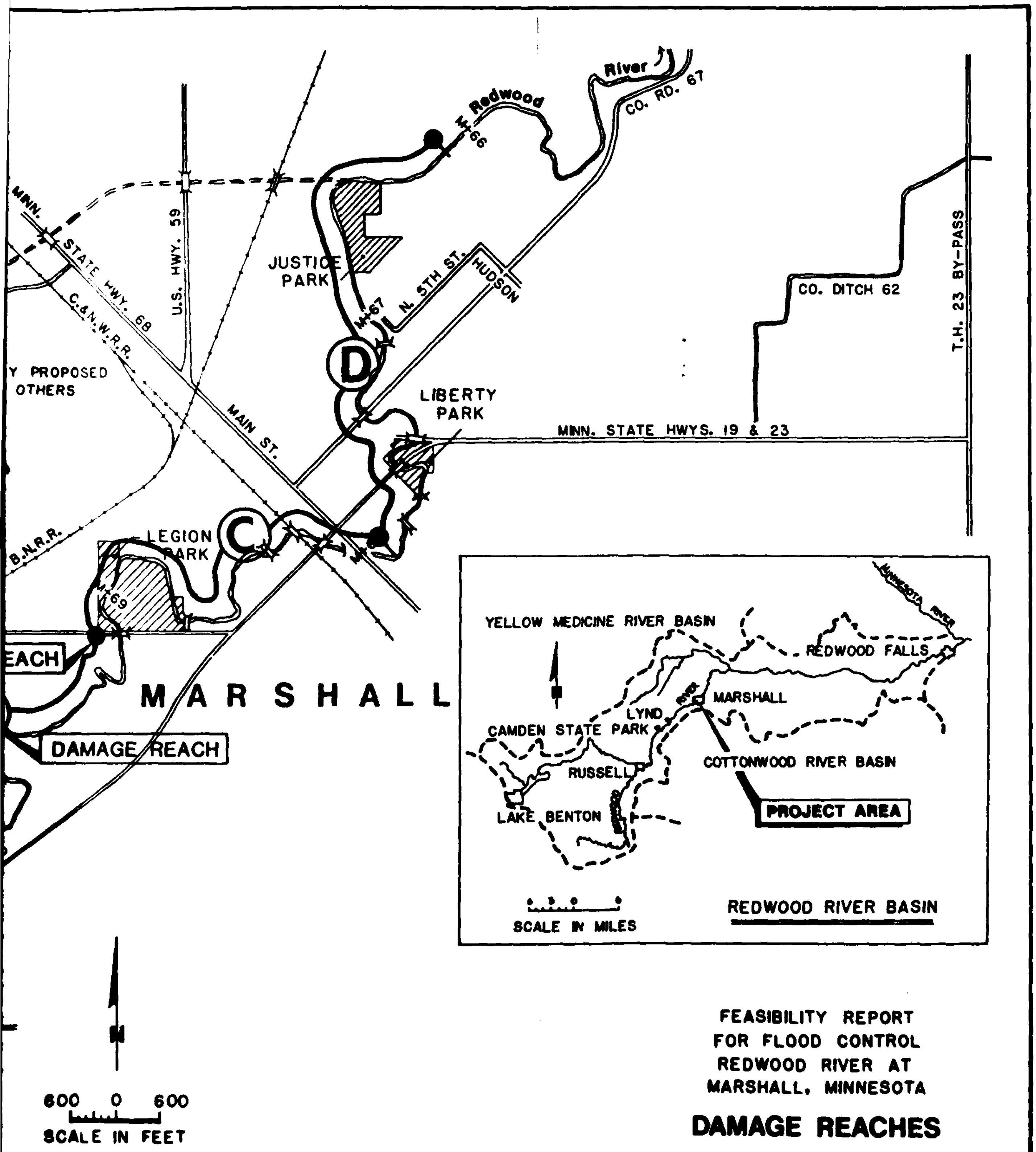
REDWOOD RIVER AT MARSHALL MINNESOTA

FLOODED AREAS

PROPOSED CONDITIONS

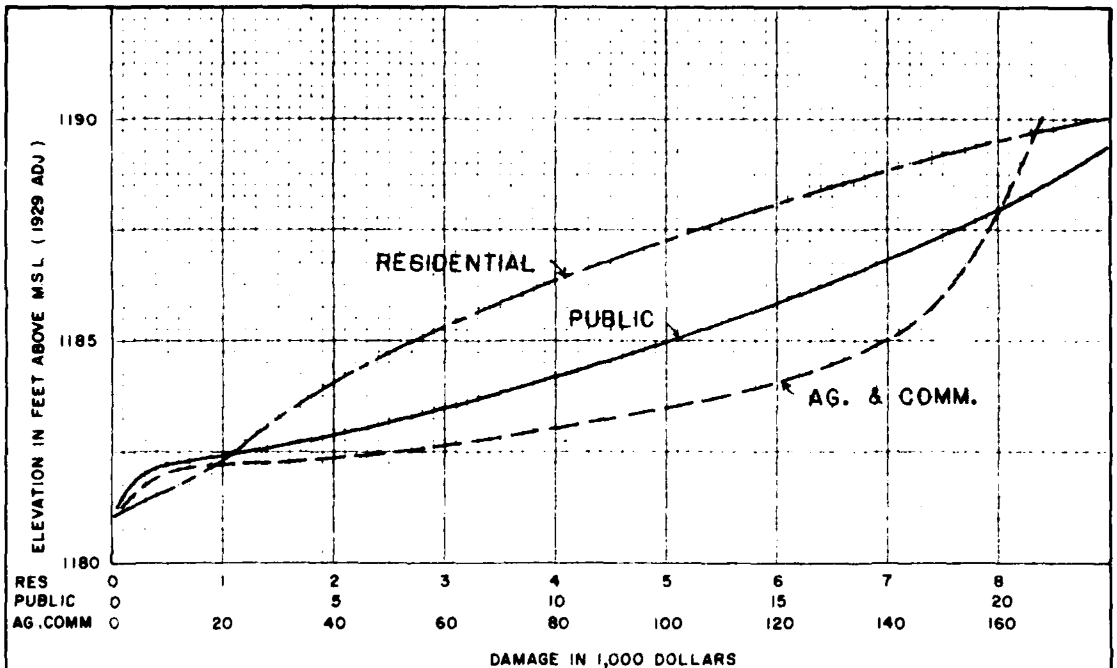


LOCATION MAP
N. DAKOTA
MINNESOTA
LAKE SUPERIOR
DULUTH
WISCONSIN
S. DAKOTA
MINNEAPOLIS
ST. PAUL
MARSHALL
PROJECT AREA
100 0 100
SCALE IN MILES
DIVERSION CHANNEL
PARKWAY PROPOSED BY OTHERS
MINN. STATE HWY. 68
C.&N.W.R.R.
B.N.R.R.
MARSHALL MUNICIPAL AIRPORT
MINN. STATE HWY. 19
LIMITS OF REACH
COUNTY STATE AID HWY. 7
DAMAGE
B
A
M-69
M-70
M-71
M-72
Redwood River
MINN. STATE HWY. 23
T.H. 23 BY-PASS
WAYSIDE PARK
CO. DITCH 70
N
600 0
SCALE IN

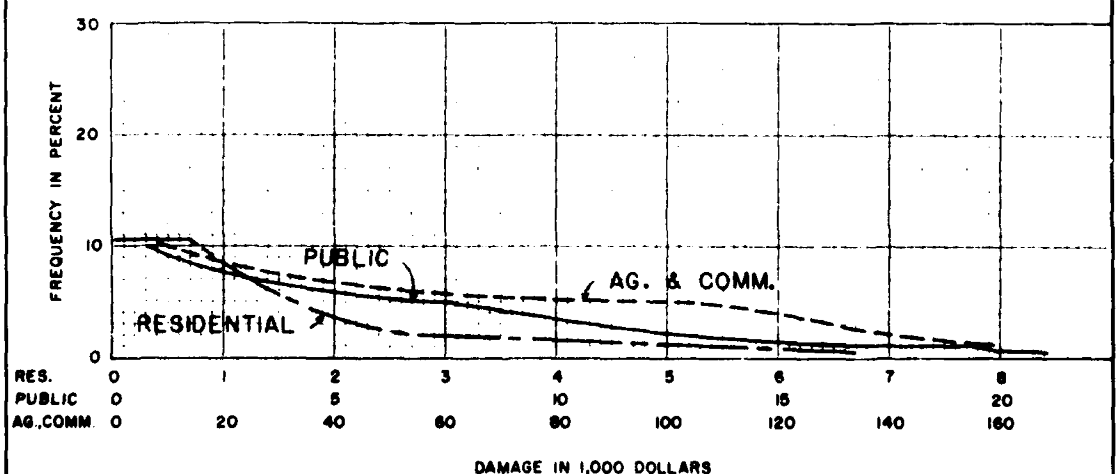


FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

DAMAGE REACHES



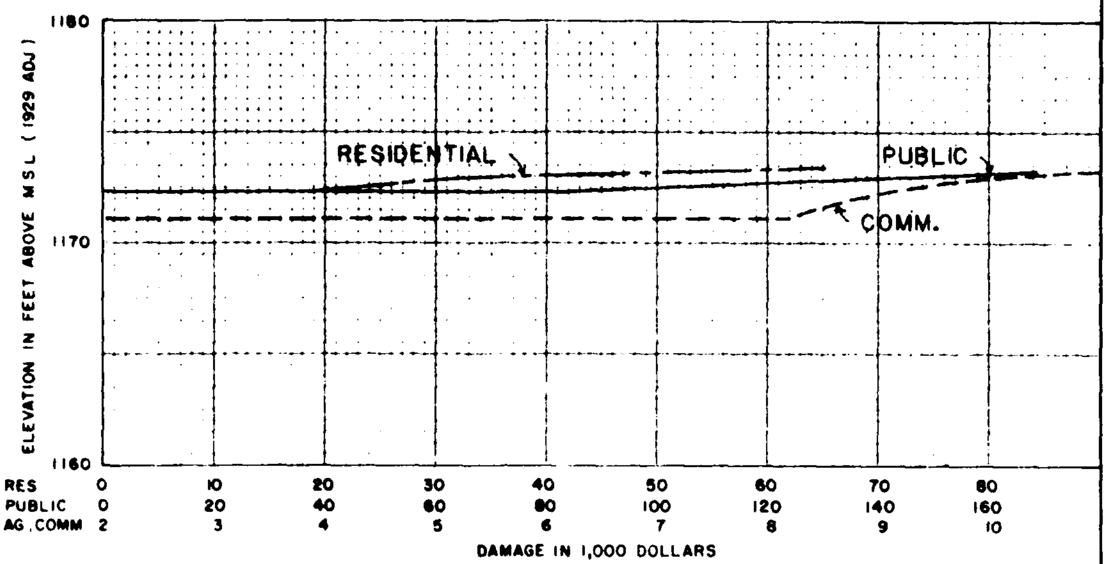
ELEVATION - DAMAGE CURVES



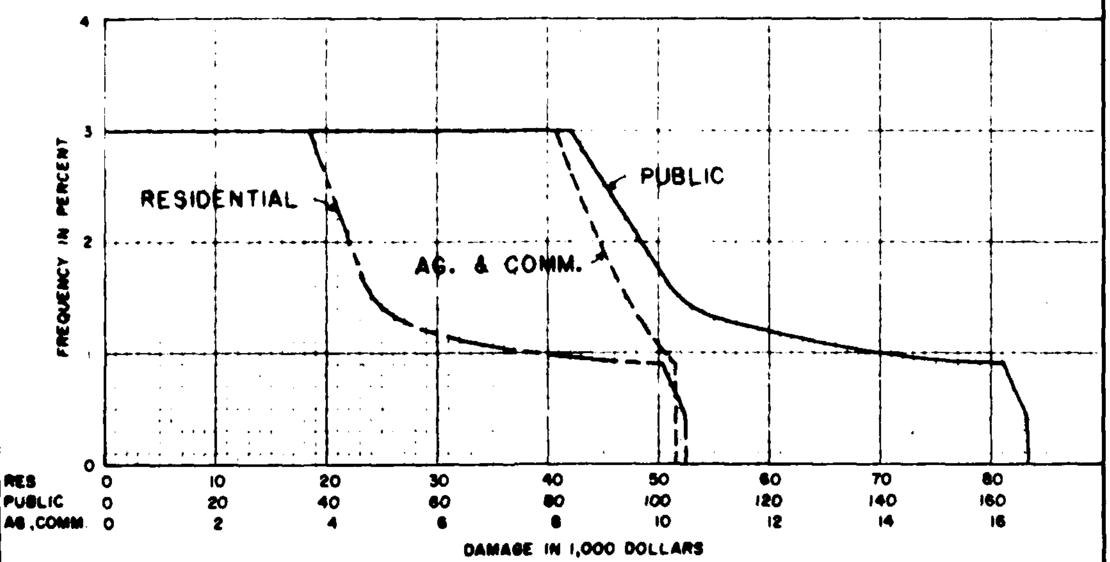
FREQUENCY - DAMAGE CURVES

FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA
ELEVATION - DAMAGE CURVES
FREQUENCY - DAMAGE CURVES
REACH "A"

PLATE F-4



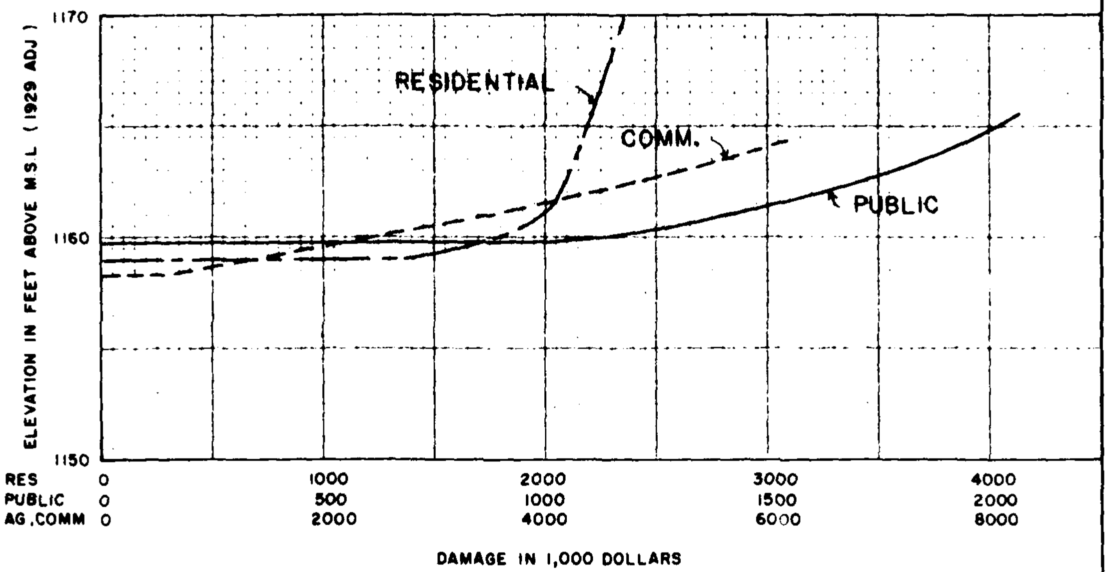
ELEVATION - DAMAGE CURVES



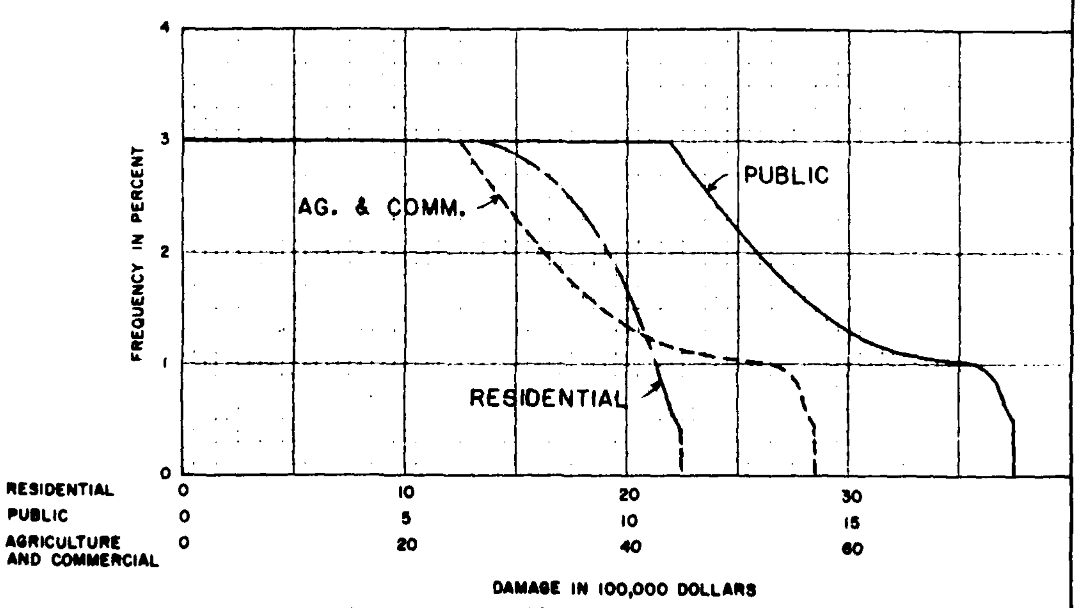
FREQUENCY - DAMAGE CURVES

FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA
ELEVATION - DAMAGE CURVES
FREQUENCY - DAMAGE CURVES
REACH "B"

PLATE F-5



ELEVATION - DAMAGE CURVES

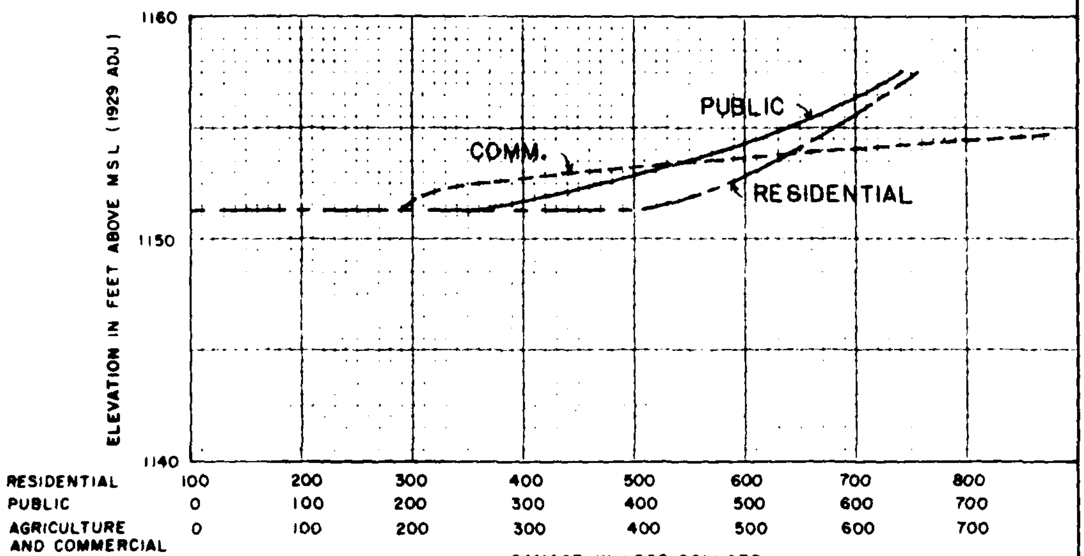


FREQUENCY - DAMAGE CURVES

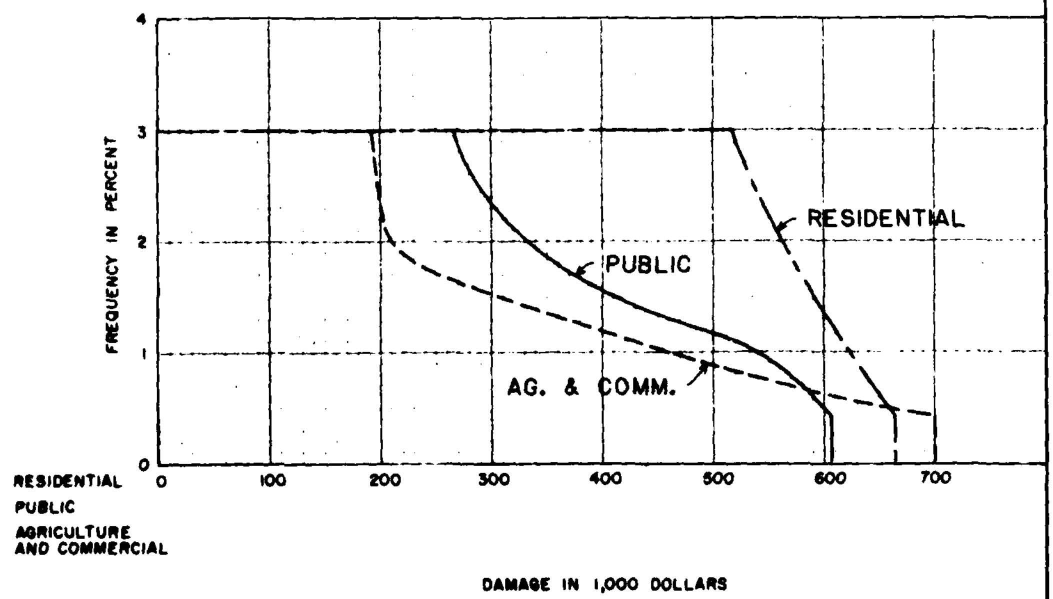
FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA

ELEVATION - DAMAGE CURVES
FREQUENCY - DAMAGE CURVES
REACH "C"

PLATE F-6



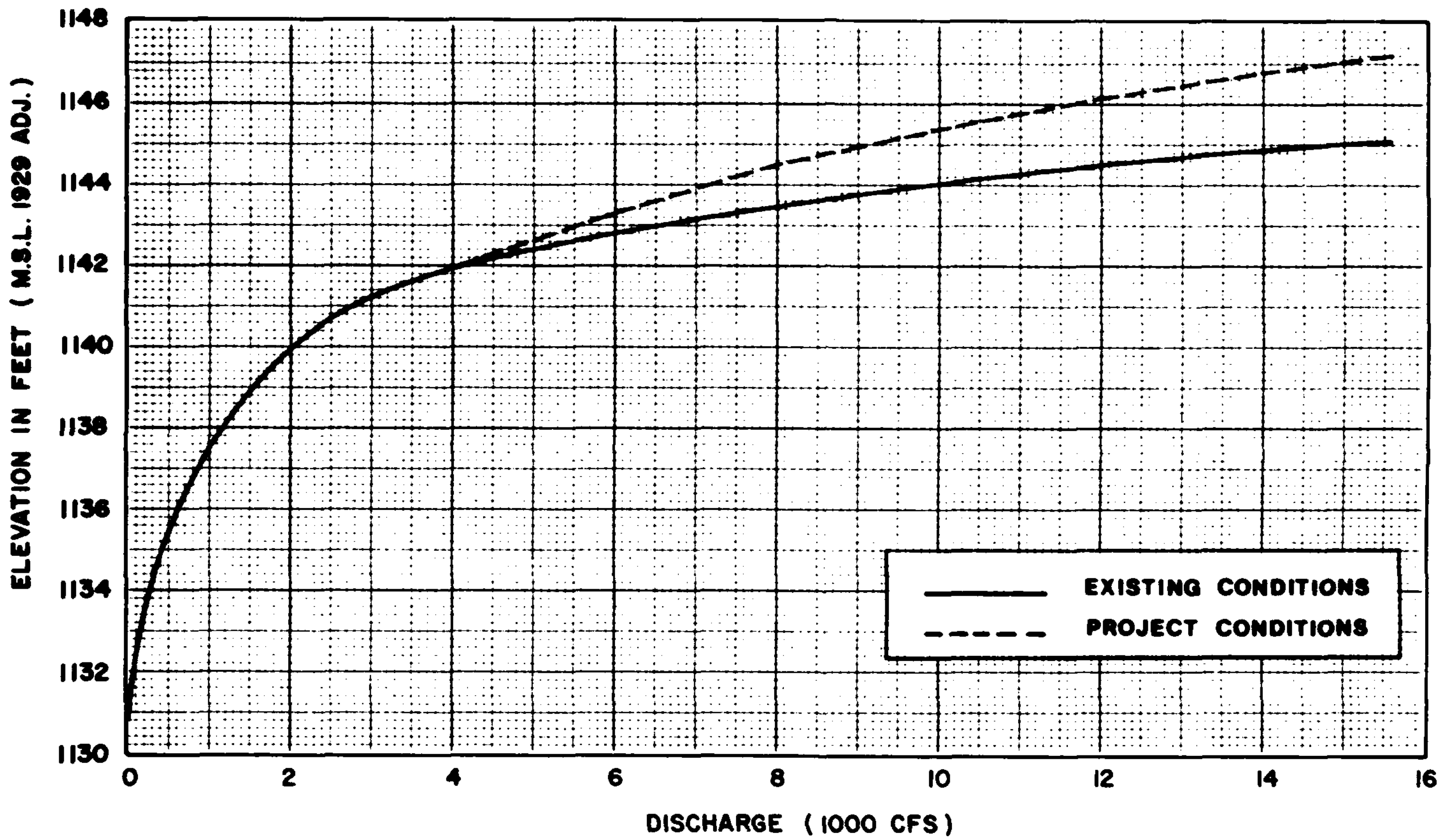
ELEVATION - DAMAGE CURVES



FREQUENCY - DAMAGE CURVES

FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA
ELEVATION - DAMAGE CURVES
FREQUENCY - DAMAGE CURVES
REACH "B"

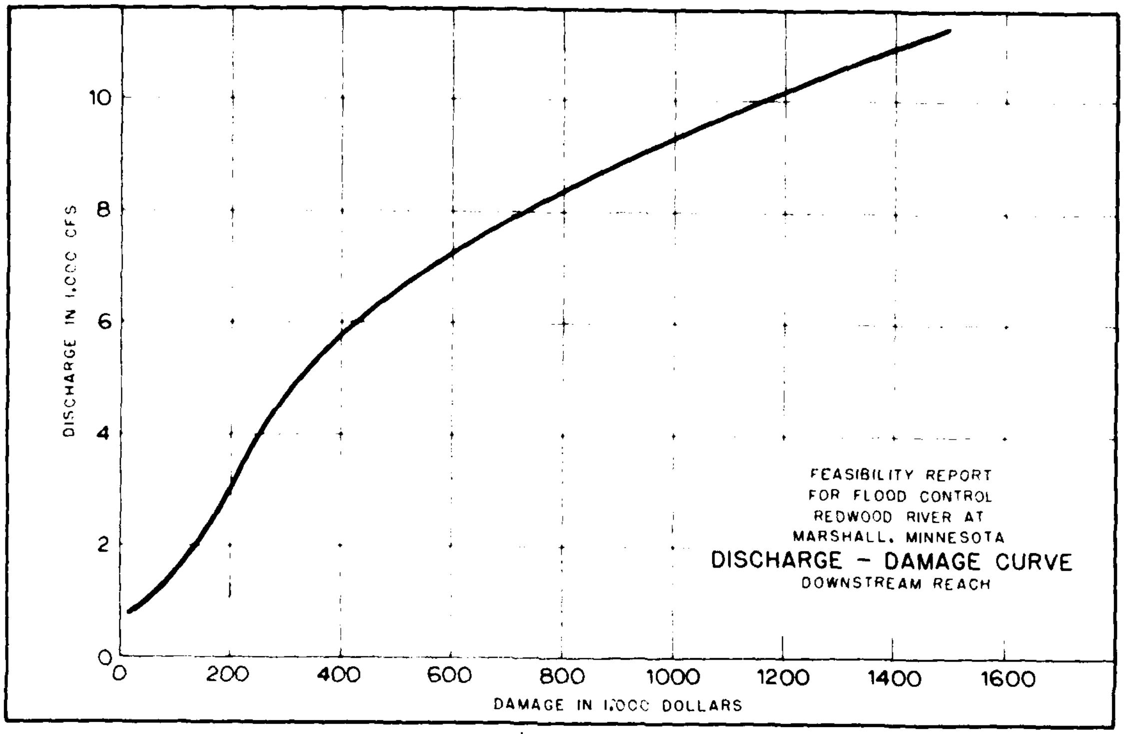
PLATE F-7



FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA

DISCHARGE RATING CURVE

DOWNSTREAM OF CONFLUENCE (MILE 65.16)


DISCHARGE IN 1,000 CFS
DAMAGE IN 1,000 DOLLARS
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA
DISCHARGE – DAMAGE CURVE
DOWNSTREAM REACH

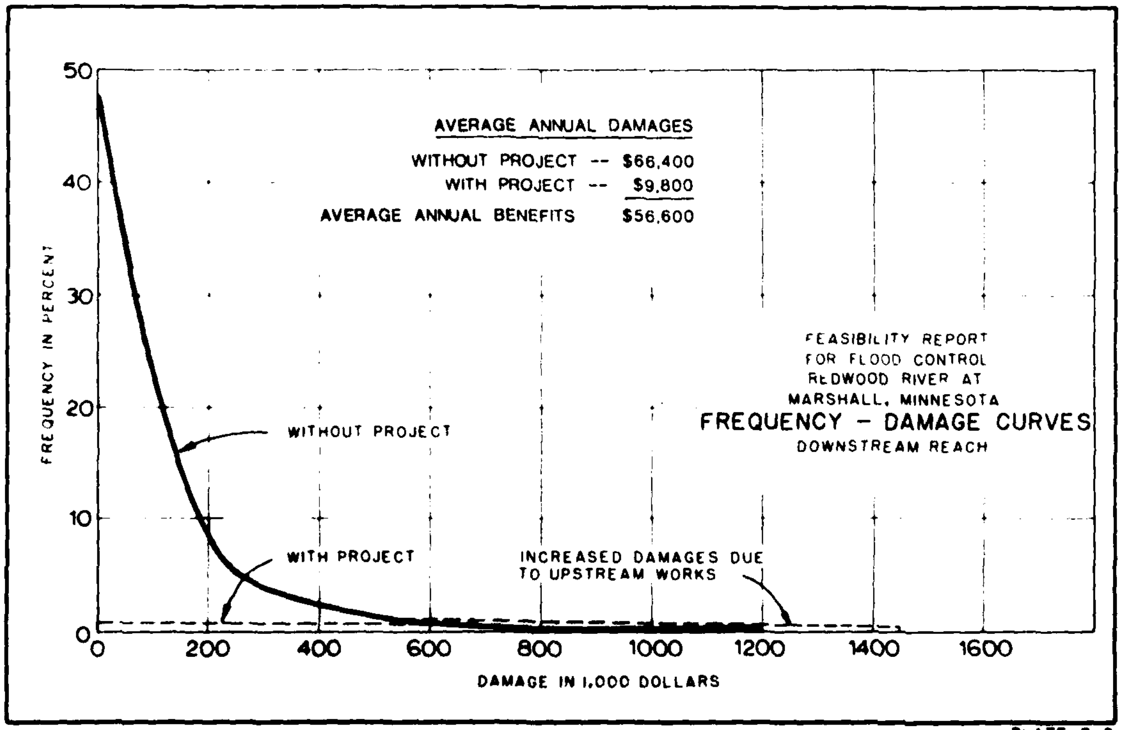
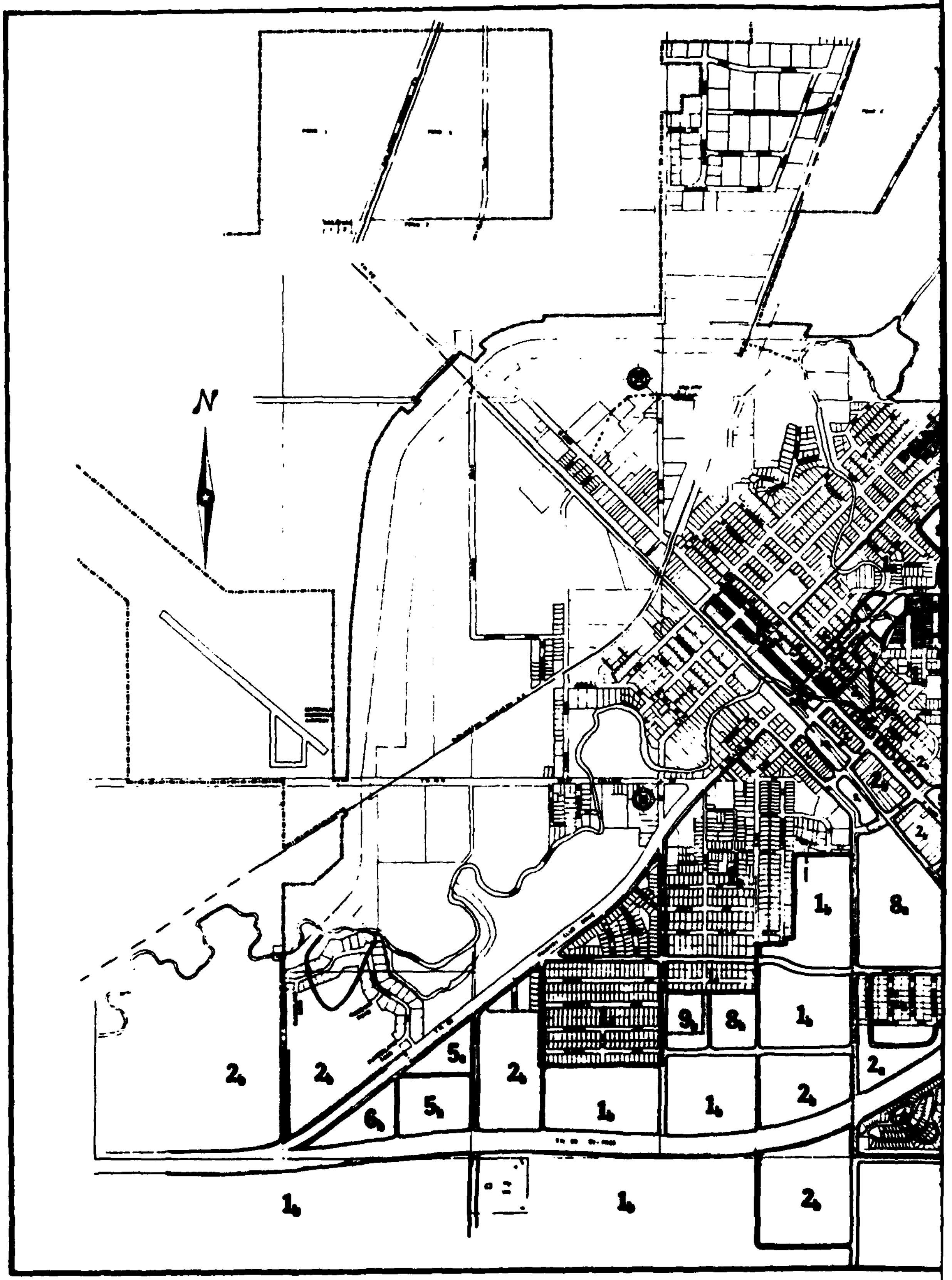

AVERAGE ANNUAL DAMAGES
WITHOUT PROJECT -- $66,400
WITH PROJECT -- $9,800
AVERAGE ANNUAL BENEFITS $56,600
FREQUENCY IN PERCENT
WITHOUT PROJECT
WITH PROJECT
INCREASED DAMAGES DUE TO UPSTREAM WORKS
DAMAGE IN 1,000 DOLLARS
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA
FREQUENCY – DAMAGE CURVES
DOWNSTREAM REACH

PLATE F-9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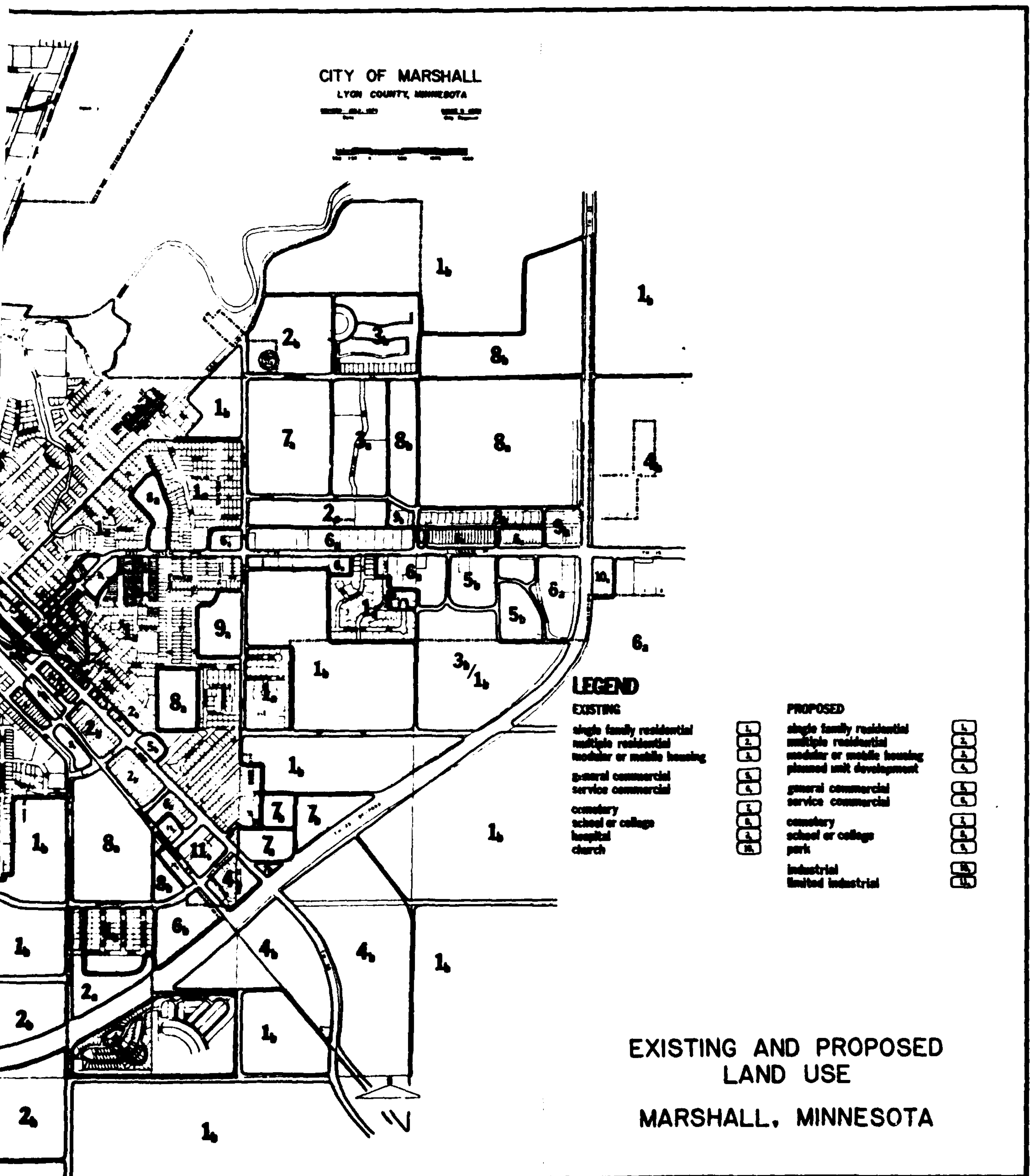
CITY OF MARSHALL
LYON COUNTY, MINNESOTA
LEGEND
EXISTING
single family residential
multiple residential
modular or mobile housing
general commercial
service commercial
cemetery
school or college
hospital
church
PROPOSED
single family residential
multiple residential
modular or mobile housing
planned unit development
general commercial
service commercial
cemetery
school or college
park
industrial
limited industrial
EXISTING AND PROPOSED
LAND USE
MARSHALL, MINNESOTA

PLATE F-10

SECTION G

RECREATION RESOURCES

SECTION G

RECREATION RESOURCES

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SECTION G

RECREATION RESOURCES

AUTHORITY

1. Section 4 of the 1944 Flood Control Act, as subsequently amended by Section 207 of the 1962 Flood Control Act, grants the Corps of Engineers general permissive authority to construct recreational developments at all water resource developments under control of the Secretary of the Army. The Federal Water Project Recreation Act of 1965 (P.L. 89-72) established development of the recreational potential at Federal water resource projects as a full project purpose. Corps policy (ER1120-2-404) establishes guidelines for cost sharing agreements on local flood control projects in keeping with the principles of P.L. 89-72).

PURPOSE

2. This report section appraises area recreation resources and facilities, provides estimates of the magnitude of existing and projected growth of public use, and identifies additional needed resources. It also displays the optimum scale of initial and future recreational developments, related costs and benefits, and location and extent of lands to be acquired for public use.

SCOPE

3. The investigation of recreational resource needs at Marshall considered geographically, the same upstream and downstream reaches of the flood control study and the existing diversion channel right-of-way. Specific elements of the study were established early in project efforts. Specific study elements investigated included the need for:

- o A combined bike-walking and a cross-country ski trail along the proposed levee alignments or river corridor commencing at the State Highway 23 roadside park and extending downstream via the existing diversion channel and proposed levee works to the Highway 23 service drive north of the college.
- o Limited picnicking facilities at Justice Park in conjunction with the proposed levee works.
- o The need for quiet area development and nature education areas.

4. Lands quired for any considered recreational developments would, in accordance with current Federal policy, be limited to those lands acquired for the existing and proposed flood control project or immediately adjacent lands purchased entirely at local expense to provide access to considered developments.

5. At the onset of this study, local interests indicated a need (See Section C-Improvements Desired) for improvements to the softball complex located on existing diversion channel right-of-way just north of State Highway 19. However, these improvements are expected to be made in the near future in conjunction with contemplated modifications to the ball fields to accommodate the proposed diversion channel parkway and are thus not considered in this study.

6. Required base resource information developed for the flood control study is also sufficient for this study and is documented in Section B of the appendix. Local interests have expressed a desire and willingness to participate in construction of the needed recreational facilities as indicated in a resolution (See Appendix II) passed by the Marshall City Council on 2 March 1979.

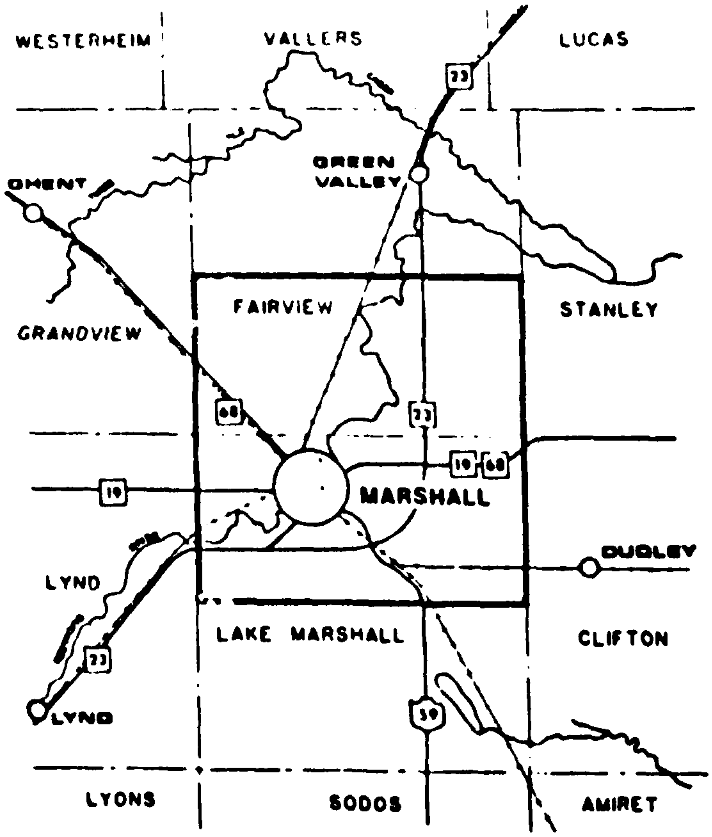
7. Background information used in this analysis included results of city-conducted user surveys; numerous discussions with the city recreation planner, other city officials, a local member of the Governor's Trails Advisory Committee, and local sporting goods stores. It also included analysis of the 1974 State Comprehensive Outdoor Recreation Plan with accompanying "Projections Methodology Report", and results of a 1974 user survey for nearby Camden State Park.

RECREATION MARKET AREA

RECREATION ZONE OF INFLUENCE

8. The area that can be expected to contribute 80 percent of the recreational day use includes the City of Marshall and the adjacent one-half of each of the surrounding two townships. Only one-half of the population of each township (the half adjacent to Marshall) would be expected to frequently use facilities at Marshall. Residents in the outer one-half of the Townships would more likely use the closer facilities at Garvin and Camden Parks. This contributing area would exclude competing day use at Camden State Park, 8 miles southwest of the city, and the Garvin County Park, located 12 miles south of Marshall. This investigation indicates that some of the present recreational

use at these two areas by Marshall area residents would undoubtedly revert to similar facilities at Marshall, if provided. This is particularly true of present school use of nature, educational and scientific facilities at these areas. Some usage of the considered facilities at Marshall could be expected from regional sports teams and informal groups outside the established market area during tournaments, but this usage is expected to be relatively minor.



PRESENT AND PROJECTED MARKET AREA POPULATION

Current (1970) population within the zone of influence is shown on Table G-1.

Table G-1 Population[1] in Zone of Influence

Area	Population
City of Marshall	9,886
Fairview Township	300[2]
Lake Marshall Township	379[2]
Total	10,565

[1] 1970 U.S. Census statistics

[2] One-half of Township population.

9. Although the southwest region of Minnesota is expected to experience a continuing population decline, Marshall is expected to grow but at a declining rate. Future growth at Marshall is most probably due to the City's strong position as the regional retail trade and farm service center. The presence of the Southwest State College, expanded air service facilities, and new shopping centers are all expected to maintain Marshall's positive growth posture in relation to the rest of the region. The two contributing Townships are expected to incur continuing population losses, due either to migration to Marshall or annexation by Marshall. In either case, the contributing day use population would remain about the same. Projected population within the zone of influence is shown on table G-2.

Table G-2 - Projected Population within Zone of Influence

Area	1980	2000	2030
Marshall	11,856	15,436	20,375
Fairview Township	325	300	275
Lake Marshall Township	350	325	300
Total	12,531	16,061	20,950

[1] Minnesota Department of Health, et al.

RECREATION DEMAND

10. The enjoyment of leisure time always has been and continues to be an important activity at Marshall. To help meet the needs of this continuing activity, the City and Lyon County have developed a system of attractive existing parks and other recreational facilities. However, these facilities fall far short of meeting current demands for some area activities, such as bicycling, picnicking and cross-country skiing. Camden State Park, 8 miles southwest of Marshall is the only regional state park convenient to Marshall.

11. Existing recreational facilities in the Marshall area are shown on plates G-1 and G-2. Supporting data on the capacity of existing facilities in the market area is presented in table G-7 entitled "Existing Facilities Serving Market Area:. An increasing shortage of needed recreational facilities is particularly true at Marshall which is increasing in population while other areas in the region are losing people. Activities and related facility needs considered for analysis were selected based on known project resource capacities and identified market area needs as determined and documented by the contractor. A detailed discussion of the demand for area recreational activities is presented in the following paragraphs.

12. Bicycling is an increasing area activity as indicated by limited registration data and sales information. Current traffic, both functional and recreational, must use moderate to heavily travelled streets with a potential for auto-bicycling accidents. The City is presently planning a circumferential recreational bike trail system which would, in part, traverse the existing diversion channel right-

of-way and proposed levee works. This sytem would divert much of the recreational traffic off auto lanes. A portion of the city bike trail system along the diversion channel between CSAH 7 and State Highway 19 is expected to be completed prior to construction of any authorized project-related recreational improvements.

13. Picnicking, popular most everywhere, is increasing at all parks in the city. Present group picnicking facilities at Legion Park (plate G-1) are used on a reservation basis to permit optimum use. Only very limited facilities are available for northeast Marshall residents at Justic Park (plate G-2). The City desires further expansion of picnic facilities, quiet areas, play lots, etc. at this park. A summary of existing recreation facilities is shown on Table G-3.

14. The recognition of natural resources and aesthetic values is translated into an increasing nature walk activity. Presently limited by inadequate public access to the river corridor, this activity would be participated in by both the casual observer and organized school education groups. Local interest indicates that area high school students involved in nature education and ecology classes must travel to other regional parks for field research activities with time consuming travel involved. This activity, as indicated, would most likely utilize local facilities, if provided.

15. Similarly, the demand for pleasure walking or pedestrian sightseeing is enjoying an increase. Again, however, the availability

Table G-3 - Existing Recreation Facilities at Marshall

Park or Location	Picnic Facilities Tables	Picnic Facilities Shelters	Playground Equipment (area)	Softball Fields	Baseball Fields	Tennis Courts	Outside Basketball Courts	Multi-Use Hard Surface Areas	Sanitary Facilities
Legion Park	14	1	1	2	1	6	1	-	1
Liberty Park	8	4	2	-	-	-	-	-	1
Justice Park	-	-	1	-	-	-	-	-	-
Freedom Park	4	-	1	1	-	-	2	-	1
Diversion Channel ballfield complex	-	-	-	4	-	-	-	-	-
Highway 23 Roadside Park	6	-	-	-	-	-	-	-	1
High School 1/	-	-	-	-	1	-	-	-	-
West Side Elementary School 1/	-	-	1	-	-	-	-	1	-
East Side Elementary School 1/	-	-	1	2	-	-	-	1	-
Parochial School	-	-	1	-	-	-	-	1	-
Southwest State University 1/	-	-	-	3	1	6	-	1	-

1/ Public access to school facilities limited to non-school use periods and is controlled by schools.

of public access to the river setting is restricted. A continuous trail along the river corridor at Marshall would offer vastly increased visual-hiking opportunities.

16. Although no documented data is available, bird watching along the river is significant at Marshall. The annual visitation of transient waterfowl provides the most important present focus for this activity. Two state-noted ornithologists provide guidance and field leadership in this area activity. Local interests again indicate that public access to wooded songbird habitat and other areas restricts this activity. A companion activity, wildlife photography, though not a major activity, is enjoyed by the bird watchers, plant and animal researchers and others. Again, the demand for improved access to conducive habitat is indicated.

17. Local sales figures indicate that the sales of cross-country skis have increased 75 fold at Marshall in the last five years. With no designated or improved trails, local enthusiasts must make use of open hospital, cemetery, and school grounds. With increasing demands for informal and weekend tour group use, the City desires an improved ski trail in conjunction with a biking trail if possible.

18. Other recognized recreational activities and related resource problems includes a minimal springtime canoeing activity. Canoeing needs generally relate to the lack of convenient accesses.

19. In support of local trends, the Minnesota State Comprehensive Outdoor Recreation Plan (SCORP) indicates a continued demand for regional (region 8) recreational facilities as shown on table G-4. Facility needs for picnicking are projected to increase about 8 percent between years 1975 and 1990. A statewide 1990 increase of 32 percent is projected for pleasure walking.

Table G-4 - Projected Region 8 Facility Needs (SCORP-1974)

Activity	Unit	1975	1980	1990
Bicycling	Miles	1/	1/	1/
Picnicking	No. of tables	1188 2/ (-216) 3/	1280 (-308)	1287 (-315)
Canoeing	Stream Miles	38 (+58)	44 (+52)	51 (+45)

1/ No SCORP facility requirements for bicycling.

2/ Projected facility requirements.

3/ Projected surplus or deficiency of facilities as compared to 1972 SCORP base conditions (+ denotes surplus)

DETERMINATION OF OUTDOOR RECREATIONAL ATTENDANCE

PER CAPITA PARTICIPATION RATES

20. The following paragraphs present a discussion of the methodology used to determine per capita participation rates for expected activities and the assumptions made to adjust the regional rates to reflect local conditions in the study area. Also discussed is the expected annual participation for the various activities as measured in visitor days for the years 1980, 2000 and 2030.

21. Per capita participation rates developed for the recreational activities expected at the project reflect the limited marked area, short travel distances involved, and mix of opportunities provided. In the absence of documented local user data, the rates displayed in table G-5 were determined from discussions with the City recreation director and other interests knowledgeable on local day use characteristics, an analysis of rates provided in the SCORP, and a review of the Bureau of Outdoor Recreation's 1969 participation rates published for the West North Central Region. Major departures from the SCORP rates were reductions in rates for bicycling, walking for pleasure, and canoeing. Rates for cross-country skiing were derived from an analysis of the local activity without the benefit of comparative values from other sources.

ASSUMPTIONS AFFECTING DEVELOPMENT OF LOCAL PARTICIPATION RATES

22. The present and projected participation in area bicycling can be expected to follow the state trend of an increasing rate of adult use with a declining rate of increase for sub-adult use. Local bicycle retail outlets confirm this observation via the recent and continuing increase in new and used bikes to area adults. Although widely popular for both functional and recreational use, the extent of local participation is expected to be inhibited for some time to come due to the limited availability of separate and safe bikeways.

23. Local participation in walking for pleasure in the project area is not expected to equal the state average. While a significant activity, it is not expected to reach the status of a similar recreation experience enjoyed -- say in walking through a continuous developed parkway or greenbelt area. A 1980 value for this local activity would appear to be about one-half of the statewide figure of 10.0.

24. Increasing local participation in cross-country skiing is evident by the 75-fold increase in ski sales over the last 5 years. Local enthusiasts estimate the extent of this activity to be at least equal to the recreational bicycling activity. Lower than SCORP rates for the local canoeing activity are indicated due to the relatively short six-week duration and fairly unique nature of this spring high water activity which appeals to a limited sector of the population.

25. All of the activities are expected to experience some increase in rates of participation as shown in Table G-5. With minor exceptions, these projected increases are generally expected to follow statewide trends to year 2000. Projected rates for year 2030 generally represent a declining rate of increase after year 2000, or in a few instances, a straight-line projection of the 1990-2000 rate of increase.

Table G-5 - Participation Rates

Activity	Estimated Rates for Market Area 1980	2000	2030	SCORP Rates for Region 8[1] 1980	1990
Bicycling	20.0	24.4	27.1	48.0	54.3
Picnicking	5.7	6.9	8.7	5.7	6.3
Nature walks	1.0	1.08	1.21	2/	2/
Walking for pleasure	5.0	5.8	6.2	10.0	11.0
Bird watching	1.10	1.28	1.32	2/	2/
Wildlife photography	0.19	0.25	0.34	2/	2/
Cross-country skiing	1.8	2.2	2.6	2/	2/
Canoeing	0.20	0.22	0.29	0.86	1.04

1/ No SCORP rates available for year 2000 and 2030.

2/ No SCORP rates (1974 report) for these activities.

INITIAL AND PROJECTED ATTENDANCE

26. Total potential annual participation in each of the given activities is obtained by multiplication of the established participation rates by the market area population. Annual attendance expressed in annual activity occasions and visitor days for years 1980, 2000, and 2030 is given in table G-6.

Table G-6 - Total Projected Annual Activity Occasions Within Market Area

Activity	1980 Pop - 12,531 Participation Rate	1980 Total Annual Activity Occasions	2000 Pop. - 16,061 Participation Rate	2000 Total Annual Activity Occasions	2030 Pop. - 20,950 Participation Rate	2030 Total Annual Activity Occasions
Bicycling	20.0	250,620	24.4	391,888	27.1	567,745
Picnicking	5.7	71,427	6.9	110,821	8.7	182,265
Nature walks	1.0	12,531	1.08	17,346	1.21	25,350
Walking for pleasure	5.0	62,655	5.8	93,154	6.2	129,890
Bird watching	1.10	13,784	1.28	20,558	1.32	27,654
Wildlife photography	0.19	2,381	0.25	4,015	0.34	7,123
Cross-country skiing	1.8	22,556	2.2	34,334	2.6	54,470
Canoeing	0.2	2,506	0.22	3,533	0.29	6,075
Totals		438,460		676,649		1,000,572
Total visitor-days 1/		175,384		270,660		400,229

1/ Visitor-days = Activity occasions ÷ 2.5
Term "Visitor-Day" is synonymous with "Recreation-Day" in Supplement No. 1 to Senate Document 99.

LAND AND FACILITY REQUIREMENTS

GENERAL

27. The determination of land and facility needs to meet present and projected usage is obtained as the difference between needs determined via a design-day load-facility load criteria analysis and suitable existing facilities.

FACILITY LOAD CRITERIA

28. Facility load criteria for the considered recreational resource needs is based on the maximum use rate which will still permit a relaxing and pleasing experience. Specific criteria are based on accepted industry and governmental planning standards as available. Others, such as for cross-country skiing were based upon an examination of the potential resource capability such as trail length, governing grades, ingress and egress, and shelter. No criteria is established for bird watching and wildlife photography since spatial demands for these activities can be reflected in walking trail criteria. Only limited needs for additional canoeing stream miles are indicated for the project area. However, the lack of an improved canoe access at or near the un-supervised roadside park results in continued safety hazard for persons landing or launching canoes at the steep river banks. These potential threats to public safety are even more acute during the most favorable spring high water canoeing period. Facility load criteria for selected activities is given in table G-7.

DESIGN DAY LOAD

29. To convert total visitation to required facilities, the following formula was used to compute the design day load as peak weekend day use for each activity.

$L = \frac{(a)}{(2.5w)} d$ where L = design day load
a = seasonal attendance expressed as a percent of total annual attendance
w = number of weeks in normal recreation season
d = weekend day use as a percent of weekly use
2.5 = factor used to convert annual activity occasions to annual recreation days.

To illustrate the use of this relationship, the following computation is shown for expected 1980 design picnicking day use in visitor days.

$a = 0.80^{1/} \times 71,427 = 57,142$

$d = 0.3^{2/}$

$w = 13$

$L = \frac{57,142}{2.5 \times 13} \times .3 = 527$

1/ Percentage equals seasonal use divided by total annual use.

2/ Percentage equals design Sunday use divided by total week use.

Similar computations for projected years 2000 and 2030 give design day use values of 818 and 1346 respectively. Design day use values for all activities are also given in table G-7.

REQUIRED FACILITIES

30. Applying the facility load criteria to the computed market area design day use values provides the total number or extent of required facilities. Required facilities for bicycling, picnicking, nature walks, walking for pleasure, cross-country skiing, and canoeing are given in table G-7.

Table G-7 - Determination of Required Lands and Facilities

Activity	Design Day Use 1/ 1980	2020	2030	Facility Load Criteria: Unit Load	Turn-over Rate	Total Facilities Required to Serve Market Area Population 1980	2000	2030
Bicycling	948	1447	2096	10 bikes/mile	8	11.9	18.1	26.2
Picnicking	527	818	1346	4 persons/table	2	66	102	168
Cross-country skiing	271	412	654	20 persons/mi./hr.	6	2.3	3.4	5.5
Nature walks	46	64	94	4 persons/mi./hr	6	1.9	2.7	3.9
Walking for pleasure	202	301	420	16 persons/mi./hr.	4	3.1	4.7	6.6
Birdwatching	34	51	68	---	--	--	--	--
Wildlife photography	14	24	43	---	--	--	--	--
Canoeing	25	35	61	17.2 persons/ stream mile	20	0.7	1.0	1.8

1/ Calculated design-day for cross-country skiing is based on a 10-week season from 25 December to 7 March. The canoeing season extends over a 6-week period between 15 April and 1 June. All other activities are based on a 13-week summer season.

PROPOSED RECREATIONAL IMPROVEMENTS

DESCRIPTION

31. The proposed recreation improvements as shown on Plates G-1 and G-2 would generally consist of a 5.2 mile long by 8-foot wide paved biking-walking trail including trail head facilities, a rest stop and benches; a 5.7 mile long cross-country ski trail; and limited picnic facilities at the softball complex and on project lands at Justice Park. Local improvements to provide a continuous trail system would include a 0.6 mile section of bike-walking trail between CSAH 7 and State Highway 19 (See Plate G-1) and a 0.3 mile section of both bike-walking trail and cross-country ski trail extending westward from County Highway 67 as shown on Plate G-2. The 0.6 mile bike-walking trail is currently in the planning stages and is expected to be completed prior to any authorized federally cost-shared improvements. The 0.3 mile section of trail upstream of County Highway 67 would be constructed by local interests on non-project lands adjacent to the proposed parkway at the time of construction of any authorized recreational improvements.

32. The proposed bike-walking trail would extend from the eastern terminus of the downstream reach levee (Plate G-2) upstream along the existing diversion channel to the CSAH 7 bridge (Plate G-1) and provide a much needed facility, largely free of conflicts with motorized vehicles. The trail would offer a variety of visual and other sensory experiences. These experiences would occur in an open prairie environment -- unprotected from the elements, a linear "closed in" environment, and possibly in the future with an upstream extension, a natural wooded - streamside environment. Although much of the proposed trail would be nearly flat, a number of slopes to seven

and one-half percent would challenge the bike rider as well as the pleasure walker. A rest area is proposed as part of the improvements at the playfield facilities north of U.S. Highway 19. The proposed trail would be hard surfaced with a bituminous mat. Typical sections showing how the trail would relate to the levees, the diversion channel, etc. are given on plate G-3.

33. Trail head facilities would be located at each end of the trail system. A trail head with drinking water, toilet facilities, bike racks, and parking area would be located at the eastern or downstream trail terminus at the service drive adjacent to State Highway 23 (See plate G-2). Pedestrian or bike access to these facilities would be provided by an 8-foot wide gravel trail from the college area and which would be constructed at local expense. Existing park facilities would satisfy similar trail-end needs at the upstream terminus of trail system at the Highway 23 wayside park as shown on Plate G-1. Also included as part of the trail facilities would be a rest stop with a shelter, toilet, and drinking facilities, and benches as illustrated in Sketch 1 on Plate G-3.

34. The trail system along the existing diversion channel right-of-way would pass over or under four highway and three railroad bridges as dictated by available clearance. Timber retaining walls would be used to retain diversion channel side slopes along trail crossings under bridges. A typical trail crossing incised into the diversion channel side slope is illustrated on Section B-B of Plate G-3. Where bridge clearances are inadequate, marking signs would be provided at the two-street level trail crossings required.

35. Upstream of CSAH, the proposed trail system would traverse project lands to be acquired for floodway purposes. Two 8-foot wide timber bridges would be provided in this reach as shown on Plate G-1. An illustration of a proposed typical bridge is given in Sketch 3 of Plate G-3.

36. The cross-country ski trail generally would follow the alignment of the bike-walking trail except that it may freely transgress the invert of the diversion channel whereas the bike-walking trail could not. The ski trail, therefore, would generally occur on the north and west side of the diversion channel and traverse proposed wooded areas. These new wooded areas would provide protection from wind as well as improve and preserve snow cover. The relationship between the ski trail and the bike-walking trail is illustrated on plate G-3.

37. Limited picnic facilities are proposed as part of the improvements on project lands at Justice Park and at the outdoor games area located north of U.S. Highway 19. It is anticipated that the proposed limited picnic facilities at the softball complex rest stop would serve both trail users, softball players and spectators. A sketch showing possible arrangements of these latter facilities is shown on plate G-3.

38. Planting improvements are also included as part of the proposed development for the west and north side of the diversion channel and the rest area at the outdoor games area north of U.S. Highway 19. A very high priority should be assigned these improvements for reason described earlier and perhaps more importantly, to upgrade the general character of the recreational area.

39. A future rest area and picnic facilities desired by the community at Justice Park, which would complement the proposed trail systems, might include additional picnicking equipment, nature trails and quiet area development, added child play area, tree and shrub planting, toilet and drinking water facilities, and hard surface parking area. Local planning efforts for these facilities which would be provided by the City at its own expense are currently underway.

40. A substantial area for nature walks, bird watching and wildlife photography is located between the Minnesota Highway Department's Highway 23 wayside park and CSAH 7. Use of this area would be compatible with the proposed use of the area as a designated floodway. Nature trails that would link to the biking trail would be located in the future by local interests within the area after careful field study.

41. Implementation of the proposed recreational improvements would provide facilities which are generally unavailable within the Marshall service area at the present time. They could be provided at a moderate cost by utilization of the existing and proposed flood control facilities for location of these improvements.

AREA MANAGEMENT CONCERNS

42. A potential management problem could be the unauthorized use of motorized vehicles on the trail. The project sponsor would be expected to prohibit access to motorized vehicles. Vertical timber or other suitable barriers would be provided at trail access points to bar the use of these vehicles. Although some occasional conflicts may occur, the simultaneous trail use by bicyclists, wheelchair patients, and pedestrians along some segments is considered manageable. Occasional rest and widened areas on the trail would help maintain a suitable balance of activities on the trail. Skiing on the bicycle trail is not provided for nor encouraged due to the hard paved surface and expected lack of continuous snow cover on the levee crown.

43. Also of some local concern is the close proximity of the proposed trails to nearby residences immediately upstream of CSAH 7. Chain-link fencing and screen plantings would be provided to screen the trail from view and prohibit indiscriminate entry on non-project lands.

CAPABILITY OF PROJECT TO SATISFY EXCESS DEMAND

44. Construction of the proposed facilities would satisfy part or in some cases all of the projected demand within the market area. Results of an analysis of project-related capability is given in table G-8.

DETERMINATION OF RECREATION BENEFITS

GENERAL

45. The derivation of project recreation benefits is dependent on actual project-related use, the extent of facilities which can be accommodated with the proposed flood damage reduction measures and application of a dollar unit recreation day value to the average annual recreation day value. Total recreation day use is discounted over a 50-year project life at a 6 7/8 percent interest rate.[1/]

PROJECT-RELATED USE

A potential management problem could be the unauthorized use of motorized vehicles on the trail. The project sponsor would be expected to prohibit access to motorized vehicles. Although some occasional conflicts may occur, the simultaneous trail use by bicyclists, wheelchair patients, and pedestrians along some segments is considered manageable. Occasional rest and widened areas on the trail would help maintain a suitable balance of activities on the trail. Skiing on the bicycle trail is not provided for nor encouraged due to the hard paved surface and expected lack of continuous snow cover on the levee crown.

Table [illegible] - Satisfaction of [illegible] Market Area Demand by Proposed Facilities

Activity	Estimated Design Day Use[1] 1980	2000	2030	Maximum Project Design Day Use Cap	Demand Met By Existing Facilities	Total Unmet Demand 1980	2000	2030	Unmet Facility Requirements 1980	2000	2030
Bicycling	948	1447	2096	440	240	268	[illegible]	1416	[illegible] mi	9.6	17.7
Picnicking	527	818	1346	80	240	207	498	1026	26	62	128
Nature walks	40	64	94	40 (est.)	0[2]	6	24	54	0.2 mi.	1.0	[illegible]
Walking for pleasure	202	301	420	108 (est.)	0[3]	94	193	312	1.5 mi	3.0	4.9
Bird watching	34	51	68	--	--	Not estimated			--	--	--
Wildlife photography	14	24	43	--	--	Not estimated			--	--	--
Cross-country skiing	271	412	654	552	0	0	0	0	0 mi.	0	0
Canoeing	25	35	61	61+	0	0	0	0	0	0	0

1/ Number of persons on a design season Sunday.

2/ Presently utilized undeveloped walking areas not evaluated.

3/ No estimate made of extent of city streets and open areas presently used.

Table G-9 - Estimated Actual Project-Related Recreational Use

Activity	Estimated Maximum Project Capacity as a Percent of Total Use 1980	2000	2030	Estimated Actual Project Use as a Percent of Total Demand 1980	2000	2030
Bicycling	46	30	21	20	20	20
Picnicking	15	10	6	10	10	6
Nature walks	87	63	43	20	20	20
Walking for pleasure	53	36	26	10	10	10
Bird watching	-	-		20	20	20
Wildlife photography	-	-	-	15	15	15
Cross-country skiing	83	186	117	25	25	25
Canoeing	-	-	-	0	3	3

47. What table G-9 indicates, say for bicycling, is that while the proposed trail could accommodate 46 percent of the total 1980 market area demand (72 percent of the 1980 demand including existing facilities), it is unlikely that this level of actual utilization would be reached. As indicated, for reasons of constraints discussed previously a more realistic estimate of project utilization would be about 20 percent. Particularly, as in the case of pleasure walking, the actual estimates attempt to account for the unestimated available quantities of less desirable present facilities which are available.

48. As evident in the table, some project-related use for nature walks, walking for pleasure, bird watching, and wildlife photography can be expected generally as the result of improved public access to the riverine corridor. Adjusted project-related recreational use in total activity occasions based on proposed facility capacity and estimated use is given in Table G-10.

Table G-10 - Adjusted Project-Related Recreational Use

Activity	Percent Efficient 1/	1980 Adjusted Activity Occasions 2/	Percent Efficient	2000 Adjusted Activity Occasions 2/	Percent Efficient	2030 Adjusted Activity Occasions 2/
Bicycling	20	50,124	20	78,278	20	113,549
Picnicking	10	7,140	10	11,082	6	18,226
Nature walks	20	2,506	20	3,469	20	5,070
Walking for pleasure	10	6,265	10	9,315	10	12,989
Bird watching	20	2,757	20	4,117	20	5,531
Wildlife photography	15	357	15	602	15	1,068
Cross-country skiing	25	5,639	25	8,833	25	13,617
Canoeing	0	0	3 3/	106	3	182
Total Adjusted Activity Occasions		74,788		115,902		175,232
Recreation days 4/		29,915		46,360		70,093

1/ Estimated percent of peak day use that proposed facilities would satisfy as given in Table G-9.

2/ Adjusted activity occasions = Activity Occasions (table G-6 x Percent Effective (project-related).

3/ Only minor use attributed to improved river access in future years.

4/ Recreation days = Activity Occasions ÷ 2.5 (average number of activity occasions per recreation-day).

49. The growth of recreation day use at the proposed project recreation facilities is shown graphically on figure G-1. Also shown

is expected attendance three years after construction of the recreation features. The following methodology was used to compute average annual recreation day use. Specific area designations correspond to those shown on figure G-1.

Area A

Rate of increase per year (32,511 ÷ 3)	= 10,837
Value of increasing annuity for 3 years @ 6-7/8%	= 5.144
Interest and amortization over 50 years	= 0.07132
Ave. ann. recreation days = (10,837) (5,172) (0.07132)	= 3,997

Area B

Constant value of 32,511 over 47 years	= 32,511
Value of constant amortization of $1 for 47 years	= 13.9064
Present worth of $1 - 3 years hence	= .8192
Interest and amortization over 50 years	= .07132
Ave. Ann. Recreation days = (32,511) (13.9064) (0.8192) x (0.07132)	= 26,415

Area C

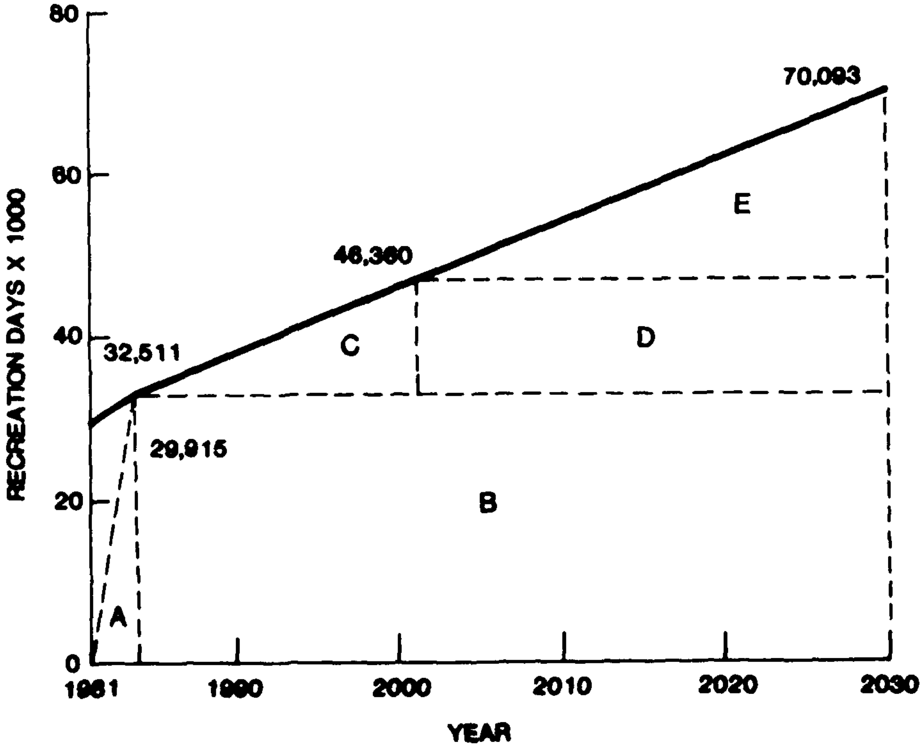
(See Area A procedure). Rate of Increase = $\frac{46360 - 32{,}511}{17 \text{ years}}$ = 815

Ave. ann. recreation days = (815) (73,2453) (0.8192) x (0.07132) = 3,485

Area D

(See Area B procedure)

Ave. Ann. recreation days = (13,849) (12.5665) (0.2645) x (0.07132) = 3,285



EXPECTED VISITATION FIGURE G-1

Area E

(See Area A procedure)

Ave. ann. recreation days = (791) (135,982) (0.2645) x (0.07132)	=	2,030
Total Average Annual Recreation Days	=	39,212

ESTIMATE OF RECREATION BENEFITS

50. The U.S. Water Resources Council has established that unit dollar values for recreational experiences similar to those expected at Marshall range from $0.75 to $2.25 per recreation day. Recognizing that a suitable value is based on factors such as user willingness to pay, degree of opportunities provided, and the extent of development, a reasonable user day value for activities at Marshall is considered to be about $1.10. Multiplying average annual recreation days of 39,12 by this unit benefit value gives average annual recreation benefits of $43,130.

COORDINATION

51. Active participants or agencies and interests providing impact to the recreation study included the following:

Minnesota Department of Natural Resources - Bureau of Environmental Planning and Protection

Division of Parks and Recreation

Minnesota Department of Health

City of Marshall - City Engineer's Office

Department of Parks and Recreation

Member, Governor's Trails Advisory Committee

Local sporting goods retail outlets.

52. Review and comment on this study element was also provided by the Federal, state, and local agencies listed in section A of this technical report. Late-stage meetings to discuss the proposed recreation facilities were held with City officials on 2 March 1978 and 2 April 1979. Based on these discussions, major changes, including addition of trail head facilities at the downstream end of the trail and the deletion of 0.6 miles of proposed hike trail between CSAH and State Highway 19 were made to the proposed recreation facility plan.

IDENTIFICATION OF SPECIAL PROBLEMS

53. There is little potential for encroachment on proposed project areas because of the proposed levee project which should prevent further development of the presently undeveloped river corridor. Proposed facilities located within the existing diversion channel right-of-way would also be spared interim or future encroachment as this city-owned right-of-way is reserved for flood control and commensurate purposes only.

54. The City of Marshall is presently planning a parkway (FAU 5764) along a portion of the diversion channel right-of-way. Maximum vehicle speeds on this route would be posted at 40 mph. Designs for this highway in the vicinity of the softball complex would necessarily include provisions for bicycle access from the trail system to the proposed rest stop. This parkway crossing could be accomplished with either an overhead or underground trail crossing. Because of the uncertain timing of the considered parkway at this time, development of designs for this crossing would be accomplished in post-authorization studies.

55. Gentle grades at trail access points and other features such as widened rest and passing areas and highly visible signs at two street level crossings would provide for wheelchair use and the elderly in conformance with existing city and college programs and facilities for these users. A few short trail segments along the diversion channel would traverse the channel slope at gentle grades under two highway bridges and three railroad bridges to avoid busy street and rail crossings.

56. No conflicts with other agency programs are expected as the proposed facilities would complement and be in concert with the City's flood control and recreational program.

MANAGEMENT AND COST SHARING

CORPS RESPONSIBILITY

57. Section 4 of the Flood Control Act of 1944 (16 U.S.C. 460d), as amended by Section 207 of the Flood Control Act of 1962, grants general permissive authority to construct recreational developments at all water resource developments.[1/] The Federal Water Project Recreation Act of 1965 (PL 89-72) modifies section 4 authority by imposing requirements of non-Federal cooperation and cost sharing for recreation and fish and wildlife enhancement at projects authorized after 1 January 1965. This law requires matching local participation in terms of money and/or lands that will equal the Federal share. In this instance, if the local interests are not financially capable of participating, no Federal recreational development will be provided. Corps policy (ER1120-2-404) establishes guidelines for cost sharing agreements on local flood control projects in keeping with the principles of PL89-72.

NON-FEDERAL RESPONSIBILITIES

58. The City of Marshall must provide all lands required for development and control of the proposed public use areas. Present policy indicates that lands are not eligible for credit towards the non-Federal sponsor's share of recreation development costs.

59. Of the proposed facilities, the Federal government would provide one-half the cost of all features except for lands required for trail development. The City would operate, maintain, and replace without expense to the Federal Government the recreational areas and all installed facilities. If long-term repayment is elected, however, all costs, including interest, must be repaid within 50 years of the date of first use of the initial recreation facilities. If all or part of long-term repayment of the City's share of initial separable costs is to be financed through user fees, the schedule of such fees and the portion thereof dedicated to repayment are subject to renegotiation at intervals not exceeding 5 years. User fees can be collected and may be used to support operation and maintenance costs. Monies received from non-Federal interests shall be deposited in the Treasury as miscellaneous receipts. By a resolution of the City Council adopted 2 April 1979, the City of Marshall furnished assurances of its willingness and ability to meet conditions proposed for non-Federal assumption of responsibilities for development, operation, maintenance, and replacement of the proposed recreational facilities.

ENVIRONMENTAL QUALITY

60. Public acceptance of the proposed recreational facilities would depend on its environmental and/or aesthetic quality. Various grass mixes, shrub and tree plantings would be provided to enhance wildlife habitat, improve aesthetics, and optimize the recreational experience. Overburden sections with plantings along the levee portion of the trail would provide rest and observation areas, and help blend the entire works into the natural setting.

COSTS

FIRST COSTS

61. Estimated Federal and non-Federal first costs for the proposed facilities based on existing cost-sharing legislation are given in table G-11 and are based on October 1977 price levels. These costs are presently estimated at $192,800 and $192,800 respectively. Applying the President's proposed cost-sharing policies would result in Federal and non-Federal first costs of $173,500 and $212,100 respectively.

