BC hydro

Evaluating Power and Non-Power Operating Constraints - BCHydro September 3rd , 2009

PaS1

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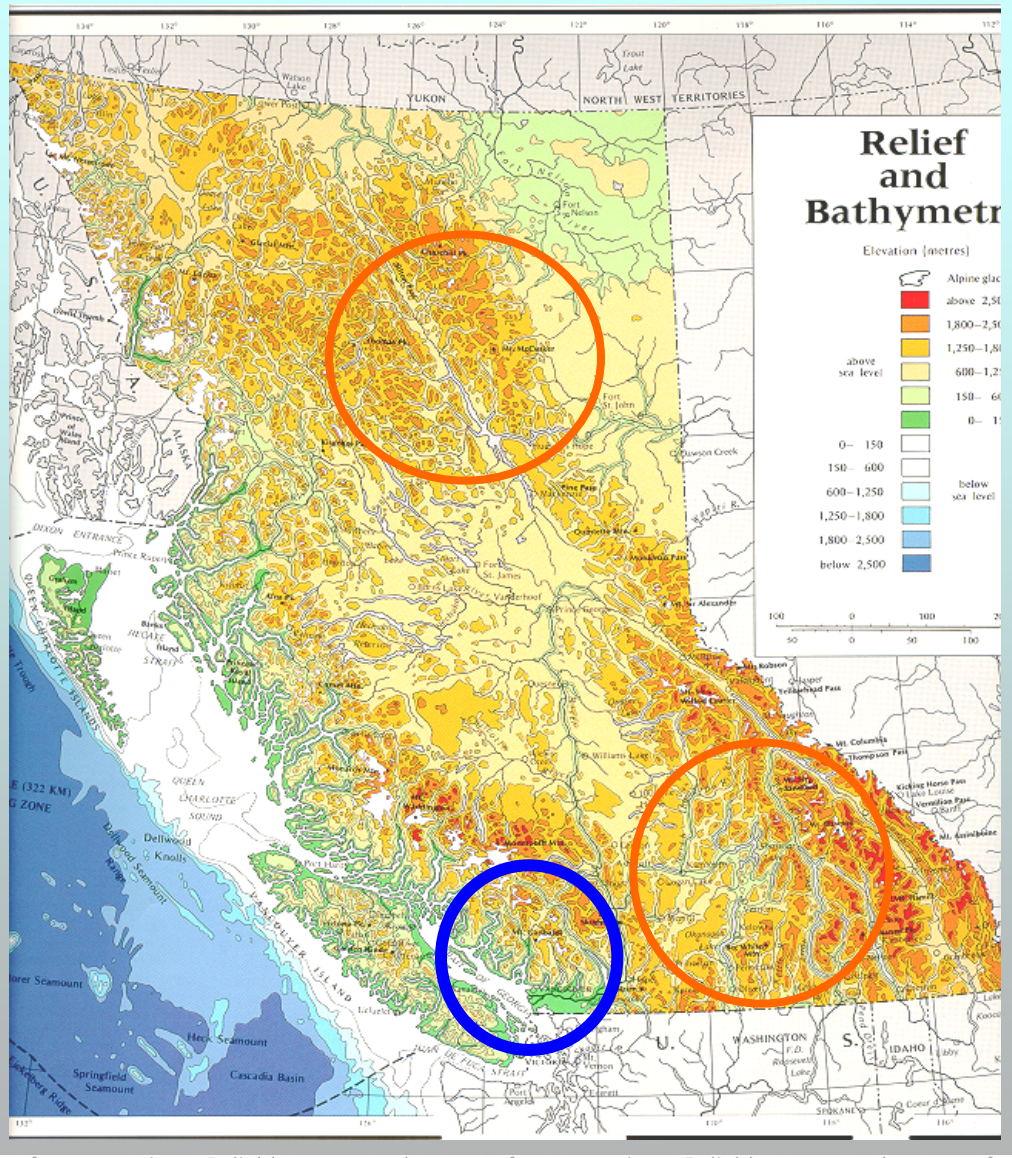
(BC Hydro Resources Management – Operations Planning)

