Yakima River Basin Study

Instream Flow Needs
Technical Memorandum

U.S. Bureau of Reclamation
Contract No. 08CA10677A ID/IQ, Task 3

Prepared by

Anchor QEA
HDR Engineering

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

April 2011

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1.0 Introduction

This technical memorandum describes results of an assessment of the instream flow needs in the Yakima River Basin, including recommended instream flow objectives of the Integrated Plan of the Yakima River Basin Water Enhancement Project (YRBWEP). The recommendations were developed by Anchor QEA, with input from the YRBWEP Workgroup and its Instream Flow Needs Subcommittee. The effectiveness of the proposed YRBWEP projects in meeting the recommended instream flow objectives were evaluated in the hydrologic modeling effort (see Volume 2 technical memorandum, “Hydrologic Modeling and Climate Change”).

The term “instream flow” is used to identify a specific stream flow (typically measured in cubic feet per second, or cfs) at a specific location or reach of river for a defined time. Instream flows are usually defined as the stream flows needed to protect and preserve instream resources and values, such as fish, wildlife, water quality and recreation.

The purpose of this technical memorandum is to document the following:

- Initial work performed on an assessment and prioritization of instream flow needs in the Yakima River Basin
- Instream flow objectives that were evaluated in the hydrologic modeling performed for the Yakima River Basin Study
- Potential benefits to fish species and life stages from instream flow improvements resulting from implementation of the Integrated Water Resources Management Plan (See Volume 1 “Proposed Integrated Water Resource Management Plan”).

1.1 Background

Surface water supply for the Yakima Project comes from the natural, unregulated runoff of the Yakima River and its tributaries, irrigation return flows, and releases of stored water from the five main reservoirs in the upper Yakima and Naches river basins: Keechelus, Kachess, Cle Elum, Tieton, and Bumping. The reservoirs store approximately 30 percent of the average annual runoff in the basin and are operated to meet irrigation demands, flood-control needs, and instream flow requirements. The Yakima Project also provides water for hydroelectric power generation, fish and wildlife benefits, and recreation.

The Yakima Project depends heavily on the timing of unregulated spring and summer runoff from snowmelt and rainfall. Flow from spring and early summer natural runoff supplies most river basin demands through June in an average year. Since the majority of spring and summer runoff is from snowmelt, the snowpack is often considered a “sixth reservoir.”

In most years, the five major reservoirs are operated to maximize storage in June, which typically coincides with the end of the major natural runoff. The reservoirs have a combined storage capacity of about 1.07 million acre-feet. The irrigation divisions in the Yakima Project (Kittitas, Roza, Sunnyside, Tieton, Wapato and Kennewick) have entitlements totaling 2.04 million acre-feet. Most of those entitlements (1.94 million acre-feet) are diverted above the U.S. Bureau of Reclamation (Reclamation) stream gage at Parker (Parker gage), the main control point for the Yakima Project.

Other surface-water users that are not part of the Yakima Project rely on flow in the Yakima and Naches rivers. Entitlements above the Parker Gage total 470,000 acre-feet for these users (see Volume 2 technical memorandum, "Water Needs for Out-of-Stream Uses").

Demand for water from the Yakima River cannot always be met in years with below-average runoff. A poor water year sets in motion the process of equally reducing the amount of water delivered to junior ("proratable") water-right holders during the irrigation season. Proratable entitlements above the Parker gage total 1.32 million acre-feet.

The operations of the Yakima Project cause reduced summer and early fall and winter streamflows and unnaturally high summer flows in some reaches, and inhibit migrating, spawning, and rearing conditions for anadromous fish populations in the basin. In most years, as a result of Project operations, spring flows in the middle and lower Yakima River are not sufficient to optimize smolt outmigration and summer flows in many reaches of the Yakima Basin are too low to provide desired conditions for salmonid survival and production. In other stream reaches, late summer high flows related to Project operations disrupt salmonid rearing.

1.2 Objectives of the Instream Flow Needs Assessment

Objectives for this Instream Flow Needs Assessment were developed in coordination with the Instream Flow Needs Subcommittee and include the following:

- Characterize and validate stream flow needs and priorities by river reach, organized to be consistent with the reach framework established in the RiverWare modeling tool (see Volume 2 technical memorandum, "Hydrologic Modeling and Climate Change").
- Characterize existing reservoir operations and identify opportunities to optimize existing operations.
- Manage and shape flows to maximize biological benefits.
- Focus on improving instream flows in average and wet water years (all seasons) (i.e., optimize the good years).
- Provide channel forming and maintenance flows to support habitat-forming processes.
- For dry years, focus on improving winter and spring flow habitat conditions, and meet out-of-stream demands in a way that maximizes benefits for fish within operating and infrastructure constraints.
- Try to mimic (or move closer to mimicking) the unregulated hydrograph whenever possible.
- Provide additional flexibility within the system to manage flows and meet water supply needs.
- Characterize how proposed habitat improvements link to flow enhancements; identify where flow improvements would provide side-channel reconnection; and characterize benefits.
- Develop revised operating rules and policy framework for managing potential new supply and storage (considering items such as revised rules for increasing carryover storage by reducing October supply deliveries, and filling and spilling reservoirs earlier in the year when water is available to help with outmigration).

Not all of the objectives could be addressed within time constraints for this study and with the hydrologic model used in this study. The last two objectives listed above will require further analysis and discussion among Reclamation and basin stakeholders including fisheries interests.

The subcommittee also provided the following guidance for conducting hydrologic analyses to identify how instream needs would be met by proposed projects from the Integrated Plan:

- Use existing conditions as the baseline (also called Future Without Integrated Plan [FWIP]), which includes YRBWEP Phase II water conservation projects planned to be constructed.
- Identify water management projects from the draft Integrated Plan that provides the most benefit (describes where and when, and expected improvements).
- Verify whether water management projects are adequate to meet the Basin's needs (and for how long).
- Evaluate whether flood-control rule curves can be revised to provide additional flexibility in water management.
- Build in flexibility for operations and do not lock into specific blocks of water that are dedicated to instream flows. Assess expected flow variations and effects from climate change.

2.0 Summary of Findings

Fifteen mainstem reaches and eight tributaries or groups of tributaries within the Yakima Basin were identified for review in this study. In coordination with the Instream Flow Needs Subcommittee, the study team characterized reach-specific flow problems, identified recommended flow objectives and species that would benefit from improved instream flows, categorized stream reaches and flow objectives as high, medium or lower priority, and discussed how potential projects in the Integrated Plan could address the flow objectives. Nine reaches with high priority flow objectives were identified. In some reaches on the Yakima River a spring pulse was identified as a high priority flow objective but was not identified as a high priority in the adjacent downstream reach or reaches. The Subcommittee assumed those flow pulses would propagate downstream and downstream reaches did not have to be assigned the same high priority.

Table 1 summarizes the reaches with high-priority flow objectives, which were used in the RiverWare hydrologic model to test the effectiveness of projects or groups of projects in the various elements of the Integrated Plan. Results from the hydrologic modeling of the Integrated Plan scenario are summarized in Section 6.0 of this technical memorandum. A more detailed presentation of results of the hydrologic modeling is provided in the Volume 2 technical memorandum "Modeling of Reliability and Flows Technical Memorandum".

As described in Section 6.0, the Integrated Plan would help meet high-priority flow objectives in eight out of nine mainstem reaches, including substantial improvement in six of these reaches. Although flows in Taneum and Manastash creeks were not modeled, the Integrated Plan would also significantly improve flows in those reaches. The only mainstem reach that did not show a benefit was the lower Naches River. While the hydrologic model is very complex and the flow targets were difficult to meet in the model configuration, the modeling did show that Bumping and Tieton reservoirs would have enough carryover storage to allow for flexibility in operations and meeting instream flow needs in the lower reach of the Naches River.

Table 1. High-Priority Reaches and Flow Objectives

Reach	High-Priority Flow Objectives
Yakima River, Keechelus Dam to Lake Easton	• Reduce flows to 500 cfs during July. • Ramp flows down from 500 cfs beginning August 1 to 120 cfs by the first week of September. • Increase base flow to 120 cfs year-round. • Provide one pulse flow (500 cfs peak) in early April. • In drought years, provide an additional pulse of 500 cfs in early May.
Yakima River, Easton Reach	• Increase September and October spawning flows to 220 cfs. • Increase minimum flows to 250 cfs all other times for rearing which provides access to side channels.
Cle Elum River	• Increase minimum flow to 500 cfs (previous analyses performed for Integrated Water Resource Management Alternative: Final EIS [Ecology, 2009] indicated 300 cfs could be provided so a range of 300-500 cfs will be tested in the hydrologic modeling). • Decrease flows by 1,000 cfs beginning the first of August.
Yakima River, Cle Elum to Teanaway River	• Ramp flows down starting July 1 to 1,000 cfs flow rate by August 31.
Yakima River, Teanaway River to Roza Dam (Ellensburg Reach)	• Reduce flow by 1,000 cfs beginning July 1. • Reach a flow of 1,000 cfs by August 31.
Yakima River, Roza Dam to Naches River	• Increase flows in the spring to a minimum of 1,400 cfs. • Increase flows in the fall and winter to between 1,000 and 1,400 cfs.
Tieton River	• Increase minimum flows to 125 cfs from late October to April 1.
Lower Naches River	• Increase minimum flow rate to 550 cfs from June 1 to November 1. • Change the ramping rates from spring to summer flows to a more gradual decline. • Reduce September flows to as close as possible to unregulated conditions.
Yakima River, Parker to Toppenish Creek (Wapato Reach)	• Provide a spring pulse of 15,000 to 20,000 acre-feet in early May in dry years. • Change ramping rate at end of high flows that occur in June-July in average to wet years.
Manastash, Taneum, Cowiche Creeks	• Replace current diversions with Yakima or Naches River water; deliver water directly to tributaries if supply replacement is not feasible. No specific flow objectives were identified.
Ahtanum Creek	• No flow objectives or augmentation alternatives were identified by subcommittee.

. Flow objectives that are not high priority were also compared to the results of the modeling. It was found that medium- and lower-priority flow objectives could be met in nine of 11 mainstem reaches, and flows improved in some Kittitas County tributaries. In addition, an increase in September 30th carryover storage of about 330,000 acre-feet (on average, not including Wymer Reservoir) is predicted by the hydrologic model. The additional storage could be used to provide operational flexibility and provide additional flow improvement. As noted in Section 5.0, these flow objectives and operational scenarios are not intended to be definitive or final.

In two reaches, the Yakima River between Roza Dam and Naches River and the Yakima River between Prosser Dam and Chandler Powerplant, Yakima River flow is affected by diversions for hydropower. Flow objectives for those two reaches could be met through additional subordination of hydroelectric generation. The technical memorandum “Roza and Chandler Powerplants Subordination Evaluation” describes the potential for subordination.

3.0 Previous Instream Flow Recommendations

A number of instream flow studies and recommendations have been published for the Yakima River Basin. Flow recommendations by reach for selected instream flow studies are summarized in Table A-1 in Appendix A, including the following instream flow recommendations:

- Flow recommendations from the Instream Flow Technical Advisory Group (IFTAG) published in 1984 (IFTAG, 1984)
- Flow recommendations from U.S. Fish and Wildlife Service (USFWS) provided in 1981 to Yakima County Superior Court for the Acquavella adjudication (Simmons, 1981)
- Operational flows described in the Interim Comprehensive Operating Plan (IOP) (Reclamation, 2002)
- Flow recommendations provided in Draft Planning Report/EIS Yakima River Water Storage Feasibility Study (Reclamation and Ecology, 2008)
- Flow recommendations provided in Discussion of Biologically Based Flows for the Purpose of Determination of Average Water Year Instream Flow Demand for the Yakima River Basin Study (Hubble, undated but provided to subcommittee in 2010). Joel Hubble is a fisheries biologist for Reclamation.

A summary of previous instream flow recommendations was provided to the subcommittee for background and their use in preparing recommendations for flow objectives in reaches of the Yakima River and its major tributaries that would be affected by the Integrated Plan.

4.0 Description and Prioritization of Reaches

River reaches described in the Final EIS Yakima River Basin Integrated Water Resource Management Alternative (Ecology 2009) were used as a starting point in this Instream Flow Needs Assessment to prioritize and assess desired instream flow regimes. The reaches were adjusted (either split or combined) based on comments from the Instream Flow Needs Subcommittee and to make the reaches consistent with locations of RiverWare model nodes and previous studies. Tables 2 and 3 list the Yakima and Naches River reaches used in this study. Figure 1 shows the location of the reaches and important tributaries affected by diversions.

Table 2. Yakima River Reaches Used in This Study

Reach Name*	Yakima River Mile Location	Length (miles)
Upper Yakima River	214.5 to 127.9	86.6
Yakima River from Keechelus Dam to Lake Easton	214.5 to 202.5	12.0
Kachess River from Kachess Dam to Yakima River	*203.5*	*0.9*
Yakima River from Lake Easton to Cle Elum River	202.5 to 185.6	16.9
Cle Elum River from Cle Elum Dam to Yakima River	*185.6*	8.2
Yakima River from Cle Elum River to Teanaway River	185.6 to 176.1	9.5
Yakima River from Teanaway River to Roza Dam	176.1 to 127.9	48.2
Middle Yakima River	127.9 to 47.1	80.8
Yakima River from Roza Dam to Naches River to Sunnyside Diversion Dam	127.9 to 103.8	24.1
Naches River (details in Table 3)	*116.3*	*44.6*
Yakima River from Sunnyside Diversion Dam to Toppenish Creek	103.8 to 80.4	23.4
Yakima River from Toppenish Creek to Prosser Dam	80.4 to 47.1	33.3
Lower Yakima River	47.1 to 0.0	47.1
Yakima River from Prosser Dam to Chandler Powerplant	47.1 to 35.8	11.3
Yakima River from Chandler Powerplant to Columbia River	35.8 to 0.0	35.8

* Italicized entries are tributaries of the Yakima River.
Source: Modified from Final EIS Integrated Water Resource Management Alternative (Ecology 2009).

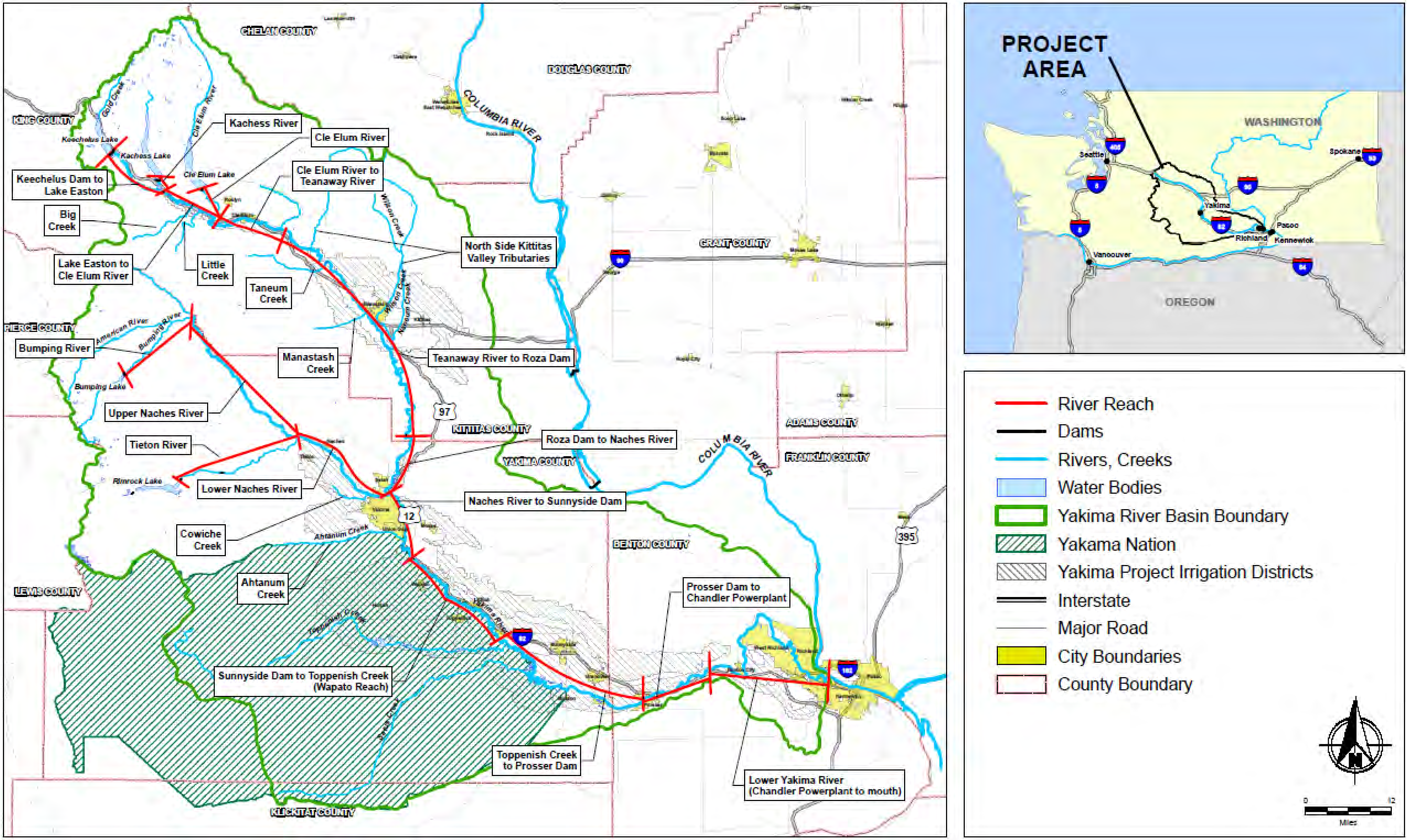

Figure 1. Yakima River Basin Stream Reaches and Tributaries Affected by Diversions

Table 3. Naches River Reaches

Reach Name	Naches River Mile Location	Length (miles)
Bumping River from Bumping Dam to Little Naches River	44.6	16.6
Upper Naches River from Bumping River to Tieton River	44.6 to 17.5	27.1
Tieton River from Tieton Dam to Naches River	17.5	21.3
Lower Naches River from Tieton River to Yakima River	17.5 to 0.0	17.5
Source: Final EIS Integrated Water Resource Management Alternative (Ecology 2009).		

In conjunction with the subcommittee, the study team prepared a table summarizing the flow problems experienced in each reach, along with flow objectives and relative priority of meeting those flow objectives compared to other reaches (see Appendix B). The subcommittee ranked each reach high, medium or lower priority, and the hydrologic modeling focused on meeting flow objectives for high-priority reaches to assess the performance of the elements of the Integrated Plan. The following section discusses the flow objectives in the high-priority reaches in more detail.

5.0 High-Priority Reach Conditions

This section describes the instream flow needs, salmonid species benefits and recommended flow objectives for each of the nine high-priority reaches. The flow objectives were developed to guide the hydrologic modeling, which is described in the “Hydrologic Modeling and Climate Change” technical memorandum in Volume 2. These flow objectives and the results of the hydrologic modeling are not meant to be definitive or final approaches to managing water supplies in the Yakima Basin for fisheries. While modeling demonstrates how certain projects or groups of projects can meet flow objectives, future operations of the system would be determined through consultation with Yakima Project operators, water users and agency and tribal biologists in a forum such as the Systems Operation Advisory Committee (SOAC).

Representative hydrographs for average (2003), dry (2001) and wet (2002) water years for each of the high-priority reaches are presented in Appendix C. The hydrographs overlay species and life stages along with estimates of unregulated flow over the recorded flow for each year. The species and life stages shown on the hydrographs are only for the periods of time they benefit from the changes in flow resulting from the Integrated Plan. Instream flow objectives are called out on the figures in text and graphical form. The figures were prepared to illustrate the timing and magnitude of proposed flow changes compared to fish utilization of the reaches.

5.1 Yakima River from Keechelus Dam to Lake Easton

Instream Flow Needs and Salmonid Species Benefits

The instream flow objective for the Keechelus Dam to Lake Easton reach is to improve fish-rearing conditions. Currently, flows are too high from July through early September when juvenile Chinook and steelhead (and potentially coho if reestablished) are rearing in this reach. Juvenile salmon seek protection against high-velocity flows to avoid being pushed downstream into less desirable habitat and minimize energy expenditures. High summer flows reduce the amount of suitable rearing habitat for these same species as a result of high water velocities. The negative effects on rearing juvenile salmonids from high summer flow conditions in this reach occur during all water year types but are most significant in wet years. Flows in summer during a wet year such as 2002 average about 1,000 cfs.

During winter, flows are lower than desired by fish biologists, and flow pulses are absent in the spring due to runoff being captured by Keechelus Reservoir. Lower flows reduce available rearing and overwintering habitat throughout the fall and winter, and into early spring in dry years. Flow pulses in spring are needed to mimic natural conditions and support juvenile outmigration. Increasing base flows should increase available juvenile rearing and overwintering habitat in the Keechelus Dam to Lake Easton reach.

An early April flow pulse would benefit spring Chinook and steelhead juveniles and smolts moving down into the lower basin to rear or outmigrate as smolts. Once reestablished in the upper Yakima River Basin, coho and sockeye would also benefit from increased base flows and spring pulses. During dry years, an additional pulse in early May would further benefit spring Chinook, steelhead, and coho rearing juveniles and outmigrants.[1] Additionally, increased base flows year-round, as well as spring pulses, would benefit all anadromous salmonids – spring Chinook, steelhead, coho, and sockeye – returning to the upper Yakima River Basin to spawn. Increased base flows could also increase available spawning habitat for both spring spawners (steelhead) and fall spawners (spring Chinook and coho).

Recommended Flow Objectives Evaluated in Hydrologic Modeling

Recommended flow objectives for the hydrologic modeling evaluation of the Keechelus Dam to Lake Easton reach are as follows:

- Reduce flows to 500 cfs during July (high priority)
- Ramp flows down from 500 cfs on August 1 to 120 cfs the first week of September (high priority)
- Increase base flow to 120 cfs year-round (high priority)
- Provide one pulse flow (500 cfs peak) in early April (high priority)
- In drought years, provide an additional pulse of 500 cfs in early May (high priority)

5.2 Easton Reach, Yakima River

Instream Flow Needs and Salmonid Species Benefits

The instream flow objectives in the Easton reach are to increase spawning and rearing habitat and improve outmigration conditions. These objectives can be met by adding flow during the fall and winter and adding a spring pulse. Increasing base flows to 220 cfs in September and October in dry years and to 250 cfs during the rest of the year would benefit spring Chinook and steelhead, which spawn and rear in the Easton reach. Once coho are firmly reestablished in the upper Yakima River Basin, this species would also benefit from increased base flows, especially if increasing base flows reconnects side-channel habitat.

Side-channel habitat would provide access to more variable habitat conditions, accommodating coho spawning needs more readily and providing low-velocity habitat for rearing juveniles of all salmonid species in the Yakima River Basin. Adult sockeye salmon, once reestablished, would

[1] Sockeye smolts likely would already have outmigrated by this time.

migrate through the Easton reach on their way to upper-basin lake spawning and rearing habitat. Sockeye would benefit from increased September base flows as they migrate upstream from late June through September.

Adding one pulse flow (1,000 cfs peak) in early April and an additional pulse in drought years in early May would benefit all salmonid outmigrants in the Yakima River Basin, especially sockeye, once reestablished. Sockeye have the most compressed outmigration, likely to occur in April based on mid- and upper-Columbia River transponder tag data for Wenatchee and Okanogan sockeye populations. Spring flows would be augmented occasionally for channel maintenance (every five years for riparian recruitment and bank-full flows during wet years) to improve habitat conditions.

Recommended Flow Objectives Evaluated in Hydrologic Modeling

Recommended flow objectives for the hydrologic modeling evaluation in the Easton reach are as follows:

- Increase September and October spawning flows to 220 cfs (high priority)
- Increase minimum flows to 250 cfs all other times for rearing (high priority)
- Add one pulse flow (1,000 cfs peak) in early April (medium priority)
- In drought years, add a pulse (1,000 cfs peak) in early May (medium priority)

5.3 Cle Elum River

Instream Flow Needs and Salmonid Species Benefits

The instream flow objective for the Cle Elum River is to improve fish-rearing conditions. Under present operations, flows are too high during July and August, and low flow and a lack of flow variation from September 10 through March limits access to available side channels when juvenile Chinook and steelhead (and potentially coho if reestablished) are rearing in this reach. Juvenile salmon seek low-velocity habitat as protection against being pushed out of a reach and to minimize energy expenditures. High summer flows reduce the amount of suitable rearing habitat for these species as a result of high water velocities.

