US Bureau of Reclamation

Turbine Replacements – Lessons Learned

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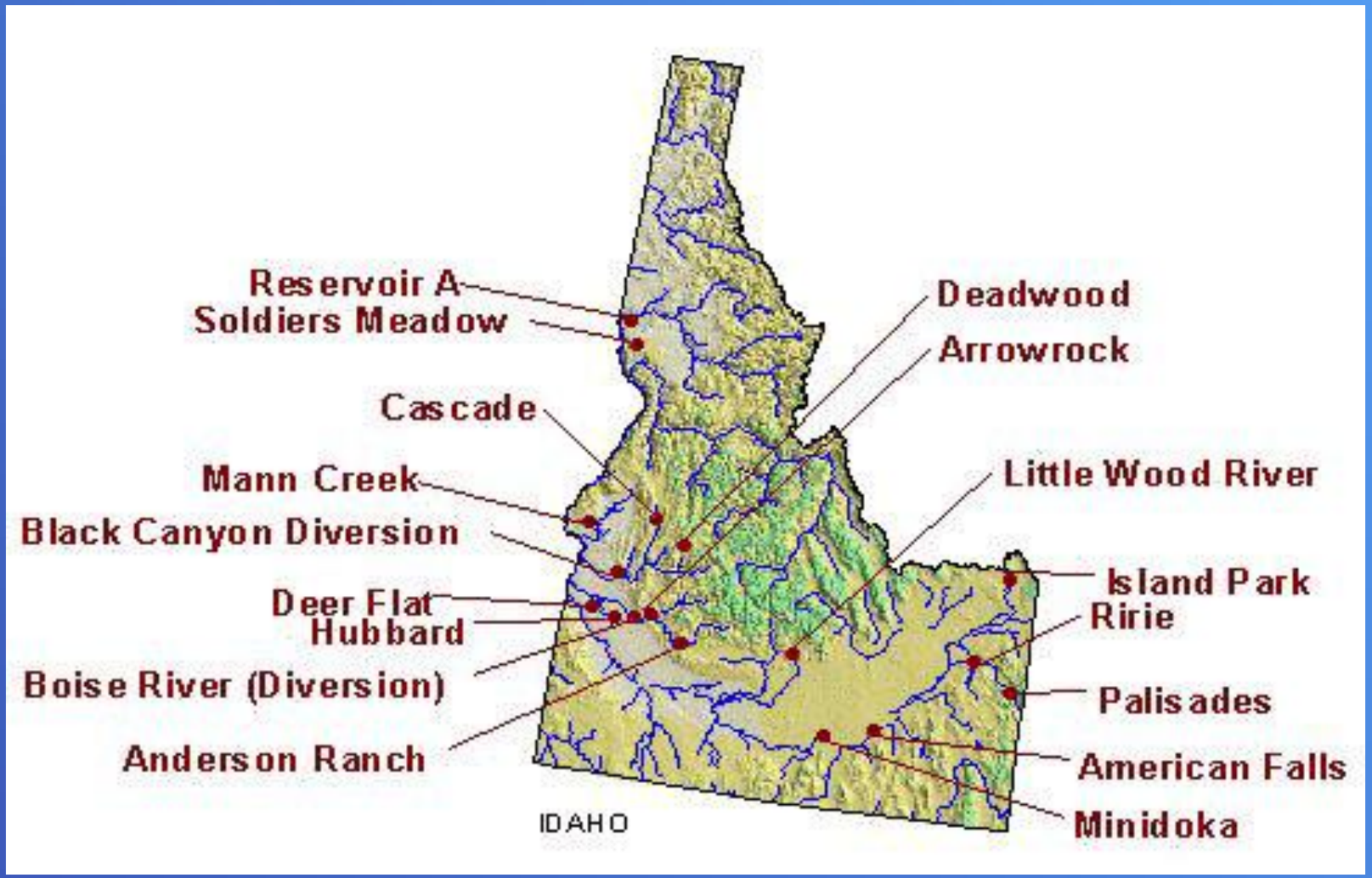
Presentation Outline

- Reclamation's Pacific Northwest Region projects
- Reclamation-wide projects

Palisades Dam



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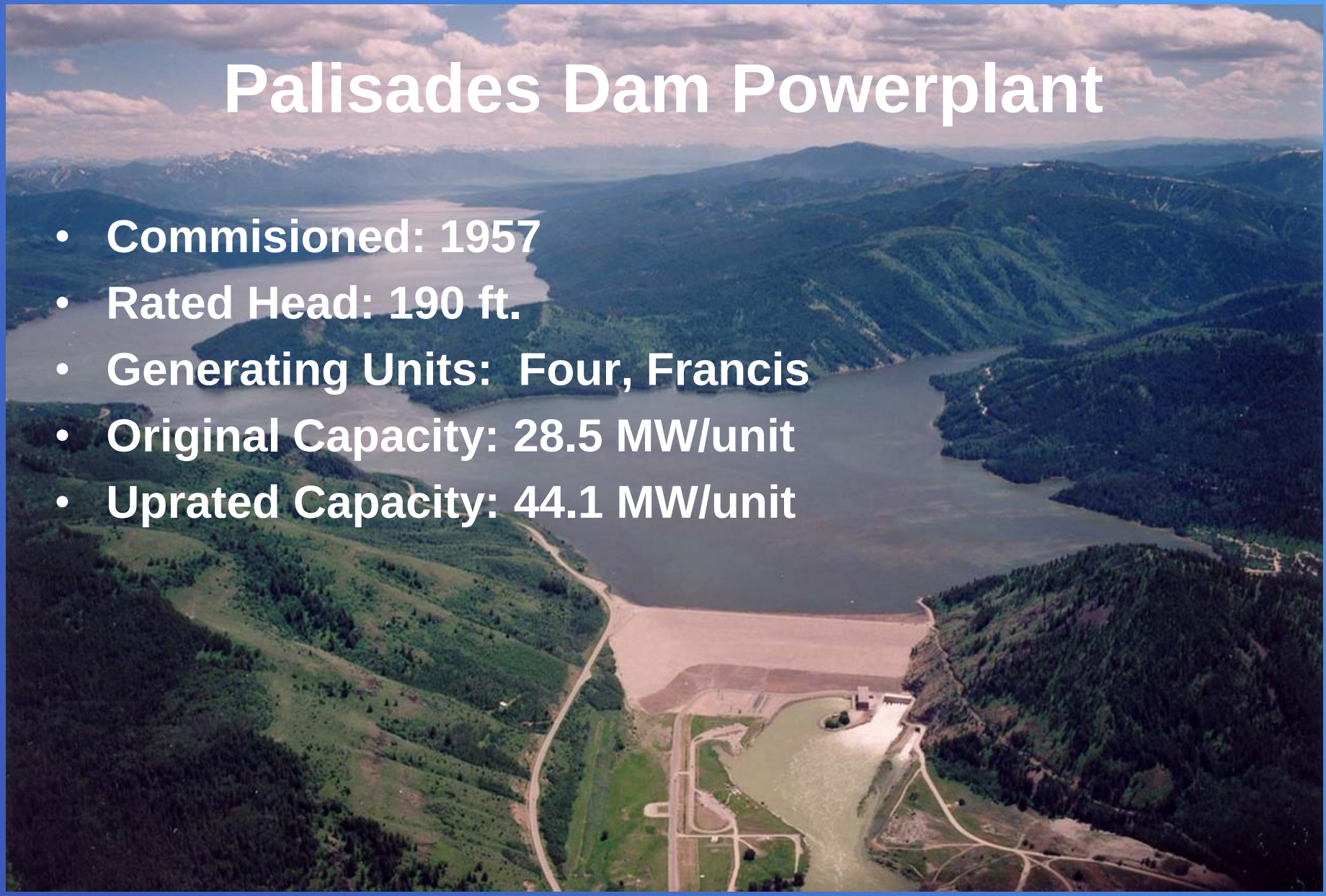
Palisades Dam Powerplant



