Chapter 4

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES: JOINT ALTERNATIVES

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4.1 Introduction

This chapter presents a description of the affected environment and an evaluation of the environmental consequences of implementing each of the proposed Joint Alternatives. Effects under the Joint Alternatives are compared to the No Action Alternative, and effects under the No Action Alternative are compared to the current condition, as appropriate. In cases in which alternatives would have the same effects on an environmental component, the analysis is presented once and summarized or referenced in subsequent analyses to eliminate redundancy. Environmental consequences, impacts, and effects are synonymous in this document.

Some alternatives may cause effects outside the Yakima River basin, in specific reaches of the Columbia River. Therefore, some discussions address Columbia River reaches, as appropriate, and then address the Yakima River basin.

Resources and/or resource issues identified during scoping activities are addressed in a hierarchical fashion. For example, water resources are presented first because changes in this resource resulting from the Joint Alternatives would likely affect other resources.

Finally, because resources in the Storage Study area are numerous and complex, potential effects on some resources were evaluated using representative indicators. For example, rather than analyzing all fish populations, certain species were selected to provide a focused analysis of the effects of the alternatives.

Chapter 1 contains a detailed description of the Storage Study location and setting, along with a history of water management in the Yakima River basin.

4.2 Water Resources

4.2.1 Affected Environment

Water resources within both the Columbia River Basin and the Yakima River basin could be affected by the proposed Joint Alternatives. This section addresses river regulation and water supply available. The current operation is discussed in detail in chapter 2 in the description of the No Action Alternative.

4.2.1.1 River Regulation

The natural flow regime defines river ecosystems. The availability and diversity of habitats are determined by physical processes, especially the movement of water and sediment within the channel, and between the channel and floodplain. Different habitat features are created and maintained by a wide range of flows. For example, many channel and floodplain features, such as river bars and riffle-pool sequences, are formed and maintained by dominant or bank-full runoff that can move significant quantities of sediment. Occurring frequently enough, bank-full runoff can modify the channel, which, in turn, maintains a healthy river ecosystem. For many riverine species, including anadromous and resident salmonids, the complete life cycle requires an array of different habitat types, which are produced by the flow regime.

River basins such as the Yakima that are regulated for irrigation and flood control purposes exhibit a change from the natural flow. A portion of the natural flows produced from precipitation during the winter and snowmelt during the spring and early summer are captured for storage. Downstream from major reservoirs, flows are greatly altered from the major variations observed under natural hydrologic conditions. Peaking natural flows from rain, and rain-on-snow events, causing "flood events," are captured in available storage and bypassed during a lower flow period. Consequently, the magnitude and frequency of ecologically significant discharges (overbank and channel-forming flows) are reduced.

Patterns of spring and summer flows are largely influenced by irrigation demands, with flows typically reaching peaks during July and August upstream of the major diversions. Downstream from these diversions, flows can be low, even to the point of being below natural flows. Unnatural flow patterns result from reservoir storage and releases intended to meet downstream irrigation demands.

Yakima Project irrigation diversions generally began in mid-March when "flood flows" are diverted to "prime" (fill) the irrigation systems. These flows are returned to the rivers as operational spills. Irrigation deliveries generally begin in April and continue through mid-to-late October. In the initial part of the irrigation season, diversion demands are met by unregulated runoff accruing to the river system downstream from the reservoirs (or being spilled from the reservoirs) and irrigation return flows. On the average, this period has generally extended to June 24. When Yakima River flows at the Parker gage must be controlled to meet the Title XII flows by using supplemental storage releases, the Yakima Project is deemed to be on "storage control" and depletions of reservoir storage begin. Storage control has begun as early as April 1 and as late as August 17. The variability in the date of storage control depends on the extent of precipitation and snowpack and the timing of the snowmelt.

The cumulative impacts of the regulated Yakima River basin system result in major changes throughout the water year on the flow regime. These changes can

best be illustrated by the hydrographs in chapter 2, which show flows at six Yakima River locations: Umtanum gage (RM 140), which is the upstream boundary of the middle Yakima River basin and near the point of diversion for the Roza Division (RM 127.9); Parker gage (RM 104), which is the downstream boundary of the middle Yakima River basin just downstream from Sunnyside Diversion Dam; Easton gage (RM 202); Cle Elum gage (RM 7.9); lower Naches River gage (RM 17); and Kiona gage (RM 29). Water entitlements in this subarea account for about 60 percent of the total.[1]

The flow regimes depicted in these hydrographs are an approximation of natural flows that might have occurred under predevelopment runoff conditions without the influence of reservoir storage or diversions. The current condition hydrograph reflects current Yakima Project operations. As shown, there is a substantial "shift" in the timing and volume of peak spring flows and summer flows from the unregulated regime to the current condition.

4.2.1.2 Water Supply Available

The major control point for operating the Yakima Project is the Yakima River near the Parker gage. Yakima Project operations are keyed to meet the irrigation entitlements upstream of the Parker gage, maintain instream target flows for the fishery resources, and provide maximum flood control benefits for the Yakima River basin. Since April 1995, the Yakima Project has been operated to provide the target flows downstream from Sunnyside Diversion Dam as specified in the Title XII legislation (table 4.1). These flows are based on total water supply estimates and range from 300 to 600 cfs for the period of April 1 through October 31. Runoff and return flows downstream from the Parker gage in the lower Yakima River basin subarea exceed irrigation demands in that area and, therefore, do not influence storage releases.

Table 4.1 Title XII target flows

TWSA estimate for period (maf)					Target flows from date of estimate through October downstream from:	
Scenario	**Apr-Sep**	**May-Sep**	**Jun-Sep**	**Jul-Sep**	**Sunnyside Diversion Dam (cfs)**	**Prosser Diversion Dam (cfs)**
1	3.2	2.9	2.4	1.9	600	600
2	2.9	2.65	2.2	1.7	500	500
3	2.65	2.4	2.0	1.5	400	400
Less than scenario 3 water supply					300	300

[1] The major diverters are the Roza Division (RM 127.9), Wapato Irrigation Project (RM 106.7), and the Sunnyside Division (RM 103.8).

Total Water Supply Available Estimates

The TWSA estimate is a primary component of the *1945 Consent Decree* and Yakima Project operations. TWSA represents the combined quantity of forecasted runoff, return flows, and stored water available upstream of the Parker gage. Each year, Reclamation prepares TWSA forecasts for the Yakima River basin upstream of the Parker gage beginning in March for the April-September period. The estimate is updated each subsequent month through July, and, in dry years, forecasts may continue throughout the irrigation season. These forecasts are the basis for determining Title XII target flows and irrigation water entitlements and deciding the amount of proration, if any, which may be necessary.[2]

Simply put, TWSA is equal to the sum of:

- The natural runoff forecast for April 1 through September 30,
- The reservoir storage at the end of March 31, and
- The usable return flows upstream of the Parker gage.

TWSA is used to determine the instream flow targets for the year in accordance with Title XII operating criteria.

The water supply available for irrigation (WSAI) is equal to the TWSA minus:

- The estimated reservoir contents at the end of September 30 (desired carryover), and
- The flows downstream from the Parker gage for the period April 1 through the end of September (the combination of undiverted unregulated flows, operational spills, and Title XII quantified target flows).

Nonproratable irrigation entitlements are subtracted from the total water supply available for irrigation as these are the senior (pre-1905) entitlements. The remaining WSAI is the water supply available to meet proratable (post-1905) entitlements. If the remaining WSAI divided by the proratable entitlements is less than 100 percent, prorationing may be necessary.

Projected runoff forecasts are made for the five major reservoirs and at three key checkpoints on the Yakima River system.[3] While the runoff volume for a given period can be estimated with some degree of accuracy, the timing of how and when the runoff will occur is unknown, as it is affected by temperature variation,

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[2] In calculating TWSA, only the irrigation water entitlements in the *1945 Consent Decree* for the mainstem Yakima River basin are included; irrigation diversions on tributaries or other adjudicated streams are not included.

[3] These three key checkpoints are the Yakima River at Cle Elum (RM 185.6), Naches River near Naches (RM 16.8), and Yakima River at Parker (RM 103.7).

snowpack density, rainfall intensity, and subsequent snowfall. Warm temperature or precipitation, especially in combination, greatly affects the intensity of the runoff. Generally, runoff begins about mid-March and peaks about mid-June. As the season progresses, a portion of runoff becomes reservoir storage until the date of storage control or the storage is filled. Consequently, the TWSA estimate becomes more accurate as the runoff component declines and the reservoir storage component increases.

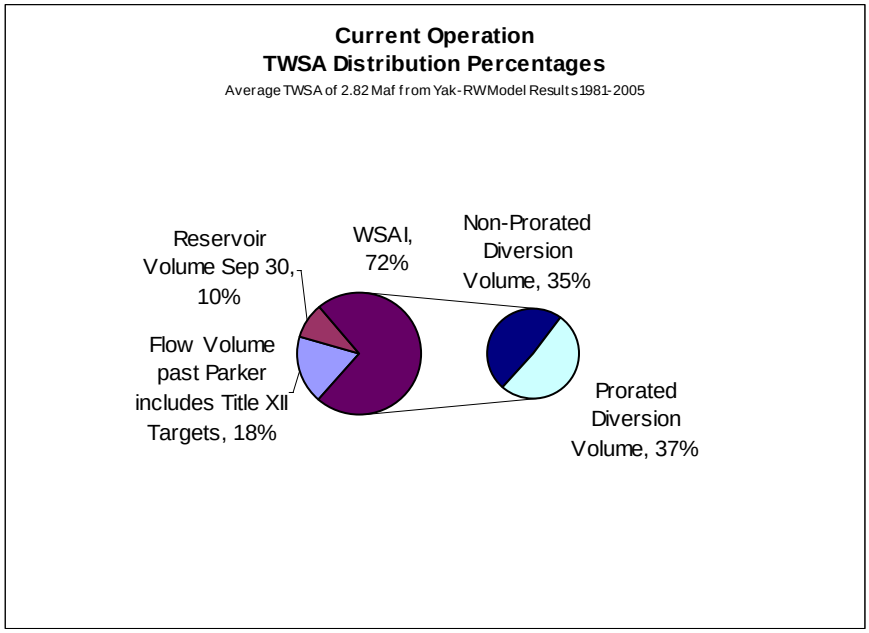
Return flows resulting from irrigation diversions upstream of Sunnyside Diversion Dam are an integral part of the TWSA estimate. The timing of return flows and the location where they enter the river system determines whether or not they can be reused. Return flows depend on the level of diversion, which is conditioned by the amount, time, and availability of runoff. The return flow volume varies from year to year, but the useable portion is fairly uniform.

Reservoir contents are the volume of water available in the total storage system. In most years, Yakima Project reservoirs are operated to peak storage contents in mid-June, about the same time the major natural runoff ends.

RiverWare Model

A reservoir and river simulation computer model known as the Yak-RW model is used to assess potential physical and operational changes to the Yakima Project. The Yak-RW model is a daily time-step reservoir and river operation simulation model of the Yakima Project that uses a 25-year Yakima River basin historical hydrologic period of water years 1981 through 2005 (November 1, 1980, through October 31, 2005). Current-day operation criteria such as the Title XII instream target flows (implemented in 1995) and current minimum streamflow maintenance releases from Yakima Project reservoirs are input to the model for the entire 25-year period. Further, actual day-to-day “hands-on” operation decisions cannot be reflected in the Yak-RW model. Consequently, the proration levels generated by the Yak-RW model for the current operations are different than actually experienced in the prorated water years for the 25-year period of record (1981-2005). The Yak-RW model is used in the Storage Study to compare the operational effects and accomplishments of Joint Alternatives to a no action operation (i.e., No Action Alternative).

Yak-RW model results show the average April 1 TWSA estimate for the 25-year period of record is about 2.82 million acre-feet, ranging from a maximum (1997) of 4.54 million acre-feet to a minimum (1994) of 1.74 million acre-feet. The components and the distribution of this average TWSA are shown in figure 4.1.



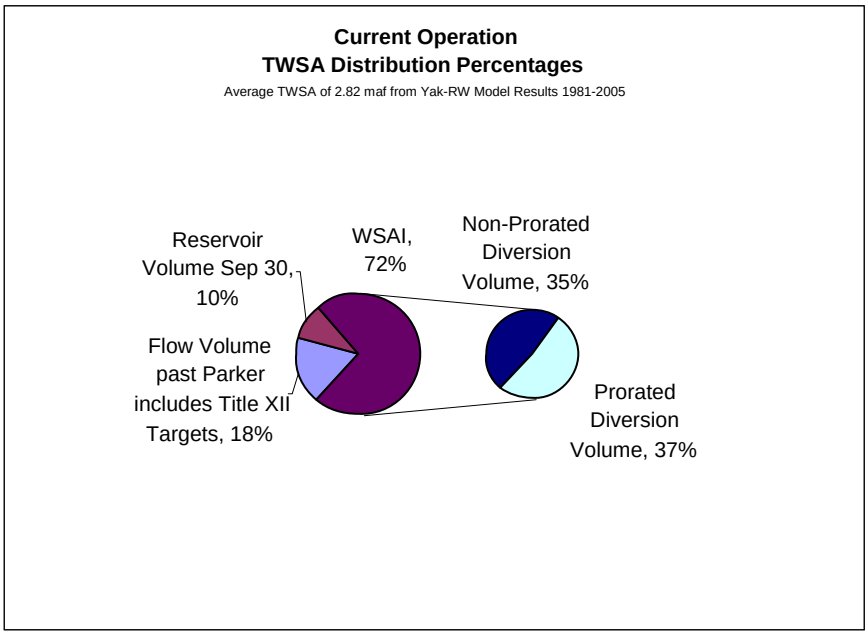


Figure 4.1 Components and distribution of average TWSA—(1) reservoir volumes and (2) flow volumes compared to prorated and nonprorated diversion volumes.

Drought Operations

The years 2001 and 2005 were single dry years. The TWSA was 1.80 million acre-feet and 1.76 million acre-feet in 2001 and 2005, respectively, which resulted in major single-year irrigation proration levels of 40 percent and 38 percent, respectively. The 3-year dry cycle of water years 1992, 1993, and 1994 resulted in a downward trend in TWSA of 2.1 maf in 1992; 2.1 maf in 1993; and 1.75 maf in 1994; and irrigation proration levels of 68 percent, 56 percent, and 28 percent, respectively. Reservoir carryover was severely depleted at the end of October 1992 and 1993; in 1994, total system contents were 50,000 acre-feet, about 5 percent of the total reservoir capacity.

Irrigation entities with major proratable water entitlements are the ones most critically affected by dry water years—both from short- and long-term agricultural cropping and production and economic considerations. The Kittitas and Roza Divisions, with only proratable entitlements of 336,000 and 375,000 acre-feet, respectively, and the Wapato Irrigation Project, with 350,000 acre-feet (53 percent) of its water entitlements proratable, are significantly affected. Table 4.2 summarizes the distribution of water entitlements in the Yakima River basin.

Table 4.2 Yakima River basin annual water entitlements

Irrigation entity	Annual water entitlements (maf)1		
	Proratable	Nonproratable	Total
Kittitas Division	.336		.336
Roza Division	.375		.375
Wapato Irrigation Project	.350	.306	.656
Sunnyside Division	.143	.316	.459
Tieton Division	.038	.076	.114
Other	.042	.519	.561
Total basin	1.284	1.217	2.501

[1] Entitlements used when prorationing of the water supply available for irrigation is required. Conditional Final Orders of the Adjudication Court and Water Right Settlement Agreements have, in some cases, established limitations on the volume that can be diverted in any year.

In dry years, instream flows throughout the Yakima River basin are also substantially reduced. The Title XII target flows downstream from Sunnyside Diversion Dam can be 300 cfs less than (or half) the target flows in wet years and 100 to 200 cfs lower than in average years; summer base flows are substantially lower than the unregulated flow regime.

Future Municipal Water Supply

The Storage Study used the average municipal supply provided over the 25-year period of record and the water supply provided in dry years to indicate future (year 2050) municipal water needs.

4.2.2 Environmental Consequences

Chapter 2 provides information on the hydrologic indicators used to evaluate the success in meeting the Storage Study goals of improving instream flows, dry year irrigation proratable water supply, and future municipal water needs. This section discusses the environmental consequences to the Yakima River basin's water resources of the current Yakima Project operation and the operation of each Joint Alternative in comparison to the No Action Alternative as measured by the hydrologic indicators.

Table 4.3 presents a summary of the "absolute values" of the hydrologic indicators shown in chapter 2. An explanation of why these were selected as the hydrologic indicators for the assessing the system operations studies is also provided in chapter 2.

Table 4.3 Hydrologic indicators

Hydrologic indicator	Current operation	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Average for water years 1981-2005 (maf)					
April 1 TWSA	2.82	2.84	2.90	2.94	2.94
Apr-Sep flow volume at the Parker gage	0.51	0.62	0.98	0.59	0.90
Apr-Sep diversion volume upstream of the Parker gage	2.02	1.91	1.47	1.95	1.64
Sep 30 reservoir contents	0.27	0.30	0.43	0.40	0.40
Apr-Sep flow volume at the mouth of the Yakima River	0.85	0.86	1.22	0.83	0.83
Water year 1994 (maf)					
Irrigation delivery volume shortage	0.40	0.38	0.12	0.38	0.38
Irrigation proration level	28%	27%	70%	29%	29%

4.2.2.1 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

April 1 TWSA Estimate.—Model results show that the April 1 TWSA estimate is 20,000 acre-feet greater under the No Action Alternative than under the current operation. This difference is the result of greater September 30 carryover storage, which, in turn, is the result of implementing No Action Alternative water conservation measures and the ability to retain some of the irrigation portion of the conserved water as carryover storage in wet and average years. Table 4.4 presents the environmental consequences on the Yakima River basin's reservoir resources. These consequences are represented by the average contents of the Yakima Project reservoir system for three periods: March 31 (prior to the beginning of the irrigation season and used in the April 1 TWSA estimate); June 30 (the target date for the reservoirs to reach full storage capacity); and September 30. Cle Elum Lake contents are shown for June 30.

Table 4.4 Yakima Project total reservoir contents and Cle Elum Lake contents (maf) (1981-2005)

Period	Current operation	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
March 31	0.60 (56% full)	0.62 (58% full)	0.68 (63% full)	0.72 (58% full)	0.73 (59% full)
June 30 Yakima Project total	0.91 (85% full)	0.92 (86% full)	0.91 (85% full)	1.05 (85% full)	1.05 (85% full)
June 30 Cle Elum Lake	0.35 (80% full)	0.36 (82% full)	0.34 (78% full)]	0.33 (75% full)	0.33 (75% full)
September 30	0.27 (25% full)	0.30 (28% full)	0.43 (40% full)	0.40 (37% full)	0.40 (32% full)

April-September Flow Volume Downstream from the Parker Gage.—The April-September flow volume is greater under the No Action Alternative than under the current operation because the Title XII flows are greater as a result of implementation of water conservation measures and changes in points of diversions. Table 4.5 presents the April-September flow volume and the July-September flow volume downstream from the Parker gage under all the alternatives.

Table 4.5 Flow volume downstream from the Parker gage for April-September and July-September (maf)

Period	Current operation	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Apr-Sep	0.51	0.62	0.98	0.59	0.90
Jul-Sep	0.09	0.13	0.23	0.13	0.29

The No Action Alternative July-September higher flow volume of 40,000 acre-feet is about 36 percent of the total 6-month change of 110,000 acre-feet. The daily average flow for the July-September period is 470 cfs under the current operation compared to 720 cfs under the No Action Alternative.

