City of Newport
Big Creek Dams – Securing Water System Resiliency

Mid-Coast Water Planning Partnership
04-23-2019

The problem, the risks, and the plan for addressing the seismic deficiencies of the Big Creek Dams

Presented by
Timothy Gross, P.E.
Director of Public Works/City Engineer
City of Newport, OR

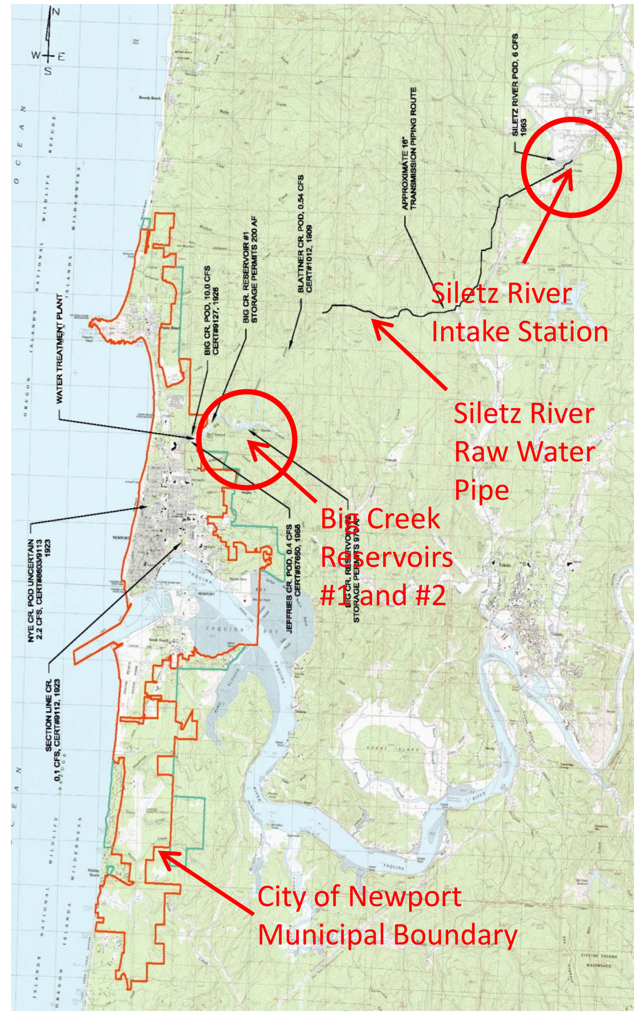
Background: How the Water System of Newport Works

City of Newport
Statistics/Watersheds/Water Rights

Statistics
- Population
  - 10,000 regular residents
  - Up to 50,000 with tourists
- Production
  - 764 MG in FY 17-18
  - average 2 MGD, max 5 MGD
- Large water dependent industrial base

Watersheds
- Primary Watersheds:
  - Siletz River Watershed (200 sq mi)
  - Big Creek Watershed (3.3 sq mi)

Water Rights
- Water rights in 10 different locations
- Primary water rights:
  - Big Creek
    10 CFS (4,488 GPM/6.46 MGD)
  - Siletz River Diversion
    6 CFS (2,700 GPM/3.88 MGD)



Siletz River Intake Station and Raw Water Line

Siletz Intake Station

- 3-200 HP Pump
- 208 psi discharge pressure

Siletz Raw Water Line

- 5.7 miles of pipe
- 550’ of elevation change
- 1.9 miles of open channel flow
- Total Distance from intake to reservoir: 7.6 miles

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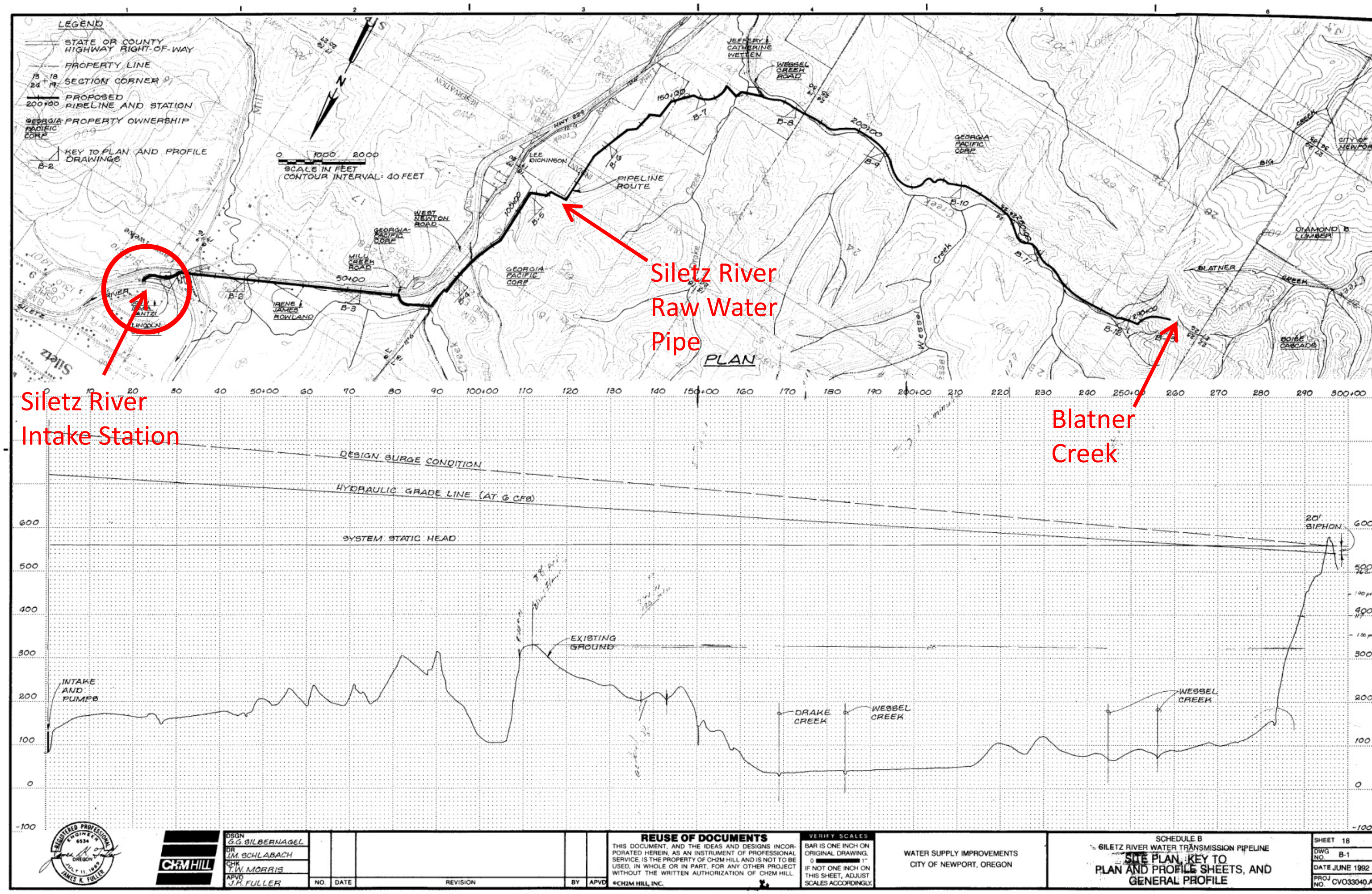
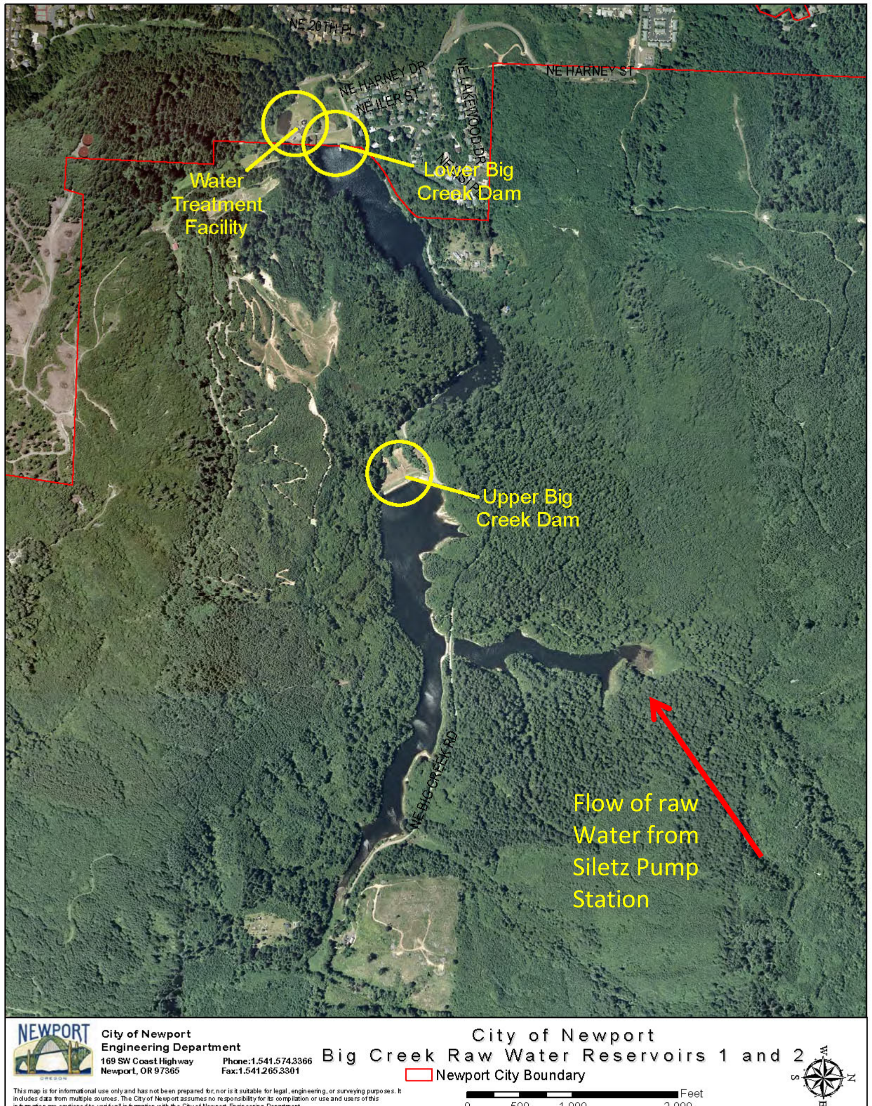
Siletz River Intake Station and Raw Water Line



Big Creek Reservoirs 1 and 2



Raw Water Storage Capacity

- Big Creek Reservoir #1 – 200 Ac Ft (56 MG)
- Big Creek Reservoir #2 – 970 Ac Ft (271.6 MG)
- Total Storage 1,170 Ac Ft (327.6 MG)

Big Creek Dam #1

- Constructed: 1951
- Type: Embankment
- Length: 315 ft
- Height: 21 ft
- Crest Width: 12 ft
- Const. Cost: $40,706

Big Creek Dam #2

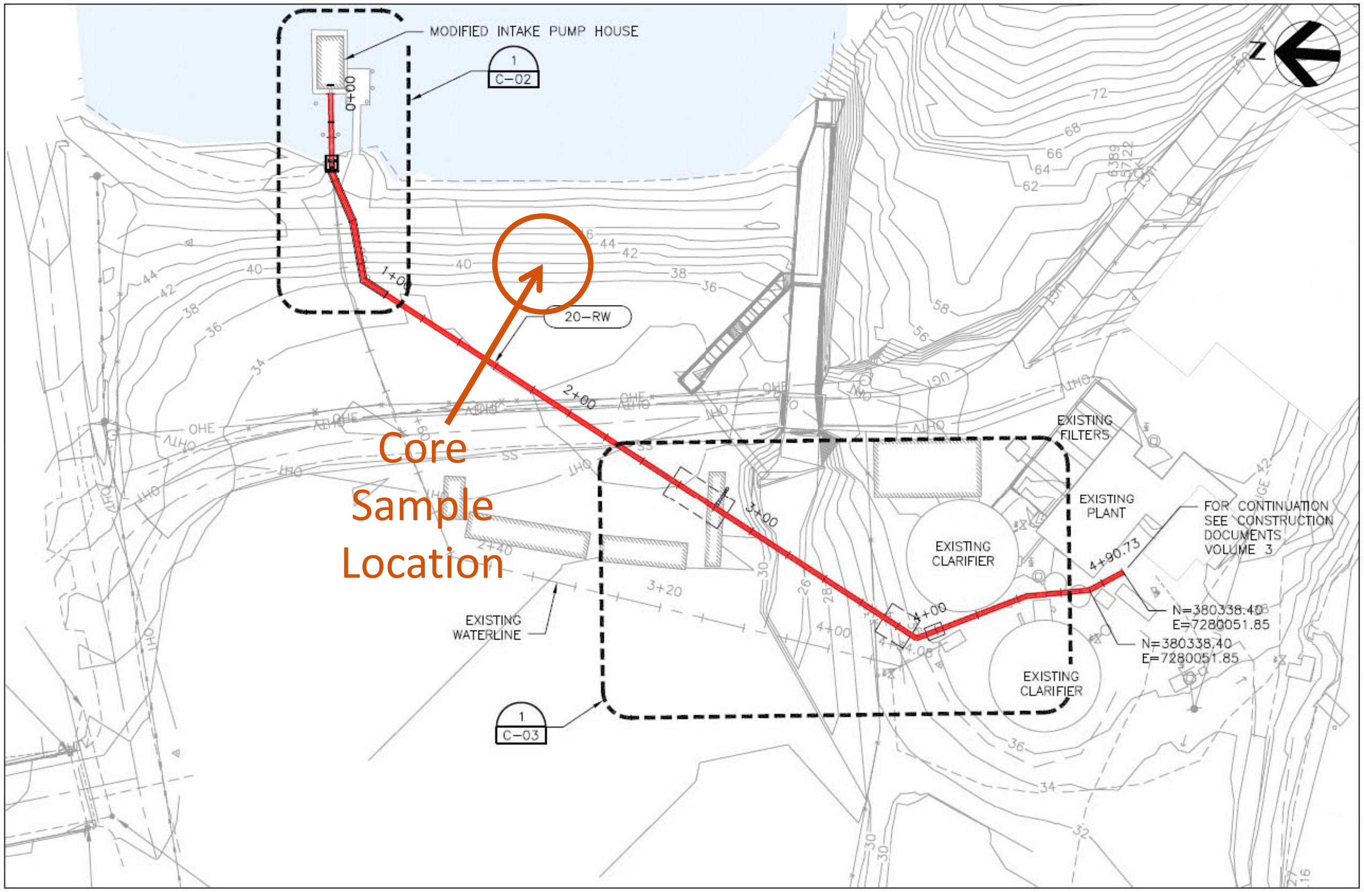
- Constructed: 1968
- Raised: 1976
- Type: embankment dam
- Length: 455 ft
- Height: 56 ft
- Crest Width: 20 ft
- Cont. Cost: $126,864
- Raise Cost: $273,631

The Problem…

Initial Lower Big Creek Dam Condition Assessment
Raw Water Intake Structure Construction

- Beginning in 2010, the City began construction on a new water treatment facility and raw water intake station
- The existing raw water intake structure was planned to be rebuilt on the existing wood piles.
- Piles were to be encased in grout filled steel casings
- During a preconstruction inspection by divers, it was discovered that the as-builts on the existing pump station were incorrect and the existing piles did not have sufficient stability to support the proposed intake structure