- Commisioned: 1957
- Rated Head: 190 ft.
- Generating Units: Four, Francis
- Original Capacity: 28.5 MW/unit
- Uprated Capacity: 44.1 MW/unit

Palisades Dam Powerplant

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Palisades Dam Powerplant

Problem:

- **Mechanical fatigue**
- **Original, inefficient turbines**
- **Winter operations**
  - **Large rough zone**
  - **1500 cfs**
  - **Two units at 6 MW/each (54% efficiency)**

Palisades Turbine Replacement Contract Details

- **New:**
  - **Stainless steel vertical Francis runners**
  - **Coupling bolts/nuts**
  - **Stainless steel wicket gates**
  - **Wear rings**
  - **Shaft sleeve**
  - **Non-lube bushings**
  - **Shear pins, link pins and eccentric pins**
  - **Discharge ring**
- **Refurbish:**
  - **Head cover**
  - **Packing box**
  - **Guide bearings**
  - **Servomotors**

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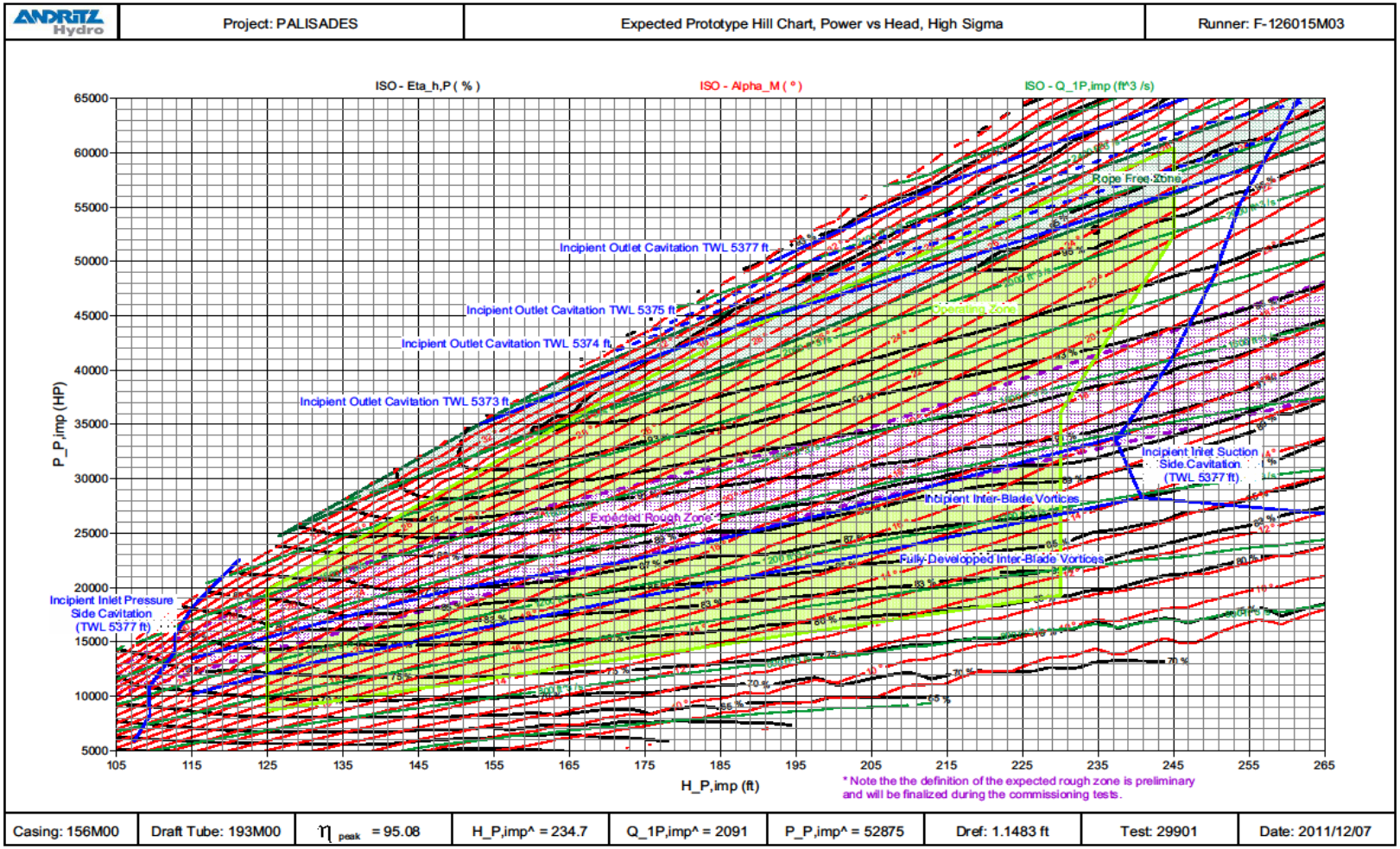
Palisades Dam Powerplant Turbine Efficiency

- Original Peak Efficiency: 90.7%; Full-gate, 85.9%
- New Peak Efficiency: 94.7%; Full-gate, 93.5%
- New runners have flat efficiency hill chart
- Winter Operation (1,500 cfs):
  - Old: Two units at 6 MW at 54% efficiency
  - New: One unit at 20 MW at 85% efficiency

Palisades Turbine Replacement Contract Status

- Contractor: Andritz Hydro
- Cost: $24.8M
- Schedule: One unit/year (September through May)
- Unit 1 complete in 2013
- Unit 4 complete in 2014 (late)
- Unit 3 anticipated to be complete in July 2015 (late start)
- Unit 2 will start in September 2015; completion in May 2016