April-September Diversion Volume Upstream of the Parker Gage.—April-September diversions upstream of the Parker gage average 110,000 acre-feet less

over the 25-year period of record under the No Action Alternative than under the current operation because the water conservation measures are implemented. Water conservation measures result in a total diversion reduction of about 157,200 acre-feet (conserved water), of which 84,700 acre-feet is the instream flow portion and 72,500 acre-feet is the irrigation portion retained by the conserving entities for use in dry years.

September 30 Reservoir Contents.—See "April 1 TWSA."

April-September Flow Volume at the Mouth of the Yakima River.—See "April-September Flow Volume at Parker."

Irrigation Delivery Volume Shortage and Proration Level (1994 Dry Year).— The current operation does not include the water conservation measures of the No Action Alternative. Water conservation measures improve the irrigation delivery volume shortage, and, since these measures are included in the No Action Alternative, the irrigation delivery shortage volume is less (20,000 acre-feet) than under the current operation. These measures, however, do not improve the irrigation proratable level in the third year (1994) of the 3-year 1992-1994 dry cycle, and the current operation proration level of 28 percent is slightly better than the No Action Alternative proration level of 27 percent.[4]

[4] The irrigation water supply benefits of the conservation actions are realized in 1992 and 1993 as shown by the improved irrigation proration levels of the No Action Alternative. By 1994, the third year of the dry cycle, the difference in the proration level of the No Action Alternative and the current operation is negligible and is due to rounding of the Yak-RW model results.

4.2.2.2 Black Rock Alternative

Construction Impacts

No construction-related impacts to the storage and delivery of water are anticipated under this alternative.

Long-Term Impacts

April 1 TWSA.—The April 1 TWSA estimate for the Black Rock Alternative is 60,000 acre-feet greater than under the No Action Alternative. This difference is the result of the water exchange whereby a sizeable irrigation demand of the Roza and Sunnyside Divisions is removed from the Yakima Project and met by the delivery of water stored in Black Rock reservoir. As a result, the September 30 reservoir carryover is greater, which increases the April 1 TWSA. It should be noted that the only storage included in the TWSA estimate is storage in the existing reservoirs filled from Yakima River basin runoff. The TWSA estimate does not include the volume of stored water in Black Rock reservoir. Further, the additional release of 185-200 cfs from Cle Elum Lake to improve the aquatic resources begins in September and continues through May. While some "backfilling" of the vacated storage space does occur, there is no Yakima Project storage downstream from Cle Elum Lake to capture these releases and they continue downstream to the Columbia River confluence. The environmental consequences of this water exchange on the Yakima River basin's reservoir resources are presented in table 4.4.

April-September Flow Volume Downstream from the Parker Gage.—The April-September flow volume downstream from the Parker gage is 360,000 acre-feet greater than under the No Action Alternative, which is the result of the water exchange and the enhanced instream flows based on the April 1 TWSA estimate (chapter 2). Table 4.5 presents a summary of the April-September and July-September flow volumes downstream from the Parker gage.

The Black Rock Alternative flow volume downstream from the Parker gage during July-September of 230,000 acre-feet is equivalent to about a daily average flow of about 1,260 cfs. A hydrograph showing median daily flows at Parker under the Black Rock Alternative and the No Action Alternative is shown in chapter 2.

April-September Diversion Volume Upstream of the Parker Gage.—An increase in the April-September diversion volume upstream of the Parker gage is associated with the future municipal water supply. Irrigation diversions are less than under the No Action Alternative, as a major portion of the Roza and Sunnyside Divisions' water needs are from Black Rock reservoir. The net effect is a decrease of 440,000 acre-feet.

September 30 Reservoir Contents.—See "April 1 TWSA."

April-September Flow Volume at the Mouth of the Yakima River.—With the integration of the Black Rock Alternative and Yakima Project operations, the April-September flow volume at the mouth of the Yakima River is 360,000 acre-feet greater under the Black Rock Alternative than under the No Action Alternative, which is the result of importing water into the basin.

Irrigation Delivery Volume Shortage and Proration Level (1994 Dry Year).— The irrigation delivery volume shortage is substantially less under the Black Rock Alternative, and the irrigation proration level is improved to the 70-percent goal in the third year of the 3-year dry cycle. These differences are the result of the greater proratable irrigation water supply that is available in dry years.

The environmental consequences of these actions include the following:

- Agricultural irrigated areas would receive an adequate water supply to sustain cropping through extreme dry cycles.
- Instream flows for aquatic habitat would be maintained throughout the Yakima River basin in these dry years at a reduced, but much better, flow level than under the No Action Alternative.

4.2.2.3 Wymer Dam and Reservoir Alternative

Construction Impacts

No construction-related impacts to the storage and delivery of water are anticipated under this alternative.

Long-Term Impacts

April 1 TWSA.—With the addition of Wymer reservoir to the Yakima Project, several primary changes occur, increasing the April 1 TWSA estimate.

The contents in the 162,500 acre-feet of Wymer reservoir capacity is included in the TWSA estimate.

The additional October-May Cle Elum Lake releases to improve aquatic habitat conditions in the Cle Elum River and downstream to the Wymer pumping plant result in the capability to "backfill" vacated storage space in Cle Elum Lake. This, in turn, provides more stored water for the April 1 TWSA.

However, all of the Cle Elum Lake vacated space cannot be "backfilled." As a result, total Yakima Project reservoir contents would be higher, but the Cle Elum Lake contents would be lower. The average contents of the Yakima Project reservoir system for the 25-year period of record are shown in table 4.4 for three periods: March 31 (prior to the beginning of the irrigation season and used in the

April 1 TWSA estimate), June 30 (the target date for the reservoirs to full storage capacity), and September 30. Cle Elum Lake contents are also shown for June 30.

April-September Flow Volume Downstream from the Parker Gage.—The April-September volume of flows downstream from the Parker gage would be slightly reduced with implementation of the Wymer Dam and Reservoir Alternative. This reduction is due to (1) the "backfilling" of Cle Elum Lake vacated space, which results from the additional October-May releases and (2) future municipal water supply diversions upstream of Parker which are provided from unregulated flows prior to the storage control period (generally about April-June). Title XII target flows are the same as under No Action Alternative.

Table 4.5 presents the volume of flows downstream from the Parker gage during the April-September and July-September periods for the Wymer Dam and Reservoir Alternative. The flow reduction occurs during April-June, which is normally prior to the storage control period. The average volume reduction of 30,000 acre-feet is about a 5-percent decrease from the No Action Alternative and is equivalent to a daily average flow of about 83 cfs. The July-September flow volume downstream from the Parker gage is the same under the No Action Alternative (130,000 acre-feet) and is equivalent to a daily average flow of about 720 cfs.

April-September Diversion Volume Upstream of the Parker Gage.—Diversions upstream of the Parker gage are an average of about 40,000 greater for the 25-year period of record (1981-2005) under the Wymer Dam and Reservoir Alternative than under the No Action Alternative. This difference is the result of the following two actions: (1) diversions to meet future municipal water needs and (2) improvement in the dry year water supply for proratable irrigation entitlements.

September 30 Reservoir Contents.—See "April 1 TWSA."

April-September Flow Volume at the Mouth of the Yakima River.—The April-September volume of water exiting the Yakima River basin at the Columbia River confluence with implementation of a Wymer Dam and Reservoir Alternative is an average of about 30,000 acre-feet (about 4 percent) less than under the No Action Alternative. This decrease in flow volume is associated with the added diversions to meet future municipal water supply needs. This average decrease takes into account the return flows that would accrue to the river from the additional future municipal water use.

Irrigation Delivery Volume Shortage and Proration Level (1994 Dry Year).—Model results show a slight improvement in the proration level under the Wymer Dam and Reservoir Alternative as the result of the Wymer reservoir storage space of 80,000 acre-feet for dry year proratable irrigation water supply. The shortage

in the volume of water delivered to the farm turnout does not show an appreciable difference under the Wymer Dam and Reservoir Alternative compared to the No Action Alternative.

4.2.2.4 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

No construction-related impacts to the storage and delivery of water are anticipated under this alternative.

Long-Term Impacts

April 1 TWSA.—The greater April 1 TWSA estimate is the result of the same primary changes as noted for the Wymer Dam and Reservoir Alternative. Table 4.4 presents the environmental consequences on the Yakima River basin's reservoir resources.

April-September Flow Volume Downstream from the Parker Gage.—Under the Wymer Dam Plus Yakima River Pump Exchange Alternative, the April-September flow volume downstream from the Parker gage is 280,000 acre-feet greater than under the No Action Alternative. This increase is the result of establishing instream flow objectives at Parker gage and implementing the Yakima River pump exchange whereby some of the water that would normally be diverted by the Roza and Sunnyside Divisions remains in the river. The volume of flow downstream from the Parker gage is presented in table 4.5.

The July-September daily average flow downstream from the Parker gage is equivalent to 1,580 cfs, or 860 cfs (121 percent) greater than under the No Action Alternative, as shown in the hydrographs in chapter 2.

April-September Diversion Volume Upstream of the Parker Gage.—April-September diversion volume upstream of the Parker gage is greater under this alternative than under the No Action Alternative as a result of the future municipal water supply. However, the net effect is a decrease of about 270,000 acre-feet in diversions because of the water exchange whereby water pumped from the mouth of the Yakima River is substituted for irrigation diversions that would have been made from the Yakima River by the Roza and Sunnyside Divisions.

September 30 Reservoir Contents.—See "April 1 TWSA."

April-September Flow Volume at the Mouth of the Yakima River.—Average flows in the Columbia River at the mouth of the Yakima River are less than under the No Action Alternative. While the pump exchange is bucket-for-bucket, the Columbia River flows at the mouth of the Yakima River are reduced because of the added diversions to meet future municipal

water supply needs. The environmental consequences are a very slight reduction in Columbia River discharge.

Irrigation Delivery Volume Shortage and Proration Level (1994 Dry Year).— Model results show a minor improvement in the shortage in the volume of water delivered to the farm turnout in 1994, the third year of the 3-year dry-cycle. The improvement is because the irrigation proration level is 29 percent, slightly greater than the No Action Alternative proration level of 27 percent. The environmental consequences associated with these actions are that more water is provided to the agricultural lands and return flows to the river system are about 11 percent greater (10,000 acre-feet) than under the No Action Alternative.

4.2.2.5 Mitigation

No mitigation would be required.

4.2.2.6 Cumulative Impacts

Columbia River Basin Water Management Program

The Columbia River Basin Water Management Program could affect water resources in both the Yakima and Columbia Rivers. The conservation provisions could improve irrigation deliveries and instream flows in both the Yakima and Columbia Rivers, but conservation actions under the program are not well enough defined to estimate what the changes might be. The same is true with respect to future storage. Options being considered might improve streamflows and irrigation deliveries in the Yakima River basin, but options are not sufficiently developed to determine the potential impacts, adverse or beneficial. Currently, three sites are under consideration for development of a large off-stream storage reservoir off the Columbia River. It would be difficult to develop both the Black Rock Alternative and a large mainstem off-stream storage option as both would depend upon flows in the Columbia River to fill the reservoirs.

Global Climate Change

Global climate change has the potential to impact water resources in the study region. Potential impacts relate to changes in future temperatures and precipitation patterns, and the resulting implications to stream runoff rate and timing, water temperatures, and reservoir operations.

Current Understanding on Global to Regional Climate Change.—Assessments on climate change science and contemporary projections have been periodically released by the Intergovernmental Panel on Climate Change (IPCC) since 1988. The IPCC was established by the World Meteorological Organization and the United Nations Environment Programme, and has been coordinating the assessments of "*…climate change, its potential impacts and options for adaptation and mitigation*" (www.ipcc.ch). IPCC has recently released its Fourth Assessment Report (FAR) (IPCC, 2007). The IPPC report offers statements and

associated uncertainties about recent trends, apparent human influence and projections for various extreme weather events (e.g., table SPM.2, IPCC 2007). Relatively more certain statements are offered about warming-related events. For example, table SPM.2 states that global trends of "*warmer and fewer cold days*" and "*warmer and more frequent hot days*" occurred with greater than 90 percent probability during the 20th century and that it is "*virtually certain*" that these trends will continue based on 21st century projections of climate response to future greenhouse gas emissions scenarios (IPCC, 2000). Relatively less certain statements are offered about precipitation-related events (e.g., phenomena like the areal extent of droughts, heavy precipitation event frequency).

Recent Studies of Climate Change Impacts on Pacific Northwest Water Resources.—Numerous studies have been conducted on the potential consequences of climate change for water resources in the Pacific Northwest. This section summarizes findings from recent studies demonstrating evidence of regional climate change during the 20th century, and exploring water resources impacts associated with various climate change scenarios.

Recent Historical Trends in Pacific Northwest Climate and Snowpack.—It appears that the Pacific Northwest has became generally warmer and wetter during the 20th century. Based on results from Mote et al. (2003), the region experienced average temperature and precipitation trends of approximately +1.4 degrees °F (+0.8 degree Celsius [°C]) and +14 percent, respectively, during 1916-1997. Hamlet et al. (2007) showed similar findings in an annual sense, however seasonal trends in precipitation were found to differ in sign from about the mid-20th century (table 4.6).

Table 4.6 Pacific Northwest Region meteorological trends during 1916–2003 and 1947–2003 (Hamlet et al., 2007)[1]

Season	Period	Precipitation	Temperature maximum	Temperature minimum
Cool (Oct-Mar)	1916-2003	7.86	1.81 (1.01)	3.01 (1.670
	1947-2003	-11.07	3.47 (1.93)	4.09 (2.27)
Warm (Apr-Sep)	1916-2003	27.67	0.40 (0.22)	2.43 (1.35)
	1947-2003	16.16	2.68 (1.49)	3.47 (1.93)

[1] Precipitation units are percent change per century. Temperatures units are °F (°C) per century.

Coincident with these trends, the region also experienced a general decline in spring snowpack, as indicated by analysis of 20th century snow water equivalent (SWE) measurements dating back to at least 1950 (Mote, 2003). It appears that at most regional SWE measurement stations, particularly those located below about 5,900 feet above mean sea level (i.e., 1,800 meters), there has been a decline in SWE coincident with observed temperature increase and in spite of coincident

precipitation increase (Mote, 2003). In the latter study, declines in SWE were found to be largest in the Cascades and Coast ranges, and trend magnitudes were found to diminish at elevations above about 1,800 meters.

Mote (2006) explored the separate roles of temperature trend, precipitation trend, and climate variability in explaining observed SWE trends in the Pacific Northwest. Results showed that about half of the Pacific Northwest's SWE trend since the mid-20th century can be accounted for by an indicator of Pacific climate variability, the North Pacific Index on sea level pressure conditions, and the other half by the coincidental warming in the region. The significance of the results is that, even after accounting for the influence of climate variability, there still seems to be a substantial decreasing trend in Pacific Northwest snowpack conditions consistent with the observed warming.

These findings are significant for regional water resources management and reservoir operations because snowpack has traditionally played a central role in determining the seasonality of natural runoff. In many Pacific Northwest headwater basins, the precipitation stored as snow during winter accounts for a significant portion of spring and summer inflow to lower elevation reservoirs. The mechanism for how this occurs is that (with precipitation being equal) warmer temperatures in these watersheds causes reduced snowpack development during winter, more runoff during the winter season, earlier spring peak flows associated with an earlier snowmelt, and reduced warm season natural runoff (Hamlet et al., 2007).

Climate Change Studies in the Columbia River Basin.—A study conducted by Hamlet and Lettenmaier (1999) was framed by future climate scenarios derived from four state-of-the-art global climate models and focused on scenario changes in regional climate, Columbia River Basin runoff, and Columbia River reservoir system management. The relevance of Hamlet and Lettenmaier (1999) for this report is that their assumed climate scenarios span different increments of future warming and precipitation changes that remain within the range of changes surveyed among contemporary climate projections. (See the following section.)

Hamlet and Lettenmaier (1999) highlight water resource impacts associated with two of the scenarios analyzed (table 4.7). The impacts analysis starts from the treatment of each climate scenario, where change in long-term mean temperature and precipitation conditions is superimposed on observed climate variability. In other words, their study does not consider change in the spread or extremes of temperature or precipitation conditions about the mean.

Table 4.7 Scenario changes in climate analyzed by Hamlet and Lettenmaier, 1999

Scenario	Change in…			Change in…		
	Winter temperature	Summer temperature	Annual temperature	Winter precipitation	Summer precipitation	Annual precipitation
HC	+3.6 (+2.0)	+2.7 (+1.5)	+3.2 (+1.8)	+20	+22	+21
MPI	+3.4 (+1.9)	+4.0 (+2.2)	+3.8 (+2.1)	+3	-9	-3

[1] Precipitation units are percent change per century. Temperatures units are °F (°C).

[2] HC and MPI scenarios were derived from climate simulations produced by the United Kingdom Hadley Centre and Deches Klimarechenzntrum at the Max Planck Institute as part of the IPCC's global climate change experiments conducted during 1998-1999.

Results showed that changes in Columbia River runoff at The Dalles varied significantly by scenario (table 4.8). The two scenarios were consistent in that increased winter runoff volumes would be expected as warmer temperatures cause a greater fraction of winter precipitation to fall as rain rather than snow. This, in turn, results in reduced snowpack accumulation during winter leading to less snowmelt support of summer runoff. The results from these two scenarios suggest that without an increment of precipitation increase to offset warming, dry season runoff in the region would decrease. Further, it highlights the importance of seasonally focused climate change on the regional water response.

Table 4.8 Scenario changes in natural runoff at The Dalles, simulated by Hamlet and Lettenmaier, 1999

Scenario	Change in…		
	Winter mean	Summer mean	Annual mean
HC	162	107	123
MPI	121	88	98

[1] Change is expressed as percent of base runoff, as simulated using 20th century meteorology over the basin.

[2] Scenarios are the same as those listed in table 4.7.

Hamlet and Lettenmaier (1999) subsequently translated simulated changes in Columbia River runoff into reservoir operations response. Their results suggest that the scenario runoff changes presented in table 4.8, particularly for scenario MPI, could lead to increased competition for water during the spring, summer, and early fall between nonfirm energy production, irrigation, instream flow, and recreation. Other studies focused on Columbia River system response to scenario climate changes have produced similar findings (Mote et al., 1999; Mote et al., 2003; Payne et al., 2004).

Past Climate Change Studies in the Yakima River Basin.—Several recent investigations have explored scenario climate change impacts for runoff and water demand response in the Yakima River basin. Both of the two studies

discussed in this section (Scott et al., 2006; Mastin and Sharp, 2006) were based on warming-only scenarios and did not include the influence of coincidental precipitation change.

Scott et al. (2006) focused on how scenario climate changes could translate into shifts in water shortages for irrigated agriculture and associated impacts on regional agribusiness. Their results showed that the "normal years" probability of needing more than 50 percent prorationing among basin junior water users increased from about 14 percent under current climate to about 54 percent with 3.6 ºF (2 °C) warming.

Mastin and Sharp (2006) used an application of the U.S. Geological Survey's Modular Modeling System and simulated runoff under historical meteorology (1950-2005) (i.e., base) and then again with the same historical meteorology warmed by a uniform 3.6 ºF (+2 °C) during the simulation period (i.e., climate change). Results showed that runoff was seasonally redistributed during the year, and would seem to necessitate water management adjustments in the Yakima River basin in order to continue serving present operating objectives.

Table 4.9 presents "dry season" runoff responses to the scenario increment of warming (i.e., change in April-August natural runoff volume in the warmed climate scenario versus the base climate scenario) for five locations in the basin.

