CONNECTICUT RIVER FLOOD CONTROL

# LANCASTER

# LOCAL FLOOD PROTECTION

ISRAEL RIVER

NEW HAMPSHIRE

# DETAILED PROJECT REPORT

(ADVANCE DRAFT)

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

SEPTEMBER 1973

22

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:

NEDED-E

28 September 1973

SUBJECT: Advance Draft - Detailed Project Report for Lancaster Local Protection, Israel River, Connecticut River Basin, Lancaster, New Hampshire

HQDA (DAEN-CWP-E)
WASH DC 20314

1. In accordance with ER 1165-2-12 dated 1 April 1965, there are submitted herewith, for review and approval, advance draft copies of the Detailed Project Report, Lancaster Local Protection, Israel River, Lancaster, New Hampshire.

2. Appendix A contains letters from the Town of Lancaster which indicate that $105,000 was authorized as the local cost for purchase of project lands at the 1971 town meeting. Formal assurances of local cooperation will be obtained pending approval and authorization of final designs for the project.

3. Plans and specifications will be prepared substantially in accordance with this report as approved. Funds in the amount of $32,000 for preparation of plans and specifications and in the amount of $510,000 for construction will be required. Construction funds will be requested upon completion of plans and specifications and prior to the receipt of bids for construction.

FOR THE DIVISION ENGINEER:

JOHN H. MASON
Colonel, Corps of Engineers
Division Engineer

Incl (12 cys)
Advance Draft of
Detailed Project Report

# CONNECTICUT RIVER FLOOD CONTROL

# LANCASTER

## LOCAL PROTECTION PROJECT

## ISRAEL RIVER

## LANCASTER, NEW HAMPSHIRE

## DETAILED PROJECT REPORT

DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

WALTHAM, MASSACHUSETTS

SEPTEMBER 1973

LANCASTER LOCAL PROTECTION PROJECT
ISRAEL RIVER, CONNECTICUT RIVER BASIN
LANCASTER, NEW HAMPSHIRE

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LANCASTER LOCAL PROTECTION PROJECT

ISRAEL RIVER, CONNECTICUT RIVER BASIN

LANCASTER, NEW HAMPSHIRE

SEPTEMBER 1973

## A. PERTINENT DATA

| | |
|---|---|
| 1. Purpose | Local ice-jam flood protection |
| 2. Location | Israel River, Town of Lancaster, Coos County, New Hampshire |
| 3. Type of Improvement | Concrete overflow weir, concrete abutments and other appurtenant work to hold floating ice during spring runoff periods |
| 4. Hydrology | |
| Maximum flood of record without ice | |
| Discharge | 8,840 c.f.s. (November 1927) |
| Elevation | 863.5 |
| Maximum flood stage of record with ice | Elevation 966.6 (March 1968) 866.6 |
| Drainage area | 133 square miles |
| 5. Dam | |
| Type | Concrete, mass |
| Length | 140 feet |
| Top Elevation | 920 m.s.l. |
| Top Width | 2 feet |
| Maximum height | 10 feet |
| 6. Reservoir | |
| Surface area | El. 920 - 56 acres |
| Capacity | El. 920 - 200 acre-feet |

7. Principal Quantities

| | |
|---|---|
| Excavation | 16,000 c.y. |
| Concrete-Abutments | 1,150 c.y. |
| Concrete-Spillway | 2,550 c.y. |
| Rock Slope Protection | 1,100 c.y. |

8. Cost Estimates

First Costs

| | |
|---|---|
| Federal | $542,000 |
| Non-Federal | 130,000 |
| Total | $672,000 |

Annual Costs

| | |
|---|---|
| Federal | $ 32,500 |
| Non-Federal | 9,100 |
| Total | $ 41,600 |

9. Benefits

| | |
|---|---|
| Average annual benefits | $ 47,400 |
| Benefit-cost ratio | 1.13 to 1.0 |

## B. PROJECT AUTHORITY

This Detailed Project Report is submitted pursuant to authority contained in Section 205 of the 1948 Flood Control Act, as amended by Public Law 874, 87th Congress, adopted 23 October 1962. Further authority is contained in 1st Indorsement dated 2 June 1969 from the Chief of Engineers, to report dated 21 March 1969 from the Division Engineer, New England Division, subject: "Reconnaissance Report, Lancaster Dam and Reservoir, Israel River, Connecticut River Basin, Lancaster, New Hampshire."

## C. SCOPE OF DETAILED PROJECT REPORT

1. SCOPE

This Detailed Project Report reviews the ice-jam flood problem and general overflow of the Israel River into the developed area of the town of Lancaster. High river stages and flooding are caused primarily by runoff and ice jamming in the reach of the Israel River from the Main Street bridge to the confluence of the Connecticut River. The ice-jam flood of record occurred in March 1968. This report submits a definite project plan of improvement which includes construction of an upstream ice-retention dam and reservoir and appurtenant structures.

2. TOPOGRAPHIC SURVEYS AND SUBSURFACE EXPLORATIONS

Topographic surveys and cross sections of the proposed local protection project area on a scale of 1" = 40' and a contour interval of two feet were made during October 1968 and November 1969.

Subsurface explorations were performed during December 1969-January 1970 and consisted of test borings along the proposed alignment of the concrete dam. The location and description of the borings are shown on Plate 5.

3. ECONOMIC INVESTIGATIONS

A survey of damages in the flood problem areas of Lancaster was made during May 1968, and supplemented information obtained in earlier damage surveys. The survey included personal interviews with town officials and personnel from commercial and industrial properties affected by flooding. Additional field inspections have been performed since May 1968 to confirm that conditions have not changed in the flood prone area.

4. REAL ESTATE STUDIES

Real estate studies were made during June 1970. The study concluded that approximately 120 acres of land would be required in fee while about 80 acres would be acquired under flowage easements. Real estate costs are currently estimated at $105,000. Details of the studies are set forth in Appendix B.

5. CONFERENCES WITH LOCAL OFFICIALS

Close liaison has been maintained with town and state officials and other interested parties. Desires of local interests are described in Section O. A strong desire for construction and completion of the proposed project has been expressed and is exemplified by the vote of the March 1971 town meeting which appropriated $105,000 for project lands. A letter of intent indicating the town's willingness and ability to participate in the proposed improvement is contained in Appendix A of this report. Formal assurances will be furnished by the town and the State of New Hampshire prior to completion of final design.

## D. PRIOR REPORTS

6. DETAILED PROJECT REPORT

During September 1967 a Detailed Project Report was forwarded to OCE. This report recommended construction of channel improvements along the Israel River downstream of the Main Street bridge. However, in light of the record flood levels experienced at Lancaster during March 1968 the

Detailed Project Report was recalled in order to evaluate the effect of increased flood stages on flood prone properties. Our effort at that time determined that a substantial increase in project benefits warranted further detailed study to determine if an upstream ice-retention dam and reservoir culd be constructed. Our findings were reported in the Reconnaissance Report described in Paragraph 7.

7. RECONNAISSANCE REPORT

In response to requests from local interests and in compliance with ER 1165-2-12, a Reconnaissance Report dated 21 March 1969, concerning ice-jam flooding along the Israel River in Lancaster, New Hampshire, was submitted to OCE. The report stated that the construction of a concrete dam across the Israel River at a location just below its confluence with Otter Brook would retain floating ice, thereby preventing the formation of ice jams in the vicinity of the central area of Lancaster. The reconnaissance report indicated that the project was economically feasible and within the scope of Section 205, Public Law 87-874. It was recommended that the New England Division be authorized to prepare a Detailed Project Report. By 1st Indorsement dated 2 June 1969 the Chief of Engineers authorized preparation of a second Detailed Project Report.

## E. DESCRIPTION OF AREA

8. GENERAL

The Town of Lancaster is located in northern New Hampshire about 93 miles north of Concord, New Hampshire, and 165 miles north of Boston, Massachusetts. Lancaster is the Shire Town of Coos County. The commercial center of Lancaster is situated on the Israel River about 1.5 miles upstream from its confluence with the Connecticut River. The Main Street bridge over the Israel River carries the traffic of U.S. Routes 2 and 3 through Lancaster. The Israel River enters the Connecticut River from the east and has a length of about 21 miles and a drainage area of 133 square miles, located wholly within the State of New Hampshire. Two principal tributaries of the Israel River are Otter Brook (drainage area 20 square miles) and Stag Hollow Brook (drainage area 13 square miles). Otter Brook and Stag Hollow Brook enter the Israel River about 3.5 and 14 miles upstream from Main Street, respectively. The watershed area is generally steep, except for the flat reach from the confluence of the Connecticut River to Main Street.

9. TOPOGRAPHY

Lancaster is located in the Upland Section of New England, a mature region of moderate relief which has been considerably modified by glaciation. The hills are generally rounded and thinly blanketed till. Valleys are relatively wide and are deeply filled with outwash and glacial lake deposits which form broad flood plains in the valley bottoms and extensive terraces along the valley sides. Bedrock in the region consists primarily of crystalline rocks including schist, quartzite, slate and amphibolite.

## 10. SURFICIAL GEOLOGY

The project is located in the margin of the White Mountain section of the New England Physiographic province. Glaciation has modified the details of a pre-glacial, maturely dissected topography by erosion and more so by deposition. Glacial till, a heterogeneous mixture of glacial materials mantles the rock surface and constitutes the major portion of over burden at the higher elevations.

The river is constricted in the vicinity of the site by steep-faced terraces which rise abruptly from the water's edge on both sides of the channel. Immediately upstream from the site, the valley flares to form a very wide, flat-bottomed basin with the river flowing generally along the western side. It is expected that the wide valley is floored with thin alluvial deposits and outwash overlying glacial lake beds composed of silt and clay. The steep face of the terrace which forms the left abutment at the site is approximately 25 feet high but the surface of the terrace continues to rise gently southward to the railroad and the hill which forms the southern valley wall. The generally flat top of the right abutment terrace is about 35 feet above the river and extends northward to the low hills which rim the valley. A brick yard, now abandoned, formerly occupied the right abutment. Material for the manufacture of the bricks was apparently excavated from a low terrace adjacent to the upstream side of the right abutment. Gravel bars and numerous boulders occur in the river channel. Bedrock consisting of quartz-diorite and schist outcrops in a railroad cut approximately 600 feet downstream from the railroad bridge.

## 11. MAIN RIVER AND TRIBUTARIES

The Israel River originates in the mountains of the White Mountain National Forest and flows in a general northerly direction to the Town of Lancaster, where it turns to flow westerly to its confluence with the Connecticut River. Other than Lancaster there are no large communities in the Basin. Jefferson, the second largest town in the Basin, with a population of about 600 (1960 census) is located on the Israel River seven miles upstream from Lancaster. Two of the tributaries of the Israel River, Stag Hollow Brook and Mill Brook, enter the main stream above Jefferson forming a fan shaped drainage pattern. Other major tributaries include Garland Brook and Otter Brook. Numerous short and steep tributaries primarily located in the upper reaches of the basin, have slopes of 70 to 80 feet per mile. The watershed is largely wooded where it drains mountain slopes but is mostly open pasture land in the vicinity of Lancaster.

## 12. STREAM CHARACTERISTICS

The Israel River Watershed is characterized by a relatively flat main stream and steep tributary streams which drain the slopes of the Pliny Range (El. 4000') of the White Mountains to the North and the

Dartmouth Range (El. 3700') to the south. There are no large swampy areas to retard flood flows in the watershed. The gradient of the Israel River is fairly uniform throughout, dropping from about elevation 1400 feet at its headwaters to elevation 800 feet at its confluence with the Connecticut River. The river is approximately 21 miles long.

13. MAPS

The Israel River Basin, including the site of the proposed protection project, is shown on Department of the Interior, U. S. Geological Survey Maps indexed as Whitefield, Guildhall, Percy and Mt. Washington quadrangles (1:62,500). The Israel River Basin is shown on Plate No. 1 accompanying this report.

## F. CLIMATOLOGY

14. GENERAL

The Israel River Basin has a variable climate characterized by frequent but generally short periods of heavy precipitation. It lies in the path of the "prevailing westerlies" and is exposed to the cyclonic disturbances that cross the country from west or southwest toward the east or northeast. The area is also subject to coastal storms that travel up the Atlantic seaboard in the form of hurricanes of tropical origin or storms of extratropical nature, often called "northeasters". The winters in the basin area are moderately severe with most of the precipitation occurring in the form of snow and temperatures in the minus "thirties" having been recorded. The spring melting of the winter snow cover usually occurs in the months of April and May.

15. TEMPERATURE

The mean annual temperature at Lancaster, New Hampshire is about 42 degrees Fahrenheit. Recorded temperature extremes at Lancaster have varied from occasional highs slightly in excess of 90 degrees Fahrenheit to infrequent lows of minus 36 degrees Fahrenheit. Monthly mean, maximum and minimum temperatures at Lancaster are shown on Table 1.

16. PRECIPITATION

The average annual precipitation at Lancaster is about 36 inches. The maximum and minimum annual precipitation at Lancaster is 51.4 and 32 inches, respectively. Table 1 also shows the mean, maximum, and minimum monthly precipitation at Lancaster.

17. SNOWFALL AND SNOW COVER

The mean annual snowfall over the Israel River watershed is estimated to be 80 inches, based upon records for Bethlehem, New Hampshire

TABLE 1

MONTHLY TEMPERATURE AND PRECIPITATION

LANCASTER, NEW HAMPSHIRE
(Elevation 940 feet, msl)

| | Temperature (Degrees Fahrenheit) 8 Years of Record | | | Precipitation (Inches) 30 Years of Record | | |
|---|---|---|---|---|---|---|
| Month | Mean | Maximum | Minimum | Mean | Maximum | Minimum |
| January | 13.2 | 56 | -36 | 2.46 | 5.88 | 0.96 |
| February | 16.6 | 55 | -32 | 1.93 | 3.63 | 0.78 |
| March | 28.4 | 69 | -17 | 2.28 | 5.44 | 0.63 |
| April | 41.8 | 85 | 12 | 2.95 | 5.62 | 1.44 |
| May | 53.6 | 90 | 21 | 3.14 | 5.86 | 1.29 |
| June | 61.6 | 90 | 29 | 3.96 | 8.28 | 1.96 |
| July | 64.8 | 93 | 33 | 3.66 | 7.11 | 0.77 |
| August | 63.8 | 90 | 30 | 3.46 | 6.40 | 1.18 |
| September | 57.6 | 90 | 23 | 3.74 | 10.70 | 1.31 |
| October | 45.9 | 80 | 13 | 2.88 | 6.15 | 0.63 |
| November | 34.3 | 71 | - 3 | 3.31 | 6.04 | 0.98 |
| December | 20.2 | 58 | -29 | 2.49 | 4.89 | 0.89 |
| ANNUAL | 41.8 | 93 | -36 | 36.26 | 51.42 | 32.06 |

TABLE 2

MEAN MONTHLY SNOWFALL

BETHLEHEM, NEW HAMPSHIRE
(Elevation 1550 Feet, msl)

68 Years of Record

Average Depth in Inches

| Month | Snowfall |
|---|---|
| January | 16.3 |
| February | 16.5 |
| March | 14.1 |
| April | 6.3 |
| May | 2.6 |
| June | 0 |
| July | T |
| August | 0 |
| September | T |
| October | 1.7 |
| November | 9.1 |
| December | 13.9 |
| ANNUAL | 80.5 |

which are summarized in Table 2. Snow cover on the average reaches a maximum depth in late March or early April with water content normally ranging from 6 to 8 inches. Melting of the snow results in heavy spring runoff, but this cause alone seldom produces a damaging flood at Lancaster. However, the possibility of sudden thaws and heavy rains create a potential flood hazard every spring.

18. STORMS

The Israel River Basin is subjected to storms of continental origin which move easterly or northeasterly across the country under the influence of the "westerlies" and to maritime storms which move northward along the Atlantic seaboard, some of which are of tropical origin. Critical flood conditions at Lancaster are the result of a rapid "breakup" of the ice and concurrent high river flow which may be from snow-melt supplemented by runoff from rainfall. Because periods of moderate to heavy precipitation occur frequently in the springtime over the upper Connecticut River basin there is an annual flood potential in the region.

## C. RUNOFF AND STREAMFLOW DATA

19. DISCHARGE RECORDS

There are no published records of streamflow in the Israel River. The U. S. Geological Survey has published records of river stage and discharge for several streams in the vicinity of Lancaster, New Hampshire. Records from three locations in the upper Connecticut River Basin are summarized in Table 3.

TABLE 3

STREAMFLOW RECORDS

THROUGH WATER YEAR 1970

| Location | Drainage Area | Period of Record | Discharge (cfs) Mean | Maximum | Minimum |
|---|---|---|---|---|---|
| Connecticut River at North Stratford, New Hampshire | 799 | 1930-1970 | 1548 | 28,700 | 108** |
| Connecticut River near Dalton, New Hampshire | 1514 | 1927-1970 | 2843 | 48,300 | 115** |
| Upper Ammonoosuc River near Groveton, New Hampshire | 232 | 1940-1970 | 470 | 24,100 | 32* |

*Instantaneous discharge
**Daily discharge

20. RUNOFF

The average annual runoff of 470 c.f.s. in the Upper Ammonoosuc River near Groveton, New Hampshire is considered typical of the Upper Connecticut River Basin and the Israel River. The mean, maximum and minimum annual and monthly runoff near Groveton is shown in Table 4.

TABLE 4

MONTHLY RUNOFF

UPPER AMMONOOSUC RIVER NEAR GROVETON, NEW HAMPSHIRE
(Drainage area 232 Square miles)

30 Years of Record

Discharge in Cubic Feet per Second

| Month | Mean | Maximum | Minimum |
|---|---|---|---|
| January | 220 | 525 | 56 |
| February | 201 | 851 | 71 |
| March | 402 | 1376 | 77 |
| April | 1481 | 2418 | 641 |
| May | 1170 | 2563 | 405 |
| June | 459 | 1119 | 181 |
| July | 227 | 447 | 121 |
| August | 195 | 575 | 83 |
| September | 205 | 1429 | 54 |
| October | 230 | 704 | 72 |
| November | 468 | 1128 | 121 |
| December | 336 | 986 | 70 |
| ANNUAL | 470 | 698 | 331 |

## H. FLOOD HISTORY

21. GENERAL

The flood history of the Israel River dates back to 1870 and during this period 25 significant floods occurred which resulted from high river discharges, ice-jams or a combination of both. Of the seven floods reported prior to 1940 only one, that of 1895, resulted from ice-jam flooding. Of the remaining 18 floods sine 1940, 15 were caused by ice-jams Local residents report that, since 1940, ice conditions have been aggravated because of the destruction by flood discharges of several small upstream dams which previously contained the ice until it melted. Table 5 lists the most severe ice-jam and ice-free floods of record.

The greatest ice-jam flood of record occurred in March 1968 and was three feet higher than the record ice-free flood of November 1927. The second highest ice-jam flood occurred in April 1950 and approximated the high water elevation of the 1927 flood. Ice-jam conditions have occurred as many as four times in one year as observed in the winter of 1953.

## I. DEVELOPMENT OF FLOODS

### 22. GENERAL

The principal tributaries of the Israel River drain the western slopes of the White Mountains. In addition, many small tributaries enter the main stem throughout its 21-mile length. High stages on the Israel River in Lancaster are caused principally by rapid runoff and/or ice-jams at bridges and at sharp bends in the river downstream of the town.

### 23. NON-ICE FLOODS

On 3 and 4 November 1927, torrential rains fell over much of New England causing the most severe floods ever experienced over extensive areas of Vermont and New Hampshire. At the time of the storm the ground had been saturated by heavy rains which fell from the 18th to the 21st of October. The natural lakes and swamps filled and most of the tributary rivers were at moderately high stages. Practically all the available surface storage had been utilized. As a result, the rivers quickly overflowed their banks and filled many of the valleys. The flood was produced entirely by rainfall with heaviest amounts centered in the Green Mountains of Vermont.

The flood of March 1936, a basin wide flood on the Connecticut River, caused backwater up the Israel River to a point above the Main Street bridge in Lancaster. The March 1936 high water level in the Connecticut River at the confluence was about 5 feet higher than the channel bottom at Main Street.

### 24. ICE-JAM FLOODS

The ice-jam flooding of March 1968 was preceded by an earlier ice-jam that occurred on 12 December 1967 when moderate rains, coupled with temperatures in the 50's, caused upstream cover ice to break up and float downstream to an area just below the center of Lancaster. This ice jammed at a sharp bend in the river causing an ice build-up which subsequently resulted in overbank flooding.

Periods of prolonged cold spells in early January 1968 and again in February resulted in a deep penetration of frost and a thick ice cover. On 17-18 March the area received 1 to 2 inches of rainfall. During the period of 18-23 March, ice piled upon the previous jam producing a massive blockage and severe overbank flooding occurred when the ice reached the road level at the Main Street bridge.

The transition from a steep mountainous stream to a relatively flat grade occurs at the Main Street bridge in Lancaster. Sheet ice readily forms on the lower reach between the bridge and the Connecticut River. During the wintertime, large amounts of frazil ice are constantly being formed in the steeper upstream reaches with anchor ice forming in the lower section. This condition reduces the channel section sufficiently to cause backwater flooding in Lancaster whenever the discharge is suddenly increased by rainfall or thawing snow. This condition may occur quickly at any time from midwinter until after the spring ice break up.

## 25. STAGE-DISCHARGE RECORD

The highest recorded stage on the Israel River at Lancaster occurred during the ice-jam flood of March 1968. Above the Main Street bridge, this level exceeded the ice-free flood of November 1927 by over 3 feet. Table 5 shows the recorded high water levels on the Israel River in Lancaster and the estimated peak discharges for non-ice floods.

TABLE 5

RECORDED HIGH WATER LEVELS ON THE ISRAEL RIVER AT LANCASTER, NEW HAMPSHIRE (Main Street Bridge)

| Date | Elevation (ft., msl) | Estimated Peak Discharge (cfs) |
|---|---|---|
| High Stages Produced by Ice-Jams | | |
| March 1968 | 866.6 | |
| April 1950 | 863.8 | |
| March 1964 | 859.5 | |
| April 1960 | 859.4 | |
| Jan-Feb 1953 | 858.7 | |
| High Stages Produced by Flood Discharges | | |
| Nov 1927 | 863.5 | 8,840 |
| March 1936 | 862.9 | 6,260 |
| Sept. 1938 | 862.9 | 5,340 |
| March 1945 | 861.9 | * |
| March 1953 | 861.2 | * |

*Peak discharge unknown

BUILDINGS ADJACENT TO MAIN STREET BRIDGE MARCH 1968

LANCASTER TOWN HALL MARCH 1968

BUILDINGS ADJACENT TO MAIN STREET BRIDGE MARCH 1968

THOMPSON MFG. CO. CANAL STREET MARCH 1968

## J. FLOOD FREQUENCY

### 26. GENERAL

Because of the complicated factors which produce ice-jam flooding, there appears to be little or no correlation between natural river discharges and ice-induced stages. Therefore, separate elevation-frequency curves have been estimated for non-ice and ice-jam floods.

### 27. NON-ICE FLOODS

Discharge-frequency relationships were determined for non-ice floods on the Israel River at Lancaster from a regional analysis of the upper Connecticut River Basin. These relationships were developed by procedures set forth in ER 1110-2-1450, dated October 1962. There are only sporadic discharge records on the ungaged Israel River. A tabulation of the estimated discharge-frequency relationship for non-ice floods at Lancaster is shown in Table 6.

TABLE 6

DISCHARGE-FREQUENCY DATA
NON-ICE FLOODS
ISRAEL RIVER, MAIN STREET BRIDGE
(DA = 133 square miles)

| Frequency or Per Cent Chance of Occurrence | Discharge (cfs) | Water Surface Elevation (ft.,msl) |
|---|---|---|
| 1.0 | 21,000 | 865.5 |
| 2.0 | 12,000 | 864.1 |
| 5.0 | 5,400 | 862.1 |
| 10.0 | 4,100 | 860.5 |
| 20.0 | 3,100 | 858.8 |
| 30.0 | 2,800 | 858.0 |
| 40.0 | 2,500 | 857.5 |
| 50.0 | 2,400 | 857.2 |

Records indicate that the Israel River has not experienced as proportionately large a non-ice flood as other adjacent watersheds. This is probably due to orographic influences since the Israel River rises on the western slopes of the Presidential Range of the White Mountains.

### 28. ICE-JAM FLOODS

It is considered appropriate to consider high river stages produced by ice-jams in an entirely different statistical array from the stages related directly to high stage flow without ice. Since data for maximum stages produced by ice-jams are meager and their causes do not follow any specific meteorological pattern, it is difficult to apply a sound mathematical approach in determining a probability relationship. The elevation-frequency data in Table 7 are based on the following:

a. The March 1968 ice-jam flood on the Israel River in Lancaster is the greatest flood of record. Prior to 1936, few ice-jam floods were reported in this area. Several dams on the Israel River were destroyed in 1936 and since that time ice-jam flooding has been more frequent. Therefore, the March 1968 event was considered a 33-year event and assigned a 3 per cent exceedence frequency.

b. The second highest ice-jam stage in recent years occurred in April 1950 and was assigned an exceedence frequency of 10 per cent.

c. An estimated frequency curve was drawn through these two points.