Table G-11 Estimated First Cost for Recreation Facilities

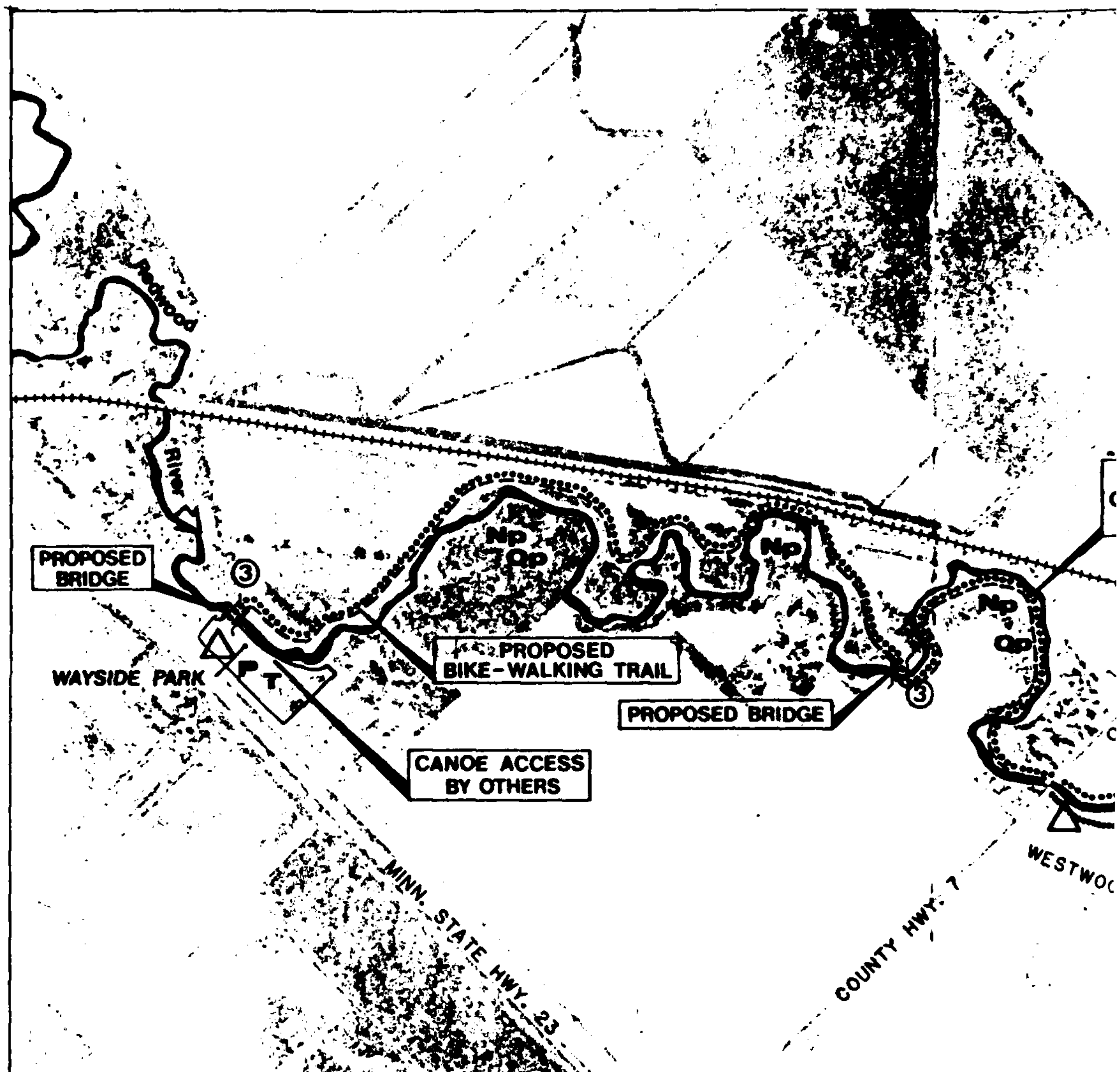
Item	Unit	Quantity	Unit Cost	Federal Cost	Non-Federal Cost	Total Cost
I. TRAIL DEVELOPMENT						
A. Bicycle Trail and Trail Head						
Grading	yd^3	19,910	0.90	$ 8,960	$ 8,960	$ 17,920
Base Course	s.y.	25,700	1.25	16,060	16,060	32,120
Wear course	s.y.	25,700	2.40	30,840	30,840	61,680
Seeding	acre	8.0	675.00	2,700	2,700	5,400
Clearing & Grubbing	acre	1.8	1,000.00	900	900	900
Timber Retaining Walls	l.f.	2,050	14.00	14,350	14,350	28,700
Benches	ea.	10	110.00	550	550	1,100
Bike Racks	ea.	2	500.00	500	500	1,000
Toilet Building and Drinking Fountain	ea.	2	34,500.00	34,500	34,500	69,000
Signs	ea.	30	30.00	450	450	900
Bridges	ea.	2	30,000.00	30,000	30,000	60,000
Sub-total Bicycle Trail				$139,810	$139,810	$279,620
B. Cross-Country Ski Trail						
Clearing & Grubbing	acre	1.3	1,000.00	650	650	1,300
Marking signs	ea.	52	30.00	780	780	1,560
Trail Plantings Tree and shrub planting	ea.	1,500	24.00	18,000	18,000	36,000
Sub-total Ski Trail				$ 19,430	$ 19,430	$ 38,860
TOTAL TRAIL DEVELOPMENT				$159,240	$159,240	$318,480
II. PICNICKING						
Picnic Tables[1/]	ea.	10	$280.00	$ 1,400	$ 1,400	$ 2,800
Sub-total Picnicking				1,400	1,400	2,800
TOTAL CONSTRUCTION COST				$160,640	$160,640	$321,280
Contingencies (20%)				32,160	32,160	64,320
Engineering and Design (10%)				19,200	19,200	38,400
Supervision and Administration				9,600	9,600	19,200
TOTAL FIRST COST - PROPOSED DEVELOPMENT				$221,600	$221,600	$443,200

[1/] Federal cost sharing in picnic tables on flood control project lands only.

62. Estimated Federal and non-Federal annual costs, including non-Federal operation and maintenance costs, and based on existing cost-sharing legislation are shown in table G-12 below. The operation and maintenance costs reflect annualized costs of periodic trail maintenance, annual grooming, periodic repair of other facilities and normal trash removal and clean-up activities.

Table G-12 - Estimated Annual Costs

Federal	
Total First Cost	$221,600
Interest and Amortization ($221,600 x 0.07132)	15,800
Total Federal Annual Costs	$ 15,800
Non-Federal	
Total First Cost	$221,600
Interest and Amortization ($221,600 x 0.07132)	15,800
Operation and Maintenance	2,690
Total Non-Federal Annual Costs	$ 18,490
TOTAL ANNUAL COSTS	$ 34,290



LEGEND

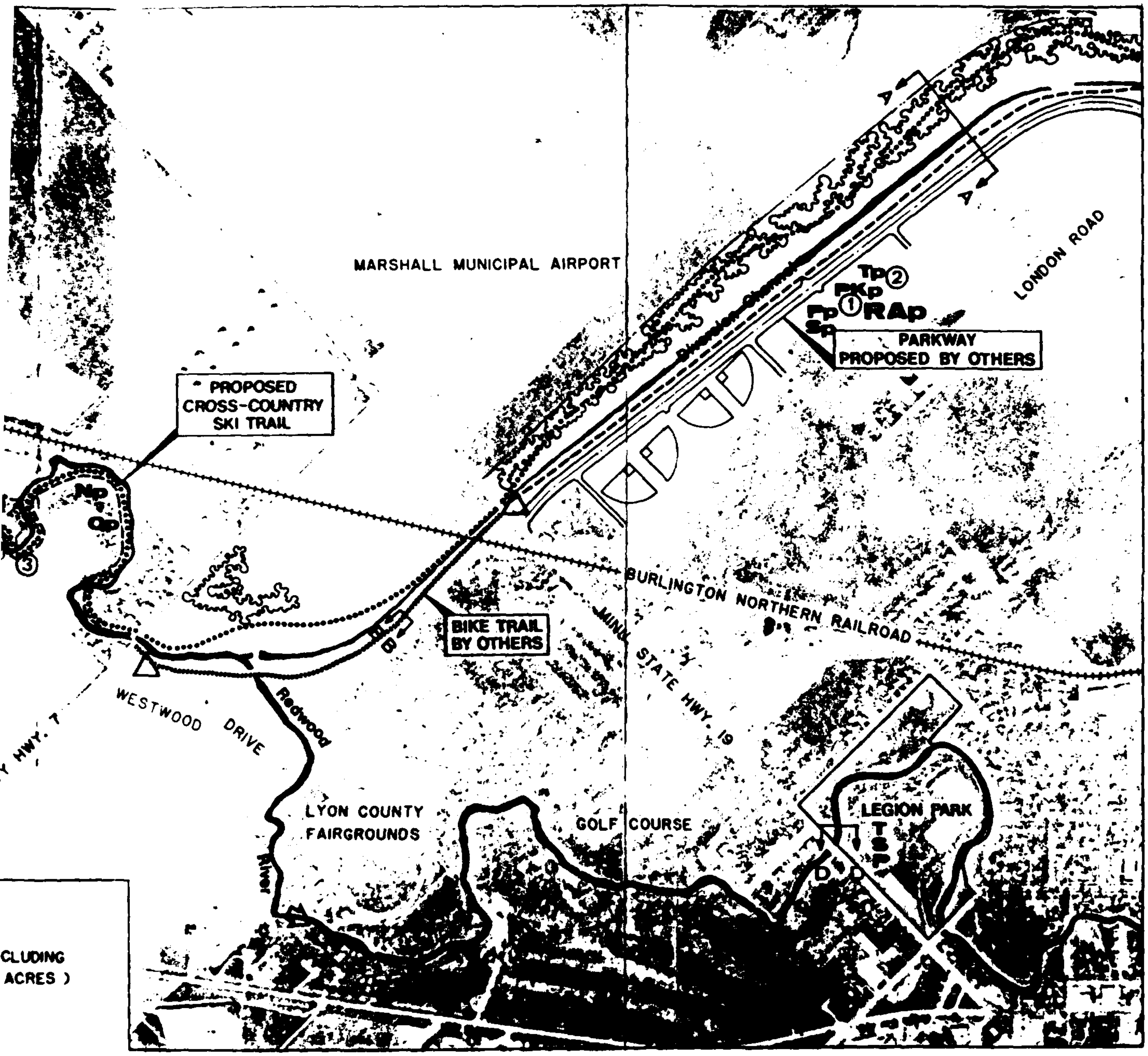
PROPOSED OVERSTORY AND UNDERSTORY TREES OF TYPICAL SPECIES INCLUDING ASH, HACKBERRY, OAK, RUSSIAN OLIVE, HAWTHORN ETC. (APPROX. 35 ACRES)

EXISTING	PROPOSED	
RA	RAp	REST AREA
S	Sp	SHELTER
T	Tp	SANITARY FACILITY
PA	PAp	PLAY / ACTIVITY AREA
P	Pp	PICNIC AREA
PK	PKp	PARKING AREA
Q	Qp	QUIET AREA (BY OTHERS)
N	Np	NATURE AREA (BY OTHERS)

N

0 500 1000

SCALE IN FEET



NOTE:
CROSS SECTIONS & FEATURES ① ② ③
ILLUSTRATED ON PLATE G-3.
△ TRAIL ACCESS POINT
WITH VEHICLE CONTROL BARRIERS

FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

GENERAL PLAN

PROPOSED RECREATIONAL MEASURES

PLATE G-1

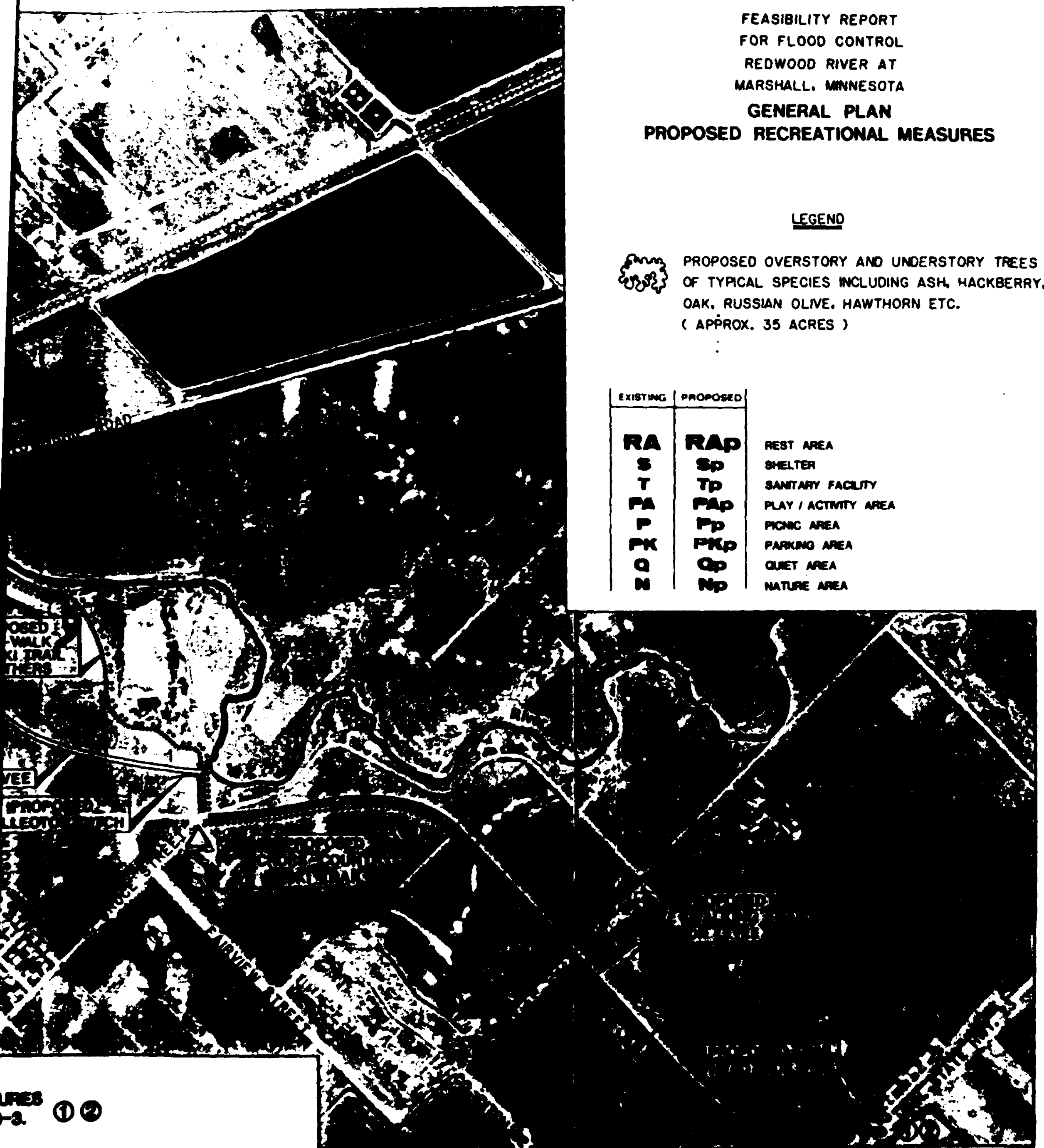
NOTE:

CROSS SECTIONS & FEATURES ILLUSTRATED ON PLATE G-3. ① ②

△ TRAIL ACCESS POINT WITH VEHICLE CONTROL BARRIERS

FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

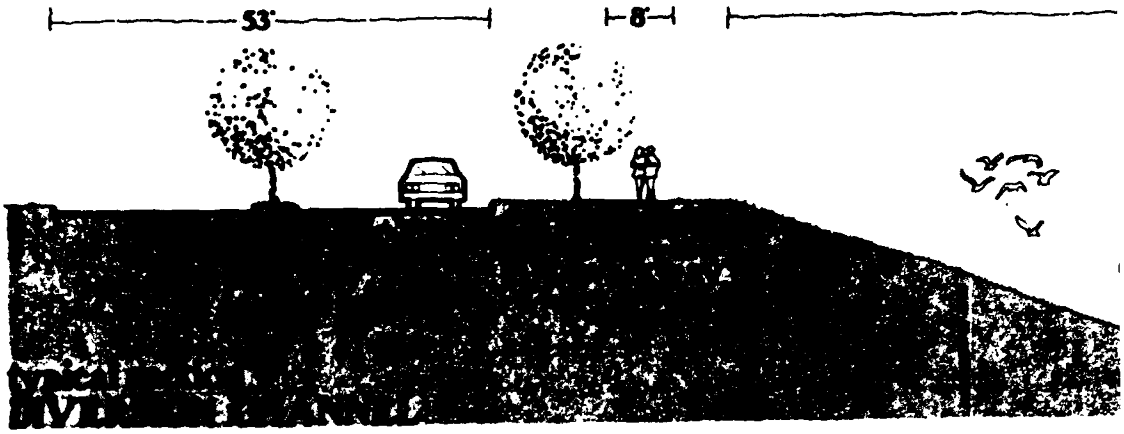
GENERAL PLAN
PROPOSED RECREATIONAL MEASURES



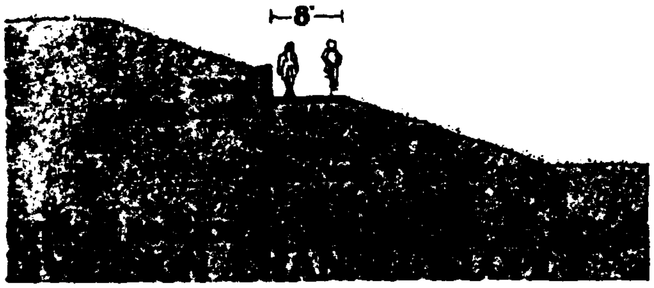
LEGEND

PROPOSED OVERSTORY AND UNDERSTORY TREES OF TYPICAL SPECIES INCLUDING ASH, HACKBERRY, OAK, RUSSIAN OLIVE, HAWTHORN ETC. (APPROX. 35 ACRES)

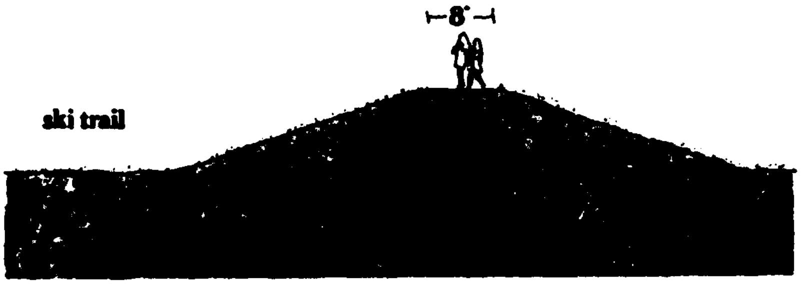
EXISTING	PROPOSED	
RA	RAp	REST AREA
S	Sp	SHELTER
T	Tp	SANITARY FACILITY
PA	PAp	PLAY / ACTIVITY AREA
P	Pp	PICNIC AREA
PK	PKp	PARKING AREA
Q	Qp	QUIET AREA
N	Np	NATURE AREA



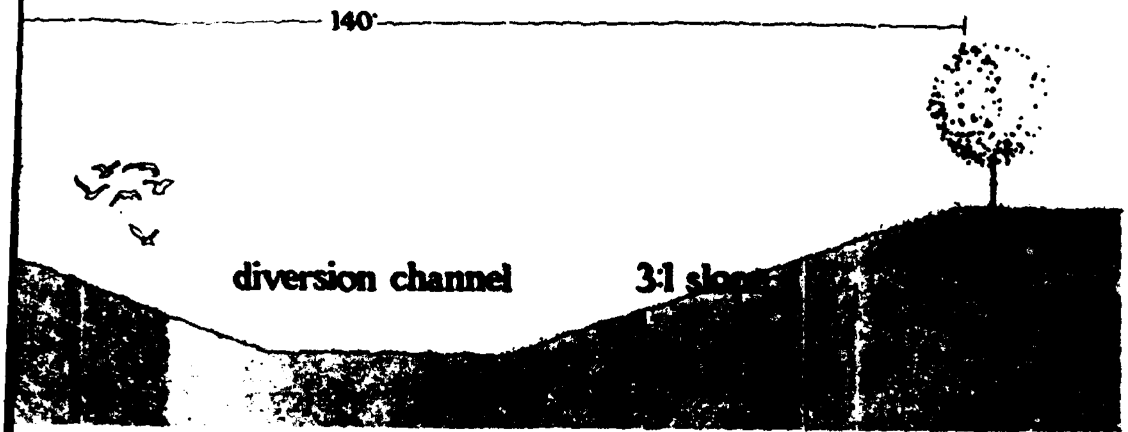
SECTION A–A

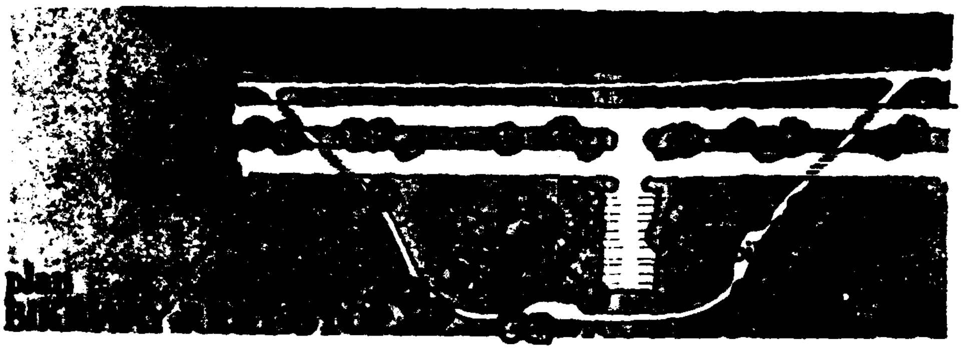


SECTION B–B



SECTION C–C





① plan

② sketch
BIKEWAY REST STOP

③ sketch
BIKEWAY BRIDGE

NOTE:

LOCATIONS OF THESE
CROSS SECTIONS AND SKETCHES
SHOWN ON PLATES G-1 AND G-2.

FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

TYPICAL
RECREATIONAL FACILITY
ILLUSTRATION

PLATE G-3

SECTION H

DETAILED DESIGNS

DESIGN CONSIDERATIONS

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SECTION H

DESIGN CONSIDERATIONS

GENERAL

1. This section presents a detailed discussion of the data used in designing the selected plan. Included are discussions of hydrologic and hydraulic studies, geologic and soils studies, and structural designs made in support of the overall study.

HYDROLOGIC AND HYDRAULIC DESIGN

MAJOR FLOODS OF RECORD

2. Table H-1 lists the pertinent data for all the floods that exceeded 1,500 cfs since the establishment of the Fourth Street U.S.G.S. gage at Marshall in 1940. Included in the table are the dates of occurrence, instantaneous peak discharge, and maximum observed flood stage. To compare the peak stages to the existing conditions, all stages have been adjusted to the U.S.G.S. rating curve No. 22, effective November, 1971, and shown on table H-1. Channel cutoffs, clearing and snagging and scour below Marshall have greatly reduced river stages at the U.S.G.S gaging station at Marshall.

3. Flood of April 1969 - The flood of April 1969, the greatest known flood at Marshall, was caused by the melting of a heavy snow cover (water equivalent approximately 8 inches) and approximately one inch of rain. The maximum discharge at the Burlington Northern Railroad (river mile 72.6) has been estimated at 8,090 cfs. This discharge has a frequency of occurrence of once in approximately 100 years. With an emergency levee raise on CSAH 7 preventing flow over this road into Marshall, approximately 2,500 cfs of this flow is estimated to have crossed over Trunk Highway (T.H.) 23 into the Cottonwood River basin. Of the remaining 5,590 cfs (8,090 - 2,500), 4,090 cfs passed through the existing diversion channel and 1,500 cfs in the Redwood River through the city of Marshall.

4. River stages during the 1969 flood were considerably affected by backwater from ice jams downstream of Marshall, as evident from the observed stages at the U.S.G.S. gaging station at North 4th Street (plate H-1). The hydrograph adopted by the U.S. Army Corps of Engineers for the April 1969 flood reflects the flow into the Cottonwood River basin, the overbank storage upstream of CSAH 7, and is shown on plate H-2.

5. Flood of June 1957 - The flood of June 1957 was caused by heavy rainfall and related fast runoff. The largest 24-hour rainfall depth of 8.67 inches, resulting from this storm, was recorded at the National Weather Service Station at Minnesota, 12 miles northwest of Marshall and outside of the Redwood basin on June 17, 1957. The corresponding 24-hour rainfall depth at Marshall was 8.03 inches. Special surveys conducted by the National Weather Service, shortly after this storm, showed that amounts exceeding 10 inches fell in an area west of Marshall.

6. The maximum stream flow at the U.S.G.S. gaging station was determined to be 5,370 cfs. This includes the flow through the business

district which bypassed the gage. However, this does not include the natural diversion of approximately 800 cfs into the Cottonwood River basin at the wayside park. The discharge, upstream of the natural diversion of the roadside park is estimated at 6,170 cfs. This has the frequency of occurrence of once in 51 years. After having reached the peak, the flow dropped down to a discharge of 2,900 cfs approximately 20 hours later. After approximately 12 more hours, or 36 hours after the first flood stage peak, a second peak at 4,200 cfs occurred. It is possible that the second peak could have been caused by a second storm occurring shortly after the first one[1/] and/or by the discharge from Coon Creek which drains into the Redwood River at Russell, southwest of Marshall.

Table H-1 - Flood Data, Redwood River at Marshall, Minnesota under Existing Conditions [2/]

Date	Maximum Discharge (cfs)	Maximum Recorded Gage Height (ft)	Estimated Maximum Stage on Rating Curve No. 22 [3/] (ft)
April 9, 1969	5590	7.62[4/]	10.17
June 17, 1957	5370[1/]	10.14	10.12
April 6, 1951	2740	11.05	9.22
April 9, 1965	2220	5.76	8.34
April 8, 1952	1800	10.22	7.32
June 10, 1947	1800	9.64	7.32
May 5, 1944	1530	8.97	6.56

[1/] In 1957, there were no recording gages in the Redwood River basin to measure the distribution of the rainfall.

[2/] 1965 and 1969 Floods affected by existing project that was completed in 1963.

[3/] All gage heights are based on the assumption that entire discharge would pass through town and do not take into account flow that crossed over to the Cottonwood Basin.

[4/] The gage height is for a discharge of 1,500 cfs flowing through the Redwood River Channel.

FLOOD FREQUENCY RELATIONSHIPS

7. The discharge-frequency relationships developed for this study are for existing conditions and for the total discharge above the natural diversion into the Cottonwood River Basin. These frequency curves are related to a location 1.2 miles upstream of the Burlington Northern railroad bridge.

8. The adopted discharge-frequency curve for the Redwood River at Marshall, Minnesota, is based on 34 years of US Geological Survey records (1940-1973) at Marshall. This data is summarized on Table H-2. This period includes two floods that overflowed into the Cottonwood Basin. These floods (17 June 1957 and 9 April 1969) were estimated by the Corps of Engineers as having peak overflows of 800 cfs and 2,500 cfs, respectively. Thus the peak was raised to 6170 cfs from 5370 and the 1969 peak was raised to 8090 from 5590 cfs, from the published values respectively. Both were adjusted to a longer record period due to the large storm rainfall in 1957 and the high snow water-equivalent in 1969. The adopted discharge frequency curve is based on statistical computations using annual peaks and expected probability adjustment (P_N). The statistical computed line was used below 5 percent; above 5 percent the line is drawn through the 100-year value of 8200 cfs and guided graphically by the two highest flood peaks, which were considered to be the highest values in a 66-year period. The plotting positions for the lowest 32 values were plotted in a 34-year period. The statistical computations were made with two low flows adjusted, 1959 peak from 24 to 100 cfs and 1956 peak from 47 to 130 cfs. The 100-year intermediate regional or regulatory flood (8200 cfs) was agreed to by the U.S. Geological Survey, the Soil Conservation Service, and the Corps of Engineers. This discharge-frequency curve was used for the Marshall flood plain information report, December 1974 and for the Marshall

flood insurance study, August 1976 and is now adopted for the Section 216 Feasibility Study for Flood Control, Redwood River at Marshall, Minnesota. This frequency curve is shown on Plate H-3. This adopted discharge frequency curve which was computed using the latest guidelines and procedures outlined in the WRC Bulletin No. 17 and is also shown on Plate H-4.

9. The peak discharge data for the partial-duration series are summarized on Table H-2, and the partial-duration series curve is shown as a dashed line on the adopted curve on Plate H-4.

Table H-2 Plotting Points For Discharge-Frequency, Floods Of Record, Redwood River At Marshall, Minnesota (Annual Peaks and Partial - Duration Series)

ANNUAL PEAKS				PARTIAL-DURATION SERIES		
DATE	YEAR	PEAK DISCHARGE (CFS)	PROBABILITY (PERCENT)	DATE	YEAR	PEAK DISCHARGE (CFS)
9 April	1969	8090 1/	1.0	9 April	1969	8090 1/
17 June	1957	6170 1/	2.5	17 June	1957	6170 1/
6 April	1951	2740	7.8	6 April	1951	2740
9 April	1965	2220	10.7	9 April	1965	2220
8 April	1952	1800	13.6	8 April	1952	1800
10 June	1947	1800	16.6	10 June	1947	1800
20 May	1944	1640	19.5	20 May	1944	1640
1 April	1960	1410	22.4	1 April	1960	1410
31 March	1962	1270	25.3	31 March	1962	1270
22 March	1948	1250	28.2	22 March	1948	1250
7 April	1949	1080	31.1	20 October	1968	1100 2/
30 March	1940	1040	34.0	7 April	1949	1080
3 June	1943	891	36.9	30 March	1940	1040
22 March	1954	890	39.8	3 June	1943	891
12 March	1973	830	42.7	22 March	1954	890
31 July	1963	677	45.6	12 March	1973	830
4 May	1972	668	48.6	26 March	1943	700 2/
21 March	1953	628	51.4	15 June	1943	700 2/
16 March	1946	623	54.4	24 May	1962	700 2/
3 April	1950	578	57.3	31 July	1963	677

Table H-2 (Continued)

ANNUAL PEAKS				PARTIAL-DURATION SERIES		
DATE	YEAR	PEAK DISCHARGE (CFS)	PROBABILITY (PERCENT)	DATE	YEAR	PEAK DISCHARGE (CFS)
7 July	1971	523	60.2	4 May	1972	668
5 April	1970	485	63.1	21 March	1953	628
13 March	1966	445	66.0	16 March	1946	623
1 July	1942	437	68.9	7 July	1962	620 2/
9 April	1958	388	71.8	27 March	1944	600 2/
27 March	1941	382	74.7	19 April	1962	600 2/
16 June	1967	373	77.6	3 April	1950	578
15 March	1945	320	80.5	7 July	1971	523
19 May	1961	190	83.4	24 April	1947	500 2/
21 Sept.	1968	162	86.4	23 June	1952	500 2/
14 March	1955	162	89.3	1 June	1972	500 2/
2 July	1964	138	92.2	5 April	1970	485
26 June	1956	130 3/	95.1	13 March	1966	445
23 March	1959	100 4/	98.0	1 July	1942	437

1/ Peak discharge includes overflow into Cottonwood River Basin

2/ Instantaneous peaks estimated from mean daily peaks.

3/ Peak flow for 1956 adjusted from 47 cfs to 130 cfs.

4/ Peak flow for 1959 adjusted from 24 cfs to 100 cfs.

DEVELOPMENT OF FREQUENCY CURVE USING WRC BULLETIN NO. 17

10. The discharge-frequency curve for the Redwood River at Marshall, Minnesota, was computed in accordance with WRC Bulletin No. 17 subsequent to completion of the Draft Feasibility Report. The frequency curve is based on annual series with the distribution based on a log Pearson type III distribution. The expected probability adjustment P_n is used in accordance with draft ER 1110-2-1450 dated 30 August 1976. The Weibull plotting position formula was used for plotting the discharge-frequency data. This discharge-frequency curve is for existing conditions for the Redwood River at Marshall and for the total discharge above the natural diversion into the Cottonwood River basin. The curve applies to the upstream limit of existing improvements at river mile 73.8 as shown on Plate C-1.

11. During the period of record at Marshall, from 1940 through 1976, peak flows from the Redwood River naturally diverted into the Cottonwood River basin on two occasions. Studies made by this office indicated that the overflow for the 17 June 1957 flood peak was 800 cfs and that the total discharge upstream from this overflow area was 5,370 + 800 = 6,170 cfs. The Corps of Engineers estimate of the overflow for the 9 April 1969 flood was 2,500 cfs or a total discharge of 5,590 + 2,500 = 8,090 cfs upstream of the natural diversion. It has been determined that the April 1969 flood at Marshall was the largest flood, at least since 1882, and one high outlier was used when computing the discharge frequency curve in accordance with Bulletin No. 17. Two peak flows, 1956 (47 cfs) and 1959 (29 cfs), were adjusted to 60 cfs and 80 cfs, respectively.

12. A generalized skew value of 0.0 was used in accordance with the St. Paul District skew map (17 February 1977). Using Bulletin No. 17 and the previously described conditions, the adopted skew was zero and the computed skew was zero.

13. Table H-3 shows the annual maximum peak discharge-year data inputs and statistical output from the computer program. The frequency curve is shown on Plate H-4 along with the adopted 216 feasibility study curve dated 25 June 1974 for comparison. The 5 percent and 95 percent confidence limit lines are also plotted and indicate that both of the curves are well within these limits. The curve using Bulletin No. 17 is slightly lower than the adopted curve. The adopted curve passed through the 1-percent chance flood discharge of 8,200 cfs which is also the regulatory flood for Minnesota State flood plain management purposes.

14. 100-Year Flood - In 1963, when the diversion channel was constructed, the design discharge of 6,500 cfs had an expected frequency of occurrence of once in 114 years. However, after the 1969 flood, and the occurrence of the major floods over a short time period (1957 and 1969), the discharge frequency curve has been revised. The new curve, derived by the U.S. Army Corps of Engineers, in cooperation with U.S.G.S. and S.C.S. is based on statistical computations and 34 years of records (1940-1973) at Marshall. This curve shows that a discharge of 8,200 cfs has a frequency of occurrence of once in 100 years as shown on plate H-3.

15. As a supplement to the discharge-frequency curve at the upstream study limit, discharge-frequency curves were developed by approximate methods for three additional locations within the study reaches. These additional curves are shown on Plates H-5 through H-7 and their locations are shown on Plate H-10. Rating curves which were developed utilizing the HEC-2 computer model for the same locations are also shown on these plates.

TABLE H-3

FINAL RESULTS
-ANNUAL PEAKS - 515 REDWOOD RIVER AT MARSHALL, MINN.

DATA ANALYZED				ORDERED DATA			
MON	DAY	YEAR	FLOW	RANK	WATER YEAR	FLOW	WEIBULL PLOT POS
0	0	1940	1040.	1	1969	8090.	.0104
0	0	1941	382.	2	1957	6170.	.0292
0	0	1942	437.	3	1951	2740.	.0564
0	0	1943	891.	4	1965	2220.	.0836
0	0	1944	1640.	5	1947	1900.	.1108
0	0	1945	320.	6	1952	1800.	.1380
0	0	1946	623.	7	1944	1640.	.1652
0	0	1947	1900.	8	1960	1410.	.1924
0	0	1948	1250.	9	1962	1270.	.2196
0	0	1949	1080.	10	1948	1250.	.2468
0	0	1950	578.	11	1949	1080.	.2740
0	0	1951	2740.	12	1940	1040.	.3012
0	0	1952	1800.	13	1973	1038.	.3284
0	0	1953	628.	14	1943	891.	.3556
0	0	1954	890.	15	1954	890.	.3828
0	0	1955	162.	16	1963	677.	.4100
0	0	1956	80.	17	1972	668.	.4372
0	0	1957	6170.	18	1953	628.	.4644
0	0	1958	388.	19	1946	623.	.4916
0	0	1959	60.	20	1950	578.	.5188
0	0	1960	1410.	21	1971	523.	.5460
0	0	1961	190.	22	1970	485.	.5732
0	0	1962	1270.	23	1966	445.	.6004
0	0	1963	677.	24	1942	437.	.6276
0	0	1964	138.	25	1976	400.	.6548
0	0	1965	2220.	26	1958	388.	.6820
0	0	1966	445.	27	1941	382.	.7092
0	0	1967	373.	28	1967	373.	.7364
0	0	1968	162.	29	1945	320.	.7636
0	0	1969	8090.	30	1975	204.	.7908
0	0	1970	485.	31	1961	190.	.8180
0	0	1971	523.	32	1968	162.	.8452
0	0	1972	668.	33	1955	162.	.8724
0	0	1973	1038.	34	1974	144.	.8996
0	0	1974	144.	35	1964	138.	.9268
0	0	1975	204.	36	1956	80.	.9540
0	0	1976	400.	37	1959	60.	.9812

NOTE- PLOTTING POSITIONS BASED ON 95 YEARS(H) AND 1 HIGH VALUES(Z), WEIGHT(W) FOR SYSTEMATIC VALUES= 2.5111 .

0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 29.9

FINAL RESULTS
-FREQUENCY CURVE- 515 REDWOOD RIVER AT MARSHALL, MINN.

PEAK FLOWS			CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	EXCEEDANCE PROBABILITY	.05 LIMIT	.95 LIMIT
11900.	15200.	.002	26100.	6820.
8660.	10400.	.005	17800.	5200.
6670.	7730.	.010	13000.	4150.
5010.	5600.	.020	9170.	3240.
3450.	3950.	.040	[illegible]	[illegible]
2240.	2350.	.100	3500.	1590.
1410.	1500.	.200	2050.	1040.
584.	584.	.500	760.	438.
242.	237.	.800	328.	167.
153.	146.	.900	215.	97.
104.	97.	.950	155.	62.
51.	44.	.990	82.	26.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.7665	SYSTEMATIC DATA	36
STANDARD DEVIATION	.4547	HISTORIC EVENTS	0
COMPUTED SKEW	-.0070	HIGH OUTLIERS	1
GENERALIZED SKEW	0.	LOW OUTLIERS	0
ADOPTED SKEW	-.0012	ZERO OR MISSING	0
		TOTAL PERIOD,YEARS	95

STANDARD PROJECT FLOOD (SPF) HYDROGRAPH

16. The standard project flood (SPF) hydrograph, computed by U.S. Army Corps of Engineers, was derived using the unit hydrograph adopted for the 1969 flood. The SPF which was computed for a total runoff of 7.50 inches, results in a peak discharge of 16,700 cfs as shown on Plate H-9. The SPF index rainfall was 10.0 from Plate 2 of EM 1110-2-1411. The loss rate used was 0.9 inches per 6-hours. A higher than normal base flow (500 cfs) was used to account for the 40 square miles eliminated above Lake Benton. Table H-4 shows the standard project storm and rainfall and rainfall excess.

17. The unit hydrograph adopted for this study is based on an estimated observed hydrograph of the April 1969 flood upstream of the natural overflow into the Cottonwood River basin. This hydrograph was based on all available published data plus estimates of the magnitude and time of overflow. The rise portion of this observed hydrograph was shortened because of slow snowmelt for the first few days. The recession of this observed hydrograph was estimated (shortened) excluding 40.5 square miles of drainage area above the mouth of Benton Lake. Benton Lake has a surface area of approximately 2,900 acres.

18. For the computation of the unit hydrograph, the drainage area above Lake Benton (approximately 40 square miles) was eliminated. The unit hydrograph derived in the recently completed flood plain information study in accordance with accepted criteria was computed for a net area of 210 square miles and was from a runoff of 4.53 inches. The peak discharge from this unit hydrograph was computed to be 1,750 cfs and was peaked 25 percent to 2,200 cfs. This adopted 6-hour unit hydrograph is for discharge above the natural breakout into the Cottonwood River basin and is shown on Plate H-8.

19. The unit hydrograph for the April 1969 flood was not optimized since the recorded flow at the gage is only a small part of the total flow. The greater part of the total flow passes through the diversion channel. Cross-flow into the Cottonwood River basin upstream of Marshall further complicates any attempt at optimization.

Table H-4 - Standard Project Rainfall and Rainfall Excess

Hour	Rainfall (inches)	Loss (inches)	Rainfall Excess (inches)
6	0.01	0.01	0
12	0.04	0.04	0
18	0.26	0.26	0
24	0.02	0.02	0
30	0.05	0.05	0
36	0.17	0.17	0
42	1.23	0.90	0.33
48	0.10	0.10	0
54	0.32	0.32	0
60	1.09	0.90	0.19
66	7.88	0.90	6.98
72	0.66	0.66	0
78	0.02	0.02	0
84	0.06	0.06	0
90	0.44	0.44	0
96	0.03	0.03	0
Total	12.38	4.88	7.50

Note: Rainfall depth in inches ending at hour.

STREAM FLOW

18. Stream flows at Marshall, ordinarily range from periods of no flow during winter to well under 100 cfs during summer. Spring floods have mostly occurred between late March and early April, occasional summer floods are not uncommon. Ice jams during spring floods have caused considerable back water effect, resulting in higher stages as evident during the 1969 flood which resulted in stage two feet higher at mile 66.1. Heavy summer rains, with considerable runoff, frequently result in a double peak approximately a day apart at Marshall.

19. The U.S. Geological Survey (USGS) has maintained a stream gage on the Redwood River at Marshall since March 1940, on the downstream side of North 4th Street Bridge (river mile 67.2). The largest flood of record occurred on April 9, 1969. The discharge for this flood has been estimated at 8,090 cfs[1/]. The second largest flood occurred on June 17, 1957, with a peak discharge estimated at 6,170 cfs[2/]. The average discharge for the 32-year period through 1972 was 48.1 cfs. Average annual runoff total about 2.61 inches over the 250.7[3/] square miles (sq.mi.) of drainage area above Marshall.

Historical Flood Flow Distributions

20. The floods of 1957 and 1969 proved that high Redwood River stages will overtop the minimum roadway elevation of Highway 23 at the wayside park, and therefore, during times of high river stages, some

---

1/ Discharges at the Burlington Northern Railroad Bridge, upstream from natural diversion into Cottonwood River basin.

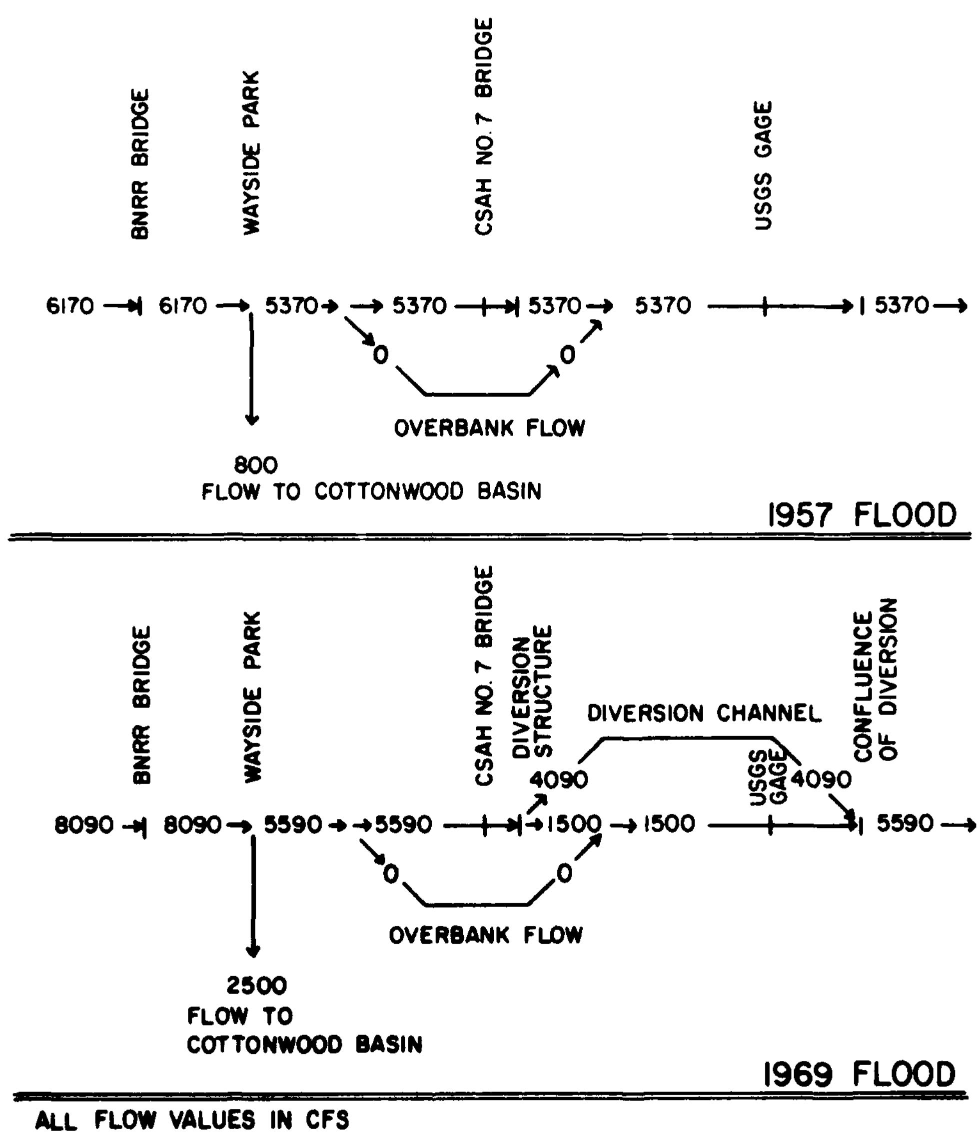
2/ Discharges at the Burlington Northern Railroad Bridge, upstream from natural diversion into Cottonwood River basin.

3/ After a recent study by Soil Conservation Service (SCS), the drainage area has been revised from 307 square miles.

flow will be discharged into the Cottonwood River basin. During the 1957 flood, it was estimated by Corps employees observing the phenomenon, that approximately 800 cfs passed into the Cottonwood Basin (see figure H-1). During the 1969 flood, it was estimated that about 2,500 cfs flowed into the Cottonwood Basin. However, it was also estimated that about 1,100 cfs of this was forced by the emergency dike on CSAH 7, and the breaching of Highway 23, and therefore, only 1,400 cfs of the total overflow to the Cottonwood basin was considered to be natural as illustrated on the flow distribution diagrams for the 1969 flood in Figure H-1. It was also estimated that overflows commenced at a Redwood River discharge of 4000 cfs. Since the 1969 flood, the Minnesota State Department of Transportation has upgraded Highway 23 to a four lane structure. The roadway was raised about 0.5 feet as a part of the improvement. The maximum flow that will now pass through the wayside park with no overflow to the Cottonwood is 6,500 cfs. Also indicated on Figure H-1 are flow values at other locations along the Redwood River at Marshall.

Future Flood Flow Distributions - 100 Year Flood

21. It has been determined in a recently completed (1974) flood plain information study at Marshall, that under existing conditions and a 100-year discharge of 8,200 cfs, an estimated 1,500 cfs would cross over T.H. 23, in the vicinity of the wayside park, and flow into the Cottonwood River basin. It was also determined that 1,090 cfs would cross over the right overbank of C.S.A.H. 7, bypassing the diversion structure and re-entering the Redwood River approximately 2,500 feet downstream of the diversion structure. Of the remaining 5,610 cfs (8,200 - (1,500 + 1,090)), reaching the diversion structure, 4,110 cfs would pass through the diversion channel and 1,500 cfs would enter the natural Redwood River channel as shown in Table H-5 and Figure H-3. Thus, the total discharge in the Redwood River,



HISTORIC FLOW DISTRIBUTIONS
REDWOOD RIVER
MARSHALL, MINNESOTA

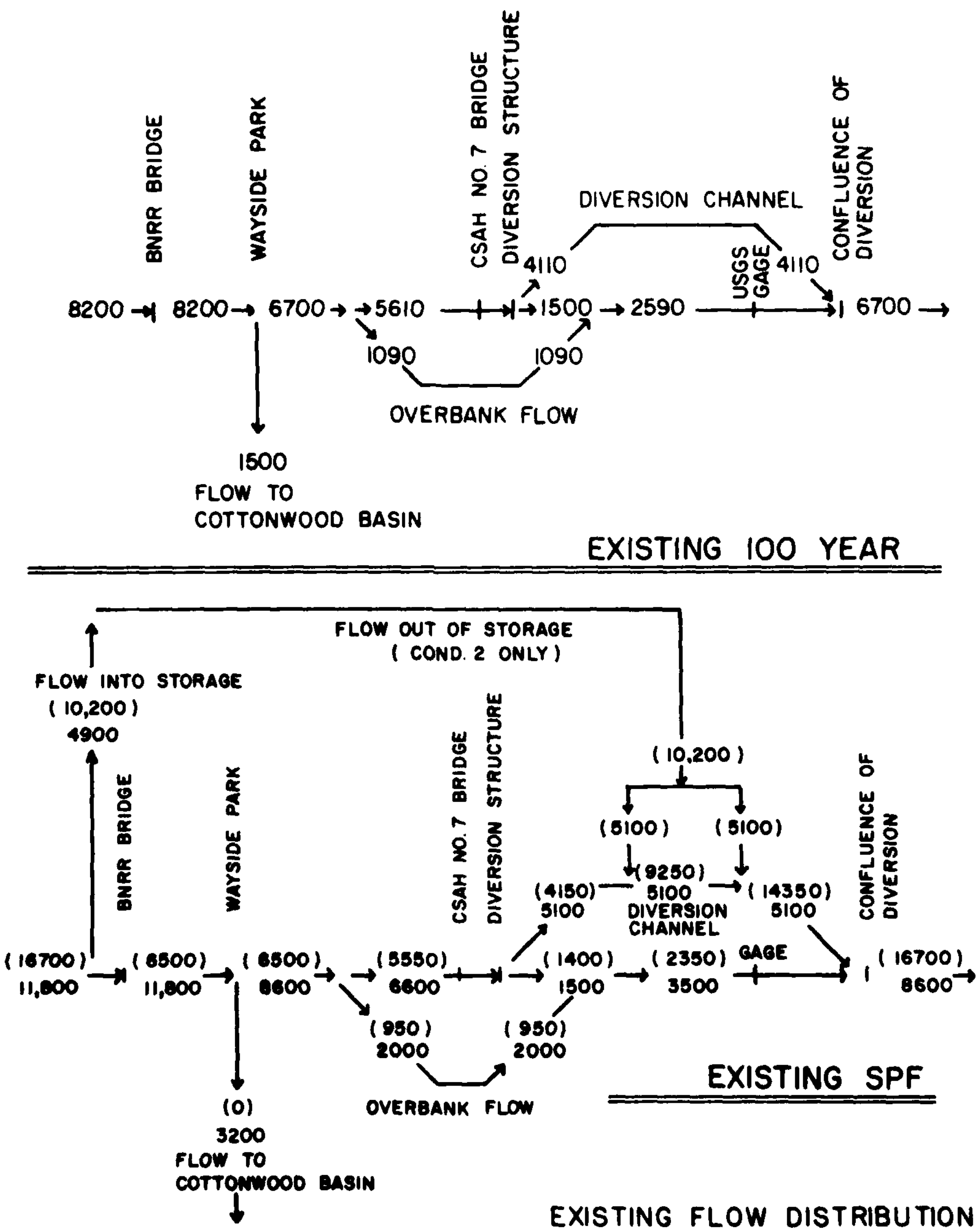
FIGURE H-1

through the city of Marshall would be 2,590 cfs (1,500 + 1,090). The total discharge at the downstream confluence of the diversion channel and the Redwood River would be 6,700 cfs (4,110 + 2,590). See Figure H-2 for a schematic view of this existing 100-year condition flood flow distribution. The 100-year and 133-year design flood flow distributions with the proposed project are shown on Figure H-3.

Standard Project Flood

22. The SPF was also analyzed in the previously mentioned flood plain information study and, in this analysis of the SPF, two conditions were considered. The first condition would occur about one-half day before the SPF peak arrives and would result in maximum damages to the upstream reach at Marshall; the second condition, occurring at the time of the peak, would result in maximum damages to the downstream reach at Marshall. Existing flow distributions for both of these conditions are shown on Figure H-2.

23. A part of the existing flood control project is a levee, with a minimum top elevation of 1199, located on the left bank of the Redwood River upstream of the Burlington Northern Railroad bridge. Discharges in excess of 11,800 cfs, about the 250-year flood, would overtop this levee. For the SPF with a peak flow of 16,700 cfs, certain assumptions with respect to the mode of failure of this levee have been made. The hydrograph of the SPF, Plate H-9, indicates that a flow of 11,800 cfs would occur approximately one-half day before the peak. It is assumed that by the time the peak occurs the levee is completely washed away. Under this assumption, the maximum discharge that would flow under the Burlington Northern Railroad bridge is 11,800 cfs occurring one-half day before the peak (condition 1). At the peak only 6,500 cfs would flow under the bridge (condition 2).



NOTE:
ALL FLOW VALUES IN CFS
VALUES W/O PARENTHESES - SPF CONDITION 1
VALUES W/ PARENTHESES - SPF CONDITION 2

EXISTING FLOW DISTRIBUTION
REDWOOD RIVER
MARSHALL, MINNESOTA

FIGURE H-2

Table H-5 - Flood Flow Distribution At Marshall

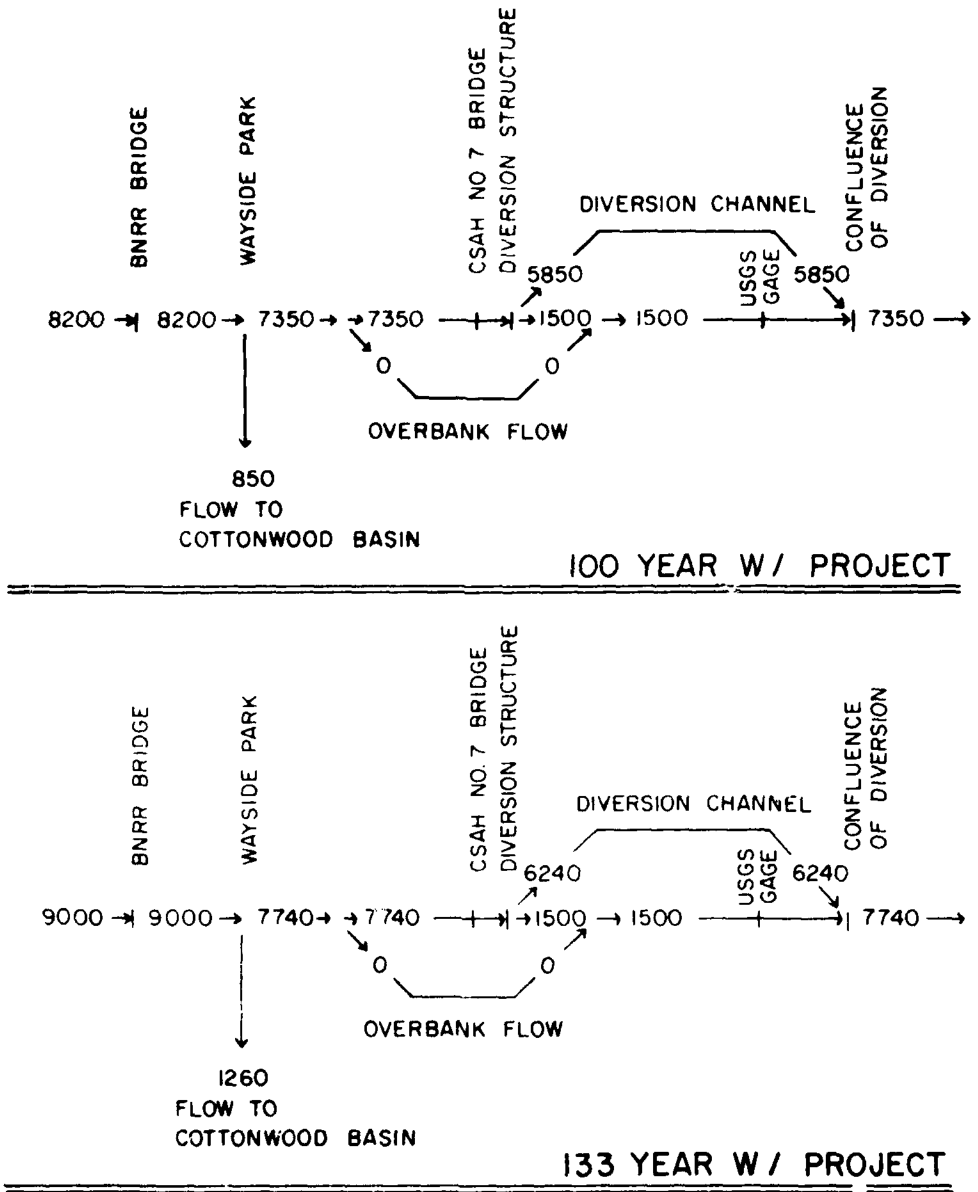
Existing Conditions

Discharge Changes Throughout Study Reach

	100 YR (CFS)	SPF Cond. 1 (CFS)	SPF Cond. 2 (CFS)
Burlington Northern RR Bridge			
Upstream	8200	16700	16700
Downstream	8200	11800	6500
Wayside Park			
Downstream	6700	8600	6500
CSAH #7			
Downstream	5610	6600	5550
Diversion Structure			
Upstream	5610	6600	5550
Downstream			
Redwood River	1500 1/	1500	1400 2/
Div. Channel	4110 1/	5100	4150 2/
U.S.G.S. Gage			
Redwood River	2590	3500	2350
Confluence			
Downstream	6700	8600	16700

1/ These discharges differ slightly from the original project report rating curve values of 1400 and 4210 cfs respectively as obtained from Plate H-11. However, the tabulated values have been used in the Marshall FPM and Flood Insurance Study reports.

2/ These figures from original project report rating curve.



PROJECT FLOW DISTRIBUTION
REDWOOD RIVER
MARSHALL, MINNESOTA

FIGURE H-3

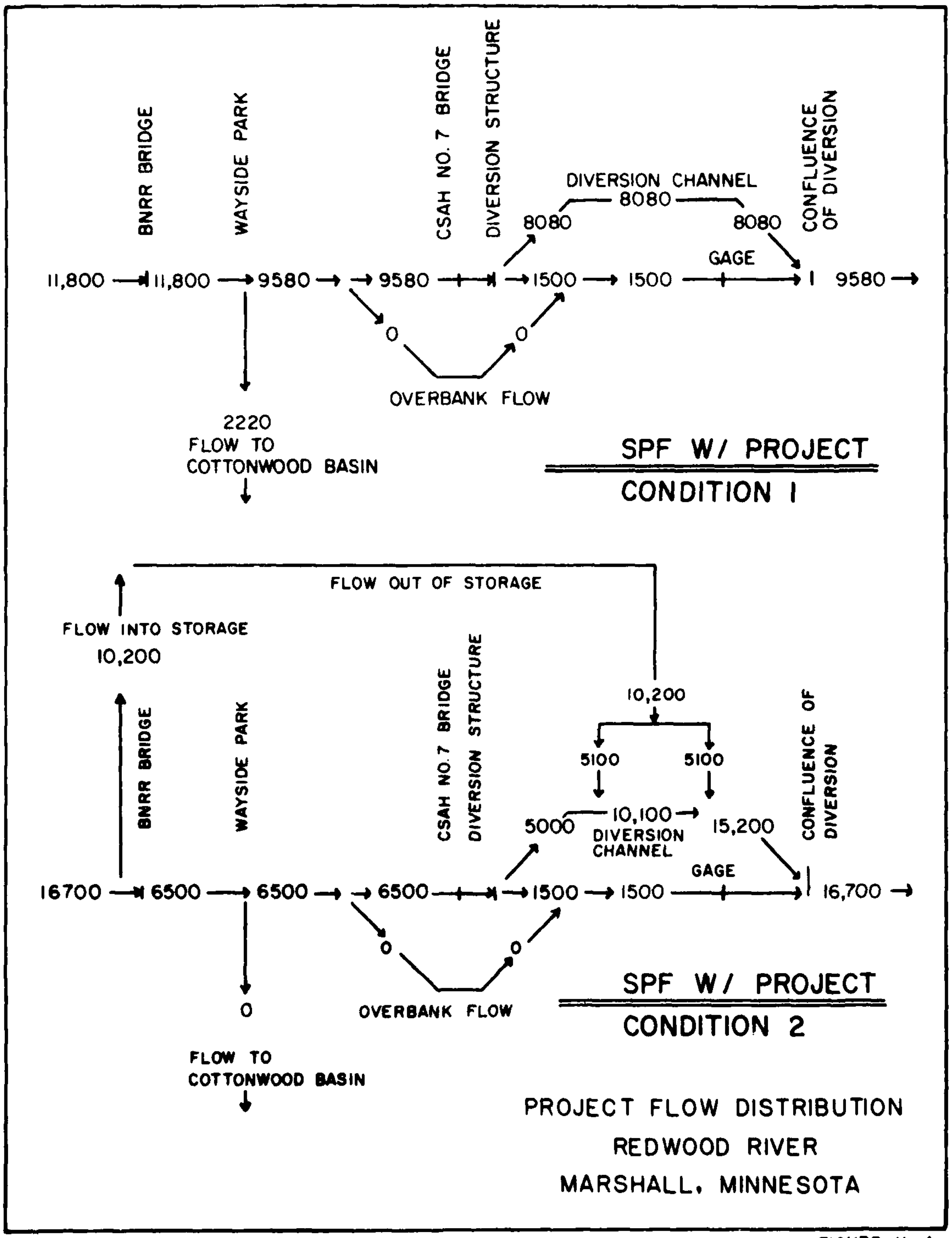

BNRR BRIDGE
WAYSIDE PARK
CSAH NO. 7 BRIDGE
DIVERSION STRUCTURE
DIVERSION CHANNEL
8080
8080
8080
CONFLUENCE OF DIVERSION
GAGE
11,800
11,800
9580
9580
1500
1500
I
9580
0
0
OVERBANK FLOW
2220
FLOW TO
COTTONWOOD BASIN
SPF W/ PROJECT
CONDITION I
FLOW OUT OF STORAGE
FLOW INTO STORAGE
10,200
10,200
5100
5100
5000
10,100
DIVERSION CHANNEL
15,200
BNRR BRIDGE
WAYSIDE PARK
CSAH NO.7 BRIDGE
DIVERSION STRUCTURE
CONFLUENCE OF DIVERSION
GAGE
16700
6500
6500
6500
1500
1500
16,700
0
0
OVERBANK FLOW
0
FLOW TO
COTTONWOOD BASIN
SPF W/ PROJECT
CONDITION 2
PROJECT FLOW DISTRIBUTION
REDWOOD RIVER
MARSHALL, MINNESOTA

FIGURE H-4

24. When the levee is overtopped by discharges greater than 11,800 cfs, the excess water flows north of the Burlington Northern Railroad tracks in a northeasterly direction and eventually enters the diversion channel upstream of Minnesota State Highway 68. It is assumed that, until the SPF reaches the peak, all the flows going north of the Burlington Northern Railroad tracks would go into storage on lands north of the tracks and west of the diversion channel. This would result in a volume of 6,300 acre-feet flooding approximately 2,800 acres at an average depth of 2.3 feet. At the peak of the SPF, 10,200 cfs would pass through the storage area. Two low spots on the diversion channel - at the drop structure and Chicago-Northwestern Railroad (CNR) bridge - are the most likely places where the flow would enter the diversion channel. It is assumed that one-half of the discharge, flowing north of the Burlington Northern Raoilroad tracks, would enter the diversion channel at the existing drop structure and the other half at the Chicago Northwestern Railroad bridge.

25. Under Condition 1, of the 11,800 cfs that would flow under the Burlington Northern Railroad bridge, an estimated 3,200 cfs would cross over T.H. 23 into the Cottonwood River basin, 2,000 cfs would cross over the right overbank and the CSAH 7 embankment, bypassing the diversion structure, and reentering the Redwood River approximately 2,500 feet downstream of the diversion structure. Of the 6,600 cfs (11,900 - (3,200 + 2,000) reaching the diversion structure, 5,100 cfs would enter the diversion channel. The total discharge at the downstream confluence of the diversion channel and the Redwood River would be 8,600 cfs (5,100 + 3,500). This discharge reflects the temporary loss of flow due to temporary storage northeast of the Burlington Northern Railroad tracks.

26. Under Condition 2, the discharge through the Burlington Northern Railroad bridge would be approximately 6,500 cfs with no flow entering the Cottonwood basin. The flow traveling northeast of the Burlinton Northern

tracks would be 10,200 cfs. By the time the flow reaches this magnitude, however, the available storage north of the BNRR tracks will have been used up so 10,200 cfs will be discharged almost immediately into the diversion channel via the two low areas. Based on this assumption, the discharge downstream of the confluence will be 16,700 cfs. Of the 6,500 cfs which continues down the Redwood River channel below the Highway 23 Roadside Park, 950 cfs would flow over CSAH 7, eventually reentering the river 2,500 feet downstream of the diversion structure, leaving 5,550 cfs to be split at the diversion structure. Of this 5,550 cfs, 1,400 cfs would flow through the diversion structure culverts into the main channel and 4,150 cfs would flow into the diversion channel. At the U.S.G.S. gage the flow would be 2,350 cfs (1,400 + 950).

27. The Condition 1 and Condition 2 SPF flow distributions with the proposed project are shown on Figure H-4. Overflow to the Cottonwood River basin would be reduced to 2,220 cfs for Condition 1, and flow over CSAH 7 would be reduced to zero for both conditions.

WATER SURFACE PROFILES

General

28. Water surface profiles for both existing and proposed project conditions were derived by backwater computations using a computer model based on the Hydrologic Engineering Center's computer program HEC-2. The existing condition profiles were obtained using the model which was developed for the report titled "Flood Plain Information, Redwood River at Marshall, Minnesota". The various hydraulic parameters for this report were established using a manual optimization technique which involved establishing or revising hydraulic parameters, then comparing the computed profile with the recorded 1969 flood profile until the desired reproduction of the recorded profile was obtained. See Table H-6 for a summary of the finalized modeling data from the Flood Plain Information report. For the proposed conditions, channel roughness coefficients and cross section geometery were appropriately adjusted for reaches where channel excavation and/or riprap are proposed. Typical channel cross-sections for the existing diversion structure and Redwood River channel through Marshall are shown on Plate H-18.

UPSTREAM REACH

29. Backwater computations for the upstream study reach were started at critical depth at the diversion structure spillway. (See plate H-19 for sketch). The discharge over the spillway was determined from the diversion structure rating curve shown on plate H-11. The rating curve was obtained from an earlier study, "Flood Control General Design Memorandum on Redwood River at Marshall, Minnesota". At the design discharge, the proposed levee would result in approximately a 0.75 foot stage increase. However, upstream of the wayside park, there would only be a slight increase in stage. Water surface profiles for existing and proposed conditions along the upstream reach are shown on plates H-10 and plates E-1, E-2, and E-3.

COMPUTER MODEL DATA FOR MARSHALL, MN

Cross Sect. No.	Description	Elevations: Observed 1969	Elevations: HEC-2 Computed	Mannings "n": Left Bank	Mannings "n": Right Bank	Mannings "n": Channel
16	Highway 67	1125.8	1125.8	0.1	0.1	.035
26	FPI Limit	------	1139.81	0.1	0.1	.035
27	Southwest State College		1141.52	0.1	0.1	.035
28	Dike		1142.09	.08	.08	.035
29	Residential Dike	1145	1144.46	.08	.08	.035
31	Mile 66.1	1149.5 **	1147.51	.08	.08	.035
513	Township Road Bridge	------	1149.77	.05	.05	.03
597	Drop Structure T.W.	------	1153.40	.05	.05	.03
599	Diversion Channel Drop Structure	------	1159.7	.05	.05	.035
643.5	Diversion Structure	------	1168.67	.05	.05	.034
34	Kossuth Ave. Bridge	1149.4	1149.4	0.1	0.1	.0365
40	N. 4th St. (U.S.G.S. gaging station)	1152.5	1152.49	0.1	0.1	.0365
43	N. 3rd Street		1154.31	0.1	0.1	.044
45	N. 2nd St. (E. College Drive)		1154.96	0.1	0.1	.044
49	Main Street		1157.82	0.1	0.1	.044
51	W. College Drive (S. 2nd St.)		1158.22	0.1	0.1	.044
53	C & N. W. R. R.		1158.73	0.1	0.1	.046
[illegible]	Saratoga Street	------	1159.69	0.1	0.1	.046
58	S 4th Street		1162.33	0.1	0.1	.042
64	West College Dr. (TH 19)		1165.06	0.1	0.1	.042
72	Diversion Channel Culverts		1174.25	0.1	0.1	.047
76	CSAH 7	1177.8	1177.72	0.1	0.1	.0495
87	B.N.R.R. Bridge (Upstream study limit)	1195.9*	1195.87	0.1	0.1	.040

* Estimated High Water Mark

** It was assumed that this elevation was unnaturally high due to ice in downstream channel, therefore, the rating curve elevation of 1147.57 was matched.

Shock loss coefficients = .3 and .1 at All Locations (Expansion and Contraction Respectively)

Special Bridge Routine Used At All Bridges

30. D2 and tailwater rating curves for the existing diversion structure and existing diversion channel drop structure are shown on Plate H-17. Tailwater elevations computed using the HEC-2 computer program (n assumed = 0.030) are also shown for each structure. The computed tailwater elevations correspond closely to the most probable extension of the original design curve. Illustrations of these structures are shown on Plate H-19.

DOWNSTREAM REACH

31. Backwater computations for the downstream reach were made using slope-area methods starting with normal depth at a point upstream of the T.H. 23 bridge (mile 58.3). At design discharge, the proposed levee would result in approximately a 0.5 foot stage increase over existing conditions. The proposed channel widening between station 0 + 00 and 13 + 50 would eliminate river stage increases upstream of the confluence of the Redwood River and diversion channel caused by the 1260 cfs flow increase from the upstream reach under proposed diversion conditions. Water surface profiles for existing and proposed conditions along the downstream reach are shown on Plate H-10.

STREAM VELOCITIES

32. Average design flow velocities for improve conditions at selected locations are shown in Table H-7.

Table H-7 - Computed Average Velocities Under Proposed Conditions at Selected Locations

River Station[1/]	Channel (fps)	Maximum Overbank (fps)
Upstream Reach		
8 + 75	4.7	*[2/]
9 + 25 (CSAH 7 bridge)	4.9	*[2/]
9 + 90	5.7	0.9
21 + 75	7.2	1.1
40 + 00	4.6	1.0
42 + 87	7.2	1.4
71 + 75	6.9	1.4
91 + 75	5.1	1.1
100 + 75	7.5	1.6
121 + 40 (BNR bridge)	5.0	*[2/]
Downstream Reach		
3 + 80	6.1	0.7
15 + 20	8.0	1.4
24 + 00	5.6	1.1
32 + 30	3.0	0.7
57 + 20	5.2	1.0
75 + 00	4.8	1.2

[1/] Stationing proceeds upstream from the existing diversion structure and downstream from the drop structure at the confluence of the diversion channel and the Redwood River.

[2/] No overbank flooding.

EFFECT ON BRIDGES

33. Two bridges are located along the upstream reach. These are the C.S.A.H. 7 bridge and the Burlington-Northern Railroad bridge. Riprap slope protection would be required only at the C.S.A.H. 7 bridge. At design conditions, the proposed improvements would have no significant effect on the existing 100-year water surface elevation and/or the velocity at the Burlington-Northern Railroad bridge. However, at the 133-year design conditions, the proposed improvement would result in a 2.1-foot increase in stage and 0.1 decrease in velocity at the C.S.A.H. 7 bridge. Two bridges are also located along the downstream study reach. However, these bridges are located downstream of the proposed improvements with the nearest bridge approximately 3-1/2 miles downstream of the proposed improvements. Pertinent bridge data and design water surface elevation are given in table H-8.

Table H-8 - Bridge Data

Item	C.S.A.H. 7 Bridge	Burlington-Northern Railroad Bridge
Deck elevation	1184.2	1205.0
Low steel elevation	1182.9	1201.5
Design water surface	1182.58	1195.4
Length	152 feet	85 feet
Waterway opening[1]	1607 square feet	2335 square feet

[1] Net flow area up to low steel

BACKWATER EFFECTS WITHIN MARSHALL

34. During times of major flooding, backwater effects caused by the combined Redwood River and diversion channel flows are evident within the downstream areas of the City of Marshall. This phenomenon was verified by the HEC-2 model by utilizing a constant 1500 cfs discharge through the City and downstream reaches to determine a natural profile. The model was then used to compute the 100-year and SPF existing condition profiles. These profiles were then compared to the natural profile to determine the extent of backwater effect within Marshall. According to this analysis, the 100-year backwater effect will extend to approximately North 6th Street and the SPF (Condition 2) effect will extend to East Main Street. (See plate H-10 for street crossing locations). However, the proposed channel widening measures downstream of the confluence would eliminate the 100-year backwater effects.

ANALYSIS OF PROPOSED OVERFLOWS TO COTTONWOOD BASIN

35. Water surface profiles of the 133-year and Standard Project flood overflows to the Cottonwood Basin were derived using the HEC-2 Computer Program. These profiles followed the alignment of County Ditch #70, starting at critical depth approximately 1,000 feet downstream of County Road 67 and extending upstream west of CSAH #7 to the approximate end of the proposed overflow channel. The computations indicated an SPF profile which was 3-9 feet below the Highway 23 profile at all locations except in the vicinity of the intersections of the ditch and CSAH #7. At this location, the elevation of the SPF overflow profile would be about 1/2 foot below the elevation of Highway 23. SPF floodwaters could pass through five culverts through the Hwy.23 embankment but would not reach the developed area of Marshall based on existing topographic information. None of the culverts would be affected at the design flood level.

SEDIMENT TRANSPORT

36. A comparison of the pre-existing project with the existing project rating curves for the USGS gage site (mile 67.2) reveals the occurrence of sediment deposition between gage heights of 0 to 7 feet. The maximum increase in stage due to sediment deposition occurs at a stage of about 5 feet (1,000 cfs). Between the gage heights of 7 and 10 feet sediment loss is evident, and at a gage height of 9 feet the maximum decrease in stage (0.12 feet) due to this loss occurs. The above phenomena indicates that at low stages, the sediment load within the Redwood river is less than at high stages. This is due primarily to low velocities, characteristic of low stages, which allow the sediment to settle out and the opposite which is true for the high velocities characteristic of high stages.

HYDRAULIC DESIGN OF OVERFLOW-DIVERSION STRUCTURE

37. The hydraulic design of the proposed overflow diversion structure is based on controlled overflows commencing at a Redwood River discharge of approximately 6,500 cfs. Approximately one-half of the discharge in excess of 6,500 cfs would be diverted into the Cottonwood basin with the remaining 50 percent passing downstream through Marshall. The 540-foot long overflow diversion structure would commence at right bank levee station 58 + 90 and extend westward along the Redwood River as shown on plate E-3. The structure would consist of a gabion embankment with a 6-inch high by 6-inch wide concrete projection on the crest to provide positive control. The crest elevation would be 1192.64 at the downstream end and 1192.94 at the upstream end. Plate E-3, section A-A, shows a typical section through the overflow diversion structure.

38. At the design discharge of 9,000 cfs, approximately 1260 cfs would be diverted into the Cottonwood River basin. Plate H-12 depicts the rating curve for the overflow diversion structure. The rating curve on plate H-13 shows the discharge relationship between Redwood River flows and flows diverted into the Cottonwood River basin.

HYDRAULIC DESIGN OF GABION DROP STRUCTURE

39. The proposed gabion drop structure would be located at station 97 + 45 (river mile 72.04), approximately 220 feet downstream of the proposed overflow weir. The design for this structure was based on ETL 110-2-194. The structure would be 6.1 feet high, have 1V on 4H and 1V on 6H slopes on the respective upstream and downstream faces. The weir crest (elev. = 1186.1) would be grouted, have a length of 91.6 feet, and a width of 9 feet. Four 36" RCP culverts through the structure would pass low flows (maximum = 300 cfs).

40. Approximately once every 1.3 years, discharges would exceed the capacity of the culverts and this additional flow would pass over the weir crest. Plate H-13 shows the rating curve for the proposed gabion drop structure. According to Plate 4 of the ETL, free flow would still exist during the design and SPF discharges and therefore the structure would provide a positive control of river stages in the vicinity of the overflow diversion. Channel widening upstream of the drop structure would lower the water surface upstream of the park to that of existing conditions.

HYDRAULIC DESIGN OF OVERFLOW CULVERTS

41. Three 115-inch by 72-inch arch culverts, 155 feet long, would be required to pass the design discharge of 1,260 cfs through T.H. 23 embankment. These culverts would have a slope of 0.25 percent and an inlet invert elevation of 1183.9. At design discharge of 1,260 cfs, the water surface in the park would be 1.5 feet below the minimum highway elevation of 1193.3. A maximum flow of 1,500 cfs would pass through the culverts before T.H. 23 is overtopped. This flow would correspond to a discharge of 9,800 cfs (167-year flood) in the Redwood River upstream of the overflow diversion structure. At standard project flood conditions, 2,220 cfs would be diverted into the Cottonwood River basin. Hydraulic design details for the culverts are shown on plate E-4.

HYDRAULIC DESIGN OF RIPRAP

42. A hydraulic study was made to determine required riprap sizes based on an analytical determination of shear force created by channel flow and the ability of the riprap revetment to withstand these forces. This method is defined in EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", July 1, 1970, and ETL 1110-2-120, "Additional Guidance for Riprap Channel Protection", May 16, 1971. In addition, Report No. 47 of Massachusetts Institute of Technology Hydrodynamics Laboratory on "Stream Dynamics and Boundary Stream

Distributions for Curve Trapezoidal Channels", by A. T. Ippen, et al, January, 1962, was referred to.

43. Studies indicate that the riprap size required would range from 12 inches to 24 inches (D_{50} minimum from 5 to 17 lb.). The entire channel would be lined with riprap in the vicinity of C.S.A.H. 7 bridge (30 feet upstream and 50 feet downstream). Channel side slopes in the vicinity of the proposed gabion drop structure (both 40 feet upstream and downstream) would be rip-rapped. In other areas, riprap would be placed on the outside bank of the channel bends. Table H-9 gives the required riprap types. Plates E-1 through E-3 and E-11 show the locations of required riprapped bank areas.

44. Bedding material (uniformly graded coarse material) would be placed in thicknesses ranging from 6 inches to 9 inches. This material would be placed at one-half the riprap thickness to a maximum of 12 inches for above water placement and 18 inches for underwater placement.

Table H-9 - Proposed Riprap Type

Location	Riprap Type
Upstream reach stations:	
8 + 35 to 9 + 65	Type A
All other locations	Type B
All headwalls	Type C

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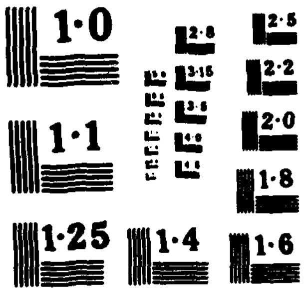

1·0
1·1
1·25
1·4
1·6
1·8
2·0
2·2
2·5
2·8
3·2
3·6
4·0

Table H-9 - Proposed Riprap Type (continued)

Location	Riprap Type
Overflow channel stations:	
3 + 60 to 6 + 90	Type D
5 + 20 to 7 00	Type D
All other locations	Type C
Downstream reach stations:	
0 + 00 to 13 + 50	Type B

INTERIOR DRAINAGE

UPSTREAM REACH

45. Required upstream interior drainage works would include modification of the State Highway 23 drainage system at the roadside park, installation of flap-gates on two double 30-inch railroad culverts (headwalls A and B), an 18-inch flap-gated culvert (headwall C) at station 11 + 20 of the left bank levee, installation of a flap-gate on an existing driveway culvert (headwall E) at stations 63 + 50, and installation of a 12-inch C M P culvert through a driveway at right bank levee station 10 + 00. Modification of the State Highway 23 drainage system would include installation of a flap-gate on the existing 36-inch highway culvert (headwall F), excavation of a 10-foot wide parabolic channel leading to the overflow structure, and a flap-gated 36-inch reinforced concrete culvert (headwall E) through the structure. Minor landscaping measures would also be accomplished at right bank levee station 27 + 00 to fill a low area adjacent to the proposed levee.