Table 4.9 Change in April-August natural runoff at various Yakima River basin locations based on a 3.6 ºF (2 °C) warming scenario (Mastin and Sharp, 2006)

Basin location	Difference (%)		
	Exceedence percentile		
	10%	50%	90%
Bumping Lake	-27	-28	-37
Rimrock Lake	-25	-20	-16
Cle Elum Lake	-40	-49	-39
Kachess Lake	-47	-54	-55
Keechelus Lake	-45	-53	-53
Yakima River near Parker gage	-38	-41	-37

They show a median reduction of dry season runoff of -28 to -54 percent, varying by location. Mastin and Sharp (2006) attributed their simulated seasonal redistribution of runoff to reduction in snowpack.

Contemporary Climate Projection Information.—The preceding section highlighted earlier modeling efforts by Scott et al. (2006) and Mastin et al. (2006) reflecting future warming without precipitation change in the Pacific Northwest that could impact water resources in the Yakima River basin. The climate scenarios modeled by Scott and Mastin can be viewed as "what if" scenarios. It is of interest to understand how their scenarios compare to a survey of contemporary climate projection information, which this section introduces in some detail. In

summary, the contemporary information reveals consensus among reputable climate models that future warming should occur. Further, there appears to be a split-majority among the models that, with this future warming, there will also be an increase in mean-annual precipitation over the region.

For this study, the survey was on projections contained within the World Climate Research Programme's Coupled Model Intercomparison Project – Phase 3 multi-model dataset (World Climate Research Programme [WCRP] CMIP3, http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php). These are the same projections referenced in the IPCC Fourth Assessment Report (IPCC, 2007). Specifically, the WCRP CMIP3 dataset was sampled to collect regional information from 112 contemporary climate projections (http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections) representing 16 different climate models. Each projection was spatially sampled over the Columbia River Basin and adjusted for climate model bias and downscaled to 1/8º spatial resolution (Wood et al., 2002; Wood et al., 2004).

Results from the survey are summarized for two areas in this study: near Cle Elum Lake and Kachess Lake in the upper Yakima River watershed (figure 4.2), and over the greater Upper Columbia River Basin region (figure 4.3). From the surveyed projections, there is consensus that Yakima-region warming should occur during the 21st century (figure 4.4), with median warming projections being about 1.8 ºF (+1.0 ºC) and 3.4 ºF (+1.9 ºC) by early- and mid-21st century, respectively. As for regional precipitation change, there is a split-majority, with more projections suggesting wetter rather than drier conditions. Roughly 75 percent of the projections suggest wetter conditions with median expected change being about +3.3 percent and +5.8 percent by early- to mid-21st century. From the distribution of projected paired-changes in the Yakima region (figure 4.5), there does not appear to be a significant relationship between projected temperature (T) and precipitation (P) changes. For example, the correlation between projected T and P by period (n = 112) was -0.14 and -0.06, neither of which passes a test of statistical significance at the 90-percent confidence level given 112 paired observations. This suggests that contemporary projections of T and P change are somewhat independent, and that the systematic drivers behind projected T change cannot be used to explain projected P changes. This raises questions about the spread and central tendency of projected P changes. In other words: What is the paradigm for Pacific Northwest precipitation response to global warming scenarios, and is this paradigm reflected on contemporary climate projections? This question relates to more general questions of regional climate responses to anthropogenic warming in the context of natural climate variability, and remains a focus of ongoing research (e.g., WRCP CLIVAR activities, www.clivar.org/science/components.php).

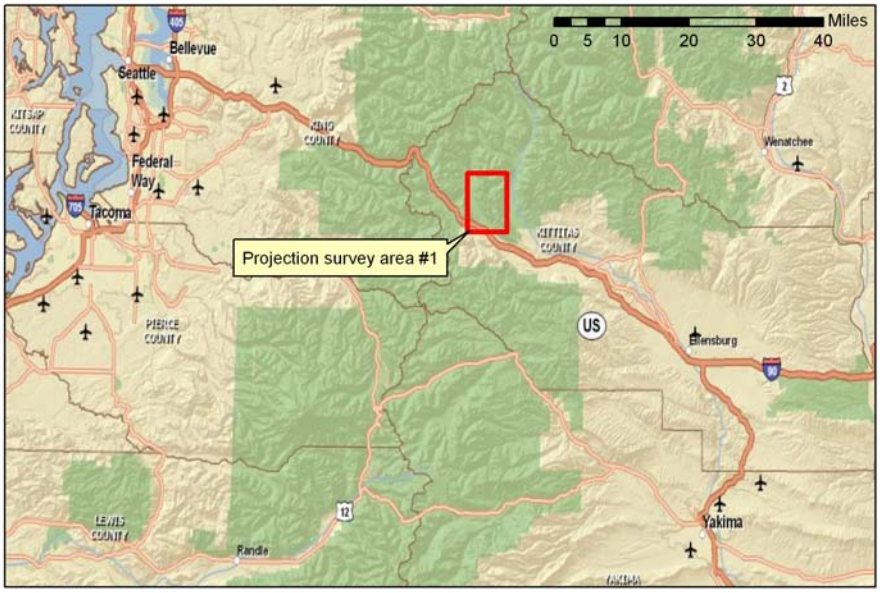


Figure 4.2 Projection survey area #1 near Cle Elum and Kachess Lakes, Washington.

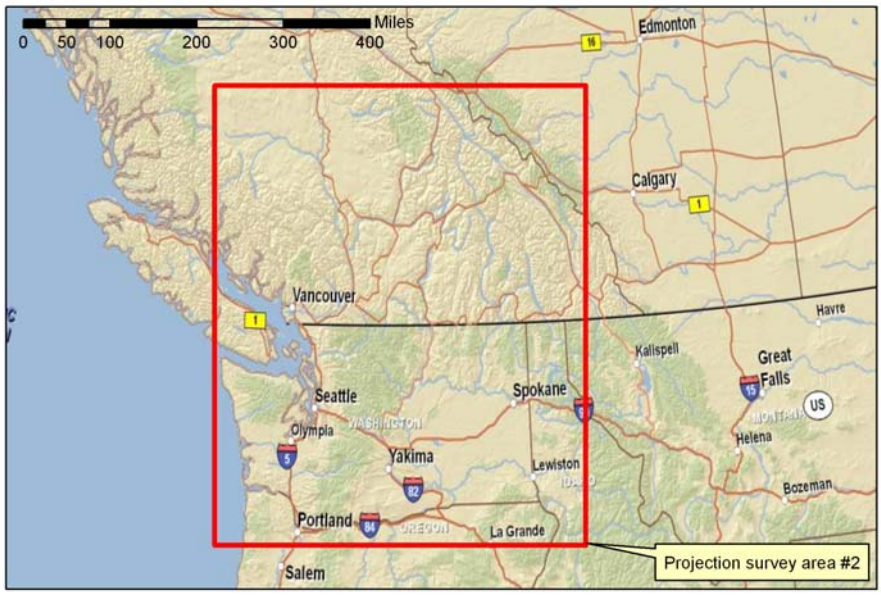


Figure 4.3 Projection survey area #2 over the Upper Columbia River Basin and surrounding region.

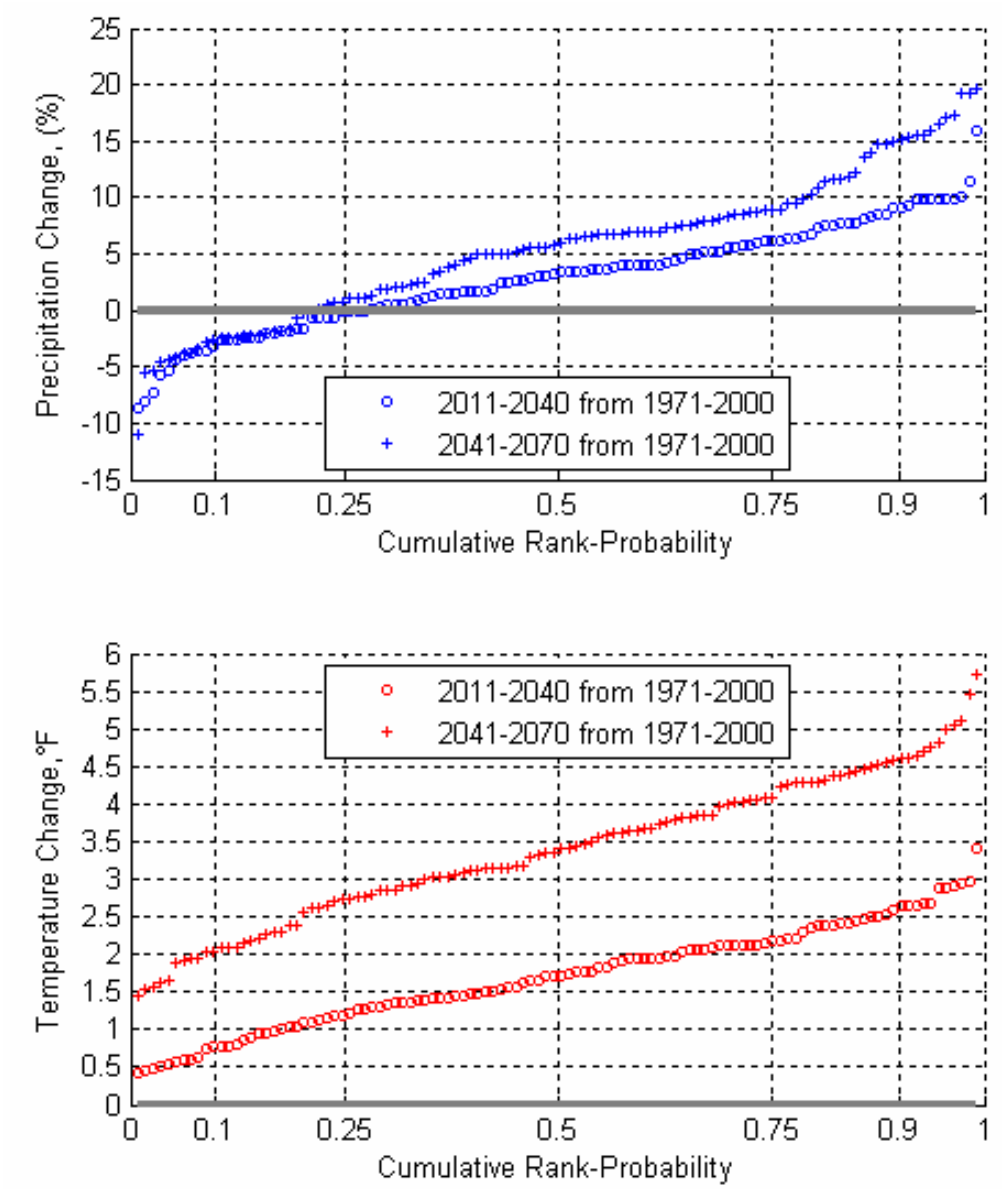


Figure 4.4 Variable-specific 21st century climate projections over Cle Elum and Kachess Lakes, Washington.

Plots show projection-specific changes in surface air temperature (ºF) and precipitation (percent) by 2011-2040 (top panel) and 2041-2070 (bottom panel) relative to 1971-2000 from 112 climate projections. The projections were collectively produced by 16 WCRP CMIP3 climate models offering one or more simulations of the IPCC Special Report on Emissions Scenarios pathways A2, A1b and B1 (IPCC, 2000).

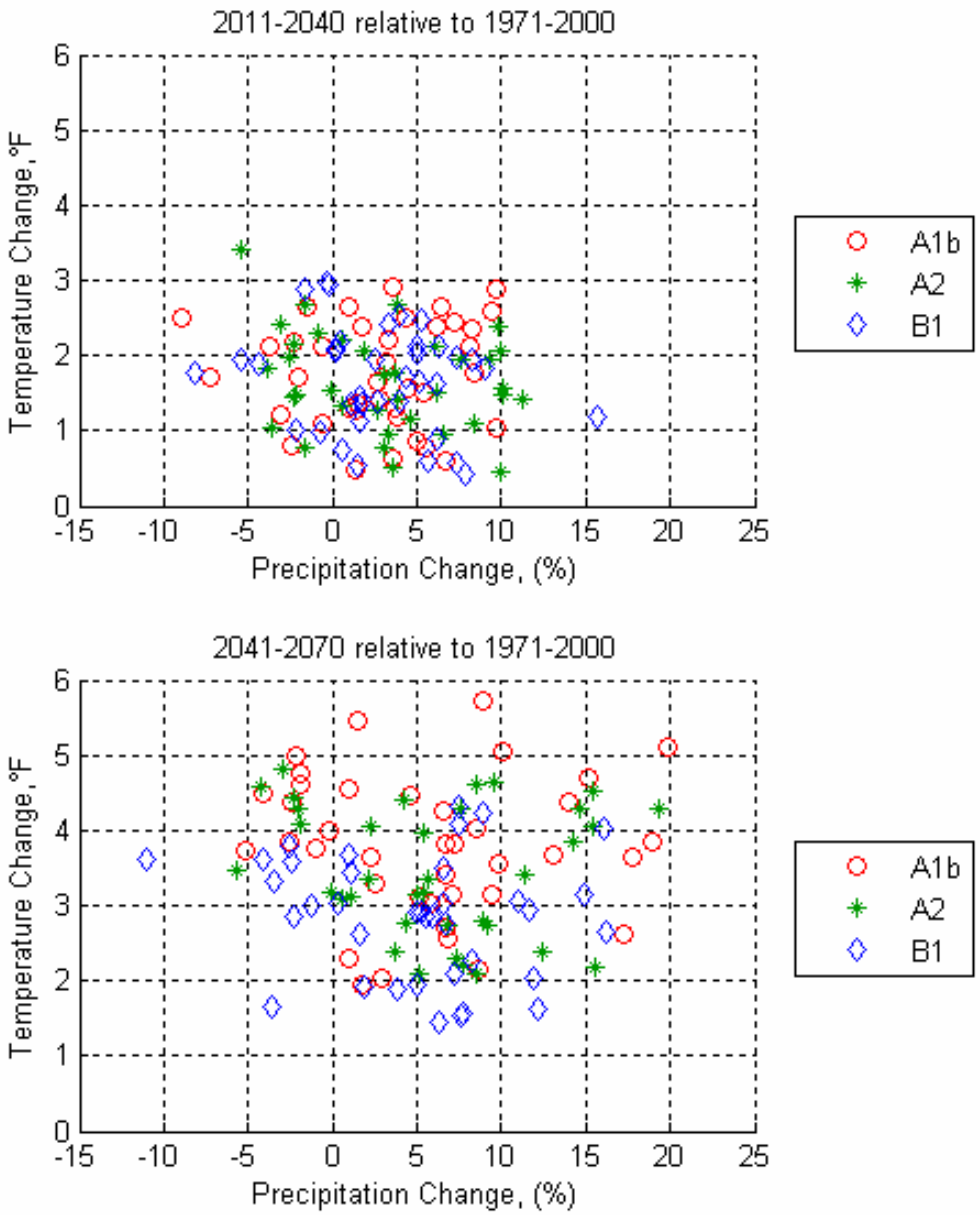


Figure 4.5 Paired 21st century climate projections over Cle Elum and Kachess Lakes, Washington.

Plots show paired projection-specific changes in surface air temperature (ºF) and precipitation (percent) by 2011-2040 (top panel) and 2041-2070 (bottom panel) relative to 1971-2000 for the same 112 climate projections summarized on figure 4.4.

Moving to the second survey area, figures 4.6 and 4.7 illustrate how projected T and P changes are spatially distributed throughout the region by early- and mid-21st century, respectively. At each 1/8º location in the projection datasets, all 112 projections were surveyed for mean-annual T and P change by early- and mid-21st century period. The 25-, 50- and 75-percent exceedence changes were then sampled and mapped as shown on the panels of figures 4.6 and 4.7. Similar to information on figure 4.4 and 4.5, it appears that there is consensus among the projections that warming is projected to occur throughout the basin, and that for roughly 75 percent of the projections, there is an expectation for wetter conditions throughout the basin.

It is noted that the data shown on figures 4.4 through 4.7 do not infer regional "climate change probabilities." The data represent only the surveyed results from a heterogeneous mix of WCRP CMIP3 climate models, three IPCC FAR emissions pathways, and various states of climate modeling capability. Not represented among these projections are the uncertainties associated with the many factors still absent from current climate models or in the pathways included here (e.g., assumed global technological development, distributed energy-technology portfolios, resultant spatial distribution of greenhouse gas sources and sinks through time, and biogeochemical interaction with greenhouse gas sources and sinks through time, and many others). Further, these data do not fully represent how climate change impacts on large-scale weather patterns (e.g., Pacific storm tracks affecting the region) could interact with local-scale features relevant to Yakima River basin hydroclimate (e.g., Cascade orographic controls on Yakima River basin precipitation fed by storms tracking in from the Pacific Ocean, and how those controls vary with rainfall versus snowfall storms).

Treatment of Climate Change in this Draft PR/EIS.—Initial efforts for this Draft PR/EIS focused on two "what-if" climate scenarios and their associated impacts on Yakima River basin and Columbia River Basin water resources. Those two climate scenarios assumed amounts of mean-annual warming (i.e., +1 ºC and +2 ºC) with no change in precipitation. Reclamation proceeded to coordinate scenario analyses of runoff response in both the Yakima River basin and in the Columbia River basins, operations response in the Columbia River reservoir system, and related water supply available for diversion at Priest Rapids.

While that work was underway, the IPCC released its Fourth Assessment Report. As presented earlier, a survey of projections from the WCRP CMIP3 dataset suggests that the assumption of "no precipitation change" implicit in the scoped climate change scenarios may not be well representative of the future. However, this survey of contemporary precipitation projections is not accompanied by information on regional projection credibility. For example, the IPCC FAR (IPCC, 2007) did not offer information suggesting that global climate models can credibly translate global warming scenarios into regional precipitation response.

