Northwest Power and Conservation Council

March 25, 2011

MEMORANDUM

TO: Council Members

FROM: Terry Morlan

SUBJECT: Presentation on Potential for Pumped Storage at Banks Lake

Pumped storage is one potential strategy for shifting energy production from off-peak to on-peak times, increasing system capacity, and potentially providing additional flexibility to the power system. In other parts of the country, pumped hydro has been economically feasible because of the difference between on-peak and off-peak electricity prices. That is, the lost energy for pumping can be paid for by the difference between off-peak prices, when the water is pumped up, and the on-peak prices when the energy generated from the stored water is sold. In the Pacific Northwest, pumped hydro has not generally been attractive because the difference between peak and off-peak is too small.

The attractiveness of pumped storage may be changing in the region, however, because of increased constraints on the flexibility of hydrosystem operations, increased variable wind generation, and growing capacity needs.

As part of the irrigation development in the Columbia plateau, water is pumped from the reservoir behind Grand Coulee dam up to Banks Lake, where it is distributed for irrigation. The facility used for this is the John W. Keys III Pump Generating Plant. Some of the pumps used in this process can be run backwards; that is water can be run from Banks Lake back to the reservoir behind Grand Coulee and the pumps used as electricity generators. This is essentially how a pumped storage project works except that in the case of Banks Lake the system has not typically been operated in that mode.

Bonneville and the Bureau of Reclamation have been exploring the feasibility and potential for changes to use the system more for pumped storage and flexibility. Mark Jones and Wayne Todd from Bonneville will describe this work and some of the issues involved in adding a new focus to the operation of the Banks Lake system to include more pumped storage operations. The first page of the attachment contains some background information

Attachment
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RECLAMATION
Managing Water in the West

U.S. Department of the Interior
Bureau of Reclamation

John W. Keys III Pump-Generating Plant

The John W. Keys III Pump-Generating Plant pumps water uphill 280 feet from Franklin D. Roosevelt Lake to Banks Lake. This water is used to irrigate approximately 670,000 acres of farmland in the Columbia Basin Project. More than 60 crops are grown in the basin and distributed across the nation.

Congress authorized Grand Coulee Dam in 1935, with its primary purpose to provide water for irrigation. When the United States entered World War II in 1941, the focus of the dam shifted from irrigation to power production. It was not until 1943 that Congress authorized the Columbia Basin Project to deliver water to the farmers of central Washington State.

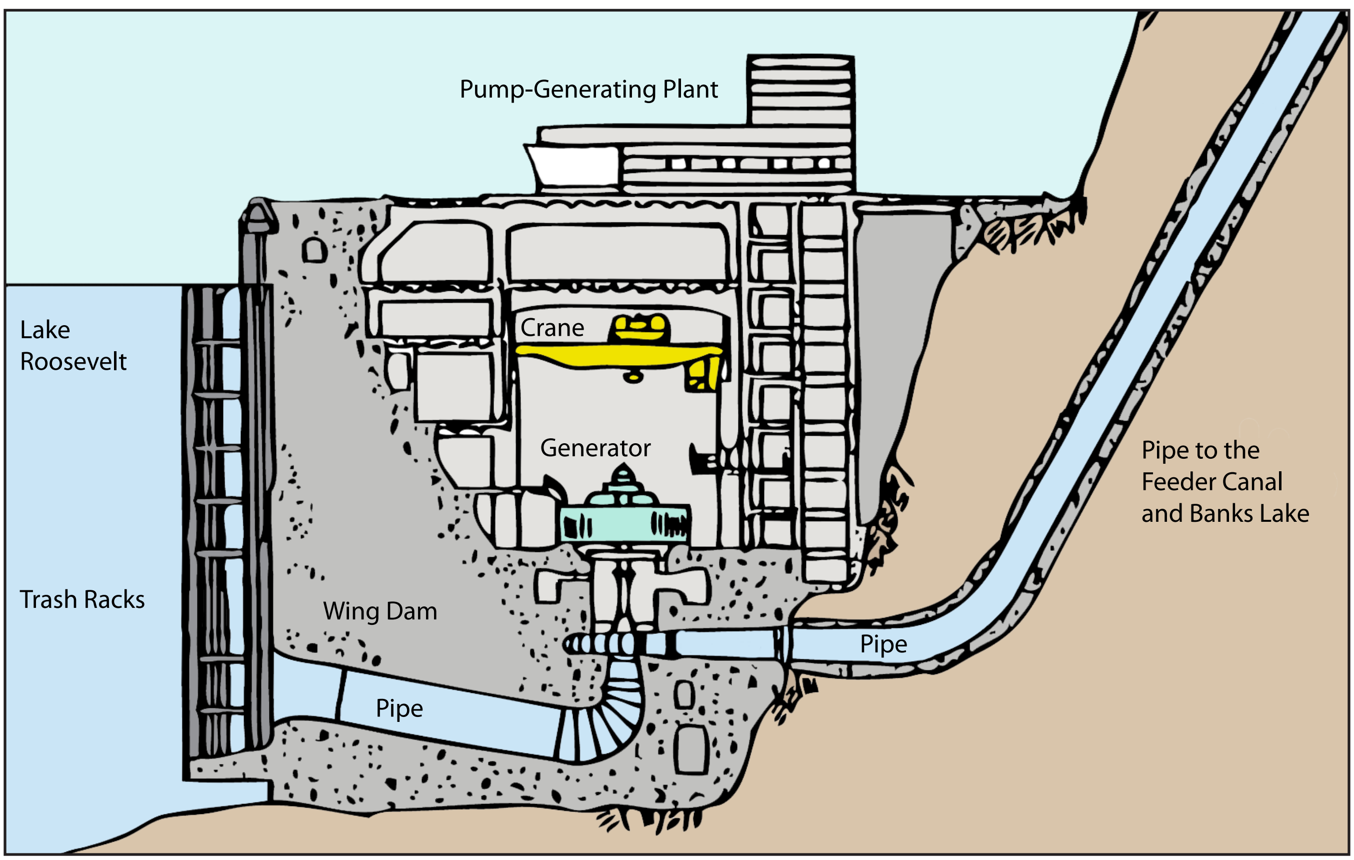
Construction of the irrigation facilities began in 1948. Components of the project include the pump-generating plant, feeder canal, and equalizing reservoir, which was later named Banks Lake.

