Glen Canyon Dam
Low-Head Hydropower Modifications
Summary

- Background
- Purpose and Needs
- Alternatives
- Next Steps
Background: Glen Canyon Dam and Powerplant

Lake Powell
23,314,000 ac-ft

Intakes
Spillways
Powerplant
River Outlets
Spillway Flip Buckets
Background: Glen Canyon Dam

- **ROW centerline = 3,374’**
  - 30’ above designer’s estimated 100-year silt level
- **Penstock centerline = 3,470’**
  - 45’ above designer’s estimated 150-year silt level
- **Current silt level of forebay is ~3,200’**
Background: Value Analysis

- **Reclamation’s Value Program**
- Systematic process of reviewing and analyzing the requirements and functions of...
  - Facilities
  - Projects
  - Systems
  - Etc.
- **Value planning study**
  - conducted at the conceptual stage
  - considers various alternatives to meet the identified needs
  - Alternative(s) selected for further analysis/study
Background: Glen Canyon Dam – Then vs Now
Background: P.L. 117-43

• Extending Government Funding and Delivering Emergency Assistance Act
• Reclamation received $200 million for Addressing Drought in the West
  • Glen Canyon Bypass and Intake Generation Appraisal Studies due to drought conditions - $2 million
Purpose and Needs

- Develop alternatives to address concerns with power generation and water releases at Glen Canyon Dam and Powerplant.

- Power revenue from Glen Canyon funds Reclamation and WAPA programs.

- Annual releases are determined by Interim Guidelines, and per the Law of the River.

- The Minimum Power Pool (MPP) is set based on the existing penstock elevations.

- Ongoing western drought is decreasing the water pool elevation, and increasing the risk of dropping below the MPP.

- The current pool elevation of Lake Powell (3522.85) is more than 177 feet below full and 32 ft above MPP.
Alternatives

1. New intakes through Glen Canyon Dam
   a) Low-Level Power Intake with New Low Head Runners
   b) Mid-Level Power Intake with Existing Runners

2. Outlet Works Powerplant
   a) New Powerplant, 2 Units
   b) Existing Powerplant connection

3. Abutment Powerplant
   a) Left Abutment Underground Powerplant
   b) Right Abutment In-River Powerplant

4. Adjust Colorado River Basin Operations

5. Refine MPP Operating Limit

6. Invest in Solar or Wind Generation
Alternatives discussed but not further considered

- Remove river diversion tunnel plug(s)
  - Downstream sections incorporated into spillway tunnels
  - Inlets buried in sediment (41-ft diameter tunnels)
    - Right invert (bottom) elevation – 3,137.37 feet
    - Left invert (bottom) elevation – 3,170.67 feet
  - Sediment could damage tunnel lining, penstocks, wicket gates, turbine runners
- Modify 2007 interim guidelines
  - Independent effort, already underway
- Re-operate upstream reservoirs
  - Insufficient storage capacity, only a temporary reprieve
- Low level outlet works
  - No power generation, can be incorporated into other alternatives
Alternative 1a: Low-Level Power Intake - New Low Head Runners

Description:
Penetrate through the dam, intake located in current dead pool, connect to existing penstocks downstream of the dam. Use existing power generating units with installation of new low-head runners.

Considerations:
- New intake @ 3285 ft (or other elevation)
- Up to 185 ft additional operating range
- Requires at least 4 units
- New guard gate and trash rack required
- Increased risk from penetration through dam
Alternative 1b: Mid-Level Power Intake - Existing Runners

Description:
• (4) new Mid-Level intakes
• Connects to existing penstocks
• Extended Gate/Trashrack

Considerations:
• Uses existing turbine runners and power plant
• Operation of power plant limited to elev. 3445
• New guard gate and trash rack required
• Increased risk from penetration through dam
Alternative 2a: Bypass Powerplant (New) – Outlet Works

Description:
• Artist’s rendering with PP sited at left abutment, near Machine Shop & river OW.
• Four conduits provide flow to new units with two conduits providing flow to each unit.
• Extend river OW downstream.

Considerations:
• Releases either through power plant or ROW only, not both
• High velocity = large friction loss
• Deep excavation (~100 ft) for substructure
• Low level release provides operational flexibility
Alternative 2b: Powerplant (Existing) – Outlet Works

Description:
• Use the existing infrastructure (as much as possible)
• Connect 2 of the ROW conduits to existing penstocks

Considerations:
• Requires bypass operation in addition to power plant releases to meet 2007 IG release volumes
• High head loss requires low-head runners
• Limited space for construction
Alternative 3a: Left Abutment Underground Powerplant

Description:
• Tunnel through left abutment
• Underground power plant

Considerations:
• Penstock and power plant size can be designed to maximize water/power
• Rock mechanics, seepage control, construction underground, maintenance, cost
• Low level release provides operational flexibility
• Increased capacity for HFEs
Alternative 3b: Right Abutment Powerplant

Description:
- Tunnel through right abutment
- Power plant in river bed

Considerations
- Penstock and power plant size can be designed to maximize water/power
- Rock mechanics, construction in river, maintenance, cost
- Low level release provides operational flexibility
- Increased capacity for HFEs
Alternative 4: Adjust Colorado Basin Operations

Description:
Adjust operations on a system-wide basis (Glen Canyon and Hoover) to maximize power generation under low flow conditions using existing infrastructure.

