Yakima River Basin Study

Modeling of Reliability and Flows Technical Memorandum

U.S. Bureau of Reclamation
Contract No. 08CA10677A ID/IQ, Task 6

Prepared by

HDR Engineering, Inc
Anchor QEA

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Columbia-Cascades Area Office

State of Washington
Department of Ecology
Office of Columbia River

June 2011

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1.0 Introduction

The purpose of this memorandum is to document the development of the RiverWare model and results used in the Yakima Basin Study. The Yakima Basin Study will result in an Integrated Water Resources Development Plan for meeting the instream and out-of-stream needs for current and future water supply associated with the Yakima River system. The model of the system (YAKRW) is being used to estimate the specific effects of proposed new water resources projects on water supply and instream flow conditions. It is also being used to estimate the effects of potential climate change on future water supplies and instream flows.

The RiverWare software was developed by the Center for Advanced Decision Support for Water and Environmental Systems at the University of Colorado. The YAKRW model of the Yakima Basin (which uses the RiverWare software) was originally developed for the Yakima Field Office to evaluate seasonal operations strategies, it was adapted for use as part of the Yakima River Basin Storage Assessment Appraisal Study, completed from 2006 through 2008. It was further updated in 2009 and 2010 to represent current operations practices for use in the Columbia Basin River Management Joint Operations Committee (RMJOC) studies. The specific version of the model used in this study was obtained from Reclamation's Technical Service Center (TSC) in the spring/summer of 2010, where it had been modified slightly for use in evaluating the effects of potential climate change. HDR Engineering, Inc. further modified this TSC model to incorporate the planned water conservation measures and water demand increases anticipated for the basin. This model was used to estimate water supplies, stream flows, and reservoir levels associated with a scenario titled "Future without Integrated Plan" (FWIP).

A second scenario was then developed by including six proposed projects considered for inclusion in the Integrated Plan – Kachess to Keechelus Pipeline, Kachess Inactive Storage, Wymer Offstream Storage, Bumping Reservoir Enlargement, Enhanced Water Conservation, and Groundwater Infiltration. A Non-Storage Scenario (that included only the Enhanced Conservation and Infiltration projects) was also evaluated. Finally, the FWIP and Integrated Plan scenarios were evaluated under the estimated hydrologic impacts associated with three different climate change assumptions.

The YAKRW model provides a massive amount of output related to daily time-step stream flows, water levels, and water deliveries in the Yakima Basin. For this analysis, four primary metrics were used to summarize and compare modeled scenarios. These include:

- Total water supply available (TWSA), which is a combined measure of available water in streams and reservoirs
- Prorationing, which represents the percent of a given year's supply that is available to the proratable water right holders, who may have their supplies cut in low supply years
- April through September deliveries, which sums the total volume of water delivered to water users during the critical demand period
- End of September reservoir storage, which shows how much additional water is available to be carried over to next year at the end of the water year (the effective end of the irrigation season is October 20).

A fifth metric (a comparison between instream flow target levels and modeled stream flow in 15 critical reaches throughout the basin) was also used to evaluate results and impacts, although not as a simple, single metric. Instead, instream flow under scenario conditions is summarized in a matrix and on map-based figures.

The following sections briefly describe the Yakima Basin, the development of the model used in this study, and the assumptions used in each of the three modeled scenarios (FWIP, Integrated Plan and Non-

Storage). This is followed by the results from the simulation of the three scenarios and from several adjusted scenarios. The adjusted scenarios are based on a modified Integrated Plan that excludes one of the three major proposed storage projects (Kachess, Wymer, or Bumping). These adjusted scenarios were evaluated to show the effectiveness of the Integrated Plan if one of the large storage projects is not completed. Finally, results from the Integrated Plan and FWIP scenarios are presented under climate-impacted conditions.

2.0 Basin and Model Description

This section summarizes the Yakima Basin and major irrigation districts, the key components of the YAKRW model, the process of developing the scenarios used in this study, including stakeholder input, and a summary of the significant revisions to the model inputs used in generating the scenarios and their results.

2.1 YAKRW Sub-Basins and Irrigation Districts

Figure 1 shows a map of the Yakima River Basin, including the major proposed projects considered in the Integrated Plan. Figures 2 and 3 provide a schematic representation of inflows and diversions modeled in YAKRW along the mainstem of the Yakima River. For this memo, the basin is divided into several geographic areas. The upper Yakima contains three water supply lakes: Keechelus Lake, Kachess Lake, and Cle Elum Lake. Downstream on the Yakima River, several diversions take water for irrigation and municipal and industrial (M&I) uses in the Kittitas Reclamation District (KRD). The Naches River, a major tributary to the Yakima River, has two reservoirs (Rimrock and Bumping) that deliver water to several irrigation districts in the lower Naches River area. The Naches River joins the Yakima River near the city of Yakima, and marks the boundary between the upper and lower Yakima.

In the lower Yakima River area, several major canals, including the Roza, Sunnyside, and Wapato, supply multiple irrigation districts. The United States Geological Survey (USGS) gaging station on the Yakima River at Parker is a key flow indicator location where target flows are defined. The last area of interest is the Yakima River near the Columbia River. The Chandler power plant generates energy from run-of-river flows. Several smaller irrigation districts, Kennewick, Columbia, and Kiona, are also located in the lower Yakima River area.

Kittitas Reclamation District

The KRD area is on the upper Yakima River between Easton and the head of the Yakima Canyon. Lakes Keechelus and Kachess flow into Lake Easton, which serves as the diversion point for the KRD Main Canal. The KRD Main Canal splits into the South Branch Canal and North Branch Canal; the latter passes via siphon under the Yakima River. The South Branch Canal serves three irrigation areas in the model, before flowing into Long Tom Creek.

Several other canals in the Kittitas Valley divert downstream of Lake Easton. These include the Cascade Canal (which has separate gravity and pumped diversions), the West Side Canal, the Town Canal, and Ellensburg Power Canal. Flows can be diverted from the North Branch to the Cascade Canal and Town Canal. The Taneum Canal diverts from Taneum Creek, a tributary of the Yakima.

Model schematics of the KRD canals are included in Appendix A.

Multiple direct diversions from the Yakima River are not supplied by KRD canals. These diversions include the City of Cle Elum M&I needs, Younger, O'Conner, Knoke, Mills and Son, Woldale, Ellensburg M&I, Ellensburg Mill and Feed, Bull Canal, Fogarty Dyer Canal, Vertrees Diversions 1 and 2, and Tjossem, and Stanfield canals.

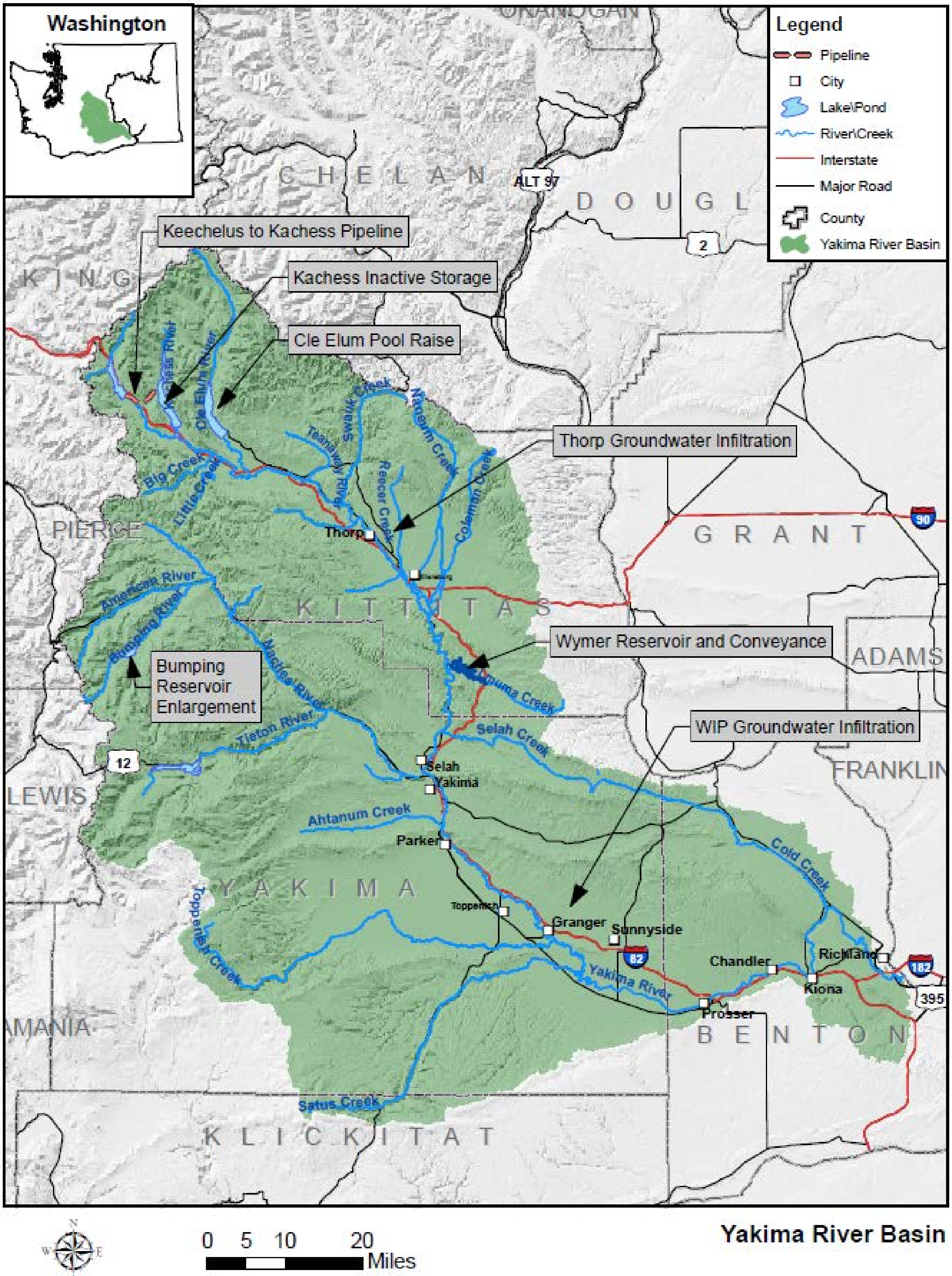

Figure 1. Yakima Basin Study Area and Major Projects Included in the Integrated Plan

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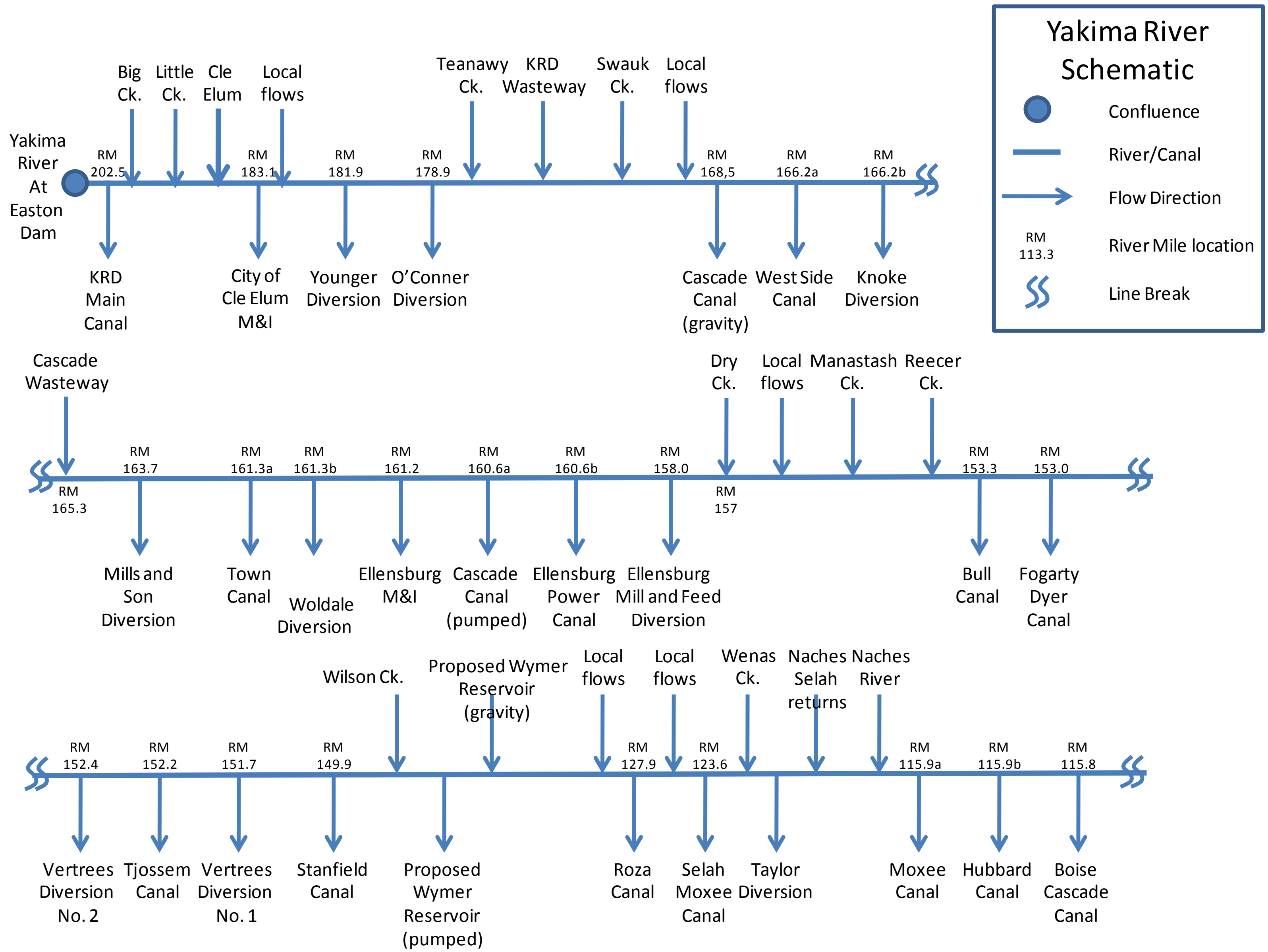

Figure 2. Yakima River Mainstem Model Schematic

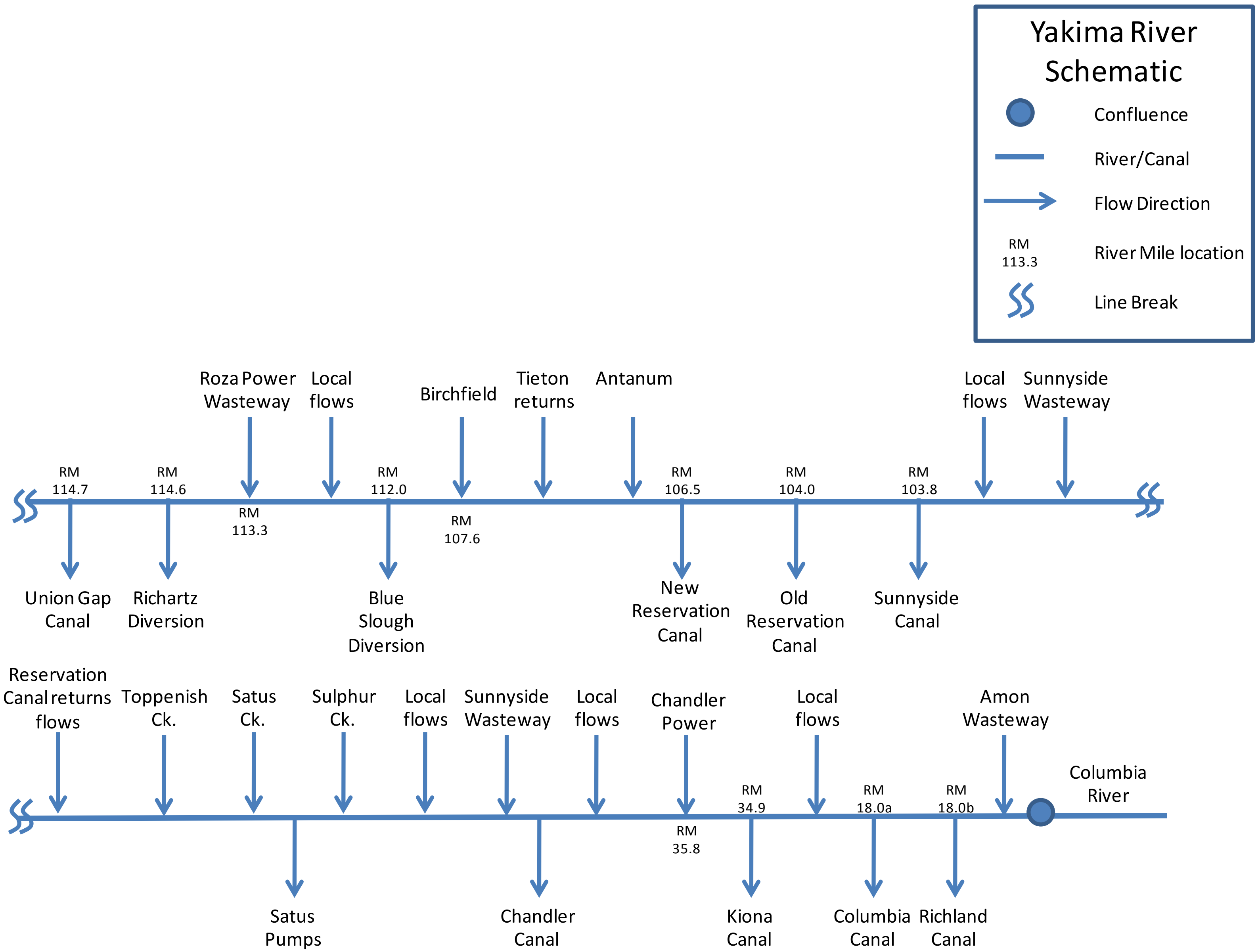

Figure 2. Yakima River Mainstem Model Schematic (cont.)

Naches River Basin

A schematic of the lower portion of the Naches River is provided in Figure 3. Bumping and Rimrock reservoirs are located in the upper basin. Two significant irrigation districts have diversions in the Naches basin; the Yakima-Tieton Irrigation District and the Naches Selah Irrigation District.

The following water use diversions are in this area:

- Anderson
- Emerick
- Nile Valley
- Carmack Parker
- Fredricks Hunting
- Stevens
- Naches Selah Canal
- Wapatox (irrigation and M&I components)
- Foster Naches
- Clark
- South Naches
- Kelly Lowry
- Yakima-Tieton Canal
- City of Yakima (irrigation and M&I components)
- Gleed
- Morrissey
- Congdon
- Chapman Nelson
- Naches Cowiche

Lower Yakima

Irrigation districts located in the lower Yakima area include the Roza Irrigation District, Sunnyside Valley Irrigation District, Selah & Moxee Irrigation District, Union Gap Irrigation District, Ahtanum Irrigation District, Grandview Irrigation District, and diversions for the Confederated Tribes and Bands of the Yakama Nation (Wapato Canal). The Benton Irrigation District is located off of the tail of the Sunnyside Canal. Model schematics for the lower Yakima canals are included in Appendix A.

The following points of diversion are located in this area:

- Roza Canal
- Selah Moxee Canal
- Taylor Diversion
- Moxee Canal
- Hubbard Canal
- Boise Cascade CanalUnion Gap Canal
- Richartz Diversion
- Blue Slough Diversion
- Reservation, or Wapato, Canal
- Sunnyside Canal

The canals on the north side of the Yakima River, which include Roza, Selah Moxee, Moxee, Hubbard, and Sunnyside, provide return flows into several common wasteways. Return flow also enter s the wasteways from the south side of the Yakima River from the Yakima Nation drains. Portions of flows in the wasteways can be recaptured for irrigation.

Yakima River near Columbia Confluence

The area of the Yakima River near the confluence with the Columbia River has three irrigation districts – the Kiona, Kennewick, and Columbia. Appendix A contains the model schematics for these districts.

The Chandler Canal diverts flow from the Yakima River. The Chandler Canal bifurcates to allow operation of a hydropower plant, which discharges to the Yakima River. The remaining flow is used by the Kennewick Irrigation District; a portion goes to the canal while the other portion is used by hydro turbines to pump the water up to the KID canal. The hydro turbine water returns to the Yakima River at the Chandler power plant. KID's water is transmitted via siphon under the Yakima River to the Kennewick Main Canal, which does not receive water directly from the Yakima River.

Further downstream on the Yakima River are diversions for the Kiona, Columbia, and Richland canals. The latter two divert from the Horne Rapids diversion dam. The Columbia Canal runs parallel to the Yakima River on the south side, while the Richland Canal continues on the north side. The Richland canal also appears to be referred to as the Horne Rapids Ditch in U.S. Geological Survey (USGS) mapping.

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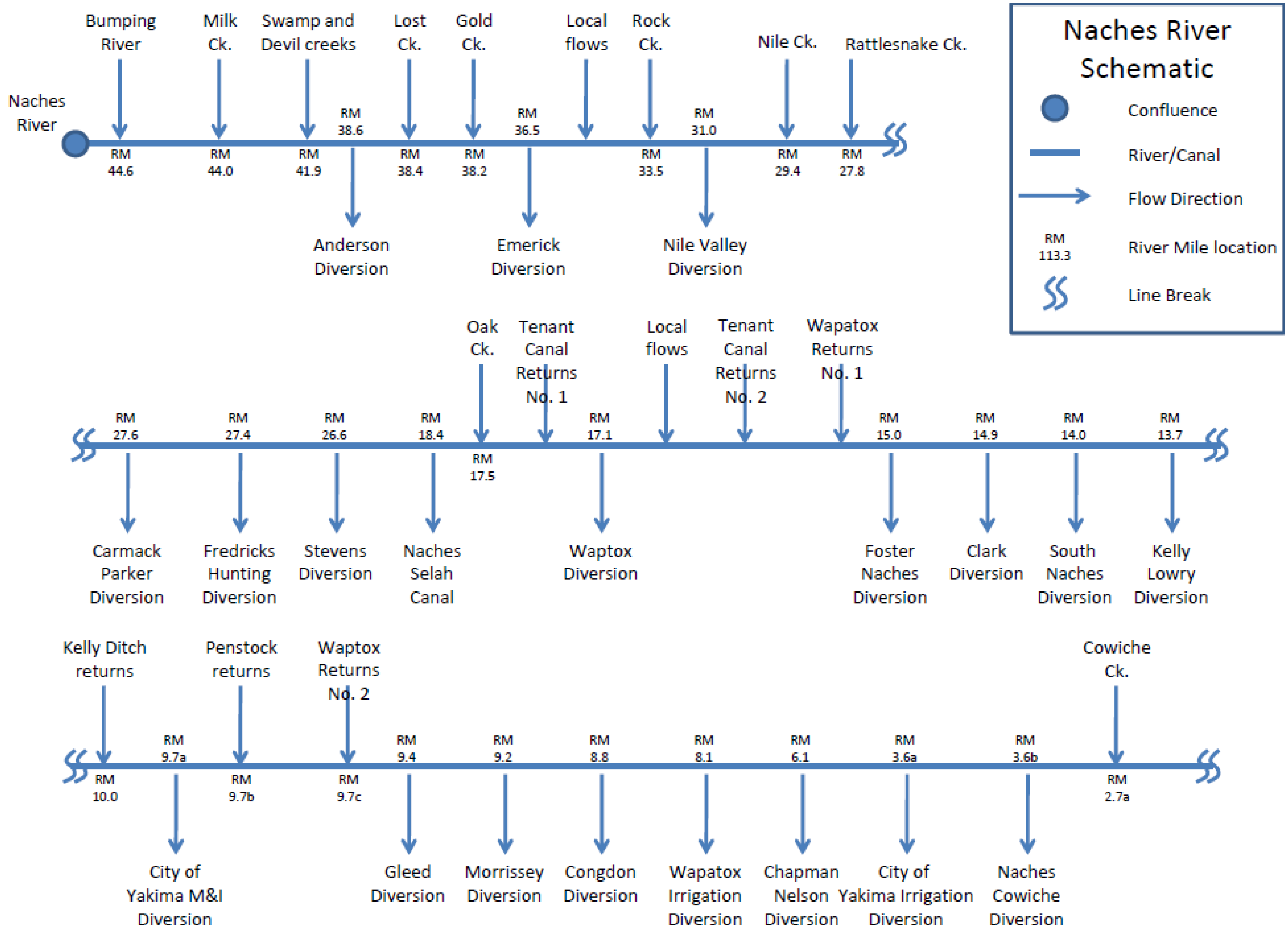

Figure 3. Naches River Model Schematic and Tieton River Model Schematic

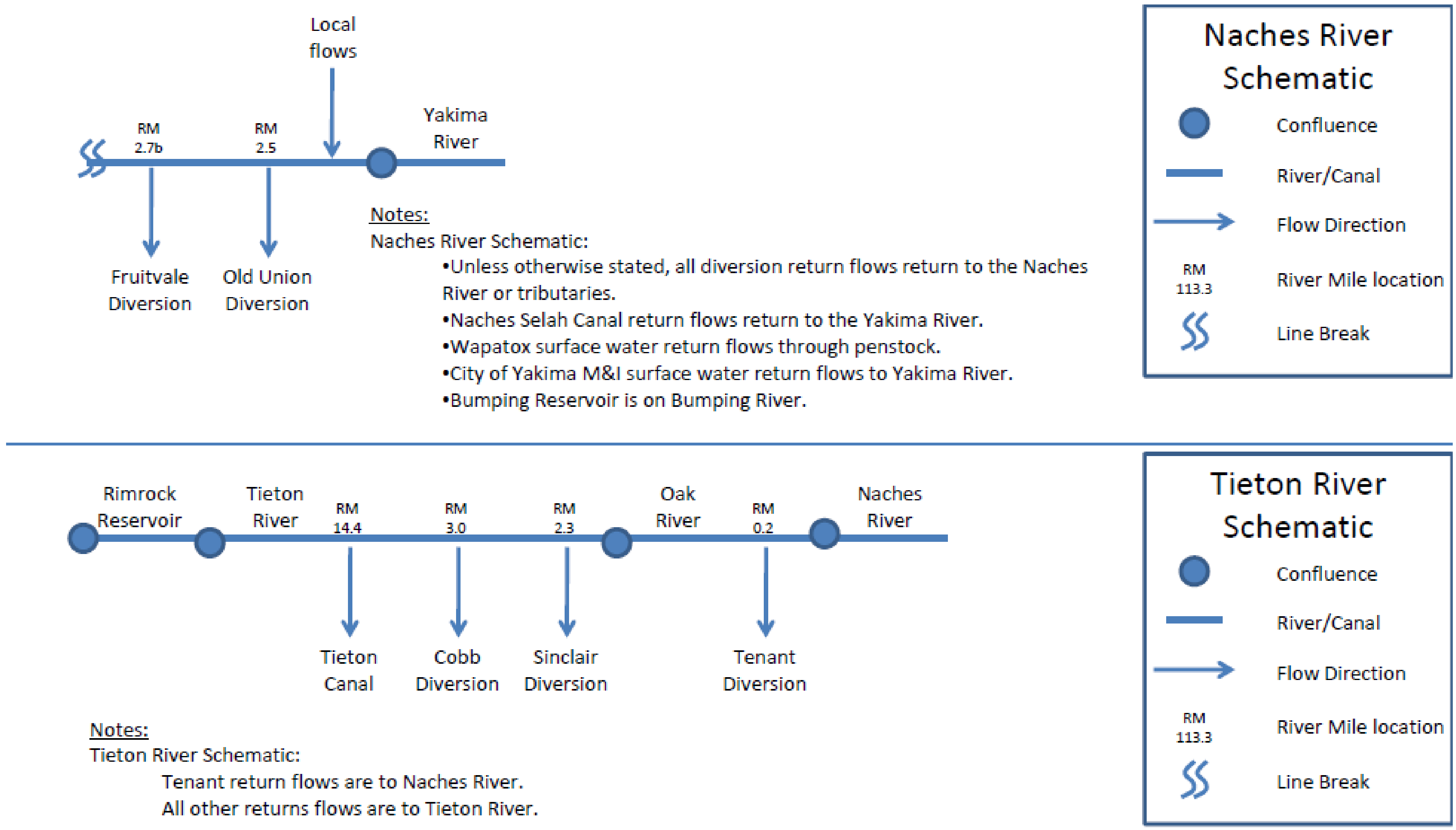

Figure 3. Naches River Model Schematic and Tieton River Model Schematic (cont.)

2.2 YAKRW Description

Inflows

Reclamation provided five hydrologic inflow datasets, one natural flow dataset and four climate change data sets. The first is the primary dataset used in scenario analysis called “No Regulation No Irrigation” (NRNI). This dataset, known as a “naturalized dataset,” is derived from USGS and Reclamation’s Hydromet observed data and represents stream flows as they would have been if there were no reservoirs and no diversions from the system. The dataset consists of daily values representing historical hydrologic conditions from water years 1981 through 2005. This historically-based period of record was used to predict how the system will operate in the future with new facilities, new operational arrangements, and (in some scenarios) climate-impacted flows and water needs. The remaining four datasets were provided by Reclamation’s Technical Service Center (TSC) in Denver for climate change analysis. These datasets are described in the “Climate Change” section.

The following inflow locations (including specific tributaries and local inflows) are used in the model:

Yakima River

- Inflows into reservoirs
- Big Creek
- Little Creek
- Dry Creek
- Manastash Creek
- Reecer Creek
- Taneum Creek
- Robinson Creek
- Cherry Creek
- Wilson Creek
- Wenas Creek
- Toppenish Creek
- Satus Creek
- Sulphur Creek
- Teanaway River
- Swauk Creek
- Little Naches River
- American River

Naches River

- Inflows into reservoirs
- Milk Creek
- Swamp Creek
- Devil Creek
- Lost Creek
- Gold Creek
- Rock Creek
- Nile Creek
- Rattlesnake Creek
- Oak Creek
- Cowiche Creek
- Tieton River
- Little Naches River
- American River

Additional tributaries not included in the lists above are also used in the model and can be seen in Figures 2 and 3.

Reservoir Operations and Target Flows

For modeling purposes, reservoir releases are generally composed of:

- Flood releases to follow flood control space guidelines, at times based on forecasting[1]
- Water supply for irrigation and M&I releases, including canal losses
- Augmentation for demand shortages generated by other reservoirs failing to meet their scheduled demand releases due to other overriding constraints
- Target flows at each reservoir outfall and Reclamation gages at Easton, below Tieton Canal, Naches, and Parker (EASW, TICW, NACW, and PARW)

[1] The model implements this and other types of forecasting that do not incorporate any forecasting error, thus generating a “perfect knowledge forecast”. A TSC study using the Yakima model indicated negligible differences when forecasting error was introduced.

Instream flow targets generally vary by available storage in the reservoirs and hydrologic condition of a given year. Using a table provided by Reclamation, the model forecasts the September 1 storage in each reservoir based on inflows and anticipated demand releases. The El Niño/La Niña-Southern Oscillation (ENSO) index is included in the model and used to determine whether the year is more likely to have below average, average, or above average runoff. Based on ENSO and forecasted storage, the model selects a dry or average instream target dataset.

Table 1 lists the range of instream flow targets. The Parker (PARW) target is described in more detail in Section 2.2.3. These existing instream flow targets are applied to the baseline FWIP and Non-Storage scenarios. The Integrated Plan uses augmented instream flow targets described in Section 2.2.5.

Table 1. Current Conditions Instream Flow Targets

LOCATION	RANGE OF INSTREAM FLOW TARGETS (CUBIC FEET PER SECOND)
Keechelus Reservoir	80 to 100
Kachess Reservoir	15
Cle Elum Reservoir	180 to 220
Rimrock Reservoir	45 to 100
Bumping Reservoir [1]	0 to 130, with 600 to 900 cfs peak flows in summer
Yakima River at Easton (EASW)	190 to 220
Tieton River	50
Yakima River near Parker (PARW) [2]	300 to 600

[1] Bumping Reservoir instream flow target is a function of current Bumping storage and TWSA.
[2] PARW instream flow target is a function of the TWSA index, described in Section 2.2.5.

Existing reservoir operations are governed by what is called “flip-flop” operations, which serve to meet water supply demands while balancing fishery lifecycle needs. These operations are as follows:

During early spring and mid-summer, Yakima River mainstem demands are primarily met through releases from the three upper Yakima River reservoirs. The two Naches River system reservoirs will release flows to meet Naches system demands; Bumping Reservoir will release flows to meet upper Naches demands; and Rimrock Reservoir releases for Tieton and lower Naches demands.

Beginning in late August, the Yakima River mainstem demands will “flip-flop” from the upper Yakima reservoirs to the Naches system reservoirs. Demand releases from upper Yakima reservoirs are reduced to meet KRD system demands and upper river instream flow targets. Rimrock releases are applied to meet Yakima mainstem demands and the instream flow target at Parker. The goal of this operation is to target upper Yakima River stages during the spawning period at roughly the same levels that will be targeted during the winter. Chinook salmon and other anadromous species will construct their nests below the river’s water surface. The eggs will suffer higher mortality if the river stage falls after spawning and exposes the eggs. A “mini-flip flop” operation also takes placed between Keechelus and Kachess reservoirs to supply KRD demands and reduced flows in the Yakima River between Keechelus and Lake Easton.

Table 2 shows the initial reservoir storage quantities used for the simulation period. These quantities correspond to historic storages on October 1, 1980, the start date of the simulation period. These storage levels are also typical for this time of year, so should adequately represent initial conditions without imparting a bias to the results.

Lake Easton is a reregulating reservoir that maintains a constant pool elevation of 2,180.33 feet, which corresponds to 3,999 acre-feet. There is no simulation of precipitation, evaporation, or seepage from any of the reservoirs in the model because these factors are assumed to be incorporated into the natural flow determination used in the original development of the hydrology.

Table 2. Initial Reservoir Storage

RESERVOIR	INITIAL STORAGE (ACRE-FEET)	% OF CAPACITY
Keechelus Lake	18,982	12%
Kachess Lake	90,641	38%
Cle Elum Lake	23,934	5%
Lake Easton	3,999	100%
Bumping Reservoir	4,839	14%
Rimrock Reservoir	44,493	22%

Modeling of Demands and Groundwater Storage

RiverWare is an "object-oriented" modeling tool. This means that it uses graphical "objects" to represent features of the simulated system. These objects can be river reaches, reservoirs, groundwater elements, etc., and frequently include detailed functions that describe their operations. Figure 4 shows a generic schematic of canal and water use in the model. A generic "main canal" object diverts flow from a river for all associated service areas. Each reach of the main canal can have seepage based on the rate of flow, which is transferred to a groundwater simulation object. Delivery laterals pull water from the main canal to a service area. A portion of flow becomes seepage and is transferred to the groundwater object. Water delivered to the service area is divided into consumptive use and return flows. A fixed portion of service area return flow is recharged to the groundwater object while the remainder is surface water returns to a river.

The groundwater simulation object implements a linear response function, which translates groundwater recharge into surface water impacts. A storage value is maintained by the object that represents the state of the aquifer. Impacts to a surface water body are calculated as a fraction of the groundwater storage. According to Reclamation (C. Lynch, personal communication) these groundwater parameters were based on trial-and-error in matching observed flows.

The initial storage of the groundwater object needs to be set to represent steady-state conditions. A groundwater object that is not initialized to a steady-state condition can artificially accumulate recharge or generate additional surface-water impacts. For example, setting the initial storage to a value of zero creates a condition where no irrigation-related aquifer recharge has occurred prior to starting the model run. During simulation, the aquifer accumulates recharge until the overall recharge and discharge balance. During the transition from no irrigation to an irrigated condition, discharge to the river is artificially low.

Setting the initial storage is a trial-and-error approach. An initial aquifer storage estimate is selected and then compared to the final simulated aquifer storage value. If the difference is greater than a specified difference, the initial storage is set to the final storage. The model is rerun until final and initial storages converge to within a given tolerance.

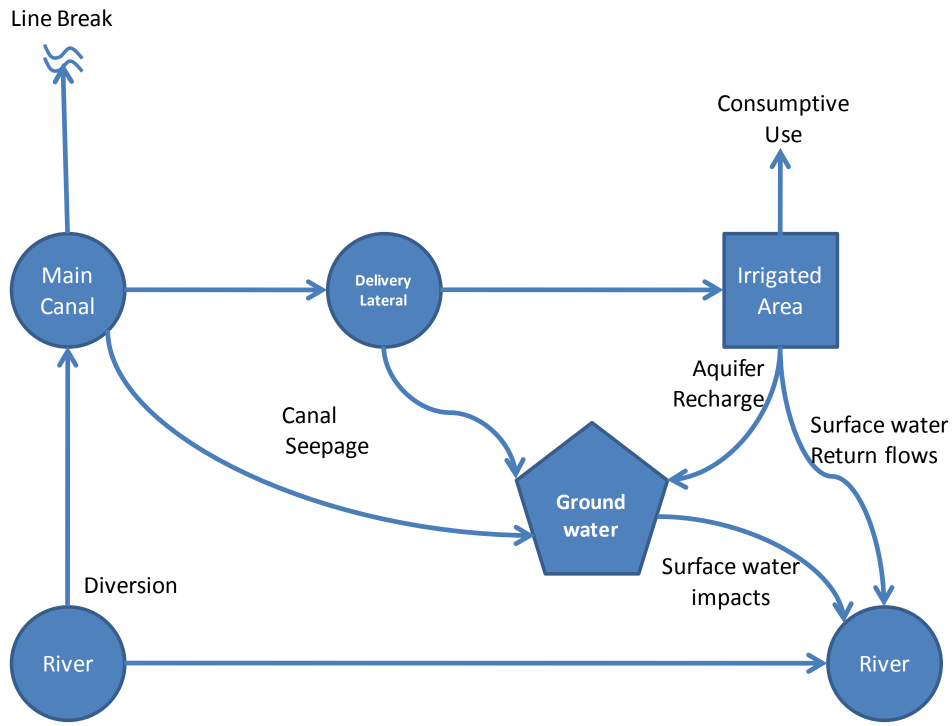

Figure 4. Generic Irrigation Model Schematic

Water Use Efficiencies

Water use efficiency is defined here as the portion of water diverted from a specific point that is applied for a consumptive beneficial use in a service area. Three components of efficiency are used in the model:

1. Efficiency of a main canal is the amount of water diverted from a river that arrives at a given lateral; seepage to the aquifer affects this efficiency value.
2. Efficiency of a delivery lateral is the portion of water reaching the lateral that is delivered to a use site (e.g., a field). Seepage losses along the delivery lateral will affect delivery efficiency.
3. Efficiency at the site of use is the consumptive portion of the delivery. This is affected by the quantity that runs off or seeps back into the groundwater system.

The overall efficiency, from the point of diversion on a river to a site of consumptive use, is the multiplication of the three component efficiencies listed above.

Table 3 lists the efficiencies for the water uses in the model in alphabetical order by irrigation district. Efficiency values were extracted from the Reclamation RiverWare model and expressed as a seepage loss as a function of flow. These efficiencies are increased during simulations incorporating conservation as the canal and other losses are decreased (see Table 6).

Demand Amounts

Estimates of the available water supply are described in the TWSA index. This index is calculated as the sum of the reservoir storage and the forecast of irrigation return flows and runoff below the reservoirs. Only a portion of the TWSA index is available to meet irrigation and M&I demands in a given year. A second index, Water Supply Available for Irrigation is calculated as TWSA minus the flow past the Parker gage (which includes excess natural flow and the instream flow targets at this downstream-most target location), minus the estimated September 30 reservoir carryover storage. The Parker instream flow target is a step-wise function of TWSA, as provided in Table 4. As TWSA increases, the instream flow target increases in steps. The September 30 carryover storage is estimated in the model with the minimum value fixed at 85,000 acre-feet.

Proration is the method of shortage-sharing in the Yakima River Basin project. Irrigation systems have shares denoted as non-proratable or proratable. Non-proratable shares predate the Yakima Storage project and are considered to be within the firm yield of the system and are always supplied (although the model can proportionally reduce the non-proratable shares, if necessary, in severe drought years). The proratable shares have a priority date of May 5, 1905, and are above the firm yield and may be subject to proportional curtailment. A proration ratio is calculated based on the ratio of Water Supply Available for Irrigation in excess of the non-proratable shares divided by the total proratable shares but is capped at 1.0. A proration ratio of 1.0 indicates a full supply where all shares are fully satisfied. A lower ratio means that all proratable shares are curtailed by a given amount. For example, a proration ratio of 0.70 indicates that proratable shares will receive 70 percent of their nominal supply entitlement. The model however will assign a district's diversion amount based on the lesser of the prorated supply or their median accepted diversion for a non-drought (wet) year.

Irrigation diversions start no earlier than March 1 and end no later than October 31. The model converts annual values into daily values using a fixed daily pattern. Table 5 lists the average diversion values for dry and wet years for each demand along with the proportion of the demand that is proratable. These values were obtained from the Reclamation RiverWare model. The demand time series were developed by Reclamation based on observed canal flows.

For many water users, diversions are higher in wet years (even though demand may be lower) because water supply is greater. In some cases it is possible for the opposite to occur, with diversions higher in dry rather than wet years. In part, this happens because the "dry" and "wet" categories are based on TWSA, not the meteorological conditions occurring during the irrigation season.

Table 3. Water Use Efficiencies

LOCATION	EFFICIENCY			
	MAIN CANAL	DELIVERY	SITE	OVERALL
Benton	n/a	85%	64%	54%
Cascade Canal (pumped)				
Diversion 1	98%	58%	64%	36%
Diversion 2	97%	80%	64%	50%
Diversion 3	94%	82%	64%	49%
Diversion 4	87%	86%	64%	48%
Chandler-Kennewick				
Diversion 1	45%	95%	64%	27%
Diversion 2	23%	95%	64%	14%
Diversion 3	11%	95%	64%	7%
Columbia Canal				
Diversion 1	50%	95%	64%	30%
Diversion 2	25%	95%	64%	15%
Ellensburg Power				
Diversion 2	93%	82%	64%	49%
Diversion 3	85%	82%	64%	45%
Hubbard	90%	81%	64%	47%
Kiona	n/a	95%	64%	61%
KRD North Branch				
Diversion 1	97%	65%	52%	33%
Diversion 2	96%	77%	52%	38%
Diversion 3	95%	78%	52%	39%
Diversion 4	83%	84%	52%	36%
KRD South Branch				
Diversion 1	94%	79%	52%	38%
Diversion 2	89%	79%	52%	37%
Diversion 3	85%	81%	52%	36%
Moxee	90%	82%	64%	47%
Naches Selah Canal	n/a	80%	64%	51%
Reservation (Wapato) Canal				
Diversion 1	98%	84%	64%	53%
Diversion 2	74%	72%	64%	34%
Richland Canal				
Diversion 1	95%	95%	64%	58%
Diversion 2	90%	95%	64%	55%

LOCATION	EFFICIENCY			
	MAIN CANAL	DELIVERY	SITE	OVERALL
Roza				
Diversion 1	99%	68%	64%	43%
Diversion 2	96%	89%	64%	55%
Diversion 3	91%	90%	64%	53%
Diversion 4	83%	82%	64%	44%
Diversion 5	81%	90%	64%	46%
Diversion 6	72%	89%	64%	41%
Selah Moxee				
Diversion 1	98%	82%	64%	52%
Diversion 2	88%	82%	64%	47%
South Naches	n/a	30%	64%	19%
Sunnyside				
Diversion 3	98%	94%	64%	59%
Diversion 4	92%	91%	64%	54%
Diversion 5	87%	93%	64%	52%
Diversion 6	81%	90%	64%	47%
Taneum Ditch	95%	75%	64%	46%
Tieton Canal				
Diversion 1	100%	99%	64%	63%
Diversion 2	99%	99%	64%	62%
Town Canal				
Diversion 1	100%	100%	64%	64%
Diversion 2	100%	100%	64%	64%
Diversion 3	100%	100%	64%	64%
Diversion 4	100%	100%	64%	64%
Union Gap	90%	81%	64%	47%
Wapatox	n/a	95%	64%	61%
West Side Canal				
Diversion 1	98%	82%	64%	52%
Diversion 2	96%	82%	64%	51%
Diversion 3	87%	82%	64%	46%
Small Irrigation Diversions	n/a	75%	64%	48%
M&I Diversions	n/a	100%	50%	50%

n/a = Not Available

Table 4. Yakima River at Parker Instream Flow Targets

MINIMUM TWSA (ACRE-FEET)	PARKER INSTREAM FLOW TARGET (CFS)
Month of April	
3,200,000	600
2,900,000	500
2,650,000	400
0	300
Month of May	
2,900,000	600
2,650,000	500
2,400,000	400
0	300
Month of June	
2,400,000	600
2,200,000	500
2,000,000	400
0	300
Months of July to September	
1,900,000	600
1,700,000	500
1,500,000	400
0	300
All other months	400

The model assumes a wet year demand value for March. Between April 1 and September 30, either a wet year demand value or a prorated demand value can be used based on the hydrologic condition of a given year. If full water supply cannot be achieved, the October demand value is also based on prorationing. Each canal system has a unique pattern of demand. Figures 5 through 10 show the average daily pattern of total basin-wide proratable and non-proratable demand. In no case will the model use a value greater than what the wet year curve would indicate even if the proration rate times the entitlement would equal a greater value.

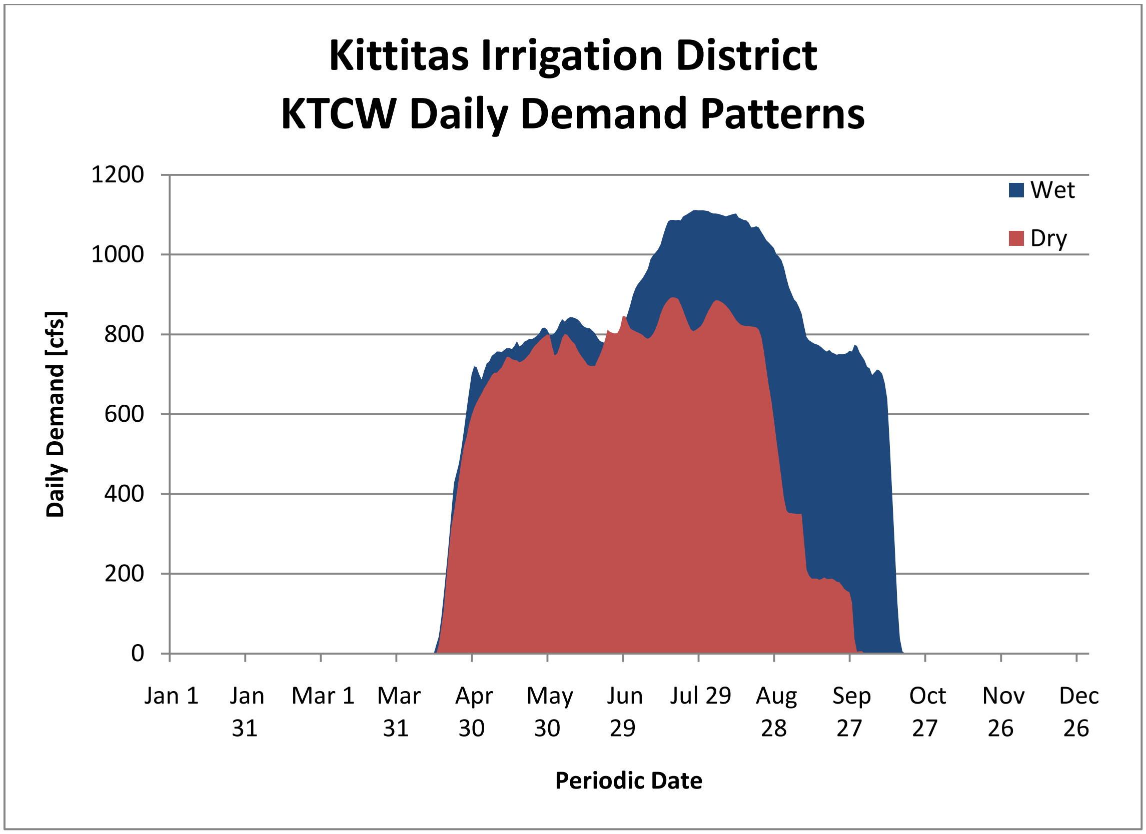

Figure 5. Kittitas Irrigation District Modeled Proratable and Non-Proratable Demand

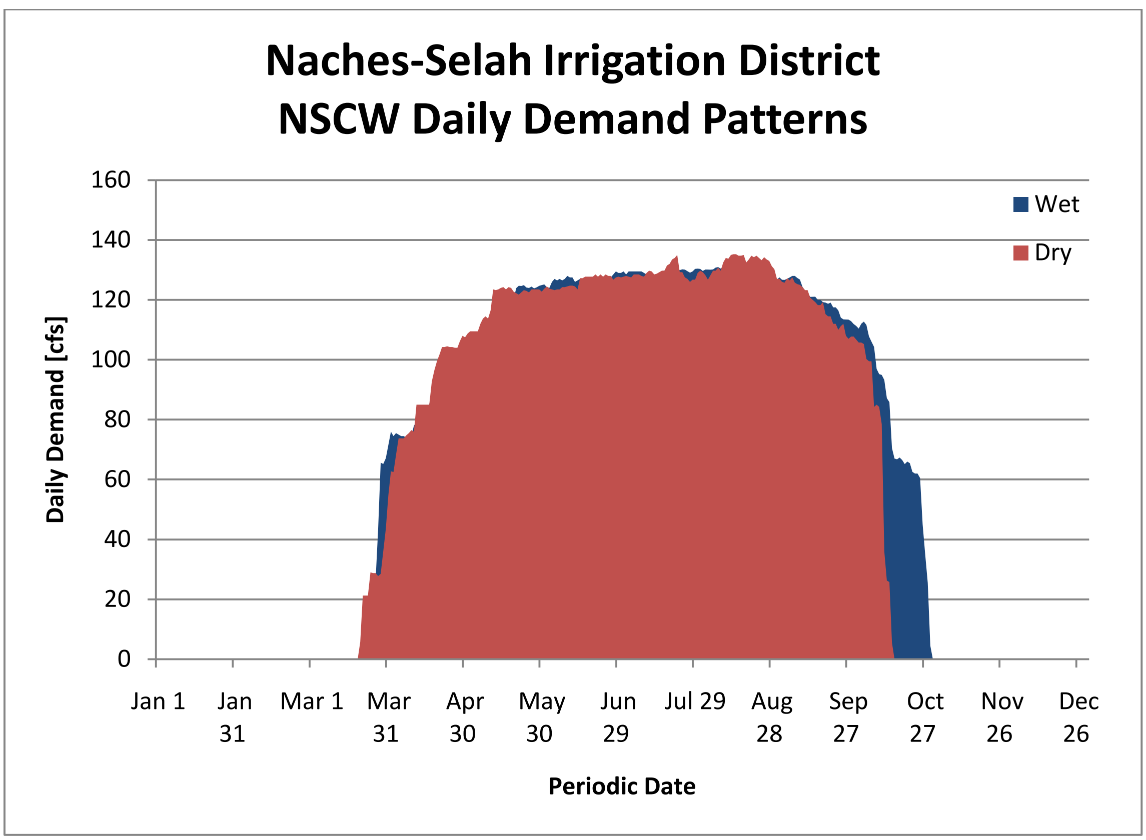

Figure 6. Naches-Selah Irrigation District Modeled Proratable and Non-Proratable Demand

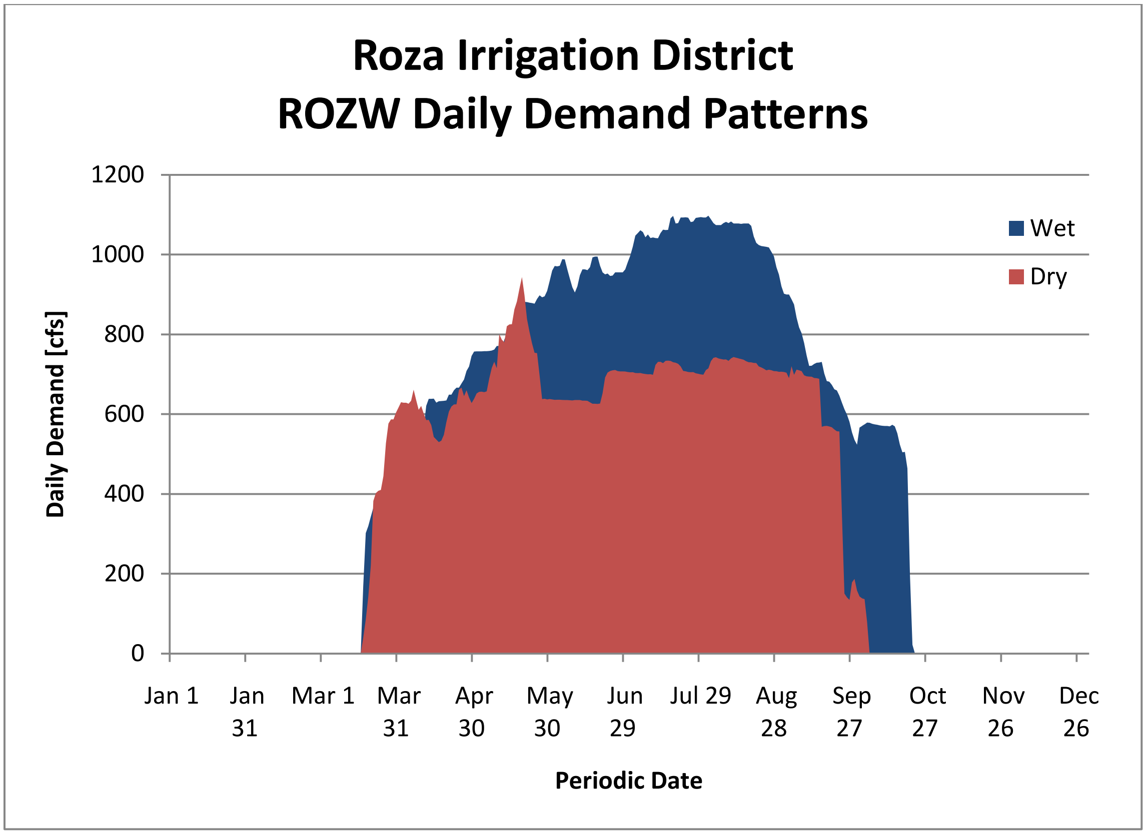

Figure 7. Roza Irrigation District Modeled Proratable and Non-Proratable Demand

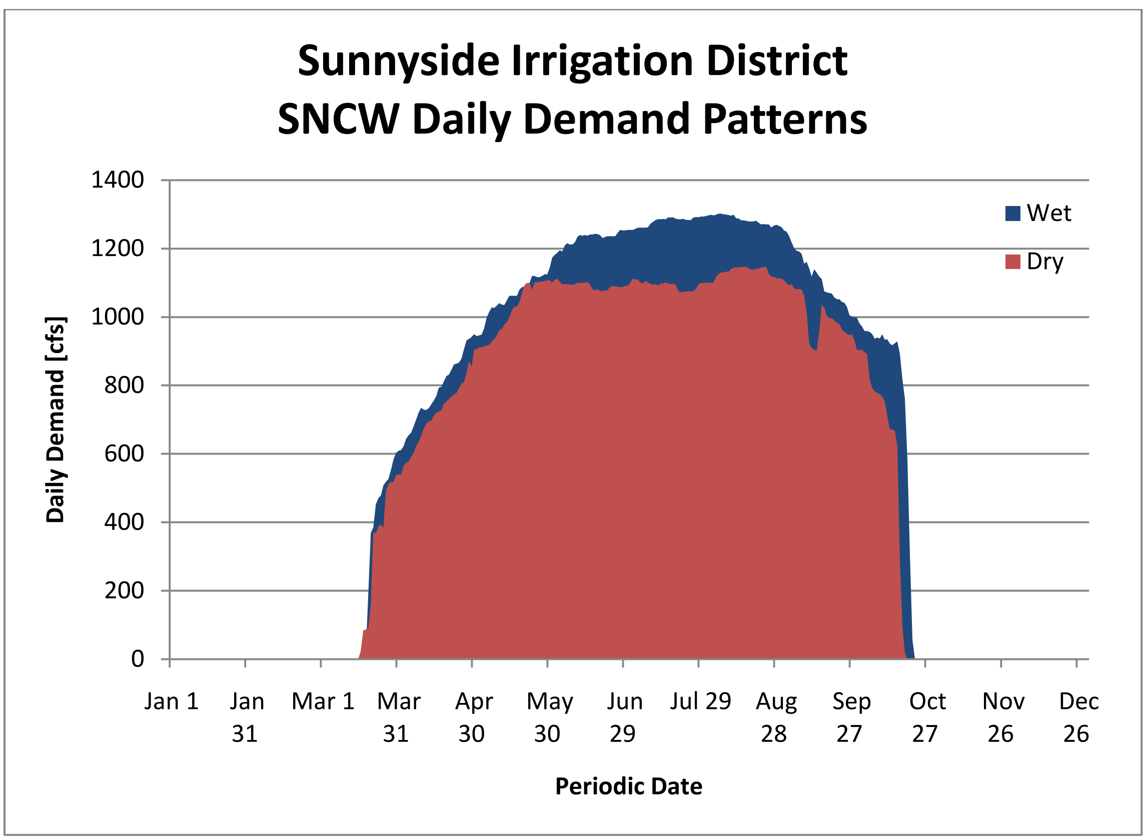

Figure 8. Sunnyside Irrigation District Modeled Proratable and Non-Proratable Demand

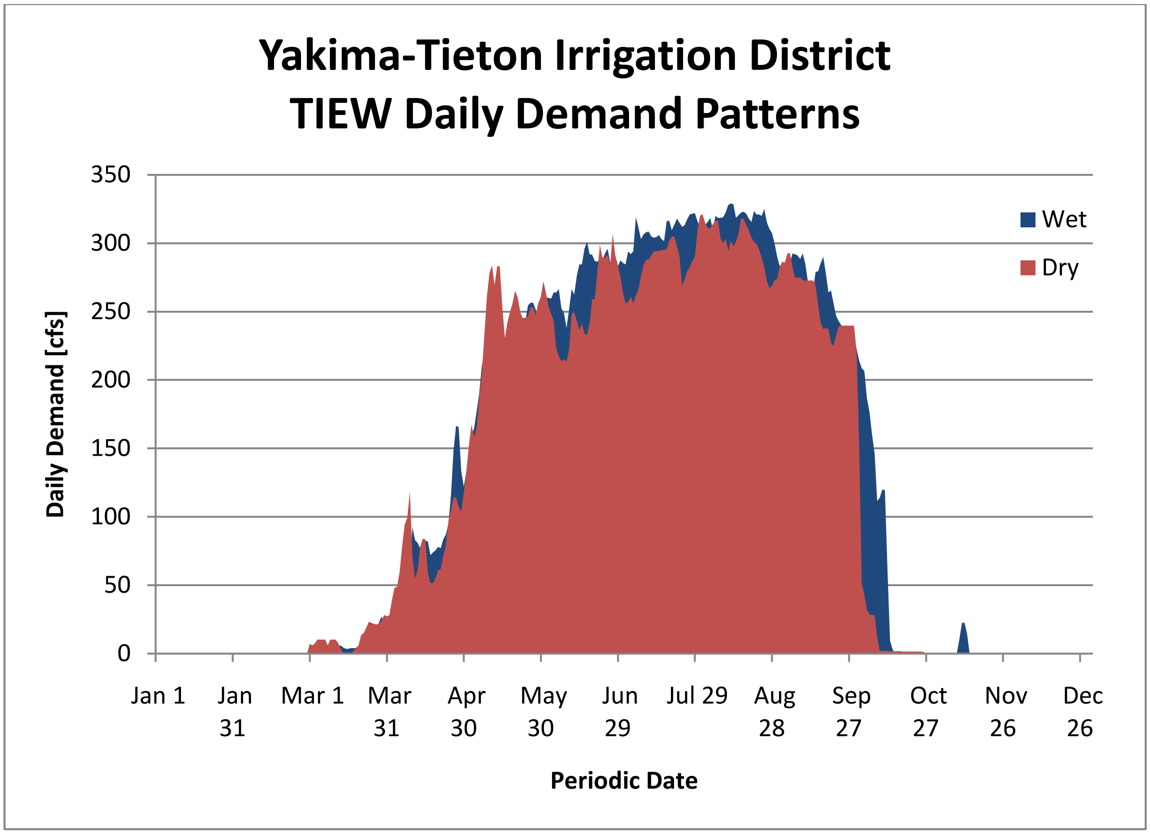

Figure 9. Yakima-Tieton Irrigation District Modeled Proratable and Non-Proratable Demand

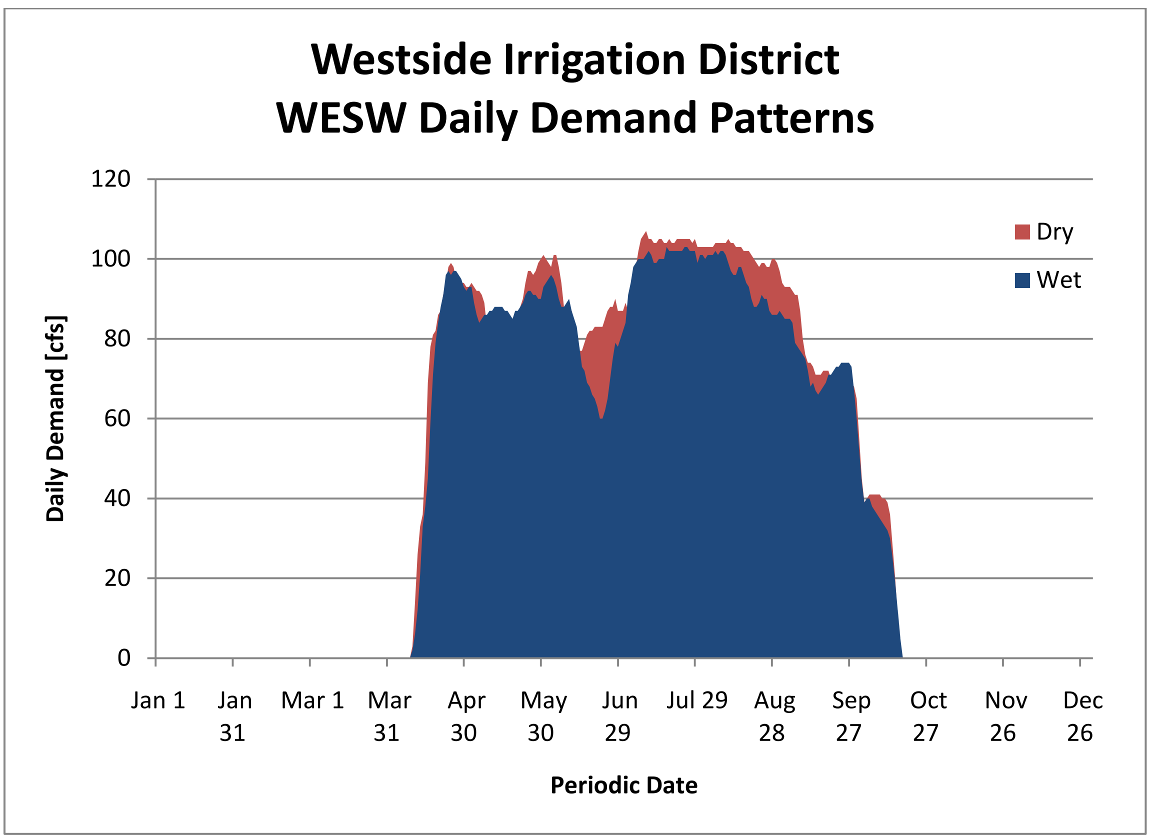

Figure 10. Westside Irrigation District Modeled Proratable and Non-Proratable Demand

Table 5. Average Annual Diversions and Proratable Proportions

CANAL LOCATION	ANNUAL DIVERSIONS (ACRE-FEET/YEAR)		NON-PRORATABLE	PRORATABLE
	DRY YEAR	WET YEAR		
Irrigation Districts and Canals, including Hydropower Generation				
Anderson	239	250	100%	0%
Benton Canal	16,173	18,400	69%	31%
Blue Slough	646	675	100%	0%
Boise Cascade	1,409	1,473	99%	1%
Bull	1,327	1,315	100%	0%
Cascade Pumps below Slide	6,907	6,841	100%	0%
Carmack Parker	97	102	100%	0%
Cascade Gravity	-	-		
Chapman Nelson	1,163	1,216	100%	0%
Clark	694	726	100%	0%
Cobb Upper	111	116	100%	0%
Congdon	4,266	4,460	85%	15%
Ellensburg Mill and Feed	985	976	100%	0%
Ellensburg Power	1,237	1,225	100%	0%
Ellensburg Town	9,795	9,702	100%	0%
Emerick	105	109	100%	0%
Fredricks Hunting	145	151	100%	0%
Fogarty Dyer	757	750	100%	0%
Foster Naches	230	240	100%	0%
Fruitvale	2,695	2,818	100%	0%
Gleed	3,473	3,631	100%	0%
Hubbard	1,699	1,777	100%	0%
Kelly Lowry	1,292	1,351	100%	0%
Knoke	328	325	100%	0%
KRD Main	232,455	334,489	0%	100%
Mills and Son	1,544	1,530	100%	0%
Morrissey	184	192	100%	0%
Moxee	792	828	82%	18%
Naches Cowiche	2,298	2,402	100%	0%
New Reservation Canal	538,279	612,529	47%	53%
Nile Valley	662	692	100%	0%
O'Conner	636	630	100%	0%
Old Reservation Canal	-	-		
Old Union	2,690	2,813	100%	0%
Richartz	969	1,013	100%	0%
Roza Canal	254,070	350,463	0%	100%
Selah Moxee	4,836	5,056	87%	13%
Sinclair	120	125	100%	0%
South Naches	3,493	3,651	100%	0%
Stanfield	328	325	100%	0%

Table 5. Average Annual Diversions and Proratable Proportions (cont.)

CANAL LOCATION	ANNUAL DIVERSIONS (ACRE-FEET/YEAR)		NON-PRORATABLE	PRORATABLE
	DRY YEAR	WET YEAR		
Stevens	297	310	100%	0%
Sunnyside Canal	400,420	455,559	69%	31%
Tieton Canal	86,984	92,752	67%	33%
Tenant	239	250	100%	0%
Tjossem	979	969	100%	0%
Taylor	1,218	1,273	100%	0%
Union Gap	3,849	4,024	82%	18%
Vertrees 2	144	143	100%	0%
Vertrees 1	444	440	100%	0%
Wapatox Irrigation	3,079	3,219	100%	0%
Woldale	2,661	2,635	100%	0%
Younger	617	611	100%	0%
Subtotal, Irrigation	1,600,060	1,937,552		
Municipal and Industrial (M&I) Uses				
City of Cle Elum M & I	258	256	100%	0%
City of Ellensburg M & I	1,231	1,219	0%	100%
City of Yakima M & I	1,424	1,489	52%	48%
City of Yakima Irrigation	1,568	1,640	85%	15%
Subtotal M&I	4,481	4,604		
Total	1,604,540	1,942,155		

Minor Deficiencies Identified in Model

Several apparent deficiencies were identified in reviewing the models provided by Reclamation. These items have been forwarded to Reclamation for consideration. They are considered to be relatively minor and did not require correction to run the model for overall purposes of the Yakima Basin Study. However some of these items may affect the precision of specific model outputs in the study. The apparent deficiencies include the following:

- Gold Creek and Cowiche Locations:

  Gold Creek in the model flows into the Naches River below Lost Creek. Based on the USGS hydrographic map, Gold Creek is located upstream of Lost Creek. This difference may impact demands met at the Anderson Diversion location because it may indicate that the Anderson water right does not include Gold Creek.

- Reservoir Evaporation, Precipitation, and Seepage:

  Evaporation, precipitation, and seepage for reservoirs are not simulated in the model, although historical effects were incorporated in the stream flows and reach gains and losses used in developing the model's hydrologic database. The lack of these reservoir water budget components will not impact scenario evaluation, except where new (or significantly enlarged) reservoirs are assumed, or reservoirs are operated much differently than under baseline conditions. Even then, effects are likely to be very small compared with the water volumes being considered in this study.

- Water Use Efficiencies:

  Chandler-Kennewick Canal and Columbia Canal appear to have lined delivery canals but high seepage from the main canal. The main and delivery canals for Town Canal also appear to be lined. These items should be verified for scenarios considering water conservation.

- Groundwater Returns:

  Several groundwater return flows are not linked to surface-water locations. This causes the groundwater returns to be consumptively used. This could be caused by wetlands or phreatophytes sustained, in part, by irrigation recharge. The missing groundwater / surface-water interactions should be verified to ensure this assumption is correct. The specific groundwater objects are: GW KRD South 2; GW KRD South 3; GW Sunnyside 6; and GW Westside 3.

- M&I Demands:

  M&I demands in the model are assumed to be associated with landscape watering, and therefore use the irrigation demand pattern. There are no M&I demands during the non-irrigation season (November through February). A revised M&I pattern may need to be added to the model.

- Power Generation and Consumption:

  While the model simulates flows through hydropower generation and pumping facilities, it does not calculate energy production or consumption. Power generation would need to be estimated outside of the YAKRW modeling effort.

2.3 Yakima River Basin Study - RiverWare Model Scenario Development

The preceding description of the YAKRW model is common to all versions of the model provided to HDR. To evaluate the effects of potential projects on water supplies and instream flows in the Yakima Basin, HDR needed to develop several versions of the model to represent conditions with and without the potential projects. For use in this study, HDR first developed a preliminary FWIP (Future without Integrated Plan) model using components of three RiverWare models provided by Reclamation. Next a Non-Storage Scenario was developed from the FWIP model. Finally the Integrated Plan scenario model was developed from the Non-Storage Scenario. Development of each scenario is described below and in Section 3.0.

Future without Integrated Plan Scenario

The No Action baseline model is referred to as the Future without Integrated Plan (FWIP) model. The component models were:

1. A current conditions model[2] reflecting current conditions from water years 1981 to 2005. This model was provided by the Reclamation Columbia Cascades Area Office (CCAO) and formed the basis of modeling used in the 2009 Department of Ecology Environmental Impact Statement.
2. A No Action model[3] reflecting current conditions plus planned water conservation measures for water years 1981 to 2005. This model was also provided by Reclamation and formed the basis of modeling used in the 2008 Reclamation Environmental Impact Statement.
3. A revised current conditions model[4] developed and provided by the TSC for use in climate change estimates.

[2] Model "2007.05.01_v4.8.3_Yakima_Basin_Network_25yr_Current"
[3] Model "2007.05.01_v.4.8.3_Yakima_Basin_Network_25yr_NoAction"
[4] Model "Yakima Planning Model”

Simulation object differences between the current conditions and revised current conditions, and the No Action versions of the Yakima model include:

- The proposed diversion to Wymer Reservoir occurs on the Yakima River from Taneum to Ellensburg reach (Thorp Diversion) in the No Action model and the Wilson to Umtanum reach in the current conditions model. Both models have Wymer releases to the Yakima River, Wilson to Umtanum reach.
- A pumped diversion occurs on the Yakima River in the Ahtanum to Parker reach to Union Gap Canal in the 2007 No Action model.
- Bumping reservoir in the 2007 No Action model is divided into three reservoirs; two of these represent extra water for fish and Roza purposes. The extra water from Bumping Reservoir bypasses the Parker gage for accounting purposes.
- Seepage from the KRD North Branch Canal immediately downstream of the bifurcation from the main canal returns to a location below Easton Reservoir in the 2007 No Action model. Seepage returns in the summer are 500 cubic feet per second (cfs), and there is no seepage in the winter months.

Based on the recommendation of the Reclamation CCAO-YFO operations personnel, the current conditions model revised by the CCAO-YFO for the RMJOC Modified Flows Study and by TSC for the RMJOC Climate Change Study was used as the initial basis for the FWIP model. The revised current conditions included but were not limited to:

- Ability to distribute shortages to nonproratable rights during more severe shortages
- Deliberate introduction of forecasting errors in estimating April TWSA
- Smoothing of changes to reservoir outflow targets to avoid unrealistically rapid release changes
- Bumping Reservoir minimum release targets adjusted based on available storage

The historic No Regulation No Irrigation inflows from the EIS current conditions model from November 1, 1980 to October 31, 2005 were transferred to the revised current conditions model to retain the same hydrology developed for the EIS. Planned water conservation measures in the previous Reclamation No Action model were also incorporated into the revised current conditions model. These are described in Section 3.1. Figure 11 illustrates the combination of models used to develop the FWIP model.

Non-Storage and Integrated Plan Scenarios

Once the HDR-modified FWIP model was finished, two additional models were developed using the FWIP model as the framework.[5] HDR created a Non-Storage model that incorporated additional future enhanced water conservation measures and two groundwater storage and recovery locations (modeled at Thorp and at Marion Drain near Wapato Canal).

[5] While referred to as separate models, from a model management perspective each "model" is a unique set of inputs to a single file. Using RiverWare rulebase programming, the model is reconfigured "on-the-fly" to generate a specific scenario. This allows noted errors and operational adjustments common to all scenarios to be applied or corrected in one file rather than maintaining separate model files. The inputs are described in detail in Section 2.5.

An Integrated Plan model was then created from the Non-Storage model by including several proposed storage projects and other potential structural changes in the Yakima Project. The three models and the assumptions used in each of them are discussed in greater detail in the sections below. Figure 12 illustrates the three HDR models.

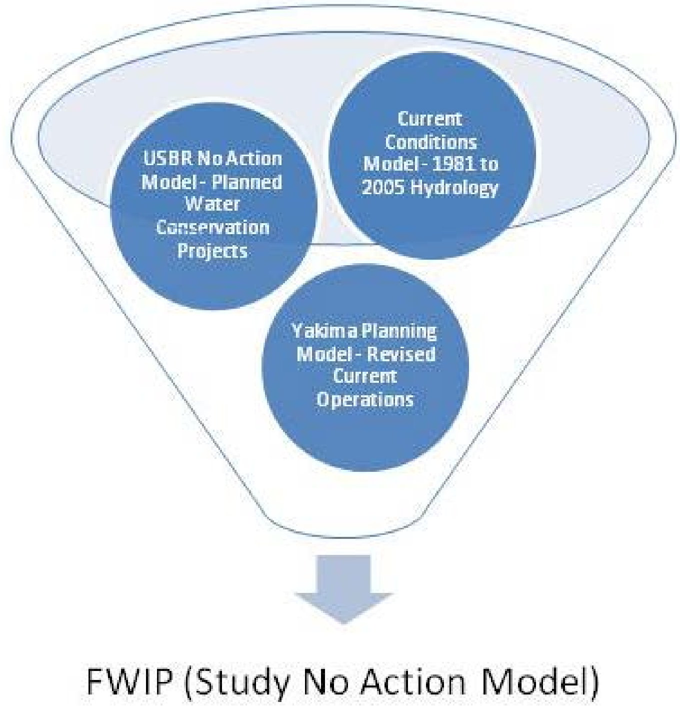

Figure 11. Model Components Used in Yakima Basin Study No Action Model

2.4 Stakeholder Input

Model assumptions and operational changes were discussed with the CCAO operations personnel and Yakima River Basin fisheries experts from Reclamation and other agencies. Model results were provided to Reclamation after each change in modeling assumptions. Frequent emails and phone calls were exchanged to verify the suitability of modeled operations and assumptions.

Preliminary model results were presented at five Yakima River Basin Water Enhancement Project Workgroup meetings and four modeling subcommittee meetings from July to November of 2010. The workgroup consists of representatives from Reclamation, the Yakama Nation, Washington Department of Ecology, various irrigation districts, resource agencies, counties and municipalities in the basin, and environmental stakeholders. The modeling subcommittee group is a smaller, more focused team of individuals who are more familiar with the detailed operations of the Yakima River Basin and the RiverWare modeling efforts.

At each of the meetings, the preliminary results were presented and discussed, and suggestions were solicited for changes to be incorporated into the next round of model runs. Many of the changes to the FWIP and Non-Storage scenarios that resulted from stakeholder input were discussed above in Section 2.3.

Based on feedback from the CCAO, modeling subcommittee, and workgroup, the following changes were made, primarily to the Integrated Plan scenario model:

1. Revised Bumping Reservoir expanded storage to 190,000 acre-ft. Prior runs had been using a larger expanded storage option considered in Reclamation's storage study.
2. Bumping Reservoir minimum outflows revised based on operating rules provided by Anchor/QEA.
3. Irrigation conservation benefits first apply to achieving a full irrigation supply and then to increasing storage in reservoirs. Some irrigation districts were previously assumed to always provide irrigation conservation to decrease reservoir releases.

4. Revised water conservation values to reflect conservation already achieved and what will be achieved both with and without the additional funding associated with the Integrated Plan.

5. Adjusted spring pulse flows on a year-by-year basis. Reservoirs will not release a spring pulse flow if it occurs naturally.

6. Used a revised storage carryover target table provided by Reclamation that includes an expanded Bumping Reservoir storage.

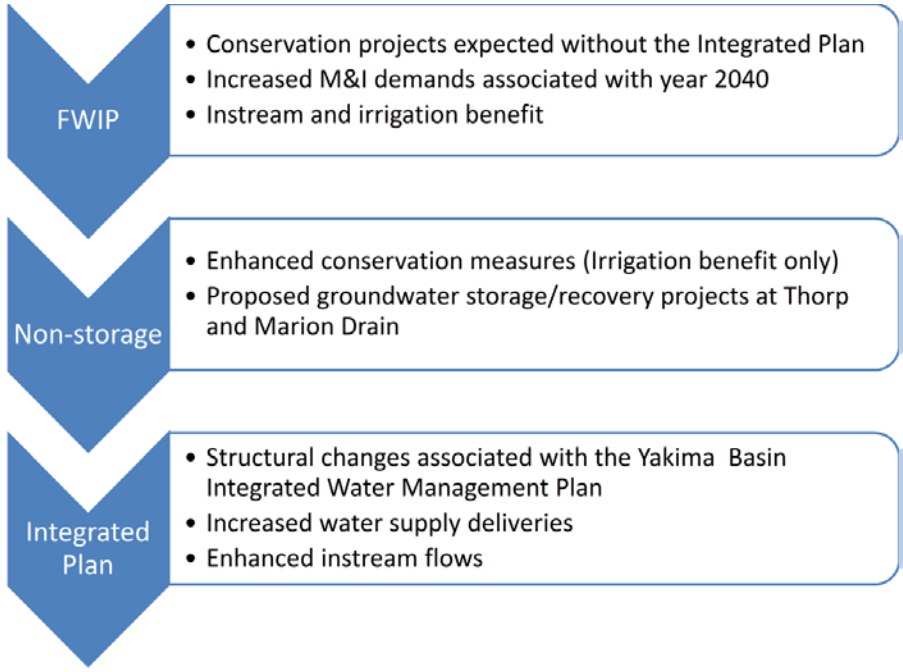

Figure 12. Relationship of Project RiverWare Models

7. Parker Title XII flows are calculated based on original reservoir storage plus storage in groundwater recharge projects, Wymer instream flow storage water account, and instream conservation benefits. Previously all proposed and existing project storage was applied, which further increases Title XII flows. Title XII flows refer to the target flows that have been defined at two points in the Yakima River Basin, as mandated by Congress through the Yakima River Basin Water Enhancement Project (Title XII of the Act of October 31, 1994, United States Congress [Public Law 103-434]). Target flows are defined in a manner that allows them to be increased as more conservation elements of YRBWEP are implemented over time.

8. Two prorationing values are calculated. The first is based on the original system and applied to Sunnyside and Tieton demands. The second is based on the Integrated Plan and applies to all other (non-Sunnyside and non-Tieton) prorated demands.

9. Returned the flip-flop and mini-flip-flop functions for the FWIP and Non-Storage scenarios to their original configuration. Flip-flop operations are only adjusted under the Integrated Plan scenario.

10. Increased Kachess inactive storage tunnel/pump capacity from 1,000 cfs to 1,200 cfs, based on current engineering analysis. This capacity can limit the model's ability to completely use Kachess inactive storage during a single year.

11. Wymer Reservoir can fill from Cle Elum releases (which are diverted to the instream storage account) and from flood flows above 1,000 cfs (which are diverted to the irrigation storage account).

12. Irrigation storage for proposed projects is utilized only when prorationing without the projects is below 70 percent. Only a portion of this storage is used to increase prorationing to 70 percent, reserving remaining storage for future dry years.

13. Revised proposed groundwater recharge areas are based on preliminary hydrogeologic parameters provided by Golder Associates (see Groundwater Infiltration Report).

14. The modeling function “Forecast System September 1 Storage” was changed to always use the storage in each reservoir. This previously was linked to a function that included expanded storage only if proration was less than or equal to 70 percent. This was usually causing forecasting of the September 1 carry-over storage to be too low. It is not clear how the groundwater recharge storage should be included in this forecast.
15. Modified the slot “TWSA PARW_Data. MaximumCarryoverStorage”. This was previously hard-coded to 1,066,000 acre-feet, which limits the September 1 forecast carryover storage. This slot was replaced with an expression slot that increased the maximum carryover storage if expanded storage options are used.
16. Added new flip-flop factors in tables “MiddleYakimaSystemStatus, FlipFlop Table” and “NachesSystemStatus. Rimrock Bumping Release Table”. The “Proration” column is used if proration levels are less than or at 70 percent. The intent is to move demand from the upper Yakima to the Naches system sooner and split demand between Bumping and Rimrock. This is to address the comment that 1993 releases from Rimrock were too low and Kachess outflows were too high. This draws down Bumping and Rimrock more than previously, although the Kachess full dead pool is only partially used.
17. Added a 1 percent proration buffer to the function “Use Integrated Plan Projects”. This function triggers calling for additional storage if proration is less than or at 70 percent. The function may not have the desired effect if proration is slightly above 70 percent prior to the proration date since the Water Supply Available for Irrigation calculation is fixed to values occurring at the proration date. As a result, 1 percent was added (71 percent proration trigger) before the proration date to attempt to avoid this condition.

2.5 Revisions to Model Operation

HDR revisions to the Reclamation model primarily involved additional datasets. These datasets, combined with revised rules, determined if the model operated in FWIP, Non-Storage, or full Integrated Plan scenarios. The following datasets were added to the model:

- Historic Inflows: The Not Regulated Not Irrigated hydrology was transferred to a separate dataset. For model runs that did not involve climate change scenarios, a model operating rule would copy this dataset to the inflow inputs of reservoirs and river reaches.
- VIC (Variable Infiltration Capacity) Inflows: This dataset contained the hydrology generated from the global climate change models. Based on a specific climate change scenario, the appropriate hydrology is copied to inflow inputs of reservoirs and river reaches.
- System Diversions: In the original Reclamation model, each canal with water conservation measures had a specific rule with hard-coded conservation parameters. In the full Integrated Plan, the number of conservation measures had increased. Different scenarios also applied to different conservation approaches. The System Diversions dataset was created to have a uniform approach to estimating conservation benefits for any number of canal systems. Rules were made generic by looping through each canal and extracting values from this dataset.
- Integrated Plan Projects: The Integrated Plan Projects is the primary table used to configure the model among different scenarios. Based on inputs in this table, the model will operate in the FWIP, Non-Storage, or Integrated Plan scenario.

Table 6 shows the settings that are available within the Integrated Plan projects model data object:

Table 6. Integrated Plan Projects Model Settings

PARAMETER AND DESCRIPTION	MODEL SETTINGS FOR:		
	FWIP	NON-STORAGE	INTEGRATED PLAN
Conservation. Active Determines if a conservation line item is enabled 0=Conservation line item not used 1=Conservation line item is used	Varies by canal location		
Conservation. Total Conservation The total conservation savings in acre-feet per year during full water supply	Varies by canal location		
Conservation. Instream Conservation The portion of the conservation savings, in acre-feet per year, applied to instream flow benefits	Varies by canal location		
Conservation. Irrigation Conservation The portion of conservation savings, in acre-feet per year, applied to irrigation benefits	Varies by canal location		
Conservation. Full Irrigation Supply A setting determining if the irrigation benefit will first go to achieving a full irrigation supply during water short years 0=Irrigation benefit will always reduce diversions and reservoir releases 1=Irrigation benefit will first increase deliveries to achieve a full irrigation supply and then to reducing diversions	1	1	1
Point of Diversion Changes. Active Determines if a point of diversion change line item is active. If active, the existing diversion is removed and the proposed river diversion is used 0=Proposed point of diversion change is not active 1=Proposed point of diversion change is active	Varies by canal location Benton and Wapato changes are included in all scenarios. Naches Selah point of diversion change is included in the Integrated Plan.		
Proposed Wymer Reservoir. Active A value of 0 configures the model to not use the proposed Wymer Reservoir while a value of 1 activates the reservoir.	0	0	1
Proposed Wymer Reservoir. In Stream Account The portion of the proposed Wymer Reservoir, in acre-feet, allocated for supply of instream flows	n/a	n/a	82,500
Proposed Wymer Reservoir. Irrigation Account The portion of the proposed Wymer Reservoir, in acre-feet, allocated for supply to Roza Irrigation District	n/a	n/a	80,000
Proposed Wymer Reservoir. Max Flow The capacity of the Thorp pipeline which delivers inflows to Wymer Reservoir	n/a	n/a	1,000 cfs
Proposed Wymer Reservoir. Min Flow The minimum flow in the Yakima River below which Thorp pipeline will not divert unregulated water. Cle Elum and Keechelus reservoir releases specifically for supply to Wymer ride on top of the unregulated water and always diverted at Thorp.	n/a	n/a	1,000 cfs
Proposed Wymer Reservoir. Skim Fraction The portion of the excess unregulated Yakima River water above the minimum flow which is diverted into the Thorp pipeline.	n/a	n/a	0.90
Proposed Wymer Reservoir. Storage Supplemental Configures whether Cle Elum and Keechelus reservoirs can release storage to supply to Wymer. A value of 0 indicates that only unregulated flows can be diverted into Wymer. Diverted flows are allocated equally to instream and irrigation Wymer storage accounts. A value of 1 indicates that upper reservoir storage can be released to Wymer. Water from reservoir releases are accrued to the instream flow account while unregulated water diversion accrued to the irrigation account.	n/a	n/a	1
Groundwater Recharge New Areas. Active Indicates if the aquifer recharge and recovery projects are active. A value of 0 indicates that the project is not used, while a value of 1 allows the proposed project to be used	0	1	1
Groundwater Recharge New Areas. Min Flow The minimum flow in the Yakima River below which the recharge project will not divert water	n/a	1,000 cfs	1,000 cfs

Table 6. Integrated Plan Projects Model Settings (cont.)

PARAMETER AND DESCRIPTION	MODEL SETTINGS FOR:		
	FWIP	NON-STORAGE	INTEGRATED PLAN
Groundwater Recharge New Areas. Skim Fraction The portion of Yakima River flows, above the minimum flow amount, which can be diverted into the recharge area basin	n/a	0.90	0.90
Groundwater Recharge New Areas. Max Flow The maximum monthly infiltration rate which can be diverted into the recharge project basin.	n/a	300 cfs	300 cfs
Groundwater Recharge New Areas. Max Annual Volume The maximum annual diversion allowed into the recharge project.	n/a	54,000 acre-feet	54,000 af
Groundwater Recharge New Areas. Alpha Coefficient The rate at which recharged water passively returns to the Yakima River as baseflow, specified in units of 1/day.	n/a	0.0070	0.0070
Groundwater Recharge New Areas. Portion Pumped The portion of recharged water which is actively recaptured through wells for direct irrigation application	n/a	0	0
Proposed K to K Pipeline. Active Determines if the proposed pipeline between Keechelus and Kachess reservoirs is active. A value of 0 is inactive while 1 allows flow through the pipeline	0	0	1
Proposed K to K Pipeline. Pipeline Capacity The physical capacity of the pipeline.	n/a	n/a	400 cfs
Proposed K to K Pipeline. Pipeline Invert The elevation of the pipeline invert in Keechelus reservoir; flow is not physically permitted to occur below this elevation	n/a	n/a	2425.00 ft
Proposed K to K Pipeline. Keechelus Target Storage The minimum target storage in Keechelus. Flow is not permitted in the pipeline when Keechelus is below this storage amount. Roughly set to prevent complete drawn down of Keechelus in the worse year that is simulated.	n/a	n/a	60,000 af
Proposed K to K Pipeline. Kachess Target Storage The maximum storage in Kachess during the flood control season, above which pipeline flow is not permitted. Roughly set to prevent additional flood control spills from occurring. Outside of the flood control season Kachess target storage is the top of the conservation pool	n/a	n/a	450,000 af (including the dead pool volume)
Proposed K to K Pipeline. Smolt Restriction Restriction on the pipeline capacity for smolt migration from March 31st to August 1st	n/a	n/a	200 cfs
Proposed Kachess Inactive Storage. Active Indicates if use of the dead pool storage in Kachess can be used to meet water supply and instream flow targets. A value of 0 limits reservoir withdrawals to the top of the dead pool while a value of 1 permits dead pool draw drawn during water short years	0	0	1
Proposed Kachess Inactive Storage. Percent Usable In Active Storage HDR estimated storage of 250,000 acre-feet below the top of the dead pool. This fraction limits the extent of dead pool drawn down, determined as 200,000 acre-feet (or 81% of 250,000 acre-feet) by the modeling subcommittee	n/a	n/a	0.81
Proposed Kachess Inactive Storage. Pump Capacity The tunnel or pumping capacity used to access flows from the dead pool.	n/a	n/a	1,200 cfs
Proposed Cle Elum Raise. Active Determines if Cle Elum reservoir dam is raised an additional 3 feet. A value of 0 uses the existing dam height while a value of 1 runs the model with expanded storage.	0	0	1
Proposed Bumping Reservoir. Active Determines if Bumping Reservoir is expanded. A value of 0 uses the existing Bumping storage while a value of 1 models an expanded storage	0	0	1
Proposed Bumping Reservoir. Max Storage The size of the expanded Bumping reservoir; the model allocates the same flood space size as in the existing reservoir	n/a	n/a	190,000 af

Table 6. Integrated Plan Projects Model Settings (cont.)

PARAMETER AND DESCRIPTION	MODEL SETTINGS FOR:		
	FWIP	NON-STORAGE	INTEGRATED PLAN
Proposed Instream Flows. Active Determines if additional stream flows considered by the instream flow subcommittee are modeled. A value of 0 defaults the model to the existing instream flow target, while a value of 1 uses the instream flow subcommittee values	0	0	1
Keechelus Max Outflow. Max Outflow Places limitations on the maximum outflow of Keechelus below the physical release restrictions. For the integrated plan, this table augments mini-flip-flop and K to K pipeline operations by reducing flows from July to the end of the irrigation season	4,000 cfs	4,000 cfs	120 to 4,000 cfs
Projects Proration Trigger Proration trigger below which proposed integrated plan projects (Wymer irrigation account use, Kachess inactive storage, Cle Elum and Bumping expanded storage) are used	n/a	n/a	0.70
Use Conservation Seepage Rates Specifies if the existing condition canal seepage rates (value of 0) or reduced conservation seepage rates (value of 1) are used	0	1	1
No Carryover During Proration Determines if the 85,000 acre-feet system carryover storage is suspended to maximize use of storage when the proration trigger is active	0	0	1
Use Future M&I Specifies if M&I demands are increased to a year 2040 conditions. A value of 1 permits the increase while a value of 0 uses existing condition demands	1	1	1
Hydrologic Dataset Specifies the hydrologic inflow dataset that is used. Values are: 0 = historic NRNI 1 = replication of historic conditions from global climate change model 2 = cgcm31t47 climate change scenario 3 =hadcm climate change scenario 4 =hadgem1 climate change scenario	0	0	0 to 4

3.0 Modeled Scenarios under Existing Hydrology

This section summarizes the primary elements of each modeled scenario under existing hydrologic conditions (without future climate change). The final subsection presents the simulation results from the final simulation runs for each scenario. The scenarios include Future without Integrated Plan (FWIP), Non-Storage, Integrated Plan, and Adjusted Integrated Plan.

3.1 Future without Integrated Plan Scenario

The FWIP model was developed to represent the No Action scenario. This model incorporates conservation projects that have been completed or are in the process of being completed under the Yakima River Basin Water Enhancement Project. It also incorporates expected growth in municipal uses and domestic wells that may require water deliveries for supply or mitigation.

Conservation

Conservation measures modeled in the FWIP scenario include projects by the Roza, Sunnyside and Benton irrigation districts. Conservation water savings can be applied to a combination of irrigation or instream needs. Irrigation conservation benefits serve to either increase delivered water supply during water-short years or reduce reservoir releases in full supply years. Instream conservation benefits increase the instream flow target at Parker gage. Benefits to irrigation are applied as conservation occurs.

As irrigation deliveries peak in the summer, the irrigation conservation benefits also peak. Benefits for instream flows are applied based on paper accounting[6]. The total conservation benefit for the year is forecasted at the beginning of the irrigation season. The instream flow conservation benefit is applied uniformly throughout the irrigation season. This results in debits from irrigation to instream purposes at the beginning of the season, which are paid back later in the season.

Conservation by the Roza Irrigation District is solely for irrigation benefit, whereas conservation at Sunnyside and Benton irrigation districts applies to both instream and irrigation benefits. These conservation measures have been advanced by the modeling subcommittee group as having either already occurred (but not reflected in model demand inputs) or will occur in the future with secured funds (see Table 7).

Table 7. Conservation In Future Without Integrated Plan (FWIP)

LOCATION	TOTAL CONSERVATION (ACRE-FEET/YEAR)	INSTREAM BENEFIT (ACRE-FEET/YEAR)	IRRIGATION BENEFIT (ACRE-FEET/YEAR)
1: RZCW Roza	36,000	0	36,000
3: SNCW Sunnyside	54,600	36,400	18,200
4: BENW Benton	6,870	5,420	1,450

Notes: Conservation amounts are based on a full water supply. Proration will result in lower realized conservation. Irrigation benefit may accrue through decreased reservoir releases during a full water supply or increased diversions during prorated years to obtain a full irrigation supply.

Point of Diversion Changes

The intended benefit of point of diversion (POD) changes is to move the diversions closer to the point of use to leave the water in the river longer and maintain higher river flows in targeted reaches. Two POD changes were modeled under the FWIP scenario; the Benton Irrigation District (BID) project and the WIP 50 cfs project. The BID POD was relocated from the Sunnyside canal diversion to a new diversion on the Yakima River about 70 miles downstream at Benton City. To simulate the change, Sunnyside canal diversions were reduced by the ratio of Benton Irrigation District volume to total Sunnyside volume (18,520 acre-feet to 458,520 acre-feet), or approximately 4 percent.

The second POD change involved using Satus Creek pumps to move approximately 50 cfs of diversion from the Wapato main canal to a location downstream of Granger. The pumps are used when diversions into the canal exceed 50 cfs. This typically allowed the pumps to operate from March 17 to October 18.

Future Municipal and Industrial Consumptive Demands

Future M&I for 2040 is applied to the upper Yakima River (Kittitas County area estimate), Yakima River below the Naches (Yakima County area estimate), and lower Yakima River (Benton County area estimate). The annual values and monthly use pattern were obtained from the draft out-of-stream water needs report prepared for the Yakima Basin Study[7]. The annual consumptive amounts are distributed from April to October, based on an average M&I pattern above the winter uses. The amounts are (in acre-feet per year): 9,100 for Yakima Co.; 1,600 for Kittitas Co. and 1,100 for Benton. The M&I pattern was selected to reflect the consumptive use portion of the demand, not non-consumptive return flows. As described in the out-of-stream report, future M&I demands include population growth, conservation, and the net water increase after converting agricultural water rights to M&I use within the Urban

[6] Paper accounting means that the quantity of water was tabulated from water right or other legal document stating how much water should or is being used. The paper amount is not an indicator of actual water in the river. For example, you can have more paper water (i.e. water allocated thru water rights) than water actually flowing in the river.

[7] HDR Engineering and Anchor QEA, "Yakima River Basin Study: Water Needs for Out-of-Stream Uses", Draft, August 2010.

Growth Boundary (see M&I Demands TM). This includes potential mitigation needs associated with domestic wells. It is possible that future M&I demands might be constrained by the available water rights. For this analysis the assumption was that future demand would not be water-right limited.

3.2 Non-Storage Scenario

The Non-Storage model was developed to include additional conservation measures, POD changes, and two groundwater storage and recovery projects. These features are also included in the Integrated Plan model.

Conservation

The Non-Storage scenario included modeling of additional conservation measures and the three conservation projects from the FWIP model. Each of the new conservation projects provide irrigation benefits only. No Wapato conservation projects were considered, based on the assumption that conserved water from these projects would contribute to full build-out of tribal irrigation. Table 8 summarizes conservation projects in the Non-Storage and Integrated Plan scenarios.

Table 8. Conservation in Non-Storage and Integrated Plan Scenarios

LOCATION	TOTAL CONSERVATION (ACRE-FEET/YEAR)	INSTREAM BENEFIT (ACRE-FEET/YEAR)	IRRIGATION BENEFIT (ACRE-FEET/YEAR)
0: KTCW Kittitas	40,735	0	40,735
1: RZCW Roza	36,000	0	36,000
2: RZCW Roza	23,900	0	23,900
3: SNCW Sunnyside	54,600	36,400	18,180
4: BENW Benton	6,870	5,420	1,450
5: KTCW Kittitas	2,000	0	2,000
6: WESW Westside	600	0	600
7: WESW Westside	2,618	0	2,618
8: ELTW Ellensburg Town	3,026	0	3,026
9: CADW Cascade Pumps below Slide	2,088	0	2,088
10: CADW Cascade Pumps below Slide	2,579	0	2,579
11: BUCW Bull	639	0	639
12: BUCW Bull	429	0	429
13: UNGW Union Gap	200	0	200
14-16: Wapato	0	0	0
17: SNCW Sunnyside	4,265	0	4,265
18: SOUW South Naches	9,733	0	9,733
19: NSCW Naches Selah	16,675	0	16,675
20: KNCW Kennewick	28,200	0	28,200

Notes: Conservation amounts are based on a full water supply. Proration will result in lower realized conservation in years with supply shortages. Irrigation benefit may accrue through decreased reservoir releases during a full water supply, or increased diversions during prorated years to move water users closer to a full irrigation supply.

Canal seepage rates are reduced to reflect conservation from canal lining. When seepage is reduced, the amount of water delivered to the canal turnout is kept constant (except in times of shortage), but the amount of water that must be diverted from the river is reduced. Table 9 shows the revised seepage rates provided by Anchor QEA. Conservation was not differentiated between canal and on-farm improvements. Conservation benefits were modeled as a reduction in reservoir releases during times of full supply or as an improvement in shortage deliveries. Return flows were reduced based on an assumption by Anchor QEA regarding the proportion of the benefits derived from canal lining.

Table 9. Canal Seepage Rates

CANAL	CANAL SEEPAGE RATES	
	NON-CONSERVATION CONDITION	FULL CONSERVATION CONDITION
KRD	48%	48%
Roza	36%	36%
Sunnyside	36%	36%
Cascade	36%	25%
Town	36%	25%
Westside	36%	25%
Wapato	36%	32%
Bull	36%	25%
Other Irrigation Canals	36%	36%
M&I systems	50%	50%

Point of Diversion Changes

The Benton Irrigation District and Satus Creek pump diversion changes in the FWIP were retained under this Non-Storage scenario. The Kennewick POD was changed to the Columbia River and no Kennewick water is diverted from the Yakima basin.

Future M&I Consumptive Demands

The same future M&I consumptive demands from FWIP were modeled in the Non-Storage scenario.

Groundwater Storage and Recovery

Two groundwater storage and recovery locations were modeled one at Thorp and another at Marion Drain (near Wapato Canal). Diversions during the non-irrigation season (November through February) were made if river flows were above 1,000 cfs. No more than 90 percent of the flow above 1,000 cfs was diverted up to a maximum rate of 10,000 acre-feet per month or 50,000 acre-feet per year for each project. Groundwater recovery occurs passively (increased base flow over time to Yakima River) at a rate of 0.01/day (that is, 1 percent of the volume in aquifer storage is released each day) at Thorp and 0.005/day (one-half of 1 percent is released each day) at Marion Drain. These release rates correspond to approximately a 70-day and a 140-day average return period, respectively. No active recovery (pumping out of the aquifer based on irrigation needs) is modeled. Estimates of monthly and annual infiltration rates and return rates were provided by Golder (see Groundwater Infiltration Report).

3.3 Integrated Plan Scenario

In addition to the Non-Storage elements, the Integrated Plan includes a new reservoir at Wymer, a pipeline from Keechelus to Kachess, access to Kachess inactive storage, a 3 foot raise of the Cle Elum Dam, an enlarged Bumping Reservoir, and enhanced stream flows.

Conservation

Conservation projects listed in the Non-Storage scenario were used in modeling the Integrated Plan scenario.

Point of Diversion Changes

Point of diversion changes listed in the Non-Storage scenario were used in the Integrated Plan scenario. Additionally, the diversion for Naches Selah irrigation is moved to the Wapatox Canal.

Future Municipal and Industrial Consumptive Demands

The same M&I future consumptive demands from the FWIP are used.

Groundwater Storage and Recovery

Groundwater storage and recovery projects listed in the Non-Storage scenario were used in the Integrated Plan scenario.

Proposed Wymer Reservoir

The capacity of the proposed Wymer Reservoir is 162,500 acre-feet. The reservoir was split into two storage accounts – 82,500 acre-feet to provide benefit to instream flow and the remaining 80,000 acre-feet to provide additional irrigation supply. The proposed reservoir is filled by diverting water from the Yakima River at Thorp during winter and spring, keeping a minimum of 1,000 cfs in the river. The Thorp pumping and pipeline capacity is 1,000 cfs. During the non-irrigation season, flood flows exceeding 1,000 cfs (and exceeding diversion to groundwater recharge) can be diverted into the irrigation storage account of Wymer. Lake Cle Elum can release flows up until the storage control date for accrual in the instream storage account in Wymer. The irrigation storage account contributes to total water supply available only at times when prorationing without Integrated Plan projects is less than 70 percent. Wymer irrigation water can only be used to the extent needed to bring prorationing up to 70 percent. The instream account does contribute to total water supply available each year and is applied to Parker gage minimum flows between July and the end of September.

Proposed Keechelus to Kachess Pipeline

The 5-mile-long pipeline from Keechelus Lake to Kachess Lake is intended to reduce high flows during the summer time caused by reservoir releases in the river below Keechelus and capture additional storage that may be spilled. Pipeline capacity of 400 cfs, is reduced to 200 cfs after March 31 based on the smolt migration, then increased to 400 cfs after August 1st. Transfers would occur when Keechelus is above 60,000 acre-feet and would stop if Keechelus drops below this level (this level was arbitrarily set to maintain some storage in Keechelus during the worst drought year). Flows into Kachess occur if Kachess is below 450,000 acre-feet (includes 248,000 acre-feet of inactive storage of which 48,000 acre-feet is inaccessible) during the flood season (to prevent additional spills from Kachess) or below the conservation pool in non-flood season.

Kachess Inactive Storage

Revisions were made to the outlet works (using a tunnel or a pump station) to allow the reservoir to be drawn down by an additional 200,000 acre-feet when prorationing is less than 70 percent. The maximum outlet capacity is modeled at 1,200 cfs. While prorationing will be recalculated when inactive storage is used, Title XII flows will not consider additional storage in the inactive pool. The outlet from the inactive storage is currently assumed to go to Lake Easton.

Proposed Cle Elum Dam Raise

A 3-foot increase of the maximum flood pool and conservation pool was modeled in the Integrated Plan. Total water supply available and prorationing consider this expanded pool when prorationing falls below 70 percent. No other operational changes were made to Cle Elum. Title XII flows will not consider the expanded pool storage.

Proposed Bumping Reservoir Expansion

Bumping Reservoir was increased to 190,000 acre-feet total size, which may be limited to approximately 156,000 acre-feet during the flood-control season based on existing guidance and operations practices. The current size of the flood pool is maintained, with elevations increased. Prorationing will consider the expanded Bumping Reservoir storage when prorationing falls below 70 percent. Title XII flows will not consider expanded Bumping Reservoir storage. Bumping may release flows to cover irrigation shortages on the Naches when Rimrock Reservoir is depleted. No other operational changes are made. For example, the Bumping Reservoir is not divided into irrigation and instream accounts. The initial (starting) storage for the expanded Bumping Reservoir is set at 100,000 acre-feet.

Enhanced Instream Flow Operations

Enhanced instream flows were incorporated by modifying minimum flows in the Keechelus, Cle Elum, Easton, lower Naches and Tieton reaches. The Keechelus minimum flow is set at 120 cfs, with a 7-day spring flood pulse near the end of April, peaking at 500 cfs. The date of the spring flood may change each year to make use of the natural hydrograph, and the peak is not supplemented by reservoir releases if it already reaches 500 cfs. The Cle Elum minimum flow is 300 cfs, with a spring flood pulse of 1,000 cfs. This peak is also not supplemented if reached naturally. The Easton reach uses a 250-cfs minimum flow, decreasing to 220 cfs from September to December. The spring pulse flow is 1,000 cfs at this location. The Tieton reach has a minimum flow of 125 cfs from October to April, while the lower Naches reach minimum flow is 550 cfs between June and October.

Minimum outflows from Bumping Reservoir vary based on the storage in the reservoir. During winter, the minimum flow depends on storage and minimum target outflow of 130 cfs. Between April 15 and April 29, the flow increases to 365 cfs, when storage is less than 75,000 acre-feet, to 500 cfs for higher storage. Between April 29 and May 20, the flow increases further, to between 600 and 900 cfs. The minimum flow rate declines to between 365 cfs and 500 cfs until September 1, followed by a return to the winter flow rate. If the projected April 1 TWSA is less than 2.4 million acre-feet (MAF), the maximum minimum flow released is 600 cfs.

Outflows from Keechelus Lake are limited to no more than 500 cfs in July, decreasing to 120 cfs from the end of August to the end of the irrigation season. Water demands that cannot be met from Keechelus Lake as a result of these maximum flow levels are transferred to other reservoir releases.

3.4 Adjusted Integrated Plan Scenarios

The Integrated Plan scenario described above was modified to produce three different adjusted scenarios representing water supply and instream flow conditions with a part of the Integrated Plan eliminated. The three adjusted scenarios are:

1. Integrated Plan without Kachess Inactive and without Keechelus to Kachess Pipeline
2. Integrated Plan without Bumping Reservoir enlargement
3. Integrated Plan without Wymer Reservoir.

Detailed refinement of modeling assumptions and operational rules was not conducted in developing and simulating these adjusted scenarios. Instead the relevant portions of the Integrated Plan scenario model were simply switched off.

3.5 Model Scenario Results

Results for the FWIP, Non-Storage, Integrated Plan, and Adjusted Integrated Plan scenarios are summarized below and in the figures and tables in Appendix B and C. The hydrologic data under which the scenarios were modeled represent conditions that occurred historically from 1981 through 2005. This historic period was chosen to test future operations and facilities because it had the most complete data available on conditions in the basin. The period included multiple dry years and one period (1992-1994) of three consecutive dry years.

FWIP Results

The Future without the Integrated Plan scenario provides a baseline condition against which the effects of the planned projects can be compared. Table 10 summarizes the water resources conditions under FWIP. The critical conclusions related to water supply are as follows:

- Average April total water supply available is 2.79 MAF
- Average April to September diversion is 1.61 MAF
- Average September 30 reservoir storage totals 0.23 MAF
- Average prorationing level is 80 percent

For the four dry years summarized:

- Minimum April total water supply available is 1.71 MAF
- Minimum April to September diversion is 1.23 MAF
- Minimum September 30 reservoir storage totals 0.04 MAF
- Minimum prorationing level is 21 percent; Average prorationing level is 31 percent

Simulated instream flow conditions for FWIP are summarized in the Instream Flow Technical Memorandum. The results show that there are significant deficiencies in the instream flows under FWIP conditions.

Table 10. FWIP and Integrated Plan Water Resources Modeling Results

Resource indicator (measurement)	Future without Integrated Plan	Integrated Plan	Change from FWIP
Average for water years 1981–2005 (maf)			
April 1 total water supply available (TWSA)	2.79	3.00	0.22
April–September Parker flow volume	0.64	0.60	-0.04
April–September diversion	1.61	1.69	0.09
September 30 reservoir contents	0.23	0.58	0.34
Irrigation proration level	80%	92%	12%
1993 dry-year (maf)			
April 1 total water supply available (TWSA)	2.06	2.24	0.18
April–September Parker flow volume	0.36	0.30	-0.06
April–September diversion	1.42	1.57	0.15
September 30 reservoir contents	0.04	0.26	0.21
Irrigation proration level	44%	70%	26%
1994 dry-year (maf)			
April 1 total water supply available (TWSA)	1.74	2.22	0.48
April–September Parker flow volume	0.31	0.25	-0.07
April–September diversion	1.23	1.52	0.29
September 30 reservoir contents	0.05	-0.07	-0.11
Irrigation proration level	21%	70%	49%
2001 dry-year (maf)			
April 1 total water supply available (TWSA)	1.76	2.45	0.69
April–September Parker flow volume	0.25	0.20	-0.05
April–September diversion	1.29	1.55	0.27
September 30 reservoir contents	0.06	0.22	0.16
Irrigation proration level	32%	70%	38%
2005 dry-year (maf)			
April 1 total water supply available (TWSA)	1.71	2.32	0.61
April–September Parker flow volume	0.25	0.18	-0.06
April–September diversion	1.25	1.53	0.28
September 30 reservoir contents	0.08	0.12	0.05
Irrigation proration level	28%	70%	42%

Shading shows greater than 10% improvement from FWIP conditions, or Prorationing >70%.

Shading shows greater than 10% decrease from FWIP conditions, or Prorationing <70%.

* September 30 reservoir contents do not include 200,000 acre-feet of inactive storage in Kachess that is available in critically dry years under scenarios that include that project.

Non-Storage Results

The Non-Storage scenario provides an interim condition against which the effects of the major reservoir storage projects can be compared. Table 11 summarizes the water resources conditions under the Non-Storage scenario. The critical conclusions related to water supply are as follows:

- Average total water supply available is 2.87 MAF
- Average April to September diversion is 1.58 MAF
- Average September 30 reservoir storage totals 0.27 MAF
- Average prorationing level is 81 percent

For the four dry years summarized:

- Minimum total water supply available is 1.79 MAF
- Minimum April to September diversion is 1.23 MAF
- Minimum September 30 reservoir storage totals 0.04 MAF
- Minimum prorationing level is 22 percent

Simulated instream flow conditions for the Non-Storage scenario are essentially unchanged from baseline or FWIP conditions, since reservoir operations are not changed in the scenario. The results show that there are significant deficiencies in the instream flows under Non-Storage scenario conditions.

Integrated Plan Results

The Integrated Plan scenario results represent the conditions and the benefits associated with the project. The water resources conditions under the Integrated Plan scenario (and the change from the FWIP scenario conditions) are summarized in Table 10. The critical conclusions related to water supply are as follows:

- Average total water supply available is 3.00 MAF
- Average April to September is 1.69 MAF
- Average September 30 reservoir storage totals 0.58 MAF
- Average prorationing level is 92 percent

For the four dry years summarized:

- Minimum total water supply available is 2.22 MAF
- Minimum April to September diversion is 1.52 MAF
- Minimum September 30 reservoir storage totals 0.13 MAF (including 0.20 MAF in Kachess Inactive)
- Minimum prorationing level is 70 percent

The Integrated Plan scenario includes reservoir releases to meet reach-specific target flows. The relative success of achieving the simulated targets are summarized in the Instream Flow Technical Memorandum and in Figure 13 below. Hydrographs displaying the reach-by-reach flow improvements are included in Appendix B. The results show that the Integrated Plan would help meet flow objectives in 13 of 14 critical reaches, including substantial improvement in six reaches. In addition, nearly 200,000 acre-feet of additional water left in September 30 carryover storage could be used to provide additional improvement in flows in certain critical years, if desired. It should be noted that after the inactive storage is used, it would have to be refilled before being used again, and likely would not be available in consecutive years. Also, power subordination at Chandler and construction of the KRD South Branch project (which are not included in the modeling results) could also significantly improve flows on the lower Yakima and in many flow-deficient tributaries for the Integrated Plan.

Table 11. FWIP and Non-Storage Scenario Water Resources Modeling Results

Resource indicator (measurement)	Future without Integrated Plan	Non-Storage	Change from FWIP
WATER RESOURCES			
Average for water years 1981–2005 (maf)			
April 1 total water supply available (TWSA)	2.79	2.87	0.08
April–September Parker flow volume	0.64	0.68	0.04
April–September diversion	1.61	1.58	-0.03
September 30 reservoir contents	0.23	0.27	0.04
Irrigation proration level	80%	81%	1%
1993 dry-year (maf)			
April 1 total water supply available (TWSA)	2.06	2.11	0.05
April–September Parker flow volume	0.36	0.36	0.00
April–September diversion	1.42	1.42	0.00
September 30 reservoir contents	0.04	0.04	0.00
Irrigation proration level	44%	47%	2%
1994 dry-year (maf)			
April 1 total water supply available (TWSA)	1.74	1.79	0.05
April–September Parker flow volume	0.31	0.31	0.00
April–September diversion	1.23	1.23	0.00
September 30 reservoir contents	0.05	0.04	0.00
Irrigation proration level	21%	22%	2%
2001 dry-year (maf)			
April 1 total water supply available (TWSA)	1.76	1.86	0.10
April–September Parker flow volume	0.25	0.25	0.00
April–September diversion	1.29	1.32	0.04
September 30 reservoir contents	0.06	0.05	0.00
Irrigation proration level	32%	37%	5%
2005 dry-year (maf)			
April 1 total water supply available (TWSA)	1.71	1.80	0.09
April–September Parker flow volume	0.25	0.25	0.01
April–September diversion	1.25	1.28	0.03
September 30 reservoir contents	0.08	0.07	0.00
Irrigation proration level	28%	33%	4%

Shading shows greater than 10% improvement from FWIP conditions, or Prorationing >70%.

Shading shows greater than 10% decrease from FWIP conditions, or Prorationing <70%.

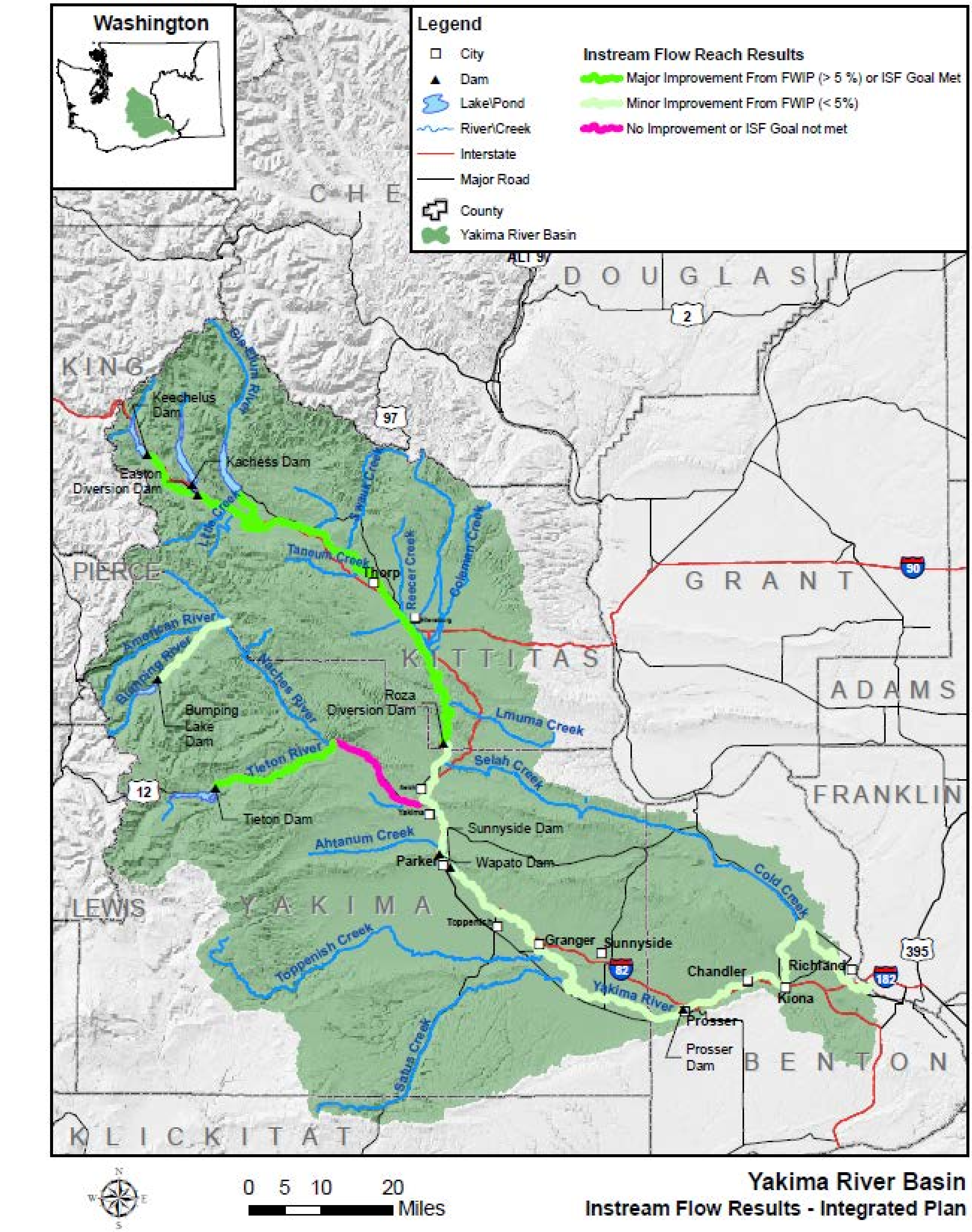

Figure 13. Improvements in Instream Flows

Adjusted Integrated Plan Results

The Integrated Plan scenario described above was modified to produce three different adjusted scenarios representing water supply and instream flow conditions with part of the Integrated Plan eliminated. The results from the three Adjusted Integrated Plan scenarios are summarized in Table 12.

Table 12. Adjusted Integrated Plan Scenario Simulation Results

Resource indicator (measurement)	Future without Integrated Plan	Integrated Plan	IP w/o Bumping Enlarge.	IP w/o Kachess & KtoK	IP w/o Wymer
WATER RESOURCES					
Average for water years 1981–2005 (maf)					
April 1 total water supply available (TWSA)	2.79	3.00	2.96	3.00	2.88
April–September Parker flow volume	0.64	0.60	0.60	0.61	0.65
April–September diversion	1.61	1.69	1.69	1.69	1.59
September 30 reservoir contents	0.23	0.58	0.43	0.59	0.35
Irrigation proration level	80%	92%	91%	91%	85%
1993 dry-year (maf)					
April 1 total water supply available (TWSA)	2.06	2.24	2.19	2.26	2.35
April–September Parker flow volume	0.36	0.30	0.30	0.31	0.30
April–September diversion	1.42	1.57	1.56	1.57	1.52
September 30 reservoir contents	0.04	0.26	0.12	0.27	0.01
Irrigation proration level	44%	70%	70%	70%	70%
1994 dry-year (maf)					
April 1 total water supply available (TWSA)	1.74	2.22	2.09	2.01	1.89
April–September Parker flow volume	0.31	0.25	0.23	0.26	0.25
April–September diversion	1.23	1.52	1.48	1.44	1.33
September 30 reservoir contents	0.05	-0.07	-0.12	0.07	-0.15
Irrigation proration level	21%	70%	68%	56%	48%
2001 dry-year (maf)					
April 1 total water supply available (TWSA)	1.76	2.45	2.30	2.25	2.23
April–September Parker flow volume	0.25	0.20	0.19	0.20	0.18
April–September diversion	1.29	1.55	1.55	1.55	1.51
September 30 reservoir contents	0.06	0.22	0.07	0.21	0.03
Irrigation proration level	32%	70%	70%	70%	70%
2005 dry-year (maf)					
April 1 total water supply available (TWSA)	1.71	2.32	2.16	2.13	2.10
April–September Parker flow volume	0.25	0.18	0.17	0.19	0.15
April–September diversion	1.25	1.53	1.53	1.53	1.49
September 30 reservoir contents	0.08	0.12	-0.02	0.15	-0.04
Irrigation proration level	28%	70%	70%	70%	70%

Shading shows greater than 10% improvement from FWIP conditions, or Prorationing >70%.

