The Role of Geology in the Construction of the Lake Dorothy Hydroelectric Project

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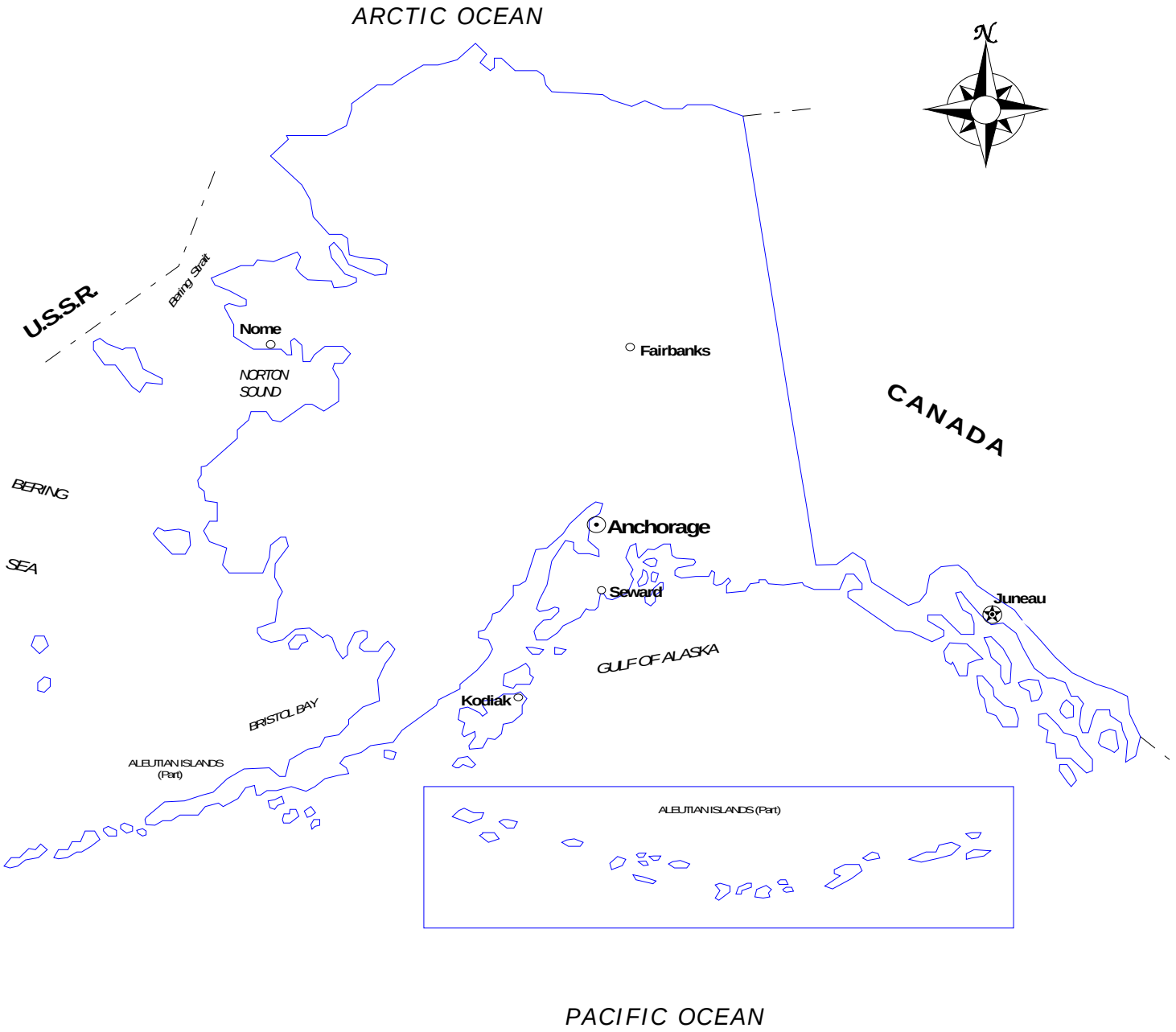
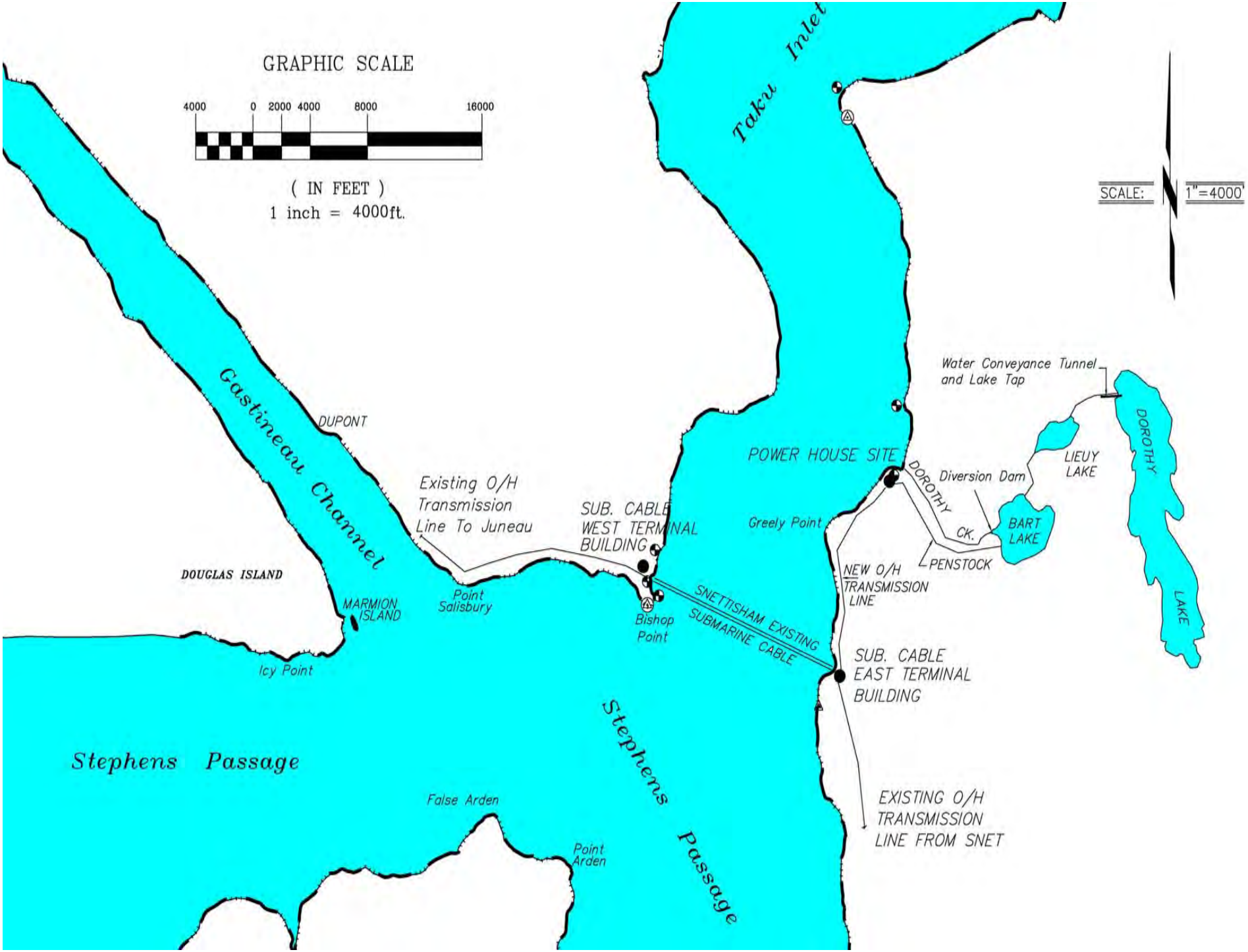
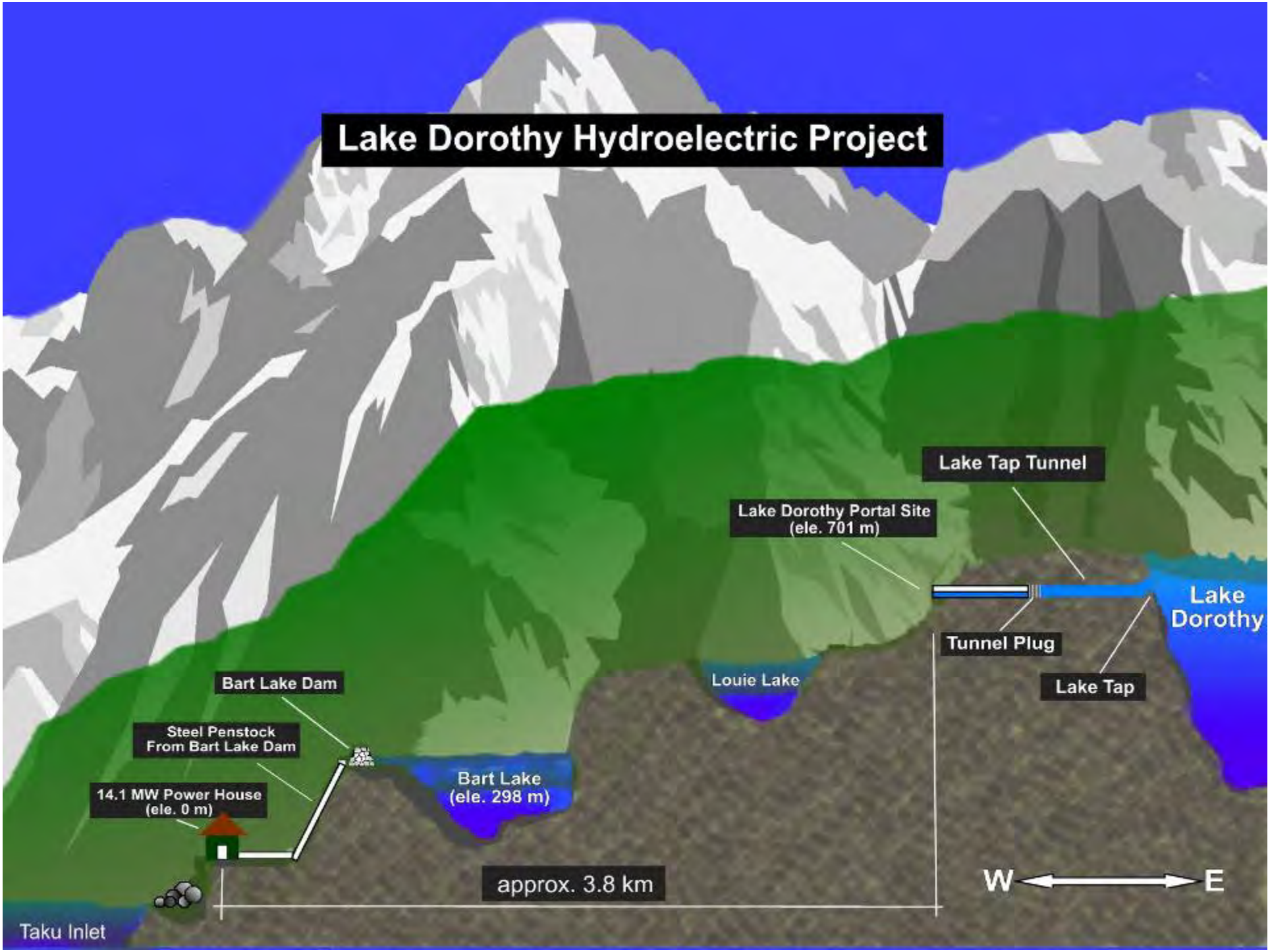