During the remainder of the year, flows are lower than desired for fish, and flow pulses are absent in the spring. Lower flows result in reduced available rearing and overwintering habitat throughout the fall and winter and extending through early spring. Flow pulses that mimic natural conditions in spring are needed to support juvenile outmigration. Increasing base flows should increase available juvenile rearing and overwintering habitat in this reach. An early April flow pulse would benefit spring Chinook and steelhead juveniles and smolts that are moving down into the lower basin to rear or outmigrate as smolts.

Once reestablished in the upper Yakima River Basin, coho and sockeye would also benefit from these flow changes. Increased base flows year-round, as well as a spring pulse, would benefit all anadromous salmonids – spring Chinook, steelhead, coho, and sockeye – returning to the upper Yakima River Basin to spawn. Integrated with floodplain restoration efforts in this reach, increased base flows and spring pulses can have additive benefits to Yakima River Basin salmonid species.

Recommended Flow Objectives Evaluated in Hydrologic Modeling

Recommended flow objectives for the hydrologic modeling evaluation of Cle Elum River are as follows:

- Increase minimum flow targets to 500 cfs (previous analyses performed for Integrated Water Resource Management Alternative: Final EIS [Ecology, 2009] indicated 300 cfs could be provided so 300-500 cfs will be tested in the hydrologic modeling) (high priority)
- Decrease flows by 1,000 cfs beginning August 1 (high priority)
- Add one pulse flow (1,000 cfs peak) in early April (medium priority)

5.4 Yakima River from Cle Elum to Teanaway River

Instream Flow Needs and Salmonid Species Benefits

The highest priority instream flow objective in the Cle Elum to Teanaway River reach is to improve fish-rearing conditions. Under present operations, flows are too high from July through early September (as high as 3,000 cfs in August) when juvenile Chinook and steelhead are rearing in this reach. Once coho are firmly reestablished in the upper Yakima River Basin, juvenile coho would also be rearing in this reach. High summer flows reduce the amount of suitable rearing habitat for these species as a result of high water velocities. Juvenile salmon seek low-velocity habitat as protection against being pushed out of a reach and to minimize energy expenditures. The negative effects on rearing juvenile salmonids from high summer flow conditions in this reach occur during all water year types, but are most significant in wet years.

It is desirable to occasionally augment spring flows to promote riparian restoration (with large flow pulses approximately every five years) and benefit migrating adult steelhead with smaller flow pulses when available. In winter, flow pulses would provide access to available habitat when juvenile Chinook, steelhead, and coho are rearing in this reach.

Recommended Flow Objectives Evaluated in Hydrologic Modeling

Recommended flow objectives for the hydrologic modeling evaluation of the Cle Elum to Teanaway River reach are as follows:

- Ramp flows down starting July 1 to 1,000 cfs flow rate by late August (high priority)
- Occasionally produce channel-shaping flows in spring for riparian restoration and flow variability during the winter (medium priority)

5.5 Yakima River from Teanaway River to Roza Dam (Ellensburg Reach)

Instream Flow Needs and Salmonid Species Benefits

The instream flow objective in the Ellensburg reach is to improve fish-rearing conditions. Under present operations, flows are too high from July through early September when juvenile Chinook, steelhead, and coho are rearing in this reach. High summer flows reduce the amount of suitable rearing habitat for these species as a result of high water velocities. Juvenile salmon seek low-velocity habitat as protection against being pushed out of a reach and to minimize energy expenditures. The negative effects on rearing juvenile salmonids from high summer flow conditions in this reach occur during all water year types, but are most significant in wet years.

It is desirable to occasionally augment spring flows to promote riparian restoration (with large flow pulses approximately every five years). In winter, flow pulses would provide access to available habitat when juvenile Chinook, steelhead, and coho are rearing in this reach.

Recommended Flow Objectives Evaluated in Hydrologic Modeling

Recommended flow objectives for the hydrologic modeling evaluation of the Ellensburg reach are as follows:

- Reduce flow by 1,000 cfs beginning July 1 (high priority)
- Reach a flow of 1,000 cfs by August 31 (high priority)

5.6 Yakima River from Roza Dam to Naches River

Instream Flow Needs and Salmonid Species Benefits

The instream flow objectives in the Roza Dam to Naches River reach are to improve conditions for fall and winter spawning and rearing and spring smolt outmigration. Increasing base flows from around mid-September through May would improve habitat quality and quantity for spring Chinook, steelhead, and coho that rear in this reach. Increased base flows during that period would also benefit adult salmonids, mostly coho, which migrate through this reach mid-September through mid-December on their way to spawning grounds in the upper Yakima River Basin, but also spawn in this reach during the fall and early winter. Increased flows could provide additional spawning habitat and may improve water quality conditions in the fall.

Steelhead, which migrate through this reach beginning as early as March, would also benefit from increased base flows. Spring Chinook and sockeye also migrate through this reach on their way to spawning grounds, but they would benefit the least among the adult migrants because the majority of their spawning migration falls outside the period of increased base flows.

Additional flows during smolt outmigration in the spring (March to May) would benefit all salmonid species in the Yakima River Basin: spring Chinook, steelhead, coho, and sockeye. Increasing spring flows should be coordinated with floodplain restoration efforts in this reach to maximize benefits.

Recommended Flow Objectives Evaluated in Hydrologic Modeling

The recommended flow objectives for the hydrologic modeling evaluation of the Roza Dam to Naches River reach are as follows:

- Increase flows in the spring to a minimum of 1,400 cfs (high priority)
- Increase flows in the fall and winter to between 1,000 and 1,400 cfs (high priority)

The Yakima Basin Joint Board has been working with Reclamation and other partners to formulate a study of the biological basis for flow enhancements in this reach. The results of the study are expected in 12-24 months. The flow recommendations may change as a result of that study.

5.7 Tieton River

Instream Flow Needs and Salmonid Species Benefits

The instream flow objective in the Tieton River is to improve fish-rearing conditions. Under present operations, winter flows are low (50 to 100 cfs) with limited variation in flow from November to early April. In September, flows are too high as a result of flip-flop operations (reducing flows in the upper arm of the Yakima River and increasing flows in the Naches River with increased water releases from Rimrock Reservoir). Increasing winter base flows to 125 cfs from November to early April would benefit rearing spring Chinook and steelhead in the Tieton River. Early adult steelhead migrants into the Tieton River could also benefit by increased base flows. Adult steelhead migrates into the Tieton River from February through May.

Spring Chinook and steelhead smolt outmigrants would benefit slightly because smolt outmigration may start as early as mid-March. Reducing flows in the Tieton River as much as possible in September would benefit spring Chinook and steelhead juveniles because they may overwinter in the Tieton River if they do not get pushed out by high flows during the flip-flop operation.

Recommended Flow Objectives Evaluated in Hydrologic Modeling

The recommended flow objectives for the hydrologic modeling evaluation of the Tieton River are as follows:

- Increase minimum flows to 125 cfs from November 1 to April 1 (high priority)
- Change ramping rates from spring to summer (medium priority)
- Reduce flows as much as possible in September (medium priority)

5.8 Lower Naches River

Instream Flow Needs and Salmonid Species Benefits

The instream flow objective in the Lower Naches River is to improve fish-rearing conditions. Summer flows are low and the ramping rate from high spring flows to summer flows is abrupt, negatively affecting rearing conditions for steelhead, coho and spring Chinook. Changing the ramping rates so the decline from spring flows to summer flows is less abrupt and increasing base flows to 550 cfs from early June to early November would benefit spring Chinook, steelhead, and coho rearing in this reach year-round. A more gradual decrease in flow to a higher base flow would allow rearing salmonids to more easily avoid stranding and entrapment, provide access to additional available rearing habitat, and potentially contribute to improving water quality. Habitat access benefits would be most pronounced during drought years.

Coho spawn in this reach from mid-September to mid-December. Coho may benefit from an increase in available spawning habitat due to increased base flows. Adult species that migrate through the lower Naches River during summer (spring Chinook and sockeye) and fall (steelhead and coho) would also have more habitat and improved water quality due to increased base flows. The effect on those benefits from flow loss to groundwater in the lower parts of this reach was identified as an issue by the subcommittee but is unknown.

Reducing fall flows as much as possible in September, when high flows occur as a result of the flip-flop operations, would benefit spring Chinook, steelhead, and coho juveniles that rear in the lower Naches River and may overwinter there if not pushed out by high flows during flip-flop operations.

Recommended Flow Objectives Evaluated in Hydrologic Modeling

Recommended flow objectives for the hydrologic modeling evaluation of the lower Naches River are as follows:

- Increase minimum flow rate to 550 cfs from June 1 to November 1 (high priority)
- Change the ramping rates from spring to summer flows to a more gradual decline (high priority)
- Reduce September flows to as close as possible to unregulated conditions (high priority)

5.9 Yakima River from Parker to Toppenish Creek (Wapato Reach)

Instream Flow Needs and Salmonid Species Benefits

The instream flow objectives in the Wapato reach are to improve spring smolt outmigration in dry years and summer rearing conditions. From March through June, the Wapato reach is a primary migration corridor for all salmonid smolts produced upstream in the basin (spring and fall Chinook, steelhead, coho, and sockeye). Providing an early May flow pulse of 15,000 to 20,000 acre-feet in dry years would improve flow conditions over current conditions, which can be inadequate to support outmigration in drought years. A spring pulse may also provide a small benefit to adult spring Chinook and steelhead migrating through this reach in May to upstream spawning areas.

The Wapato Reach is also a primary rearing area for coho and fall Chinook, and although fall Chinook smolts migrate out of this reach by the end of June, coho rear in this reach year-round. This reach is an important overwintering area for juvenile spring Chinook, coho, and steelhead. Maintaining an increased base flow condition year-round would benefit all rearing salmonids that remain in this reach year-round. It would also improve spawning conditions for fall Chinook and coho that spawn in this reach in fall through early winter.

Recommended Flow Objectives Evaluated in Hydrologic Modeling

The recommended flow objectives for the hydrologic modeling evaluation of the Wapato reach are as follows:

- Provide a spring pulse of 15,000 to 20,000 acre-feet in early May in dry years (high priority)
- Based on available water supply, increase flows from June to October 15 to 550 cfs in drought years, 750 cfs in average years, and 850 cfs in wet years (no priority assigned by subcommittee)

6.0 Effects on Instream Flow from Integrated Plan

This section summarizes the effects on instream flow under the Integrated Plan scenario. Where benefit comparisons are made, Integrated Plan results are compared against the modeled results for the Future Without the Integrated Plan (FWIP) scenario. Modeling methods, assumptions, and detailed results are presented in the Modeling of Reliability and Flows Technical Memorandum in Volume 2.

Comparing instream flow conditions under two modeled scenarios is complex and somewhat subjective. In this section, instream flow comparisons are based on the high-priority flow objectives presented in Section 5. Where single, clear, numerical flow standards are presented in the flow objectives, evaluation of success under the Integrated Plan is based on the relative amount of time that the flow standard is met. Where more qualitative flow objectives are presented (e.g., “reduce flows”), the evaluation of success is similarly qualitative, and based on the relative level of improvement toward the flow standard observed in the model results.

Not all flow objectives were specifically included in the Integrated Plan operational modeling. The Integrated Plan model also does not use all of the water stored in new and expanded reservoirs. Increased carryover storage is provided, which would allow flexibility in operations to meet instream flow objectives. It is understood that significant additional instream benefits could be achieved by resource managers working with Yakima Project operators to optimize reservoir operations for both instream and out-of-stream purposes.

Table 4 summarizes the flow objectives for the high-priority reaches, and a generalized evaluation of the level of success achieved in the modeled outcome from the Integrated Plan scenario. This table is organized as follows:

- Cells shaded light blue represent significant improvement.
- Cells shaded light green represent minor improvement.
- Unshaded cells represent no significant change.
- Cells shaded light red represents conditions that worsen under the Integrated Plan.

The Yakima River tributaries are not represented in the RiverWare model and flow improvements could not be modeled. The tributaries are shown as unshaded, even though the Integrated Plan would have the potential of improving flow conditions and passage.

The results in Table 4 show that the Integrated Plan would help meet high-priority flow objectives in eight of nine mainstem reaches, including substantial improvement in six of these reaches. While not modeled, it would also significantly improve flows in Taneum and Manastash creeks. Appendix C contains figures showing flows under Integrated Plan conditions compared to FWIP conditions. Affected species and life stages are shown on the figures for only the time periods that are benefitted by changes in flow. In some reaches, unregulated flow hydrographs are available and are plotted with the Integrated Plan and FWIP hydrographs to illustrate the difference between regulated and unregulated conditions.

Three sets of hydrographs are provided for each reach. The first encompasses a severe drought (2001), the second a wet year (2002), and the third an average runoff year (2003). The volume of runoff in 2003 was slightly below average but close enough to consider its use as an average year, especially considering it provides a view of consecutive years (2001-2003) with very different runoff and water supply conditions. The plots illustrate the potential benefits from the Integrated Plan, with improvements to rearing conditions for all species in most reaches, smolt outmigration in the Yakima River, and spawning and adult migration conditions in a number of reaches.

Flow objectives that are not high priority (described in the table provided in Appendix B) are shown in Table 5 along with a generalized evaluation of the level of success achieved in the modeled outcome from the Integrated Plan scenario. The color scheme used in Table 4 to describe the levels of success is followed in Table 5.

The results in Table 5 show the Integrated Plan would help meet medium- and lower-priority objectives in nine of 11 mainstem reaches, and improve flows in some Kittitas County tributaries. In addition, approximately 330,000 acre-feet of additional water left in September 30 carryover storage (on average, not including Wymer Reservoir) could be used to provide additional improvement in flows, if desired.

In two reaches, the Yakima River between Roza Dam and Naches River and the Yakima River between Prosser Dam and Chandler Powerplant, Yakima River flow is affected by diversions for hydropower. Flow objectives for those two reaches could be met through additional subordination of hydroelectric generation. The Volume 2 technical memorandum "Roza and Chandler Powerplants Subordination Evaluation" describes the potential for subordination.

Table 4. Yakima Basin High-Priority Instream Flow Needs and Modeled Outcomes by Reach

<table>
<tr><th>River Reach</th><th>Desired Flow Objectives and Modeled Outcomes of Integrated Plan</th><th>Priority</th></tr>
<tr><td rowspan="2">Yakima River, Keechelus Dam to Lake Easton</td><td>Flow Objectives:
• Reduce flows to 500 cfs during July.
• Ramp flows down from 500 cfs at August 1 to 120 cfs at the first week of September.
• Increase base flow to 120 cfs year-round.
• Provide one pulse flow (500 cfs peak) in early April.</td><td>High</td></tr>
<tr><td colspan="2">Modeled Outcome: Flows are reduced below 500 cfs in July with the Integrated Plan projects. Flows are also ramped down from about 500 cfs to 120 cfs at the first week of September. From that time through March, 120 cfs is exceeded 99.6% of the time under the Integrated Plan compared to 20.2% under the FWIP. Winter pulse flows would be available in most years because Keechelus Reservoir carryover storage is increased by 39,000 acre-feet on average.</td></tr>
<tr><td rowspan="2">Yakima River, Easton Reach</td><td>Flow Objectives:
• Increase September and October spawning flows to 220 cfs.
• Increase minimum flows to 250 cfs all other times for rearing which provides connection to side channels.</td><td>High</td></tr>
<tr><td colspan="2">Modeled Outcome: November-to-March flows are above 250 cfs 98.6 percent of the time (average = 462 cfs) under the Integrated Plan compared to 64.9 percent under the FWIP (average = 407 cfs). Spawning flows are held at 220 cfs from October 1-10 in 21 out of 25 years under the Integrated Plan compared to 10 out of 25 years under the FWIP.</td></tr>
</table>

Table 4. Yakima Basin High-Priority Instream Flow Needs and Modeled Outcomes by Reach (continued)

River Reach	Desired Flow Objectives and Modeled Outcomes of Integrated Plan	Priority
Cle Elum River	*Flow Objectives*: • Increase minimum flow to 500 cfs (previous analyses performed for Integrated Water Resource Management Alternative: Final EIS [Ecology, 2009] indicated 300 cfs could be provided so 300-500 cfs will be tested in the hydrologic modeling). • Decrease flows by 1,000 cfs beginning the first of August.	High
	Modeled Outcome: Average fall/winter flows (October-March) have increased from 325 cfs in the FWIP to 436 cfs with the Integrated Plan. Higher fall/winter releases up to 500 cfs minimum were tested however storage was depleted in most years and a minimum release of 300 cfs was used in the final model runs. Average summer (July-August) flows have decreased from 2,779 in the FWIP to 2,280 cfs under the Integrated Plan. The flow reduction starts earlier (July) than the objective stated by the Subcommittee. Other flow benefits of the Integrated Plan include providing spring pulse flows in non-drought years. Additional pulse flows or flow variability would be available in most years with the Integrated Plan as Upper Yakima River Basin reservoir carryover storage is increased by 39,000 acre-feet and Cle Elum Reservoir carryover storage is increased by 84,000 acre-feet on average.	
Yakima River, Cle Elum to Teanaway River	*Flow Objective*: • Ramp flows down starting July 1 to 1,000 cfs flow rate by August 31.	High
	Modeled Outcome: Average flow in August has been reduced from 4,016 cfs under the FWIP to 3,005 cfs under the Integrated Plan. Average flow on August 31 has been reduced from 3,142 cfs under the FWIP to 2,174 cfs under the Integrated Plan. A flow rate of 1,000 cfs was not able to be attained under the Integrated Plan but summer flows are significantly reduced.	
Yakima River, Teanaway River to Roza Dam (Ellensburg Reach)	*Flow Objectives*: • Reduce flow by 1,000 cfs beginning July 1. • Reach a flow of 1,000 cfs by August 31.	High
	Modeled Outcome: Average summer (July-August) flows have been reduced from 3,204 cfs under the FWIP to 2,471 cfs under the Integrated Plan. Summer flows are significantly reduced but the objective of reaching 1,000 cfs was not able to be attained.	
Yakima River, Roza Dam – Naches River	*Flow Objectives*: • Increase flows in the spring to a minimum of 1,400 cfs. • Increase flows in the fall and winter to between 1,000 and 1,400 cfs.	High
	Modeled Outcome: Some small flow benefits accrue to this reach because of increased flow in upstream reaches. However flows in this reach are primarily affected by diversions for hydropower. Subordination of hydropower was not modeled in this study. Additional flow would be provided and flow objectives met if subordination of Roza Powerplant flows is adopted.	

Table 4. Yakima Basin High-Priority Instream Flow Needs and Modeled Outcomes by Reach (continued)

River Reach	Desired Flow Objectives and Modeled Outcomes of Integrated Plan	Priority
Tieton River	*Flow Objective*: • Increase minimum flows to 125 cfs from late October to April 1.	High
	Modeled Outcome: The high priority flow objective of 125 cfs in winter (November to March) was met 99.8% of the time under the Integrated Plan compared to 28.3% under the FWIP.	
Lower Naches River	*Flow Objectives*: • Increase minimum flow rate to 550 cfs from June 1 to November 1. • Change the ramping rates from spring to summer flows to a more gradual decline. • Reduce September flows as much as possible.	High
	Modeled Outcome: Compared to FWIP, the average summer (July and August) flow has decreased by approximately 157 cfs, resulting in an average flow of 867 cfs under the Integrated Plan. However, since the lower Naches River was not targeted by reservoir operation rules the outcome of reduced summer flow appears to be a result of the model not being able to properly balance storage and flows well in that reach. Carryover storage in Tieton and Bumping reservoirs is increased by about 207,000 acre-feet on average which will provide operational flexibility. It is expected that some of the carryover storage can be used to change the ramping rate and increase summer instream flows greater than shown in the model. The objective of reducing September flows (through changing flip-flop operations) was not achieved.	
Yakima River from Parker to Toppenish Creek (Wapato Reach)	*Flow Objectives*: • Provide a spring pulse of 15,000 to 20,000 acre-feet in early May in dry years. • Change ramping rate at end of high flows that occur in June-July in average to wet years.	High
	Modeled Outcome: Pulse flows in dry years were not modeled, but system carryover storage is increased by 330,000 acre-feet on average. The additional storage can be used to provide pulse flows during dry years as well as flow to change ramping rates in average to wet years. In addition, storage in Wymer Reservoir is available for fisheries purposes, some of which can be used for pulse flows, although Wymer is lower in the river system. The hydrologic modeling also indicates average spring flow has increased from 3,377 cfs in the FWIP to 3,578 cfs in the Integrated Plan, an increase of 201 cfs.	

Table 4. Yakima Basin High-Priority Instream Flow Needs and Modeled Outcomes by Reach (continued)

River Reach	Desired Flow Objectives and Modeled Outcomes of Integrated Plan	Priority
Tributaries		
Manastash, Taneum, Cowiche	*Flow Objectives*: • Replace current diversions with Yakima or Naches River water; deliver water directly to tributaries if supply replacement is not feasible. No specific flow objectives were identified.	High
	Modeled Outcome: Tributary flows were not addressed in the model at this time, but the KRD South Branch project included in the Integrated Plan can provide 27 cfs in Manastash, and Taneum Creeks. Cowiche Creek is not addressed in the projects at this time.	
Ahtanum Creek	*Flow Objective*: • No flow objectives or augmentation alternatives were identified by subcommittee.	High
	Modeled Outcome: Tributary flows were not addressed in the model at this time. No significant change in flow is anticipated in Ahtanum Creek under the Integrated Plan.	

Color Code for Modeled Outcomes:

(light blue)	Significant improvement under integrated plan
(light green)	Minor improvement under integrated plan
(light red)	Conditions become worse under integrated plan
(white)	No significant change

Table 5. Yakima Basin Lower-Priority Instream Flow Needs and Modeled Outcomes by Reach

River Reach	Desired Flow Objectives and Modeled Outcomes of Integrated Plan	Priority
Kachess River	*Flow Objective:* • No change proposed – Kachess River is a lesser priority for improving river flow because of other objectives.	Lower
Yakima River, Easton Reach	*Flow Objective:* • Provide spring pulse of 1,000 cfs for 48 hours during dry years, occasionally augment spring flow for channel maintenance (5-years for riparian recruitment – bank full during wet years).	Medium
	Modeled Outcome: Spring pulse flows are provided in 18 of 25 years under the Integrated Plan compared to 12 out of 25 years under the FWIP. Additional storage is available in most years to provide additional pulses; in wet years sufficient storage should be available to provide channel maintenance flows if not provided in winter.	
Yakima River, Cle Elum to Teanaway River	*Flow Objectives:* • Provide channel shaping flows about every 5 years. • Provide flow variability; see Cle Elum River.	Medium
	Modeled Outcome: Additional September 30th carryover storage of 123,000 acre-feet in upper Yakima reservoirs (Keechelus, Kachess and Cle Elum), on average (not including Wymer Reservoir), would allow additional pulse flow or increases in flow variability. In wet years sufficient storage should be available to provide channel maintenance flows if not provided in winter.	

