Water Use Planning in BC
Case Study: Campbell River Watershed

Dan Ohlson, M.Sc., P.Eng., MCIP

Compass Resource Management Ltd.
200 - 1260 Hamilton St.
Vancouver, B.C. V6B 2S8 Canada

Phone: 604-641-2875
Fax: 604-641-2878
www.compassrm.com

OUTLINE – Campbell River WUP Case Study

- The Watershed & Facilities
- The Multi-Stakeholder Process
- Structured Decision Making Tasks:
  - Defining Objectives and Performance Measures
  - Developing Alternatives
  - Evaluating Trade-offs
- Lessons Learned

Campbell River Watershed

Campbell River Watershed

1,500 square kms

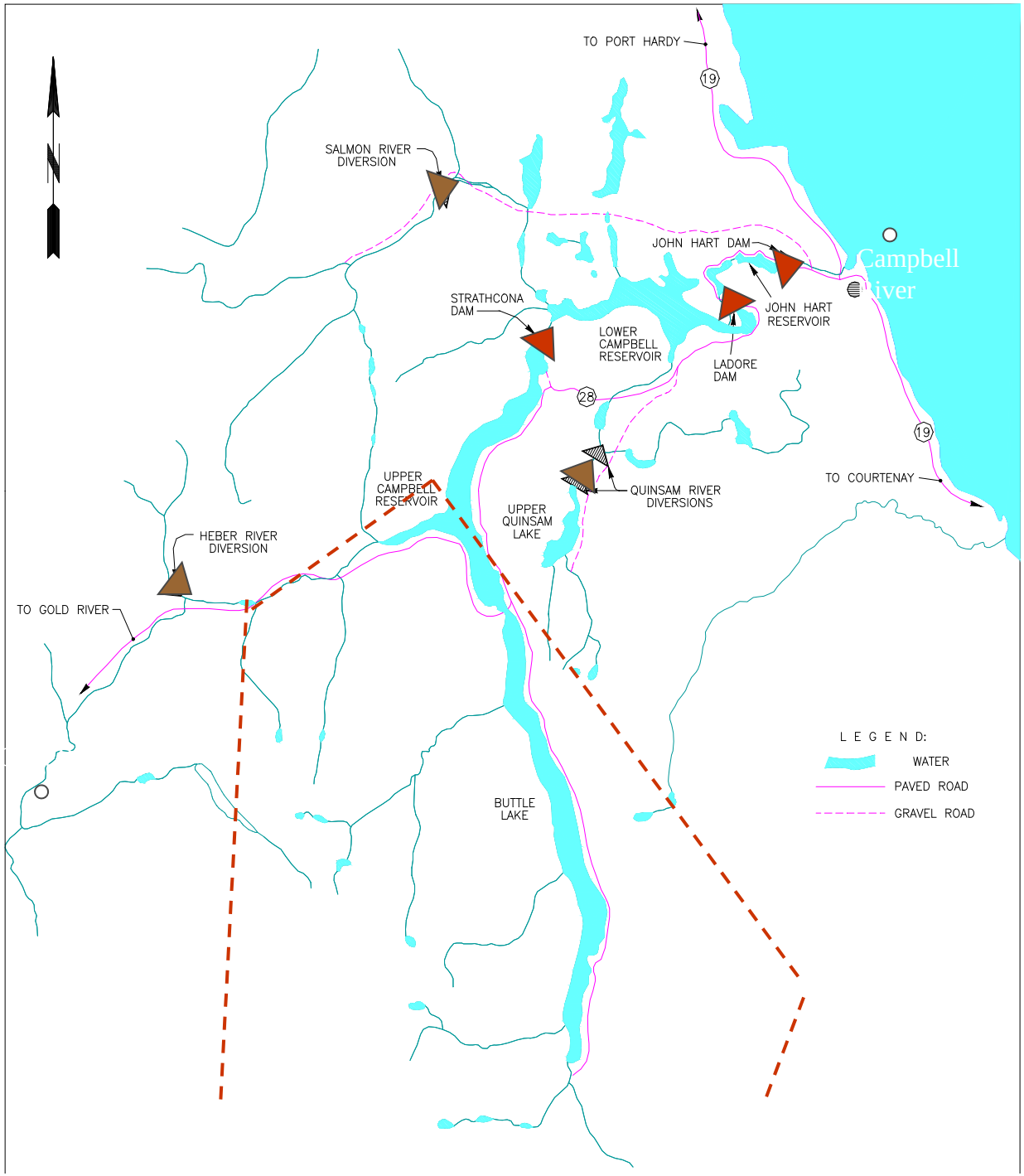
3 Main Dams & Reservoirs

3 River Diversions

Annual Inflows = 100 cms/days

HUGE Hydrologic variability

Dozens of formal recreation sites



next

Strathcona Dam (1958)

- 500 metre-long dam
- 6,700 hectare reservoir
- 1 Million m^3 storage

- High recreation use
- Fish / wildlife use

return

John Hart Dam (1947)

- 750 metre long dam

- Significant canyon / mainstem habitat
- Community water supply

return

Heber River Diversion

- Inter-basin diversion, First Nations rights
- Relatively low volume, yet high financial value
- Heber River steelhead under a recovery plan

return

Campbell River Watershed – Summary Context

- Hydropower Facilities on Vancouver Island with capacity of ~ 250 MW (52%)
- Multiple salmonid species including world-famous Chinook salmon runs and endangered steelhead runs
- Facilities within B.C.'s oldest Provincial Park – significant recreation use area
- First Nations resource claims under negotiation; particular controversy over inter-basin water transfers