Banks Lake was formed by damming the northern 27 miles of the Grand Coulee, and has an active storage capacity of 715,000 acre-feet. The lake stores water for irrigation and also provides important recreational benefits to the region.

The pump-generating plant began operation in 1951. From 1951 to 1953, six pumping units, each rated at 65,000 horsepower and with a capacity to pump 1,600 cubic feet per second, were installed in the plant.

In the early 1960s, investigations revealed the potential for power generation. Reversible pumps were installed to allow water from Banks Lake to flow back through the units to generate power during periods of peak demand. The first three generating pumps came online in 1973. Two more generating pumps were installed in 1983; the final generating pump was installed in January 1984. The total generating capacity of the plant is now 314,000 kilowatts.

In 2008, the pump-generating plant was renamed in honor of John W. Keys III. Keys was Commissioner of the Bureau of Reclamation from 2001 to 2006 and Pacific Northwest Regional Director from 1986 to 1998. He was killed in a plane crash in 2008.



Revised April 2009

Making Electricity at Grand Coulee Dam

How a Turbine Works

Electricity is made by spinning an electromagnetic field (rotor) through a stationary field of copper (stator). Falling water is the driving force; gravity ensures that water will always flow downhill.

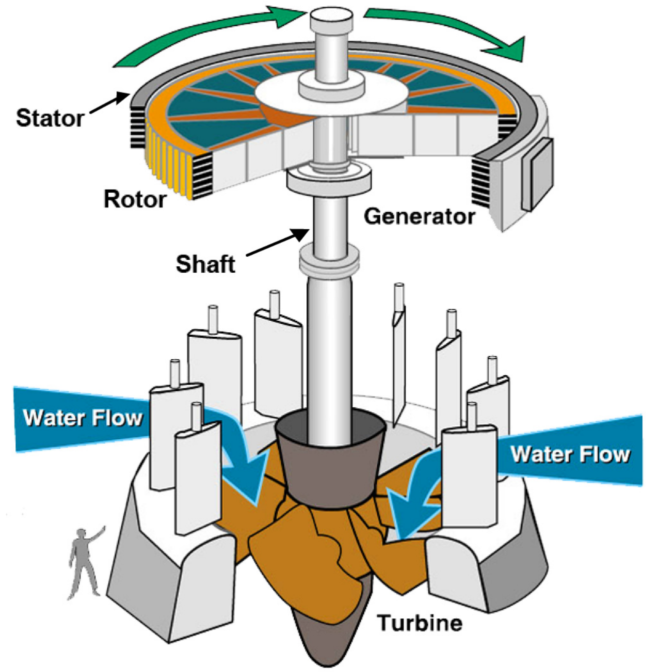
The water flows through a large pipe called a penstock. The water pushes against the blades of the water wheel (turbine) causing it to spin.

The turbine is connected to the generator by a shaft. As the rotor in the generator spins, the magnetic field sweeps through the copper, inducing an electron flow, which becomes electricity.

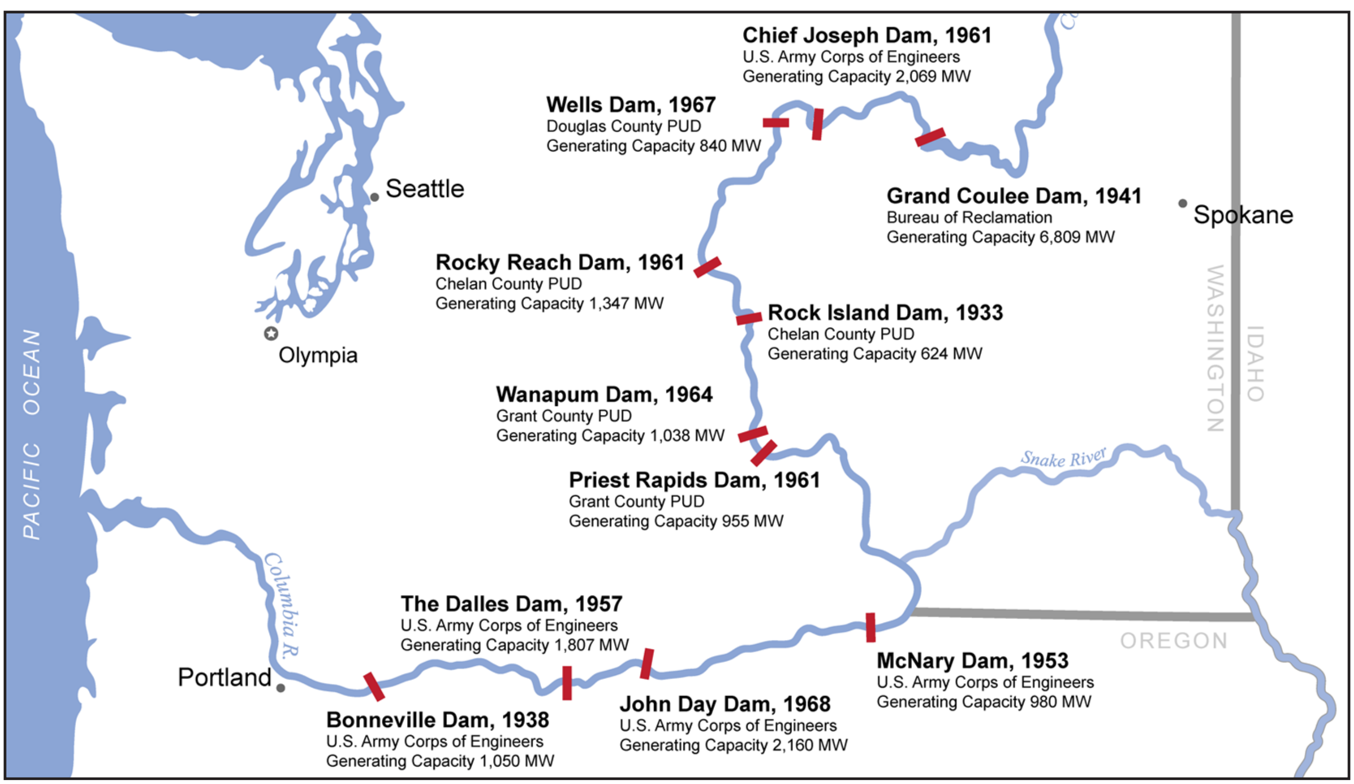
The electricity passes through a system of controlling switches, voltage changing transformers, and miles of wire before it is delivered to homes, industries, and businesses.

