U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM 54, MASS.

ADDRESS REPLY TO:
DIVISION ENGINEER

REFER TO FILE NO.

18 MAR 1963

NEDGW

SUBJECT: General Design Memorandum, Local Protection Project, Three Rivers, Palmer, Massachusetts

TO: Chief of Engineers
Attn: ENGCW-E
Department of the Army
Washington, D.C.

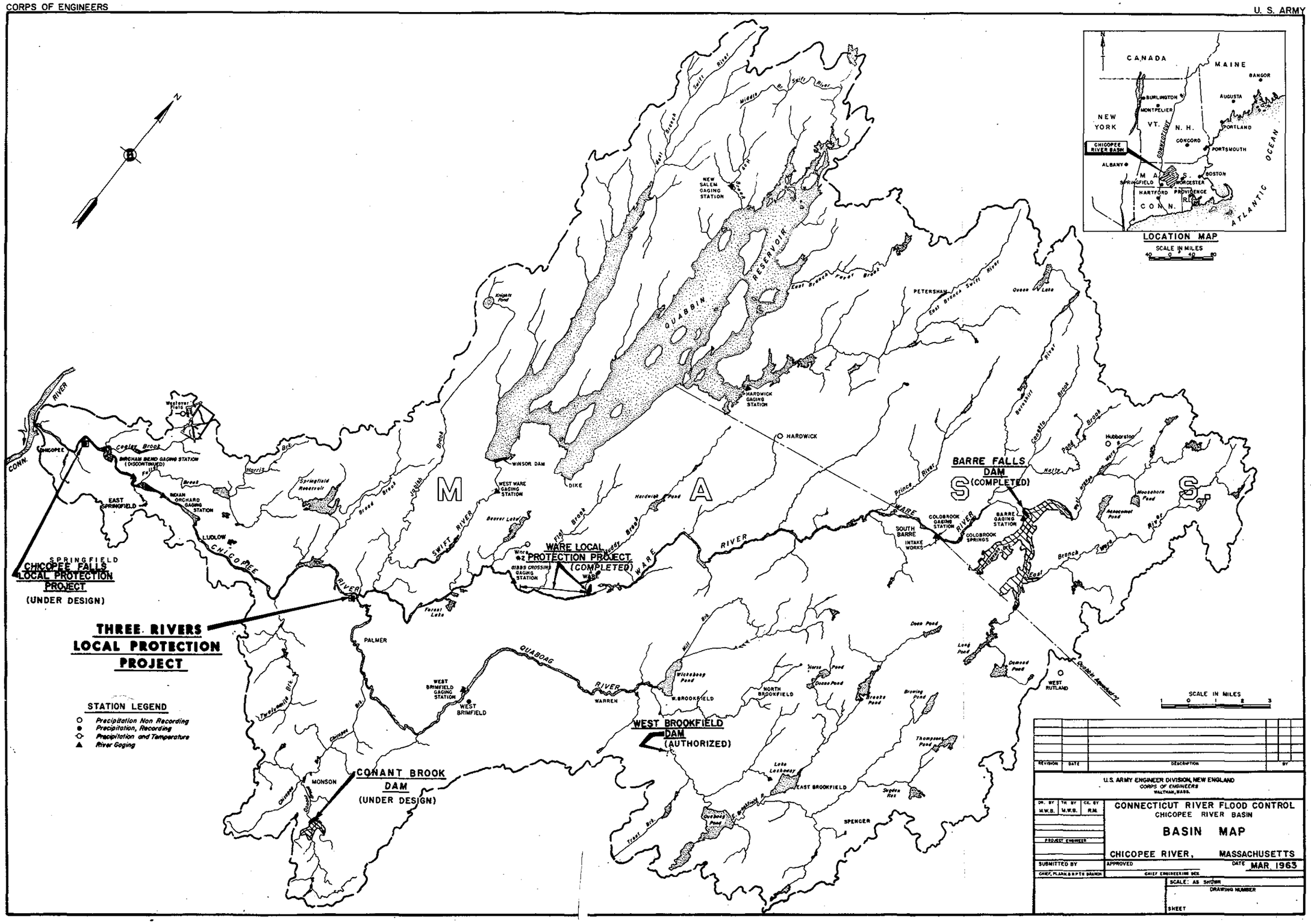
In accordance with EM 1110-2-1150, there are submitted herewith for review and approval ten (10) copies of General Design Memorandum for the Local Protection Project, Three Rivers, Palmer, Massachusetts.

FOR THE DIVISION ENGINEER:

John Wm Leslie

JOHN WM. LESLIE
Chief, Engineering Division

1 Incl.(10 cys)
General Design Memo
Three Rivers, Palmer, Mass.


CANADA
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CHICOPEE RIVER BASIN
ALBANY
CONNECTICUT
M A S S.
BOSTON
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WORCESTER
HARTFORD
PROVIDENCE
CONN.
R.I.
ATLANTIC OCEAN
LOCATION MAP
SCALE IN MILES
QUABBIN RESERVOIR
NEW SALEM GAGING STATION
HARDWICK GAGING STATION
HARDWICK
PETERSHAM
WINSOR DAM
DIKE
WEST WARE GAGING STATION
WARE
SOUTH BARRE
COLDBROOK GAGING STATION
COLDBROOK SPRINGS
INTAKE WORKS
BARRE FALLS DAM (COMPLETED)
BARRE GAGING STATION
Hubbardston
WEST RUTLAND
WARE LOCAL PROTECTION PROJECT (COMPLETED)
GIBBS CROSSING GAGING STATION
CHICOPEE
CONN.
RIVER
Westover Field
Cooley Brook
BIRNHAM BEND GAGING STATION (DISCONTINUED)
EAST SPRINGFIELD
INDIAN ORCHARD GAGING STATION
LUDLOW
SPRINGFIELD
CHICOPEE FALLS LOCAL PROTECTION PROJECT (UNDER DESIGN)
THREE RIVERS LOCAL PROTECTION PROJECT
PALMER
WEST BRIMFIELD GAGING STATION
WEST BRIMFIELD
WARREN
W. BROOKFIELD
NORTH BROOKFIELD
WEST BROOKFIELD DAM (AUTHORIZED)
EAST BROOKFIELD
SPENCER
MONSON
CONANT BROOK DAM (UNDER DESIGN)
STATION LEGEND
Precipitation Non Recording
Precipitation, Recording
Precipitation and Temperature
River Gaging
SCALE IN MILES
REVISION
DATE
DESCRIPTION
BY
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
DR. BY M.W.B.
TR. BY M.W.B.
CK. BY R.M.
PROJECT ENGINEER
CONNECTICUT RIVER FLOOD CONTROL
CHICOPEE RIVER BASIN
BASIN MAP
CHICOPEE RIVER, MASSACHUSETTS
SUBMITTED BY
CHIEF, PLANN. & RPTS BRANCH
APPROVED
CHIEF ENGINEERING DIV.
DATE MAR. 1963
SCALE: AS SHOWN
DRAWING NUMBER
SHEET

CONNECTICUT RIVER FLOOD CONTROL

THREE RIVERS

PALMER, MASSACHUSETTS

DESIGN MEMORANDUM

GENERAL DESIGN

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THREE RIVERS

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CONNECTICUT RIVER FLOOD CONTROL

CHICOPEE RIVER BASIN

LOCAL PROTECTION PROJECT

THREE RIVERS, PALMER, MASSACHUSETTS

GENERAL DESIGN MEMORANDUM

MARCH 1963

A. PERTINENT DATA

1.	Purpose	Local Flood Protection
2.	Location	At confluence of Quaboag, Ware and Chicopee Rivers in Town of Palmer, Hampden County, Mass.
3.	Type of Improvement	Deepen and widen channels, remove existing dam, remove and construct one highway bridge, and alter one highway and one railroad bridge.
4.	Stream Flow Data	Drainage Area (Basin) 645 sq. miles. Project design flood 50,000 c.f.s. Maximum flow of record 41,000 c.f.s.
5.	Channel Improvement	Deepen and widen about 5200 lineal feet to minimum bottom width of 80 feet and maximum bottom width of 200 feet. Side slopes vary.
6.	Bridge Alterations	Removal and construction of new Bridge Street bridge and alteration of Main Street bridge by local interests. Alteration of railroad bridge.
7.	Removal of Dam	Removal of dam to flow line and powerhouse superstructures, to elevation 284.9 m.s.l.
8.	Sewers	Revision of existing sewers by local interests.

9. Real Estate

Improvements to be removed include fire station, 2 lean-to structures, storage structure, a small concrete building, and dam and power house. Residential, commercial and industrial land by easement - 10.5 acres; and access roads by easement - 1.5 acres.

10. Principal Quantities

Earth Excavation	211,000 CY
Rock Excavation	55,000 CY
Slope Protection	20,000 CY
Dam Removal	1 Job
Constr. Bridge St. Bridge	1 Job
Main Street Bridge Alterations	1 Job
Railroad Bridge Alterations	1 Job

11. Estimated Project Costs (1963 Price Level) Federal Costs

Channel Improvement	$713,000
Bridge Alterations	270,000
Removal of Structures	71,000
Preauthorization Studies	10,000
Engineering and Design	114,000
Supervision and Administration	92,000
Total Estimated Federal Cost	$1,270,000

Non-Federal Costs

Lands and Damages	100,000
Bridges	400,000
Utility Relocations	35,000
Total Estimated Non Federal Cost	535,000
Total Estimated Project Cost	$1,805,000

12. Benefits

Benefit - Cost Ratio ~~1.6~~ 1.7 to 1

Wrong Interest Rate

B. INTRODUCTION

1. Purpose. The purpose of this memorandum is to set forth a complete definite project report for local flood protection of the community of Three Rivers in the Town of Palmer, Massachusetts.

2. Scope. This memorandum covers the entire project including a description of the project plan, data on geology, hydrology, and flood damages; a summary of severe floods; structural and bank protection designs; and other engineering details together with estimates of costs and benefits.

C. AUTHORIZATION

3. Authorization. The Three Rivers Project was authorized as a part of the Chicopee River flood protection plan authorized by Public Law 86-645, 86th Congress, adopted 11 July 1960, which reads in part as follows:

"The plan for flood protection on the Chicopee River, Massachusetts is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers in House Document Numbered 434, Eighty-sixth Congress, at an estimated cost of $5,180,000. No obligation shall be incurred for the cost of this project where the flood control benefits are exclusively for local flood control, as determined by the Secretary of the Army (except costs of planning, design, and acquisition of water rights), unless the State or one or more other non-Federal entities shall have entered into an agreement in advance to assume at least 20 per centum of the cost (except costs of planning, design, and acquisition of water rights) of the completed project allocated to the production of local flood control benefits, payable either as construction proceeds or pursuant to a contract providing for repayment with interest within 50 years. The actual cost, or fair market value of the lands, easements, rights-of-way, and work performed or services rendered prior to completion of construction of the project, which are furnished by a non-Federal entity, shall be included in the share of the cost to be borne by the non-Federal entity.

Full monetary authorization for the project was provided by this Act.

4. In House Document No. 434, 86th Congress, 2nd Session, the Chief of Engineers recommended the "Three Rivers Local Flood Protection Project, consisting of enlargement of the channel and removal of a dam and power house; generally in accordance with the plans of the Division Engineer and with such modifications thereof as in the discretion of the Chief of Engineers may be advisable; at an estimated cost to the United States

of $1,260,000 for construction; provided that, prior to construction, local interests give assurances satisfactory to the Secretary of the Army that they will: (1) Provide without cost to the United States all lands, easements, and rights-of-way necessary for the construction of the project; (2) Make necessary alterations to roads, highway bridges, sewers, and utilities; (3) Obtain necessary rights to permit the United States to remove the New England Power Company Dam and Powerhouse on the Chicopee River; (4) Hold and Save the United States free from damages due to the construction works; (5) Permit no encroachment on improved channels including the waterway areas under the bridges; and (6) Maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army." The cost of these items is expected to exceed the 20 percent local contribution requirement contained in the authorizing document and therefore no cash contribution is anticipated.

D. INVESTIGATIONS

5. Previous Investigations. Flood control of the Chicopee River and its tributaries has been considered in the following published reports on the Connecticut River Basin;

a. Survey Report, printed in 1936 in House Document No. 412, 74th Congress, 2nd Session, presented comprehensive plan for combined flood control and power development of the Connecticut River and tributaries consisting of 20 reservoirs and dikes in 7 localities. Recommended that the authorization for additional reservoirs be deferred and that the authorized project be modified to provide for the protection by dikes and related works of 7 cities, including Chicopee, Massachusetts.

c. The first interim review report on Connecticut River and tributaries, printed in 1920 in House Document no. 653, 76th Congress, 3rd Session, recommended that the authorized project for protection by dikes and related works of 7 cities, including Chicopee, Mass., be modified for construction in accordance with revised plans.

d. The second interim review report on the Connecticut River and tributaries, printed in 1940 in House Document No. 724, 76th Congress, 3rd Session, recommended modification of the approved flood control plan to include local protective works at 4 additional sites and 20 reservoirs including reservoirs on the Quaboag River at West Brookfield, Mass., and on the Ware River at Barre Falls, Mass.

e. Flood control of the Chicopee River and its tributaries is considered in Part Two, Chapter XXI of "The Resources of the New England-New York Region", printed in 1957 in Senate Document No. 14, 85th Congress, 1st Session. It is a comprehensive report on the potentialities of power, land, water, and related natural resources of the region and included protective works in the Chicopee River Basin.

f. An Interim Report on Review of Survey for Flood Control, Connecticut River Basin, Chicopee River Basin, Mass. was submitted by the Division Engineer on 8 September 1959, pursuant to authority contained in resolution of the Senate Public Works Committee, adopted 14 September 1955. This report was printed in 1960 in House Document No. 434, 86th Congress, 2nd Session, and included the recommended construction of local protection work at Three Rivers.

6. Reports of Other Agencies. In 1956 a report titled "Report on Flood Protection Survey" was prepared by Charles T. Main, Inc., Engineering Consultants, for the Town of Palmer, and in 1958 a flood control study for Three Rivers was made by Tighe and Bond, Inc., Consulting Engineers.

7. Current Investigations. In order to determine the most practical design for the project, basic data obtained in connection with previous studies and past reports were fully utilized. In addition, the following new data were obtained and studies made:

a. Topographic surveys of the project area.

b. All available subsurface information was reviewed and new geological and soils investigations of the channel area and foundation conditions were completed.

c. Hydrologic studies were reviewed and new studies were made to determine the most practical channel gradient and cross-section.

d. Appraisals of lands and damages are being undertaken by the Town of Palmer, and are subject to approval by the Corps of Engineers.

e. The design of a new highway bridge and the alteration of another together with the revision of sewer lines is being done by engineering consultants for local interests. This design is being coordinated with the project plans.

f. A relocation agreement will be executed with the Central Vermont Railroad for design and construction of necessary alterations to its railroad bridge.

8. Coordination with Other Agencies. Close coordination has been maintained with officials of Federal, State and local agencies as well as officials of industrial concerns involved. The Town of Palmer has approved the layout of the project. The project as proposed has little or no effect on hydro-electric power, (except for the demolition of a small hydro plant) recreation, pollution abatement, fish migration or other collateral purpose.

9. Public Hearings. A public hearing was held in Chicopee Falls, Mass., on 15 October 1958, to obtain the views of interested parties relative to flood control and allied measures on the Chicopee River Basin. The hearing was attended by representatives of the communities in the river basin including the Town of Palmer. It was the preponderant opinion that devastating damages were incurred in the Chicopee River Basin from past floods and that flood control is urgently needed.

E. LOCAL COOPERATION

10. Local Cooperation. The proposed project is located entirely within the limits of the Town of Palmer, Massachusetts. On 3 June 1959, the selectmen of the Town of Palmer passed a resolution which provided that the Town would furnish certain items of local responsibility without cost to the United States. These items were estimated at that time to have a project first cost of $460,000.

In an Act approved on 18 July 1962 (chapter 692, Acts of 1962, Commonwealth of Massachusetts) the Water Resources Commission of the Commonwealth of Massachusetts was authorized as the agency to furnish the local cooperation and to pay sums not exceeding $550,000 for the non-Federal cost of the project. This Act was accepted by the Town of Palmer on 1 October 1962.

Formal assurances of local cooperation were executed by the Massachusetts Water Resources Commission on 9 November 1962.

F. LOCATION OF PROJECT

11. Location and Extent of Project Area. The Three Rivers Local Flood Protection Project is located at the confluence of the Quaboag, Ware and Chicopee Rivers in the Town of Palmer, Hampden County, in the south central part of Massachusetts. The project would extend from the existing New England Power Company Dam on the Chicopee River upstream to the confluence of the Chicopee, Quaboag and Ware Rivers, and about 700 feet on the Ware River and 1500 feet on the Quaboag River, a total distance of about 2500 feet. The site of this project lies in a pool formed by the New England Power Company dam. The pool extends from the dam up the river beyond the extent of the project area. A stone-faced multiple-arch concrete highway bridge crosses the Chicopee River about midway in the project area and forms a major obstruction during flood stages.

Trees line the river banks at the lower portion of the project area while the upstream portion is developed and utilized by manufacturing firms and a central business area. Rock lies below the stream bed in a portion of the area where it is proposed to lower the elevation of the channel bottom. A railroad bridge also crosses the Chicopee River and a concrete highway bridge crosses the Quaboag River. These bridges will be altered to fit the proposed channel layout.

12. Chicopee River Basin. The entire Chicopee River Basin is fan-shaped. Its topography in the western part of the basin is less rugged than to the north and northeast. The general conformation is low, with rolling hills and several upland plains. The hills and streams of the basin contain outcrops of rock. The banks and beds of the streams are lined with stone and the valleys and hills are dotted with boulders. From the confluence of the Ware and Quaboag Rivers to its confluence with the Connecticut River, a distance of about 18 miles, the Chicopee River flows through well-developed manufacturing centers.

