

HARZA-EBASCO

Susitna Joint Venture
Document Number

94

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DOCUMENT CONTROL

HARZA-EBASCO
SUSITNA HYDROELECTRIC PROJECT

Lost 7- GROUP 8

WATANA

GEOTECH ASSUMPTIONS

BINDER NO. 1

94
(ONLY)

(1) Watana 10/10/10

Estimating Assumptions

Geotech Assumptions - Watana

WATANA - GEO TECH ASSUMPTIONS

from info. package WATANA
10/8

STRUCTURE: 910 ' HIGH ROCKFILL DAM

INVESTIGATIONS:

USBP. 1950-1953	RECONNAISSANCE		
COE 1975	RECONNAISSANCE	ACRES 1980	ACRES 1981
	22500 LF SEISMIC		
COE 1978	28 BOREHOLES	3 HOLES	4 HOLES *
	30-600 ' DEEP	376-752' DEEP	300-955'*
	18 AUGER HOLES	21 AUGER	18 AUGER
	27 TEST PITS		21 PITS *
	47665 LF SEISMIC	24800 LF	38200 LF
	10 PIEZOMETERS	1 PIEZO	4 PIEZOS*
	13 TEMP. PROBES	1 THERMISTER	2 THERMISTERS*

SIGNIFICANT FEATURES:

VALLEY 300' AT BASE, 6000' AT RIM, 30-60° SLOPES
10-40' OVERBURDEN
5-40' WEATHERED ROCK
ALLUVIUM - SANDS AND GRAVELS, SOME TALUS, POSSIBLY PARTLY FROZEN
RELICT CHANNEL UPSTREAM OF DAM, GLACIAL AND ALLUVIAL MATERIALS
UP TO 454' IN DEPTH.
MAJOR SHEAR ZONES ("THE FINS", "FINGERBUSTER") BORDER DAMSITE.
LOCALIZED NARROW ZONES OF SHEARING AND INTENSE THERMAL ALTERATION.
3 MAJOR JOINT SETS (PROMINENT N30-60°W)
DAMSITE IN PLUTON, BOUNDED BY VOLCANICS AND SEDIMENTS.

*NOTE: IN PROGRESS, NUMBER MAY INCREASE.

9/16/81

MATERIALS SOURCES:

CONCRETE AGGREGATE & FILTER MATERIALS AVAILABLE 2-4 MILES DOWNSTREAM OF SITE.

ROCKFILL AVAILABLE FROM EXCAVATIONS AND IMMEDIATELY ADJACENT TO LEFT END OF DAM CREST.

GRAVEL SHELL MATERIAL AVAILABLE IN RIVER WITHIN 6-8 MILES UPSTREAM AND DOWNSTREAM - STILL BEING EVALUATED FOR SUITABILITY.

IMPERVIOUS/SEMI-IMPERVIOUS MATERIAL FOR CORE AVAILABLE 1-3 MILES UPSTREAM OF AXIS.

AREAS TO ADDRESS IN DESIGN:

MAJOR SHEAR ZONES LIMIT UPSTREAM AND DOWNSTREAM LAYOUT FLEXIBILITY.

LEFT ABUTMENT SHEAR ZONE AND ALTERED ZONE LIMIT STRUCTURES, WILL REQUIRE ADDITIONAL GROUTING AND DRAINAGE PROVISION.

DEEP ALLUVIUM IN CHANNEL, OF UNKNOWN DYNAMIC (SEISMIC RESPONSE) PROPERTIES MANDATES REMOVAL UNTIL PROVEN SUITABLE AS FOUNDATION.

LOCAL SHEAR ZONE INFLUENCE UNDERGROUND STRUCTURE ORIENTATION.

DEEP RELICT CHANNEL ALLUVIUM REQUIRES INVESTIGATION FOR WATER-TIGHTNESS AND SENSITIVITY TO HYDROSTATIC HEAD FROM RESERVOIR.

SPORADIC PERMAFROST WILL REQUIRE CONSIDERATION IN CONSTRUCTION.

UNDERGROUND STRUCTURES:

ROCK QUALITY GOOD BELOW 250' IN DEPTH, PERMEABILITIES LOW.

STRUCTURES REQUIRE ORIENTATION TO AVOID LOCAL JOINTING, SHEARS.

8) WATANA DAMSITE
FOUNDATIONS, EXCAVATION & ROCK MECHANICS
GENERAL FEASIBILITY LEVEL DESIGN CRITERIA

SUSITNA HYDROELECTRIC PROJECT
WATANA DAM

MAIN DAM

EXCAVATION

OVERBURDEN - AVERAGE 20 FEET DEPTH OVER ALL FOUNDATION AREA.
WEATHERED ROCK UNDER CORE AND FILTERS - 40' DEPTH.
WEATHERED ROCK UNDER SHELLS - 10' DEPTH.

MAXIMUM SLOPES - 1H:2V BELOW 1800' ELEVATION
1H:1V ABOVE 1800' ELEVATION

CONSOLIDATION GROUTING

10' X 10' GRID OF HOLES 30' DEEP OVER AREA OF CORE AND FILTERS.

SUSITNA HYDROELECTRIC PROJECT
WATANA DAM

CURTAIN GROUTING

DOUBLE ROW CURTAIN - VERTICAL..

350' MAXIMUM DEPTH (AT MAXIMUM HEAD).

50' MINIMUM DEPTH IN ABUTMENTS.

HOLE SPACING PRIMARY 40'.

SECONDARY

TERTIARY

QUATERNARY

SPLIT SPACING TO GIVE
FINAL SPACING 5'.

GALLERIES FULL LENGTH OF DAM, APPROXIMATE SIZE 10' X 10'.

DRAINAGE

50' DEEPER THAN GROUT CURTAIN.

HOLE SPACING 10'.

DRILLED FROM GROUT GALLERIES.

FULL LENGTH OF DAM, EXTENDING 600' INTO LEFT ABUTMENT.

CONNECTING TO INTAKE AND SPILLWAY STRUCTURES RIGHT ABUTMENT.

HOLES INCLINED DOWNSTREAM 15° FROM VERTICAL.

SUSITNA HYDROELECTRIC PROJECT
WATANA DAM

CURTAIN GROUTING

DOUBLE ROW CURTAIN - VERTICAL.

350' MAXIMUM DEPTH (AT MAXIMUM HEAD).

50' MINIMUM DEPTH IN ABUTMENTS.

HOLE SPACING PRIMARY 40'.

SECONDARY

TERTIARY

QUATERNARY

SPLIT SPACING TO GIVE
FINAL SPACING 5'.

GALLERIES FULL LENGTH OF DAM, APPROXIMATE SIZE 10' X 10'.

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FULL LENGTH OF DAM, EXTENDING 600' INTO LEFT ABUTMENT.

CONNECTING TO INTAKE AND SPILLWAY STRUCTURES RIGHT ABUTMENT.

HOLES INCLINED DOWNSTREAM 15° FROM VERTICAL.

SUSITNA HYDROELECTRIC PROJECT
WATANA DAM

SURFACE STRUCTURES

INTAKE AND SPILLWAY

EXCAVATION - OVERBURDEN - AVE 10'
WEATHERED ROCK - AVE 40' (MINIMUM).

CONSOLIDATION GROUTING - 10' X 10" GRID OF HOLES 30' DEEP.

CURTAIN GROUTING - CONTINUATION OF DAM CURTAIN. 50' MINIMUM
DEPTH. SPLIT SPACING AS MAIN DAM.

DRAINAGE - FROM GALLERIES IN BASE OF STRUCTURES.

TUNNEL PORTALS (TUNNEL SPAN = D)

COVER TO TOP SOUND ROCK 1.5D.

SPACING CENTER TO CENTER 2.5D. WHERE TUNNEL IS STRUCTURALLY
REINFORCED, SPACING MAY BE REDUCED TO 2.0D.

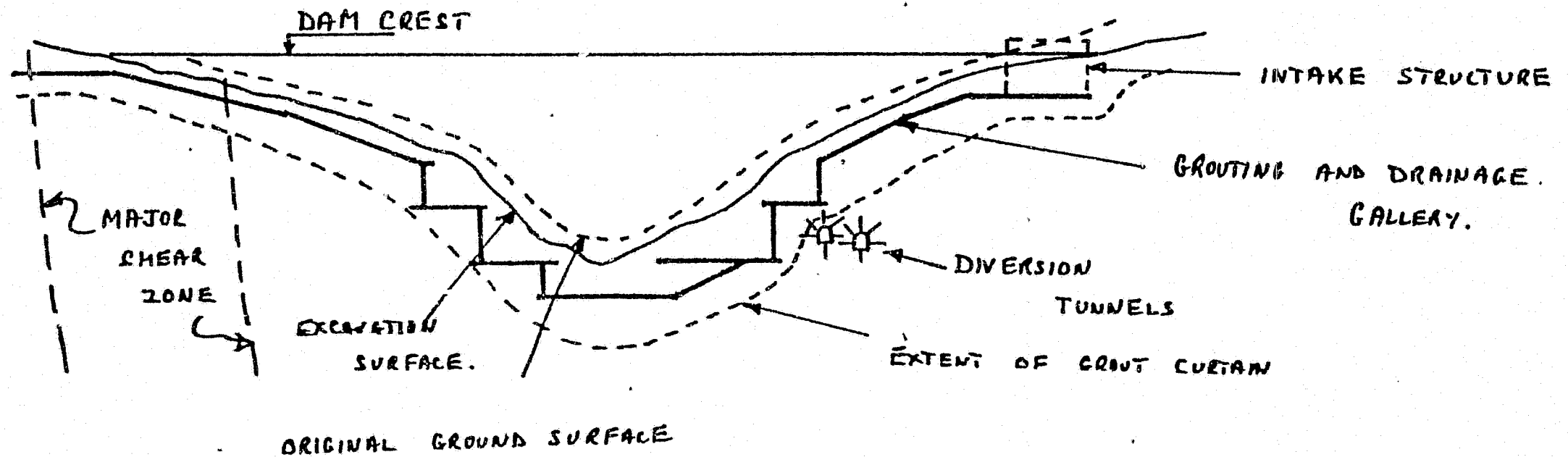
ALL TUNNEL LININGS CONTACT GROUTED.

DRAINAGE PROVIDED IN LININGS OF DIVERSION TUNNELS.

