Review of Structural Stability
West Branch Farmington River
Colebrook, Connecticut

Colebrook River Lake

SEPT 1990

US Army Corps
of Engineers
New England Division

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SUBJECT: Review of Structural Stability - Colebrook River Lake,
West Branch Farmington River, Colebrook, CT

20 NOV 1990

HQ, U.S. Army Corps of Engineers, Washington, D.C. 20314-1000

FOR Commander, New England Division, ATTN: CENED-ED-P

The subject report has been reviewed and is satisfactory.

FOR THE DIRECTOR OF CIVIL WORKS:

3 Encls
wd all encls

for JOHN A. McPHERSON
Acting Chief, Engineering Division
Directorate of Civil Works

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
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REPLY TO
ATTENTION OF

CENED-ED-P

24 September 1990

MEMORANDUM FOR Commander, U.S. Army Corps of Engineers, Attn: CECW-E~~X~~P, 20 Mass. Ave., N.W. Washington, D.C. 20314-1000

SUBJECT: Review of Structural Stability - Colebrook River Lake, West Branch Farmington River, Colebrook, CT

1. Forwarded herewith are three (3) copies of a report titled, "Review of Structural Stability" dated September 1990 for Colebrook River Lake, West Branch Farmington River, Colebrook, CT. This analysis was performed by the Structural Branch of our Design Division, based upon current criteria (par. 2e, appendix A of ER 1110-2-100). One (1) copy of the "Review of Structural Stability -Appendix A - Calculations" is also enclosed.

2. The structures analyzed satisfied all stability criteria for overturning, sliding and foundation pressure. It is therefore concluded that all structures have adequate stability in accordance with current stability criteria and do not require any additional strengthening.

FOR THE COMMANDER:

Encls

RICHARD D. REARDON
Director of Engineering

REVIEW OF STRUCTURAL STABILITY:
COLEBROOK RIVER LAKE
WEST BRANCH, FARMINGTON RIVER
COLEBROOK, CONNECTICUT

PREPARED BY

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

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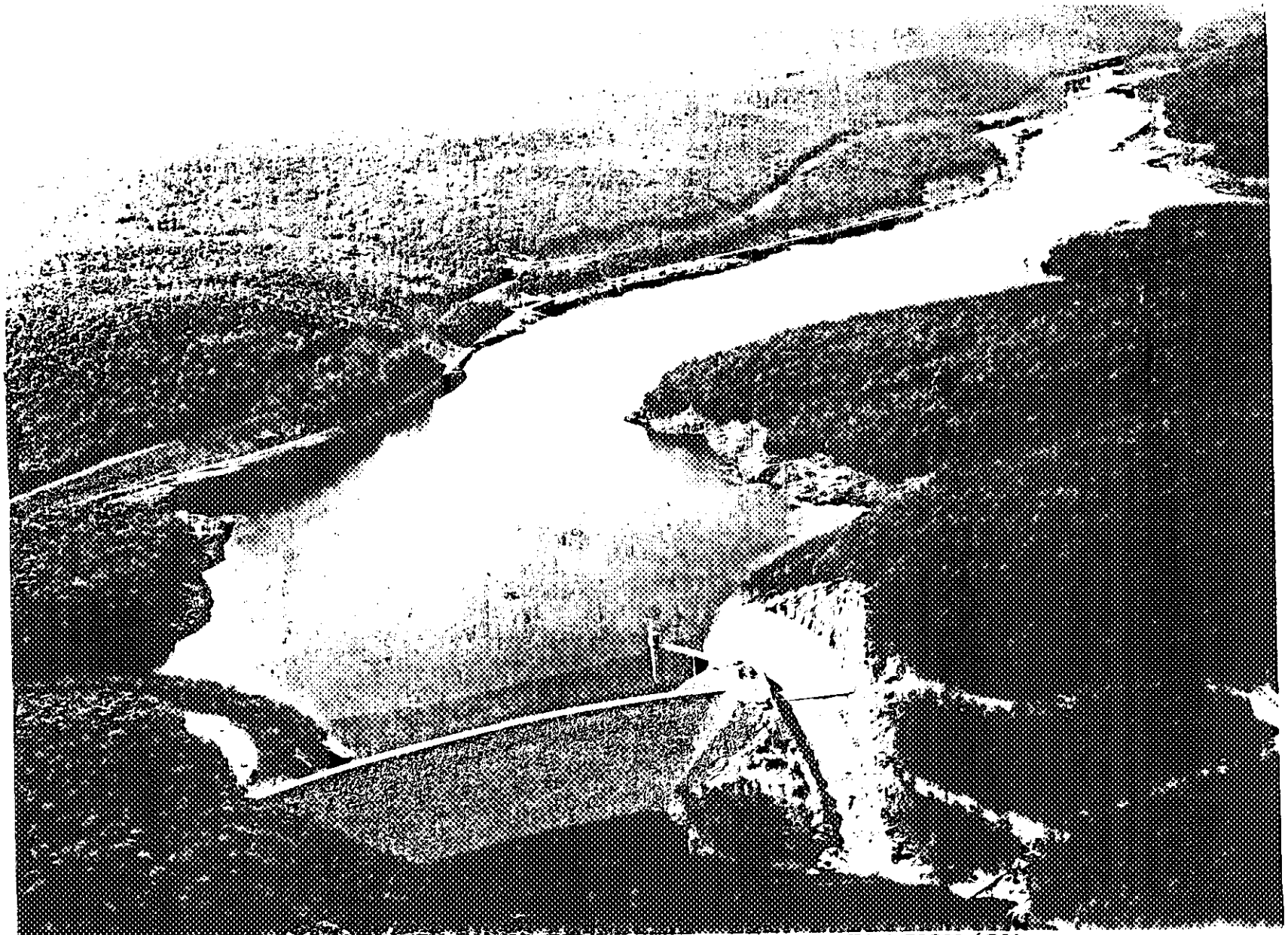
Appendix A: Stability Calculations
Note: Appendix A is a separate volume.



COLEBROOK RIVER RESERVOIR - POOL ELEVATION 673'

REVIEW OF STRUCTURAL STABILITY
COLEBROOK RIVER LAKE

SUMMARY OF REPORT

Stability analyses of the existing principal concrete structures at the Colebrook River Lake were performed to determine whether these structures satisfy current stability criteria. The methods used were a combination of conventional hand calculations and computer modeling. The computer program used was CORPS library CASE program "A Three-Dimensional Stability Analysis/Design Program (3DSAD)" X8100E (edition E, PC version).

The structural elements considered and the qualitative results of the analysis are listed below:

Structure	All Criteria Satisfied
Spillway Weir	Yes
Spillway West Retaining Wall	Yes
Service Bridge Pier	Yes
Service Bridge Abutment	Yes
Intake Tower with Crane	Yes

The conclusion of this study is all structures, have adequate stability in accordance with current stability criteria and do not require any additional strengthening.

TABLE 1 - Summary of Foundation Material Parameters

	Unit Wt. (lb/cu ft) dry	sat	sub	Bearing Capacity (ksf)	Angle of Internal Friction (degrees)	At Rest Earth Press. Coefficient (K_o)	Average Shear Strength (ksf)
Rock Fill	120	140	78	N.A.	40	.36	N.A.
Pervious Fill	135	147	85	7	37	.60	0.42
Impervious Fill	130	145	83	8	30	.50	1.5
Foundation Rock	165	-	-	70*	58	.84	149.0
Concrete	150	-	-	130	30*	.50	11.5*

Notes:

1. The (*) values govern for rock/concrete calculations.
2. Assumed internal angle of friction, 0 = 30 for concrete / rock interface, and K_o = 0.5 for At-rest Soil Pressure Coefficient.
3. Bearing capacity for Pegmatite Granite was reduced by 56% from NAVFAC DM-7.2 recommended value due to foliations and schists in boring logs.
4. The 11.5 ksf shear strength of concrete value, is taken from ACI 318-77 section 17.5.2.1

TABLE 2 - STABILITY CRITERIA FOR 3DSAD CDAMS MODULE*

	Minimum Percent Eff. Base	Maximum Bearing Pressure	Minimum Sliding FS
(1) LONG TERM	100%	1.0 x ALLOWABLE	2.0
(2) SHORT TERM	75%	1.33 x ALLOWABLE	2.0
(3) INSTANTANEOUS	0	1.33 x ALLOWABLE	1.3

* From: Criteria for 3DSAD, A Computer Program for Stability Analysis and/or Design of Three Dimensional Gravity Structures, JUN 1978, page 16.

Table 3 - Retaining Wall Stability Criteria*

Case No.	Loading Condition	Sliding Factor of Safety, FS	Overturning Criteria Minimum Effective Base Area in Compression Soil Fnd.	Rock Fnd.	Minimum Bearing Capacity FS
R1	Usual	1.5	100% **	75% **	3.0
R2	Unusual	1.33	75% **	50% **	2.0
R3	Earthquake	1.1	Resultant within base		1.0

* Table 2 is taken from EM 1110-2-2502, 29 Sep 89 Table 4-1 Page 4-5.

** Note: Less base area in compression than the minimum shown may be acceptable provided adequate safety against unacceptable differential settlement and bearing failure is obtained.

TABLE 4 - STABILITY ANALYSIS SUMMARY

	LOADING CASE	IN MIDDLE THIRD	IN BASE	SLIDING FACTOR OF SAFETY(2)	LENGTH OF BASE IN BEARING	BEARING ON ROCK MAXIMUM	PRESSURE KIPS/S.F. MINIMUM
SPILLWAY WEIR							
Typical Section	I	Yes	—	1058.71	40	1.824	1.202
Elev. 745.0	II	Yes	—	70.08	40	1.088	0.869
Height = 16ft.	III	Load Case III not Applicable					
Base = 40ft.	IV	Yes	—	17.49	40	0.621	0.320
	V	Yes	—	81.79	40	1.941	1.085
	VI	Yes	—	34.78	40	1.020	0.937
SPILLWAY WEST							
RETAINING WALL	R-1	Yes	—	66.71	5.5	0.905	0.560
Typ. Section	R-2	Yes	—	66.71	5.5	0.905	0.560
Elev. 785.0	R-3	Yes	—	41.43	5.5	1.211	0.205
Height = 6ft.	(Load Cases II, IV, VI Equivalent)						
Base = 5.5ft.							
SERVICE BRIDGE PIER							
Typ. Section	I	Yes	—	79.88	10.5	14.366	2.336
Elev. 698	II	Yes	—	59.14	10.5	7.783	4.150
Height = 84ft.	IV	Yes	—	39.22	10.5	6.994	3.412
Base = 10.5ft.	V	No	Yes	18.64	7.12	24.662	0.000
	VI	No	Yes	28.70	7.64	20.034	0.000
	Load Case III not applicable						
BRIDGE ABUTMENT							
Section	R-1	Yes	—	38.19	6ft.	7.775	0.864
Elev. 778	R-2	Yes	—	36.40	6ft.	7.517	0.864
Height = 16ft.	R-3	Yes	—	78.69	6ft.	4.796	2.704
Base = 6ft.	(Load Cases II, IV and VI Equivalent)						

TABLE 5 - STABILITY ANALYSIS SUMMARY (FOR INTAKE TOWER)

	LOADING CASE	IN MIDDLE THIRD*	IN BASE	SLIDING FACTOR OF SAFETY	PERCENT BASE IN BEARING	BEARING ON ROCK MAXIMUM	PRESSURE KIPS/S.F. MINIMUM
INTAKE TOWER							
Bottom 569.0	I (N-S)	Yes	—	23	100	10.5	8.3
Top Elev. 823.5	I (E-W)	Yes	—	610	100	9.8	8.0
(Crane +15')	II,III,IV	Yes	—	36	100	6.9	4.0
Base = 40ft.	(combined)						
	V,VI	Yes	—	38	100	8.4	1.9
	IA (N-S)	Yes	—	11.9	100	14.5	4.7
	(w/ E-quake)						
	IIA, IIIA, IVA	Yes*	—	9.6	61	41.5	28.4
	(w/ E-quake)						

*NOTE: Because of Tower 3-D analysis and irregular shape of the base, the resultant may fall within the middle 1/3 of the base but not within the 3D kern. Criteria requires 75% effective base for earthquake loads which the tower has met.

REVIEW OF STRUCTURAL STABILITY

COLEBROOK RIVER LAKE DAM

PART ONE: GENERAL DESCRIPTION

1.1 Purpose

The objective of this study is to review the stability of the existing concrete structures at Colebrook River Lake, based upon the most recent and updated stability criteria. This review is performed to comply with Corps of Engineers regulation ER-1110-2-100, "Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures", dated 8 April 1988. Periodic review of existing projects using current engineering practice is to protect public safety.

The major structural elements and project features analyzed for stability consist of the following:

a. Spillway Weir
b. Spillway West Retaining Wall
c. Service Bridge Pier
d. Service Bridge Abutment
e. Intake Tower with Crane

1.2 Stability Criteria

The current stability criteria and governing regulations by which this project is evaluated are obtained in the following U.S. Army Corps of Engineers publications:

A. ENGINEERING MANUALS:

EM 1110-1-2101	Working Stresses for Structural Design, 1 Nov. 1963 (with change No. 2, 17 Jan. 1972)
EM 1110-2-2200	Gravity Dam Design, 25 Sept. 1958 (with change No. 2, 23 Nov. 1960)
EM 1110-2-2400	Structural Design of Spillways and Outlet Works, 2 Nov. 1964
EM 1110-2-2502	Retaining & Floodwalls, 29 Sept. 1989

B. ENGINEERING TECHNICAL LETTERS:

ETL 1110-2-256	Sliding Stability for Concrete Structures, 24 June 198158

C. ENGINEERING REGULATIONS:

ER-1110-2-100	Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures, 8 April 1988
ER 1110-2-1806	Earthquake Design and Analysis for Corps of Engineer Dams, 16 May 1983

D. Additional Design and Analysis Criteria References:

ACI 318-83	American Concrete Institute, Building Code Requirements for Reinforced Concrete
NAVFAC DM-7.2	Foundations and Earth Structures, Design Manual 7.2, May 1982
ETL 1110-2-184	Gravity Dam Design - Stability, 25 February 1974 (rescinded), (Only, Table I - GRANITIC VARIETIES, was used for pegmatite rock material parameters.)

E. U.S. ARMY CORPS OF ENGINEERS COMPUTER-AIDED STRUCTURAL ENGINEERING (CASE) PROJECT DOCUMENTS:

A Three-Dimensional Stability Analysis/Design Program (3DSAD) Report 4 Special-Purpose Module for Dams (CDAMS) AUG 1983

CORPS Library program "A Three-Dimensional Stability Analysis/Design Program (3DSAD)" X8100E (edition E 1989, PC version)

Criteria for 3DSAD : A Computer Program for Stability Analysis and/or Design of Three Dimensional Gravity Structures (CASE Task Group on 3-D Stability Analysis, June 1978)

F. NEW ENGLAND DIVISION DOCUMENTS:

Design Memorandum Report No. 10, Detail Design of Structures, COLEBROOK RIVER DAM & RESERVOIR, September 1964

Periodic Inspection Report No. 1, Colebrook River Lake, Feb. 1972

Periodic Inspection Report No. 4, Colebrook River Lake, July 1989

Record Drawings - Colebrook River Dam, Jan. 1965

1.3 Method of Computation:

The methods used were a combination of manual calculations and computer modeling. The computer program used was CORPS library CASE program "A Three-Dimensional Stability Analysis/Design Program (3DSAD)" X8100E (edition E, PC version). Manual calculations were performed on the tower, other structure calculations were performed using 3DSAD.

There are minor differences between the stability criteria between 3DSAD and EM-1110-2-2200 Gravity Dam Design. The 3DSAD program criteria for gravity dam overturning and bearing for the Category 2 (short-term) and Category3 (earthquake) load cases, are similar to the criteria for retaining wall Unusual loading R-2, and Instantaneous loading R-3. For this analysis retaining walls were modeled as non-overflow gravity structures. By adjustment of 3DSAD input for soil parameters, ground water level and water surface, Gravity Dam Load Cases II IV, and VI became equivalent and simulated Retaining Wall Load Cases R-1, R-2 ,R-3.

1.4 Project Description

a. Colebrook River Lake dam embankment is located on the West Branch, Farmington River, in the town of Colebrook, Connecticut, 3.9 miles above its confluence with the Still River. The dam was constructed for the purposes of flood control, water supply, and fish and wildlife conservation. It was completed in June 1969. A hydro-power turbine was installed in the outlet works tunnel and 22 ton crane was installed on top of the tower in 1988.

b. The dam embankment is 1300' long, consisting of zoned rolled earth construction with an impervious fill core. Embankment slopes are compacted pervious fill, compacted gravel fill, covered by a three zone rock fill blanket. Under the impervious core is a grouted concrete cutoff curtain. Top of dam elevation is 790.0' National Geodetic Vertical Datum of 1929 (NGVD). The crest is 30' wide, topped by an 18' wide access road, and is approximately 223' above the original streambed. The reservoir is normally maintained at elevation 717' NGVD for water supply purposes. A chute type spillway, 198' wide at the spillway ogee weir (crest 520.0'NGVD), is cut through rock along the eastern side of the embankment. The outlet works consists of a normally submerged intake channel, intake tower with three gates, a 10' diameter tunnel, and a normally submerged outlet structure.

1.5 Pertinent Hydraulic Data

a. The hydraulic data used for this review are as follows:

Full Pool Condition: Reservoir at spillway crest elevation 761'NGVD, no tail water.

Flood Discharge Condition - Maximum surcharge condition at elevation 785'NGVD, spillway tailwater at elevation 761'NGVD.

b. Major impoundments are:

Stage (NGVD)	% Full	Date
757.5	90	June 1984
747.1	68	April 1983
739.8	53	July 1972
734.2	42	June 1979

1.6 Discussion of Stability Analysis and Criteria

A. Background:

The original design calculations, were based on EM 1110-2-2200 Gravity Dam Design, 25 September 1958 and, EM 1110-2-2400 Structural Design of Spillways and Outlet Works. The retaining walls were designed using EM 1110-2-2502 Retaining Walls, 29 May 1961. The process of designing the project structures consisted of selection of the section geometry, applying service loads and then analysis of three stability factors: overturning, sliding, and bearing.

B. Overturning:

The resistance to overturning by the structure is determined by determination of where the resultant of all forces is located on the structure base. For hydraulic structures the resultant should be located within the middle third of the base (the "kern") for all loading cases, except earthquake loading. For earthquake loading cases, it is acceptable for the resultant to fall outside the kern but must be within the base, provided that allowable foundation bearing pressures are not exceeded. For retaining walls, the resultant of all applied loads should fall within the middle third of the base, however if the wall bears on rock, a location farther out is permissible if sliding and foundation pressure criteria are satisfied.

C. Sliding:

For the outlet works (spillway and tower), under normal and flood loading conditions a 2.0 sliding factor of safety is required; for earthquake loading this is reduced to 1.3. For gravity walls and the bridge abutment the required sliding factor is 1.5 for usual loading (R-1), 1.33 for Unusual (R-2), and 1.1 for Earthquake (R-3).

Sliding theory and design criteria has undergone the largest amount of evolution since project design. The Sliding Resistance Method (basically an empirical limiting ratio) was used by the designer to select section dimensions. Sliding Resistance Method ratio is:

$$(H/V) > 0.65$$

The designers then checked the selected section for the sliding factor of safety, S s-f, using a modified early form of the Shear Friction Method, based on Henny, and defined by:

$$S\ s\text{-}f = fV + rSA/H > 4.0$$

S (shear friction) = 0.5 and f= .65 were assumed by the designer.

Sliding stability of structures subjected to lateral loadings is now governed by the criteria outlined in ETL 1110-2-256: Sliding Stability for Concrete Structures 24 June 1981 and adapted in EM 1110-2-2502 Retaining & Floodwalls 29 Sept. 1989. Current acceptable sliding stability approaches, are a Multiple Wedge model using Mohr-Coulomb theory and an Alternate Method of Analysis (the "Expanded" Shear Friction Method) using a single wedge model.

The Multiple Wedge Approach considers the effects of a structural wedge acted on by both an active and passive sides of multiple soil wedges and multiple failure planes. Each wedge is considered to have homogeneous soil parameters and is assumed to shear along the unique shear failure plane of that soil.

This approach is appropriate when soil conditions are well known and detailed design is required for economic reasons.

The Alternate Method of Analysis, (Expanded Shear Friction Method), which was used in this analysis, combines Mohr-Coulomb theory and refinements to Henny's work. The analytical model is a single structural wedge acted on by service loads, and the shear failure plane is assumed to be the structure's interface of concrete base and foundation material. Colebrook River Lake structures have horizontal foundations or, in the case of the anchored spillway wall, "the clip angle" assumed along the construction joint is horizontal. With assumed horizontal failure plane, the Governing Wedge Equation reduces to:

$$FS = (cA+(V-U)\tan \phi)/H \quad > \quad 2.0$$

Solving for FS > 2 (1.3 for earthquake) is an interation process governed by careful consideration of soil parameters. Although the usual analysis uses at-rest soil pressures, application of lateral earth passive pressure is allowed if such conditions can develop. At areas subject to scour it is best to neglect resisting soil wedge.

D. Bearing:

Bearing failure of structures founded on sound rock is not common. Simply stated a failure is the exceeding of the maximum allowable bearing pressure q_{all} (a function of f'c compressive strength) of the concrete or the foundation material. This can cause unsatisfactory structure rotation by a material or a shear failure. The shear failure plane is a function of the angle of internal friction of a non-stratified homogeneous material. The shear failure plane in stratified materials usually occurs along the defined bedding planes. The structures analyzed in this report are founded on sound pegmatite granite rock, a non-stratified type of rock.

1.7 SERVICE LOADS:

A. Seismic: The original design calculations used a 0.05 g acceleration coefficient for seismic effects on the outlet works. The spillway weir and north spillway retaining wall were not analyzed for seismic. For this analysis, a pseudodynamic, static seismic analysis is performed on all structures using a coefficient of 0.1 g (from Table 1 moderate zone in ER 1110-2-1806: Earthquake Design and Analysis for Corps of Engineers Projects. Colebrook River Lake is in Seismic Zone 2 (moderate damage) on the Seismic Zone Map of Contiguous United States of America (TM 5-809-10 Seismic Design for Buildings Fig 3-1.)

In accordance with EM-1110-2-2200: Gravity Dam Design, two types of earthquake forces are applied to the hydraulic structures: inertia forces of the structure itself, and hydrodynamic forces resulting from the reaction of reservoir water. The inertia force of the structure is computed by the principle of mass times acceleration, and acts through the center of gravity of the tower. The hydrodynamic force uses a parabolic distribution based on Westagaard's work, to approximate the pressure on the structure due to the reservoir water during an earthquake.

For retaining walls, lateral forces produced by horizontal seismic accelerations of the backfill and the concrete section are applied, in addition to the static forces, to the center of gravity of the structural section. (EM 1110-2-2502 Retaining & Floodwalls 29 Sept. 1989)

B. Uplift: Uplift pressure at any point under a structure is the tailwater pressure plus the pressure measured along the hydraulic gradient between the upstream and downstream pool. Uplift pressure is considered to act over 100% of the area upon which it occurs. The line of creep method was used to determine uplift at a point.

