
# BC Hydro
# Generation system operation

## Columbia Basin Regional Advisory Committee

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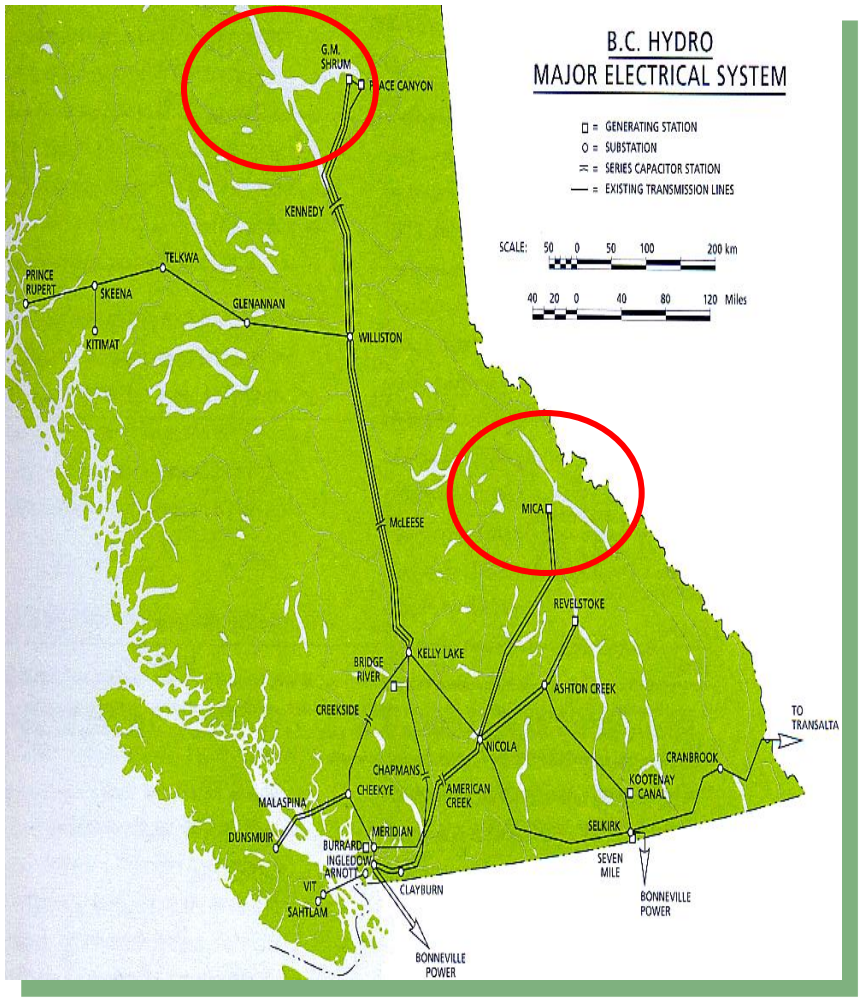
BC hydro

# Generation System Operation

- Coordination of provincial generation (Heritage resources, IPPs, partner generation under Canal Plant Agreement)

- Operation mainly impacted by:
  - Inflows
  - Market Prices
  - Loads
  - Generation Availability
  - Columbia River Treaty
  - Water Use Plans

- BC Hydro large (multi-year) storage system is operated for long term, as opposed to annual, economic goals on a consolidated basis (domestic and trade activity)

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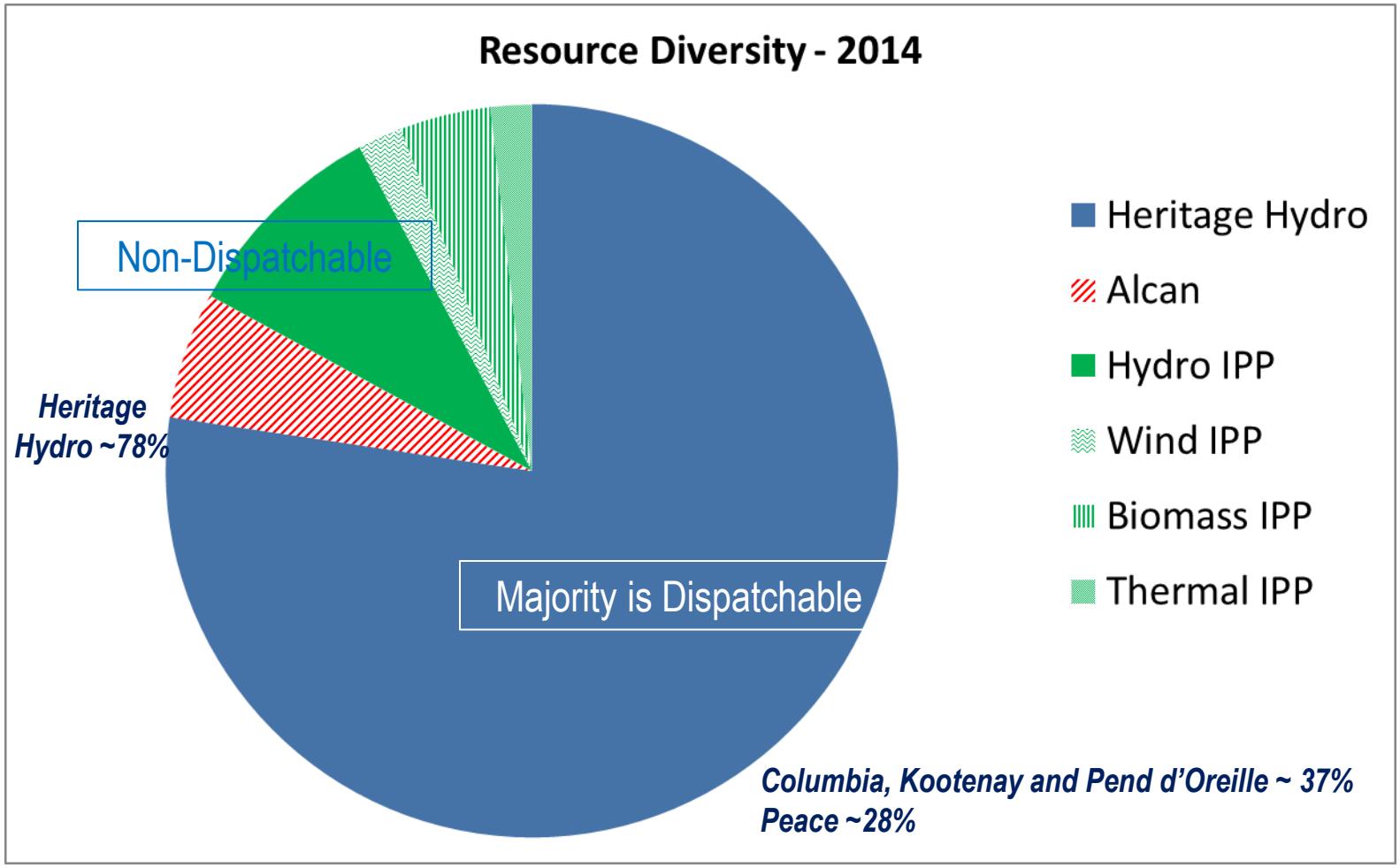
# Generation Mix - Energy

