SUSITNA HYDROELECTRIC PROJECT

TASK 6

TASK 6
1981 UPPER LIMIT
CAPITAL COST ESTIMATE

Prepared by:

ACRES

ALASKA POWER AUTHORITY

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SUSITNA HYDROELECTRIC PROJECT

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CAPITAL COST ESTIMATE

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1 - INTRODUCTION

1.1 - Study Objective

As part of Task 6 (Design Development) and Task 9 (Construction Cost Estimates and Schedules) studies for the Susitna Hydroelectric Project, Acres American Incorporated is to provide capital cost estimates for the chosen project developments. These tasks are defined in the Acres American Incorporated Plan of Study (POS) dated February 1980 and in the subsequent POS revision dated September 1980. In line with these requirements, Acres prepared initial cost estimates based upon preliminary layouts for the chosen Devil Canyon and Watana sites. In addition, Acres with the reference to R.W. Retherford Associates (IECo) experience prepared initial transmission line cost estimates as part of Task 8 Transmission Studies.

Subsequently, in February 1981, Acres was requested by the Alaska Power Authority (APA) to provide an update of the estimates to 1981 costs. In addition, Acres was requested by APA to provide a conservative "not to be exceeded" estimate. Such an estimate was intended to provide a reasonable upper limit capital cost estimate that could be used for comparative and planning purposes. The results of these studies are contained in this report.

1.2 - Report Contents

The report is structured into four sections. Section 2 is a summary of the work undertaken and the results obtained. Section 3 describes the assumptions made in obtaining a conservative upper limit on the Devil Canyon and Watana cost estimates and provides a listing of item costs based upon structure type. Section 4 provides the details for the transmission line updates and outlines the assumed line routing and sizes. Finally, Section 5 contains the study conclusions.

Appendix A contains a detailed summary of the upper limit estimate and a listing of special assumptions for each site.

2 - SUMMARY

This section summarizes the work undertaken in the preparation of the "1981 Upper Limit Capital Cost Estimate" and the results obtained.

2.1 - Watana/Devil Canyon Cost Estimates

Similar procedures were followed in developing the upper limit estimates for both the Watana and Devil Canyon sites. In each case, an estimate was made for a "base case" general arrangement drawing that reflected current (February 1981) design considerations. These estimates were produced through an item-by-item review of each major element of the project. Item quantities were derived from the drawings under the direction of an experienced construction cost estimator. A conservative approach was used in determining quantities so as to account for the numerous uncertainties that still exist regarding site conditions and design criteria. Detailed consideration was given to determining actual production rates and, therefore, unit costs for the major elements. As an example, representative crew sizes and equipment needs were determined for the major tunneling works. Present Alaskan wage and equipment rates were then applied, and a unit rate was produced. Items of lesser importance were taken as lump sum items.

Camp requirements and costs were determined by applying the manpower needs for the various work items to an approximate construction schedule. This resulted in an estimate of total manpower requirements, as well as of peak camp size.

An upper limit estimate was then determined for each site by expanding the "base case" estimate to include items about which there was some degree of uncertainty as to ultimate feasibility. A reasonable "upper case" general arrangement and estimate was obtained. As an example, the dam slopes at Watana were flattened to reflect an extremely conservative seismic design. The major design adjustments made are listed in Section 4.

In line with the above methodology, a capital cost estimate of $3,069,889,000 (Table 2.1) was developed for the Watana rockfill dam scheme and a capital cost estimate of $1,519,054,000 (Table 2.2) was developed for the Devil Canyon thin arch scheme. These costs were reviewed during May 1981 and reflect a revised upper limit estimate of the original March 1981 figures. These adjustments were made to include more current information and to appropriately consider camp and accommodation costs. The original upper limit costs for March 1981 were $2,963,517,000 (Watana) and $1,419,829,000 (Devil Canyon).

2.2 - Transmission Line Cost Estimates

Transmission line cost estimates were updated to 1981 dollars and to reflect the development of the Susitna Basin with generating facilities at Watana and Devil Canyon.

These estimates were based upon the presently proposed levels of generating capacity at the various sites. They were reconciled with the R.W. Retherford Associates (IECo) estimate of 1979 and provide for a contingency of 20 percent and an engineering, construction management, and owner's fees allowance of 12.5 percent. These factors are in line with other similarly sized projects and are consistent with the line estimates as developed by Commonwealth Associates in January 1981.

The total costs developed for the Susitna development are about $522 million.

2.3 - Conclusions

The total upper limit capital cost for the Susitna Basin development in June 1981 dollars is therefore estimated as follows:

Watana	$3,070 million
Devil Canyon	$1,519 million
Transmission	$ 522 million
TOTAL	$5,111 million

Summary cost estimates are presented in Tables 2.1 and 2.2.

TABLE 2.1 WATANA PROJECT - SUMMARY COST ESTIMATE

	$000
Land Acquisition	$ 35,000
Reservoir Cleaning	15,000
Main Dam	1,199,824
Diversion & Cofferdams	101,967
Penstocks	13,614
Power Intakes	57,154
Powerhouse and Associated Items	179,539
Service Spillway	195,440
Tailrace	12,198
Saddle Dam	45,538
Switchyard	7,018
Miscellaneous Structures & Equipment	8,000
Access Road/Airstrip	97,700
Support and Camp	306,000
SUBTOTAL	$2,273,992
Contingency	$ 454,798
Engineering Owner Costs Administration	341,099
TOTAL	$3,069,889

TABLE 2.2 DEVIL CANYON PROJECT - SUMMARY COST ESTIMATE

	$000
Land Acquisition	$ 21,000
Reservoir Cleaning	10,000
Main Dam	458,178
Diversion & Cofferdams	30,299
Penstocks	11,939
Power Intakes	28,386
Powerhouse and Associated Items	153,911
Secondary Powerhouse	30,000
Service Spillway	81,810
Emergency Spillway	33,455
Tailrace	51,053
Saddle Dam	15,976
Switchyard	6,718
Miscellaneous Structures & Equipment	9,000
Access Roads/Rail Spur	27,000
Support and Camp	156,500
SUBTOTAL	$1,125,225
Contingency	$ 225,045
Engineering, Owner Costs Administration	168,784
TOTAL	$1,519,054

3 - WATANA/DEVIL CANYON PROJECT COST ESTIMATES

As noted in Section 2, an extremely conservative approach was taken in determining "upper limit" costs. In effect, an estimate was developed for the "worst" case based upon presently available data. It is expected that as additional data becomes available and site and structure arrangements are optimized under the various Task 6 Subtasks the project costs will be reduced from the upper limit estimates.

In line with this methodology, conservative assumptions have been made for each site in regard to the following aspects:

a) site conditions,

b) project design assumptions,

c) project layouts and support facilities, and

d) unit and lump sum costs.

These are discussed in the following paragraphs.

3.1 - Watana Project

Plate 1 shows the project general arrangement and profiles upon which this cost estimate has been based. The basis of this estimate is as follows:

a) Site Conditions

In view of the level of established data regarding the geology of the site, assumptions have been made as to the condition and depth of bedrock. In line with information derived from boreholes and seismic lines, upwards of 20 feet of overburden on the embankments and 70 feet of alluvium in the riverbed have been conservatively estimated. The rock has been assumed to be highly weathered to a depth of 20 feet but at greater depths to be capable of supporting underground excavations for the powerhouse and water passages with the provision of heavy support systems. The project has been kept downstream of the severe shear zone, the "Fins," at the expense of including the less severe shear zone, the "Fingerbuster". The existence of a relict-channel on the right bank upstream of the dam, with the possibility of its overlying pervious materials, has also been recognized. Finally, it has been assumed that the alluvial material within the riverbed will be unsuitable for supporting any portion of the main dam and, its complete excavation will be required.

b) Project Design Assumptions

The main dam is intended to withstand dynamic loading based on the maximum credible earthquake, currently estimated as giving a peak ground acceleration of 0.5g. The cofferdams are constructed outside the main dam to eliminate any uncertainty in the foundation materials and the main dam slopes are flattened to approximate those of the Oroville dam which has been checked to

withstand severe ground acceleration.

The construction diversion is designed to pass the routed 1:50 year flood. The double stilling basin spillway is designed to pass the probable maximum flood in order to avoid surcharge of the stilling basins beyond their design discharge which could wash out the structures.

c) Project Layout and Support Facilities

The large rock-fill dam is located on the same alignment as proposed by the Corps of Engineers. A crest width of 80 feet has been adopted, and upstream and downstream slopes of the rock shell are 1:2.75 and 1:2 respectively. The area under the dam has been shown to be completely excavated to sound bedrock, with the area under the impervious core being extended a further 20 feet into the sound rock. The rockfill shell of the dam consists of 50 percent blasted rock and 50 percent gravel from the upstream riverbed and is placed and compacted in two foot layers. An extensive network of galleries and shafts for grouting and drainage has been included. Rockfill cofferdams are placed outside the main dam, founded on the alluvium, with cutoff trenches to bedrock. Allowances have been made for the location of a saddle dam in a low area beyond the right abutment. Curtain grouting and a cutoff trench have also been provided for on the right bank in the area of the buried channel.

Twin concrete lined diversion tunnels, which are designed to pass the 50-year flood during construction, extend well downstream of the main dam on the right bank. A low level inlet for emergency releases is located above the diversion tunnel downstream of the location of the final concrete plug. The single spillway, which is designed to pass the PMF, is located on the right bank and consists of the control structure, a concrete lined chute, and intermediate and terminal stilling basins. The chute crosses the area of the "Fingerbuster", and provision has been made for excavating poor quality material in the shear zone area and replacing it with dental concrete. Heavy rock bolting and rock anchors have been assumed to be required along the complete length of the spillway.