TABLE 7

ELEVATION-FREQUENCY DATA
ICE JAM FLOODS
ISRAEL RIVER, MAIN STREET BRIDGE

| Frequency of Per Cent Chance of Occurrance | Ice-Jams (ft.,msl) | |
|---|---|---|
| 1.0 | 868.6 | 3 |
| 2.0 | 867.5 | 3.4 |
| 5.0 | 865.4 | 3.3 |
| 10.0 | 863.8 | 3.3 |
| 20.0 | 861.7 | [illegible] |
| 30.0 | 860.5 | [illegible] |
| 40.0 | 859.5 | 2.6 |
| 50.0 | 858.8 | 1.6 |

## K. HYDROLOGIC CONSIDERATIONS OF PROPOSED IMPROVEMENT

### 29. GENERAL

The U. S. Army Cold Regions Research and Engineering Laboratory (CRREL) Technical Memorandum entitled: "Control of Ice-Jams at Lancaster, New Hampshire", 1968, concluded that a low dam constructed at the location shown on Plate 1 would decisively alleviate ice-jam conditions at Lancaster. The dam, shown on Plate 2, would create a 56-acre pool which would hold and gradually waste the incoming ice and therefore eliminate downstream ice-jam problems. The entire Technical Memorandum is included as Appendix D to this report.

### 30. STANDARD PROJECT FLOOD

The proposed ice barrier dam for the Israel River will meet standard 4 spillway capacity requirements as outlined in the following references:

a. EM 1110-2-1101 "Design Criteria for Systems of Small Dams," February 1968.

b. EC 1110-2-27, "Policies and Procedures Pertaining to Determination of Spillway Capacities and Freeboard Allowances for Dams."

The spillway will be designed to pass a 100-year frequency peak discharge of 21,000 cfs, and because of the small amount of storage no reduction was made for surcharge storage.

The spillway crest of the dam will be 10 feet above existing river bottom and, under design flood conditions, there would be only 4.7 feet difference in elevation between headwater and tailwater. Also, in accordance with standard 4 criteria, a freeboard of 1 foot above project design flood level will be adopted for design of nonoverflow sections. The hydraulics of a dam failure are discussed under paragraph 31f.

31. HYDRAULIC DESIGN

a. General. The dam is designed to safely pass a discharge of 21,000 cfs which is equivalent to the hundred year flood event and is much greater than the 1927 flood of record (Q = 8,840 cfs).

b. Spillway

(1) Length of crest and maximum surcharge. The spillway will be 140 feet in length and the crest, at elevation 920 feet, msl, will be laid out on a 227 foot radius. For the design discharge of 21,000 cfs, the surcharge will be 12 feet. The spillway will be vented on both ends to aerate the nappe to prevent oscillation. A general plan of the spillway is shown on Plate 3.

(2) Crest shape. The crest will be constructed of a concrete trapezoidal section and is shown on Plate 4. The 45 degree upstream face is designed to improve approach conditions and the vertical downstream face will allow the overflowing nappe to separate from the spillway and drop into the plunge basin.

(3) Discharge rating curve. The discharge rating curve for the spillway is plotted on Plate 6 and was computed by the following conventional weir formula: $Q = CLH^{3/2}$. The head loss of the flow approaching the weir was found to have a negligible effect on the stage-discharge relationship. The coefficient of discharge varies from 3.1 at low heads to 3.6 at the maximum design discharge and was determined from those values for similarly shaped weirs found in Robert E. Horton's "Weir Experiments, Coefficients and Formulas," USGS Water Supply Paper No. 200, 1907.

(4) Tailwater. The tailwater rating curve is also shown on Plate 6 and was computed by a backwater analysis beginning at the railroad

bridge just downstream from the project. Roughness coefficients, n = 0.03 for the channel and n = 0.04 for the overbank were used in the computations and assumed to be characteristic of this reach. The water surface profile for the design flood (Q = 21,000 cfs) at the project site is shown on Plate 7.

c. Dam. The nonoverflow portion consists of reinforced concrete training walls and concrete gravity abutment walls that tie into high ground on the adjacent riverbanks. The top of the abutment walls will be constructed to elevation 933 feet msl to allow for one foot of freeboard above the 12-foot surcharge. The training walls will extend along the full length of the spillway cross section and the leading edge of the walls will be rounded to improve the hydraulic flow conditions. An access road will be constructed on the right abutment for easy removal of stoplogs in the gate structure.

d. Outlet structure. A 6-foot gate structure consisting of stoplogs is located in the spillway adjacent to the right abutment. It will have the capacity to evacuate the pool during normal low flow periods for necessary maintenance of the dam. Logs will be removed by a temporary hoist set up from the right abutment.

e. Plunge basin

(1) General. The purpose of the basin is to allow the flow to expand and dissipate excess energy through turbulence caused by the plunging nappe striking the stagnant pool rather than the channel bottom and sides. According to the experimental results published in the St. Anthony Falls report, entitled: "Straight Drop Spillway Stilling Basin," November 1954 by Charles Donnelly and Fred Blaisdell, the overflow nappe is considered to plunge for all discharges when the tailwater is below two-thirds of the critical depth of flow at the crest. This point is reached at a flow of 15,000 cfs. Therefore, the nappe "plunges" for discharge below 15,000 cfs and "floats" at greater discharges.

(2) Geometry. The basin invert will be constructed to elevation 905 feet msl for a distance of 30 feet downstream of the dam and then will rise up on a 1 on 2 slope to the natural stream invert (elevation 910 feet msl). A 5-foot layer of rock will line the basin invert and the 1 on 2 side slopes up to elevation 928 feet msl to protect the basin from erosion.

(3) Rock design. A discharge equal to 5,000 cfs equivalent to the 20-year frequency is used to design the rip-rap for the plunge basin because it was found to be more economical to make plunge basin repairs after less frequent events than to place the expensive larger rock in the basin. Very little information was found on plunge basin rock design, however, it was decided to use a rock size $d_{50}$ = 1.0 ft. ($W_{50}$ = 85 lb.) due to the availability of rock, engineering judgment and unpublished criteria established by Grace and Pickering at the U. S. Army Waterways Experiment Station. This criteria is a plot of the ratio $d_{50}$ (rock diameter) to depth of flow v. s. Froude number, $F_N$, at the downstream end of the plunge basin.

The size of rock was determined by entering the plot with $F_N = 0.42$ and adopting the point which falls between curves for high and low dams and represents the 1.0 foot diameter rock.

(4) Erosion effects. The point at which the nappe strikes the basin floor was determined by criteria established in the St. Anthony Falls report. Scour depths for the basin were computed from the following formula found in the Bureau of Reclamation's "Design of Small Dams," section 203, Plunge Pools.

$$ds = 1.32\, H_T^{0.225} q^{0.54}$$

ds = depth of scour

$H_T$ = head from reservoir to tailwater levels

q = discharge cfs/ft

As shown on Plate 8, which is a plot of depth of scour versus discharge within the basin, no erosion would occur for discharges up to 3,200 cfs (5-year event). For less frequent events erosion will take place down to the minimum depth of 905 feet msl for a discharge of 15,000 cfs (the maximum discharge which the nappe is considered to plunge). The erosion pattern for this discharge is shown on Plate 9.

Minor erosion of the rock on the horizontal invert and complete erosion of the downstream toe of the basin is possible but can be tolerated for the rare events because the integrity of the dam will not be jeopardized. However, plunge basin repairs will be required after floods which occur less frequently than one every five years.

f. Dam failure - cause and effect. The possibility of a dam failure was investigated for flows between the design discharge of 21,000 cfs and the standard project flood. Upon observation of the site and project plans it was concluded that complete and sudden failure of the dam would not take place due to the following considerations:

(1) The concrete weir and abutments are so massive that they would continue to act as a substantial obstruction in the stream.

(2) Erosion would most likely occur in the earth around the abutments of the dam and this type of failure would take place gradually precluding the possibility of downstream surges.

(3) Downstream of the dam the river narrows at the Boston and Maine railroad bridge, then widens and turns to the right before reaching buildings which are located 3,000 feet downstream of the dam. These physical features would preclude the possibility of a significant surge at the dam reaching downstream damage areas.

From

(4) The headwater to tailwater differential will vary from 2.0 feet for the standard project flood to a maximum of 4.7 feet for the design flood and it is considered that the 4.7 feet is too small to create a severe surge potential.

The above considerations attest that failure of the dam can take place but in such a gradual manner that neither the discharge nor the energy of the water would be significantly increased to cause more damage downstream than would occur naturally without the project.

g. Timber ice holding cribs. Three timber ice holding cribs will be located in the natural river channel 90 feet upstream of the dam and 35 feet apart. The cribs will be constructed of 8 x 8 inch timbers layed out 8 feet square at the top and 8 x 15 feet at the base and filled with rock. The cribs will rise to an elevation of 924 feet msl and be used to retain the larger size blocks of ice. Details of the timber crib are shown on Plate 4.

32. EXISTING FLOOD SITUATION

The critical area for the formation of ice jams threatening the town is located below the Main Street bridge. The longitudinal slope in the lower reach of this area is negligible and the bed is relatively wide and flat covered with sandbars and debris. During the early winter this stretch accumulates frazil ice drifting from open stretches of the river above. This ice freezes to the bottom and because of the limited flow of water during the winter only a small channel is cut through this ice accumulation.

During spring break-up, ice coming from up-river freezes in this area thereby increasing the roughness of the bed which could cause ice jams. The inspected evidence clearly points to this area as the main cause of trouble. The worst location is at the abandoned railroad embankment where the foot of the ice jams form. The backwater from the Connecticut river may cause ice jams when it reaches up to the abandoned railroad embankment because the ice cannot easily discharge. On the other hand backwater may alleviate an existing ice jam when the water level rises to provide higher stages, thereby disengaging the foot of the ice jam.

## L. FLOOD DAMAGE AND ECONOMIC DEVELOPMENT

33. EXTENT AND CHARACTER OF FLOODED AREA

Two important highway routes, U. S. Route 3 running in a north-south direction, and U. S. Route 2 which runs east and west between Burlington, Vermont, and the principal cities of Maine to the east, intersect near the center of the town's built-up commercial center. As these roads are major tourist routes to the White Mountains to the south and east of Lancaster, a sizeable service industry has developed in the town to

meet the tourist trade. The permanent population of 3,400 undergoes a rapid increase during the recreation season, and may reach as high as 10,000 people. In addition, Lancaster is the commercial and banking center for a fair sized rural area.

34. FLOOD DAMAGES

A portion of the commercial center is subject to ice-jam flooding. Twenty-one commercial properties, the Town Hall, one small industrial plant (45 employees) and 15 dwellings in the town's center suffer from such flooding. Based on assessments for properties and contents, it is estimated that the value of these flood prone properties is in excess of $1,200,000. Some 12 acres of commercial and residential properties in the center of Lancaster are subject to ice-jam flooding.

Flood damage surveys were made of the area following the ice-jam flood of March 1964, and again during May 1968. Property owners were interviewed and the town manager and other public officials were consulted. Estimates were made of the damages in the 1968 event and for stages above and below the 1968 water level. The stage of zero damage was also determined.

35. AVERAGE ANNUAL LOSSES

It is estimated that a recurrence of the 1964 (Stage 859.5) event would cause losses of $11,200 under 1973 conditions. An increase of a half a foot in stage would increase this loss by 50 per cent. In a recurrence of the 1968 ice-jam flood of record (Stage 866.6) the losses would amount to $111,000.

Recurring losses at various stages of flooding were combined with stage frequency data for conditions with and without ice to determine annual losses. Annual losses so derived amount to $41,600 with ice and $7,000 without ice at current price levels.

36. TRENDS OF DEVELOPMENT

As noted in the description of the location of the problem area, there is a well established demand for the goods and services of the properties in the flood prone area. Recreational tourism may be expected to grow. Physical conditions limit much additional growth in the area, but more intensive use of existing facilities will help meet the demand. Based on this, it is reasonable to assume that annual losses will remain at, or slightly above, their present level over the project life.

## M. EXISTING CORPS OF ENGINEERS FLOOD CONTROL PROJECTS

There are no existing Corps of Engineers flood control projects on the Israel River. Comprehensive basin studies have been made for the

Connecticut River Basin, which includes the Israel River. The Soil Conservation Service has also considered the upper watershed of the Israel River with a view to small water-retarding structures as part of the basin studies. An ice-retention structure being recommended under the Section 205 Authority would be consistent with any future upstream improvement that might result from the Connecticut River Basin studies or efforts by the Soil Conservation Service.

## N. IMPROVEMENTS OF FEDERAL AND NON-FEDERAL AGENCIES

There are no current Federal or non-Federal improvements within the watershed of the Israel River.

## O. IMPROVEMENTS DESIRED

Several meetings have been held with local interests to determine the attitude of townspeople and local officials towards the proposed plan of ice-jam flood control. Not only does the commercial center of Lancaster experience frequent damaging floods from ice-jams but also the continual flood threat, which causes deep concern and social disruption of the townspeople, is an important factor in the overall analysis of the proplem. The citizens and manufacturers of the town are desirous of preventing future losses to properties along the Israel River and feel that the proposed plan, as outlined herein, will reduce future damage potential and alleviate their fears of the constant threat of flooding. Local interests have expressed a willingness to fully cooperate on this proposal for flood protection. Letters of concurrence and comment from local interests are included in Appendix A of this report.

## P. FLOOD PROBLEM AND ALTERNATIVES CONSIDERED

### 37. FLOOD PROBLEM

The Town of Lancaster is susceptible to floods caused by ice jams, heavy rains, melting snow, or combinations of each. During major floods, high discharges on the Israel River overflow both banks of the stream inundating portions of the central business district of Lancaster. The flood of record without ice, occurred in November 1927 and was produced entirely by intense rainfall associated with a low pressure system which traveled northward along the Atlantic coast. The major flood of March 1936 was produced by the combined runoff from melting snow and rainfall from a storm centered over the Connecticut River Basin. High flood stages in the developed area of Lancaster were slightly less than water levels of the 1927 flood.

Ice-jams in the lower reach of the Israel River are an annual threat to the Town of Lancaster. The ice-jam flood of record occurred in March 1968. Flood levels exceeded the ice free flood of 1927 by about 3 feet

incurring more extensive damages and losses to the developed area of Lancaster. The flat gradient and sharp bends of the Israel River from the Main Street bridge to the Connecticut River confluence, create ice-jams causing backwater conditions upstream to overflow the low banks incurring damages to the built-up area of Lancaster. In addition, snags and obstructions encroaching upon the river channel are also a cause of ice-jams. Fifteen ice-jam floods have been noted from 1940 to 1973.

38. ALTERNATIVES CONSIDERED

Consideration has been given to several alternate plans of local protection against ice jams and non-ice flooding from the Israel River in Lancaster. These alternates include:

a. Excavation of the existing channel below the Main Street bridge.

b. Construction of two low timber crib dams at sites located in the reach upstream from the Mechanic Street bridge.

c. Construction of a large multi-purpose dam for flood control, ice control and recreation in the area just below the Otter Brook-Israel River confluence.

d. Sheet pile or timber crib barriers in the broad, flat flood plain upstream from the Otter Brook-Israel River confluence.

e. Log booms across the river in the same area as (d) above.

f. Construction of wall and dikes along the river in the commercial center of Lancaster.

g. Sheet pile cellular cofferdam.

h. Construction of a low, concrete sill across the Israel River downstream from the Otter Brook confluence.

A discussion of each of these proposals follows:

a. During Operation Foresight 1969 the sharp curve in the channel located just upstream from the abandoned railroad embankment was eliminated by excavating part of the island in this area. In addition, the left bank, concrete abutment to the old railroad bridge was also removed. These measures will prevent ice-jam formation under certain conditions. However, a plan to accomplish further channel excavation is not considered practical as it would not give permanent ice-jam flood protection to the community. It is estimated that within a few years the channel would again fill with gravel. Also, backwater from the Connecticut River and the flat

gradient below the railroad embankment precludes passage of ice during high water periods on the Connecticut River. The U. S. Fish and Wildlife Service, in their Conservation and Development Report of 3 January 1967, stated that this plan of flood protection was not acceptable as it would have serious adverse effects on fishery resources and spoil waterfowl habitat.

b. The plan to construct timber crib dams at two abandoned dam sites in the relatively steep reach of the Israel River upstream from the Mechanic Street bridge was eliminated because of the high replacement cost for such structures and the steep riverbanks in this area that precludes the displacement of floating cover ice into large retention areas.

c. Construction of a high level, multi-purpose dam would not be justified because of the excessive costs for required land taking. In addition, such a project would be beyond the scope and cost limitation of the Section 205 Authority.

d. Although sheet pile or timber crib barriers would be comparatively inexpensive, they would not provide the same high degree of ice-jam protection as the recommended plan. Because of the depth of water during carrying water-borne ice during spring runoff periods, the barriers would have to be over 10 feet high above the riverbed and extend across the flood plain. Unless the sheet piles were driven to a depth for a suitable foundation, they would be susceptible to failure from the resulting ice and water pressure.

e. Log beams across the river would not be suitable for ice-jam protection along the Israel River because of high velocities associated with flood discharges. This method could only be utilized for ice control in areas where ponding of ice could occur in slack water.

f. Consideration was given to construction of dikes and floodwalls along both banks of the Israel River. Although most of the annual benefits are derived from properties on the right bank of the river, separate alternate local protection projects were considered for individual right bank and left bank projects. Right bank protection would require the construction of approximately 1,700 linear feet of concrete floodwalls, 600 linear feet of earth dike, a pumping station and appurtenances. Left bank protection would consist of 800 feet of concrete floodwalls, 1,500 feet of earth dike, pumping station and appurtenant structures. Both proposals were found to have annual costs which exceeded the total annual benefits or the separated right and left bank benefits.

g. A plan to construct a 150-foot long sheet steel cellular overflow section filled with concrete in combination with a downstream rock-lined plunge basin was investigated. This plan was rejected because of high costs and stability problems.

h. Of all alternates considered, by far the most effective solution for the ice jam problem would be a low, trapezoidal shaped overflow section with rock-lined plunge basin, located just below the Otter Brook-Israel River confluence. This project would flood the extensive meadows in this area and create a wide reservoir for the accumulation and gradual wastage of ice.

## Q. PROPOSED IMPROVEMENT

### 39. OVERFLOW WEIR

The proposed plan of improvement would provide for the construction of a concrete overflow weir across the Israel River about 200 feet downstream of the Otter Brook confluence. This location is approximately 1.5 miles upstream from the Main Street Bridge.

The overflow section of the ice-retention dam would be an arch having a radius of 227 feet and a length of about 158 feet. The spillway crest could be at elevation 920.0 mean sea level, or about 10 feet above the existing streambed elevation of 910 m.s.l. The upstream face of the spillway would have a one vertical to one horizontal slope while the downstream face would be vertical to elevation 910 with a sloping deflector to elevation 905 m.s.l. The top width of the concrete gravity structure would be two feet. Five feet of rock protection would extend 30 feet from the base of the weir at elevation 905 to provide erosion control and a stilling basin at the downstream side of the structure. A six-foot wide stoplog opening adjacent to the right bank abutment wall would allow for drawdown of the ice-retention pool during low flow periods.

The non-overflow sections of the structure would have a top elevation of 933 m.s.l., or 13 feet above the weir crest. The right bank concrete abutment would have a top width of 10 feet to allow access to the stoplogged outlet, while the left bank abutment would have a two-foot top width. Both of these abutments would extend about 60 feet into the adjacent earth embankments to prevent erosion caused by foundation seepage. The right bank abutment would have vertical faces above elevation 921 m.s.l., while the left bank abutment would have a 3 vertical to 2 horizontal slope on the downstream face. The footings for these walls would vary between elevation 910 m.s.l., and 900 m.s.l.

Three rock-filled timber cribs would be constructed about 65 feet upstream of the spillway to act as ice holding structures for the sheet of cover ice. The cribs would be 35 feet apart and have a top elevation of 924 m.s.l. They would be eight feet square at the top and have a base dimension of 8x15 feet.

Overburden at the site consists of till and glacial lake deposits. In the river channel the lake beds occur at depths of approximately 5 to 15 feet beneath variable silty sands and gravels which apparently are reworked till. The lake beds are buried beneath 30 to 40 feet of till

on the abutments. The lake deposits, which range in thickness from 10 up to 40 feet or more in thickness, are underlain throughout the entire site by till. At boring FD-4 thin lenses of till were encountered in the lake beds at depths of approximately 24 feet and 34 feet. The lake deposits are stratified and laminated and consist mainly of silty sand and sandy to clayey silt. The fill is composed of variable gravelly sandy silt, gravelly silty and sandy, silty to clayey gravel with cobbles and boulders scattered throughout. The till on the abutments is blanketed by silty sands and sandy silts, apparently dune deposits up to 10 feet thick. Bedrock is deeply buried throughout the site as indicated by explorations, which did not encounter rock at depths of 50 feet or more. Descriptions of materials encountered in borings are presented in geologic log section A-A on Plate 5.

A plan, profile and sections of the weir and appurtenant structures is shown on Plates 3 and 4.

40. ICE-RETENTION RESERVOIR

The proposed permanent pool would encompass about 56 acres of pasture land at elevation 920 m.s.l. It has been reported by ice engineering specialists from the Cold Regions Research and Engineering Laboratory that a 50-acre minimum pool would be required to provide the necessary protection, based on contributing drainage area and the amount of ice that could be expected from upstream reaches of the Israel River. The sheet of cover ice that forms on the pond during the winter will be held in place so that floating river ice from upstream areas will pile up on the sheet ice and spread across the pasture. Ice engineering specialists have stated that this plan for accumulation and gradual wastage of ice will provide the highest degree of protection against ice-jam flooding in Lancaster.

## R. CONSTRUCTION MATERIALS

The proposed project, will require approximately 3,700 cubic yards of concrete for the construction of a spillway and abutments. The concrete will be subjected to severe climatic conditions with alternate cycles of freezing and thawing during the winter months. Therefore, for durability air-entrained concrete is considered mandatory. The concrete will not be subjected to high velocity flows of water; therefore, regular strength (3,000 psi) concrete will be required. Considering the relatively small quantity of concrete involved, the specifications will provide for the use of a manual concrete plant and ready-mixed concrete.

In view of the small quantity of concrete required, aggregate investigation has been confined to established commercial sources supplying

transit-mix concrete plants within a 30-mile haul distance of the project site. Three commercial sand and gravel sources who supply aggregates to ready-mix concrete plants are located within a twenty-seven mile haul distance of the project site. Two of these sources, Lessard Sand and Gravel Company, Incorporated and Caledonia Sand and Gravel, Incorporated, have been previously investigated and tested for civil works construction. A recent reconnaissance has been made to review the previously tested sources to determine their status and plant prices. The inspection of these two sources indicates they are petrographically similar as to when originally tested. These two sources are reported in Technical Memorandum No. 6-370, "Test Data - Concrete Aggregate in Continental United States," Volume 5. Both under Latitude 44°N - Longitude 71°W with Caledonia Sand and Gravel, Incorporated under Index No. 1 and Lessard Sand and Gravel Company, Incorporated under Index No. 2. The third source, Lawrence Sangravco, Incorporated, has been previously investigated but not tested. The recent reconnaissance indicated that their operation and materials are petrographically similar to when previously investigated.

Lawrence Sangravco, Incorporated operate an aggregate processing plant and manual control transit-mix type concrete plant located in Guildhall, New Hampshire, approximately a seven mile haul distance to the project site. The quoted plant prices and delivered prices respectively are $2.00 and $2.52 per ton for gravel and $1.35 and $1.86 per ton for sand.

Lessard Sand and Gravel Company, Incorporated operate an aggregate processing plant located in Gorham, New Hampshire, approximately a twenty-two mile haul distance to the project site. Quoted plant prices and delivered prices respectively are $2.29 and $3.70 per ton for gravel and $1.30 and $2.71 per ton for sand. Lessard Sand and Gravel Company, Incorporated regularly supply aggregate to Crushing, Incorporated located in Gorham, New Hampshire, who operate a manual control transit-mix plant approximately twenty-two miles from the project site. Lessard also regularly supplies aggregates to Brideau Redimix, Incorporated located in Berlin, New Hampshire who operate a manual control transit-mix plant approximately twenty-nine miles from the subject project.

Caledonia Sand and Gravel, Incorporated operate an aggregate processing plant located in Waterford, Vermont, approximately a twenty-seven mile haul distance to the project site. Quoted plant prices and delivered prices respectively are $2.26 and $3.97 per ton for gravel and $1.20 and $2.91 per ton for sand. Caledonia Sand and Gravel, Incorporated regularly supplies aggregates to Crushing Incorporated located in Littleton, New Hampshire who operate a manual-control transit-mix plant approximately twenty-two miles from the project site. Caledonia also regularly supplies aggregates to Calkins Redimix Concrete located in Lyndonville, Vermont who operate a manual-control transit-mix plant approximately thirty miles from the subject project.