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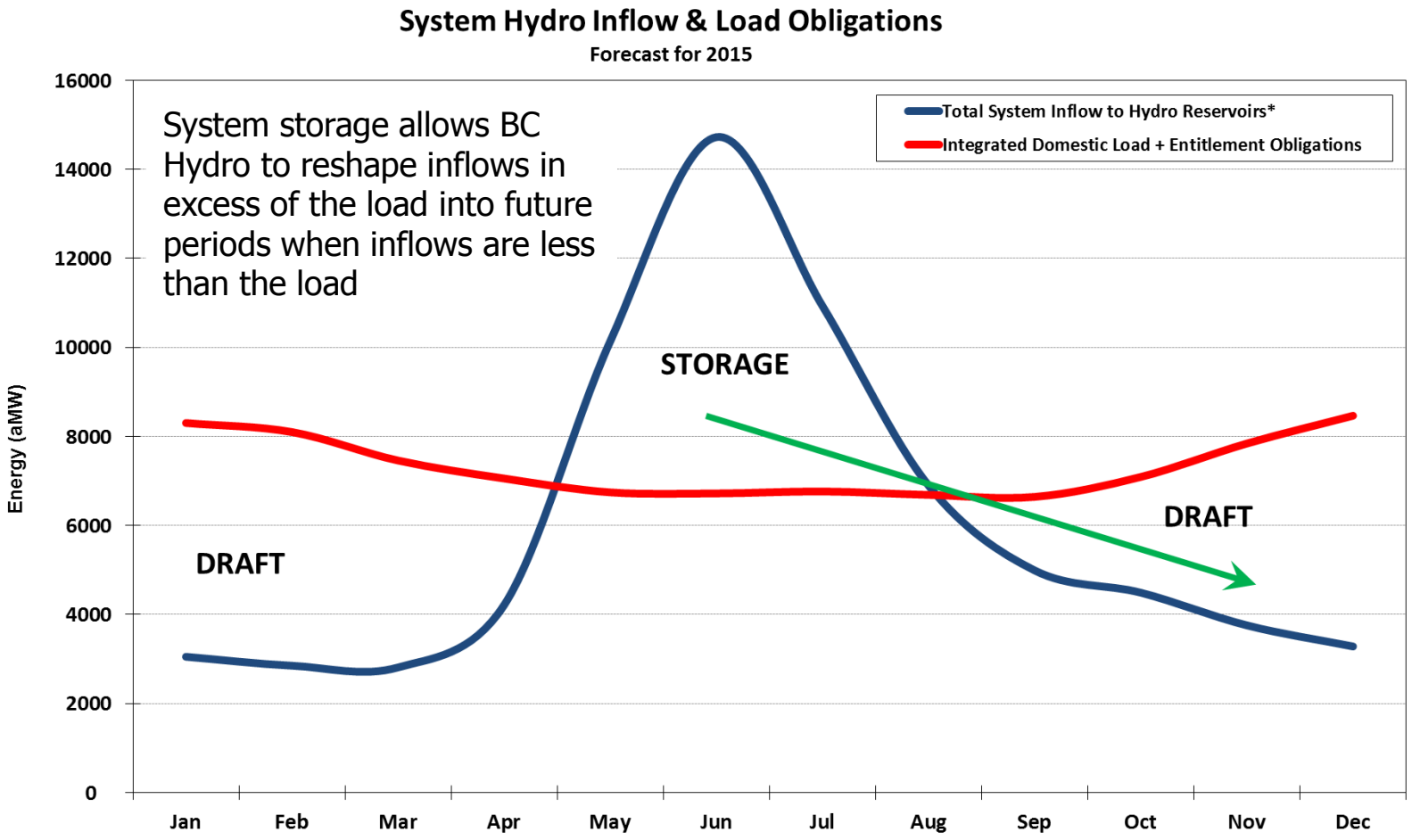
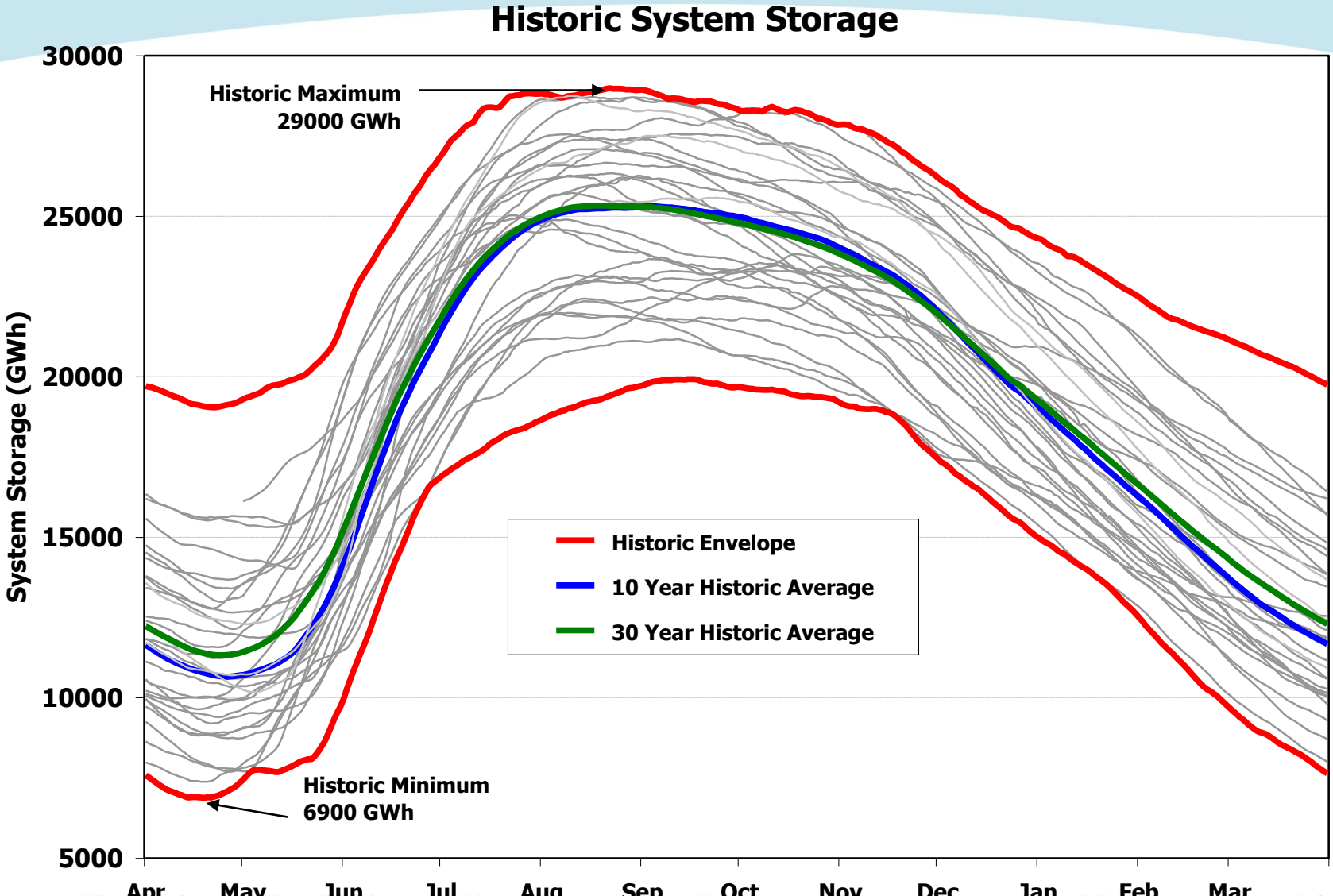
# Benefits of System Storage




* Inflows are representative of system-normal as of Feb 2014

# Annual Profile of System Storage

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Source: Historic System Storage.xls (jdb presentations)

# Generation System Operation

Timeframe:
Beyond 3 years

Timeframe:
3 years to real time

| Planning (IRP) | Energy studies | Operations Planning | Real Time Dispatch |
|---|---|---|---|
| Forecasts future load, determines supply needs (energy and capacity) and acquires resources | Monthly system modeling maximizes long term net revenue from operations and determines:<br>- storage operation<br>- water values<br>- domestic buy/sell<br>- system surplus capability for trade | Short term operations planning<br>- detailed operating plans for individual plants<br>- considers all risks and constraints, incl. water conveyance, flood control, WUP requirements | Day ahead operating plan and hourly generation dispatch / water conveyance to meet load requirements and trade opportunities in a most economical manner; manages within the day unexpected events |

Informed by forecasts:

weather and inflows, market prices, loads, unit outages, transmission availability