The power facilities are located on the left bank. The deep intake structure serves four lined tunnel penstocks which lead to an underground four-unit 800MW powerhouse. Twin concrete lined tailrace tunnels lead from the powerhouse and cross the "Fingerbuster," where additional support has been provided.

Access to the site is via a road from the Denali Highway to the northeast and by a road from the Anchorage-Fairbanks Highway to the west. An airstrip is also provided for at the site, together with a 50-unit permanent operation community.

d) Costs

Unit costs have been developed for the major items based on a simplified contractor's type estimate. Labor rates in Alaska have been determined from publications and other projects, and a tentative construction plant has been determined. Construction access roads have been considered together with haul distances for dam fill. For the purposes of the upper limit estimate

it has been assumed that all excavated rock will be wasted and, therefore, all necessary fill required will have to be excavated. Electrical and mechanical equipment costs have been estimated from costs for equipment and its installation on similar projects.

Table 3.1 is an itemized list of the upper list cost developed under this section. It shows a total capital cost of $3,069,889,000 which includes a 20 percent contingency and a 12.5 percent factor for engineering, construction management, and owner's cost.

The estimate is based upon a ten-year construction schedule from the time of first road access to the site.

It is estimated that staging the installation of the generator units adds about $30 million to the total capital costs as follows:

400MW with initial construction	$2,940 million
400MW approximately 3 years later	160
800MW total	$3,100 million

3.2 - Devil Canyon Project

Plates 2 and 3 show the project general arrangement and profiles on which this cost estimate has been based. The basis of the estimate is as follows:

a) Site Conditions

Overburden on the right bank has generally been accepted as 20 feet deep. On the left bank overburden has been assumed as up to 70 feet in depth, and approximately 35 feet of alluvium has been assumed in the riverbed. The rock is intensely weathered to a depth of 20 feet, but is presumed to be able to support underground structures at depth with heavy support.

b) Project Design Assumptions

The main dam is assumed to be capable of supporting dynamic loading based upon a maximum credible earthquake giving a peak seismic ground acceleration of 0.5g. The diversion scheme is designed to pass the routed 1:50 year flood during construction. The right bank and central orifice spillways are designed to pass the design flood corresponding to the routed 1:10,000 year flood with additional flows corresponding to the probable maximum flood discharged through a fuse plug on the left bank.

c) Project Layout and Support Facilities

The concrete thin arch dam is located within the upper and narrowest portion of Devil Canyon. The height of the dam is 650 feet above a 50' thick concrete plug. The developed crest length is 1,230 feet, and the base width at the crown is 90 feet. The dam rests on a concrete plug at the center of the valley and terminates in concrete thrust blocks high in the abutments. All foundations beneath the plug, dam and thrust blocks are excavated deep into sound bedrock and form a smooth profile. Shafts and galleries for grouting and drainage have been provided beneath the dam. A rockfill saddle dam with

impervious fill core ties into the left bank thrust block, and a slurry trench cutoff trench is provided to bedrock.

Twin concrete lined diversion tunnels are located within the rock of the left abutment, and upstream and downstream rockfill cofferdams are provided with slurry trench cutoffs to bedrock.

The main service spillway is located on the right bank and consists of a control structure, concrete lined chute, and a stilling basin located at river level. Heavy rock bolting and rock anchors have been provided along the length of the spillway. Complementing the main spillway are four submerged orifice auxiliary spillways within the upper section of the dam. These discharge into a downstream concrete lined plunge pool. On the left bank a fuse plug is located within a discharge channel excavated in the rock and will pass high flows in excess of the design flood.

The power facilities are located on the right bank and are similar in concept to Watana except that the powerhouse houses four-150MW units and the transformer gallery is on the upstream side of the powerhouse. The single tailrace tunnel extends 1-1/2 miles downstream to Portage Creek in order to take advantage of the fall in the level of the river over the length of Devil Canyon. A secondary power plant (50MW) is included to take advantage of the required flow in the river section between the dam site and the tailrace outlet near Portage Creek.

Access to the site is via a road connecting with the Gold Creek-Watana Highway proposed under the Watana scheme. In addition, a rail spur is provided from the existing rail line at Gold Creek to the Devil Canyon site.

d) Costs

Unit costs have been developed for major items in the same manner as for Watana. Aggregates for the dam concrete have been considered to come from the upstream Cheechako terraces. Table 3.2 shows a total capital cost of $1,519,054,000. The estimate is based upon a seven-year construction schedule from the time of first road access to the site.

Table 3.1. UPPER LIMIT COST ESTIMATE, MAY 1981
WATANA ROCKFILL DAM (Crest El. 2225)

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	$000 TOTAL	$000 ITEM TOTAL	$000 FINAL TOTAL
LAND	Land Acquisition		LS	35,000,000	35,000	35,000	
RESERVOIR	Reservoir Clearing		LS	15,000,000	15,000	15,000	
MAIN DAM	Excavate Rock	5,263,000	cy	20	105,260		
	Excavate Overburden	8,121,000	cy	8	64,968		
	Excavate Grout Gallery - Horizontal	12,000	cy	85	1,020		
	Excavate Grout Gallery - Vertical	2,200	cy	100	220		
	Surface Preparation	680,500	sy	15	10,207		
	Rockfill/Gravelfill	57,448,000	cy	13.50	775,548		
	Coarse Filter	1,214,000	cy	14	16,996		
	Fine Filter	5,530,000	cy	8	44,240		
	Semi-Pervious Core	3,363,000	cy	7	23,541		
	Impervious Core	8,961,000	cy	9	80,649		
	Concrete Grout Gallery - Horizontal	15,340	cy	240	3,681		
	Concrete Grout Gallery - Vertical	265	cy	450	119		
	Consolidation Grouting	474,000	LF	60	28,440		
	Grouting from Surface	93,000	LF	50	4,650		
	Grouting from Adits	176,000	LF	60	10,560		
	Relief Drains		LS	3,000,000	3,000		
	Rockbolts Grout Gallery	200	ton	2,500	500		
	Support Steel-Grout Gallery	350	ton	3,500	1,225		
	Low Level Release		LS	25,000,000	25,000	1,199,824	
DIVERSION/ COFFERDAMS	Excavate Rock Portal	278,000	cy	14	3,892		
	Excavate Overburden Portal	92,000	cy	5	460		
	Excavate Tunnels	556,000	cy	45	25,020		
	Concrete Liner	100,000	cy	240	24,000		
	Concrete Portals	4,000	cy	250	1,000		
	Concrete Plugs	20,000	cy	480	9,600		
	Upstream Cofferdam	3,140,000	cy	4	12,560		
	Downstream Cofferdam	125,000	cy	7	875		
	Dewatering		LS	3,500,000	3,500		
	Cutoff		LS	6,500,000	6,500		
	Reinforcing Steel Portal	80	ton	2,000	160		
	Rockbolts Tunnels	1,550	ton	2,500	3,875		
	Rockbolts Portals	60	ton	2,500	150		
	Support Steel	2,050	ton	3,500	7,175		
	Gates, Etc.		LS	3,200,000	3,200	101,967	

Table 3.1 (Continued)

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	$000 TOTAL	$000 ITEM TOTAL	$000 FINAL TOTAL
PENSTOCKS	Excavate Tunnel	58,850	cy	50	2,942		
	Concrete Line	19,500	cy	360	7,020		
	Rockbolts	525	ton	2,500	1,312		
	Steel Line	520	ton	4,500	2,340		
						13,614	
POWER INTAKES	Excavate Rock	737,000	cy	12	8,844		
	Excavate Overburden	300,000	cy	6	1,800		
	Concrete Base Slab	23,000	cy	180	4,140		
	Concrete Structures	74,000	cy	285	21,090		
	Reinforcing Steel	4,365	ton	2,000	8,730		
	Rockbolts	180	ton	2,500	450		
	Gates, Etc.		LS	12,100,000	12,100		
						57,154	
POWERHOUSE AND ASSOCIATED ITEMS	Excavate Powerhouse Vault	201,000	cy	40	8,040		
	Excavate Draft Tube	20,000	cy	45	900		
	Excavate Surge Chamber	102,000	cy	40	4,080		
	Excavate Transformer Gallery	38,000	cy	45	1,710		
	Excavate Rock Tunnel Portal	3,700	cy	14	52		
	Excavate Overburden Tunnel Portal	11,000	cy	5	55		
	Excavate Access Shaft	10,900	cy	65	709		
	Excavate Cable & Transformer Shafts	14,400	cy	65	936		
	Excavate Access Tunnel	119,400	cy	40	4,776		
	Concrete Substructure Powerhouse	41,200	cy	300	12,360		
	Concrete Superstructure Powerhouse	20,600	cy	360	7,416		
	Concrete Draft Tube	12,400	cy	500	6,200		
	Concrete Surge Chamber	30,500	cy	340	10,370		
	Concrete Transformer Gallery	10,100	cy	300	3,030		
	Concrete Transformer Shaft	4,000	cy	450	1,800		
	Concrete Line Access Shaft	850	cy	450	383		
	Concrete Line Cable Shaft	1,860	cy	450	837		
	Concrete Line Access Tunnel	9,000	cy	240	2,160		
	Concrete Access Tunnel Portal	1,000	cy	300	300		
	Support Steel Access Tunnel	480	ton	3,500	1,680		
	Rockbolts Powerhouse/Draft Tube	305	ton	2,500	762		
	Rockbolts Access Shaft	95	ton	2,50[illegible]	238		
	Rockbolts Cable Shaft	50	ton	2,500	125		
	Rockbolts Access Tunnel	330	ton	2,500	825		
	Rockbolts Access Tunnel Portal	5	ton	2,500	13		
	Reinforcing Steel Powerhouse	3,640	ton	2,000	7,280		
	Reinforcing Steel Transformer Gallery	610	ton	2,000	1,220		
	Reinforcing Steel Surge Chamber	1,830	ton	2,000	3,660		
	Reinforcing Steel Draft Tube	746	ton	2,000	1,492		
	Turbines and Valves		LS	26,950,000	26,950		
	Cranes		LS	2,600,000	2,600		
	Generators		LS	31,000,000	31,000		
	Mechanical/Electrical Equipment		LS	18,500,000	18,500		
	Auxiliary Mechanical/Electrical Equipment		LS	12,000,000	12,000		
	Draft Tube Gates		LS	580,000	580		
	Architectural Powerhouse		LS	1,500,000	1,500		
	Auxiliary Generators		LS	3,000,000	3,000		
						179,5[illegible]	