Palisades Turbines – Hill Chart



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Palisades Dam Powerplant
New Francis Turbine

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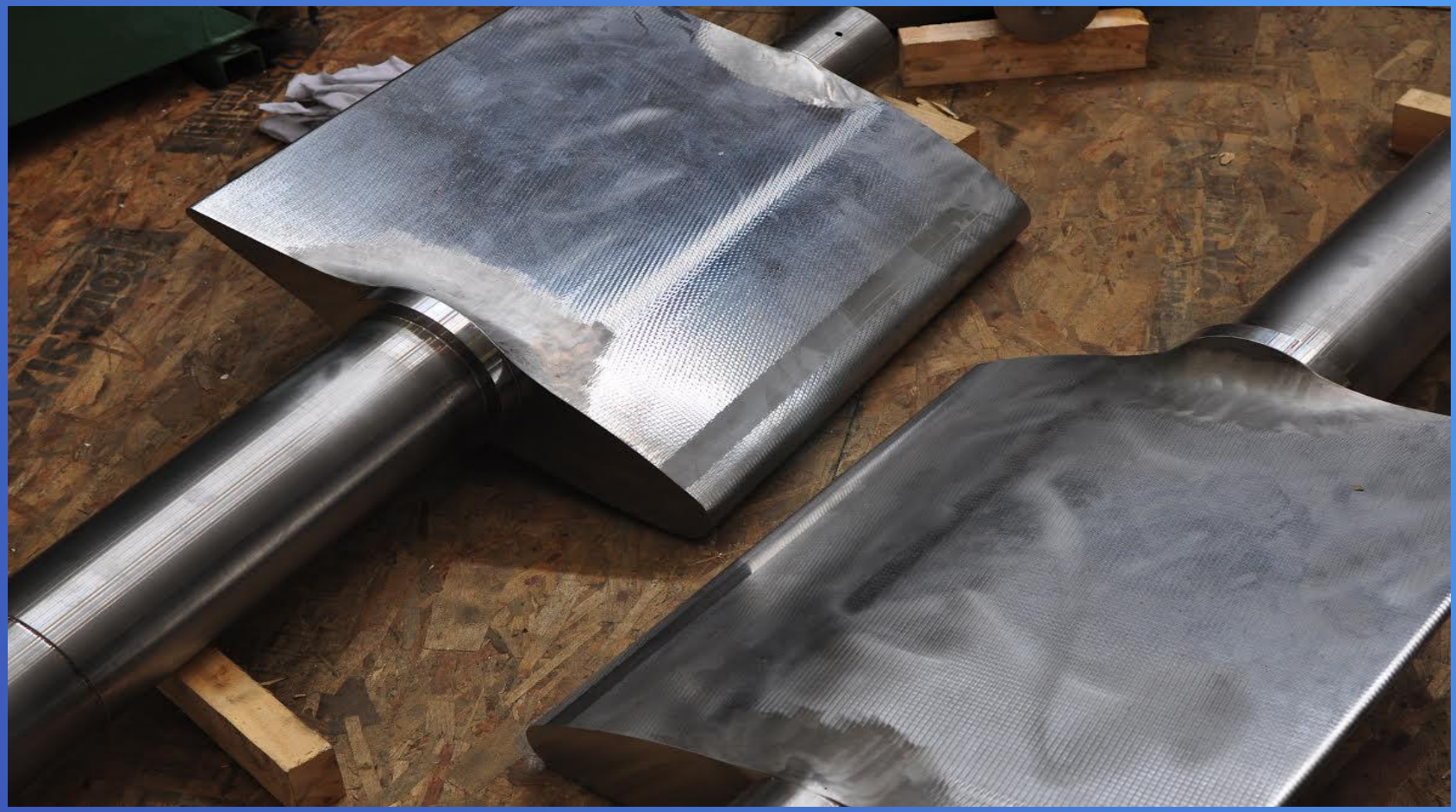
Palisades Dam Powerplant
New Wicket Gates



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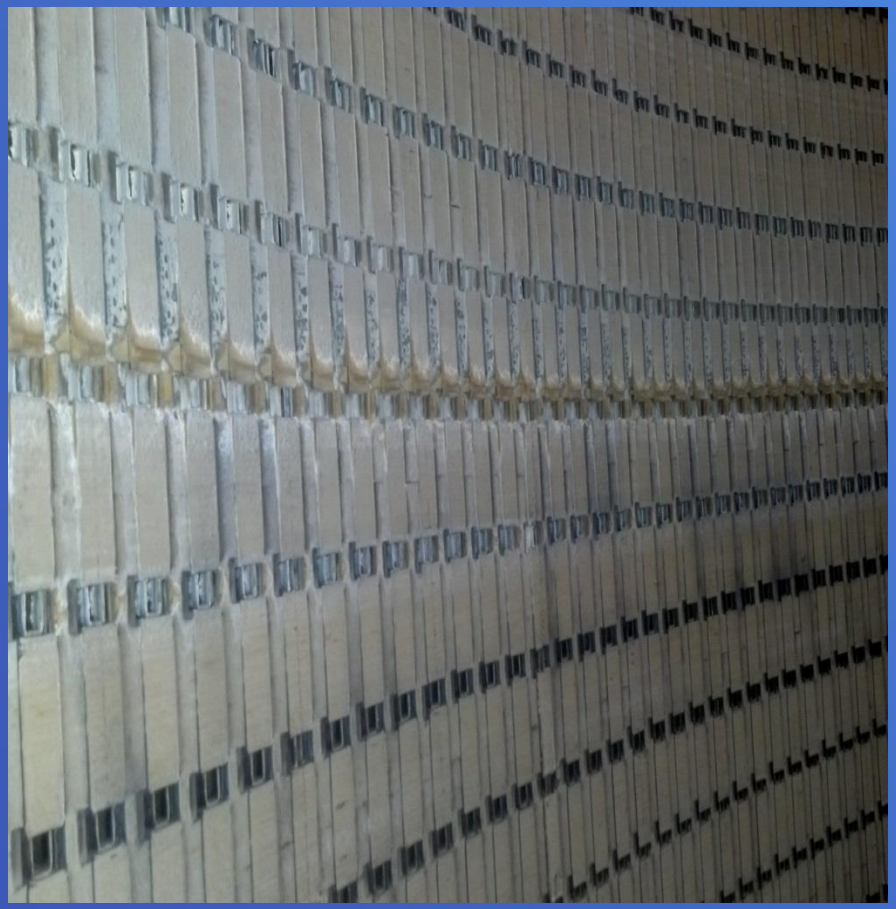
Palisades Dam Powerplant
Unit 4 Water Damage



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Palisades Dam Powerplant
Unit 4 Head Cover

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Palisades Dam Powerplant
Unit 4 Head Cover