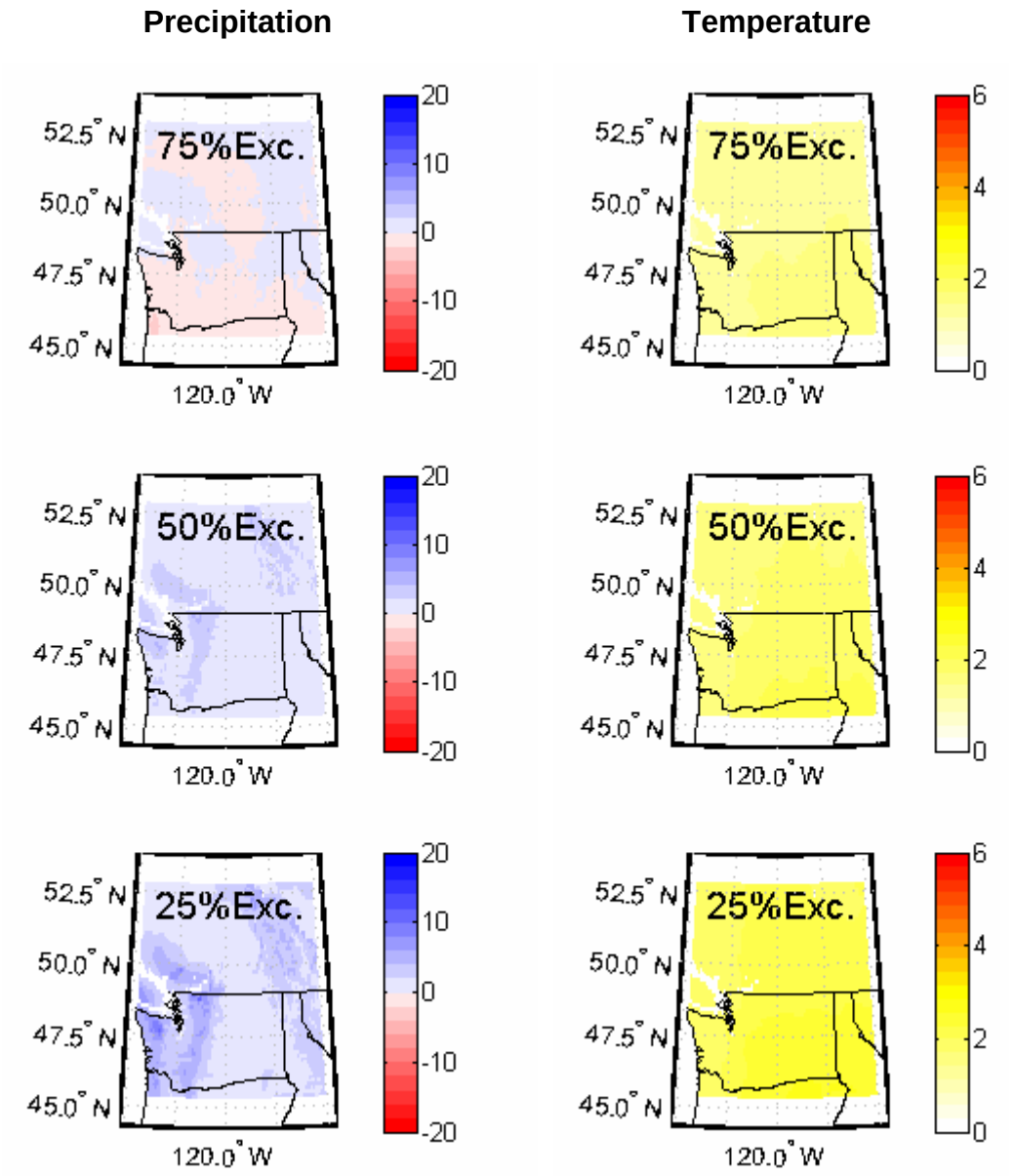


Figure 4.6 Early-21st century WCRP CMIP3 climate change projections over the Upper Columbia Region.

Maps show projected changes in surface air temperature (ºF) and precipitation (inches per year) by 2011-2040 relative to 1971-2000 from 112 climate projections, as described in the caption of figure 4.4. At each downscaled location (i.e., 1/8-degree spatial resolution), projections were sorted to identify 75-, 50-, and 25-percent exceedence projection values.

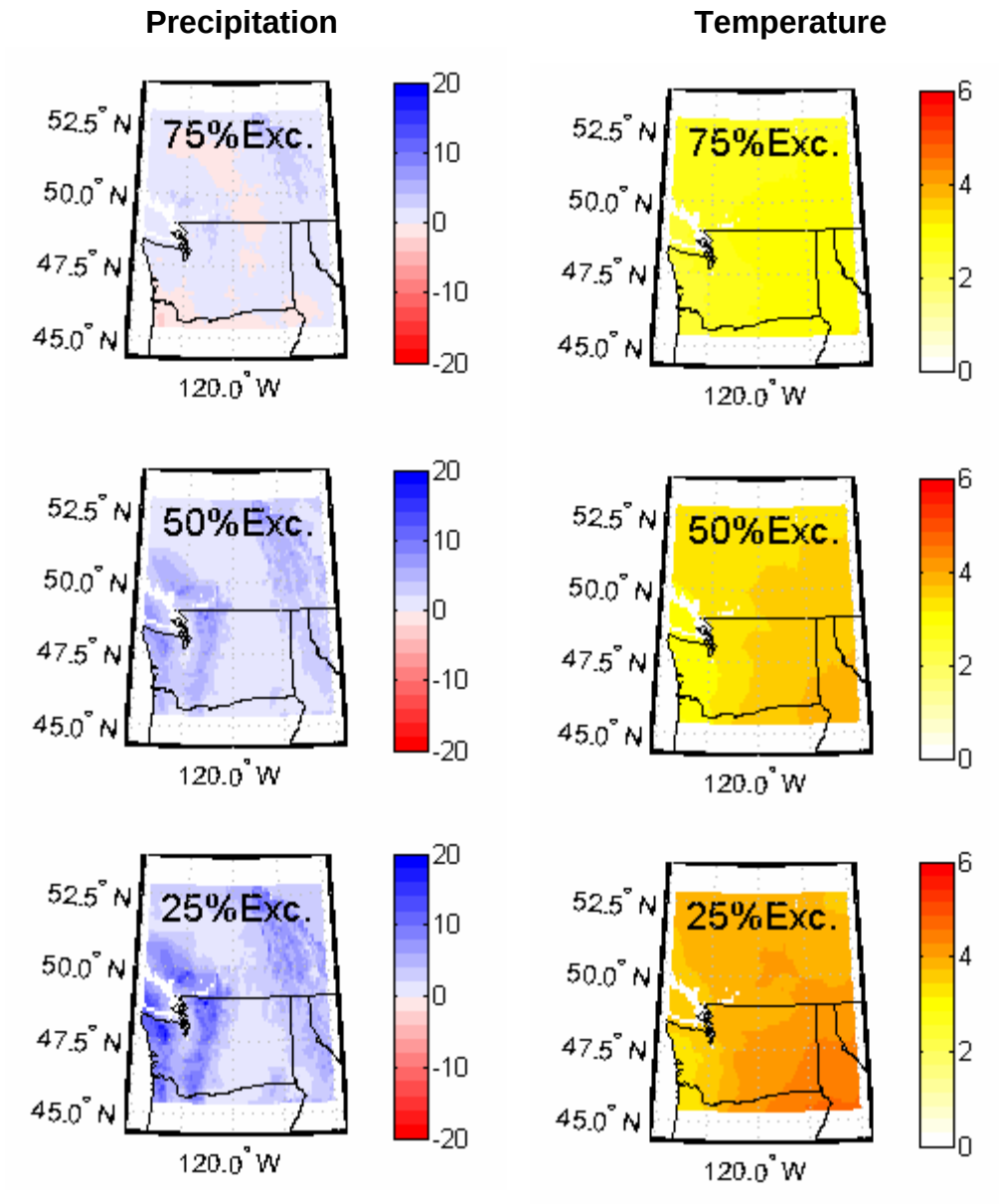


Figure 4.7 Mid-21st century WCRP CMIP3 climate change projections over the Upper Columbia Region.

Same as figure 4.6, but for projected changes in surface air temperature (ºF) and precipitation (inches per year) by 2041-2070 relative to 1971-2000.

In contrast, the IPCC FAR offered information that suggested climate models can credibly simulate global- to continental-scaled temperature trends, which also suggests credibility on a regional scale as continental and regional temperature trends are similar.

Realistic projections of future runoff appear to be dependent upon our ability to predict future changes in both temperature and precipitation. As noted above credible projections of temperature changes can now be made but the credibility of contemporary regional precipitation projections remains questionable. The uncertainly associated with the regional precipitation projections is a significant concern when trying to develop quantitative results since scenario studies have shown that warming-induced decreases in Pacific Northwest runoff during spring and summer can be offset by some amount of precipitation increase (Hamlet and Lettenmaier, 1999). Given this uncertainty, the treatment of climate change for this Draft PR/EIS was modified to involve a qualitative discussion rather than a presentation of quantitative results from the originally scoped scenarios. Therefore, the remainder of this section provides a qualitative assessment of climate change impacts on alternative operations and resources.

Potential Climate Change Impacts on Regional Water Resources.— This section summarizes potential climate change impacts related to PR/EIS action-alternative analyses, including runoff and surface water supplies, flood control, hydropower, fisheries, surface water quality, and groundwater.

- Runoff and Surface Water Supplies
    - Based on recent scenario studies of climate change impacts to Columbia River and Yakima River runoff, it appears that *warming without precipitation change* would trigger a seasonal shift toward increased runoff during winter and decreased runoff during summer. It appears that such runoff shifts would lead to reduced scenario water supplies under the No Action Alternative.
    - Based on contemporary climate projections, it appears plausible that precipitation increase could occur with regional warming and offset a significant portion of summer runoff decreases associated with warming alone. The resultant affect could be a minor change in dry season water supply (albeit with significantly increased winter runoff to manage).
- Flood Control
    - With or without offsetting precipitation increases, it would appear that winter runoff increases under regional warming could motivate adjustments to Columbia River flood control strategies. If current flood protection values in the Columbia River reservoir system are to

be preserved, it could become necessary to make flood control rule adjustments as climate evolves (e.g., deeper winter draft requirements) which may further affect dry season water supply at Priest Rapids.

- Hydropower
  - Hydropower production is generally a function of reservoir storage while demand generally tracks with temperature (e.g., heating demand during cold days, air conditioning demand during warm days). Climate changes that decrease the quantity or alter the timing of reservoir inflows have the potential to adversely impact the productivity of hydroelectric facilities (Hamlet and Lettenmaier 1999). Alternatively, increases in average flows would increase hydropower production.
- Fisheries
  - The scenario studies on regional warming, which assumed no change in precipitation, would seem to indicate adverse effects on Pacific Northwest salmon due to increased winter flows, reduced summer and fall flows, and warmer stream and estuary temperatures (Mote et al., 2003). Assumptions about possible changes in precipitation, which could affect projected summer runoff, may alter these conclusions.
- Surface Water Quality
  - Water quality depends on several variables including water temperature, flow, runoff rate and timing, and the physical characteristics of the watershed. Climate change has the potential to alter all of these variables. Increased summer air temperatures could increase dry season aquatic temperatures and affect fisheries habitat.
- Groundwater
  - Reduced mountain snowpack, earlier snowmelt, and reductions in spring and summer streamflow volumes originating from snowmelt would likely affect surface water supplies and could trigger heavier reliance on groundwater resources (Scott et al. 2006). However, warmer, wetter winters could increase the amount of water available for groundwater recharge.

Considering how climate change could influence each of these areas, it seems questionable whether contemporary water management objectives and operations would persist as climate evolves. Previous scenario studies on climate change impacts for regional water resources have typically assumed contemporary management paradigms and constraints while allowing climate change to modify

surface water supplies. On the contrary, it seems possible that new water management paradigms could emerge in the region as an adaptation response, thereby affecting the assumptions framing these EIS analyses. Social systems could play a role, as they define values related to local and regional flood protection, environmental habitat support, energy management, recreational objectives, etc.

4.3 Groundwater Resources

4.3.1 Affected Environment

Groundwater is the principal source of drinking water in the Yakima River basin and supplies about 330,000 people, or about 80 percent of the population, in a three-county area. At least 45,000 wells withdraw water in the basin. Irrigation of cropland is the largest use of groundwater, pumped from about 2,300 irrigation wells (Vaccaro and Sumioka, 2006).

The headwaters of the Yakima River basin are on the forested east slope of the Cascade Range, where annual precipitation is more than 100 inches. However, the sedimentary and metamorphic rocks in the upper basin are generally poor aquifers and groundwater recharge in the upper basin is not available to the majority of wells in the lower basin. The lower Yakima River basin is generally arid, with an annual precipitation of less than 10 inches. Mean annual recharge to the basin has increased about 31 percent since predevelopment conditions due to the application of irrigation water to croplands (Vaccaro and Olsen, 2007).

The addition of surface water storage and conveyance facilities could affect the groundwater resource by providing the opportunity for water to seep into the ground. This additional seepage could have either beneficial or detrimental effects, depending on the quantity and location.

4.3.1.1 Geology Overview

Basaltic rocks that underlie the majority of the Yakima River basin are part of the larger Columbia River Basalt Group (CRBG). The CRBG is comprised of more than 300 individual basalt flows that erupted from fissures in the eastern part of the Columbia Plateau during the Miocene Epoch (6 to 17 million years ago). Individual flows range from a few feet to more than 300 feet thick, with an average about 100 feet. The CRBG hosts multiple aquifers in various layers and formations that are collectively called the Columbia Plateau Aquifer System. The Columbia Plateau Aquifer System underlies about 63,000 square miles in central and eastern Washington, north-central and eastern Oregon, and a small portion of northwestern Idaho (figure 4.8).

Figure 4.8 Location of Yakima River basin and Columbia Plateau Aquifer System.

The Columbia Plateau Aquifer System lies in the Columbia Intermontane physiographic province, which has been divided into three subprovinces: the Yakima Fold Belt, the Palouse, and the Blue Mountains. The three subprovinces are largely defined by structural differences. The Yakima River basin lies within the Yakima Fold Belt, which has experienced more tectonic folding and faulting than the other areas (figure 4.8). The topography of the Yakima Fold Belt consists of northwest-southeast-trending ridges (anticlines) separated by broad, flat valleys (synclines) that were folded and faulted under north-south compression.

The basalts have been divided into separate formations based on their physical, geochemical, and paleomagnetic polarity differences. From oldest to youngest the basaltic formations include the following:

- **Grande Ronde Basalt -** found mainly in the subsurface and only exposed at the surface where faulting or erosion has occurred. It is the thickest and most extensive of the basalt formations. The top of the Grande Ronde Basalt is generally defined by a zone of weathering or the presence of a sedimentary interbed (the Vantage sandstone).

- **Wanapum Basalt -** overlies the Grande Ronde Basalt and is found nearly everywhere in the Yakima River basin at depth. The Wanapum Basalt is a very productive aquifer throughout the Columbia Plateau and is widely used for irrigation and municipal wells.

- **Saddle Mountains Basalt -** is less than 1 percent of the total volume of the CRBG, yet is the most chemically diverse of any of the basaltic formations in the group (Swanson and Wright, 1978). The thickness and extent of the Saddle Mountains Basalt also varies more than other basalt formations.

Interbedded sediments between some of the basalt flows are assigned to the Ellensburg Formation and are mainly found between flows of the Saddle Mountains Basalt. Toward the end of the volcanism period, there were longer intervals of time between subsequent basalt flows for deposition to occur. The interbed materials were derived chiefly from volcanic activity and erosion from the Cascade Range and from the anticlinal ridges. The interbeds are relatively thin, compared to the thick sequence of basalts, and are generally fine-grained, weakly consolidated, and have low permeability. However, in some areas, the interbeds are coarse-grained and serve as aquifers.

Folding, faulting, and other large-scale geologic deformation can affect regional groundwater flow direction, influence hydraulic gradients, and create flow conduits or barriers. At least some of the faults in the Yakima Fold Belt are proven hydraulic barriers. Others appear to be conductive and may connect deep

basaltic formations with shallower formations and surface springs. Folding increases the occurrence of fractures on the anticlinal ridges and tends to enhance aquifer hydraulic conductivity.

4.3.1.2 Groundwater Occurrence

Groundwater within the basalts is controlled primarily by the physical characteristics of the rock units, the geometry and relationship between rock units, and the geologic structure. The physical characteristics of the basaltic flows (density and texture, fractures, and internal structures) are important in determining their hydraulic properties. Internal structures found in the flows may influence both the ease of water movement and direction of flow through the formation. Individual basalt flows typically exhibit features that are formed from the emplacement and cooling of the flow. These features may include a vesicular flow top (having many small cavities), dense flow interior, and vesicular or brecciated (having many sharp angled fragments) flow bottom. If the basalt flowed into a body of water or encountered saturated sediments, a pillow-shaped structure is often formed and the space between the pillows is usually composed of palagonite (hydrated basaltic glass). "Pillow basalts" generally exhibit high hydraulic conductivity values. Hydraulic conductivity (permeability) is a measure of the ease with which water flows through geologic layers. Below the basalt flow top, in the dense interior portion of the flow, the basalt has very low horizontal conductivity and the flow interiors often serve as confining beds that separate adjacent aquifers. The flow bottom has hydraulic properties similar to the flow top and the combination of flow top and adjacent flow bottom is called an "interflow." The interflow zone generally has high horizontal conductivity and is where most of the horizontal groundwater flow occurs within the basalt units. The basaltic flows and permeable interflow zones are often laterally continuous for tens of miles.

The thickness and extent of basalt flows and the occurrence or absence of fine-grained sedimentary interbeds also influence groundwater movement. At the distal ends of the basalt flows or where erosion has interrupted the continuity of flows, interbedded sediments are able to commingle and may serve as a vertical conduit between previously separated flow systems.

Groundwater flow is generally from the anticlinal ridges toward the streams and rivers in the synclinal valleys. Shallow groundwater flow is usually vertically downward from the surface to the underlying basalt units. However, because of the geologic structure of the synclinal basins, there are a number of areas that have upward flow and artesian wells in the lower valleys.

4.3.1.3 Aquifer Recharge and Discharge

Local-, intermediate-, and regional-scale groundwater flow systems within the Yakima River basin are recharged by various mechanisms. Local and

intermediate flow systems are recharged through basalts that are exposed to precipitation at the ground surface on the anticlinal ridges, and through groundwater exchange with other basins and formations. On a regional scale, basaltic units are recharged along the western margin of the Columbia Plateau where the basalts interfinger with prebasaltic rocks and sediments at higher elevations in the Cascade Range.

Much of the natural recharge (from precipitation) occurs in the upper basin and is not available to the bedrock aquifers where most pumping takes place (Vaccaro and Olsen, 2007). The lower, arid portion of the Yakima River basin generally receives about 6 to 10 inches of precipitation annually, and most groundwater recharge is from application and distribution of irrigation water (Vaccaro and Olsen, 2007).

About 45 percent of the water diverted for irrigation is eventually returned to the river system as surface-water inflows and groundwater discharge (Reclamation, 1999). Irrigation return flows to the lower Yakima River account for about 75 percent of the streamflow downstream from the Parker gage (Vaccaro and Sumioka, 2006).

Aquifer discharge occurs principally to major surface drainage systems (i.e., Yakima and Columbia Rivers) and through irrigation well pumping. Annual pumping in the Yakima River basin increased almost 270 percent from 1960 to 2000 (Vaccaro and Sumioka, 2006). About 395,096 acre-feet were pumped in 2000; 60 percent of the pumping was for irrigation, another 12 percent was for municipal water supply. The annual quantities appropriated in State water right certificates and permits are about 529,231 acre-feet (Vaccaro and Sumioka, 2006).

4.3.1.4 Hydraulic Properties

Physical variations within the basalt flows indicate that a wide range of hydraulic conductivity values exist within a single basalt flow. Hydraulic conductivities can be inferred from injection or pumping tests in drill holes and from water level measurements and trends. Aquifer testing at the Hanford Site and at other locations around the Columbia Plateau has provided a range of hydraulic conductivity values for various zones within the basalt units (Lindsey et al., 2003).

Hydraulic conductivity, along with gradient and other material properties, determine the likelihood and quantity of seepage from the proposed Black Rock and Wymer reservoir sites.

Hydrogeologic unit	Range of horizontal hydraulic conductivity (Kh)[1]
Basalt flow tops	$1x10^{-6}$ to $1x10^{3}$ feet/day
Basalt flow interiors	$1x10^{-9}$ to $1x10^{-3}$ feet/day (vertical K estimated about 1 to 3 times Kh or $3x10^{-9}$ to $3x10^{-3}$ feet/day)
Sedimentary interbeds	$1x10^{-6}$ to 1 feet/day

[1] Kh = horizontal hydraulic; k = hydraulic conductivity.

4.3.2 Environmental Consequences

4.3.2.1 Methods and Assumptions

Several methods were used to help evaluate the effects of the Joint Alternatives on groundwater, as described in the following sections.