Note: This graphic of a Kaplan turbine is provided courtesy of the U.S. Army Corps of Engineers. Grand Coulee Dam contains Francis turbines.

Visit www.usbr.gov/pn/grandcoulee/index.html for more information.



Major Hydropower Dams on the Columbia River in the U.S.



Pumped Storage Evaluation

Council Meeting, April 12-13, 2011
Wenatchee, WA

Introduction to BPA

Federal Columbia River Power System (FCRPS)

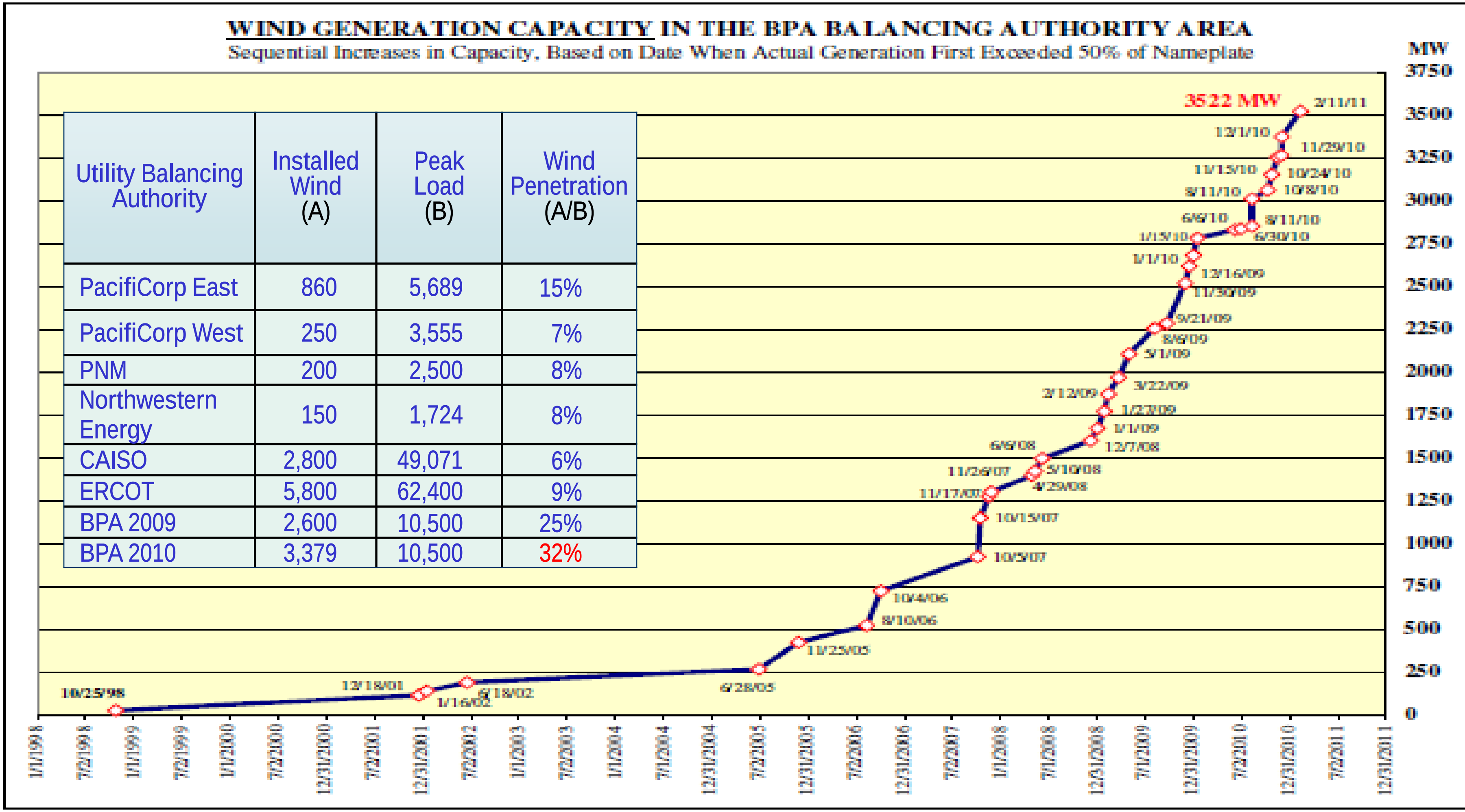
- BPA markets power from 31 Federal Hydropower Plants (21 COE/10 BOR)(8,018 avg. MW; about 22,000 installed MW), Columbia Generating Station Nuclear Plant and some non-Federal hydro and wind