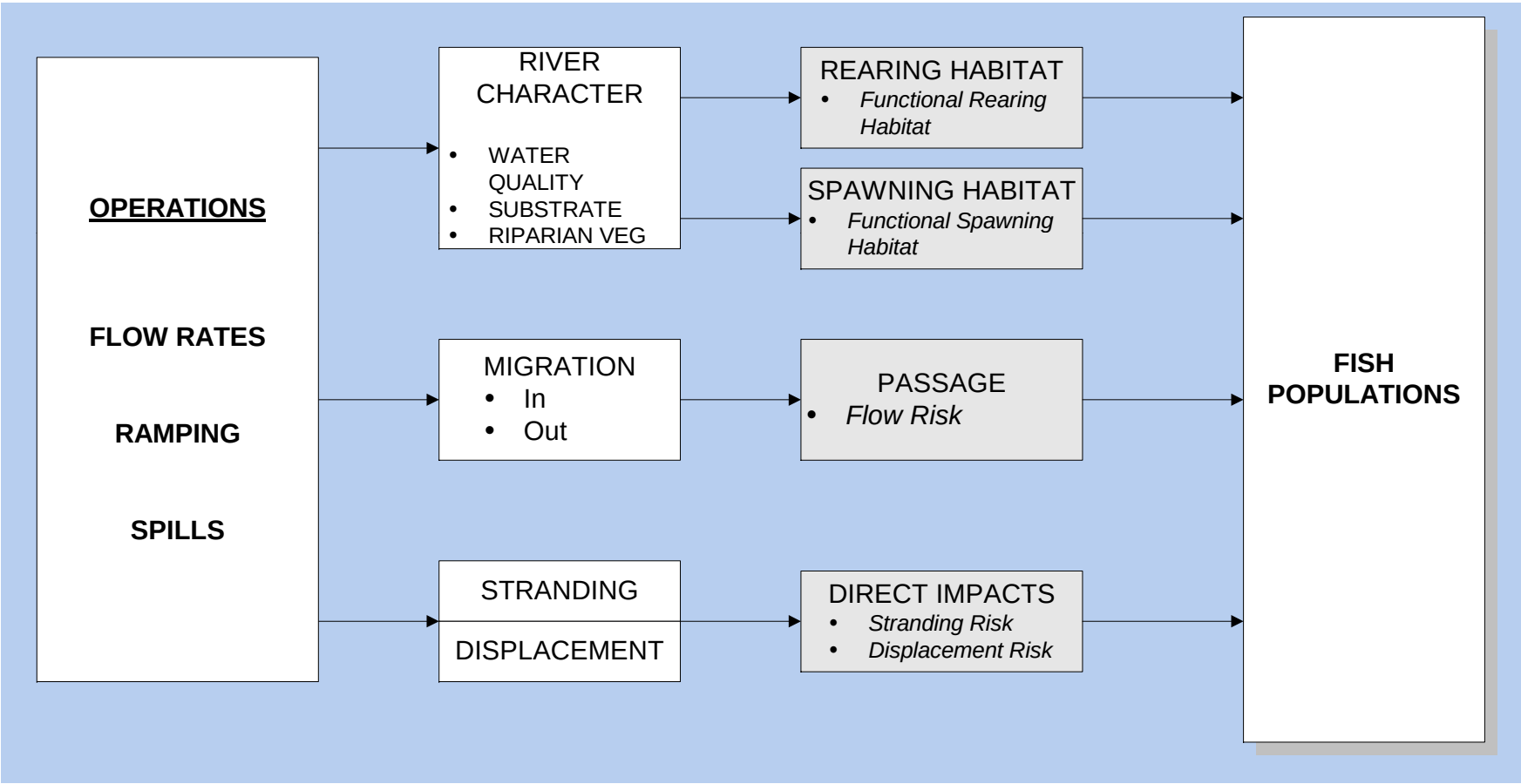
The Multi-Stakeholder Process

- Planning Period = 3 years
  - 20 Consultative Committee meetings
  - Dozens of Technical Committee meetings
    - *Fish, Wildlife, Recreation, First Nations*
- Participants:
  - BC Hydro (Crown Corporation)
  - Federal Government (DFO)
  - Provincial Government (MOE)
  - Local Government
  - First Nations
  - Local Business, Residents

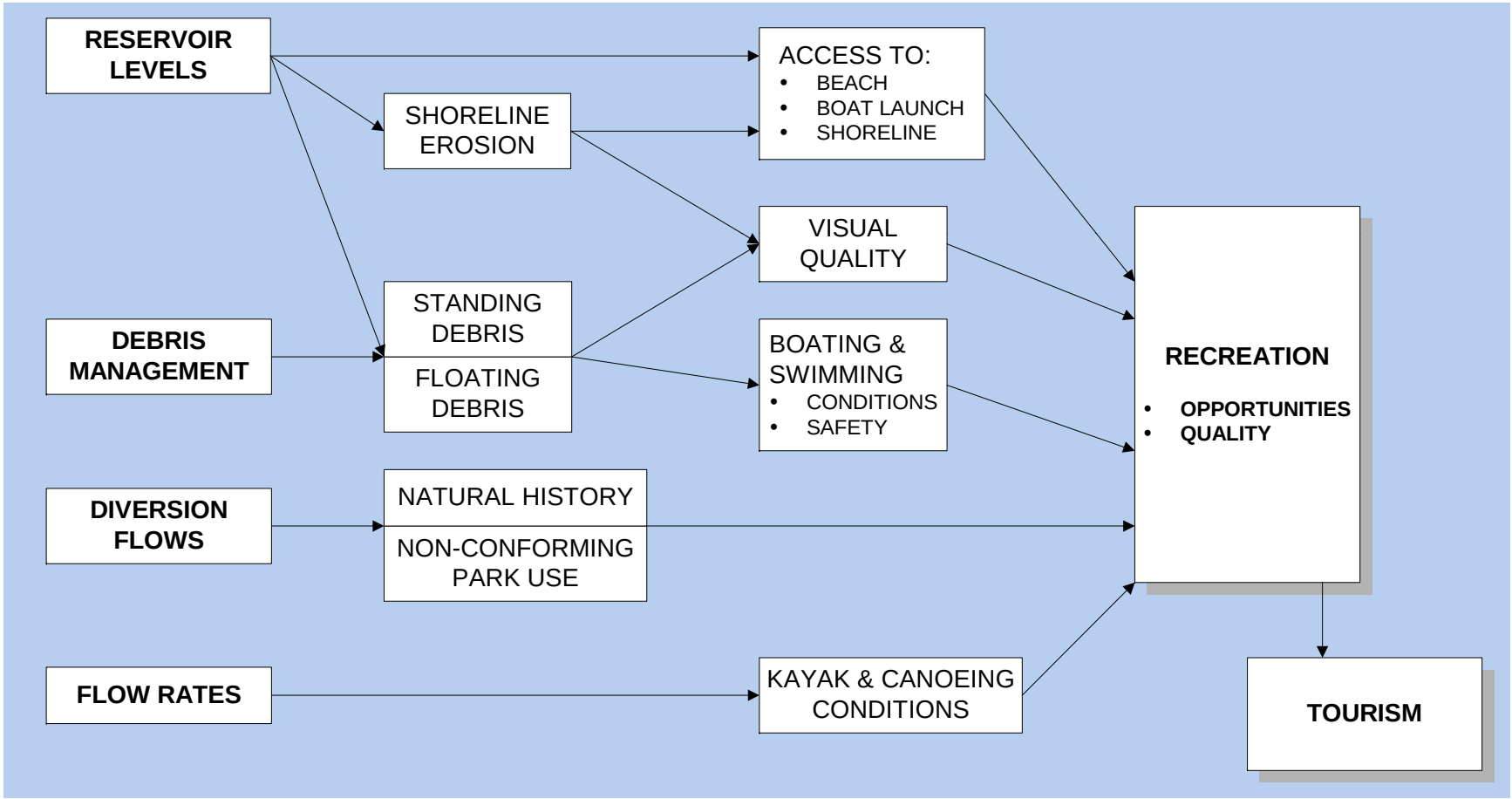
Screening of Issues

- Initial “Issues List” developed through:
  - Public open houses
  - Past technical planning efforts
  - Initial Committee brainstorming
- Scope control → clarified what was on the planning table
- Organization with “means-ends” or influence diagrams

Influence Diagrams



Influence Diagrams



Using Influence Diagrams

- Influence diagrams useful for:
  - Building a common understanding of how things work (impact mechanisms) and what is on the table (scope control)
  - Linking operations (practical alternatives) with endpoints of interest (objectives)
  - Framing the technical tasks:
    - *Impact hypotheses*
    - *Information sources and requirements*
    - *Key uncertainties*

Setting Objectives

Recreation

- Enhance and protect the quality of recreation; increase the quantity of recreation and tourism opportunities

Flooding and Erosion

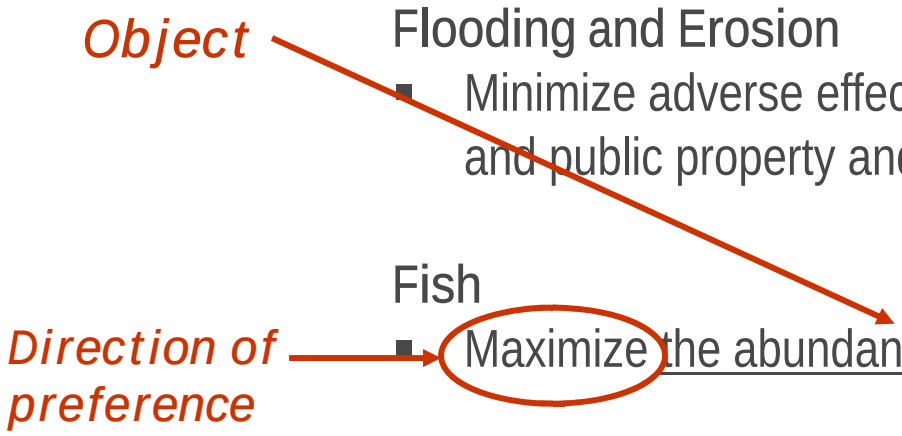
- Minimize adverse effects of flooding and high water levels on private and public property and personal safety