Slide 1

PaS1 Paul and Shelia, 30/08/2009

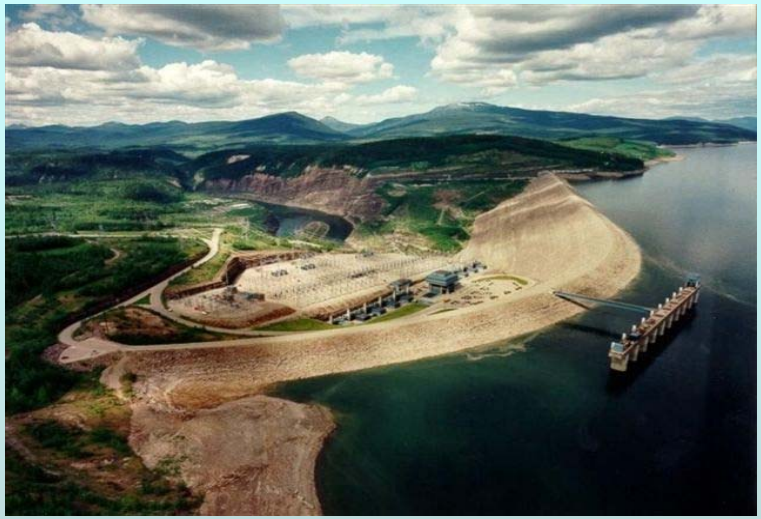
What is BC Hydro?

- State Corporation
- Third largest electrical utility in Canada
- Trades in western North America



Reliable power, at low cost, for generations. Reliable power, at low cost, for generations. Reliable power, at low cost, for generations. Reliable power, at low cost, for generations.

Example Facilities



GMS Peace River 2730 MW

Mica Columbia River 1792 MW

Alouette 9 MW

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Generation Line of Business Mandate

- Responsible for operating to meet domestic load
- 3 Year Horizon
- Management of Heritage Resources
- Making surplus resources available for trade
- Commodity risk management in meeting domestic load
- Trade Account Storage

Generation Line of Business

Two levels for planning and operations:

- **System - maximize overall BCH profits, thereby providing the lowest cost to consumers and maximum revenue to shareholder**

- **Facility – physical characteristics, water licenses, environmental legislation, First Nations, societal acceptance, system requirements**

Facility Operations Planning

- Inflow forecasts
- Non power requirements
- Agreements
- System requirements

Operational Objectives: Environmental, Social and Economic

Review of Facility Operations; BC Hydro's Water Use Planning Program

- A process to review BC Hydro operations and ensure that these operations reflect today's societal values
- This process carries out modeling which enables stakeholders to undertake tradeoff based on values
- Therefore critical to link modeling with dialog

What is a Water Use Plan?

- Sets out how water is to be managed at each hydroelectric facility
- Review of all BCH generation and storage operations
  - **Started Nov 1998, 23 hydro-electric developments with a budget of $25 M to develop plans, $1 M for reg. approvals**
- Sustainable and balanced management of facilities for
  - **Hydro-power**
  - **Environment (fish, wild-life, etc.)**
  - **Society (First Nations, flooding, recreation etc.)**
- WUP clarifies/defines
  - **Operating boundaries**
  - **Regulatory compliance**
- Provides consent to operate
  - **clear operational constraints are written into BC Hydro's water licenses**

Key Features of WUP

- **Addresses full range of interests**
  - Fish and wildlife – habitat and stocks
  - Water quality and quantity
  - Social and land
  - Energy / capacity
- **Open consultative process**
  - BC Hydro an equal partner
  - Trade-offs in terms of objectives ("power vs non-power")
  - Document areas of consensus & disagreement
- **A clearly defined and structured process**
  - Water Use Planning *Guidelines* (set budget and timeline)
  - Project Management (tools for decision making and transparency)
  - Who participates (Gov. agencies, indigenous peoples, interest groups, etc.)
- **Comply with laws and regulations**
  - Must not infringe on existing treaties, etc.

Water Use Planning Process

- Step 1. Consultative committees set objectives and define performance measures (criteria for operations) with assistance from technical experts
- Step 2. Performance Measures, representative of multiple demands, are used to define operating constraints on the systems
- Step 3. Constraints are applied to reservoir elevations and discharge points. A set of constraints defines and operating alternative
- Step 4. The reservoir system is simulated with a hydro operations model which attempts to satisfy constraints
- Step 5. Output from the hydro operations model i.e. reservoir elevations, discharges, and generation is processed to calculate Performance Measures
- Step 6. Stakeholders carry out resource valuation exercise, trading between objectives, identify new options and alternative operations

Steps 2-6 are repeated as stakeholders converge toward a water use plan.

