NON-TREATY STORAGE AGREEMENT

“Introduction to Operations and the Non Treaty Storage Scenarios”

Presenter: Jim Gaspard
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System Overview
Overview of the BC Hydro System

- Electricity supplied to 94% of BC’s population
- 61 dams & 44 hydro generating stations
- Source of Electricity:
  - 30% Peace
  - 25% Mica and Revelstoke
  - 25% Smaller Hydro
  - 20% IPP energy purchases
- BC Hydro system connected to:
  - US
  - Alberta
  - Fortis BC
The Role of Reservoir Storage

Electricity Demand

Reservoir Inflow

Reservoir Level
Treaty Overview
Why do we have a Treaty?

About 1/3 of the Columbia River water comes from Canada.

• Canada has 15% of the basin area, but produces, on average, 38% of the runoff for the total basin.

• 50% of water from worst Columbia flood at Portland (1894) came from Canada.
1948 Flood

• 1,000 kcfs at Portland:
  • Current flood damage: ~450 kcfs

• 370 kcfs at Trail:
  • 1997 flood: 160 kcfs
Columbia River Treaty

• Canadian Obligation:
  • Build 15.5 MAF of storage
  • Operate storage for optimal power generation and flood control.

• US Obligation:
  • Pay Canada 50% future flood control benefits.
  • Deliver to Canada 50% of the increased power generated at U.S. plants

• Other Provisions:
  • US can construct and operate the Libby
  • Canada can divert Kootenay river at Canal Flats
Based on AOP 2012, with critical supplemental agreements, and Mica Flexibility.
Treaty Operations (modeled): Arrow Reservoir

Based on AOP 2012, with critical supplemental agreements, and Mica Flexibility.
Treaty Operations (modeled): Arrow Releases

Based on AOP 2012, with critical supplemental agreements, and Mica Flexibility.
Modifications to Operations
Supplemental Agreements
Supplemental Agreements

• A mutual agreement between BCH and BPA/COE to:
  – Adjust the level of storage in a reservoir, or
  – Adjust flows at Arrow

• Purpose:
  – To increase power benefits, and
  – Improve the non-power outcome in Mica and/or Arrow.
Arrow Reservoir level Comparison (ft)

- Peak = 1435 ft
- Peak = 1443 ft

With Agreement
Without Agreement
Fall Storage Agreement (2006/07)

Arrow Reservoir level Comparison (ft)

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<tr>
<th>Date</th>
<th>Level (ft)</th>
<th>With Agreement</th>
<th>Without Agreement</th>
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Arrow Reservoir level Comparison (ft)

Arrow Flow Comparison (kcfs)
Modifications to Operations
Non-Treaty Storage Operations
Non-Treaty Storage Usage in Operations

• Used to capture *Downstream Power Benefits*:
  – Releasing water during periods of energy shortages (high energy value)
  – Storing water during periods of energy surplus (low energy value)

• Used to capture *System Operations Benefit*. Provides flexibility to:
  – Reduce frequency of full pool and spill at Mica
  – Manage Arrow Soft Constraints, and other system objectives
  – Draft Kinbasket deeper in Fall/Winter to serve load
    • System commonly short of energy in Fall/Winter
    • Option to draft has a reliability benefit (even if not used)
Storage Operation
- Initial -

- **Summer**: Treaty storage typically filled to at/near full

[Diagram showing storage operation with nodes labeled Mica Discharge and Arrow Discharge]
Non-Treaty Storage – Fall/Winter Draft

Storage Operation
- Winter Draft -

- *Late Winter* Treaty storage drafted to near empty.

Still significant water at Kinbasket.
Storage Operation
- Utilize Flex -

- **BCH can draft more than Specified Treaty Q from Mica (Flex).**

Still significant water at Kinbasket.
Non-Treaty Storage Seasonal Operation

Storage Operation
- NTSA Release -

- **NTSA release facilitates greater draft at Mica**

Draft benefit of NTSA

Mica Discharge
+ NT Discharge

Flood Control Elevation

Arrow Discharge
+ NT Discharge
Modeling Process
Modeling Process

- Proposed Non-Treaty Storage Scenarios
  - Market Energy Prices
  - System Operations Model: HYSIM, Excel, GOM
  - Reservoir Levels, River Flows / Releases
  - Electricity Generation
  - Inputs: Historical Inflows, Facility Specifications

- Performance Measure Models
  - Reservoir Levels, River Flows / Releases
  - Electricity Generation
  - Value of Energy (VOE) Model

- Inputs: Channel and Reservoir Contours, Locations and Specifications of Interest
  - Fish & Wildlife Models
  - Recreation Models
  - Flooding & Erosion Models

- Results Reporting (Consequence Tables)
Four scenarios considered:

- Scenario A: High Potential Utilization (4.5 MAF Max)
- Scenario B: Mod Potential Utilization (3.0 MAF Max)
- Scenario C: Low Potential Utilization (2.0 MAF Max)
- Scenario D: No Utilization
Non-Treaty Storage Utilization Scenarios

