Northwest **Power** and **Conservation** Council

September 9, 2015

MEMORANDUM

TO: **Council Members**

FROM: Elizabeth Osborne and Gillian Charles

SUBJECT: Proposed Pump Storage Project at Banks Lake

BACKGROUND:

Presenter: Tim Culbertson, Manager, Columbia Basin Hydropower

Summary: Tim Culbertson will brief the Council on a potential pumped storage project at Banks Lake and Lake Roosevelt being studied by Columbia Basin Hydropower and other partners. He will discuss the purpose of the project, preliminary costs, current status and expected timeline.

Columbia Basin Hydropower, formally the Grand Coulee Project Hydroelectric Authority, is the result of an agreement between the East Columbia Basin Irrigation District, Quincy Columbia Basin Irrigation District, and South Columbia Basin Irrigation District, to develop, operate, and maintain hydroelectric generating facilities on the irrigation systems of the Columbia Basin Project. To date, Columbia Basin Hydropower operates and maintains five power developments and provides Federal Energy Regulatory Commission liaison support for two power developments.

In April 2015, Columbia Basin Hydropower concluded a pre-feasibility study for a pumped storage project at Banks Lake, near Grand Coulee Dam, which would provide up to 1,000 MW generating capacity. The study included a preliminary analysis of the costs and benefits of the project.

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Overall, the project could provide greater value than other similarly-sized pumped storage projects because of its large reservoir sizes and because the project would not require construction of new dams or reservoirs, but could also have higher installation costs.

Moving forward from the pre-feasibility study will require further analysis of the site's geological characteristics, potential environmental impacts of the project, and existing operational constraints in Banks Lake or Lake Roosevelt. Next steps include assessing utility interest, studying environmental issues, and analyzing the costs and benefits of the project in more depth.

Relevance: Energy storage technologies decouple the production and consumption of electricity, and can provide regulation, sub-hourly load-following, hour-to-hour storage and shaping, firm capacity, and other ancillary services. With the increased penetration of variable energy resources such as wind and solar photovoltaic, and with the advancement of energy storage technologies, the role of energy storage in an integrated power system is becoming more important and relevant. For the draft Seventh Power Plan, the Council is looking to energy storage technologies as a potential new resource and ancillary service provider.

One of the challenges with the development of energy storage is capturing and recouping revenues for its full value stream. Council staff, along with the Generating Resources Advisory Committee, have crafted a draft action plan item to develop a white paper on this issue – see ANLYS-17 below.

Workplan: 1.B. Develop Seventh Power Plan and maintain analytical capability

Background: There is currently only one pumped storage project in the region - the 6-unit, 314 megawatt Grand Coulee pumped-generator at Banks Lake. This plant is primarily used for pumping water up to Banks Lake, the headworks of the Columbia Basin Irrigation System. There are many proposed pumped storage projects, however, and at the January 27 GRAC meeting, staff convened a panel of pumped storage experts to discuss a few of these proposed projects, along with the advancements in technology and the challenge of capturing its full value stream.

See http://www.nwcouncil.org/energy/grac/meetings/2015_01/ for materials from that meeting.

More Info: Draft action item in draft Seventh Plan, Chapter 4, Action Plan.

ANLYS-17 Research and develop a white paper on the value of energy storage to the future power system. [Council Staff, GRAC subgroup of Storage Experts] Council staff should convene a group of subject matter experts to assist in the research and development of a Council white paper on the full value stream of energy storage

and its role in the power system, including transmission, distribution, and generation. In addition, the white paper should investigate the existing need for frequency and voltage regulation and balancing reserves in the regional power system. Council staff should author the white paper with help from industry experts, or lead a request for proposals and select a consultant to write the paper. The white paper should be completed in advance of the Eighth Power Plan.

One of the potential constraints to extensive storage development is the ability of the developer and/or investor to capture and aggregate the full value of the storage system's services in a non-organized market and transform interest and overall system need into revenue streams and project funding. Many of the benefits of large scale storage are the portfolio effects for an optimized regional system, not just solely to a specific power purchaser, utility or end-user, and therefore it can be difficult to raise funds and seek cost-recovery for storage projects if the purchaser is not directly benefiting from all of the services, or is paying for a service that benefits others who are not also contributing funds. The white paper should clearly identify the issues and barriers and provide useful information that would be beneficial to the region's decision makers, power planning entities and integrated resource planning processes.