C. Wind: A wind pressure of 30 pounds per square foot is used in this stability analysis. (EM 1110-2-2200: Gravity Dam Design)

D. Ice : The ice loading for this analysis was neglected for all structures. Ice pressure of 6000 psf was applied to the tower in the original design memorandum. Ice is considered not valid, due to the conservative conditions analyzed. The full pool "normal" condition is 44'± above the long term conservation pool. Large pool stage rise, coupled with the distance of the tower from the embankment make ice loads highly unlikely during critical events. Ice has not historically been a problem; valid significant ice loads at Colebrook during major events is questionable and therefore is neglected.

1.7 STABILITY ANALYSIS LOAD CASES :

The various Engineering Manual load cases are specific by type of gravity structure. The computer program 3DSAD load cases are described in a slightly more general way. The description of the load cases extracted from the various criteria sources are as follows:

A. GRAVITY DAMS AND SPILLWAY WEIR: From EM 1110-2-2200: Gravity Dam Design

Case I: Construction Condition. Spillway completed but no water in reservoir, no tailwater, and wind load on the downstream face.

Case II: Normal Operating Condition. Pool elevation at spillway crest. Minimum tailwater. Ice if applicable.

Case III: Induced Surcharge Condition. Pool elevation at top of partially opened spillway gate. (This load case is not applicable to because the spillway at Colebrook River Lake is not gated.)

Case IV: Flood Discharge Condition. Reservoir at maximum flood pool (surcharge) elevation and height over spillway crest. Tailwater pressure at about 0.6 of flood surcharge height, except that full value is used for computation of the uplift. Tailwater weight acts on downside of spillway. No ice pressure.

Case V: Construction Condition with Earthquake. Earthquake acceleration in a downstream direction. No water in reservoir. No wind load. No tailwater.

Case VI: Normal Operating Condition with Earthquake. Earthquake acceleration in an upstream direction. Reservoir at spillway crest. Minimum tailwater. No ice pressure.

B. OUTLET WORKS: From EM 1110-2-2400 Structural Design of Spillways and Outlet Works, 2 Nov. 1964 (Para 3-07 c. Stability of Gate Structure at Upstream End)

(NOTE: For this analysis of the tower, Cases II, III and IV, were combined due to the "normal" pool stage being at spillway crest. Cases V and VI were also combined due to balanced gate operating procedures during flood events.)

Case I:

(a) Reservoir empty.
(b) Dead load of structure.
(c) Wind load in direction to produce most severe foundation pressures.

Case II:

(a) Gate Structure operating at maximum operating pool with all gates open.
(b) Dead load of structure.
(c) Reservoir at full flood control storage pool. (Top of spillway crest)
(d) Earth loads (if any)
(e) Ice pressure, if applicable.
(f) 100 percent uplift on base over 100 percent of area.
(g) Water surface inside structure drawn down to hydraulic gradient with all gates open.

Case III:

(a) Gate Structure operating at maximum operating pool with one outside gate c closed others open.
(b) Dead load of structure.
(c) Reservoir at full flood control storage pool. (Top of spillway crest).
(d) Earth loads (if any)
(e) Ice pressure, if applicable.
(f) 100 percent uplift on base over 100 percent of area.
(g) Service or emergency gate in one outside passage closed(Whichever gives more severe condition).
(h) Well full of water upstream from closed gate.
(i) Other gates open with water drawn down to hydraulic gradient in remainder of structure.

Case IV:

(a) Gate Structure with all gates closed.
(b) No Flow in conduits.
(c) Dead load of structure.
(d) Reservoir at full flood control storage pool. (Top of spillway crest).
(e) Earth loads (if any)
(f) Ice pressure, if applicable.

(g) 100 percent uplift on base over 100 percent of area.
(h) One Gate (service or emergency) closed in each passage in combination causing most severe condition. Conduit empty down stream.
(j) Structure full of water upstream from closed gates.

Case V:
(a) Reservoir raised to spillway design flood level for whichever of preceding Case II,III,IV is most critical.
(b) No ice pressure.

Case VI:
(a) Bulkheads in place.
(b) Dead load of structure.
(c) Reservoir at maximum pool bulkheads are used (Design flood pool.)
(d) Earth loads (if any).
(e) Ice pressure, if applicable.
(f) All bulkheads in place no water in structure.

Case IA, IIA, IIIA or IVA:
Same as Case I,II,III,or IV with earthquake load added if applicable, except that earthquake is substituted for wind in Case IA and for ice in other cases.

C. RETAINING WALLS: From EM 1110-2-2502, Retaining & Floodwalls, 29 Sept. 1989

Case R1 - Usual Loading: Backfill in place to final elevation. Surcharge is not applicable for these structures. The backfill is dry or moist or partially saturated, as the case may be; existing lateral and uplift pressures due to water are applied. Uplift pressure due to water surface elevation above the bottom of the wall analysis clip plane.

Case R2 - Unusual Loading: The same as Case R1 except for the water table level in the backfill rises for a Short duration, or another type of loading of Short duration is applied; e.g., high wind loads, equipment surcharge during construction. Flood discharge conditions exist.

Case R-3 - Earthquake Loading: This is the same as Case R1 with the addition of earthquake-induced lateral and vertical loads. The uplift is the same as for Case R1.

D. GENERAL HYDRAULIC 3D GRAVITY STRUCTURES (3DSAD): From the Criteria For 3DSAD a Computer Program for Stability Analysis and/or Design of Three Dimensional Gravity Structures, June 1978.

NOTE: Load categories, (1 - Long term, 2 - Short term, 3 - Instantaneous)

Case I: Construction Condition (Category 1) - Dead load of structure with addition of active earth backfill or silt, and wind load in most critical direction.

Case II: Normal Operating Condition. (Category 1, equivalent to R-1) Dead load of structure: active earth backfill or silt; headwater at spillway crest; minimum tailwater; ice pressure if any.

Case III: Induced Surcharge Condition. (Category 2) This load case is not applicable because the spillway at Colebrook River Lake is not gated.

Case IV: Spillway Design Flood Discharge Condition. (Category 2, equivalent to R-2) Dead load of structure with addition of active earth backfill or silt; headwater at spillway design flood elevation; all gates open; tailwater at sixty percent of full overflow value, with full uplift.

Case V: Construction Condition with Earthquake. (Category 3) Earthquake acceleration in a downstream direction. No water in reservoir. No wind load. No tailwater.

Case VI: Normal Operating Condition with Earthquake. (Category 3, equivalent to R-1) Normal Operating condition with additional lateral loads due to earthquake in most critical direction. No ice load.

1.9 Field Observation:

Periodic Inspection No. 4 was conducted 13, July 1989, no deficiencies indicating stability problems were found. The general condition of concrete in all structures in the study are normal, showing expected deterioration based on age and climate.

1.10 Discussion of Foundations and Foundation Parameters:

The "state of the art" in geology and foundations has changed since Colebrook River Lake design in 1960. When interpreting the structural analysis results, it is essential to understand the accuracy limitation due to the assumptions made for foundation parameters. The foundation material parameters, are based on review of the following:

1. Record drawings of borings locations and logs.
2. Design Memorandum No. 3 Site Geology
3. EM 1110-2-2200 Gravity Dam Design, 25 Sept. 1958 (with change No. 2, 23 Nov. 1960)
4. ETL 1110-2-184 Gravity Dam Design - Stability, 25 February 1974 (rescinded), Table I - GRANITIC VARIETIES,(used for pegmatite values only)
5. American Concrete Institute, Building Code Requirements for Reinforced Concrete (ACI 318-83), section 17.5 Horizontal shear strength.
6. NAVFAC DM-7.2 Foundations and Earth Structures, Design Manual 7.2, May 1982, Table 1 - Presumptive Values of Allowable Bearing Pressures

Important borings were FD08 at the intake tower, FD15 at the bridge pier, FD47 at spillway and FD6 at the outlet. Sliding and bearing calculations assume the failure plane at the concrete/rock interface.

PART 2: RESULTS OF THE ANALYSIS

2.1 Spillway Weir: The actual as-built spillway weir meets current stability criteria.

Note that there is a difference in the weir section between the Design Memorandum #10, and the as-built plans. Disregard design memorandum calculations and diagram labeled Case III for Maximum Design Flood. The Design Memorandum shows a reduced base with the force resultant outside the middle third of the base (the kern). This violated overturning criteria outline in EM 1110-2-2200 Gravity Dam Design. The weir design was modified sometime after design memorandum submission, with changes to the base elevation and inclusion of a grout cutoff under the weir centerline, the as-built section is stable in overturning.

2.2 West Spillway Retaining Wall: The wall meets all current stability criteria.

Only the top six feet of the west spillway retaining wall acts as a gravity retaining wall, and this section was analyzed using 3DSAD. It was modeled as a non-overflow monolith. The geometry is exact, the depth of the monolith is 20', based on the contraction joint spacing, and the assumed sliding failure plane (clip plane) is the construction joint at EL-785.0 NGVD.

2.3 Service Bridge Pier: The bridge pier meets all current stability criteria.

The bridge pier was analyzed as a gravity structure using 3DSAD. The bridge pier geometry was modeled in three sections, two overflow and one non-overflow. Batter slope on the long axis was not able to be modeled due to the limitation of the program CDAMS module, but differences are negligible. The pier is founded on rock, and any lateral bracing by the bridge deck was neglected. Bridge bearing reactions were applied as a concentric 340 kips point load. For Case VI (Normal with earthquake), the headwater was the long term pool at 715' NGVD. The results show a reduced effective base for Case V and VI earthquake loading, but with the resultant well within the base. Sliding and bearing were well within limits.

2.4 Service Bridge Abutment: The bridge abutment meets all current stability criteria.

The bridge abutment was analyzed as a 3-D gravity structure using 3DSAD, the bridge abutment geometry was computer modeled as a three section monolith, two overflow and one non-overflow section. Any differences in geometry due to limitations of the CDAMS module are negligible.

The abutment is cast against rock, in a box-like cut of sound pegmatite at an exposed spur of bedrock at the dam embankment. Cut rock does not exert lateral soil pressure. Soil loading would only occur if the entire rock driving wedge developed a failure plane.

In the flood case R-2 the abutment has a slightly reduced effective base (99%) as the resultant falls outside the 3-D kern. The percent of effective base is well above the required 50% (on rock). Sliding and bearing were all within limits.

2.5 Intake Tower with Crane: The Intake tower meets all current stability criteria.

Final design of the Colebrook River Lake Tower is slightly different than the typical tower outline in para 3-07 Stability of Gate Structure Upstream, EM 1110-2-2400 Structural Design of Spillways and Outlet Works, 2 November 1964. The Colebrook River Lake Tower is a dry-well type and both the intake and outlet are submerged. The tower was analyzed with manual calculations for Case I (Construction), a combined load Case II,III,IV (Normal), and a combined load Case V, VI (Flood). Differences from the design memorandum calculations include addition of the force from the new 22 ton crane, an increase of the seismic acceleration coefficient to 0.1 g and inclusion of the force from the concrete stoplog structure. The rational to combine load cases was a submerged conduit combined with standard operating procedures which preclude non-symmetric gate operation during critical events. These make the differences between analyses load cases very minor.

During earthquake the resultants of the tower falls outside 3-D kern, but within the base meeting overturning criteria for instantaneous loading. The reduced effective base is 61%. Sliding and bearing meet criteria for instantaneous loading.

Part 3 - Colebrook River Lake Drawings

INDEX OF SELECTED RECORD DRAWINGS

Plate No.	Title	Dwg. No.
1	Watershed Map	
2	General Plan	Con-16, Sh 3
3	Dam - Embankment Plan	Con-16, Sh 4
4	Dam - Typical Embankment Sections	Con-16, Sh 5
5	Dam - Embankment Profile and Section	Con-16, Sh 6
6	Dam - Grouting Details	Con-16, Sh 7
7	Outlet Works and Spillway - Plan	Con-16, Sh 8
8	Spillway - Profile and Sections	Con-16, Sh 9
9	Spillway - Concrete Plan and Sections	Con-16, Sh 9
10	Outlet Works - Profile and Sections	Con-16, Sh 10
11	Outlet Works - Inlet Channel - Concrete Details	Con-16, Sh 11
12	Outlet Works - Intake Tower, Sectional Plan at El. 575.0 & Gate Chamber	Con-16, Sh 14
13	Outlet Works - Intake Tower, Sections to El. 657.0	Con-16, Sh 12
14	Transition and Tunnel - Concrete Sections	Con-16, Sh 49
15	Dike and Access Road - Plan and Profile	Con-16, Sh 50
16	Dike Typical Embankment Sections	Con-16, Sh 60
17	Dam - Plan of Foundation Explorations	Con-16, Sh 66
18	Detailed Plan of Explorations - Spillway and Outlet Works	Con-16, Sh 67
19	Dam - Geologic Log Sections	Con-16, Sh 67
20	Outlet Works - Geologic Log Sections	Con-16, Sh 70
21	Plan and Record of Explorations - Dike	Con-16, Sh 76
22	Service Bridge - Structural Details No.1	Con-16, Sh 55
23	Service Bridge - Structural Details No.2	Con-16, Sh 56
24	Service Bridge - Pier and Abutment Details	Con-16, Sh 57
25	Stability Diagrams	DM #10, Pl 10-4
26	Outlet Works - Structural Details	DM #10, Pl 10-3
27	22 Ton Bridge Crane (FERC Design Anal.)	Page 6 of 38

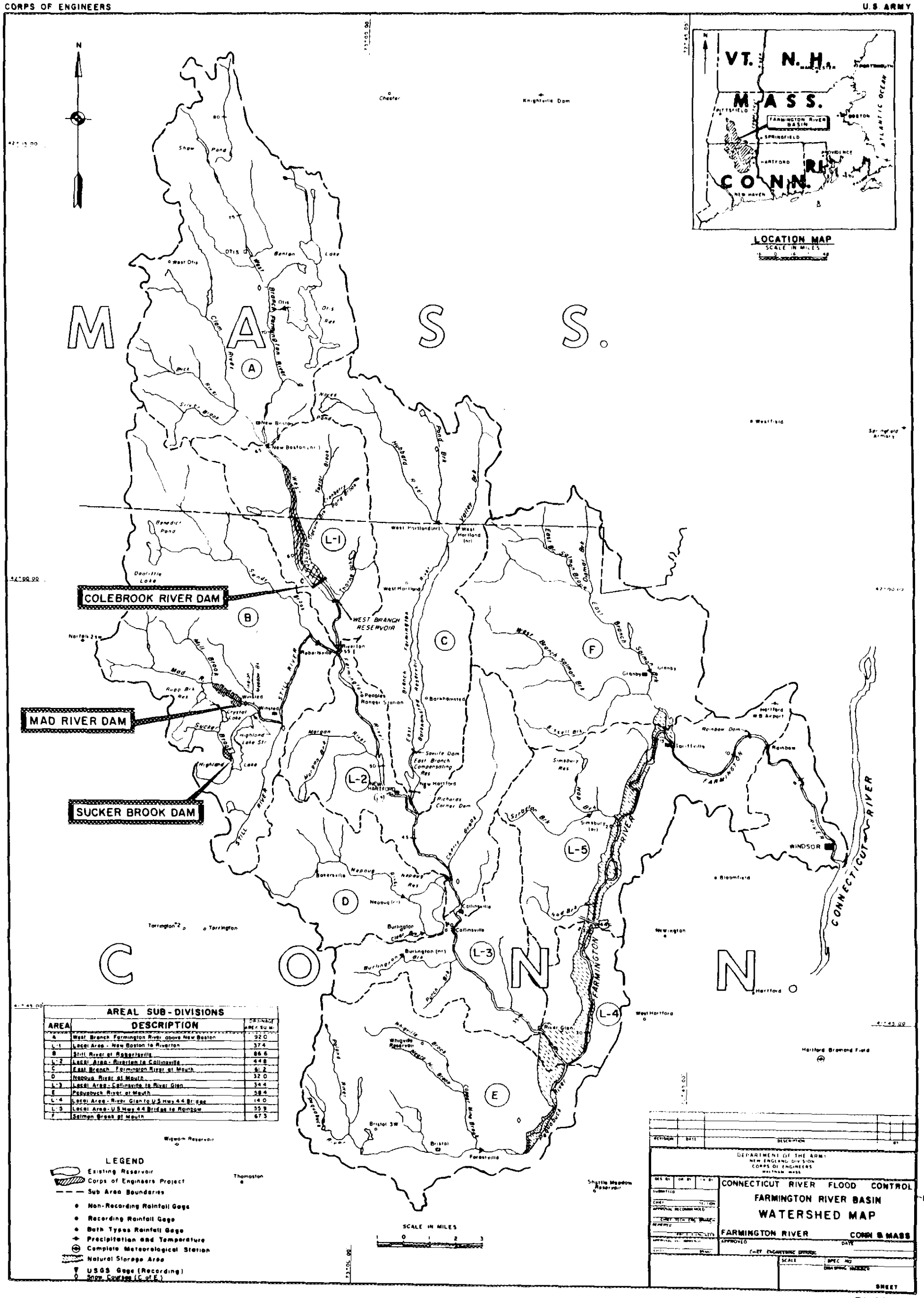
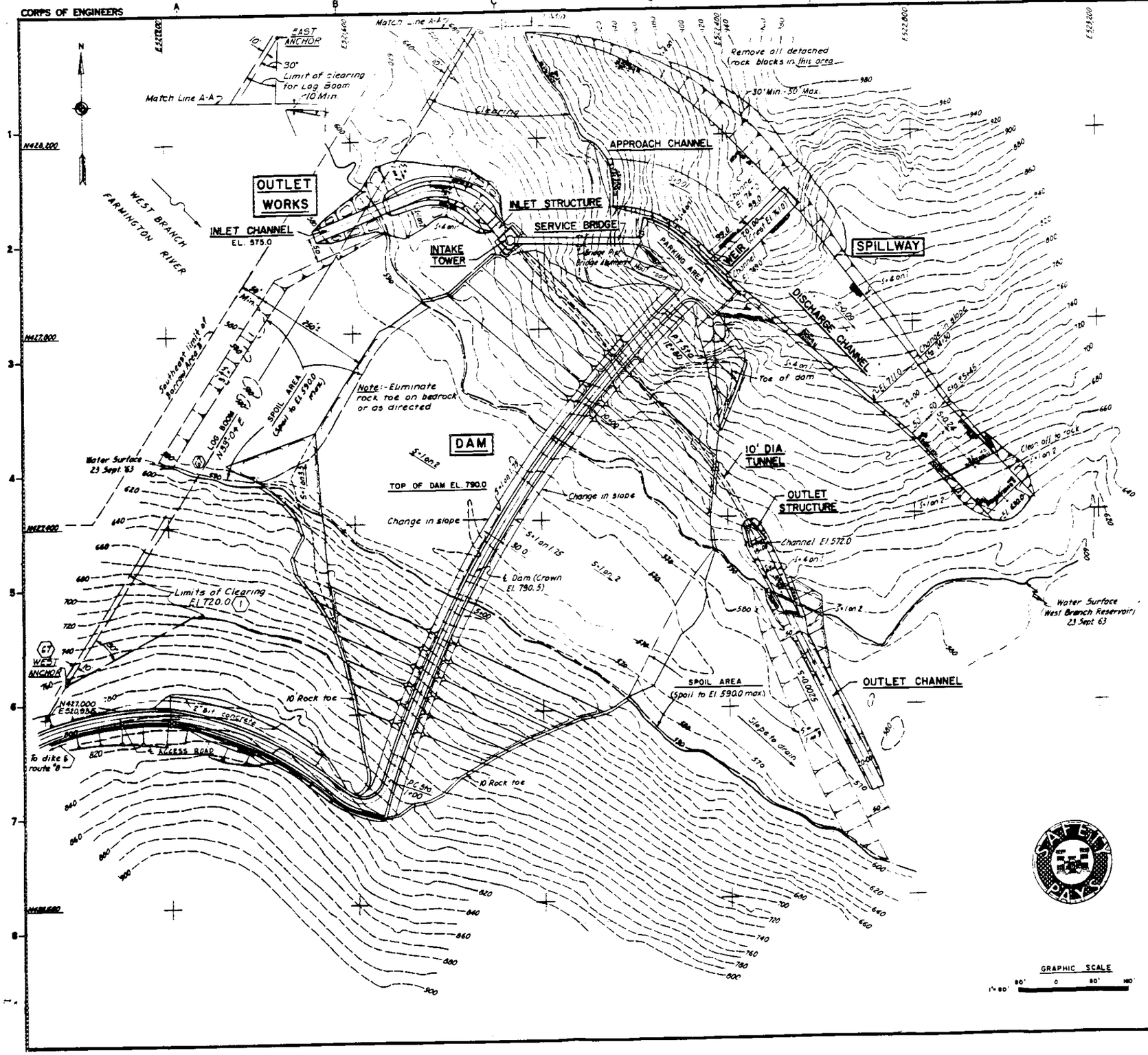

M A S S.
C O N N.
VT.
N.H.
MASS.
R.I.
CONN.
ATLANTIC OCEAN
FARMINGTON RIVER BASIN
LOCATION MAP
SCALE IN MILES
COLEBROOK RIVER DAM
MAD RIVER DAM
SUCKER BROOK DAM
WEST BRANCH RESERVOIR
Knightville Dam
Chester
Otis
West Otis
Shaw Pond
Benton Lake
New Boston
Hubbard River
West Hartland
Riverton
Robertsville
Winsted
Peoples Ranger Station
Barkhamsted
Saville Dam East Branch Compensating Res
New Hartford
Richards Corner Dam
Simsbury Res
Tariffville
Rainbow Dam
Rainbow
Hartford
WINDSOR
Bloomfield
Newington
West Hartford
Hartford Brainard Field
Bristol
Forestville
Burlington
Collinsville
Nepaug Res
Torrington
Thomaston
Wigwam Reservoir
Shuttle Meadow Reservoir
CONNECTICUT RIVER
FARMINGTON RIVER
A
B
C
D
E
F
L-1
L-2
L-3
L-4
L-5
AREAL SUB-DIVISIONS
AREA | DESCRIPTION | DRAINAGE AREA SQ MI
A | West Branch Farmington River above New Boston | 92.0
L-1 | Local Area - New Boston to Riverton | 37.4
B | Still River at Robertsville | 86.6
L-2 | Local Area - Riverton to Collinsville | 44.8
C | East Branch Farmington River at Mouth | 91.2
D | Nepaug River at Mouth | 32.0
L-3 | Local Area - Collinsville to River Glen | 34.4
E | Pequabuck River at Mouth | 58.4
L-4 | Local Area - River Glen to U.S. Hwy 44 Bridge | 14.0
L-5 | Local Area - U.S. Hwy 44 Bridge to Rainbow | 55.9
F | Salmon Brook at Mouth | 67.3
LEGEND
Existing Reservoir
Corps of Engineers Project
Sub Area Boundaries
Non-Recording Rainfall Gage
Recording Rainfall Gage
Both Types Rainfall Gage
Precipitation and Temperature
Complete Meteorological Station
Natural Storage Area
USGS Gage (Recording)
Snow Courses (C. of E.)
SCALE IN MILES
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
CONNECTICUT RIVER FLOOD CONTROL
FARMINGTON RIVER BASIN
WATERSHED MAP
FARMINGTON RIVER
CONN & MASS
APPROVED
SCALE
SPEC NO
SHEET

PLATE 1

CORPS OF ENGINEERS

U. S. ARMY



LEGEND - EXTERIOR FEATURES

NEW	EXISTING	DESCRIPTION
20	20	Contours
x147	147	Elevations
		Chain Link fence
		Paved Areas
		Tree Line
		Ditch - Grade to Drain
		Rock or Ledge Outcrop
		Limit of Contractor's Work Area
		Earth Cut and Rock Cut
		Earth Fill
		Earth Surface (Section)
		Assumed Rock Surface or Rock Cut (Section)
		Earth Cut with Rock Slope Protection
		Earth Fill with Rock Fill on Slope
GR		Cable Guide Rail
DI		Drain inlet
DMH		Drain manhole
SD		Storm Drain
C	C	Culvert
W		Water Line
SS		Sewer Line
		Swamp
	E	Electric Line - Overhead
		Secondary Line - Overhead

GENERAL NOTES

1. Elevations refer to Mean Sea Level Datum
2. Plane Coordinates refer to Connecticut Lambert Grid System.
3. Figures in hexagons indicate Item Numbers under which Payment will be made.
4. For limits of Contractors Work Area, see Sheet 2.