Shading shows greater than 10% decrease from FWIP conditions, or Prorationing <70%.

* September 30 reservoir contents do not include 200,000 acre-feet of inactive storage in Kachess that is available in critically dry years under scenarios that include that project.

4.0 Climate Change Impacts Modeling

Hydrologic input for 12 climate change scenarios was provided by Reclamation's Technical Service Center (RMJOC 2010 and RMJOC 2011); six scenarios represented 2020s climate, while the other six represent 2040s climate. An additional seven scenarios were also provided, including six transient-climate scenarios and a historical scenario. The scenarios were developed from climate-specific hydrologic modeling conducted by the University of Washington[8]. Four of the climate-specific scenarios featured in RMJOC's report were selected for incorporation into the Yakima Basin Study's RiverWare models – one to represent historic climate and the others to represent a range of possible future climates.

The historical hydrology dataset, like data for future climates, was based on watershed hydrologic simulation. The remaining three climate scenarios use future hydrologies that portray "hybrid-delta" (HD) climate change, which reflects a shifted envelope of historically based climate variability. The HD scenarios represent climate associated with projected atmospheric and climate conditions that may occur during the 2040s. This "delta" (or change) from historic to 2040 conditions is imposed on 90 years of historically varying hydrologic data (associated with observations during 1917 through 2006). The climate-adjusted hydrologic data from the 1981-2006 sub-period were then used from each of the climate-specific hydrologies (historical and three 2040s scenarios). The three selected HD scenarios represent a "more adverse" (hadgem1), "moderately adverse" (hadcm) and "less adverse" (cgcm3.1 t47) climate change. Table 13 summarizes the historical and the three climate change scenarios.

Table 13. Summary of Climate Change Scenarios

SCENARIO	CLIMATE MODEL USED	RMJOC LABEL	AVERAGE TEMPERATURE CHANGE	AVERAGE PRECIPITATION CHANGE	AVERAGE ANNUAL RESERVOIR INFLOW (ACRE-FEET)
NRNI (Existing or Historical)	Historically Based	None	0	0	1.66 M
Moderately Adverse	HADCM	Central Change (2040s C)	1.7 ºC average increase	3.7% increase	1.48 M
Less Adverse	CGCM3.1	None (2040s LW/W)	1.8 ºC average increase	13.4% increase	1.86 M
More Adverse	HADGEM1	More Warming, Drier (2040s MW/D)	2.8 ºC average increase	2.5% decrease	1.38 M

Climate change impacts on hydrology and water demands associated with the three climate scenarios were incorporated into the FWIP and Integrated Plan scenario models by importing the bias-corrected VIC hydrology using the Reclamation's "Daily Bias Correction Calculator" spreadsheet[9]. Irrigation demands were increased by an average of 9 percent to represent climate change-impacted conditions (Water Needs for Out of Stream Uses - Technical Memorandum – Appendix C). M&I demands were increased by an average of 5 percent based on information from the Water Needs Technical Memorandum. The 9 percent increase is based on the Moderately Adverse scenario, but was used in all three climate-influenced scenarios. Because precipitation and evaporation are not simulated in the YAKRW model, there was no way to directly include the effects of climate change on these parameters in the modeling analysis. The demand changes should approximate the influence of temperature and evaporation change on that factor, but no attempt was made to estimate changes in reservoir storage due

[8] Additional information on the University of Washington's climate change models can be found here: http://www.hydro.washington.edu/2860/

[9] File "DMI_ManageModelsRuns.xlsm"

to evaporation and precipitation changes. Because the climate change scenarios include both increases in precipitation and increases in temperature (which would increase evaporation), effects on reservoir storage are likely to be somewhat offsetting, and small compared with the flow changes that are incorporated.

In addition to the changes in demands described above, the primary impact of the projected climate changes is on the streamflow at each major reservoir. The climate changes incorporated into each scenario change the volume and timing of flow into the reservoirs and at each diversion location, thereby changing both the need for water from reservoir storage and the ability of the reservoirs to meet those needs. The following three figures (Figures 14 through 16) show how the total of the flow into all five major reservoirs is affected by the projected climate change scenarios.

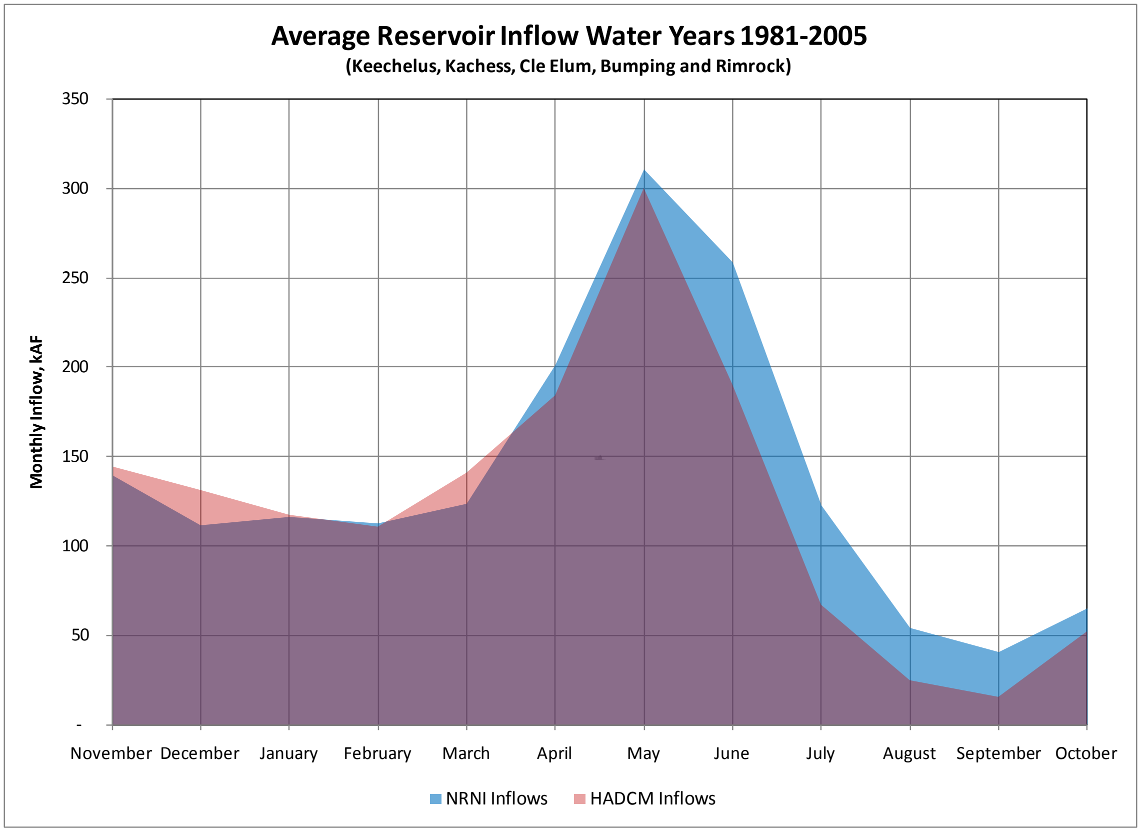

Figure 14.Comparison of Average Monthly Reservoir Inflows between Historically-based (NRNI) and Moderately Adverse Scenario

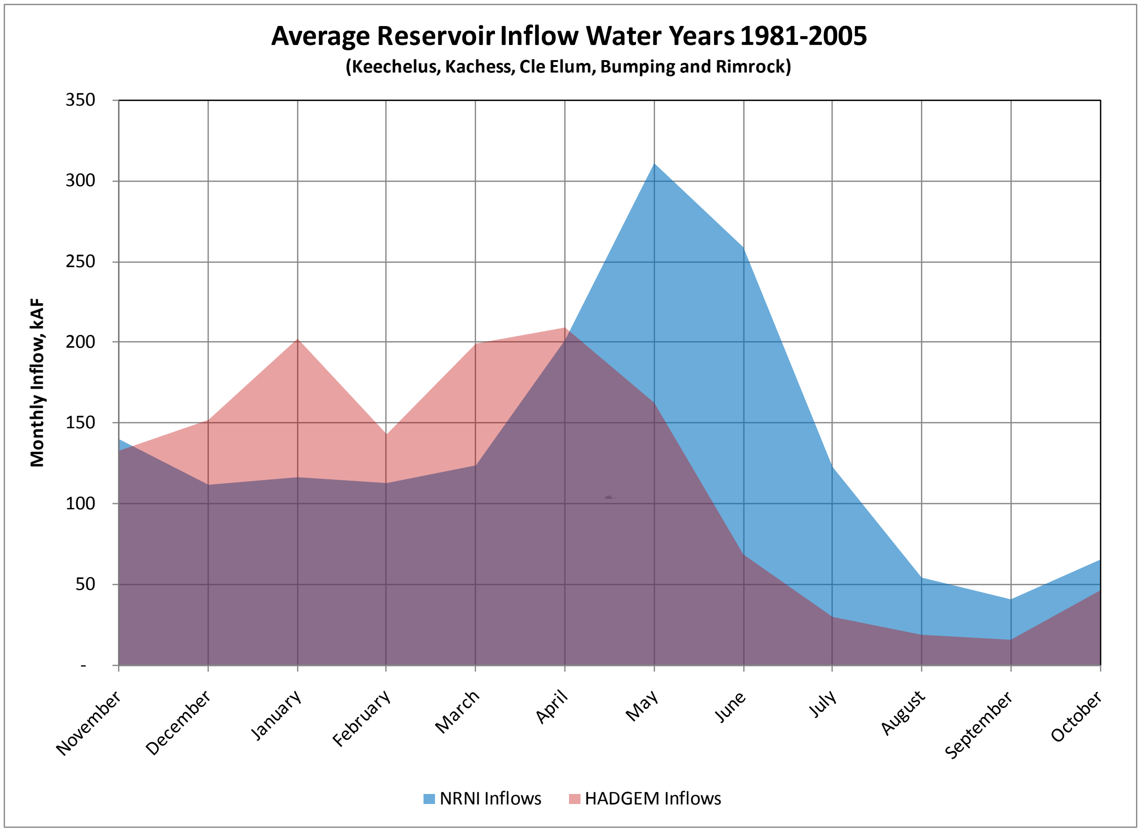

Figure 15.Comparison of Average Monthly Reservoir Inflows between Historically-based (NRNI) and More Adverse Scenario

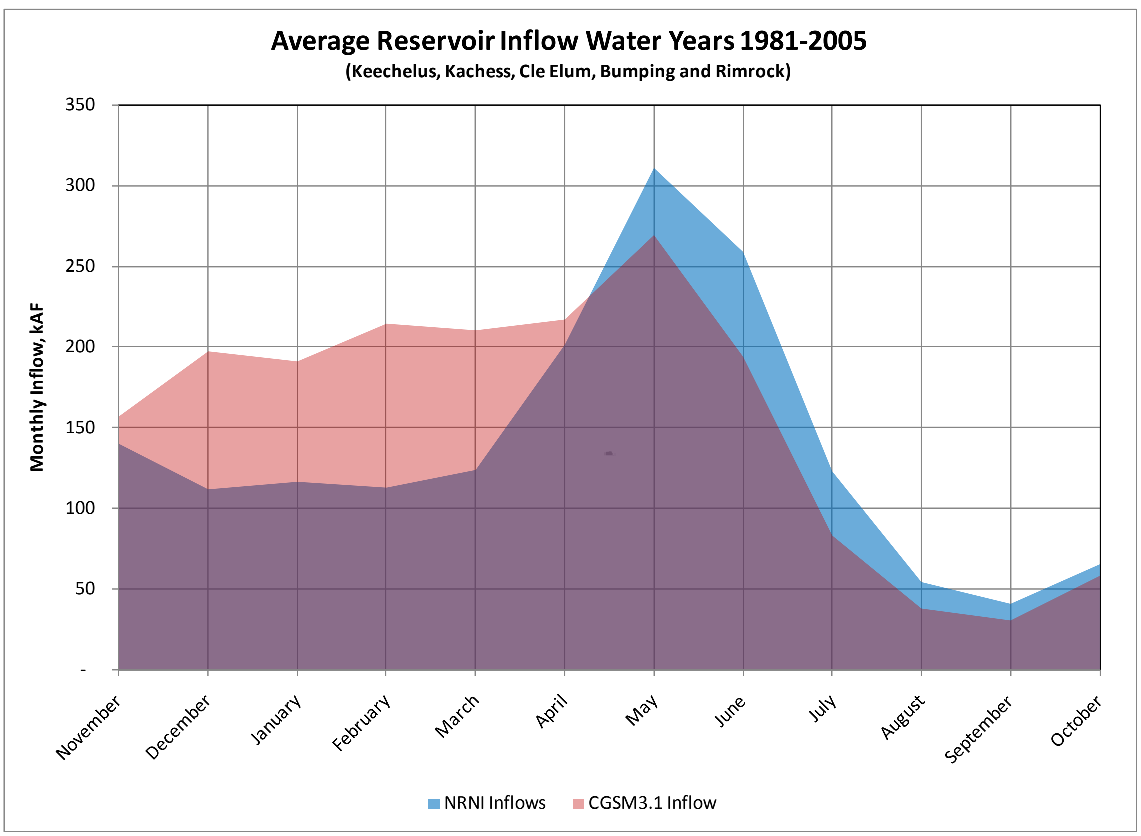

Figure 16.Comparison of Average Monthly Reservoir Inflows between Historically-based (NRNI) and Less Adverse Scenario

4.1 Climate Change Simulation Results

The three climate change scenarios were modeled based on input of the hydrological datasets received from TSC. Results for the three climate change scenarios are summarized in Table 14 below and in the figures and tables in Appendix D.

Table 14. Climate Change Scenario Simulation Results

Resource indicator (measurement)	FWIP (Moderately Adverse) HADCM	Integ Plan - Moderately Adverse HADCM	FWIP (Less Adverse) CGSM	Integ Plan - Less Adverse CGSM	FWIP (More Adverse) HADGEM1	Integ Plan - More Adverse HADGEM
Average for water years 1981–2005 (maf)						
April 1 total water supply available (TWSA)	2.31	2.47	2.64	2.79	1.84	2.02
April–September Parker flow volume	0.51	0.43	0.60	0.53	0.36	0.30
April–September diversion	1.51	1.64	1.67	1.79	1.29	1.43
September 30 reservoir contents	0.08	0.17	0.10	0.39	0.07	0.00
Irrigation proration level	54%	72%	74%	88%	30%	50%
1993 dry-year (maf)						
April 1 total water supply available (TWSA)	1.86	2.00	2.50	2.65	1.61	1.69
April–September Parker flow volume	0.38	0.27	0.57	0.57	0.29	0.28
April–September diversion	1.30	1.46	1.61	1.65	1.16	1.24
September 30 reservoir contents	0.03	-0.16	0.05	0.25	0.08	-0.17
Irrigation proration level	30%	52%	58%	70%	7%	23%
1994 dry-year (maf)						
April 1 total water supply available (TWSA)	1.51	1.60	1.73	2.24	1.30	1.43
April–September Parker flow volume	0.29	0.27	0.25	0.20	0.23	0.21
April–September diversion	1.10	1.20	1.29	1.56	0.97	1.09
September 30 reservoir contents	0.08	-0.17	0.05	-0.03	0.10	-0.14
Irrigation proration level	9%	25%	32%	70%	0%	14%
2001 dry-year (maf)						
April 1 total water supply available (TWSA)	1.58	2.16	1.69	2.26	0.85	1.38
April–September Parker flow volume	0.33	0.26	0.29	0.22	0.23	0.20
April–September diversion	1.11	1.49	1.24	1.56	0.53	1.07
September 30 reservoir contents	0.05	-0.06	0.05	0.00	0.07	-0.17
Irrigation proration level	9%	61%	25%	70%	0%	10%
2005 dry-year (maf)						
April 1 total water supply available (TWSA)	1.76	2.02	2.20	2.29	1.48	1.58
April–September Parker flow volume	0.33	0.26	0.39	0.35	0.30	0.25
April–September diversion	1.27	1.46	1.56	1.63	1.08	1.16
September 30 reservoir contents	0.04	-0.12	0.05	0.29	0.07	-0.15
Irrigation proration level	27%	61%	59%	70%	4%	21%

Shading shows greater than 10% improvement from FWIP conditions, including effects of climate, or Prorationing >61%.

Shading shows greater than 10% decrease from FWIP conditions, including effects of climate, or Prorationing <61%.

* September 30 reservoir contents do not include 200,000 acre-feet of inactive storage in Kachess that is available in critically dry years under scenarios that include that project.

5.0 Conclusions

The hydrologic simulations described in this technical memorandum provided the technical results necessary for the Workgroup to understand how effectively the proposed Integrated Plan water supply facilities and other changes are able to meet existing and projected water supply needs of the Yakima Basin. The estimates produced by the YAKRW model allow quantified comparison of the following conditions:

- Total water supply available
- Prorationing (the percent of the deliverable supply to the lower-priority water right holders)
- April through September deliveries
- End of September reservoir storage
- Relative success in meeting instream flow target levels

For the Integrated Plan, the model results under existing climate conditions indicate that total water supply available can be increased from an average of 2.79 MAF to 3.00 MAF. During critical drought conditions, total water supply available can be increased from 1.74 MAF to 2.22 MAF. Prorationing levels are increased by the Integrated Plan from an average of 80 percent to an average of 92 percent, and worst critical year prorationing is increased from 21 percent to 70 percent.

Average April through September deliveries are increased from 1.61 MAF to 1.69 MAF, despite projected conservation efforts that reduce demands. Average end of September reservoir storage levels increase under Integrated Plan conditions from 233,000 acre-feet to 577,000 acre-feet. The simulation model indicates improvement in meeting instream flow target objectives in 13 of 14 critical reaches. Hydrographs displaying the reach-by-reach flow improvements are included in Appendix B.

When potential "moderately adverse" climate changes are incorporated into the analysis, similar improvements in water supply and streamflow conditions are estimated when FWIP and Integrated Plan results are compared. In particular, average total water supply available increases from 2.31 MAF to 2.47 MAF. During critical drought conditions, total water supply available is increased from 1.51 MAF to 1.64 MAF.

Prorationing levels are increased by the Integrated Plan under moderately adverse climate impacts from an average of 54 percent to an average of 72 percent, and worst critical year prorationing is increased from 9 percent to 25 percent. Average April through September deliveries are increased from 1.51 MAF to 1.64 MAF, despite projected conservation efforts that reduce demands. End of September reservoir storage levels increase under Integrated Plan moderately adverse climate change conditions from 80,000 acre-feet to 170,000 acre-feet. The simulation model also indicates improvement in meeting instream flow targets objectives. Hydrographs displaying the reach-by-reach flow improvements are included in Appendix B.

6.0 Limitations

This technical memorandum and the hydrologic simulations were completed by HDR to estimate the effectiveness of certain proposed water supply development projects in meeting estimated demands and instream flow targets. The model utilized (YAKRW) was previously developed by Reclamation to describe the operations of the Yakima Basin Project and other facilities and components of the hydrologic system.

The Yakima Basin and the YAKRW model are very complex. Based on engineering judgment and discussion with Reclamation staff and others who have expertise on the Yakima Basin, HDR made certain changes to the YAKRW model to complete this study. These changes appear to be appropriate, but certain changes could affect results.

The model result summaries presented in this memorandum are accumulations of a large amount of model-simulated results that are affected by assumptions (recognized and unrecognized) that are incorporated into the model and its data files. HDR has exercised a standard level of care in conducting this study that is typical of this level or stage of project planning. However, results should be carefully reviewed for reasonableness prior to using them for decision-making. Results are not appropriate for design-level decision-making. The 2011 RMJOC report[11] provides further discussion on the uncertainties of assessing operation impacts in a changing climate (Section 5.0) and the limitations of relating climate projections to hydrologic and operations impacts (Section 6.0).

7.0 References

1. Bureau of Reclamation. 2008. "Final Planning Report/Environmental Impact Statement: Yakima River Basin Water Storage Feasibility Study." December 2008.
2. Bureau of Reclamation, U.S. Army Corps of Engineers, and Bonneville Power Administration. 2010. Climate and Hydrology Datasets for Use in the RMJOC Agencies' Longer-Term Planning Studies: Part I - Future Climate and Hydrology Datasets (not published). U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado and Pacific Northwest Regional Office, Boise, Idaho; U.S. Army Corps of Engineers, Northwest Division, Portland District, Portland, Oregon; and Bonneville Power Administration, Portland, Oregon. December 2010.
3. Bureau of Reclamation. 2011. Climate and Hydrology Datasets for Use in the RMJOC Agencies' Longer-Term Planning Studies: Part II - Reservoir Operations Assessment for Reclamation Tributary Basins (not published). U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Regional Office, Boise, Idaho. January 2011.
4. Washington State Department of Ecology, "Final Environmental Impact Statement: Yakima River Basin Integrated Water Resource Management Alternative", June 2009.

8.0 List of Preparers

Name	Background	Responsibility
HDR Engineering, Inc.		
Steven M. Thurin	Hydrology	Task Manager
Ted Shannon	Hydrology	RiverWare Modeling
David Minner	Hydrology	Data Processing
Anchor QEA		
Bob Montgomery	Hydrology	Technical Advisor

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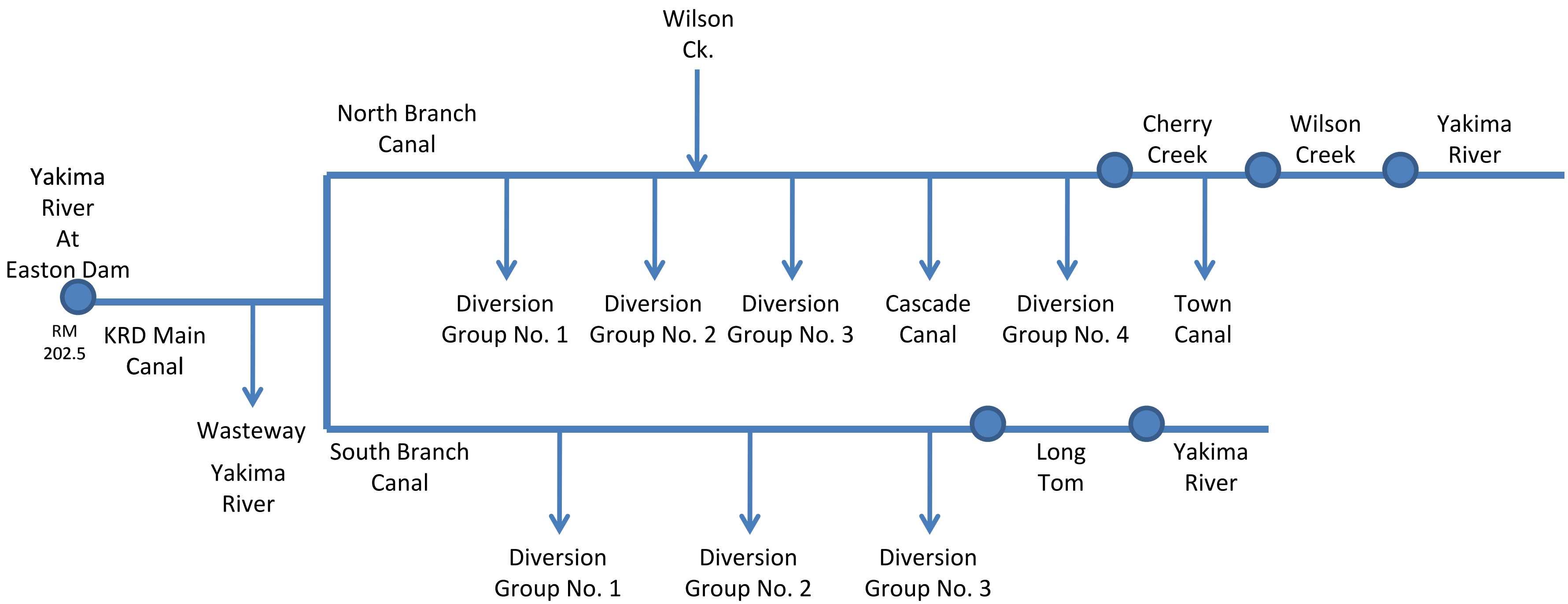
Appendix A –

RiverWare Model Canal Schematics



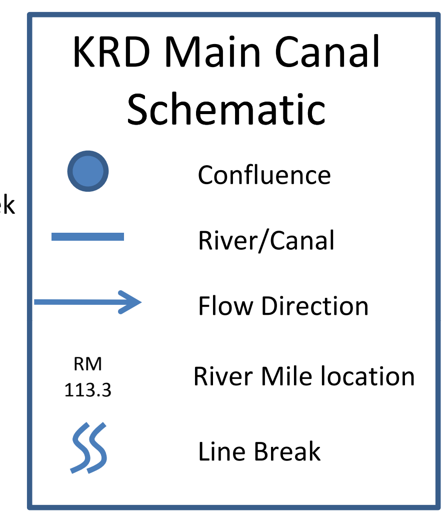
<u>Notes:</u>

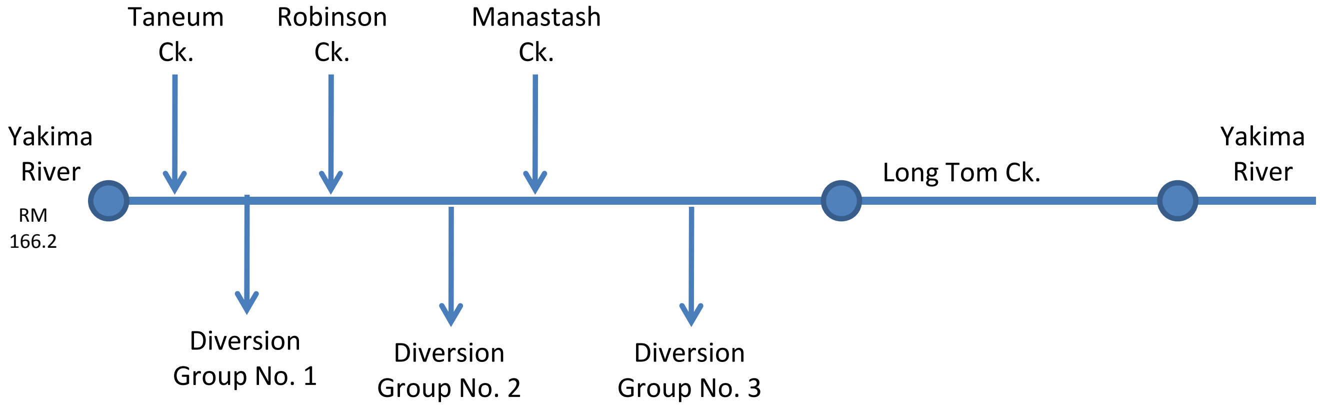
North Branch Canal:

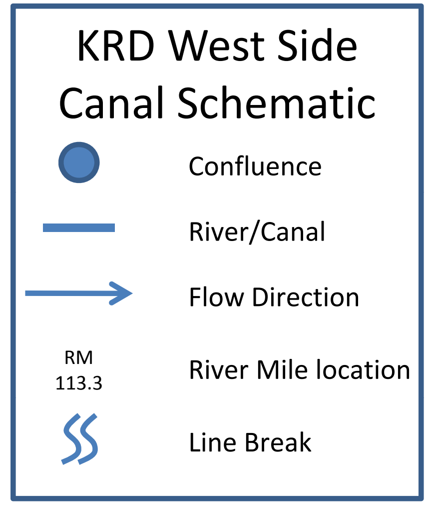
Groundwater returns from Diversion Groups 1 through 4 to Cascade Canal groundwater system
Surface water returns from Diversion Group No. 1 to Dry Creek
Surface water returns from Diversion Group No. 2 to Reecer Creek
Surface water returns from Diversion Group No. 3 to Wilson Creek
Surface water returns from Diversion Group No. 4 to Cherry Creek
A portion of Wilson Creek is captured by the canal between Diversion groups 2 and 3

South Branch Canal:

Groundwater and Surface water returns from Diversion Group No. 1 to Taneum Creek
Groundwater and Surface water returns from Diversion Group No. 2 to Robinson Creek
Groundwater and Surface water returns from Diversion Group No. 3 to Manastash Creek







<u>Notes:</u>

KRD West Side Canal:

Groundwater returns from Diversion Groups 1 through 2 to Yakima alluvium goundwater system
Groundwater returns from Diversion Group No. 3 is consumptively used
Surface water returns from Diversion Group No. 1 to Taneum Creek
Surface water returns from Diversion Group No. 2 to Robinson Creek
Surface water returns from Diversion Group No. 3 to Manastash Creek
A portion of flows from Taneum, Robinson, and Manastash creeks are captured by the canal

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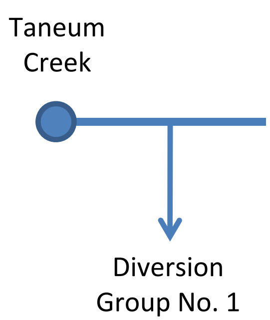
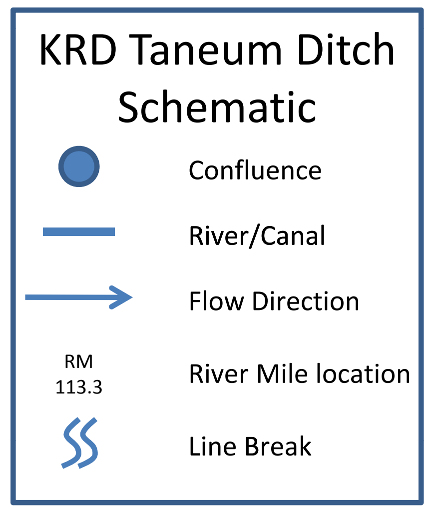
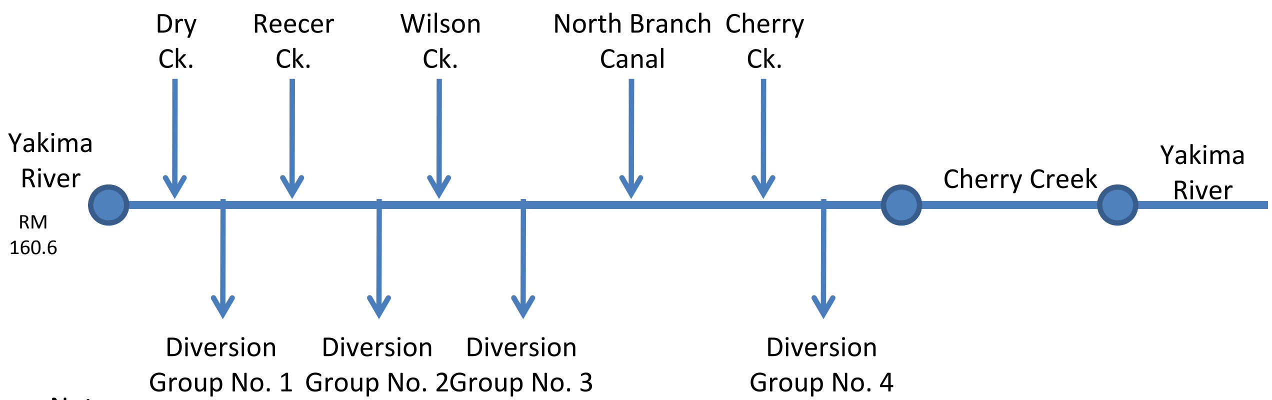


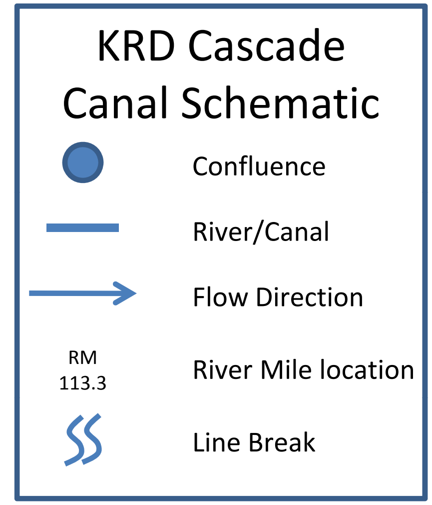


<u>Notes:</u>

KRD Taneum Ditch:

Groundwater returns from Diversion Group No. 1 to West Side canal groundwater system
Surface water returns from Diversion Group No. 1 to Taneum Creek

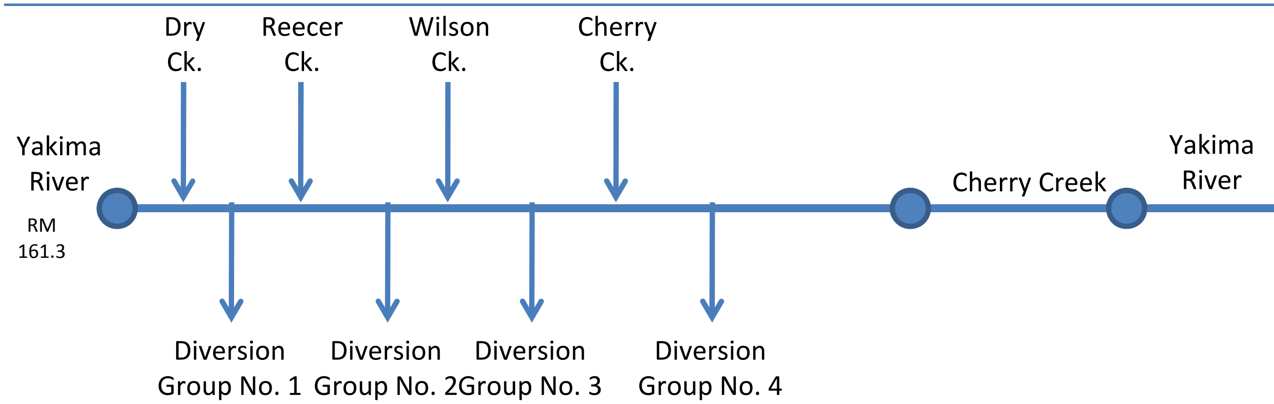


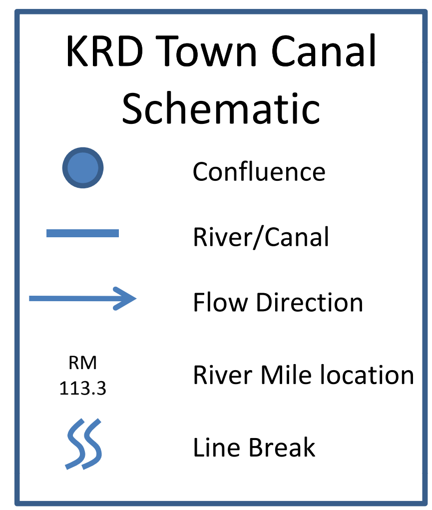


Notes:

KRD Cascade Canal:

Schematic covers the pumped portion of the canal.
Groundwater returns from Diversion Groups 1 through 4 to Town Canal groundwater system
Surface water returns from Diversion Group No. 1 to Dry Creek
Surface water returns from Diversion Group No. 2 to Reecer Creek
Surface water returns from Diversion Group No. 3 to Wilson Creek
Surface water returns from Diversion Group No. 3 to Cherry Creek
A portion of flows from Dry, Reecer, Wilson, and Cherry creeks are captured by the canal.
Flows can be diverted from the North Branch Canal into the Cascade Canal.

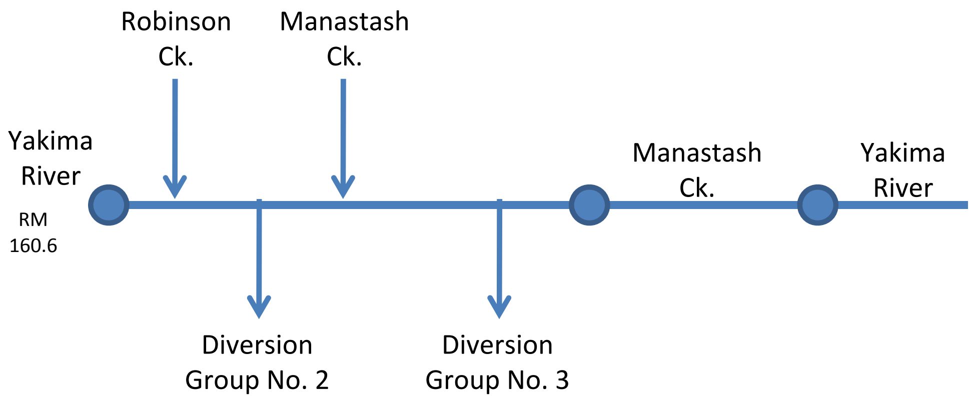


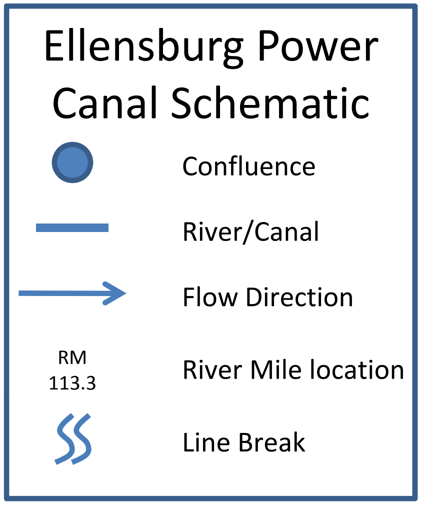


Notes:

KRD Town Canal:

Groundwater returns from Diversion Groups 1 through 4 to Yakima River alluvium groundwater system
Surface water returns from Diversion Group No. 1 to Dry Creek
Surface water returns from Diversion Group No. 2 to Reecer Creek
Surface water returns from Diversion Group No. 3 to Wilson Creek
Surface water returns from Diversion Group No. 3 to Cherry Creek
A portion of flows from Dry, Reecer, Wilson, and Cherry creeks are captured by the canal.





<u>Notes:</u>

Ellensburg Power Canal:

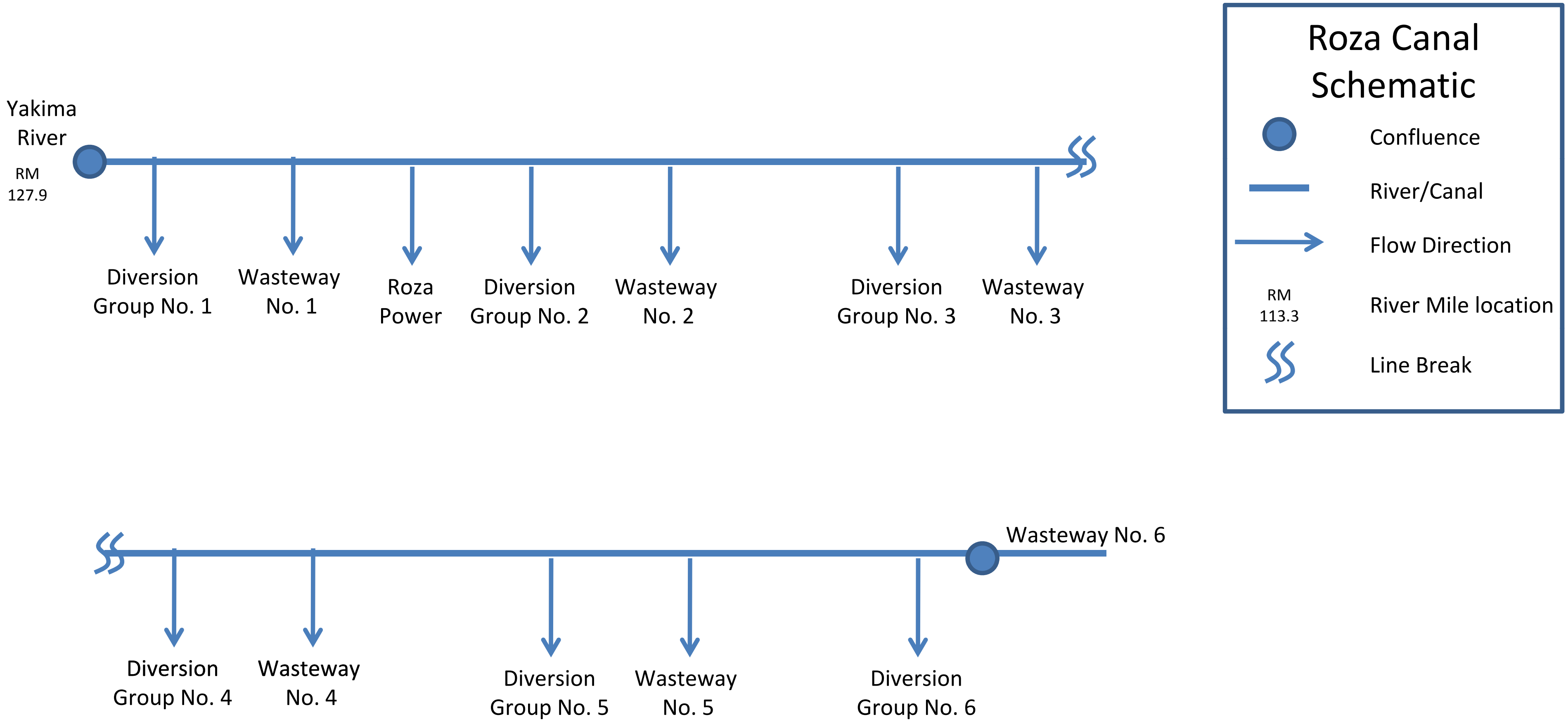
Diversion Group No. 1 is not in the model. This may indicated a reserved diversion for future use.

Groundwater returns from Diversion groups 2 and 3 to Yakima alluvium groundwater system

Surface water returns from Diversion Group No. 2 to Robinson Creek

Surface water returns from Diversion Group No. 3 to Manastash Creek

A portion of Robinson and Manastash creeks are captured by the canal.



<u>Notes:</u>

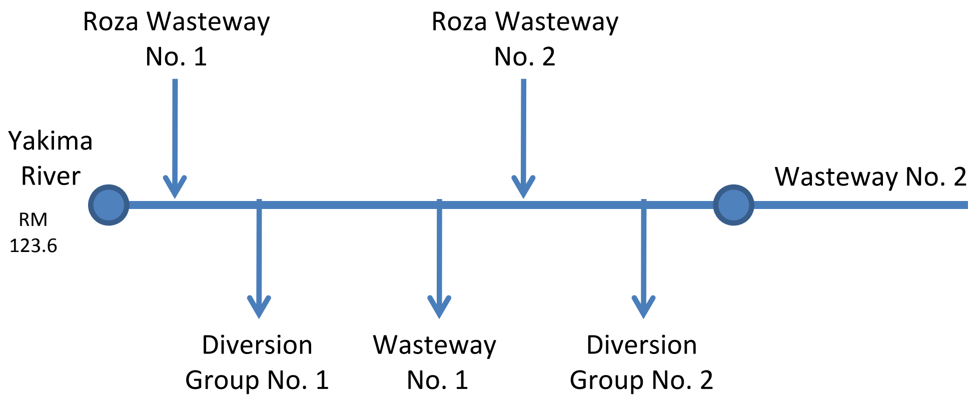
Roza Canal Schematic:

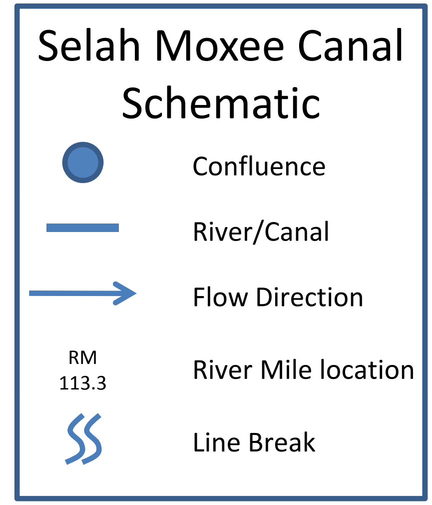
Surface water returns from Diversions return to the nearest wasteway.

Groundwater returns from Diversions No. 1 and 2 return to the Selah Moxee groundwater system

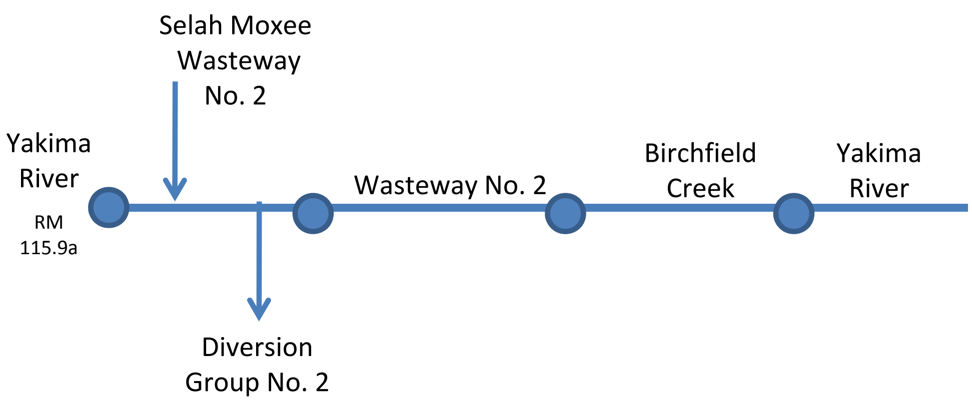
Groundwater returns from Diversion No. 3 return to the Union Gap groundwater system

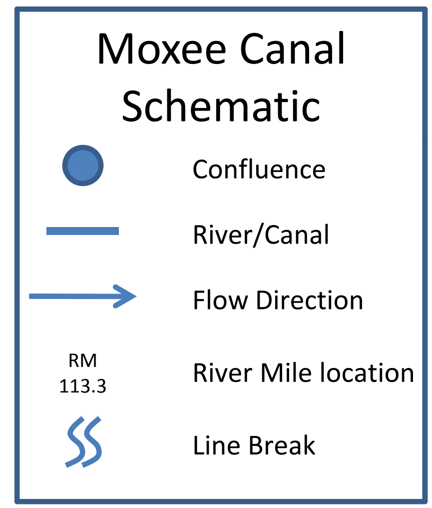
Groundwater returns from Diversions No. 4 to 6 return to the Sunnyside groundwater system



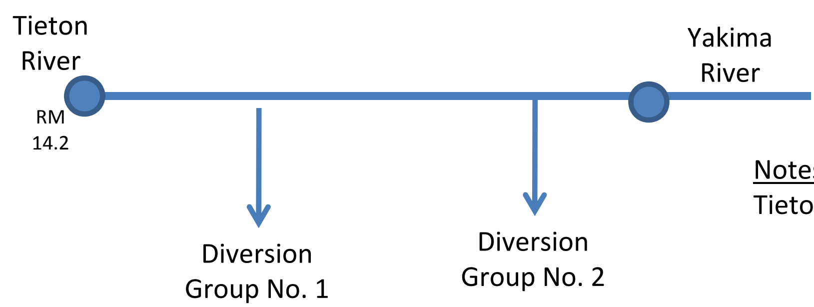


Notes:
Selah Moxee Canal Schematic:
 Surface water returns from Diversions return to the nearest wasteway.
 Groundwater returns from Diversion No. 1 return to the Hubbard groundwater system
 Groundwater returns from Diversion No. 2 return to the Moxee groundwater system
 Portions of flow from wasteways 1 and 2 are captured by the canal





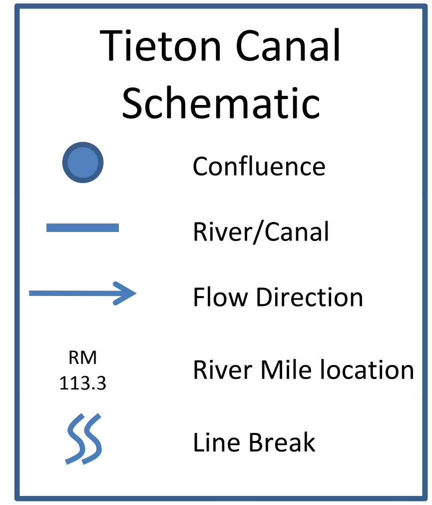
Notes:
Moxee Canal Schematic:
 Diversion Group No. 2 return flows to Wasteway No. 2
 Portions of flow from wasteway 2 are captured by the canal

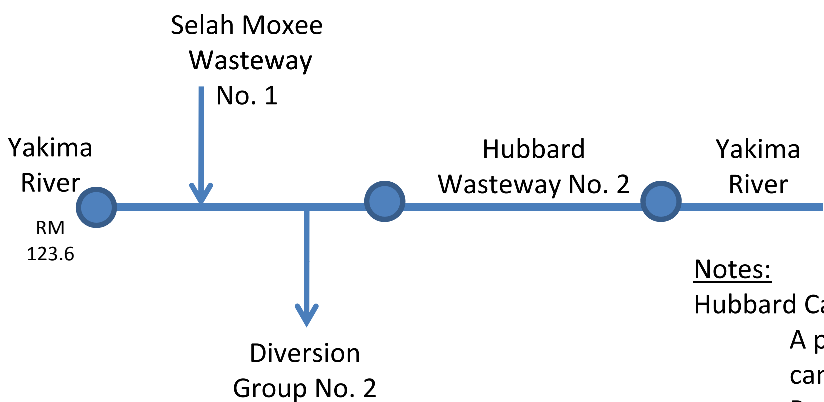


<u>Notes:</u>
Tieton Canal Schematic:

Diversion Group No. 1 return flows to Naches River

Diversion Group No. 2 return flows to Yakima River

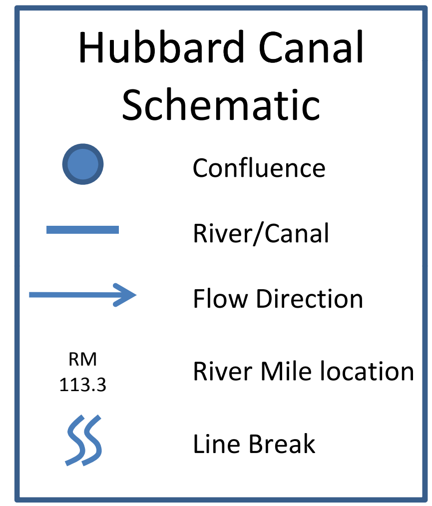


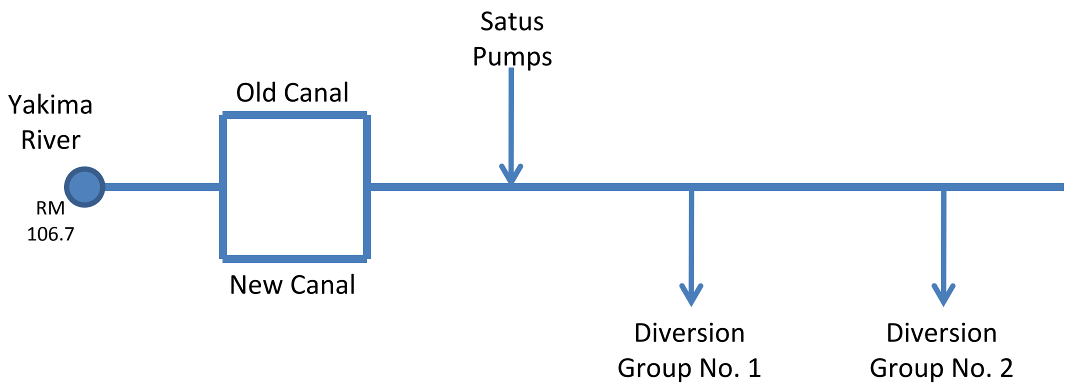


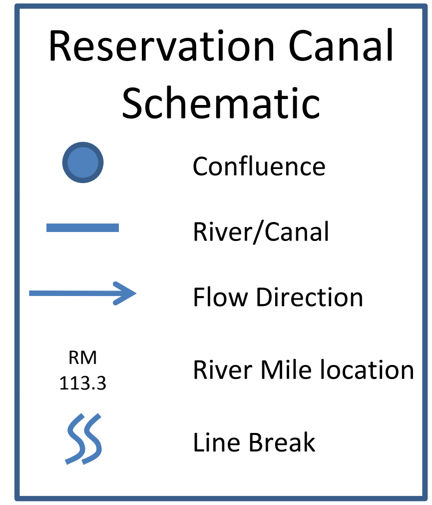
<u>Notes:</u>
Hubbard Canal Schematic:

A portion of Wasteway No. 1 is captured by the canal

Return flows to Hubbard Wasteway No. 2





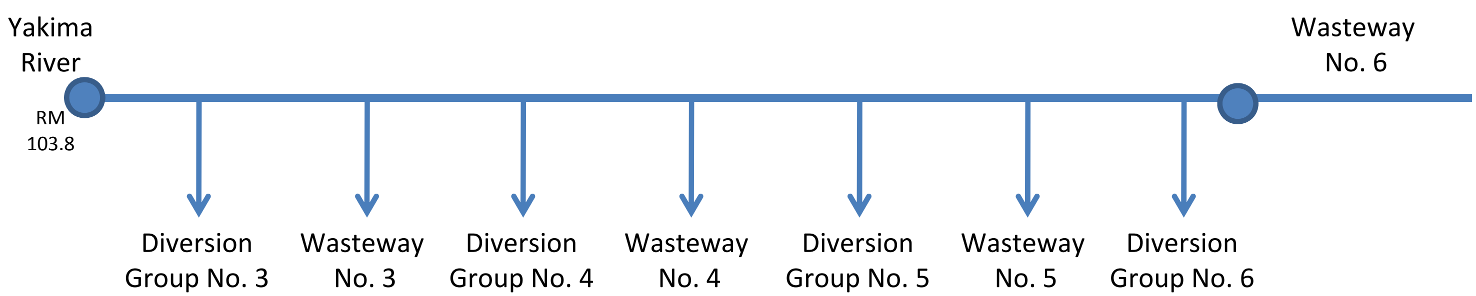


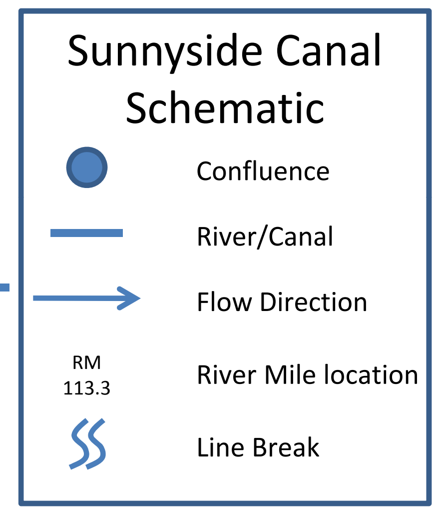
Notes:

Reservation Canal Schematic:

Two canal diversions (Old and New canals) from the Yakima River and one pumping (Satus) diversion

Diversion groups No. 1 and 2 return flows to Yakima River.

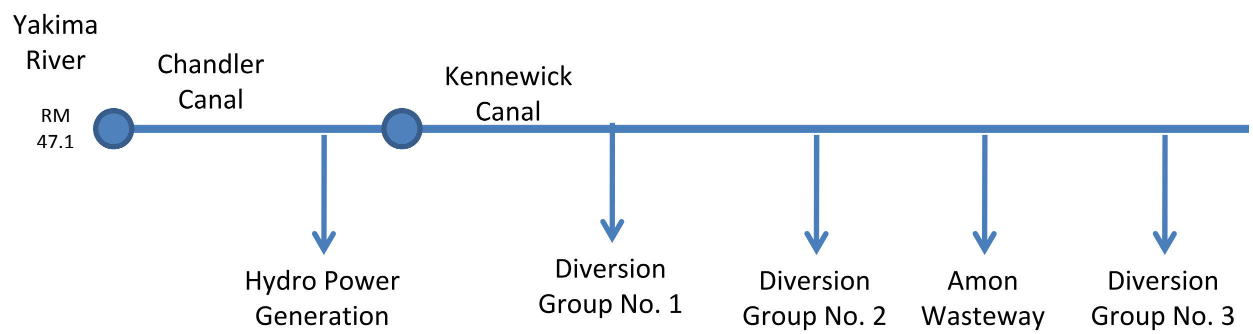


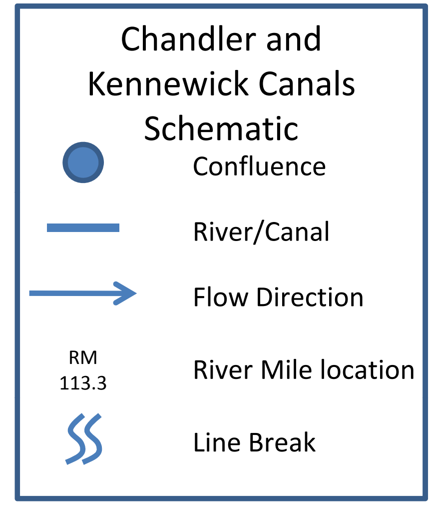


Notes:

Sunnyside Canal Schematic:

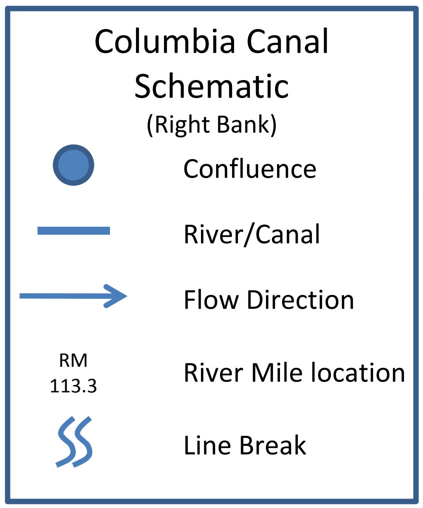
Return flows from Diversions are to nearest wasteway.

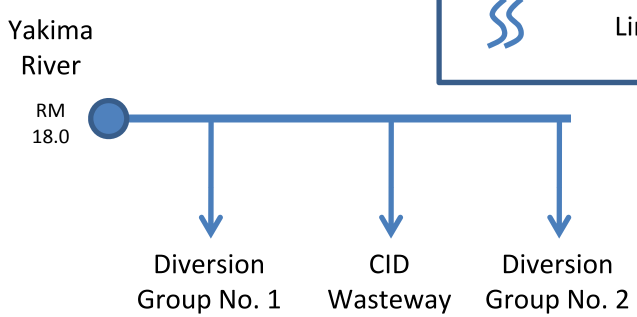




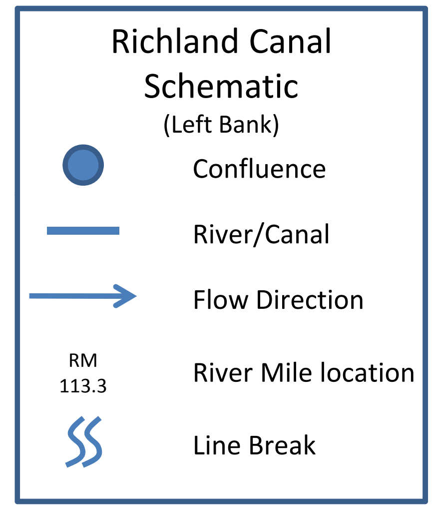
<u>Notes:</u>
Chandler and Kennewick Canals Schematic:
All return flows are to Yakima River except for Diversion Group No. 3 which is to Columbia River

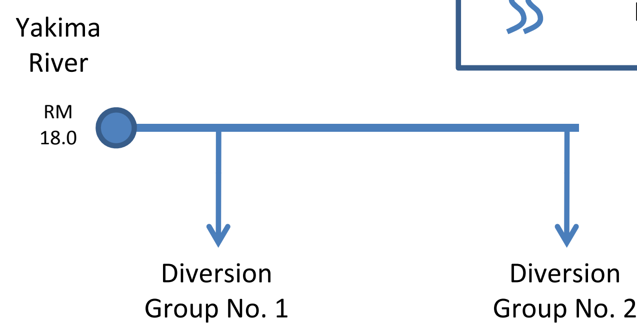
Notes:
Diversion Group No. 1 return flows to Yakima River
Diversion Group No. 2 return flows to Columbia River





Notes:
Diversion Group No. 1 return flows to Yakima River
Diversion Group No. 2 return flows to Columbia River
This canal may be referred to as the Horn Rapids Canal by USGS





Appendix B –

Integrated Plan Results

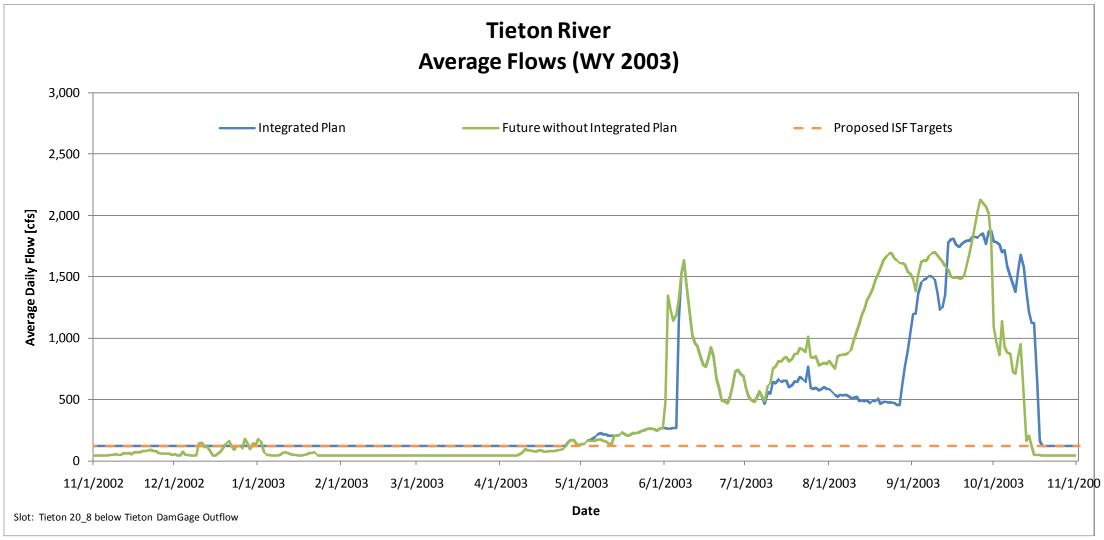
Hydrologic Indicator	Integrated Plan					Future without Integrated Plan				
	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997
April 1 TWSA (maf)						2.79				
April-September flow volume at Parker gage (kaf)	3.00 605	2.22 245	198	2.32 181	4.73 1937	644	1.74 313	1.76 252	1.71 245	4.52 1937
March-October flow volume at Parker gage (kaf)	907	400	2.45 335	310	2638	940	456	377	366	2603
April-September diversion volume upstream of Parker gage (maf)	1.69	1.52	1.55	1.53	1.73	1.61	1.23	1.29	1.25	1.71
September 30 non-Bumping or Wymer reservoir contents (kaf)	348	-121	75	-19	709	218	41	48	62	510
October 31 non-Bumping or Wymer reservoir contents (kaf)	329	-120	74	-26	802	213	65	67	56	619
September 30 Bumping and Wymer reservoir contents (kaf)	229	56	145	144	267	15	7	11	14	18
April-September flow volume at mouth of Yakima River (kaf)	867	349	272	293	2262	888	386	300	333	2245
Irrigation proration level (percent)[1]	92%	70%	70%	70%	100%	80%	21%	32%	28%	100%

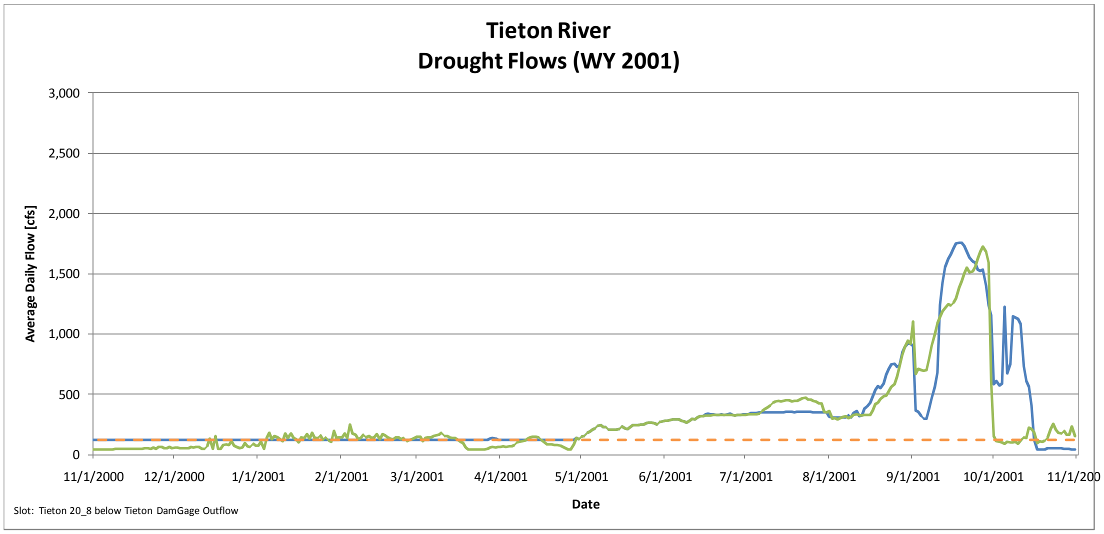
Resource indicator (measurement)	Integrated Plan	Future without Integrated Plan
WATER RESOURCES		
Average for water years 1981–2005 (maf)		
Water supply		
April 1 total water supply available (TWSA)	3.00	2.79
Water distribution		
April–September Parker flow volume	0.60	0.64
April–September diversion	1.69	1.61
September 30 reservoir contents	0.58	0.24
April–September flow volume at mouth of Yakima River	0.87	0.89
1994 dry-year (maf)		
Water supply		
April 1 TWSA	2.22	1.74
Water distribution		
April–September Parker flow volume	0.25	0.31
April–September diversion	1.52	1.23
September 30 reservoir contents	-0.06	0.05
April–September flow volume at mouth of Yakima River	0.35	0.39
Irrigation proration level	70%	21%

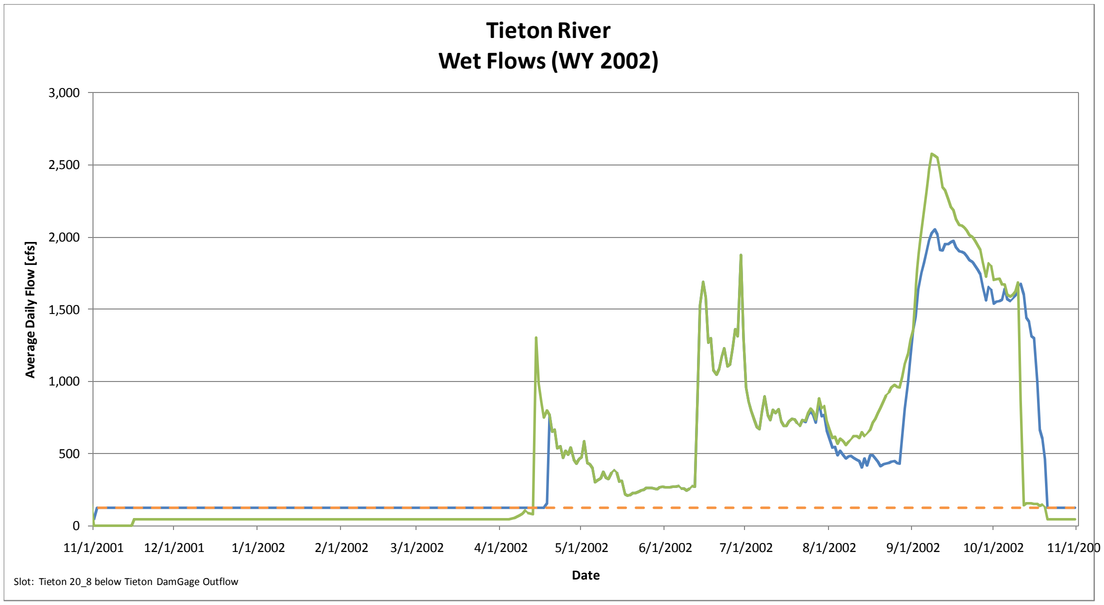
Resource indicator (measurement)	Integrated Plan	Future without Integrated Plan
ANADROMOUS FISH		
Rate of change in flow during flip-flop (average cfs/day August 16–September 14)		
Easton reach	-7	-21
Ellensburg reach	-45	-103
Lower Naches River reach	31	33
Pre- (August 1-15) and post- (September 14-28) flip-flop flow and absolute change in flow		
Easton reach		
Pre-flip-flop flow (cfs)	574	890
Post-flip-flop flow (cfs)	364	287
Absolute change in flow (cfs)	-211	-603
Ellensburg reach		
Pre-flip-flop flow (cfs)	2,867	4,346
Post-flip-flop flow (cfs)	1,574	1,364
Absolute change in flow (cfs)	-1,293	-2,982
Lower Naches River reach		
Pre-flip-flop flow (cfs)	644	824
Post-flip-flop flow (cfs)	1,548	1,776
Absolute change in flow (cfs)	904	953

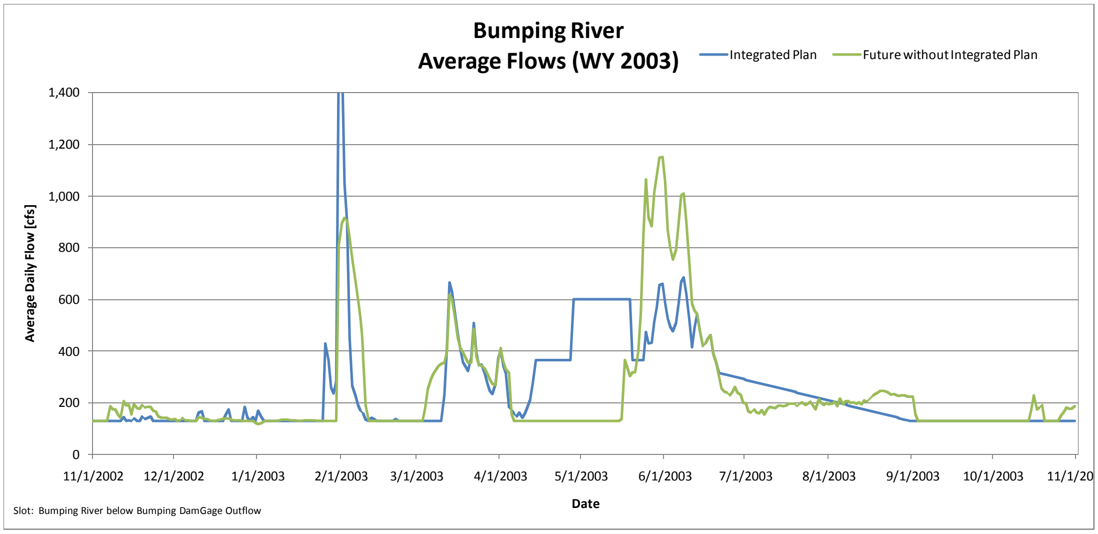
Average, minimum, and maximum reservoir elevation (feet) during bull trout spawning migration: July 15–September 15 (feet)		
Kachess Lake	2235.41 2146.99-2261.96	2239.13 2198.02-2261.96
Keechelus Lake	2476.7 2432.28-2516.96	2465.38 2432.44-2516.88
Rimrock Lake	2914.66 2801.26-2926	2905.93 2846.64-2926

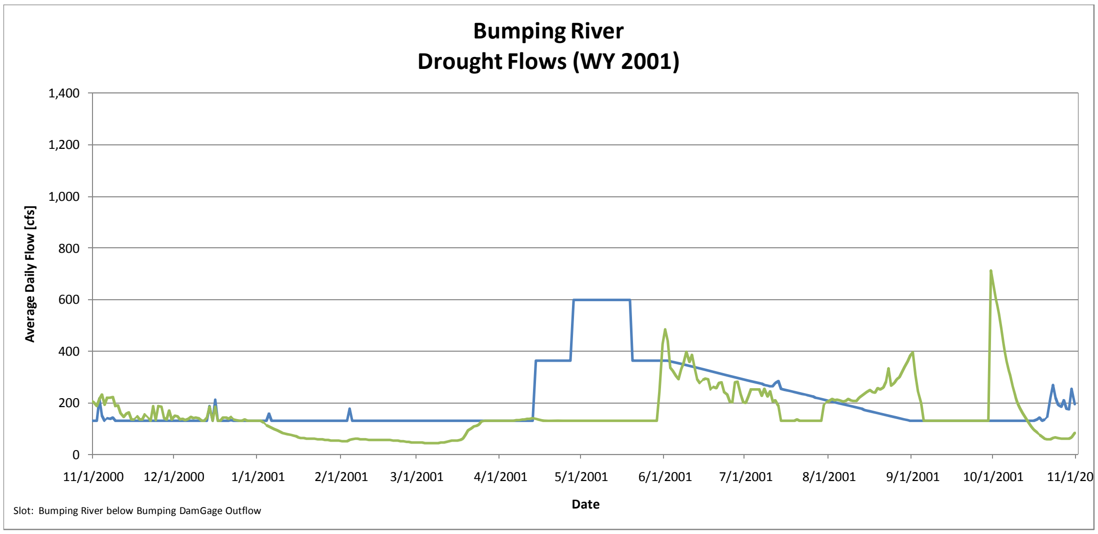
Item	Future without Integrated Plan	Integrated Plan	Improvement
Average 1981-2005			
TWSA [April 1, kaf]	2789.0	3004.9	215.9
March-October flow volume at Parker gage [kaf]	940.2	906.7	-33.6
Drought Year 1994			
TWSA [April 1, kaf]	1740.3	2215.7	475.4
March-October flow volume at Parker gage [kaf]	456.2	399.8	-56.4
Drought Year 2001			
TWSA [April 1, kaf]	1762.1	2453.2	691.1
March-October flow volume at Parker gage [kaf]	377.4	335.5	-41.9
Drought Year 2005			
TWSA [April 1, kaf]	1706.3	2320.8	614.5
March-October flow volume at Parker gage [kaf]	365.7	310.2	-55.5
Wet Year 1997			
TWSA [April 1, kaf]	4517.9	4728.6	210.7
March-October flow volume at Parker gage [kaf]	2603.3	2638.3	35.0

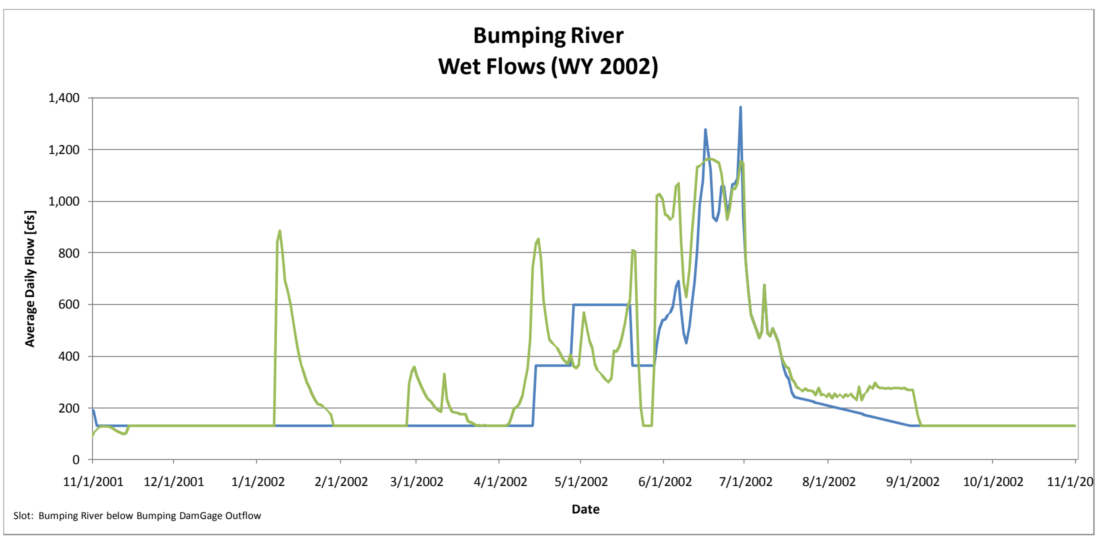

Tieton River
Average Flows (WY 2003)
Integrated Plan
Future without Integrated Plan
Proposed ISF Targets
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

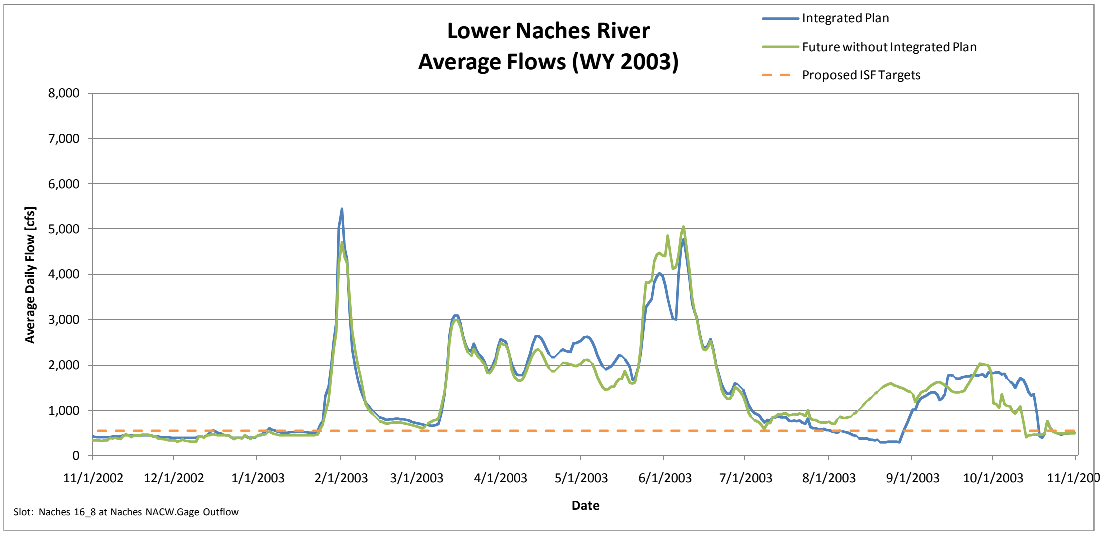

Tieton River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

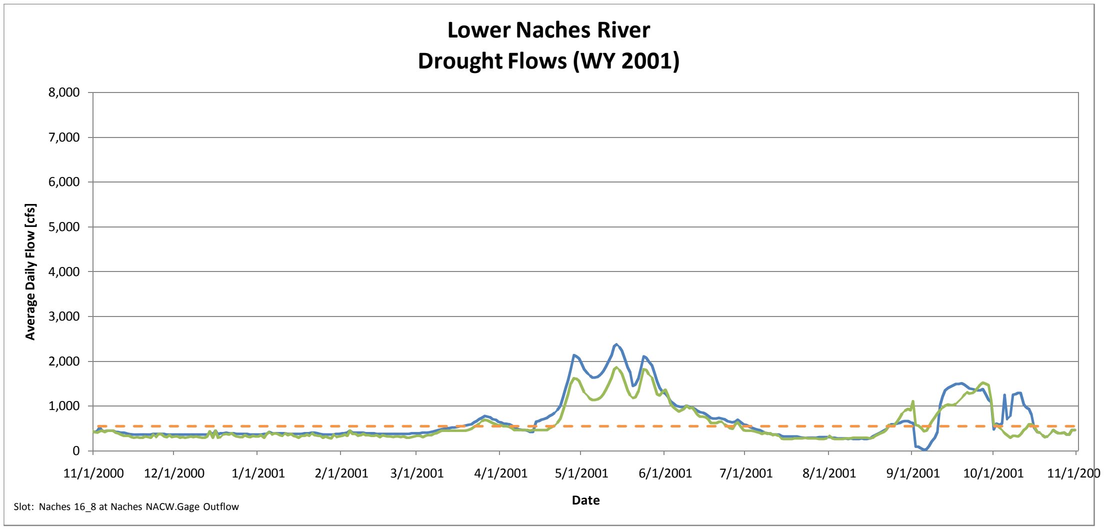

Tieton River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

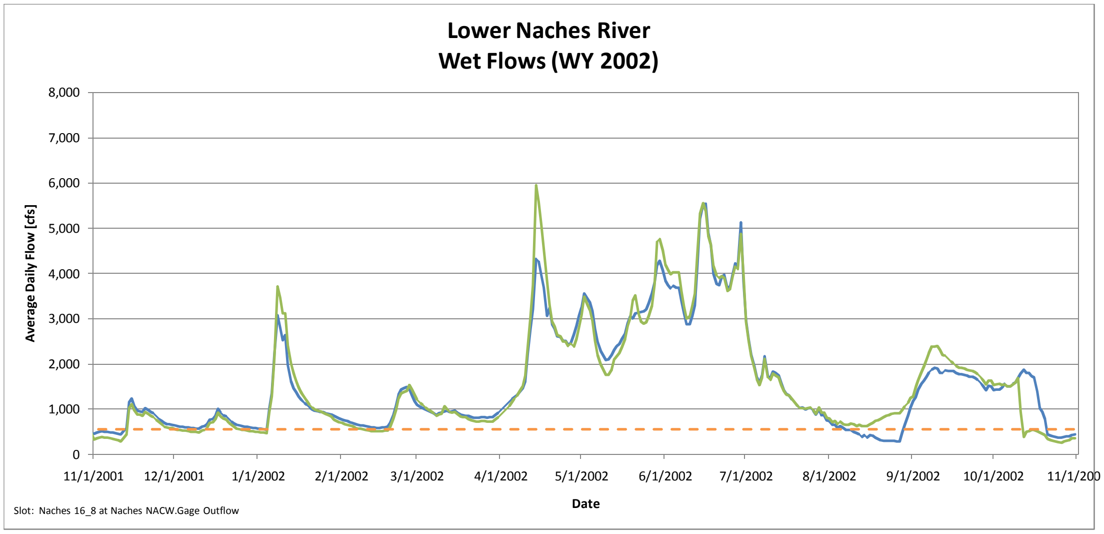

Bumping River
Average Flows (WY 2003)
Integrated Plan
Future without Integrated Plan
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

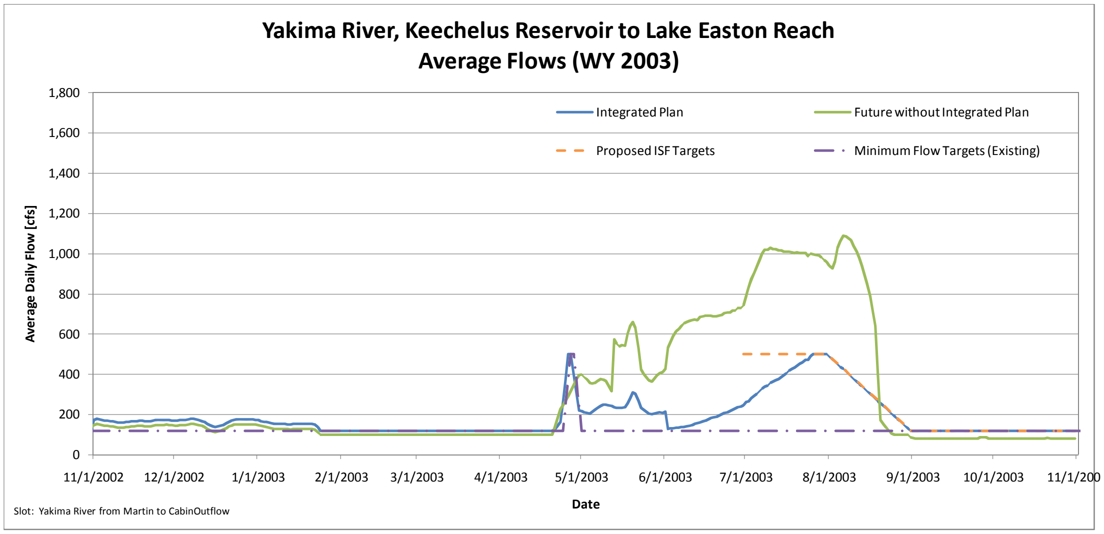

Bumping River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

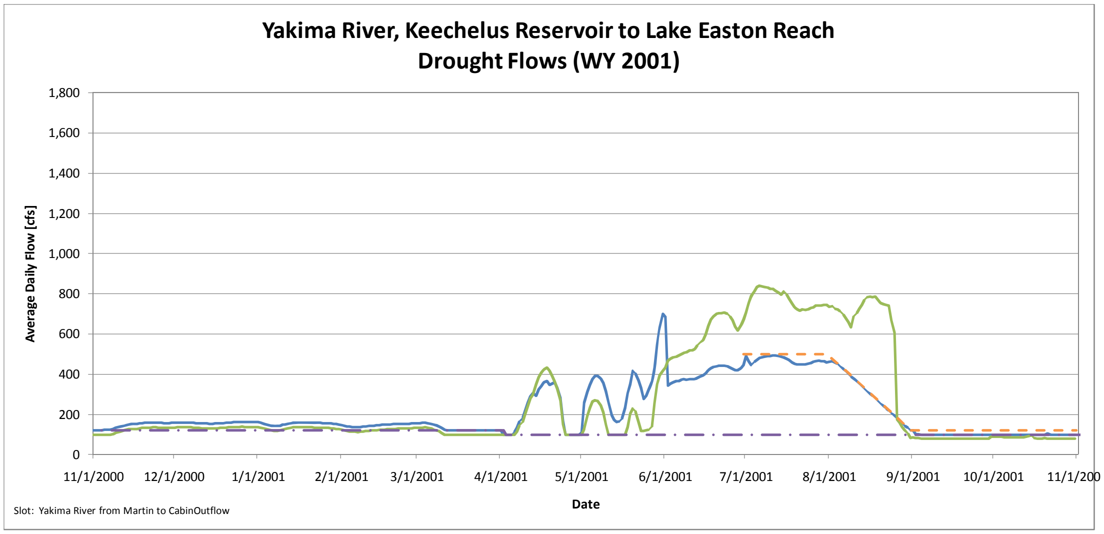

Bumping River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

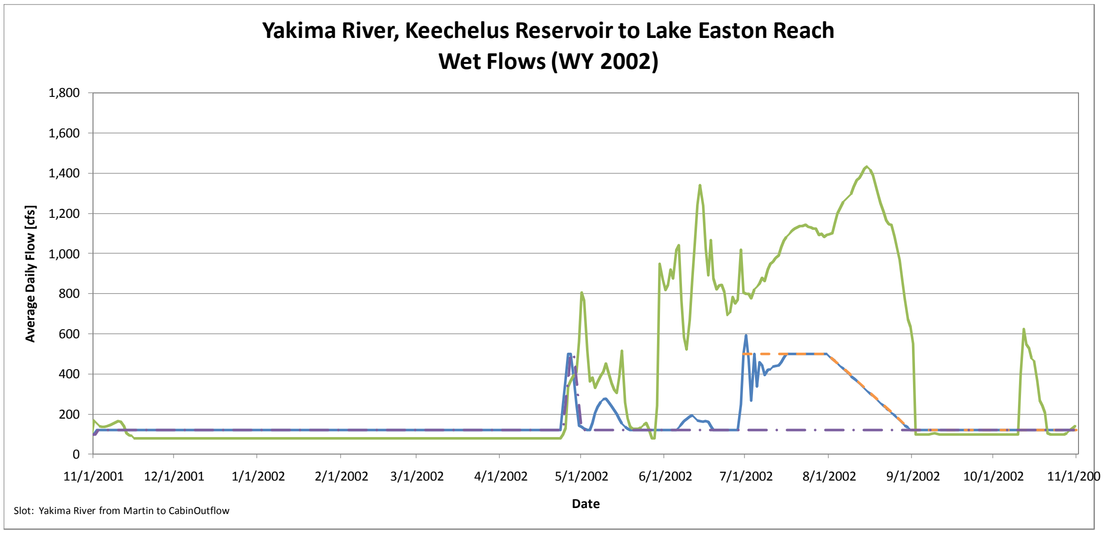

Lower Naches River
Average Flows (WY 2003)
Integrated Plan
Future without Integrated Plan
Proposed ISF Targets
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

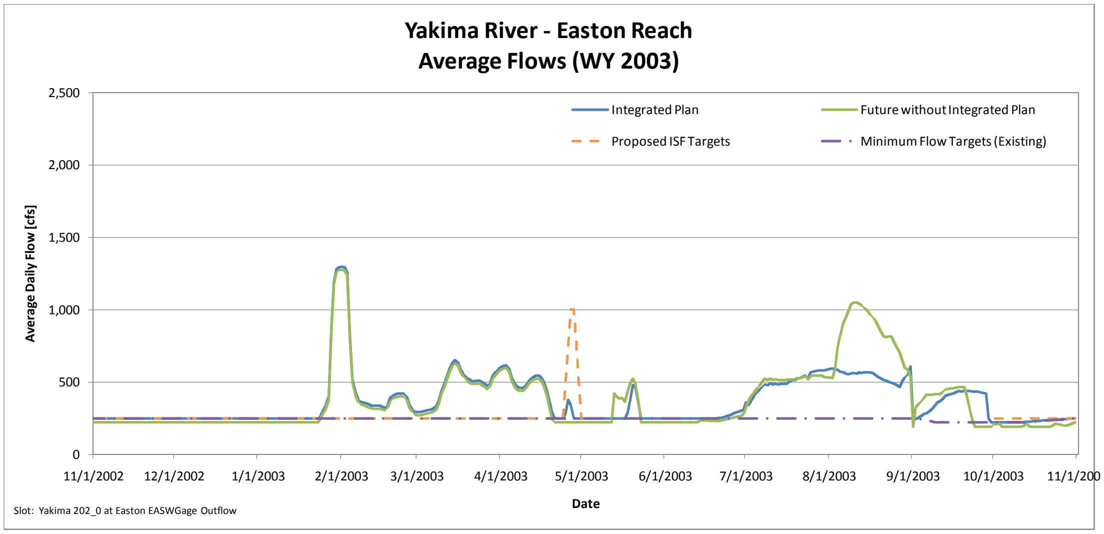

Lower Naches River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

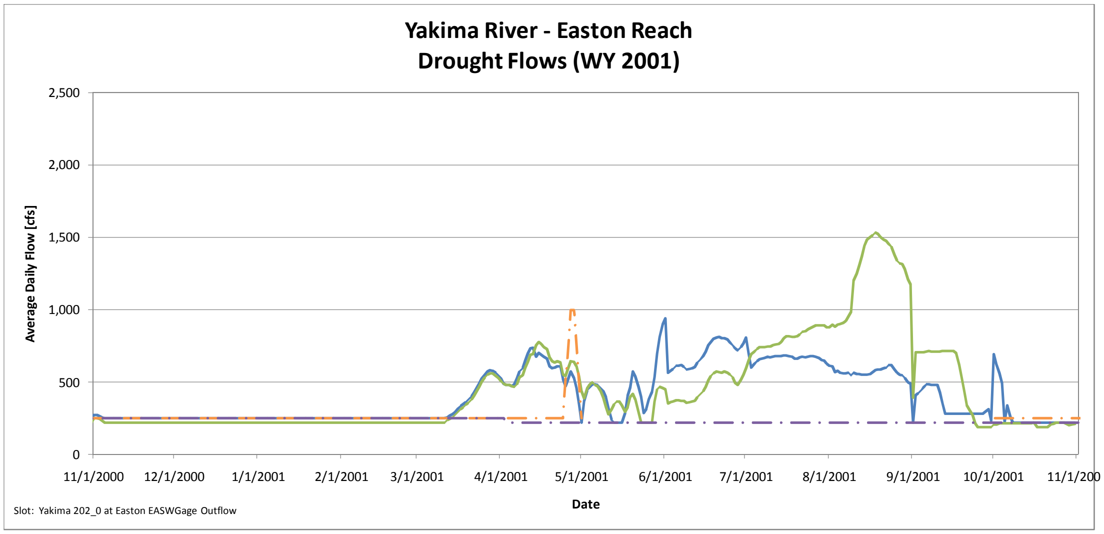

Lower Naches River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

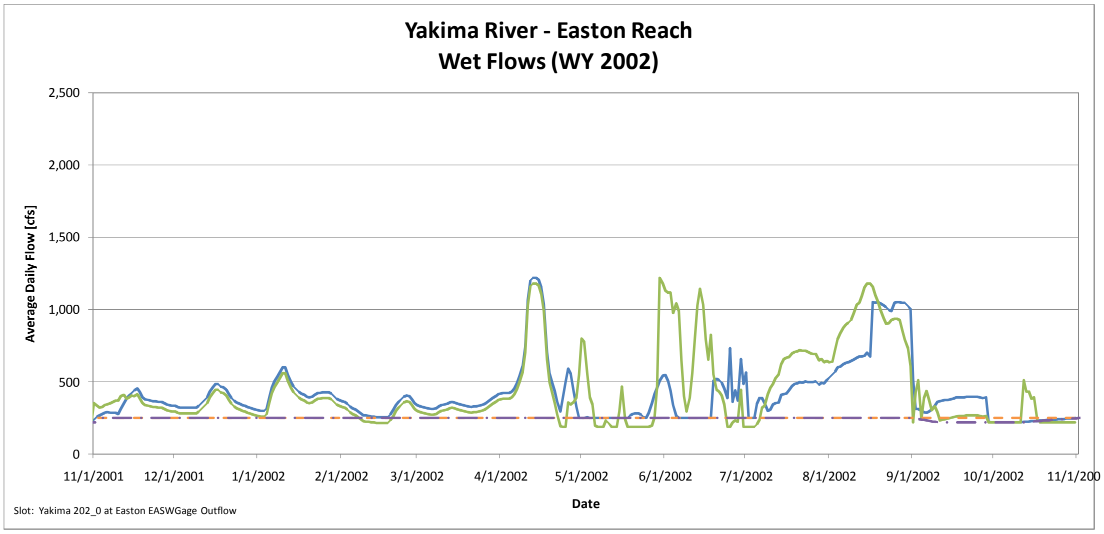

Yakima River, Keechelus Reservoir to Lake Easton Reach
Average Flows (WY 2003)
Integrated Plan
Future without Integrated Plan
Proposed ISF Targets
Minimum Flow Targets (Existing)
Average Daily Flow [cfs]
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Yakima River from Martin to CabinOutflow

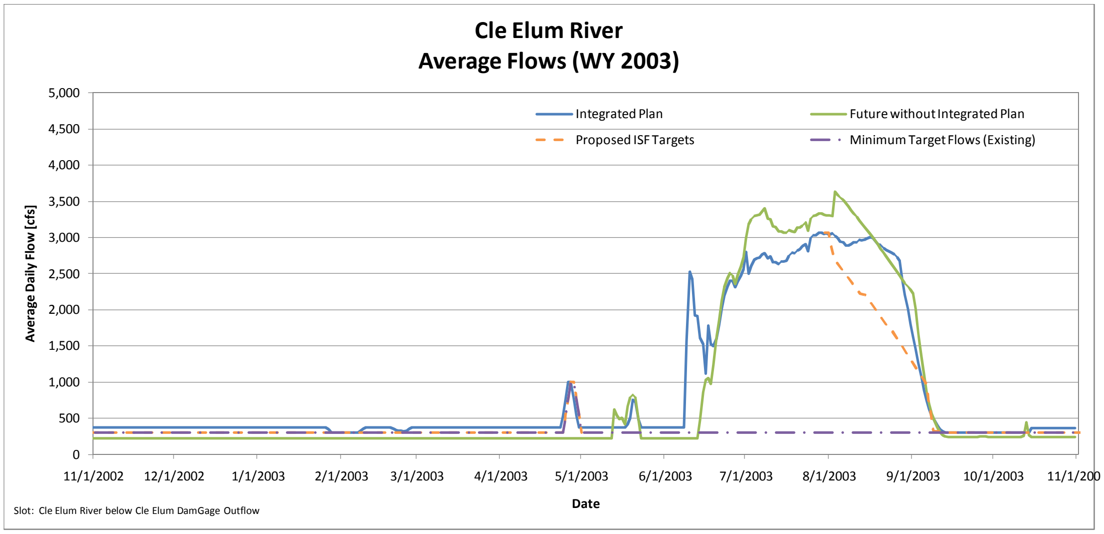

Yakima River, Keechelus Reservoir to Lake Easton Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Yakima River from Martin to CabinOutflow

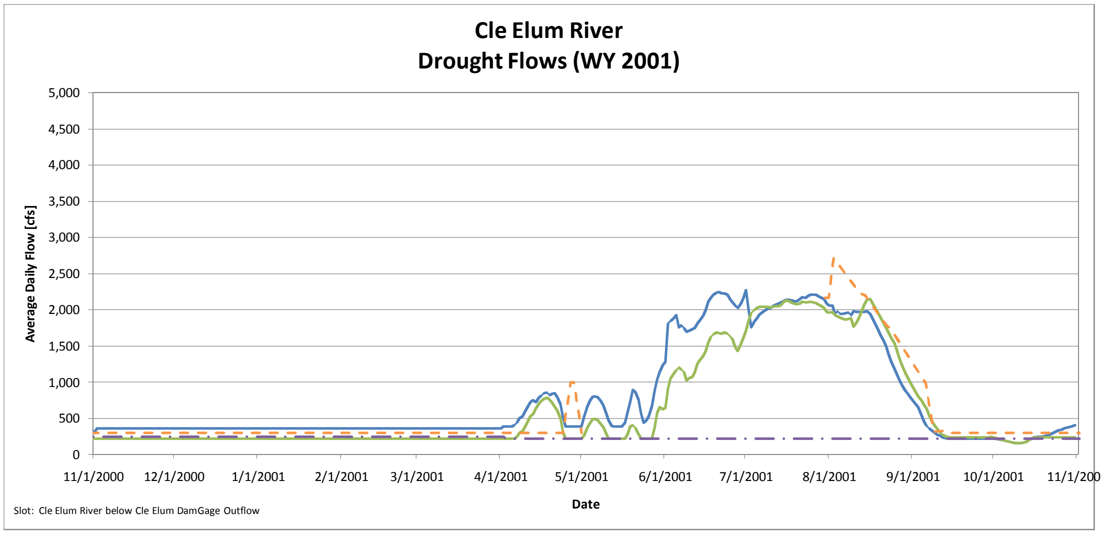

Yakima River, Keechelus Reservoir to Lake Easton Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Yakima River from Martin to CabinOutflow

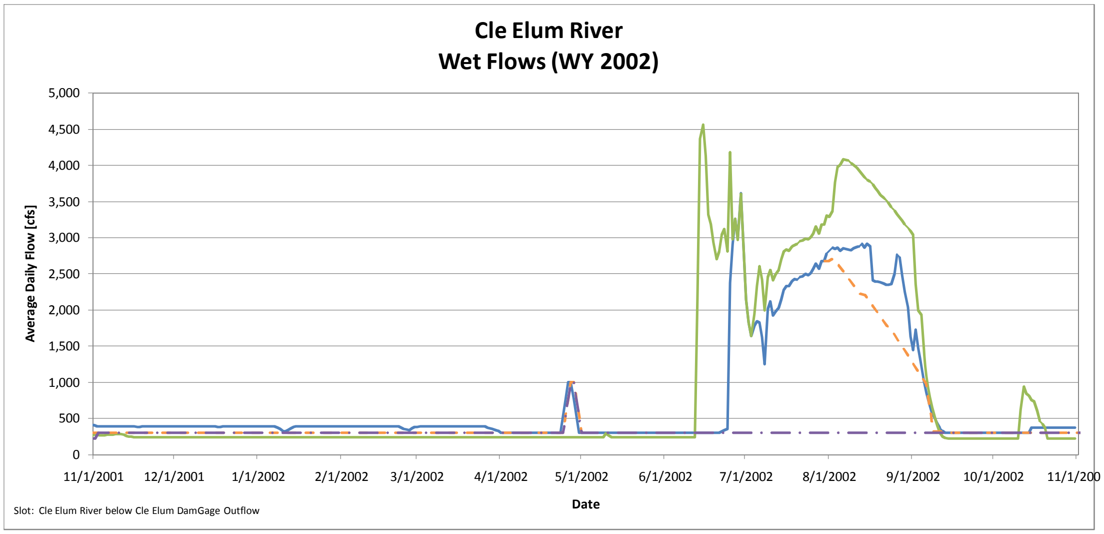

Yakima River - Easton Reach
Average Flows (WY 2003)
Average Daily Flow [cfs]
2,500
2,000
1,500
1,000
500
0
Integrated Plan
Future without Integrated Plan
Proposed ISF Targets
Minimum Flow Targets (Existing)
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

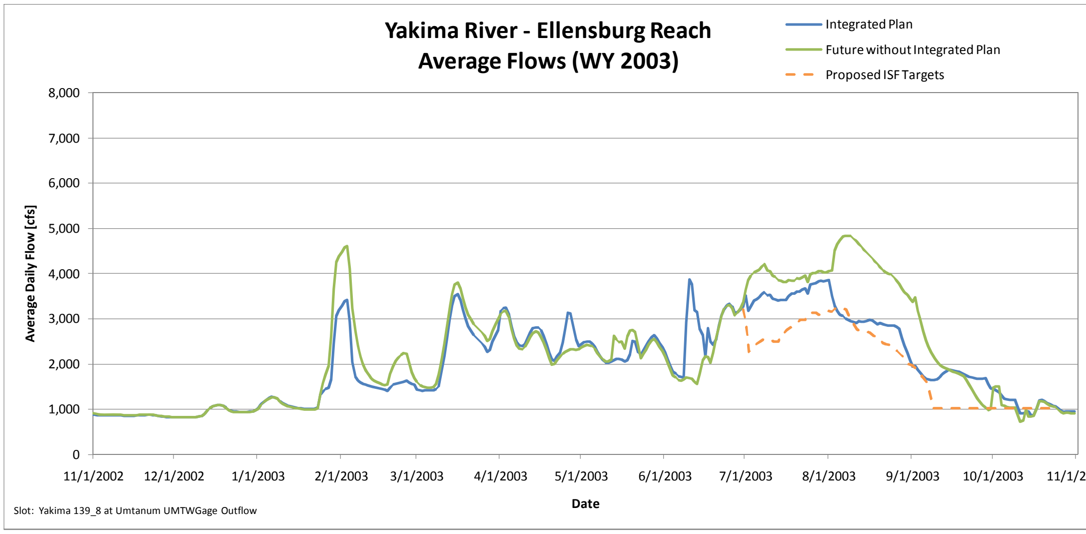

Yakima River - Easton Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

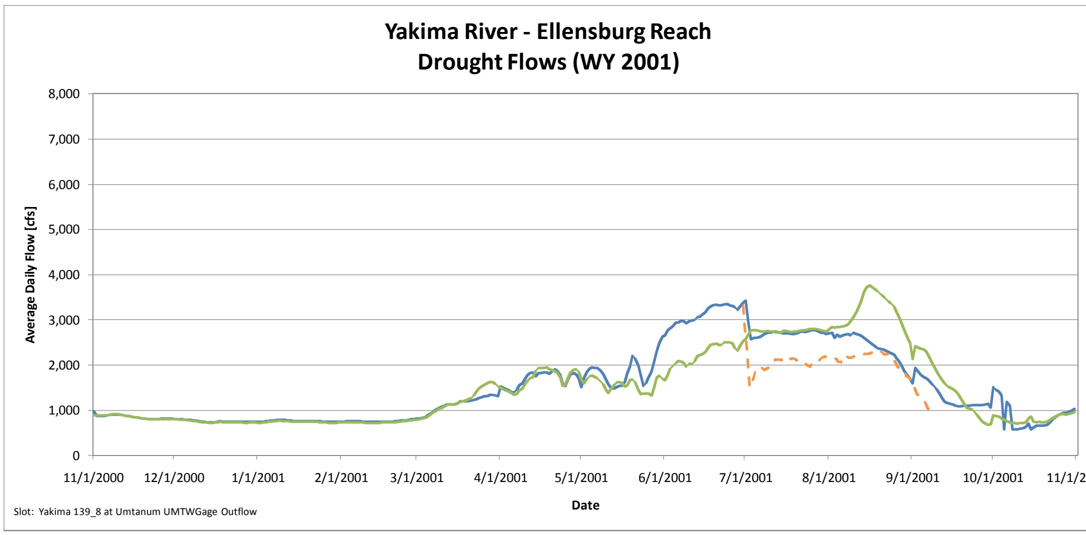

Yakima River - Easton Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

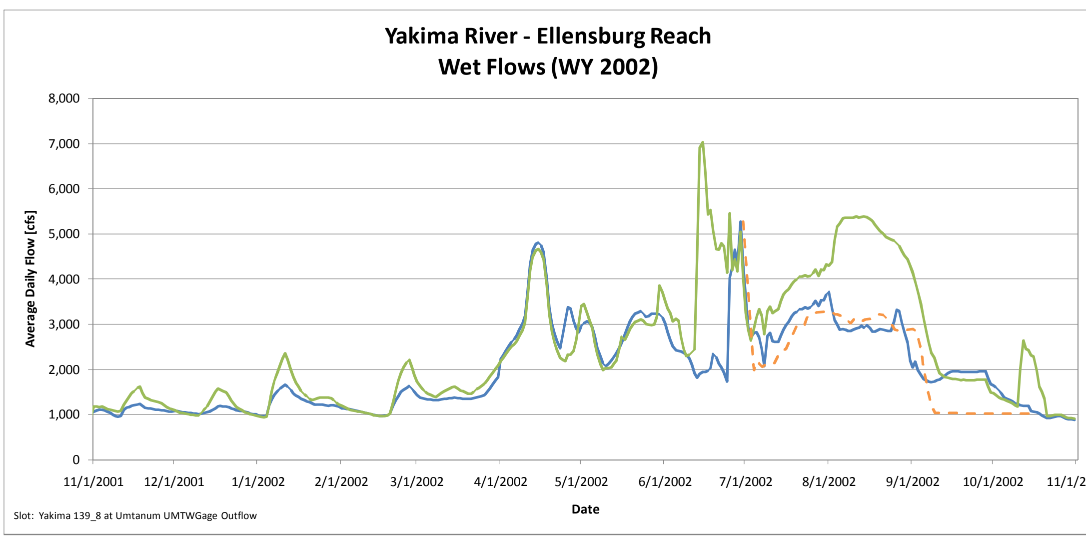

Cle Elum River
Average Flows (WY 2003)
Integrated Plan
Future without Integrated Plan
Proposed ISF Targets
Minimum Target Flows (Existing)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

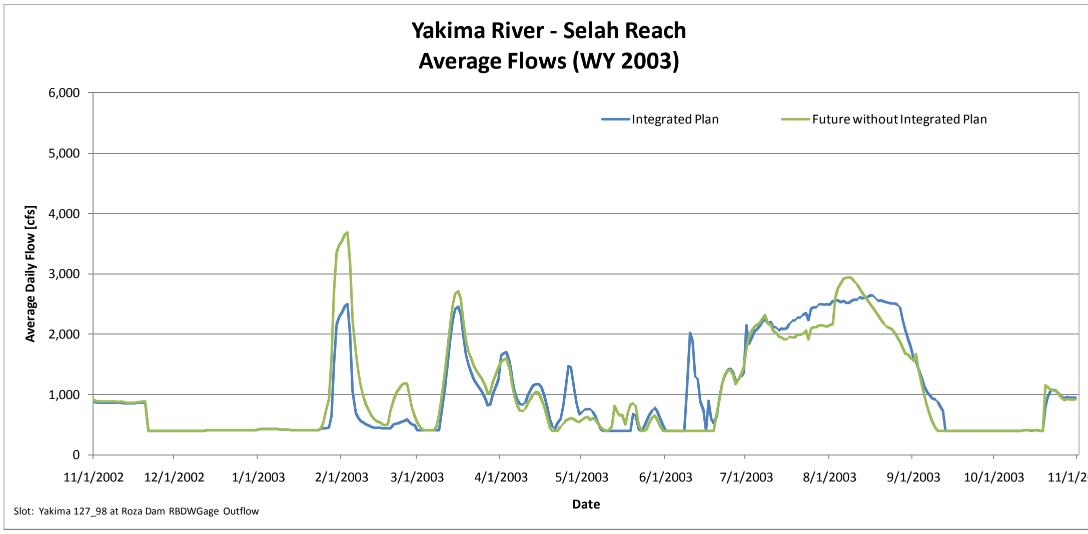

Cle Elum River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

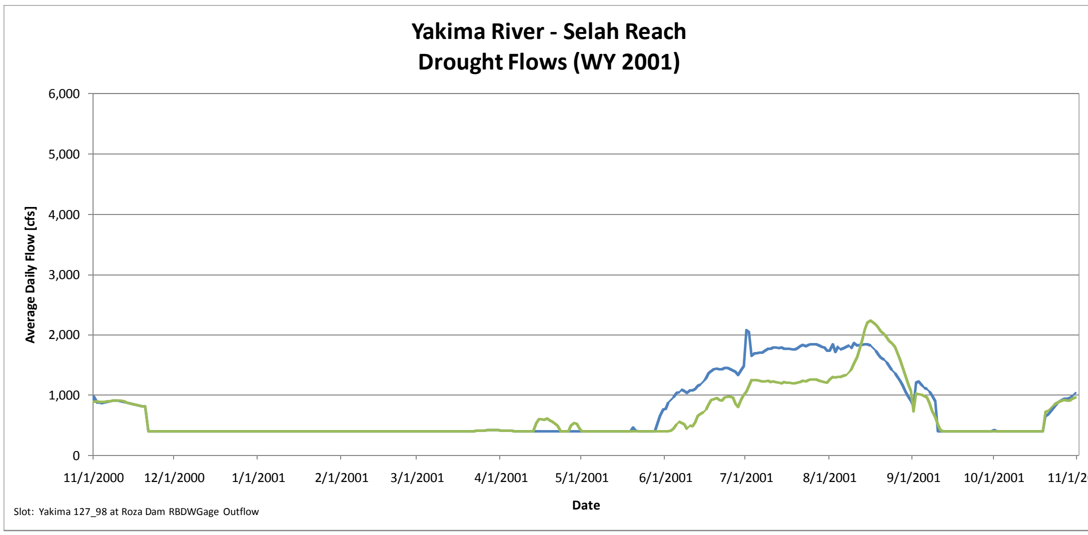

Cle Elum River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

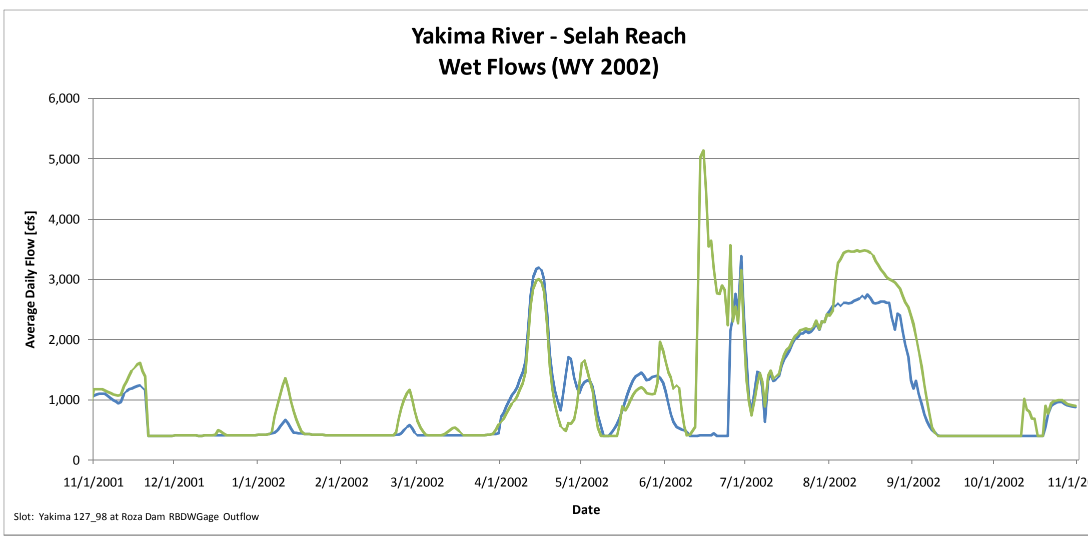

Yakima River - Ellensburg Reach
Average Flows (WY 2003)
Integrated Plan
Future without Integrated Plan
Proposed ISF Targets
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

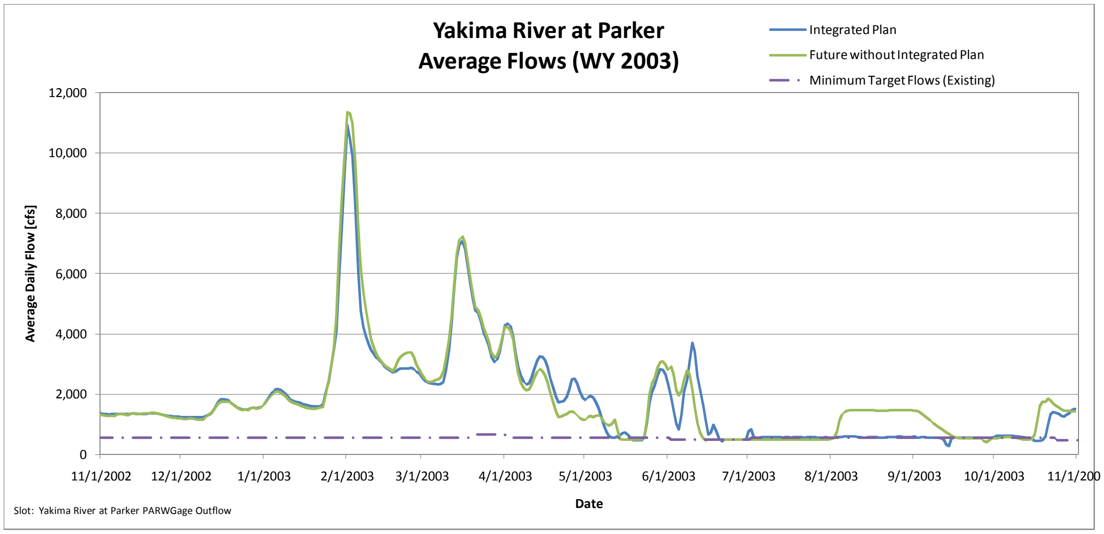

Yakima River - Ellensburg Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

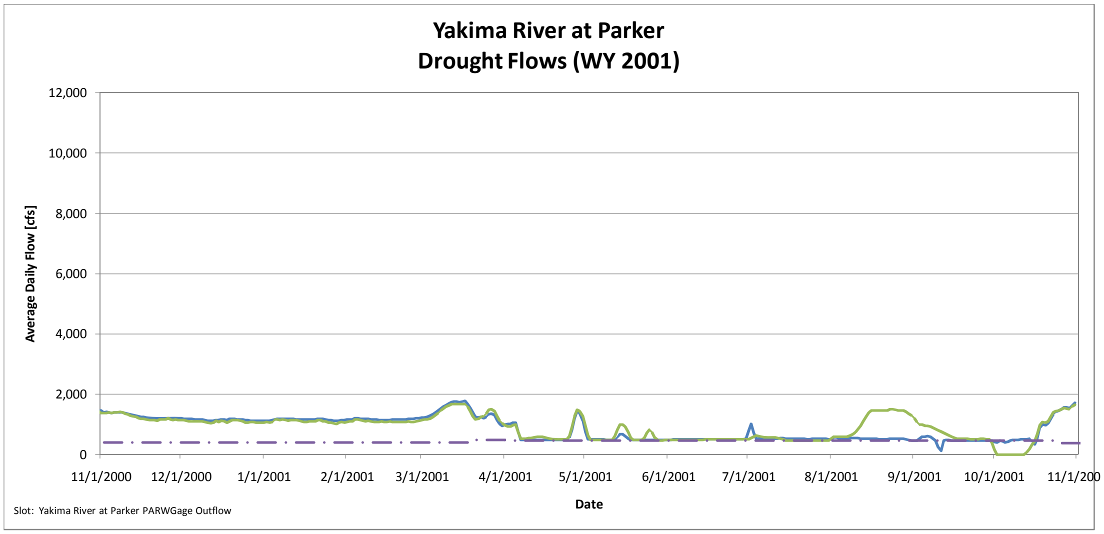

Yakima River - Ellensburg Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

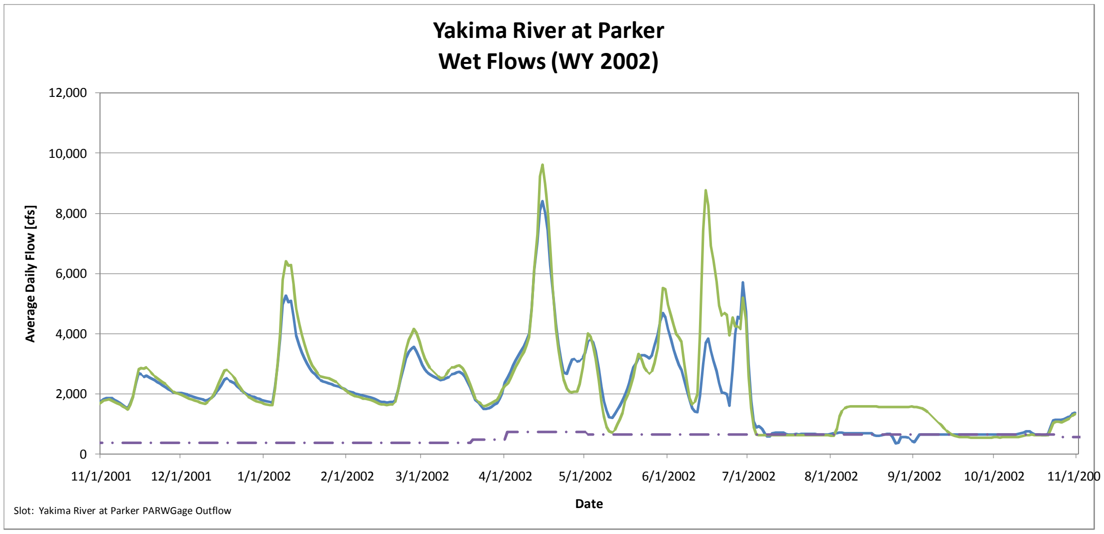

Yakima River - Selah Reach
Average Flows (WY 2003)
Integrated Plan
Future without Integrated Plan
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