ARCTIC OCEAN
N
U.S.S.R.
Bering Strait
Nome
NORTON SOUND
Fairbanks
CANADA
BERING SEA
Anchorage
Seward
Juneau
GULF OF ALASKA
Kodiak
BRISTOL BAY
ALEUTIAN ISLANDS (Part)
ALEUTIAN ISLANDS (Part)
PACIFIC OCEAN


Skagway
Haines
Tongass National Forest
Mendenhall Glacier
Juneau
Douglas
Gustavus
Icy Strait
Hoonah
Elfin Cove
Pelican
Chichagof Island
Tenakee
Admiralty Island
Gulf of Alaska
Angoon
Lake Dorothy Project


GRAPHIC SCALE
4000 0 2000 4000 8000 16000
(IN FEET)
1 inch = 4000ft.
SCALE: 1"=4000'
Taku Inlet
Gastineau Channel
DUPONT
DOUGLAS ISLAND
MARMION ISLAND
Icy Point
Point Salisbury
Existing O/H Transmission Line To Juneau
SUB. CABLE WEST TERMINAL BUILDING
Bishop Point
SNETTISHAM EXISTING SUBMARINE CABLE
POWER HOUSE SITE
Greely Point
DOROTHY CK.
Diversion Dam
PENSTOCK
BART LAKE
LIEUY LAKE
Water Conveyance Tunnel and Lake Tap
DOROTHY LAKE
NEW O/H TRANSMISSION LINE
SUB. CABLE EAST TERMINAL BUILDING
EXISTING O/H TRANSMISSION LINE FROM SNET
Stephens Passage
False Arden
Point Arden
Stephens Passage


Lake Dorothy Hydroelectric Project
Lake Tap Tunnel
Lake Dorothy Portal Site
(ele. 701 m)
Lake
Dorothy
Tunnel Plug
Lake Tap
Louie Lake
Bart Lake Dam
Steel Penstock
From Bart Lake Dam
Bart Lake
(ele. 298 m)
14.1 MW Power House
(ele. 0 m)
approx. 3.8 km
W
E
Taku Inlet

REGIONAL CHARACTERIZATION OF BEDROCK

- Landforms Shaped by Pleistocene Glaciation
- Ice Carved Valleys, Often With Deep Lakes
- Rock Generally Hard and Competent

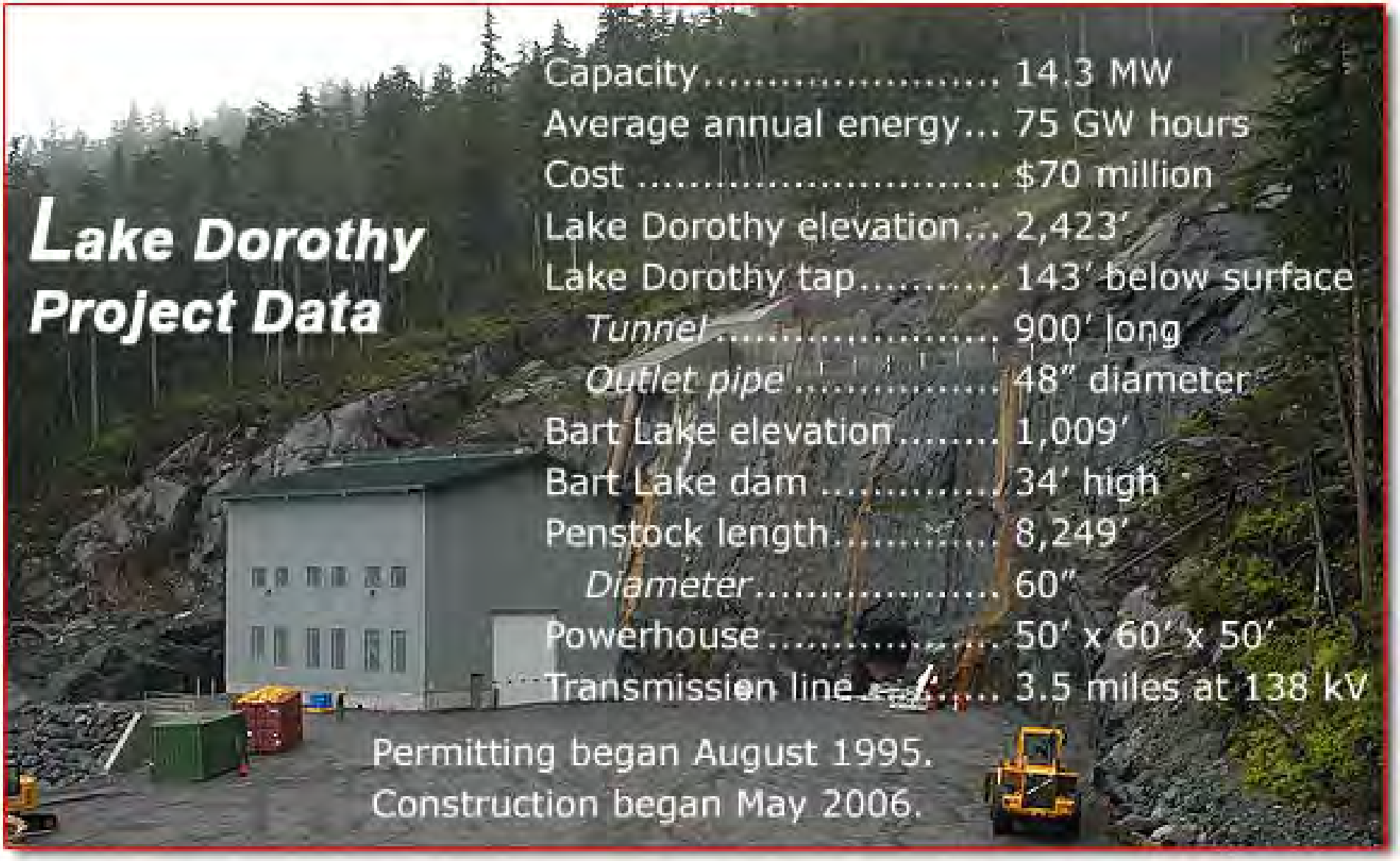
Predominant Bedrock at Project

Composite of:

- Granodiorite,
- Quartz Diorite (tonalite)
- and related plutonic (deep intrusive) Bedrock Types
- Strong Gneissic Characteristics

Characterized as:

- Very Strong
- Competent
- Metamorphosed
- Wavy
- Alternating Dark & Light Bands


Lake Dorothy
Project Data
Capacity ..... 14.3 MW
Average annual energy... 75 GW hours
Cost ..... $70 million
Lake Dorothy elevation... 2,423'
Lake Dorothy tap..... 143' below surface
Tunnel ..... 900' long
Outlet pipe ..... 48" diameter
Bart Lake elevation..... 1,009'
Bart Lake dam ..... 34' high
Penstock length..... 8,249'
Diameter ..... 60"
Powerhouse ..... 50' x 60' x 50'
Transmission line ..... 3.5 miles at 138 kV
Permitting began August 1995.
Construction began May 2006.