NOTES

1. For Embankment Plan, Profile, Sections & Details see Sheets 4, 5, and 6.
2. For Grouting Details, see Sheet 7.
3. For Spillway & Outlet Works Plan see Sheet 8.
4. For Spillway Profile, Sections and Concrete Details see Sheets 9 and 10.
5. For Outlet Works Profile Concrete, Mechanical and Electrical Details, see Sheets 11 thru 52.
6. For Dike and Access Road Plans, Profiles, Sections and Details, see Sheets 59 thru 64.
7. For Parking Area details see Sheet 54.
8. For complete limits of Borrow Area "B" see Sheet 77.

REVISION	DATE	DESCRIPTION	BY
		Final field corrections	

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

CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
GENERAL PLAN

WEST BRANCH-FARMINGTON RIVER — CONN & MASS

DATE JAN 1965

SCALE 1" = 80'

CON - 16

SHEET

PLATE 2

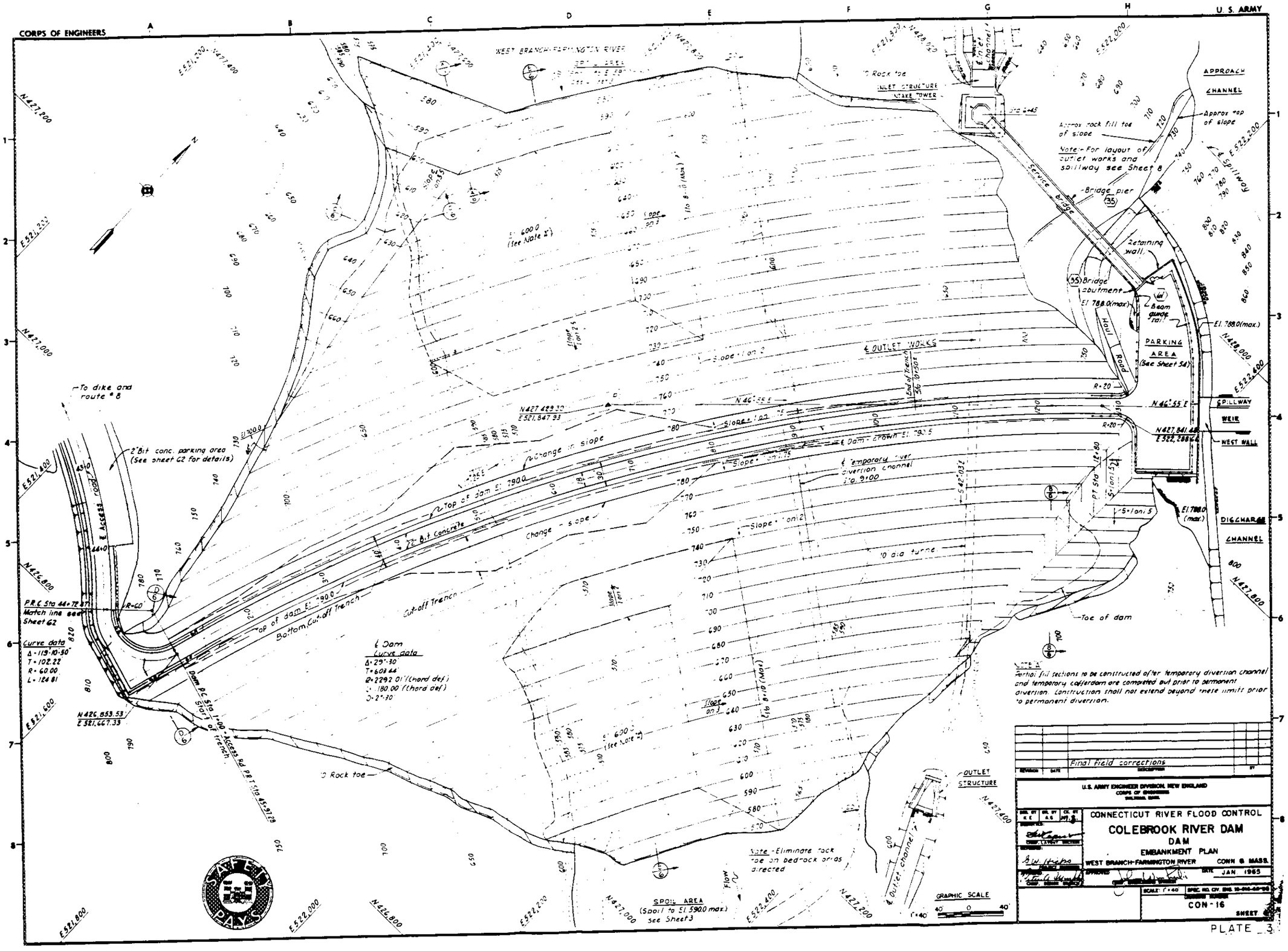
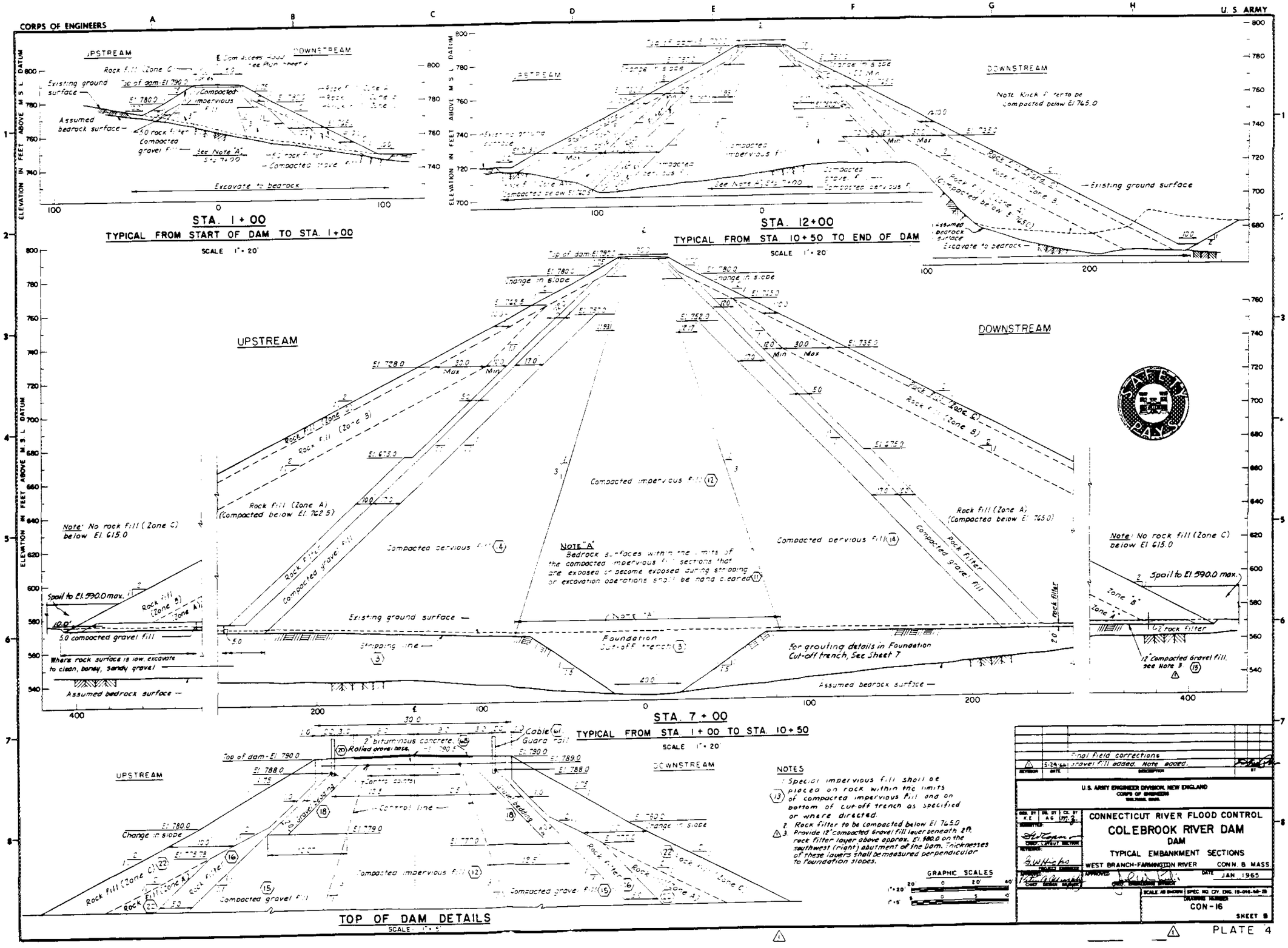

CORPS OF ENGINEERS
U. S. ARMY
WEST BRANCH-FARMINGTON RIVER
INLET STRUCTURE
INTAKE TOWER
APPROACH CHANNEL
Approx top of slope
Approx rock fill toe of slope
Note - For layout of outlet works and spillway see Sheet 8
Service bridge
Bridge pier
Retaining wall
Bridge abutment
Beam guide rail
El. 788.0 (max.)
Haul Road
PARKING AREA (See Sheet 54)
SPILLWAY WEIR
WEST WALL
DISCHARGE CHANNEL
℄ OUTLET WORKS
℄ Temporary river diversion channel
Top of dam El. 790.0
Bottom Cut-off Trench
Cut-off Trench
Change in slope
Toe of dam
To dike and route #8
2" Bit conc. parking area (See sheet 62 for details)
℄ Access road
P.R.C. Sta 44+72.87 Match line see Sheet 62
Curve data
Δ = 119°-10'-50"
T = 102.22
R = 60.00
L = 124.81
℄ Dam
Curve data
Δ = 29°-30'
T = 603.44
R = 2292.01' (Chord def)
L = 1180.00' (Chord def)
D = 2°-30'
Dam P.C. Sta 1+00 - Access Rd P.R.T. Sta 45+97.28
Start of trench
Rock toe
OUTLET STRUCTURE
℄ Outlet channel
Note - Eliminate rock toe on bedrock areas directed
SPOIL AREA (Spoil to El. 590.0 max.) see Sheet 3
GRAPHIC SCALE
Note "A"
Partial fill sections to be constructed after temporary diversion channel and temporary cofferdam are completed but prior to permanent diversion. Construction shall not extend beyond these limits prior to permanent diversion.
Final field corrections
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
DAM
EMBANKMENT PLAN
WEST BRANCH-FARMINGTON RIVER
CONN & MASS.
JAN. 1965
CON-16
SAFETY PAYS

PLATE 3

CORPS OF ENGINEERS

U. S. ARMY



NOTES

1. Special impervious fill shall be placed on rock within the limits of compacted impervious fill and on bottom of cut-off trench as specified or where directed.
2. Rock filter to be compacted below El 745.0
3. Provide 12" compacted gravel fill layer beneath 2 ft. rock filter layer above approx. El. 590.0 on the southwest (right) abutment of the Dam. Thicknesses of these layers shall be measured perpendicular to foundation slopes.

GRAPHIC SCALES

REVISION	DATE	DESCRIPTION	BY
1	5-24-65	Final field corrections gravel fill added. Note added.	

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

CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
DAM
TYPICAL EMBANKMENT SECTIONS
WEST BRANCH-FARMINGTON RIVER CONN. & MASS.

DATE JAN 1965

SCALE AS SHOWN | SPEC. NO. CIV. ENG. 19-016-65-23

DRAWING NUMBER CON-16

SHEET 8

PLATE 4

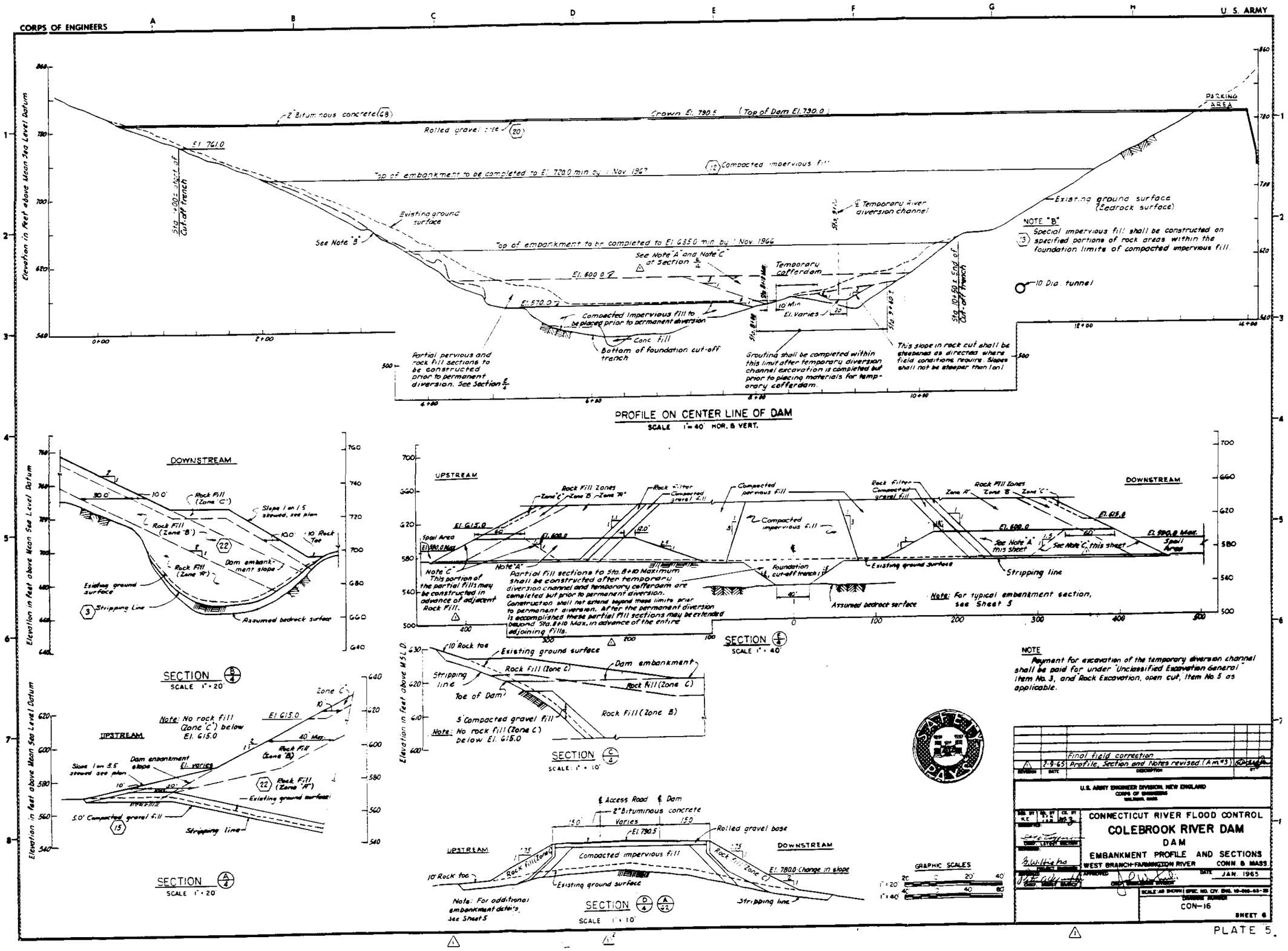
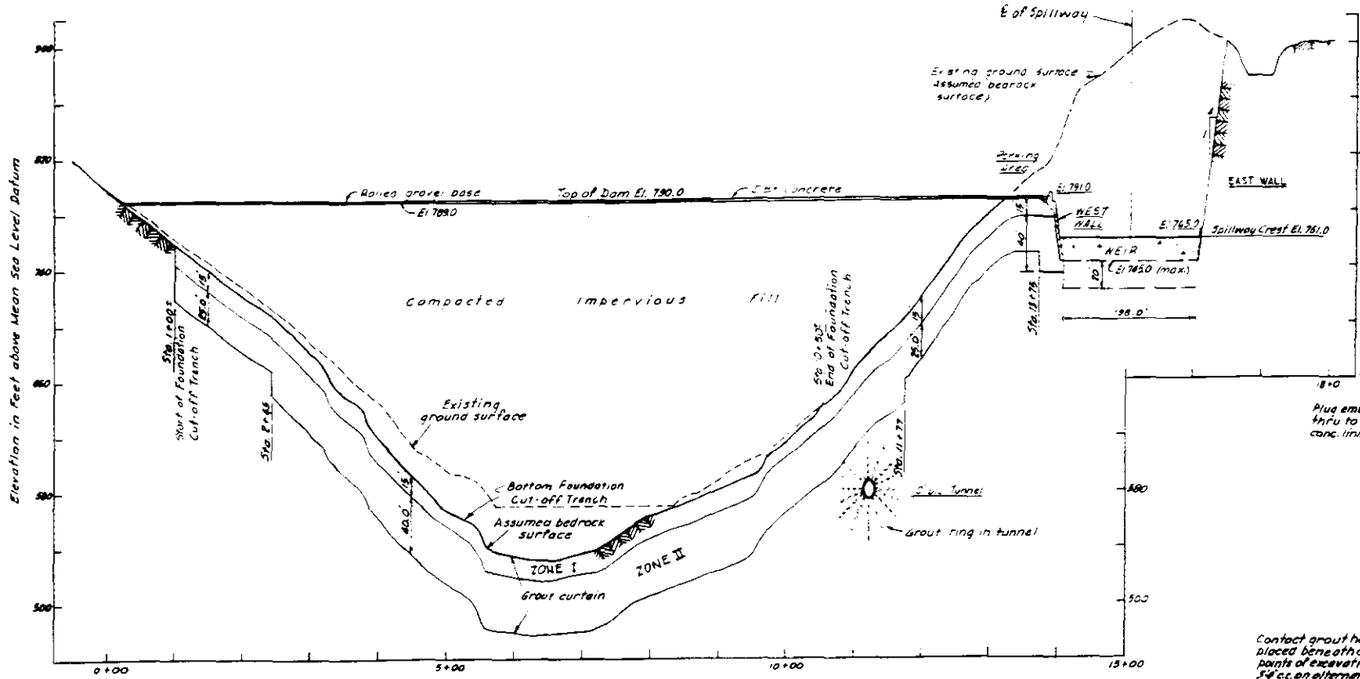

CORPS OF ENGINEERS
U. S. ARMY
PROFILE ON CENTER LINE OF DAM
SCALE 1" = 40' HOR. & VERT.
Crown El. 790.5 (Top of Dam El. 790.0)
Rolled gravel base
Top of embankment to be completed to El. 720.0 min by 1 Nov. 1967
Compacted impervious fill
Existing ground surface
Existing ground surface (Bedrock surface)
Temporary River diversion channel
Temporary cofferdam
Compacted impervious fill to be placed prior to permanent diversion
Conc. fill
Bottom of foundation cut-off trench
Partial pervious and rock fill sections to be constructed prior to permanent diversion. See Section E/4
Grouting shall be completed within this limit after temporary diversion channel excavation is completed but prior to placing materials for temporary cofferdam.
This slope in rock cut shall be steepened as directed where field conditions require. Slopes shall not be steeper than 1 on 1
10 Dia. tunnel
NOTE "B"
Special impervious fill shall be constructed on specified portions of rock areas within the foundation limits of compacted impervious fill.
PARKING AREA
Elevation in Feet above Mean Sea Level Datum
DOWNSTREAM
Rock Fill (Zone "C")
Rock Fill (Zone "B")
Rock Fill (Zone "A")
Dam embankment slope
Existing ground surface
Stripping Line
Assumed bedrock surface
SECTION B/4
SCALE 1" = 20'
UPSTREAM
Rock Fill Zones
Rock filter
Compacted gravel fill
Compacted pervious fill
Compacted impervious fill
Spoil Area
Note "C" This portion of the partial fills may be constructed in advance of adjacent Rock Fill.
Note "A" Partial fill sections to Sta. 8+10 Maximum shall be constructed after temporary diversion channel and temporary cofferdam are completed but prior to permanent diversion. Construction shall not extend beyond these limits prior to permanent diversion. After the permanent diversion is accomplished these partial fill sections may be extended beyond Sta. 8+10 Max. in advance of the entire adjoining fills.
Foundation cut-off trench
Existing ground surface
Stripping line
Assumed bedrock surface
Note: For typical embankment section, see Sheet 5
SECTION E/4
SCALE 1" = 40'
Note: No rock fill (Zone "C") below El. 615.0
Dam embankment slope
Slope 1 on 3.5 skewed see plan
El. varies
Existing ground surface
5.0' Compacted gravel fill
Stripping line
SECTION A/4
SCALE 1" = 20'
10' Rock toe
Existing ground surface
Dam embankment
Rock fill (Zone C)
Rock fill (Zone B)
Toe of Dam
5' Compacted gravel fill
Note: No rock fill (Zone C) below El. 615.0
SECTION C/4
SCALE 1" = 10'
Elevation in feet above M.S.L.D.
Access Road
Dam
2" Bituminous concrete
Rolled gravel base
El. 790.5
Compacted impervious fill
El. 780.0 Change in slope
Existing ground surface
Stripping line
Note: For additional embankment details, see Sheet 5
SECTION D/4 A/62
SCALE 1" = 10'
GRAPHIC SCALES
NOTE
Payment for excavation of the temporary diversion channel shall be paid for under "Unclassified Excavation General" Item No. 3, and Rock Excavation, open cut, Item No. 5 as applicable.
Final field correction
2-9-65 Profile, Section and Notes revised (Am #3)
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
DAM
EMBANKMENT PROFILE AND SECTIONS
WEST BRANCH FARMINGTON RIVER CONN. & MASS.
JAN. 1965
CON-16
SHEET 6

PLATE 5.

CORPS OF ENGINEERS — U. S. ARMY



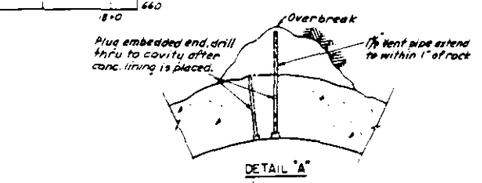
PROFILE ON ℄ OF DAM

SCALE: HOR. 1" = 80' VER. 1" = 40'

Conical recess to be formed by wooden plug or other means of protecting coupling from damage or fouling by conc. Plug shall be oil soaked or greased. Contractor may use pipe nipples in lieu of conical wood plugs. Nipples shall not be in recess when holes are plugged.

