SUSITNA HYDROELECTRIC PROJECT

CONSULTANTS MEETING

HARZA-EBASCO
SUSITNA JOINT VENTURE

APRIL 15,1985
DOCUMENT NO.2653

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

EXTERNAL REVIEW PANEL

MEETING ON STAGED CONSTRUCTION
April 15 and 16, 1985
Sixth Floor Conference Room

AGENDA

April 15, 1985

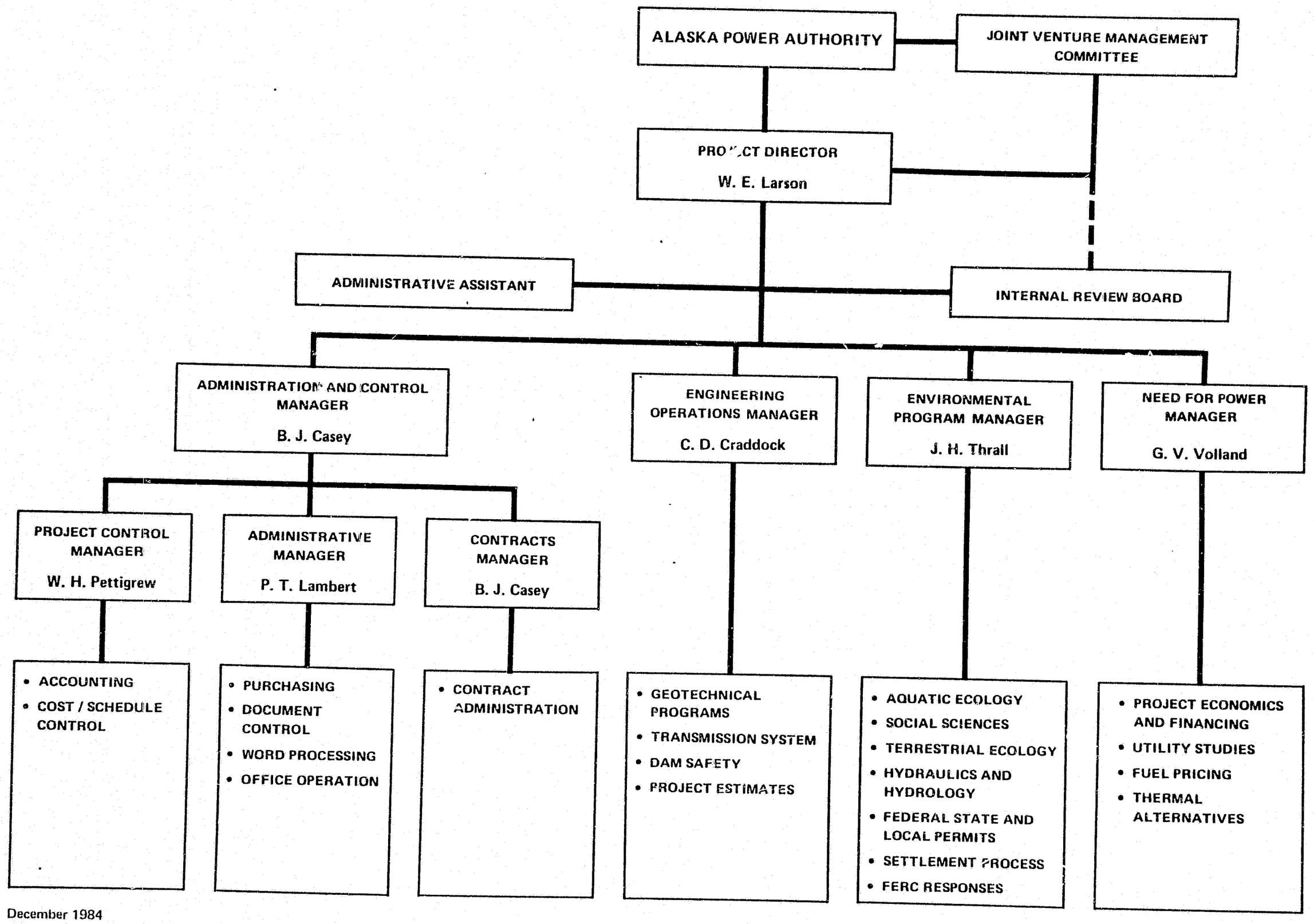
0900-0915	Introductions - Opening Remarks	J. B. Dischinger & J. C. Stafford
0915-0930	Susitna Project Description	C. D. Craddock
0930-1000	Project Master Schedule	C. D. Craddock
	Project Status	
1000-1015	a) Licensing Effort	W. E. Larson
1015-1030	b) Engineering Effort	W. E. Larson
	Engineering Update	
1030-1100	a) Design Refinements	C. D. Craddock
1100-1130	b) 1984 Exploration Program	M. P. Bruen
1130-1200	c) Design Memorandum Concept	C. D. Craddock
1200-1300	Lunch	
1300-1415	Staged Construction Concept	C. D. Craddock
	Future Engineering Work Effort	
1415-1430	a) Staged Construction	C. D. Craddock
1430-1500	b) Watana Support Facilities Master Plan	C. D. Craddock
1500-1530	c) Watana Camp Expansion	C. D. Craddock
1530-1600	d) Future Geotechnical Investigations	M. P. Bruen
1600-1700±	Discussion	

April 16, 1985

0900-1200	Consultants Prepare Report	Consultants
1300-1400	Outbriefing	Consultants
1400-1430	Future Involvement of Consultants	J. B. Dischinger & C. D. Craddock

HARZA-EBASCO SUSITNA JOINT VENTURE

ORAGANIZATION – PHASE I SERVICES – LICENSING



December 1984

PROJECT MASTER SCHEDULE

SUSITNA HYDROELECTRIC PROJECT

WATANA SCHEDULE MILESTONES

- DAM DESIGN CANNOT BEGIN UNTIL POWER SALES AGREEMENT

- CONSTRUCTION ON DAM CANNOT BEGIN UNTIL FERC LICENSE ISSUED

- WATANA SCHEDULED FOR COMPLETION WITH POWER ON LINE IN 1997

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SUSITNA HYDROELECTRIC PROJECT

WATANA SCHEDULE MILESTONES

- TO PROVIDE POWER ON LINE IN 1997, DIVERSION OF THE RIVER MUST TAKE PLACE IMMEDIATELY AFTER BREAKUP IN 1991

- TO ACCOMPLISH DIVERSION IN SPRING OF 1991, DAM CONSTRUCTION MUST BEGIN IN OCTOBER 1989

- TO ALLOW DAM CONSTRUCTION TO BEGIN IN OCTOBER 1989, SUPPORT FACILITY CONSTRUCTION MUST BEGIN IN DECEMBER 1987 (FERC LICENSE)

- TO ALLOW SUPPORT FACILITY CONSTRUCTION TO BEGIN IN DECEMBER 1988 AND DAM CONSTRUCTION IN OCTOBER 1989, THE PERIOD FOR PLANS AND SPECIFICATIONS, DESIGN MEMOS AND CONTRACT BID EVALUATION AND AWARD MUST BE PRECEDED BY A GEOTECHNICAL EXPLORATION PROGRAM STARTING IN THE SPRING OF 1987.

- TO PROVIDE HOUSING FOR THE GEOTECHNICAL PROGRAM PERSONNEL, THE PRESENT CAMP MUST BE EXPANDED DURING THE WINTER OF 1986-87 BY USE OF A SNOW ROAD FROM THE DENALI HIGHWAY

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PROJECT STATUS

LICENSING EFFORT

SUSITNA HYDROELECTRIC PROJECT

REQUIRED AND PLANNED ACTIVITIES - FY85

ENVIRONMENTAL - SLIDE 1

° FOR THE PROGRAM AS A WHOLE:

- COMPLETION OF THE POSITION PAPERS IN SUPPORT OF THE THE SETTLEMENT PROCESS

° FOR THE TERRESTRIAL AND WILDLIFE PROGRAM:

- COMPLETION OF THE MITIGATION PLAN FOR WILDLIFE AND BOTANNICAL RESOURCES INCLUDING DEVELOPMENT OF MONITORITY PROGRAMS

- COMPLETION OF WETLANDS MAPPING AND BROWSE VEGETATION MAPPING, REFINEMENT OF THE POOL OF CANDIDATE MITIGATION LANDS

- COMPLETION OF BIG GAME AND FUR BEARER FIELD STUDIES

SUSITNA HYDROELECTRIC PROJECT

REQUIRED AND PLANNED ACTIVITIES - FY85

ENVIRONMENTAL - SLIDE 2

° FOR THE AQUATIC/FISHERIES PROGRAM:

- COMPLETION OF THE INSTREAM FLOW RELATIONSHIPS REPORT AND THE MITIGATION AND MONITORING PLANS IN SUPPORT OF THE FLOW REGIME SELECTION AND SETTLEMENT PROGRAM.

° FOR THE CULTURAL RESOURCES:

- COMPLETION OF IDENTIFICATION OF ARCHEOLOGICAL SITES IN THE DAM AND IMPOUNDMENT AREA

- COMPLETION OF FINAL REPORT FOR UAA-MUSEUM ARCHEOLOGICAL PROGRAM (1980-1984)

- COMPLETION OF A PREDICTIVE MODEL FOR DETERMINING POTENTIAL FOR ARCHEOLOGICAL SITES ON LINEAR FEATURES (PROJECT ROADS AND TRANSMISSION LINES)

- COMPLETION OF DETERMINATIONS OF ELIGIBILITY OF SITES FOR NATIONAL REGISTER OF HISTORIC PLACES.

SUSITNA HYDROELECTRIC PROJECT

REQUIRED AND PLANNED ACTIVITIES - FY85

ENVIRONMENTAL - SLIDE 3

° FOR SOCIOECONOMICS:

- REVIEW AND DEFINE CONSTRUCTION FOR RELATED IMPACTS REFINEMENT OF COMMUNITY IMPACT ANALYSES

- COMPLETION OF RESOURCE USER IMPACT ASSESSMENT

- REFINEMENT OF SOCIOECONOMIC MITIGATION PLAN.

° FOR RECREATION:

- REFINEMENT OF THE RECREATION PLAN
- BEGIN OBTAINING OPERATION AND MAINTENANCE AGREEMENTS.

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850405

SUSITNA HYDROELECTRIC PROJECT

REQUIRED AND PLANNED ACTIVITIES - FY86

LICENSING AND PERMITTING

- ASSIST IN REVIEW OF FERC FEIS AND PREPARATION FOR HEARINGS
- CONTINUE PERMIT APPLICATIONS FOR FIELD ACTIVITIES
- COMPLETE PREPARATION OF MOST OF THE MAJOR CONSTRUCTION PERMITS
- COMPLETE SETTLEMENT ON MOST ISSUES

SUSITNA HYDROELECTRIC PROJECT

REQUIRED AND PLANNED ACTIVITIES - FY86

LICENSING AND PERMITTING

- ASSIST IN REVIEW OF FERC FEIS AND PREPARATION FOR HEARINGS
- CONTINUE PERMIT APPLICATIONS FOR FIELD ACTIVITIES
- COMPLETE PREPARATION OF MOST OF THE MAJOR CONSTRUCTION PERMITS
- COMPLETE SETTLEMENT ON MOST ISSUES

SUSITNA HYDROELECTRIC PROJECT

REQUIRED AND PLANNED ACTIVITIES - FY86

ENVIRONMENTAL - SLIDE 1

- GENERAL ACTIVITIES WILL INCLUDE
  - SUPPORT OF THE SETTLEMENT PROGRAM THROUGH AGENCY MEETINGS
  - REVISION OF POSITION PAPERS AND DRAFTING OF MEMORANDA OF AGREEMENT
  - PREPARATION OF TESTIMONY FOR THE HEARINGS

- REVIEW OF AND PREPARATION OF COMMENTS ON THE FEIS WILL OCCUR IN THE FIRST HALF OF FY86

- TERRESTRIAL AND WILDLIFE PROGRAM WILL INCLUDE FINALIZATION OF THE BROWSE INVENTORY PROGRAM AND REFINEMENT TO THE MITIGATION PROGRAM INCLUDING THE CANDIDATE LANDS SELECTION PROCESS AS PART OF THE SETTLEMENT PROGRAM

SUSITNA HYDROELECTRIC PROJECT

REQUIRED AND PLANNED ACTIVITIES - FY86

ENVIRONMENTAL - SLIDE 2

- AQUATIC FISHERIES PROGRAM FOR FY86 ACTIVITIES WILL FOCUS ON REFINEMENT OF THE FLOW REGIME, MITIGATION PLAN AND MONITORING PROGRAM

- FOR THE CULTURAL RESOURCES, TESTING PREDICTIVE MODEL BY SAMPLING ALONG THE LINEAR FEATURES, COMPLETION OF THE IMPACT ASSESSMENT AND MITIGATION PLAN

- FOR SOCIOECONOMICS, FINALIZE MITIGATION PLAN

- FOR RECREATION, OBTAIN O & M AGREEMENTS

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850405

SUSITNA HYDROELECTRIC PROJECT

NEED FOR POWER - SLIDE 1

- NEED FOR POWER HEARINGS:
  - TESTIMONY WILL BE UPDATED AS NECESSARY PRIOR TO THE NEED FOR POWER HEARINGS SCHEDULED FOR NOVEMBER 1985
  - DISCOVERY ACTIVITIES, THE HEARINGS, AND THE PREPARATION OF BRIEFS WILL BE REQUIRED IN FY86

- PROVISIONAL POWER SALES AGREEMENTS:
  - PROVISIONAL POWER SALES AGREEMENTS ARE ANTICIPATED BY DECEMBER 1, 1985
  - DEPENDING UPON THE LEVEL OF AGREEMENT, WORK MAY CONTINUE TO REFINE THESE THESE AGREEMENTS

SUSITNA HYDROELECTRIC PROJECT

NEED FOR POWER - SLIDE 2

° FLOW REGIME NEGOTIATIONS AND ENVIRONMENTAL SUPPORT:

- THE PROJECT OPERATION STUDIES IDENTIFIED FOR FY85 WILL CONTINUE THROUGH FY86

° FEIS AND LICENSING SUPPORT:

- THE FEIS WILL REQUIRE A THOROUGH REVIEW AND THE PREPARATION OF TECHNICAL COMMENTS WHEN IT IS RELEASED IN SEPTEMBER

- RESPONSES TO REQUESTS BY FERC MAY BE REQUIRED PRIOR TO THE INITIATION OF THE HEARING PROCESS

ENGINEERING EFFORT

SUSITNA HYDROELECTRIC PROJECT

REQUIRED AND PLANNED ACTIVITIES - FY85

ENGINEERING - SLIDE 1

- PROVIDE DETAILED OVERALL PROJECT SCHEDULE FOR ENGINEERING AND CONSTRUCTION AND UPDATE AS REQUIRED

- PARTICIPATE IN REVIEW AND PREPARATION OF BEST PRACTICES MANUALS

- INITIATE MASTER PLAN FOR WATANA SUPPORT FACILITIES

- DAM SAFETY HEARINGS PREPARATION

- MONITORING AND EVALUATION OF GEOTECHNICAL AND HYDROLOGIC OBSERVATION DEVICES

- PARTICIPATE IN REVIEW AND PREPARATION OF POSITION PAPERS

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SUSITNA HYDROELECTRIC PROJECT

REQUIRED AND PLANNED ACTIVITIES - FY85

ENGINEERING - SLIDE 2

- DEVELOP SUSITNA STAGED CONSTRUCTION CONCEPT
- PREPARE DEIS SUPPLEMENTAL COMMENTS ON STAGED CONSTRUCTION
- INITIATE FERC LICENSE APPLICATION REVISION IN REGARD TO STAGED CONSTRUCTION
- EVALUATION OF EXISTING TRANSMISSION SYSTEMS
- TRANSMISSION LINE PLANNING - VICINITY OF ANCHORAGE AND FAIRBANKS

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850410

SUSITNA HYDROELECTRIC PROJECT

REQUIRED AND PLANNED ACTIVITIES - FY85

LICENSING AND PERMITTING

- CONTINUE COORDINATION OF PREPARATION AND SUBMITTAL OF FLOW REGIME IN RESPONSE TO FERC INFORMATION REQUEST

- CONTINUE PREPARATION OF FIELD PERMIT APPLICATIONS AND APPLICATIONS FOR MAJOR CONSTRUCTION PERMITS

- CONTINUE SETTLEMENT PROCESS INCLUDING FINISHING POSITION PAPERS AND BEGINNING FORMAL NEGOTIATIONS WITH AGENCIES, INTERVENORS AND NATIVE ORGANIZATIONS

- COMPLETE THE SERIES OF FIVE BEST MANAGEMENT PRACTICES MANUALS AND DISTRIBUTE

SUSITNA HYDROELECTRIC PROJECT

REQUIRED AND PLANNED ACTIVITIES - FY86

ENGINEERING - SLIDE 1

- DEVELOP ORGANIZATIONAL CONCEPT FOR IMPLEMENTING DESIGN OF WATANA DAM AND RESERVOIR

- UPDATE OVERALL PROJECT SCHEDULE FOR ENGINEERING AND CONSTRUCTION

- PREPARE TESTIMONY FOR DAM SAFETY AND ENVIRONMENTAL HEARINGS, SUPPORT DISCOVERY PROCESS

- FEIS REVIEW AND COMMENT

- FINALIZE FERC LICENSE APPLICATION REVISION FOR STAGED CONSTRUCTION

SUSITNA HYDROELECTRIC PROJECT

REQUIRED AND PLANNED ACTIVITIES - FY86

ENGINEERING - SLIDE 2

- INITIATE PLAN OF STUDY FOR MAJOR GEOTECHNICAL EXPLORATION PROGRAM AT WATANA
- INITIATE SPECIFICATIONS FOR WATANA GEOTECHNICAL EXPLORATION PROGRAM
- INITIATE DEVELOPMENT OF DESIGN MEMORANDA CONCEPT FOR WATANA
- MONITORING AND EVALUATION OF GEOTECHNICAL AND HYDROLOGIC OBSERVATION DEVICES
- RESPOND TO FERC REQUESTS FOR ADDITIONAL INFORMATION

ENGINEERING UPDATE

DESIGN REFINEMENTS

SUSITNA HYDROELECTRIC PROJECT
WATANA AND DEVIL CANYON DESIGN REFINEMENTS

1. Introduction

Described herein are design refinements to the Susitna Hydroelectric Project License Application filed by the Alaska Power Authority (Power Authority) in February, 1983.

1.1 Watana Development Design Refinements

The proposed design refinements for Watana development are as follows:

1. Reduced bedrock and alluvium excavation and treatment for the dam embankment foundation.

2 Revised configuration and composition of the dam and the cofferdams' internal zoning.

3. revised vertical setting and size of diversion tunnels and inversed cofferdam heights.

4. Relocation and reorientation of the transformer gallery, powerhouse and surge chamber caverns.

5. Revised arrangement of power conduits and power intake.

6. Increase in size of main service spillway to pass all of the probable maximum flood and elimination of the emergency (fuse-plug type) spillway.

7. Revised layout of approach channels to the Power intake and spillway.

8. Construction facilities reduced in accordance with reductions in above construction work.

9. Rotational speed of turbine-generator units increased from 225 to 257.1 rpm.

10. SF6 gas-insulated switchgear and bus selected instead of an open-air switchyard supplied by oil-filled main leads from the underground powerhouse.

11. Selection of open-cut trench instead of tunnel for spillway chute drainage.

1.1.1 Excavation and Foundation Treatment for Dam

The main dam foundation treatment, as refined, would reduce rock excavation beneath the core and shells and limit excavation of the river valley alluvium to the central 80% of the dam foundation.

The areas of the dam in proximity to the upstream and downstream toes of the embankment are now planned to be founded on the river bed alluvium, with the central 80% to have a bedrock foundation.

The 1983 Winter Geologic explorations have shown that the bedrock is of a better quality than originally anticipated. Therfore, only limited excavation of bedrock beneath the embankment is foreseen in the river channel. Fresh hard diorite in most instances exists from the bedrock surface. Removal or foundation treatment (dental excavation or concrete backfill) will be performed in local areas beneath the shells where erodible or otherwise unsatisfactory foundation bedrock is encountered. The quantity of rock to be removed under the embankment will be reduced from that estimated in License Application by about 3.75 million cubic yards. The License Application cost estimates assumed a trench beneath the impervious core and filters averaging 40

feet deep, and an average excavated depth under the shells of 10 feet. The design refinement provides a core trench 10 feet deep in the river section, and 20 feet deep on the abutments. Excavation under the shells on the abutments averages one foot. A reduction in the total length of grout galleries, grout curtain drilling, and grouting was also made in view of the better quality foundation bedrock.

1.1.2 Dam and Cofferdam Configuration and Composition

The License Application design for the dam cross section has been essentially retained as it is considered to be satisfactory and will produce a stable structure. To increase safety against seismic shaking, the steepening of the exterior slopes near the embankment crest has been eliminated. This results in the same exterior slope from crest to toe both upstream and downstream. The embankment internal zoning design has also been modified to incorporate materials from the required excavations along with by-product materials from the processing operations. The refined layout includes the use of rock and processed granular materials in the shells outside the impervious core. This section increases the utilization of available materials and will reduce required borrow as well as reduce spoil requirements.

The cofferdam sections were revised to a more conservative design and a positive slurry trench cutoff to bedrock would be provided.

1.1.3 Vertical Setting and Size of Diversion Tunnels and Cofferdam Heights

The two diversion tunnels as shown in the License Application were 38 foot diameter concrete lined. The total discharge capacity is 80,500 cfs. One tunnel has an intake portal invert below the river bed level, while the other is 70 feet higher. With the deep alluvium in the river bed upstream, the low tunnel could result in sediment deposition during flood recession. This tunnel could be partially filled with gravels thereby reducing its hydraulic capacity for the next flood season.

Therefore, the refinement consists of raising the intake portal invert of the lower tunnel to El. 1445. The refinements also consist of adjusting the location and orientation of the tunnels based on more recent geological information and lowering the upper tunnel for greater hydraulic efficiency which permits decreasing the diameters of both tunnels to 36 feet.

The cofferdam locations would simultaneously be adjusted to utilize the reduced excavation of alluvium in the dam foundation. The length of the upstream cofferdam would be reduced by relocating it further downstream. The freeboard of the cofferdam was increased to provide additional safety against ice pileup or higher water levels caused by ice jams.

A comparison of the refined design with the License Application follows:

	License Application	Refined Design
Tunnel 1 U/S Invert El.	1490	1468
Tunnel 1 D/S Invert El.	1450	1455
Tunnel 2 U/S Invert El.	1420	1445
Tunnel 2 D/S Invert El.	1405	1430
U/S Ice-Free Water Level El.	1535	1532
U/S Cofferdam Crest El.	1545	1550
U/S Cofferdam Freeboard (ft.)	10	18
D/S Ice-free Water Level E	1468	1468
D/S Cofferdam Crest El.	1472	1495
D/S Cofferdam Freeboard (ft.)	4	27

1.1.4 Relocation and Reorientation of Caverns

A review of the site geology, as presented in prior geotechnical reports (1980-81 and 1982), indicated a major set of fracures which trended N 50°W and a second minor set perpendicular to these. The caverns for the powerhouse, transformer gallery, and surge chamber, as shown in the License Application, trend in a direction approximately N 20°W, straddling between the major joint system and a subjoint system.

Excavation of the longitudinal walls would be improved if the major joint planes were to intersect the walls as near to the perpendicular as possible. Consequently, the caverns were rotated accordingly. This change will result in less over break of rock in the cavern faces, lessen construction problems and contribute to greater safety during construction. This change was also beneficial to the changes in the water conduit and access tunnel geometry described below.

1.1.5 Power Conduits and Intake

The License Application indicates a single structure power intake with six intake passages located approximately 1,000 feet upstream from the dam axis. The power conduits consist of six individual penstock tunnel and shafts with a developed length of about 1,500 feet each connecting the intake structure to the powerhouse, and two tailrace tunnels approximately 2,000 feet long connecting the powerhouse to the river. The downstream 300 feet of one of the tailrace tunnels utilized the downstream portion of one of the diversion tunnels.

To reduce the power conduit length in the design refinement, the intake structure was shifted to a location between the spillway and the river channel and nearer to the dam axis resulting in relocation and shortening of the power conduits. The number of penstock tunnels was reduced from six to three, each of which bifurcates to smaller penstock tunnels at a point approximately 200 feet upstream from the powerhouse.

Guard valves will be provided for each turbine. The net head on the generating units will be greater, and the shorter, more efficient power conduits will provide better unit operation. Overall, the three power tunnel design will be more cost effective than the six penstock tunnel design. Vertical shafts are also recommended instead of sloping shafts because excavation and concreting of vertical shafts requires less time, personnel, and equipment, and given the geologic conditions, should result in less overbreak.