The size of the project and the quantity of concrete does not warrant evaluation testing of untested concrete aggregate sources. The two tested sources of aggregates will be listed in the specifications as approved sources. If the Contractor elects other than a previously approved source, evaluation and acceptance testing will be performed on the source submitted.

## S. MULTIPLE-PURPOSE FEATURES

The provision of a permanent impoundment of 56 acres behind the proposed overflow spillway would provide considerable potential for recreational development, as well as an area for fish and wildlife management. Because of the relatively deep area near the dam, the town and/or State could construct a small beach and provide facilities for swimming and picnicking. In the winter the pond would readily accommodate ice skating. Local interests have expressed a desire for this multi-purpose use.

It is anticipated that the upstream limits of the permanent pool could be utilized as a waterfowl refuge and nesting area as it is far enough from the dam and is sheltered by brush and trees along the existing banks of both Otter Brook and the Israel River.

The New Hampshire Fish and Game Department has stated that because there are no anadromous fish in the Israel River, a fish ladder would not be required in the dam. This would allow for introduction of a managed "put-and-take" fishery resource upstream of the dam.

## T. REAL ESTATE REQUIREMENTS

The acquisition of land for the proposed project will be the responsibility of local interests. There are no highway or cemetery relocations involved in the project. The total area to be acquired consists of 120 acres of permanent easement and 85 acres of temporary access and flowage easements. Appendix B incorporates the details of real estate requirements and estimated costs.

## U. ESTIMATES OF FIRST COSTS AND ANNUAL CHARGES

### 41. GENERAL

The estimates of Federal and non-Federal first costs and annual charges are given in Table 8, and have been prepared on the basis that local interests would furnish all lands, easements, and rights-of-way necessary for project construction and operate and maintain the project after completion. Unit prices used in estimating costs are based on average bid prices for similar work in the general area. Unit costs are based on 1972 price levels, and include minor items of work which are not separately detailed.

42. BASIS OF COST ESTIMATES

Detailed cost estimates have been made upon the basis of a design which would provide an economical and safe project. Estimates of quantities are based on neat outlines of the proposed design requirements. Costs were computed as outlined in Engineering Manual 1120-2-104.

43. CONTINGENCIES, ENGINEERING, SUPERVISION AND ADMINISTRATION

Estimates of construction costs have been increased by 15 per cent to cover contingencies. The cost of engineering and design including pre-authorization studies has been taken as 22 per cent of the construction costs while cost of supervision and administration has been taken as 12 per cent of the construction costs.

44. BASIS OF ANNUAL CHARGES

Annual charges are based on a project life of 50 years. Federal annual charges include 5-5/8 per cent of the total investment for interest and 0.390 per cent for amortization. Non-Federal annual charges include 5-5/8 per cent for interest and 0.390 per cent for amortization plus maintenance and operation costs which are based on the particular site conditions and previous experience with similar projects.

## V. AVERAGE ANNUAL BENEFITS

45. FLOOD DAMAGE PREVENTION BENEFITS.

Average annual flood damage prevention benefits from ice-jam floods were measured as the difference between annual losses due to ice-jam floods under current conditions and annual losses to be expected without ice. Annual benefits so derived amount to $34,600.

46. ELIMINATION OF EMERGENCY COSTS

Because of the frequency of ice-jam floods in Lancaster a routine of emergency steps has been developed to minimize flood damages. Contents of basements and lower floors of structures are raised to upper floors, lower floor openings are sand-bagged or otherwise barricaded and on occasions ice is blasted to keep flows to non-damaging levels. There have been five damaging ice-jam floods and seven other icing occasions without flooding since 1950. In the 1960-1970 period there were seven periods of alarm. It is estimated that each alarm occasions costs of approximately $8,000 under 1973 conditions. With seven of these events in a ten year period the total cost was $56,000, or $5,600 annually. This cost would be eliminated by the project and is claimed as a project benefit.

TABLE 8

ESTIMATES OF FIRST COSTS AND ANNUAL CHARGES
LOCAL PROTECTION, LANCASTER, NEW HAMPSHIRE
FIRST COST
(1972 Price Level)

Federal Cost

| Item | Quantity | Unit | Unit Price | Amount |
|---|---|---|---|---|
| Preparation of Site | 1 | Job | L. S. | $ 10,000 |
| Reservoir Clearing | 200 | Acres | 50.00 | 10,000 |
| Control of Water | 1 | Job | L. S. | 25,000 |
| Unclassified Excavation-General | 16,000 | c. y. | 1.50 | 24,000 |
| Compacted Fill | 3,300 | c. y. | 1.50 | 4,950 |
| Rock Slope Protection | 1,100 | c. y. | 15.00 | 16,500 |
| Concrete-Abutment Walls | 1,150 | c. y. | 70.00 | 80,500 |
| Concrete-Spillway | 2,550 | c. y. | 70.00 | 178,500 |
| Cement | 20,830 | cwt | 1.60 | 33,328 |
| Steel Reinforcement | 16,000 | lb. | 0.25 | 4,000 |
| Control Gate | 1 | Job | L. S. | 5,000 |
| Timber Holding Crib (3) | 1 | Job | L. S. | 5,000 |
| Topsoil | 150 | c. y. | 5.00 | 750 |
| Seeding | 0.3 | Acre | 1000. | 300 |
| Sub-Total | | | | $ 397,828 |
| Contingency | | | | 59,172 |
| TOTAL CONSTRUCTION COST | | | | $ 457,000 |
| Engineering & Design | | | | 32,000* |
| Supervision & Administration | | | | 53,000 |
| TOTAL ESTIMATE FEDERAL FIRST COST | | | | $ 542,000 |

*Does not include preauthorization costs of $105,500.

TABLE 8 (continued)

| | | |
|---|---|---|
| NON-FEDERAL | | |
| Lands & Damages | | $130,000 |
| TOTAL ESTIMATED NON-FEDERAL FIRST COST | | $130,000 |
| TOTAL ESTIMATED PROJECT FIRST COST | | $672,000 |

ANNUAL CHARGES

| | | |
|---|---|---|
| Federal | | |
| Interest & Amortization (.06015 x 542,000) | | 32,500 |
| Non-Federal | | |
| Interest & Amortization (.06015 x 130,000) | $7,800 | |
| Maintenance | 1,300 | |
| | | $ 9,100 |
| TOTAL ANNUAL COST | | $ 41,600 |

47. REDEVELOPMENT BENEFITS

Senate Document No. 97 notes that where a project area has been designated as a Redevelopment Area by the Area Redevelopment Administration project benefits will be increased by the amount paid for unemployed or under-employed labor and resources put to work by the project. Coos County has been designated as a Redevelopment Area by the Economic Development Administration under P. L. 89-136. The records of this office indicate that the average labor cost on civil works construction is 27% of the total construction cost. While not all the labor put to work by the project will be locally hired the isolation of Lancaster will occasion a large percentage of the payroll being local. It is estimated that 90 per cent of the labor payroll will be local. The derivation of the benefit is set forth below.

| | |
|---|---|
| Estimated Total Construction Cost | $500,000 |
| 27% of Cost-Labor Component | 135,000 |
| 90% of Labor-Local Hires | 121,500 |
| Annual equivalent benefit with interest at 5.5% 0.059061 (CRF 5.5% 50 years) $121,500 x 0.059061 | $ 7,176 |
| Called | $ 7,200 |

Labor spent on maintenance would be minimal and was not computed.

48. TOTAL AVERAGE ANNUAL BENEFITS

Total average annual benefits to the project amount to $47,400 consisting of $34,600 flood damages prevented, $5,600 emergency costs eliminated and $7,200 in redevelopment benefits.

## W. COMPARISON OF BENEFITS & COST

Average annual benefits for the Lancaster Local Flood Protection Project are estimated at $47,400 as indicated in paragraph V. Average annual costs are estimated at $41,600 as shown in Table 8, resulting in a benefit to cost ratio of 1.13 to 1.0.

## X. PROJECT FORMULATION AND ECONOMIC JUSTIFICATION

Of all the alternative plans studied for local ice-jam flood protection along the Israel River in Lancaster the proposed plan as outlined herein is considered to provide the highest degree of protection at the least cost. Formulation of the final plan has been delayed on

several occasions. Since the original Detailed Project Report for channel work was recalled in light of the record ice-jam flood of March 1968. During the period September 1970 to March 1971 it was necessary to suspend our efforts pending receipt of local assurances that the town would purchase necessary lands for the project. At the March 1971 town meeting the town appropriated necessary funds for the project. Subsequent discussions with OCE personnel disclosed that because action had been taken at a town Public Meeting that it would be unnecessary for the Corps to hold another public meeting. The intent and desire of local interests for construction of the project is readily apparent as shown in the assurance (see Appendix A).

The configuration of the proposed concrete overflow structure is based on estimates of soil conditions in the riverbed. Foundation explorations were made in the abutment area but because of severe weather conditions appropriated monies for this work were expended before a necessary boring could be made in the river. If this report is approved a foundation boring would be required at this location. Depending on foundation conditions in the channel we may realize savings in concrete quantities if suitable foundation conditions are encountered at a higher elevation.

There were formulation problems in determining whether or not the pool would be permanent or if it would be drawn down to allow for summer usage for hay growth. The permanent pool plan was recommended for the following reasons:

a. Local interests desire the pool for all season recreation.
b. Subsequent hay crops would become retarded because of silt accumulation during spring drawdown periods.
c. Expensive bascule or tainter gates would be required to regulate non-ice flows so that crops would not be flooded during high river discharge periods.

A major consideration during project formulation was the premise that the pool would not be suitable for swimming because of algae growth that would occur because of high nutrient concentration within the proposed pool. Contacts with local interests indicate that there is a market for topsoil in the area and that it could be stripped from the reservoir and stockpiled and sold by the town. This would not only make the pond deeper for swimming but would also prevent the algae growth.

Although Corps of Engineers design criteria requires that the spillway be designed to pass a non-ice standard project flood (100-year storm) of 24,000 c.f.s. the primary purpose of the dam is only to create a sufficient pool of cover ice so that flood flows from the spring thaw will allow floating ice from upstream reaches of the Israel River to be retained in the area behind the dam. The river discharges during these spring thaws could vary considerably but, from past experience, it is estimated that they will be considerably less than 24,000 c.f.s. design requirement.

## Y. ENVIRONMENTAL STUDIES

The draft Environmental Impact Statement was submitted for review by various Federal, State and local agencies on 2 August 1973. The statement indicates that the proposed ice-retention dam and reservoir will have several beneficial environmental impacts in addition to the alleviation of the ice jam flood problem. These include the creation of a pool for limited recreational use and the creation of a protected land area near the center of Lancaster. An adverse impact of the proposed action would be the loss of over one mile of high quality trout stream. However, with an abundance of trout streams in nearby areas this loss would be relatively minor.

## Z. SCHEDULES FOR DESIGN AND CONSTRUCTION

Pending approval of this report it is estimated that preparation of contract plans and specifications for the project will cost $32,000 and can be completed in 9 months. Construction of the project can be accomplished under a single contract during a 12 month period. Funds for the construction of the project would be requested upon completion of plans and specifications.

## AA. OPERATION AND MAINTENANCE

Maintenance of this project will be the responsibility of local interests. Periodic inspections will be made by the Corps to assure that adequate maintenance is performed in accordance with regulations prescribed by the Secretary of the Army. It is estimated that maintenance and operation for the project will cost local interests $1,300 annually. An Operation and Maintenance manual will be provided to the Town of Lancaster upon completion of the project.

## BB. LOCAL COOPERATION

In accordance with Section 205 of the 1948 Flood Control Act, as amended, local interests are required to provide without cost to the United States, all lands, easements, rights-of-way, and utility relocations and alterations necessary for the construction and operation of the project, including disposal areas; hold and save the United States free from damages due to the construction work, and adjust all claims concerning water rights; and maintain and operate all the works after completion in accordance with existing regulations prescribed by the Secretary of the Army. Local interests would also be required to furnish the added assurance that they would contribute to the United States all necessary funds over and above the Federal cost limitation of $1,000,000 should this become necessary. Town officials have indicated a willingness to fulfill conditions of local cooperation. A letter from the Town Selectman which constitutes preliminary assurances is included in Appendix A of this report.

In areas where easement takings are not required for construction of project features, the Town of Lancaster will establish ordinances to prevent further encroachment in the natural flood plain of the stream. The channel would be maintained and kept free of obstructions and debris by local interests. The restrictions in the flood plain, which is reserved for the passage of the design flood, will include the following: (1) no new construction of any type will be permitted, and (2) existing hazardous structures will be removed when obsolete.

## CC. COORDINATION WITH OTHER AGENCIES

Plans for local protective works in Lancaster have been reviewed by officials of the Town of Lancaster and the State of New Hampshire. Their endorsement of the proposed plan is indicated by letters in Appendix A. Copies of comments from other Federal agencies are also included as exhibits in Appendix A of this report. Attention is invited to the Conservation and Development report prepared by the U. S. Department of the Interior, Fish and Wildlife Service, in Appendix A which basically is in opposition to construction of the proposed ice-jam flood prevention structure. A copy of our reply to this Conservation and Development report is included in Appendix A and indicates that the cost of constructing a multi-purpose dam and reservoir at the site of the ice-retention spillway would far exceed project benefits.

## DD. CONCLUSIONS

Investigations and studies for the local protection project covered by this report lead to the following conclusions:

a. The Town of Lancaster faces the threat of significant damages in future floods. In addition the threat of annual ice-jam flooding is a continuing burden upon the town which has a tendency to lower real estate values. The area is considered to be depressed and survives largely because of its recreation tourism business.

b. The desires of local interests are for the best form of protection that can be afforded to their commercially developed area which would secure the economic base of the town. Solution of the ice-jam flood problem is beyond the capability of the town.

c. Ice-jam flood protection can be provided most suitably by the proposed plan at a total estimated Federal first cost of $542,000 and local cost of $130,000.

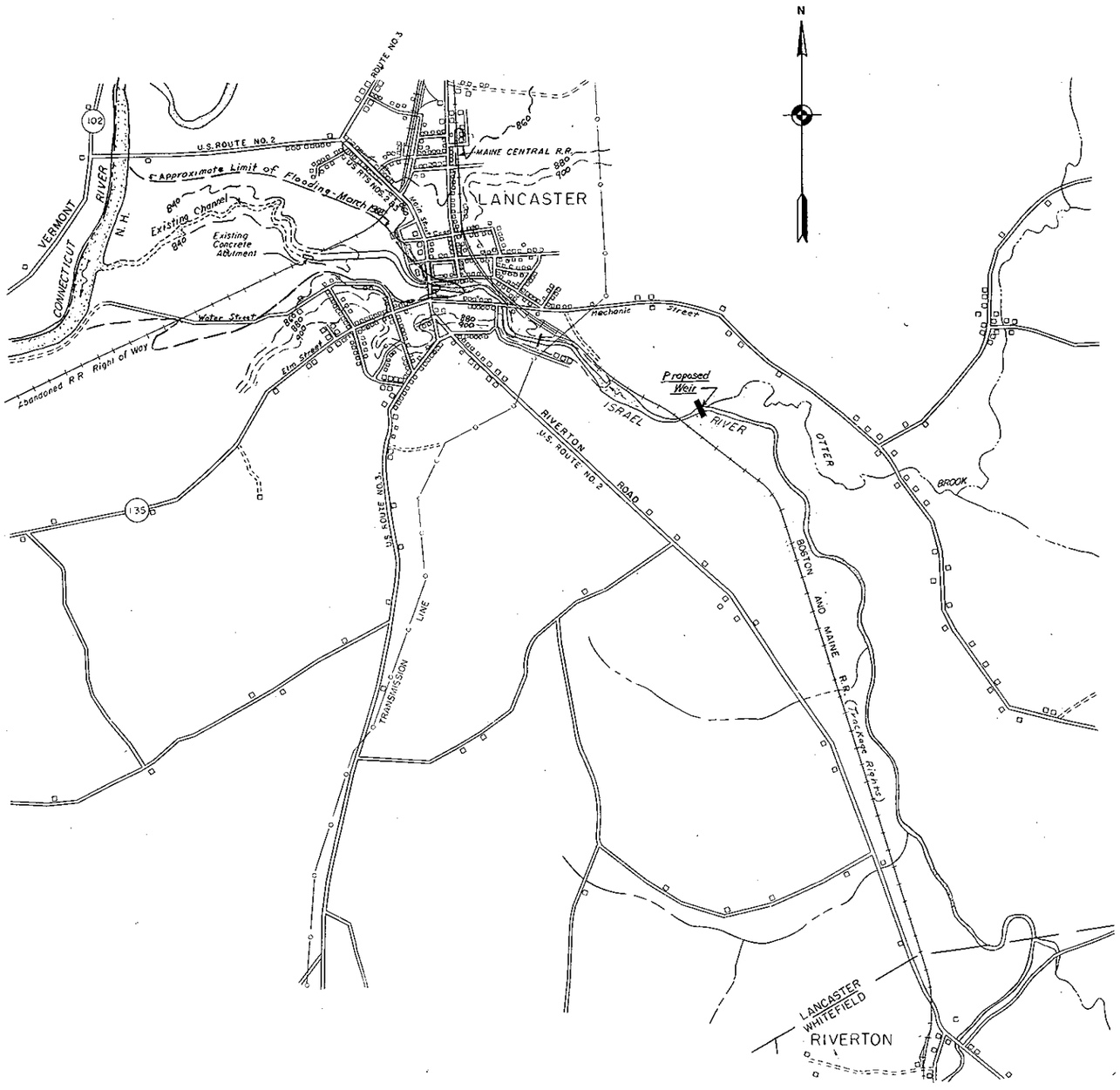
d. The project is economically justified by the ratio of annual benefits to annual costs of 1.13 to 1.0.

e. The threat of recurring damaging ice-jam floods makes it desirable to construct the project as soon as possible.

## EE. RECOMMENDATIONS

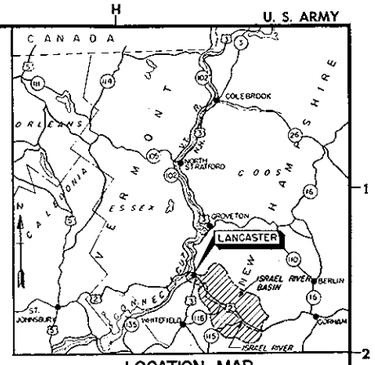
It is recommended that the project, as submitted in this report, be authorized by the Chief of Engineers under the provisions of the Flood Control Act of 1948, as amended, and that funds be allotted in the amount of $32,000 for preparation of plans and specifications. Funds for construction will be requested upon receipt and analysis of bids for construction.

CORPS OF ENGINEERS — U. S. ARMY



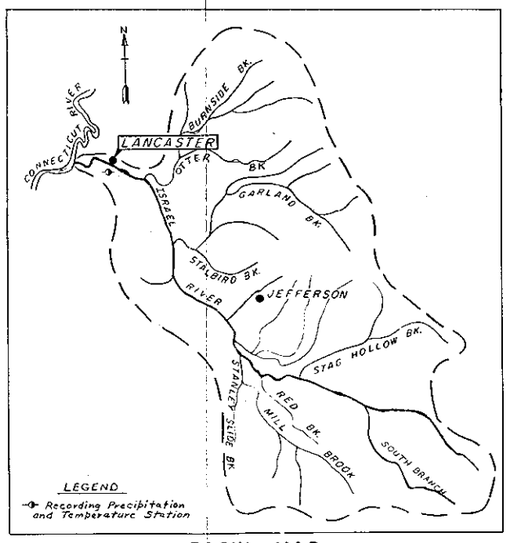

PROJECT PLAN

SCALE: 1" = 1000'




LOCATION MAP

SCALE IN MILES




BASIN MAP

SCALE: 1" = 2 MILES

(D.A. 133 SQ. MI.)

| REVISION | DATE | DESCRIPTION | BY |
|---|---|---|---|

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

DES. BY C.M.H. | DR. BY D.L.M. | CK. BY

SUBMITTED:

CHIEF, SECTION

REVIEWED:

PROJECT ENGINEER

APPROVED:

CHIEF, DESIGN BRANCH

CONNECTICUT RIVER FLOOD CONTROL

LANCASTER LOCAL PROTECTION

PROJECT PLAN

ISRAEL RIVER — NEW HAMPSHIRE

APPROVED — DATE

CHIEF, ENGINEERING DIVISION

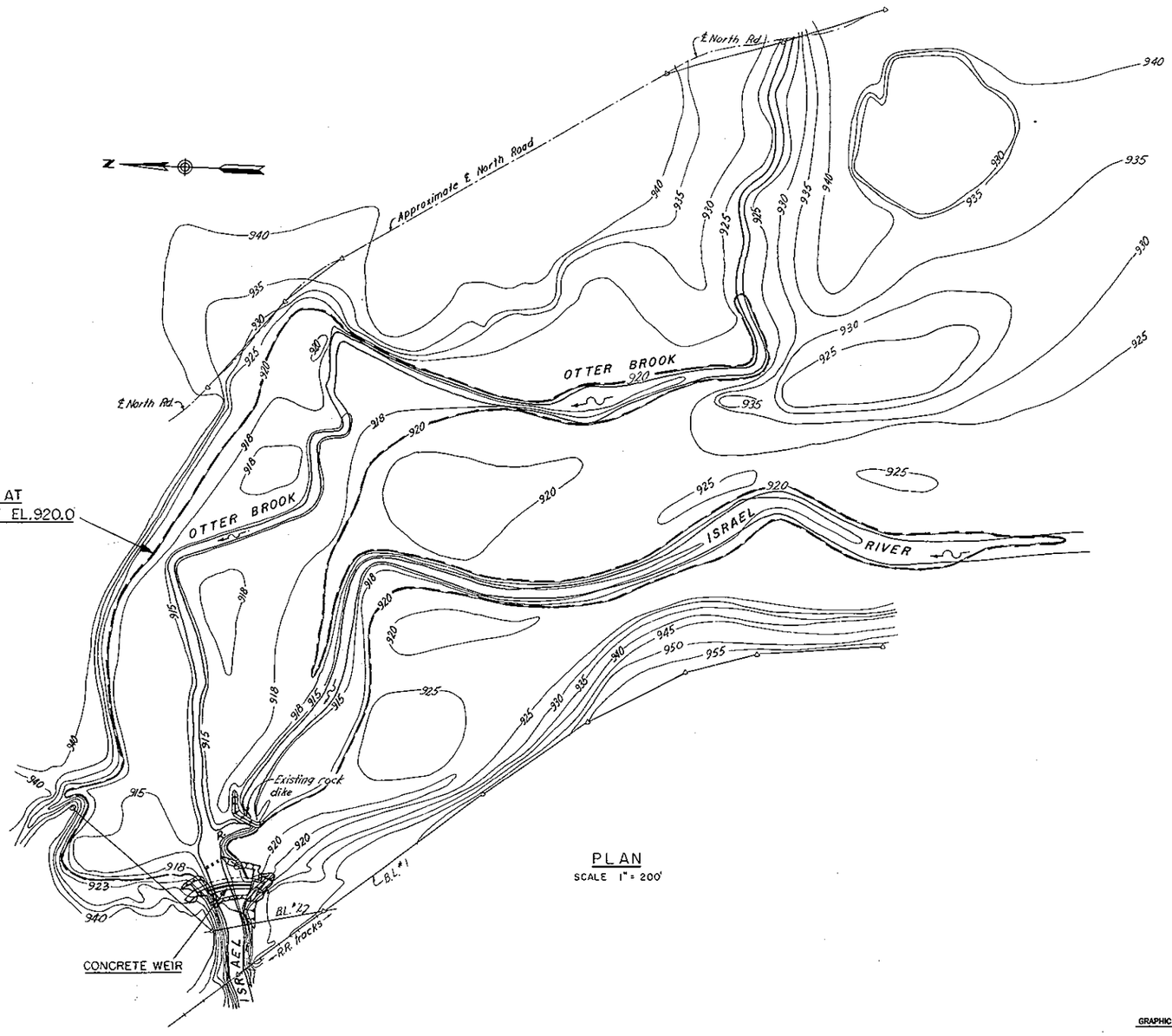
SCALE AS NOTED — SPEC. NO.