Geotechnical Soil Analysis
Lower Big Creek Dam- Raw Water Intake Structure

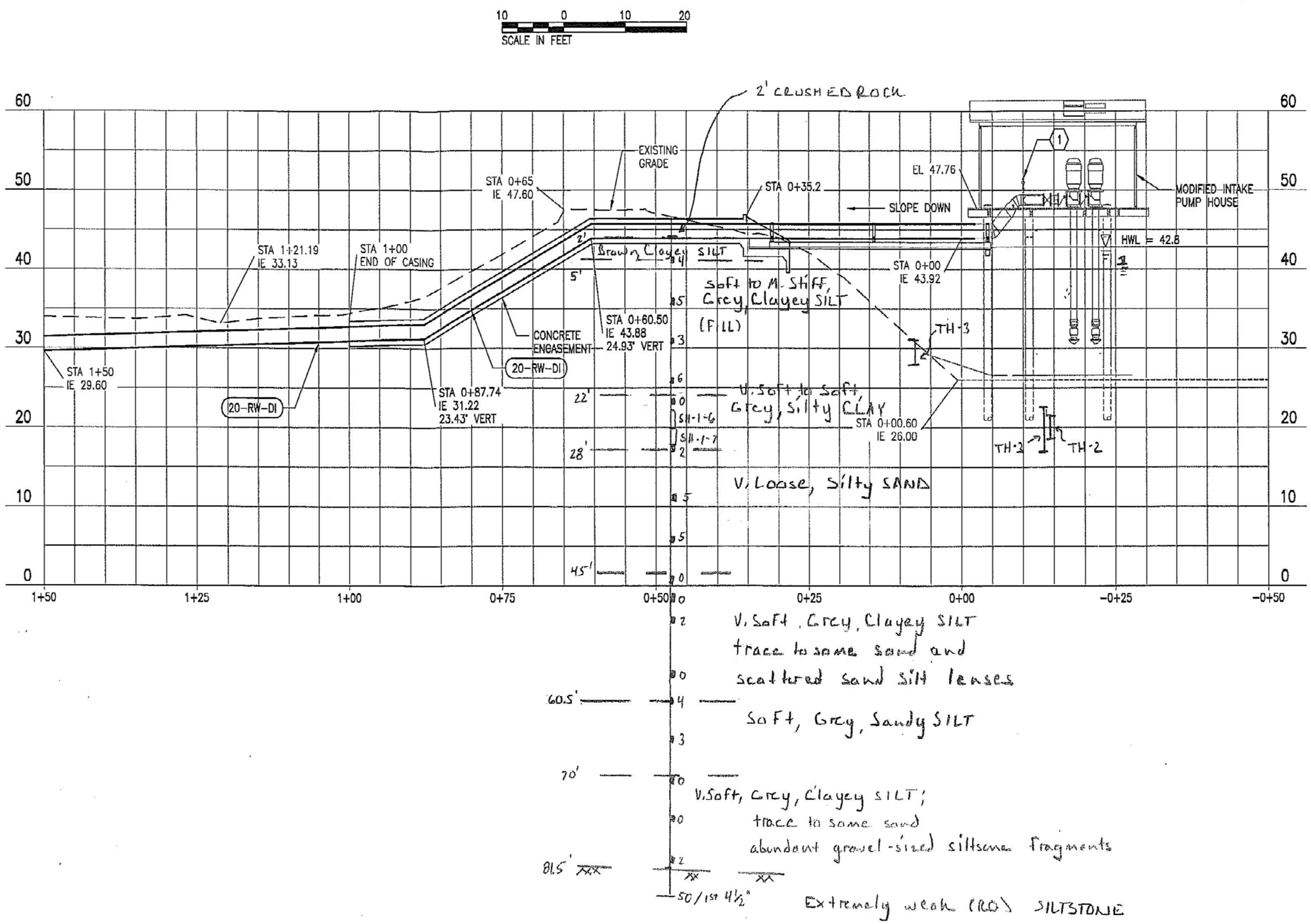


- A core sample was taken in the middle of the dam to assess soil conditions for alternative pile options.

Drilling during Construction – Discovery of the Problem

Geotechnical Soil Analysis
Lower Big Creek Dam - Estimated Subsurface

- ± 22 to 28 feet - very soft to soft, grey, clayey silt (alluvium)
- ± 38 to 45 feet - very loose, silty sand
- ± 45 to 60 - feet very soft, clayey silt with scattered sandy silt lenses
- ± 60 to 70 feet - soft, sandy silt
- ± 70 to 81.5 feet - very soft, clayey silt with sand to gravel-sized, decomposed siltstone fragments
- 81.5 to 85.4 feet (bottom of the boring) – extremely weak (R0) siltstone (Nye Formation)



More Geotechnical Explorations – BC 1

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More Geotechnical Explorations – BC 2

Timeline of Events

Timeline		Activity
April 2011	→	1st Boring sample – discovered the issue
Dec 2011	→	2nd Round of sampling at both dams
Jan - May 2012	→	Laboratory testing of 2nd round samples
Feb 2013	→	Report "Geotechnical Investigation & Seismic Evaluation"
Nov 2013	**→**	**3rd Round of sampling**
Jan - June 2014	**→**	**Laboratory testing of 3rd round samples**
June 2015	**→**	**Report "Engineering Evaluation & Corrective Action Alternatives"**

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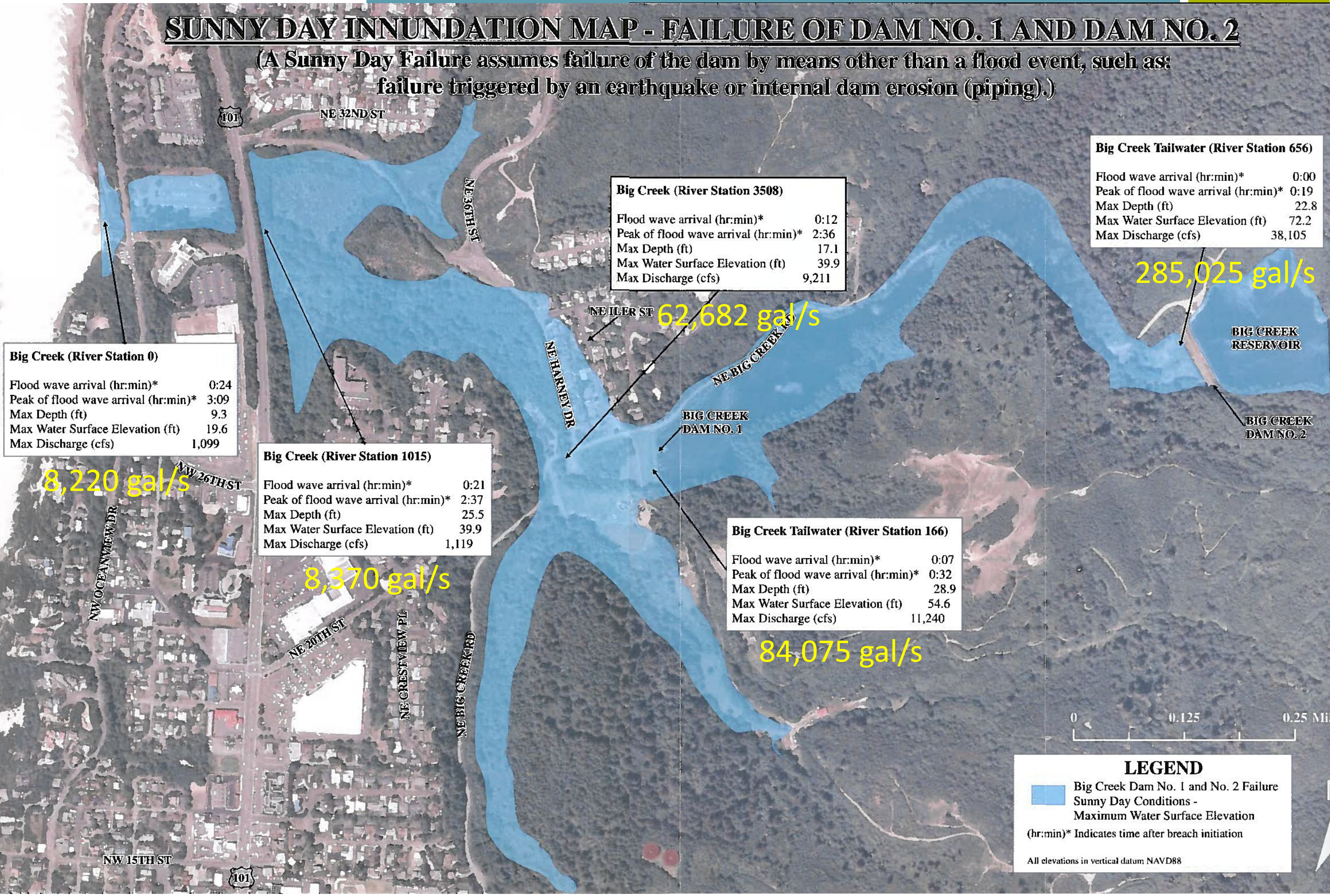
Engineering Analysis/Deficiency Verification Results

Results:

- The lab testing and engineering analysis show:
    - Soils are predominantly high plasticity silts and very soft
    - Will loosen strength during earthquake and move in any direction
    - Causes deformation of the dams and consequent failure

The Risk…


SUNNY DAY INNUNDATION MAP - FAILURE OF DAM NO. 1 AND DAM NO. 2
(A Sunny Day Failure assumes failure of the dam by means other than a flood event, such as:
failure triggered by an earthquake or internal dam erosion (piping).)
101
NE 32ND ST
NE 36TH ST
Big Creek (River Station 3508)
Flood wave arrival (hr:min)* 0:12
Peak of flood wave arrival (hr:min)* 2:36
Max Depth (ft) 17.1
Max Water Surface Elevation (ft) 39.9
Max Discharge (cfs) 9,211
62,682 gal/s
Big Creek Tailwater (River Station 656)
Flood wave arrival (hr:min)* 0:00
Peak of flood wave arrival (hr:min)* 0:19
Max Depth (ft) 22.8
Max Water Surface Elevation (ft) 72.2
Max Discharge (cfs) 38,105
285,025 gal/s
NE ILER ST
NE BIG CREEK RD
BIG CREEK RESERVOIR
Big Creek (River Station 0)
Flood wave arrival (hr:min)* 0:24
Peak of flood wave arrival (hr:min)* 3:09
Max Depth (ft) 9.3
Max Water Surface Elevation (ft) 19.6
Max Discharge (cfs) 1,099
8,220 gal/s
NE HARNEY DR
BIG CREEK DAM NO. 1
BIG CREEK DAM NO. 2
NW 26TH ST
Big Creek (River Station 1015)
Flood wave arrival (hr:min)* 0:21
Peak of flood wave arrival (hr:min)* 2:37
Max Depth (ft) 25.5
Max Water Surface Elevation (ft) 39.9
Max Discharge (cfs) 1,119
8,370 gal/s
NW OCEANVIEW DR
Big Creek Tailwater (River Station 166)
Flood wave arrival (hr:min)* 0:07
Peak of flood wave arrival (hr:min)* 0:32
Max Depth (ft) 28.9
Max Water Surface Elevation (ft) 54.6
Max Discharge (cfs) 11,240
84,075 gal/s
NE 20TH ST
NE CRESTVIEW PL
NE BIG CREEK RD
0 0.125 0.25 Mi
LEGEND
Big Creek Dam No. 1 and No. 2 Failure
Sunny Day Conditions -
Maximum Water Surface Elevation
(hr:min)* Indicates time after breach initiation
All elevations in vertical datum NAVD88
NW 15TH ST
101

Primary concerns as associated with dam failure

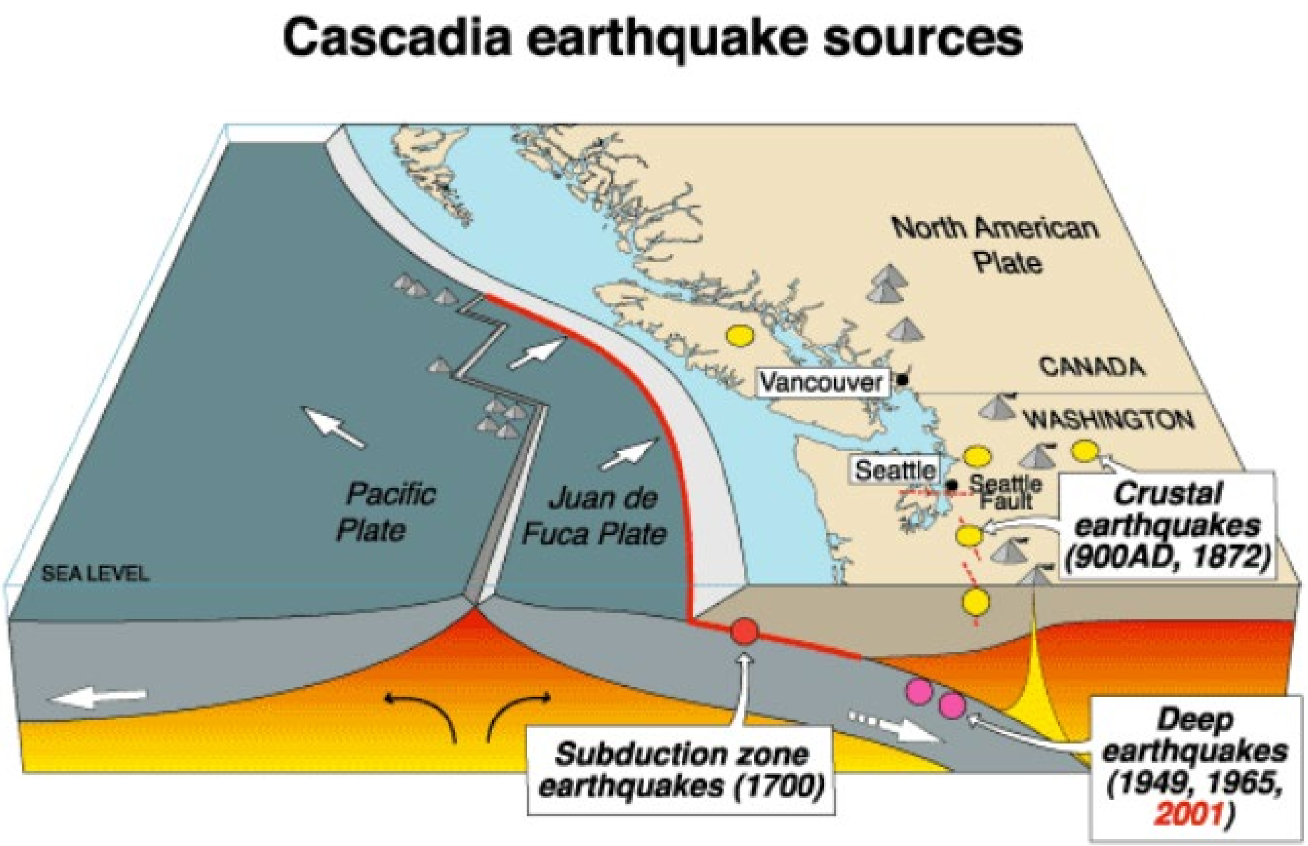
1. **Risk to Life and Safety**
   - Failure inundation area affects 11 homes and Agate Beach State Park day-use parking lot
2. **Loss of Raw Water Supply/Long-term Risk to Public Health**
   - No clean water for an indefinite period of time
   - Affects 10,000-50,000 people per day indefinitely
   - Emergency Management Planners estimate that coastal communities could be isolated between 2-6 months after a major Cascadia event
   - It will years to rebuild a dam and intake structure sufficient to provide raw water for the water treatment plant under normal circumstances, without the devastation caused by an earthquake.
3. **Economic Disaster/Recovery**
   - The City conservatively estimates that for every day of water disruption, a minimum of $120 in Gross Domestic Product (GDP) is sacrificed per employee, per day. If the Big Creek Dams fail, the annual cost of water service disruption could be approximately $80 million in GDP for the 7,470-people employed in the City of Newport. [1]