Fish

- Maximize the abundance and diversity of indigenous fish populations

Wildlife

- Protect and enhance the quantity and quality of wildlife habitat



Setting Objectives

Water Quality and Supply

- Protect and maintain drinking water quality, and maximize the availability of drinking water supply

Heritage and Culture

- Protect heritage values and enhance opportunities for cultural activities

Power / Financial

- Maximize the value of power generation to BC Hydro, Vancouver Island, the District of Campbell River and the Province
- Minimize greenhouse gas emissions

Setting Objectives

- Setting objectives may have been the single most important step
  - Provided a tangible means of facilitating an “interest-based” vs. “position-based” process
  - Validation → all interests were treated equally
  - Bounded the process

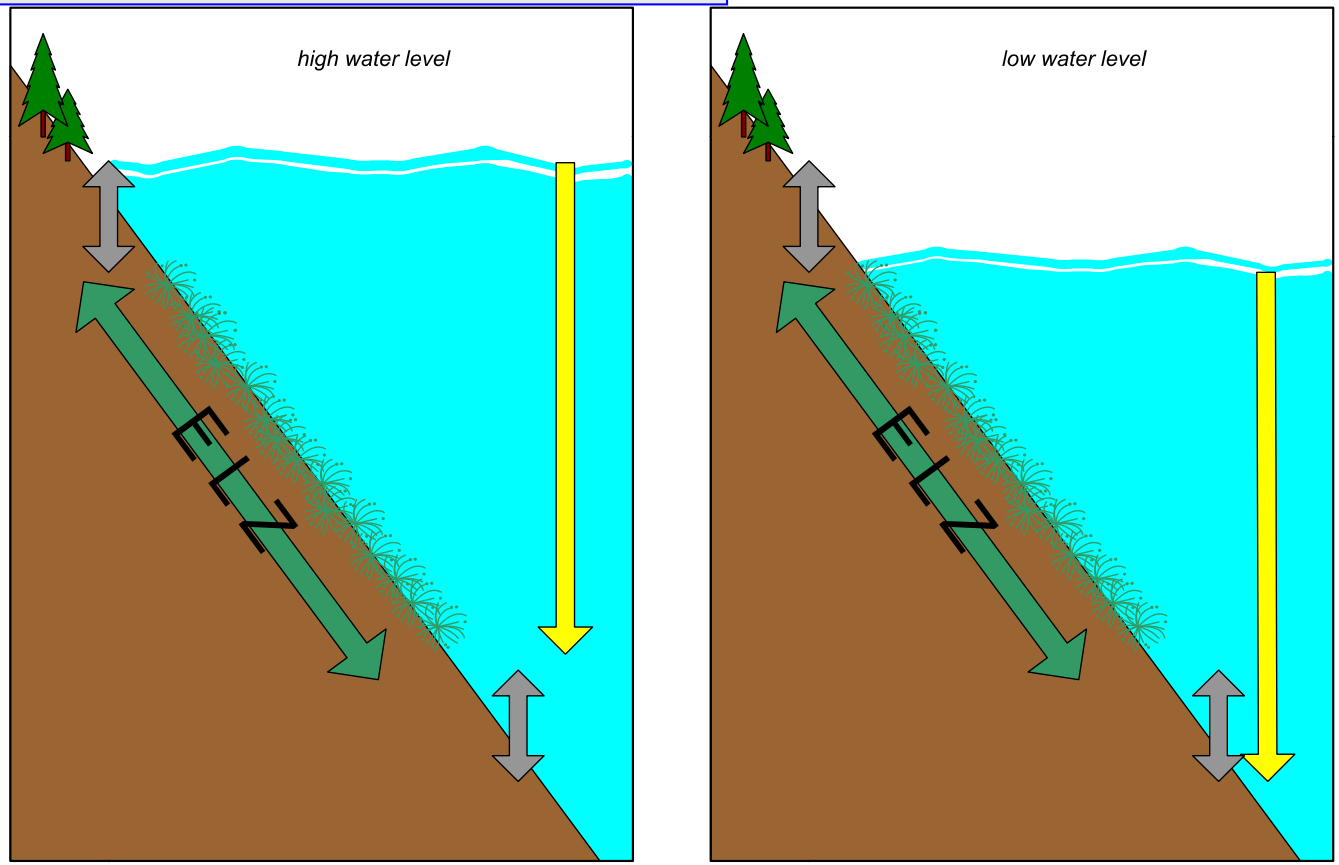
Developing Performance Measures

- Performance measures are specific metrics for comparing the predicted consequences or impacts of the alternatives on the objectives.

- Calculated in their “Natural Units”

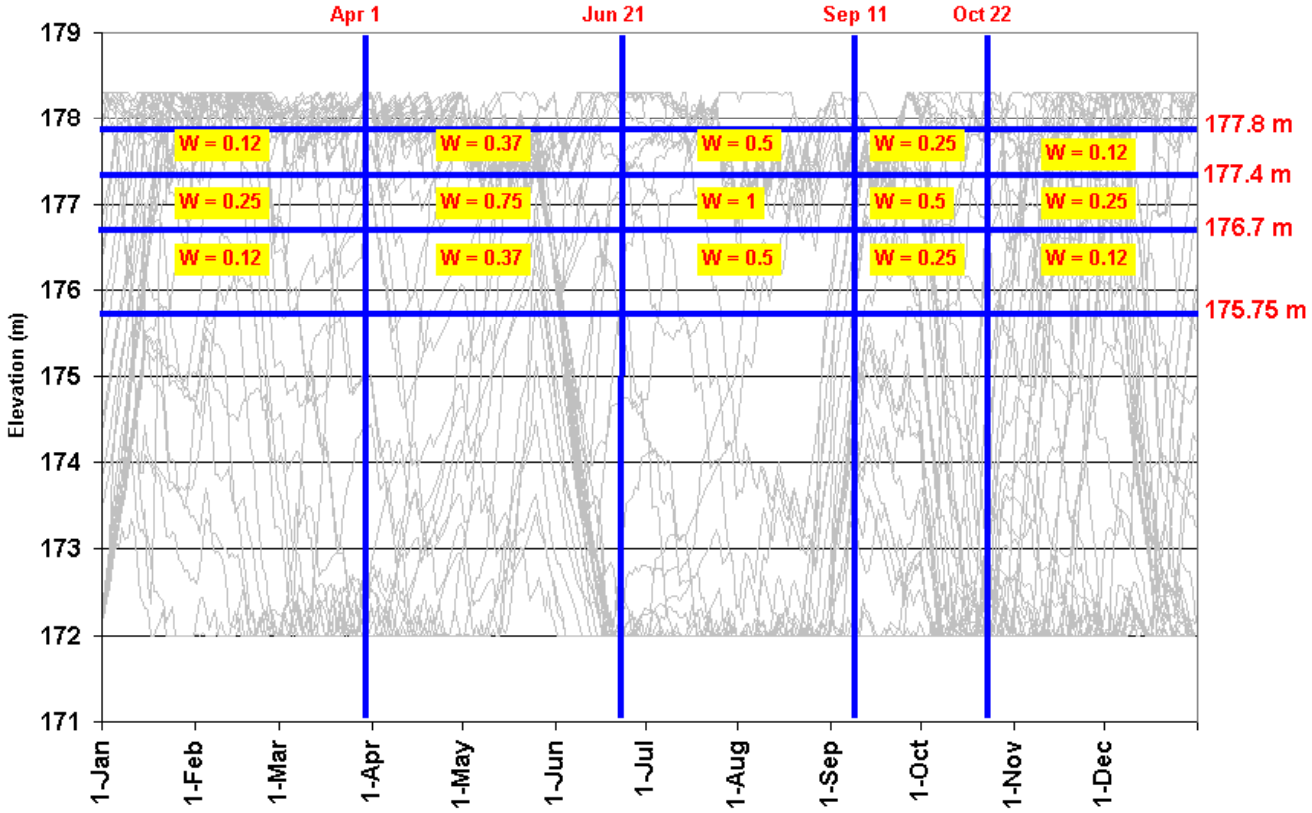
Example 1: Effective Littoral Zone

Objective: Reservoir Fish
Measure of overall fish productivity (abundance)
Units = hectares / year