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Unit 4 Head Cover

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Unit 4 Head Cover

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Unit 4 Head Cover

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Palisades Dam Powerplant
Unit 3 Operating Ring

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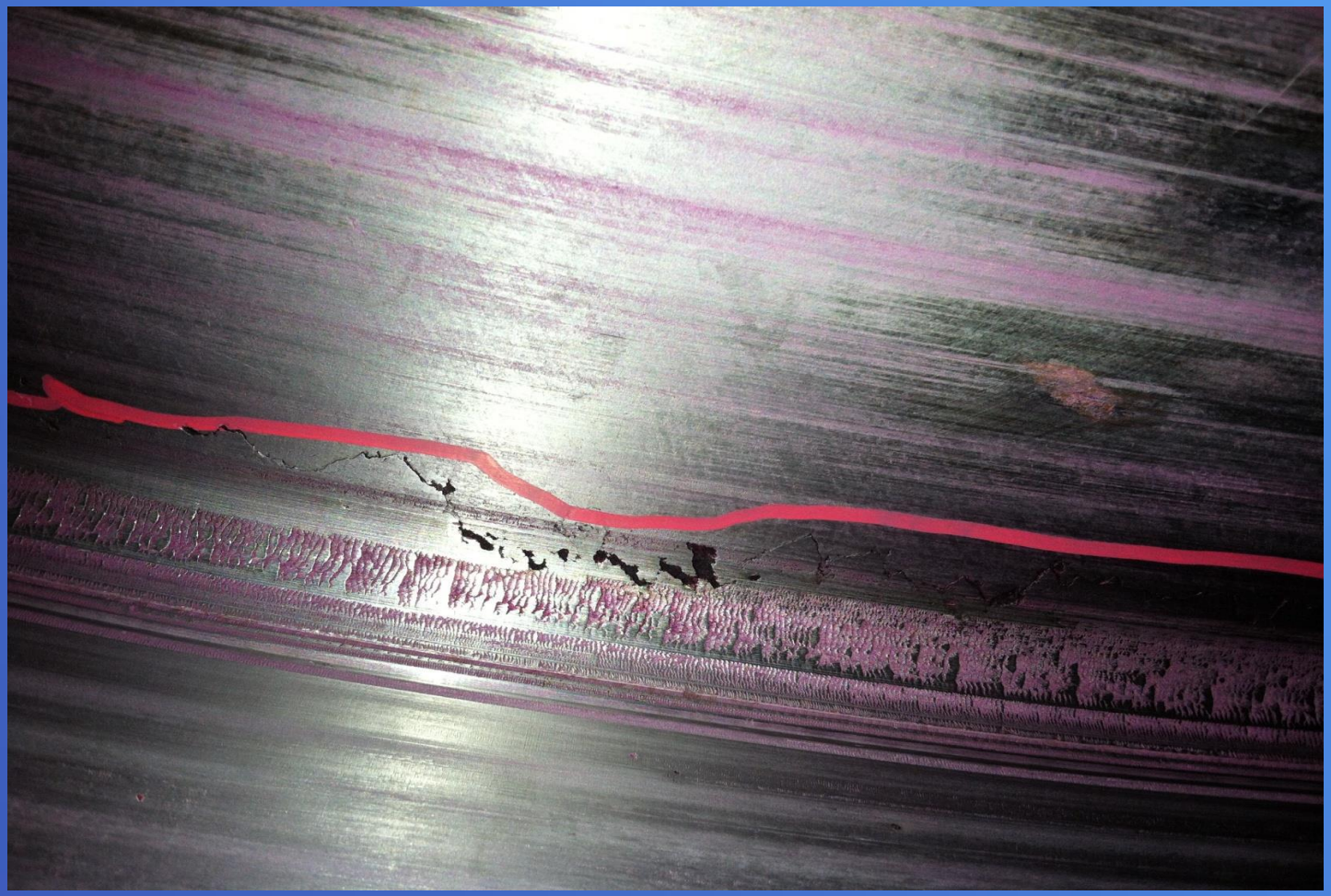
Palisades Dam Powerplant
Unit 3 Operating Ring



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Palisades Dam Powerplant
Unit 3 TGB Housing

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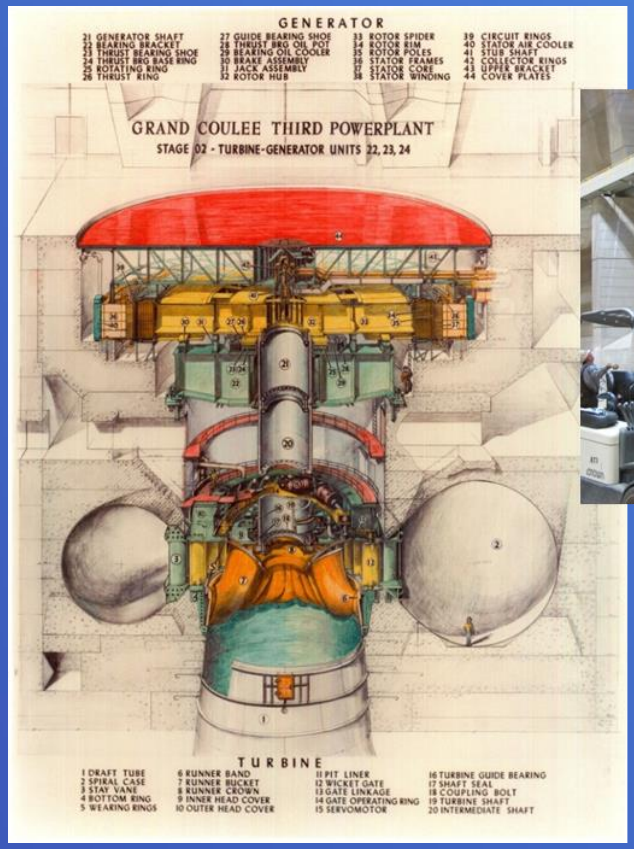
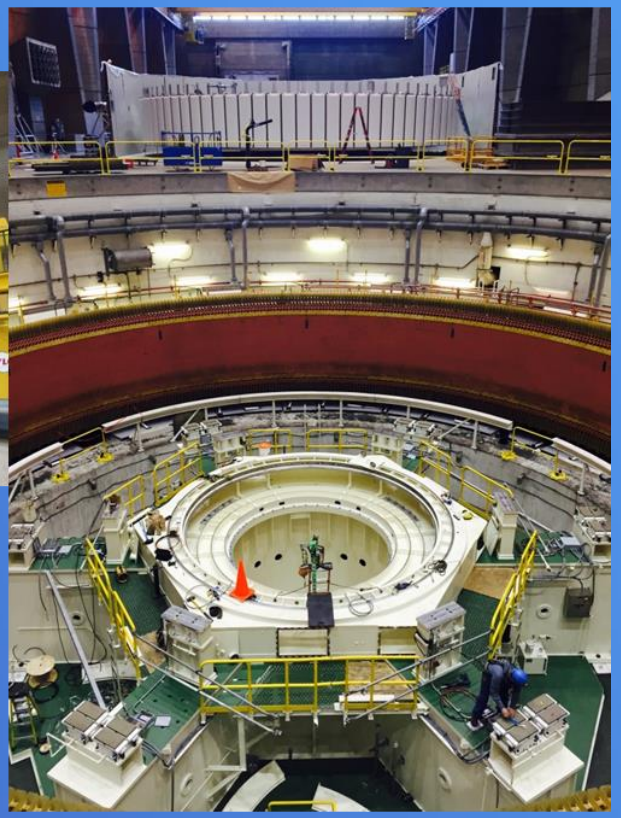
Palisades Dam Powerplant Turbine Replacement Lessons Learned