DRAWING NUMBER

SHEET

PLATE I

CORPS OF ENGINEERS U. S ARMY




PLAN
SCALE 1" = 200'

GRAPHIC SCALES
200' 0 200' 400'
1" = 200'

SAFETY PAYS

| REVISION | DATE | DESCRIPTION | BY |
|---|---|---|---|

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF BRANCH

CONNECTICUT RIVER FLOOD CONTROL
LANCASTER LOCAL PROTECTION
RESERVOIR MAP

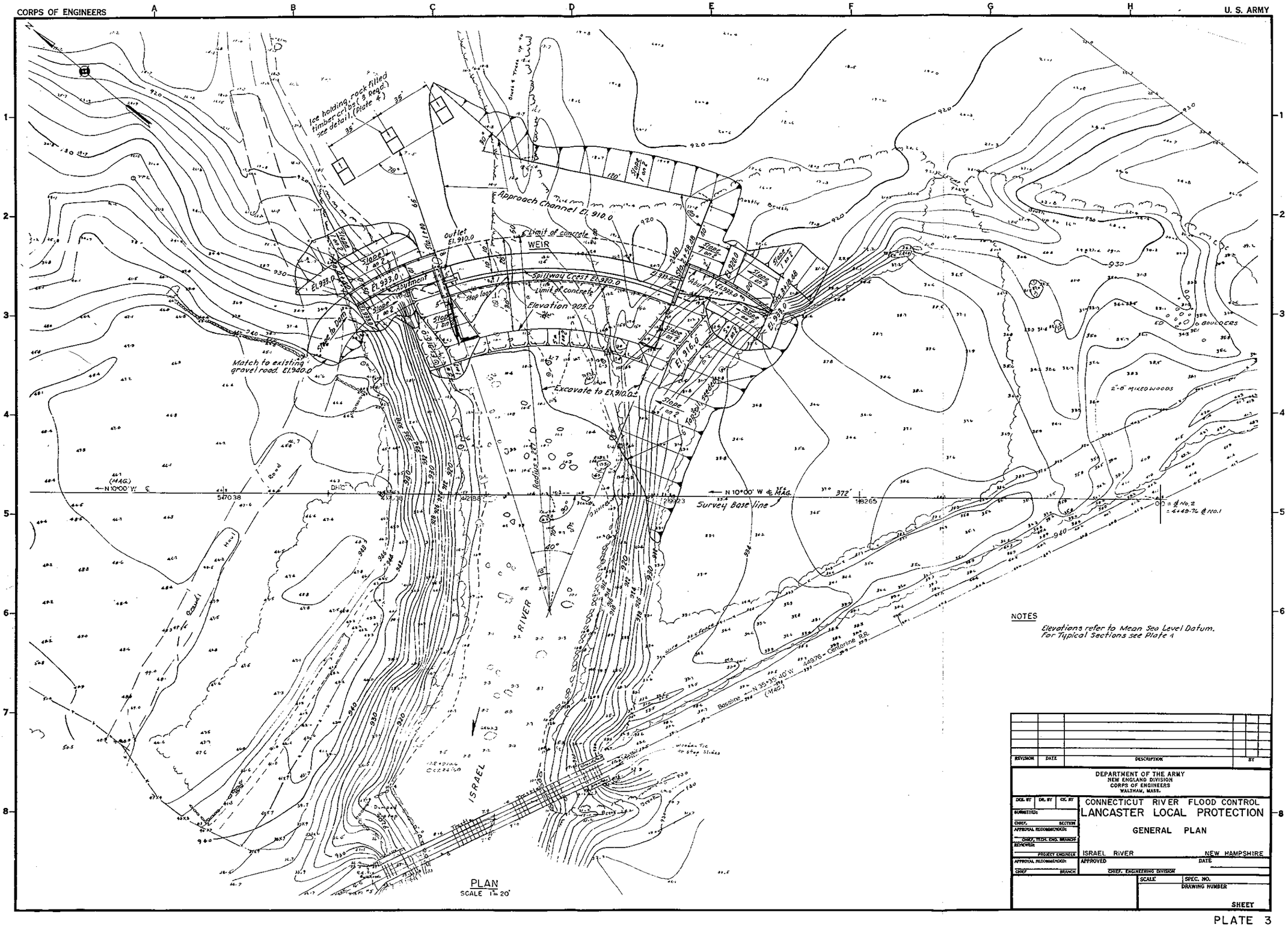
ISRAEL RIVER NEW HAMPSHIRE

APPROVED DATE
CHIEF, ENGINEERING DIVISION

SCALE | SPEC. NO.
DRAWING NUMBER
SHEET

PLATE 2

CORPS OF ENGINEERS U. S. ARMY




PLAN
SCALE 1" = 20'

| REVISION | DATE | DESCRIPTION | BY |
|---|---|---|---|

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF BRANCH

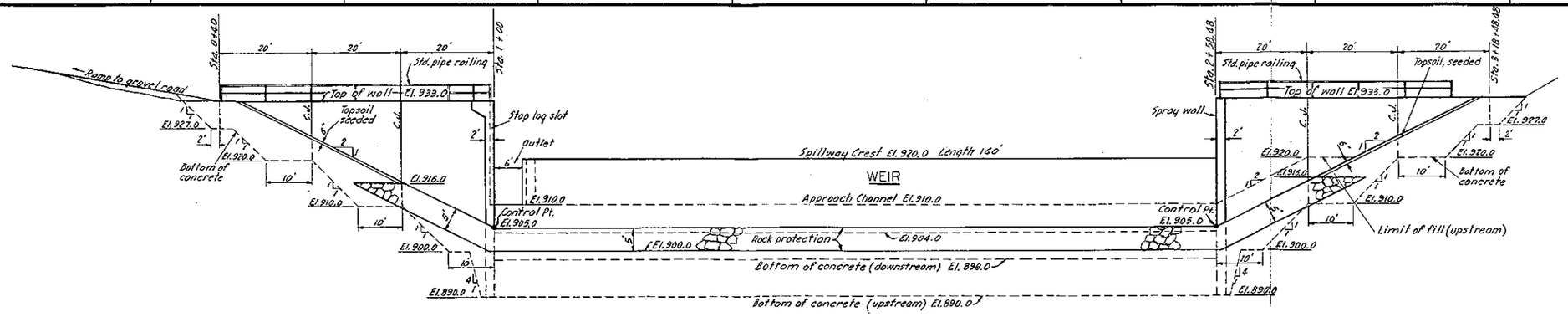
CONNECTICUT RIVER FLOOD CONTROL
LANCASTER LOCAL PROTECTION
GENERAL PLAN

ISRAEL RIVER NEW HAMPSHIRE

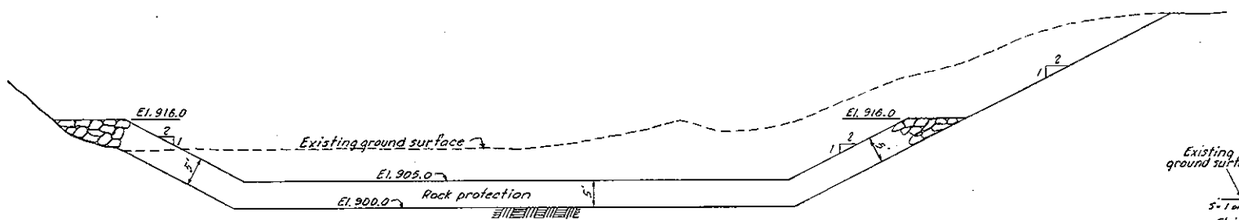
APPROVED DATE
CHIEF, ENGINEERING DIVISION

SCALE | SPEC. NO.
DRAWING NUMBER
SHEET

CORPS OF ENGINEERS U. S ARMY

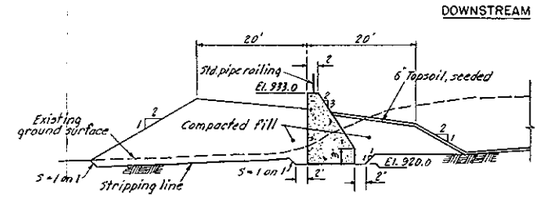



DOWNSTREAM ELEVATION - DEVELOPED
SCALE 1" = 10'

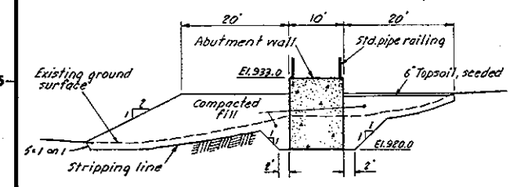



UPSTREAM

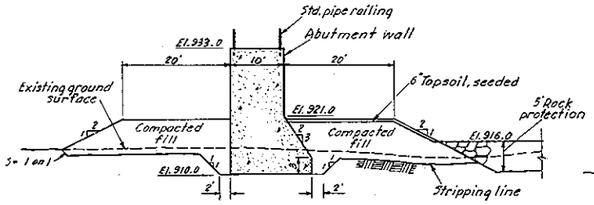
SECTION A - A



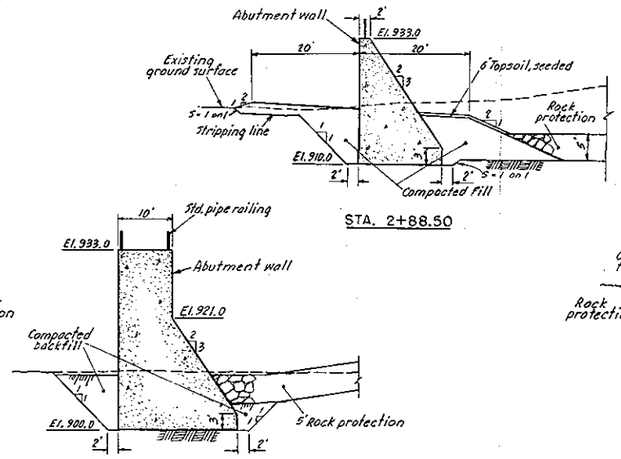

STA. 3+08.50




STA. 0+50

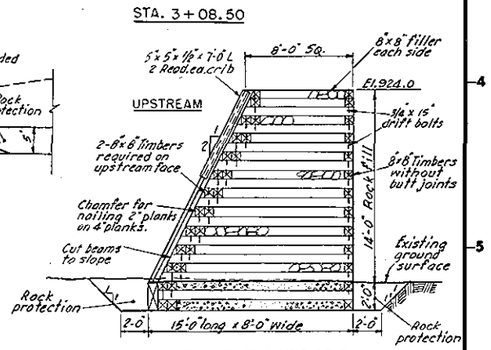



STA. 0+70



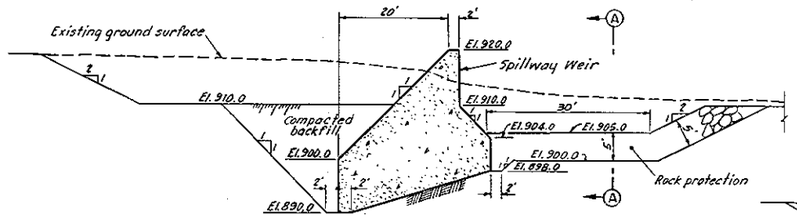

STA. 2+88.50

STA. 0+90



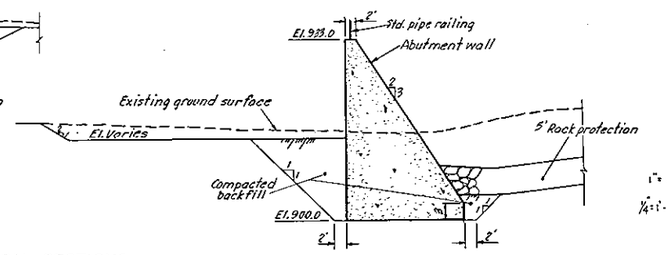

TIMBER ICE HOLDING CRIB
SIDE ELEVATION - 3 REQUIRED
SCALE 1/4" = 1'-0"
For location of cribs see Plan, Plate 3

UPSTREAM




STA. 2+00

DOWNSTREAM




STA. 2+68.5

TYPICAL SECTIONS
SCALE 1" = 10'

GRAPHIC SCALES
1" = 10' 10' 0 10' 20'
1/4" = 1'-0" 4' 0 4' 8'

| REVISION | DATE | DESCRIPTION | BY |
|---|---|---|---|

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY
SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF BRANCH

CONNECTICUT RIVER FLOOD CONTROL
LANCASTER LOCAL PROTECTION

ELEVATIONS AND TYPICAL SECTIONS

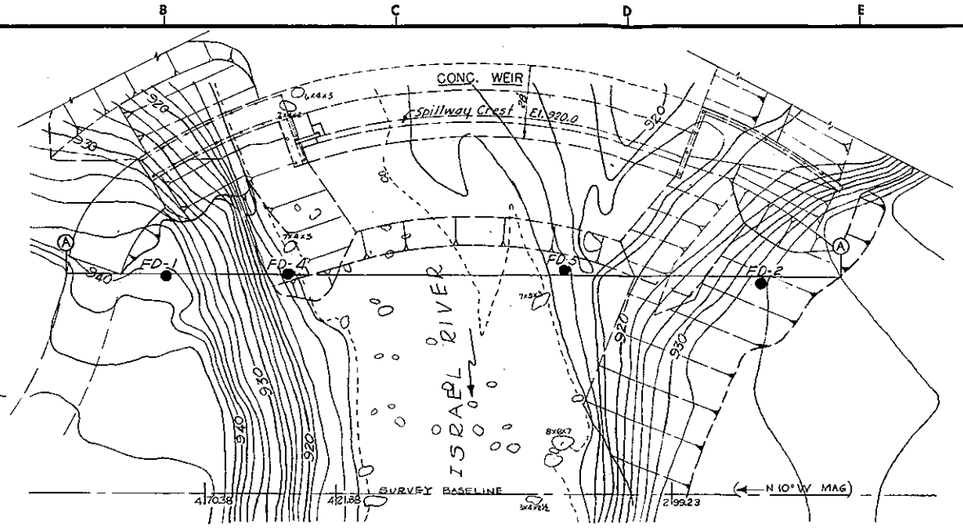
ISRAEL RIVER NEW HAMPSHIRE

APPROVED DATE
CHIEF, ENGINEERING DIVISION

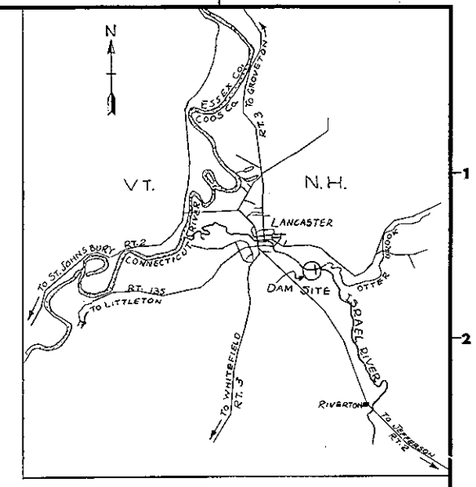
SCALE | SPEC. NO.
DRAWING NUMBER
SHEET

PLATE 4

CORPS OF ENGINEERS U. S. ARMY



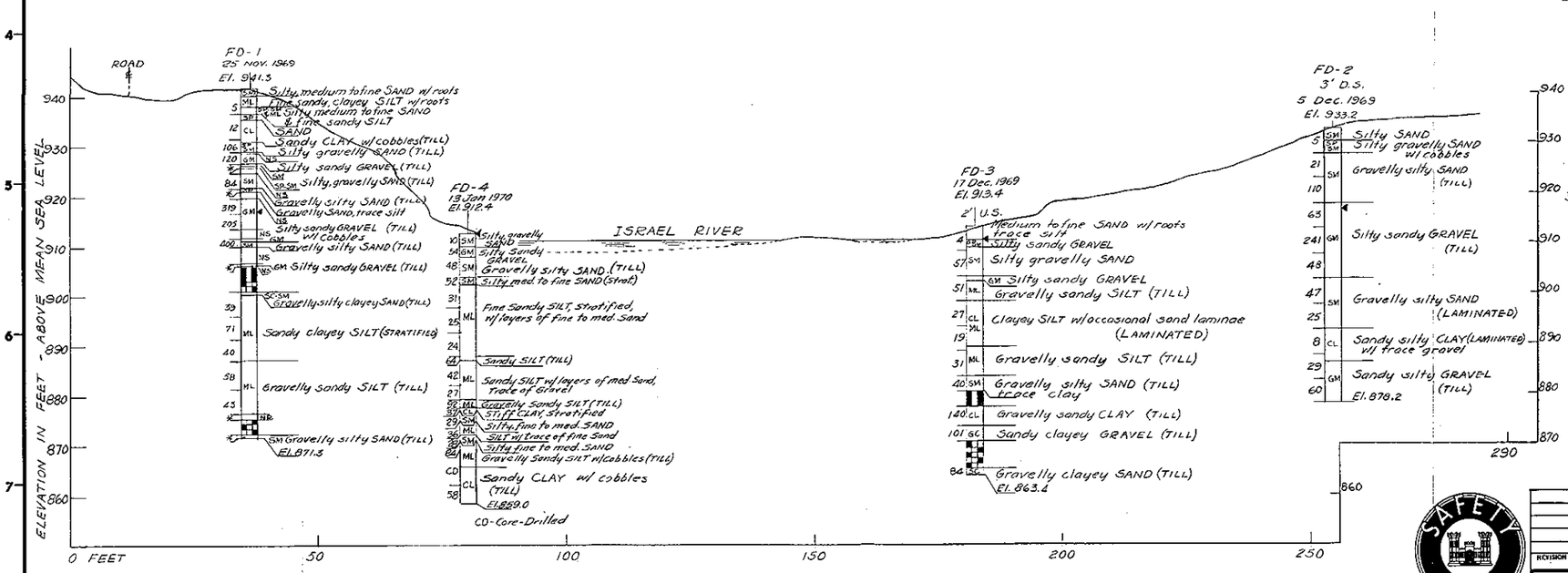

PLAN
SCALE: 1" = 20'




LOCATION MAP
SCALE IN MILES

LEGEND FOR GRAPHIC LOGS

FD- Foundation Test Boring
3 May 1969 Date exploration completed
El. 642.1 Elevation of ground surface during time of exploration
Subsurface water level in boring at time of exploration
Group letter symbol according to Unified Soil Classification System
NR No recovery or unsatisfactory soils samples recovered
NS Not sampled. Hole advanced by core-drilling, blasting and/or wash boring due to operational difficulty.
Blows per foot of penetration considered most representative for each sample drive using a 350 pound hammer with a free fall of about 18" on a standard, 5 foot, solid sample spoon with a beveled, sharpened drive shoe
* Blow count 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 611.1 Elevation, bottom of exploration




SECTION A-A
LOOKING UPSTREAM
SCALE: HOR. & VERT. 1" = 10'

GRAPHIC SCALES
1" = 20' 20' 0 20' 40'
1" = 10' 10' 0 10 20

SAFETY PAYS

| REVISION | DATE | DESCRIPTION | BY |
|---|---|---|---|

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

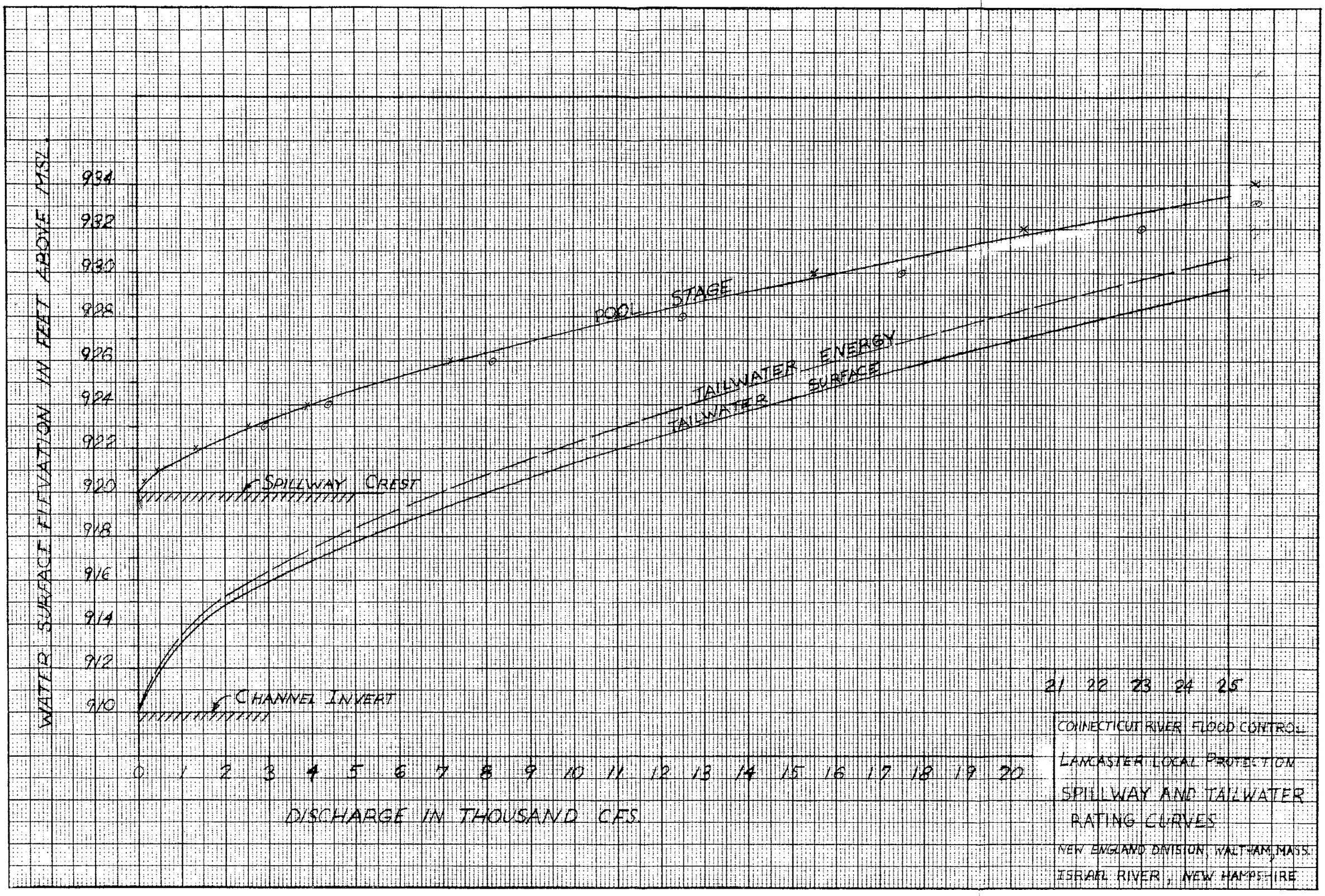
DES. BY HAV | DR. BY | CK. BY HAV

SUBMITTED: R.C. Hurley
CHIEF, GEOLOGY SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF BRANCH

CONNECTICUT RIVER FLOOD CONTROL
LANCASTER LOCAL PROTECTION
GEOLOGY

ISRAEL RIVER NEW HAMPSHIRE
APPROVED DATE FEB. 1970
CHIEF, ENGINEERING DIVISION
SCALE AS SHOWN SPEC. NO.
DRAWING NUMBER
SHEET

PLATE 5


WATER SURFACE ELEVATION IN FEET ABOVE MSL
934
932
930
928
926
924
922
920
918
916
914
912
910
POOL STAGE
TAILWATER ENERGY
TAILWATER SURFACE
SPILLWAY CREST
CHANNEL INVERT
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
DISCHARGE IN THOUSAND CFS.
CONNECTICUT RIVER FLOOD CONTROL
LANCASTER LOCAL PROTECTION
SPILLWAY AND TAILWATER
RATING CURVES
NEW ENGLAND DIVISION, WALTHAM, MASS.
ISRAEL RIVER, NEW HAMPSHIRE