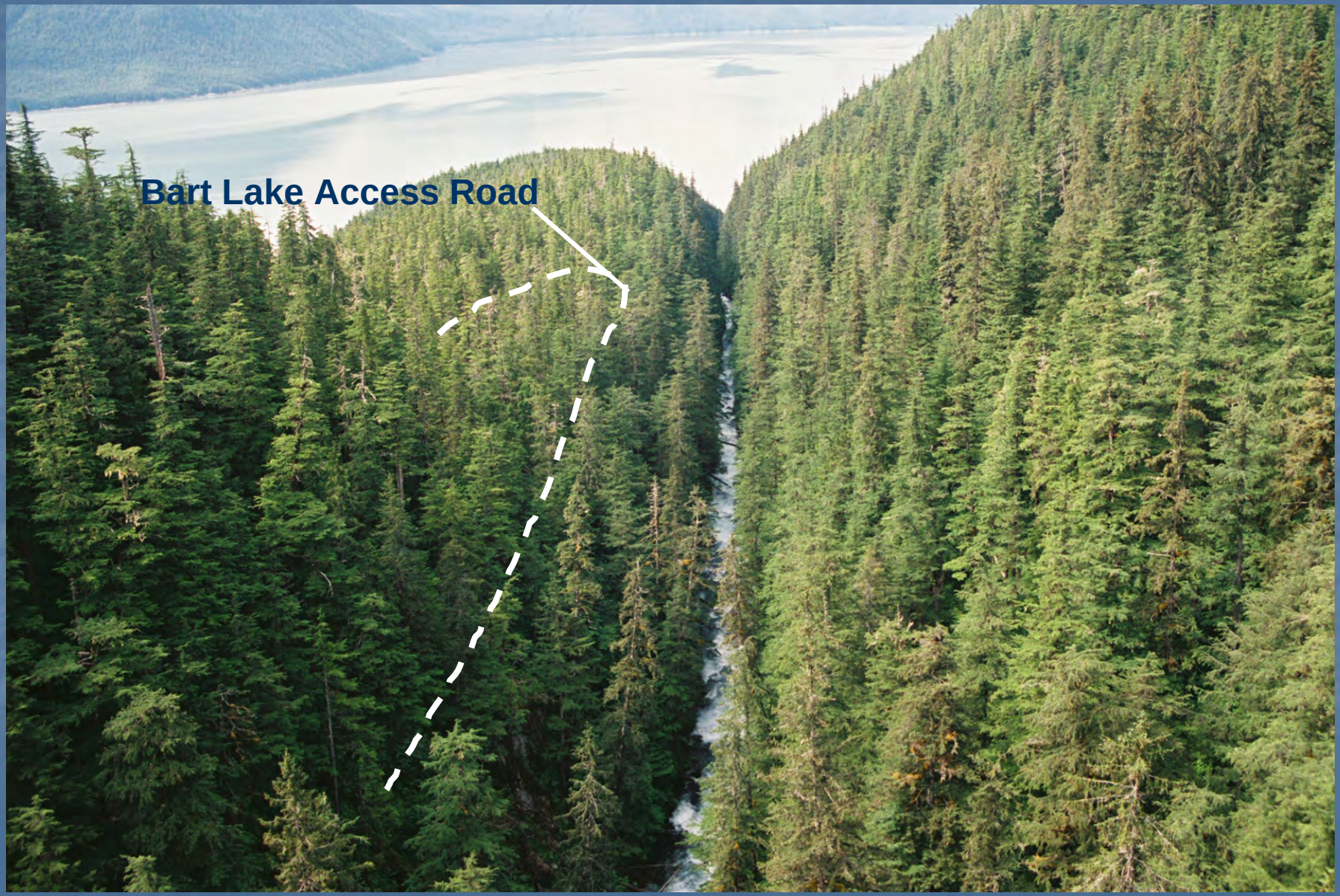

LATE MAY 2006 – GETTING STARTED
Access by Water
KOBELCO


Powerhouse Site

Upper sites by Helicopter

Construct 8,000 ft. of Access Road to Reach Bart Lake


Access Road
Substation &
Camp
Powerhouse
Shop & Crew
Quarters
Barge Landing Facility