SUSITNA HYDROELECTRIC PROJECT

WATANA DAM

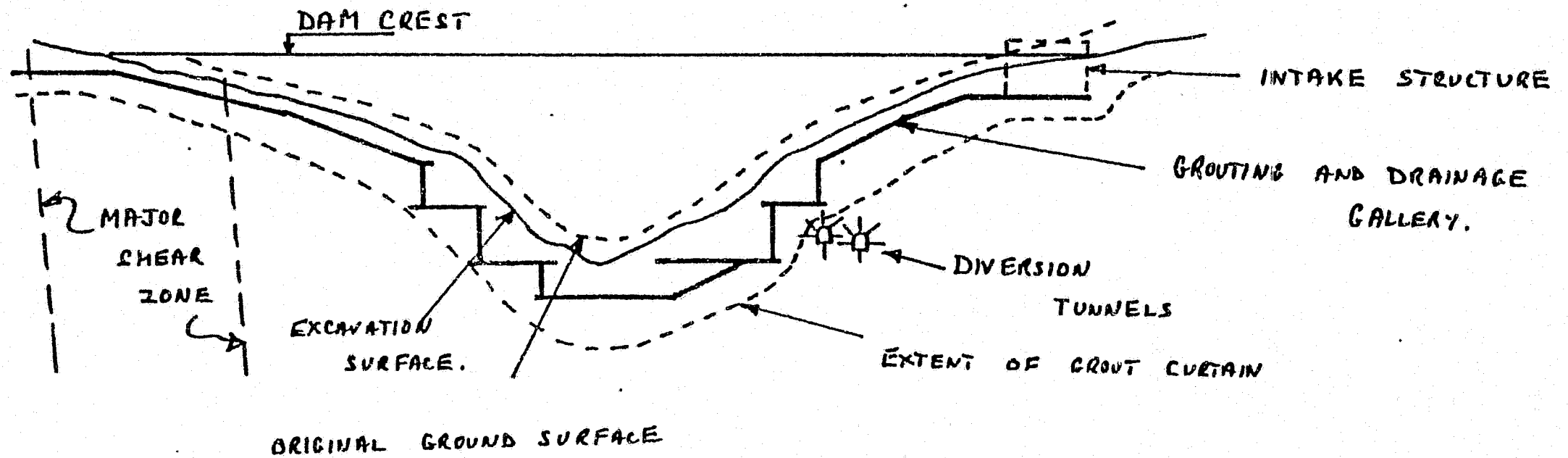
GROUTING ARRANGEMENT



(LOOKING DOWNSTREAM)

SUSITNA HYDROELECTRIC PROJECT

WATANA DAM GROUTING ARRANGEMENT



(LOOKING DOWN STREAM)

SCHEDULE 1

SUSITNA HYDROELECTRIC PROJECT
 UNDERGROUND ROCK BOLTING
 WATANA

STRUCTURE	LOCATION	SIZE	SPACING/PATTERN				
			38%	21%	21%	11%	9%
			PERCENT TUNNEL LENGTH BOLTED				
TUNNELS							
Diversion	Ceiling	1" x 12'	NA	1 Bolt/10 LF Tunnel	5' x 5'	3' x 3'	NA
	Walls	1" x 9'	NA	NA	1 Bolt/10 LF Tunnel	6' x 6'	NA
Main Access*	Ceiling	1" x 12'	NA	1 Bolt/10 LF Tunnel	6' x 6'	3' x 3'	NA
	Walls	1" x 9'	NA	NA	1 Bolt/10 LF Tunnel	6' x 6'	NA
Penstock	Ceiling	1" x 6'	NA	NA	NA	3' x 3'	3' x 3'
Tailrace	Ceiling	1" x 12'	NA	NA	5' x 5'	3' x 3'	NA
	Walls	1" x 9'	NA	NA	1 Bolt/10 LF Tunnel	6' x 6'	NA
Grout & Drainage**	Ceiling	3/4" x 6'	NA	4 Bolts/3 LF Tunnel	NA	NA	NA
CHAMBERS			40%	20%	30%	10%	
			PERCENT AREA BOLTED				
Powerhouse	Ceiling	1" x 25'	6' x 6' H.Y.	6' x 6' H.Y.	6' x 6' H.Y.	NA	
	Walls	1" x 15'	NA	5' x 5'	5' x 5'	NA	
Surge Chamber	Ceiling	1" x 25'	6' x 6' H.Y.	6' x 6' H.Y.	6' x 6' H.Y.	NA	
	Walls	1" x 15'	NA	5' x 5'	5' x 5'	NA	
Transformer Gallery	Ceiling	1" x 25'	6' x 6' H.Y.	6' x 6' H.Y.	5' x 5' H.Y.	NA	
	Walls	1" x 15'	NA	1/360 SF	6' x 6'	NA	

SCHEDULE 1 (continued)

SUSITNA HYDROELECTRIC PROJECT
UNDERGROUND ROCK BOLTING
WATANA

<u>SHAFTS</u>	<u>LOCATION</u>	<u>SIZE</u>		
Cable	Walls	3/4" x 6'	4' x 4' pattern	25% of shaft length
Main Access	Walls	3/4" x 6'	4' x 4' pattern	25% of shaft length
Grout & Drainage	Walls	3/4" x 6'	6 Bolts/3 LF shaft	25% of shaft length

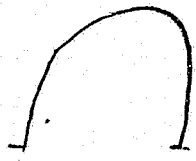
ADDITIONAL BOLTS AT OPENINGS

Bus Gallery	18 Bolts	1" x 25'
Draft Tube	24 Bolts	1" x 25'
Penstocks	24 Bolts	1" x 25'

* For All Access Tunnels Greater Than 10' In Diameter.

** For All Access Tunnels Less Than or Equal to 10' In Diameter.

All Bolts Grade 60 Unless Noted As H.Y. (High Yield).

SCHEDULE 2SUSITNA HYDROELECTRIC PROJECT
UNDERGROUND ROCK-STEEL SUPPORT
WATANA

<u>STRUCTURE</u>	<u>PERCENT OF EXCAVATION LENGTH SUPPORTED</u>	<u>SPACING BETWEEN SETS</u>	<u>SET SECTION</u>	<u>WEIGHT * lb/LF</u>
Diversion Tunnels	9	4'	10" x 10" Column	36
* Main Access Tunnels	9	3'	10" x 10" Column	36
Penstocks	NA	NA		
Tailrace Tunnels	9	4'	10" x 10" Columns	36
* Grout & Drainage Galleries	5	3'	4" x 4" Column	15
Powerhouse	10	3'	16" I-BEAM Heavy Section	90
Surge Chamber	10	3'	16" I-BEAM Heavy Section	90
Transformer Gallery	10	3'	10" x 10" Column	36

* Includes 10 percent allowance for hardware and tiebacks.

14.

SCHEDULE 3

SUSITNA HYDROELECTRIC PROJECT

~~SHOTCRETE~~
WATANA

STRUCTURE	LOCATION	THICKNESS SHOTCRETE			
		55%	21%	11%	9%
		PERCENT OF TUNNEL LENGTH			
Diversion*	Ceiling	NA	2"	2"	1"
	Walls	NA	NA	NA	1"
Main Access Tunnels**	Ceiling	NA	2"	2"	1"
	Walls	NA	NA	NA	1"
Penstock Tunnels*	Ceiling	NA	NA	2"	3"
	Walls	NA	NA	NA	3"
Tailrace Tunnels*	Ceiling	NA	2"	2"	1"
	Walls	NA	NA	NA	1"
Grout & Drainage Tunnels***	Ceiling	NA	NA	2"	1"

MESH Full ceiling + 20% walls (over 10 ft)
20% ceiling 10 ft & under

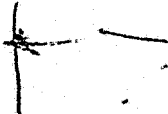
OTHER		
All shafts	25% of length	2" Shotcrete
Powerhouse &)	30% of ceiling area	4" Shotcrete
Surge Chamber:)	30% of wall area	4" Shotcrete
Transformer Gallery:	NA	

- * Tunnels are concrete lined; shotcrete used as protective measure during construction until covered by concrete lining.
- ** For all access tunnels greater than 10' diameter.
- *** For all access tunnels less than or equal to 10' diameter.

SUSITNA HYDROELECTRIC PROJECT
Reinforcing Steel Ratio's lb/cy
WATANA - DEVIL CANYON

<u>ITEM</u>	<u>DESCRIPTION</u>	<u>REINFORCING STEEL/CY YD</u>	<u>REMARKS</u>
1	Deversion Tunnels	75 lb	Reinforcement shall be used for 2 D length at exit end only.
2A	Pillar E' Rollway	130 lb	To be used for thickness over 4'-0 and exposed to weather.
2B	Apron Slab, Guide Wall Downstream Against Rock.	80 lb	Wall & Slab thickness 4' or more.
2C	Upstream Guidewall	80 lb	
2D	Gravity Type Retaining Wall	70 lb	40% 4000 PSI Concrete. 60% 3000 PSI Concrete.
3	Intake & Portal Structure	130 lb	Walls & Slab thickness 4' or more. Walls & Slab 1'-0 to 4'-0 thick.
4A	Primary Concrete	100 lb	Walls & Slab over 1'-6 thick.
4B	Slabs	100-120 lb	Slab less than 18" thick.
5	Devil Canyon Dam	7 lb	
6	Access Tunnels & DRAINAGE Galleries	70 lb	(11111111) SLABS

SUSITNA HYDROELECTRIC PROJECT
Reinforcing Steel Ratio's lb/cy
WATANA & DEVIL CANYON

<u>DESCRIPTION</u>	<u>REINFORCING STEEL/CY YD</u>	<u>REMARKS</u>
Diverson Tunnels & Other Water Passages	75 lb	Reinforcement shall be used for 2 Diameter lengths at exit end only.
Spillway		
Pillar & Rollway	130 lb	To be used for thickness over 4'-0 and exposed to weather.
Apron, Slab, Guide Wall Downstream Against Rock	80 lb	Wall & Slab thickness 4' or more.
Upstream Guidewall	80 lb	
Gravity Type Retaining Wall	70 lb	
 Intake & Portal Structure	130 lb	Walls & Slab thickness 4' or more. Walls & Slab 1'-0 to 4'-0 thick.
Powerhouse Concrete DRAFT TUBE	100 lb 165 LB	Throughout
Devil Canyon Dam	7 lb	
Access Tunnels	70 lb	(If lined) Slabs

