Benefit-Cost Analysis of the Yakima River Basin Integrated Plan Projects

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Acknowledgments

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- The list of acknowledgments is too long to provide here, but a special thanks goes to HDR Engineering for the use of and help with YAKRW. However, I bear responsibility for its use in this report.
- I also bear responsibility for any remaining omissions or errors in methods or interpretation in this study.

Legislative charge

2013 Capital Budget (5035-S.SL), Section 5057

- The SWWRC is to prepare separate benefit-cost analyses for each proposed project in Yakima Basin Integrated Plan.
- Directed to use existing studies to the greatest extent possible, supplemented by primary research.
- Report economic benefits of each project on a disaggregated basis, showing contributions of individual projects to:
  - increases in fish populations,
  - increases in irrigation water reliability,
  - improvements in municipal and domestic water supply.

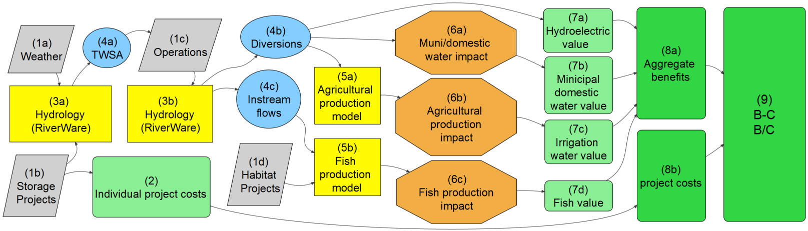
Projects identified in the legislation

- Surface water and aquifer storage & recovery projects
- Structural & operational changes
- Fish passage
- Agricultural & municipal conservation projects
- Tributary/mainstem habitat enhancements
- Water market and water bank development

Moving along

- Discuss methods
  - Hydrologic model
  - Agricultural benefits
  - Municipal/domestic benefits
  - Fish benefits
- Discuss results for the Full IP, compare to FAA, and discuss differences.
- Discuss representative IP project results.

Modeling overview



Hydrologic modeling: YAKRW

- YAKRW provided by HDR Engineering
- Basin inflows determined via climate scenarios:
  - The historic climate regime (1925-2009).
  - Three CMIP3 climate scenarios.
- Individual IP project settings
  - Keechelus to Kachess Conveyance (KKC) & the Kachess Drought Relief Pumping Plant (KDRPP)
  - Cle Elum Pool Raise (CEPR)
  - Passive Aquifer Storage and Recovery (ASR)
  - Agricultural conservation
  - Bumping Lake expansion
  - Wymer Dam & reservoir
  - Proposed IP instream flows
- Primary output used: Basin-wide water proration rate
- B-W proration rate depends on climate and IP projects.

Agricultural benefits

- Irrigation district water rights and basin-wide proration rates define irrigation curtailment rates during drought.
- Crop-water model (based on Scott 2004 used in the FAA) is the basis for irrigation water value by crop.
- Distribution of available water across crops within and across irrigation districts during drought depends in part water rights, regulations, and water markets.
- Flexibility to selectively allocate water to its highest valued uses affects the economic impact of drought.
- Unlike the FAA, we include Kittitas senior water rights to examine their potential role in markets in the basin.

Water allocation and market scenarios

- Water allocation across crops and districts
  - Proportional fallowing: equiv. to "No trade" even within farms.
  - Selective fallowing within district. Equivalent to perfect trade within districts — "intra-district trade".
  - "Full trade': intra- and inter-district trading conditional on some restrictions.
- "No Trade" and "Full Trade" are useful theoretical benchmarks on water allocation flexibility.
  - "No trade" is unrealistically restrictive.
  - Full trade is unachievable due transaction costs, legal/regulatory constraints.
- "Intra-district trade" outcomes are useful intermediate point estimates for discussion.
- Intermediate trade benefits are comparable to FAA results.

Municipal/domestic benefits

- We use the same basic approach as the FAA.
  - Water security for existing water users - benefits assumed to come from improved water market infrastructure and function.
  - IP water provides cost savings to municipalities for new growth.
- We rely on the same non-economic data (population growth, conservation impacts, etc.).
- Different water value assumptions and calculations lead to different results than FAA.

Fish impacts modeling

- We rely heavily on the data and methods used in the FAA and supporting studies for sockeye and non-sockeye abundance impacts of restoration (incl. instream flows) and fish passage.
- We use the same fish valuation model as in the FAA.
- However, we use different baseline fish abundance and growth rates based on supporting empirical evidence.

Results

- Our legislative charge is to do individual B-C analyses for the IP projects.
- However, an examination of full IP results is useful context for the individual results.
- We begin with a summary of our IP results and a comparison to the FAA results.
- We then move on to results for individual projects.

Summary of results, full IP

- Full IP: moderate climate change and market assumptions:
  - Agricultural benefits: \$117 million.
  - Municipal benefits: \$32 million.
  - Fish benefits: \$1 to \$2 billion.

Summary of results, full IP

- Full IP: moderate climate change and market assumptions:
  - Agricultural benefits: $117 million.
  - Municipal benefits: $32 million.
  - Fish benefits: $1 to $2 billion.
- FAA results
  - Agricultural benefits: $800 million.
  - Municipal benefits: $400 million.
  - Fish benefits: $5 to $7.4 billion.
- Why the difference?

Why the difference from FFA?