Columbia Basin Hydropower

Banks Lake Pumped Storage Project (North Dam Site)

FERC Project No. 14329

NW Power & Conservation Council
Eagle, ID
September 16, 2015

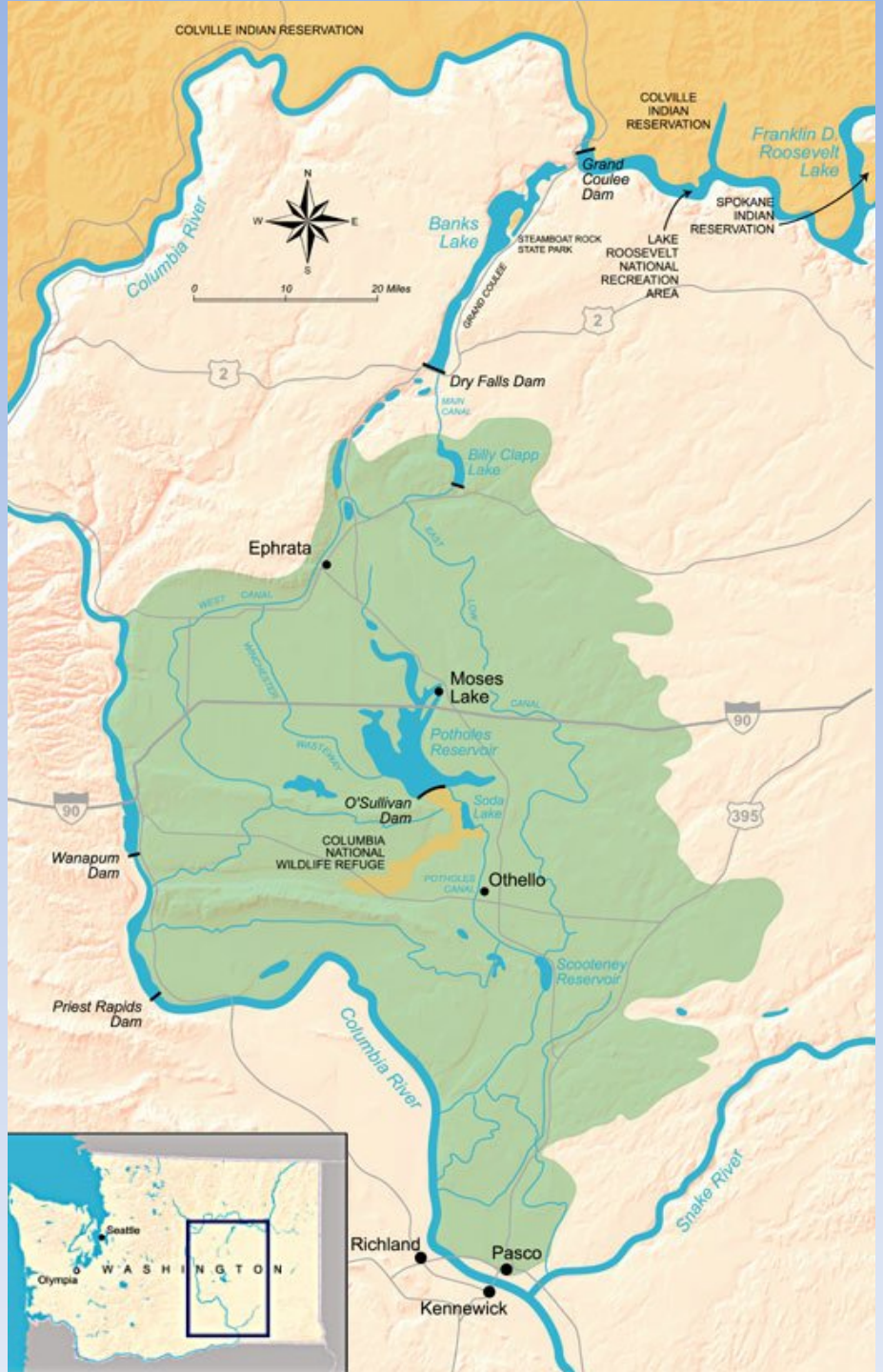
Presented By:
Tim Culbertson, Larry Thomas, and Lloyd Reed