1.1.6 Spillways

The License Application shows provisions for dual spillways. In this concept, the service spillway, the outlet works, and two generating units would discharge flows corresponding to floods with 1:10,000 year occurance probability (Exhibit E, pp.E-2-107 4.1.3, (a), (iii)). For larger floods, the reservoir would be surcharged to a maximum of El.2201 (during the PMF event). Prior to reaching that reservoir level, the fuse plug would begin to be breached and after a period of time, would be fully eroded. At this time, the service spillway and fuse-plug emergency spillway will reach their peak discharges of 152,000 cs and 120,000 cfs, respectively. This spillway concept would allow passing of the Probable Maximum Flood (PMF) without overtopping the dam. During the PMF, the minimumn reservoir freeboard would be 6 feet.

Alternative spillway arrangements of a gated, single spillway were studied, sized for the PMF with criteria of maintaining the same freeboard as the dual spillway scheme and hence the same safety against dam overtopping. While these studies were initiated to seek lower costs, elimination of the fuse plug was considered a benefit environmentally, aesthetically and, in a minor way, to dam safety. Questions had been raised by FERC in their request for supplemental information of April 12, 1983 (See Comment No. 2 on pp. 34 of Exhibit F

of that request) as to the safety of the fuse plug against adverse conditions of freezing weather. While the response to the comment indicated that the design could be arranged with proper selection of granular materials to erode under freezing conditions successfully and thereby provide the desired flood release, elimination of the fuse plug structure would eliminate all risk of the fuse plug not operating.

Inasmuch as a gated spillway is required in both the single and dual spillway concepts, and the reliability of a given gate design is not materially affected by its size, the larger single spillway design, absent the fuse plug, has equivalent or slightly enhanced safety over the dual spillway design in the License Application. A more tangible benefit of the single spillway design over the dual spillway design included in the License Application is its lower cost for the same total design capacity.

Moreover, the analyses led the Power Authority to conclude that a single spillway design had certain environmental advantages, in addition to being as safe and as effective as the dual spillway design. Environmental advantages to the single spillway scheme are as follows;

a) Visual impact of the project would be reduced by eliminating the fuse plug spillway. Because of the significant extent of the cut for this water passage, its elimination is considered a major improvement in project aesthetics.

b) The overall ground surface areas that would be disturbed by construction would be reduced. Construction of the License Application service spillway would entail disturbing approximately 13 acres and construction of the emergency spillway would entail disturbing 55 acres for a total 68 acres for the dual spillway scheme. The single spillway design would require disturbance of approximately 22 acres, thus resulting in a net

reduction of 46 acres of ground surface to be disturbed by construction.

c) With either the single or dual spillway scheme, the service spillway would be operated only for floods greater than the 1:50 year occurance. For smaller floods, spill discharges in excess of power flows would be made with the hollow cone valves. Thus, there would be no difference in environmental consequences for either the single or dual spillway design for such flows.

d) For flows between the 1:50 and 1:10,000 year flood flow, only the gated service spillway would be operated with the dual spillway scheme (The fuse plug would remain intact). Service spillway operation for the dual spillway scheme in this flow range would have environmental effects equal to or slightly worse than the larger gated service spillway being proposed in the single spillway scheme.

This statement can be amplified as follows:

FACTOR (For any given flow in the range considered)	ESTIMATED EFFECT OF SERVICE SPILLWAY OPERATION	
	SMALL SPILLWAY (License Application)	LARGE SPILLWAY (Proposed Refinement)
1. Operating Head	Same	Same
2. Height of spillway bucket exit above tailwater	Same	Same
3. Approximate width of spillway chute exit	80 feet	120 feet
4. Chute exit velocity	Reference Value	Same or slightly less because of increased air and skin friction drag

5.	Flow energy concentration (Energy per unit width of chute requiring dissipation)	Reference	Lower by approximately 33%
6.	Plunge depth	Reference Value	Same or slightly less because of lower unit energy in the impact area
7.	Gas supersaturation	Reference	Same or slightly less
8.	River bed erosion	Reference	Same or slightly less
9.	River bank erosion	Same	Same

While it can be argued that the absolute differences of the factors cited above may be infinitestimal in those cases which are presented as "slightly less", it is the intent of the above presentation to show, at the least, environmental equivalence between the two schemes in the flow range considered. For both spillway schemes and for any given flood flow between the 1:50 year up to the 1: 10,000 year event, all flows higher than the hydraulic capacity of the turbines and the cone valves will be passed over the spillway with resultant erosion and gas supersaturation effects. While logic clearly dictates that these effects will necessarily be less for the large spillway, the differences cannot be quantified in any meaningful way using existing state of the art analyses.

e) For floods of the 1:10,000 year or greater recurrence interval, the proposed larger service spillway would eliminate severe erosion of about 60 acres which would be associated with operation of the fuse plug spillway as described in the License Application. However, a one in 10,000 year or greater event which differentially impacts only 60 acres is not within a reasonable

range of importance to be seriously considered from an environmental point of view.

Thus, a single spillway is recommended with the capacity to pass the PMF while maintaining the same reservoir surcharge criterion.

The design refinement also recommends use of radial gates instead of vertical lift gates as shown in the License Application. A radial gate installation would cost less than a vertical lift gate installation and in the experience of the project design consultant and other agencies radial gates are the usual choice for operation under subfreezing conditions.

1.1.7 Power Intake and Spillway Approach Channels

The hydraulic conditions of the approach channels to the power intake and spillway as shown in the License Application can be improved with the relocation of the powerhouse and the power conduits. In the License Application, the power intake is located such that it appears to impede flow to the spillway. The design refinement location of the power intake will eliminate this effect. The approach channels as refined will require larger quantities of rock excavation; however, this material can be used for fill in the dam and for concrete aggregate.

1.1.8 Construction Facilities

The lower construction quantities will reduce labor requirements thereby reducing the size of the construction camp and catering services.

1.1.9 Turbine-Generator Unit Speed

The design refinement consists of increasing the synchronous speed of the turbine-generator units from 225 rpm as shown in the License Application to 257.1 rpm.

Basically, a higher speed unit requires a deeper setting of the turbine distributor below tailwater. The depth shown in the License Application is, however, lower than necessary for the 225 rpm turbine and is also sufficient for the 257.1 rpm turbine. This increase in speed will reduce the physical size and cost of the turbine-generator set and also may possibly result in some reduction in the powerhouse size at the time the final design is made.

1.1.10 Gas Insulated Switchgear and Bus

Revisions of the high voltage conductors from the main power transformer to the ground surface and elimination of the ground level switchyard by use of SF6 gas insulated switchgear and bus are proposed in the design refinement. The revisions include use of a single 9' - 0" diameter vertical SF6 bus shaft instead of two vertical 7' - 6" diameter cable shafts from the transformer gallery to the surface. All switching equipment will be underground thus simplifying maintenance. This refinement will provide an improved environment for operation and maintenance by elimination of the potential for icing of equipment in a ground level switchyard. Substitution of SF6 buses for oil-filled cables will improve safety by removal of fire hazards from the cable shaft area. Elimination of the switchyard will also reduce environmental impact and improve aesthetics by the construction of fewer and smaller surface structures.

1.1.11 Spillway Chute Drainage

Drainage of the spillway chute as shown on the License Application consists of a drainage tunnel excavated 30 feet below the chute slab under the longitudinal centerline of the chute. Angled drainage holes would lead form box drains under the chute slab to the drainage tunnel. The design refinement consists of substituting for the drainage tunnel a gallery excavated in an open cut trench also along the longitudinal centerline of the chute. Box drains would then lead to this gallery. This refinement simplifies the construction procedure from that of a tunnelling operation to open cut excavation.

1.2 Devil Canyon Development Design Refinement

The design refinement proposed for Devil Canyon Development consists of increasing the main service spillway capacity to pass the Probable Maximum Flood (PMF), thereby allowing elimination of the fuse-plug type emergency spillway shown in the License Application.

This refinement provides the following listed advantages to which the discussion heretofore under 1.1.6 for the same Watana development features applies:

a) The larger single spillway will be less costly than the dual spillways.

b) Reduction of visual impact and improved aesthetics.

c) The net ground surface areas to be disturbed by construction can be reduced. Construction of the License Application service and emergency spillways are approximately 12 and 15 acres, respectively for a total of 27 acres. The enlarged single spillway would require disturbance of approximately 15 acres

resulting in a reduction by 12 acres of ground surface disturbance.

d) No net differential environmental impacts due to operation of the spillway, as previously described for Watana.

SUSITNA HYDROELECTRIC PROJECT

WATANA DESIGN REFINEMENTS - SLIDE 1

1. REDUCED BEDROCK AND ALLUVIUM EXCAVATION AND TREATMENT FOR THE DAM EMBANKMENT FOUNDATION

2. REVISED CONFIGURATION AND COMPOSITION OF THE DAM AND THE COFFERDAMS' INTERNAL ZONING

3. REVISED VERTICAL SETTING AND SIZE OF DIVERSION TUNNELS AND INVERSED COFFERDAM HEIGHTS

4. RELOCATION AND REORIENTATION OF THE TRANSFORMER GALLERY, POWERHOUSE AND SURGE CHAMBER CAVERNS

5. REVISED ARRANGEMENT OF POWER CONDUITS AND POWER INTAKE

6. INCREASE IN SIZE OF MAIN SERVICE SPILLWAY TO PASS ALL OF THE PROBABLE MAXIMUM FLOOD AND ELIMINATION OF THE EMERGENCY (FUSE-PLUG TYPE) SPILLWAY

SUSITNA HYDROELECTRIC PROJECT

WATANA DESIGN REFINEMENTS - SLIDE 2

7. REVISED LAYOUT OF APPROACH CHANNELS TO THE POWER INTAKE AND SPILLWAY

8. CONSTRUCTION FACILITIES REDUCED IN ACCORDANCE WITH REDUCTIONS IN ABOVE CONSTRUCTION WORK

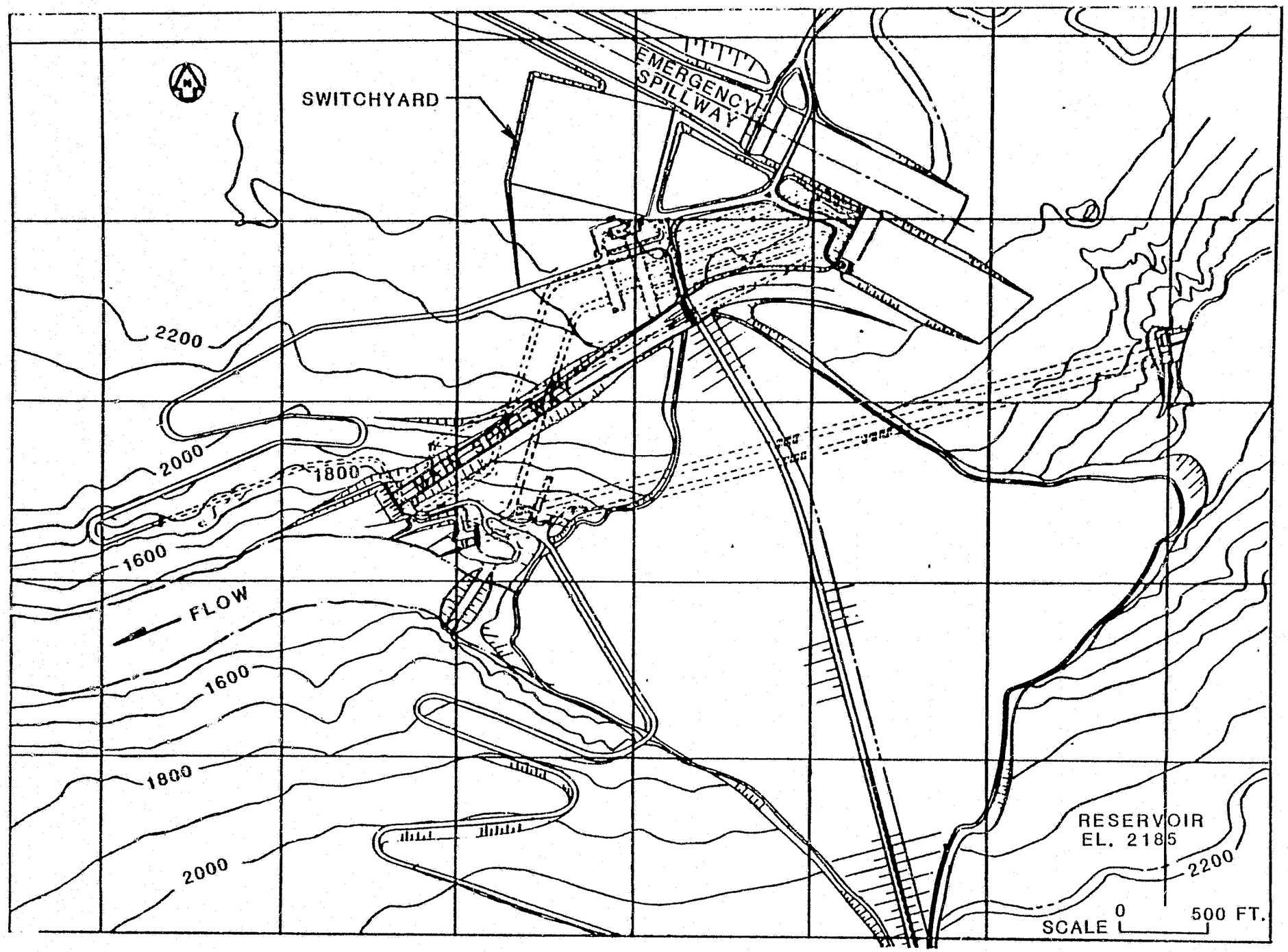
9. ROTATIONAL SPEED OF TURBINE-GENERATOR UNITS INCREASED FROM 225 TO 257.1 RPM

10. SF6 GAS-INSULATED SWITCHGEAR AND BUS SELECTED INSTEAD OF AN OPEN-AIR SWITCHYARD SUPPLIED BY OIL-FILLED MAIN LEADS FROM THE UNDERGROUND POWERHOUSE

11. SELECTION OF OPEN-CUT TRENCH INSTEAD OF TUNNEL FOR SPILLWAY CHUTE DRAINAGE

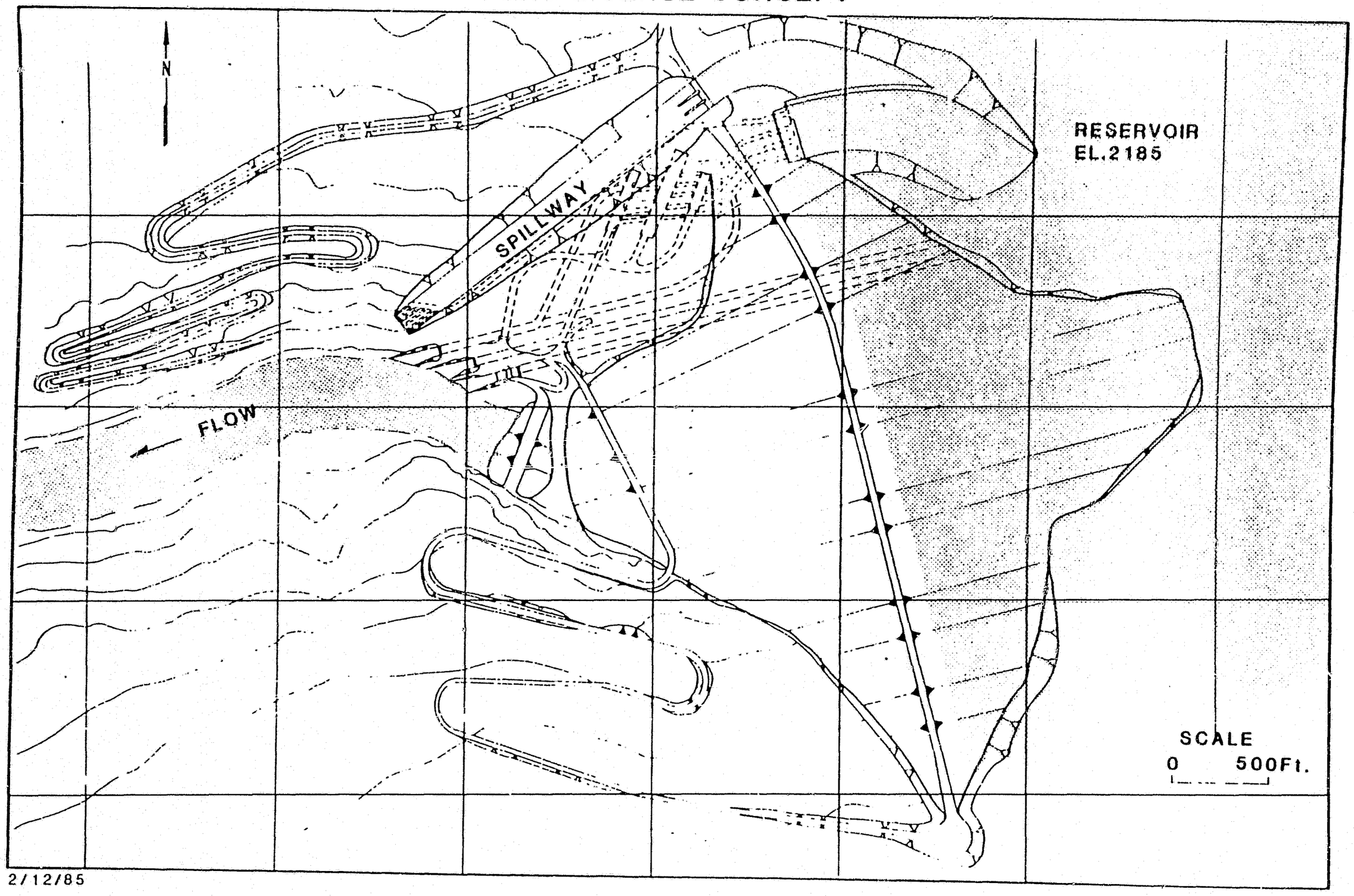
12. REVISION OF RELICT CHANNEL TREATMENT

WATANA DAM GENERAL PLAN
ORIGINAL FERC LICENSE CONCEPT



WATANA DAM GENERAL PLAN

FERC LICENSE CONCEPT



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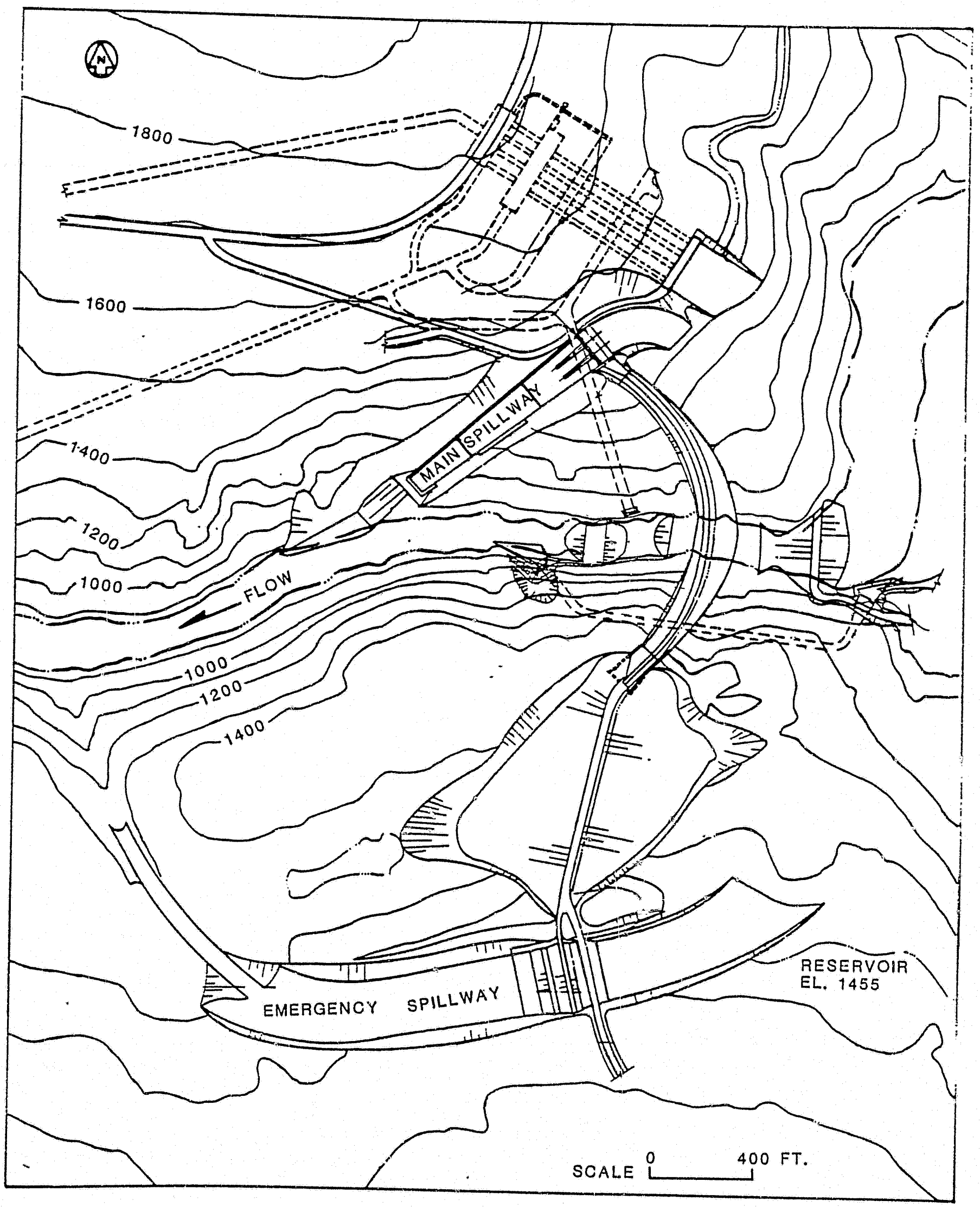
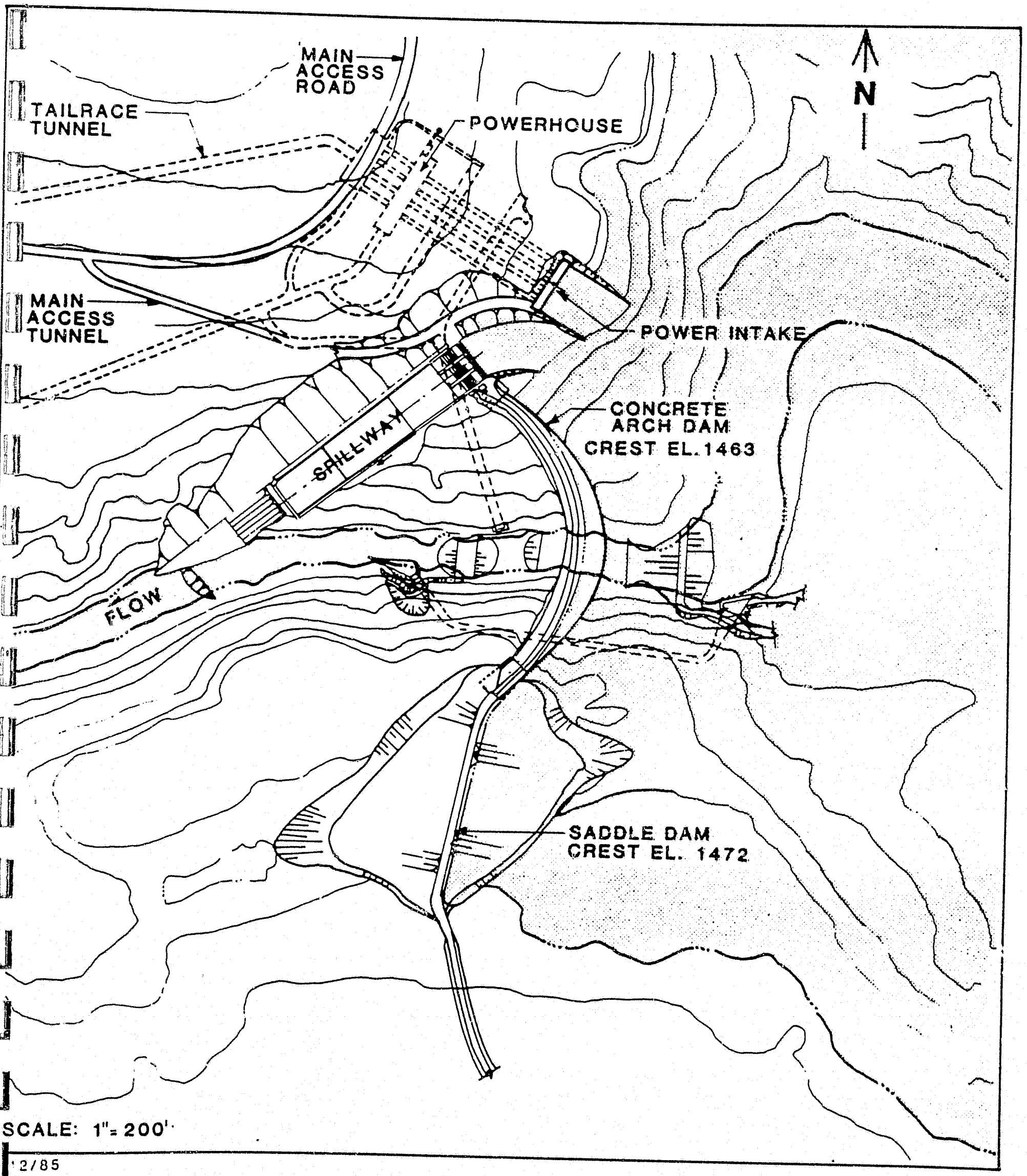
EE 6