- Be ready for modifications
- You don’t know what is wrong until the unit is disassembled
- Hope for the best, prepare for the worst
- Unit 4 cracked head cover – poor original welding
- Unit 3 cracked operating ring, turbine guide bearing housing – poor original welding
- Unit 4’s rotor and stator had significant water damage; cleaned and replaced one rotor pole

Grand Coulee
Third Power Plant Overhaul





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Grand Coulee
Third Power Plant Overhaul

- Original Construction:
  - Installed 1975-1980
  - G22-G24 805 MW Each
  - G19-G21 690 MW Each
  - Annual Power Production exceeds $500 mil.
  - Increased forced outages in recent years
  - Units' mechanical components have met their life expectancy (Shear Pin and Shaft seal failures, Increased water leakage, stator cooling, gates, and many auxiliary and hydraulic systems)

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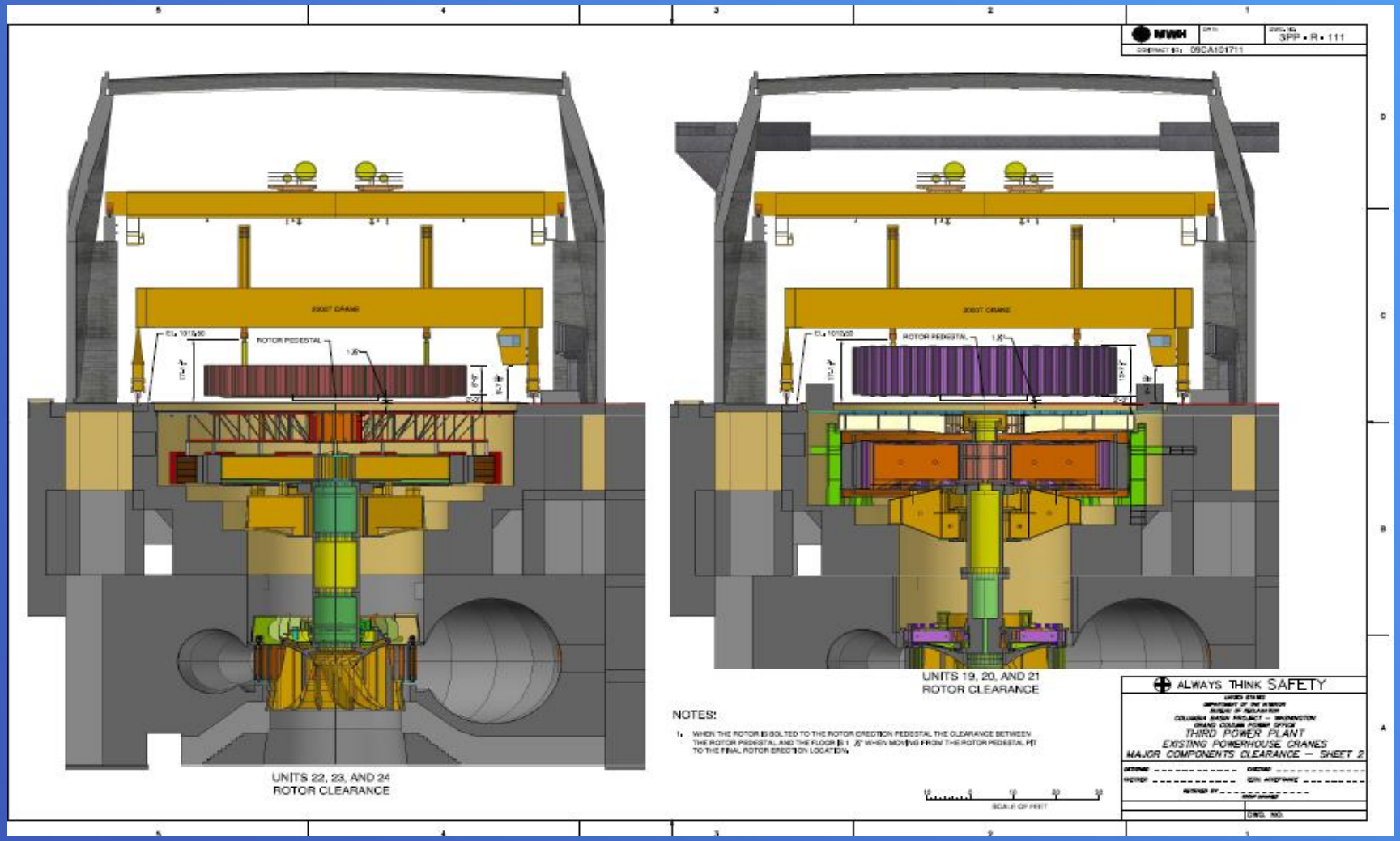
G19-21 versus G22-24



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Grand Coulee
Third Power Plant Overhaul

- Contractor: Andritz Hydro
- Scope: Mechanical overhaul, new mechanical shaft seal
- Work on Unit G24 began 3/10/13
- Currently 12 months behind schedule 55 Contract Mods to date
- Lessons Learned held
- Project Team and Contractor to meet in June to discuss ways to recover schedule