GROUT PIPE DETAIL

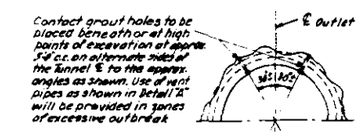
NO SCALE



DETAIL "A"

CONTACT GROUTING IN EXCESSIVE OVERBREAK ZONES

NO SCALE



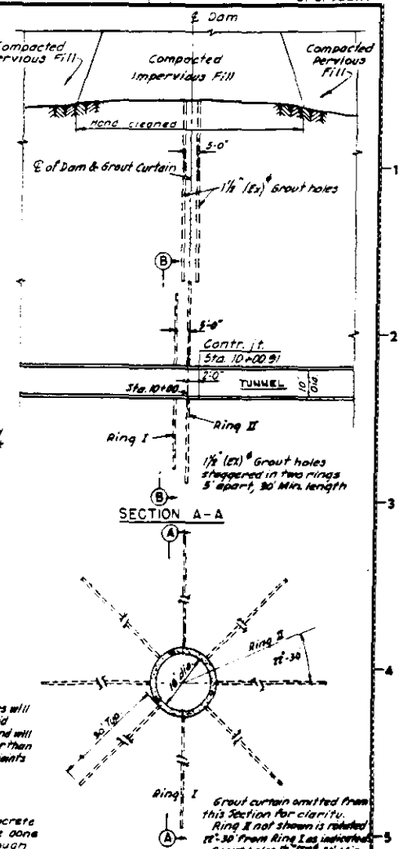
Contact grout holes to be placed beneath or at high points of excavation at approx. 3'-0" c.c. on alternate sides of the Tunnel ℄ for the approx. angles as shown. Use of vent pipes as shown in Detail "A" will be provided in zones of excessive outbreak

Contact grout holes will be located to avoid imbedded items and will not be placed closer than 1'-0" to structural joints in the concrete.

Contact grout holes in the transition Sections will be located at approx. 5'-0" c.c. longitudinally and at a lateral spacing to assist advantageously seal voids between the rock and concrete where tunnel is steel lined contact grouting shall be done the same as for other sections of the tunnel through holes in the steel liner.

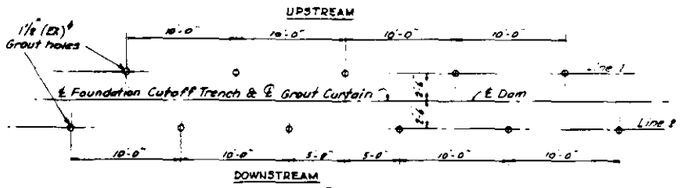
CONTACT GROUT DETAIL

NO SCALE



GROUT RING IN TUNNEL

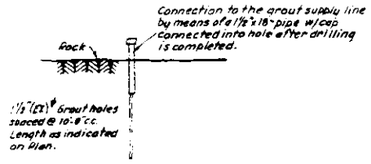
NO SCALE



PLAN

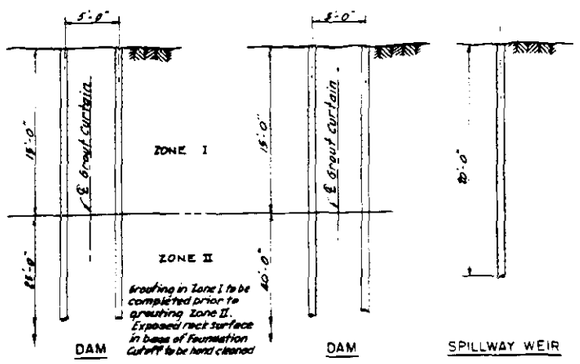
NO SCALE

Typical initial grout hole spacing along Dam foundation cutoff



GROUT HOLE DETAIL

NO SCALE



Grouting in Zone I to be completed prior to grouting Zone II. Exposed rock surface in base of Foundation Cutoff to be hand cleaned

Sta. 1+00 to Sta. 2+45
Sta. 11+77 to Sta. 13+75

Sta. 2+45 to Sta. 11+77
Sta. 13+75 to Spillway

TYPICAL SECTIONS — GROUT CURTAIN

NO SCALE

NOTES

1. Tunnel drilling and grouting to be paid for under item No. 24
2. Foundation drilling and grouting to be paid for under item No. 25.
3. For Embankment Plan and Sections see Sheets 4, 5 and 6.
4. For Spillway Plan and Sections, see Sheets 8, 9 and 10.

GRAPHIC SCALES

1" = 40' 40' 0 40' 80'

1" = 80' 80' 0 80' 160'

REVISION	DATE	DESCRIPTION	BY
		Final field corrections	

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

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

CONNECTICUT RIVER FLOOD CONTROL

COLEBROOK RIVER DAM

DAM

GROUTING DETAILS

WEST BRANCH-FARMINGTON RIVER CONN & MASS.

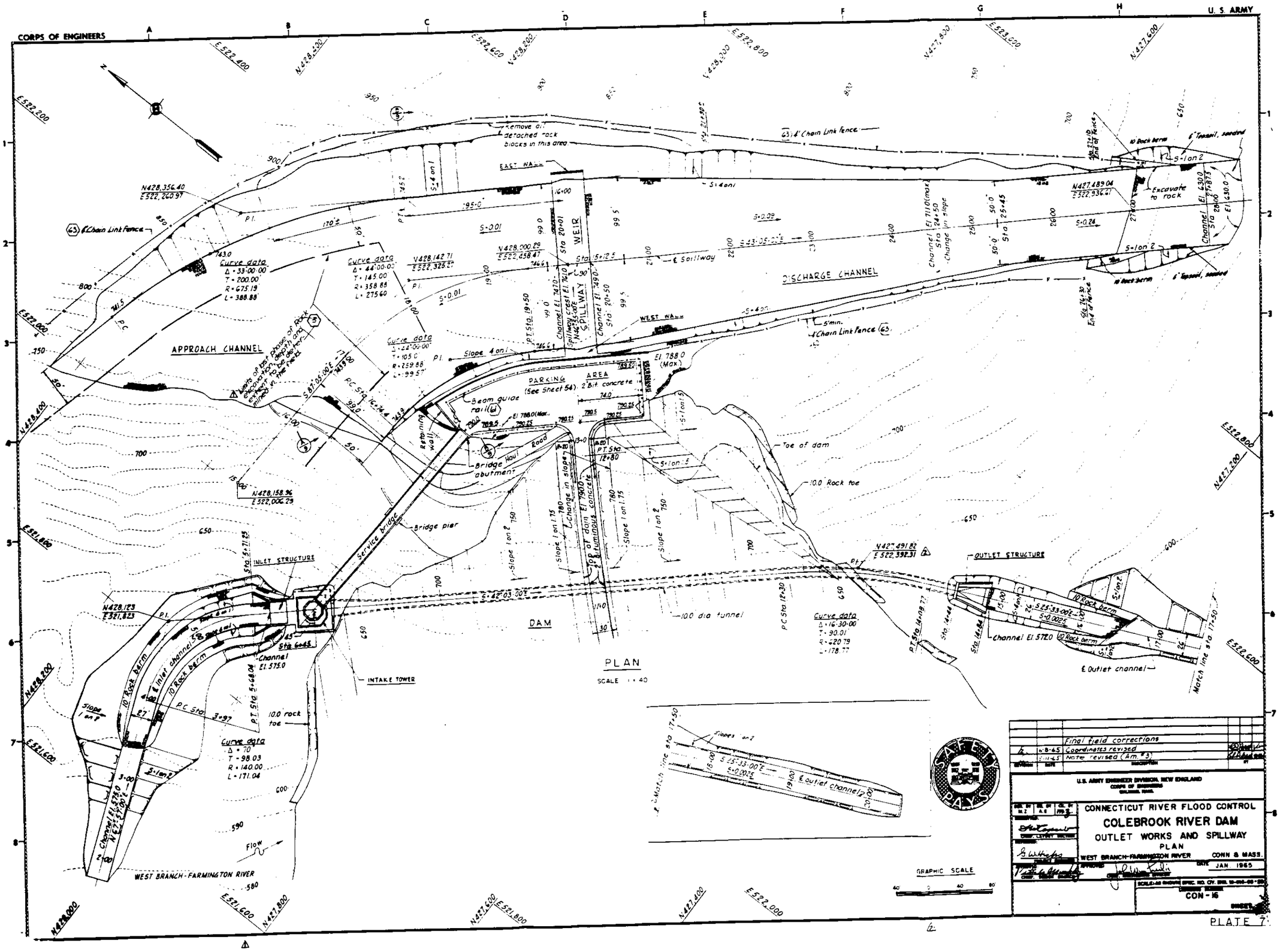
DATE JAN. 1965

SCALE AS SHOWN | SPEC. NO. CIV. ENG. 19-016-65-29

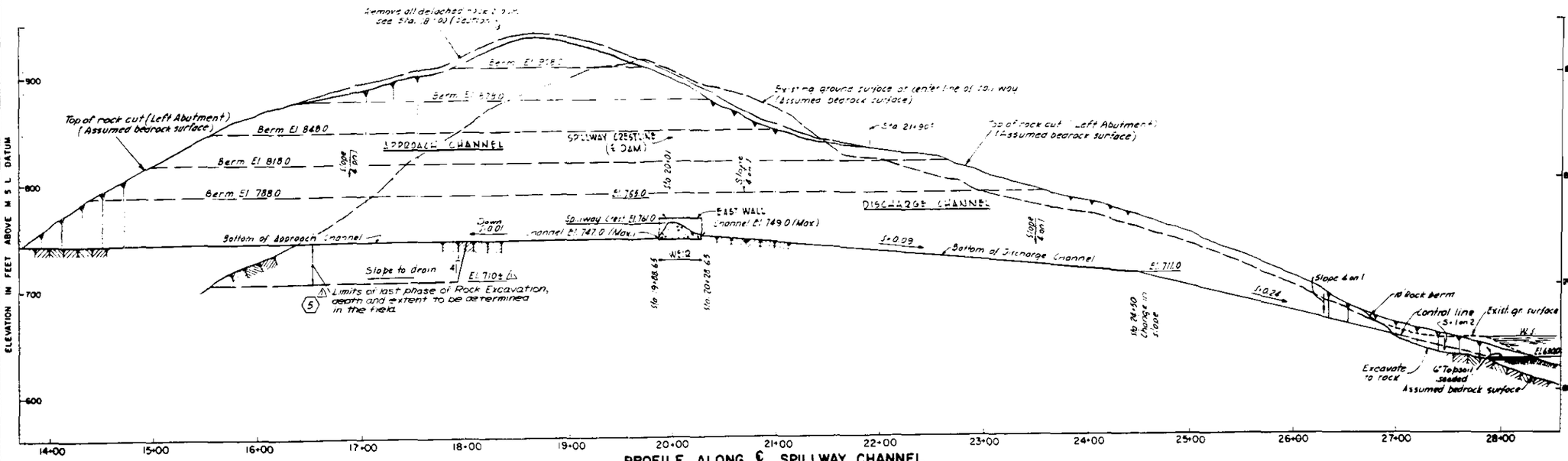
DRAWING NUMBER CON-16

SHEET 7

PLATE 6

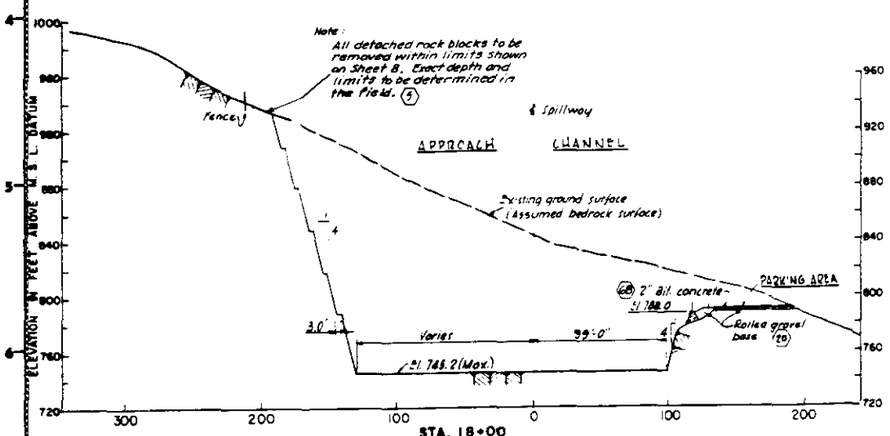

CORPS OF ENGINEERS
U. S. ARMY
APPROACH CHANNEL
DISCHARGE CHANNEL
WEIR
SPILLWAY
EAST WALL
WEST WALL
PARKING AREA
(See Sheet 54)
Beam guide rail
Retaining wall
Bridge abutment
Haul Road
Service bridge
Bridge pier
Toe of dam
Rock toe
INLET STRUCTURE
OUTLET STRUCTURE
INTAKE TOWER
DAM
PLAN
SCALE 1" = 40'
WEST BRANCH-FARMINGTON RIVER
Flow
GRAPHIC SCALE
Final field corrections
Coordinates revised
Note revised (Am. #3)
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
OUTLET WORKS AND SPILLWAY
PLAN
WEST BRANCH-FARMINGTON RIVER
CONN & MASS.
JAN 1965
CON-16
PLATE 7

CORPS OF ENGINEERS — U. S. ARMY

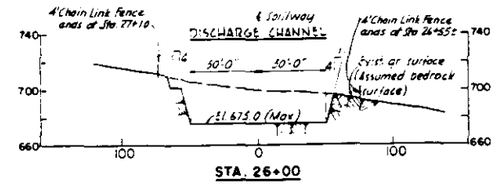


PROFILE ALONG ℄ SPILLWAY CHANNEL

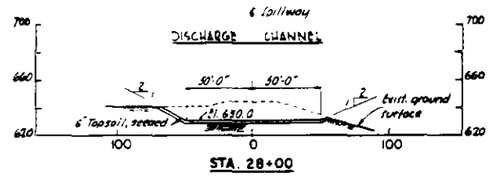
SCALE: 1" = 40'



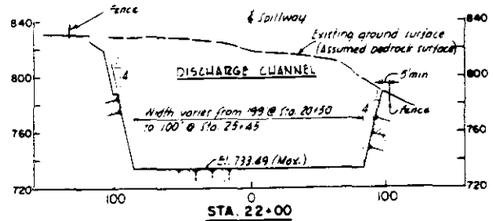
STA. 18+00 (SECTION A/B)



STA. 26+00

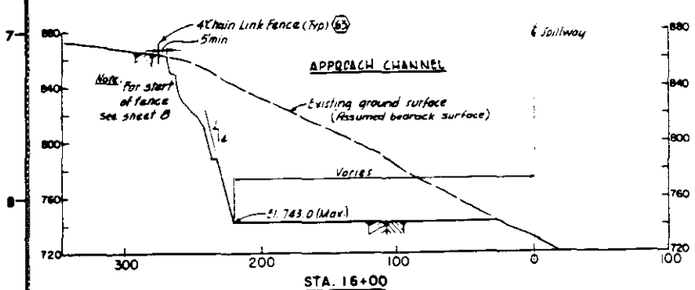


STA. 28+00

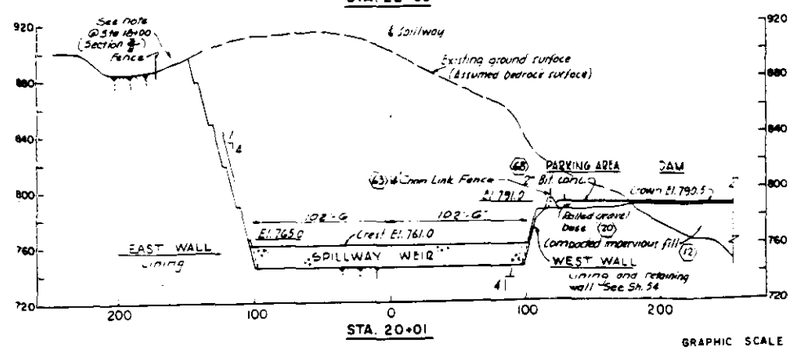


STA. 22+00

NOTES:
1. For General Notes, See Sheet 3.
2. All open cut rock excavation shall be paid for under Item No. 5
3. All unclassified excav. shall be paid for under Item No. 3



STA. 16+00 (SECTION A/B)



STA. 20+01

SECTIONS

SCALE: 1" = 40'

GRAPHIC SCALE 1" = 40'

REVISION	DATE	DESCRIPTION	BY
		Final field corrections	
1	5-11-65	Note and elevation revised (Ar. #3)	

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

SUBMITTED: CHIEF, LATHAT BRANCH
REVIEWED:
PROJECT ENGINEER
PROJECT ENGINEER
APPROVED: CHIEF, DESIGN BRANCH
DATE: JAN 1965

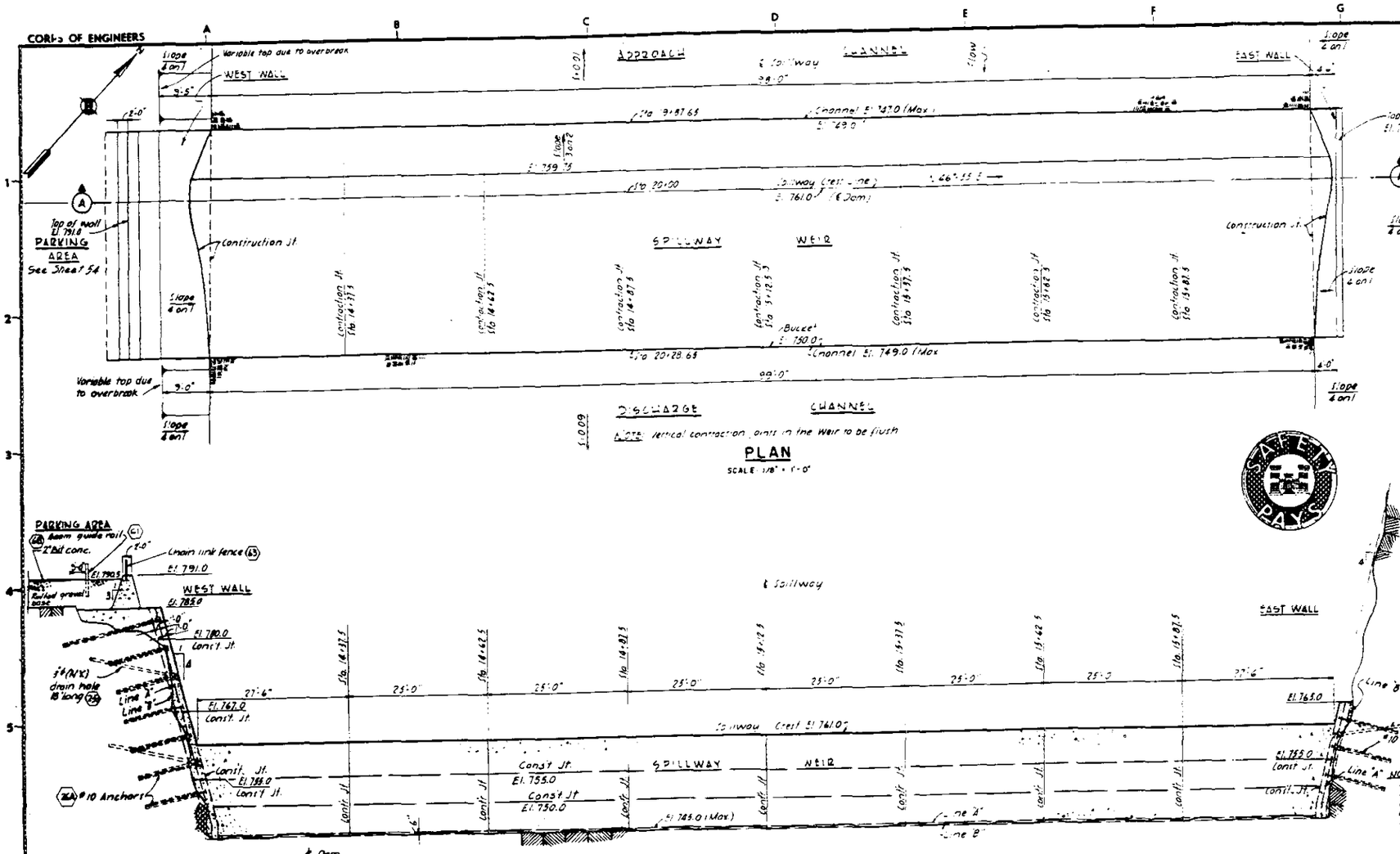
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
SPILLWAY
PROFILE AND SECTIONS
WEST BRANCH-FARMINGTON RIVER CONN. & MASS.

SCALE: 1"=40' | SPEC. NO. CIV. ENG. 19-016-65-65
DRAWING NUMBER: CON-16
SHEET 9

PLATE 8

CORPS OF ENGINEERS

U. S. ARMY

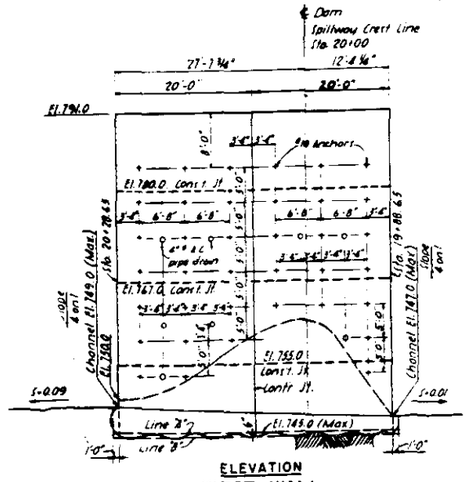


PLAN

SCALE: 1/8" = 1'-0"

SECTION A-A

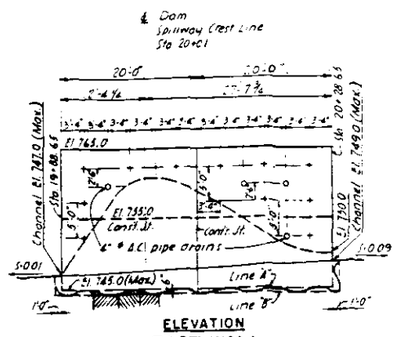
SCALE: 1/8" = 1'-0"



ELEVATION

WEST WALL

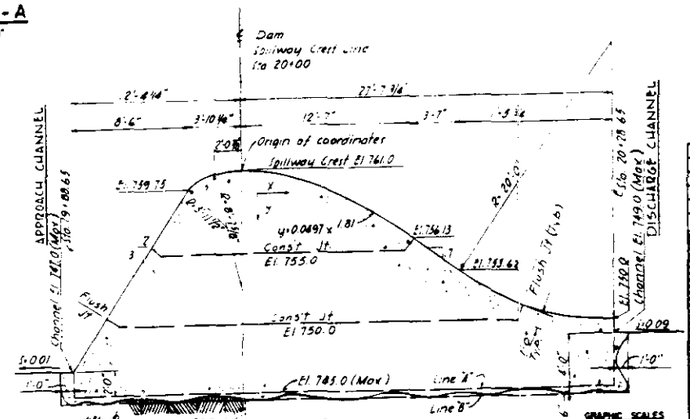
SCALE: 1/8" = 1'-0"



ELEVATION

EAST WALL

SCALE: 1/8" = 1'-0"

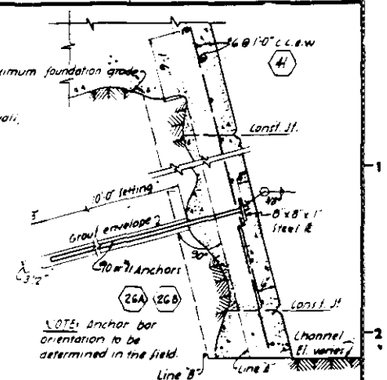


(14)(2x) anchor holes spaced @ 10'-0" o.c. 20' long (for details, See Sheet 7)

SECTION

SPILLWAY WEIR

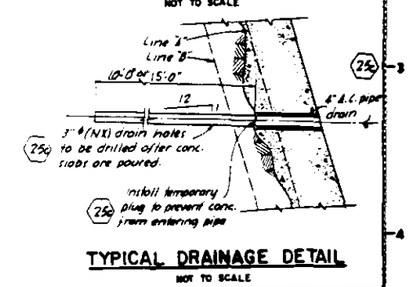
SCALE: 1/4" = 1'-0"



NOTE: Anchor bar orientation to be determined in the field.