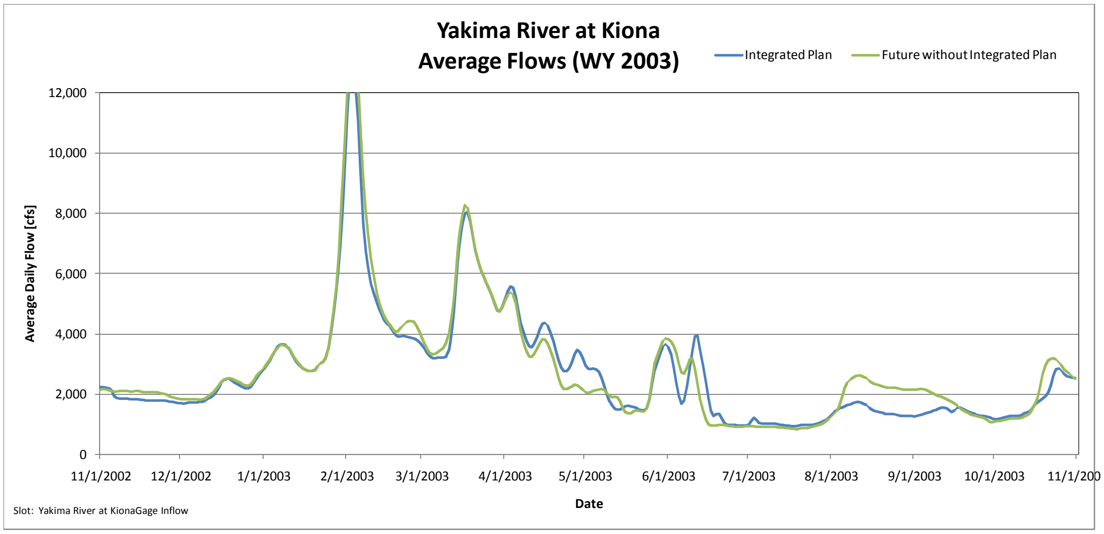

Yakima River - Selah Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

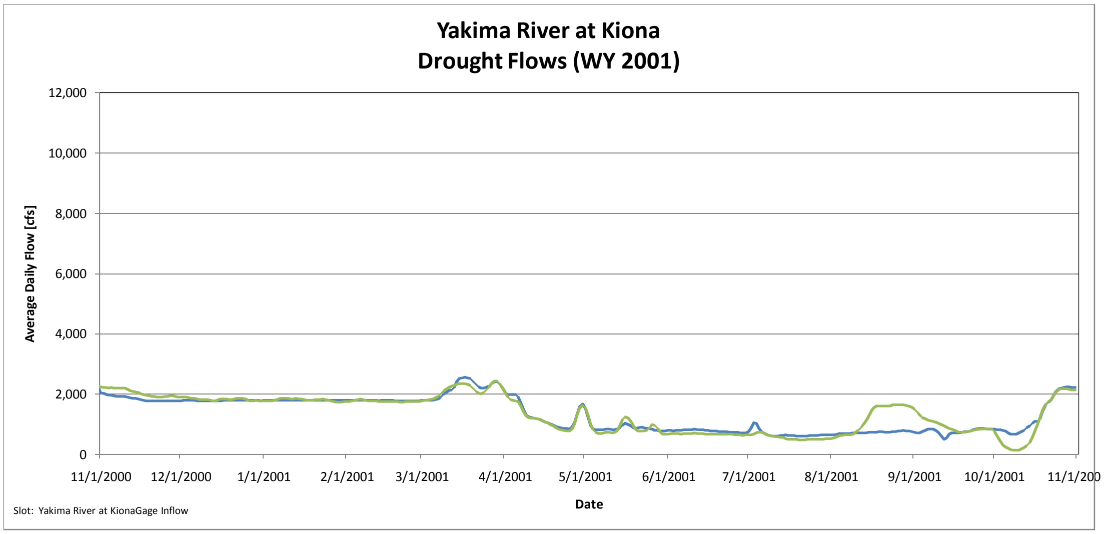

Yakima River - Selah Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

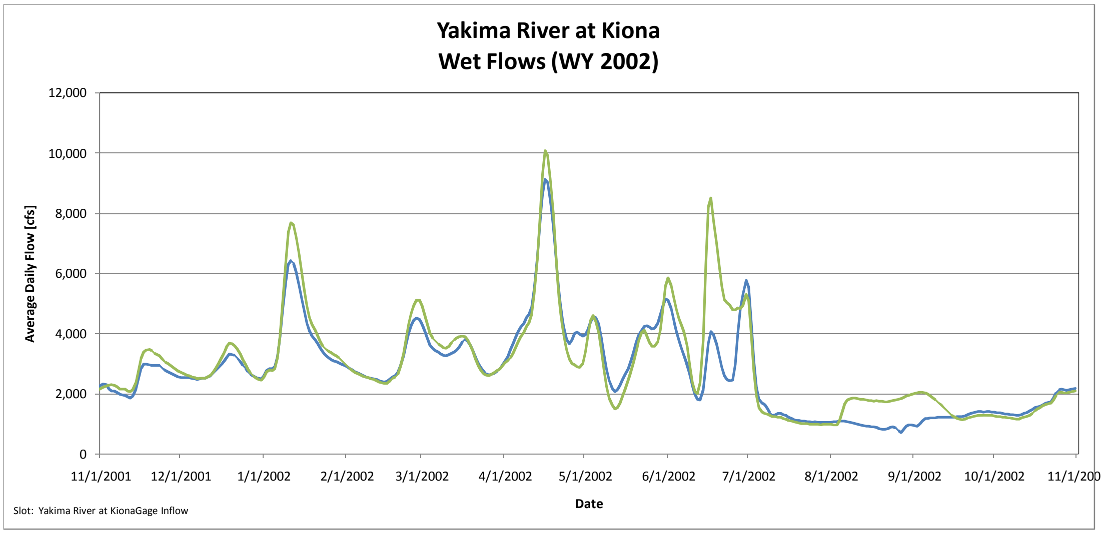

Yakima River at Parker
Average Flows (WY 2003)
Integrated Plan
Future without Integrated Plan
Minimum Target Flows (Existing)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Yakima River at Parker PARWGage Outflow

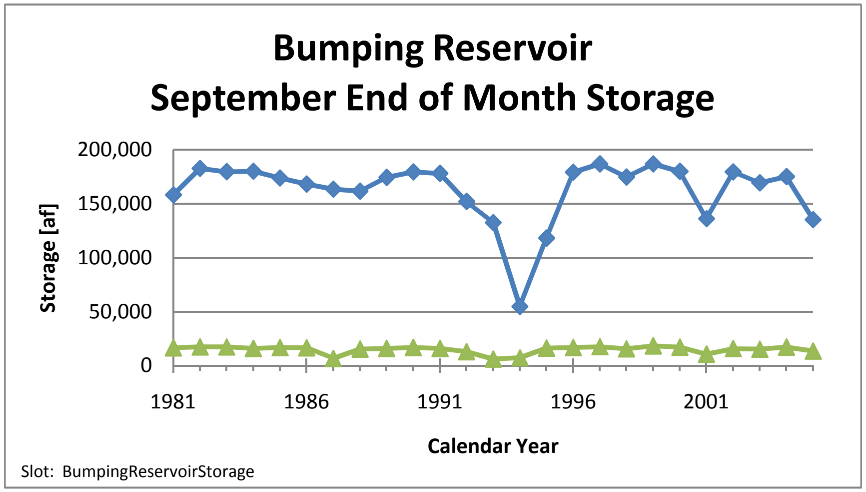

Yakima River at Parker
Drought Flows (WY 2001)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Yakima River at Parker PARWGage Outflow

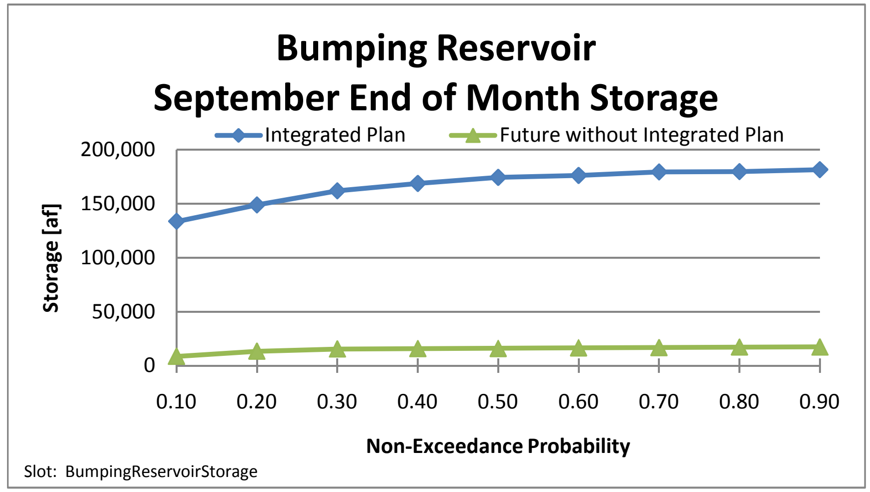

Yakima River at Parker
Wet Flows (WY 2002)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Yakima River at Parker PARWGage Outflow

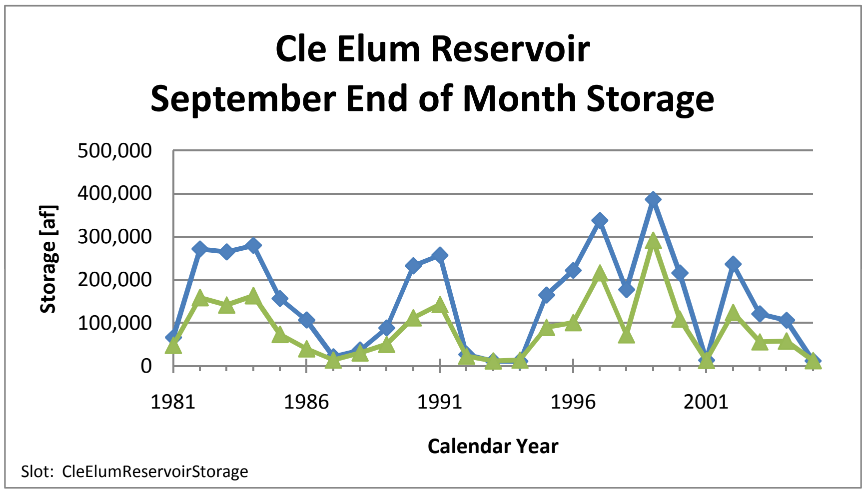

Yakima River at Kiona
Average Flows (WY 2003)
Integrated Plan
Future without Integrated Plan
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Yakima River at KionaGage Inflow

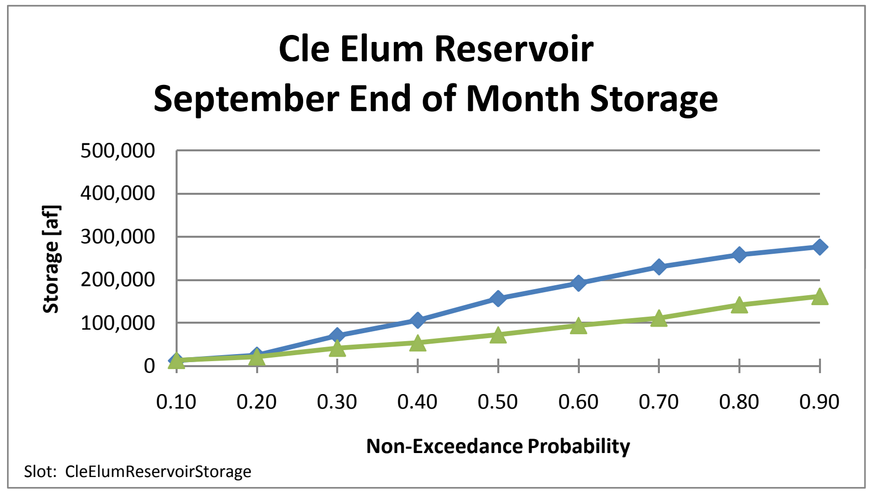

Yakima River at Kiona
Drought Flows (WY 2001)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Yakima River at KionaGage Inflow

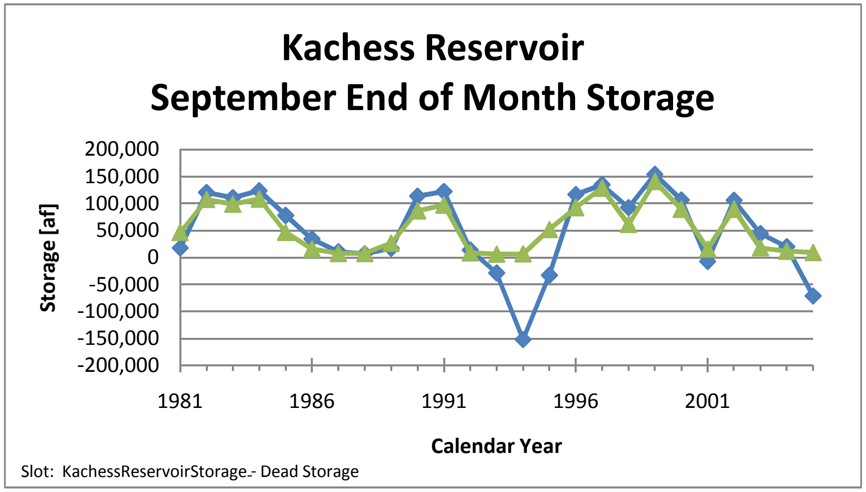

Yakima River at Kiona
Wet Flows (WY 2002)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Yakima River at KionaGage Inflow

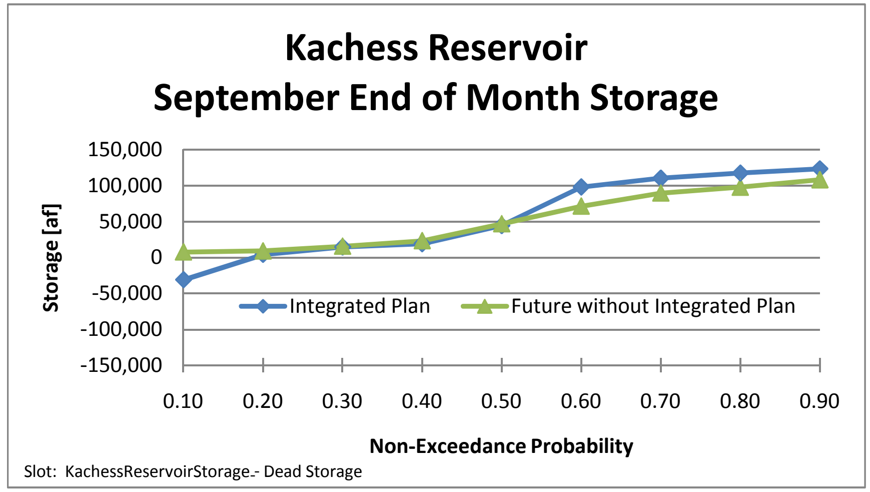

Bumping Reservoir
September End of Month Storage
Storage [af]
200,000
150,000
100,000
50,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: BumpingReservoirStorage

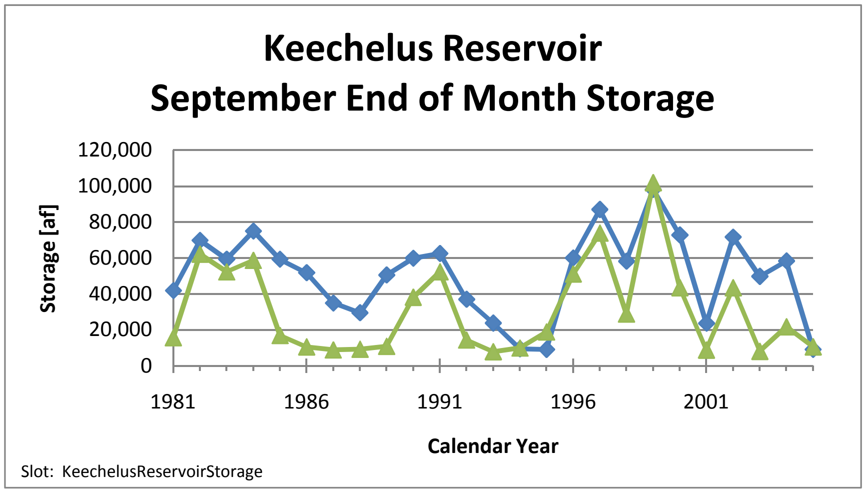

Bumping Reservoir
September End of Month Storage
Integrated Plan
Future without Integrated Plan
Storage [af]
200,000
150,000
100,000
50,000
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: BumpingReservoirStorage

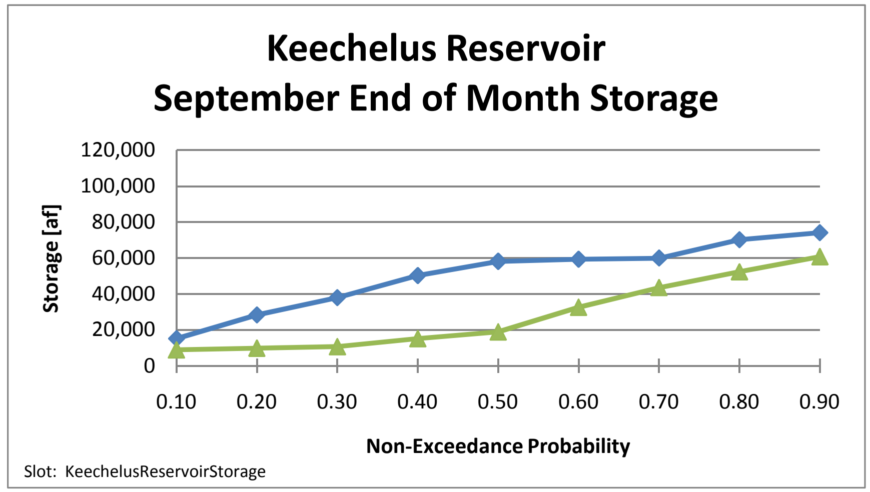

Cle Elum Reservoir
September End of Month Storage
Storage [af]
500,000
400,000
300,000
200,000
100,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: CleElumReservoirStorage

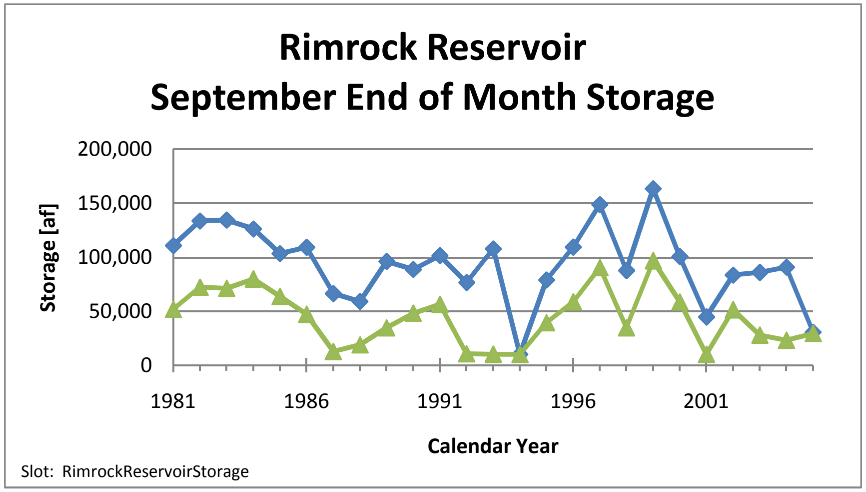

Cle Elum Reservoir
September End of Month Storage
Storage [af]
500,000
400,000
300,000
200,000
100,000
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: CleElumReservoirStorage

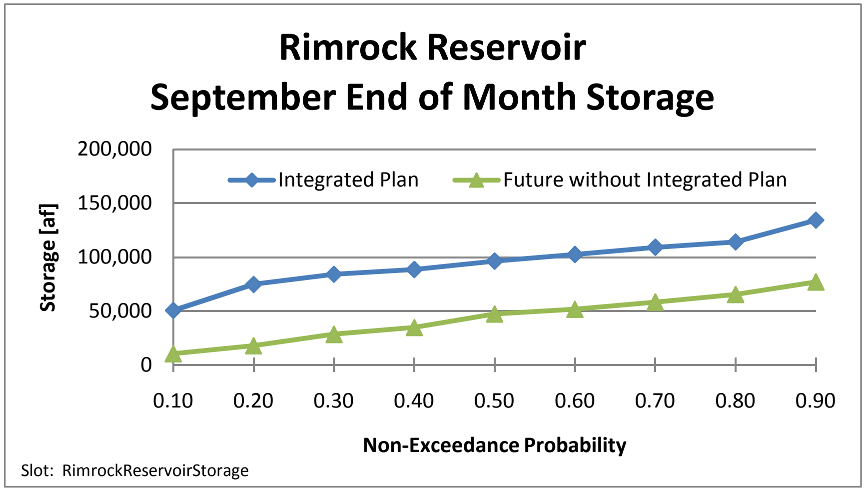

Kachess Reservoir
September End of Month Storage
200,000
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
-200,000
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: KachessReservoirStorage.- Dead Storage

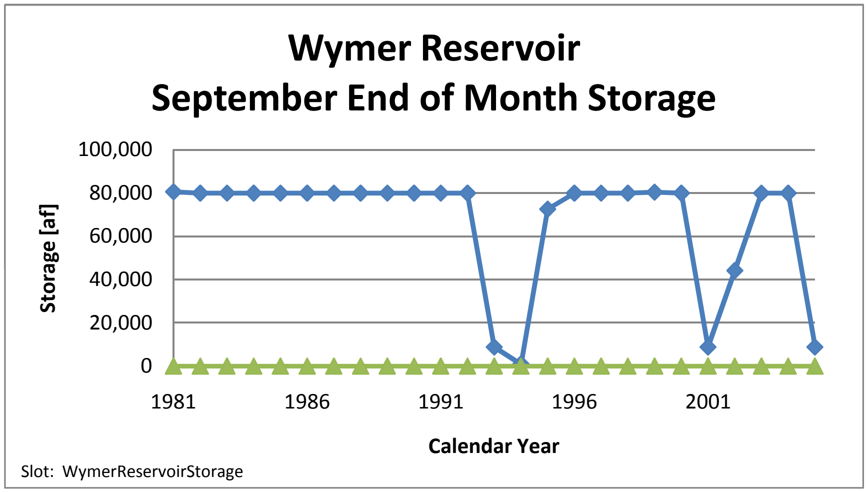

Kachess Reservoir
September End of Month Storage
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
Storage [af]
Integrated Plan
Future without Integrated Plan
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KachessReservoirStorage.- Dead Storage

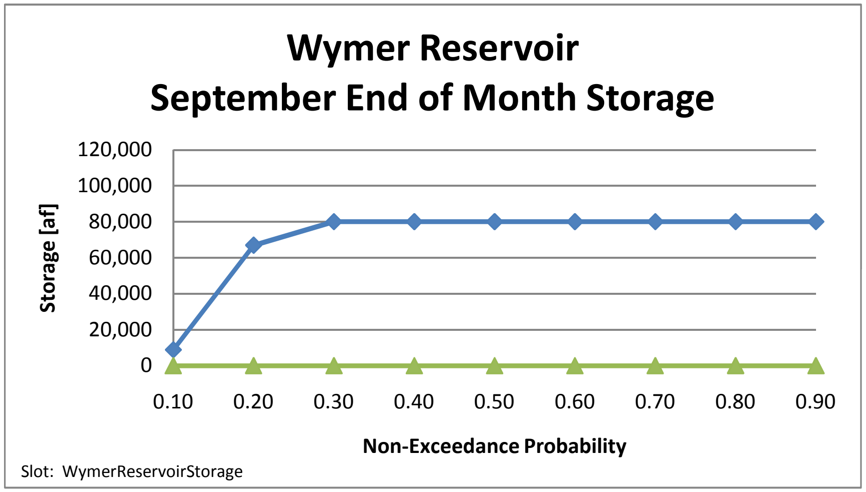

Keechelus Reservoir
September End of Month Storage
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: KeechelusReservoirStorage

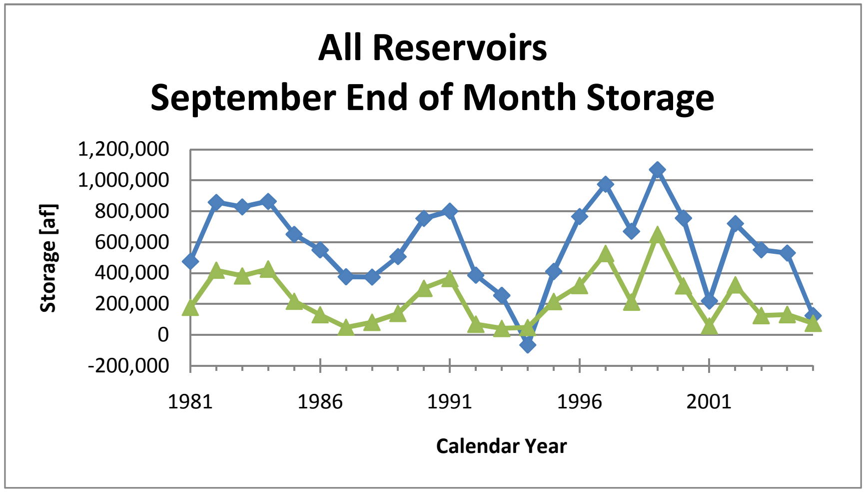

Keechelus Reservoir
September End of Month Storage
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KeechelusReservoirStorage

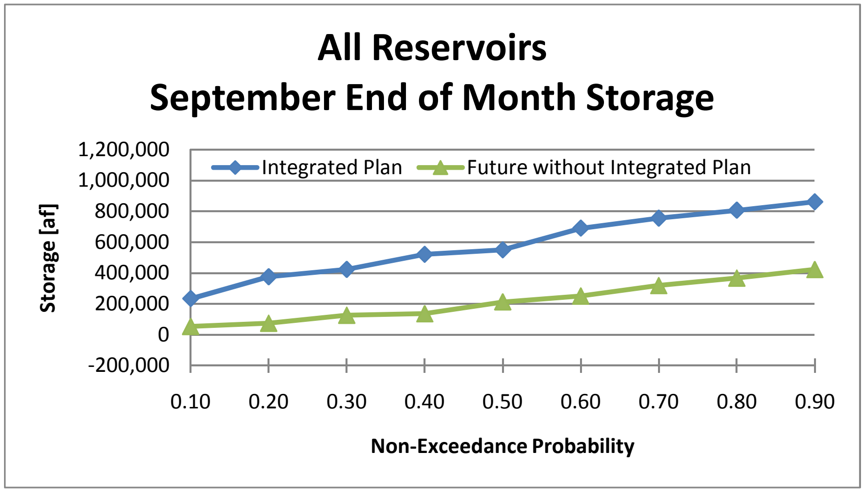

Rimrock Reservoir
September End of Month Storage
Storage [af]
200,000
150,000
100,000
50,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: RimrockReservoirStorage

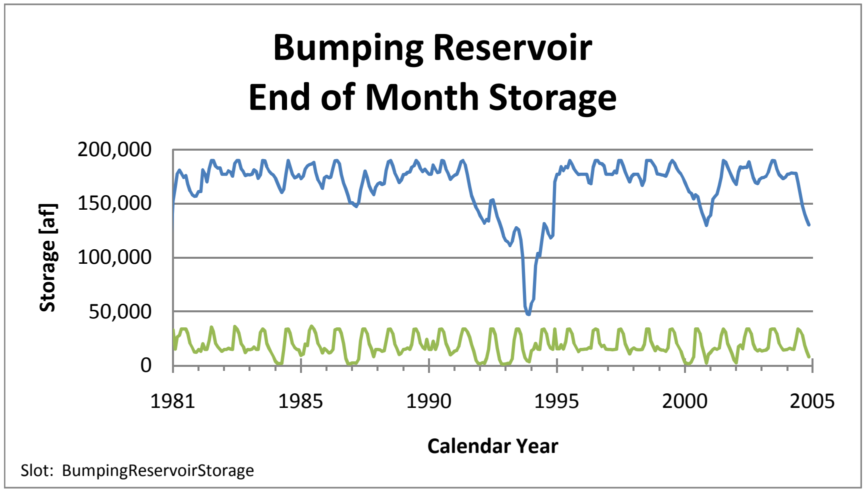

Rimrock Reservoir
September End of Month Storage
Storage [af]
200,000
150,000
100,000
50,000
0
Integrated Plan
Future without Integrated Plan
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: RimrockReservoirStorage

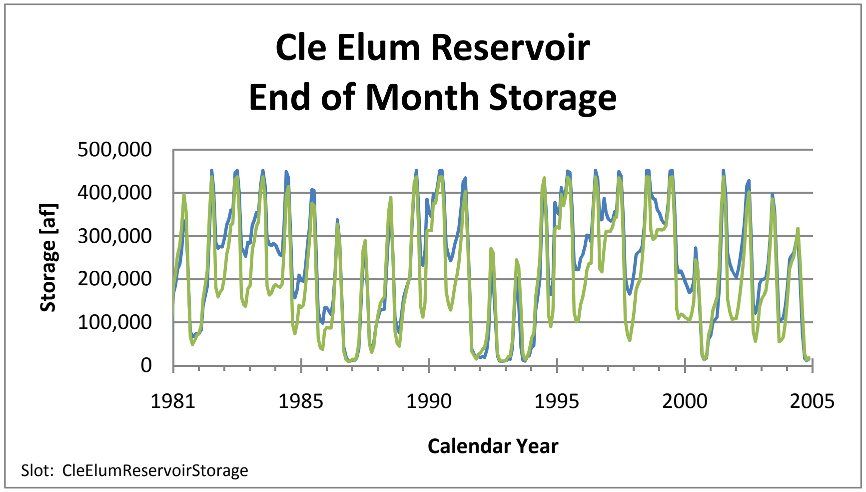

Wymer Reservoir
September End of Month Storage
Storage [af]
100,000
80,000
60,000
40,000
20,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: WymerReservoirStorage

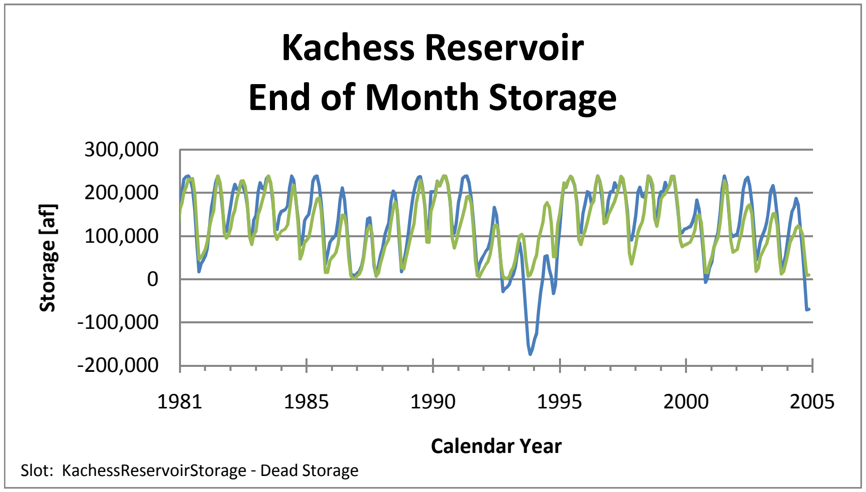

Wymer Reservoir
September End of Month Storage
Storage [af]
120,000
100,000
80,000
60,000
40,000
20,000
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: WymerReservoirStorage

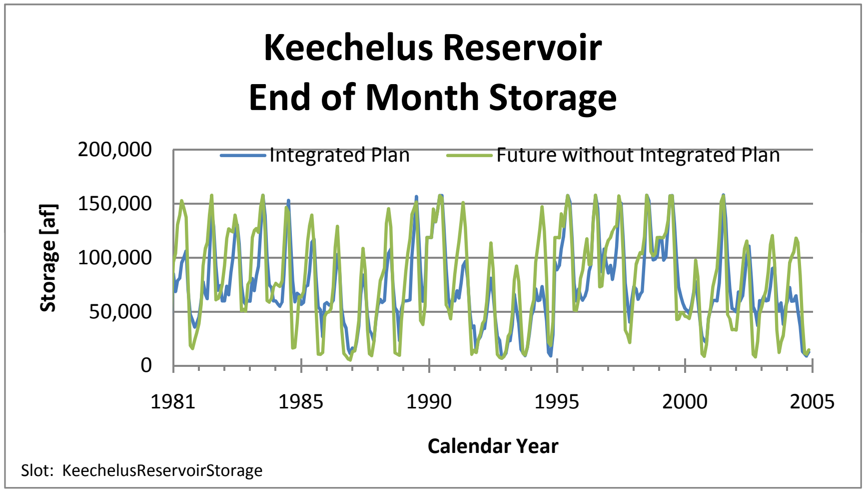

All Reservoirs
September End of Month Storage
Storage [af]
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
-200,000
1981
1986
1991
1996
2001
Calendar Year

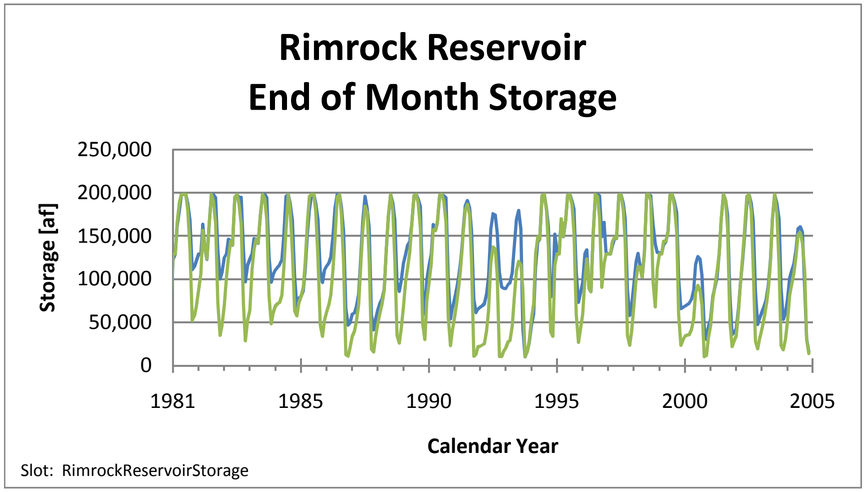

All Reservoirs
September End of Month Storage
Integrated Plan
Future without Integrated Plan
Storage [af]
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
-200,000
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability

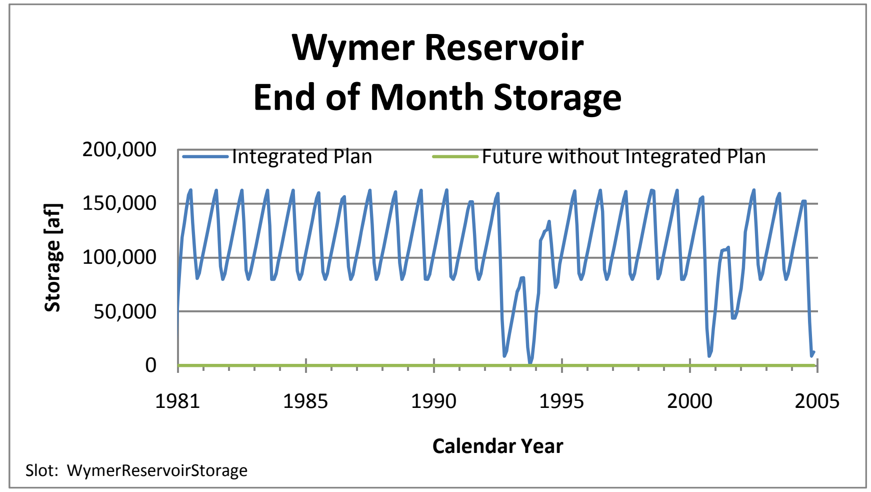

Bumping Reservoir
End of Month Storage
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: BumpingReservoirStorage

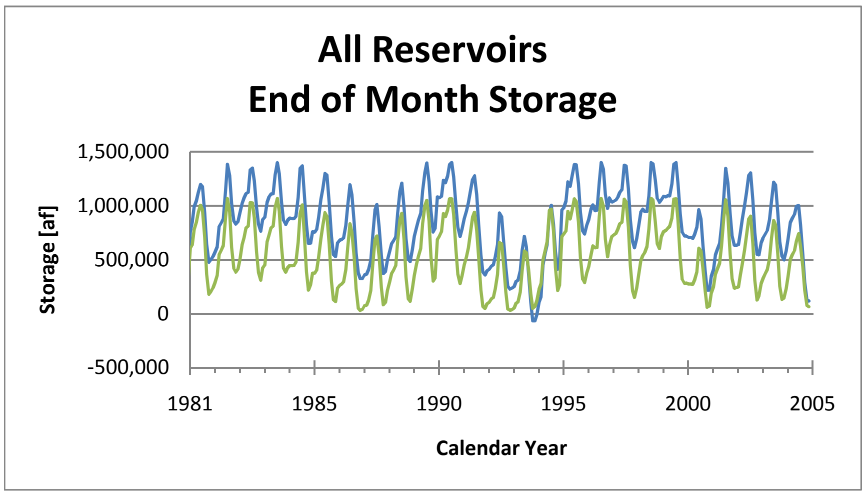

Cle Elum Reservoir
End of Month Storage
500,000
400,000
300,000
200,000
100,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: CleElumReservoirStorage

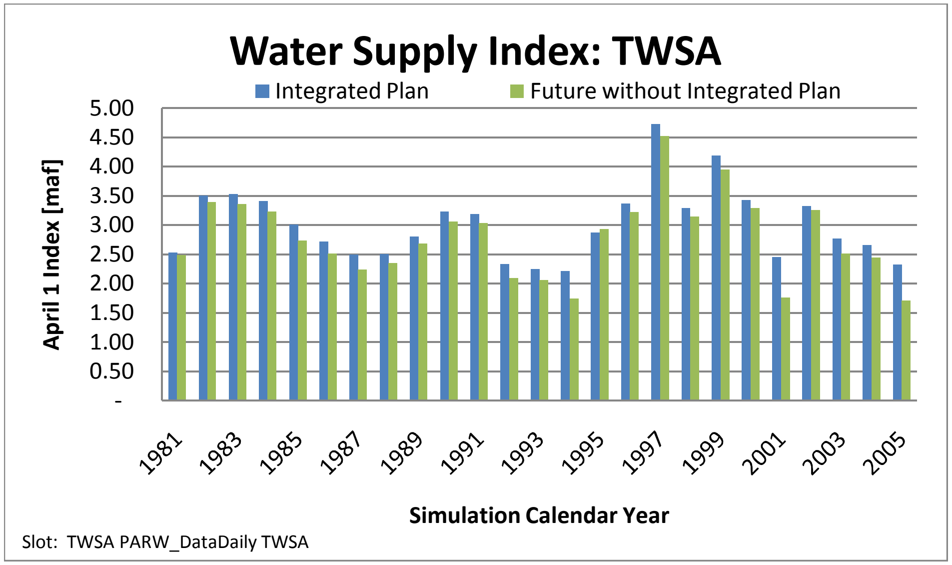

Kachess Reservoir
End of Month Storage
300,000
200,000
100,000
0
-100,000
-200,000
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KachessReservoirStorage - Dead Storage

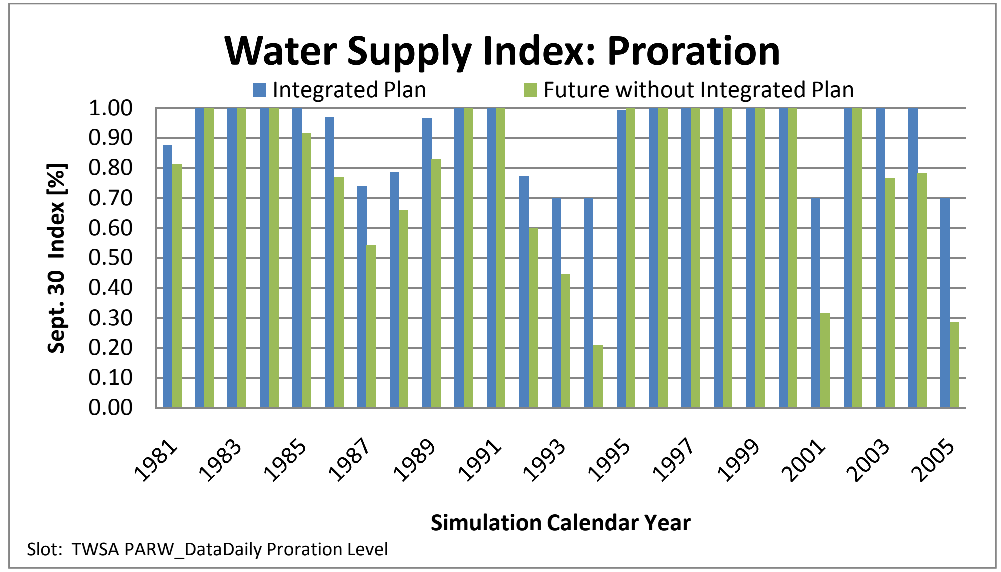

Keechelus Reservoir
End of Month Storage
Integrated Plan
Future without Integrated Plan
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KeechelusReservoirStorage

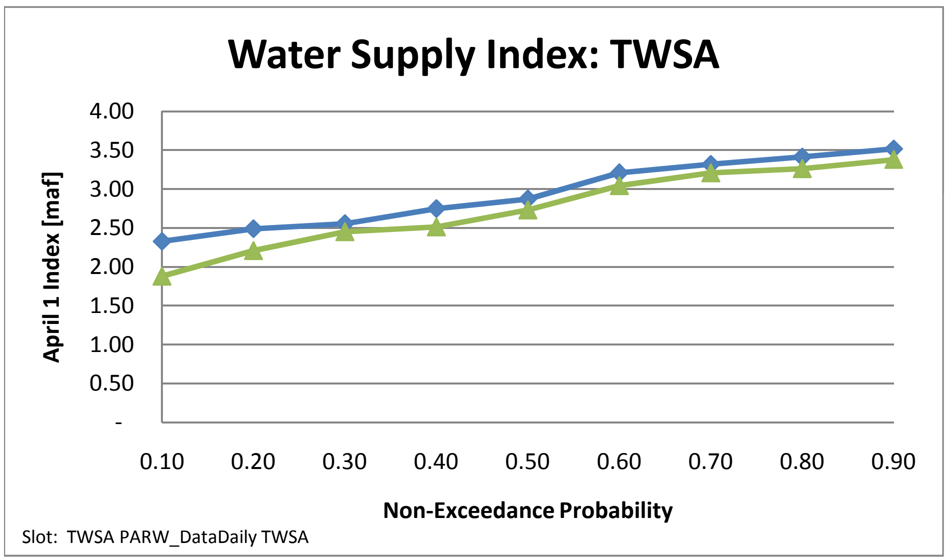

Rimrock Reservoir
End of Month Storage
250,000
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: RimrockReservoirStorage

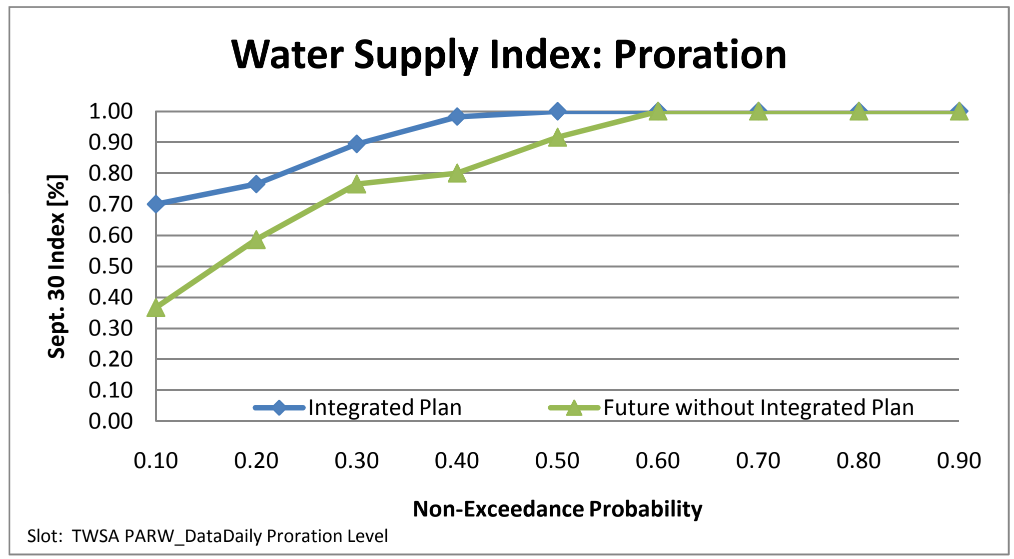

Wymer Reservoir
End of Month Storage
Integrated Plan
Future without Integrated Plan
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: WymerReservoirStorage

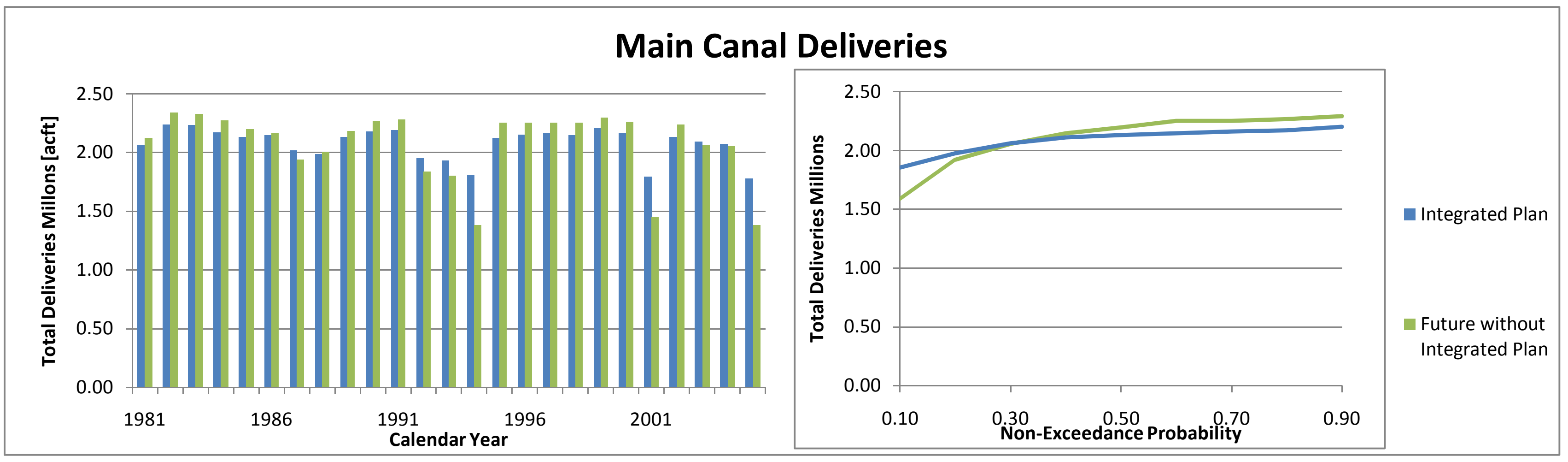

All Reservoirs
End of Month Storage
1,500,000
1,000,000
500,000
0
-500,000
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year

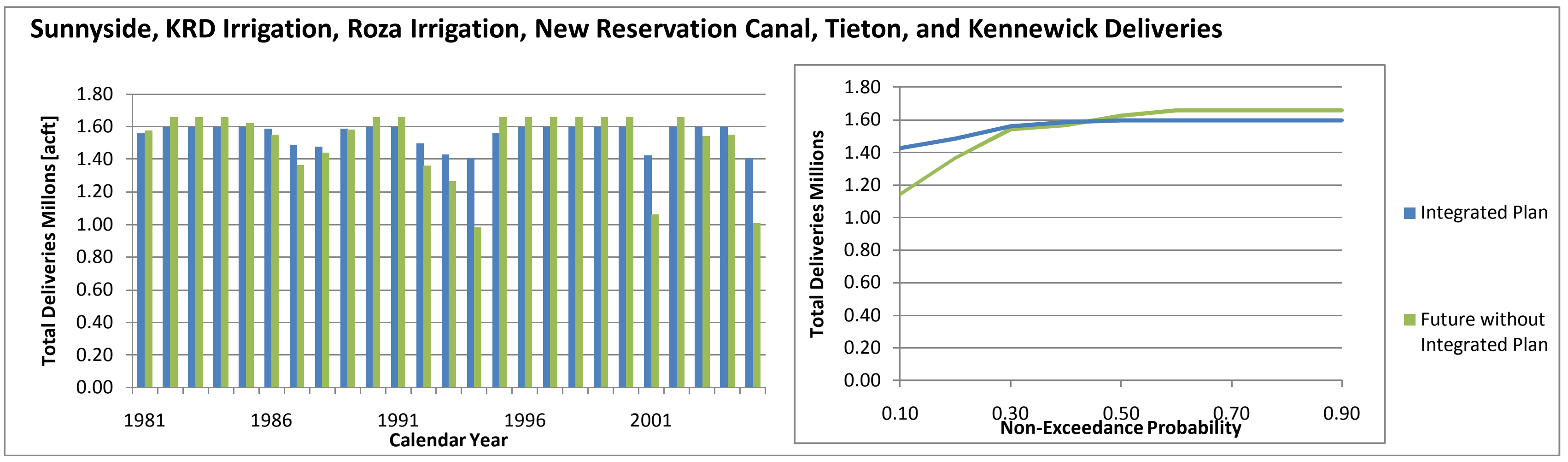

Water Supply Index: TWSA
Integrated Plan
Future without Integrated Plan
April 1 Index [maf]
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
-
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
Simulation Calendar Year
Slot: TWSA PARW_DataDaily TWSA

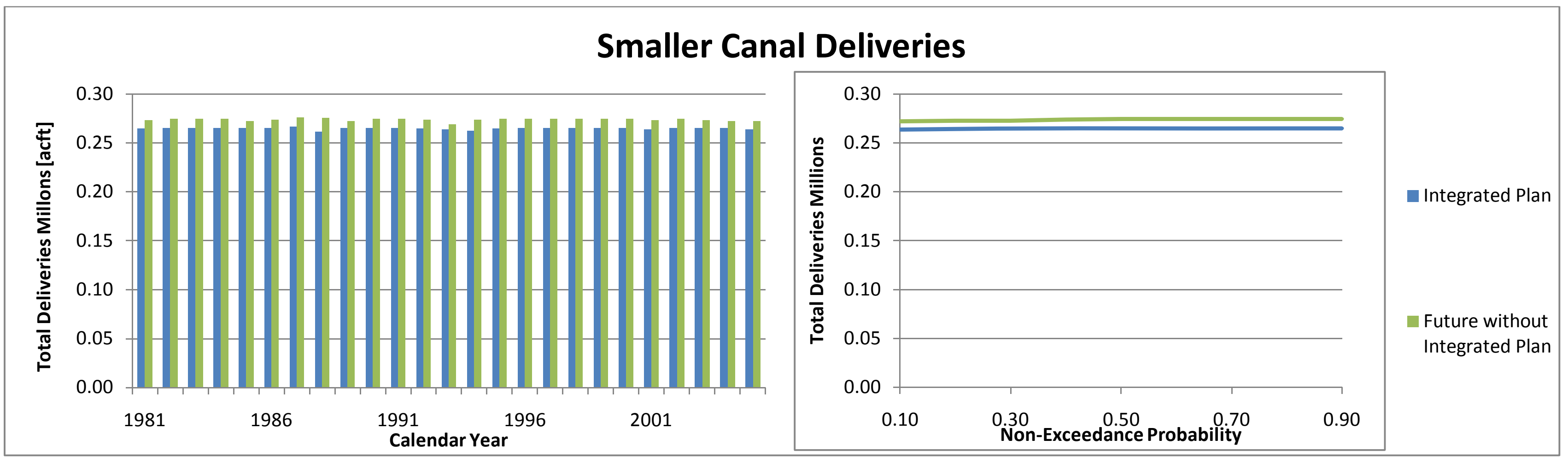

Water Supply Index: Proration
Integrated Plan
Future without Integrated Plan
Sept. 30 Index [%]
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
Simulation Calendar Year
Slot: TWSA PARW_DataDaily Proration Level

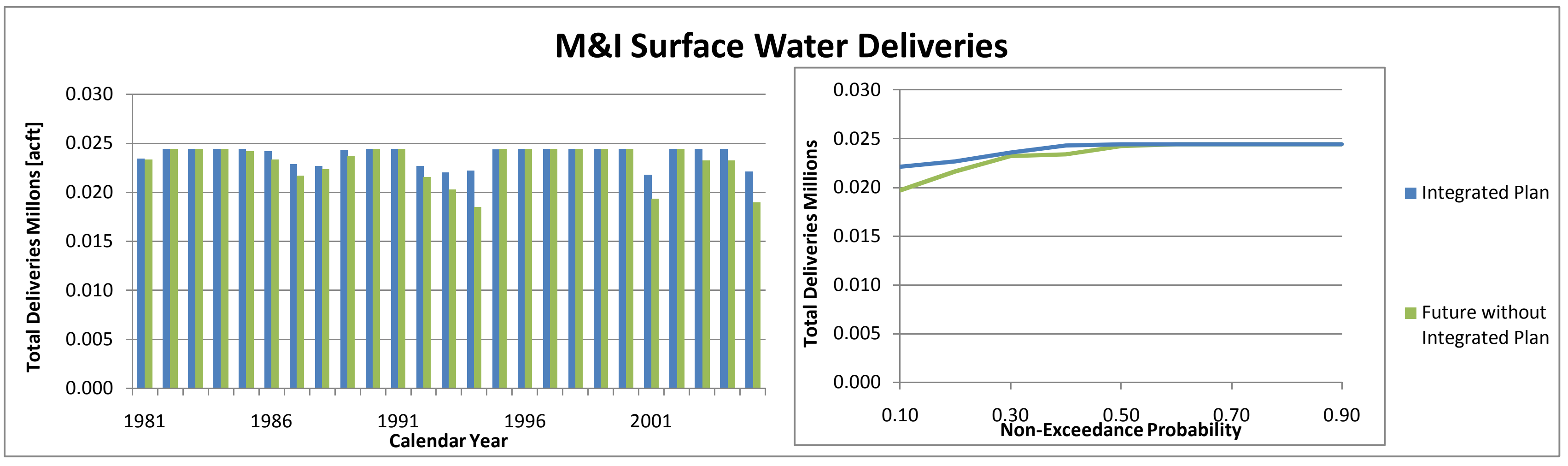

Water Supply Index: TWSA
April 1 Index [maf]
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
-
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily TWSA


Water Supply Index: Proration
Sept. 30 Index [%]
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Integrated Plan
Future without Integrated Plan
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily Proration Level


Main Canal Deliveries
Total Deliveries Millons [acft]
Calendar Year
Total Deliveries Millions
Non-Exceedance Probability
Integrated Plan
Future without Integrated Plan


Sunnyside, KRD Irrigation, Roza Irrigation, New Reservation Canal, Tieton, and Kennewick Deliveries
Total Deliveries Millons [acft]
Calendar Year
Total Deliveries Millions
Non-Exceedance Probability
Integrated Plan
Future without Integrated Plan


Smaller Canal Deliveries
Total Deliveries Millons [acft]
Calendar Year
Total Deliveries Millions
Non-Exceedance Probability
Integrated Plan
Future without Integrated Plan


M&I Surface Water Deliveries
Total Deliveries Millons [acft]
Calendar Year
Total Deliveries Millions
Non-Exceedance Probability
Integrated Plan
Future without Integrated Plan

Appendix C – Adjusted Integrated Plan Results

C-1 Adjusted Integrated Plan Results without Bumping Reservoir Enlargement

C-2 Adjusted Integrated Plan Results without Kachess Inactive Storage and Keechelus to Kachess (K to K) Pipeline

C-3 Adjusted Integrated Plan Results without Wymer Reservoir

Appendix C – 1

Adjusted Integrated Plan Results Without Bumping Reservoir Enlargement

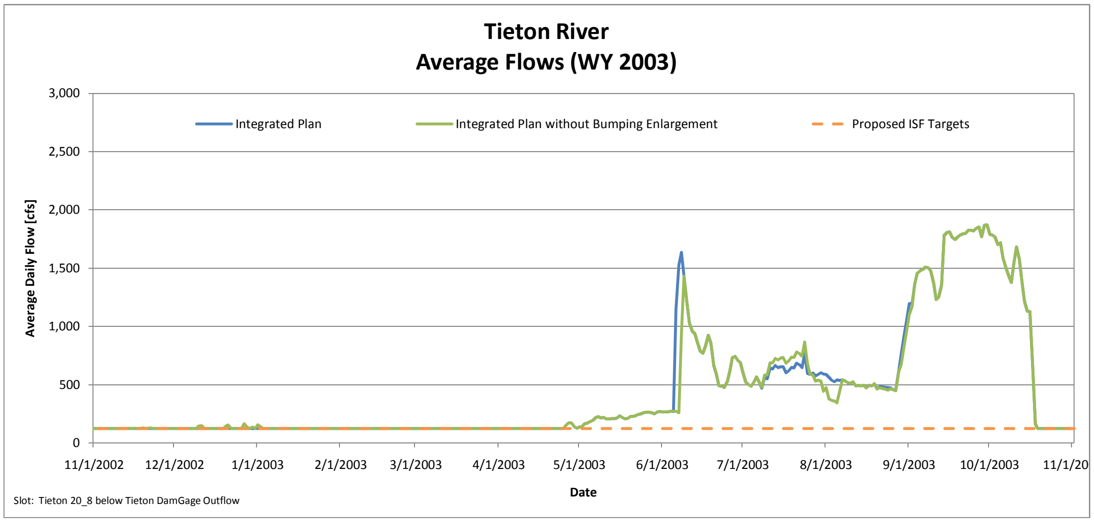
Resource indicator (measurement)	Integrated Plan	Integrated Plan without Bumping Enlargement
WATER RESOURCES		
Average for water years 1981–2005 (maf)		
Water supply		
April 1 total water supply available (TWSA)	3.00	2.96
Water distribution		
April–September Parker flow volume	0.60	0.60
April–September diversion	1.69	1.69
September 30 reservoir contents	0.58	0.44
April–September flow volume at mouth of Yakima River	0.87	0.86
1994 dry-year (maf)		
Water supply		
April 1 TWSA	2.22	2.09
Water distribution		
April–September Parker flow volume	0.25	0.23
April–September diversion	1.52	1.48
September 30 reservoir contents	-0.06	-0.12
April–September flow volume at mouth of Yakima River	0.35	0.33
Irrigation proration level	70%	68%

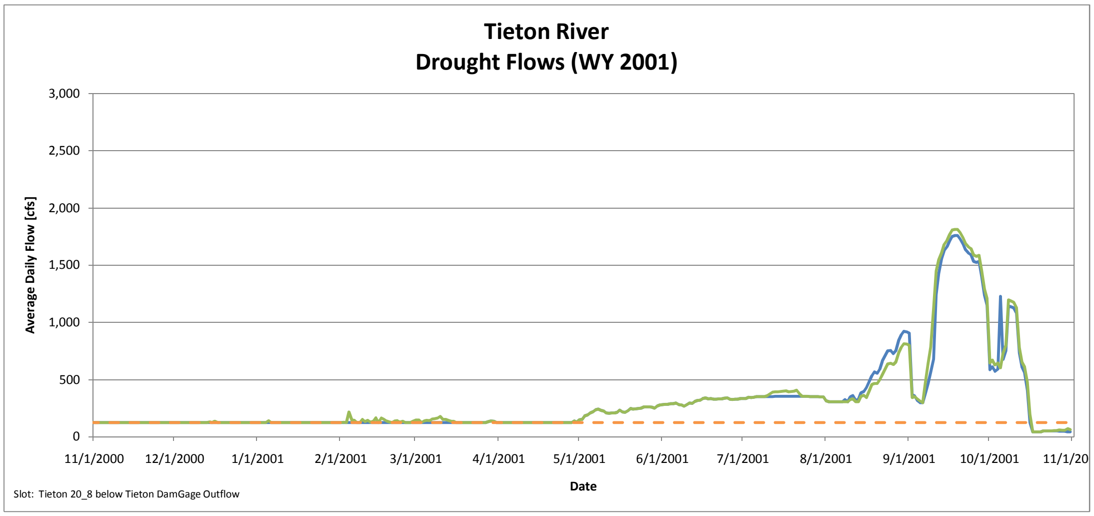
Resource indicator (measurement)	Integrated Plan	Integrated Plan without Bumping Enlargement
ANADROMOUS FISH		
Rate of change in flow during flip-flop (average cfs/day August 16–September 14)		
Easton reach	-7	-6
Ellensburg reach	-45	-43
Lower Naches River reach	31	25
Pre- (August 1-15) and post- (September 14-28) flip-flop flow and absolute change in flow		
Easton reach		
Pre-flip-flop flow (cfs)	574	535
Post-flip-flop flow (cfs)	364	368
Absolute change in flow (cfs)	-211	-167
Ellensburg reach		
Pre-flip-flop flow (cfs)	2,867	2,823
Post-flip-flop flow (cfs)	1,574	1,580
Absolute change in flow (cfs)	-1,293	-1,244
Lower Naches River reach		
Pre-flip-flop flow (cfs)	644	748
Post-flip-flop flow (cfs)	1,548	1,487
Absolute change in flow (cfs)	904	739

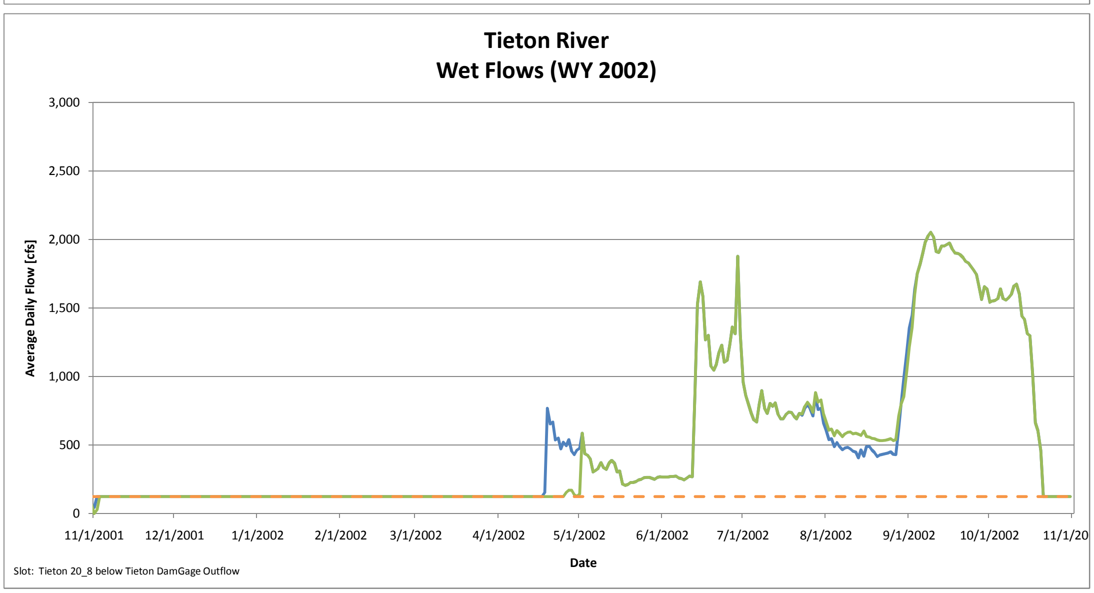
Average, minimum, and maximum reservoir elevation (feet) during bull trout spawning migration: July 15–September 15 (feet)		
Kachess Lake	2235.41 2146.99-2261.96	2235.67 2145.81-2261.96
Keechelus Lake	2476.7 2432.28-2516.96	2476.75 2432.51-2516.96
Rimrock Lake	2914.66 2801.26-2926	2912.23 2801.03-2926

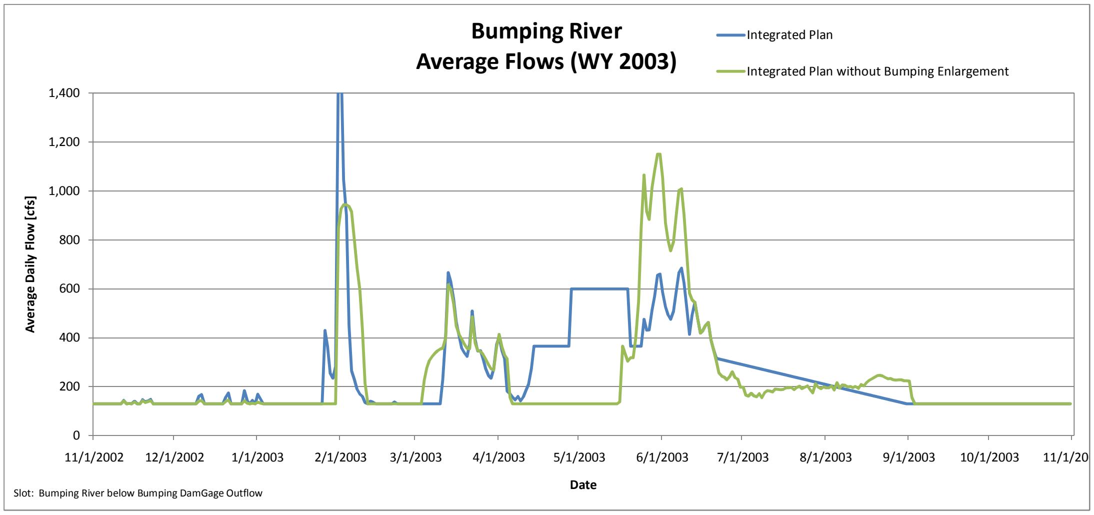
Hydrologic Indicator	**Integrated Plan**					**Integrated Plan without Bumping Enlargement**				
	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997
April 1 TWSA (maf)	3.00	2.22	2.45	2.32	4.73	2.96	2.09	2.30	2.16	4.70
April-September flow volume at Parker gage (kaf)	605	245	198	181	1937	598	226	194	173	1938
March-October flow volume at Parker gage (kaf)	907	400	335	310	2638	901	375	329	301	2637
April-September diversion volume upstream of Parker gage (maf)	1.69	1.52	1.55	1.53	1.73	1.69	1.48	1.55	1.53	1.72
September 30 non-Bumping or Wymer reservoir contents (kaf)	348	-121	75	-19	709	350	-124	51	-49	720
October 31 non-Bumping or Wymer reservoir contents (kaf)	329	-120	74	-26	802	332	-127	51	-54	810
September 30 Bumping and Wymer reservoir contents (kaf)	229	56	145	144	267	83	3	23	24	100
April-September flow volume at mouth of Yakima River (kaf)	867	349	272	293	2262	860	328	269	282	2263
Irrigation proration level (percent)[1]	92%	70%	70%	70%	100%	91%	68%	70%	70%	100%

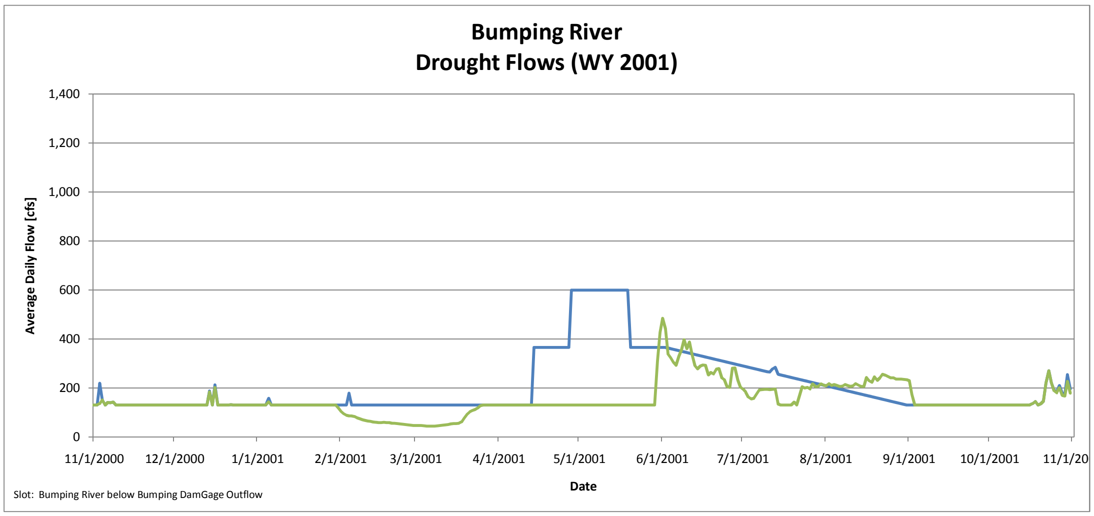
Item	Integrated Plan without Bumping Enlargement	Integrated Plan	Improvement
Average 1981-2005			
TWSA [April 1, kaf]	2958.4	3004.9	46.5
March-October flow volume at Parker gage [kaf]	901.5	906.7	5.2
Drought Year 1994			
TWSA [April 1, kaf]	2086.7	2215.7	129.0
March-October flow volume at Parker gage [kaf]	374.8	399.8	25.0
Drought Year 2001			
TWSA [April 1, kaf]	2303.2	2453.2	150.0
March-October flow volume at Parker gage [kaf]	329.2	335.5	6.3
Drought Year 2005			
TWSA [April 1, kaf]	2158.3	2320.8	162.6
March-October flow volume at Parker gage [kaf]	300.6	310.2	9.6
Wet Year 1997			
TWSA [April 1, kaf]	4695.5	4728.6	33.0
March-October flow volume at Parker gage [kaf]	2637.1	2638.3	1.2

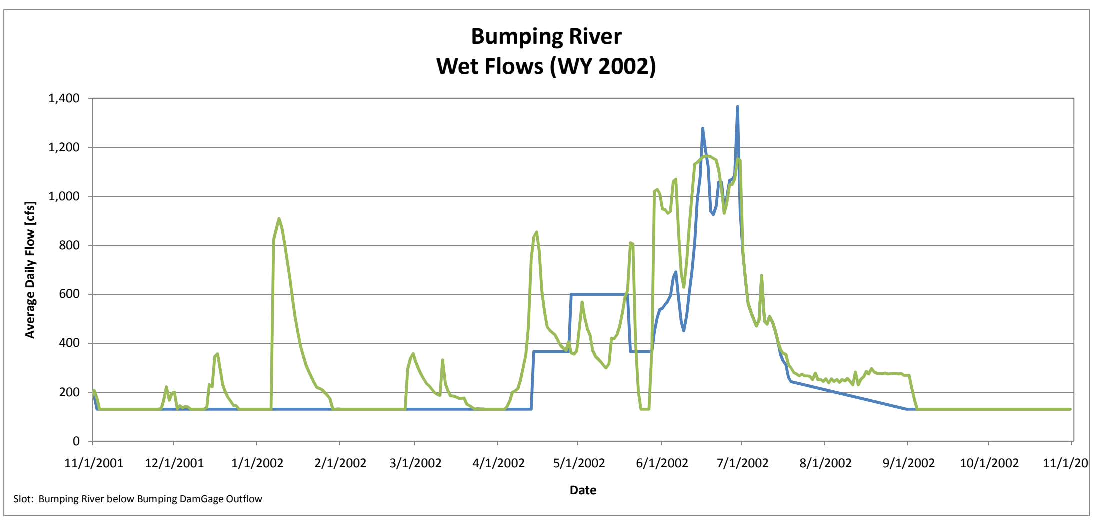

Tieton River
Average Flows (WY 2003)
Integrated Plan
Integrated Plan without Bumping Enlargement
Proposed ISF Targets
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

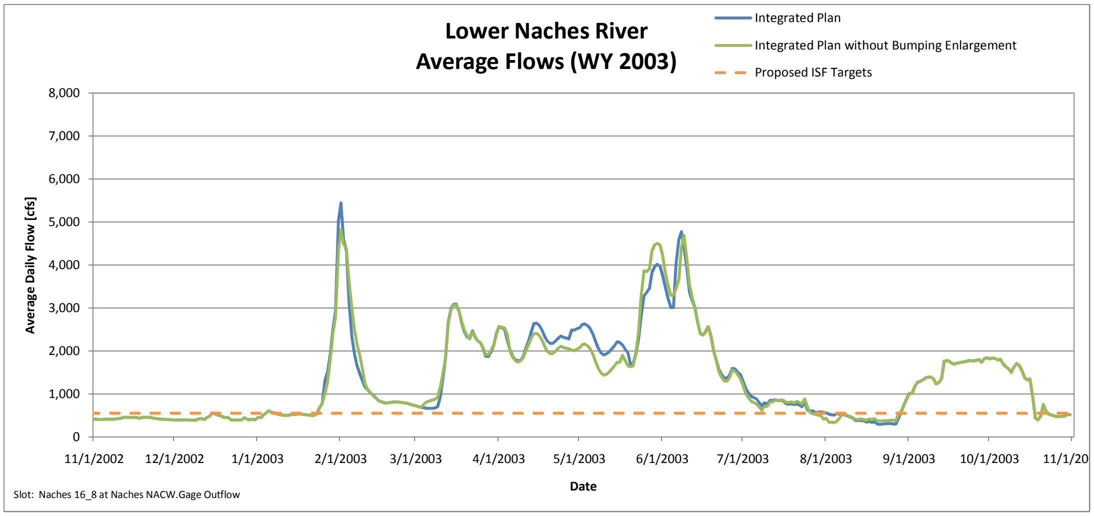

Tieton River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

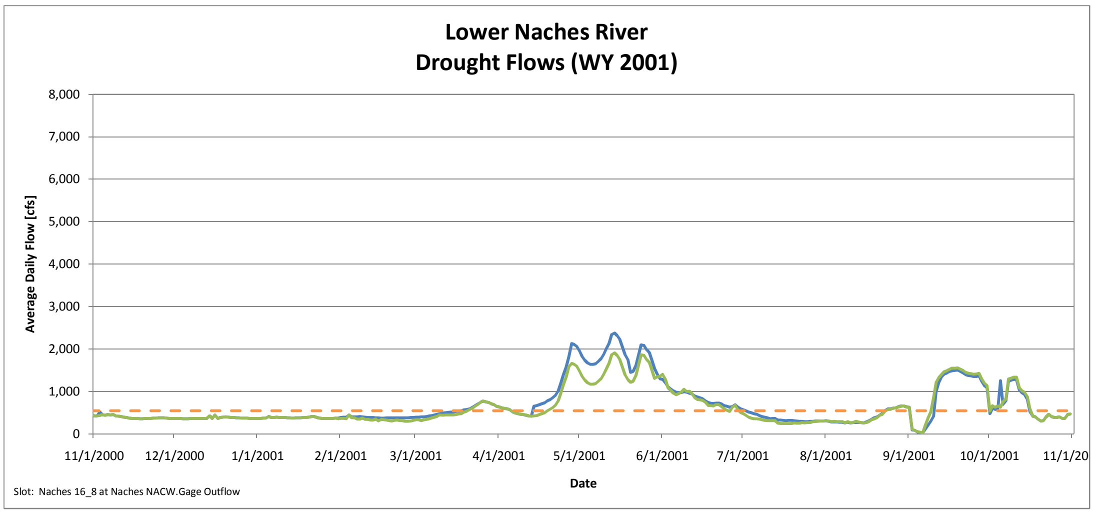

Tieton River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

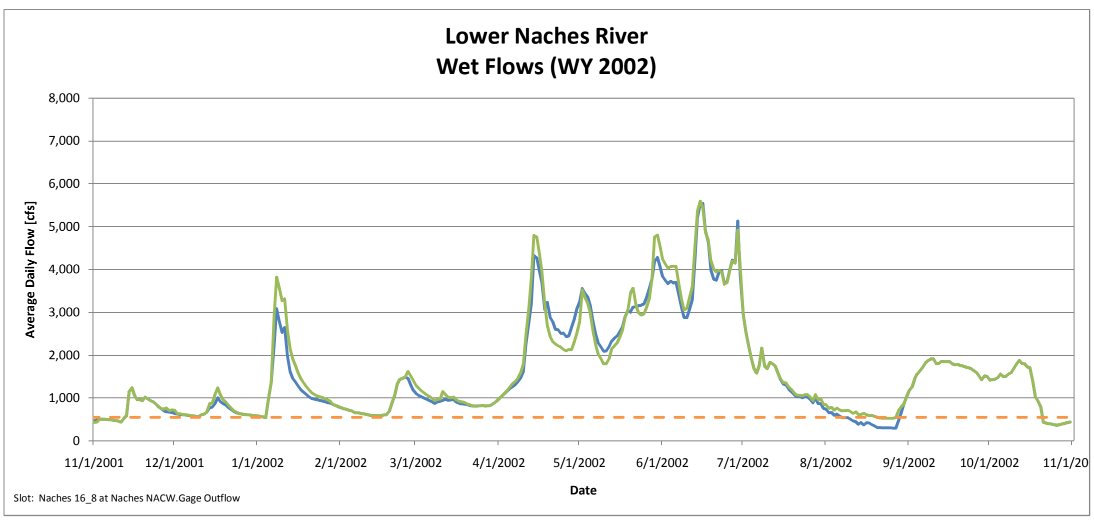

Bumping River
Average Flows (WY 2003)
Integrated Plan
Integrated Plan without Bumping Enlargement
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

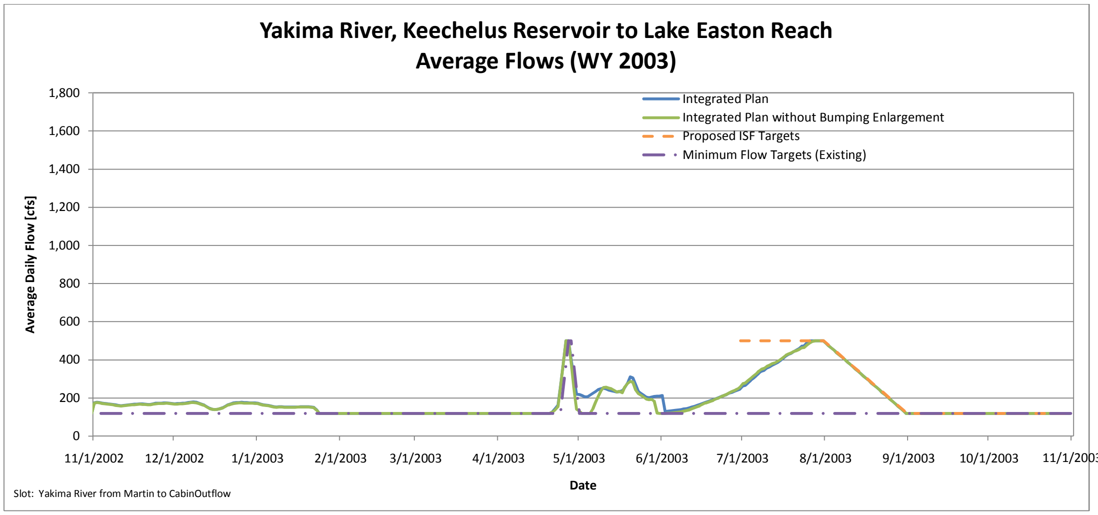

Bumping River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

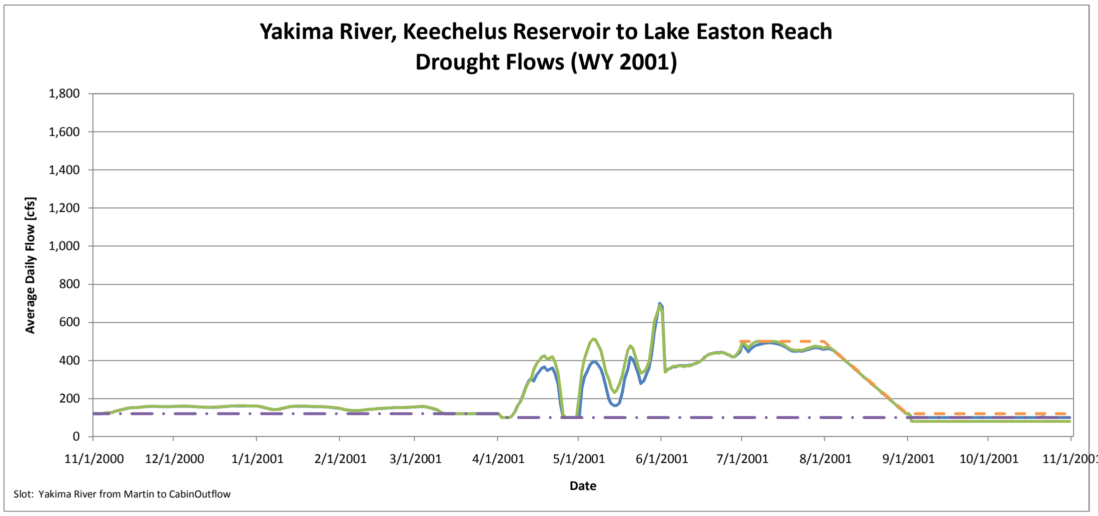

Bumping River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

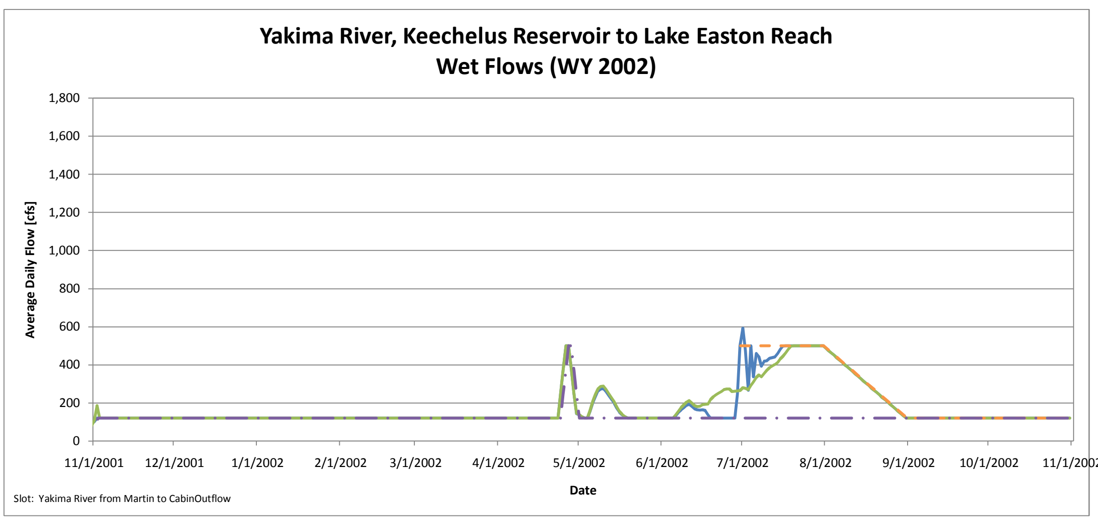

Lower Naches River
Average Flows (WY 2003)
Integrated Plan
Integrated Plan without Bumping Enlargement
Proposed ISF Targets
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Average Daily Flow [cfs]
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

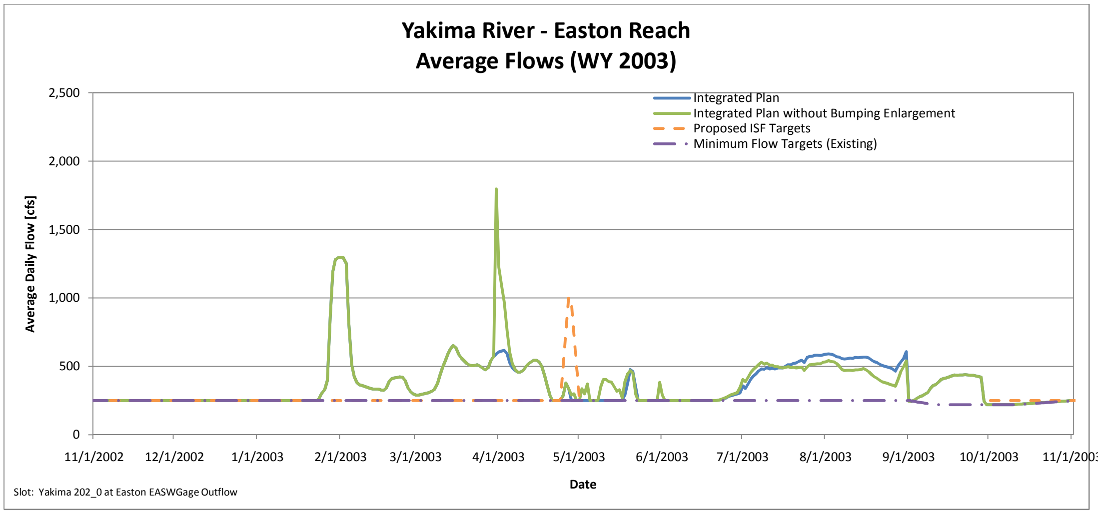

Lower Naches River
Drought Flows (WY 2001)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Average Daily Flow [cfs]
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

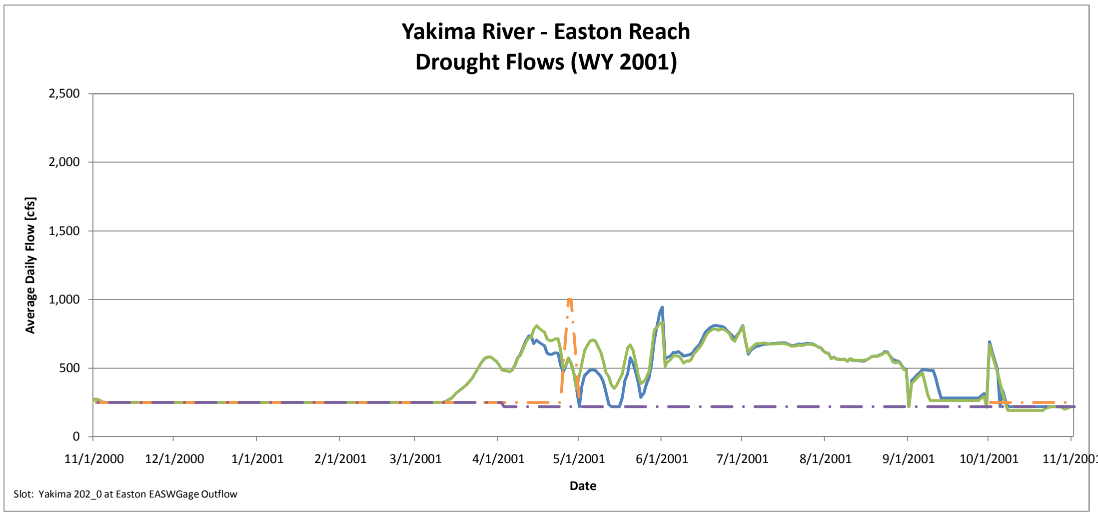

Lower Naches River
Wet Flows (WY 2002)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Average Daily Flow [cfs]
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

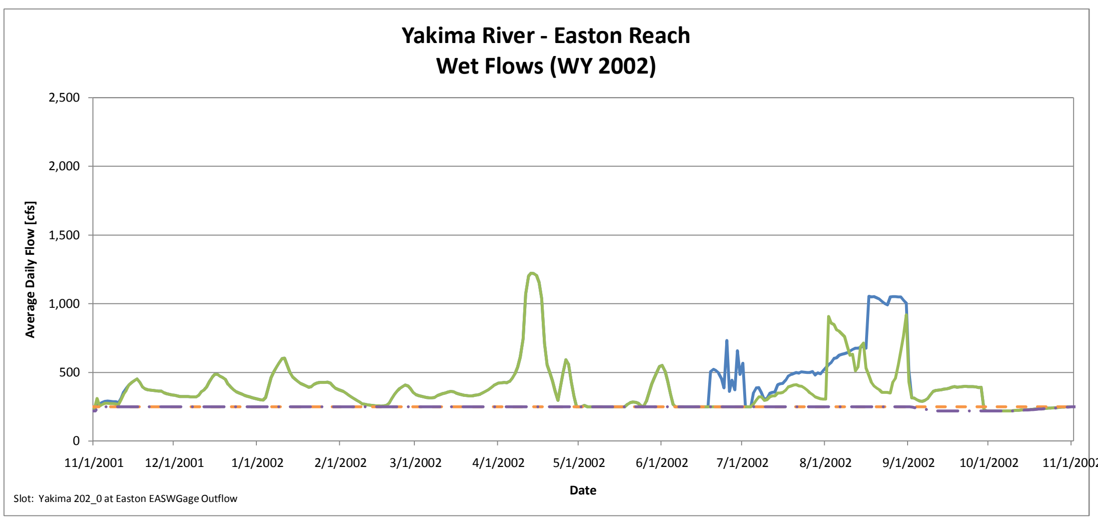

Yakima River, Keechelus Reservoir to Lake Easton Reach
Average Flows (WY 2003)
Integrated Plan
Integrated Plan without Bumping Enlargement
Proposed ISF Targets
Minimum Flow Targets (Existing)
Average Daily Flow [cfs]
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima River from Martin to CabinOutflow

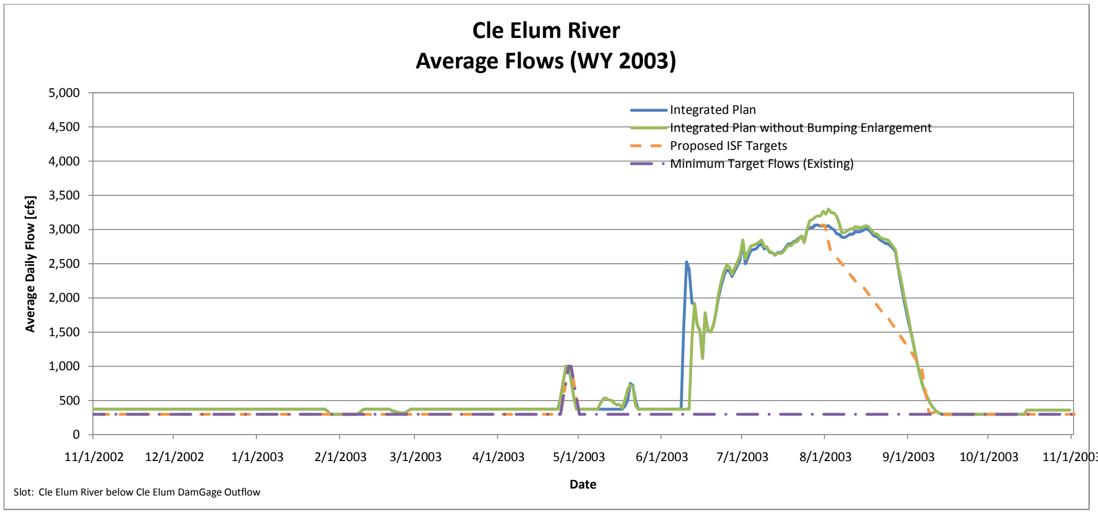

Yakima River, Keechelus Reservoir to Lake Easton Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima River from Martin to CabinOutflow

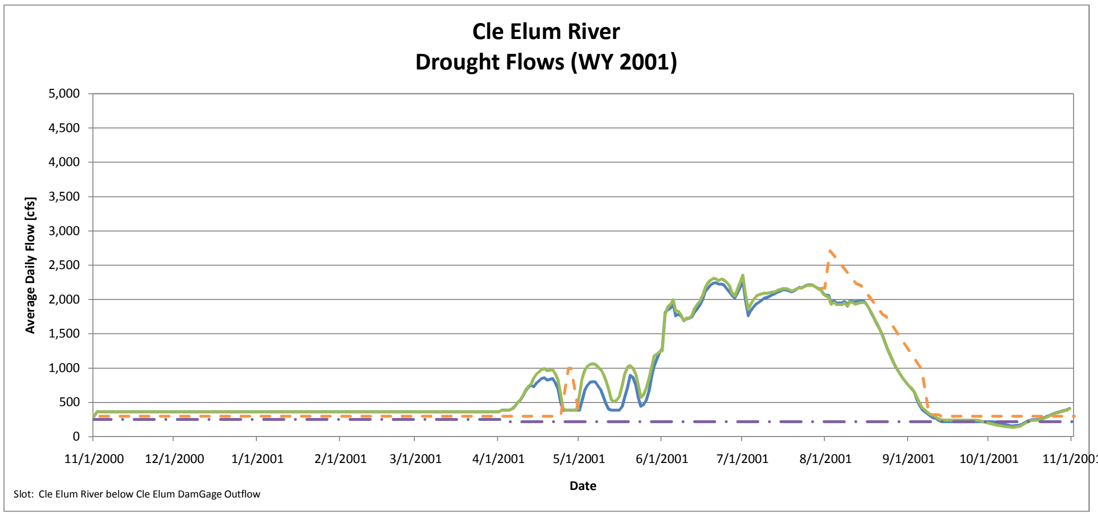

Yakima River, Keechelus Reservoir to Lake Easton Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima River from Martin to CabinOutflow

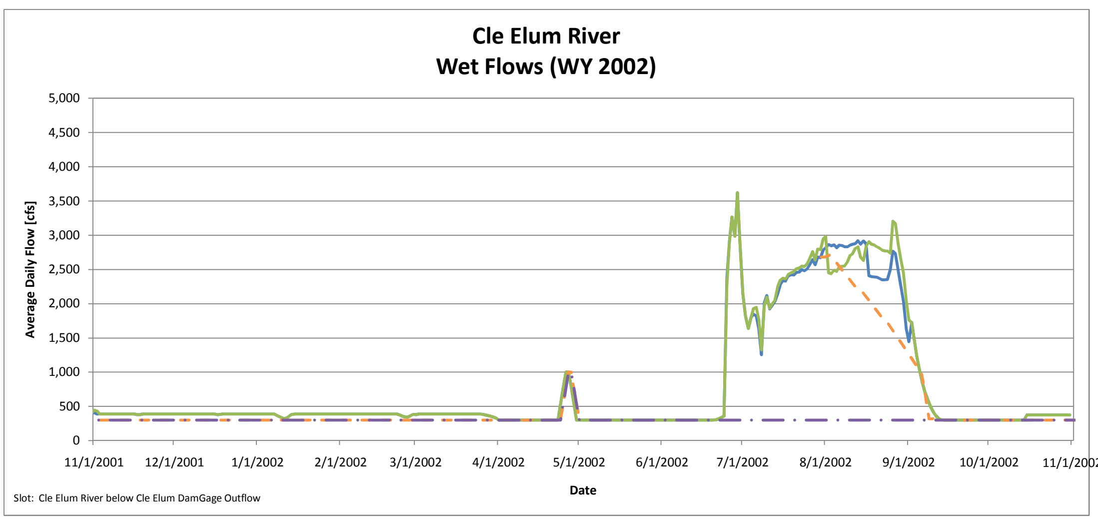

Yakima River - Easton Reach
Average Flows (WY 2003)
Integrated Plan
Integrated Plan without Bumping Enlargement
Proposed ISF Targets
Minimum Flow Targets (Existing)
Average Daily Flow [cfs]
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

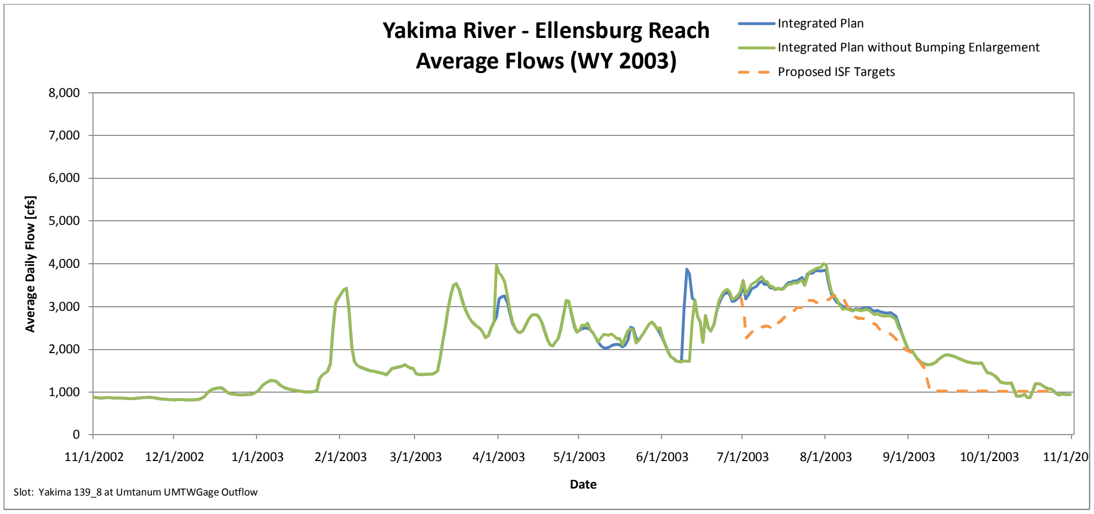

Yakima River - Easton Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

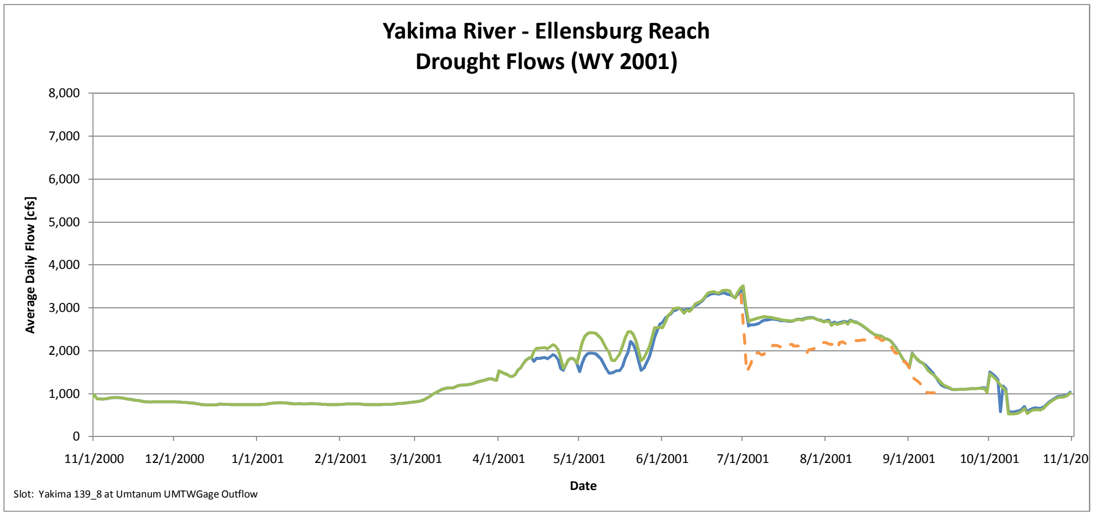

Yakima River - Easton Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

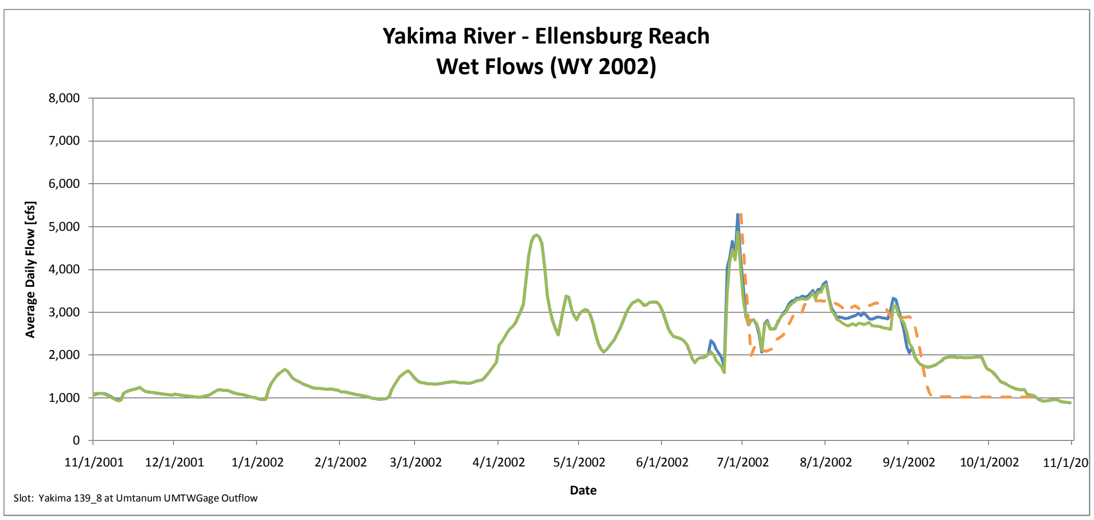

Cle Elum River
Average Flows (WY 2003)
Integrated Plan
Integrated Plan without Bumping Enlargement
Proposed ISF Targets
Minimum Target Flows (Existing)
Average Daily Flow [cfs]
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

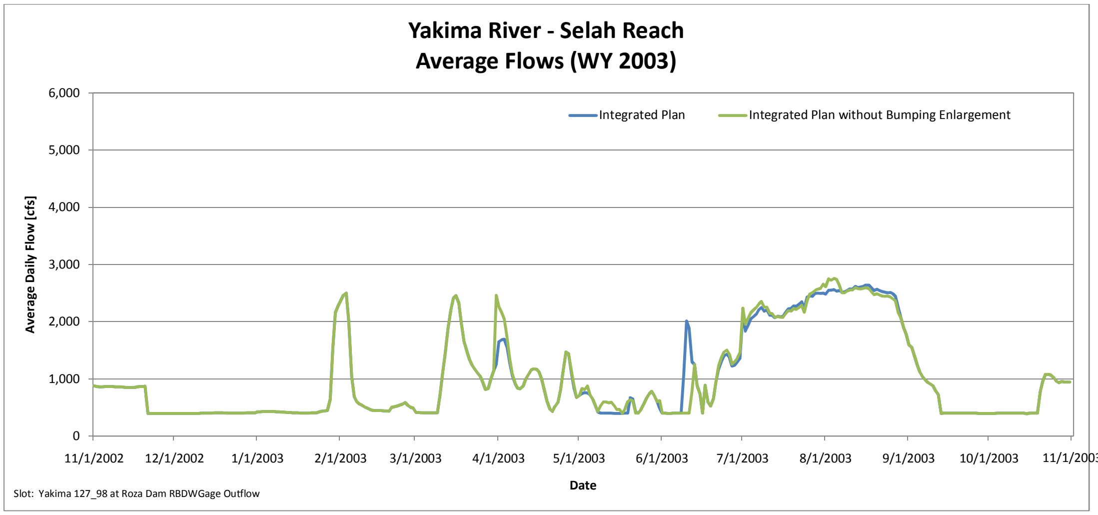

Cle Elum River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

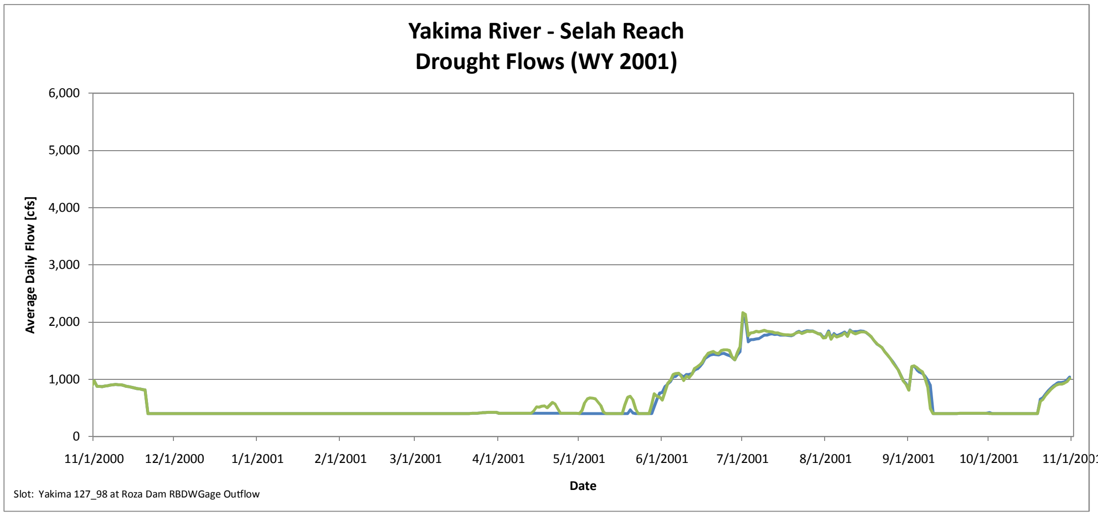

Cle Elum River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

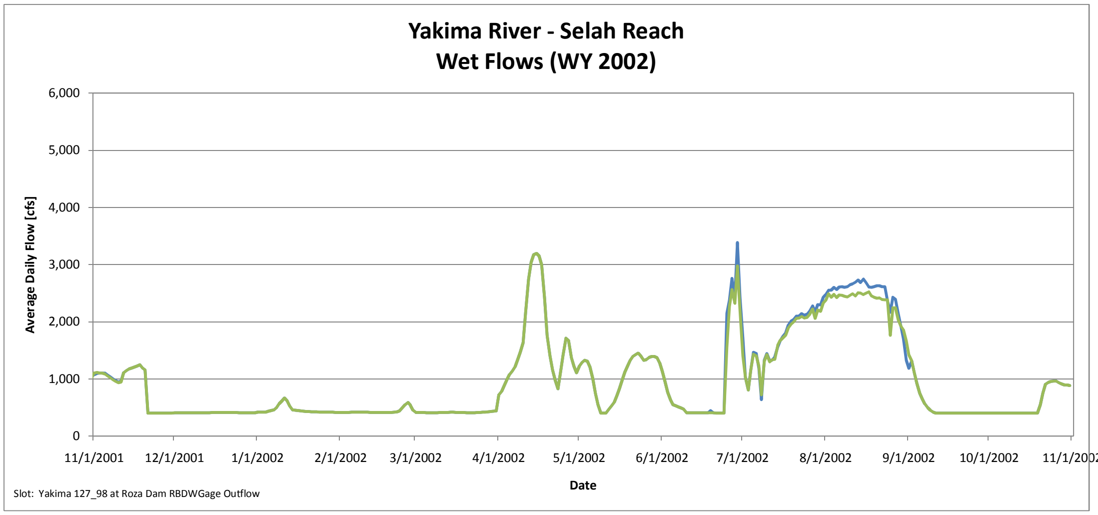

Yakima River - Ellensburg Reach
Average Flows (WY 2003)
Integrated Plan
Integrated Plan without Bumping Enlargement
Proposed ISF Targets
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

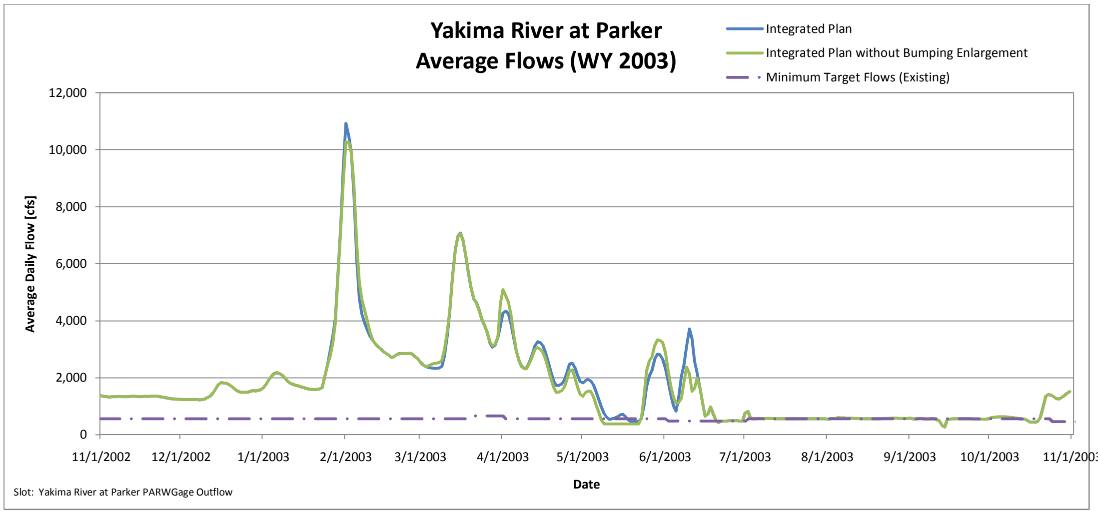

Yakima River - Ellensburg Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

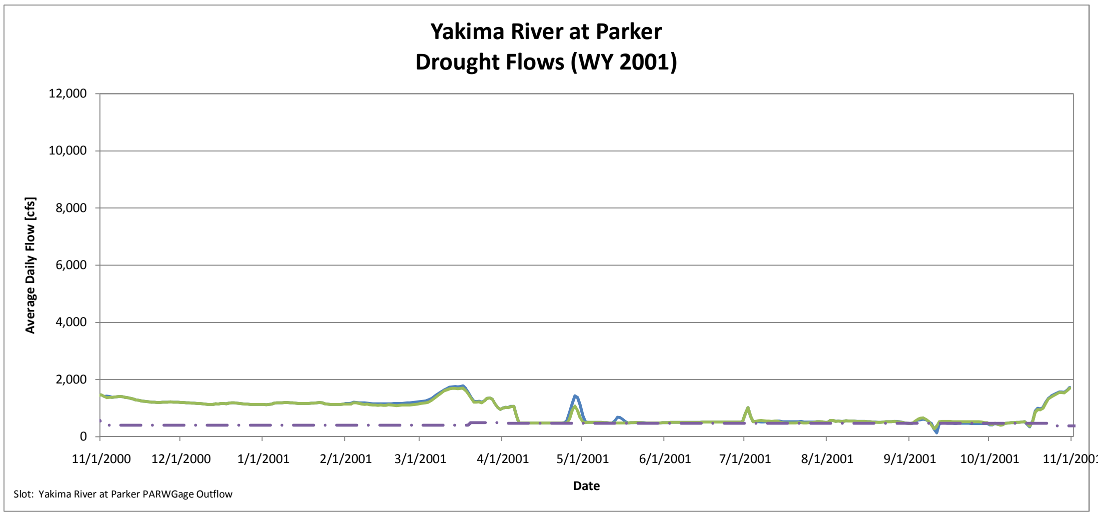

Yakima River - Ellensburg Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

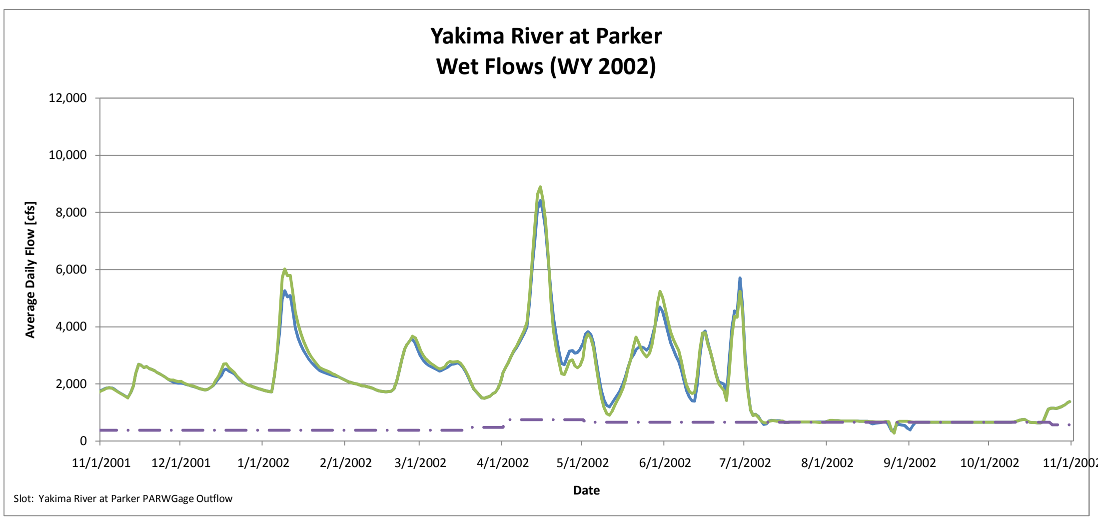

Yakima River - Selah Reach
Average Flows (WY 2003)
Integrated Plan
Integrated Plan without Bumping Enlargement
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

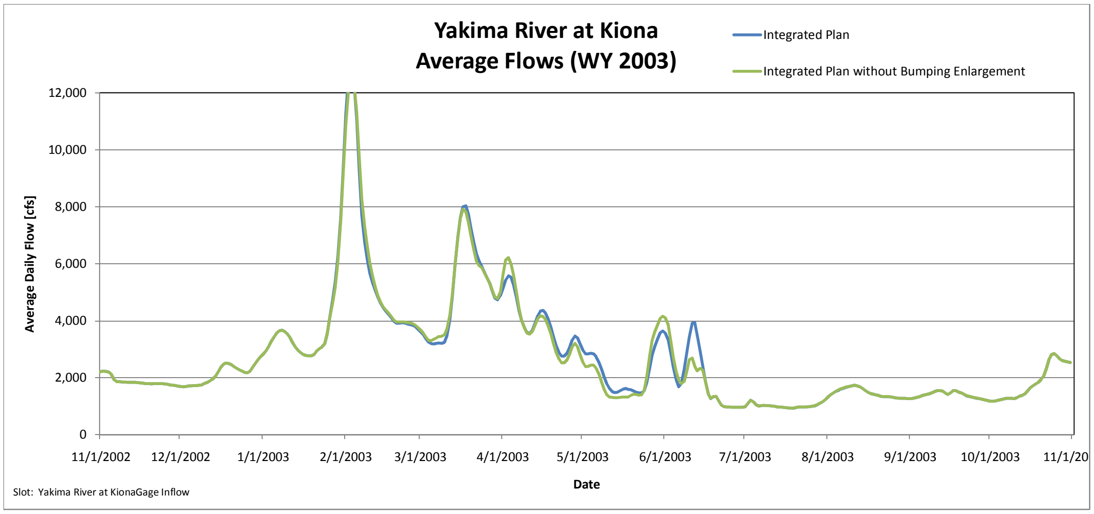

Yakima River - Selah Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

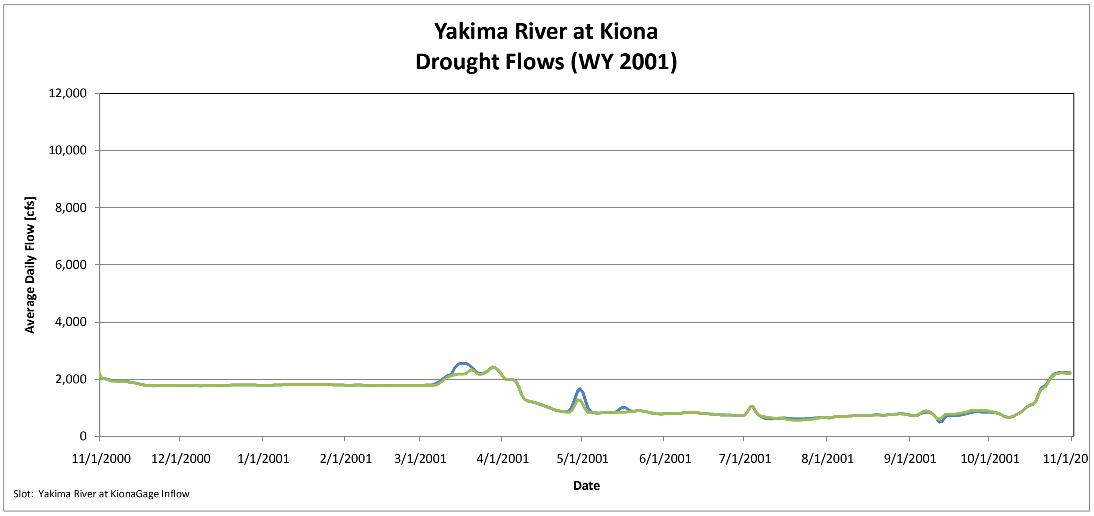

Yakima River - Selah Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

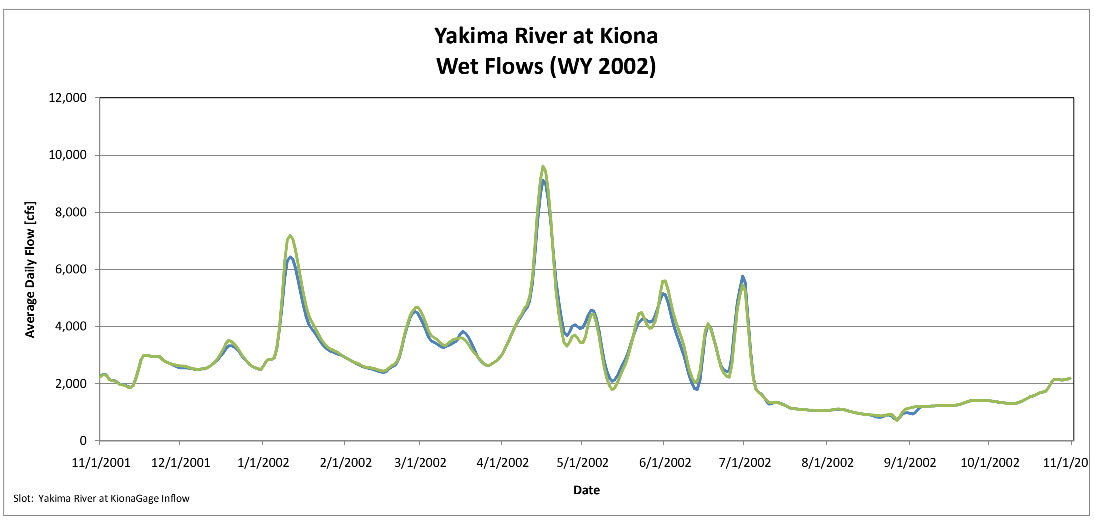

Yakima River at Parker
Average Flows (WY 2003)
Integrated Plan
Integrated Plan without Bumping Enlargement
Minimum Target Flows (Existing)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima River at Parker PARWGage Outflow

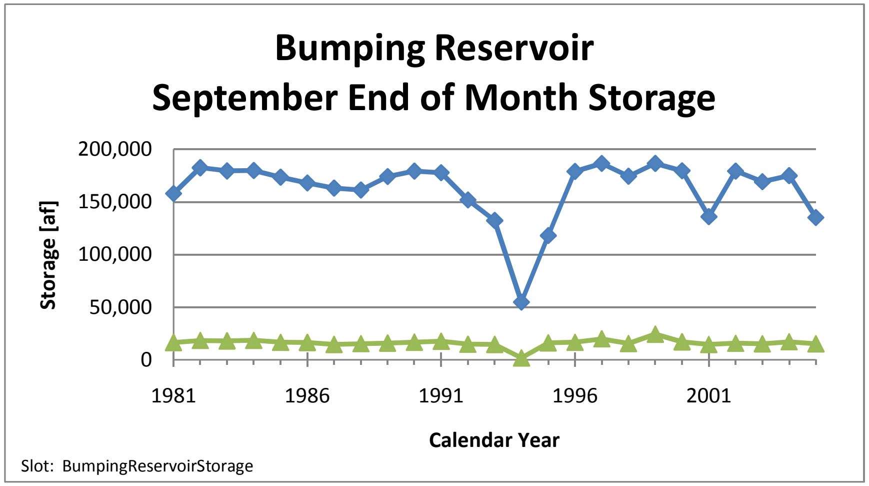

Yakima River at Parker
Drought Flows (WY 2001)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima River at Parker PARWGage Outflow

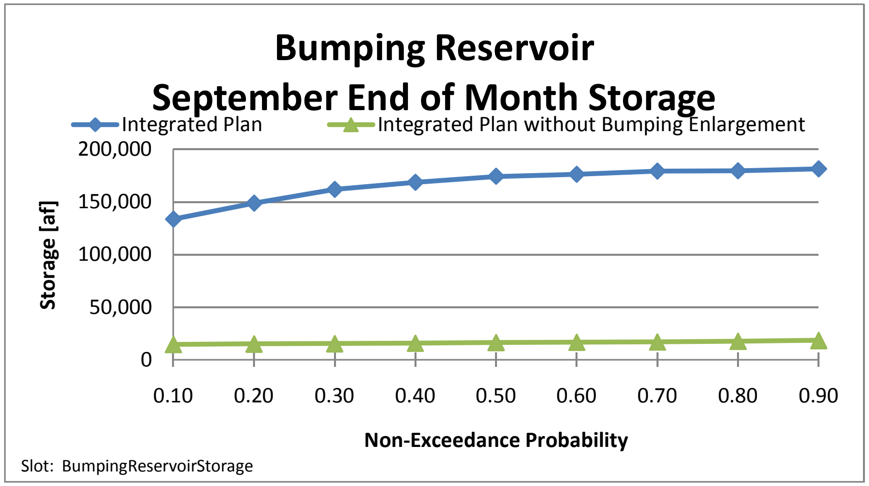

Yakima River at Parker
Wet Flows (WY 2002)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima River at Parker PARWGage Outflow