DEVIL CANYON GENERAL PLAN
ORIGINAL FERC LICENSE CONCEPT



DEVIL CANYON GENERAL PLAN

FERC LICENSE OR STAGED CONSTRUCTION



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EE 13

1984 EXPLORATION PROGRAM

FY84 EXPLORATION PROGRAM

BACKGROUND

- FERC ENGINEERS SITE VISIT
  - EXPRESSED CONCERN OVER ERODIBILITY AND SEEPAGE POTENTIAL OF THE FINS
- FERC LETTER - FORMALLY EXPRESSED CONCERNS
  - EXPLORATIONS IN THE FINS AREA ARE INADEQUATE TO PREDICT THE SEEPAGE POTENTIAL UNDER FULL RESERVOIR CONDITIONS
  - NEED TO RECONSIDER THE SCHEDULING OF ADDITIONAL SITE INVESTIGATIONS IN FY84/85 IN ORDER TO AVOID DELAYS IN LICENSE
- APA RESPONDED TO FERC
  - TRANSMITTED COST ESTIMATES FOR TREATMENT OF THE RELICT CHANNEL
  - PROPOSED AN EXPLORATION PROGRAM IN THE FINS, OUTLET (FINGERBUSTER), AND POWERHOUSE AREAS

50761.0
50410

FY84 EXPLORATION PROGRAM

FINS

- OBJECTIVES
  - REVIEW EXISTING DATA
  - DELINEATE OVERBURDEN STRATIGRAPHY AND MATERIAL PROPERTIES
  - DETERMINE ROCK QUALITY; EXTENT OF WEATHERING, FRACTURING, SHEARING, AND ALTERATION
  - DETERMINE PERMEABILITY WITHIN THE ROCK
- NUMBER OF HOLES
  - 5 ANGLE HOLES; 254 TO 849 FEET

50761.1
850410

FY84 EXPLORATION PROGRAM

FINS - REVIEW EXISTING DATA

- GEOLOGIC MAPPING OF FINS

  - THREE NW-SE SHEARS AND FRACTURE ZONES OF SIGNIFICANT WIDTH AND CONTINUITY TO BE CONSIDERED

- CORE FROM DR-18, 19, AND 20

  ROCK IN DR-18, 19 CONSISTS OF HARD, STRONG, CLOSELY JOINTED DIORITE AND FELSITE, RQD = 0 - 98%; DR-20 CONSISTS OF HIGHLY WEATHERED DIORITE, RQD IS ZERO THROUGHOUT

  - NO WATER LOSSES DURING DRILLING WERE NOTED ON THE CORE LOGS

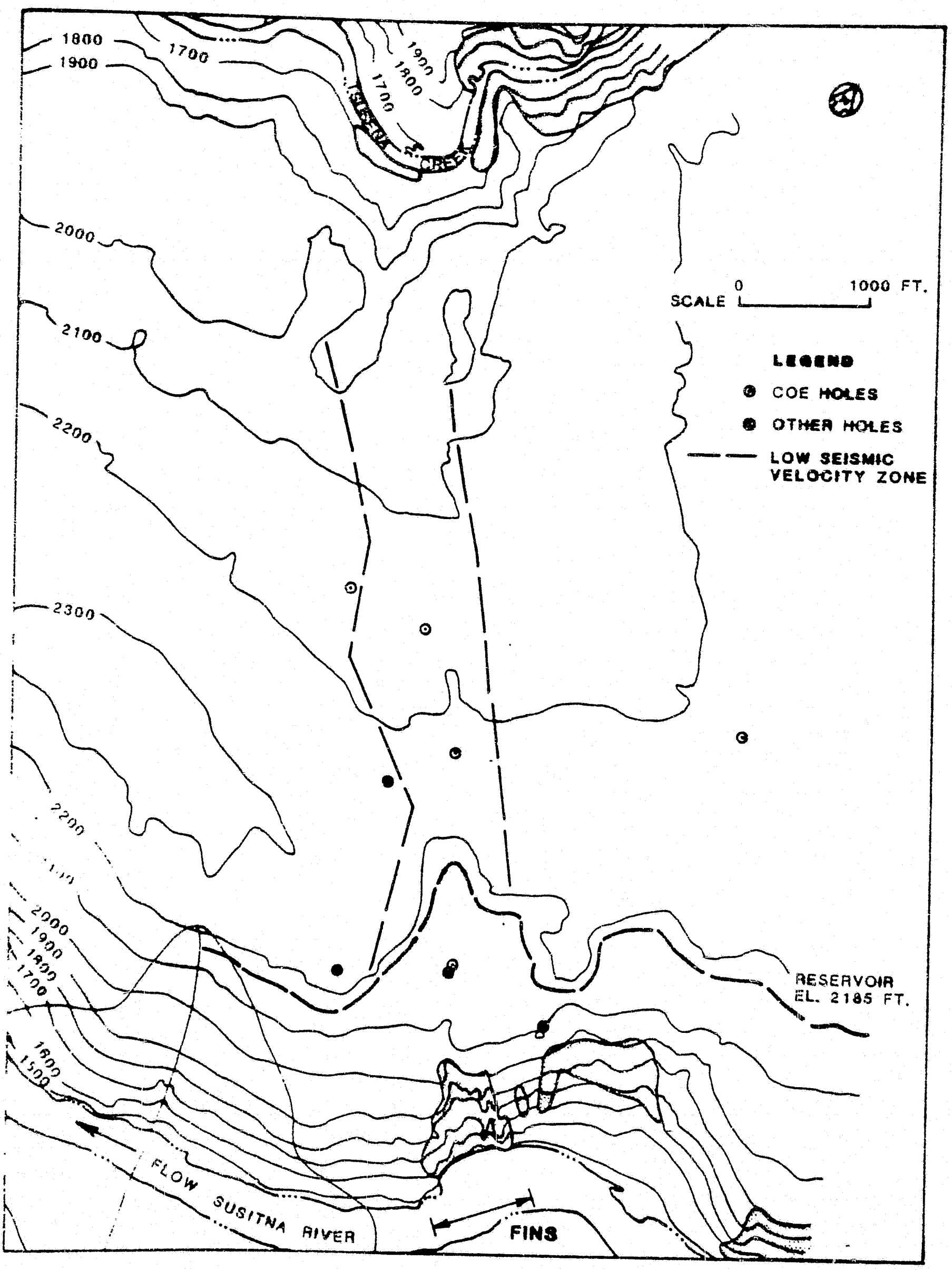
  - LIMITED PIEZOMETRIC DATA INDICATES THAT THE PRESENT AND POST RESERVOIR PIEZOMETRIC LEVELS APPROXIMATE THE GROUND SURFACE

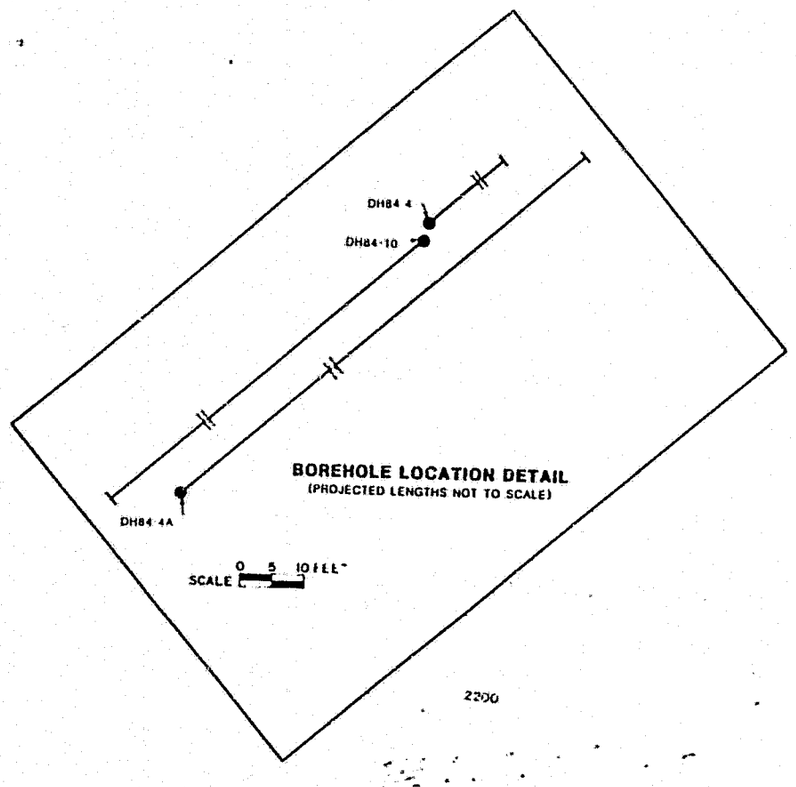
  - PRESENCE OF IMPERVIOUS STRATA IMMEDIATELY OVERLYING BEDROCK, THUS MINIMIZING AN ENTRANCE FOR WATER

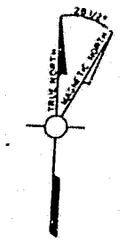
- GEOPHYSICS

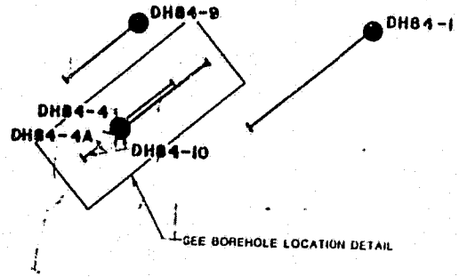
  - EXTENSION OF FINS TO NW IS INFERRED BASED ON SEISMIC REFRACTION; LOW VELOCITY ZONE APPROXIMATELY 1,000 FEET WIDE

  - LOW SEISMIC VELOCITY ZONE COINCIDES WITH A BEDROCK LOW


1800
1900
1700
1900
1800
1700
2000
2100
2200
2300
2200
2000
1900
1800
1700
1600
1500
SCALE
0
1000 FT.
LEGEND
COE HOLES
OTHER HOLES
LOW SEISMIC VELOCITY ZONE
RESERVOIR EL. 2185 FT.
FLOW SUSITNA RIVER
FINS







ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

WATANA DAM AND RESERVOIR

1984 GEOTECHNICAL PROGRAM BOREHOLE LOCATION PLAN

ANCHORAGE, ALASKA

APPROVED

DATE JULY 1984

DRAWING NO. EXHIBIT 3

FY84 EXPLORATION PROGRAM

FINS - 1984 DATA SUMMARY

- OVERBURDEN CONSISTS MOSTLY OF OUTWASH WITH A DISCONTINUOUS LAYER OF DENSE TILL IMMEDIATELY OVERLYING BEDROCK

- BEDROCK CONSISTS PRIMARILY OF HARD, STRONG DIORITE AND QUARTZ DIORITE WITH ALTERED AND HIGHLY WEATHERED ZONES OCCURRING LOCALLY

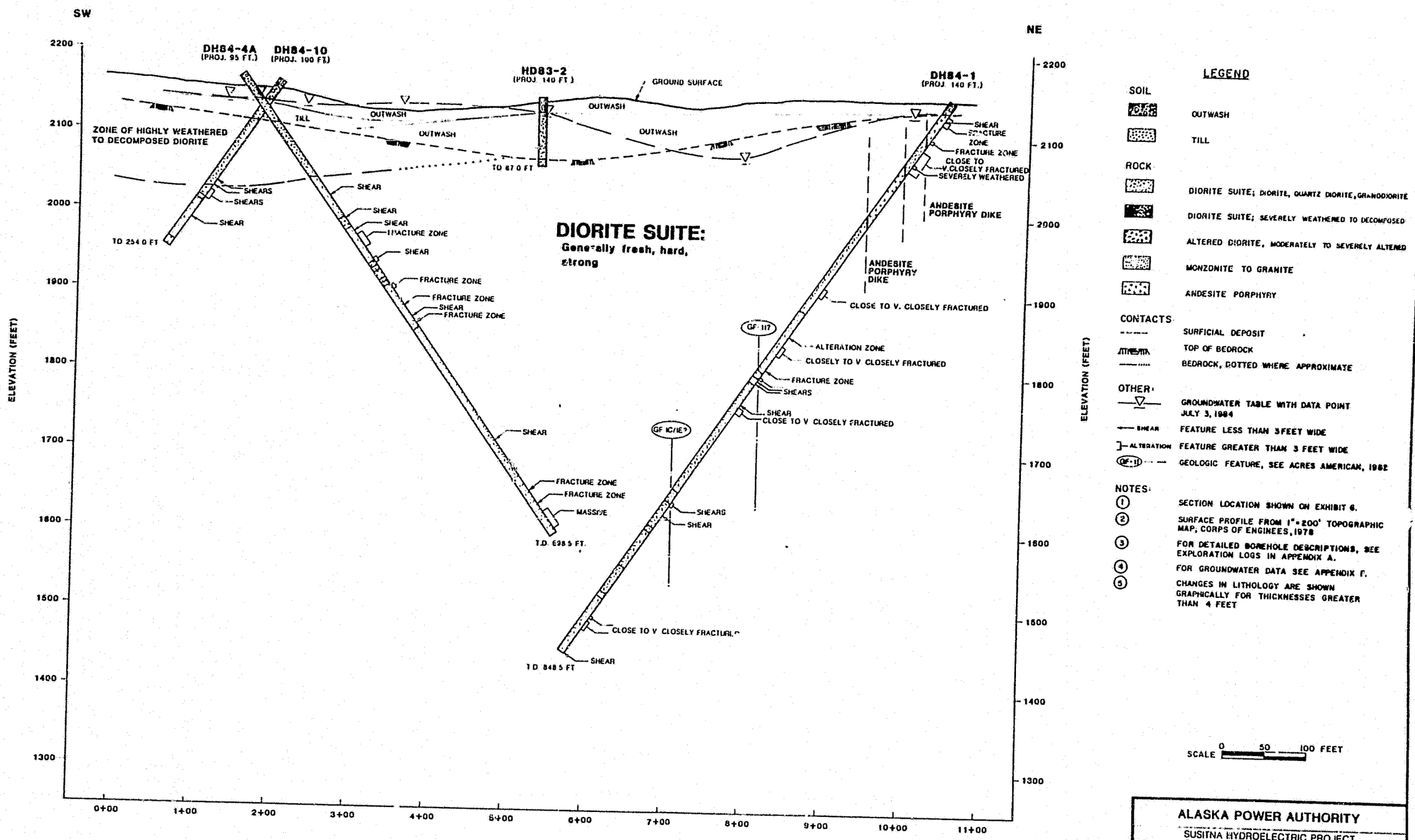
  - RECOVERY WAS GOOD, RQD VALUES VARIED CONSIDERABLY

  - LOW LUGEON VALUES, 0.0 - 3.5

  - A LAYER OF HIGHLY WEATHERED DECOMPOSED DIORITE EXISTS AT THE SOIL/ROCK INTERFACE OVER A PORTION OF THE AREA; THE ROCK IS SOFT TO SLIGHTLY HARD, LOCALLY FRIABLE; LAYER UP TO 80 FEET THICK, AREAL EXTENT UNKNOWN

- GROUNDWATER LEVEL IS AT A GENERAL DEPTH OF 10 TO 20 FEET BELOW THE GROUND SURFACE, ELEVATION 2070 TO 2142

50761.3
850410



GEOLOGIC SECTION B-B

LEGEND

SOIL
- OUTWASH
- TILL

ROCK
- DIORITE SUITE; DIORITE, QUARTZ DIORITE, GRANODIORITE
- DIORITE SUITE; SEVERELY WEATHERED TO DECOMPOSED
- ALTERED DIORITE, MODERATELY TO SEVERELY ALTERED
- MONZONITE TO GRANITE
- ANDESITE PORPHYRY

CONTACTS
- SURFICIAL DEPOSIT
- TOP OF BEDROCK
- BEDROCK, DOTTED WHERE APPROXIMATE

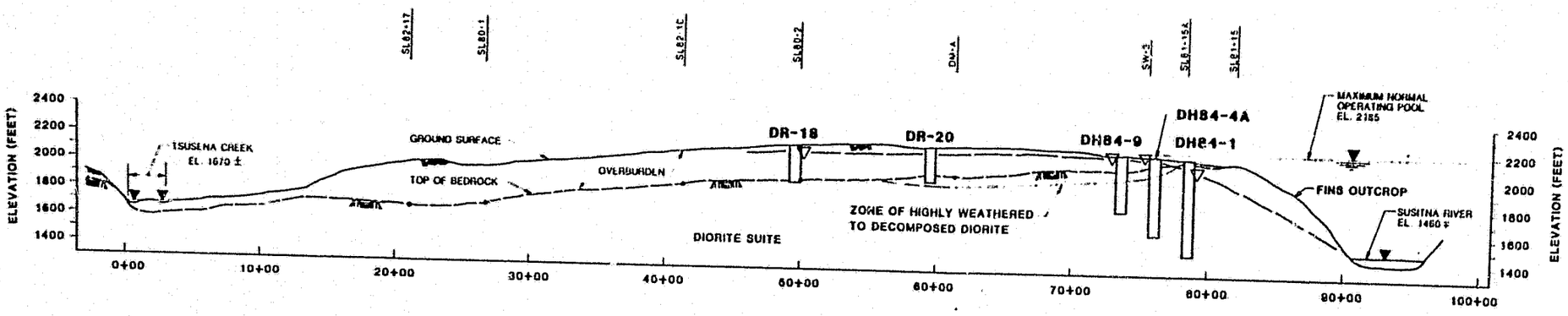
OTHER
- GROUNDWATER TABLE WITH DATA POINT JULY 3, 1984
- SHEAR — FEATURE LESS THAN 3 FEET WIDE
- ALTERATION — FEATURE GREATER THAN 3 FEET WIDE
- GF-11 — GEOLOGIC FEATURE, SEE ACRES AMERICAN, 1982

NOTES:
1. SECTION LOCATION SHOWN ON EXHIBIT 6.
2. SURFACE PROFILE FROM 1"=200' TOPOGRAPHIC MAP, CORPS OF ENGINEES, 1978
3. FOR DETAILED BOREHOLE DESCRIPTIONS, SEE EXPLORATION LOGS IN APPENDIX A.
4. FOR GROUNDWATER DATA SEE APPENDIX F.
5. CHANGES IN LITHOLOGY ARE SHOWN GRAPHICALLY FOR THICKNESSES GREATER THAN 4 FEET

SCALE 0 50 100 FEET

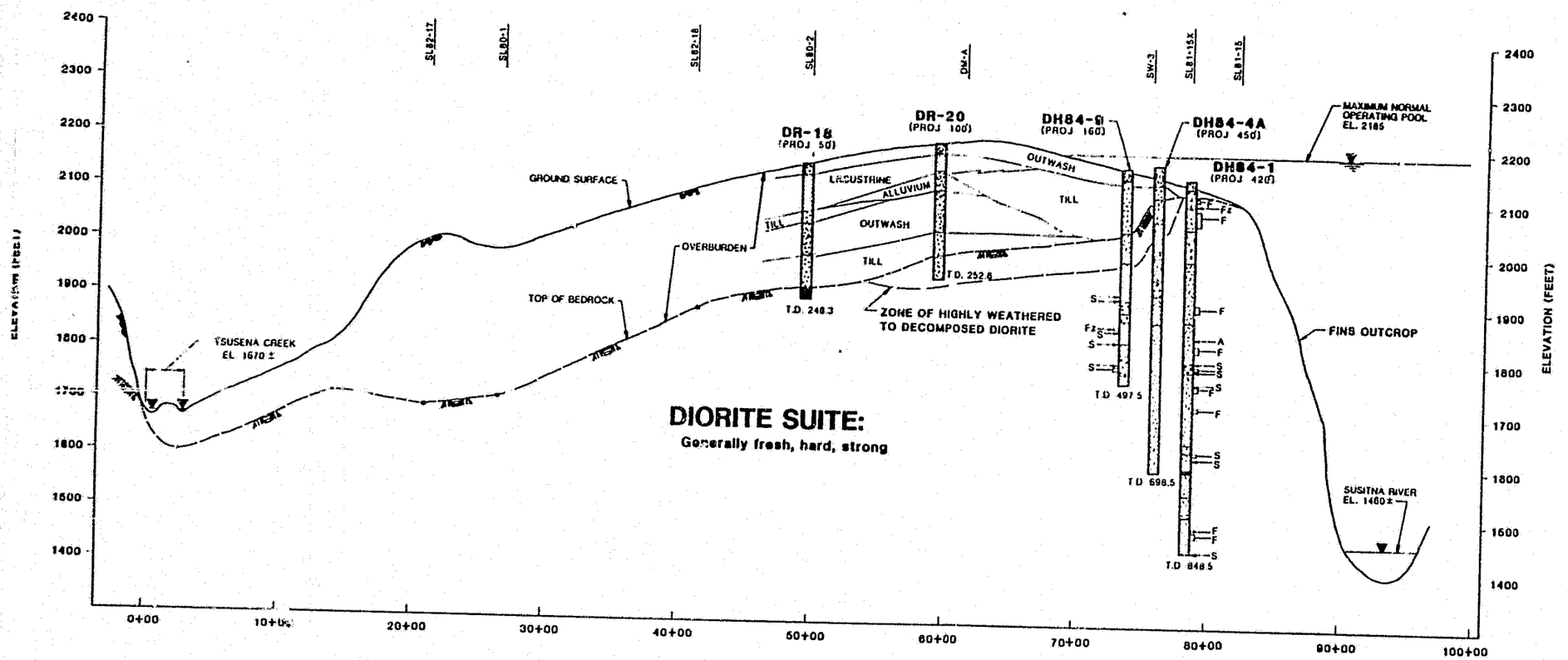
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT
WATANA DAM AND RESERVOIR
FINS AREA
GEOLOGIC SECTION B-B

ANCHORAGE, ALASKA | JULY 1984 | EXHIBIT 9



GEOLOGIC PROFILE A-A

TRUE SCALE



DIORITE SUITE:
Generally fresh, hard, strong

GEOLOGIC PROFILE A-A

SCALE EXAGGERATED 4V TO 1H

LEGEND

SOIL
- OUTWASH
- TILL
- LACUSTRINE
- ALLUVIUM

ROCK
- DIORITE SUITE, DIORITE, QUARTZ DIORITE, GRANODIORITE
- DIORITE SUITE, SEVERELY WEATHERED
- ALTERED DIORITE, MODERATELY TO SEVERELY ALTERED
- MONZONITE TO GRANITE
- ANDESITE PORPHYRY
- FELSIC

CONTACTS
- SURFICIAL DEPOSIT
- TOP OF BEDROCK
- BEDROCK, DOTTED WHERE APPROXIMATE

OTHER:
- GROUNDWATER TABLE WITH DATA POINT JULY 3, 1984
- S — FEATURE LESS THAN 3 FEET WIDE
- S — FEATURE GREATER THAN 3 FEET WIDE
- S — SHEAR
- F — CLOSELY TO VERY CLOSELY FRACTURED
- Fz — FRACTURE ZONE (VERY CLOSELY FRACTURED)
- A — ALTERED, WEAK

NOTES:
1. SECTION LOCATION SHOWN ON EXHIBIT 6.
2. SURFACE PROFILE FROM 1"=200' TOPOGRAPHIC MAP; CORPS OF ENGINEERS, 1978.
3. FOR DETAILED BOREHOLE DESCRIPTIONS, SEE EXPLORATION LOGS IN APPENDIX A.
4. FOR GROUNDWATER DATA SEE APPENDIX F.
5. CHANGES IN LITHOLOGY ARE SHOWN FOR THICKNESSES GREATER THAN 4 FEET.
6. TOP OF ROCK PROFILE ADJUSTED TO FIT THE BEDROCK ELEVATION IN EACH PROJECTED BOREHOLE
7. FOR GEOLOGIC NOTES ON DH84-4A, SEE FINS AREA GEOLOGIC PROFILE B-B
8. ELEVATION OF GROUNDWATER TABLE IN DR-18 IS FROM AUG. 1978. INSTRUMENTATION MONITORING INDICATES LITTLE CHANGE IN GROUNDWATER TABLE AFTER WATER LEVELS HAVE STABILIZED, THEREFORE DATA FROM DR-18 IS CONSIDERED VALID.
9. ALL BOREHOLES ARE PROJECTED. THE DISTANCE PROJECTED IS FROM THE BOREHOLE COLLAR.