The following indicators were selected to evaluate groundwater:

- Increased hydraulic head and pore pressures (resulting from the creation of surface storage reservoirs at the Black Rock or Wymer sites)
- Volume and direction of seepage flow
- Construction impacts – dewatering and water disposal

Groundwater Flow Model

Reclamation developed a groundwater flow model to estimate potential seepage and hydrologic impacts from the Black Rock reservoir (Reclamation, 2007d). The groundwater flow model used the USGS MODFLOW software package (Harbaugh et al., 2000), a computer program that provides a mathematical representation of the groundwater flow system. MODFLOW is recognized as the industry standard for groundwater flow models, and it has been reviewed and used for more than 20 years. It numerically solves the three-dimensional groundwater flow equation for a porous medium by using a finite-difference method. The modeled area is represented by a three-dimensional grid of cells that are laid out in a series of rows, columns, and layers. The model layers simulate confined or unconfined aquifers. Each cell has a single point, called a node, where head is calculated. Hydraulic boundary conditions, hydraulic parameters and stresses to the system (such as pumping wells, flow to riverbeds, aerial recharge) are defined as model input. Model output includes head and flow at each node within the model domain.

Black Rock Reservoir Modeling

The seepage model for the Black Rock Alternative quantifies the expected change in head and seepage flows for that area. The Black Rock seepage model relied heavily on previous hydro geologic studies, including the USGS Columbia

Plateau regional groundwater model (Hansen et al., 1994) and the Yakima River basin hydro geologic framework study (Jones et al., 2006). The seepage model study was used first to represent the current condition in the model area (called the base case in the seepage study and comparable to the No Action Alternative in the reservoir area), then to predict a range of expected impacts related to the presence of the Black Rock reservoir. Data used in the model were acquired through various literature reviews, field work, hydrological testing of wells, geological mapping, and from the model itself. The investigation also incorporated the results of recent geologic drilling and aquifer testing by Reclamation at the proposed Black Rock site (Pacific Northwest National Laboratory [PENN], 2007; Reclamation, 2004g).

Wymer Reservoir Modeling

A comparable study has not been completed for the Wymer Dam and Reservoir Alternative, but head increases and seepage flows can be qualitatively described based on site investigations and available data. Field investigations and borehole testing were recently completed, and the results of these and previous studies were used to evaluate the likely effects under the Wymer Dam and Reservoir Alternative.

4.3.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

During dry water years, State law allows emergency pumping from numerous drought relief wells as a source of supplemental irrigation supply. Historical water level data indicate that pumping from these wells during droughts has caused long-term water level declines in the deep basalts. The potential use of these emergency wells is expected to be less under any of the Joint Alternatives than under the No Action Alternative.

4.3.2.3 Black Rock Alternative

Construction Impacts

During excavation of the pumping plants, tunnels, and appurtenant structures associated with the Black Rock Alternative, dewatering may be necessary during construction in some areas. The Priest Rapids member of the Wanapum Basalt would be excavated for the intake pumping plant along the Columbia River. The amount of dewatering necessary would depend on the occurrence of rock fractures and interflow zones encountered in the excavation. Some provision for dewatering and disposal of pumped water would be necessary.

The tunnels would be excavated above the regional water table and may not require substantial dewatering during construction (Reclamation, 2004e).

Long-Term Impacts

Table 4.10 presents total annual reservoir seepage, annual rate of increase in aquifer storage, and annual rate of increase in discharge to creeks, drains, and springs, as estimated by the seepage model, with respect to time since reservoir filling begins. The table provides a range of seepage values resulting from a sensitivity analysis that was conducted to bracket most of the uncertainty in model input parameter values.

Table 4.10 Model-based estimates of total annual reservoir seepage rates (Reclamation, 2007d)

Time since reservoir filling begins	Total annual reservoir seepage rate (acre-feet)[1]			Annual rate of increase in aquifer storage (acre-feet)			Annual rate of increase in discharge to creeks, drains, and springs (acre-feet)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
13 months	72,900 101 cfs	121,000 168 cfs	96,950 135 cfs	49,900 69 cfs	80,000 111 cfs	64,950 90 cfs	22,400 31 cfs	40,400 56 cfs	31,400 44 cfs
5 years	32,100	54,300	44,900	2,400	14,700	8,600	25,600	51,100	36,300
25 years	30,700	53,400	42,200	1,000	6,100	3,400	27,600	51,400	38,800
100 years	29,900	53,200	41,300	200	2,900	1,300	28,500	51,500	40,000
300 years	29,800 41 cfs	52,300 73cfs	40,900 57 cfs	1 0 cfs	1,500 2 cfs	600 1 cfs	29,200 41 cfs	51,600 72 cfs	40,400 56 cfs

[1]Total annual reservoir seepage is generally not the exact sum of its two components in this table because the minimum, maximum, and mean values presented are from different model runs.

Model results indicate that the effect of reservoir seepage on aquifer hydraulic head conditions is greatest in the immediate area of the proposed reservoir itself, but especially at the dam, where the reservoir would be deepest (Reclamation, 2007d). A full reservoir would ultimately increase head directly beneath the reservoir in the sediments, Saddle Mountains, and Wanapum basalts by 250 to 650 feet. Model results show that the effect of seepage on head diminishes rapidly with distance from the reservoir. Five to ten miles from the reservoir, the head increase in the basalts to the south and northwest is generally less than 20 feet.

A minimal increase in head is expected in the sediments west of the reservoir because the west end is the upper, shallow end and there would be a lower hydraulic gradient in that direction. In the Saddle Mountains Basalt, the head increase is mainly to the south since the unit is absent in the Yakima Ridge anticline, north of the reservoir. Likewise, the Wanapum Basalt thins slightly to the west of the reservoir and the unit outcrops along the north and south anticlinal ridges. These conditions and variations in vertical conductivity

influence the pattern of increased head in the basalts. The modeled head increase in the basalts is generally less than 10 feet in the lower Yakima valley after 300 years (Reclamation, 2007d).

Most of the increase in aquifer discharge to creeks, drains, and springs occurs into the Dry Creek drainage. Seepage is expected to "daylight" at the upstream end of Dry Creek (to the east of the reservoir) then reinfiltrate into the sediments that overlie the basalts at the downstream end of Dry Creek and result in an increase in head of up to 250 feet. Along Cold Creek, at the western boundary of the Hanford Site, head increases can range up to 60 feet and the increased head continues, although diminished, into the Hanford Site.

Seepage from the Black Rock reservoir has the potential to affect aquifer head, magnitude, and direction of groundwater flow and rate of contaminant movement on the Hanford Site. The U.S. Department of Energy is evaluating treatment, storage, and closure options for tanks and other units around the Hanford Site through the ongoing "Tank Closure and Waste Management Environmental Impact Statement," to be completed in 2008. The Department of Energy (DOE) intends to include an analysis of the potential impacts to groundwater beneath the Hanford Site as a result of seepage from the Black Rock reservoir in that EIS. The results of that analysis will be included in the Storage Study Final PR/EIS.

The model estimates that current west-to-east groundwater flow beneath Cold Creek in the sediment layer is about 8,000 acre-feet per year. Cold Creek in this area is synonymous with the western Hanford Site boundary. As a result of seepage reinfiltration, the model estimates that groundwater flow in the sediments beneath Cold Creek could ultimately increase to 23,000-30,000 acre-feet per year, an increase of between 15,000 and 22,000 acre-feet per year compared to the current condition. Most of the increased flow beneath Cold Creek would occur near the confluence with Dry Creek. The model predicts little increase in groundwater flow beneath Cold Creek in the Saddle Mountains and Wanapum layers.

Landslides are common in the Yakima Fold Belt and generally form on the over-steepened south limbs of the anticlines. Several ancient landslides have been identified on the Horsethief Mountain anticline, which comprises the right abutment of the proposed Black Rock dam (Columbia Geotechnical Associates, 2004). The steeply dipping orientation and layering of the low-strength sediments and the presence of the Horsethief Mountain Thrust Fault along the southern edge of the reservoir valley present a potentially hazardous combination. Though the slide areas are currently stable, seepage from the reservoir into the presently unsaturated basalts and interbedded sediments would increase pore pressures within those materials and would likely reactivate some of those slides as well as initiate new landslides along the reservoir rim and dam abutments. Slope stability would also be an issue for the re-alignment of SR-24 along the south rim of the reservoir.

4.3.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

The pumping plant to supply the Wymer reservoir would be located along the Yakima River, and construction of the plant would require dewatering. Approximately 25 feet of alluvial material lies above the Grande Ronde Basalt in the pumping plant location, and the groundwater level would be expected to follow the river stage, which is about 10 feet below ground surface. The pumped water would need to be treated or allowed to settle to remove turbidity and suspended sediments prior to discharging the water back to the river. There are no private wells in the immediate area that would be affected by the dewatering.

Dewatering also would be required during construction of the dam foundation. Artesian conditions were encountered at a depth of about 55 feet (35 feet into the Grande Ronde Basalt) during the drilling of two wells in the river valley (Reclamation, 1988). About 20 gpm flowed at the ground surface under unknown pressure from each well. Additional water may be encountered with depth and excavation into additional water-bearing basalt flows.

Long-Term Impacts

The majority of groundwater seepage from the proposed Wymer reservoir would be west toward the Yakima River and could involve substantial volumes. Permeability testing in a drill hole on the left abutment indicates very high hydraulic conductivity values in the upper basaltic layers. The basalt was so pervious that no pressure could be established within the test zone while injecting water at the capacity of the pump (50-60 gpm). The upper dam abutments would be in the Frenchman Springs member of the Wanapum Basalt. This basalt member is a widely used aquifer because of its high conductivity and water-bearing properties.

The Vantage interbed lies below the Frenchman Springs member. Results of hydraulic conductivity testing indicate moderate values in the sandstone and siltstone: $1x10^1$ to $2x10^3$ feet per day; similar values are indicated in the underlying Grande Ronde Basalt: $1x10^1$ to $2x10^2$ feet per day. The Vantage interbed is currently unsaturated. Reservoir seepage would cause a rise of pore pressures within the unit and could cause instability of the low-strength materials in the reservoir basin. There are seeps and springs along the lower contact of the Vantage interbed, indicating that the underlying Grande Ronde Basalt is a lower permeability unit and probable confining bed.

As under the Black Rock Alternative, hydraulic head increases would be greatest near the downstream end of the proposed reservoir and would decrease with distance away from the reservoir. Because the Yakima River valley is less than a mile from the Wymer damsite, seepage would have a relatively short flow path and would be under a high-flow gradient from the

full reservoir to the river valley below. Mitigation would be required to control the seepage and potential for sediment transport through the abutments and reservoir rim.

4.3.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

The environmental consequences of this alternative would include all of the impacts for the Wymer Dam and Reservoir Alternative, plus the impacts from the pump exchange project in the lower Yakima River basin.

Construction Impacts

The Yakima River pump exchange component of this alternative includes construction of a pumping plant in Columbia Park that would require dewatering by wells. In addition, excavation of the pipeline delivery system to a depth of about 18 feet would require dewatering in areas where the water table is shallow and where the pipeline crosses the Yakima River and other minor creeks. The dewatering may lower water levels in nearby wells and temporarily affect the water supply to those wells.

Long-Term Impacts

Other groundwater impacts (decrease of recharge or return flows) due to decreasing the amount of irrigation water delivered and applied would be relatively small and would be spread out over a relatively large area, and so have not been quantified for this analysis.

4.3.2.6 Mitigation

Mitigation is proposed for Black Rock reservoir seepage. Seepage would occur in all directions from the reservoir, but the most important impact could come from the seepage that travels in an easterly direction toward the Hanford Site, described in chapter 1. The seepage that would enter the groundwater under the Hanford Site could remobilize contaminants and move them into the Columbia River at a higher rate than is currently taking place. MODFLOW model estimates of the total seepage rates from the reservoir range from 41 to 74 cfs (Reclamation, 2007d). The model also estimated that, at steady state conditions 20 to 31 cfs of groundwater would flow under Cold Creek, which is the western boundary of the Hanford Site.

Measures being proposed to minimize the impacts from the Black Rock reservoir seepage to the Hanford Site include blanketing, cutoff walls, grout curtains, drainage tunnels, and wells. These measures would be in addition to the features included in the Black Rock designs and cost estimates which were included to protect and stabilize the structure of the dam from impacts of groundwater seepage. Some measures would be used to control the direction of the groundwater flow, and others would be used to remove and transport the groundwater to a location away from the Hanford Site.

Modeling of the groundwater flow system in and around the damsite showed potential for a large amount of groundwater seepage through the south abutment of the dam due to the fragmented nature of the geologic formations. It is anticipated that tunnels and drain holes would be placed in the south abutment of the dam. These features would be underground. The water collected from these features would be contained in pipelines and not allowed to seep back into the groundwater.

Another feature would likely be a cutoff wall located downstream from the Black Rock reservoir to block groundwater that has not been collected by the features in the right abutment. This cutoff wall could be up to 400 feet deep and would be underground. Wells could be placed downstream from this structure to collect and deliver the seepage to a location away from the Hanford Site.

In addition, other wells would be located downstream from the cutoff wall to collect any groundwater flows that moved around the wall and were not collected by the right abutment features. The wells would be placed so that this groundwater would be pumped from the ground and collected into pipelines or canals to convey it away from the Hanford Site.

All groundwater collected by the above mentioned features would be conveyed away from the Hanford Site and would be available for consumptive uses such as drinking water, irrigation, and even to supplement streamflows.

If the Black Rock Alternative were selected, additional geologic investigations would have to be undertaken to establish the exact locations for any seepage mitigation features. Facilities would be constructed to provide the best control and removal of the groundwater seepage when the dam is constructed. Also, a monitoring well program would be established to determine where the water flows and how much water could be expected. Additional facilities would be constructed as the monitoring program indicated was necessary.

The Wymer reservoir would not require mitigation for seepage.

4.3.2.7 Cumulative Impacts

Currently, groundwater pumping occurs on the Hanford Site as part of cleanup operations. Additional pumping may occur in the future as cleanup options are selected. Pumping on the Hanford Site is not anticipated to affect conditions at the Black Rock dam or reservoir or affect the quantity of seepage from the reservoir. However, depending on the quantity and location of pumping, the area of influence from Hanford Site pumping could extend to or beyond the western Hanford Site boundary and affect the hydraulic gradient across the boundary at Cold Creek. A steepening of the gradient could increase the amount of groundwater flow (including Black Rock seepage) entering the Hanford Site.

4.4 Hydropower Resources

This section describes the mid-Columbia River hydroelectric power generation system and the possible effects of the Joint Alternatives.

4.4.1 Affected Environment

The following discussion of the mid-Columbia River hydroelectric power generation system is from Grant County's PUD 2003 relicensing report (Grant County PUD, 2003).

The Priest Rapids Project is located on the mainstem Columbia River in central Washington and includes two hydroelectric developments–Wanapum and Priest Rapids–owned and operated by Grant County PUD. Each development consists of a dam, powerplant, fishways, reservoir, 230-kV transmission lines, and ancillary facilities. Wanapum and Priest Rapids powerplants each have 10 turbine-generators with capacities of 900 megawatts (MW) and 850 MW, respectively, for a presently authorized, installed capacity of 1,750 MW. The maximum hydraulic capacity of each powerplant is approximately 175,000 cfs, assuming all units are operating at full capacity.

The two developments produced a total of 9.65 billion kilowatthours (kWh) of electricity in 2002, which is equivalent to the energy consumed in a year by a city of approximately the size of Seattle. Under current power purchase agreements, Grant County PUD reserves 36.5 percent of the energy produced for its own use. The remaining 63.5 percent of the generation is provided under long-term contracts, at cost, to 12 Pacific Northwest utilities that collectively serve customers in Washington, Idaho, Oregon, Montana, and Utah.

Priest Rapids development is part of the much larger, seven-dam, mid-Columbia River hydroelectric system of about 14,000 MW, which extends from near the United States/Canada border to the beginning of the Hanford reach, for a total of 351 miles. This system includes two Federal facilities, Grand Coulee Dam (Reclamation) with an installed generation capacity of about 6,800 MW, and Chief Joseph Dam (U.S. Army Corps of Engineers) with an installed capacity of about 2,600 MW.

Three Washington PUDs own and operate the five hydroelectric projects downstream from Chief Joseph Dam, with a combined installed generation capacity of about 4,500 MW. Priest Rapids Dam is at the downstream end of this integrated system of hydropower facilities.

Table 4.11 presents information on the mid-Columbia River system. Figure 4.9 shows many of the important dams in the Federal Columbia River Power System.

Table 4.11 Summary of hydroelectric projects in the mid-Columbia River system

Project	Owner	Location (RM)	Drainage area (mi^2)	Usable storage[1] (million acre-feet)	Maximum plant hydraulic activity (cfs)	Installed capacity (MW)
Grand Coulee	Reclamation	596.6	74,700	5.22	280,000	[2]6,809
Chief Joseph	U.S. Army Corps of Engineers	545.1	75,000	0.12	213,000	2,614
Wells[3]	Douglas PUD	515.8	86,100	0.10	220,000	840
Rocky Reach[3]	Chelan PUD	473.7	87,800	0.04	220,000	1,287
Rock Island[3]	Chelan PUD	453.4	89,400	0.01	220,000	660
Wanapum[3]	Grant PUD	415.8	90,900	0.16	180,000	900
Priest Rapids[3]	Grant PUD	397.1	96,000	0.04	175,000	855

[1] The volume of water contained within the normal reservoir operating range.

[2] Includes generating capacity of the pump/generator plant.

[3] Date for these private facilities obtained from Grant PUD's relicensing report of 2003.

Figure 4.9 Important dams in the Federal Columbia River Power System.

Downstream from the mouth of the Yakima River, Federal powerplants on the lower Columbia River are at McNary, John Day, The Dalles, and Bonneville Dams.

The seven-dam, mid-Columbia system contains a substantial amount of active storage that enhances the reliability and flexibility of the Northwest's entire electric generation system. The usable storage in the mid-Columbia system is primarily at Grand Coulee (Franklin D. Roosevelt Lake) with more than 5,200,000 acre-feet, while the six downstream projects account for about 440,000 acre-feet, or about 10 percent. Overall, 86 percent of the annual flow at Priest Rapids Dam is provided by controlled releases from Grand Coulee Dam.

4.4.2 Environmental Consequences

4.4.2.1 Methods and Assumptions

Black Rock Alternative

The Black Rock Alternative would affect the mid-Columbia River hydroelectric power generation system by (1) adding an additional power demand associated with pumping water from Priest Rapids Lake to a Black Rock reservoir and (2) changing the Columbia River flow regime available for hydropower generation at Federal and non-Federal powerplants by the depletion of water withdrawn at Priest Rapids Lake and the accretion of water from Yakima Project operations about 62 miles downstream at the confluence of the Yakima River.

These effects on power generation due to altered flows on the Columbia River were evaluated using the Bonneville Power Administration's HYDSIM computer model. The HYDSIM computer model simulated the current monthly operating requirements of the FCRPS based on recurrence of flows and the alteration of such flows by Black Rock operations during the historical hydrologic period of record of 1929-98. This period provides an 18-year overlap with the Yak-RW model's hydrologic period of 1981-2005 and includes the high-flow years of 1996-97 and the low-flow years of 1992-94.

The value of net loss in power generation due to such alteration of flows, as well as the value of power to operate Black Rock pumps, was computed using prior cost estimates developed by BPA for the historical runoff years of 1929-78 for the *Summary Report, Appraisal Assessment of the Black Rock Alternative* (Reclamation, 2004e). These cost estimates reflected the same assumptions in BPA's August 2003 rate case. However, the monthly costs for each year in 1981-98 were determined by Reclamation based on BPA cost estimates for a similar runoff year in 1929-78.