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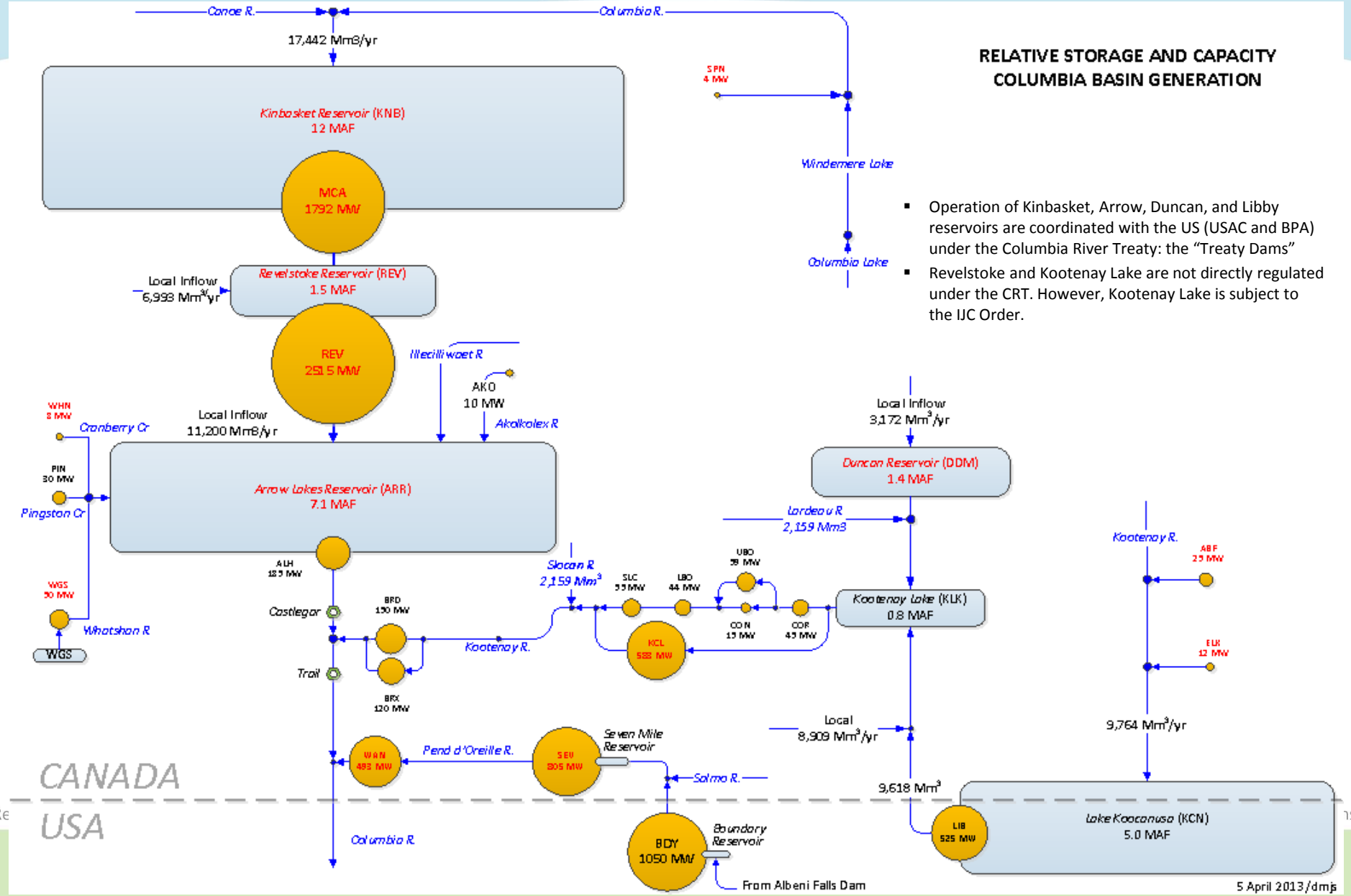
# Columbia Basin in Canada




**RELATIVE STORAGE AND CAPACITY COLUMBIA BASIN GENERATION**

- Operation of Kinbasket, Arrow, Duncan, and Libby reservoirs are coordinated with the US (USAC and BPA) under the Columbia River Treaty: the "Treaty Dams"
- Revelstoke and Kootenay Lake are not directly regulated under the CRT. However, Kootenay Lake is subject to the IJC Order.

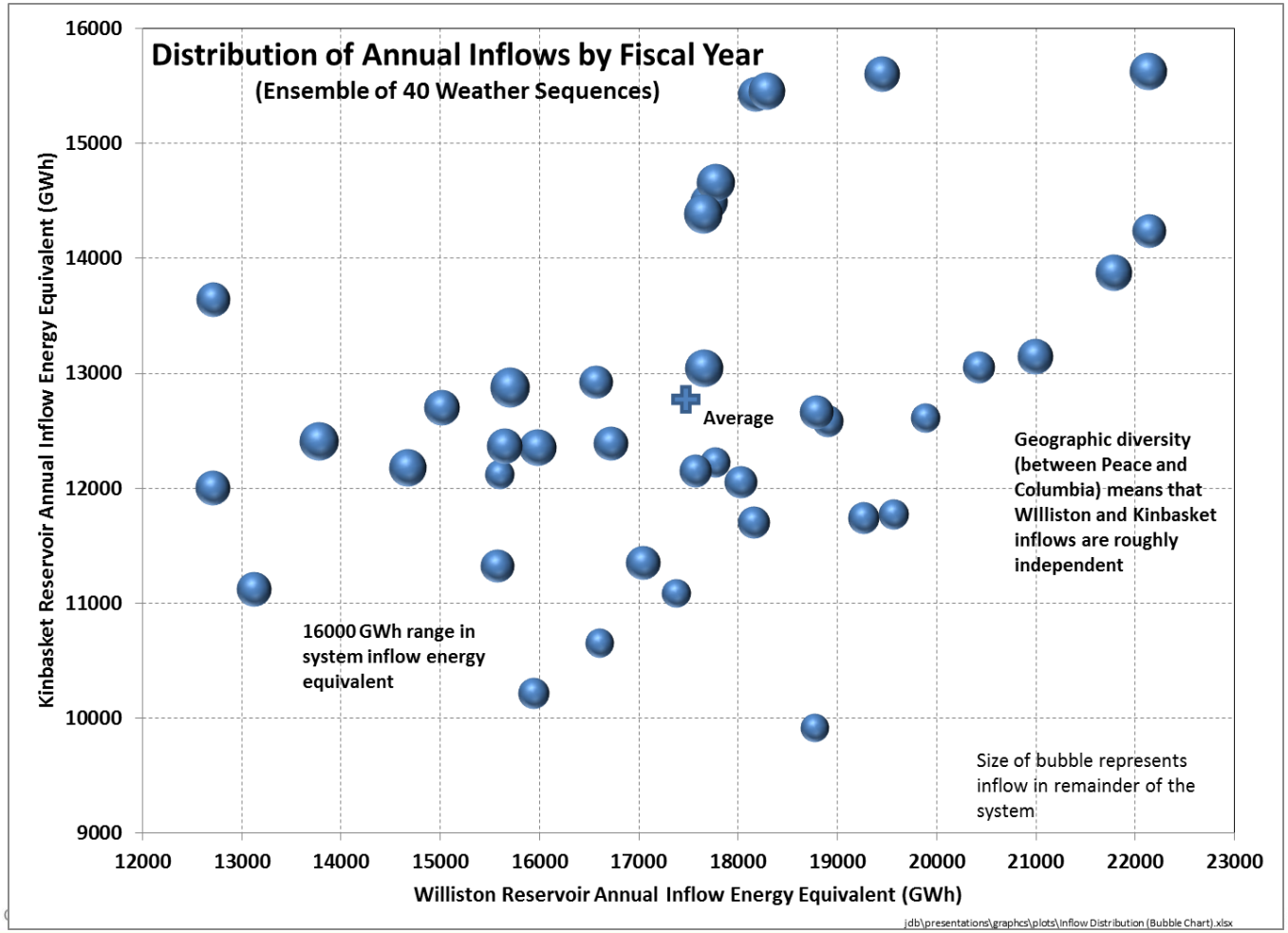
# What Impacts Columbia Basin Operations?