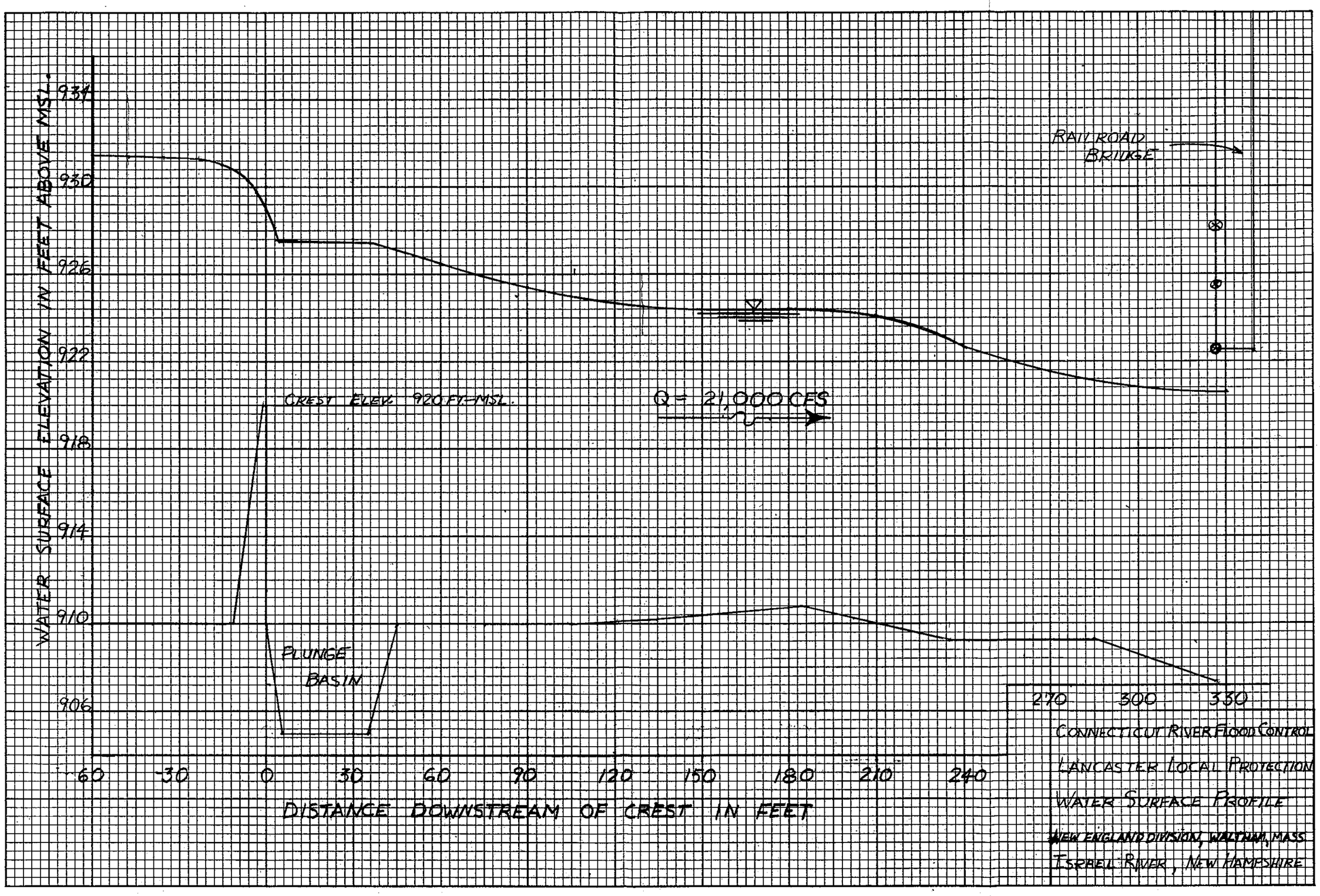
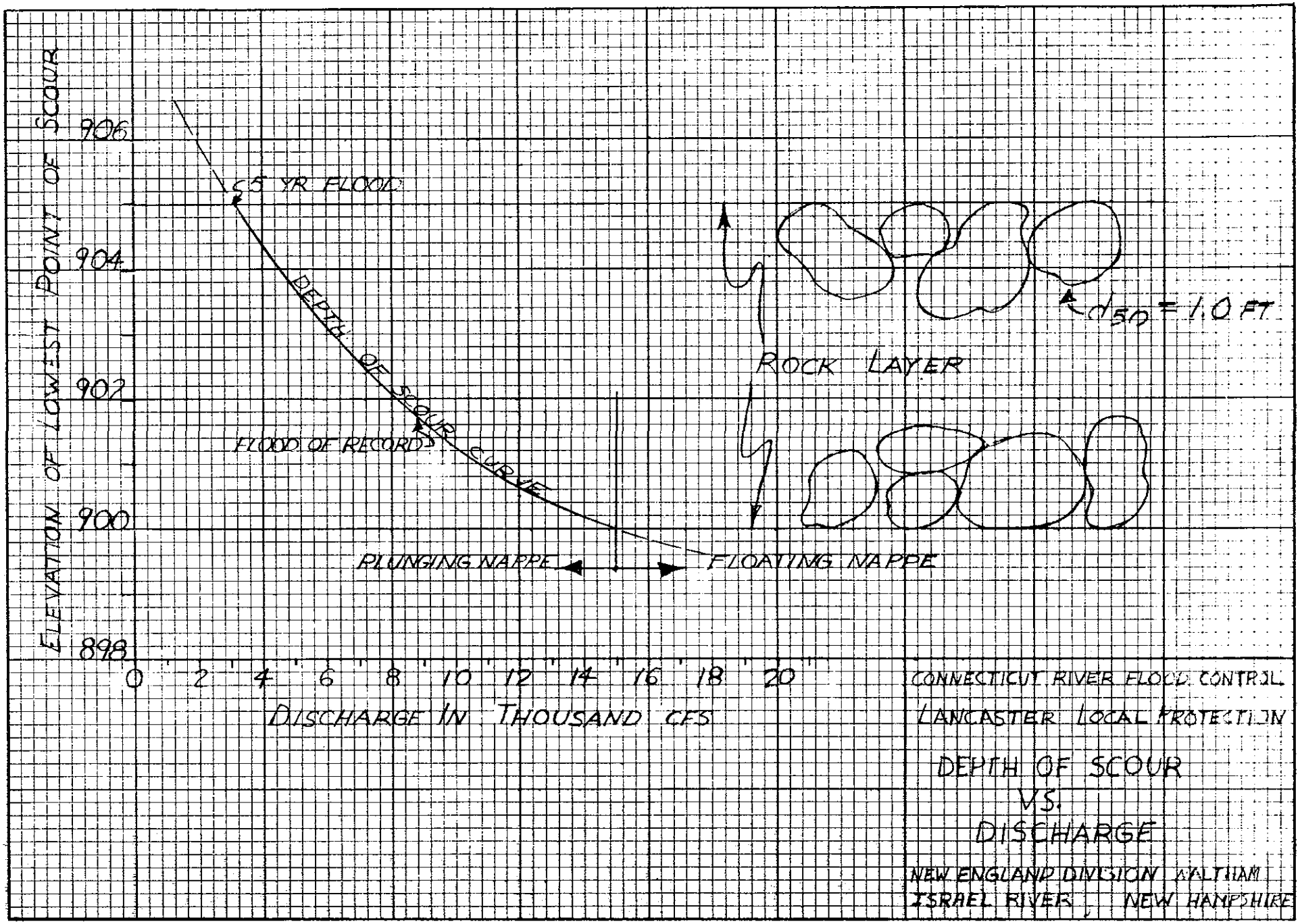

ELEVATION IN FEET ABOVE MSL.
WATER SURFACE
934
930
926
922
918
914
910
906
RAILROAD BRIDGE
CREST ELEV. 920 FT-MSL.
Q = 21,000 CFS
PLUNGE BASIN
-60
-30
0
30
60
90
120
150
180
210
240
270
300
330
DISTANCE DOWNSTREAM OF CREST IN FEET
CONNECTICUT RIVER FLOOD CONTROL
LANCASTER LOCAL PROTECTION
WATER SURFACE PROFILE
NEW ENGLAND DIVISION, WALTHAM, MASS.
ISRAEL RIVER, NEW HAMPSHIRE

PLATE 7

K+E 7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.



KEUFFEL & ESSER CO.

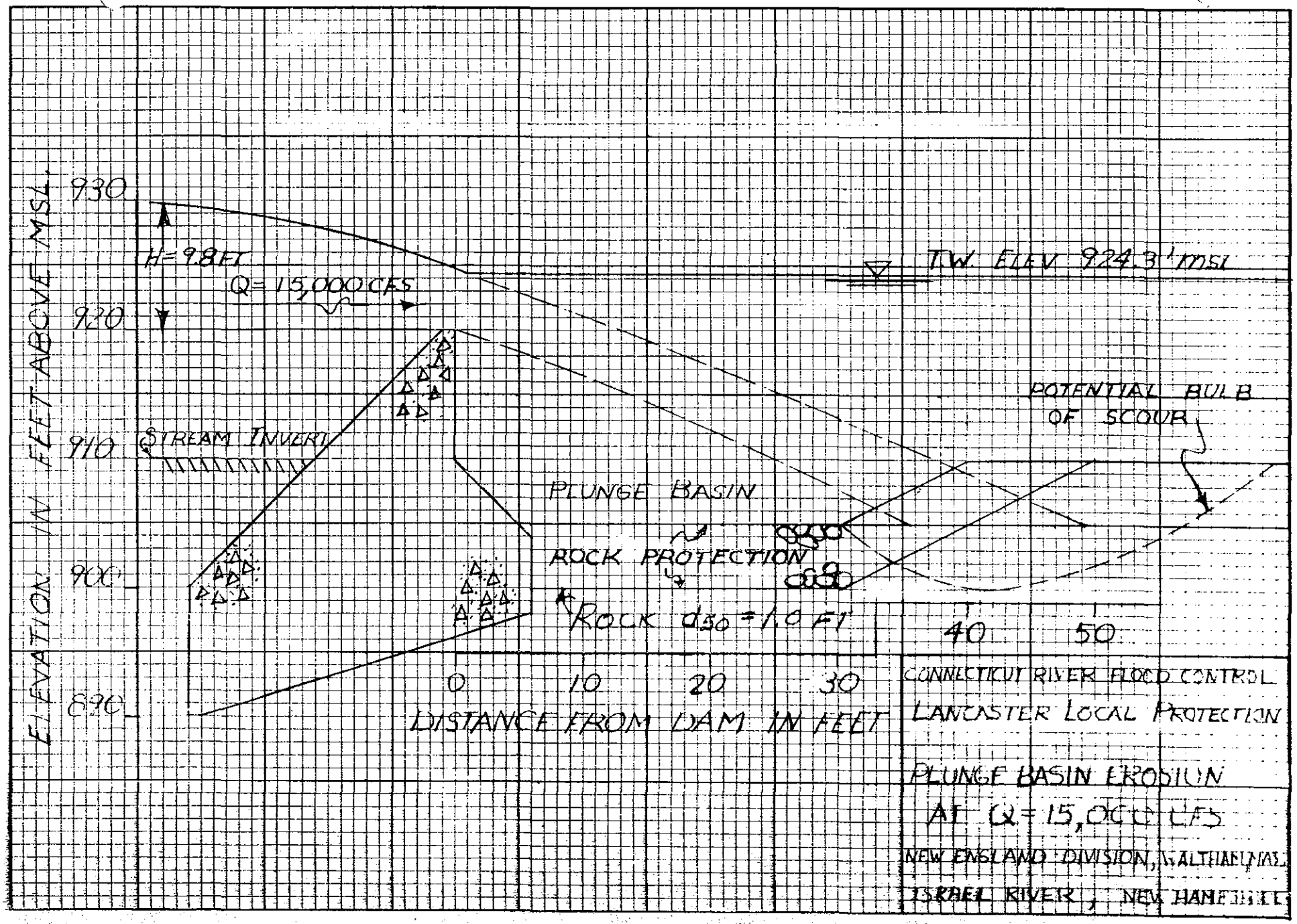



PLATE No. 7

# APPENDIX A

## LETTERS OF CONCURRENCE AND COMMENT

## APPENDIX A

## LETTERS OF CONCURRENCE AND COMMENTS

| Exhibit No. | Agency | Letter Dated |
|---|---|---|
| 1 | Town of Lancaster, New Hampshire | 12 March 1971 |
| 2 | Town of Lancester, New Hampshire | 16 March 1971 |
| 3 | U.S. Dept. of Agriculture, Soil Conservation Service | 27 June 1972 |
| 4 | U.S. Dept. of the Interior, Fish & Wildlife Service & Reply | 15 Nov 72 |
| 5 | State of New Hampshire Water Resources Board | 25 Jan 73 |

TOWN OF LANCASTER - *New Hampshire* 03584

*"The Friendly Town in The Friendly State"*

DONALD E. CRANE, *Town Manager*

Telephone 603 788-3391

March 12, 1971

Mr. John Wm. Leslie
Chief, Engineering Division
New England Division, Corps of Engineers
424 Trapelo Road,
Waltham, Mass. 02154

Ref: NEDED-B

Dear Mr. Leslie:

This is in response to your letter of September 9, 1970 in which you express concern as to the town's ability to provide the necessary lands for the proposed ice-retention structure on the Israel River.

The Board of Selectmen presented the requirements specified in your September 9th letter, as they understand them, to the people at the annual town meeting. The meeting was favorable to the Board continuing to do what may be necessary for the eventual construction of a permanent ice retention structure in the Israel River .

It is assumed that the studies will continue without further delay. Thank you for your continued interest.

Sincerely yours

Donald E. Crane,
Town Manager

DEC:dpy

Exhibit No. 1

# TOWN OF LANCASTER - *New Hampshire* 03584

*"The Friendly Town in The Friendly State"*

DONALD E. CRANE, *Town Manager*

Telephone 603 788-3391


March 16, 1971

Mr. John Wm. Leslie,
Chief Engineering Division
New England Division, Corps of Engineers
424 Trapelo Road,
Waltham, Mass. 02154

Ref: NEDED-B

Dear Mr. Leslie:

At the request of Mr. William Swaine I enclose herewith a copy of the Town Meeting warrant Article, the motion made under the article and the results of the vote.

An inquirer at the meeting asked if a multi-purpose dam was planned considering the amount of land needed. The reply was that a design had not yet been fully determined. The Board ofSelectmen and myself request that the multi-purpose aspect be considered in the planning of the project.

We believe that if the acreage in question or any part of it needs to be under water at all times that the potential for recreation is a real possibility.

Thank you for your consideration to this request.

Sincerely yours

Donald E.Crane,
Town Manager

DEC:dpy
encls.

Exhibit No. 2

TO WHOM IT MAY CONCERN:

I, Dorothy H. Willson, duly elected Town Clerk for the Town of Lancaster, New Hampshire , do hereby certify that the following was the 5th Article appearing in the 1971 town meeting watrant for the Town and that the attached was the motion made and duly seconded under the Article.

I further certify that the town meeting voted favorably for the article.

Dorothy H. Willson
Town Clerk

5. To determine by majority vote the sense of the voters at the Town Meeting as to whether the Selectmen should do what is necessary and required by the Corps of Engineers of the Department of the Army of the United States so as to enable said Corps to construct a permanent ice retention structure, so-called, in the Israel River without cost to the Town for the construction thereof; except, that the Town will be required to furnish the land, easements, rights of way and utility relocations necessary for said project construction at the present estimated cost to the Town of about One Hundred Five Thousand Dollars ($105,000.00).

Motion - Article 5

I move that this meeting record itself as being in favor of the Selectmen doing what is necessary and required by the Corps of Engineers of the Department of the Army of the United States so as to enable said Corps to construct a permanent ice retention structure, so-called, in the Israel River without cost to the Town for the construction thereof; except, that the Town will be required to furnish the land, easements, rights of way and utility relocations necessary for said project construction at the present estimated cost to the Town of about $105,000.

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Federal Building, Durham, New Hampshire 03824

June 27, 1972

Mr. John W. Leslie
Chief, Engineering Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear John:

We appreciated the opportunity to review the plans for local ice jam flood protection along the Israel River in Lancaster, New Hampshire.

From our knowledge of the area, such an ice control structure is badly needed to alleviate the ice jams and consequent flooding that occur in Lancaster in the spring of the year.

Upon reviewing your plans, we have the following comments to make:

1. The weir length of 140 feet on plate 4 does not agree with the scaled length of 153 feet plus 6 feet.

2. If 35 feet c-c spacing on cribs is minimum spacing to stop ice, there is a large area between crib and 920 contour (right side looking upstream through which ice can pass (i.e. ice will bypass cribs on right side). This situation becomes worse with increased stages.

3. Is four feet difference between crest elevation 920 and top of crib (elevation 924.0) sufficient depth to stop ice during spring runoff?

4. Is spacing of any supports under railroad bridge adequate to pass ice that gets through 27 feet clear opening between cribs.

5. Is there any possibility of anchor ice forming on the cribs during low flow? Sloping all faces of the cribs might reduce uplift from a higher flow if anchor ice had previously formed during low flow.

6. Will there be any anchorage at the heel of the cribs to prevent overturning. Sloping the upstream face allows ice to slide upward. Sloping the downstream face as on the concrete structures would increase the resistance to overturning.

Exhibit No. 3

As a matter of information, we are currently conducting a flood hazard analysis and floodplain delineation study for Lancaster on the Israel River. This is being carried out under the Unified National Program for Reducing Flood Losses.

Sincerely,

D. G. Burbank

Donald G. Burbank
State Conservationist

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE

November 15, 1972

Mr. F. William Swaine
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Swaine:

Attached is our draft Conservation and Development Report on the proposed ice-jam flood control project for the Israel River, Lancaster, Coos County, New Hampshire. We would appreciate having your comments and suggestions by November 27, 1972.

Sincerely yours,

Melvin R. Evans

Melvin R. Evans
Supervisor
Concord Area Office

ATTACHMENT

Exhibit No. 4

DRAFT OF NOVEMBER 15, 1972

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Sir:

This is our conservation and development report on fish and wildlife resources related to your study of measures needed to reduce ice-jam related flooding of the Israel River at Lancaster, Coos County, New Hampshire. The project is being prepared under Section 205 of P.L. 874, 87th Congress. Our report is prepared under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-666 inc.), in cooperation with the New Hampshire Fish and Game Department (comments to be inserted).

The purpose of the project is to retain ice that, in spring, jams downstream from Lancaster and in Lancaster causing flooding in the town. We also understand there is local interest in development of recreation facilities at the site. The proposed site for the proposed dam is located on the Israel River just east (upstream) from Lancaster and about 3 miles upstream from the Israel River's confluence with the Connecticut River.

DESCRIPTION OF THE AREA

Lancaster is located on the Israel River at the intersection of U. S. Highway Routes 2 and 3, about 1.5 miles upstream of the confluence of the Israel River with the Connecticut River. The population of Lancaster is approximately 2,500. The Israel River is about 21 miles long with a watershed of 133 square miles (85,120 acres). Principal tributaries of the Israel in the project area are the Otter and Stag Hollow Brooks. The watershed drains the western slopes of the

White Mountains and is generally steep except for the moderately sloping flood plain area from the Connecticut River upstream to Main Street in Lancaster. Vegetation is mostly forest trees with the watershed being in a transition zone between beech-birch-maple and spruce-fir. There is some pasture and crop land in the downstream area of the watershed.

The stream in the vicinity of the proposed dam site cuts through a slope resulting in a gorge-like aspect of a short reach of stream which is quite scenic.

We understand that, for several reasons, ice jams cause recurrent flooding in Lancaster. Ice has piled up against the low, narrow Main Street Bridge where buildings flank the stream. It also can jam in the wide, shallow stream-bed downstream from the bridge causing flooding. The river downstream from Lancaster is in the Connecticut River floodplains and flooding of the Connecticut can cause ice-jam flooding in Lancaster when Israel River ice piles up against Connecticut River ice. A number of temporary expedients to reduce flooding have been tried in the past, including installation of a submarine net to catch the ice and installation of a rock dike for the same purpose.

PLAN OF DEVELOPMENT

We understand that project plans call for construction of a concrete overflow dam with a permanent pool and appurtenances across the Israel River just downstream of the Otter Brook confluence and about 1.5 miles upstream from Lancaster.

The spillway will be about 140 feet long and its crest will be at elevation 920.0 feet msl (refers to elevation above mean sea level) or about 10 feet above stream bed elevation. A 6' by 10' stop log section will be located at the right

abutment. The dam will create a permanent pool which, at spillway crest, will have a maximum depth of ten feet and a surface area of 53-56 acres. Average depth at spillway crest will be less than 4 feet. We understand that the dam is designed for addition of a fishway at a later date should it prove desirable.

FISHERIES WITHOUT THE PROJECT

Brook trout are the most abundant game fish of the Israel River. The New Hampshire Fish and Game Department annually stocks the upstream section of the river which receives moderate-to-heavy fishing pressure. Downstream from Lancaster the river is polluted, mainly with domestic sewage. Anticipated pollution abatement in Lancaster will increase the trout fishing potential from Lancaster downstream to the Connecticut River.

Brook, brown, rainbow trout, and possibly land-locked Atlantic salmon presently make spawning runs of the Israel River from the Connecticut River. Restoration of Atlantic salmon is underway in the Connecticut River Basin. Problems caused by pollution and man-made obstructions to fish passage are being solved and we anticipate this progress to continue. The Israel River, especially upstream of Lancaster, contains significant amounts of spawning and rearing habitat for Atlantic salmon and other salmonids. To reach this habitat, fish coming from the Connecticut River (resident or anadromous species) will have to pass through the project area. Atlantic salmon, however, are not expected to reach the project area within the near future. Otter Brook is a good trout stream and is stocked by New Hampshire Fish and Game with brook trout.

FISHERIES WITH THE PROJECT

The project as planned will have adverse effects on fishery resources. With the pool elevation at 920 msl approximately 4,400 feet of Israel River and 4,800 feet of Otter Brook will be inundated with the resultant loss of 9,200 feet or almost 1-3/4 mile of trout stream.

The pool created by the dam will be shallow - mostly less than four feet deep. This will result in the pool being warmed in summer and thus unsuited for trout. The warm water from the pool will flow over the dam and downstream degrading the fish habitat. This is particularly bad when coupled with existing low summer flows and sewage pollution from Lancaster.

Extensive siltation of the river bed may result from construction activities. The dam will be a barrier to the spawning runs of fish; and will greatly reduce fish management opportunities.

WILDLIFE WITHOUT THE PROJECT

Wildlife species present in the watershed include white-tailed deer, black bear, fisher, lynx, bobcat, red fox, otter, raccoon, beaver, mink, weasel, snowshoe hare, woodcock, ruffed grouse, porcupine, waterfowl, wading birds, songbirds, hawks, and owls. Principal resident waterfowl species are black ducks, wood duck and mallards. Migrant teal and Canada geese are seasonally present. The most important waterfowl areas are the shallow oxbows of the lower reach of the river. There is significant seasonal hunting and trapping activity in the watershed.

WILDLIFE WITH THE PROJECT

Transient waterfowl may make limited use of the pool, but it is unlikely that

much successful waterfowl reproduction will occur because of anticipated human disturbance. The effect of the project on other wildlife in the watershed will probably be negligible.

DISCUSSION

The most significant aspect of this project is the negative impact on the Israel River cold-water sport fishery. The loss of 1-3/4 miles of good trout stream is highly undesirable. It is unlikely that the shallow, warm pool behind the dam will produce a quality sport fishery and the warming of a downstream trout water will make worse the already precarious summer conditions. The dam will act as a barrier to movement of brook, brown and rainbow trout and possible landlocked salmon movement.

We understand that local interests are interested in water-based recreation at the proposed site, but we would point out that within easy driving distance of Lancaster are a number of lakes and ponds with public access. We feel that the addition of another pond to this area is akin to taking coals to Newcastle.

There may be limited waterfowl benefits at the pool, but the New Hampshire Fish and Game is managing a waterfowl area a few miles to the north on Indian Brook. The Indian Brook area is far more likely to attract waterfowl use, including reproduction, than the proposed pool on the Israel River.
We feel that several alternatives to the existing proposal exist, that singly or in combination they provide the desired ice-jam flood relief, and that the feasibility of these should be thoroughly studied. They are:

a. Replace the existing anti-submarine net with one having larger mesh. This alternative has the advantages of not harming the

existing trout habitat and not interferring with fish movement. It will not cause the warming of water. The total initial and annual maintenance costs may be less than that required for the proposed dam.

b. Replace the existing cement bridge in Lancaster with one that is higher and longer.

c. Construct a dry-bed dam without a permanent pool.

d. Selectively deepen the wide, shallow sections of the channel downstream from Lancaster. Design of such deepening must be coordinated with the New Hampshire Fish and Game Department and this Bureau to assure that it will cause minimum damage to the stream habitat.

These alternatives have the advantages of not acting as a barrier to fish movement and not forming a permanent pool.

For your guidance in preparing the Environmental Impact Statement for this project, we offer the following:

Environmental Setting Without the Project

The Israel River is about 21 miles long with a watershed of 133 square miles (85,120 acres). Principal tributaries of the Israel are the Otter and Stag Hollow Brooks. The watershed drains the western slopes of the White Mountains and is generally steep except for the flat area from the Connecticut River upstream to Main Street in Lancaster. Vegetation is mostly forest trees with the watershed being in a transition zone between beech-birch-maple and spruce-fir.

Brook trout are the main game fish of the Israel River. Downstream of Lancaster the river is polluted, mainly with domestic sewage. Anticipated pollution abatement in Lancaster will increase the trout fishing potential from Lancaster downstream to the Connecticut River. The river supports spawning runs of brook, brown, and rainbow trout, and possibly landlocked salmon, from the Connecticut River.

Restoration of Atlantic salmon is underway in the Connecticut River Basin; and Atlantic salmon may eventually reach the project area. The Israel River contains significant amounts of spawning and rearing habitat for salmonids and to reach this habitat fish coming from the Connecticut River will have to pass through the project area. Otter Brook is a good trout stream and is stocked by New Hampshire Fish and Game with brook trout. Wildife species of the watershed include white-tailed deer, black bear, fisher, lynx, bobcat, red fox, otter, raccoon, beaver, mink, weasel, snowshoe hare, woodcock, ruffed grouse, porcupine, waterfowl, wading birds, songbirds, hawks, and owls. Principal resident waterfowl species are black ducks, wood duck and mallards. Migrant teal and Canada geese are seasonally present. The most important waterfowl areas are the shallow oxbows of the lower reach of the river. There is significant seasonal hunting and trapping activity in the watershed.