Above Three Rivers, Mass., where the Swift, Quaboag and Ware Rivers join to form the Chicopee River, the terrain is hill and exhibits the surface characteristics and irregular drainage pattern typical of glaciated areas of southern New England. Hills are prominent and valleys are steep and narrow. Most of the tributary streams are oriented in a north-south direction and flow almost due southerly to where the pre-glacial valleys enter the Ware River. The Ware River Valley is devoted to manufacturing and agriculture.

On the Quaboag River, from Three Rivers, Mass., to its origin, the valleys are broad with gentle slopes. Except in the dairy country of the Brookfields and Spencer and parts of Monson, the land in the Quaboag Basin is generally sandy and contains large boulders, making it unfavorable for agriculture.

The Chicopee River Watershed contains many natural lakes and ponds, supplemented by numerous artificial ponds developed by local power and manufacturing plants. The largest of the natural ponds is Quaboag Pond with an area of about 512 acres, while the Quabbin Reservoir is the largest man-made lake in the State, with a surface area of approximately 19 square miles.

The relief of the basin varies from elevation 40 feet, mean sea level, at the mouth of the Chicopee River, to elevation 1,720 feet, mean sea level, at Wachusett Mountain in Princeton, Mass., in the northeast end of the East Branch Ware River watershed. Elevations at the project area vary roughly from 80 to 120 feet. Although a very large percentage of the Chicopee River Basin has some sort of tree growth, very little is under heavy woodland cover. Gray birch, pitch

pine, and other shrub trees are the principal varieties found in the valley.

13. General Geology. The Chicopee River and its tributaries drain an area comprising portions of two distinct geologic and physiographic regions, the New England Upland and the Connecticut Valley Lowland. The major, eastern part of the area lies within the upland Section, a rough, maturely dissected region underlain by crystalline rocks. Westerly of Ludlow, the area extends into the Connecticut Valley Lowland, a low, broad, structural basin underlain by sedimentary rocks and igneous "trap rock."

The upland region is one of moderate to high relief characterized by relatively deep, steep-sided, poorly drained valleys and broad, rough-sided hills. The bottom of many of the valleys have been given an appearance of widening by partial filling with outwash sands and gravels. Above the outwash deposits, the upland surface is blanketed by glacial till consisting of a compact, heterogenous mixture of materials ranging in grain size from clay to boulders. Bedrock protrudes through the thin till mantle on the upper slopes and tops of many of the hills, and is also exposed in and along the bottom of some of the valleys.

The lowland region is generally flat to gently rolling and, except where resistant trap rock ridges rise above the general lowland surface, is underlain by sandstone, shale and conglomerate. In general, the lowland surface is represented in the eroded surfaces of glacial lake sediments and delta outwash plains, comprising varved clays, silts, and poorly sorted sands and gravels, deposited in and around the margins of glacial lakes, and post-glacial flood plain and terrace deposits composed of roughly stratified sands and gravels.

Detailed site geology is discussed in Paragraph P, Site Geology.

14. Area Maps. The Chicopee River and its watershed are shown on standard quadrangle sheets of the U.S. Geological Survey (scale 1:31,680) and on standard quadrangle sheets of the Army Map Service (scale 1:25,000).

G. OTHER PLANS INVESTIGATED

15. Design for Standard Project Flood. To provide for a design to take care of the standard project flood of 69,000 c.f.s., it would be necessary to deepen and widen the channel to a minimum bottom width of 120 feet. To obtain this channel width, the F.&D. Machine Tool Works building in the right bank of the Chicopee River would have to be removed and reconstructed in another location. Additional bridge work would also be required over and above the amount required for the recommended plan. The cost to provide protection against the standard

project flood was found to be economically unjustified. A project design flood of 50,000 c.f.s. was selected.

16. Design for Other Channel Widths. Studies were also made for minimum channel widths of 90 and 100 feet for the project design flood of 50,000 c.f.s. Such channel widths would require the removal of a portion of the F.&D. Machine Tool Works building which extra cost did not justify the marginal hydraulic benefit involved.

H. DEPARTURE FROM PROJECT DOCUMENT PLAN

17. Project Document Plan. The Three Rivers Local Protection Project, as authorized, proposed protection from a flood of 50,000 c.f.s. on the Chicopee River. This discharge is approximately 28 percent greater than the 1955 flood discharge as modified by Barre Falls Reservoir and the authorized Conant Brook Reservoir.

18. Departure from Project Document Plan. The following modifications and changes from the approved document plan were made during the development of detailed studies based on additional investigation and information obtained:

a. Minor changes and refinements were made in the profile and cross-sections of the channel.

b. Main Street bridge is extended to the west instead of to the east at the request of the Town of Palmer in order to prevent damages to local business establishments, even though it will require the removal of an obsolete fire station.

c. The railroad bridge is extended to the south instead of to the north to permit a smooth channel alignment to conform to the change in the Main Street bridge.

d. The method of protecting the foundations to the railroad bridge and the Main Street highway bridge was changed from a steel sheeted box structure to a heavily-riprapped footing protection.

I. HYDROLOGY AND HYDRAULICS

19. Climatology. a. General. The Chicopee River Basin has a variable climate characterized by frequent but usually short periods of precipitation. The basin lies in the path of the "prevailing westerlies" and the cyclonic disturbances that cross the country from the west or southwest. It is also exposed to occasional coastal storms, some of tripical origin, that travel up the Atlantic seaboard. In late summer and autumn months these storms occasionally attain hurricane intensity.

b. Temperature. Average monthly temperatures in the Chicopee River Basin vary widely throughout the year with a mean annual temperature of approximately 50°F. Freezing temperatures have been experienced from the latter part of September until the early part of May. The mean, maximum and minimum monthly temperatures for stations at Worcester, Massachusetts, located about 80 miles east of Three Rivers, and Westover Field, Mass., near the Chicopee River Basin, about 30 miles west of Three Rivers, are shown in Table I.

TABLE 1

MONTHLY TEMPERATURES

(Degrees Fahrenheit)

	Worcester, Mass.			Westover Field, Mass.		
Elevation (feet msl)	628			240		
Years of Record	68			19		
Month	Mean	Max.	Min.	Mean	Max.	Min.
January	25.4	69	-18	24.9	65	-22
February	25.5	67	-24	27.8	65	-18
March	34.9	84	-6	36.2	86	-13
April	45.8	91	8	47.6	87	13
May	57.3	92	25	58.1	93	29
June	65.9	98	33	67.4	102	37
July	71.0	102	41	72.3	97	45
August	69.0	99	35	70.2	99	36
September	62.0	100	26	62.7	101	27
October	51.7	89	13	52.6	89	17
November	40.2	81	3	41.7	81	8
December	28.5	67	-17	28.5	64	-15
Annual	48.2	102	-24	49.2	102	-22

c. Precipitation. The mean annual precipitation over the Chicopee River Basin is approximately 44 inches, ranging from less than 40 inches in the Chicopee Area to more than 50 inches at the headwaters of the Ware River. In general, the precipitation is uniformly distributed throughout the year, although considerable variation in precipitation occurs in individual months. Table 2 summarizes the precipitation records at Hubbardston, Massachusetts and Ware #2, Massachusetts

Table 2

MONTHLY PRECIPITATION RECORD

(In Inches)

	Hubbardston, Mass.			Ware #2, Mass.		
Elevation (feet msl)	1,030			500		
Years of Record	43			30		
Month	Mean	Max.	Min.	Mean	Max.	Min.
January	2.92	6.17	0.61	3.35	6.46	1.00
February	2.44	4.83	1.18	2.87	5.55	0.93
March	3.38	8.89	1.32	3.66	7.52	1.59
April	3.60	7.62	1.01	3.41	6.49	0.71
May	3.45	6.96	1.17	3.69	6.27	0.70
June	4.00	11.82	0.46	4.46	8.29	1.22
July	4.10	8.00	1.07	4.13	10.14	1.21
August	3.45	9.83	0.79	4.18	20.65	0.46
September	4.25	18.28	0.94	4.12	15.70	1.02
October	3.28	8.05	0.13	3.10	9.12	0.81
November	4.04	7.44	0.95	3.83	8.41	0.83
December	2.96	6.83	0.50	3.33	6.11	0.74
Annual	41.87	61.34	32.81	44.13	62.78	33.51

d. Snow. The mean annual snowfall in the Chicopee River Basin is about 50 inches, with considerably greater depths at the higher elevations. Snow cover reaches a maximum depth in late February with the water content in early spring often reaching about three or four inches. Monthly and annual snowfall at Westover Field, Mass. and Hubbardston, Mass. are tabulated in Table 3.

TABLE 3

MEAN MONTHLY SNOWFALL

	Westover Field, Mass.	Hubbardston, Mass.
Elevation (feet msl)	240	1,030
Years of Record	16	25
Month	Snowfall	Snowfall
January	12.7	15.0
February	13.3	14.2
March	10.1	7.6
April	1.6	2.5
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
October	Trace	0.4
November	2.0	4.2
December	11.3	10.1
Annual	51.0	54.0

e. Storms. The rapidly moving cyclonic storms or "lows" that move into New England from the west or southwest produce frequent periods of unsettled, but not extremely severe weather. The region is also exposed to occasional coastal storms, some of tropical origin, that travel up the Atlantic coast and move over or within striking distance of the New England States. Some of these storms attain hurricane intensity, such as those of September 1938 and August 1955. These storms were the two most severe of record over the basin. Thunderstorms may be of local origin or of the frontal type associated with summer storms.

RUNOFF

20. Discharge Records. a. The U.S. Geological Survey publishes records at eight stream gaging stations in the Chicopee River Basin. Three gaging stations, one on the Ware River, one on the Quaboag River, and one on the Chicopee River are all in the general vicinity of the project. Streamflow records at these three gaging stations are summarized in Table 4.

TABLE 4

STREAMFLOW RECORDS - CHICOPEE RIVER BASIN

Location of Gaging Station	Drainage Area (sq. mi)	Period of Record	Mean (cfs)	Discharge Maximum (1)	Minimum(1) (cfs)
Ware River at Gibbs Crossing	199	1912-1960	326	22,700(3)	6.0
Quaboag River at West Brimfield	151	1909-1960	245	12,800(3)	6.6
Chicopee River at Indian Orchard	688	1939-1960	1,120	45,200(2)	16.0
Chicopee River at Bircham Bend	703	1928-1938	(Continued as Indian Orchard)		

(1) Instantaneous Discharge
(2) September 1938
(3) August 1955

b. Runoff. The mean annual runoff for 21 years of record through September 1960 at Indian Orchard varied from 460 to 1,449 cfs with a mean of 853 cfs. Table 5 is a summary of the maximum, minimum, and mean monthly runoff in cfs for the period of record at Indian Orchard since the construction of Quabbin reservoir.

TABLE 5

MONTHLY RUNOFF - CHICOPEE RIVER AT INDIAN ORCHARD, MASS.

(In cfs)

D.A. = 688 Square Miles
October 1939 - September 1960

Month	Mean	Maximum	Minimum
January	869	1,968	252
February	959	1,848	378
March	1,437	2,137	690
April	1,822	3,956	776
May	1,248	2,680	489
June	818	2,475	322
July	478	1,238	209
August	508	3,719	176
September	394	1,516	160
October	411	1,953	131
November	737	3,022	258
December	787	1,596	325
Annual	853	1,449	460

NOTE: Flows at Indian Orchard are affected by diversion, regulation and reservoir storage, and may not reflect the true runoff from the drainage area of 688 square miles.

FLOODS OF RECORD

21. Historic Floods. a. On the basis of meager records, it appears that the Chicopee River basin had not experienced many destructive floods prior to 1936. Damaging floods occurred in May 1854 and October 1869, but as far as can be determined neither approached the magnitude of the major floods which occurred during and after 1936.

b. Recent Floods. Four floods of major proportions have occurred in recent years. Pertinent data on these floods at the three key gaging stations on the Ware, Quaboag and Chicopee Rivers are listed in Table 6.

The first of the two March 1936 floods was caused by a combination of rainfall and snow melt. The second flood, which was the more destructive, involved only minor amounts of snow melt but had considerably more rainfall. Also, the second flood followed the first so closely as to occur with nearly saturated ground conditions and nearly bank full channels. The September 1938 flood produced the greatest flood of record along the Ware, Swift and Chicopee Rivers. Natural storage areas in the basin were filled by the time of the most intense rainfall, so the time sequency of this hurricane storm was conducive to high peak discharges. The August 1955 flood produced by far the greatest peak flows of record along the Quaboag River. On the Ware and Chicopee Rivers the 1955 flood was second only to that of September 1938. Swift River flows were minor as all runoff above Windsor Dam was controlled by Quabbin Reservoir.

TABLE 6

MAJOR FLOODS

	Ware River at Gibbs Crossing (D.A.=199 sq. mi)		Quaboag River At West Brimfield (D.A.=151 sq. mi)		Chicopee River at Indian Orchard (D.A.=688 sq. mi)	
Flood	Average Rainfall (inches)	Peak Dis. Observed (cfs)	Average Rainfall (inches)	Peak Dis. Observed (cfs)	Average Rainfall (inches)	Peak Dis. Observed (cfs)
12 March 1936	2	5,210	2	2,040	2	14,200*
19 March 1936	4.5	11, 200	5	3,620	4	20,400*
September 1938	13.0	22,700	11.5	8,470	10.5	45,200*
August 1955	8	12,200	15	12,800	13	40,500

* Chicopee River at Bircham Bend

c. Flood Frequency. Peak discharge frequency curves, as developed for the Interim Survey Report for the Chicopee River Basin, were reviewed and brought up-to-date. An additional three years of record had no appreciable effect on the curves used in the survey report. The frequency analysis was made in accordance with procedures described in Civil Works Engineer Bulletin 31-1 and 51-14 which are predicated on the

assumption that the logarithmic values of annual peak flow are normally distributed. The frequency curve for this project is shown on Plate No. B-7 of the survey report.

PROJECT DESIGN FLOOD

22. Hydraulics of Flood Problem. a. The flood problem at the project site is caused by several existing factors, chief of which is the backwater effect of the New England Power Company Dam, located about 3,000 feet downstream from the confluence of the Ware and Quaboag Rivers. The spillway crest elevation of the dam is 299.3 feet, m.s.l. Further serious restrictions to channel flow are caused by the narrow channel width between the buildings of the Zero Manufacturing Company, and the F.&.D. Machine Company about 2,000 feet upstream of the dam; and the inadequacy of the stone arch bridge at Bridge Street, the Central Vermont Railroad bridge, and the Main Street bridge. Lack of depth in the Ware and Quaboag Rivers adjacent to their confluence is also a factor in restriction of flow. The combined effect of these conditions is to limit the channel capacity of the Chicopee River at the site to about 13,000 c.f.s.

b. Standard Project Flood. A standard project flood was developed for the Chicopee River basin by using the synthetic rainfall from Civil Works Bulletin 52-8 and unit hydrographs developed for subareas from floods of record. The storm was considered to be stationary for the entire duration of the precipitation, and was centered along the topographic ridge between the Ware and Quaboag Rivers with the long axis oriented approximately parallel to the rivers. This storm location and orientation tends to assign relatively light precipitation to the area above Windsor Dam which is considered noncontributing. It also produces the most critical conditions on the main stem of the Chicopee River. Unit hydrographs were developed for ten subareas, based on the September 1938 and August 1955 floods. The components for subareas were developed by applying subarea storm rainfall to the applicable unit hydrographs. The component for each subarea was routed progressively to all downstream index points. The resulting peak discharge at Indian Orchard is 77,800 cfs, or about 72 percent greater than the record flood of 45,200 cfs experienced in September 1938. The derivation of the standard project flood is described in detail in Appendix 13, of the Interim Report on Review of Survey, Chicopee River basin, dated 8 September 1959.

c. Project Design Flood. The adopted design flood for the Chicopee River portion of the Three Rivers project is 50,000 cfs, which is about 72 percent of the standard project flood modified by Barre Falls and Conant Brook Reservoirs (69,000 cfs), and which is about 25 percent in excess of the maximum flood of record modified by the two reservoirs. Because of the channel restrictions caused by adjacent industrial buildings and the many bridges at Three Rivers,

it was found impracticable and economically unjustified to design the project for the standard project flood discharge of 69,000 cfs. It is considered that the project design flow of 50,000 cfs will provide a reasonably high degree of protection. The improvements will also considerably reduce the damages that would be experienced during a standard project flood.

TABLE 7

COMPARISON OF FLOOD DISCHARGES

	Drainage Area (sq. mi)	Standard Project Flood (cfs)	Project Design Flood (cfs)	Max. Flood of Record (cfs)
Ware River (modified by Barre Falls)	435	(a) 43,800	32,000	(b) 24,700
Quaboag River (modified by Conant Brook)	210	28,200	20,000	(c) 19,700
Chicopee River (modified by Barre Falls and Conant Brook)	645	69,000	50,000	(b) 40,000

(a) Ware River Discharge of 36,500 cfs. plus 7,300 cfs from Swift River

(b) September 1938

(c) August 1955

HYDRAULIC DESIGN

23. Removal of New England Power Company Dam. a. The New England Power Company Dam, located about 3,000 feet below the confluence of the Ware and Quaboag Rivers, constitues the present major hydraulic control. Its spillway crest elevation of 299.3 feet, msl, causes a serious backwater effect on flood flows, raising stages to overbank levels. The dam will be removed to the level of the stream bed and the power house superstructure to elevation 284.9 msl. Since the power house foundation will have no significant affect on the backwater profile, and its removal would be costly the foundation will be left in place and the voids will be filled with excavated materials for the purposes of appearance and safety.

b. Alterations in Channel Widths and Grades. Several combinations of channel widths and grades were tested, using the design flood of 50,000 cfs and a flow of 15,000 cfs, the latter being used to test velocities at a lower flow, particularly at the piers of the railroad bridge. The final selected channel, mostly trapezoidal, will have a bottom width of 120 feet at Station 0+00, the present location of the New England Power Company Dam. The bottom width will converge at a uniform rate to 80 feet at Station 12+00, and will remain at 80 feet to Station 21+00, due to physical limitations imposed by the location of the Buildings of the Zero Manufacturing Co on the left bank and the F.&D. Machine Company on the right bank. From Station 21+00 the bottom width will increase uniformly to 140 feet at Station 24+00 and from there to 200 feet at Station 27+00 and will remain at 200 feet to Station 28+00, just below the confluence of the Ware and Quaboag Rivers. From this point the side lines will be altered to provide a smooth transition to both banks of the Chicopee and Quaboag Rivers. The minimum bottom width of the Ware River will be 140 feet up to Station 37+49 the limit of the project on this stream. The Quaboag River will also have a minimum bottom width of 140 feet to the limit of the project at Station 45+00.