Table 3.1 (Continued)

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	$000 TOTAL	$000 ITEM TOTAL	$000 FINAL TOTAL
SERVICE SPILLWAY	Excavate Rock	3,222,000	cy	16	51,552		
	Excavate Overburden	1,037,000	cy	6	6,222		
	Concrete Sloping Slab	46,300	cy	180	8,334		
	Concrete Rollways/Weirs	206,000	cy	200	41,200		
	Concrete Keys	74,000	cy	260	19,240		
	Concrete Walls	70,000	cy	245	17,150		
	Concrete Piers	14,000	cy	280	3,920		
	Concrete Bridge Deck	925	cy	500	462		
	Reinforcing Steel	10,900	ton	2,000	21,800		
	Rockbolts	1,120	ton	2,500	2,800		
	Gates, Etc.		LS	7,260,000	7,260		
	Dental Concrete		LS	4,500,000	4,500		
	Grouting		LS	2,000,000	2,000		
	Winterization		LS	9,000,000	9,000		
						195,440	
TAILRACE	Excavate Rock Outlet	37,000	cy	14	518		
	Excavate Overburden Outlet	46,000	cy	5	230		
	Excavate Tunnels	89,000	cy	45	4,005		
	Concrete Base Slab Outlet	2,200	cy	220	484		
	Concrete Walls Outlet	700	cy	300	210		
	Concrete Line Tunnels	13,600	cy	260	3,536		
	Reinforcing Steel	100	ton	2,000	200		
	Rockbolts	450	ton	2,500	1,125		
	Support Steel	540	ton	3,500	1,890		
						12,198	
SADDLE DAM	Surface Preparation	16,600	sy	10	166		
	Rockfill	120,000	cy	12	1,440		
	Filters	18,000	cy	15	270		
	Impervious Material	81,000	cy	10	810		
	Excavate Overburden	140,000	cy	6	840		
	Slurry Trench	77,800	sy	540	42,012		
						45,538	
SWITCHYARD	Excavate Switchyard Overburden	146,000	cy	4	584		
	Fill	146,000	cy	4	584		
	Surface Preparation	35,000	sy	10	350		
	Electrical		LS	4,000,000	4,000		
	Civil Works		LS	1,500,000	1,500		
						7,018	

Table 3.1 (Continued)

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	$000 TOTAL	$000 ITEM TOTAL	$000 FINAL TOTAL
MISCELLANEOUS STRUCTURES & EQUIPMENT	Recreation Facilities		LS	1,000,000	1,000		
	Buildings and Grounds		LS	4,000,000	4,000		
	Permanent Operating Equipment		LS	3,000,000	3,000		
						8,000	
ACCESS ROAD/ AIR STRIP	Permanent Access Road	114	miles	600,000	68,400		
	Permanent Bridges		LS	20,000,000	20,000		
	Construction Access Site	15	miles	220,000	3,300		
	Airstrip		LS	6,000,000	6,000		
						97,700	
SUBTOTAL							1,967,992
SUPPORT AND CAMP	Construction Power		LS	53,000,000	53,000		
	Trailer Camp	50	units	70,000	3,500		
	Permanent Housing	50	units	150,000	7,500		
	Clinic/School	1	units	1,000,000	1,000		
	Camp Cost	3,300	units	20,000	66,000		
	Catering/Support	5.0	million mandays	35	175,000		
						306,000	
SUBTOTAL							2,273,992
20% CONTINGENCY							454,798
12.5% ENGINEERING, OWNER COSTS, ADMINISTRATION							341,099
TOTAL PROJECT COST							3,069,889

Table 3.2 - UPPER LIMIT COST ESTIMATE, MAY 1981
DEVIL CANYON THIN ARCH (Crestr El. 1460)

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	$000 TOTAL	$000 ITEM TOTAL	$000 FINAL TOTAL
LAND	Land Acquisition		LS	21,000,000	21,000		
						21,000	
RESERVOIR	Reservoir Clearing		LS	10,000,000	10,000		
						10,000	
MAIN DAM	Excavate Rock Dam & Thrust Blocks	271,000	cy	20	5,420		
	Excavate Overburden Dam & Thrust Block	281,000	cy	10	2,810		
	Excavate Rock - Plunge Pool	80,000	cy	24	1,920		
	Excavate Overburden - Plunge Pool	122,000	cy	6	732		
	Excavate Grout Gallery- Horizontal	8,400	cy	85	714		
	Excavate Grout Gallery - Vertical	1,500	cy	100	150		
	Surface Preparation	19,000	sy	15	285		
	Concrete Arch Plug	39,200	cy	200	7,840		
	Concrete Dam	1,409,400	cy	200	281,880		
	Concrete Thrust Blocks	115,000	cy	200	23,000		
	Concrete Grout Gallery - Horizontal	10,740	cy	240	2,577		
	Concrete Grout Gallery - Vertical	200	cy	450	90		
	Reinforcing Steel	5,320	ton	2,000	10,640		
	Reinforcing Steel Plug	330	ton	2,000	660		
	Consolidation Grouting	650,000	LF	60	39,000		
	Grouting from Surface	150,000	LF	50	7,500		
	Grouting from Adits	270,000	LF	60	16,200		
	Relief Drains		LS	4,000,000	4,000		
	Rockbolts Grout Gallery	140	ton	2,500	350		
	Support Steel Grout Gallery	500	ton	3,500	1,750		
	Concrete Lining - Plunge Pool	57,000	cy	180	10,260		
	Reregulation Capability		LS	20,000,000	20,000		
	Low Level Release		LS	10,000,000	10,000		
	Winterization		LS	10,400,000	10,400		
						458,178	
DIVERSION & COFFERDAMS	Excavate Rock Portal	280,000	cy	14	3,920		
	Excavate Overburden Portal	92,000	cy	5	460		
	Excavate Tunnels	106,000	cy	45	4,770		
	Concrete Liner	19,600	cy	240	4,704		
	Concrete Portals	4,000	cy	250	1,000		
	Concrete Plugs	10,854	cy	480	5,209		
	Cofferdams	92,000	cy	7	644		
	Dewatering		LS	3,500,000	3,500		
	Reinforcing Steel Portal	40	ton	2,000	80		
	Rockbolts Tunnels	365	ton	2,500	912		
	Rockbolts Portals	60	ton	2,500	150		
	Support Steel	500	ton	3,500	1,750		
	Gates, Etc.		LS	3,200,000	3,200		
						30,299	

Table 3.2 (Continued)

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	$000 TOTAL	$000 ITEM TOTAL	$000 FINAL TOTAL
PENSTOCKS	Excavate Tunnels	44,000	cy	50	2,200		
	Concrete Line	14,600	cy	360	5,256		
	Rockbolts	425	ton	2,500	1,063		
	Steel Line	760	ton	4,500	3,420		
						11,939	
POWER INTAKES	Excavate Rock	388,000	cy	12	4,656		
	Excavate Overburden	104,000	cy	6	624		
	Concrete Base Slab	3,100	cy	180	558		
	Concrete Structures	27,000	cy	285	7,695		
	Reinforcing Steel	1,220	ton	2,000	2,440		
	Rockbolts	125	ton	2,500	313		
	Gates, Etc.		LS	12,100,000	12,100		
						28,386	
POWERHOUSE ASSOCIATED ITEMS	Excavate Powerhouse Vault	201,000	cy	40	8,040		
	Excavate Draft Tube	21,000	cy	45	945		
	Excavate Transformer Gallery	38,000	cy	45	1,710		
	Excavate Rock Tunnel Portal	7,000	cy	14	98		
	Excavate Overburden Tunnel Portal	22,000	cy	5	110		
	Excavate Access Shaft	7,300	cy	65	474		
	Excavate Cable & Transformer Shafts	6,100	cy	65	397		
	Excavate Access Tunnel	20,000	cy	40	800		
	Concrete Substructure Powerhouse	41,000	cy	300	12,300		
	Concrete Superstructure Powerhouse	21,000	cy	360	7,560		
	Concrete Draft Tube	12,400	cy	285	3,534		
	Concrete Transformer Gallery	10,000	cy	300	3,000		
	Concrete Line Access Shaft	600	cy	450	270		
	Concrete Line Cable Shaft	800	cy	450	360		
	Concrete Line Access Tunnel	3,700	cy	240	888		
	Concrete Access Tunnel Portal	2,000	cy	300	600		
	Concrete Transformer Shaft	4,000	cy	450	1,800		
	Support Steel Access Tunnel	400	ton	3,500	1,400		
	Rockbolts Powerhouse/Draft Tube	275	ton	2,500	687		
	Rockbolts Access Shaft	65	ton	2,500	163		
	Rockbolts Cable Shaft	20	ton	2,500	50		
	Rockbolts Access Tunnel	130	ton	2,500	325		
	Rockbolts Access Tunnel Portal	8	ton	2,500	20		
	Reinforcing Steel Powerhouse	3,660	ton	2,000	7,320		
	Reinforcing Steel Transformer Gallery	600	ton	2,000	1,200		
	Reinforcing Steel Draft Tube	740	ton	2,000	1,480		
	Turbines and Valves		LS	26,950,000	26,950		
	Cranes		LS	2,600,000	2,600		
	Generators		LS	31,000,000	31,000		
	Mechanical/Electrical Equipment		LS	20,780,000	20,780		
	Auxiliary Mechanical/Electrical Equipment		LS	12,000,000	12,000		
	Draft Tube Gates		LS	550,000	550		
	Architectural Powerhouse		LS	1,500,000	1,500		
	Auxiliary Generators		LS	3,000,000	3,000		
						153,911	