Environmental Impact of the Proposed Action

The proposed action will have the significant negative impacts of destroying by inundation approximately 1-3/4 miles of high quality trout stream. The action will cause summer-warmed water to flow downstream aggravating the existing fishery problems caused by pollution and low summer flows. In addition, it will be a barrier to fish movement. It is not anticipated that the proposed action will significantly affect wildlife, including waterfowl. Construction

related sediment increase will beexperienced, but this effect should be temporary.

Any Adverse Environmental Effects Which Cannot be Avoided Should the Project be Implemented

The effects cited above cannot be avoided if the project proceeds as planned.

Alternatives to the Proposed Action

No action.

Replace the existing anti-submarine net used to hold ice with a larger mesh one that will not foul with stream debris.

Replace the existing cement bridge in Lancaster with a higher and longer one.

Build the dam as a dry-bed structure that self-empties.

Selective deepening of the channel downstream of the Lancaster bridge.

Irreversible and Irretrievable Commitments of Resources

To the extent that the proposed dam is permanent, the trout fishery of the 1-3/4 miles of stream inundated is permanently lost and fish are permanently barred from upstream reaches.

Consultation with Appropriate Federal Agencies and Review by State and Local Agencies Developing and Enforcing Environmental Standards

We suggest that this section indicate this project was studied by the U. S. Fish and Wildlife Service and New Hampshire Fish and Game biologists who coordinated in developing the views expressed in these comments.

RECOMMENDATIONS

We recommend that:

1. The project not be constructed as planned.
2. The following alternatives be given careful study to assure that flood protection is provided in a manner least damaging to the resources:
    a. Replacement of the existing anti-submarine net with one having larger mesh.
    b. Replacement of the existing Lancaster bridge with one that is higher and longer.
    c. Changing the proposed dam to be a dry-bed structure.
    d. Selective deepening of the Israel River channel downstream from the Lancaster bridge.

We appreciate this opportunity to report on the project proposals. Please advise us of any changes in project plans so that we can conduct any additional fish and wildlife studies necessary.

Sincerely yours,

NEDED-R 14 December 1972

Mr. Melvin R. Evans, Supervisor
Department of the Interior
Fish and Wildlife Service
55 Pleasant Street
Concord, New Hampshire 03301

Dear Mr. Evans:

This is in reply to your draft Conservation and Development Report of 15 November 1972 pertaining to local ice-jam flood control along the Israel River in Lancaster, New Hampshire. The alternate solutions to the proposed multi-purpose dam and lake that you have proposed have been considered in our preliminary analysis. However, our recommended plan is considered to offer the highest degree of ice-jam flood protection, and is also favored by local interests. This was brought out by the favorable action taken at the Lancaster town meeting, which authorized the appropriation of funds for local cost sharing.

During the winter months the proposed 56± acre pool will form a thick sheet of cover ice. During the spring freshet season or during winter thaw periods when floating ice is discharged from upstream areas, the sheet of cover ice will effectively hold the floating ice which will, in turn, spread out over the low-lying, adjacent pasture land. This accumulation and subsequent wastage of river ice in this area would prevent future ice-jam flooding in the commercial center of Lancaster. Because of the relatively steep channel gradient in the reach below the proposed dam, this area only forms cover ice during extended, extremely cold periods. Although this area does contribute frazil ice, which is discharged to areas below Main Street, this will not cause future ice jams if the proposed dam and reservoir area are constructed.

Exhibit No. 4

NEDED-R 14 December 1972
Mr. Melvin R. Evans

The following comments directly pertain to recommendations included in your draft Conservation and Development Report.

The existing rock dike and submarine net were constructed as part of our emergency operations during March 1970. This structure was meant to operate as a temporary emergency measure and was so described to local officials. The existing net has standard 16-inch grommets. Replacement would require special fabrication of a net at considerably more expense and would not provide the degree of protection or permanence of the recommended concrete dam. The existing net does catch considerable debris during spring runoff and has to be removed after ice has gone out of the river in order to prevent continued inundation of the adjacent pasture land. A larger mesh would most likely pass the smaller floating debris but could still present a problem if larger debris became snagged. This larger debris would in turn prevent passage of the smaller material. Consequently, your recommendation is not considered to be a viable alternative to the proposed plan of permanent ice-jam flood protection.

The expense of replacing the Main Street bridge with a higher and longer span would be excessive and unwarranted. During the record ice-jam flood of March 1968, the build-up of ice at Main Street was at the same level both upstream and downstream of the bridge. This was positive indication that the jam had formed in areas below the bridge and that subsequent jamming at the bridge was attributable to the back-up of ice from this area. Other recent ice jams in Lancaster have also formed below the Main Street bridge. For this reason we can see no justification for replacing the Main Street bridge.

Consideration was given to construction of bascule gates in lieu of the concrete overflow structure in order to allow for summer drawdown of the ice-retention pool. However, studies indicated that the cost for such construction could not be economically justified. In addition, by letter dated 16 March 1971, the Lancaster town manager and Board of Selectmen stated that multi-purpose construction should be considered. Although there are, as you suggest, several existing areas for water-oriented recreation, these cater primarily to a more regional usage. The proposed recreation facilities would mostly be used by local residents and would fulfill a real need for such facilities.

Because of the lengthy winter and spring period that would be necessary to flood the existing farmland upstream from the proposed dam, it has been estimated that this would result in decreasing utilization of the land for hay crops and that after a few years only an undesirable barren area covered with silt from the reservoir would be in evidence. The projected loss of 1-3/4 miles of trout fishery resource can readily be compensated for by other areas within the Israel River watershed or adjacent watersheds. It cannot be foreseen how this pool will prevent a "put-and-take" fishery resource from utilizing upstream reaches of the Israel River. The proposed structure will be constructed with a special monolith adjacent to the right abutment that can be readily modified to incorporate a fish ladder at a later date, if necessary. With respect to seasonal hunting and trapping, although there may be activity in the watershed, the proposed ice-retention pool will not significantly curtail such activities.

Widening and deepening of the channel downstream of Main Street was accomplished during Operation Foresight 1970. However, this work is not considered to be a permanent solution. Under certain conditions of high water levels on the Connecticut River, ice jamming could still occur, thereby exposing the community to flooding, if permanent upstream ice-retention facilities are not constructed.

The "no action" alternative to the proposed construction is not considered to be in the best interest of the local community. The frequency and severity of recent ice-jam floods has become an intolerable situation to Lancaster officials and concerned citizens. The creation of a 50 acre minimum pool for ice-retention is also considered to be the best plan by ice engineering specialists of the U.S. Army Cold Region's Research and Engineering Laboratories (CRREL). This recommended plan of improvements is economically justified and is endorsed by local interests.

Your Conservation and Development Report will be included in our Advance Draft-Detailed Project Report, which will be submitted to the Chief of Engineers for approval during early 1973. It is anticipated that a draft environmental impact statement (E.I.S.) will also be submitted at that time. In the preparation of an environmental impact

NEDED-R
Mr. Melvin R. Evans

14 December 1972

statement the negative fishery impact, as described by you, will be included. In accordance with the National Environmental Policy Act, the Environmental Impact Statement will discuss all impacts of the project, both positive and negative, as related to man's environment, as well as an assessment of the relative merits of each.

Sincerely yours,

JOHN WM. LESLIE
Chief, Engineering Division

Coordinated w/ Environmental
Resources Sec.

State of New Hampshire
WATER RESOURCES BOARD

37 Green Street
CONCORD 03301

January 25, 1973

Mr. John Wm. Leslie
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Mass. 02154

Re: NEDED-R

Dear Mr. Leslie:

The set of preliminary plans showing the limits and scope of the proposed local ice-jam flood control project across Israel River in Lancaster was received and reviewed in this office.

A copy of your detailed project report and detailed plans and specifications, when completed, may be sent to this office for review and record.

Very truly yours,

George M. McGee Sr.

George M. McGee, Sr.
Chairman

GMMC:PDK/js

Exhibit No. 5

# APPENDIX B

## REAL ESTATE

## APPENDIX B

## REAL ESTATE

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## A - DESCRIPTIVE DATA

1. PURPOSE

The purpose of this preliminary report is to estimate the real estate acquisition costs for the proposed Lancaster Ice-Retention Dam and Reservoir, as of the date of my field inspection, 11 June 1970.

2. LOCATION

The proposed project is located in the Town of Lancaster, Coos County, New Hampshire. The proposed dam will be situated just downstream of the confluence of the Israel River and Otter Brook.

3. AREA DESCRIPTION

The Town of Lancaster is situated in the northwestern part of New Hampshire, at the confluence of the Israel and Connecticut Rivers. It is bounded on the west by the Connecticut River and State of Vermont, on the north by the Towns of Northumberland and Stark, on the east by the Town of Kilkenny, and on the south by the Towns of Daiton, Whitefield, and Jefferson, New Hampshire. It is located just to the north and west of the White Mountain National Forest in an area of New Hampshire which receives heavy tourist traffic.

The Town is predominantly a sparsely settled, rural, residential-agricultural community. It has a current year-round population of approximately 3,400, however, it is reported that this population may reach as high as 10,000 during the heavy tourist season.

There is limited industry in the Town, the primary ones being Timberland Machine Company, distributors of timber machinery and "Ski-doo" skimobiles and the Thompson Manufacturing Company, a wood processing and machine shop.

Commercial development in the center of Town, though limited, is adequate to service most daily needs of the local residents as well as residents of lesser developed, neighboring communities. Much of the commercial development is tourist oriented, as evidenced by many motels, inns, guest houses, and other enterprises which cater to the tourist trade.

Highway transportation to and from the Town is reasonably good via U.S. Routes 2 and 3.

Lancaster is the County Seat for Coos County. Local town government is presided over by a Town Manager and Board of Selectmen.

4. SITE DESCRIPTION

The proposed project will be situated in a low area located on the southwesterly side of North Road, a paved road, approximately one mile southeast of the Town's central business district.

The area surrounding the proposed site is predominantly a rural agricultural neighborhood, interspersed with several newer residences and a few older residential properties which have recently been renovated.

The immediate area, along North Road, is serviced by town water, electric and telephone facilities.

5. LAND REQUIREMENTS

The proposed project consists of the construction of an ice retention dam and reservoir across the Israel River just downstream of its confluence with Otter Brook. The guide taking line will be established at elevation 935' msl, fifteen feet above the spillway crest elevation of 920' msl.

The project will require the acquisition of land in fee up to elevation 925' msl, a total of approximately 120 acres. The remaining land requirement extending from elevation 925' msl to 935' msl, will be acquired under flowage easements. This area constitutes an additional 80 acres. The frequency of flooding in the area to be acquired under flowage easements will range from approximately once in 20 years at elevation 925' msl to about once every 200 years at elevation 935' msl.

Based on only preliminary ownership data, it is estimated that the subject project will require partial takings of land from a total of nine ownerships.

There are no improvements within the taking area.

Almost all of the land within the proposed reservoir area is prime river-bottom tillage used in conjunction with several farms which front on North Road. The only exceptions are those lands which fall within the channels and banks of the Israel River and Otter Brook and a small portion of land which is being used for gravel removal purposes.

6. BORROW REQUIREMENTS

No land has been included in this report for borrow purposes.

7. RELOCATIONS

A Public Service Company power line (3-pole) crosses the proposed reservoir approximately 1500 feet upstream of the proposed dam.

It is anticipated that this power line will require either relocation or raising in place. However, these plans have not yet been formulated and therefore, there is no land included in this report for this purpose.

8. ZONING

All of the land required for the project falls within an agricultural zone. Minimum area requirements include a 22,000 square foot lot with 150 feet of frontage.

9. PRESENT USE AND HIGHEST AND BEST USE

Almost all of the land required for the project is prime, river-bottom tillage and is used for agricultural purposes. Some gravel is being removed from a small area within the project bounds.

The highest and best uses of the lands required for the project are considered to be the present uses.

10. MINERAL DEPOSITS

As previously mentioned, a small amount of gravel is being removed from three ownerships within the project area. The Town of Lancaster has been purchasing gravel from one of these pits and the Town Manager reports that this pit is just about depleted. Another ownership is reported to have only a very limited amount of gravel available. The third tract is being used by the owner who does some construction work. For purposes of this report, an estimated 10 acres will be used as gravel bearing land within the project area.

11. AGRICULTURAL CROPS

The river-bottom tillage, proposed to be acquired for project purposes, is used for growing hay and grazing animals. It is anticipated that the agricultural land will be acquired under a sound program which will allow owners sufficient time for harvesting and, therefore, no special damages are anticipated for loss of crops.

12. OUTSTANDING RIGHTS

The Town Manager indicated to the writer that the Public Service Company of New Hampshire has flowage rights over an undetermined land area within the project bounds. These flowage rights were formerly used in conjunction with the operation of an old dam located just downstream of the project. The rights have not been exercised for many years and the extent of these rights are unknown. The Town has requested information from the Public Service Company relative to the possible use of these rights for project purposes.

## B - REAL ESTATE ACQUISITION COSTS

13. LAND VALUES

The value of land within the project area has been estimated by the use of the market data or comparable sales approach. This approach to value involves a comparison between the property being appraised and recent transactions of similar lands in the vicinity of the property being appraised.

A search was made in the general area to obtain market data for use in estimating the value of the required land. Local officials, a real estate broker and knowledgeable persons were contacted to secure data and value estimates.

Several recent sales of properties situated on North Road, in the immediate project area, were considered in this evaluation, including two properties which will be acquired in part for the project.

Based on a study and analysis of these sales and other data gathered in this investigation, the fee value of the good river-bottom tillage is estimated at $300 per acre and the gravel bearing land at $500 per acre.

The value of the flowage easements is estimated at an average of approximately 30% of fee value or $90 per acre for the tillage and $150 per acre for the gravel land.

Based on this estimate, the total land values are shown as follows:

Land to be Acquired Under Fee Estates

| | | | | | |
|---|---|---|---|---|---|
| 104 Acres | Agricultural land | @ $300 per acre | = | $31,200 | |
| 5 Acres | Gravel land | @ $500 per acre | = | 2,500 | |
| 11 Acres | In the Israel River & Otter Brook | | | -0- | |
| 120 Acres | | TOTAL | | | $33,700 |

Land to be Acquired Under Flowage Easements

| | | | | | |
|---|---|---|---|---|---|
| 72 Acres | Agricultural land | @ $ 90 per acre | = | $ 6,480 | |
| 5 Acres | Gravel land | @ $150 per acre | = | 750 | |
| 3 Acres | In the Israel River & Otter Brook | | | -0- | |
| 80 Acres | | TOTAL | | | $ 7,230 |
| 200 Acres | | TOTAL FEE & EASEMENTS | | | $40,930 |

14. SEVERANCE DAMAGES

All of the acquisitions required for this project will consist of partial takings which, in most cases will cause severance damages to remaining properties in addition to the value of the land actually taken.

For purposes of clarification, severance damage is the damage to the part not taken which arises by reason of the taking and/or construction of the improvement. Elements which contribute to damages of this type are predicated upon the following:

a. loss in value due to a reduction of the highest and best use of the remainder.

b. loss in value due to the resulting insufficiency of the remainder to support the normal operation.

c. loss in value due to distortion in plottage or shape which handicaps normal use.

d. loss in value due to a more limited or difficult access.

e. loss in value due to the requirement of relocating or installing appurtenant facilities such as fencing, walks, drives, utilities, etc.

Severance damages for the subject project are predicated on a loss in value to several sets of reamining farm buildings which will become over-adequate for the reduced operations due to the taking of tillage and, also a loss in value to remaining land due to distortion in plottage or shape and/or more difficult or limited access.

These severance damages are estimated at a total of $35,000 in addition to the value of the land actually taken.

15. ADMINISTRATIVE COSTS FOR ACQUISITION

Experience of this office in acquiring similar properties in other civil works projects indicates that administrative costs for acquisition will average approximately $1,200 per tract. These costs include mapping, surveying, legal descriptions, appraising, title evidence, negotiating, closings and possible administrative costs for condemnation.

There are an estimated nine tracts required for the project and, therefore, the total administrative costs are estimated at $10,800.

16. CONTINGENCIES

A contingency allowance of 20% is considered reasonable to provide for possible adjustments or refinements of the taking lines, for unknown ownerships which may develop, for adverse condemnation awards and to provide for actual practical and realistic negotiations.

## C - RECOMMENDATIONS AND ASSUMPTIONS

17. RECOMMENDATIONS

It is recommended that the possible use of existing flowage rights, owned by the Public Service Company of New Hampshire, be further explored

by the Town of Lancaster. The use of these rights if sufficient for project purposes, could possibly lower the required acquisition costs for this project.

18. ASSUMPTIONS AND LIMITING CONDITIONS

The value estimates set forth in this report are subject to the following assumptions:

a. that title to the properties affected by the project are free, clear and marketable.

b. that the data gathered for this report has been obtained from reliable sources and is assumed to be correct, although no guarantee is possible.

c. that the project maps provided this office, which delineate the required taking lines, are correct and accurate.

d. that the frequency of flooding data provided this office for those areas to be acquired under flowage easements is correct and accurate.

e. that all disturbed fencing and landscaping on the periphery of the area required for the structures will be restored or replaced, where practical, and

f. that this preliminary report has been compiled without benefit of detailed ownership data or detailed property inspections, and therefore, the estimates contained herein are subject to further revision and refinement upon the completion of individual appraisals.

19. COST SUMMARY

| | |
|---|---|
| LAND VALUE | $ 40,930 |
| SEVERANCE DAMAGES | 35,000 |
| ADMINISTRATIVE COSTS | 10,800 |
| CONTINGENCIES (20% of above) | 17,346 |
| TOTAL | $104,076 |
| ROUNDED TO | $105,000 |

# APPENDIX C

# STRUCTURAL DESIGN

# APPENDIX C

## STRUCTURAL DESIGN

## TABLE OF CONTENTS


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| 2 | Scope | C-1 |
| 3 | Design Criteria | C-1 |
| 4 | Basic Data and Assumptions | C-2 |
| 5 | Spillway | C-4 |
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| 8 | Stability | C-4 |

LOCAL FLOOD PROTECTION

ISRAEL RIVER

LANCASTER, N.H.

## STRUCTURAL DESIGN

1. PURPOSE.

This section of the design memorandum presents the design criteria, basic data and assumptions used in the structural design of the dam and appurtenant structures. A brief description of the structures with loading conditions is included herein.

2. SCOPE.

The structural design including stability investigations of the dam and spillway weir are included in the appendix.

3. DESIGN CRITERIA.

a. General. All working stresses conform to those specified in the Engineering Manual EM 1110-1-2101 "Working Stresses for Structural Design" dated 1 Nov 1963. Loading conditions, design assumptions and other design criteria are based on the following applicable parts of the Engineering Manual for Civil Works issued by the office of the Chief of Engineers: Standard Practice for Concrete (EM 1110-2-2000) Dec 1965; Structural Design of Spillways and Outlet Works (EM 1110-2-2400) 2 Nov 1964; Gravity Wall Design (EM 1110-2-2200) Nov 1960; Retaining Walls (EM 1110-2-2502) May 1961. Accepted engineering practice is utilized in cases where the Engineering Manuals for Civil Works do not apply.

b. Concrete. Concrete working stresses are in general accord with ACI Standard Building Code requirements for reinforced concrete. All structures are hydraulic structures and all concrete shall have a minimum compressive strength of 3,000 lbs. per sq. in. and a working flexural stress of 1,050 lbs. per sq. in.

c. Reinforcement.

(1) Grade and Working Stresses. All reinforcement in the structures including temperature and shrinkage reinforcement, is designed for 20,000 psi in flexural tension, which is the working stress for new billet steel, intermediate grade, deformed bars. The reinforcement shall conform to the requirements of Federal Specification QQ-S-632b, Type II, Class B-40 and to ASTM A-305.

(2) Spacing. The clear distance between parallel bars will not be less than 1-1/2 times the diameter of the round bars except that in no case will the clear distance between parallel bars be less than 1-inch or 1-1/2 times the maximum size of the coarse aggregate.

(3) Minimum Cover for Reinforcement.

| Item | Min. Cover (inches) |
|---|---|
| Concrete poured against forms | 4" |
| Concrete poured against earth | 6" |

(4) Splices. All splices will be in accordance with the ACI Building Code and as set forth in Table 14c. of the "Reinforced Concrete Design Handbook", ACI Publication SP-3.

(5) Temperature and shrinkage Reinforcement. (Ref. EM 1110-2-2103).

(a) Members Restrained at One Edge. The area of steel parallel to the restrained edges will be 0.40% of cross-sectional area, 1/2 each face, except not more than #9 @ 12 inches. This steel will be used for a distance equal to 1/4 of the length of restraint from the restrained edge. For the remainder, the steel ration will be 0.20%.

(b) Temperature and Shrinkage Combined with Other Loads. Temperature steel will not be used in the direction and plane of the main tensile steel. However, the main steel will not be less than that required for shrinkage and temperature.

d. Structural Steel. Structural steel is designed for a working stress of 18,000 psi with a yield point of 36,000 psi (A-36). Design conforms to the latest AISC "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings" and to EM 1110-1-2101. Basic working stress is 18,000 psi (0.50Fy).

e. Increase in Normal Working Stresses. Allowable working stresses are increased 33-1/3% only where wind loads and earthquake loads are used.

4. BASIC DATA AND ASSUMPTIONS.

a. Controlling Elevations of Dam and Appurtenant Structures (m.s.l.)

| | |
|---|---|
| Top of Dam | El. 933 |
| Spillway Crest | 920 |
| Maximum Water Surface | 932 |
| Maximum Tailwater | 927 |
| Permanent Pool Elevation | 920 |

b. Loads.

(1) Dead Loads. The following unit weights for materials are used:

| Material | (Unit Weight - lbs./cu. ft.) Dry | Saturated | Moist | Submerged |
|---|---|---|---|---|
| Concrete | 150 | --- | --- | --- |
| Back Fill | 110 | 130 | 120 | 68.0 |

(2) Live Loads. The following live loads are used:

| | |
|---|---|
| Water | 62.5 lbs. per cu. ft. |
| Wind | 30 lbs. per sq. ft. |

c. External Water Pressure. In cases where hydrostatic pressure affects the design of a structure, it is assumed to act over the entire area in question under the full head available.

d. Earth Pressure. Earth pressures are determined in general accordance with EM 1110-2-2502, Retaining Walls.

e. Earthquake Forces. Structures are located in Zone 2 and are investigated for an earthquake shock of 0.10g. Cases 5 and 6 of the stability investigations of the gravity dam and spillway designs considered earthquake forces applied in accordance with the method outlined in EM 1110-2-2000.

f. Ice Pressure. Horizontal forces due to the expansion of ice are considered in the design of the dam structure below Elevation 920.0. A force of 7,500#/lin. ft. is applied to the structure at the normal pool elevation upstream and a force of 3,750#/lin. ft. is applied at the plunge pool elevation downstream.

g. Wind Pressure. A wind pressure of 30 lbs/sq. foot is used in the design of the gravity wall and spillway.

h. Wave Pressure. Wave pressure on the structure is disregarded in the design.

i. Frost Protection. A minimum frost protection cover of 6 feet above foundation level is used for any structure founded on earth.

j. Location of Resultant. In the design of structures, the resultant of the horizontal and vertical loads is within the middle third except on earthquake loadings where it falls within the base.

k. Allowable Soil Bearing. In the design of the structures, an allowable soil bearing of 3.0 tons/sq.ft. is used.

5. SPILLWAY. The weir is 140 ft. in length with crest elevation 920 and features a sloped base with the heel 8 feet below the toe to provide passive pressure reaction. Overflow and non-overflow monoliths will be 20 feet wide at intrados and separated by contraction joints with a single Type "B" rubber or vinyl waterstop located near the upstream face.

6. GRAVITY SECTION. The gravity non-overflow section of the dam is founded on earth. It has a vertical upstream face, a 2 on 3 slope on the downstream face extending to the top of the section, and a 2 ft. wide top at left abutment and 10 ft. wide on right to accommodate a roadway. The section is stable.

7. STOP-LOG STRUCTURE. The inlet consists of a 10 foot deep by 6 foot wide opening in the weir with invert elevation at 910. Timber stop-logs will be provided.

8. STABILITY (GRAVITY NON-OVERFLOW SECTION AND SPILLWAY). The following loading conditions were investigated in the design of the dam and spillway.

a. Case I - Construction Condition. Dam completed but no water in reservoir, no tailwater, wind load on downstream face.

b. Case II - Normal Operating Condition. Pool elevation at spillway crest. Tailwater at El. 910. Ice load. Uplift varying from full head at heel to head of tailwater at toe.

c. Case III - Not used.

d. Case IV - Flood Discharge Condition, Reservoir at maximum flood pool elevation, (El. 932.0). Tailwater at El. 927. Uplift varying from maximum head at heel to maximum tailwater head at toe. No ice.

e. Case V - Construction Condition with Earthquake. Earth acceleration in downstream direction. No water in reservoir, no wind load and no tailwater.

f. Case VI - Normal Operating Condition with Earthquake. Earthquake acceleration in upstream direction. Reservior pool at spillway crest. Tailwater at El. 910. Uplift varies from maximum head at heel to head of tailwater elevation at toe.

g. Under all conditions of loading, it is found that the resultant falls within the middle third with the exception of the Case VI loading where the resultant falls outside the middle third, but does fall within the base. All bearing pressures are within limits of allowable bearing of the foundation materials.