The bottom will be excavated to elevation 270.0 feet, msl, at Station 0+00 and will be level to Station 21+00. From this point the bottom will rise to an elevation of 284.0 feet, msl, at Station 26+00, with a slope of 0.028. The slope from this station will be 0.0064 to an elevation of 286.8 feet, msl, at Station 30+35. The same slope will be continued up the Quaboag River to meet the existing elevation of 296.2 feet, msl,at Station 45+00. The bottom of the Ware River will rise from the elevation of 286.8 feet, msl at Station 30+35 to the existing elevation of 286.8 feet, msl, at Station 37+50, with a slope of 0.0100.

The channels will be trapezoidal, except for a vertical wall on the left bank of the Quaboag River between Station 31+50 and 32+60. The side slopes will be 4 on 1 in rock and 1 on 1.5 in earth, with a 5-foot berm between the top of the excavated rock and the toe of the earth slopes. For improved flow conditions, spoil will be placed at the junction of the Quaboag and Ware Rivers below Main Street bridge, and on the right bank of the Quaboag River above the Main Street Bridge. In both cases the fill will be placed on a 1 on 2.5 slope from the top edge of the excavated channel. This provides sufficient cross sectional area on the Quaboag River to carry 35,000 cfs, the flow of the standard project flood. Although the project as a whole is designed to prevent damage during the project design flood, spoil areas will be restricted in order to provide adequate channel capacity to pass the standard project flood.

c. Bridge Street Bridge. The present stone arch bridge at Bridge Street constitutes a severe restriction to flood flows. It consists of three circular arched spans of 56 feet with a maximum clearance above the existing river bed of about 22 feet. In order to provide required channel capacity, a new bridge will be constructed, consisting of three 80-foot spans, with a minimum bottom member elevation of 309.0 feet, msl, at the center and 308.0 msl at the left bank providing three feet of freeboard for the design flow. This length will permit the required amount of widening at the left bank.

d. Central Vermont Railroad Bridge. In connection with the required widening on the left banks of the Chicopee and Quaboag Rivers, the existing bridge of the Central Vermont Railroad is to be lengthened by the construction of an additional span. In order to retain the same upstream chord length on the existing southerly span, the present abutment will be replaced by a pier pivoted on the upstream end of the abutment with alignment parallel to the new abutment, which will be constructed about 70 feet south of the existing one. This will provide an additional bridge opening of about 45 feet, normal to the river flow. The new abutment will be connected by a retaining wall to the new southerly abutment of the Main Street bridge.

e. Main Street Bridge. The bridge at Main Street consists of two 56 foot spans. A new span of about 50 feet in length will be constructed to provide the necessary waterway area required to pass the design flood. This will be accomplished by replacement of the existing westerly abutment with a pier and construction of a new abutment.

f. Water Surface Elevations. The design water surface profile as shown on Plate No. 10 was developed by backwater computations, using Manning's Formula as outlined in Engineering Manual for Civil Works Construction, Part CXIV, Chapter 9. The starting elevation of 290.4 feet, msl, at Station -(1+30) was determined from a rating curve based on high water data and tailwater conditions. Using a coefficient "n" of 0.035, the computed water surface represents depths of water between 6 and 20 feet per second on the Chicopee River. On the Quaboag River depths varied from 14 to 20 feet, with velocities ranging from 6 to nearly 9 feet per second. On the Ware River depths vary between 15 and 21 feet, with velocities between 6 and 14 feet per second. The bottom grades between Stations 21+00 and 30+50 were selected so as to avoid excessive velocities at bridge piers with low and moderate flows. The design channel was tested for a discharge of 15,000 cfs, resulting in critical flow at about Station 26+00, with supercritical flow between Stations 25+00 and 26+00. Since this area is in rock, no problems are caused by the resulting high velocities. Depths between Stations 26+50 and 30+50 varied from 19 to 21 feet, with velocities ranging from 6 to 13 feet per second.

J. GEOLOGY, FOUNDATIONS AND EMBANKMENTS

24. Physiography. The Three Rivers area is located on the Worcester Plateau in a region of moderate though sharp relief, characterized by wide, poorly-drained valleys, and broad rough-sided hills. The topography is the result of normal erosion modified by glacial erosion and deposition, and is controlled largely by the underlying crystalline bedrock. The Chicopee, Ware and Quaboag rivers constitute the regional drainage. Remnants of once vast deposits of outwash, which choked many of the valleys at the close of the glacial period, are present as terrace and flood plain features. Above the outwash the slopes are mantled with glacial till, through which bedrock outcrops rather extensively at the higher elevations. Limited exposure of bedrock are also present in and along the floors of some of the major valleys where streams, in their meandering and downcutting, have completely removed the glacial debris.

25. Surficial and Subsurface Investigations. a. Previous Investigations. Ten (10) drive-sample borings were made in 1947 as a part of an engineering study prepared for the Town of Palmer by F.H. Feldman, Consulting Engineer, in connection with the design of a new Main Street bridge. The locations and logs of these exploration are shown respectively on the Plan of Foundation Explorations, and on the Record of Foundation Explorations, No. 2. Additional explorations consisting of a few borings and probes are in progress to respectively determine the nature of materials for design of cut slopes extending above the present river banks and the thickness of soft materials under the spoil retaining dikes.

26. Site Geology. The Ware and Quaboag Rivers enter the project area from the north and east respectively through a relatively broad flood plain. These streams merge near the upper end of the project to form the Chicopee River which flows westerly through the area in a narrow, steep-sided valley. A low flood plain feature, the surface of which is some 10 to 15 feet above normal river level, and which is occupied by several large factory buildings and stores, forms the left or south bank of the Chicopee upstream of Station 19+00. A similar feature forms the right or north bank upstream of Bridge Street. Downstream of these features the banks rise steeply from the river's edge to heights of over 35 feet and bedrock is exposed more or less continuously along the toe of both banks, in places presenting high, sheer faces. Scattered outcroppings also occur on the slopes well above the river and the overburden is generally thin over the steeply-pitching bedrock surface. Rather extensive scatterings and local concentrations of large blocks occur on the slopes on both sides of the river along the middle and lower reaches of the project. The Chicopee River is flowing close to or against bedrock along much of the reach between Bridge Street and the New England Power Company dam at the lower end of the project. Above Bridge Street, the Chicopee and also the Ware and Quaboag Rivers largely flow on variably thick deposits of glacial materials and alluvium.

27. Subsurface Conditions. a. Overburden. General. Earth excavation will average approximately 10 feet throughout the project area, ranging from an average of less than 5 feet in the river channels to over 20 feet in the riverbanks upstream. Downstream of Station 19+00 earth excavation will generally be carried back to, and up the bedrock surface where encountered within design slopes. Overburden materials of appreciable thickness occur in the upper part of the project area above Station 19+00. These materials consist of glacial till and outwash, overlain by variable thicknesses of alluvium and, in places, artifical fill. Maximum explored thickness of overburden, 35 feet, occurs in the flood plain feature along the left side of the Chicopee River. Similar features extend up the Ware and Quaboag Rivers where they occupy the entire valley floors. Downstream of Station 19+00 the overburden is generally less than 5 feet in thickness in the bed of and on the banks of the Chicopee. For some distance upstream from the New England Power Company dam the natural materials in the river bed are overlain by organic sludge of unknown thickness and extent. Throughout the rest of the project area the river bed materials are capped rather extensively by a 1-to5-foot thick layer of soft mud.

b. Glacial Till. The till consists generally of a moderately compact to compact gravelly silty sand containing numerous cobbles. This material rests on the rock surface and is confined generally to that part of the project area in the vicinity and upstream of the Central Vermont Railroad bridge where the maximum explored thickness is less than 10 feet. The fill surface is at a depth of 25 feet in the flood plain feature at the west end of the East Main Street bridge and dips southeasterly beneath the Quaboag at a depth of less than 10 feet along the west shore to over 20 feet along the east shore.

c. Glacial Outwash, Alluvium and Fills. The outwash deposits, consist of a moderately compact, variably sorted mixture of silty sands and gravels with occasional lenses or strata of silt. These materials occur rather extensively in the flood plain features along the Chicopee and in the bed of the Quaboag where they rest partly on till and partly on bedrock. Overlying, and commonly grading into the outwash, are deposits of alluvium comprised of loose to moderately compact layers of silty gravelly to fine sand and silt. The outwash and alluvial materials, exclusive of the layers of fine sand and silt in the upper portions of the latter, possess similar characteristics and are treated and discussed as a single unit. Explorations encountered from 5 to 25 feet of these materials in the flood plain feature along the left side of the Chicopee. These deposits thicken in an upstream direction with the heaviest accumulation occurring in the vicinity of the Central Vermont Railroad. In this feature these materials are overlain by a 2- to 10-foot thick section of artificial fill consisting principally of silty gravelly sand admixed with variable amounts of cobbles, cinders, bricks and pieces of wood.

A comparable thickness of outwash and alluvial materials was encountered in the bed of the Quaboag in the vicinity of the East Main Street bridge where thickest deposition is along the east shore. Alluvial sands and gravels, capped by mud overlie bedrock fairly persistently in the bed of the Chicopee downstream of Station 19+00 to at least Station 9+00. Materials in the flat-topped feature along the right side of the Chicopee, upon which the F.& D. Machine Company is located, are largely composed of artificial fill. In the vicinity of the buildings this fill consists of some 5 to 10 feet of gravelly silty sand admixed with boulders, bricks, cinders, concrete blocks, railroad ties and scrap metal. In some places the fill rests directly on bedrock but is generally separated from it by a thin layer of silty sand.

d. Bedrock. General. The bedrock in the project area is predominantly a quartz diorite with occasional localized zones of biotite schist. For the most part this rock is of medium texture, hard and massive though closely joined and fractured. Many of the joints, which are well developed at angles of 30,50 and 70 degrees, are open and stained and some have a silt filling. Secondary mineralization is also prevalent along many of the joint planes and in a few places the joint surfaces show minor evidence of slickensiding. Also apparent is a faint to distinct high angle structural lineation along which much of the fracturing has occurred.

e. Rock Excavations. Channel excavations in rock will be made in the portion of the project in the vicinity and downstream of the railroad bridge. Depths of excavation will generally average less than 10 feet with deepest cuts of about 30 feet along the right bank of the river. This rock is expected to break readily due to its highly jointed and fractured nature. This condition will result in small fragmentation and a tendency to easy overbreak, particularly in the upper portions. Between the Zero Manufacturing and F.& D. Machine Company's building the river is severely restricted and proposed channel excavations will be made to within a few feet of both buildings which are founded on rock as shown in section on Plan of Explorations. Rock excavations adjacent to the buildings will be carefully controlled to prevent vibratory damage, and line drilling or pre-splitting will be employed to minimize overbreak and subsequent damage to the foundations. Similar careful excavation methods may be required in excavations of channel side slopes where concrete walls will be founded in proximity to edge of cuts. Provision will be made for use of rock bolts where applicable in stabilizing the slopes.

f. Rock Foundations. Rock is available at shallow depth for foundations in the vicinity of Bridge Street bridge and the south abutment of the railroad bridge. It is expected that only nominal excavations below the rock surface will generally be required to provide sound foundations in these areas.

g. Rockfill and Slope Protection. Rock materials from required channel excavations will be utilized in the construction of dumped rockfill dikes on the banks of the Ware and Quaboag Rivers for retention of fill consisting of waste excavation materials. Rock for slope protection is required on the retention dikes and on channel slopes in overburden. Much of the channel rock excavations will be less than 10 feet below the rock surface and will largely produce small fragmentation due to open, close jointing and weathering in that zone. However, excavation quantity exceeds requirements for rockfill and slope protection and selection of suitable stone for the latter use will be possible, particularly from the deeper excavations.

28. Foundations, Embankments and Slopes. a. General. Protective dikes and flood walls are not required for this project. Foundations of bridge piers and abutments with the exception of the Main Street bridge abutment will be on rock. Selected excavation material will be utilized for rock slope protection, rockfill and for construction of spoil fills. Excavation materials in excess of project requirements will be disposed of by the contractor outside the limits of the project.

b. Foundations. Rock is at shallow depths at the location of the Bridge Street, Main Street and railroad bridges. The Bridge Street bridge which is to be designed by local interests will be founded on rock.

Design and alteration of the railroad bridge will be accomplished by the Central Vermont Railroad except that channel deepening and protection of piers will be included in the Corps of Engineers contract. The left abutment will be founded on rock. Explorations indicate existing foundations bear on a thin stratum of overburden, varying to 5 feet in thickness, overlying rock. The proposed channel bottom is to be a maximum of 3 feet below the bottom elevation of existing piers. Excavation limits will provide for a 3-foot berm 2-feet above the bottom of footings and 1 on 2 side slopes to the channel bottom. The berm and side slopes will be protected by 2-feet of hand placed riprap.

The foundation in the areas of spoil fill along the left bank of the Ware river and the right bank of the Quaboag river is composed of soft unstable organic silts to an average depth of 5- feet. This unstable material will be excavated to firm material adjacent to the

river slope of the spoil fill to provide for stability of the slopes.

c. Embankments and Slopes. A substantial thickness of rockfill from required excavations will be utilized on the face of the spoil fills to retain lower strength spoil materials and to provide stability of the slopes. Since placement of the spoil fill is expected to displace soft surface materials in the river bed, it is expected the contractor will construct the face of the spoil fills as a retention dike to contain displaced foundation materials. The face of the spoil fill will be contiguous with the protected channel slope. 1 on $2\frac{1}{2}$ slopes have been selected to provide adequate hydraulic capacity.

Existing natural unprotected slopes of the bank at the river's edge are about 1 on $1\frac{1}{2}$. This slope has been adopted for channel slopes in overburden to minimize excavation quantities and to avoid disturbance of vegetative cover on the presently stable slopes to the river. However, in those portions of the project where the new slopes are entirely within the existing river area, the soft unstable river deposits would not be stable. These unstable materials will be excavated to firm material for a distance of 10-feet from the normal excavation and backfill of rockfill will be placed to provide stability.

d. Slope Protection. Slope protection for the channel and the spoil retention dikes will generally consist of a 2-foot layer of rock selected from required excavations placed on a 12-inch layer of gravel bedding. This slope protection satisfies current criteria for the maximum anticipated velocity of 15 ft/sec.

Generally, overburden slopes are less than 15 feet in height however, in two areas, between Stas. 16 and 20 on the left bank and between Stas. 22 and 25 on the right bank, the slopes are of the order of 30 feet in height. Rock slope protection in these areas will be increased to a 5-foot thickness to increase stability and to prevent difficulties in holding steep slopes during and immediately after construction.

e. Sources of Construction Material. All required earth and rockfill materials, except gravel bedding, will be obtained from required excavations. Bank-run gravel, suitable for bedding is available from numerous commercial sources within 10 miles of the site.

K. CONCRETE

29. Concrete Materials. Approximately 3,740 cubic yards will be required for construction of relocated bridges for this project. In

view of the small quantity of concrete required, aggregate investigation has been confined to established commercial sources within a 20-mile haul distance of the site.

Two commercial sources have previously been tested and approved for fine and coarse aggregate for civil works construction projects. North Wilbraham Sand and Gravel Company with its processing plant for sand and gravel and concrete batching plant is located in North Wilbraham, Massachusetts, a 6-mile haul distance to the project site. A. Giard and Sons, Incorporated with a processing plant for sand and gravel and concrete batching plant is located in Ware, Massachusetts, a 7-mile haul distance to the project site. Data on these sources are reported in Technical Memorandum No. 6-370 "Test Data - Concrete Aggregate in Continential United States", Volume 5, Latitude 42° N-Longitude 72° W, Index Nos. 11 (rev.) and 12, respectively.

Five other commercial sources are available within the area. D.D. Ruxton Company, Inc., located in Ludlow, Massachusetts, which had been previously tested and approved for civil works construction has been abandoned. Monson Sand and Gravel Company located in Monson, Massachusetts has recently been tested and disapproved for civil works construction. John Lizak, Banas Sand and Gravel Company and Berkshire Asphalt, Incorporated, indicated they were not interested in supplying concrete aggregates for the subject project.

L. STRUCTURAL DESIGN

30. General. There are no items that will require structural design by this office. The highway bridges will be designed by local interests. The railroad bridge alteration will be designed by the owner under relocations agreement.