Example 2 – Weighted User Days

Objective: Reservoir Recreation
Measure of quality and opportunity for recreation
Units = weighted user days



Summary: Objectives & Performance Measures

Objectives	Performance Measures
Recreation	*User Days (weighted by season & elevation)*
Erosion	*Erosion Days (weighted by elevation)*
Flooding	*Flood Days (weighted by flow level)*
Fish	*% Available Habitat, Risk Indexes, Littoral Zone*
Wildlife	*Habitat Suitability Rating*
Water Supply	*Water Quality Impact Rating*
F.N. Heritage	*Consistency Rating*
Financial	*Annual Revenues M$ / Year*

Developing Alternatives

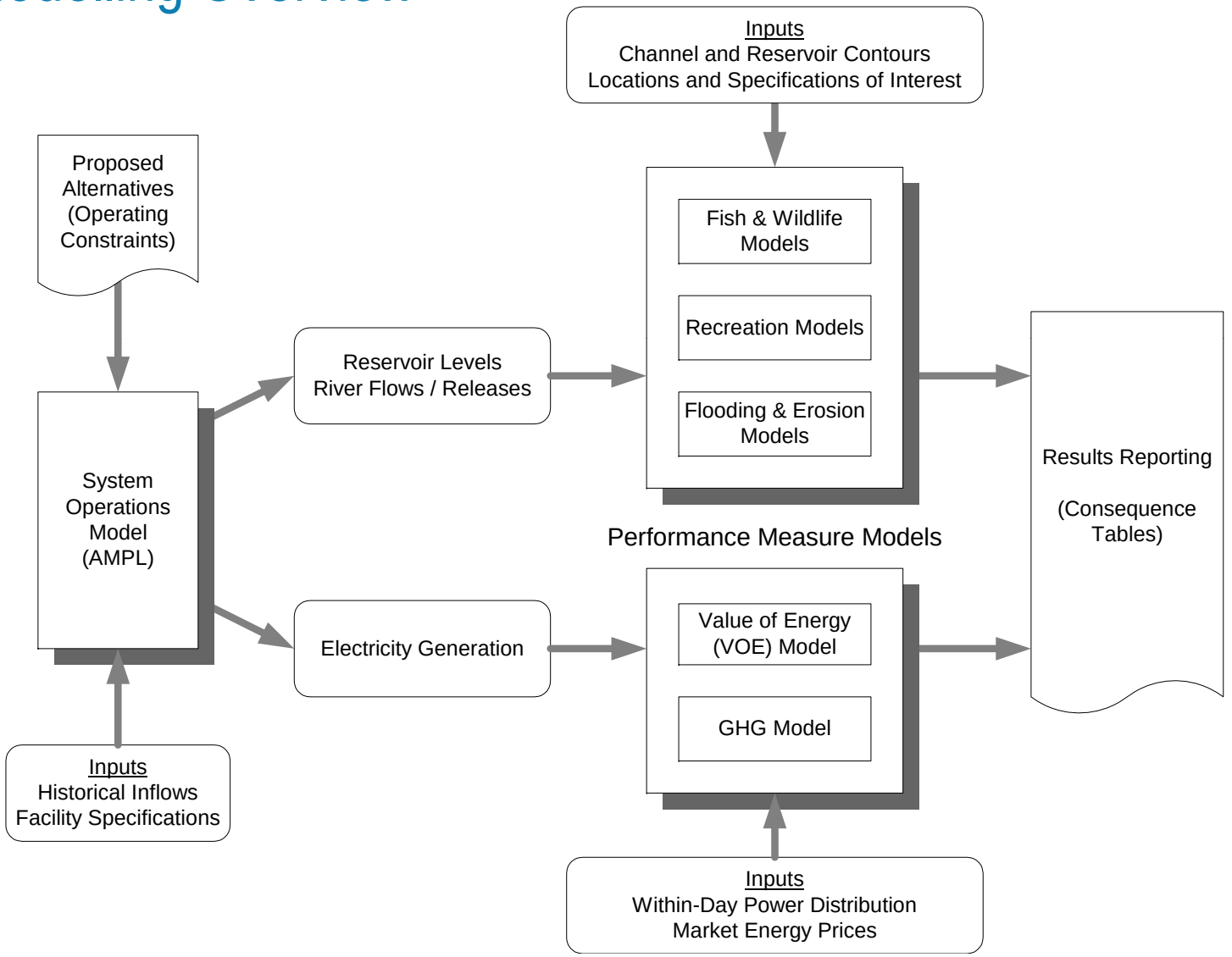
- Started with “Bookend” Alternatives:
  - *Stable reservoirs*
  - *Fish-friendly river flows*
  - *Maximize power generation*

- Multiple iterative rounds of analysis and refinement
  - Sub-committees used to generate alternatives
  - Continual refinement of analytical methods
  - Simplified decision to the fundamental trade-offs