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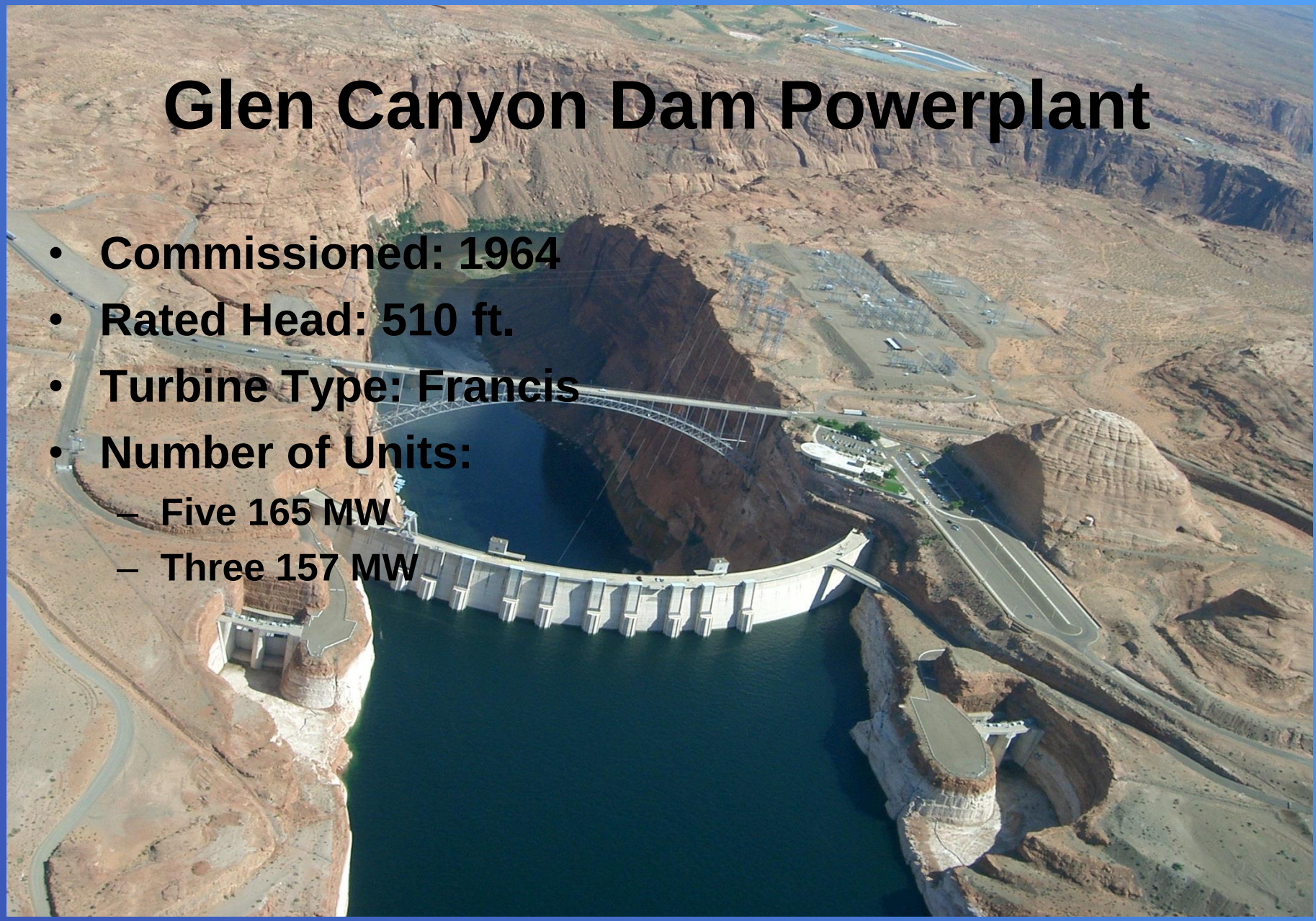
Glen Canyon Dam Powerplant



- Commissioned: 1964
- Rated Head: 510 ft.
- Turbine Type: Francis
- Number of Units:
  - Five 165 MW
  - Three 157 MW

Glen Canyon Dam Powerplant

- **Scope:**
  - Eight units (currently on last unit)
  - New stainless steel runners, wickets gates
  - Complete mechanical overhaul
- **Lessons Learned:**
  - Lot of shear pin breaks
  - Wicket gate stems were machined incorrectly
  - After re-machining to correct lengths, unit was reinstalled with no further issues