M. DESCRIPTION OF PROPOSED STRUCTURES AND IMPROVEMENTS

31. General. A description of each of the principal elements of the proposed plan of improvement for the Three Rivers Local Protection Project is present in the following paragraphs:

a. Removal of Dam and Powerhouse. The dam and powerhouse owned by the New England Power Company is to be deeded to the Town of Palmer. The dam will be removed by demolition to the level of the river bed. The superstructure of the powerhouse will be removed to Elevation 285 msl and openings backfilled. The overflow section of the dam is about 195 feet long and 35 feet high, which together with the non-overflow section contains about 4800 cu. yds. of concrete.

b. Channel Improvement. The present channels of the rivers are proposed to be widened and deepened according to the layout in the

drawings. This will entail the excavation of about 210,000 cu. yds of earth and 55,000 cu. yds. of rock with the side slopes of the rock cuts specified as 4 on 1 and the earth embankments at 1 on $1\frac{1}{2}$ protected by a 2-foot to5-foot layer of rock over a 1-foot filter zone. Foundation explorations indicate that there is sufficient rock of good quality available for this fill from the required excavation. A portion of the balance of the usable excavated material will be deposited at the confluence of the Ware and Quaboag Rivers and along the easterly side of the Quaboag River above the Main Street bridge to improve flow conditions.

c. Railroad Bridge. The railroad bridge crossing the Chicopee River within the project site is owned by the Central Vermont Railroad. It is a single track, 3 span, steel girder bridge about 250 feet long, and will be lengthened about 80 feet. This will involve the removal of an abutment and the construction of a new pier and a new abutment. It is intended to enter into a relocation agreement providing for design and construction by the railroad since daily freight traffic is heavy and work can be done effectively and economically by this method.

d. Highway Bridge. There are two highway bridges crossing the proposed new channels, namely the Bridge Street bridge, which is a 3-span, 2-lane, multiple arch stone-faced concrete bridge 200 feet long with inadequate waterway openings for major floods; and the Main Street bridge which is a 2-span, 3-lane girder bridge 110 feet long. The Bridge Street bridge is to be removed and replaced with a longer bridge, approximately 260 feet long, of 3 spans and of adequate clearance above the design flood crest. The Main Street bridge is to be lengthened about 50 feet which will involve the removal of an abutment and the construction of a new pier and abutment. To facilitate traffic movement during the construction work on these bridges, it is planned to build temporary bridges or to make an arrangement to utilize the railroad bridge.

e. Protection of Bridge Foundations. The elevation of the proposed channel bottom is near the foundation elevations of the existing pier footings of the railroad bridge and the Main St. bridge. Since new piers and abutments are to be erected on the left side of the river, the remaining piers and abutment will require protection, namely two piers and an abutment on the railroad bridge and one pier and an abutment on the Main Street bridge. It has been ascertained through several borings that the north abutment of the railroad bridge is founded on ledge but that the two northerly piers, where footings will be protected, are not directly on ledge even though the ledge is only a few feet below the footings. The Main Street bridge is on a granular foundation with ledge indicated at 7 to 12 feet below the footings. The maximum river velocities through these bridges are expected to be 8.7 c.f.s. and for these flows it is planned to use rock

berms around the various piers. These berms of hand-placed rock, will be placed on a 1 on 2 slope to a thickness of 2 feet in the slope and 3 feet in the toe.

f. Sewage and Utility Lines. The existing sewage disposal problem in the Three Rivers Area will be aggravated by the removal of the New England Power Company dam because raw sewage is now discharged into the pool which acts as an oxidation and settling pond. Lowering of the pool will expose the outfalls of the sewer pipes and will cause a nuisance during low river flows. The Town of Palmer plans to build a modern treatment plant but prior to its construction collector lines will be built to intercept the various outfalls and discharge them in the lower reach of the project into a pool that is formed by the present Ludlow Mfg. dam located about 2 miles downstream of the present New England Power dam.

32. Channel Alignment. The alignment of the river channels under this project generally follow the old courses of the rivers except at the upper part of the Chicopee River and the lower part of the Quaboag River where the channel is to be widened about 50 feet to the south and west. Changes in the channels will also occur for better hydraulic control at the junction of the Quaboag and Ware Rivers and on the right bank of the Quaboag River above the Main Street bridge. These areas will be formed by depositing usable rock and earth from required excavation which will be in excess of other project requirements.

N. REAL ESTATE REQUIREMENTS

33. General. Land requirements and appurtenant property rights will be acquired by local authorities.

34. Land Requirements. It is assumed that the required land interests will be acquired under permanent easement whenever this estate is adequate to serve project requirements.

The land types from steep rocky river bank areas to commercial and industrial land. A total of about 10½ acres will be required for work and construction areas. The access road requirements will be about 1½ acres. The major portions of the lands to be taken under permanent easements are undeveloped sections at the rear edges of residential and retail store lots. Another type of land involved in easements is steep, wooded river banks. The rear land of two industrial plants will also have to be taken under easement and a portion of a paved parking lot of one plant. The major improvement involved is the village fire station, which is a two-story brick building. Two lean-to structures adjacent to an industrial plant will be removed. A minor storage building at another manufacturing plant will be acquired. The fifth building that is in the path of construction is a small building of concrete construction.

Reference is made to paragraph C.4(3), AUTHORIZATION. The New England Power Company, in a letter dated 8 June 1958 addressed to the Board of Selectmen of the Town of Palmer reaffirmed the Company's willingness to contribute the Dam, powerhouse and appurtenant lands to the town. Therefore the estimated value of the rights to be taken in connection with this facility is based on the town owning the property. However, the property will be burdened with the restriction that the powerhouse and dam must be removed; thus, damages are considered nominal.

Since the easement taking will impair the access to the rear of one manufacturing plant, severance damages are estimated.

Consideration has been given to the special benefits which the properties will receive by the river improvement. The estimates herein presented are on a "Before and After" basis.

It is estimated that 38 properties will be involved in this project.

Valuation

Total Estimated cost of land, Improvements and Water Rights -

Resident, commercial and industrial land (10.5 acres)	$16,500
Access Roads (1.5 acres)	4,000
Improvements (5 buildings)	48,000
Water Rights	1,000
Severance Damage	5,000
Contingencies: 10%	7,450
Acquisition & Administrative Expenses: Estimated 38 Ownerships @ $500.	19,000
Total(round)	$100,000.

O. RELOCATIONS

35. Railroad Bridge. To provide an adequate channel width, the railroad bridge owned by the Central Vermont Railroad will be lengthened about 80 feet. This will include the removal of an abutment and the construction of a new pier and abutment. This bridge carries a single-track freight main line with heavy daily traffic between Montreal, P.Q., and New London, Connecticut. It is planned to execute a relocation agreement with the railroad for the design and construction of this extension. (Copy of attorney's report under Appendix A).

36. Highway Bridges. Two highway bridges are involved in the deepening and widening of the channel on this project. The Bridge Street bridge, which is a multiple-arch concrete structure, will be removed and a new and larger bridge will be erected. The Main Street bridge, which is a concrete girder structure will be lengthened including the construction of a new pier and abutment. Appurtenant utility relocation will be included in this work. The cost of this highway bridge will be paid for by local interests.

37. Utilities. Local interests will also make necessary modifications to and pay the cost of the sewage and drainage facilities that will become exposed with the lowering of the power pool. It is the intention of the Town to install a collection main to connect with the present drains and dispose of the effluent well below the community center of the Town.

38. Roads. No road relocations will be required for this project.

P. COST ESTIMATES

39. Estimate of Cost. The estimated cost is as follows:

FIRST COST
(1963 Base)

Item	Quantity	Unit	Unit Price	Amount
Federal Cost				
Channel Improvement				
Stream control	1	Job	L.S.	$75,000
Earth excavation	210,000	C.Y.	$1.25	262,500
Rock excavation	55,000	C.Y.	3.50	192,500
Earth fill	80,000	C.Y.	.20	16,000
Rock Fill	55,000	C.Y.	.50	27,500
Gravel Bedding	6,000	C.Y.	3.00	18,000
Stone slope Protection	19,000	C.Y.	1.50	28,500
				$620,000

Estimate of Cost (cont)

Item	Quantity	Unit	Unit Price	Amount
Contingencies				$ 93,000
Total Channel Improvement Cost				713,000
Bridge Alterations				
Earth Excavation	600	C.Y.	2.50	1,500
Stone protection, hand placed	800	C.Y.	10.00	8,000
Alteration to railroad bridge				225,000
				$234,500
Contingencies				35,500
Total Bridge Alteration Cost				$270,000
Removal of Structures				
Removal of dam and powerhouse superstructure (6500 cy. concrete and 500 sq. ft. building)				$ 60,000
Removal of Buildings				2,000
				$ 62,000
Contingencies				9,000
Total Removal of Structures Cost				$ 71,000
				$1,054,000
Engineering and Design				114,000
				$ 1,168,000
Supervision and Administration				92,000
Total Federal First Cost				1,260,000
Preauthorization Studies				10,000
Total Federal First Cost				$ 1,270,000
Non-Federal Cost				
Lands and Damages				
Land in fee				
Land, improvements and water rights				69,500
Severance damage				5,000
Contingencies: 10%				7,450

Non-Federal Cost (cont).

Resettlement Cost Acquisition and Administrative Expenses	19,000	
Total Lands and Damages Costs	$100,000	
Bridges (including appurtenant utility lines and removal of structures)		
New Bridge Street Bridge	300,000	
Addition to Main Street Bridge	100,000	
Total Bridges Cost	$400,000	
Sewer Alterations		
Extension of existing sewers	35,000	
Total Non-Federal First Cost		$535,000
TOTAL PROJECT COST	$1,805,000*	

*Includes $10,000 for costs to date for preauthorization studies.

Q. SCHEDULE OF DESIGN AND CONSTRUCTION

40. Design. Contract plans and specifications are scheduled to be complete in April 1963.

41. Construction. Construction of the project will require about 21 months. It is planned to consolidate all the work under one contract except that for the railroad bridge extension to be done under agreement with the railroad and the utility work to be performed by the local authorities.

R. OPERATION AND MAINTENANCE

42. Operation. The project will function without any supervision by local interests.

43. Maintenance. The new channel will be maintained by the local authorities. Maintenance will be based on regular inspection of the areas and will include all actions necessary to preserve the channel areas from obstructive materials that would lower the efficiency of the waterways.

S. COORDINATION WITH OTHER AGENCIES

44. General. Close coordination has been maintained with officials of Federal, State and local agencies as well as officials of adjacent industrial concerns. The Town of Palmer has approved the general alignment and layout of the project. The project as proposed has no capacity for hydroelectric power, except that the presently installed power plant is to be removed. The project has no effect on recreation, fish migration or other collateral purposes.

Copies of letters commenting on the Three Rivers Local Protection Project from the Federal Power Commission; The Connecticut River Valley Flood Control Commission; the Soil Conservation Service; the Bureau of Public Roads; and the Bureau of Sport Fisheries and Wildlife are included in this report under Appendix B.

T. ECONOMICS

45. General. The Three Rivers section of Palmer is vulnerable to flooding by the Quaboag and Ware Rivers, which, joining to form the Chicopee River at this point, give the area its name. Upstream of the confluence, along the Quaboag, additional portions of the Town of Palmer are also susceptible to flooding at times of high river stages. The flood of August 1955 caused losses estimated at $6,975,000 in Palmer, with the bulk of the losses occurring in and upstream of the project area on the Quaboag. A recurrence of the flood levels of August 1955 under today's economic conditions would cause losses estimated at $6,600,000 without additional flood protection. Conant Brook Reservoir, presently under design, acting with the existing Barre Falls Reservoir, would prevent damages of $2,140,000 in Palmer. The local protection project would prevent an additional $3,765,000 in losses.

46. Annual Benefits. Annual benefits to flood damage prevention have been derived by determining the annual losses in the project area, after reduction of flood flows and stages by completed and authorized reservoirs and the losses remaining after project construction. The difference in annual losses before and after construction are credited to the project as benefits.

Annual benefits, so derived, adjusted for the growth expected to take place in the area over the 100 year life of the project amount to $92,000.

47. Advance Replacement Benefit. To pass the design flood the project requires the replacement of Bridge Street bridge with a bridge having a larger water-way opening. The existing bridge, built in 1910, was reconstructed in 1938 after receiving severe flood damage. Its estimated useful life is 50 years or from 1938 to 1988. The construction

of a new bridge will extend the benefits from a bridge in this location by an estimated 26 years. The project is therefore credited for the value of the advance replacement of Bridge Street bridge by an estimated annual amount of $1400.

Total benefits to the Three Rivers project amount to $93,400.

48. Economic life. The economic life of the project has been established for a 100-year period. The purpose of this project is the protection of life and property from major floods by the deepening and widening of the river channel which work can easily be considered, with reasonable annual maintenance, to be of a nearly permanent character, both physically and economically. In addition, an analysis of present and expected economic conditions within the project area revealed substantial justification for project utilization over a 100-year project life.

49. Annual Costs. Total annual charges amounting to $57,600 are summarized below:

1. Federal Investment		
Total Federal First Cost	$1,270,000	
Total Federal Investment	1,270,000	
2. Annual Federal Charges		
Interest on Federal Investment (2.875% x 1,270,000)	36,500	
Amortization (100 yrs)(.179% x 1,270,000)	2,300	
Total Federal Annual Charges	$ 38,800	
3. Non-Federal Investment		
Total Non-Federal Cost	$ 535,000	
Total Non-Federal Investment	535,000	
4. Annual Non-Federal Charges		
Interest on Non-Federal Investment (3.25% x 535,000)	17,400	15,400
Amortization (100 yrs)(.138x535,000)	800	1,000

Annual Non-Federal Charges (cont.)

Estimated Tax Losses	$100	
Maintenance and Operation	500	
Total Non-Federal Annual Charges	18,800	17,[illegible]
Total Annual Charges	57,600	55,[illegible]

50. Benefit-Cost Ratio. The ratio of benefits to cost is ~~1.6~~ to 1.0.
1.7

U. RECOMMENDATIONS

51. It is recommended that the project plan submitted in this report be approved as a basis for the preparation of contract plans for the Three Rivers Local Flood Protection Project.

APPENDIX A

ATTORNEY'S REPORT

APPENDIX A

ATTORNEY'S REPORT

Three Rivers Local Protection Project, Palmer, Massachusetts

1. Public Law 86,645, 86th Congress, approved July 14, 1960, provides for local protection project on the Chicopee River in Palmer, Massachusetts. This project is authorized substantially in accordance with the recommendations of the Chief of Engineers in House Document No. 434, 86th Congress at a then estimated cost of $1,730,000.00

2. Within the proposed project area, there are Town roads, telephone exchange lines, electric distribution lines, railroad bridge and municipal fire station. Local interests under the terms of the project document are required to provide land and easements necessary for the construction of the project. However, under Section 3 of the Flood Control Act approved 24 July 1946, necessary alterations of railroad bridges and approaches in connection with local cooperation projects will be carried out at Federal expense. The local interest must, however, furnish the necessary rights of way for such alteration. EM 1120-2-101, Paragraph i covers this situation. However, municipal facilities are not included in this deviation from policy according to ER 1180-1-1, Part 7, Paragraph 53-703.1 c.

3. Central Vermont Railway, Inc. operates and maintains a railroad line within the Three Rivers Local Protection Project and includes a bridge crossing the river. The portion of the railroad line and bridge affected by the project crosses the river and private property. The railroad was laid out around 1852 by deed of Octavius Pickering to the Amherst and Belchertown Railroad Company dated June 10, 1852, recorded in Hampden County Registry of Deeds, book 227, page 447. This strip of land was acquired adjacent to the river. The actual river crossing was acquired by this same railroad by filing a location plan and taking in the Town Clerk's office, Palmer, Massachusetts. The Amherst and Belchertown Railroad subsequently conveyed its property to the Amherst, Belchertown and Palmer Railroad which then transferred its real estate rights to the New London Northern Railroad Company. The Central Vermont Railway, Inc. then acquired this railroad from the New London Company. This railroad bridge will be affected by the construction, operation and maintenance of the project and its rearrangement or alteration is required. It is my opinion that the Central Vermont Railway, Inc. has a compensable interest therein and is entitled to the reasonable costs of any necessary rearrangement and alteration.

Morris S. Phillips

MORRIS S. PHILLIPS, Attorney
Real Estate Division

12 February 1963

APPENDIX B

COMMENTS OF OTHER AGENCIES

Exhibit No.	
1.	Federal Power Commission
2.	United States Department of Agriculture
3.	Bureau of Public Roads
4.	United States Department of the Interior Fish and Wildlife Service
5.	Commonwealth of Massachusetts Division of Fisheries and Game
6.	Connecticut River Valley Flood Control Commission

FEDERAL POWER COMMISSION
REGIONAL OFFICE
346 Broadway
New York 13, New York

November 1, 1962

Division Engineer
U. S. Army Engineer Division, New England
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

Reference is made to your letter of October 30, 1962, relating to the Three Rivers Local Flood Protection Project, located in Palmer, Massachusetts at the confluence of the Chicopee, Ware and Quaboag Rivers.

Inasmuch as the proposed project consists essentially of channel rectification work for local flood protection and no reservoirs for possible hydroelectric power development are involved, we have no comments on the subject at this time.

Your courtesy in furnishing information on the project is appreciated.

Sincerely yours,

D. J. Wait
Regional Engineer

EXHIBIT NO. 1

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

29 Cottage Street, Amherst, Massachusetts

November 16, 1962

The Division Engineer
U. S. Army Engineer Division, New England
Corps of Engineers, 424 Trapelo Road
Waltham 54, Massachusetts

Dear Colonel Hyzer:

Thank you for your letter of October 30, 1962, advising us of the plans for the Three Rivers Local Flood Protection Project, located in Palmer, Massachusetts, at the confluence of the Chicopee, Ware and Quaboag Rivers.

Since the Soil Conservation Service has no project plans in this area we have no specific comments to make on the Three Rivers project.

Sincerely yours,

Benjamin Isgur,
State Conservationist.

Growth Through Agricultural Progress

EXHIBIT NO. 2

REGION ONE
CONNECTICUT
MAINE
MASSACHUSETTS
NEW HAMPSHIRE
NEW JERSEY
NEW YORK
RHODE ISLAND
VERMONT
PUERTO RICO

U. S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
14 Court Square
Boston 8, Massachusetts

November 28, 1962

Colonel P. C. Hyzer
Division Engineer
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

Receipt is acknowledged of your letter of October 30 which requests our comments on the Three Rivers Local Flood Protection Project. A plan of the project was enclosed with your letter.

The project as outlined on the plan is considered necessary and desirable. Your design flood of 50,000 c.f.s. is believed adequate.

It is noted that a new bridge will be constructed at Bridge St. but the old structures will be retained and lengthened at the railroad and Main St. crossings. Your attention is invited to the fact that when the stream bed is lowered, some of the existing footings which will remain in place will be less than two feet below new stream bed. Also, that footing of the new pier which will replace the present Main St. Bridge abutment is only three feet below the new stream bed. These depths to bottoms of footings may be inadequate protection against scour unless additional precautions are taken to safeguard the footings.