Table 5. Yakima Basin Lower-Priority Instream Flow Needs and Modeled Outcomes by Reach (continued)

River Reach	Desired Flow Objectives and Modeled Outcomes of Integrated Plan	Priority
Yakima River, Teanaway to Roza Dam	*Flow Objectives:* • Provide channel shaping flows about every 5 years. • Provide flow variability, time pulses to match natural events.	Medium
	Modeled Outcome: Pulse flows are provided from upstream reservoirs. Additional system carryover storage of 123,000 acre-feet in upper Yakima Basin reservoirs would allow additional pulse flow or increases in flow variability. In wet years sufficient storage should be available to provide channel maintenance flows if not provided in winter.	
Yakima River, Roza Dam to Naches River	*Flow Objective:* • Provide flow variability.	Lower to Medium
	Modeled Outcome: Subordination was not modeled, so flow variability could be provided when desired if subordination of Roza Powerplant flows is adopted.	
Bumping River, Bumping Dam to Naches River	*Flow Objective:* • Reduce flows by 70-100 cfs from August through October.	Medium
	Modeled Outcome: Average daily flow from August through October has decreased from 189 cfs under the FWIP to 165 cfs under the Integrated Plan.	
Tieton River	*Flow Objective:* • Reduce September flows to as close as possible to unregulated conditions.	Medium
	Modeled Outcome: Average flow in September has decreased from 1,534 cfs under the FWIP to 1,166 cfs under the Integrated Plan. Flip-flop could not be eliminated.	
Yakima River, Naches River to Parker	*Flow Objective:* • Reduce high summer flows as much as possible.	Lower
	Modeled Outcome: The average summer flow under the Integrated Plan has decreased by approximately 215 cfs, resulting in an average flow of 3,185 cfs.	
Yakima River from Parker to Toppenish Creek (Wapato Reach)	*Flow Objective:* • Link to habitat needs.	No priority assigned[2]
Yakima River: Toppenish Creek to Prosser Dam	*Flow Objective:* • See Wapato Reach.	See Wapato Reach
Yakima River-Prosser Dam to Chandler Powerplant	*Flow Objectives:* • Need greater than 1,000 cfs in September. • Although some subordination occurs to provide 1,000 cfs, need more flow in Spring	Lower
	Modeled Outcome: Average September flow has decreased from 650 cfs under the FWIP to 492 cfs under the Integrated Plan, but subordination of Chandler Powerplant was not modeled. Additional flow and habitat benefits would occur if subordination is adopted. Average flow in July has increased from 682 cfs under the FWIP to 758 cfs under the Integrated Plan. Average spring flows have increased by 188 cfs, resulting in an average spring flow of 2,490 cfs under the Integrated Plan. Additional storage is available for Spring pulse flows (see high priority flow objective for Wapato Reach).	

[2] This reach needs to better understanding of existing conditions. Design and implement research, monitoring and evaluation (RM&E) program to better understand improvements needed. Develop flow objectives from RM&E results.

Table 5. Yakima Basin Lower-Priority Instream Flow Needs and Modeled Outcomes by Reach (continued)

River Reach	Desired Flow Objectives and Modeled Outcomes of Integrated Plan	Priority
Lower Yakima River (Chandler Powerplant to mouth)	*Flow Objectives:* • See Wapato Reach for Spring flow objective. • Link summer flow objective to habitat needs	Lower
	Modeled Outcome: Pulse flows in dry years were not modeled, but system carryover storage is increased by 330,000 acre-feet on average. The additional storage can be used to provide pulse flows during dry years. In addition, storage in Wymer Reservoir is available for fisheries purposes including pulse flows.	
Tributaries		
Big, Little, Tillman, Spex Arth and Peterson Creeks	*Objective:* Increase summer and early fall flows.	Medium
Ahtanum Creek	*Objective:* Increase summer and early fall flows.	Medium
Wenas Creek	*Objective:* Increase summer and early fall flows.	Lower
North Side Kittitas Valley Tributaries	*Objective:* Improve passage	Lower
	Modeled Outcome: Tributary flows were not addressed in the model at this time. The KRD South Branch project can improve instream flow in Big, Little and other south side creeks however the flow available is also needed to increase flow in Taneum and Manastash creeks, which were rated a higher priority. No change in flow is anticipated in Ahtanum or Wenas Creek with projects under the Integrated Plan. The North Branch Canal has potential to improve flow conditions and passage in the north side Kittitas Valley tributaries by restoring flow or removing irrigation water conveyance through creeks and removing diversion structures.	

Color Code for Modeled Outcomes:

Blue	Significant improvement under integrated plan
Green	Minor improvement under integrated plan
Red	Conditions become worse under integrated plan
White	No significant change

7.0 References

1. Ecology (Washington State Department of Ecology) 2009. *Yakima River Basin Integrated Water Resource Management Alternative: Final Environmental Impact Statement.* Ecology Publication #09-12-009.

2. Hubble, Undated (Received April 2010). Discussion on Biologically Based Flows For The Determination Of Average Water Year Instream Flow Demand For The Yakima River Basin Study, U.S. Bureau of Reclamation.

3. IFTAG. 1984. Initial flow recommendations Yakima River Basin, Washington. Final document prepared by Instream Flow Technical Advisory Group, Yakima, Washington. December 21, 1984. 10 pp. (Yakima River, Washington).

4. Reclamation (United States Bureau of Reclamation) and Ecology (Washington State Department of Ecology) 2009. *Preliminary Integrated Water Resource Management Plan for the Yakima River Basin Yakima Project Washington*.

5. Reclamation (United States Bureau of Reclamation) and Ecology (Washington State Department of Ecology) 2008. *Yakima River Basin Water Storage Feasibility Study: Draft Planning Report/Environmental Impact Statement.*
6. Reclamation (United States Bureau of Reclamation) 2002. *Interim Comprehensive Basin Operating Plan for the Yakima Project.*
7. Simmons, Dell. 1981. Affidavit No 77-2-01484-5, Yakima County Superior Court.

8.0 List of Preparers

NAME	BACKGROUND	RESPONSIBILITY
Agency Staff and Other Subcommittee Participants		
See list of Instream Flow Subcommittee Members, Volume 1: *Proposed Integrated Water Resources Management Plan*		
HDR Engineering		
Steven Thurin	Water Resources Engineer	Hydrology and Modeling
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Ben Floyd	Planner	Subcommittee coordination

Appendix A
Previous Instream Flow Recommendations

Table A-1

REACH	METHOD	RECOMMENDED INSTREAM FLOW/ FLOW OBJECTIVES (cfs)											
		Spring				Summer				Winter			
		March	April	May	June	July	August	September	October	November	December	January	February
Keechelus Dam to Lk. Easton	IFTAG Recommended (1984)	125	125	125	100	100	100	125	125	100	100	100	125
	IFTAG Optimal (1984)	150	125	125	75	75	75	125	125	100	100	75	150
	USFWS (1981)(abv. Kachess R.)	175	425	750	640	150	150	170	260	135	125	150	175
	Interim Operating Plan (2002) (Keechelus Outflow to Crystal Springs)							60 - 100 cfs, Sept. 1 - Oct. 20					
	Interim Operating Plan (2002) (Keechelus Outflow to Crystal Springs)	15 - 100							15 - 100 cfs, Oct. 21 - March 31				
	Interim Operating Plan (2002) (Crystal Springs to Lk. Easton)							60 - 100 cfs, Sept. 1 - Oct. 20					
	Interim Operating Plan (2002) (Crystal Springs to Lk. Easton)	30 - 100							30 - 100 cfs, Oct. 21 - March 31				
	U.S. Bureau of Reclamation (2008)	No recommended flows for this reach.											
	Hubble White Paper (2010)	No recommended flows for this reach.											
Kachess River		Not summarized as reach is lesser priority											
Easton Reach	IFTAG Recommended (1984) (Easton Dam to Cle Elum R)	275	275	275	225	225	225	400	400	350	350	275	275
	IFTAG Optimal (1984)	250	250	250	225	225	250	250	400	250	250	250	250
	USFWS (1981)(blw. Easton Dam)	275	845	1465	1215	250	250	220	375	375	375	300	275
	Interim Operating Plan (2002)							150 - 300 cfs, Sept. 10 - Oct. 20					
		80 - 300							80 - 300 cfs, Oct. 21 - March 31				
	U.S. Bureau of Reclamation (2008)	722	1166	1400	787	450	375	375	375	425	450	450	450
	Hubble White Paper (2010)	600	970	1165	665	450	375	375	375	425	450	450	450
Cle Elum River	IFTAG Recommended (1984)	250	225	225	150	150	150	250	250	250	250	250	250
	IFTAG Optimal (1984)	250	200	200	150	150	150	150	150	150	150	150	250
	USFWS (1981) (at mouth)	250	1235	2570	2375	150	150	150	250	200	200	200	250
	Interim Operating Plan (2002)							150 - 650 cfs, Sept. 10 - Oct. 20					
		60 - 300							60 - 300 cfs, Oct. 21 - March 31				
	U.S. Bureau of Reclamation (2008)	511	954	1500	1301	589	400	400	400	425	425	425	425
	Hubble White Paper (2010)	430	805	1265	1095	495	400	400	400	425	425	425	425
Cle Elum to Teanaway River	IFTAG Recommended (1984)	500	500	500	600	600	600	650	650	600	600	525	525
	IFTAG Optimal (1984)	600	800	800	800	800	800	600	550	800	800	800	600
	USFWS (1981) (abv. Teanaway River)	740	2450	4385	3780	450	470	550	550	600	675	700	700
	Interim Operating Plan (2002)							400 - 800 cfs, Sept. 10 - Oct. 20					
		200 - 325							200 - 325 cfs, Oct. 21 - March 31				
	U.S. Bureau of Reclamation (2008)	No recommended flows for this reach.											
	Hubble White Paper (2010)	No recommended flows for this reach.											
Teanaway River	USFWS (1981) (at mouth)	150	785	1,800	485	65	65	30	60	150	150	100	150
Teanaway to Roza Dam	IFTAG Recommended (1984) (Wilson Crk to Roza Dam)	900	750	750	750	750	750	750	1000	1000	750	750	900
	IFTAG Optimal (1984)	900	750	750	750	750	750	750	900	900	750	750	900
	USFWS (1981) (abv. Roza Dam)	1000	4100	7000	5400	1000	900	825	950	950	1000	1000	1000
	Interim Operating Plan (2002)	No recommended flows for this reach.											
	U.S. Bureau of Reclamation (2008) (used Ellensburg Reach recommended flows)	1982	2424	3700	2586	2000	1000	1000	1000	980	1016	1257	1459
	Hubble White Paper (2010) (used Ellensburg Reach recommended flows)	1980	2425	3700	2590	2000	1000	1000	1000	980	1015	1255	1460
Manastash Creek	USFWS (1981) (at mouth)	43	135	240	215	55	25	20	20	25	35	30	35
Roza - Naches	IFTAG Recommended (1984)	900	1000	1000	1300	1300	1300	1000	800	800	1000	1000	900
	IFTAG Optimal (1984)	1100	1200	1200	1300	1300	1300	1200	800	800	1200	1200	800
	USFWS (1981) (abv. Naches)	900	4100	7000	5400	1000	865	785	900	900	1000	1000	900
	Interim Operating Plan (2002)					200 - 300 cfs, July 1 - Oct. 20							
		300 - 400							300 - 400 cfs, Oct. 21 - March 31				
		300 - 600							300 - 600 cfs, Oct. 21 - March 15				
	U.S. Bureau of Reclamation (2008)	No recommended flows for this reach.											
	Hubble White Paper (2010)	No recommended flows for this reach.											
Wenas Creek	USFWS (1981) (at mouth)	16	50	85	75	20	9	8	7	9	12	11	13
Bumping Dam - Lower Naches	IFTAG Recommended (1984) (Bumping River)	200	200	200	100	100	150	150	150	150	150	150	150
	IFTAG Optimal (1984)	150	100	100	100	100	100	100	100	100	100	100	150
	USFWS (1981) (blw. Bumping Dam)	200	300	730	795	100	90	75	115	195	200	150	200
	Interim Operating Plan (2002) (Dam to American River)	50 - 120							50 - 120 cfs, Oct. 21 - March 31				
	U.S. Bureau of Reclamation (2008)	No recommended flows for this reach.											
	Hubble White Paper (2010)	No recommended flows for this reach.											

Table A-1

REACH	METHOD	RECOMMENDED INSTREAM FLOW/ FLOW OBJECTIVES (cfs)											
		Spring				Summer				Winter			
		March	April	May	June	July	August	September	October	November	December	January	February
Tieton River	IFTAG Recommended (1984) (Lower Tieton River)	125	125	125	200	200	150	150	200	200	200	200	125
	IFTAG Optimal (1984) (Lower Tieton River)	125	125	125	275	275	175	125	275	275	275	275	125
	USFWS (1981) (at mouth)	150	725	1230	1240	200	125	250	250	200	200	200	150
	Interim Operating Plan (2002)	15 - 50							15 - 50 cfs, Oct. 21 - March 31				
	U.S. Bureau of Reclamation (2008)	No recommended flows for this reach.											
	Hubble White Paper (2010)	No recommended flows for this reach.											
Lower Naches River	IFTAG Recommended (1984)	No recommended flows for this reach.											
	IFTAG Optimal (1984)												
	USFWS (1981) (at mouth)	400	2065	3790	3655	400	400	500	500	400	400	400	400
	Interim Operating Plan (2002)	Recommended IOP flows no longer applicable - were for Wapatox Powerplant.											
	U.S. Bureau of Reclamation (2008)	1265	1802	2297	2291	988	550	550	550	500	576	691	720
	Hubble White Paper (2010)	1265	1800	2295	2290	990	550	550	550	500	575	690	720
Yakima River from Naches River to Parker	IFTAG Recommended (1984)	No recommended flows for this reach.											
	IFTAG Optimal (1984)												
	USFWS (1981) (abv. Sunnyside Dam)	820	5900	11150	8510	955	955	965	1455	1420	920	920	820
	Interim Operating Plan (2002)	No recommended flows for this reach.											
	U.S. Bureau of Reclamation (2008)	No recommended flows for this reach.											
	Hubble White Paper (2010)	No recommended flows for this reach.											
Ahtanum Creek	USFWS (1981) (at mouth)	50	215	355	300	20	20	20	20	20	20	20	50
Yakima River from Parker to Toppenish Creek (Wapato Reach)	IFTAG Recommended (1984) (Sunnyside Dam - Marion Drain)	700	800	800	800	800	800	800	700	700	700	700	600
	IFTAG Optimal (1984)	800	800	800	900	900	900	900	800	800	900	900	600
	USFWS (1981) (avb. Toppenish)	820	5900	11150	8510	955	955	965	1455	1429	920	920	820
	Interim Operating Plan (2002)	-	Title XII Legislative Target Flows, varies between 300 and 600 cfs depending on the total water supply available (TWSA), Apr. 1 - Oct. 31.							-	-	-	-
	U.S. Bureau of Reclamation (2008)	3109	2794	3500	2655	1300	1300	1300	1300	1758	1854	2163	2460
	Hubble White Paper (2010)	3110	2795	3500	2655	1300	1300	1300	1300	1760	1855	2165	2460
Yakima River between Toppenish Creek and Prosser Dam	IFTAG Recommended (1984)	No recommended flows for this reach.											
	IFTAG Optimal (1984)												
	USFWS (1981) (abv. Prosser)	1000	5900	11700	8750	1000	1000	1000	1500	1500	1000	1000	1000
	Interim Operating Plan (2002)	–	Title XII Legislative Target Flows, varies between 300 and 600 cfs depending on the total water supply available (TWSA), Apr. 1 - Oct. 31.							–	–	–	–
	U.S. Bureau of Reclamation (2008)(Wapato Reach)	3109	2794	3500	2655	1300	1300	1300	1300	1758	1854	2163	2460
	Hubble White Paper (2010)	No recommended flows for this reach.											
Yakima River - Chandler Reach	IFTAG Recommended (1984) (Prosser Dam - Chandler PH)	800	700	700	800	800	800	800	1000	1000	800	800	800
	IFTAG Optimal (1984)	1400	750	750	750	750	750	750	1000	1000	1400	1400	1400
	USFWS (1981) (abv. Kiona Canal)	1000	5800	9800	7900	1000	1000	1000	1500	1500	1000	1000	1000
	Interim Operating Plan (2002)		1000 cfs, Apr. 1 - June 30			Subordination flows of 450 cfs or Title XII flows, whichever is greater, July 1 - Oct. 31							
	U.S. Bureau of Reclamation (2008)	No recommended flows for this reach.											
	Hubble White Paper (2010)	No recommended flows for this reach.											
Lower Yakima River (Chandler Powerplant to mouth)	IFTAG Recommended (1984) (blw. Horn Rapids Dam)	900	800	800	800	800	800	900	1300	1300	900	900	900
	IFTAG Optimal (1984)	1000	1000	1000	1000	1000	1000	1000	1500	1500	1000	1000	1000
	USFWS (1981) (at mouth)	1000	5800	9800	7900	1000	1000	1000	1400	1400	1000	1000	1000
	Interim Operating Plan (2002)	No recommended flows for this reach.											
	U.S. Bureau of Reclamation (2008)	No recommended flows for this reach.											
	Hubble White Paper (2010)	No recommended flows for this reach.											

Sources: Instream Flow Technical Advisory Group (IFTAG) 1984
U.S. Fish & Wildlife Service (Simmons, 1981)
Interim Comprehensive Operating Plan for the Yakima Project Washington.
U.S. Department of Interior, U.S. Bureau of Reclamation, November, 2002
Planning Report/EIS Yakima River Basin Water Storage Feasibility Study
Yakima Project Washington, U.S Bureau of Reclamation January 2008
Discussion on Biologically Based Flows For The Determination Of Average
Water Year Instream Flow Demand For The Yakima River Basin Study, Hubble,
U.S. Bureau of Reclamation, Undated (Received April 2010)

Appendix B

Instream Flow Improvement Matrix

River Reach	Problem	Flow Objective	Priority	Projects Within Integrated Plan That May Help Meet Flow Objective	Other Notes
Yakima River, Keechelus Dam to Lake Easton	Flow too high in July, August and first week of September; over 800 cfs.	Improve summer rearing by reducing flows to 450-550 cfs. Increase winter flow to 120 cfs (connection to side channels at that flow). Provide pulse in spring (April 1). Provide additional pulse May 1 in dry years.	High	K to K Pipeline, Storage downstream from Keechelus, including Wymer, Cle Elum pool raise, Bumping, Kachess Inactive Storage, Aquifer storage	Spring flow low only in drought years
Kachess River	No change in flow objectives proposed – lesser priority for improving river flow because of other objectives				
Yakima River, Easton Reach	Spring – need outmigration flow for spring Chinook, steelhead, sockeye, and coho	Provide spring pulse of 1,000 cfs for 48 hours during dry and average years; occasionally augment spring flow for channel maintenance (about every 5 for riparian recruitment – bank full during wet years).	Medium	Wymer Cle Elum pool raise Bumping Kachess Inactive Storage Aquifer storage	There are uncertainties because fish would be introduced in the future. Are the flow objectives adequate for other species reintroduced? Look at PIT-tag relationship to determine pulse size/duration.
	Fall/winter – need additional flow for spawning and rearing	Currently 180 cfs, start spawning flow at 220 cfs, increase to 250-300 cfs in winter, 250 cfs provides connection to side channels. Spawning flows at 220 cfs.	High		
Cle Elum River	Summer flows (July and August) are too high	Reduce flow, modify flip-flop to give more gentle change in hydrograph. In wet years, spill earlier but hold water back in August to reduce flow by 1,000 cfs. Also desirable to bridge peaks between spring and summer to improve cottonwood establishment.	High	Bumping Wymer Flip-flop modification Aquifer storage K to K pipeline Cle Elum pool raise	This reach is ripe for restoration because floodplain ownership is held in conservation easements. One-third of spring Chinook population spawns here.
	Fall/winter flows (September 10 through March): no flow variation (spring. Chinook, steelhead)	Increase to 500 cfs September through March. Side channels are thought to be activated at about 500 cfs; one was recently modified to activate at 200 cfs; provide pulse flows.			
Yakima River, Cle Elum to Teanaway River	Summer flows are too high	Reduce flows from 4000 cfs to 1000 cfs by late August. Ok to have high flow in July, as it mimics unregulated hydrograph.	High	See Cle Elum list	Spring flows support cottonwood regeneration.
	Need occasional channel-shaping flows in spring for riparian restoration.	Provide channel shaping flows about every 5 years.	Medium		
	Flat hydrograph in winter	Provide flow variability. See Cle Elum River.	Medium		

River Reach	Problem	Flow Objective	Priority	Projects Within Integrated Plan That May Help Meet Flow Objective	Other Notes
Yakima river, Teanaway River to Roza Dam (Ellensburg Reach)	Summer flows are too high	Reduce flows	High	See Cle Elum list	Tributaries in this reach reduce effects in spring and winter
	Need occasionally channel-shaping flows in spring for riparian restoration. Not as big an issue as upstream reach because of tributary inflow.	Provide channel-shaping flows about every 5 years	Medium		
	Some flow variability exists because of tributaries, but magnitude could be increased.	Provide flow variability, time pulses to match natural events.	Medium		
Yakima River, Roza Dam to Naches River	Need additional outmigration flow in spring from beginning of March to end of May.	Increase flow to about 1,400 cfs for high and average water years from March through May[3].	High	See Cle Elum list Roza hydropower subordination Roza dam removal	Predation Issues: In late fall to early winter flow is at 400 cfs to support power production Uncertainties: Opportunity to support reintroduced sockeye and summer Chinook Consider three potential scenarios: -Current operations -Without operating powerplant -With subordination Try to more closely mimic unregulated flow during subordination period(s)
	Sufficient flow needed in fall/winter to support movement of fish to lower river, rearing and spawning.	Increase to 1,000-1,400 cfs (use IFTAG flows). Link flows to habitat needs. Compare to 2-D habitat model for reach above Roza Dam.	High		
	High summer flow is not an issue because of Roza diversions, but ability to modify flow in this reach may be useful. Discuss with habitat subcommittee.	Variability	Lower to medium		
Bumping River, Bumping Dam – Lower Naches	Fall flows after flip-flop are too high, then get reduced in winter.	Reduce flows by 70-100 cfs from August through October.	Medium	Bumping Reservoir, other storage reservoirs	Bumping Lake expansion, change operations in Naches arm

[3] Roza – Sunnyside Joint Board of Control is planning to conduct a study below Roza to improve the biological basis for flow enhancements in this reach. Results are expected in 12 -18 months.