Table 3.2 (Continued)

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	$000 TOTAL	$000 ITEM TOTAL	$000 FINAL TOTAL
SECONDARY POWERHOUSE	Secondary Powerhouse		LS	30,000,000	30,000	30,000	
SERVICE SPILLWAY	Excavate Rock	599,000	cy	16	9,584		
	Excavate Overburden	427,250	cy	8	3,418		
	Concrete Sloping Slab	26,550	cy	180	4,779		
	Concrete Rollway/Weirs	12,350	cy	200	2,470		
	Concrete Flip Bucket	10,530	cy	200	2,106		
	Concrete Walls	16,750	cy	245	4,103		
	Concrete Piers	4,250	cy	280	1,190		
	Concrete Bridge Deck	700	cy	500	350		
	Reinforcing Steel	5,600	ton	2,000	11,200		
	Rockbolts	360	ton	2,500	900		
	Gates, Etc.		LS	7,260,000	7,260		
	Stilling Basin		LS	30,000,000	30,000		
	Dental Concrete		LS	1,900,000	1,900		
	Grouting		LS	950,000	950		
	Winterization		LS	1,600,000	1,600	81,810	
EMERGENCY SPILLWAY	Excavate Rock	1,610,000	cy	16	25,760		
	Excavate Overburden	610,000	cy	8	4,880		
	Rock Fill Plug	20,000	cy	8	160		
	Filters - Plug	3,000	cy	15	45		
	Impervious Material Plug	11,000	cy	10	110		
	Channel Line		LS	2,500,000	2,500	33,455	
TAILRACE	Excavate Rock Outlet	37,000	cy	14	518		
	Excavate Overburden Outlet	46,000	cy	5	230		
	Excavate Tunnels	475,000	cy	45	21,375		
	Dredge Downstream	100,000	cy	6	600		
	Concrete Base Slab Outlet	2,000	cy	220	440		
	Concrete Walls Outlet	700	cy	300	210		
	Concrete Line Tunnels	59,000	cy	260	15,340		
	Reinforcing Steel	170	ton	2,000	340		
	Rockbolts	1,650	ton	2,525	4,125		
	Support Steel	2,250	ton	3,500	7,875	51,053	

Table 3.2 (Continued)

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	$000 TOTAL	$000 ITEM TOTAL	$000 FINAL TOTAL
SADDLE DAM	Surface Preparation	50,000	sy	10	500		
	Excavate Overburden	170,000	cy	6	1,020		
	Rockfill	561,000	cy	12	6,732		
	Filters	81,000	cy	15	1,215		
	Impervious	294,000	cy	10	2,940		
	Slurry Trench	6,100	sy	585	3,569		
						15,976	
SWITCHYARD	Excavate Overburden	146,000	cy	4	584		
	Fill	146,000	cy	4	584		
	Surface Preparation	35,000	sy	10	350		
	Electrical Equipment		LS	3,700,000	3,700		
	Civil Works		LS	1,500,000	1,500		
						6,718	
MISCELLANEOUS STRUCTURES & EQUIPMENT	Recreation Facilities		LS	3,000,000	3,000		
	Buildings and Grounds		LS	4,000,000	4,000		
	Permanent Operating Equipment		LS	2,000,000	2,000		
						9,000	
ACCESS ROADS/ RAIL SPUR	Permanent Bridges	2	each	2,500,000	5,000		
	Permanent Roads	15	miles	600,000	9,000		
	Construction Access Roads	10	miles	300,000	3,000		
	Rail Spur		LS	10,000,000	10,000		
						27,000	
SUBTOTAL							968,725
SUPPORT & CAMP	Construction Power		LS	30,000,000	30,000		
	Camp Cost	2,300	units	20,000	46,000		
	Catering/Support	2.3	million mandays	35	80,500		
						156,500	
SUBTOTAL							1,125,225
20% CONTINGENCY							225,045
12.5% ENGINEERING, OWNER COSTS, ADMINISTRATION							168,784
TOTAL							1,519,054

4 - TRANSMISSION LINE COST ESTIMATES

4.1 - Description of System

In line with the development of an upper limit capital cost estimate, the transmission line system was developed and costed as a separate item.

Characteristics of the system are outlined as follows:

Figure 4.1 illustrates the 345 kV transmission system with Watana and Devil Canyon developments and Beluga thermal plant delivering power to Anchorage and Fairbanks.

For purposes of this estimate it has been assumed that the electrical power from Watana and Devil Canyon is transmitted via three 345 kV lines to a switching station at Gold Creek. Two lines continue in each of the north and south directions, with the ultimate load centers at Fairbanks and Anchorage, respectively. The Fairbanks' termination shows a transformer substation stepping down the voltage to 138 kV for subtransmission to the utilities.

The two lines to Anchorage from Gold Creek have been sectionalized at Willow. This will improve the contingency performance of the system and facilitate the supply of a future load. Series compensation has been shown for the two line sections to Anchorage, which will allow the line to handle heavier loading at 345 kV. The station at Willow will allow subtransmission at 138 kV.

Two termination points have been shown at Anchorage and designated as Anchorage I and II. The two substations have been arbitrarily shown as located 15 miles apart. The switching stations are interconnected by a 345 kV line. The electrical power is stepped down at each substation to 138 kV for distribution to the utilities.

The Beluga thermal station is connected to Anchorage II bus via two 345 kV lines. The connection at Anchorage II allows the Beluga power to be easily absorbed into the system.

Table 4.1 indicates the lengths of the various transmission lines necessary for the Susitna Basin option.

4.2 - Cost Estimate Summary

The line cost estimates of $522,200,000, as shown in Table 4.2, were developed with reference to R.W. Retherford Associates' experience in Alaska. The line costs are based on a X-type tower. The cost figures developed are consistent with the Commonwealth Associates' January 1981 estimate for line costs. Table 4.2 indicates a total transmission line cost of about 525 million dollars.

TABLE 4.1. TRANSMISSION LINE DISTANCES

SUSITNA BASIN DEVELOPMENT OPTION	Miles
- Watana to Devil Canyon	27
- Devil Canyon to Gold Greek	13
- Gold Creek to Fairbanks	176
- Gold Creek to Willow	77
- Willow to Anchorage	65
- Beluga to Anchorage	50
- Anchorage I to Anchorage II	15
THERMAL PLANT OPTION	
- Beluga to Anchorage II	50
- Anchorage II to Anchorage I	15
- Anchorage II to Willow	65
- Willow to Fairbanks	253

TABLE 4.2: TRANSMISSION LINE COST ESTIMATES

SUSITNA HYDROELECTRIC TRANSMISSION COSTS (1981 $'s)

		Millions	Total Millions
(i)	**Watana (1993)**		
	Lines	$181.0	
	Substations and Series Compensation	82.8	
	Var Generation	24.3	
		288.1	
	Contingency	57.6	
	Engineering etc. (12.5% - Engineering 5%, cost 2.5%)	43.2	
	Land Acquisition	32.9	
	TOTAL	$421.8	$421.8
(ii)	**Devil Canyon (2000)**		
	Lines	$ 3.7	
	Substations and Series Compensation	25.1	
	Var Generation	5.9	
		34.7	
	Contingency 20%	7.0	
	Engineering etc., - 12.5%	5.2	
	Land Acquisition	--	
	TOTAL	$ 46.9	$ 46.9
	Susitna Transmission		$468.7
(iii)	**Beluga Coal (2008)**		
	Lines	$ 21.1	
	Substations and Series Compensation	13.9	
	Var Generation	1.8	
		36.8	
	Contingency 20%	7.4	
	Engineering etc. - 12.5%	5.5	
	Land Acquisition	3.8	
	TOTAL	$ 53.5	$ 53.5
	Total Susitna and Beluga		$522.2

NOTES:

1) Costs do not include switchyards at generating plants or dispatch center.
2) Engineering and other fees equal 12.5% of total line, substation, series compensation, var generation and contingency costs.