None of the affected structures are on the Federal-aid System and Federal highway funds will not participate in the cost of the project.

Very truly yours,

W. L. Patton
for J. A. Hanson
Division Engineer

EXHIBIT NO. 3

The
Connecticut River Valley
FLOOD CONTROL COMMISSION

28 MECHANIC STREET • KEENE • NEW HAMPSHIRE

Officers
ALBAN J. PARKER, *Chairman*
WALTER G. WHITE, *Vice Chairman*
NATHAN TUFTS, *Treasurer*
WAKEFIELD DORT, *Clerk*
PHILIP SHUTLER
Director

November 5, 1962.

Colonel P. C. Hyzer,
Corps of Engineers,
Division Engineer,
424 Trapelo Road,
Waltham 54, Massachusetts.

Dear Colonel Hyzer:

In your letter of October 30th, with copy of plan of the Three Rivers Local Flood Protection Project, you asked for comments. As I take it comments reflecting the position of this Commission.

On May 14th, 1959 Brigadier General Sibley sent plans for Conant Brook dam and reservoir and for local protection on the Chicopee River at Three Rivers and Chicopee, and asked to be informed of the Commission's position on these projects. A copy of my reply is enclosed.

On July 19th, 1959 at its meeting in Keene the Commission by unanimous vote approved the Conant Brook dam and reservoir after it had been informed that the appropriate agency of Commonwealth of Massachusetts and the governing body and other officials of the Town of Munson were in favor of having the dam built.

The Commission did not alter its position on the Chicopee River projects as it was stated in the enclosed letter.

This afternoon Mr. Clarence I. Sterling, Jr., Chief Engineer of the Massachusetts Water Resources Commission, a member of this Commission also, informed me that he was familiar with the plan for Three Rivers Local Protection Project and that the Water Resources Commission and the local government approved them.

EXHIBIT NO. 6

Colonel P. C. Hyzer,

Under those conditions it follows that this Commission also is in favor of the Three Rivers Project.

Sincerely yours,

Philip Shutler,
Director.

PS/t
Encl.

cc C. I. Sterling, Jr.

CONNECTICUT RIV VALLEY FLOOD CONTR COMMISSION.

June 12, 1959.

Brigadier General Alden K. Sibley,
Corps of Engineers, U. S. Army,
424 Trapelo Road,
Waltham 54, Massachusetts.

Dear General Sibley:

You asked in your letter of May 14th to be informed prior to June 15th of this Commission's position on the projects you propose to recommend on the Chicopee River and tributaries.

The Commission has not met since receipt of your letter, therefor no official action has been taken. The consensus of the majority of members from each state, polled on the subject by telephone, is The Commission will support requests for these projects if the Commonwealth of Massachusetts and the local beneficiaries favor them.

The Connecticut River Flood Control Compact requires this Commission to determine the desirability of flood control projects which consist of dams and reservoirs after balancing the annual flood control benefits which downstream states would receive against costs to them in repayment for tax and economic losses.

The proposed flood control dam and reservoir on Conant Brook above South Monson is such a project. Its cost benefit ratio is 1.5 to 1. There may be a small tax loss since the Town of Monson does not own quite all of the property which would be acquired. Connecticut would be liable for repayment to Massachusetts of 40% of such small loss if it occurs even if Connecticut would receive no flood control benefit. However, a majority of Connecticut members have said that based on present information they would support the project.

Sincerely yours,

S/ Philip Shutler

Philip Shutler,
Director.

COPY

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
59 TEMPLE PLACE
BOSTON 11, MASSACHUSETTS

January 8, 1963

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

This letter constitutes our conservation and development report on the Three Rivers local flood protection project located in Palmer, Massachusetts, at the confluence of the Chicopee, Ware, and Quaboag Rivers, and was prepared under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), in cooperation with the Massachusetts Division of Fisheries and Game. That agency concurs in the report as indicated by its letter dated January 4, 1963.

It is our understanding that this project is being designed for protection against a flood of 50,000 c.f.s. on the Chicopee River and would consist of: (1) the deepening and widening of about 5,000 feet of the Chicopee, Ware, and Quaboag Rivers to grades of about 5' per 500' of river length and to minimum bottom width of 80 feet, (2) removal of the dam and powerhouse now owned by the New England Power Company, (3) removal and reconstruction of the Bridge Street bridge; the lengthening of the Maine Street bridge and the Central Vermont Railroad bridge, and (4) relocation of existing sewer and drainage lines to discharge in the Chicopee River in the lower reach of the project into the upstream portion of the pool formed by the Ludlow Dam, located about 2 miles downstream.

EXHIBIT NO. 4

The Three Rivers project has been investigated and it has been determined that the project would have no significant detrimental effect on the fish and wildlife resources nor do there appear to be any opportunities to enhance these resources. In view of this we do not intend to report further on this project. However, should you find it necessary to revise your plans concerning the deepening and widening of the channels of the three rivers involved to include an additional half mile or more of either the Ware River or the Quaboag River, then we would wish to prepare another fish and wildlife report. In this event we would wish to be notified of changes in plans at the earliest possible date in order to give us ample time to conduct the necessary fish and wildlife studies.

Sincerely yours,

John S. Gottschalk
Regional Director

The Commonwealth of Massachusetts

Division of Fisheries and Game

73 Tremont Street, Boston 8

January 4, 1963

Mr. Earl T. Walker
U. S. Fish and Wildlife Service
59 Temple Place
Boston, Massachusetts

Dear Mr. Walker:

In reference to your correspondence of January 2, relative to your review draft of a conservation and development report on the Three Rivers local protection project, please be advised of our concurrence with the aforementioned report.

Thank you for the opportunity to review and comment on this proposed project.

Very truly yours,

Colton H. Bridges

Colton H. Bridges
State Ornithologist

CHB:ak

EXHIBIT NO. 5

CORPS OF ENGINEERS

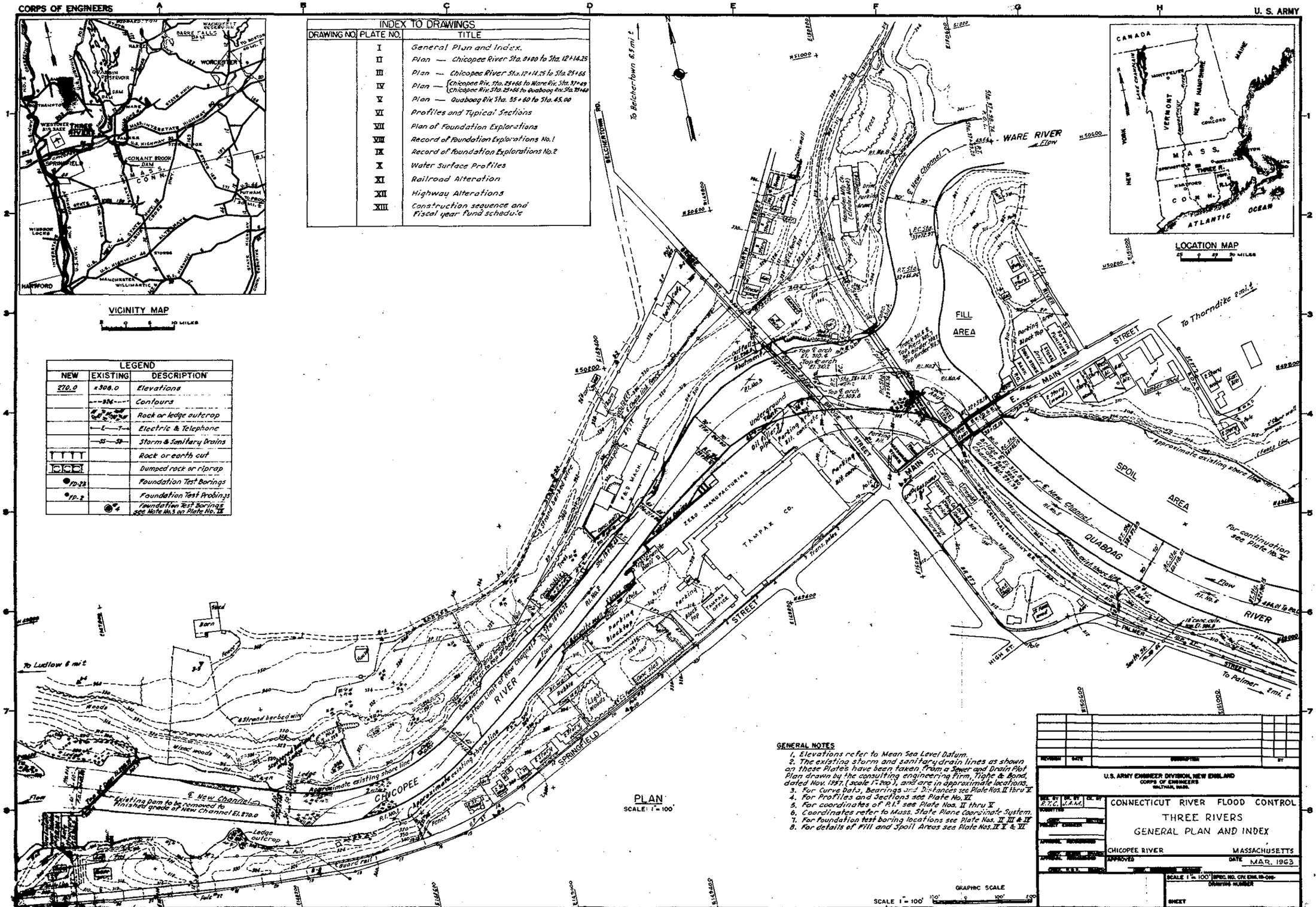
U. S. ARMY

VICINITY MAP

5 0 5 10 MILES

INDEX TO DRAWINGS		
DRAWING NO.	PLATE NO.	TITLE
	I	General Plan and Index.
	II	Plan — Chicopee River Sta. 0+00 to Sta. 12+14.25
	III	Plan — Chicopee River Sta. 12+14.25 to Sta. 25+66
	IV	Plan — Chicopee Riv. Sta. 25+66 to Ware Riv. Sta. 37+49; Chicopee Riv. Sta. 25+66 to Quaboag Riv. Sta. 35+60
	V	Plan — Quaboag Riv. Sta. 35+60 to Sta. 45.00
	VI	Profiles and Typical Sections
	VII	Plan of Foundation Explorations
	VIII	Record of Foundation Explorations No. 1
	IX	Record of Foundation Explorations No. 2
	X	Water Surface Profiles
	XI	Railroad Alteration
	XII	Highway Alterations
	XIII	Construction sequence and Fiscal year fund schedule

LEGEND		
NEW	EXISTING	DESCRIPTION
270.0	x308.0	Elevations
	---324---	Contours
		Rock or ledge outcrop
	—E—T—	Electric & Telephone
	—SS—SD—	Storm & Sanitary Drains
		Rock or earth cut
		Dumped rock or riprap
● FD-23		Foundation Test Borings
• FD-2		Foundation Test Probings
	◉ 4	Foundation Test Borings see Note No. 3 on Plate No. IX



PLAN

SCALE: 1" = 100'

LOCATION MAP

25 0 25 50 MILES

GENERAL NOTES

1. Elevations refer to Mean Sea Level Datum.
2. The existing storm and sanitary drain lines as shown on these Plates have been taken from a Sewer and Drain Plot Plan drawn by the consulting engineering firm, Tighe & Bond, dated Nov. 1957. (scale 1" = 200'), and are in approximate locations.
3. For Curve Data, Bearings and Distances see Plate Nos. II thru V
4. For Profiles and Sections see Plate No. VI
5. For coordinates of P.I.'s see Plate Nos. II thru V
6. Coordinates refer to Mass. State Plane Coordinate System.
7. For foundation test boring locations see Plate Nos. II III & IV
8. For details of Fill and Spoil Areas see Plate Nos. IV V & VI

GRAPHIC SCALE

SCALE 1" = 100'

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY R.T.C. | DR. BY J.A.M. | CK. BY

CONNECTICUT RIVER FLOOD CONTROL

THREE RIVERS

GENERAL PLAN AND INDEX

CHICOPEE RIVER — MASSACHUSETTS

APPROVED — DATE MAR. 1963

SCALE 1" = 100' — SPEC. NO. CIV. ENG. 18-016

DRAWING NUMBER

SHEET

PLATE NO. I

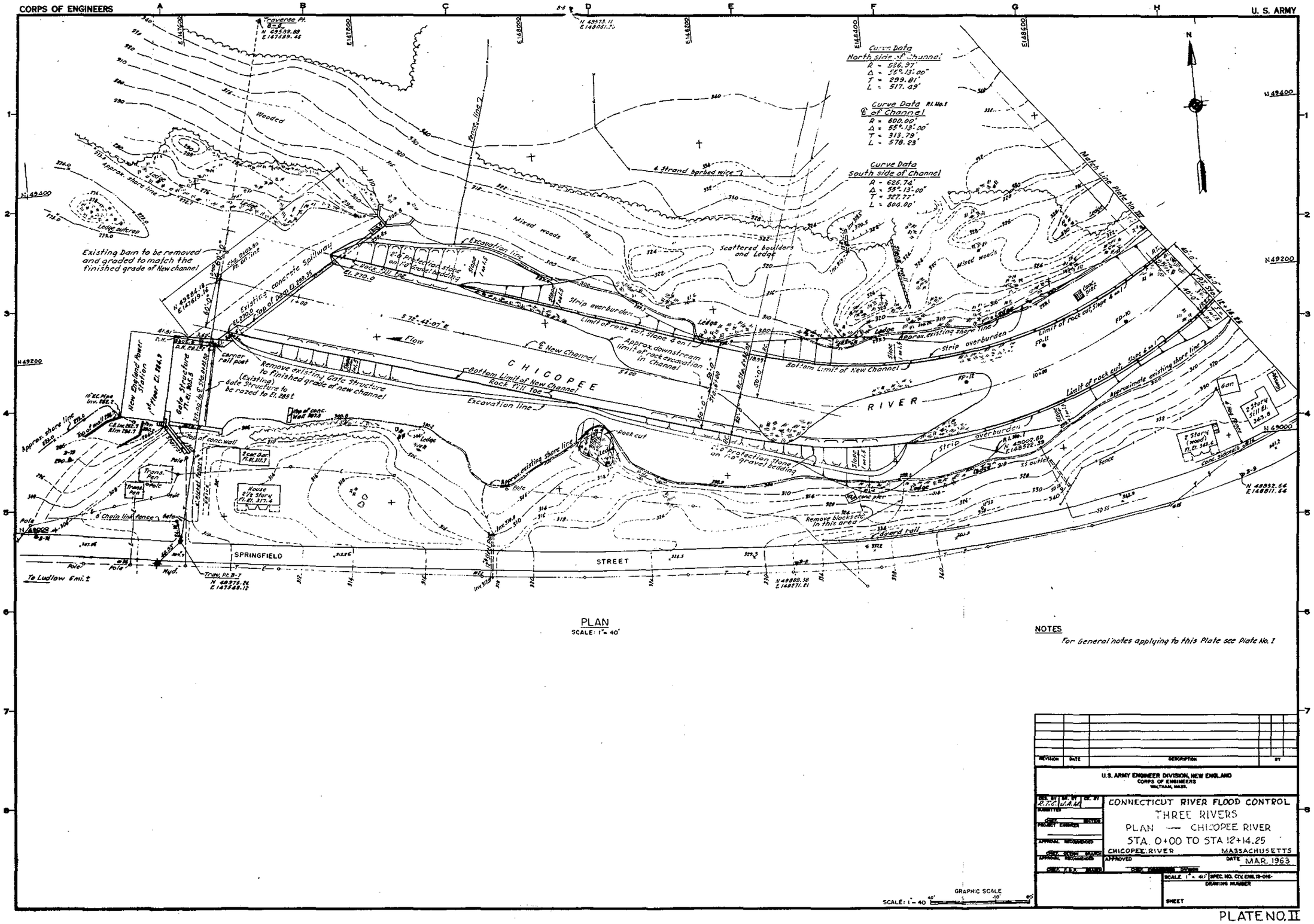
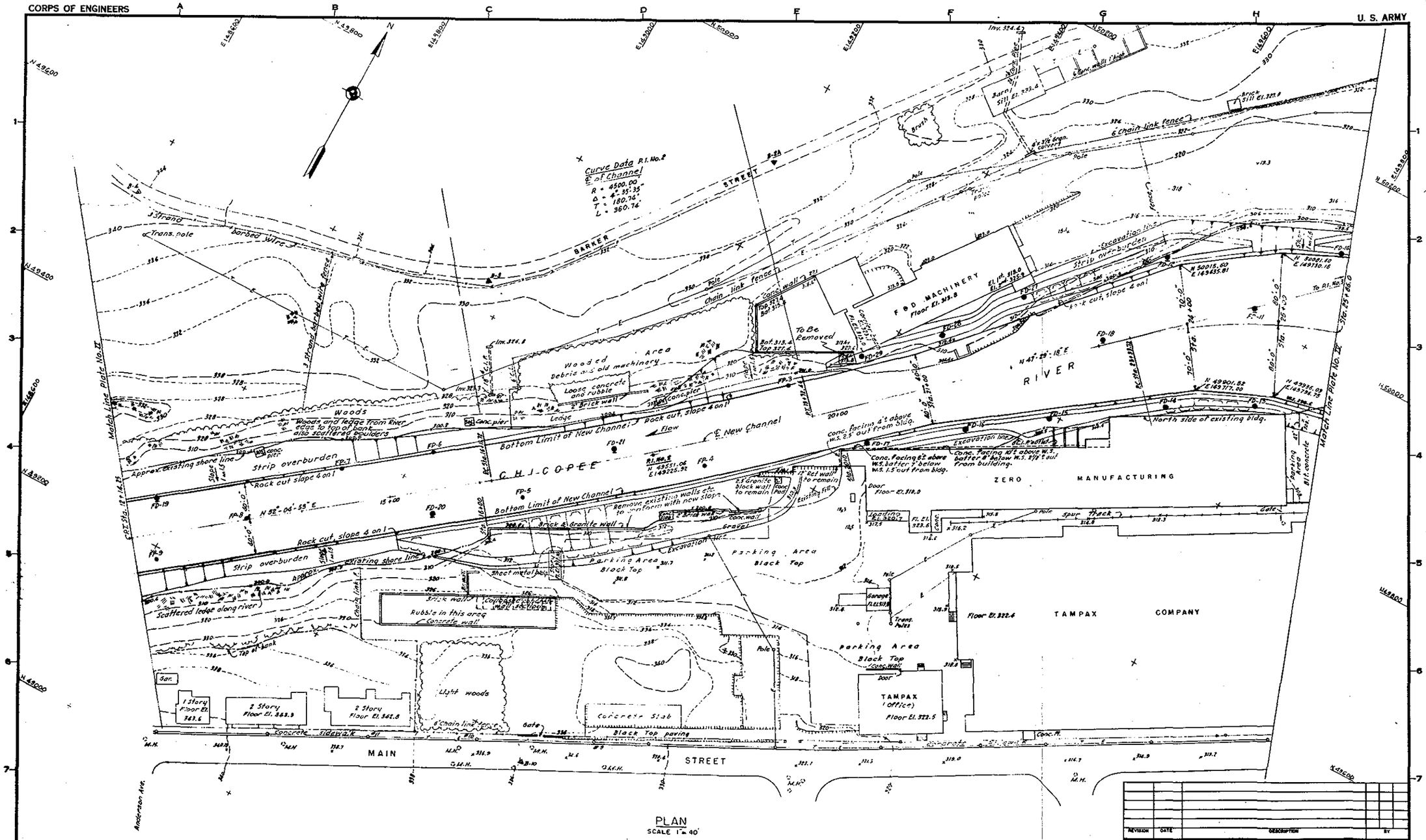