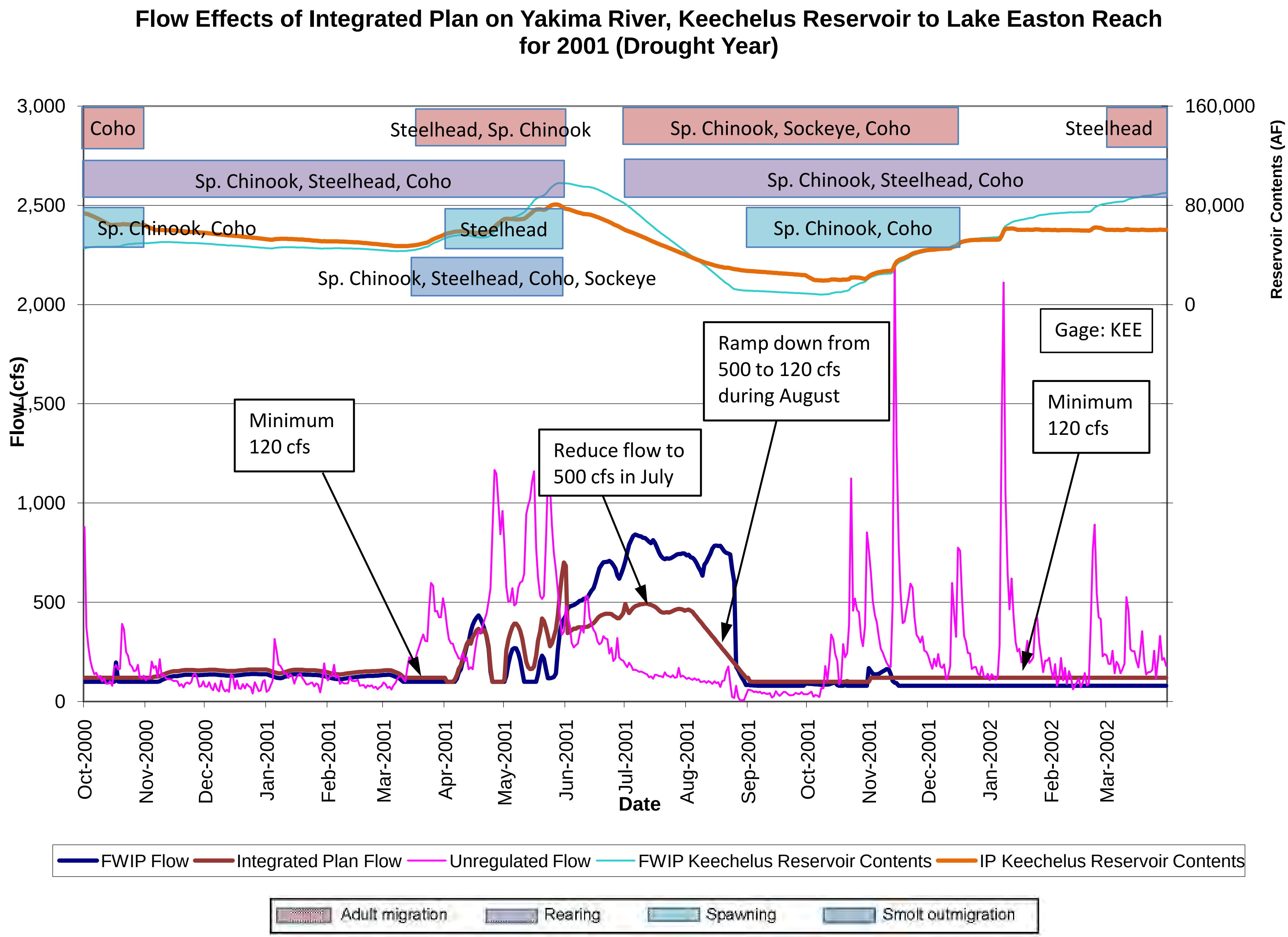
River Reach	Problem	Flow Objective	Priority	Projects Within Integrated Plan That May Help Meet Flow Objective	Other Notes
Tieton River	Low flows (late fall/winter/early spring and no variation (November to March)	Maintain minimum 125 cfs flow November to April 1.	High	Change in operations (minor improvements on shoulders of flip-flop) Bumping Lake (for operational flexibility), contingent on South Fork Fish Passage Project to allow more flexibility in reservoir operations	Current winter flows (75 – 120 cfs) Key project is South Fork Fish Passage Project; needs to be to constructed to allow flexibility in reservoir operations.
	High flows in September due to flip-flop (and shoulders)	Reduce flows as much as possible.	Medium		
Lower Naches River	Summer flows are low, ramping rate from high spring flows to summer flows is abrupt, affects rearing for steelhead, coho, spring Chinook. Up to ½ of flow in river is lost to groundwater in part of this reach.	Change ramping rate from spring to summer, increase summer low flows to 550 cfs from June 1 to November 1, and check habitat needs vs. flow.	High	Bumping Reservoir Water Conservation for Gleed, Naches Selah, and other systems (non-YRBWEP projects) to improve summer flow.	Uncertainties: Gaining/losing reaches Complexity Limited recharge Try to stay below flow level that affects cottonwood regeneration.
	High flows in flip-flop operations	Reduce flows as much as possible, look at releasing more in summer and reducing flip-flop.	High		
Yakima River from Naches River to Parker	High summer flow	Reduce as much as possible	Lower	Habitat improvement projects to provide more habitat during high flows	Habitat improvements would be primary enhancement strategy.
Yakima River from Parker to Toppenish Creek (Wapato Reach)	In spring, flow is low and outmigration flow needed, mostly during dry years.	15,000-20,000 acre-feet to use specifically for smolt outmigration in dry years. See SOAC recommendations for pulse flows. Maybe early and late pulse? Sockeye passage also? Change ramping rate at end of high flows that occur in June-July in average-wet years.	High	Water storage in Wymer, Cle Elum, Kachess dead storage, Bumping Lake for pulse flows. Water conservation would also provide flow. Modify operations	Temperature issues with shoulders of spring and fall. Fit channel to river.
	Low Summer flow	Link to habitat needs	No priority assigned[4]		
Yakima River between Toppenish Creek to Prosser Dam	Flow is low in spring (similar to Wapato Reach).	See Wapato Reach	See Wapato Reach	See Wapato Reach	Summer and Winter flow OK

[4] This reach needs to better understanding of existing conditions. Design and implement research, monitoring and evaluation (RM&E) program to better understand improvements needed. Develop flow objectives from RM&E results.

River Reach	Problem	Flow Objective	Priority	Projects Within Integrated Plan That May Help Meet Flow Objective	Other Notes
Yakima River – Chandler Reach	Need more flow in July (shoulder period) and September.	Need greater than 1,000 cfs in September	Lower	Chandler Powerplant subordination, KID projects See Wapato Reach for more projects	Biggest issue: mortality at canal Winter flow OK
	Need more flow in spring	Although some subordination occurs to provide 1,000 cfs, need more flow.	Lower		
Lower Yakima River (Chandler Powerplant to mouth)	Flow is low in spring (similar to Wapato Reach), but more emphasis in June needed to push fish out.	See Wapato Reach	Lower	See Wapato Reach KID	Winter OK
	Flow can be low in summer; cover is an issue.	Link to habitat needs	Lower		
Tributaries					
Manastash, Taneum, Cowiche creeks	Summer and early fall flow issues	None stated at this time	High	Deliver water directly to tributaries if supply replacement not feasible.	See Kittitas Conservation District flow study for Manastash Creek. See other IFIM studies. Discuss with habitat group.
Big, Little creeks	Summer and early fall flow issues	None stated at this time	Medium	Same as above	-
Ahtanum Creek	Urbanization, irrigation conservation are issues	Summer and early fall flow issues	High	None proposed at this time	Water rights concerns would limit ability to implement any projects in Ahtanum Creek.
Wenas Creek	Need to redo irrigation diversions. Will there be water for streamflow?	Summer and early fall flow issues	Lower	None proposed at this time	-
North Side Kittitas Valley Tributaries	Fish barriers are big issue	None stated at this time	To be determined	Thorp to Wymer, using KRD North Branch Canal, could serve water users.	Need to figure out creek systems — too many distributaries. May need to simplify systems to keep enough water in stream.

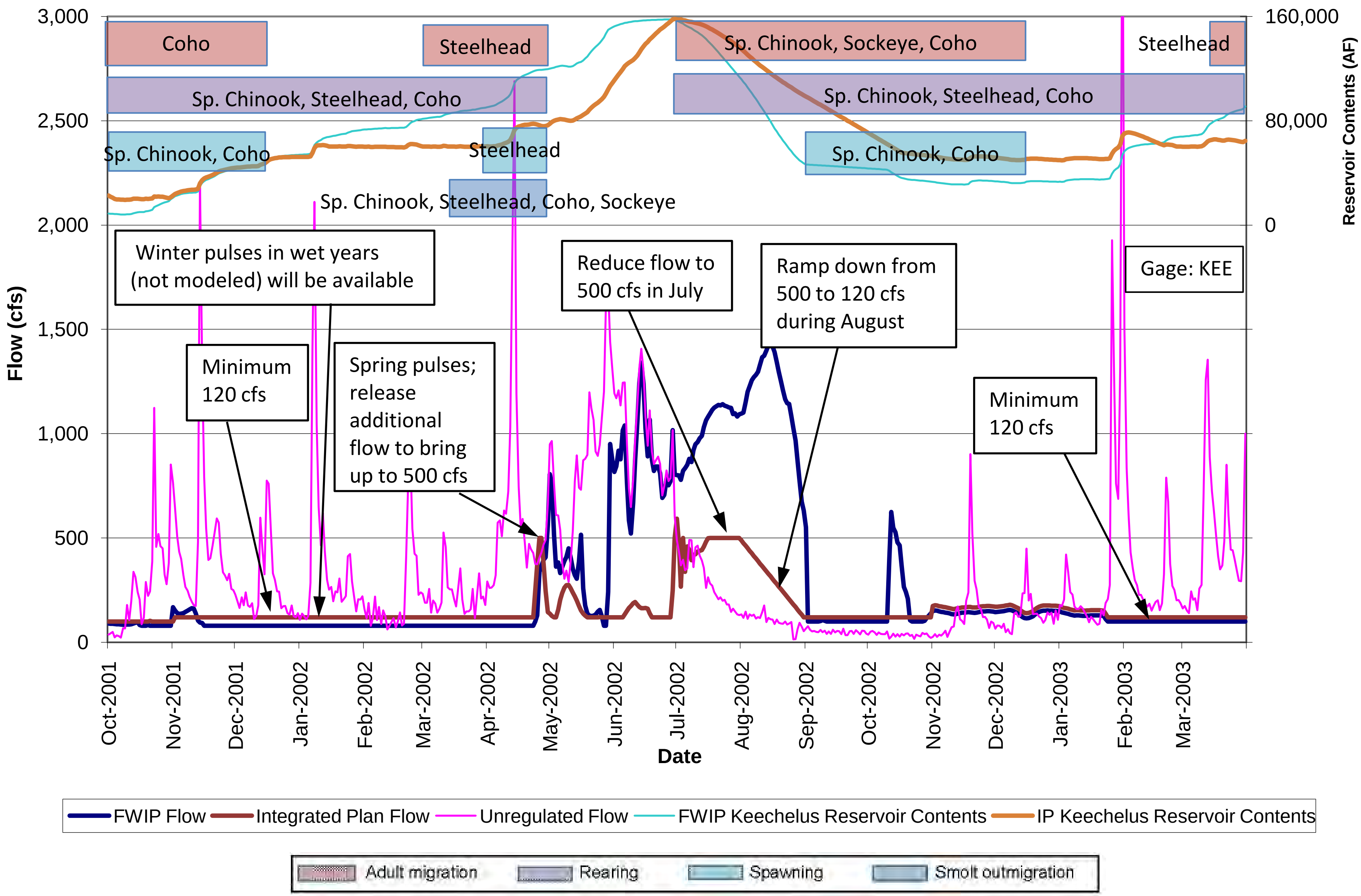
Appendix C

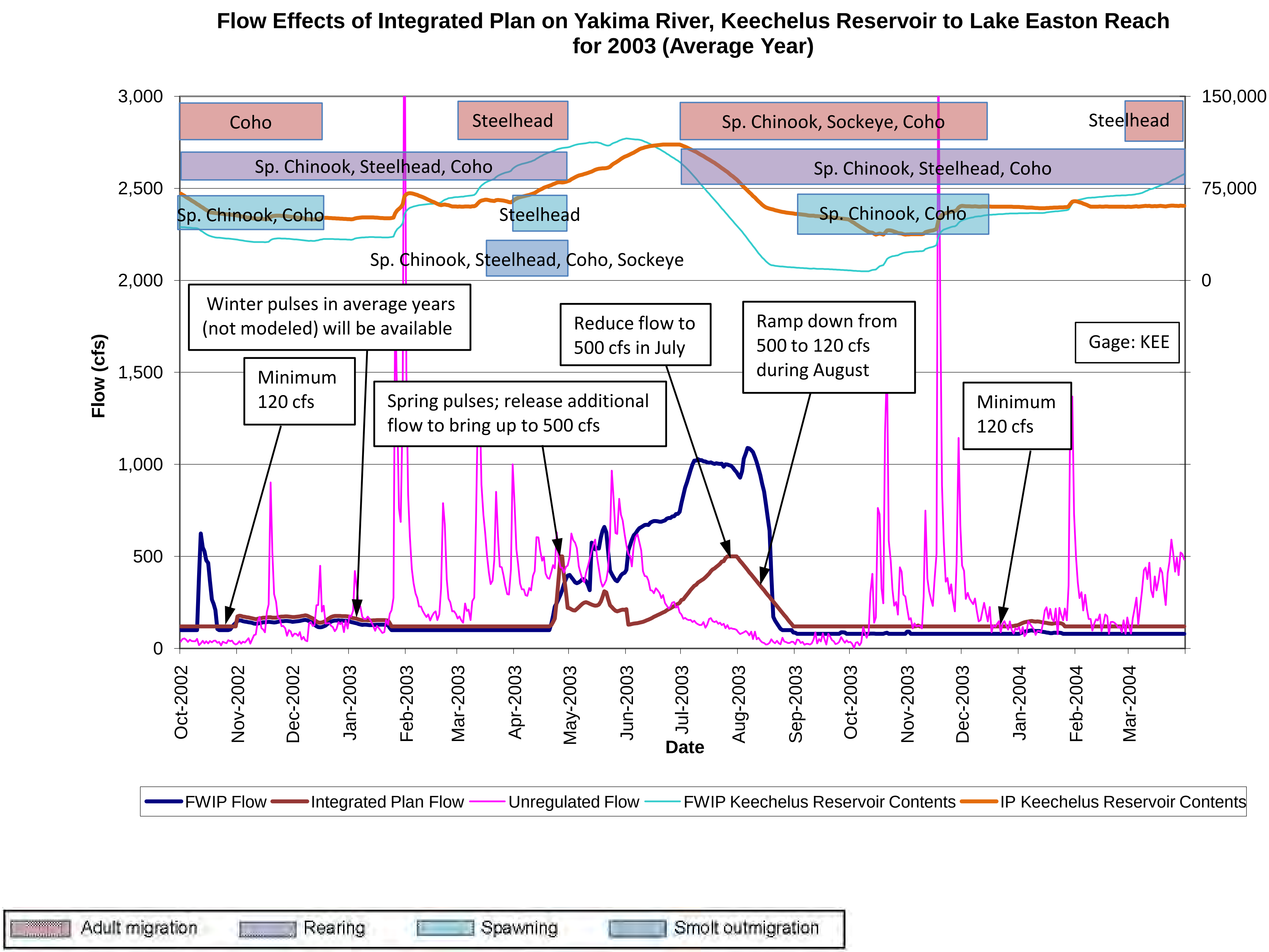
Representative Hydrographs Under Integrated Plan Conditions for the High Priority Reaches



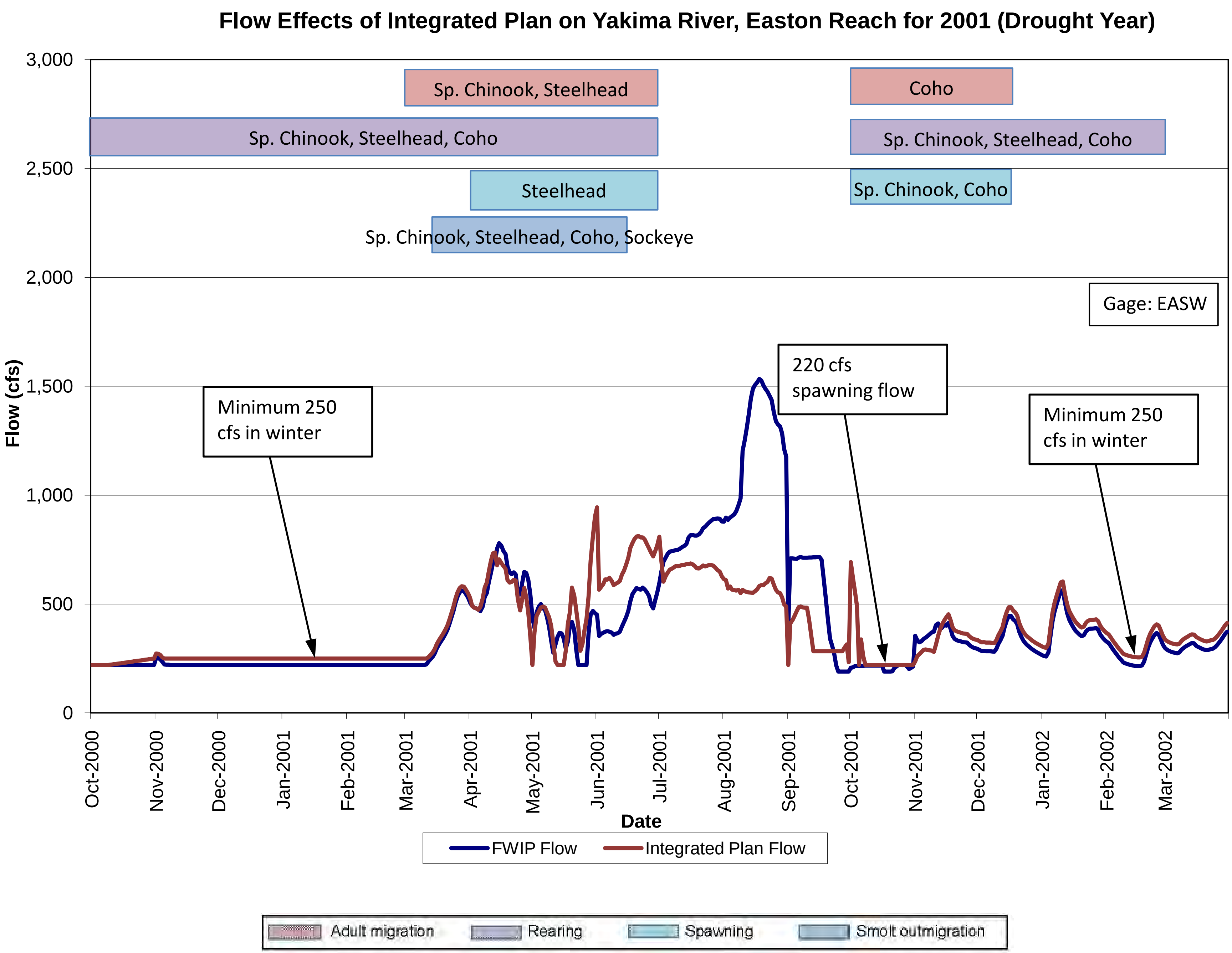
Flow Effects of Integrated Plan on Yakima River, Keechelus Reservoir to Lake Easton Reach
for 2001 (Drought Year)
Coho
Steelhead, Sp. Chinook
Sp. Chinook, Sockeye, Coho
Steelhead
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Coho
Steelhead
Sp. Chinook, Coho
Sp. Chinook, Steelhead, Coho, Sockeye
Gage: KEE
Ramp down from 500 to 120 cfs during August
Minimum 120 cfs
Reduce flow to 500 cfs in July
Minimum 120 cfs
3,000
2,500
2,000
1,500
1,000
500
0
Flow (cfs)
160,000
80,000
0
Reservoir Contents (AF)
Oct-2000
Nov-2000
Dec-2000
Jan-2001
Feb-2001
Mar-2001
Apr-2001
May-2001
Jun-2001
Jul-2001
Aug-2001
Sep-2001
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Date
FWIP Flow
Integrated Plan Flow
Unregulated Flow
FWIP Keechelus Reservoir Contents
IP Keechelus Reservoir Contents
Adult migration
Rearing
Spawning
Smolt outmigration

Flow Effects of Integrated Plan on Yakima River, Keechelus Reservoir to Lake Easton Reach for 2002 (Wet Year)

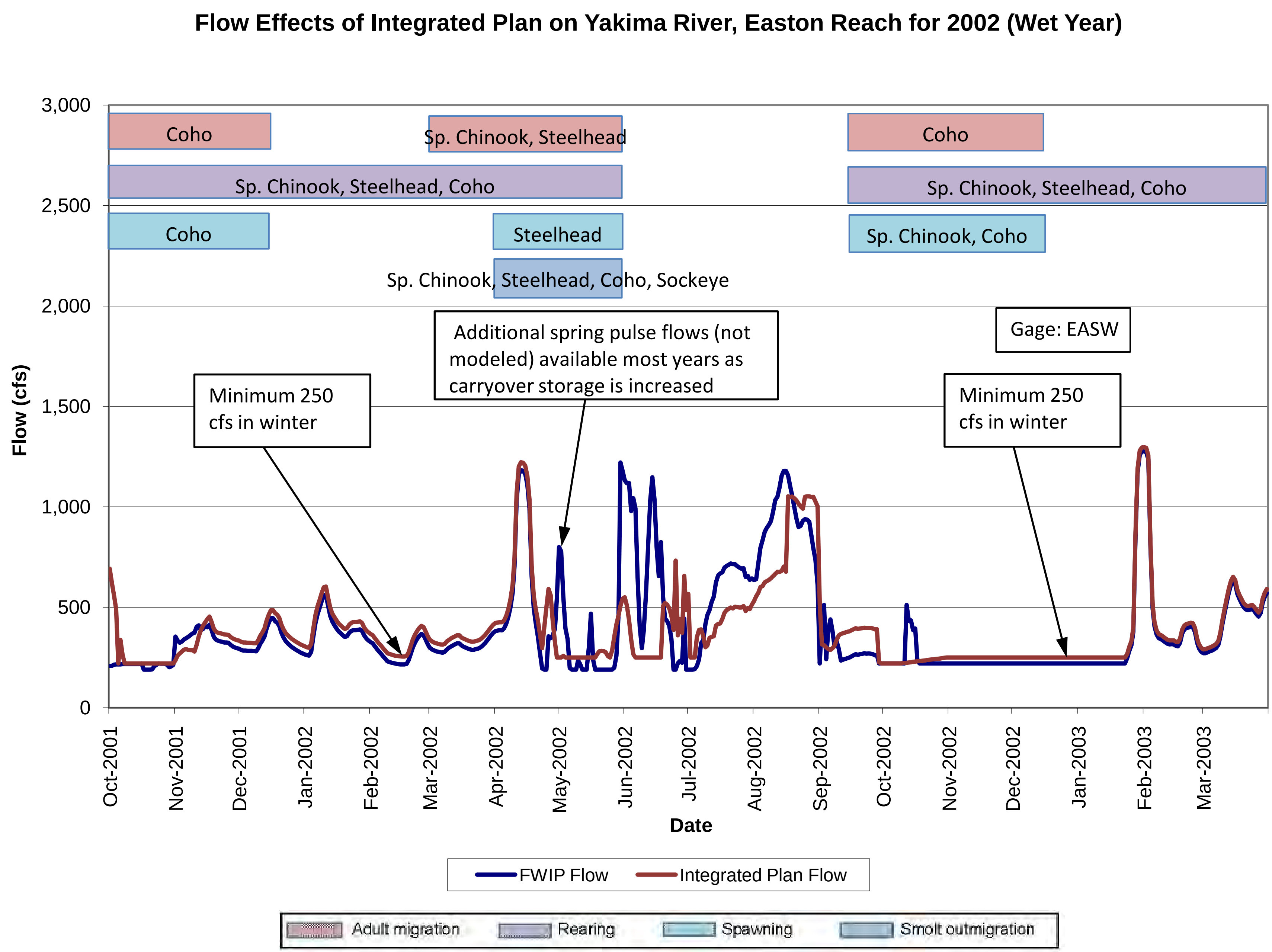




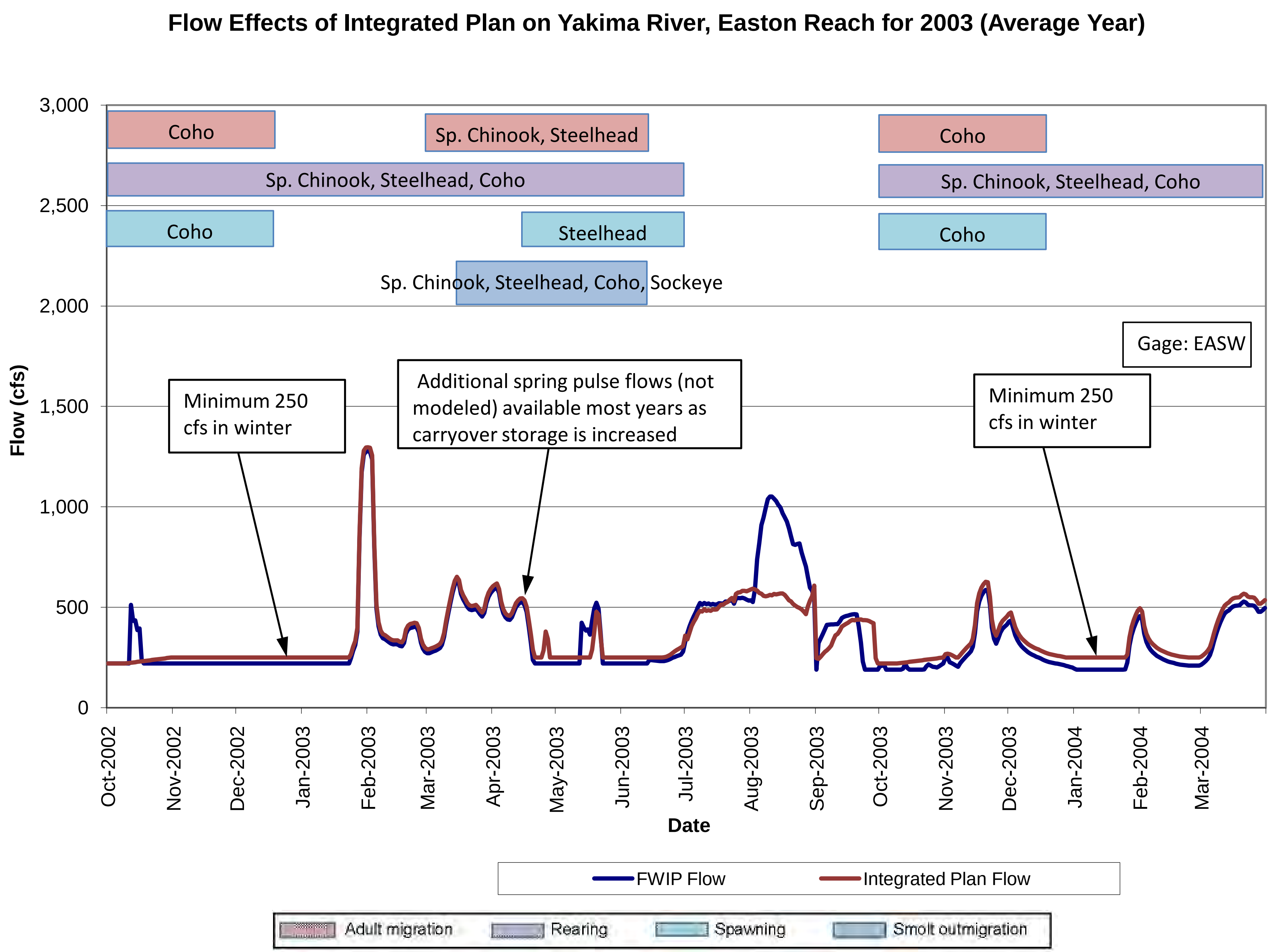
Flow Effects of Integrated Plan on Yakima River, Keechelus Reservoir to Lake Easton Reach
for 2003 (Average Year)
Coho
Steelhead
Sp. Chinook, Sockeye, Coho
Steelhead
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Coho
Steelhead
Sp. Chinook, Coho
Sp. Chinook, Steelhead, Coho, Sockeye
Winter pulses in average years (not modeled) will be available
Reduce flow to 500 cfs in July
Ramp down from 500 to 120 cfs during August
Gage: KEE
Minimum 120 cfs
Spring pulses; release additional flow to bring up to 500 cfs
Minimum 120 cfs
Flow (cfs)
Reservoir Contents (AF)
3,000
2,500
2,000
1,500
1,000
500
0
150,000
75,000
0
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Apr-2003
May-2003
Jun-2003
Jul-2003
Aug-2003
Sep-2003
Oct-2003
Nov-2003
Dec-2003
Jan-2004
Feb-2004
Mar-2004
Date
FWIP Flow
Integrated Plan Flow
Unregulated Flow
FWIP Keechelus Reservoir Contents
IP Keechelus Reservoir Contents
Adult migration
Rearing
Spawning
Smolt outmigration