- More than 80% of the power BPA sells is hydroelectric

- BPA accounts for about 33% of the electric power consumed within the Region

Bonneville Power Administration

Wind Power is Growing



Utility Balancing Authority	Installed Wind (A)	Peak Load (B)	Wind Penetration (A/B)
PacifiCorp East	860	5,689	15%
PacifiCorp West	250	3,555	7%
PNM	200	2,500	8%
Northwestern Energy	150	1,724	8%
CAISO	2,800	49,071	6%
ERCOT	5,800	62,400	9%
BPA 2009	2,600	10,500	25%
BPA 2010	3,379	10,500	32%

WIND_InstalledCapacity_current.xls 3/15/2011

Bonneville Power Administration

Pumped Storage Evaluation – Overall Plan

Summer-Fall 2009 | **Fall 2009 - Present**

Information Gathering

1. **Evaluate Storage Technology Options** (PNNL)
2. **Evaluate State of the Art Pumped Storage** (MWH/USACE)
3. **Pumped Storage Forum** (USACE/BPA)
   Voith, Toshiba, Alstom, Andritz
4. **Banks Lake Pumped Storage Evaluation** (USBR)

Pumped Storage Evaluation

System Analysis, Design Parameters, and Economics

Contract Awarded to HDR/DTA

Banks Lake Pumped Storage

- Equipment Upgrades
- Expansion Alternatives
- Operational Changes

Specific Build Decisions

Add Pumped Storage to an Existing Federal Facility

- USACE
- USBR

New Federal Pumped Storage Project

- USACE
- USBR

Non-Federal Pumped Storage Project

- Purchase Use
- Partnering Arrangement

Banks Lake Pumped Storage Improvements

HDR/DTA Report

Hydroelectric Pumped Storage for Enabling Variable Energy Resources within the Federal Columbia River Power System

- Pumped storage has significant potential in the Pacific Northwest…
- Keys Pump-Generating Plant is underutilized and with modernization and potential upgrades can be a near term resource for wind integration.
- Grid scale energy storage would be a valuable asset for long term expected levels of wind in the future.

Recommendations and Suggested Next Steps:

- Model Development - Develop Tools to more accurately assess the capabilities of pumped storage to enable the integration of higher levels of variable generation in the FCRPS.
- Keys Pump-Generating Plant - Pursue Equipment Modernization and Upgrades
- Greenfield Project – Continue evaluation of a greenfield pumped storage project
- Regional/National Communication – Pursue regional collaborative evaluation of a greenfield pumped storage project