Columbia Basin Hydropower

"Generation from Irrigation"

- Columbia Basin Hydropower (CBHP) provides administration, operations, and maintenance functions for hydroelectric generation facilities owned by the 3 Irrigation Districts that make up the Columbia Basin Irrigation Project, approximately 700,000 acres.
- The Districts currently own seven projects, ranging in size from 2-94 MW with total generation capacity of all projects = approx. 150 MW
- The power from the five projects that CBHP operates and maintains goes to the cities of Seattle and Tacoma.
- Two other hydroelectric facilities are operated and maintained under contract by Grant County PUD.
- All of the existing projects are FERC licensed projects.
- CBHP has a number of FERC preliminary permits for new development. Projects range from 600 kw small hydro, up to 1000 MW pumped storage.

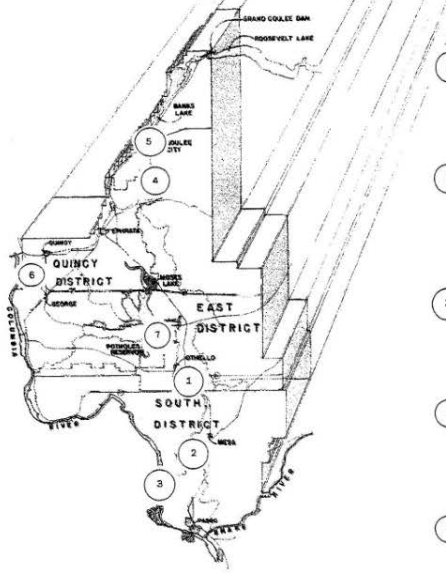
Columbia Basin Project



Existing Projects

6 QUINCY CHUTE	
MAX. TURBINE DISCHARGE	2,000 CFS
AVERAGE FLOW	1,400 CFS
EFFECTIVE HEAD	59 FT
INSTALLED CAPACITY	9.4 MW
AVERAGE ANNUAL ENERGY*	32,407 MWH

7 P.E.C. HEADWORKS	
MAX. TURBINE DISCHARGE	2,200 CFS
AVERAGE FLOW	1,400 CFS
EFFECTIVE HEAD	31 FT
INSTALLED CAPACITY	6.5 MW
AVERAGE ANNUAL ENERGY	21,398 MWH



POWER PLANTS

1 RUSSELL D. SMITH	
MAX. TURBINE DISCHARGE	1,700 CFS
AVERAGE FLOW	861 CFS
EFFECTIVE HEAD	52 FT
INSTALLED CAPACITY	6.1 MW
AVERAGE ANNUAL ENERGY*	13,079 MWH

2 E.B.C. 4.6	
MAX. TURBINE DISCHARGE	226 CFS
AVERAGE FLOW	188 CFS
EFFECTIVE HEAD	127 FT
INSTALLED CAPACITY	2.2 MW
AVERAGE ANNUAL ENERGY*	8,236 MWH

3 P.E.C. 66.0	
MAX. TURBINE DISCHARGE	92 CFS
AVERAGE FLOW	112 CFS
EFFECTIVE HEAD	325 FT
INSTALLED CAPACITY	2.4 MW
AVERAGE ANNUAL ENERGY*	7,942 MWH

4 SUMMER FALLS	
MAX. TURBINE DISCHARGE	8,000 CFS
AVERAGE FLOW	5,090 CFS
EFFECTIVE HEAD	165 FT
INSTALLED CAPACITY	92 MW
AVERAGE ANNUAL ENERGY*	369,943 MWH

5 MAIN CANAL	
MAX. TURBINE DISCHARGE	8,020 CFS
AVERAGE FLOW	5,290 CFS
EFFECTIVE HEAD	42 FT
INSTALLED CAPACITY	26.0 MW
AVERAGE ANNUAL ENERGY*	100,346 MWH

COLUMBIA BASIN PROJECT HYDROPOWER DEVELOPMENT

INTRODUCTION & ACKNOWLEDGEMENTS

- A pre-feasibility study of the Banks Lake Pumped Storage Project was jointly conducted earlier this year by the following organizations:
  - Columbia Basin Hydropower
  - Kleinschmidt Associates
  - Reed Consulting
  - Muchlinski Consulting
  - Lands Energy