[1]*Quinn, Alexander et al. "The Economic Benefits of Investing in Water Infrastructure." The Value of Water Campaign. 2017.*

The Earthquake Hazard

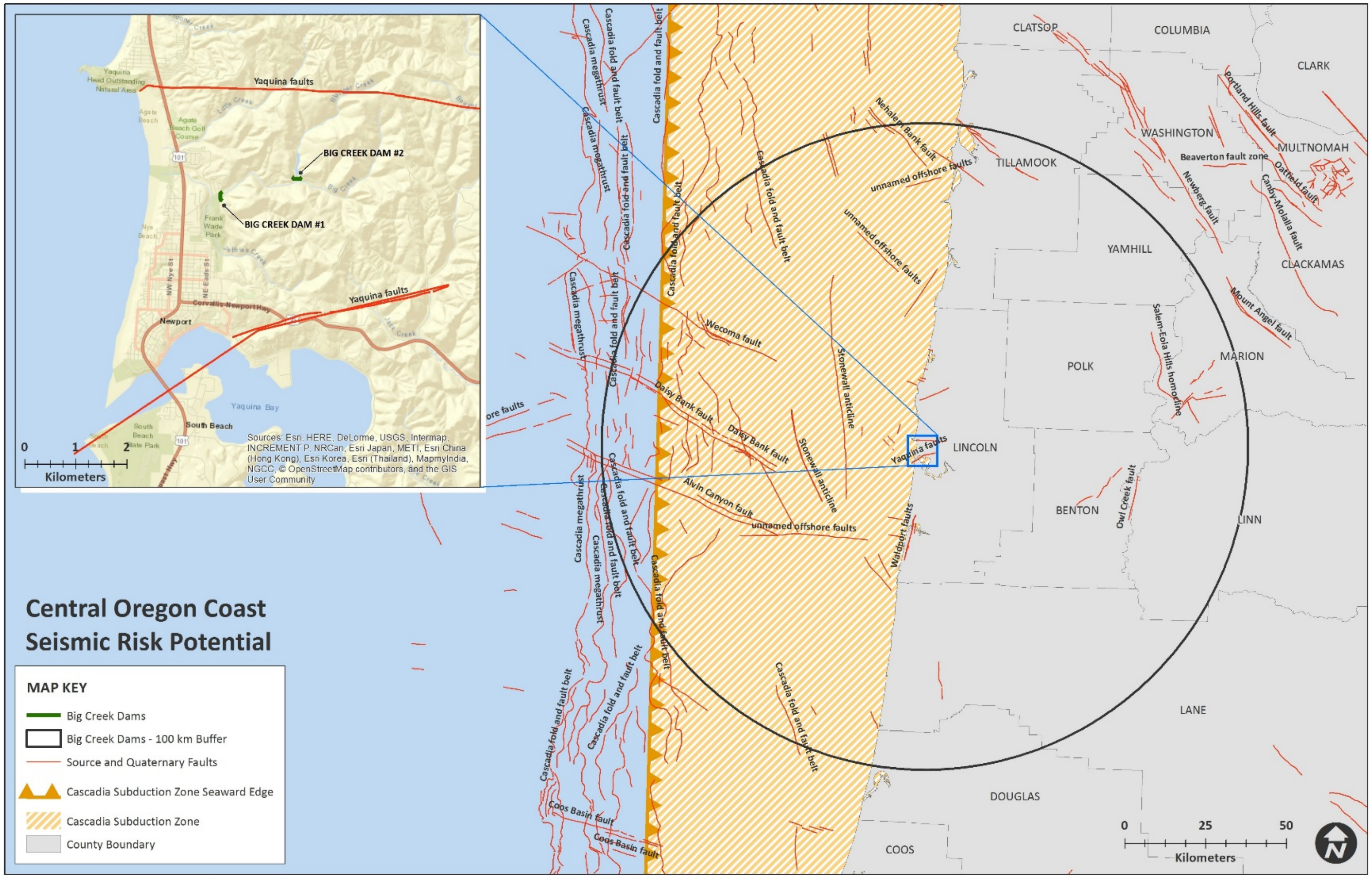
Types of Earthquakes

Cascadia Subduction Zone (CSZ)



Types of Earthquakes

Crustal Faults

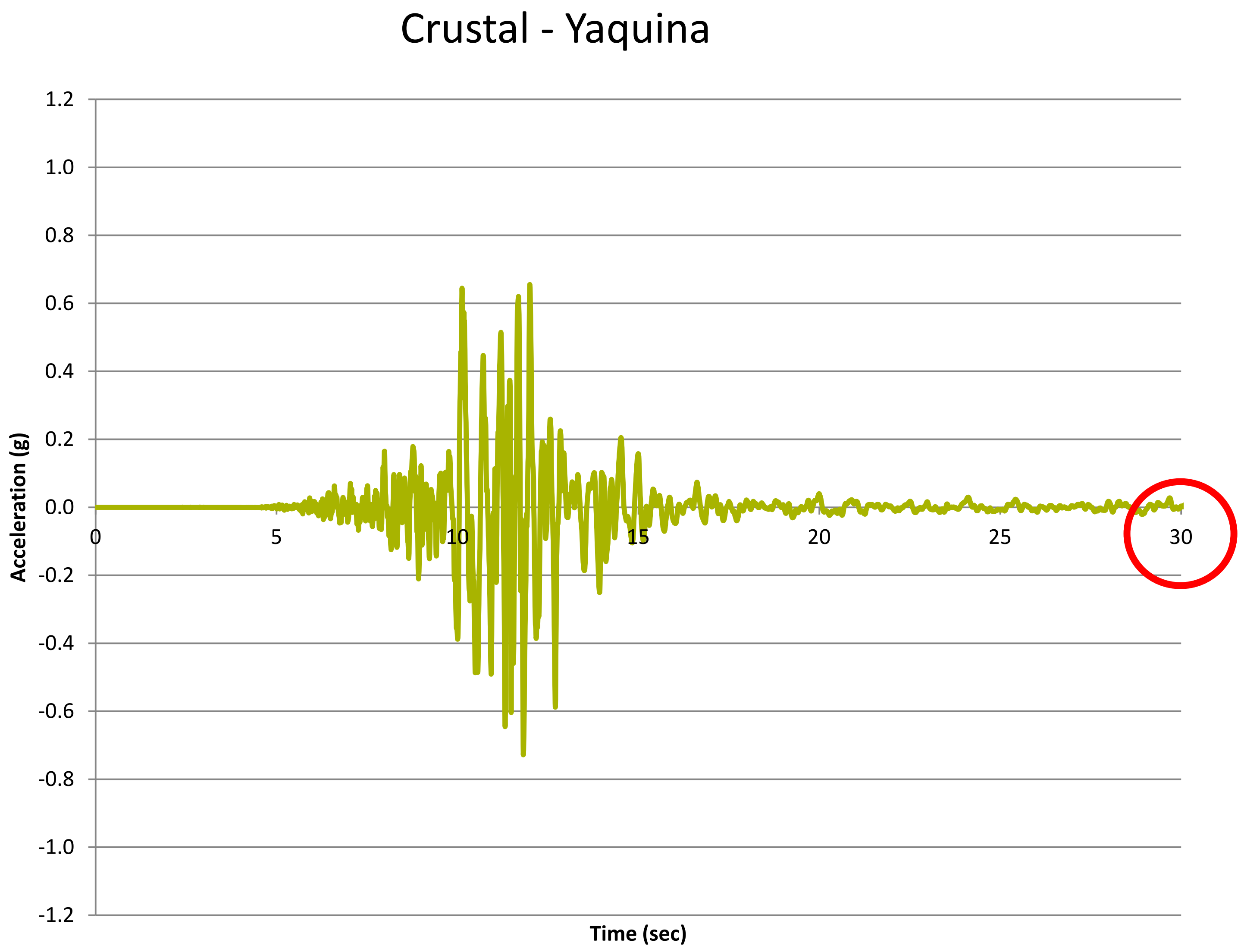


The Earthquake Hazard at the Newport Dam Sites

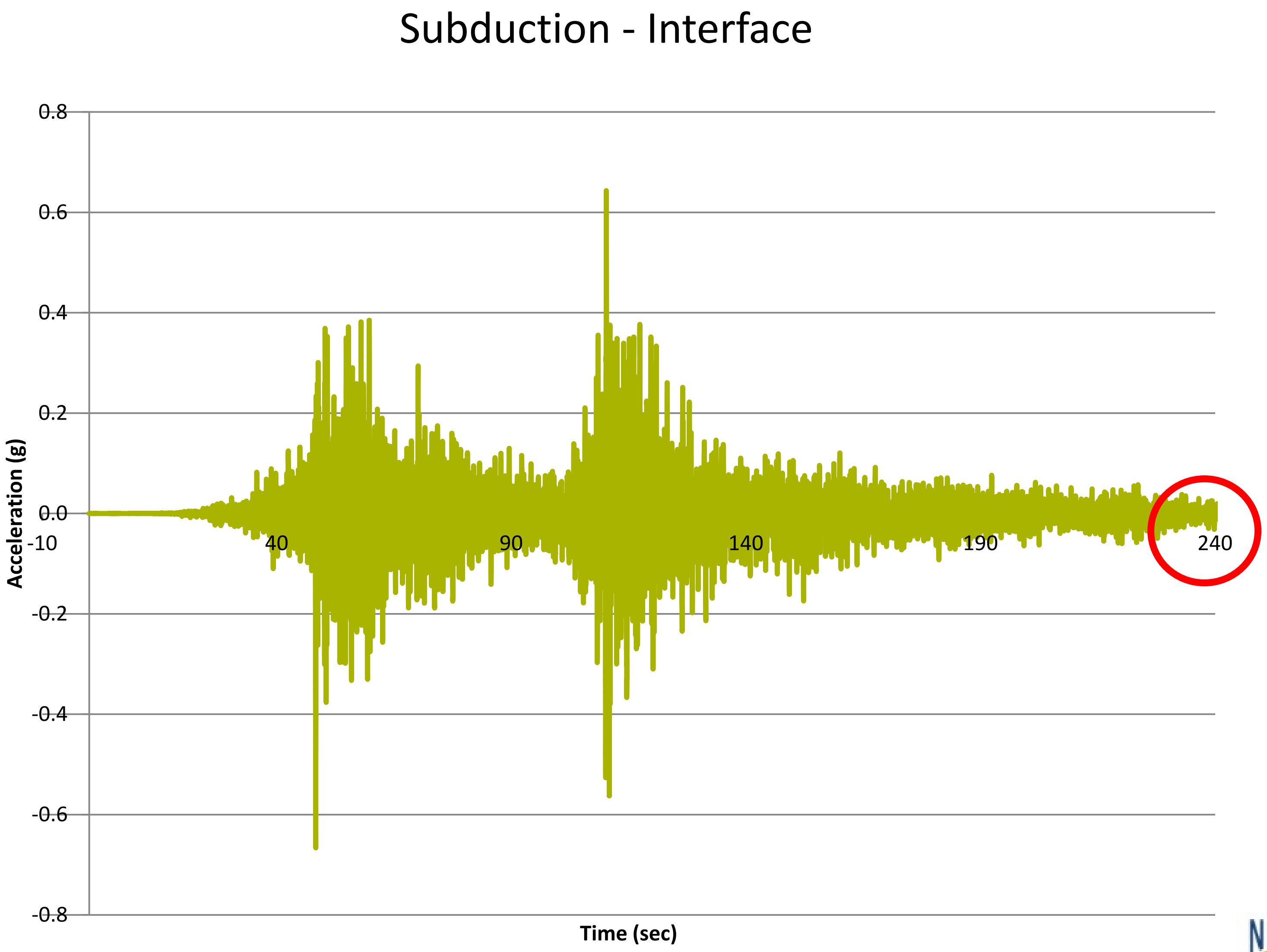
- Earthquakes have multiple parameters to describe them
  - » Magnitude – length of rupture and total amount of energy released
  - » Distance between location of rupture and critical structure
  - » Return period – how often the energy is released
  - » PGA – peak ground acceleration of the entire earthquake
  - » Duration of strong shaking

- Cascadia Subduction Zone
  - » High magnitude (M 8 to 9+), long duration (200+ seconds)

Response of Earth Embankments to Earthquakes



Response of Earth Embankments to Earthquakes



Breach Through Transverse Cracks and Overtopping

Figure 8: View of Breach in Fujinuma Main Dam from Right Abutment
(N37.3014˚, E140.1957˚, April 23, 2011)

The Earthquake Hazard at Newport Dam Sites

Table 2A. Probabilistic Seismic Hazard Deaggregation Contributions at PGA

Return Period	PGA (g)	Contributions from Principal Sources at PGA (%)			
		Gridded (other crustal)	Yaquina Faults	Cascadia Subduction Zone	
				Interface[1]	Intraslab
475-year	0.30	4.4	30.4	59.0	4.4
975-year	0.52	<3	35.8	60.4	<3
2,475-year	0.86	<3	35.2	63.5	<3
4,975-year	1.15	<3	32.8	66.6	<3
9,950-year	1.47	<3	29.8	69.9	<3

[1]CSZ Interface includes Cascadia M8.0-M8.2 floating, M8.3-M8.7 floating and megathrust sources

Summary of Estimated Deformations of Newport Dams

Table 1: Summary of Estimated Embankment Crest/Downstream Slope Deformations at BC-1 and BC-2

Recurrence Interval Event (years)	Estimated Peak Ground Acceleration (PGA – g's)	Est. Deformations - Empirical (Swaisgood, 2003) (inches)			Est. Deformations – Newmark (inches)		
		Lower Bound	Best Estimate	Upper Bound	Lower Bound	Best Estimate	Upper Bound
BC 1							
2475	0.79	15	33	68	50	>76	90
4975	1.12	218	478	>478	116	>160	184
BC 2							
2475	0.79	15	33	68	32	>48	54
4975	1.12	218	478	>478	56	>96	112

Green – Acceptable, no corrective actions required
Yellow – Marginal to unacceptable, corrective actions required
Red - Unacceptable, expedited corrective actions needed

Engineering Analysis/Deficiency Verification

- BC-1:
  - Will fail by settlement and overtopping during a large earthquake.
  - Smaller earthquakes will result in significant damage to the dam, outlet works, water supply pump station, and ability to operate the reservoir
  - Foundation material is very deep. Remediation is challenging and expensive.
  - Small amount of storage in the reservoir and the very large anticipated remediation costs, rehabilitation of this dam is judged as non-feasible.

Engineering Analysis/Deficiency Verification

- BC-2:
  - Unacceptable deformations large earthquake events
  - Likely to fail due to overtopping and/or seepage through transverse cracks after the shaking
  - Significant damage during more frequent seismic events
  - Deformations of the upstream slope will be significant for the larger earthquakes resulting in damage or failure of the outlet works, intake structure, and discharge pipeline (similar to BC1)

The Plan: Corrective Action Alternatives

Alternatives for Corrective Actions – Options

What do we do?