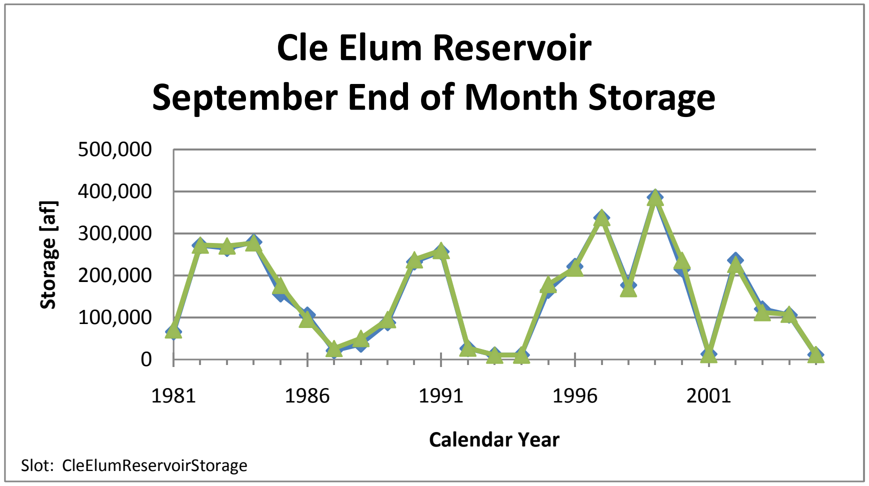

Yakima River at Kiona
Average Flows (WY 2003)
Integrated Plan
Integrated Plan without Bumping Enlargement
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

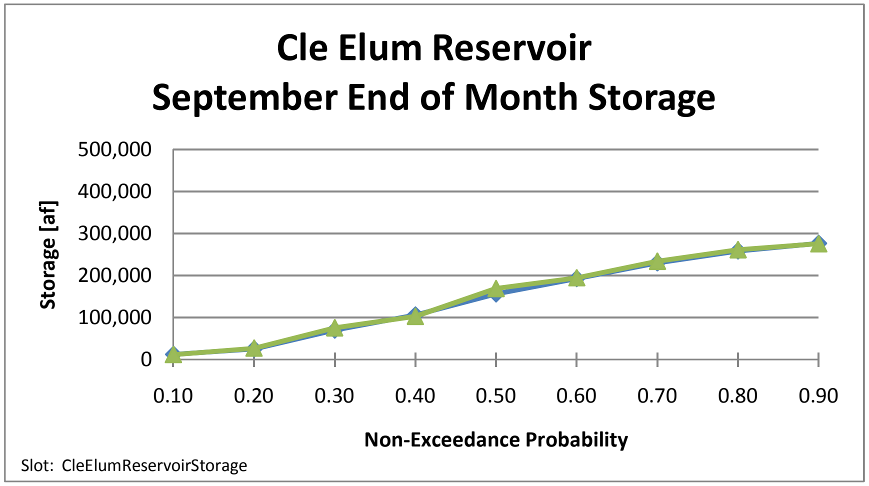

Yakima River at Kiona
Drought Flows (WY 2001)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

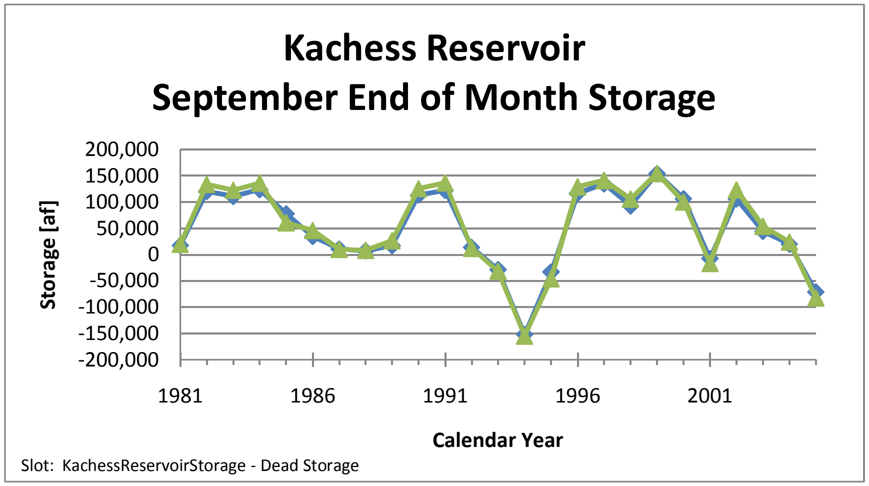

Yakima River at Kiona
Wet Flows (WY 2002)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

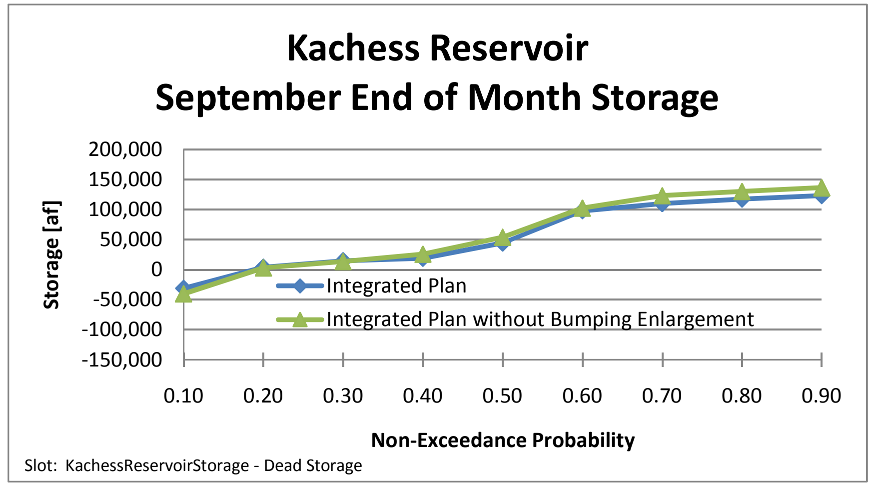

Bumping Reservoir
September End of Month Storage
Storage [af]
200,000
150,000
100,000
50,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: BumpingReservoirStorage

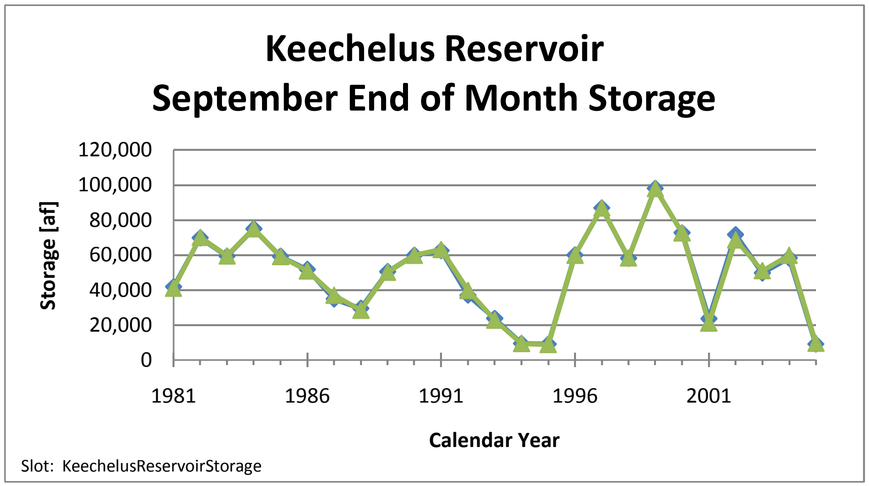

Bumping Reservoir
September End of Month Storage
Integrated Plan
Integrated Plan without Bumping Enlargement
Storage [af]
200,000
150,000
100,000
50,000
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: BumpingReservoirStorage

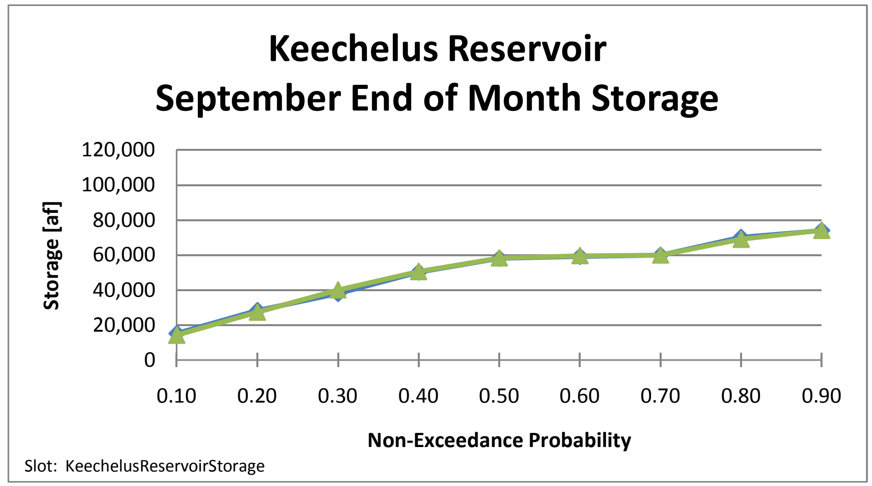

Cle Elum Reservoir
September End of Month Storage
Storage [af]
500,000
400,000
300,000
200,000
100,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: CleElumReservoirStorage

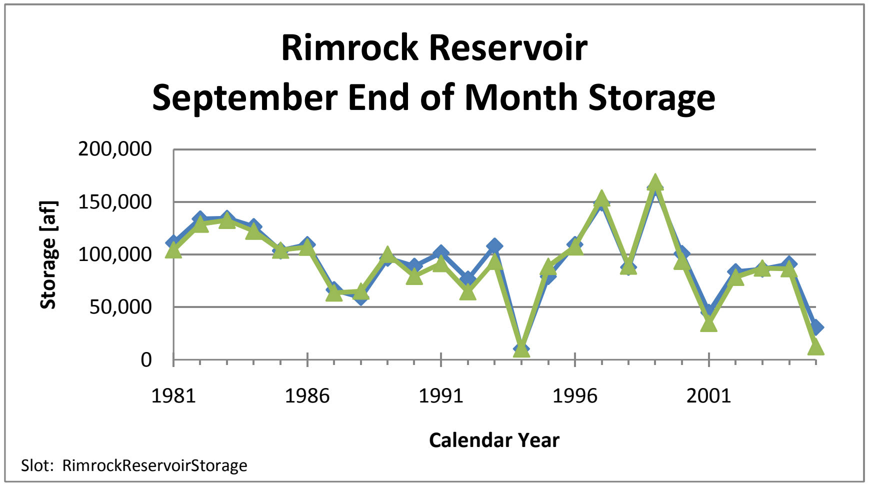

Cle Elum Reservoir
September End of Month Storage
Storage [af]
500,000
400,000
300,000
200,000
100,000
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: CleElumReservoirStorage

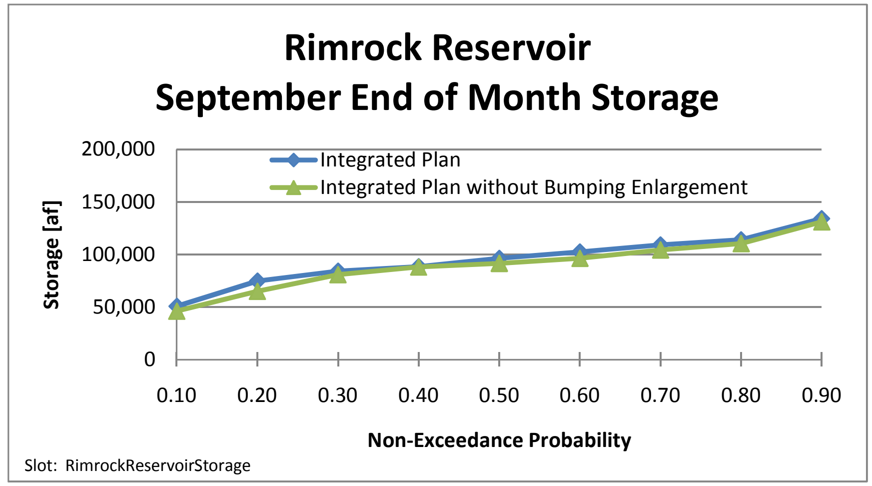

Kachess Reservoir
September End of Month Storage
Storage [af]
200,000
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
-200,000
1981
1986
1991
1996
2001
Calendar Year
Slot: KachessReservoirStorage - Dead Storage

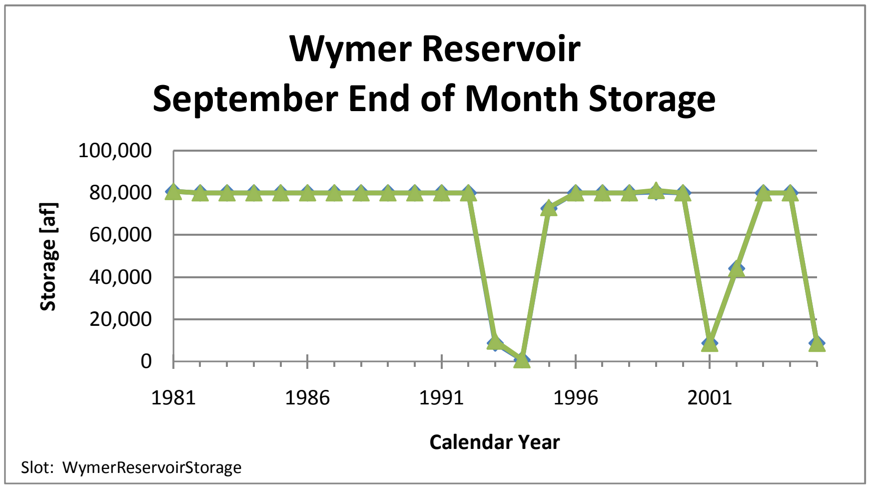

Kachess Reservoir
September End of Month Storage
Storage [af]
200,000
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
Integrated Plan
Integrated Plan without Bumping Enlargement
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KachessReservoirStorage - Dead Storage

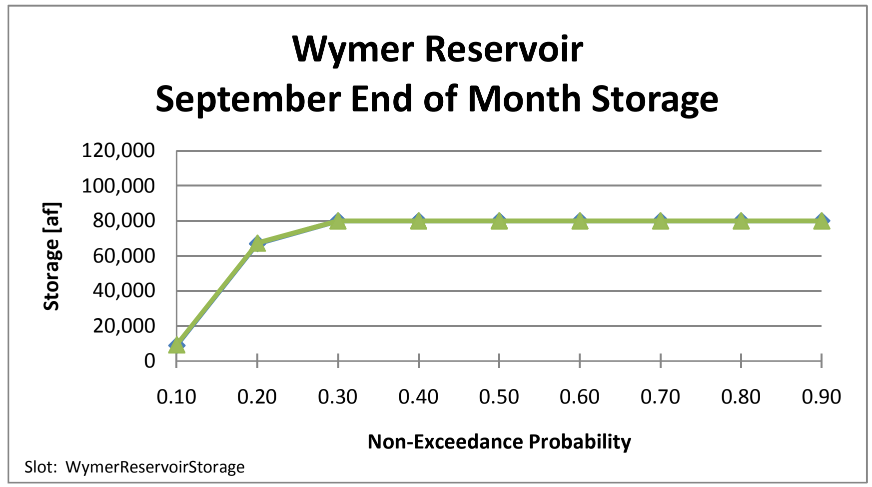

Keechelus Reservoir
September End of Month Storage
Storage [af]
120,000
100,000
80,000
60,000
40,000
20,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: KeechelusReservoirStorage

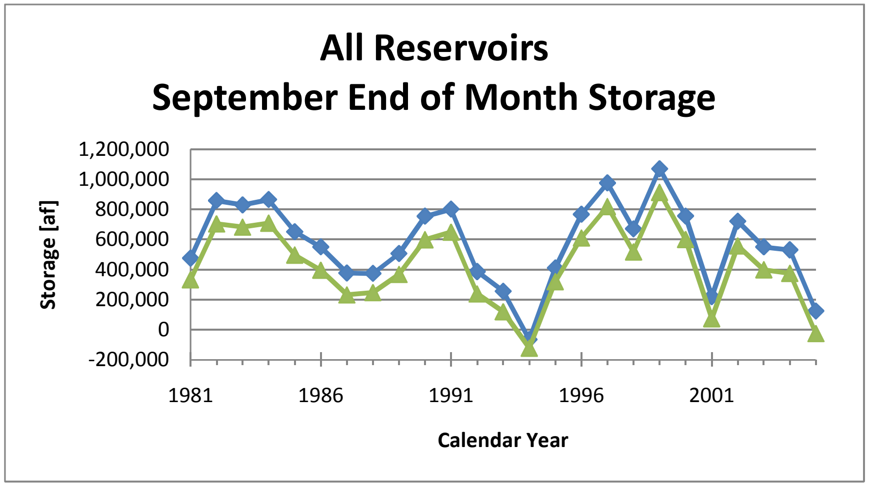

Keechelus Reservoir
September End of Month Storage
Storage [af]
120,000
100,000
80,000
60,000
40,000
20,000
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KeechelusReservoirStorage

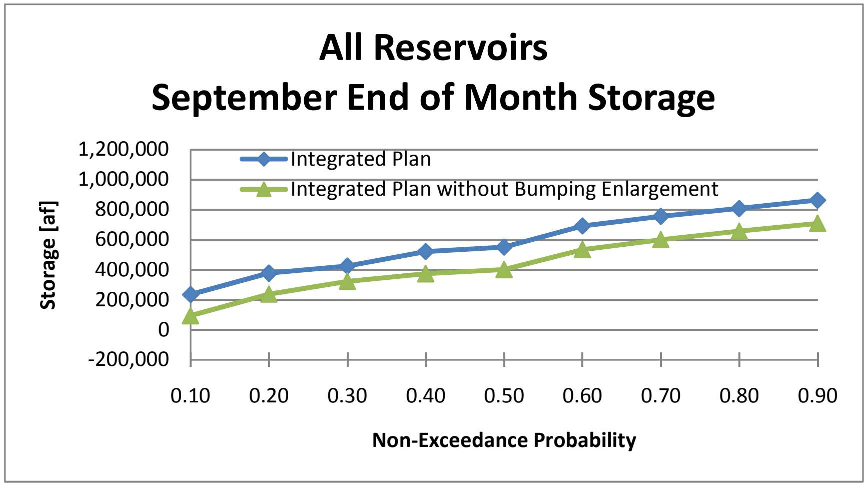

Rimrock Reservoir
September End of Month Storage
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: RimrockReservoirStorage

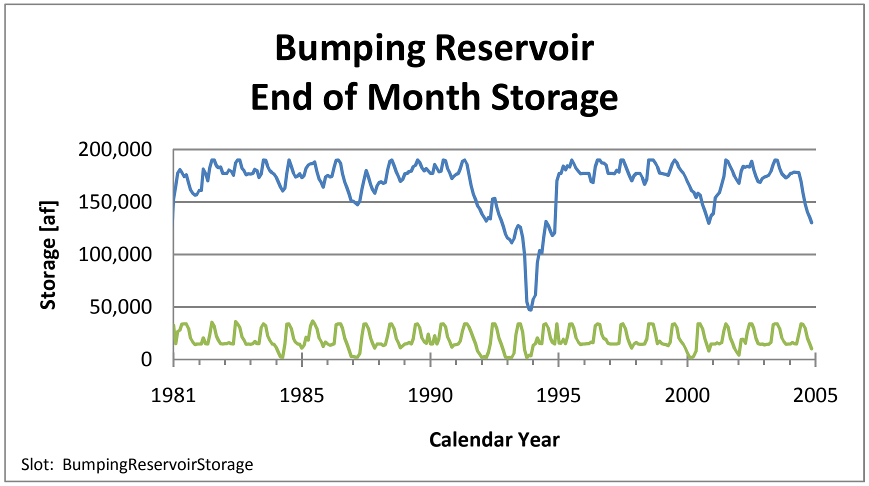

Rimrock Reservoir
September End of Month Storage
Integrated Plan
Integrated Plan without Bumping Enlargement
200,000
150,000
100,000
50,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: RimrockReservoirStorage

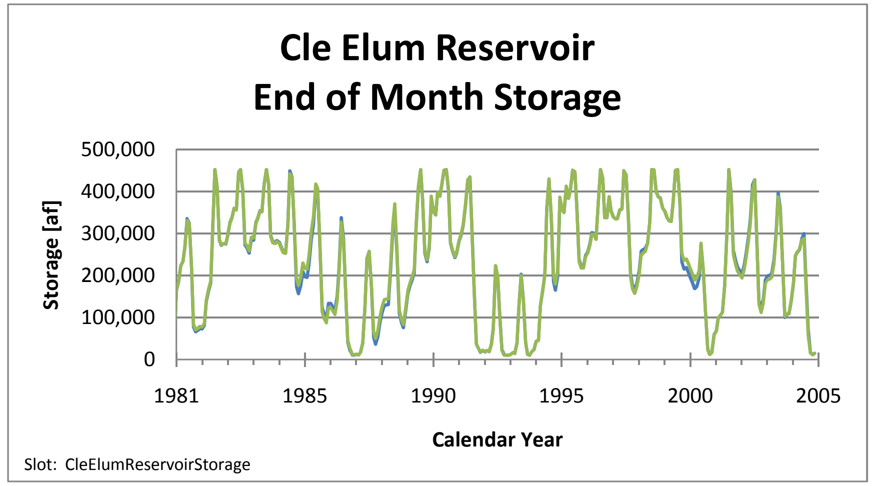

Wymer Reservoir
September End of Month Storage
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: WymerReservoirStorage

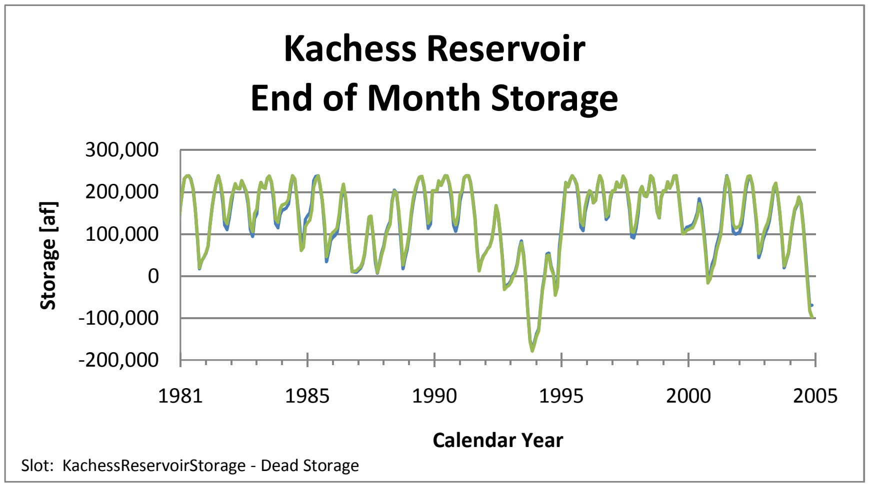

Wymer Reservoir
September End of Month Storage
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: WymerReservoirStorage

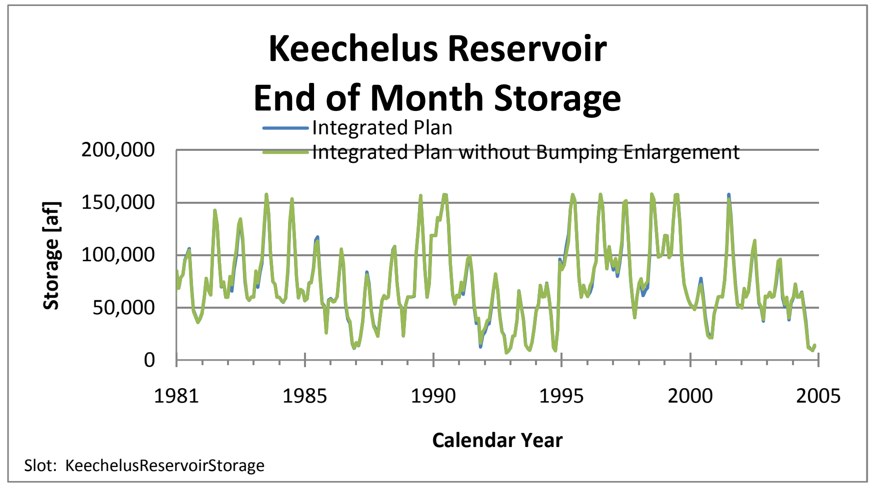

All Reservoirs
September End of Month Storage
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
-200,000
Storage [af]
1981
1986
1991
1996
2001
Calendar Year

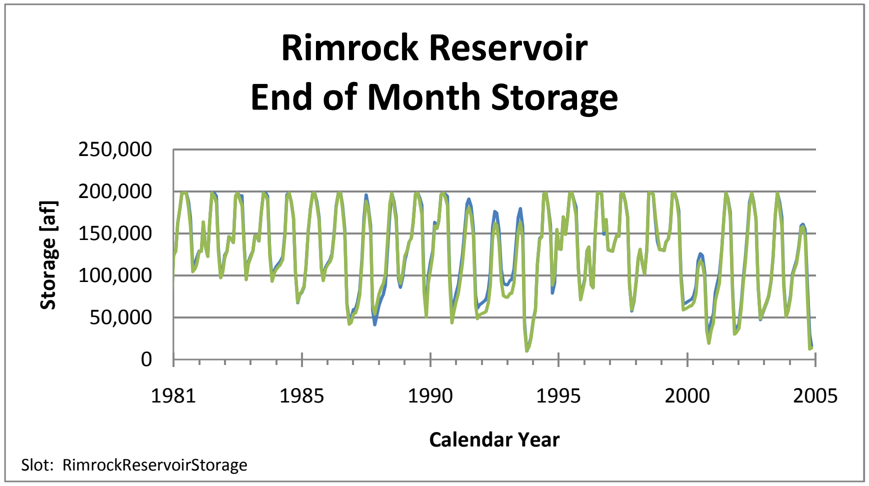

All Reservoirs
September End of Month Storage
Integrated Plan
Integrated Plan without Bumping Enlargement
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
-200,000
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability

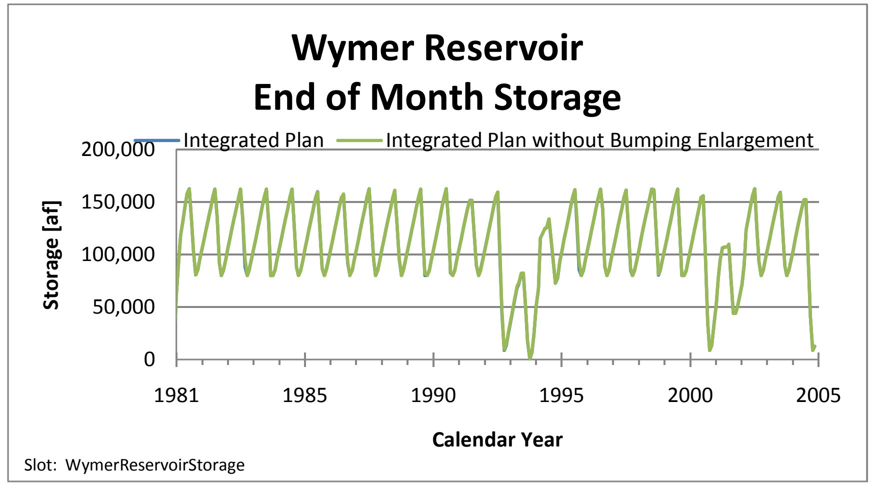

Bumping Reservoir
End of Month Storage
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: BumpingReservoirStorage

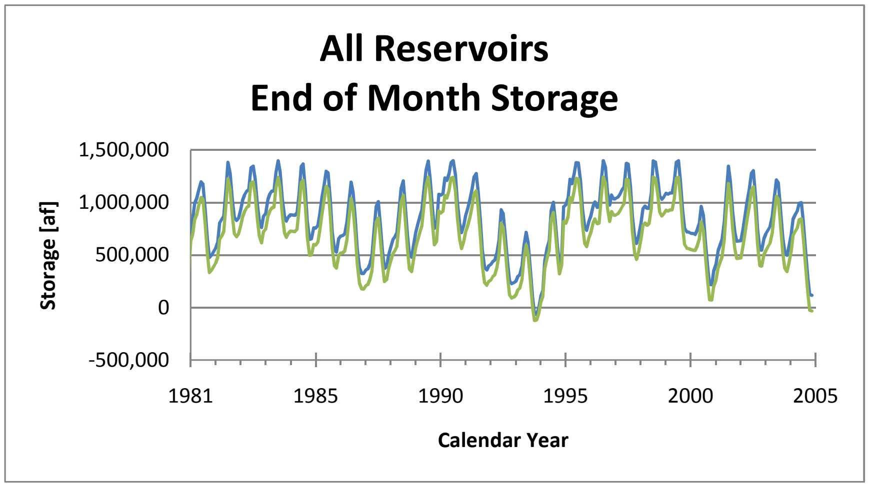

Cle Elum Reservoir
End of Month Storage
500,000
400,000
300,000
200,000
100,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: CleElumReservoirStorage

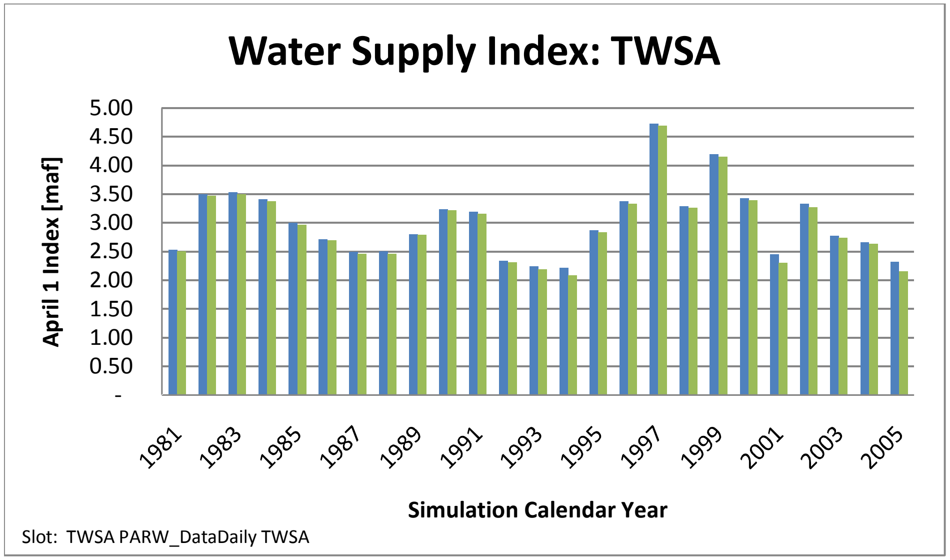

Kachess Reservoir
End of Month Storage
300,000
200,000
100,000
0
-100,000
-200,000
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KachessReservoirStorage - Dead Storage

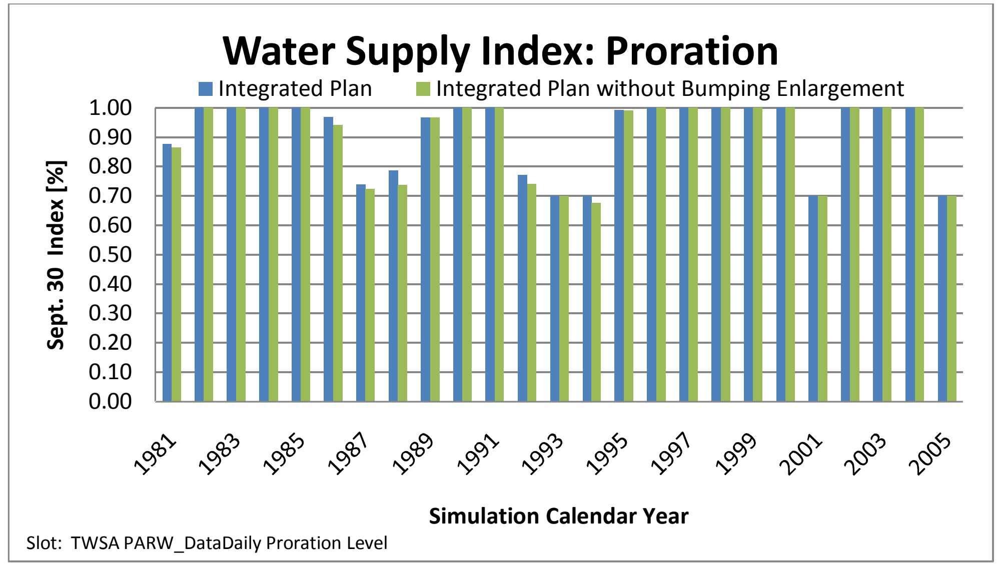

Keechelus Reservoir
End of Month Storage
Integrated Plan
Integrated Plan without Bumping Enlargement
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KeechelusReservoirStorage

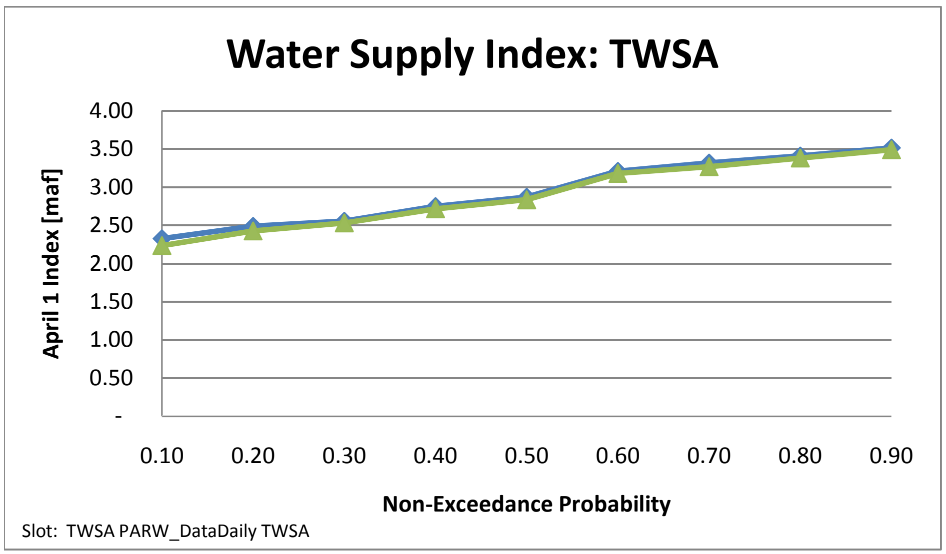

Rimrock Reservoir
End of Month Storage
250,000
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: RimrockReservoirStorage

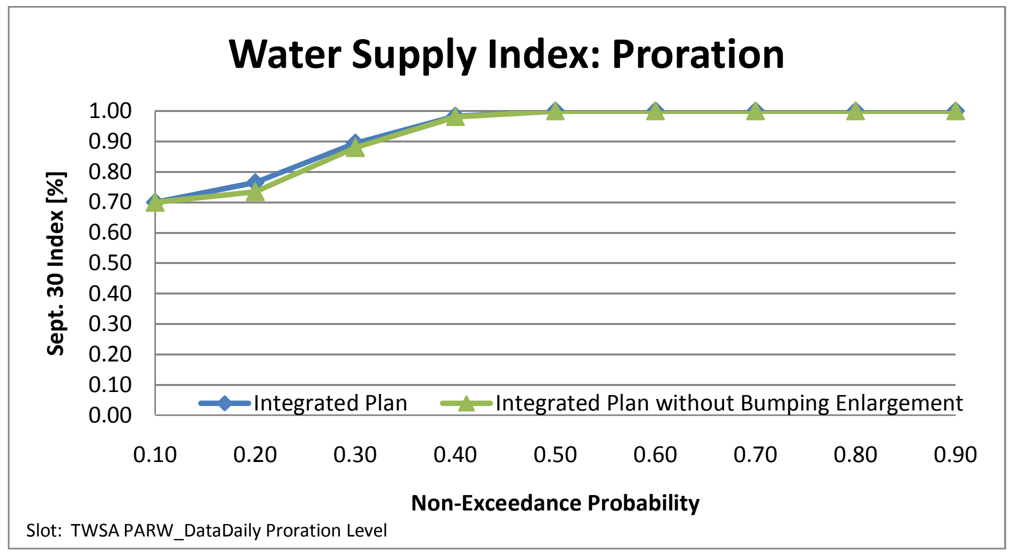

Wymer Reservoir
End of Month Storage
Integrated Plan
Integrated Plan without Bumping Enlargement
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: WymerReservoirStorage

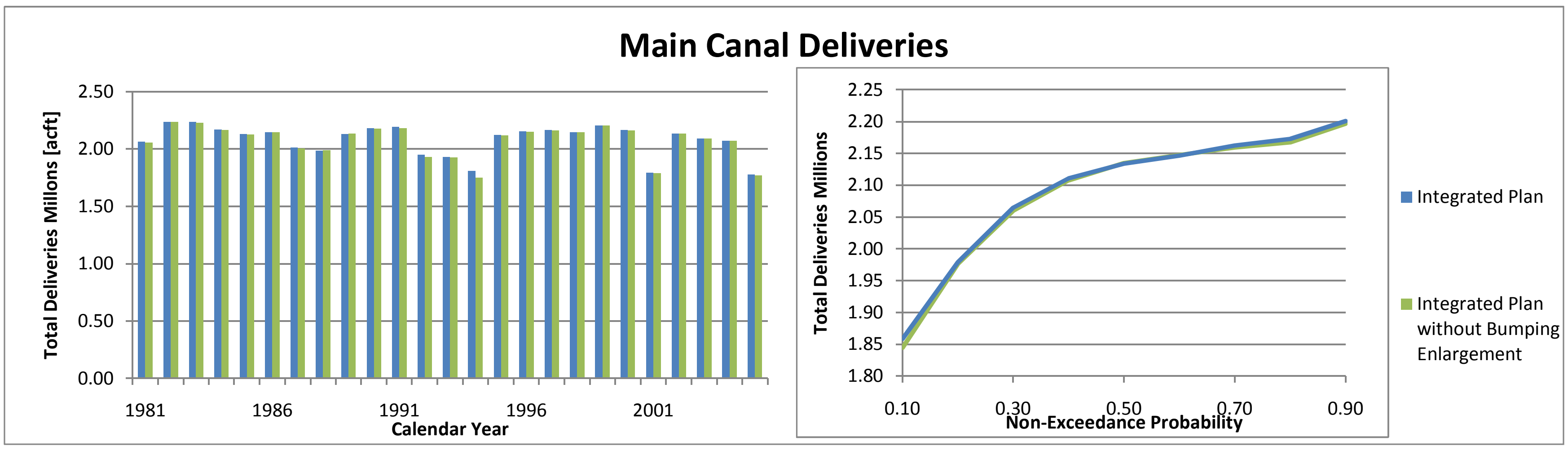

All Reservoirs
End of Month Storage
1,500,000
1,000,000
500,000
0
-500,000
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year

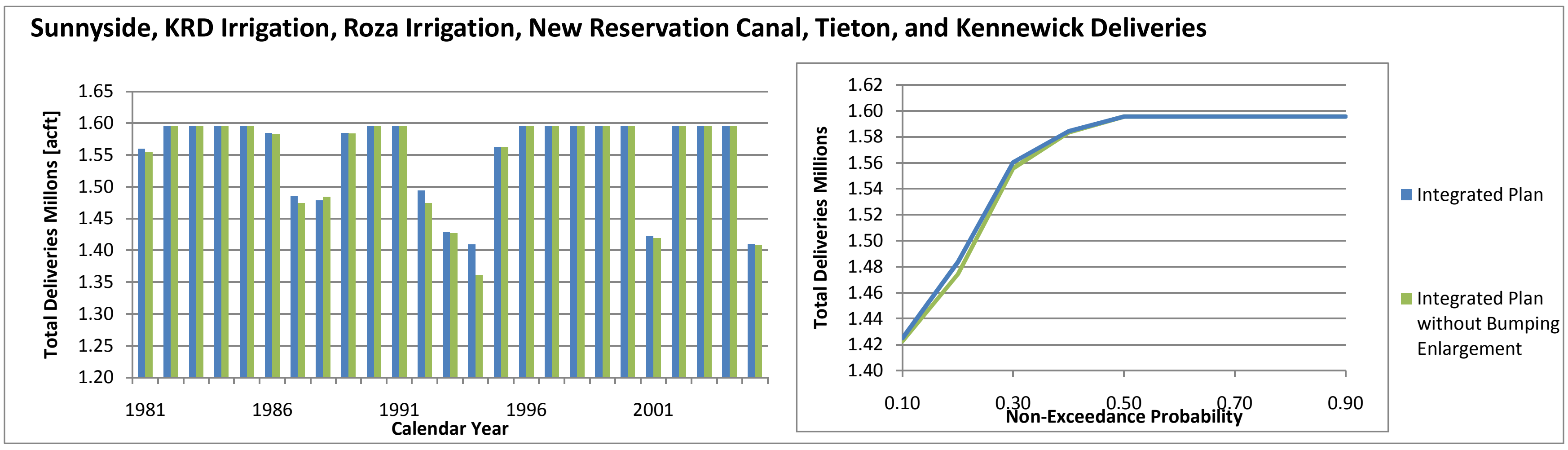

Water Supply Index: TWSA
April 1 Index [maf]
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
-
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
Simulation Calendar Year
Slot: TWSA PARW_DataDaily TWSA

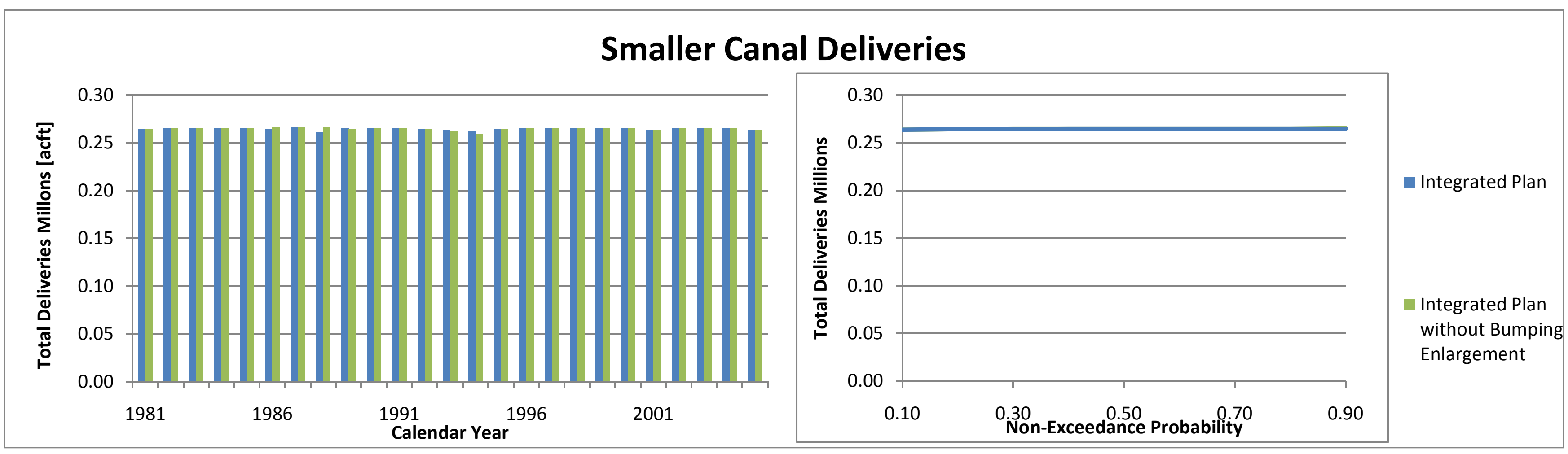

Water Supply Index: Proration
Integrated Plan
Integrated Plan without Bumping Enlargement
Sept. 30 Index [%]
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
Simulation Calendar Year
Slot: TWSA PARW_DataDaily Proration Level

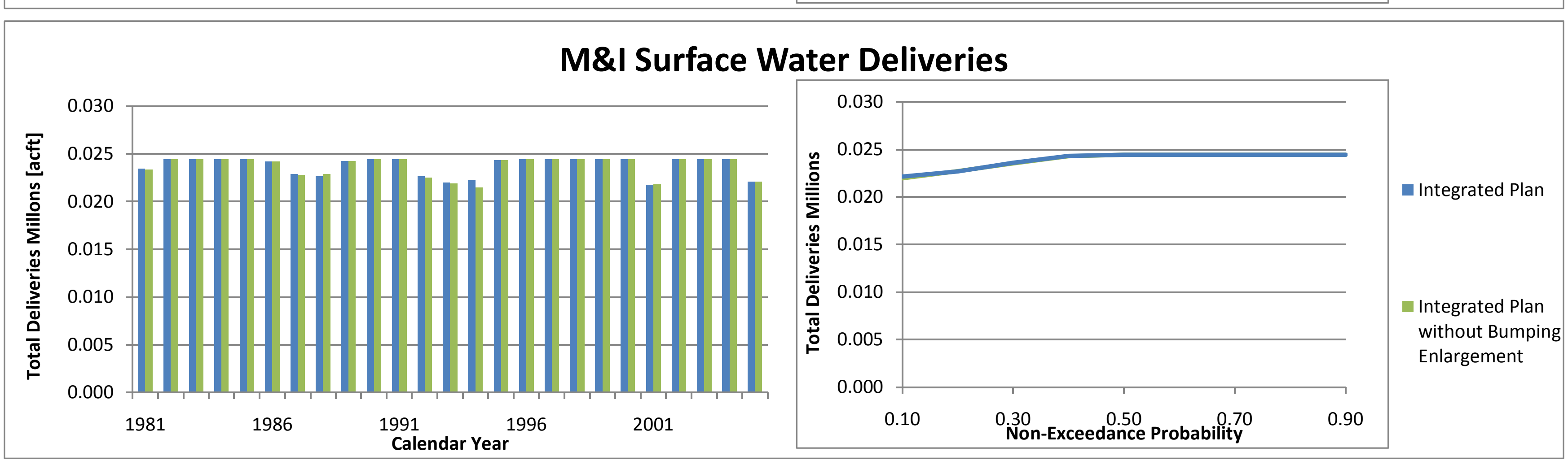

Water Supply Index: TWSA
April 1 Index [maf]
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
-
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily TWSA


Water Supply Index: Proration
Sept. 30 Index [%]
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Integrated Plan
Integrated Plan without Bumping Enlargement
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily Proration Level


Main Canal Deliveries
Total Deliveries Millons [acft]
Calendar Year
1981
1986
1991
1996
2001
Total Deliveries Millions
Non-Exceedance Probability
Integrated Plan
Integrated Plan without Bumping Enlargement


Sunnyside, KRD Irrigation, Roza Irrigation, New Reservation Canal, Tieton, and Kennewick Deliveries
Total Deliveries Millons [acft]
Calendar Year
1981
1986
1991
1996
2001
Total Deliveries Millions
Non-Exceedance Probability
Integrated Plan
Integrated Plan without Bumping Enlargement


Smaller Canal Deliveries
Total Deliveries Millons [acft]
Calendar Year
1981
1986
1991
1996
2001
Total Deliveries Millions
Non-Exceedance Probability
Integrated Plan
Integrated Plan without Bumping Enlargement


M&I Surface Water Deliveries
Total Deliveries Millons [acft]
Calendar Year
1981
1986
1991
1996
2001
Total Deliveries Millions
Non-Exceedance Probability
Integrated Plan
Integrated Plan without Bumping Enlargement

Appendix C – 2

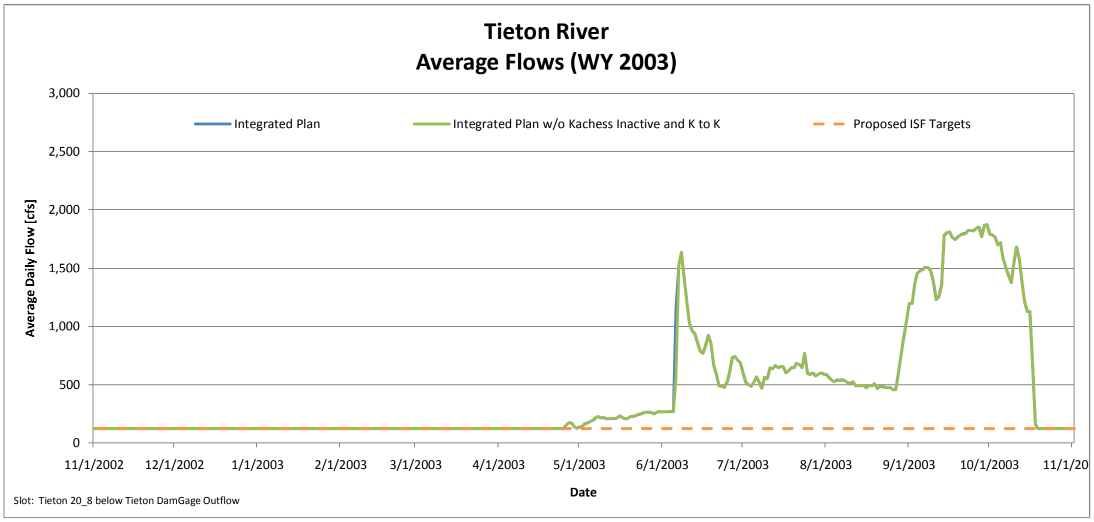
Adjusted Integrated Plan Results
Without Kachess Inactive Storage and Keechelus to Kachess (K to K) Pipeline

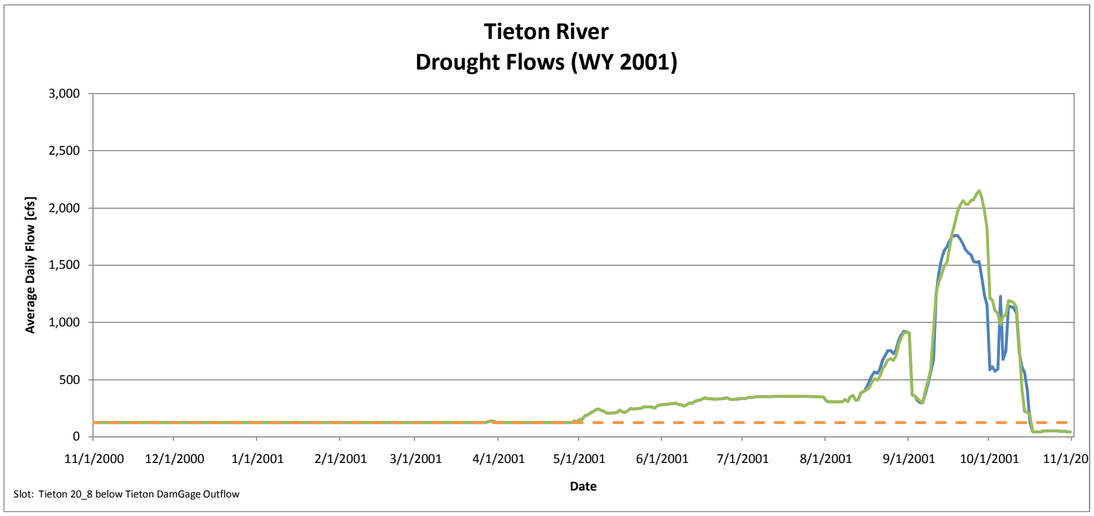
Resource indicator (measurement)	Integrated Plan	Integrated Plan w/o Kachess Inactive and K to K
WATER RESOURCES		
Average for water years 1981–2005 (maf)		
Water supply		
April 1 total water supply available (TWSA)	3.00	3.00
Water distribution		
April–September Parker flow volume	0.60	0.61
April–September diversion	1.69	1.69
September 30 reservoir contents	0.58	0.60
April–September flow volume at mouth of Yakima River	0.87	0.87
1994 dry-year (maf)		
Water supply		
April 1 TWSA	2.22	2.01
Water distribution		
April–September Parker flow volume	0.25	0.26
April–September diversion	1.52	1.44
September 30 reservoir contents	-0.06	0.07
April–September flow volume at mouth of Yakima River	0.35	0.36
Irrigation proration level	70%	56%

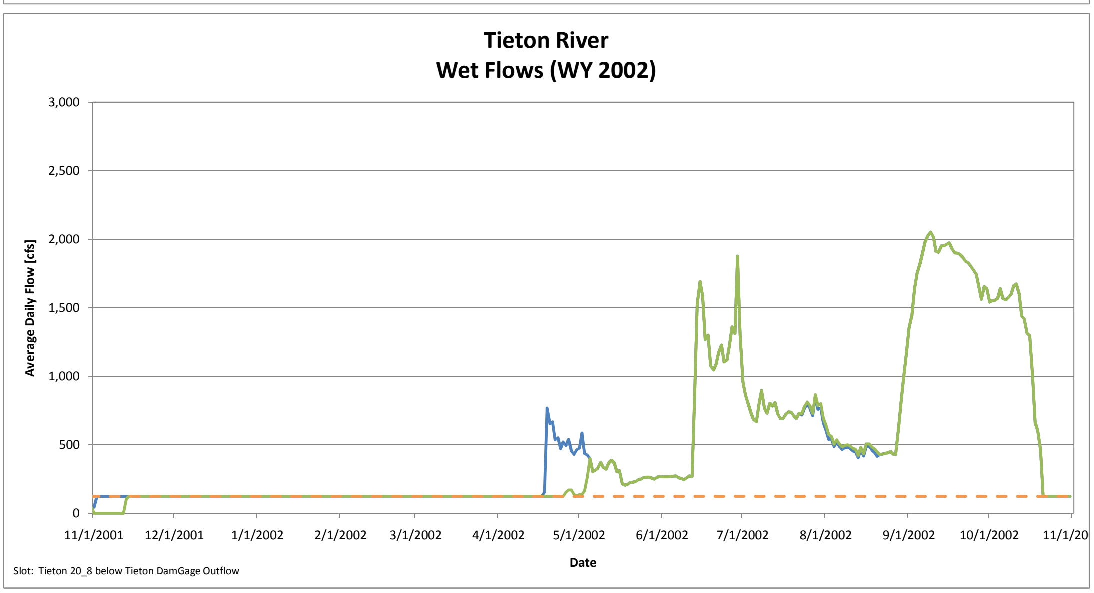
Resource indicator (measurement)	Integrated Plan	Integrated Plan w/o Kachess Inactive and K to K
ANADROMOUS FISH		
Rate of change in flow during flip-flop (average cfs/day August 16–September 14)		
Easton reach	-7	-7
Ellensburg reach	-45	-45
Lower Naches River reach	31	32
Pre- (August 1-15) and post- (September 14-28) flip-flop flow and absolute change in flow		
Easton reach		
Pre-flip-flop flow (cfs)	574	571
Post-flip-flop flow (cfs)	364	378
Absolute change in flow (cfs)	-211	-193
Ellensburg reach		
Pre-flip-flop flow (cfs)	2,867	2,863
Post-flip-flop flow (cfs)	1,574	1,568
Absolute change in flow (cfs)	-1,293	-1,295
Lower Naches River reach		
Pre-flip-flop flow (cfs)	644	632
Post-flip-flop flow (cfs)	1,548	1,574
Absolute change in flow (cfs)	904	942
Average, minimum, and maximum reservoir elevation (feet) during bull trout spawning migration: July 15–September 15 (feet)		
Kachess Lake	2235.41 2146.99-2261.96	2243.12 2193.96-2262
Keechelus Lake	2476.7 2432.28-2516.96	2467.89 2431.86-2516.99
Rimrock Lake	2914.66 2801.26-2926	2915.16 2801.03-2926

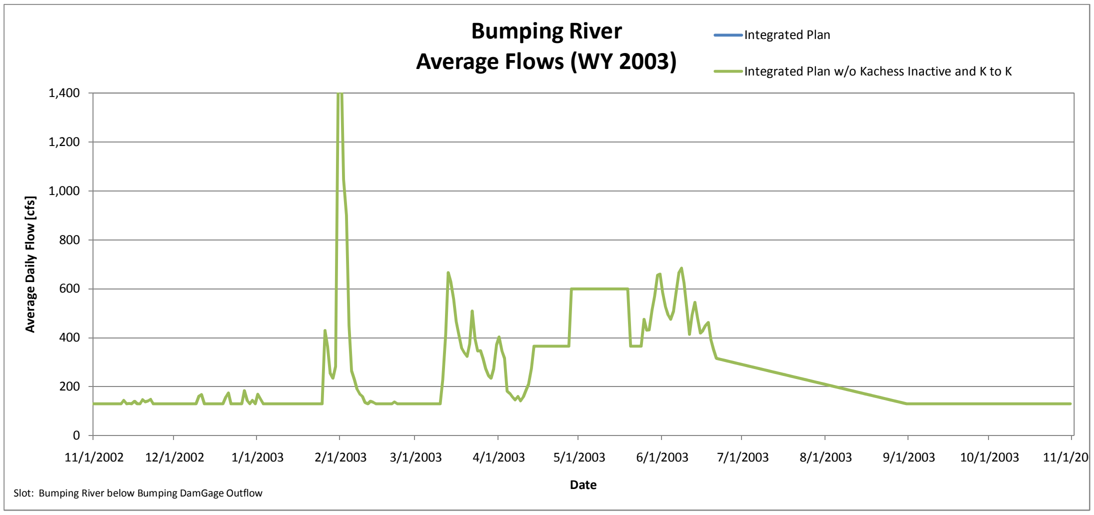
Hydrologic Indicator	Integrated Plan					Integrated Plan w/o Kachess Inactive and K to K				
	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997
April 1 TWSA (maf)	3.00	2.22	2.45	2.32	4.73	3.00	2.01	2.25	2.13	4.74
April-September flow volume at Parker gage (kaf)	605	245	198	181	1937	609	259	203	187	1947
March-October flow volume at Parker gage (kaf)	907	400	335	310	2638	907	398	340	311	2666
April-September diversion volume upstream of Parker gage (maf)	1.69	1.52	1.55	1.53	1.73	1.69	1.44	1.55	1.53	1.73
September 30 non-Bumping or Wymer reservoir contents (kaf)	348	-121	75	-19	709	366	31	69	35	709
October 31 non-Bumping or Wymer reservoir contents (kaf)	329	-120	74	-26	802	348	61	69	48	803
September 30 Bumping and Wymer reservoir contents (kaf)	229	56	145	144	267	226	37	145	119	267
April-September flow volume at mouth of Yakima River (kaf)	867	349	272	293	2262	871	361	277	301	2273
Irrigation proration level (percent)[1]	92%	70%	70%	70%	100%	91%	56%	70%	70%	100%

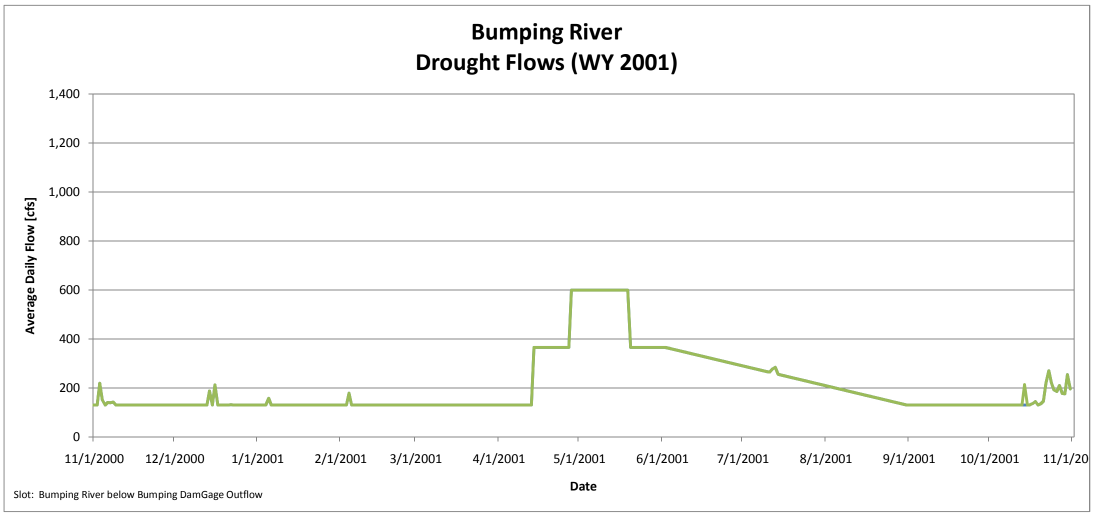
Item	Integrated Plan w/o Kachess Inactive and K to K	Integrated Plan	Improvement
Average 1981-2005			
TWSA [April 1, kaf]	2996.4	3004.9	8.5
March-October flow volume at Parker gage [kaf]	906.8	906.7	-0.1
Drought Year 1994			
TWSA [April 1, kaf]	2009.9	2215.7	205.8
March-October flow volume at Parker gage [kaf]	398.4	399.8	1.4
Drought Year 2001			
TWSA [April 1, kaf]	2252.4	2453.2	200.8
March-October flow volume at Parker gage [kaf]	340.4	335.5	-4.9
Drought Year 2005			
TWSA [April 1, kaf]	2125.9	2320.8	195.0
March-October flow volume at Parker gage [kaf]	311.0	310.2	-0.8
Wet Year 1997			
TWSA [April 1, kaf]	4736.6	4728.6	-8.1
March-October flow volume at Parker gage [kaf]	2666.4	2638.3	-28.1

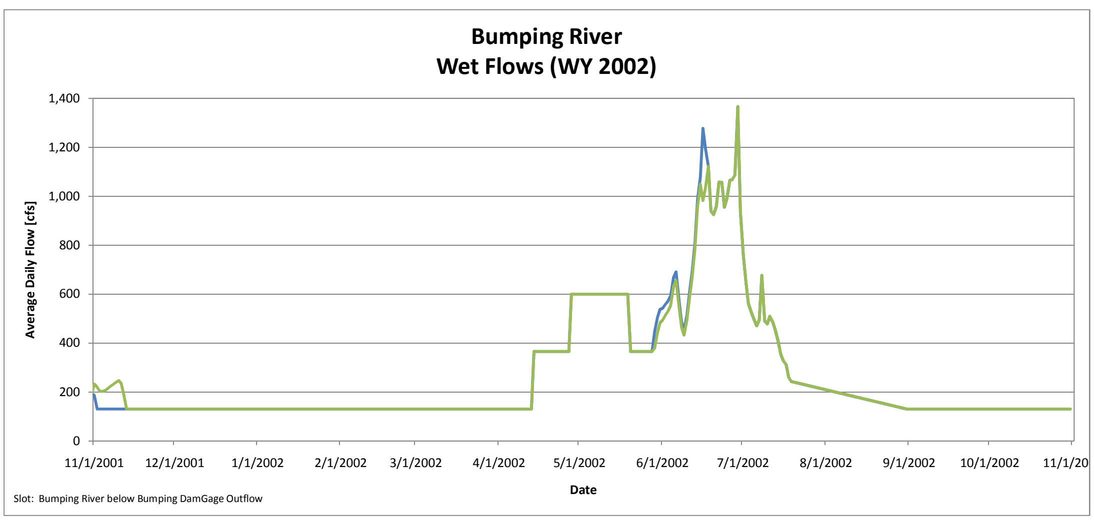

Tieton River
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Proposed ISF Targets
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

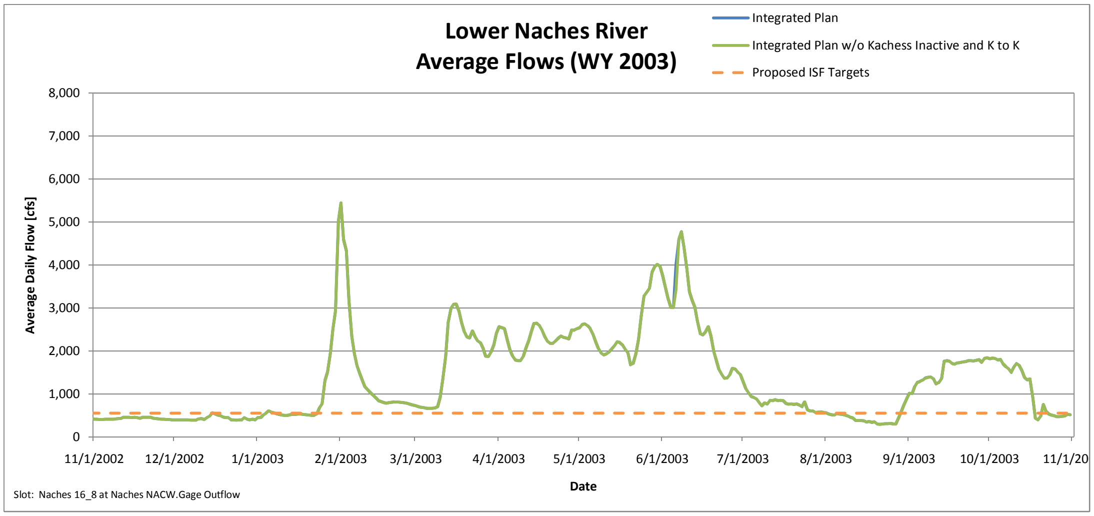

Tieton River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

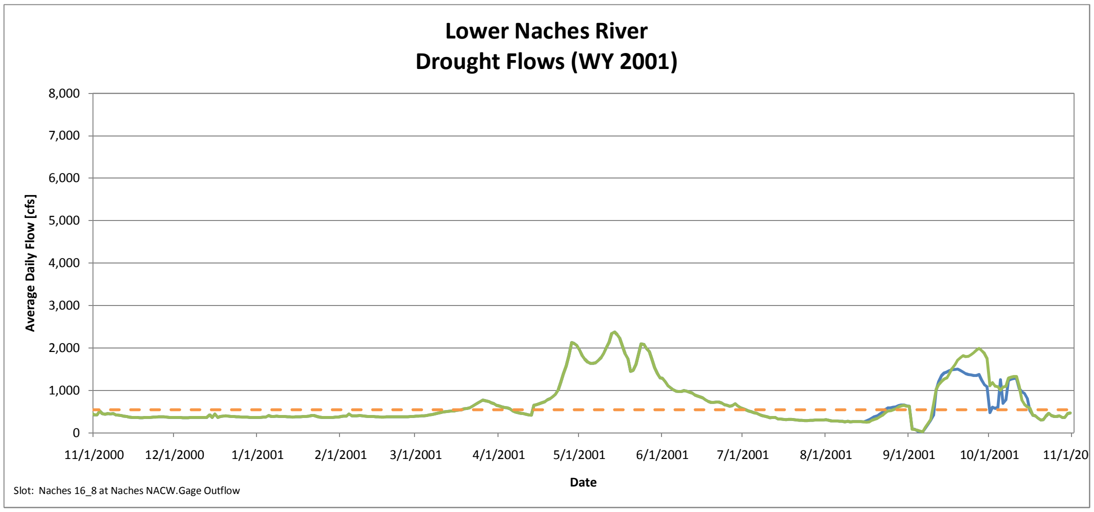

Tieton River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

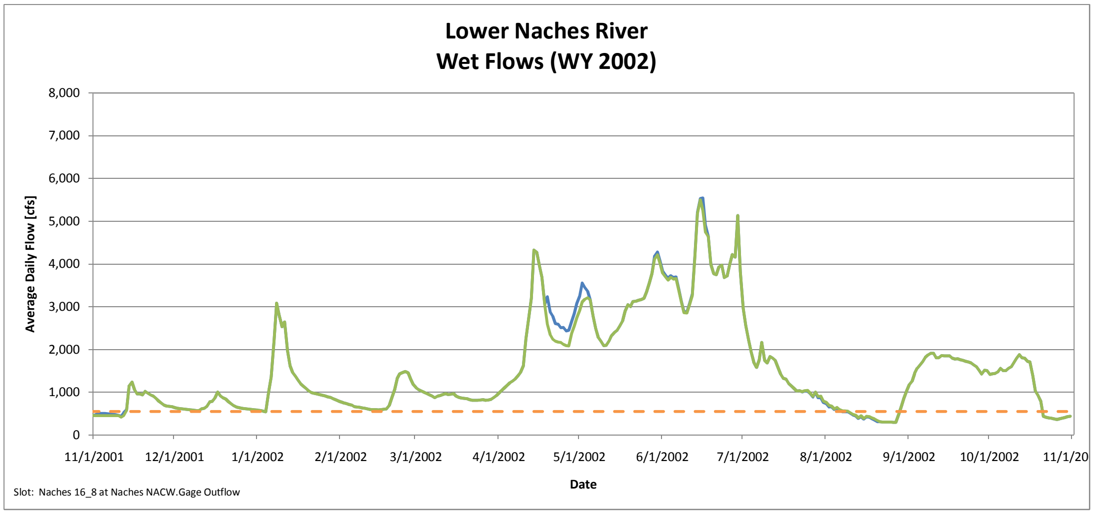

Bumping River
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

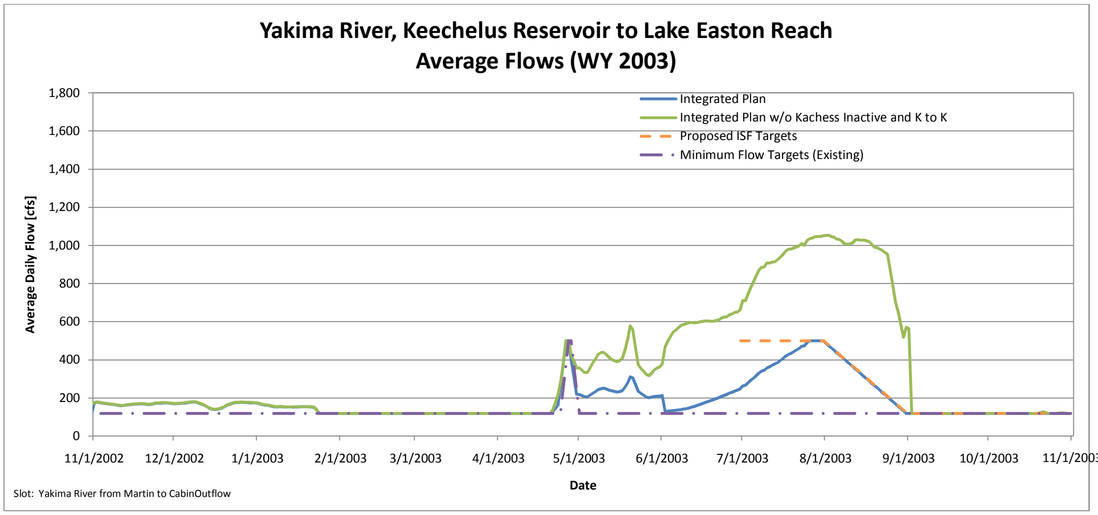

Bumping River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

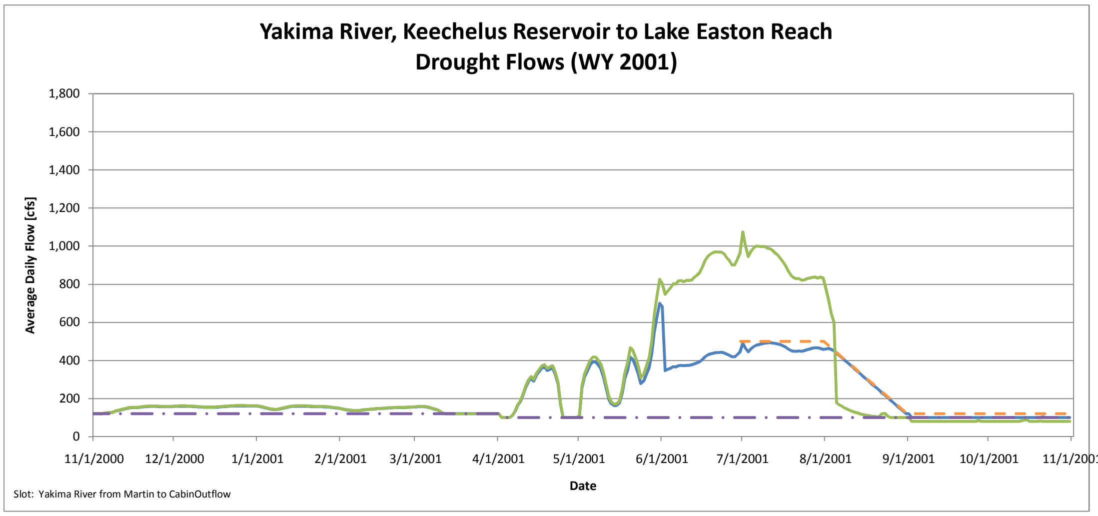

Bumping River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

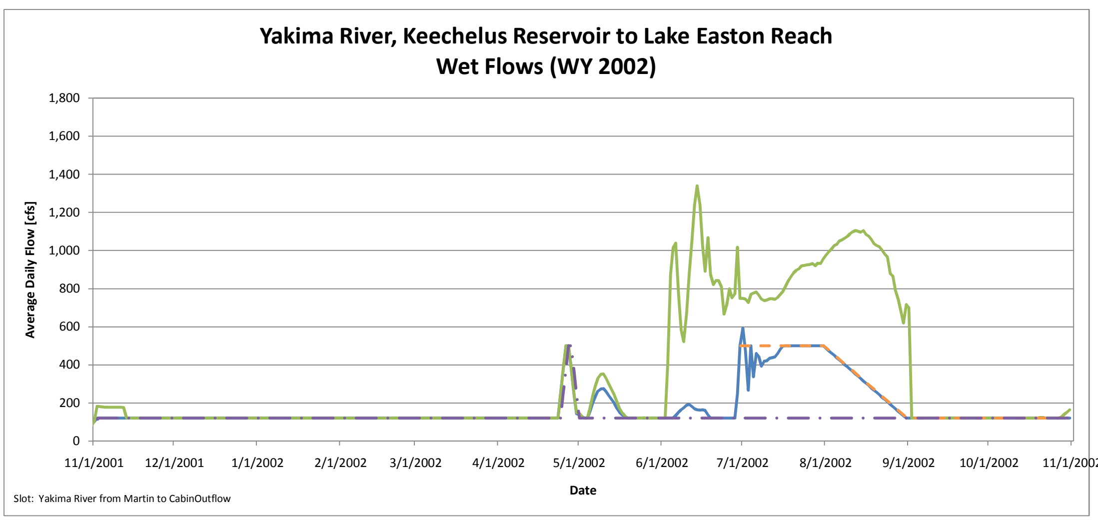

Lower Naches River
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Proposed ISF Targets
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

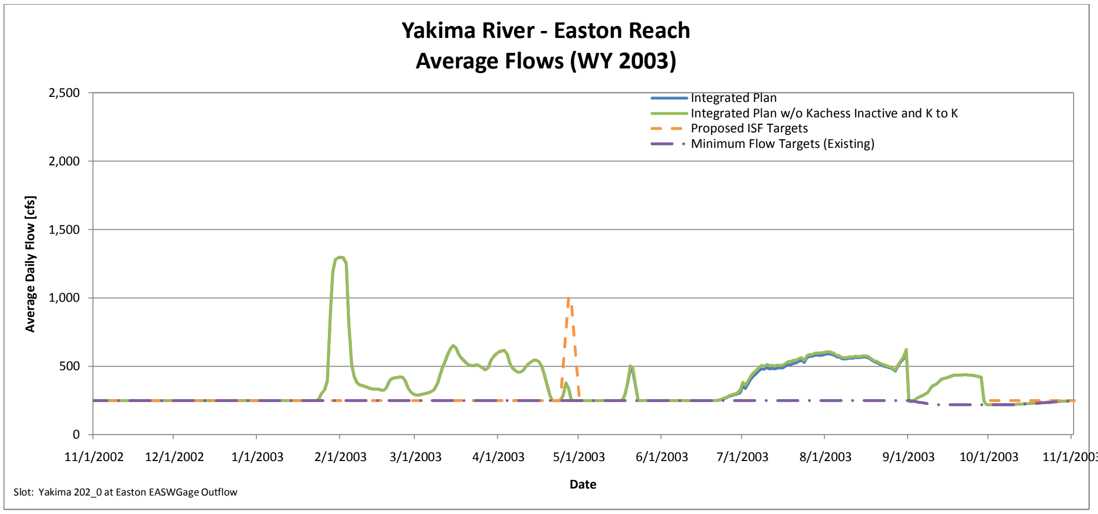

Lower Naches River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

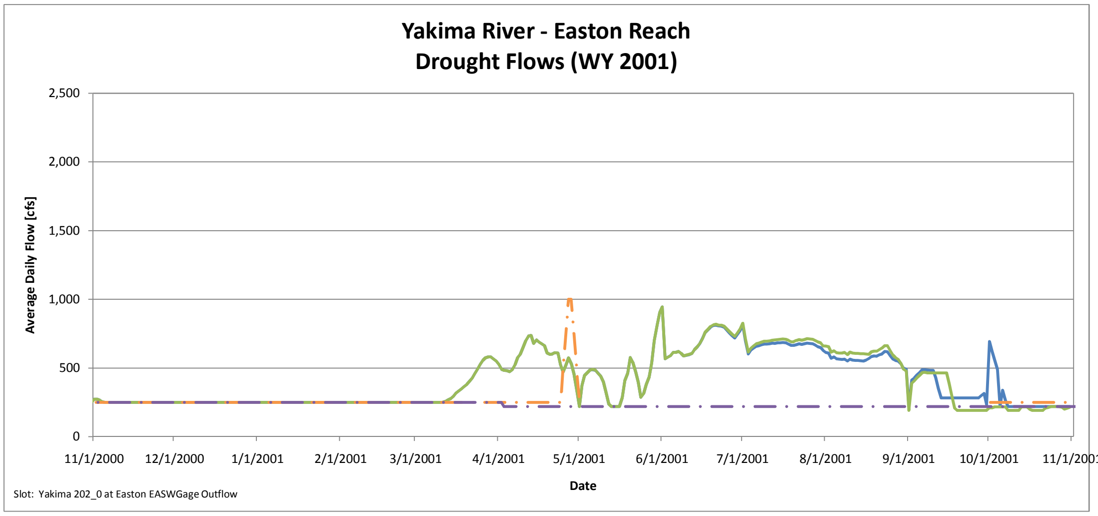

Lower Naches River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

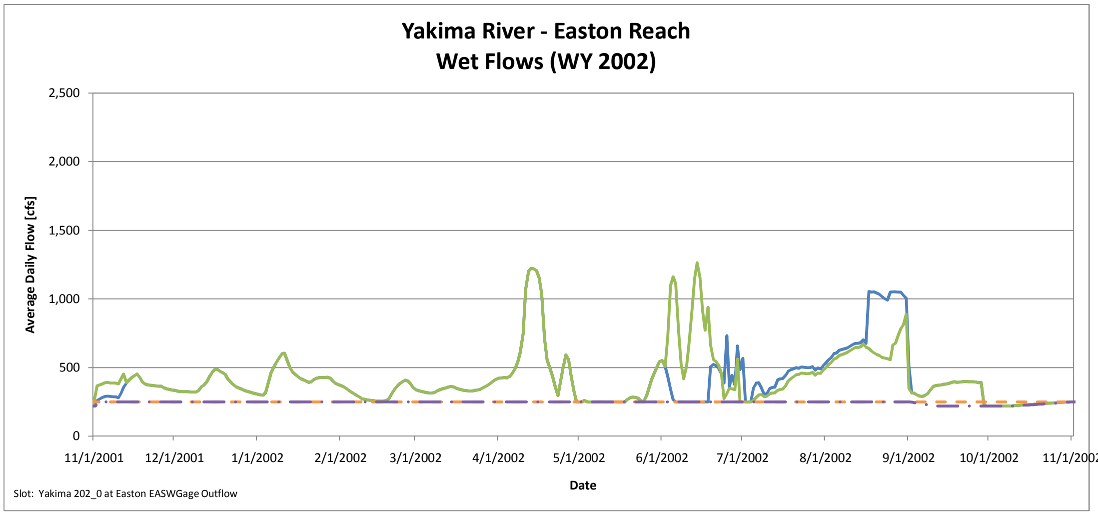

Yakima River, Keechelus Reservoir to Lake Easton Reach
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Proposed ISF Targets
Minimum Flow Targets (Existing)
Average Daily Flow [cfs]
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima River from Martin to CabinOutflow

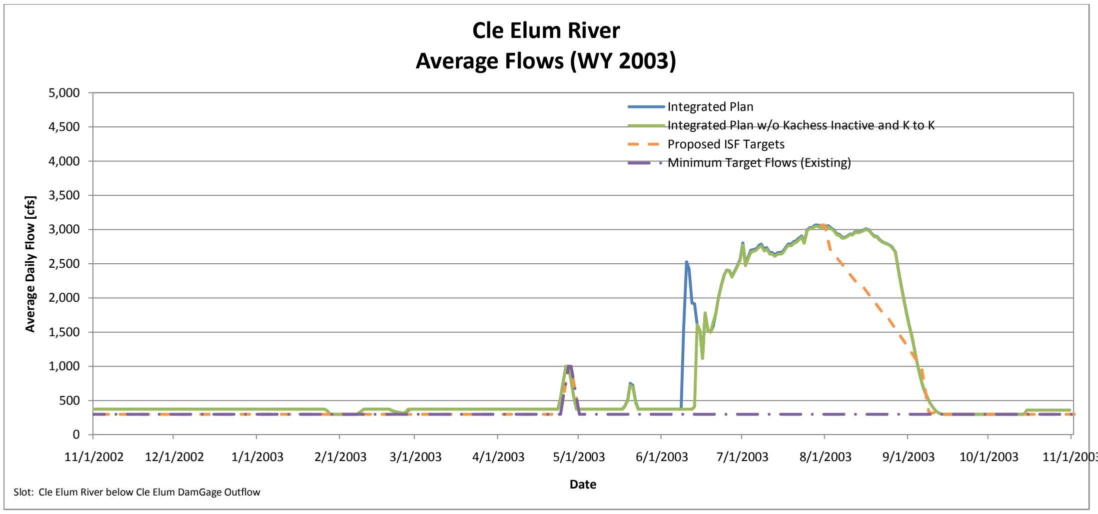

Yakima River, Keechelus Reservoir to Lake Easton Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima River from Martin to CabinOutflow

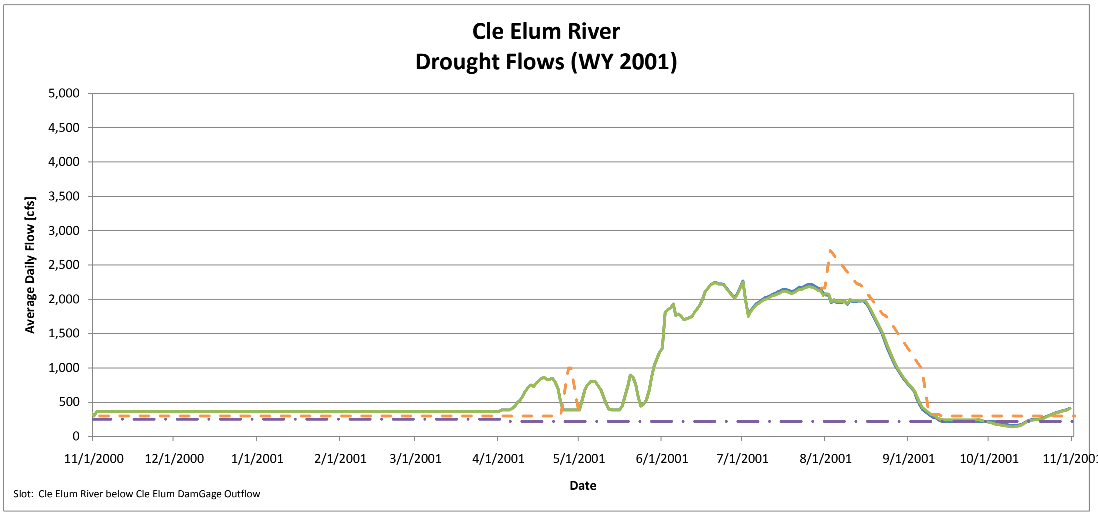

Yakima River, Keechelus Reservoir to Lake Easton Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima River from Martin to CabinOutflow

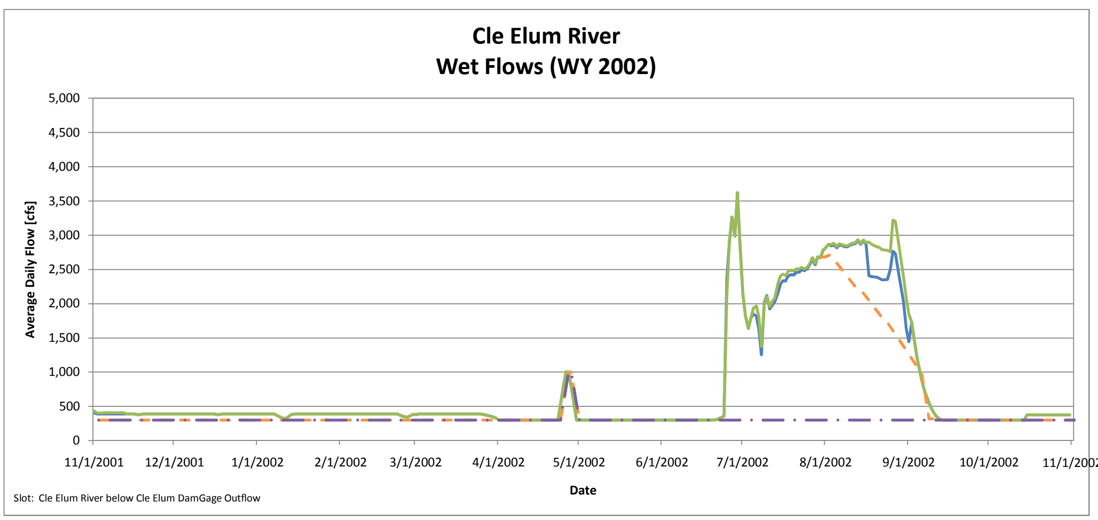

Yakima River - Easton Reach
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Proposed ISF Targets
Minimum Flow Targets (Existing)
Average Daily Flow [cfs]
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

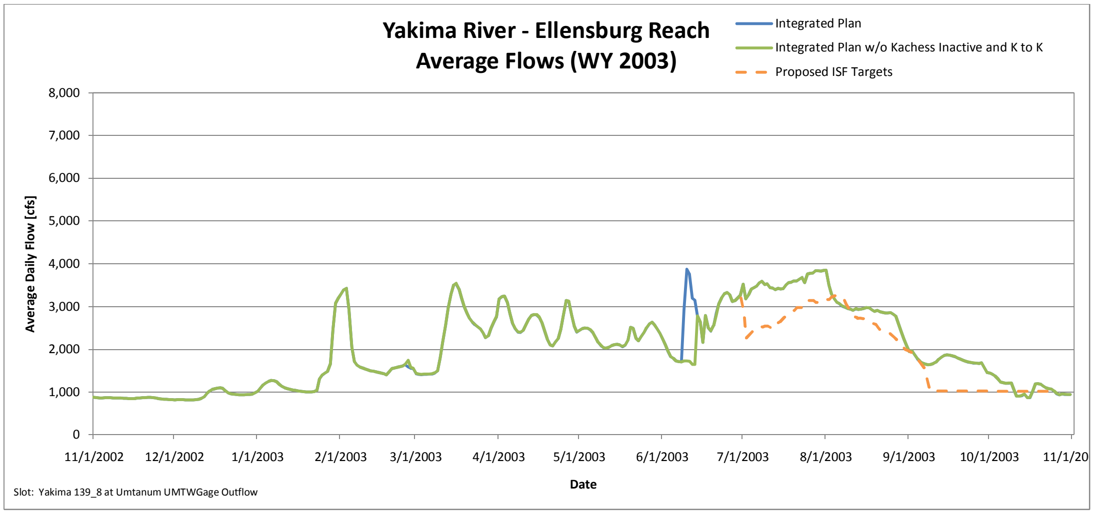

Yakima River - Easton Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

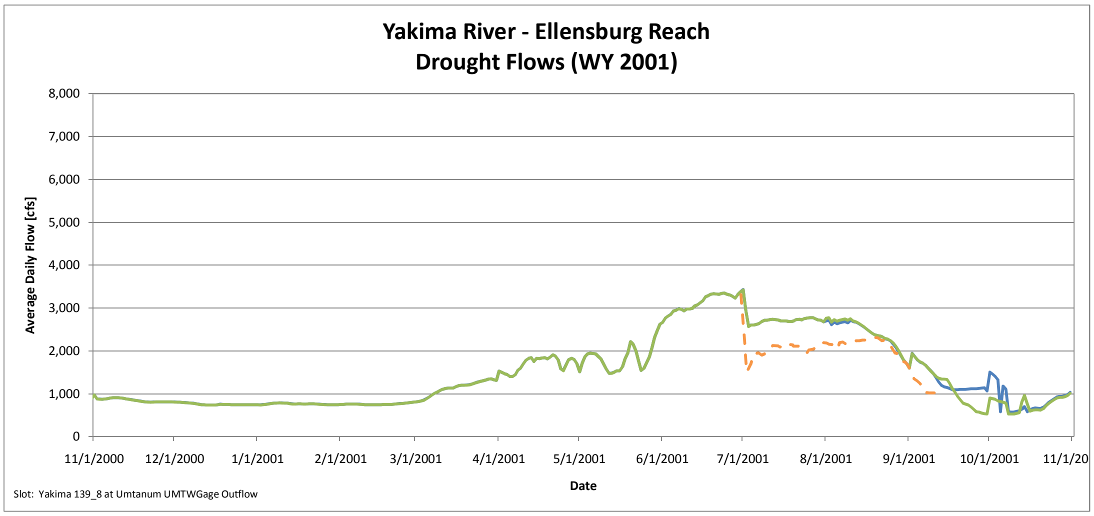

Yakima River - Easton Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

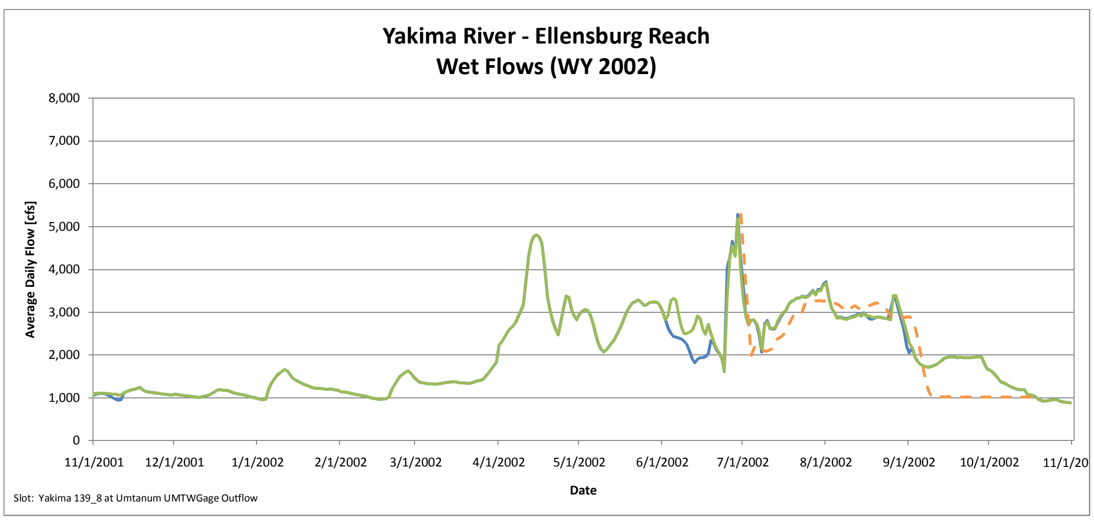

Cle Elum River
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Proposed ISF Targets
Minimum Target Flows (Existing)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

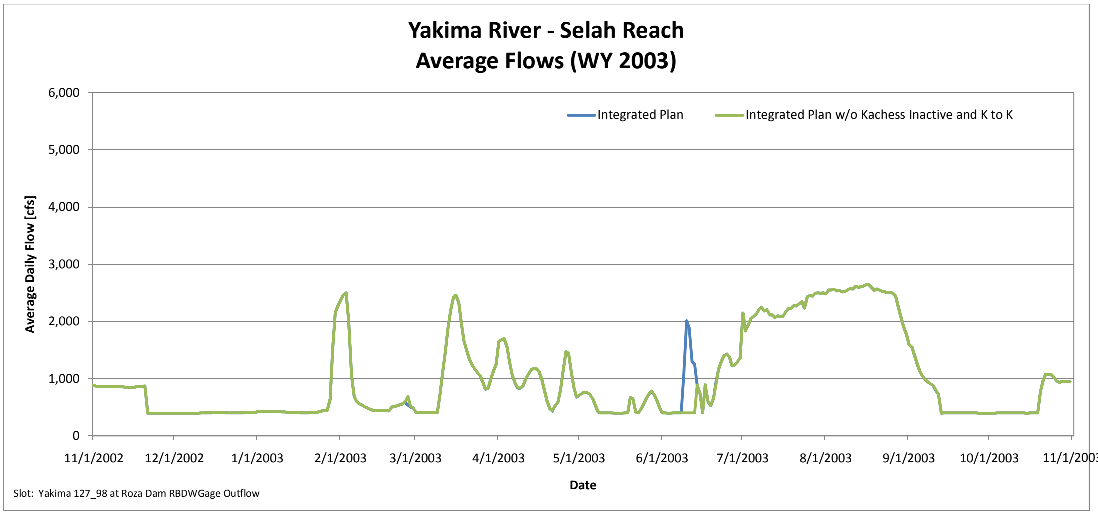

Cle Elum River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

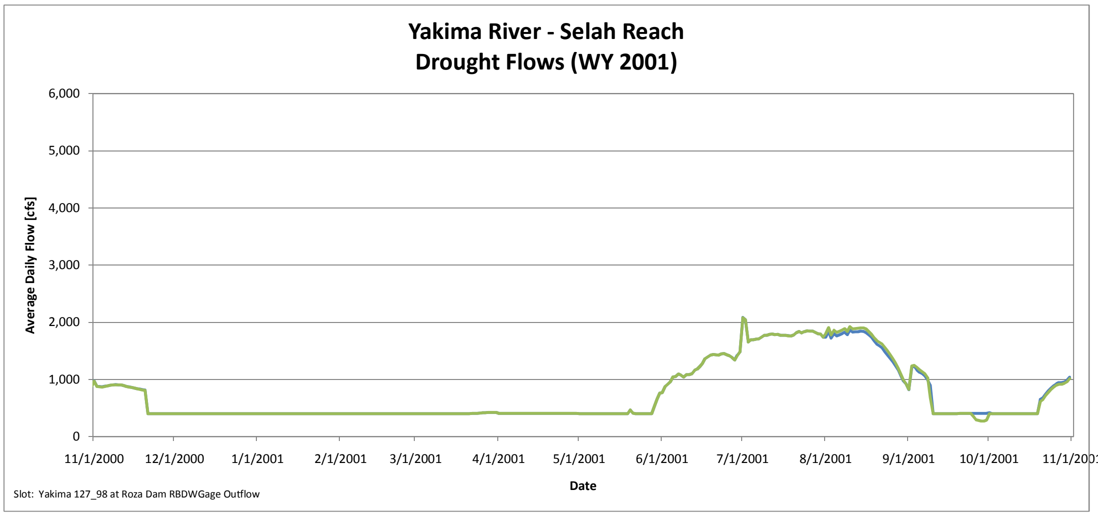

Cle Elum River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

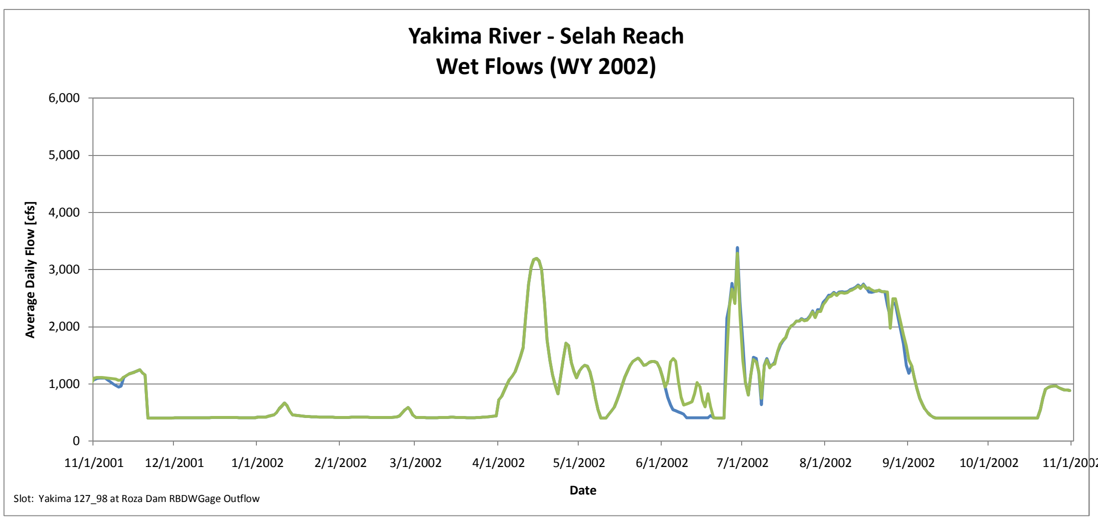

Yakima River - Ellensburg Reach
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Proposed ISF Targets
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

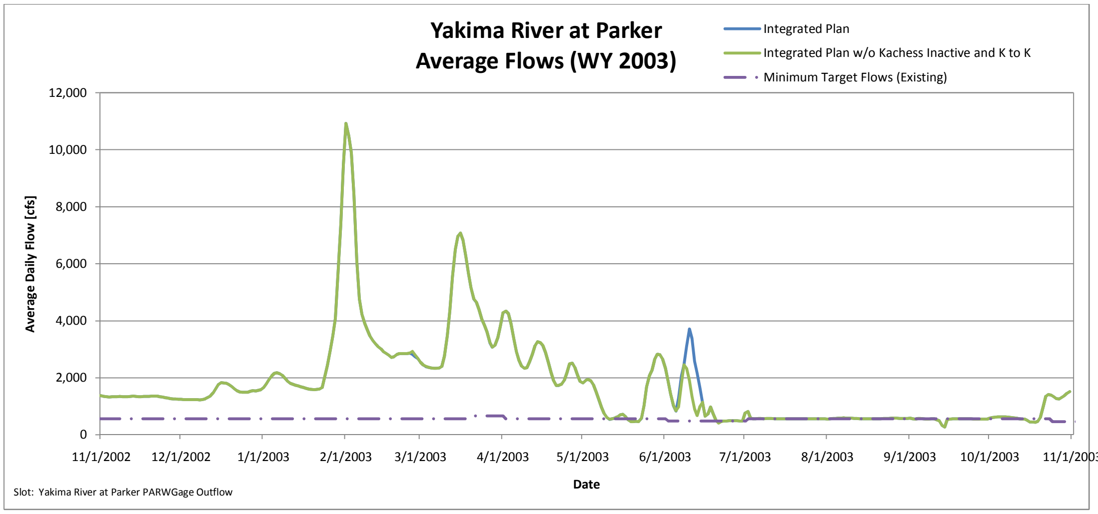

Yakima River - Ellensburg Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

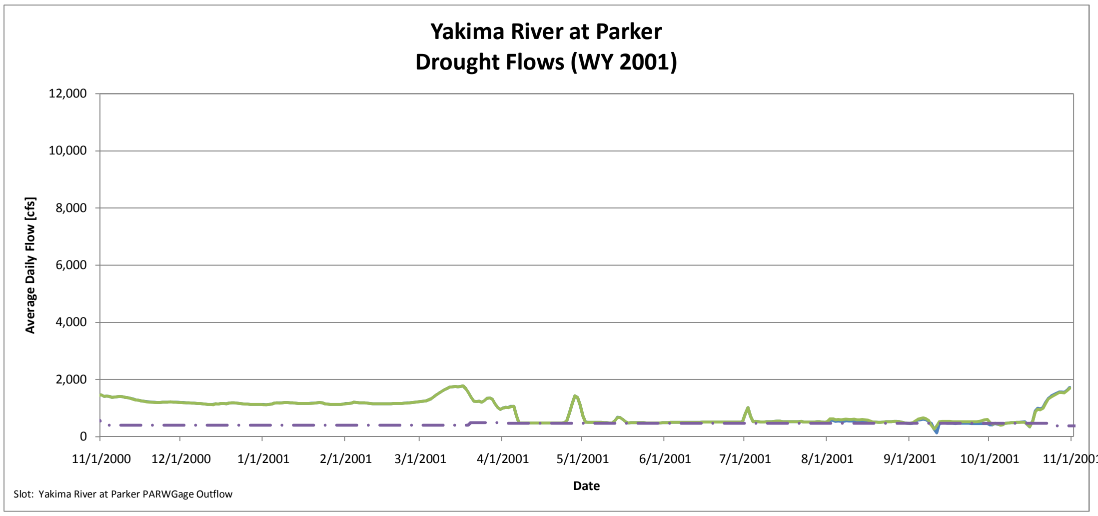

Yakima River - Ellensburg Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

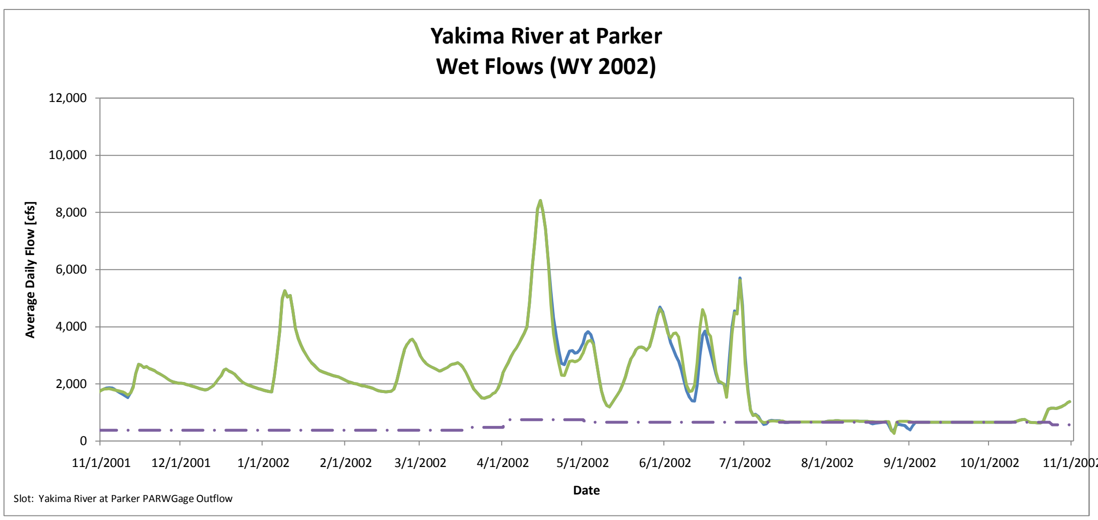

Yakima River - Selah Reach
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

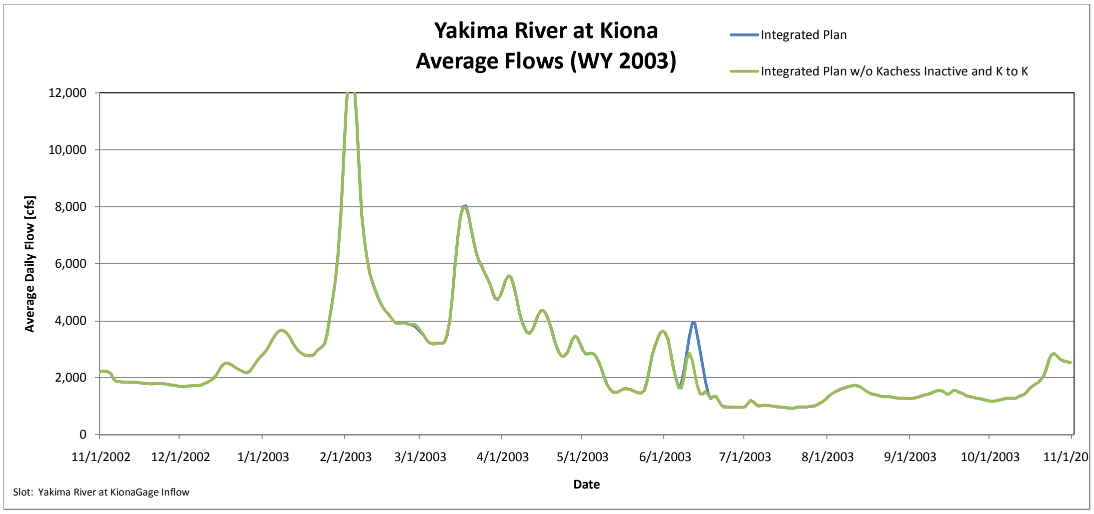

Yakima River - Selah Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

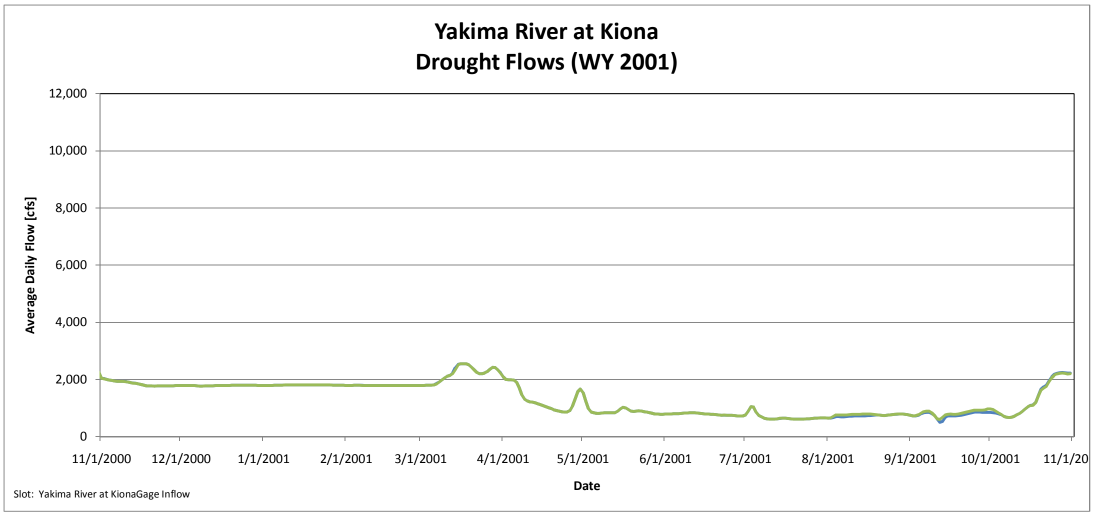

Yakima River - Selah Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

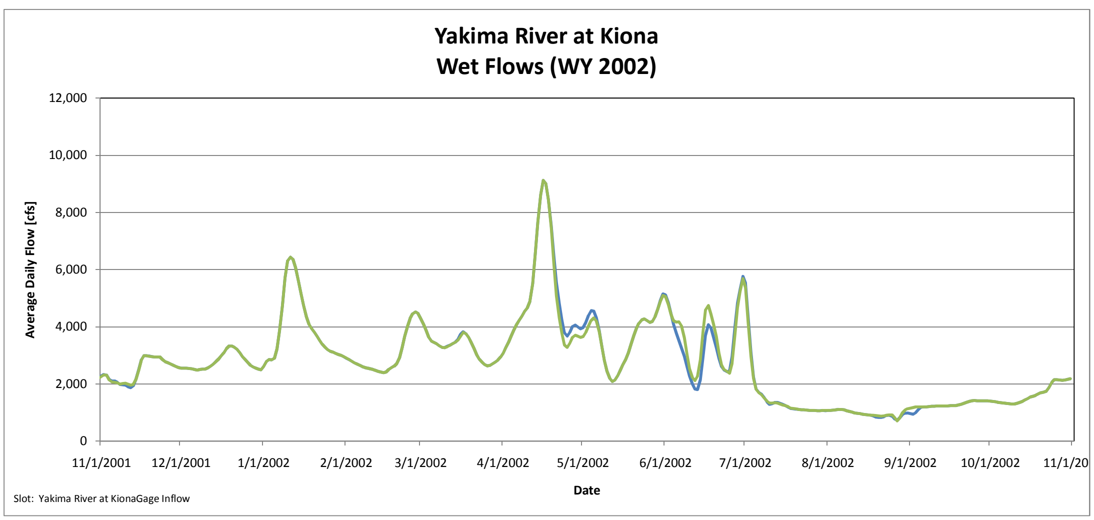

Yakima River at Parker
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Minimum Target Flows (Existing)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima River at Parker PARWGage Outflow

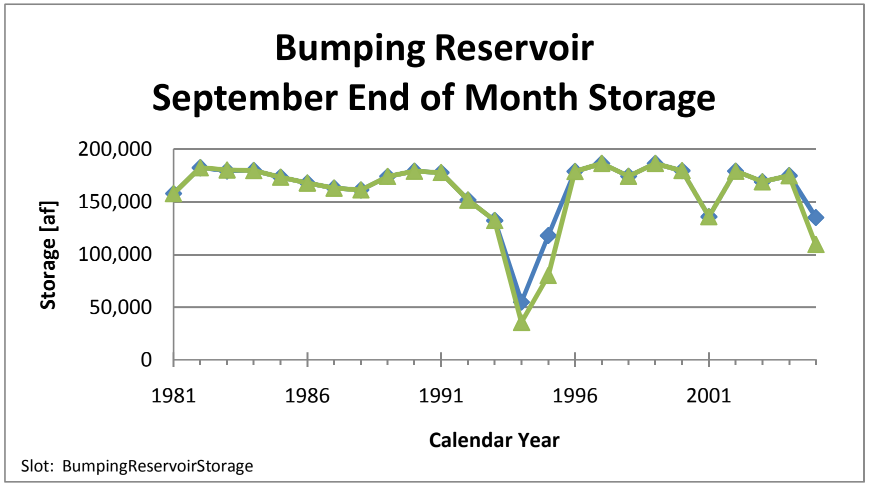

Yakima River at Parker
Drought Flows (WY 2001)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima River at Parker PARWGage Outflow

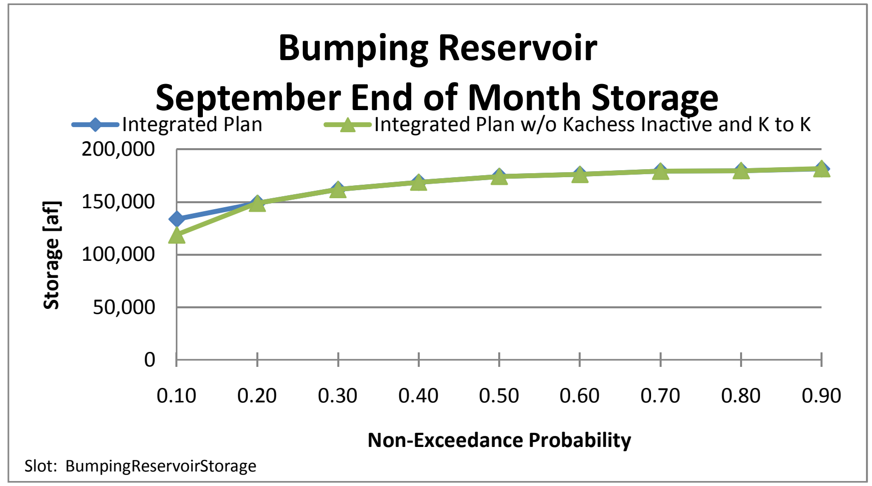

Yakima River at Parker
Wet Flows (WY 2002)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima River at Parker PARWGage Outflow

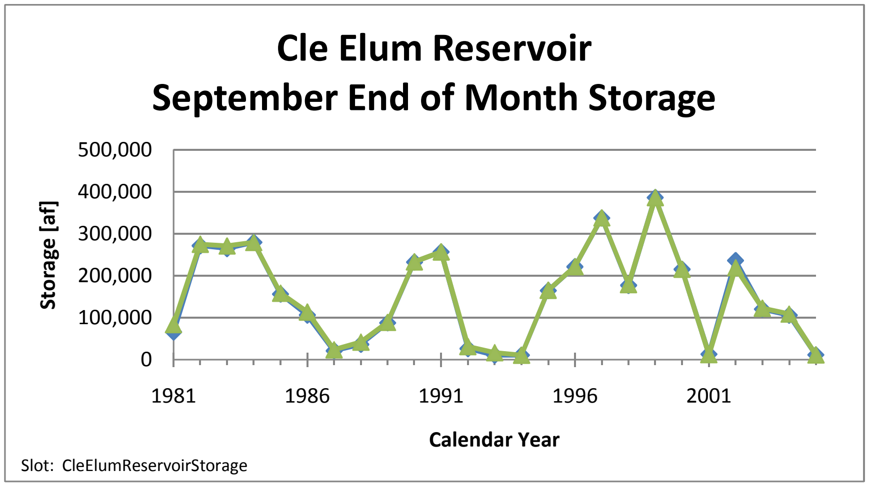

Yakima River at Kiona
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

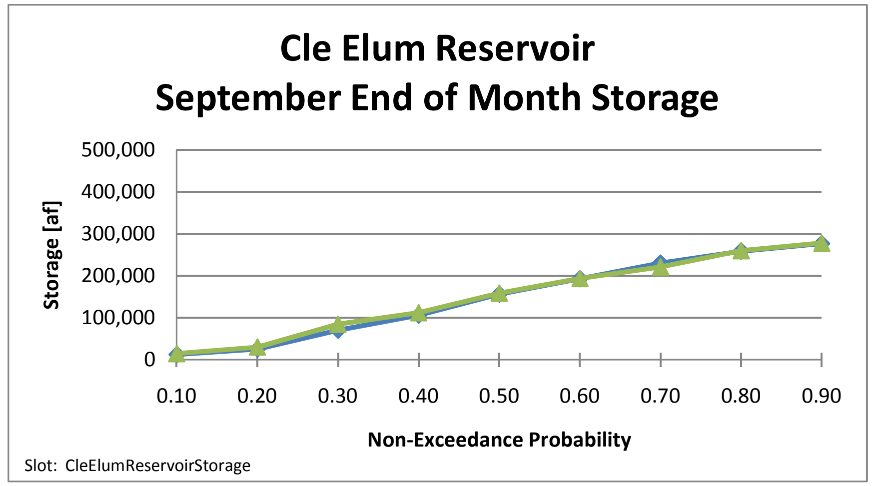

Yakima River at Kiona
Drought Flows (WY 2001)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

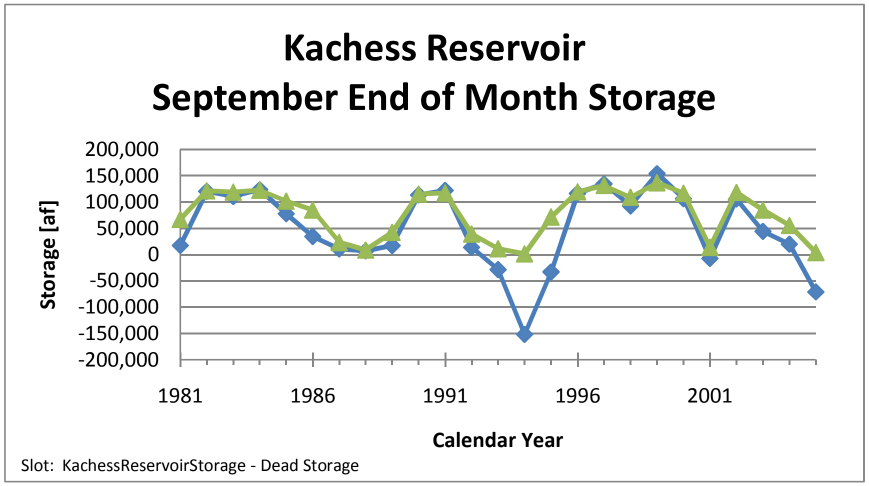

Yakima River at Kiona
Wet Flows (WY 2002)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

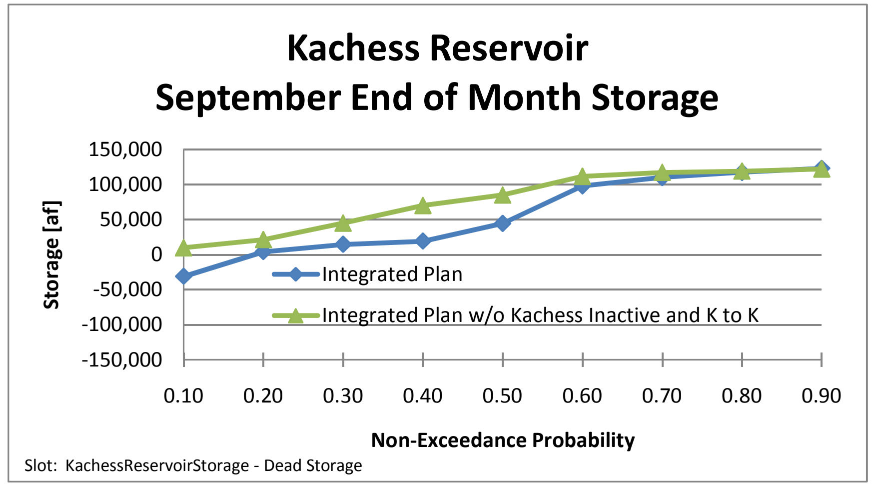

Bumping Reservoir
September End of Month Storage
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: BumpingReservoirStorage

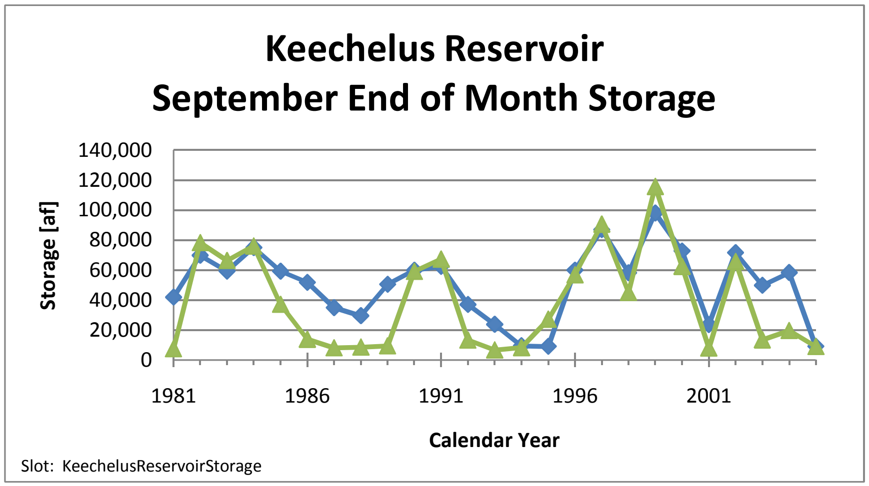

Bumping Reservoir
September End of Month Storage
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
200,000
150,000
100,000
50,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: BumpingReservoirStorage

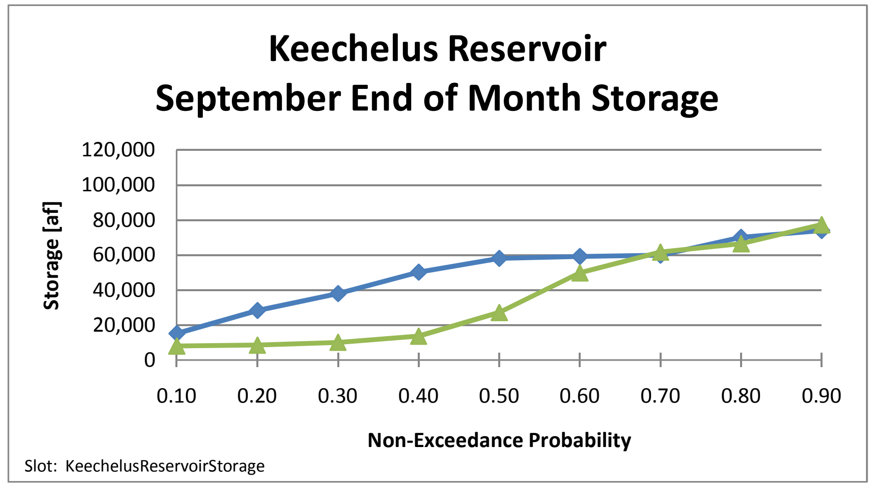

Cle Elum Reservoir
September End of Month Storage
500,000
400,000
300,000
200,000
100,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: CleElumReservoirStorage