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PRESENTATION OUTLINE

- Overview of the Banks Lake North Dam Pumped Storage Project:
  - Purpose of the Project, current status and major stakeholders
  - Capacity, expected energy output
  - Preliminary Project costs and benefits
  - Barriers/challenges to development
  - Next steps

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PUMPED STORAGE PLANTS IN THE US

- 40 Pumped Storage Plants in US
- 14 Pumped Storage Plants in Western US
- 1 Pumped Storage Plant in Washington (Keys Plant)
- 4 Pumped Storage Plants actively under consideration in the PNW:
  - JD Pool: Washington – 1,200 MW
  - Swan Lake: Oregon – 1,000 MW
  - Gordon Butte: Montana – 400 MW
  - Coffin Butte: Montana – 250 MW

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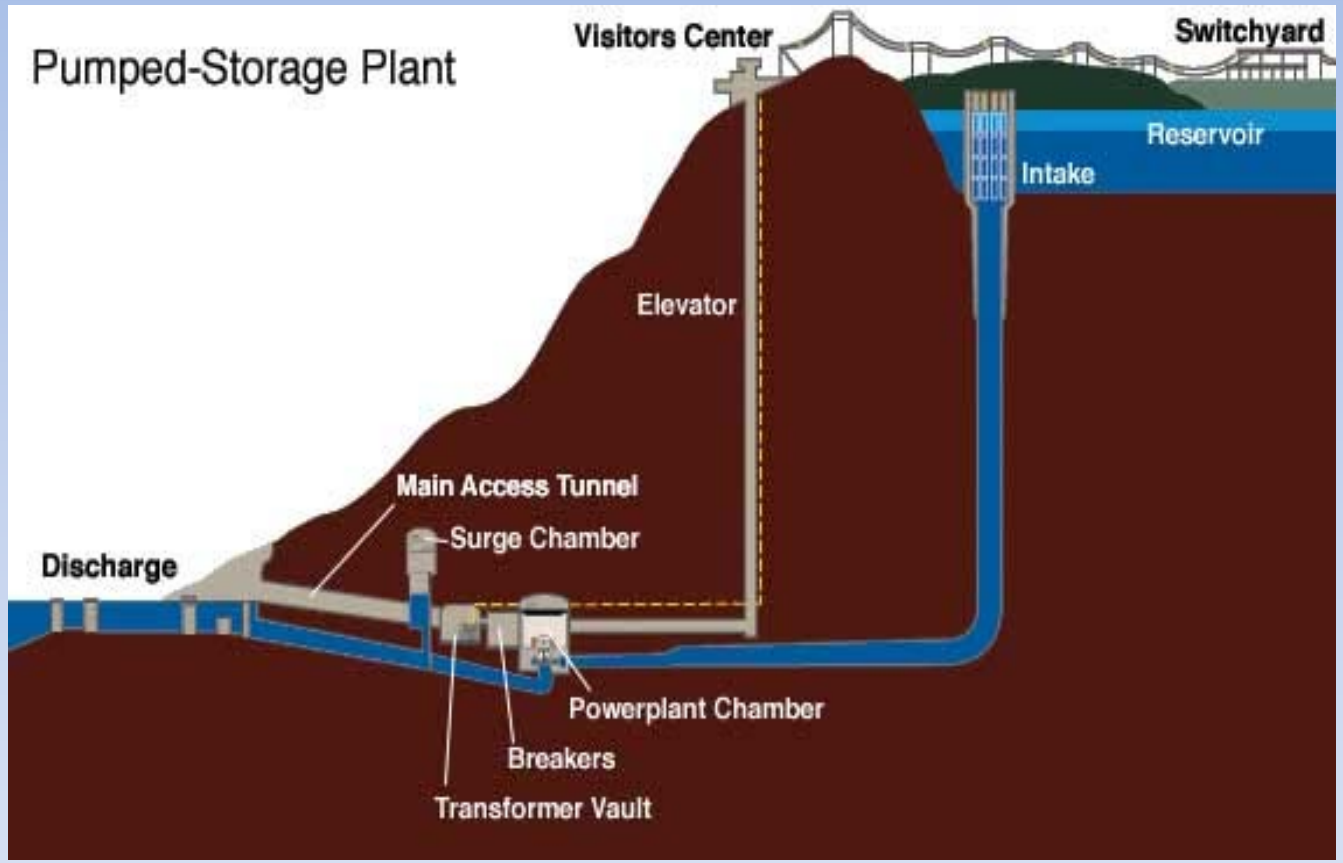
TYPICAL PUMPED STORAGE PROJECT LAYOUT