CORPS OF ENGINEERS
U. S. ARMY
Curve Data
North side of Channel
R = 536.97'
Δ = 55°13'00"
T = 299.81'
L = 517.49'
Curve Data
℄ of Channel
R = 600.00'
Δ = 55°13'00"
T = 313.79'
L = 578.23'
Curve Data
South side of Channel
R = 626.74'
Δ = 55°13'00"
T = 327.77'
L = 604.00'
Existing Dam to be removed and graded to match the finished grade of New channel
Existing concrete Spillway
Wooded
Mixed woods
Scattered boulders and Ledge
Strip overburden
Limit of rock cut, Slope 4 on 1
Approx. downstream limit of rock excavation in Channel
Bottom Limit of New Channel
Rock fill toe
Excavation line
℄ New Channel
CHICOPEE
RIVER
Flow
Remove existing Gate Structure to finished grade of new channel
(Existing) Gate Structure to be razed to El. 285±
New England Power Station
Gate Structure
Approx. shore line
Approx. existing shore line
Match Line Plate No. III
Remove blocks etc. in this area
SPRINGFIELD
STREET
To Ludlow 6 mi.±
PLAN
SCALE: 1" = 40'
NOTES
For General notes applying to this Plate see Plate No. I
GRAPHIC SCALE
SCALE: 1" = 40'
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
CONNECTICUT RIVER FLOOD CONTROL
THREE RIVERS
PLAN — CHICOPEE RIVER
STA. 0+00 TO STA 12+14.25
CHICOPEE RIVER
MASSACHUSETTS
DATE MAR. 1963
SCALE 1" = 40'
SPEC. NO. CIV. ENG. 19-016-
DRAWING NUMBER
SHEET

PLATE NO. II

CORPS OF ENGINEERS

U. S. ARMY



PLAN
SCALE 1" = 40'

NOTES

For General notes applying to this Plate see Plate No. 1

GRAPHIC SCALE
SCALE: 1" = 40'

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

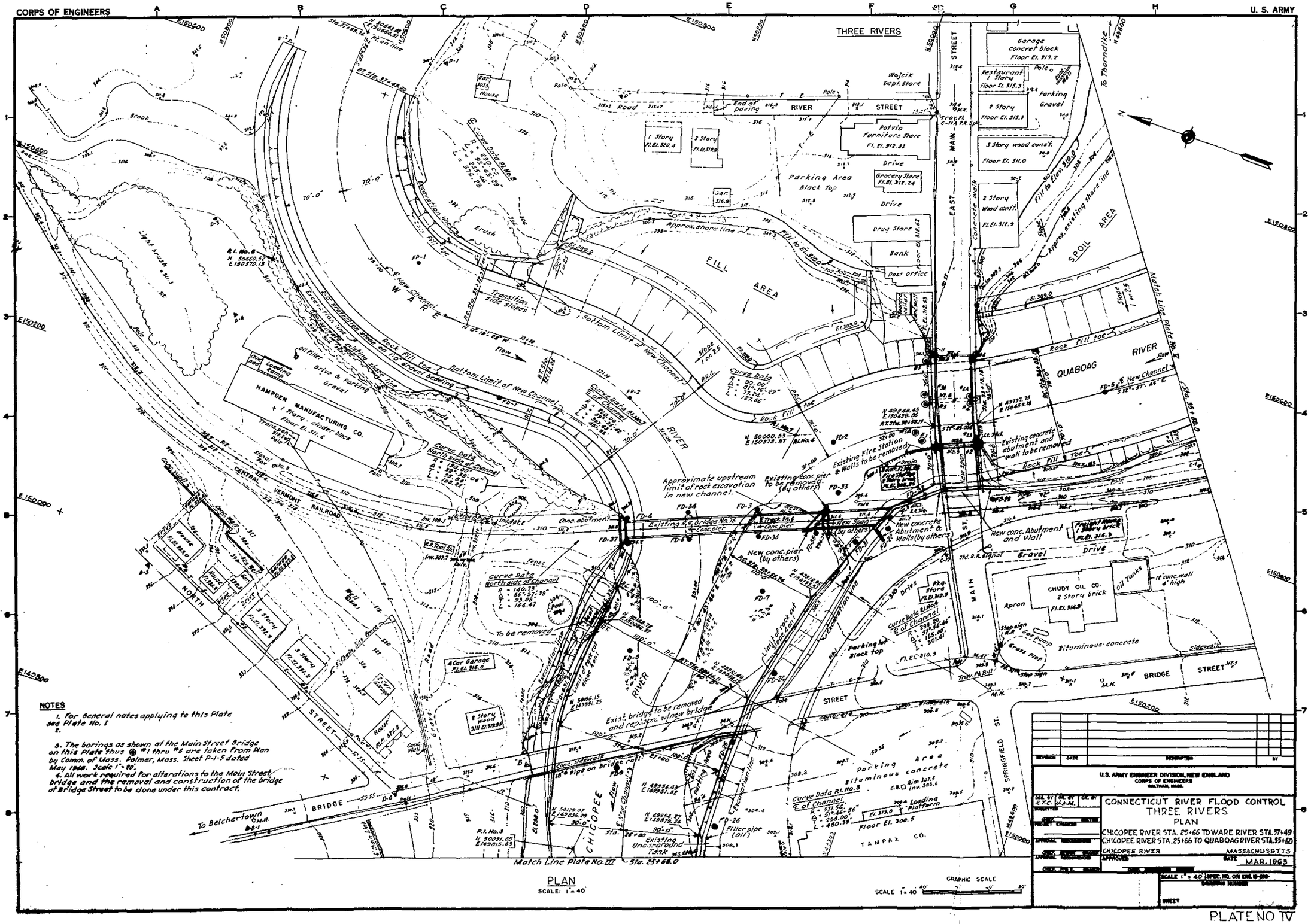
DES. BY | DR. BY | CK. BY
SUBMITTED
CHIEF, SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED
CHIEF, R.E.D. BRANCH

CONNECTICUT RIVER FLOOD CONTROL
THREE RIVERS
PLAN — CHICOPEE RIVER
STA. 12+14.25 TO STA. 25+66
CHICOPEE RIVER MASSACHUSETTS
APPROVED
DATE MAR. 1963
CHIEF, ENGINEERING DIVISION

SCALE 1" = 40'
SPEC. NO. CIV. ENG. 19-016-
DRAWING NUMBER
SHEET

PLATE NO. III

CORPS OF ENGINEERS U. S. ARMY



NOTES

1. For General notes applying to this Plate see Plate No. I
2.
3. The borings as shown at the Main Street Bridge on this Plate thus ⊕ #1 thru #8 are taken from Plan by Comm. of Mass., Palmer, Mass. Sheet P-1-5 dated May 1948. Scale 1" = 40'.
4. All work required for alterations to the Main Street bridge and the removal and construction of the bridge at Bridge Street to be done under this contract.

PLAN
SCALE: 1" = 40'

GRAPHIC SCALE
SCALE 1" = 40'

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY R.T.C. | DR. BY J.A.M. | CK. BY

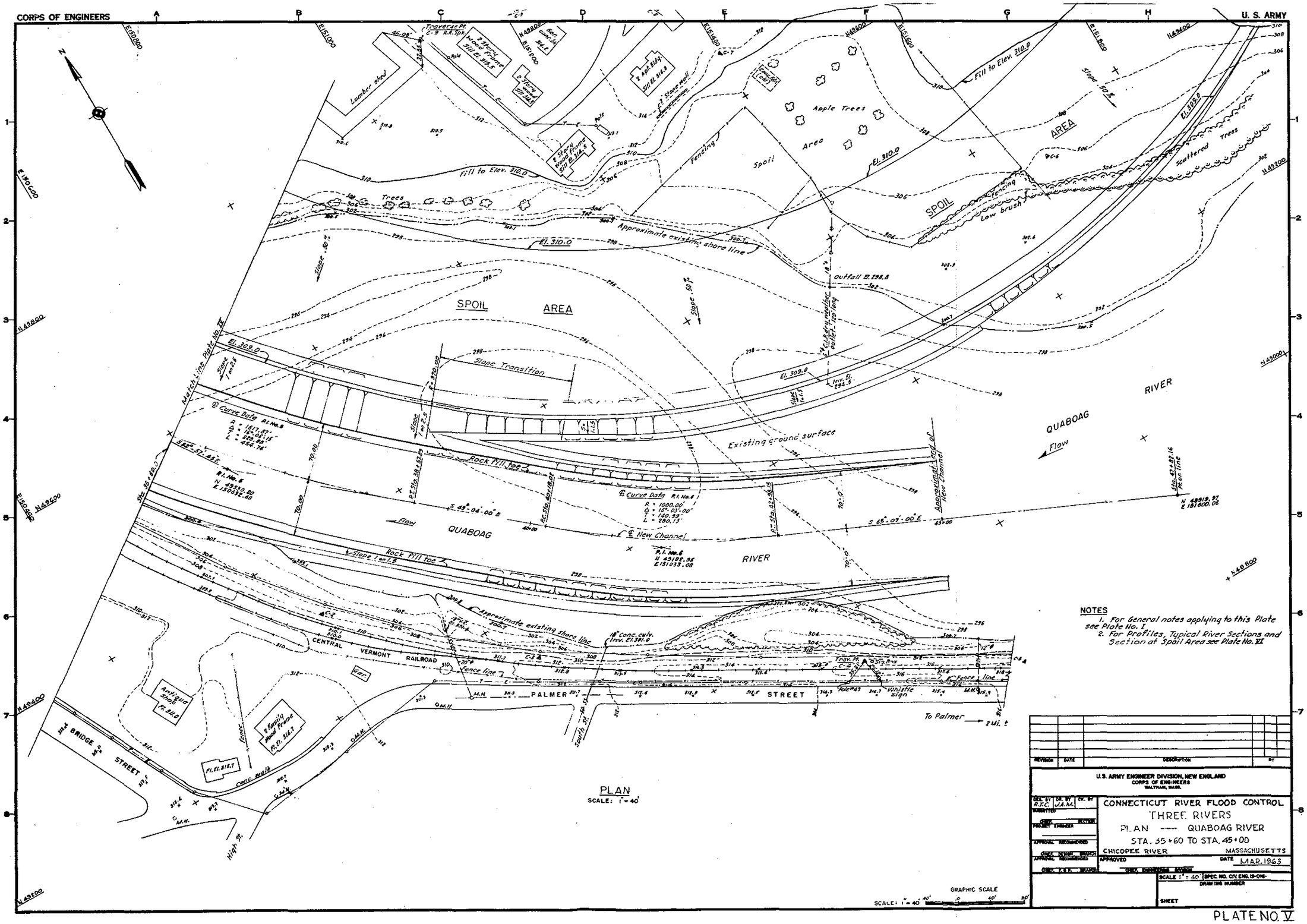
CONNECTICUT RIVER FLOOD CONTROL
THREE RIVERS
PLAN
CHICOPEE RIVER STA. 25+66 TO WARE RIVER STA. 37+49
CHICOPEE RIVER STA. 25+66 TO QUABOAG RIVER STA. 55+60
CHICOPEE RIVER MASSACHUSETTS

APPROVED DATE MAR. 1963

SCALE 1" = 40' SPEC. NO. OCE ENG 19-[illegible]
ENGINEERING DIVISION
SHEET

PLATE NO IV

CORPS OF ENGINEERS — U. S. ARMY



PLAN
SCALE: 1" = 40'

GRAPHIC SCALE
SCALE: 1" = 40'

NOTES
1. For General notes applying to this Plate see Plate No. I
2. For Profiles, Typical River Sections and Section at Spoil Area see Plate No. VI

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

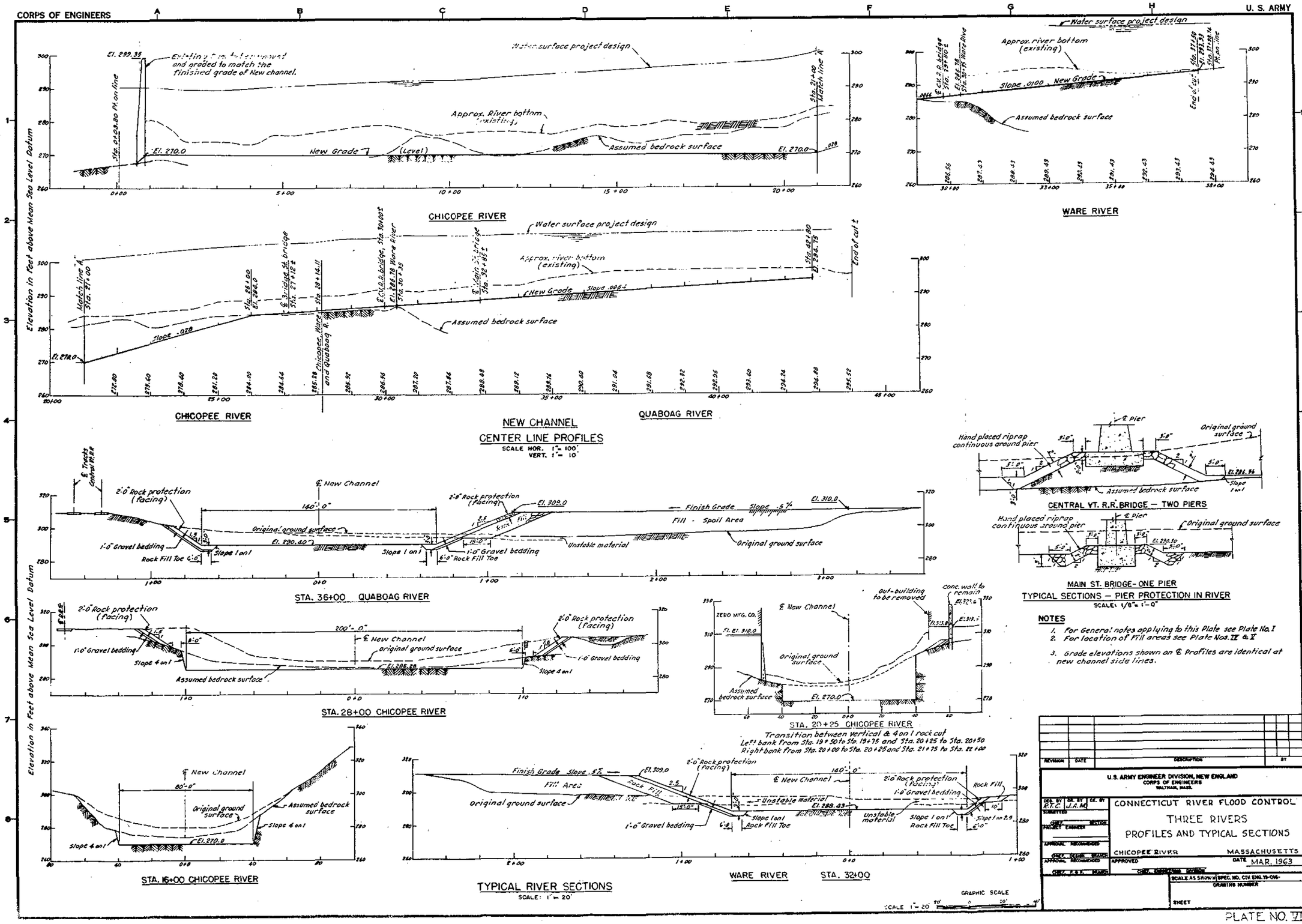
DES. BY R.T.C. DR. BY J.A.M. CK. BY
SUBMITTED
CHIEF, SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED
CHIEF, F.E.D. BRANCH

CONNECTICUT RIVER FLOOD CONTROL
THREE RIVERS
PLAN — QUABOAG RIVER
STA. 35+60 TO STA. 45+00
CHICOPEE RIVER MASSACHUSETTS
APPROVED DATE MAR. 1963
CHIEF, ENGINEERING BRANCH

SCALE 1" = 40' SPEC. NO. CIV. ENG. 19-016-
DRAWING NUMBER
SHEET

PLATE NO. V

CORPS OF ENGINEERS U. S. ARMY



NOTES

1. For General notes applying to this Plate see Plate No. I
2. For location of Fill areas see Plate Nos. II & V
3. Grade elevations shown on ℄ Profiles are identical at new channel side lines.