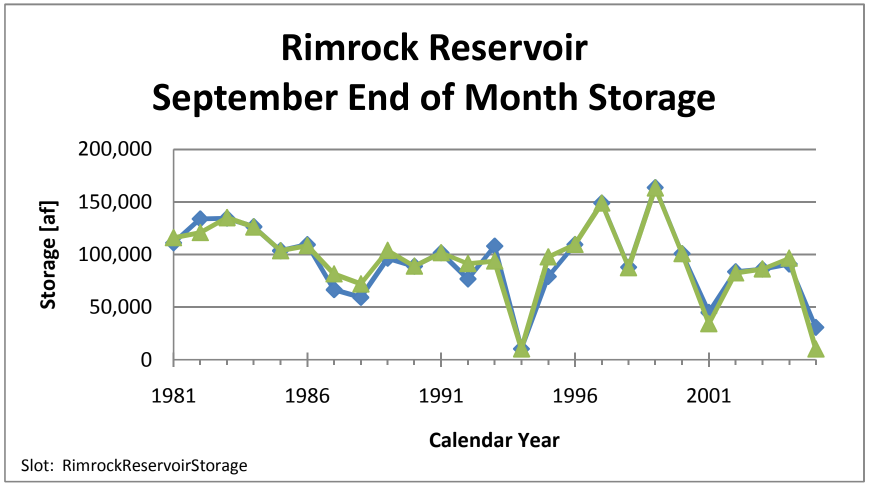

Cle Elum Reservoir
September End of Month Storage
500,000
400,000
300,000
200,000
100,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: CleElumReservoirStorage

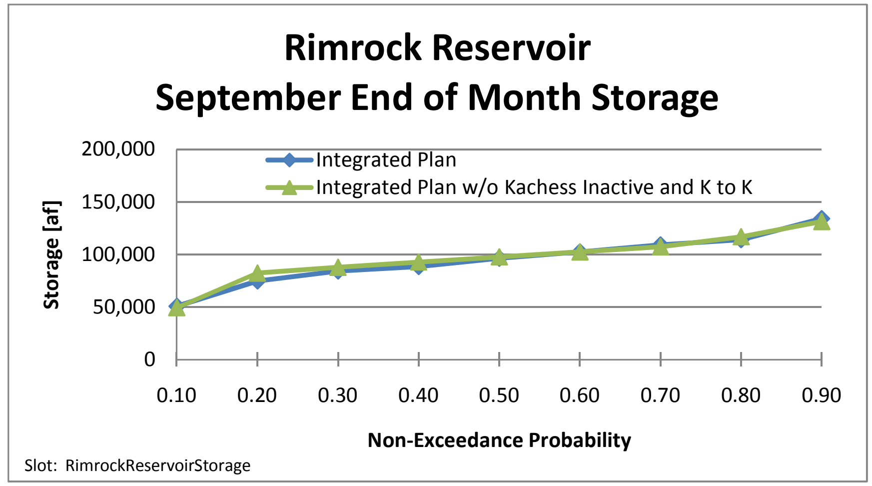

Kachess Reservoir
September End of Month Storage
200,000
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
-200,000
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: KachessReservoirStorage - Dead Storage

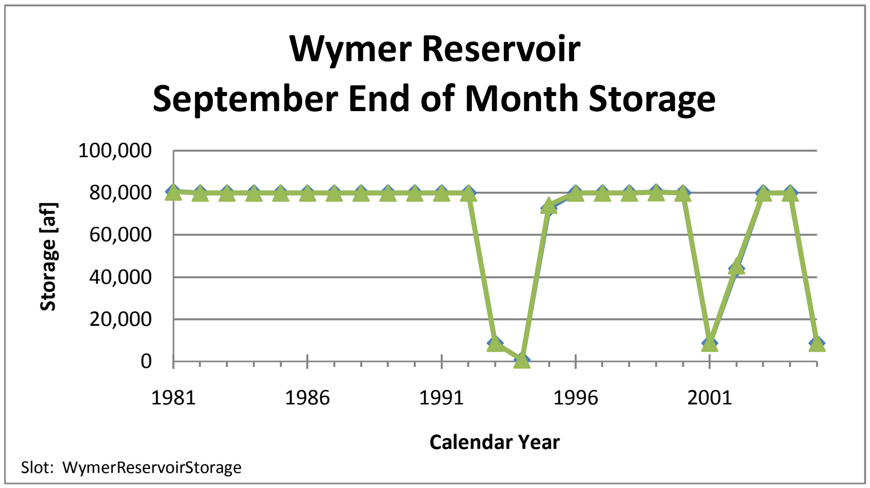

Kachess Reservoir
September End of Month Storage
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
Storage [af]
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KachessReservoirStorage - Dead Storage

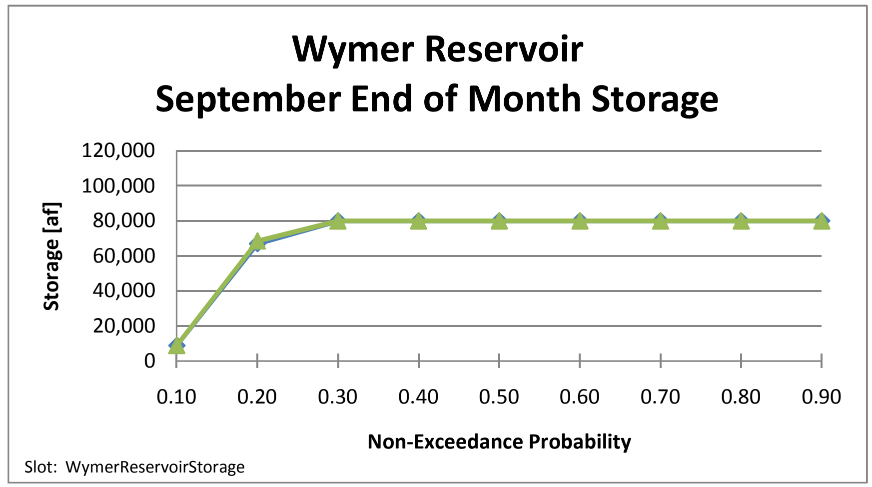

Keechelus Reservoir
September End of Month Storage
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: KeechelusReservoirStorage

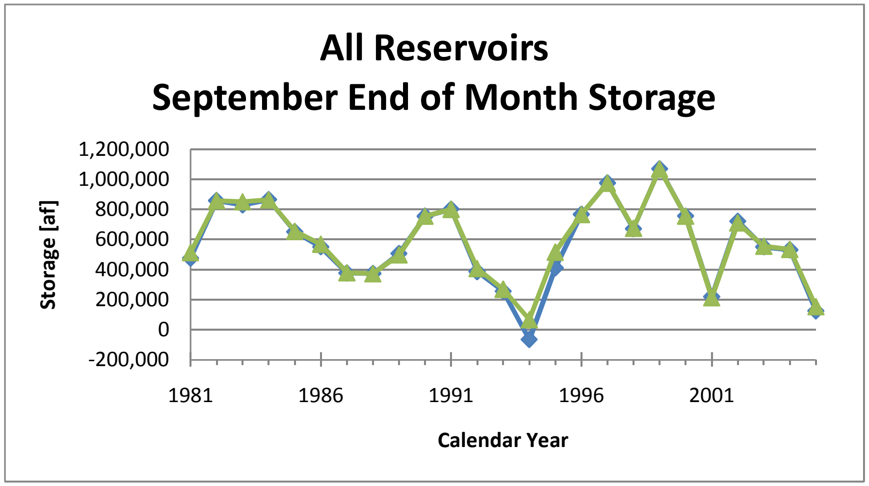

Keechelus Reservoir
September End of Month Storage
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KeechelusReservoirStorage

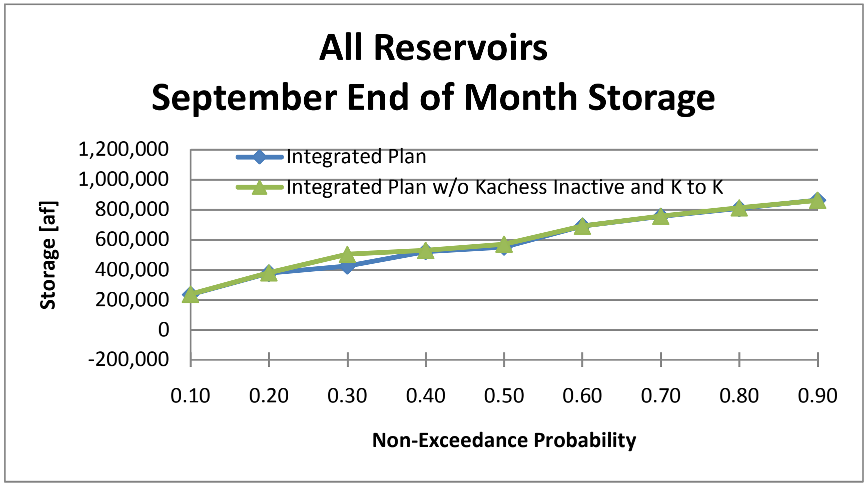

Rimrock Reservoir
September End of Month Storage
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: RimrockReservoirStorage

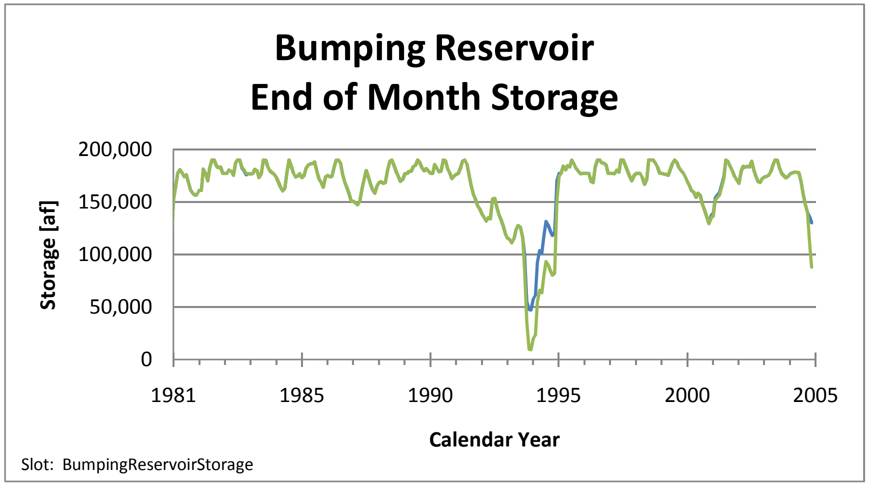

Rimrock Reservoir
September End of Month Storage
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
200,000
150,000
100,000
50,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: RimrockReservoirStorage


Wymer Reservoir
September End of Month Storage
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: WymerReservoirStorage

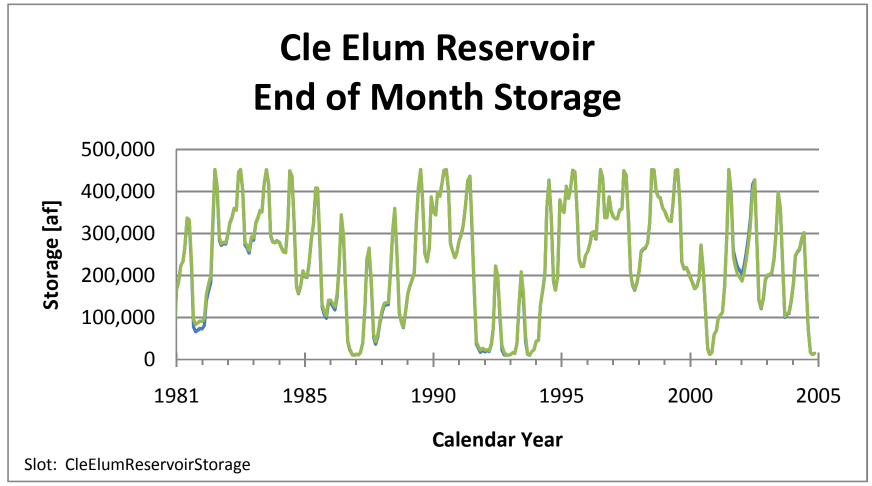

Wymer Reservoir
September End of Month Storage
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: WymerReservoirStorage


All Reservoirs
September End of Month Storage
Storage [af]
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
-200,000
1981
1986
1991
1996
2001
Calendar Year

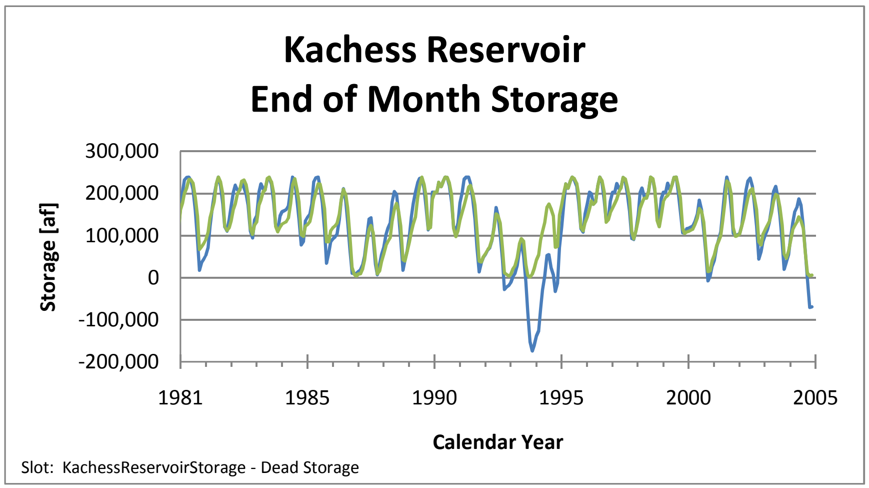

All Reservoirs
September End of Month Storage
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Storage [af]
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
-200,000
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability



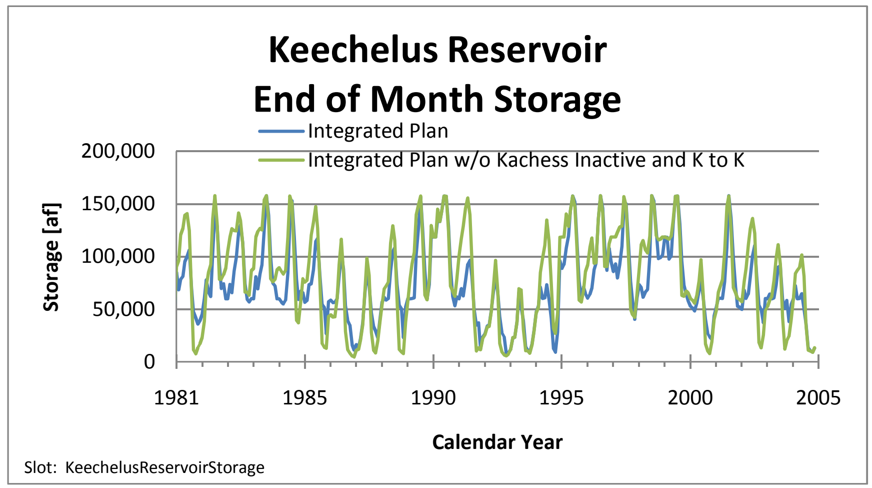
Bumping Reservoir
End of Month Storage
Storage [af]
200,000
150,000
100,000
50,000
0
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: BumpingReservoirStorage



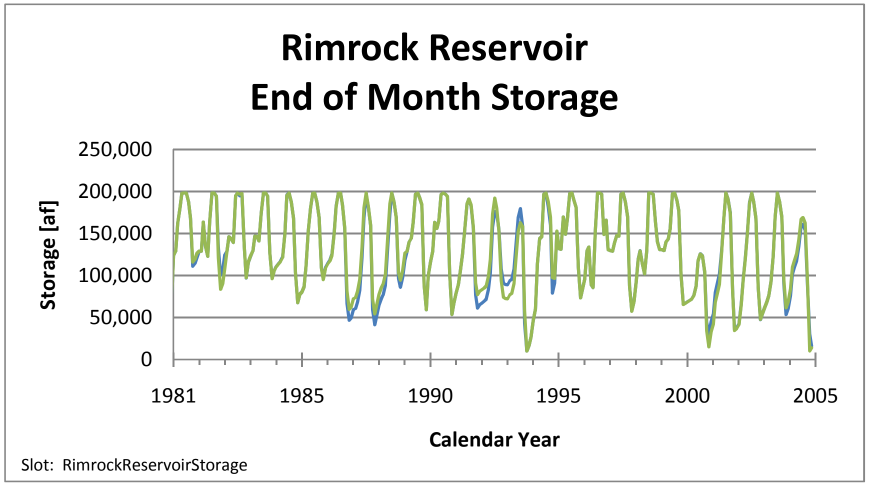
Cle Elum Reservoir
End of Month Storage
Storage [af]
500,000
400,000
300,000
200,000
100,000
0
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: CleElumReservoirStorage

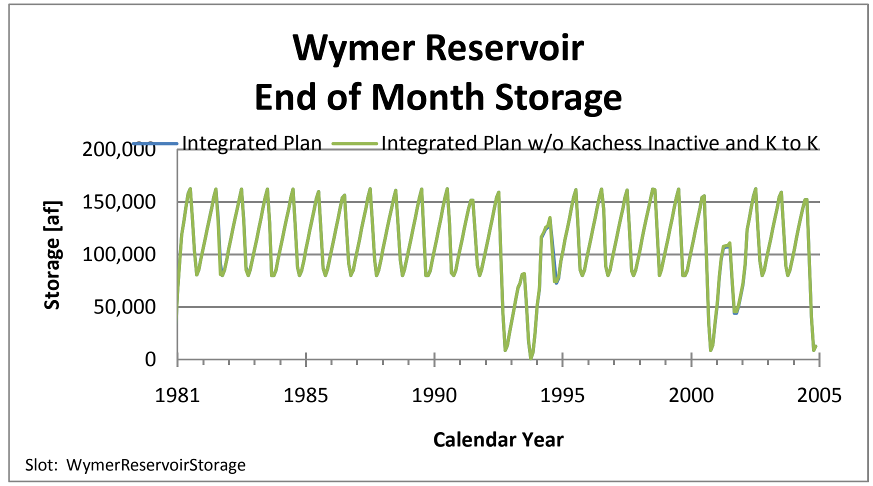


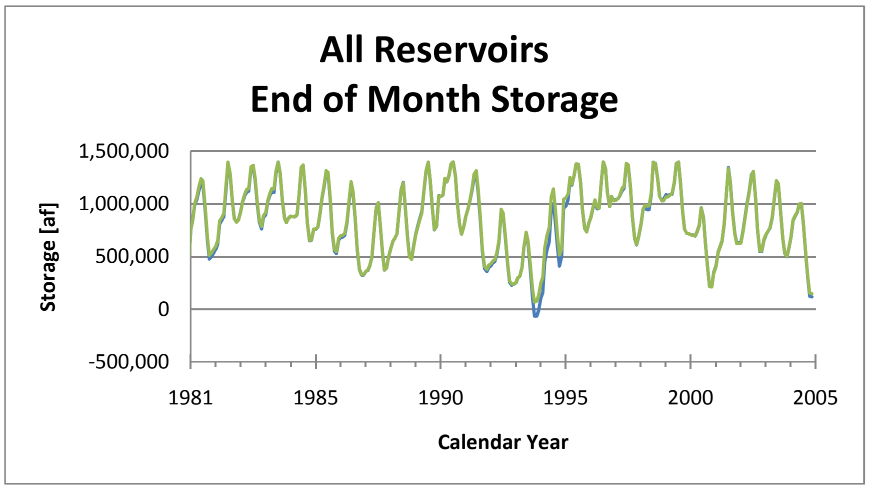
Kachess Reservoir
End of Month Storage
Storage [af]
300,000
200,000
100,000
0
-100,000
-200,000
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KachessReservoirStorage - Dead Storage

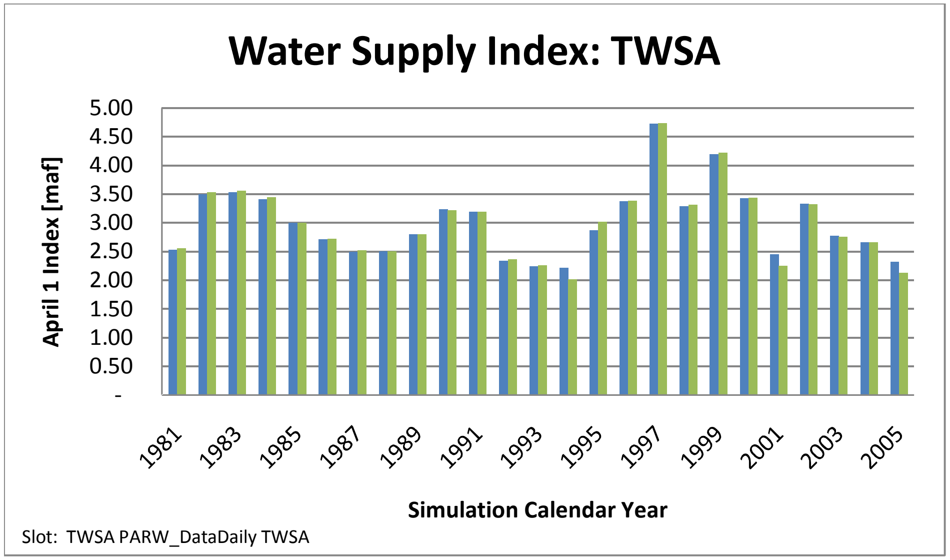


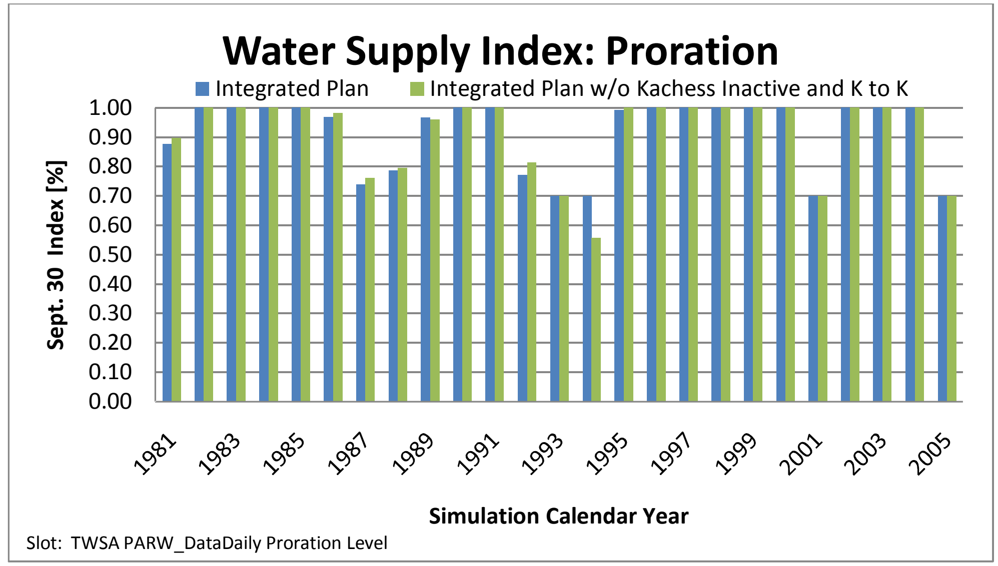
Keechelus Reservoir
End of Month Storage
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Storage [af]
200,000
150,000
100,000
50,000
0
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KeechelusReservoirStorage

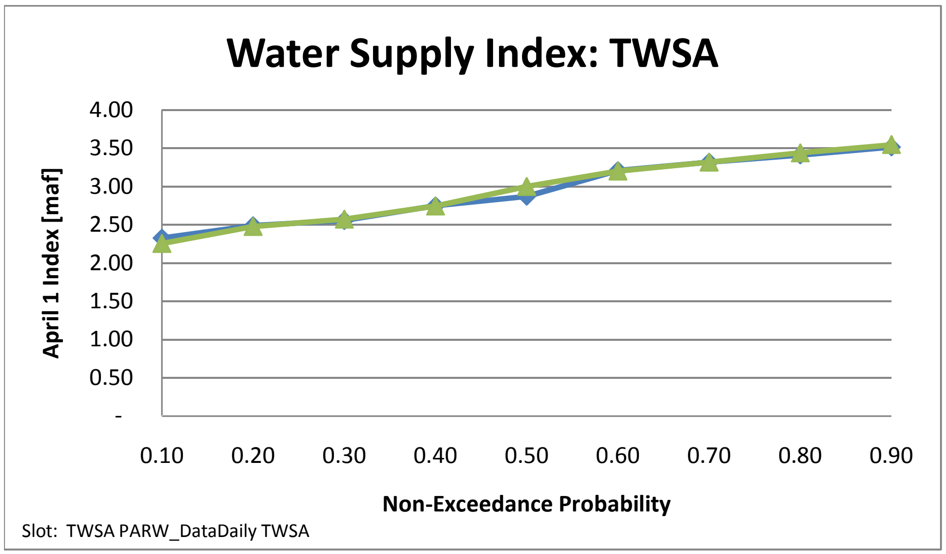

Rimrock Reservoir
End of Month Storage
250,000
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: RimrockReservoirStorage

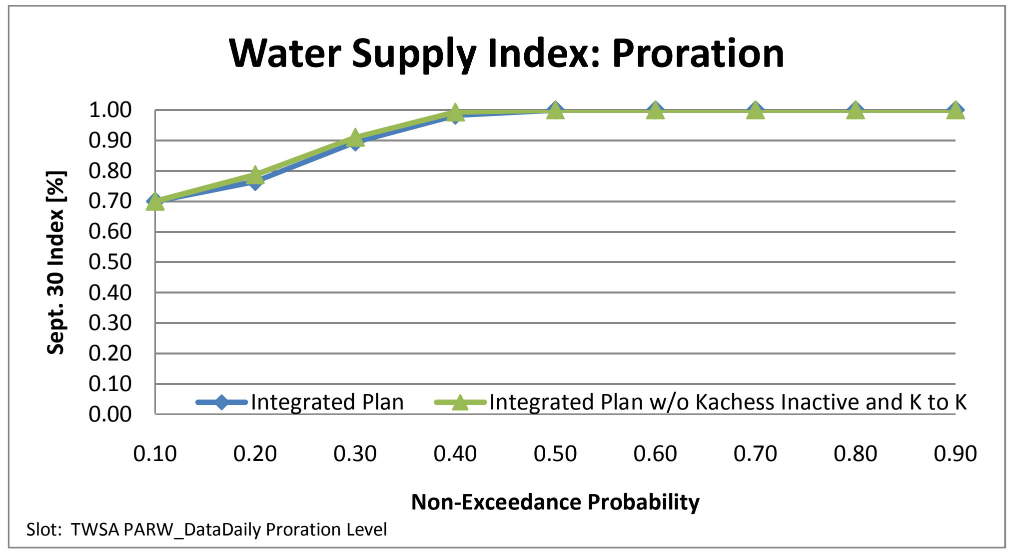

Wymer Reservoir
End of Month Storage
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: WymerReservoirStorage

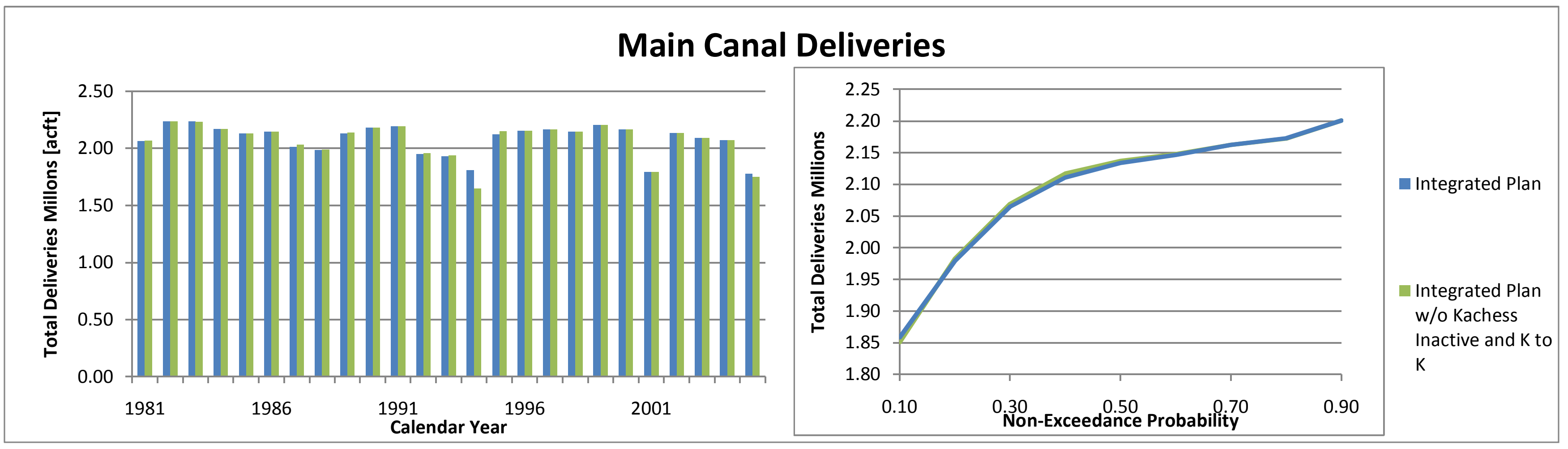

All Reservoirs
End of Month Storage
1,500,000
1,000,000
500,000
0
-500,000
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year

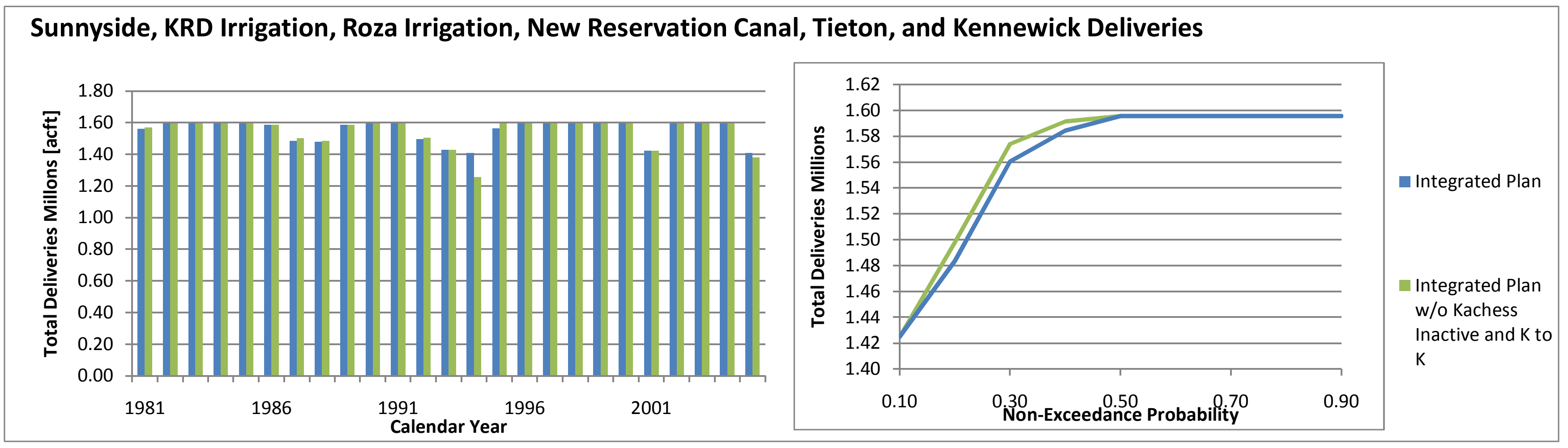

Water Supply Index: TWSA
April 1 Index [maf]
Simulation Calendar Year
Slot: TWSA PARW_DataDaily TWSA

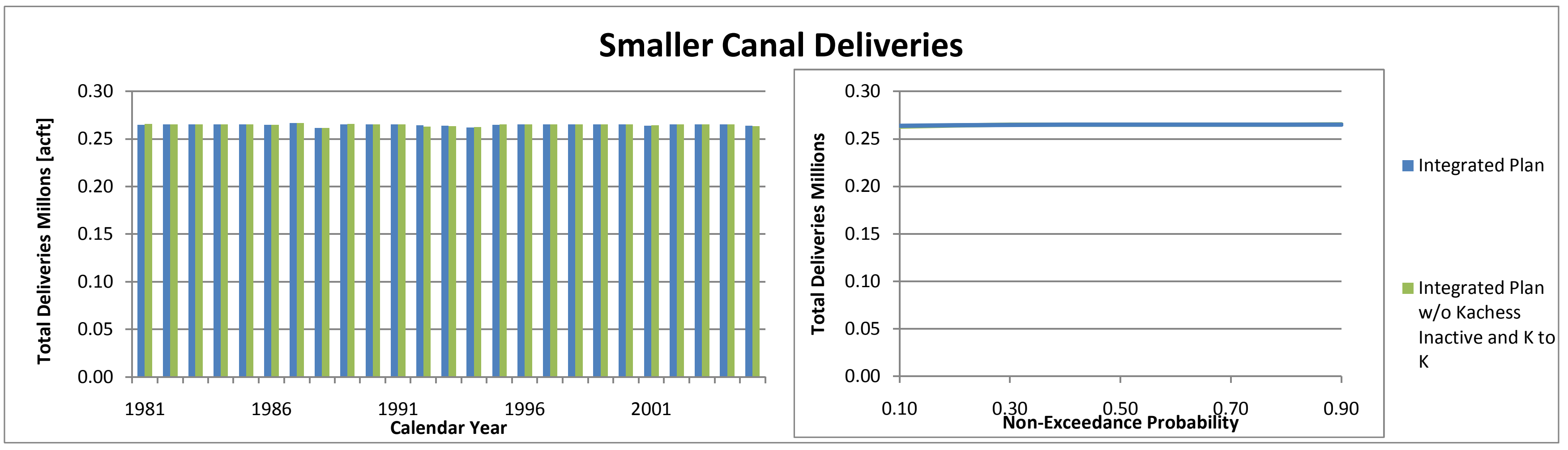

Water Supply Index: Proration
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Sept. 30 Index [%]
Simulation Calendar Year
Slot: TWSA PARW_DataDaily Proration Level

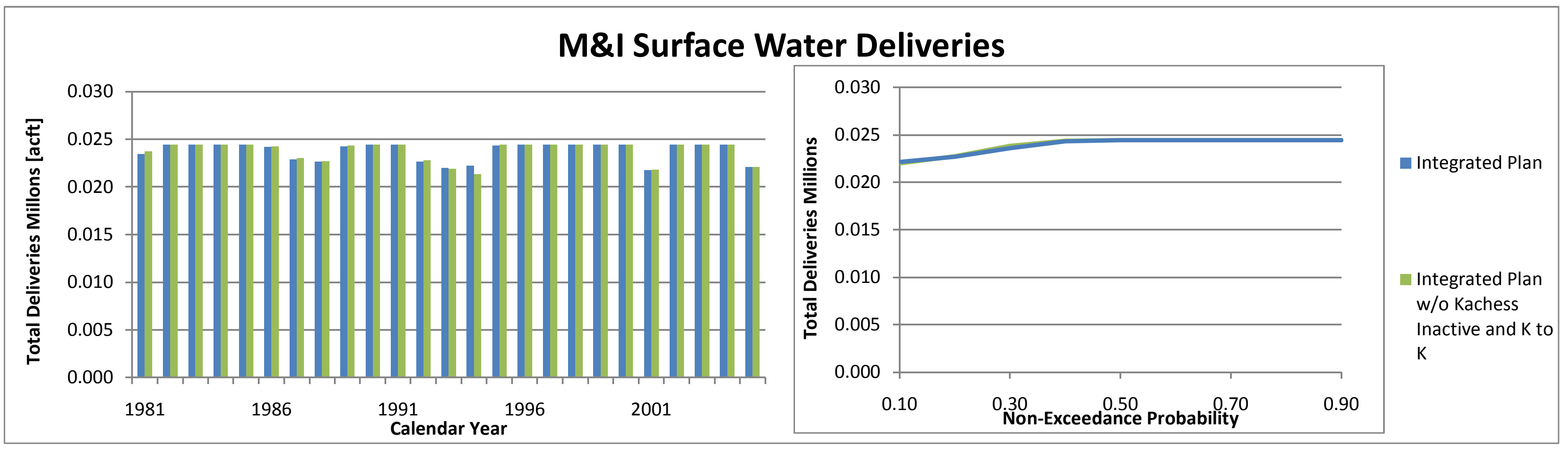

Water Supply Index: TWSA
April 1 Index [maf]
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily TWSA


Water Supply Index: Proration
Sept. 30 Index [%]
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily Proration Level


Main Canal Deliveries
Total Deliveries Millons [acft]
2.50
2.00
1.50
1.00
0.50
0.00
1981
1986
1991
1996
2001
Calendar Year
Total Deliveries Millions
2.25
2.20
2.15
2.10
2.05
2.00
1.95
1.90
1.85
1.80
0.10
0.30
0.50
0.70
0.90
Non-Exceedance Probability
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K


Sunnyside, KRD Irrigation, Roza Irrigation, New Reservation Canal, Tieton, and Kennewick Deliveries
Total Deliveries Millons [acft]
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1981
1986
1991
1996
2001
Calendar Year
Total Deliveries Millions
1.62
1.60
1.58
1.56
1.54
1.52
1.50
1.48
1.46
1.44
1.42
1.40
0.10
0.30
0.50
0.70
0.90
Non-Exceedance Probability
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K


Smaller Canal Deliveries
Total Deliveries Millons [acft]
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1981
1986
1991
1996
2001
Calendar Year
Total Deliveries Millions
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.10
0.30
0.50
0.70
0.90
Non-Exceedance Probability
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K


M&I Surface Water Deliveries
Total Deliveries Millons [acft]
0.030
0.025
0.020
0.015
0.010
0.005
0.000
1981
1986
1991
1996
2001
Calendar Year
Total Deliveries Millions
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.10
0.30
0.50
0.70
0.90
Non-Exceedance Probability
Integrated Plan
Integrated Plan w/o Kachess Inactive and K to K

Appendix C – 3

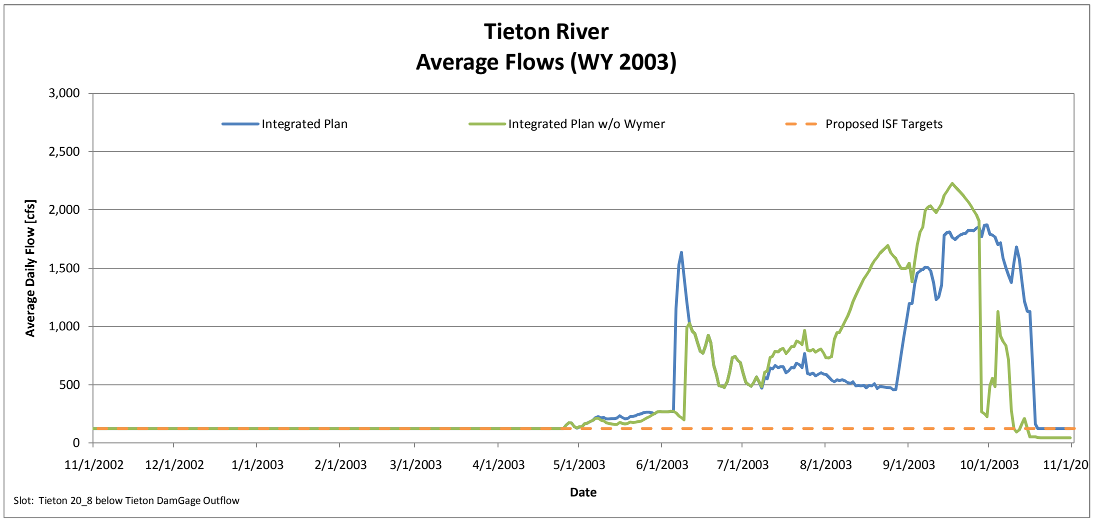
Adjusted Integrated Plan Results
Without Wymer Reservoir

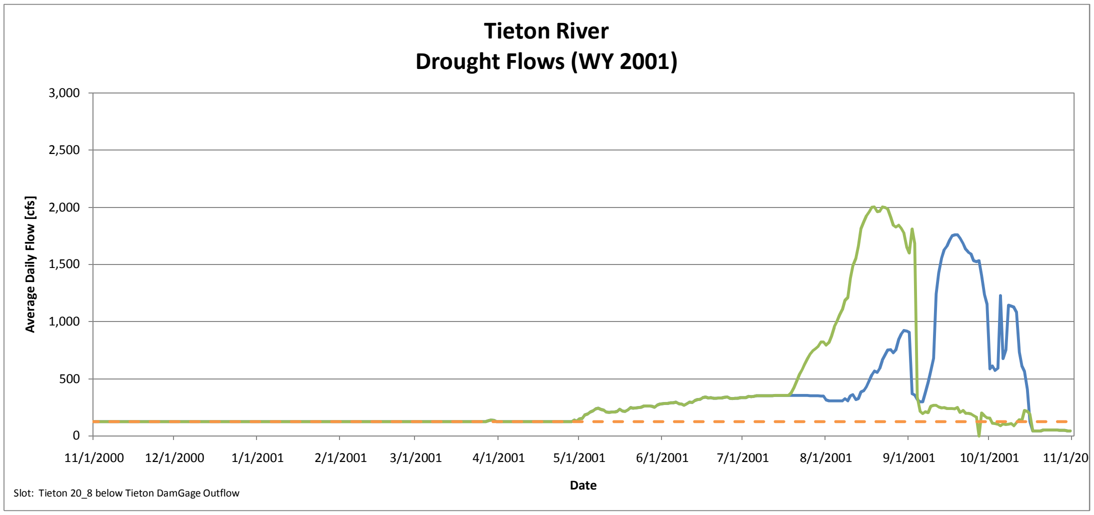
Resource indicator (measurement)	Integrated Plan	Integrated Plan w/o Wymer
WATER RESOURCES		
Average for water years 1981–2005 (maf)		
Water supply		
April 1 total water supply available (TWSA)	3.00	2.88
Water distribution		
April–September Parker flow volume	0.60	0.65
April–September diversion	1.69	1.59
September 30 reservoir contents	0.58	0.36
April–September flow volume at mouth of Yakima River	0.87	0.91
1994 dry-year (maf)		
Water supply		
April 1 TWSA	2.22	1.89
Water distribution		
April–September Parker flow volume	0.25	0.25
April–September diversion	1.52	1.33
September 30 reservoir contents	-0.06	-0.15
April–September flow volume at mouth of Yakima River	0.35	0.34
Irrigation proration level	70%	48%

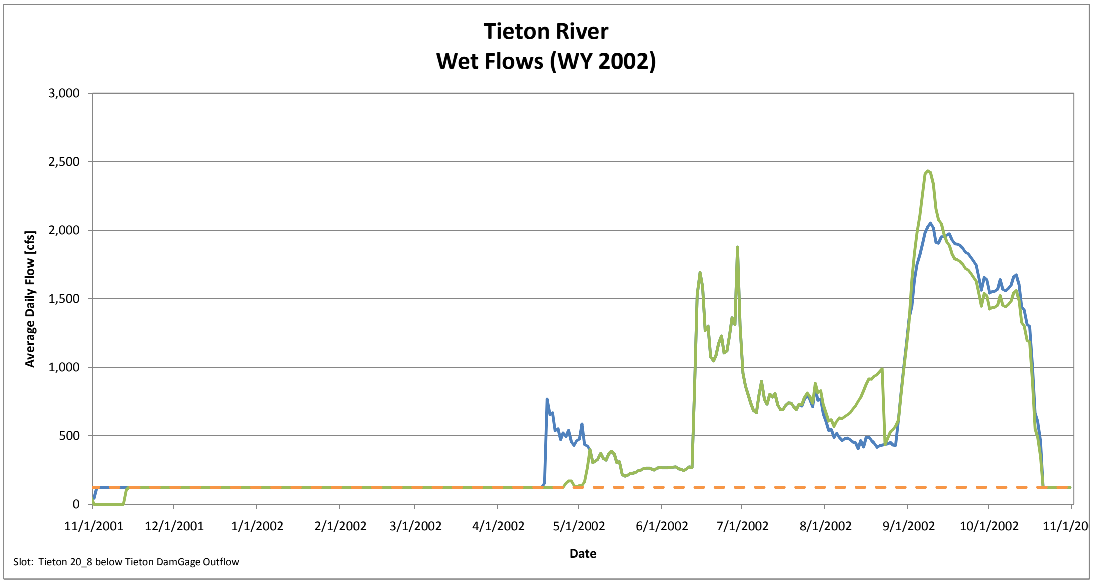
Resource indicator (measurement)	Integrated Plan	Integrated Plan w/o Wymer
ANADROMOUS FISH		
Rate of change in flow during flip-flop (average cfs/day August 16–September 14)		
Easton reach	-7	-16
Ellensburg reach	-45	-90
Lower Naches River reach	31	18
Pre- (August 1-15) and post- (September 14-28) flip-flop flow and absolute change in flow		
Easton reach		
Pre-flip-flop flow (cfs)	574	820
Post-flip-flop flow (cfs)	364	360
Absolute change in flow (cfs)	-211	-460
Ellensburg reach		
Pre-flip-flop flow (cfs)	2,867	4,154
Post-flip-flop flow (cfs)	1,574	1,557
Absolute change in flow (cfs)	-1,293	-2,597
Lower Naches River reach		
Pre-flip-flop flow (cfs)	644	995
Post-flip-flop flow (cfs)	1,548	1,522
Absolute change in flow (cfs)	904	527
Average, minimum, and maximum reservoir elevation (feet) during bull trout spawning migration: July 15–September 15 (feet)		
Kachess Lake	2235.41 2146.99-2261.96	2224.94 2134.41-2261.96
Keechelus Lake	2476.7 2432.28-2516.96	2472.59 2432.34-2516.96
Rimrock Lake	2914.66 2801.26-2926	2901.5 2800.7-2926

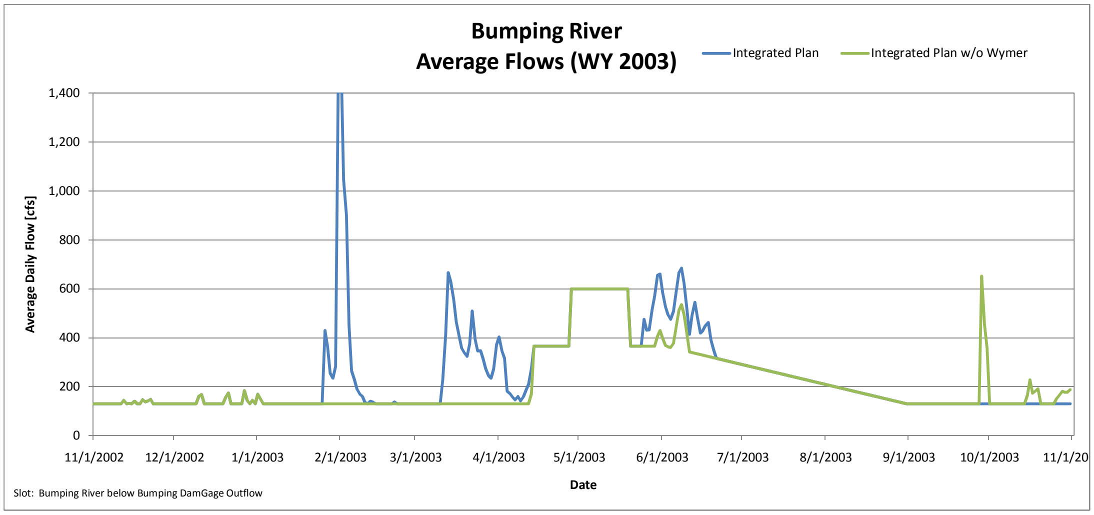
Hydrologic Indicator	Integrated Plan					Integrated Plan w/o Wymer				
	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997
April 1 TWSA (maf)	3.00	2.22	2.45	2.32	4.73	2.88	1.89	2.23	2.10	4.62
April-September flow volume at Parker gage (kaf)	605	245	198	181	1937	646	247	176	155	1976
March-October flow volume at Parker gage (kaf)	907	400	335	310	2638	946	395	321	291	2663
April-September diversion volume upstream of Parker gage (maf)	1.69	1.52	1.55	1.53	1.73	1.59	1.33	1.51	1.49	1.65
September 30 non-Bumping or Wymer reservoir contents (kaf)	348	-121	75	-19	709	208	-152	-32	-72	564
October 31 non-Bumping or Wymer reservoir contents (kaf)	329	-120	74	-26	802	199	-139	-27	-76	670
September 30 Bumping and Wymer reservoir contents (kaf)	229	56	145	144	267	144	2	65	29	187
April-September flow volume at mouth of Yakima River (kaf)	867	349	272	293	2262	910	339	249	264	2300
Irrigation proration level (percent)[1]	92%	70%	70%	70%	100%	85%	48%	70%	70%	100%

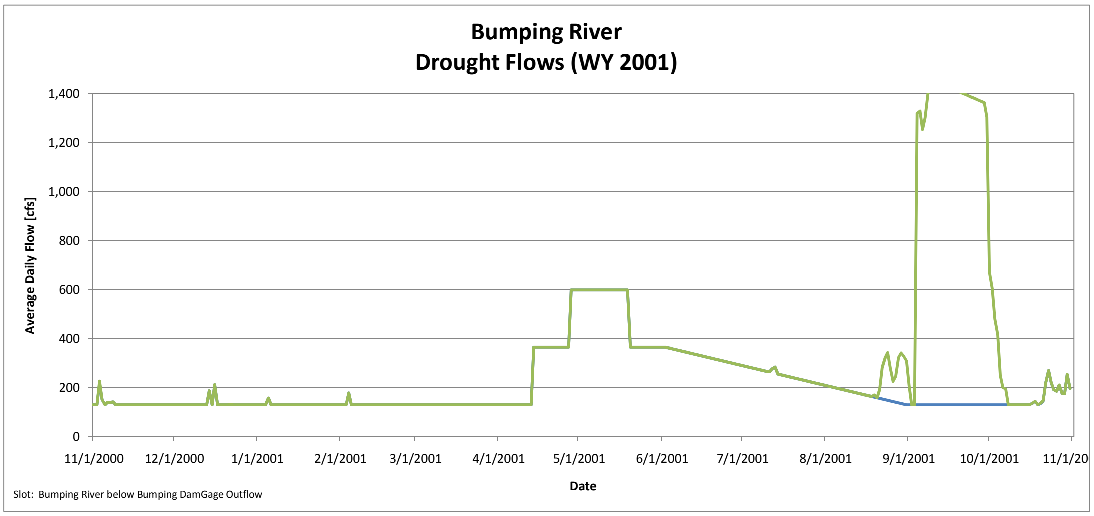
Item	Integrated Plan w/o Wymer	Integrated Plan	Improvement
Average 1981-2005			
TWSA [April 1, kaf]	2877.5	3004.9	127.4
March-October flow volume at Parker gage [kaf]	946.3	906.7	-39.6
Drought Year 1994			
TWSA [April 1, kaf]	1890.7	2215.7	324.9
March-October flow volume at Parker gage [kaf]	395.4	399.8	4.4
Drought Year 2001			
TWSA [April 1, kaf]	2226.8	2453.2	226.4
March-October flow volume at Parker gage [kaf]	320.9	335.5	14.6
Drought Year 2005			
TWSA [April 1, kaf]	2098.8	2320.8	222.0
March-October flow volume at Parker gage [kaf]	291.1	310.2	19.0
Wet Year 1997			
TWSA [April 1, kaf]	4622.9	4728.6	105.6
March-October flow volume at Parker gage [kaf]	2663.0	2638.3	-24.6

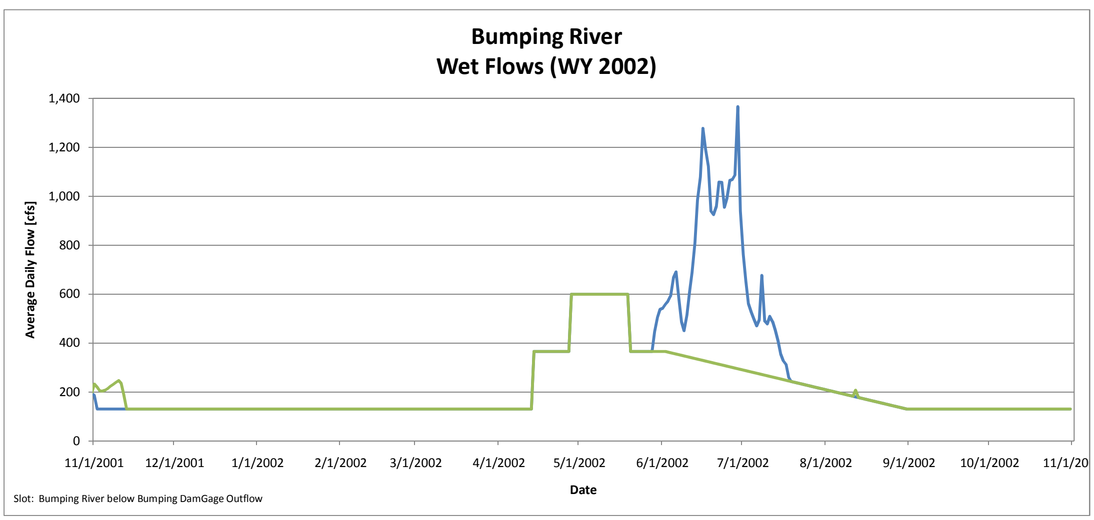

Tieton River
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Wymer
Proposed ISF Targets
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

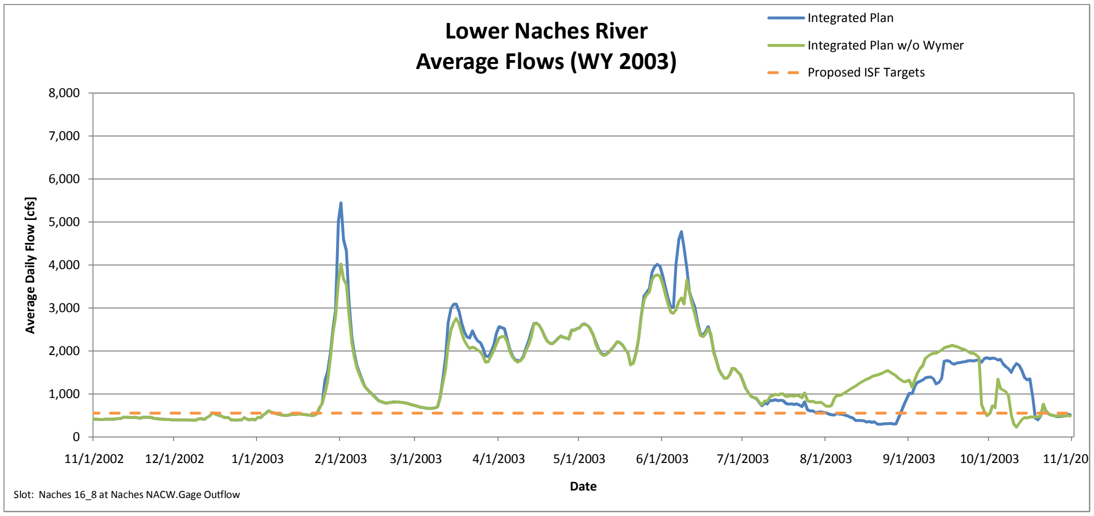

Tieton River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

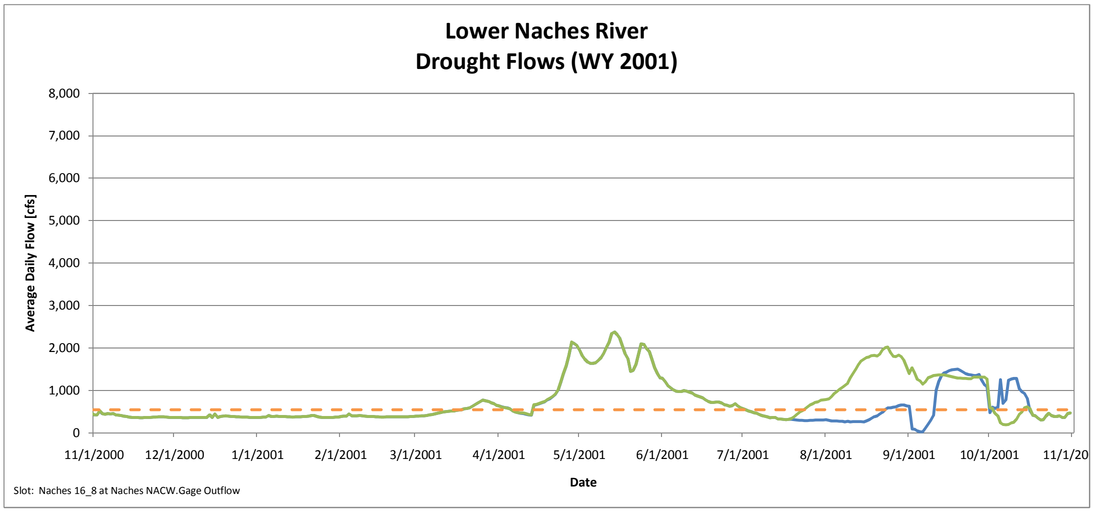

Tieton River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

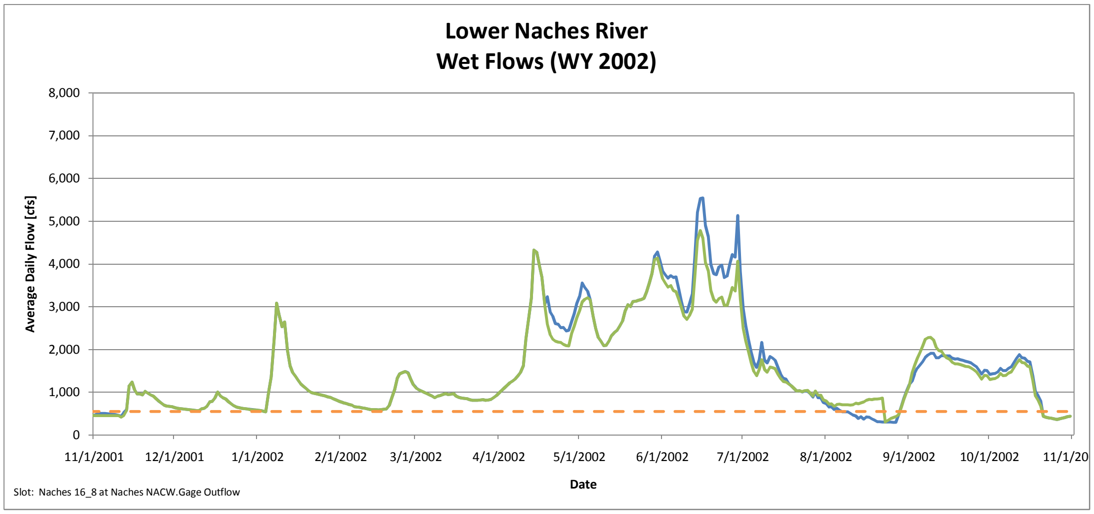

Bumping River
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Wymer
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

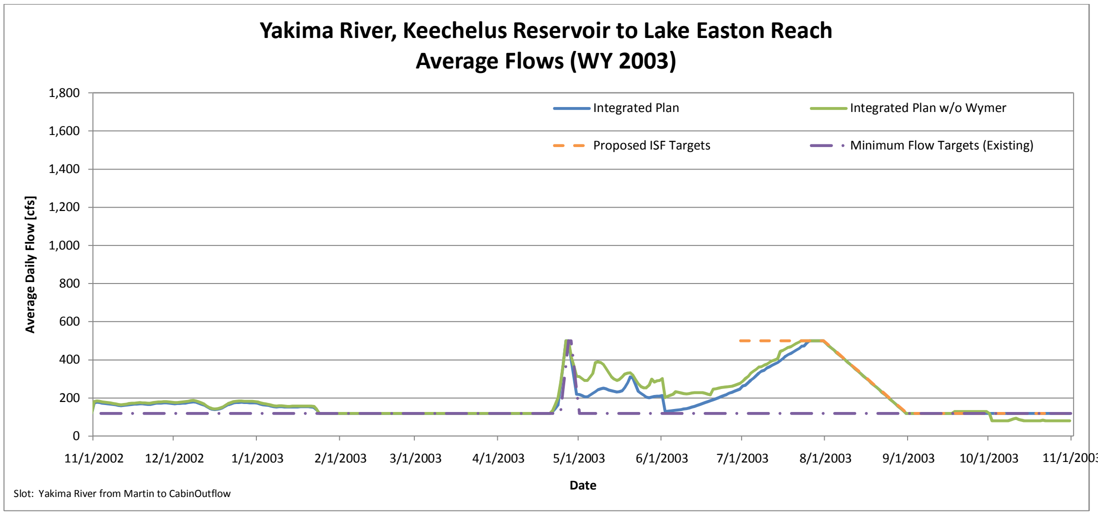

Bumping River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

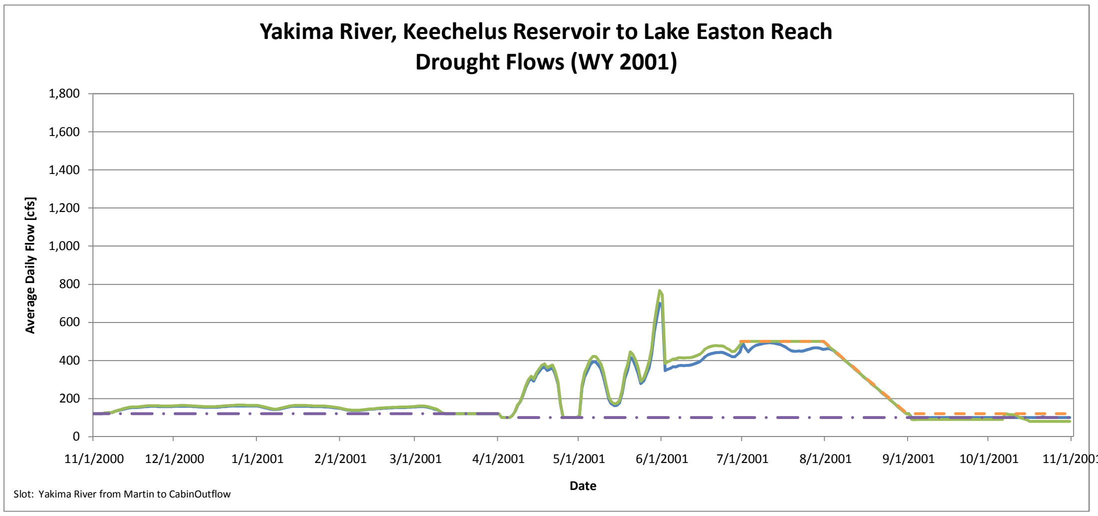

Bumping River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

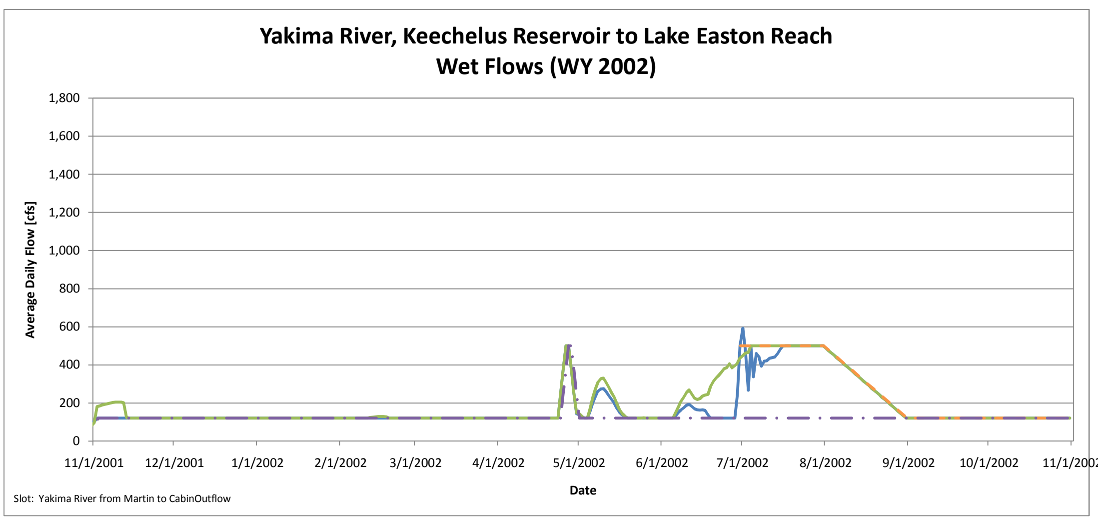

Lower Naches River
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Wymer
Proposed ISF Targets
Average Daily Flow [cfs]
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

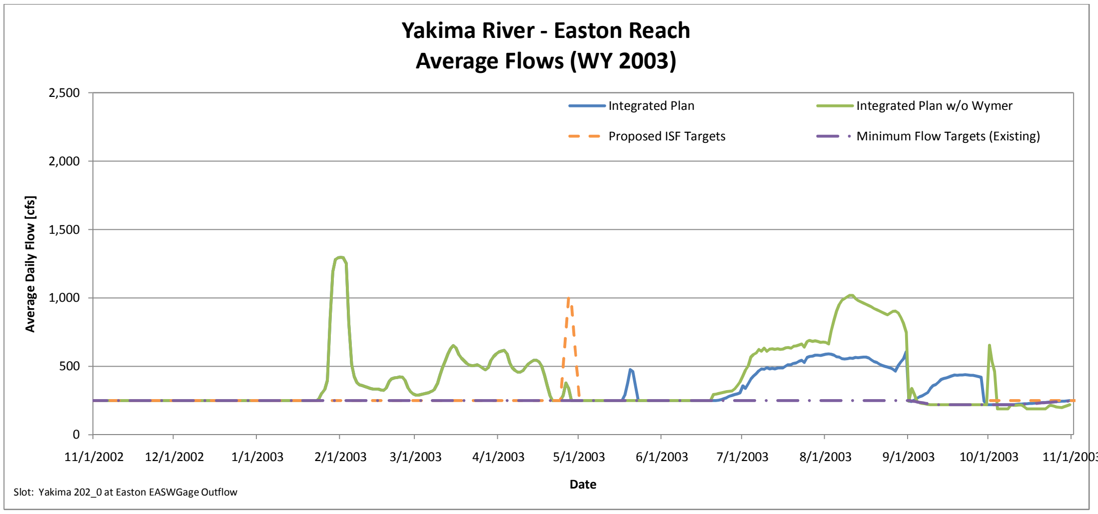

Lower Naches River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

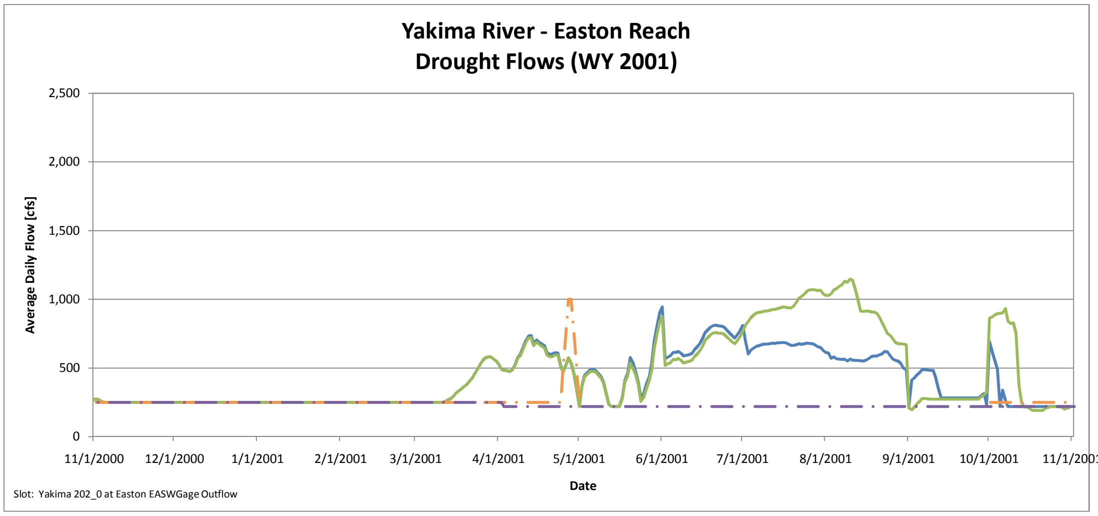

Lower Naches River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

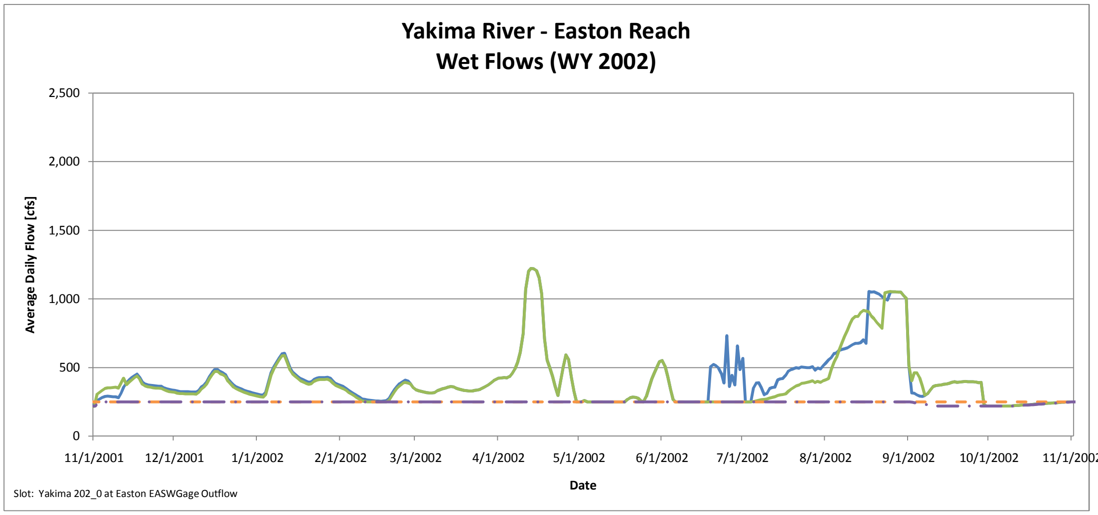

Yakima River, Keechelus Reservoir to Lake Easton Reach
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Wymer
Proposed ISF Targets
Minimum Flow Targets (Existing)
Average Daily Flow [cfs]
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima River from Martin to CabinOutflow

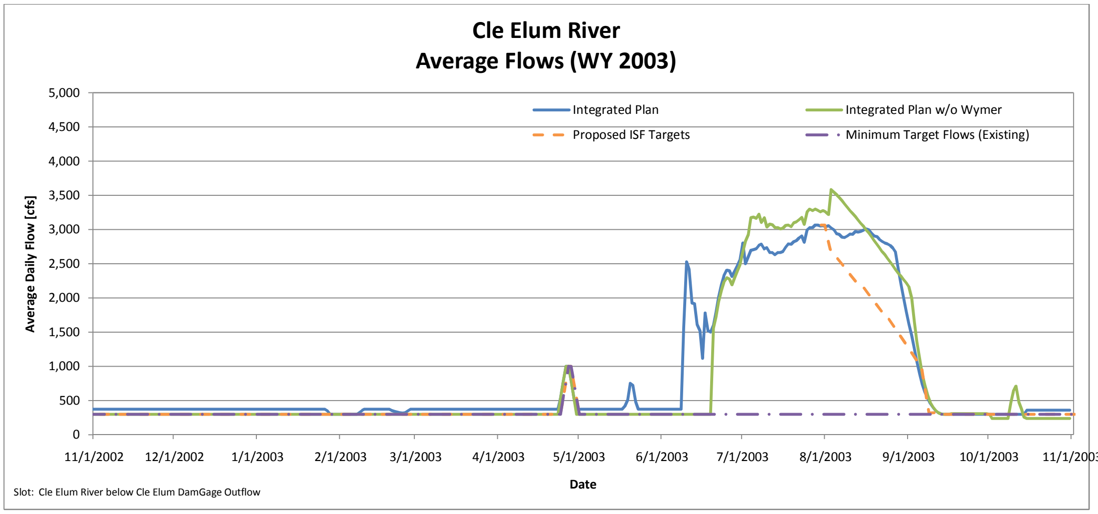

Yakima River, Keechelus Reservoir to Lake Easton Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima River from Martin to CabinOutflow

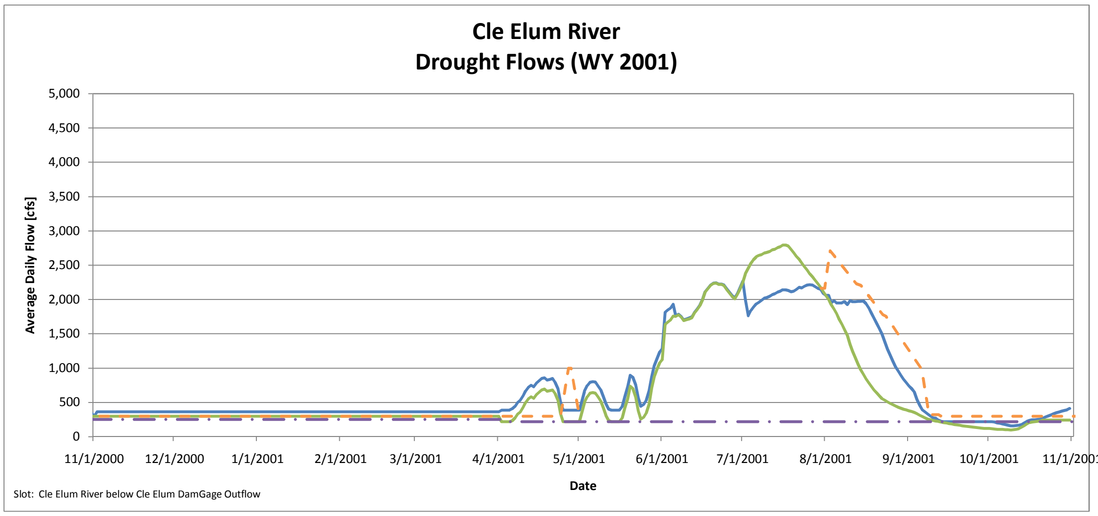

Yakima River, Keechelus Reservoir to Lake Easton Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima River from Martin to CabinOutflow

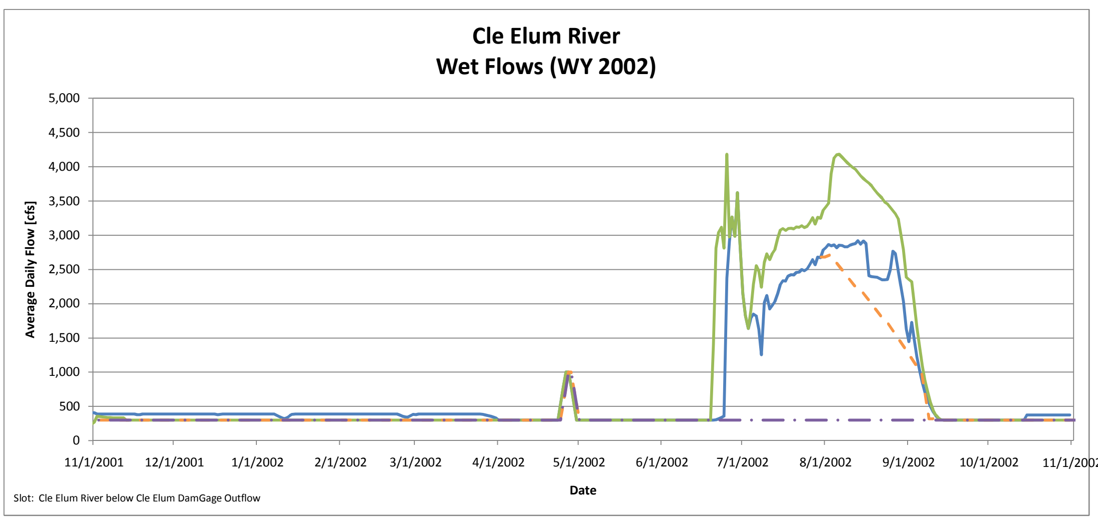

Yakima River - Easton Reach
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Wymer
Proposed ISF Targets
Minimum Flow Targets (Existing)
Average Daily Flow [cfs]
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

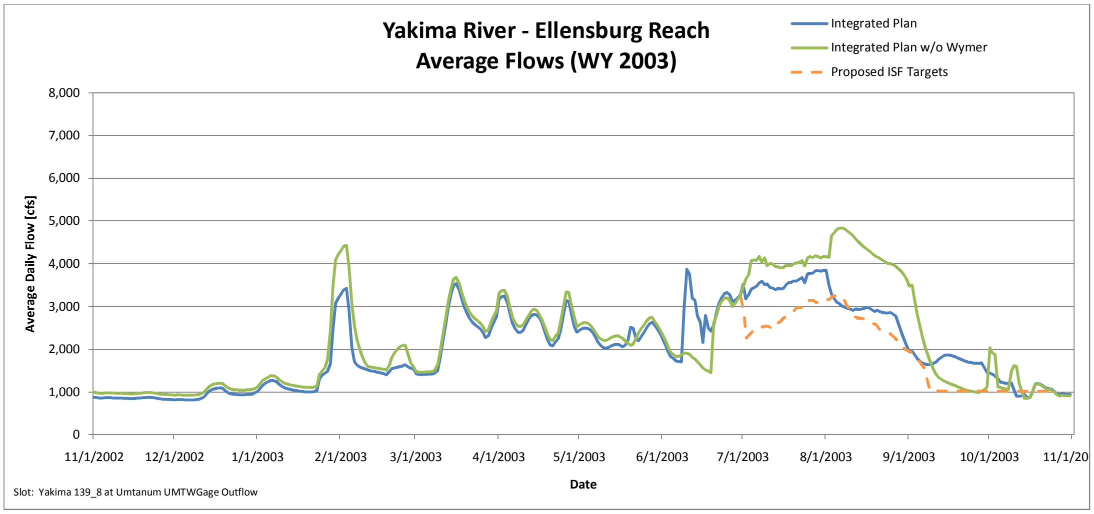

Yakima River - Easton Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

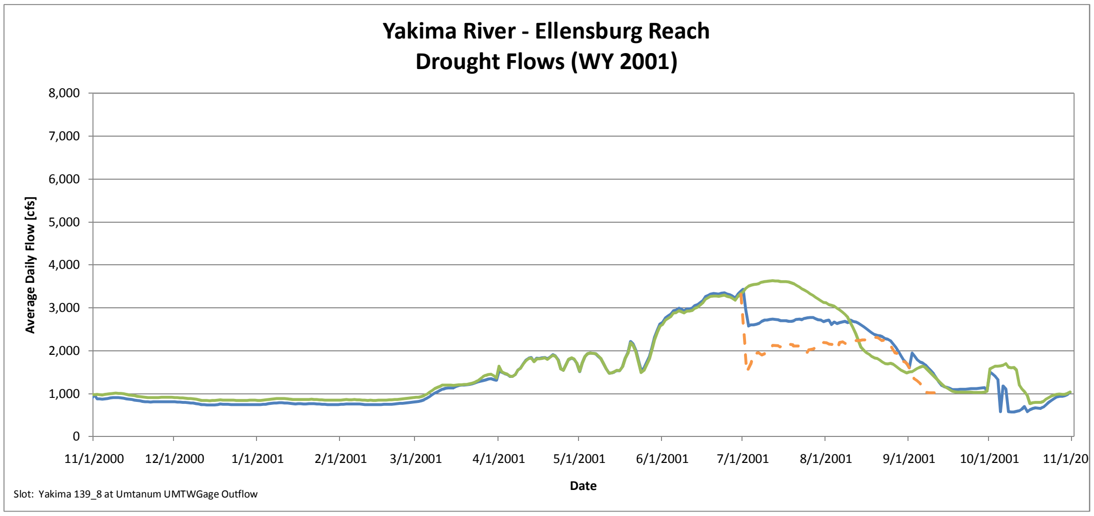

Yakima River - Easton Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

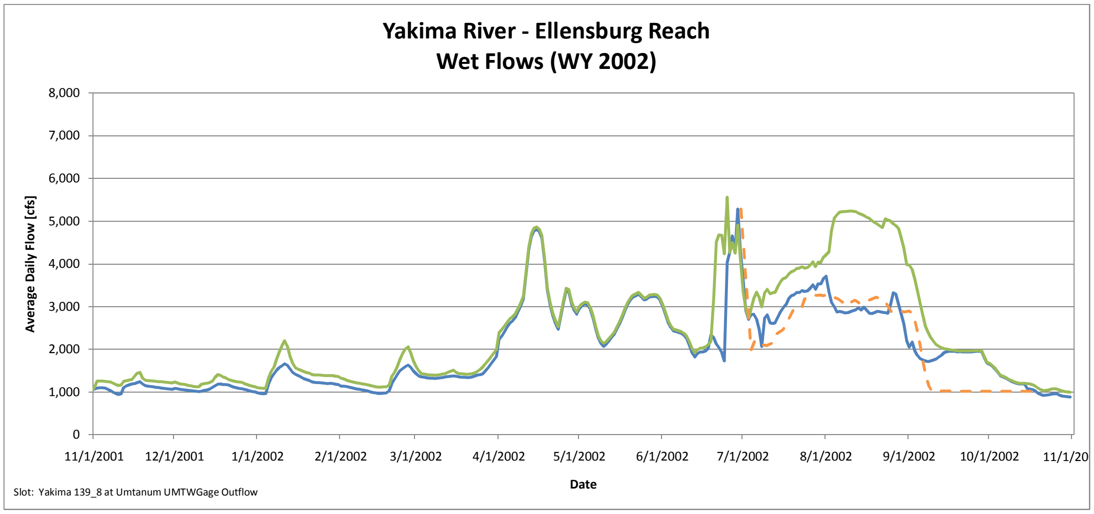

Cle Elum River
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Wymer
Proposed ISF Targets
Minimum Target Flows (Existing)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

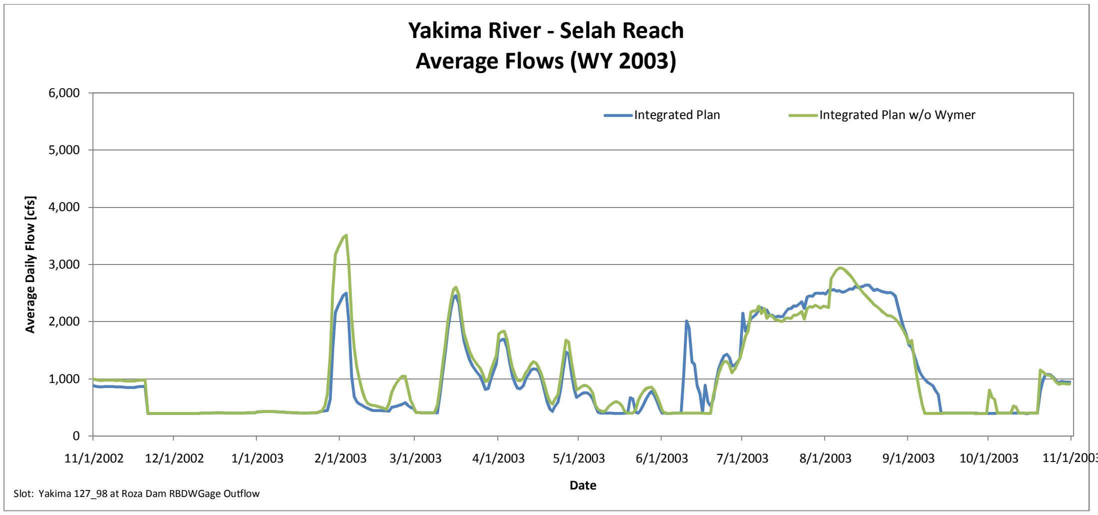

Cle Elum River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

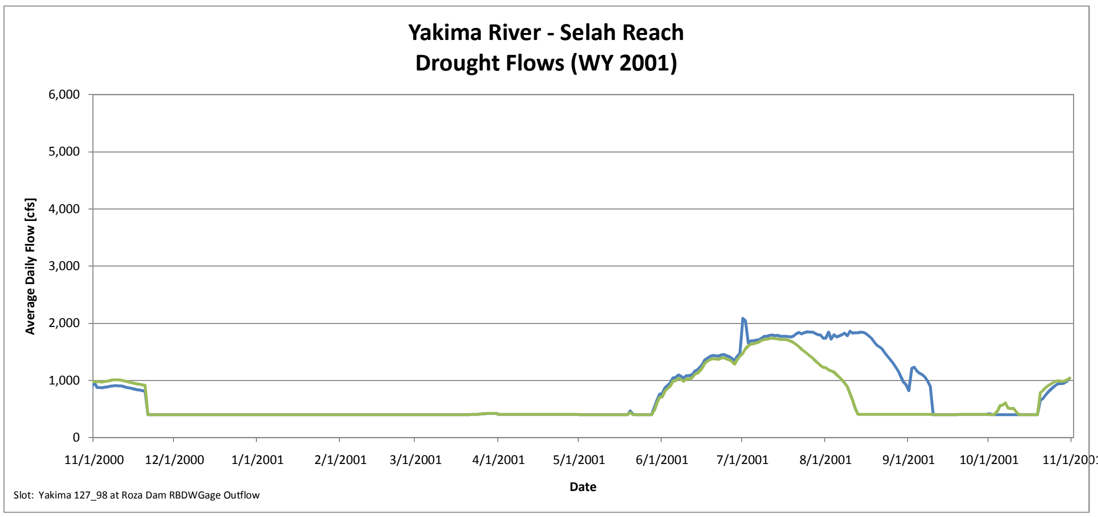

Cle Elum River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

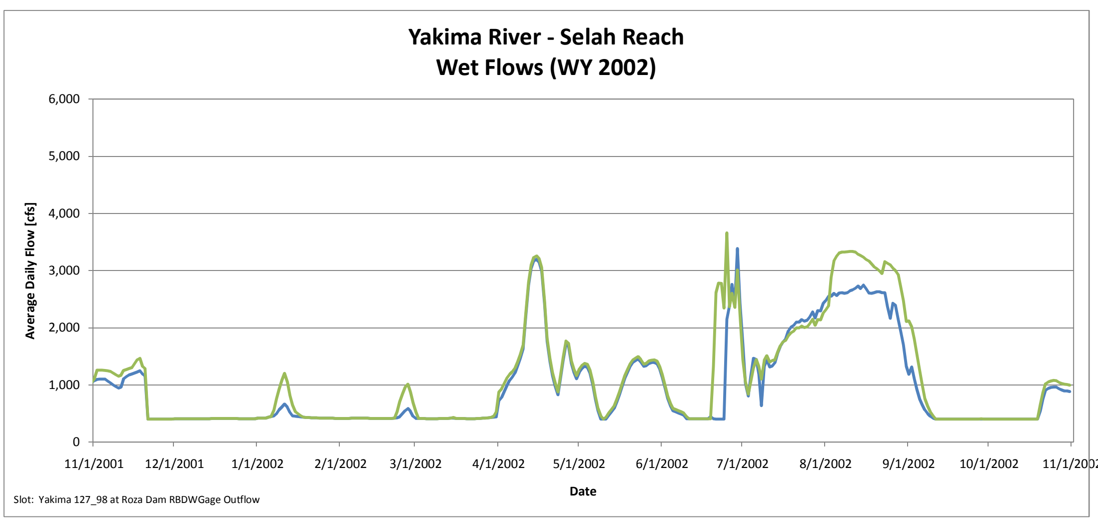

Yakima River - Ellensburg Reach
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Wymer
Proposed ISF Targets
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

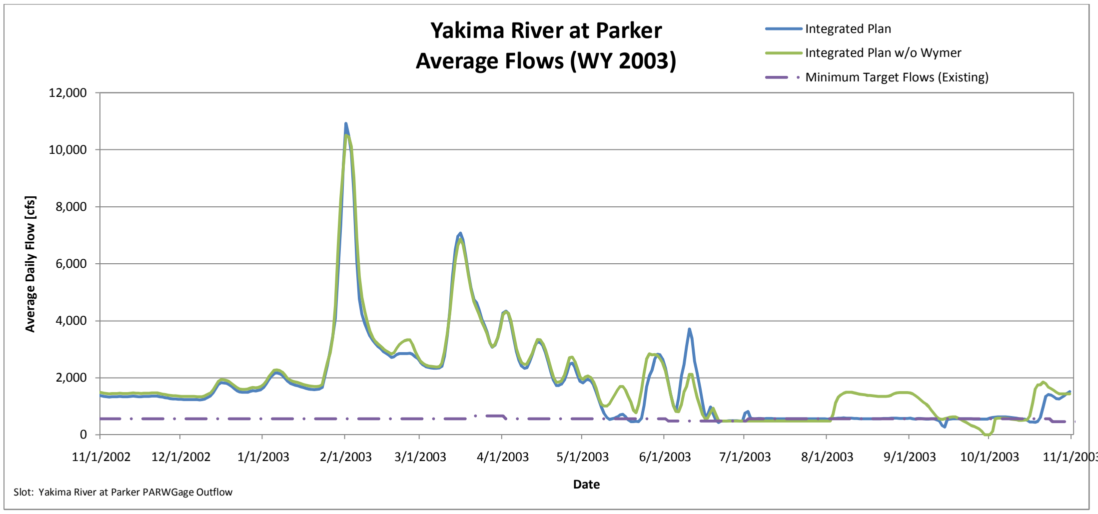

Yakima River - Ellensburg Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

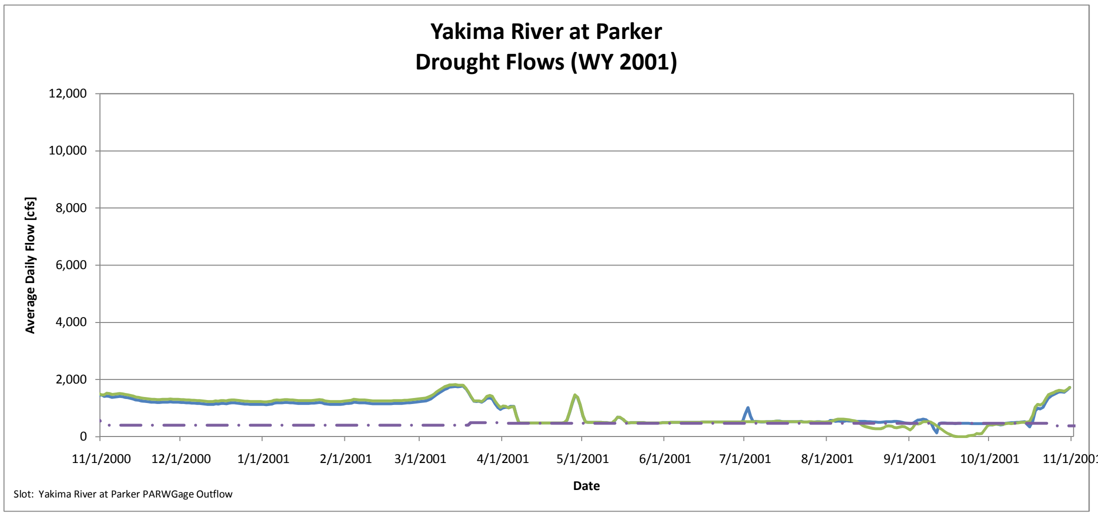

Yakima River - Ellensburg Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

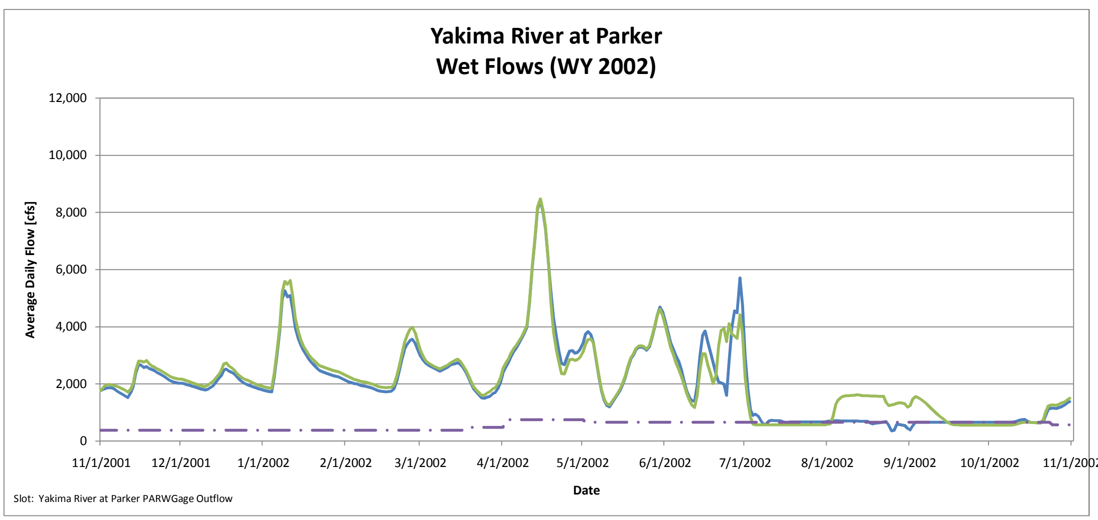

Yakima River - Selah Reach
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Wymer
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

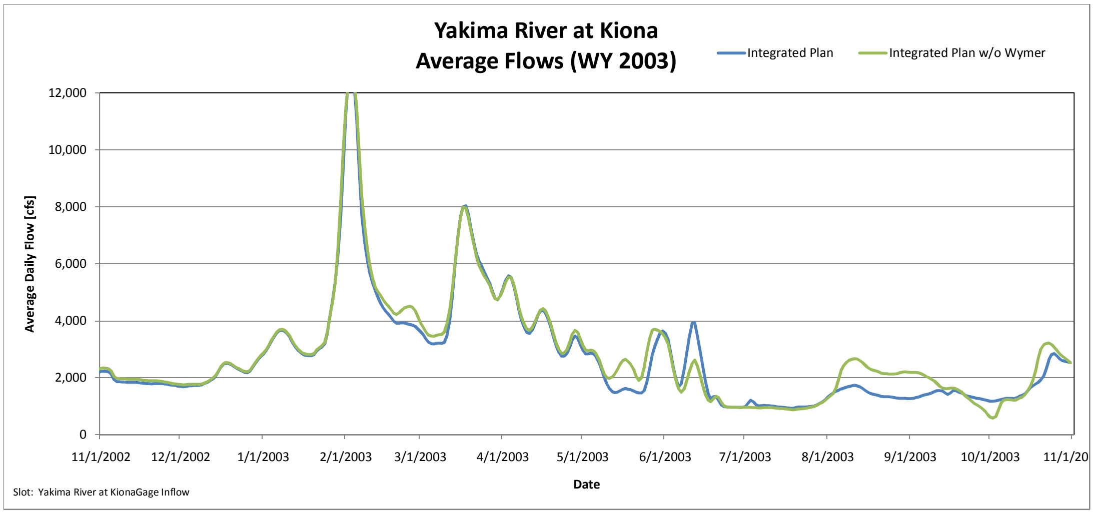

Yakima River - Selah Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

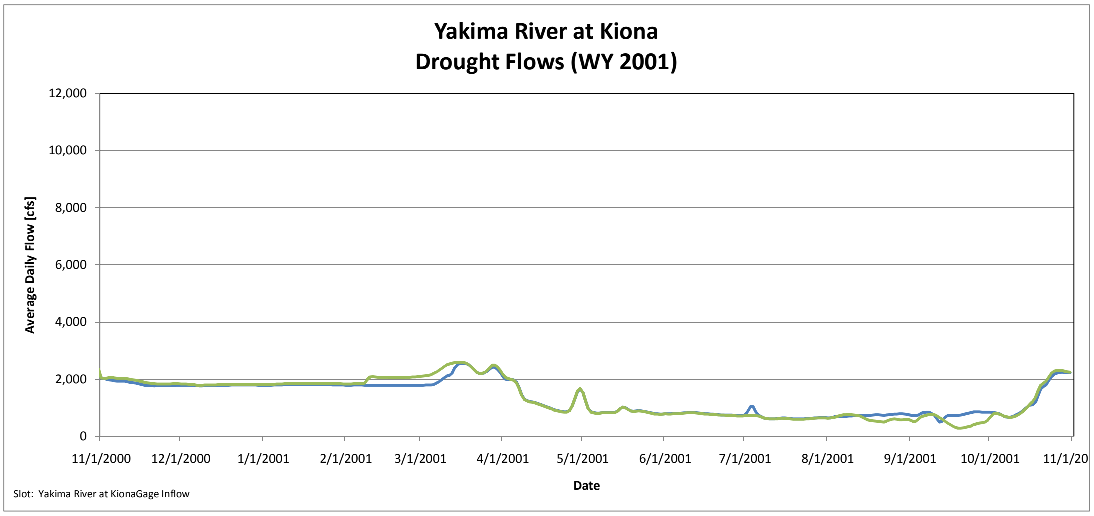

Yakima River - Selah Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

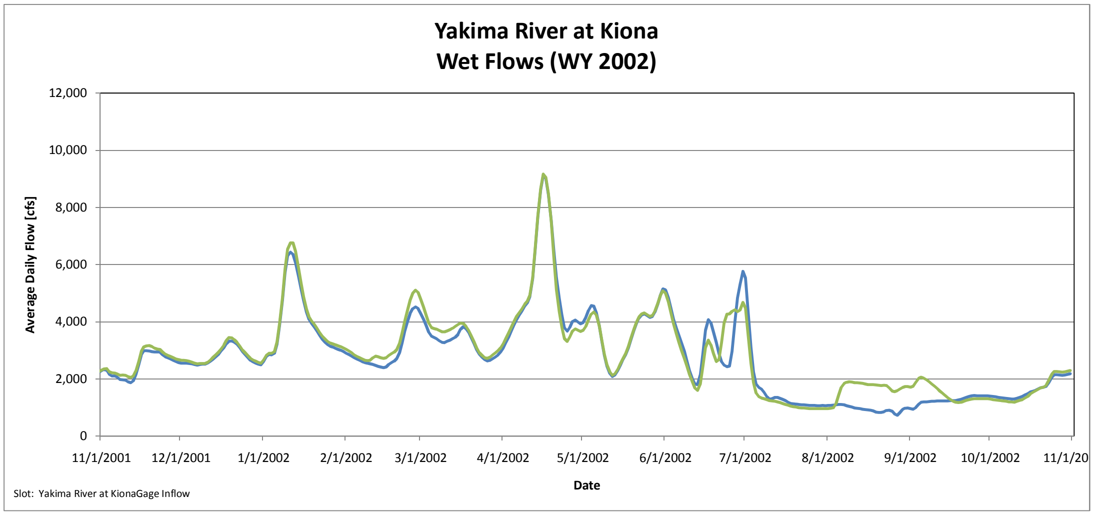

Yakima River at Parker
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Wymer
Minimum Target Flows (Existing)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima River at Parker PARWGage Outflow

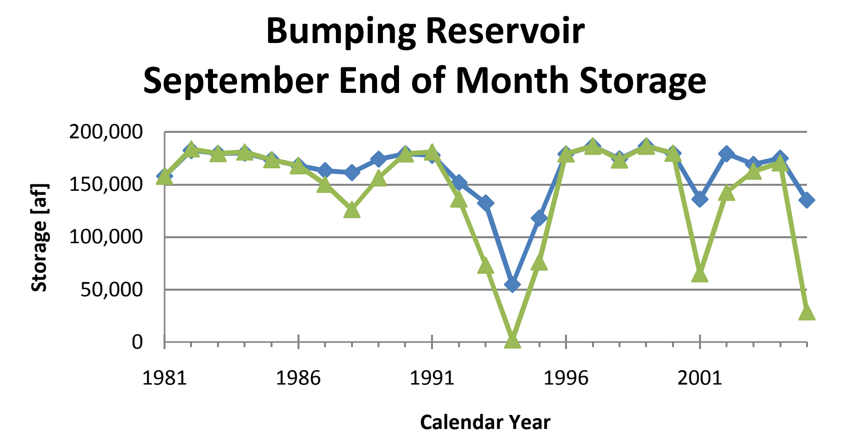

Yakima River at Parker
Drought Flows (WY 2001)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima River at Parker PARWGage Outflow


Yakima River at Parker
Wet Flows (WY 2002)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima River at Parker PARWGage Outflow

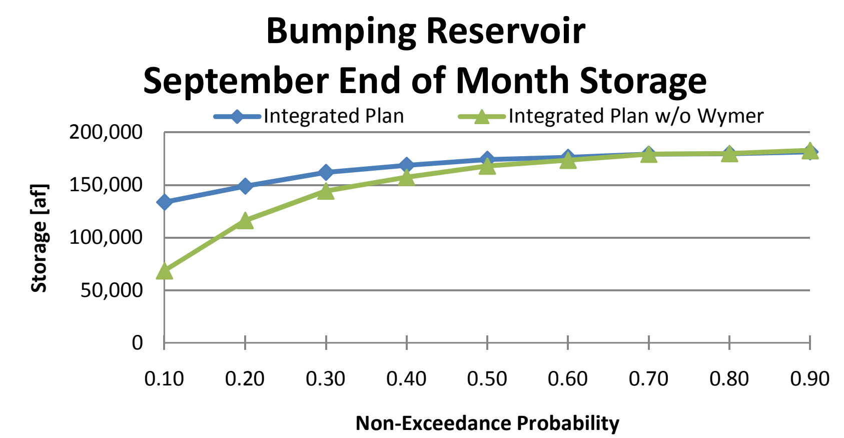

Yakima River at Kiona
Average Flows (WY 2003)
Integrated Plan
Integrated Plan w/o Wymer
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Yakima River at KionaGage Inflow


Yakima River at Kiona
Drought Flows (WY 2001)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

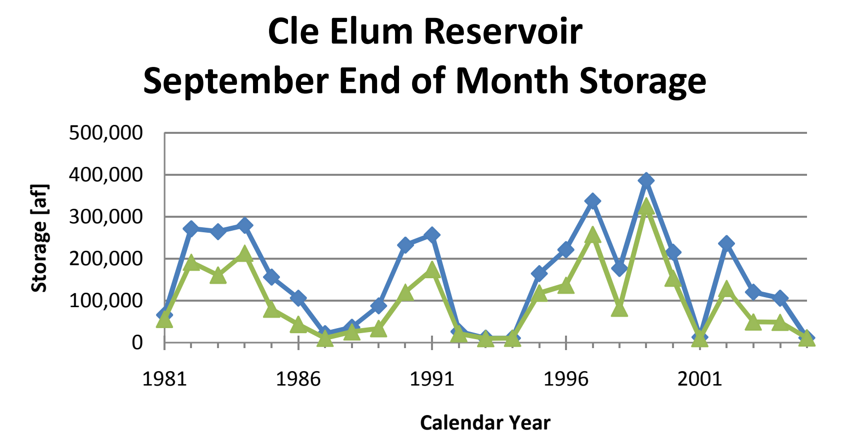

Yakima River at Kiona
Wet Flows (WY 2002)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Yakima River at KionaGage Inflow



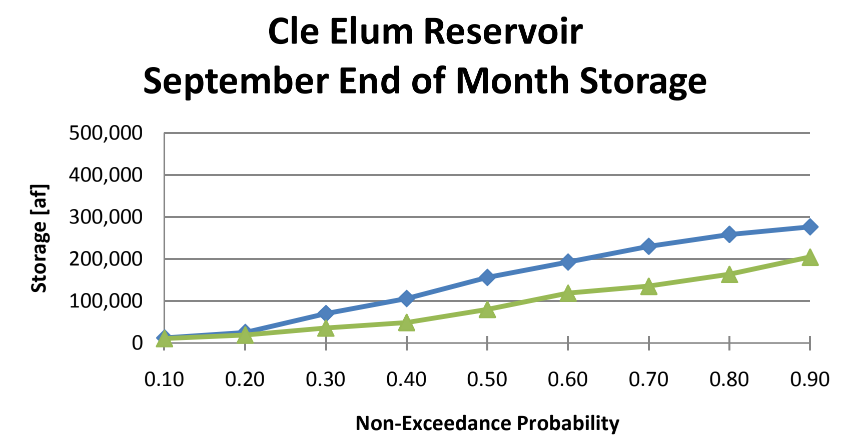
Slot: BumpingReservoirStorage



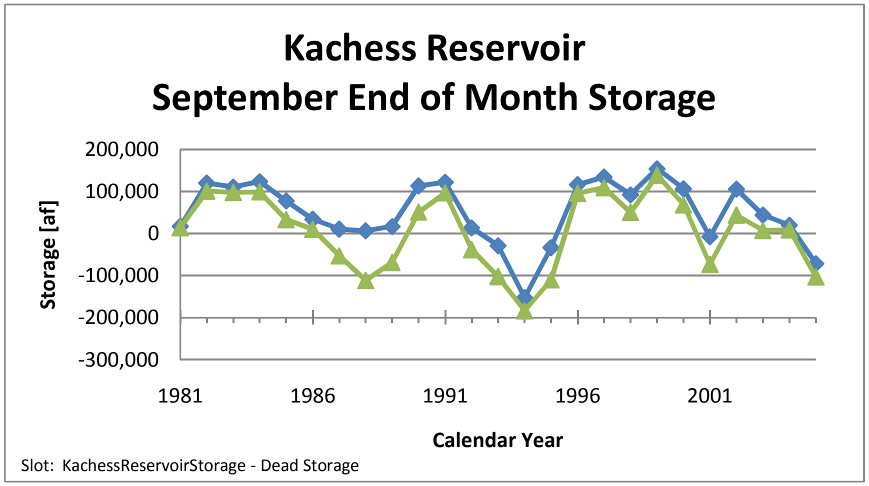
Slot: BumpingReservoirStorage

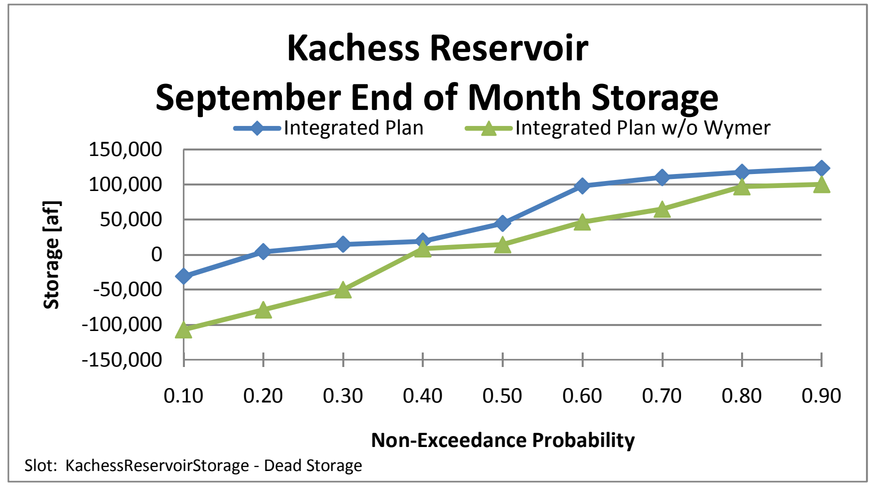


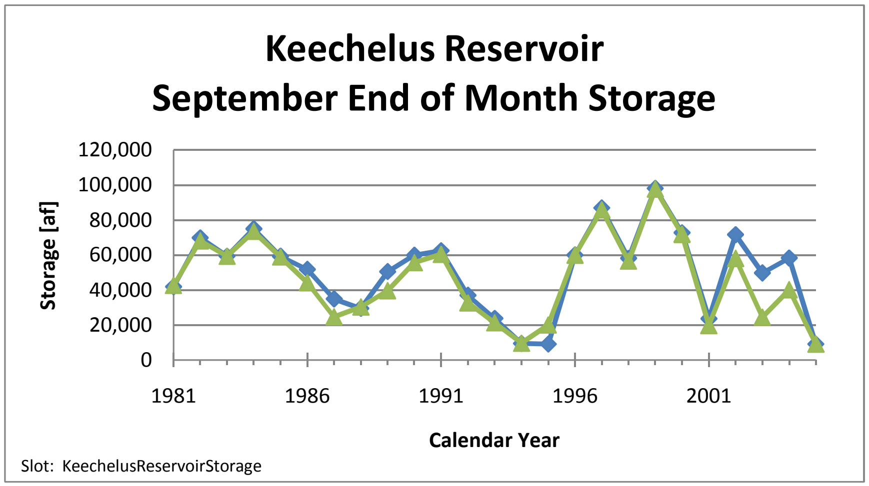
Slot: CleElumReservoirStorage

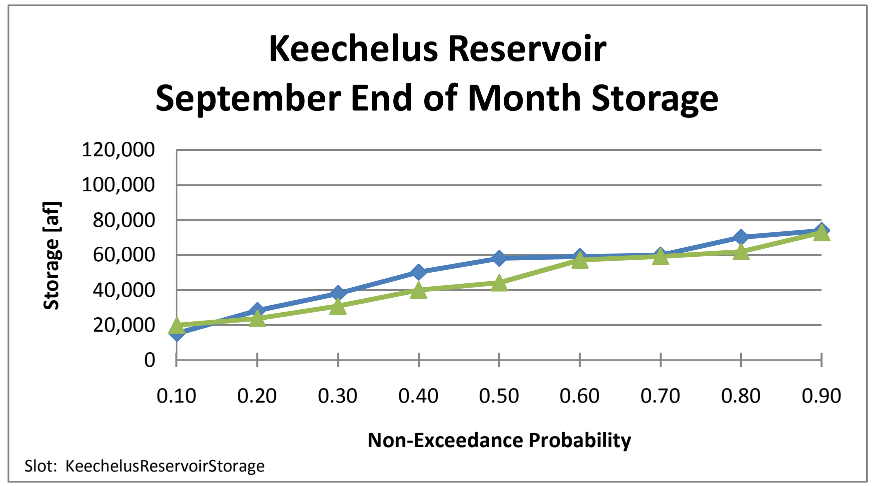


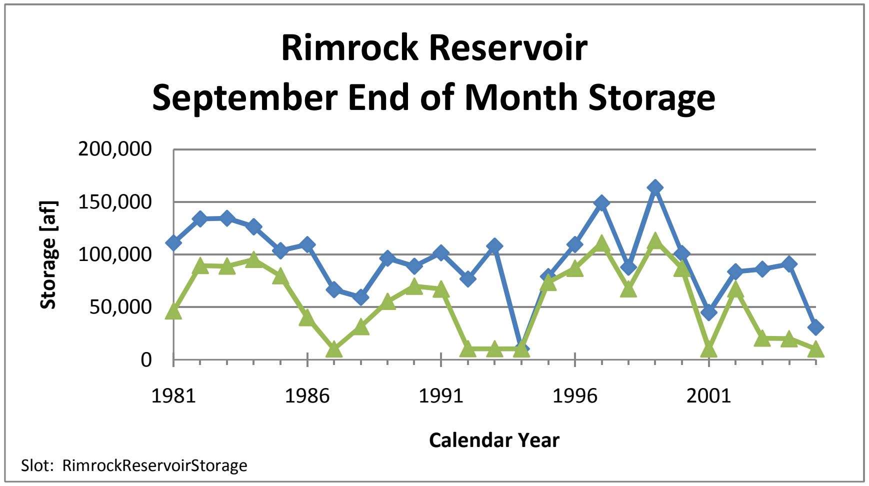
Slot: CleElumReservoirStorage

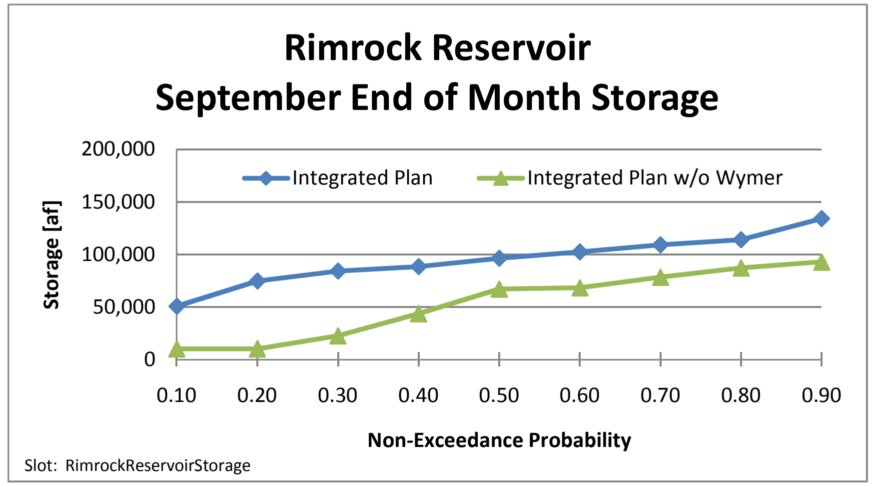

Kachess Reservoir
September End of Month Storage
Storage [af]
200,000
100,000
0
-100,000
-200,000
-300,000
1981
1986
1991
1996
2001
Calendar Year
Slot: KachessReservoirStorage - Dead Storage

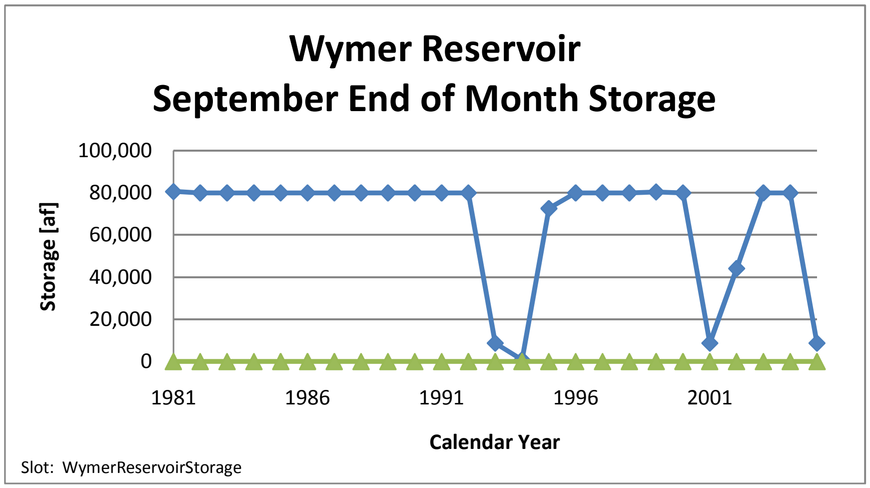

Kachess Reservoir
September End of Month Storage
Integrated Plan
Integrated Plan w/o Wymer
Storage [af]
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KachessReservoirStorage - Dead Storage

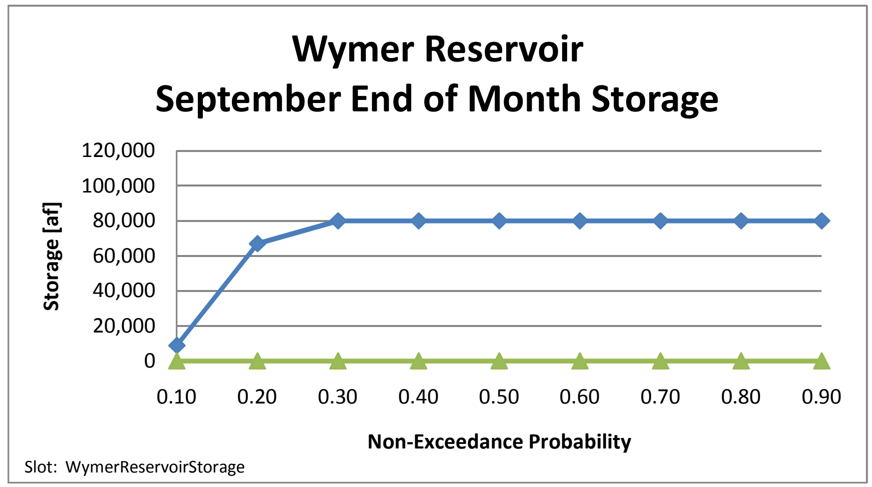

Keechelus Reservoir
September End of Month Storage
Storage [af]
120,000
100,000
80,000
60,000
40,000
20,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: KeechelusReservoirStorage

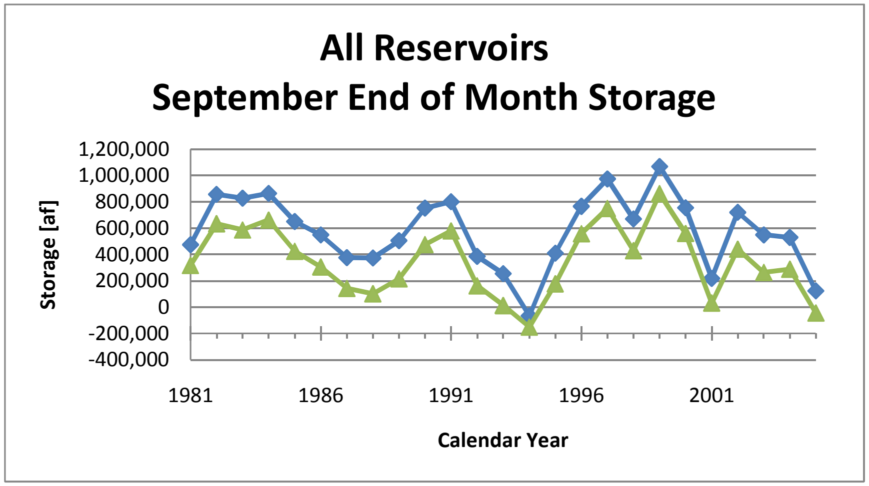

Keechelus Reservoir
September End of Month Storage
Storage [af]
120,000
100,000
80,000
60,000
40,000
20,000
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KeechelusReservoirStorage

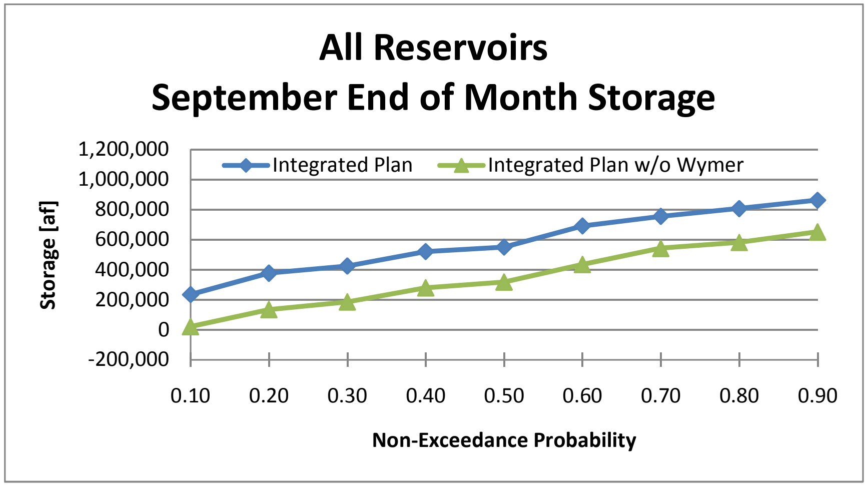

Rimrock Reservoir
September End of Month Storage
Storage [af]
200,000
150,000
100,000
50,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: RimrockReservoirStorage