The following indicators were selected to evaluate effects on hydropower for the Black Rock Alternative:

- Average annual pumping power requirement
- Additional hydropower generation used (average annual MW)
- Additional generation value (average annual $ million)
- Additional generation capacity (average annual MW)

Wymer Dam and Reservoir Alternative

For the Wymer Dam and Reservoir Alternative, the indicator of average annual pumping power requirement was selected. The amount of power required to pump water from the Yakima River into Wymer reservoir was computed using daily flow data from the Yak-RW model. The difference in pumping head was computed from the daily elevation of the water in the reservoir and the average elevation of the Yakima River at the pumping plant. Because the elevation of the water of the Yakima River at the pumping plant ranges from 1,275 to 1,284 feet, the average elevation used in the daily computations was 1,279.5 feet. The daily energy used was totaled, and an average computed for each month. The average monthly megawatt hours of pumping was then determined. From this, the average monthly pumping cost was computed by applying monthly pumping energy cost estimates forecast by the BPA in its August 2003 rate case. These reflect an average hourly rate for the respective month. Finally, an average annual pumping power requirement was computed.

Wymer Dam Plus Yakima River Pump Exchange Alternative

Energy use and power cost were calculated for pumping into Wymer reservoir as outlined above. Energy use and power costs for the exchange portion of this alternative were also calculated. These costs were based on the energy required to pump the water at all three pumping plants, plus the energy needed for plant service needs. Volume to be pumped was determined from a schedule of deliveries derived for the proposed project to the Sunnyside and Roza Canals (Sonnichsen, 2007). The needs were calculated from historic daily data of canal diversions from 1980 through 2003. These values were averaged for each month. The head loss and pumping head were calculated using these average flows. The pumps were assumed to have a water-to-wire efficiency of 80 percent. The deliveries from pumping plant #3 would be by gravity and pump. It was assumed that the deliveries by pump would be up to the pump capacity. The flows above this were assumed to be delivered by gravity, which provides a conservative estimate of the energy requirements.

Once energy needs were calculated, average monthly pumping cost was computed by applying monthly pumping energy cost estimates forecast by the BPA in its August 2003 rate case. These reflect an average hourly rate for the respective month. Finally, an average annual pumping power requirement was computed.

4.4.2.2 No Action Alternative

There would be no construction or long-term impacts on hydropower generation under the No Action Alternative.

4.4.2.3 Black Rock Alternative

Construction Impacts

No construction-related impacts to hydropower resources are anticipated under this alternative.

Long-Term Impacts

Pumping Energy Requirements and Costs.—Table 4.12 presents monthly pumping power requirements (average MW) and estimated pumping costs for the Black Rock Alternative. The average annual power required for pumping to a Black Rock reservoir is estimated at 132 MW.

Table 4.12 Black Rock Alternative monthly pumping power requirements and costs

Month	Pumping power required (average MW)[1]
November	27
December	40
January	98
February	43
March	50
April 1-15	74
April 16-30	64
May	128
June	184
July	No pumping[2]
August 1-15	No pumping[2]
August 16-31	No pumping[2]
September	511
October	430
Annual average	132[3]
Range of costs	$33 to $93 million
Average annual costs	$50 million

[1] The monthly power required represents the 18-year average for the respective month.

[2] Pursuant to the Columbia River Basin Water Management Program authorized by the Washington Legislature in 2006, the policy is that no withdrawal of water from the Columbia River will occur in July and August (unless appropriate mitigation is provided).

[3] Represents the average annual megawatts required for the 18-years of 1981-1998. Computed by summing the monthly pumping requirements for each year and dividing by 18 years.

Current Hydropower Generation.—Hydropower generation effects associated with Black Rock Alternative would occur at both Federal and non-Federal projects wherever the flows are altered due to: (a) pumping withdrawals from Priest Rapids forebay into Black Rock reservoir, and (b) altered operations of FCRPS reservoirs upstream of Priest Rapids in reaction to power loss on the coordinated system due to Black Rock pumping, or power gain due to return flows from Yakima River into McNary forebay. In HYDSIM's monthly simulation, the alterations in Coulee's and Libby's operations are minor. Also, Hungry Horse operations do not change because Hungry Horse has been at its operating limits; hence, there are no power impacts on downstream projects on the Clark Fork River basin. However, in actual operations, all FCRPS reservoir draft or fill, as well as the availability of water for pumping into Black Rock, are contemplated to be coordinated on a weekly basis with parties to the Endangered Species Act of 1973, as amended (ESA) in-season management forums.

Hydropower Generation at Non-Federal Hydropower Projects.—Diversion of 3,500 cfs from Priest Rapids Lake for pumping to a Black Rock reservoir would reduce generation at Priest Rapids Powerplant on the average by about 4 MW, which is less than 1 percent annually. Power generation impacts at other non-Federal projects on the Mid-Columbia River are power gains or losses. These power gains or losses are due to additional draft or fill of FCRPS reservoirs (primarily Grand Coulee) in order to maintain firm coordinated system load with the addition of Black Rock pumping demand and the return flow from the Yakima River into McNary forebay. Table 4.13 presents the monthly difference in generation at non-Federal Columbia River hydropower projects and the estimated value of the difference.

Hydropower Generation at Federal Hydropower Projects.—Hydropower generation would change at Federal facilities upstream of Priest Rapids Dam and downstream from the Yakima River confluence. With the Black Rock reservoir in operation, diversions from Priest Rapids Lake would diminish streamflow in the 62-mile reach from Priest Rapids Dam to the Yakima River confluence, where there are no Federal hydropower facilities. Streamflow depletions from Black Rock pumping would be somewhat offset by greater flows entering the Columbia River from the Yakima River as the result of use of the exchange water. On average, the FCRPS would lose approximately 5.4 MW of annual generation, as shown on table 4.13, at an average annual value of $3 million.

Changes in the drawdown pattern in Franklin D. Roosevelt Lake would occur primarily in the fall and winter months; the greatest average monthly change in drawdown of less than 0.1 foot would occur in November.

Table 4.13 Monthly difference in non-Federal, Federal, and regional combined non-Federal and Federal Columbia River hydropower generation related to operation of the Black Rock Alternative (average MW)

Month	Priest Rapids only	Non-Federal hydropower without Priest Rapids	Non-Federal hydropower including Priest Rapids	FCRPS	Combined Federal and Non-Federal[1]
October	-14.8	0	-14.8	-53.4	-68.2
November	-1.7	-3.2	-4.9	-5.7	-10.6
December	-0.8	+1.7	+0.9	+7.6	+8.5
January	-2.7	+0.9	-1.8	-5.5	-7.3
February	-1.2	+0.5	-0.7	-0.1	-0.8
March	-1.5	-0.1	-1.6	-1.9	-3.5
April 1-15	-2.0	+0.2	-1.8	+10.8	+9.0
April 16-30	-0.4	0	-0.4	+14.3	+13.9
May	-1.1	0	-1.1	+17.7	+16.6
June	-1.9	0	-1.9	+9.1	+7.3
July	0	0	0	+7.1	+7.1
August 1-15	-0.1	-2.0	-2.1	+1.1	-1.0
August 16-31	+0.4	+2.3	+2.7	+16.3	+19.0
September	-18.2	0	-18.2	-61.8	-80.0
Annual average	-3.7	0	-3.7	-5.4	-9.2
Range of value	-$3 million to -$1 million		-$5 million to +$1 million	-$17 million to +$8 million	-$21 million to +$9 million
Average annual value	-$2 million		-$2 million	-$3 million	-$4 million

[1] Due to rounding, these values do not equal precisely the sum of the previous columns.

New Hydropower Generation.—Two new powerplants would be constructed as a part of the Black Rock Alternative at the point of discharge of water from the Black Rock outflow conveyance system to the Roza Canal at MP 22.6 (Black Rock powerplant) and to the Sunnyside Canal at MP 3.83 (Sunnyside powerplant).

Each powerplant would consist of one turbine generator; the Black Rock powerplant would have a generating capability of 23 MW, and the Sunnyside powerplant would have a generating capability of 29.5 MW. Generation would occur during the Yakima Project irrigation season of April through October when water would be released from Black Rock reservoir to the two exchange participants.

Annual generation is estimated to total about 196,000 MWh (72,000 MWh at the Black Rock powerplant and 125,000 MWh at the Sunnyside powerplant).

4.4.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

No construction-related impacts to hydropower resources are anticipated under this alternative.

Long-Term Impacts

Pumping power requirements, costs, and energy rates (October through May) are presented in table 4.14. The average monthly pumping power requirement ranges from 0 MW in June through September to 9.7 MW in March. The average annual pumping power requirement for the 25-year period of record (1981-2005) is 4.8 MW. Average monthly pumping costs range from $0 in June through September to about $300,000 in March. Total average annual pumping costs are estimated at about $1.9 million, but these costs could be higher or lower if a new rates analysis is performed due to changes in market conditions (Reclamation 2006b).

Table 4.14 Average monthly pumping power requirements, costs, and energy rates

Month	Average monthly pumping power requirements (MW)	Average monthly pumping costs ($)	Average monthly energy rates ($/MWh)
October	4.6	190,000	55.56
November	5.3	220,000	58.16
December	5.7	240,000	56.32
January	7.0	245,000	47.27
February	8.4	285,000	50.63
March	9.7	300,000	42.14
April	8.3	220,000	37.60
May	8.5	200,000	31.92
Average annual	[1]4.8	1,900,000	

[1] Represents the average annual megawatts required for the 25-year period of record (1981-2005). Computed by summing the monthly pumping requirement for each year and then dividing by 25.

4.4.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

No construction-related impacts to hydropower resources are anticipated under this alternative.

Long-Term Impacts

In addition to the Wymer pumping power requirements, costs, and energy rates presented in table 4.14, the pumping power requirements, costs, and energy rates (March through October) are presented in table 4.15 for the Yakima River pump exchange component of the Wymer Dam Plus Yakima River Pump Exchange Alternative. The average monthly pumping power requirement ranges from 0 MW in November through February to 110.7 MW in June. The average annual pumping power requirement for the 23-year period of record (1981-2003)[5] is 56.9 MW. Average monthly pumping costs range from $0 in November through February to about $3.3 million in August. Total average annual pumping costs are estimated at about $17.9 million, but these costs could be higher or lower if a new rates analysis is performed due to changes in market conditions (Golder and Associates, 2006).

Table 4.15 Yakima River pump exchange component of Wymer Dam Plus Yakima River Pump Exchange Alternative: average monthly pumping energy requirements, costs, and energy rates

Month	Average monthly pumping power requirements (MW)	Average monthly pumping power costs ($)	Average monthly energy rates ($/MWh)
March	41.1	624,000	42.14
April	80.4	2,177,000	37.60
May	109.3	2,595,000	31.92
June	110.7	1,808,000	22.68
July	110.5	2,650,000	32.24
August	110.3	3,341,000	40.69
September	99.4	3,125,000	43.64
October	79.7	1,595,000	55.56
Average annual	[1]56.9	17,915,000	

[1] Represents the average annual power in megawatts required for the 23-year period of record from 1981-2003. Computed by dividing the average annual energy required in megawatthours for the period of record by 8,760 hours, the average operational time during 1 year (365 days x 24 hours per day).

Table 4.16 presents the average annual power requirements and energy costs at each pumping plant for the Wymer Dam Plus Yakima River Pump Exchange Alternative.

4.4.2.6 Mitigation

No mitigation would be required.

[5] Prior to 2007, Storage Study operation studies used a 23-year period of hydrologic record of 1981-2003. This has subsequently been expanded to a 25-year period of 1981-2005. The work conducted by Golder and Associates in 2006 is based on the 23-year period of record.

Table 4.16 Average annual pumping power requirements and costs

	Wymer Dam Plus Yakima River Pump Exchange Alternative	
	Average annual pumping power requirement (MW)	Average annual energy cost ($)
Wymer pumping plant	4.8	1,900,00
Pumping plant #1	35.1	11,118,000
Pumping plant #2	17.3	5,444,000
Pumping plant #3	4.4	1,353,000
Total	61.7	$19,815,000

4.4.2.7 Cumulative Impacts

As the FCRPS mitigation projects on the mainstem Columbia River and Biological Opinion continue to be implemented, hydropower generation in the FCRPS will continue to be reduced. Coupled with Black Rock Alternative, there could be additional loss of power generation in the FCRPS.

4.5 Sediment Resources

Sediment transport investigations in a river basin serve two purposes:

- To improve understanding of aquatic resources important in defining habitat suitability for fish
- To provide potential scenarios of future channel change

Changes in basin hydrology and the construction of roads, bridges, levees, and other structures within floodplains alter the transport of sediment within the basin. Future changes in hydrology would likely affect sediment transport and, therefore, aquatic habitat conditions, because of linkages and dependencies among system processes and components (figure 4.10).

4.5.1 Affected Environment

It was assumed that any effects of the Joint Alternatives would occur within the Yakima River basin, and that any potential effects to sediment from water withdrawal from the Columbia River would be nondetectable and/or nonmeasurable within the Columbia River due to the size of the withdrawal relative to riverflow; thus, sediment resources in the Columbia River were not evaluated.

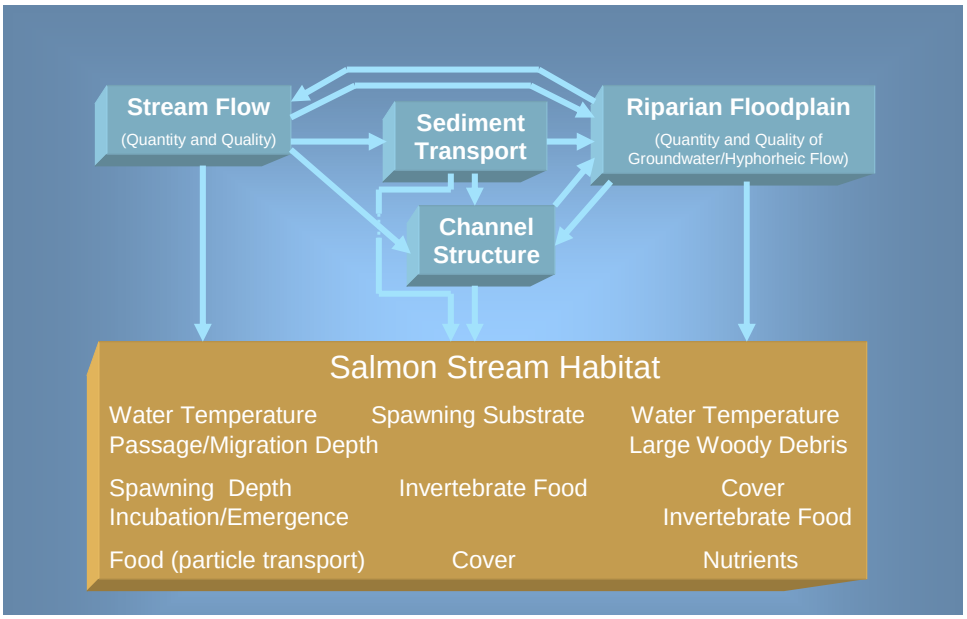


Figure 4.10 Streamflow and sediment transport attributes that define the quality of salmon stream habitat.

The western part of the Yakima River basin is mountainous and formed by sedimentary, volcanic, and metamorphic rock, while the eastern portion of the basin is comprised of a thick sequence of lava flows that have folded into ridges and troughs (Kinnison and Sceva, 1963). This type of geology has an important impact on sediment transport, as the riverflows from alluvial valleys through bedrock canyons and gaps. It has been stated that the Yakima River has a low sediment discharge for a river of its size (Dunne and Leopold, 1978), which might be attributed to the lack of available sediment in the canyon reaches and bedrock control at many locations. Intensive flow regulation and levee construction have more recently affected the transport of sediment and channel morphology since the early part of the 20th century.

Yakima River floodplains were also likely historically important in providing habitat resources for anadromous salmonids and resident fish (Snyder and Stanford, 2001), but are now degraded (Stanford et al., 2002). Key fluvial processes include erosion and deposition of sediments and channel movement. These processes shape the floodplain and result in a continual shifting mosaic of physical channel attributes that either provide habitat resources directly, or support habitat resources for fish and other aquatic organisms (figure 4.10). Maintaining this shifting mosaic is dependent on the ability of the river to move freely about the historic floodplain, and on the balance between channel movement and sediment erosion and deposition. Native aquatic species have evolved to these historical fluvial processes, and their alteration is likely to have adverse effects on one or more life stages of salmonids. Fluvial processes are also dependent on a sufficient sediment supply needed to build new bars and islands,

and to prevent channel incision that would disconnect important groundwater-surface water interactions (Stanford et al., 2002).

4.5.2 Environmental Consequences

Changes in sediment transport and bed scour are related to the changes in the flow regime. Those alternatives that would significantly increase flows in particular reaches could change the sediment transport locally. Because the most significant changes in flow occur downstream from the Parker gage, the reaches that would be most affected are in that area. Changes in operations, particular in the upper portions of the Yakima River, would affect bed scour, although generally, these changes are not biologically significant, even in years with the highest scour values.

4.5.2.1 Methods and Assumptions

Several methods were used to evaluate sediment resources, as discussed in the following sections. The indicators of sediment transport and bed scour were selected to evaluate sediment resources.

Sediment Transport

The analysis of sediment transport was performed using techniques from the model, Sediment Impact Analysis Methods (SIAM). SIAM simulates the movement of sediment through a drainage network to estimate the effect of sediment dynamics on channel morphology. Using principles of sediment continuity and channel response, SIAM links basinwide processes to perform a trend analysis on a river system identifying the current state as well as the direction of potential adjustments in both the short and long term. The model was developed to accommodate large basins, incorporate sediment sources, and prescribe rehabilitation alternatives using a system perspective. More information about SIAM can be found at http://www.usbr.gov/pmts/sediment/model/srhsiam/index.html. This analysis assumed equilibrium conditions where inflowing load restocked any transported material and, therefore, long-term changes could not be detected. A lack of calibration and verification data for high-flow hydraulics and the reference shear stresses results in high levels of uncertainty for interpreting results quantitatively (i.e., actual tons in the river). However, the underlying assumptions are unlikely to change significantly between reaches or between alternatives for the same reach. The analysis can provide a relative sense of the impact from changes in discharge.

Results are only for those reaches modeled, not the entire basin. The reaches modeled for sediment are the same as those modeled for one-dimensional (1-D) hydraulics, as the 1-D hydraulic model provided the geometric input to the sediment model (Hilldale and Mooney, 2007a).

Hydraulic Engineering Center-River Analysis System (HEC-RAS) is a 1-D hydraulic model intended for calculating water surface profiles for steady, gradually varied, and unsteady flow conditions. More information about HEC-RAS can be found at http://www.hec.usace.army.mil/software/hec-ras/hecras-document.html.

The modeling performed for this assessment used a steady flow analysis over a wide range of discharges to evaluate flow depth, top width, and cross section averaged values of velocity. The primary purpose of the HEC-RAS modeling effort was to provide input to the decision support system (DSS), SIAM and temperature models. The HEC-RAS output was also used as input for some of the attributes for the Ecosystem Diagnosis and Treatment (EDT) biological model.