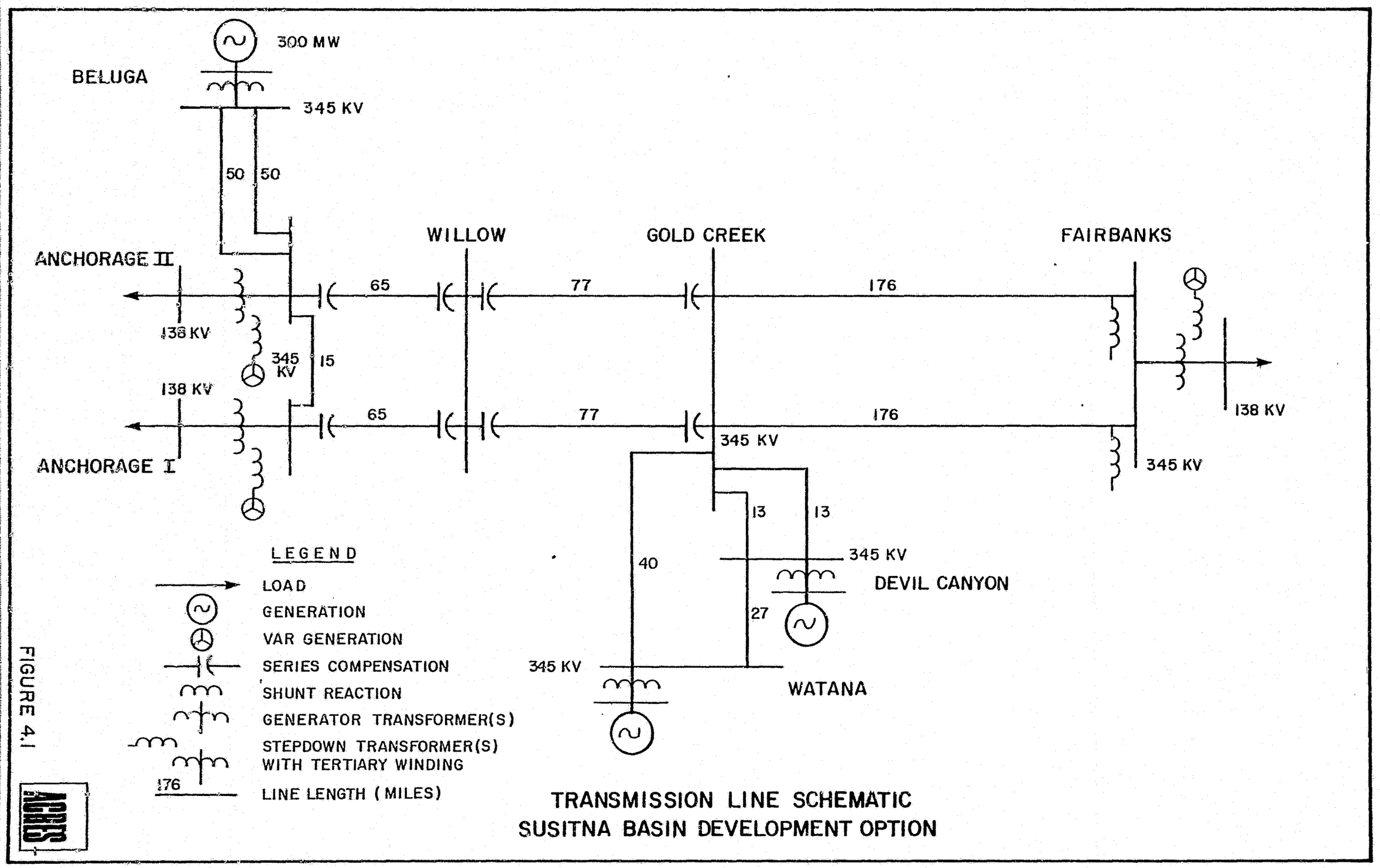


FIGURE 4.1

ACRES

TRANSMISSION LINE SCHEMATIC
SUSITNA BASIN DEVELOPMENT OPTION

5 - CONCLUSIONS

A total cost of $5.11 billion dollars was developed as a reasonable upper limit capital cost estimate for the development of the Susitna Basin with major dams at Watana and Devil Canyon. This cost is based upon information made available and for layouts as developed up to March 1981. It is expected that sufficient allowance has been made in dam volume quantities to permit optimization of the dam heights around the crest elevations as shown on the layouts. Further refinement of the project estimate will be carried out under Task 9 studies as the project design develops under Task 6.

APPENDIX A

APPENDIX A

TABLE 1

SPECIFIC ASSUMPTIONS
UPPER LIMIT CAPITAL COST ESTIMATE
WATANA ROCKFILL DAM

Land Acquisition - taken as lump sum at $35,000,000; COE (1979) estimated 100,000 acres at $20,000,000.

Reservoir Clearing - taken as lump sum at $15,000,000; COE (1979) estimated 5,100 acres at $4,300,000.

Main Dam --

- Dam volume based upon slopes of 1:2.75 (upstream) and 1:2 (downstream).
- Shell assumed to be 50 percent quarried rock at $15/cy; 50 percent river gravel at $12/cy; average price $13.50/cy.
- Quarrying of rock estimated at $7/cy and hauling and placement at $8/cy; 60,000 cy/day production assumed based upon two, 10-hour shifts per day; two to three foot lifts assumed; haul distance averaged at about four miles.
- Filters and cores estimated by similar procedure.
- Grouting assumed to be through series of vertical and horizontal tunnels on either side. Grout curtain extended to 70 percent head with maximum depth of 300 feet. Horizontal galleries 6 feet by 10 feet, horseshoe shape with concrete invert and shotcrete lining with additional steel support of 6 feet on center ribs for 25 percent of tunnel length; rock bolts included for 25 percent of tunnel length; vertical shafts 6 feet in diameter with one-half foot concrete and 25 percent rock bolting.
- Low level release lump sum item (includes intake, gates, and tunnel into lower end of diversion tunnels).

Diversion/Cofferdams --

- Two diversion tunnels, total length 13,000 feet, 35 foot inside diameter; fully lined with concrete one and one-half feet thick, steel support included for approximately 25 percent of length; rock bolts included for 25 percent of length.
- Gates' lump sum estimated.
- Cofferdams estimated with 2:1 slopes - upstream dam taken as 250 feet high (crest elevation 1,650) and downstream as 50 feet high (crest elevation 1,450).
- Dewatering for entire duration of job lump sum estimated.
- Diversion tunnel plugs included to plug after use (upstream of any drawdown tunnel).
- Cutoff trench assumed to be installed during installation of cofferdam from banks of river.

TABLE 1 (Cont'd)

Penstocks --

- Four penstocks for total length of 4,180 feet with 18 foot inside diameter included; full liner of two feet thick concrete assumed with fifty percent rock bolting; steel liners of three-fourths inch thickness and 150 feet in length included at powerhouse.

Power Intakes --

- Twenty-five foot overburden excavation assumed.
- Reinforcing steel assumed at 90 lb/cy throughout structure.
- Rockbolting assumed throughout area.

Powerhouse & Associated Items --

Vault & Associated Structures

- Excavation and concrete quantities based upon standard underground powerhouse.
- Reinforcing steel based upon 90 lb/cy for secondary; 120 lb/cy for primary and structural concrete.
- Rockbolting based upon standard powerhouse arrangement - generally 5 feet by 5 feet pattern on all vertical surfaces and ceilings except only 10 percent of powerhouse walls.

Mechanical & Electrical Equipment

- Total estimate based upon standard underground powerhouse arrangement and with reference to switchyard location.

Access Tunnels & Shafts

- Vertical shafts 50 percent rock bolted.
- Horizontal shafts and tunnels 25 percent rock bolted and 25 percent steel supported.
- Cable shafts 15 feet in diameter; 550 LF total length, one-half foot thick concrete liner.
- Access shafts 25 feet in diameter, 600 LF total length, one-half foot thick concrete liner.
- Access tunnel assumed 32 feet wide by 22.5 feet high, horseshoe shape, 25 percent rockbolted; 25 percent steel support; one foot thick liner for 50 percent tunnel length.

Service Spillway --

- Twenty-five foot overburden assumed, remainder of excavation in rock.
- Concrete reinforcing: 40 lb/cy rollways, weirs, walls; 80 lb/cy all other concrete.
- Lump sum items for gates; dental concrete; grouting; winterization.
- Rockbolts, 10 feet by 10 feet pattern walls and slab.
- Assumes concrete work can continue through winter with proper winterization.

TABLE 1 (Cont'd)

Tailrace --

- Fully lined with one foot thick concrete.
- 4,900 LF total length.
- Twenty-three foot inside diameter.
- Twenty-five percent length supported by rockbolts; 25 percent length supported by steel.
- Outlet portal tied to walls with rockbolts.
- Rock and overburden quantities at portal are minimal.

Saddle Dam --

- Small saddle dam required near relicit channel to contain reservoir.
- Approximately one and one-half mile long by 100 feet deep bentonite slurry trench included as cutoff to relicit channel (with associated curtain).

Switchyard --

- Yard assumed to be directly above powerhouse location.
- Overburden excavation sufficient to level area.
- No rock excavation.
- Electrical and civil work items taken as lump sum items.

Miscellaneous Structures & Equipment --

- Items taken as lump sums.

Access Roads/Airstrip --

- Access road from Denali Highway and also from Park Highway assumed.
- Two large permanent bridges also assumed; smaller bridges incorporated in per mile roadway cost.
- Airstrip of sufficient size to handle Hercules C-130 assumed; minimum navigation and control equipment required; runway of 6,300 feet by 150 feet assumed, with associated loading pad/parking area.

Support & Camp --

- Construction power based upon size of project.
- Fifty temporary higher quality housing units (trailers) assumed for senior staff.
- Fifty single family homes and clinic/school assumed for senior staff and for permanent operations.
- Single status camp for 3,300 workers assumed.
- Five million mandays required for construction; based upon assumed schedule and associated labor requirements for each structure; 10 percent service personnel and 15 percent turnover, visitors and staff included in anticipated construction work force.