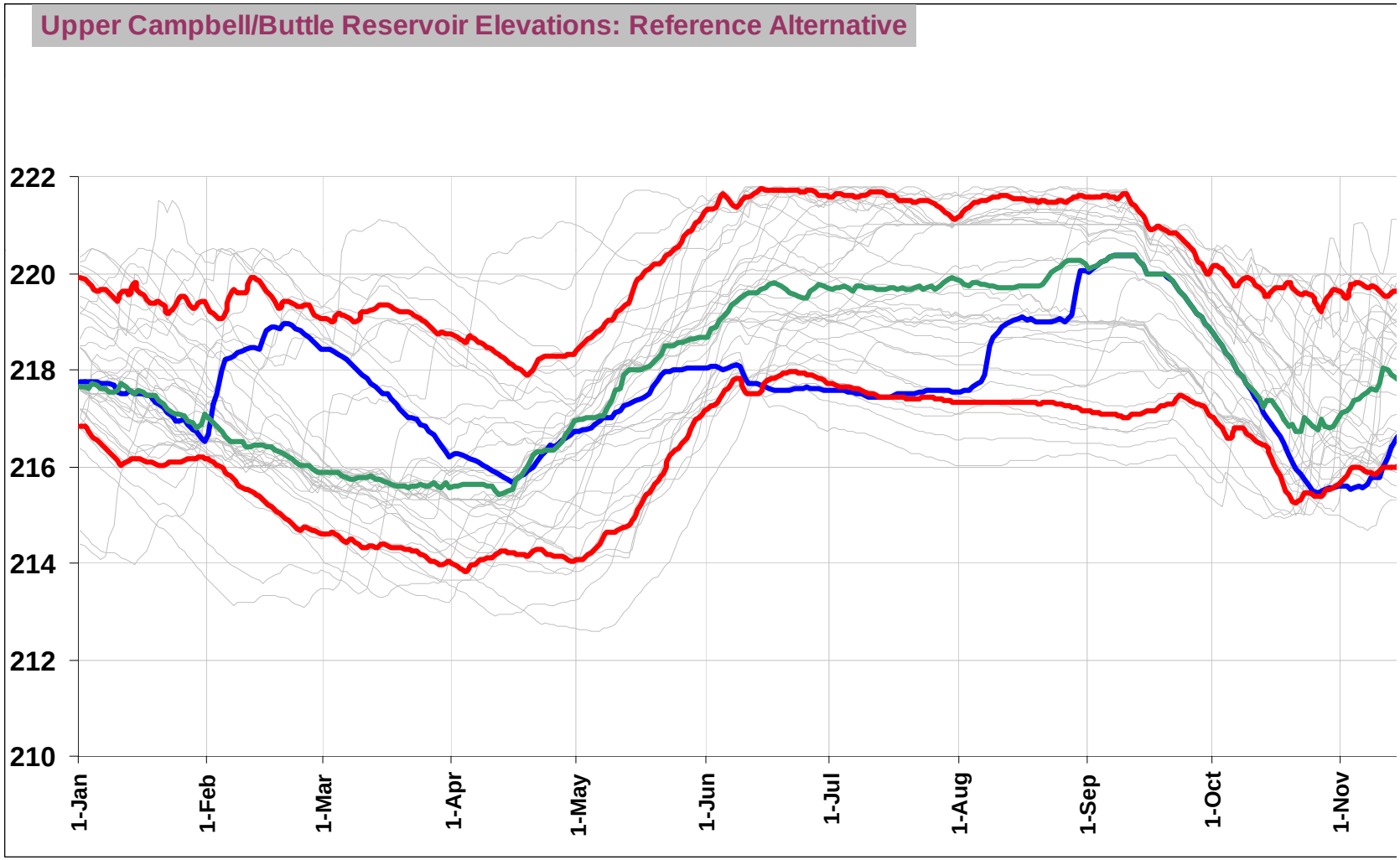
Strategy Table

U.C. Reservoir Options	L.C. Reservoir Options	Lower Campbell River Options	Canyon Flow Options	Heber / Crest Diversion Options	Salmon Diversion Options	Quinsam Diversion Options
No constraints	No constraints	No constraints	No constraints	No constraints	No constraints	No constraints
Min Level	Min Level	Min Flow	No Spills	No Flow	No Flow	No Flow
Max Level	Max Level	Max Flow	Min Flow	Min Flow	Min Flow	Min Flow
Stable Seasons	Stable Seasons	Ramping	Max Flow	Max Flow	Max Flow	Max Flow
Drawdown/ Fill Rates	Drawdown/ Fill Rates			Ramping	Ramping	Ramping

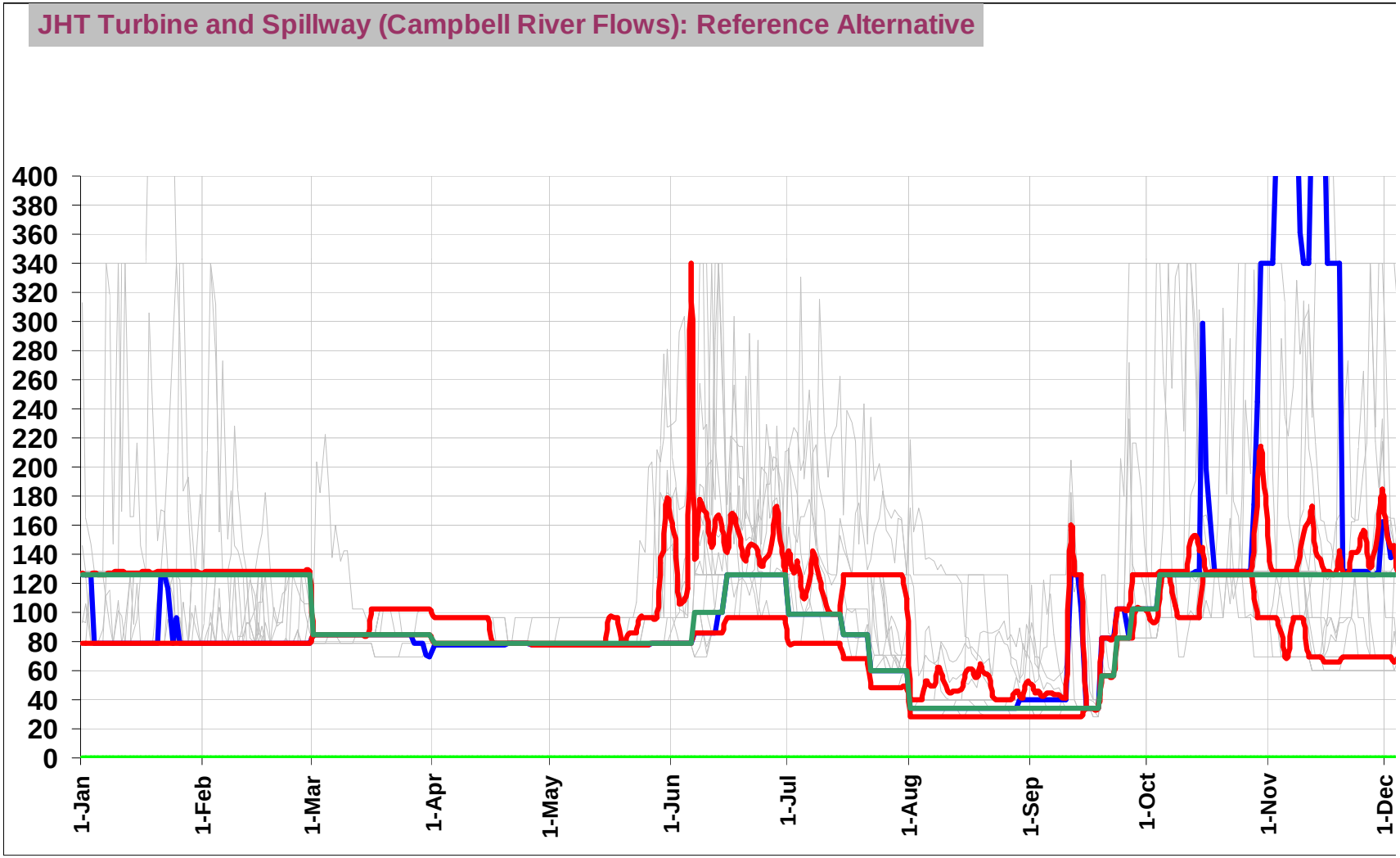
Modelling Overview



System Hydrology: Strathcona Reservoir



System Hydrology: Campbell River



Summary Consequence Table

Objective	Attribute	Alternatives E	F	G	H	I	J
Upper Campbell / Buttle Lake							
Erosion - Days / Year	weighted days (220 and 221 m)	37	13	4	3	3	3
Recreation - Days / Year	weighted days (217.5, 218.5, 200m by seaso	43	40	106	158	158	158
Effective Littoral Zone	hectares	91	107	93	214	215	220
Lower Campbell / McIvor / Fry							
Erosion - Days / Year	weighted days (177.4 and 178.3 m)	3	27	13	0	0	0
Recreation - Days / Year	weighted days (175.75 - 177.8 by season)	115	43	83	167	170	167
Spawning Habitat - Cutthroat	% Available Habitat	78	18	95	79	79	78
Spawning Habitat - Rainbow	% Available Habitat	26	3	49	49	47	50
Campbell River							
Flooding - Total Days	weighted days (300, 453, 530 cms)	34	48	24	59	59	59
Recreation - Days / Year	weighted days (28 cms - 80 cms)	66	83	51	81	79	81
Total Spill Days - All Species	days (Q>340cms, Sept 22 - April 15)	118	214	102	176	177	176
Spawning Habitat - All Species	% successful redds (Chum as indicator)	55	89	78	59	59	59
Rearing Habitat - All Species	"Average" risk index (scale 0 - 1)	0.53	0.48	0.53	0.50	0.49	0.49
Salmon River							
Canoe Route - Days / Year	days (Q<6cms, April 1 - Oct 22)	162	167	153	204	183	204
All Habitat - All Species	"Average" risk index (scale 0 - 1)	0.54	0.47	0.44	0.48	0.47	0.47
System-Wide							
Power / Financial	Annual Revenue M $ / Year	68.5	64.6	68.6	65.1	65.3	64.1