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT
WATANA DAM AND RESERVOIR

FINS AREA
GEOLOGIC PROFILE A-A

ANCHORAGE ALASKA | JULY 1984 | EXHIBIT 8

FINS - CONCLUSION

° EROSION AND SEEPAGE POTENTIAL IS CONSIDERED LOW BASED ON THE FOLLOWING:

- NO VERTICAL THROUGH-GOING ZONES OF ANY SIGNIFICANT WIDTH OR CONTINUITY OCCUR WHICH COULD TRANSMIT WATER; A SURFICIAL LAYER OF HIGHLY WEATHERED ROCK OCCURS LOCALLY

- LOW HYDRAULIC GRADIENT BETWEEN THE SUSITNA RIVER AND TSUSENA CREEK

- LOW PERMEABILITY WITHIN THE ROCK MASS

FY84 EXPLORATION PROGRAM

OUTLET AND POWERHOUSE AREAS

- OBJECTIVES
  - REVIEW EXISTING DATA
  - DELINEATE TYPE OF OVERBURDEN
  - DELINEATE TOP OF ROCK
  - DETERMINE ROCK QUALITY; EXTENT OF WEATHERING, FRACTURING, SHEARING, AND ALTERATION
  - DETERMINE ROCK PERMEABILITY AND STRENGTH
  - GROUNDWATER MONITORING
- NUMBER OF HOLES
  - 5 ANGLE HOLES IN THE OUTLET AREA; 100 TO 265 FEET
  - 1 ANGLE HOLE IN THE POWERHOUSE AREA; 765 FEET

FY84 EXPLORATION PROGRAM

OUTLET AREA - REVIEW EXISTING DATA

- GEOLOGIC MAPPING
  - LACK OF OUTCROPS IN THE UPSTREAM PORTION OF THE AREA AND BELOW EL. 1750
  - SEVERAL NW-SE AND N-S CLOSELY FRACTURED ZONES AND SHEARS; CONCEALED OVER MUCH OF THE AREA

- CORE
  - LACK OF CORE HOLES

- GEOPHYSICS
  - LOW VELOCITY LAYER EXTENDING TO DEPTHS OF 50 TO 100 FEET OVER A PORTION OF THE AREA

FY84 EXPLORATION PROGRAM

OUTLET AREA - 1984 DATA SUMMARY

- OVERBURDEN CONSISTS PRIMARILY OF TALUS WITH SOME POSSIBLE TRACES OF ALLUVIUM BELOW EL. 1525; OVERBURDEN THICKNESS VARIES FROM 5 TO 15 FEET

- BEDROCK CONSISTS OF DIORITE AND QUARTZ DIORITE; ROCK QUALITY VARIES AS A FUNCTION OF THE DEGREE OF ALTERATION AND FRACTURING

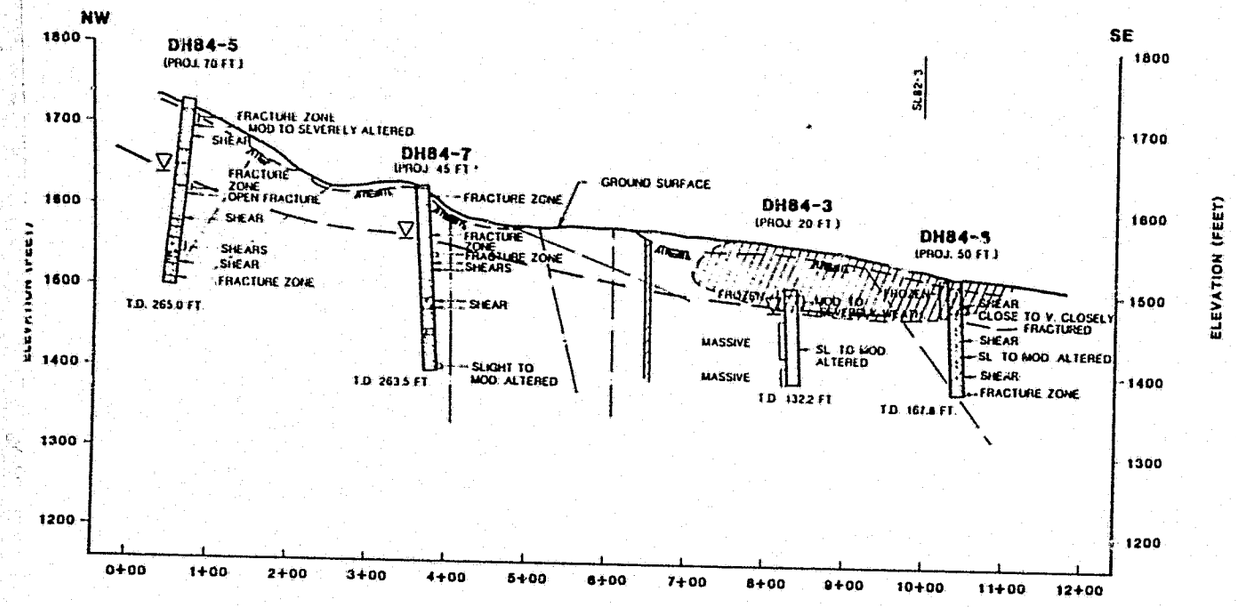
  - RQD VALUES VARIED CONSIDERABLY, LOW VALUES ARE FOUND IN THE DOWNSTREAM HOLES DH84-5, 7

  - LUGEON VALUES VARIED CONSIDERABLY, RANGING FROM 0 TO 50+; LOCALLY HIGH IN DH84-5, 7, 8

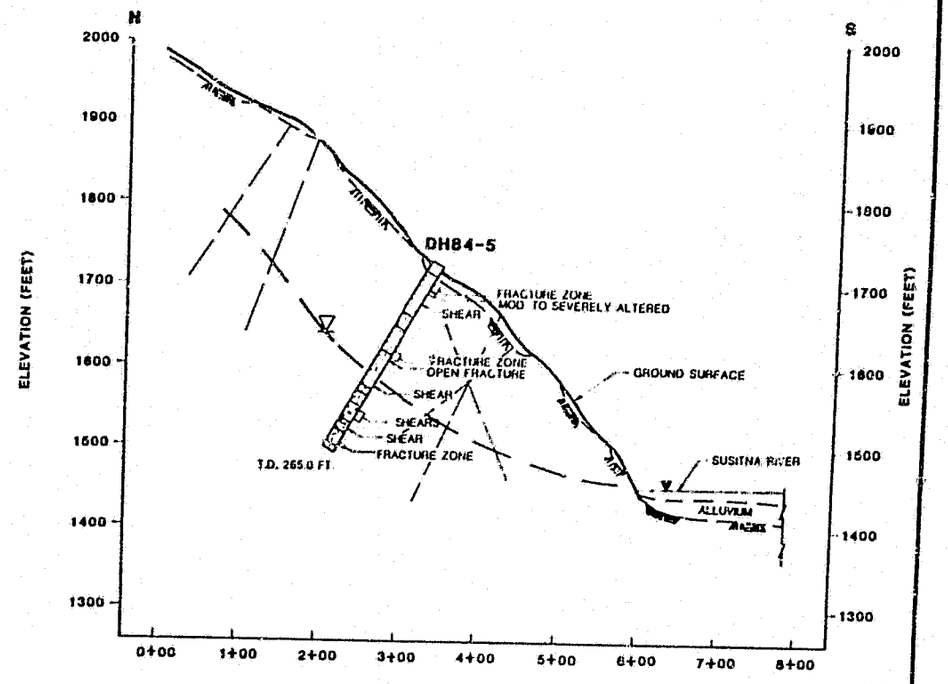
  - GEOPHYSICS INDICATES INCREASING DENSITY WITH DEPTH BELOW 65 FEET

- PERMAFROST, ICE-FILLED JOINTS WERE DETECTED IN DH 84-3, 6, 8; MAY EXIST TO DEPTHS OF 60+ FEET

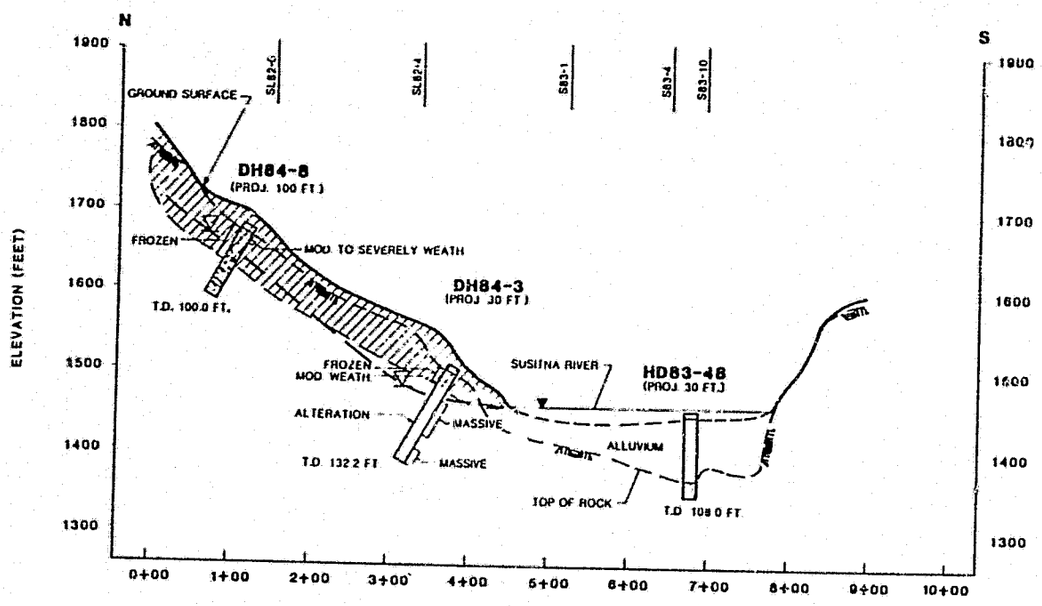
- GROUNDWATER LEVEL IS GENERALLY 40 TO 80 FEET BELOW THE GROUND SURFACE; ARTESIAN FLOW OF APPROXIMATELY 1.0 GPM OCCURS IN DH84-8



GEOLOGIC SECTION D-D



GEOLOGIC SECTION E-E



GEOLOGIC SECTION F-F

LEGEND

SOIL:

- ALLUVIUM

ROCK:

- DIORITE SUITE; DIORITE, QUARTZ DIORITE, GRANODIORITE
- ALTERED DIORITE; MODERATELY TO SEVERELY ALTERED
- MONZONITE TO GRANITE

STRUCTURE:

- SHEAR ZONE, WIDTH 1 TO 5 FEET
- FRACTURE ZONE, WIDTH GREATER THAN 5 FEET
- FRACTURE ZONE, WIDTH 1 TO 5 FEET

CONTACTS:

- TOP OF BEDROCK

OTHER:

- GROUNDWATER TABLE WITH DATA POINT, JULY 5, 1984
- SHEAR — FEATURE LESS THAN 5 FEET WIDE
- ALTERATION — FEATURE GREATER THAN 5 FEET WIDE
- PERMAFROST INDICATED BY BOREHOLES

NOTES:

1. SECTION LOCATIONS SHOWN ON EXHIBIT II.
2. SURFACE PROFILE FROM 1" = 200' TOPOGRAPHIC MAP, CORPS OF ENGINEERS, 1978.
3. FOR DETAILED BOREHOLE DESCRIPTIONS, SEE EXPLORATION LOGS IN APPENDIX A.
4. FOR GROUNDWATER DATA SEE APPENDIX F.
5. CHANGES IN LITHOLOGY ARE SHOWN GRAPHICALLY FOR THICKNESSES GREATER THAN 5 FEET.
6. ALL BOREHOLES ARE PROJECTED. THE IDENTIFIED DISTANCE IS TO THE BOREHOLE COLLAR.

SCALE 0 100 200 FEET

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

WATANA DAM AND RESERVOIR

DOWNSTREAM PORTALS AREA GEOLOGIC SECTIONS D-D, E-E, F-F

ANCHORAGE, ALASKA

APPROVED

DATE JULY 1984

EXHIBIT 12

FY84 EXPLORATION PROGRAM

OUTLET AREA - CONCLUSION

- FOUNDATION CONDITIONS ARE SATISFACTORY:
  - BEDROCK IS AT A DEPTH OF 0 TO 15 FEET
  - THE STEEP SLOPES ARE LARGELY CONTROLLED BY STRESS RELIEF; EROSION OF SLOPES IS ACCELERATED BY FROST ACTION
  - SHEARS AND FRACTURE ZONES ARE WIDESPREAD LOCALLY; APPEAR TO LACK CONTINUITY
  - OCCASSIONAL MODERATELY TO SEVERELY ALTERERED ZONES
- EXISTENCE OF PERMAFROST IN THE LOWER ELEVATIONS (BELOW EL. 1750) OF THE NORTH ABUTMENT HAVE BEEN CONFIRMED; WILL AFFECT SCHEDULING OF GROUTING PROGRAM AFTER THAWING OF ABUTMENT

FY84 EXPLORATION PROGRAM

POWERHOUSE AREA - REVIEW EXISTING DATA

- GEOLOGIC MAPPING
  - LACK OF OUTCROPS IN THE GENERAL AREA OVERLYING THE POWERHOUSE

- CORE
  - TWO BOREHOLES WERE DRILLED INTO THE ORIGINAL PROPOSED CHAMBERS APPROXIMATELY 500 FEET TO THE NW; ROCK CONSISTED OF HARD, STRONG DIORITE AND QUARTZ DIORITE WITH ZONES OF FRACTURING AND ALTERATION
  - ANDESITE WAS ENCOUNTERED IN THE UPPER PORTION OF BH-W4

FY84 EXPLORATION PROGRAM

POWERHOUSE AREA - 1984 DATA SUMMARY

- BEDROCK CONSISTS OF HARD TO VERY HARD, STRONG DIORITE AND QUARTZ DIORITE WITH MINOR FELSIC DIKES

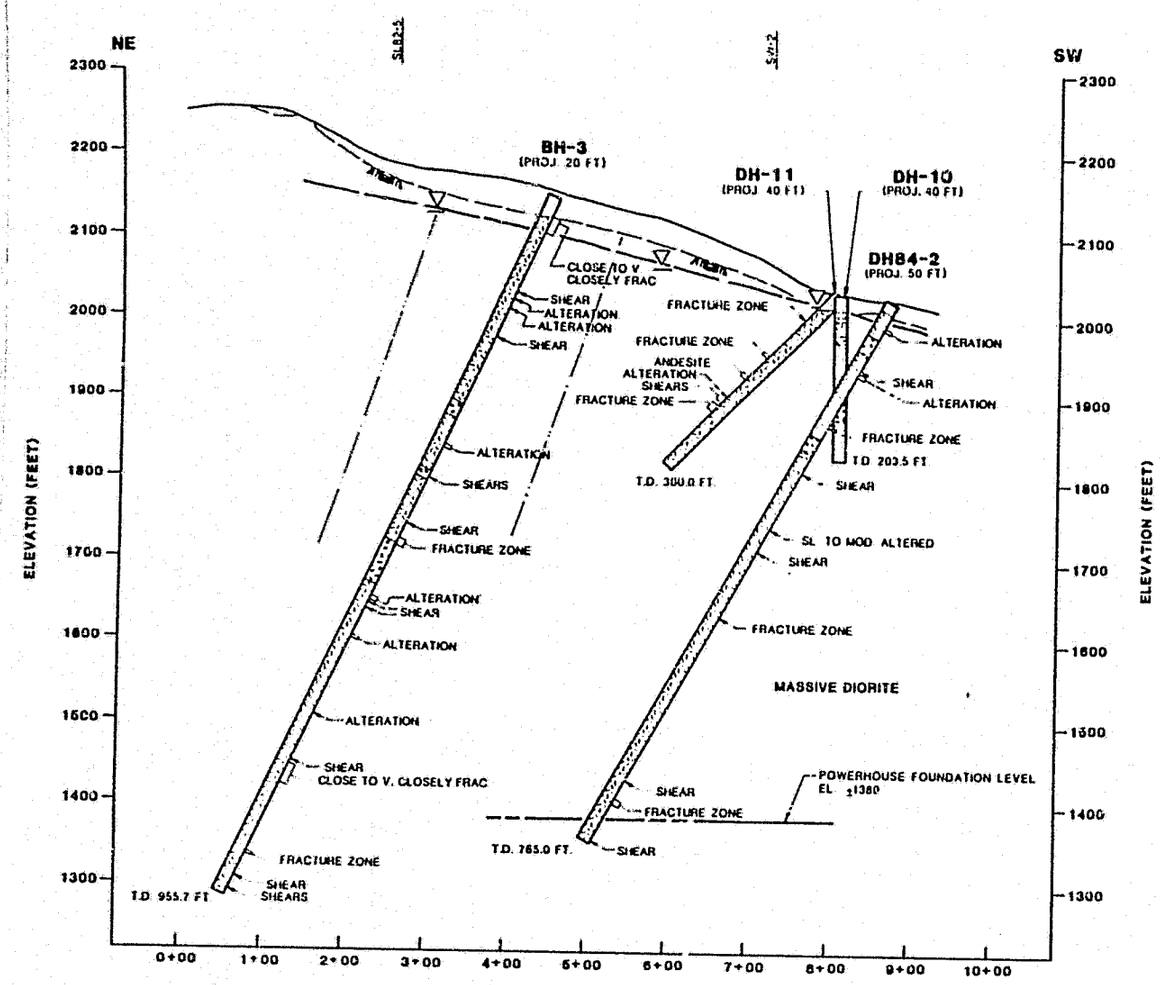
  - RQD VALUES IN THE LOWER PORTION OF THE BOREHOLE ARE HIGH, ROCK RANGES FROM GOOD TO EXCELLENT, GENERALLY MASSIVE

  - OCCASIONAL SHEARS AND FRACTURE ZONES WERE ENCOUNTERED LOCALLY; SLIGHT ALTERATION IS COMMON

  - LOW LUGEON VALUES, 0.0 TO 0.4

  - GEOPHYSICAL LOGS INDICATE TIGHT FRACTURES AND HIGH DENSITY IN LOWER PORTION OF BOREHOLE

- GROUNDWATER LEVEL IS MONITORED AT TWO DEPTHS: ARTESIAN FLOWS OF 0.5 TO 1.5 GPM WERE ENCOUNTERED IN THE LOWER INSTRUMENT; IN GENERAL THE GROUNDWATER LEVEL IS 20 TO 40 FEET BELOW THE GROUND SURFACE



GEOLOGIC SECTION C-C

LEGEND

ROCK:

- DIORITE SUITE; DIORITE, QUARTZ DIORITE, GRANODIORITE
- ALTERED DIORITE; MODERATELY TO SEVERELY ALTERED
- MONZONITE TO GRANITE

STRUCTURE:

- SHEAR ZONE, WIDTH 1 TO 5 FEET

CONTACTS:

- TOP OF BEDROCK

OTHER:

- GROUNDWATER TABLE WITH DATA POINT, JUNE/JULY 1984
- SHEAR — FEATURE LESS THAN 2 FEET WIDE
- ALTERATION — FEATURE GREATER THAN 5 FEET WIDE

NOTES:

1. SECTION LOCATIONS SHOWN ON EXHIBIT 12
2. SURFACE PROFILE FROM 1"=200' TOPOGRAPHIC MAP; CORPS OF ENGINEERS, 1979.
3. FOR DETAILED BOREHOLE DESCRIPTIONS, SEE EXPLORATION LOGS IN APPENDIX A.
4. FOR GROUNDWATER DATA SEE APPENDIX F.
5. CHANGES IN LITHOLOGY ARE SHOWN GRAPHICALLY FOR THICKNESSES GREATER THAN 5 FEET.
6. ALL BOREHOLES ARE PROJECTED. THE IDENTIFIED DISTANCE IS TO THE BOREHOLE COLLAR.
7. THE NOTES FOR BH-3 AND DH-11 ARE MODIFIED FROM ACRES AMERICAN, 1981.

SCALE 0 50 100 FEET

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT
WATANA DAM AND RESERVOIR
POWERHOUSE AREA
GEOLOGIC SECTION C-C

JULY 1984

EXHIBIT 15

FY84 EXPLORATION PROGRAM

POWERHOUSE AREA - CONCLUSION

- PRELIMINARY RESULTS INDICATE THAT FOUNDATION CONDITIONS IN THE AREA OF THE PROPOSED POWERHOUSE CHAMBER ARE FAVORABLE

DESIGN MEMORANDUM CONCEPT

TASK 21

DESIGN MEMORANDUM #1 GENERAL

FY8_

ENGINEERING & DESIGN BASE BUDGET

Purpose

This design memorandum presents the general plan for the design, construction, and development of the overall Watana Project. This report will serve as the review and approval document as well as a basis for the preparation of the more detailed design memoranda for the various structures and/or project features.

Work Items

Task 21 will support the engineering effort by preparing a design memorandum report which includes but is not limited to the following:

Geotechnical Conceptual Studies

Foundation Designs for Embankments and Structures
Embankment Designs
River Diversion Scheme
Required Geotechnical Exploration Activities
Laboratory and Field Testing Programs for Design Parameters
Dam Freeboard

Structural Conceptual Studies

Spillway Design
Power Facility Design
Outlet Works Design
Emergency Facility Design

Hydrology Conceptual Studies

Reservoir area - capacity Curves
Sediment Storage
Flood Control Storage
Design Floods
Tailwater Rating Curves
Reservoir Regulation

Mechanical Conceptual Studies

Gate Type
Powerhouse Equipment

Electrical Conceptual Study

Power Facility Equipment

General

Cost Estimates and Schedules
Project Economics

The precise number of studies to be accomplished will be determined as the conceptual design progresses.

Direct Cost

Direct costs cover air fare, travel expenses, relocation costs, use of computers, word processing, printing of the report, etc.

Subcontract

An independent panel of consultants to the Alaska Power Authority has been retained and will review the General Design Memorandum.

Design Memorandum #1 will require work effort in FYs 198_ and 198_.

TASK 22

DESIGN MEMORANDUM #2 - HYDROLOGY

FY8_

ENGINEERING & DESIGN BASE BUDGET

Purpose

The purpose of the Hydrology Design Memorandum is to present basic hydrologic data to be used in developing the conceptual and detailed design for the Watana Dam and Reservoir.

Work Items

Task 22 will support the engineering effort by preparing a design memorandum report which includes the following:

Hydraulics Design

Evaluation of Records

Evaluation of Past Floods

Extending Period of Record

Analysis of Runoff Records

Routing studies

Final storage selection

Design Floods

Storms and Floods of Record

Design Storm Development

Spillway Design Flood Routing

Wind Evaluations

Reservoir sedimentation

Reservoir ice modeling

The precise number of issues to be covered in Task 22 will be determined as the design progesses.

Direct Costs

Direct costs cover air fare, travel expenses, use of computers, word processing, printing of the report, etc.

Subcontracts

An independent panel of consultants to the Alaska Power Authority has been retained and will review the Hydrology Design Memorandum.

Design Memorandum #2 will require work effort in FY's 198_ and 198_.

TASK 23

DESIGN MEMORANDUM #3 - GEOLOGY

FY8_

ENGINEERING & DESIGN BASE BUDGET

Purpose

The purpose of this design memorandum is to present a general summary of the geologic conditions in the area of the dam and reservoir. Emphasis will be placed on (1) nature and thickness of overburden, (2) stratigraphy and structure of bedrock, (3) character of proposed foundations and excavations, (4) the groundwater and thermal conditions, and (5) geologic investigations to date, and those proposed to complete the necessary geological studies in support of detailed design. More detailed geologic data pertinent to the embankment, spillway, power facilities, and outlet works will be presented in the design memoranda covering those features.

Work Items

Task 23 will support the engineering effort by preparing a design memorandum which includes the following:

Geotechnical Design

Physiography and Topography
Regional Geology
Reservoir Geology
Site Geology
Foundation Conditions
Seismic History

Because of the need for additional foundation investigations, Design Memorandum #3 will require work efforts in FYs 198_, 198_ and 198_.

TASK 24

DESIGN MEMORANDUM #4 - RIVER DIVERSION

FY8_

ENGINEERING & DESIGN BASE BUDGET

Purpose

The purpose of the River Diversion Design Memorandum is to formulate and present the basic overall concept for handling river flows during Watana construction. Also covered will be the various aspects of the cofferdams and diversion tunnel design.

Work Items

Task 24 will support the engineering effort by preparing a design memorandum which includes the following:

Geotechnical Design

Cofferdam Foundation Design

Cofferdam Embankment Design

Diversion Plan

Diversion Tunnel Rock Mechanics Design

Structural Design

Tunnel Liner Design

Intake Structure Design

Outlet Structure Design

Hydraulic Design

Tunnel Size and Shape

Pool and Tailwater Determinations

Mechanical Design

Gat. Design
Intake and Outlet Mechanical Features

The precise amount of work performed under Task 24 will be determined as the design progresses.

Direct Cost

Direct costs cover air fare, travel expenses, use of computers, word processing, printing of report, etc.

Subcontracts

An independent panel of consultants to the Alaska Power Authority has been retained and will review the River Diversion Design Memorandum.