TYPICAL ANCHOR BAR AND REINFORCEMENT DETAIL

NOT TO SCALE



TYPICAL DRAINAGE DETAIL

NOT TO SCALE

COORDINATES TO SPILLWAY WEIR			
X		Y	
0' - 4 3/4"			1/8"
0' - 9 5/8"			3/8"
0' - 0"			3/8"
2' - 0"		2'	
3' - 0"		4 5/8"	
4' - 0"		7 1/4"	
5' - 0"		10 TYP.	
6' - 0"		1 - 3 1/4"	
6' - 0"		1 - 6 1/8"	
8' - 0"		1 - 1 5/8"	
9' - 0"		1 - 3 1/2"	
10' - 0"		1 - 5 1/2"	
12' - 0"		1 - 5 1/2"	
12' - 7"		1 - 10 TYP.	

NOTES:

Payment for Concrete in Spillway Weir will be made under Item No. 27
Payment for Concrete in Channel Lining will be made under Item No. 28
Line "A" indicates minimum thickness of concrete.
Line "B" indicates payment line for rock excavation and concrete.
All reinforcing steel shall be paid for under Item No. 61
Bar splices shall lap 24 diameters of the smaller bar.
Minimum cover for all steel reinforcement shall be 4" except as noted.
All exposed edges of concrete, including top of walls, to be chamfered 1"-45°, except Spillway Weir which shall have flush joints.

REVISION	DATE	DESCRIPTION	BY
		Final field corrections	

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

DES. BY N.Z. | DR. BY J.B.L. | CK. BY

CHIEF, LAYOUT BRANCH

CHIEF, DESIGN BRANCH

CHIEF, DESIGN DIVISION

CONNECTICUT RIVER FLOOD CONTROL

COLEBROOK RIVER DAM

SPILLWAY

CONCRETE PLAN AND SECTIONS

WEST BRANCH FARMINGTON RIVER — CONN. & MASS.

DATE JAN. 1965

SCALE AS SHOWN | SPEC. NO. CIV. ENG. 19-065-65-29

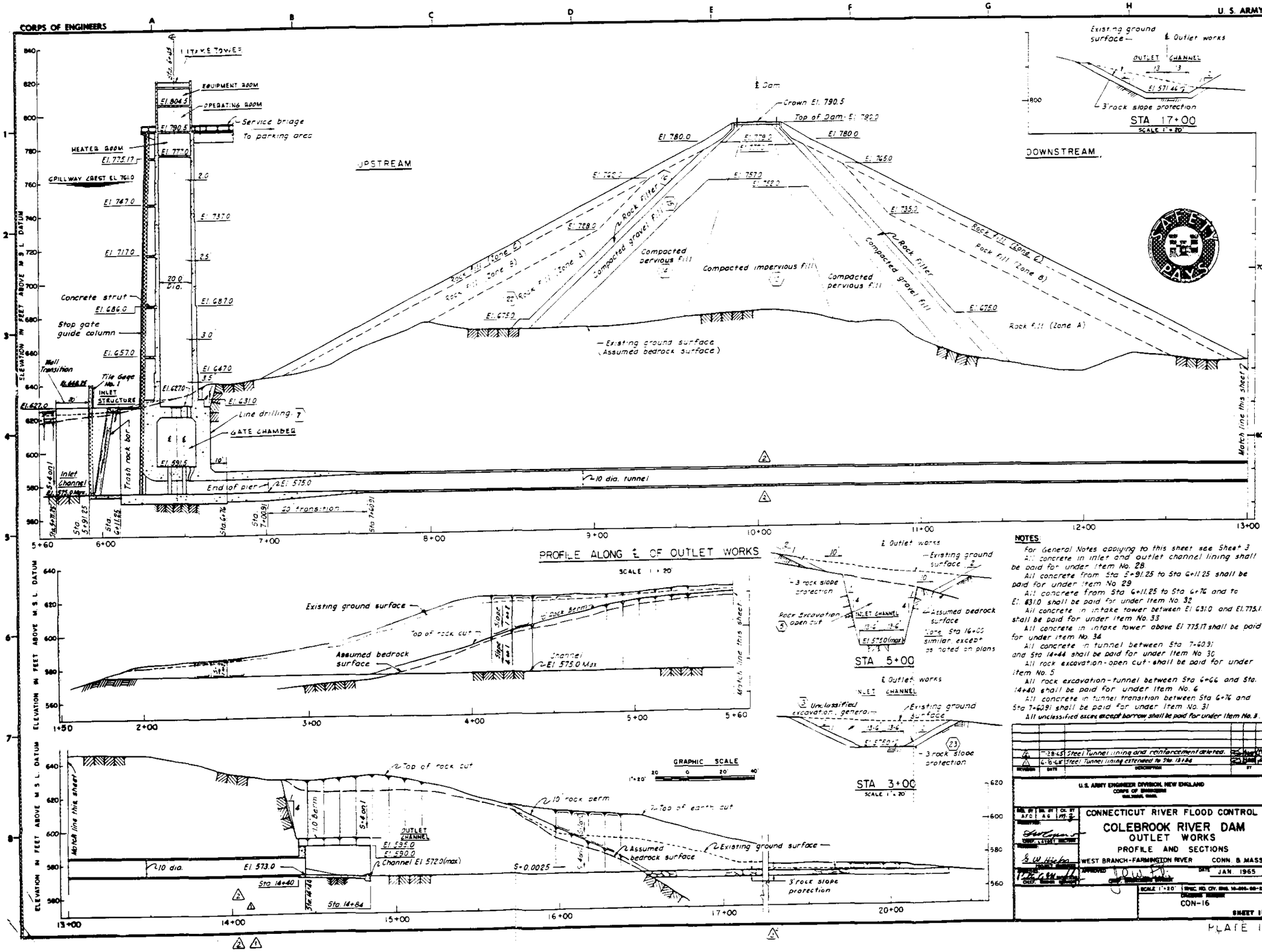
DRAWING NUMBER CON-16

SHEET 10

PLATE 9

CORPS OF ENGINEERS

U. S. ARMY



NOTES:

For General Notes applying to this sheet see Sheet 3

All concrete in inlet and outlet channel lining shall be paid for under Item No. 28.

All concrete from Sta 5+91.25 to Sta 6+11.25 shall be paid for under Item No 29

All concrete from Sta 6+11.25 to Sta 6+76 and to El. 631.0 shall be paid for under Item No. 32

All concrete in intake tower between El 631.0 and El. 775.17 shall be paid for under Item No. 33

All concrete in intake tower above El 775.17 shall be paid for under Item No. 34

All concrete in tunnel between Sta 7+60.91 and Sta 14+44 shall be paid for under Item No 30

All rock excavation - open cut - shall be paid for under Item No. 5

All rock excavation - tunnel between Sta 6+66 and Sta. 14+40 shall be paid for under Item No. 6

All concrete in tunnel transition between Sta 6+76 and Sta 7+60.91 shall be paid for under Item No. 31

All unclassified excav. except borrow shall be paid for under Item No. 3.

REVISION	DATE	DESCRIPTION	BY
4	7-28-65	Steel Tunnel lining and reinforcement deleted.	
3	6-10-65	Steel Tunnel lining extended to Sta. 13+84	

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

CONNECTICUT RIVER FLOOD CONTROL

COLEBROOK RIVER DAM
OUTLET WORKS
PROFILE AND SECTIONS

WEST BRANCH - FARMINGTON RIVER CONN. & MASS

DATE JAN. 1965

SCALE 1" = 20'

CON-16

SHEET 11

PLATE 10

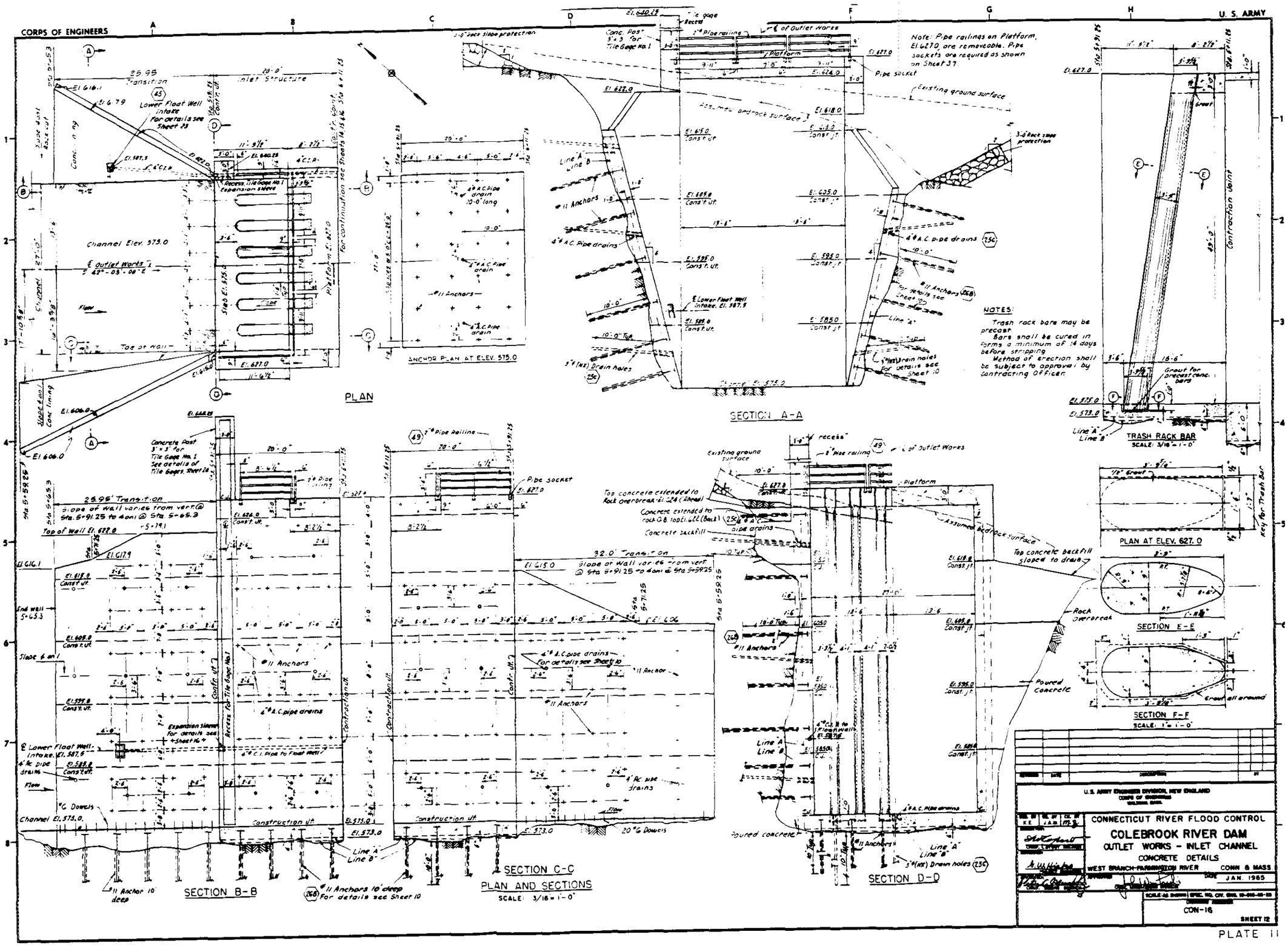
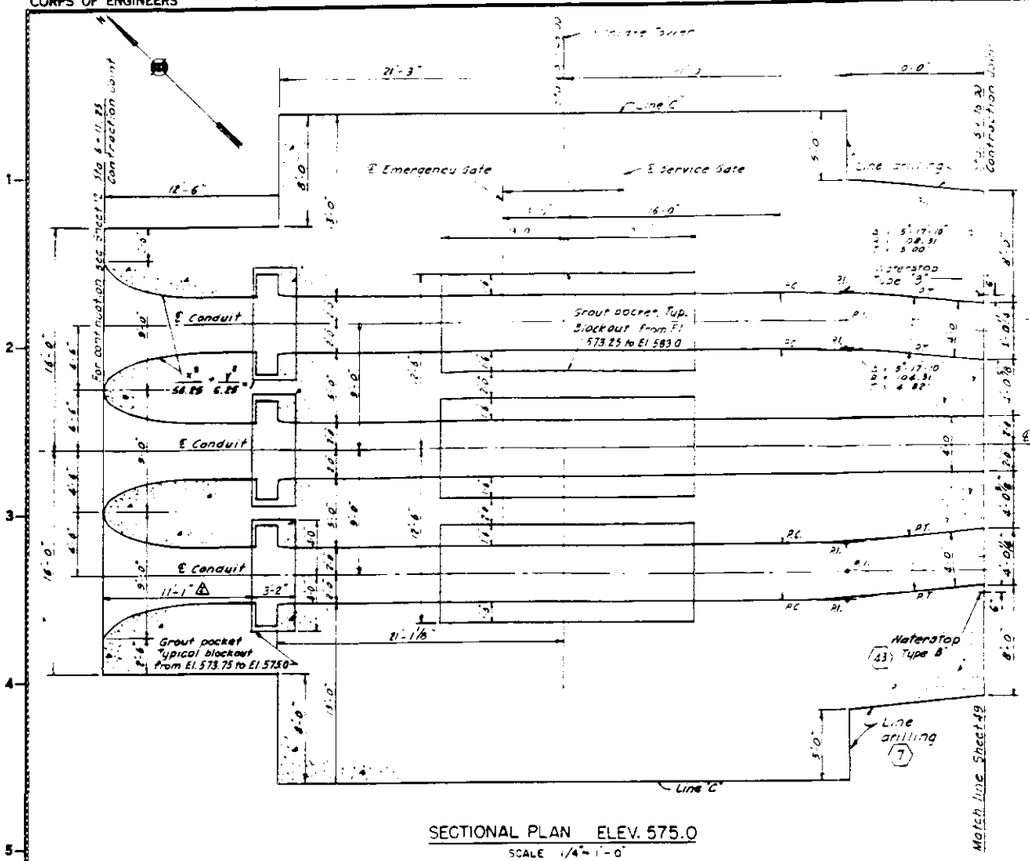

CORPS OF ENGINEERS
U. S. ARMY
PLAN
ANCHOR PLAN AT ELEV. 575.0
SECTION A-A
TRASH RACK BAR
SCALE: 3/16" = 1'-0"
PLAN AT ELEV. 627.0
SECTION E-E
SECTION F-F
SCALE: 1" = 1'-0"
SECTION B-B
SECTION C-C
PLAN AND SECTIONS
SCALE: 3/16" = 1'-0"
SECTION D-D
NOTES:
Trash rack bars may be precast.
Bars shall be cured in forms a minimum of 14 days before stripping.
Method of erection shall be subject to approval by Contracting Officer.
Note: Pipe railings on Platform, El. 627.0, are removable. Pipe sockets are required as shown on Sheet 37.
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
OUTLET WORKS - INLET CHANNEL
CONCRETE DETAILS
WEST BRANCH-FARMINGTON RIVER
CONN & MASS
JAN. 1965
CON-16
SHEET 12

PLATE 11

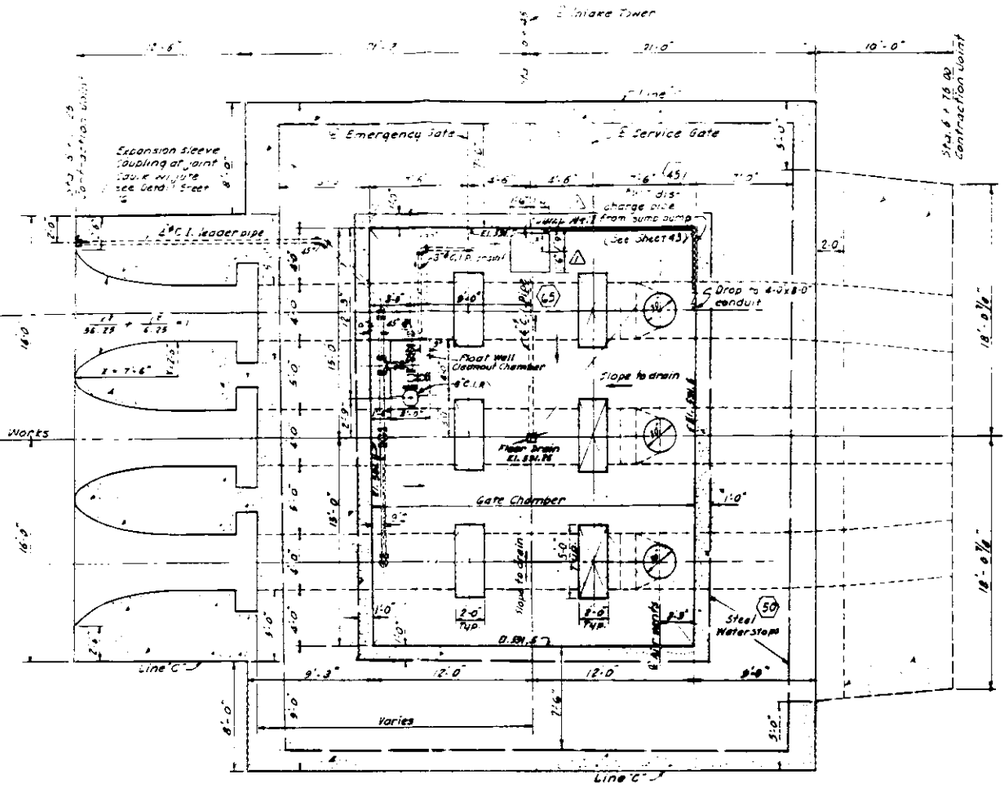
CORPS OF ENGINEERS

U. S. ARMY



SECTIONAL PLAN ELEV. 575.0

SCALE 1/4" = 1'-0"



SECTIONAL PLAN - GATE CHAMBER

SCALE 1/4" = 1'-0"

NOTE:
For notes applying to this sheet, see Sheets 11 and 16.

GRAPHIC SCALE

1/4" = 1'-0"

REVISION	DATE	DESCRIPTION	BY
2	11-5-65	Dimension revised.	
1	2-9-65	Sump Well and notes revised. (Am. #3)	

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

CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
OUTLET WORKS - INTAKE TOWER
SECTIONAL PLANS AT
ELEVATION 575.0 & GATE CHAMBER
WEST BRANCH-FARMINGTON RIVER CONN. & MASS.

DATE JAN. 1965

SCALE: AS SHOWN | SPEC. NO. OIV. ENG. 19-010-65-69

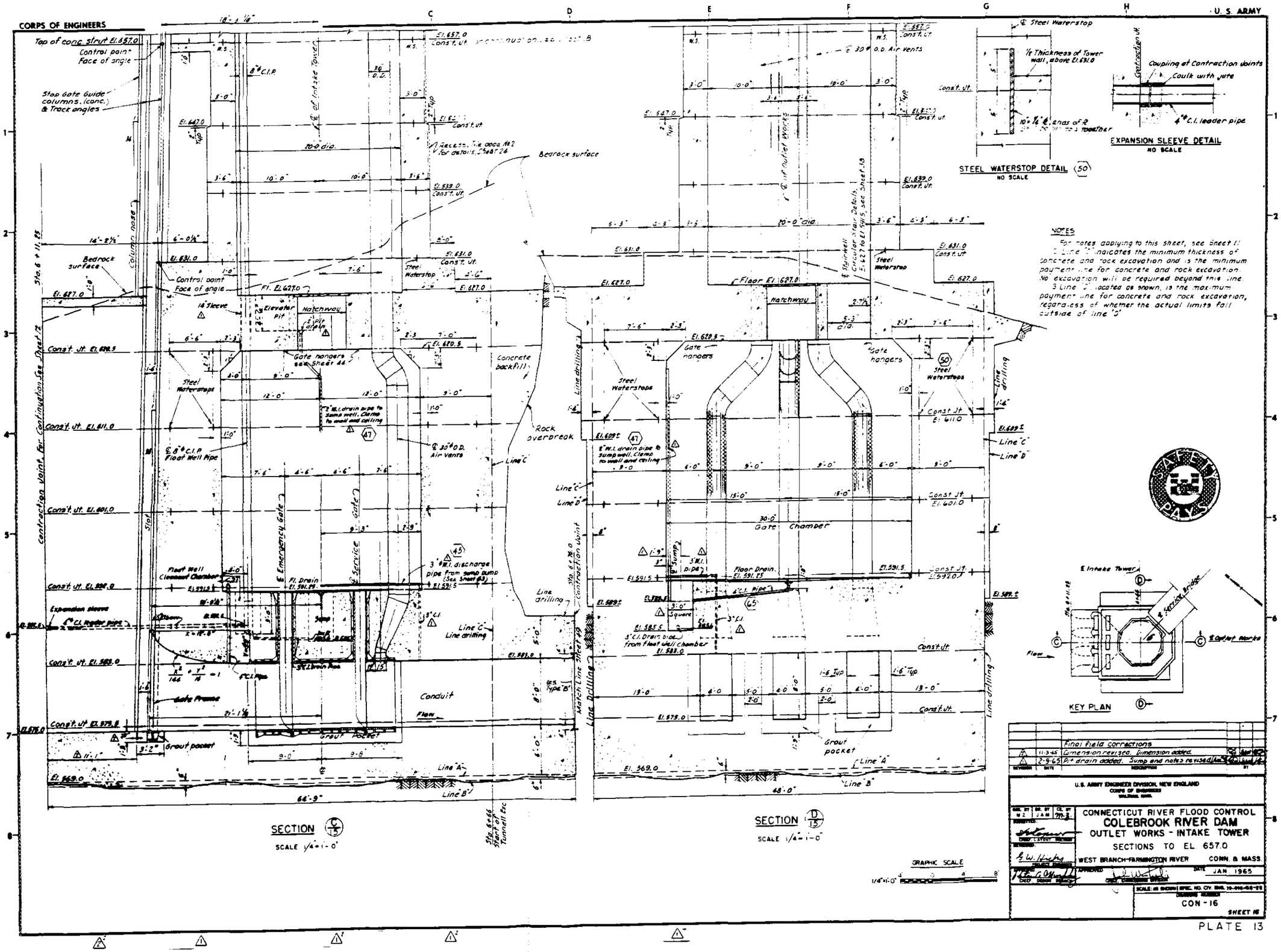
DRAWING NUMBER CON-16

SHEET 16

PLATE 12

CORPS OF ENGINEERS

U. S. ARMY



NOTES

For notes applying to this sheet, see Sheet 11.

2 Line "D" indicates the minimum thickness of concrete and rock excavation and is the minimum payment line for concrete and rock excavation. No excavation will be required beyond this line.

3 Line "C" located as shown, is the maximum payment line for concrete and rock excavation, regardless of whether the actual limits fall outside of line "D".

REVISION	DATE	DESCRIPTION	BY
		Final Field corrections	
1	11-3-65	Dimension revised. Dimension added.	
2	2-9-65	Pit drain added. Sump and notes revised	

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

CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
OUTLET WORKS - INTAKE TOWER
SECTIONS TO EL. 657.0
WEST BRANCH-FARMINGTON RIVER CONN. & MASS.