Objectives, Performance Measures and Constraints

Example objective: Maximize the abundance and diversity of fish

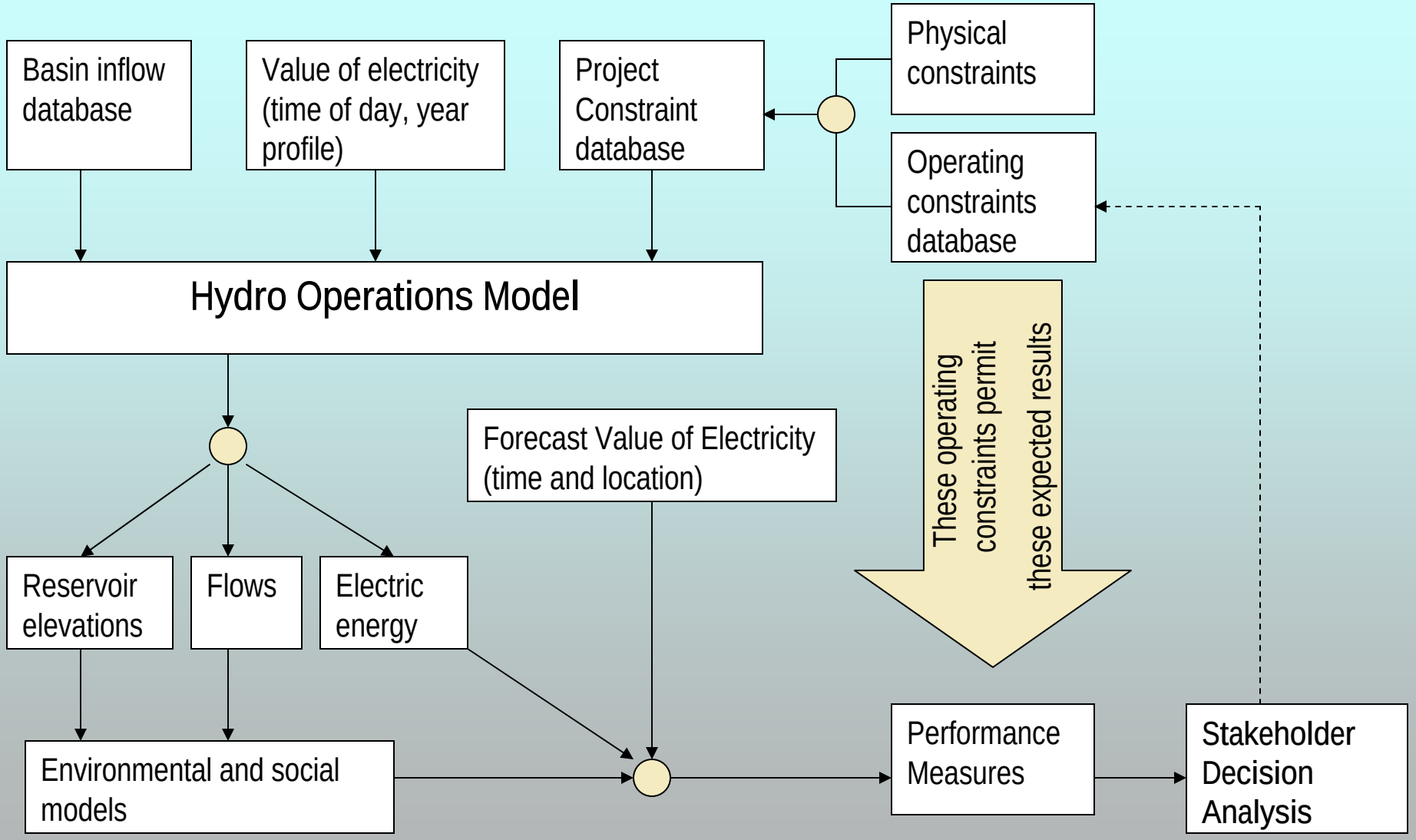
Performance Measures:

- **Littoral (shoreline) productivity grams carbon produced per year)**
- **Pelagic (open water) productivity grams carbon produced per year)**
- **Tributary fish spawning success (hectares)**
- **Entrainment Risk**
- **Stranding Risk (hectares of isolated pools)**