ACRES
ACRES

Calculations

SUBJECT: SUSITUA

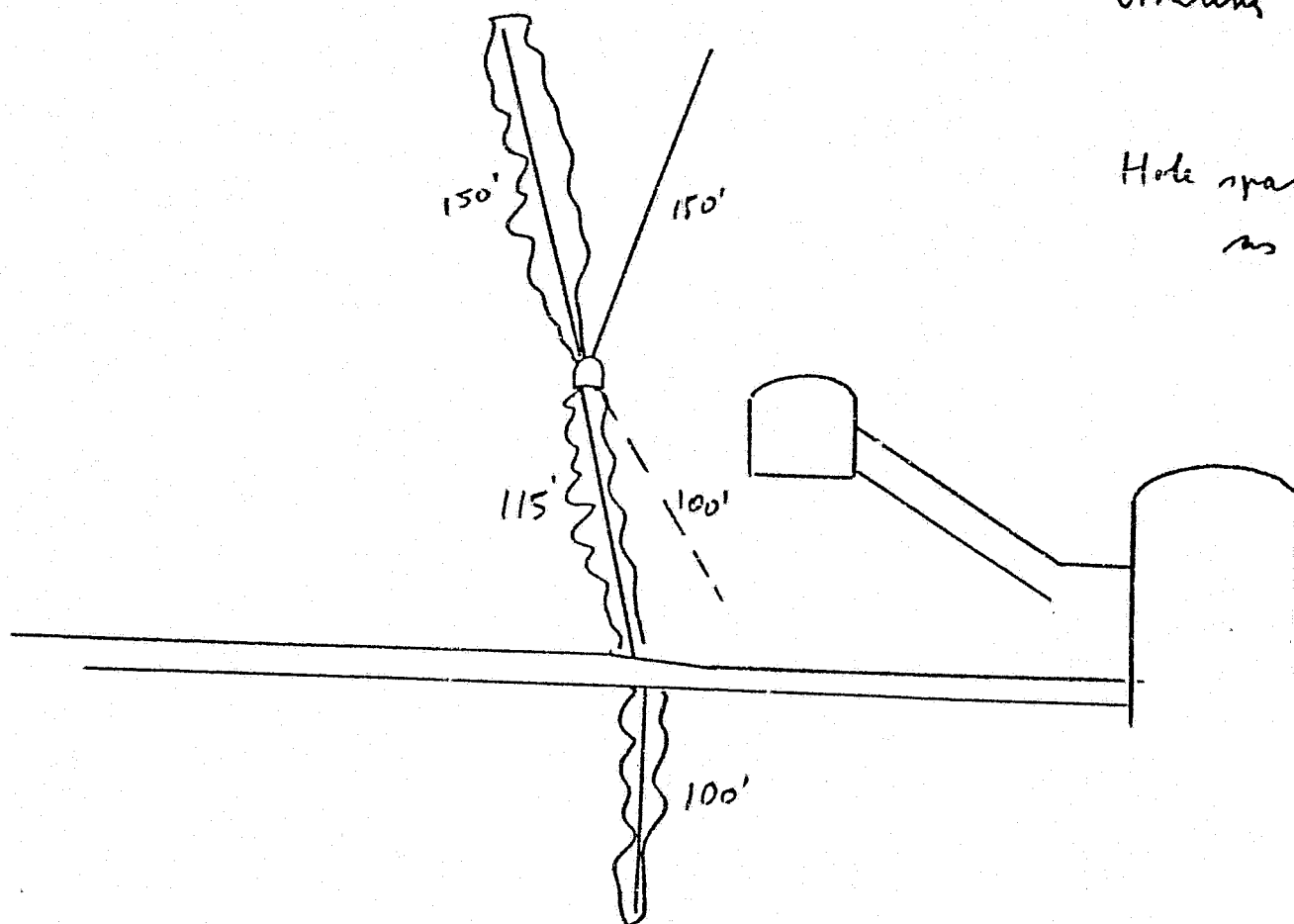
WATANA

Grouting of power house

At Denim Melheda.

Watan Power house

Grouting curtain 600' long.

Hole spacing, holes etc
as dam curtain

Drawing not yet complete for Denim Canyon
but will be same arrangement also 600 feet long.

FROM

SK 5700-CG-518

JOB NUMBER PS700-06

FILE NUMBER

SHEET OF

BY AAS

DATE 26/1/82

APP DATE



Calculations

SUBJECT: SUSITNA

TUNNEL LINING GROUTING.

JOB NUMBER PS700.06

FILE NUMBER _____

SHEET 1 OF _____

BY NAB DATE 26/1/87

APP _____ DATE _____

Tunnel lining Contact Grouting.

The amount of grout take is, for average quality rock which we have at Watamu and Devil Canyon, 95% dependant on the quality of contractors work.

Therefore it is usual, in my experience, to include contact grouting in the rate for concreting. This is one of the reasons we have higher tunnel lining concrete prices.

The situation can arise where a void is left in ^{the} crown which extends inside your line.

The contractor then gets paid twice, once for concrete because volume ^{of concrete} is calculated to pay line and secondly for grouting up the void.

The figures given next page can vary upwards by factor of 3 or 4 if blasting and concreting work is poor.

I strongly recommend that the grouting be reflected in concrete price not in a separate item.



Calculations

SUBJECT: SUSITNA.

TUNNEL LINING GROUTING

JOB NUMBER P5700.06.

FILE NUMBER

SHEET 2 OF 2

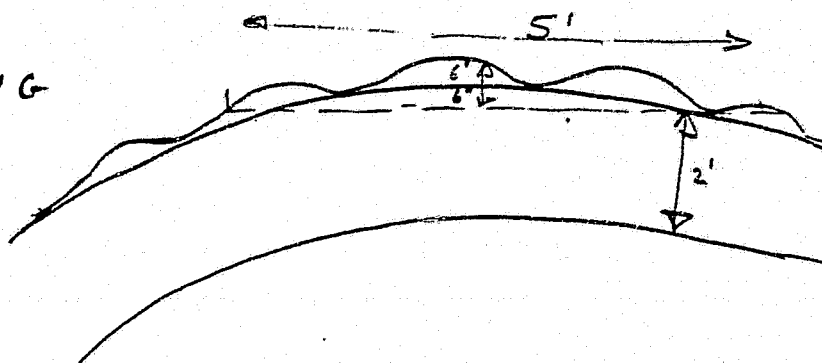
BY WATB DATE 26/1/82

APP DATE

PENSTOCKS

CONTACT GROUTING

Tunnel 21' diam. Watana
20' dia Devil Canyon



Horizontal Section of penstock volume of cement 2.5 cu ft / ft tunnel.

Inclined Section of penstock " " " 0.5 cu ft / ft tunnel

Grouting around plugs in rock. 0.2 cu ft / ft hole.

Contact grouting around plugs

Devil Canyon (lining removed before plug constructed)

avg 2.5 cu ft / ft tunnel.

Watana (Plug concrete cast against lining)

avg 1.0 cu ft / ft tunnel.



Calculations

SUBJECT: SUSITNA.
WATANA FOUNDATION GROUTING - DRAINAGE
QUANTITIES

JOB NUMBER 5700 05
FILE NUMBER _____
SHEET 1 OF 7
BY MAJB DATE 15/12/81
APP _____ DATE _____

Watana Grouting and Drainage.

Gallerie. 10' x 10'

Floor slab 12" ^{WEEK 1/8/82} thick. concrete un-reinforced.

Tunnel support required

Rock bolts 6'-0" long 3/4" dia.

3'-0" centres

i.e. 4 No bolts per 3 ft tunnel length.

Bolts required 25% of tunnel length.

Additional bolts required at portals, junctions etc

26 No. @ 20 additional bolts = 520 bolts.

Shotcrete

Assume 20% of tunnel length Crown only. 12 feet surface width.

Additional 520 feet for junctions - portals

at 2" thick

Mesh

4" x 4" x 3/16" ϕ 20% shotcrete area.

Steel Arches

5% of tunnel length @ 3 feet centres.

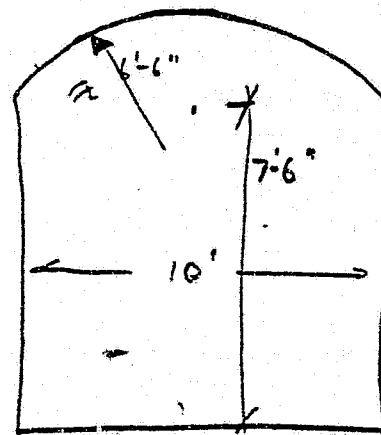
4" x 4" column section with fish plates, tie bars and base plates.

13# / LF

27 LP / set

10% Hardware & Tie Bars Per E. GORNY 1/8/82

Note 2 Access tunnels from 1500' el. to d/s toe of dam drainage outlet below tail water level. Not shown on SK 5700 CP 5/8 will be shown on dam design





Calculations

SUBJECT:

JOB NUMBER _____

FILE NUMBER _____

SHEET 2 OF 7

BY _____ DATE _____

APP _____ DATE _____

Shafts

10 feet diameter

Rock bolts 6'-0" long. $\frac{3}{4}$ " dia.

Assume 6 bolts per 3' length of shaft.

25% length of shaft bolted.

Assume Shotcreting 2" thick full circumference.

25% of length of shafts.

Stairway and small elevator required each shaft.

Access Tunnel portals

Portals within dam foundation entire rock bolts already allowed for.

Excavation included in dam item.

4 portals required downstream of dam

Inclined Tunnel

Will require rail mounted car with electrical hoist for each inclined section.

Steps formed in concrete slabs will be required.

Calculations

SUBJECT:

JOB NUMBER

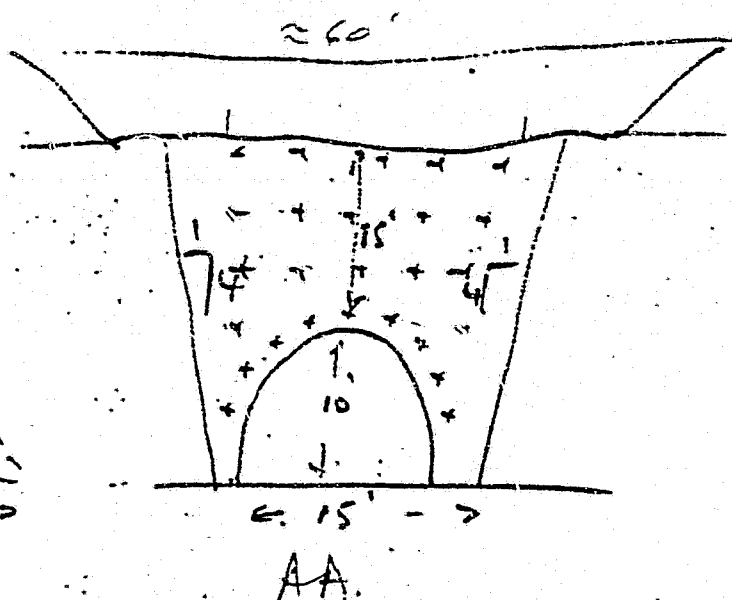
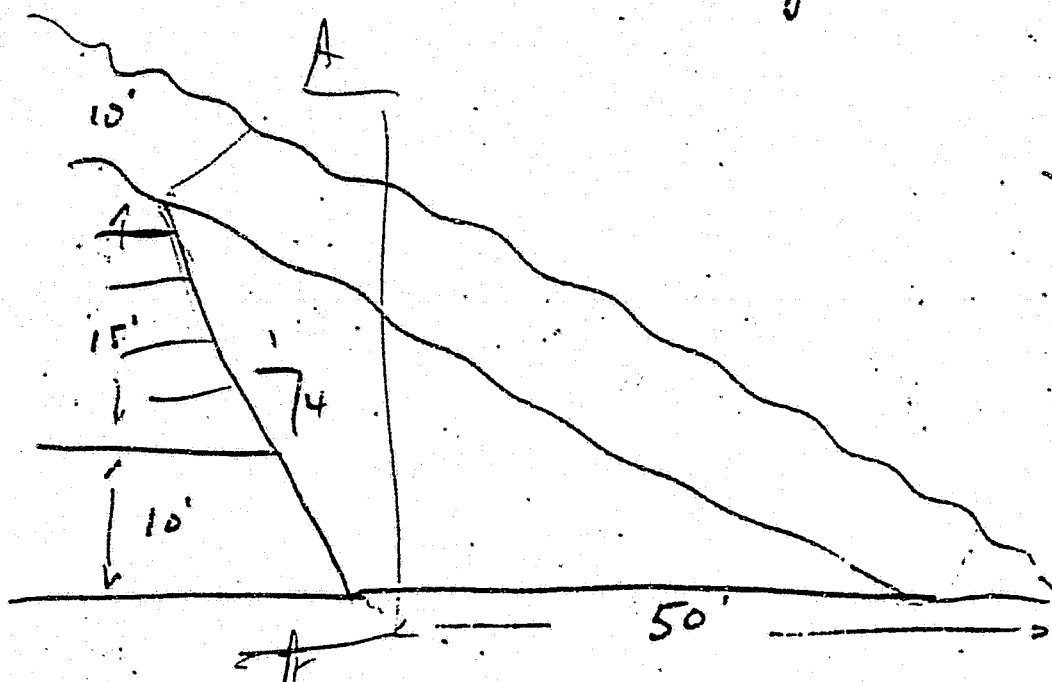
FILE NUMBER

SHEET 3 OF 7

BY DATE

APP DATE

Tunnel Ports. 4 No for access tunnels.