Highlighting Tradeoffs

Objective	Attribute	Alternatives E	F	G	H	I	J
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Exploring Trade-offs

- Approach:
  - Explicitly asked for people's preferences
  - Required that people's choices are based on an understanding of the trade-offs
  - Explored and discussed the uncertainties in all results
  - Used structured methods designed to improve quality of individual judgments and quality of group dialogue

Exploring Trade-offs

Two basic ways to explore trade-offs and preferences:

"Rank the alternatives in order of preference" Top Down (holistically)

"How important is a 15% gain in fish habitat relative to a loss of 25 quality recreation days?" Bottom Up (analytically)

		Alternatives					
Objective	**Attribute**	**E**	**F**	**G**	**H**	**I**	**J**
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Power / Financial	Annual Revenue M $ / Year	68.5	64.6	68.6	65.1	65.3	64.1

Exploring Trade-offs

- Two day workshop
  - Review objectives and performance measures
  - Review consequence table
  - Discuss uncertainties, intangibles, and key trade-offs

  - Complete questionnaires for each method
    - *Method 1: Direct Ranking*
      - Rank and score the alternatives based on review of the consequence table
    - *Method 2: Swing Weighting*
      - Rank and score the Performance Measure results
      - Calculate scores and ranks for alternatives

  - Review individual / group results
  - Develop next steps

Method 1: Direct Ranking

INSTRUCTIONS

STEP 1

Rank the Alternatives with 1 being your most preferred alternative. Ties are OK.

STEP 2

A. Assign 100 points to the #1 ranked alternative.

B. Then, assign points to the other Alternatives to reflect their importance relative to the #1 ranked alternative.

EXERCISE

Alternative Name	Rank	Points (from 0 - 100)
E	4	50
F	2	80
G	1	100
H	3	70
I	5	40
J	6	10

Method 2: Swing Weighting

INSTRUCTIONS

For each table:

A. Rank the measures in terms of their relative importance, with a rank = 1 being your most important measure. Ties are okay.

B. Assign 100 points to the #1 ranked measure.

C. Assign points to the other measures to reflect their importance relative to the #1 ranked measure.

Remember to assign points based on how important it is to swing the measure from its worst to its best. If the range from worst to best is very small or very large, that should affect the importance you give it.

Table 1

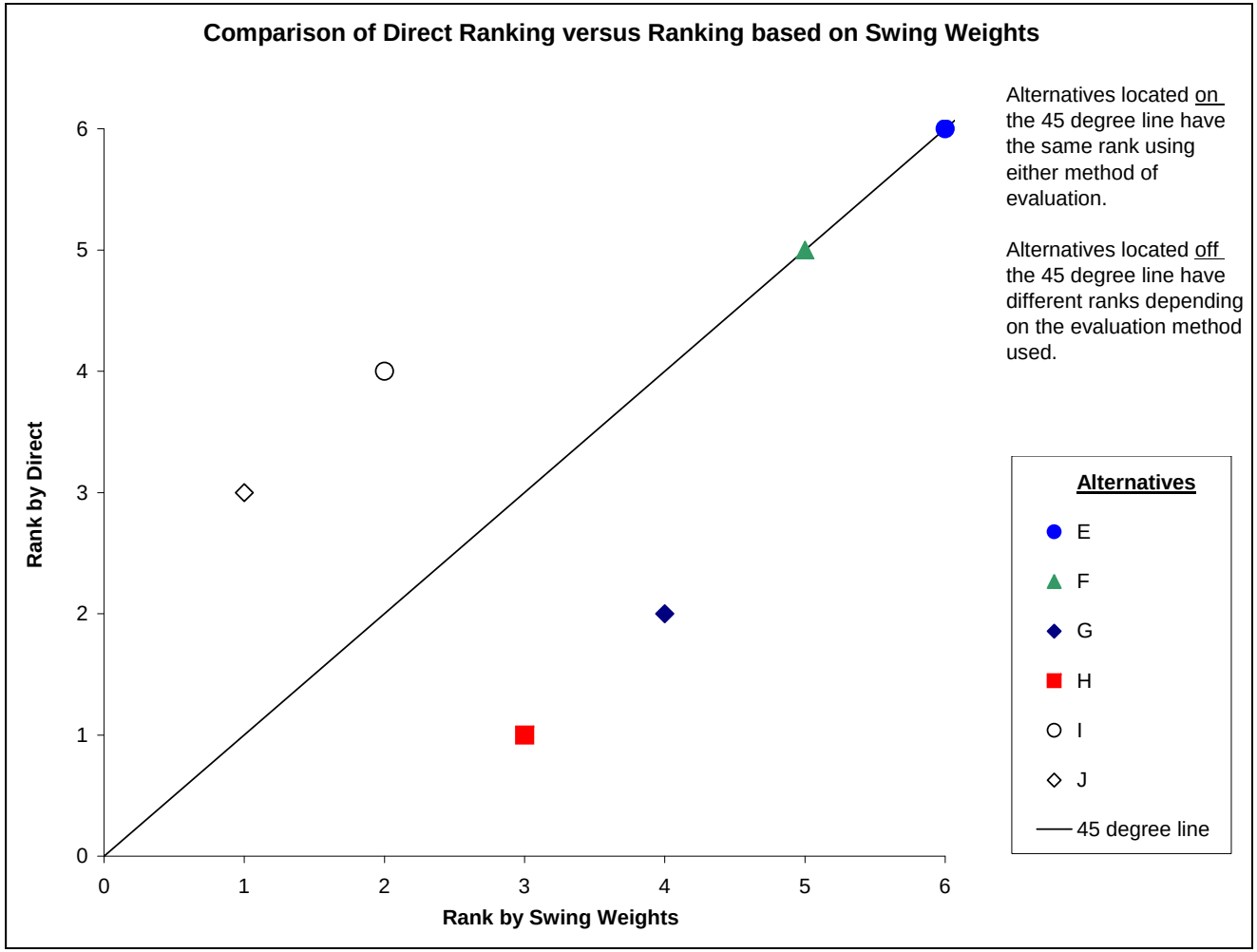
Location	Performance Measure	Units	Worst Case	Best Case	Rank	Points (0 to 100)
Upper Campbell Lake	Erosion - Days / Year	weighted days (220 and 221 m)	37	3	1	100
	Recreation - Days / Yea	weighted days (217.5, 218.5, 200m by	40	158	1	100
	Effective Littoral Zone	hectares	91	220	2	50