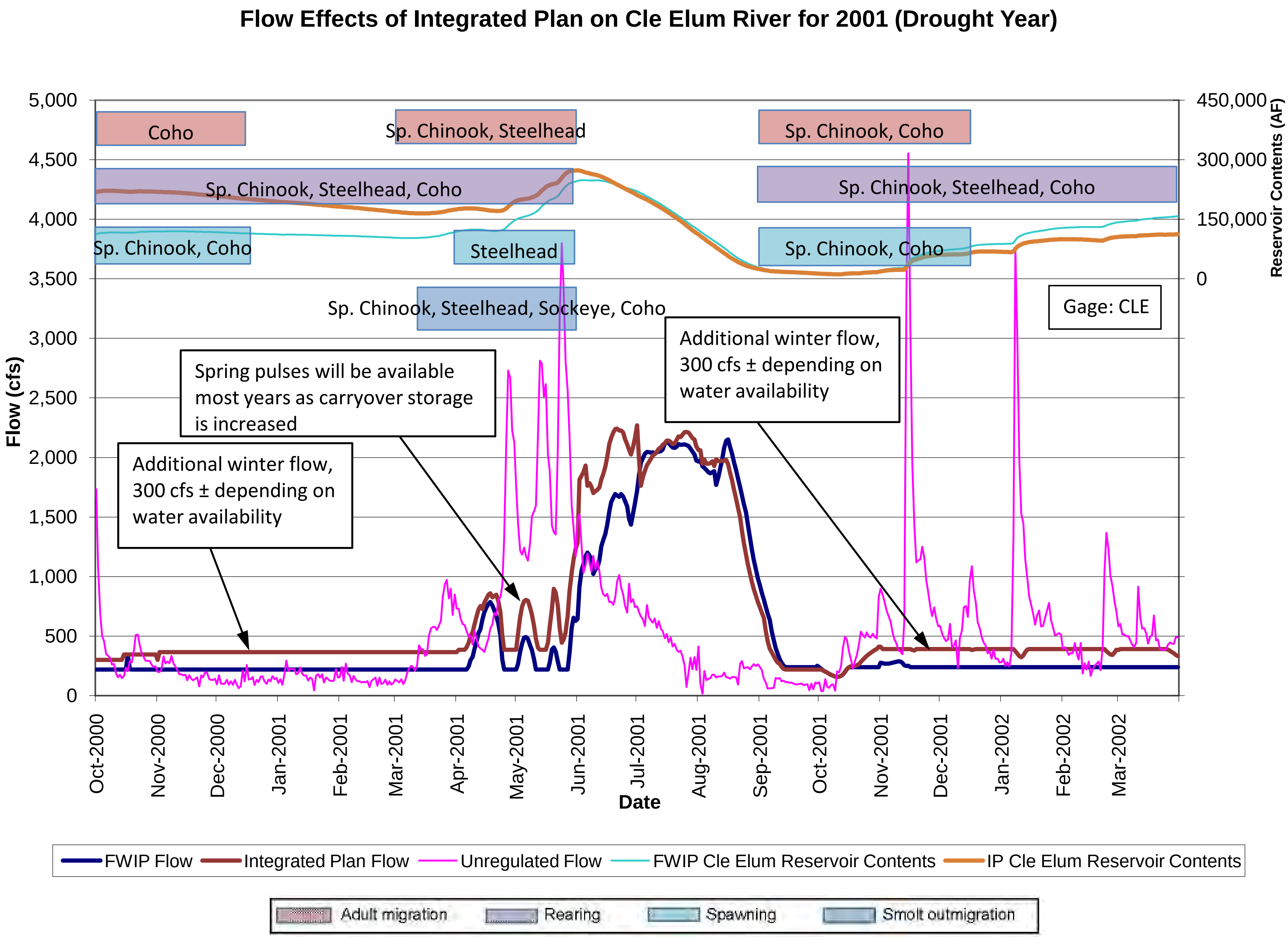


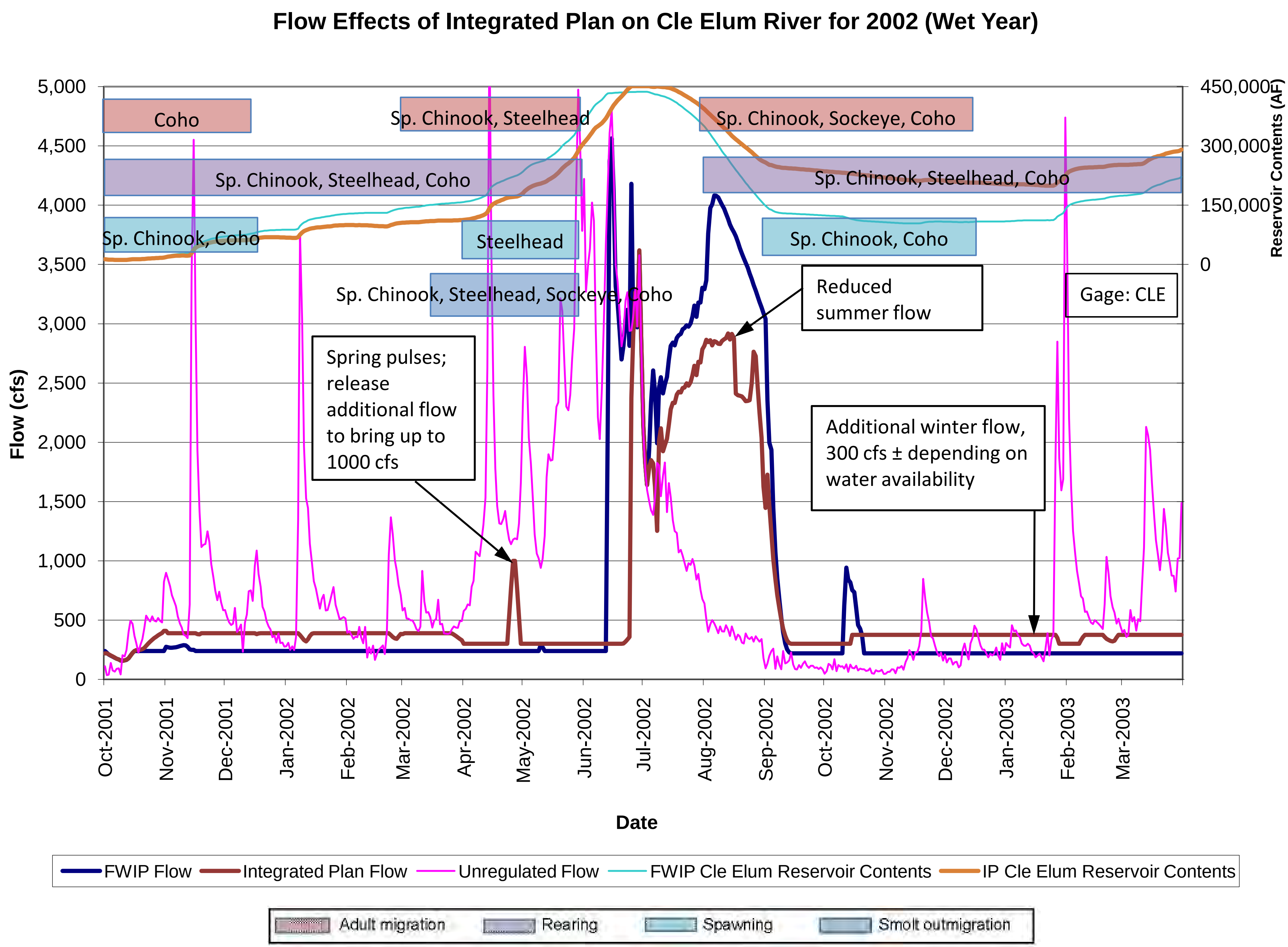
Flow Effects of Integrated Plan on Yakima River, Easton Reach for 2001 (Drought Year)
Sp. Chinook, Steelhead
Coho
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Steelhead
Sp. Chinook, Coho
Sp. Chinook, Steelhead, Coho, Sockeye
Gage: EASW
220 cfs spawning flow
Minimum 250 cfs in winter
Minimum 250 cfs in winter
Flow (cfs)
3,000
2,500
2,000
1,500
1,000
500
0
Oct-2000
Nov-2000
Dec-2000
Jan-2001
Feb-2001
Mar-2001
Apr-2001
May-2001
Jun-2001
Jul-2001
Aug-2001
Sep-2001
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Date
FWIP Flow
Integrated Plan Flow
Adult migration
Rearing
Spawning
Smolt outmigration



Flow Effects of Integrated Plan on Yakima River, Easton Reach for 2002 (Wet Year)
Coho
Sp. Chinook, Steelhead
Coho
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Coho
Steelhead
Sp. Chinook, Coho
Sp. Chinook, Steelhead, Coho, Sockeye
Additional spring pulse flows (not modeled) available most years as carryover storage is increased
Gage: EASW
Minimum 250 cfs in winter
Minimum 250 cfs in winter
Flow (cfs)
3,000
2,500
2,000
1,500
1,000
500
0
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Apr-2002
May-2002
Jun-2002
Jul-2002
Aug-2002
Sep-2002
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Date
FWIP Flow
Integrated Plan Flow
Adult migration
Rearing
Spawning
Smolt outmigration

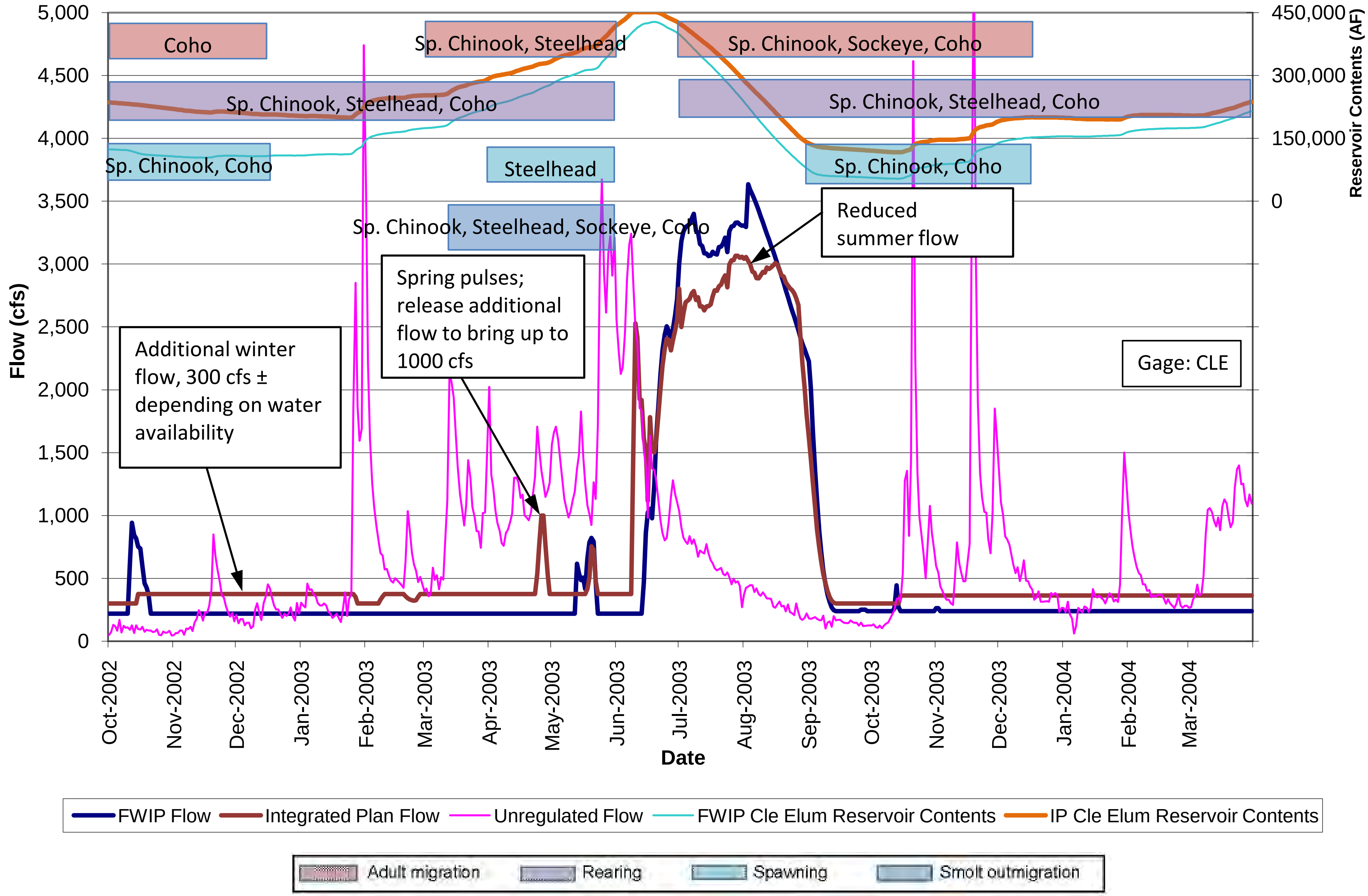

Flow Effects of Integrated Plan on Yakima River, Easton Reach for 2003 (Average Year)
Coho
Sp. Chinook, Steelhead
Coho
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Coho
Steelhead
Coho
Sp. Chinook, Steelhead, Coho, Sockeye
Gage: EASW
Minimum 250 cfs in winter
Additional spring pulse flows (not modeled) available most years as carryover storage is increased
Minimum 250 cfs in winter
Flow (cfs)
3,000
2,500
2,000
1,500
1,000
500
0
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Apr-2003
May-2003
Jun-2003
Jul-2003
Aug-2003
Sep-2003
Oct-2003
Nov-2003
Dec-2003
Jan-2004
Feb-2004
Mar-2004
Date
FWIP Flow
Integrated Plan Flow
Adult migration
Rearing
Spawning
Smolt outmigration

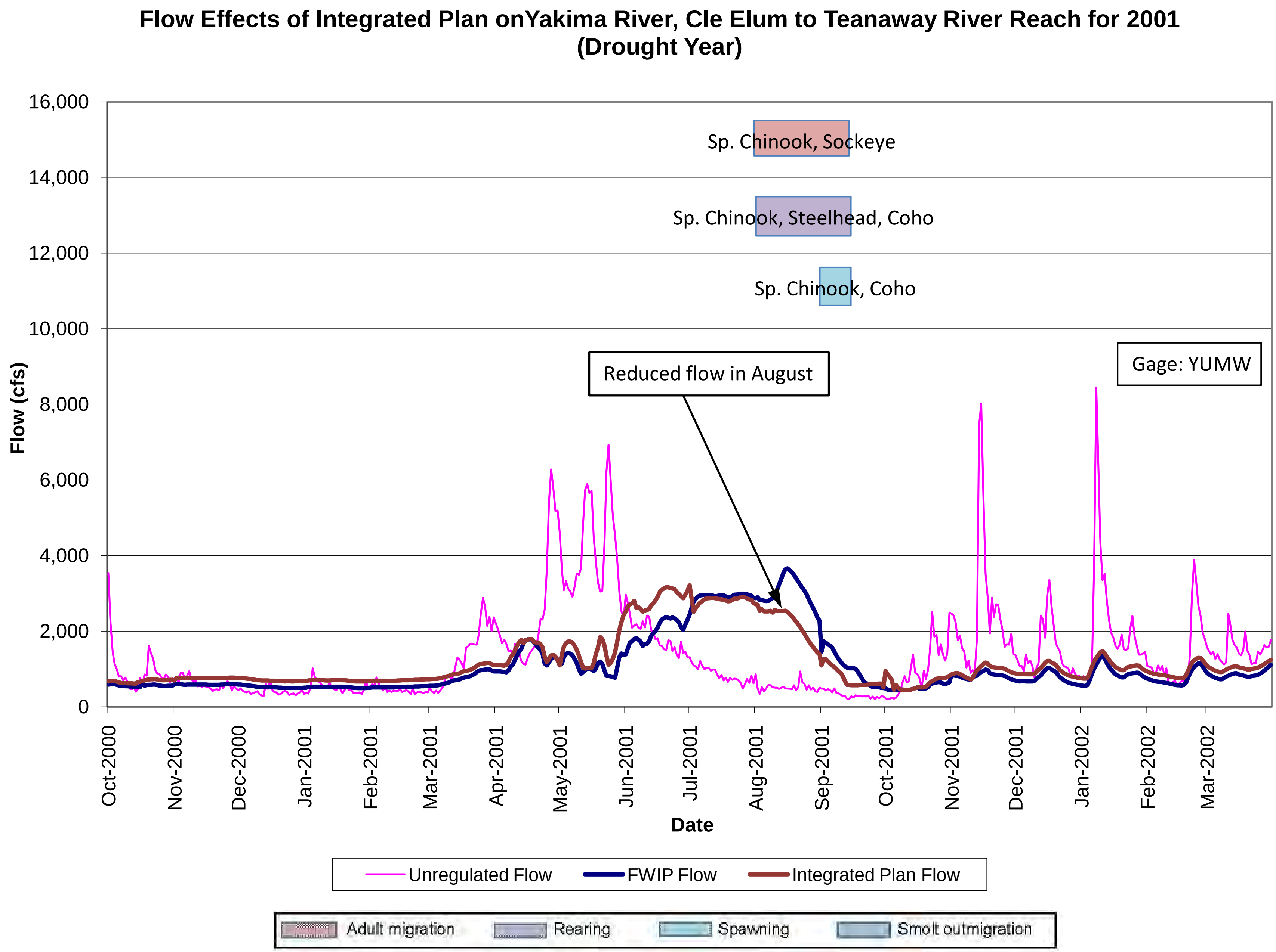

Flow Effects of Integrated Plan on Cle Elum River for 2001 (Drought Year)
Flow (cfs)
Reservoir Contents (AF)
Date
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
450,000
300,000
150,000
0
Oct-2000
Nov-2000
Dec-2000
Jan-2001
Feb-2001
Mar-2001
Apr-2001
May-2001
Jun-2001
Jul-2001
Aug-2001
Sep-2001
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Coho
Sp. Chinook, Steelhead
Sp. Chinook, Coho
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Coho
Steelhead
Sp. Chinook, Coho
Sp. Chinook, Steelhead, Sockeye, Coho
Gage: CLE
Additional winter flow, 300 cfs ± depending on water availability
Spring pulses will be available most years as carryover storage is increased
Additional winter flow, 300 cfs ± depending on water availability
FWIP Flow
Integrated Plan Flow
Unregulated Flow
FWIP Cle Elum Reservoir Contents
IP Cle Elum Reservoir Contents
Adult migration
Rearing
Spawning
Smolt outmigration



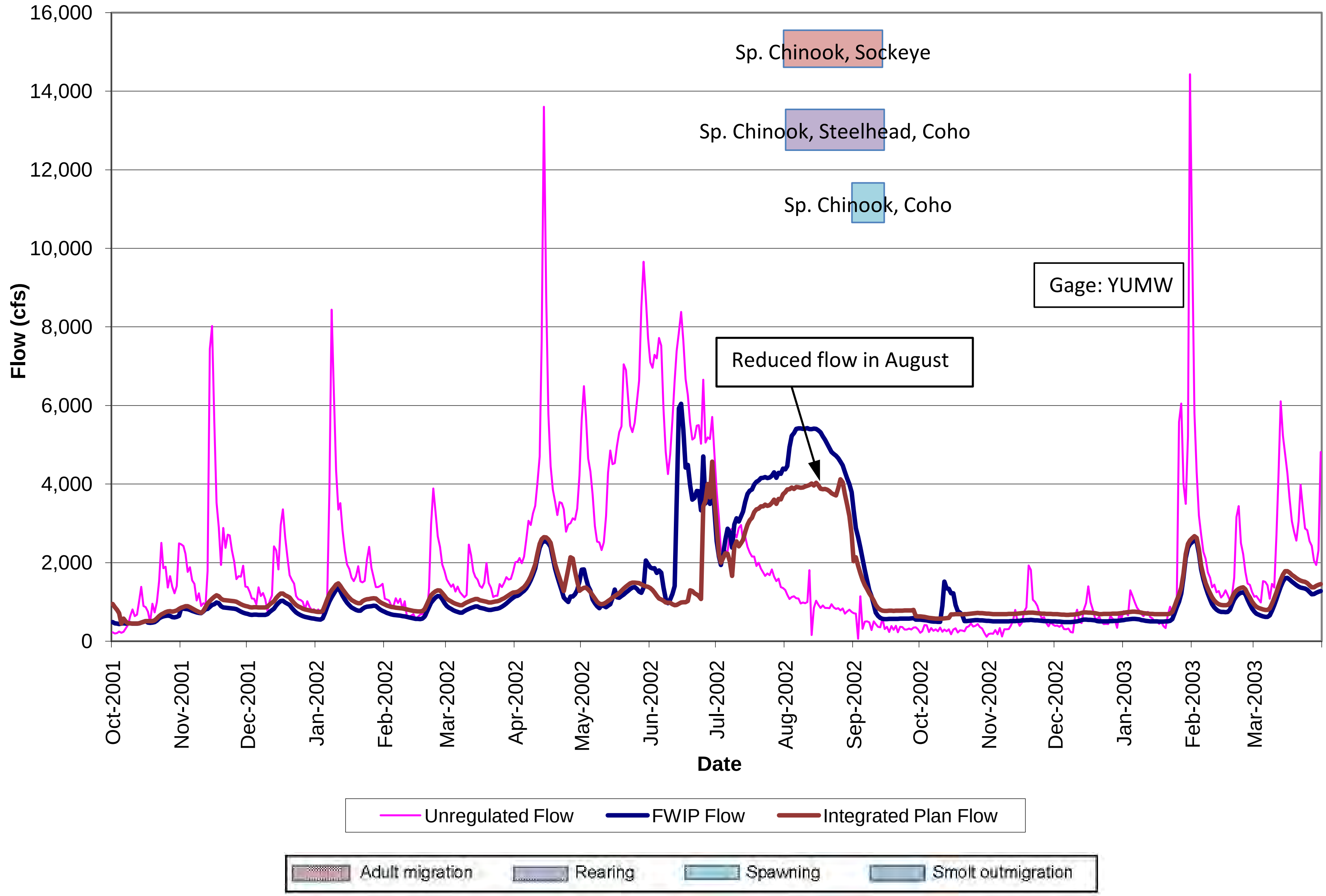
Flow Effects of Integrated Plan on Cle Elum River for 2002 (Wet Year)
Flow (cfs)
Reservoir Contents (AF)
Date
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
450,000
300,000
150,000
0
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Apr-2002
May-2002
Jun-2002
Jul-2002
Aug-2002
Sep-2002
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Coho
Sp. Chinook, Steelhead
Sp. Chinook, Sockeye, Coho
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Coho
Steelhead
Sp. Chinook, Coho
Sp. Chinook, Steelhead, Sockeye, Coho
Reduced summer flow
Gage: CLE
Spring pulses; release additional flow to bring up to 1000 cfs
Additional winter flow, 300 cfs ± depending on water availability
FWIP Flow
Integrated Plan Flow
Unregulated Flow
FWIP Cle Elum Reservoir Contents
IP Cle Elum Reservoir Contents
Adult migration
Rearing
Spawning
Smolt outmigration