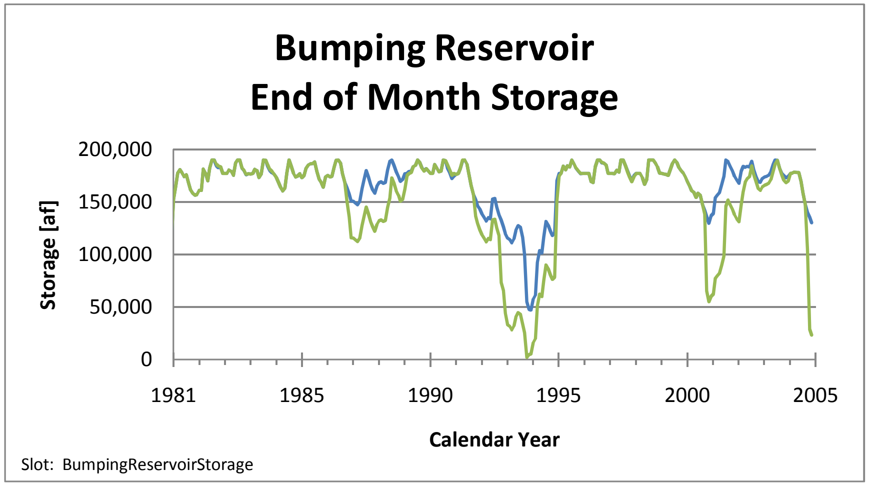

Rimrock Reservoir
September End of Month Storage
Integrated Plan
Integrated Plan w/o Wymer
Storage [af]
200,000
150,000
100,000
50,000
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: RimrockReservoirStorage

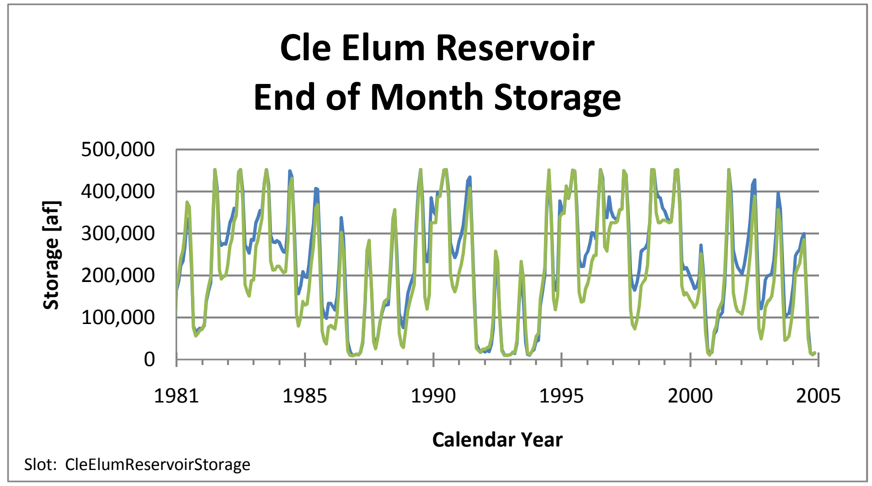

Wymer Reservoir
September End of Month Storage
Storage [af]
100,000
80,000
60,000
40,000
20,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: WymerReservoirStorage

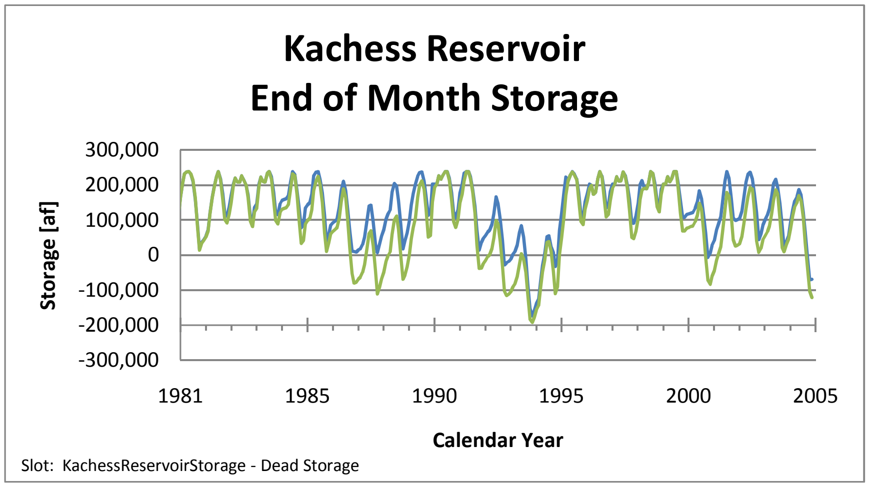

Wymer Reservoir
September End of Month Storage
Storage [af]
120,000
100,000
80,000
60,000
40,000
20,000
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: WymerReservoirStorage

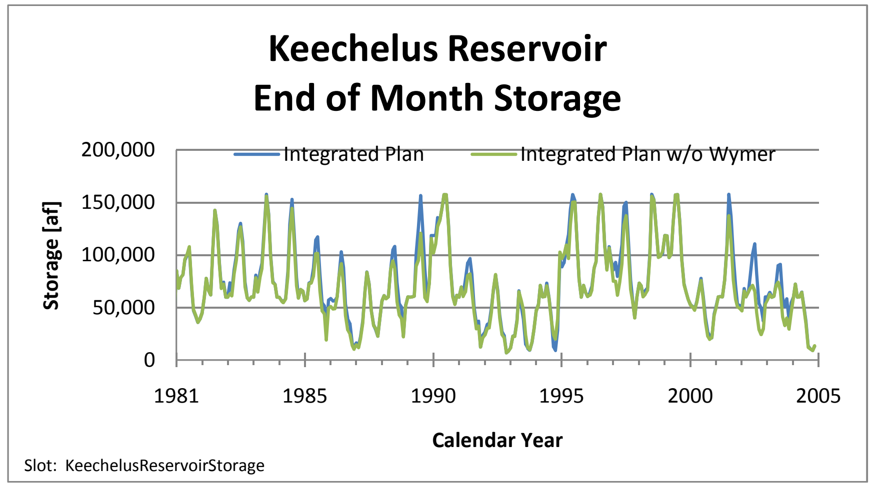

All Reservoirs
September End of Month Storage
Storage [af]
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
-200,000
-400,000
1981
1986
1991
1996
2001
Calendar Year

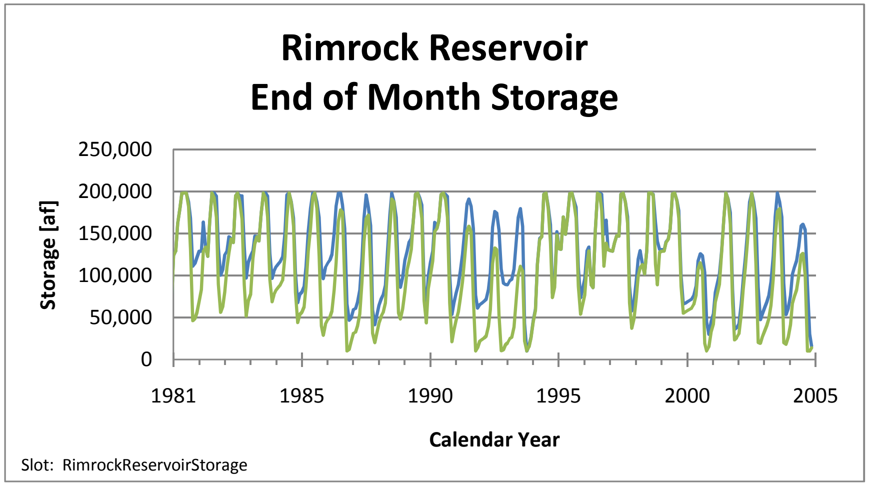

All Reservoirs
September End of Month Storage
Integrated Plan
Integrated Plan w/o Wymer
Storage [af]
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
-200,000
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability

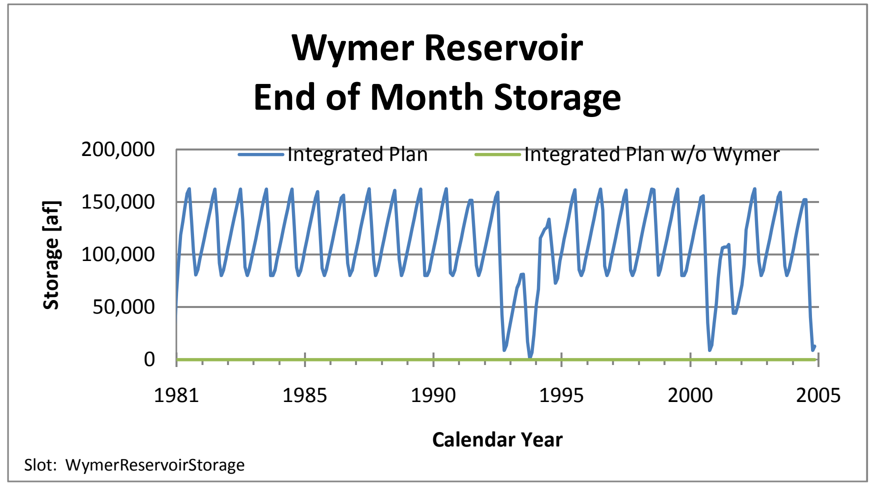

Bumping Reservoir
End of Month Storage
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: BumpingReservoirStorage

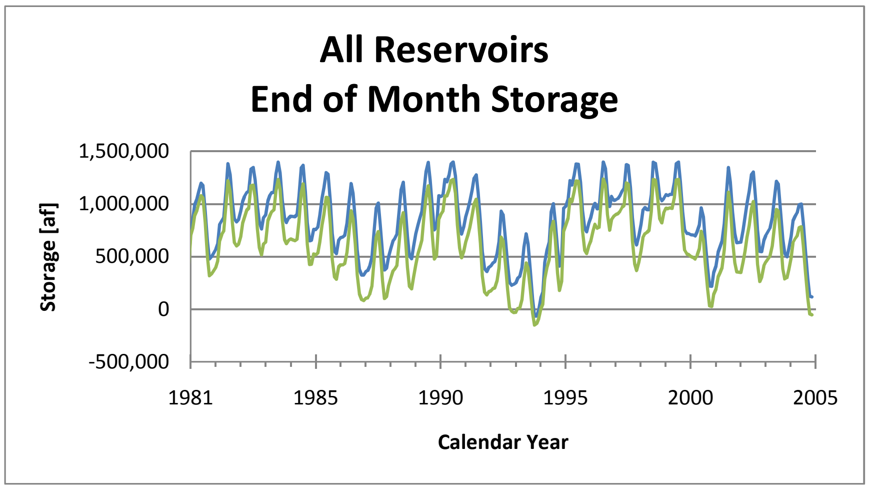

Cle Elum Reservoir
End of Month Storage
500,000
400,000
300,000
200,000
100,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: CleElumReservoirStorage

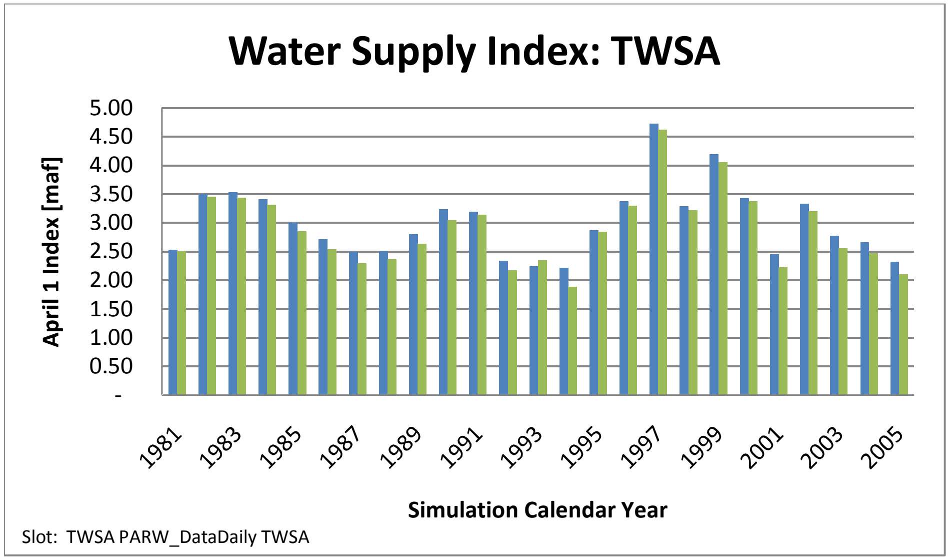

Kachess Reservoir
End of Month Storage
300,000
200,000
100,000
0
-100,000
-200,000
-300,000
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KachessReservoirStorage - Dead Storage

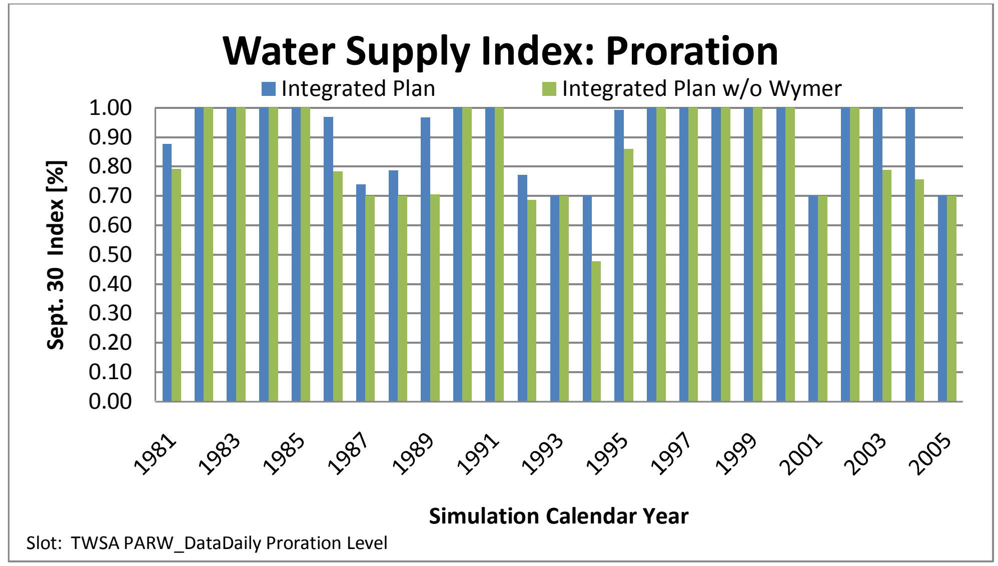

Keechelus Reservoir
End of Month Storage
Integrated Plan
Integrated Plan w/o Wymer
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KeechelusReservoirStorage

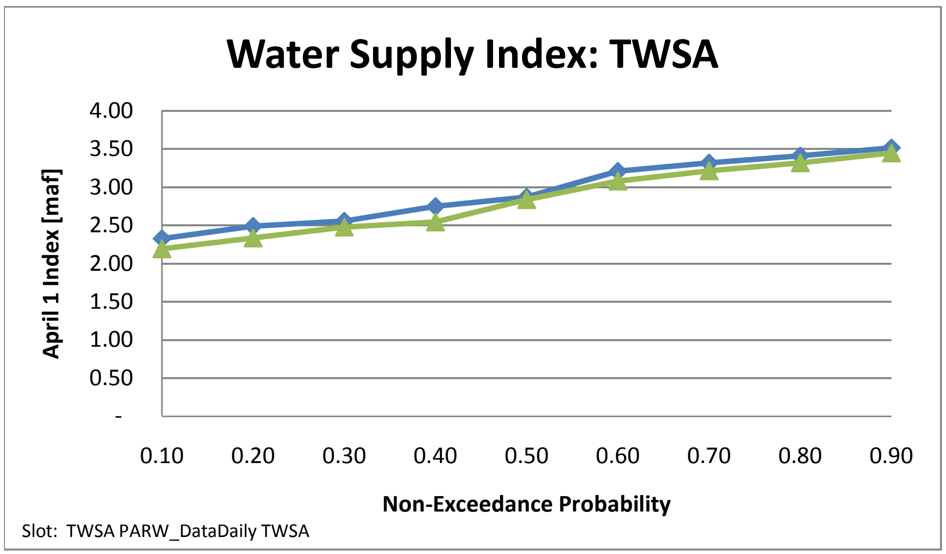

Rimrock Reservoir
End of Month Storage
250,000
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: RimrockReservoirStorage

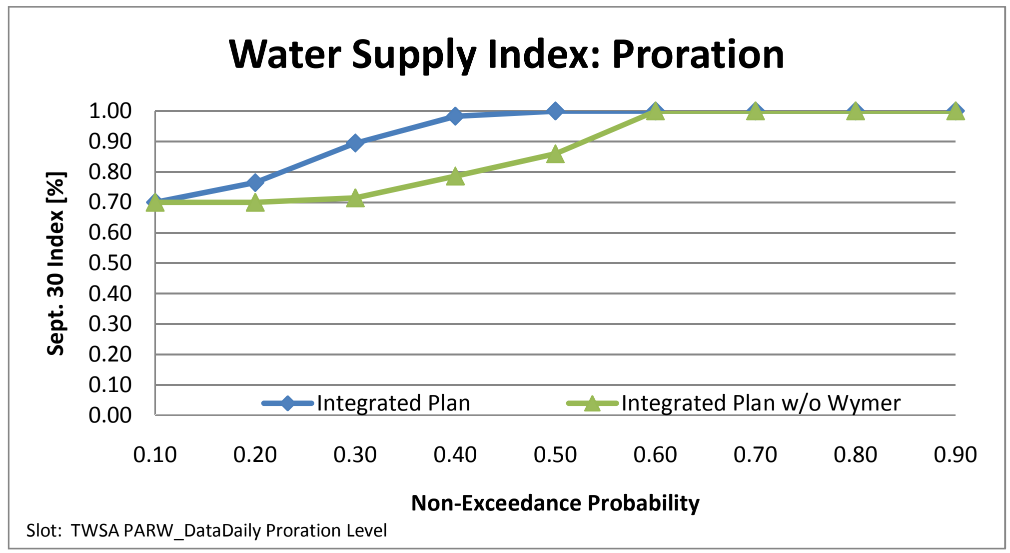

Wymer Reservoir
End of Month Storage
Integrated Plan
Integrated Plan w/o Wymer
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: WymerReservoirStorage


All Reservoirs
End of Month Storage
1,500,000
1,000,000
500,000
0
-500,000
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year

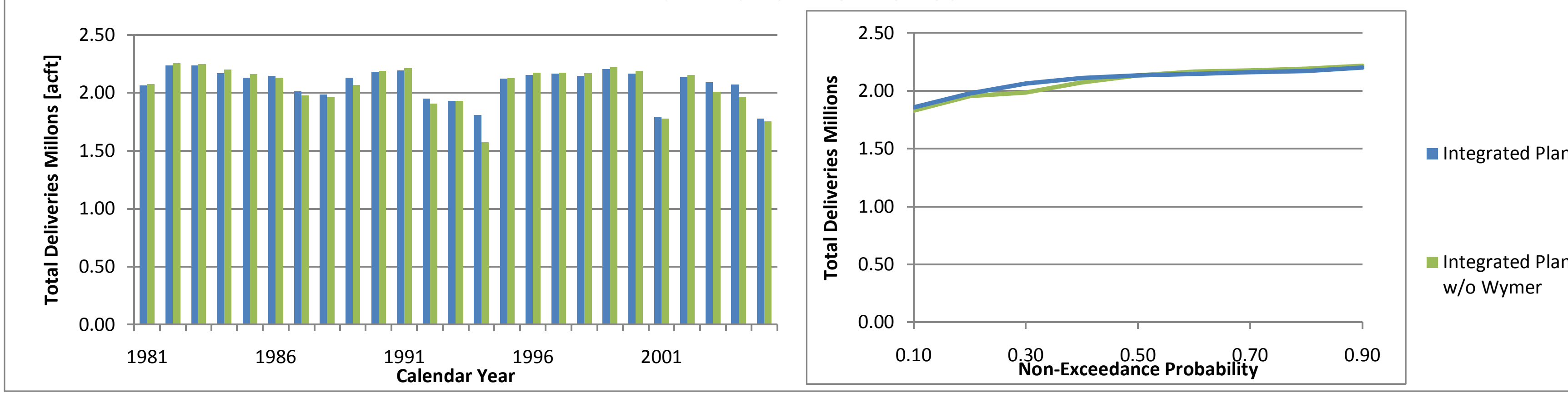

Water Supply Index: TWSA
April 1 Index [maf]
Simulation Calendar Year
Slot: TWSA PARW_DataDaily TWSA


Water Supply Index: Proration
Integrated Plan
Integrated Plan w/o Wymer
Sept. 30 Index [%]
Simulation Calendar Year
Slot: TWSA PARW_DataDaily Proration Level

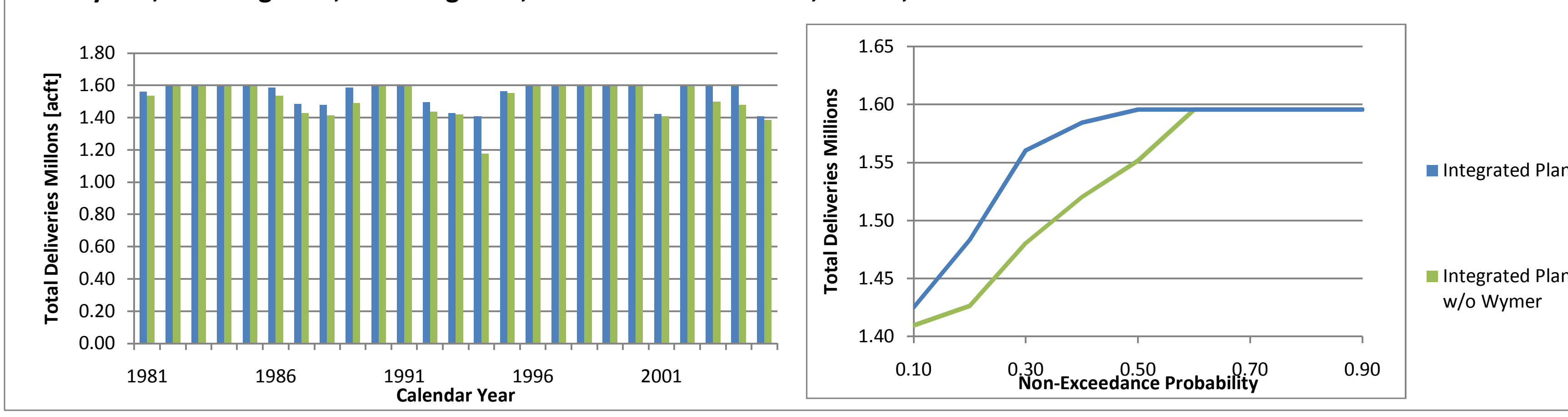

Water Supply Index: TWSA
April 1 Index [maf]
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily TWSA


Water Supply Index: Proration
Sept. 30 Index [%]
Integrated Plan
Integrated Plan w/o Wymer
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily Proration Level

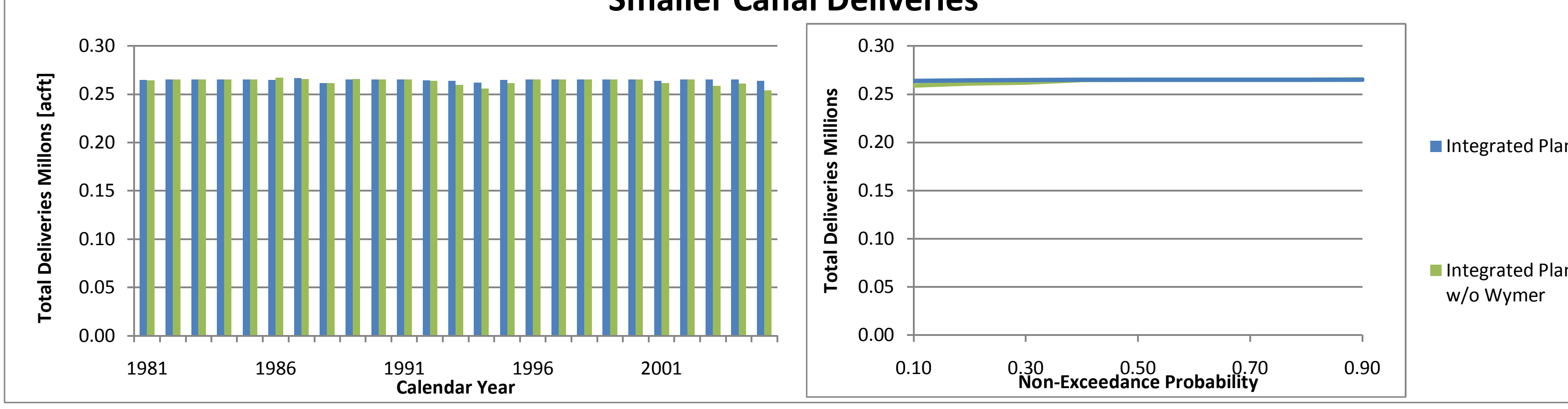
Main Canal Deliveries



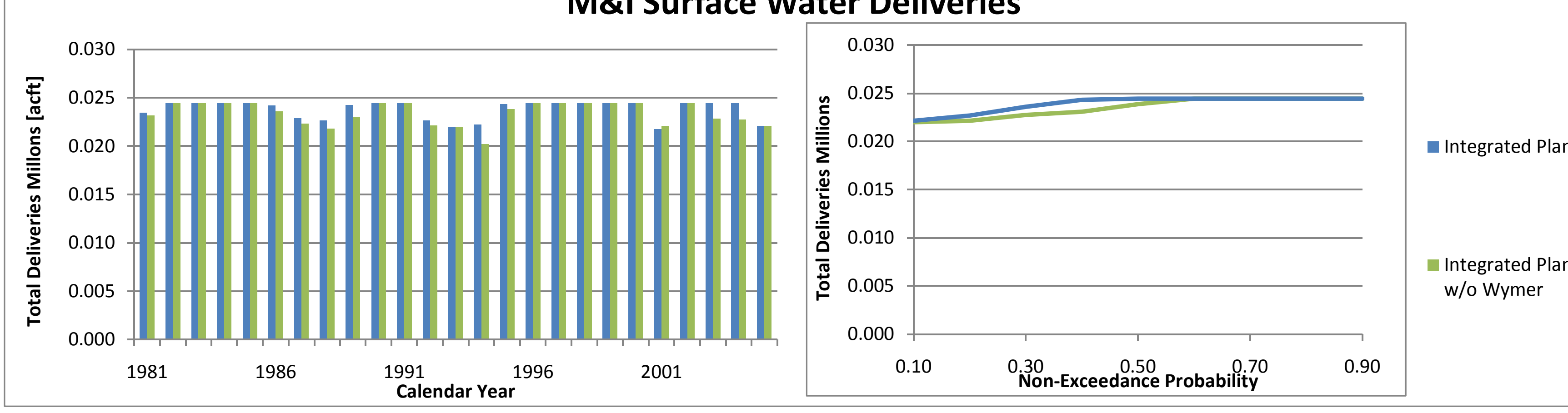
Sunnyside, KRD Irrigation, Roza Irrigation, New Reservation Canal, Tieton, and Kennewick Deliveries



Smaller Canal Deliveries



M&I Surface Water Deliveries



Appendix D – Climate Change Integrated Plan Results

Appendix D –1

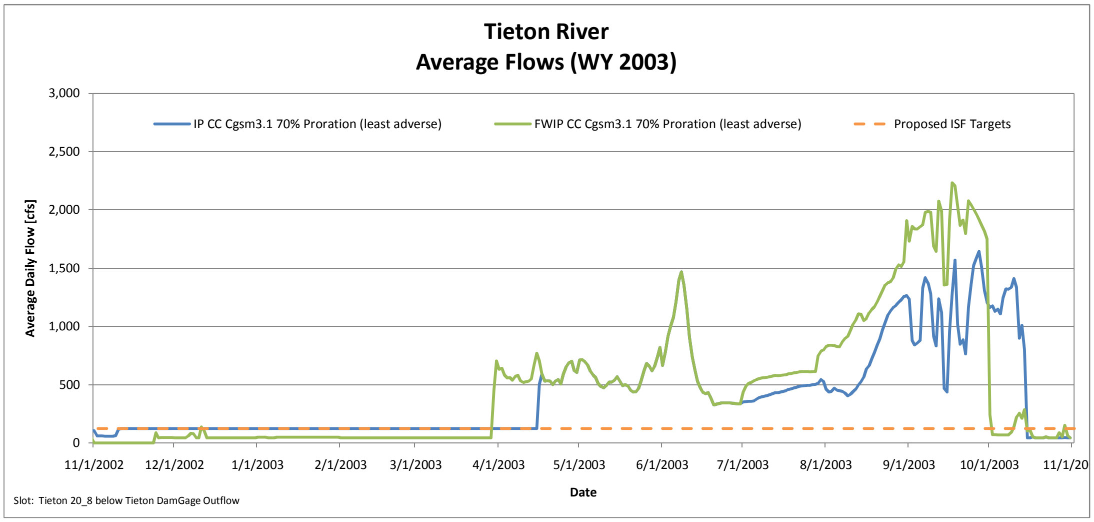
Integrated Plan Results with Climate Change Least Adverse Scenario (CGSM3.1)

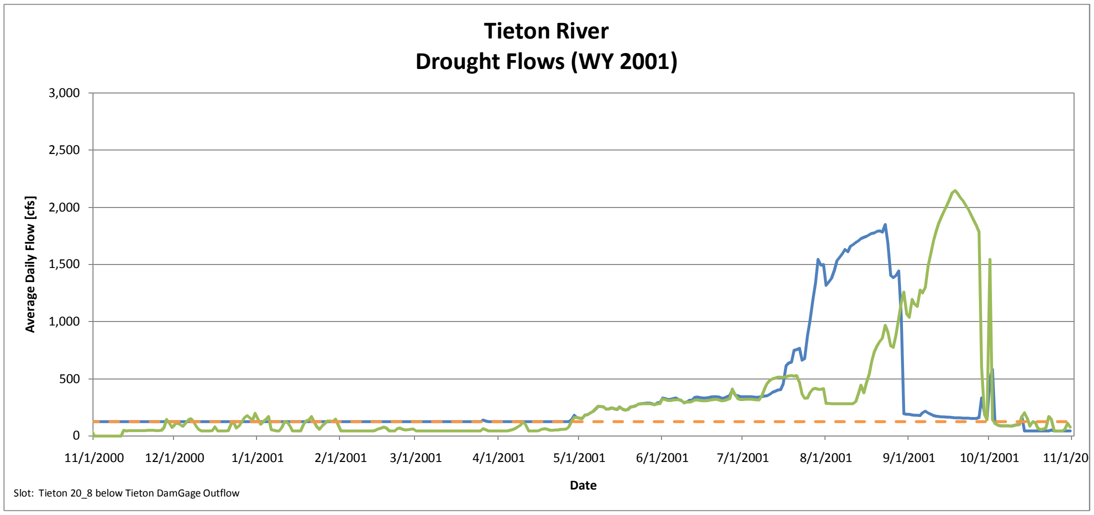
Resource indicator (measurement)	IP CC Cgsm3.1 70% Proration (least adverse)	FWIP CC Cgsm3.1 70% Proration (least adverse)
WATER RESOURCES		
Average for water years 1981–2005 (maf)		
Water supply		
April 1 total water supply available (TWSA)	2.79	2.64
Water distribution		
April–September Parker flow volume	0.53	0.60
April–September diversion	1.79	1.67
September 30 reservoir contents	0.39	0.10
April–September flow volume at mouth of Yakima River	0.85	0.90
1994 dry-year (maf)		
Water supply		
April 1 TWSA	2.24	1.73
Water distribution		
April–September Parker flow volume	0.20	0.25
April–September diversion	1.56	1.29
September 30 reservoir contents	-0.03	0.06
April–September flow volume at mouth of Yakima River	0.39	0.41
Irrigation proration level	70%	32%

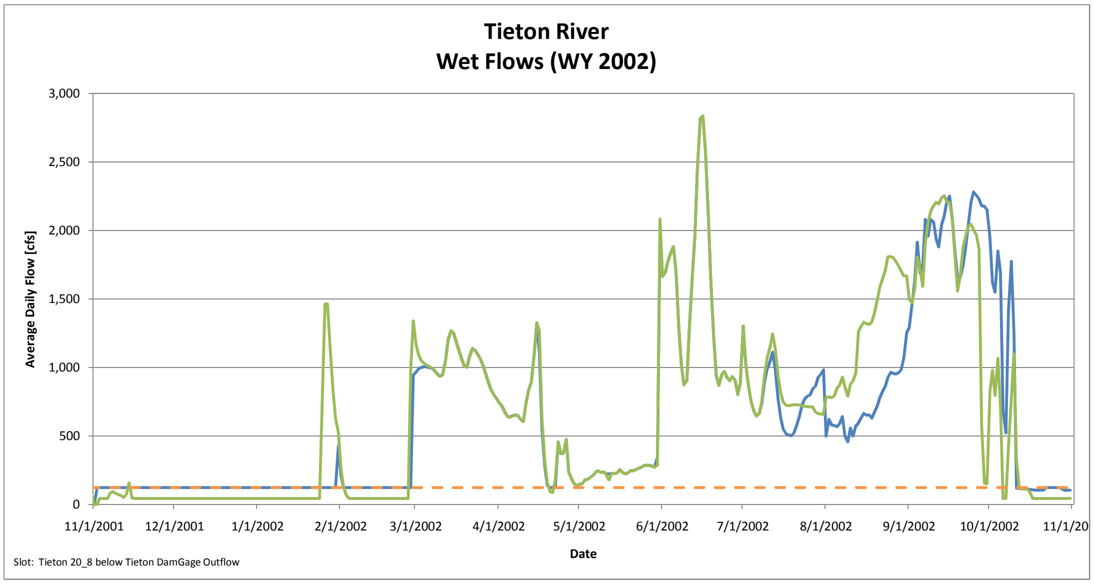
Resource indicator (measurement)	IP CC Cgsm3.1 70% Proration (least adverse)	FWIP CC Cgsm3.1 70% Proration (least adverse)
ANADROMOUS FISH		
Rate of change in flow during flip-flop (average cfs/day August 16–September 14)		
Easton reach	-8	-28
Ellensburg reach	-50	-107
Lower Naches River reach	35	30
Pre- (August 1-15) and post- (September 14-28) flip-flop flow and absolute change in flow		
Easton reach		
Pre-flip-flop flow (cfs)	575	1,104
Post-flip-flop flow (cfs)	333	294
Absolute change in flow (cfs)	-242	-810
Ellensburg reach		
Pre-flip-flop flow (cfs)	2,969	4,374
Post-flip-flop flow (cfs)	1,519	1,275
Absolute change in flow (cfs)	-1,451	-3,099
Lower Naches River reach		
Pre-flip-flop flow (cfs)	610	883
Post-flip-flop flow (cfs)	1,629	1,743
Absolute change in flow (cfs)	1,019	860
Average, minimum, and maximum reservoir elevation (feet) during bull trout spawning migration: July 15–September 15 (feet)		
Kachess Lake	2225.79 2137.76-2261.05	2231.2 2197.08-2260.89
Keechelus Lake	2463.71 2430.48-2515.5	2453.8 2432.26-2513.74
Rimrock Lake	2910.37 2801.09-2925.97	2900.95 2848.97-2925.76

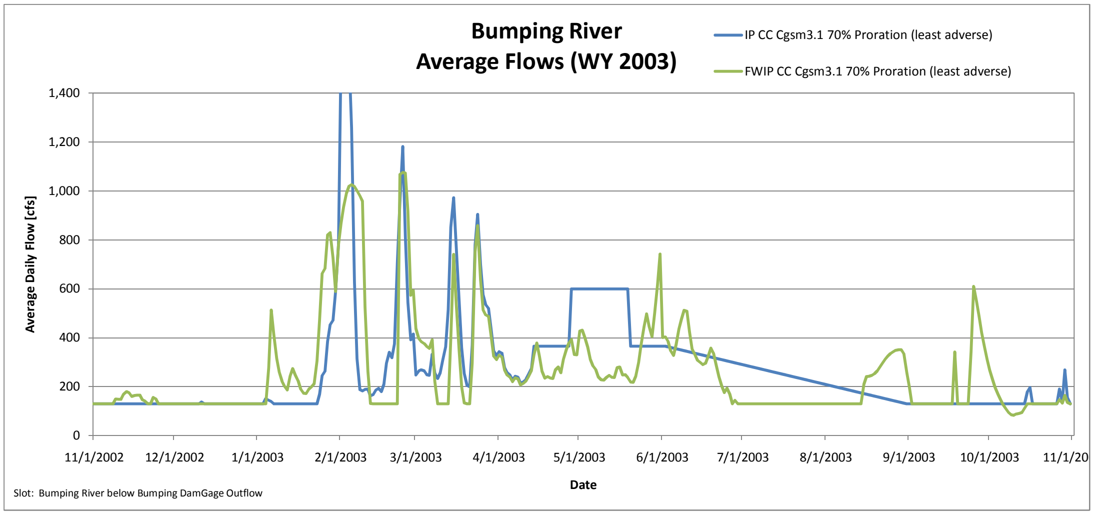
Hydrologic Indicator	IP CC Cgsm3.1 70% Proration (least adverse)					FWIP CC Cgsm3.1 70% Proration (least adverse)				
	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997
April 1 TWSA (maf)	2.79	2.24	2.26	2.29	4.27	2.64	1.73	1.69	2.20	4.12
April-September flow volume at Parker gage (kaf)	527	199	220	347	1563	596	245	285	390	1606
March-October flow volume at Parker gage (kaf)	993	469	462	641	2420	1072	513	517	674	2457
April-September diversion volume upstream of Parker gage (maf)	1.79	1.56	1.56	1.63	1.91	1.67	1.29	1.24	1.56	1.87
September 30 non-Bumping or Wymer reservoir contents (kaf)	168	-150	-80	135	525	88	48	43	42	341
October 31 non-Bumping or Wymer reservoir contents (kaf)	140	-141	-71	132	505	90	63	75	47	327
September 30 Bumping and Wymer reservoir contents (kaf)	222	120	81	154	263	11	4	5	5	17
April-September flow volume at mouth of Yakima River (kaf)	852	394	456	651	2075	905	414	497	675	2102
Irrigation proration level (percent)[1]	88%	70%	70%	70%	100%	74%	32%	25%	59%	100%

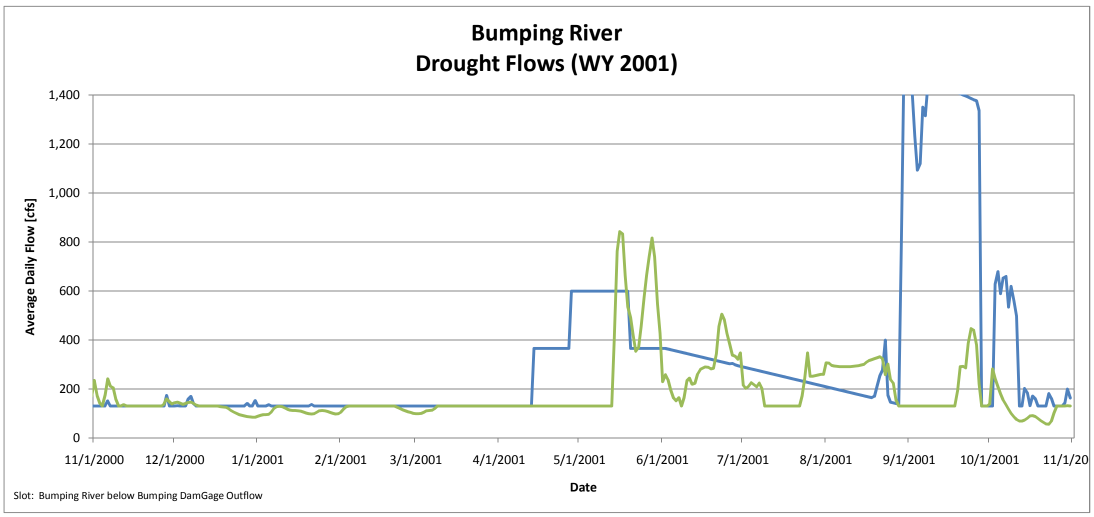
Item	FWIP CC Cgsm3.1 70% Proration (least adverse)	IP CC Cgsm3.1 70% Proration (least adverse)	Improvement
Average 1981-2005			
TWSA [April 1, kaf]	2637.3	2793.5	156.2
March-October flow volume at Parker gage [kaf]	1072.2	993.0	-79.1
Drought Year 1994			
TWSA [April 1, kaf]	1733.9	2237.5	503.6
March-October flow volume at Parker gage [kaf]	512.7	469.5	-43.2
Drought Year 2001			
TWSA [April 1, kaf]	1685.3	2258.4	573.1
March-October flow volume at Parker gage [kaf]	516.7	462.3	-54.4
Drought Year 2005			
TWSA [April 1, kaf]	2201.4	2286.0	84.7
March-October flow volume at Parker gage [kaf]	674.4	640.8	-33.6
Wet Year 1997			
TWSA [April 1, kaf]	4119.6	4266.2	146.6
March-October flow volume at Parker gage [kaf]	2457.3	2420.0	-37.2

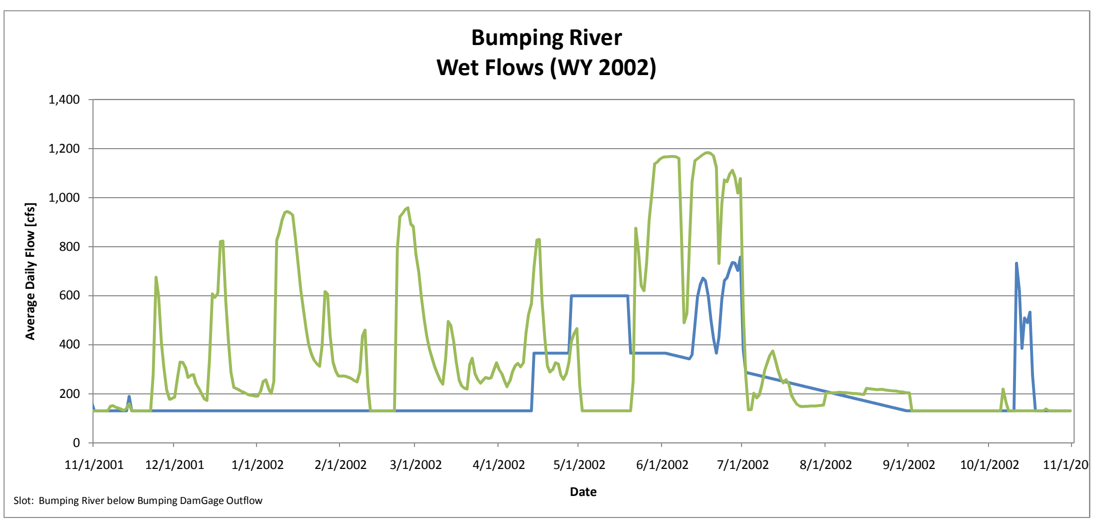

Tieton River
Average Flows (WY 2003)
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
Proposed ISF Targets
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

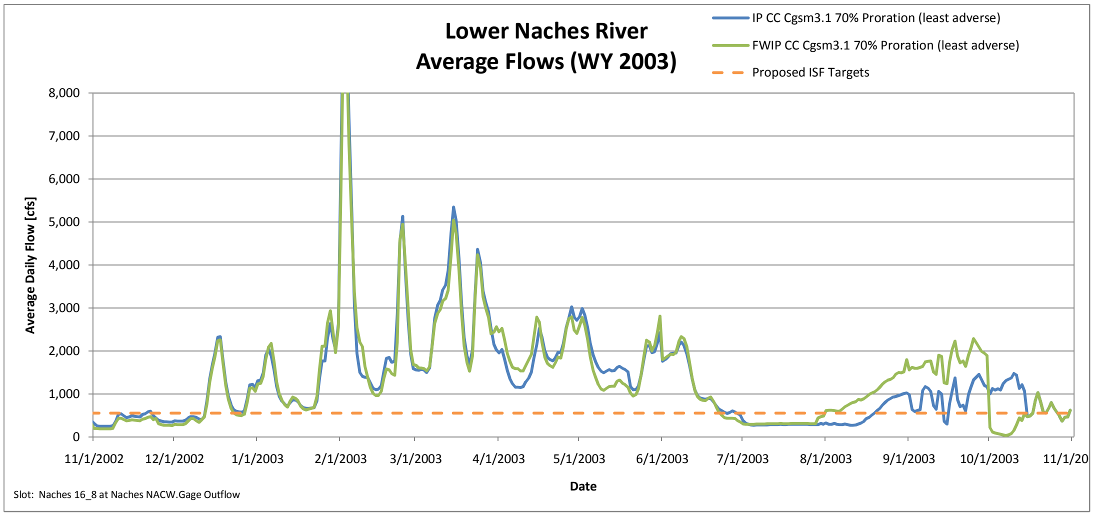

Tieton River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

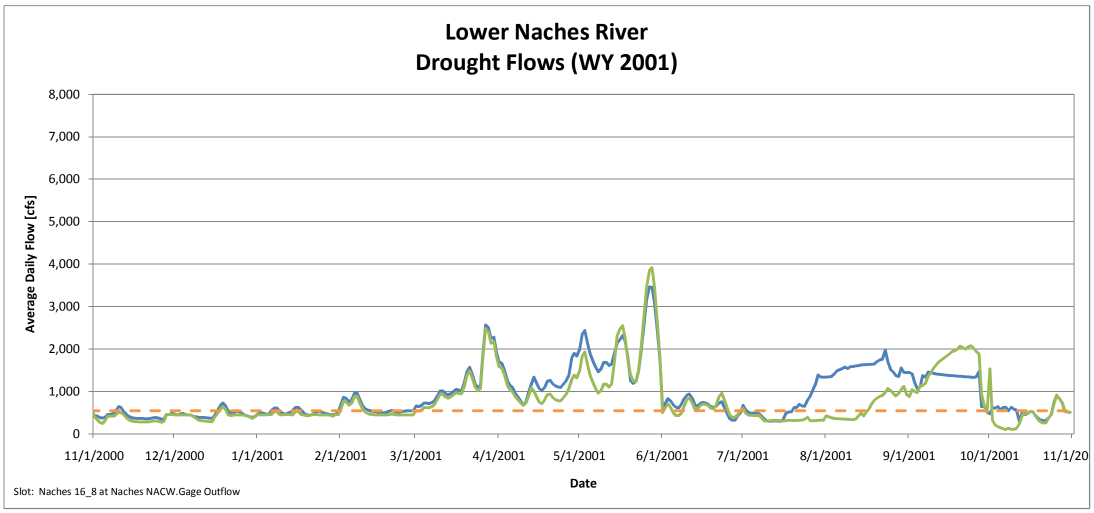

Tieton River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

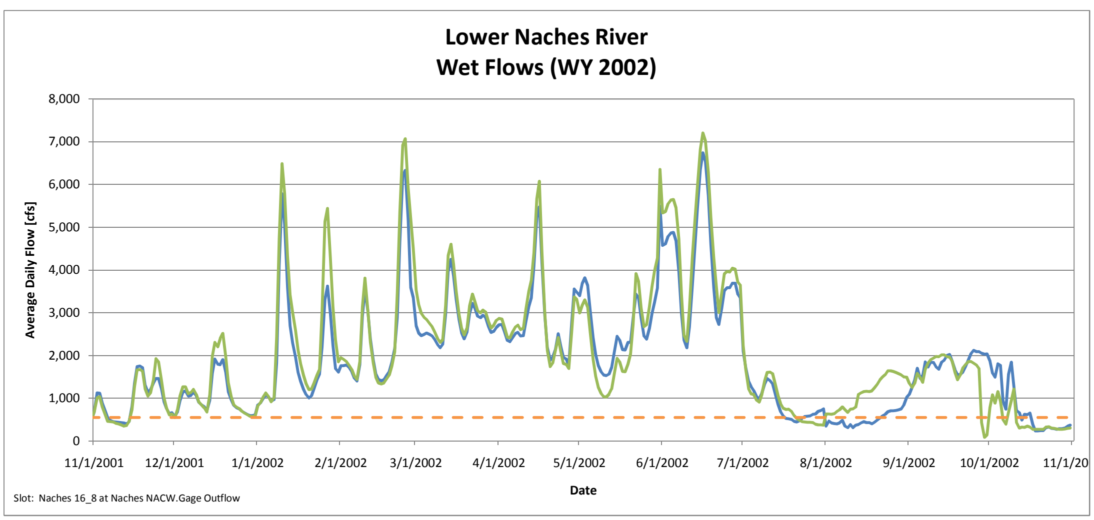

Bumping River
Average Flows (WY 2003)
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
Average Daily Flow [cfs]
Date
Slot: Bumping River below Bumping DamGage Outflow

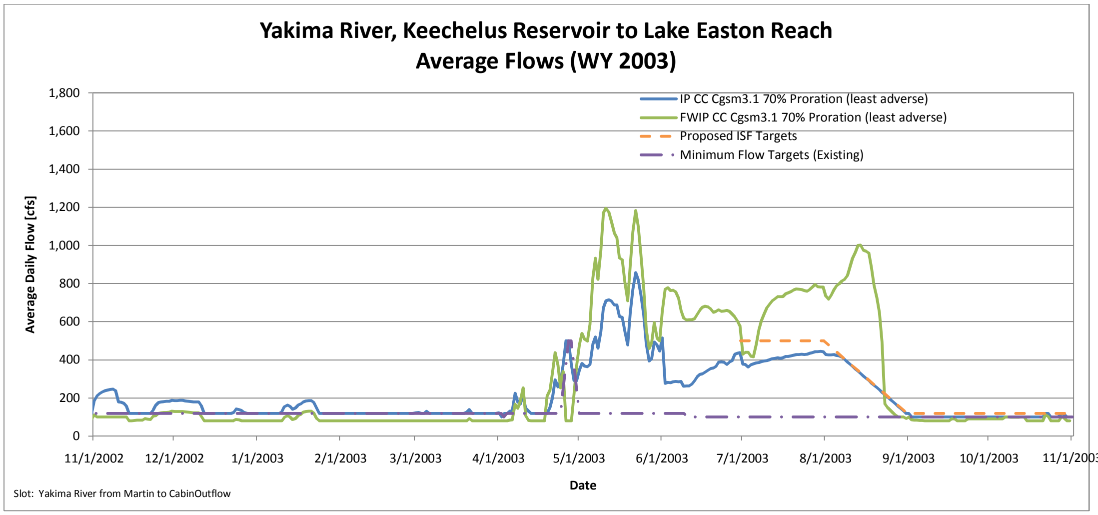

Bumping River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
Date
Slot: Bumping River below Bumping DamGage Outflow

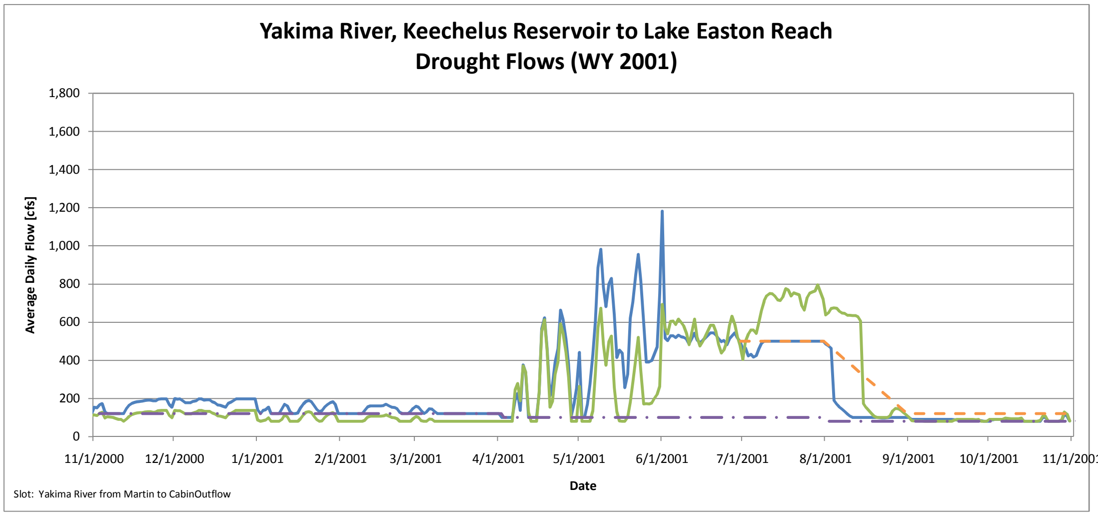

Bumping River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
Date
Slot: Bumping River below Bumping DamGage Outflow

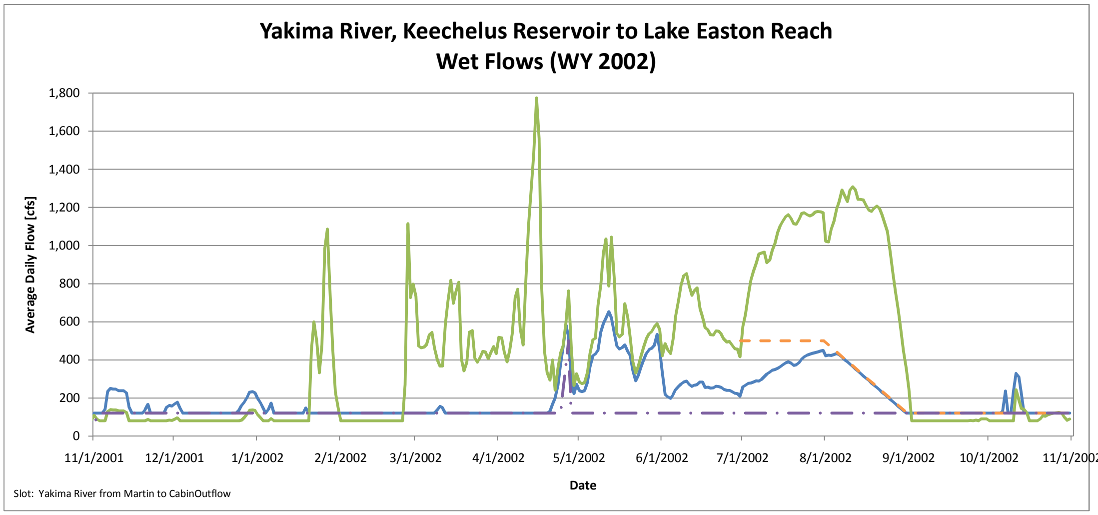

Lower Naches River
Average Flows (WY 2003)
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
Proposed ISF Targets
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

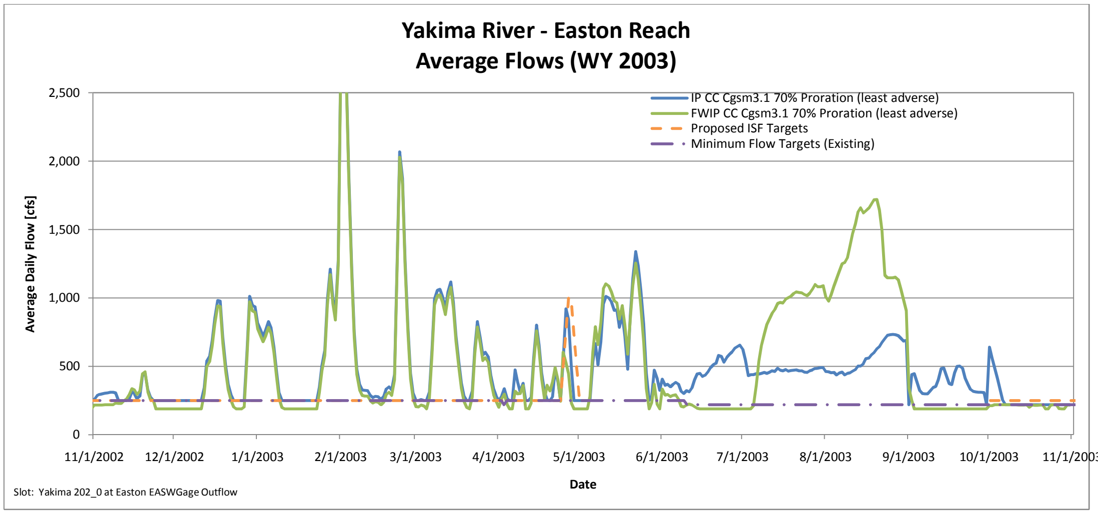

Lower Naches River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

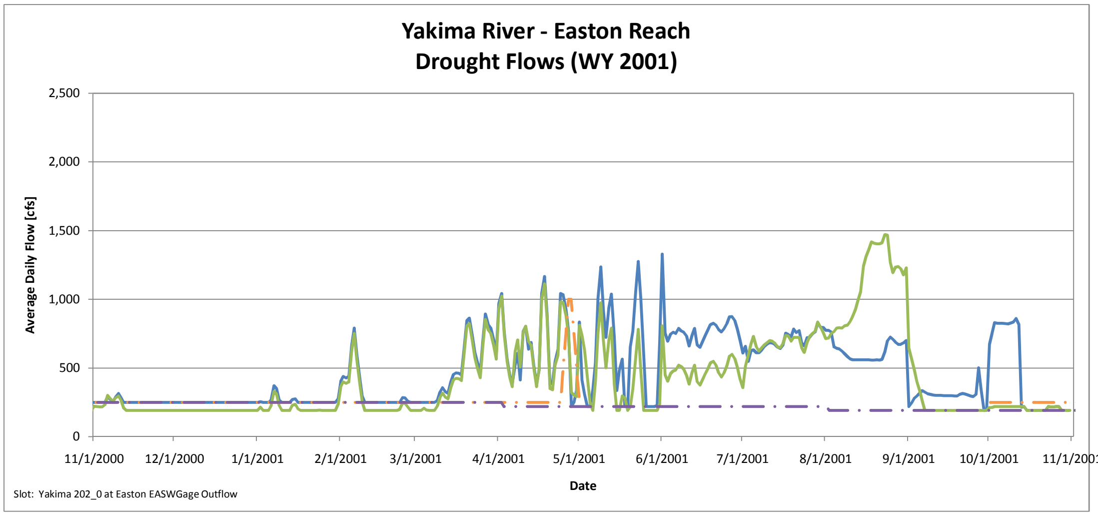

Lower Naches River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

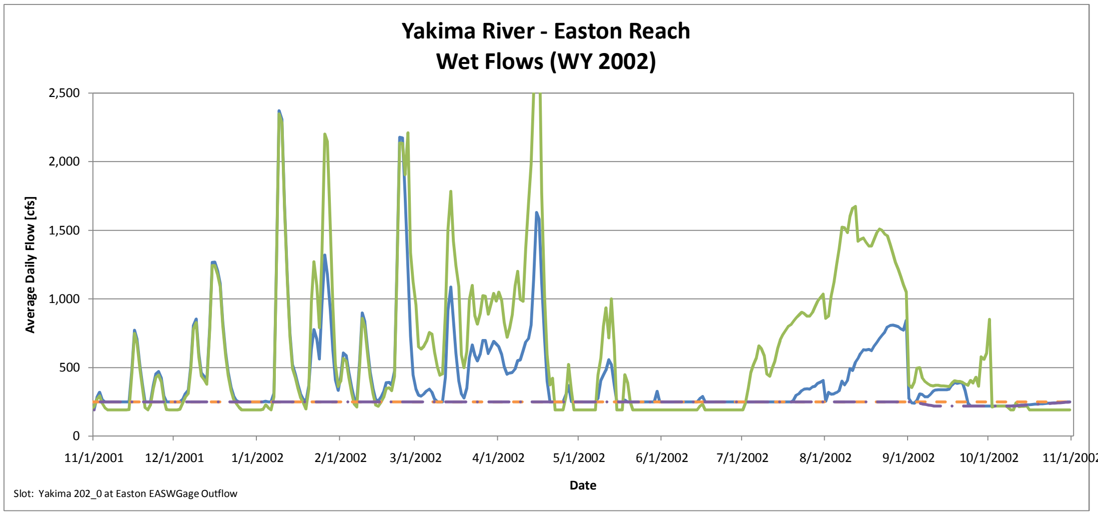

Yakima River, Keechelus Reservoir to Lake Easton Reach
Average Flows (WY 2003)
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
Proposed ISF Targets
Minimum Flow Targets (Existing)
Average Daily Flow [cfs]
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima River from Martin to CabinOutflow

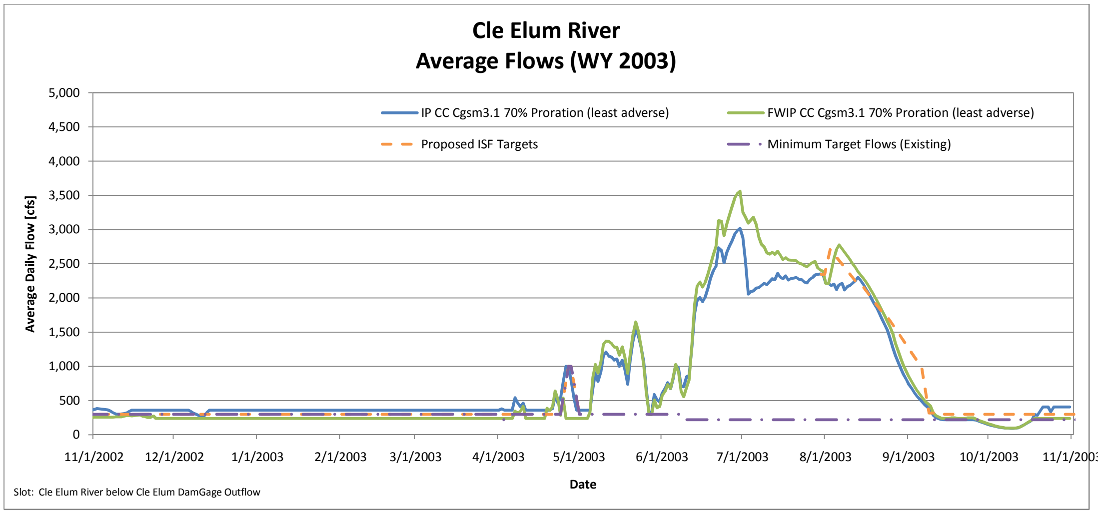

Yakima River, Keechelus Reservoir to Lake Easton Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima River from Martin to CabinOutflow

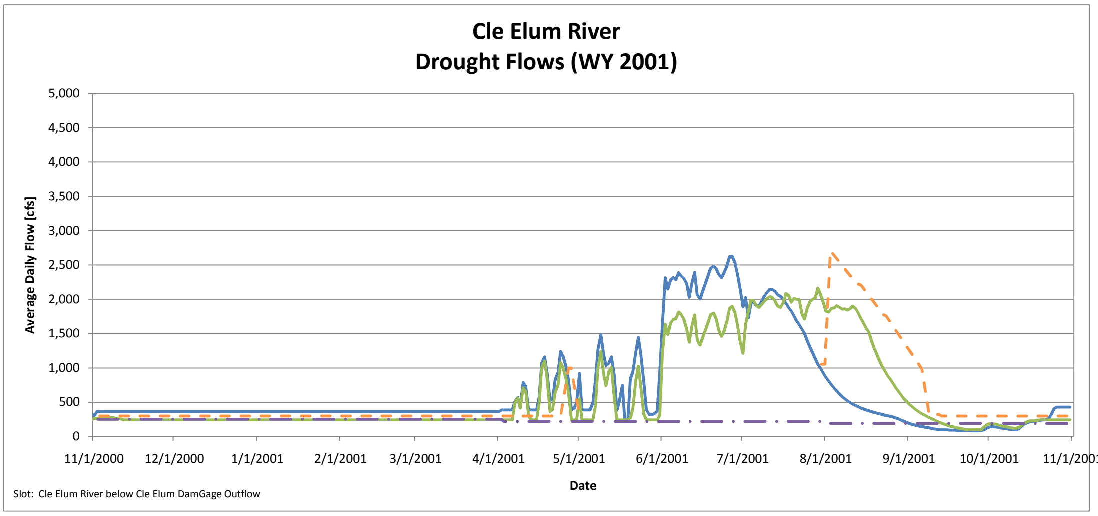

Yakima River, Keechelus Reservoir to Lake Easton Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima River from Martin to CabinOutflow

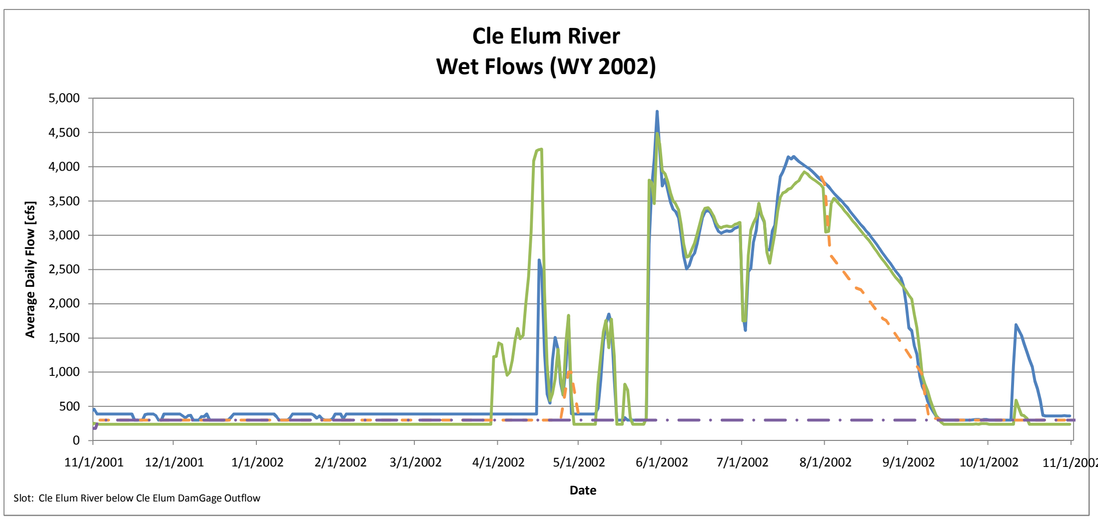

Yakima River - Easton Reach
Average Flows (WY 2003)
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
Proposed ISF Targets
Minimum Flow Targets (Existing)
Average Daily Flow [cfs]
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

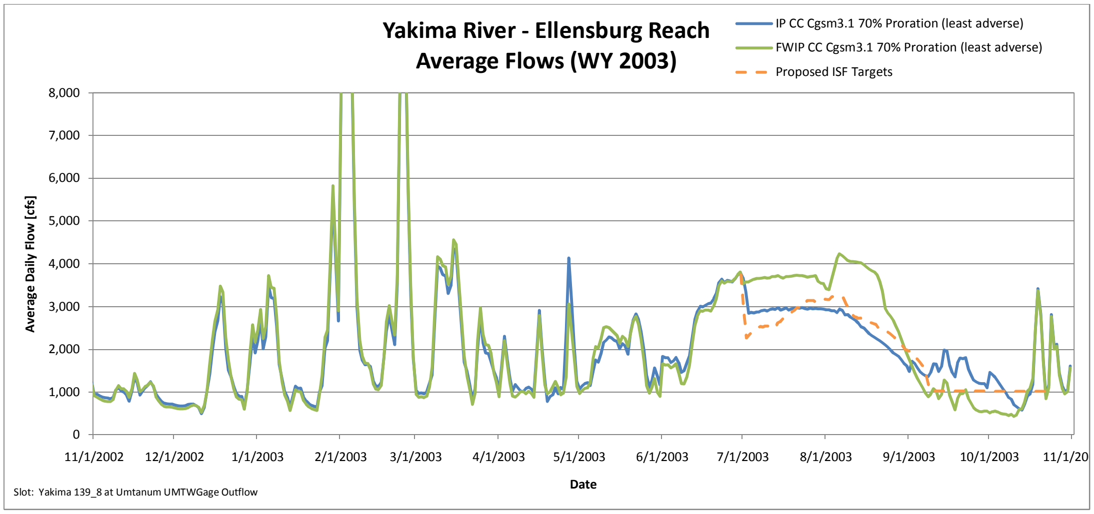

Yakima River - Easton Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

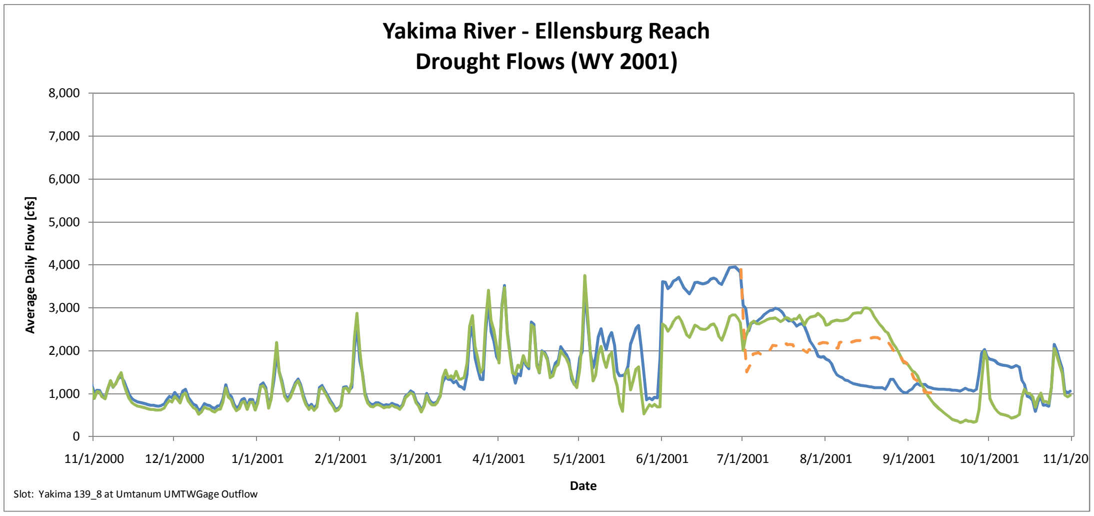

Yakima River - Easton Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

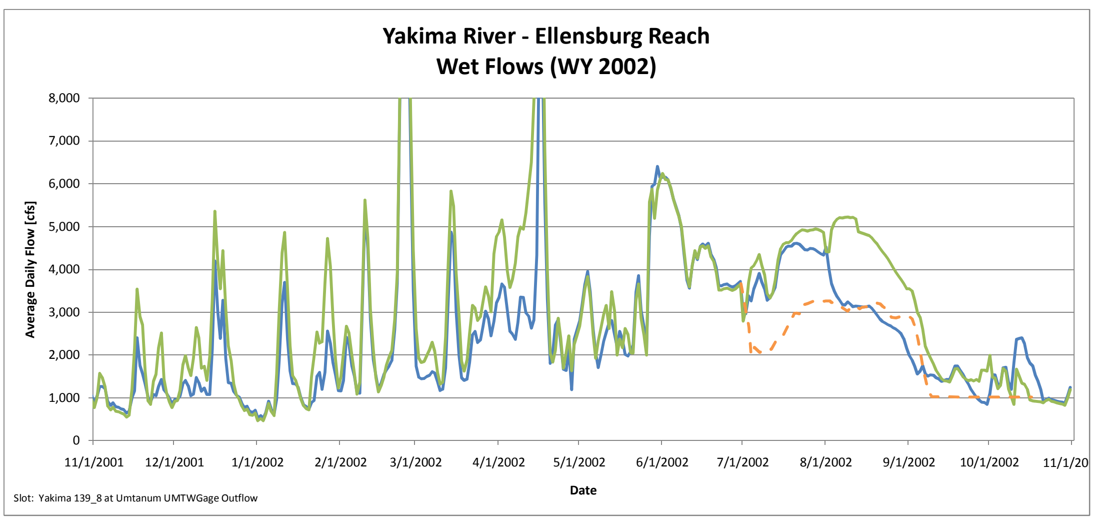

Cle Elum River
Average Flows (WY 2003)
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
Proposed ISF Targets
Minimum Target Flows (Existing)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

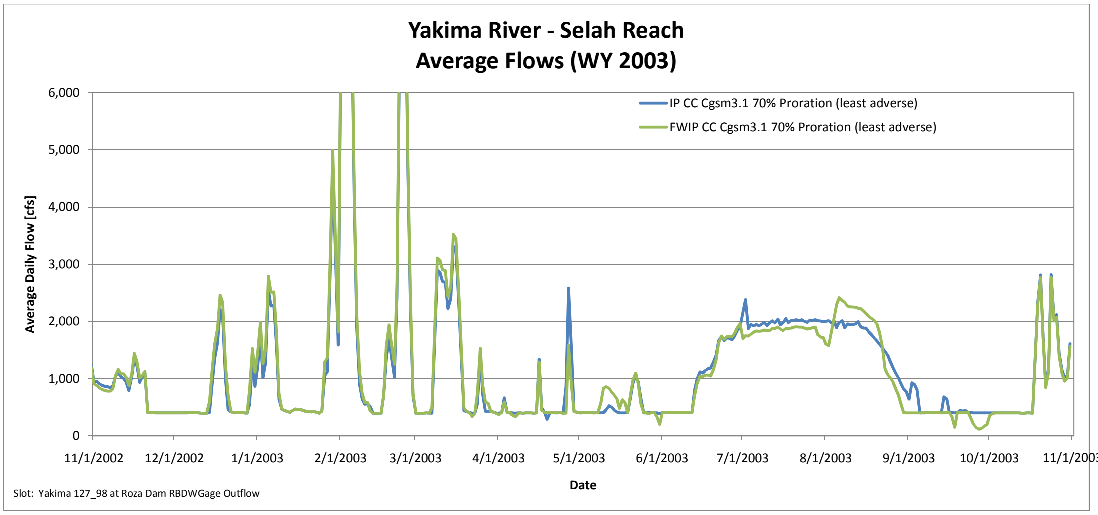

Cle Elum River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

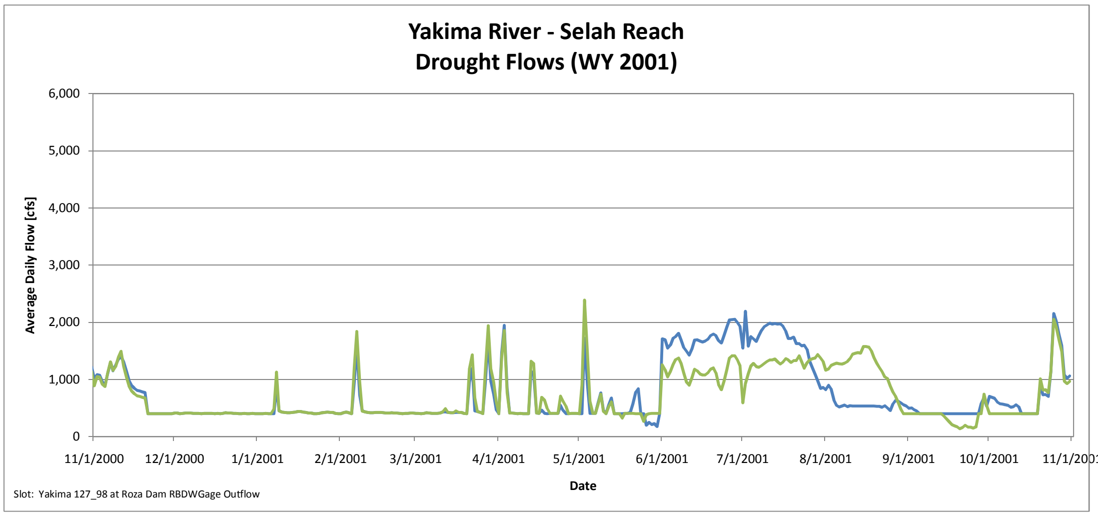

Cle Elum River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

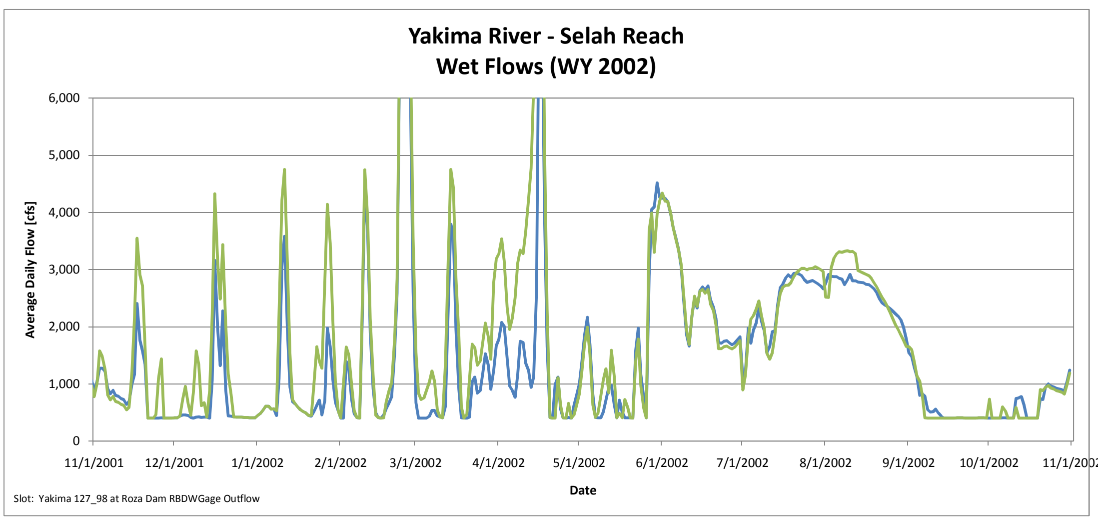

Yakima River - Ellensburg Reach
Average Flows (WY 2003)
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
Proposed ISF Targets
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

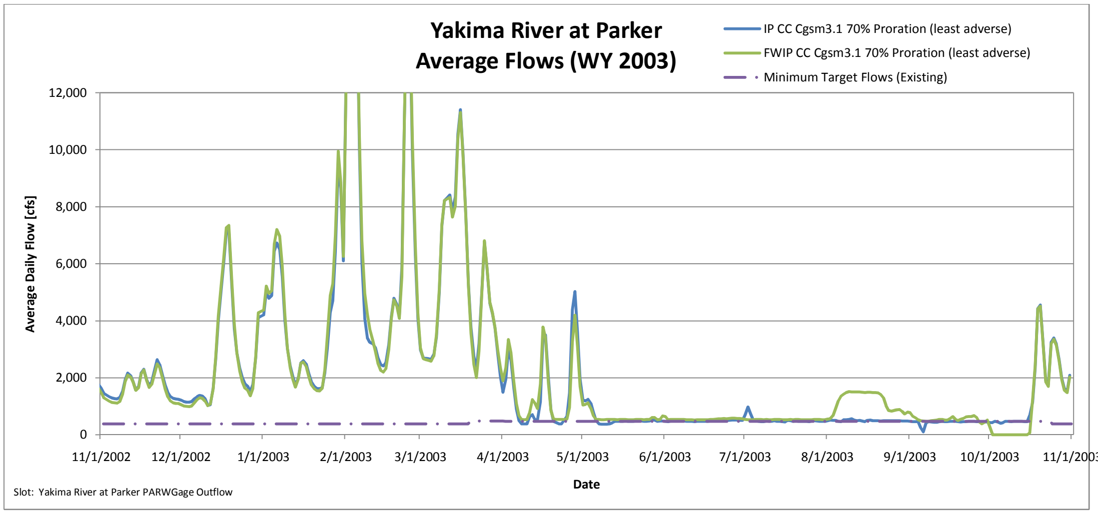

Yakima River - Ellensburg Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

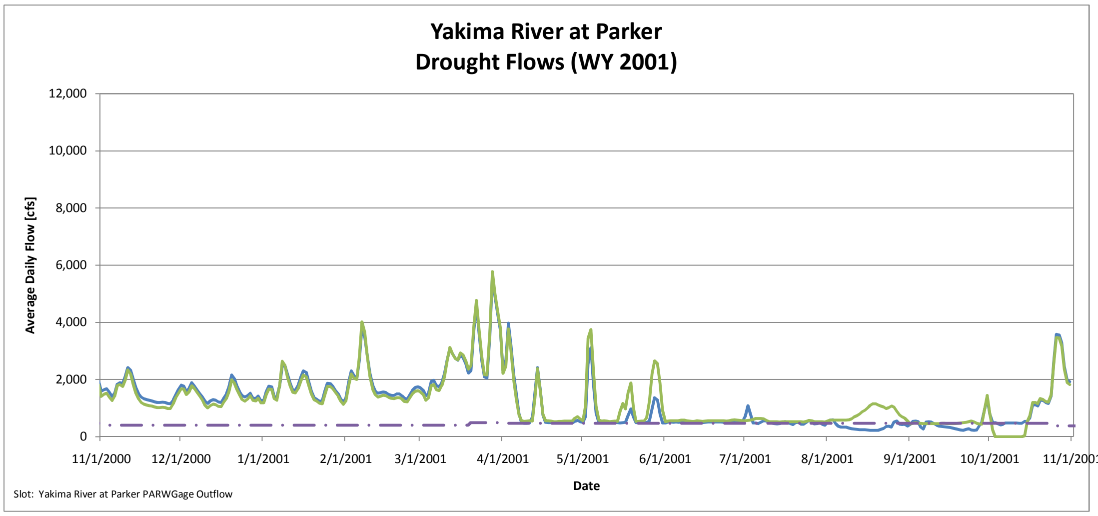

Yakima River - Ellensburg Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

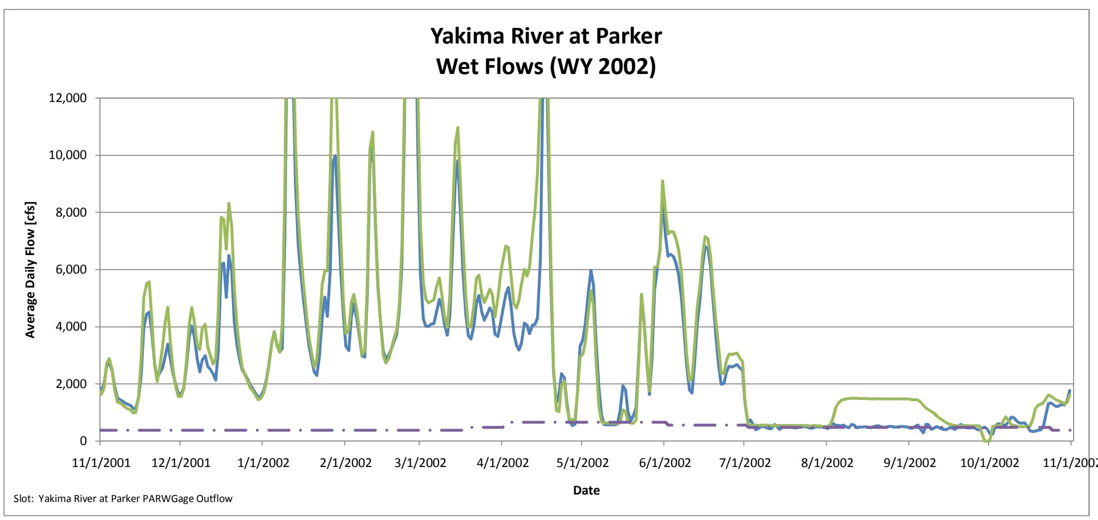

Yakima River - Selah Reach
Average Flows (WY 2003)
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

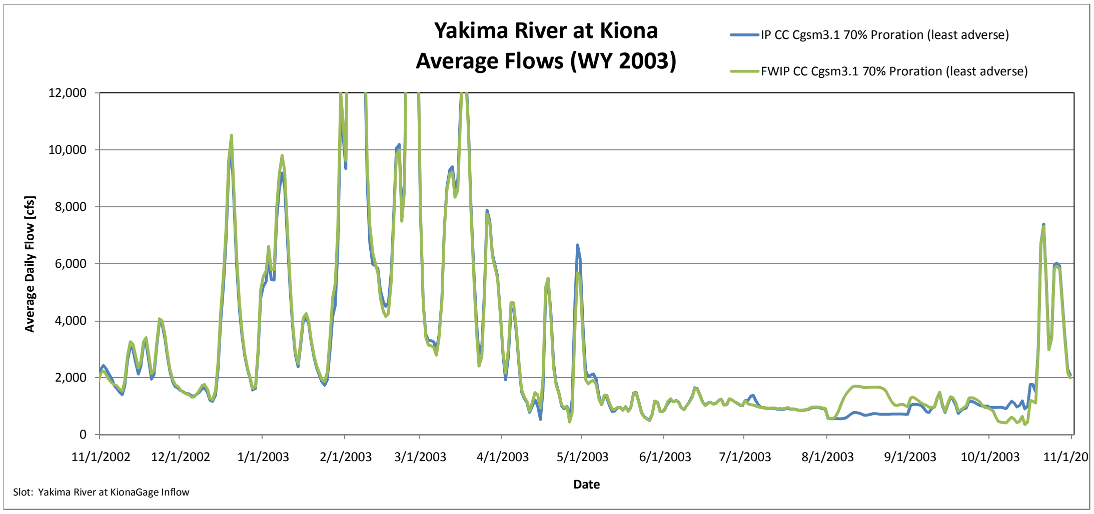

Yakima River - Selah Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

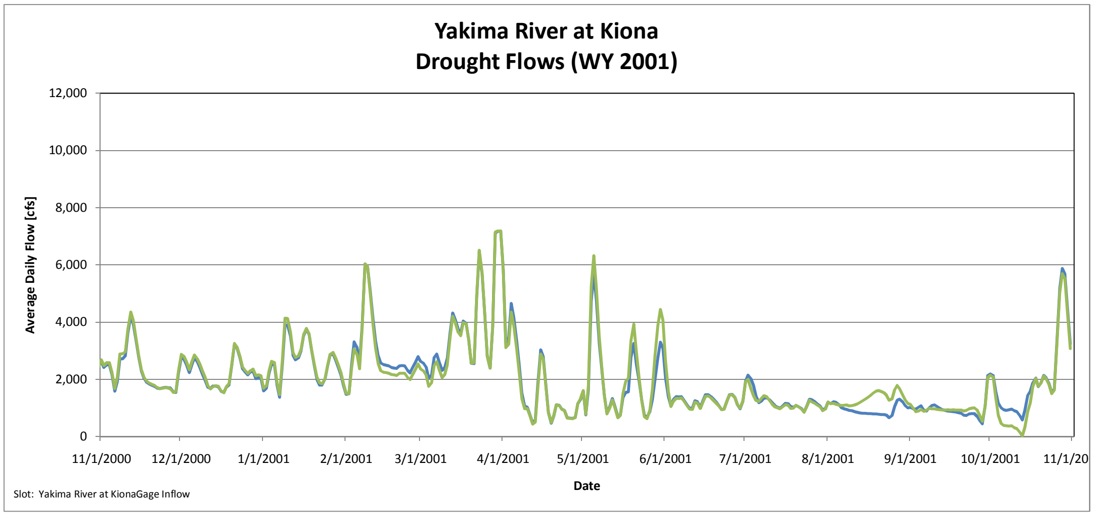

Yakima River - Selah Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

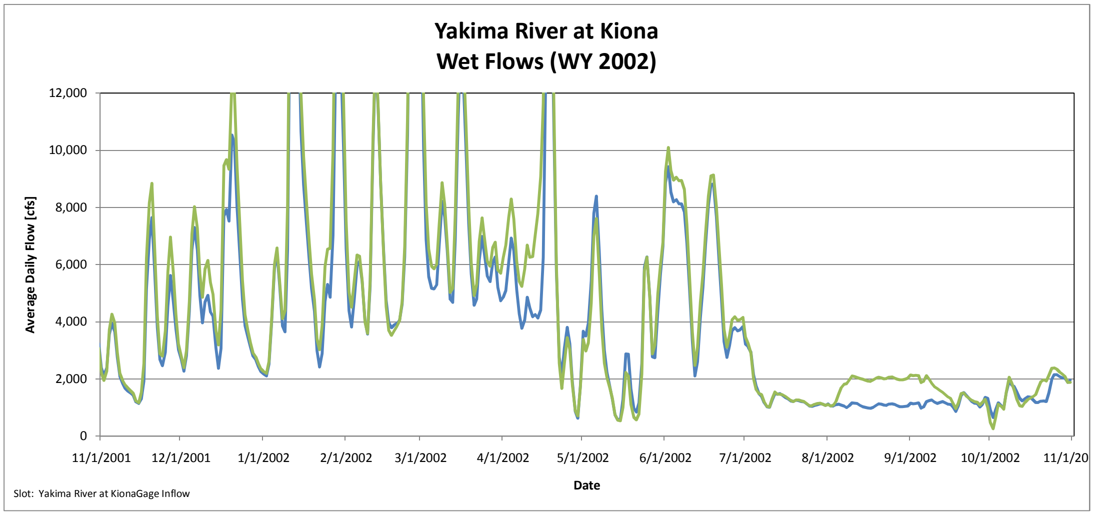

Yakima River at Parker
Average Flows (WY 2003)
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
Minimum Target Flows (Existing)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima River at Parker PARWGage Outflow

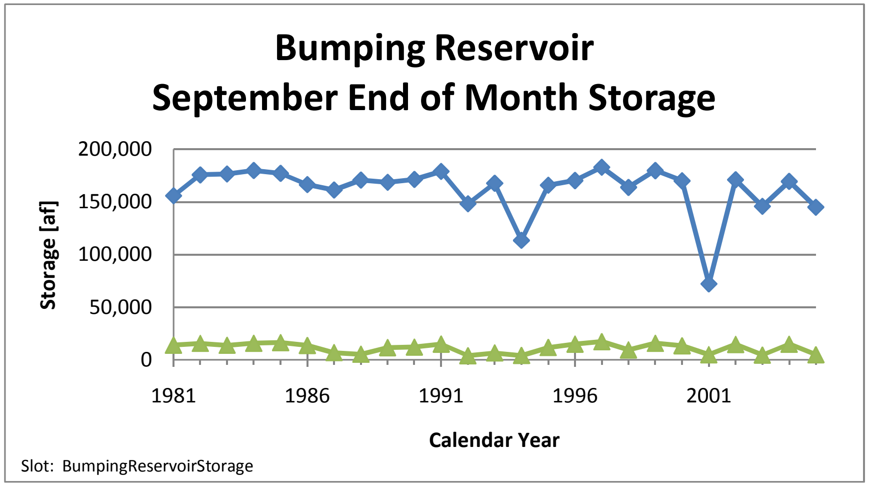

Yakima River at Parker
Drought Flows (WY 2001)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima River at Parker PARWGage Outflow

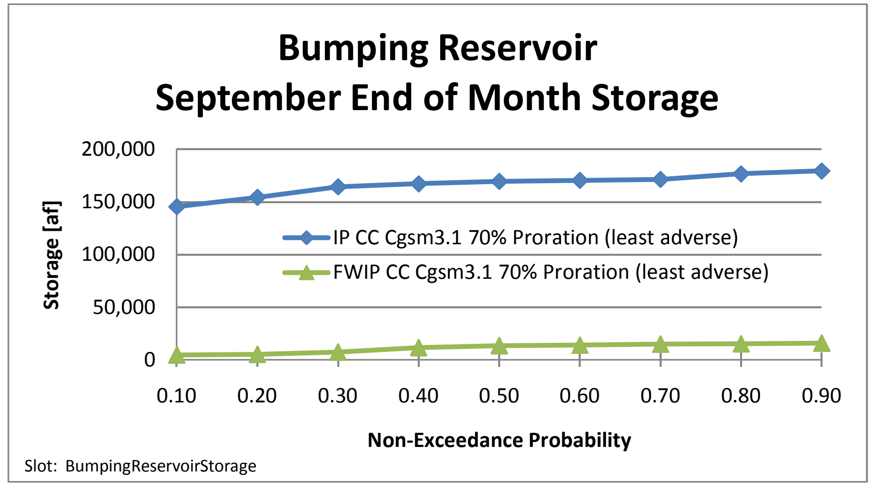

Yakima River at Parker
Wet Flows (WY 2002)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima River at Parker PARWGage Outflow

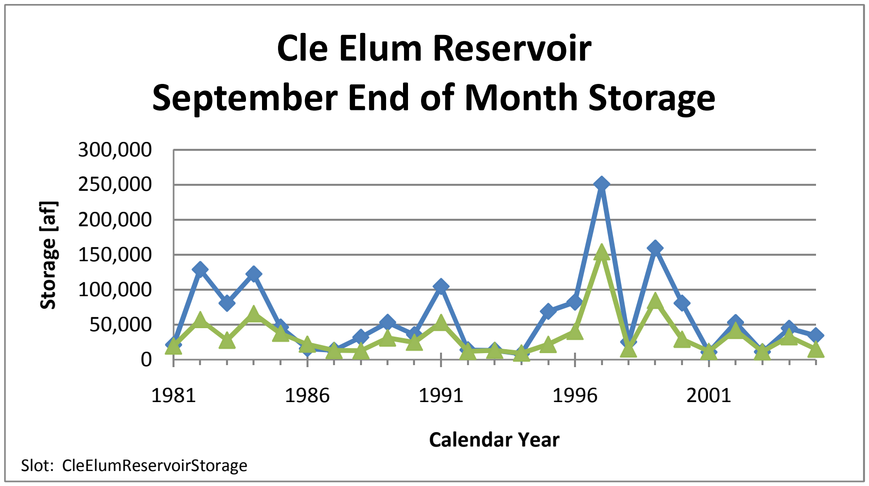

Yakima River at Kiona
Average Flows (WY 2003)
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
12,000
10,000
8,000
6,000
4,000
2,000
0
Average Daily Flow [cfs]
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

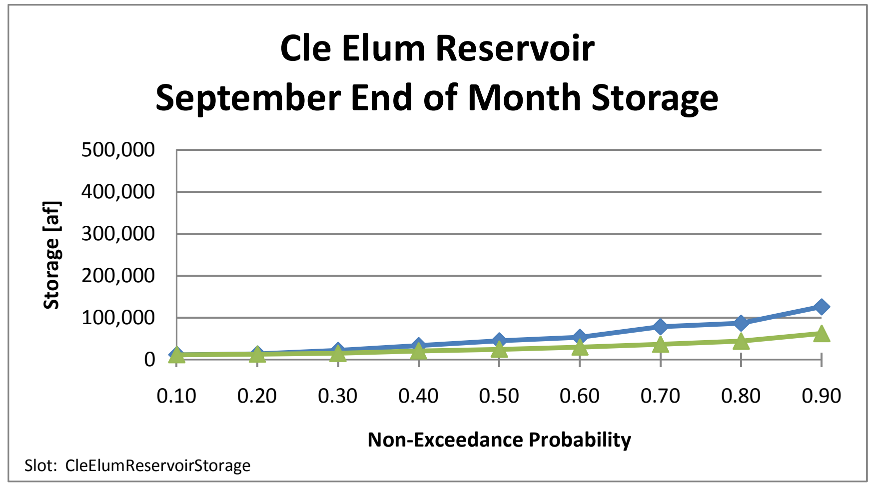

Yakima River at Kiona
Drought Flows (WY 2001)
12,000
10,000
8,000
6,000
4,000
2,000
0
Average Daily Flow [cfs]
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

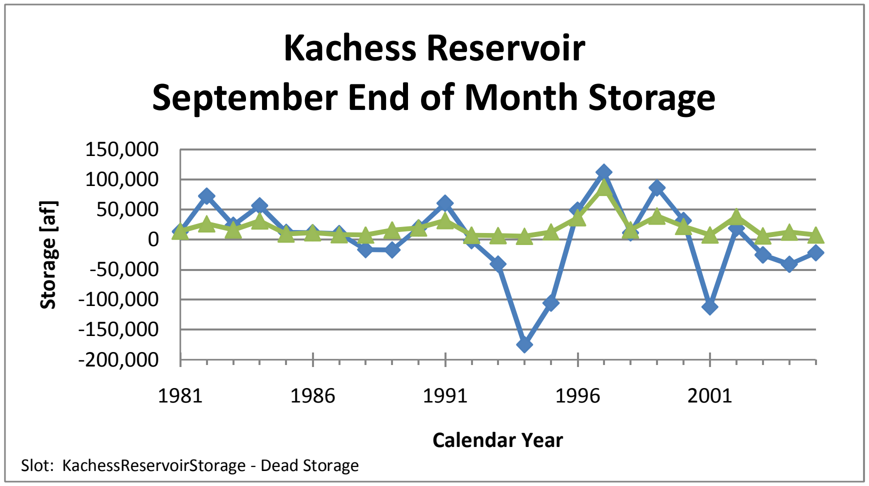

Yakima River at Kiona
Wet Flows (WY 2002)
12,000
10,000
8,000
6,000
4,000
2,000
0
Average Daily Flow [cfs]
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

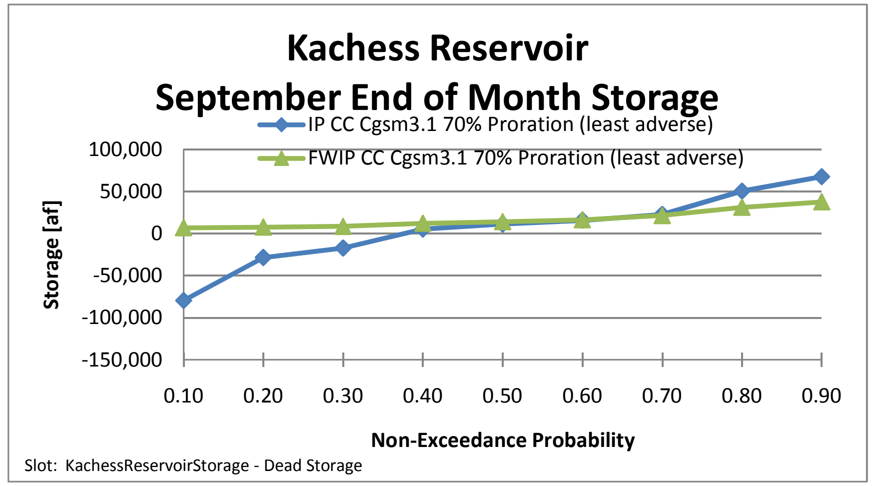

Bumping Reservoir
September End of Month Storage
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: BumpingReservoirStorage

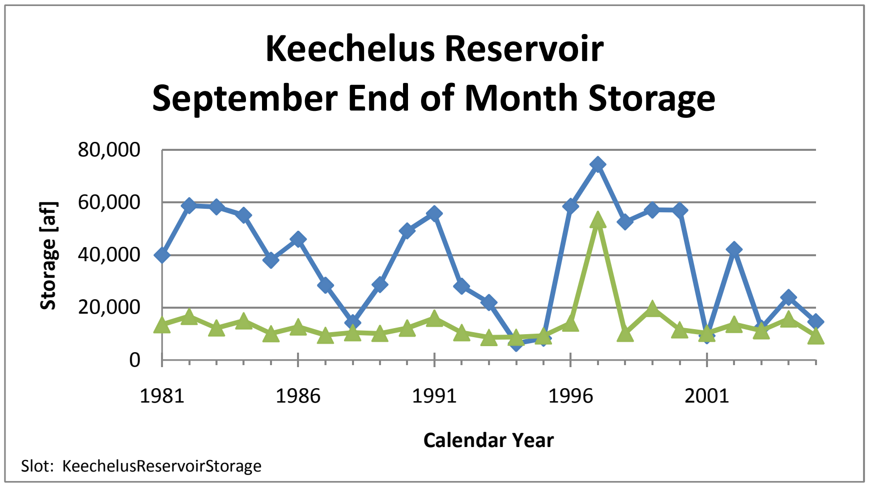

Bumping Reservoir
September End of Month Storage
200,000
150,000
100,000
50,000
0
Storage [af]
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: BumpingReservoirStorage

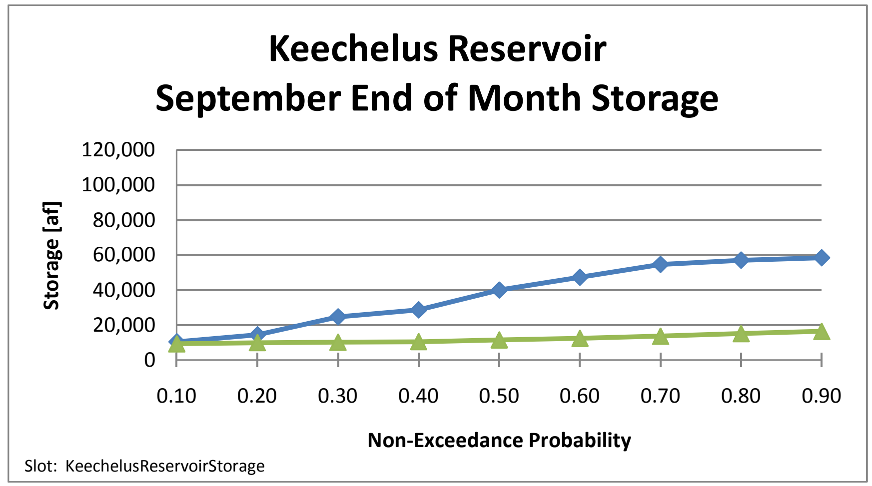

Cle Elum Reservoir
September End of Month Storage
300,000
250,000
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: CleElumReservoirStorage

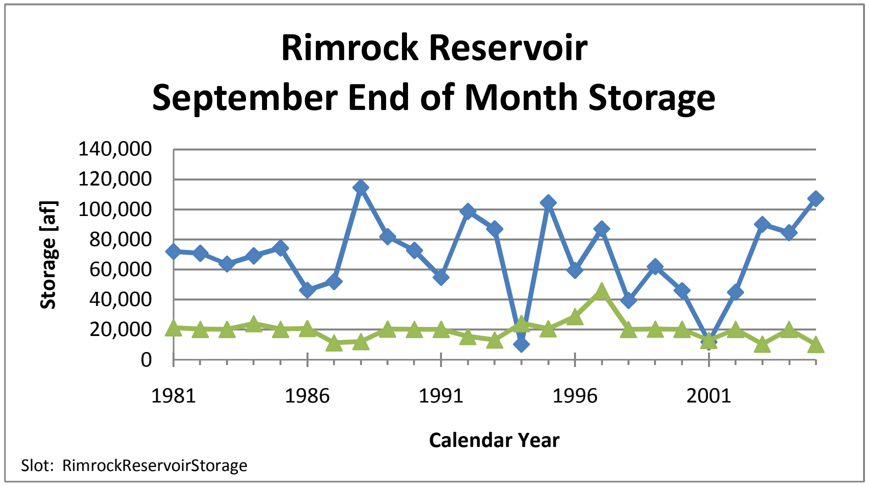

Cle Elum Reservoir
September End of Month Storage
500,000
400,000
300,000
200,000
100,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: CleElumReservoirStorage

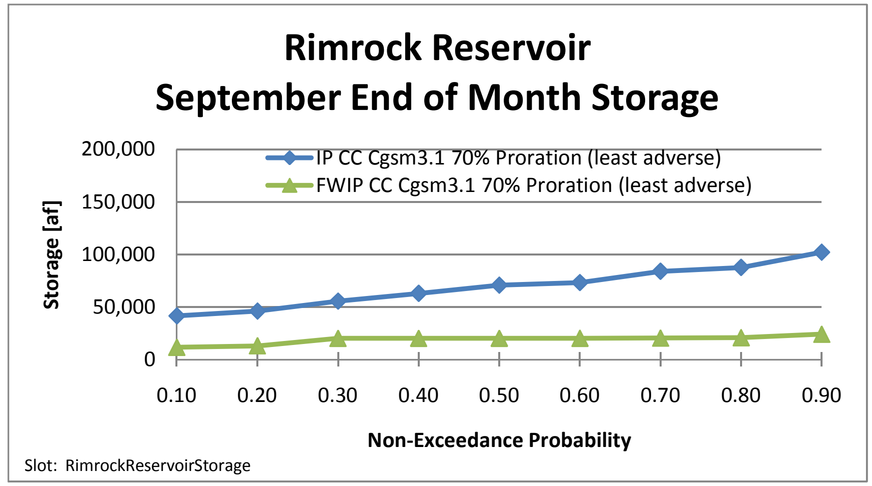

Kachess Reservoir
September End of Month Storage
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
-200,000
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: KachessReservoirStorage - Dead Storage

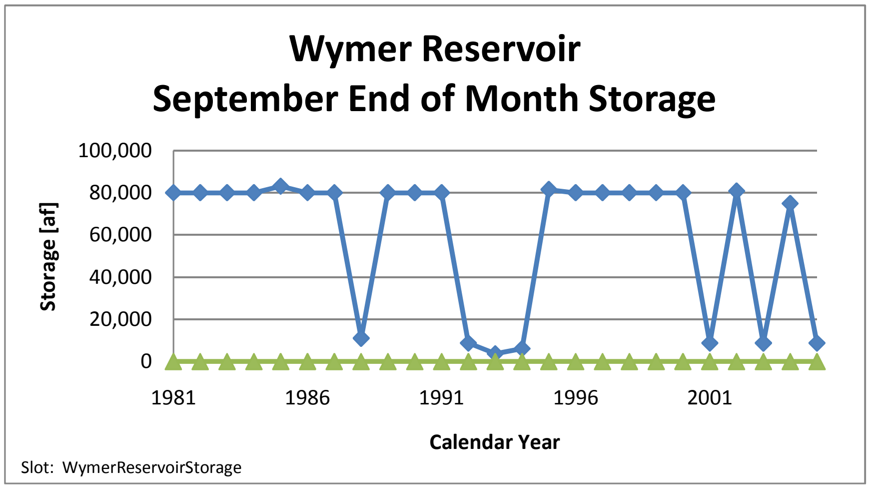

Kachess Reservoir
September End of Month Storage
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
100,000
50,000
0
-50,000
-100,000
-150,000
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KachessReservoirStorage - Dead Storage

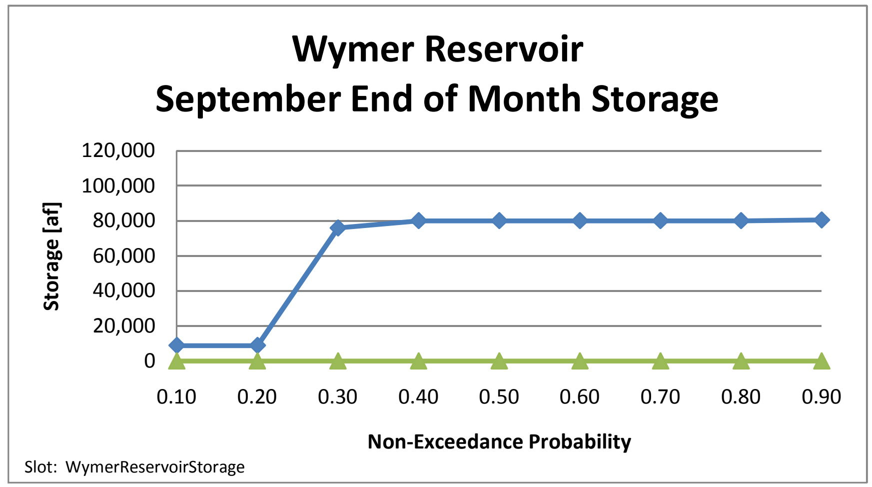

Keechelus Reservoir
September End of Month Storage
80,000
60,000
40,000
20,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: KeechelusReservoirStorage

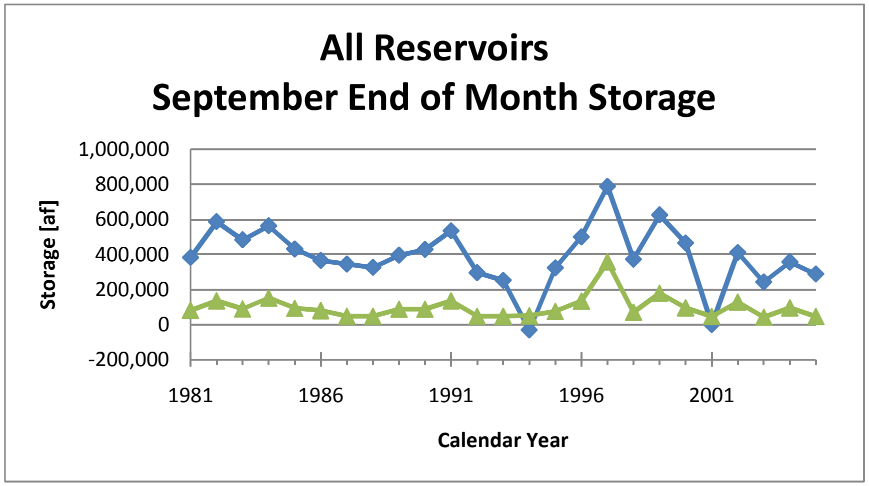

Keechelus Reservoir
September End of Month Storage
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KeechelusReservoirStorage

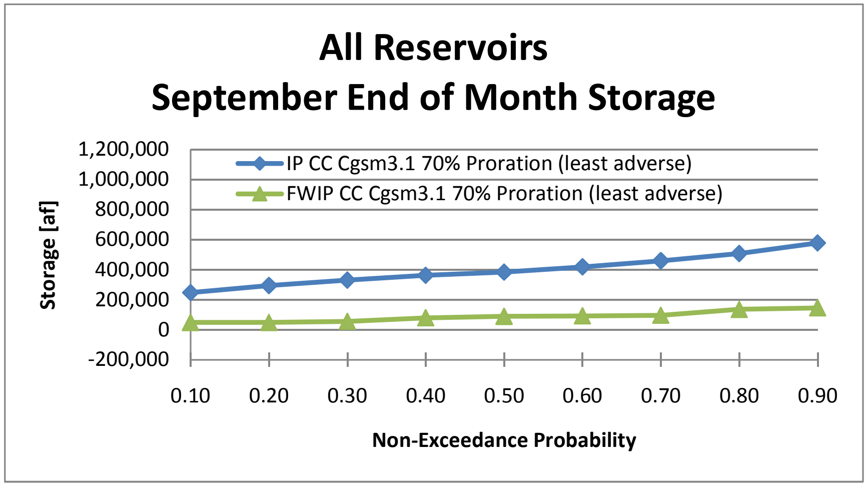

Rimrock Reservoir
September End of Month Storage
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: RimrockReservoirStorage

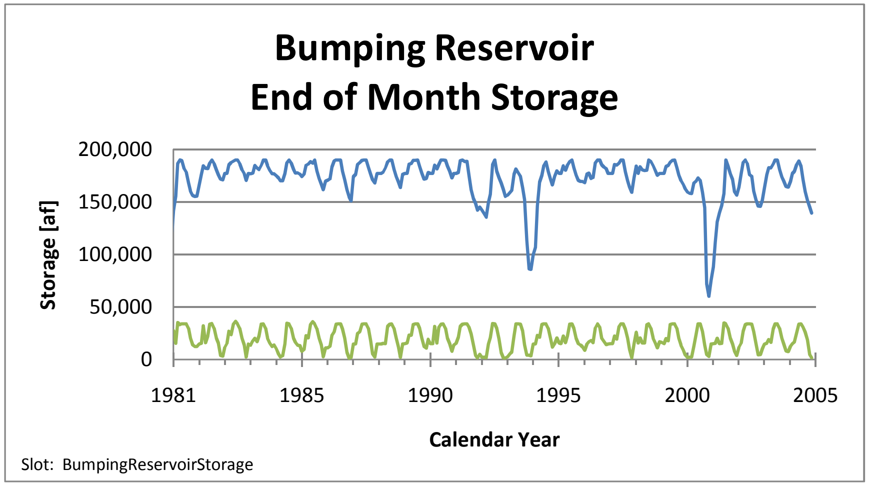

Rimrock Reservoir
September End of Month Storage
200,000
150,000
100,000
50,000
0
Storage [af]
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: RimrockReservoirStorage


Wymer Reservoir
September End of Month Storage
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: WymerReservoirStorage

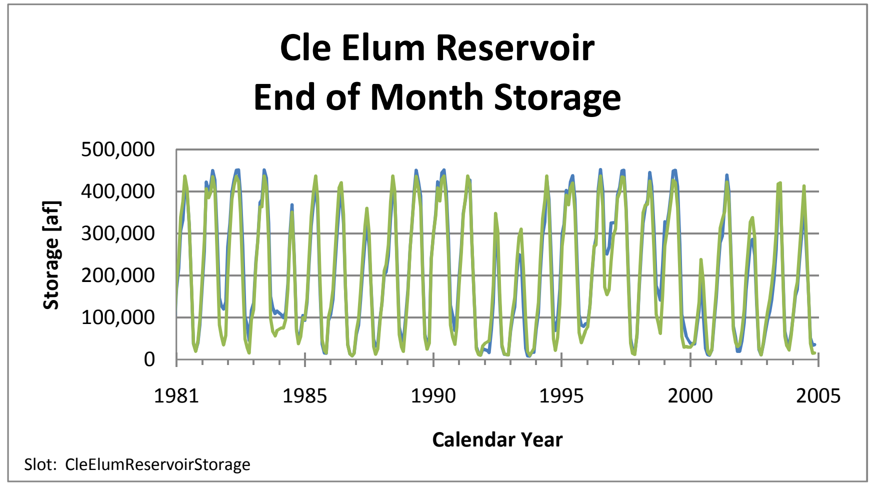

Wymer Reservoir
September End of Month Storage
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: WymerReservoirStorage


All Reservoirs
September End of Month Storage
Storage [af]
1,000,000
800,000
600,000
400,000
200,000
0
-200,000
1981
1986
1991
1996
2001
Calendar Year

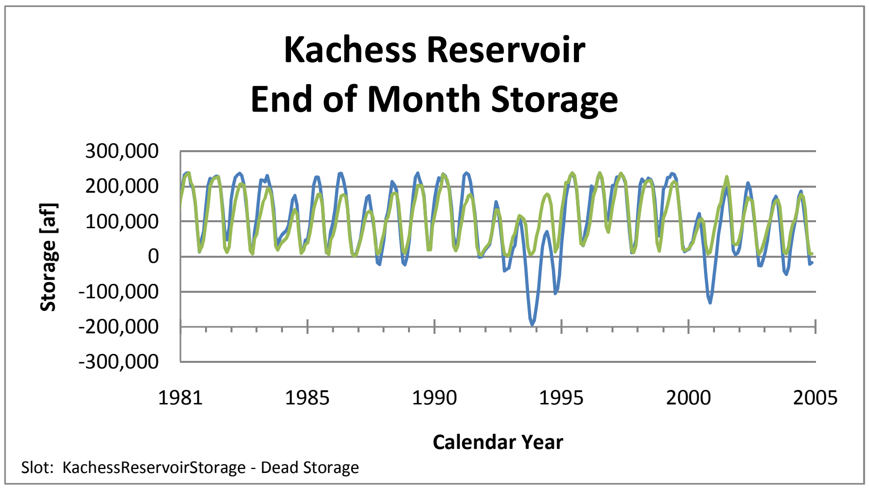

All Reservoirs
September End of Month Storage
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
Storage [af]
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
-200,000
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability



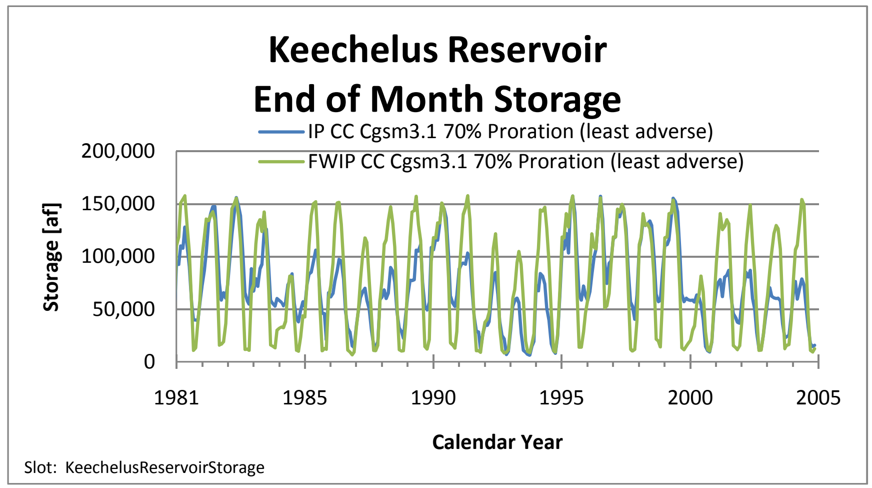
Bumping Reservoir
End of Month Storage
Storage [af]
200,000
150,000
100,000
50,000
0
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: BumpingReservoirStorage



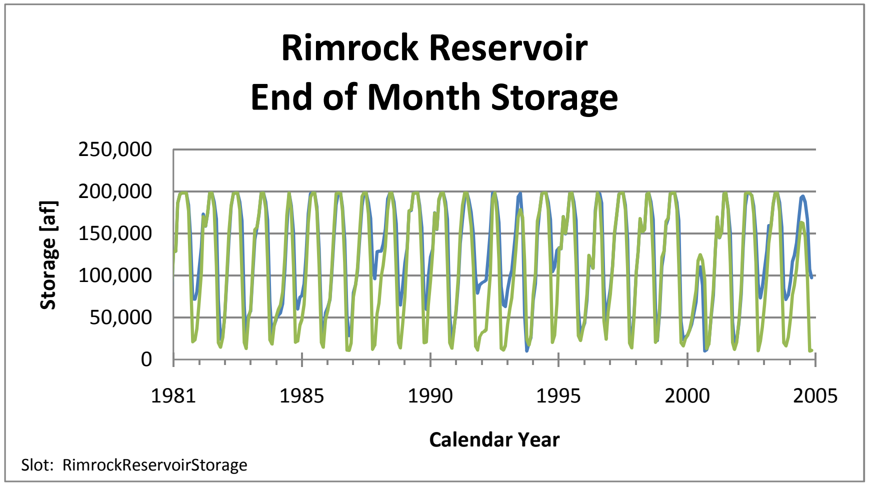
Cle Elum Reservoir
End of Month Storage
Storage [af]
500,000
400,000
300,000
200,000
100,000
0
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: CleElumReservoirStorage



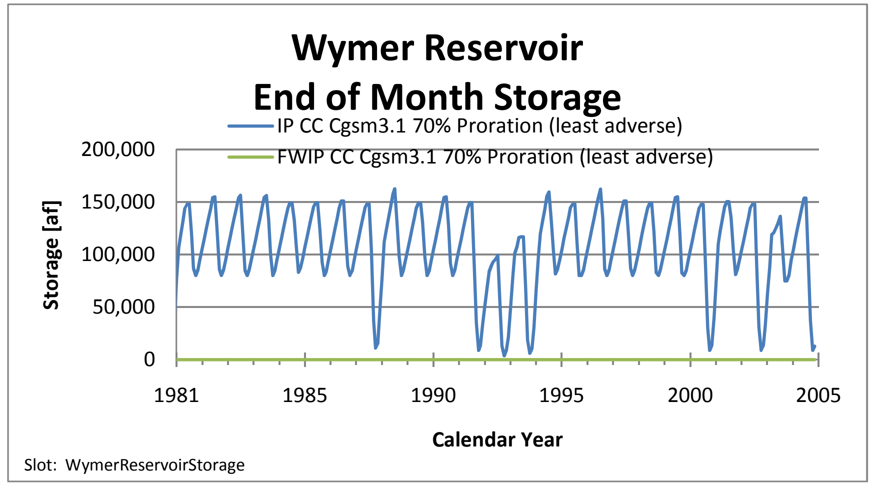
Kachess Reservoir
End of Month Storage
Storage [af]
300,000
200,000
100,000
0
-100,000
-200,000
-300,000
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KachessReservoirStorage - Dead Storage