Bart Lake Access Road


Road to Bart Lake


Creek


Slides Block Dorothy Creek


Top Slope Slides
Became a Growing
Problem


Morning
Surprise


Losing Downhill Slope

Abandon Higher Heading and Drop Alignment

rial view of the roadway from about Station 98 to about Station 106. 10/20/2007

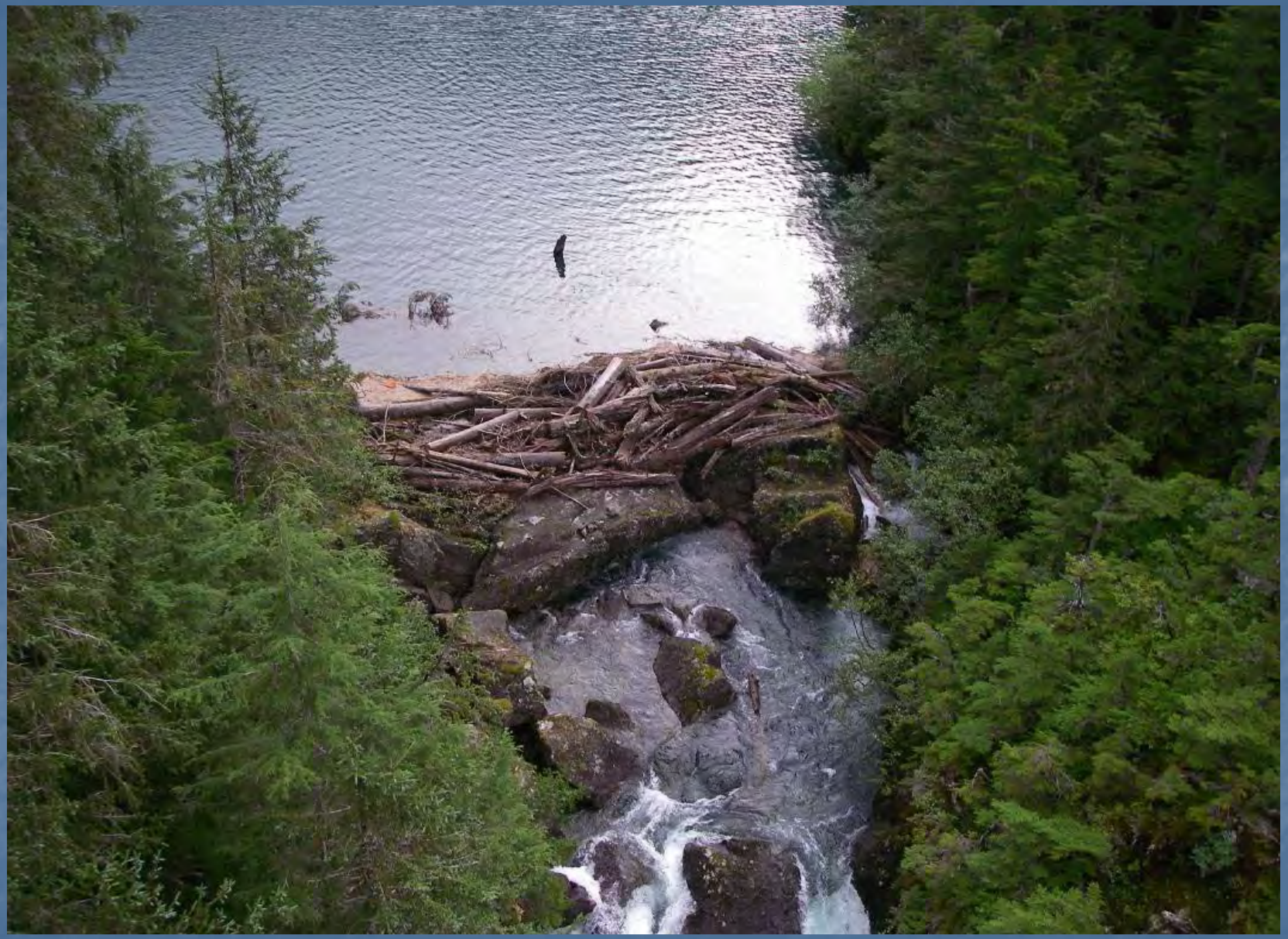
Completed Road

The Cat 375 worked to clear a talus slide above the road in the area of Station 84. 5/16/2008