1. Nothing
   - OWRD has directed the City that the dams either needs to be rehabilitated/replaced or the water drawn down to a level so that the reservoirs no longer present a hazard.
   - Drawing down the reservoirs would result in not having enough water to meet demand.
2. Move the water supply elsewhere
   - Rocky Creek or alternate site
   - Desalinization
   - Wastewater Reuse
3. Rebuild/Rehabilitate the Existing Dam(s)
   - BC1 – bad soils too deep – unfeasible
4. Replace the existing Dams with a new Dam(s)

Alternatives for Corrective Actions – Options

Rocky Creek - History

- Initiative started by the City of Newport in 1997 to find a secondary water source to meet future demand.

- Resulting report was the *Long-Range Water Supply Report* created by Fuller & Morris Engineers in 1997. This document was a study of Newport's water supply and the potential for regionalization of water supplies. This report rated the alternatives identified in order of least environmental impact and most desirable from the standpoint of Newport or a regional supply as follows:

Newport	Regional
1.) Big Creek	1.) Rocky Creek
2.) Rocky Creek	2.) Big Rock Creek
3.) Big Rock Creek	

- Resulted in the creation of the *Central Coast Water Council*, a consortium of Coastal water suppliers working to develop a regional supply at Rocky Creek.

  -City of Lincoln City
  -City of Newport
  -City of Siletz
  -City of Toledo
  -City of Waldport
  -City of Yachats
  -Seal Rock Water District
  -Southwest Lincoln County Water District
  -Kernville/Gleneden Beach/Lincoln Beach Water District

Alternatives for Corrective Actions – Options

Rocky Creek - History

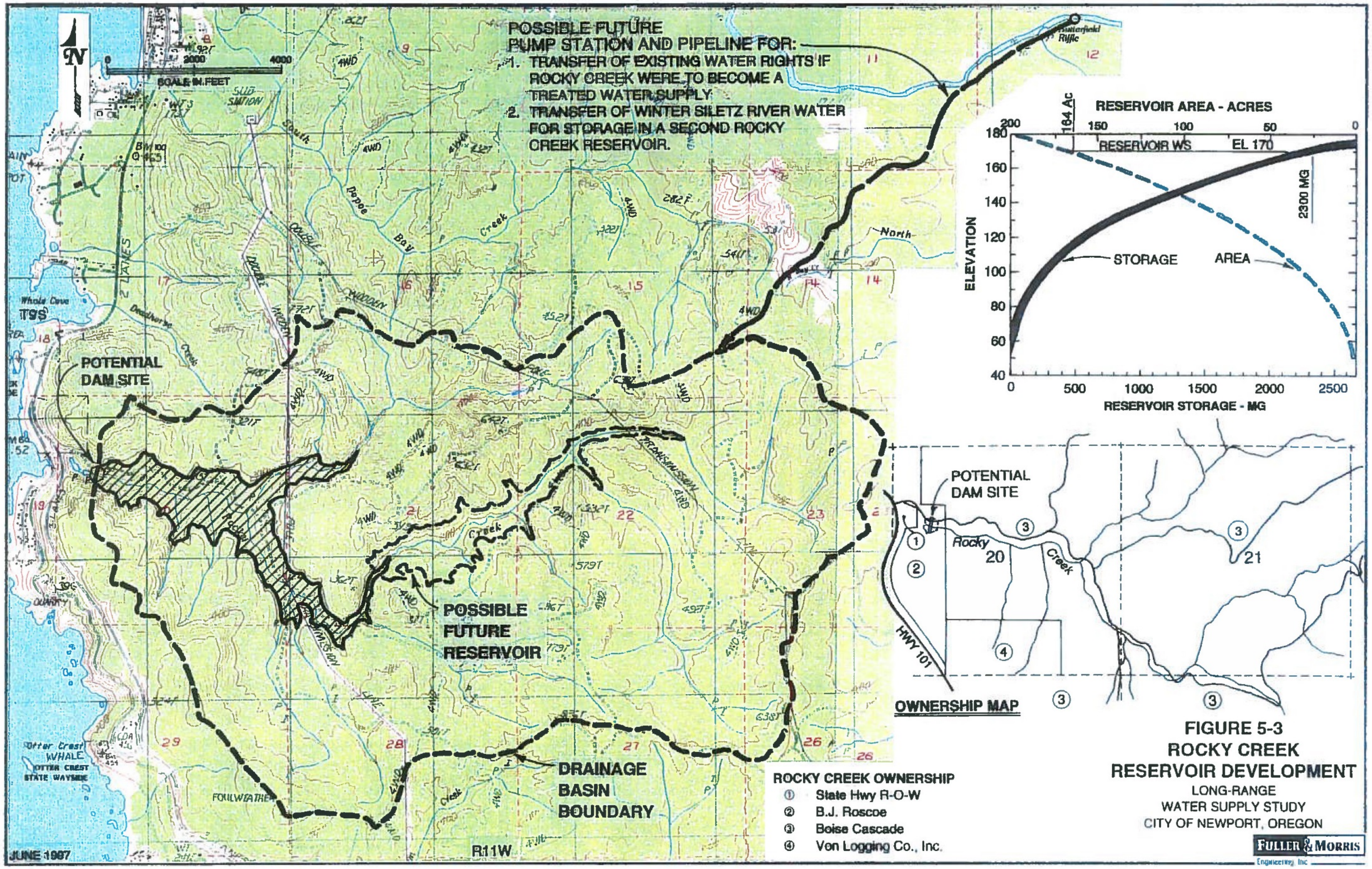
- The costs for the pre-construction development of the Rock Creek Reservoir would be carried by the City of Newport and Lincoln City and other Council members could choose to participate at the point of construction and would reimburse Newport and Lincoln City for their share of the development costs

- A water rights application was submitted by the City's of Newport and Lincoln City in April of 1998 to construct a reservoir at Rock Creek to store 9,000 AF of water. The application resulted in the creation of the *Rocky Creek Regional Water Supply Project – Preliminary Water Management Plan* created to answer questions raised during review of the application.

- Application was incomplete and placed on administrative hold until 2012 at which time OWRD indicated that the application would be rejected unless it was completed.

- The City of Lincoln City did not want to participate any longer, therefore Newport withdrew the original application and submitted a completed alternate application which was subsequently approved as complete pending a proposed final order. The City of Newport then asked that the application be placed on administrative hold pending the completion of the Mid-Coast Water Planning Partnership.

Alternatives for Corrective Actions – Options
Rocky Creek Drainage Area



Alternatives for Corrective Actions – Options
Regional Water Supply Plan

Alternatives for Corrective Actions – Options

Rocky Creek was rejected as a viable alternative for the following reasons:

- Construction costs according to ENR Construction Cost Index have increased 189% since 1997. The planning level estimate of $40M in 1997 is $76M in 2018.
- The Rocky Creek project assumed to be in addition to the storage in the Big Creek reservoirs. The reservoirs would still need to be either removed or rehabilitated.
- The Rocky Creek concept did not consider seismic design standards nor tsunami risk. The proposed raw water alignment is down Hwy 101 between Cape Foulweather and Newport which is unstable and within the tsunami zone.
- The Rocky Creek development was expected to be completed by 2025, 28 years. The City of Newport does not have the time to develop a new water source considering the imminent seismic risk to the current reservoirs.
- There is currently not regional support to develop Rocky Creek and the original planning documents concur that the project is unfeasible for Newport to attempt alone.

Alternatives for Corrective Actions – Options

Other rejected alternatives:

1. **Desalinization:**

- Negatives:
  - Costly: estimated at $113M
  - Doubles cost of operation/doubles rates
  - High electrical demand. Unlikely current electrical infrastructure is sufficient.
  - Not seismically resilient because of electrical demand.
- Benefits:
  - Unlimited water supply
  - No longer drawing water from the Siletz

2. **Raw Water Re-use:**

- Negatives:
  - People do not like the concept of drinking treated wastewater
  - ½ of Newport water demand is from fishing industry and is discharged to the Bay, therefore water supply will need to be constantly supplemented
  - Costly: estimated at $64M
  - Will still need to withdraw from Siletz

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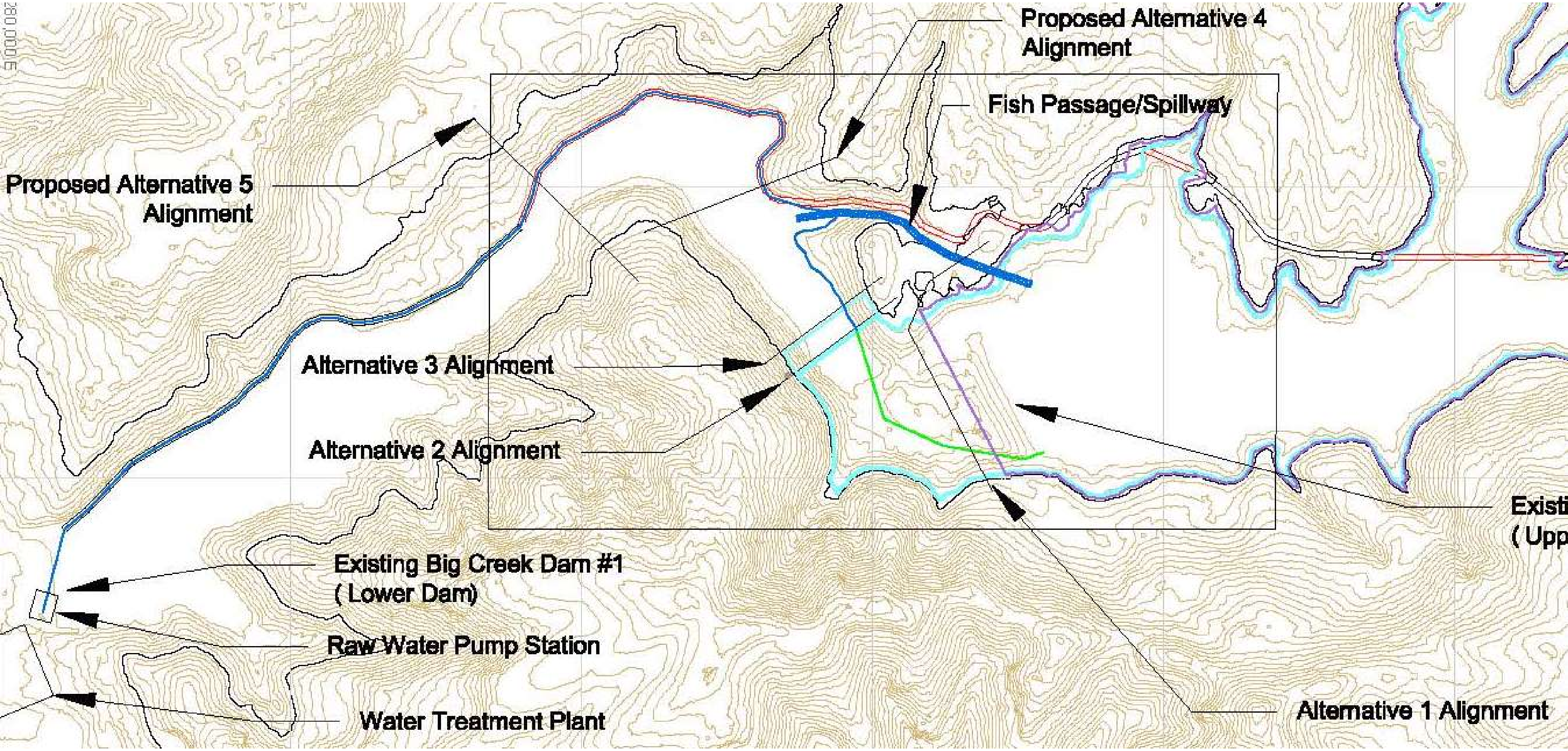
Alternatives for Corrective Actions
Storage Capacity

3. Rebuild/Rehabilitate the Existing Dam(s)
4. Replace the existing Dams with a new Dam(s)

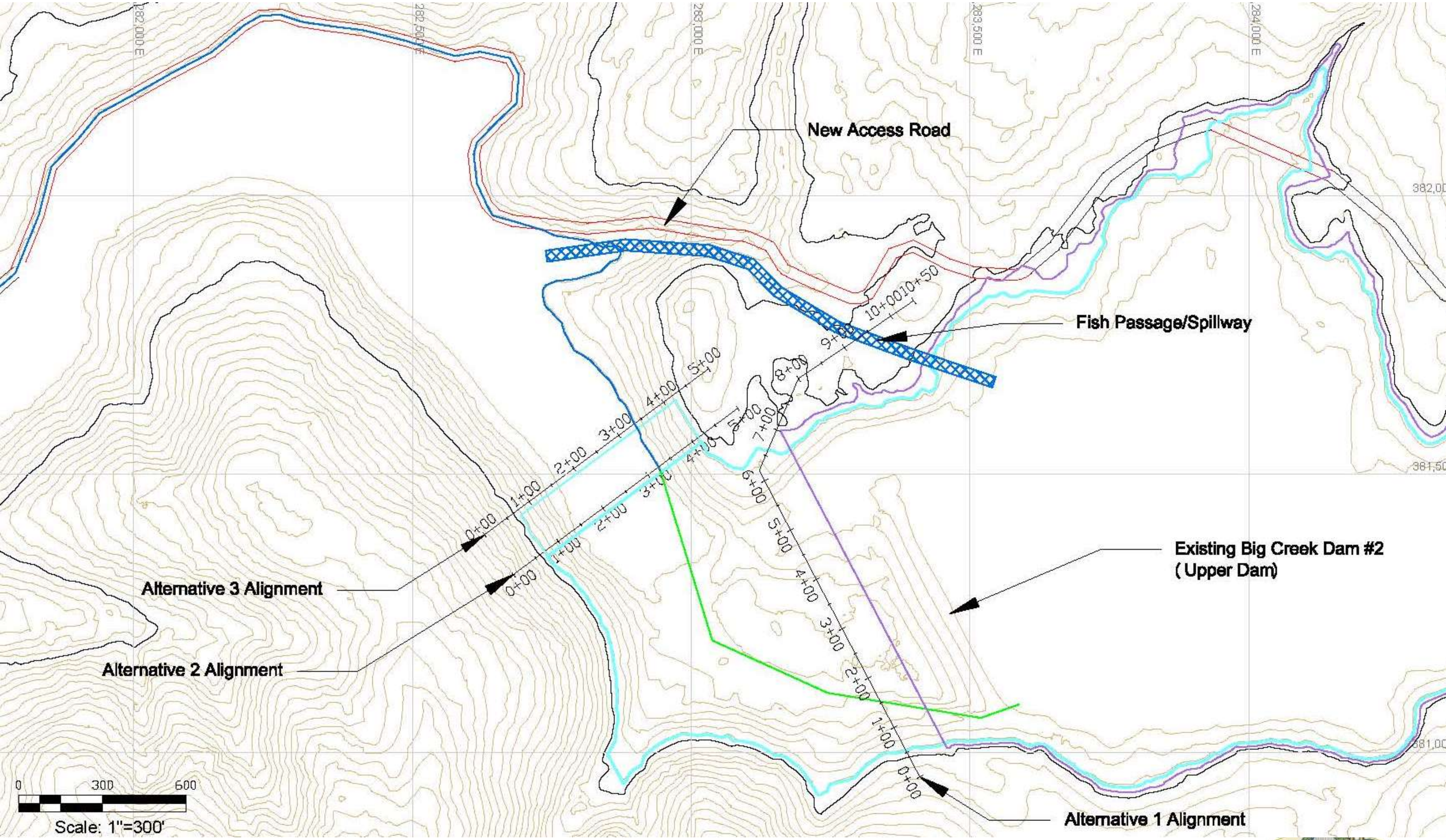
- Storage capacities:

BC-1	= 200 acre-feet
BC-2	= 970 acre-feet
Future projection	= 1000 acre-feet
Sediment storage	= 100 acre-feet
Total Future	**= 2,270 acre-feet**

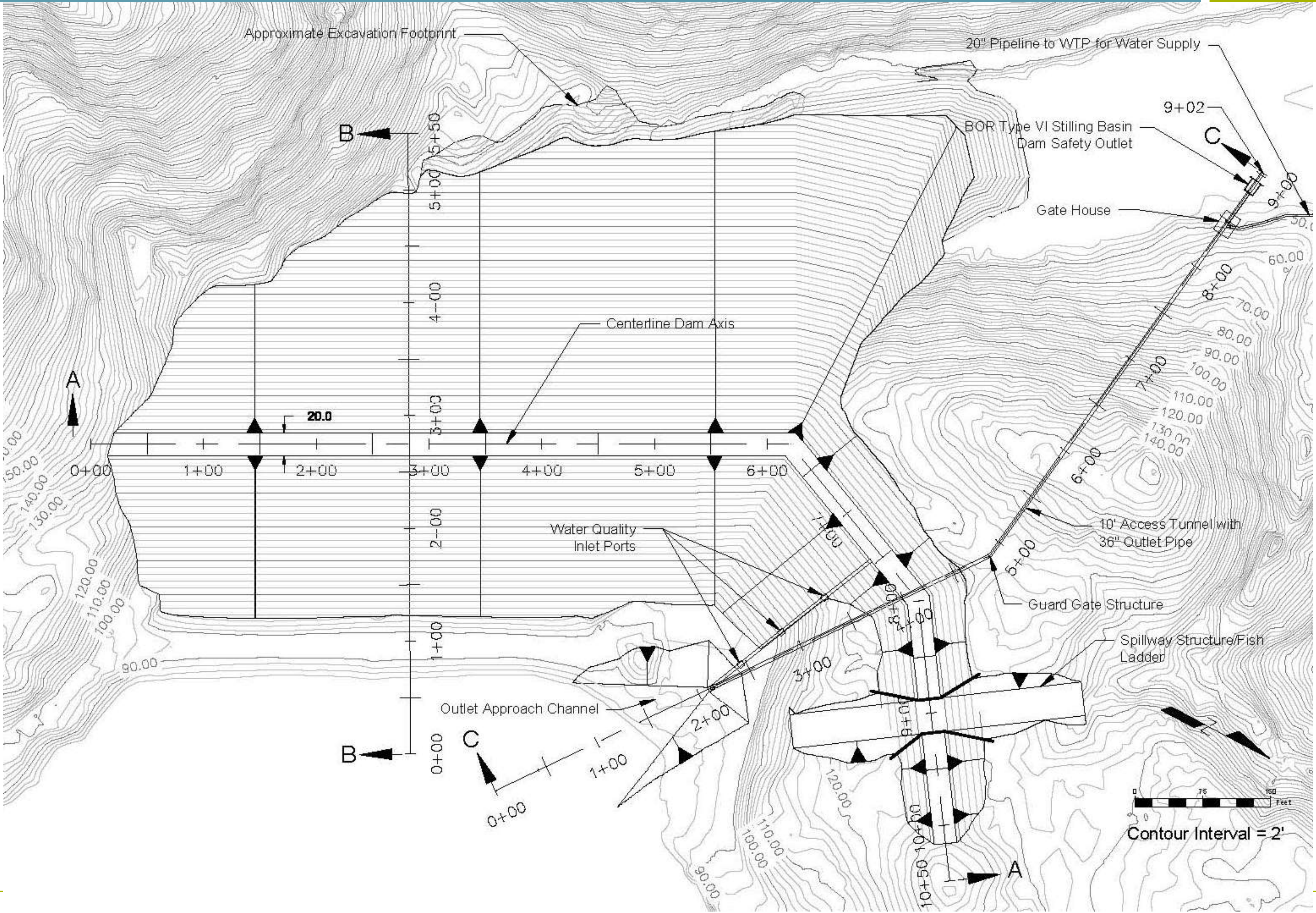
Alternatives for Corrective Actions Started with 5 Options



Alternatives for Corrective Actions
Narrowed down to 3 Options



Alternatives 1 – Raising & Modifying Existing Dam



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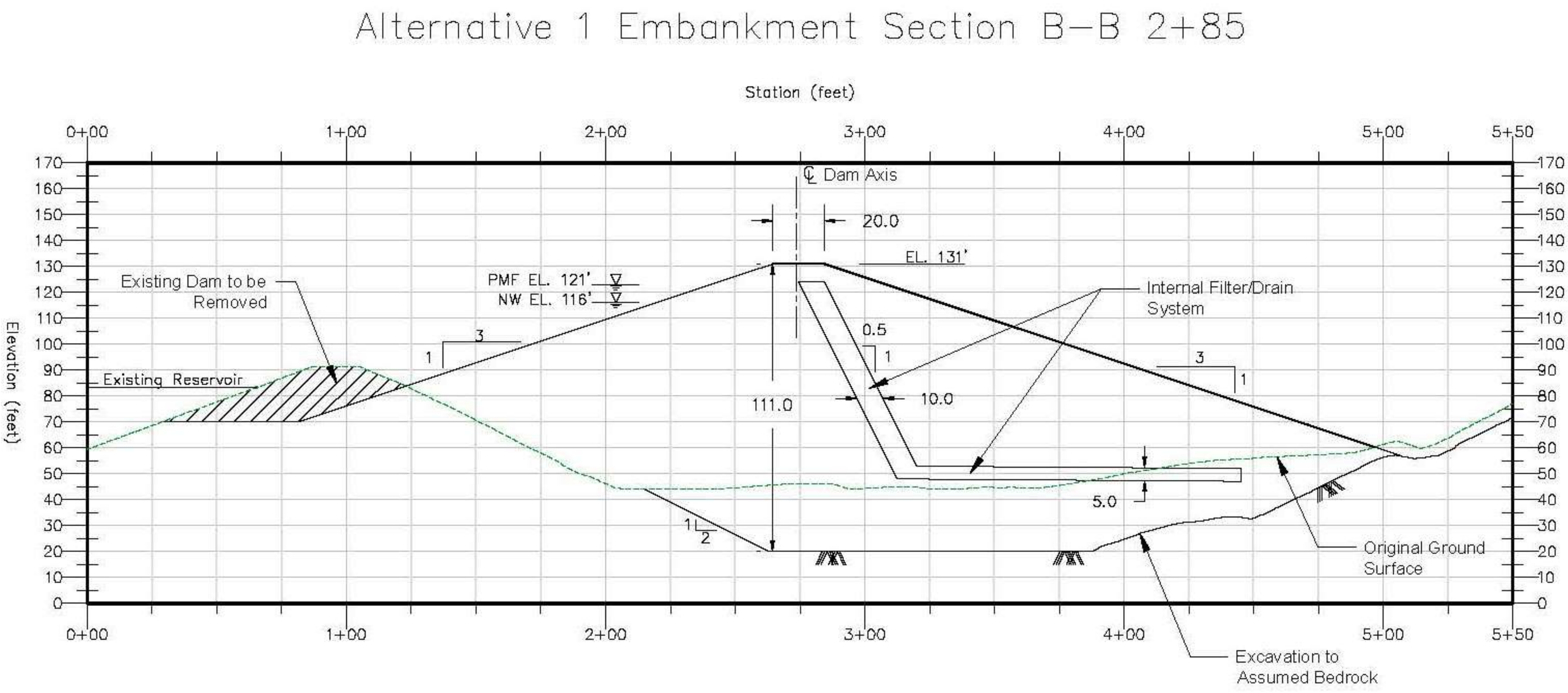
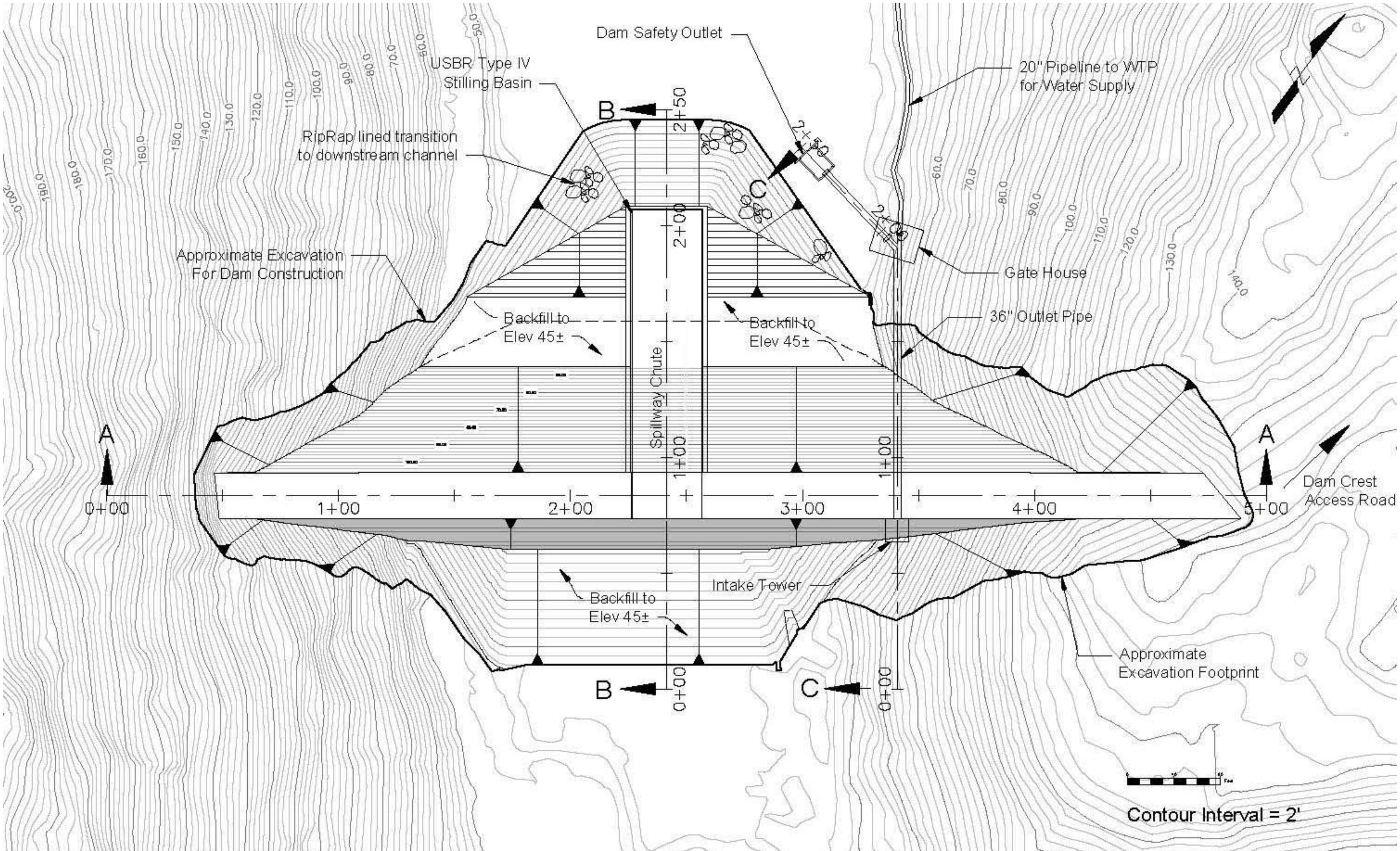


Alternatives 2 – RCC Dam (Roller Compacted Concrete)



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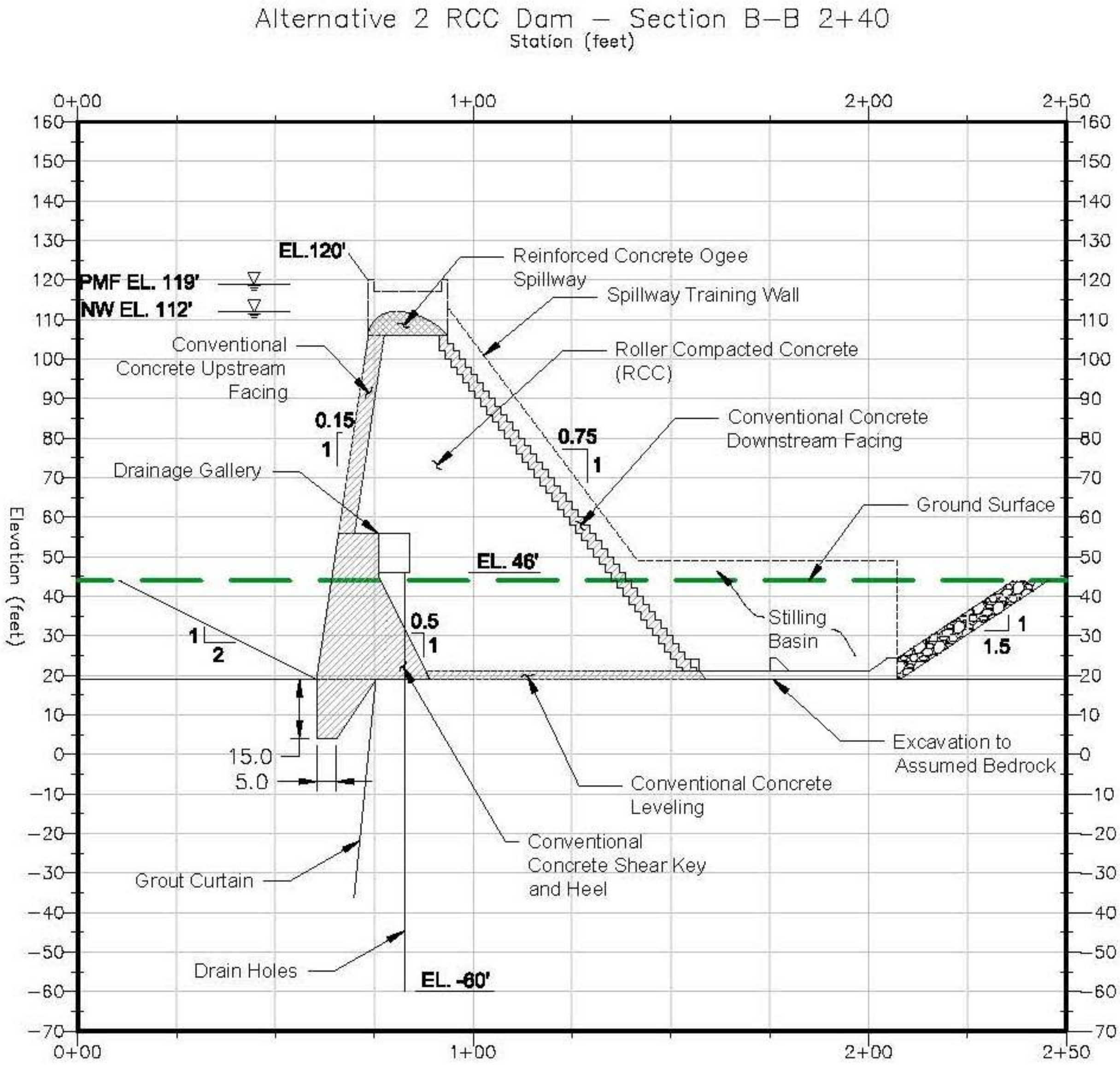
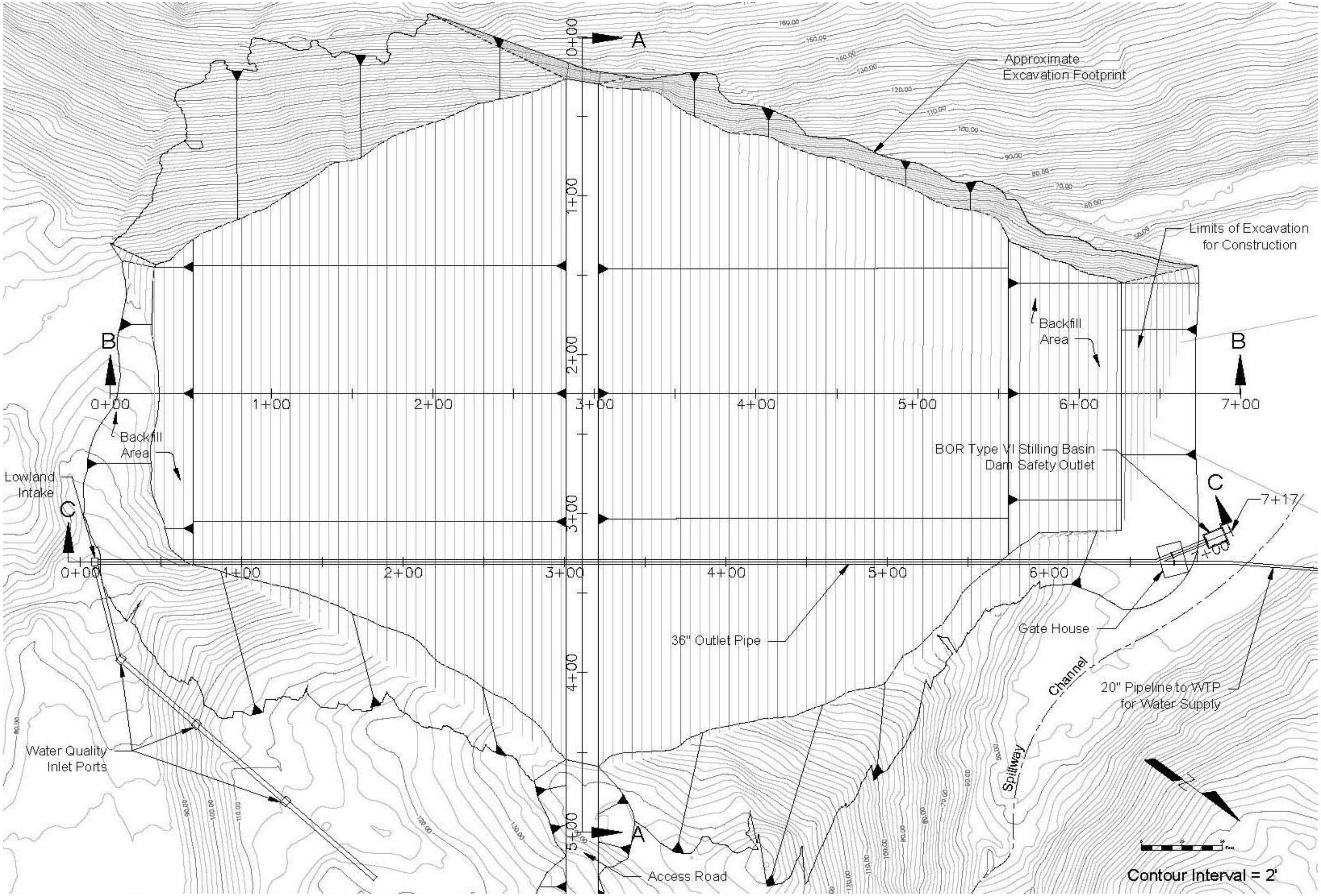