46. The ditch on the north side of the railroad tracks slopes in the northeasterly direction towards the city of Marshall. Headwalls A and B will prevent water from entering the ditch and flowing towards the city. The culvert at headwall C will provide drainage for approximately 2.5 acres of land located adjacent to the levee. Installation of flap-gated headwalls D and F will prevent Redwood River water from getting into the Cottonwood River basin except via the overflow diversion channel. The land south of State Highway 23 slopes in the southeasterly direction towards County Ditch 70. Thus, flap-gating the State Highway 23 culvert will not create any problems. The existing culvert at station 63 + 50 provides drainage for less than one acre of land. The installation of a flap-gate on this culvert will likewise not create any adverse effects. Typical details for the upstream reach interior drainage facilities are shown on plates E-4 and E-8 at the end of Section E.

DOWNSTREAM REACH

General

47. The proposed levee alignment would obstruct the runoff from approximately 57 acres of land under existing conditions. This runoff would flow unrestricted into the Redwood River. The proposed plan incorporating a 7-acre pond at approximate levee station 27 + 00 would provide approximately 36 acre-feet of storage at elevation 1138.0. A collector ditch would be provided alongside the levee for collection and transfer of runoff to the ponding area. The pond would be drained into County Ditch 62 via a 24-inch R C P. The inlet to the 24-inch R C P would consist of a flared section with a trestle guard. Outflows into the County

ditch would be controlled by a manually-operated gate well and flap-gate. Since this portion of County Ditch No. 62 is several miles upstream from its junction with the Redwood River, water levels in the ditch upstream of the State Highway 23 crossing are unaffected by river stage changes in the Redwood River. Plates E-9 and E-12 show the details of the pond and the outlet structures.

48. The proposed pond and gravity outlet were studied in detail to determine the maximum pond level and added flow into County Ditch No. 62. For this analysis, two major past floods -- the floods of 1957 and 1969, and the 50-year, 100-year, and standard project storms were considered. Results of these studies are presented in the following paragraphs.

49. Unit hydrograph -- A unit hydrograph, using Snyder's method, was developed for the 57-acre area. The following parameters were used in the development of the unit hydrograph.

$A = 0.089$ square miles.

$L = 0.756$ miles.

$t_p = 0.897$ hours.

$C_p = 0.469$

$C_t = 1.4$

where A = drainage area

L = length of channel to outlet

t_p = lag time for unit rainfall duration to peak of unit hydrograph.

C_p and C_t = drainage basin characteristics coefficients.

Table H-10 depicts 30-minute unit hydrograph ordinates.

Table H-10 - Unit Hydrograph

Time (hours)	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
Runoff (cfs)	0	12	30	29	18	11	6	4	2	1	1	1	0

50. Precipitation and Precipitation Excess -- Rainfall and rainfall excess values for the 1957 flood were obtained from an earlier flood control study of the Redwood River at Marshall, Minnesota. Table H-11 shows the precipitation, precipitation excess and the computed runoff hydrograph. The initial snow pack moisture content for the 1969 flood was obtained from data gathered during field surveys by the Corps of Engineers. Snow melt computations were based on mean daily temperature. Rainfall that occurred between 8 and 15 April was added to the snow melt. Precipitation and temperature records were obtained from climatologic data recorded by the National Weather Service. Table H-12 depicts the precipitation excess and values for the computed runoff hydrograph.

Table H-11- Precipitation, Precipitation Excess and Runoff Hydrograph for 1957 Storm

Time (hours)[1/]	3	6	9	12	15	18	21	24	27
Rainfall (ins.)	0.48	0.82	0.62	1.12	1.50	2.47	0.38	0.10	0.05
Loss (ins.)	0.48	0.82	0.19	0.22	0.15	0.15	0.15	0.10	0.05
Rainfall Excess (ins.)	0.00	0.00	0.43	0.90	1.35	2.32	0.33	0.00	0.00

[1/] Time in hours from start of rainfall on June 16

Table II-11- Precipitation, Precipitation Excess and Runoff Hydrograph for 1957 Storm (continued)

Time in Hours[1/]	Runoff in cfs.
8.5	0
9.0	5
9.5	13
10.0	12
10.5	8
11 0	5
11.5	3
12.0	13
12.5	28
13.0	27
13.5	17
14.0	10
14.5	5
15.0	20
15.5	42
16.0	40
16.5	25
17.0	16
17.5	8
18.0	33
18.5	72
19.0	69
19.5	43
20.0	27
20.5	14
21.0	13
21.5	15
22.0	12
22.5	8
23.0	6

1/ Time in hours from start of rainfall on June 16.

Table H-12 Precipitation Excess and Runoff from 1969 Snow Melt

Date:	April 2	3	4	5	6	7	8	9	10	11	12	13	14	15
Excess (ins.)	0.75	0.57	0.9	0.0	0.63	1.2	1.71 1/	0.38 1/	0.11 1/	0.0	0.0	0.03 2/	0.0	0 .12 2/

Runoff - April 8 3/

Time in Hours	Runoff (cfs)
0.0	0
0.5	5
1.0	13
1.5	12
2.0	8
2.5	5
3.0	3
3.5	2
4.0	1
4.5	.5

1/ Includes rainfall
2/ Runoff from rainfall only.
3/ Date of maximum snowmelt

Table H-13 Precipitation, Precipitation Excess and Runoff Hydrograph for Hypothetical Storm

Time in Hours 1/	50-Yr. Storm Rainfall: Rainfall (ins.)	50-Yr.: Rainfall Excess (ins.)	50-Yr.: Runoff (cfs)	100-Yr. Storm Rainfall: Rainfall (ins.)	100-Yr.: Rainfall Excess (ins.)	100-Yr.: Runoff (cfs)	Standard Project Storm Rainfall: Rainfall (ins.)	SPS: Rainfall Excess (ins.)	SPS: Runoff (cfs)
89.0			0			0			0
89.5	0.335	0.234	3	0.536	0.375	5	0.353	0.328	4
90.0	0.165	0.116	8	0.264	0.185	13	0.187	0.162	12
90.5	0.058	0.033	11	0.125	0.100	18	0.126	0.101	16
91.0	0.042	0.017	9	0.075	0.050	16	0.075	0.050	14
91.5	0.125	0.100	7	0.125	0.100	13	0.126	0.101	12
92.0	0.075	0.050	7	0.075	0.050	11	0.075	0.050	11
92.5	0.125	0.100	8	0.125	0.100	10	0.260	0.235	11
93.0	0.075	0.050	8	0.075	0.050	9	0.140	0.115	14
93.5	0.190	0.165	9	0.259	0.234	11	0.260	0.235	16
94.0	0.108	0.083	11	0.141	0.116	14	0.140	0.115	18
94.5	0.393	0.368	15	0.393	0.368	18	0.528	0.503	22
95.0	0.207	0.182	20	0.207	0.182	23	0.273	0.248	29
95.5	1.934	1.909	43	2.135	2.110	47	2.739	2.714	61
96.0	0.966	0.941	83	1.065	1.040	91	1.361	1.336	117
96.5			92			102			131
97.0			67			73			95
97.5			41			45			58
98.0			24			26			33
98.5			14			16			20
100.0			8			9			12
100.5			4			5			6
101.0			3			3			4
101.5			3			3			4
102.0			1			1			1
102.5			0			0			0

1/ Hypothetical flood time - accumulative hours to end of period.

51. Future Storms - Rainfall and rainfall excess values for the 50-year, 100-year and the standard project storm were computed according to the method described in EM 1110-2-1410. These storms resulted in a peak discharge of 92 cfs, 102 cfs and 113 cfs respectively. Table H-13 depicts the precipitation, precipitation excess and runoff for these storms.

52. Other Past Storm - Other past storms considered but not analyzed in detail are the June 1947 and June 1952. The June 1947 storm had a total precipitation of 2.86 inches. The June 1952 storm resulted in a total precipitation of 2.13 inches. None of these storms have the intensity of the 1957 storm or the runoff magnitude of the 1969 snow melt. Consequently, they were dropped from further consideration.

53. Collector Ditch - The collector ditch was designed to accommodate the runoff from the 50-year storm. In determining the capacity of the collector ditch, the peak discharge of 92 cfs has been prorated along the length of the levee. The collector ditch would have a slope of 0.00167 feet/foot and 0.00256 feet/foot between levee stations 62 + 00 to 50 + 10 and 50 + 10 to 29 + 20 respectively. The bottom width would be 7 feet and 9 feet between levee stations 62 + 00 to 38 + 00 and 38 + 00 to 29 + 20 respectively The ditch side slopes would be 1 vertical on 3 horizontal. Two 24-inch R C P culverts would pass ditch flows under County Highway 67. The protected land area on the east side of the ponding area either slopes towards County Ditch 62 or towards the pond. Thus a collector ditch is not needed in this area.

54. The maximum recorded runoff occurred during the 1969 snow melt. The 1969 snow melt (table H-12) between April 2 and 15 resulted in 6 4 inches of runoff. This would require approximately 30.4 acre-feet

of storage. As shown on plate H-15, the design storage capacity of the proposed pond including the collector ditch is approximately 36 acre-feet. The 50-year, 100-year, and standard project storms would result in 4.35, 5.06, and 6.29 inches of runoff respectively. These storms would require 20.65, 24.03, and 29.89 acre-feet of storage respectively. Thus, the Standard Project Storm runoff or the largest recorded historical runoff could be stored in the proposed ponding area.

55. Outflow from Ponding Area - The outflow from the ponding area into County Ditch 62 would be via an 800-foot long by 24-inch diameter R C P pipe and would be controlled by a gate well. Proposed gate operating procedure requires that the gate well would not be opened until the water level in County Ditch 62 recedes to the crown of the outlet pipe. With the maximum water surface in the pond and the water surface in the County Ditch at the crown of the outlet pipe, the peak outflow would be approximately 13 cfs. It would take approximately 2-1/2 days for the pond to drain out completely.

FOUNDATIONS AND MATERIALS

SUBSURFACE EXPLORATION AND TESTING

56. Soil borings were taken in the upstream sector of the project and six in the downstream sector to determine the levee foundation profile. Two borings were taken at the location of the overflow channel. All borings were 20 feet deep and taken by a truck-mounted rig. Three-inch diameter tube samples were obtained at most holes. The borings are shown on plates E-1 thru E-3 and E-9 thru E-11.

57. Laboratory testing of subsurface samples included 29 moisture content and Atterberg limit determinations, 33 graduations, and 11 Q-triaxial tests on undisturbed samples. The results of these tests are shown on tables H-15 and H-16 and Plates H-20 thru H-51.

SUBSURFACE PROFILE

58. The surface profile at Marshall is quite variable. The levee sites were divided into 9 typical reaches based on the subsurface profile and surface geometry. The limits of these reaches are shown on plate H-17. Borings for reaches 8 and 9 found cohesive soil throughout the full depth of the boring. Borings in reaches 1, 3, 4, 5 and 7 show a pervious zone greater than 5 feet thick and a semi-pervious zone overlying it. The semi-pervious zone is greater than 5 feet thick except in reaches 1 and 3. The boring in reach 1 shows mostly cohesive soil and a 3-foot seam of slightly pervious material while reach 6 appears to have 13 feet of pervious material overlying cohesive material. Cohesive soils in the project area are generally low plasticity clays with moisture contents ranging from 15 percent to 40 percent and liquid limits from 25 to 60. Pervious soils in the area range from medium sands to silty sand. D_{10} sizes range as high as .37 mm.

SEEPAGE AND UPLIFT

GENERAL

59. Methods for development of the various constants and analyses for seepage and uplift pressures were taken from Technical Memorandum No. 3-424, Volume 1, "Investigation of Underseepage and Its Control - Lower Mississippi River Levees by Waterways Experiment Station, Vicksburg, Mississippi," October, 1956. As described under the heading "Subsurface Profile", the foundation conditions for the levee generally consist of an impervious to a semi-impervious blanket overlying a relatively pervious sand zone.

60. Average horizontal permeabilities (k_f) of the pervious strata were determined by using the method shown on plate H-16. Values of K_b used in the analysis were determined from the D_{10} grain sizes of field pumping tests as summarized on figure 17, page 51, TM3-424. In this analysis, the various layers of soil making up the top stratum were transformed to a single blanket with a permeability equal to that of the most impervious stratum as illustrated by the sample calculation on plate H-16. Plate H-16 also summarizes the major parameters used in seepage and uplift analysis, along with the results. Values of k_v were based on data suggested in table 38, page 265, TM 3-424 according to soil classification and total thickness of blanket to the bottom of each stratum.

UPLIFT PRESSURES

61. Uplift pressures were analyzed using hydrostatic pressures caused by a water surface at the top of the flood barrier. The

blanket in reaches 1 and 3 was considered to be so thin that it probably would not be continous or effective in causing uplift pressures. There is no uplift problem in reaches 8 and 9 since the subsurface is mostly clay. The factor of safety for reach 7 is 2.1. This is dependent on the blanket being continuous throughout the surrounding area, giving an S distance of 400 feet. This assumption seems to be justified since all borings in the downstream area show as great or greater depth of clay. This assumption, however, will be verified by more borings prior to construction. The factor of safety in all other reaches was calculated to be greater than 1.5 and these reaches were consequently considered to be safe. A unit weight of 110 pcf for the semi-pervious zone was used for all uplift calculations.

NOTATIONS

62. Notations used in the relief well design shown on plate C-26 are as follows:

- c A constant for natural top stratum where $c = \left[\frac{k_b}{k_f \quad z_b D}\right]^{1/2}$
- D_{10} Effective grain size, 10 percent of grains smaller than stated size
- d Thickness of each stratum comprising pervious substratum
- D Total thickness of the pervious substratum
- F Factor of safety against uplift
- g Acceleration due to gravity
- H Total net head on levee, or height of top of flood barrier above average low-ground surface, or tail water, landward of levee
- h_a Allowable (net) head beneath landside top stratum

H_{ws} Total net head on levee, height of design water surface, above average low-ground surface, or tail water, landward of levee

k_b Vertical permeability of top stratum

k_f Permeability of pervious foundation

k_h Horizontal permeability of individual strata

k_v Vertical permeability of individual strata

L Length of reach

L_2 Horizontal width of levee from landward toe to riverward toe

q_s Total unit seepage within a reach

Q_s Total seepage within a reach

S Distance from landside toe of levee to effective source of seepage entry

X_3 Distance from landside toe of levee to effective seepage exit

z Total thickness of top stratum

z_b Transformed thickness of top stratum (for seepage)

z_t Thickness of landside top stratum (for uplift)

m Moist unit weight of soil

w Unit weight of water

SEEPAGE

63. In all reaches seepage quantities were computed using maximum hydrostatic pressures at the design water surface as follows:

a. In reach 6, where no blanket was defected, seepage was calculated by:

$$Q_s = Lq_s = \frac{7.48\ L\ K_f\ H_{ws}\ D}{L_2 + .86\ D} \qquad \text{(gpm)}$$

b. In all other reaches seepage is:

$$Q_s = Lq_s = \frac{7.48\ L\ K_f\ DH_{ws}}{S + X_3}$$

Total seepage quantities are shown on plate H-16.

STABILITY

64. The levee foundation is a variable mixture of cohesive and non-cohesive soils. Since no strikingly weak stratum were detected by the borings, the stability section was chosen at a location where the geometry was most critical. This occurred in reach 6 near boring 75-35M. The soil constants used and problem geometry are shown on plate H-16. The undrained strength of the foundation clay was based on Q-triaxial tests, estimated to be at the lower one-third point of the range. The drained parameter of the sand was estimated from blow counts. The undrained strength of the embankment and OH layer were conservatively estimated based on testing for other projects. Safety factors were calculated with the aid of a digital computer conforming with the methods stated in EM 1110-2-1902 for the end of construction case for circular and noncircular arcs. The critical factor of safety was 1.25. This was considered satisfactory since it is the factor of safety for a natural sand slope calculated by the infinite slope formula. Any failure associated with this formula would be only a surface slough. The factor of safety for all arcs through the levee were well in excess of 1.3.

CHANNEL SIDE SLOPES

65. With two exceptions, channel side slopes of 1V and 3H are proposed for channel improvements along the existing river channel. The riverward slope of the gabion and riprapped surfaced overflow weir would be 1V on 2.5H. Riprapped channel side slopes immediately downstream of the C.S.A.H. 7 bridge would also be 1V on 2.5H. Channel side slopes along the overflow channel would be 1V on 6H on the highway shoulder slope and 1V on 4H on the back slope to meet highway safety design criteria. Other reaches of the channel would have 1V on 6H side slopes to permit movement of farm machinery. The channel reach along the highway right-of-way would also have a parabolic channel bottom in conformance with highway safety standards.

LEVEE EMBANKMENT

66. Levee side slopes would be 1V or 3H in all cases except at the overflow-diversion structure where both the riverward and landward side slopes would be 1V on 2.5H and along three short levee reaches in close proximity to residences. At these locations, the landward slope would be an irregular flattened slope to better blend the levee into the natural setting. Where not otherwise protected, all levee slopes and crowns would be topsoiled to a six-inch depth and seeded with selected grasses.

INSPECTION TRENCH

67. To insure that there are no buried pipes, drain tiles, sand lenses, or other items beneath the levee foundation which would cause unforeseen seepage, it will be necessary to inspect the foundation to a depth of 6 feet below the ground surface whenever the height of the levee is greater than 5 feet for a significant length of levee. Reaches 1 and 3 will be inspected regardless of levee height. Such an inspection will be accomplished by several means. In areas where the channel excavation is directly adjacent to the levee alignment, the open face on the channel cut will serve the purposes of an inspection trench. In other areas where feasible, the excavation for the installation of the interior drainage system will be deepened to a depth of 6 feet for inspection and then backfilled to the grade required for the interior drainage systems. In areas where neither the channel excavation nor the excavation for interior drainage will serve for foundation inspection, a trench with a 6-foot bottom width will be excavated beneath the levee and backfilled with impervious fill.

SLOPE PROTECTION

68. Where proposed levees are from 20 to 50 feet from the channel bank, the levee-ward channel side slope would be riprapped up to the top of the channel banks along reaches where, at design discharge, velocities in excess of 4 feet per second occur. Where the riverward levee side slopes are extensions of the channel side slopes, these slopes would be riprapped up to the top of the levee. The left channel bank within 100 feet of the Burlington Northern Railroad embankment (stations 27 + 50 and 52 + 00) would also be

riprapped. The entire channel cross-section would be riprapped a distance of 30 feet upstream and 50 feet downstream of the C.S.A.H. 7 bridge. Riprap would be provided to the design water surface elevation over the channel transition at the gabion drop structure. Riprap would also be provided on the widened right channel bank reach below the downstream confluence of the existing diversion channel.

69. Required riprap sizes would range from 12 to 18 inches. Table H-14 shows the riprap gradation and thickness needed at the various locations.

Table H-14 Riprap Type, Gradation, and Layer Thickness

Type	Percent Lighter	Limits of Stone Weight Pounds	Layer Thickness
A	100	26 - 10	12 inches above water
	50	11 - 5	surface and 18 inches
	15	5 - 2	below water surface.
B	100	86 - 35	12 inches above water
	50	26 - 17	surface and 18 inches
	15	13 - 5	below water surface.
C	------Same as B ------		12 inches.
D	100	56 - 35	18 inches.
	50	36 - 17	
	15	18 - 5	

70. The above riprap design was determined from guidance contained in EM 1110-2-1601 and ETL 1110-2-120. Design conditions were based on the 133-year flood. Riprap design shear is based on channel and levee side slopes of 1 on 3 at all places except in the vicinity of the C.S.A.H. 7 bridge, where the channel and levee side slopes would be 1 on 2.5 and 1 on 3 respectively.

SOURCES OF CONSTRUCTION MATERIAL

BORROW

71. Required levee fill for the upstream reach levees would be obtained in sufficient quantity from the required channel works. In most instances, this material, after removal of unsuitable material, would be placed directly on or near the levee alignment without the need for extensive truck haul. Levee fill for the downstream reach levees would be obtained from the channel widening works, collector ditch excavation, and proposed ponding area. Maximum haul distance in any one direction would be 0.9 mile from the proposed ponding area.

RIPRAP AND BEDDING

72. Material of adequate quality for riprap and bedding can be obtained from quartzite or granite quarries located near New Ulm, Morton, Sanborn, and Ortonville, Minnesota. The haul distances from these sources range from 44 to 80 miles, and the material can be transported by truck or railroad. Riprap previously used at Marshall was fieldstone obtained from the

immediate Marshall area. The availability of fieldstone for the proposed project has not, however, been determined.

CONCRETE AGGREGATE

73. Concrete aggregate of suitable quality can be furnished in the required quantities from local suppliers.

STRUCTURAL DESIGN

74. Structural measures included in the proposed improvements include the culvert headwalls, the control weir on the overflow diversion structure, and the gatewell at the outlet of the ponding area drainage conduit. All culvert headwalls would be cast in place and involve minor amounts of reinforcing steel
Tl 540-foot long overflow weir control device would involve 90 cubic yards of concrete and is designed to withstand overturning or dislodgement at peak discharges as shown on section A-A, plates E-3.

75. The reinforced concrete gatewell would include a 24-inch diameter R C P with a 24-inch by 24-inch flat back sluice gate and a manually operated gate lift system. Other features would include a standardized manhole frame with cover, and safety hand railing. Structural details of the proposed gatewell are shown on plate E-12.

CONSTRUCTION

76. Construction of the proposed project could be completed in two construction seasons Placement of the arch culverts through the Highway 23 embankment would require the restriction and diversion of highway traffic for a two to four-week period. Placement of the collector ditch culverts through County Highway 67 would require traffic control for a few days.

OPERATION AND MAINTENANCE

77. Operation and maintenance of the project would include: upkeep of levee and channel slopes, ponding area, and collector ditch; regular mowing of selected levee and overflow channel areas excluding specified ground cover for wildlife habitat; periodic inspection and maintenance of riprap, culvert flap, gates, and drop structure culverts, sediment removal from the roadside park and overflow channel as required; manual operation of the sluice gate at the ponding area outlet as needed; and maintenance of the service roads on the levees. Also included would be the periodic placement of the two temporary sandbag closures as required and maintenance of the recreational facilities. These operation and maintenance measures would be in addition to the present responsibility of maintaining and operating the existing project. The average annual cost of the proposed operation and maintenance is estimated at $9,000.

Table H-15 · Laboratory Test Data

DATE: October 13, 1975

Boring No.	Sample No.	Depth (in Ft)	Soil Type	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index
75-29M	4	5'-6'	Sandy Clay (CL)	17.2	36.1	17.7	18.4
75-29M	5	7½'-8½'	Sandy Clay (CL)	17.9	31.0	15.6	15.4
75-30M	8	12½'-13½'	Silty Clay (CL)	26.9	35.2	18.5	16.7
75-30M	13	25½'-26½'	Silty Clay (MH-CL)	37.1	53.6	32.5	21.1
75-31M	3	2½'-3½'	Clayey Silt (ML-CL)	6.2	23.7	19.0	4.7
75-31M	9	20'-21'	Lean Clay (CL)	28.1	48.7	20.3	28.4
75-31M	10T	21'-23'	Silty Clay (CL)	23.3	29.7	13.8	15.9
75-32M	9	20'-21'	Silty Clay (CL)	34.4	44.6	20.0	24.6
75-32M	11T	26'-28'	Fat Clay (CH)	40.9	59.5	25.9	33.6
75-33M	5	7½'-8½'	Silty Clay (MH-CL)	27.7	55.1	29.7	25.4
75-33M	12	25'-26'	Silty Clay (CL)	34.8	46.5	20.5	26.0
75-33M	13	30'-31'	Silty Clay (CL)	21.1	38.1	21.2	16.9
75-35M	5	10'-11'	Organic Silty Clay (OH)	64.3	79.7	45.1	34.6
75-35M	9T	18'-19½'	Sandy Clay (CL)	23.5	38.7	15.7	23.0
75-35M	10	20'-21'	Sandy Clay (CL)	23.7	36.6	17.6	19.0
75-35M	11	25'-26'	Clayey Sand (SC)	18.5	25.1	19.9	5.2
75-35M	12	30'-31'	Sandy Clay (CL)	18.6	28.5	15.3	13.2
75-36M	7	15'-16'	Sandy Clay (CL)	19.7	34.6	17.7	16.9
75-38M	5	7½'-8½'	Sandy Clay (CL)	21.1	30.4	17.9	12.5
75-38M	10	15'-16'	Sandy Clay (CL)	17.6	30.5	16.4	14.1
75-38M	11	15-16	Sandy Clay (CL)	15.4	26.9	14.8	12.1
75-39M	8T	16'-18'	Sandy Clay (CL)	16.8	27.9	15.5	12.4
75-40M	2	2½'-3½'	Medium Fat Clay (CH)	22.6	55.3	22.7	32.6
75-40M	3	5'-6'	Medium Fat Clay (CL-CH)	30.2	46.5	22.5	24.0
75-40M	5T	6'-7½'	Sandy Clay (CL)	20.6	28.7	17.0	11.7
75-40M	7	10'-11'	Sandy Clay (CL)	30.7	39.0	20.5	18.5
75-40M	8	12½'-13½'	Sandy Clay (CL)	16.8	24.6	15.9	8.7
75-40M	10	20'-21'	Sandy Clay (CL)	17.7	27.6	15.7	11.9
75-41M	3	5'-6'	Sandy Clay (CL)	19.2	34.9	17.6	17.3

PROJECT: REDWOOD RIVER - MARSHALL, MN

JOB NO. #21791

DATE: October 13, 1975

Table H-16 - Sieve Analysis Tests

Boring No.	75-29M	75-30M	75-30M	75-31M	75-31M	75-31M	75-31M	75-31M	75-31M
Sample No.	3	3	14	4	5	6	-	8	12
Depth (ft)	2½'-3½'	5'-6'	30'-31'	5'-6'	7½'-8½'	10'-11'	12½'-13½'	15'-16'	25'-26'
Soil Type	Silty Sand (SM)	Sand, fine grained (SP-SM)	Sandy Silt (ML-SM)	Sand, fine grained (SP-SM)	Silty Sand (SM)	Sand, fine grained (SP)	Sand, fine grained (SP)	Sand, medium grained (SP)	Sand, medium grained (SP)
Weight of Total Sample (Grams)	106	131	102	137	104	133	216	173	201
Based on Total Sample, % finer than 1"	100	100	100	100	100	100	100	100	100
3/8"	100	100	100	100	100	100	100	97.7	100
#4	100	100	100	100	100	100	100	92.6	92.2
#10	100	100	100	100	100	100	100	79.3	69.0
#40	99.3	98.6	99.5	89.7	97.5	87.2	64.9	22.3	44.5
#100	62.8	37.7	88.9	33.2	54.0	13.6	6.8	5.0	9.3
#200	34.1	14.4*	59.5*	13.6*	38.0	6.3*	2.6	3.3	5.7

* Percentage of fines influenced by lenses

PROJECT: REDWOOD RIVER - MARSHALL, MN

JOB NO. #21791

Table H-16. Sieve Analysis Tests (continued)

Boring No.	75-31M	75-32M	75-32M	75-32M	75-33M	75-33M	75-34M	75-34M	75-35M
Sample No.	13	3	4	5	9	10	11	12	1
Depth (ft)	30'-31'	2½'-3½'	5'-6'	7½'-8½'	12½'-13½'	15'-16'	25'-26'	30'-31'	½'-1½'
Soil Type	Sand, medium grained (SP)	Sand, medium to fine grained (SP-SM)	Sand, medium to fine grained (SP-SM)	Sand, medium grained (SP)	Sand, medium to coarse grained (SP)	Sand, medium grained (SP)	Sand, fine to medium grained (SP-SM)	Sand, fine grained (SP)	Fill, Silty sand and sand mixture
Weight of Total Sample (Grams)	263	175	183	270	243	245	188	273	77
Based on Total sample, % finer than									
1"	100	100	100	100	88.7	100	100	100	100
3/8"	97.8	89.5	87.5	84.5	72.7	100	100	100	100
#4	86.3	79.0	79.8	69.6	52.1	98.6	98.9	99.8	99.5
#10	61.6	67.1	70.7	53.8	34.6	89.9	95.9	90.5	99.4
#40	16.5	34.2	40.8	15.9	15.0	28.7	59.0	68.6	96.3
#100	4.5	11.1	18.0	4.1	4.5	2.3	12.8	3.7	62.7
#200	3.2	6.8	10.4	3.0	3.1	1.2	8.6	2.2	41.3

PROJECT: REDWOOD RIVER - MARSHALL, MN JOB NO. #21791

Table H-16. Sieve Analysis Tests (continued)

Boring No.	75-35M	75-35M	75-35M	75-35M	75-35M	75-36M	75-36M	75-36M	75-36M
Sample No.	2	3	4	6	7	2	3	4	9
Depth (ft)	2½'-3½'	5'-6'	7½'-8½'	12½-13½'	15'-16'	2½'-3½'	5'-6'	7½'-8½'	25'-26'
Soil Type	Clayey sand (SC)	Sand, medium to fine grained (SP-SM)	Sand, fine grained (SP-SM)	Sand, medium to coarse grained (SP)	Silty sand (SM)	Sand, fine grained (SP-SM)	Sand, medium grained (SP)	Sand, medium to coarse grained (SP)	Sand, coarse grained (SP-SM)
Weight of Total Sample (Grams)	111	84	74	264	126	101	220	243	269
Based on Total Sample, % finer than									
1"	100	100	100	100	100	100	100	100	100
3/8"	100	100	100	95.3	100	100	67.7	80.7	75.5
#4	99.9	96.8	99.7	79.0	100	99.8	54.4	61.7	59.8
#10	99.2	86.9	98.2	54.1	99.6	96.7	42.0	43.9	40.2
#40	97.5	58.6	94.9	7.0	98.6	85.5	33.4	20.6	21.6
#100	57.0	29.5	34.9	4.2	61.1	40.2	6.6	4.5	8.1
#200	39.1	16.9*	22.8*	3.2	39.0	22.7*	3.7	2.8	6.7

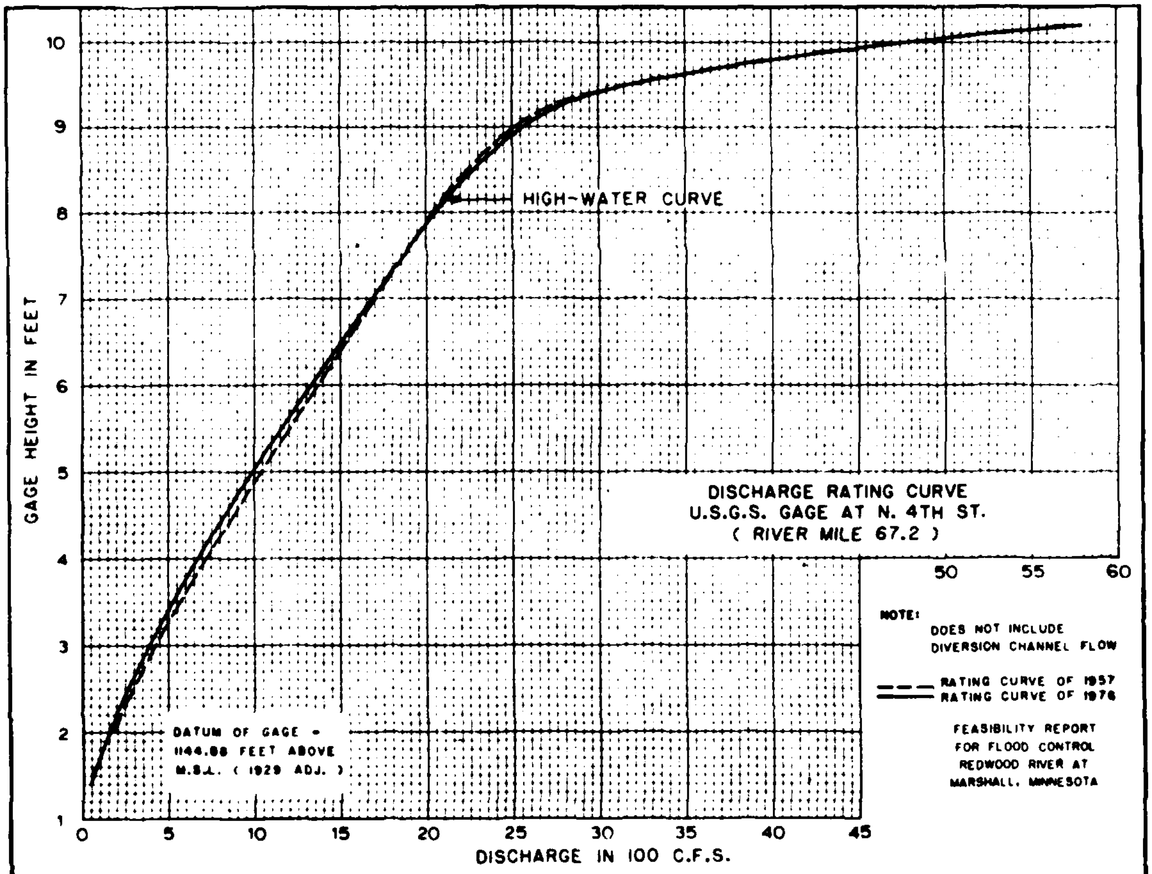
* Percentage of fines influenced by lenses

PROJECT: REDWOOD RIVER - MARSHALL, MN JOB NO. #21791

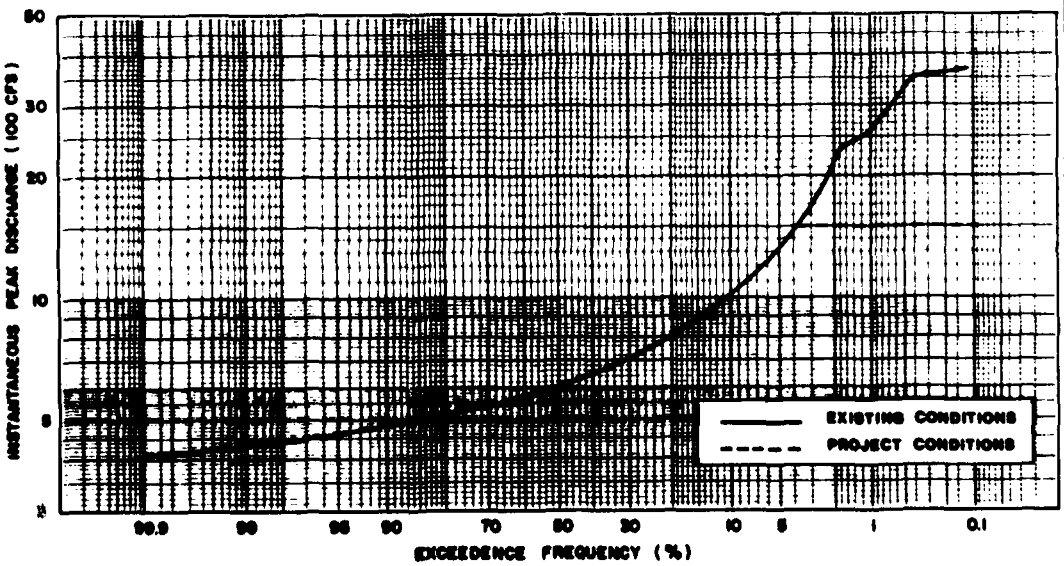
Table H-16 Sieve Analysis Tests (continued)

Boring No.	75-36M	75-39M	75-41M	75-41M	75-41M	75-42M
Sample No.	10	5	5	6	7	10
Depth (ft)	30'-31'	10'-11'	10'-11'	12½'-13½'	15'-16'	15'-16'
Soil Type	Sand, coarse to medium grained (SP-SM)	Sandy Clay (CL-SC)	Sand, fine grained (SP-SM)	Sand, fine grained (SP-SM)	Sand, fine grained (SP)	Sand, fine grained (SP)
Weight of Total Sample (Grams)	184	102	116	175	180	126
Based on Total Sample, % finer than 1"	100	100	100	100	100	100
3/8"	90.5	100	100	98.5	99.4	87.4
#4	71.3	99.3	99.4	91.9	98.3	85.9
#10	46.5	95.7	98.0	82.9	96.3	80.2
#40	11.2	91.4	87.9	76.8	87.1	72.2
#100	7.1	64.8	17.9	13.5	17.6	14.3
#200	5.5	52.9	7.5	6.5	8.6*	5.3

* Percentage of fines influenced by lenses



DISCHARGE RATING CURVE



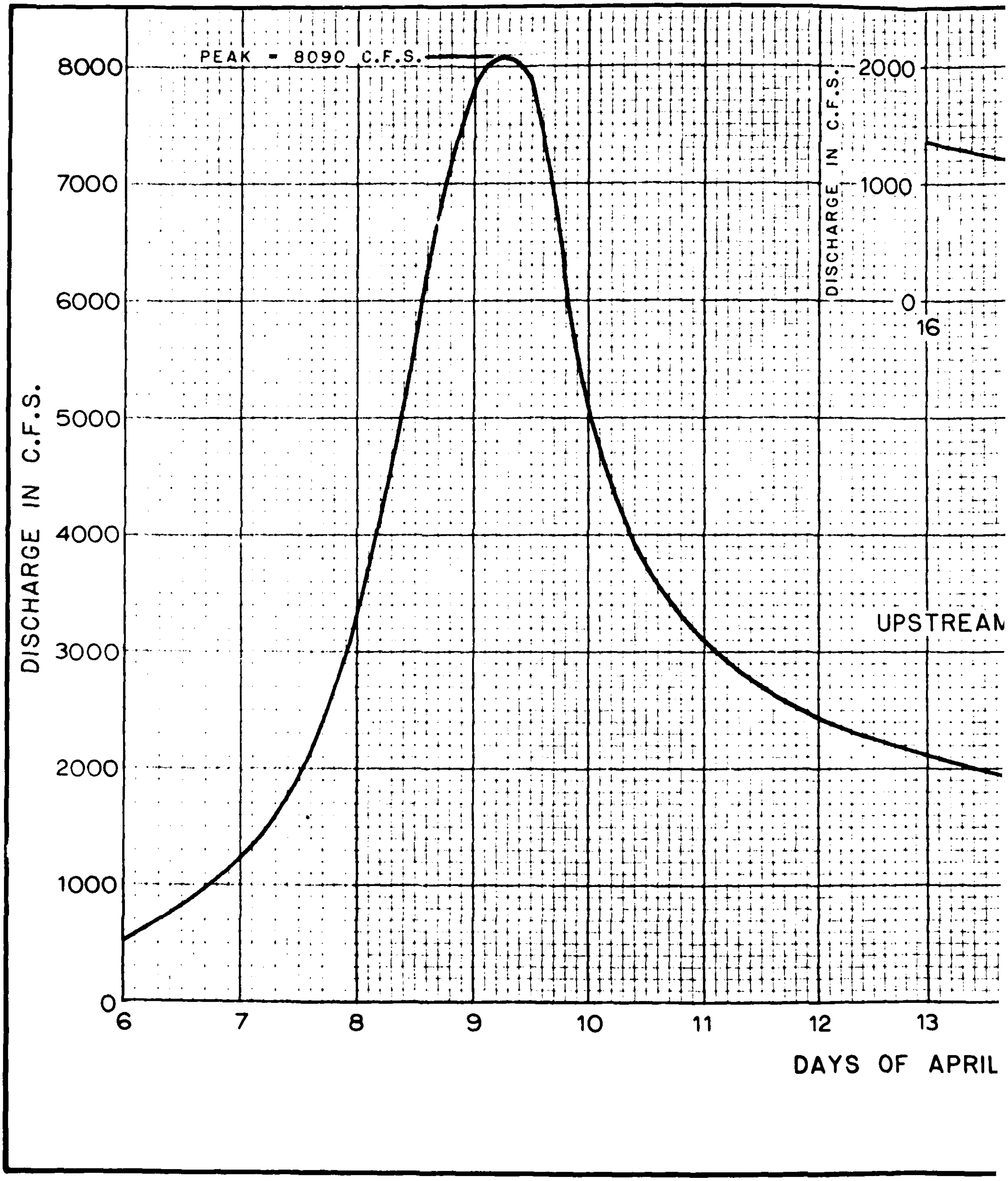
DISCHARGE - FREQUENCY CURVE

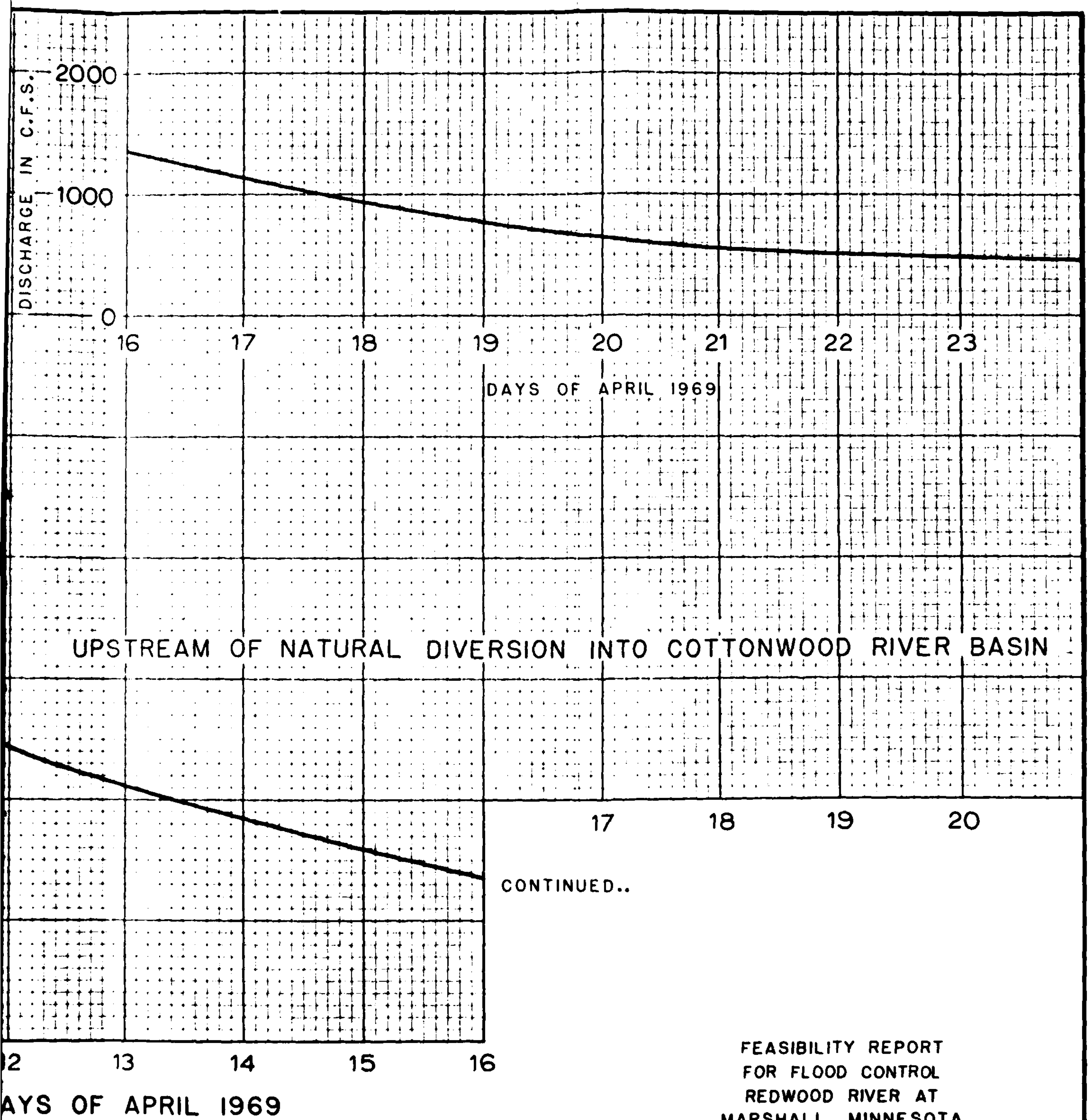
FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA

DISCHARGE RATING CURVE
DISCHARGE - FREQUENCY CURVE

USGS GAGE (MILE 67.2)

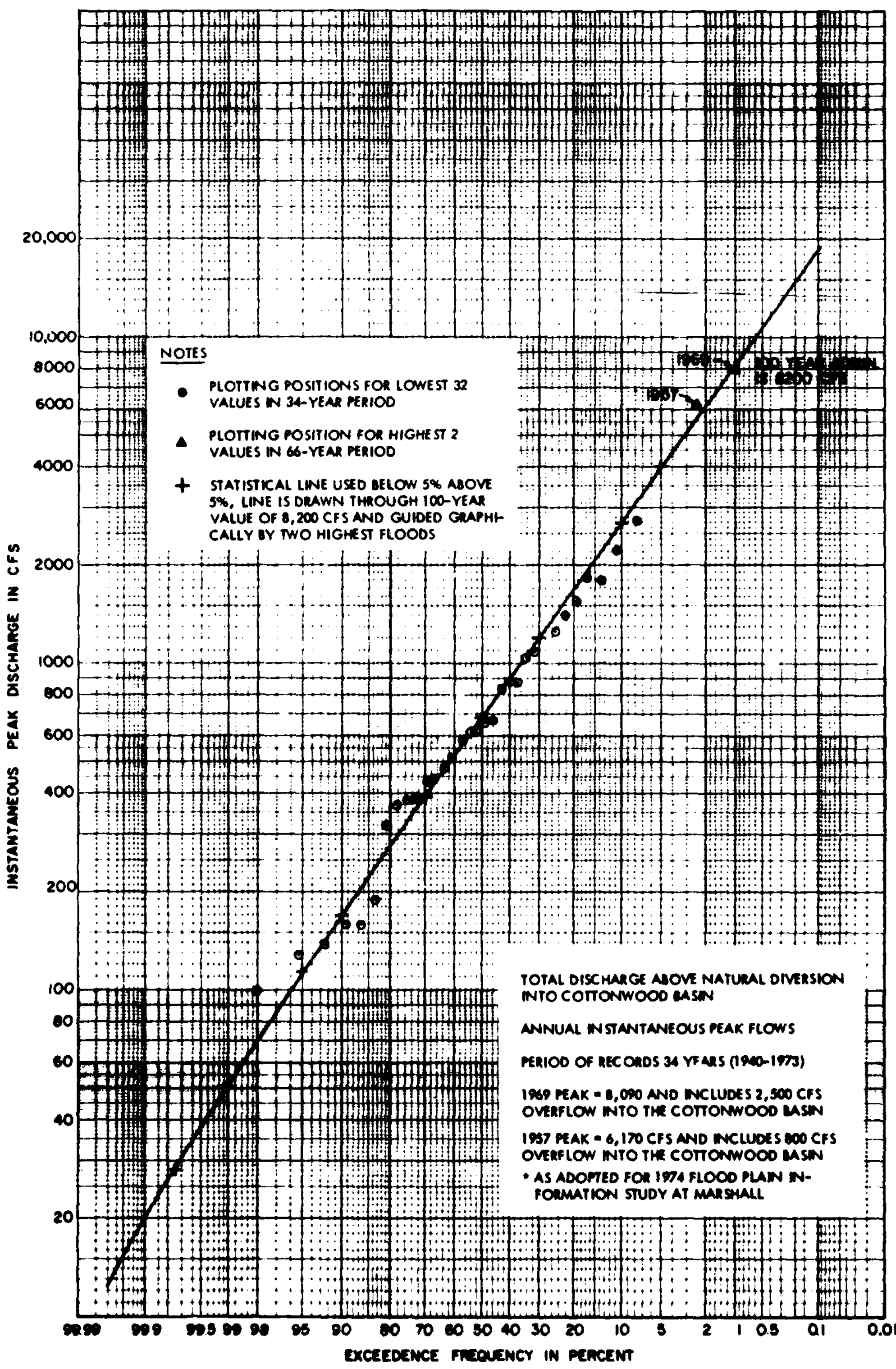
PLATE H-1


PEAK = 8090 C.F.S.
DISCHARGE IN C.F.S.
0
1000
2000
3000
4000
5000
6000
7000
8000
DISCHARGE IN C.F.S.
0
1000
2000
16
UPSTREAM
6
7
8
9
10
11
12
13
DAYS OF APRIL



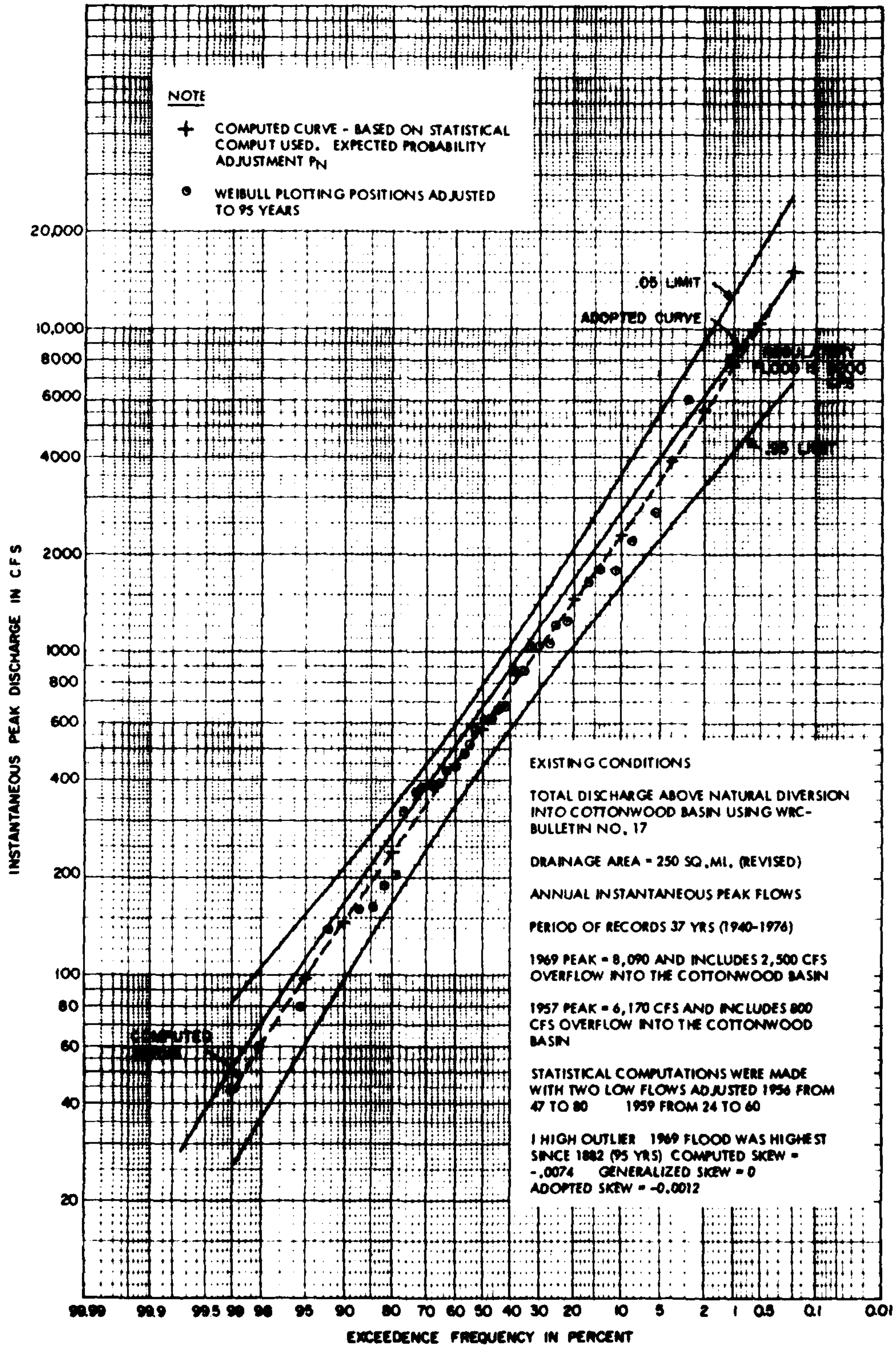
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

1969 ADOPTED FLOOD HYDROGRAPH



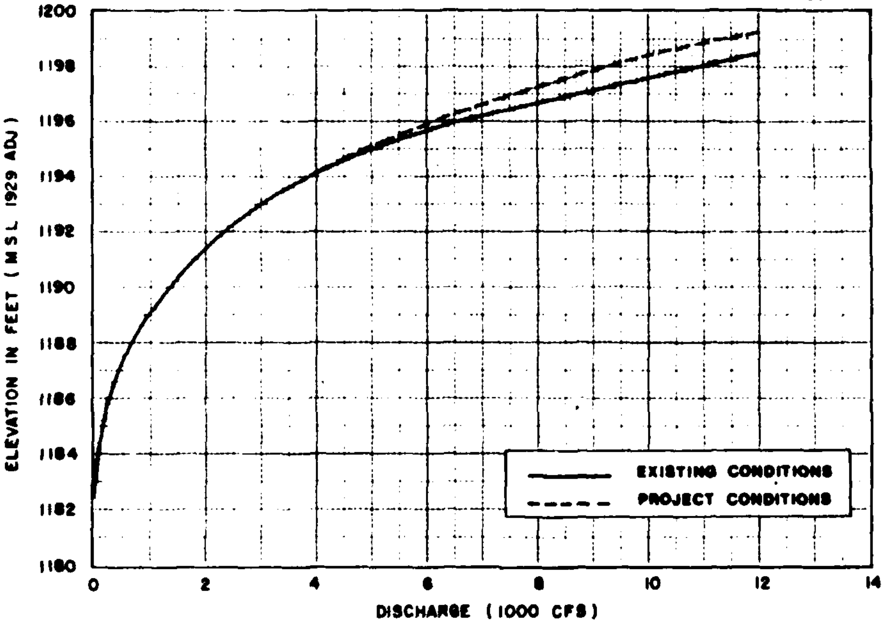
FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA
DISCHARGE - FREQUENCY CURVE*

PLATE H-3

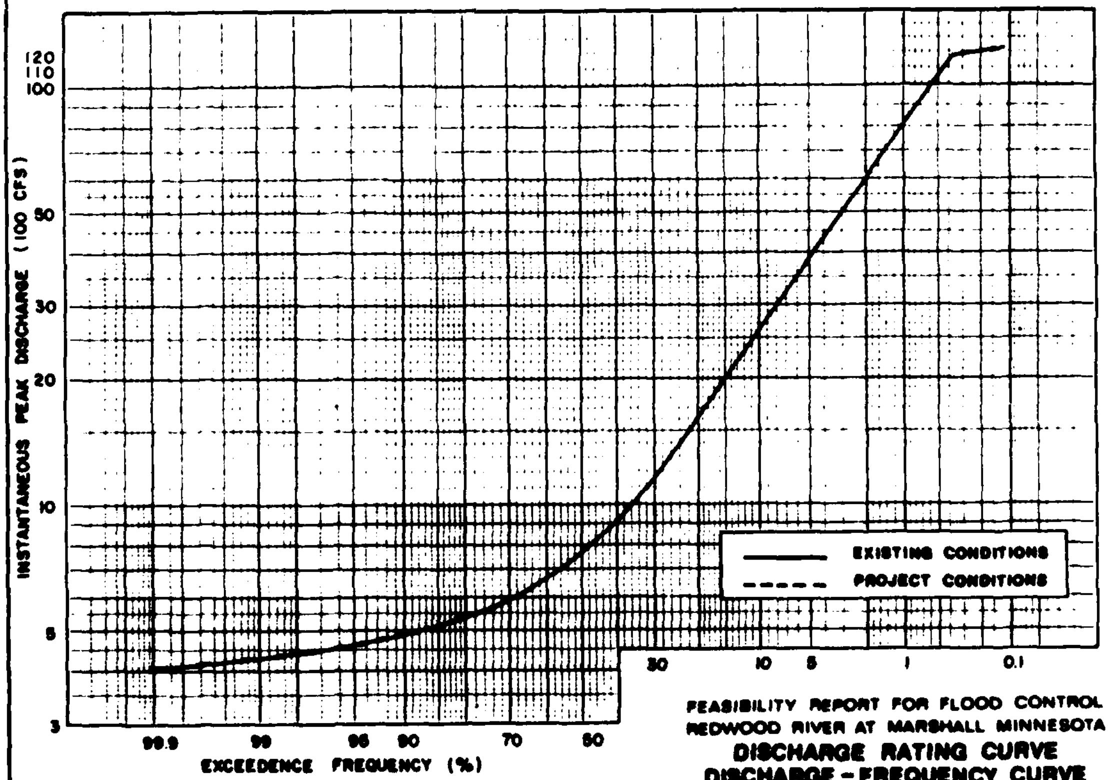


FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA

DISCHARGE - FREQUENCY CURVE

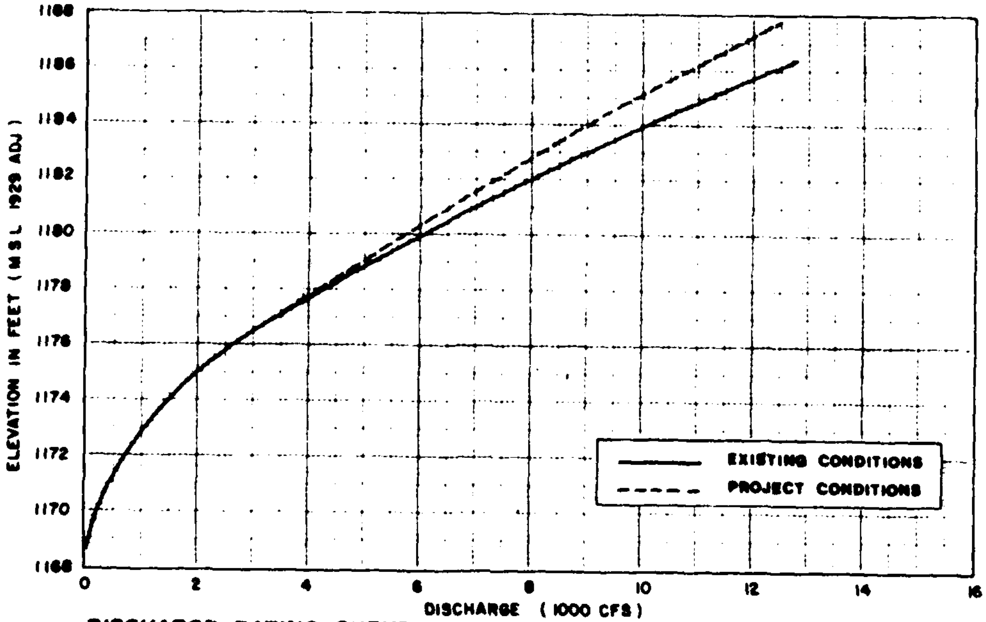


DISCHARGE RATING CURVE

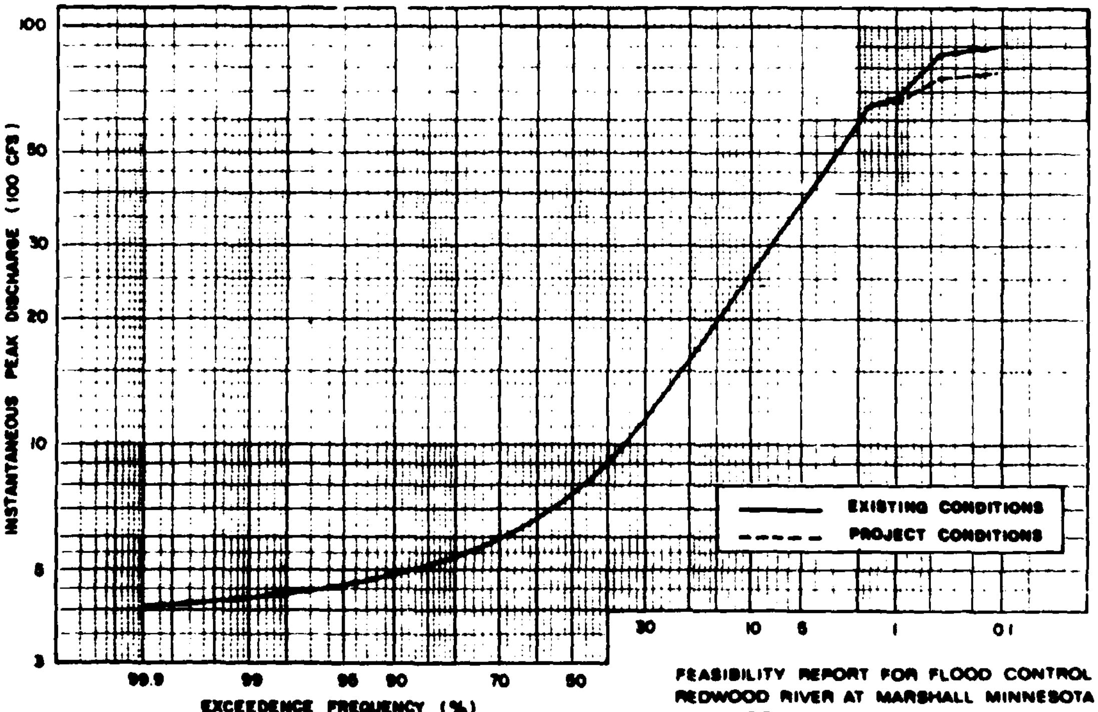


DISCHARGE - FREQUENCY CURVE

FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA
DISCHARGE RATING CURVE
DISCHARGE - FREQUENCY CURVE
DOWNSTREAM OF BNRR BRIDGE (MILE 72.6)



DISCHARGE RATING CURVE

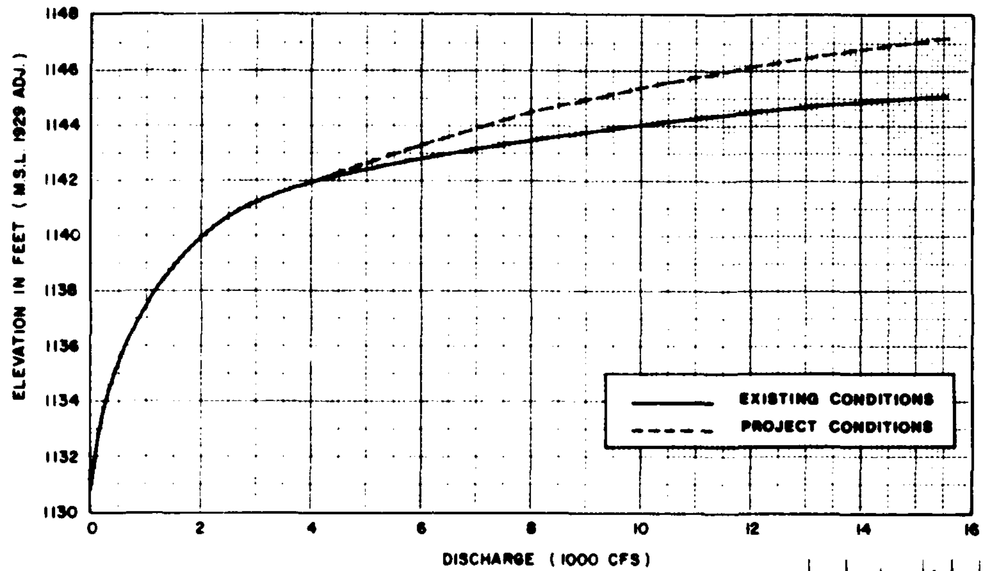


DISCHARGE - FREQUENCY CURVE

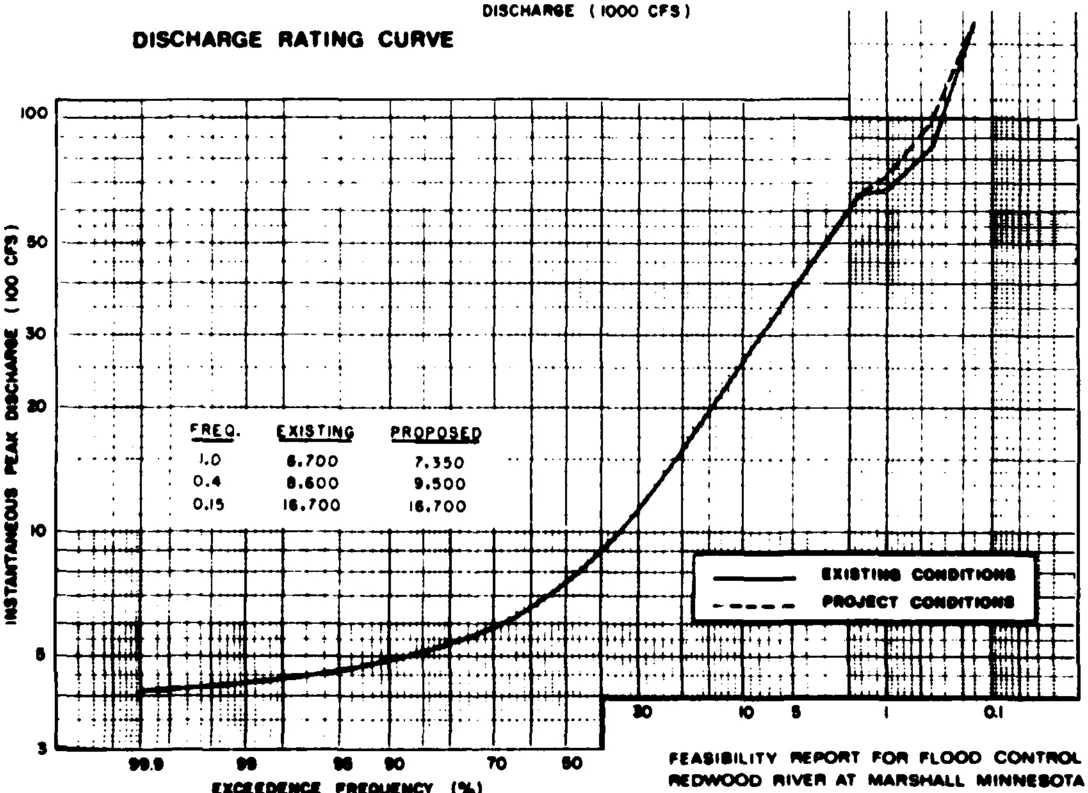
FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA

DISCHARGE RATING CURVE
DISCHARGE - FREQUENCY CURVE

UPSTREAM OF CSAH #7 BRIDGE



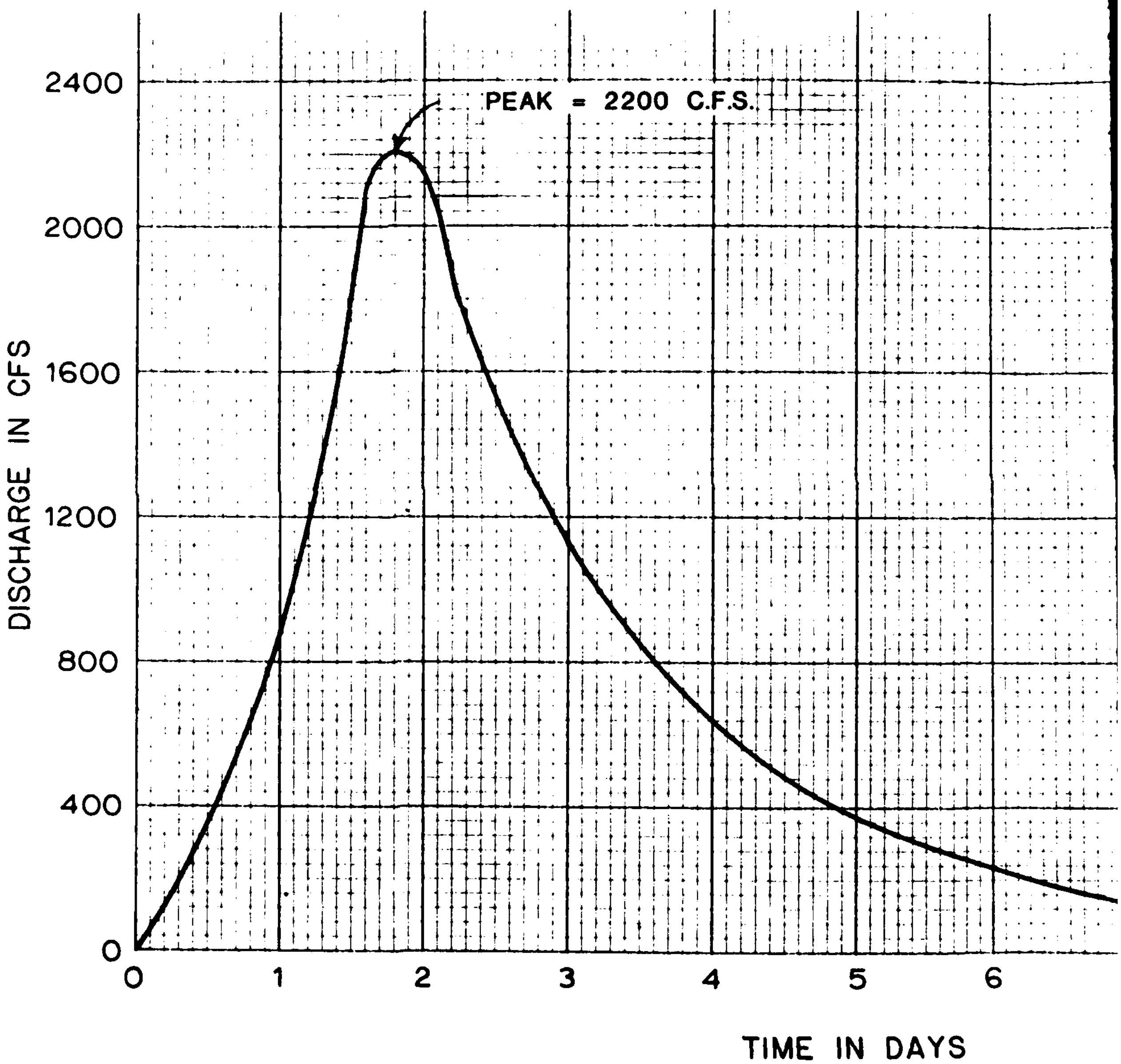
DISCHARGE RATING CURVE



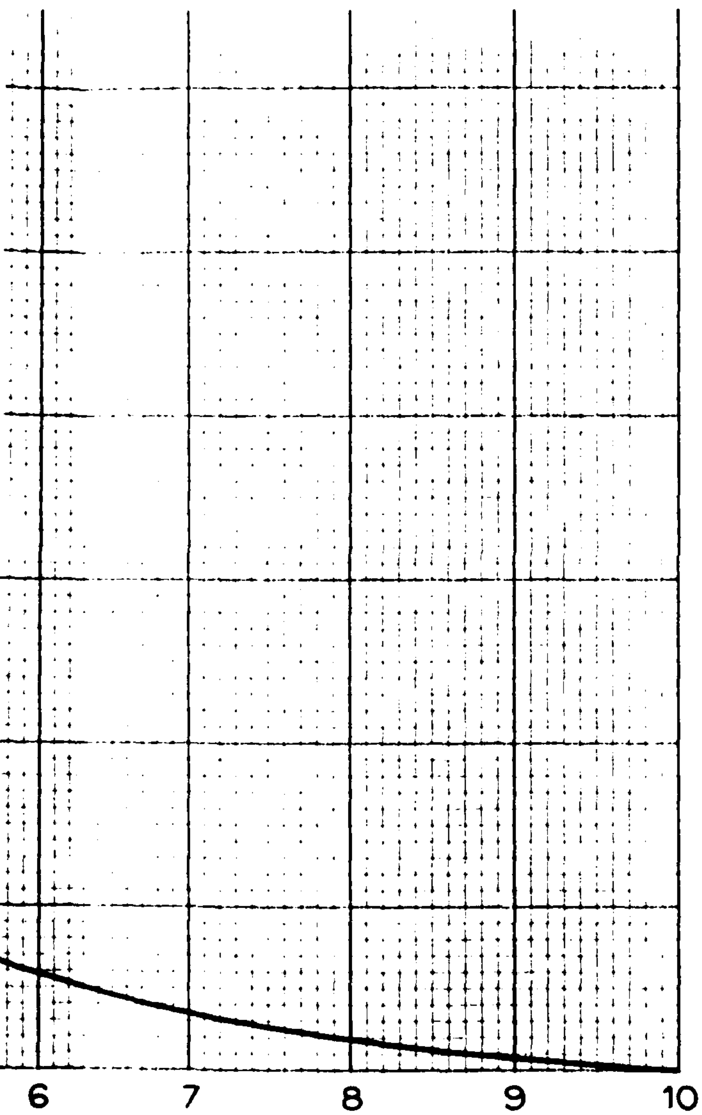
FREQ.	EXISTING	PROPOSED
1.0	6.700	7.350
0.4	8.600	9.500
0.15	16.700	16.700

DISCHARGE - FREQUENCY CURVE
NOTE: CURVES REFLECT SPF CONDITION I

FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA
DISCHARGE RATING CURVE
DISCHARGE - FREQUENCY CURVE
DOWNSTREAM OF CONFLUENCE (MILE 66.16)

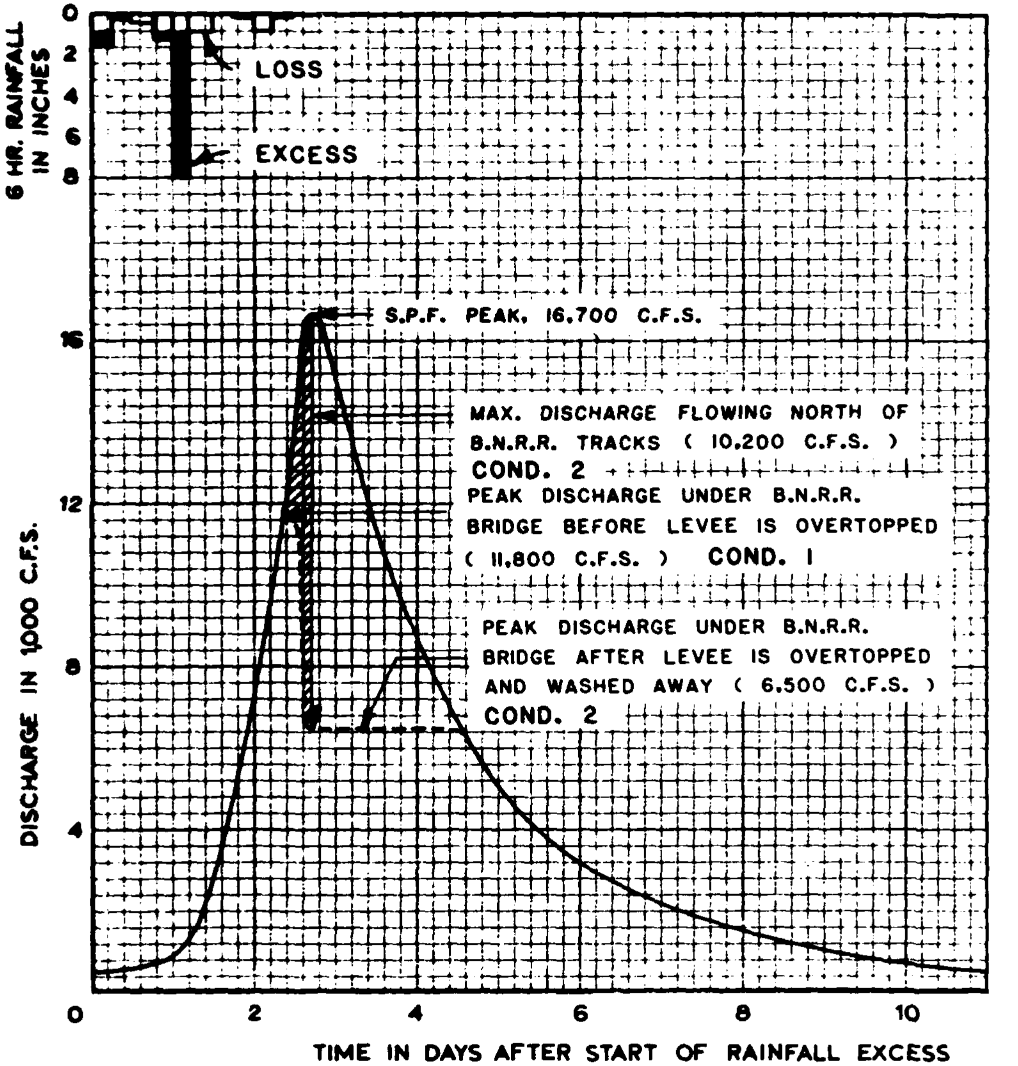


PEAK = 2200 C.F.S.
DISCHARGE IN CFS
2400
2000
1600
1200
800
400
0
0
1
2
3
4
5
6
TIME IN DAYS



FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

6-HOUR UNIT HYDROGRAPH

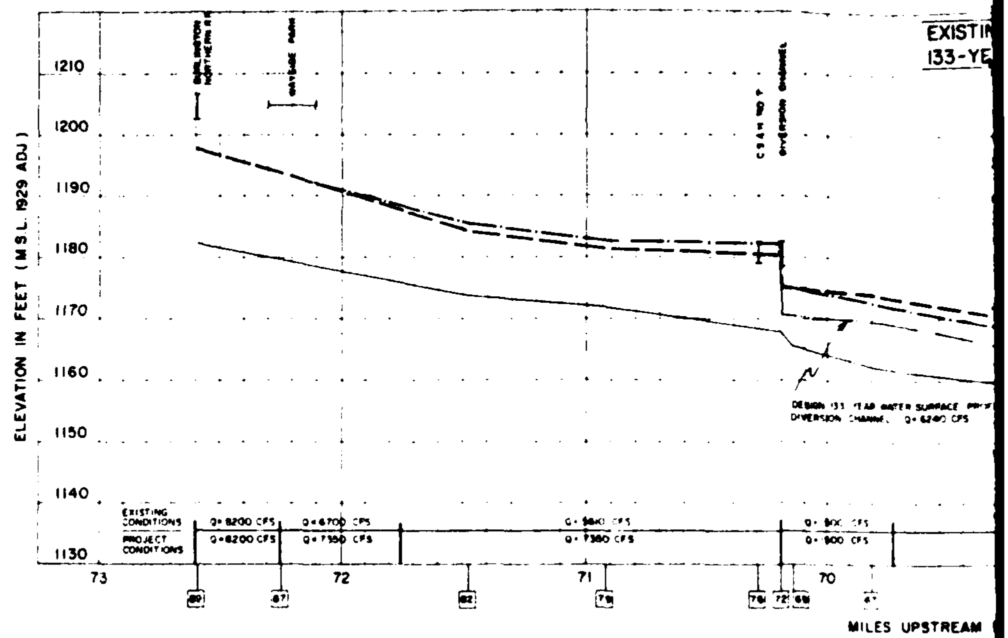


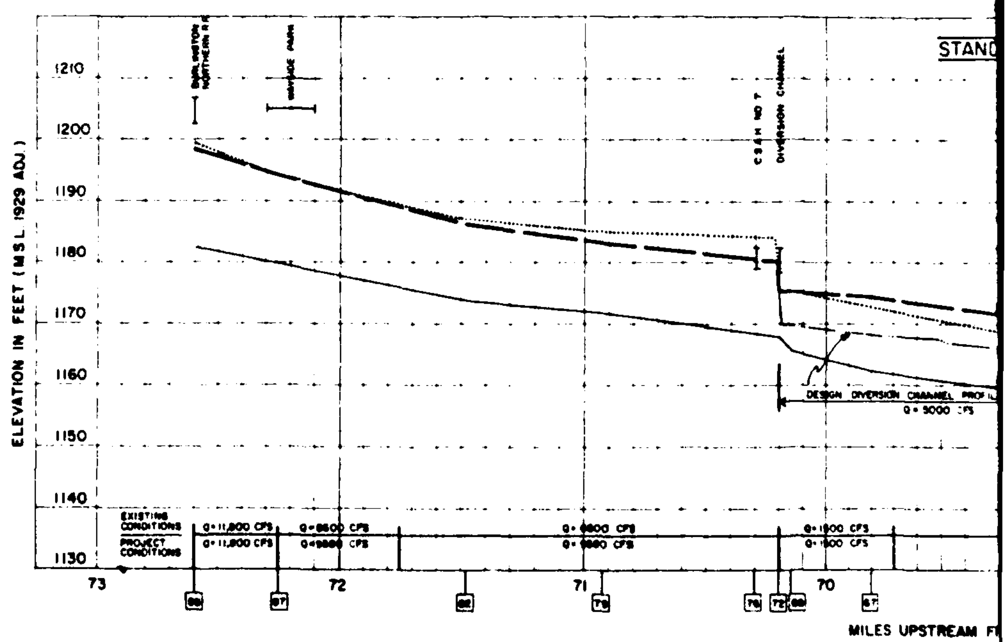
UPSTREAM OF
BURLINGTON NORTHERN R.R. BRIDGE
(RIVER MILE 72.6)

FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

STANDARD PROJECT FLOOD HYDROGRAPH

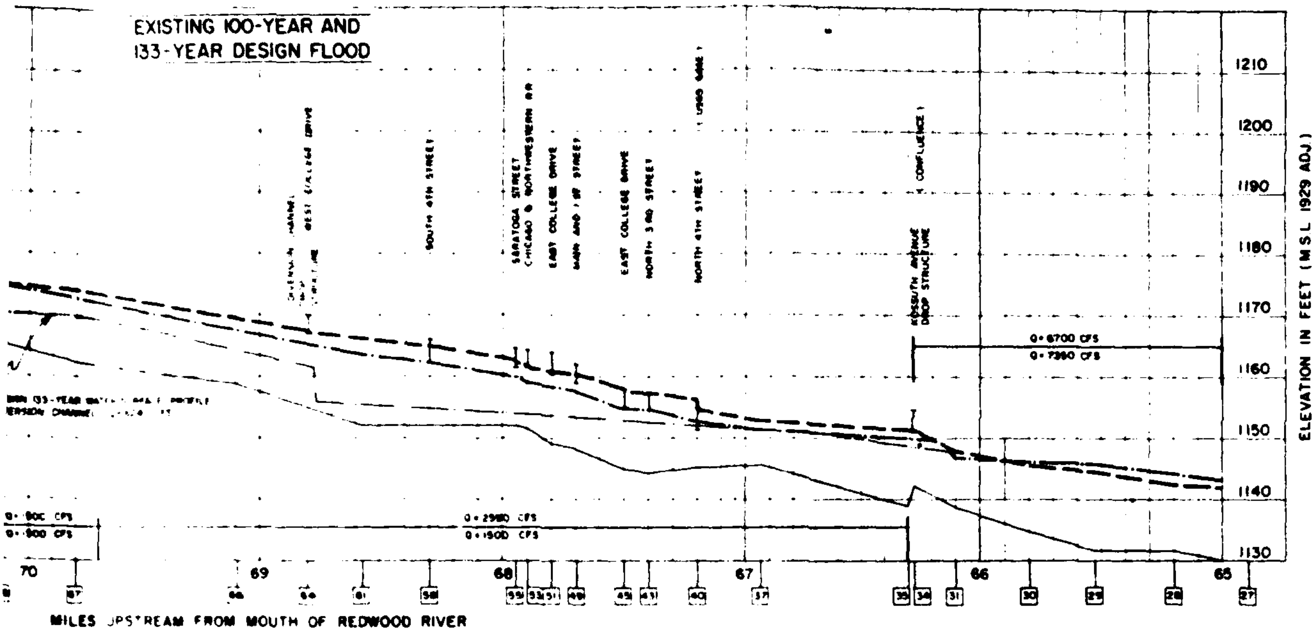
PLATE H-9

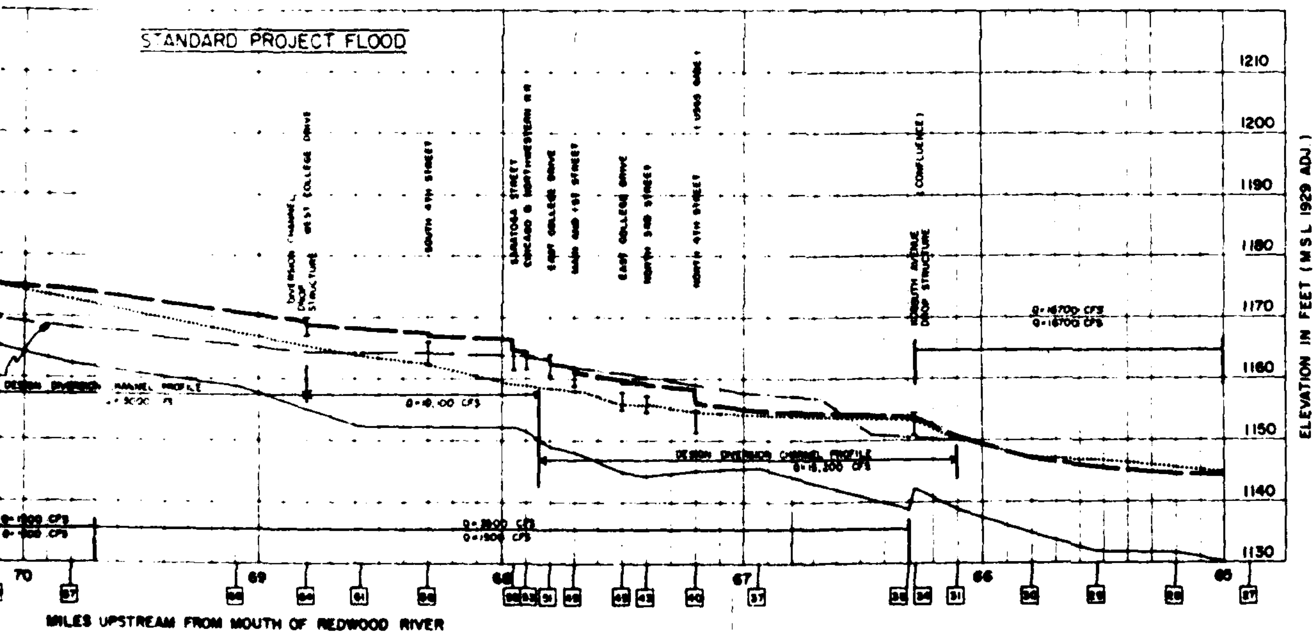




NOTE

FOR MORE DETAILED REPRESENTATION OF DISCHARGE DISTRIBUTION SEE FIGURES H-1 THRU H-4.