Flow Effects of Integrated Plan on Cle Elum River for 2003 (Average Year)

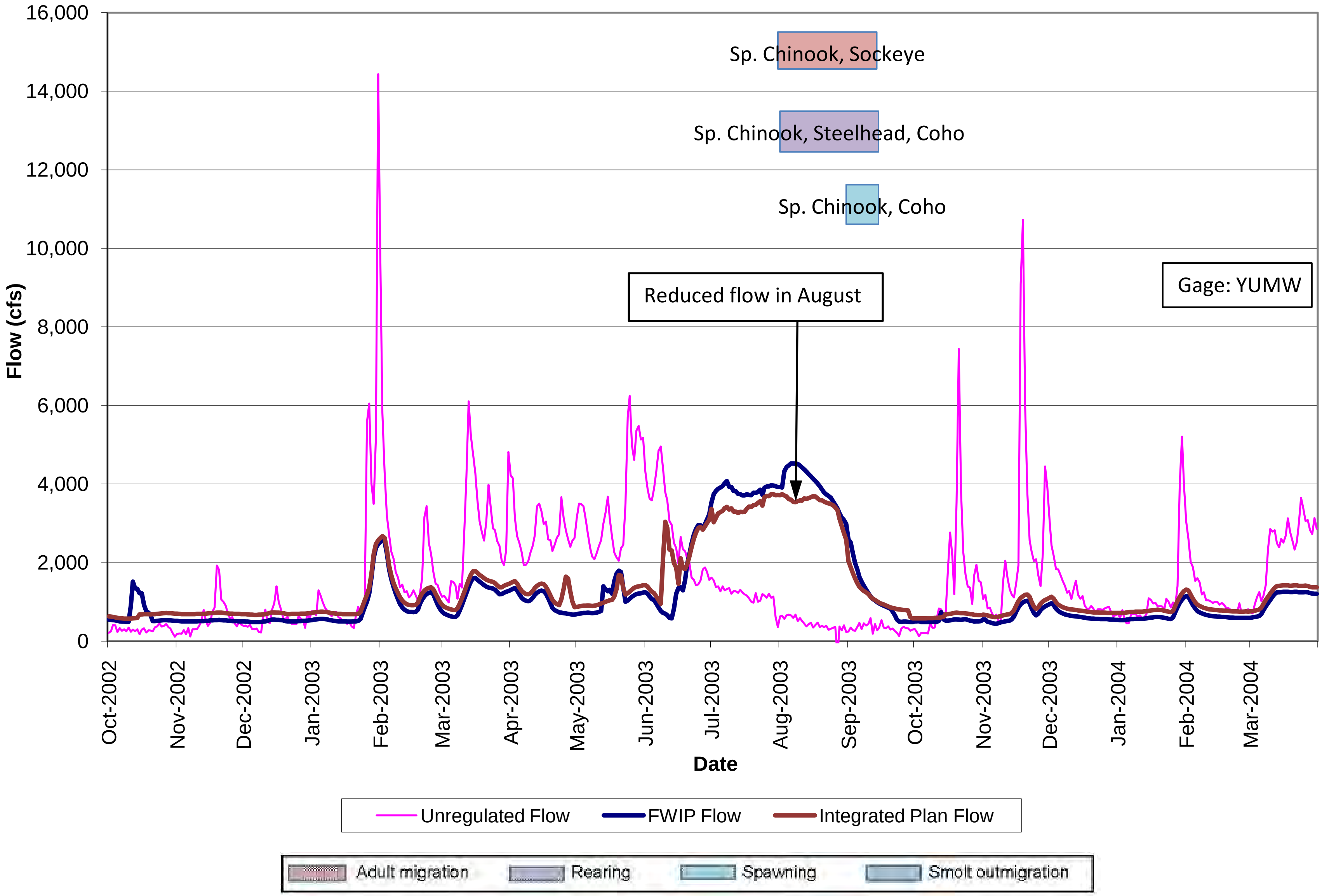


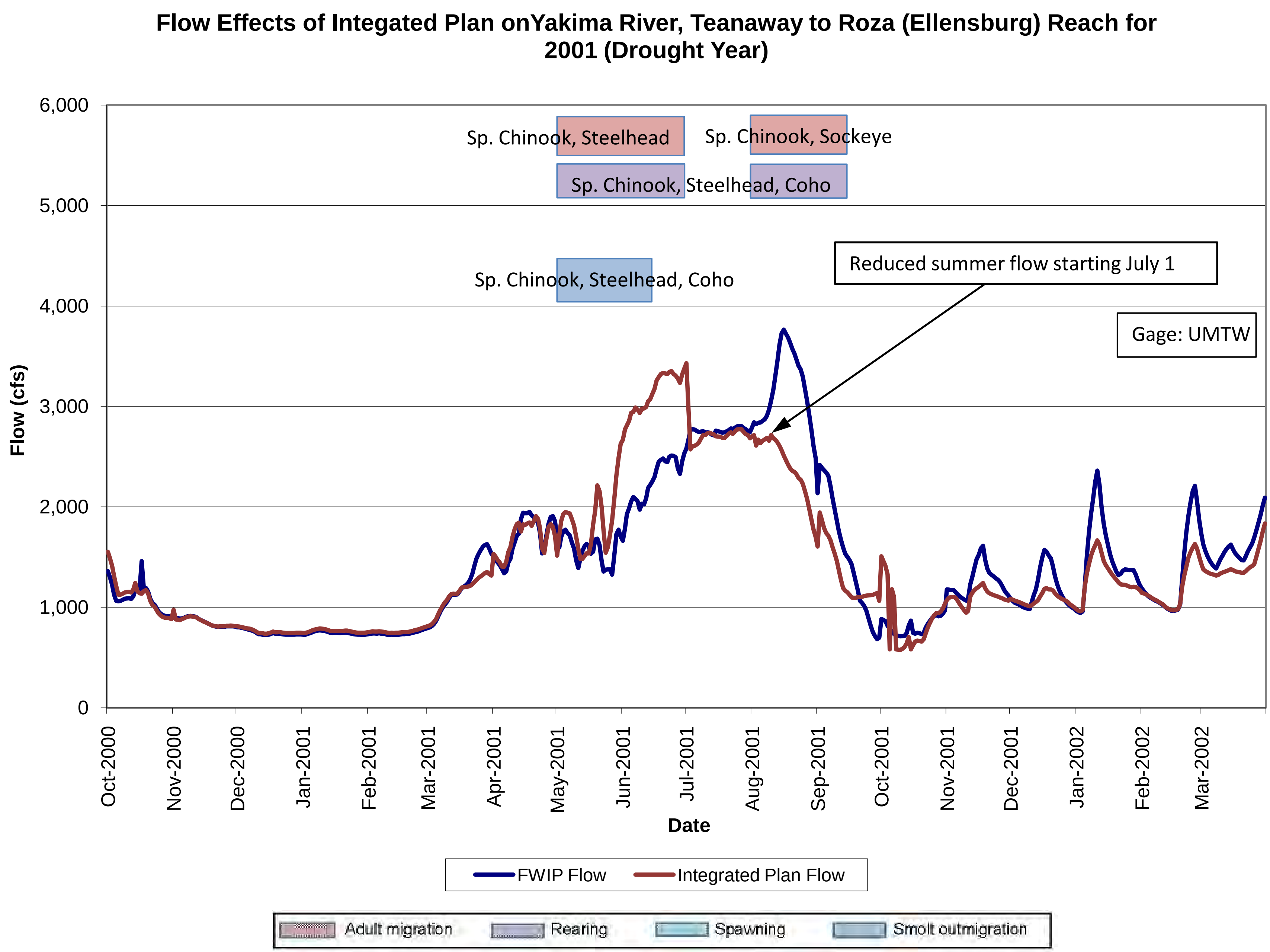

Flow Effects of Integrated Plan onYakima River, Cle Elum to Teanaway River Reach for 2001
(Drought Year)
Flow (cfs)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Sp. Chinook, Sockeye
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Coho
Reduced flow in August
Gage: YUMW
Oct-2000
Nov-2000
Dec-2000
Jan-2001
Feb-2001
Mar-2001
Apr-2001
May-2001
Jun-2001
Jul-2001
Aug-2001
Sep-2001
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Date
Unregulated Flow
FWIP Flow
Integrated Plan Flow
Adult migration
Rearing
Spawning
Smolt outmigration

Flow Effects of Integrated Plan on Yakima River, Cle Elum to Teanaway River Reach for 2002 (Wet Year)

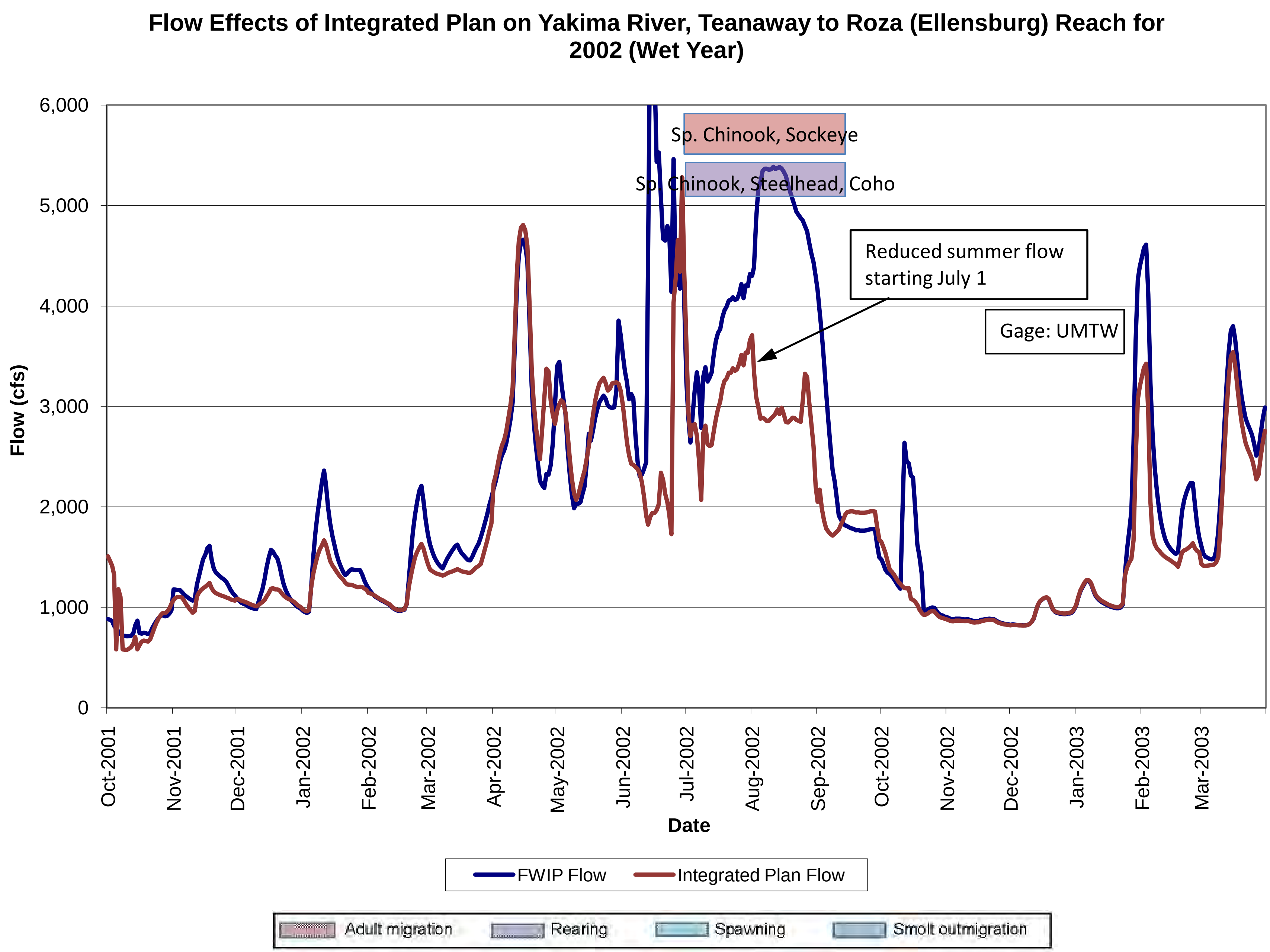


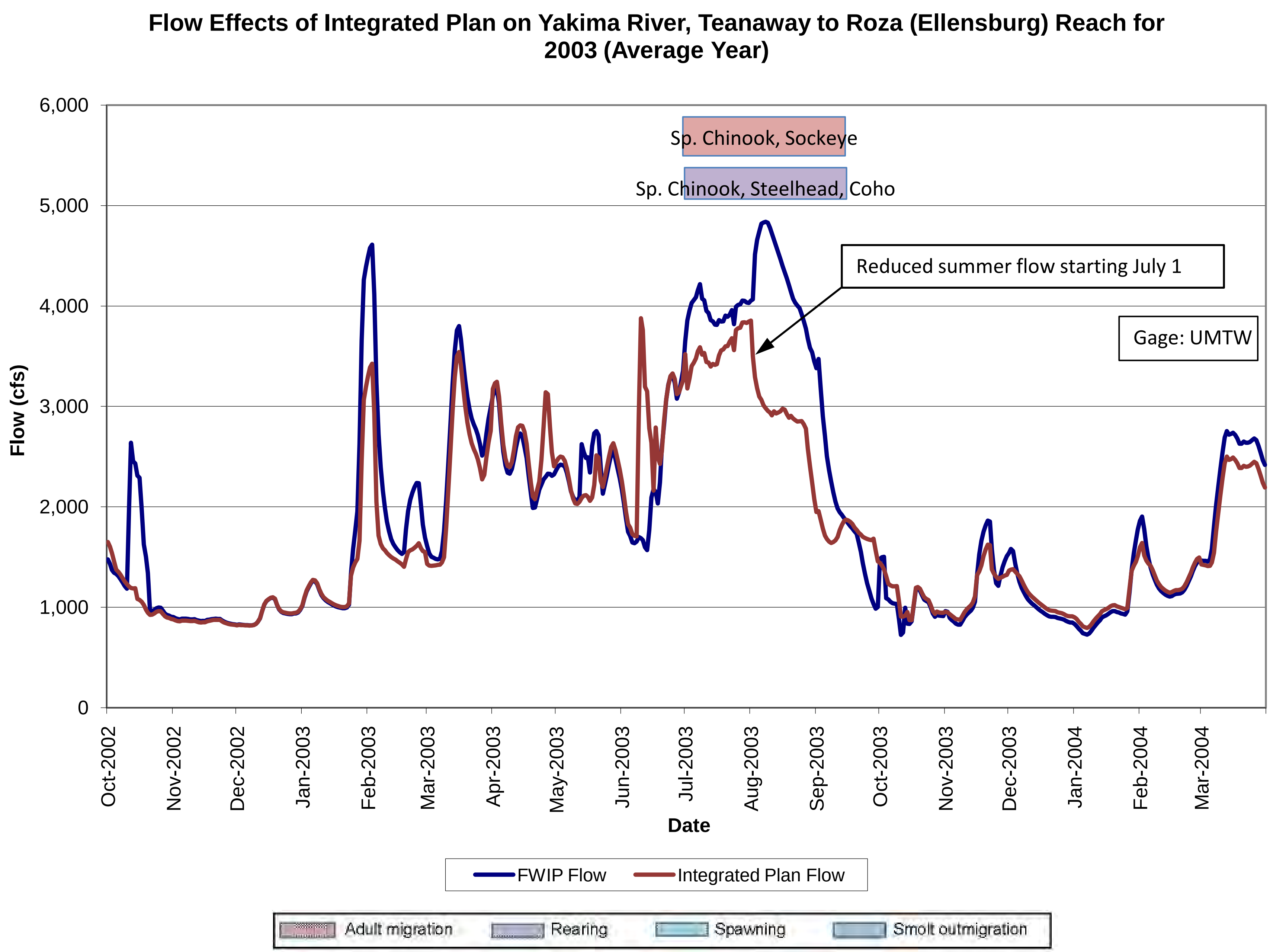
Flow Effects of Integrated Plan on Yakima River, Cle Elum to Teanaway River Reach for 2003 (Average Year)



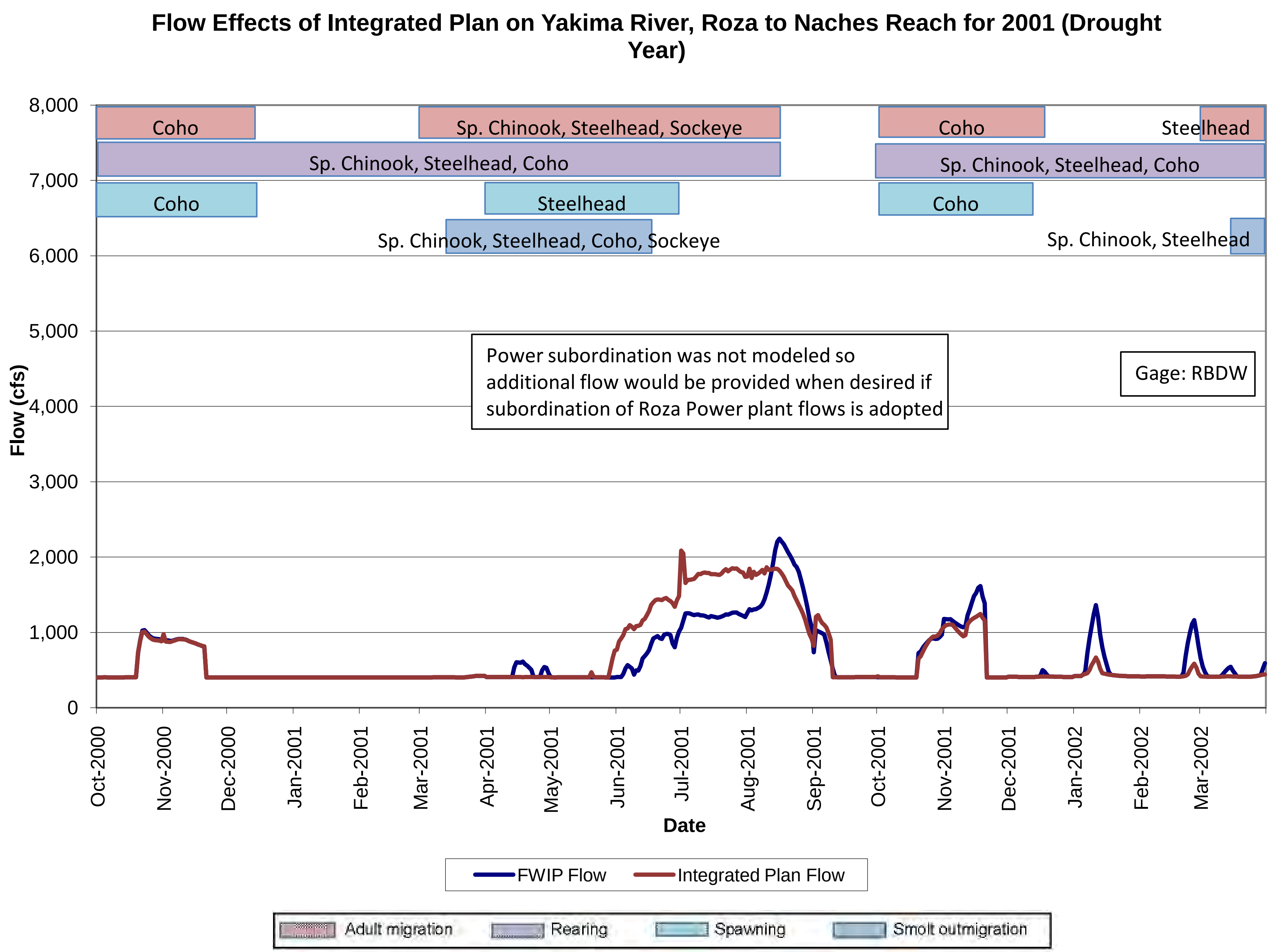


Flow Effects of Integated Plan onYakima River, Teanaway to Roza (Ellensburg) Reach for 2001 (Drought Year)
Sp. Chinook, Steelhead
Sp. Chinook, Sockeye
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Reduced summer flow starting July 1
Gage: UMTW
Flow (cfs)
6,000
5,000
4,000
3,000
2,000
1,000
0
Oct-2000
Nov-2000
Dec-2000
Jan-2001
Feb-2001
Mar-2001
Apr-2001
May-2001
Jun-2001
Jul-2001
Aug-2001
Sep-2001
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Date
FWIP Flow
Integrated Plan Flow
Adult migration
Rearing
Spawning
Smolt outmigration