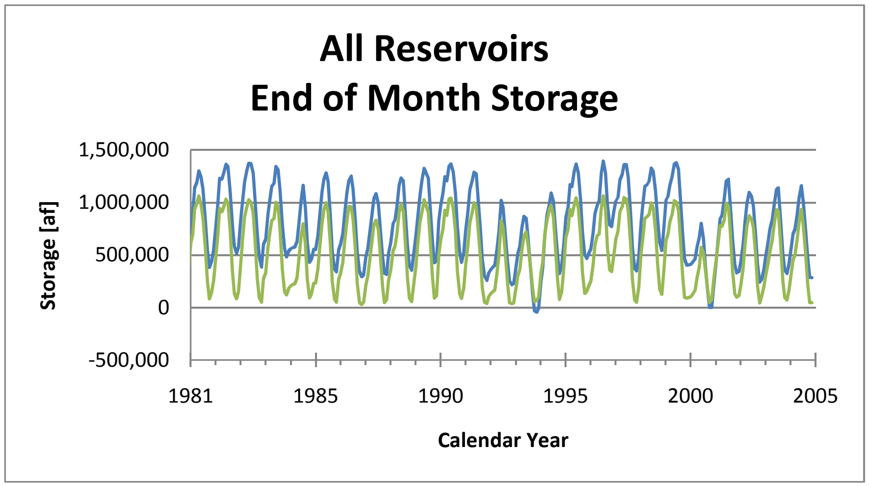
Keechelus Reservoir
End of Month Storage
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
Storage [af]
200,000
150,000
100,000
50,000
0
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KeechelusReservoirStorage



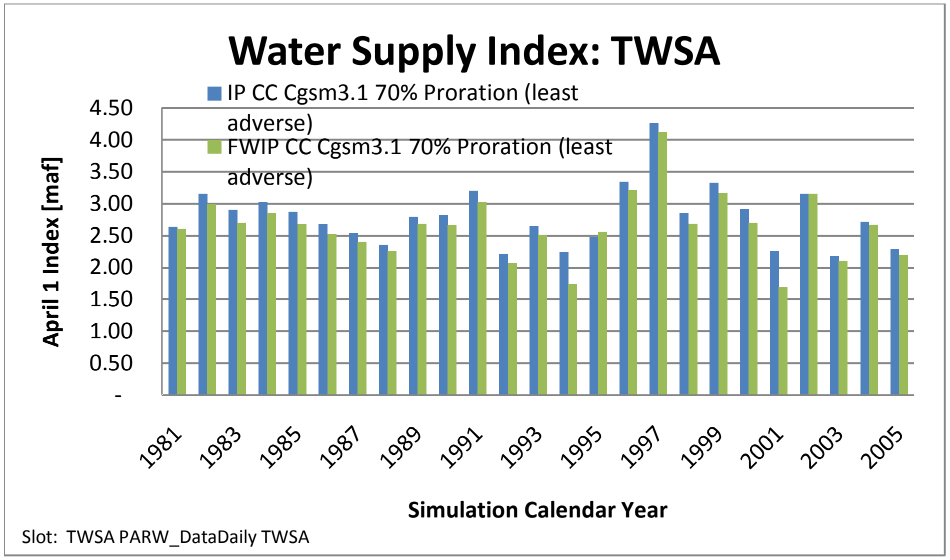
Rimrock Reservoir
End of Month Storage
250,000
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: RimrockReservoirStorage

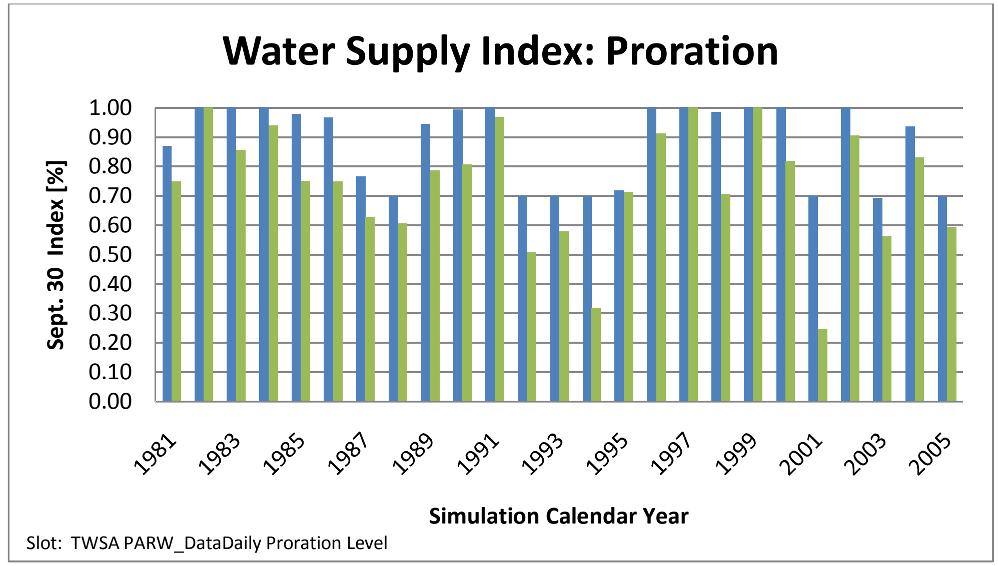


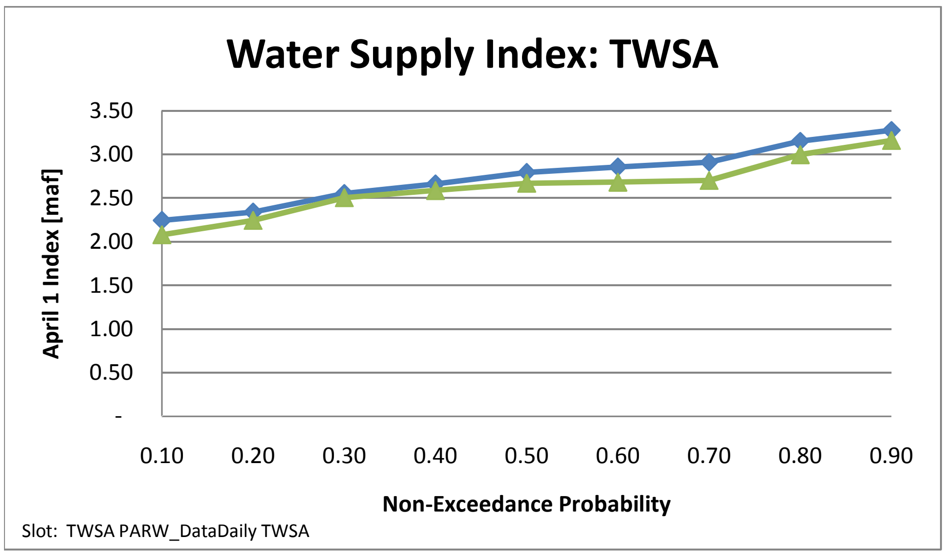
Wymer Reservoir
End of Month Storage
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: WymerReservoirStorage

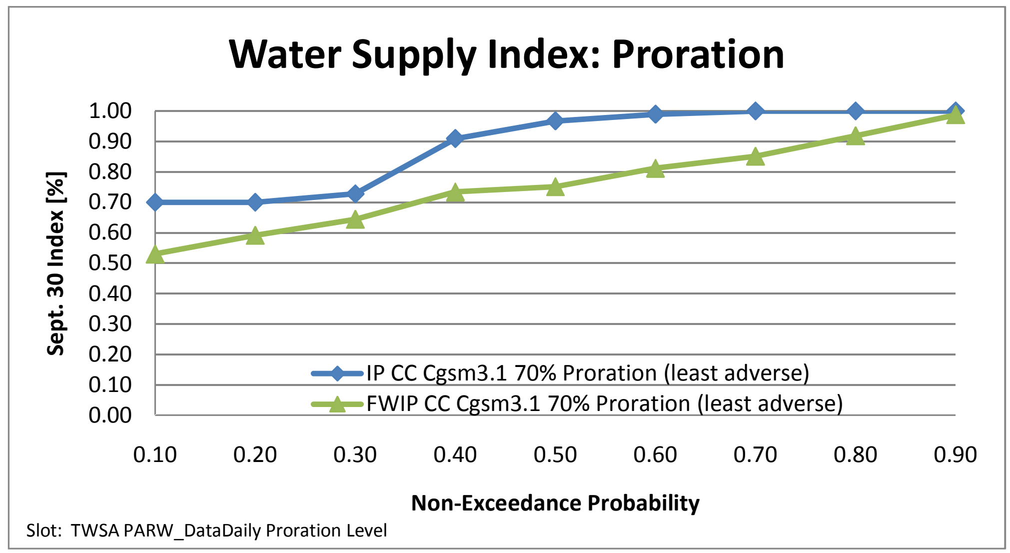


All Reservoirs
End of Month Storage
1,500,000
1,000,000
500,000
0
-500,000
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year

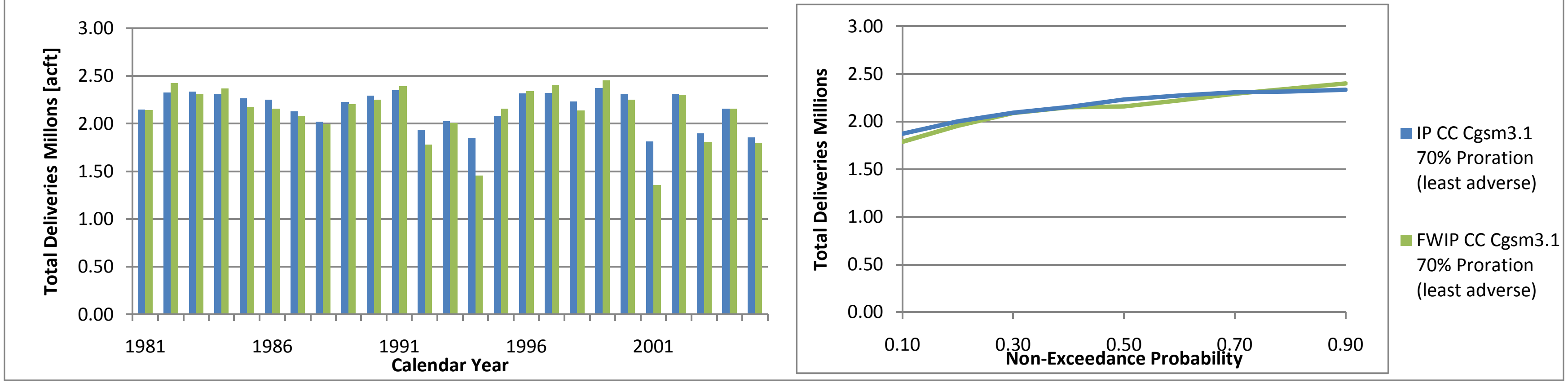

Water Supply Index: TWSA
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
April 1 Index [maf]
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
-
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
Simulation Calendar Year
Slot: TWSA PARW_DataDaily TWSA


Water Supply Index: Proration
Sept. 30 Index [%]
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
Simulation Calendar Year
Slot: TWSA PARW_DataDaily Proration Level

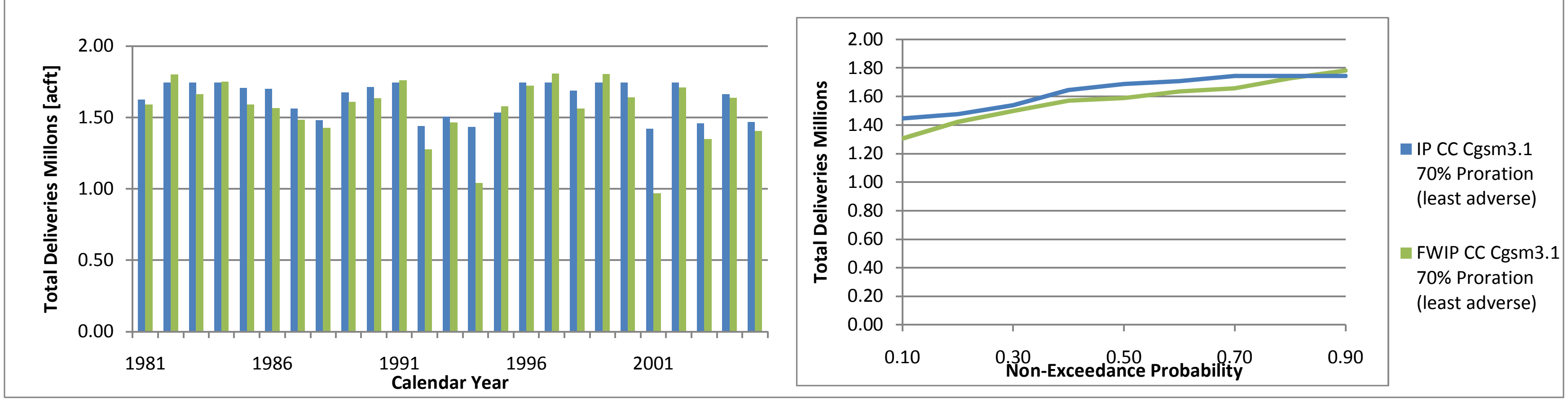

Water Supply Index: TWSA
April 1 Index [maf]
3.50
3.00
2.50
2.00
1.50
1.00
0.50
-
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily TWSA


Water Supply Index: Proration
Sept. 30 Index [%]
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
IP CC Cgsm3.1 70% Proration (least adverse)
FWIP CC Cgsm3.1 70% Proration (least adverse)
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily Proration Level

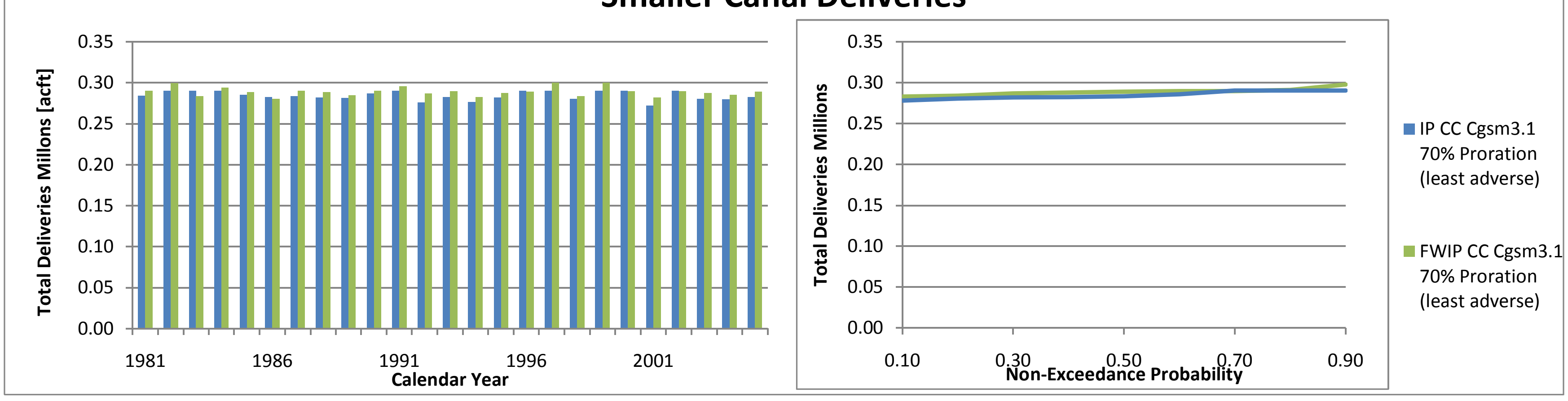
Main Canal Deliveries



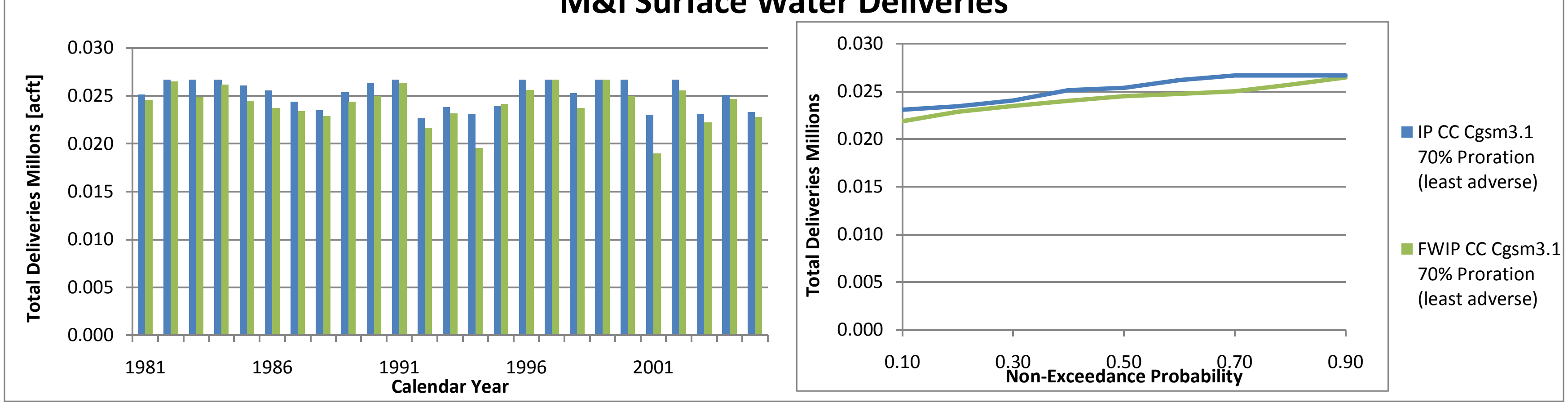
Sunnyside, KRD Irrigation, Roza Irrigation, New Reservation Canal, Tieton, and Kennewick Deliveries



Smaller Canal Deliveries



M&I Surface Water Deliveries



Appendix D – 2

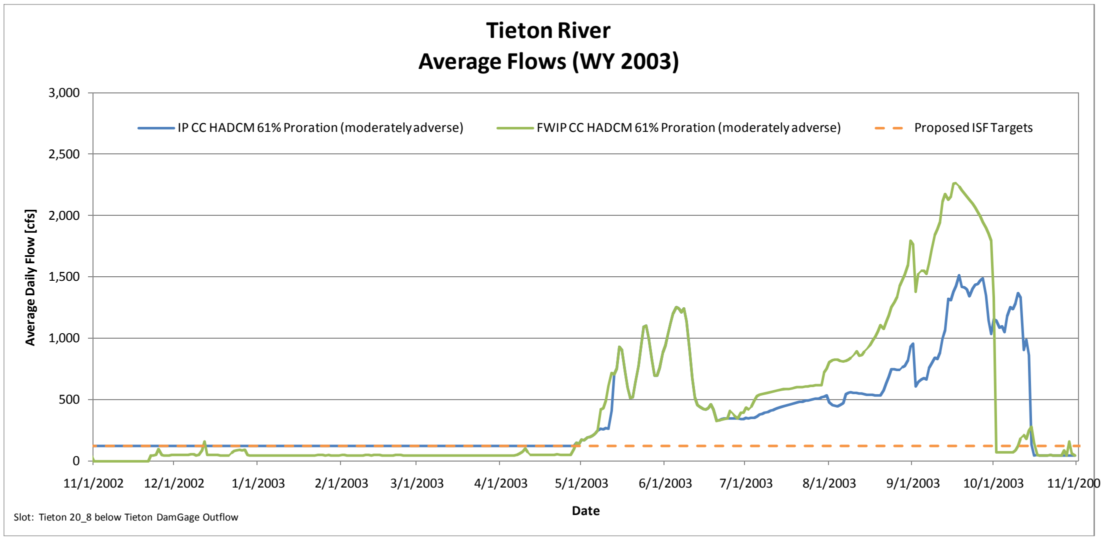
Integrated Plan Results with Climate Change Moderately Adverse Scenario (HADCM)

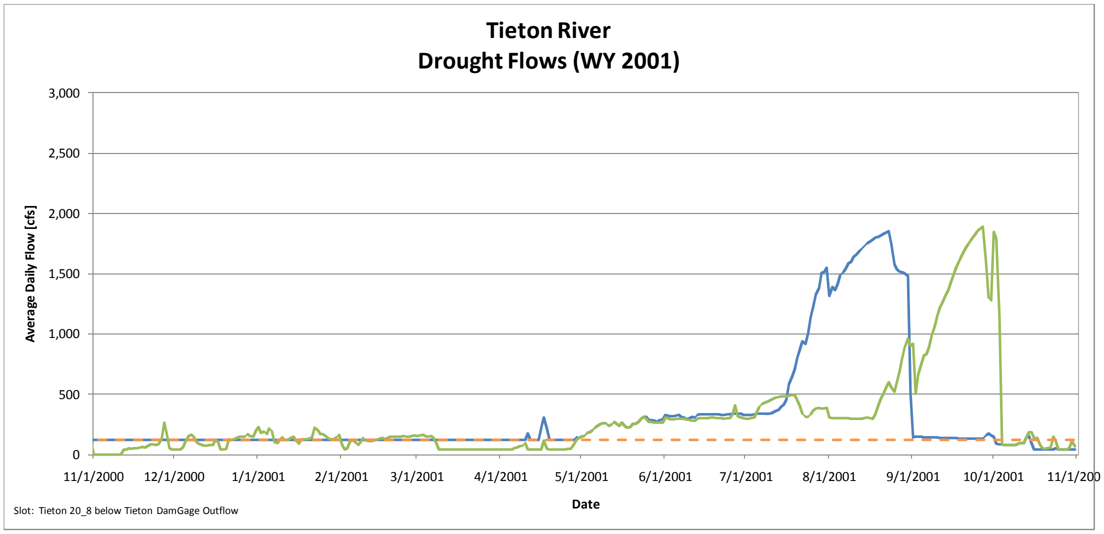
Resource indicator (measurement)	IP CC HADCM 61% Proration (moderately adverse)	FWIP CC HADCM 61% Proration (moderately adverse)
WATER RESOURCES		
Average for water years 1981–2005 (maf)		
Water supply		
April 1 total water supply available (TWSA)	2.47	2.31
Water distribution		
April–September Parker flow volume	0.43	0.51
April–September diversion	1.64	1.51
September 30 reservoir contents	0.17	0.08
April–September flow volume at mouth of Yakima River	0.70	0.76
1994 dry-year (maf)		
Water supply		
April 1 TWSA	1.60	1.51
Water distribution		
April–September Parker flow volume	0.27	0.29
April–September diversion	1.20	1.10
September 30 reservoir contents	-0.17	0.08
April–September flow volume at mouth of Yakima River	0.43	0.42
Irrigation proration level	25%	9%

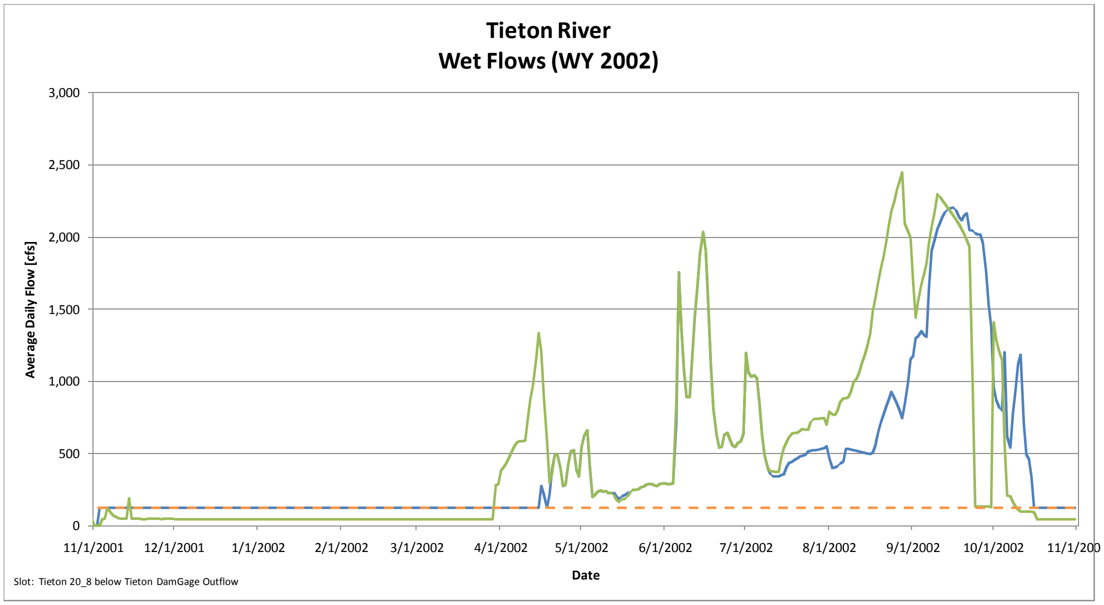
Resource indicator (measurement)	IP CC HADCM 61% Proration (moderately adverse)	FWIP CC HADCM 61% Proration (moderately adverse)
ANADROMOUS FISH		
Rate of change in flow during flip-flop (average cfs/day August 16–September 14)		
Easton reach	-7	-22
Ellensburg reach	-48	-96
Lower Naches River reach	32	39
Pre- (August 1-15) and post- (September 14-28) flip-flop flow and absolute change in flow		
Easton reach		
Pre-flip-flop flow (cfs)	494	903
Post-flip-flop flow (cfs)	283	252
Absolute change in flow (cfs)	-210	-651
Ellensburg reach		
Pre-flip-flop flow (cfs)	2,502	3,757
Post-flip-flop flow (cfs)	1,104	970
Absolute change in flow (cfs)	-1,397	-2,787
Lower Naches River reach		
Pre-flip-flop flow (cfs)	723	654
Post-flip-flop flow (cfs)	1,660	1,794
Absolute change in flow (cfs)	937	1,140
Average, minimum, and maximum reservoir elevation (feet) during bull trout spawning migration: July 15–September 15 (feet)		
Kachess Lake	2186.83 2111.62-2260.82	2225.88 2196.51-2259.86
Keechelus Lake	2448.53 2428.79-2513.19	2449.3 2430.76-2508.79
Rimrock Lake	2898.55 2800.95-2925.8	2900.25 2848.38-2926

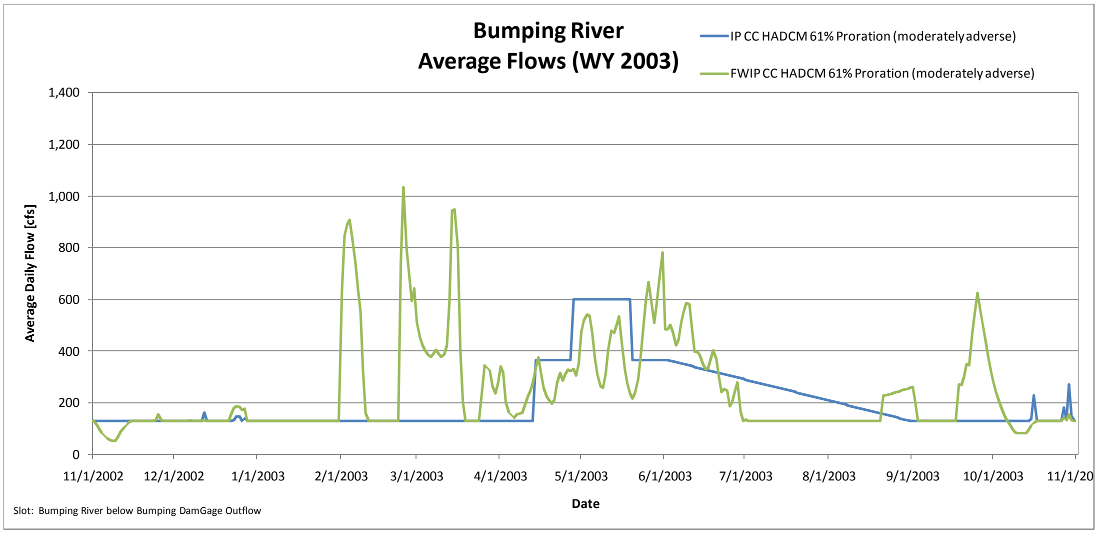
Hydrologic Indicator	**IP CC HADCM 61% Proration (moderately adverse)**					**FWIP CC HADCM 61% Proration (moderately adverse)**				
	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997
April 1 TWSA (maf)						2.31				
April-September flow volume at Parker gage (kaf)	2.47 431	1.60 269	262	2.02 262	3.98 1414	509	1.51 294	1.58 327	1.76 334	3.86 1485
March-October flow volume at Parker gage (kaf)	732	455	2.16 467	505	1881	810	503	527	579	1953
April-September diversion volume upstream of Parker gage (maf)	1.64	1.20	1.49	1.46	1.91	1.51	1.10	1.11	1.27	1.87
September 30 non-Bumping or Wymer reservoir contents (kaf)	12	-179	-134	-181	401	70	68	45	32	211
October 31 non-Bumping or Wymer reservoir contents (kaf)	1	-145	-136	-170	358	72	63	59	36	186
September 30 Bumping and Wymer reservoir contents (kaf)	156	5	76	61	257	10	11	8	4	16
April-September flow volume at mouth of Yakima River (kaf)	704	428	506	478	2053	761	425	545	524	2107
Irrigation proration level (percent)[1]	72%	25%	61%	61%	100%	54%	9%	9%	27%	100%

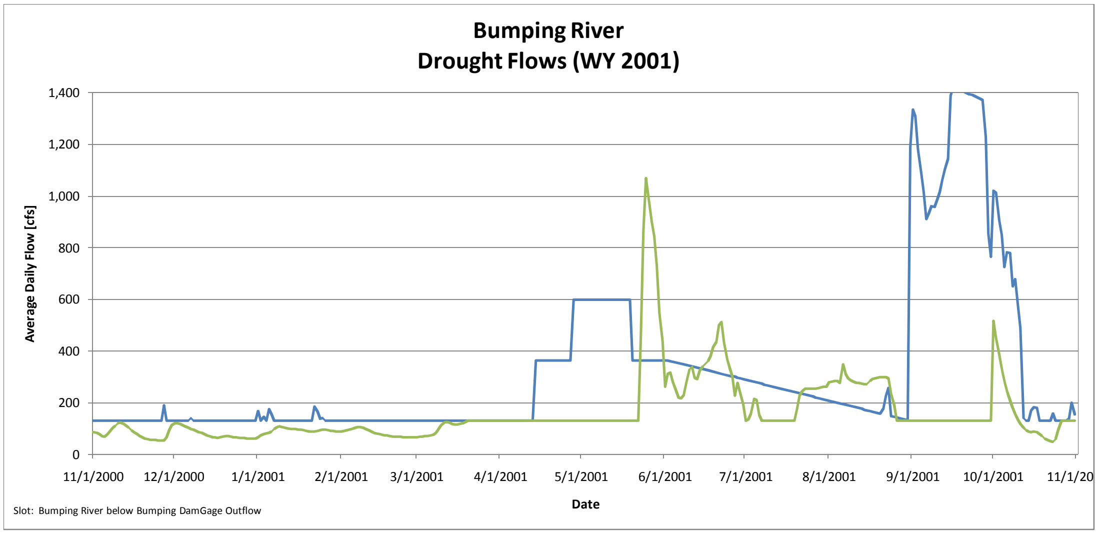
Item	FWIP CC HADCM 61% Proration (moderately adverse)	IP CC HADCM 61% Proration (moderately adverse)	Improvement
Average 1981-2005			
TWSA [April 1, kaf]	2314.0	2471.7	157.7
March-October flow volume at Parker gage [kaf]	810.2	732.0	-78.3
Drought Year 1994			
TWSA [April 1, kaf]	1507.5	1598.9	91.4
March-October flow volume at Parker gage [kaf]	502.7	455.3	-47.3
Drought Year 2001			
TWSA [April 1, kaf]	1582.8	2157.4	574.6
March-October flow volume at Parker gage [kaf]	526.7	466.9	-59.9
Drought Year 2005			
TWSA [April 1, kaf]	1758.1	2018.4	260.3
March-October flow volume at Parker gage [kaf]	579.3	505.0	-74.3
Wet Year 1997			
TWSA [April 1, kaf]	3861.4	3981.8	120.4
March-October flow volume at Parker gage [kaf]	1952.7	1880.6	-72.1

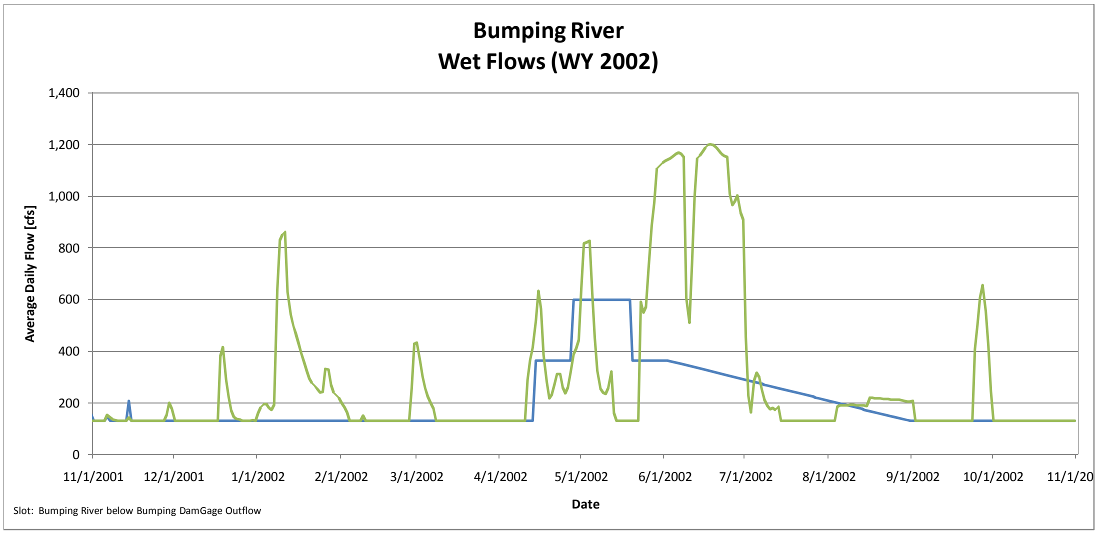

Tieton River
Average Flows (WY 2003)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
Proposed ISF Targets
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

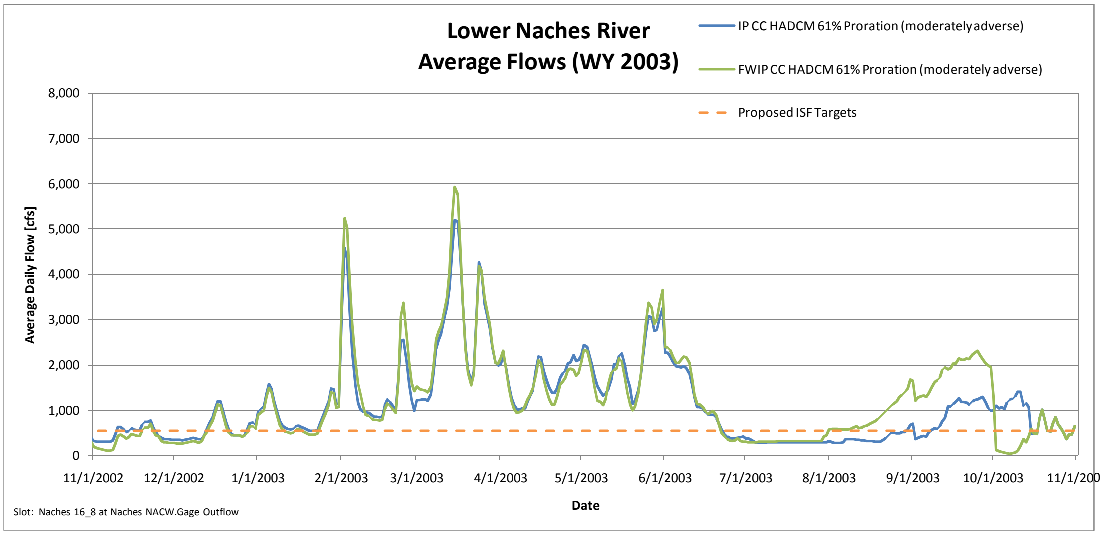

Tieton River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

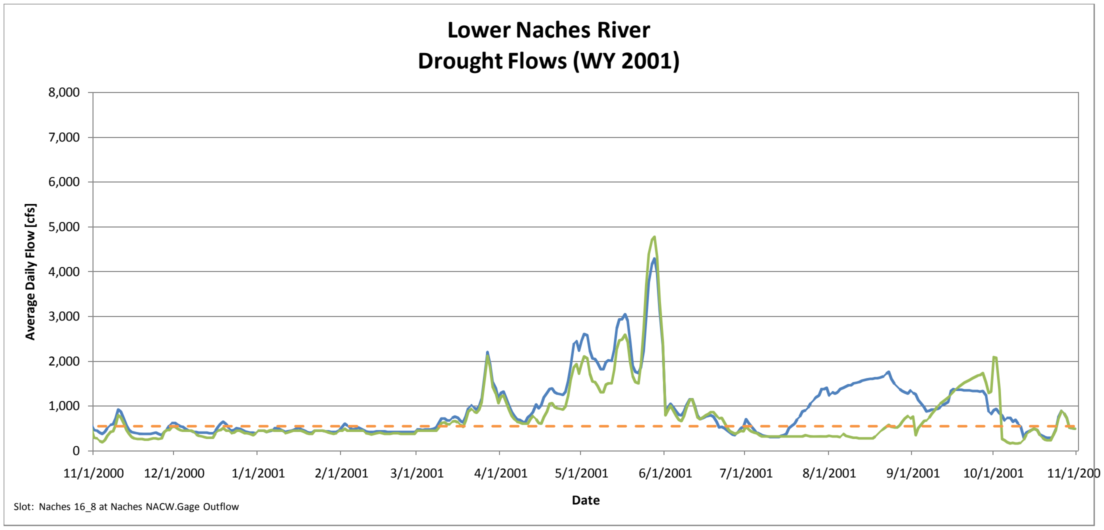

Tieton River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

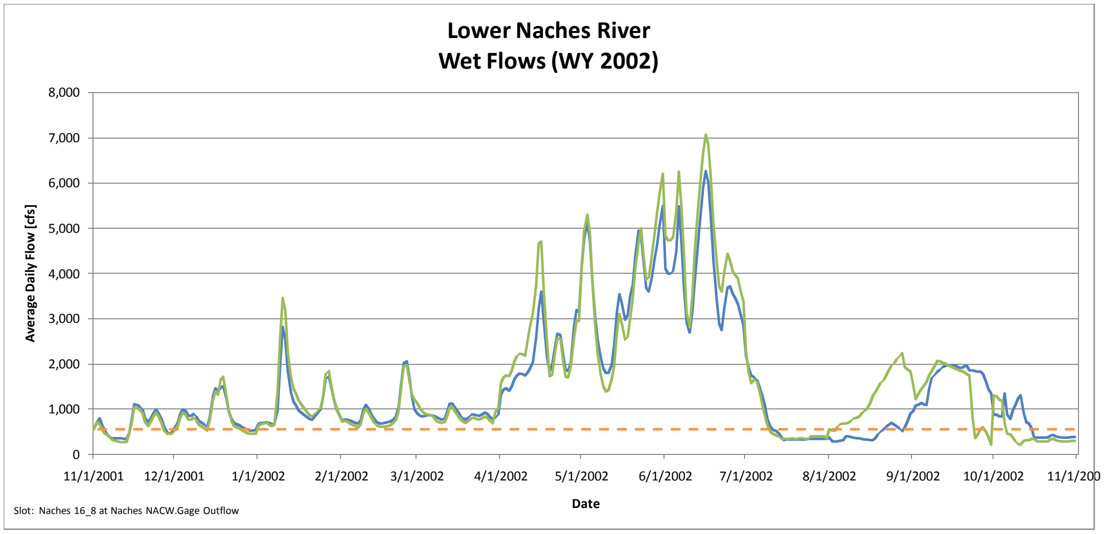

Bumping River
Average Flows (WY 2003)
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

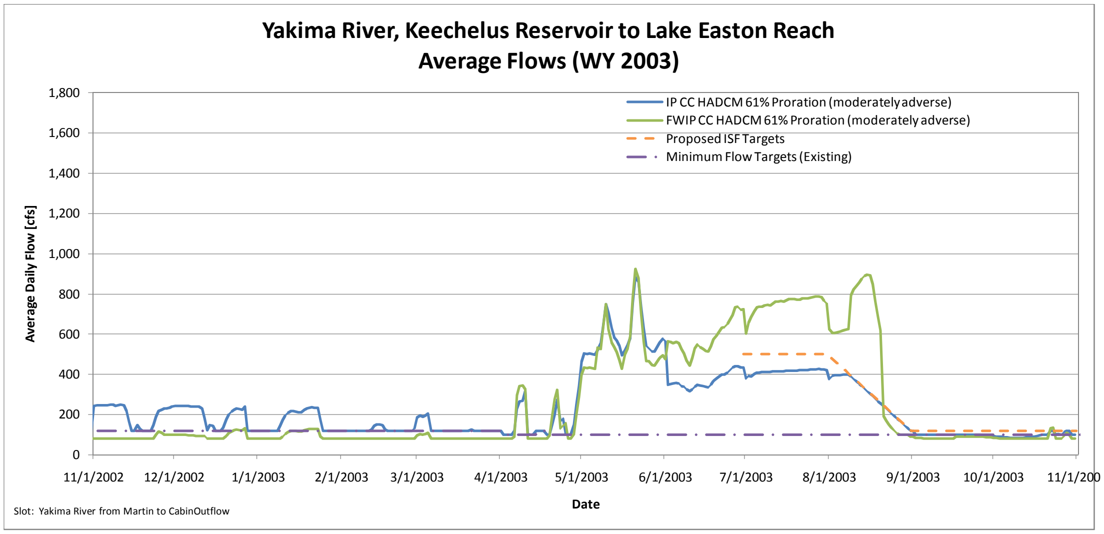

Bumping River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

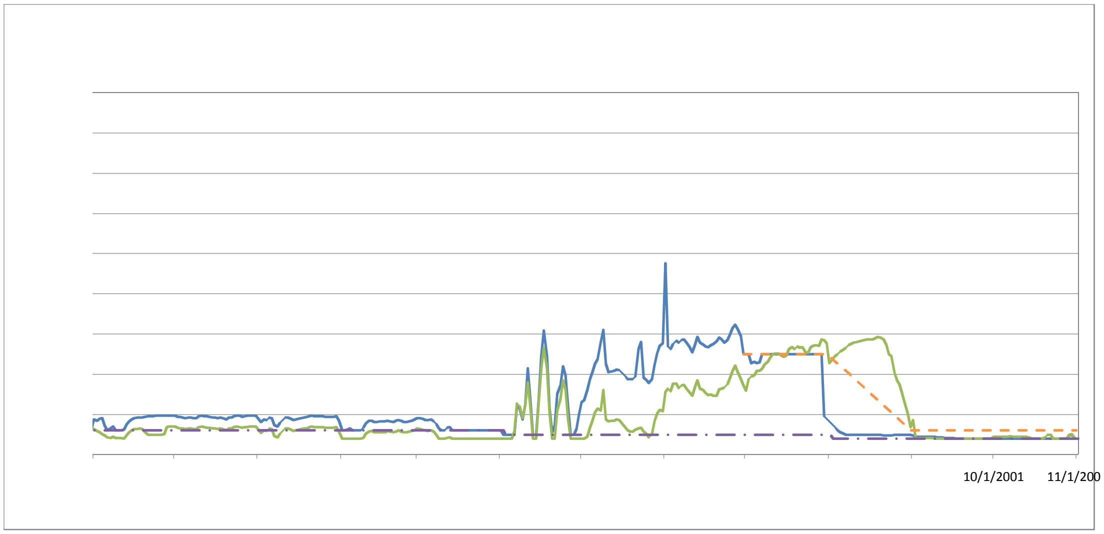

Bumping River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

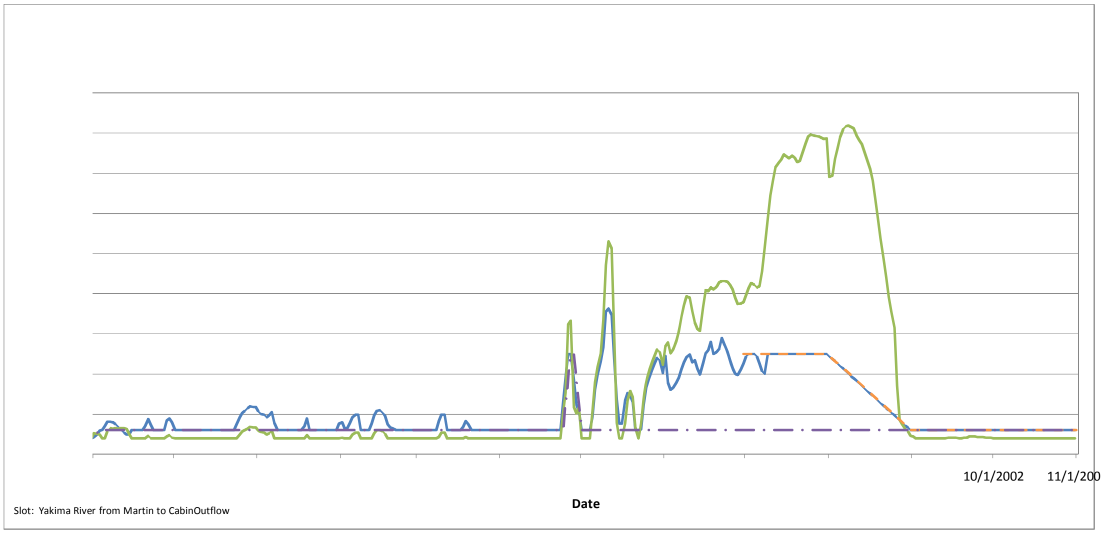

Lower Naches River
Average Flows (WY 2003)
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
Proposed ISF Targets
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

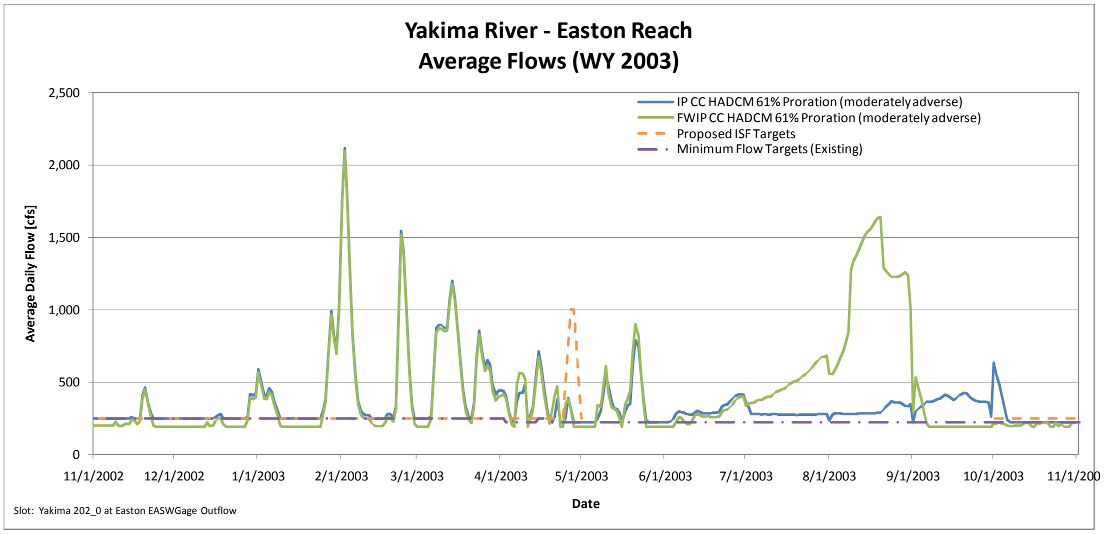

Lower Naches River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

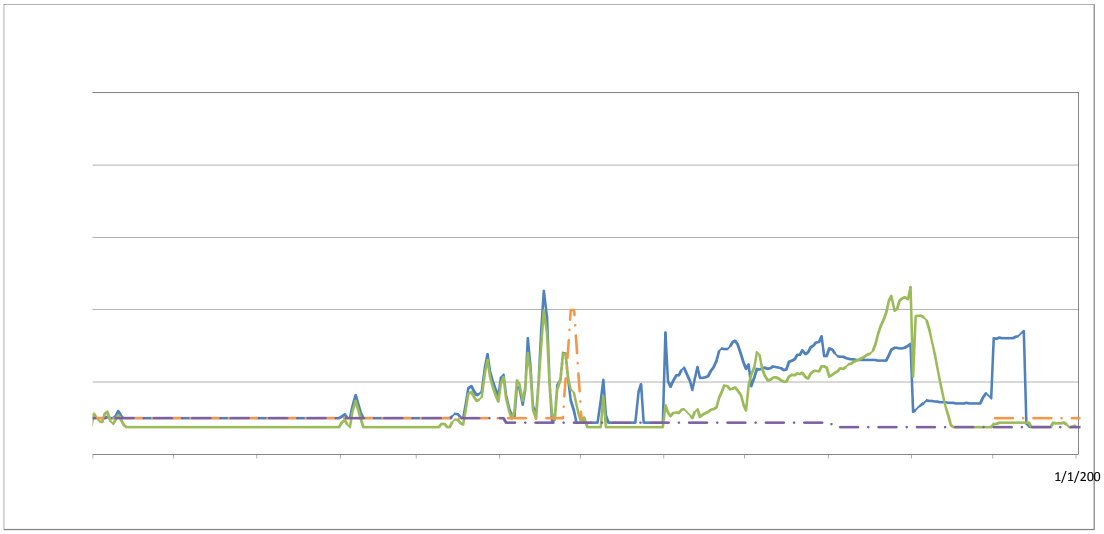

Lower Naches River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

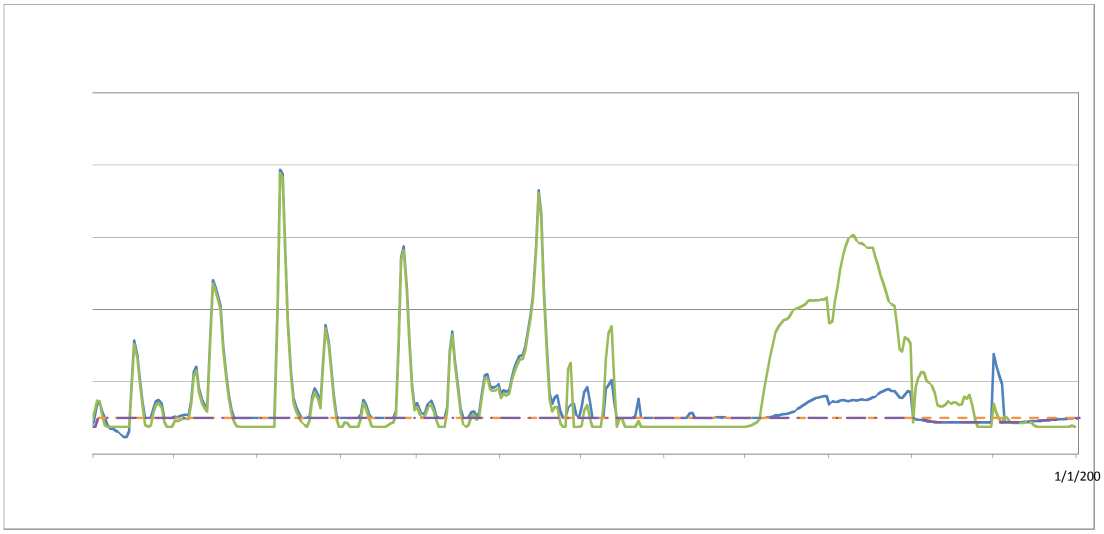

Yakima River, Keechelus Reservoir to Lake Easton Reach
Average Flows (WY 2003)
Average Daily Flow [cfs]
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
Proposed ISF Targets
Minimum Flow Targets (Existing)
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Yakima River from Martin to CabinOutflow

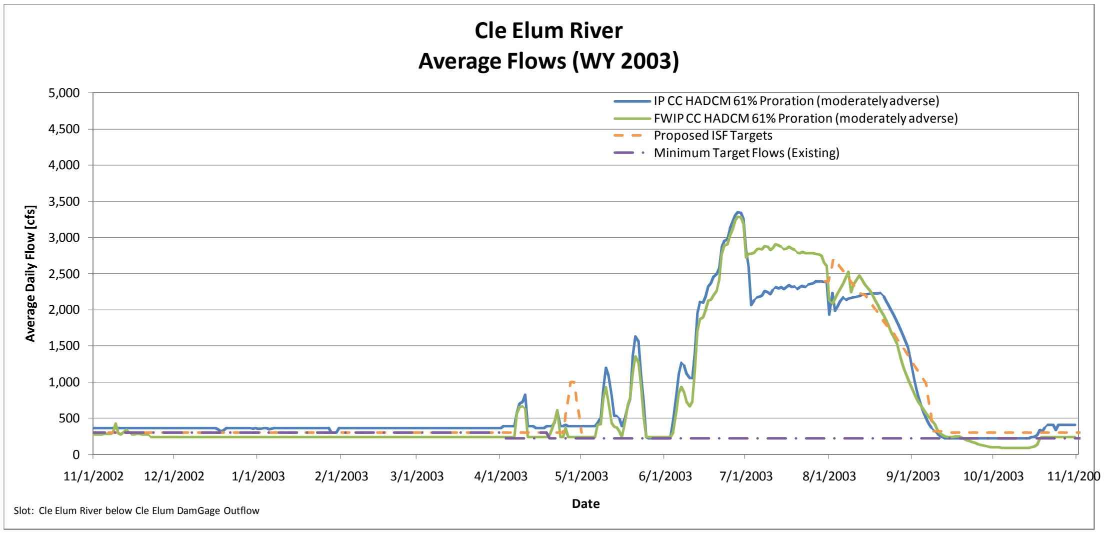

10/1/2001
11/1/200

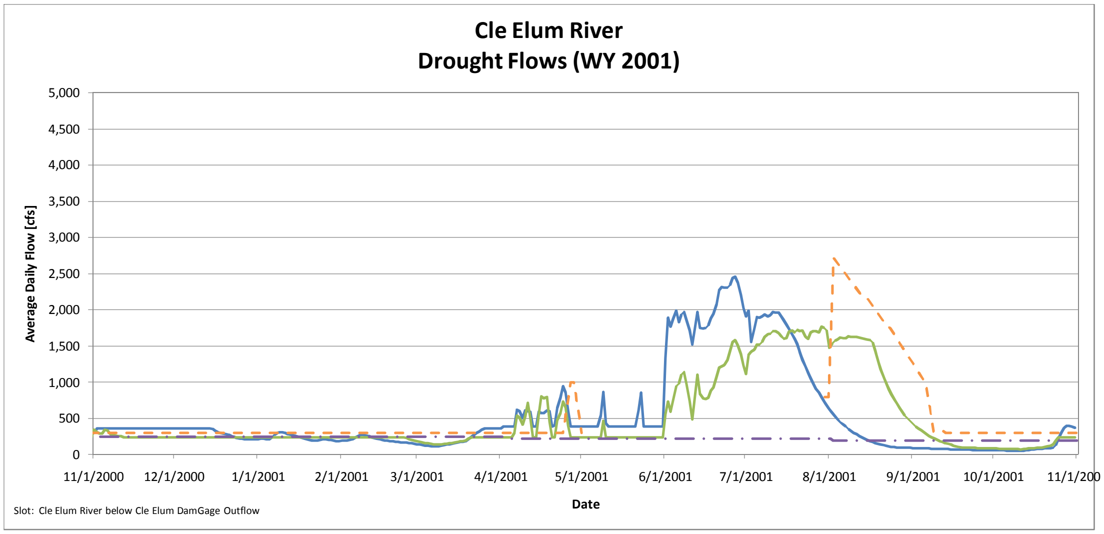

10/1/2002
11/1/200
Date
Slot: Yakima River from Martin to CabinOutflow

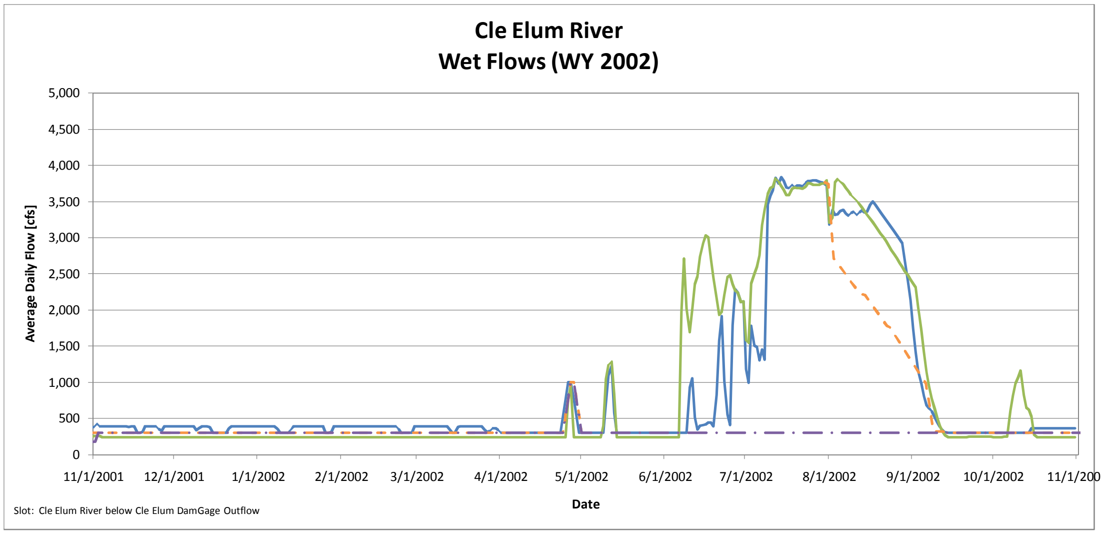

Yakima River - Easton Reach
Average Flows (WY 2003)
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
Proposed ISF Targets
Minimum Flow Targets (Existing)
Average Daily Flow [cfs]
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

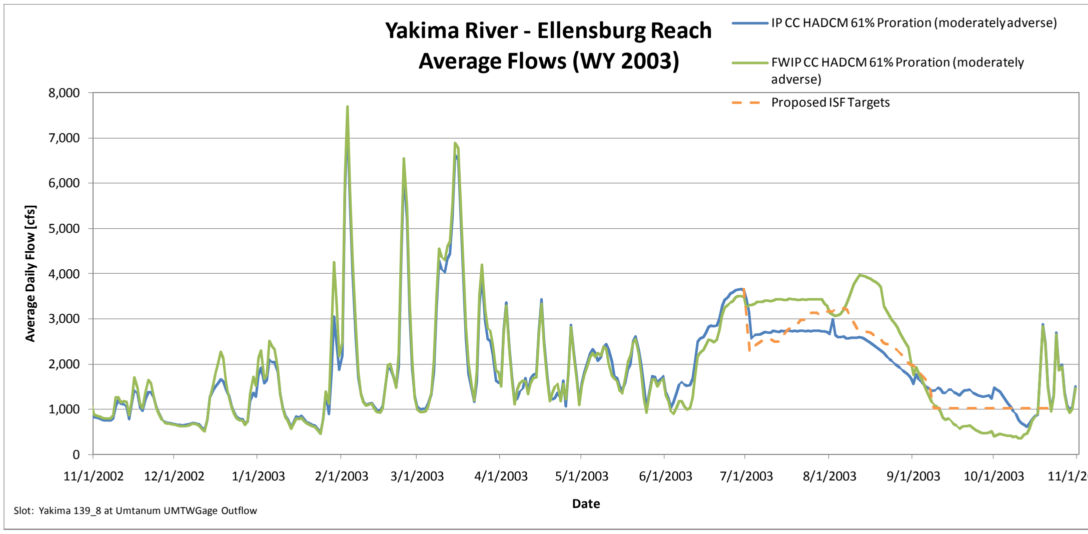

1/1/200

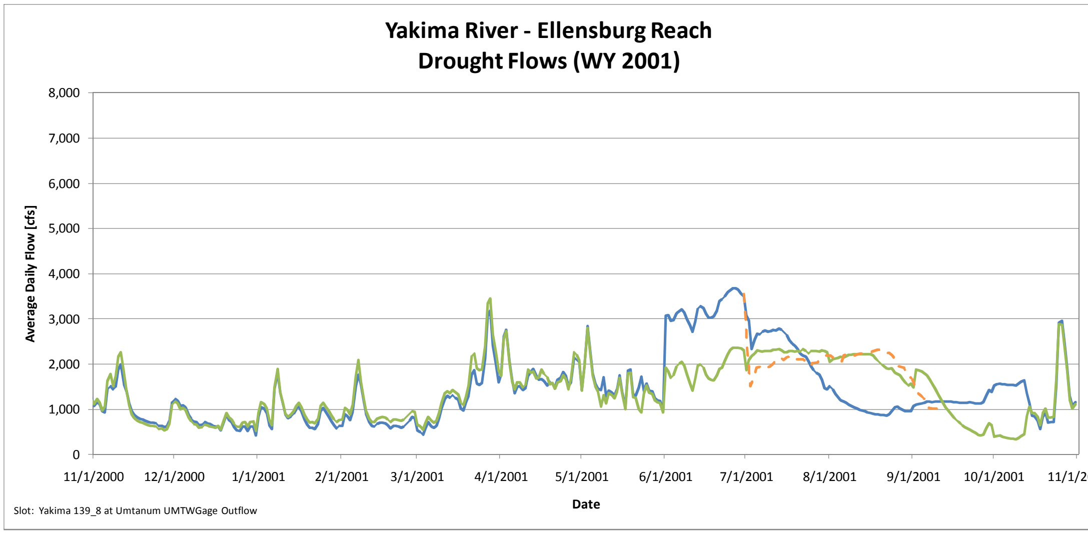

1/1/200

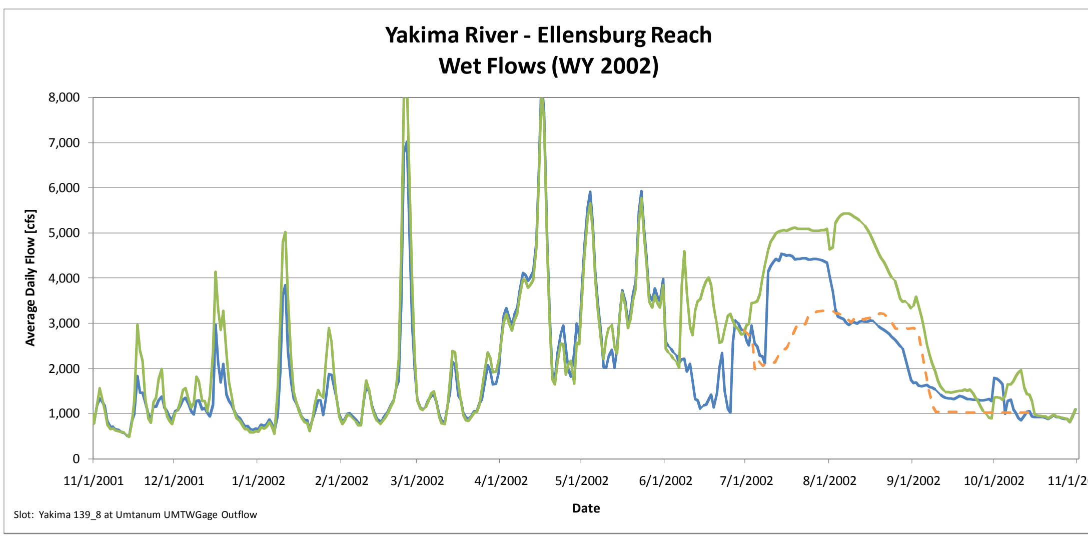

Cle Elum River
Average Flows (WY 2003)
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
Proposed ISF Targets
Minimum Target Flows (Existing)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

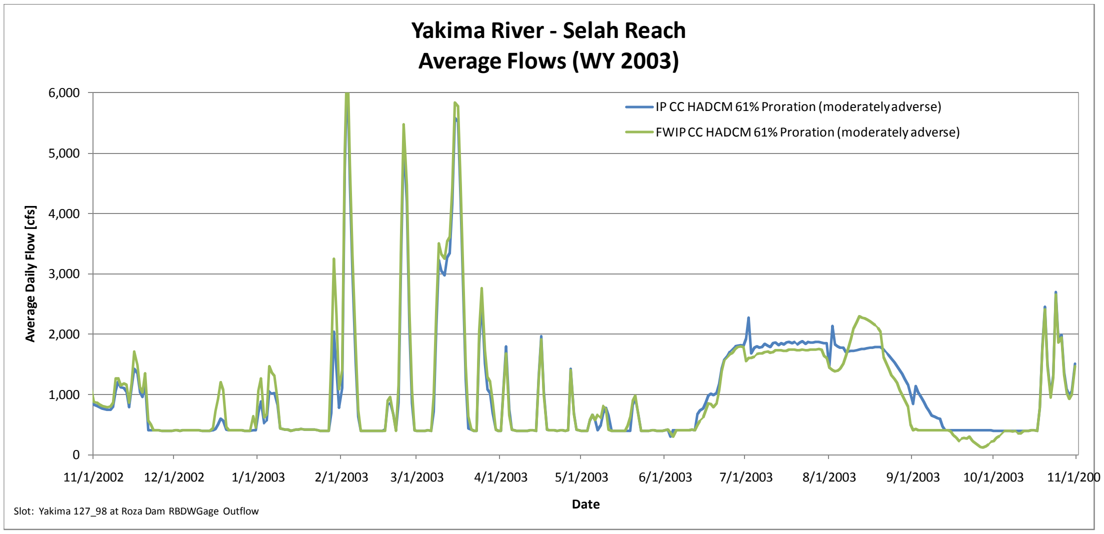

Cle Elum River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

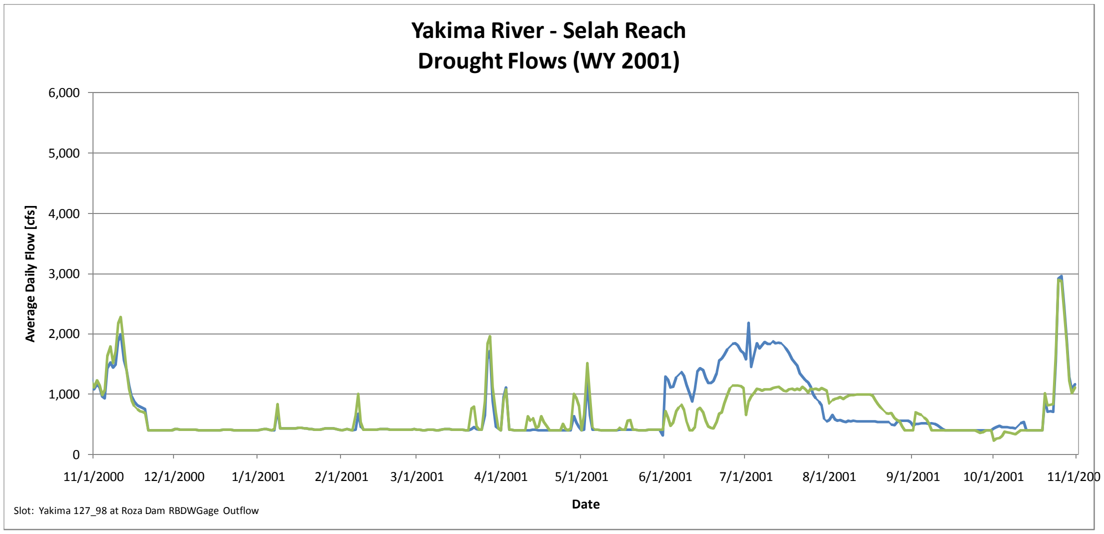

Cle Elum River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

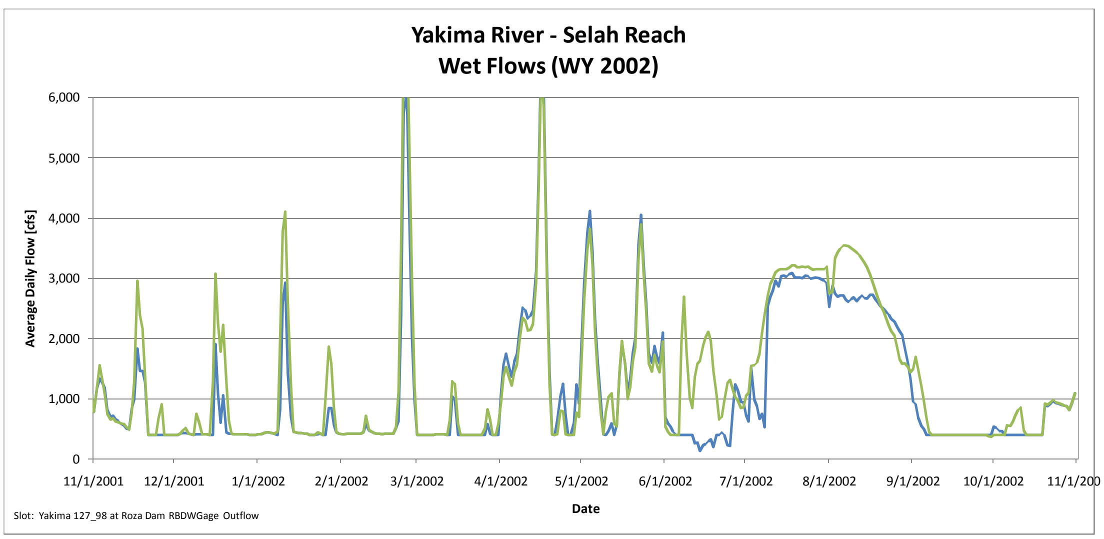

Yakima River - Ellensburg Reach
Average Flows (WY 2003)
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
Proposed ISF Targets
Average Daily Flow [cfs]
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

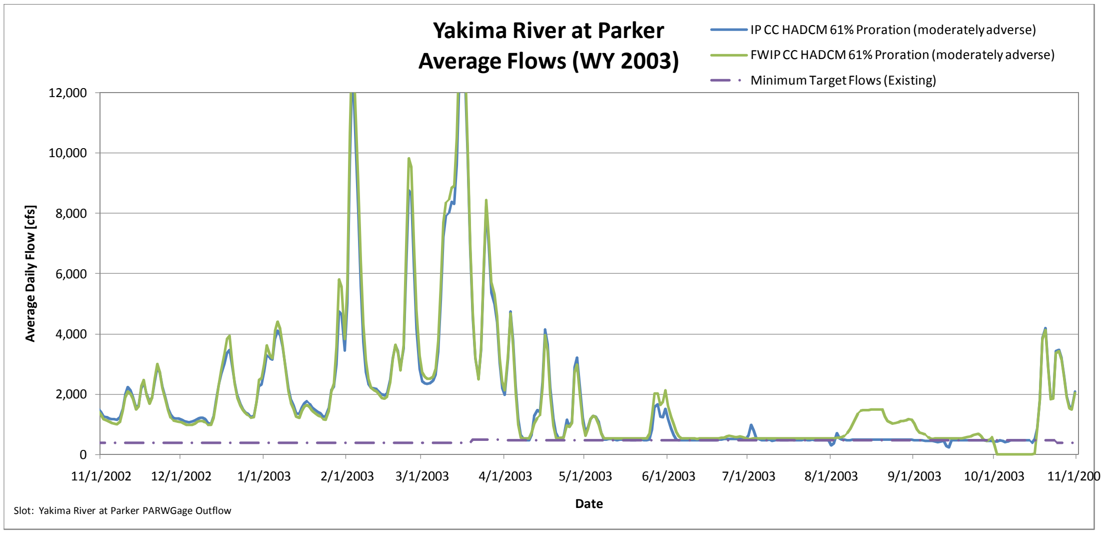

Yakima River - Ellensburg Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

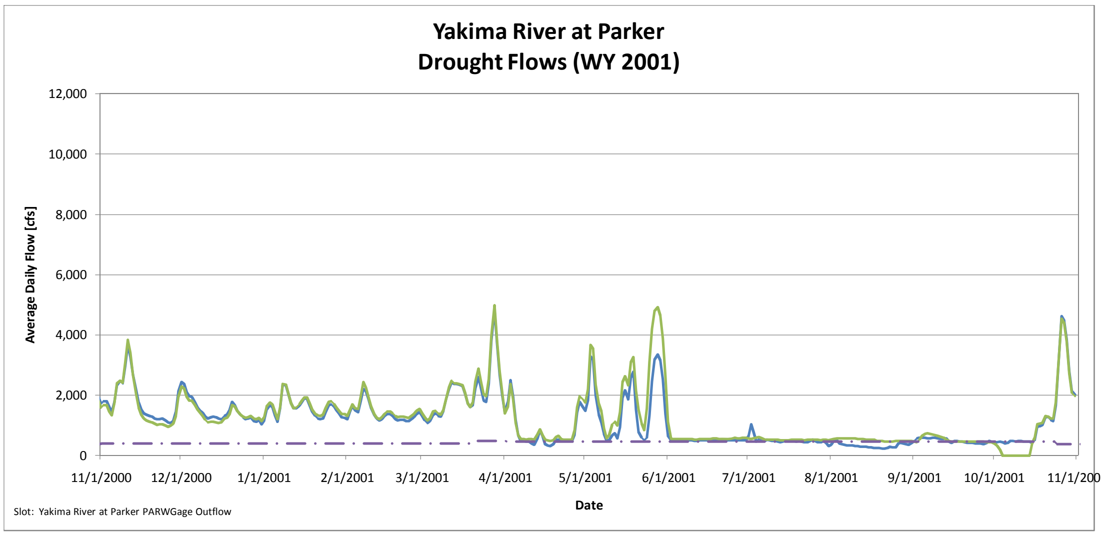

Yakima River - Ellensburg Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

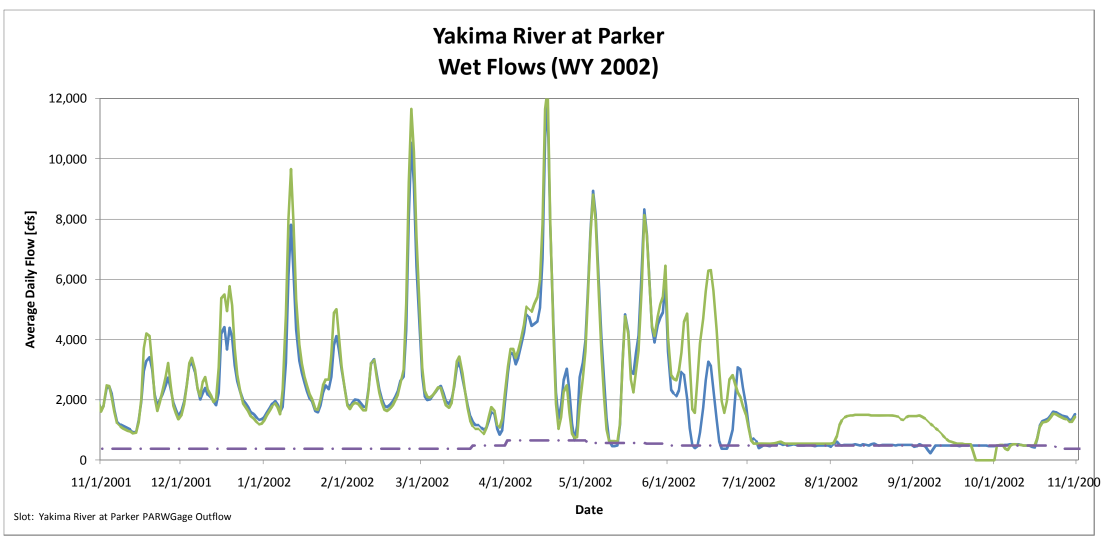

Yakima River - Selah Reach
Average Flows (WY 2003)
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

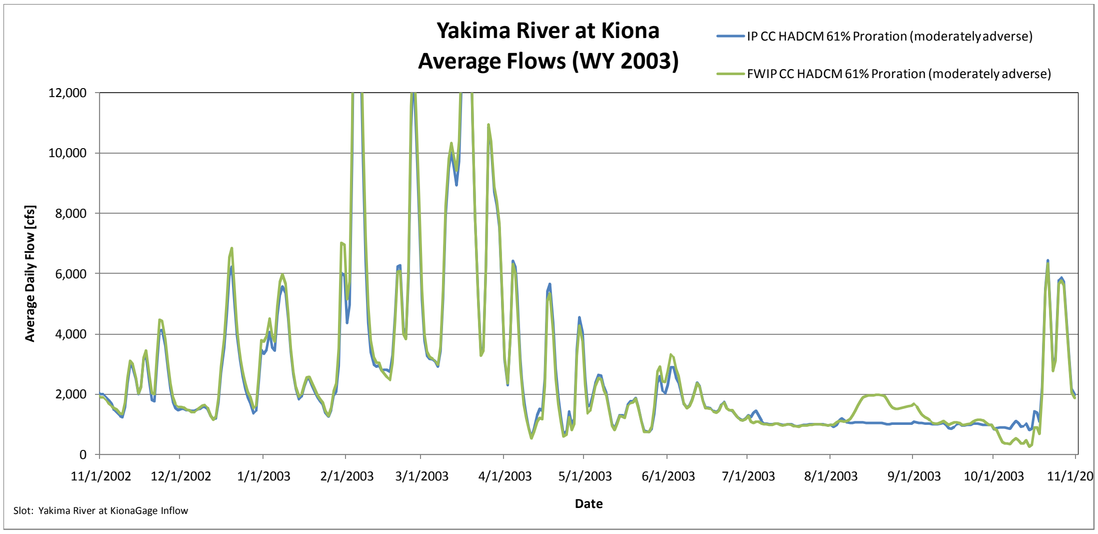

Yakima River - Selah Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

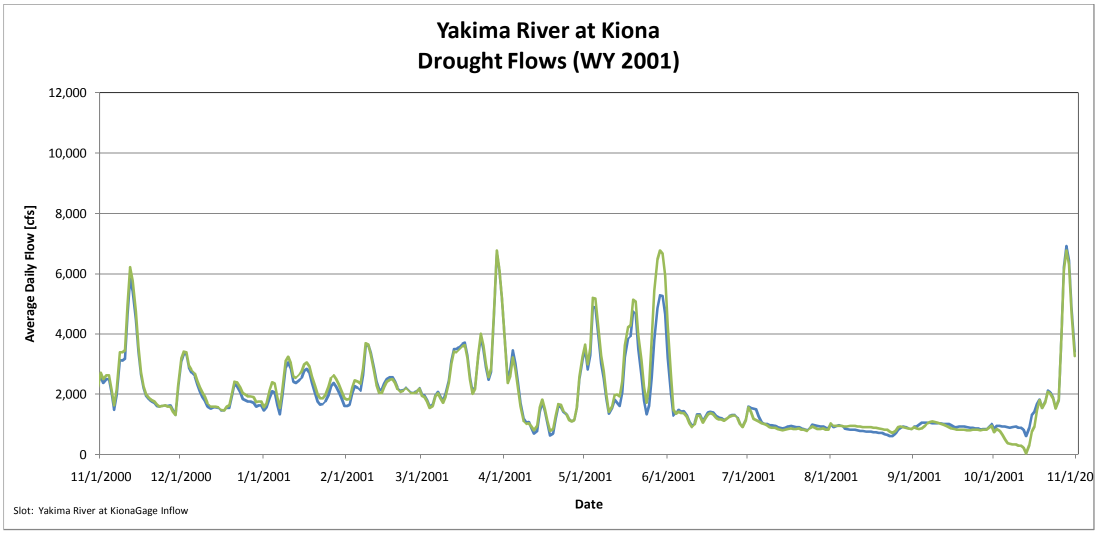

Yakima River - Selah Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

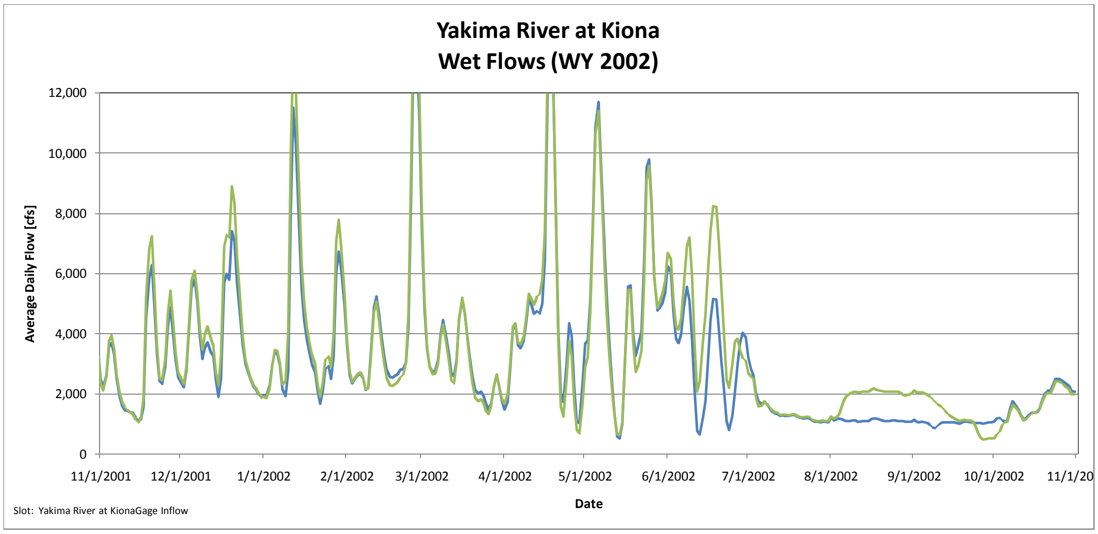

Yakima River at Parker
Average Flows (WY 2003)
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
Minimum Target Flows (Existing)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/200
Date
Slot: Yakima River at Parker PARWGage Outflow

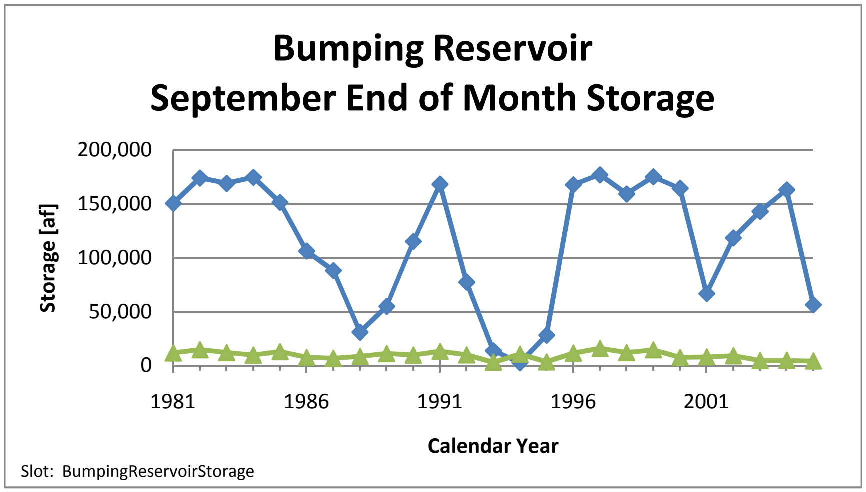

Yakima River at Parker
Drought Flows (WY 2001)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/200
Date
Slot: Yakima River at Parker PARWGage Outflow

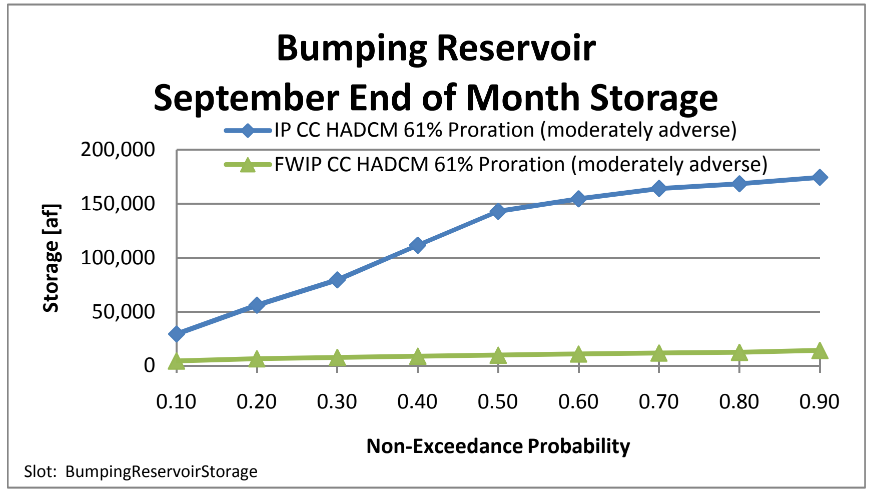

Yakima River at Parker
Wet Flows (WY 2002)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/200
Date
Slot: Yakima River at Parker PARWGage Outflow

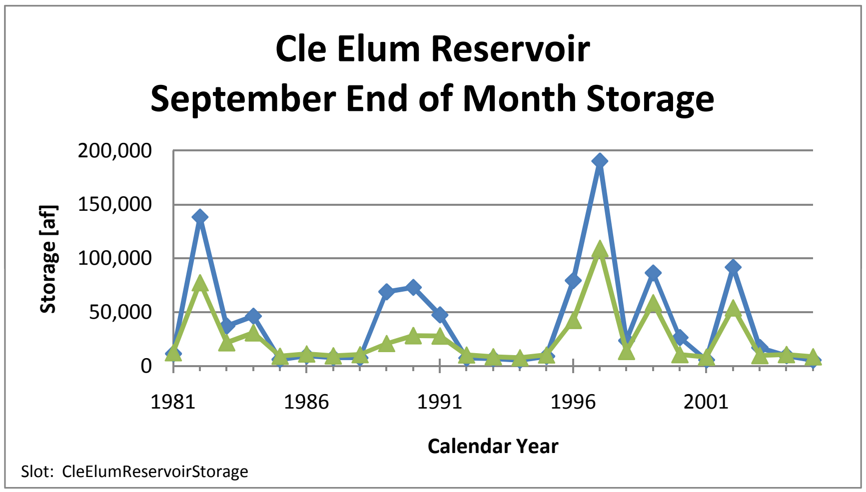

Yakima River at Kiona
Average Flows (WY 2003)
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

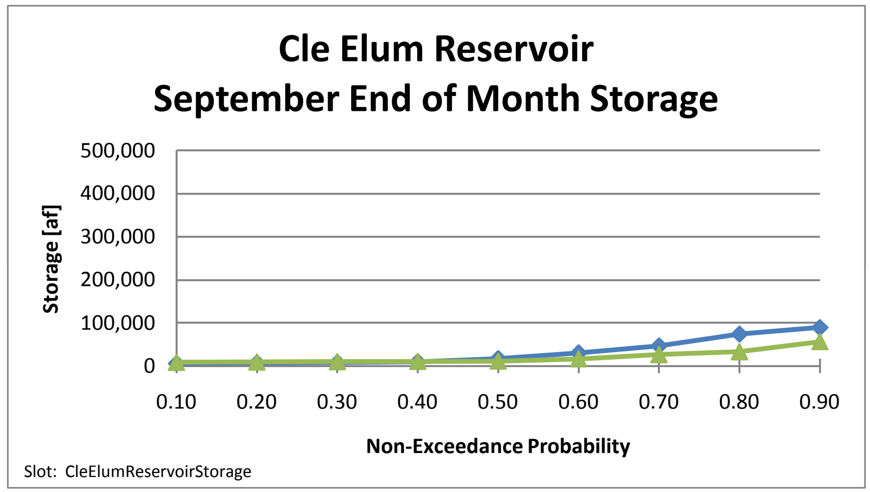

Yakima River at Kiona
Drought Flows (WY 2001)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

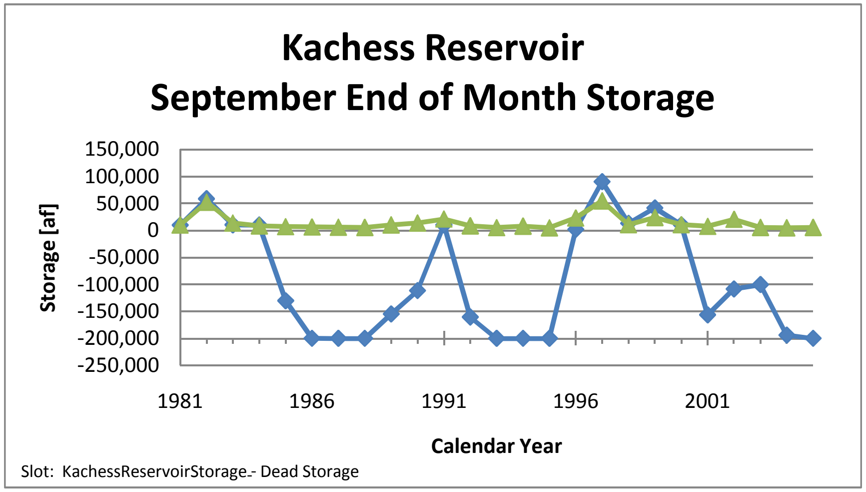

Yakima River at Kiona
Wet Flows (WY 2002)
Average Daily Flow [cfs]
12,000
10,000
8,000
6,000
4,000
2,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

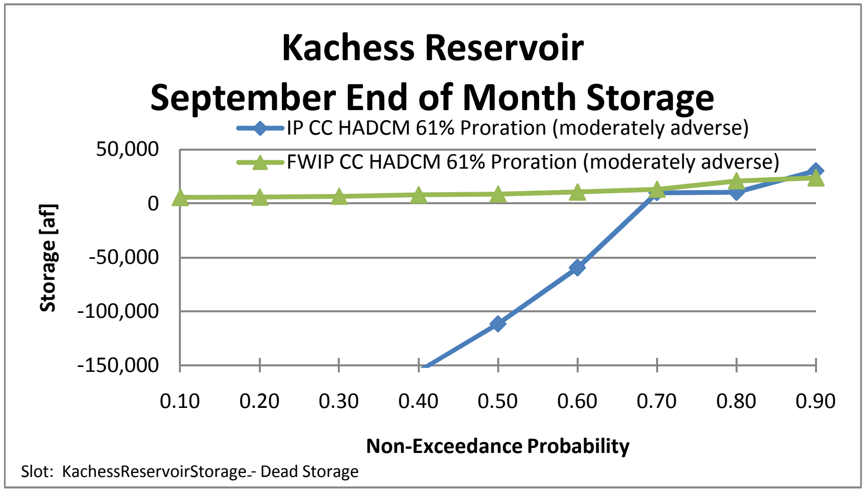

Bumping Reservoir
September End of Month Storage
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: BumpingReservoirStorage

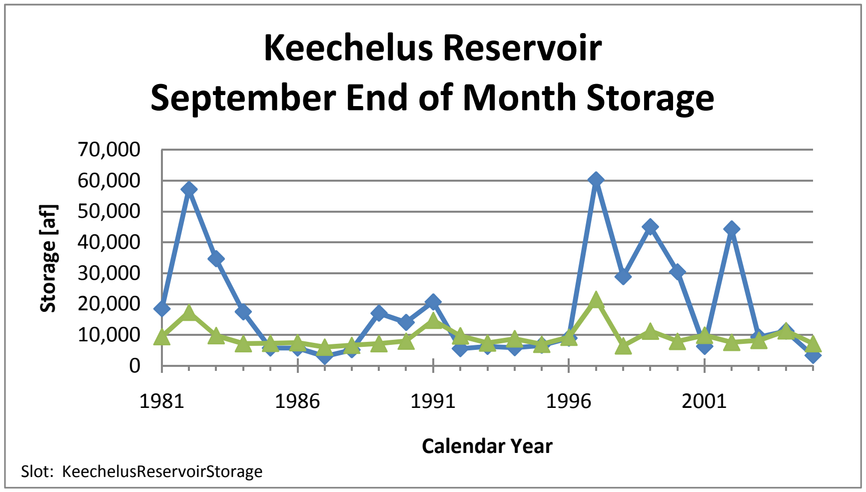

Bumping Reservoir
September End of Month Storage
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
200,000
150,000
100,000
50,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: BumpingReservoirStorage

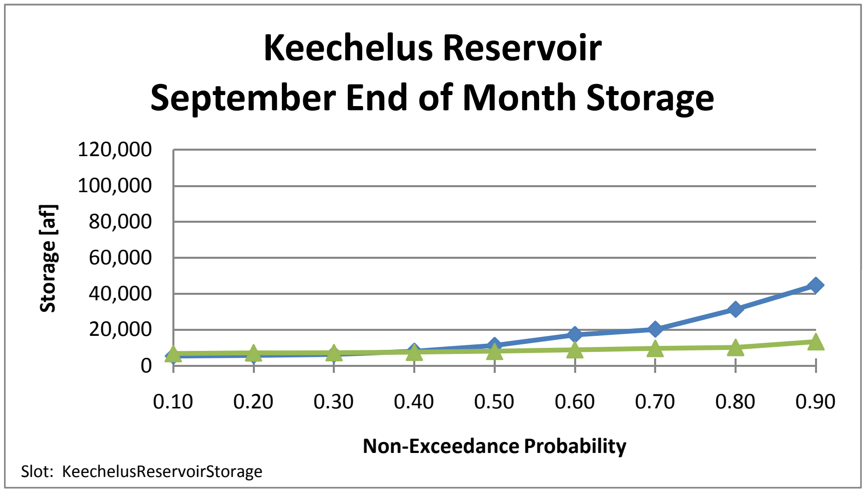

Cle Elum Reservoir
September End of Month Storage
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: CleElumReservoirStorage

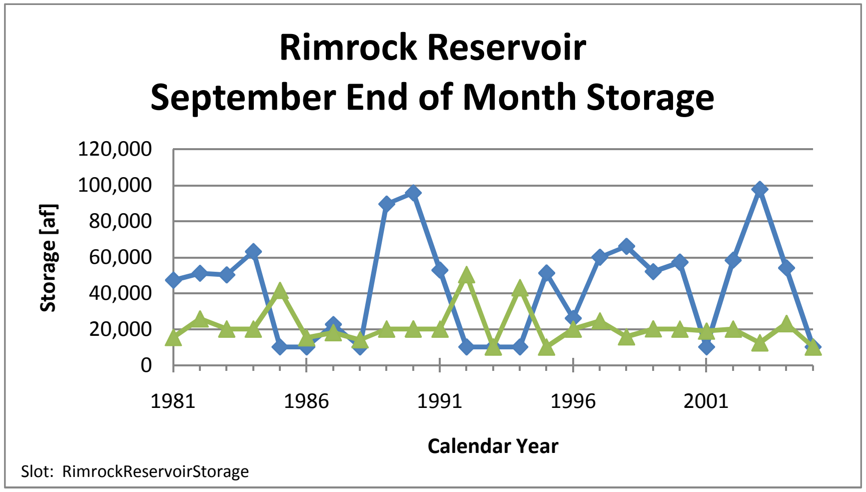

Cle Elum Reservoir
September End of Month Storage
500,000
400,000
300,000
200,000
100,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: CleElumReservoirStorage

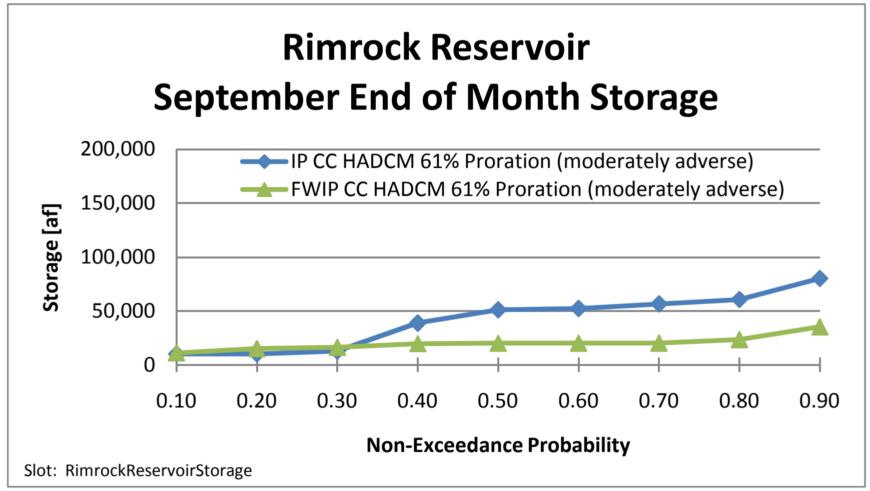

Kachess Reservoir
September End of Month Storage
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
-200,000
-250,000
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: KachessReservoirStorage.- Dead Storage

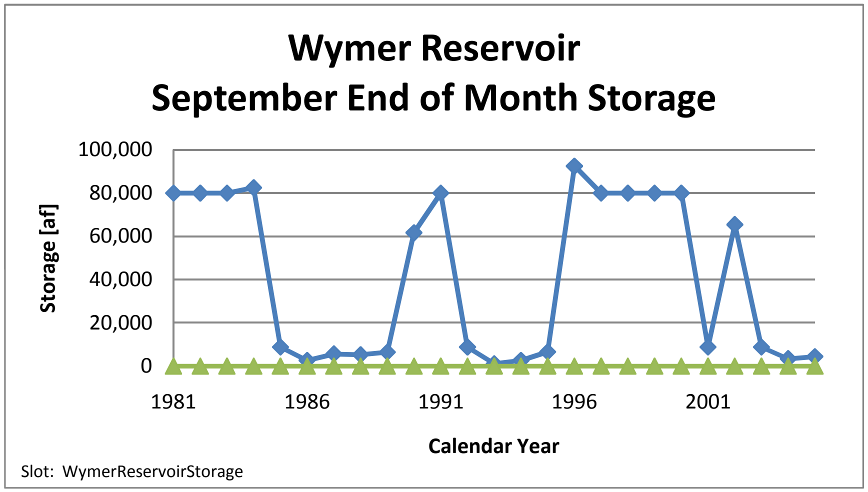

Kachess Reservoir
September End of Month Storage
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
50,000
0
-50,000
-100,000
-150,000
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KachessReservoirStorage.- Dead Storage

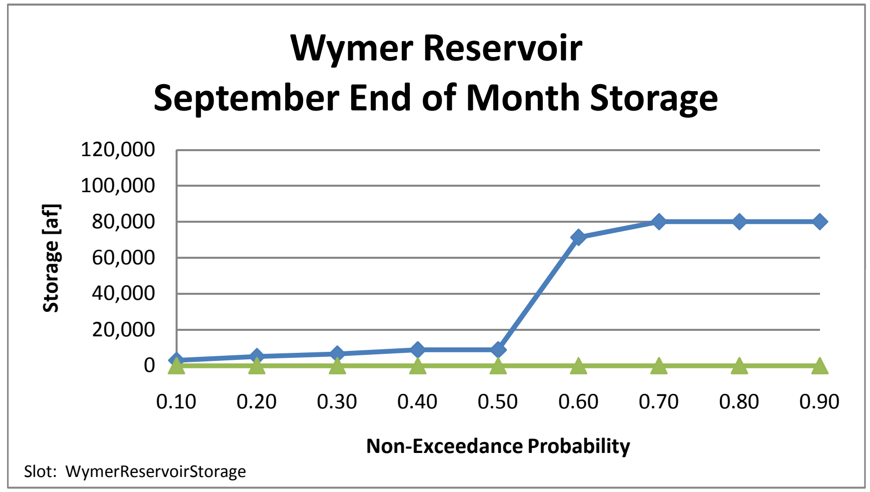

Keechelus Reservoir
September End of Month Storage
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: KeechelusReservoirStorage

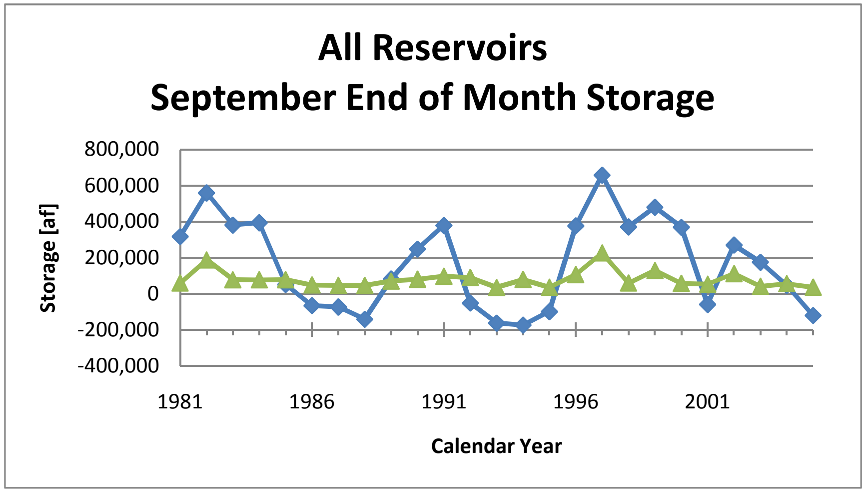

Keechelus Reservoir
September End of Month Storage
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KeechelusReservoirStorage

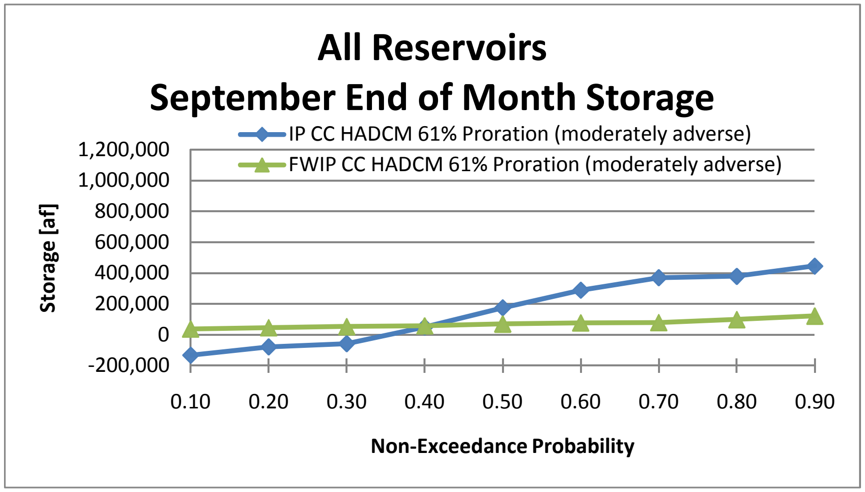

Rimrock Reservoir
September End of Month Storage
Storage [af]
120,000
100,000
80,000
60,000
40,000
20,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: RimrockReservoirStorage

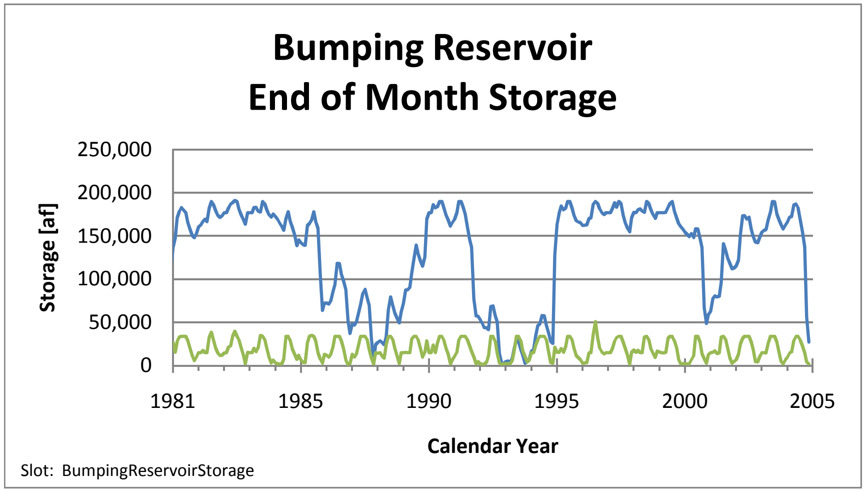

Rimrock Reservoir
September End of Month Storage
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
Storage [af]
200,000
150,000
100,000
50,000
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: RimrockReservoirStorage

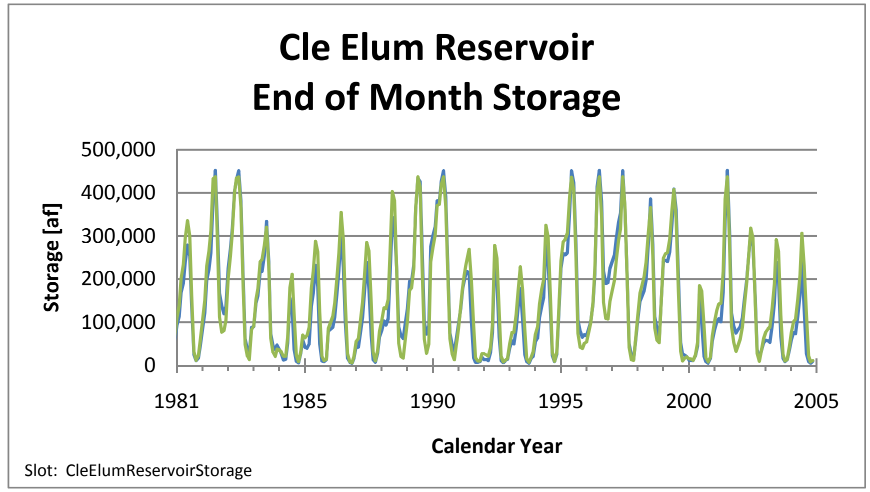

Wymer Reservoir
September End of Month Storage
Storage [af]
100,000
80,000
60,000
40,000
20,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: WymerReservoirStorage

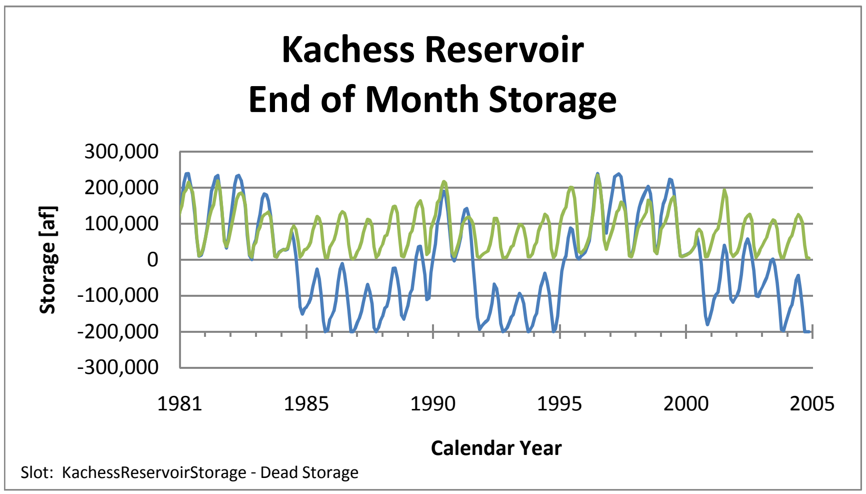

Wymer Reservoir
September End of Month Storage
Storage [af]
120,000
100,000
80,000
60,000
40,000
20,000
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: WymerReservoirStorage

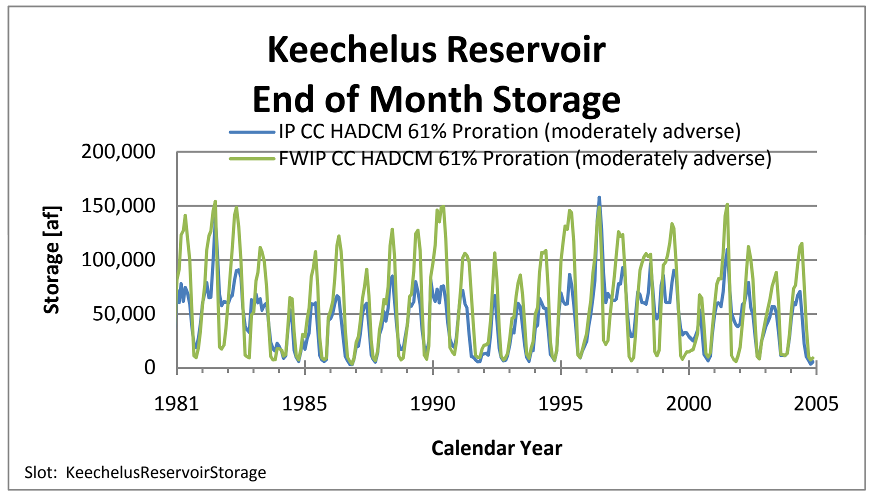

All Reservoirs
September End of Month Storage
Storage [af]
800,000
600,000
400,000
200,000
0
-200,000
-400,000
1981
1986
1991
1996
2001
Calendar Year

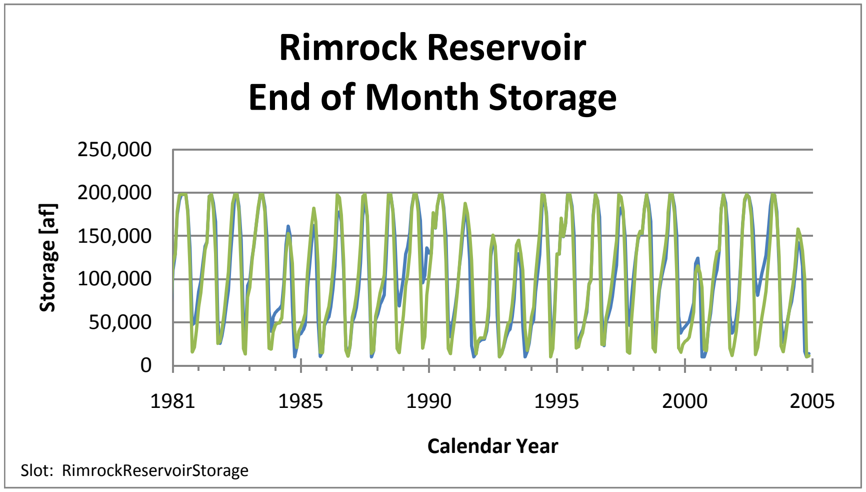

All Reservoirs
September End of Month Storage
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
Storage [af]
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
-200,000
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability

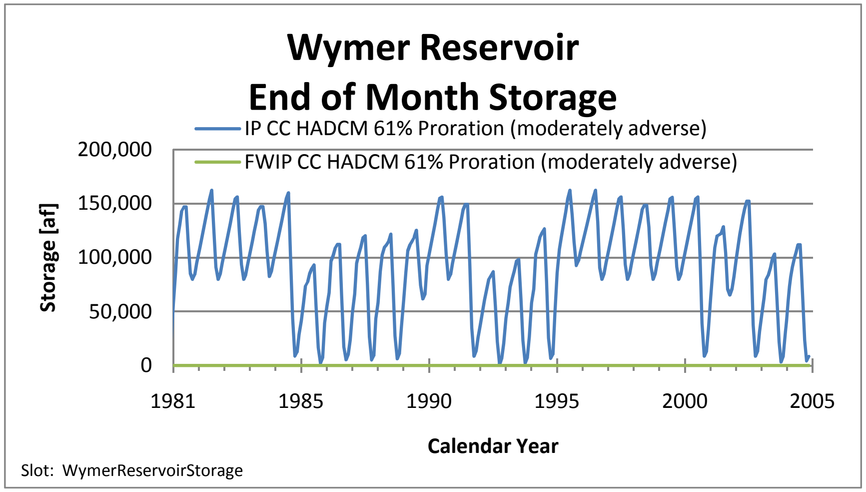

Bumping Reservoir
End of Month Storage
250,000
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: BumpingReservoirStorage

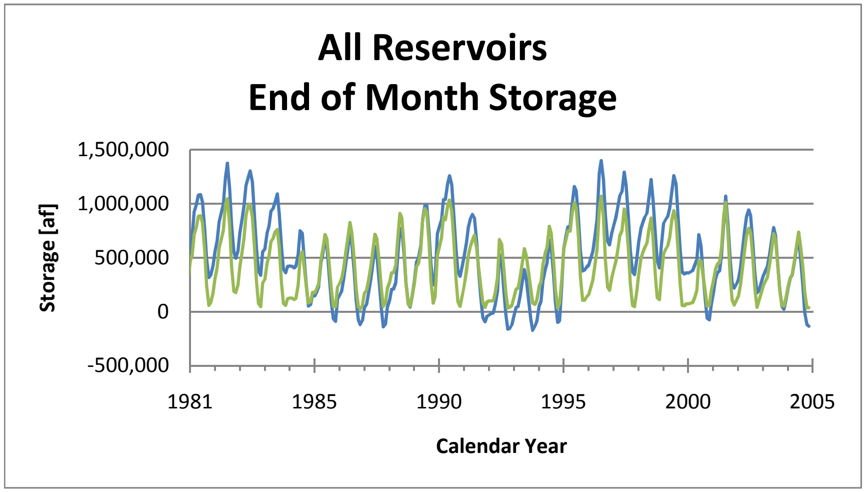

Cle Elum Reservoir
End of Month Storage
500,000
400,000
300,000
200,000
100,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: CleElumReservoirStorage

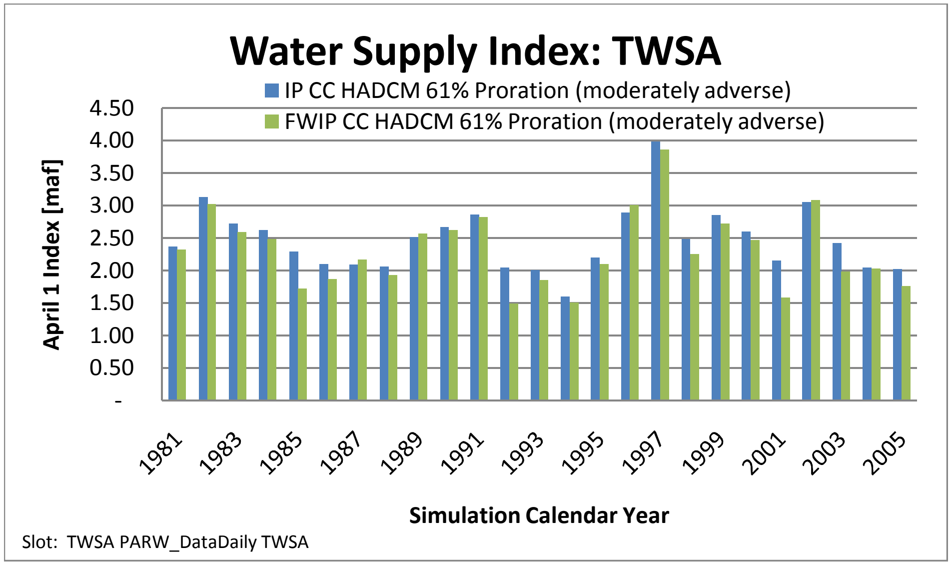

Kachess Reservoir
End of Month Storage
300,000
200,000
100,000
0
-100,000
-200,000
-300,000
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KachessReservoirStorage - Dead Storage

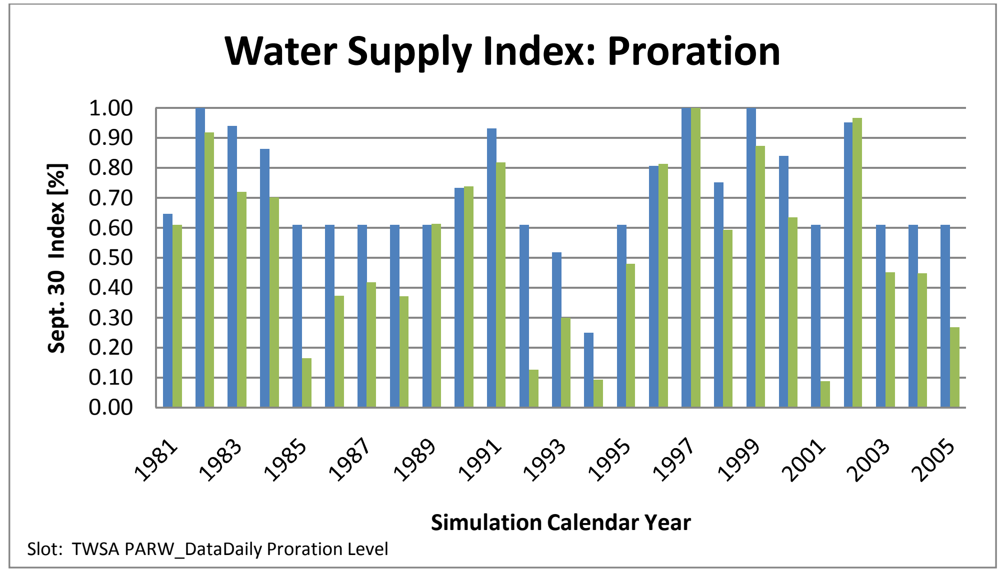

Keechelus Reservoir
End of Month Storage
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KeechelusReservoirStorage

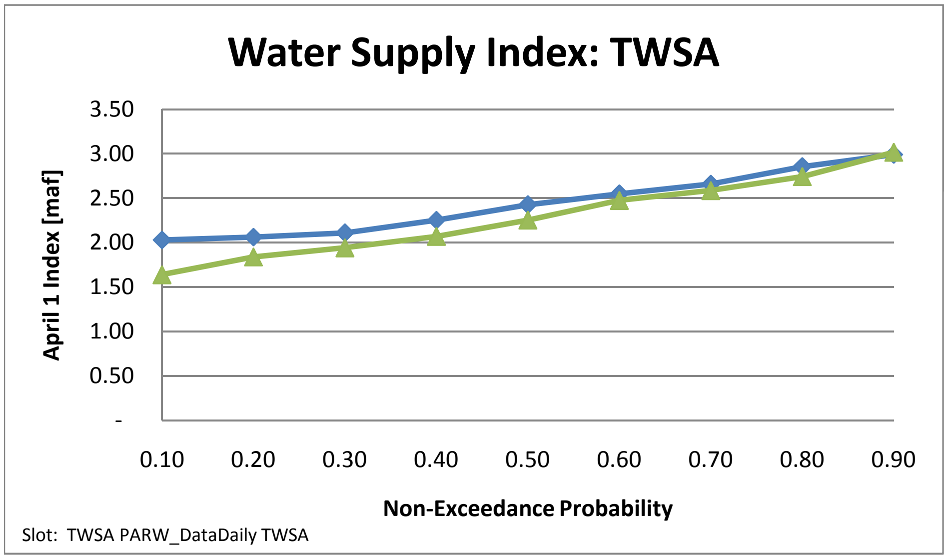

Rimrock Reservoir
End of Month Storage
250,000
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: RimrockReservoirStorage

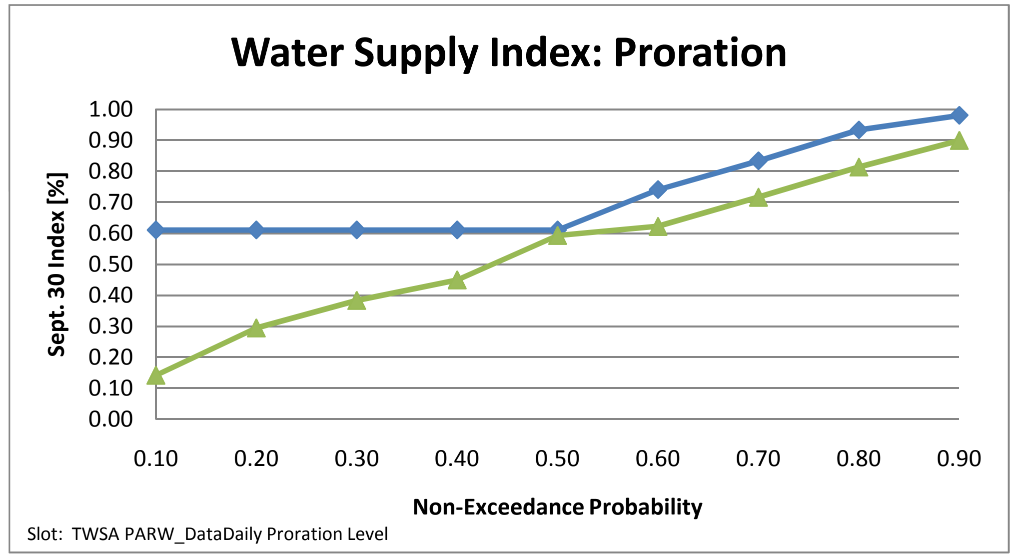

Wymer Reservoir
End of Month Storage
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: WymerReservoirStorage