LEGEND

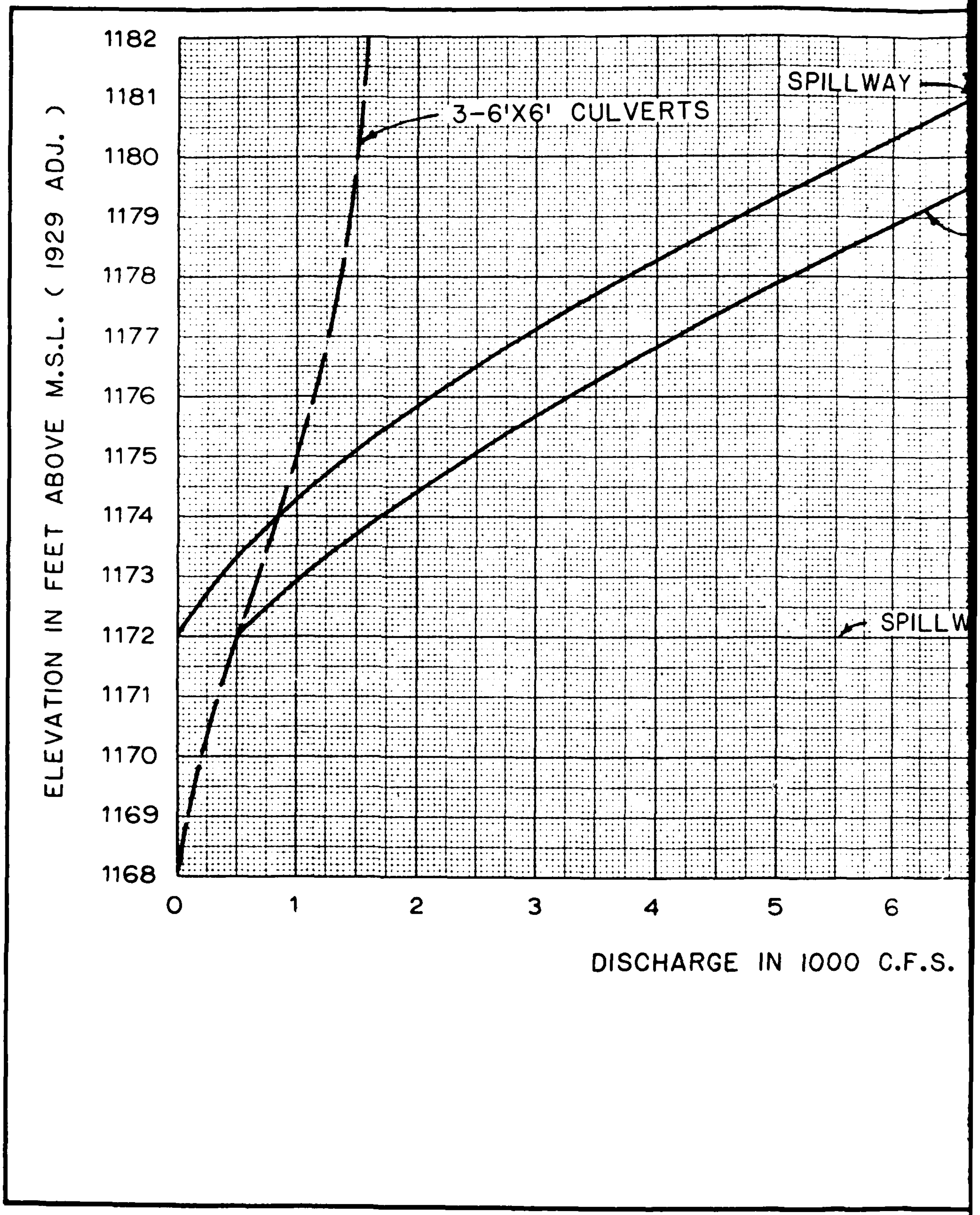
- BRIDGE FLOOR
- UNDERCLEARANCE
- CROSS SECTION
- CHANNEL THALWEG
- EXISTING 100-YEAR PROFILE (RIVER CHANNEL)
- EXISTING SPF PROFILE (RIVER CHANNEL)
- PROPOSED 133-YEAR DESIGN (RIVER CHANNEL)
- PROPOSED CONDITION SPF (RIVER CHANNEL)

SAFETY PAYS

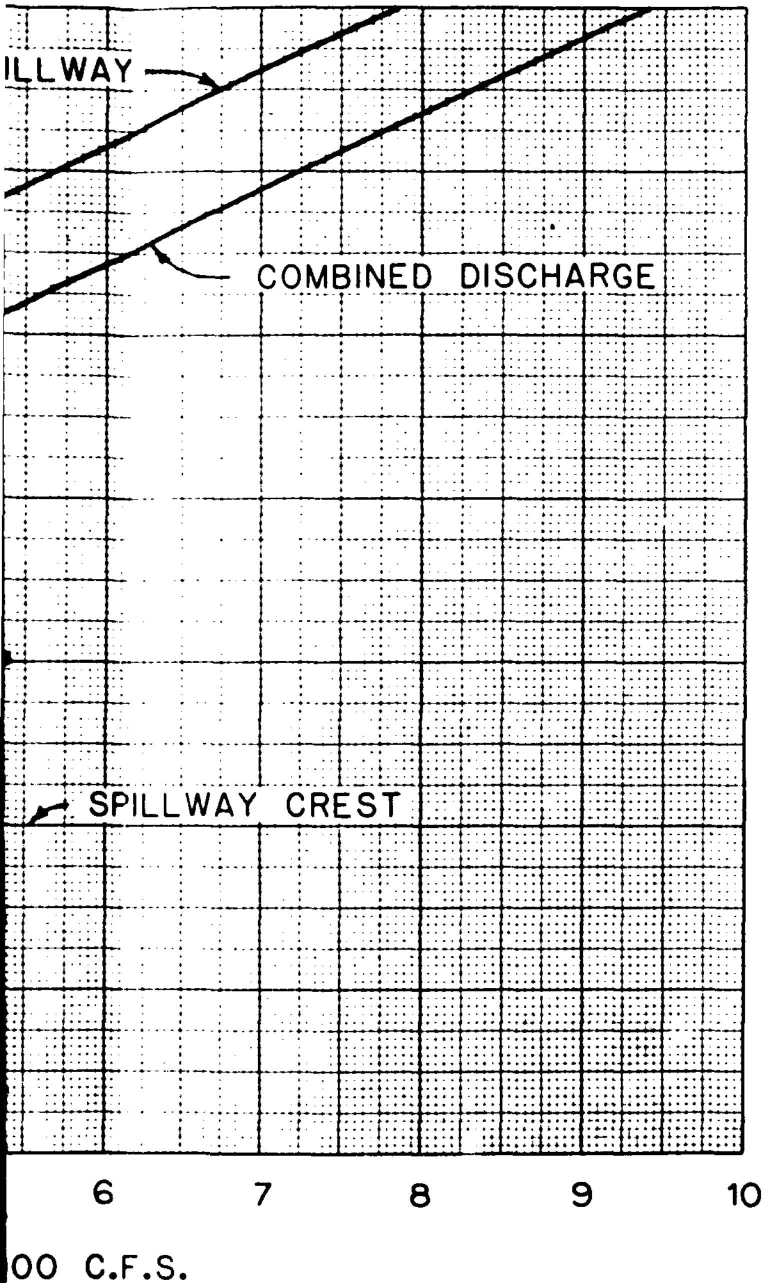
FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA

WATER SURFACE PROFILES

PLATE H-10



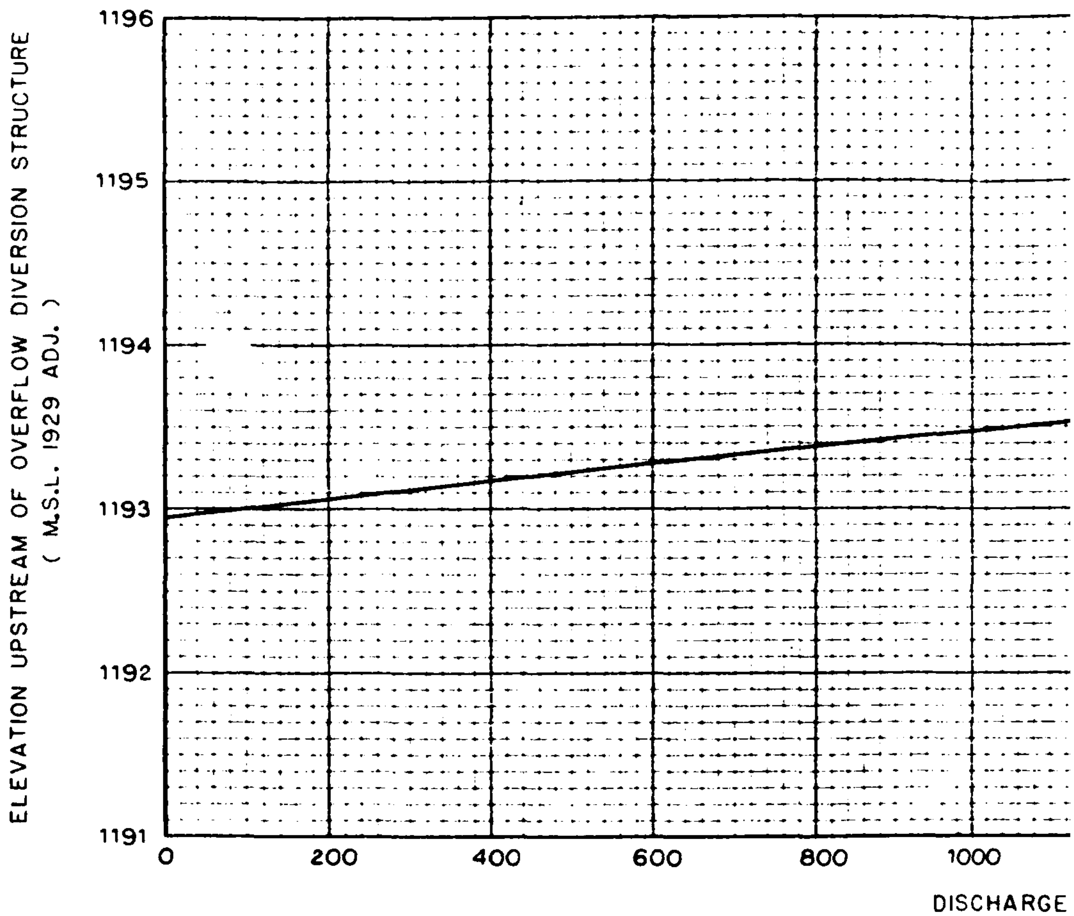
ELEVATION IN FEET ABOVE M.S.L. (1929 ADJ.)
1182
1181
1180
1179
1178
1177
1176
1175
1174
1173
1172
1171
1170
1169
1168
0
1
2
3
4
5
6
DISCHARGE IN 1000 C.F.S.
3-6'X6' CULVERTS
SPILLWAY
SPILLW



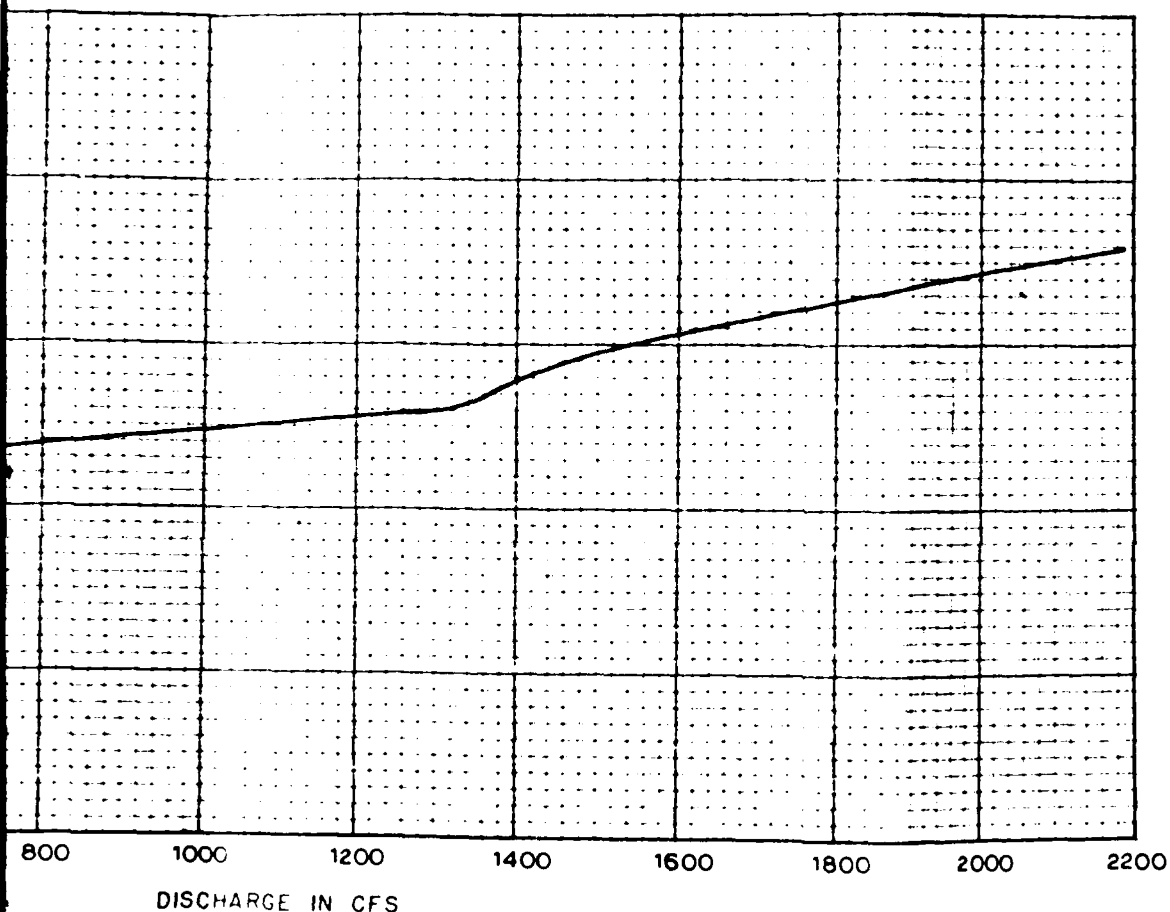
DISCHARGE RATING CURVE
AT DIVERSION STRUCTURE
(RIVER MILE 70.2)

FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

DISCHARGE RATING CURVE



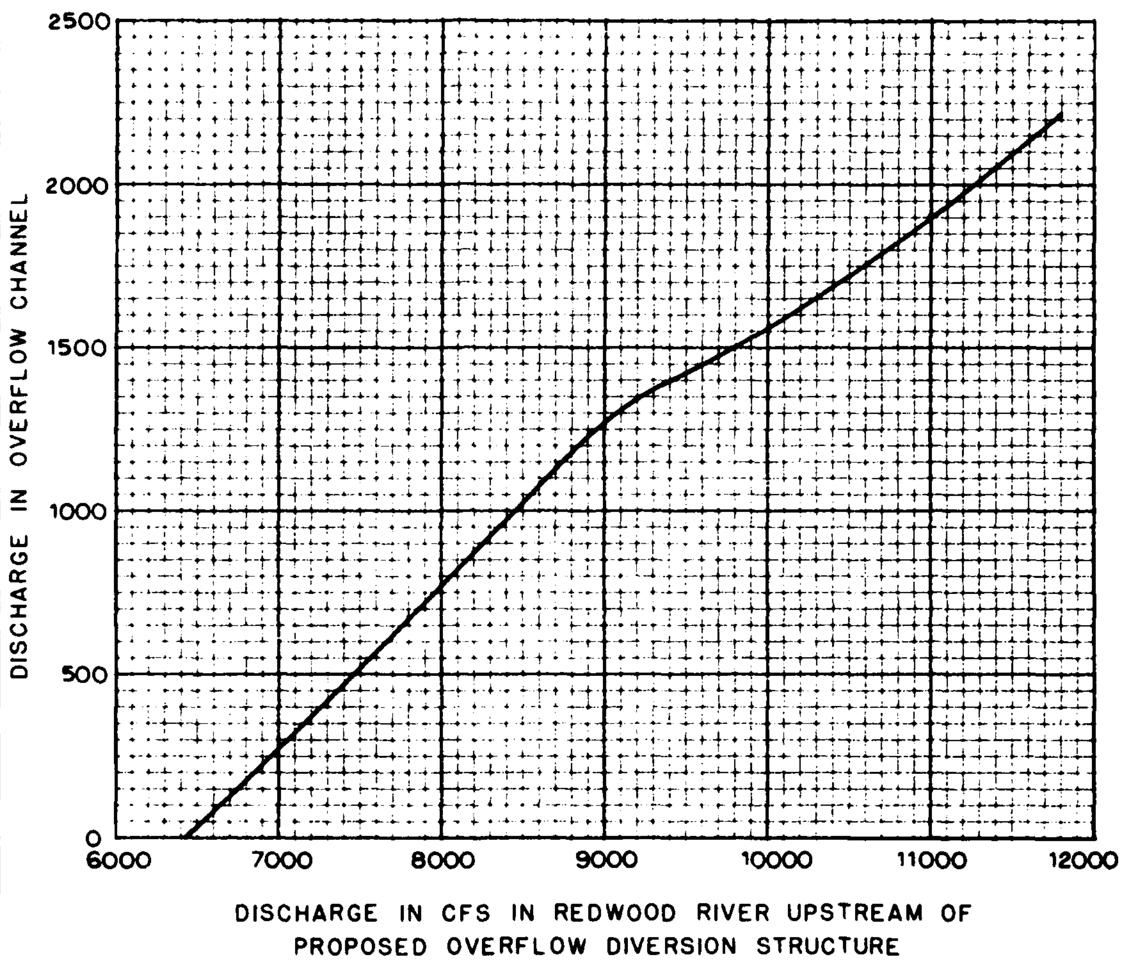
DISCHARGE RATING CURVE
FOR PROPOSED OVERFLOW DIVERSION
STRUCTURE (RIVER MILE 72.18)



ERSION
8)

FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

DISCHARGE RATING CURVE

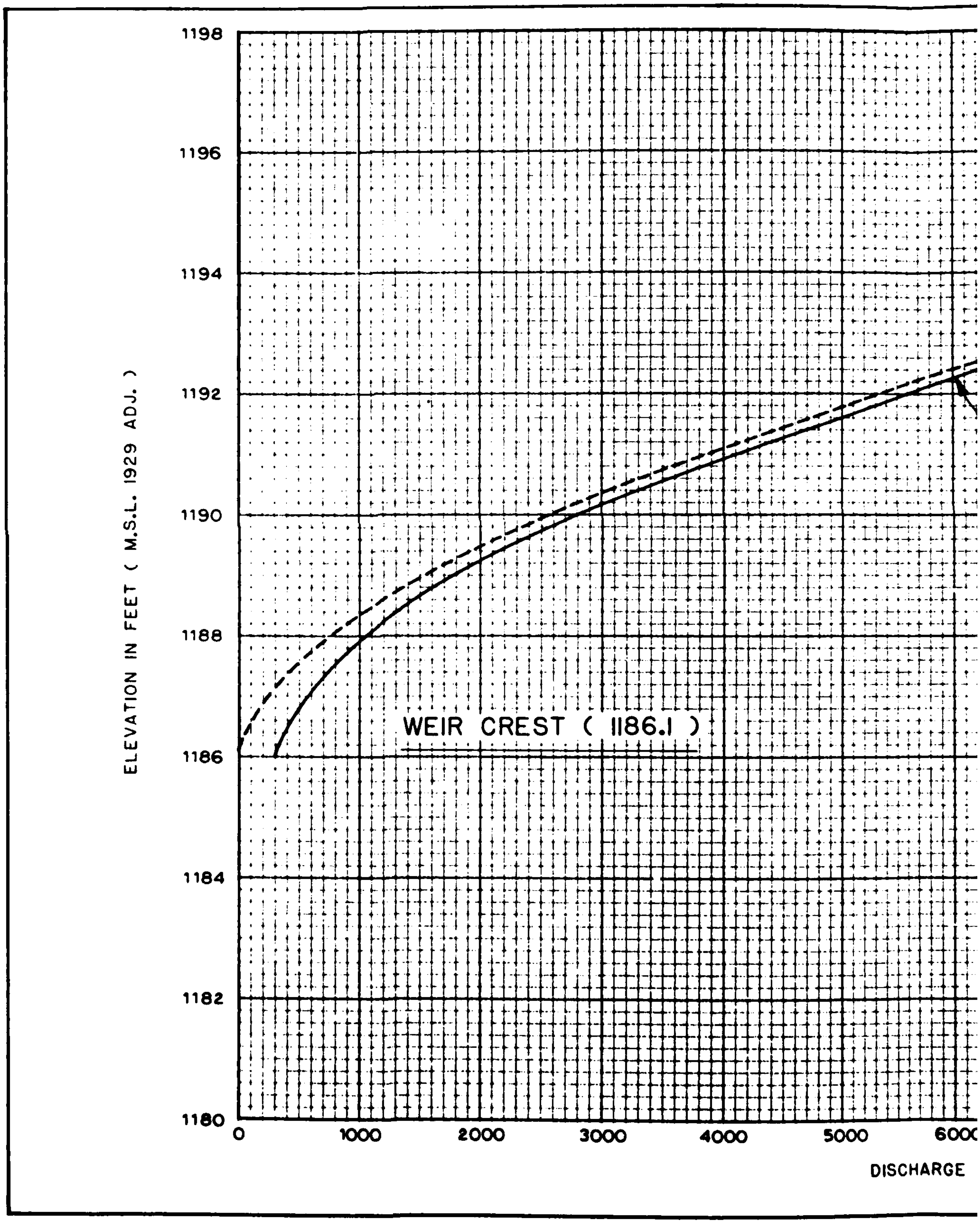


DISCHARGE RELATIONSHIPS – OVERFLOW DIVERSION STRUCTURE (RIVER MILE 72.18)

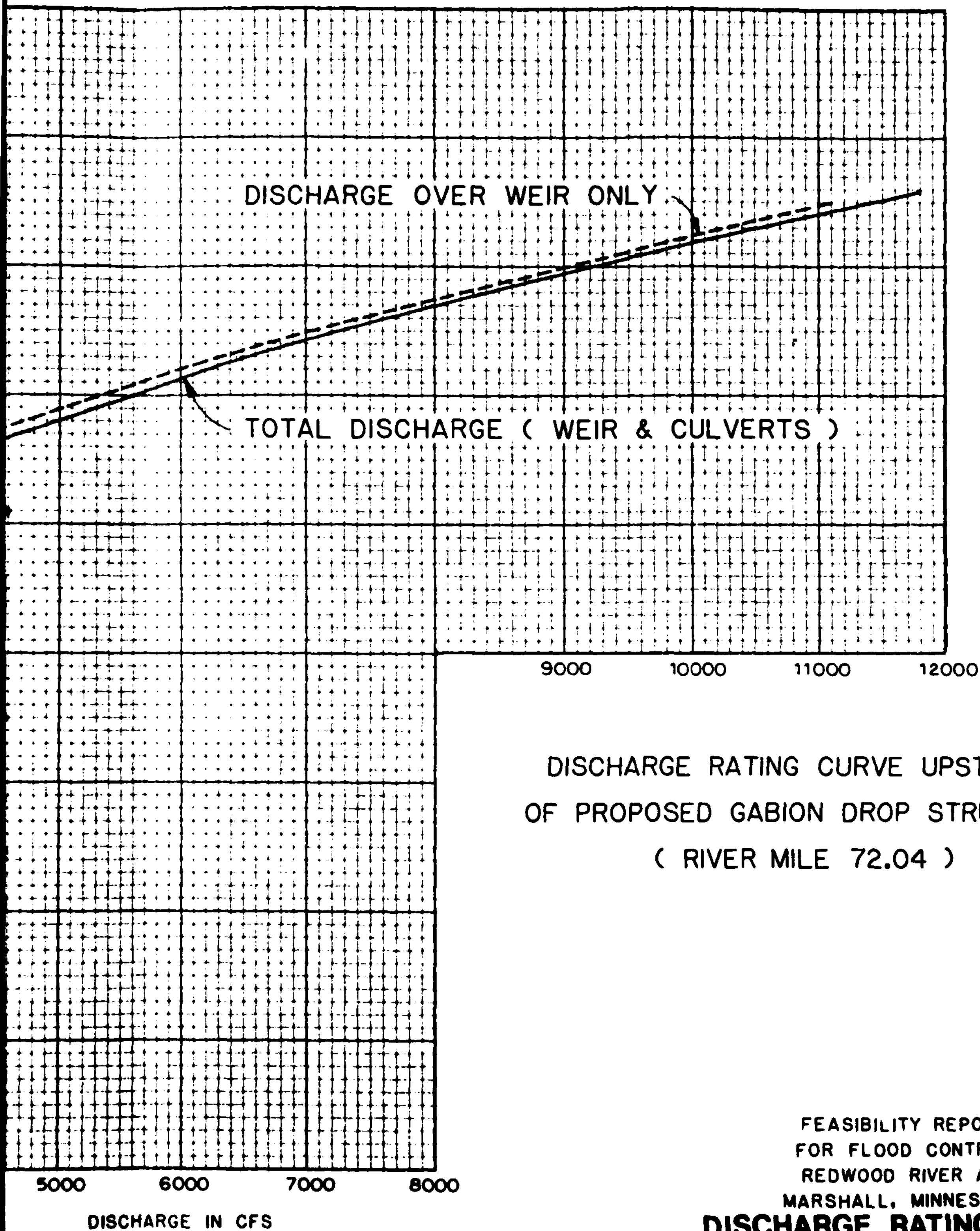
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

DISCHARGE RATING CURVE

PLATE H-13



ELEVATION IN FEET (M.S.L. 1929 ADJ.)
1198
1196
1194
1192
1190
1188
1186
1184
1182
1180
WEIR CREST (1186.1)
0
1000
2000
3000
4000
5000
6000
DISCHARGE

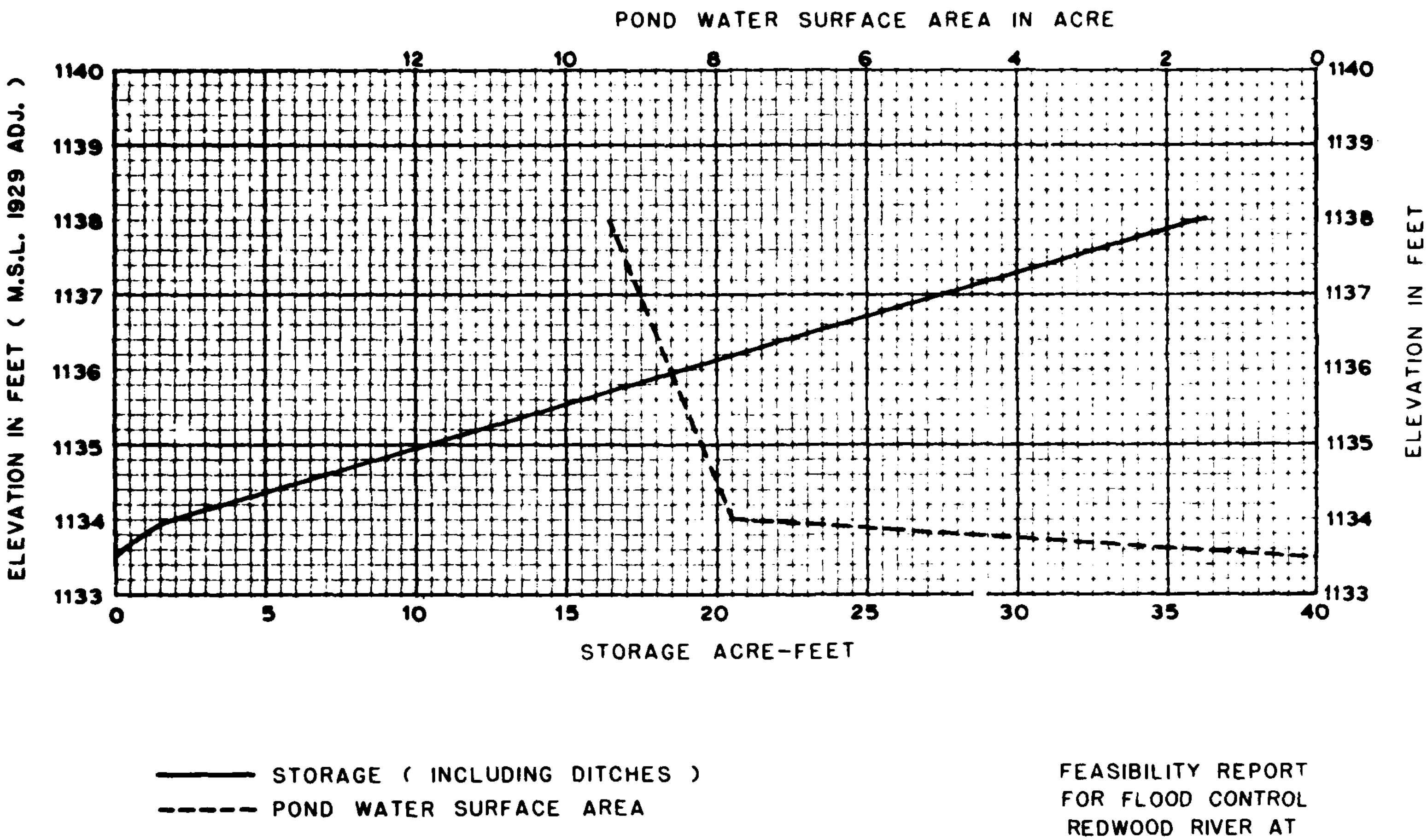


DISCHARGE RATING CURVE UPSTREAM
OF PROPOSED GABION DROP STRUCTURE
(RIVER MILE 72.04)

FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

DISCHARGE RATING CURVE

PLATE H-14



FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

AREA-CAPACITY CURVES

CALCULATION OF CRITICAL FACTOR OF SAFETY BY INFINITE SLOPE FORMULA:

$\tan \phi = \tan 33° = .6494$

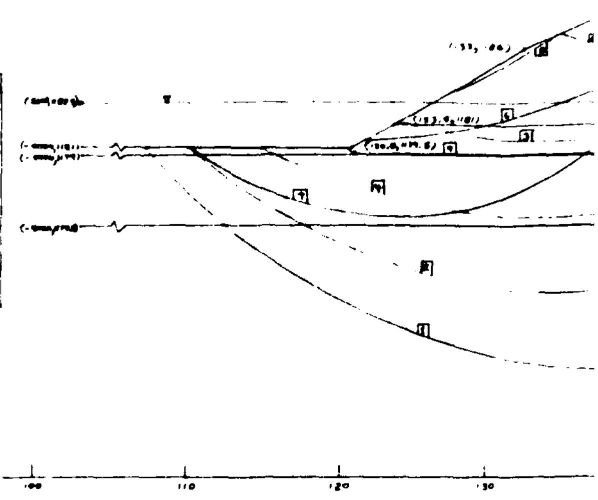
$\tan \theta = \frac{1186-1181}{135-129.0} = \frac{5}{6.0} = .8263$

$F.S. = \frac{\tan \phi}{\tan \theta} = \frac{.6494}{.7863}$

F.S. = 1.834

CIRCLE NUMBER	X-COORD.	Y-COORD.	RADIUS	FACTOR OF SAFETY
1	139.2	1207	42.0	2.86
2	126.4	1202.7	27.7	2.440
3	136	1219.8	44.8	2.303
4	133	1219.8	49.6	1.843
5	134	1210	43	2.153
6	96	1210	29	4.016
7	120	1219.8	49.6	2.237
8	24.2	1198.8	23.6	1.907
9	00	1227.8	49.8	1.380
9A	46.5	1209.9	310	1.904
	DRIVING CIRCLE			

NON-CIRCULAR ARC



SLOPE STAB

SAMPLE CALCULATIONS USING REACH 7

PERVIOUS ZONE --

SOIL CLASS	D_{10}	K_f (CM/S)	d	$K_f d$
SP-SM	.11	.052	3.5	.182
SP-SM	.12	.066	2.5	.165
SP-SM	.10	.038	4.5	.171
			10.5	.518

$K_f = \frac{\sum (K_f d)}{\sum d} = \frac{.518}{10.5} = .0493 \approx .05$

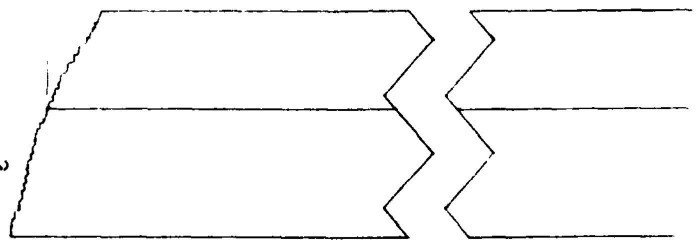
$D = \sum d = 10.5$

LANDWARD TOP STRATUM --

SOIL CLASS	K_b	Z (FT)	TRANSFORMATION FACTOR	Z_t (FT)	Z_b (FT)
CH	.0006	2.0	.75	1.5	1.5
CL	.0006	6.5	1.0	6.5	6.5
		8.5		8.0	8.0

($Z_b = Z_t = 3.7$ at ditch)

$K_b = K_{min} = .0006$



FACTOR OF SAFETY --

$x_1 = \frac{1}{c} = \sqrt{\frac{K_f D Z_b}{K_b}} = \sqrt{\frac{.05 \times 10.5 \times 3.7}{.0006}} = 56.9$

$S = 900'$

$H = 10.8$

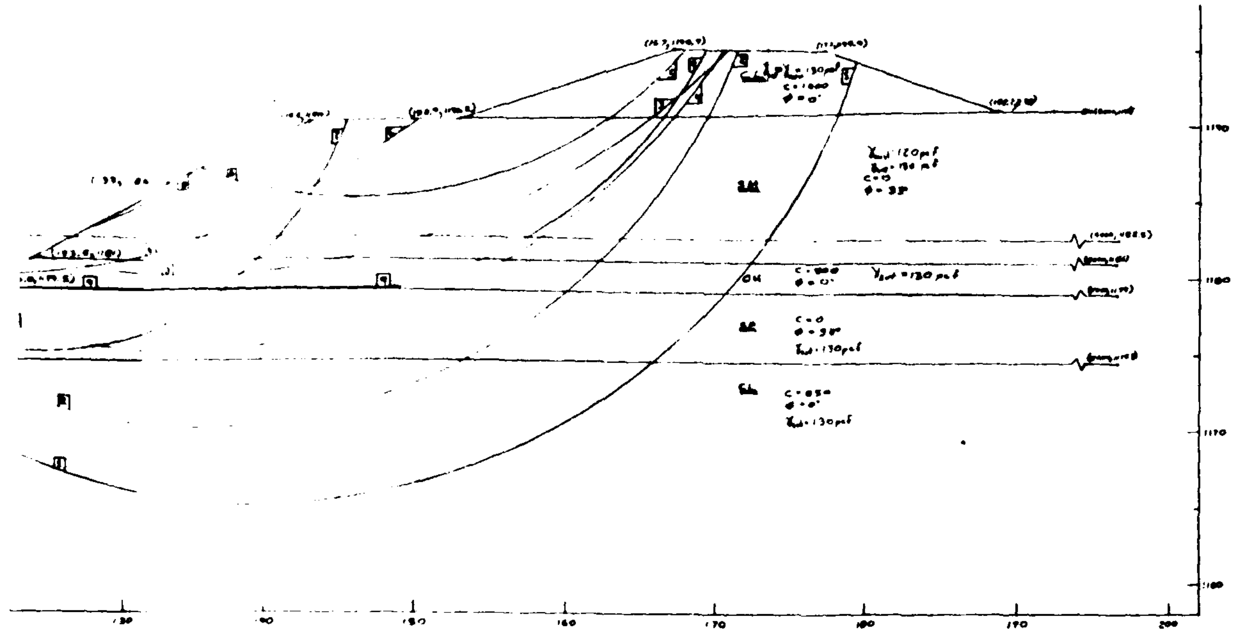
$h_o = \frac{H x_3}{S + x_3} = \frac{10.8 \times 56.9}{900 + 56.9} = 1.35$

$F.S. = \frac{(\gamma_s - \gamma_w) Z_t}{h_o \gamma_w} = \frac{(110 - 62.4) 3.7}{1.35 \times 62.4} = 2.09$

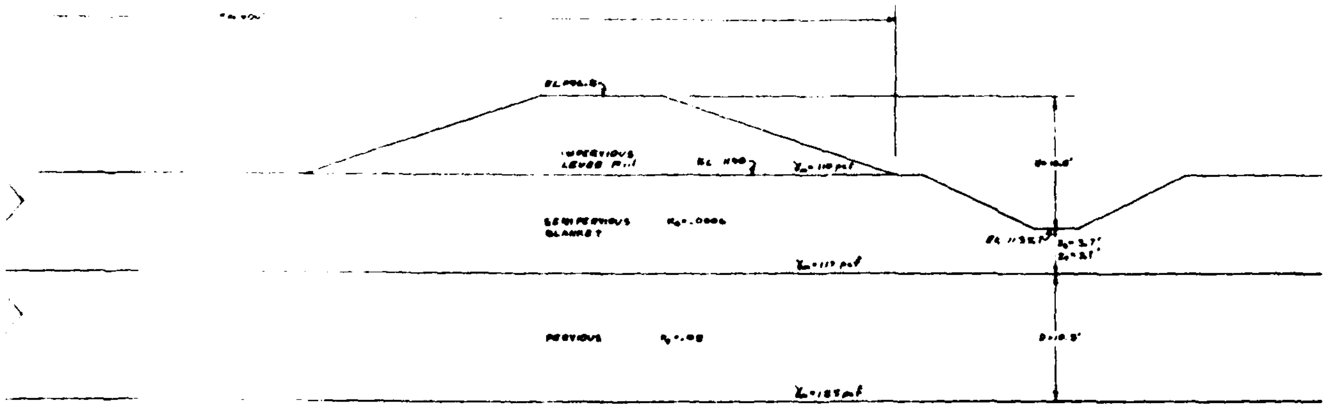
REACH NO.	* TOP OF LEVEE	** GROUND SURFACE AT TOE OF LEVEE	* TOP OF PERVIOUS STRATUM	* DESIGN W.S. ELEV.	TYPICAL FOUNDATION BORING	D (FT)	K_f (CM/S)	TYPICAL BLANKET BORING	Z_b (FT)	K_b (FT/M)
	ELEVATIONS				PERVIOUS FOUND			LANDWARD		
1	1189.8	1181	1177	1186.8	75-31	20.5	.171	75-4	4.0	.000[illegible]
2	1199.8	1181	1177	1186.8	75-30	3.0	.095	75-30	4.0	.000[illegible]
3	1188.5	1184	1182	1188.8	75-32	10.5	.08	75-32	2.0	.000[illegible]
4	1191.8	1187	1176.25	1188.8	75-33	7.5	.34	75-33	8.75	.000[illegible]
5	1193.0	1187	1179.7	1190.0	75-34	6.6	.19	75-34	12.5	.000[illegible]
6	1192.2	1188	1180	1192.2	75-35	13.0	.13	75-35	NO B[illegible]	
7	1196.5	1185.7	1158	1192.2	75-41	10.5	.05	75-41	*3.7	.000[illegible]
8	1198.1	1192	—	1195.7	75-37	NO PERVIOUS ZONE		75-37	—	—
9	1198.3	1194	—	1192.9	75-38	NO PERVIOUS ZONE		75-38	—	—

* These values are an average of critical values for the reach and do not necessarily correspond to the typical boring.

** An average ground surface elevation of 1190 was used for uplift, not 1185.7 which is the bottom of the ditch at the critical section.



SLOPE STABILITY



UPLIFT

...UND	LANDWARD BLANKET						LEVEE GEOMETRY			SEEPAGE			LOCATION
[illegible]	TYPICAL BLANKET BORING	Z_b (FT)	K_b [illegible]	[illegible] (FT)	[illegible] (PCF)	[illegible] (FT)	[illegible] (FT)	[illegible] (FT)	FACTOR OF SAFETY	[illegible] (FT)	[illegible] (GPM/FT)	EST. TOTAL SEEPAGE (GPM)	LEVEE STATIONING
.171	[illegible]	4.0	[illegible]	4.0	110	132	60	-	NOT APPLICABLE	0.8	.12	271	[illegible]
[illegible]	79-30	4.0	[illegible]	4.0	110	10	60	-	0.3	0.9	.001	2	[illegible]
.88	79-32	2.0	[illegible]	2.0	110	80	60	-	NOT APPLICABLE	1.5	.23	322	[illegible]
.30	79-33	[illegible]	.0006	7.6	110	510	60	-	2.1	1.8	.08	80	[illegible]
.10	79-34	12.3	.0001	12.3	110	380	60	-	1.6	3.0	.06	40	[illegible]
.19	79-38	NO BLANKET			110	—	60	60	NO UPLIFT	4.2	.90	972	[illegible]
.09	79-41	3.7	.0006	3.7	110	97	60	-	2.1	3.2	.11	358	[illegible]
[illegible]	79-??	-	—	—	—	—	—	-	NO UPLIFT	3.7	—	SMALL	[illegible]
[illegible]	79-??	-	—	—	—	—	—	-	NO UPLIFT	1.7	—	SMALL	[illegible]

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

SUBMITTED BY:

APPROVED:

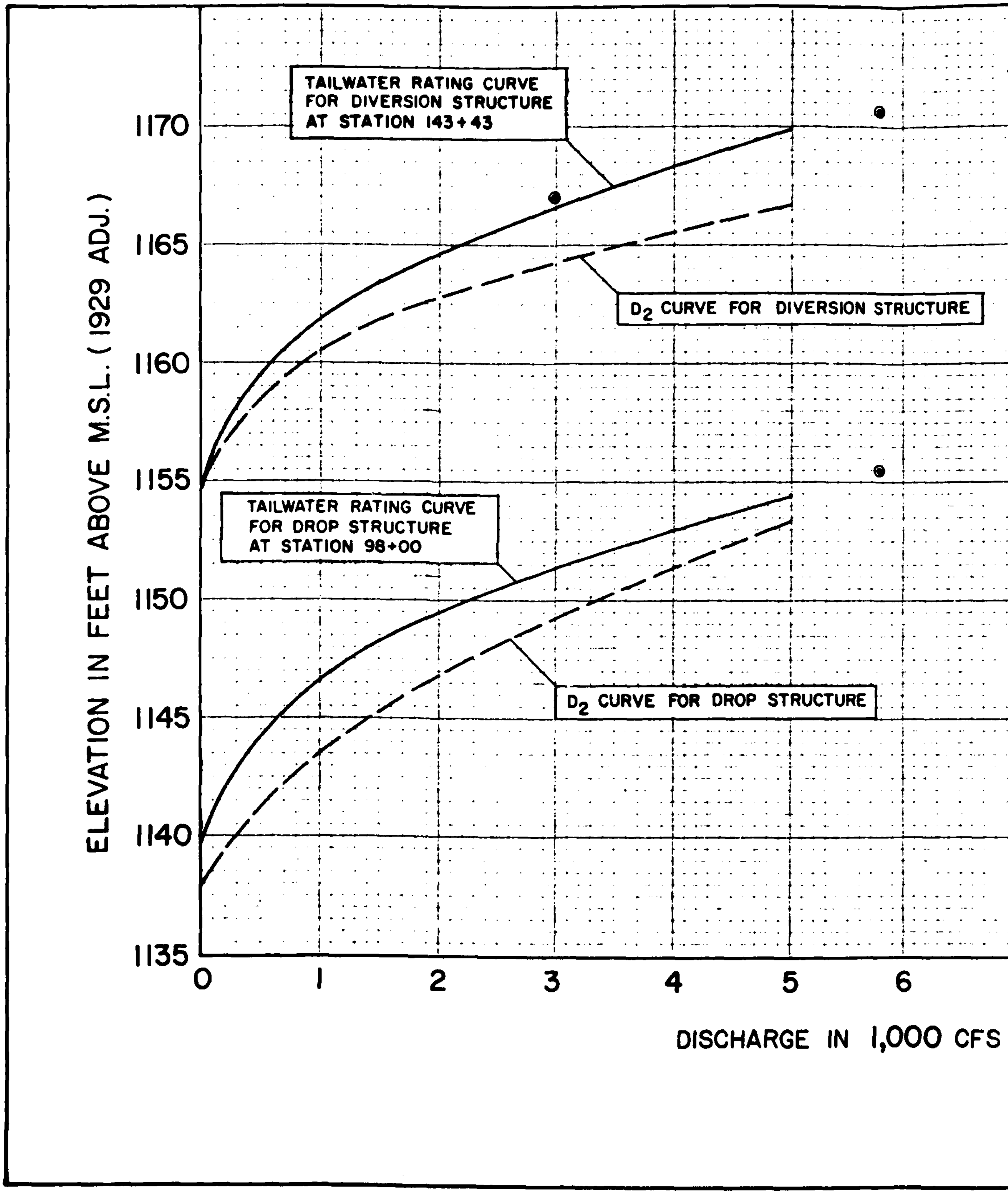
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

STABILITY AND SEEPAGE ANALYSIS

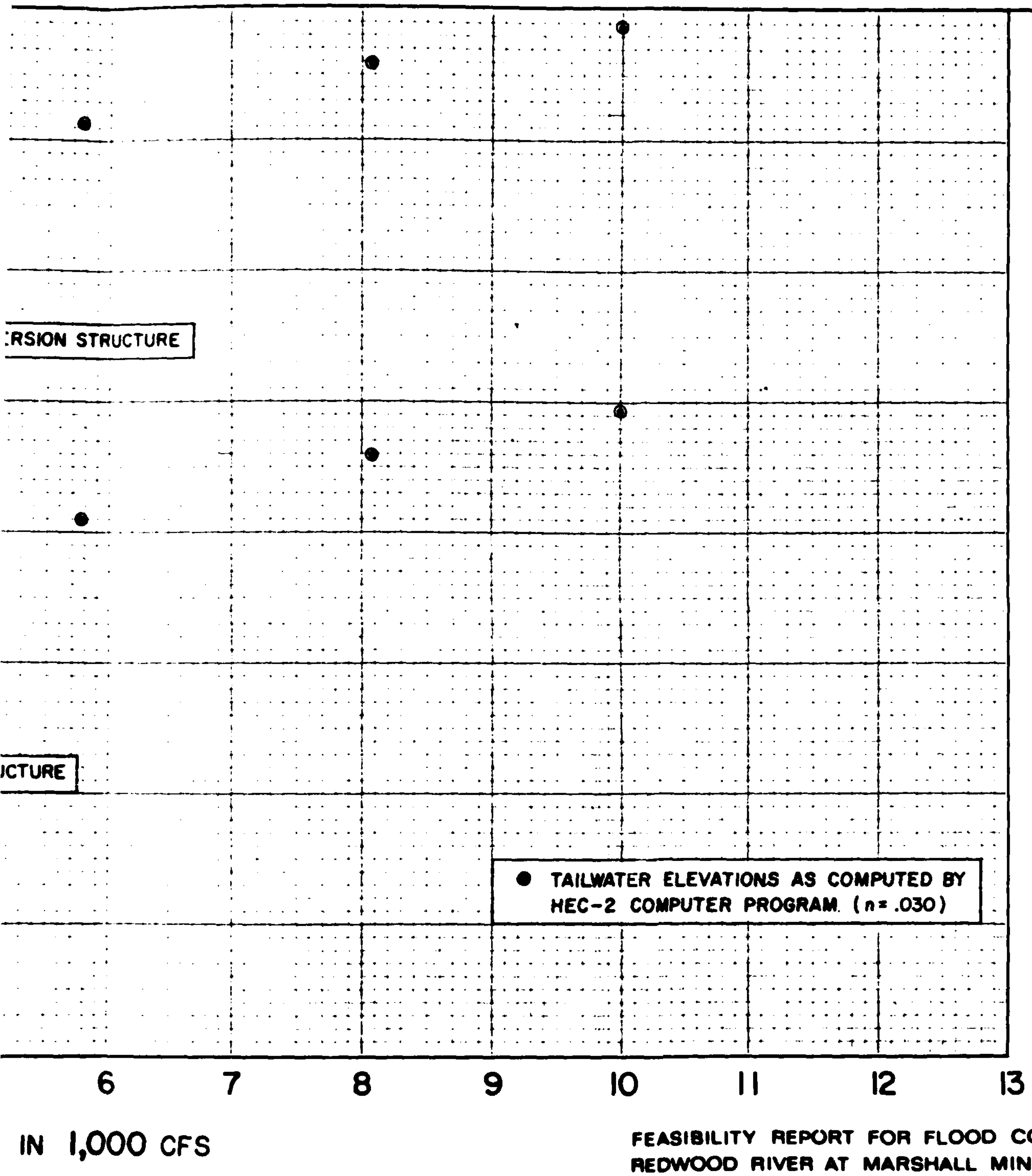
DRAWING NUMBER

SHEET ___ OF ___

PLATE H-16

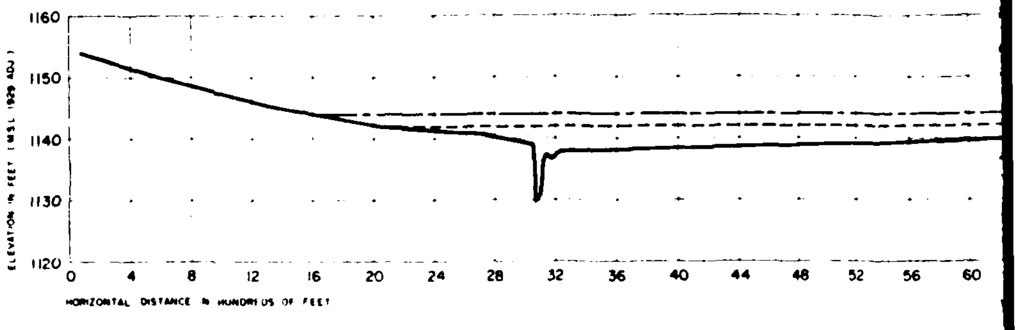


TAILWATER RATING CURVE FOR DIVERSION STRUCTURE AT STATION 143+43
D2 CURVE FOR DIVERSION STRUCTURE
TAILWATER RATING CURVE FOR DROP STRUCTURE AT STATION 98+00
D2 CURVE FOR DROP STRUCTURE
ELEVATION IN FEET ABOVE M.S.L. (1929 ADJ.)
1135
1140
1145
1150
1155
1160
1165
1170
0
1
2
3
4
5
6
DISCHARGE IN 1,000 CFS

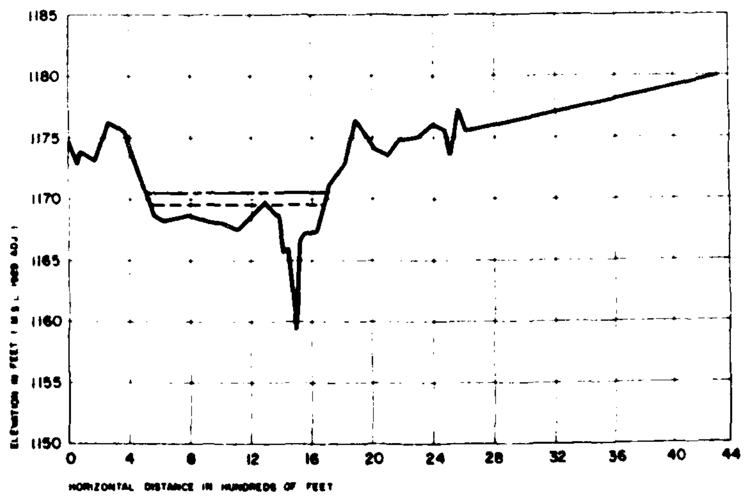


FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA

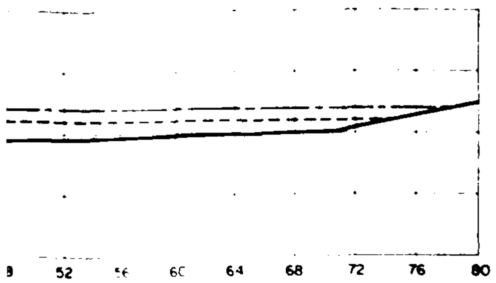
D_2 AND TAILWATER RATING CURVES EXISTING DROP STRUCTURE AND DIVERSION STRUCTURE

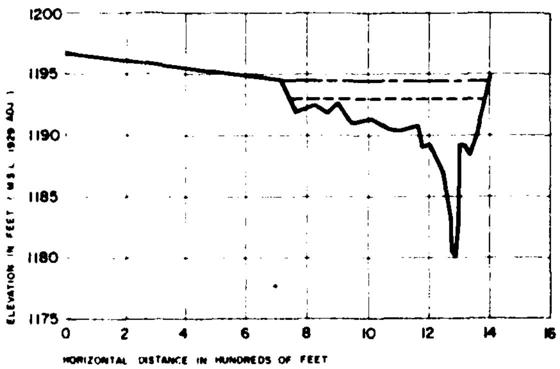


TYPICAL CROSS SECTION DOWNSTREAM OF MARSHALL
CROSS SECTION NO 27
MILE 65.0

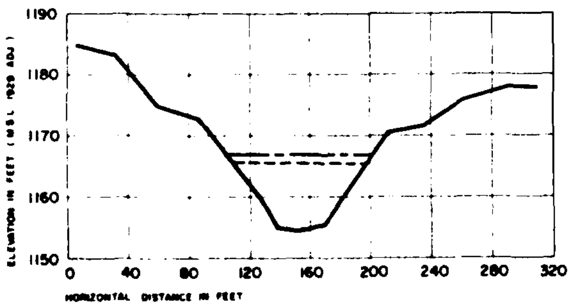


TYPICAL CROSS SECTION IN MARSHALL
CROSS SECTION NO. 66
MILE 69.1





TYPICAL CROSS SECTION UPSTREAM OF MARSHALL
CROSS SECTION NO 85
MILE 72.3



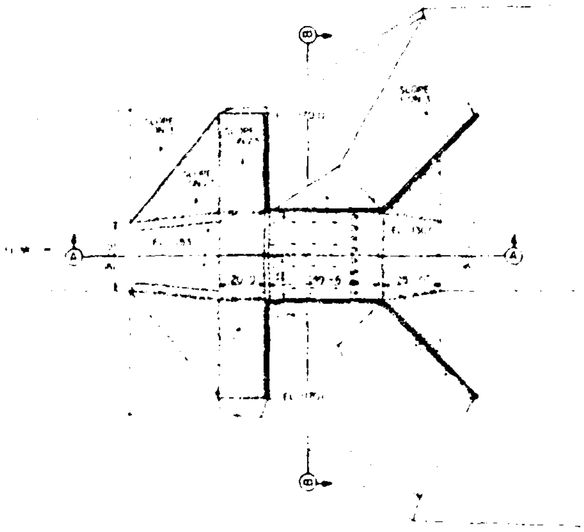
TYPICAL CROSS SECTION DIVERSION CHANNEL
CROSS SECTION NO 623
MILE 68.4

LEGEND

—·— STANDARD PROJECT FLOOD
----- INTERMEDIATE REGIONAL FLOOD
SECTIONS SHOWN LOOKING DOWNSTREAM

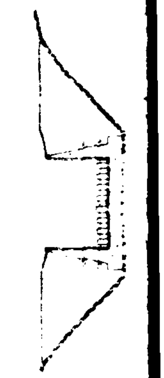
SAFETY PAYS

FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA
TYPICAL CROSS SECTIONS

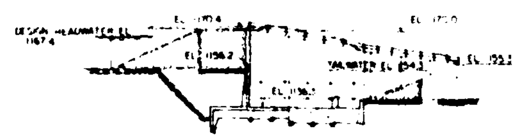


PLAN
DROP STRUCTURE

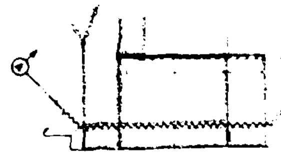
SCALE IN FEET



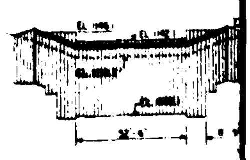
SECTION B-B



SECTION A-A

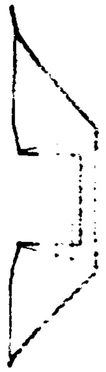


ENLARGED PLAN - DROP STR
AT CHANNEL CONFLUENC

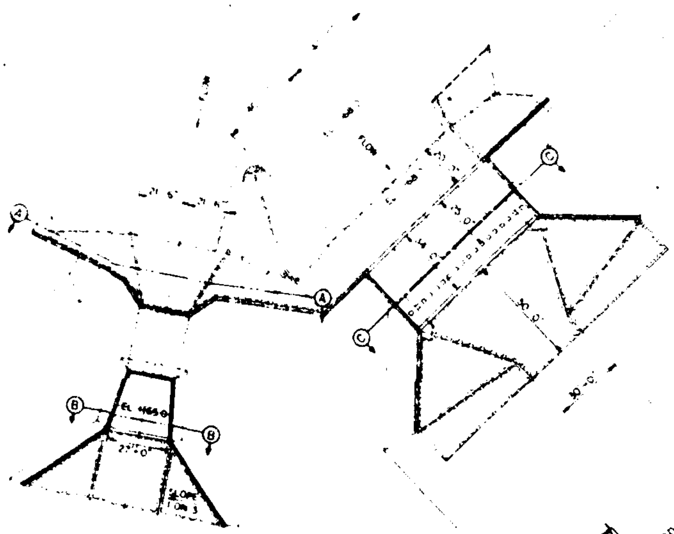


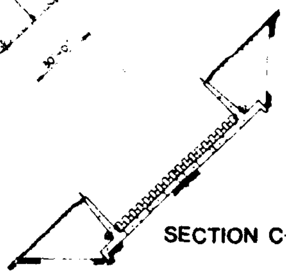
SECTION A-A

SECTION A-A



SECTION B-B



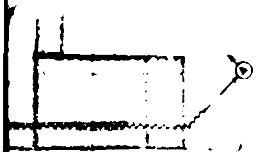


SECTION C-C

PLAN
DIVERSION STRUCTURE

SCALE IN FEET

SECTION B-B



PLAN - DROP STRUCTURE
ANNEL CONFLUENCE

SECTION A-A

FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA

STRUCTURE SKETCHES

SL-21 (73-A)

Job No. 21791

Boring No. ______ Sample No. ______ Depth ______

Classification (ASTM:D2487) ______

Description ______

SOIL EXPLORATION COMPANY

662 CROMWELL AVENUE
ST PAUL MN 55114
PHONE 612 645 6446

Project REDWOOD RIVER - MARSHALL, MN

Reported To Wehrman, Chapman Associates, Inc

GRAIN SIZE DISTRIBUTION CURVE

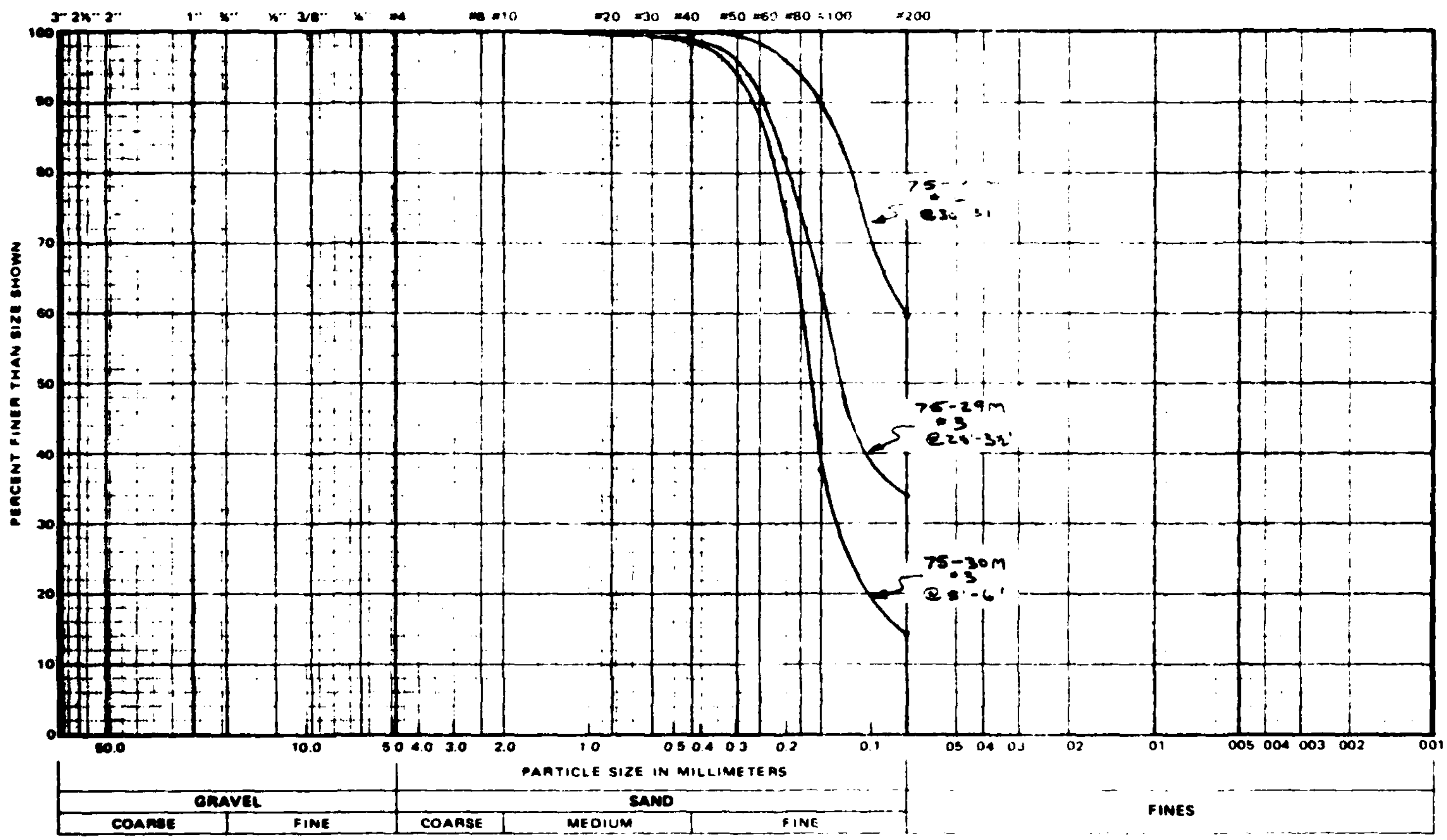


PLATE H-20

SL-21 (73-A)

Job No. 21791

Boring No. ______ Sample No. ______ Depth: ________

Classification (ASTM:D2487) ____________

Description ____________

SOIL EXPLORATION COMPANY
662 CROMWELL AVENUE
ST PAUL, MN 55114
PHONE 612/645 6446

Project REDWOOD RIVER - MARSHALL, MN

Reported To Wehrman, Chapman Associates, Inc

GRAIN SIZE DISTRIBUTION CURVE

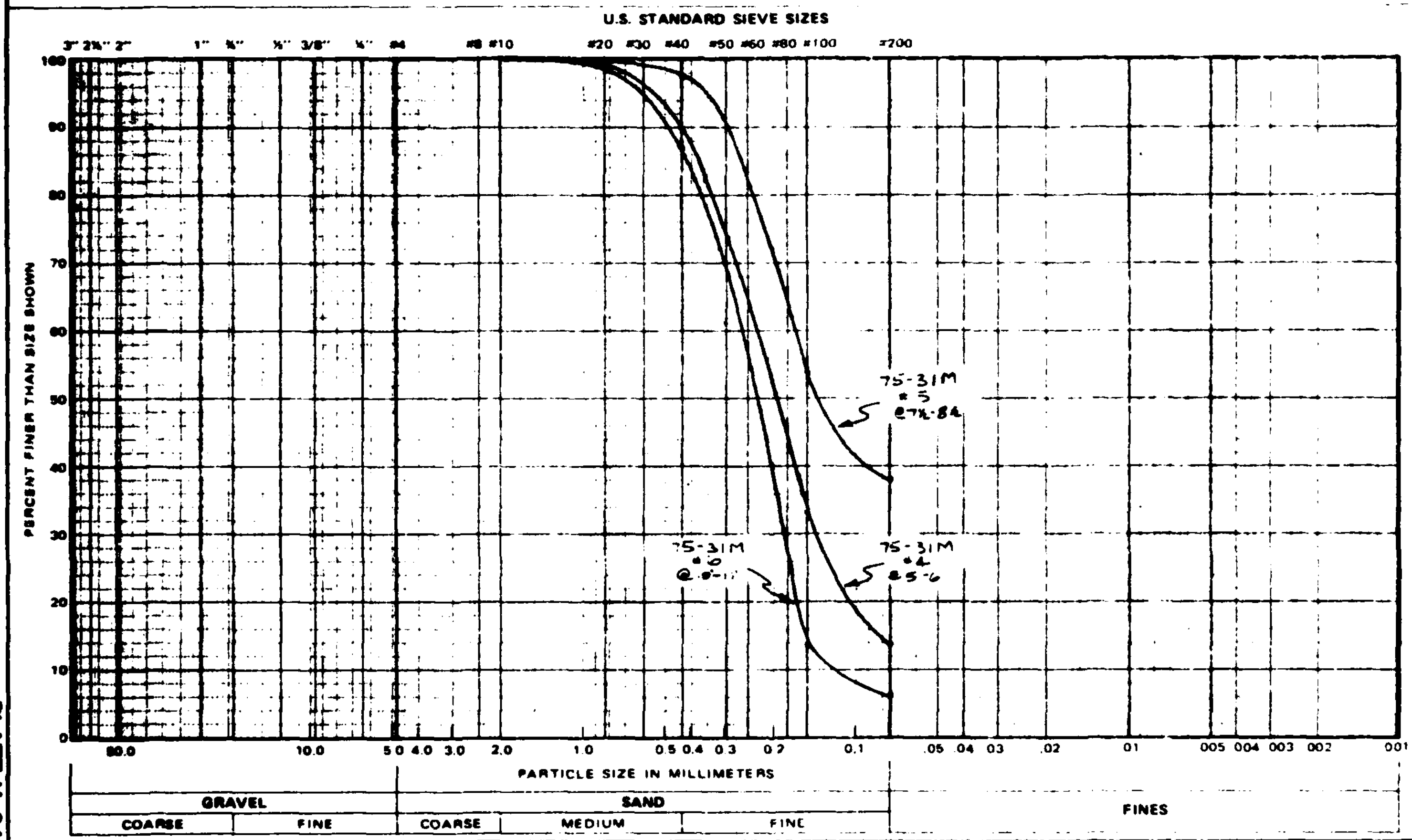


PLATE H-21

SL-21 (73-A)

Job No. 21791

Boring No. ______ Sample No. ______ Depth: ______

Classification (ASTM:D2487) ______

Description ______

SOIL EXPLORATION COMPANY
662 CROMWELL AVENUE
ST. PAUL, MN 55114
PHONE 612/645 6446

Project: REDWOOD RIVER - MARSHALL, MN

Reported To: Wehrman, Chapman Associates, Inc.

GRAIN SIZE DISTRIBUTION CURVE

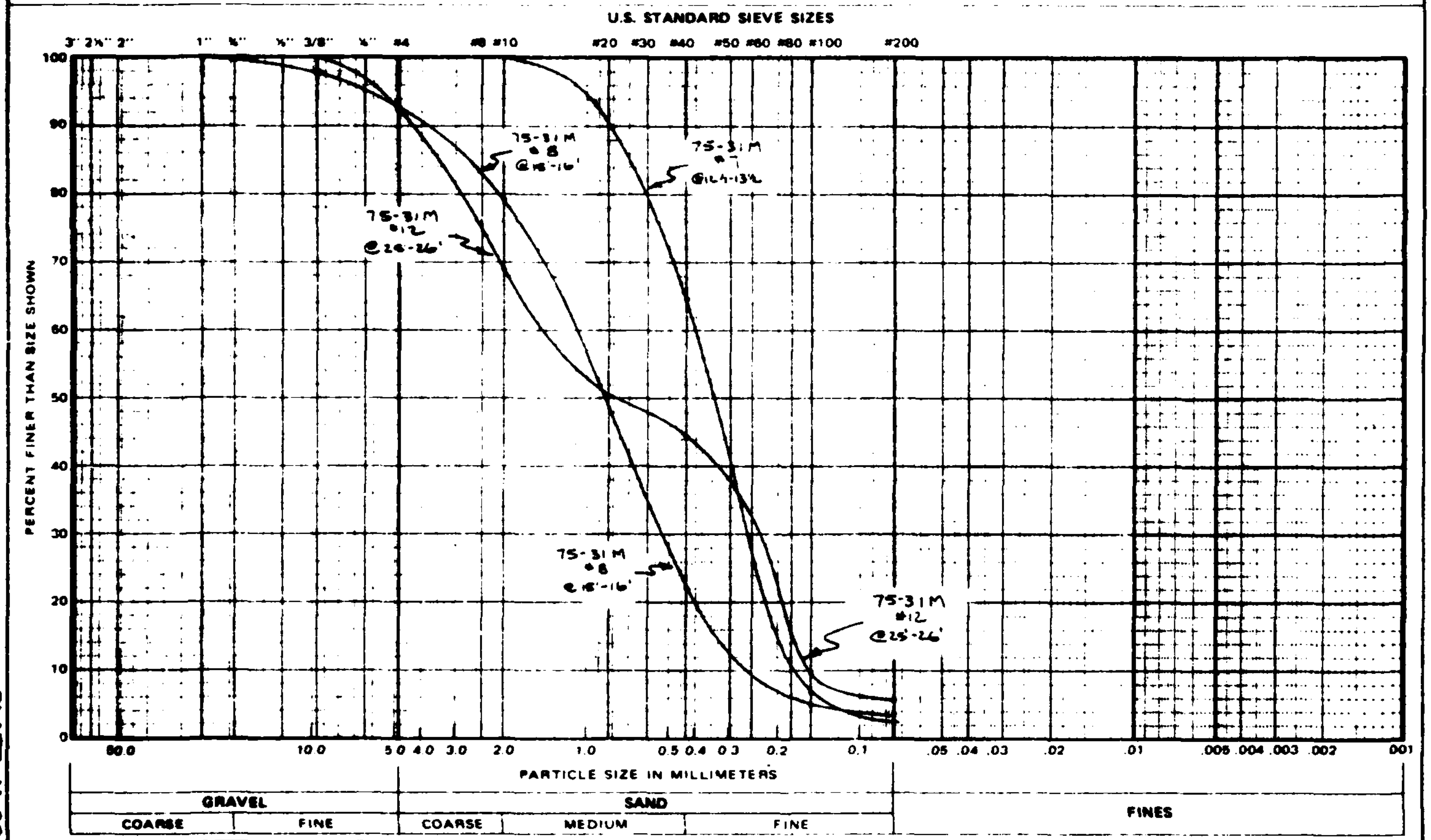


PLATE H-22

SL-21 (72-A)

Job No. 21791

Boring No. ______ Sample No. ______ Depth ______

Classification (ASTM:D2487) ______

Description ______

SOIL EXPLORATION COMPANY

662 CROMWELL AVENUE
ST PAUL, MN 55114
PHONE 612/645 6446

Project REDWOOD RIVER - MARSHALL, MN

Reported To Nehrman, Chapman Associates, Inc.