APPENDIX A

TABLE 2

SPECIFIC ASSUMPTIONS
UPPER LIMIT CAPITAL COST ESTIMATE
DEVIL CANYON THIN ARCH DAM

Land Acquisition - taken as lump sum at $21,000,000; COE (1979) estimated 14,000,000 acres for this item.

Reservoir Clearing - taken as lump sum at $10,000,000; COE (1979) estimated 1,920 acres at $1,613,000.

Main Dam --

- Concrete thin arch dam assumed with 10 percent additional volume concrete added to expected design quantities to negate any possible seismic problems.
- Sound rock taken at elevation 1,350 for thrust blocks; overburden taken as 25 feet deep; an additional 40 feet of unsound rock under dam also assumed.
- Dam sits on concrete plug of 50 foot depth.
- Reinforcing steel in dam taken as 7 lb/cy.
- Grouting assumed to be through series of vertical and horizontal tunnels on either side of dam; tunnel sizes and support assumed to be same as at Watana; lengths are somewhat less due to smaller height and breadth of canyon; grouting assumed to be more extensive than Watana in order to ensure complete integrity and cutoff.
- Low level release lump sum estimated (includes intake, gates and tunnel into lower end of diversion tunnel); reregulation capability also included to ensure adequate river flow between dam and tailrace.
- Plunge pool lined with 10 feet thick concrete.

Diversion/Cofferdams --

- Two diversion tunnels with total length of 3,800 LF assumed; 26 feet inside diameter; fully lined with concrete one and one-half feet thick; approximately 25 percent steel supported and 25 percent rockbolted.
- Gates' lump sum estimated.
- Portals rockbolted for entire contact area; reinforced at 40 lb/cy.
- Cofferdams estimated at 60 feet (upstream) and 40 feet (downstream) in height with 2:1 slope.
- Dewatering assumed the same as Watana.
- No cutoff assumed to be needed.
- Diversion tunnel plugs included to plug after use (upstream of any drawdown tunnel).

Penstocks --

- Four penstocks of total length of 3,500 LF assumed, with 18 feet inside diameter; full length of tunnel lined with two feet thick concrete.
- Fifty percent rockbolting assumed; steel liner of three-fourths inch thickness and 220 feet in length included at powerhouse.

TABLE 2 (Cont'd)

Power Intakes --

- Same assumptions as Watana; greater volume of excavation required.

Powerhouse & Associated Items

- Same assumptions as Watana, except no surge chamber needed due to lower operating head; also additional electrical work needed to connect north bank powerhouse to south bank switchyard; access tunnels total length 2,000 LF; access shaft total length 400 LF, cable shafts total length 930 LF.

Secondary Powerhouse --

- Fifty MW unit lump sum estimated at $600,000/MW for power facilities only.

Service Spillway --

- Same assumptions as Watana; stilling basin lump sum estimated.

Emergency Spillway --

- Twenty-five feet overburden assumed; localized channel lining lump sum estimated; rock-fill fuse plug.

Tailrace --

- Outlet portal assumed to be approximately as at Watana.
- Assumes two, 29 feet diameter tunnels approximately one and one-half miles long to take full advantage of available head to Portage Creek.

Saddle Dam --

- Saddle dam required on south bank to contain reservoir.
- Slurry trench beneath dam included as cutoff.

Switchyard --

- Yard assumed to be on south bank of river.
- No rock excavation required.
- Electrical and civil work taken as lump sum items.

Miscellaneous Structures & Equipment --

- Items taken as lump sums

Access Roads/Rail Spur --

- Two permanent fifteen mile roads assumed to connect site with previously constructed Park Highway-Watana Road.
- Lump sum item included for construction rail spur from Gold Creek to the site.

TABLE 2 (Cont'd)

Support & Camp --

- Construction power based upon overall size of project.
- 2.3 million mandays required for construction; based upon assumed schedule and associated labor requirements; 10 percent service personnel and 15 percent turnover, visitors and staff added to anticipated construction work force.
- Single status camp for 2,300 workers assumed, based upon peak manpower loading.

APPENDIX A

TABLE 3

BASE ASSUMPTIONS
WATANA/DEVIL CANYON

1) Rock Bolts

A. General
- Standard pattern five feet from center to center, 15 to 20 feet long, 1-1/4 inch diameter, 100 lbs each - 25 sq ft contact area per bolt.

B. Tunnels
- Generally bolted for twenty-five percent of tunnel's length.
- Standard pattern.
- Add 100% to quantity for upper limit estimate purpose.

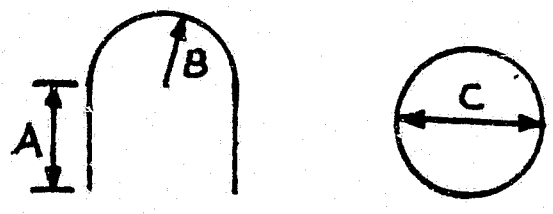
C. Portals
- Generally bolted with standard pattern.
- Face and 50 feet either side.
- Concrete contact area only.
- Add 100% to quantity.

D. Powerhouse and Power Facilities
- Generally bolted standard pattern.
- Fully bolted dome and ten percent of walls.
- Fifty percent of penstock length bolted
- Add 100% to quantity.

E. Spillways
- Generally bolted standard pattern over slab and wall concrete contact area.
- Add 100% to quantity.

2) Penstock Liner
- 30.6 lb/sf for three quarter inch thick plate assumed.

3) Steel Tunnel Supports



$P_{horseshoe} = A + A + 1/2\ (2B)\pi$

$= 2A + \pi B$

$P_{round} = \pi C$

In general assumed for 25 percent tunnel length.

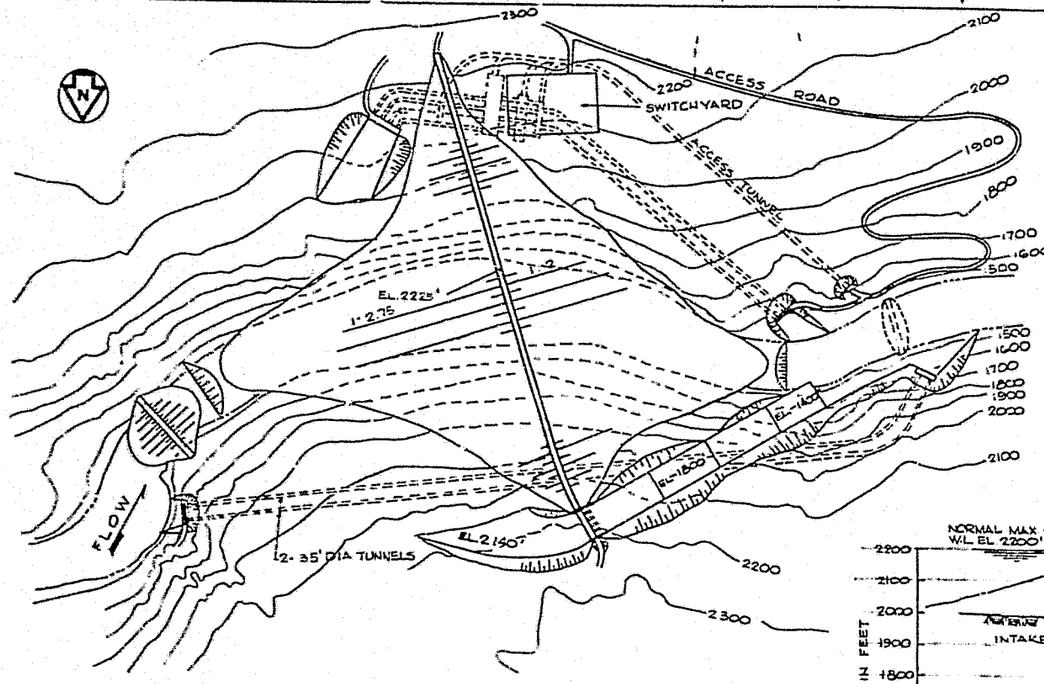
TABLE 3 (Cont'd)

- Six feet on center at 55 lb/lf.
- Eight cross members at 6 feet length at 20 lb/lf.
- Therefore weight steel/6 lf tunnel = 55(p) + 8 (6) (20)

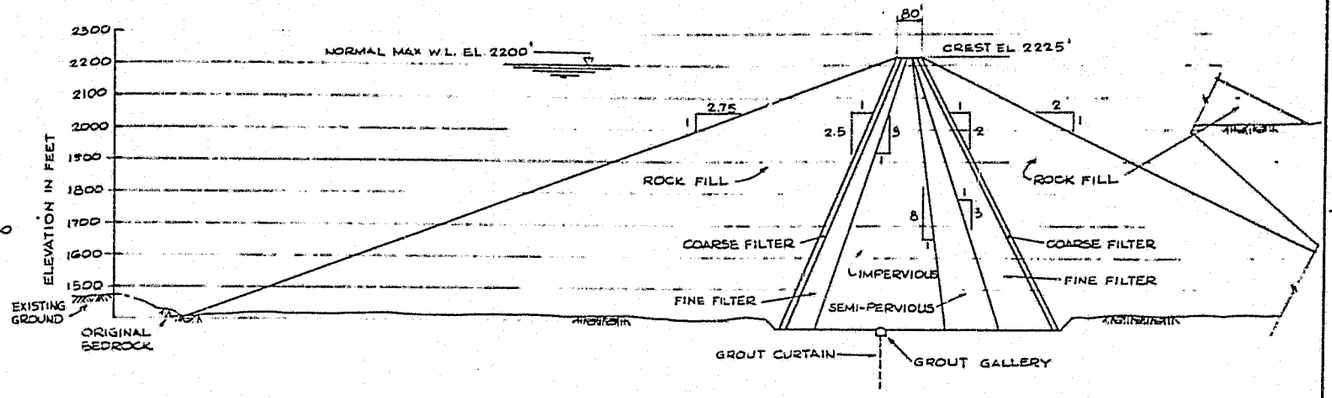
4) Reinforcing Steel (lbs. % steel/cubic yard of concrete)
- Primary concrete 120 lb/cy.
- Secondary concrete 190 lb/cy.
- Spillway slab 80 lb/cy.
- Spillway wall 40 lb/cy.
- Intake 90 lb/cy.
- Main dam/thrust block 7 lb/cy (mass concrete).