27 Sept 49 CORPS OF ENGINEERS, U. S. ARMY PAGE

SUBJECT LANCASTER ICE DAM

COMPUTATION STABILITY SUMMARY

COMPUTED BY PRL CHECKED BY DATE 9 Feb 72

# SUMMARY TABLE

## STABILITY COMPUTATIONS

| MON | STA | CASE | DIST WITHIN KERN, FT | BEARING, K/FT² MIN | BEARING, K/FT² MAX | SLIDING FS FRICTION | SLIDING FS W/ PASSIVE |
|---|---|---|---|---|---|---|---|
| 1 & 2 | 0+60 | 1 | 1.54 | 1.79 | 2.10 | 23. | — |
| " | " | 2 | 1.67 | 1.95 | 1.95 | ∞ | — |
| " | " | 4 | 0.41 | 0.33 | 2.37 | 2.1 | 3.4 |
| " | " | 5 EQ | 4.35 | 1.19 | 2.71 | 4.7 | — |
| " | " | 6 EQ | 4.35 | 1.19 | 2.71 | 4.7 | 6.5 |
| 3 | 1+00 | 1 | 0.32 | 0.29 | 6.17 | 33. | — |
| " | " | 2 | 3.54 | 2.27 | 2.43 | 1.8 | 2.1 |
| " | " | 4 | 3.65 | 1.90 | 1.92 | 2.1 | 2.5 |
| " | " | 5 EQ | 6.52 | .00 | 7.27 | 4.7 | — |
| " | " | 6 EQ | 10.99 | 2.34 | 2.36 | 1.3 | 1.5 |
| * 4 - 10 | — | 1 | 4.67 | 2.45 | 2.45 | 1.5 | — |
| " | — | 2 | 0.21 | 0.07 | 3.18 | 1.5 | 2.6 |
| " | — | 4 | 0.59 | 0.17 | 2.61 | 1.0 | 2.0 |
| " | — | 5 EQ | 5.06 | 2.24 | 2.66 | 1.1 | — |
| " | — | 6 EQ | 1.80 | 0.63 | 3.13 | 1.1 | 2.1 |
| 11 & 12 | 2+58 | 1 | 0.36 | 0.29 | 5.52 | 30. | — |
| " | | 2 | 3.22 | 1.78 | 2.26 | 1.6 | 1.9 |
| " | | 4 | 2.99 | 1.32 | 1.91 | 1.8 | 2.2 |
| " | | 5 EQ | 6.75 | 0.00 | 6.31 | 4.7 | — |
| " | | 6 EQ | 10.89 | 1.96 | 2.09 | 1.2 | 1.4 |
| 13 | 2+98 | 1 | 0.34 | 0.33 | 2.42 | 14. | — |
| " | | 2 | 0.67 | 0.65 | 2.16 | ∞ | — |
| " | | 4 | 0.39 | 0.22 | 1.46 | 1.1 | 2.4 |
| " | | 5 EQ | 2.92 | 0.04 | 2.71 | 4.7 | — |
| " | | 6 EQ | 4.06 | 1.14 | 1.67 | 4.8 | 7.9 |

* MONOLITHS 4 THRU 10 IS SPILLWAY SECTION

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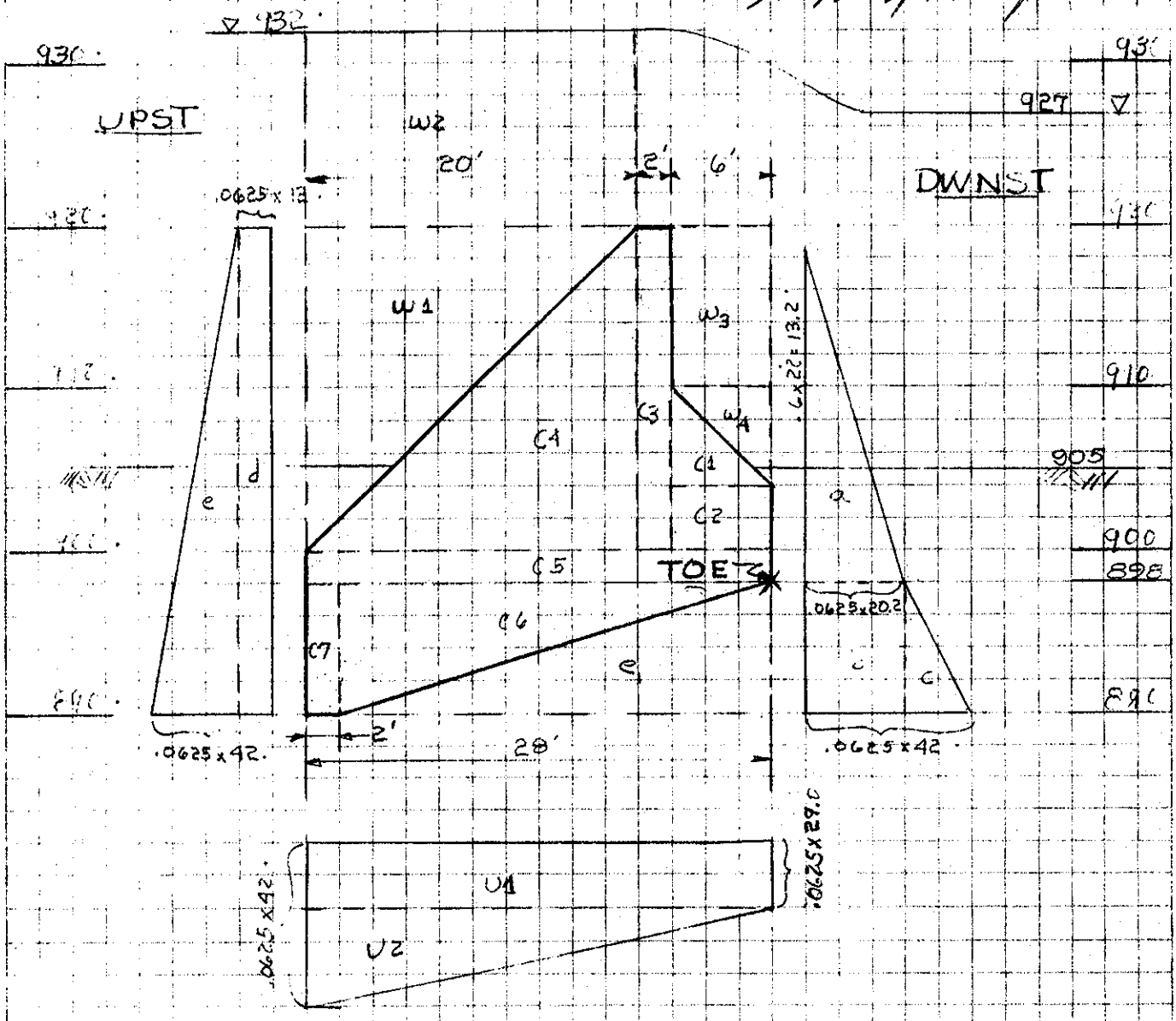
27 Sept 49

**NEW ENGLAND DIVISION**
**CORPS OF ENGINEERS, U. S. ARMY**



SUBJECT: LANCASTER ICE DAM
COMPUTATION: STABILITY COMPS.
COMPUTED BY: PRL CHECKED BY: DATE: 21 Feb 72

FLOOD DISCHARGE CASE 4 60% tailwater press
100% uplift press




SPILLWAY SECTION

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SUBJECT: LANCASTER ICE DAM
COMPUTATION: STABILITY COMPS
COMPUTED BY: PRL  CHECKED BY:  DATE: 21 Feb 72

CASE 4
OVERTOPPING

(MOMENTS ABOUT TOE)

↓ + VER, KIPS
← + HOR, KIPS
↺ + MOM, FT-KIPS

| | VERTICAL | FORCE | SUBTOT | ARM | MOM | SUBTOT |
|---|---|---|---|---|---|---|
| C1 | .15(6)²(1/2) | 2.7 | | 4.0 | 10.8 | |
| C2 | .15(6)(4) | 3.6 | | 3.0 | 10.8 | |
| C3 | .15(2)(20) | 6.0 | | 7.0 | 42.0 | |
| C4 | .15(20)(20)(1/2) | 30.0 | | 14.67 | 440.1 | |
| C5 | .15(2)(28) | 8.4 | | 14.0 | 117.6 | |
| C6 | .15(26)(8)(1/2) | 15.6 | | 17.33 | 270.34 | |
| C7 | .15(2)(8) | 2.4 | | 27.0 | 64.8 | |
| | CONCRETE → | | 68.7 | | | 956.44 |
| W1 | .0625(1/2)(20)² | 12.5 | | 21.33 | 266.63 | |
| W2 | .0625(20)(12) | 15.0 | | 18.0 | 270.0 | |
| W3 | .0625(10)(4) | 3.75 | | 3.0 | 11.25 | |
| W4 | .0625(6)²(1/2) | 1.125 | | 2.0 | 2.25 | |
| | WATER → | | 32.38 | | | 550.13 |
| U1 | -.0625(29.0)(28) | -50.75 | | 14.0 | -710.5 | |
| U2 | -.0625(1/2)(13.0)(28) | -11.38 | | 18.67 | -212.5 | |
| | UPLIFT → | | -62.13 | | | -923.0 |

CYC = 68.7/.15/27
= 16.93
say 17 cy

| | | HORIZONTAL | FORCE | SUBTOT | ARM | MOM | SUBTOT |
|---|---|---|---|---|---|---|---|
| DS | a | ½(.0625)(20.2)³ | 12.75 | | 6.73 | 85.81 | |
| | b | .0625(20.2)(8) | 10.1 | | -4.0 | -40.4 | |
| | c | ½(.0625)(21.8)(8) | 5.45 | | -5.33 | -29.05 | |
| | | WATER DS → | | 28.3 | | | 16.36 |
| US | d | -.0625(12)(30) | -22.5 | | 7.0 | -157.5 | |
| | e | -.0625(30)²(1/2) | -28.13 | | 2.0 | -56.26 | |
| | | WATER US → | | -50.63 | | | -213.76 |

ΣVER FORCES = 38.95 Kips
ΣHOR FORCES = -22.33 Kips
ΣMOMENTS = 386.2 FT-Kips

$$\Sigma M/\Sigma V = \frac{386.2}{38.95} = 9.92' \text{ fr toe}$$

$$\text{Kern} = \tfrac{1}{3}(28) = 9.33' < 9.92' \text{ OK}$$

SUBJECT LANCASTER ICE DAM
COMPUTATION STABILITY COMPS
COMPUTED BY PRL CHECKED BY DATE 21 Feb 72

CASE 1

PASSIVE RESISTANCE

| | | | |
|---|---|---|---|
| Wgt a | $\frac{1}{2}(.0625)(20.2)^2$ | 12.751 | |
| b | $.0625(20.2)(8)$ | 10.1 | |
| c | $\frac{1}{2}(.0625)(42-20.2)(8)$ | 5.45 | |
| | | | 28.301 |
| d | $-.0625(12)(30)$ | -22.5 | |
| e | $-\frac{1}{2}(.0625)(30)^2$ | -28.125 | |
| | | | -50.625 |
| | | TOTAL | -22.324 |

$\phi = 30°$
$\alpha = 45 - \phi/2 = 30°$
$\phi + \alpha = 60°$

$\tan\phi = .577$
$\tan\alpha = .577$
$\tan(\phi+\alpha) = 1.732$

$d = 15/.577 = 26'$

$$W = \frac{1}{2} \times \gamma \times \frac{d}{\tan\alpha} \times d = \frac{1}{2}(.068)(15)(15)/.577 = 13.258$$

$$P_p = W\tan(\phi+\alpha) = 13.258(1.732) = 22.963$$

$$SF_{pass} = P_p/\Sigma H = \frac{22.963}{22.324} = 1.03$$

$$SF_p = 1.0$$

SLIDING RESISTANCE

HORIZONTAL PLANE @ DEEPEST PENETRATION OF THE EARTH

$e_1 = \frac{1}{2}(.068)(26)(8) = 7.07$ ↓

$\Sigma V = 38.95 + 7.07 = 46.02$ ↓ $\Sigma H = -22.33$

coef sliding friction = .466

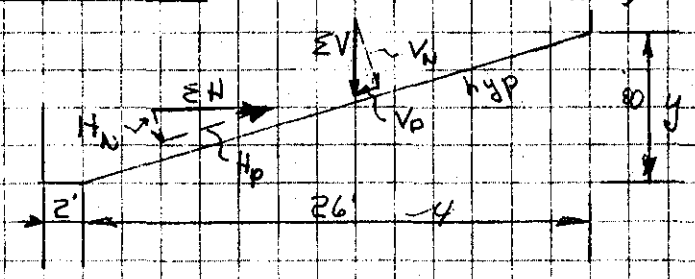
$$SF_s = .466\frac{\Sigma V}{\Sigma H} = .466\left(\frac{46.02}{22.33}\right) = 1.0$$

$$SF_s = 1.0$$

SF = FRIC + PASS = 2.0

SUBJECT LANCASTER ICE DAM
COMPUTATION STABILITY COMPS
COMPUTED BY PRC CHECKED BY DATE 21 Feb 72

CASE 4
SLIDING RESISTANCE ALONG INCLINED BASE




$hyp = \sqrt{26^2 + 8^2} = 27.2'$

$\Sigma V = 38.95$
$\Sigma H = -22.33$

$\Sigma V_N = \Sigma V \frac{x}{hyp} = 38.95 \times 26/27.2 = 37.2^K$
$\Sigma H_N = \Sigma H \frac{y}{hyp} = 22.33 \times 8/27.2 = 6.6^K$

$\Sigma V_p = \Sigma V \, y/hyp = 38.95 \times 8/27.2 = 11.46^K$
$\Sigma H_p = \Sigma H \, x/hyp = 22.33 \times 26/27.2 = 21.34^K$

$\Sigma N = 37.2 + 6.6 = 43.8$ kips
$\Sigma P = -21.34 + 11.46 = 9.9$ kips
$FRIC = .46 \times 43.8 / 9.9 = 2.06$

$SF_1 = 2.1$

---

RESULTS CASE 4 FLOOD DISCHARGE

OVERTURNING — RESULTANT IS 7.08 inch within 1/3 pt

SLIDING FACTOR 1 — RESISTANCE ALONG A PLANE AT THE DEEPEST PENETRATION OF THE BASE AND SURFACING 26 FEET BEYOND THE TOE. SF1 = 2.0

SLIDING FACTOR 2 — RESISTANCE ALONG A PLANE AT THE BASE OF THE STRUCTURE AND SURFACING AT THE TOE. SF2 = 2.1

NED FORM 223
27 Sept 49

**NEW ENGLAND DIVISION**
**CORPS OF ENGINEERS, U. S. ARMY**

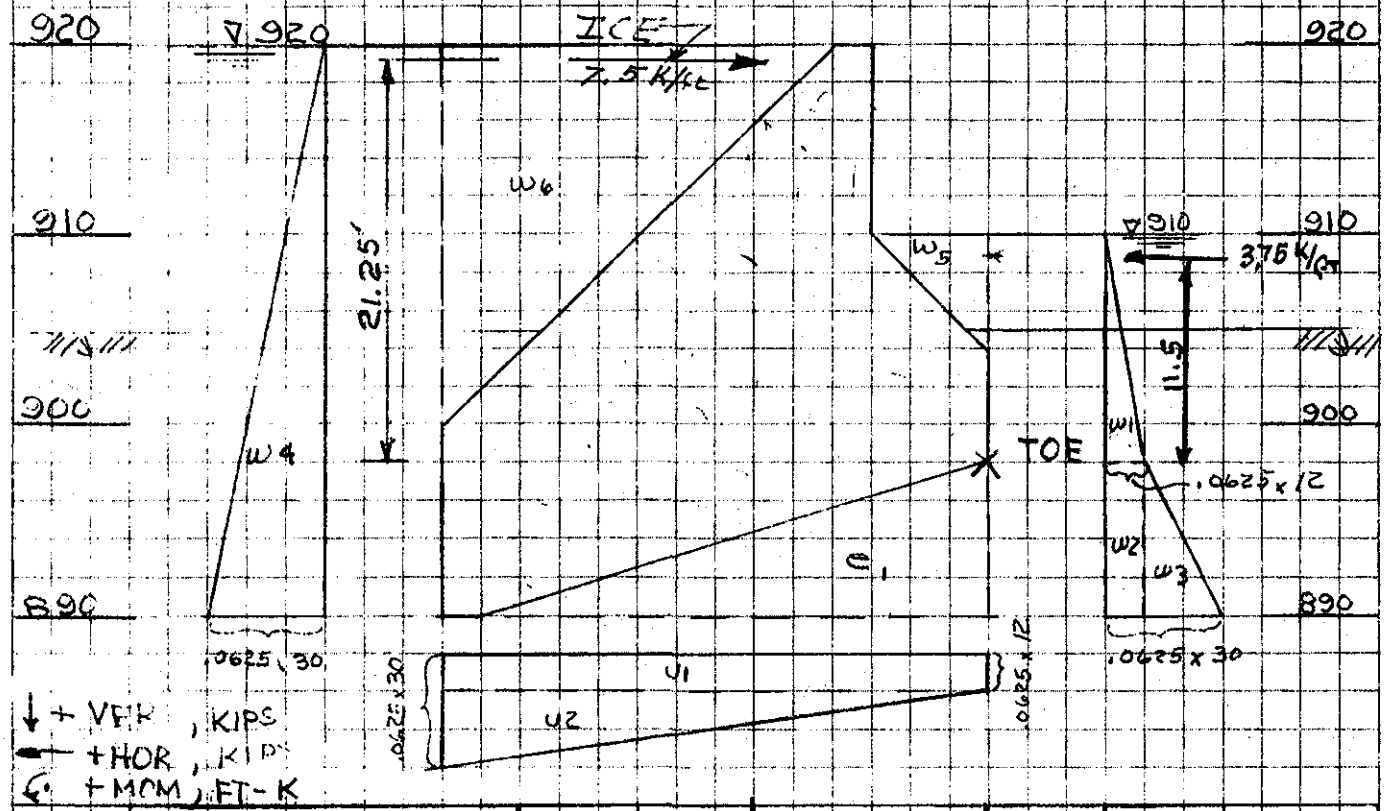


SUBJECT

COMPUTATION

COMPUTED BY DEL CHECKED BY DATE 22 Feb 72

CASE 2 NORMAL OPERATING




↓ + VER, KIPS
← + HOR, KIPS
↻ + MOM, FT-K

| | COMPUTATION | VER | SUB TOT | HOR | SUB TOT | ARM | MOM | SUB TOT |
|---|---|---|---|---|---|---|---|---|
| CONC | see p. 2 of comps | 68.7 | | — | | | 956.4 | |
| | | | 68.7 | | — | | | 956.4 |
| W1 | $\frac{1}{2}(.0625)(12)^2$ | | | 4.5 | | 4.0 | 18.0 | |
| W2 | $(.0625)(12)(3)$ | | | 6.0 | | -4.0 | -24.0 | |
| W3 | $\frac{1}{2}(.0625)(30-12)(8)$ | | | 4.5 | | -5.33 | -24.0 | |
| W4 | $-\frac{1}{2}(.0625)(30)^2$ | | | -28.13 | | 2.0 | -56.3 | |
| W5 | $\frac{1}{2}(.0625)(6)^2$ | 1.13 | | | | 2.0 | 2.3 | |
| W6 | $\frac{1}{2}(.0625)(20)^2$ | 12.5 | | | | 21.33 | 266.6 | |
| | | | 13.6 | | -13.13 | | | 182.6 |
| U1 | $-.0625(12)(28)$ | -21.0 | | | | 14.0 | -294.0 | |
| U2 | $-.0625(30-12)(28)/2$ | -15.75 | | | | 18.67 | -294.1 | |
| | | | -36.75 | | — | | | -588.1 |
| ICE | -7.5 | | | -7.5 | | 21.25 | -159.4 | |
| | 3.75 | | | 3.75 | | 11.5 | 43.1 | |
| | | | | | -3.75 | | | -116.3 |
| TOTALS | | | 45.55 | | -16.88 | | | 434.6 |

SUBJECT

COMPUTATION

COMPUTED BY VKL CHECKED BY DATE 22 Feb 72

OVERTURNING ABOUT TOE

$\Sigma V = 45.55 \downarrow$ $\Sigma M/\Sigma V = 9.54$

$\Sigma H = 16.88 \rightarrow$ $\text{kern} = 1/3(28) = 9.33$

$\Sigma M = 434.6$ ↺ $\therefore$ 2 1/2" within kern.

CREEP RATIO = $(2+27.2+1)/10 = 3.02$

SLIDING ALONG HOR PLANE @ THE DEEPEST PENETRATION OF THE BASE

$e_1 = 1/2(.068)(8)(26) = 7.07 \downarrow$

$\Sigma V = 45.55 + 7.07 = 52.62 \downarrow$
$\Sigma H = 16.88 \rightarrow$
coef fric = .466

$\therefore SF_f = .466(52.62)/(16.88) = 1.5$

$SF_f = 1.5$

PASSIVE RESISTANCE

See page 3 of computations.