DATE JAN. 1965

SCALE: AS SHOWN | SPEC. NO. CIV. ENG. 19-010-65-22

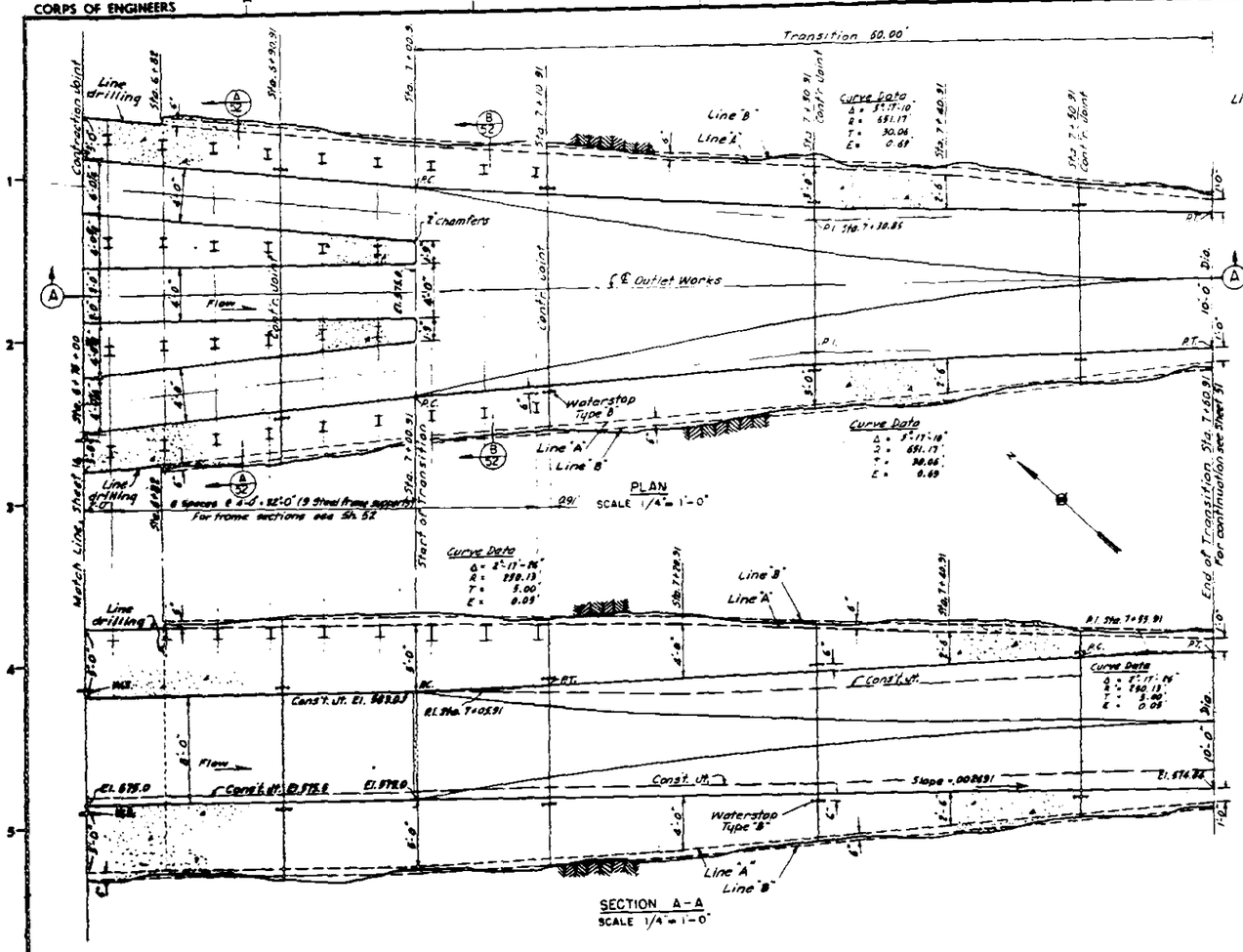
DRAWING NUMBER
CON-16

SHEET 16

PLATE 13

CORPS OF ENGINEERS

U. S. ARMY



NOTES

For notes applying to this sheet, see Sheet 11.
For steel reinforcement, see Sheet 50.

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

CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
OUTLET WORKS
TRANSITION AND TUNNEL
CONCRETE SECTIONS
WEST BRANCH FARMINGTON RIVER CONN. & MASS.

DATE JAN. 1965

CON-16

SHEET 48

PLATE 14

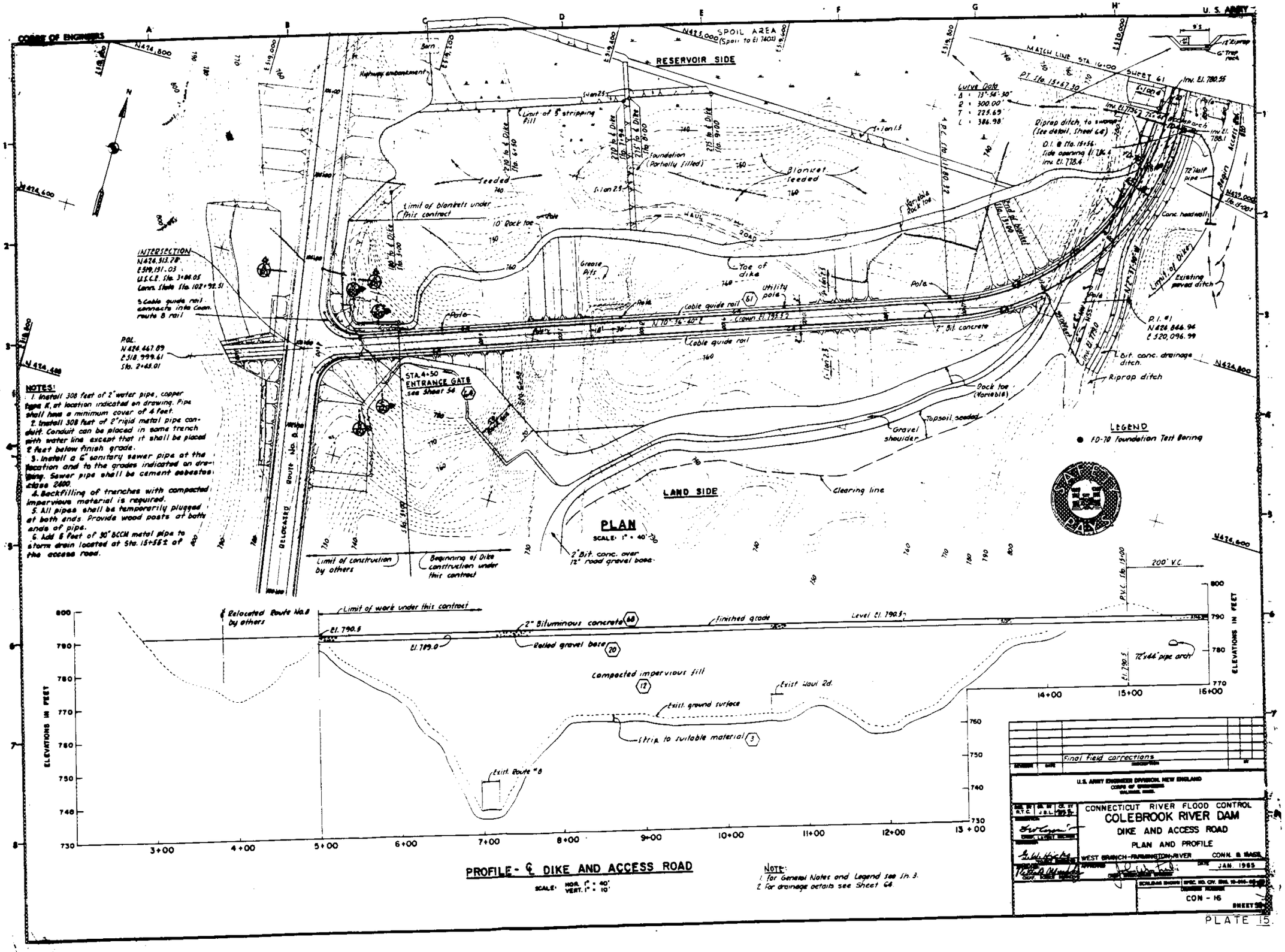

U. S. ARMY
CORPS OF ENGINEERS
SPOIL AREA
RESERVOIR SIDE
LAND SIDE
MATCH LINE STA. 16+00 SHEET 61
Curve Data
Δ = 13°-54'-30"
R = 300.00'
T = 225.69'
L = 386.98'
PI Sta. 15+67.30
Riprap ditch, to swamp (See detail, Sheet 64)
Existing paved ditch
Limit of Dike
Conc. headwall
72" Half pipe
Bituminous access road
Riprap ditch
Bit. conc. drainage ditch.
Dock toe (Variable)
Topsoil seeded
Gravel shoulder
Clearing line
Blanket seeded
Seeded
Limit of blankets under this contract
10' Rock toe
Toe of dike
Utility pole
Cable guide rail
Crown El. 793.32
7" Bit. concrete
Limit of stripping Pill
Foundation (Partially filled)
Grease Pits
Pole
Barn
Highway embankment
INTERSECTION
N474,513.78
E519,151.03
U.S.C.E. Sta. 3+84.05
Conn. State Sta. 102+92.51
Cable guide rail connects into Conn. route 8 rail
POL
N474,467.89
E518,999.61
Sta. 2+45.01
STA. 4+50 ENTRANCE GATE
see Sheet 54
Relocated Route No. 8
Limit of construction by others
Beginning of Dike construction under this contract
2" Bit. conc. over 12" road gravel base
PLAN
SCALE: 1" = 40'
LEGEND
F0-70 Foundation Test Boring
NOTES:
1. Install 308 feet of 2" water pipe, copper type K, at location indicated on drawing. Pipe shall have a minimum cover of 4 feet.
2. Install 308 feet of 2" rigid metal pipe conduit. Conduit can be placed in same trench with water line except that it shall be placed 2 feet below finish grade.
3. Install a 6" sanitary sewer pipe at the location and to the grades indicated on drawing. Sewer pipe shall be cement asbestos class 2400.
4. Backfilling of trenches with compacted impervious material is required.
5. All pipes shall be temporarily plugged at both ends. Provide wood posts at both ends of pipe.
6. Add 6 feet of 30" BCCM metal pipe to storm drain located at Sta. 15+55± of the access road.
PROFILE - ℄ DIKE AND ACCESS ROAD
SCALE: HOR. 1" = 40' VERT. 1" = 10'
Limit of work under this contract
Relocated Route No. 8 by others
El. 790.5
El. 789.0
2" Bituminous concrete (68)
Rolled gravel base (20)
Finished grade
Level El. 790.5
Compacted impervious fill (12)
Exist. ground surface
Exist. Haul Rd.
Strip to suitable material (3)
Exist. Route "8"
72"x44" pipe arch
ELEVATIONS IN FEET
NOTE:
1. For General Notes and Legend see Sh. 3.
2. For drainage details see Sheet 64.
Final field corrections
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
DIKE AND ACCESS ROAD
PLAN AND PROFILE
WEST BRANCH-FARMINGTON RIVER
CONN. & MASS.
JAN. 1965
CON - 16

PLATE 15

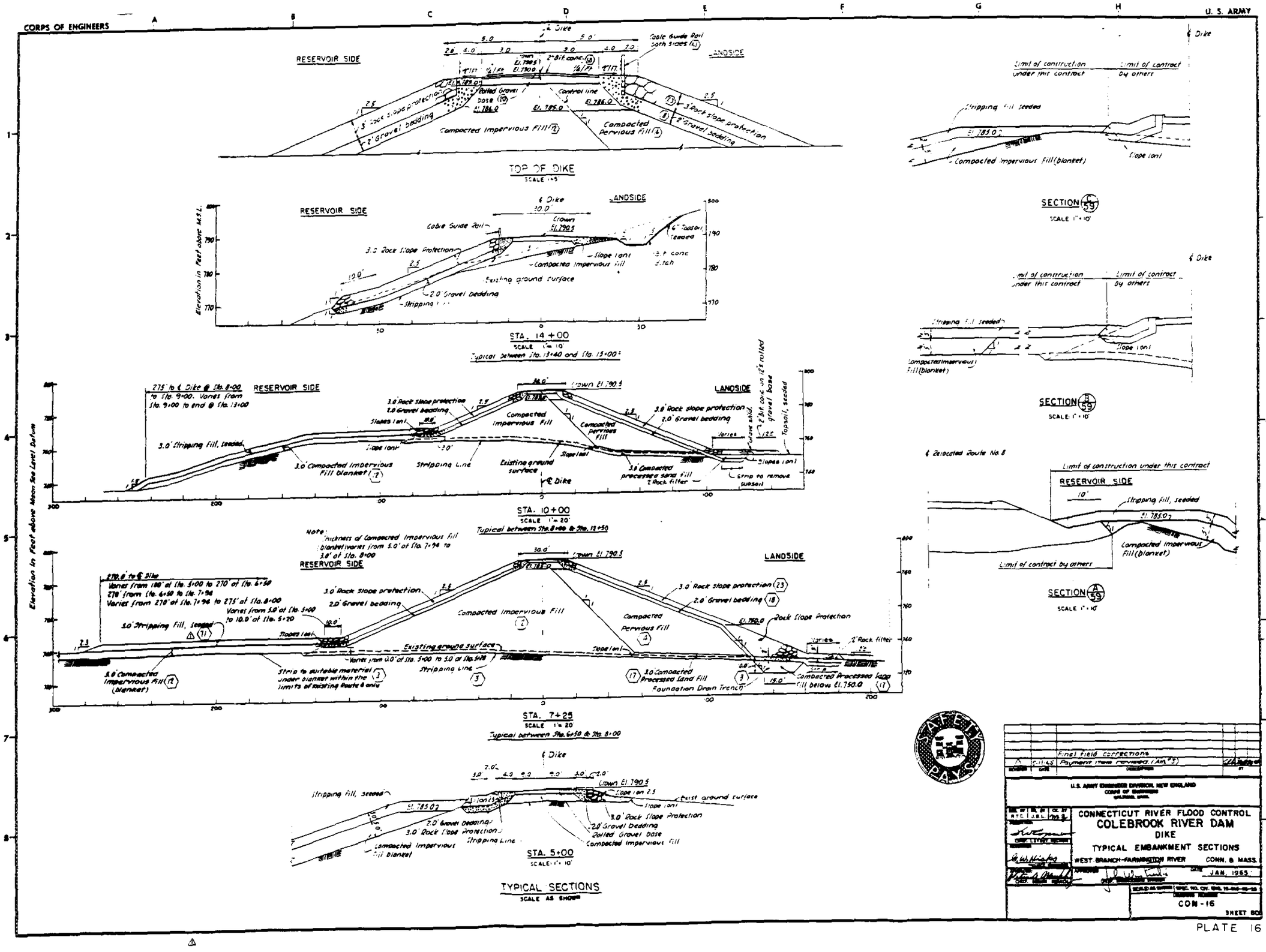

CORPS OF ENGINEERS
U. S. ARMY
RESERVOIR SIDE
LANDSIDE
TOP OF DIKE
SCALE 1"=5'
STA. 14+00
SCALE 1"=10'
Typical between Sta. 13+40 and Sta. 15+00±
STA. 10+00
SCALE 1"=20'
Typical between Sta. 8+00 & Sta. 12+50
STA. 7+25
SCALE 1"=20'
Typical between Sta. 6+50 & Sta. 8+00
STA. 5+00
SCALE 1"=10'
TYPICAL SECTIONS
SCALE AS SHOWN
SECTION C/59
SCALE 1"=10'
SECTION B/59
SCALE 1"=10'
SECTION A/59
SCALE 1"=10'
Elevation in Feet above Mean Sea Level Datum
Final field corrections
Payment item revised (Am. #3)
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
DIKE
TYPICAL EMBANKMENT SECTIONS
WEST BRANCH-FARMINGTON RIVER
CONN. & MASS.
JAN. 1965
CON-16
SHEET 80