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Legend
Dam
Trap
CHJ
WEL
GCL
Lake Roosevelt
ENT
Banks Lake
Banks Lake North Dam
Pump/Generation
Project Site
RRH
RIS
IDAHO
WASHINGTON
WAN
PRD
Snake River
LGR
DWR
LGS
CLW
LMN
SNK
IHR
GRN
Columbia River
MCN
BON
TDA
JDA
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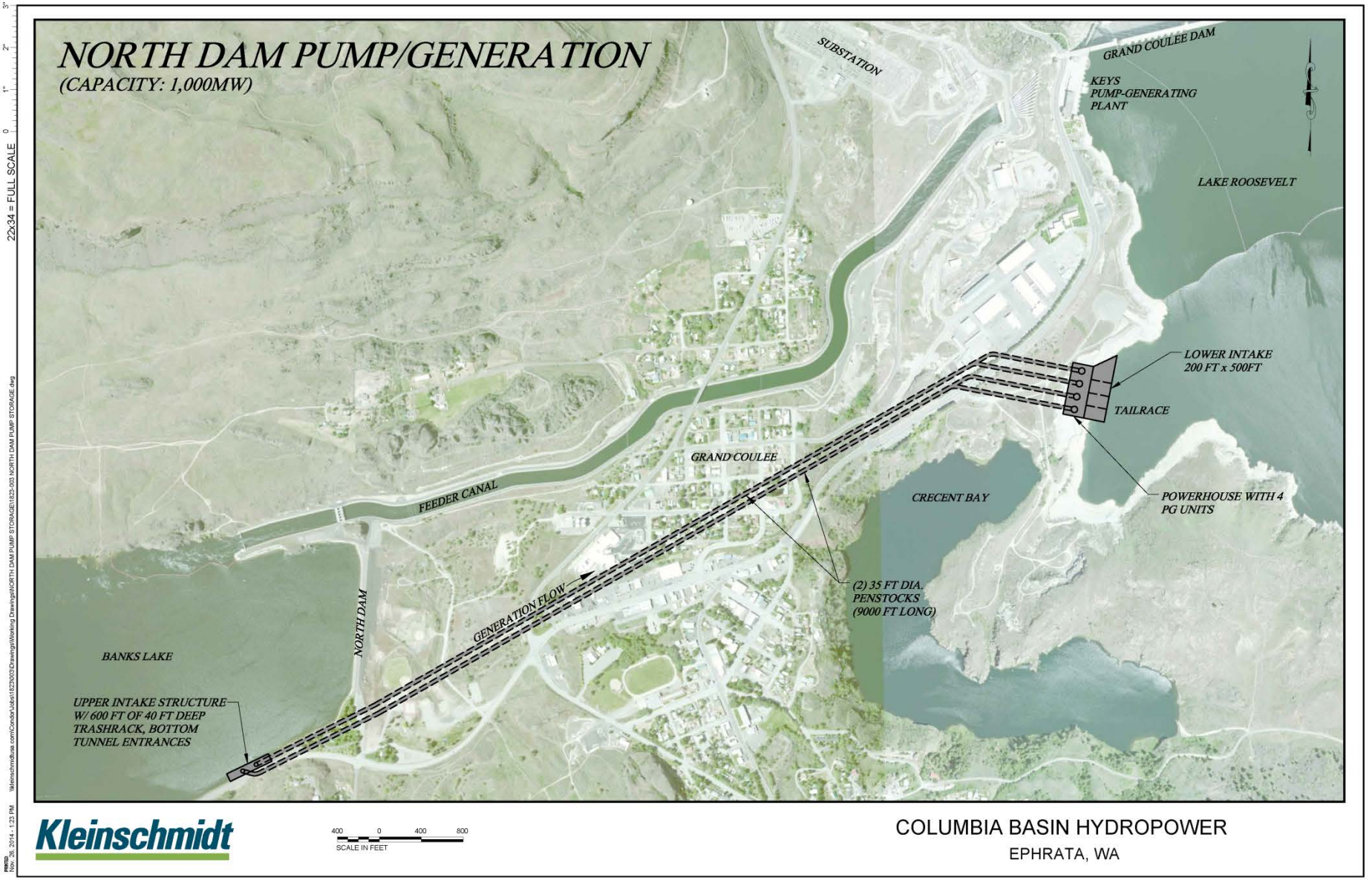
IMN
OREGON