Operating Constraint

- **Maintain reservoir between elevation 80-82 m from May 1st to Sep 15th**

Water Use Planning – Modeling Framework



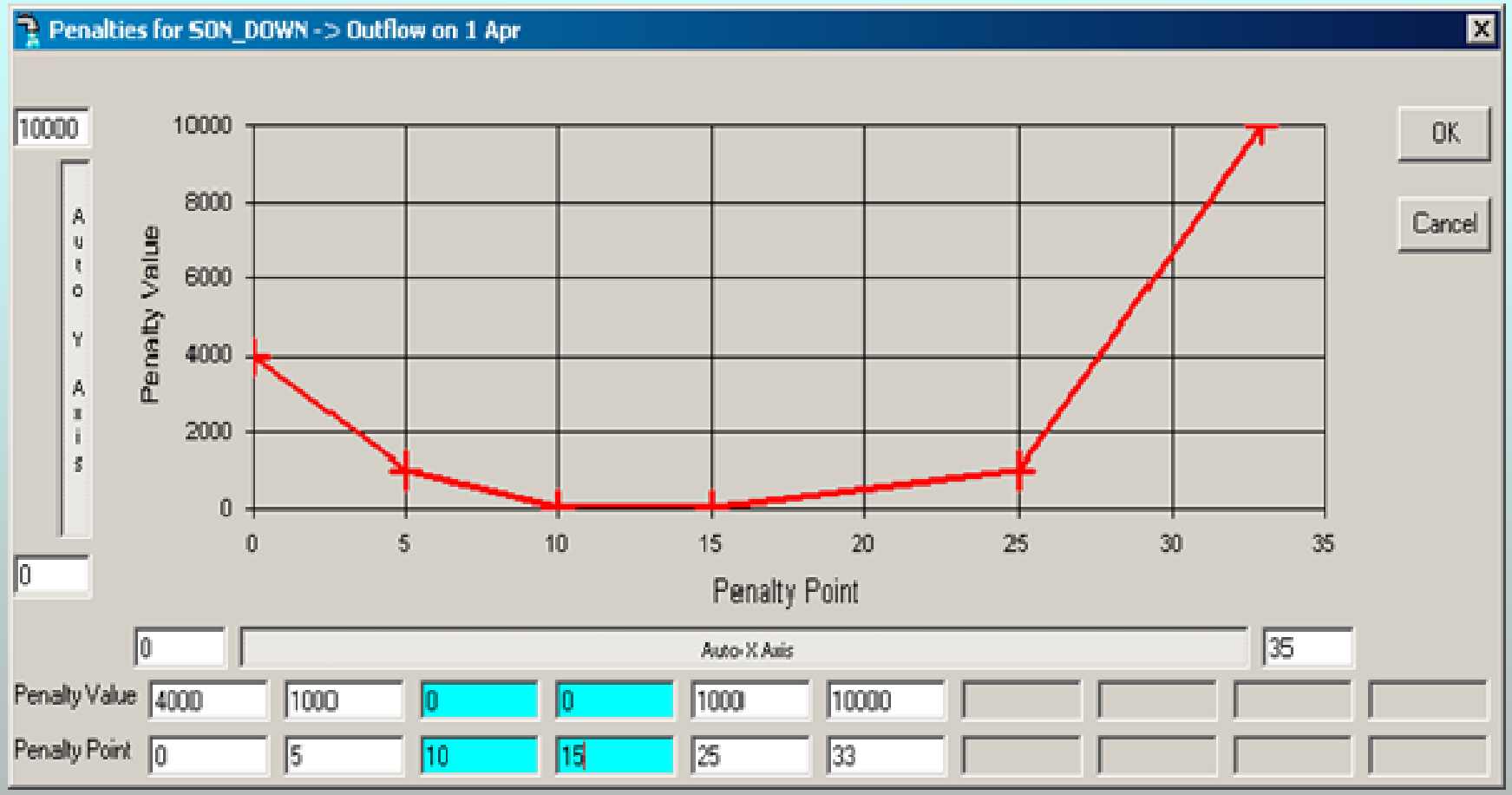
Operating Constraints

These are desirable from various perspectives, including safety, legal compliance, economics, social and environmental considerations. The constraints prescribe:

- ❑ Maximum, target, minimum reservoir levels
- ❑ Maximum, target, minimum flows
- ❑ Rates of change

These are “soft” constraints and can be violated. A set of operating constraints define an alternative.