GRAIN SIZE DISTRIBUTION CURVE

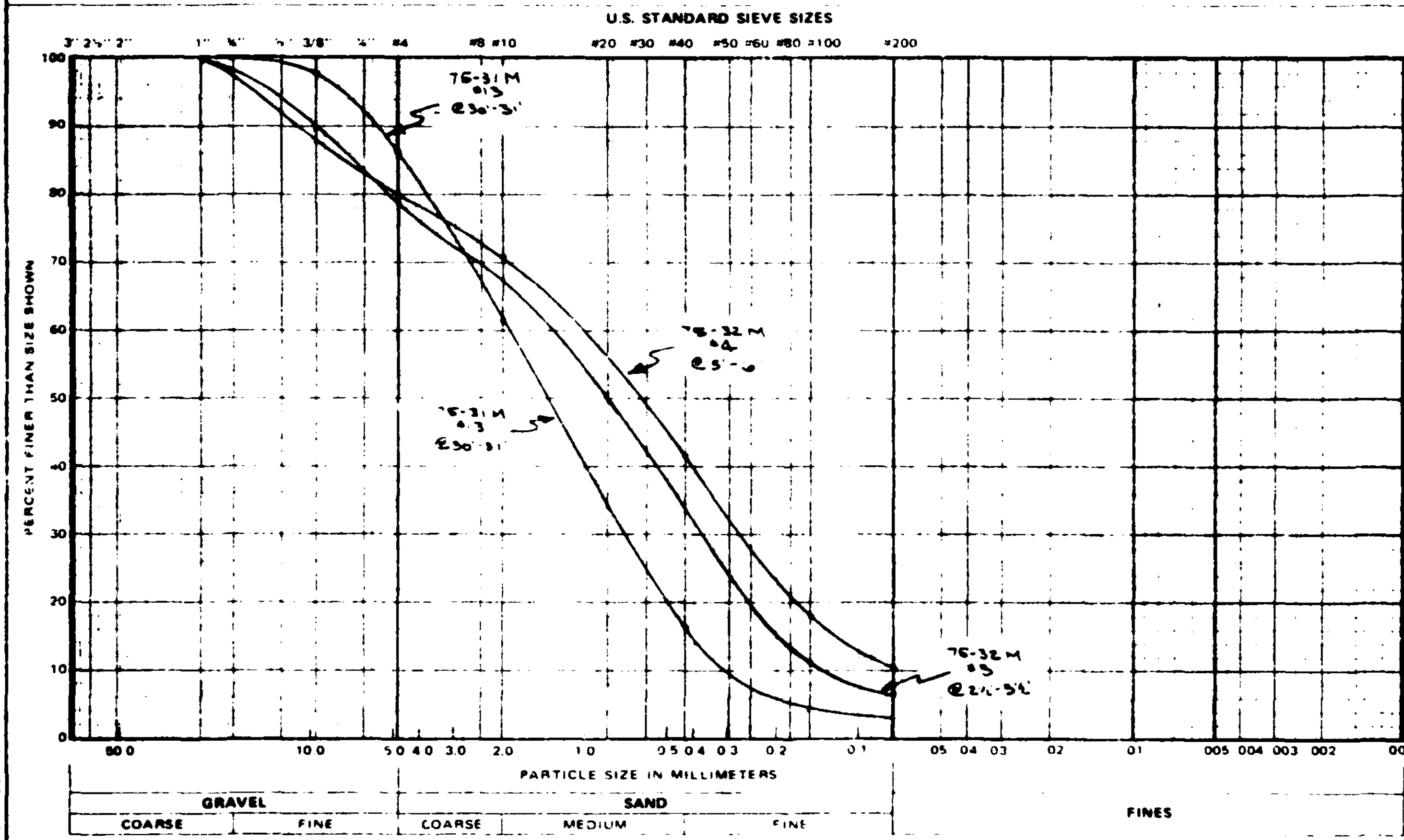


PLATE H-23

SL-31 (73-A)

SOIL EXPLORATION COMPANY

662 CROMWELL AVENUE
ST PAUL MN 55114
PHONE 612/645 6446

Job No. 21791

Boring No. ______ Sample No. ______ Depth ______

Classification (ASTM:D2487) ______

Description ______

Project REDWOOD RIVER - MARSHALL, MN

Reported To Wehrman, Chapman Associates, Inc

GRAIN SIZE DISTRIBUTION CURVE

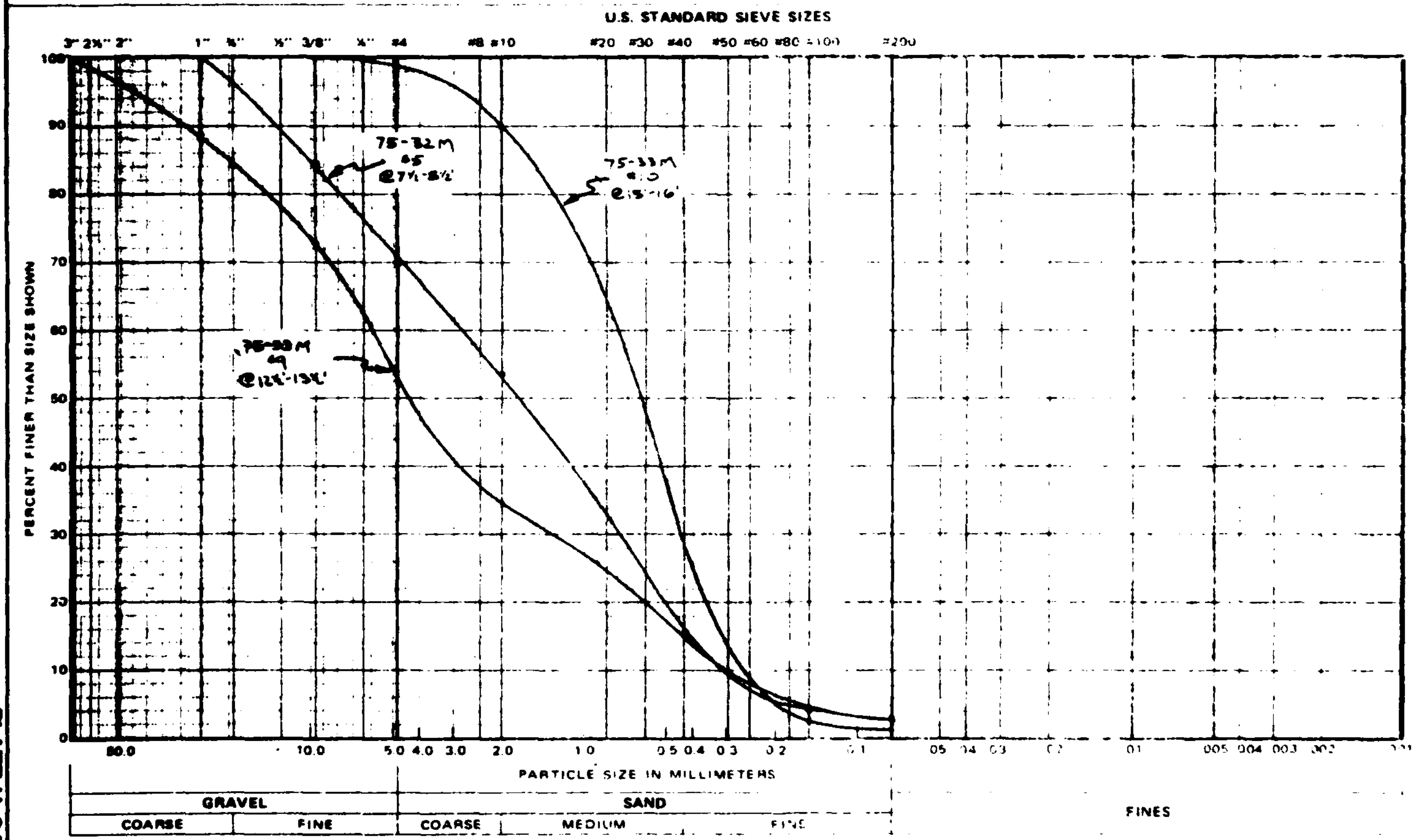


PLATE H-24

SL-21 (72-A)

Job No. 21791

Boring No. ______ Sample No. ______ Depth ______

Classification (ASTM D2487) ______

Description ______

SOIL EXPLORATION COMPANY

662 CROMWELL AVENUE
ST PAUL MN 55114
PHONE 612/645 6446

Project REDWOOD RIVER - MARSHALL, MN

Reported To Wehrman, Chapman Associates, Inc.

GRAIN SIZE DISTRIBUTION CURVE

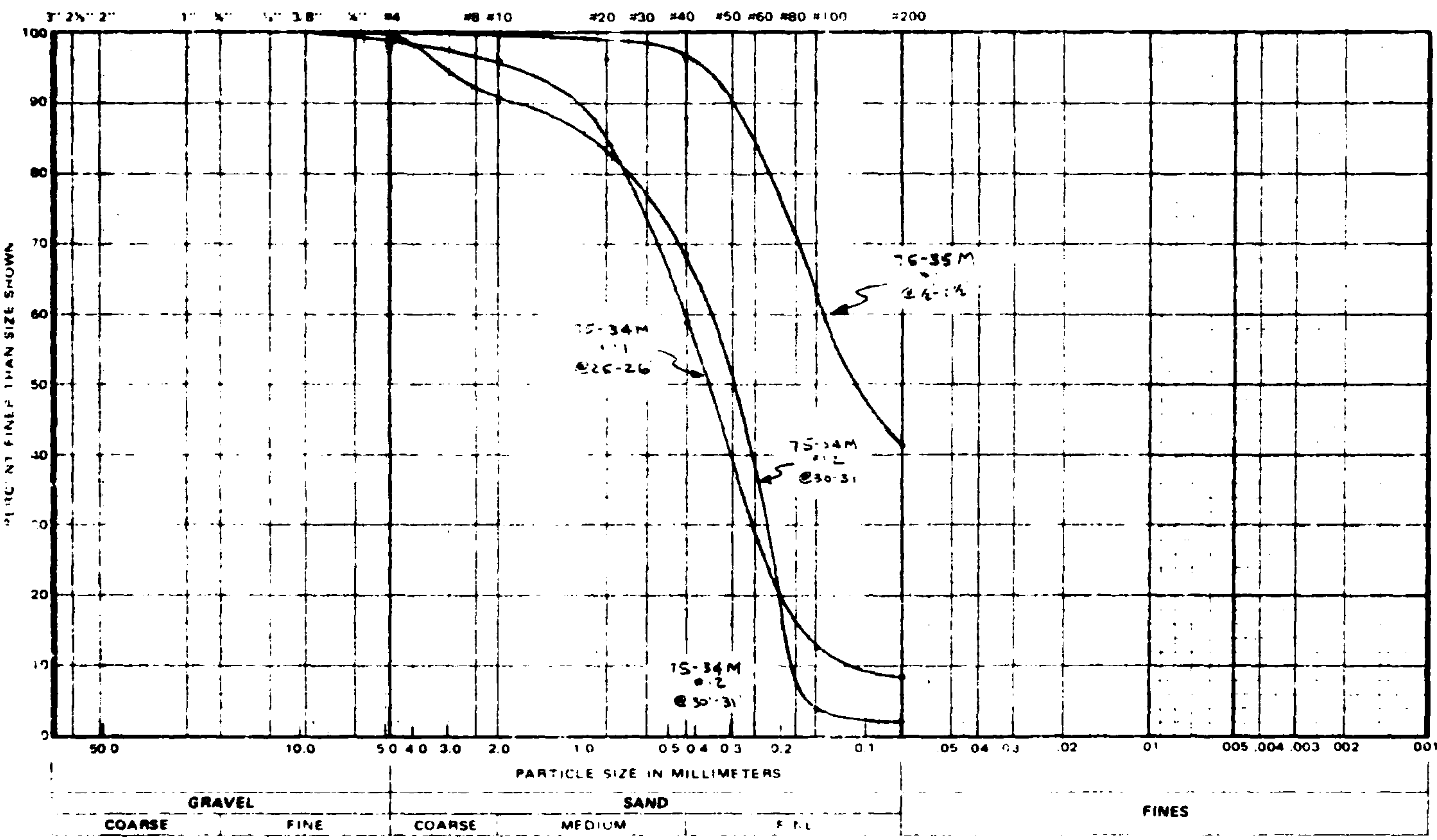


PLATE H-26

SL-21 (73-A)

Job No. 21791

Boring No. ______ Sample No. ______ Depth ______

Classification (ASTM:D2487) ______

Description ______

SOIL EXPLORATION COMPANY

662 CROMWELL AVENUE
ST PAUL MN 55114
PHONE 612 645 6446

Project REDWOOD RIVER - MARSHALL, MN

Reported To Wehrman, Chapman Associates, Inc

GRAIN SIZE DISTRIBUTION CURVE

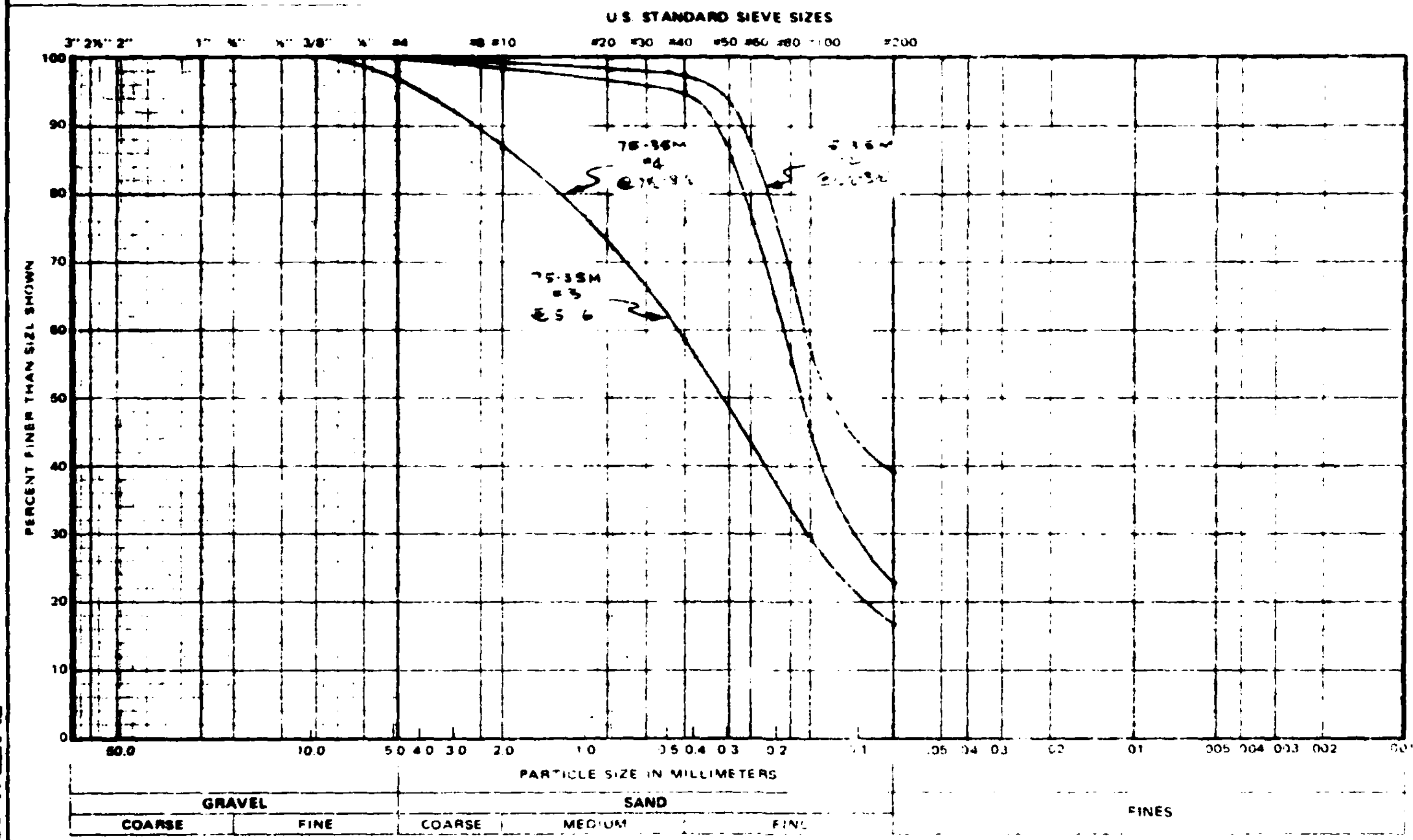


PLATE H-26

SL-21 (72-A)

Job No. 21791

Boring No. ______ Sample No. ______ Depth ______

Classification (ASTM D2487) ______

Description ______

SOIL EXPLORATION COMPANY
662 CROMWELL AVENUE
ST PAUL MN 55114
PHONE 612/645 6446

Project REDWOOD RIVER - MARSHALL, MN

Reported To Wehrman, Chapman Associates, Inc.

GRAIN SIZE DISTRIBUTION CURVE

U.S. STANDARD SIEVE SIZES

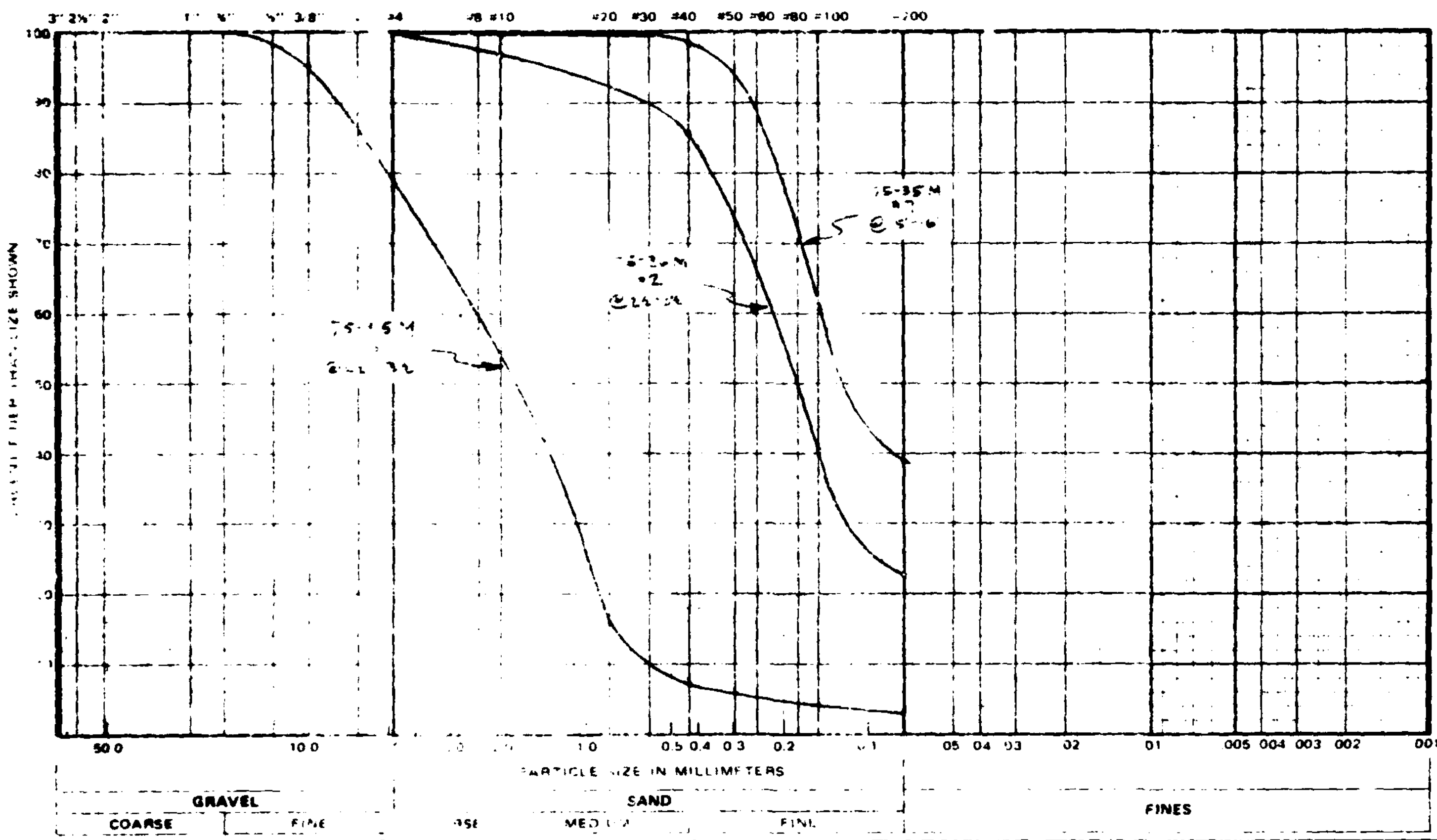


PLATE H-27

SL-21 (73-A)

Job No. 21791

Boring No. ______ Sample No. ______ Depth ______

Classification (ASTM D2487) ______

Description ______

SOIL EXPLORATION COMPANY
662 CROMWELL AVENUE
ST PAUL MN 55114
PHONE 612/645 6446

Project REDWOOD RIVER - MARSHALL, MN

Reported To Wehrman, Chapman Associates, Inc

GRAIN SIZE DISTRIBUTION CURVE

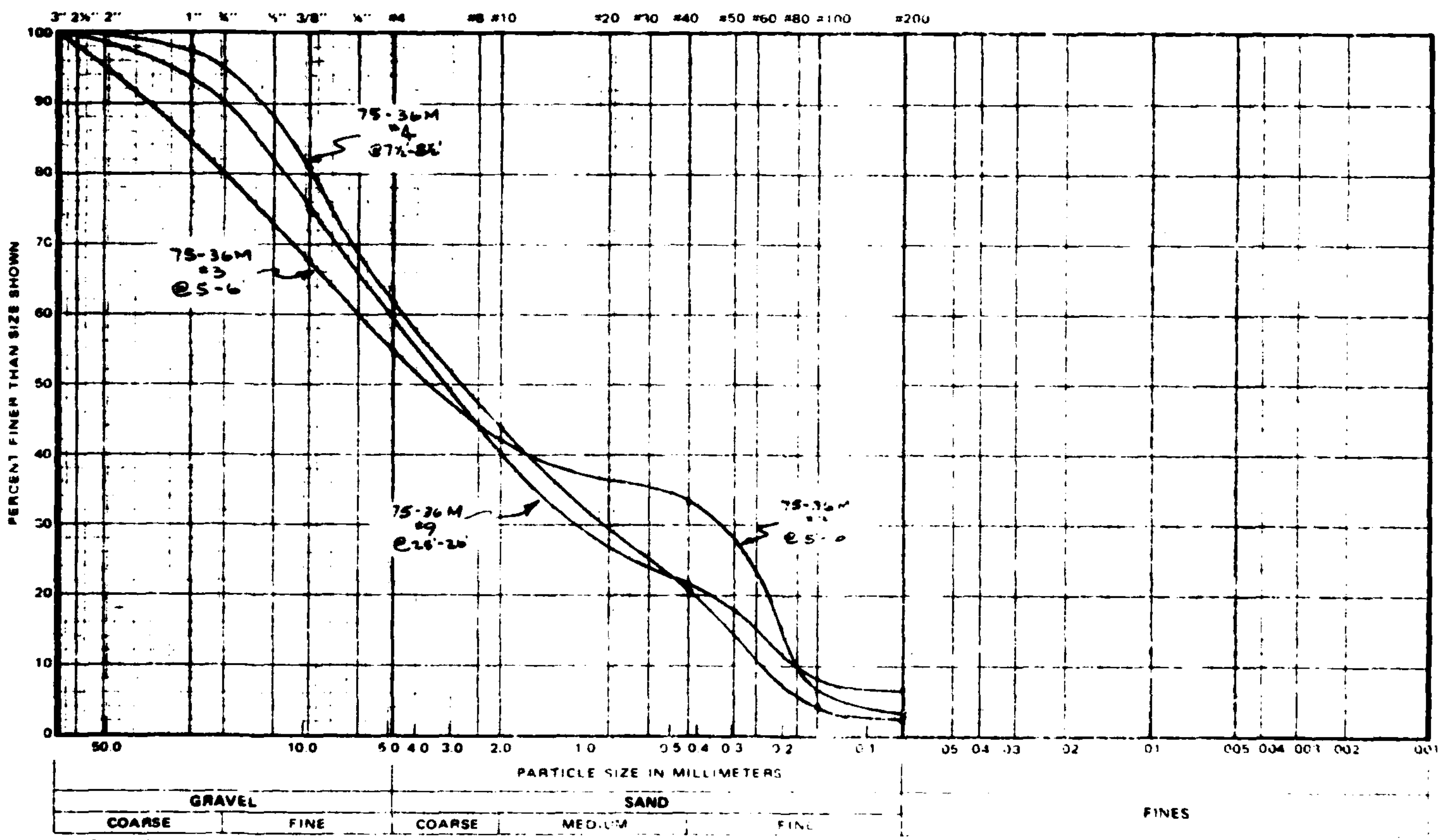


PLATE H-28

SL-21 (73-A)

SOIL EXPLORATION COMPANY

662 CROMWELL AVENUE
ST PAUL MN 55114
PHONE 612 645 6446

Job No. 21791

Boring No. ______ Sample No. ______ Depth. ______

Classification (ASTM:D2487) ______

Description ______

Project: REDWOOD RIVER MARSHALL, MN

Reported To: Wehrman, Chapman Associates, Inc

GRAIN SIZE DISTRIBUTION CURVE

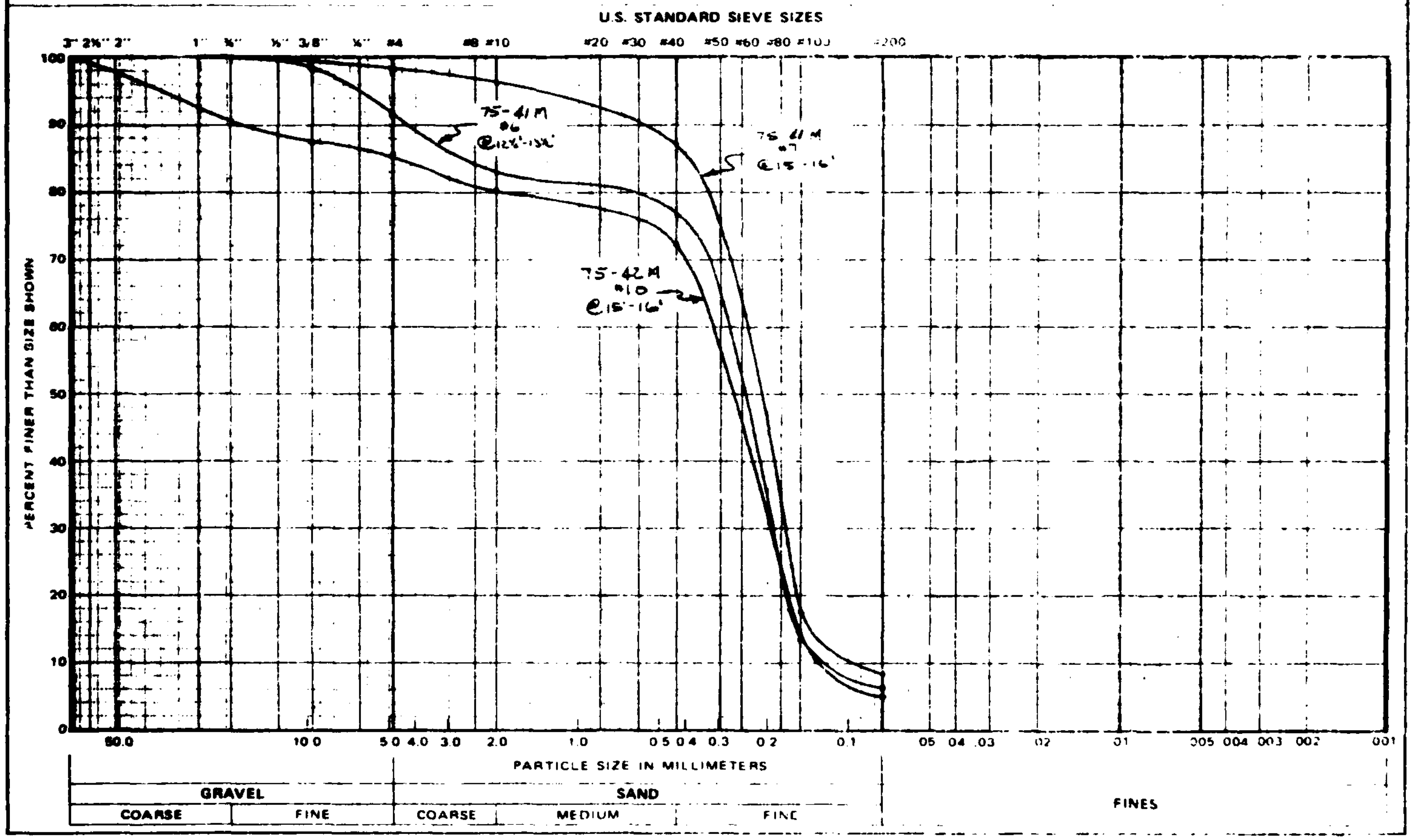


PLATE H-29

SL-21 (73-A)

Job No. 21791

Boring No ____ Sample No ____ Depth

Classification (ASTM D2487) ____

Description ____

SOIL EXPLORATION COMPANY

662 CROMWELL AVENUE
ST PAUL MN 55114
PHONE 612/645 6446

Project REDWOOD RIVER - MARSHALL MN

Reported To Weirman, Chapman Associates, Inc.

GRAIN SIZE DISTRIBUTION CURVE

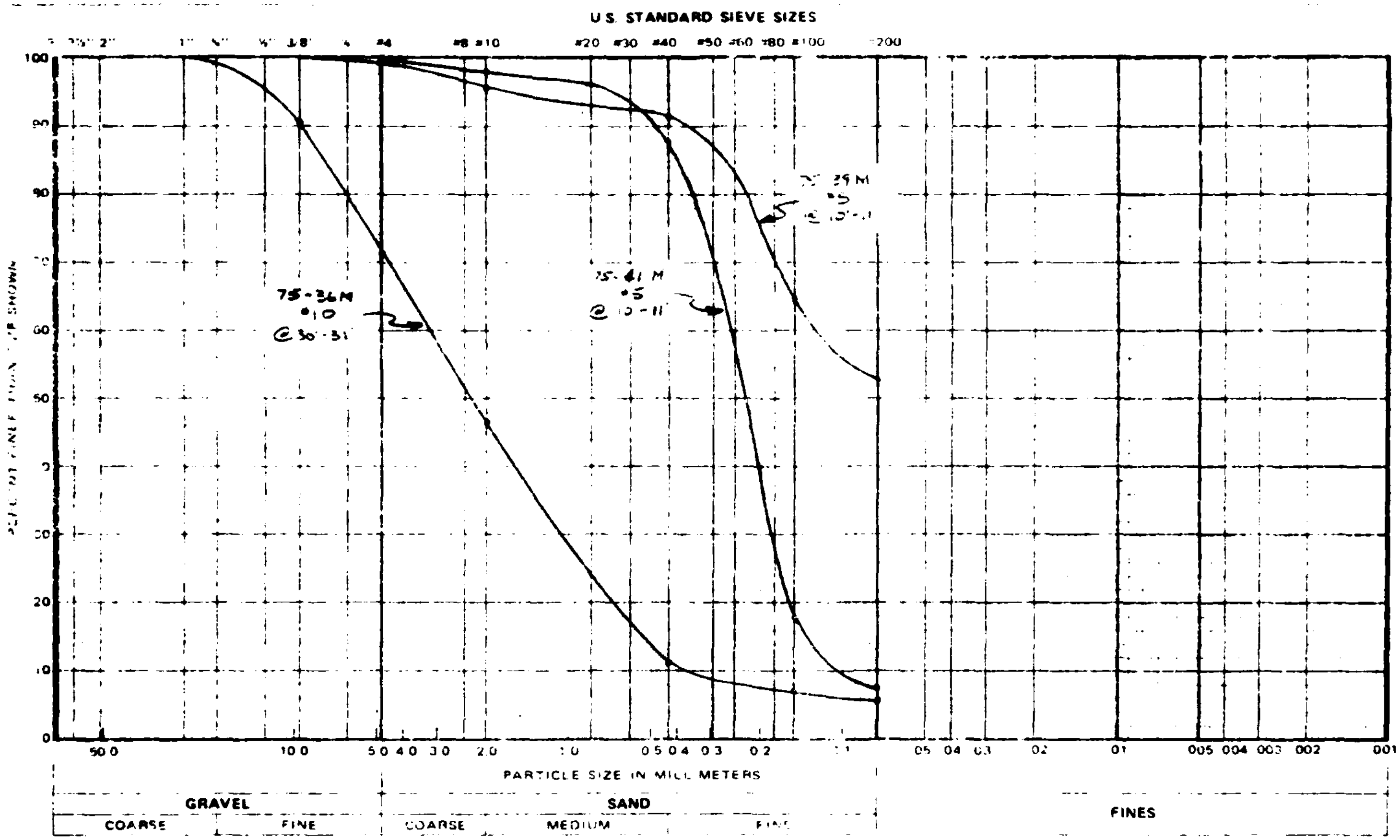


PLATE H-30

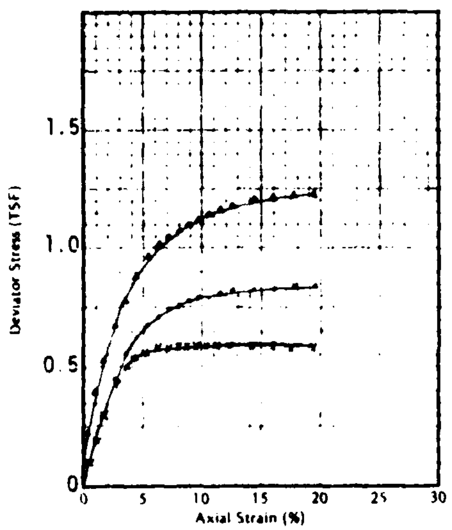
TRIAXIAL TEST DATA Date October 17, 1975 Job No. 21791

Project REDWOOD RIVER - MARSHALL, MINNESOTA

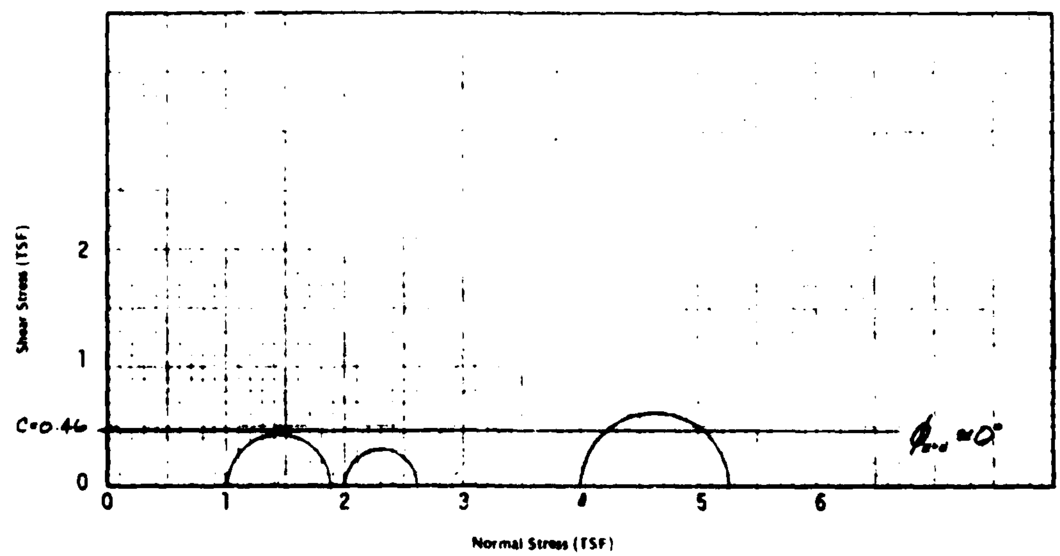
Boring No. 75-31M Sample No. 10 Depth (ft) 21-23 Type of Sample 3T

Soil Type Silty Clay (CL) Type of Test Unconsolidated - Undrained

Remarks: Samples trimmed to given lengths, both ends plugged, stressed to 20% strain at constant rate of 0.060"/min.



	SPECIMEN NO.	1	2	3	
Initial	Diameter (inches)	2 13/16	2 13/16	2 13/16	
	Height (inches)	5 5/8	5 5/8	5 5/8	
	Moisture Content (%)		23.3		
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
Before Shear	Moisture Content (%)				
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
	Back Pressure (TSF)	0	0	0	
Minor Principal Stress TSF		1.0	2.0	4.0	
Maximum Deviator Stress TSF		0.84	0.59	1.23	
Ultimate Deviator Stress TSF					
LL 29 7 / PL 13.8	PI 15.9 / Gs				



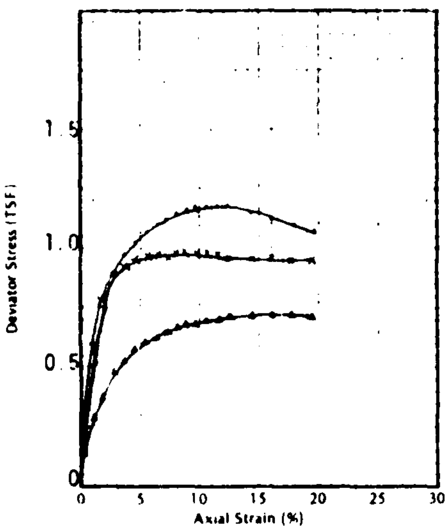
TRIAXIAL TEST DATA Date October 17, 1975 Job No. 21791

Project REDWOOD RIVER - MARSHALL, MINNESOTA

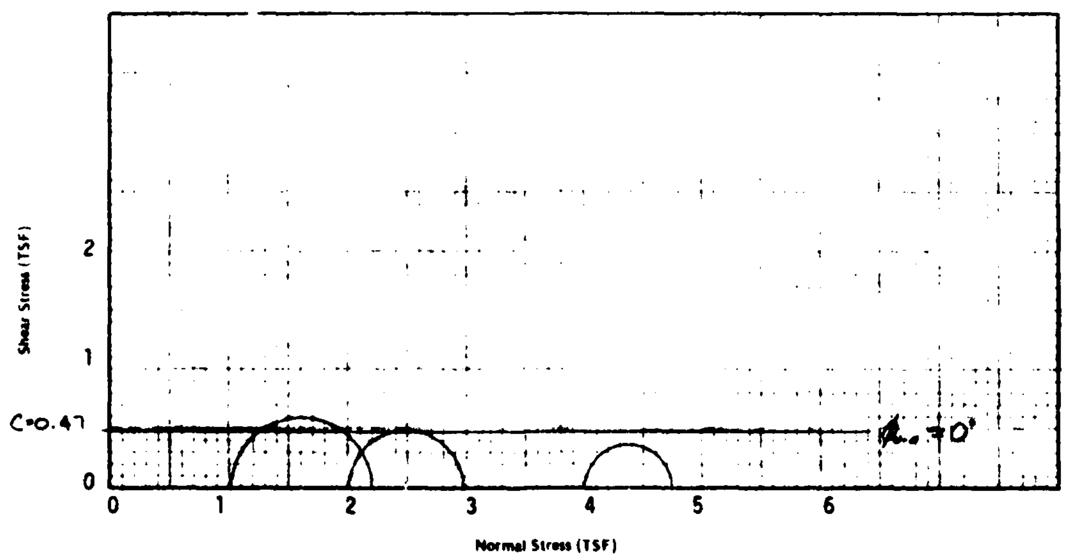
Boring No. 75-32M Sample No. 11 Depth (ft) 26-28 Type of Sample 3T

Soil Type Fat Clay (CH) Type of Test Unconsolidated - Undrained

Remarks: Samples trimmed to given lengths, both ends plugged, stressed to 20% strain at constant rate of 0.060"/min



SPECIMEN NO.		1	2	3	
Initial	Diameter (inches)	2 13/16	2 13/16	2 13/16	
	Height (inches)	5 5/8	5 5/8	5 5/8	
	Moisture Content (%)		40.9		
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
Before Shear	Moisture Content (%)				
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
	Back Pressure (TSF)	0	0	0	
Minor Principal Stress TSF		1.0	2.0	4.0	
Maximum Deviator Stress TSF		1.17	0.98	0.72	
Ultimate Deviator Stress TSF					
LL 59.5	PI 33.6				
PL 25.9	G_s				



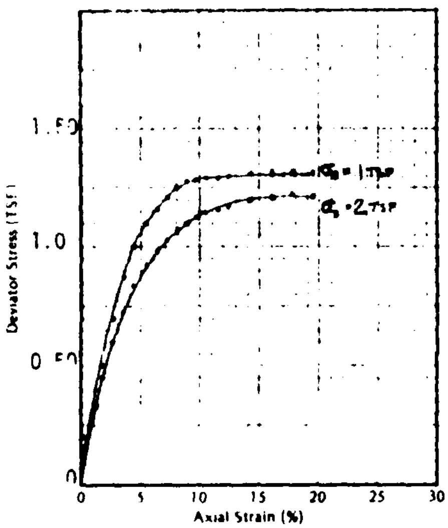
TRIAXIAL TEST DATA Date October 17, 1975 Job No. 21791

Project REDWOOD RIVER - MARSHALL, MINNESOTA

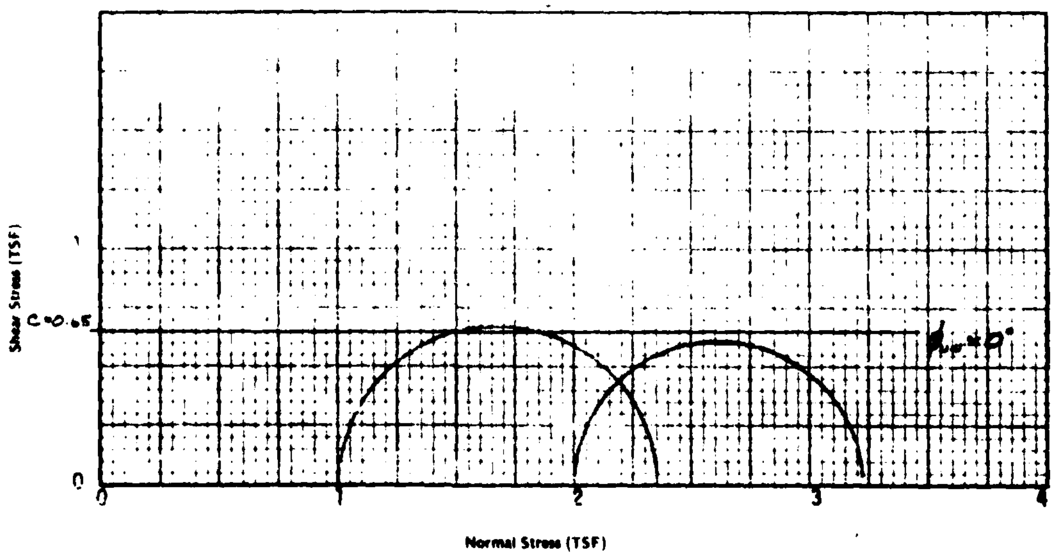
Boring No. 75-3SM Sample No. 9 Depth (ft) 18-19 1/2 Type of Sample 3T

Soil Type Sandy Clay (CL) Type of Test Unconsolidated - Undrained

Remarks: Samples trimmed to given lengths, both ends plugged, stressed to 20% strain at constant rate of 0.060"/min.



	SPECIMEN NO.	1	2		
Initial	Diameter (inches)	2 13/16	2 13/16		
	Height (inches)	5 5/8	5 5/8		
	Moisture Content (%)	23.5			
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
Before Shear	Moisture Content (%)				
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
	Back Pressure (TSF)	0	0		
Minor Principal Stress TSF		1.0	2.0		
Maximum Deviator Stress TSF		1.32	1.22		
Ultimate Deviator Stress TSF					
LL 38.7	PI 23.0				
PL 15.7	Gs				



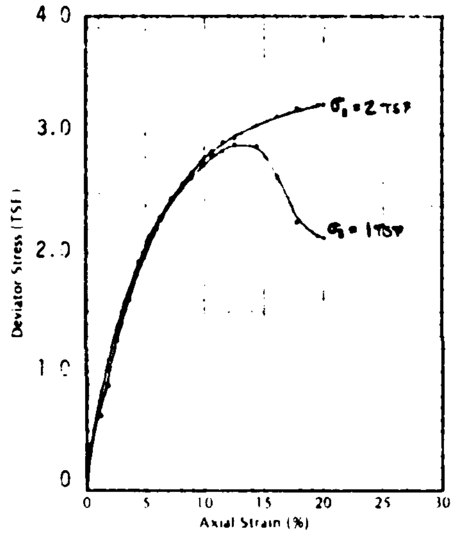
TRIAXIAL TEST DATA Date October 17, 1975 Job No. 21791

Project REDWOOD RIVER - MARSHALL, MINNESOTA

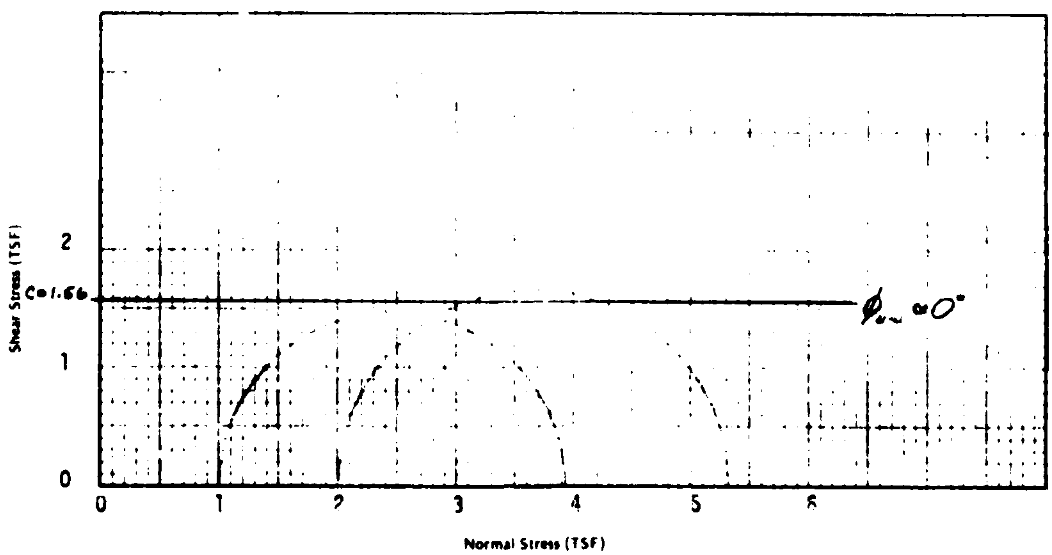
Boring No. 75-39M Sample No. 8 Depth (ft) 15'-18 Type of Sample 3T

Soil Type Sandy Clay (CL) Type of Test Unconsolidated - Undrained

Remarks: Samples trimmed to given length, both ends plugged, stressed to 20% of strain at constant rate of 0.060"/min



	SPECIMEN NO.	1	2		
Initial	Diameter (inches)	2 13/16	2 13/16		
	Height (inches)	5 5/8	5 5/8		
	Moisture Content (%)		16.8		
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
Before Shear	Moisture Content (%)				
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
	Back Pressure (TSF)	0	0		
Minor Principal Stress TSF		1.0	2.0		
Maximum Deviator Stress TSF		2.91	3.25		
Ultimate Deviator Stress TSF					
LL 27.9	PI 12.4				
PL 15.5	Gs				



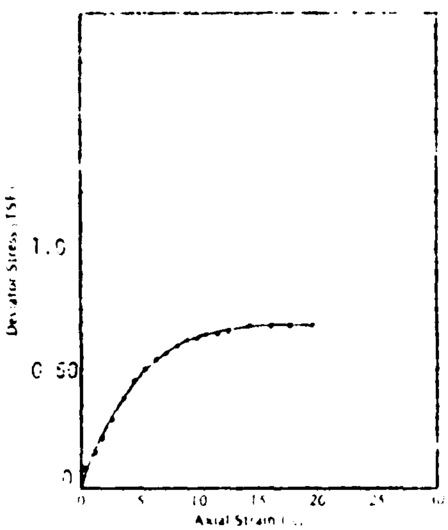
TRIAXIAL TEST DATA Date October 17, 1975 Job No. 21791

Project REDWOOD RIVER - MARSHALL, MINNESOTA

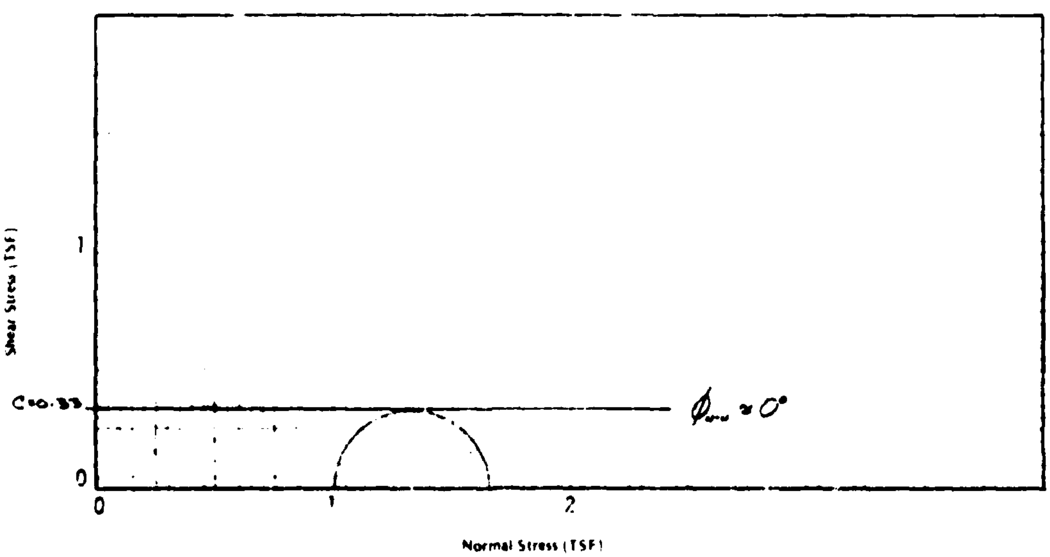
Boring No. 75-40M Sample No. 4 [illegible] Type of Sample 3T

Soil Type Sandy Clay (CL) Type of Test Unconsolidated-Undrained

Remarks: Sample trimmed to given length, both ends [illegible], stressed to 20% of strain at constant rate [illegible]



[illegible]		1			
[illegible]	[illegible]	2 13/16			
	Height (inches)	5 5/8			
	[illegible]	22.6			
	[illegible]				
	[illegible]				
	Void Ratio				
Before [illegible]	Moisture Content				
	Dry Density PCF				
	Saturation %				
	Void Ratio				
	Back Pressure (TSF)	0			
Minor Principal Stress TSF		1.0			
Maximum Deviator Stress TSF		0.68			
Ultimate Deviator Stress TSF					
LL 28.7	PL 11.7				
PI 17.0	[illegible]				



SOIL EXPLORATION COMPANY NO. SL-27 (76-A)

PLATE H-35

SOIL EXPLORATION COMPANY

JOB NO 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO 75-29M

PROJECT REDWOOD RIVER - MARSHALL, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	SILTY CLAY, dark brownish gray, rather stiff (CL)	TOPSOIL	13		1	SS				
1	CLAYEY SILT, brownish gray, rather stiff, a few lenses of sandy silt **	FINE ALLUVIUM			2	SS				
2½	SILTY SAND, fine grained, brown, moist, loose, a few lenses of sandy silt (SM)	COARSE ALLUVIUM	8		3	SS				M.A.*
4½	SANDY CLAY, a little gravel, brown mottled, medium to rather stiff, a few lenses of sand above 5½' (CL)	TILL	6		4	SS	17		36/18	
			6	▼	5	SS	18		31/16	
			7		6	SS				
			15		7	SS				
			11		8	SS				
19½	SANDY CLAY, a little gravel, gray, rather stiff (CL)		12		9	SS				
					10	3T				
					11	3T				
			9		--	---				
29	FAT CLAY, gray, rather stiff, a boulder at 30.1' (CH)	See Note	25/0.1		12	SS				
30.1	Obstruction Note: FINE ALLUVIUM or SHALE ** (ML-CL)									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-4	12:05	30.1'	29½'	30'	to	None
9-4	12:25	30.1'	None	16'	to	None
9-6	7:40	30.1'	None	12'	to	9'
					to	

START 9-4-75 COMPLETE 9-4-75

METHOD 3¼ HSA 0' - 29½' @ 12:05

CREW CHIEF Hagedorn

SE-2 (70-A)

PLATE H-36

SOIL EXPLORATION COMPANY

JOB NO 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO 75-30M

PROJECT REDWOOD RIVER - MARSHALL, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	LAB W	LAB D	LAB LL/PL	LAB Qu
	CLAYEY SILT, dark brownish gray, rather stiff (ML-CL)	TOPSOIL	9		1	SS				
2	CLAYEY SILT, dark brown, medium (ML-CL)	FINE ALLUVIUM	8		2	SS				
4	SAND, fine grained, light brown, moist, medium dense, lenses of silty sand (SP-SM)	COARSE ALLUVIUM	9		3	SS				M.A.*
7	SILTY CLAY, gray and brown, medium, a few lenses of silty sand (CL)	FINE ALLUVIUM	8		4	SS				
8½	LEAN CLAY, black, medium (CL)				5	3T				
					6	3T*				
			7		7	SS				
11½	SILTY CLAY, brown mottled, medium, some lenses of silty sand and silt (CL)		6		8	SS	27		35/19	
14	SILTY CLAY, gray and brownish gray mottled, medium to soft, a few lenses of silty sand (CL)		5		9	SS				
			4		10	SS				
					11	3T				
24					12	3T				
	SILTY CLAY, brownish gray, soft, a few lenses of silty sand, a few lenses of peat below 26' (MH-CL)		4		13	SS	37		54/33	
29	SANDY SILT, gray, wet, loose, a few lenses of silty sand and waterbearing sand (ML-SM)	COARSE ALLUVIUM	6	▼	14	SS				M.A.*
32	End of Boring									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-5	8:45	32'	29½'		to	28'
9-5	9:05	32'	None	18½'	to	None
9-6	9:45	32'	None	9'	to	None
					to	

START 9-5-75 COMPLETE 9-5-75

METHOD 3¼ HSA 0' - 29½' @ 8:45

CREW CHIEF Hagedorn

SE-2 (70-A)

PLATE H-37

SOIL EXPLORATION COMPANY

JOB NO 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO 75-31M

PROJECT REDWOOD RIVER - MARSHALL, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
½	FILL, mixture of LEAN CLAY, see Note	FILL			1	SS				
	CLAYEY SILT, dark grayish brown, rather stiff (ML-CL)	TOPSOIL	12		2	SS				
2	CLAYEY SILT, dark brown, medium (ML-CL)	FINE ALLUVIUM	7		3	SS	6		24/19	
4	SAND, fine grained, light brown, moist, loose, a few lenses of silty sand (SP-SM)	COARSE ALLUVIUM	[illegible]		4	SS				M*A.
[illegible]	SILTY SAND, fine grained, grayish brown and brown, moist, very loose, a few lenses of silt (SM)		4		5	SS				M*A.
9½	SAND, fine grained, brown, moist, loose, a few lenses of silty sand (SP)		8		6	SS				M*A.
12	SAND, fine grained, light brown, moist, loose (SP)		7		7	SS				M*A.
14½	SAND, medium grained, a little gravel light brown, moist, dense, a few lenses of lean clay (SP)		16		8	SS				M*A.
17½	LEAN CLAY, dark gray to gray, rather stiff (CL)	FINE ALLUVIUM	9		9	SS	28		49/20	
21	SILTY CLAY, light grayish brown mottled, medium, a lenses of silty sand below 22' (CL)				10	3T	23		30/14	
23½	SAND, medium grained a little gravel, gray, waterbearing, medium dense (SP)	COARSE ALLUVIUM			11	3T				
			12		12	SS				M*A.
	Note: and SILTY CLAY, a little gravel, dark brownish gray and brown									
31			9		13	SS				M*A.
	End of Boring									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-5	10:15	26'	23'		to	20½'
9-5	10:45	31'	29½'		to	23'
9-5	11:05	31'	None	14'	to	None
					to	

START 9-5-75 COMPLETE 9-5-75

METHOD 3¼ HSA 0' - 29½' @ 10:45

CREW CHIEF Hagedorn

SE-2 (70-A)

PLATE H-38

SOIL EXPLORATION COMPANY

JOB NO. 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO. 75-32M

PROJECT REDWOOD RIVER - MARSHALL, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	CLAYEY SILT, dark brownish gray, soft (ML-CL)	TOPSOIL	5		1	SS				
1	CLAYEY SILT, dark brown, medium (ML-CL)	See Note:			2	SS				
2	SAND, medium to fine grained, a little gravel, brown, moist, loose to medium dense, some lenses of silty sand and silty clay (SP-SM)	COARSE ALLUVIUM	6		3	SS				M.A.*
			14		4	SS				M.A.*
6	SAND, medium grained, a little gravel, light brown, moist, dense (SP)		17		5					M.A.*
9½	LEAN CLAY, a trace of gravel, dark gray, soft (CL)	MIXED ALLUVIUM	3		6	SS				
11½	SILTY SAND, medium grained, a little gravel, brown, moist to wet, loose, a few lenses of silty clay and moist to waterbearing sand (SM)	COARSE ALLUVIUM	8	▼	7	SS				
14½	ORGANIC SILTY CLAY, dark gray, soft with some lenses of brownish gray, muck (OL)	SWAMP DEPOSITS	1½		8	SS				
18	SILTY CLAY, gray, soft (CL)	FINE ALLUVIUM	2		9	SS	34		45/20	
22	FAT CLAY, gray and brown mottled, medium (CH) Note: FINE ALLUVIUM		6		10	SS				
					11	3T	41		60/26	
					12	3T				
29½	SILTY CLAY, dark brownish gray mottled, medium (CL-OL)		5		13	SS				
31	End of Boring									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-5	2:10	16½'	14½'	14½'	to	13'
9-5	4:10	31'	28'		to	25'
9-5	4:35	31'	None	9'	to	None
					to	

START 9-5-75 COMPLETE 9-5-75

METHOD 3¼ HSA 0' - 28' @ 2:55

CREW CHIEF Hagedorn

SE-2 (70-A)

PLATE H-39

SOIL EXPLORATION COMPANY

JOB NO 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO 75-33M

PROJECT REDWOOD RIVER- MARSHALL, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
1	SILTY CLAY, dark brownish gray medium (CL)	TOPSOIL	6		1	SS				
	CLAYEY SILT, dark gray, medium (ML-CL)	FINE ALLUVIUM			2	SS				
			6		3	SS				
5	SILTY CLAY, brown and gray mottled, soft to medium, a few lenses of sand and silty sand above 7' (CL to MH-CL)		4		4	SS				
			8		5	SS	28		55/30	
					6	3T				
9½	MEDIUM FAT CLAY, brownish gray, medium (CH)				7	3T*				
			8		8	SS				
12	SAND, medium to coarse grained, with gravel, brown, waterbearing, dense (SP)	COARSE ALLUVIUM	19	▼	9	SS				M.A.*
14	SAND, medium grained, a little gravel, brown, waterbearing, very loose (SP)		4		10	SS				M.A.*
19	SILT, light brownish gray, wet, very loose, a few lenses of silty sand and silty clay (ML)	FINE ALLUVIUM	3		11	SS				
22	SILTY CLAY, dark brownish gray, soft (CL)		4		12	SS	35		21	
26	SILTY CLAY, gray, soft, lenses of silt, silty sand, and waterbearing sand (CL)		4		13	SS	21		38/21	
32	End of Boring									

* Thinwall tube sample obtained from adjacent secondary boring

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-5	5:20	13½'	12'	12½'	to	12'
9-5	5:55	32'	29½'		to	22'
9-5	6:15	32'	None	11'	to	None
					to	

START 9-5-75 COMPLETE 9-5-75

METHOD 3¼ HSA 0' - 29½' @ 5:55

CREW CHIEF Hagedorn

SE 2 (70-A)

PLATE H-40

SOIL EXPLORATION COMPANY

JOB NO. 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO. 75-34M

PROJECT REDWOOD RIVER MARSHALL, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	LAB TESTS W	D	LL/PL	Qu
	CLAYEY SILT, dark brownish gray, soft (OL-CL)	TOPSOIL	7	*	1	SS				
2	SILT, brown, moist, loose, some lenses of silty clay and sand (ML)	FINE ALLUVIUM	7		2	SS				
			6		3	SS				
7	SILTY CLAY, brown and gray mottled, medium, some lenses of silty sand and sand (CL)		6		4	SS				
9½	SILTY CLAY, brownish gray and brown mottled, rather stiff (CL)		10		5	SS				
12½	SILTY CLAY, brown and gray mottled, soft, a few lenses of silty sand and waterbearing sand (CL)		4		6	SS				
			4		7	SS				
16	SILTY CLAY, gray, medium (CL-CH)				8	3T				
					9	3T				
	*Note: Water level is expected to rise to depth of about 13' based on observation while sampling.		5		10	SS				
25	SAND, fine to medium grained, a little gravel, gray, waterbearing, loose (SP-SM)	COARSE ALLUVIUM	6		11	SS				M*A.
27	SAND, medium grained, a little gravel, brown, waterbearing, medium dense (SP)		15		12	SS				M*A.
31	End of Boring									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-6	9:10	31'	29½'		to	22*
9-6	9:30	31'	None	12½'	to	None
					to	
					to	

START 9-6-75 COMPLETE 9-6-75

METHOD 3¼ HSA 0' - 29½' @ 9:10

CREW CHIEF Hagedorn

SE-2 (70-A)

PLATE H-41

SOIL EXPLORATION COMPANY

JOB NO 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO 75-35M

PROJECT REDWOOD RIVER - MARSHALL, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	FILL, mixture of SAND and SILTY SAND, brown and grayish brown	FILL	13		1	SS				*M.A.
2½	CLAYEY SAND, a trace of gravel, dark grayish brown, stiff (SC)	TOPSOIL	17		2	SS				*M.A.
4	SAND, medium to fine grained, a little gravel, brown, moist, loose, a few lenses of silty sand and clayey sand (SP-SM)	COARSE ALLUVIUM	8		3	SS				*M.A.
7	SAND, fine grained, grayish brown, moist to 8' then waterbearing, loose, a few lenses of silty sand and organic silty clay (SP-SM)		5	▼	4	SS				*M.A.
9½	ORGANIC SILTY CLAY, black, soft (OH)	SWAMP DEPOSITS	3		5	SS	64		80/45	
11½	SAND, medium to coarse grained, with gravel, black, waterbearing, very loose (SP)	COARSE ALLUVIUM	3		6	SS				*M.A.
13½	SILTY SAND, fine grained, brown and gray mottled, wet, very loose (SM)		4		7	SS				*M.A.
					8	3T	23		39/16	
18'	SANDY CLAY, a little gravel, brown and a little light gray mottled, medium to rather stiff, a few lenses of waterbearing sand (CL)	TILL			9	3T	24		37/18	
			9		10	SS				
24	CLAYEY SAND, a little gravel, gray and brown mottled, stiff, a few lenses of waterbearing sand (SC)		23		11	SS	19		25/20	
27	SANDY CLAY, a little gravel, gray, rather stiff (CL) * No measurement recorded		10		12	SS	19		29/15	
32	End of Boring									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-4	3:45	9'	7'	8½	to	8'
9-4	5:00	32'	29½'		to	*
9-4	5:20	32'	None		to	*
					to	

START 9-4-75	COMPLETE 9-4-75
METHOD 3¼ HSA 0' - 29½'	@ 5:00
CREW CHIEF Hagedorn	

SE-2 (70-A)

PLATE H-42

SOIL EXPLORATION COMPANY

JOB NO 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO 75-36M

PROJECT REDWOOD RIVER - MARSHALL, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	CLAYEY SILT, dark brownish gray, medium (ML-CL)	TOPSOIL	6		1	SS				
2	SAND, fine grained, light brown, moist, lenses of silty sand (SP-SM)	COARSE ALLUVIUM	6		2	SS				M.A.*
4½	SAND, medium grained, a little gravel, light brown, moist, medium dense (SP)		9		3	SS				M.A.*
7	SAND, medium to coarse grained, a little gravel, brown, moist to 7½' then waterbearing, medium dense (SP)		10	▼	4	SS				M.A.*
9½	SANDY CLAY, a little gravel, brown mottled, soft, a few lenses of water-bearing sand (CL)	TILL	4		5	SS				
11½	LEAN CLAY, a little gravel, brownish gray and brown mottled, rather stiff (CL)		9		6	SS				
13½	SANDY CLAY, a little gravel, gray, medium to rather stiff (CL)		7		7	SS	20		35/18	
			11		8	SS				
23½	SAND, coarse grained, with gravel, gray, waterbearing, dense, a lense of gray sandy clay at about 31' (SP-SM)	COARSE ALLUVIUM	29		9	SS				M.A.*
31			16		10	SS				M.A.*
	End of Boring * No measurement recorded									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-4	1:50	9'	7'	8'	to	7½'
9-4	2:30	31'	29½'		to	*
9-4	2:50	31'	None		to	*
					to	

START 9-4-75 COMPLETE 9-4-75

METHOD 3¼ HSA 0' - 29½' @2:30

CREW CHIEF Hagedorn

SE-2 (70-A)

PLATE H-45

SOIL EXPLORATION COMPANY

JOB NO 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO 25-32M

PROJECT REDWOOD RIVER - MARSHALL, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	FILL, mostly SANDY CLAY, a little SILTY CLAY and gravel, brown, brownish gray, and black	FILL	5	*	1	SS				
			15		2	SS				
			4		3	SS				
7	SILTY CLAY, dark brown and gray mottled, soft, some lenses of silty sand and sand (CL)	FINE ALLUVIUM	3		4	SS				
9½	SAND, medium to coarse grained, some gravel, brown, waterbearing, medium dense (SP)	COARSE ALLUVIUM	25** / 0.1		5	SS				
11½	SANDY CLAY, a little gravel, brown mottled, rather stiff, a few lenses of waterbearing sand (CL)	TILL	9		6	SS				
			13		7	SS				
16	SANDY CLAY, a little gravel, gray, rather stiff, some lenses of waterbearing sand below 18' (CL)				8	ST				
			[illegible]		9	[illegible]				
21	End of Boring									

* Note: Water level is expected to rise to depth of about 9½' based on observation while sampling.

** High blow count due to encounter of gravel or small boulder

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-6	11:00	21'	19½'		to	18'
9-6	11:10	21'	None	9'	to	None
					to	
					to	

START 9-6-75 COMPLETE 9-6-75

METHOD 3¼ HSA 0' - 19½' @ 11:00

CREW CHIEF Hagedorn

SE-2 (70 A)

PLATE H-44

SOIL EXPLORATION COMPANY

JOB NO 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO 75-38M

PROJECT REDWOOD RIVER - MARSHALL, MN

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
1	FILL, mixture of LEAN CLAY and SILTY SAND, a little gravel, see Note #1	Fill	6		1	SS				
2	LEAN CLAY, a trace of gravel, dark brownish gray, medium (CL)	TOPSOIL			2	SS				
	LEAN CLAY, a trace of gravel, grayish brown, medium (CL)		7		3	SS				
4	SANDY CLAY, a little gravel, brown mottled, medium to rather stiff (CL)	TILL	9		4	SS				
			11		5	SS	21		30/18	
				▼	6	3T				
					7	3T*				
			12		8	SS				
12	SANDY CLAY, a little gravel, gray and brown mottled, rather stiff (CL)		12		9	SS				
16	SANDY CLAY, a little gravel, gray, rather stiff (CL)		12		10	SS	18		31/16	
			12		11	SS	15		27/15	
22	End of Boring									

* Thinwall tube sample obtained from adjacent secondary boring

Note #1. brownish gray

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-4	10:10	22'	19½'	22'	to	None
9-4	10:20	22'	None	16'	to	None
9-5	12:05	22'	None	11'	to	9'
					to	

START 9-4-75 COMPLETE 9-4-75

METHOD 3¼ HSA 0' - 19½' @ 10:10

CREW CHIEF Hagedorn

SE-2 (70-A)

PLATE H-46

SOIL EXPLORATION COMPANY

JOB NO 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO [illegible] 9M

PROJECT REDWOOD RIVER - MARSHALL, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	MEDIUM FAT CLAY, black, medium (CH)	TOPSOIL	8		1	SS				
2	LEAN CLAY, a trace of gravel, dark brownish gray, rather stiff (CL)		10		2	SS				
4	SANDY CLAY, a little gravel, brown and light grayish brown mottled, medium (CL)	TILL	6		3	SS				
			7		4	SS				
10	SANDY CLAY, a little gravel, brown mottled, rather stiff, a lense of *		9		5	SS				M.A.
11½	LEAN CLAY, a little gravel, a boulder at 12', brown and gray mottled, rather stiff (CL)		14		6	SS				
13½	SANDY CLAY, a little gravel, gray, rather stiff, some lenses of water-bearing sand below 15½' (CL)		13		7	SS				
					8	ST	17		28/16	
					9	ST				
			14		10	SS				
21	End of Boring									

* waterbearing sand at about 10' (CL-SC)

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-4	8:50	21'	19½'		to	17½'
9-4	9:00	21'	None	15½'	to	None
9-5	12:05	21'	None	11'	to	8'
					to	

START 9-4-75 COMPLETE 9-4-75

METHOD 3¼ HSA 0 - 16' @ 8:50

CREW CHIEF Havedown

SE-2 (70-A)

PLATE H-46

SOIL EXPLORATION COMPANY

JOB NO 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO 75-40M

PROJECT REDWOOD RIVER - MARSHALL, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION ___)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	MEDIUM FAT CLAY, black, rather stiff (CH)	TOPSOIL	9		1	SS				
2	MEDIUM FAT CLAY, brownish gray and gray mottled, rather stiff to soft, a few white shells (CH to CL-CH)	FINE ALLUVIUM	12		2	SS	23		55/33	
			4	▼	3	SS	30		47/23	
6	SANDY CLAY, a little gravel, brown and a little gray mottled, medium, a few lenses of waterbearing sand below 8½', a few white shells above 7½' (CL)	MIXED ALLUVIUM			4 5	3T 3T*	21		29/17	
			5		6	SS				
			6		7	SS	31		39/21	
12½	SANDY CLAY, a little gravel, a few boulders, gray, rather stiff to stiff, some lenses of waterbearing sand (CL)	TILL	10		8	SS	17		25/16	
			10		9	SS				
			19		10	SS	18		28/16	
21	End of Boring									

* Thinwall tube samples obtained from adjacent secondary boring.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-3	5:20	21'	19½'		to	16'
9-3	5:35	21'	None	11'	to	9½'
9-5	12:15	21'	None	9½'	to	5½'
					to	

START 9-3-75 COMPLETE 9-3-75

METHOD 3¼ HSA 0' - 19½' @ 5:20

CREW CHIEF Hagedorn

SE-2 (70-A)

PLATE H-47

SOIL EXPLORATION COMPANY

JOB NO 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO 75-41M

PROJECT REDWOOD RIVER - MARSHALL, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	MEDIUM FAT CLAY, black, medium (CH)	TOPSOIL	5		1	SS				
2	SANDY CLAY, a little gravel, brown and light grayish brown mottled, rather stiff to medium stiff, lenses of silty sand and waterbearing sand below 6½' (CL)	TILL	9		2	SS				
			7	▼	3	SS	19		35/18	
			17		4	SS				
8½	SAND, fine grained, a trace of gravel, brown, waterbearing, medium dense (SP-SM)	COARSE ALLUVIUM	13		5	SS				M.A.*
12	SAND, fine to medium grained, a little gravel, grayish brown, waterbearing, dense (SP-SM)		17		6	SS				M.A.*
14½	SAND, fine grained, a trace of gravel, gray, waterbearing, dense, a few lenses of silty sand (SP)		21		7	SS				M.A.*
19	SANDY CLAY, a little gravel, gray, rather stiff, a lense of sand at about 20' (CL)	TILL	9		8	SS				
21	End of Boring									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-3	4:00	21'	19½'		to	13'
9-3	4:15	21'	None	9'	to	7½'
9-5	12:15	21'	None	7½'	to	6'
					to	

START 9-3-75 COMPLETE 9-3-75

METHOD 3¼ HSA 0' - 19½' @ 4:00

CREW CHIEF Hagedorn

SE-2 (70-A)

PLATE H-48

SOIL EXPLORATION COMPANY

JOB NO 21791 VERTICAL SCALE 1" = 4' LOG OF TEST BORING NO 75-42M

PROJECT REDWOOD RIVER - MARSHALL, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
1½	LEAN CLAY, dark grayish brown, medium (CL)	TOPSOIL	7		1	SS				
2	LEAN CLAY, a trace of gravel, See **	TILL			2	SS				
	SANDY CLAY, a little gravel, brown mottled, medium to rather stiff (CL)		7		3	SS				
			7		4	SS				
					5	3T				
					6	3T*				
			9		7	SS				
			10	▼	8	SS				
12½	SANDY CLAY, a little gravel, gray, stiff a few lenses of silty sand below 13' (CL)		17		9	SS				
14	SAND, fine grained, a little gravel, brownish gray, waterbearing, dense, a few lenses of sandy clay above 15½' (SP)	COARSE ALLUVIUM	19		10	SS				M.A.
20	SANDY CLAY, a little gravel, gray, rather stiff (CL)	TILL	13		11	SS				
21	End of Boring									

** Brown and brownish gray, mottled, rather stiff (CL)

* Thinwall tube sample obtained from adjacent secondary boring

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE IN DEPTH	BAILED DEPTHS	WATER LEVEL
9-3	2:35	21'	19½'		to	16'
9-3	2:45	21'	None	14'	to	13'
9-5	12:25	21'	None	11'	to	10'
					to	

START 9-3-75 COMPLETE 9-3-75

METHOD 3¼ HSA 0' - 19½' @ 2:35

CREW CHIEF Hagedorn

SE 2 (70-A)

PLATE H-49

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS

SYMBOL	DEFINITION
C S	Continuous Sampling
P D	2-3 8" Pipe Drill
C O	Cleanout Tube
3¼ HSA	3¼" I D Hollow Stem Auger
4 FA	4" Diameter Flight Auger
6 FA	6" Diameter Flight Auger
2½ C	2½" Casing
4C	4" Casing
D M	Drilling Mud
J. W.	Jet Water
H A	Hand Auger
NXC	Size NX Casing
BXC	Size BX Casing
AXC	Size AX Casing
SS	2" O D Split Spoon Sample
2T	2" Thin Wall Tube Sample
3T	3" Thin Wall Tube Sample

LABORATORY TEST SYMBOLS

SYMBOL	DEFINITION
W	Moisture content percent of dry weight
D	Dry density-pounds per cubic foot
LL PL	Liquid and plastic limits determined in accordance with ASTM D 423 and D 424
Qu	Unconfined compressive strength-pounds per square foot in accordance with ASTM D 2166-66

Additional insertions in Qu column

Pq	Penetrometer reading-tons/square foot
Ts	Torvane reading-tons/square foot
G	Specific gravity - ASTM D 854-58
SL	Shrinkage limit - ASTM D 427-61
pH	Hydrogen ion content-meter method
O	Organic content-combustion method
M A *	Grain size analysis
C*	One dimensional consolidation
Qc*	Triaxial compression

*See attached data sheet and or graph

WATER LEVEL
SYMBOL - ▼

Water levels shown on the boring logs are the levels measured in the borings at the time and under the conditions indicated. In sand, the indicated levels can be considered reliable ground water levels. In clay soil, it is not possible to determine the ground water level within the normal scope of a test boring investigation except where lenses or layers of more pervious waterbearing soil are present and then a long period of time may be necessary to reach equilibrium. Therefore the position of the water level symbol for cohesive or mixed texture soils may not indicate the true level of the ground water table. The available water level information is given at the bottom of the log sheet.

DESCRIPTIVE TERMINOLOGY

DENSITY

TERM	"N" VALUE
Very loose	0-4
Loose	5-8
Medium Dense	9-15
Dense	16-30
Very Dense	Over 30

CONSISTENCY

TERM	"N" VALUE
Soft	0-4
Medium	5-8
Rather Stiff	9-15
Stiff	16-30
Very Stiff	Over 30

Standard "N" Penetration Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch OD split spoon.

RELATIVE PROPORTIONS

TERM	RANGE
Trace	0-5%
A Little	5-15%
Some	15-30%
With	30-50%

PARTICLE SIZES

Boulders	Over 3"
Gravel	
Coarse	¾"-3"
Fine	#4-¾"
Sand	
Coarse	#4-#10
Medium	#10-#40
Fine	#40-#200
Silt and Clay	Determined by plasticity Characteristics

Note: Sieve sizes shown are U.S. Standard

SE-4170A1

PLATE H-60

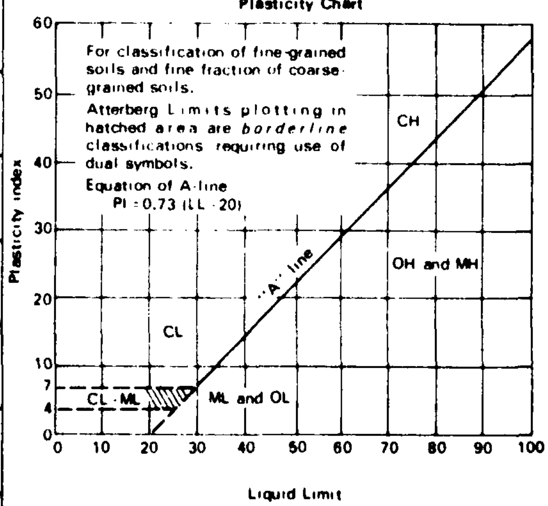
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 – 69 AND D 2488 – 69

(Unified Soil Classification System)

Major divisions			Group symbols	Typical names	Classification criteria		
Coarse grained soils More than 50% retained on No. 200 sieve*	Gravels 50% or more of coarse fraction retained on No. 4 sieve	Clean gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines: Less than 5% pass No. 200 sieve ...... GW, GP, SW, SP; More than 12% pass No. 200 sieve ...... GM, GC, SM, SC; 5 to 12% pass No. 200 sieve ...... *Borderline* classifications requiring use of dual symbols	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW	
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
	Sands More than 50% of coarse fraction passes No. 4 sieve	Clean sands	SW	Well graded sands and gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW	
		Sands with fines	SM	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
Fine grained soils 50% or more passes No. 200 sieve*	Silts and clays Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands	Plasticity Chart (see below)		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	Organic silts and organic silty clays of low plasticity			
	Silts and clays Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts			
			CH	Inorganic clays of high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity			
Highly organic soils			Pt	Peat, muck and other highly organic soils			

Plasticity Chart



*Based on the material passing the 3 in. (76 mm) sieve.

SECTION I

DIVISION OF PLAN RESPONSIBILITIES

SECTION I

DIVISION OF PLAN RESPONSIBILITIES

TABLE OF CONTENTS

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SECTION I

DIVISION OF PLAN RESPONSIBILITIES

INTRODUCTION

1. This section presents the details of project responsibilities and related cost apportionment between Federal and non-Federal agencies. The proposed improvements are principally for a single purpose, i.e. flood control, with minimal related recreation and aesthetic measures. Since the proposed recreational facilities and resulting benefits do not have a decisive influence on project feasibility, the recreation purpose and costs were considered incremental. Therefore, cost allocation between project purposes are not considered warranted. The apportionment of project costs, including appropriate engineering, design, supervision, and administrative costs under both existing legislation and the President's proposed cost-sharing policies, is shown in table I-1.