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BANKS LAKE PUMPED STORAGE PROJECT
FACTS & FIGURES

- The Project is located at the North Dam of Banks Lake in central Washington State near Grand Coulee Dam.
- The Project is a separate project from the Bureau of Reclamation's existing Keys pump-generation plant (which is sometimes referred to as the Banks Lake pumped storage plant).
- Generating Capacity: Up to 1,000 MW.
- Turbine Type: 2 to 6 adjustable speed pump-generating units.
- Maximum Project design flow: 50,000 CFS.
- Head: 280 to 360 feet (average = approx. 300 feet).

BANKS LAKE PUMPED STORAGE PROJECT
FACTS & FIGURES (cont.)

- Powerhouse: Located on the west side of Lake Roosevelt just upstream of Grand Coulee Dam and near the BOR's existing Keys pump-generation plant.
- Estimated average annual generation: 1,430,000 Mwh.
- Upper Intake/Reservoir: Banks Lake.
- Lower intake/Reservoir: Lake Roosevelt.
- Transmission Interconnection: Grand Coulee Dam 230 kV or 500 kV switchyards.

BANKS LAKE PUMPED STORAGE PROJECT
NEED FOR THE PROJECT

- Construction of base load power plants has slowed
- Increase of non-dispatchable intermittent generation resources (Wind Plants, Solar Panels) are stressing the grid
- Utilities need to meet State imposed renewable portfolio standards
- Early retirement of two large coal-fired power plants in the region due to environmental reasons and potential retirement of others in the near future.
- Installation and operation of gas fired combustion turbines may be limited due to greenhouse gas emission restrictions
- Additional electrical capacity needed in 2019 - 2021

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BENEFITS OF THE BANKS LAKE PUMPED STORAGE PROJECT

- The Project would not require the construction of any new dams/reservoirs.

- Both of the Project's upper and lower reservoirs have very large storage capabilities relative to other proposed PNW pumped storage facilities.
  - Banks Lake active storage = 715,000 acre-feet.
  - Lake Roosevelt active storage = 4,200,000 acre-feet.

- The Project would utilize adjustable-speed pump/generators which would allow the plant's pumping load to be varied in real-time (in addition to being able to vary generation output in real-time).

- The Project might have the capability to provide back-up pumping services to the BOR's existing Keys pump-generation plant.

BENEFITS OF THE BANKS LAKE PUMPED STORAGE PROJECT (cont.)

- The Project would be used in coordination with Keys, Grand Coulee, and may be integrated into Mid-Columbia Hourly Coordination.

- The Project would have the ability to conduct energy shifting/arbitrage operations across a weekly timeframe.
  - Under normal operations the Project would only shift water (on a short-term basis) between FDR reservoir and Banks Lake.

- The Project would have a very long (for a hydro pumped storage plant) sustained peaking capability due to the large size of the upper reservoir (Banks Lake).
  - The Project could generate at its maximum capacity of 1,000 MW for approximately 35 continuous hours assuming a maximum five foot drawdown at Banks Lake.

BENEFITS OF THE BANKS LAKE PUMPED STORAGE PROJECT (cont.)

- The Project would have the capability of rapidly releasing water into Lake Roosevelt that could in turn be utilized to supplement discharges thru Grand Coulee Dam.

- Supplemental Flow operations could occur during periods when Grand Coulee Dam is approaching or at its daily draft limit.

- Supplemental Flow operations could be utilized to increase the energy and sustained peaking capability of the PNW hydro system from Grand Coulee Dam and downstream dams during regional power system stress events (i.e. high loads, generation/transmission outages, etc.)