All Reservoirs
End of Month Storage
1,500,000
1,000,000
500,000
0
-500,000
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year

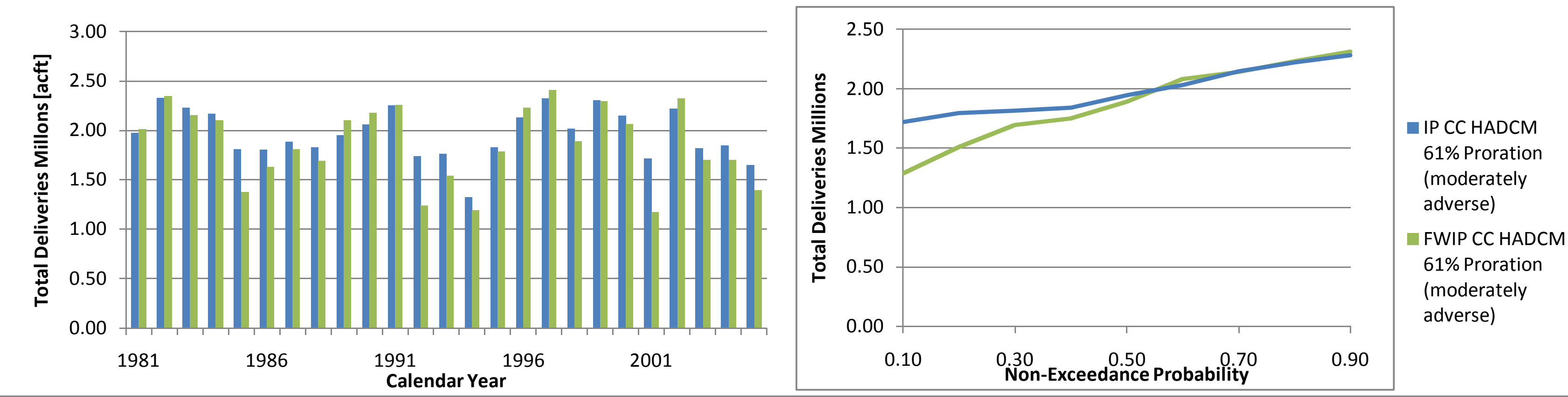

Water Supply Index: TWSA
IP CC HADCM 61% Proration (moderately adverse)
FWIP CC HADCM 61% Proration (moderately adverse)
April 1 Index [maf]
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
-
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
Simulation Calendar Year
Slot: TWSA PARW_DataDaily TWSA


Water Supply Index: Proration
Sept. 30 Index [%]
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
Simulation Calendar Year
Slot: TWSA PARW_DataDaily Proration Level

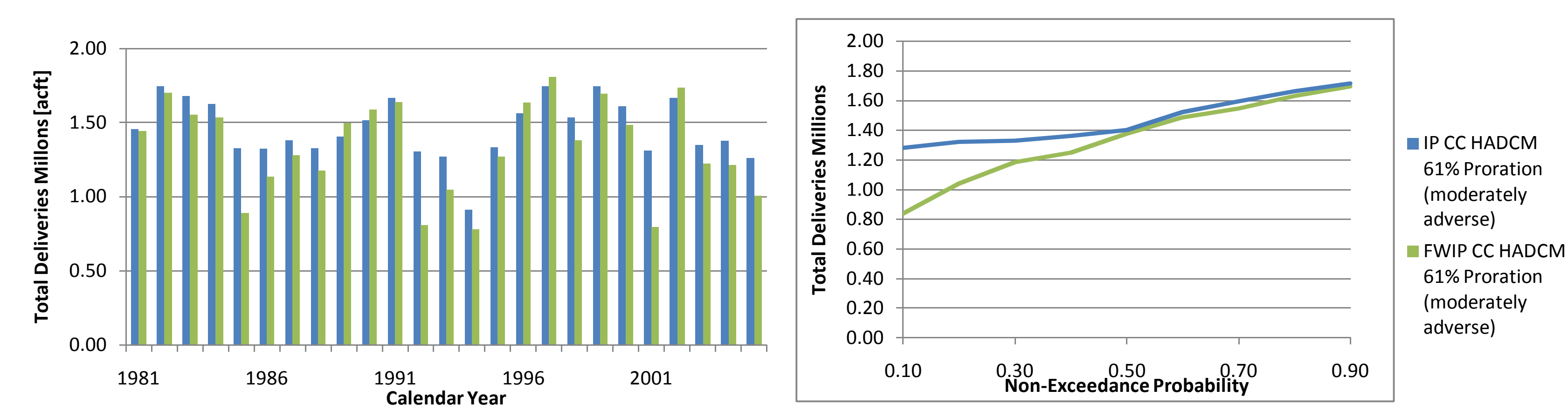

Water Supply Index: TWSA
April 1 Index [maf]
3.50
3.00
2.50
2.00
1.50
1.00
0.50
-
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily TWSA


Water Supply Index: Proration
Sept. 30 Index [%]
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily Proration Level

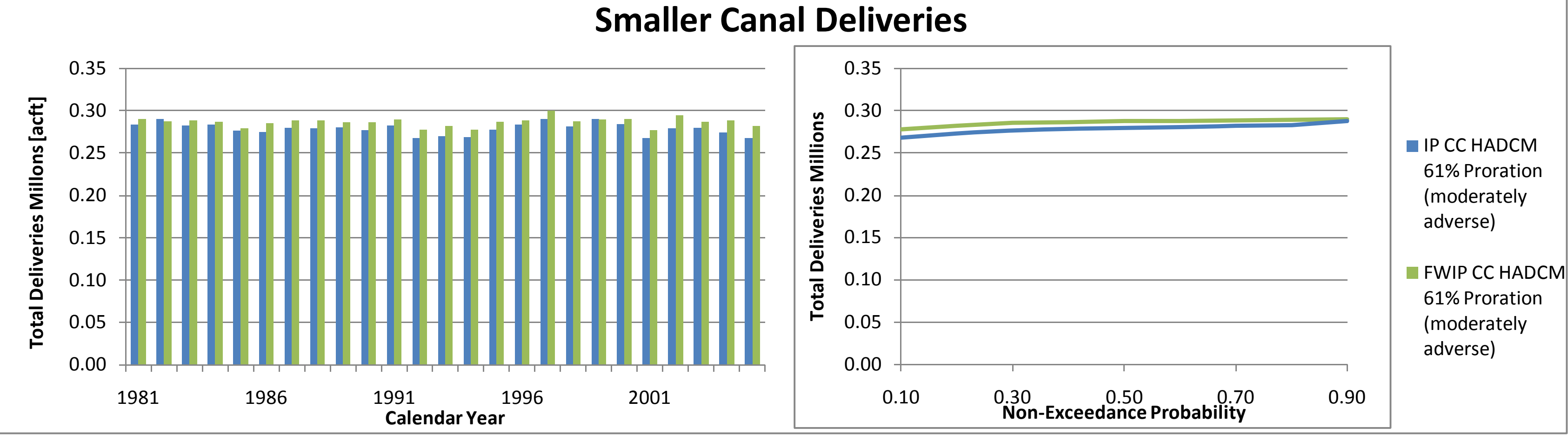
Main Canal Deliveries



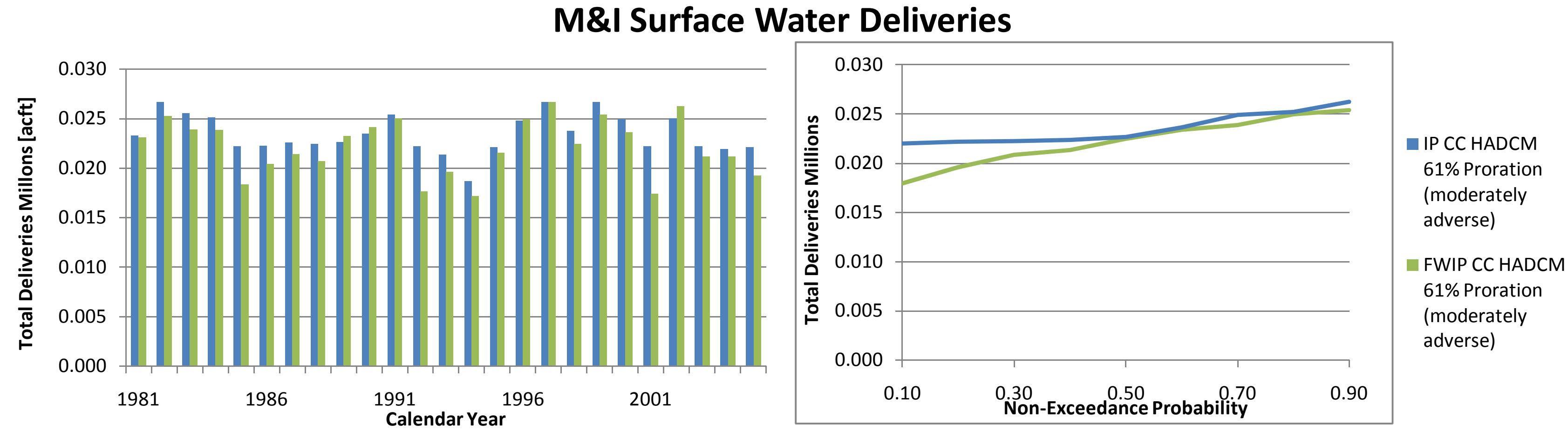
Sunnyside, KRD Irrigation, Roza Irrigation, New Reservation Canal, Tieton, and Kennewick Deliveries



Smaller Canal Deliveries



M&I Surface Water Deliveries



Appendix D – 3

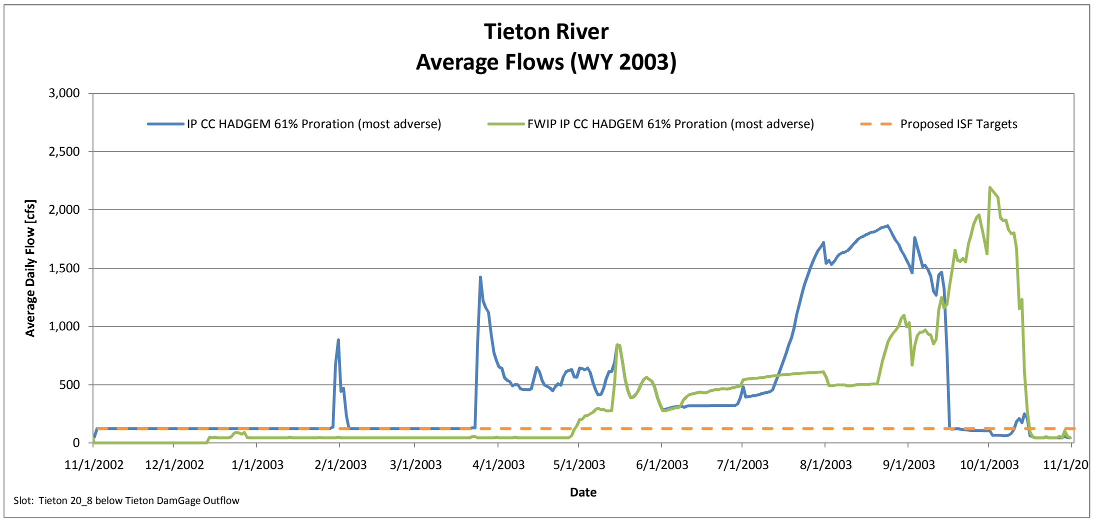
Integrated Plan Results with Climate Change –Most Adverse Scenario (HADGEM)

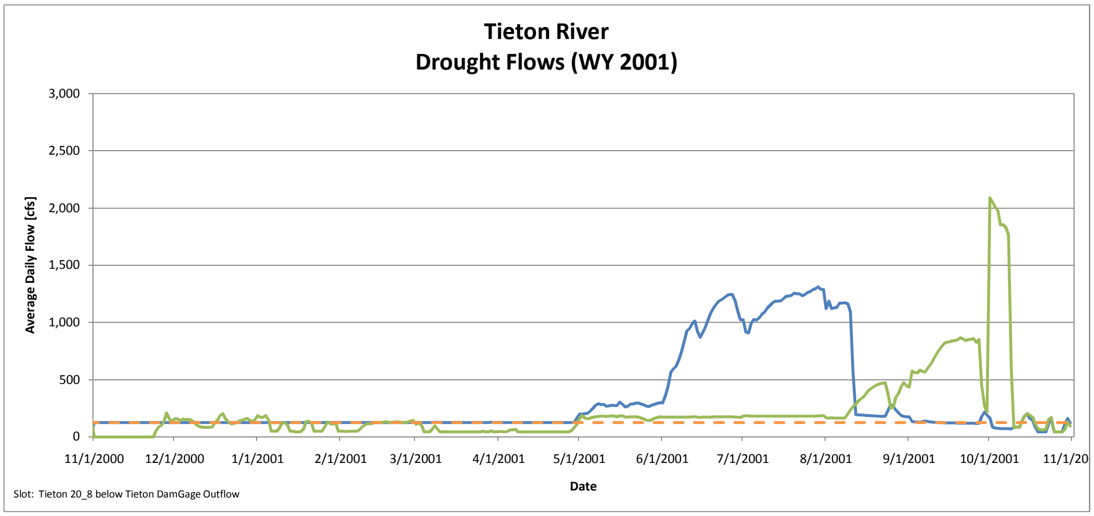
Resource indicator (measurement)	IP CC HADGEM 61% Proration (most adverse)	FWIP IP CC HADGEM 61% Proration (most adverse)
WATER RESOURCES		
Average for water years 1981–2005 (maf)		
Water supply		
April 1 total water supply available (TWSA)	2.02	1.84
Water distribution		
April–September Parker flow volume	0.30	0.36
April–September diversion	1.43	1.29
September 30 reservoir contents	0.00	0.07
April–September flow volume at mouth of Yakima River	0.52	0.55
1994 dry-year (maf)		
Water supply		
April 1 TWSA	1.43	1.30
Water distribution		
April–September Parker flow volume	0.21	0.23
April–September diversion	1.09	0.97
September 30 reservoir contents	-0.14	0.11
April–September flow volume at mouth of Yakima River	0.35	0.34
Irrigation proration level	14%	0%

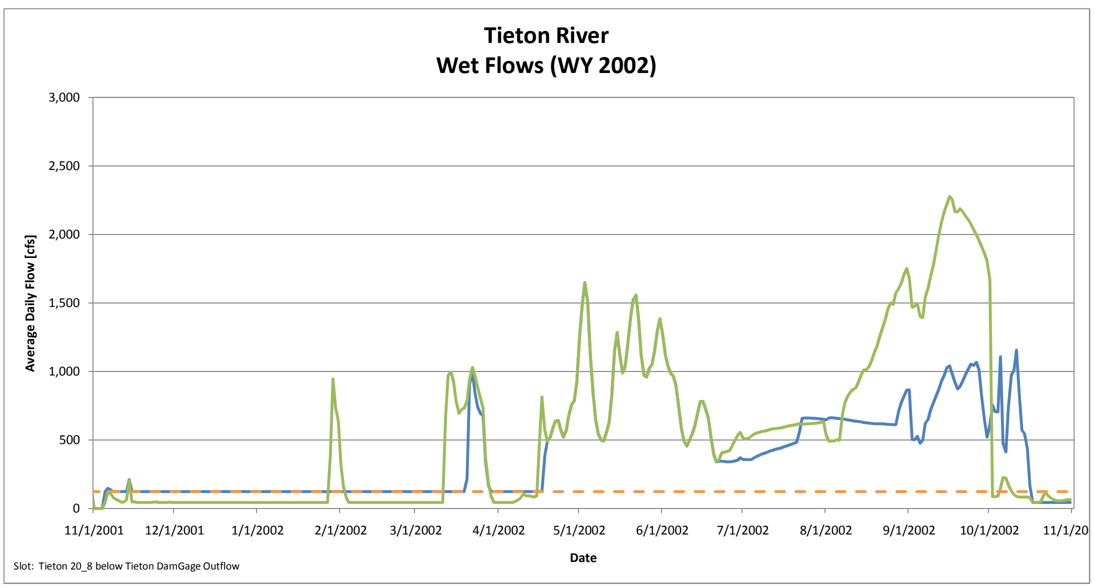
Resource indicator (measurement)	IP CC HADGEM 61% Proration (most adverse)	FWIP IP CC HADGEM 61% Proration (most adverse)
ANADROMOUS FISH		
Rate of change in flow during flip-flop (average cfs/day August 16–September 14)		
Easton reach	-9	-27
Ellensburg reach	-24	-74
Lower Naches River reach	8	41
Pre- (August 1-15) and post- (September 14-28) flip-flop flow and absolute change in flow		
Easton reach		
Pre-flip-flop flow (cfs)	574	1,007
Post-flip-flop flow (cfs)	299	221
Absolute change in flow (cfs)	-274	-786
Ellensburg reach		
Pre-flip-flop flow (cfs)	1,728	2,921
Post-flip-flop flow (cfs)	1,027	787
Absolute change in flow (cfs)	-701	-2,134
Lower Naches River reach		
Pre-flip-flop flow (cfs)	929	450
Post-flip-flop flow (cfs)	1,171	1,631
Absolute change in flow (cfs)	242	1,181
Average, minimum, and maximum reservoir elevation (feet) during bull trout spawning migration: July 15–September 15 (feet)		
Kachess Lake	2163.53 2111.62-2245.06	2219.99 2197.26-2250.44
Keechelus Lake	2434.72 2427.26-2477.77	2446.56 2431.77-2487.87
Rimrock Lake	2885.06 2800.91-2925.22	2897.46 2842.34-2924.51

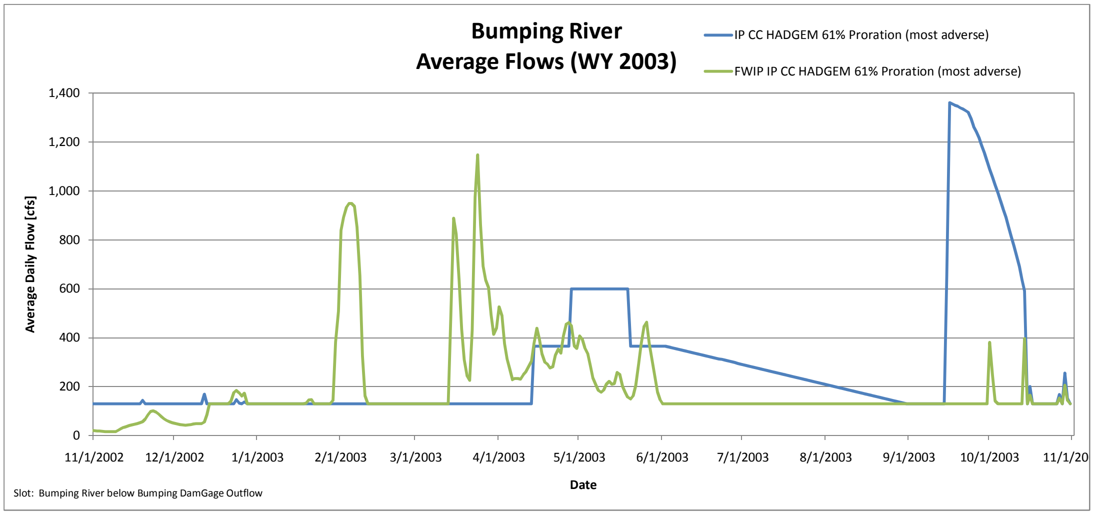
Hydrologic Indicator	IP CC HADGEM 61% Proration (most adverse)					FWIP IP CC HADGEM 61% Proration (most adverse)				
	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997	Average 1981-2005	Drought Year 1994	Drought Year 2001	Drought Year 2005	Wet Year 1997
April 1 TWSA (maf)	2.02	1.43	1.38	1.58	2.95	1.84	1.30	0.85	1.48	2.93
April-September flow volume at Parker gage (kaf)	303	208	196	247	876	361	233	227	300	992
March-October flow volume at Parker gage (kaf)	652	468	313	470	1662	720	517	365	541	1759
April-September diversion volume upstream of Parker gage (maf)	1.43	1.09	1.07	1.16	1.80	1.29	0.97	0.53	1.08	1.71
September 30 non-Bumping or Wymer reservoir contents (kaf)	-90	-180	-182	-161	111	61	93	73	60	70
October 31 non-Bumping or Wymer reservoir contents (kaf)	-86	-156	-161	-168	121	56	60	53	49	92
September 30 Bumping and Wymer reservoir contents (kaf)	89	37	15	8	235	9	9	2	10	12
April-September flow volume at mouth of Yakima River (kaf)	518	350	362	481	1274	551	339	338	500	1373
Irrigation proration level (percent)[1]	50%	14%	10%	21%	89%	30%	0%	0%	4%	73%

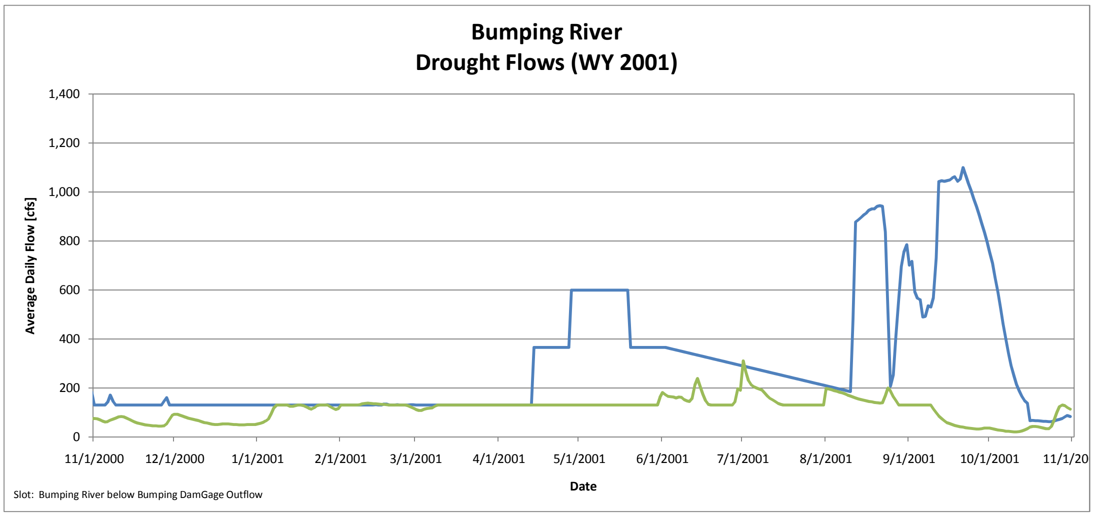
Item	FWIP IP CC HADGEM 61% Proration (most adverse)	IP CC HADGEM 61% Proration (most adverse)	Improvement
Average 1981-2005			
TWSA [April 1, kaf]	1839.3	2017.5	178.2
March-October flow volume at Parker gage [kaf]	719.7	651.9	-67.7
Drought Year 1994			
TWSA [April 1, kaf]	1304.8	1434.0	129.2
March-October flow volume at Parker gage [kaf]	517.0	468.2	-48.8
Drought Year 2001			
TWSA [April 1, kaf]	847.9	1382.7	534.7
March-October flow volume at Parker gage [kaf]	365.4	313.0	-52.4
Drought Year 2005			
TWSA [April 1, kaf]	1477.2	1582.2	105.0
March-October flow volume at Parker gage [kaf]	541.1	470.0	-71.0
Wet Year 1997			
TWSA [April 1, kaf]	2930.6	2953.7	23.2
March-October flow volume at Parker gage [kaf]	1758.6	1661.6	-97.0

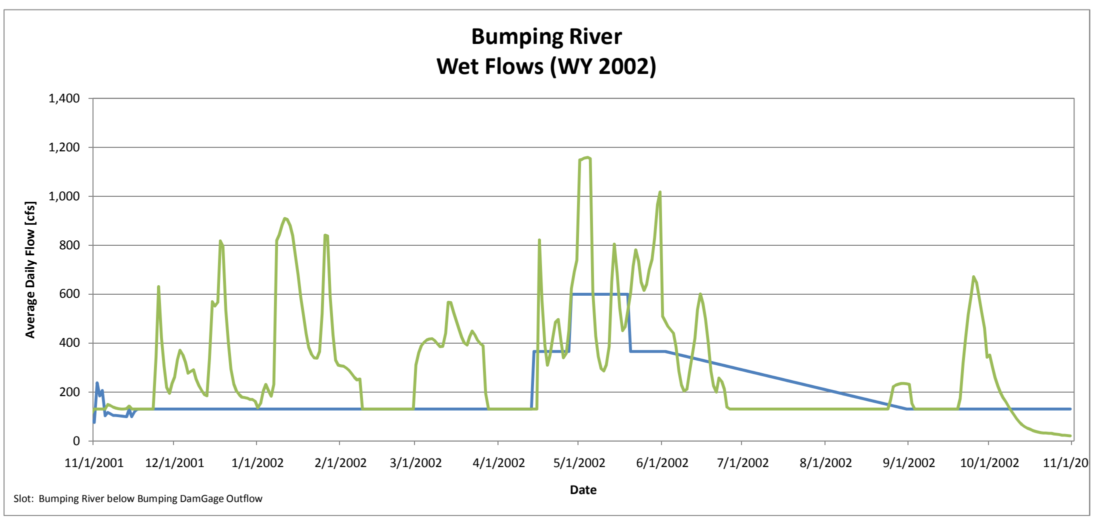

Tieton River
Average Flows (WY 2003)
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Proposed ISF Targets
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

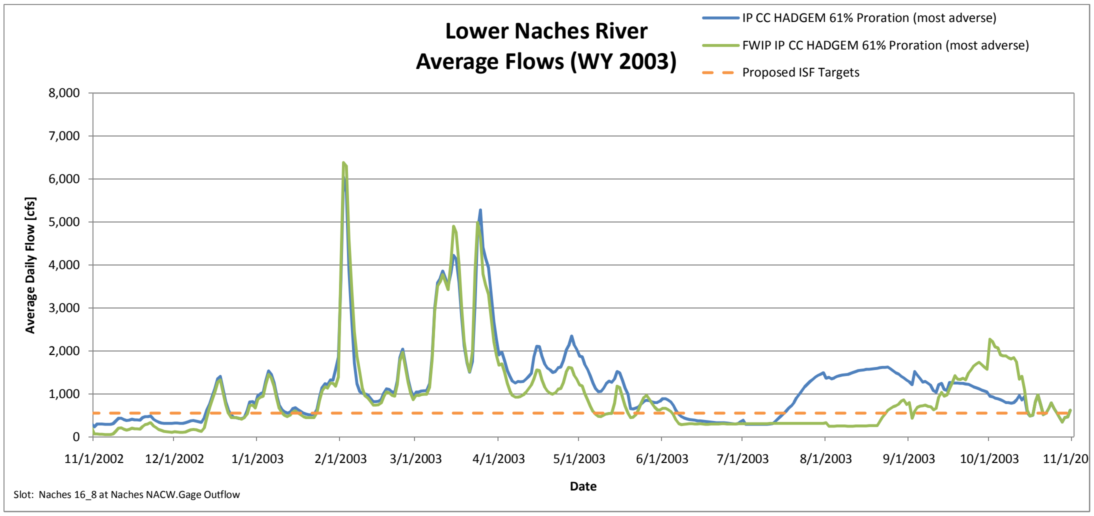

Tieton River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

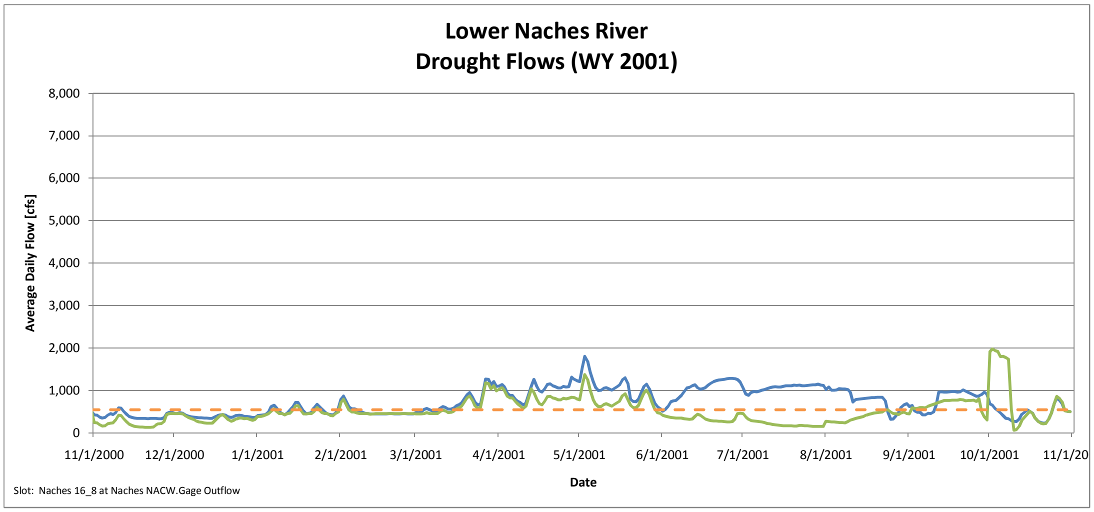

Tieton River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
3,000
2,500
2,000
1,500
1,000
500
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Tieton 20_8 below Tieton DamGage Outflow

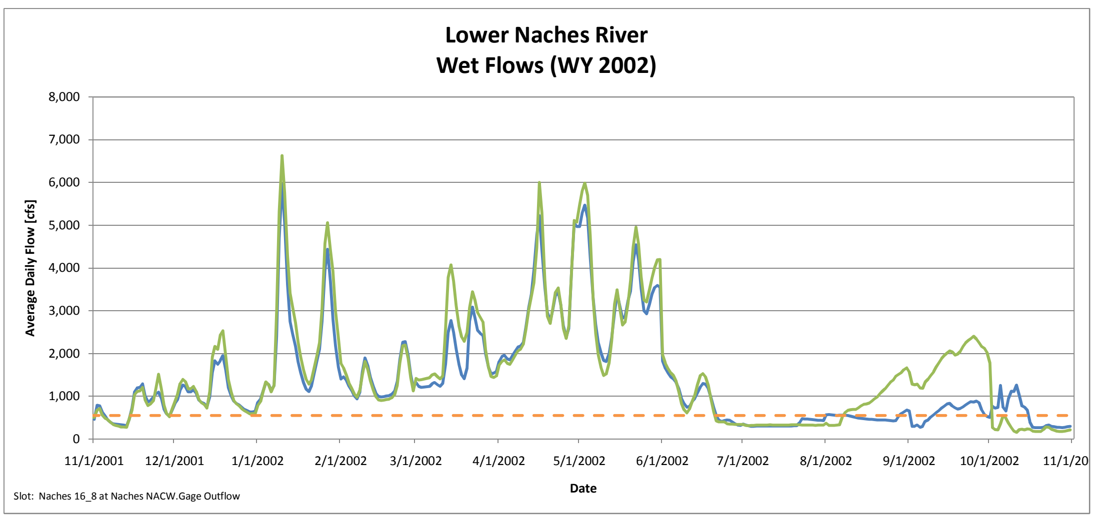

Bumping River
Average Flows (WY 2003)
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

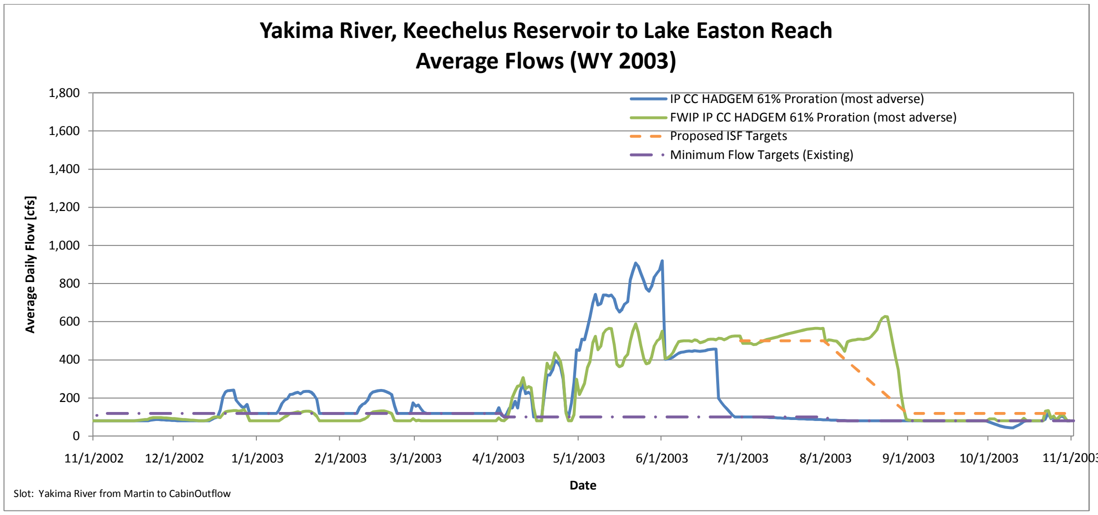

Bumping River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

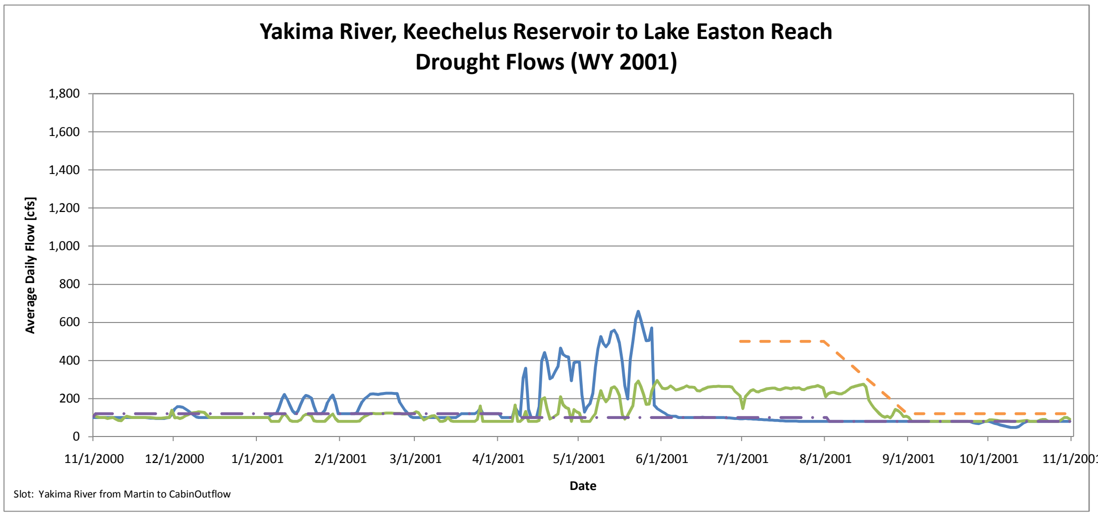

Bumping River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
1,400
1,200
1,000
800
600
400
200
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Bumping River below Bumping DamGage Outflow

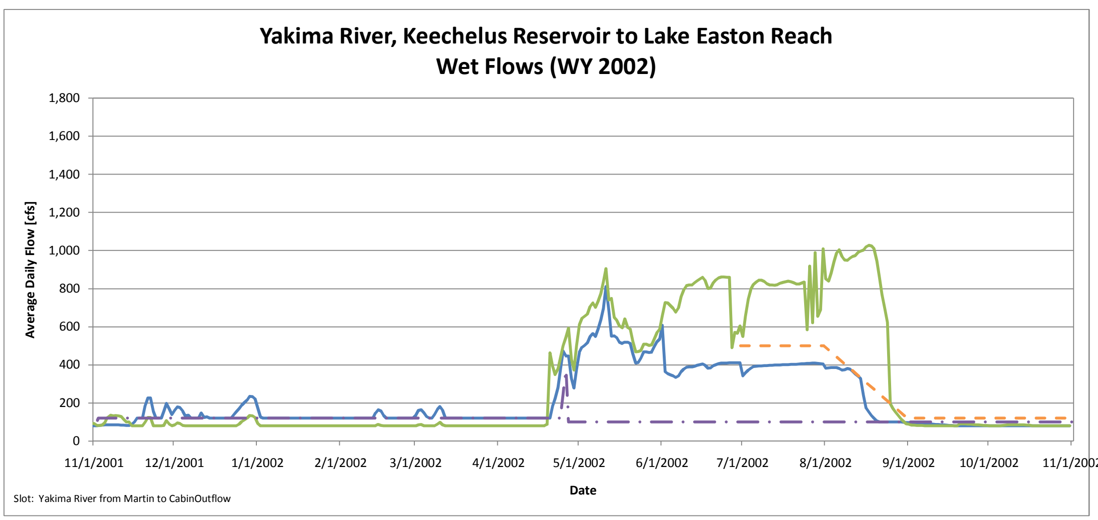

Lower Naches River
Average Flows (WY 2003)
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Proposed ISF Targets
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

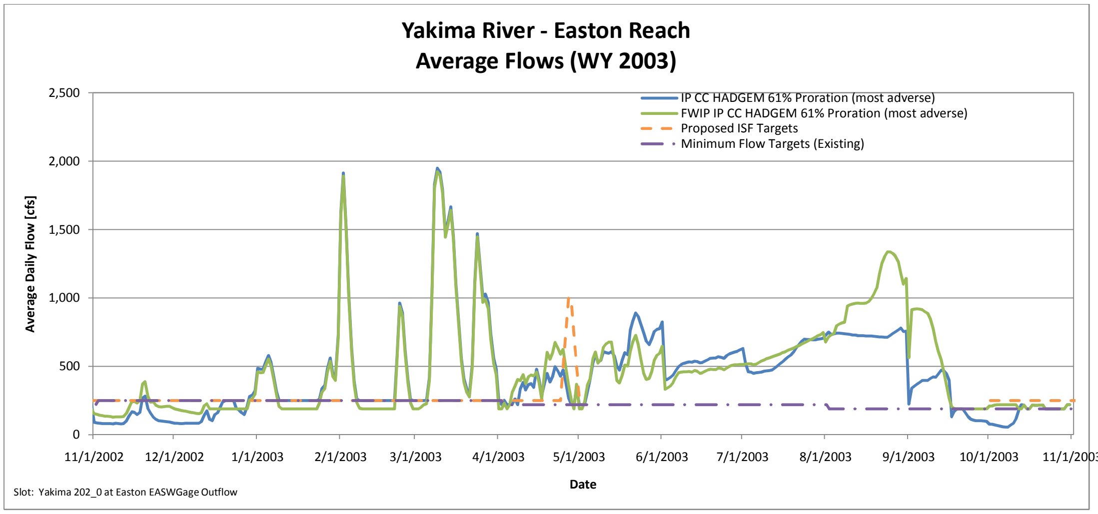

Lower Naches River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

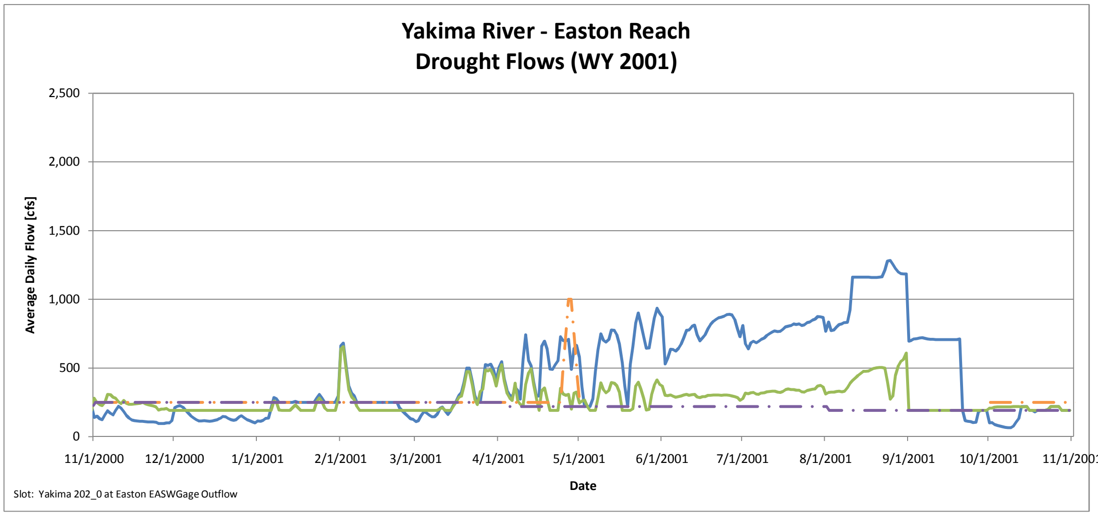

Lower Naches River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Naches 16_8 at Naches NACW.Gage Outflow

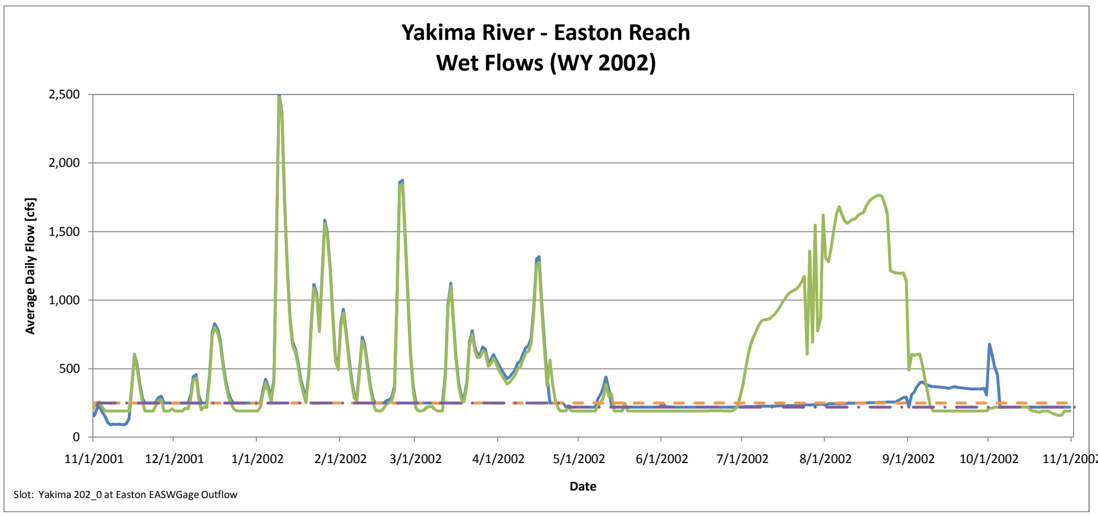

Yakima River, Keechelus Reservoir to Lake Easton Reach
Average Flows (WY 2003)
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Proposed ISF Targets
Minimum Flow Targets (Existing)
Average Daily Flow [cfs]
Date
Slot: Yakima River from Martin to CabinOutflow

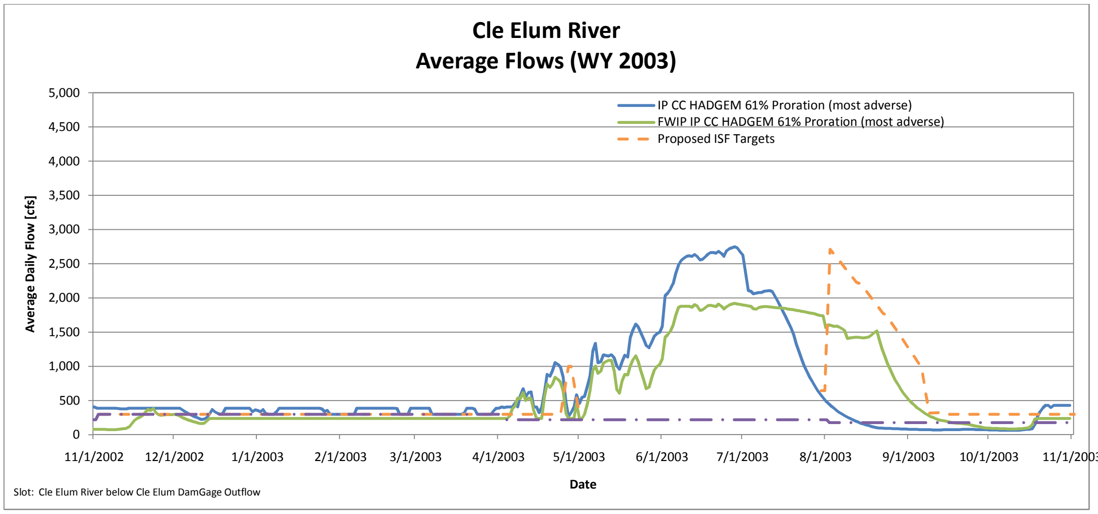

Yakima River, Keechelus Reservoir to Lake Easton Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
Date
Slot: Yakima River from Martin to CabinOutflow

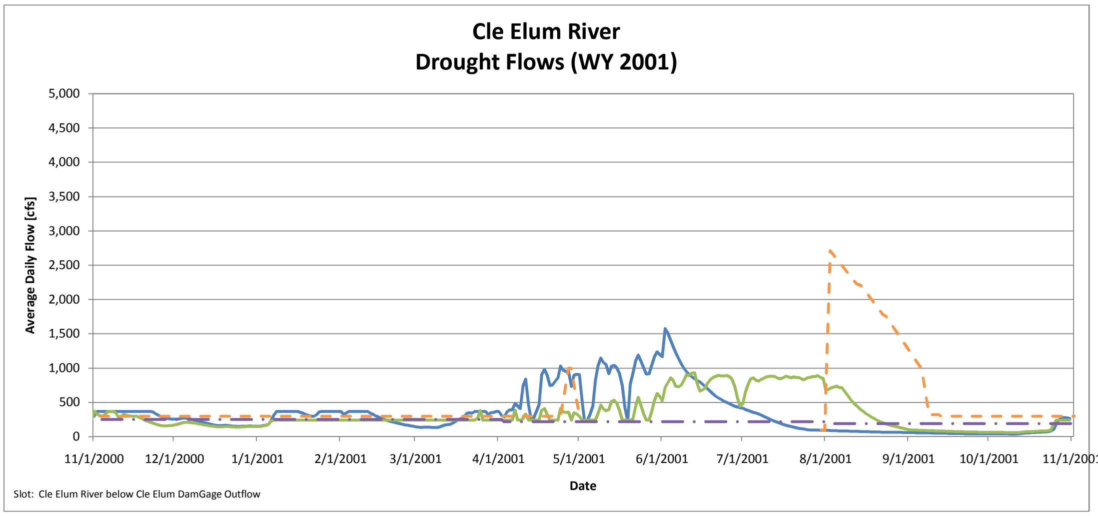

Yakima River, Keechelus Reservoir to Lake Easton Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
Date
Slot: Yakima River from Martin to CabinOutflow

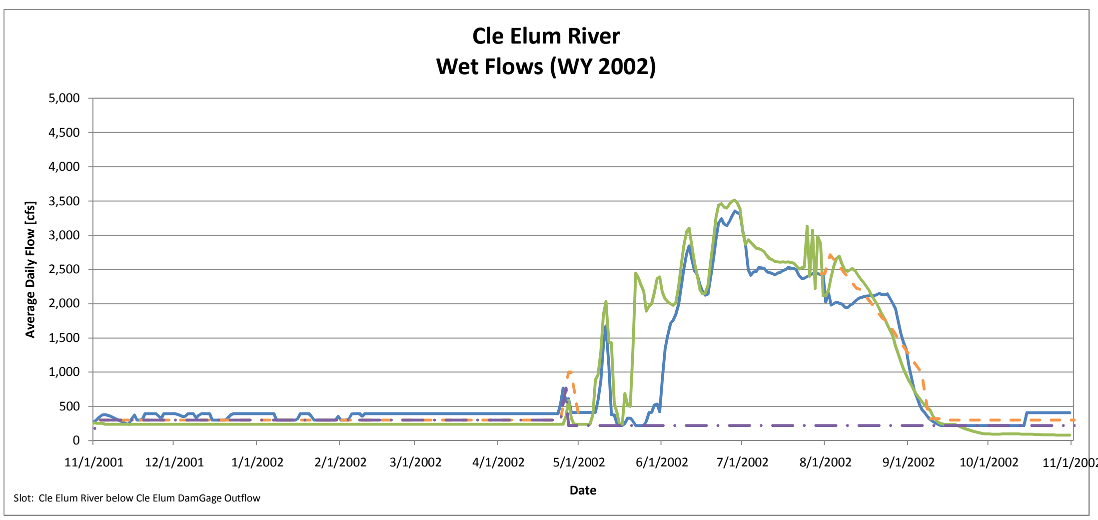

Yakima River - Easton Reach
Average Flows (WY 2003)
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Proposed ISF Targets
Minimum Flow Targets (Existing)
Average Daily Flow [cfs]
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

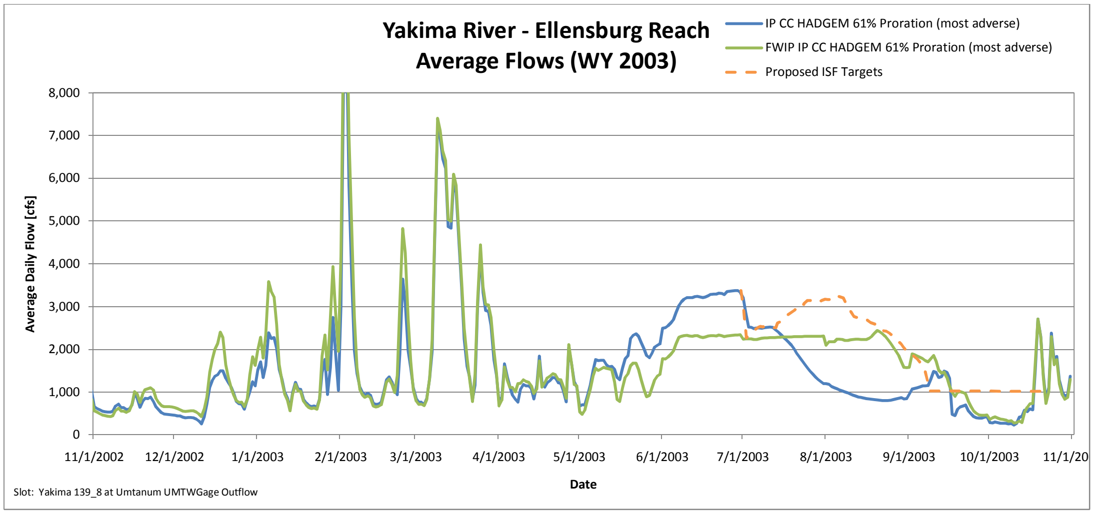

Yakima River - Easton Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

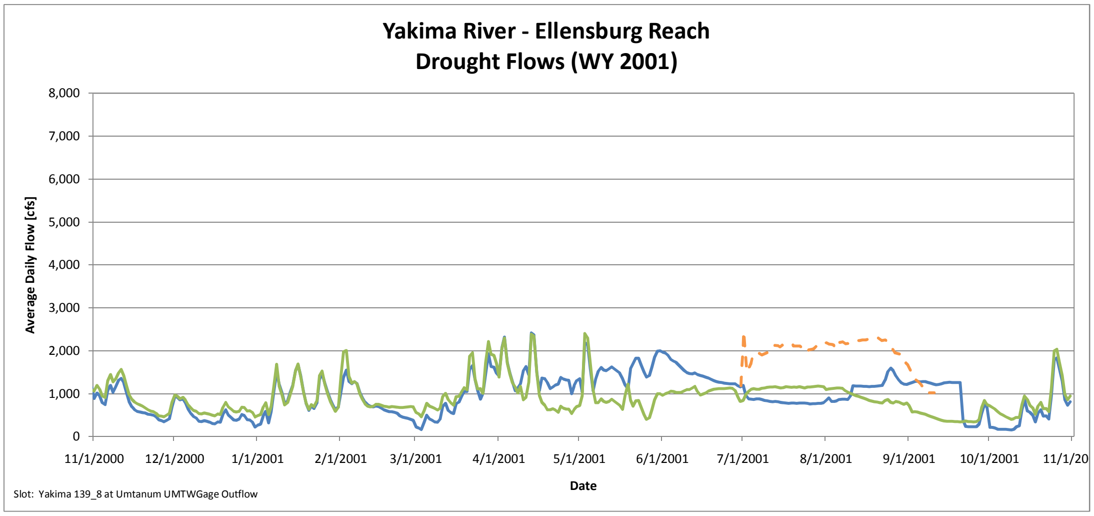

Yakima River - Easton Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
Date
Slot: Yakima 202_0 at Easton EASWGage Outflow

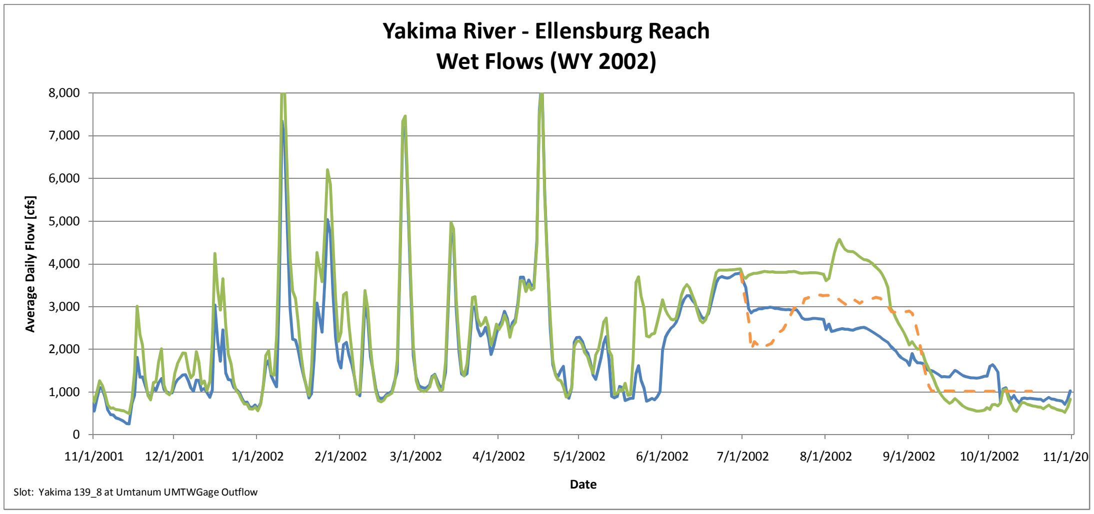

Cle Elum River
Average Flows (WY 2003)
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Proposed ISF Targets
Average Daily Flow [cfs]
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

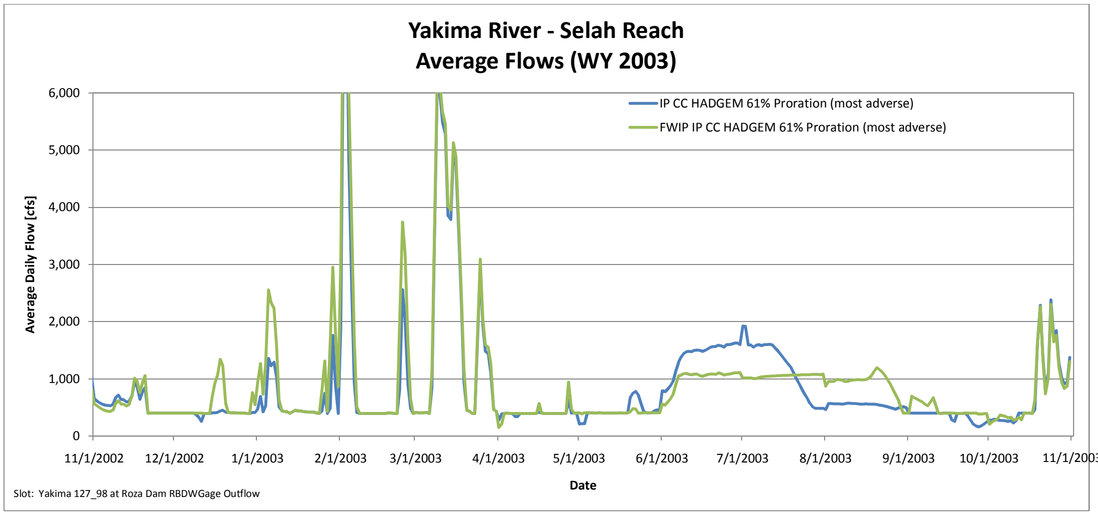

Cle Elum River
Drought Flows (WY 2001)
Average Daily Flow [cfs]
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

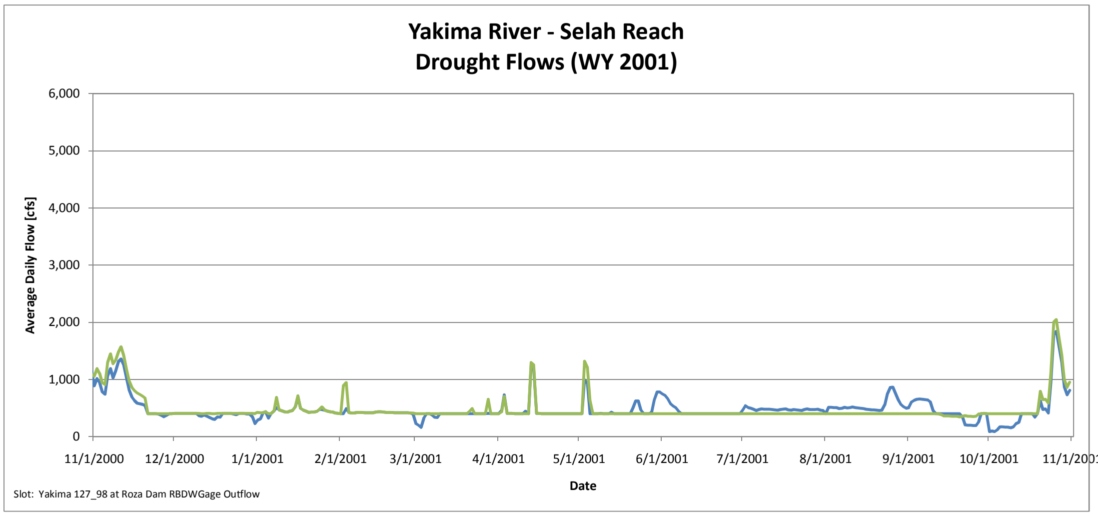

Cle Elum River
Wet Flows (WY 2002)
Average Daily Flow [cfs]
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Cle Elum River below Cle Elum DamGage Outflow

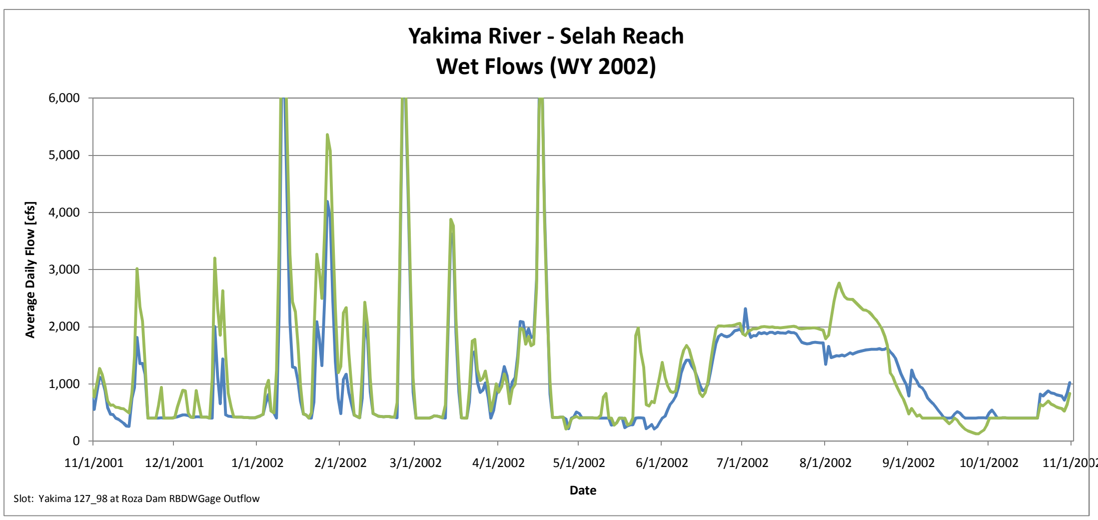

Yakima River - Ellensburg Reach
Average Flows (WY 2003)
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Proposed ISF Targets
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

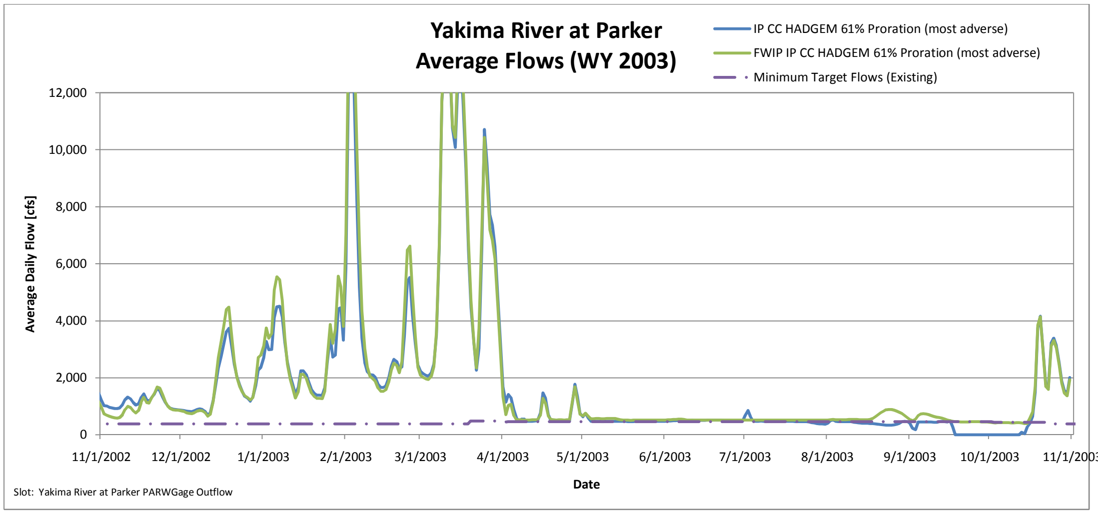

Yakima River - Ellensburg Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

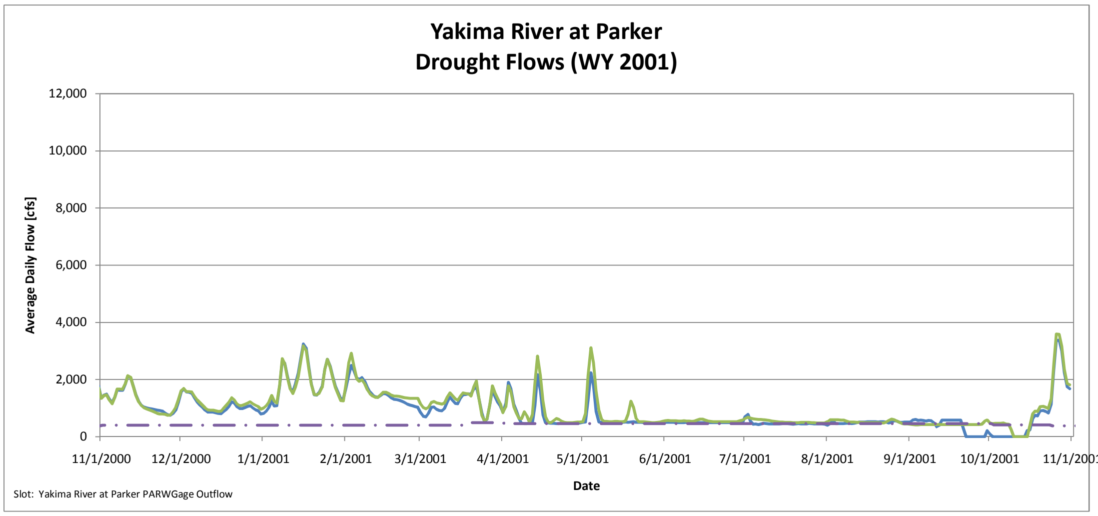

Yakima River - Ellensburg Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Yakima 139_8 at Umtanum UMTWGage Outflow

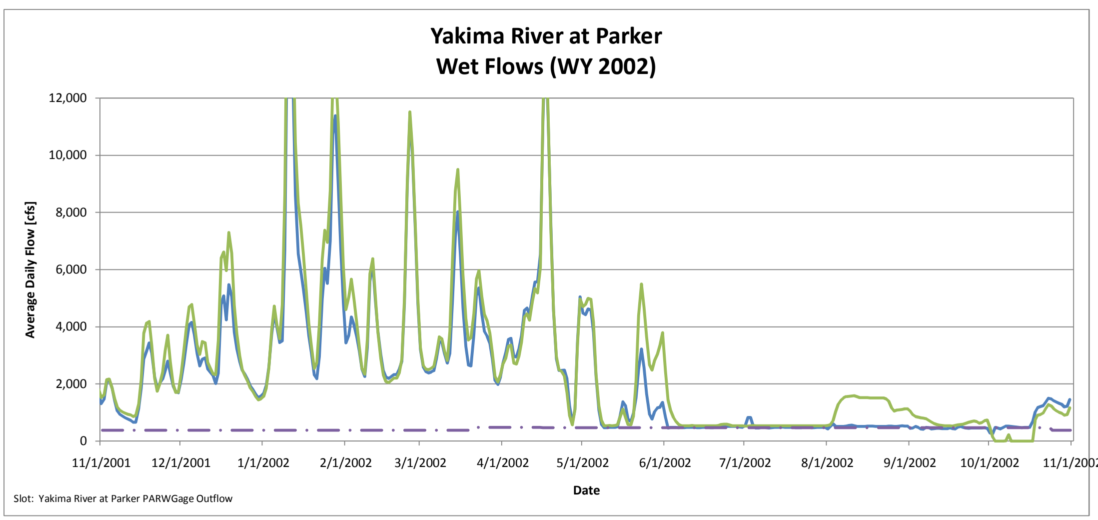

Yakima River - Selah Reach
Average Flows (WY 2003)
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Average Daily Flow [cfs]
0
1,000
2,000
3,000
4,000
5,000
6,000
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

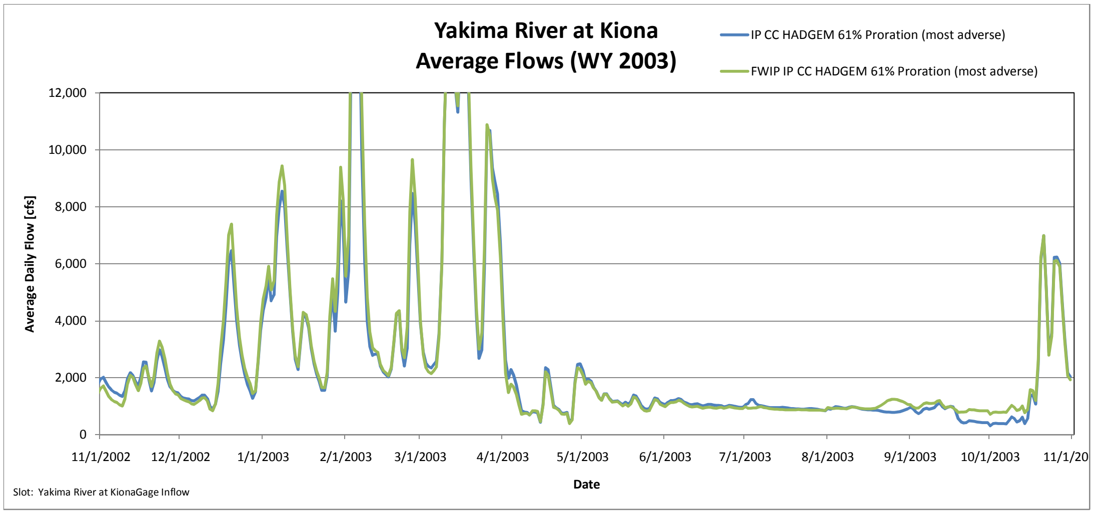

Yakima River - Selah Reach
Drought Flows (WY 2001)
Average Daily Flow [cfs]
0
1,000
2,000
3,000
4,000
5,000
6,000
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

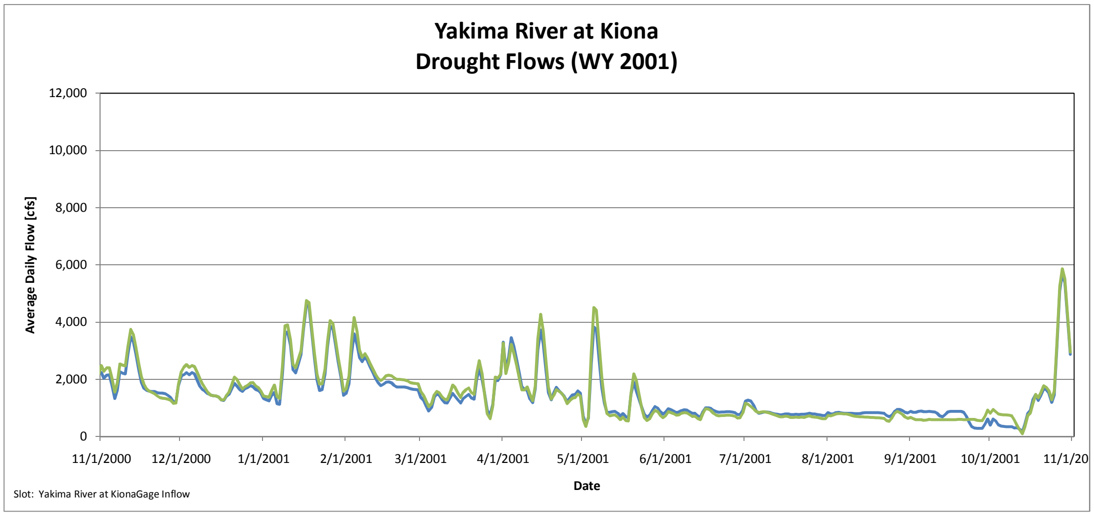

Yakima River - Selah Reach
Wet Flows (WY 2002)
Average Daily Flow [cfs]
0
1,000
2,000
3,000
4,000
5,000
6,000
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima 127_98 at Roza Dam RBDWGage Outflow

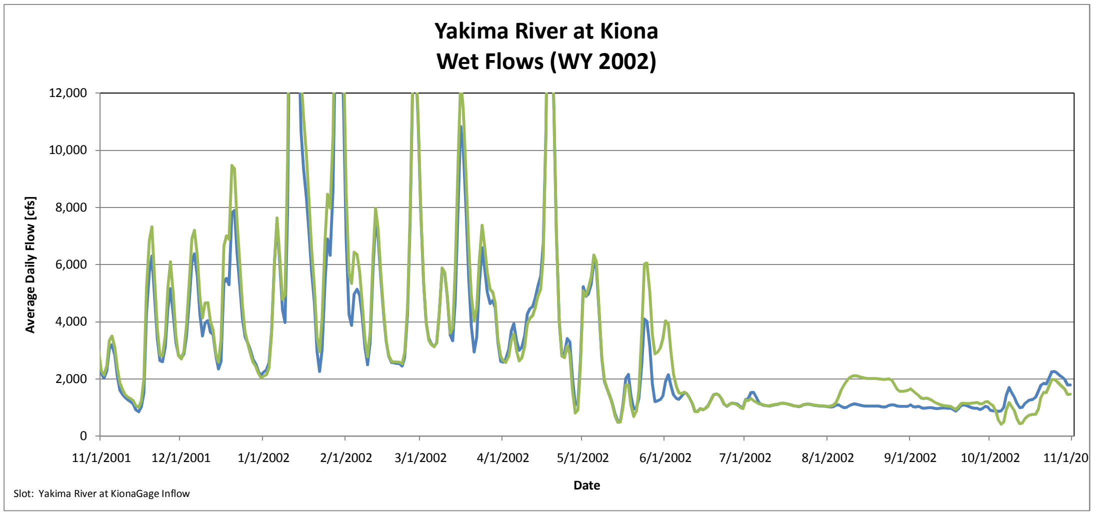

Yakima River at Parker
Average Flows (WY 2003)
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Minimum Target Flows (Existing)
12,000
10,000
8,000
6,000
4,000
2,000
0
Average Daily Flow [cfs]
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Slot: Yakima River at Parker PARWGage Outflow

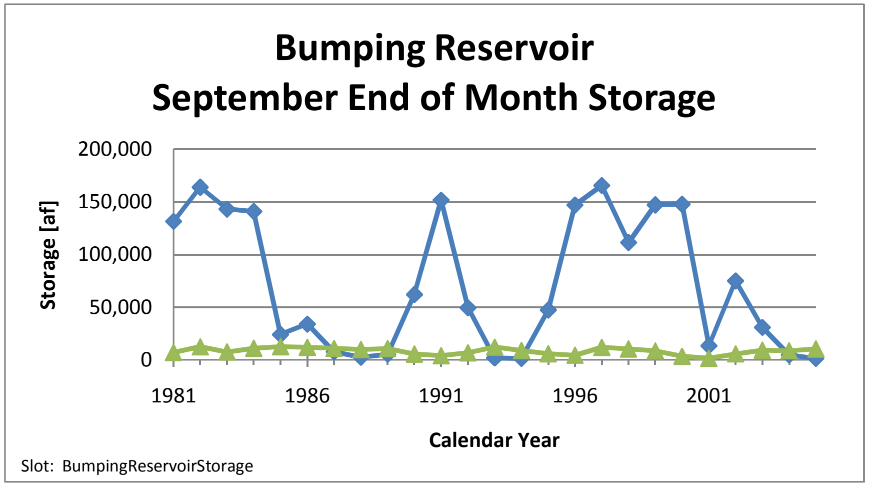

Yakima River at Parker
Drought Flows (WY 2001)
12,000
10,000
8,000
6,000
4,000
2,000
0
Average Daily Flow [cfs]
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/2001
Date
Slot: Yakima River at Parker PARWGage Outflow

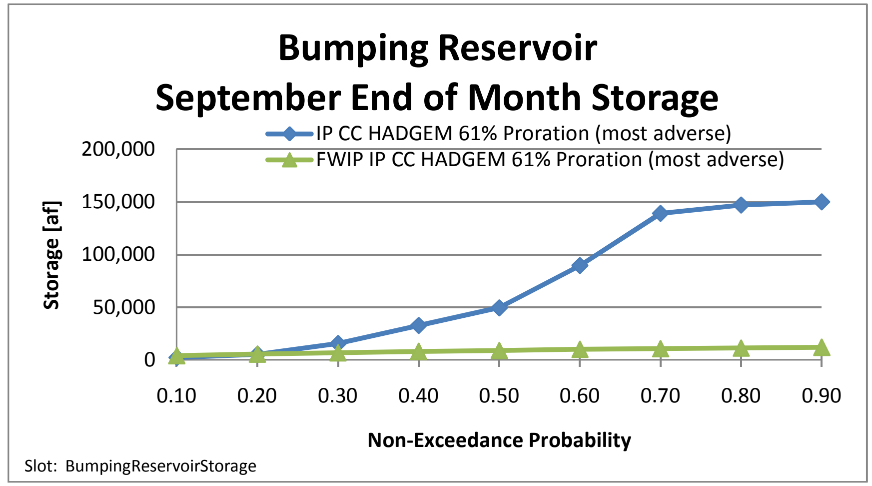

Yakima River at Parker
Wet Flows (WY 2002)
12,000
10,000
8,000
6,000
4,000
2,000
0
Average Daily Flow [cfs]
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/2002
Date
Slot: Yakima River at Parker PARWGage Outflow

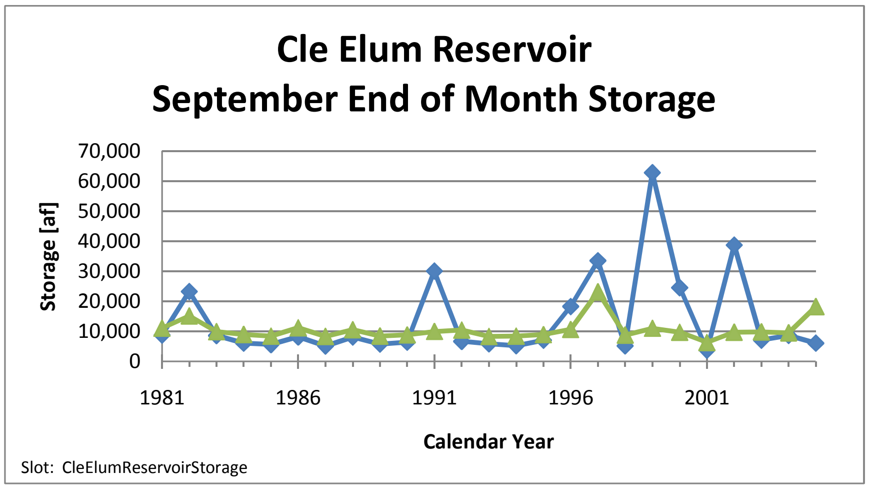

Yakima River at Kiona
Average Flows (WY 2003)
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Average Daily Flow [cfs]
0
2,000
4,000
6,000
8,000
10,000
12,000
11/1/2002
12/1/2002
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

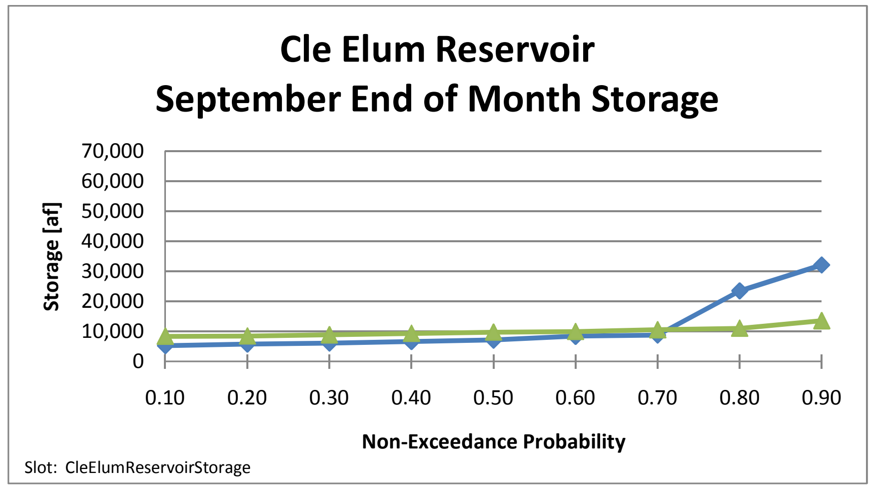

Yakima River at Kiona
Drought Flows (WY 2001)
Average Daily Flow [cfs]
0
2,000
4,000
6,000
8,000
10,000
12,000
11/1/2000
12/1/2000
1/1/2001
2/1/2001
3/1/2001
4/1/2001
5/1/2001
6/1/2001
7/1/2001
8/1/2001
9/1/2001
10/1/2001
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

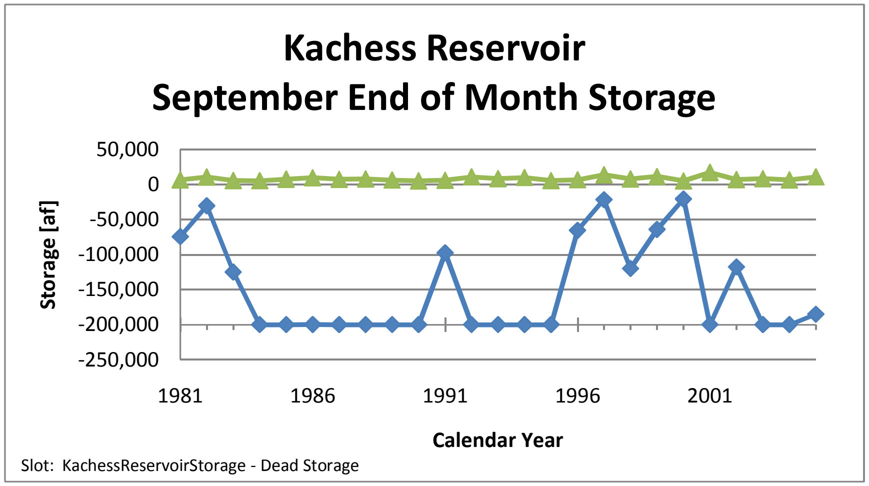

Yakima River at Kiona
Wet Flows (WY 2002)
Average Daily Flow [cfs]
0
2,000
4,000
6,000
8,000
10,000
12,000
11/1/2001
12/1/2001
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
8/1/2002
9/1/2002
10/1/2002
11/1/20
Date
Slot: Yakima River at KionaGage Inflow

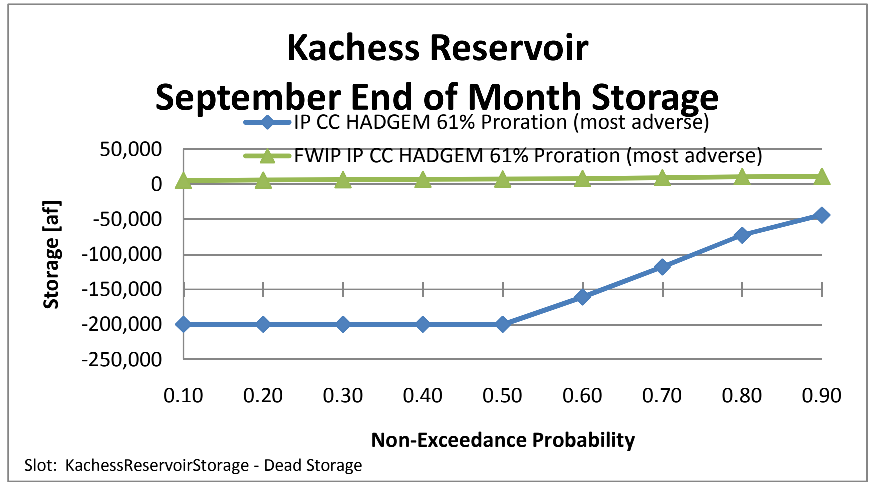

Bumping Reservoir
September End of Month Storage
Storage [af]
200,000
150,000
100,000
50,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: BumpingReservoirStorage

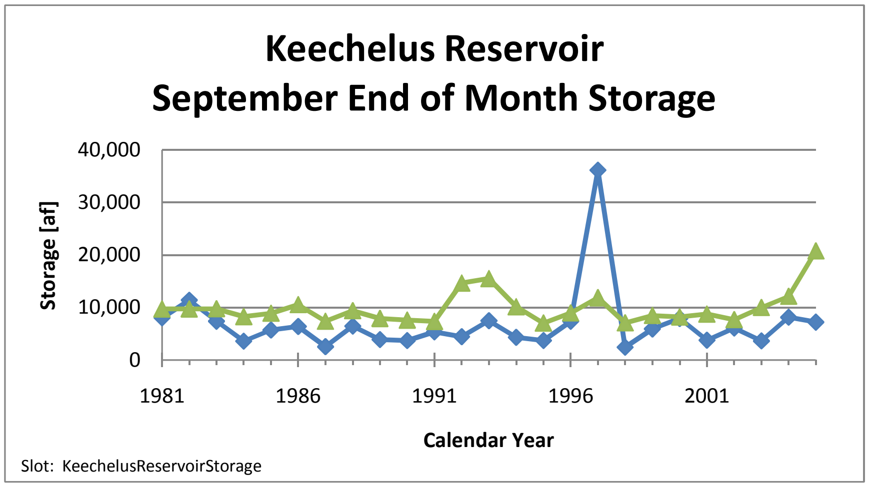

Bumping Reservoir
September End of Month Storage
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Storage [af]
200,000
150,000
100,000
50,000
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: BumpingReservoirStorage

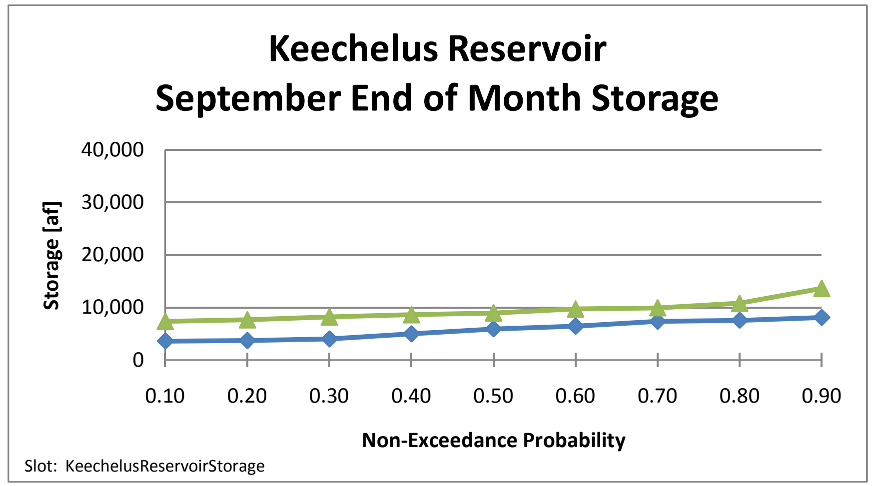

Cle Elum Reservoir
September End of Month Storage
Storage [af]
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1981
1986
1991
1996
2001
Calendar Year
Slot: CleElumReservoirStorage

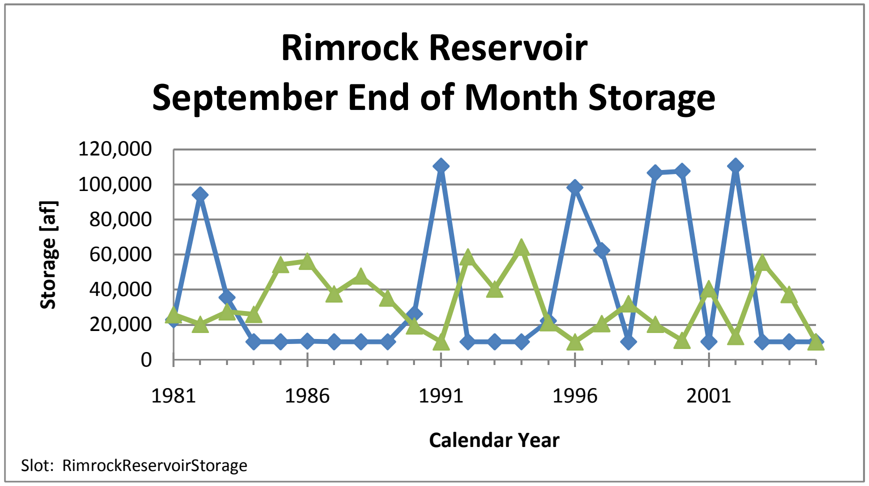

Cle Elum Reservoir
September End of Month Storage
Storage [af]
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: CleElumReservoirStorage

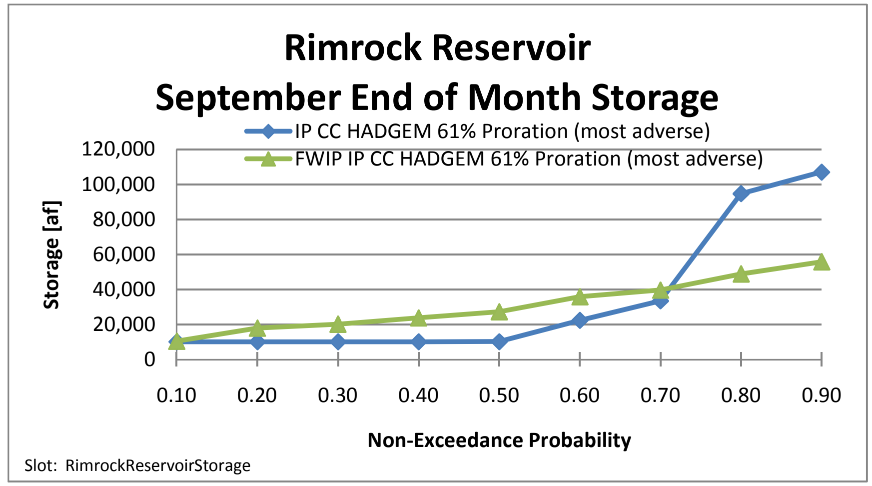

Kachess Reservoir
September End of Month Storage
50,000
0
-50,000
-100,000
-150,000
-200,000
-250,000
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: KachessReservoirStorage - Dead Storage

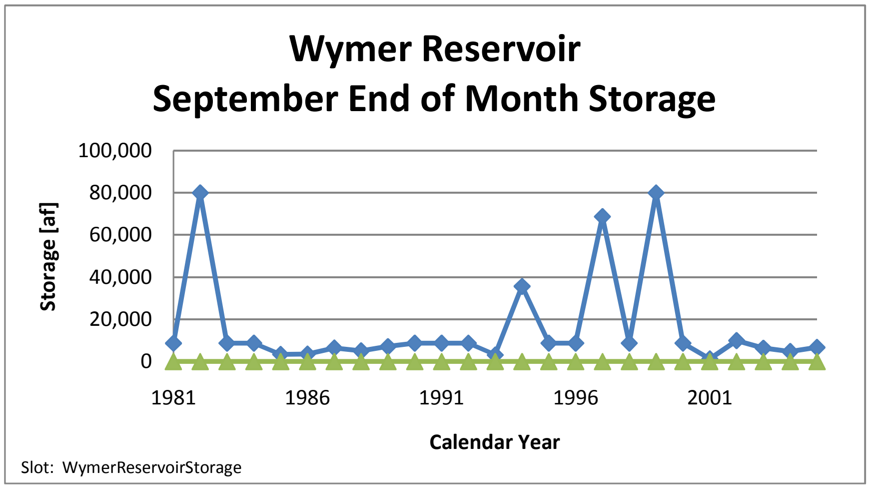

Kachess Reservoir
September End of Month Storage
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
50,000
0
-50,000
-100,000
-150,000
-200,000
-250,000
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KachessReservoirStorage - Dead Storage

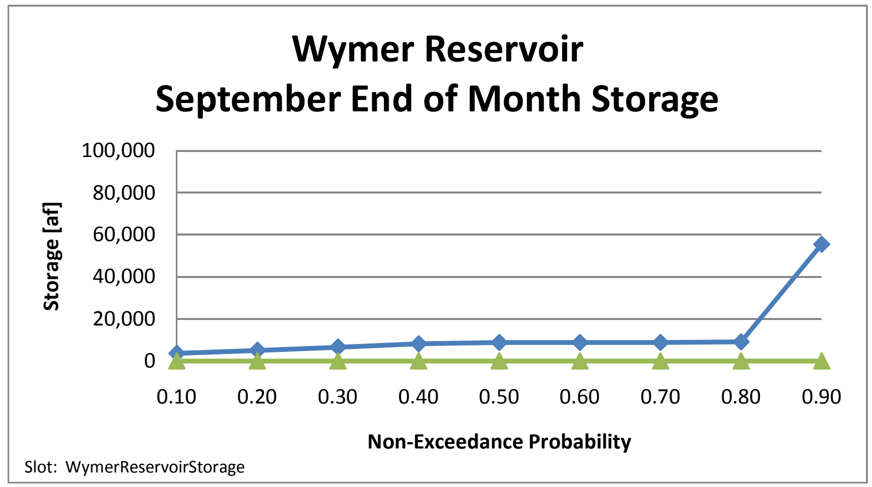

Keechelus Reservoir
September End of Month Storage
40,000
30,000
20,000
10,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: KeechelusReservoirStorage

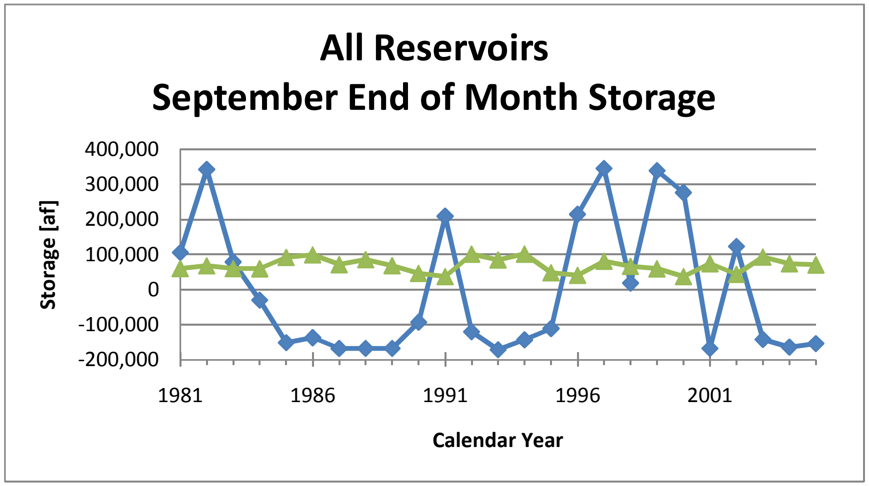

Keechelus Reservoir
September End of Month Storage
40,000
30,000
20,000
10,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: KeechelusReservoirStorage

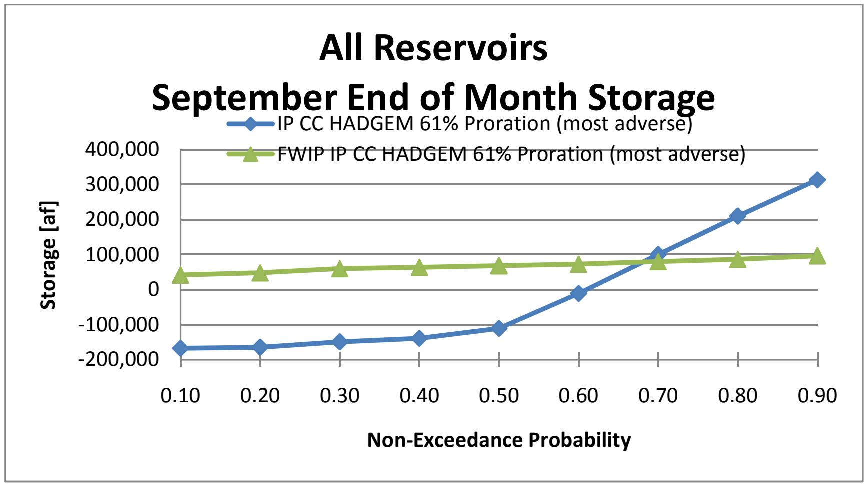

Rimrock Reservoir
September End of Month Storage
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: RimrockReservoirStorage

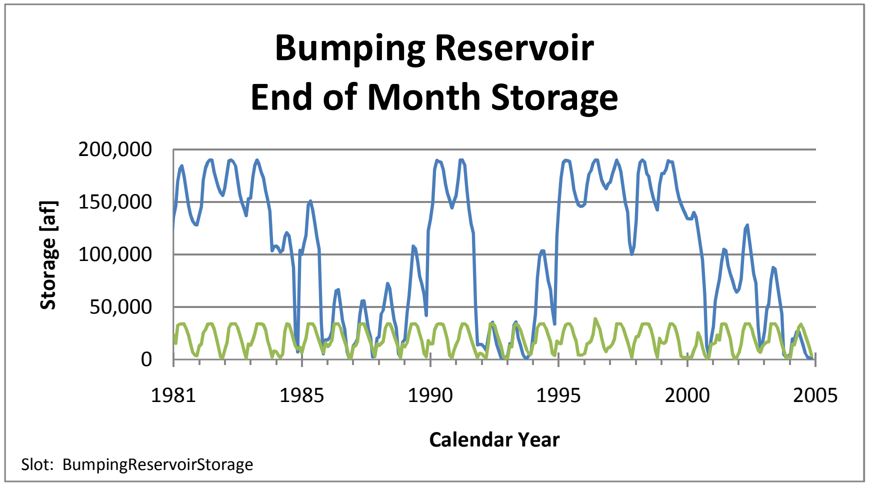

Rimrock Reservoir
September End of Month Storage
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
120,000
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: RimrockReservoirStorage

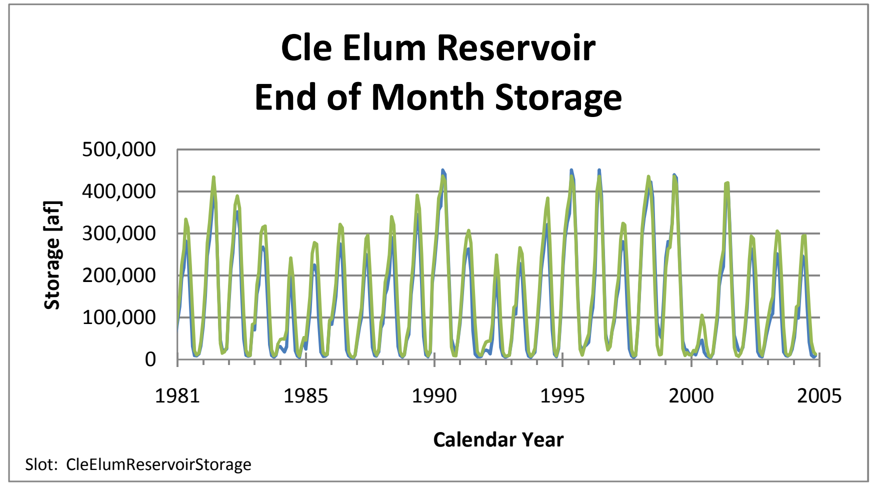

Wymer Reservoir
September End of Month Storage
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
1981
1986
1991
1996
2001
Calendar Year
Slot: WymerReservoirStorage

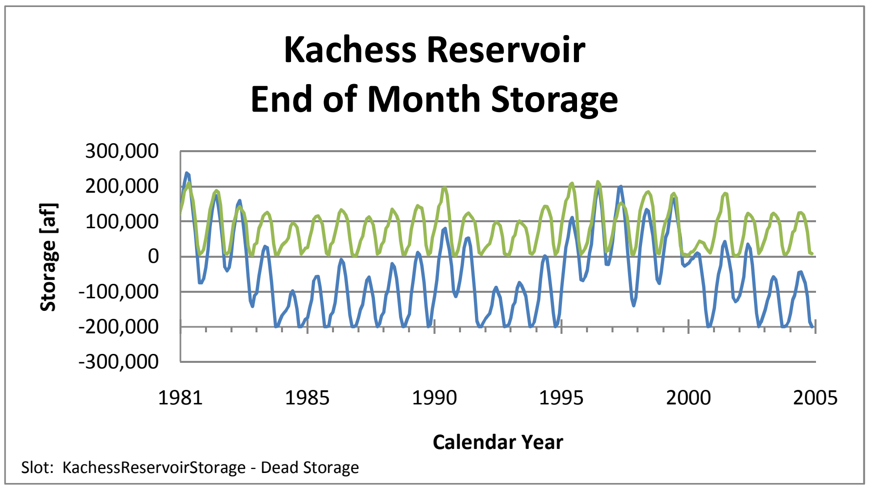

Wymer Reservoir
September End of Month Storage
100,000
80,000
60,000
40,000
20,000
0
Storage [af]
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability
Slot: WymerReservoirStorage

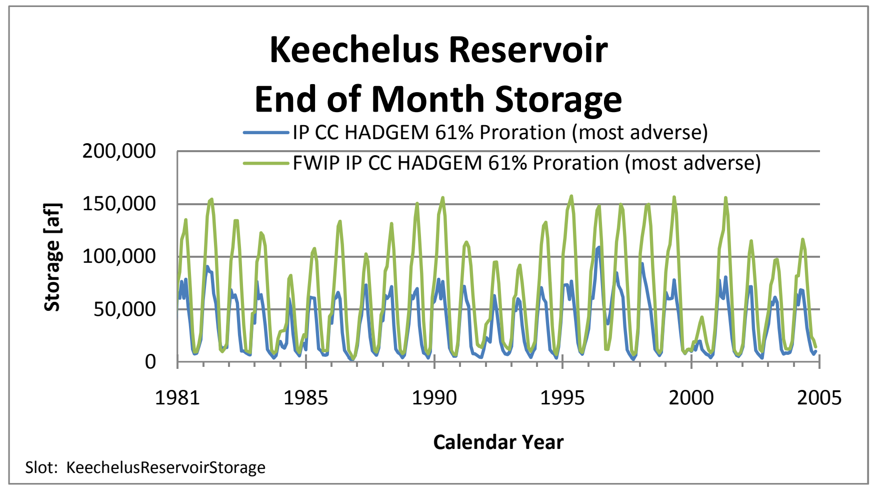

All Reservoirs
September End of Month Storage
Storage [af]
400,000
300,000
200,000
100,000
0
-100,000
-200,000
1981
1986
1991
1996
2001
Calendar Year

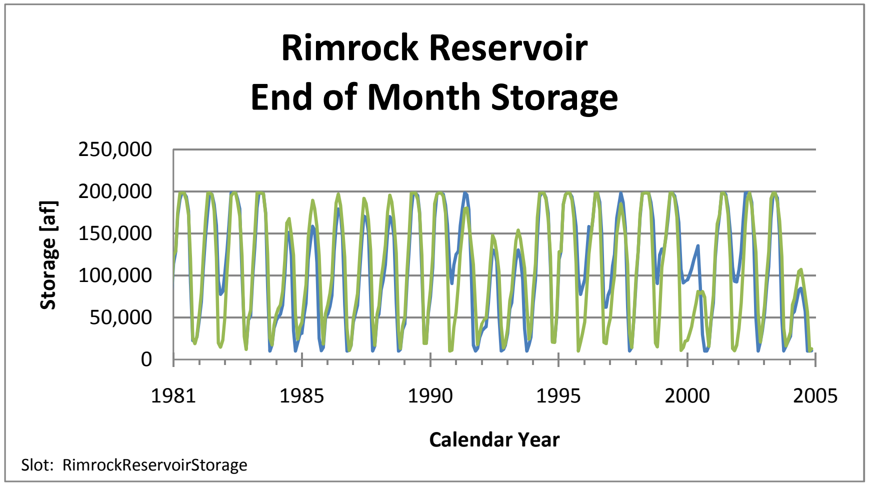

All Reservoirs
September End of Month Storage
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Storage [af]
400,000
300,000
200,000
100,000
0
-100,000
-200,000
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Non-Exceedance Probability

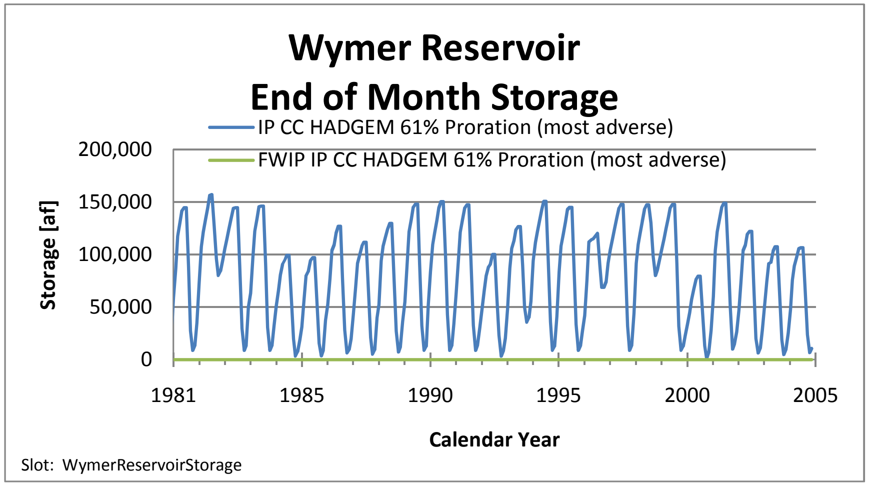

Bumping Reservoir
End of Month Storage
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: BumpingReservoirStorage

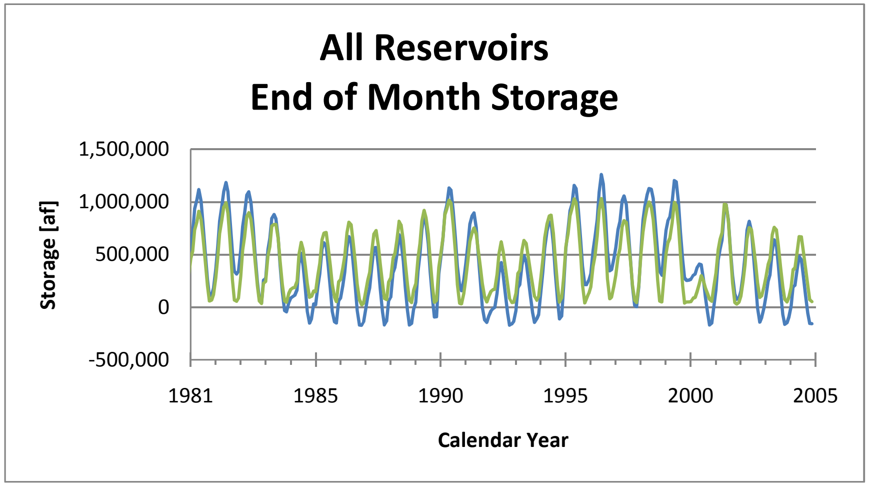

Cle Elum Reservoir
End of Month Storage
500,000
400,000
300,000
200,000
100,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: CleElumReservoirStorage

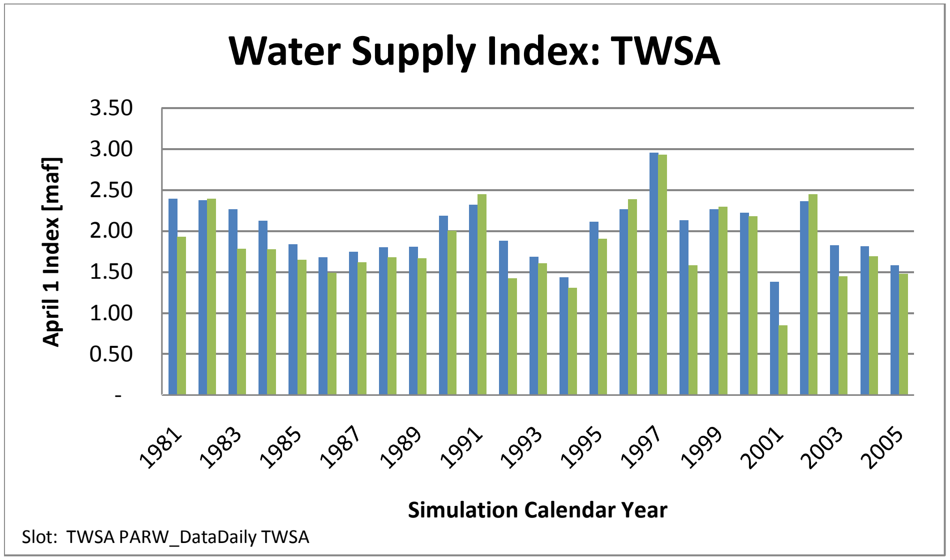

Kachess Reservoir
End of Month Storage
300,000
200,000
100,000
0
-100,000
-200,000
-300,000
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KachessReservoirStorage - Dead Storage

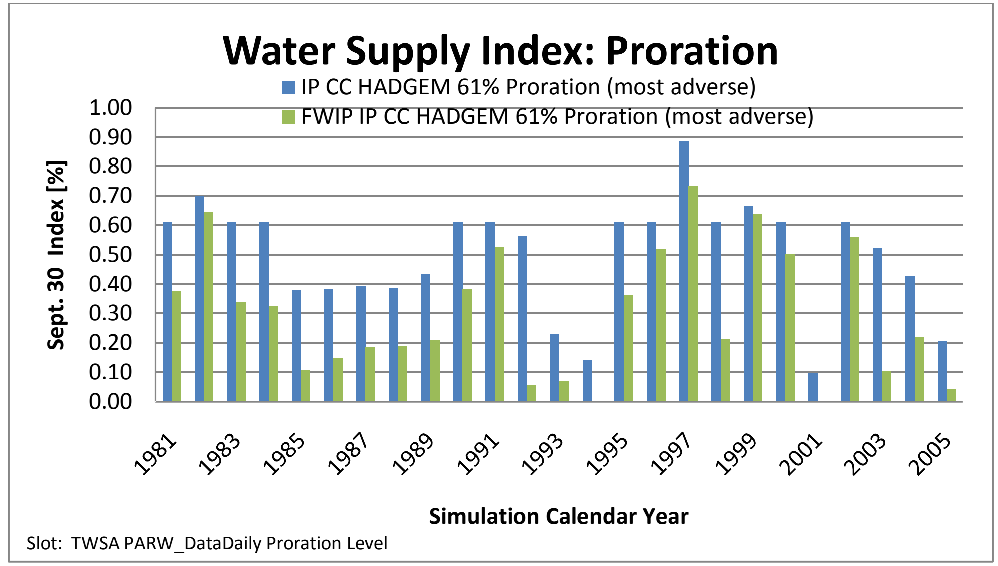

Keechelus Reservoir
End of Month Storage
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: KeechelusReservoirStorage

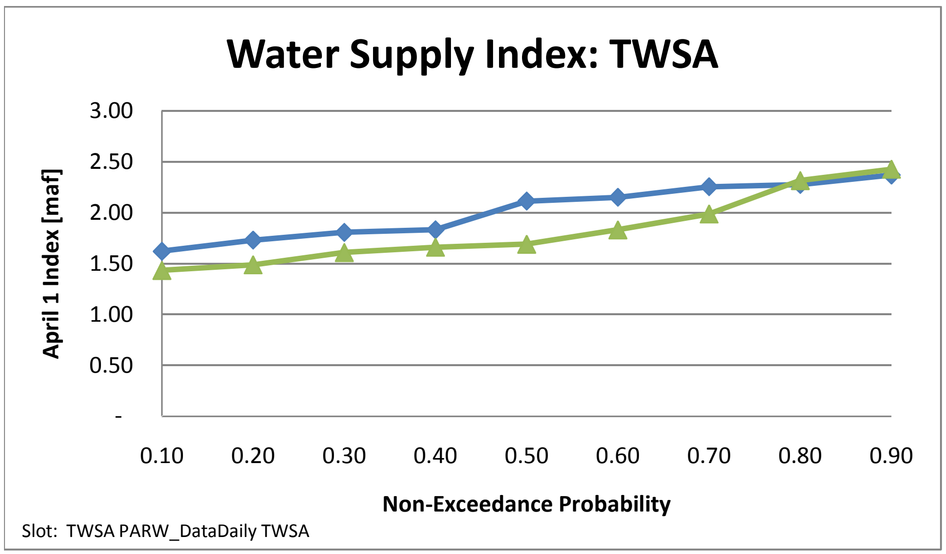

Rimrock Reservoir
End of Month Storage
250,000
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: RimrockReservoirStorage

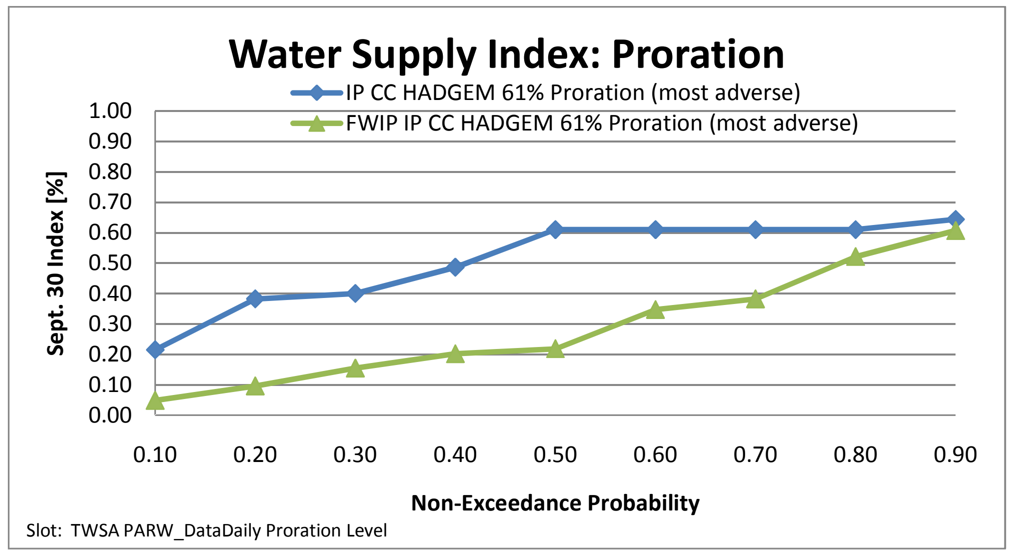

Wymer Reservoir
End of Month Storage
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
200,000
150,000
100,000
50,000
0
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year
Slot: WymerReservoirStorage


All Reservoirs
End of Month Storage
1,500,000
1,000,000
500,000
0
-500,000
Storage [af]
1981
1985
1990
1995
2000
2005
Calendar Year

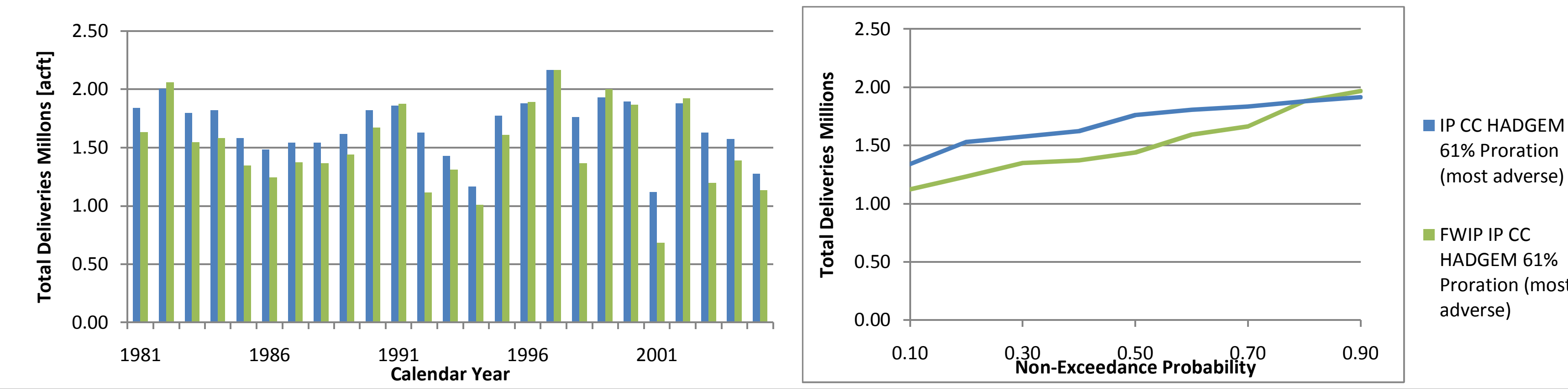

Water Supply Index: TWSA
April 1 Index [maf]
Simulation Calendar Year
Slot: TWSA PARW_DataDaily TWSA


Water Supply Index: Proration
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Sept. 30 Index [%]
Simulation Calendar Year
Slot: TWSA PARW_DataDaily Proration Level

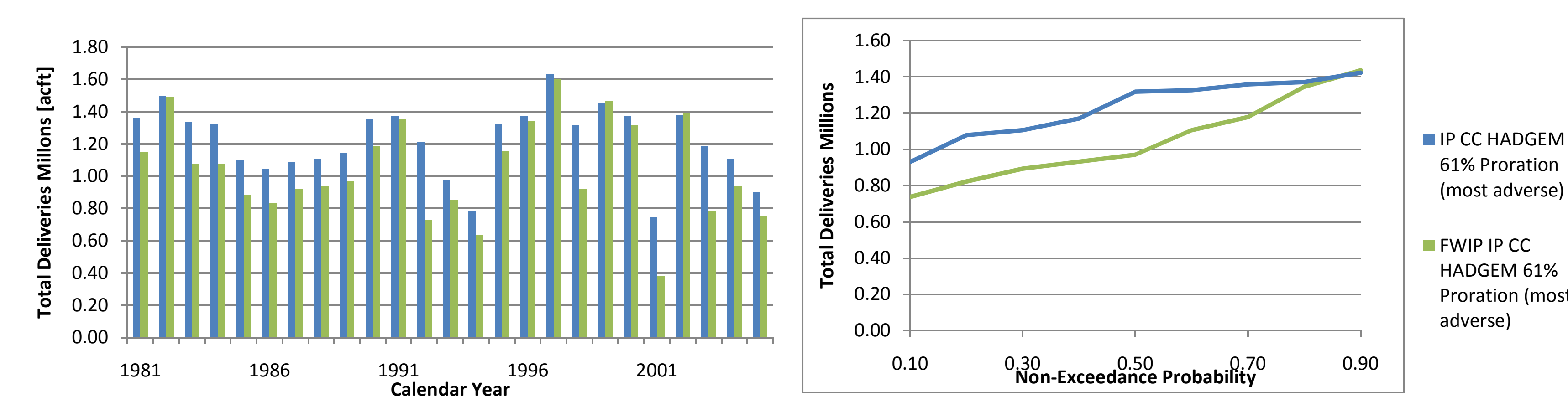

Water Supply Index: TWSA
April 1 Index [maf]
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily TWSA


Water Supply Index: Proration
IP CC HADGEM 61% Proration (most adverse)
FWIP IP CC HADGEM 61% Proration (most adverse)
Sept. 30 Index [%]
Non-Exceedance Probability
Slot: TWSA PARW_DataDaily Proration Level

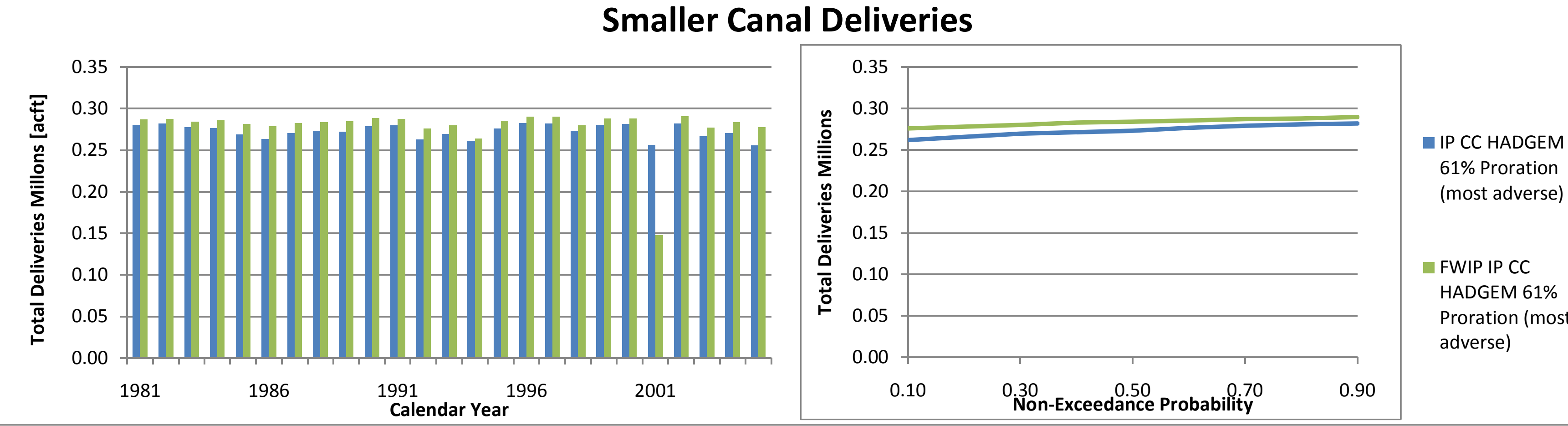
Main Canal Deliveries



Sunnyside, KRD Irrigation, Roza Irrigation, New Reservation Canal, Tieton, and Kennewick Deliveries



Smaller Canal Deliveries



M&I Surface Water Deliveries