COST APPORTIONMENT

FEDERAL

2. The Federal government would design and construct the various features of the flood protection and recreation works. The work

charged as a Federal cost includes that for all upstream and downstream reach levee and channel works, interior drainage works, and a maximum of three percent of the total construction cost for aesthetic mitigation-beautification measures. Federal cost sharing would also include approximately one-half the first costs of the recreational trail system and project related picnicking facilities at Justice Park. The Federal Government also assumes the cost of this study. The total Federal first cost for both upstream and downstream reach improvements excluding costs of this study is estimated at $2,008,800 based on existing cost-sharing legislation. However, applying the President's proposed cost-sharing policies would result in a total Federal first cost of $1,745,100 as shown on table I-1.

NON-FEDERAL

3. The City of Marshall would be required to operate and maintain all project works and bear all costs of required lands, easements and rights-of-way required for construction and subsequent operation and maintenance of the project; all relocations and alterations to structures, roads, and utilities (except parts of utilities passing over, through, or under the protective works); and one-half the first costs of recreational facilities eligible for Federal cost sharing.

Table 1 - Apportionment of first costs among interests

Item	Federal	Non-Federal State	Non-Federal City	Total
Based on existing cost-sharing legislation:				
Lands	-	-	$211,600	$211,600
Relocations	-	-	52,400	52,400
Channels	$738,600	-	-	738,600
Levees	171,800	-	-	171,800
Overflow works	418,200	-	-	418,200
Interior drainage	184,000	-	-	184,000
Recreation facilities	192,800	-	192,800	385,600
Engineering, administration	303,400	-	38,400 (1)	341,800
Total (existing legislation)	2,008,800	-	495,200	2,504,000
Based on President's proposed cost-sharing policy:				
Flood damage prevention	$1,332,500	$88,800	$355,300	$1,776,600
Recreational facilities	173,500	19,300	192,800	385,600
Engineering, administration	239,100	17,100 (2)	85,600 (3)	341,800
Total (President's policy)	1,745,100	125,200	633,700	2,504,000

(1) Includes 50 percent of the separable Engineering, Administration (E,A) cost ($28,800) and 100 percent separable E,A relocations cost ($9,600).
(2) Includes 5 percent of total E,A.
(3) Includes 20 percent of flood damage prevention E,A cost ($56,800) and 50 percent of recreational facility E,A cost ($28,800).

4. All maintenance and operation costs for the proposed project are assigned to non-Federal interests. The estimated annual charges, based on a 6-7/8 percent interest rate and a 50-year project life, are given in table I-2 below.

Table I-2 - Estimate of Annual Charges

Federal		
Interest and amortization ($2,008,800 x 0,07132)		$143,270
Non-Federal		
Interest and amortization ($495,200 x .07132)	$35,320	
Operation and Maintenance (Flood Control)	6,300	
(Recreation)	2,700	
Total Non-Federal Charges		44,320
TOTAL ANNUAL CHARGES		$187,590

5. Prior to the start of construction and in accordance with Section 221 of the 1970 Flood Control Act of 1970, the City would be required to enter into a local cooperation agreement satisfactory to the Secretary of the Army, which would provide that the City will:

a. Provide, without cost to the United States, all lands, easements, and rights-of-way, including suitable areas for borrow and disposal of excavated material as determined by the Chief of Engineers, for construction, operation and maintenance of the project.

b. Hold and save the United States free from damages that may result from construction and maintenance of the project, not including damages which are due to the fault or negligence of the United States or its contractors.

c. Maintain and operate the project after completion in accordance with regulations prescribed by the Chief of Engineers.

d. Accomplish without cost to the United States all relocations and alterations of buildings (except nonstructural measures), transportation facilities, storm and sanitary sewer systems, public and private utilities, local betterments, drainage facilities, and other structures and improvements made necessary by construction of the recommended plan, as determined by the Chief of Engineers, excluding facilities necessary for the normal interception and disposal of local interior drainage at the line of protection.

e. Prescribe and enforce regulations to prevent obstructions or encroachment on channels, floodway areas, and ponding areas which would reduce their flood-carrying capacity or hinder maintenance and operation.

f. Provide a cash contribution for recreation equal to 50 percent of the final separable cost allocated to this function less a credit for the value of lands, easements, rights-of-way, alterations, and relocations furnished therefore.

g. Publicize flood plain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to insure compatibility between future development and protection levels provided by the project.

h. In acquiring lands, easements, and rights-of-way for construction of the project, the local sponsor will comply with the applicable provisions of the "Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970", Public Law 91-646, approved 2 January 1971.

SECTION J

EXECUTIVE ORDERS
11988 AND 11990

SECTION J

EXECUTIVE ORDERS 11988 AND 11990

INTRODUCTION

1. This section describes in detail the evaluation of an alternative levee alignment formulated to address compliance with Executive Order 11988, pertaining to direct or indirect inducement of flood plain development, and Executive Order 11990, pertaining to the protection of wetlands.

EXECUTIVE ORDER 11988

OBJECTIVE

2. The objective of Executive Order 11988 is to avoid to the extent possible the long- and short-term adverse impacts associated with occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. The order requires Federal agencies to provide leadership and take action to:

a. Avoid the base floodplain unless it is the only practicable alternative.

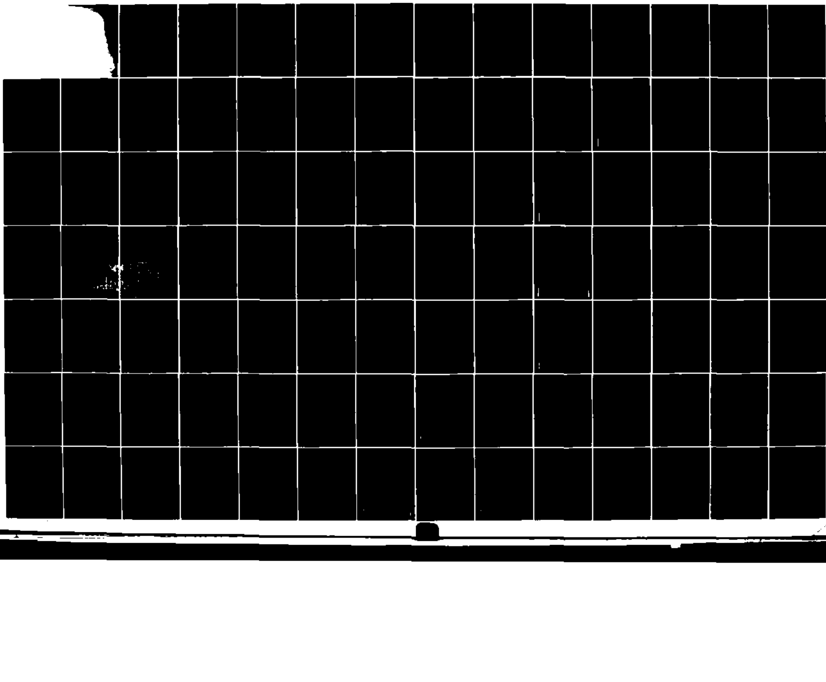
b. Reduce the hazard and risk of flood loss.

c. Minimize the impact of floods on human safety, health and welfare.

d. Restore and preserve the natural and beneficial floodplain values. Direct support of floodplain development is an action in the floodplain that encourages, allows, serves, or otherwise facilitates additional floodplain development. An example of direct support would be provision of flood protection measures to undeveloped or underutilized floodplain lands for the purpose of permitting future development and growth.

AD A146 926 REDWOOD RIVER AT MARSHALL MINNESOTA; FEASIBILITY REPORT FOR FLOOD CONTROL(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT JUN 79 **6/7**

UNCLASSIFIED F/G 13/2 NL



DESCRIPTION OF THE AREAS AFFECTED

3. The existing diversion channel at Marshall is unable to adequately protect the city due to insufficient channel capacity both upstream and downstream of the diversion structure. Upstream, should a flood greater than or equal to the 1969 flood occur, overflows would bypass the diversion channel and rejoin the Redwood River in Marshall, causing damages to developing residential areas and the central city. Downstream of the diversion channel, considerable development has occurred that is not protected by the existing project. The majority of this development consists of Southwest State University and student and other local housing.

4. The selected project modifications upstream and downstream of the diversion channel consist of channel widening, straightening, and bank reshaping measures; levees; an overflow diversion structure with appurtenant control and outlet works; interior drainage works; aesthetic measures; recreation facilities; required relocations; and revegetation of all disturbed areas. The selected plan would provide 133-year protection for the city of Marshall.

UPSTREAM REACH

5. Problem area. - The area of concern for the upstream reach is located upstream of the existing diversion structure and bypass channel between State Highway 23 and the Redwood River. This area is divided by County Highway 7 which crosses the Redwood River about 1,000 feet above the existing flood diversion structure. The existing project was designed to allow a near natural division of high flows south across Highway 23 to the Cottonwood River basin with the balance flowing down the Redwood River to the diversion structure. The flood of 1969 did not overflow as expected. About 2,500 cfs overflowed into the Cottonwood River basin in the vicinity of the Highway 23 wayside park. Additional overbank flow entered the area from overbank areas downstream of the park and flowed southeast toward the junction of County Highway 7 and State Highway 23.

This latter overflow threatened to overtop County Highway 7, reenter a residential area, and flow through the Marshall business district at a point downstream of the existing diversion structure. To prevent this overflow, County Highway 7 was temporarily raised. Subsequently, Highway 23 near the junction of County Highway 7 was breached to let some of the ponded overflow pass into the Cottonwood River basin. This raising and resulting flood-flow backup and subsequent breaching is believed to have caused about 1,100 cfs of the total 25,000-cfs overflow into the Cottonwood River basin. Legal claims due to floodwater retention riverward of Highway 23 and the sudden release of water from the subsequent breaching of Highway 23 resulted in a payment of $124,000 to affected property owners between Highways 7 and 23 and the Redwood River and about $80,000 to affected property owners south of Highway 23 in the Cottonwood River basin.

6. Under existing conditions the city would be in an untenable position should another flood equal to or greater than the 1969 flood occur. Without some structural measures, overflows would cross Highway 7, pass through the developing residential area downstream of the highway, enter the Redwood River below the diversion structure, and cause damages in the central city. In addition, since the distance via the overflow route is shorter than the Redwood River meander channel, high velocities could develop as a specific overflow channel concentrated the overflow. Highway 7 would probably wash out, with gully erosion developing from the Redwood River upstream through the developed area. Ultimately, the overflow area could possibly capture the entire river flow and become the main river channel. If the city were to take emergency action to prevent future flooding in the central city by raising Highway 7, it would again be liable for substantial damage claims, with a precedent having been established.

7. Selected plan. - The selected plan described in section E, appendix 1 (see attached plate J-1 for alignment) provides for an earth levee along the right bank extending from the existing diversion structure upstream to the Highway 23 roadside park. The location of this right bank levee was selected to minimize impacts on forested areas and adjacent cropland areas and provide a technically sound and cost effective alignment. As designed, the levee would provide the 150-acre area with protection against a 133-year flood with 4.6 feet of freeboard (2.0 feet freeboard above SPF). All former overland flows would be confined to the area riverward of the proposed levee. With flows exceeding the design flood flow, the 4.6 feet of freeboard above the proposed levee would prevent overtopping or failure of the levee (and subsequent damages to developing residential areas) by confining the flood flow between the BNRR embankment and the proposed levee.

8. The floodplain area east of County Highway 7 is a developing residential area with several new homes in place and others under construction. Utilities are in place for the area. The 150-acre area west of County Highway 7 is presently about 85-percent (125 acres) cropland and 15-percent residential and commercial land. This area is presently zoned by Lyon County as an agricultural area. The city of Marshall's land use plan developed in 1974 (see plate F-10) indicates that this area is proposed for multi-family residential development. Required utilities can easily be extended from nearby facilities serving the area east of County Highway 7.

DOWNSTREAM REACH

9. Problem area. - The downstream channel reach has insufficient channel capacity to pass even the original design flow of 6,500 cfs with the diversion channel. This condition was evident during the 1969 flood when, with a peak downstream discharge of 5,600 cfs,

extensive emergency diking was needed to prevent damages to Southwest State University and other developments. Under existing conditions, damages would begin to occur in the downstream reach whenever flood flows exceed 725 cfs unless emergency protective measures are provided.

10. Selected plan. - The selected plan described in section E, appendix I (see attached plate J-2 for alignment) provides for an earth levee along the right bank commencing at high ground near the Highway 23 embankment and extending 7,670 feet to high ground at Fifth Street and Hudson Avenue. For the most part, this alignment would follow the alignment of a proposed highway under joint consideration by the city and Lyon County. If later desired, the highway could incorporate the levee embankment or be constructed adjacent to it. As designed, the levee would provide protection to downstream areas against a 133-year flood with 3 feet of freeboard.

11. Approximately 80 acres of downstream reach floodplain land presently in crop use would be protected by the selected levee alignment. The city's 1974 land use plan indicates the proposed land use for this area is single- and multiple-family residential, and school or college.

DESCRIPTION OF ALTERNATIVES

12. The selected alignment's compliance with Executive Order 11988 was evlautaed because the upstream levee alignment protects 125 acres of undeveloped floodplain and the downstream levee alignment protects an additional 80 acres of undeveloped floodplain. An alternative levee alignment was formulated to exclude these areas from protection.

UPSTREAM REACH

13. To evaluate the applicability of Executive Order 11988 to protection of the floodplain area, an alternative flood barrier alignment (see plate J-1) excluding the 125 acres of undeveloped

floodplain from protection was analyzed. This alternative could involve either raising County Highway 7 and State Highway 23 or constructing levees paralleling the highways. Since levees would accomplish the same purpose with only minor additional land requirements but at reduced costs, the highway raises were not considered further. These alternate levees would include a levee having an average height of 7.5 feet extending from the County Highway 7 bridge south along the west side of the highway to the State Highway 23 right-of-way, then a levee with an average height of 4.7 feet from that point west along Highway 23 to the driveway at the east side of the roadside park.

14. This alternative would eliminate the need for about 5,500 feet of the selected alignment right bank levee extending upstream from County Highway 7. The selected plan's right bank channel modifications (Plates E-1, E-2, E-3) along most of this removed levee section would also be eliminated. Flood flows would freely enter the affected area at a location downstream of the wayside park. At the standard project flood level, a farmstead and three other residences would be inundated. The maximum design water level in the ponded area would be at elevation 1182, an approximate 1-foot (4 ft. at standard project flood level) increase over existing conditions. With this alternative, Federal first costs would be reduced by about $490,400. However, because of increased water level and inducement of flood damages the city would be required to either acquire by fee or easement about 125 acres at an estimated cost of $3,600 per acre.

15. The $3,600 per acre land value reflects prime agricultural land with excellent near-term development potential. In addition, local interests would have to purchase four homes and a farmstead, pay relocation assistance expenses, and remove affected structures from the area. Thus, non-Federal first costs would increase by $910,300 over the selected plan. The net change in total plan first costs with the alternate levee alignment would be $910,300 less $490,000 or a $419,900 increase.

16. With the alternative levee alignment, land required for construction would increase by 144 acres over land required for the selected alignment. The majority of this increase would be agricultural lands; however, a reduction of 2.6 acres of forested land would be realized. In addition, the alternative levee alignment would require relocation of 4 residences and 10 structures, displacing 10 to 15 residents. A comparison of the economic, environmental, and social impacts of the selected and alternative levee alignment and net effects is displayed in table J-1.

Table J-1 - Upstream reach impacts

	Selected project	Project with Executive Order 11988 modification	Net change with Executive Order 11988
Economics			
Federal first costs	$2,008,800	$1,518,400	-490,400
Non-Federal first costs	495,200	1,405,400	+910,300
Total first costs	2,504,000	2,923,900	419,900
Benefit-cost ratio	1.82	1.57	
Cost to developers 1/	0	500,000	+500,000
Environmental			
Channel modifications (feet)	8,750	4,750	-4,000
Lands required for project (acres)			
- Agricultural	28.1	168.6	+140.5 2/
- Forest	41.0	38.4	-2.6
- Other (open)	30.4	36.6	+6.2
	99.5	243.6	+144.1
Effect on local and regional growth patterns (see separate write-up)			
Social			
Residences relocated	1	4	+3
Structures relocated	-	10	+10
Utilities relocated (ft)	1,200	1,750	+550
Number of persons displaced	1-3	10-15	+9-12

Table J-1 - Upstream reach impacts (Cont)

Other

- Driveways to two residences would be impassable during high flood flows with water (100-year level) very near one of the homes.
- Increased local costs of about $910,300.
- Affected access to area via road ramps and/or closure structures.

1/ Developable area is about 125 acres and 105 acres for selected project and Executive Order 11988 modified project, respectively.

2/ This area could continue to exist as productive agricultural land. In accordance with E.O. 11988, agriculture is an acceptable use of floodplain lands.

DOWNSTREAM REACH

17. An alternative flood barrier alignment was developed for the downstream reach in response to Executive Order 11988 (see plate J-2) excluding the 80 acres of agricultural land from flood protection. This alternative involves an earth levee commencing at high ground near the State Highway 23 embankment, following the alignment of County Ditch 62, to the Camelot Square Trailer Court. The levee then follows the exterior boundary of the trailer court to high ground at Fairview Street. A second levee commencing at high ground near Fifth Street and Hudson Avenue follows north of Hudson Avenue, east to Bruce Street, and then follows Bruce Street north to high ground at Fairview Street.

18. With this alternative, Federal first costs would be increased $202,000. Non-Federal first costs used for purchase of required lands would decrease $2,600. The net change in total first costs would be an increase of $199,400. A reduction of 3.8 acres of lands required for the project would be realized, with only minor relocation of residential fencing required. A comparison of the economic, environmental, and social impacts of the selected and alternative levee alignments and net effects is displayed in table J-2.

Table J-2 - Downstream reach impacts

Item	Selected project	Project with Executive Order 11988 modifications	Net change with Executive Order 11988 modifications
Economic			
Federal first costs	$2,008,800	$2,210,800	+$202,000
Non-Federal first costs	495,200	492,600	-2,600
Total first costs	2,504,000	2,703,400	199,400
Benefit-cost ratio	1.82	1.69	
Environmental			
Lands required for project (acres)			
Agricultural	15.0	12.0	-3.0
Forest	-	0.5	+0.5
Other (open)	5.3	4.0	-1.3
	20.3	16.5	-3.8
Effect on local and regional growth patterns - (see separate write-up)			
Social			
Residences relocated	-	-	
Structures relocated	-	Residential fencing	
Utilities relocated (feet)	900	900	
Number of persons displaced	-	-	

DEVELOPMENT OF AFFECTED AREAS

19. Marshall can be described as a vibrant community. The projected growth rate to the year 2000 is from 15 to 20 percent. Development at Marshall will most likely occur southeast, west, and northwest of the city, all south of the Redwood River, in or adjacent to the floodplain. The proposed levee alignment would protect 205 acres of undeveloped land, located near existing utilities, northwest and southeast of the city.

UPSTREAM DEVELOPMENT

20. Development under existing conditions. - Under the existing flood and institutional setting, only a very small portion (5 acres) of the affected area could be developed without changes to the topography. This small area is located immediately upstream of County Highway 7, south of the river, and in the immediate vicinity of the only farmstead in the area. To develop the remaining portion, the floodplain lands would require fill to the 100-year flood elevation plus 1 foot. Maximum fill height would be about 6 feet and the average fill height would be about 2.2 feet. Any such landfill would have to provide for maintenance of a suitable floodway meeting State floodplain management requirements. Any future developments would be subject to flooding from floods exceeding the flood protection elevation.

21. Various options would be available to local interests to achieve a designed floodway. One would be the creation of a floodway along the southeast overland flood flow path to the County Highway 7 overflow area and through the area east of County Highway 7 to the river below the existing diversion structure. Floodway requirements could also be met by routing the floodway along the edge of the affected area to tie into the County Highway 7 overflow area. Third, a floodway could be designated along the river channel only with no provision for future overflow over County Highway 7. Preliminary studies indicate that approximately 10 to 15 acres of the cropland area would be required for floodway purposes.

22. Under existing conditions, with no provision for a floodway through the area, approximately 460,000 cubic yards of fill would be required to achieve the 100-year plus 1-foot elevation in the area above Highway 7. Estimated local fill costs would be about $250,000. This area can be developed with or without the selected project. The city's proposed land use of this area is multifamily residential (see plate F-10). Sewer and water facilities of an adjacent development are of sufficient size to accommodate development in this area, and the area is easily accessible to downtown shopping and other essential public facilities.

23. With the selected alignment, the 125 acres could be developed in accordance with State floodplain management criteria without any fill requirements. Thus, the selected levee alignment would result in a direct savings of about $250,000 by not having to fill the area.

24. Development with alternative levee alignment. - With the alternative levee alignment, at least four options are evident for future use of the affected lands: (1) the city, having purchased the land in fee (city considers alternative purchase of flood easements to cost as much) could choose to let the land revert to a natural vegetative state; (2) the city could choose to develop the purchased lands as flood damage-free open-space recreation area, not a critical need now or in the foreseeable future; (3) the city could lease the acquired lands to an operator for continued agricultural productivity; or (4) the acquired lands could be resold for development provided that landfill elevations and floodway requirements are in accordance with State floodplain management regulations.

25. Thus, under the alternative levee alignment, local interests could also develop the floodplain area bounded by the roadside levees provided fill elevation requirements were met. As this alternative would result in an increase in design water surface levels of about 2 feet over existing conditions (due to restriction of the flood flow area), fill requirements would be about double those required under existing conditions for a fill cost of around $500,000.

DOWNSTREAM DEVELOPMENT

26. Development under existing conditions. - Under existing conditions, the 80 acres of agricultural floodplain lands could be developed in compliance with State floodplain management law, if the area were filled to an elevation 1 foot above the 100-year flood level. A 3- to 5-foot maximum fill would be needed to fulfill these requirements. The city's proposed land use of this area is single- and multi-familv residential, and school or college (see plate F-10).

27. Development with selected levee alignment. - The selected leve alignment allows for development of the 80 acres of floodplain witho requiring the fill that would have been necessary under existing conditions. This is an induced benefit of the levee, in that flood protection afforded by the levee may encourage development in the floodplain to occur sooner than the conditions without flood protection.

28. Development with alternative levee alignment. - As the 80 acres of agricultural land are excluded from flood protection by the levee, development could occur only by filling the area 1 foot above the 100-year flood level, in accordance with State floodplain management criteria. Therefore, there is no direct or indirect encouragement for development by the Executive Order 11988 proposal. However, if the Highway 23 bypass was constructed along the proposed highway alignment, the alternative levee would be rendered obsolete, with a resultant loss of $199,000 to the national economic development account, in addition to the cost of additional fill required by the bypass to replace the levee that would have been used under the selected plan.

SUMMARY OF FLOODPLAIN DEVELOPMENT POSSIBILITIES

29. The primary purpose in developing the alternative levee alignment was to preclude development of undeveloped agricultural floodplain protected by the proposed levee alignment. However, development in the floodplain may still occur, in accordance with State floodplain management criteria, by filling the floodplain lands to 1 foot above the 100-year flood elevation. With the upstream reach alternative levee alignment, fill costs would be approximately double those with existing conditions (due to the increase in flood stages), while the downstream fill costs would stay approximately the same. Therefore, floodplain development with both the upstream and downstream alternative levee alignments is more expensive, but not precluded.

PRACTICABILITY CONSIDERATIONS

30. Included in the objective of the Executive Order is a statement: "Avoid the base floodplain unless it is the only practicable alternative." The practicability of the alternative levee alignment versus the proposed levee alignment was evaluated on the basis of 16 factors listed in the guidelines for implementing the Executive Order.

DEFINITION OF PRACTICABILITY

31. Practicable is defined in the guidelines for implementing the Executive Order as "capable of being done within the existing constraints. The test of what is practicable depends upon the situation and includes consideration of the pertinent factors, such as environment, cost, or technology." Table J-3 is the comparison table developed for determining the practicability of the alternative levee alignment.

Table J-3 - Comparison table for determining most practicable alternative

Factors	Selected levee alignment	Alternative levee alignment
Conservation	May accelerate future development of agricultural lands in the floodplain which provide wildlife habitat.	Would discourage or retard future development of agricultural lands in the floodplain which provide wildlife habitat.
Economics		- Increase in total first costs of $619,300 - Increase in non-Federal first costs of $910,300. It is considered unlikely that the city has the financial capability to provide this amount. - Forgone cost to the city in that sewer and water mains have been sized to facilitate development in the area excluded from protection.
Aesthetics	May accelerate future development of agricultural lands in the floodplain.	Would discourage or retard future development of agricultural lands in the floodplain.
Natural and beneficial values served by the floodplain	May accelerate future development of agricultural lands in the floodplain.	Would discourage or retard future development of agricultural lands in the floodplain.
Impact of floods on human safety	- With the selected alignment, there is sufficient freeboard (4.6 feet over 133-year design flood level, 2.0 feet over SPF level) to assure that no overflows would occur to the undeveloped floodplain in question. At floods higher than design levels, the additional freeboard would cause water to be contained between the levee and the Burlington Northern Railroad tracks. Therefore, there is no significant difference between alignments. - - - - - - - - - - - - - - - - - -	
The functional need for locating the development in floodplain	Proposed upstream development is not immediately floodplain dependent. However, any downstream development involving Southwest State University is floodplain dependent.	Proposed upstream development is not immediately floodplain dependent because of the added cost for fill, alternative sites may be more favorable.
Historic values	- - - - - - No major differences between alignments - - - - - - -	
Fish and wildlife habitat values	- Riverbank alignment requires removal of approximately 30 large mature shade trees, with resulting long-term adverse effects on songbirds and small mammals which depend on the trees for habitat. May accelerate future development of agricultural lands in the floodplain which provide wildlife habitat.	Would discourage or retard future development of agricultural lands in the floodplain which provide wildlife habitat.
Endangered and threatened species	- - - - - - - - - - - - - - None - - - - - - - - - - - - - - - -	
Federal and State designation of scenic or wild rivers	- - - - - - - - - - - - - None - - - - - - - - - - - - - - - -	
Refuges	- - - - - - - - - - - - - - None - - - - - - - - - - - - - - - -	
Recreational	- - - - - - No major differences between alignments - - - - - -	
Water supply	- - - - - - No major differences between alignments - - - - - -	
Water quality	- - - - - - No major differences between alignments - - - - - -	
Food production	Future development of floodplain agricultural lands may be accelerated.	Future development of floodplain agricultural lands would be discouraged or retarded.
Locational advantage	- Makes use of existing high ground, is economically cheaper, and is a more engineeringly efficient levee alignment. - Lower cost to develop, realizing that adjacent sewer and water mains in place are of sufficient size to accommodate development in this area, and fill to 1 foot above the 100-year flood level would not be required under State floodplain management criteria. -Requires relocation of 1 residential and displaces 1-3 people.	- Increases the amount of fill required for development under existing conditions. -Requires relocation of 4 residences, 10 structures, and displaces 10-15 people.
Needs and welfare of the people	- Acceptable to the city of Marshall.	- Not acceptable to the city of Marshall. - Designed to deter unwise flood plain development.

EVALUATION OF ALTERNATIVE LEVEE ALIGNMENT

32. The determination of whether a practicable alternative exists is based on the advantages and disadvantages of floodplain and nonfloodplain sites. Factors to be considered in making this determination and the evaluation of these factors are shown in table J-3.

33. As shown in table J-3, one of the major factors considered in this situation was economics. The alternative levee alignment would result in a $910,300 increase in non-Federal costs, an amount city officials say is "far beyond the reasonable acceptance of the city."1/ In addition, the alternative levee alignment would approximately double the amount of fill needed to meet State floodplain management regulations for development of the area, which amounts to an increase in cost of $250,000. Adjacent sewer and water facilities can accommodate development in this area. Additional location benefits are realized by the selected levee alignment in that it makes use of existing high ground, is economically cheaper, and is a more engineeringly efficient levee alignment.

34. Of the remaining factors listed for practicability considerations, additional benefits to fish and wildlife habitat values were realized by the alternative levee alignment. Approximately half of the proposed channel modifications would not be necessary with the alternate levee alignment. In addition, the alternative levee alignment would discourage or retard future development of agricultural lands which provide wildlife habitat. The selected riverbanks levee alignment requires the removal of approximately 30 large mature shade trees with resulting long-term adverse effects on songbirds and small mammal populations.

35. The alternative levee alignment was determined not to be a practicable alternative as the negative economic and location benefits far outweigh

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1/ Taken from a letter to the Corps of Engineers from Mr. Robert C. Hirmer, President of the Marshall City Council, dated 10 August 1978.

the benefits realized to fish and wildlife habitat values. In addition, the alternative levee alignment is unacceptable to the city of Marshall.

PRESIDENT'S BUDGETARY CRITERIA

36. The President's fiscal year 1980 budgetary criteria require that a "Project does not, directly or indirectly, support future floodplain development in areas other than those near already urbanized areas or where floodplain values have been largely lost and avoids, to the extent possible, the long- and short-term adverse impacts associated with the destruction or modification of wetlands." The selected levee alignment generally meets requirements in that Marshall is an urbanized area, the floodplain land is presently in agricultural use, and the alignment avoids, to the extent possible, adverse impacts associated with any destruction or modification of wetlands.

EXECUTIVE ORDER 11990

OBJECTIVE

37. The objective of Executive Order 11990 is to avoid to the extent possible the long- and short-term impacts associated with destruction or modification of wetlands wherever there is a practicable alternative.

DESCRIPTION OF AREAS AFFECTED

38. The area of concern pertaining to Executive Order 11990 is located upstream of the diversion structure and was described previously in the Executive Order 11988 upstream problem area description (paragraph 5, section J). The selected project is also discussed in the Executive Order 11988 analysis (paragraph 7, section J). Conflict with the objective of Executive Order 11990 resulted from the loss of 2.3 acres of riparian woodland (Type 1 wetland) required by the selected plan for channel modifications.

DESCRIPTION OF ALTERNATIVES

39. The alternative levee alignment described previously in the Executive Order 11988 analysis (paragraph 13, section J) was evaluated with regard to Executive Order 11990 and protection of wetlands. By removing the right bank levee and replacing it with the highway levee alignments, right bank channel modifications would not be required. However, this alternative would still result in the loss of 1.4 acres of riparian woodland (Type 1 wetland) required by the left bank channel improvements. The left bank channel improvements are necessary to protect the Burlington Northern Railroad embankment and the left bank levees near County State Aid Highway 7 and downstream of the drop structure.

PRACTICABILITY CONSIDERATIONS

GENERAL

40. Included in the President's Executive Order 11990 is a statement that new construction should not be allowed in the wetlands unless "there is no practicable alternative to such construction and . . . the proposed action includes all practicable measures to minimize harm to wetlands which may result from such use." The alternative levee alignment was evaluated to determine if it was a practicable alternative capable of minimizing the loss of 2.3 acres of Type 1 wetland.

EVALUATION OF ALTERNATIVE LEVEE ALIGNMENT

41. The alternative levee alignment would save 0.9 acre of riparian woodland from destruction due to right bank channel modifications, resulting in an increase in non-Federal first costs of $910,300.

However, this alignment would still require the taking of 1.4 acres of Type 1 wetland. This large increase in costs is unacceptable to the city of Marshall. Other factors relating to the practicability of the alternative were discussed previously in the Executive Order 11988 analysis (paragraph 32, section J). For these reasons, the alternative levee alignment is considered not to constitute a practicable alternative.

CONCLUSION

42. The District Engineer has determined that the selected alignment is in complete compliance with Executive Orders 11988 and 11990 and is the only practicable alternative for providing flood protection to the city of Marshall. The selected alignment is also generally in agreement with the requirements in the President's 1980 fiscal year budget criteria pertaining to floodplain development. The selected alignment has been coordinated with and reviewed by the Minnesota Department of Natural Resources. The alternative levee alignment was found to be not implementable as it does not constitute a practicable alternative, does not preclude development in the floodplain, and is not acceptable to the city of Marshall.

30. Current projection C represents the most likely future based on recent changes and information. Estimates for 1975 through 1979 use the census estimate for 1977 as a basis for adjusting estimates between 1975 and 1979. The estimates by Southwest State University for student population were assumed throughout the projection period. Increase in dwelling units of all types thus becomes the only other source of resident population increase. According to Barton-Aschman Associates, Inc. there were 3,474 dwelling units in 1977. Based on building and permit activities during 1977 and estimates through 1979, there will be a phemonenal 18 percent increase in dwelling units to a total of 4,077 during the 3-year span. Records of building permit activity for the past 5-years are presented in Table J-5.

Table J-5 - Building permits for new housing (dwelling units) for Marshall, Mn., 1975-79

Year	Single Family	Multiple Family	Total
1975	62	54	116
1976	61	102	163
1977	80	138	218
1978	100	85	185
1979	75	125	200
TOTAL	378 (45 percent)	504 (55 percent)	882 (100 percent)

31. The estimated corresponding increases in population represented by occupancy of these dwelling units is shown in table J-5. An average of three persons per dwelling unit was used to convert dwelling units to population. Estimated absorption of residential land for these dwelling units is also represented based on land use of three single-family dwelling units per acre and 12 multiple-family dwelling units per acre.

Table J-6 - Estimated Increase in Yearly Resident Population at Marshall and Corresponding Demand for Residential Land, 1975-79

Year	Population changes	New residential land absorbed (acres)
1975	+ 348	+ 26
1976	+ 489	+ 29
1977	+ 654	+ 45
1978	+ 555	+ 41
1979	+ 600	+ 36
TOTAL	,646	177

32. In addition to these residential lands absorbed, other categories of public and commercial also increased. These have not been estimated over the same period.

33. Population and economic growth at Marshall was spurred by the location and expansion of Southwest State University during the period 1965-1970. However, population fell during the 1970 to 1975 period as student enrollment dropped drastically. Similar declines at universities were recorded elsewhere in the State and throughout the country. Since 1975 student population at Southwest State University has slowly risen. Marshall is a very vibrant community at the present time. Growth and development at Marshall since 1975 has therefore

been stimulated principally by commercial/business activity. Employment has increased significantly at two agribusiness production companies. These companies have entered an expansion period which has seen development and production of new food products. Aggressive marketing and distribution of these food products throughout the region has been very successful to date. Steady increases in employment at these companies and others is projected to increase for some years to come based on local announcements. In addition to food products, a large nationally known manufacturer of glass products for energy saving storm windows established a plant since 1975 with a large work force. Recent announcements indicate that plant expansion in the next 3 to 5 years will probably double employment. Together with employment multipliers, which increase the service related employment industry, and attendant location of dependents of new employees at Marshall, significant vigorous population growth and economic development can be easily predicted between now and 1985. To a much greater extent than the student population growth from 1965-70, employment growth significantly increases related economic and population changes. However, since the economic activity horizon at Marshall cannot be visualized beyond 1985, a lesser normal increase was assumed from 1985 to 1990. The population change from 1990 to 2000 was extended at the average compound rate of growth for the entire decade of the 1980 to 1990 period. The projected population change from 1979 to 1990 represents an implicit demand for and a projected use of 340 acres of current developable land. These land use needs, estimated by category, are presented in Table J-7.

Table J-7 - Projected land use needs at Marshall, Mn. (1979-1990)

Category	Development lands (acres)
Residential - single	180
Residential - multiple	50
Commercial	50
Public and Other	60
TOTAL	340

34. Lands required for residential use are based on densities per acre previously discussed. Commercial and public categories are in consonance with ratios and needs identified by Barton-Aschman Associates, Inc.[1]

35. The land supply analysis indicates that, at this time, sufficient land (725 acres) is available for site selection through the market process. Generally, as a minimum, twice the number of acres actually used during the demand period should be zoned for the proposed uses.

36. The most probable location of the projected development before 1990 includes land in both the upstream and downstream existing undeveloped floodplain areas as well as the available undeveloped nonfloodplain. Identified development pressure is in the process of determining this future land use pattern. Factors affecting and limiting supply have also been evaluated. Partial residential development is projected to be a pre-project condition in the upstream 125-acre alternate levee alignment area. At a minimum, one residential addition of from 15 to 30 acres is projected before 1990. A maximum development of 30 to 60 acres could occur before 1990. Ultimate development, however, is not projected to occur until after 1990.

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(1) Source:

37. Pre-project development conditions in the downstream area will depend on the needs of Southwest State University and ownership of floodplain lands. Residential development will occur unless institutional arrangements (legal options) have precluded such development. Since the University is floodplain dependent for ready expansion, these acres should be protected and reserved for future expansion at Southwest State University.

38. The above pre-project development conditions are readily predictable based on the above analysis. Specific factors which will stimulate the predicted development pattern are summarized below:

a. Intense near-term demand for 340 acres of available developable land before 1990.
b. Near-term reduction of 150 to 200 acres in supply of existing undeveloped nonfloodplain land due to the Green Acres Protection Act. A portion of these lands should become available prior to project construction but not quickly enough to satisfy the immediate demands.
c. The 315 acres of developable floodplain are all in the 50- to 100-year floodplain except for about 30 acres upstream.
d. Floodplain and nonfloodplain existing undeveloped lands are nearly cost-equal for development purposes above the 50-year flood elevation.
e. Forecast development is presently ongoing in and out of the floodplain adjacent to the floodplain areas associated with the alternate levee alignment and Executive Order 11988; affected upstream area lands are already developer-owned with a similar residential floodplain development project on the market.
f. Undeveloped nonfloodplain lands are available outside the city boundaries which would be developed at higher costs with additional limitations in the existing service delivery system. This type of development is not compatible with the present city development approach as it would necessitate leap-frog development.

SOCIAL CONSIDERATIONS

39. Social considerations involved in local floodplain development decisions for the affected areas included an analysis of related development costs, perceptions of the flood threat, related attractiveness, and access to essential services. Thus, the purpose of this discussion is to assess the potential social implications involved in floodplain development decisions at Marshall.

40. The preceeding paragraphs discuss in detail the existing conditions in the community related to supply and demand for vacant developable lands as well as prospective growth and development in the city. At the present, time, the largest proportion of immediately developable lands within the city boundaries are located in the Marshall floodplain. Consequently, on a short-term basis, it is expected that new development will locate in these floodplain areas, as opposed to areas of higher development cost outside the city limits. Additional development costs would include increased investments in the form of either alterations to the city sewer and water system, or separate well and self-enclosed sewage disposal systems. The Minnesota State Floodplain Management requirement for fill 1 foot above the 100-year floodplain is not considered to be of a sufficient cost (in areas requiring relatively low fill requirements) to offset the added development expense necessary to construct outside the city boundaries at this time.

41. On an intermediate and long-term basis, it is expected that both floodplain and nonfloodplain lands, within the city limits, will be available for development and sufficient to meet projected needs. Choices between these lands for development purposes (assuming equivalent availability) will be made on the basis of cost, perceptions of threat, relative attractiveness, and access to services and amenities.

The relative development costs of readily available floodplain and nonfloodplain areas within the city appear to be equivalent at this time, therefore cost will probably not be a distinguishing criteria in decisions on where to develop.

42. Perceptions of flood threat are not currently impeding development in floodplain area. The Minnesota State Floodplain Management requirements are perceived as providing sufficient protection against severe flood damages, and the provision for flood insurance offered by the Federal Flood Insurance Program provides compensatory payments for any residual damages which may occur from flood events exceeding this level of protection. Threats to human safety associated with potential flooding exceeding this level of protection are not guaranteed against by the fill requirements, yet these residual threats have not served as operational factors in deciding to avoid floodplain areas for residential development. Perceptions of threat may affect development location decisions in areas where personal injuries or deaths have occurred from flood events in recent years. However, no personal injuries or deaths have occurred in the Marshall floodplain during recent floods and therefore the flood threat is not expected to be a major factor in development locational decisions.

43. Aesthetic factors often serve as criteria in determining locations for development, especially for residential uses. As such, development is often attracted to natural floodplains in rural areas, due to the diversity of natural vegetation provided by riverine environments. In the undeveloped portions of the Marshall floodplain the majority of the area is currently under agricultural production and only those lands in close proximity to the river channel exhibit a diverse, riverine vegetation pattern. Therefore, this type of aesthetic consideration is not expected to be an important development inducement for most of the floodplain lands. Another type of aesthetic consideration involved in residential development attraction is compatibility

of different land uses visually proximate to the developable area. Zoning plans by the city for both undeveloped floodplain and nonfloodplain lands provide for highly compatible uses (e.g. areas zoned for residential development are physically separated from lands zoned for commercial and industrial use). In the case of the nonfloodplain developable acreage, park facilities are either currently available or lands are projected for park development in the near future.

44. Access to services and amenities in the form of transportation, retail shopping, and social services also plays a role in locating residential development. The existing road system in Marshall provides easy access to the downtown service area from both the floodplain and nonfloodplain vacant lands being considered for development. As Marshall does not provide a mass transit system which could be used for transportation from outlying residential areas, private vehicles serve as the primary mode of transportation for area residents to necessary services Neither of the undeveloped floodplain or nonfloodplain areas under study could be considered within easy and safe pedestrian access to all existing community services.

45. In summary, there appears to be little differentiation in the relative attractiveness of floodplain and nonfloodplain lands in determining potential development locations, according to the social factors discussed above. Development patterns, should, therefore, be determined solely on the basis of relative cost and availability during periods of peak demand. Since cost are roughly equivalent for both floodplain and nonfloodplain areas, availability is expected to be the key determinant in locating new development. On this basis, a significant proportion of the available undeveloped floodplain acreage is projected to be developed prior to the initiation of any Corps' protection works.

UPSTREAM DEVELOPMENT

46. Development under existing conditions -- Under the existing flood and institutional setting, only a very small portion (5 acres) of the affected area could be developed without changes to the topography. This small area is located immediately upstream of County Highway 7, south of the river, and in the immediate vicinity of the only farmstead in the area. To develop the remaining portion, the floodplain lands would require fill to the 100-year flood elevation plus 1 foot. Such changes are currently occurring inside the alternative levee area on floodplain lands and are readily predictable outside the alternative levee area in the upstream floodplain. Maximum fill height would be about 6 to 8 feet and the average fill height would be about 2.2 feet. Any such landfill would have to provide for maintenance of a suitable floodway meeting State floodplain management requirements. Any future development would be subject to flooding from floods exceeding the flood protection elevation. Residential development of 15 to 60 acres of this floodplain is predicted to be a pre-project condition.

47. Various options would be available to local interests to achieve a designated floodway. One would be the creation of a floodway along the southeast overland flood flow path to the County Highway 7 overflow area and through the area east of County Highway 7 to the river below the existing diversion structure. Floodway requirements could also be met by routing the floodway along the edge of the affected area to tie into the County Highway 7 overflow area. Third, a floodway could be designated along the river channel only with no provision for future overflow over County Highway 7. Preliminary studies indicate that approximately 10 to 15 acres of the cropland area would be required for floodway purposes.

48. Under existing conditions, with no provision for a floodway through the area, approximately 460,000 cubic yards of fill would be required to achieve the 100-year plus 1-foot elevation in the area above Highway 7. Estimated local fill costs would be about $250,000. This area can be developed with or without the selected project. The city's proposed land use of this area is multi-family residential (see plate F-10). Sewer and water facilities of an adjacent development are of sufficient size to accommodate development in this area, and the area is easily accessible to downtown shopping and other essential public facilities.

49. Development of portions of the 125 acre upstream floodplain area would result in certain social effects. Structural flood damages should be avoided for those structures built to State floodplain management standards and any residual damages for flood events exceeding these standards would be compensated for those residences possessing flood insurance. The reduction in risk for property damages, however, does not necessarily imply that no adverse social effects would occur. Until full development of the upstream floodplain area occurred, the periodic presence of ponded water in low-lying unfilled areas would present a safety hazard, especially for small children, if the area was not properly cordoned off. This would be particularly true for that area which currently serves as an overflow area near County Highway #7. In addition to the flood hazard in the 150-acre upstream floodplain area, the developing lands immediately downstream of County Road #7 would have to continue to comply with State floodplain management fill requirements due to continuance of floodwater overflows of County Road #7 during flood events. Other adverse social effects would occur to residents of the floodplain area from disruptions in transportation patterns and the delivery of goods and services.

50. Development with Selected Levee Alignment -- With the selected alignment, the 125 acres could be developed in accordance with State floodplain management criteria without any fill requirements. Thus, the selected levee alignment would result in a direct savings of about $250,000 by not having to fill the area. This is an induced benefit of the levee in that flood protection afforded by the levee may encourage development in the floodplain to occur sooner than the conditions without flood protection. This is particularly true for the low-lying overflow areas on both sides of County Highway #7. However, in the long-term, these areas would be developed under either condition.

51. As previously described in the discussion under "Selected Plan", measures have been incorporated into the levee design to minimize the impacts on human safety, health, and welfare. Based on considering the exposure, severity, and preventative measures, the risk to human safety, potential for loss of life, and magnitude of economic loss are less with the selected plan than without. Interior drainage facilities have been included in the levee design and appropriate storm sewer systems would be required in the upstream floodplain area as urban development occurs.

52. Development with Alternative Levee Alignment -- In the absence of action by the city, 15 to 60 acres of residential development is predicted to occur prior to project construction outside the alternative levee. Alignment with the alternative levee alignment presents at least four evident options for future use of the undeveloped affected lands: (1) the city, having purchased the land in fee (city considers alternative purchase of flood easements to cost as much) could choose to let the land revert to a natural vegetative state; (2) the city could choose to develop the purchase of lands as flood damage-free open-space recreation area, not a critical need now or in the foreseeable future; (3) the city could lease the acquired lands to an operator for continued agricultural productivity; or (4) the acquired lands could be resold for development provided that landfill elevations and floodway requirements are in accordance with State floodplain management regulations.

53. Thus, under the alternative levee alignment, local interests could also develop the floodplain area bounded by the roadside levees provided fill elevation requirements were met. As this alternative would result in an increase in design water surface levels of about 2 feet over existing conditions (due to restriction of the flood flow area), fill requirements would be about double those required under existing conditions for a fill cost of around $500,000. Likewise, the added 2 feet would make the pre-project development again subject to 100-year flood elevations despite raised 1st floors.

54. The alternative levee alignment would result in a number of adverse social impacts in the upstream floodplain area. Development which has and would occur prior to project construction would have to be relocated from the area, as the current fill levels would be inadequate to meet floodproofing requirements with the raised flood elevations. Residential development of the area would be hampered by the levee which would rise well above the first floor elevations of most homes. If the area were not used for residential development purposes, an adequate amount of land would not be available to satisfy short-term demands. Thus, a short-term "tight" land market would occur resulting in escalation of land values in the area. This alternative would have accelerated growth effects similar to those of the selected plan in the low lying floodplain area east of County Road #7.

DOWNSTREAM DEVELOPMENT

55. Development under existing conditions -- Under existing conditions, the 80 acres of agricultural floodplain lands could be developed in compliance with State floodplain management law, if the area were filled to an elevation 1 foot above the 100-year flood level. A 3- to 5-foot maximum (1.7 foot average) fill would be needed to fulfill these requirements. This would involve approximately 220,000 cubic yards of fill at estimated local costs of $120,000. The city's proposed land use of this area is single- and multi-family residential, and a school or college (see plate F-10). Pre and post-project residential

development is predicted to occur in this area in order to satisfy future urban residential growth and development and Southwest State University expansion. The projected expansion of Southwest State University is limited in terms of potential location by the need for keeping facilities (especially student housing) in close proximity to the existing University complex. Development of these facilities on the east side of the T.H. 23 bypass would require certain safety precautions. This might include traffic semaphores or pedestrian overpasses which would either be not in keeping with highway department standards or beyond the present financial capacities of the University. On the west side of T.H. 23, the only nonfloodplain lands available for development and in close proximity to the campus area are presently zoned by the city for general and service commercial development. As growth is also projected for these uses, it is questionable whether the city would transfer these lands for University development. Although city residential growth is floodplain dependent, it can be accommodated in other areas of the city. However, development of the downstream floodplain area is essential to the expansion needs of Southwest State University. Additional undeveloped lands zoned for residential use are available on the east side of T.H. 23, and are currently undergoing minor development. Extension of city services to these lands, however, would result in costs in excess of those required to develop the available floodplain lands, and city annexation of this area might prove difficult due to the present outside development activites.

56. Development with selected levee alignment -- The selected levee alignment allows for development of the 80 acres of floodplain without requiring the fill that would have been necessary under existing conditions. Thus, the selected levee alignment would result in a direct savings of about $120,000 by not having to fill the area. This is an induced benefit of the levee, in that flood protection afforded by the levee may encourage development in the floodplain to occur sooner than the conditions without flood protection. However, on the long-term, the area would be developed under either condition.

57. Development with alternative levee alignment -- As the 80 acres of agricultural land are excluded from flood protection by the levee, development could occur only by filling the area 1 foot above the 100-year flood level, in accordance with State floodplain management criteria. The fill requirements and cost of fill would be the same as that required under existing conditions. Therefore, there is no direct or indirect encouragement for development by the Executive Order 11988 proposal. However, the pre- and post-project residential urban development and Southwest State University expansion which is floodplain dependent would be outside the levee projected area and separated by the embankment from existing pertinent university facilities. Further, if the Highway 23 bypass was constructed along the proposed highway alignment, the alternative levee would be rendered obsolete, with a resultant loss of $199,000 to the national economic development account, in addition to the cost of additional fill required by the bypass to replace the levee that would have been used under the selected plan.

SUMMARY OF FLOODPLAIN DEVELOPMENT POSSIBILITIES

58. The primary purpose in developing the alternative levee alignment was to preclude any induced development of undeveloped agricultural floodplain protected by the proposed levee alignment. Floodplain development with both the upstream and downstream alternative levee alignments is more expensive, but not precluded. Development in the floodplain may still occur in accordance with State floodplain management criteria by filling the floodplain lands to 1 foot above the 100-year flood elevation. With the upstream reach alternative levee alignment, fill costs would be approximately double those with existing conditions (due to the increase in flood stages), while the downstream fill costs would stay approximately the same.

PRACTICABILITY CONSIDERATIONS

59. Included in the objective of the Executive Order is a statement: "Avoid the base floodplain unless it is the only practicable alternative." The practicability of the alternative levee alignment versus the proposed levee alignment was evaluated on the basis of 16 factors listed in the guidelines for implementing the Executive Order.

DEFINITION OF PRACTICABILITY

60. Practicable is defined in the guidelines for implementing the Executive Order as "capable of being done within the existing constraints. The test of what is practicable depends upon the situation and includes consideration of the pertinent factors, such as environment, cost, or technology." Table J-8 is the comparision table developed for determining the practicability of the alternative levee alignment.

EVALUATION OF ALTERNATIVE LEVEE ALIGNMENT

61. The determination of whether a practicable alternative exists is based on the advantages and disadvantages of floodplain and nonfloodplain sites. Factors to be considered in making this determination and the evaluation of these factors are shown in table J-8.

62. As shown in table J-8, one of the major factors considered in this situation was economics. The alternative levee alignment would result in a $891,100 increase in non-Federal costs, an amount city officials say is "far beyond the reasonable acceptance of the city".(1)

In addition, the alternative levee alignment would approximately double the amount of fill needed to meet State floodplain management regulations for development of the area, which amounts to an increase in cost of $250,000. Adjacent sewer and water facilities can accommodate development in this area. Addition location benefits are realized by the

(1)Taken from a letter to the Corps of Engineers from Mr. Robert C. Hirmer, President of the Marshall City Council, dated 10 August 1978.

Table J-8 - Comparison table for determining most practicable alternate

Factors	Selected levee alignment	Alternative levee alignment
Conservation	May accelerate future development of agricultural lands in the floodplain which provide wildlife habitat	Would discourage or retard but not prevent future development of agricultural lands in the floodplain which provide wildlife habitat.
Economics		- Increase in total first costs of $630,700[1] - Increase in non-Federal first costs of $691,100[1] It is considered unlikely that the city has the financial capability to provide this amount.
Aesthetics	May accelerate future development of agricultural lands in the floodplain.	Would discourage or retard but not prevent future development of agricultural lands in the floodplain. Would create a barrier between existing and predicted pre- and post-project development.
Natural and beneficial values served by the floodplain	May accelerate future development of agricultural lands in the floodplain	Would discourage or retard future development of agricultural lands in the floodplain
Impact of floods on human safety	With the selected alignment, there is sufficient freeboard (4.6 feet over 133-year design flood level, 2.0 feet over SPF level) to assure that no overflows would occur to the undeveloped floodplain in question. At floods higher than design levels, the additional freeboard would cause water to be contained between the levee and the Burlington Northern Railroad tracks. Therefore, there is no significant difference between alignments.	With the alternative alignment, there is sufficient freeboard (4.6 feet over 133-year design flood level, 2.0 feet over SPF level) to assure that no overflows would occur to the existing developed city floodplain area. However, the alignment would cause water to be contined between the alternative levee and Burlington Northern Railroad track which would impound water and raise stages, frequency, and duration of flooding to the undeveloped upstream floodplain in question.
The functional need for locating the development in floodplain.	Based on market analysis, pre- and post-project upstream development and downstream development involving Southwest State University are floodplain dependent and protected by project alignment.	Based on market analysis, pre- and post-project upstream development and downstream development involving Southwest State Univeristy are floodplain dependent and not protected by project alignment.
Historic values	---------- No major differences between alignments ----------	
Fish and wildlife habitat values	Riverbank alignment requires removal of approximately 30 large mature shade trees, with resulting long-term adverse effects on song-birds and small mammals which depend on the trees for habitat. May accelerate future development of agricultural lands in the floodplain which provide wildlife habitat.	Would discourage or retard but not prevent future development of agricultural lands in the floodplain which provide wildlife habitat.
Endangered and threatened species	---------- None ----------	
Federal and State designation of scenic or wild rivers	---------- None ----------	
Refuges	---------- None ----------	
Recreational	---------- No major differences between alignments ----------	
Water supply	---------- No major differences between alignments ----------	
Water quality	---------- No major differences between alignments ----------	
Food production	Future development of floodplain agricultural lands may be accelerated.	Future development of floodplain agricultural lands would be discouraged or retarded but not prevented.
Locational advantage	- Makes use of existing high ground, is economically cheaper, and is a more engineeringly efficient levee alignment. - Lower cost to develop, realizing that adjacent sewer and water mains in place are of sufficient size to accommodate development in this area, and fill to 1 foot above the 100-year flood level would not be required under State floodplain management criteria. - Requires relocation of 1 residence and displaces 2 people.	- Increases the amount of fill required for development under existing conditions. - Requires relocation of 4 residences,[2] 5 structures, and displaces 11 people.
Needs and welfare of the people	Acceptable to the city of Marshall and satisfies present and projected future needs.	- Not acceptable to the city of Marshall satisfies existing, but not future needs. - Designed to deter unwise floodplain development.

[1] Includes acquisition and relocation cost of pre-project construction residential development on 15 to 60 acres of land.
[2] Includes relocation and displacements of pre-project construction residential development of 45 to 180 residences and 135 to 460 residents.

selected levee alignment in that it makes use of existing high ground, is economically cheaper, and is a more engineeringly efficient levee alignment.

63. Of the remaining factors listed for practicability considerations, additional benefits to fish and wildlife habitat values were realized by the alternative levee alignment. Approximately half of the proposed channel modifications would not be necessary with the alternative levee alignment. In addition, the alternative levee alignment would discourage or retard future development of agricultural lands which provide wildlife habitat. The selected riverbanks levee alignment requires the removal of approximately 30 large mature shade trees with resulting long-term adverse effects on songbirds and small mammal populations.

64. The alternative levee alignment was determined not to be a practicable alternative as the negative economic, functional need for locating development in the floodplain, and location advantages far outweigh the benefits realized to fish and wildlife habitat values. In addition, the alternative levee alignment is unacceptable to the city of Marshall.

PRESIDENT'S BUDGETARY CRITERIA

65. The President's fiscal year 1980 budgetary criteria require that a "Project does not, directly or indirectly, support future floodplain development in areas other than those near already urbanized areas or where floodplain values have been largely lost and avoids, to the extent possible, the long-and short-term adverse impacts associated with the destruction or modification of wetlands." The selected levee alignment generally meets requirements in that Marshall is an urbanized area, the floodplain land is presently in agricultural use, and the alignment avoids, to the extent possible, adverse impacts associated with any destruction or modification of wetlands.

EXECUTIVE ORDER 11990

OBJECTIVE

66. The objective of Executive Order 11990 is to avoid to the extent possible the long- and short-term impacts associated with destruction or modification of wetlands wherever there is a practicable alternative.

DESCRIPTION OF AREAS AFFECTED

67. The area of concern pertaining to Executive Order 11990 is located upstream of the diversion structure and was described previously in the Executive Order 11988 upstream problem area description (paragraph 5, section J). The selected project is also discussed in the Executive Order 11988 analysis (paragraph 7, section J). Conflict with the objective of Executive Order 11990 resulted from the loss of 2.3 acres of riparian woodland (Type 1 wetland) required by the selected plan for channel modifications.

DESCRIPTION OF ALTERNATIVES

68. The alternative levee alignment described previously in the Executive Order 11988 analysis (paragraph 13, section J) was evaluated with regard to Executive Order 11990 and protection of wetlands. By removing the right bank levee and replacing it with the highway levee alignments, right bank channel modifications would not be required. However, this alternative would still result in the loss of 1.4 acres of riparian woodland (Type 1 wetland) required by the left bank channel improvements. The left bank channel improvements are necessary to protect the Burlington Northern Railroad embankment and the left bank levees near County State Aid Highway 7 and downstream of the drop structure.

PRACTICABILITY CONSIDERATIONS

GENERAL

69. Included in the President's Executive Order 11990 is a statement that new construction should not be allowed in the wetlands unless "there is no practicable alternative to such construction and ... the proposed action includes all practicable measures to minimize harm to wetlands which may result from such use." The alternative levee alignment was evaluated to determine if it was a practicable alternative capable of minimizing the loss of 2.3 acres of Type 1 wetland.

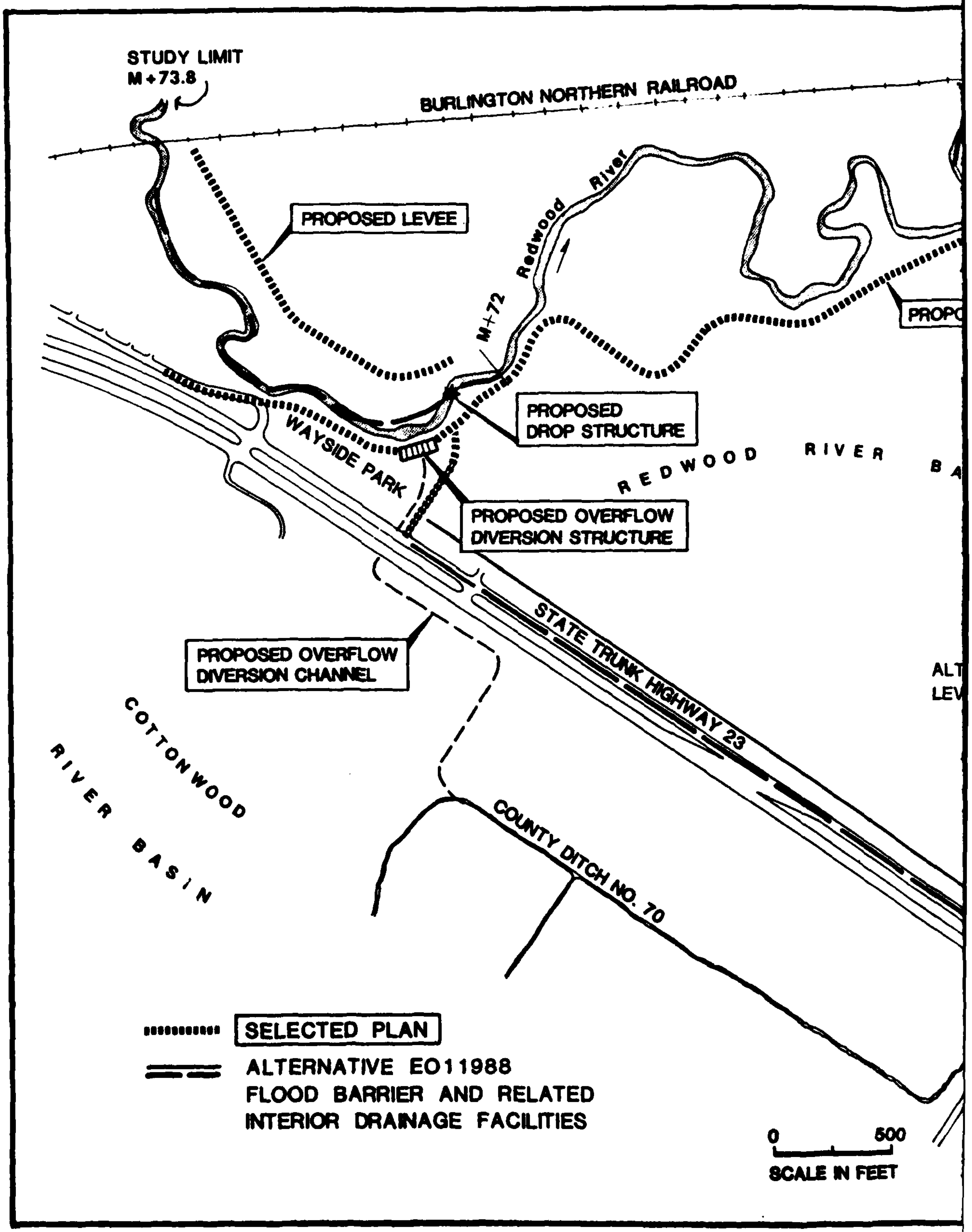
EVALUATION OF ALTERNATIVE LEVEE ALIGNMENT

70. The alternative levee alignment would save 0.9 acre of riparian woodland from destruction due to right bank channel modifications, resulting in an increase in non-Federal first costs of $891,000. However, this alignment would still require the taking of 1.4 acres of Type 1 wetland. This large increase in costs is unacceptable to the city of Marshall. Other factors relating to the practicability of the alternative were discussed previously in the Executive Order 11988 analysis (paragraph 54, section J). For these reasons, the alternative levee alignment is considered not to constitute a practicable alternative.

CONCLUSION

71. The District Engineer has determined that the selected alignment is in complete compliance with Executive Orders 11988 and 11990 and is the only practicable alternative for providing flood protection to the city of Marshall. The selected alignment is also generally in agreement with the requirements in the President's 1980 fiscal year budget

criteria pertaining to floodplain development. The selected alignment has been coordinated with and reviewed by the Minnesota Department of Natural Resources. The alternative levee alignment was found to be not implementable as it does not constitute a practicable alternative, does not preclude development in the floodplain, and is not acceptable to the city of Marshall.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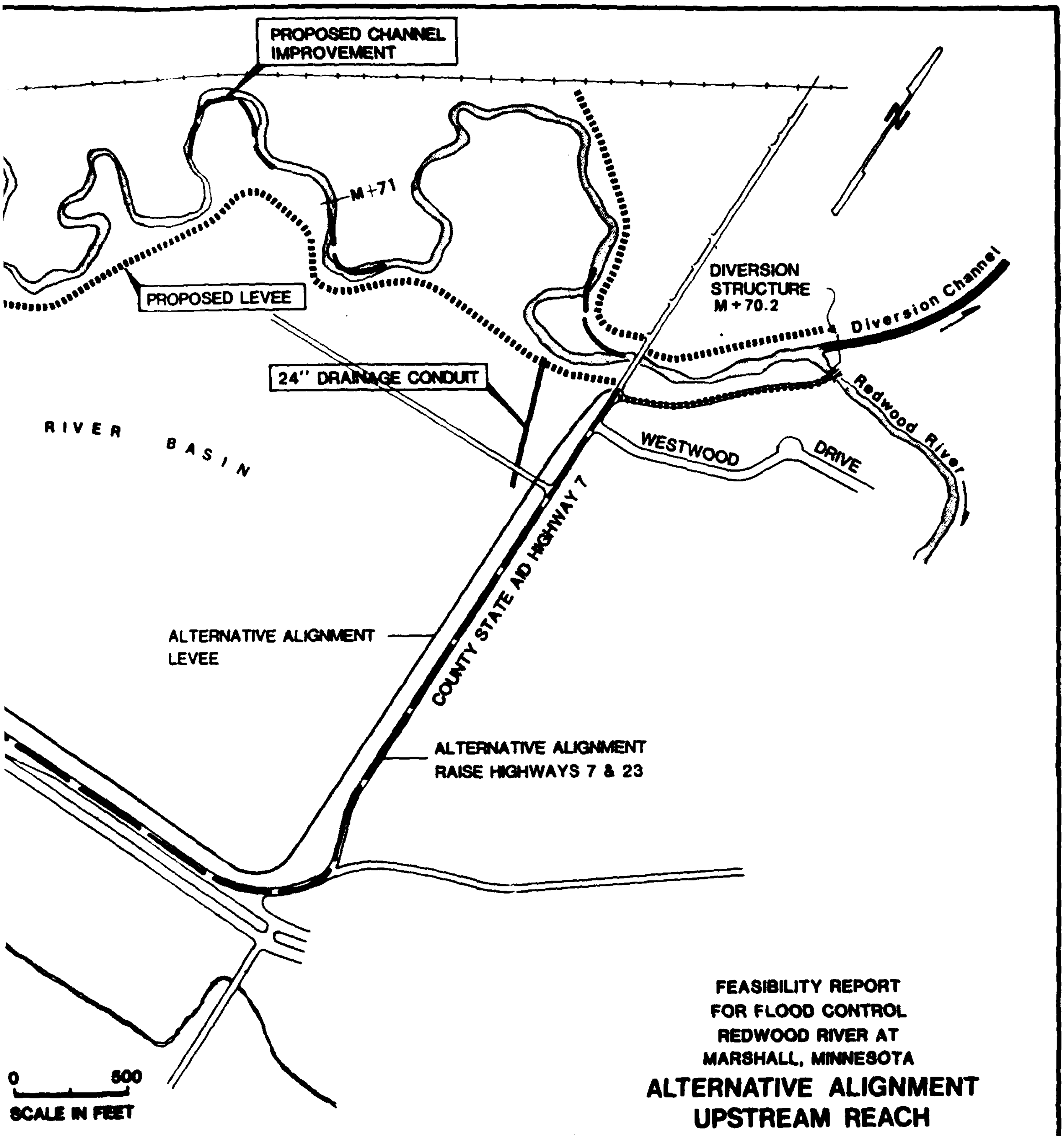
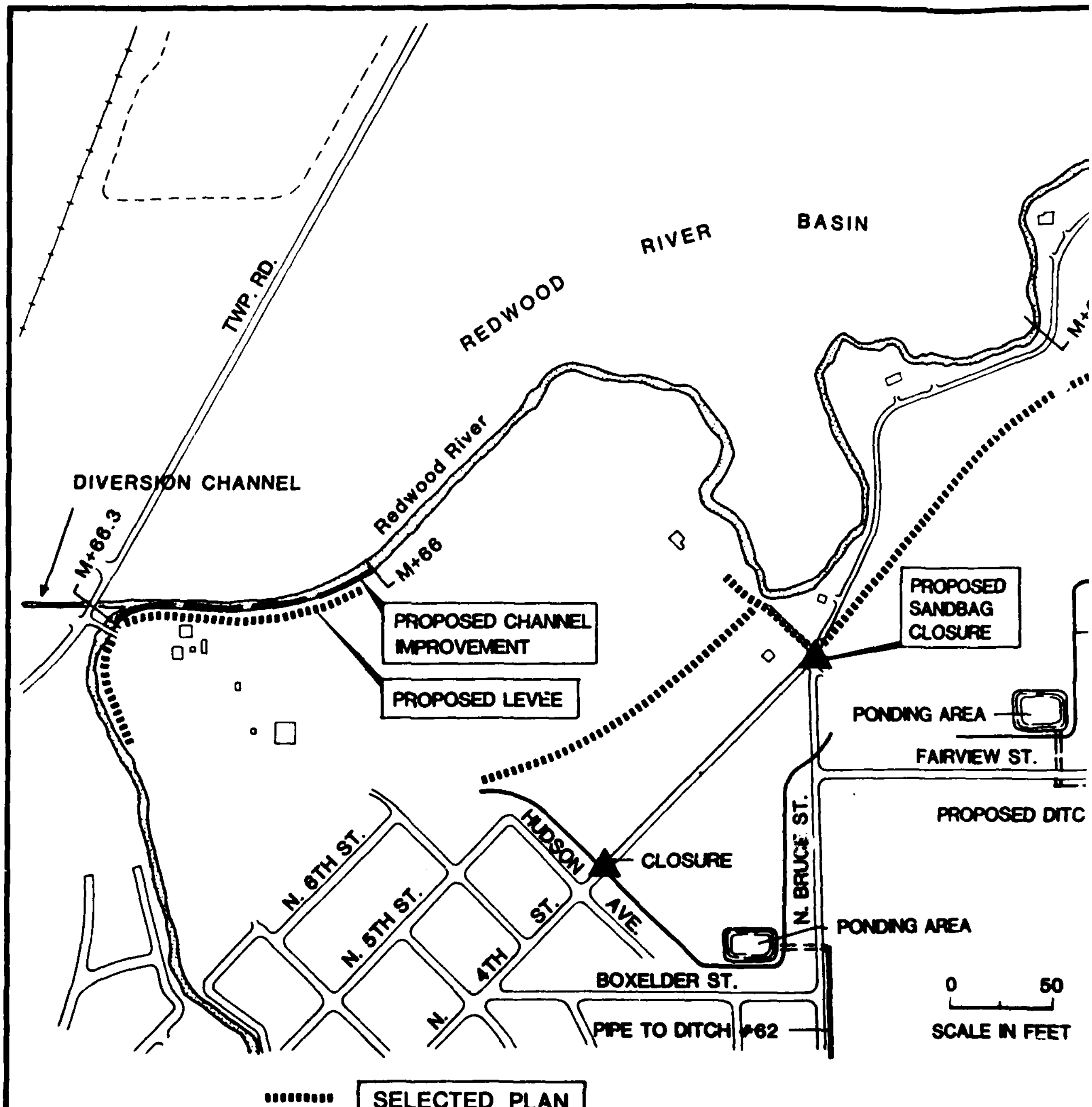
M+73.8
BURLINGTON NORTHERN RAILROAD
PROPOSED LEVEE
Redwood River
M+72
PROPOSED DROP STRUCTURE
WAYSIDE PARK
REDWOOD RIVER BA
PROPOSED OVERFLOW DIVERSION STRUCTURE
STATE TRUNK HIGHWAY 23
PROPOSED OVERFLOW DIVERSION CHANNEL
COTTONWOOD RIVER BASIN
COUNTY DITCH NO. 70
SELECTED PLAN
ALTERNATIVE EO11988
FLOOD BARRIER AND RELATED
INTERIOR DRAINAGE FACILITIES
0
500
SCALE IN FEET



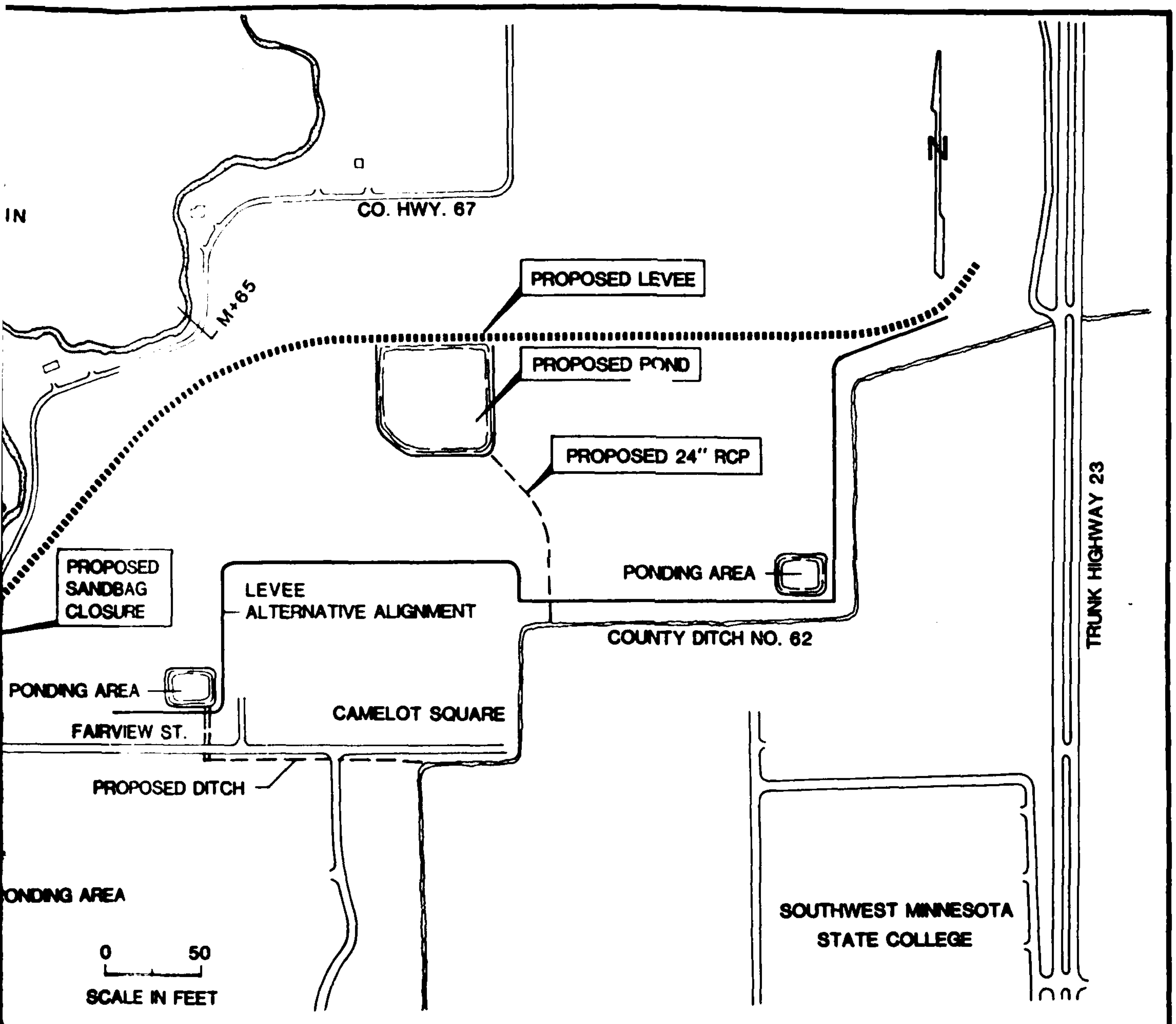
FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

ALTERNATIVE ALIGNMENT
UPSTREAM REACH

PLATE J-1



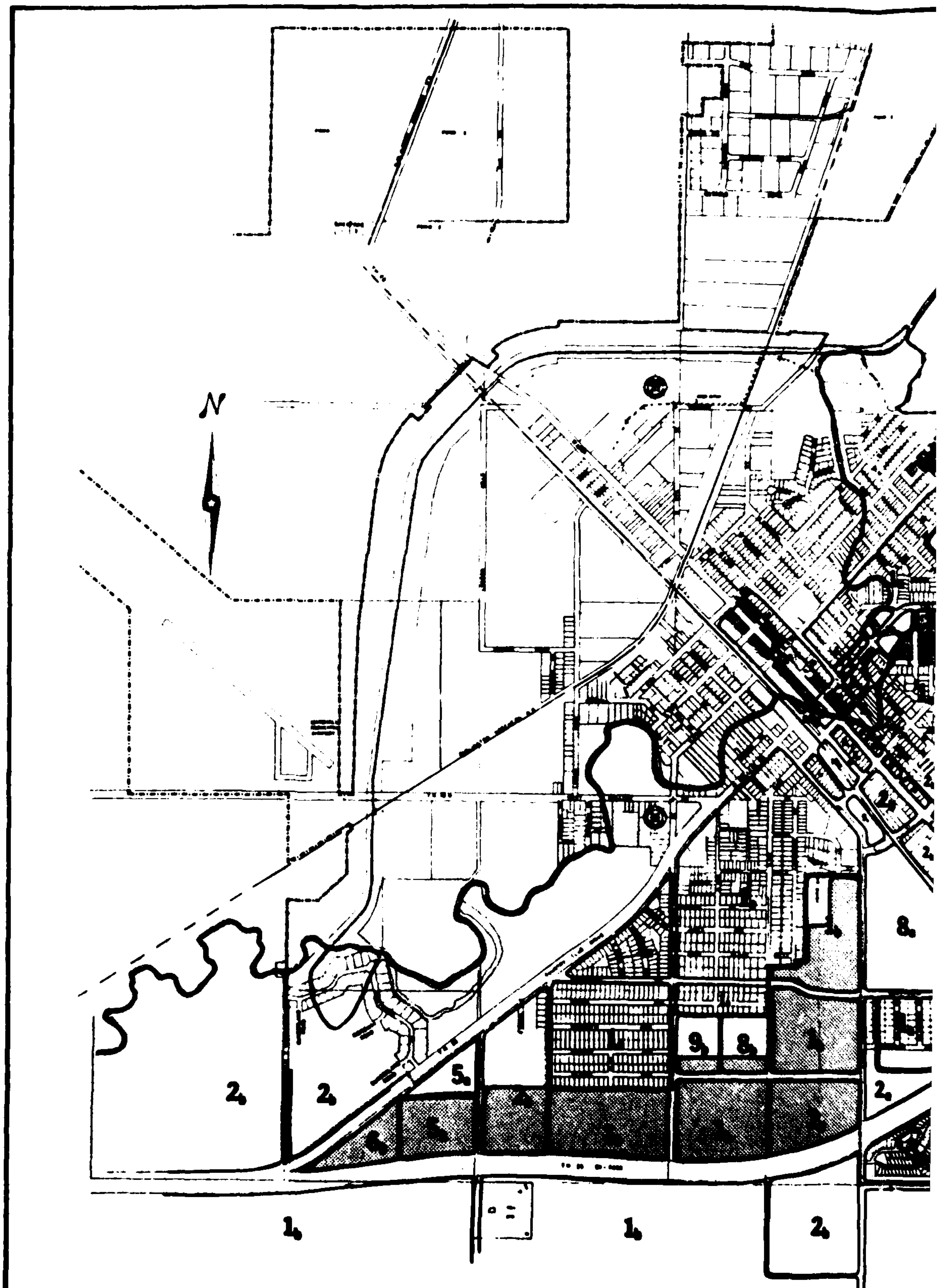
ALTERNATIVE EO11988
FLOOD BARRIER AND RELATED
INTERIOR DRAINAGE FACILITIES



FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

ALTERNATIVE ALIGNMENT
DOWNSTREAM REACH

PLATE J-2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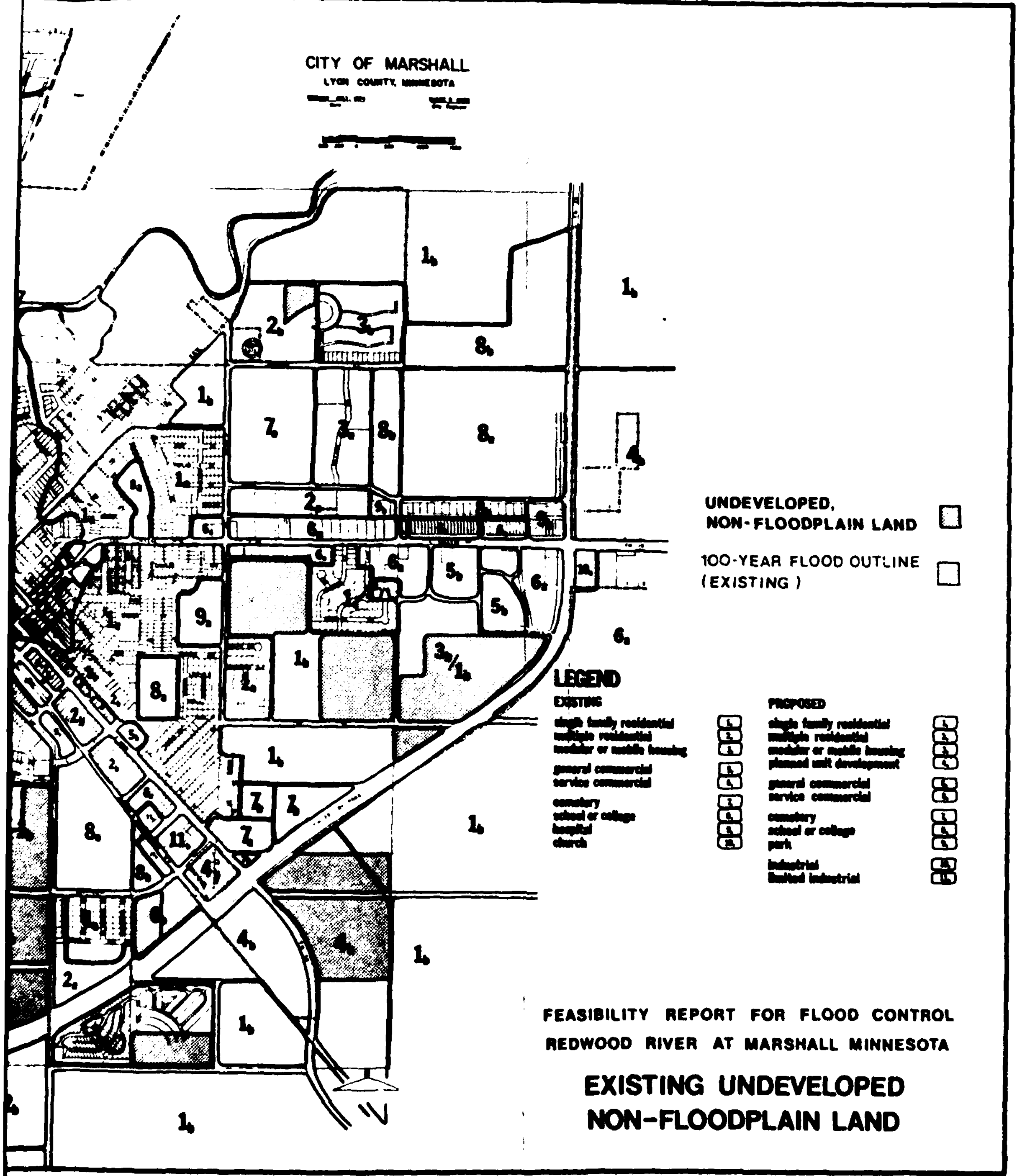

FEASIBILITY REPORT FOR FLOOD CONTROL
REDWOOD RIVER AT MARSHALL MINNESOTA

EXISTING UNDEVELOPED NON-FLOODPLAIN LAND

PLATE J-3

FEASIBILITY REPORT FOR FLOOD CONTROL

REDWOOD RIVER AT MARSHALL, MINNESOTA

PERTINENT CORRESPONDENCE

APPENDIX 2

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

Appendix 2

Coordination With Other Interests and Public Involvement

Coordination

The Marshall feasibility study for flood control was initiated in 1974. Several working meetings were held with representatives of the City of Marshall, Lyon County, Minnesota Department of Transportation regional office at Willmar, Minnesota, and the Minnesota Department of Natural Resources field office at Marshall. Various other State and Federal agencies having an interest in the study area were either contacted in person or by correspondence. Other organizations and individuals contacted during the study included the Burlington Northern Railroad regarding their improvements in the area, the State College at Marshall, and numerous individuals interested in area flood damage reduction and recreation needs.