- Water Licenses (diversion and storage for power generation)
- Inflows (across the system, incl. US Columbia basin)
- Market Prices
- Loads
- Generation Availability (across the system)
- Columbia River Treaty
- WUP constraints and other environmental/social objectives
- Other Agreements
  - Non Treaty Storage
  - Libby Coordination Agreement
  - Non-Power Uses (or "Flow Augmentation") Agreement

# Inflows

**Benefit of "Two River" policy is inflows into system reservoirs are roughly independent – but range of variation in system inflows is 16,000 GWh**

Kinbasket Inflow variability

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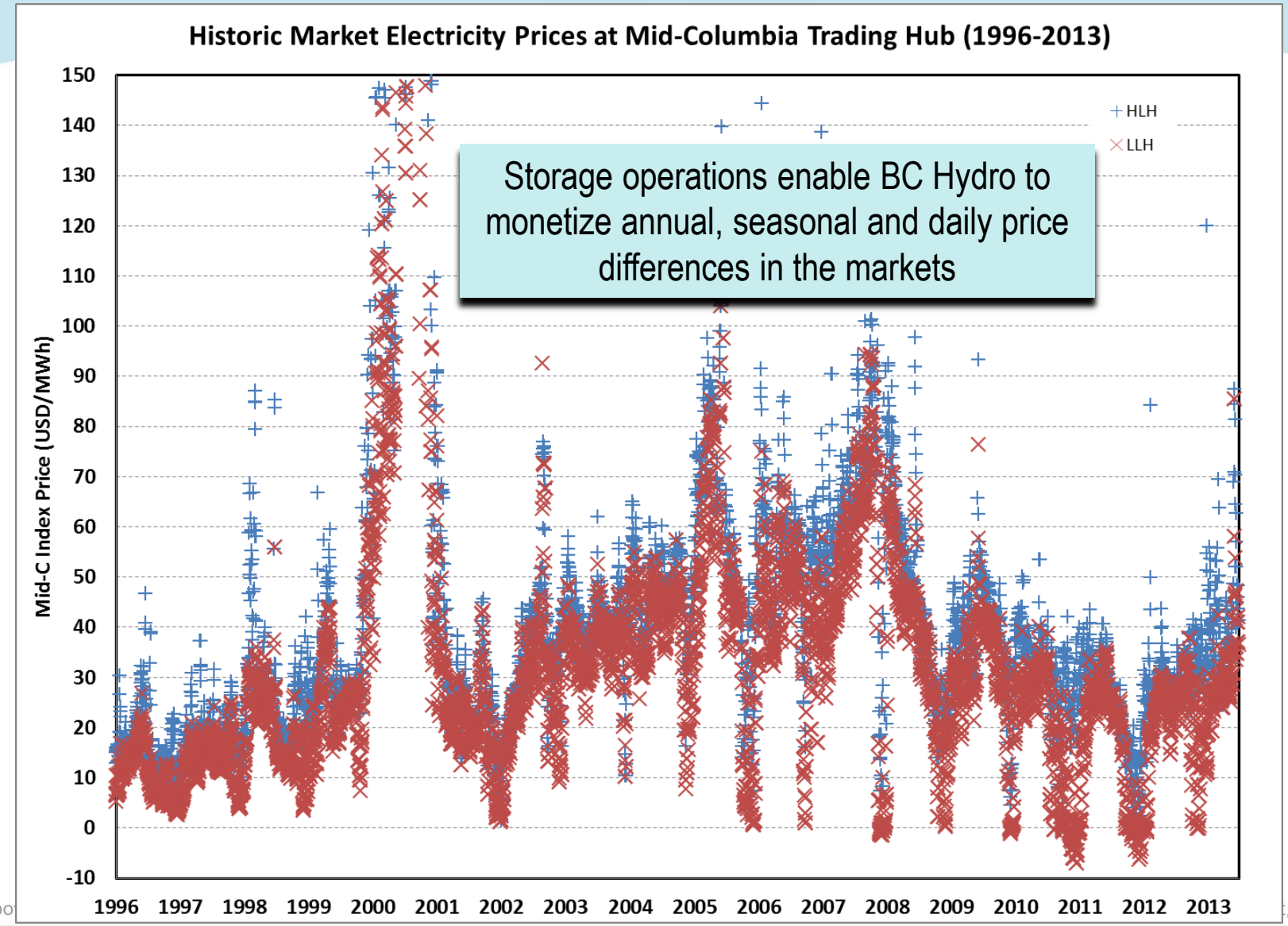
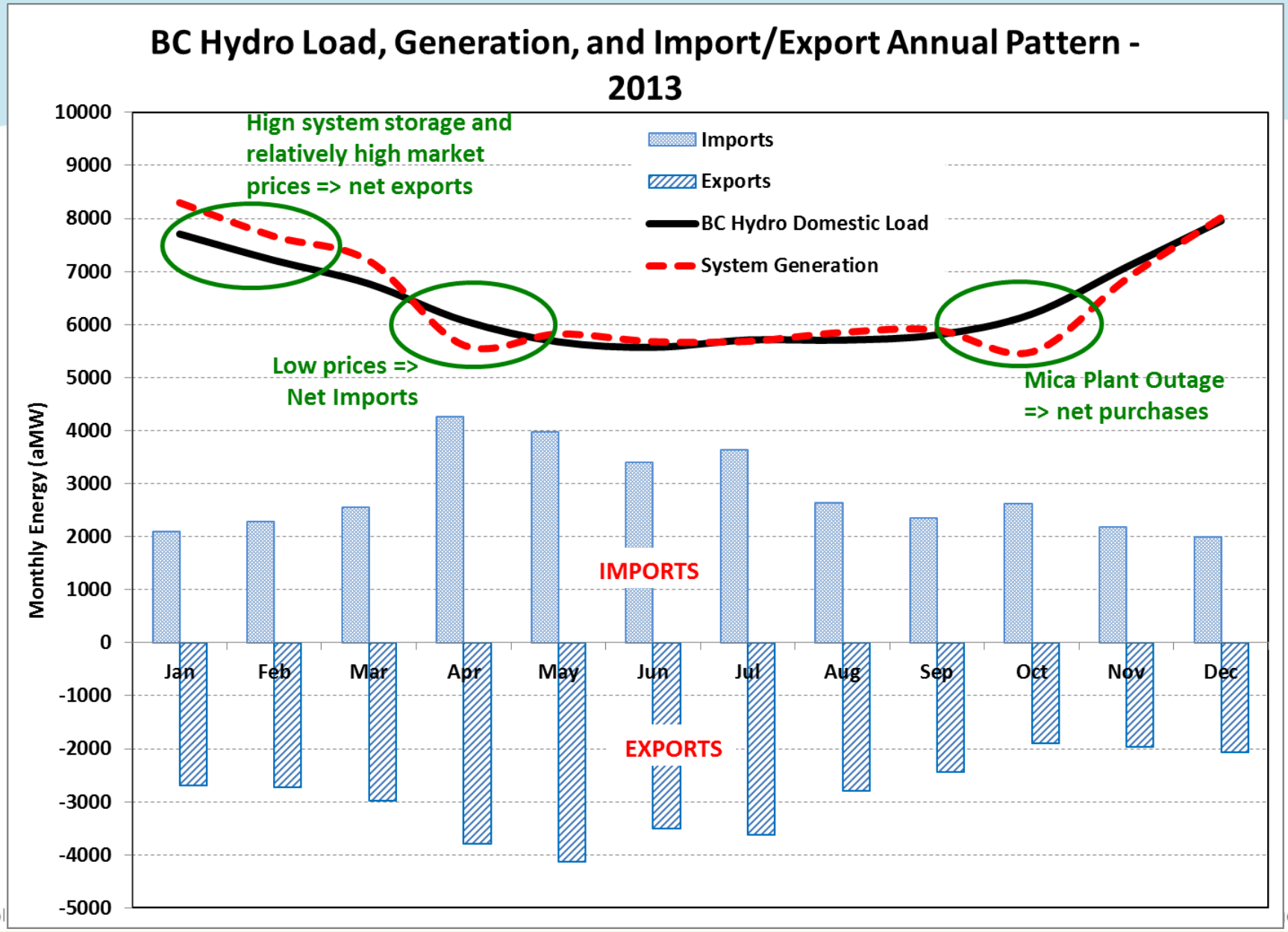
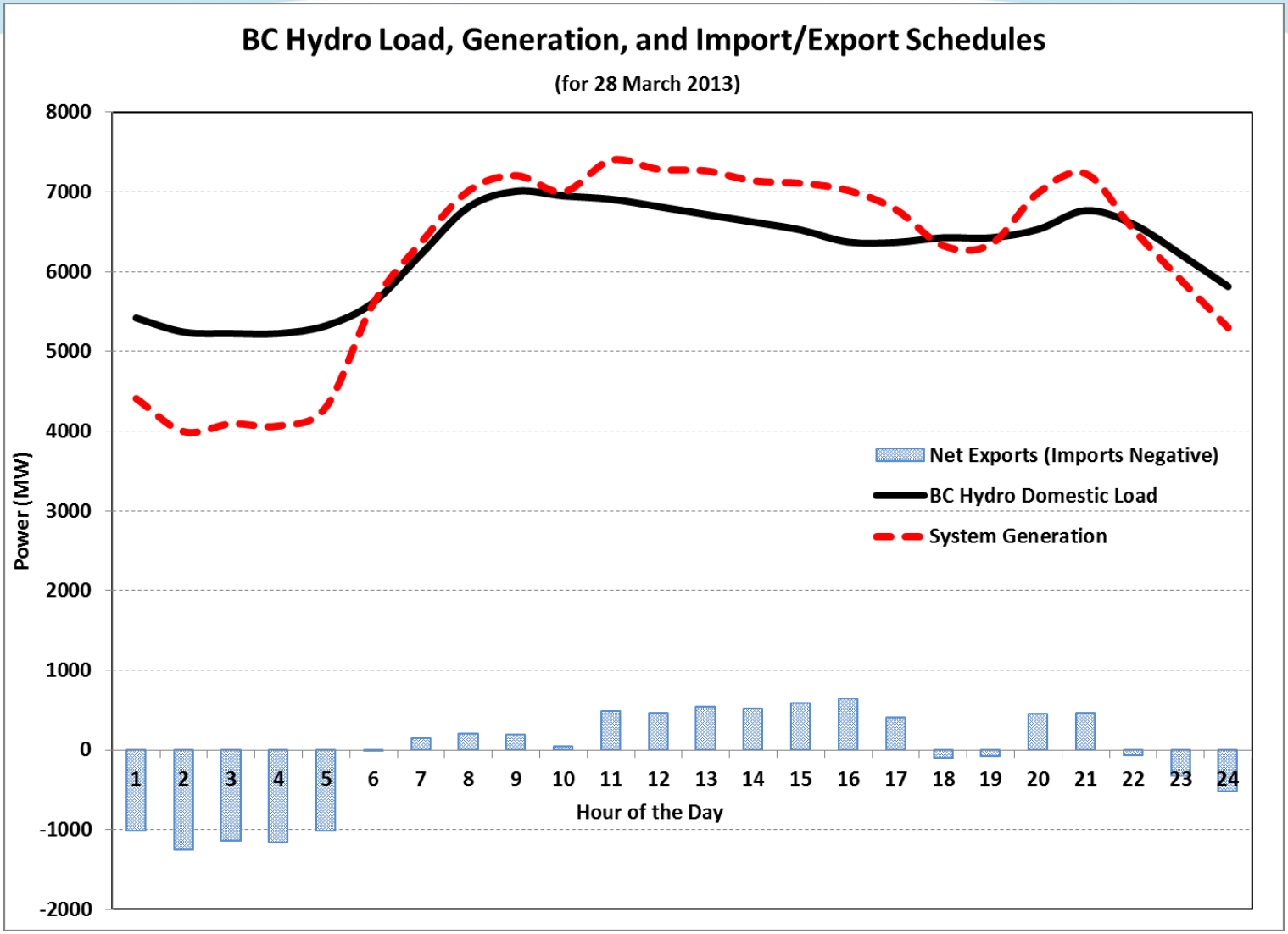
# Market Electricity Prices