Reclamation

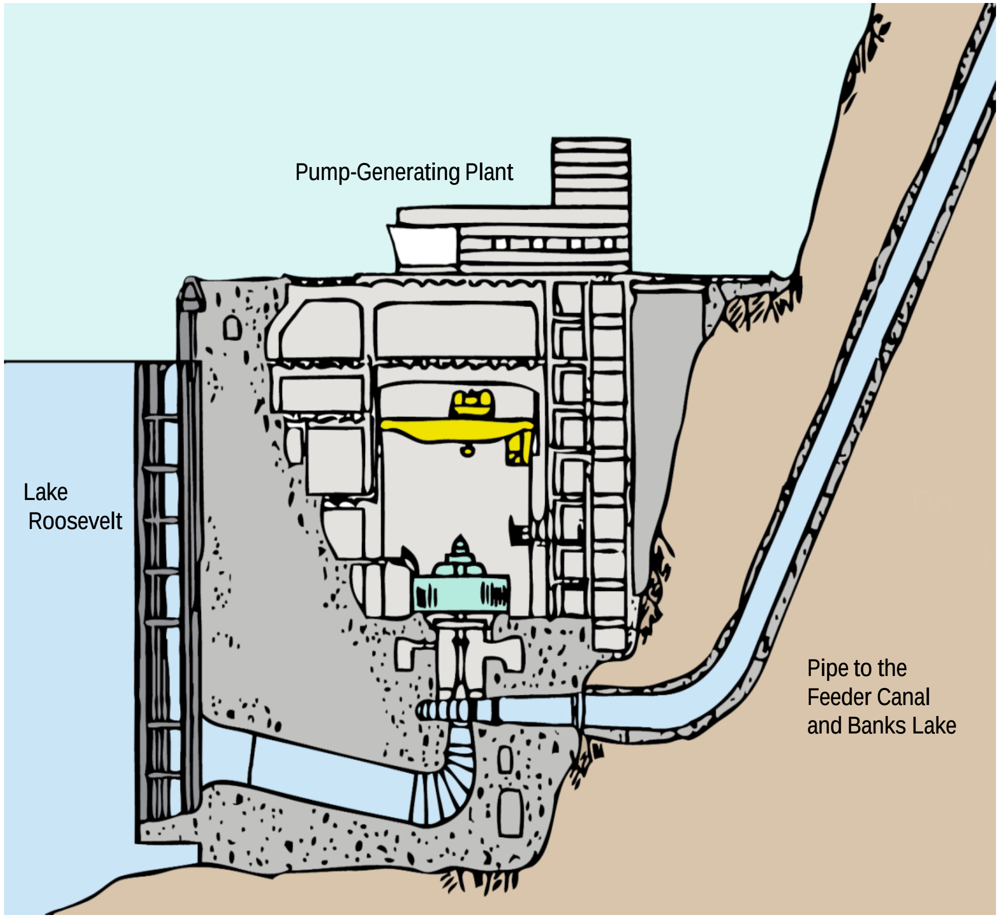
Technical Service Center

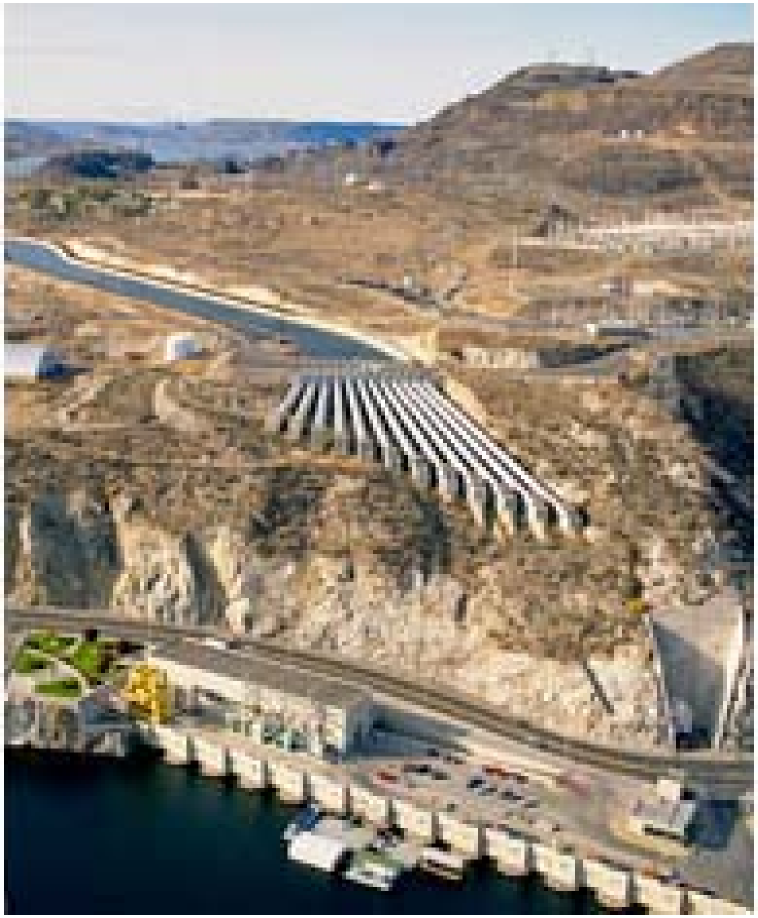
- **John W. Keys III Pump Generating Plant, Columbia Basin Project**
  Special Report
  October 2009

- **Appraisal Level Technical Evaluation for Modernization of John W. Keys III Pump Generating Plant, Columbia Basin Project**
  Phase II Planning Study
  February 2011

Funding Agreement for Evaluation of Keys Pump-Generating Plant Modernization signed by BPA and Reclamation on June 15, 2010

Reclamation's John W. Keys III Pump Generating Plant at Grand Coulee





John W. Keys III Pump Generating Plant

Original installation in 1951
six 50 MW pumping units

Upgrade in 1973
two 50 MW pump/generators installed

Upgrade in 1983-84
four 53.5 MW pump/ generators installed

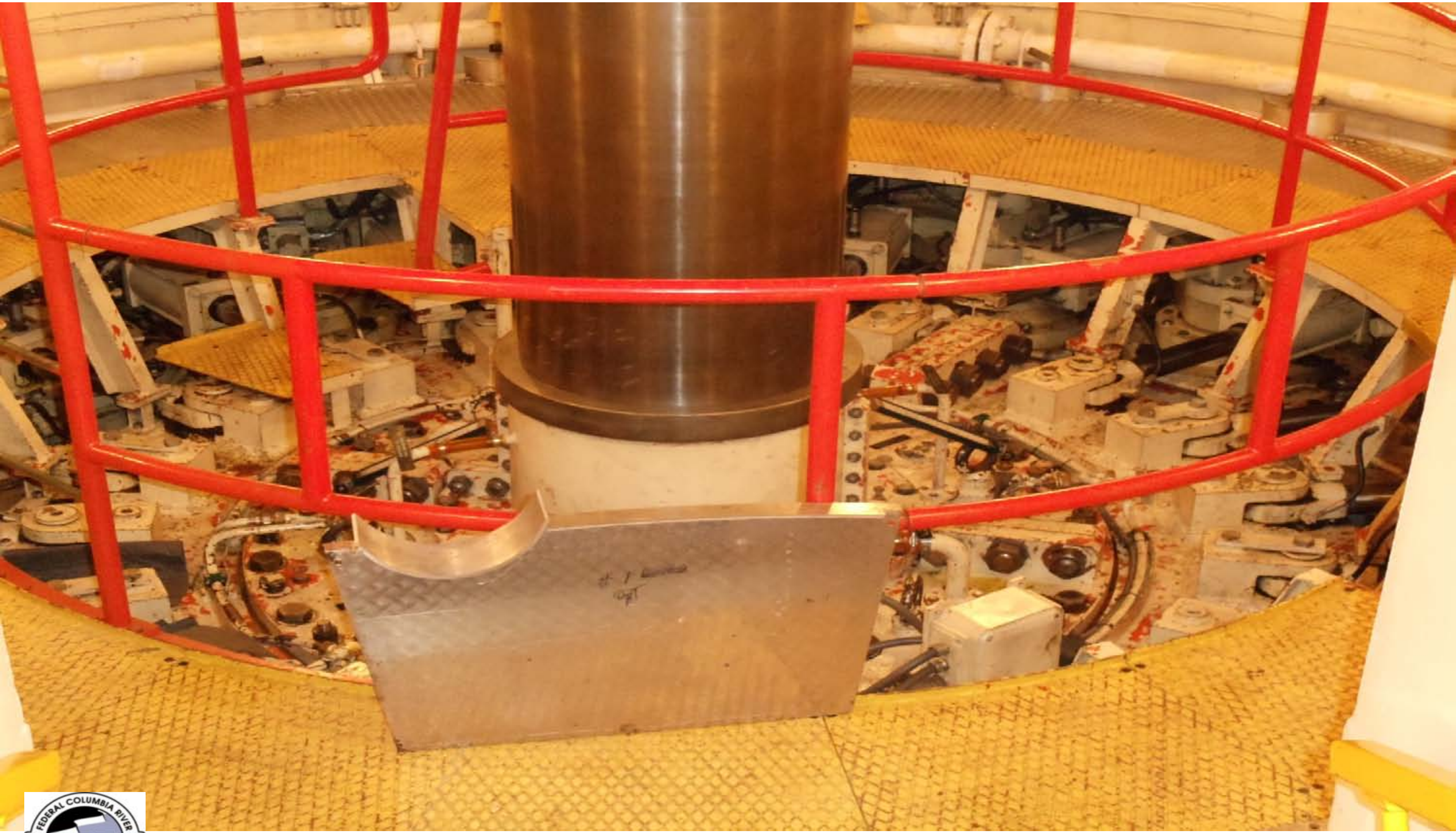
Current Capacity
Pumping – 12 Units 614 MW
Generating – 6 Units 314 MW