Table 3

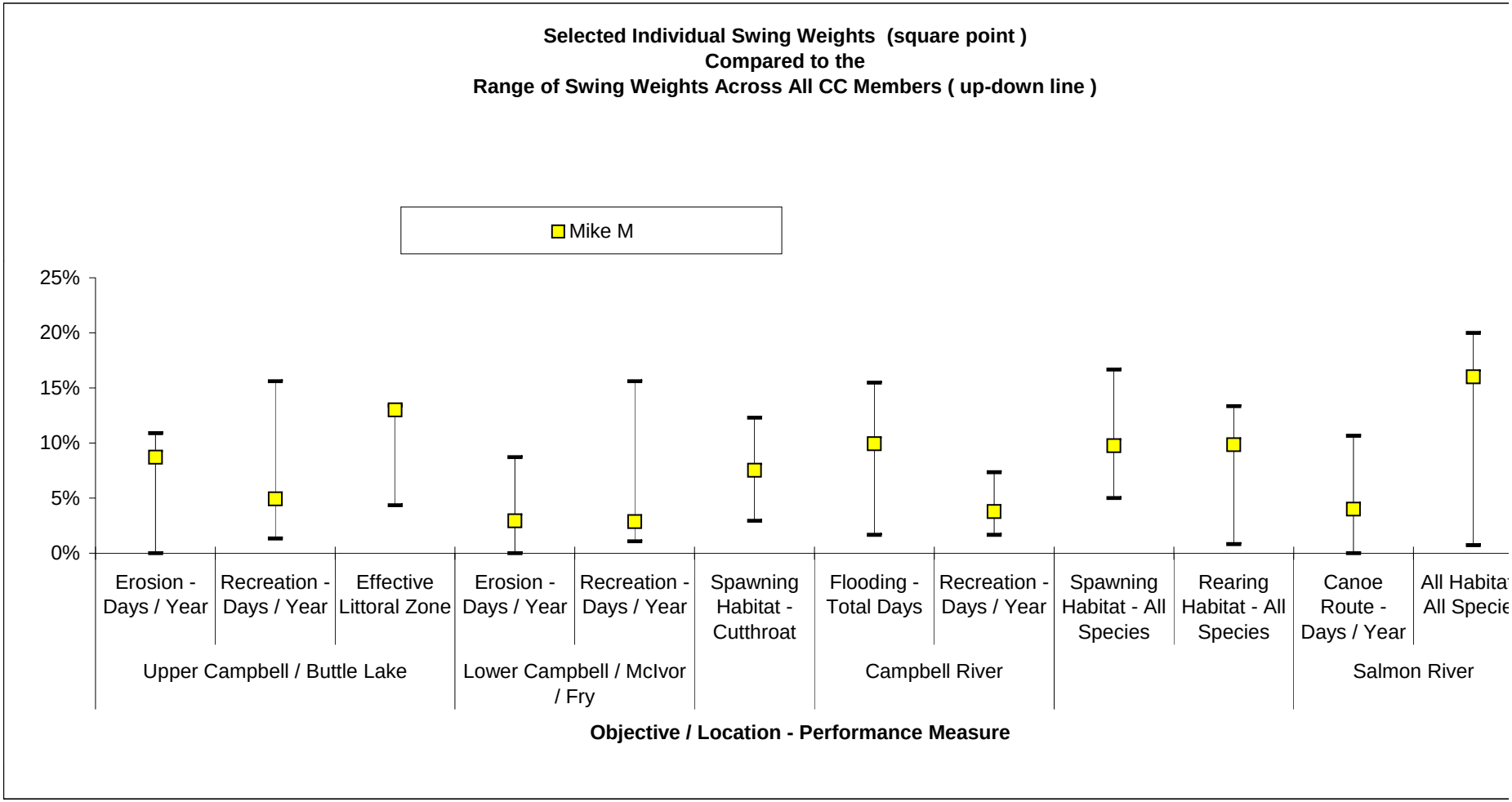
Location	Performance Measure	Units	Worst Case	Best Case	Rank	Points (from 0 to
Campbell River	Flooding - Total Days	weighted days (300, 453, 530 cms)	59	24	1	100
	Recreation - Days / Yea	weighted days (28 cms - 80 cms)	51	83	3	50
	Spawning Habitat - All S	% successful redds (Chum as indicato	55	89	2	70
	Rearing Habitat - All Sp	"Average" risk index (scale 0 - 1)	0.53	0.48	4	10

Uncovering Bias and Anchoring

CC Member	Mike M



Informing the Negotiations



Working Toward Consensus

Rank of Alternatives by Stakeholder and by Method								
		Alternatives						
Stakeholder	Weighting/ Ranking Method	E	F	G	H	I	J	
1	Direct	6	5	2	1	4	3	
	Swing	6	5	4	3	2	1	
2	Direct	6	5	1	3	4	2	
	Swing	6	5	4	3	2	1	
3	Direct	6	3	5	1	2	4	
	Swing	6	5	2	4	1	3	
4	Direct	5	6	4	1	3	2	
	Swing	5	6	4	1	3	2	
5	Direct	2	3	1	4	4	4	
	Swing	5	6	4	2	3	1	
6	Direct	3	4	1	2	4	6	
	Swing	5	6	1	2	3	4	
7	Direct	6	2	1	3	3	3	
	Swing	6	5	4	3	2	1	
8	Direct	2	3	1	4	4	4	
	Swing	6	5	4	3	2	1	
9	Direct	2	6	1	5	4	3	
	Swing	5	6	1	3	2	4	
10	Direct	3	2	1	4	5	6	
	Swing	6	5	1	3	2	4	
11	Direct	5	6	4	1	2	3	
	Swing	5	6	4	1	3	2	
12	Direct	6	3	2	4	5	1	
	Swing	6	5	4	3	2	1	
13	Direct	6	5	4	3	2	1	
	Swing	6	5	4	2	3	1	
14	Direct	2	5	1	4	3	6	
	Swing	2	6	1	4	3	5	
15	Direct	2	3	1	4	5	6	
	Swing	5	6	4	1	3	2	

Working Toward Consensus

- Next Steps Included
  - Refining the operating alternatives for the mainstem river and diversions
  - Designing “physical works” or non-operating projects
  - Designing and prioritizing monitoring programs

Working Toward Consensus

Final Operating Alternatives

Physical Works

Monitoring Programs

Consequence Table November 2002 - CORE OPERATING STRATEGY DECISION

Location	Performance Measures (1)	Units	What's Good	Significant Difference	Alternatives REF	R15 Heber	S15 Heber
Upper Campbell / Buttle Lake							
	Erosion - Days / Year	weighted days	less	10%	16	4	4
	Recreation - Days / Year	weighted days	more	10%	50	82	65
	Effective Littoral Zone	hectares	more	10%	80	94	92
	Spawning Habitat - Cutthroat	% Available Habitat	more	10%	6	10	10
	Spawning Habitat - Rainbow	% Available Habitat	more	10%	3	5	5
Lower Campbell / McIvor / Fry							
	Erosion - Days / Year	weighted days (2)	less	10%	11	11	10
	Recreation - Days / Year	weighted days (2)	more	10%	102	96	98
	Elevation Variability	Coefficient of Variation	less	10%	0.08	0.16	0.09
	Effective Littoral Zone	hectares	more	10%	86	82	83
	Spawning Habitat - Cutthroat	% Available Habitat	more	10%	4	3	2
	Spawning Habitat - Rainbow	% Available Habitat	more	10%	25	31	15 (22)
Campbell River							
	Flooding - Total Days	weighted days	less	10%	27	18	20
	Recreation - Days / Year	weighted days	more	10%	79	60	60
	Total Spill Days - All Species	total days	less	10%	160	111	114
	Spawning Habitat - All Species	% successful redds (Chum)	more	10%	69	71	69
	Rearing Habitat - All Species	"Average" risk index (0 - 1)	less	10%	0.54	0.59	0.58
	Elk Canyon	FTC judgement	more	0%	O	++++	++++
Salmon River							
	Canoe Route Safety	Flow Rating	more		O	O	O
	All Habitat - All Species	"Average" risk index (0 - 1)	less	10%	0.54	0.46	0.46
	Fish Screen Performance	Fishing Efficiency, Fish Condition	more		O	O	O
System-Wide							
	Power / Financial	Annual Revenue M $ / Year	more	1%	66.9	68.2	68.5
		Cost: Salmon Fish Screen (M $ / Year)	less	1%	0	0	0
		Cost: All Other Physical Works (M $ / Year)	less	1%	-0.10	-0.10	-0.10
		Cost: Monitoring (M $ / Year)	less	1%	-0.70	-0.70	-0.70
	GHG	Equivalent Mtonnes CO2/Year	less	1%	-600	-614	-618
	Diversions	Status of Heber Diversion (3)			Status Quo	Heber decision	Heber decision

Relative to REF: Better / Neutral / Worse

Notes: 1) All PM results are median values over 37 years, except for ELZ and Annual Revenue (average over 37 years), Flooding and Fish Spills (total days over 37 years), and Physical Works Costs (levelized costs as described in proposals).
2) Adjustments were made to account for these PM's sensitivity to the 177.4 vs. 177.5 summertime maximum target elevation.
3) It has previously been decided to continue operation of the Salmon and Quinsam diversions.