APP-A/T-1
APP-A/T-1.1
APP-A/T-1.2

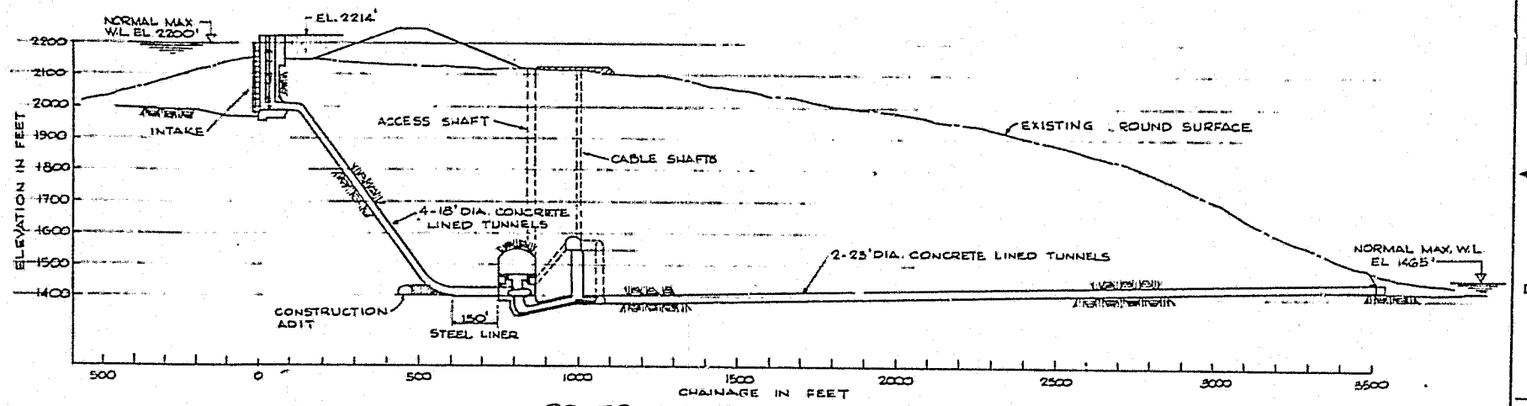
APP-A/T-2



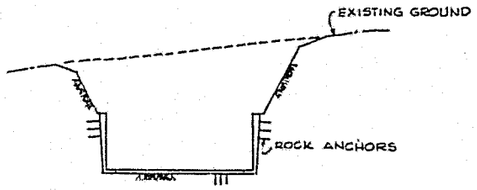
GENERAL ARRANGEMENT
SCALE: A



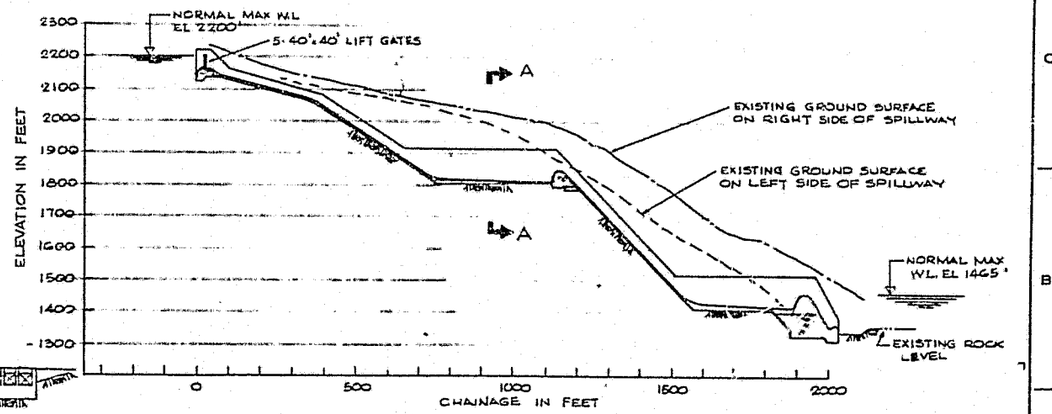
SECTION THRU DAM
SCALE: B



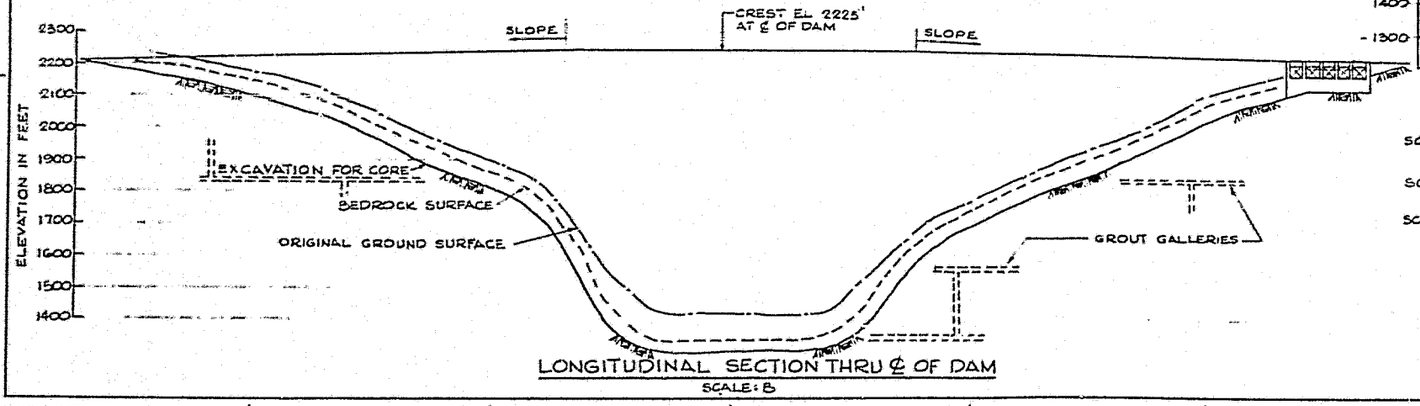
POWER FACILITIES PROFILE
SCALE: B



SECTION A-A
SCALE: C



SPILLWAY PROFILE
SCALE: B



LONGITUDINAL SECTION THRU ℄ OF DAM
SCALE: B

SCALE A 0 500 1000 FEET
SCALE B 0 200 400 FEET
SCALE C 0 100 200 FEET

PLATE 1

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

WATANA
SCHEME I

SCALE AS SHOWN
DRAWING NO. SK-5700-C6-205
REV
SHEET OF

ACRES AMERICAN INCORPORATED
PROJECT
DATE
DRAWN
CH
APP
APP
DATE NO REVISIONS

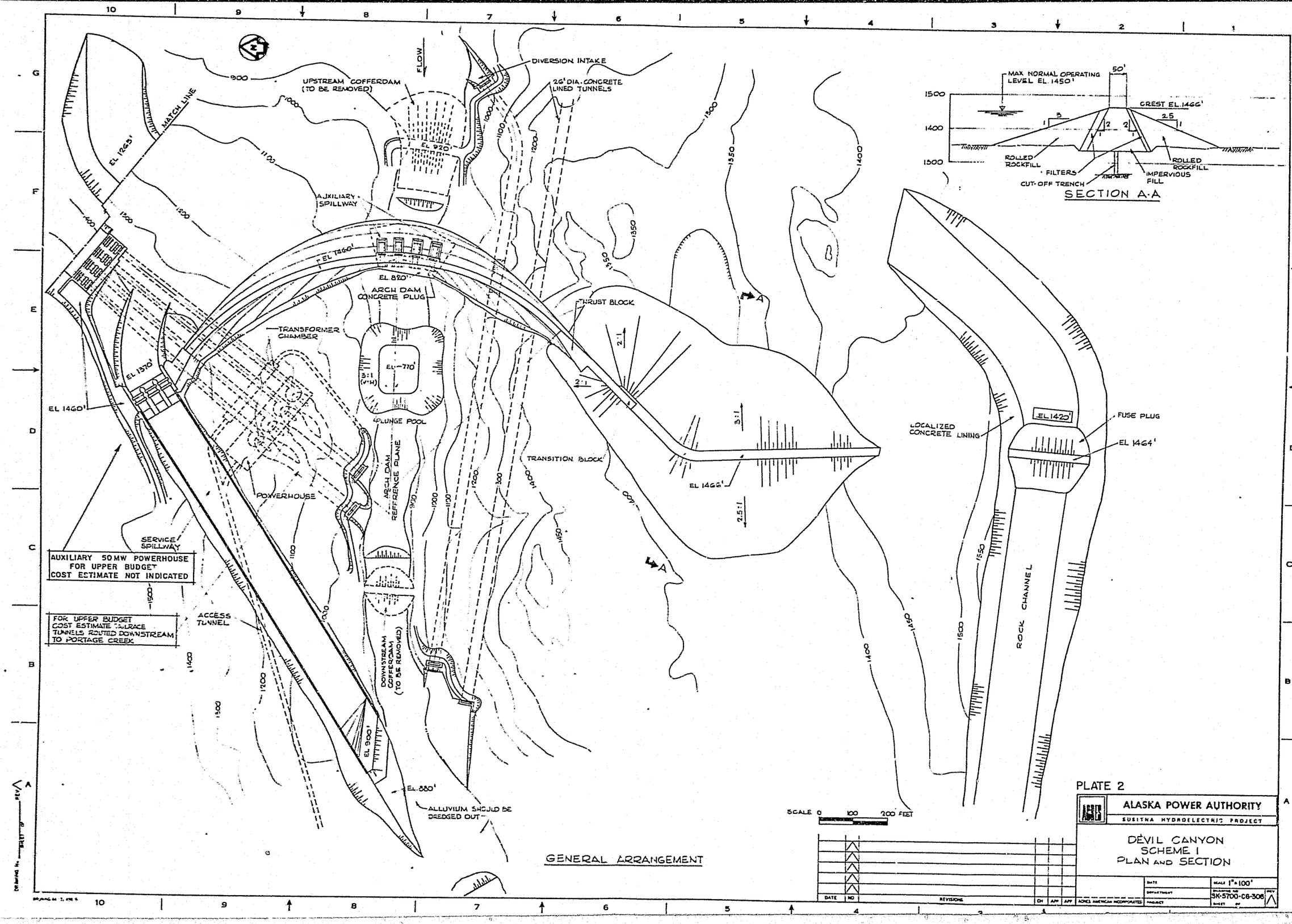


PLATE 2