BC Hydro Load, Generation, and Import/Export Annual Pattern - 2013
Hign system storage and relatively high market prices => net exports
Low prices => Net Imports
Mica Plant Outage => net purchases
Imports
Exports
BC Hydro Domestic Load
System Generation
IMPORTS
EXPORTS
Monthly Energy (aMW)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

# BC Hydro Domestic Load, Generation, & Market Activity - Daily Pattern

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# Columbia River Treaty

- Regulate flow for optimum power and flood control in both countries
- Creates requirement for:
  - flood control space at Mica, Arrow and Duncan
  - specific flows across the border (Arrow discharges)
- Power generation and flood control are generally well aligned – drafting in winter when load high creates flood control space in reservoirs in expectation of spring flows
- Flood control requirements rarely limiting at Mica & Duncan, but often at Arrow (and Libby)
- Silent on other values (ie fisheries, recreation)
- Entities enter into supplemental agreements to "adjust", by mutual agreement, flows at the border to accommodate other interests

# Non Treaty Storage Agreement

- Commercial agreement between BC Hydro and BPA to coordinate use of Mica storage not covered by Treaty for mutual benefit
- Decisions are made weekly by mutual agreement
- Provides for adjustments to Arrow discharges from those required by CRT (store into NTS when discharges reduced and vice versa)
- Optimizes both power and non-power benefits
  - BC Hydro gains better flexibility to create economic value and balance Columbia WUP objectives
  - BC Hydro receives a share of downstream benefits created by improved regulation under the NTSA
  - More flexibility to generate at Mica across fall/winter for system load
  - Reduced spill risk at Mica
- BC Hydro and BPA low water supply event releases – firm energy and fisheries benefit

# Short Term Libby Coordination Agreement

- Original LCA (signed in 2000) addressed the impacts of power losses as a result of US unilaterally changing Libby operation in 1993 to support white sturgeon spawning but to the detriment of Kootenay River power generation

- Canadian Entity objected to further US changes to Libby operation implemented in 2003 and as a temporary and partial mitigation entered into a Short Term (supplemental) LCA that provides additional power loss mitigation and ensures cooperation prior to and during flood events.

- Canada desires to better address flood risk management in any future long term agreement

# Non Power Uses Agreement

- Canadian interests:
  - Decreases Arrow discharges (storage) in Jan and keeps flows more steady until Mar for whitefish spawning
  - Provides flexibility to keep flows steady or increasing from Apr through Jun for trout spawning

- US interests:
  - Release of storage in Jul to supplement Treaty flows for salmon outmigration (hence agreement also called Flow Augmentation Agreement); note that flows may be further augmented in Jul and Aug by release of NTSA if there was NTSA storage during the period of Apr - Jun

# WUP operating constraints

| WUP Name | Date Signed | Operational Constraints |
|---|---|---|
| Columbia River Project (Mica/Revelstoke/Arrow) | 11 Jan 2007 | • MIN and MAX reservoir levels.<br>• MIN Revelstoke downstream flow requirements.<br>• Soft constraints |
| Water Hardman Project | 21 Mar 2006 | • MIN and MAX headpond reservoir levels.<br>• MIN downstream flow requirements. |
| Whatshan Project | 15 Jun 2005 | • MIN reservoir levels. |
| Elko Project | 7 Apr 2005 | • MIN downstream flow requirements.<br>• Generation station discharge ramping rates. |
| Spillimacheen Project | 15 Jul 2005 | • MIN downstream flow requirements.<br>• Generation station discharge ramping rates. |
| Aberfeldie Project | 6 Nov 2006 | • MIN and MAX headpond reservoir levels.<br>• MIN downstream flow requirements.<br>• Generation station discharge ramping rates. |
| Seven Mile Project | 8 Dec 2006 | • MIN and MAX reservoir levels.<br>• Considerations for reservoir recreation/fisheries. |
| Duncan Project | 20 Dec 2007 | • MIN and MAX reservoir levels<br>• MIN and MAX downstream flow requirements.<br>• Dam spill discharge ramping rates. |