Alternatives 3 – New Embankment Dam



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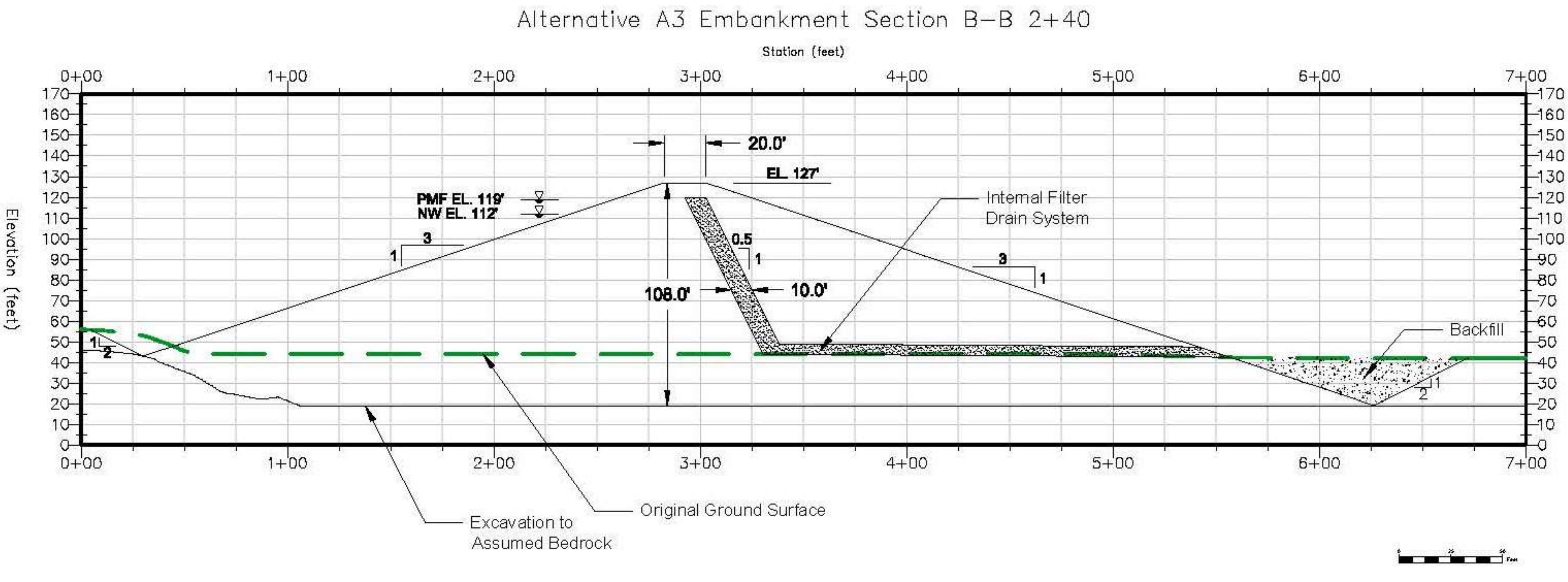
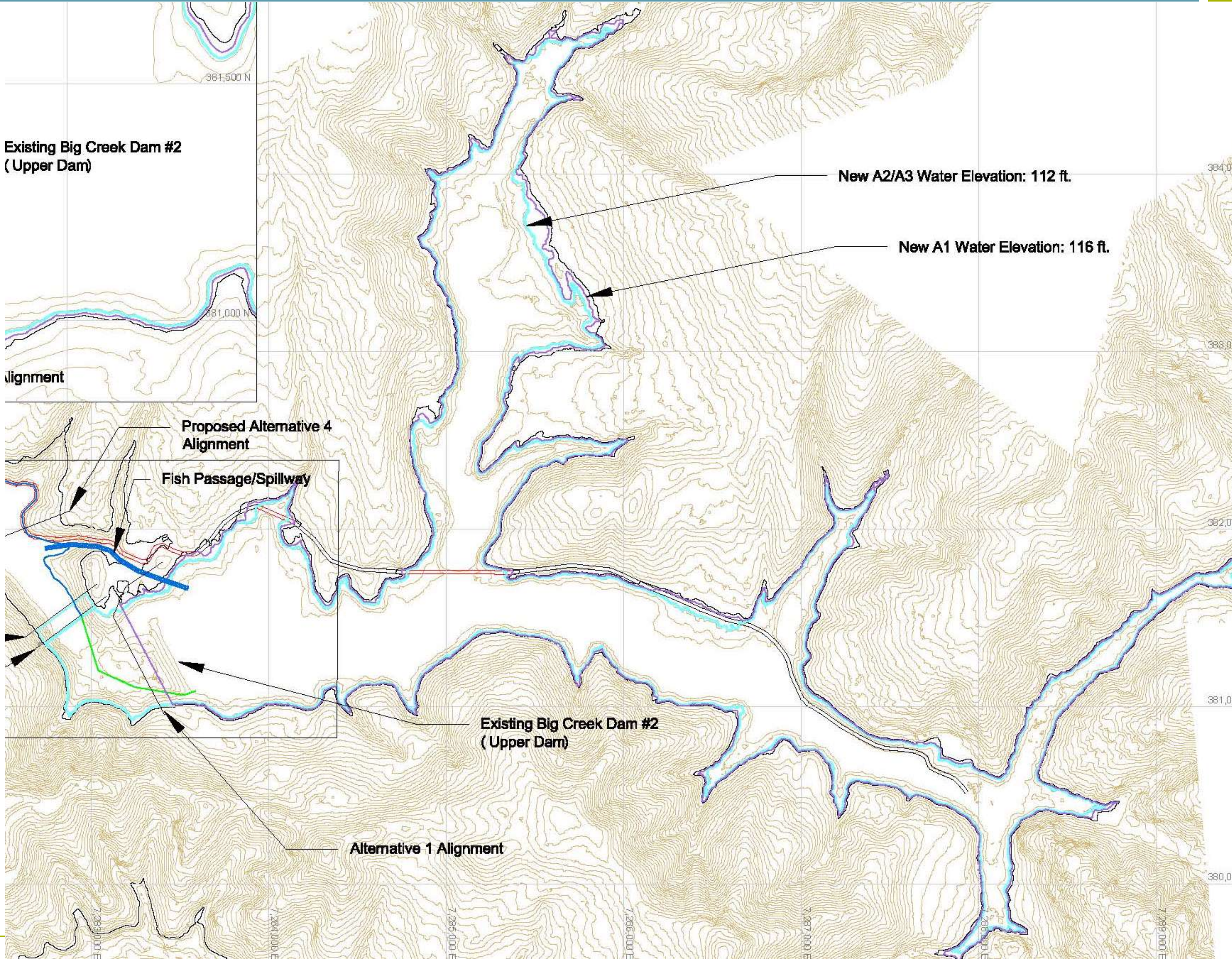


Alternatives for Corrective Actions – Inundation Area



All Alternatives – Comparison

- Constructability
- Excavation volume
- Construction material
- Foundation conditions
- Spillway design
- Intake structure
- Outlet works
- Dewatering
- Seismic resiliency
- Hydraulic resiliency
- Environmental impacts
- Maintenance
- Total costs

Recommended Option

Based on cost estimate & advantages/disadvantages:

Alternative 2 – RCC Dam

- Constructability
- Spillway included
- Less construction time
- Less footprint – less excavation
- Better intake structure
- Less environmental impacts
- Better seismic resiliency
- Less maintenance

Evaluation of the Recommended Alternative

Geotechnical Site Investigation

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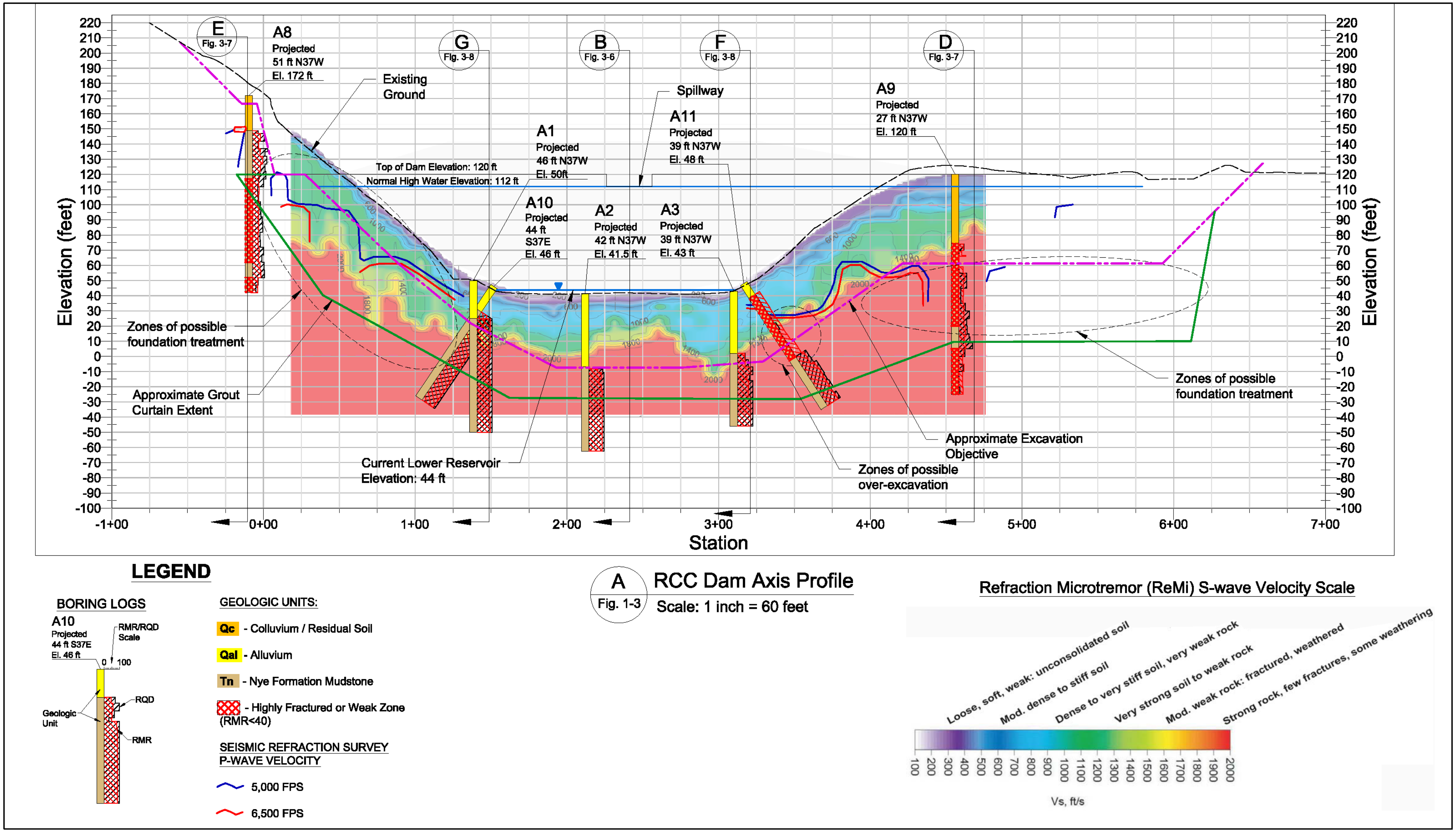
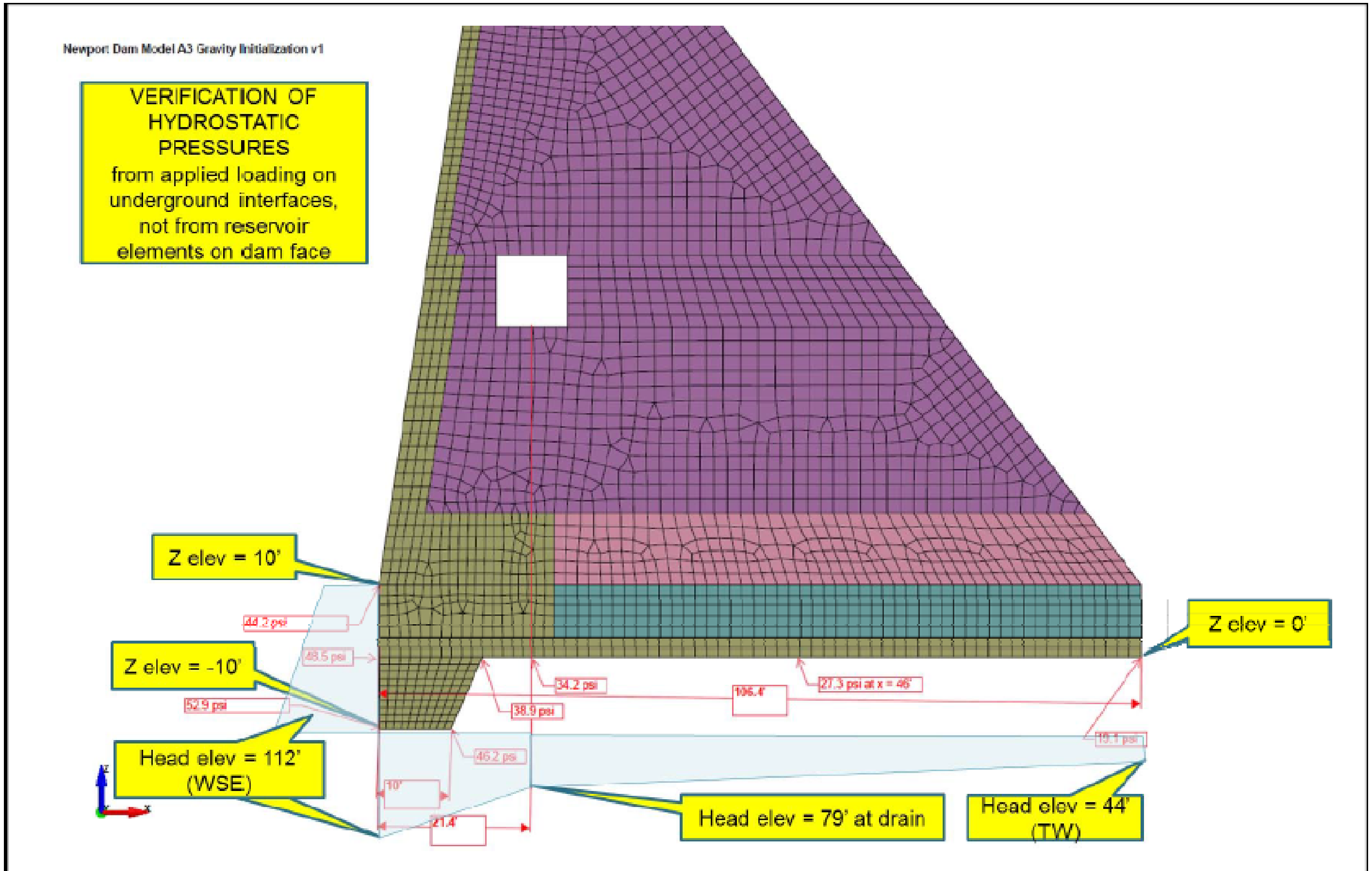
Geotechnical RCC Dam Profile