- Transmission interconnect with BPA at Grand Coulee 230kV or 500kV Switchyard

BENEFITS OF THE BANKS LAKE PUMPED STORAGE PROJECT (cont.)

- Ability to provide products for SCED and EIM
- Management of Variable Intermittent Resources/Need for Additional Grid Flexibility Services.
- Overall observation: Due to the above noted benefits, the Banks Lake Pumped Storage Project can likely provide a greater level of overall value as compared to similarly sized pumped storage plants.

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POWER PRICE FORECASTS

Energy Price Forecasts

- Energy price forecasts at the Mid-Columbia were used to value the energy-shifting capabilities of the Project.
- 2025 average energy prices:
  - Off-peak/nighttime - $39.43/Megawatt hour
  - On-peak/daytime - $49.61/Megawatt hour

Capacity and Ancillary Services Price Forecasts

- Capacity price forecasts for the PNW region were used to value capacity-for-load, ancillary services, and Grand Coulee supplemental flow operations.
- 2025 average capacity prices:
  - Low scenario - $9.43/Kilowatt-month
  - High scenario - $10.55/Kilowatt-month

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PROJECT ANNUAL REVENUE FORECASTS

- Four categories of forecasted Project revenues:
  - Energy Shifting/Price Arbitrage
  - Firm Capacity for Meeting Peak Loads
  - Ancillary Services (i.e. transmission grid flexibility services)
  - Grand Coulee Supplemental Flow Benefits

- Overall Forecasted Annual Power Revenue Summary beginning in 2025:
  ($ in Millions)

	500 MW	1000 MW
Energy Shifting	$7.9 - $10.1	$15.8 - $20.2
Firm Capacity for Load	$56.6 - $63.3	$113.2 - $126.6
Ancillary Services	$17.0 - $19.0	$34.0 - $38.0
Grand Coulee Supplemental Flows	$4.25 - $4.75	$8.5 - $9.5
Total Project Revenues	$85.75 - $97.15	$171.5 - $194.3

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PRELIMINARY PROJECT COST/BENEFIT ANALYSIS

Preliminary cost estimates for the Banks Lake Pumped Storage Project: $3,000 – $4,000 per kW.

40 YEAR NET PRESENT VALUES – Example 1 (500 MW)

Scenario	Conditions	Net Present Value ($M)
1	Low Revenue/Low Costs	+807.4
2	Low Revenue/High Costs	+363.7
3	High Revenue/Low Costs	+1,131.1
4	High Revenue/High Costs	+686.8

40 YEAR NET PRESENT VALUES – Example 2 (1000 MW)

Scenario	Conditions	Net Present Value ($M)
1	Low Revenue/Low Costs	+1,616.6
2	Low Revenue/High Costs	+728.1
3	High Revenue/Low Costs	+2,262.9
4	High Revenue/High Costs	+1,374.4

GENERIC COSTS & ASSUMPTIONS FOR THE COST BENEFIT ANALYSIS - 500 MW

- DOE financing at 2.75% interest for 30 years (70% for Years 1-30).
- Tax exempt financing at 4.25% interest for 40 years (30% for Years 1-30).

Net Present Value Discount Rate (%)	4.00
Annual Plant Cost Escalation Factor (%)	2.00
Project Capital Cost – Low Case ($/kW)	3,000
Project Capital Cost – High Case ($/kW)	4,000
2010 Project Fixed + Variable O&M Costs ($/Mwh)	4.37
2010 Project A&G as a Percent of O&M (%)	35
2010 Project Capital Replacement Costs ($M/Unit)	10.00
Annual Project Generation (Mwh)	715,077

Note: Capital replacement costs are forecasted to occur in Project Years 19-20 only.

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GENERIC COSTS & ASSUMPTIONS FOR THE COST BENEFIT ANALYSIS - 1000 MW

- DOE financing at 2.75% interest for 30 years (70% for Years 1-30).
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2010 Project Fixed + Variable O&M Costs ($/Mwh)	4.37
2010 Project A&G as a Percent of O&M (%)	35
2010 Project Capital Replacement Costs ($M/Unit)	10.00
Annual Project Generation (Mwh)	1,430,153

Note: Capital replacement costs are forecasted to occur in Project Years 19-22 only.