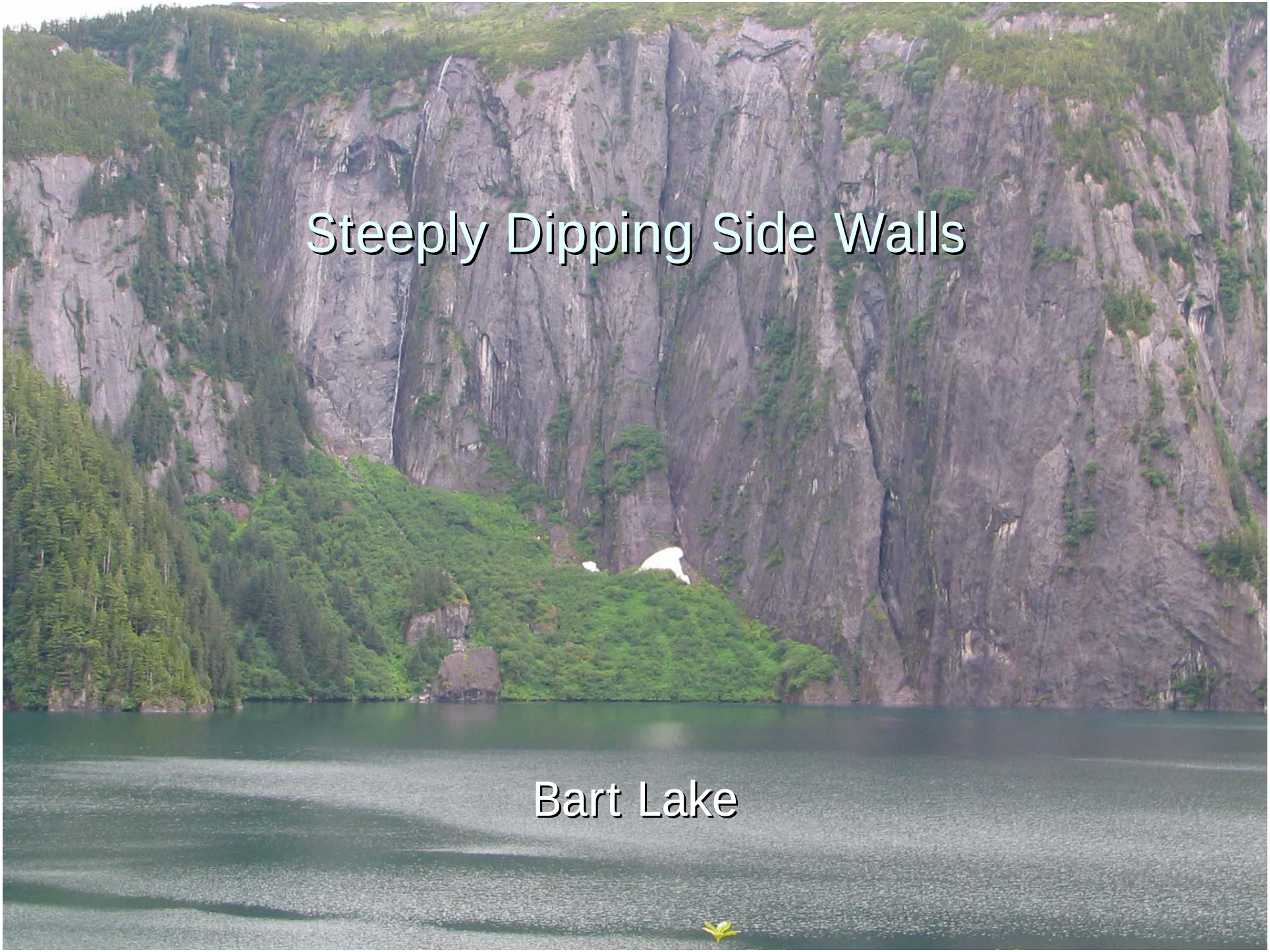
Slides

Bart Lake Dam

- 36-foot-high rockfill structure with an impervious core
- No site exploration
- Basis of Design: Visual observations that when lake level drops to elevation 985 ft, no outflow is seen from the lake.
- Therefore; Bedrock is “just below the debris pile”



The debris dam at Bart Lake, 9/17/2007


Steeply Dipping Side Walls
Bart Lake

Site Inaccessable

Bart Lake site, 10/04/2007

Field Survey of Bart Lake Dam Site . 10/13/2007


Begin Clearing Debris
Dam


CAT
No Bedrock Found


Near Vertical Rock Face
Talus Slope Material
End of 2007 Construction Session


CAT
375
CAT
4/02/2008


CAT

Dashed line indicates proposed dam axis

Bedrock much deeper than expected – change design

An aerial view of the near vertical rock along the right abutment.


Bart Lake 6/4/2008


First attempt to drill for bedrock
4/26/2008

July 22, 2008

Rockfill Dam Designs

- Concrete Core Wall
- Sheetpile Wall with Concrete Plinth
- Asphalt Core Wall
- Upstream Asphalt Face
- Upstream Concrete Face
- Concrete Face with Upstream Bituminous Geo-Membrane Seepage Blanket


Two 24-Diameter Low
Level Outlet Pipes
Encased in Concrete


CAT


CAT


Toe
Plinth
Low Level
Outlet
Works
Dewatering Pipes


Friday
5/09/2009

Arrive on Site May 12, 2009 – Surprise!

Overlay Geo-Membrane with 18-in of ¾-minus material


Mats overlapped 18 inches
Propane torch

Construction of concrete face panels


Grouted Riprap on downstream face


Time to start filling Bart Lake


7/06/09 FILLING BART LAKE
Reservoir Elevation 985 feet


Elev. 985 ft, 7/10/2009


7/20/2009


7/26/2009


Elevation 995 Ft.


7/28/2009; Elev. 995 ft

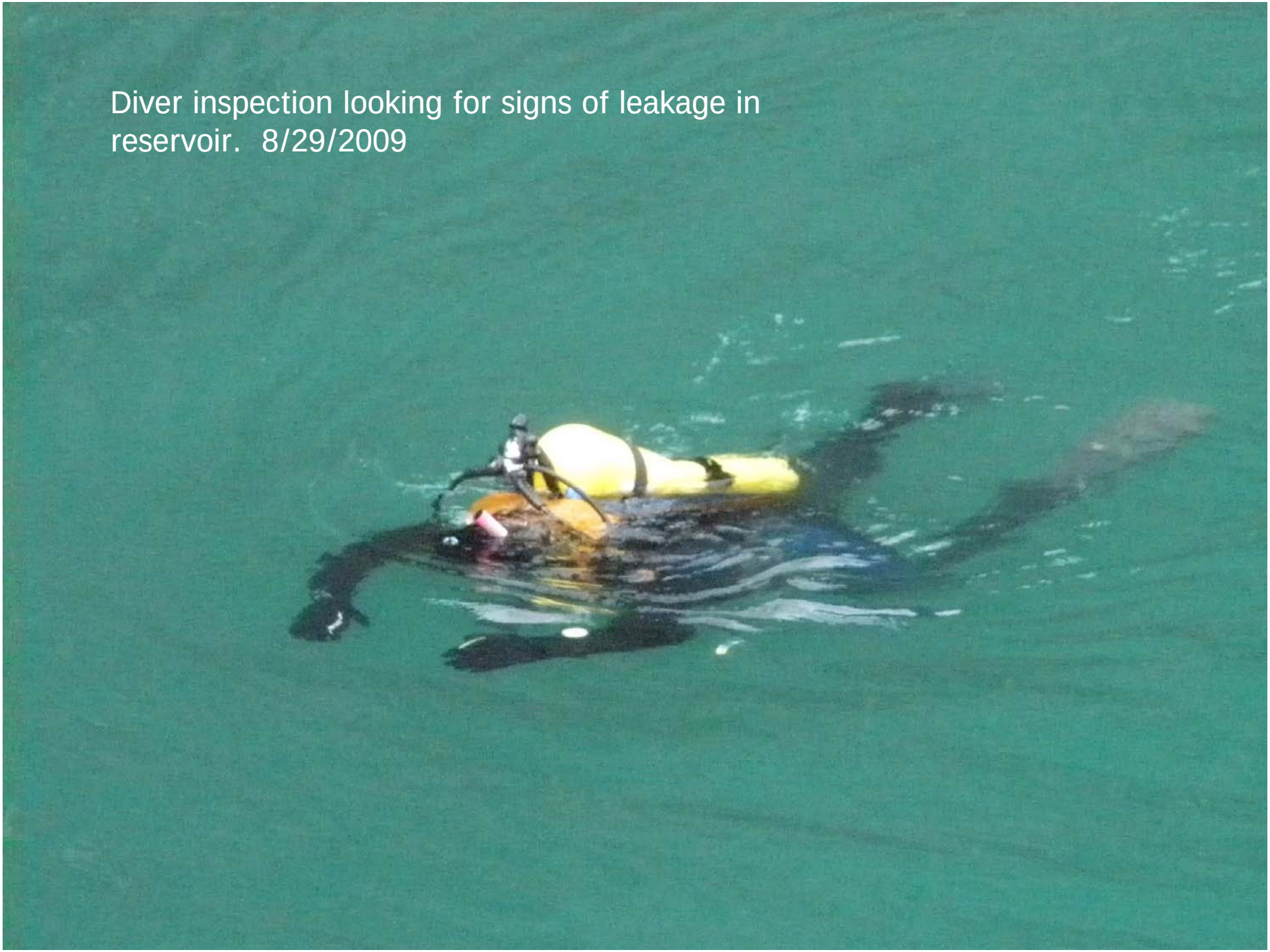

Elevation 1000 ft
8/19/2009
3.8 cfs


4.2 cfs
8-26-2009 at 1003.2'