TASK 25

DESIGN MEMORANDUM #5 - DAM EMBANKMENT

FY8_

ENGINEERING & DESIGN BASE BUDGET

Purpose

The purpose of this memorandum is to present the geotechnical data and the embankment design which will establish the embankment slopes, slope protection, internal zoning, control of seepage, and slopes for the required excavations. All of these form the basis for the preparation of contract plans and specifications. This design memorandum discusses in detail, soil and bedrock data, foundation conditions, embankment design and foundation treatment including grouting, earthwork usage, required excavations, observation devices, and a cost estimate of the recommended plan. This memorandum will be initiated in FY87 and completed in FY89.

Work Items

Task 25 will support the engineering effort by preparing a design memorandum which includes the following:

Geotechnical Design

a) Geology as it affects design
b) Investigations
c) Foundation conditions
d) Construction Material Evaluation
e) Laboratory Test Results
f) Design Parameters
g) Embankment Configuration

h) Seepage Control
i) Settlement
j) Stability Analysis
k) Freeboard Studies
l) Earthwork Usage
m) Observation Devices
n) Construction Schedule
o) Cost Estimate

The exact number of studies performed in Task 25 will be determined as the design progresses.

Direct Costs

Direct costs cover air fare, travel expenses, relocation costs use of computers, word processing, printing of report, etc.

TASK 26

DESIGN MEMORANDUM #6 - CONSTRUCTION MATERIALS

FY8_

ENGINEERING & DESIGN BASE BUDGET

Purpose

The purpose and scope of this design memorandum are: (1) to present results of laboratory and field tests and other pertinent data regarding sources of construction materials; (2) to discuss the suitability of coarse and fine aggregates, rockfill, riprap, bedding, filter and transition material, concrete mixing and curing water, cement, natural cement and fly ash; and (3) to evaluate each of the material sources. This memorandum will be initiated in FY8_ and will continue through FY8_.

Work Items

Task 26 will support the engineering effort by preparing a design memorandum which includes the following:

Geotechnical Design

a) Geological affect on materials
b) Availability and quality of filter, rockfill, coarse aggregate, fine aggregate and impervious materials
c) Sources proposed for construction materials
d) Sources not proposed for construction materials
e) Cementitious materials

Direct Cost

Direct costs cover air fare, travel expenses, use of computers, word processing, printing, etc.

TASK 34

DESIGN MEMORANDUM #14 - SUPPORT FACILITY MASTER PLAN

FY8_

ENGINEERING & DESIGN BASE BUDGET

Purpose

This design memorandum presents the criteria and data substantiating selection of the site for each of the Watana support facilities. The Master Plan will serve as the basis for the design and contract documents as prepared by CIRI/Moolin and their subcontractors.

Work Items

Major support facilities for Watana are:

D.M. 14 A Watana Camp Expansion
D.M. 14 B Access Road (including Cantwell Staging Area)
D.M. 14 C Construction Camp (Phase I and II)
D.M. 14 D Airfield (Phase I and II)
D.M. 14 E Operators Village
D.M. 14 F Reservoir Clearing

The scope of work for the Watana Camp Expansion, Access Road, Construction Camp (Phase I and II), Airfield (Phase I and II) and the Operator's Village (Permanent Town) will be defined in Design Memorandum #14.

Direct Cost

Direct Costs cover air fare, travel expenses, and printing of the report.

Subcontracts

In order to perform the necessary work H-E will enter into contracts for drilling and surveying services.

Design Memorandum #14 is a continuation of the work effort which began in FY8_.

SUSITNA HYDROELECTRIC PROJECT

WATANA DAM AND RESERVOIR

DESIGN MEMORANDA CONCEPT

- THE DESIGN MEMORANDA WILL CONTAIN THE RESULTS OF DESIGN PARAMETERS AND STUDIES STUDIES, ENGINEERING AND COST ANALYSES, DESIGN CALCULATION SUMMARIES, SKETCHES AND DRAWINGS.

  THE INFORMATION WILL BE PRESENTED IN A MANNER TO DESCRIBE AND JUSTIFY THE FINAL DESIGN OF THE INDIVIDUAL PROJECT FEATURES AND COMPONENTS.

  THE REPORT WILL BE IN SUFFICIENT DETAIL THAT CONSTRUCTION DRAWINGS AND SPECIFICATIONS CAN BE PREPARED AS APPROPRIATE.

- DESIGN MEMORANDA WILL ALSO BE PREPARED BY EQUIPMENT MANUFACTURERS UNDER PROCUREMENT CONTRACTS.

  THESE REPORTS WILL FORM THE BASIS FOR THE EQUIPMENT PROCUREMENT SPECIFICATION AND PROCUREMENT DRAWINGS.

SUSITNA HYDROELECTRIC PROJECT

WATANA DAM AND RESERVOIR

SUMMARY LIST OF DESIGN MEMORANDA

NO.	TITLE
1.	GENERAL DESIGN MEMORANDUM
2.	HYDROLOGY
3.	GEOLOGY
4.	RIVER DIVERSION
5.	DAM EMBANKMENT
6.	GEOTECHNICAL CONSTRUCTION MATERIALS
7.	EMERGENCY RELEASE FACILITIES
8.	OUTLET WORKS FACILITIES
9.	RELICT CHANNEL TREATMENT
10.	SPILLWAY
11.	POWER GENERATION FACILITIES
12.	POWER DISPATCH AND COMMUNICATIONS FACILITIES
13.	GOLD CREEK TRANSMISSION LINE
14.	PROJECT SUPPORT FACILITIES

STAGED CONSTRUCTION CONCEPT

SUSITNA HYDROELECTRIC PROJECT
STAGED CONSTRUCTION PRESENTATION

- THE REASONS FOR PROPOSING STAGED CONSTRUCTION ARE:

  - REDUCE THE INITIAL FINANCIAL COMMITMENT OF THE STATE

  - ALLOW MORE FLEXIBILITY IN MEETING LOAD GROWTH.

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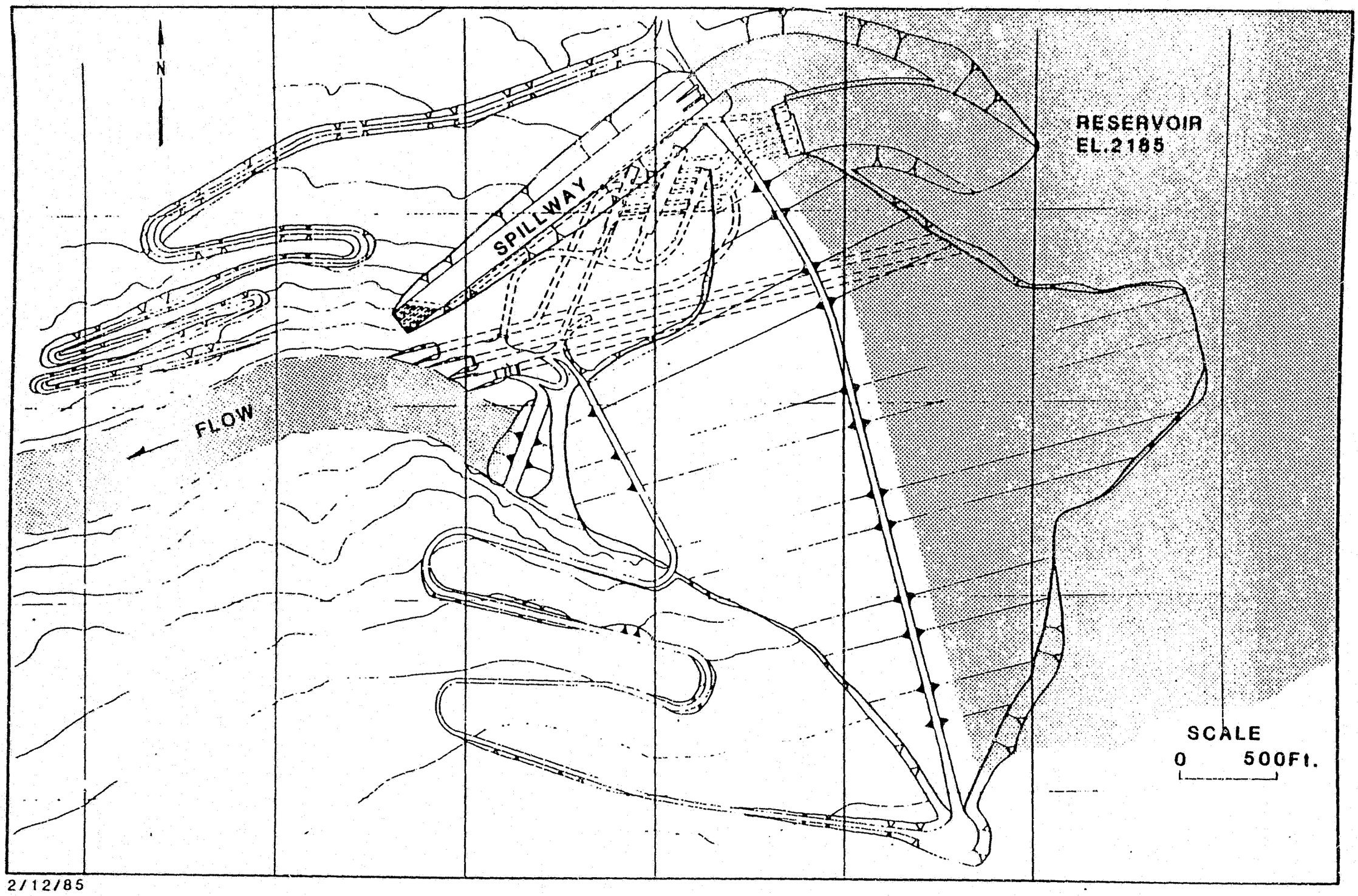
WATANA DAM GENERAL PLAN

FERC LICENSE CONCEPT



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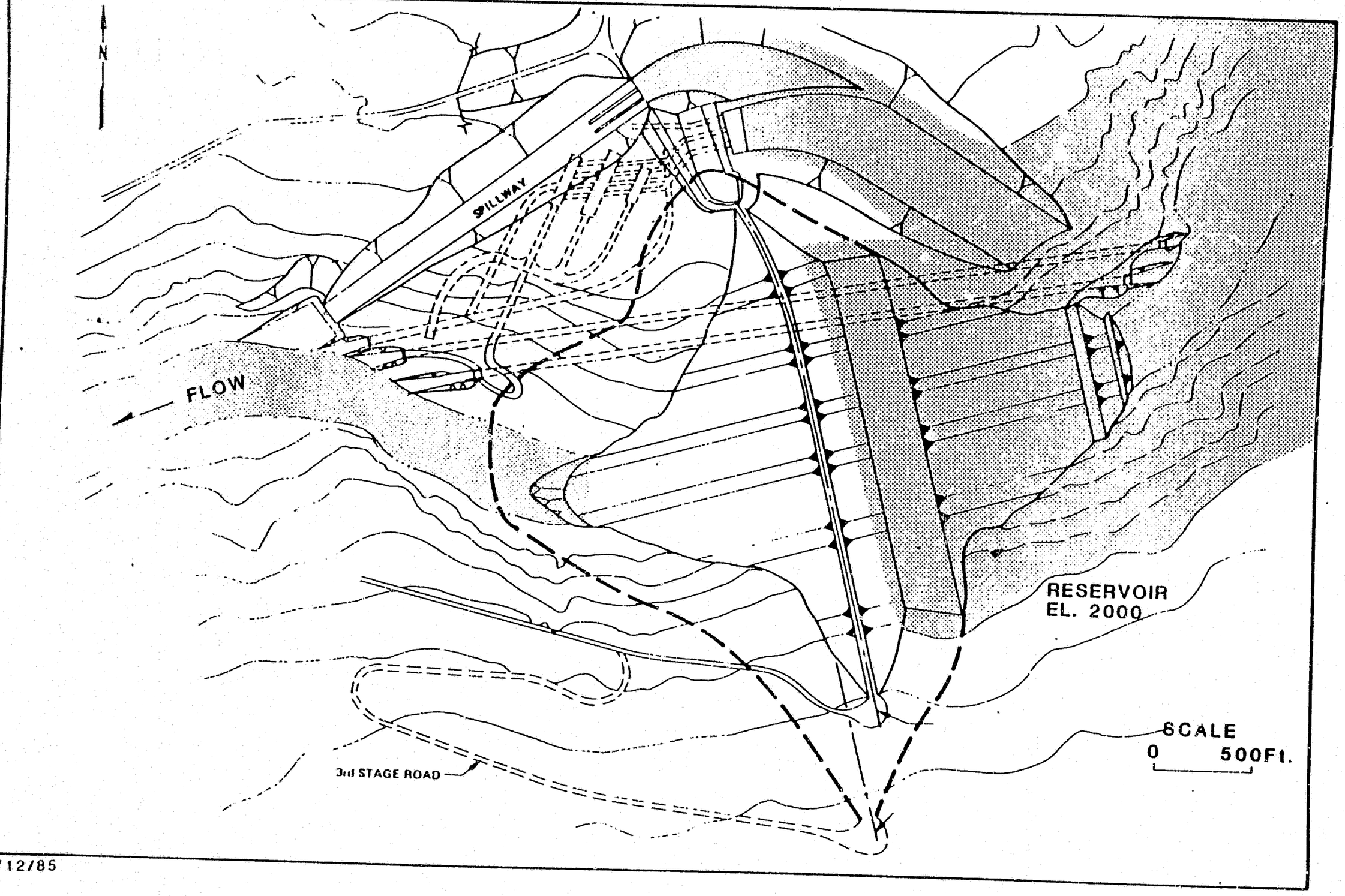
WATANA DAM GENERAL PLAN
STAGED CONSTRUCTION CONCEPT



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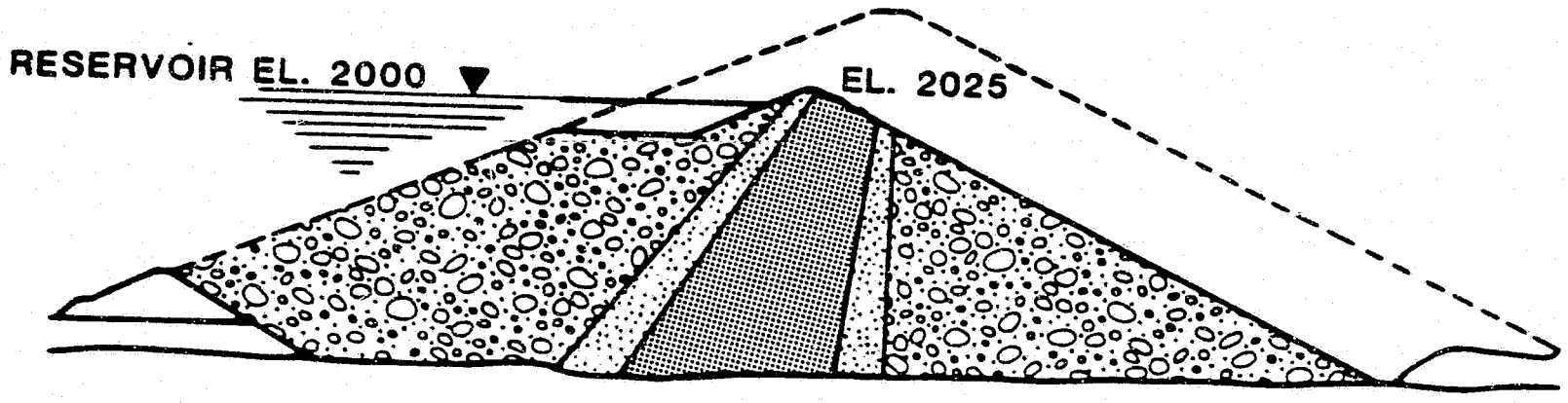
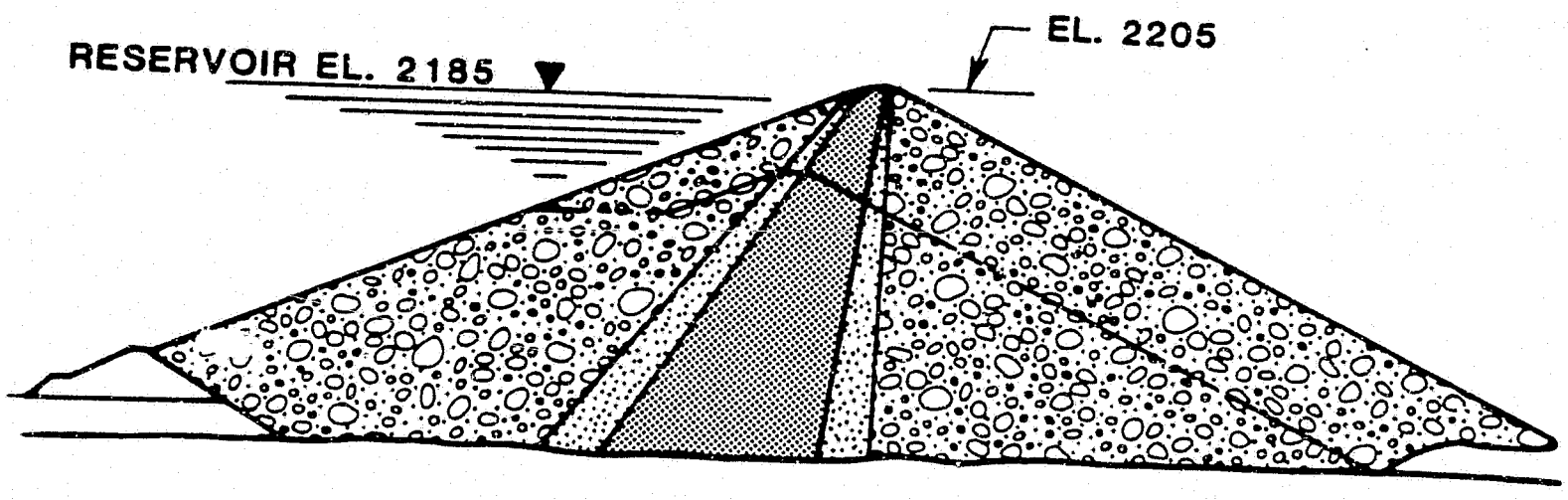
SUSITNA HYDROELECTRIC PROJECT
STAGED CONSTRUCTION PRESENTATION

CROSS SECTION THRU THE DAM



STAGE I–WATANA INITIAL DAM



STAGE III–WATANA HIGH DAM

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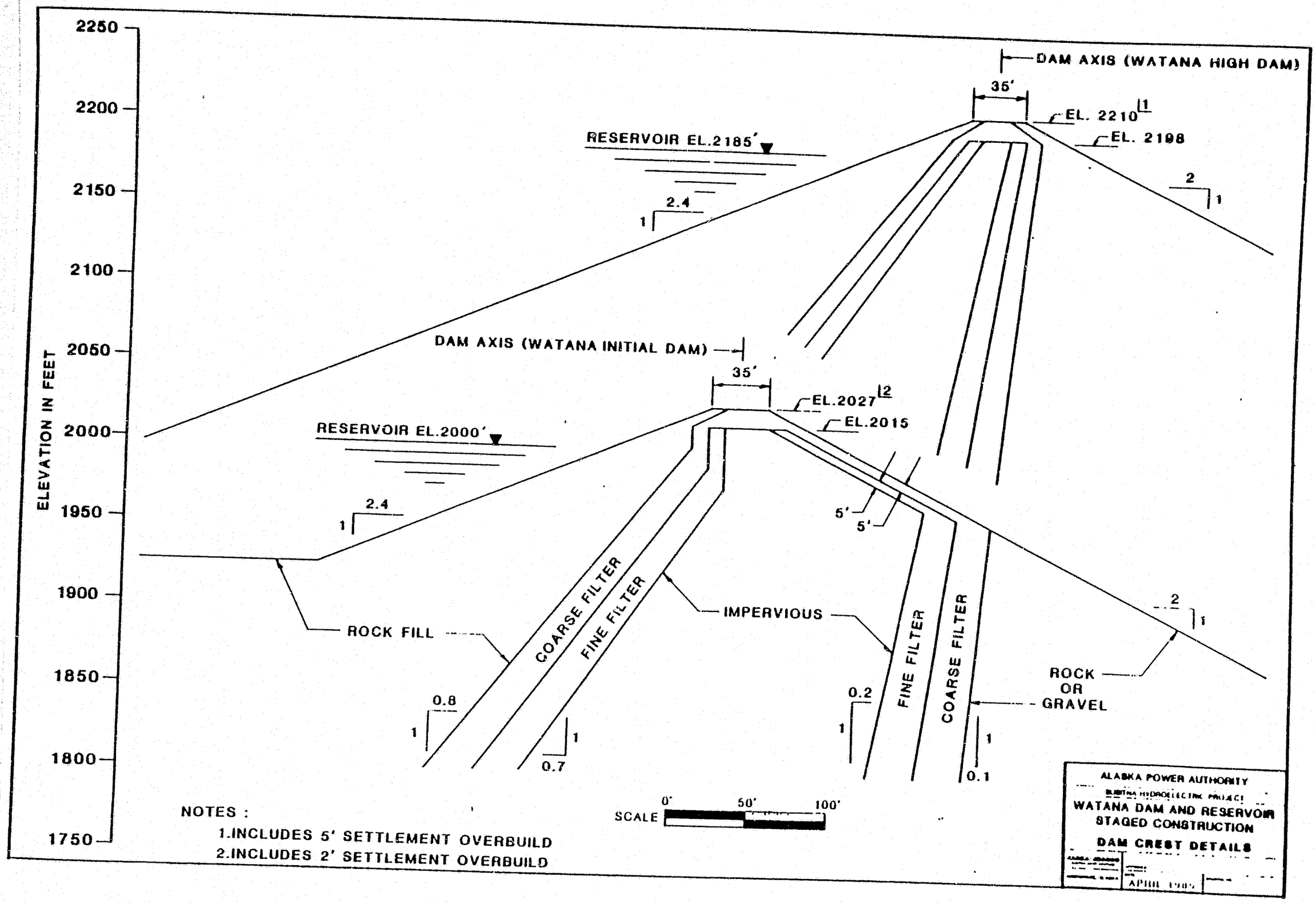
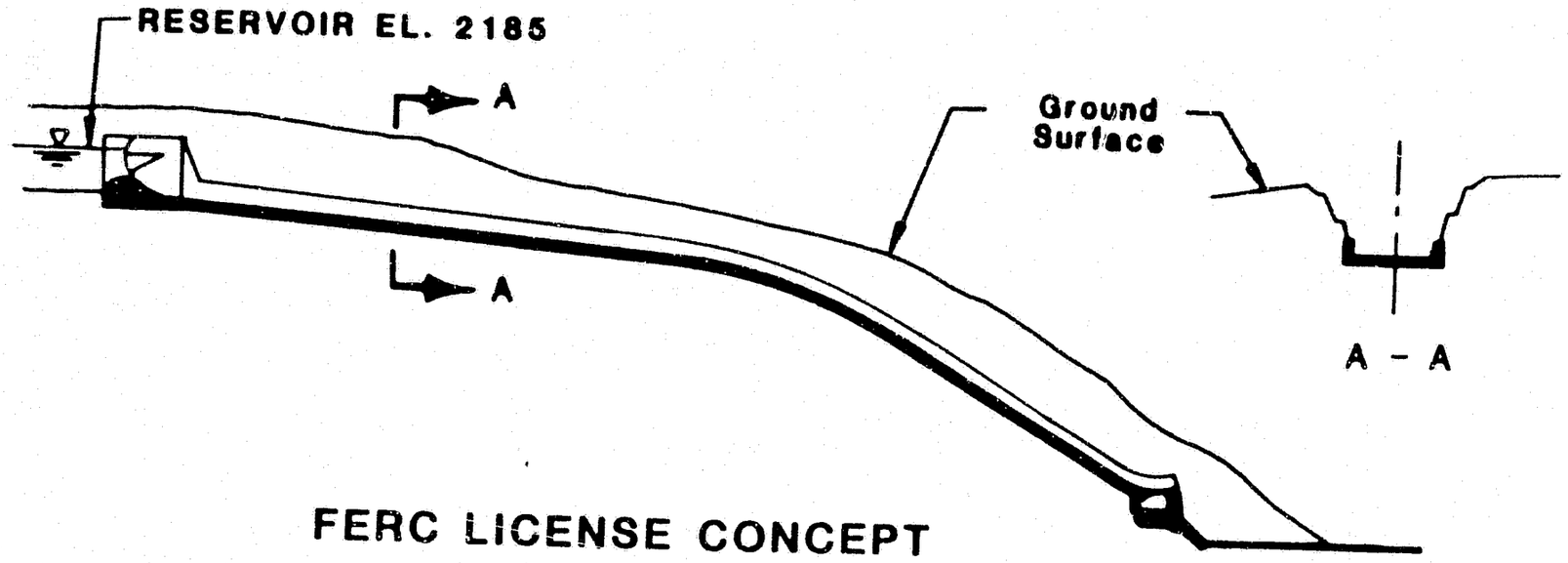