Glen Canyon Dam Powerplant

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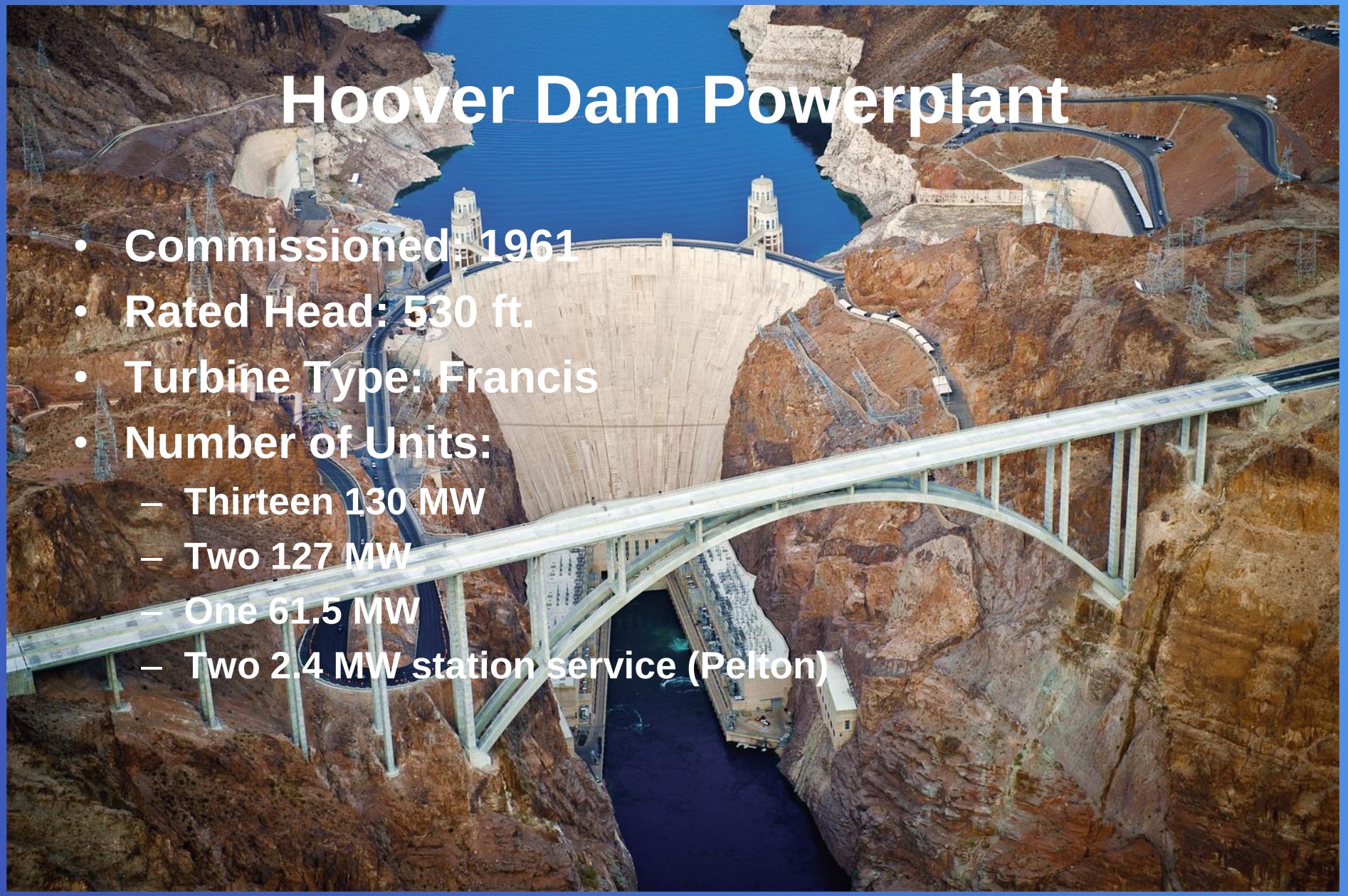
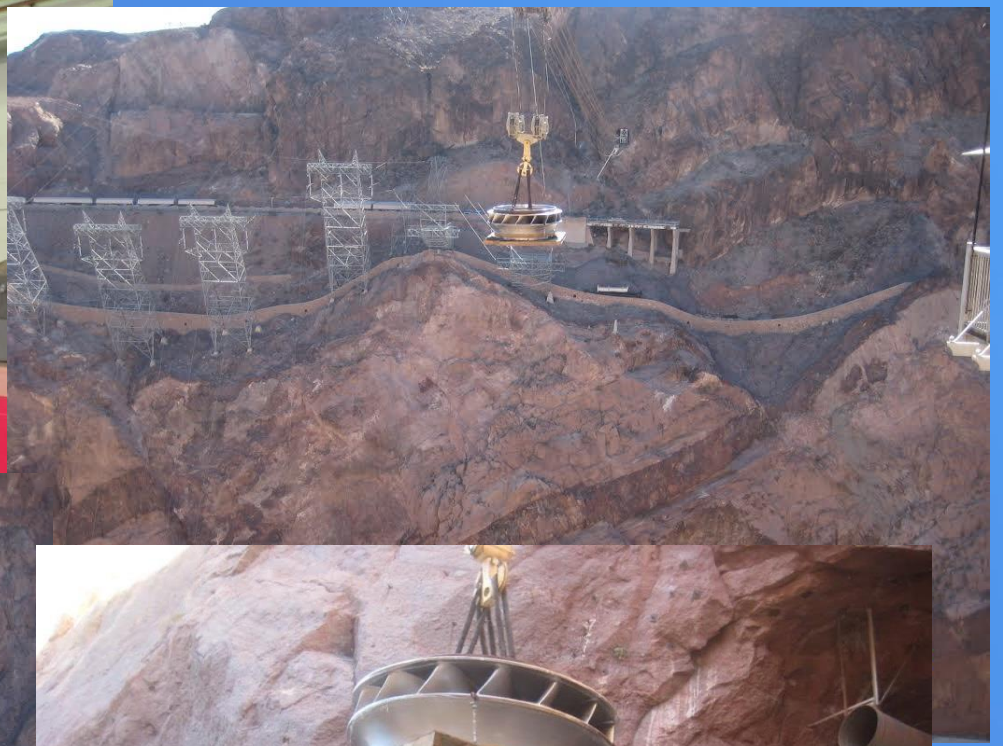
Hoover Dam Powerplant



- Commissioned: 1961
- Rated Head: 530 ft.
- Turbine Type: Francis
- Number of Units:
  - Thirteen 130 MW
  - Two 127 MW
  - One 61.5 MW
  - Two 2.4 MW station service (Pelton)

Hoover Dam Turbine Replacement

- Replaced four turbines with wide-range head turbines (each 130 MW)
- Supply contract; government forces installed new runners, wicket gates and performed mechanical overhaul
- Lessons Learned: none so far



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Fremont Canyon

- Commissioned: 1961
- Rated Head: 300 ft.
- Turbine Type: Francis
- Number of Units: Two
- Original Capacity: 24 MW/each
- Current Capacity: 33 MW/each