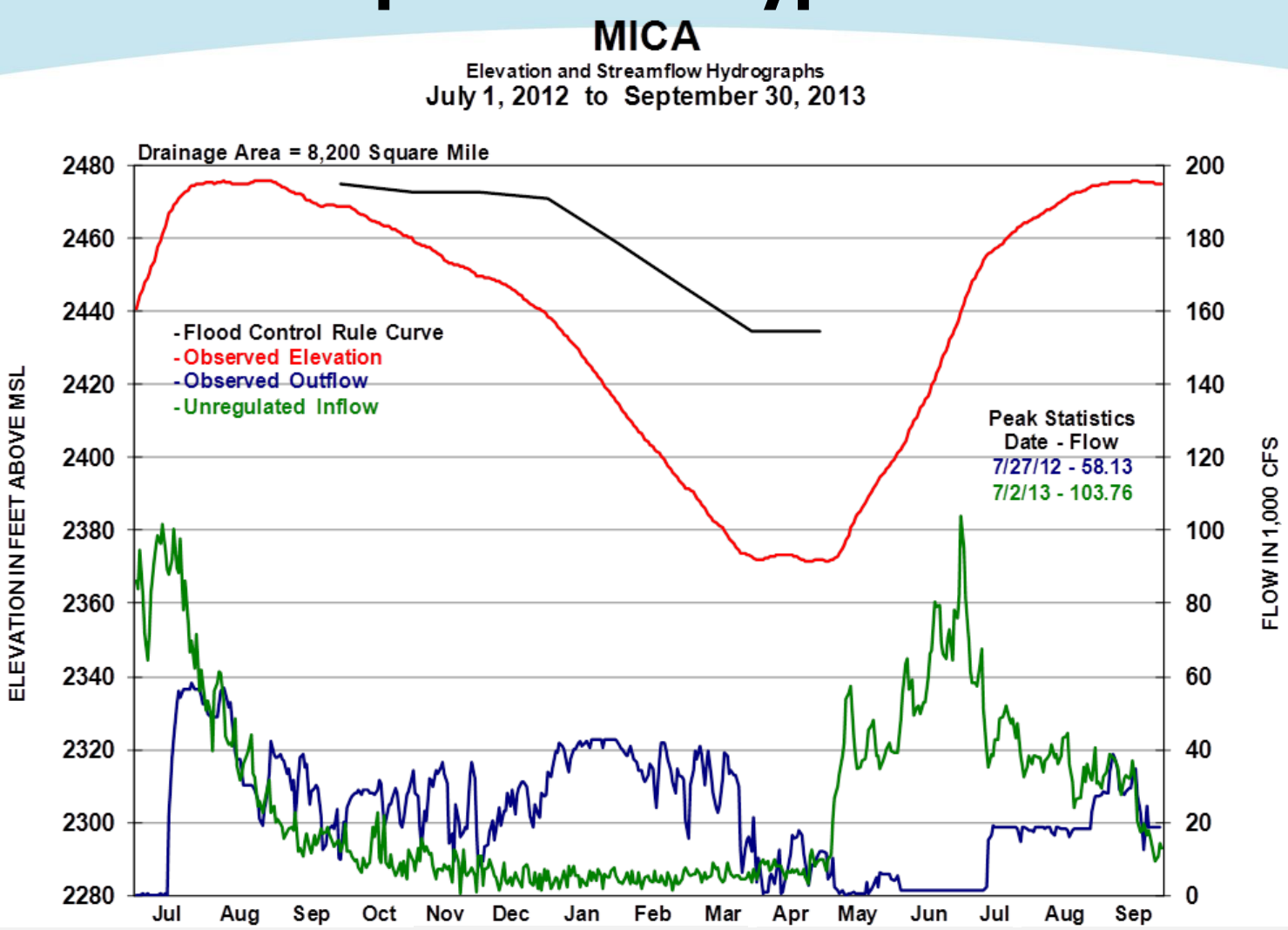
# WUP monitoring and physical works

| WUP Name | Key WUP Monitoring and Physical Works | Total Cost of Monitoring and Works* |
|---|---|---|
| Columbia River Project (Mica/Revelstoke/Arrow) | Physical works: Boat ramp access , debris removal, vegetation replanting; Monitoring studies: Recreation & boat use; Wildlife (birds, amphibians & reptiles); Fish (whitefish, rainbow trout, white sturgeon, and burbot); Vegetation inventory & erosion; Archeological site assessments | $108 M Expected completion in 2019 |
| Water Hardman Project | Physical works: Diversion Dam Min Flow Release Facility; Annual Gravel Placement; Monitoring studies: Fish (kokanee, rainbow trout, temperature effects and habitat monitoring) | $973 k Program completed in 2012 |
| Whatshan Project | Physical works: Boat ramp access , Habitat Enhancement; Monitoring studies: Wildlife; Fish (rainbow trout); Vegetation mapping; Archeological site assessments | $764 k Expected completion in 2015 |

# WUP operating constraints and works

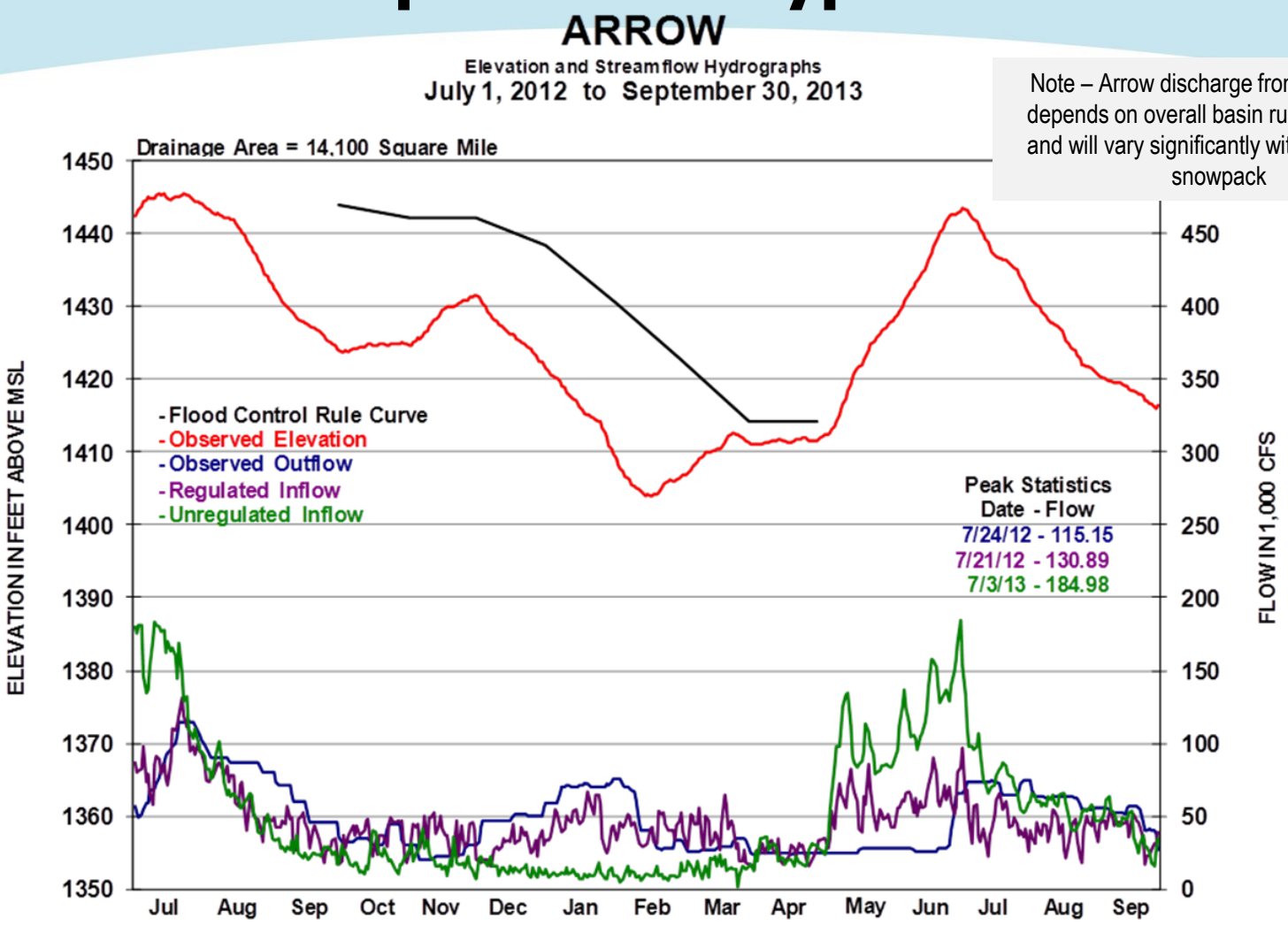
| WUP Name | Key WUP Monitoring and Physical Works | Total Cost of Monitoring and Works* |
|---|---|---|
| Elko Project | Monitoring studies: Monitoring of Habitat Maintenance Flows; Side Channel Sinkholes, Total Suspended Solids and fish stranding | $89 k Program completed in 2011 |
| Spillimacheen Project | Monitoring studies: Assessment of Rampdown Rates; Gravel Recruitment; Monitoring of Habitat Maintenance Flows | $68 k Program completed in 2011 |
| Aberfeldie Project | Monitoring studies: Fish (Habitat; Productivity and Effectiveness of Fish Habitat Works) | $641 k Program completed in 2013 |
| Seven Mile Project | Monitoring studies: Fish (Stranding and Bull Trout entrainment) | $395 k Program completed in 2009 |
| Duncan Project | Physical works: Boat ramps & erosion protection<br>Monitoring studies: Wildlife & mosquitos; Fish habitat & use(kokanee, bull trout, Burbot); Vegetation monitoring; Archeological site erosion | $10.6 M Expected completion in 2018 |