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY R.T.C. DR. BY J.A.M. CK. BY
SUBMITTED
CHIEF, SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED
CHIEF, P. & R. BRANCH

CONNECTICUT RIVER FLOOD CONTROL
THREE RIVERS
PROFILES AND TYPICAL SECTIONS

CHICOPEE RIVER MASSACHUSETTS
APPROVED DATE MAR. 1963
CHIEF, ENGINEERING SECTION
SCALE AS SHOWN SPEC. NO. CIV. ENG. 19-016-
DRAWING NUMBER
SHEET

PLATE NO. VI

CORPS OF ENGINEERS — U. S. ARMY

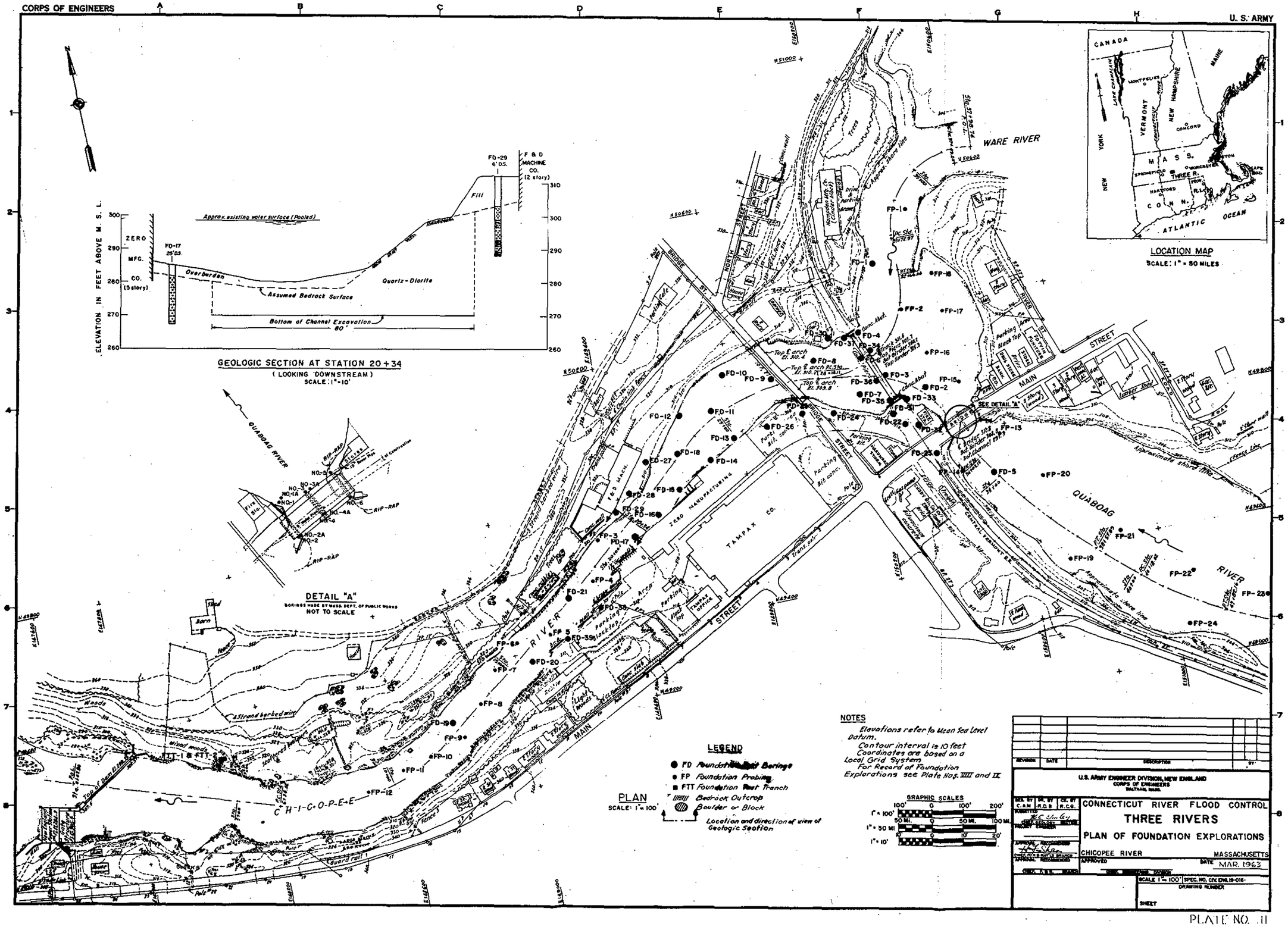
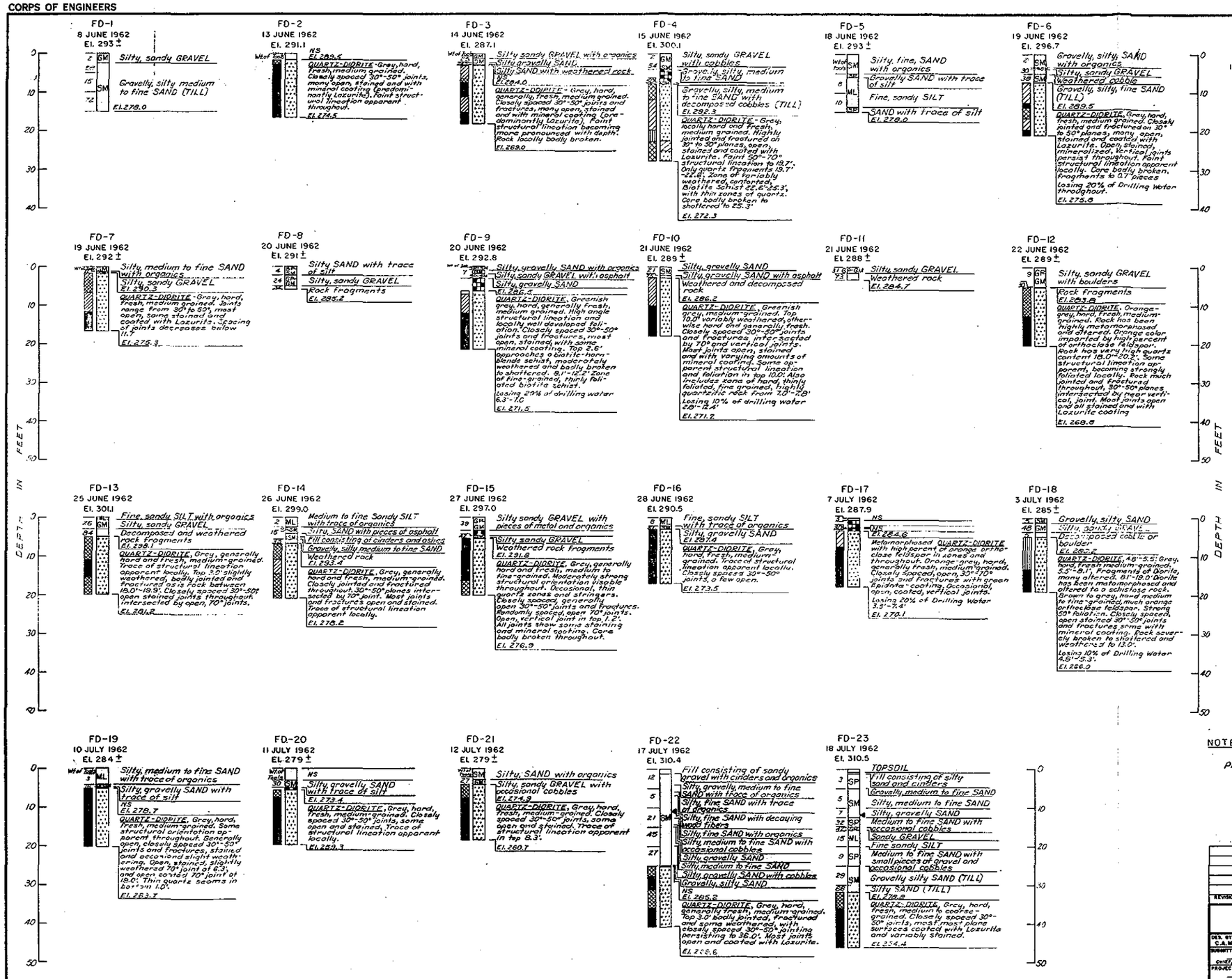


PLATE NO. 11



LEGEND FOR GRAPHIC LOGS

FD-2 — Foundation Test Boring
13 JUNE 1962 — Date exploration completed
El. 291.0 — Elevation of ground surface during time of exploration

- Subsurface water level in boring at time of exploration.
- SM — Group letter symbol according to Unified Soil Classification System.
- NR — No Recovery or unsatisfactory soil samples recovered.
- NS — Not Sampled. Hole advanced by Core-drilling, blasting and/or wash boring due to operational difficulty
- CD — Sampling in overburden by Core-drilled method.
- 25 — Blows per foot of penetration considered most representative for each sample drive using a 300 or 350 pound hammer with a free fall of about 18" on a 1½" I.D. or 2" O.D. 2" I.D. or 2½" O.D. and/or 2½" I.D. or 3" O.D. size sample spoon equipped with a beveled and sharpened drive shoe.
- Blow counts not recorded or not considered representative.
- Cobble or boulder (Core-drilled)
- Cobbles, or boulders, continuous or nested (Core-drilled and/or blasted and chopped).
- El. 289.4 — Elevation of bedrock surface
- Rock symbol
- El. 274.4 — Elevation bottom of exploration

- Rock core recovery 0-25%
- Rock core recovery 25-50%
- Rock core recovery 50-75%
- Rock core recovery 75-90%
- Rock core recovery 90-100%

NOTE:
For Plan of Foundation Explorations See Plate No. VII

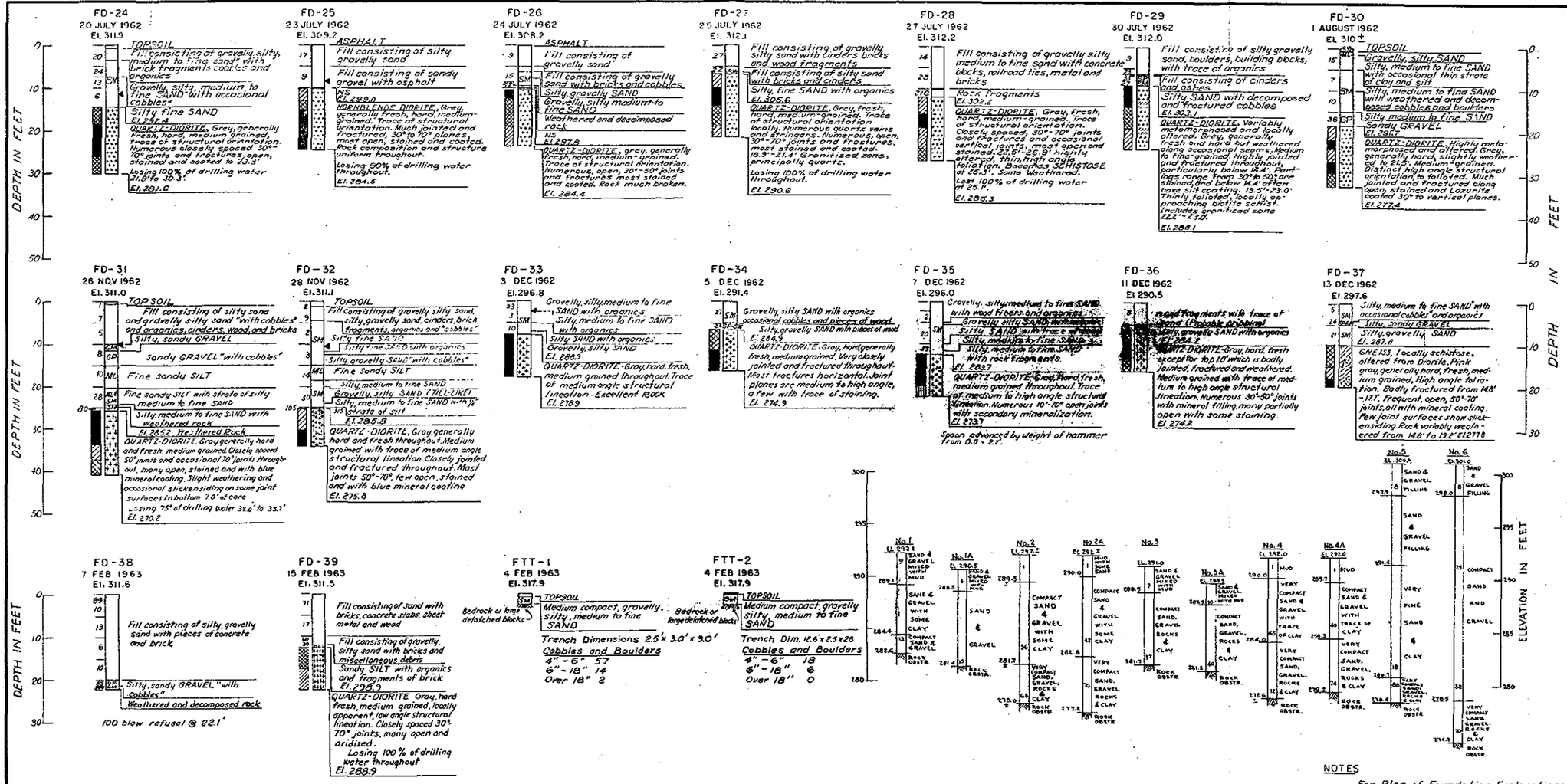
REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

DES. BY C.A.M. | DR. BY R.D.B. | CK. BY R.C.G.
SUBMITTED — CHIEF, GEOLOGY SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED — CHIEF, FOR & SPT'S BRANCH
APPROVAL RECOMMENDED — CHIEF, PLANN. & SPT'S BRANCH
APPROVED — CHIEF, ENGINEERING DIVISION

CONNECTICUT RIVER FLOOD CONTROL
THREE RIVERS
RECORD OF FOUNDATION EXPLORATIONS NO. 1
CHICOPEE RIVER — MASSACHUSETTS
DATE MAR. 1963
SCALE — SPEC. NO CIV. ENG.-19-016
DRAWING NUMBER
SHEET

PLATE NO. VIII



PROBING TABLE

PROBING NUMBER	WATER DEPTH RIVER	APPROX. BOTTOM ELEV.	BOTTOM THICKNESS PROBED (FT.)	REMARKS
FP-1	2.9	296	15.0	No Refusal El. 281.0
FP-2	–	293	15.0	No Refusal El. 278.0
FP-3	8.2	297	9.9	Refusal El. 281.1
FP-4	15.1	281	1.4	" El. 279.6
FP-5	12.7	286	7.5	" El. 278.5
FP-6	13.8	288	9.4	" El. 278.6
FP-7	20.0	281	1.9	" El. 279.1
FP-8	20.4	277	2.2	" El. 274.8
FP-9	22.6	278	5.8	" El. 272.2
FP-10	22.7	277	6.9	" El. 270.1
FP-11	20.1	279	6.4	" El. 272.6
FP-12	19.9	277	10.4	" El. 266.6

NOTE
All probings made by wash boring with an open end "A" rod.
Refusals established in FP-3 through FP-12 by 150 blows on an open end "A" rod using a 350 lb. hammer.

PROBING TABLE

PROBING NUMBER	WT. OF TOOLS	WT. OF 1 MAN	WT. OF 2 MEN	PENETRATION DEPTH AND BLOWS / FT. REQ'D (8" HAMMER ON ¾" OPEN END PIPE)									
FP-13	0.0-0.8	0.8-5.4	5.4-5.4	5.4-10.3	17	11	12	25	38/9				
FP-14	0.0-0.9	0.9-3.3	3.3-3.3	3.3-8.0	33	34	37	47	63/7				
FP-15	0.0-2.6	2.6-7.5	7.5-7.5	7.5-13.3	27	63	35	37	63	89/8			
FP-16	0.0-1.9	1.9-6.0	6.0-7.2	7.2-14.8	66	97	57	35	38	35	59	74/6	
FP-17	0.0-2.3	2.3-6.0	6.0-6.4	6.4-9.9	24	35	72	90/5					
FP-18	0.0-1.0	1.0-5.1	5.1-5.3	5.3-9.7	42	48	31	57	84/4				
FP-19	——	0.0-5.5	5.5-5.5	5.5-14.4	24	16	17	18	28	33	60	68	74/9
FP-20	0.0-0.2	0.2-4.4	4.4-4.4	4.4-11.0	56	28	61	44	42	41	72/6		
FP-21	0.0-2.6	2.6-8.8	8.8-8.8	8.8-13.6	36	63	71	70	84/8				
FP-22	0.0-0.9	0.9-4.0	4.0-7.4	7.4-10.7	61	72	93	110/3					
FP-23	0.0-0.2	0.2-8.6	8.6-8.6	8.6-16.1	57	50	51	34	54	59	93	96/5	
FP-24	0.0-0.2	0.2-5.7	5.7-5.7	5.7-13.4	31	17	23	42	44	62	69	87/7	

NOTE
All probings except FP-15 driven to refusal.
Fractional foot of penetration indicated thus: blows per foot / tenth of a foot (150/3)

NOTES
For Plan of Foundation Explorations, See Plate No. VII
For Legend for Graphic Logs, see Plate No. VIII

Borings No. 1 through No. 6 made by the Commonwealth of Massachusetts, July 19, 1947.
Figures in columns indicate blows per foot on spoon produced by 24" drop of 140 lb. hammer.