Excavation. Overburden

$$60' + \underline{60'} + 10' = 133' \text{ eq. eq. (1)}$$

Rock. $\frac{40' \times 25' \times 20'}{2} = 1000 \text{ cu yds.}$ ()

Bolting. 10' long bolts.

Portal face. $5 \times 3 \text{ mm.} = 15.$

Circum. = 8

23 N: $\approx 10'$ long

$$= 230 \text{ ft.}$$

Walls say. 20 No bolts per panel
= 200'

157.4

430 ft rock bolts. Assume 1" dia bolt

For 4 No rentals.

Root Overburden

5332 in yds.

Rock

1450: au gels

Rock bolts.

1720 Pl.

Shot-crocks

8 car yards

25



Calculations

SUBJECT:

JOB NUMBER _____

FILE NUMBER _____

SHEET 4 OF 7

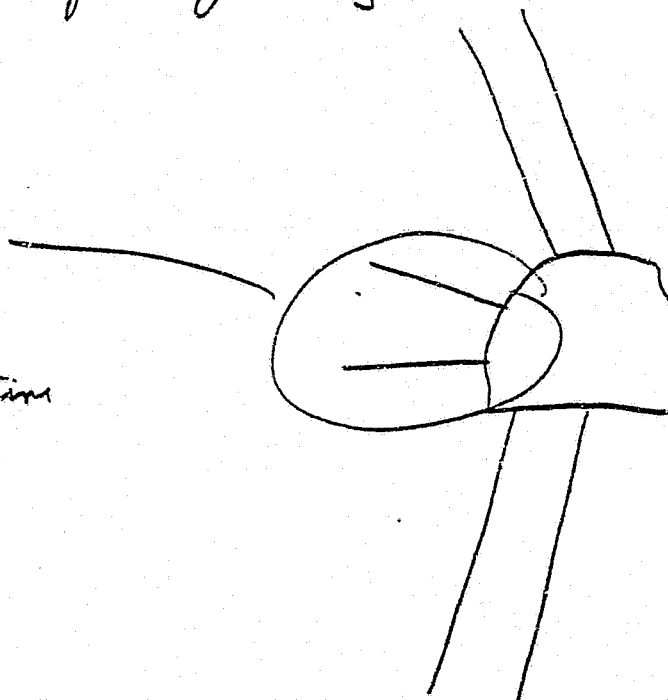
BY _____ DATE _____

APP _____ DATE _____

Extra subhorizontal grout holes from gallery

2 No @ 10 feet long.

5' spacing along entire
length of gallery.



Concrete plugs in access tunnels into dam foundation

6 No. — length — full depth of consolidation grouting zone.
approx 60' horizontal.



Calculations

SUBJECT:

JOB NUMBER _____
FILE NUMBER _____
SHEET 5 OF 7
BY _____ DATE _____
APP _____ DATE _____

Powerhouse Drainage.

See SK 5700 CG 518

Section B-B.

Revision 15 Dec 81.

Transformer gallery.

8 Holes 25' long.

10' spacing entire length of gallery.

Powerhouse cavern

12 Holes

40' long.

1 hole

130' long.

10' spacing

entire length of gallery

Surge chamber.

13 Holes

35' long.

10' spacing entire length of surge chamber.

Penstocks

Drainage gallery from transformer gallery.

See SK 5700 CG 518 Section B-B.

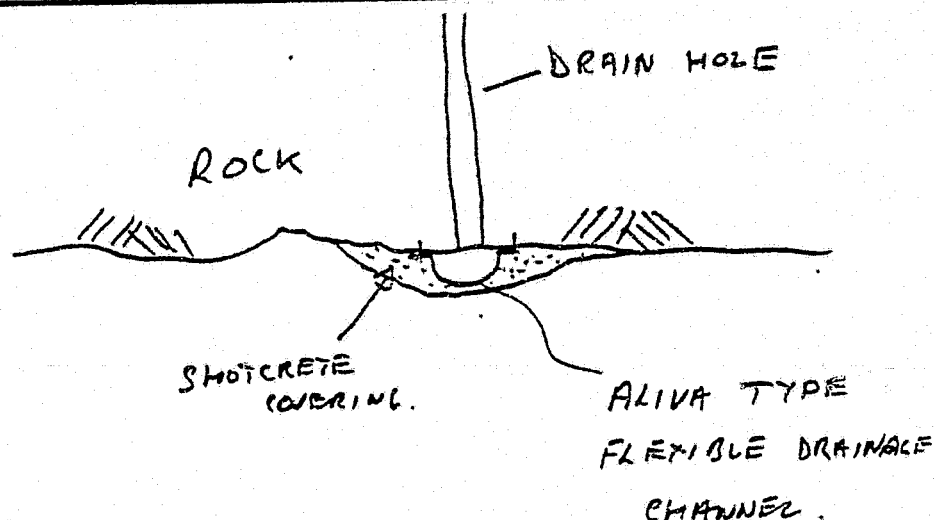


Calculations

SUBJECT:

JOB NUMBER _____
FILE NUMBER _____
SHEET 6 OF 7
BY _____ DATE _____
APP _____ DATE _____

SW face drains Caverns.



Length -

Transformer gallery 130' @ 10 feet centres entire length of gallery

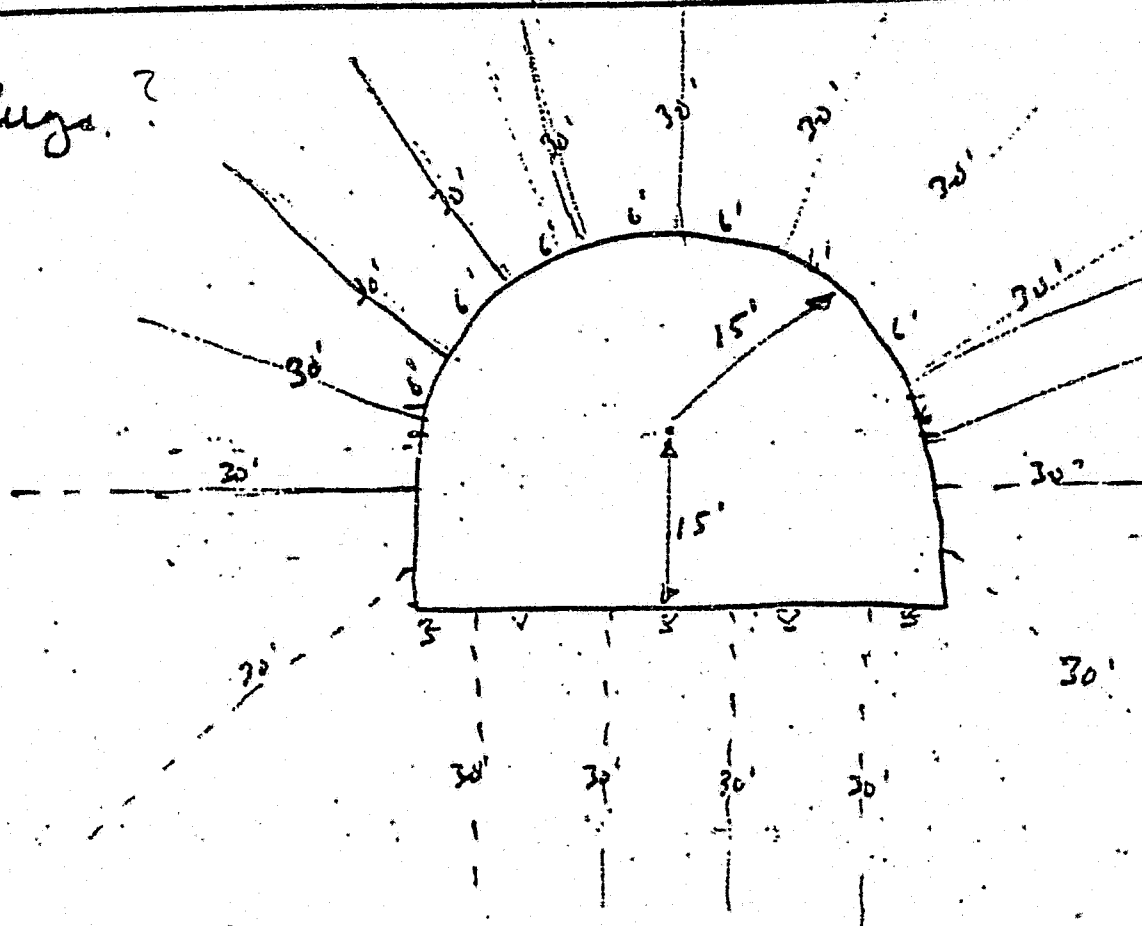
Power house cavern 250' @ 10 feet centres " " "

Surge chamber 200 @ 100 feet centres " " "

Additional 10% to allow for connection to drainage system and additional wet areas.

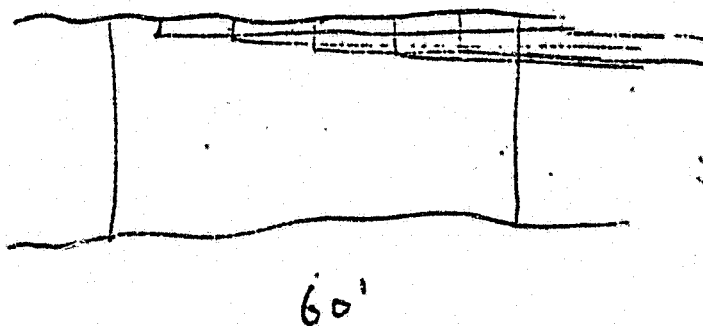
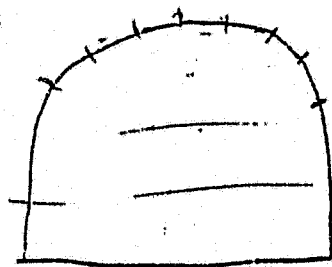
SUBJECT:

Curtain grating



Cement is good say. 5 lbs / ft drill hole.

7 No outlets per row
5 No rows.



Length of wire

7415 ~ 105.

1225 ft grout pipe.