Structural Engineering Evaluation



PROJECT NO. 10050775	**Verification of Hydrostatic Pressures**		FIGURE
DRAWN: 12-8-2017	**Proposed Newport RCC Dam Newport, Oregon**		**4**
DRAWN BY: GG			
CHECKED BY: STA	ORIGINATOR: STA	DRAWING CATEGORY:	
FILE NAME: <file name>	APPROVED BY: VW		

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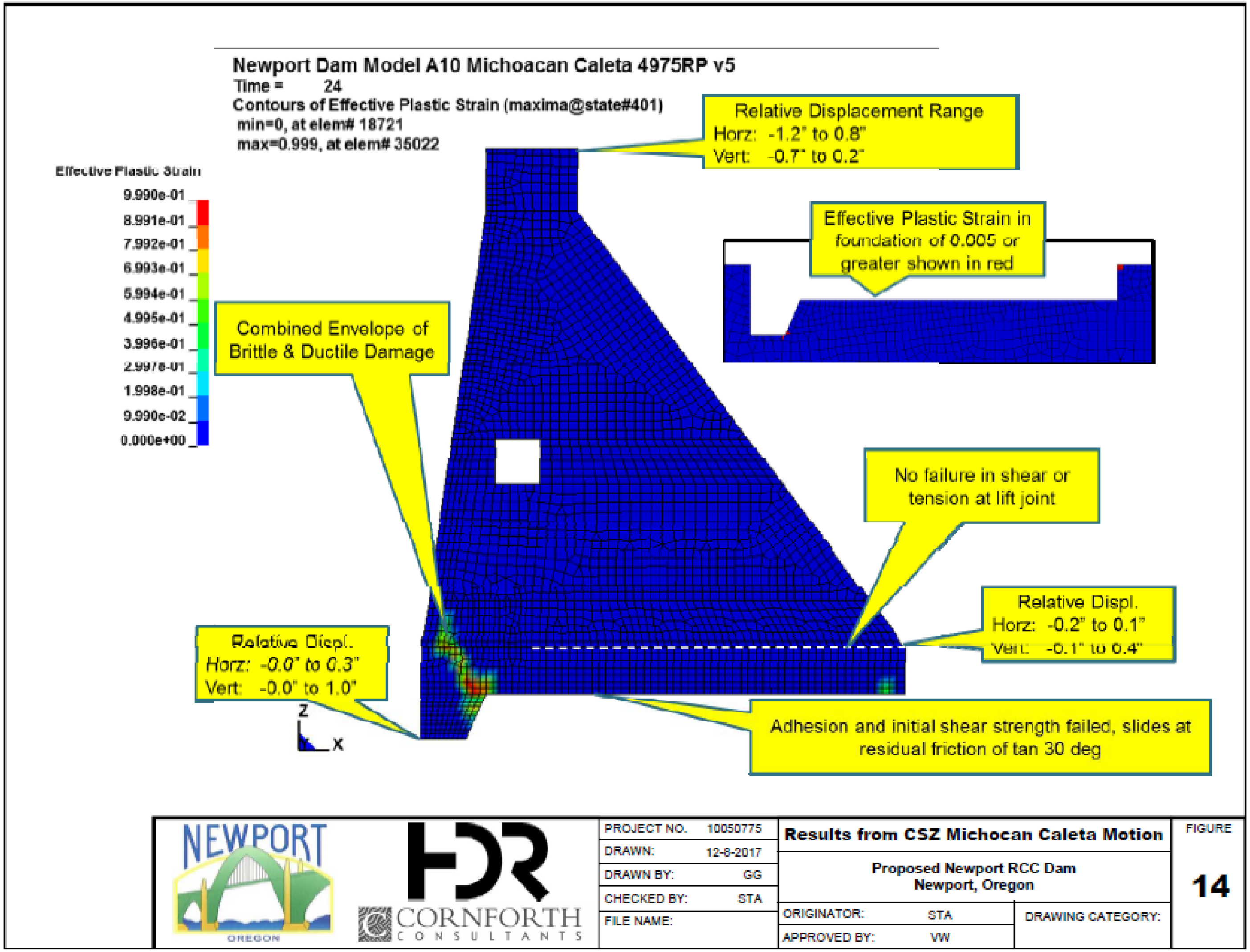
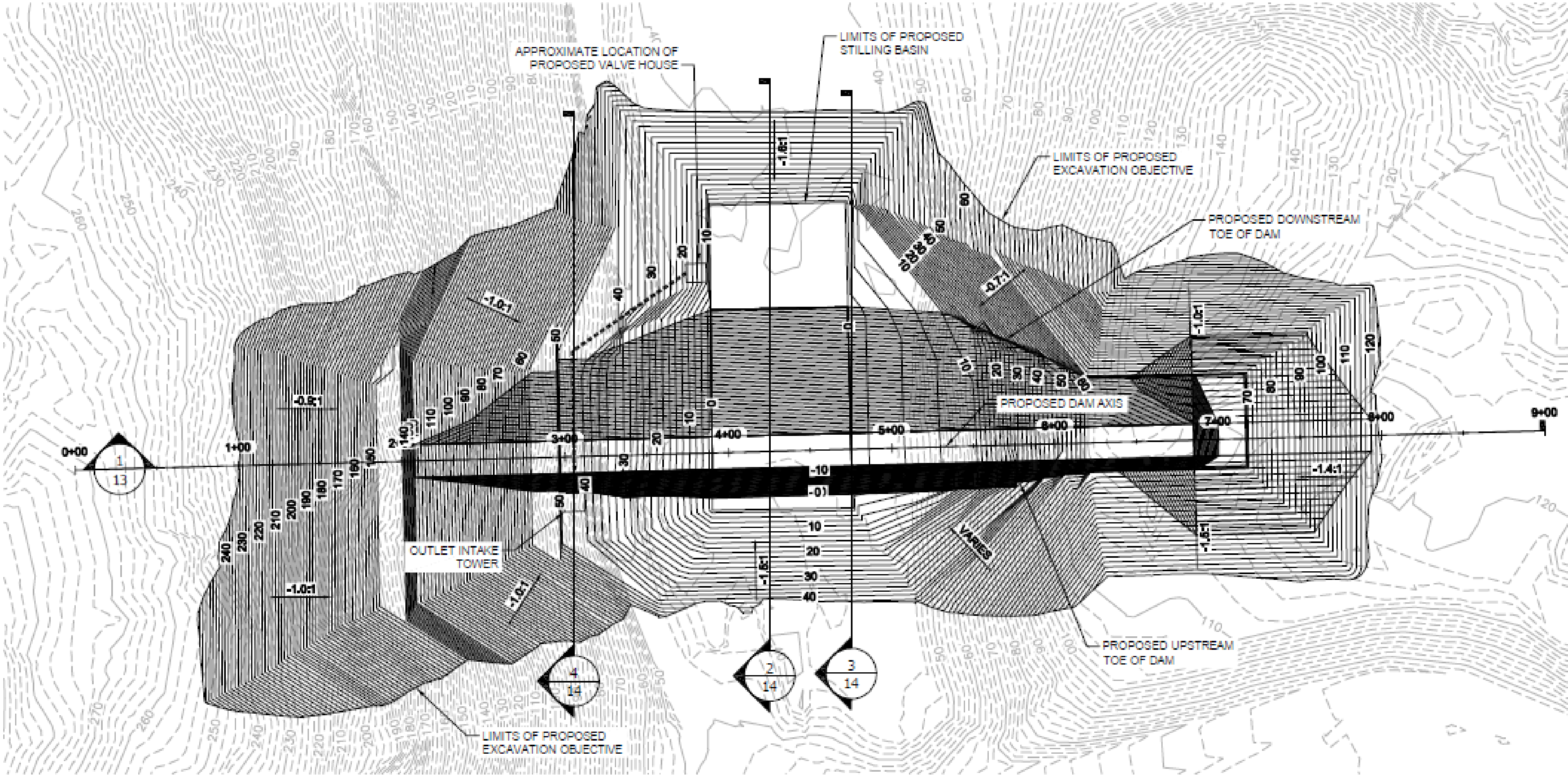
Structural Engineering Evaluation