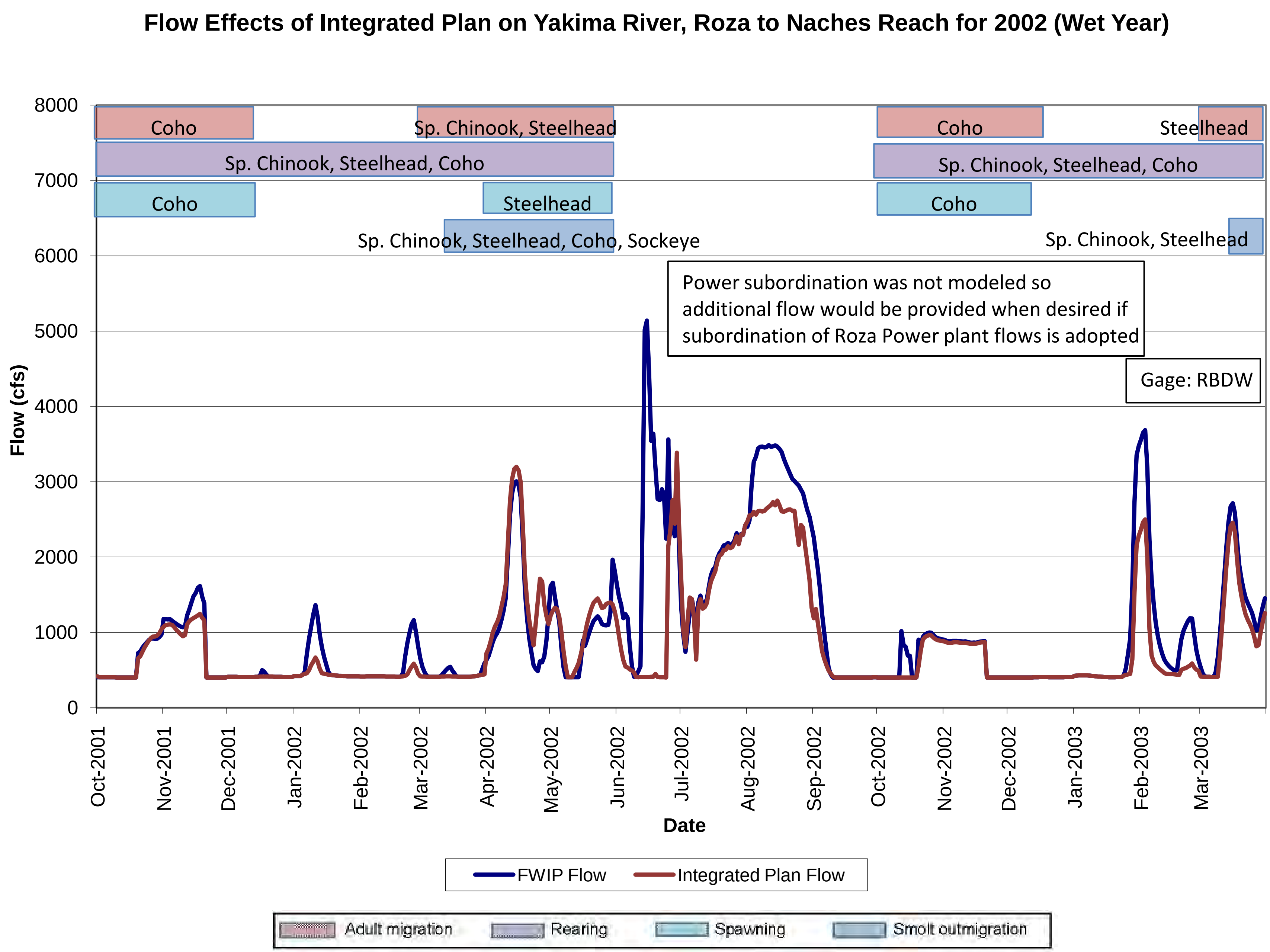

Flow Effects of Integrated Plan on Yakima River, Teanaway to Roza (Ellensburg) Reach for 2002 (Wet Year)
Flow (cfs)
6,000
5,000
4,000
3,000
2,000
1,000
0
Sp. Chinook, Sockeye
Sp. Chinook, Steelhead, Coho
Reduced summer flow starting July 1
Gage: UMTW
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Apr-2002
May-2002
Jun-2002
Jul-2002
Aug-2002
Sep-2002
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Date
FWIP Flow
Integrated Plan Flow
Adult migration
Rearing
Spawning
Smolt outmigration



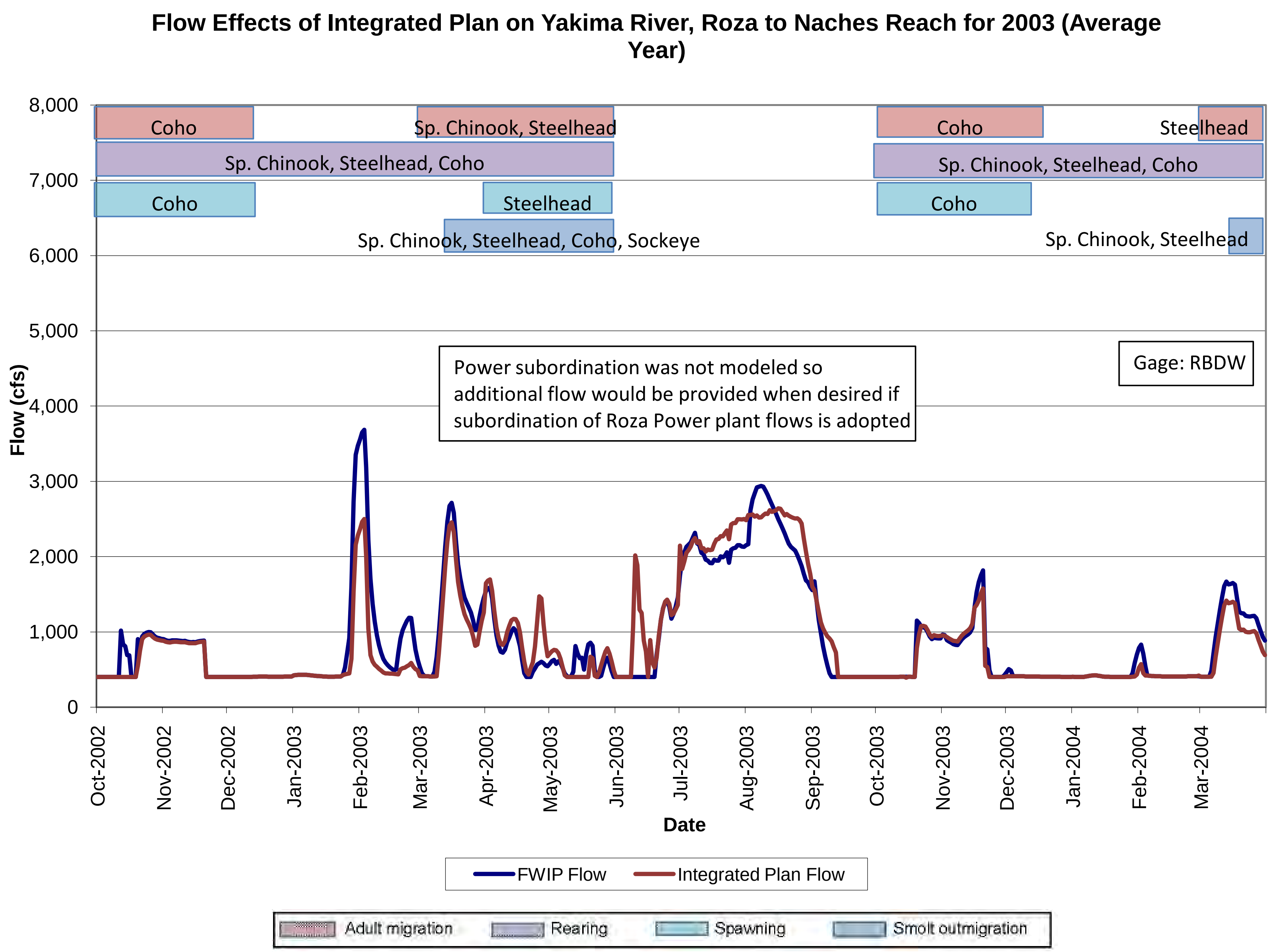
Flow Effects of Integrated Plan on Yakima River, Teanaway to Roza (Ellensburg) Reach for 2003 (Average Year)
Sp. Chinook, Sockeye
Sp. Chinook, Steelhead, Coho
Reduced summer flow starting July 1
Gage: UMTW
Flow (cfs)
6,000
5,000
4,000
3,000
2,000
1,000
0
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Apr-2003
May-2003
Jun-2003
Jul-2003
Aug-2003
Sep-2003
Oct-2003
Nov-2003
Dec-2003
Jan-2004
Feb-2004
Mar-2004
Date
FWIP Flow
Integrated Plan Flow
Adult migration
Rearing
Spawning
Smolt outmigration



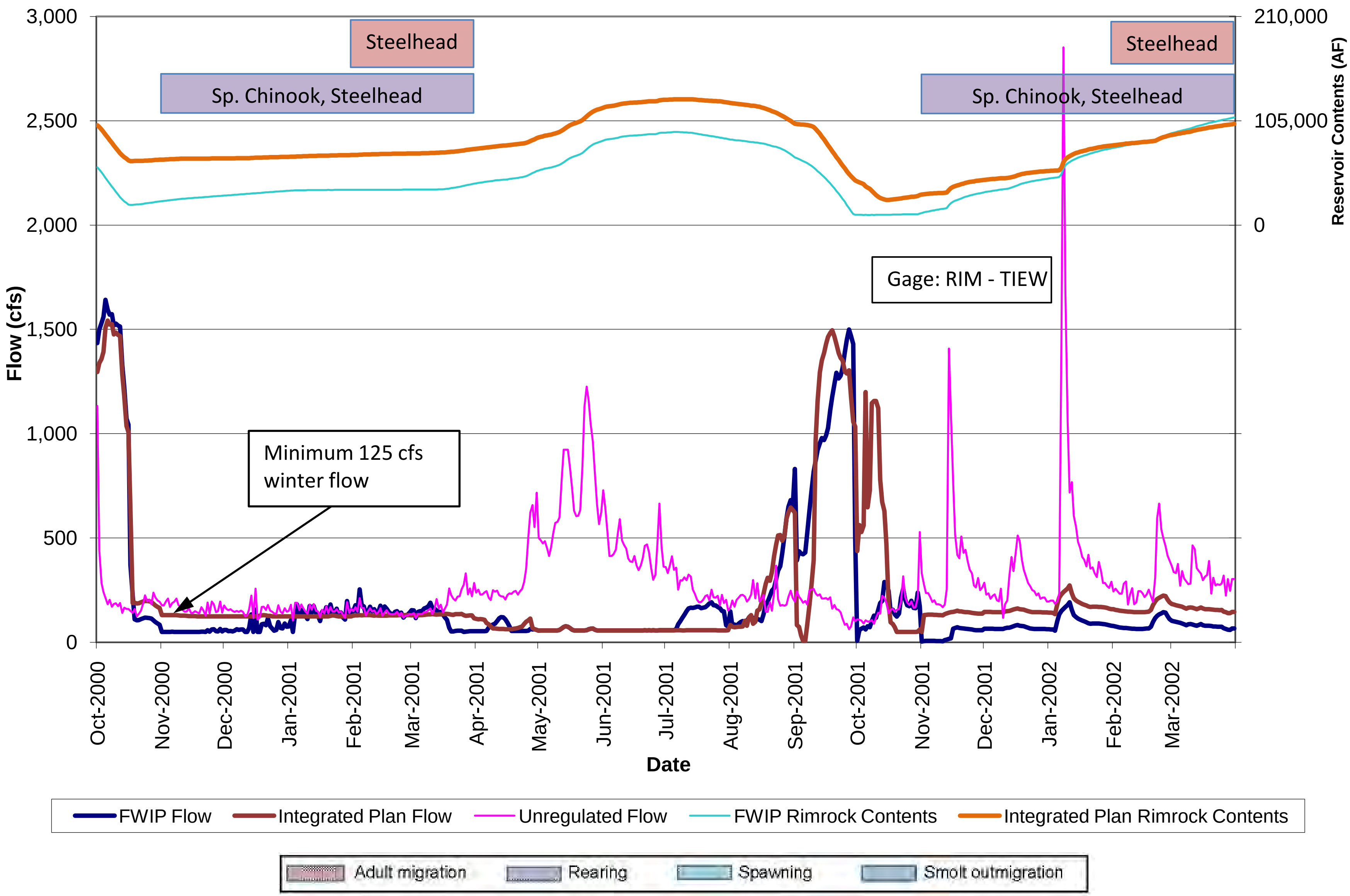
Flow Effects of Integrated Plan on Yakima River, Roza to Naches Reach for 2001 (Drought Year)
Coho
Sp. Chinook, Steelhead, Sockeye
Coho
Steelhead
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Coho
Steelhead
Coho
Sp. Chinook, Steelhead, Coho, Sockeye
Sp. Chinook, Steelhead
Power subordination was not modeled so additional flow would be provided when desired if subordination of Roza Power plant flows is adopted
Gage: RBDW
Flow (cfs)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Oct-2000
Nov-2000
Dec-2000
Jan-2001
Feb-2001
Mar-2001
Apr-2001
May-2001
Jun-2001
Jul-2001
Aug-2001
Sep-2001
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Date
FWIP Flow
Integrated Plan Flow
Adult migration
Rearing
Spawning
Smolt outmigration

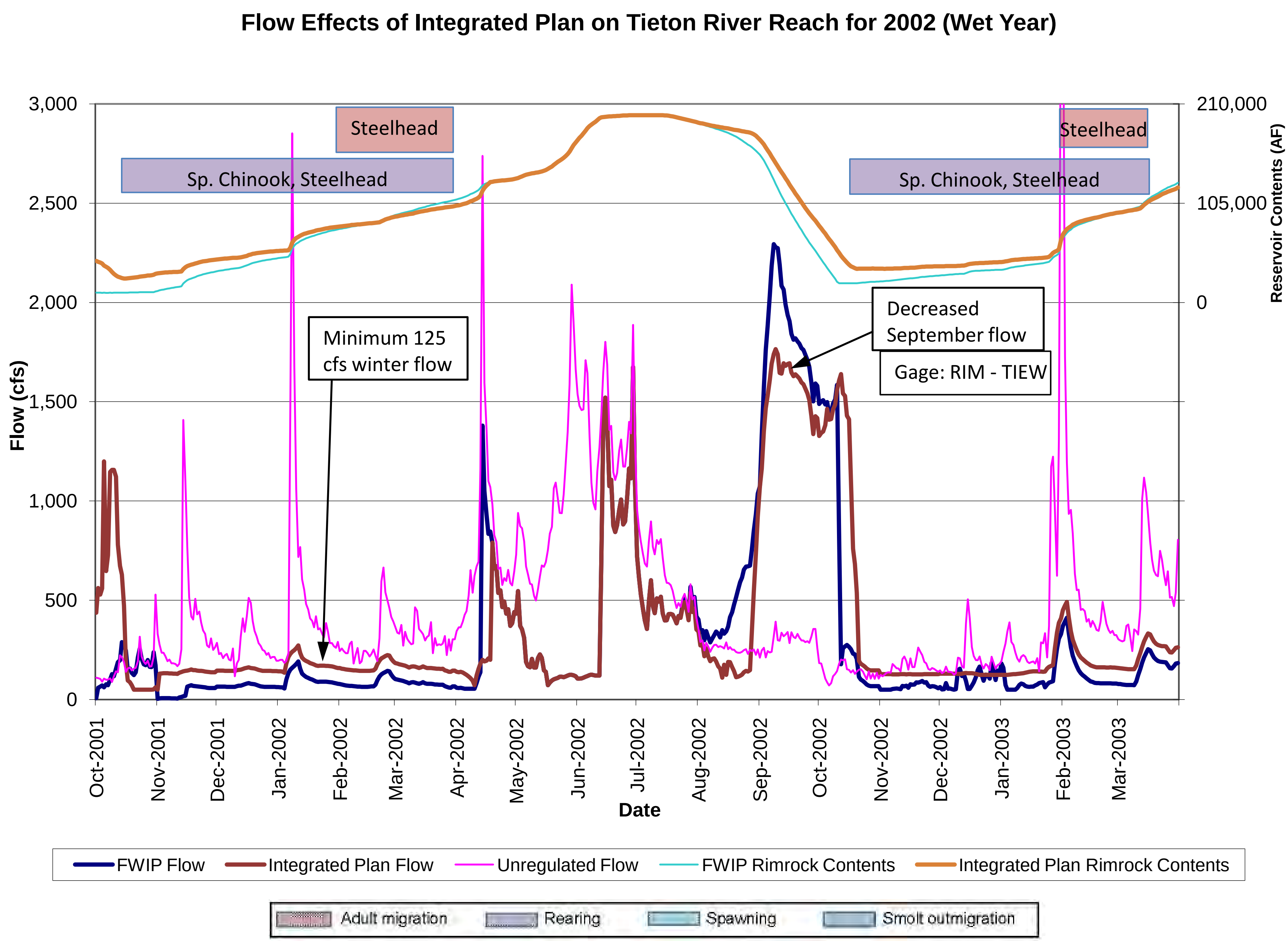


Flow Effects of Integrated Plan on Yakima River, Roza to Naches Reach for 2002 (Wet Year)
Coho
Sp. Chinook, Steelhead
Coho
Steelhead
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Coho
Steelhead
Coho
Sp. Chinook, Steelhead, Coho, Sockeye
Sp. Chinook, Steelhead
Power subordination was not modeled so additional flow would be provided when desired if subordination of Roza Power plant flows is adopted
Gage: RBDW
Flow (cfs)
8000
7000
6000
5000
4000
3000
2000
1000
0
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Apr-2002
May-2002
Jun-2002
Jul-2002
Aug-2002
Sep-2002
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Date
FWIP Flow
Integrated Plan Flow
Adult migration
Rearing
Spawning
Smolt outmigration


Flow Effects of Integrated Plan on Yakima River, Roza to Naches Reach for 2003 (Average Year)
Coho
Sp. Chinook, Steelhead
Coho
Steelhead
Sp. Chinook, Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Coho
Steelhead
Coho
Sp. Chinook, Steelhead, Coho, Sockeye
Sp. Chinook, Steelhead
Power subordination was not modeled so additional flow would be provided when desired if subordination of Roza Power plant flows is adopted
Gage: RBDW
Flow (cfs)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Apr-2003
May-2003
Jun-2003
Jul-2003
Aug-2003
Sep-2003
Oct-2003
Nov-2003
Dec-2003
Jan-2004
Feb-2004
Mar-2004
Date
FWIP Flow
Integrated Plan Flow
Adult migration
Rearing
Spawning
Smolt outmigration

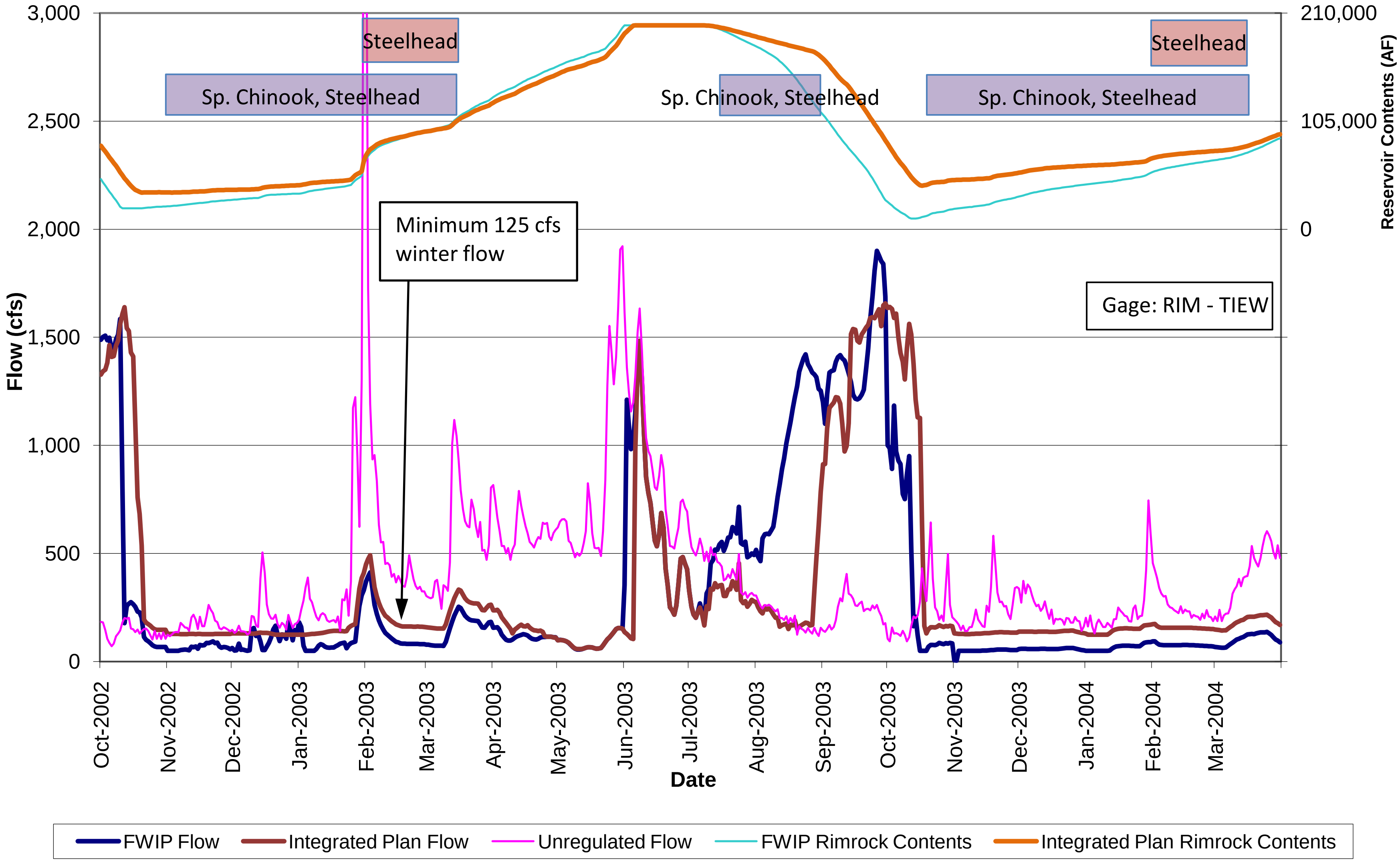
Flow Effects of Integrated Plan on Tieton River Reach for 2001 (Drought Year)