Current for granting is decided
in rate for convert of policy



Calculations

SUBJECT:

WATANA

TUNNEL

ROCK

SUPPORTS

JOB NUMBER P5700-06
FILE NUMBER
SHEET OF
BY NAB DATE 13 Jan 8
APP DATE

RQD.	% Length of tunnel.	Q	Diversion Tunnel 40' ID Concrete lined 43' excavated diam $\frac{Span}{ESR} = 27 (27m)$ No Support	Access Tunnel. 35' Span (no concrete lining) $\frac{Span}{ESR} = 27 (27m)$ No support.	Penstock Tunnel. 17' ID. 21' excavated span Concrete lined $\frac{Span}{ESR} = 13 (14m)$ No support	Tailrace Tunnel. 35' ID. 38' excavated span Concrete lined $\frac{Span}{ESR} = 24 (24m)$ No support
95-100	28	49				
90-95	10	46	No support	No support	No support	No support
75-90	21	28	Spot bolting. (1 bolt every 10' of tunnel length)	Spot bolting	No support	No support
50-75	21	7	Bolts 5' centres. + 2" shotcrete crown. Spot bolting walls.	Bolts 5' centres. + 2" shotcrete crown. Spot bolting walls.	No support	Bolts 5' centres + 2" shotcrete crown. Spot bolting walls.
25-50	11	1.6	Bolts 3' centres + 2" shotcrete crown. Bolts 6' centre walls.	Bolts 3' centres + 2" shotcrete crown Bolts 6' centre walls.	Bolts 3' centres 2" shotcrete crown only	Bolts 3' centres + 2" shotcrete crown Bolts 6' centre walls.
6-25	9	0.4	concrete lined Steel sets or Bolts 3' centres + 6" shotcrete crown and walls	Steel sets, concrete lined or Bolts 3' centres + 6" shotcrete crown and walls	Bolts 3' centres 3" shotcrete crown + walls.	Steel sets concrete lined or Bolts 3' centres + 6" shotcrete crown and walls.



Calculations

SUBJECT: WATANA

POWER HOUSE CAVERNS.

JOB NUMBER	
FILE NUMBER	
SHEET	OF
BY	DATE
APP	DATE

R.Q.D	%	Powerhouse.	Surge Chamber	Transformer Gallery.
		Span 74' $\frac{Span}{Esa} = 74'$	Span 58' $\frac{Span}{Esa} = 58'$	Span 42' $\frac{Span}{Esa} = 42'$
100-95	40	Crown Rock bolts 6' centres	Ditto Powerhouse.	Rock bolts 6' centres crown (Grade 60)
95-90		Walls no support.		
90-75	20	Crown Rock bolts 6' centres (High Yield) Walls rock bolts 5' centres (Grade 60)	"	Rock bolts 6' centres crown (Grade 60) Spdt bolting walls
75-50	30	Crown Rock bolt 6' centres (High Yield)	"	Rock bolts 5' centres crown (Grade 60) Rock bolt 6' centres walls. (" -)
50-25		Walls Rock bolts 5' centres (Grade 60) + 4" concrete		
0-25	10%	Structural steel with ins. concrete 12" thick	"	Structural steel with ins. concrete 12" thick

① Spdt bolting say 10% of 6' centres pattern

For each opening allow.

Bus gallery	3 rows	6 per row	18 bolts per opening (as wall bolts)
Drip tube	3 rows	8 per row	24 bolts per opening (" -)
Penstock	3 rows	8 per row	24 bolts per opening (" -)
			31



Calculations

SUBJECT:

WATANA

POWER HOUSE

JOB NUMBER _____

FILE NUMBER _____

SHEET _____ OF _____

BY _____ DATE _____

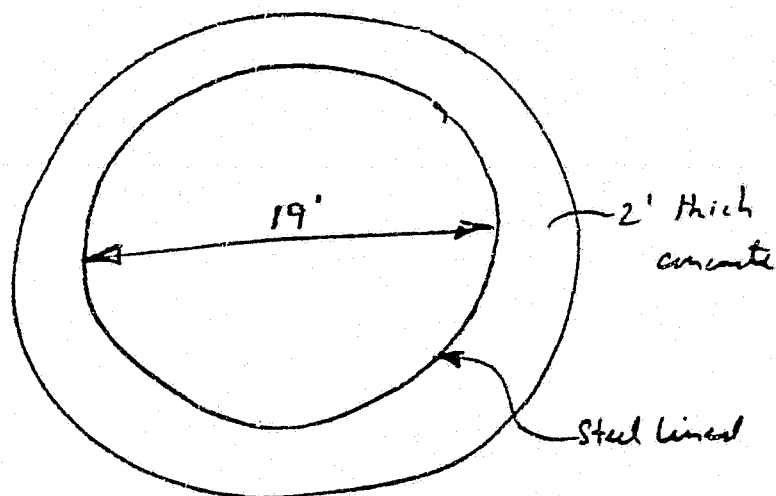
APP _____ DATE _____

DRAFT TUBE

No support over majority of tunnel length required. Allow substantial support each end at junction with cavern.

15' bolts $8 \times 8 = 64$ No.

For both ends 128 bolts 15' long per draft tube.

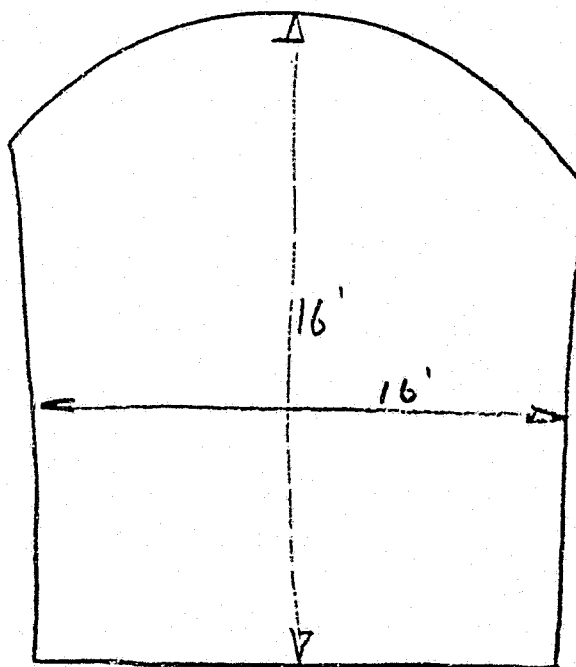


BW GALLERY

No support over majority of tunnel length required. Allow substantial support each end at junction with cavern.

15' bolts $6 \times 10 = 60$ No.

For both ends 120 bolts 15' long per bw gallery.





Calculations

SUBJECT:

WATANA

JOB NUMBER _____

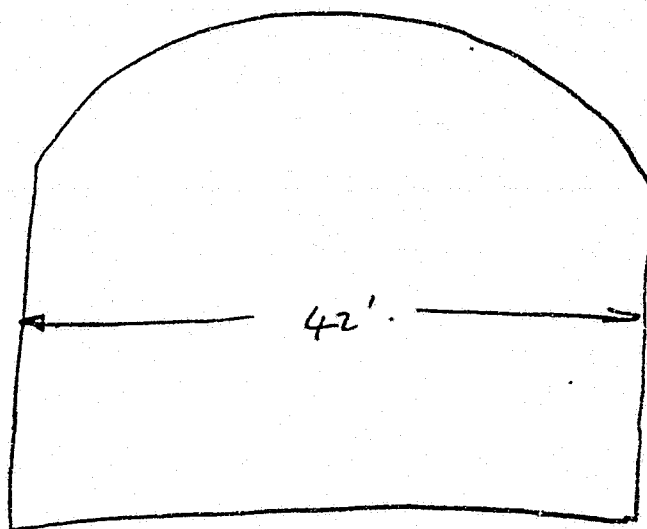
FILE NUMBER _____

SHEET _____ OF _____

BY _____ DATE _____

APP _____ DATE _____

TRANSFORMER GALLERY





Calculations

SUBJECT:

WATANA

POWER HOUSE
CAVERNS

JOB NUMBER _____

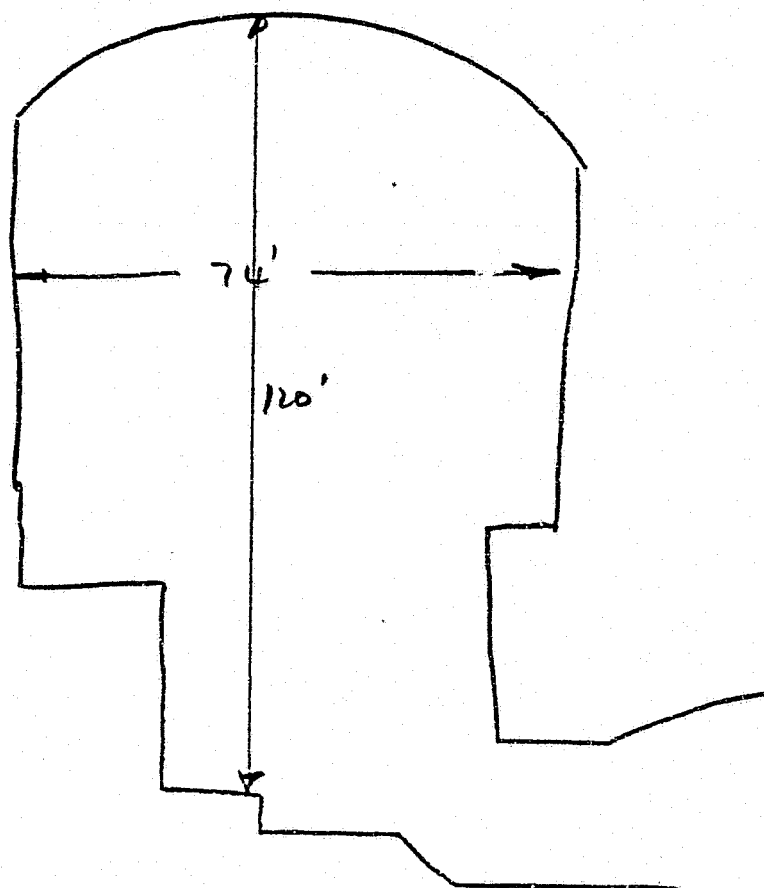
FILE NUMBER _____

SHEET _____ OF _____

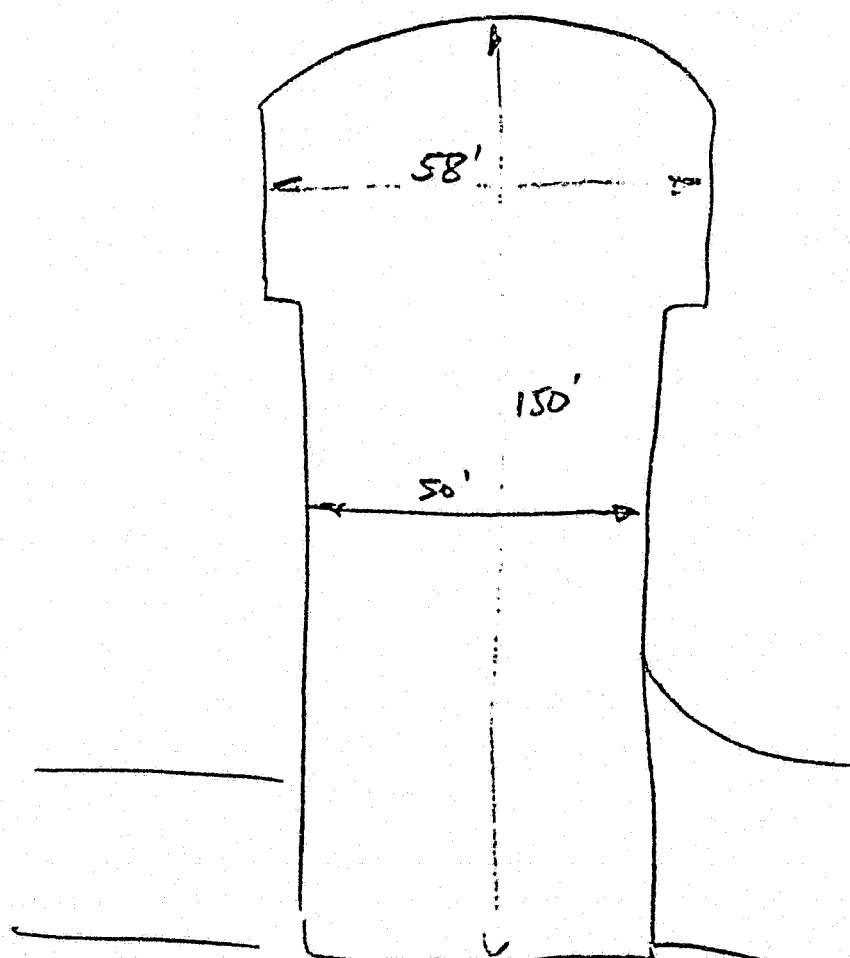
BY MAJB DATE 15 Jan 82

APP _____ DATE _____

POWER HOUSE



SURGE CHAMBER





Calculations

SUBJECT: SUSITNA.
WATANA FOUNDATION GROUTING & DRAINAGE
QUANTITIES

JOB NUMBER 5700 05
FILE NUMBER
SHEET 1 OF 7
BY MAJB DATE 15/12/81
APP DATE

Watana Grouting and Drainage.