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GRANT, TAX AND LOAN OPPORTUNITIES

- No apparent Grants available for Pumped Storage Projects at this time, but will continue to seek them out.
- Due to the size and technology (Hydro) of the Project, it is not eligible for Production Tax and Investment Tax Credits.
- DOE Loan Programs Office (LPO) – Financial Terms
  - $4 Billion In Remaining Loan Authority
  - LOAN GUARANTEE: A loan guarantee can support debt from a commercial lender or the U.S. Treasury
  - LOAN TENOR: Long-term financing is available based on the useful life of the asset – up to 30 years
  - INTEREST RATES: Interest rates set based on equivalent U.S. Treasury rate plus a credit-based spread (~0.5-1.5%)
  - EQUITY: LPO can only guarantee up to 80% of the total project cost. Most projects have at least 35% equity
  - CO-LENDING: Co-lending with commercial lenders is encouraged but not required

GRANT, TAX AND LOAN OPPORTUNITIES (cont.)

- DOE Loan Programs Office (LPO) – Eligibility
  - INNOVATIVE TECHNOLOGY
    - Eligible projects must utilize new or significantly improved technology or systems
  - GREENHOUSE GAS BENEFITS
    - Eligible projects must reduce, avoid, or sequester greenhouse gases
  - LOCATED IN THE U.S.
    - Eligible projects must be located in the United States but may be foreign-owned
  - REASONABLE PROSPECT OF REPAYMENT

POTENTIAL PURCHASERS OF CAPACITY, ENERGY AND ANCILLARY SERVICES FROM THE PROJECT

- Investor Owned Utilities
- Public Power Entities
- Power Marketers
- Independent Power Producers
- California Independent System Operator

PROJECT CONTRACTS AND AGREEMENTS

- Long Term Power Purchase Agreements
- Transmission Interconnection Agreement
- BPA/BOR Operational Coordination Agreements
- Grand Coulee Supplemental Flow Operations
- Mid-Columbia Hourly Coordination

ENVIRONMENTAL AND REGULATORY CONSIDERATIONS

Environmental

- Resource concerns by agencies
- Studies to be performed: fisheries, habitat, RT&E, water quality, recreation, cultural resources, other…
- Water availability/allocation analysis (irrigation)

Regulatory

- FERC/BOR regulatory coordination & MOA
- Preliminary Permit – Extension Request in 2016
- Advancement of licensing is necessary to meet deadlines
- Begin consultation with agencies, tribes, and stakeholders

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BARRIERS/CHALLENGES TO THE BANKS LAKE PUMPED STORAGE PROJECT DEVELOPMENT

- Relatively high initial capital cost.
- Long development timeline (approx. 7-10 years).
- Investors needed to proceed from the pre-feasibility stage to feasibility to design stage.
- The Project's overall cost will be highly dependent upon site-specific conditions (especially geological) that have not yet been fully evaluated.
- Existing operational and/or environmental constraints at Lake Roosevelt and Banks Lake.

BARRIERS/CHALLENGES TO THE BANKS LAKE PUMPED STORAGE PROJECT DEVELOPMENT (cont.)

- CBHP must secure the cooperation of the BOR, BPA, the Upper Columbia River Tribes and other partners/stakeholders.
- Pumped storage plants in general are very complex to analyze from both an operational and economic perspective.
- Valuation of the capacity and ancillary service products that the Project can provide is challenging due to the lack of liquid spot and forward markets for these products in the PNW region.
- The Project will need to enter into one or more long-term contracts with off-takers in order to secure bond financing.

NEXT STEPS:

- Based on the results of the pre-feasibility study:
  - Continue to meet with the BOR and BPA to discuss operational issues, transmission interconnection, and Lease of Power Privilege Agreement.
  - Meet with regional utilities to gauge level of interest.
  - Perform more detailed valuation studies that include potential regional benefits.
  - Begin preliminary engineering evaluation.
  - Refine Project costs.
  - Initiate stakeholder consultation/begin environmental scoping for project licensing and permitting.
  - Submit applicable filings to the FERC.
  - Continue discussions with FERC regarding project jurisdiction and possible license requirements.

Columbia Basin Hydropower

THANK YOU

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