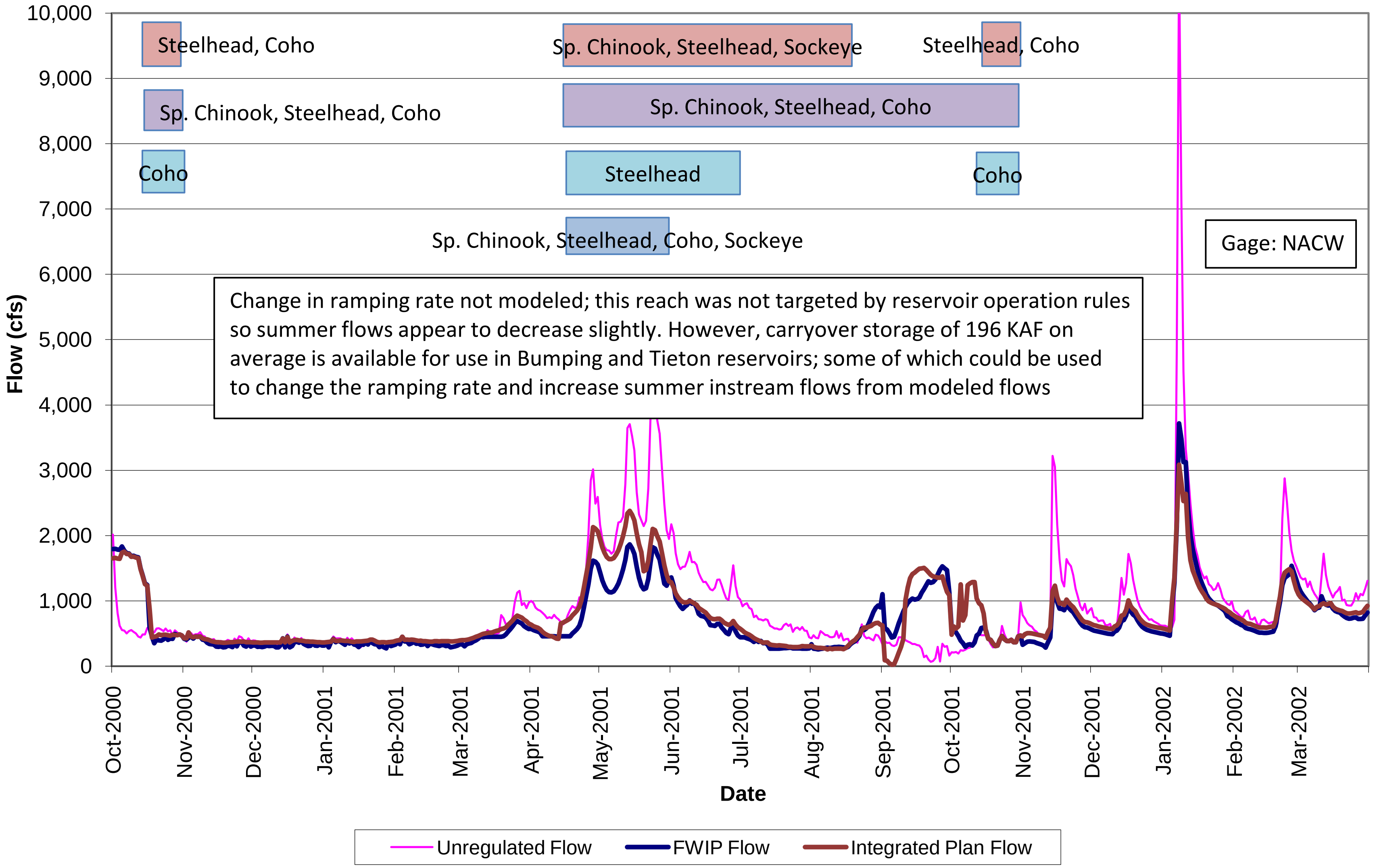


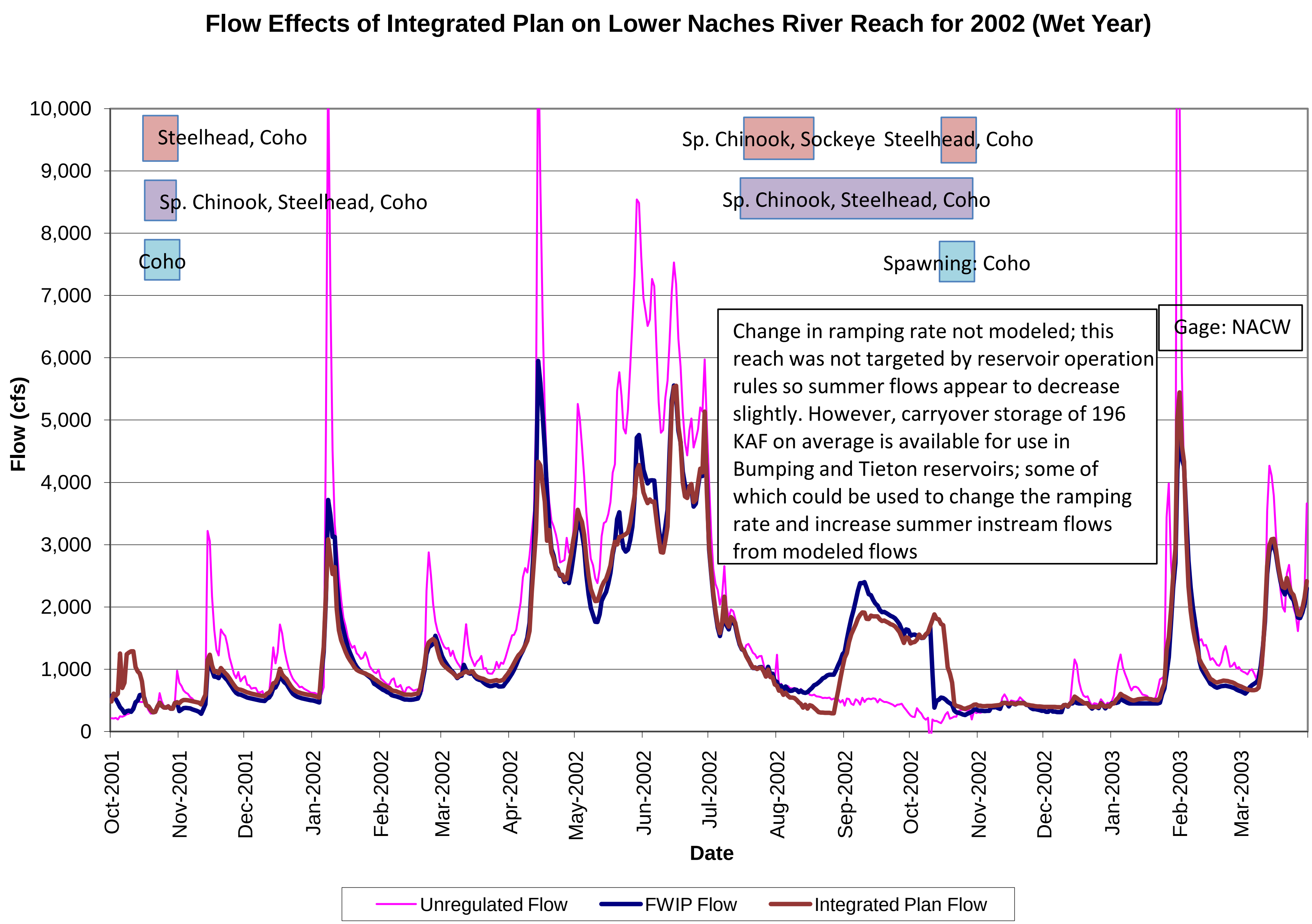
Flow Effects of Integrated Plan on Tieton River Reach for 2002 (Wet Year)
Steelhead
Sp. Chinook, Steelhead
Minimum 125 cfs winter flow
Decreased September flow
Gage: RIM - TIEW
Flow (cfs)
Reservoir Contents (AF)
3,000
2,500
2,000
1,500
1,000
500
0
210,000
105,000
0
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Apr-2002
May-2002
Jun-2002
Jul-2002
Aug-2002
Sep-2002
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Date
FWIP Flow
Integrated Plan Flow
Unregulated Flow
FWIP Rimrock Contents
Integrated Plan Rimrock Contents
Adult migration
Rearing
Spawning
Smolt outmigration

Flow Effects of Integrated Plan on Tieton River Reach for 2003 (Average Year)

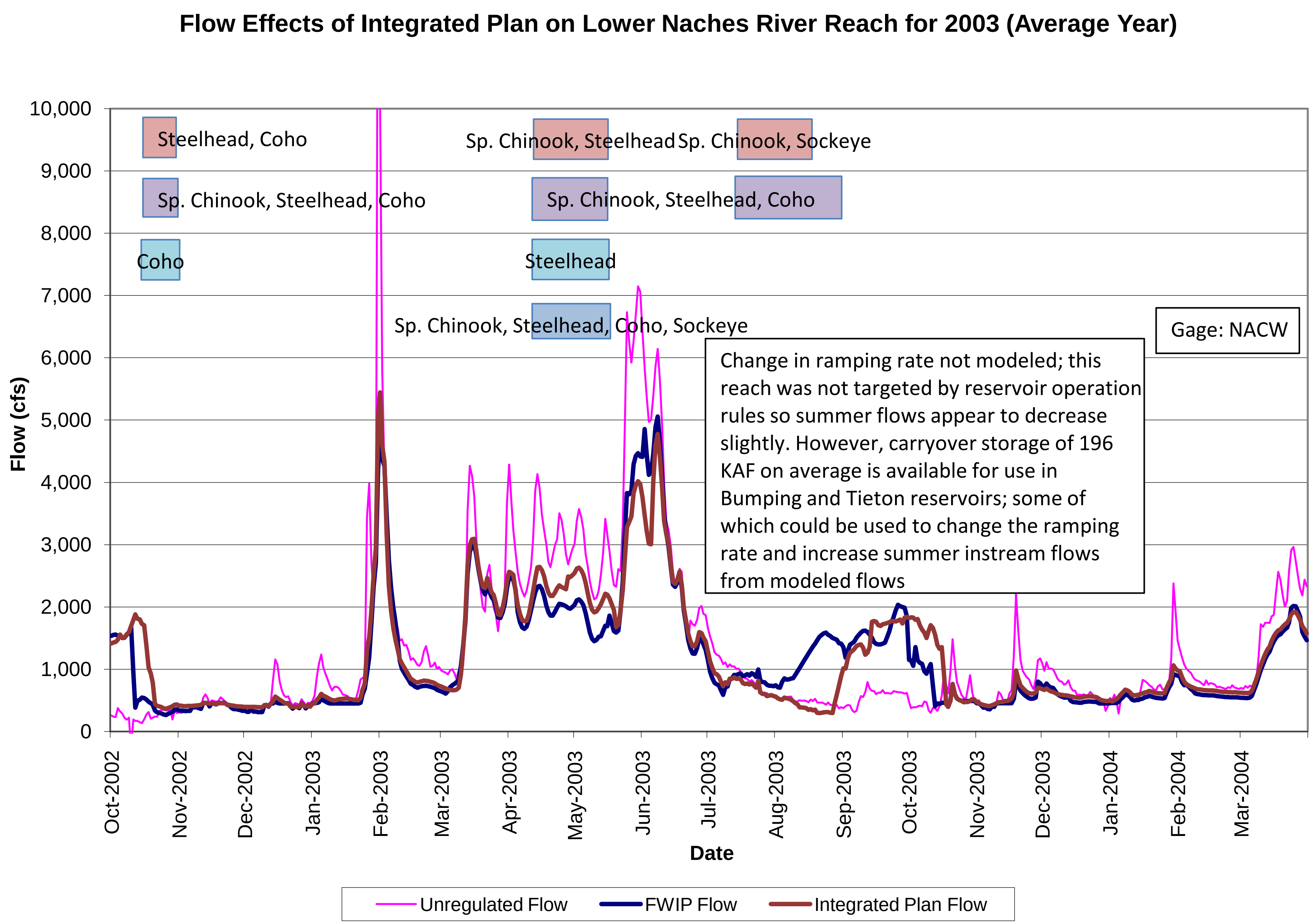


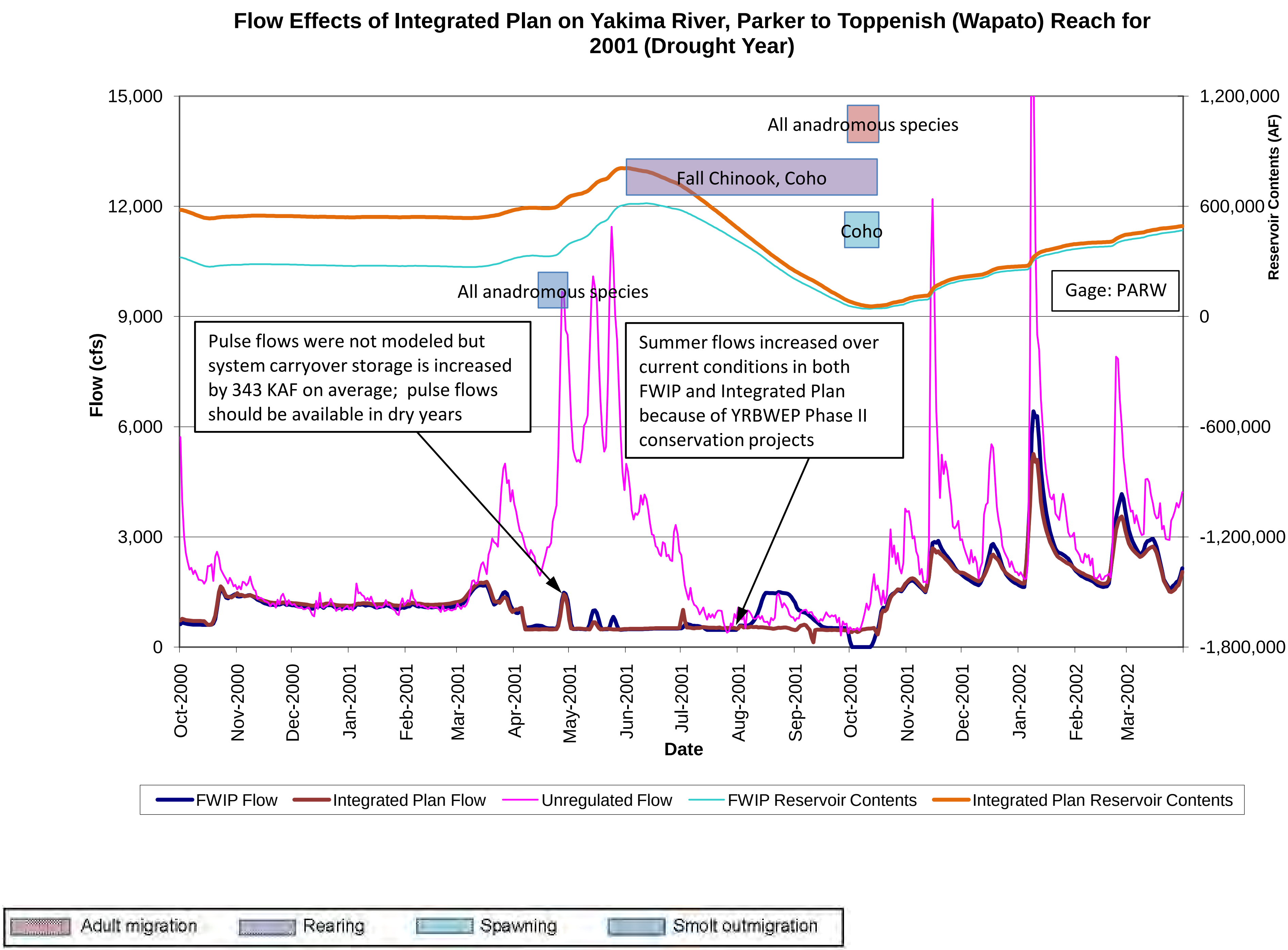
Flow Effects of Integrated Plan on Lower Naches River Reach for 2001 (Drought Year)



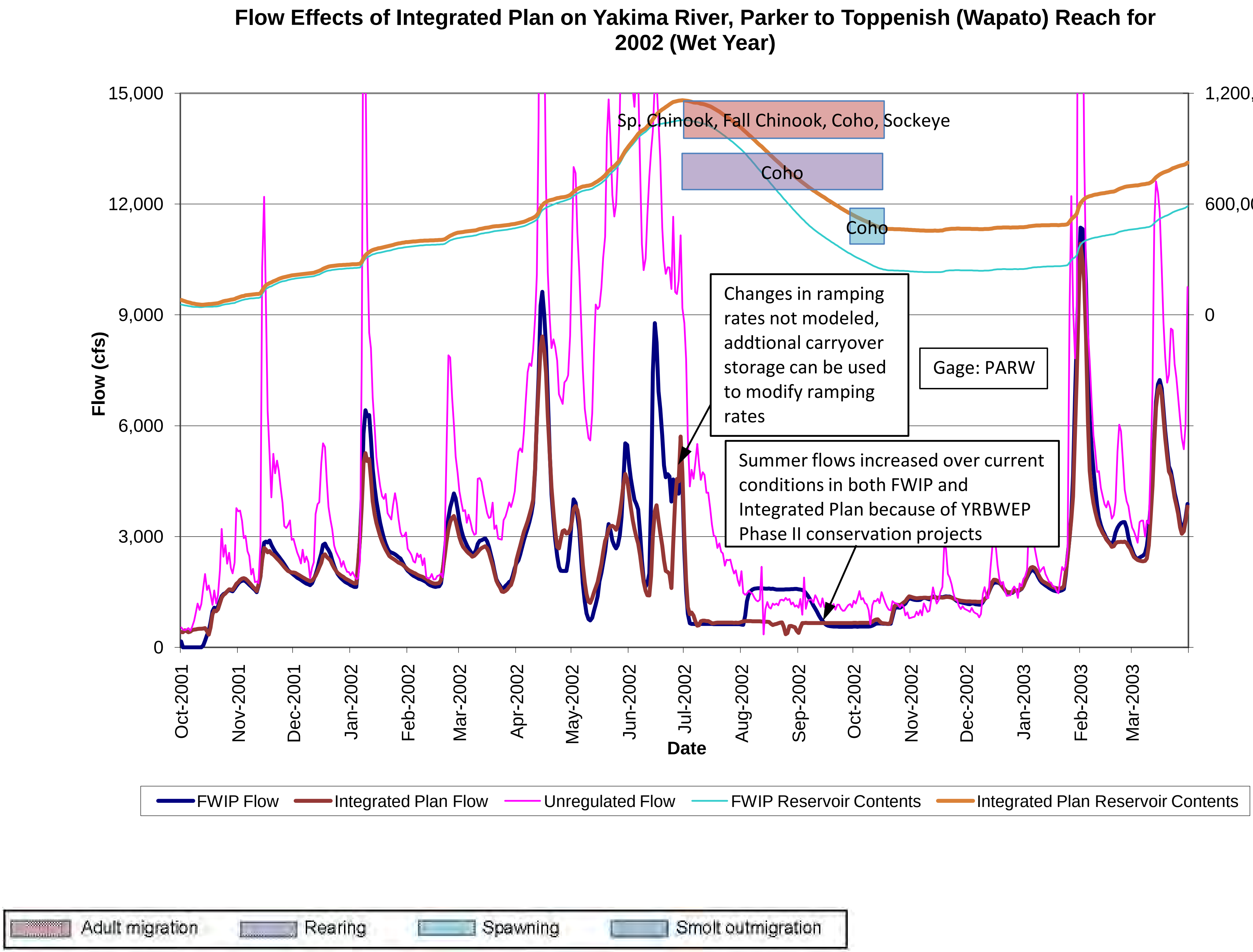


Flow Effects of Integrated Plan on Lower Naches River Reach for 2002 (Wet Year)
Flow (cfs)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Coho
Sp. Chinook, Sockeye
Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Spawning: Coho
Change in ramping rate not modeled; this reach was not targeted by reservoir operation rules so summer flows appear to decrease slightly. However, carryover storage of 196 KAF on average is available for use in Bumping and Tieton reservoirs; some of which could be used to change the ramping rate and increase summer instream flows from modeled flows
Gage: NACW
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Apr-2002
May-2002
Jun-2002
Jul-2002
Aug-2002
Sep-2002
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Date
Unregulated Flow
FWIP Flow
Integrated Plan Flow

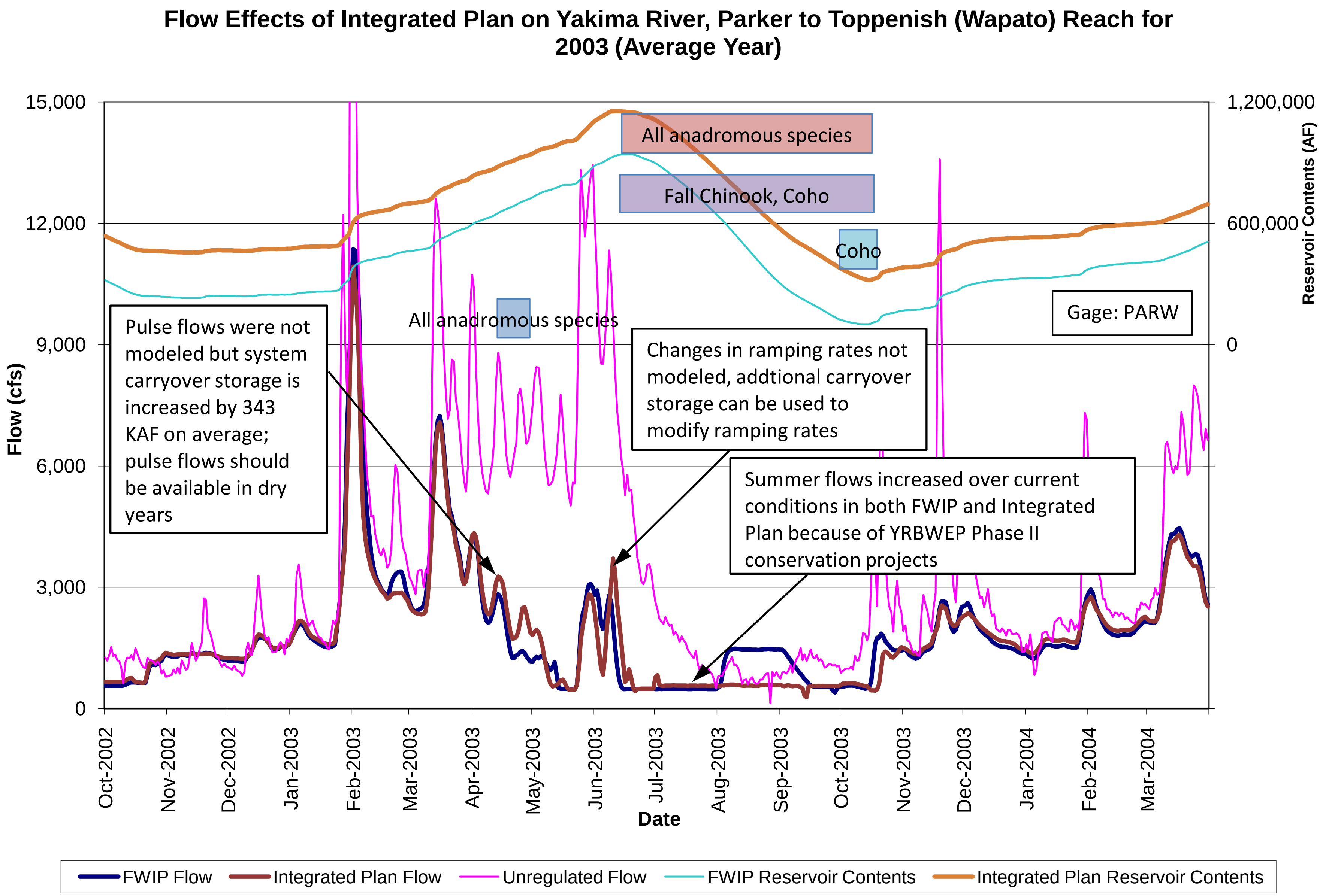

Flow Effects of Integrated Plan on Lower Naches River Reach for 2003 (Average Year)
Flow (cfs)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Steelhead, Coho
Sp. Chinook, Steelhead, Coho
Coho
Sp. Chinook, Steelhead
Sp. Chinook, Sockeye
Sp. Chinook, Steelhead, Coho
Steelhead
Sp. Chinook, Steelhead, Coho, Sockeye
Gage: NACW
Change in ramping rate not modeled; this reach was not targeted by reservoir operation rules so summer flows appear to decrease slightly. However, carryover storage of 196 KAF on average is available for use in Bumping and Tieton reservoirs; some of which could be used to change the ramping rate and increase summer instream flows from modeled flows
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Apr-2003
May-2003
Jun-2003
Jul-2003
Aug-2003
Sep-2003
Oct-2003
Nov-2003
Dec-2003
Jan-2004
Feb-2004
Mar-2004
Date
Unregulated Flow
FWIP Flow
Integrated Plan Flow



Flow Effects of Integrated Plan on Yakima River, Parker to Toppenish (Wapato) Reach for 2001 (Drought Year)
15,000
12,000
9,000
6,000
3,000
0
Flow (cfs)
1,200,000
600,000
0
-600,000
-1,200,000
-1,800,000
Reservoir Contents (AF)
All anadromous species
Fall Chinook, Coho
Coho
All anadromous species
Gage: PARW
Pulse flows were not modeled but system carryover storage is increased by 343 KAF on average; pulse flows should be available in dry years
Summer flows increased over current conditions in both FWIP and Integrated Plan because of YRBWEP Phase II conservation projects
Oct-2000
Nov-2000
Dec-2000
Jan-2001
Feb-2001
Mar-2001
Apr-2001
May-2001
Jun-2001
Jul-2001
Aug-2001
Sep-2001
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Date
FWIP Flow
Integrated Plan Flow
Unregulated Flow
FWIP Reservoir Contents
Integrated Plan Reservoir Contents
Adult migration
Rearing
Spawning
Smolt outmigration



Flow Effects of Integrated Plan on Yakima River, Parker to Toppenish (Wapato) Reach for 2002 (Wet Year)
15,000
12,000
9,000
6,000
3,000
0
Flow (cfs)
1,200,000
600,000
0
Reservoir Contents (AF)
Sp. Chinook, Fall Chinook, Coho, Sockeye
Coho
Coho
Changes in ramping rates not modeled, addtional carryover storage can be used to modify ramping rates
Gage: PARW
Summer flows increased over current conditions in both FWIP and Integrated Plan because of YRBWEP Phase II conservation projects
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Apr-2002
May-2002
Jun-2002
Jul-2002
Aug-2002
Sep-2002
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Date
FWIP Flow
Integrated Plan Flow
Unregulated Flow
FWIP Reservoir Contents
Integrated Plan Reservoir Contents
Adult migration
Rearing
Spawning
Smolt outmigration



Flow Effects of Integrated Plan on Yakima River, Parker to Toppenish (Wapato) Reach for 2003 (Average Year)
15,000
12,000
9,000
6,000
3,000
0
Flow (cfs)
1,200,000
600,000
0
Reservoir Contents (AF)
All anadromous species
Fall Chinook, Coho
Coho
All anadromous species
Gage: PARW
Pulse flows were not modeled but system carryover storage is increased by 343 KAF on average; pulse flows should be available in dry years
Changes in ramping rates not modeled, addtional carryover storage can be used to modify ramping rates
Summer flows increased over current conditions in both FWIP and Integrated Plan because of YRBWEP Phase II conservation projects
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Apr-2003
May-2003
Jun-2003
Jul-2003
Aug-2003
Sep-2003
Oct-2003
Nov-2003
Dec-2003
Jan-2004
Feb-2004
Mar-2004
Date
FWIP Flow
Integrated Plan Flow
Unregulated Flow
FWIP Reservoir Contents
Integrated Plan Reservoir Contents