Galleries 10' x 10'

Floor slab 6" thick. concrete unreinforced.

Tunnel support required

Rock bolts 6'-0" long. 3/4" dia.

3'-0" centres

i.e. 4 No bolts per 3 ft tunnel length.

Bolts required 25% of tunnel length

Additional bolts required at portals, junctions etc

26 No. @ 20 additional bolts = 520 bolts

Shotcrete

Assume 20% of tunnel length. Crown only. 12 feet surface width

Additional 520 feet for junctions & portals

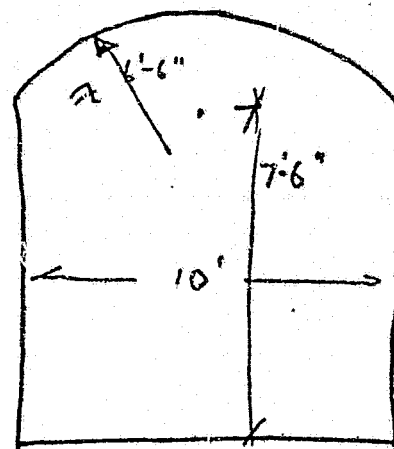
at 2" thick

Mesh 4" x 4" x 3/16" ϕ 20% of concrete area.

Steel Anchors 5% of tunnel length @ 3 feet centres.

4" x 4" column section with gusset plates, base plates and

Note 2 Access tunnels from
1500' el to d/s toe of dam
drainage outlet below tailwater level.
Not shown on SK 5700, 5701
with the shown on dam
drawing





Calculations

SUBJECT:

JOB NUMBER _____

FILE NUMBER _____

SHEET 2 OF 7

BY _____ DATE _____

APP _____ DATE _____

Shafts

10 feet diameter

Rock bolts 6'-0" long $\frac{3}{4}$ " dia.

Assume 6 bolts per 3' length of shaft.

25% length of shaft bolted.

Assume Shoring 2" thick full circumference.

25% of length of shafts.

Stairway and small elevator required each shaft.

Access tunnel portals

Portals within dam foundations entire rock bolts already allowed for.

Excavation included in dam items.

4 portals required downstream of dam.

Inclined Tunnel

Will require rail mounted car with electrical hoist for each inclined section.

Step formed in concrete slab will be required.



Calculations

SUBJECT:

SUSTNA.

JOB NUMBER P5700:06

FILE NUMBER _____

SHEET _____

OF _____

BY WATB

DATE 14/Jun 82

APP _____

DATE _____

DEVIL CANYON AND WATANA
POWER HOUSE CAVERNS.

Revised Rock bolts for caverns.

1" diam. High Yield steel ASTM A 722-75.

Using 0.6 of yield stress as working stress, working load
= 81.6 kips (Design load 80 kips.)

#14 bar.

Original 1 3/4" diam. grade 60 steel was getting too
heavy and requiring large hole size and greater amount
of resin grout.



Calculations

SUBJECT:

JOB NUMBER _____

FILE NUMBER _____

SHEET 2 OF 3

BY N/A DATE 12-5-82

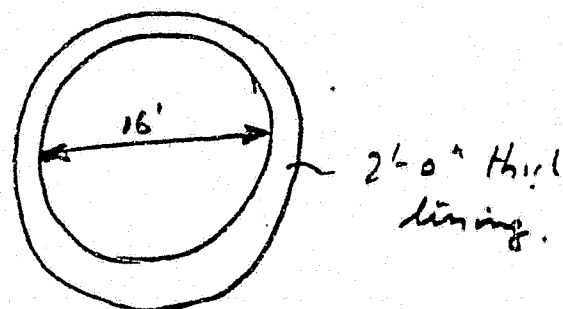
APP _____ DATE _____

Penstock Tunnel.

Rock bolt length
Crown 6' long.

Bolts not required below axis.

1" diam resin anchored resin grouted.



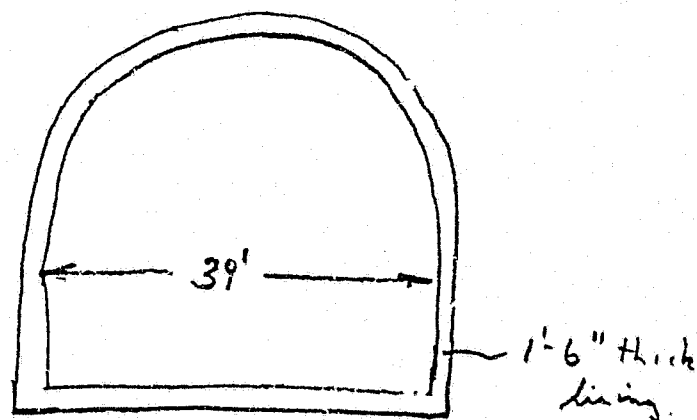
Tail race Tunnel.

Rock bolt length

Crown 12' long

Walls 9' long.

1" diam resin anchored resin grouted



Modified horseshoe.



Calculations

SUBJECT:

JOB NUMBER _____

FILE NUMBER _____

SHEET 3 OF 3

BY NADIS DATE 12 Jun 82

APP _____ DATE _____

CAVERNS

Powerhouse Cavern

75 ft span (height + length not yet fixed)

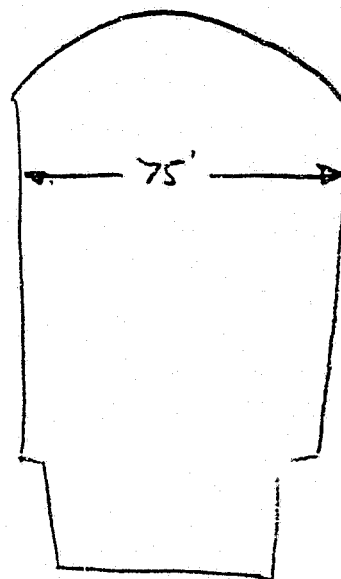
2.66''

Crown Rock bolt length 25' @ 6' centres each way.

1 3/4" diam bolt @ grade 60.

Resin anchored, resin grouted.

Walls rock bolt length 15' @ 5' centres each way.



Surge chamber.

Dimensions not yet fixed likely to be same as powerhouse

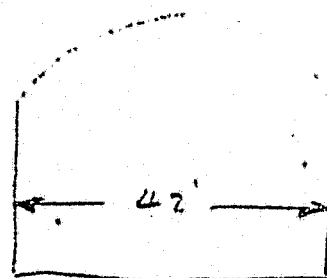
Rock bolts as powerhouse

Transformer gallery.

Crown Rock bolt length 15' @ 6' centres each way

1" diameter bolt @ grade 60

Resin anchored resin grouted



SCHEDULE 1

SUSITNA HYDROELECTRIC PROJECT
UNDERGROUND ROCK BOLTING
WATANA

STRUCTURE TUNNELS	LOCATION	SIZE	PERCENT TUNNEL LENGTH BOLTED		SPACING/PATTERN			
			38	28	7	11	9	
Diversion	Ceiling	1" x 12'	NA	1 Bolt/10 LF Tun	5' x 5'			
	Walls	1" x 9'	NA	NA	1 Bolt/10 LF Tun	6' x 6'	3' x 3'	
Main Access	Ceiling	1" x 12'	NA	1 Bolt/10 LF Tun	6' x 6'	3' x 3'	3' x 3'	
	Walls	1" x 9'	NA	NA	1 Bolt/10 LF Tun	6' x 6'	3' x 3'	
Penstock	Ceiling	1" x 6'	NA	NA	NA	3' x 3'	3' x 3'	
Tailrace	Ceiling	1" x 12'	NA	NA	5' x 5'	3' x 3'	3' x 3'	
	Walls	1" x 9'	NA	NA	1 Bolt/10 LF Tun	6' x 6'	3' x 3'	
Grout & Drainage	Ceiling	3/4" x 6'	NA	4 Bolts/3 LF Tun	NA	NA	NA	
<u>CHAMBERS</u>								
Powerhouse	Ceiling	1" x 25'		40	20	30	10	
	Walls	1" x 15'		6' x 6'	6' x 6' (High Yield)	6' x 6' (High Yield)	NA	
Surge Chamber	Ceiling	1" x 25'		NA	5' x 5'	5' x 5'	NA	
	Walls	1" x 15'		6' x 6'	6' x 6' (High Yield)	6' x 6' (High Yield)	NA	
Transformer Gallery	Ceiling	1" x 25'		NA	5' x 5'	5' x 5'	NA	
	Walls	1" x 15'		6' x 6'	6' x 6'	5' x 5'	NA	
<u>SHAFTS</u>								
Cable:			3/4" x 6'	4' x 4' pattern	25% of tunnel length			
Main Access:			3/4" x 6'	4' x 4' pattern	25% of tunnel length			
Grout & Drainage:			3/4" x 6'	6 Bolts/3LF shaft	25% of tunnel length			
Additional Bolts at Openings								
Bus Gallery				18 Bolts	1" x 25'			
Draft Tube				24 Bolts	1" x 25'			
Penstocks				24 Bolts	1" x 25'			

* Tunnels > 10' Diameter

** Tunnels < 10' Diameter

All Bolts Grade 60 Unless Noted

SCHEDULE 2SUSITNA HYDROELECTRIC PROJECT
UNDERGROUND ROCK STEEL SUPPORT
WATANA

<u>STRUCTURE</u>	<u>PERCENT OF TUNNEL LENGTH SUPPORTED</u>	<u>SPACING BETWEEN SETS</u>
Diversion Tunnels	NA	NA
Main Access Tunnels	NA	NA
Penstocks	NA	NA
Tailrace Tunnels	NA	NA
Grout & Drainage Galleries	5	3'
Powerhouse	10	
Surge Chamber	10	
Transformer Gallery	10	

Assume each set 4" x 4" columns at 13 lb/LF
plus 10% additional weight for tiebacks and hardware.