• Four scenarios considered:
  – Scenario A: High Potential Utilization (4.5 MAF Max)
  – Scenario B: Moderate Potential Utilization (3.0 MAF Max)
  – Scenario C: Low Potential Utilization (2.0 MAF Max)
  – Scenario D: No Utilization

• Scenario A: (4.5 MAF max utilization)
  – Approximates operation of Non-Treaty Storage under the 1990 Agreement
  – Provides similar flexibility to that which was modeled in the Columbia Water Use Plan
  – Achievable through:
    • Large account volume in renegotiated agreement, and
    • No restrictions placed on operation of the large accounts.
Non-Treaty Storage Utilization Scenarios

- Four scenarios considered:
  - Scenario A: High Potential Utilization (4.5 MAF Max)
  - Scenario B: Moderate Potential Utilization (3.0 MAF Max)
  - Scenario C: Low Potential Utilization (2.0 MAF Max)
  - Scenario D: No Utilization

- Scenario D: (no utilization of NTS)
  - Approximates operation that would be dictated by the Treaty
  - Achievable through:
    - No Non-Treaty Storage Agreement, or
    - BC Hydro fully restricting usage of storage
Non-Treaty Storage Utilization Scenarios

- **Scenario C:** (2.0 MAF max utilization)
  - Restrictive operation of Non-Treaty Storage
  - Considered to be low end volume that will:
    - Facilitate fall/winter draft at Kinbasket to serve system load.
    - Facilitate key fisheries/power benefit in spring/summer, and
    - Provide flexibility to manage Kinbasket Reservoir, in exceptionally high inflow years.
  - Achievable through:
    - Account volume in agreement restricted, or
    - BC Hydro restriction placed on usage of storage.
Non-Treaty Storage Utilization Scenarios

- Four scenarios considered:
  - Scenario A: High Potential Utilization (4.5 MAF Max)
  - Scenario B: Moderate Potential Utilization (3.0 MAF Max)
  - Scenario C: Low Potential Utilization (2.0 MAF Max)
  - Scenario D: No Utilization

- Scenario B: (3.0 MAF max utilization)
  - BPA proposed operation
  - Flexibility for release of additional water in summer to aid salmon out-migration in the US Columbia
    - 0.5 MAF release in May/June during dry years
    - Return of storage in upcoming year (if above average inflows)
  - Achievable through:
    - Account volume in agreement restricted, or
    - BC Hydro restriction placed on usage of storage
    - Release option for BPA under highly prescriptive conditions
Modeling of Scenarios
Modeling of Scenarios

- Spreadsheet model used
- Modeling Assumptions:
  - Restrictions in release and storage to meet:
    - Long standing BCH and US fisheries objectives
    - Treaty obligations
  - Scenarios operated to maximize economic value, given:
    - BC Hydro 2008 LTAP electricity price forecasts
    - US plant efficiencies as per 2012 Treaty Assured Operating Plan
    - Monthly time-step for 60 year period (compatible with HYSIM)
- NTS scenario transferred to System Modeling
Scenario A (4.5 MAF Maximum Utilized)

BCH Non-Treaty Storage
(Additional draft at Mica + Arrow due to release of Non-Treaty Storage)

Average: 14 feet
Outlier: 30 feet
Scenario B (3.0 MAF Maximum Utilized)

BCH Non-Treaty Storage
(Additional draft at Mica + Arrow due to release of Non-Treaty Storage)

Average: 13 feet
Outlier: 25 feet

10%
Average:
90%
Scenario C (2.0 MAF Maximum Utilized)

BCH Non-Treaty Storage
(Additional draft at Mica + Arrow due to release of Non-Treaty Storage)

Outlier: 20 feet
Average: 10 feet

10%
Average:
90%
Scenario C (2.0 MAF) vs A (4.5 MAF)

BCH Non-Treaty Storage
(Additional draft at Mica+Arrow due to NTSA)

More significant change in outlier events

Modest change in overall average usage
System Modeling Overview

• System modeling:
  – Using standard computer models used in BC Hydro long term planning.
    • HYSIM (60 year, monthly time-step simulation)
    • GOM (10 year, bi-hourly simulation)
      – Outputs: Revelstoke Release and Reservoir
Key Assumptions:

- 60 year streamflow extending from Oct 1940 to Sep 2000
- Includes Non-Treaty Storage scenario
- Gas and electricity price forecast as per Long Term Acquisition Plan (LTAP) 2008
- Loads and resources for 2016/17
  - REV 5, MCA 5 & 6
- Treaty operation based on 2012 Assured Operating Plan
- Critical fisheries agreements included.
System Modeling Overview

• Modeling provides:
  – Economic optimal operation of BC Hydro system, given constraints.

• Modeling does not provide:
  – Wind integration impacts to operations
  – Operational adjustments that may be made to manage non-power issues, including:
    • Managing flood control events.
    • Enhancing Arrow Soft Constraints or other system objectives
    • Managing non-power issues in other basins.
    • Implementing discretionary supplemental agreements, for power or non-power benefit.