Keys Pump-Generating Plant Assessment

Reclamation's Technical Service Center and HDR Recommendations Under Evaluation:

- Modernization
  - Excitation
  - Governors
  - Breakers
  - Unit Controls and Protection
  - PG Phase Reversal Switches
  - Pump Motor Disconnect Switches
  - PG7 & 8 Wicket Gate Operating Mechanism Improvements
  - Main Step-up Transformer & Transformer Disconnect Switches
  - Station Service Upgrades
  - Miscellaneous Balance-of-Plant refurbishment
  - Estimated Cost $85-$145M
- Upgrade of Pump-Generator Units 7-12
  - Preference is to increase the operating head range of the PG units
  - Secondary goal is to increase Capacity (a 20% increase would result in pumping capacity – 660MW, generating capacity – 360MW)
  - Estimated Cost $80-$140M

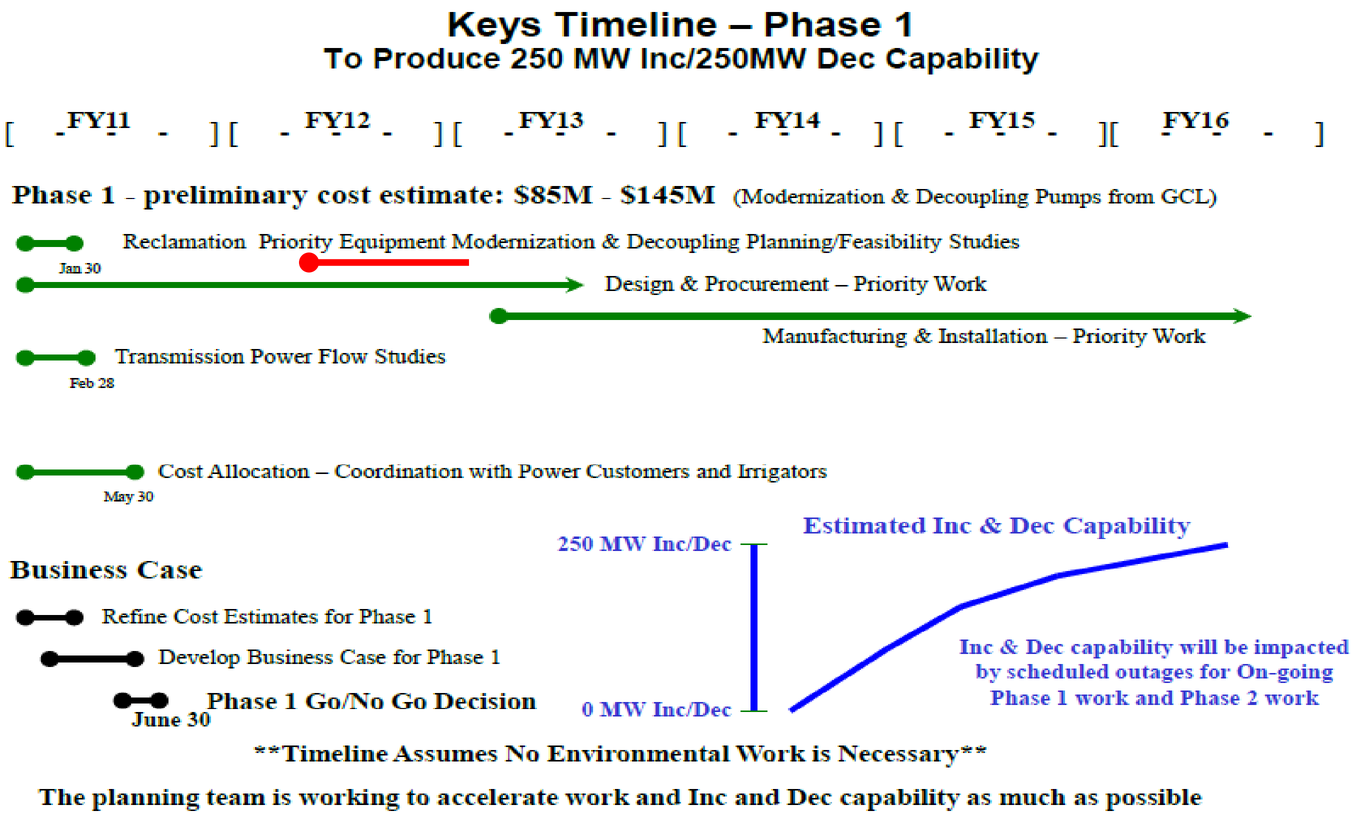
PG 7-8: A Servomotor for each Wicket Gate