Operating Constraints – Penalty Functions



Optimization Problem

- **Decision Variables**
  - releases from reservoirs and through non-storage control points
  - reservoir elevations
  - power generation releases
  - power plant outage schedules

- **Objective Function**
  - environmental and social issues, by minimizing release and reservoir elevation penalties
  - power generation revenue, by maximizing it

Maximize = Power Generation Revenue - Release Penalty - Elevation Penalty

Hydro Operations Model

- Uses high level programming language to formulate the problem (AMPL, a modeling language for mathematical programming)
- AMPL transforms a mathematical formulation to computer code
- Problem is solved with CPLEX linear / non-linear program – a package of mathematical solvers for linear and non-linear programming
- The optimization process iterates to converge on a solution
- Graphical user interface – Visual Basic (VB)
- Database to store results (Access)

Tools: Trade-off / Decision Models

An Interactive Consequence Table

PM	Direction	Units	Status Quo	Status Quo2	Alt A	Alt A2	Alt DS1	Alt G1	Alt F1
Reservoir Recreation	H	days	27	22	52	42	91	45	44
River Recreation	H	days	80	92	101	101	85	99	100
Power Revenues	H	$million	1.61	1.60	1.58	1.59	1.59	1.59	1.59
Flood Free Days	H	days	363	363	363	363	363	363	363
Erosion Free Days	H	days	287	307	332	323	352	327	330
Fish Habitat - Res	H	ha	4.50	4.30	4.30	4.30	4.40	4.20	4.10
Fish Habitat - Riv	H	ha	27	26	24	25	23	22	22

- Agreement on what constitutes a relevant “difference”:
- Apply trade-off techniques (weighting, even swaps, etc.) for best alternative selection

Operational Constraints

- Pre-WUP: Operations constrained by ~ 250 rules for environmental and social requirements.
- Post-WUP: Operations constrained by ~750 rules for environmental and social requirements.
- Will require increased planning, coordination, and execution of operations.

Results of WUP Operational Changes

- Improved environmental and social indicators across the system
- In some cases generation increased
- Overall cost of the program was only 25% of the initial estimate
- The vast majority of water use plans concluded with a consensus agreement

Using Models: BC Hydro's Approach

Strategy for developing the WUP Model:

- ❑ Understandable by non-technical stakeholders
- ❑ Credible and transparent
- ❑ Open to scrutiny by technically knowledgeable stakeholders
- ❑ Used to facilitate discussion and not to the centre of discussion

Using Models: What we learned

- Clearly delineate components – how do stakeholders participate
- Identify input/output parameters relevant to stakeholders
- Presentation of operational "soft" constraints as penalty functions facilitates tradeoffs and draw stakeholders into the modeling process

Using Models: What we learned

- Developed a modeling framework specific to the WUP program
- Stakeholders were involved in model building
- Development within the program enabled mutual learning and hence greater acceptance/confidence
- Stakeholders related to the model as WUP tool

Using Models - The process we used

- **Formalized professional process - standardized procedure for developing, quality controlling and documenting modeling:**
  - **Statement of Objectives and Scope of Work**
  - **System Configuration Memo**
  - **Independent Review**
  - **Quality Assurance Process**
  - **Hydro Operations Report**

Using Models: Conclusions

- **Design a process to address:**

  - Water Resources Engineering
    - Professional and rigorous
    - Use array of available tools and construct tailored solutions *(do not use generic template solutions)*
  - Translation
    - Plain language, an exercise in mutual education
  - Build Confidence
    - Time, Money, Patience

Using Models in Negotiating Water Resource Issues – Coordination Agreements

1. Water Use Plans

2. Columbia River Treaty

3. Canal Plant Agreement (CPA): Coordination agreement for the Kootenay River.

4. Others agreements
   - Keenleyside (Arrow Lakes Hydro)
   - Entitlement Agreement, Alcan EPA (Provides BCH with storage rights in Kemano reservoir)
   - Skagit and Boundary (City of Seattle)

Collective value of the 3 Columbia-based coordination agreements is ~$400 million per year.

Questions, Comments, Suggestions ?

Thank you