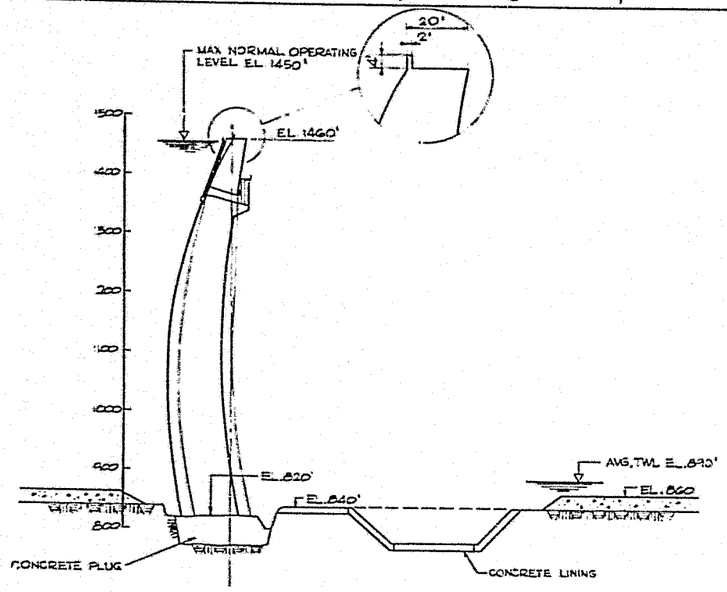
ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

DEVIL CANYON
SCHEME 1
PLAN AND SECTION

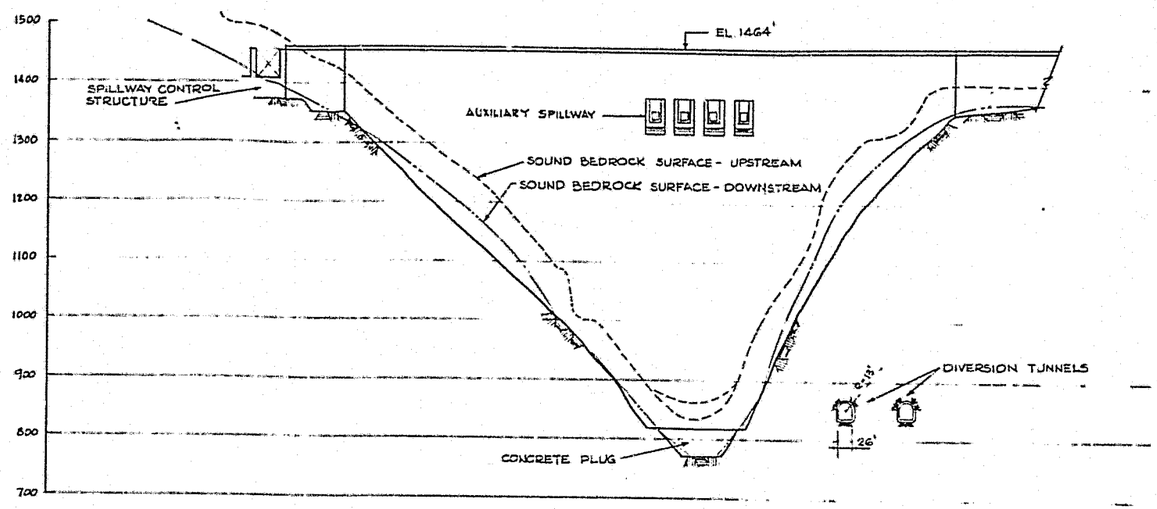
DATE | NO | REVISIONS | CH | APP | APP

ACRES AMERICAN INCORPORATED

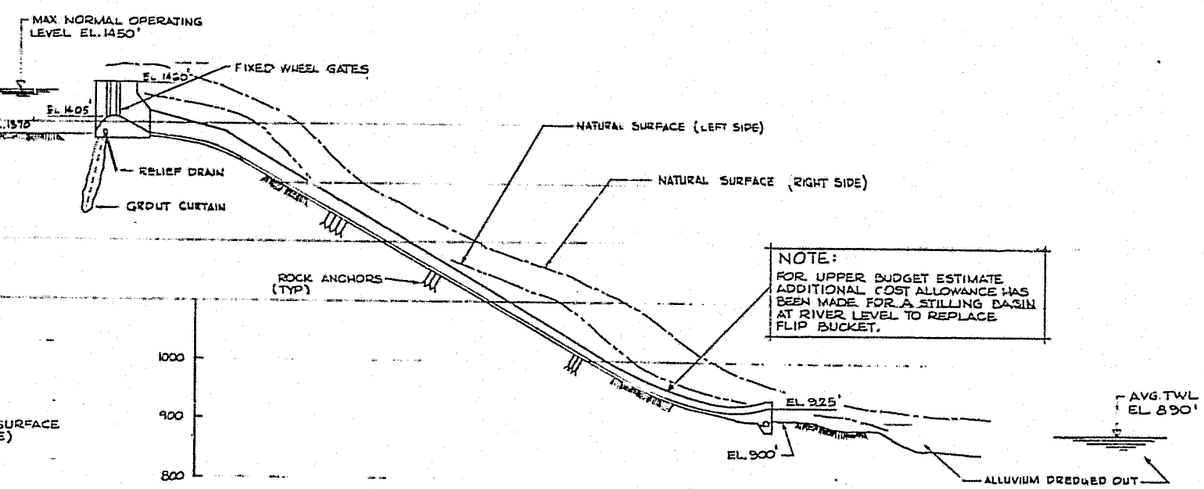
DATE | SCALE 1"=100'
DEPARTMENT | DRAWING NO SK-5700-C6-306 | REV A
PROJECT | SHEET OF



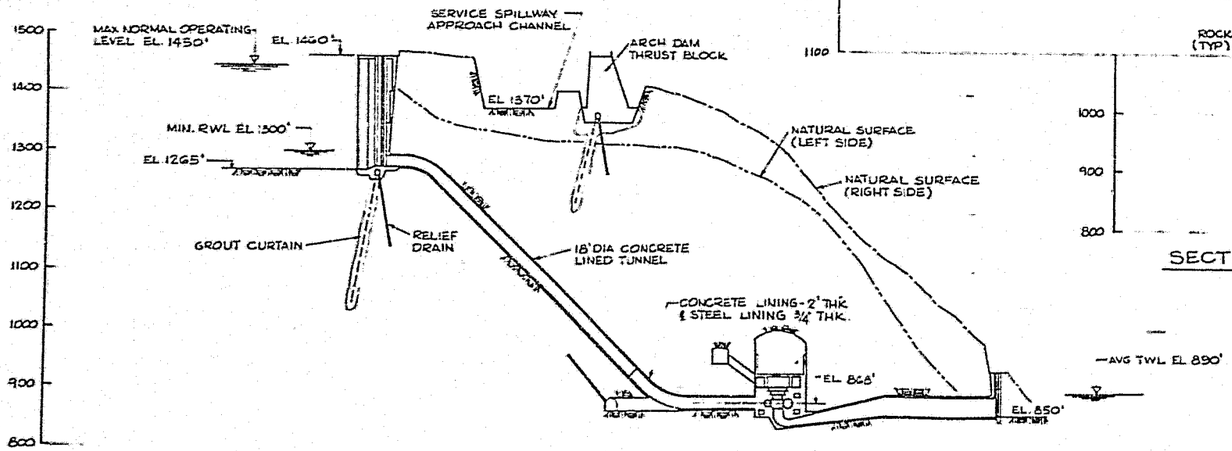
CROWN SECTION



DAM PROFILE (LOOKING UPSTREAM)



SECTION THRU SPILLWAY



SECTION THRU POWER FACILITIES

SCALE 0 100 200 FEET

PLATE 3

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

DEVIL CANYON
SCHEME 1
SECTIONS

DATE
DEPARTMENT
PROJECT
SHEET
SCALE 1"=100'
SK-57-06-06-301
REV A

ACRES AMERICAN INCORPORATED

DATE	NO.	REVISIONS	DR	APP	APP