Keys Modernization Schedule Update

Follow up from March 28 PMC Meeting

The following two slides show the original schedules as provided to Secretary Chu in September of 2010. Current updates to these schedules are shown in **RED**



Keys Timeline – Phase 2

Over Phase 1, Additional 60 MW Inc/60MW Dec Capability, Or Increased Operating Range

[FY11][FY12][FY13][FY14][FY15][FY16]

Phase 2 - preliminary cost estimate: $80M - $120M (Seeking Capacity or Operating Range Upgrade of PGs)

Reclamation PG Unit Upgrades Technical Planning/Feasibility Studies

Engineering & Design for Specifications, and Procurement

Design, Model Testing, Manufacturing, Installation

Business Case decision for Phase 2 and Go/No Go decision tied to conclusion of environmental work.

NEPA

Preliminary Information for NEPA Team

NEPA Review

No NEPA Action Required

Potential Categorical Exclusion Study

Potential EA Study (Est. 9 months to 3 years)

Potential EIS Study (18 months to 3 years)

The planning team is working to accelerate feasibility of Phase 2 as much as possible

Current NEPA Timeline:

NEPA

Preliminary Information for NEPA Team

NEPA Review – Decision made March 31 to proceed with EA Study

Preliminary draft EA schedule anticipates study to be complete by March 2012

Slide 12

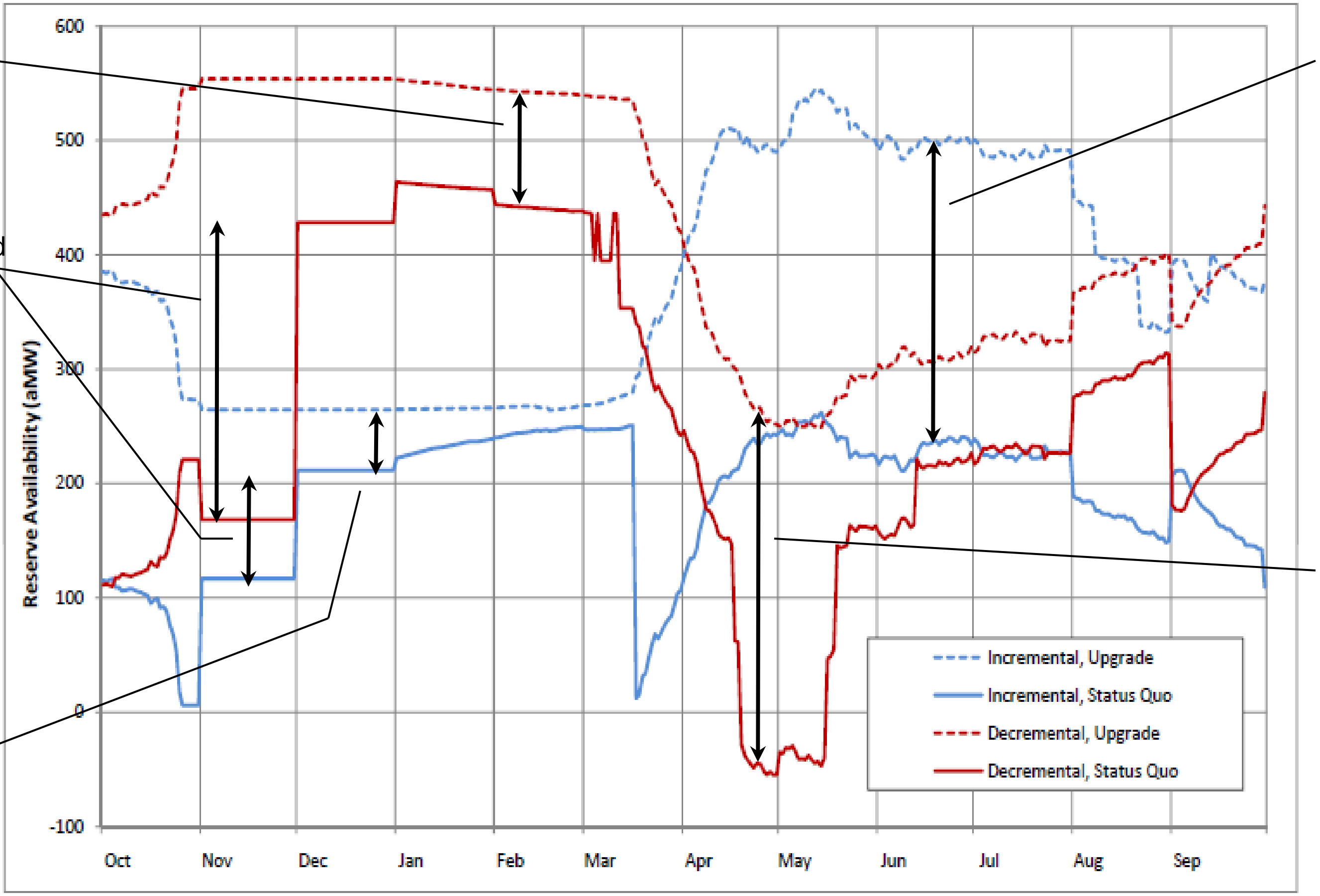
This draft slide illustrates preliminary analysis of inc and dec reserve capability with Keys PGP Option 1 and Option 2 (Modernization and Upgrades) and capability to switch between pumping and generating within hour (dashed lines), compared to inc and dec reserve capability based on recent equipment availability (solid lines).