PLATE 16

CORPS OF ENGINEERS

U. S. ARMY

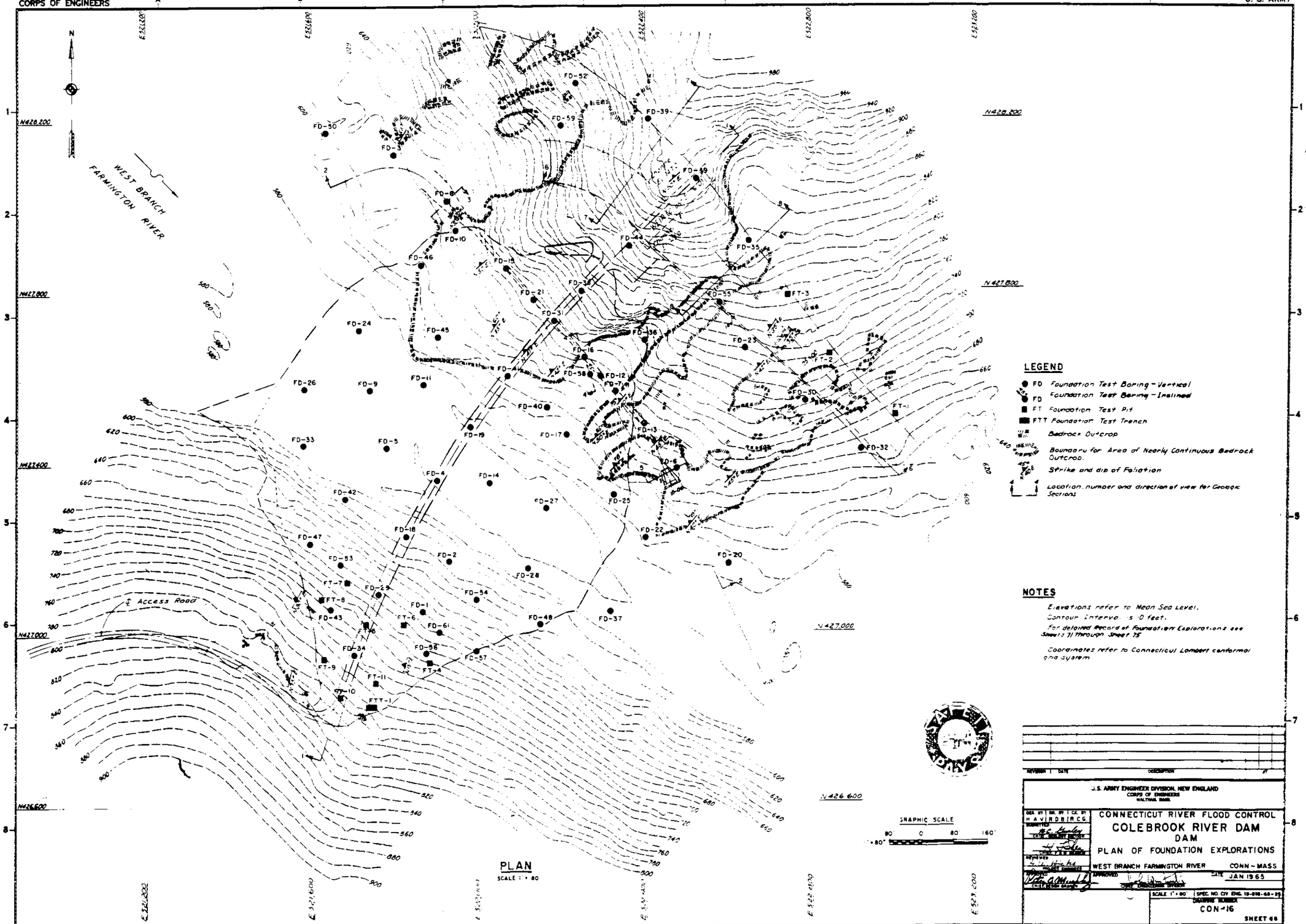


PLATE 17

CORPS OF ENGINEERS

U. S. ARMY

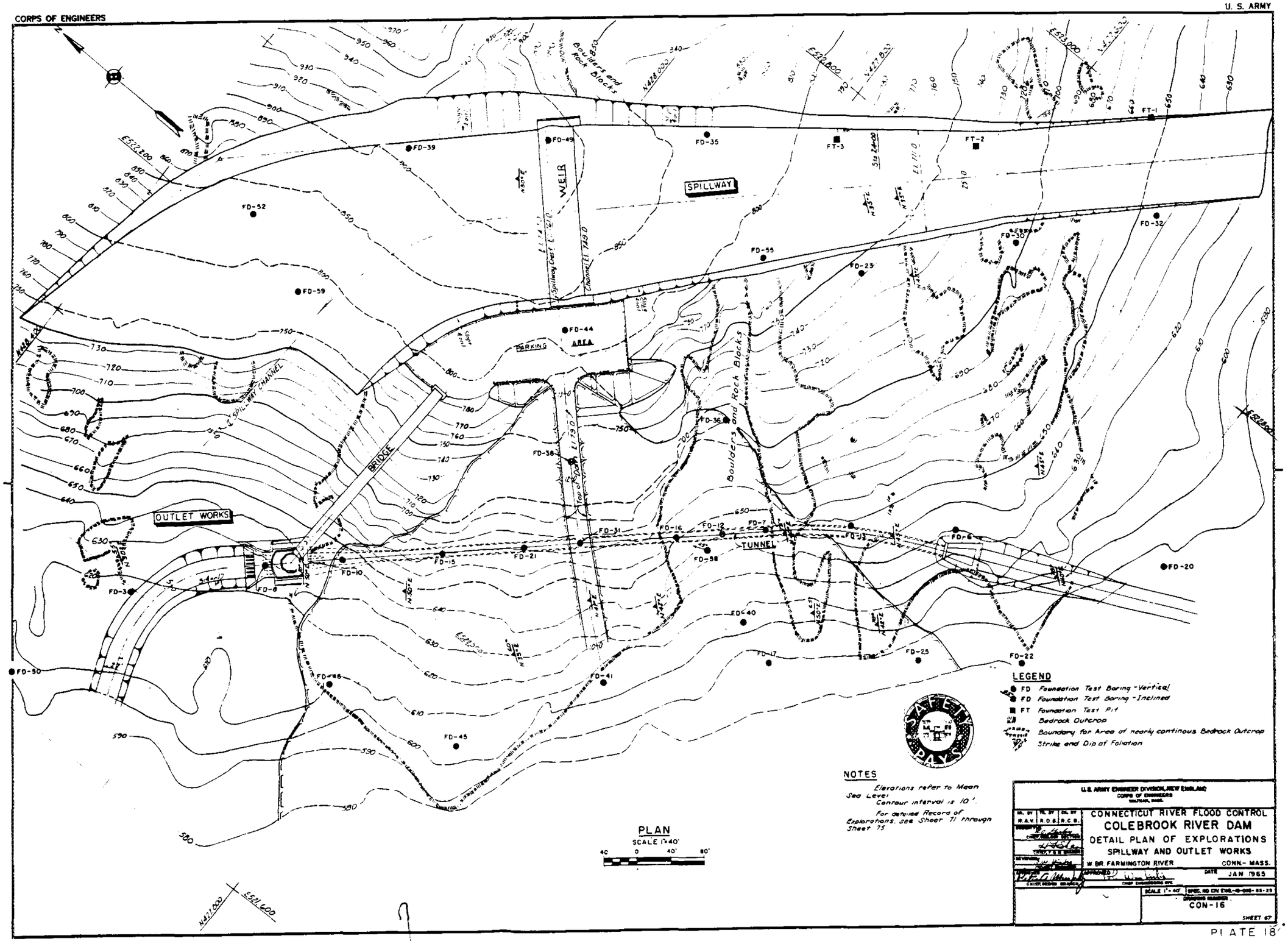


PLATE 18

CORPS OF ENGINEERS

U. S. ARMY

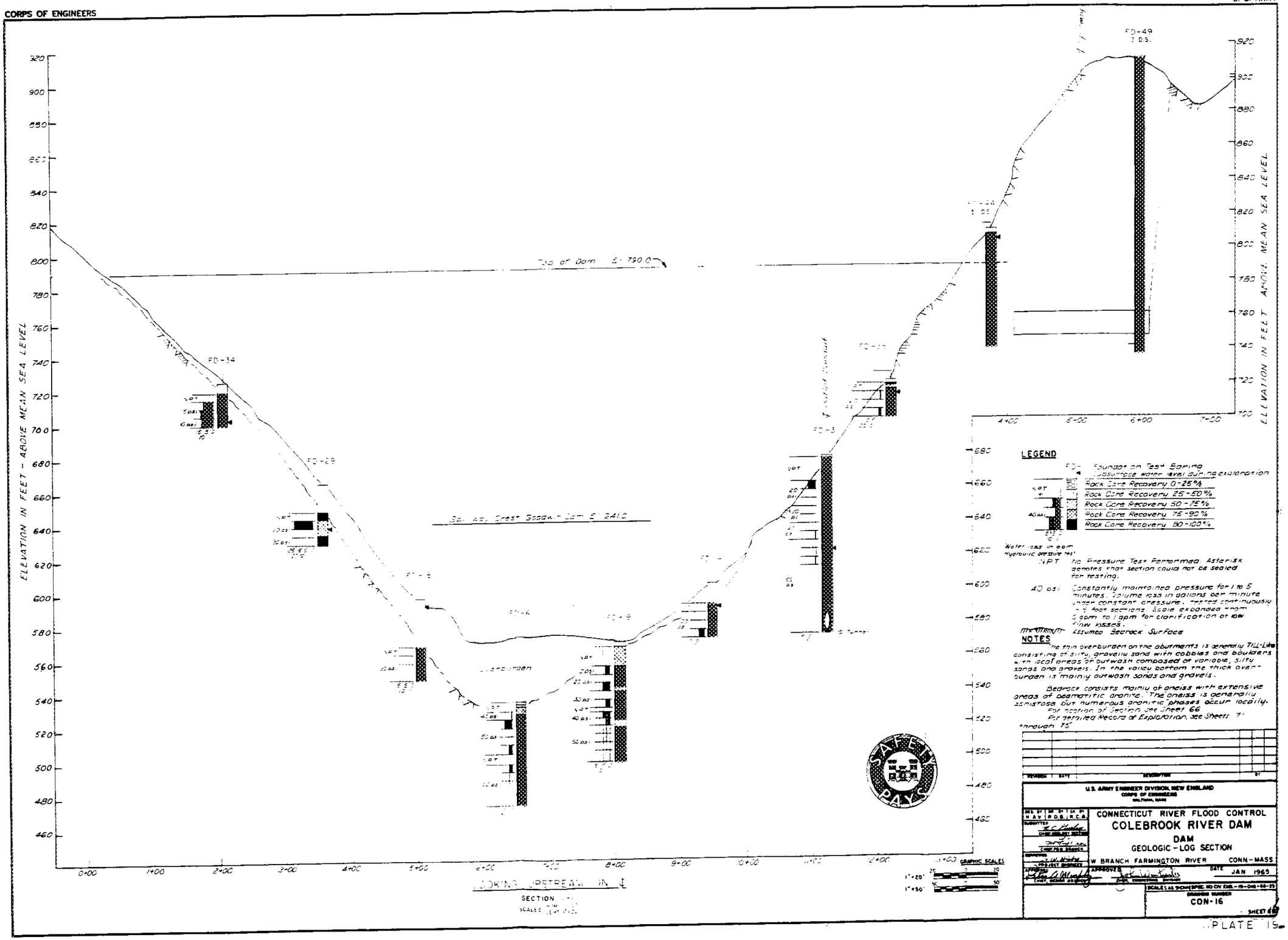
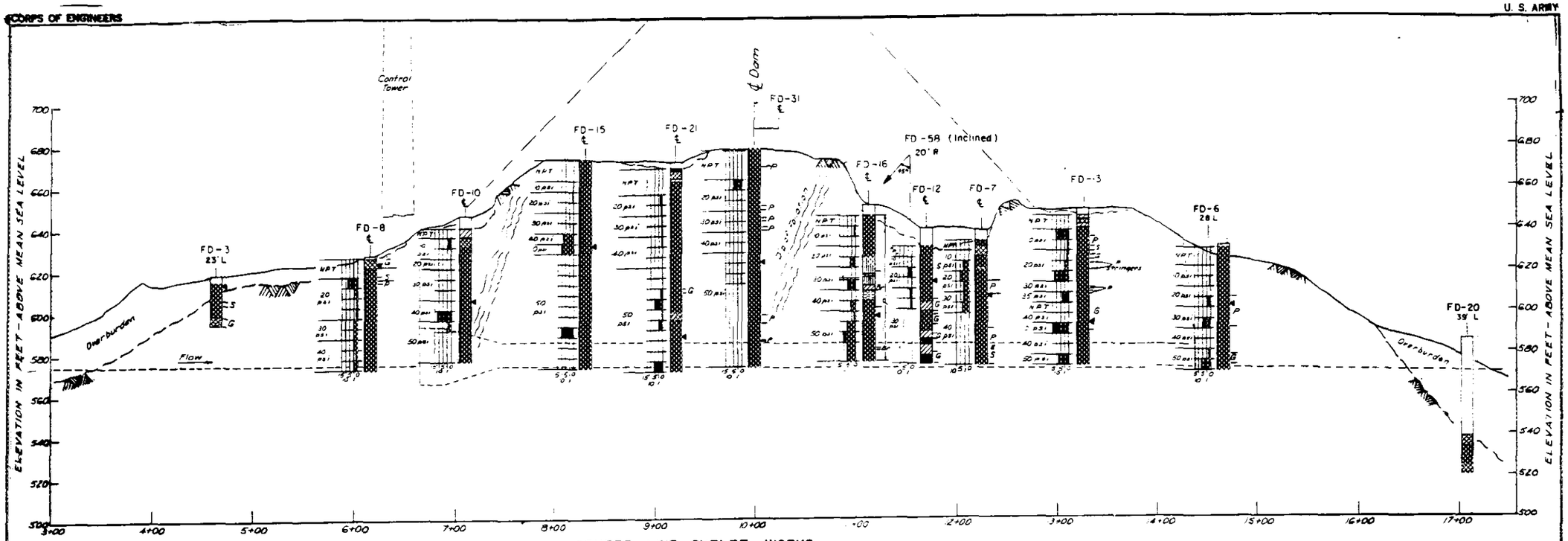


PLATE 19

CORPS OF ENGINEERS

U. S. ARMY



CENTER LINE-OUTLET WORKS

SECTION 2-2

SYMBOLS FOR ROCK TYPE

G - Granite, fine-grained
P - Granite, Pegmatite
S - Schist
Br - Breccia

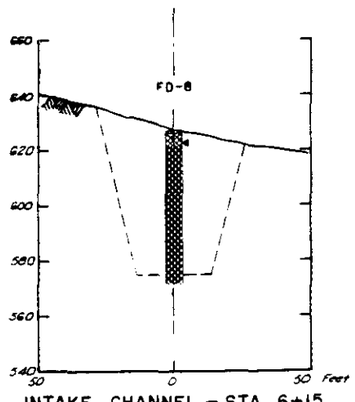
Where not otherwise designated the rock is gneiss.

NOTES:

For location of sections, see Sheet 66

For Legend for geologic-log sections and graphic logs, see Sheet 68 and 71.

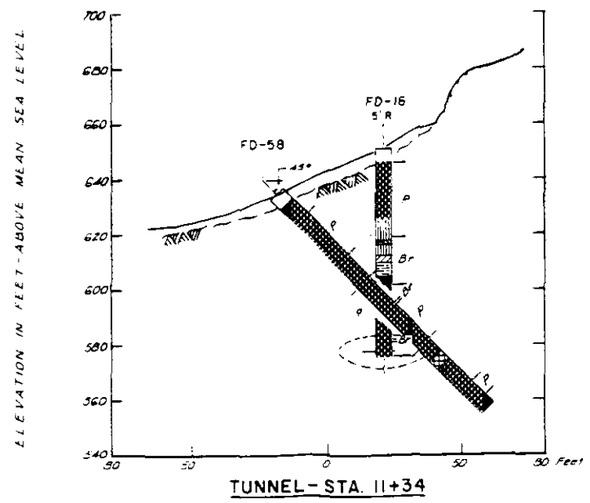
For detailed Record of Foundation Explorations, see Sheets 71 through 75.



INTAKE CHANNEL - STA. 6+15

LOOKING DOWNSTREAM

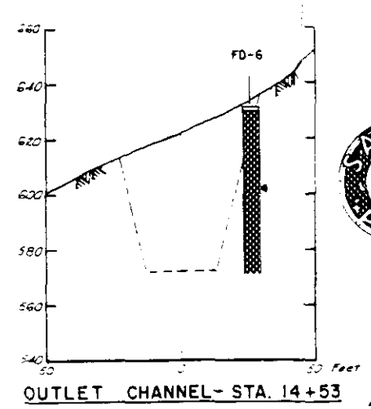
SECTION 3-3



TUNNEL - STA. 11+34

LOOKING UPSTREAM

SECTION 4-4



OUTLET CHANNEL - STA. 14+53

LOOKING UPSTREAM

SECTION 5-5

GRAPHIC SCALES

1" = 40' 40' 0 40'

1" = 20' 20' 0 20'

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

CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
OUTLET WORKS
GEOLOGIC-LOG SECTIONS
WEST BRANCH FARMINGTON RIVER CONN.-MASS.

DATE JAN. 1965

CON-16

SHEET 70

PLATE 20

CORPS OF ENGINEERS

U. S. ARMY

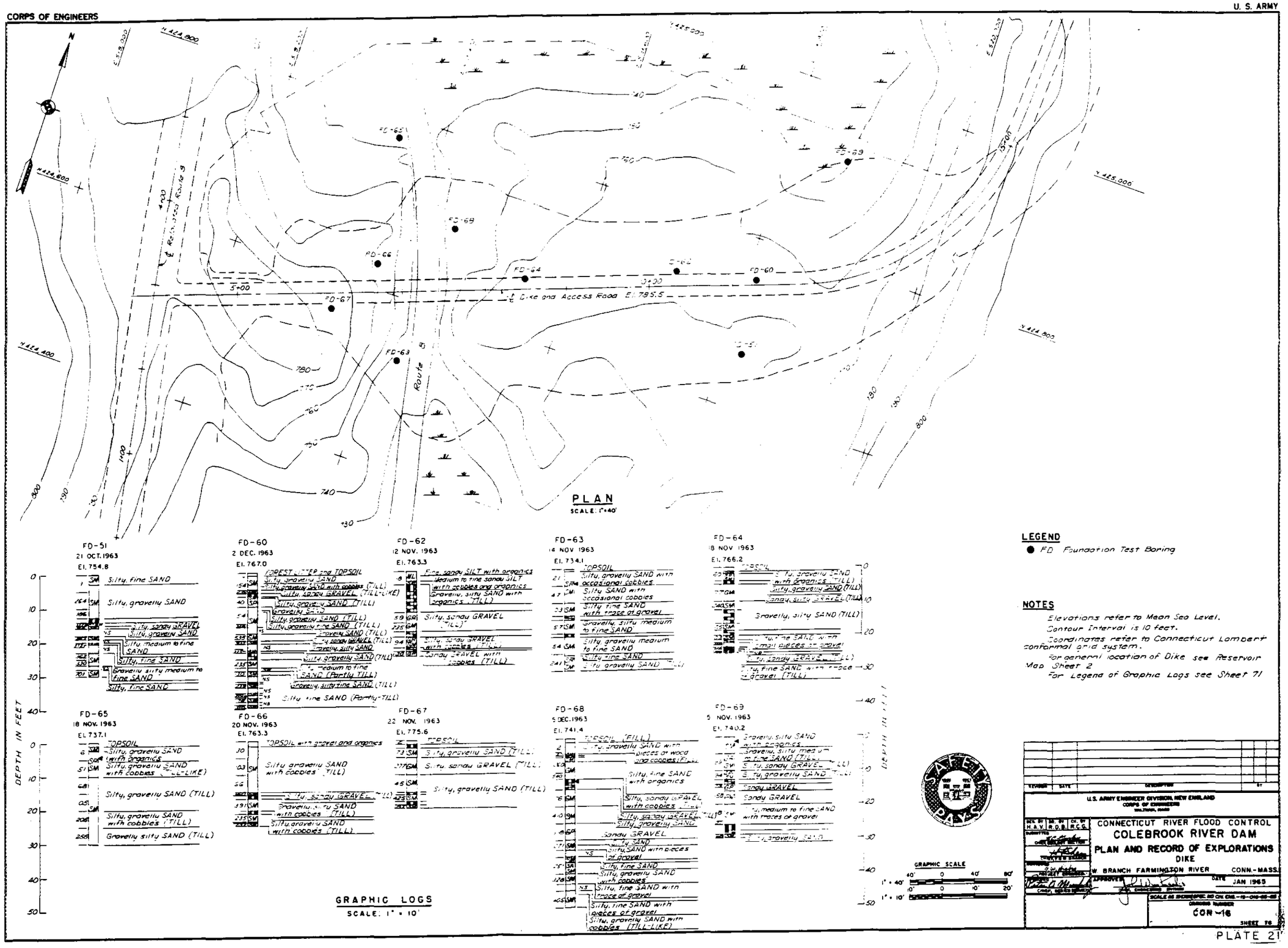
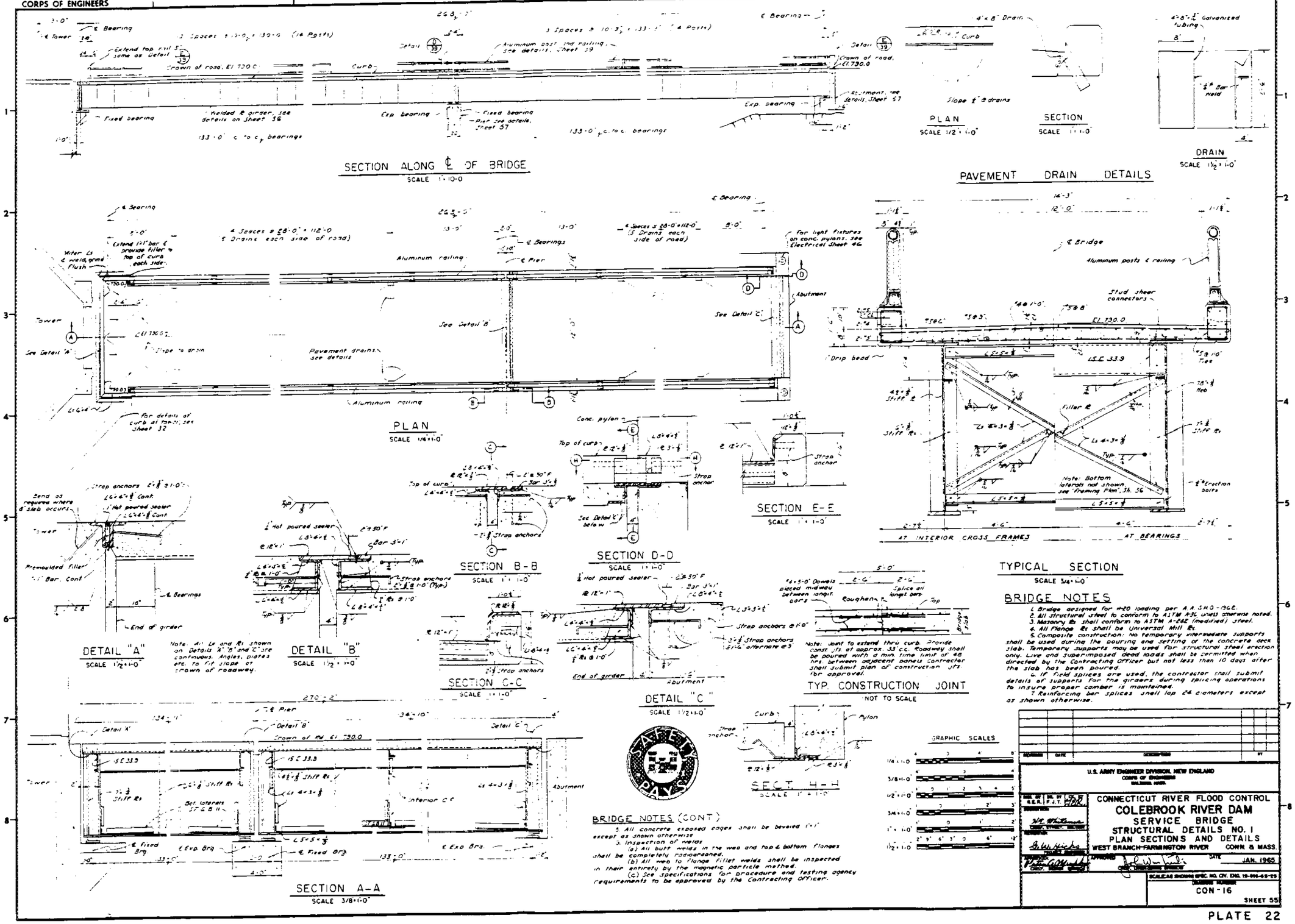


PLATE 21



BRIDGE NOTES

1. Bridge designed for H-20 loading per A.A.S.H.O.-1962.
2. All structural steel to conform to ASTM A-36 unless otherwise noted.
3. Masonry Rs shall conform to ASTM A-242 (modified) steel.
4. All Flange Rs shall be Universal Mill Rs.
5. Composite construction: No temporary intermediate supports shall be used during the pouring and setting of the concrete deck slab. Temporary supports may be used for structural steel erection only. Live and superimposed dead loads shall be permitted when directed by the Contracting Officer but not less than 10 days after the slab has been poured.
6. If field splices are used, the contractor shall submit details of supports for the girders during splicing operations to insure proper camber is maintained.
7. Reinforcing bar splices shall lap 24 diameters except as shown otherwise.

BRIDGE NOTES (CONT)

8. All concrete exposed edges shall be beveled 1"x1" except as shown otherwise.
9. Inspection of welds
   (a) All butt welds in the web and top & bottom flanges shall be completely radiographed.
   (b) All web to flange fillet welds shall be inspected in their entirety by the magnetic particle method.
   (c) See specifications for procedure and testing agency requirements to be approved by the Contracting Officer.

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

CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
SERVICE BRIDGE
STRUCTURAL DETAILS NO. 1
PLAN SECTIONS AND DETAILS
WEST BRANCH-FARMINGTON RIVER CONN. & MASS.

DATE JAN. 1965

SCALE AS SHOWN SPEC. NO. CIV. ENG. 19-016-65-29

DRAWING NUMBER CON-16

SHEET 55

PLATE 22

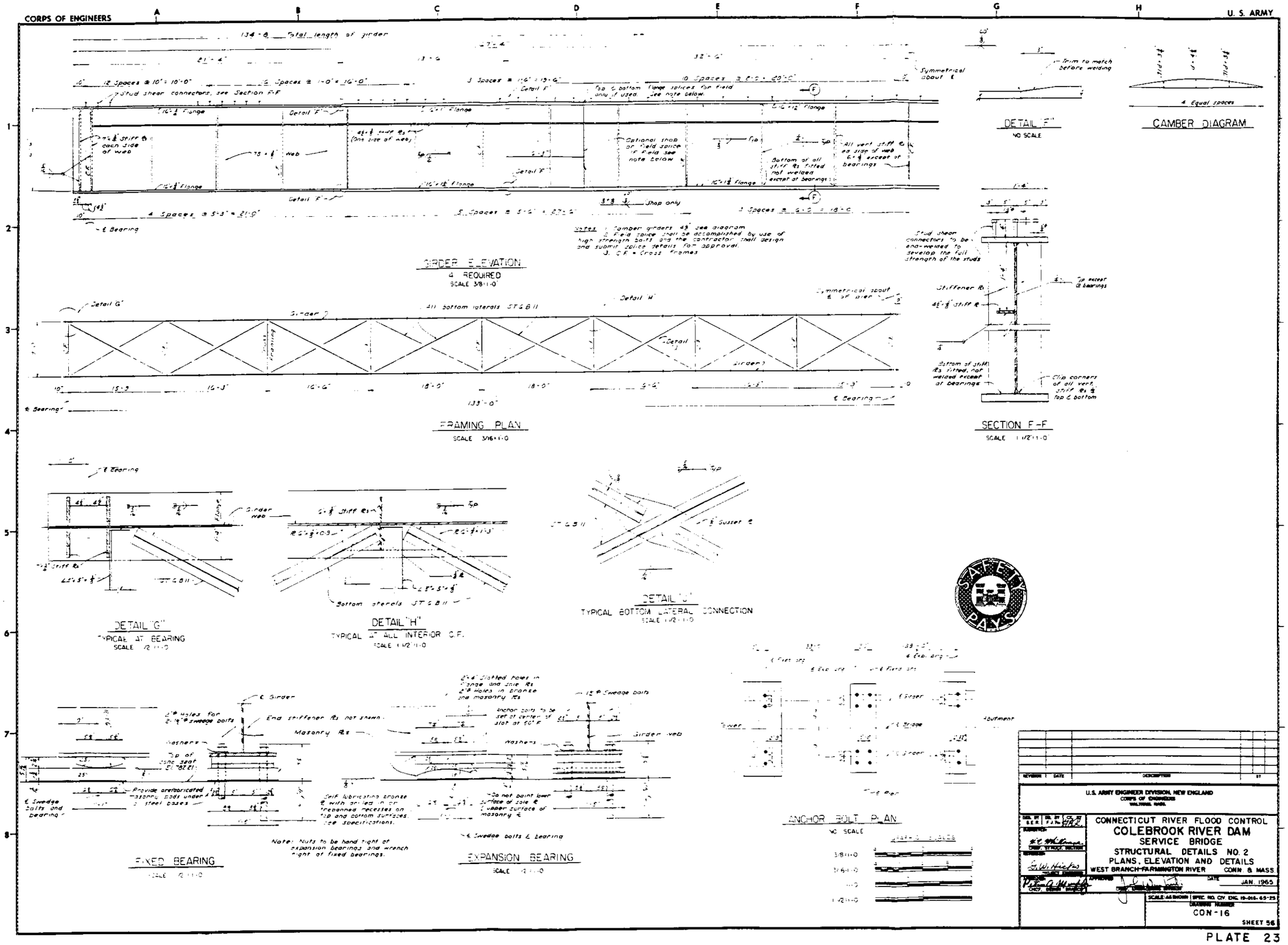
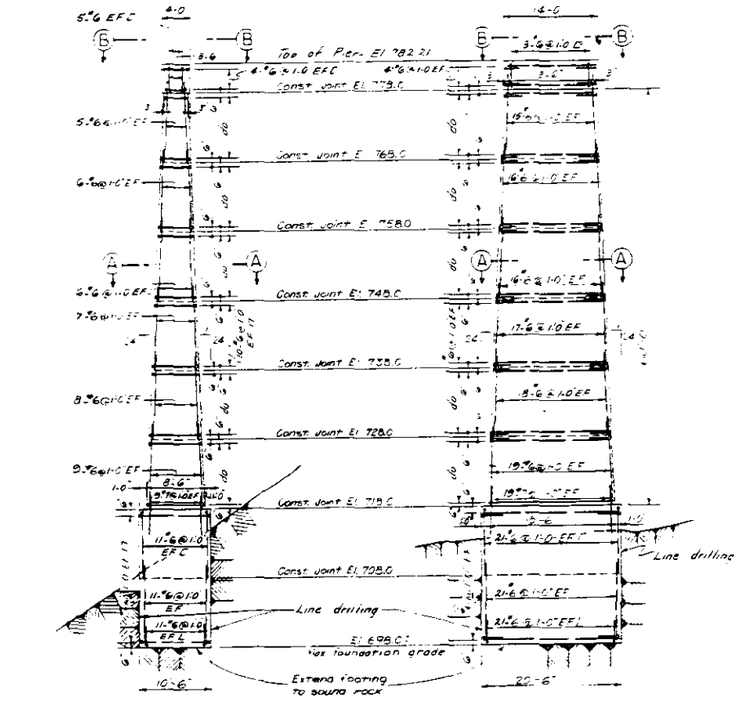