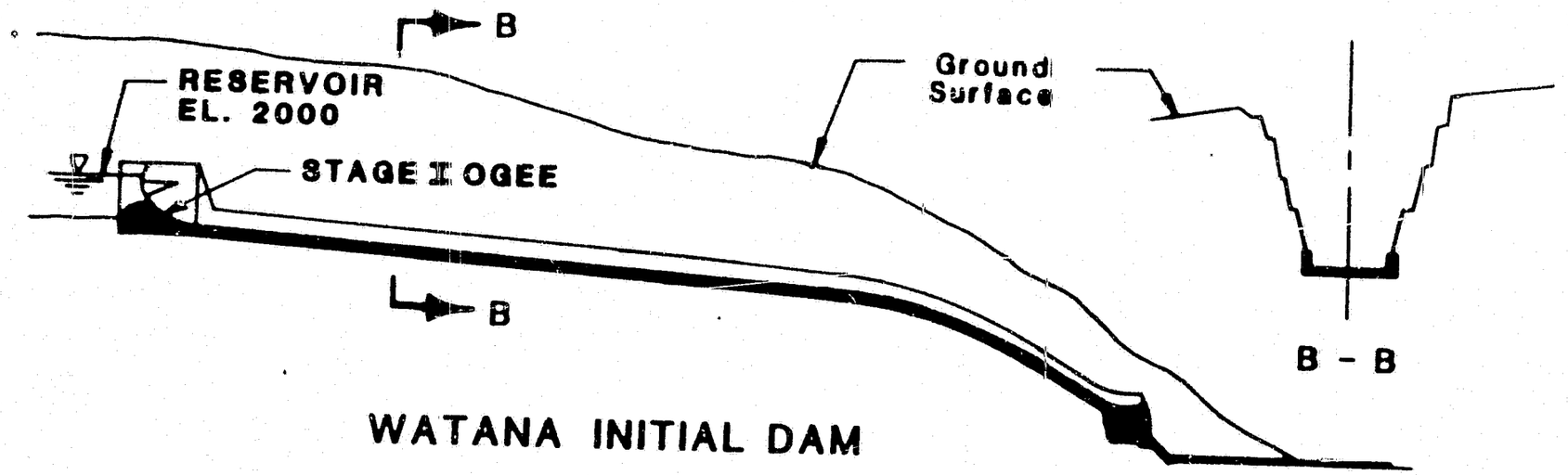
F drawing of Section

SUSITNA HYDROELECTRIC PROJECT
STAGED CONSTRUCTION PRESENTATION

WATANA SPILLWAY CROSS SECTION



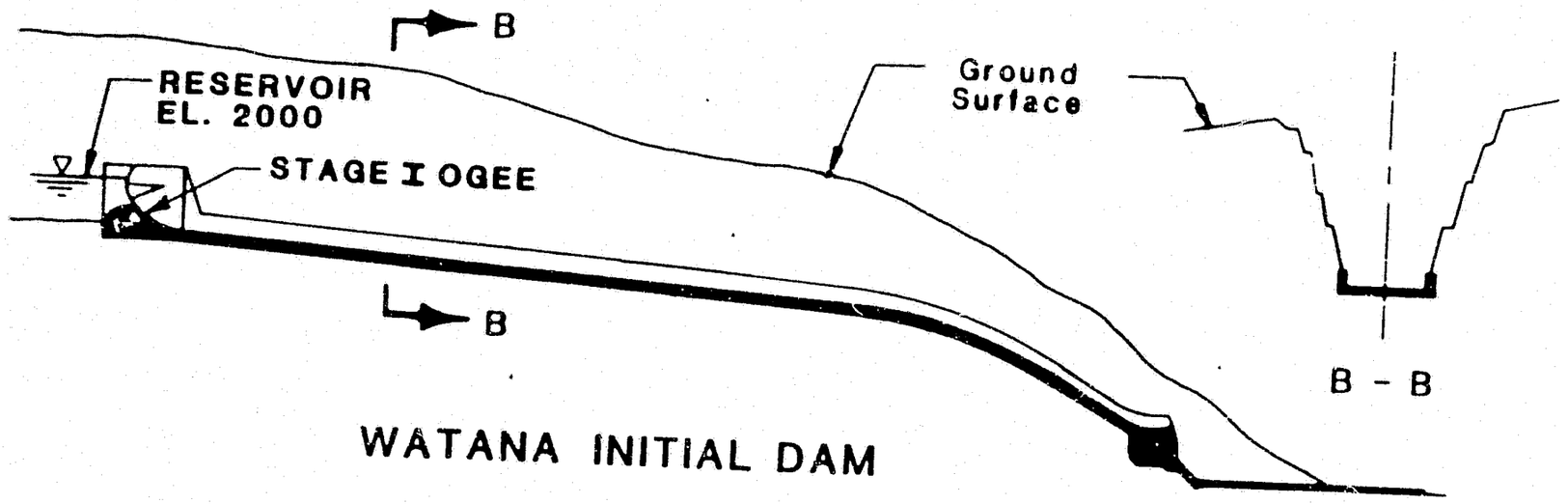
FERC LICENSE CONCEPT



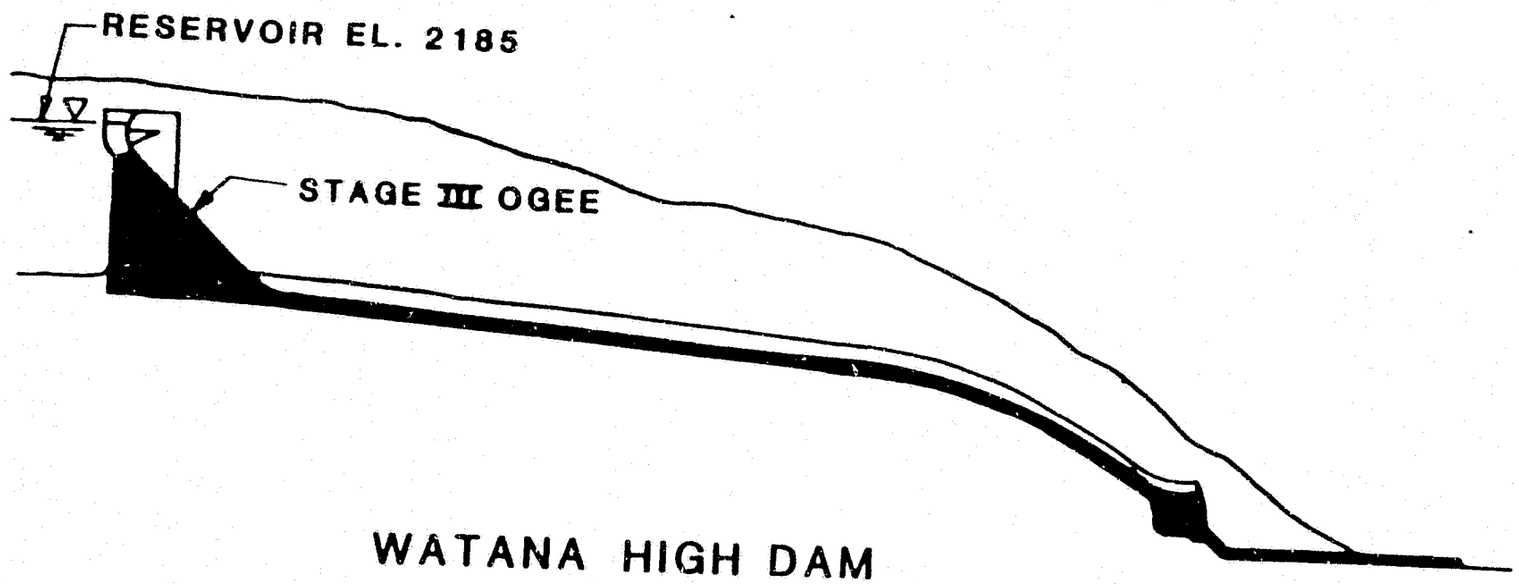
WATANA INITIAL DAM

SUSITNA HYDROELECTRIC PROJECT
STAGED CONSTRUCTION PRESENTATION

WATANA SPILLWAY RAISING



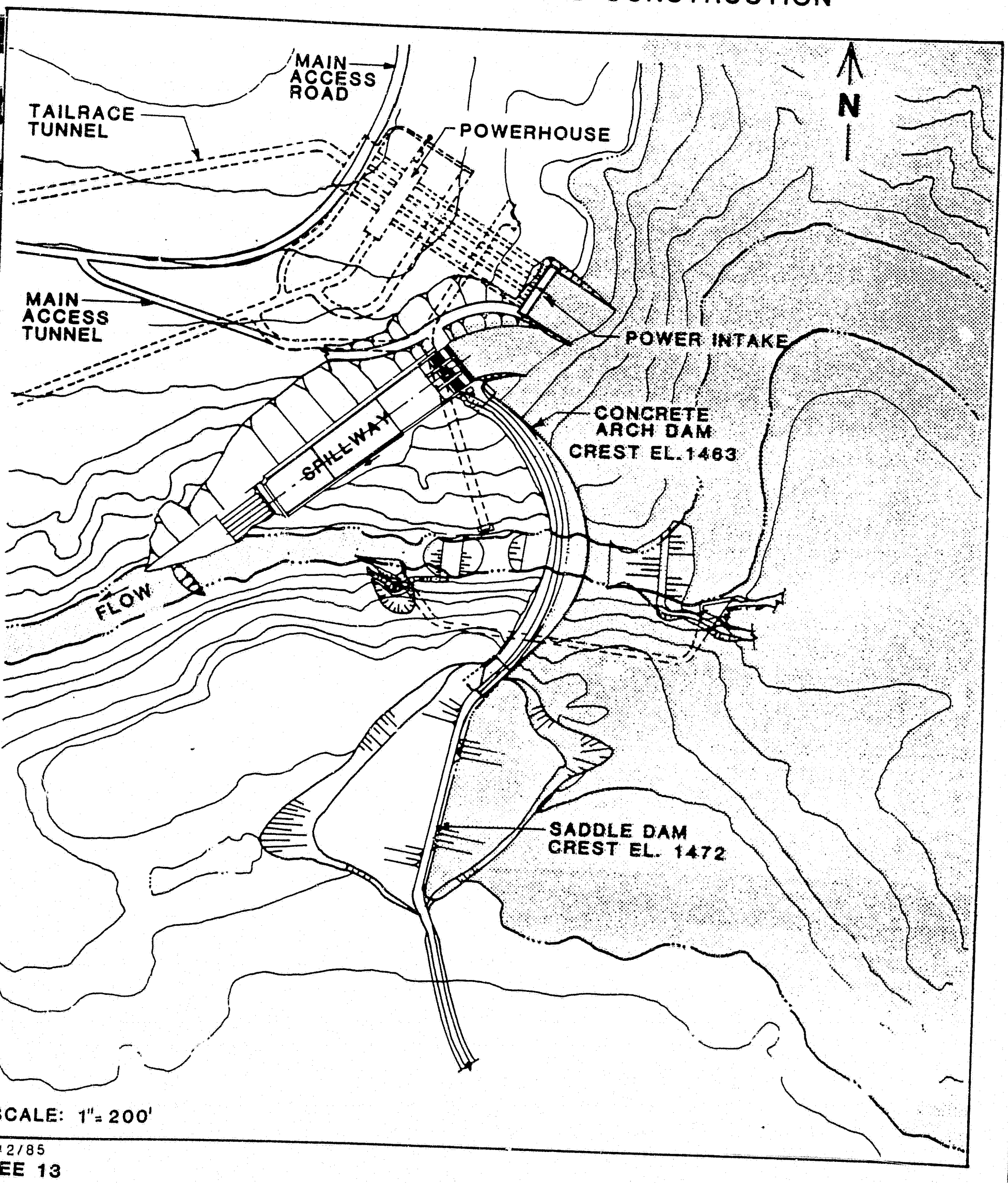
WATANA INITIAL DAM



WATANA HIGH DAM

DEVIL CANYON GENERAL PLAN

FERC LICENSE OR STAGED CONSTRUCTION



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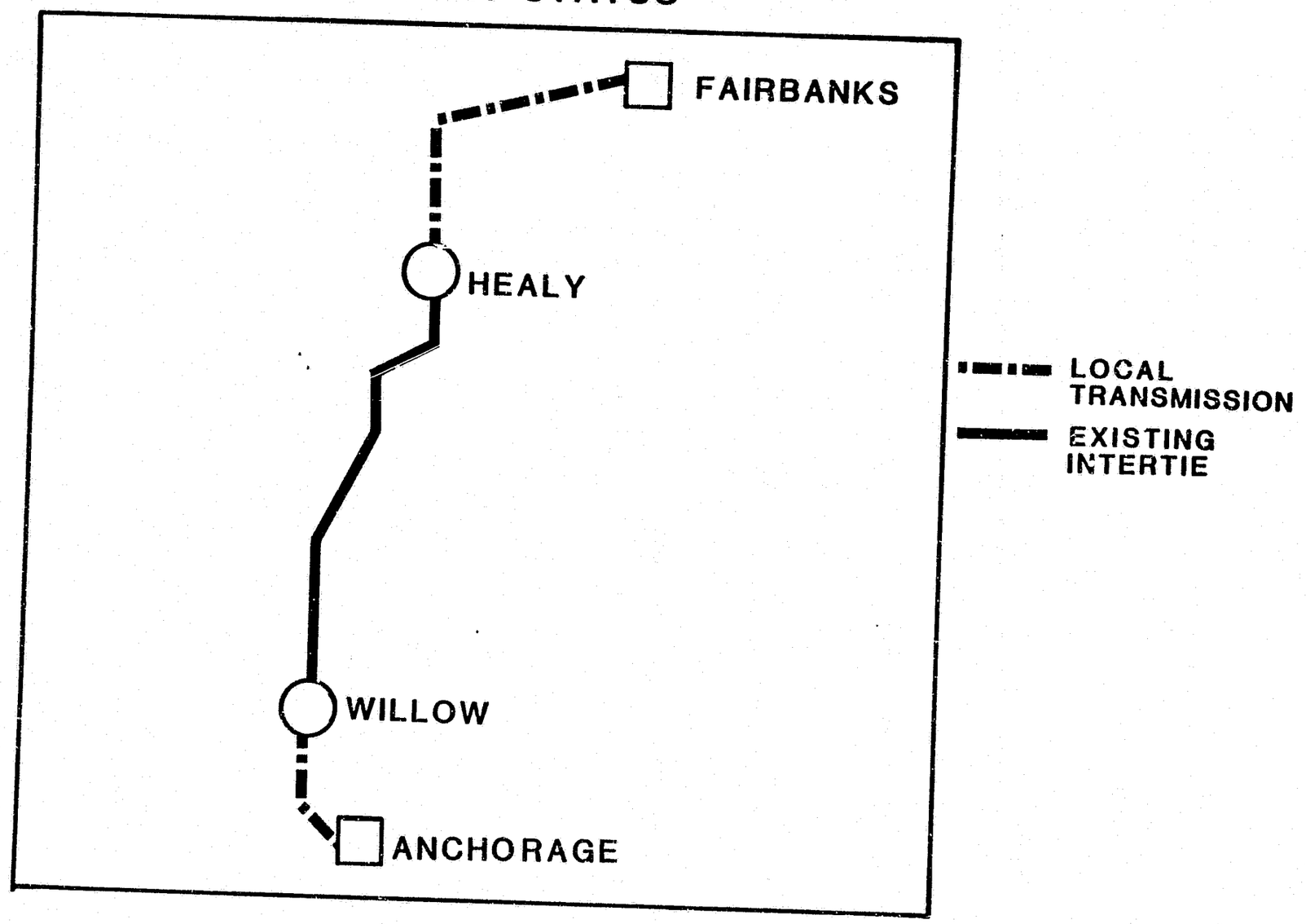
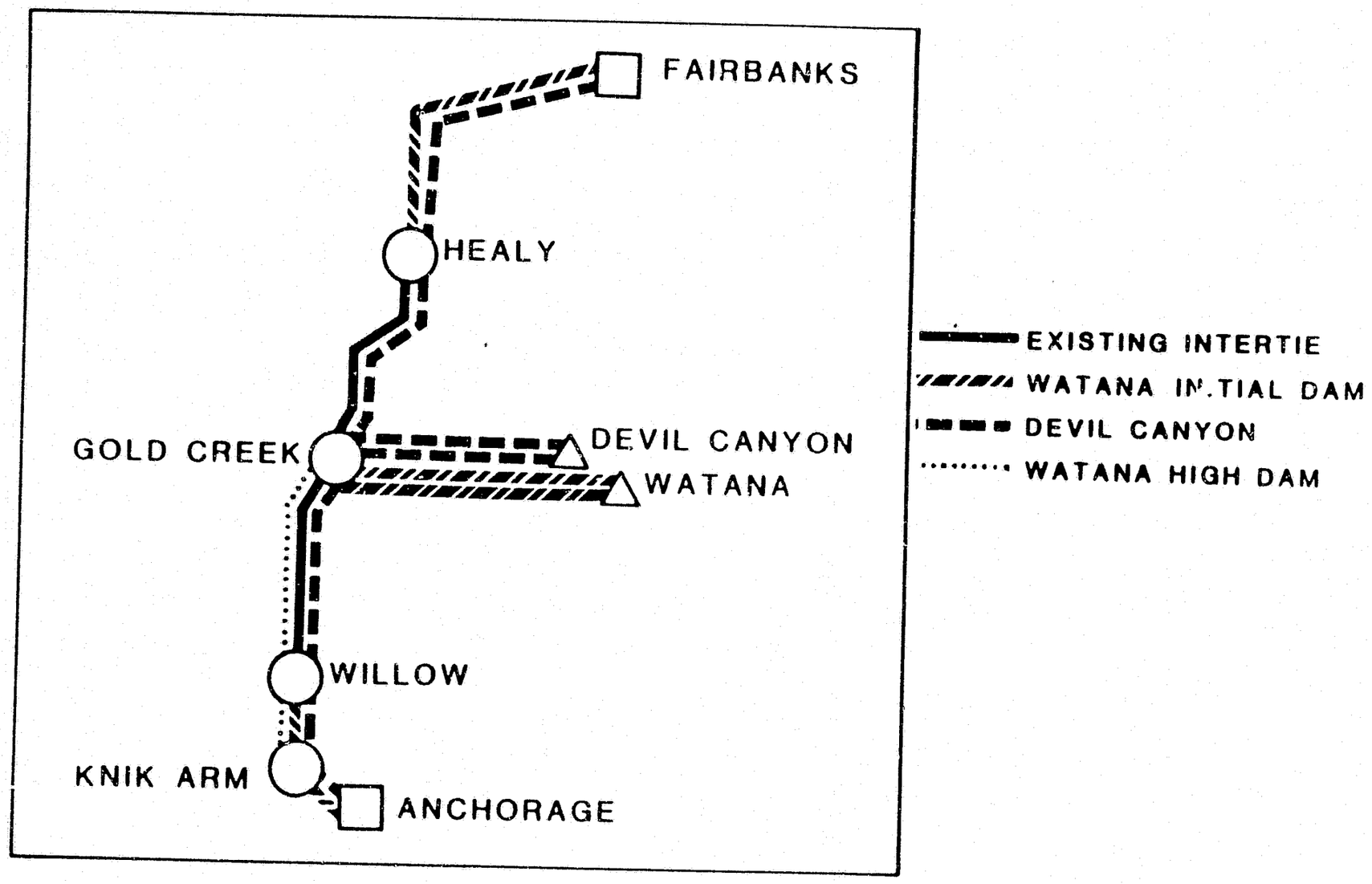
SUSITNA HYDROELECTRIC PROJECT
STAGED CONSTRUCTION PRESENTATION

STAGED CONSTRUCTION TRANSMISSION LINES
PRESENT STATUS



SUSITNA HYDROELECTRIC PROJECT
STAGED CONSTRUCTION PRESENTATION

STAGED CONSTRUCTION TRANSMISSION LINES
STAGE III



SUSITNA HYDROELECTRIC PROJECT

STAGED CONSTRUCTION PRESENTATION

EFFECTS ON PROJECT COSTS

($ MILLION 1982)

	FERC LICENSE	STAGED CONSTRUCTION
WATANA INITIAL DAM	N/A	$2,559
DEVIL CANYON	$1,469	$1,621
WATANA HIGH DAM	$3,361	$1,160
TOTAL	$4,830	$5,340
COST DIFFERENTIAL		+ $510

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SUSITNA HYDROELECTRIC PROJECT

STAGED CONSTRUCTION PRESENTATION

ENVIRONMENTAL EFFECTS

- THROUGH STAGE I AND II
  - LESS LAND INUNDATED
  - MINOR CHANGE IN FLOW RELEASES

- THROUGH STAGE III
  - LONGER DURATION FOR CONSTRUCTION WORK DISTURBANCE

- LONG TERM IMPACTS ARE EQUAL TO PRESENT PROJECT

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SUSITNA HYDROELECTRIC PROJECT
STAGED CONSTRUCTION PRESENTATION

PROJECT SCHEDULE

CALENDAR YEAR

1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010

FEASIBILITY STUDY

FERC LICENSE ①

FINANCIAL PLAN — BOND SALES

POWER SALES AGREEMENTS ②

STATE CONTRIBUTIONS

WATANA:

LAND ACQUISITION

DESIGN AND PROCUREMENT

CONSTRUCTION MANAGER PARTICIPATION ③

PROJECT LABOR AGREEMENT

ACCESS & SUPPORT FACILITIES CONST. ①

EL. 2027 DAM CONSTRUCTION (4 UNITS) ④ ⑤

EL. 2205 :ADDITION (2 UNITS) ⑨

DEVIL CANYON:

DESIGN & PROCUREMENT

LAND ACQUISITION

ACCESS & SUPPORT FACILITIES CONST. ⑥

DAM CONSTRUCTION ⑦ ⑧

KEY DATES

① MAY 1988
② DEC 1985
③ JUN 1986
④ JUN 1989
⑤ DEC 1996
⑥ JUL 1992
⑦ JUL 1995
⑧ SEPT 2002
⑨ DEC 2010

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SUSITNA HYDROELECTRIC PROJECT
STAGED CONSTRUCTION PRESENTATION

COMPARISON OF CAPACITY AND ENERGY

	INSTALLED CAPACITY (MW)	AVG ANNUAL ENERGY (GWHR)
FERC LICENSE CONCEPT:		
WATANA HIGH DAM	1020	3500
DEVIL CANYON	600	3400
	1620	6900
STAGED CONSTRUCTION		
STAGE 1–WATANA INITIAL DAM	520	2470
STAGE 2–DEVIL CANYON	600	3120
STAGE 3–WATANA HIGH DAM	500	1310
	1620	6900