# Mica operation – typical drivers




| | | | | |
|---|---|---|---|---|
| **Typical Operational drivers:** | Jul to Oct*: discharge adjusted as needed to refill reservoir, minimize spill, & maximize electricity value | Nov to Mar: high discharge to meet electricity demand, discharge sometimes limited in Feb-Mar by Arrow Reservoir flood control curve. | Apr to mid-Jul: low electricity value, so discharge reduced to refill reservoir | *Note – Mica discharges during Jul-Oct can be quite variable, depending on spill probability at Mica and other reservoirs (e.g. Williston) as well as market electricity values |

# Arrow operation – typical drivers

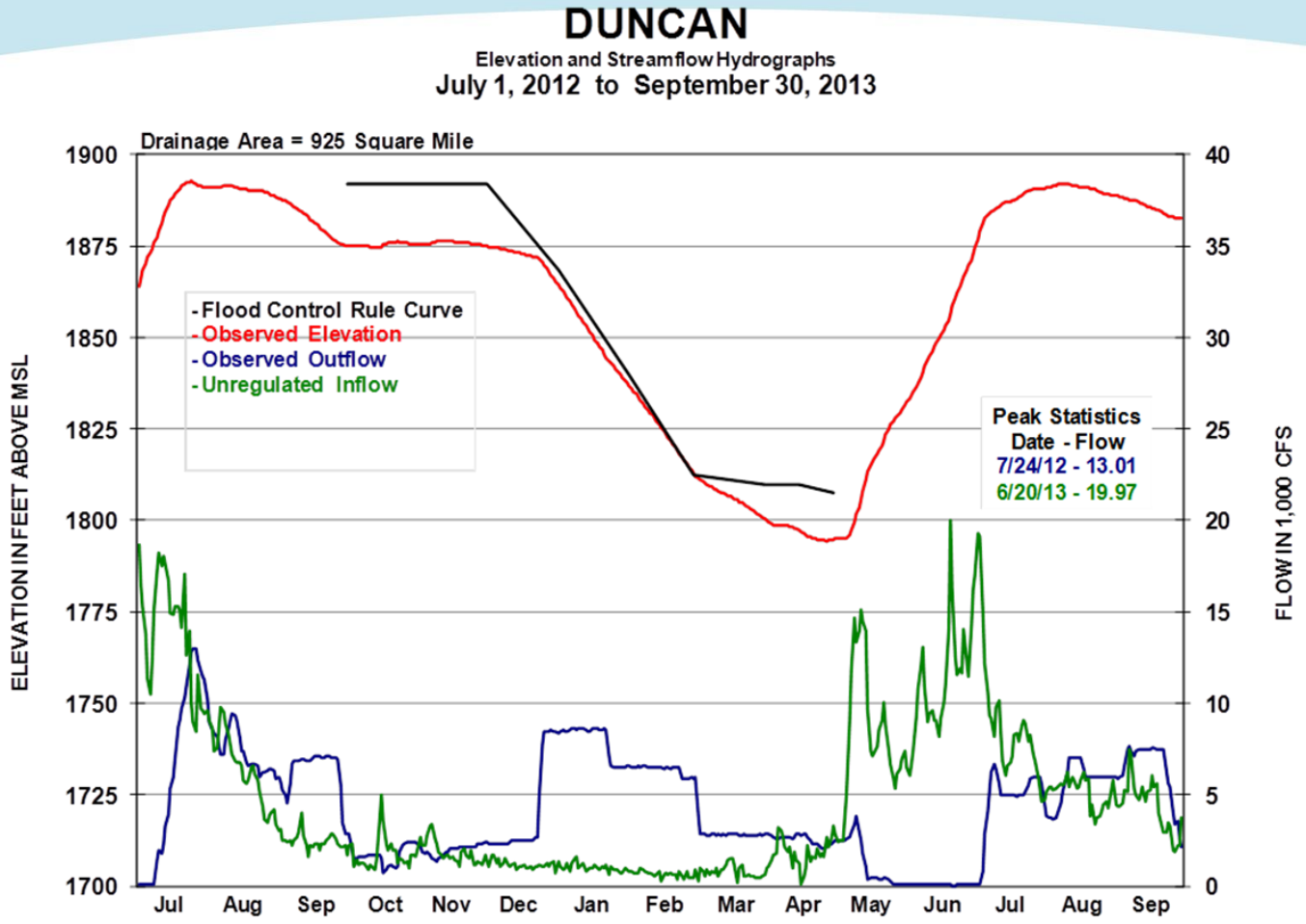



Note – Arrow discharge from Jan to July depends on overall basin runoff forecast, and will vary significantly with basin-wide snowpack

**Typical CRT & operational drivers:**

| Jul-Aug: discharge increased to meet CRT needs & release Flow Aug water | Sep-Dec: discharge lower to preserve storage in case of low snowpack. NTSA & STLA activity if economic. | Jan-Mar: higher discharges (if snowpack OK); sup. agrmts manage for steadier whitefish spawning flows | Apr-June: lower, stable discharges to refill reservoir, manage trout spawning |
|---|---|---|---|