$P_p = 22.963$

$\therefore SF_p = 22.963/20.63 = 1.1$

$SF_p = 1.1$

COMBINED SLIDING FACTOR

$SF_c = SF_f + SF_p$
$= 1.2 + 1.1 = 2.3$

$SF_c = 2.6$

SUBJECT

COMPUTATION

COMPUTED BY PRL CHECKED BY DATE 22 Feb 72

SLIDING ALONG INCLINED BASE

see page 4 of comps

$\Sigma V = 45.55 \downarrow$
$\Sigma H = 16.88 \rightarrow$

$\Sigma V_N = 45.55(26)/(27.2) = 43.5^K$
$\Sigma H_N = 16.88(8)/(27.2) = 5.0^K$

$\Sigma V_p = 45.55(8)/27.2 = 13.4^K$
$\Sigma H_p = 16.88(26)/27.2 = 16.1^K$

$\Sigma N = 43.5 + 5.0 = 48.5^K$
$\Sigma V = -16.1 + 13.4 = -2.7^K$

$F_{RICA} = .466 \times 48.5/2.7 = 8.4$

$SF_c = \underline{\underline{8.0}}$

RESULTS CASE 2 NORMAL OPERATING WITH TC-F

OVERTURNING RESULTANT IS 2½" within kern

SLIDING FACTOR 1 SLIDING FACTOR ALONG A PLANE AT THE DEEPEST PENETRATION OF THE BASE AND SURFACING 26 FT BEYOND THE TOE = 2.6

SLIDING FACTOR 2 SLIDING FACTOR ALONG A PLANE AT THE BASE OF THE STRUCTURE AND SURFACING AT THE TOE = 8.0

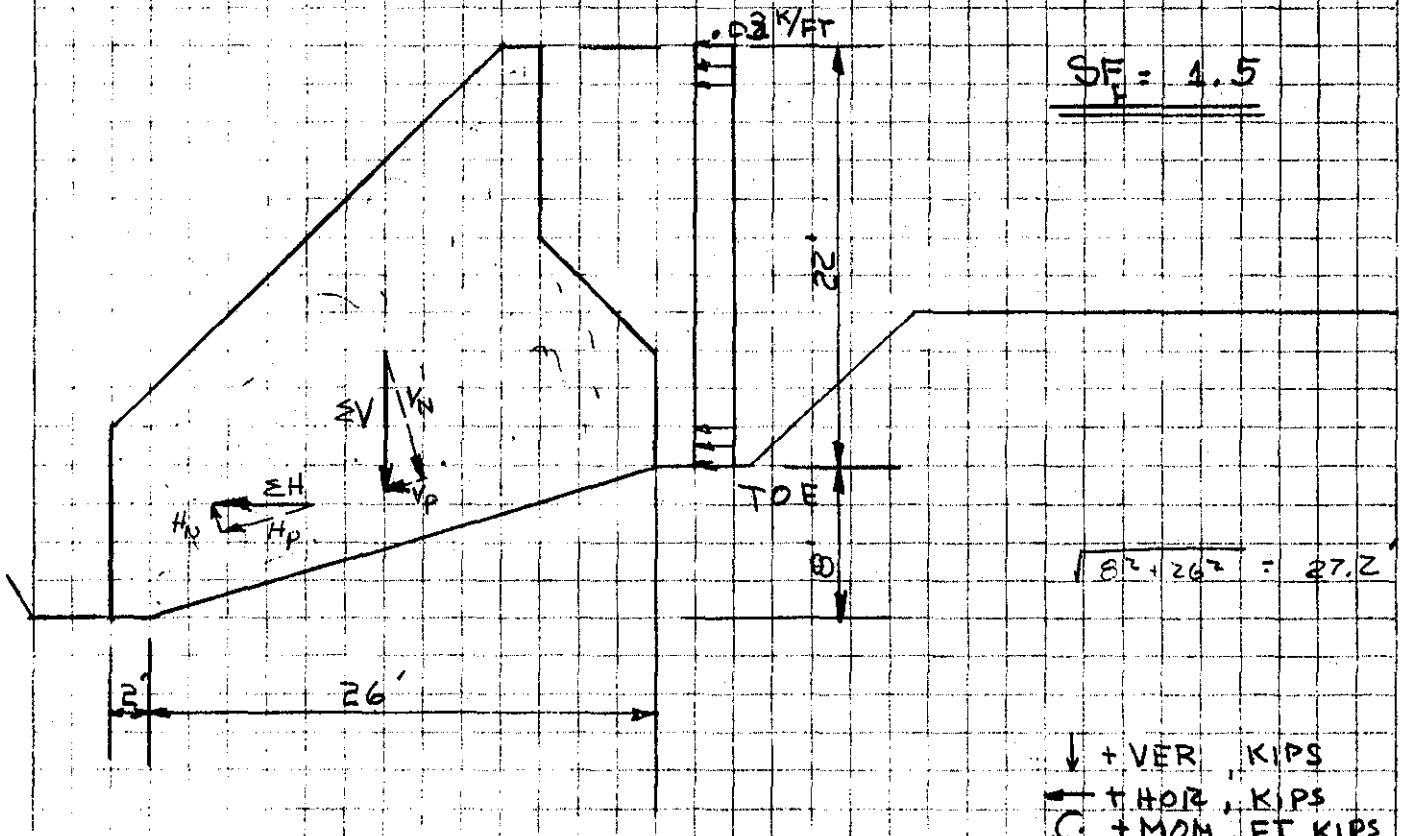
NED FORM 223
27 Sept 49

**NEW ENGLAND DIVISION**
CORPS OF ENGINEERS, U. S. ARMY



SUBJECT LANCASTER ICE DAM
MPUTATION STABILITY OVERFLOW SECTION
COMPUTED BY PRL CHECKED BY DATE 24 Feb 72

## CASE 1 CONSTRUCTION COND




$SF_H = 1.5$

$\sqrt{8^2 + 26^2} = 27.2'$

↓ + VER, KIPS
← + HOR, KIPS
↻ + MOM, FT KIPS

| | | VER | SUB TOT | HOR | SUB TOT | ARM | MOM | SUB TOT |
|---|---|---|---|---|---|---|---|---|
| CONC | see page of comps | | 68.7 | | | | | 956.44 |
| WIND | .03 x 22 | | | .66 | | 11 | 7.26 | |
| | | | | | .66 | | | 7.26 |
| TOTAL | | | 68.7 | | .66 | | | 963.7 |

OVERTURNING:

$\Sigma M / \Sigma V = 963.7 / 68.7 = 14.0$ within Kern OK

SLIDING DOWN INCLINE:

$V_N = 68.7 \times 26/27.2 = 65.67$ $F_N = 65.48$ Kips

$H_N = .66 \times 8/27.2 = .19$

$V_P = 68.7 \times 8/27.2 = 20.21$ $F_P = 20.84$ Kips

$H_P = .66 \times 26/27.2 = .63$

$SF_F = .466(65.48)/20.84 = 1.46$

NED FORM 223
27 Sept 49

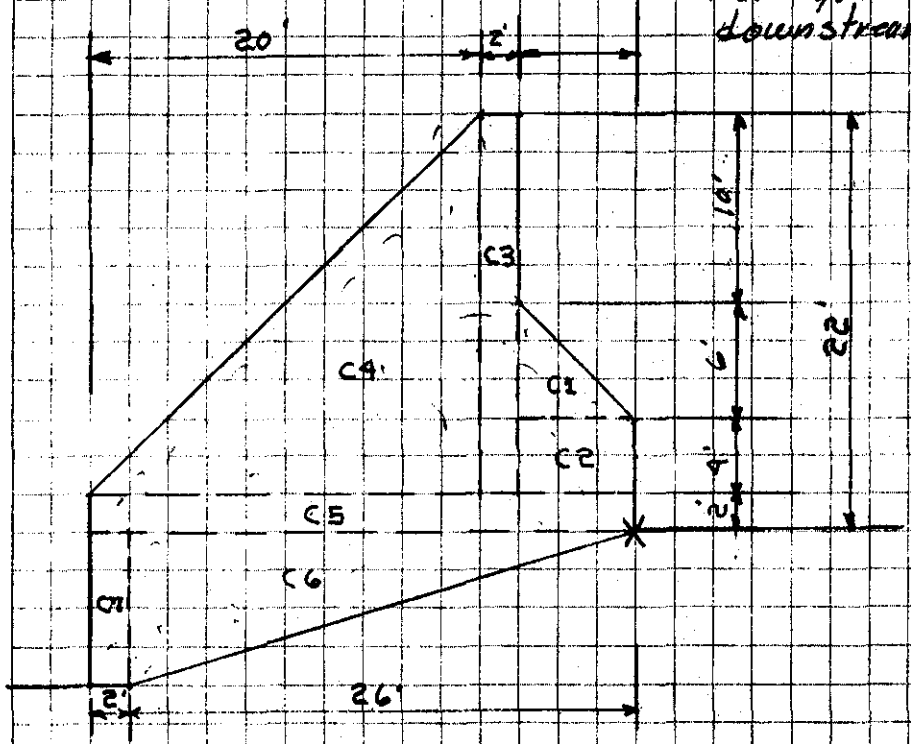
NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY



SUBJECT LANCASTER ICE DAM
COMPUTATION STABILITY OVERFLOW SECTION
COMPUTED BY PRL CHECKED BY DATE 29 Feb 12

## CASE 5 CONSTRUCTION CONDITION W/ EARTHQUAKE

Earthquake acceleration in downstream direction




$\alpha$ = ratio accel. = 0.1

$SF_F = 1.1$

+ MOM
+ VER
+ HOR

| | COMPUTATION | AREA | XARM | XA | YARM | YA |
|---|---|---|---|---|---|---|
| C1 | ½ x 6 x 6 | 18. | 4. | 72. | 8. | 144. |
| C2 | 4 x 6 | 24. | 3. | 72. | 4. | 96. |
| C3 | 2 x 20 | 40. | 7. | 280 | 12. | 480. |
| C4 | ½ x 20 x 20 | 200. | 14.67 | 2934. | 8.67 | 1734. |
| C5 | 2 x 28 | 56. | 14. | 784. | 1. | 56. |
| C6 | ½ x 8 x 26 | 104. | 17.33 | 1802.3 | -2.67 | -277.7 |
| C7 | 2 x 8 | 16. | 27. | 432. | -4. | -64. |
| | Σ | 458 | | 6376.3 | | 2168.3 |

$\bar{X}_c = 13.92$ $\bar{Y}_c = 4.73$

| | COMPUTATION | VER | ARM | | HOR | ARM | MOM |
|---|---|---|---|---|---|---|---|
| $P_e$ | .1 x 68.7 | | | | 6.87 | 4.73 | 32.5 |
| Conc | 458 x .15 | 68.7 | 13.92 | | | | 956.4 |
| | Σ | 68.7 | | | 6.87 | | 988.9 |

$\Sigma M/\Sigma V = 14.4$

$F_N = 68.7 \times 26/27.2 - 6.87 \times 8/27.2 = 63.65$

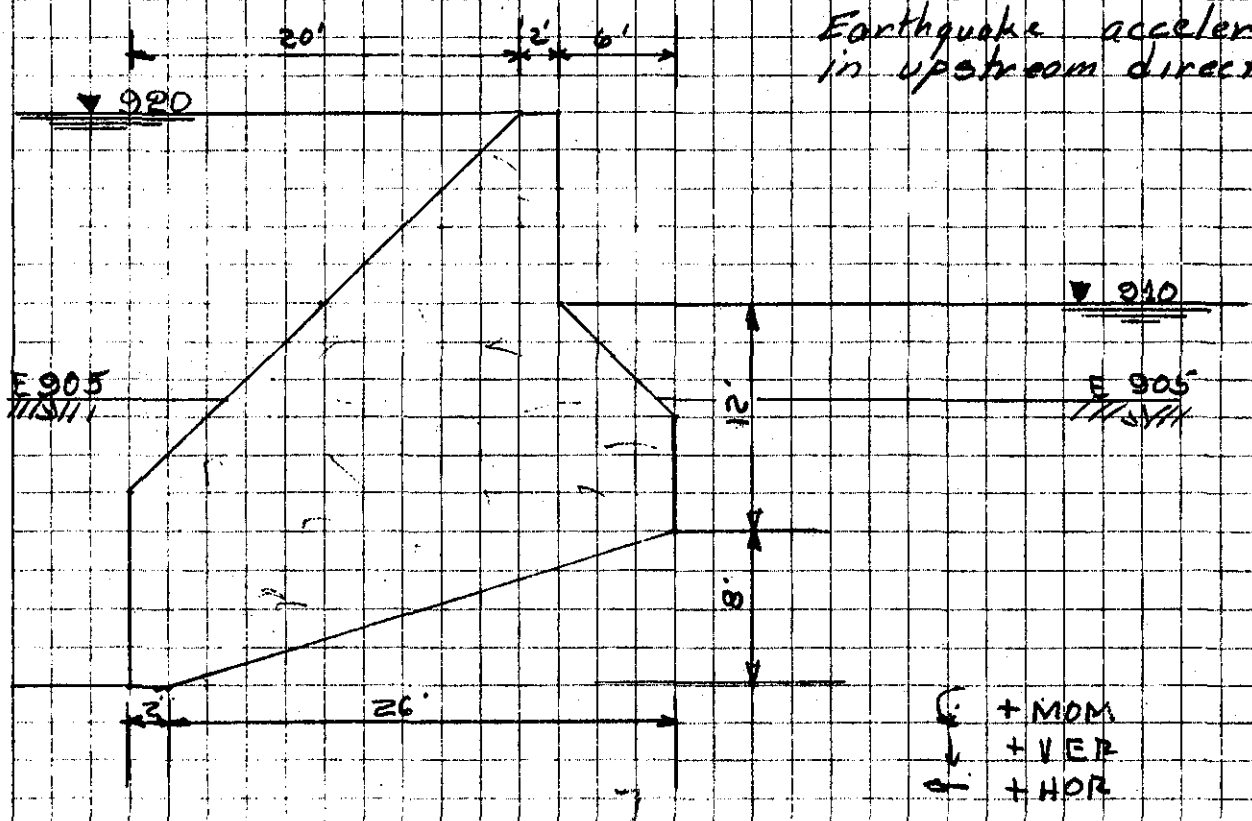
$F_P = 68.7 \times 8/27.2 + 6.87 \times 26/27.2 = 26.8$

$SF_F = .466(63.65)/26.8 = 1.11$

SUBJECT LANCASTER - ICE DAM
COMPUTATION STABILITY OVERFLOW SECT
COMPUTED BY PRL CHECKED BY DATE 29 Feb 72

CASE 6 NORMAL OPERATING W/ EARTHQUAKE

Earthquake acceleration in upstream direction




| | COMPUTATION | VER | X-ARM | HOR | Y-ARM | MOM |
|---|---|---|---|---|---|---|
| Conc | see page 2 comps | 68.7 | 13.92 | | | 956.4 |
| $P_{e_1}$ | see page 9 comps | | | -6.87 | 4.73 | -32.5 |
| $P_{e_2}$ | $\frac{2}{3} C_e \alpha y \sqrt{hy}/1000$ | | | -3.06 | 4. | -12.24 |
| UP | see page 9 comps | -36.8 | | | | -588.1 |
| WAT | see page 9 comps | 13.6 | | -13.1 | | 82.6 |

$A_{e_2} = \frac{2}{5} y - k_e y = \frac{2}{5}(30) - 8 = 4$

$C_e = \frac{51}{\sqrt{1 - .72\left(\frac{h}{1000\, t_e}\right)^2}}$ $\alpha = .1$, $y = 30$, $h = 30$

$= \frac{51}{\sqrt{1 - .72\left(\frac{30}{1000(1)}\right)^2}}$

$= 51.02$

$\Sigma V = 45.5 \downarrow$
$\Sigma H = 23.0 \rightarrow$
$\Sigma M = 806.2$ G

CASE 6 con't

OVERTURNING

$\Sigma V = 45.5 \downarrow$
$\Sigma H = 23.0 \rightarrow$
$\Sigma M = 506.2$

$\Sigma M / \Sigma V = 11.13$ within base OK

SLIDING ALONG HOR PLANE @ DEEPEST PENETRATION OF THE BASE

$e_1 = \frac{1}{2}(.069)(8)(26) = 7.07$ k

$\therefore SF_F = .466(45.5 + 7.07)/23.0 = 1.07$

$SF_F = 1.1$

PASSIVE RESISTANCE

See page 3 of computations
$P_p = 22.963$

$\therefore SF_p = 22.963/23.0 = 1.0$

$SF_p = 1.0$

COMBINED FACTOR SAFETY

$SF_c = SF_F + SF_p = 2.1$

$SF_c = 2.1$

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY



SUBJECT LANCASTER ICE DAM
COMPUTATION BEARING PRESS FROM CASES 1-2-4
COMPUTED BY PRL CHECKED BY DATE 24 Feb 72

BPMIN = ΣV/BASE - 6.0 (ΣV)(e)/BASE²

BPMAX = ΣV/BASE + 6.0 (ΣV)(e)/BASE²

CASE 1 CONSTRUCTION CONDITION

ΣV = 68.7 ↓ K
ΣM = 963.76 FT-K

e = ΣM/ΣV - BASE/2 = 14.0 - 14.0 = 0

∴ $BP_{min}$ = $BP_{max}$ = ΣV/BASE = 68.7/28 = 2.45 K/ft²

$BP_{min}$ = 2.45 K/sq ft
$BP_{max}$ = 2.45 K/sq ft

CASE 2 NORMAL OPERATING WITH ICE UPSTREAM

ΣV = 45.55 K ΣM = 434.6 FT-K

e = 9.54 - 14.0 = -4.46

$BP_{min}$ = 45.55/28 - 6.0(45.55)(4.46)/28² = .07 K/FT²

$BP_{max}$ = 45.55/28 + 6.0(45.55)(4.46)/28² = 3.18 K/FT²

$BP_{min}$ = 0.07 K/sq FT
$BP_{max}$ = 3.18 K/sq ft

(max 22 psi)

CASE 4 FLOOD DISCHARGE CONDITION

ΣV = 38.95 K ΣM = 386.21 FT-K

e = 9.92 - 14.0 = -4.08

$BP_{min}$ = 38.95/28 - 6.0(38.95)(4.08)/28² = 0.17 K/FT²

$BP_{max}$ = 38.95/28 + 6.0(38.95)(4.08)/28² = 2.61 K/FT²

$BP_{min}$ = 0.17 K/sq FT
$BP_{max}$ = 2.61 K/sq FT

SUBJECT LANCASTER ICE DAM
COMPUTATION STABILITY OVERFLOW SECT
COMPUTED BY PRL CHECKED BY DATE 29 Feb 76

CASE 5 CONSTRUCTION W/ EARTHQUAKE

$\Sigma V = 68.7^K$ $e = 14.4' - 14' = .4'$

$BP_{min} = 68.7/28 - 6(68.7)(.4)/28^2 = 2.24$ K/sq ft
$BP_{max} = 68.7/28 + 6(68.7)(.4)/28^2 = 2.66$ K/sq ft

$BP_{min} = 2.24$ K/□'
$BP_{max} = 2.66$ K/□'

CASE 6 NORMAL OPERATION W/ EARTHQUAKE

$\Sigma V = 45.5$

$e = 11.13 - 14 = -2.87$

$BP_{min} = 45.5/28 - 6(68.7)(2.87)/28^2 = 0.63$ K/□'
$BP_{max} = 45.5/28 + 6(68.7)(2.87)/28^2 = 3.13$ K/□'

$BP_{min} = 0.63$ K/sq ft
$BP_{max} = 3.13$ K/sq ft

# APPENDIX D

# TECHNICAL MEMORANDUM

# CRREL

TECHNICAL MEMORANDUM

CRREL

SITE DEFINITIONS

1. Confluence of Israel River and Connecticut River.
2. Abandoned Railroad Bridge Abutment.
3. Sharp bend in River just upstream from No. 2 above.
4. Main Channel downstream from Main Street Bridge.
5. Secondary by-pass Channel downstream from Main Street Bridge.
6. Abandoned Damsite upstream from Mechanic Street.
7. Abandoned Damsite below railroad bridge.
8. North Road.
9. Otter Brook at North Road Bridge.

A. Main Street Bridge

B. Mechanic Street Bridge

C. B&M Railroad Bridge

U. S. Army Cold Regions Research
and Engineering Laboratory
Hanover, N.H. 03755

June 1968

TECHNICAL MEMORANDUM

# Control of Ice Jams at Lancaster, New Hampshire

1. The following appraisal was prepared upon invitation of U. S. Army Engineer Division, New England, Corps of Engineers. It is based upon a visit to the area on 9 May 1968 by Dr. Assur and Mr. W. Huckabee and four (4) previous visits by Professor Dr. B. Michel and Mr. G. Frankenstein, starting from December 1967 and about six (6) survey trips by Mr. Huckabee during the last winter. This period coincided with one of the worst ice jam floods on record in this area.

2. In addition detailed plans and length profiles were examined, discussions were held with local inhabitants, as well as with representatives of the New England Division.

3. Although the main trouble and damage area is around the Main Street bridge A (see attached sketch), several surveys were made along the entire river wherever access permitted. This was considered necessary for a better appraisal of possible control measures.

4. The Israel River enters the Connecticut River at point 1 and meanders in a flood plain up to the abandoned railroad bridge location 2. The contour 840'

is shown to illustrate this situation.

5. The critical area for the formation of ice jams threatening the town is between 2 and A, and especially at 3. The longitudinal slope in the lower reach of this area is negligible and the bed is relatively wide and flat covered with sandbars and debris. During the early winter this stretch accumulates frazil ice drifting from open stretches of the river above. This ice freezes to the bottom and because of the limited flow of water during the winter only a small channel is cut through this ice accumulation.

6. During spring break-up ice coming from up-river stretches freezes in this area increasing thereby the roughness of the bed which could cause ice jams. The inspected evidence clearly points to this area as the main cause of trouble. The worst spot is point 3 where the foot of the ice jams forms. Statistical material on the frequency of ice jams in this stretch is not available to the undersigned.

7. Part of the trouble is due to man's past encroachment on the channel. In the long range it would have been better to provide park areas in place of some of the existing run-down manufacturing and living areas and a higher and longer bridge at point A.

8. The back-up water from the Connecticut river may cause ice jams when it reaches up to point 3 because the ice cannot easily discharge. On the other side it may alleviate an existing ice jam when the water level rises to provide

backwater up to point 4 disengaging the foot of the ice jam.

9. According to

USA CRREL, Technical Note, 26 Feb 1961, "Criteria for ice jamming", by A. Assur

the "ice jamming number"

$$P_1 = \frac{Q_i \, N^{1/6}}{G \, b \, \gamma c (H-h)^{2/3} \, S^{1/2}} \tag{1}$$

determines the beginning of an ice jam and the "ice packing number"

$$P_2 = \frac{Q_i \, N^{1/6}}{G \, b \, H^{5/3} \, S^{1/2}} \tag{2}$$

determines the initiation of an ice jam

$Q_i$ = discharge of ice

$N = n^6$ = a friction height

$n$ = Manning's friction coefficient

$G = \gamma (1-\gamma)^{2/3} \gamma c$

$\gamma = h/H$

$h$ = ice thickness

$H$ = depth of water

$\gamma$ = ratio of surface velocity to mean velocity of water

$c$ = coefficient in Manning's formula

$b$ = width of channel

$S$ = slope

10. Equations (1) and (2) were developed from simple hydraulic considerations. Formula (2) applies for this case since (1) deals with a river having

considerable discharge with ice floating relatively free until jamming starts. A qualitative discussion of (2) may be in order.

11. A high $P_2$ number will lead to ice packing and clogging in the channel. This is proportional to the discharge of ice, which in turn is proportional to its thickness and the intensity of break-up. Any arrangement, such as retaining dams upstream in the river, which would reduce the intensity of ice break-up would help.

12. The nature of ice freezing in the Israel river is such that large amounts of ice are being created in the form of frazil ice in open water stretches. Much less ice and less troublesome ice forms in quiet river courses. This points towards the advantage of retaining ponds upstream from the trouble area.

The only real limit to the ice formation in the Israel river now is the small winter discharge of water.

The steep slopes in the bank and large amounts of snow combined with heavy rains may cause rapid thawing and runoff in some winters leading to large $Q_i$.

13. The friction characterized by $N$ is high in particular between 2 and $A$ with large masses of ice adhering to the bottom. With $h$ approaching $H$, $G = \gamma(1-\gamma)^{2/3}$ is small leading to a large $P_2$. The water depth $H$ is small producing the same effect. The relatively large width $b$ is an advantage t aken by itself. The most significant factor in the critical area 3 is the small slope $S$ leading to a large ice packing number $P_2$ which is

aggravated by the sharp change in the direction of the current.

14. The described factors point therefore towards an undesirable combination of circumstances influencing the foundation of ice jams in the stretch 2 to A. The question now arises what corrective measures could be taken. We will not discuss here economic factors, whether or not a certain measure would be economically justified. We will rather concentrate at this point on the question whether or not it will be effective. There are a number of measures which could be taken alleviating the situation slightly and other more expensive measures which will prevent ice jams effectively.

15. The meandering section 1 to 2 is a nuisance which could be eliminated by cutting a channel directly towards point 1 in the Connecticut River. This would facilitate an orderly discharge into the Connecticut, but would not alleviate the situation in Lancaster itself. There are no structures affected by ice jams at the mouth of the Israel River.

16. As mentioned above, the major cause of ice jams is a sharp bend at point 3 combined with sandbars and debris in the river bed. The left bridge abutment at point 2 provides another but minor obstacle. The improvement proposed by the Corps of Engineers in this general area should be of distinct benefit. The meandering river causes difficulties for ice discharge so that channel straightening should be of benefit.

17. In deepening the channel between 2 and A one should keep in mind that

the relief may be only temporary since the channel would fill with gravel again in a few years.

18. The small channel 5 provides a relief for excess water during ice jams. A possible way to alleviate the situation would be to provide relief channels and ducts not allowing the water to exceed a defined level. The inlet of such a duct,which would pass water but not ice and would be dry during the winter,should be at least above bridge A and preferably above bridge B. It may be an expensive solution. Properly designed such a relief channel would be also helpful during catastrophic floods which occur in this area.

19. The removal of the crib just below bridge A helps but is not critical. The present construction of bridge A is not advantageous for ice jams (too many piers).

20. The river stretch from A to C has rapids and rocks. Large amounts of frazil ice are generated here during cold weather and are one of the main contributing causes to the ice jams from 2 to A since the channel gets clogged with soft and sticky ice masses. The initiation of frazil ice jams was directly observed between 2 and 3 and also at point C. The stretch just above B produced frazil ice during a large portion of the winter.

21. This situation, in principle, can be helped by a series of low dams which pond selected portions of the river. There are old dam sites at points 6 and 7 which are suitable locations. It would be also desirable to pond the

stretch between B and 6. According to old inhabitants and available records the ice jams were nowhere as severe as now when the dams at points 6 and 7 were in operation.

22. One cannot construct high retention dams in the stretch between B and C because of the narrow valley without flood plains and also because of possible damage to the understructure of the railroad bridge C.

23. The point just above bridge C is an ideal location for the construction of a high retention dam which also would give flood protection. The geological features are excellent because the river cuts a deep gorge in bedrock so that no extensive earth dams would be required. The area above the confluence of the Otter Creek provides an ideal retention basin which would also enhance the recreation potential of the area.

24. The contour 940 as shown on the sketch is somewhat in excess of a practical level. It may necessitate a short earth dyke to protect the railroad. It would require the raising of the highway at 8 as well as at 9 with rebuilding of the low quality bridge at this point. As a consequence of this solution valuable dairy type farmland would be flooded. It would produce a scenic lake from C up to D on the Israel river and up to E on the Otter Creek.

25. It is suggested to prepare a detailed topographic map of this area by means of aerial photography and automatic contouring under contract. Our Photo Interpretation Research Division could be helpful in this regard.

26. A suitable alternative, and by far the most effective solution for the ice jam but not the flood problem, would be a low dam above bridge C with a concrete spillway designed in such a way that the spring flood waters would be discharged through the opening but the ice retained behind in a flooded area.

27. It is very important to flood the extensive meadows above point C during the period of ice break-up. This creates a wide reservoir for the accumulation and gradual wastage of ice. The dam would lose a considerable portion of its effectiveness if the meadows (a former lake bed) would not be flooded. The area in question had been surveyed by inspection on foot. It is highly suitable for this solution. The farmland would not be harmed excessively but the ice jam conditions at Lancaster would be alleviated decisively. We understand that a utility company has flooding rights in this area.

A. ASSUR
Chief Scientist

G. Frankenstein
Project Engineer

W. Huckabee
Civil Engineer