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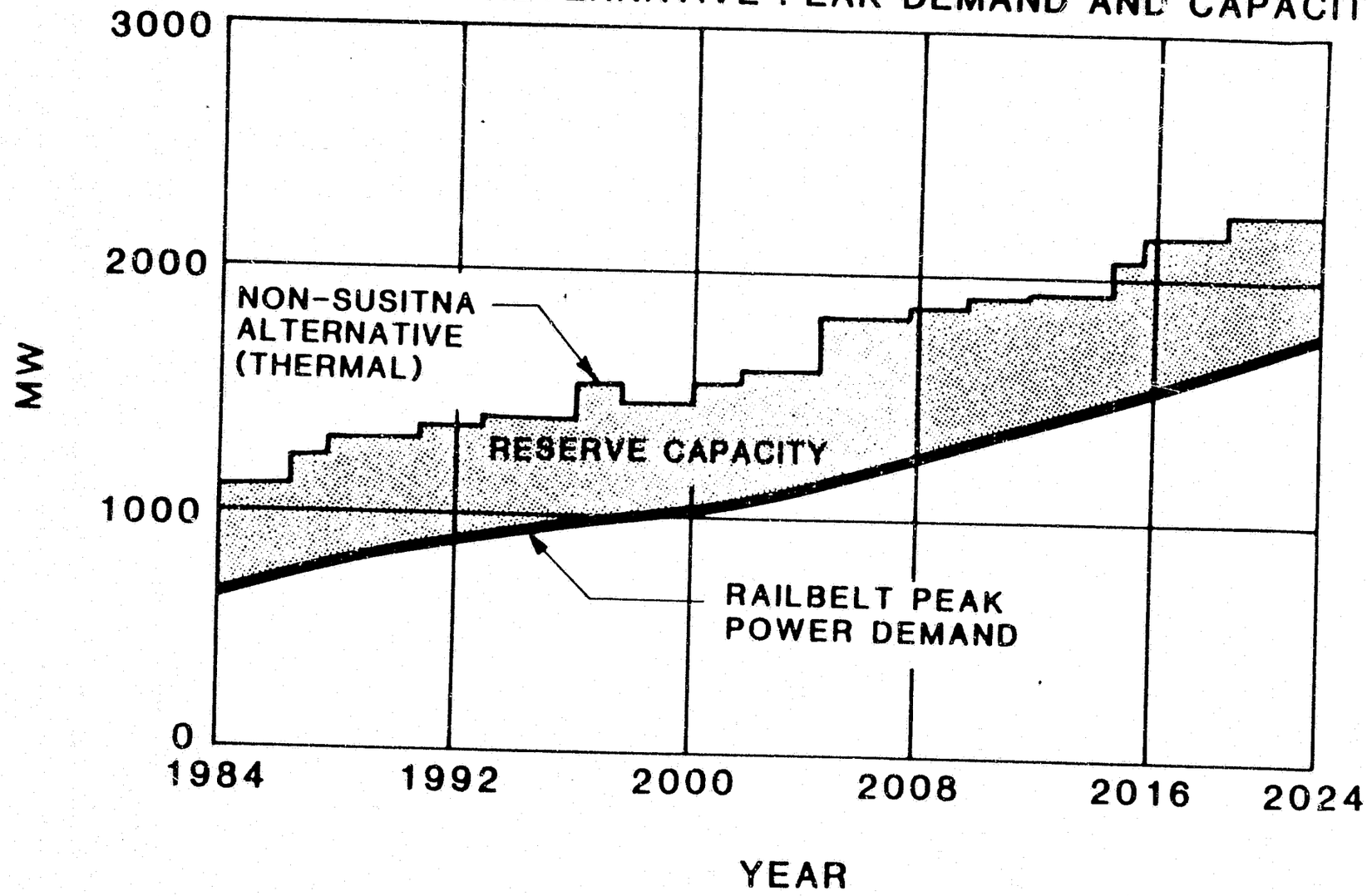
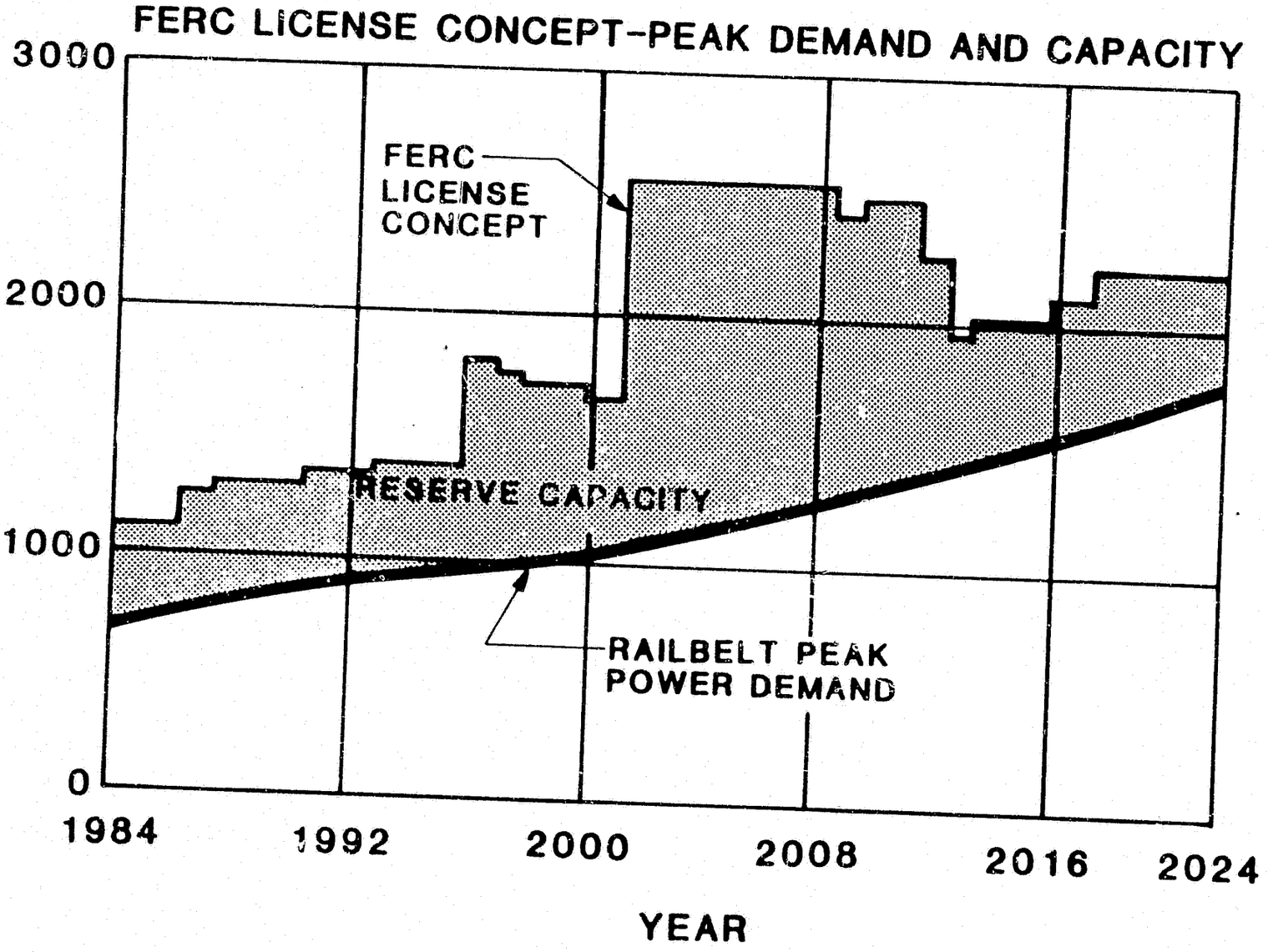
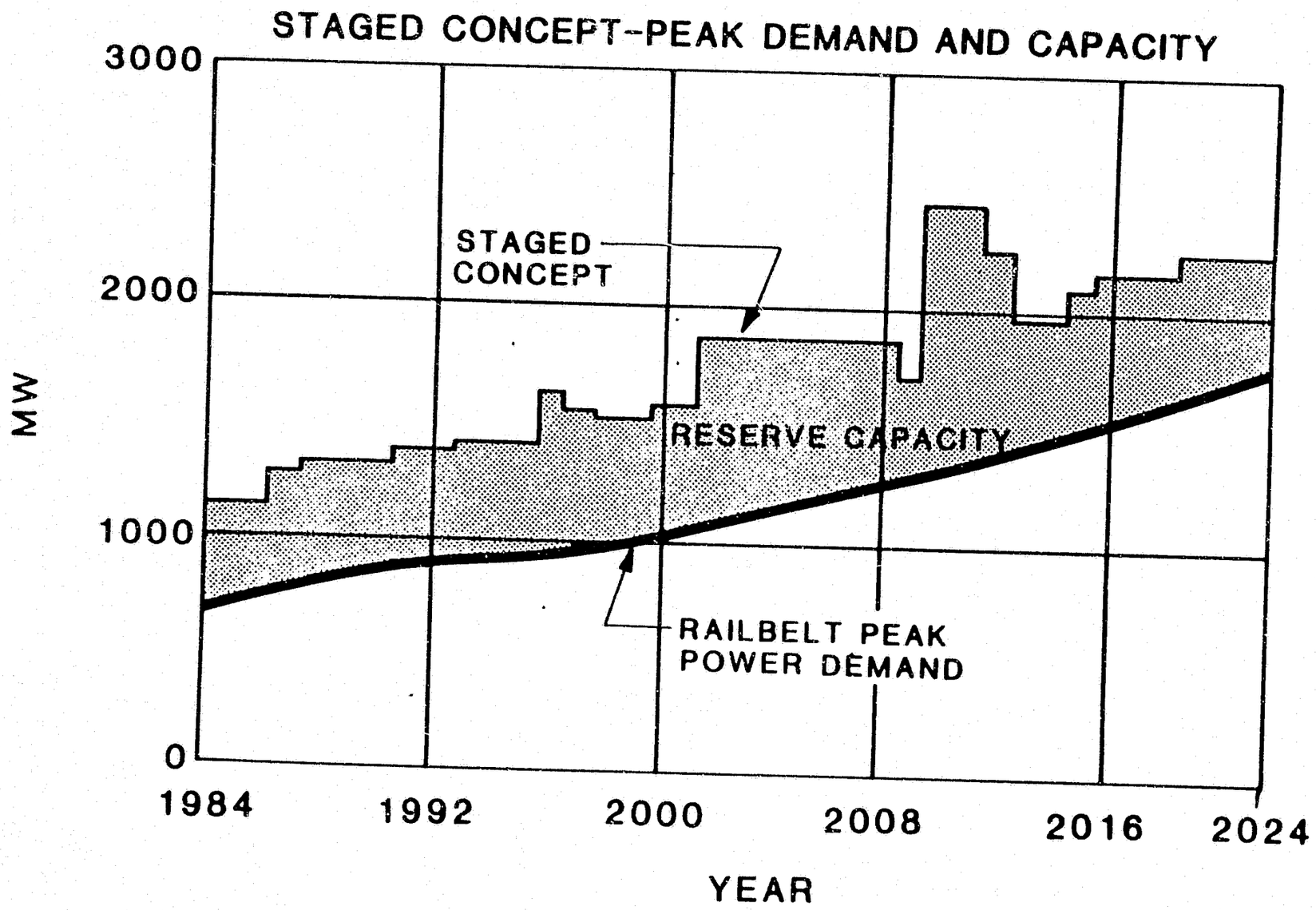
SUSITNA HYDROELECTRIC PROJECT
STAGED CONSTRUCTION PRESENTATION



SUSITNA HYDROELECTRIC PROJECT
STAGED CONSTRUCTION PRESENTATION

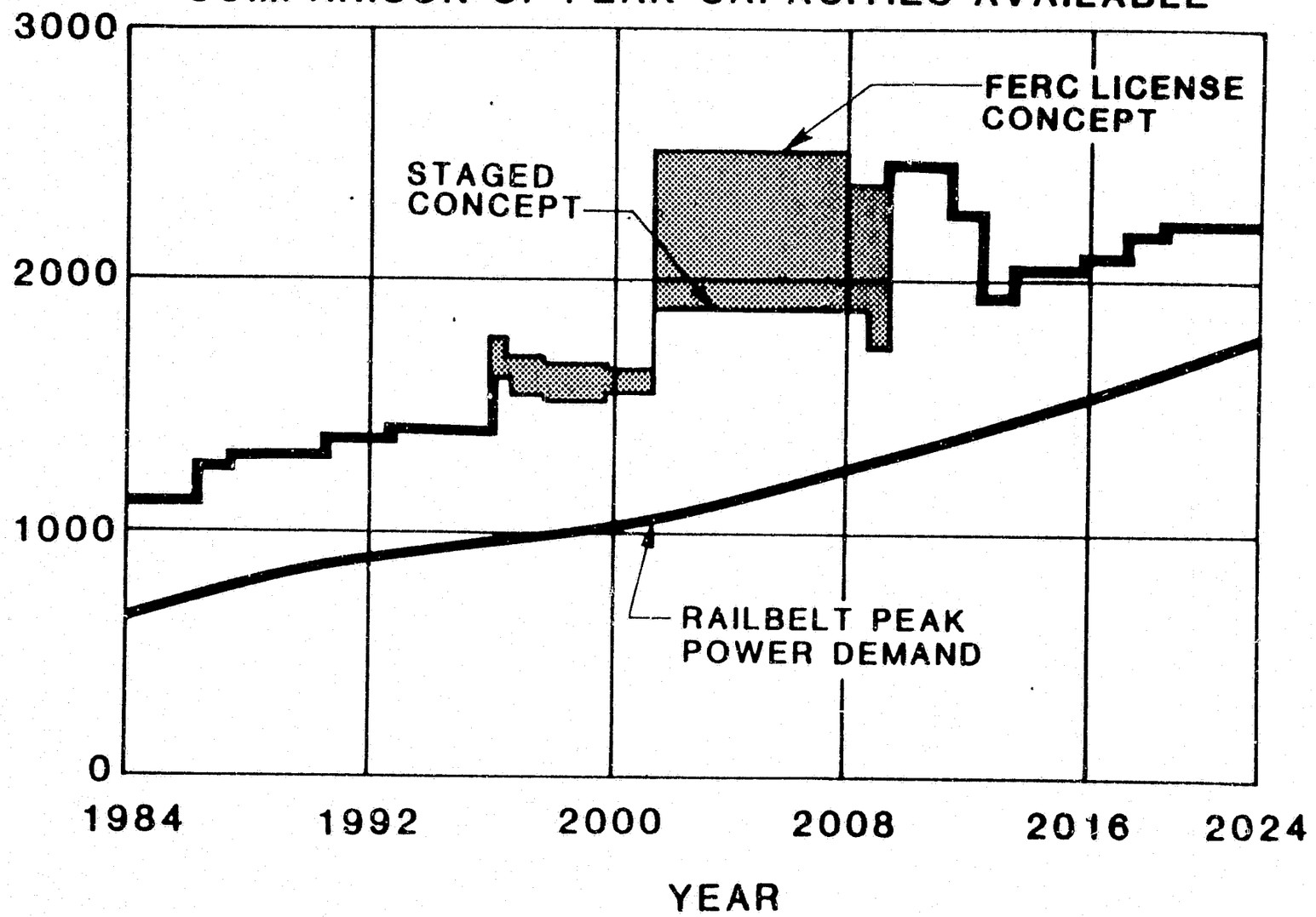


SUSITNA HYDROELECTRIC PROJECT
STAGED CONSTRUCTION PRESENTATION



SUSITNA HYDROELECTRIC PROJECT
STAGED CONSTRUCTION PRESENTATION

COMPARISON OF PEAK CAPACITIES AVAILABLE



SUSITNA HYDROELECTRIC PROJECT

STAGED CONSTRUCTION PRESENTATION

ECONOMIC EVALUATION

($ MILLION 1982)

	FERC LICENSE	STAGED CONSTRUCTION
SYSTEM COSTS - WITHOUT SUSITNA - CUMULATIVE PRESENT WORTH	$8025	$8025
SYSTEM COSTS - WITH SUSITNA - CUMULATIVE PRESENT WORTH	$5481	$5685
NET DIFFERENCE IN FAVOR OF SUSITNA ALTERNATIVE	$2544	$2340
BENEFIT/COST RATIO	1.46	1.41

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SUSITNA HYDROELECTRIC PROJECT

STAGED CONSTRUCTION PRESENTATION

ECONOMIC ANALYSIS

($ MILLION 1982)

	CUMULATIVE PRESENT WORTH		NET	BENEFIT COST
	BENEFITS	COSTS	BENEFITS	RATIO
FERC LICENSE APPLICATION PROJECT	$8025	$5481	$2544	1.46
PROPOSED THREE-STAGE CONSTRUCTION	$8025	$5685	$2340	1.41
ONLY STAGE I AND II	$8025	$6570	$1455	1.22
ONLY STAGE I	$8025	$7820	$ 205	1.03

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SUSITNA HYDROELECTRIC PROJECT

STAGED CONSTRUCTION PRESENTATION

REVIEW

ADVANTAGES

- REDUCTION IN WATANA INITIAL CONSTRUCTION COST
- REDUCTION IN STATE CONTRIBUTION
- TIMING OF RAISING WATANA CAN BE MATCHED TO ACTUAL SYSTEM LOAD GROWTH

DISADVANTAGES

- INCREASE IN TOTAL ECONOMIC COST OF THE PROJECT
- INCREASE IN NOMINAL DOLLAR AMOUNT OF BONDS REQUIRED.
- INCREASE IN POWER AUTHORITY LICENSING PROCESS COSTS TO PROVIDE FOR REVISIONS TO APPLICATION.

SUSITNA HYDROELECTRIC PROJECT

STAGED CONSTRUCTION PRESENTATION

ENGINEERING, ENVIRONMENTAL, AND ECONOMIC CONCLUSIONS

- STAGING SUSITNA PROVIDES A TRADEOFF (LESS INITIAL INVESTMENT VERSUS HIGHER TOTAL COST).

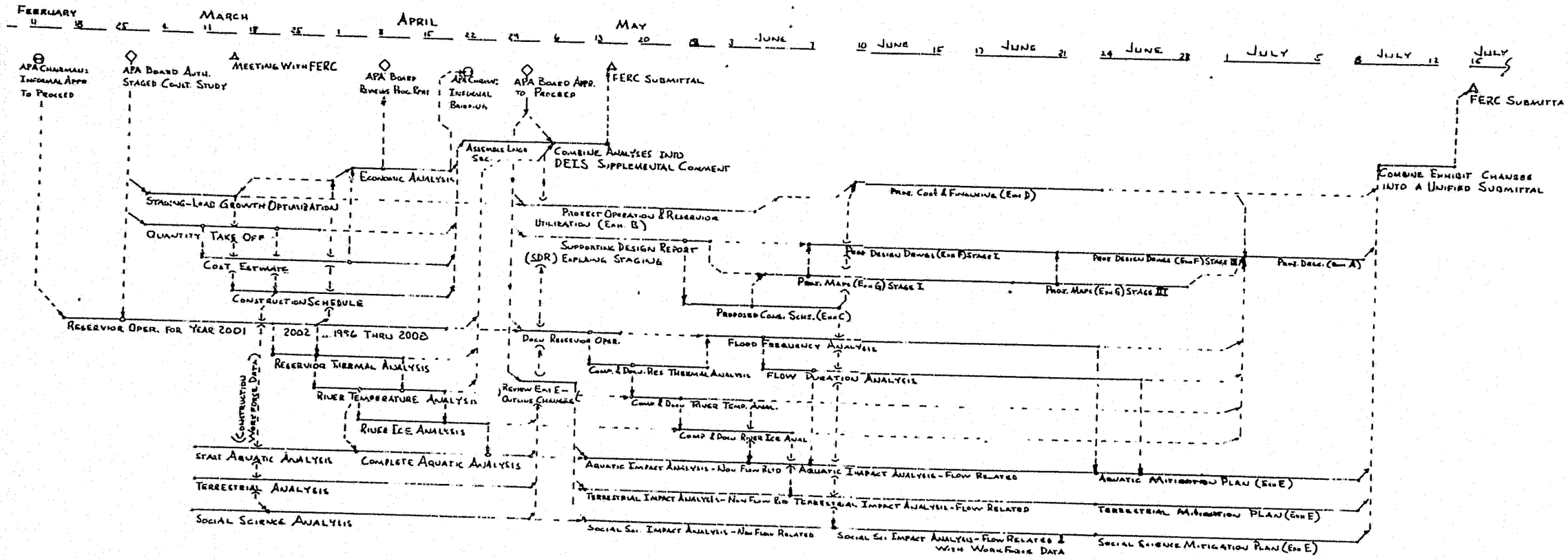
- STAGING PROVIDES MORE FLEXIBILITY IN MEETING FUTURE POWER DEMANDS.

- STAGING PROVIDES FOR FULL EVENTUAL DEVELOPMENT OF THE SUSITNA RIVER BASIN (ALL BENEFITS OF THE ORIGINAL PROJECT ARE AVAILABLE WITH STAGING).

- STAGING CAUSES NO SIGNIFICANT CHANGE IN PROJECT ENVIRONMENTAL IMPACTS.

FUTURE ENGINEERING EFFORT

STAGED CONSTRUCTION



PROPOSED STAGED CONSTRUCTION

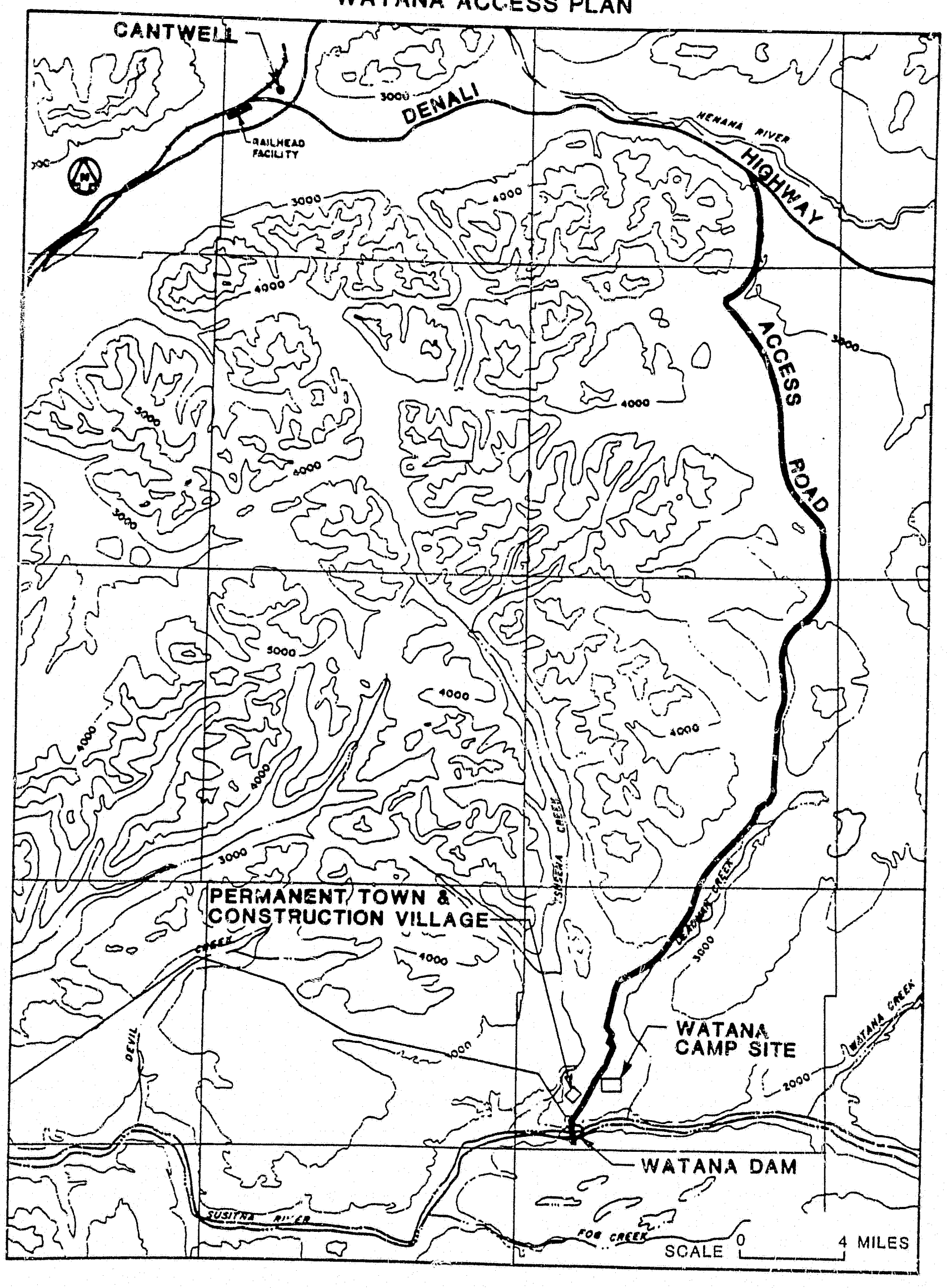
DEIS SUPPLEMENTAL COMMENT & FERC APPLICATION REVISION