Bed Scour

Female anadromous salmonids generally bury their eggs beneath the channel bed to a depth of about 6 to 8 inches (15 to 20 centimeters (cm)); smaller resident and anadromous trout bury their eggs to a depth of 2 to 4 inches (5 to 10 cm; De Vries, 1997; Montgomery et al., 1996). SIAM provides estimates of mean annual bed scour using the monthly time step provided by Yak-RW. While this value provides some information regarding bed scour, it is more critical to understand bed scour on a daily time step during periods of incubation. For this reason, bed scour as it relates to the disruption of redds was investigated using a decision support system model. The DSS model takes daily values of streamflow and sediment transport capacity for a given discharge, determined by SIAM, to arrive at a daily value of bed scour.

The DSS model estimates the amount of habitat available for various species and life stages. Habitat is measured for the various species and life stages. Flow depth, velocity, and substrate also factored into estimates of spawning habitat. For this study, it was used to estimate the quantity of habitat specific to spring and fall Chinook, coho, steelhead, bull trout, and resident rainbow trout for the adult holding, spawning/incubation, fry, summer rearing, and winter rearing lifestages in the Easton, Ellensburg, Union Gap, Wapato and lower Naches River reaches. The following input was required for this component of the DSS model to function: (1) the estimated daily average streamflow for each alternative for each of the five reaches, (2) two-dimensional hydraulic flow models that “map” flow depth and velocity through each reach at each flow of interest, and (3) the relationship between flow depth and velocity and habitat for each species and lifestage.

4.5.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Model results indicate that the potential for the Yakima River to transport sand is currently high, and it is expected to remain high under the No Action Alternative. However, sand transport under this and all the other alternatives would have no effect on habitat or morphology. Effects on channel morphology and, therefore, habitat are much more affected by gravel transport in the Yakima River. Morphologic activity of the recent past is expected to continue under the No Action Alternative. That is to say, significant morphologic change or change to habitat is only likely to occur during very large flood events and would be localized. No widespread effect on channel morphology or habitat is anticipated under the No Action Alternative.

Table 4.17 presents model results for percentage difference in average gravel load, by Yakima River reach, between each Joint Alternative and the No Action Alternative.

Table 4.17 Percentage difference in average annual gravel load, by Yakima River reach, between each Joint Alternative and No Action Alternative (Negative values indicate a decrease in the modeled load.) Modified from Mooney (2007).

Yakima River reach	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Easton	10	2	-4.1
Upstream of Ellensburg	25	0	5
Ellensburg	4.1	-1.4	4.1
Lower Naches River	2	0	3
Union Gap	14	-7	6
Wapato Dam to Sunnyside Diversion Dam	6	-7	-2
Wapato	21	-6	18
Upstream of Prosser Diversion Dam	29	-6	24
Downstream from Prosser Diversion Dam	12	4	7

The maximum bed scour estimated for the egg incubation period for steelhead, salmon, and rainbow trout in the Easton, Ellensburg, Wapato, and lower Naches River reaches of the Yakima River for all alternatives is shown in table 4.18. These are the largest values for the 25-year period of record. Overall, there is little difference in potential maximum bed scour among the alternatives for all the species for the four reaches. With the exception of the lower Naches River reach, the risk of potential egg scour is minimal for salmonids (table 4.18).

Table 4.18 Maximum annual bed scour in inches and centimeters during the egg incubation period for steelhead, salmon, and rainbow trout for the Easton, Ellensburg, Wapato, and lower Naches River reaches of the Yakima River

Reach and Species	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange
Easton				
Steelhead	1.3 in (3.2 cm)	1.3 in (3.2 cm)	1.3 in (3.2 cm)	2.5 in (6.4 cm)
Spring Chinook	2.5 in (6.4 cm)	7.6 in (19.2 cm)	3.8 in (9.6 cm)	5.0 in (12.8 cm)
Coho	2.5 in (6.4 cm)	3.8 in (9.6 cm)	3.8 in (9.6 cm)	3.8 in (9.6 cm)
Rainbow trout	1.3 in (3.2 cm)	1.3 in (3.2 cm)	1.3 in (3.2 cm)	2.5 in (6.4 cm)
Ellensburg				
Steelhead	1.3 in (3.2 cm)	1.3 in (3.2 cm)	1.3 in (3.2 cm)	1.3 in (3.2 cm)
Spring Chinook	2.5 in (6.4 cm)	2.5 in (6.4 cm)	2.5 in (6.4 cm)	2.5 in (6.4 cm)
Coho	2.5 in (6.4 cm)	2.5 in (6.4 cm)	2.5 in (6.4 cm)	2.5 in (6.4 cm)
Rainbow trout	1.3 in (3.2 cm)	1.3 in (3.2 cm)	1.3 in (3.2 cm)	1.3 in (3.2 cm)
Wapato				
Fall Chinook	2.5 in (6.4 cm)	1.3 in (3.2 cm)	2.5 in (6.4 cm)	2.5 in (6.4 cm)
Coho	1.3 in (3.2 cm)	1.3 in (3.2 cm)	2.5 in (6.4 cm)	1.3 in (3.2 cm)
Lower Naches River				
Steelhead	55.1 in (140 cm)	53.9 in (137 cm)	57.5 in (146 cm)	55.1 in (140 cm)
Coho	24.0 in (61 cm)	24.0 in (61 cm)	24.0 in (61 cm)	24.0 in (61 cm)
Rainbow trout	49.2 in (125 cm)	46.9 in (119 cm)	51.6 in (131 cm)	49.2 in (125 cm)

4.5.2.3 Black Rock Alternative

Construction Impacts

No construction-related impacts to sediment resources are anticipated under this alternative.

Long-Term Impacts

The Yakima River from Prosser Diversion Dam (RM 47) to approximately Toppenish Creek (RM 80) currently has the lowest sediment transport rate in the Yakima River (the reach upstream of Prosser Diversion Dam and portions of the Wapato reach in table 4.17), primarily because the Columbia River Basalt formation rises to the surface and exerts a control on the river, and to a lesser extent, Prosser Diversion Dam. These reaches of the Yakima River indicate the greatest likelihood of morphologic change under the Black Rock Alternative, as sediment transport would be greater under this alternative than under the No Action Alternative. Morphologic change is expected to improve habitat conditions, as there would be increased habitat diversity that may continue to change over time. Although morphologic change in this reach may benefit habitat, channel migration has the potential to affect properties

adjacent to the river. A more detailed analysis would be required to understand the magnitude of channel change in this reach.

Model results for the Wapato reach also show greater gravel transport under the Black Rock Alternative than under the No Action Alternative (table 4.17). Anticipated effects on this reach may consist of greater split channel morphology throughout much of the reach, which would represent an improvement to habitat. Much of the floodplain in this reach is low relative to the main channel, indicating greater floodplain-channel interaction with increased discharges. Channel migration in this reach is of less concern, as much of the floodplain is not developed or under cultivation.

Model results for the Union Gap reach indicate slightly greater gravel loads (table 4.17) under the Black Rock Alternative than under the No Action Alternative. Greater gravel transport through this reach may provide some benefit to surrounding infrastructure near Union Gap, as recent aggradation (accumulation of sediment) has caused the channel to migrate in this location and threaten roadways. Greater gravel transport at Union Gap is dependent on the level of control exerted on the river by Wapato Dam and the gap itself. This level of analysis has not been performed.

Model results for the reach upstream of Ellensburg indicate 25-percent greater average annual gravel load under this alternative (table 4.17) than under the No Action Alternative. Gravel transport in this reach is very low compared to other reaches and may be attributed to increased sediment sizes related to channel confinement throughout much of the reach. Additionally, irrigation diversions may limit the transport of sediment from upstream reaches to this reach. The greater sediment transport is not expected to affect morphology, as transport rates are expected to remain low in spite of the 25-percent increase. However, a more frequent disruption of the armor layer would be of some benefit to habitat.

Compared to the No Action Alternative, no consequential effects on maximum annual bed scour are expected under the Black Rock Alternative (table 4.18). Though model results show the bed scour value in the Easton reach for spring Chinook increases from 2.5 inches (6.4 cm) to 7.6 inches (19.2 cm), which is within the egg pocket depth for anadromous salmon; this level of bed scour only occurs once in the 25-year period of record. In all other years, the change in scour is not enough to reach the egg pocket depth.

4.5.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

No construction-related impacts to sediment resources are anticipated under this alternative.

Long-Term Impacts

Model results indicate slightly less sand transport throughout most of the river under the Wymer Dam and Reservoir Alternative than under the No Action Alternative. The minor difference indicated (generally less than 5 percent) would have no effect on the habitat and morphology in the Yakima River basin with respect to aggradation of sand. Model results for gravel loads also indicate no significant change in gravel transport rates. Thus, this alternative is not expected to significantly affect the morphology or habitat with respect to sediment transport compared to the No Action Alternative.

Compared to the No Action Alternative, no consequential changes to maximum annual bed scour are expected under the Wymer Dam and Reservoir Alternative.

4.5.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

No construction-related impacts to sediment resources are anticipated under this alternative.

Long-Term Impacts

This alternative would have similar effects on habitat and morphologic change as the Black Rock Alternative, although to a slightly lesser extent (referring to the Wapato reach and the reach upstream of Prosser Diversion Dam only). For the Wapato reach and the reach upstream of Prosser Diversion Dam, the increase in gravel transport loads (table 4.19) under the Wymer Dam Plus Yakima River Pump Exchange Alternative is slightly less than under the Black Rock Alternative, indicating that similar changes are likely to occur, although they may progress more slowly. No significant changes are indicated in other reaches.

Compared to the No Action Alternative, no consequential changes to maximum annual bed scour are expected.

4.5.2.6 Mitigation

No mitigation would be required.

4.5.2.7 Cumulative Impacts

Other ongoing or proposed projects in the basin would have little significant effect on seasonal or annual discharge in the basin. None of the actions predicted to occur in the reasonably foreseeable future would involve reconnecting significant portions of the floodplain to the river channel where disconnection has occurred. As a result, there would be little additional effects on sediment transport or bed scour.

4.6 Water Quality

4.6.1 Affected Environment

Surface water quality could be affected in the Columbia and Yakima Rivers, where additional storage and changes in streamflow may occur. Under two of the proposed alternatives, Black Rock and Wymer Dam Plus Yakima River Pump Exchange, water would be withdrawn from the Columbia River. The surface water quality parameters discussed in this section are limited to those parameters that appear to be of most concern and would potentially be affected under the Joint Alternatives. These parameters are either physical or chemical in nature. Physical parameters of interest include: temperature, dissolved oxygen (DO), and turbidity. Chemical parameters of interest include nutrients (such as nitrates-nitrites and total phosphorus), total suspended solids (TSS), and toxins such as pesticides or Hanford Site contaminants (Reclamation, 2007c). A brief discussion of each of these parameters and a summary of the general levels that exist for each of the reaches follows.

4.6.1.1 Columbia River

The area of interest is a portion of the Mid-Columbia River extending from Vantage, Washington, to the confluence of the Columbia and Yakima Rivers near Pasco, Washington. Temperature was one of the water quality parameters of interest, because Black Rock and Wymer Dam Plus Yakima River Pump Exchange Alternatives would remove water from the Columbia River, which could affect temperatures. Other parameters of interest with respect to the Columbia River are the contaminants found in the surface water and groundwater at the Hanford Site. Because increased seepage from the Hanford Site to the Columbia River could occur under the Black Rock Alternative, these contaminants were considered.

Temperature

The Columbia River is listed on the Washington State list of impaired water bodies (i.e., “303(d) list”) for temperature (Ecology, 2007b). Historical data retrieved from the Rock Island Dam for 1933-97 show that daily temperatures for the months of August and September, the warmest months of the year, were above 64.4 °F (18 °C) 58 percent and 43 percent of the time, respectively. Monitoring for 1997-2000 at fixed monitoring sites show that the State temperature numeric criteria standards were exceeded during the warm months of the year.

Ecology is planning to implement a temperature total maximum daily load (TMDL) for the Columbia River in the near future, which is anticipated to improve conditions.

Hanford Site Contaminants

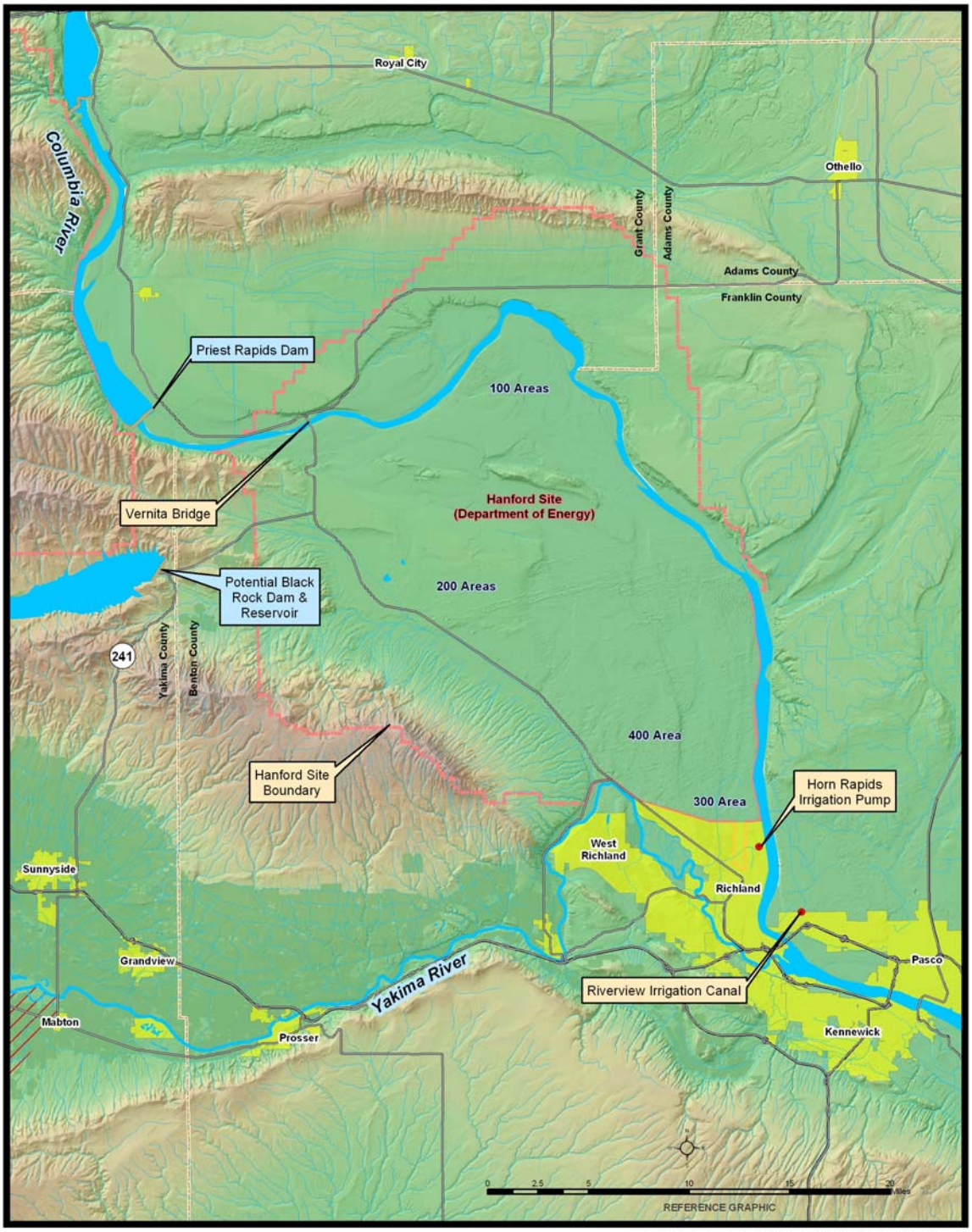
Hanford Site pollutants, both radiological and chemical, enter the Columbia River along the Hanford reach. Effluent from each direct discharge point is monitored routinely (PNNL, 2006). Potential sources of pollutants *not* associated with the Hanford Site include irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia River and industrial, agricultural, and mining effluent introduced upstream of the Hanford Site (PNNL, 2006).

Surface Water

In 2005, Columbia River water samples were collected from fixed-location monitoring stations at Priest Rapids Dam and Richland, Washington, and from cross-river transects and near-shore locations near the Vernita Bridge, 100-N Area, 100-F Area, Hanford town site, 300 Area, and the city of Richland, Washington (PNNL, 2006). (See figure 4.11.) A number of the parameters measured have no regulatory limits; however, they are useful as indicators of water quality and contaminants of Hanford Site origin. Results of the water samples collected at Priest Rapids Dam and Richland in 2005 show that radionuclide concentrations were low throughout the year. Tritium, strontium-90, iodine-129, uranium-234, uranium-238, plutonium-239/240, and naturally occurring beryllium-7 and potassium-40 were consistently measured at levels above the reported minimum detectable concentrations but below the Washington State ambient surface-water quality criteria, EPA drinking water standards, or Ecology-derived concentration guide (PNNL, 2006). Concentrations of all other radionuclides were typically below the minimum detectable concentrations.

Tritium, strontium-90, iodine-129, and plutonium-239/240 exist in worldwide fallout from historical nuclear weapons testing, as well as in effluent from Hanford Site facilities. Tritium and uranium occur naturally in the environment, in addition to being present in Hanford Site effluent.

Contaminants of Hanford Site origin continued to be detected in water from shoreline springs entering the Columbia River along the Hanford Site in 2005. Tritium, strontium-90, technetium-99, iodine-129 (2005 data pending), uranium-234, uranium-235, and uranium-238 were detected in spring water. All radiological contaminant concentrations measured in shoreline springs in 2005 were less than applicable DOE-derived concentration guides. Metals and anions (chloride, fluoride, nitrate, and sulfate) were detected in spring water. The concentrations of most metals measured in water collected from springs along the Hanford Site shoreline during 2003 through 2005 were below Washington State ambient surface-water chronic toxicity levels (Ecology, 2006). Concentrations of volatile organic compounds were near or below their detection limits in all samples. Chemicals measured with detected concentrations were nitrate and dissolved chromium. Nitrate concentrations at all spring water locations were in compliance with the Federal drinking water standard. Concentrations of



This reference graphic is intended for informational purposes only. It is meant to assist in feature location relative to other landmarks. Geographic features have been intentionally simplified in an attempt to provide a more readable product. No representation is made as to accuracy of this document. Location of pipe is based on data obtained from Golder Associates and is only approximate. Current as of January 2008.

Figure 4.11 Locations of Columbia River water sampling.

dissolved chromium at the shoreline springs were above the Washington State ambient surface water chronic toxicity level and above the acute toxicity level for the same area (PNNL, 2006).

Several metals and anions were detected in Columbia River transect samples both upstream of and downstream from the Hanford Site in the 2005 samples. The concentrations of metals and anions observed in river water in 2005 were similar to those observed in the past. Arsenic, antimony, cadmium, copper, lead, mercury, nickel, and zinc were detected in the majority of samples, with similar levels at most locations. Beryllium, cadmium, chromium, lead, selenium, silver, and thallium were detected occasionally. All metal and anion concentrations in river water were less than the Washington State ambient surface-water quality criteria for the protection of aquatic life, with the exception of arsenic concentrations, which exceeded the EPA standard for the protection of human health for the consumption of water and organisms (PNNL, 2006).