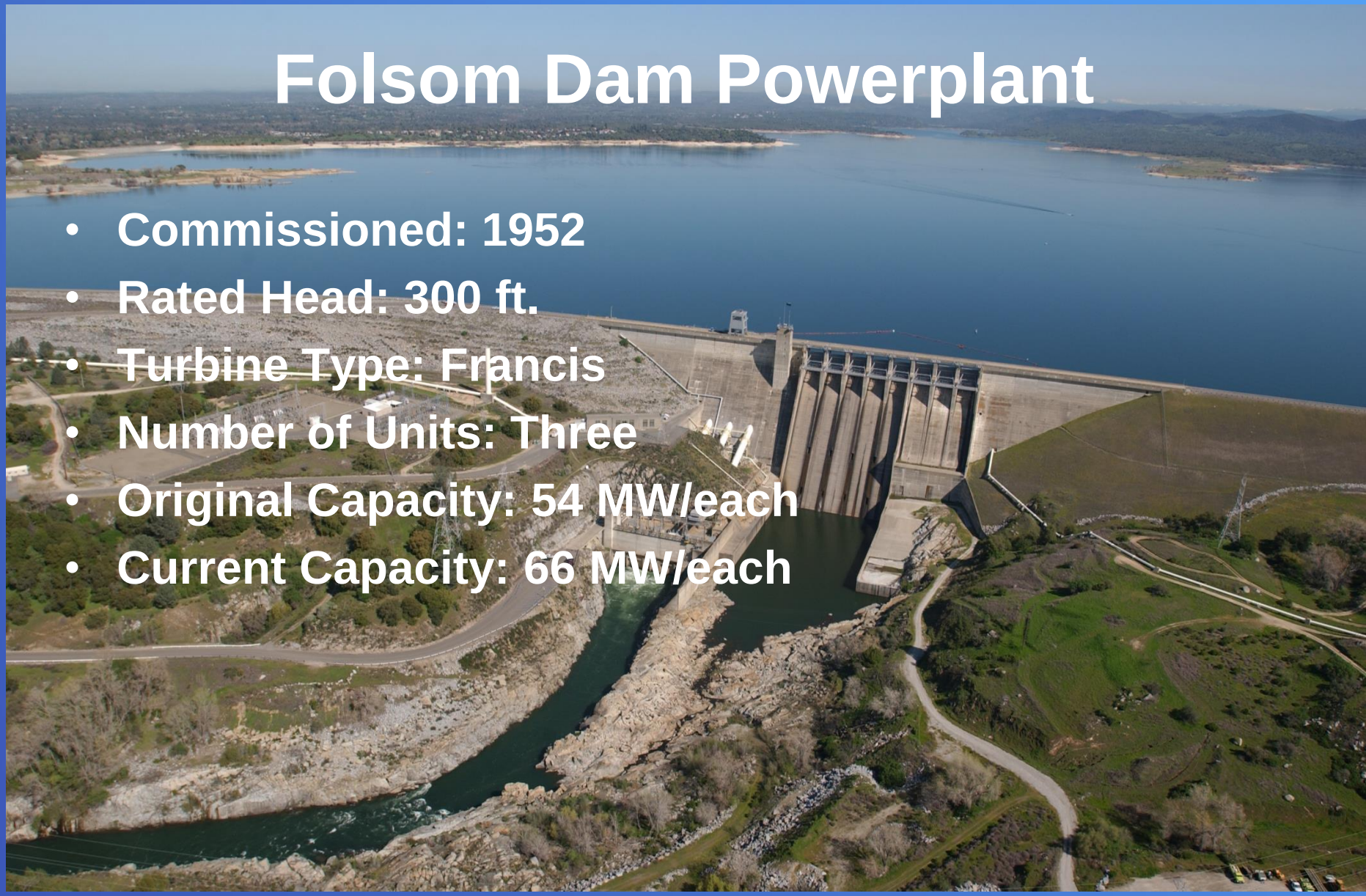
Fremont Canyon
Turbine Replacement

- Scope: new turbines, mechanical overhaul
- Original turbines had outlet edge cavitation from over gating
- Lessons learned:
  - The contractor forgot to machine the thrust relief holes
  - Contractor took responsibility and drilled the holes onsite
  - Ensure all machining steps have been completed prior to the turbine leaving the shop

Fremont Canyon

RECLAMATION

Folsom Dam Powerplant



- Commissioned: 1952
- Rated Head: 300 ft.
- Turbine Type: Francis
- Number of Units: Three
- Original Capacity: 54 MW/each
- Current Capacity: 66 MW/each

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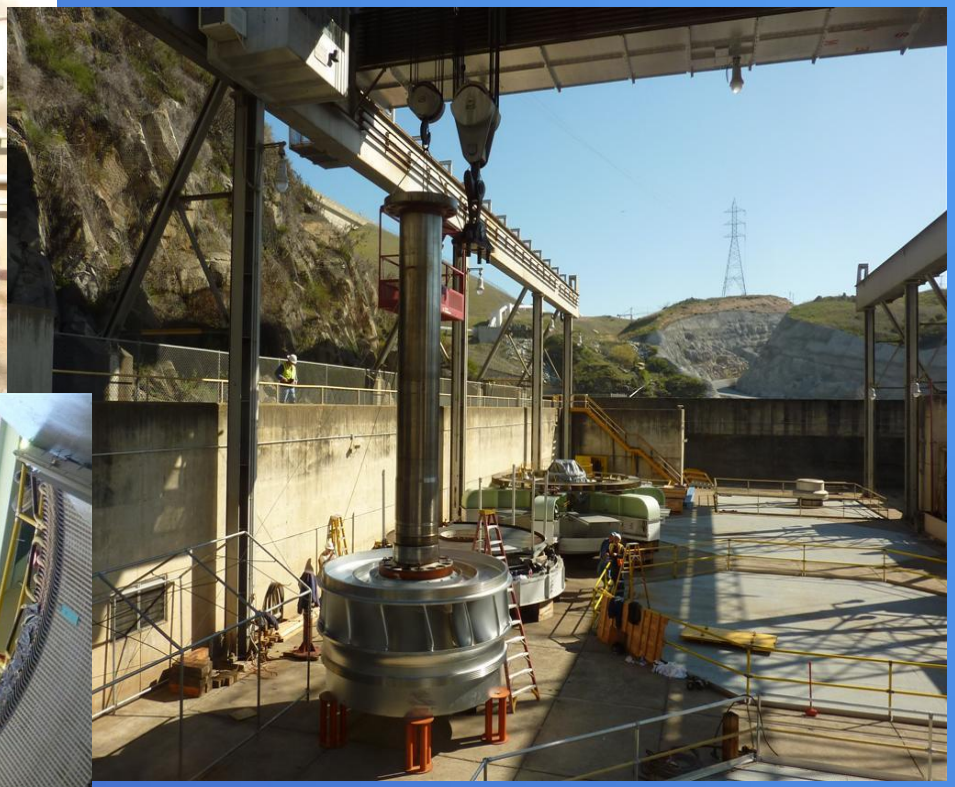
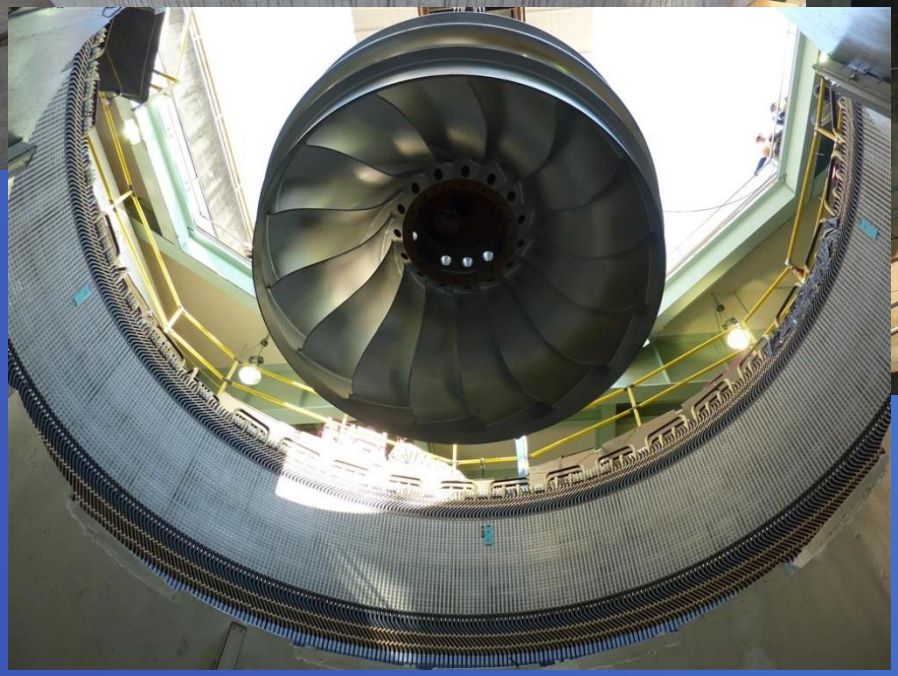
Folsom Dam Powerplant

- **Scope:**
  - New stainless steel turbines and wicket gates
- **Lessons Learned:**
  - There will be unforeseen issues regardless of age (10 or 60 years)
  - In 2005, all mechanical components were refurbished, but did not replace runners or wicket gates
  - In 2014, a lot of the 2005 components needed to be overhauled again
  - If performing a major overhaul, also include generator rewinds, turbine replacements and a thorough replacement of key components

Folsom Dam Powerplant





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Questions?

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