Elev. 1008, 8/31/2009


6.4 cfs
10-2-2009 at 1008.6'


Dye tests were inclusive



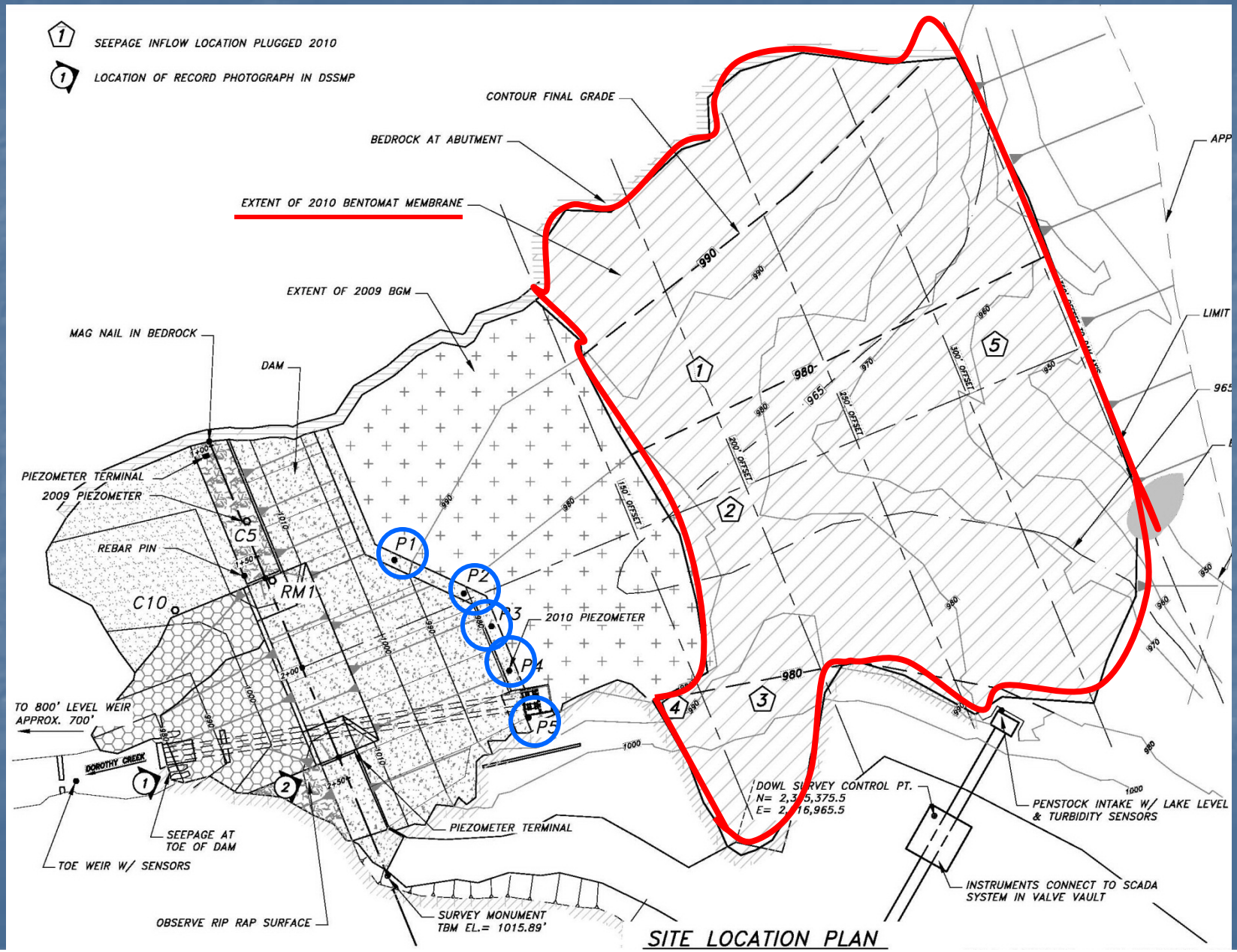
Diver inspection looking for signs of leakage in reservoir. 8/29/2009