APRIL 2, 1986

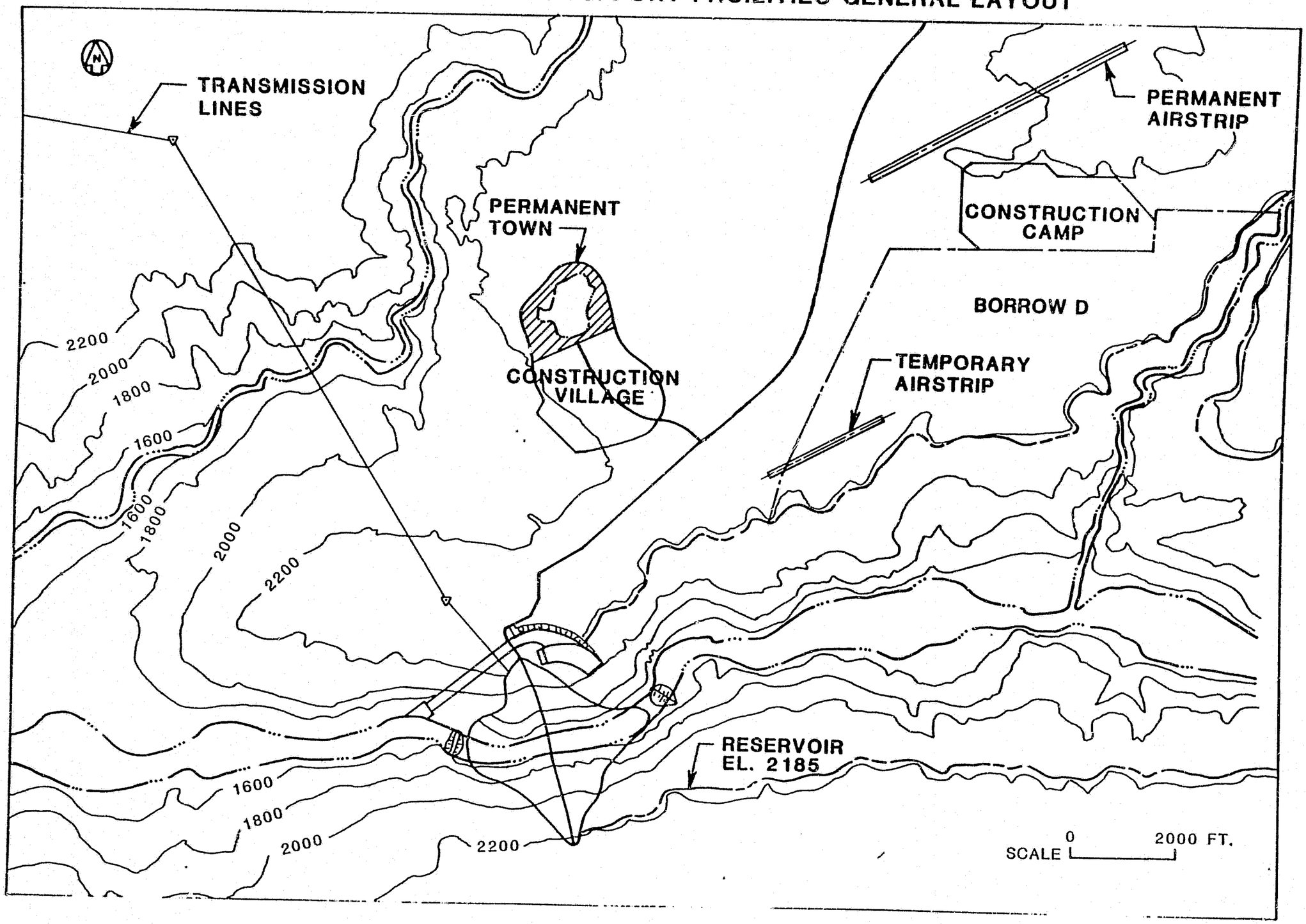
WATANA SUPPORT FACILITIES MASTER PLAN

SUSITNA HYDROELECTRIC PROJECT

WATANA ACCESS PLAN



SUSITNA HYDROELECTRIC PROJECT
FERC LICENSE WATANA SUPPORT FACILITIES GENERAL LAYOUT



WATANA CAMP EXPANSION

FUTURE GEOTECHNICAL INVESTIGATIONS

WATANA DAM AND RESERVOIR

PREVIOUS GEOTECHNICAL INVESTIGATIONS

- RECONNAISSANCE INVESTIGATIONS BY CORPS OF ENGINEERS

  1975 - RIVER CHANNEL
  1978 - DAMSITE
  BORROW AREAS

- FEASIBILITY INVESTIGATIONS BY ACRES

  1980 - DAMSITE
  BORROW AREAS
  RELICT CHANNEL
  SEISMIC STUDIES

  1981 - DAMSITE
  BORROW AREAS
  RELICT CHANNEL
  SEISMIC STUDIES
  ACCESS ROAD

  1982 - DAMSITE
  BORROW AREA
  RELICT CHANNELS

- LICENSING INVESTIGATIONS BY HARZA-EBASCO

  1983 - RELICT CHANNEL
  MAIN FOUNDATION (RIVER CHANNEL)
  COFFERDAM FOUNDATION (RIVER CHANNEL)

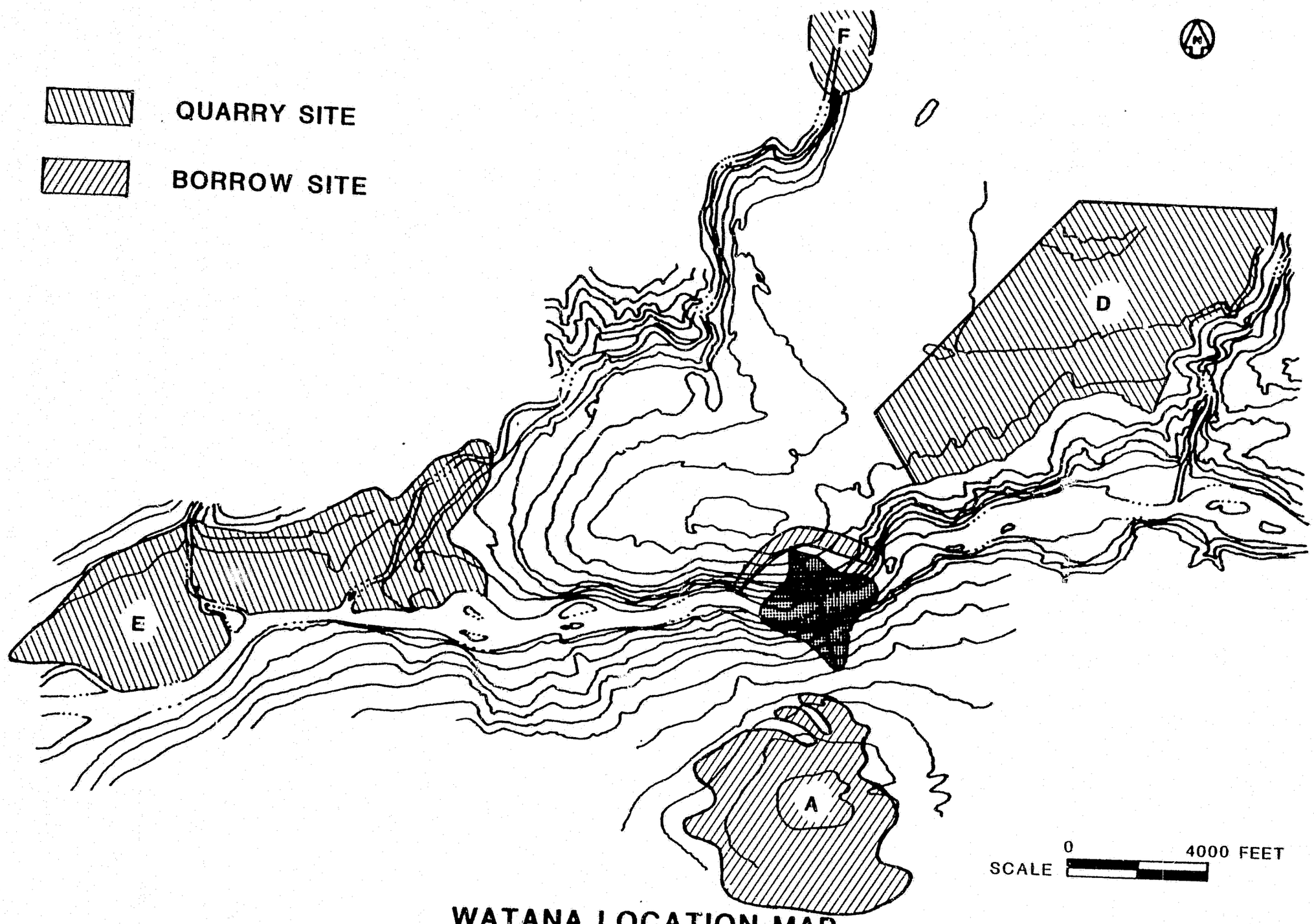
  1984 - FINS AREA
  POWERHOUSE AREA
  OUTLET AREA (FINGERBUSTER)

WATANA DAM AND RESERVOIR

GEOTECHNICAL INVESTIGATIONS FOR DESIGN

DESIGN EXPLORATIONS WILL BE MORE DETAILED THAN THE PREVIOUS FEASIBILITY INVESTIGATIONS AND WILL VARY IN SCOPE WITH THE NATURE AND SIGNIFICANCE OF THE FEATURE. THEY WILL BE IN SUFFICIENT DETAIL TO DETERMINE THE FOLLOWING:

- FOUNDATION CONDITIONS AND PROPERTIES
- TYPE OF STRUCTURE BEST SUITED TO THE SITE
- ALL CONTROLLING ELEVATIONS
- APPROXIMATE FOUNDATION ELEVATIONS OF STRUCTURES
- ANY SPECIAL FOUNDATION TREATMENT
- CONSTRUCTION MATERIAL PROPERTIES
- GENERAL RESERVOIR GEOLOGY AND THE STABILITY OF THE SHORELINE



WATANA LOCATION MAP

WATANA DAM AND RESERVOIR

GEOTECHNICAL INVESTIGATIONS FOR DESIGN

CONSTRUCTION MATERIAL INVESTIGATIONS

- BORROW AREA "D"
  - AUGER HOLES
  - CHURN HOLES
  - TEST TRENCHES
  - DRAGLINE TEST PITS
- BORROW AREA "E"
  - DRAGLINE TEST PITS
  - CHURN HOLES
  - TEST TRENCHES
- QUARRY AREA "A"
  - CORE HOLES
  - TEST BLAST
- LABORATORY TESTING
  - MOISTURE
  - GRADATION
  - RELATIVE DENSITY
  - COMPACTION
  - TRIAXIAL SHEAR TEST
  - LARGE SCALE TRIAXIAL TEST
  - FREEZE-THAW
  - L.A. ABRASION
  - REACTIVITY
  - COMPRESSIVE STRENGTH
  - POINT LOAD TEST
- INSTRUMENTATION MONITORING
  - PIEZOMETERS
  - THERMISTORS

WATANA DAM AND RESERVOIR

GEOTECHNICAL INVESTIGATIONS FOR DESIGN

- DAM FOUNDATION INVESTIGATIONS - ABUTMENTS

  - CORE HOLES (ANGLE)

    PRESSURE TESTING
    GEOPHYSICAL LOGGING
    INSTRUMENTATION

  - TEST TUNNEL

    GEOLOGIC MAPPING
    IN SITU ROCK MECHANICS TESTING

  - LABORATORY TESTING

    PETROGRAPHICS
    POINT LOAD TESTS
    COMPRESSIVE STRENGTH

  - INSTRUMENTATION MONITORING

    PIEZOMETERS
    THERMISTORS
    STRAIN GAGES

WATANA DAM AND RESERVOIR

GEOTECHNICAL INVESTIGATIONS FOR DESIGN

- DIVERSION TUNNEL INVESTIGATIONS

  - CORE HOLES (ANGLE)

    PRESSURE TESTING
    INSTRUMENTATION

  - TEST TUNNEL(S)

    GEOLOGIC MAPPING
    IN SITU ROCK MECHANICS TESTING

  - LABORATORY TESTING

    POINT LOAD TESTS
    COMPRESSIVE STRENGTH

  - INSTRUMENTATION MONITORING

    PIEZOMETERS
    STRAIN GAGES

WATANA DAM AND RESERVOIR

GEOTECHNICAL INVESTIGATIONS FOR DESIGN

° SPILLWAY AND OUTLET FACILITIES

- CORE HOLES (ANGLE)

  PRESSURE TESTS
  GEOPHYSICAL LOGGING
  INSTRUMENTATION

- CHURN HOLES (OVERBURDEN)

  INSTRUMENTATION

- LABORATORY TESTING

  POINT LOAD TESTS
  COMPRESSIVE STRENGTH

- INSTRUMENTATION MONITORING

  PIEZOMETERS
  THERMISTORS
  INCLINOMETERS

- GEOPHYSICS

  SEISMIC REFRACTION

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WATANA DAM AND RESERVOIR

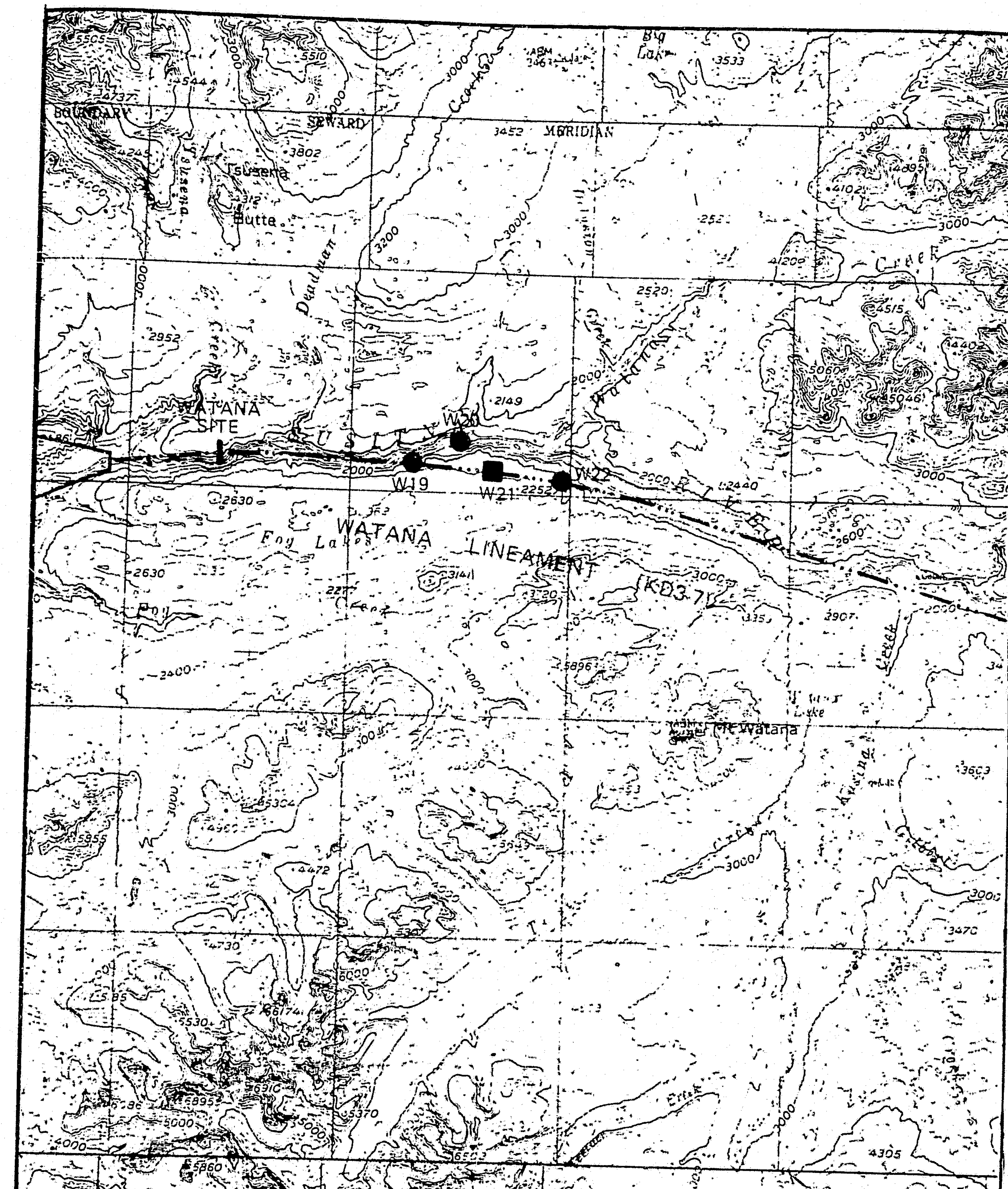
GEOTECHNICAL INVESTIGATIONS FOR DESIGN

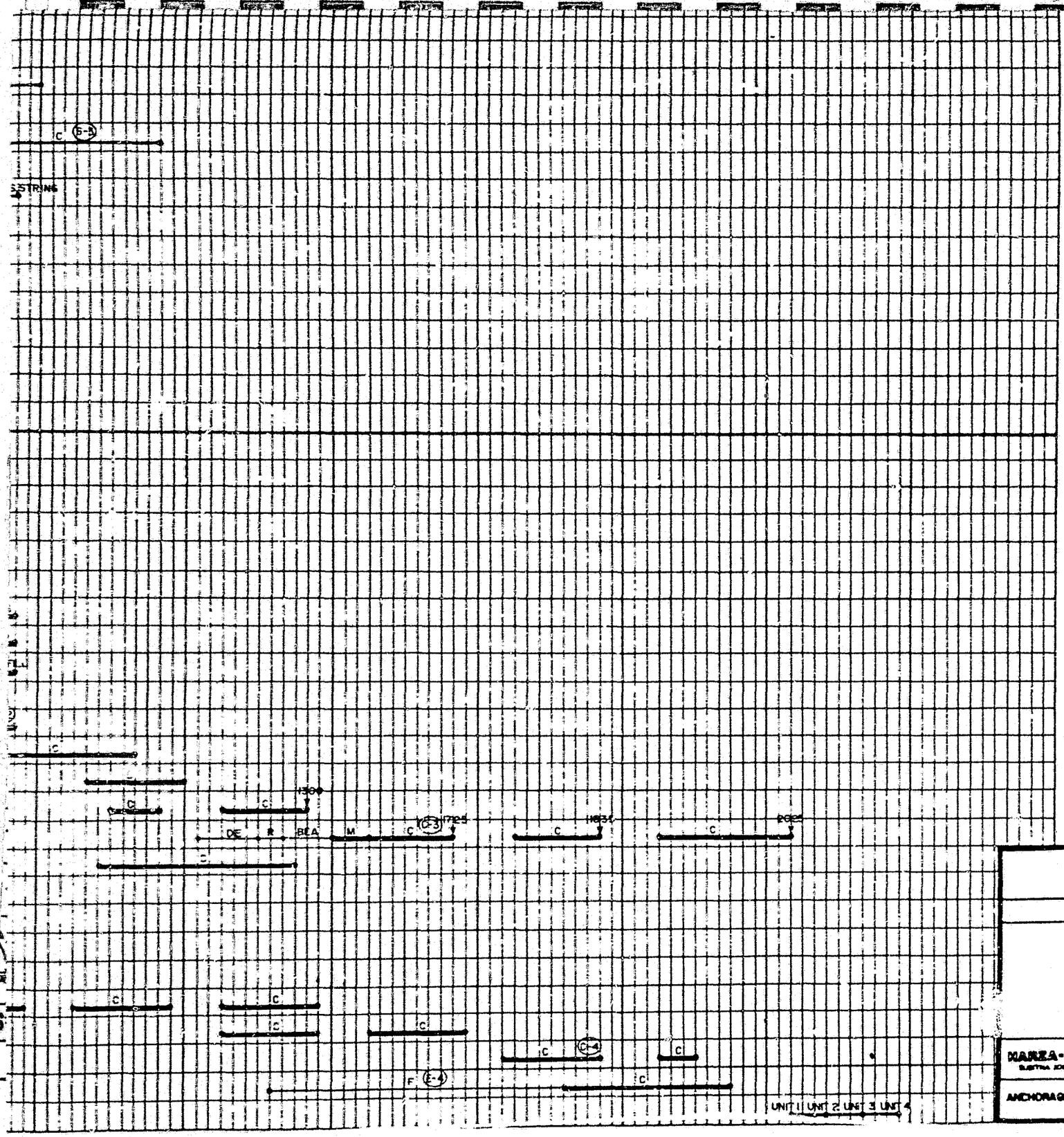
- POWER INTAKE
  - CORE HOLES (ANGLE)
    - PRESSURE TESTS
    - INSTRUMENTATION
  - LABORATORY TESTING
    - POINT LOAD TESTS
    - COMPRESSIVE STRENGTH
  - INSTRUMENTATION
    - PIEZOMETERS
- POWERHOUSE, SURGE CHAMBER, TRANSFORMER GALLERY
  - CORE HOLES (ANGLE)
    - ORIENTED CORE
    - PRESSURE TESTS
    - GEOPHYSICAL LOGGING
    - INSTRUMENTATION
  - TEST TUNNEL
    - GEOLOGIC MAPPING
    - IN SITU ROCK MECHANICS TESTING
  - LABORATORY TESTING
    - POINT LOAD TESTS
    - COMPRESSIVE STRENGTH
  - INSTRUMENTATION
    - PIEZOMETERS
    - STRAIN GAGES

WATANA DAM AND RESERVOIR

GEOTECHNICAL INVESTIGATIONS FOR DESIGN

- LINEAMENT SURVEY
  - DELINEATE WATANA LINEAMENT (IN RIVER VALLEY)
    - REMOTE SENSING
    - OVERBURDEN FOUNDATION CLEANUP
    - GEOLOGIC MAPPING
- RELICT CHANNEL
  - UPSTREAM ENTRANCE FACE
    - TEST TRENCHES
  - DOWNSTREAM EXIT FACE
    - TEST TRENCHES
  - THALWEG AREA
    - CHURN HOLES
      - PERMEABILITY TESTING
      - INSTRUMENTATION
    - LABORATORY TESTING
      - GRADATION
    - INSTRUMENTATION
      - PIEZOMETERS
    - PUMPING TESTS


BOUNDARY
SEWARD
MERIDIAN
Tsusena
Butte
Big Lake
Deadman
WATANA SITE
W20
W19
W21
W22
WATANA
LINEAMENT
KD3-7
Fog Lakes
Mt Watana
RIVER
Creek



LEGEND

D	DESIGN
DE	DETAILED ENGINEERING
R	REVIEW
P&S	PLANS AND SPECIFICATIONS
BEA	BID, EVALUATE, AWARD
F	FABRICATION/PROCUREMENT
M	MOBILIZATION
C	CONSTRUCTION
———	CONSTRUCTION ACTIVITY
▲	MILESTONE DATES

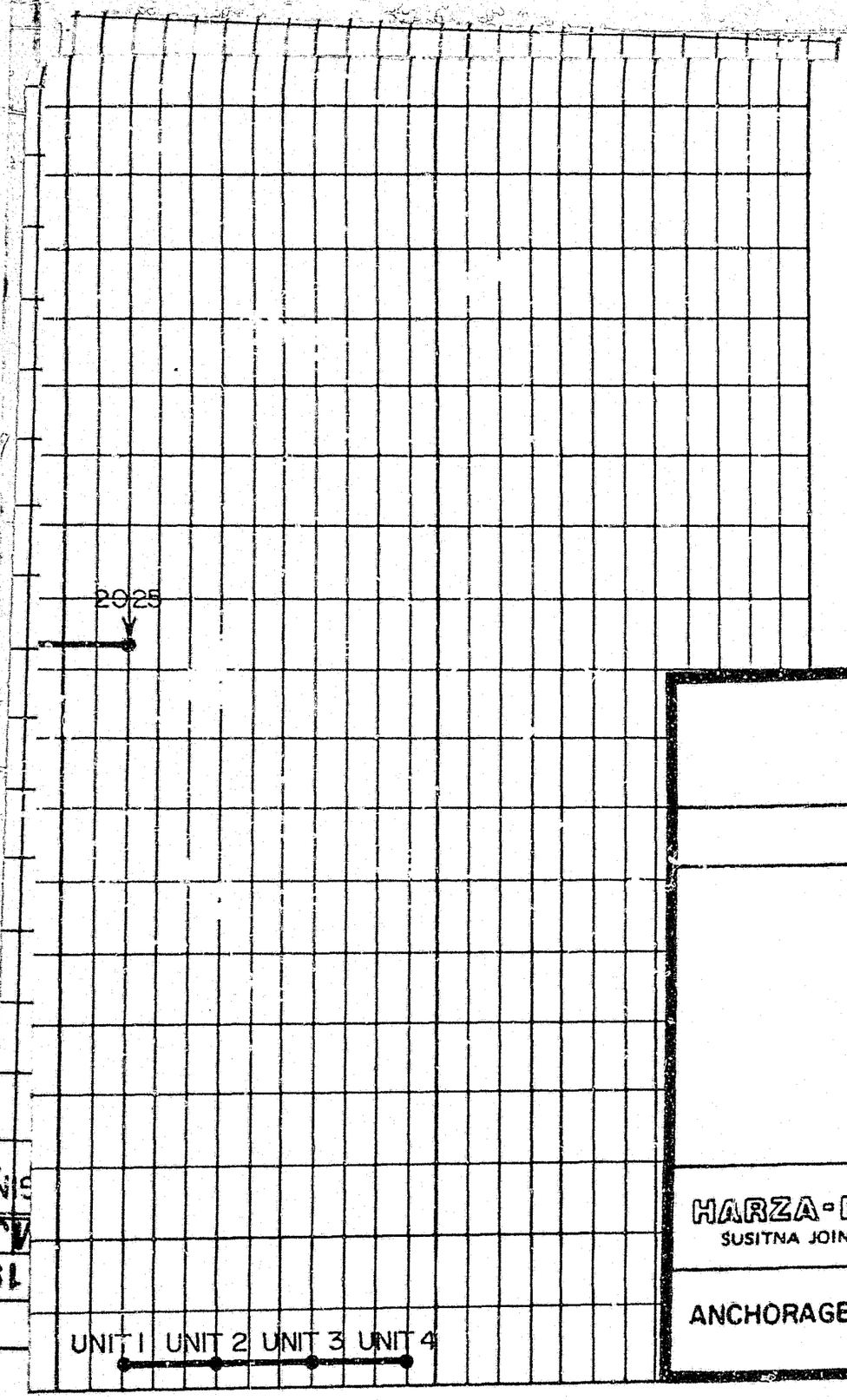
ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

WATANA DAM AND RESERVOIR

STAGED CONSTRUCTION - STAGE 1
CONSTRUCTION SCHEDULE
SHEET 1 OF 2

HARZA-EBASCO SUSITNA JOINT VENTURE	APPROVED	
ANCHORAGE, ALASKA	DATE APRIL 1985	DRAWING NO. R4-03-09



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STAGED CONSTRUCTION - STAGE 1
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SHEET 1 OF 2

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SUSITNA HYDROELECTRIC PROJECT

WATANA DAM AND RESERVOIR

STAGED CONSTRUCTION - STAGE 1
CONSTRUTION SCHEDULE

SHEET 2OF2

HARZA-EBASCO SUSITNA JOINT VENTURE	APPROVED	
ANCHORAGE, ALASKA	DATE APRIL 1985	DRAWING NO. 041285