SCHEDULE 3

SUSITNA HYDROELECTRIC PROJECT
SHOTCRETE
WATANA

STRUCTURE	LOCATION	THICKNESS SHOTCRETE PERCENT OF TUNNEL LENGTH				
		38	28	7	11	9
Diversion*	Ceiling Walls	NA	NA	2"	2"	6"
		NA	NA	NA	NA	6"
Main Access Tunnels**	Ceiling Walls	NA	NA	2"	2"	6"
		NA	NA	NA	NA	6"
Penstock Tunnels*	Ceiling Walls	NA	NA	NA	2"	3"
		NA	NA	NA	NA	3"
Tailrace Tunnels*	Ceiling Walls	NA	NA	2"	2"	6"
		NA	NA	NA	NA	6"
Grout & Drainage Tunnels**	Ceiling	NA	NA	NA	2"	2"

All shafts 2" thick shotcrete 25% of length

Powerhouse &
Surge Chamber: 30% of ceiling area
30% of wall area

Transformer Gallery: NA

* Tunnels are concrete lined; shotcrete used as protective measure during construction until covered by concrete lining

** Grout & Drainage tunnels (tunnels <10' diameter) - 20% of shotcrete area to have steel mesh

*** Includes all tunnels >10' diameter

SCHEDULE 1

*Revised
by NAB 1/19*

SUSITNA HYDROELECTRIC PROJECT UNDERGROUND ROCK BOLTING WATANA

43

STRUCTURE TUNNELS	LOCATION	SIZE	PERCENT TUNNEL LENGTH BOLTED		SPACING/PATTERN		
Diversion	Ceiling	1" x 12'	38%	NA	1 Bolt/10 LF Tun	5' x 5'	11%
	Walls	1" x 9'	28%	NA	NA	3' x 3'	9%
Main Access *	Ceiling	1" x 12'	NA	1 Bolt/10 LF Tun	5' x 5'	6' x 6'	3' x 3'
	Walls	1" x 9'	NA	NA	1 Bolt/10 LF Tun	3' x 3'	3' x 3'
Penstock	Ceiling	1" x 6'	NA	NA	NA	3' x 3'	3' x 3'
Tailrace	Ceiling	1" x 12'	NA	NA	5' x 5'	3' x 3'	3' x 3'
	Walls	1" x 9'	NA	NA	1 Bolt/10 LF Tun	6' x 6'	3' x 3'
Grout & Drainage **	Ceiling	3/4" x 6'	NA	4 Bolts/3 LF Tun	NA	NA	NA

CHAMBERS

PERCENT AREA BOLTED →

			40%	20%	H.Y.	30%	H.Y.	10%
Powerhouse	Ceiling	1" x 25'	6' x 6'	6' x 6'	(High Yield)	6' x 6'	(High Yield)	NA
	Walls	1" x 15'	NA	5' x 5'	(High Yield)	5' x 5'	(High Yield)	NA
Surge Chamber	Ceiling	1" x 25'	6' x 6'	6' x 6'	(High Yield)	6' x 6'	(High Yield)	NA
	Walls	1" x 15'	NA	5' x 5'	(High Yield)	5' x 5'	(High Yield)	NA
Transformer Gallery	Ceiling	1" x 25'	6' x 6'	6' x 6'		5' x 5'		NA
	Walls	1" x 15'	NA	1/360 SF		6' x 6'		NA

SHAFTS

Cable:	3/4" x 6'	4' x 4' pattern	25% of tunnel length
Main Access:	3/4" x 6'	4' x 4' pattern	25% of tunnel length
Grout & Drainage:	3/4" x 6'	6 Bolts/3LF shaft	25% of tunnel length

CAF Additional Bolts at Openings

Bus Gallery	18 Bolts	1" x 25'
Draft Tube	24 Bolts	1" x 25'
Penstocks	24 Bolts	1" x 25'

per opening.

- * Tunnels > 10' Diameter
- ** Tunnels ≤ 10' Diameter

All Bolts Grade 60 Unless Noted *H.Y. (HIGH YIELD)*

Bolts also allowed for draft tube and bus galleries.

SCHEDULE 2

SUSITNA HYDROELECTRIC PROJECT
UNDERGROUND JACK STEEL SUPPORT
WATANA

44

<u>STRUCTURE</u>	<u>PERCENT OF TUNNEL LENGTH SUPPORTED</u>	<u>SPACING BETWEEN SETS</u>
Diversion Tunnels	NA	NA 4'
Main Access Tunnels	NA	NA 3'
Penstocks	NA	NA
Tailrace Tunnels	NA	NA 4'
Grout & Drainage Galleries	5 %	3' 4" x 4" @ 13 lb/ft.
Powerhouse	10 %	3' } 15" I beam. heavy section 3' } 3' } 10" x 10" @ about 33 lb/ft.
Surge Chamber	10 %	
Transformer Gallery	10 %	

Assume each set 4' x 4' columns at 13 lb/LF
plus 10% additional weight for tiebacks and hardware.

SCHEDULE 3

SUSITNA HYDROELECTRIC PROJECT
SHOTCRETE
WATANA

STRUCTURE	LOCATION	THICKNESS SHOTCRETE PERCENT OF TUNNEL LENGTH				
		38 %	28 %	7 %	11 %	9 %
Diversion*	Ceiling	NA	NA	2"	2"	6"
	Walls	NA	NA	NA	NA	6"
Main Access Tunnels**	Ceiling	NA	NA	2"	2"	8"
	Walls	NA	NA	NA	NA	8"
Penstock Tunnels*	Ceiling	NA	NA	NA	2"	3"
	Walls	NA	NA	NA	NA	3"
Tailrace Tunnels*	Ceiling	NA	NA	2"	2"	8"
	Walls	NA	NA	NA	NA	8"
Grout & Drainage Tunnels***	Ceiling	NA	NA	NA	2"	2"

OTHER

All shafts ~~2" thick shotcrete~~ 25% of length

Powerhouse &
Surge Chamber: $\rightarrow$ 30% of ceiling area
30% of wall area

Transformer Gallery: NA

* Tunnels are concrete lined; shotcrete ^{and rock bolts} used as ^{support} protective measure during construction until covered by concrete lining

** Grout & Drainage tunnels (tunnels <10' diameter) - 20% of shotcrete area to have steel mesh

*** Includes all tunnels >10' diameter



Calculations

SUBJECT:

WATANA

CONSOLIDATION GROUTING

JOB NUMBER _____

FILE NUMBER _____

SHEET _____ OF _____

BY _____ DATE _____

APP _____ DATE _____

	AREA GROUTED	PATTERN	DEPTH	GROUT TAKE
MAIN DAM	UNDER CORE AND FILTERS	10'x10'	30'	
SURFACE STRUCTURES	UPSTREAM OF - Dam G, will be grouted. Downstream of Dam F, each structure will be considered separately.	10'x10'	30'	
UPSTREAM COFFERDAM				
DOWNSTREAM COFFERDAM				



Calculations

SUBJECT: WATAWA

CURTAIN GROUTING

JOB NUMBER _____
FILE NUMBER _____
SHEET _____ OF _____
BY _____ DATE _____
APP _____ DATE _____

	HOLE DEPTH	SPACING	ROWS	GROUT TAKE
MAIN DAM	350' MAX. HEAD 50' ABUTMENTS	40' primary 5' QUATERNARY	2 ROW	
SURFACE STRUCTURES	50' MINIMUM *	40' primary 5' QUATERNARY	2 ROW	

* CONTINUATION OF MAIN DAM



Calculations

SUBJECT: WATANA

UNDERGROUND STRUCTURES

JOB NUMBER _____
FILE NUMBER _____
SHEET _____ OF _____
BY _____ DATE _____
APP _____ DATE _____

	BOLTED ITEM	BOLT PATTERN	LENGTH OF BOLTS	PERCENT OF AREA BOLTED
MAIN ACCESS TUNNELS				
SECONDARY ACCESS TUNNELS				
BUS TUNNELS/ SHAFT				
DIVERSION TUNNELS				
TAILRACE TUNNELS				
PENSTOCK				
MAIN ACCESS SHAFT				
CABLE SHAFT				



Calculations WATANA

SUBJECT:

ROCK BOLTS- STRUCTURES UNDER GROUND

JOB NUMBER _____
FILE NUMBER _____
SHEET _____ OF _____
BY _____ DATE _____
APP _____ DATE _____

	BOLTED ITEM	BOLT PATTERN	LENGTH OF BOLT	PERCENT OF AREA BOLTED
FIRE PROTECTION				
SURGE CHAMBER				
TRANSFORMER GALLERY				
DRAINAGE GALLERY				



Calculations

SUBJECT:

WATANA

ROCK BOLTS- STRUCTURES ABOVE GROUND

JOB NUMBER _____
FILE NUMBER _____
SHEET _____ OF _____
BY _____ DATE _____
APP _____ DATE _____

	BOLTED ITEM	BOLT PATTERN	BOLT LENGTH	PERCENT OF BOLTED AREA
POWER INTAKE	BASE SLAB CONCRETE WALLS EXPOSED ROCK			
CHUTE SPILLWAY	BASE SLAB CONCRETE WALLS EXPOSED ROCK			
TAILRACE PORTALS	BASE SLAB CONCRETE WALLS EXPOSED ROCK			
DIVERSION PORTALS	BASE SLAB CONCRETE WALLS EXPOSED ROCK			
ACCESS TUNNEL PORTALS	BASE SLAB CONCRETE WALLS EXPOSED ROCK			



Calculations

SUBJECT:

WATANA

DRAINAGE

JOB NUMBER _____

FILE NUMBER _____

SHEET _____ OF _____

BY _____ DATE _____

APP _____ DATE _____

HOLE DEPTH - FT.

SPACING - FT

HOLE DIAMETER _____

MAIN DAM

MIN. 100'

MAX. 400'

10'

SURFACE STRUCTURES

TUNNELS



Calculation Criteria, Data and References

Further estimate items
to be included

Project No. P5700

File No. P5700.14.09

Serial No.

11/6/81

TO: Dennis Mesthede

FROM: Lance Duncan

Due to our current fulltime commitments on rock mechanics criteria and borrow area quantity mining method codes, the following line items have not yet been addressed, but will be estimated in the next few weeks. I have listed items, and a very of-the-cuff (not even back of envelope) estimate of approximate dollar value likely to be assigned to each - recommend separate line items be established for these tasks in estimate.

WATANA

D. C.

Permafrost Thawing, # 25-50 (millions) # 5-10 # (millions)
Frost Detection

Instrumentation # 1-5 " # 1-5
(includes groundwater, stress, settlement, survey monuments) plus < 1/4 million per year maint. plus < 1/4 million per year maint.

Saddle Dam Drainage or Foundation Improvement # 1-10 " # ϕ

Seismic Monitoring Network < 1 million total plus < 50K/yr maint for both sites.