Drilling left abutment for seepage joints


Oct. 29, 2009.
5.2 cfs

Owner Directed to Develop Seepage Remediation Plan

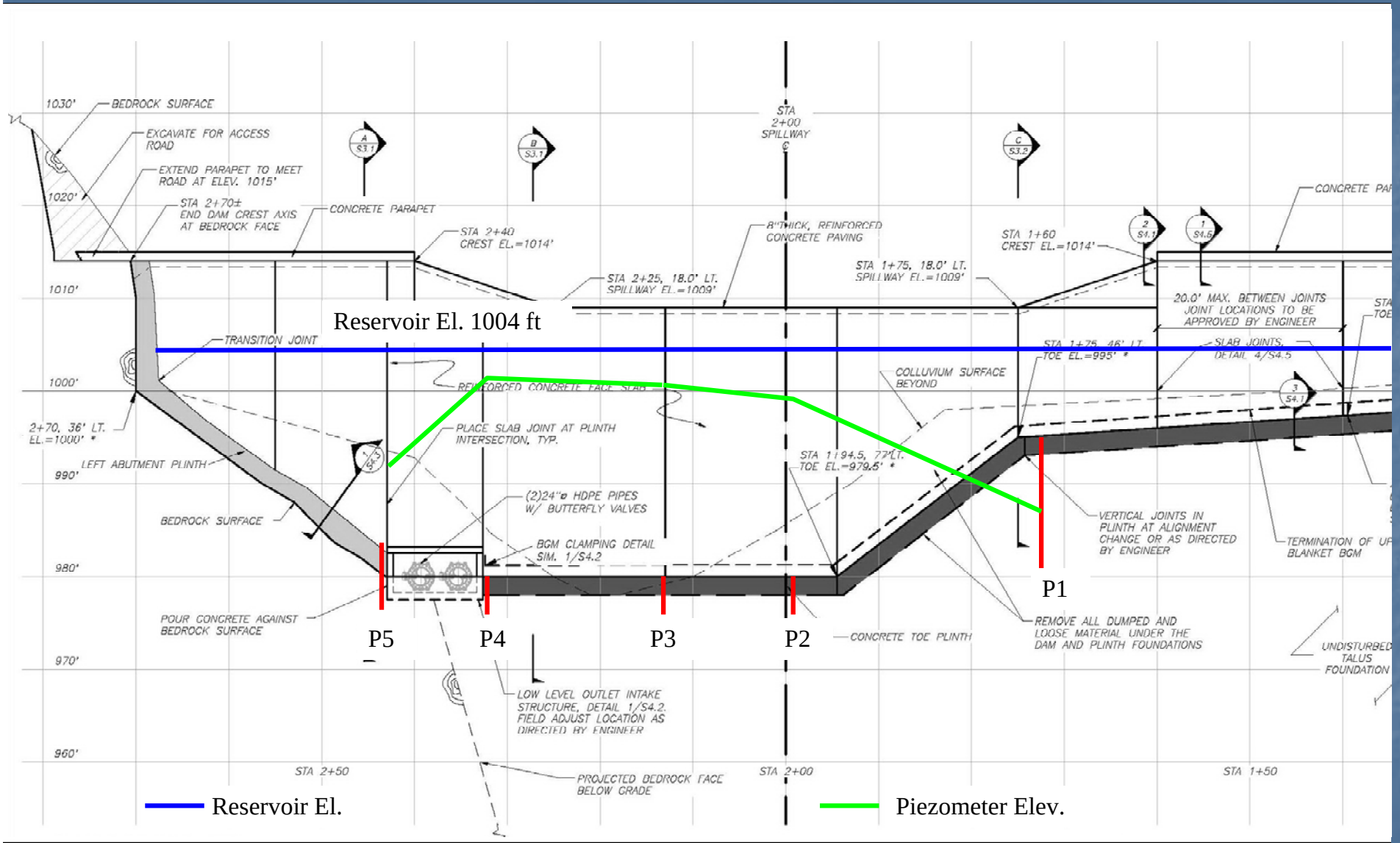
2010 Upstream Blanket Extension



Installation of Bentomat Membrane almost complete

And Fill Reservoir


No Change in Seepage
6.9 cfs
7-30-2010 at 1008.2'


Reservoir El. 1004 ft
1030'
BEDROCK SURFACE
EXCAVATE FOR ACCESS ROAD
EXTEND PARAPET TO MEET ROAD AT ELEV. 1015'
1020'
STA 2+70± END DAM CREST AXIS AT BEDROCK FACE
CONCRETE PARAPET
STA 2+40 CREST EL.=1014'
1010'
STA 2+25, 18.0' LT. SPILLWAY EL.=1009'
8"THICK, REINFORCED CONCRETE PAVING
STA 2+00 SPILLWAY ℄
STA 1+60 CREST EL.=1014'
STA 1+75, 18.0' LT. SPILLWAY EL.=1009'
20.0' MAX. BETWEEN JOINTS JOINT LOCATIONS TO BE APPROVED BY ENGINEER
CONCRETE PAR
TRANSITION JOINT
1000'
REINFORCED CONCRETE FACE SLAB
COLLUVIUM SURFACE BEYOND
STA 1+75, 46' LT. TOE EL.=995' *
SLAB JOINTS, DETAIL 4/S4.5
2+70, 36' LT. EL.=1000' *
PLACE SLAB JOINT AT PLINTH INTERSECTION, TYP.
LEFT ABUTMENT PLINTH
990'
STA 1+94.5, 77' LT. TOE EL.=979.5' *
(2)24"ø HDPE PIPES W/ BUTTERFLY VALVES
BEDROCK SURFACE
BGM CLAMPING DETAIL SIM. 1/S4.2
VERTICAL JOINTS IN PLINTH AT ALIGNMENT CHANGE OR AS DIRECTED BY ENGINEER
TERMINATION OF UP BLANKET BGM
980'
P1
POUR CONCRETE AGAINST BEDROCK SURFACE
P5
P4
P3
P2
CONCRETE TOE PLINTH
REMOVE ALL DUMPED AND LOOSE MATERIAL UNDER THE DAM AND PLINTH FOUNDATIONS
UNDISTURBED TALUS FOUNDATION
970'
LOW LEVEL OUTLET INTAKE STRUCTURE, DETAIL 1/S4.2. FIELD ADJUST LOCATION AS DIRECTED BY ENGINEER
960'
STA 2+50
PROJECTED BEDROCK FACE BELOW GRADE
STA 2+00
STA 1+50
Reservoir El.
Piezometer Elev.

After Another Year of Operation

- Seepage remains constant at given elevation
- Very little turbidity seen on monitoring pans
- Keep 5-foot drawdown (Elev.1004)
- Real time readings for the 5 piezometers
- Check daily (weather permitting)

Geologic Issues

- Rapidly changing rock quality made blasting very difficult
- Dip of bedrock resulted in slope stability problems
- Foundation conditions at Bart Lake resulted seven different dam designs
- Added two years to construction

At the Beginning of Each Project The Question is Often Asked:

How much exploration is enough?

Does the benefit of the exploration out weigh the cost and the potential delay of the project?

We grow too soon old,
and too late smart