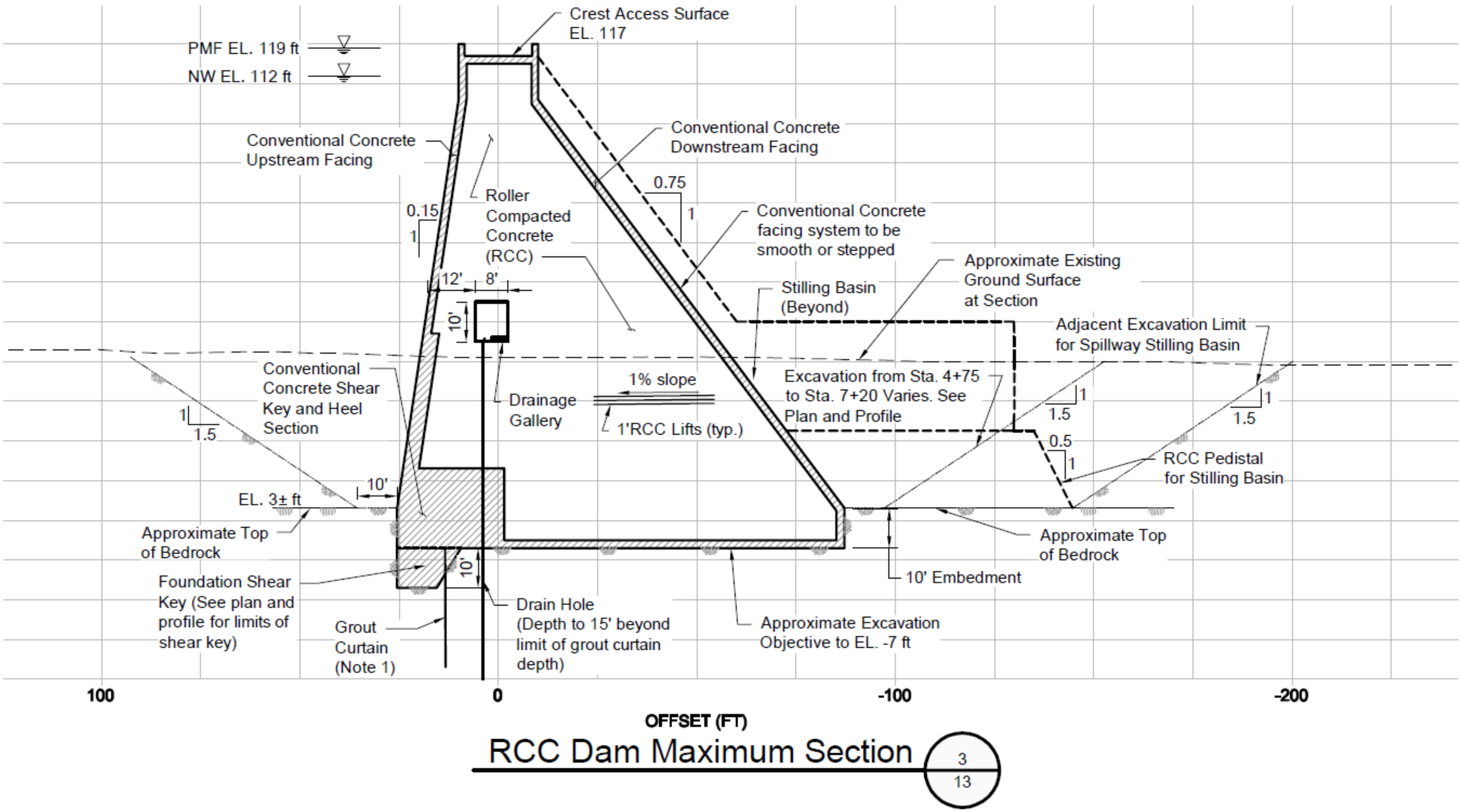


Proposed Dam - Plan

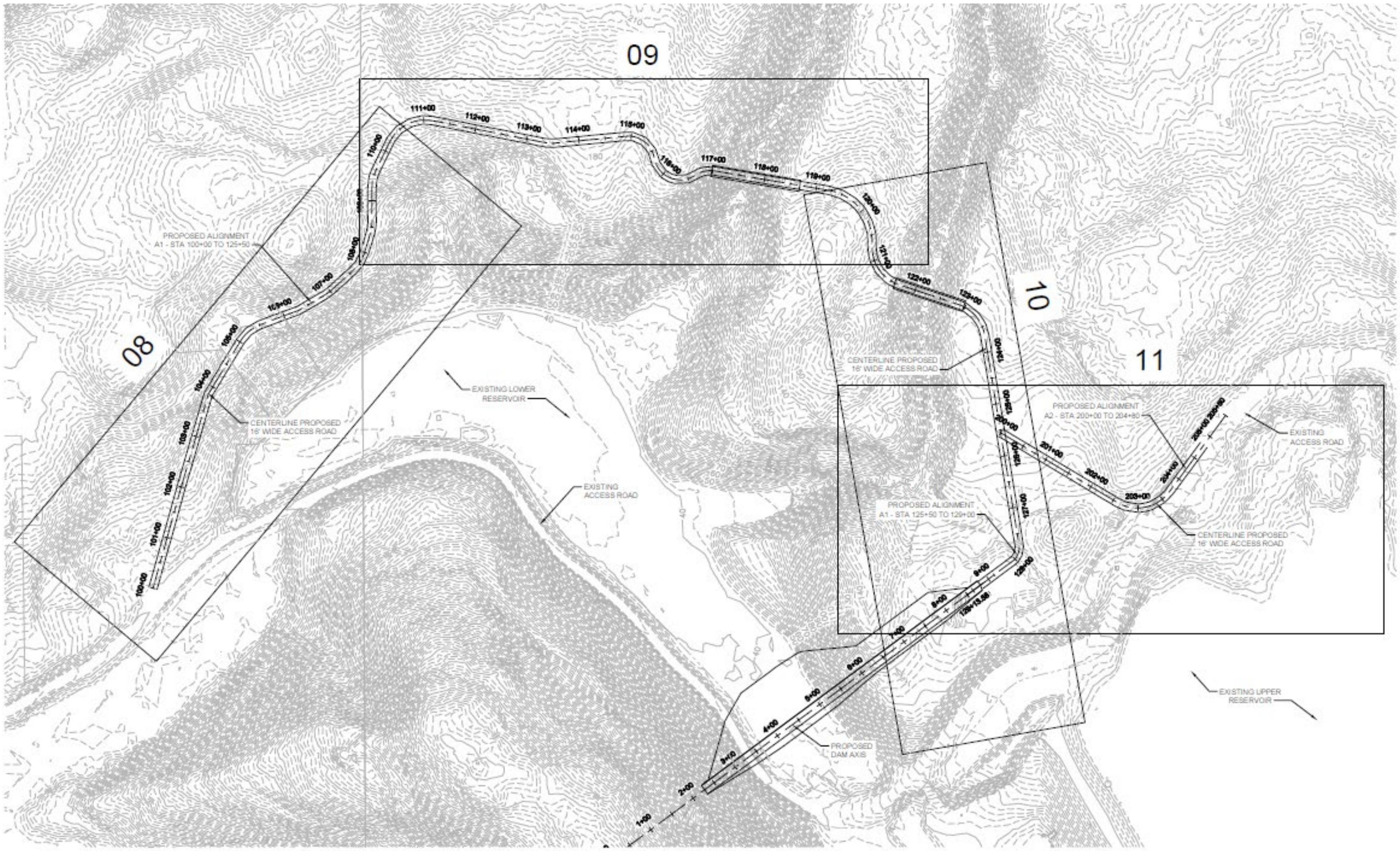


PLAN VIEW

Proposed Dam – Cross Section



Other Design Parameters
Access Road

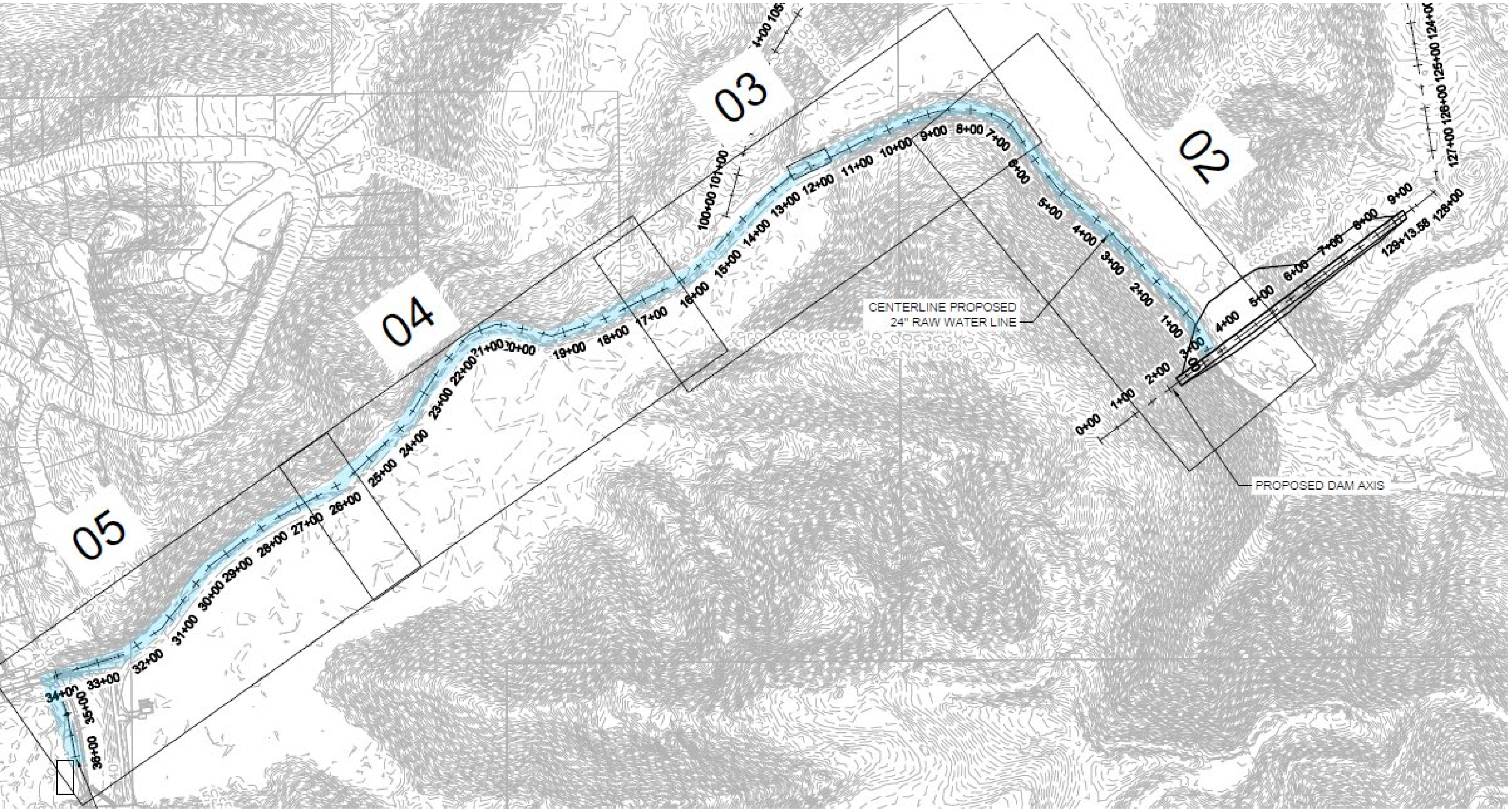


100 50 0 100 200

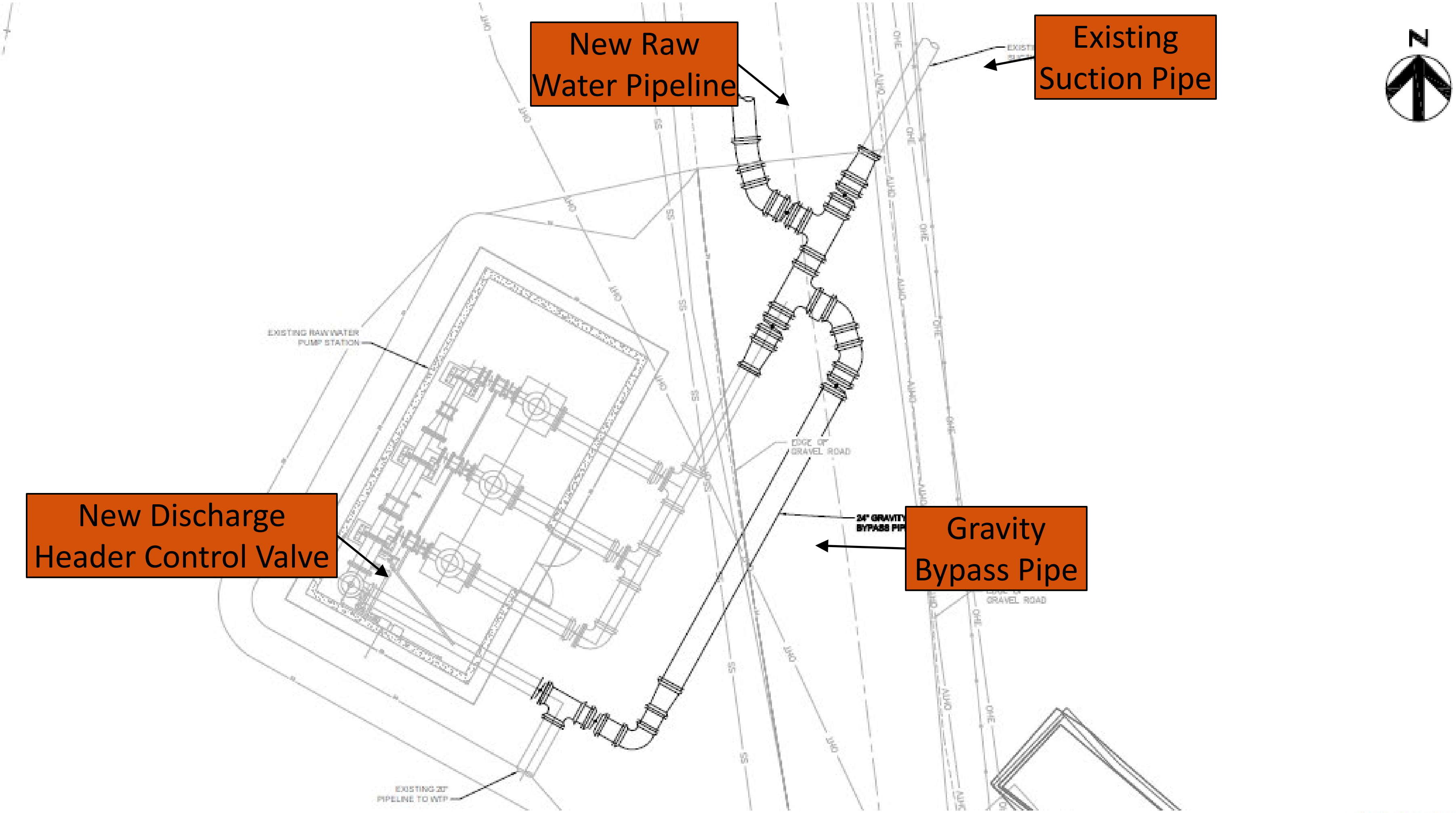
SCALE IN FEET

PRELIMINARY NOT FOR CONSTRUCTION

Other Design Parameters
Raw Water Pipeline



Other Design Parameters
Raw Water Pump Station



Construction Sequence – Work Packages

Legend

Seq ID	Package	Description	Seq ID	Package	Description
1	1	Upper dam access road - new road to left abutment	7	3	Raw water line to dam - tie in to dam outlet works
2	1	Reservoir clearing and road relocation	8	3	Dam toe access road - crossing and above
3	2	Raw water line – pump station thru crossing	9	3	Decommission upstream dam
4	2	Raw water pump station modifications	10	3	Decommission downstream dam
5	2	Improve entrance road - below crossing	11	4	Stream restoration - crossing to confluence
6	3	RCC dam - complete scope	12	4	Stream restoration - dam to crossing

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Cost Opinion Summary

Cost Basis	Base Cost	Low Range	High Range	Base Cost % of Total
Contractor "Bid" befor design contingency (2018 dollars)	**39,410,250**	**30,352,650**	**47,797,400**	**100%**
Work Package 1 - Roads & Reservoir Clearing	4,860,450	3,888,360	5,832,540	**12%**
Work Package 2 - Raw Water Line Construction	1,620,000	1,296,000	1,944,000	**4%**
Work Package 3 - Dam Construction & Decommissioning	32,004,800	24,428,290	38,910,860	**81%**
Work Package 4 - Stream Restoration	925,000	740,000	1,110,000	**2%**
Work Package 5 - Fish Passage (Waiver being pursued)	0	0	0	**0%**
Total Project Costs (after contingencies and non-contract costs, before escalation)	**61,200,000**	**47,100,000**	**74,200,000**	
Total Project Costs - Escalated at 3.5% to March 2022	**70,600,000**	**54,400,000**	**85,600,000**	
% of Base	100%	77%	121%	
Total Escalated Project Costs as % of Contractor "Bid"...	179%	179%	179%	
Select Information				
RCC Quantity - cy	87,000	87,000	87,000	
RCC Unit Cost	$ 135 /cy	$ 110 /cy	$ 155 /cy	
Work Package 3 costs per cy RCC	$368	$281	$447	

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Value Engineering

What is value engineering?

- Experts poke holes in the design, explore alternative solutions, and find ways to cut costs

- October 16th, 17th and 18th of 2018 – VE Study Workshop
- Industry experts:
    - Facilitator – Daniel Clancy, MFSI
    - Embankment Dam Seismic Engineer – Mike Beaty, Beaty Engineering LLC
    - RCC Dam Seismic Engineer – Larry Nuss, Nuss Engineering LLC
    - Overall Review Engineer – Jeff Szytel, WSC
    - Geotechnical Engineer – John Sager, Cornforth Consultants
    - Cost Estimator and Construction Engineer – Dan Hertel, Engineering Solutions LLC
    - State Dam Safety Engineer - Keith Mills, OWRD
    - City of Newport City Engineer - Timothy Gross

Value Engineering

Value Engineering - Study Objectives

- Ways to reduce cost?
- How to address maximum earthquake and/or Cascadia subduction event?
- Are there ways to separate construction and public access?
- How to address long term water supply needs?
- How to address seismic susceptibility?

VE Recommendations approved by City Council for further evaluation

Out of 34 creative ideas brainstormed, the following were developed & quantified within **functional categories**:

Construct Dam	
Curve dam in plan to improve seismic stability	-$2,312,000
Construct Road	
Use select dam foundation excavation for road embankment materials	-$314,000
Intake Water	
Replace concrete tower with multilevel steel tower	-$343,000
Restore Reservoir and Stream	
Lower BC-1 pool in lieu of stream restoration	-$1,158,000
Source Siletz Water	
Raise new dam to avoid using Siletz water	+$2,936,000
Total VE Cost Modification Recommendations:	***-$1,191,000***

Estimated Big Creek Dam Project Cost: $69,409,000

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Where Are We At Now, And What's Next ?

- HDR Engineering is completing the reservoir analysis and will soon begin environmental permitting
- City is working with Dig Deep Research to develop an outreach program called *Save our Supply* to raise awareness about the Big Creek Dams Project
- City is working with Dig Deep research to develop a funding strategy to include a variety of funding programs
- Long term - City is developing a legislative strategy to raise the awareness of the risk and costs associated with the Big Creek Dams with the goal of influencing water infrastructure investments at the State and Federal level.
  - SB894 was introduced by Senator Roblin and co-sponsored by Representative Gomberg to dedicate $44M from the State General Fund for the Big Creek Dam construction
- Short term - City is continuing to pull together funds to continue design and environmental permitting – anticipated permitting and designs costs are approximately $6M.

Thank You!
Questions?

Presented by

Timothy Gross, P.E.
Director of Public Works/City Engineer
City of Newport, OR
t.gross@newportoregon.gov
541-574-3369