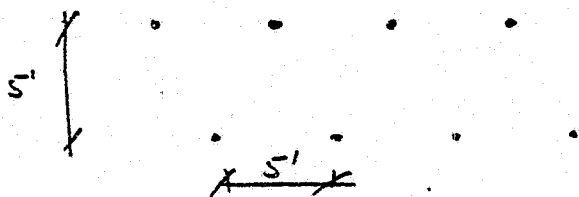


Calculations

SUBJECT: SUSITNA HYDRO ELECTRIC
PROJECT
WATANA DAM GROUT TAKES.

JOB NUMBER P5700 05
FILE NUMBER _____
SHEET 1 OF 5
BY NATB DATE 17 Nov 81
APP _____ DATE _____

Grout curtain - 2 Rows 5' centres.



RECEIVED 11/17/81

It is assumed that the grout will have a maximum penetration of 15' or minimum penetration of 5'

∴ Average width of grouted zone for two rows = 20'

For granite with permeability 10^{-4} to 10^{-5} cm/sec

n_a (porosity) = 1-4% at depth

= ... at ...

$$\text{Porosity} = \frac{\text{Volume of voids}}{\text{Total volume}}$$

For curtain grouting at depth assume worst case $n_a = 4\%$. This will allow for shear zones.

$$\begin{aligned} \text{Volume of rock treated per 1 ft of borehole} &= 5 \times 10 \times 1 \text{ ft}^3 \\ &= 50 \text{ ft}^3. \end{aligned}$$

$$\therefore \text{Volume of voids} = 2.0 \text{ ft}^3/\text{ft}$$

(volume of hole assuming 1 1/2" diam hole = 0.01 ft³/ft not worth considering for this estimate.)

Using average 3:1 water/cement ratio. by weight



Calculations

SUBJECT:

JOB NUMBER _____

FILE NUMBER _____

SHEET 2 OF 4

BY _____ DATE _____

APP _____ DATE _____

For 2 cu ft of grout Density of 3:1 w/c ratio by weight = 75 lbs/cu ft.
weight cement = 18.75×2
= 37.5 lbs / ft bore hole.

RECEIVED 11/17/81



Calculations

SUBJECT:

RECEIVED 11/17/81

JOB NUMBER _____

FILE NUMBER _____

SHEET 3 OF 4

BY _____ DATE _____

APP _____ DATE _____

Assuming 1 cu ft grout @ 3:1 mix density of 75 lb/cu ft.

Mix 56 lbs water 18.75 lbs cement

∴ for 2 cu ft of grout per linear ft borehole
= 37.5 lbs/ft.

For consolidation grouting

Grid 10' x 10' 40' deep.

Apart from outer row grouting will generally be confined.

1 ft of drill hole breaks 100 cu ft rock.

Assuming porosity of 4%

Volume of voids = 4 cu ft/ft.

Note - grouting near the surface will be at low pressure than at depth therefore less effective.

- The rock will be of a lower quality near the surface.

These two effects will tend to cancel each other out.

∴ Same porosity of 4% will be used.

Assume 1:1 water/cement ratio by weight. density of 1:1 mix = 95 lbs/cu ft.

∴ 47.5 lbs cement / cu ft.

190 lbs / ft bore hole.



Calculations

SUBJECT:

RECEIVED 11/7/80

JOB NUMBER _____

FILE NUMBER _____

SHEET 4 OF 4

BY _____ DATE _____

APP _____ DATE _____

Summary.

- 1) Curtain grouting Average 3:1 mix 37.5 lbs/ft borehole.
- 2) Consolidation grouting Average 1:1 mix 190 lbs/ft borehole.
- 3) 2% by weight of cement of bentonite will be added to all grout

Note

Grout densities used base on more reliable data than used in calculations for Devil Canyon.

Since difference is small it's not worth changing Devil Canyon at this stage.



Calculations

WATANA

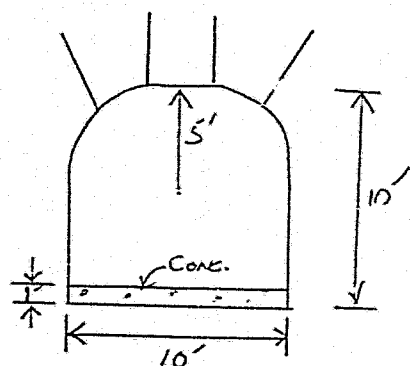
SUBJECT:

GROUTING / DRAINAGE TUNNELS

JOB NUMBER P5700.07
FILE NUMBER _____
SHEET _____ OF _____
BY SPM DATE 11/16/81
APP _____ DATE _____

	LF	TYPE	EXCAVATE CY	CONCRETE SLAB	# ROCK BOLTS	TOTAL LF BOLTS	TONS BOLTS	2" SHOTCRETE SF
MAIN DAM INCLINED	4550	A	15,061	1684	3640	14560	17	45500
RIGHT ABUTMENT	400	A	1324	148	320	1280	2	4000
LEFT ABUTMENT	600	A	1986	222	480	1920	3	6000

(A)



EXCAVATION

$$\text{END AREA} = 10(5) + (5)^2 \pi \frac{1}{2} = 89.3$$

$$\text{VOL/100 LF} = 89.3 \text{ SF} \times 100 \text{ FT} \times \frac{1 \text{ CY}}{27 \text{ FT}^3} = 331 \text{ CY/100 LF}$$

CONCRETE

$$\text{END AREA} = 10 \text{ SF}$$

$$\text{VOL/100 LF} = 37.0 \text{ CY/100 LF}$$

ROCK BOLTS

4' LONG

1" ϕ 2'-6" O.C. PATTERN

50% OF LENGTH

.8/LF TUNNEL

SHOTCRETE

Assume 2' FOR

10% WIDTH OF CR. N

FULL LENGTH



Calculations WATANA

SUBJECT:

CONSOLIDATION GROUTING

JOB NUMBER P5700.09

FILE NUMBER _____

SHEET _____ OF _____

BY _____ DATE _____

APP _____ DATE _____

	Area Grouted	Grouted Area $\frac{sq}{ft}$	Pattern	Depth ft.	LF Holes	Grout TAKE (CF) $\frac{4CF}{FT}$
MAIN DAM	UNDER CORE & FILTERS	2,224,820	10x10	40	889920	3,559,680
POWER INTAKES + CUTE SPELLWAY INTAKE	UNDER STRUCTURE	42250	10x10	40	16,900	67,600
SADDLE DAM						
U/S COFFERDAM						
D/S COFFERDAM						



Calculations

SUBJECT:

WATANA

GROUT CURTAIN

JOB NUMBER P5700.09

FILE NUMBER _____

SHEET _____ OF _____

BY _____ DATE _____

APP _____ DATE _____

	Ave Depth - FT.	SPACING FT.	CURTAIN LENGTH FT	ROWS !	TOTAL LENGTH	GROUT TAKE 2CF/LF (CF)
MAIN DAM	200'	5'	4550'	2	364,000	728,000
LEFT ABUTMENT	50'	5'	600	2	12,000	24,000
RIGHT ABUTMENT	200'	5'	400	2	32,000	64,000



Calculations

SUBJECT:

WATANK
DRAINAGE HOLES

JOB NUMBER P5700.09

FILE NUMBER _____

SHEET _____ OF _____

BY GEM DATE 11/16/91

APP _____ DATE _____

	Ave Depth Ft.	Spacing Ft.	Length of Run Ft.	Total Length Holes - LF
MAIN	250'	10'	4550'	113,750
LEFT ABUTMENT	100'	10'	600	6000
RIGHT ABUTMENT	250'	10'	400	10,000



Calculations SUSITWA

SUBJECT: WATANIA - MAIN DAM

CONSOLIDATION GROUTING

JOB NUMBER P5700.09

FILE NUMBER _____

SHEET _____ OF _____

BY WAK DATE 11/13/81

APP _____ DATE _____

REFERENCE: "X" Sects By WAK 9/15 & 9/17/81
Tadr By DM 11 Sept 81

<u>ELEV</u>	<u>SLOPE DIST</u>	<u>WIDTH</u>	<u>AREA</u>
2240		82	
	150'		12300
2200		82	
	930'		287370
2000		227	
	550		161425
1800		360	
	280		119560
1600		494	
	260		145730
1400		427	
	130		83590
1320		659	
	120		79080
1320		659	
	150		96450
1400		627	
	350		196175
1600		494	
	360		153720
1800		360	
	550		161425
2000		227	
	630		97335
2200		82	
	130		10660
2240		82	
1350-1430 D/s (Sect 800) 400 x 1550			620000
			2,224,820 ft ²
2224820 / 100 = 22248 holes x 30 =			889920
			667,500 LF



Calculations SUSITN.7

SUBJECT: WATANA - SERVICE SPILLWAY.
INTAKE, POWER INTAKE, + CHUTE
SPILLWAY CONSOLIDATION GROU.

JOB NUMBER P5700.09
FILE NUMBER _____
SHEET _____ OF _____
BY GEM DATE 11/16/91
APP _____ DATE _____

POWER INTAKE

$$100' \times 270' = 27000 \text{ SF}$$

SERVICE SPILLWAY INTAKE

$$60' \times 100' = 6000 \text{ SF}$$

CHUTE SPILLWAY INTAKE STRUCTURE

$$\frac{1}{2}(170 + 200)50 = \underline{9250 \text{ SF}}$$

↑

SCALED FROM DRAWING No. 42250 SF

SK-5700-C6-218

$$42250 \text{ SF} / 10' \times 10' \times \frac{40'}{30'} \text{ HOLE} = \frac{16900}{2675} \text{ LF OF HOLE}$$



Calculations

SUBJECT:

WATANA

CURTAIN GROUTING

JOB NUMBER P5700.09

FILE NUMBER

SHEET

OF

BY GEM

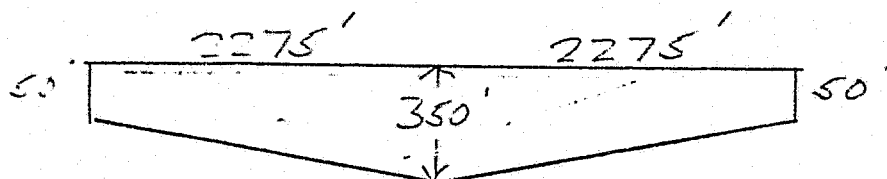
DATE 11/13/81

APP

DATE

MAIN DAM

4550 LF



$$50' \cdot 350' = 400' \cdot \frac{1}{2} = 200' \text{ AVE HOLE DEPTH}$$

$$4550' / 5' \text{ SPACING} = 910 \text{ HOLES} \times 2 \text{ ROWS} = 1820 \text{ HOLES}$$

$$1820 \text{ HOLES} \times 200' \text{ / HOLE} = 364,000 \text{ LF OF HOLE}$$

RIGHT ABUTMENT

400' - LENGTH

200' - DEPTH

$$400' / 5' \text{ SPACING} = 80 \text{ HOLES / ROW} \times 2 \text{ ROWS} = 160 \text{ HOLES}$$

$$160 \text{ HOLES} \times 200' \text{ / HOLE} = 32,000 \text{ LF OF HOLE}$$

LEFT ABUTMENT

600' - LENGTH

50' - DEPTH

$$600' / 5' \text{ SPACING} = 120 \text{ HOLES / ROW} \times 2 \text{ ROWS} = 240 \text{ HOLES}$$

$$240 \text{ HOLES} \times 50' = 12,000 \text{ LF OF HOLE}$$