	Physical Works Proposal	Project Objective	Water Use Plan Rationale	Duration (years)	Total Cost ($K)	Levelized Annual Cost (1) ($K/year)	Operational Linkage	Effectiveness (1-5 scale)
1	Seaward Canoe Route, Portage & Signage	To reduce public safety risk caused by diverted flows along a public canoe route.	In lieu of constrained diversion flows (e.g., Alt I, June 2002, 0 cms summer flow & 6 cms shoulder season flows)	1	$10	$1	Y	1
2	Erosion Control Works, Salmon Diversion	To stop erosion and reduce public safety risks along the Seaward Canoe Route (including identified problem location near Camp 5)	In lieu of constrained diversion flows (e.g., Alt H, June 2002, 0 cms summer flow & 6 cms shoulder season flows)	5	$150	$12	Y	1
3	Erosion Control Works, Upper Campbell Reservoir	To eliminate future erosion problems at problem sites (Cedar Creek Subdivision, Strathcona Park Subdivision and Strathcona Park Lodge)	In lieu of lower reservoir elevations that would further reduce the rate of erosion at these problem sites (e.g., Alt A, Dec 2001, no violations above 200.5 m)	2 + ongoing maint	$5,600	$454	Y	1
4	Recreation Facility Improvements, Upper Campbell Reservoir	To make recreation facilities operational under a wider range of elevations.	In lieu of more constrained and stable reservoir elevations (e.g., Alt H, June 2002, UC general operating range of 216 m - 220.5 m)	3	$250	$20	Y	1
5	Recreation Facility Improvements, Lower Campbell Reservoir	To make recreation facilities operational under a wider range of elevations.	In lieu of more constrained and stable reservoir elevations (e.g., Alt H, June 2002, UC operating in range 178.5 m - 177.5 m more often)	3	$250	$20	Y	1
6	Revegetation, Upper Campbell Reservoir	To revegetate reservoir perimeter sites thereby improving visual aesthetics and terrestrial habitat.	Proposed operating regime S is approximately 1 metre lower on average.	10	$475	$31	Y	3
7	Salmon Fish Screen Upgrade	To re-design and re-construct the fish screen for improved fishing efficiency and fish condition.	Would allow for an increase in the maximum allowable diversion flow during the April 1 to December 31 period from 15 cms to 30 cms. The increased diversion would generate approximately $300K on an average annual basis.	1	$2,100	$195	Y	3
8	Miller Creek	To create protected spawning habitat and eliminate redd stranding problems associated with operation of the Quinsam diversion / LC reservoir.	In lieu of minimum Quinsam diversion flow and constrained higher reservoir elevations.	1	$200	$17	Y	3
						$749		

(1) Levelized annual costs are calculated over 25 years with an 8% discount rate.

Monitoring Plan	Objectives (Data Gap Addressed)	Comments	Duration (years)	Total Cost ($K)	Levelized Annual Cost ($K/year)	Influence on Decisions (1-5)	Learning (1-5)	Transferability (1-5)
Digital Elevation Model, Lower Campbell Reservoir	Develop correlation between submerged hazards and reservoir elevation	DEM would have multiple other uses. Study would lead to a new or improved recreation PM's.	1	$50	$12	1	1	3
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Monitoring Plan	Objectives (Data Gap Addressed)	Comments	Duration (years)	Total Cost ($K)	Levelized Annual Cost ($K/year)	Influence on Decisions (1-5)	Learning (1-5)	Transferability (1-5)
				$650	$130	1	2	5
				$385	$77	1	3	3
				$435	$87	3 (2)	3	3
					$294			
Monitoring Plan	Objectives (Data Gap Addressed)	Comments	Duration (years)	Total Cost ($K)	Levelized Annual Cost ($K/year)	Influence on Decisions (1-5)	Learning (1-5)	Transferability (1-5)
Physical State Monitoring	To investigate the primary physical and biological (primary & secondary productivity) determinants of habitat quality in the Campbell System rivers.	This study works in conjunction with other studies by providing base diagnostic information.	5	$440	$88	1	3	3
Habitat Flow Relationships	Develop and validate the correlation between instream flow and fish habitat in streams: 1) Diversion stream transect analysis, 2) Diversion stream passage barriers, 3) Campbell River R2D validation	Study would lead to new or improved habitat PMs for all river systems.	3	$360	$60	1	1	3
Fish Response to Rearing Habitat	Develop correlation between rearing habitat and biological response in fish.	Study may lead to new fish behaviour or population-based PM.	2	$165	$33	1	3	1
Physical modeling of Ramping and Tripping	Develop correlation between ramp rates and tripping events on spawning/rearing habitat.	Study may lead to new ramping protocols	1	$70	$15	2	2	2
Fish Response to Load Factoring - Scaled Down Approach	Develop correlation between load factoring (ramp rates) and spawning behaviour/success.	Study would validate habitat-based PMs and could lead to new load factoring regimes. (Study may have power generation benefits to offset the costs)	2	$180	$20	2	3	1
Limits to Fish Production - Quinsam River	Conduct population monitoring: fish counting fence.	Study would lead to new, direct objective-based PMs.	5	$220	$44	1	3	3
Limits to Fish Production - Heber River	Conduct population monitoring: snorkel swims.	Study would lead to new, direct objective-based PMs. (Current stock assessment covered by Provincial funding - uncertain future)	5	$45	$9	1	3	3
Limits to Fish Production - Salmon River	Conduct population monitoring: snorkel swims.	Study would lead to new, direct objective-based PMs. (Current stock assessment covered by Provincial funding - uncertain future)	5	$122	$24	1	3	3
Limits to Fish Production - Elk Canyon	Conduct population monitoring: smolt abundance (rotary screw traps, video surveillance).	Study would lead to new, direct objective-based PMs.	5	$513	$103	1	3	3
					$396			

Working Toward Consensus

WUP Guidelines:

"Each process will strive for, but not require, consensus on all aspects of the WUP"

"Consensus is defined as a decision which participants can accept, without having to agree to all details"

In Practice……

Endorse = Strong support

Accept = Support with reservations

Block = Do not support

(Minimum needs not met)

Consensus = No Blocks

Formal Statements of Acceptance

	REF	R15	S15
Endorse		Rik, Brenda, Steve, Paul W, Cheryl	Ian, Gavin, Paul A, Brian, Don, Charlie, Roger
Accept		Ian, Gavin, Paul A, Brian, Jamie, Don, Charlie, Phil, Bert, Roger	Rik, Brenda, Steve, Phil, Paul W, Bert, Cheryl
Block	Ian, Gavin, Paul A, Brian, Rik, Jamie, Don, Brenda, Steve, Charlie, Phil, Bert, Cheryl, Craig, Roger		Jamie
Abstain	Paul W	Craig	Craig

Final Outcome

Upper Campbell Reservoir	+ reduced shoreline erosion + improved recreation + improved fish productivity
Lower Campbell Reservoir	o no change in erosion + improved recreation + improved fish productivity
Campbell River	+ reduced flooding risk - reduced recreation quality + improved fish productivity
System-wide	+ increased operating revenues (offset by investments in monitoring and works) + decommissioning Heber diversion

Lessons Learned

- A structured process can help stakeholders focus their dialogue on interests rather than positions
- Success depends on the rigorous, defensible and transparent treatment of both facts and values
- Collaborative development and exploration of alternatives enables participants to make trade-offs and find common ground
- Authentic commitment to monitoring programs and adaptive management can be the key to reaching group consensus
- It is possible to engage multi-stakeholder committees in technically rigorous water management processes

THANKS!