CORPS OF ENGINEERS
U. S. ARMY
GIRDER ELEVATION
4 REQUIRED
SCALE 3/8"=1'-0"
FRAMING PLAN
SCALE 3/16"=1'-0"
DETAIL "F"
NO SCALE
CAMBER DIAGRAM
SECTION F-F
SCALE 1 1/2"=1'-0"
DETAIL "G"
TYPICAL AT BEARING
DETAIL "H"
TYPICAL AT ALL INTERIOR C.F.
DETAIL "J"
TYPICAL BOTTOM LATERAL CONNECTION
FIXED BEARING
EXPANSION BEARING
ANCHOR BOLT PLAN
NO SCALE
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
SERVICE BRIDGE
STRUCTURAL DETAILS NO. 2
PLANS, ELEVATION AND DETAILS
WEST BRANCH-FARMINGTON RIVER CONN. & MASS.
JAN. 1965
CON-16
SHEET 56

PLATE 23

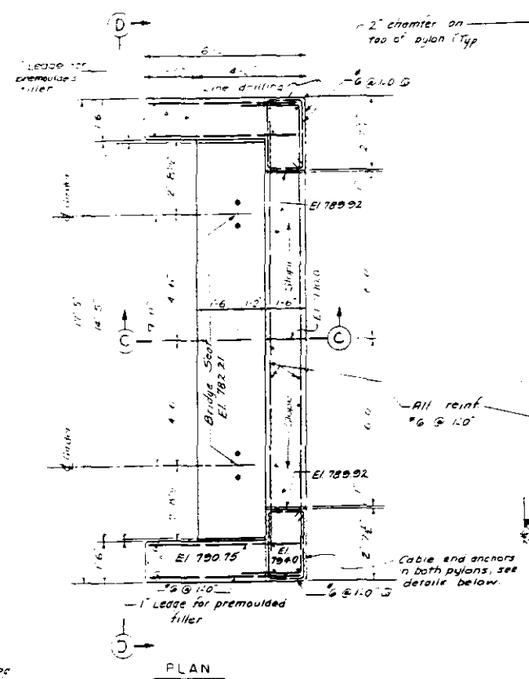
CORPS OF ENGINEERS

U S ARMY

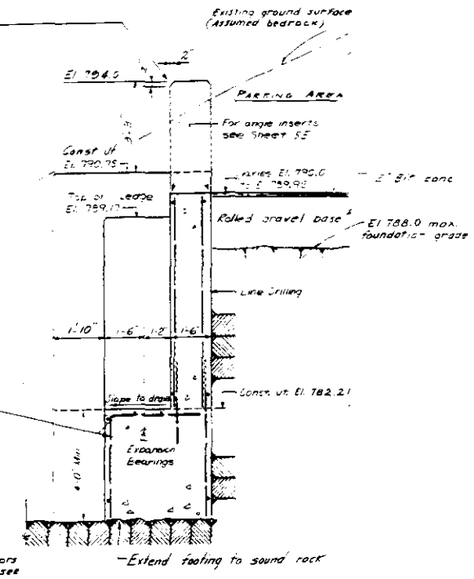


END ELEVATION
SCALE 1/8 = 1'-0"

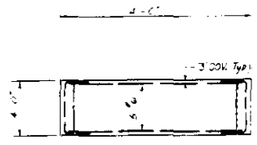
SIDE ELEVATION
SCALE 1/8 = 1'-0"



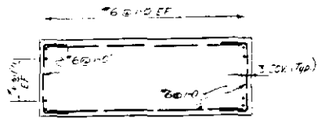
PLAN
SCALE 1/2 = 1'-0"



SECTION C - C
SCALE 1/2 = 1'-0"

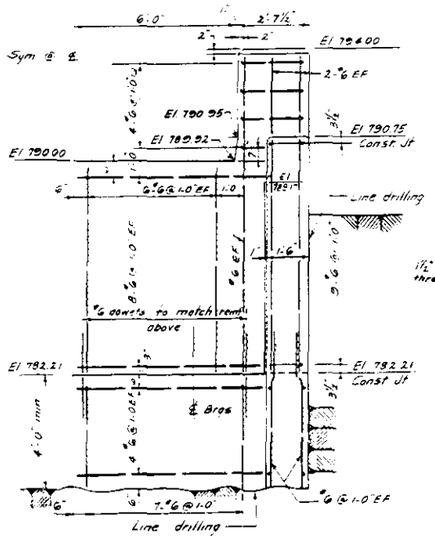


SECTION B - B
SCALE 1/4 = 1'-0"

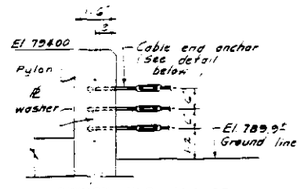


SECTION A - A
SCALE 1/4 = 1'-0"

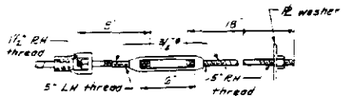
CENTER PIER



SECTION D-D
SCALE 1/2 = 1'-0"



BRIDGE END ANCHOR
SCALE 1/2 = 1'-0"



CABLE END FOR BRIDGE END ANCHOR
NOT TO SCALE

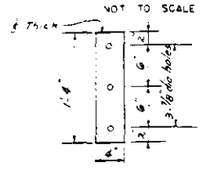


PLATE WASHER DETAIL
SCALE 1/2 = 1'-0"

ABUTMENT

GRAPHIC SCALES

REVISION	DATE	DESCRIPTION	BY

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

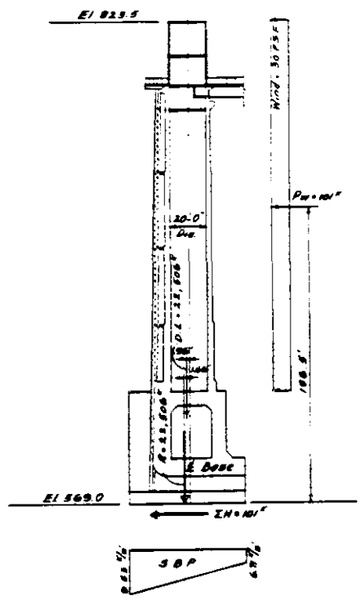
CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
SERVICE BRIDGE
PIERS AND ABUTMENT DETAILS
STEEL REINFORCEMENT
WEST BRANCH-FARMINGTON RIVER CONN & MASS

DATE JAN. 1965

SCALE AS SHOWN | SPEC NO. CIV ENG. 19-016-65-25
DRAWING NUMBER CON - 16
SHEET 57

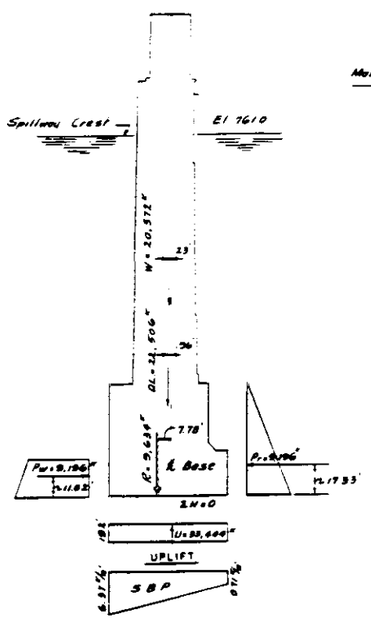
PLATE 24

CORPS OF ENGINEERS — U S ARMY



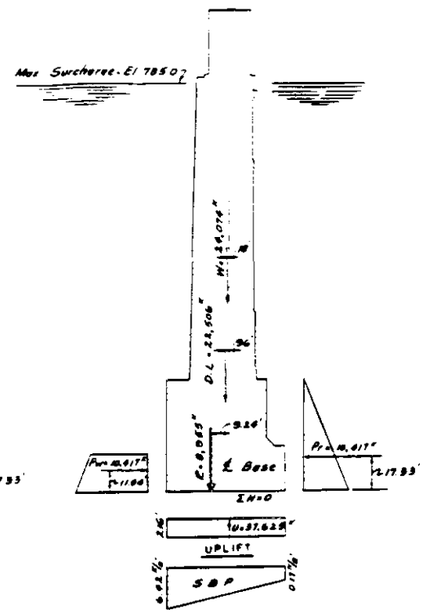
CASE I(A)

1. Reservoir empty
2. Dead load of structure
3. 30 P.S.F. wind load from east



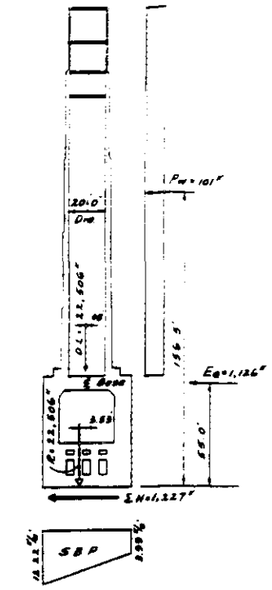
CASE II

1. Reservoir to spillway crest, El. 761.0
2. Dead load of structure
3. Full uplift on base El 569.0
4. Gates closed



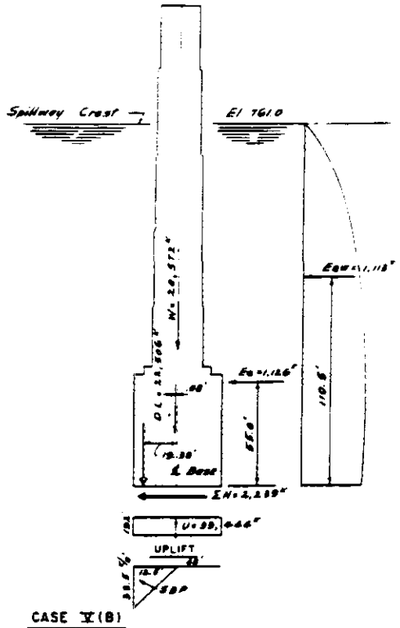
CASE III

1. Reservoir to max. surcharge, El. 785.0
2. Dead load of structure
3. Full uplift on base
4. Gates closed



CASE IV (B)

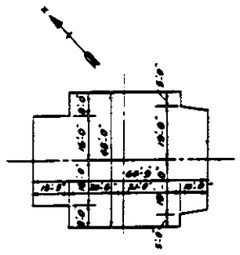
1. Case I loads
2. 30 P.S.F. wind from south
3. Earthquake from north



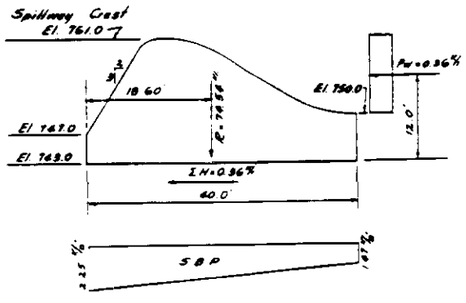
CASE V (B)

1. Case II loads
2. Earthquake from north

INTAKE TOWER STABILITY

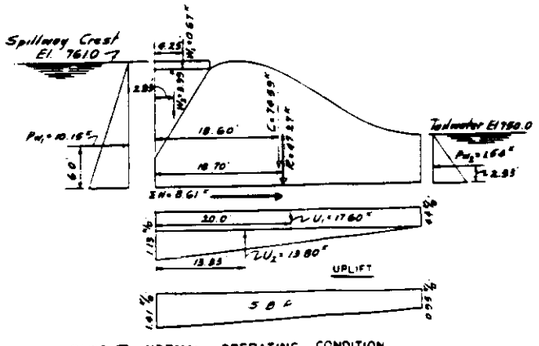


PLAN OF BASE



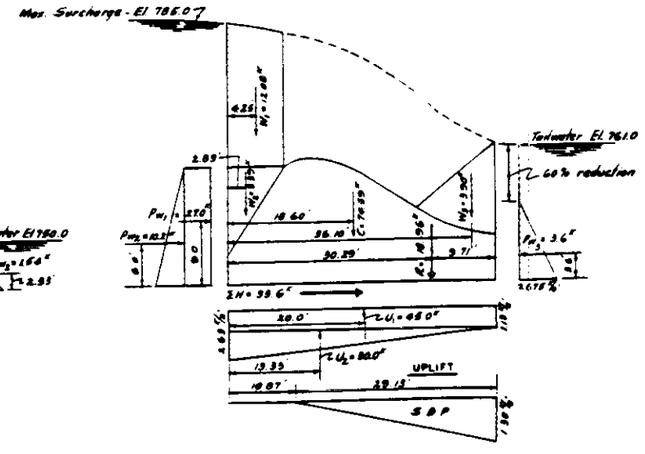
CASE I - CONSTRUCTION CONDITION

1. Spillway weir completed
2. No water
3. 30 P.S.F. wind load on downstream face
4. No uplift



CASE II - NORMAL OPERATING CONDITION

1. Pool of spillway crest, El 761.0
2. Tailwater at El 750.0
3. Full uplift over 100 % of base varies uniformly to full tailwater
4. No ice pressure
5. No wind



CASE III - FLOOD DISCHARGE CONDITION

1. Reservoir at max. flood discharge, El 785.0
2. Tailwater at El 761.0
3. Full uplift over 100 % of base to full tailwater
4. Downstream hydrostatic pressure is 60 % of tailwater

SPILLWAY WEIR STABILITY

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

CONNECTICUT RIVER FLOOD CONTROL
COLEBROOK RIVER DAM
STABILITY DIAGRAMS

WEST BRANCH FARMINGTON RIVER — CONN.-MASS.

SEPT. 1964

SHEET

PLATE NO. 25

CORPS OF ENGINEERS — U. S. ARMY

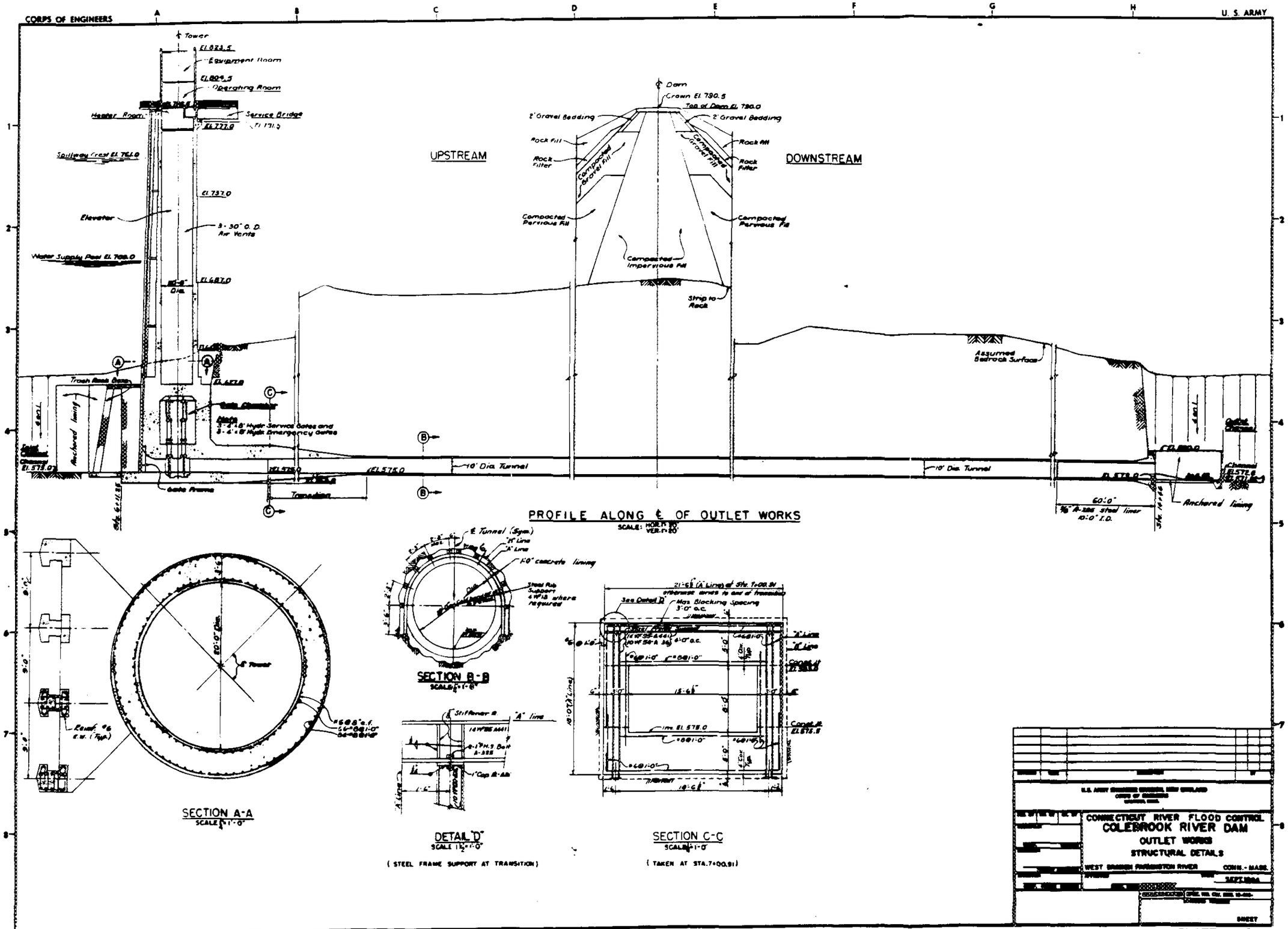
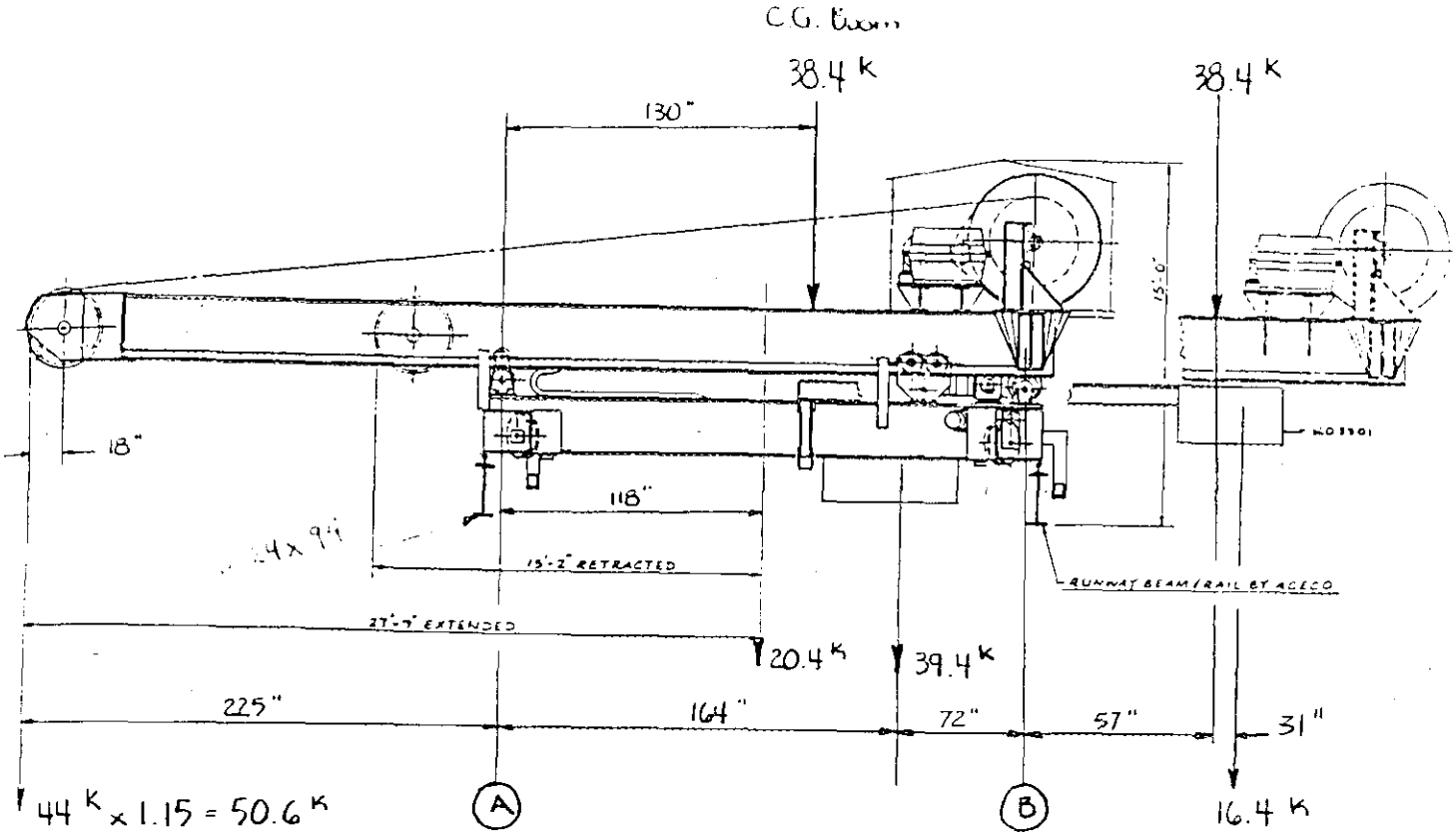


PLATE NO. 26



Stability at (A) w/22 Ton Load

$1.15 \times 44^K \times 225'' \quad : \quad 38.4^K \times 130'' + 20.4^K \times 118'' + 39.4^K \times 164'' + 16.4^K \times 2$

$11{,}385^{K''} < 4992^{K''} + 2407.2^{K''} + 6461.6^{K''} + 4132.8^{K''}$

$11{,}385^{K''} < 17993.6^{K''}$

$1 < 1.58$ Boom Extended

ck w/ Ok
ere should ext CW GO

Stability at (B) w/ No Load

$38.4^K \times 57'' \quad : \quad 39.4 \times 72'' + 18.6^K \times 118'' + 16.4^K \times 88$

$2189 : 6475$

$1 < 2.96$ Boom Retracted

ACECO DOUGLASSVILLE, PENNA. 19518	Catalyst 22 Ton Bridge Crane				WORK ORDER NO. 5361
	DOCUMENT/SKETCH NO.				
	DRAWN D. Weber	DATE 12-88	APPR'D.	DATE	PAGE 6 OF 38

DATE