Agricultural benefits: several sources of difference

- Proportional fallowing
  - Could not replicate the FAA crop model exactly, but came close with proportional fallowing (very restrictive) using their curtailment risk assumptions.
  - Normandeau Report also can only find half of the ag benefits.
- Climate/curtailment assumptions.
  - We focused on CGCM climate because average curtailment is closest to that implied by FAA assumptions (actually higher).
  - However, FAA assumption of either no drought or severe drought (70% curtailment) magnifies the impacts relative to CGCM (which has a lower curtailment variance).

Why the difference?

Municipal/domestic

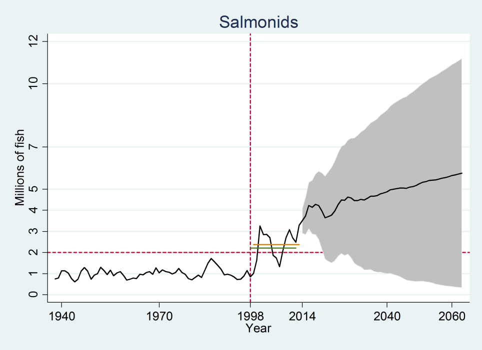
- Water security for existing users:
  - Benefits through market developments, not storage
  - Treated a sale price as a lease price. Leads to a large discrepancy. Normandeau Report also found this.
  - Didn't account for the value of existing junior rights held by municipalities.
- Demand growth
  - A wholesale water price was used to represent the cost of water. This is not supportable because it includes treatment and conveyance costs, accrued regardless of the IP. Lower price consistent with sales price in the FAA is more justifiable.

Why the difference?

Fish benefits

- FAA assumptions consistent with long-term fish growth rates of approximately 40%/year ($\lambda = 1.4$).
- A meta-analysis of salmonid pop. growth in the Columbia river finds that only 14% of populations examined have growth rates of 5% or over ($\lambda = 1.05$). We use 5% for our point estimates.
- the FAA assumes flat baseline fish populations in the Columbia River.
- The baseline assumption matters a lot economically.

Baseline fish populations



- FAA assumes constant salmon abundance in CR, 1998–2012.
- Graph suggests otherwise (but high variance)
- Avg. increase from 1998 is 200K+ fish.
- Baseline and growth rates are source of difference from FAA.

Representative results

- Out-of-stream benefits
- Instream flow: break even and opportunity costs.
- Individual project net benefits
  - Alone (with no other projects implemented)
  - Implemented along with full IP
- Fish passage
- Instream flows and habitat restoration

Out of stream benefits

Out of stream benefits of water storage and conservation (incl. municipal). $Millions.

run	Cost	Benefits	Net benefits	B/C
IP, CGCM climate	2,850	123	-2,727	0.04
IP, HADGEM climate	2,850	351	-2,499	0.12

Estimated instream + restoration benefits combined of $50 to $300 million cannot cover these out-of-stream losses of around $2.5 billion.

Cost of purchasing instream flows

The cost of proposed IP instream flows in terms of agricultural production value. Present value, $ millions.

run	Climate	$m	diversion reduction
Base+Instream	CGCM	128	71,604
Base+Instream	HADGEM	490	114,043

Less expensive to purchase instream flows than to “build them for around $2.5 billion if possible.

Each project implemented alone. Out-of-stream net benefits.

		moderate climate			adverse climate		
Project	Cost	TB	NB	B/C	TB	NB	B/C
KKC+KDRPP	334	98	-236	0.29	340	5.5	1.02
CEPR	16	10	-6	0.62	21	5.5	1.34
ASR	126	45	-82	0.35	112	-13.9	0.89
Conservation	257	11	-246	0.04	0	-268	0.00
Bumping	452	81	-371	0.18	293	-159	0.65
Wymer	1,331	115	-1,217	0.09	524	-808	0.39

Individual project benefits as part of the full IP, most adverse climate (HADGEM).

Project	NB	B/C
KKC+KDRPP	-188	0.44
CEPR	-16	0.00
ASR	-19	0.85
Conservation	-243	0.05
Bumping	-348	0.23
Wymer	-1,106	0.17

- Net benefits & B/C ratios lower for other climate scenarios.
- How to allocate instream flow benefits? Difficult to answer, but can't double count.

Potential gains from trade for with and without the IP. $ millions.

run	intra-district	+inter-district	Full trade	Net of TC
Baseline, CGCM	287	153	439	317
Full IP, CGCM	189	110	299	216
Baseline, HADGEM	1,212	787	1,999	1,436
Full IP, HADGEM	946	639	1,585	1,138

Fish passage benefits

Fish passage benefits by reservoir

	Contribution to total		Cost $mill	Benefits $mill		B/C	
Reservoir	low	high		low	high	low	high
Keechelus	12	16	79.9	114	205	1.43	2.56
Kachess	29	31	79.9	276	495	3.46	6.19
Cle Elum	27	23	81.5	257	461	3.15	5.65
Tieton	13	17	79.9	124	222	1.55	2.78
Bumping	18	14	26.3	171	307	6.52	11.68
Total	100	100	347.5	952	1,706	2.74	4.91

Conclusion

- Individual storage and conservation does not pass a B/C test as part of a full IP implementation.
- Cle Elum pool raise approaches B-C-viability *alone* in the most adverse drought scenario only; KKC+KDRPP also, less so (and with more caveats).
- Market gains from trade are potentially substantial with active market development.
- Fish passage projects are the most likely to satisfy a B-C test.

Questions?

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Report available at
http://swwrc.wsu.edu/category/research/