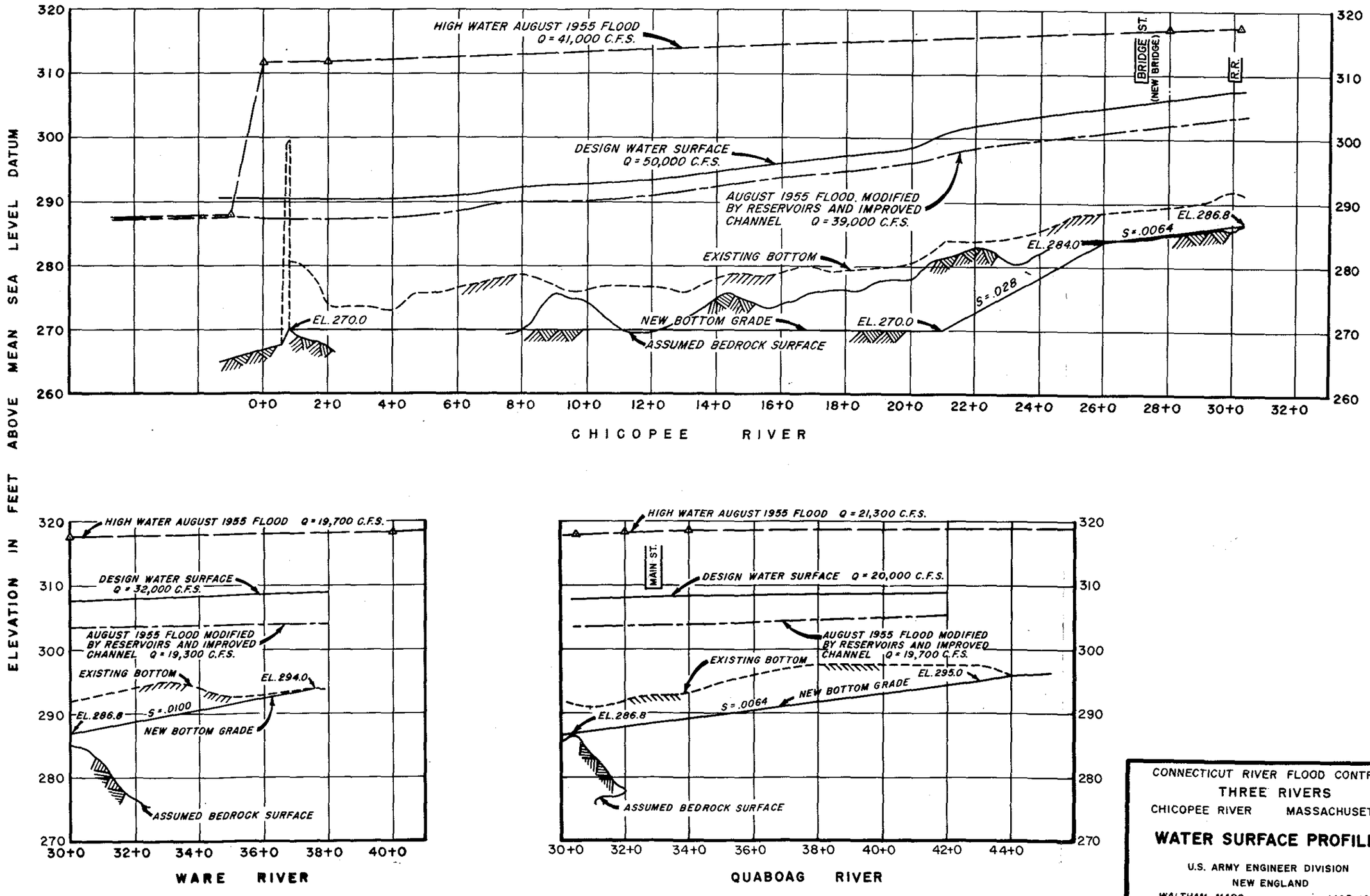
REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY C.A.M. | DR. BY L.H.I. | CK. BY R.C.G.
SUBMITTED — CHIEF, GEOLOGY SECTION — PROJECT ENGINEER
APPROVAL RECOMMENDED — CHIEF, FDN. & MAT'LS BRANCH
APPROVAL RECOMMENDED — CHIEF, PLANN. & RPTS BRANCH

CONNECTICUT RIVER FLOOD CONTROL
THREE RIVERS
RECORD OF FOUNDATION EXPLORATIONS
NO. 2
CHICOPEE RIVER — MASSACHUSETTS
APPROVED — CHIEF, ENGINEERING DIVISION
DATE MAR. 1963
SCALE
SPEC. NO CIV. ENG.-19-016
DRAWING NUMBER
SHEET

PLATE NO. IX



CONNECTICUT RIVER FLOOD CONTROL
THREE RIVERS
CHICOPEE RIVER MASSACHUSETTS

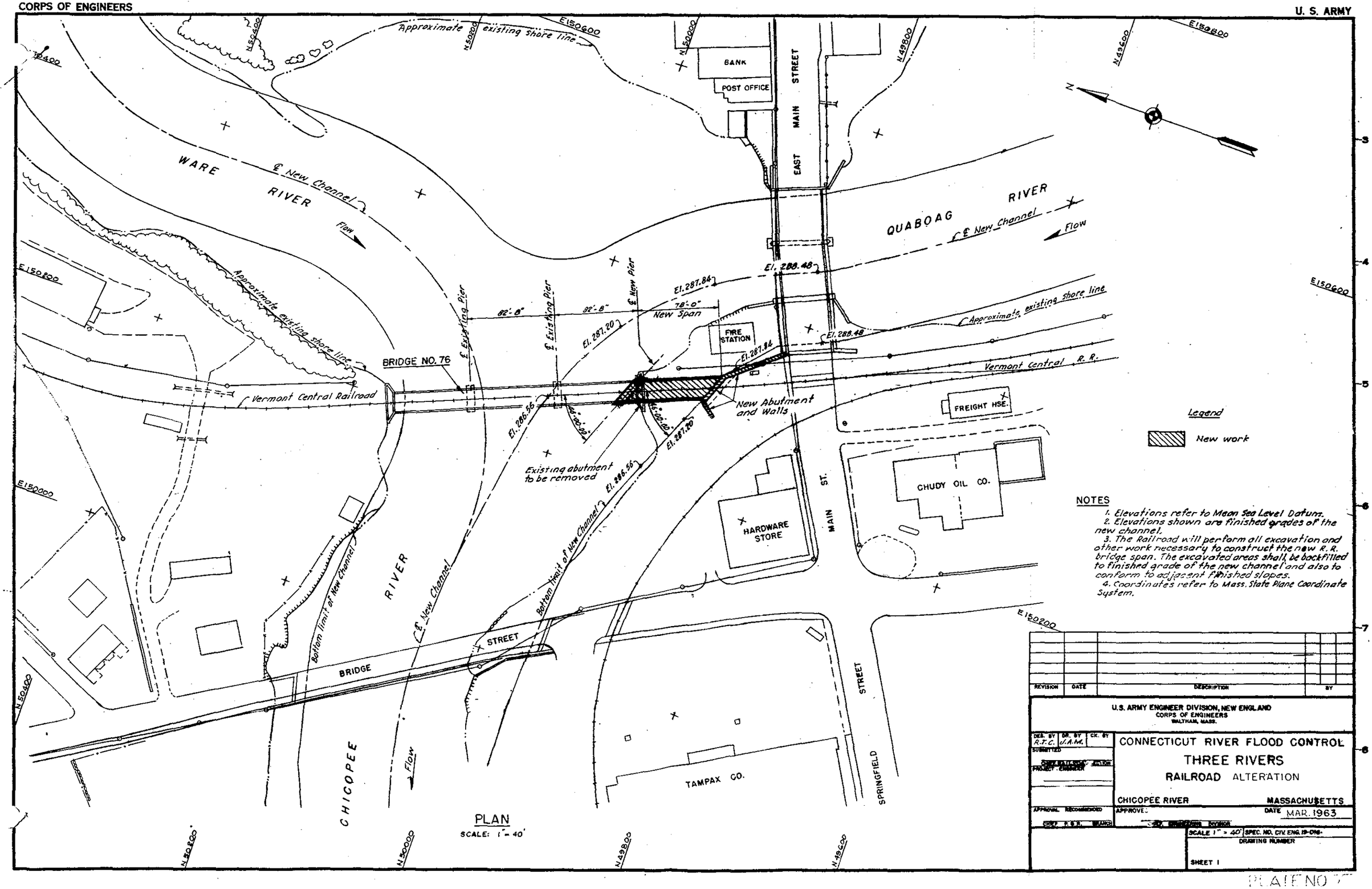
WATER SURFACE PROFILES

U.S. ARMY ENGINEER DIVISION
NEW ENGLAND
WALTHAM, MASS. MAR. 1963

PLATE NO. X

CORPS OF ENGINEERS

U. S. ARMY



PLAN

SCALE: 1" = 40'

NOTES

1. Elevations refer to Mean Sea Level Datum.
2. Elevations shown are finished grades of the new channel.
3. The Railroad will perform all excavation and other work necessary to construct the new R.R. bridge span. The excavated areas shall be backfilled to finished grade of the new channel and also to conform to adjacent finished slopes.
4. Coordinates refer to Mass. State Plane Coordinate System.

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY R.T.C. | DR. BY J.A.M. | CK. BY

SUBMITTED

CHIEF, PLANNING & REPORTS BRANCH

PROJECT ENGINEER

CONNECTICUT RIVER FLOOD CONTROL
THREE RIVERS
RAILROAD ALTERATION

CHICOPEE RIVER — MASSACHUSETTS

APPROVAL RECOMMENDED

CHIEF, R.E.D. BRANCH

APPROVED

CHIEF, ENGINEERING DIVISION

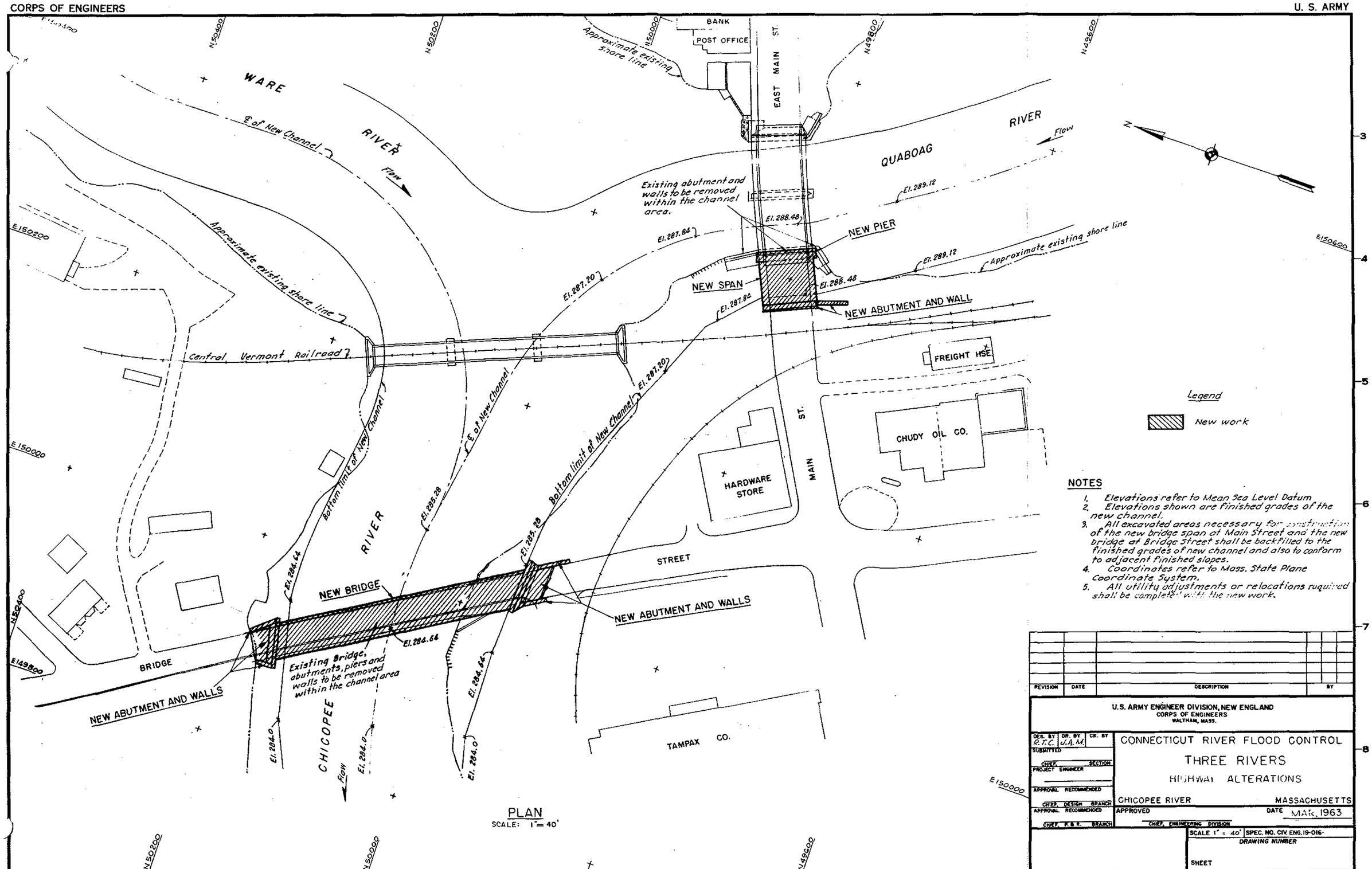
DATE MAR. 1963

SCALE 1" = 40' | SPEC. NO. CIV. ENG. 19-016-

DRAWING NUMBER

SHEET 1

PLATE NO. 7



PLAN
SCALE: 1" = 40'

PLATE NO. XII

APPROPRIATION TITLE: Construction, General
CLASSIFICATION: FLOOD CONTROL (LOCAL PROTECTION)

PROJECT: THREE RIVERS, MASSACHUSETTS

ACTIVITY LEGEND

DETAILED PROJECT SCHEDULE

(TO BE REPORTED IN THOUSANDS OF DOLLARS)

LINE NO.	COST ACCOUNT NO.	ITEM	CONT. TYPE & NO.	QUANTITY, SIZE, OR CAPACITY; DATE OF AWARD (As Applicable)	PROJECT COST ESTIMATE	TOTAL AS OF JUNE 30, 19 62	CURRENT FISCAL YEAR 19 63 TOTAL	CURRENT FISCAL YEAR 19 63 QUARTERS 1st	2nd	3rd	4th	BUDGET FISCAL YEAR 19 64 TOTAL	BUDGET FISCAL YEAR 19 64 QUARTERS 1st	2nd	3rd	4th	FUTURE FISCAL YEARS 19 65 1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	19 ___ 1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	19 ___ 1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	19 ___ 1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	19 ___ 1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	BALANCE TO COMPLETE	LINE NO.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)				(18)				(19)				(20)				(21)				(22)	
1	01.	RELOCATIONS			341.0		60.0				57.0	144.0	13.0	3.0	25.0	103.0	137.0																					1
2																																							2
3	.1	BRIDGES, FOUNDATION PROT. A3-1	c.c.	6/63	(11.0)							(8.0)	(2.0)	(3.0)		(3.0)	(3.0)																						3
4																																							4
5	.2	RAILROAD BRIDGE	c.c.	3/64	(259.0)							(125.0)			(25.0)	(100.0)	(134.0)																						5
6																																							6
7	.3	STRUCTURES A3-2	c.c.	6/63	(71.0)		(60.0)				(60.0)	(11.0)	(11.0)																										7
8																																							8
9	09.	CHANNELS AND CANALS A3-3	c.c.	6/63	713.0		100.0				100.0	408.0	150.0	83.0	10.0	165.0	205.0																						9
10																																							10
11	29.	PRE-AUTHORIZATION STUDIES			10.0	10.0																																	11
12																																							12
13	30.	ENGINEERING AND DESIGN			114.0	28.8	70.0	9.4	16.1	25.0	19.5	13.0	4.0	3.0	3.0	3.0	2.2																						13
14																																							14
15	31.	SUPERVISION AND ADMINISTRATION			92.0	2.2	39.0	0.8	1.5	2.2	34.5	35.0	14.0	5.0	1.0	15.0	15.8																						15
16																																							16
17		TOTAL APPLIED COST (Federal Funds Only)			1,270.0	41.0	269.0	10.2	17.6	27.2	214.0	600.0	181.0	94.0	39.0	286.0	360.0																						17
18		Undistributed Cost (None)																																					18
19		TOTAL PROJECT COST (Federal Funds Only)			1,270.0	41.0	269.0	10.2	17.6	27.2	214.0	600.0	181.0	94.0	39.0	286.0	360.0																						19
20		Pending Adjustments (None)																																					20
21		TOTAL COSTS (Federal Funds Only)			1,270.0	41.0	269.0	10.2	17.6	27.2	214.0	600.0	181.0	94.0	39.0	286.0	360.0																						21
22		Undelivered Orders					+100.0					-100.0																											22
23		TOTAL OBLIGATIONS				41.0	369.0					500.0																											23
24																																							24
25		METHOD OF FINANCING																																					25
26		APPROPRIATIONS				60.0	350.0																																26
27		UNOBLIGATED CARRYOVER FROM PRIOR YEAR					19.0																																27
28		TOTAL FUNDS AVAILABLE FOR OBLIGATION					369.0																																28
29		APPROPRIATION REQUIRED										500.0					360.0																						29
30																																							30
31		MULTI-COMPONENT CONTRACT																																					31
32		A3 Bridges, Foundation Protection, Structures,																																					32
33		Channels & Canals	c.c.	6/63	795.0		160.0					427.0					208.0																						33
34																																							34
35																																							35
36																																							36
37																																							37
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EFFECTIVE DATE	DIVISION	DISTRICT	BASIN	PAGE ___ OF ___ PAGES
	NEW ENGLAND		NEW ENGLAND	

ENG FORM 1 MAY 56 2201a (Translucent) EDITION OF 1 DEC. 52 MAY BE USED UNTIL EXHAUSTED (EM 11-2-101)

PLATE NO. XIII