Considerations
• Potentially addressed by ongoing SEIS and post-2026 guidelines efforts
• Lower infrastructure investment
• Does not address lost revenue if no generation below MPP
Alternative 5: Refine MPP Operating Limit

Description:
- MPP probably due to vortex formation as intake submergence is reduced
- Modeling to simulate flows at reservoir levels approaching and below the MPP
- Potential addition of vortex-suppressing structures

Considerations:
- Limited operational benefit, not greater than elev. 3477.5
- No structural modifications
- Modeling efforts are underway
- Low cost
Alternative 6: Invest in Solar or Wind Generation

Description:
- Invest in other renewable energy sources to augment hydro power resources

Considerations:
- Scalable
- Requires large land areas
- Authority – CRSP only authorizes hydropower
- Expertise – this is not Reclamation’s expertise
- Can be developed independent of Reclamation
  - Customers exploring options
<table>
<thead>
<tr>
<th>Alternative</th>
<th>Intake elevation (ft)</th>
<th>Elevation (ft)</th>
<th>Total Max flow (cfs)</th>
<th>Approx. Total Max Power Output (MW)</th>
<th>Elevation (ft)</th>
<th>Total Max flow (cfs)</th>
<th>Approx. Total Max Power Output (MW)</th>
<th>Number of Units</th>
<th>Outlet works can be used to supplement flow as needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a (Low-level intake, low-head runner)</td>
<td>3,285</td>
<td>3,390</td>
<td>8,400</td>
<td>135</td>
<td>3,490</td>
<td>10,800</td>
<td>240</td>
<td>4</td>
<td>Yes, to 3390</td>
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<td>1b (Mid-level intake)</td>
<td>3,425</td>
<td>3,445</td>
<td>10,000</td>
<td>210</td>
<td>3,490</td>
<td>12,000</td>
<td>310</td>
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<td>2a (Powerplant at outlet works)</td>
<td>3,390</td>
<td>3,390</td>
<td>4,000</td>
<td>65</td>
<td>3,490</td>
<td>15,000</td>
<td>340</td>
<td>2</td>
<td>No</td>
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<td>2b (Low Head Runner)</td>
<td>3,374</td>
<td>3,390</td>
<td>2,000</td>
<td>60</td>
<td>3,490</td>
<td>7,500</td>
<td>170</td>
<td>2</td>
<td>Yes</td>
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<tr>
<td>3a (Left Abutment Powerplant)</td>
<td>3,370</td>
<td>3,390</td>
<td>9,200</td>
<td>160</td>
<td>3,490</td>
<td>14,000</td>
<td>350</td>
<td>2</td>
<td>Yes</td>
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<tr>
<td>3b (Right Abutment Powerplant)</td>
<td>3,370</td>
<td>3,390</td>
<td>9,200</td>
<td>160</td>
<td>3,490</td>
<td>14,000</td>
<td>350</td>
<td>2</td>
<td>Yes</td>
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<td>4 (Adjust Colorado River Basin Operations)</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
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<td>5 (Refine MPP Operations)</td>
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<td>6 (Invest in Solar and Wind)</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>200</td>
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## GCD Maximum Flows

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<tbody>
<tr>
<td>Current</td>
<td>~45,000 cfs</td>
<td>15,000 cfs</td>
<td>~30,000 cfs</td>
<td>0 cfs</td>
</tr>
<tr>
<td>Alt. 1a (low level intake)</td>
<td>~45,000 cfs</td>
<td>27,000 cfs</td>
<td>~30,000 cfs</td>
<td>12,000 cfs</td>
</tr>
<tr>
<td>Alt 1b (mid-level intake)</td>
<td>~45,000 cfs</td>
<td>27,000 cfs</td>
<td>~30,000 cfs</td>
<td>12,000 cfs</td>
</tr>
<tr>
<td>Alt 2a (bypass power plant)</td>
<td>~45,000 cfs</td>
<td>15,000 cfs</td>
<td>~45,000 cfs</td>
<td>15,000 cfs</td>
</tr>
<tr>
<td>Alt 2b (ROW to existing PP)</td>
<td>~45,000 cfs</td>
<td>15,000 cfs</td>
<td>~30,000 cfs</td>
<td>7,500 cfs</td>
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<tr>
<td>Alt 3a &amp; b (abutment PPs)</td>
<td>~59,000 cfs</td>
<td>29,000 cfs</td>
<td>~44,000 cfs</td>
<td>14,000 cfs</td>
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## Non-power generation considerations

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Power intake elevation</th>
<th>Augment normal release w/colder water</th>
<th>Increased maximum discharge</th>
<th>Flexibility for water quality (dissolved oxygen or other)</th>
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<tbody>
<tr>
<td>Current</td>
<td>3,470</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Alt. 1a (low level intake)</td>
<td>3,285 (or per design)</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Alt 1b (mid-level intake)</td>
<td>3,425</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Alt 2a (bypass power plant)</td>
<td>3,374</td>
<td>Yes</td>
<td>No (&gt;powerplant max discharge)</td>
<td>Yes</td>
</tr>
<tr>
<td>Alt 2b (ROW to existing PP)</td>
<td>3,374</td>
<td>Yes</td>
<td>No (&gt;powerplant max discharge)</td>
<td>Yes</td>
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<tr>
<td>Alt 3a &amp; b (abutment PPs)</td>
<td>3,370 (or per design)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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</tbody>
</table>
Other considerations

- Authority
- Costs: capital, life cycle and O&M
- Construction time-line
- Repayment
- Environmental opportunities & impacts
  - Temperature
  - Capacity for HFEs
  - Dissolved oxygen & other water quality considerations
Next Steps

Where do we go from here?

• Partner and stakeholder briefings
• Select alternative(s) (spring 2023)
• Appraisal Study (Reclamation TSC)
  • Schedule: 2023-2024
  • $2M from 2022 CR drought funding
  • Stakeholder participation and input
Next Steps

Authority and funding would be required to proceed beyond appraisal

• Planning continued...
  • Feasibility Study
  • NEPA
• Design
• Construction
• Operation
QUESTIONS?

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