Formulation stage meetings to apprise local officials and the public on alternative measures considered for the upstream and downstream study reaches were held on 3 March 1975 and 20 October 1975 respectively. Views and comments received at these meetings were used in developing the proposed plan of improvement. A draft Marshall, Minnesota feasibility report was distributed to all interested Federal, State, and local agencies for review and comment in November 1976. A late stage public meeting was held in Marshall during February 1977 to receive comments and any suggested modifications to the proposed plan of improvement. Other than minor alignment changes suggested by the City, no major adverse comments were received regarding a plan providing a 100-year level of flood protection.

Subsequent review by higher Corps authority of the draft report resulted in a recommendation for reformulation of upstream reach alternatives to include consideration of two additional alternatives and re-analyses of the proposed level of protection. The additional studies resulted in no basic change to the proposed plan of improvement but provided for an increase in the level of protection to the 133-year flood level with attendant raises in flood barrier heights and re-sizing of the proposed State Highway 23 culverts.

On 2 March 1978, a meeting was held with City officials to review the revised study recommendations. The City generally concurs with the recommendations as indicated in their March 1978 letter included in the attachments to this report section. Since no major changes to the original study findings were made, recirculation of the draft report and draft EIS and another late-stage public meeting were not considered necessary.

On 30 March 1978, a meeting was held at the Minnesota Department of Natural Resources to discuss the proposed project. St. Paul District, Corps of Engineers, U.S. Soil Conservation Service, Southern Minnesota River Basin Commission, and Minnesota Department of Natural Resources were represented. Discussions at this meeting covered the proposed project with emphasis on the interbasin crossflow analysis, the protection of undeveloped lands, and mitigation of the 4.2 acres of woodland that would be lost. Subsequent new evaluation of these concerns resulted in no significant changes to the report other than clarification of existing condition and proposed project condition overflows into the Cottonwood River basin.

Subsequent to this coordination, extensive analysis was made of the proposed levee alignments in response to Executive Orders 11988 and 11990. A substantial reanalysis of the proposed recreational improvements was also made resulting in the extension of the proposed trail system upstream ot the Highway 23 wayside park and deletion of two connecting segments from the proposed federally cost-shared plan.

The results of these studies and studies responding to Section 404 concerns were discussed with City officials and interested public at a 2 April 1979 meeting in Marshall. Resolutions of intent to meet required items of local cooperation for both the proposed flood control and recreational improvements were adopted by the City at this meeting. Related correspondence and the resolutions from the City are included in the attachments to this report section.

A summary of comments received regarding the draft report submitted in November 1976 together with a related discussion is given on the following pages. Correspondence received subsequent to this initial review and interim correspondence received since the February 1977 late-stage public meeting is included in the attachments.

TABLE OF CONTENTS

ATTACHMENTS

LIST OF ATTACHMENTS

Agency Comments on Marshall, Minnesota
Feasibility Report For Flood Control

Agency	Comment	Response
U.S. Dept. of Transportation	We have reviewed the draft environmental impact statement and feasibility report for Flood Control on the Redwood River at Marshall, Minnesota. We have no comment to offer on either document.	Noted
U.S. Coast Guard	Thank you for the opportunity to review your feasibility report and environmental impact statement.	Noted
Federal Highway Administration	The approved Federal-aid road system is not entirely shown on the exhibits and the discussion of them is very sketchy. Proposed FAU 5764 starts west of Marshall at TH 19 just east of the existing river diversion channel and follows it northerly and easterly to where it ends at the existing river. From that point FAS 6072 extends in a generally easterly direction south of the river and ends at TH 23. This total system constitutes the northerly bypass of Marshall.	Changes have been made to the report.
	It would be desirable if the text and the exhibits would make reference to approved Federal-aid road system within the confines of the project limits. This would entail the same treatment as discussed under comments on the environmental statement.	Changes have been made to the report.
U.S. Dept. of the Interior National Park Service	No established or studies units of the National Park Service or sites eligible for registration as National Historic, Natural or Environmental Educational Landmarks appear to be adversely affected by this study.	Noted
	We note that the State Historic Preservation Officer was consulted concerning this project (page 57). Therefore, we suggest that his recommendations be followed including procedures for archaeological resource mitigation.	Noted
	Due to the high probability of archaeological sites existing within the impact area (Appendix I, B-11), we recommend an archaeological survey be undertaken for all areas affected by the proposed action. Consultation with the State Archaeologist, Dr. Elden Johnson, Department of Anthropology, University of Minnesota, Minneapolis, MN 55455, is suggested in order to coordinate archaeological survey and recovery during project development.	An archeological survey would be made of the proposed project area during the post-authorization planning studies and would be closely coordinated with the State Archeologist.

Agency Comments on Marshall Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
U.S. Dept.of Interior (continued)	Our review of this document and the Fish and Wildlife Service's investigation of the project has disclosed that fish and wildlife resources of the area would be affected in minor or temporary ways as described in the DEIS. We believe that adequate measures have been proposed in the report to minimize these adverse effects. However, we believe that the feasibility report, as an authorizing document, does not contain an adequate description of the fish and wildlife resources nor the effects of the project on them. Therefore, we recommend that the description of the fish and wildlife resources and the effects of the project on them, as found in the DEIS, be included in the appropriate sections of the Draft Feasibility Report.	We believe that as an accompanying document, the draft EIS is the appropriate document for a detailed discussion of impacts on resources discussed in Section B and F of the draft Report.
U.S. Dept.of Agriculture	The effects of the proposed project on agriculture land and agricultural production appear to be adequately addressed by the draft.	Noted
Soil Conservation Service	*Page 20, Section 4.005, last sentence - figure should be 6,500 not 8,200.*	The appropriate change has been made to the report.
	We feel that the proposed plan will provide the needed protection for Marshall and is the most feasible solution presently available for the reduction of flood damages in the city of Marshall, Minnesota.	Noted
	We suggest that the section on Upstream Reservoir Storage - Plan 4, be rewritten to allow for reappraisal under the authorized joint, Army Corps of Engineers and Soil Conservation Service "639 Study".	The description of alternative plan 4 - Upstream Storage, in both the main and technical reports has been revised to reflect consideration of upstream storage possibilities in the current joint "639" study.
	Preliminary flood routings made as a part of the Southern Minnesota Type IV Study, indicated that a reservoir structural program would reduce peak flows at Marshall. Considerable agricultural flood damages occur along the Redwood River both upstream and downstream of Marshall. This problem will be addressed by the "639 Study".	See above paragraph

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
Soil Conservation Service (Continued)	We do feel that the flood control project for Marshall will complement any overall measures proposed for the Redwood River as a part of the joint "639 Study".	See above paragraph.
U.S. Dept.of Agriculture Soil Conservation Service (Continued)	Page 18, 2nd paragraph of Draft Report, last sentence add dollar sign to 609,200.	Change made to draft report.
	Page 21, of Draft Report, Upstream Reservoir Storage - Plan 4 - Several Comments	Change Made to draft report.
	This write up should allow for possible "639 Study" project solutions. For example, "any reduction in peak flows resulting from upstream storage would compliment this proposal by reducing both the over flow into the Cottonwood River Basin and flows through the project area".	Noted
	The Southern Minnesota Type IV Study indicated that utilization of storage on Lake Benton, Dead Coon Lake and other potential upstream locations would reduce the 100-year discharge to approximately 6,500 cfs at Wayside park where the proposed diversion is located.	Noted
	Page 21, Plan 4 states in part - "Clearly shows that a single large reservoir would lack sufficient storage capacity". Appendix I-D11 states that "One site was identified as having sufficient storage".	Change made to draft report.
	Page 21, Plan 4, 2nd paragraph. Suggest changing in part to read - A system of small reservoirs on headwater tributary streams presently under consideration to solve agricultural flooding would be located too far upstream and have too little storage volume to provide the desired flood protection for the city of Marshall. The last sentence in the above paragraph could remain as is. Appendix I page D12 should be changed to reflect the above wording.	Change made to draft report.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
U.S. Department of Commerce	I would only mention the needs which the National Weather Service has with regard to its flood forecasting responsibility to the Marshall area. We see the need to locate a river gage such that complete discharge information can be obtained from a single reading. Telephone conversations between our two offices indicate that this work is proceeding which we find most reassuring.	Noted
National Weather Service Forecast Office	With climatological data received for the 1976 calendar year a change may be of value to the body of the report. On page B7 Appendix I, of the Feasibility Report under the section labelled "Climate" I offer one revision. The total liquid precipitation for 1976 totalled 12.05 inches at the NWS's Marshall station and this quite easily surpasses the previously held record of 17.36 inches.	Page B-7 of report Appendix I has been revised to reflect the most current climatological data.
	Page 18, Line 2-3 of Draft Report - "periodic" should be removed. Flood warnings are not at fixed time intervals, but are due to hydrometeorological conditions as they are anticipated to occur. Accordingly, we suggest in line 3 - "flood warnings issued by the National Weather Service Forecast Office in Minneapolis of impending Redwood River flood occurrences...etc."	Page 18 of the report has been revised to reflect suggested changes.
	Page E-2, First Para: We suggest a last sentence as follows: "In addition, river and flood forecasting, an intergral part of the design and operation of levees and other flood control systems and basic to good multi-purpose water management, will continue to be needed."	Page E-2, 1st paragraph has been expanded to include suggested additional text.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
U.S. Environmental Protection Agency	We have completed our review of the Draft Environmental Impact Statement (EIS) for Flood Control Redwood River at Marshall, Minnesota. Your letter of December 1, 1976, requested our views and comments on the proposed action. We note from our review of the EIS that construction is being permitted to take place within flood prone areas. We believe flood protection measures are appropriate for previously developed areas, but that a comprehensive flood control program should include restriction of further development in flood prone areas. Flood protection should be provided only for those areas which are developed at the time of the filing of the DRaft EIS with the Council on Environmental Quality. Furthermore, the Final EIS should also contain additional information on the construction impacts and the impacts which will result from the completion of the flood diversion channel. Our detailed comments follow.	The primary purpose of the project is to protect the developed area of Marshall both within the City and downstream of the city in the area of the college. We acknowledge that the project would make flood plain lands available for development in both upstream and downstream reaches due to increased flood protection and decreased fill requirements. Alternative levee alignments were developed that included undeveloped flood plain from protection. Analysis of these alternatives showed that they did not constitute "practicable" alternatives (as defined by E.O. 11988) nor did they preclude development of the flood plain. In addition, the selected alignment generally meets the requirements in the President's fiscal year 1980 budget criteria pertaining

Agency	Comment	Response
U.S. Environmental Protection Agency (continued)		to flood plain development. (See also Appendix 1, Section J). The City of Marshall has recently adopted a flood plain zoning ordinance which is based on a Corp of Engineers flood plain information study. The unincorporated flood plain reaches upstream and downstream of the city are subject to flood plain management regulations currently in effect for Lyon County.
	As part of the flood protection, a flood diversion channel will be constructed. This flood diversion channel will divert one-half of the excess of the present design discharge. These excess overflows will be discharged into the Cottonwood River Basin. Additional information and discussion must be provided on the present water quality of the receiving stream. The effect upon the water quality from the addition of flood flows also needs to be assessed. Based upon information in the EIS, we have assumed the diversion channel to be dry during normal periods of the year. Flood flows can have a high velocity and great amount of energy. The potential for erosion and channel damage should be assessed.	No water quality data is available for the receiving stream at the point of inflow of excess overflows from the Redwood River basin. However, since the frequency and magnitude of such overflows would both be less than occurs under present conditions, no increased adverse effects on water quality are expected. The potential for erosion during high flows in the overflow diversion channel has been anticipated with designed riprap provided at critical channel bank, bend, and bottom areas.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
U.S. Environmental Protection Agency (continued)	Since flood flows will be discharged into the Cottonwood River Basin, an assessment of flooding potential in this basin should be provided. The two watersheds are essentially next to each other and the same meteorological conditions would be expected over each basin. Therefore, if flood flows were occurring in the Redwood River Basin, one would expect flood flows in the Cottonwood River Basin. The circumstances which would change the effects of flooding in the Cottonwood Basin are the proximity to communities, areas subject to flood damages and crop and land damages and channel depth and width. The Final EIS should thoroughly discuss how the diversion of flood flows from the Redwood River basin will affect the Cottonwood basin.	The frequency and magnitude of Redwood River overflows into the Cottonwood River basin indicate both would be less than that which occurs under present conditions. Thus, flooding potential on the Cottonwood River will be slightly reduced. A detailed analysis of the diversion of flow under conditions with and without a project may be found in Section H of Appendix 1 of the Feasibility Report.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
U.S. Environmental Protection Agency (Continued)	The proposed channel work may affect the ability of stream discharges to meet water quality standards. Information on the discharge points and changes in the stream's assimilative capacity which may occur as a result of construction should be provided. This information will indicate whether or not the discharger will still be capable of meeting water quality standards.	Implementation of the proposed channel works would likely improve stream water quality due to reduced channel bank erosion and turbidity. Elimination of shallow slack water pools in areas of channel improvement would likely improve the assimilative capacity of the stream. Individual discharges would not be affected by the proposed works.
	The EIS stated the flood control project is necessary to protect new development in hazard area. It is our opinion that flood protection and flood control projects should provide protection only to areas which are presently developed, and not encourage development in flood hazard areas. To minimize flood damages and project cost, protection should be provided where development has occurred prior to the filing of the EIS with the Council on Environmental Quality. As a minimum, we recommend building restrictions on previously undeveloped flood plain areas to assure adequate flood protection to the community.	Development may occur in the flood plain in accordance with state flood plain management criteria by placement of fill to 1-foot above the 100-year flood elevating. See also response to EPA comment No. 1 and Appendix I, Section J of the Feasibility Report.
	The EIS has indicated the reoccurence interval for this project has been reduced from 114 years to 59 years. The Final EIS should discuss whether or not this reoccurence interval will be further reduced.	The recurrence interval of 114 years for the original design flood now represents a 59-year frequency based on revised frequency-discharge relationship primarily attributed to the occurrence of major floods in recent years whereas only one (the 1957 flood) had occurred prior to study of the present project. The frequency discharge relationship at Marshall under existing conditions has been formally agreed upon by interagency agreement between the Corps of Engineers, SCS, and USGS. Nor further revision of this relationship is anticipated.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
U.S. Environmental Protection Agency (Continued)	In the EIS, water quality studies have indicated any pooling of the Redwood River could promote algal growth during periods of suitable light and temperature conditions. Part of the flood control plan calls for a ponding area to be constructed. The potential for algal blooms and insect propagation at this ponding area should be assessed.	Algae blooms and insect propogation are not expected to be a problem in the proposed ponding area since the ponding area would not have any isolated shallow areas and would contain water for only a few days.
	There are two beaver dams within the watershed. One beaver dam will be removed during construction. The EIS should indicate whether or not the beaver dam is causing increased flood conditions at Redwood. This loss of the beaver dam should be avoided, if possible.	Although detailed hydraulic analysis of the effect of the beaver dam is impractical, it is considered that the dam together with others channel obstructions raises the stream level during flood periods. Required reshaping and riprapping of the river channel in the vicinity of the dam to prevent channel bank erosion requires removal of the dam.
	Additional information in regard to the disposal of levee excavation material should be provided.	Other than removal of topsoil along the levee alignment and excavation of an inspection trench along selected reaches, no other excavation would be required. Topsoil removed would be stored in the project area for re-use on the levee. Unsuitable material excavated from the inspection trench would be disposed of on the designated disposal areas.
Minn. Dept. of Agriculture	The plan proposes the conversion of 15.8 acres of agricultural land for the flood control project plus 178 acres for project-induced residential and commercial-industrial development. The report states, "This cropland loss is insignificant in itself, but a part of cumulative losses of agricultural land throughout the United States."	The report has been revised to properly indicate the significance of agricultural lands required for construction of the proposed project and in the

Agency	Comment	Response
Minn. Dept. of Agriculture (Continued)	This Department is very concerned about the loss of agricultural land in Minnesota. We feel that any loss of the magnitude proposed for this project is significant, and we do not appreciate such proposals. However, we realize the necessity for flood control projects which, hopefully, will minimize adverse conditions to the surrounding environmental, agricultural production and human life. We generally support such proposals.	future lost to induced residential development. The projected conversion of agricultural lands to future residential development is indicated in Comprehensive Plan for the City of Marshall.
	It appears at this time that any agriculturally related topics have been sufficiently addressed by the Draft Environmental Impact Statement and Feasibility Report.	Noted
Minn. Pollution Control Agency	It is our understanding that the proposed project is the third attempt for flood control measures on the Redwood River at Marshall. Previous attempts by the City and Corps of Engineers have been unsuccessful in relieving the flood problems. Several questions remain unanswered concerning the increase in flood potential. The MPCA requests that attention be given to the following concerns:	Existing flood damage reduction measures have been completed by the City and the U.S. Army Corps of Engineers. These projects have reduced flood damages as evidenced during the April 1969 flood. It was also evident that the existing federally-constructed project did function as designed but that channel upstream of Marshall prevented adequate conveyance of floodwaters to the project.
	a. What have been the impacts of such activities as drainage of wetlands, agricultural and municipal development and previous flood control measures on the flood stage?	Undoubtedly the increased drainage of wetlands and agricultural lands and increased rates of runoff from developed basin lands have contributed to an increased flood potential at Marshall. The reversal of these activities to original conditions would be unrealistic. As indicated above, the local and federally constructed measures have reduced flood stages but still leave the City without an adequate level of protection.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comments	Response
Minn. Pollution Control Agency (Continued)	b. Why have flood estimates been increased so substantially from previous estimates? Is this due to the short period of record and, if so, should the floods in recent years be considered aberrant?	Flood discharge-values have been revised based upon an updated frequency - discharge analysis reflecting recent large floods and mutually agreed upon by the Corps of Engineers, SCS, and USGS.
	c. If drained wetlands were restored and farming practices modified, would upstream reservoirs be an alternative to channelization?	The restoration of wetlands as temporary peak flood storage areas would aid in reducing peak flood stages but would be inadequate to provide enough storage for the major flood peaks
	Due to complex natural flow upstream and downstream of the project, attention should be given to the impact on flood stages downstream in the Redwood and Cottonwood Rivers. Previous failures to control floods would indicate that basin floods are not properly understood. The draft feasibility report should include a complete discussion on downstream flood impacts before an assessment of the benefits and the costs can be properly made.	The impact of flood flows downstream of Marshall on the Redwood River is understood. Approximately 50 percent of the 100-year flood overflow which would under present conditions, cross over into the Cottonwood River basin is diverted through Marshall and downstream along the Redwood River. This increase in flow would result in a slight stage rise along the agricultural reach between Marshall and the U.S. Highway 23 crossing at Redwood River mile 58.3. Average annual damages from this increase in stage are estimated at $1300 annually or 2 percent of total annual flood damages at Marshall and have been reflected in the economic analyses. The matter of interbasin flood overflows is presently being investigated in the joint SCS-Corps 639 study.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comments	Response
Minn. Pollution Control Agency (Continued)	Will further protection be needed for the wastewater stabilization ponds and other waste water treatment systems?	Located on high ground, the wastewater stabilization ponds do not require flood protection. The existing waste treatment works would be adequately protected by the proposed flood control measures.
	Can the diversion channel which was constructed in 1963 be expanded to carry flood waters? Would this alternative result in less aquatic biological, terrestrial, wildlife, aesthetic and water quality impacts?	Little benefit would be gained from increasing the capacity of the existing diversion channel since the real problem is the inadequate natural channel capacity upstream of the diversion channel.
	We believe that these studies do not adequately address the upstream and downstream impacts and increased water pollution from secondary effects. At this time, the MPCA does not believe the proposed project adequately addresses alternatives such as upstream reservoirs and expansion of the 1963 flood control measures. Finally, we believe that further evaluation of the predicted flood levels is necessary to determine the need for and/or the ultimate scope of the project.	Studies conducted by the Corps of Engineers in 1960 and a recent review of these studies together with recent SCS studies indicate that upstream storage capacity sufficient to eliminate local flood damage reduction measures is inadequate without the total environmentally adverse disruption of the Camden State Park, the only potential site of adequate capacity. Expansion of the existing facilities would be of little benefit without the proposed upstream and downstream measures.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comments	Response
Minn. State Planning Agency	In order to maintain "natural" hydrologic conditions, 50% of the overflows in the vicinity of the Highway 23 roadside park will be diverted into the Cottonwood River Basin (page 22, paragraph 1). Are conditions still "natural or pre-development"? If they are not, can an equivalent percentage of overflow be diverted to the adjacent basin without damage to land or property in this area?	It is believed that the near equal distribution of flood overflows between the Redwood and Cottonwood River most closely represents that which would occur under both predevelopment and existing conditions without emergency flood fight measures. This distribution is also considered to result in the least net economic flood damage and adverse effects to development in both basins.
	Areas downstream of the study limits were not evaluated since they would not benefit from the project (F-2, paragraph 4). Might these areas be adversely affected? If so, how and to what extent? If there are potential adverse effects downstream, shouldn't this be included in the B/C analysis as an additional cost?	The effects of the proposed flood damage reduction measures on the flood plain reach downstream of Marshall has been evaluated. At the design flood level the proposed measures would result in approximately One-half foot stage increase along the river between Marshall and the U.S. Highway 23 river crossing with dimished increases in flood water levels beyond that point. This increase in stage would result in estimated average annual losses of less than 2 percent of total estimated average annual damages.
	Newly protected floodplains will attract development. Will this expansion plus the proposed flood control facilities necessitate future flood control measures? Will future zoning restrict development in the adjacent unprotected floodplain?	The proposed flood control measures at Marshall are not expected to result in the need for additional future measures since the analysis explicitly recognizes that flood plain regulations to control development in unprotected areas be in effect and enforced prior to possible construction of the proposed measures.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comments	Response
Minn. State Planning Agency (Continued)	The Feasibility Report states the acreage that will become available for development due to the projected flood protection. Varying figures for the land types opening up for residential development are listed. (E-13, F-20) Please consolidate and clarify this information as to the acreage of land types becoming available for development. Also, is the 64 acres suggested for future nature area acquisition included in any of the acreages of land soon available for development?	In summary, 85 acres of agricultural land in the flood plain downstream of Marshall would be provided flood protection. Another 120 acres of vacant and agricultural land in the flood plain immediately upstream of Marshall would be afforded protection. Approximately 42 acres of land would be required for construction of the proposed measures.
	Please check Table 1, Comparison of Alternatives Considered Feasibility Report. It appears (x $1000) was inadvertantly omitted following the Economic Planning Objective Parameters of Flood Damage Reduction and AVerage Annual Benefits.	The appropriate changes have been made to Tables 1 and D-1 of the report.
	We question the inclusion of location benefits (F-20) in the economic analysis. Since a benefit is attributed to the increased value of newly protected floodplain land, shouldn't the possible costs to downstream areas also be included....	The inclusion of flood proofing cost savings benefits is considered appropriate in this case since the presently undeveloped area to be protected is identified as future residential development in the approved Marshall Comprehensive Plan and since this area represents the best economic choice over flood-free lands located further away from Marshall.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comments	Response
Minn. State Planning Agency (Continued)	What specifically is planned for each of the two years of construction? How will the timing of the various stages of project construction be implemented to minimize pollution (erosion, dust, etc.)?	The specific sequence of proposed construction activities would be established in detailed planning studies if authorized. However, it is expected that construction activities would be scheduled to minimize adverse effects on area wildlife. Measures to reduce pollution such as dust, turbidity, and burning of debris would be accomplished in accordance with Corps regulations.
	Basically, the report is quite complete. Our major concerns are the possibility of adverse effects in the Cottonwood River Basin and in downstream areas beyond the study limits, the possible need for expanding flood control measures in the future, and the timing of construction. We would like to stress that out agency supports more non-structural flood control alternatives, i.e., zoning to restrict residential development in floodplains that structural alternatives which encourage floodplain development.	Noted
Minn. Dept. of Natural Resources	Page 11, paragraph 2, sentence 3. This statement is inaccurate in that the adjacent flood plain reaches...in unincorporated reaches...are subject to Lyon County Flood Plain regulation rather than state regulation.	Change made to report
	Page 18, paragraph 2, sentence 3. This statement downplays the long-term results of flood plain zoning regulations. While it is true that flood plain zoning will not significantly reduce flood damage in the short-term, the long-term result will be to reduce non-conforming flood plain uses which will reduce flood damages. We would request that you be more generous to the concept of flood plain management in your next draft.	The report text has been revised to more appropriately reflect the effect of flood plain zoning.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comments	Response
Minn. Dept of Natural Resources (Continued)	Page 36, Level of Protection Section. According to this discussion, standard project protection will not be provided by all the levees proposed in this project. The exact impact of these levees being overtopped has been given only cursory review. Questions which should be addressed in the final document include: if levees are overtopped, what are the depths of flooding; what are the probably dollar damages; and what provisions are being made to provide for internal drainage? How is the project design being reconciled with the fact that Minnesota Flood Plain Regulations NR 89(-)(2) (aa) require that levees built for urban protection shall have a minimum height of at least three feet above the elevation of the regional flood or at the elevation of the Standard Project Flood, whichever provides the greater protection from flooding?	Although protection against the SPF flood level would be clearly infeasible, measures are provided to prevent the possibility of a levee failure and overflows into Marshall. The right bank levee upstream of the existing diversion structure would provide two feet of freeboard over the SPF flood level. The downstream reach flood barriers would contain the SPF flood flow within the design freeboard.
	Page F-7, Table F-1 and Section F-15. This section and table imply that public buildings would continue to be constructed in a non-conforming manner even though flood plain regulations would be in affect. Public buildings would have to conform to any applicable local ordinances. The average annual equivalent value of this future growth ($5800) would, therefore, not apply.	The analysis of damage growth to future growth of public development reflects only the residual damages with flood plain regulations in effect - i.e. the projection of similar underground flood-related damages to structures and damages to roads and utilities.
	Page F-20, Location Benefits. We would strongly recommend that location benefits, as used in the benefit/cost analysis outlined on page F-20, be re-evaluated. There is no shortage of buildable land around the City of Marshall so there should be no real net gain in land value. The increase of $1900 per acre is a one-time windfall gain for certain landowners and would come at the expense of other lands that are suitable for development without construction of the flood control project.	The report economic analysis of floodproof cost savings benefits reflects a real economic savings due to protection of the undeveloped lands slated for future development as compared to the cost of developing flood-free lands located further away from established transportation and utility

Agency Comments on Marshal , Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
Minn. Dept. of Natural Resources (Continued)		routes. Further, the inclusion of the protected acreage represents the most economically feasible and socially acceptable levee alignment to protect the developed downstream reach area.
	We would like to reiterate our concern about the problem of cross-over flooding. While the proposed project is designed to reduce flood damages in Marshall the problem of cross-over flooding is of regional concern and should be analyzed as such.	The problem of cross-flow flooding is being investigated on a regional basis in a joint U.S. Army Corps of Engineers - U.S. Soil Conservation "639" study.
	We are also concerned about the general aesthetic impact that flood control levees have. We would hope that efforts would be expanded, particularly in future projects, but to whatever extent is possible for the Marshall project, to mitigate aesthetic concerns into project design.	Aesthetic impacts of proposed flood barriers have been recognized throughout the study. Proposed mitigation measures to reduce such impacts would include tree and shrub plantings to replace those removed and warped levee cross-sections in selected areas to mitigate the physical impact of levees located close to residences
	In conclusion, the State of Minnesota supports the general concept of the proposed project, that is flood damage reduction on the Redwood River in Marshall, Minnesota. You can be assured of our continued interest and support for the goal of flood damage reduction.	Noted
Minn. State Archeologist	I have read the draft environmental impact statement on the plans for Redwood River flood control activities near Marshall, Minnesota. I agree with the statements and the recommendations concerning cultural resources that appear in sections 2.026 and 2.027 of that document.	Noted

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
City of Marshall	After review, the proposed project, as presented, appears to be totally consistant with and complimentary to all existing and currently proposed local land use plans, policies, regulations, and objectives. The same holds true for the various plans and policies for flood control, traffic thoroughfare, parks, and zoning.	Noted
	While the City of Marshall does not now have a Comprehensive Master Plan for the City, it is possible that one will be developed within the next couple of years. However, it would not appear at this time that a Comprehensive Master Plan would result in any potential conflict with the proposed flood control project.	Noted

Other Comments on the Draft Marshall
Feasibility Report for Flood Control

Individual/Organization	Comment	Response
Mr. Robert C. Runchey Rep. For Westside Acres	See Mr. Runchey's letter in "Attachments"	According to Mr. Runchey, West Side Acres located along the upstream reach south of the Redwood River would be adversely affected by the proposed plan in terms of valuable property taken and probably future flood damage. Lands required for the proposed project east of CSAH 7 are presently owned by the City as existing project right-of-way. No significant additional land needs are anticipated. Flood damages in the West Side Acres area would be substantially reduced with the elimination of present condition overflows over CSAH 7 into the area. The selected levee alignment upstream of CSAH 7 represents the most economically feasible alignment and was selected to minimize affects on adjacent lands. Plan 6U, involving a by-pass channel between CSAH 7 and the BN bridge was found to be economically infeasible and significantly more environmentally disruptive in terms of forest and ground cover losses than the proposed plan.

Agency Comments on Marshall, Minnesota
Feasibility Report for Flood Control (Continued)

Agency	Comments	Response
City Engineer - City of Marshall	It is my opinion that the project as designed for a 133 year degree of protection would very adequately provide the protection to the City of Marshall and adjacent area. Protection to the Standard Project Flood level would appear to be beyond the requirements and realisticly feasibile flood protection level. This subalternative plan which included the raising of County Highway No. 7 and State Highway No. 23 as flood barriers, additional levee height, railroad embankment protection, additional structures work, etc. in my opinion would be an extremely costly and questionable needed level of protection.	Noted
	Consequently, we basically agree with the feasibility report and plans as selected for the 133 year flood recurrence frequency protection level.	
	However, there are several minor areas of the plan that we would request further consideration be given to at the time of the detailed plans preparation. These items would not materially affect the feasibility report as written but are items that we feel should have some attention at some later date when the plans proceed to the detail planning stage. One of the primary concerns is the lands lying between County State Aid Highway No. 7 and the wayside park area in the upstream protection area. In my opinion, all lands between the proposed levee and the Burlington Northern Railroad will be for all practical purpose undevelopable due to the restrictions that would be placed on this area. Therefore, it may be more advantageous and more practical to purchase these lands in fee title in the interest of the project rather than only obtain easements on a portion of these lands. To support this statement, the report also states that access to this property will be permanently affected. If this becomes a fact, then the lands cost of the project budget would have to be increased considerably. It should also be noted that these lands could then be used for recreational purposes in the form of quiet areas, bike trails and so on as was discussed in the report. The report refers to these quiet areas as being a part of the advantage of the plan.	The report analysis have subsequently been revised to reflect the fee purchase by local interests of 71.1 acres of flood-prone land upstream of CSAH 7 for project floodway purposes.

Agency Comments on Marshall, Minnesota
Feasibility Report for Flood Control (Continued)

Agency	Comments	Response
City Engineer - City of Marshall (continued)	It may also be advantageous to make a more complete analysis of the location of the levee in the area of Mile 71 to determine whether or not the levee should follow the channel in a more close and parallel manner. At this location there is presently a considerable area of land above flood plain level. This land renders itself to being very desirable developable property and a levee would cut off this land and would protentially restrict development in the area.	This matter could also be investigated in detailed planning studies. The applicability of recently adopted city flood plain management regulations to protection of these flood plain lands would be carefully evaluated.
	In the area of Mile 66 further review should also be given to the location of the levee with the possibility of following the channel more closely than as proposed.	See previous response.
	Another area that I would request a further review of would be the ponding area located on the downstream improvement between Highway 23 and County Road No. 7. This ponding area is a sizeable area that would be undevelopable and could present some continual maintenance problems particularly as it relates to the relatively infrequent periods of time that the pond will actually be utilized. During the detail plan preparation I would request that we further review this and look at other alternatives as well as design alternatives.	This matter could also be reviewed in any subsequent detailed studies. However, the proposed [illegible]-acre ponding area is considered to represent the least costly alternative for downstream reach interior drainage. With grassed side slopes and bottom and regular mowing, maintenance is not expected to be a problem. Collected runoff from the more frequent and lesser intensity rainstorms would be quickly discharged from the ponding area leaving the area open for possible outdoor game or similar uses.
	We appreciate your attention to this project and I can advise you that the City of Marshall is very concerned over flood problems and responsive to flood improvements. As a result of the 1969 flood it was realized that there are some deficiencies. However, it should also be noted that we realize now that we are quite vulnerable to flooding conditions and therefore hope that this project can be expedited as quickly as possible to provide the protection as outlined in the feasibility report.	Noted

Agency	Comment	Response
Lyon County Dept. of Highways (7 Sept. 78 ltr.)	In response to your letter of August 29, 1978, regarding plan 5U MOD. 4 with the Redwood River in Marshall, MN, the following is an answer to the questions you posed. CSAH 7 is currently not up to standards for the volume of traffic it is projected to carry. Any improvement along this road would have to be consistent with the proper design standards. Thus, an 8 foot fill section is not only a volume of fill in the road area, but also in the recovery area and slope to meet the existing grade. (See the attached sheet for a typical section involving the 8 foot fill.) The levee could be constructed to serve as flood protection, and serve the highway needs as well. There may be problems regarding access to and from adjacent properties, but this is not a direct concern of the County Highway Department. One area of minor concern is CSAH 7 south of T.H. 23. With the grade of T.H. 23 raised, CSAH 7 will have to match. Another minor concern would be the esthetics of having an elevated road abutting a residential area. I am sure the City of Marshall and concerned residents would object in regards to this problem.	A modified alternative substituting levees in lieu of the considered CSAH 7 and State Highway 23 road raises has been evaluated in response to Executive Order 11988 concerns subsequent to receipt of these comments.
Minnesota Department of Transportation (29 Sept. 78 ltr.)	In response to your letter of August 29, 1978, which is addressed to Mr. F.C. Marshall, we have reviewed the effect of raising the T.H. 23 roadway to act as a dike (along with County Road No. 7) upstream from the City of Marshall. This relates to your modification 4 of Plan 5U on Plate D-1 " considered alternatives upstream reach". Consideration of raising only the westbound Trunk Highway 23 roadway to a maximum 3 feet above the eastbound roadway causes a problem at the highway junction with C.S.A.H. 7. Your Plate D-1 does not indicate the left-turn lanes, nor the T.H. 7 junction as they exist today. In any case, a 3 foot elevation difference between roadways at this location is not acceptable; and, at this location, the eastbound roadway would also have to be raised at least 2 feet. Five accidents (one fatal) have been investigated at this junction in the past year.	See response to Lyon County Department of Highways letter.

Agency	Comment	Response
Minnesota Department of Transportation (29 Sept. 78 ltr.) (continued)	The entire junction of C.S.A.H. 7 and T.H. 23 would have to be modified in elevation to provide suitable access. Additionally, our construction plans for T.H. 23 show that a 24 inch diameter concrete culvert is constructed through C.S.A.H. 7 to the north of T.H. 23 which drains the north roadway ditch and the proposed Redwood River Basin.	
	We would recommend that consideration to given to constructing a dike adjacent to T.H. 23 right-of-way to the desired elevation. This dike could be swung northerly and tied in with the raised C.S.A.H. 7, some distance north of its junction with a city street, about 500' north of T.H. 23. Such dike construction need not disrupt trunk highway traffic and might possible be considered less expensive than reconstructing T.H. 23. On field entrance access, some 1300' west of C.S.A.H. 7 would possibly require a sandbag plug at times of highwater.	
	Please give maximum consideration to reducing the effects of this project to our wayside rest area.	
Minnesota Historical Society (25 Aug. 78 ltr.)	Thank you very much for sending us the report "An Archaeological Survey of a Proposed Flood Control Project in Marshall, Minnesota". In order for us to fully concur with your finding that no archaeological sites will be damaged by the proposed flood control project, it is necessary for us to be able to accurately locate what kinds of investigations were done, and where. I have found it difficult to make this evaluation from the report. Therefore, I would appreciate it if you could provide this office with a copy of the appropriate portions of the Marshall, Minn., 7.5 series, USGS topographic quadrangle map showing the location of the surface finds, test pits, areas subjected to surface reconnaissance in addition to the proposed project locations.	Maps showing the area surveyed have been furnished to the Society for review.
	I might add that it is also important to review fill sources for levee construction. If these lie outside the areas surveyed, we would like the opportunity to make that review.	All fill sources for levee construction are located within the area surveyed.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
U.S. Dept. of Interior Heritage and Conservation Service (11 Aug. 1978 ltr.)	We have reviewed the report on "An Archeological Survey of a Proposed Flood Control Project in Marshall, Minnesota" by Philip H. Salking and offer the following comments.	These concerns are documented in the Archeological Survey Report and in Section B of Appendix 1 of the Draft Feasibility Report.
	Consultation with the State Historic Preservation Officer, State Archeologist, and the latest listing of properties on the National Register of Historic Places should be documented in the report.	A map showing the area surveyed in relation to the project area is included with the Archeological Survey report on file at the office of the St. Paul District, U.S Army Corps of Engineers.
U.S. Soil Conservation Service (27 March 1978 ltr.)	This is in reply to your request for assistance in identifying prime or unique farmlands that may be affected by the proposed flood control project on the Redwood River at Marshall, Minnesota. The attached soil maps identify prime farmlands within the areas outlined on plates G-1 and G-2. There is no unique farmland at this site.	Noted.
City of Marshall (21 Feb. 79 ltr.)	Mr. Robert Northrup of your office recently contact Mr. Duane Aden, our City Engineer, pertaining to the degree of protection for proposed Flood Improvement Project for the City of Marshall, Minnesota. We discussed this matter at the City Council Meeting on February 20, 1979 and it is the determination of the City staff and City Council that the originally proposed 133 year Flood frequency would still be a most acceptable level of protection. This is in accordance with the draft feasibility report as prepared by your office. We did evaluate the 150 year Flood frequency protection level and it is our opinion that the additional work and cost involved do not warrant the relatively small degree of additional protection.	The revised report discussion on the optimum scale of development reflects these concerns of the City.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
City of Marshall (18 Apr. 1979 ltr.)	Transmitted herewith please find the City of Marshall's Resolution No. 288 pertaining to the City's approval of a Flood Control Project and its intent and willingness to cooperate with the United States in the construction of the project. This resolution was approved on accordance with the feasibility report prepared by the Corps of Engineers and the appropriate local responsibilities and cost sharing analysis outlined in this report.	The referenced resolutions are included as attachments to this report appendix.
	Also enclosed is Resolution No. 289 which is a resolution declaring the intention of the City of Marshall and the Corps of Engineers concerning local participation and recreation features as a part of a project for flood control.	
	We are aware of the fact that the cost sharing provisions are being changed to a 20% local share of the total project as per recent presidential policy. However, since this project has been under development and preparation for approximately 8 of 9 years, we would suggest that the funding for the project be in accordance with the rules and policy as have been in effect during the development of this project and as outlined in the feasibility report. If it does become absolutely necessary to change the method of funding for the project, we would acknowledge this fact and I would assume the City of Marshall would be receptive to whatever decision is appropriate. Particularly due to the fact that the project is of utmost importance to the residents of the Marshall community.	Noted.
	It is also our understanding that more formal assurances will be required on the part of the city following the congressional authorization and prior to any construction activities through the Corps of Engineers contracts.	Noted.
	We would request that we continue to expedite this project as quickly as possible so that we can eliminate the existing potential flood damage and inconveniences to the residents of the Marshall community. Thank you for your assistance.	Noted.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
Chicago and North-western Transportation Company (26 March 1979 ltr.)	The proposed recreation facilities with respect to this project proposes walking-biking trails and cross-country ski trails in two locations along the diversion channel around Marshall, Minnesota. While the plans are not definitive in the location of these trails, it would appear that it would be necessary some time in the future that these trails will cross the track of the Chicago & North Western Transportation Company. At that time it will be necessary for a license to be executed between responsible public body and the Transportation Company for these crossings.	The final locations of proposed trail crossings would be reevaluated in detailed Post-authorization studies. Coordination would be maintained with all effected interests during these study efforts to develop trail crossings underneath bridges where feasible.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
U.S. Department of the Interior, Fish and Wildlife Service (23 Aug. 1978 ltr.)	This responds to your letter of August 1, 1978 requesting formal documentation of compliance with the 1958 Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) for the Redwood River Flood Control Project at Marshall, Minnesota. This Act requires agencies to coordinate with the Department of Interior to provide that wildlife conservation shall receive equal consideration with other features of resource development programs. In project planning compliance with the Act occurred through consultation with U.S. Fish and Wildlife Service and by receipt of the Department of Interior's January 31, 1977 comments on the Draft Environmental Impact Statement for the Redwood River at Marshall.	Noted.
	To solve the existing flooding problem in Marshall, Minnesota a 2,260 foot long levee along the left (north) bank and a 6,280 foot-long levee along the right (south) bank are proposed for construction in the upstream portion of the project. Also included would be upstream channel modifications consisting of 500 feet of channel realignment, reshaping and riprapping. The project alternative would involve encroachment into 4.2 acres of floodplain of which 2.3 are classified as riparian woodland or Type I wetland (U.S. Fish and Wildlife Circular 39). In the view of the Fish and Wildlife Service, this action would conflict with Executive Order 11990-Protection of Wetlands and Executive Order 11988.	The proposed project and alternatives considered have been reviewed in accordance with practicability criteria contained in Executive Orders 11988 and 11990 and the President's 1980 budgetory criteria concerning these executive orders. A determination has been made that the proposed project is in compliance with the executive orders and that no practicable alternatives exist. Detailed discussion concerning this determination is contained in Section J of Appendix 1 of this report.

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
U.S. Department of the Interior, Fish and Wildlife Service (23 Aug. 1978 ltr.) (Continued)	Executive Order 11988 - Floodplain Management is based in part of the National Environmental Policy Act of 1969, and adds new prominence to the environmental aspects of floodplain management. This Order requires that decision-making by Federal agencies clearly recognizes that floodplains have unique and significant public values. Consideration must be given, therefore, to natural and beneficial floodplain values and to the public benefit to be derived from their restoration or preservation.	This alternative together with a similar alternative incorporating levees in lieu of the road raises have been studied in detail and found to be not practical. A detailed discussion of these alternatives is contained in Section J, Appendix I of the Feasibility Report.
	To comply with Executive Order 11990 and 11988 by avoiding the direct or indirect support of construction in wetlands and floodplains further investigation into the alternative of raising the grades of State Trunk Highway 23 and County State Aid Highway 7 on the South and East border of Section 7 T. 111 N., R. 41 W., Lyons County. This would provide the necessary project objective of moderating floods by providing a broad area to spread and slow floodwaters, thereby reducing velocities and flood peaks and it would allow the floodplain to continue to provide the following benefits: water quality maintenance, ground water recharge, fish and wildlife habitat, aesthetics, outdoor education and recreation, agriculture, aquaculture, and forestry.	

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
U.S. Fish and Wildlife Service (30 March 1979 ltr)	We have reviewed the proposed construction and find problems with the project as it relates to compliance with Executive Order 11990-Protection of Wetlands and Executive Order 11988-Floodplain Management. As proposed the construction project would involve encroachment into 4.2 acres of floodplain, of which 2.3 are classified as riparian woodland or Type 1 wetland (U.S. Fish and Wildlife Circular 39). Our letter of August 23, 1978 discussed compliance with the Executive Orders. An alternative levee alignment involving raising the grades of State Trunk Highway 23 and CSAH 7 on the South and East borders of Section 7, T111N., R41W was presented in that correspondence as a method to conserve wetland and floodplain acreage. This alternative is consistent with the directives of both Executive Orders that agencies consider alternatives to avoid adverse effects and incompatible development in floodplains and wetlands. The Public Notice indicates that use of the wetland complies with Executive Order 11990-Protection of Wetlands. This finding should be clearly documented in the Revised Draft Environmental Impact Statement and Feasibility Report being prepared for this project.	Detailed studies have indicated that the road raise alternative is not a practicable alternative to the selected flood barrier alignment. This determination has been made in accordance with the provisions of Executive Orders 11988 and 11990 and the President's 1980 budgetary criteria for implementing these directives. This finding is documented in the Revised Draft Environmental Impact Statement and in Section J of the Feasibility Report.
	In addition to conserving the wetland acreage the alternative levee alignment would protect approximately 125 acres of floodplain from development. By use of this alternative, the project would not promote construction in the floodplain. The 125 acre floodplain would continue to provide an area for floodwater storage, water quality maintenance, ground water recharge, wildlife habitat and agricultural production. Compliance with Executive Order 11988 should also be documented in the Revised Draft EIS. In the view of the Fish and Wildlife Service the alternative levee alignment along T.H. 23 and CSAH 7 remains a practicable alternative.	Detailed flood routing studies have shown the added floodwater storage capability of this alternative to be insignificant. Detailed discussion concerning this finding, other plan effects, and the impracticability of the alternative alignment is contained in Section J of the Feasibility Report.
	In identifying the problems that brought about a flood damage reduction project at Marshall, Minnesota; the Public Notice indicates that recurrent floods on the Redwood River together with damaging overflows into the adjoining Cottonwood River basin resulted in flood damages and the need for local flood protection. Yet, within the construction plans chosen to solve the flooding problems, an overflow diversion structure is planned to direct	The design of the proposed diversion works is based on the premise that maintenance of the existing cross-over flow situation provides the most equitable solution to remaining flood problems at Marshall. The proposed project would be complementary to any Upper Minnesota River Subbasin plan

Agency Comments on Marshall, Minnesota (Continued)
Feasibility Report For Flood Control

Agency	Comment	Response
U.S. Fish and Wildlife Service (30 March 1979 ltr) (continued)	approximately one-half the Redwood River flood flows in excess of 6,500 cfs into the Cottonwood River basin. This as a chosen solution seems to perpetuate the crossover flooding problem noted for this project area and identified as the primary problem of the Upper Minnesota River Subbasin Study Are. (Public Law 87-639) of which the Redwood and Cottonwood River basins are a part. The Draft Plan of Study for the Upper Minnesota River Subbasin Area further states that attempts to solve the crossover flooding problem individually have had limited success because it is inter-related among 5 subbasins. Therefore, major efforts in the 639 Study are directed toward correcting the problem on the larger scale of 5 subbasins in the Upper Minnesota River Basin. The promotion of crossover flooding by the Redwood River Flood Control Project does not seem justified in view of the increased problem created for the 639 Study Area.	developed and would not restrain the formulation of alternative subbasin plans. The formulation and design of the proposed overflow diversion works have been coordinated with the joint Corps-SCS "639" subbasin study.
	These comments have been prepared under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and are consistent with the National Environmental Policy Act of 1969. In our opinion use of the construction alternative indicated in our August 23, 1978 letter would allow the project to be in compliance with Executive Order 11988 and 11990.	The determination of the impracticability of the road raise alternative is discussed in detail in Section F of the Feasibility Report.

ATTACHMENTS

ATTACHED CORRESPONDENCE

Federal

Department of Transportation	-	U.S. Coast Guard
	-	Federal Highway Administration
U.S. Department of the Interior	-	National Park Service
	-	Office of the Secretary
U.S. Department of Agriculture	-	Soil Conservation Service
U.S. Department of Commerce	-	National Weather Service Forecast Office - Minneapolis
	-	Office of the Secretary
	-	River Forecast Center - Kansas City, Missouri
	-	Assistant Secretary For Policy
U.S. Environmental Protection Agency	-	Region V
U.S. Department of Interior Heritage and Conservation Service		
U.S. Soil Conservation Service		

State

Minnesota Department of Agriculture
Minnesota State Planning Agency
Minnesota Pollution Control Agency
Minnesota Department of Natural Resources
Minnesota Department of Transportation
Minnesota Historical Society

County

Lyon County Department of Highways

Local

City of Marshall - December 9, 1976
April 11, 1978
February 21, 1979
April 18, 1979

Local (continued)

Mr. Robert C. Runchey

Chicago and Northwestern Transportation Company

Transcript of 23 February 1977 Public Meeting

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS
COMMANDER (dpl/eis)
SECOND COAST GUARD DISTRICT
FEDERAL BLDG
1520 MARKET ST
ST LOUIS MO 63103

16475
Ser 009
14 December 1976

Department of the Army
St. Paul District, Corps of Engineers
ATTN: NCSED-PB
1135 U.S. Post Office and Custom House
St. Paul, MN 55101

Gentlemen:

We have reviewed the draft environmental impact statement and feasibility report for Flood Control on the Redwood River at Marshall, Minnesota. We have no comment to offer on either document.

Thank you for the opportunity to review your feasibility report and environmental impact statement.

Sincerely,

C. E. JOHNSON, JR.
Environmental Protection Administrator
By direction of the District Commander

Copy to:
COMDT (G-WEP-2/73)
DOT SECREP Region V
DOT (tes), Office of Environmental Affairs
CEQ (5)

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
REGION 5
18209 DIXIE HIGHWAY
HOMEWOOD, ILLINOIS 60430

January 5, 1977

IN REPLY REFER TO
05-00.5

District Engineer
St. Paul District, Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Sir:

The draft environmental statement and draft feasibility report for flood control at Marshall, Minnesota on the Redwood River have been reviewed. Our review comments are as follows:

The approved Federal-aid road system is not entirely shown on the exhibits and the discussion of them is very sketchy. Proposed FAU 5764 starts west of Marshall at TH 19 just east of the existing river diversion channel and follows it northerly and easterly to where it ends at the existing river. From that point FAS 6072 extends in a generally easterly direction south of the river and ends at TH 23. This total system constitutes the northerly bypass of Marshall.

Environmental Statement - RE: ED-ER

1. The "proposed parkway by others" on Plate 2 should be shown as FAU 5764 since it is an approved route.
2. The general location of FAU 5764 should be shown on Plates 2 and 3.
3. The general location of FAS 6072 should be shown on Plate 3 because it is an approved route.
4. Highway Alignment Levees and Combined Highway Alignment Levees, as discussed on pages 38 and 39, and shown as alternates on Plate 5, should be identified as approved system routes.

Feasibility Report - RE: ED-PB

It would be desirable if the text and the exhibits would make reference to approved Federal-aid road system within the confines of the project limits. This would entail the same treatment as discussed under comments on the environmental statement.

Sincerely yours,

Donald E. Trull
Regional Administrator

W G Emrich

By:
W. G. Emrich, Director
Office of Environment and Design

United States Department of the Interior

NATIONAL PARK SERVICE
MIDWEST REGION
1709 JACKSON STREET
OMAHA, NEBRASKA 68102

IN REPLY REFER TO:

L7423 MWR DCL

[illegible]

Colonel Forrest T. Gay, III
District Engineer, St. Paul District
Corps of Engineers
1135 U. S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Gay:

Reference your letter NCSED-PB, December 1, 1976, pertaining to your feasibility study for flood control on the Redwood River at Marshall, Minnesota.

No established or studied units of the National Park Service or sites eligible for registration as National Historic, Natural or Environmental Educational Landmarks appear to be adversely affected by this study.

We note that the State Historic Preservation Officer was consulted concerning this project (page 57). Therefore, we suggest that his recommendations be followed including procedures for archaeological resource mitigation.

Due to the high probability of archaeological sites existing within the impact area (Appendix I, B-11), we recommend an archaeological survey be undertaken for all areas affected by the proposed action. Consultation with the State Archaeologist, Dr. Elden Johnson, Department of Anthropology, University of Minnesota, Minneapolis, Minnesota 55455, is suggested in order to coordinate archaeological survey and recovery during project development.

Copies of all correspondence should be included within the impact statement to aid in the review process.

Sincerely yours,

Merrill D. Beal

Merrill D. Beal
Regional Director

United States Department of the Interior

OFFICE OF THE SECRETARY
NORTH CENTRAL REGION
230 S. DEARBORN STREET, 32nd FLOOR
CHICAGO, ILLINOIS 60604

ER 76/1150

January 31, 1977

Colonel Forrest T. Gay III
District Engineer
U.S. Army Engineer District
St. Paul
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Gay:

This responds to your letter of December 1, 1976, requesting comments on the Draft Feasibility Report (your reference ED-PB) and Draft Environmental Impact Statement (your reference ED-ER) for the Redwood River at Marshall, Minnesota. You further requested that we furnish our comments separately on the two reports.

We have reviewed the documents and have the following comments:

DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)

We believe that the statement is an adequate and accurate assessment of the impacts of the flood control project on the resources within our area of jurisdiction and expertise.

DRAFT FEASIBILITY REPORT

Our review of this document and the Fish and Wildlife Service's investigation of the project has disclosed that fish and wildlife resources of the area would be affected in minor or temporary ways as described in the DEIS. We believe that adequate measures have been proposed in the report to minimize these adverse effects. However, we believe that the feasibility report, as an authorizing document, does not contain an adequate description of the fish and wildlife resources nor the effects of the project on them. Therefore, we recommend that the description of the fish and wildlife resources and the effects of the project on them, as found in the DEIS, be included in the appropriate sections of the Draft Feasibility Report.

The National Park Service has advised that its comments on this report have been presented previously to you.

Sincerely yours,

Madonna F. McGrath

Madonna F. McGrath
Acting Special Assistant
to the Secretary

United States Department of the Interior
HERITAGE CONSERVATION AND RECREATION SERVICE
INTERAGENCY ARCHEOLOGICAL SERVICES - DENVER
OFFICE OF ARCHEOLOGY AND HISTORIC PRESERVATION
1978 SOUTH GARRISON - ROOM 107
DENVER, COLORADO 80227

IN REPLY REFER TO

H2415-(HCRS)PI

AUG 11 1978

Mr. Robert F. Post
Chief, Environmental Resources Branch
Engineering Division
Army Corps of Engineers
1135 U.S. Post Office & Customhouse
St. Paul, Minnesota 55101

Dear Mr. Post:

We have reviewed the report on "An Archeological Survey of a Proposed Flood Control Project in Marshall, Minnesota" by Philip H. Salkin and offer the following comments.

Consultation with the State Historic Preservation Officer, State Archeologist, and the latest listing of properties on the National Register of Historic Places should be documented in the report.

A map outlining the actual project area along with the area surveyed should be included in the report. This map should also depict the areas of test excavations.

The author's recommendations on page 10 should be followed. Any sites discovered during construction should be reported immediately to the State Historic Preservation Officer and the State Archeologist.

Other than these few comments, we found the report to be fairly thorough and the author should be commended for doing a good job.

If we can be of any further assistance, please feel free to contact us.

Sincerely yours,

Jack R Rudy

Jack R Rudy
Chief, Interagency
Archeological Services - Denver

cc: Russell Fridley, SHPO MN
Dr. Elden Johnson, State Archeologist

United States Department of the Interior

FISH AND WILDLIFE SERVICE

IN REPLY REFER TO:

St. Paul Field Office, Ecological Services
538 Federal Building and U.S. Court House
316 North Robert Street
St. Paul, Minnesota 55101

Colonel Forrest T. Gay
District Engineer
U.S. Army Corps of Engineers
St. Paul District
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

23 AUG 1978

Attn: NCSEC-ER

Dear Colonel Gay:

This responds to your letter of August 1, 1978 requesting formal documentation of compliance with the 1958 Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) for the Redwood River Flood Control Project at Marshall, Minnesota. This Act requires agencies to coordinate with the Department of Interior to provide that wildlife conservation shall receive equal consideration with other features of resource development programs. In project planning compliance with the Act occurred through consultation with U.S. Fish and Wildlife Service and by receipt of the Department of Interior's January 31, 1977 comments on the Draft Environmental Impact Statement for the Redwood River at Marshall.

Additional comments are now proved regarding the planned construction and recent Executive Orders that recognize the Nation's floodplains as the scene of:

1. unacceptable and increasing flood losses and
2. degradation of natural and beneficial values.

To solve the existing flooding problem in Marshall, Minnesota a 2,260 foot long levee along the left (north) bank and a 6,280 foot-long levee along the right (south) bank are proposed for construction in the upstream portion of the project. Also included would be upstream channel modifications consisting of 500 feet of channel realignment, reshaping and riprapping. The project alternative would involve encroachment into 4.2 acres of floodplain of which 2.3 are classified as riparian woodland or Type I wetland (U.S. Fish and Wildlife Circular 39). In the view of the Fish and Wildlife Service, this action would conflict with Executive Order 11990 - Protection of Wetlands and Executive Order 11988 - Floodplain Management as a practicable alternative appears to exist. Most of the Nation's wetlands are located in floodplains, thus agency procedures for floodplain management will frequently apply to wetlands. Executive Order 11990 Protection of Wetlands, states that "each agency to the extent permitted by law, shall avoid undertaking or providing assistance for new construction located in wetlands unless the head of the agency finds (1) that there is no practicable alternative to such construction, and (2) that the proposed action includes all practicable measures to minimize harm to wetlands which may result from such use.

Cmt 49

Executive Order 11988 - Floodplain Management is based in part on the National Environmental Policy Act of 1969, and adds new prominence to the environmental aspects of floodplain management. This Order requires that decision-making by Federal agencies clearly recognizes that floodplains have unique and significant public values. Consideration must be given, therefore, to natural and beneficial floodplain values and to the public benefit to be derived from their restoration or preservation.

To comply with Executive Order 11990 and 11988 by avoiding the direct or indirect support of construction in wetlands and floodplains further investigation into the alternative of raising the grades of State Trunk Highway 23 and County State Aid Highway 7 on the South and East border of Section 7 T. 111 N., R. 41 W., Lyons County. This would provide the necessary project objective of moderating floods by providing a broad area to spread and slow floodwaters, thereby reducing velocities and flood peaks and it would allow the floodplain to continue to provide the following benefits: water quality maintenance, ground water recharge, fish and wildlife habitat, aesthetics, outdoor education and recreation, agriculture, aquaculture, and forestry.

We strongly suggest further consideration of this alternative that will allow the project to comply with Executive Orders 11990 and 11988.

Sincerely,

Nancy B. Walters

for Richard F. Berry
Field Office Supervisor

cc: MN DNR, St. Paul, MN

United States Department of the Interior

IN REPLY REFER TO:

FISH AND WILDLIFE SERVICE
TWIN CITIES AREA OFFICE
530 Federal Building and US Court House
316 North Robert Street
St. Paul, Minnesota 55101

MAR 30 1979

Colonel Forrest T. Gay, III
District Engineer
U.S. Army Corps of Engineers
St. Paul District
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Gay:

This responds to the Public Notice dated February 28, 1979, regarding the Corps of Engineer's compliance with Section 404 of the Clean Water Act of 1977 for flood control plans involving dredging and filling in the Redwood River at Marshall, Minnesota. The flood damage reduction plan would provide protection for the city of Marshall and adjacent agricultural areas. The plan of work on the Redwood River consists of channel widening, straightening, and bank reshaping measures; levees; an overflow diversion structure with appurtenant control and outlet works; interior drainage works; aesthetic measures; recreation facilities; and required relocations.

We have reviewed the proposed construction and find problems with the project as it relates to compliance with Executive Order 11990-Protection of Wetlands and Executive Order 11988-Floodplain Management. As proposed the construction project would involve encroachment into 4.2 acres of floodplain, of which 2.3 are classified as riparian woodland or Type 1 wetland (U.S. Fish and Wildlife Circular 39). Our letter of August 23, 1978 discussed compliance with the Executive Orders. An alternative levee alignment involving raising the grades of State Trunk Highway 23 and CSAH 7 on the South and East borders of Section 7, T111N., R41W was presented in that correspondence as a method to conserve wetland and floodplain acreage. This alternative is consistent with the directives of both Executive Orders that agencies consider alternatives to avoid adverse effects and incompatible development in floodplains and wetlands. The Public Notice indicates that use of the wetland complies with Executive Order 11990-Protection of Wetlands. This finding should be clearly documented in the Revised Draft Environmental Impact Statement and Feasibility Report being prepared for this project.

In addition to conserving the wetland acreage the alternative levee alignment would protect approximately 125 acres of floodplain from development. By use of this alternative, the project would not promote construction in the floodplain. The 125 acre floodplain would continue to provide an area for floodwater storage, water quality maintenance, ground water recharge, wildlife habitat and agricultural production. Compliance with Executive Order 11988 should also be documented in the Revised Draft EIS. In the view of the Fish and Wildlife Service the alternative levee alignment along T.H. 23 and CSAH 7 remains a practicable alternative.

In identifying the problems that brought about a flood damage reduction project at Marshall, Minnesota; the Public Notice indicates that recurrent floods on the Redwood River together with damaging overflows into the adjoining Cottonwood River basin resulted in flood damages and the need for local flood protection. Yet, within the construction plans chosen to solve the flooding problems, an overflow diversion structure is planned to direct approximately one-half the Redwood River flood flows in excess of 6,500 cfs into the Cottonwood River basin. This as a chosen solution seems to perpetuate the crossover flooding problem noted for this project area and identified as the primary problem of the Upper Minnesota River Subbasin Study Area (Public Law 87-639) of which the Redwood and Cottonwood River basins are a part. The Draft Plan of Study for the Upper Minnesota River Subbasin Area further states that attempts to solve the crossover flooding problem individually have had limited success because it is interrelated among 5 subbasins. Therefore, major efforts in the 639 Study are directed toward correcting the problem on the larger scale of 5 subbasins in the Upper Minnesota River Basin. The promotion of crossover flooding by the Redwood River Flood Control Project does not seem justified in view of the increased problem created for the 639 Study Area.

These comments have been prepared under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and are consistent with the National Environmental Policy Act of 1969. In our opinion use of the construction alternative indicated in our August 23, 1978 letter would allow the project to be in compliance with Executive Order 11988 and 11990.

Sincerely yours,

George C. [illegible]
Area Manager

Letter Gay

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

316 North Robert Street, St. Paul, Minnesota 55101

January 31, 1977

Colonel Forrest T. Gay, III
St. Paul District, Corps of Engineers
Department of the Army
1222 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Sir:

Subject: Draft Environmental Impact Statement,
Flood Control Redwood River at Marshall, Minnesota

Thank you for furnishing the subject draft to this office for review and comment.

The effects of the proposed project on agriculture land and agricultural production appear to be adequately addressed by the draft.

Page 20, Section 4.005, last sentence - figure should be 6,500 not 8,200.

Sincerely,

Harry M. Major
State Conservationist

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

316 North Robert Street, St. Paul, Minnesota 55101

January 31, 1977

Colonel Forrest T. Gay, III
St. Paul District, Corps of Engineers
Department of the Army
1222 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Sir:

Subject: Comments - Redwood River at Marshall, Minnesota
Draft Feasibility Report for Flood Control

We feel that the proposed plan will provide the needed protection for Marshall and is the most feasible solution presently available for the reduction of flood damages in the city of Marshall, Minnesota.

We suggest that the section on Upstream Reservoir Storage - Plan 4, be rewritten to allow for reappraisal under the authorized joint, Army Corps of Engineers and Soil Conservation Service "639 Study".

Preliminary flood routings made as a part of the Southern Minnesota Type IV Study, indicated that a reservoir structural program would reduce peak flows at Marshall. Considerable agricultural flood damages occur along the Redwood River both upstream and downstream of Marshall. This problem will be addressed by the "639 Study".

We also feel that the flood control project for Marshall will complement any overall measures proposed for the Redwood River as a part of the joint "639 Study".

Specific editorial comments on the subject draft are listed on the attached sheet.

Sincerely,

Harry M. Major
State Conservationist

Attachment

cc: Gerald A. Simpson, Area Conservationist, SCS, Marshall, MN
Marion Strong, Director, Midwest TSC, Lincoln, Nebraska
Jon V. Dairout, Ass't State Conservationist, SCS, St. Paul, MN

Specific Comments on Subject Draft

Page 18, 2nd paragraph, last sentence add dollar sign to 609,200.

Page 21, Upstream Reservoir Storage - Plan 4 - Several Comments

This write up should allow for possible "639 Study" project solutions. For example,"any reduction in peak flows resulting from upstream storage would compliment this proposal by reducing both the over flow into the Cottonwood River Basin and flows through the project area".

The Southern Minnesota Type IV Study indicated that utilization of storage on Lake Benton, Dead Coon Lake and other potential upstream locations would reduce the 100-year discharge to approximately 6,500 cfs at Wayside park where the proposed diversion is located.

Page 21, Plan 4 states in part -"Clearly shows that a single large reservoir would lack sufficient storage capacity". Appendix I-D11 states that "One site was identified as having sufficient storage".

Page 21, Plan 4, 2nd paragraph. Suggest changing in part to read - A system of small reservoirs on headwater tributary streams presently under consideration to solve agricultural flooding would be located to far upstream and have to little storage volume to provide the desired flood protection for the city of Marshall. The last sentence in the above paragraph could remain as is. Appendix I page D12 should be changed to reflect the above wording.

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
316 North Robert Street, St. Paul, Minnesota 55101

March 27, 1978

File: NCSED-ER

Mr. Robert F. Post
Chief, Environmental Resources
Branch, Engineering Division
Dept. of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Mr. Post:

This is in reply to your request for assistance in identifying prime or unique farmlands that may be affected by the proposed flood control project on the Redwood River at Marshall, Minnesota.

The attached soil maps identify prime farmlands within the areas outlined on plates G-1 and G-2. There is no unique farmland at this site.

Sincerely,

acting

Harry M. Major
State Conservationist

Enclosures

AD-A146 926 REDWOOD RIVER AT MARSHALL MINNESOTA; FEASIBILITY REPORT FOR FLOOD CONTROL(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT JUN 79

7/7

UNCLASSIFIED F/G 13/2 NL

END
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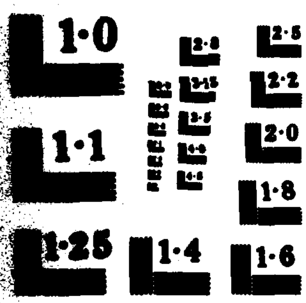
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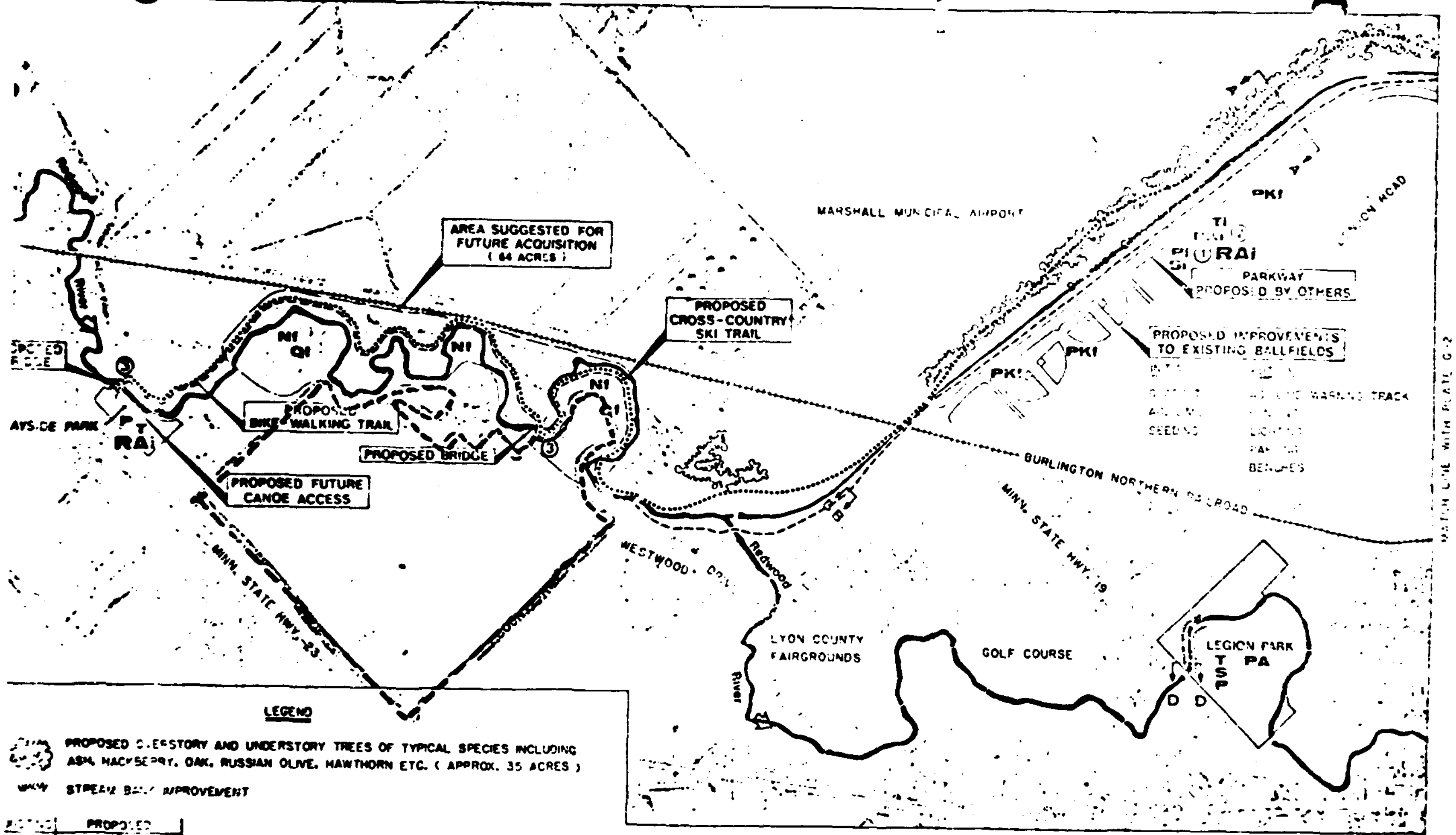


LEGEND

PROPOSED OVERSTORY AND UNDERSTORY TREES OF TYPICAL SPECIES INCLUDING ASH, HACKBERRY, OAK, RUSSIAN OLIVE, HAWTHORN ETC. (APPROX. 35 ACRES)

STREAM BANK IMPROVEMENT

EXISTING	PROPOSED INITIAL	PROPOSED FUTURE	
RA	RAI	RAI	REST AREA
S	SI	SI	SHELTER
T	TI	TI	SANITARY FACILITY
PA	PAI	PAI	PLAY / ACTIVITY AREA
P	PI	PI	PICNIC AREA
PK	PKI	PKI	PARKING AREA
Q	QI	QI	QUIET AREA
N	NI	NI	NATURE AREA

0 500 1000 SCALE IN FEET

N

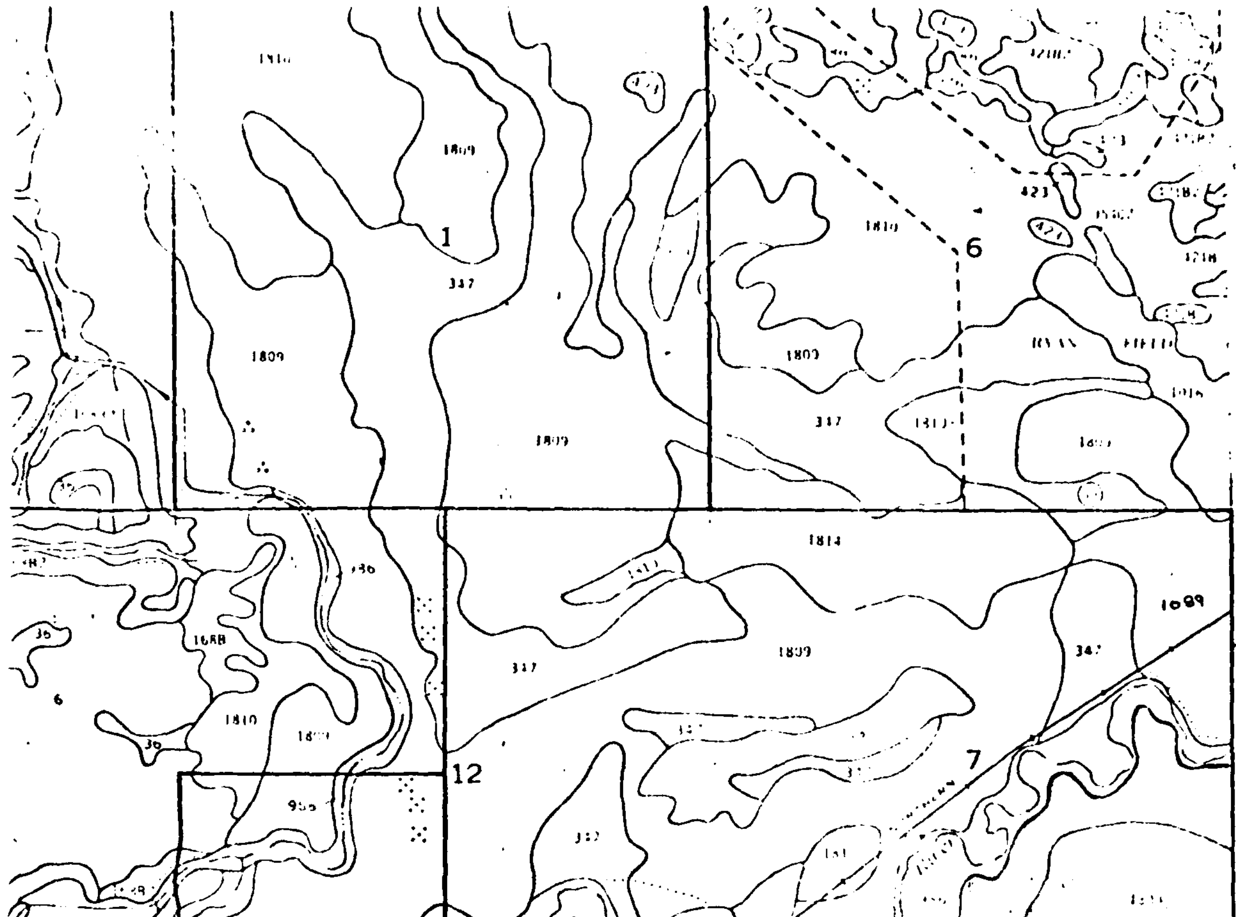
NOTE:
CROSS SECTIONS AND FEATURES ① ② ③ ILLUSTRATED ON PLATE G-3.

FEASIBILITY REPORT
FOR FLOOD CONTROL
REDWOOD RIVER AT
MARSHALL, MINNESOTA

GENERAL PLAN

PROPOSED RECREATIONAL FEATURES

PLATE G-1



Prime land - ...

other land - 7...