This preliminary analysis assumes a 'flat' 24 hour pumping operation to meet daily irrigation demands. Increased inc and dec capability could be realized with thoughtful application of real-time system needs.

This gain in dec capability is representative of the year-round increase attributed to increased Pump and Pump Generator availability.

These gains in inc and dec capability in October and November represent gains due to reduced need for iso phase bus maintenance (decoupling or improvements to the iso phase bus).

This gain in inc capability is representative of the non-irrigation season increase attributed to increased Pump and Pump Generator availability.

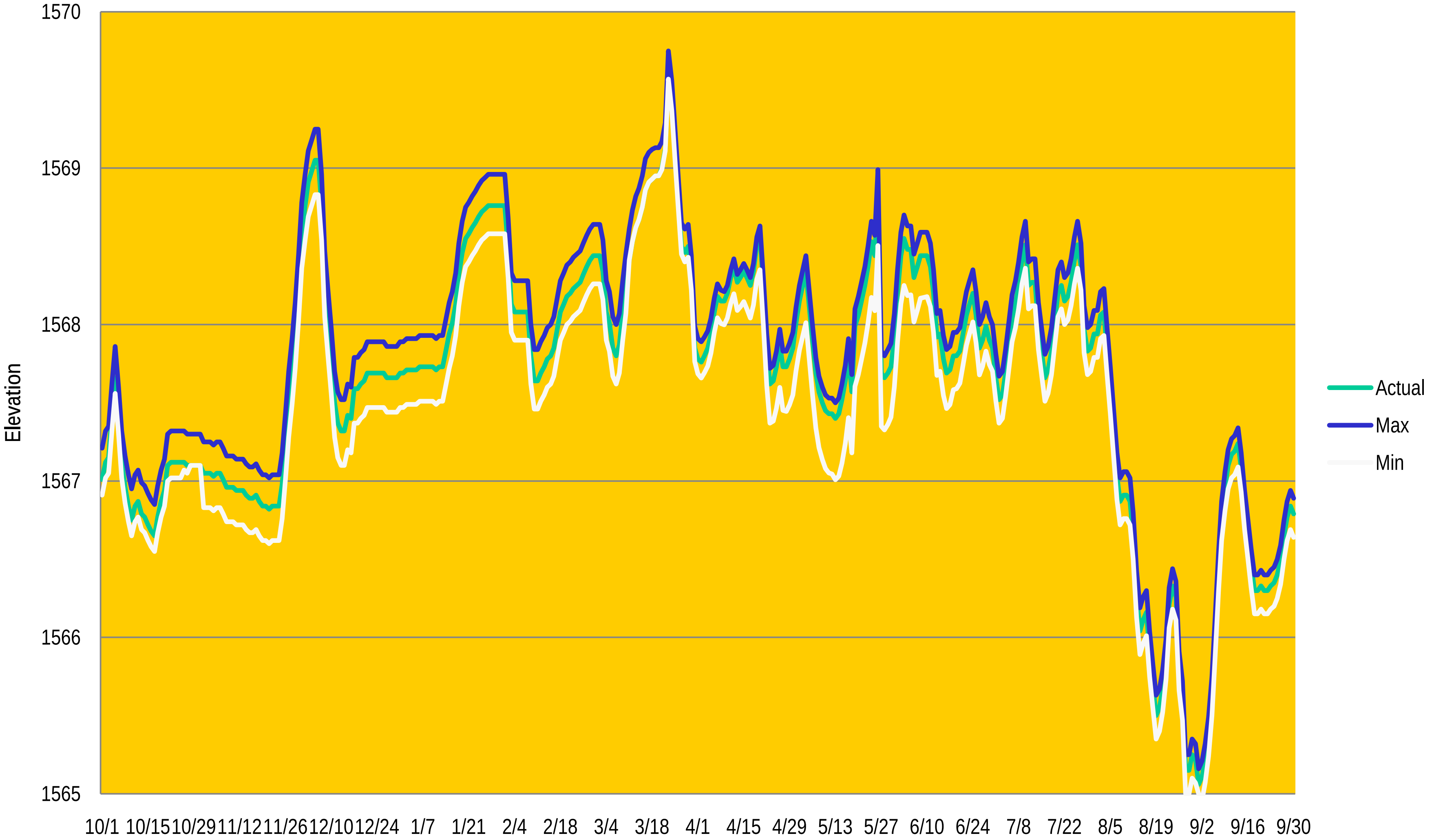


This gain in inc capability during irrigation season is attributed to capability of within hour switching between pumping and generating – may require fish screens at canal outlet to Banks Lake.

This gain in dec capability in April and May is attributed to the upgrade (Option 2) in operating range of the PG units (capability to pump from low FDR elevations typical of spring operations).

Inc – incremental reserves can be realized by reducing pumping loads or increasing generation
Dec – decremental reserves can be realized by reducing generation or increasing pumping loads

Banks Lake 2009-10 Actual, Max, & Min Elevations



Questions ?