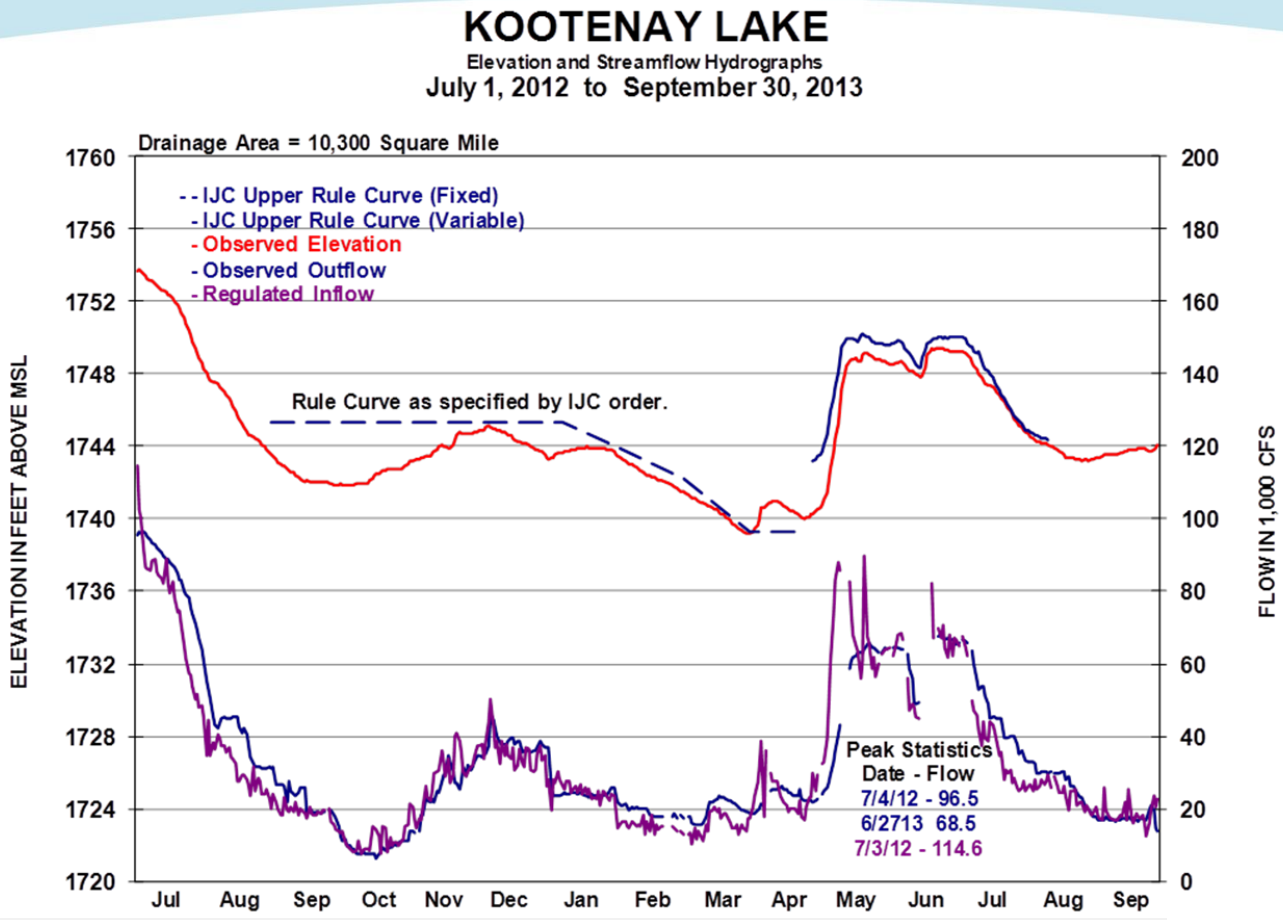
# Duncan operation – typical drivers




**Typical CRT & operational drivers:**

| Jul-Sep: discharge increased & then adjusted to manage reservoir refill & minimize downstream Can flooding | Oct-Dec: discharge limited to manage fish spawning in Duncan River. Res. level must remain below CRT flood curve. | Jan-Mar: higher discharges to improve Kootenay Lake inflows & meet CRT flood control needs. | Apr-Jun: discharge reduced to refill reservoir, subject to minimum WUP fish-flow needs in Canada |
|---|---|---|---|

# Kootenay Lake operation – typical drivers




**Typical Operational drivers:**

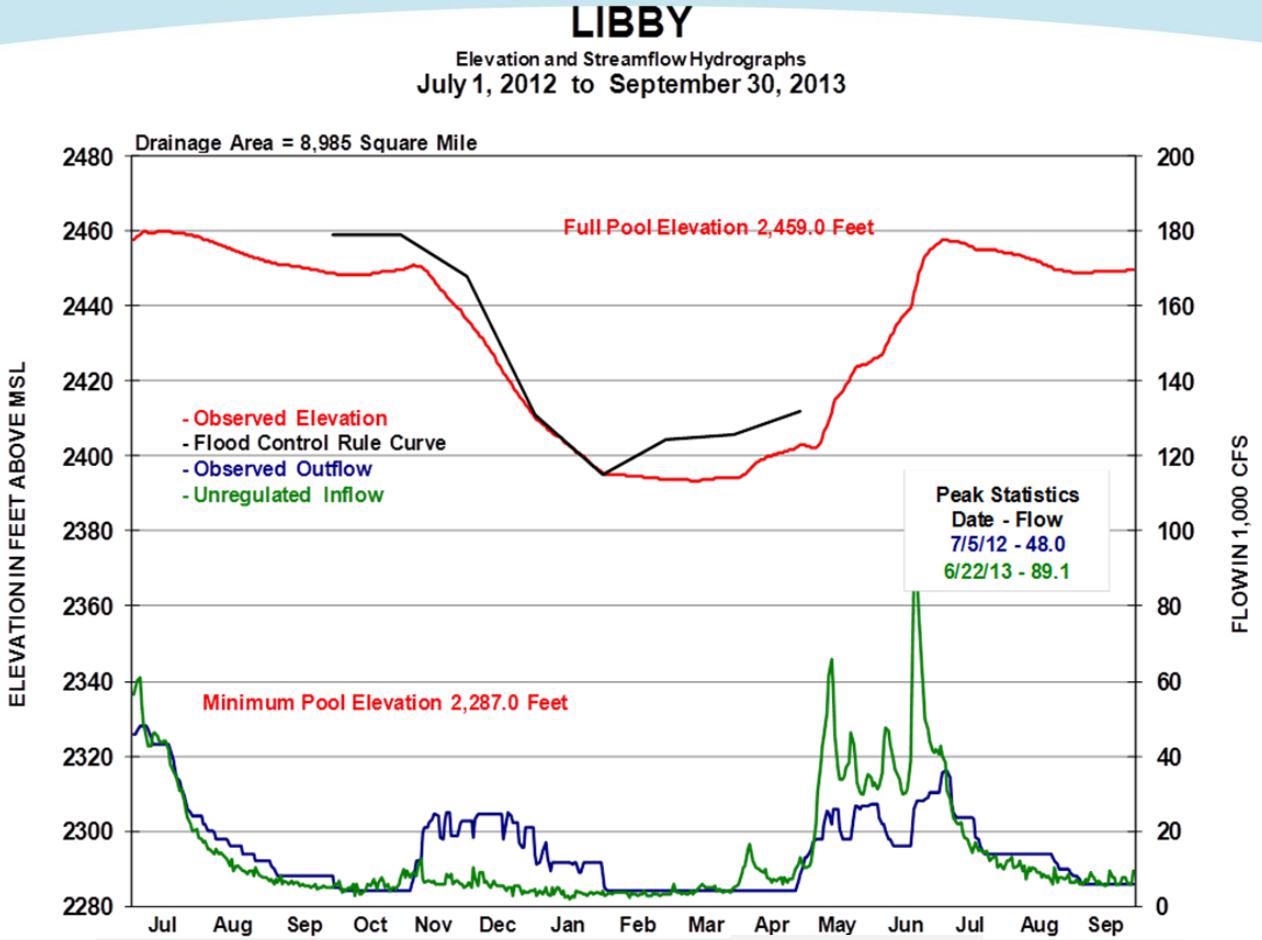
Jul-Aug: lake drafted in compliance with IJC Order

Sep-Dec: discharges adjusted to keep lake level below IJC Curve, with minimum fish flow downstream at Brilliant

Jan-Mar: lake drafted to meet IJC Curve. Discharge maximized (limited by Grohman Narrows) if lake level above IJC Curve.

Apr-Jun: typically on maximum discharge to minimize peak lake level (and meet IJC Curve)

# Libby operation – typical drivers




**Typical operational drivers:**

Jul-Sep: discharge adjusted to manage reservoir refill & provide downstream fish flows

Oct-Dec: discharge reduced to minimum, then increased in late Nov to hit 31 Dec flood control level.

Jan-Mar: discharges increased above minimum only if needed to stay at/below flood control curve.

Apr-Jun: discharges increased for fish, then high sturgeon flows in late May or June. Discharges adjusted to maintain flood management space.

# Questions?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