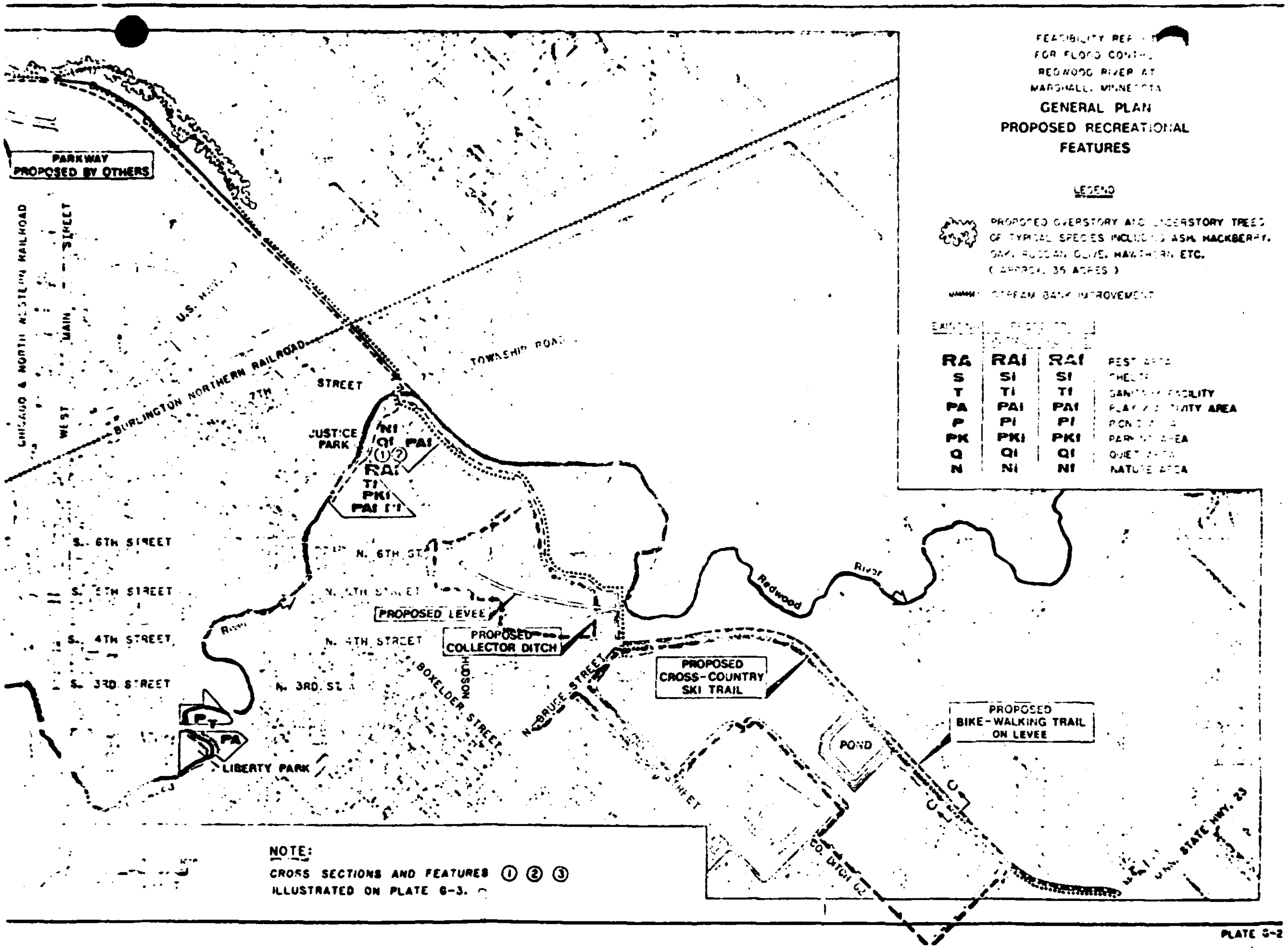
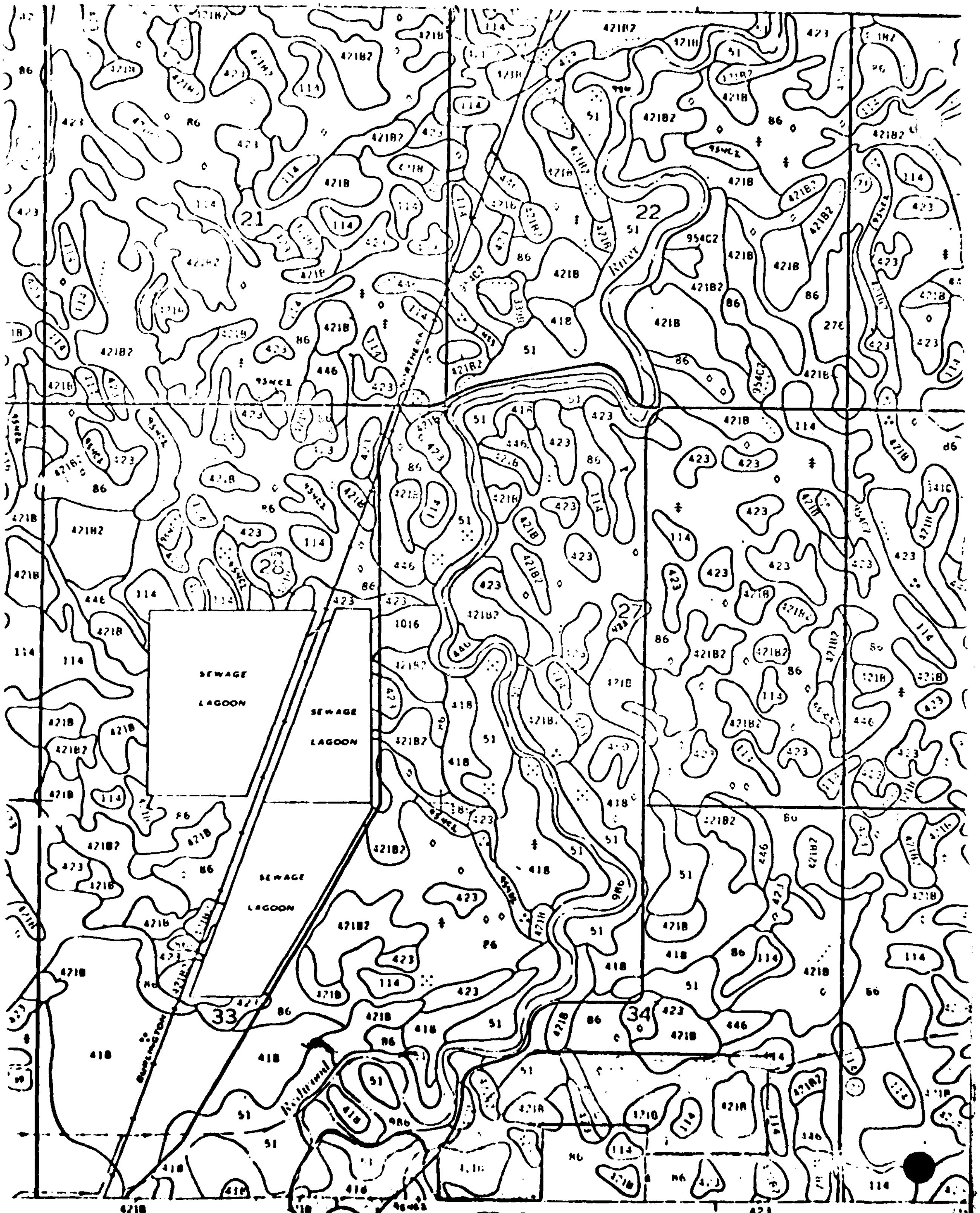

GENERAL PLAN
PROPOSED RECREATIONAL FEATURES
LEGEND
PROPOSED OVERSTORY AND UNDERSTORY TREES OF TYPICAL SPECIES INCLUDING ASH, HACKBERRY, OAK, RUSSIAN OLIVE, HAWTHORN ETC. (APPROX. 35 ACRES)
STREAM BANK IMPROVEMENT
RA RAI RAI REST AREA
S SI SI
T TI TI SANITARY FACILITY
PA PAI PAI
P PI PI
PK PKI PKI PARKING AREA
Q QI QI QUIET AREA
N NI NI NATURE AREA
PARKWAY PROPOSED BY OTHERS
CHICAGO & NORTH WESTERN RAILROAD
WEST MAIN STREET
BURLINGTON NORTHERN RAILROAD
TOWNSHIP ROAD
STREET
JUSTICE PARK
S. 6TH STREET
S. 5TH STREET
S. 4TH STREET
S. 3RD STREET
N. 6TH ST.
N. 4TH STREET
N. 3RD ST.
PROPOSED LEVEE
PROPOSED COLLECTOR DITCH
HUDSON
BOXELDER STREET
N. BRUCE STREET
PROPOSED CROSS-COUNTRY SKI TRAIL
Redwood River
POND
PROPOSED BIKE-WALKING TRAIL ON LEVEE
CO. DITCH 62
MINN. STATE HWY. 23
LIBERTY PARK
NOTE:
CROSS SECTIONS AND FEATURES ① ② ③ ILLUSTRATED ON PLATE 6-3.

PLATE 6-2



☑ Prime land –

☐ Other land 12 Ac

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE FORECAST OFFICE
Federal Aviation Building
6301 34th Avenue South
Minneapolis, MN 55450

March 1, 1977 531.1

Mr. Roger Fast
Chief, Engineering Division
St. Paul District Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, MN 55101

Dear Mr. Fast:

I wish to offer the following revised comments concerning the Feasibility Study and Environmental Impact Statement for Flood Control at Marshall, MN.

I would only mention the needs which the National Weather Service has with regard to its flood forecasting responsibility to the Marshall area. We see the need to locate a river gage such that complete discharge information can be obtained from a single reading. Telephone conversations between our two offices indicate that this work is proceeding which we find most reassuring.

With climatological data recently received for the 1976 calendar year a change may be of value to the body of the report. On page B7 Appendix I, of the Feasibility Report under the section labelled "Climate" I offer one revision. The total liquid precipitation for 1976 totalled 12.05 inches at the NWS's Marshall station and this quite easily surpasses the previously held record of 17.36 inches.

?

Graff talking about minimums. 12.05" is new minimum

Sincerely,

John V. Graff
Meteorologist in Charge

See new ltr.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE FORECAST OFFICE
Federal Aviation Building
6301 34th Avenue South
Minneapolis, MN 55450

January 25, 1977 531.1

Col. Forrest T. Gay III
District Engineer
St. Paul District Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Mn 55101

Dear Col. Gay:

Three publications from the St. Paul District Corps of Engineers have been studied recently which detail the current flood control studies for the Redwood River at Marshall, Minnesota. These publications are:

Flood Plain Information, December 1974
Draft Feasibility Report for Flood Control, November 1976
Draft E.I.S. - Flood Control, November 1976

The comments which follow are this office's efforts to supply additional facts on past floods as well as to suggest and request that Corps of Engineers-National Weather Service cooperation be maintained to assure adequate flood warning, control and avoidance at Marshall.

In neither of the afore-mentioned November 1976 reports was there any mention of the vital role which the National Weather Service has in its hydrologic responsibility of flood forecasting nor that it was responsible for accurately forecasting the floods of June 1957 and April 1969 to mention only the biggest ones.

The National Weather Service realizes the legal responsibilities and bounds of its charter, and, therefore, not only lends support to, but solicits help from cooperating agencies with related interests and concerns. As you well know, this cooperation extends to State as well as Federal agencies. In this vein, and as an important operative within the National Weather Service, this office has always given credit where deserved and we only expect an equal and fair return on this.

The late Joe Strub, my predecessor as Meteorologist in Charge, made each person in this office well aware of the delicacy with which flooding situations had to be handled. Let me sight one example in particular that occurred during the late April 1975 floods in the Mississippi River Headwaters area. Heavy rains falling over an already ripe, melting snowpack made it necessary for the Reservoir Regulation Section to increase its already sizeable discharges. In no briefing to the press or local citizens during the flood did he mention that the Corps was responsible for flow augmentation. Through carefully worded statements he attempted to save the St. Paul

District from any possible anger from Aitkin area residents.

I have been here at Minneapolis since 1969 and have been a part of many such situations. As Meteorologist in Charge, I am continuing to stress cooperation in all phases of our work. This past summer's drought with its multiple aspects was closely monitored, but each agency contributed its own complement to the crisis. The DNR conference on the Twin Cities water supply problem held on September 10 is a good example.

In a situation such as the one at Marshall where such a wide spectrum of Federal, State and Local agencies as well as private interests are involved, you are undoubtedly aware that full coordination of all duties is an absolute must. Past successes of both of our agencies speak well of the adequate ground work which was laid.

At this point in the Marshall project, I see an urgent need to coordinate our activities. This work, if started now, will allow ample time prior to the beginning of the 1977 Spring snowmelt season for us to persue other important related matters.

The problem of obtaining an accurate hydrologic picture of the Redwood River stage and discharge involves collection of same - time gage readings from both the U.S.G.S. gage in town as well as from the project structure. Our limited staff size has permitted us only recently to personally investigate the situation. Mr. Craig Sanders from this office, after an inspection of the area, made it apparent that this situation must be rectified by the establishment of a single gage. This is in agreement with the suggestions of the Regional Hydrologist at our Central Region Office in Kansas City, MO.

In a letter to John Seemann of the Reservoir Regulation Section dated October 12, 1976, I requested that work be started to resolve the problem. However, I assume that the water crises in other portions of the District took priority, thus preventing his study and immediate help, and I can fully understand this. Nonetheless, the need is still valid.

My suggestion toward consolidation of the two gages is that a wire weight or an otherwise suitable gage be set on the Highway 7 bridge 0.2 miles upstream from the diversion structure. This will suffice as an interim arragnement even though the high discharge problem of overland flow to the Cottonwood River still exists. Since rating curves and channel cross sections are presently available for both the structure and the U.S.G.S. gage, the task of synthesizing the gages does not appear to be impossible. My request of you is that we receive some affirmation that this work is being pursued so we can in turn brief and instruct our river and rainfall observer there.

In future publications from the Corps, I feel it should be explicitly mentioned that because of gage relocation, hydrologic services will be maintained despite what may appear as disorganization during the construction phase of the project. Most communities such as Marshall have law enforcement people who are instructed in reading various types of gages for us at very inopportune times. These tasks could prove most important to all of us during the construction phase should such a rainfall event affect the area. For our general information, I would like to see a tentative work schedule so we can be kept abreast of progress.

Finally, since the ultimate responsibility of operating the structure rests with the City of Marshall would you please furnish us with a copy of the current regulation manual plus any revisions which come about as a result of the planned work. It will afford us much better coordination with the city.

I am looking forward to hearing from you and would be most anxious to discuss the Marshall situation with you, your staff or other elements of the Corps. Thank you.

Sincerely,

John V. Graff
Meteorologist in Charge

UNITED STATES DEPARTMENT OF COMMERCE
Office of the Secretary
Federal Region V
CNA Building, Room 1302
55 East Jackson Boulevard
Chicago, Illinois 60604

February 14, 1977

Colonel Forrest T. Gay, III
Corps of Engineers
District Engineer
Department of the Army
1135 U. S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Gay:

This letter transmits review comments on the draft feasibility Report for Flood Control - Redwood River, Marshall, Minnesota. The Economic Development Administration is completing their review, which we will forward under separate cover.

If you have any questions, please let us know.

Sincerely,

Dianne T. Simmons (?)
James R. Stirling
Representative of the Secretary

cc:
Donald Baker

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE
River Forecast Center
Rm. 1715A, 601 E. 12th Street
Kansas City, MO 64106

February 1, 1977

TO: James P. Stirling, Representative of the Secretary
U.S. Department of Commerce
Federal Region V
CNA Building, Room 1302
55 East Jackson Blvd.
Chicago, Illinois 60604

FROM: Herman F. Mondschein
Hydrologist in Charge

SUBJECT: Draft Feasibility Report for Flood Control Redwood River at Marshall, MN (Nov 76)

Following are our comments relative to the above report:

Page 18, Line 2-3: "periodic" should be removed. Flood warnings are not at fixed time intervals, but are due to hydrometeorological conditions as they are anticipated to occur. Accordingly, we suggest in line 3 - "flood warnings issued by the National Weather Service Forecast Office in Minneapolis of impending Redwood River flood occurrences...etc."

The above comments also impact on the next paragraph. Insert a second sentence to read as follows:

"However, it is recognized that flood warnings, if timely and accurate, tend to mitigate flood losses and are essential for public safety."

Start the third sentence with:

"Nevertheless," and drop the work "periodic".

Page E-2, First Para: We suggest a last sentence as follows: "In addition, river and flood forecasting, an integral part of the design and operation of levees and other flood control systems and basic to good multi-purpose water management, will continue to be needed."

The same or similar statements should be repeated in other general paragraphs of this nature where appropriate.

cc: Dr. Gayle W. Jackson, UMRBC Commissioner, DOC
Elroy C. Balke, Regional Hydrologist, NWSCRH
Donald R. Baker, DOC Water Resources Coordinator, Office of the Assistant Secretary for Policy, Washington, DC
Allen Flanders, Assistant to the Associate Director, Hydrology, NWS

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Policy
Washington, D.C. 20230

December 21, 1976

Colonel Forrest T. Gay, III, USA
St. Paul District, Corps of Engineers
Department of the Army
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Gay:

We recently received copies of your feasibility study for flood control and its associated draft environmental impact statement on the Redwood River at Marshall, Minnesota.

The organizational structure for the area of water resources within the Department of Commerce is such that direct mailing of feasibility reports to Washington, D.C. for field review can slow the review process. Therefore, may I suggest that in the future six (6) copies of reports or studies for field review be forwarded to the Secretarial Representative in the pertinent Federal region. In this instance, we have sent all copies of the feasibility study to:

Mr. James P. Stirling
Secretarial Representative, Region V
Department of Commerce
CNA Bldg., Room 1402
55 East Jackson Blvd.
Chicago, Illinois 60604

Mr. Stirling's office will circulate the study to appropriate field offices and that office will prepare the consolidated reply to you.

In addition, please continue to send all copies of the Draft Environmental Impact Statements for review and comment to:

Dr. Sidney Galler
Deputy Assistant Secretary for
Environmental Affairs
Department of Commerce
Washington, D.C. 20230

I am confident that for a field review, direct mailing of the Corps of Engineers feasibility study to the Secretarial regional representative will result in a timely and efficient review process.

Thank you for your consideration in this matter.

Sincerely,

Don Baker

Donald R. Baker
Water Resources Coordinator

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
230 SOUTH DEARBORN ST
CHICAGO, ILLINOIS 60604

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

JAN 27 1977

Colonel Forrest T. Gay, III
District Engineer
U.S. Corps of Engineers, St. Paul
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

RE: 76-115-194
D-COE-F36047-MN

Dear Colonel Gay:

We have completed our review of the Draft Environmental Impact Statement (EIS) for Flood Control Redwood River at Marshall, Minnesota. Your letter of December 1, 1976, requested our views and comments on the proposed action. We note from our review of the EIS that construction is being permitted to take place within flood prone areas. We believe flood protection measures are appropriate for previously developed areas, but that a comprehensive flood control program should include restriction of further development in flood prone areas. Flood protection should be provided only for those areas which are developed at the time of the filing of the Draft EIS with the Council on Environmental Quality. Furthermore, the Final EIS should also contain additional information on the construction impacts and the impacts which will result from the completion of the flood diversion channel. Our detailed comments follow.

As part of the flood protection, a flood diversion channel will be constructed. This flood diversion channel will divert one-half of the excess of the present design discharge. These excess overflows will be discharged into the Cottonwood River Basin. Additional information and discussion must be provided on the present water quality of the receiving stream. The effect upon the water quality from the addition of flood flows also needs to be assessed. Based upon information in the EIS, we have assumed the diversion channel to be dry during normal periods of the year. Flood flows can have a high velocity and great amount of energy. The potential for erosion and channel damage should be assessed.

Since flood flows will be discharged into the Cottonwood River Basin, an assessment of flooding potential in this basin should be provided. The two watersheds are essentially next to each other and the same meteorological conditons would be expected over each basin. Therefore, if flood flows were occurring in the Redwood River Basin, one would expect flood flows in the Cottonwood River Basin. The circumstances which would change the effects of flooding in the Cottonwood Basin are the proximity to communities, areas subject to flood damages and crop and land damages and channel depth and width. The Final EIS should thoroughly discuss how the diversion of flood flows from the Redwood River Basin will affect the Cottonwood Basin.

The proposed channel work may affect the ability of stream discharges to meet water quality standards. Information on the discharge points and changes in the stream's assimilative capacity which may occur as a result of construction should be provided. This information will indicate whether or not the discharger will still be capable of meeting water quality standards.

The EIS stated the flood control project is necessary to protect new development in hazard areas. It is our opinion that flood protection and flood control projects should provide protection only to areas which are presently developed, and not encourage development in flood hazard areas. To minimize flood damages and project cost, protection should be provided where development has occurred prior to the filing of the EIS with the Council on Environmental Quality. As a minimum, we recommend building restrictions on previously undeveloped flood plain areas to assure adequate flood protection to the community.

The EIS has indicated the reoccurence interval for this project has been reduced from 114 years to 59 years. The Final EIS should discuss whether or not this reoccurence interval will be further reduced.

In the EIS, water quality studies have indicated any pooling of the Redwood River could promote algal growth during periods of suitable light and temperature conditions. Part of the flood control plan calls for a ponding area to be constructed. The potential for algal blooms and insect propagation at this ponding area should be assessed.

There are two beaver dams within the watershed. One beaver dam will be removed during construction. The EIS should indicate whether or not the beaver dam is causing increased flood conditions at Redwood. This loss of the beaver dam should be avoided, if possible.

Additional information in regard to the disposal of levee excavation material should be provided.

We have rated the project as ER (environmental reservations) and classified the EIS as Category 2 (additional information necessary). The date and classification of our comments will be published in the Federal Register in accordance with our responsibility to inform the public of our views on other agencies' projects.

We appreciate the opportunity to review this Draft EIS. When the Final EIS is filed with the Council on Environmental Quality, please forward 3 copies to us. If you have any questions in regard to our comments, please contact Mr. William D. Franz at 312-353-2307.

Sincerely yours,

Gary A. Williams

Gary A. Williams
Chief,
Environmental Review Section

LAND OF QUALITY FOODS

STATE OF MINNESOTA

DEPARTMENT OF AGRICULTURE
STATE OFFICE BUILDING
SAINT PAUL, MINN. 55155
TELEPHONE: (612) 296- 2856

January 20, 1977

Colonel Forrest T. Gay, District Engineer
Department of the Army
St. Paul District, Corps of Engineers
1135 U. S. Post Office and Custom Office
St. Paul, Minnesota 55101

RE: NCSED-PB

Dear Colonel Gay:

We have reviewed the Draft Environmental Impact Statement and Feasibility Report for Flood Control on the Redwood River at Marshall, Minnesota.

The plan proposes the conversion of 15.8 acres of agricultural land for the flood control project plus 178 acres for project-induced residential development. The report states, "This cropland loss is insignificant in itself, but a part of cumulative losses of agricultural land throughout the United States." This Department is very concerned about the loss of agricultural land in Minnesota. We feel that any loss of the magnitude proposed for this project is significant, and we do not appreciate such proposals. However, we realize the necessity for flood control projects which, hopefully, will minimize adverse conditions to the surrounding environmental, agricultural production and human life. We generally support such proposals.

It appears at this time that any agriculturally related topics have been sufficiently addressed by the Draft Environmental Impact Statement and Feasibility Report.

Thank you for the opportunity to comment on the proposed plans for Flood Control on the Redwood River.

Sincerely,

MINNESOTA DEPARTMENT OF AGRICULTURE

Rollin M. Dennistoun, Ph.D.
Assistant Commissioner

RMD:hk

STATE OF MINNESOTA

STATE PLANNING AGENCY
100 CAPITOL SQUARE BUILDING
550 CEDAR STREET
ST. PAUL, 55101

February 9, 1977

Colonel Forrest T. Gay, III
District Engineer
Department of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

RE: Draft Feasibility Report for Flood Control Redwood River at Marshall Minnesota

Dear Colonel:

The Environmental Division of the State Planning Agency (SPA) has reviewed the Draft Feasibility Report for Flood Control. In general the document cites the potential impacts of the proposed measures. However, we do have the following comments and questions on the extent and manner to which some issues were addressed.

I. Land

A) Will the proposed flood control measures have any adverse effects in the Cottonwood River Basin or in the floodplain downstream of the project's study limits?

1. In order to maintain "natural" hydrologic conditions, 50% of the overflows in the vicinity of the Highway 23 roadside park will be diverted into the Cottonwood River Basin (page 22, paragraph 1). Are conditions still "natural or pre-development"? If they are not, can an equivalent percentage of overflow be diverted to the adjacent basin without damage to land or property in this area?

2. Areas downstream of the study limits were not evaluated since they would not benefit from the project (F-2, paragraph 4). Might these areas be adversely affected? Is so, how and to what extent? If there are potential adverse effects downstream, shouldn't this be included in the B/C analysis as an additional cost?

B) Newly protected floodplains will attract development. Will this expansion plus the proposed flood control facilities necessitate future flood control measures? Will future zoning restrict development in the adjacent unprotected floodplain?

C) The Feasibility Report states the acreage that will become available for development due to the projected flood protection. Varying figures for the land types opening up for residential development are listed. (E-13, F-20) Please consolidate and clarify this information as to the acreage of land types becoming available for development. Also, is the 64 acres suggested for future nature area acquisition included in any of the acreages of land soon available for development?

II. Economic

A) Please check Table 1, Comparison of Alternatives Considered Feasibility Report. It appears (x $1000) was inadvertantly omitted following the Economic Planning Objective Parameters of Flood Damage Reduction and Average Annual Benefits.

B) We question the inclusion of location benefits (F-20) in the economic analysis. Since a benefit is attributed to the increased value of newly protected floodplain land, shouldn't the possible costs to downstream areas also be included as pointed out in I.A(2) of these comments?

III. Construction

What specifically is planned for each of the two years of construction? How will the timing of the various stages of project construction be implemented to minimize pollution (erosion, dust, etc.)?

Basically, the report is quite complete. Our major concerns are the possibility of adverse effects in the Cottonwood River Basin and in downstream areas beyond the study limits, the possible need for expanding flood control measures in the future, and the timing of construction.

We would like to stress that our agency supports more non-structural flood control alternatives, i.e., zoning to restrict residential development in floodplains that structural alternatives which encourage floodplain development.

If you have any questions on our comments and questions, please feel free to contact Carol Booth or Charles Kenow of my staff at 296-8254.

Sincerely,

Joseph Sizer, Director
Environmental Planning Division

JS/dh

Minnesota Pollution Control Agency

MAY 31 1977

Colonel Forrest T. Gay, III
District Engineer
U.S. Army Corps of Engineers
1135 U.S. Post Office & Custom
House
St. Paul, Minnesota 55101

Dear Colonel Gay:

The Minnesota Pollution Control Agency (MPCA) has completed the review of the feasibility report and Draft Environmental Impact Statement (EIS) for flood control on the Redwood River at Marshall, Minnesota. The following comments are offered for your consideration.

1. In the table of State Water Quality Standards, on page EIS 13, the applicable classifications of the Redwood River should include 3C,4A & B, 5 & 6.

2. It is our understanding that the proposed project is the third attempt for flood control measures on the Redwood River at Marshall. Previous attempts by the City and Corps of Engineers have been unsuccessful in relieving the flood problems. Several questions remain unanswered concerning the increase in flood potential. The MPCA requests that attention be given to the following concerns:

   a. What have been the impacts of such activities as drainage of wetlands, agricultural and municipal development, and previous flood control measures on the flood stage?

   b. Why have flood estimates been increased so substantially from previous estimates? Is this due to the short period of record and, if so, should the floods in recent years be considered aberrant?

   c. If drained wetlands were restored and farming practices modified, would upstream reservoirs be an alternative to channelization?

MAY 31 1977

3. Due to the complex natural flow upstream and downstream of the project, attention should be given to the impact on flood stages downstream in the Redwood and Cottonwood Rivers. Previous failures to control floods would indicate that basin floods are not properly understood. The draft feasibility report should include a complete discussion on downstream flood impacts before an assessment of the benefits and the costs can be properly made.

4. Will further protection be needed for the wastewater stabilization ponds and other wastewater treatment systems?

5. Can the diversion channel which was constructed in 1963 be expanded to carry flood waters ? Would this alternative result in less aquatic biological, terrestrial, wildlife, aesthetic and water quality impacts?

We believe that these studies do not adequately address the upstream and downstream impacts and increased water pollution from secondary effects. At this time, the MPCA does not believe the proposed project adequately addresses alternatives such as upstream reservoirs and expansion of the 1963 flood control measures. Finally, we believe that further evaluation of the predicted flood levels is necessary to determine the need for and/or the ultimate scope of the project.

The MPCA appreciates the opportunity to comment on the draft feasibility report and Draft EIS for flood control on the Redwood River.

If you have any questions, please contact Louis Flynn, Permits Section at 296-7225.

Yours truly,

Sandra S. Gardebring

Sandra S. Gardebring
Executive Director

SSG:pah

STATE OF
MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
CENTENNIAL OFFICE BUILDING • ST. PAUL, MINNESOTA • 55155

March 8, 1977

DNR INFORMATION
(612) 296-6157

Colonel Forrest T. Gay III
District Engineer
U.S. Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Gay:

Staff from the Department of Natural Resources has reviewed the project documents for flood control on the Redwood River at Marshall, Minnesota and the following comments are offered:

DRAFT ENVIRONMENTAL IMPACT STATEMENT:

Section 2.024 identifies the first inhabitants as being the Dakota (Sioux) Indians whereas Section 2.026 discusses pre-historic cultural materials being found in the area. Perhaps Section 2.024 should be revised to identify the Sioux as the first inhabitants in historic times.

DRAFT FEASIBILITY REPORT FOR FLOOD CONTROL:

Page 11, paragraph 2, sentence 3. This statement is inaccurate in that the adjacent flood plain reaches...in unincorporated reaches ...are subject to Lyon County Flood Plain regulation rather than state regulation.

Page 18, paragraph 2, sentence 3. This statement downplays the long-term results of flood plain zoning regulations. While it is true that flood plain zoning will not significantly reduce flood damage in the short-term, the long-term result will be to reduce non-conforming flood plain uses which will reduce flood damages. We would request that you be more generous to the concept of flood plain management in your next draft.

Page 36, Level of Protection Section. According to this discussion, standard project protection will not be provided by all the levees proposed in this project. The exact impact of these levees being overtopped has been given only cursory review. Questions which should be addressed in the final document include: if levees are overtopped, what are the depths of flooding; what are the probable dollar damages; and what provisions are being made to provide for internal drainage? How is the project design being reconciled with the fact that Minnesota Flood Plain Regulations NR 89(c)(2)(aa) require that levees built for urban protection shall have a minimum height of at least three feet above the elevation of the regional flood or at the elevation of the Standard Project Flood, whichever provides the greater protection from

Col. Forrest T. Gay III-USCE March 8, 1977

Page F-7, Table F-1 and Section F-15. This section and table imply that public buildings would continue to be constructed in a non-conforming manner even though flood plain regulations would be in affect. Public buildings would have to conform to any applicable local ordinances. The average annual equivalent value of this future growth ($5800) would, therefore, not apply.

Page F-20, Location Benefits. We would strongly recommend that location benefits, as used in the benefit/cost analysis outlined on page F-20, be re-evaluated. There is no shortage of buildable land around the City of Marshall so there should be no real net gain in land value. The increase of $1900 per acre is a one-time windfall gain for certain landowners and would come at the expense of other lands that are suitable for development without construction of the flood control project.

SOME GENERAL COMMENTS

We would like to reiterate our concern about the problem of cross-over flooding. While the proposed project is designed to reduce flood damages in Marshall, the problem of cross-over flooding is of regional concern and should be analyzed as such.

We are also concerned about the general aesthetic impact that flood control levees have. We would hope that efforts would be expended, particularly in future projects, but to whatever extent is possible for the Marshall project, to mitigate aesthetic concerns into project design.

MITIGATION MEASURES

We offer the following as acceptable alternatives for mitigation of the 4.1 acres of forested habitat that will be lost:

1. Acquisition of additional land adjacent to the Redwood Wildlife Management Area in Section 28 of Lynn Township, T.111N., R.42W., This could either be more river bottom, woods or else cropland for a food plot or nesting cover.

2. Acquisition of additional land adjacent to the Russell Wildlife Management Area in Lyons Township.

3. Restoration and future protection against the filling of the Type IV wetland located in the Eastern ½ of the Southwestern ¼ of Section 32, T.112N., R.41W., in Fairview Township.

In conclusion, the State of Minnesota supports the general concept of the proposed project, that is flood damage reduction on the Redwood River in Marshall, Minnesota. You can be assured of our continued interest and support for the goal of flood damage reduction.

Sincerely,

Gerald D. Seinwill

Gerald D. Seinwill, Director
Division of Waters

MINNESOTA DEPARTMENT OF TRANSPORTATION

TENTH & PACIFIC, BOX 758
WILLMAR, MINNESOTA 56201

PHONE: (612) 235-4554

September 29, 1978

Department of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Attn: Forrest T. Gay, III

RE: Flood Control - Marshall, Minnesota

Dear Mr. Gay:

In response to your letter of August 29, 1978, which is addressed to Mr. F. C. Marshall, we have reviewed the effect of raising the T.H. 23 roadway to act as a dike (along with County Road No. 7) upstream from the City of Marshall. This relates to your modification 4 of Plan 5U on Plate D-1 "considered alternatives upstream reach".

Consideration of raising only the westbound Trunk Highway 23 roadway to a maximum 3 feet above the eastbound roadway causes a problem at the highway junction with C.S.A.H. 7. Your Plate D-1 does not indicate the left-turn lanes, nor the T.H. 7 junction as they exist today. In any case, a 3 foot elevation difference between roadways at this location is not acceptable; and, at this location, the eastbound roadway would also have to be raised at least 2 feet. Five accidents (one fatal) have been investigated at this junction in the past year.

The entire junction of C.S.A.H. 7 and T.H. 23 would have to be modified in elevation to provide suitable access. Additionally, our construction plans for T.H. 23 show that a 24 inch diameter concrete culvert is constructed through C.S.A.H. 7 to the north of T.H. 23 which drains the north roadway ditch and the proposed Redwood River Basin.

Mr. Forrest T. Gay
-2-
September 29, 1978

We would recommend that consideration to given to constructing a dike adjacent to T.H. 23 right-of-way to the desired elevation. This dike could be swung northerly and tied in with the raised C.S.A.H. 7, some distance north of its junction with a city street, about 500' north of T.H. 23. Such dike construction need not disrupt trunk highway traffic and might possibly be considered less expensive than re-constructing T.H. 23. One field entrance access, some 1300' west of C.S.A.H. 7 would possibly require a sand bag plug at times of high water.

Please give maximum consideration to reducing the effects of this project to our wayside rest area.

Thank you for the opportunity to comment upon the proposed alternative 5U, modification 4.

Sincerely,

K. A. Madole, P.E.
District Director

Copies: F. C. Marshall
W. C. Merritt

MINNESOTA HISTORICAL SOCIETY

25 August 1978

Mr. Robert F. Post
Chief, Environmental Resources Branch
Engineering Division
Department of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Mr. Post:

RE: Archaeological Survey
Flood Control Project
Marshall, Minnesota

MHS Referral File Number G193

Thank you very much for sending us the report "An Archaeological Survey of a Proposed Flood Control Project in Marshall, Minnesota". In order for us to fully concur with your finding that no archaeological sites will be damaged by the proposed flood control project, it is necessary for us to be able to accurately locate what kinds of investigations were done, and where. I have found it difficult to make this evaluation from the report. Therefore, I would appreciate it if you could provide this office with a copy of the appropriate portions of the Marshall, Minn., 7.5 series, USGS topographic quadrangle map showing the location of the surface finds, test pits, areas subjected to surface reconnaissance in addition to the proposed project locations.

I might add that it is also important to review fill sources for levee construction. If these lie outside the areas surveyed, we would like the opportunity to make that review.

Thank you for your continuing support for preserving Minnesota's cultural resources.

Sincerely,

Russell W. Fridley
State Historic Preservation Officer

RWF/fr
cc: Philip Salkin; U.S. Army Corps of Engineers: 1135 U.S. Post Office and Custom House; St. Paul, 55101

ROBERT J. McPARTLIN
ENGINEER

LYON COUNTY
DEPARTMENT OF HIGHWAYS

September 7, 1978

Marshall, Minnesota 56258

Forest T. Gay, III
Colonel, Corps of Engineers
District Engineer
1135 U.S. Post Office & Custom House
St. Paul, MN 55101
Attention: NCSED - PB

Dear Mr. Gay:

In response to your letter of August [illegible], 1978, regarding plan 5U MOD.4 with the Redwood River in Marshall, MN, the following is an answer to the questions you posed.

CSAH 7 is currently not up to standards for the volume of traffic it is projected to carry. Any improvement along this road would have to be consistent with the [illegible] design standards. Thus, an 8 foot fill section is not only a volume of fill in the road area, but also in the [illegible] area and slope to meet the existing grade. (See the attached sheet for a typical section involving the 8 foot fill.) The levee could be constructed to serve as flood protection, and serve the highway needs as well.

Traffic safety would be slightly [illegible] with a raise in the road profile, but not something that would be prohibitive. Anytime the road deviates from the grade of the ditch, the possibility of a serious accident is greater. However, when a wide shoulder and flat inslope is provided, the "unsafe condition" is greatly reduced.

There may be problems regarding access to and from adjacent properties, but this is not a direct concern of the County Highway Department. One area of minor concern is CSAH 7 south of T.H. 23. With the grade of T.H. 23 raised, CSAH 7 will have to match.

Another minor concern would be the esthetics of having an elevated road abutting a residential area. I am sure the City of Marshall and concerned residents would object in regards to this problem.

The major objection that the Lyon County Highway Department would have against this project is the cost factor. With the amount of fill required, it would put a drain on our funding source, [illegible] half [illegible] to build. Due to the fact that inflation and [illegible] prices are spiraling upward, and the funds are not keeping up, I cannot justify spending County money for a project such as this, when so many other roads are in need of repair.

Even if the Corps were to assist in the financing, it would seem to be an unnecessary amount of fill to place - hence, tax dollars wasted. Another alternative that could be considered but was not presented in your sketch is the possibility of [illegible] levee to the west of CSAH 7 [illegible] and north of T.H. 23 [illegible] alternative would be less costly in that roadway would [illegible] to be replaced, and the fill would be smaller in volume. However, this plan would reduce the volume of the reservoir by a slight amount.

In summary, the position of the Lyon County Highway Department is:

1) The [illegible] could be built to act as a flood reservoir and serve the transportation needs.
2) Traffic safety problems would be worsened, but only to a small degree.
3) Access would be a minor problem, but more so to the City, not the County.
4) There may be an aesthetic problem with the local people.
5) There is a major problem with financing on the County level.
6) A more logical and cheaper solution has not been offered for consideration.

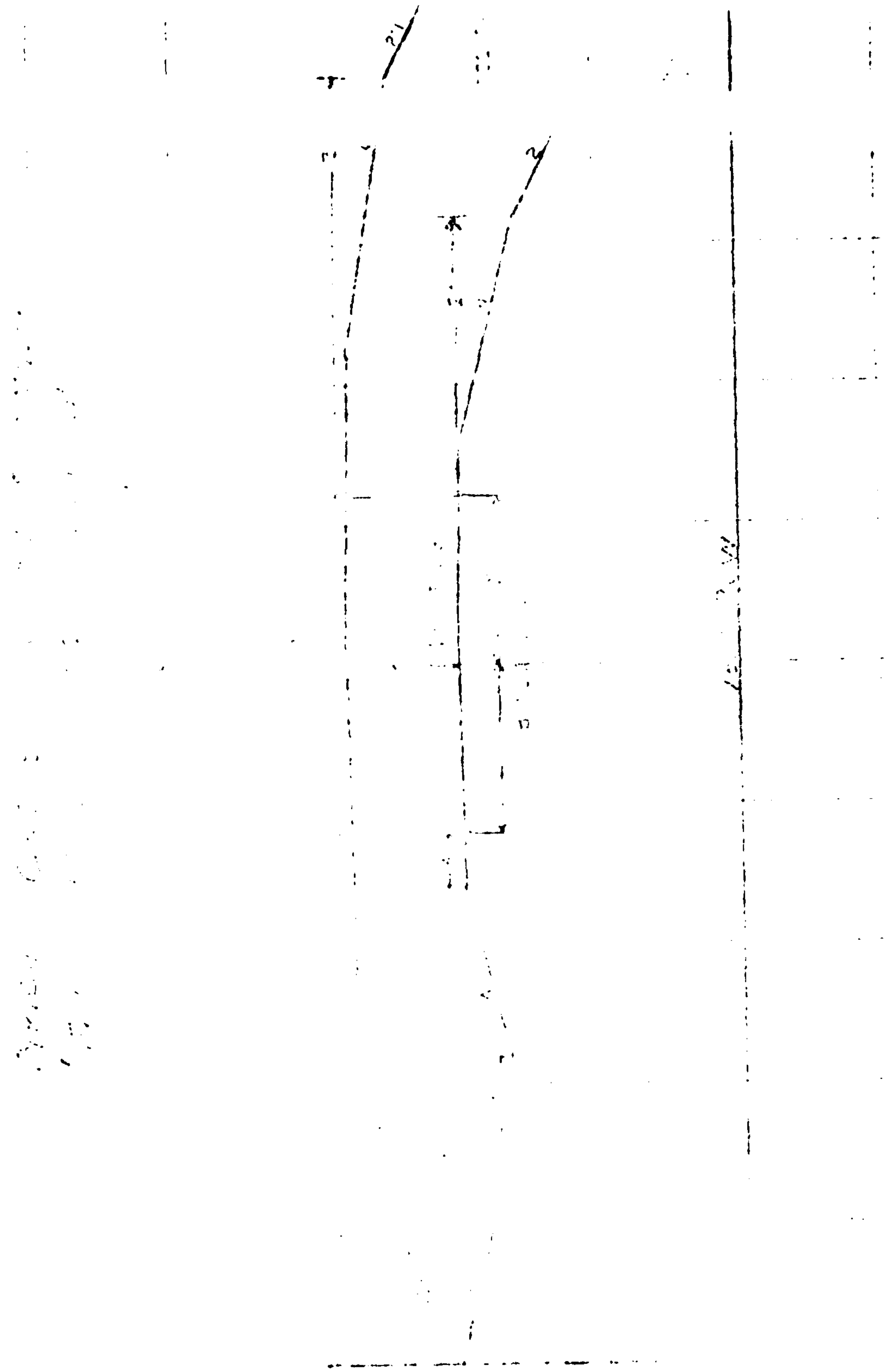
If you wish any further comments, please feel free to contact me.

Yours truly,

Robert J. McPartlin

RJM;hj

Encl.



Office of
CITY ADMINISTRA
Phone (507) 532-
P. O. Box 47

Y OF Marshall Minnesota 56258

December 9, 1976

Mr. Forrest T. Gay, III, Colonel
District Engineer
Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Mn. 55101

RE: NCSED-ER

Dear Mr. Gay:

I am writing in response to your letter of December 1, 1976 regarding an environmental impact statement being prepared for a flood control project on the Redwood River at Marshall, Minnesota.

After review, the proposed project, as presented, appears to be totally consistant with and complimentary to all existing and currently proposed local land use plans, policies, regulations, and objectives. The same holds true for the various plans and policies for flood control, traffic thoroughfare, parks, and zoning.

While the City of Marshall does not now have a Comprehensive Master Plan for the City, it is possible that one will be developed within the next couple of years. However, it would not appear at this time that a Comprehensive Master Plan would result in any potential conflict with the proposed flood control project.

I trust this provides the necessary information requested. If the City of Marshall can provide any additional assistance in the development of this project, we will of course do so.

Sincerely yours,

James R. Heller

James R. Heller
City Administrator

JRH:LM

CITY HALL BUILDI[illegible]
344 WEST [illegible]
Phone 507-532-26[illegible]

56258

OFFICE OF CITY ENGINEER

April 11, 1978

Mr. J. R. Calton
Chief, Planning Branch
Engineering Division
Department of the Army
St. Paul District Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, MN 55101

Re: NCSED-PB

Dear Mr. Calton:

Mr. Stanley Kummer of your office recently furnished me with a revised draft feasibility report for flood control on the Redwood River here in the City of Marshall. I have reviewed this feasibility report and would offer my comments to you for your consideration.

It is my opinion that the project as designed for a 133 year degree of protection would very adequately provide the protection to the City of Marshall and adjacent area. Protection to the Standard Project Flood level would appear to be beyond the requirements of a realisticly feasible flood protection level. This subalternative plan which included the raising of County Highway No. 7 and State Highway No. 23 as flood barriers, additional levee height, railroad embankment protection, additional structures work, etc. in my opinion would be an extremely costly and questionable needed level of protection.

Consequently, we basically agree with the feasibility report and plans as selected for the 133 year flood recurrence frequency protection level.

However, there are several minor areas of the plan that we would request further consideration be given to at the time of the detailed plans preparation. These items would not materially affect the feasibility report as written but are items that we feel should have some attention at some later date when the plans proceed to the detail planning stage. One of the [illegible] between County State Aid Highway No. 7 and the wayside park area in the upstream protection area.

In my opinion, all lands between the proposed levee and the Burlington-Northern Railroad will be for all practical purpose undevelopable due to the restriction that would be placed on this area. Therefore, it may be more advantageous and more practical to purchase these lands in fee title in the interest of the project rather than only obtain easements on a portion of these lands. To support this statement, the report also states that access to this property will be permanently affected. If this becomes a fact, then the lands cost of the project budget would have to be increased considerably. It should also be noted that these lands could then be used for recreational purposes in the form of quiet areas, bike trails and so on as was discussed in the report. The report refers to these quiet areas as being a part of the advantage of the plan.

It would be advantageous to make a more complete analysis of the location of the levee in the area of Mile 71 to determine whether or not the levee should follow the channel in a more close and parallel manner. At this location there is presently a considerable area of land above flood plain level. This land renders itself to being very desirable developable property and a levee would cut off this land and would potentially restrict development in the area.

In the area of Mill 66 further review should also be given to the location of the levee with the possibility of following the channel more closely than as proposed.

Another area that I would request a further review of would be the ponding area located on the downstream improvement between Highway 23 and County Road No. 7. This ponding area is a sizeable area that would be undevelopable and could present some continual maintenance problems particularly as it relates to the relatively infrequent periods of time that the pond will actually be utilized. During the detail plan preparation I would request that we further review this and look at other alternatives as well as design alternatives.

We appreciate your attention to this project and I can advise you that the City of Marshall is very concerned over flood problems and responsive to flood improvements. As a result of the 1969 flood it was realized that there are some deficiencies. However, it should also be noted that we realize now that we are quite vulnerable to flooding conditions and therefore hope that this project can be expedited as quickly as possible to provide the protection as outlined in the feasibility report.

Thank you for your opportunity to review this feasibility report and comment on it.

Sincerely,

Duane D. Aden
City Engineer

DDA:LM

CITY OF MARSHALL
MINNESOTA 56258
CITY HALL BUILDING
344 WEST MAIN
Phone 507-532-2[illegible]
OFFICE OF CITY ENGINEER

February 21, 1979

Mr. Forrest T. Gay, III
Colonel, Corps of Engineers
District Engineer
Department of the Army
St. Paul District Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, MN 55101

Ref: NCSED-PB

Dear Colonel Gay:

Mr. Robert Northrup of your office recently contacted Mr. Duane Aden, our City Engineer, pertaining to the degree of protection for proposed Flood Improvement Project for the City of Marshall, Minnesota.

We discussed this matter at the City Council Meeting on February 20, 1979 and it is the determination of the City staff and City Council that the originally proposed 133 year Flood frequency would still be a most acceptable level of protection. This is in accordance with the draft feasibility report as prepared by your office. We did evaluate the 150 year Flood frequency protection level and it is our opinion that the additional work and cost involved do not warrant the relatively small degree of additional protection.

We would request that you proceed accordingly and expedite our project as quickly as possible. If you should any further comments or questions pertaining to this decision, you may contact Mr. Duane D. Aden, the City Engineer.

Sincerely,

Robert J. Schlagel
Mayor of Marshall, MN.

RJS:jb

CITY OF

CITY HALL BUILDING
344 WEST MAIN
Phone 507 532-2612

Minnesota 56258

OFFICE OF CITY ENGINEER

April 18, 1979

Mr. Forrest T. Gay, III
Colonel, Corps of Engineers
District Engineer
Department of the Army
St. Paul District Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, MN 55101

Ref: NCSED-PB

Dear Colonel Gay:

Transmitted herewith please find the City of Marshall's Resolution No. 288 pertaining to the City's approval of a Flood Control Project and its intent and willingness to cooperate with the United States in the construction of the project. This resolution was approved on accordance with the feasibility report prepared by the Corps of Engineers and the appropriate local responsibilities and cost sharing analysis outlined in this report.

Also enclosed is Resolution No. 289 which is a resolution declaring the intention of the City of Marshall and the Corps of Engineers concerning local participation and recreation features as a part of a project for flood control.

We are aware of the fact that the cost sharing provisions are being changed to a 20% local share of the total project as per recent presidential policy. However, since this project has been under development and preparation for approximately 8 or 9 years, we would suggest that the funding for the project be in accordance with the rules and policy as have been in effect during the development of this project and as outlined in the feasibility report. If it does become absolutely necessary to change the method of funding for the project, we would acknowledge this fact and I would assume the City of Marshall would be receptive to whatever decision is appropriate. Particularly due to the fact that the project is of utmost importance to the residents of the Marshall community.

Mr. Forrest T. Gay, III
Colonel, Corps of Engineers
District Engineer
Department of the Army
St. Paul District Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, MN 55101

Ref: NCSED-PB

Page two

It is also our understanding that more formal assurances will be required on the part of the city following the congressional authorization and prior to any construction activities through the Corps of Engineers contracts.

We would request that we continue to expedite this project as quickly as possible so that we can eliminate the existing potential flood damage and inconveniences to the residents of the Marshall community. Thank you for your assistance.

Sincerely,

Robert J. Schlagel
Mayor

RJS:jb
INC

UNIVERSITY OF MINNESOTA
TWIN CITIES

Department of Anthropology
215 Ford Hall
Minneapolis, Minnesota 55455

January 14, 1977

Col. Forrest T. Gay III
District Engineer
St. Paul District, Corps of Engineers
U.S. Post Office Building
St. Paul, Minnesota 55101 Att'n: ED-PB

Dear Col. Gay:

I have examined the feasibility report on flood control on the Redwood River at Marshall, Minnesota, and agree with the statements and recommendations relating to cultural resources that appear on pages 6-8 and 43-44.

Sincerely,

Elden Johnson
State Archaeologist

EJ:dl
cc: R. Fridley

CHICAGO AND [illegible] TRANSPORTATION COMPANY

March 26, 1979

ASSISTANT DIVISION MANAGER
ENGINEERING

File 1-51-9

Mr. F. T. Gay, III
Colonel, Corps of Engineers, Dist. Engr.
St. Paul District-Corps of Engineers
1135 U. S. Post Office & Custom House
St. Paul, Minnesota 55101

Attention: Planning Branch

Dear Mr. Gay:

Please refer to your public notice regarding flood control plans involving dredging and filling in the Redwood River at Marshall, Minnesota, dated February 28, 1979.

The proposed recreation facilities with respect to this project proposes walking-biking trailsand cross-country ski trails in two locations along the diversion channel around Marshall, Minnesota. While the plans are not definitive in the location of these trails, it would appear that it would be necessary some time in the future that these trails will cross the track of the Chicago & North Western Transportation Company. At that time it will be necessary for a license to be executed between responsible public body and the Transportation Company for these crossings.

It would appear from this notice that there are no other facilities that will affect the Transportation Company. I would appreciate advice as to how this will be handled in the future.

Sincerely,

V. J. Tesar

V. J. Tesar
Asst. Div. Mgr.-Engr.

MAE:jm

P O BOX 701 / 600 [illegible] STREET, N W / MASON CITY, IOWA 50401 / (515) 424-1650

LAW OFFICES
MOLTER, RUNCHEY, LOUWAGIE & WELLMAN
WESTERN STATE BANK BUILDING
EAST COLLEGE DRIVE
MARSHALL, MINNESOTA 56258

ON B. MOLTER
OBERT C. RUNCHEY
OSEPH H. LOUWAGIE
TEVEN C. WELLMAN

PHONE
507-532-3281

March 30, 1977

Corps of Engineers
St. Paul District Office
1135 U.S. Post Office
and Custom House
St. Paul, Minnesota 55101

RE: MEETING--COUNCIL CHAMBERS--2-17-77
MUNICIPAL BUILDING
344 WEST MAIN STREET
MARSHALL, MINNESOTA 56258

Gentlemen:

Major Walter H. Heme addressed a group of Lyon County residents relative to the proposed flood control project on the Redwood River at Marshall, Minnesota, on February 17, 1977. A number of land owners were present and the undersigned represented the owners of land located to the south of said project.

The owners of valuable property on the upstream area would be directly affected by any flood control project. We pointed out that under the proposed 5U plan, the undersigned owners of the Westside Acres and their property to the south of Plan 5U would sustain substantial damages for valuable property taken for the levy involved, together with probable damage from flooding in the future.

A detailing of the previous floods experienced in this area were made known at this hearing. However, it was disclosed by the Corps of Engineers that there was no data relating to the amount of run-off water resulting from the extensive drainage and tiling of the agricultural lands in this area to the present time. There have been numerous floods in the recent years from the swift run-offs resulting in floods from any above average rains. Consequently, our area is now subjected to flooding conditions frequently, whereas heretofore floods were experienced during very infrequent periods.

We strongly urge that the most realistic solution to the problem is to have the diversion channel extended between the Redwood River and the Burlington Railroad as identified in Plan 6U. This plan would clearly result in the most feasable control necessary for the discharge of flood waters. Additionally, the costs of damages due to the property of the undersigned would be greatly reduced, which would not be the case under the proposed plan 5U.

The long range costs of this project, together with the lower land acquisition costs under plan 6U clearly make this the preferable plan for a proper flood control project.

We urge you to adopt plan 6U as the most feasable long range flood control project for the needs of our area.

Yours truly,

Robert C. Runchey

Robert C. Runchey,
Representative for Westside Acres

RCR/mm

cc Representative Richard Nolan
1019 Longworth Office Building
Washington, D.C. 20515

STATEMENT BY
DISTRICT ENGINEER
U.S. ARMY CORPS OF ENGINEERS, ST. PAUL DISTRICT

MARSHALL, MINNESOTA, PUBLIC MEETING

INTRODUCTION

THANK YOU, MAYOR SCHLAGEL.

SLIDE 1 - ST. PAUL DISTRICT LOGO

GOOD EVENING LADIES AND GENTLEMEN. I AM MAJOR WALTER HEME, DEPUTY DISTRICT ENGINEER FOR THE U.S. ARMY CORPS OF ENGINEERS, ST. PAUL DISTRICT, HEADQUARTERED IN ST. PAUL. THIS EVENING I WILL DISCUSS OUR INVOLVEMENT IN THE STUDY FOR FLOOD CONTROL IMPROVEMENT ON THE REDWOOD RIVER. FIRST, I WOULD LIKE TO INTRODUCE SOME OF THE PEOPLE WITH ME HERE TONIGHT WHO HAVE BEEN RESPONSIBLE FOR THE FLOOD CONTROL STUDY. THEY ARE MR. ROBERT STENFORS, MR. JIM HOLLERAN, AND MR. TED ONDLER OF OUR STAFF, AND MR. PAUL KERANEN OF WEHRMAN, CHAPMAN, ASSOCIATES, INC., WHOM WE HAVE CONTRACTED TO CONDUCT THE FLOOD CONTROL STUDY. THESE GENTLEMEN ARE AVAILABLE THIS EVENING TO ANSWER ANY SPECIFIC QUESTIONS YOU MAY HAVE CONCERNING THE STUDY.

BEFORE WE BEGIN, IF YOU HAVE NOT DONE SO ALREADY, I ASK THAT YOU FILL OUT THE ATTENDANCE CARD WHICH WAS GIVEN TO YOU AS YOU ENTERED. THESE ATTENDANCE CARDS ARE USED TO RECORD YOUR NAMES AND ADDRESSES SO THAT WE CAN INFORM YOU OF ANY FUTURE PUBLIC MEETINGS

RELATED TO THIS PROJECT AND ALSO TO IDENTIFY THOSE WHO WISH TO MAKE A STATEMENT HERE TONIGHT. TO ASSURE THAT ALL STATEMENTS MADE TONIGHT WILL BE AVAILABLE FOR FURTHER CONSIDERATION, WE HAVE ARRANGED FOR MR. CHARLES LEHMAN, TO RECORD THE PROCEEDINGS OF THIS MEETING. PLEASE IDENTIFY YOURSELF BY NAME WHENEVER YOU MAKE A STATEMENT OR HAVE A QUESTION SO THAT MR. LEHMAN CAN PROPERLY RECORD YOUR PART IN THE MEETING.

SLIDE 2 - REPORT COVERS- FR AND EIS

PURPOSE OF MEETING

OUR PURPOSE FOR BEING HERE THIS EVENING IS TWOFOLD: FIRST, TO INFORM YOU OF THE PROGRESS AND FINDINGS TO DATE ON THE FLOOD CONTROL STUDY AND SECOND, AND MORE IMPORTANTLY, TO OBTAIN YOUR VIEWS ON THE STUDY.

AS INDICATED IN OUR ANNOUNCEMENT OF THIS MEETING, WE RECENTLY COMPLETED A DRAFT FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT PRESENTING THE PRELIMINARY RESULTS OF OUR STUDY FINDINGS. COPIES OF THESE REPORTS HAVE BEEN MADE AVAILABLE TO ALL KNOWN INTERESTS INCLUDING FEDERAL, STATE AND LOCAL AGENCIES, ORGANIZATIONS AND INDIVIDUALS FOR REVIEW AND COMMENT.

AFTER RECEIVING ALL VIEWS AND COMMENTS, INCLUDING THOSE PRESENTED HERE TONIGHT, WE PLAN TO REVISE THE DRAFT REPORT AS NECESSARY, TO ENSURE THAT THE PLAN ULTIMATELY RECOMMENDED TO CONGRESS TRULY REFLECTS YOUR NEEDS AND DESIRES. THUS, THE RESULTS OF OUR MEETING TONIGHT REPRESENT AN IMPORTANT STEP TOWARD MEETING THAT OBJECTIVE.

BACKGROUND

SLIDE 3 - BASIN MAP

THE CITY OF MARSHALL IS LOCATED ON THE REDWOOD RIVER, A TRIBUTARY OF THE MINNESOTA RIVER AS SHOWN ON THIS SLIDE. THE REDWOOD RIVER HAS A HISTORY OF FLOODING CAUSED EITHER BY EXCESSIVE RAINFALL OR SNOWMELT. THE SECOND LARGEST FLOOD OF RECORD ON THE REDWOOD RIVER OCCURRED IN JUNE 1957 WHEN MORE THAN 8 INCHES OF RAIN FELL OVER THE BASIN AND CAUSED THE RIVER TO OVERFLOW ITS BANKS INUNDATING MOST OF THE DEVELOPED AREA OF MARSHALL. THIS NEXT SERIES OF SLIDES SHOWS THE EFFECT OF THE 1957 FLOOD IN MARSHALL.

1957 FLOOD SLIDES

BLANK SLIDE

AT THE REQUEST OF THE CITY OF MARSHALL FOLLOWING THE 1957 FLOOD WE MADE A STUDY OF THE CITY'S FLOOD PROBLEM. THIS STUDY LED TO THE CONSTRUCTION OF THE EXISTING FLOOD CONTROL PROJECT IN 1963.

EXISTING FLOOD CONTROL PROJECT

AS SHOWN ON THIS SLIDE THE EXISTING FLOOD CONTROL PROJECT AT MARSHALL INCLUDES A LEVEE ABOVE THE BURLINGTON NORTHERN BRIDGE AND CLEARING AND SNAGGING IN THE UPSTREAM REACH, AND A 2.4 MILE DIVERSION CHANNEL TO DIVERT EXCESS FLOOD FLOWS AROUND THE CITY AND CHANNEL IMPROVEMENTS IN THE DOWNSTREAM REACH. THE DIVERSION CHANNEL WAS DESIGNED TO PASS A MAXIMUM DISCHARGE OF 5,000 CFS WHILE PERMITTING NORMAL FLOWS UP TO 1,500 CFS TO PASS THROUGH THE NATURAL CHANNEL THROUGH THE CITY.

IN APRIL 1969, THE LARGEST FLOOD OF RECORD OCCURRED ON THE REDWOOD RIVER WITH A DISCHARGE OF 8,090 CUBIC FEET PER SECOND. FROM THIS FLOOD WE FOUND THAT THE DIVERSION CHANNEL WOULD HAVE HAD SUFFICIENT CAPACITY TO PASS THE PEAK FLOW BUT THE PROBLEM WAS THAT THE FLOW DID NOT ADEQUATELY REACH THE DIVERSION STRUCTURE.

DURING THE 1969 FLOOD EMERGENCY MEASURES WERE UNDERTAKEN BY THE CORPS OF ENGINEERS UNDER PUBLIC LAW 99 AS REQUESTED BY THE CITY OF MARSHALL. COUNTY ROAD 7 WAS RAISED TO PREVENT RIVER OVERFLOW FROM INUNDATING THE CENTRAL AREA OF MARSHALL AND HIGHWAY 23 WAS BREACHED TO PERMIT PART OF THE OVERFLOW TO FLOW SOUTHWARD INTO THE COTTONWOOD RIVER BASIN THEREBY FURTHER PREVENTING FLOODING IN MARSHALL. THIS NEXT SERIES OF SLIDES DEPICTS THE EMERGENCY ACTIONS THAT WERE UNDERTAKEN IN THE UPSTREAM REACH IN 1969.

1969 FLOOD SLIDES UPSTREAM

DURING THE 1969 FLOOD ANOTHER PROBLEM DEVELOPED IN THE DOWNSTREAM REACH. IN THIS REACH IT WAS NECESSARY TO CONSTRUCT AN EMERGENCY LEVEE TO PREVENT FLOODING OF THE MORE RECENTLY DEVELOPED AREA IN THE VICINITY OF SOUTHWEST STATE COLLEGE, AS SHOWN ON THESE SLIDES.

1969 FLOOD SLIDES DOWNSTREAM

WITHOUT FURTHER FLOOD CONTROL IMPROVEMENTS OR EMERGENCY MEASURES THE CITY OF MARSHALL REMAINS SUBJECT TO FLOODING BY FLOODS EQUAL TO OR GREATER THAN ONE HAVING ABOUT A 5 PERCENT CHANCE OF OCCURRING DURING ANY ONE YEAR (20-YEAR FLOOD). THIS NEXT SLIDE SHOWS THE OUTLINE IN LIGHT BLUE OF A FLOOD HAVING A 1 PERCENT CHANCE OF OCCURRING DURING ANY 1 YEAR (100-YEAR

SLIDE OF 100-YEAR FLOODPLAIN

FLOOD). THE 100-YEAR FLOOD IS APPROXIMATELY EQUAL IN MAGNITUDE TO THE RECORD 1969 FLOOD. THE RETRACTED DARK BLUE OUTLINE SHOWN ON THE SLIDE IS THE 100-YEAR FLOOD OUTLINE FOR PROPOSED CONDITIONS WHICH I WILL DISCUSS LATER. THE EXISTING CONDITIONS FLOOD OUTLINE IS TAKEN FROM OUR FLOODPLAIN INFORMATION REPORT WHICH WE COMPLETED FOR THE CITY IN DECEMBER 1974.

BLANK SLIDE

DUE TO THE LIMITATIONS OF THE EXISTING FLOOD CONTROL PROJECT AS EXPERIENCED DURING THE 1969 FLOOD, IT IS EVIDENT THAT THE PRESENT PROJECT CANNOT PROVIDE SUFFICIENT FLOOD PROTECTION TO MARSHALL AND THE DEVELOPED FLOODPLAIN AREA ADJACENT TO THE CITY. ACCORDINGLY, IN 1972, RESOLUTIONS WERE RECEIVED FROM LYON COUNTY AND THE CITY OF MARSHALL REQUESTING THAT A STUDY BE CONDUCTED TO DETERMINE WHAT IMPROVEMENTS COULD BE MADE TO PROVIDE ADDITIONAL FLOOD PROTECTION AND INCREASED EFFICIENCY OF THE EXISTING FLOOD CONTROL PROJECT. LATER, AS THE STUDY PROGRESSED, MARSHALL CITY OFFICIALS INDICATED A DESIRE FOR IMPROVED RECREATIONAL OPPORTUNITIES FOR THE CITY, INCLUDING CROSS-COUNTRY SKIING TRAILS, EXPANDED PICNICKING FACILITIES AND NATURE AREAS.

ALTERNATIVE FLOOD CONTROL MEASURES CONSIDERED

ALTERNATIVES LIST

SEVERAL ALTERNATIVE FLOOD CONTROL MEASURES HAVE BEEN CONSIDERED DURING OUR COURSE OF STUDY. TONIGHT I WILL BRIEFLY REVIEW THESE ALTERNATIVES FOR YOU. DETAILED DESCRIPTIONS CAN BE FOUND IN THE DRAFT FEASIBILITY REPORT WHICH HAS BEEN MADE AVAILABLE TO YOU.

IN OUR REPORT, WE DESCRIBE A NO FURTHER ACTION ALTERNATIVE. THIS OPTION SIMPLY MEANS RELIANCE ON EXISTING PROGRAMS TO REDUCE FLOOD DAMAGES. CURRENTLY, FUNCTIONAL FLOOD CONTROL MEASURES INCLUDE THE PRESENT FEDERALLY-CONSTRUCTED PROJECT, THE REQUIRED PURCHASE OF FLOOD INSURANCE IN FLOOD PRONE AREAS; RELIANCE ON FLOOD WARNING AND EMERGENCY FLOOD FIGHT AND DISASTER RELIEF ACTIVITIES BY GOVERNMENTAL AGENCIES; AND FLOODPLAIN MANAGEMENT REGULATIONS CURRENTLY UNDER CONSIDERATION BY THE MARSHALL CITY COUNCIL. SINCE THE NO ACTION ALTERNATIVE WOULD NOT MEET THE PRIMARY OBJECTIVE OF THE STUDY, I.E. THE PROVISION OF RELIABLE FLOOD DAMAGE REDUCTION, WE DID NOT CONSIDER THE ALTERNATIVE FURTHER.

THE SECOND ALTERNATIVE WE CONSIDERED IS EVACUATION OF THE FLOODPLAIN. THOUGH EVACUATION WOULD ACHIEVE PERMANENT PROTECTION, THIS ALTERNATIVE WOULD BE VERY COSTLY TO ACHIEVE ON SUCH A LARGE SCALE DUE TO THE MANY RESIDENTIAL AND BUSINESS DEVELOPMENTS AS WELL AS SCHOOLS AND CHURCHES IN THE AREA. IN ADDITION TO THE COSTS EXCEEDING THE BENEFITS WHICH WOULD ACCRUE, THE EVACUATION ALTERNATIVE WOULD BE TOTALLY UNACCEPTABLE TO ALL CONCERNED INTERESTS.

PLAN 3 AS DESCRIBED IN THE REPORT IS A MODIFICATION OF THE JUST-MENTIONED PLAN, CALLING FOR PARTIAL EVACUATION AND SOME FLOOD PROOFING. INSTEAD OF TOTAL EVACUATION, SOME AREAS COULD BE FLOOD PROOFED, ESPECIALLY WHERE FLOOD DEPTHS ARE NOT TOO GREAT. HOWEVER, EVEN THOUGH THE COSTS WOULD BE LESS THEN COMPLETE EVACUATION, WE FIND THAT THE COST REDUCTION WOULD NOT BE SUFFICIENT TO ECONOMICALLY JUSTIFY THE EVACUATION-FLOOD PROOFING ALTERNATIVE. IN ADDITION, SOCIAL UNACCEPTABILITY WOULD ALSO BE A DETERRENT TO THIS ALTERNATIVE.

UPSTREAM RESERVOIR STORAGE WAS ALSO CONSIDERED AS A POSSIBLE SOLUTION. TWO APPROACHES WERE REVIEWED IN CONNECTION WITH THE PROPOSAL. ONE WOULD INVOLVE A SINGLE, LARGE RESERVOIR LOCATED IN CAMDEN STATE PARK. FROM A TECHNICAL VIEWPOINT, THE PARK WOULD AFFORD THE ONLY PRACTICAL SITE. HOWEVER, UPON REVIEW, OUR STUDIES SHOWED THAT SUCH A RESERVOIR WOULD HAVE INSUFFICIENT STORAGE CAPACITY. IT WOULD ALSO RESULT IN SEVERE ENVIRONMENTAL LOSSES, SIGNIFICANTLY CHANGE THE USE OF THE PARK AND BE ECONOMICALLY UNJUSTIFIED.

THE OTHER RESERVOIR ALTERNATIVE CONSIDERED WAS A SYSTEM OF SMALL TRIBUTARY RESERVOIRS. SMALL RESERVOIRS BY THEMSELVES WERE CONSIDERED INFEASIBLE SINCE THE RESERVOIRS WOULD BE SITUATED TOO FAR UPSTREAM AND WOULD ALSO HAVE INADEQUATE STORAGE CAPABILITY TO SIGNIFICANTLY REDUCE DAMAGES FROM MAJOR FLOODS. HOWEVER, IN OUR STUDY OF FIVE MINNESOTA RIVER SUBBASINS WHICH WE ARE CONDUCTING JOINTLY WITH THE SOIL CONSERVATION SERVICE, UNDER PUBLIC LAW 87-639, WE ARE CONSIDERING A NUMBER OF SMALL RESERVOIRS ON SEVERAL TRIBUTARIES INCLUDING THE REDWOOD RIVER. DEPENDING ON THEIR FEASIBILITY, THESE SMALL RESERVOIRS WOULD SERVE AS AN IMPORTANT SUPPLEMENT TO THE PROPOSED PLAN OF IMPROVEMENT.

CONSIDERED ALTERNATIVES SLIDE

SEVERAL VARIATIONS OF LEVEES AND CHANNEL IMPROVEMENT WERE ALSO INVESTIGATED AS POSSIBLE SOLUTIONS FOR FLOOD CONTROL IN THE UPSTREAM REACH OF MARSHALL AS SHOWN ON THIS SLIDE.

[illegible] WAS GIVEN [illegible] HIGHWAY 7 BRIDGE [illegible] DIVERSION CHAN- [illegible] DAMAGE REDUCTION, BUT AT [illegible]

[illegible] WOULD IN- [illegible] TO DIVERT [illegible] RIVER FLOOD [illegible] THE COTTONWOOD RIVER BASIN AS [illegible] CONDITIONS.

[illegible] THE DESIRED PROTEC- [illegible] WERE FOUND TO BE BOTH [illegible] BECAUSE OF THIS, CHANNEL IMPROVEMENT [illegible] TO IMPROVING EXISTING [illegible] AND [illegible] UNPROTECTED DEVELOPMENTS IN AND [illegible]

[illegible] CHANNEL WIDENING, CLEARING AND [illegible], A [illegible], AND PROTECTION TO PREVENT BANK EROSION. SUCH CHANNEL WORKS WOULD PROVIDE ONLY MINOR FLOOD DAMAGE REDUCTION TO THE NEW DEVELOPMENTS.

LEVEE CONSTRUCTION WAS ANOTHER CONSIDERATION. ONE PROPOSAL IN THE DOWNSTREAM REACH WOULD INVOLVE LEVEE CONSTRUCTION, A DRAINAGE PONDING AREA WITH DITCH AND OUTLET WORKS, AND A TEMPORARY SANDBAG CLOSURE. THESE MEASURES WOULD PROVIDE MORE EFFICIENT OPERATION OF THE EXISTING PROJECT AND PROVIDE PROTECTION FOR NEW DEVELOPMENTS.

AT THE REQUEST OF THE CITY, A COMBINED HIGHWAY-LEVEE ALTERNATIVE WAS INVESTIGATED. THIS WOULD BE QUITE SIMILAR TO THE PRECEDING PLAN EXCEPT THAT THE PROPOSED HIGHWAY WOULD SERVE AS A LEVEE.

CONSIDERATION WAS ALSO GIVEN TO A COMBINED LEVEE-CHANNEL WORKS TO REDUCE FLOOD STAGES AND REQUIRED EMBANKMENT HEIGHTS. THIS ALTERNATIVE, HOWEVER, WOULD BE ENVIRONMENTALLY HARMFUL IN TERMS OF VEGETATIVE AND HABITAT LOSSES DUE TO CHANNEL BANK CLEARING AND RESHAPING.

SELECTED PLAN

PROPOSED FLOOD CONTROL PLAN

THIS NEXT SLIDE SHOWS THE SELECTED FLOOD CONTROL PLAN. THIS PLAN CONSISTS OF IMPROVEMENTS ALONG THE RIVER REACHES BOTH UPSTREAM AND DOWNSTREAM OF THE EXISTING FLOOD CONTROL PROJECT.

UPSTREAM WORKS WOULD CONSIST OF A 2,260-FOOT-LONG LEVEE ALONG THE LEFT BANK AND A 6,350-FOOT-LONG LEVEE WITH TWO TEMPORARY SANDBAG CLOSURES ALONG THE RIGHT BANK. THE LEFT AND RIGHT BANK LEVEES WOULD COMMENCE AT THE UPSTREAM END OF THE EXISTING PROJECT AND EXTEND TO

[illegible] EMBANKMENTS, [illegible] CHANNEL [illegible] AT CHANNEL BENDS, [illegible] DIVERSION STRUCTURE [illegible] CONTROL FLOOD OVER- [illegible] WORKS, AES- [illegible]

[illegible] LONG LEVEE [illegible] EMBANKMENT UP- [illegible] AND HUDSON [illegible] SANDBAG CLOSURE, [illegible] OF THE DOWN- [illegible] CHANNEL. [illegible] THE NATURAL CHANNEL [illegible], THE RIVER [illegible] CHANNEL BANK AND [illegible]. IN ADDITION, A [illegible] DITCH [illegible] IS INCLUDED IN THIS [illegible] TO THE PROPOSED LEVEE.

SLIDE OF 100-YEAR FLOODPLAIN

THE [illegible] WOULD REQUIRE [illegible] REGULATIONS PRESCRIBED BY THE MINNESOTA [illegible] OF NATURAL RESOURCES. THE RESIDUAL [illegible] THE SLIDE IN DARK BLUE.

PROPOSED RE-CREATION PLAN

THE PROPOSED PLAN WOULD ALSO PROVIDE FOR MUCH NEEDED RECREATIONAL FACILITIES. INITIAL FACILITIES WOULD INCLUDE BICYCLE AND CROSS-COUNTRY SKI TRAILS, IMPROVEMENT TO AN OUTDOOR GAMES AREA ON THE PROJECT RIGHT-OF-WAY, AND LIMITED PICNICKING ACCOMMODATIONS. FUTURE PHASE IMPROVEMENTS WOULD INCLUDE A NATURAL EDUCATION AND QUIET AREA, ADDITIONAL IMPROVEMENTS TO THE OUTDOOR GAMES AREA, AND A CANOE ACCESS AT THE HIGHWAY 23 ROADSIDE PARK.

THE SELECTED PLAN IS ECONOMICALLY FEASIBLE AT AN ESTIMATED TOTAL COST OF $2,145,000 AND A BENEFIT-COST RATIO OF 2.0. THE PROJECT WOULD BE CONSTRUCTED BY THE FEDERAL GOVERNMENT AT AN ESTIMATED FEDERAL COST OF $1,[redacted]00. THE NON-FEDERAL SHARE WOULD BE ABOUT $424,000.

LOCAL COOPERATION

THE OVERALL FLOOD CONTROL PROJECT FOR MARSHALL WOULD BE CONSTRUCTED UNDER CONTRACT BY THE FEDERAL GOVERNMENT. THE FEDERAL GOVERNMENT WOULD BE RESPONSIBLE FOR DESIGN AND CONSTRUCTION OF THE VARIOUS FEATURES OF THE PROPOSED WORKS. THE COST OF THIS STUDY IS ALSO ASSUMED BY THE FEDERAL GOVERNMENT.

FOLLOWING CONSTRUCTION, NON-FEDERAL INTERESTS WOULD BE RESPONSIBLE FOR MAINTAINING ALL PROJECT WORKS. IN ADDITION, THE LOCAL SPONSOR WOULD BE RESPONSIBLE FOR MEETING ALL ELEMENTS OF LOCAL COOPERATION AS OUTLINED IN THE DRAFT FEASIBILITY REPORT. PRIOR TO INITIATION OF ANY CONSTRUCTION WORK, THE SPONSOR WOULD ALSO BE REQUIRED TO ENTER INTO A LEGAL AND

BINDING [illegible] I WILL BE

HAPPY [illegible] WITH THE

PROBABLE [illegible]

STATUS [illegible]

[illegible] RECOMMENDING

A [illegible] BY APRIL 1977.

FROM [illegible] REVIEW ORGANIZATIONS

IN WASHINGTON [illegible] RECOMMENDED BY A WIDE

MAJORITY [illegible] PAPERS WOULD BE

SUBMITTED [illegible] COMPLETED AND

THE REPORT [illegible] CONGRESS IN FISCAL

YEAR [illegible]

AS [illegible] THIS IS SO BECAUSE

OF THE [illegible] INTERESTS HAVE HAD

TIME [illegible] IMPROVEMENT SELECTED IS

THE BEST ONE [illegible] AND THE NATION.

EVEN ASSUMING [illegible] BY CONGRESS, CONSTRUC-

TION WOULD NOT [illegible] FIRST, FUNDS HAVE TO

BE MADE [illegible] DESIGN. OUR FINAL DESIGN

WORK COULD NOT BE [illegible] AFTER PLANNING FUNDS ARE

FURNISHED BY [illegible]

THIS CONCLUDES MY FORMAL PRESENTATION. I WILL NOW OPEN THE MEETING UP FOR YOUR VIEWS AND COMMENTS ON THE SELECTED PLAN AND CONSIDERED ALTERNATIVES. FIRST, I WILL CALL ON THOSE WHO INDICATED ON THEIR CARDS THAT THEY WISH TO MAKE A STATEMENT. AFTER THAT, I WILL CALL ON OTHERS WHO MAY WISH TO EXPRESS THEIR VIEWS. AS YOU RISE TO SPEAK, PLEASE GIVE YOUR FULL NAME AND THE INTEREST YOU REPRESENT, IF ANY, SO THAT WE MAY HAVE THIS INFORMATION FOR THE PUBLIC RECORD.

CLOSING

IF THERE ARE NO FURTHER COMMENTS, I WILL TURN THE MEETING BACK OVER TO MAYOR SCHLAGEL. I TRUST THAT EVERYONE HERE TONIGHT HAS HAD AN OPPORTUNITY TO PRESENT THEIR VIEWS. HOWEVER, THE RECORD OF THIS MEETING WILL BE KEPT OPEN FOR A PERIOD OF 30 DAYS FOR ANY ADDITIONAL WRITTEN STATEMENTS. WE THANK YOU FOR COMING OUT HERE TONIGHT AND MEETING WITH US.

END

DATE
FILMED
12-84