Sediment

As a result of past operations at the Hanford Site, large amounts of radioactive and nonradioactive materials were discharged to the Columbia River. Upon release to the Columbia River, some of these materials were deposited on the riverbed as sediment, particularly in upstream areas near downstream dams. The concentrations of the radioactive materials decreased as they underwent radioactive decay. Fluctuations in the riverflow, as a result of the operation of upriver hydroelectric dams, annual spring high riverflows, and occasional floods have resulted in the re-suspension, relocation, and subsequent redeposition of the sediment. Upper layer sediment in the Columbia River contains low concentrations of radionuclides and metals of Hanford Site origin, as well as radionuclides from nuclear weapons testing fallout, along with metals and other nonradioactive contaminants from mining and agricultural activities. Radionuclides consistently detected in river sediment adjacent to and downstream from the Hanford Site in 2005 included potassium-40, strontium-90, cesium-137, uranium-238, plutonium-238, and plutonium-239/240. The concentrations of all other radionuclides were below the reported minimum detectable concentrations for most samples (PNNL, 2006).

Detectable amounts of most metals were found in all river sediment samples. Maximum and median concentrations of most metals were higher for sediment collected in the reservoir upstream of Priest Rapids Dam compared to either the Hanford site or McNary Dam sediment. The concentrations of cadmium, mercury, and zinc had the greatest differences between locations. Currently, there are no Washington State freshwater sediment quality criteria for comparison to the measured values (PNNL, 2006).

Groundwater

Current groundwater conditions on the Hanford Site are due mainly to the production of plutonium. It is for this reason that groundwater is monitored throughout the entire Hanford Site, especially in areas where contaminants were stored. The 100, 200, and 300 Areas located on the Hanford Site have ongoing extensive monitoring of groundwater. These areas are contaminated with tritium, strontium-90, nitrate, chromium, trichloroethene, sulfate, technetium-99, uranium, and iodine-99. The 400 Area is the Hanford Site water supply and is contaminated with a tritium plume, although the supply is in compliance with drinking water standards (PNNL, 2006).

Contaminant plumes with concentrations above drinking water standards were present on about 12 percent of the Hanford Site in 2006 (PNNL, 2006). The tritium and iodine-129 plumes have the largest areas. The dominant plumes had sources in the 200-East Area and extend toward the east and southeast. Tritium and iodine-129 plumes are also present in the 200-West Area. Technetium-99 plumes are present in the 200-East and 200-West Areas. One technetium-99 plume has moved northward from the 200-East Area. Uranium plumes are found in the 100-H, 200-East, 200-West, and 300 Areas. Strontium-90 concentrations exceed the drinking water standard in the 100 Areas (except the 100-D Area), the 200-East Area, and beneath the former Gable Mountain Pond. Other radionuclides, including cesium-137, cobalt-60, and plutonium, exceed drinking water standards in a few wells.

Certain contaminants, which are found only in specific areas of the site, are hexavalent chromium, carbon-14, petroleum hydrocarbons, plutonium, carbon tetrachloride, ranium, chloroform, cis-1, 2 dichloroethene, tributyl phosphate, fluoride, cesium-137, cobalt-60, cyanide, calcium, sodium, chemical oxygen demand, chlorine, coliform bacteria, and low pH (PNNL, 2006). Many of these contaminants form plumes throughout the site, while many of the same contaminates exceed drinking water standards (PNNL, 2006).

Nitrate is a widespread chemical contaminant in Hanford Site groundwater. Plumes originated from the 100 and 200 Areas and from offsite industry and agriculture. Carbon tetrachloride forms a large plume beneath the 200-West Area. Trichloroethene plumes are found in the 100-F and 200-West Areas. New wells in the 300 Area detected trichloroethene at levels above the drinking water standard at depth in the aquifer. Chromium exceeds the 100-micrograms-per-liter (µg/L) drinking water standard in parts of the 100-K and 100-D Areas. Chromium exceeds the State's aquatic standard (10 µg/L) in these areas and parts of the 100-B/C, 100-H, and 100-F Areas. Local plumes of chromium are also present in the 200 Areas, particularly the north part of the 200-West Area.

Drinking water located on the Hanford Site has ongoing extensive monitoring similar to that done for groundwater. All 11 DOE-owned drinking water systems

(10 of the 11 systems use water from the Columbia River and one system in the 400 Area uses groundwater from the unconfined aquifer beneath the site) on the Hanford Site were in compliance with drinking water standards for radiological, chemical, and microbiological contaminant levels in 2005. Contaminant concentrations measured in 2005 were similar to those observed in recent years (PNNL, 2006).

The Columbia River is the primary source of the city of Richland's drinking water. The city of Richland also monitors its water for radiological and chemical contaminants, and for general water quality.

4.6.1.2 Yakima River

The Yakima River basin was separated into the upper and lower reaches for purposes of analyzing water quality. The upper and lower Yakima River basins are separated by the Yakima River Canyon, approximately 20 miles of arid shrub-steppe and steep basalt canyon lying approximately north-south between the Kittitas and Yakima Valleys (Ecology, 2002c, 2006). The upper reach extends from RM 214.5 at the Keechelus gage to RM 140.4 at Umtanum. The lower reach extends from RM 140.4 at Umtanum to the mouth of the Yakima River at RM 0.

Water quality in headwater streams and the upper Yakima River is good but degrades downstream to the mouth. This degradation is caused both by natural processes and by the impacts from human activities, including both point and nonpoint sources (Reclamation, 1999).

Water quality parameter values indicate that current surface water quality standards for water temperature, DO, pH, turbidity, ammonia, total dichlorodiphenyltrichloroethane (DDT), and other pesticides, as well as fecal coliform bacteria, are not met on the mainstem and tributaries of the upper and lower Yakima River basin at various times. These contaminants are listed along with their impaired water body or water bodies on the 2002-2004 303(d) list (Johnson, 2007 and Coffin et al., 2006). In addition, phosphorus concentrations have been detected on occasion at levels of concern relative to effects on aquatic life.

The highest concentrations of turbidity, nutrients, bacteria, and pesticides occur in agricultural drains rather than in the mainstem or natural tributaries and, therefore, cause degradation in the water quality of the Yakima River downstream from the drain discharge points (Reclamation, 1999).

The parameters analyzed for this study that may be affected are temperature, DO, turbidity/suspended sediments, and the nutrients phosphorus and nitrogen.

Temperature

The primary factors that control the mainstem water temperatures are streamflow (river morphology and slope); air temperature; rate of vertical mixing; time of travel; and the temperature of inflowing water from natural tributaries (including groundwater discharge), canals, wasteways, and agricultural drains. Water in the upper basin is cold but warms as the riverflows to the lower basin. As water flows through the stream reaches with a high rate of vertical mixing, the water temperature quickly equilibrates near air temperature. The temperature of slow-moving water in shallow reaches increases because of the long exposure time to the sun, particularly where shading riparian vegetation is missing. Fast-flowing water in deep channels with minimal roughness, such as in canals, increases temperature the least. In the lower portion of the basin, the mainstem temperatures in the late summer tend to be similar to the temperatures of the agricultural return flows because a high percentage of riverflows in the late summer is return flows from agriculture (Reclamation, 1999).

Many of the tributaries and the mainstem Yakima River are currently listed on the 2002-2004 Washington State 303(d) list for temperature impairment (Ecology, 2007c). Temperature concerns in the Yakima River basin focus on the protection of aquatic life; Ecology has implemented TMDLs for the mainstem of the river as well as for some of its tributaries.

Dissolved Oxygen

In the lower Yakima River, few locations downstream from Prosser Diversion Dam failed to meet the DO criteria of 8 milligrams per liter (mg/L) during USGS's July 1987 synoptic sampling. A value of 7.5 mg/L was measured near sunrise, when DO levels are usually at their minimum, at the Yakima River, Van Geisen Bridge, near Richland, Washington. Review of 1986 to 1991 data showed the mainstem Yakima River at Kiona also did not meet the DO criteria. The USGS noted that the effects of agricultural return flow, urban runoff, and point source discharges are noticeable in the lower Yakima Valley, where most of the low DO levels were measured (Morace et al., 1999).

Turbidity/Suspended Sediment

Comprehensive water quality monitoring studies of the Yakima River basin were conducted in the mid- to late 1970s (Ecology, 1979) with several studies evaluating sediment loading in various parts of the basin (CH2M Hill, 1975; Boucher, 1975; Soil Conservation Service [SCS], 1978; U.S. Army Corps of Engineers, 1978; Nelson, 1979; Boucher and Fretwell, 1982). Much of the work indicated that irrigation practices directly affected suspended sediment concentrations and turbidity in the lower Yakima River and return drains from March through October (Coffin et al., 2006). The 2003 TMDL targets called for a 90th percentile turbidity limit of 25 nephelometric turbidity units (NTU) at the mouths of all irrigation drains within the Storage Study area. The turbidity limit was set to correspondingly limit the suspended sediment concentration to

56 mg/L, as based on the prior TSS/turbidity correlation. Both values were considered moderately protective of aquatic communities according to literature at the time (Joy and Patterson, 1997). Of the nine monitoring sites for turbidity, five of which are on the mainstem Yakima River and four of which are major irrigation return flows; only one (Granger Drain) did not meet the fifth-year (2003) goal of a 90th percentile turbidity of 25 NTU or less during the entire sampling period (April through October). Two of the four major tributaries, Moxee Drain and Granger Drain, did not meet the TSS concentration goal of 56 mg/L; however, sediment loads have still been reduced in each of these tributaries by approximately 60 percent and 85 percent, respectively (Coffin et al., 2006). Although, turbidity levels are decreasing, values still remain above State standard criteria.

Implementation of Best Management Practices by the irrigation districts and on-farm practices, as well as the TMDL process initiated by Ecology have resulted in significant improvements to the turbidity and suspended sediment/solid concentrations throughout the basin. With continued efforts to keep improving water quality in the drains and wasteways, the Yakima River should experience even further improvements.

Toxins

Pesticides (DDT and its metabolites, endosulphan, dieldrin, and others, as well as polychlorinated bi-phenols- [PCB] 1260) are widespread low-level contaminants that have been observed in water and sediment samples in the Yakima River system. The concentrations of dieldrin and DDT compounds have apparently been decreasing (USGS, 1991) since the early 1970s because of the EPA ban on the use of DDT in 1972 and the ban in the production of dieldrin in 1974. However, these pesticides still show up in the drains and, subsequently, in the Yakima River because of the residuals that exist in the irrigated soils in the basin. These compounds tend to adsorb to soils; subsequently, the sediment that is eroded from the agricultural fields is carried by the irrigation return flow water to the Yakima River. DDT was originally deposited in the irrigated soils decades ago when it was commonly used in agriculture. Recent water quality data have shown that the greatest concentrations of DDT and dieldrin have occurred at sites that also have the largest suspended sediment concentrations. This relation suggests that reducing suspended sediment concentrations in the drains would result in reduced concentrations of DDT and other pesticides in the Yakima River (Reclamation, 1999). TMDL effectiveness monitoring conducted by Ecology in 2003 showed turbidity has been reduced dramatically (Johnson, 2007). USGS has reported a corresponding decrease in total DDT levels in water samples from 1992 compared to 2000 (Fuhrer et al., 2004; Johnson, 2007). For example, in the Moxee Drain, maximum concentrations of suspended sediment decreased sharply from more than 600 mg/L in 1988-89 to about 200 mg/L in 1999-2000. The Granger Drain

had similar results; the total DDT concentration for a given concentration of suspended sediment decreased by a factor of three or more from 1988-89 to 1999-2000 (Fuhrer et al., 2004).

Phosphorus and Nitrogen

Nutrient (phosphorus and nitrogen) concentrations are conducive to eutrophication in the lower Yakima River. Eutrophication is the process by which a body of water becomes enriched in dissolved nutrients that stimulate the growth of aquatic plant life, usually resulting in the depletion of DO. Activities upstream of Prosser Diversion Dam, municipal effluent, runoff from agriculture and urban sources, and storm runoff affect nutrient loading. Although these concentrations are adequate to support aquatic growth, turbidity may inhibit the sunlight penetration necessary for that growth. If the turbidity were to decrease, eutrophication of the lower Yakima would occur and result in unacceptable levels of DO, pH, and aquatic growth (Morace et al., 1999).

Washington State has not established criteria for phosphorus or nitrates; however literature values for the prevention of eutrophication indicate total phosphates as phosphorus (P) should not exceed 100 µg/L in any river system; 50 µg/L in any stream at the point where it enters any lake, reservoir, or other standing water body; or 25 µg/L within the lake, reservoir, or other standing water body. EPA water quality criteria for 1986 concur with literature values. EPA has established a maximum contaminant level of 10,000 µg/L for nitrates in drinking water (EPA, 1986a).

During irrigation season, most of the water in the lower Yakima River is agricultural return flow. Concentrations of nutrients (phosphorus and nitrogen) in the river reflect the influx of agricultural chemicals. In August 1999, concentrations of total phosphorus in the Yakima River increased from 10 µg/L in the headwaters near Cle Elum to 140 µg/L near the mouth at Kiona. The concentrations of phosphorus in 71 percent of the irrigation-season samples and 80 percent of the nonirrigation-season samples exceeded the EPA desired goal of 100 µg/L to prevent nuisance growth of plants in aquatic systems. Also, 13 percent of the nonirrigation-season concentrations of nitrate exceeded 10,000 µg/L, which is the EPA drinking water standard (Fuhrer et al., 2004).

4.6.2 Environmental Consequences

4.6.2.1 Methods and Assumptions

Washington State approved water quality standards were used to assess the status of the Columbia and Yakima Rivers and the effects each alternative would have on the water quality.

Effects of the Joint Alternatives were analyzed using data obtained through literature reviews, professional judgment, ongoing monitoring, and models

created by Ecology, USGS, and Reclamation, as discussed below. The indicators of temperature, DO, nutrients, total suspended solids, and toxins were selected to evaluate water quality.

Reclamation conducted an assessment of the potential effects the Black Rock pumping plant at Priest Rapids Dam would have on water temperature using the U.S. Army Corps of Engineer's CE-QUAL-W2 model and the stream segment temperature SSTEMP model. Both models have substantial limitations with respect to their use for the Storage Study, but no other models were available. The results from both were similar with respect to temperature and suggested that building a separate model for this study was not warranted (USGS, 2007).

CE-QUAL-W2 is a water quality and hydrodynamic model that models in two dimensions, longitudinally and vertically. It can be used for rivers, estuaries, lakes, reservoirs, and river basin systems. It can be used in both stratified and nonstratified systems, and it can model a variety of water quality parameters including temperature. Its primary limitation with respect to its use for the Storage Study is its inability to model lateral reservoir variations. The laterally averaged (bank-to-bank average) assumption may be inappropriate for large waterbodies exhibiting significant lateral variations in water quality. Because the Columbia River is likely well mixed, this is not a critical limitation. Also, dynamic branches can be included for large embayments in a CE-QUAL-W2 model to minimize the limitations of the laterally averaged assumption. Input data is most often the most limiting factor in the application or misapplication of any model.

SSTEMP may be used to evaluate alternative reservoir release proposals, analyze the effects of changing riparian shade or the physical features of a stream, and examine the effects of different stream withdrawals and returns on instream temperature. It can model only single stream segments for a single time period (e.g., month, week, day) for any given "run." Initially designed as a training tool, SSTEMP may be used satisfactorily for a variety of simple cases that might be faced on a day-to-day basis. It is especially useful for performing sensitivity and uncertainty analyses (Bartholow, 2007). However, it cannot model flows of more than 100,000 cfs, which are routinely exceeded on the Columbia River. As such, the modeling had to be performed for flows of less than 100,000 cfs and then "scaled up" to higher flows.

The Department of Ecology developed a model using the QUAL2E software to address water quality issues associated with a proposal to increase flows in the lower Yakima River by forgoing diversions at Prosser Diversion Dam and, instead, diverting from the Columbia River near the mouth of the Yakima River (Carroll and Joy, 2001). The model looked at the lower Yakima River between RM 47.2 (upstream of Prosser Diversion Dam) and RM 5.6, the backwater of the McNary pool. Model input was provided to simulate water temperature; DO; biochemical oxygen demand (BOD); chloride; TSS; nitrogen (N) in the forms of

organic-N, ammonia-N, nitrate-N; phosphorus in the forms of organic-P and dissolved P; and chlorophyll a at steady-state conditions. Turbidity could not be directly modeled, so a regression relationship between TSS (a model parameter) and turbidity for the lower Yakima River was used (Joy and Patterson, 1997). Carroll and Joy (2001) have summarized and drawn conclusions from the information collected about water quality in the lower Yakima River. The results from these earlier model runs were examined in light of the changes in projected flows to help estimate water quality under the Wymer Dam Plus Yakima River Pump Exchange Alternative, which is on a larger scale than the original model.

The USGS developed a temperature model for the Storage Study. The USGS used the SNTEMP model, which was developed to help predict the consequences of stream manipulation on water temperatures. Manipulations may include reservoir discharge and release temperatures, irrigation diversion, riparian shading, channel alteration, or thermal loading. The SNTEMP model has been used to help formulate instream flow recommendations, assess the effects of altered streamflow regimes, assess the effects of habitat improvement projects, and assist in negotiating releases from existing storage projects (USGS, 2007).

Input values correlated air and water temperature for the period 1984-2003 for the Yakima River from Roza Diversion Dam to Prosser Diversion Dam and at the mouth of the Naches River. The time period used for data collection of water temperatures was April through October, which corresponds to irrigation season (Voss, 2007).

CE-QUAL-W2 modeling of Wymer reservoir was also performed. Wet (1997), average (1991), and dry (1994) years were evaluated to determine the effects of Wymer dam releases on Yakima River temperatures just downstream from Wymer reservoir releases and upstream of the Roza Diversion Dam pool.

4.6.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Under the No Action Alternative, there would be no effect, either adverse or beneficial, on Columbia River water quality. No diversions would be made from the Columbia River, and there would be no additional influx of contaminants.

Based on the modeling done by Carroll and Joy (2001) for the lower Yakima River, the relatively modest, reach-specific difference in flow are not expected to affect water quality in the Yakima River. Carroll and Joy looked at changes in flows downstream from Prosser Diversion Dam on the order of 628 to 980 cfs in the Prosser Diversion Dam to Chandler reach, and from 1,344 to 2,010 cfs from

Chandler to the mouth of the Yakima. They noted virtually no change in the water quality parameters modeled when flows were increased. The water conservation projects included in this alternative would create flow improvements of not more than a few hundred cfs, so similar effects to water quality would be anticipated.

Nutrient concentrations in the drains and wasteways would likely be greater under this alternative. The amount of nutrients that enter the drains and wasteways as a result of surface and subsurface runoff is a function of the amount of water applied for irrigation. Conservation measures would not reduce the amount of water applied but, instead, would reduce the amount that seeps or is discharged from the canals and laterals. Nutrient concentrations would increase as the amount of nutrients discharged to the drains and wasteways stays constant, but the amount of the total discharge in the drain or wasteway, which can dilute their concentrations, would decline.

4.6.2.3 Black Rock Alternative

Construction Impacts

There would be short-term impacts to water quality from instream and near-stream construction activities for the Black Rock pumping plant on the Columbia River. The required instream work may cause local, temporary increases in turbidity during installation and removal of coffer dams. These increases would likely be most intense near the construction activity itself and would decrease over time and distance. Given the slow-moving nature of the river at this location, turbidity would be expected to be confined near the site of the construction.

Long-Term Impacts

Under the Black Rock Alternative, there would be no effect, either adverse or beneficial, on the water quality in the Columbia River, excluding the Hanford Site contaminants. The water quality modeling performed for the pumping station just upstream of Priest Rapids Dam that would lift water into the Black Rock reservoir indicates no measurable difference in the water temperature prediction with or without withdrawal. Both models, discussed previously, have shortcomings with respect to their use for the Storage Study, but both indicated there would be no effect. This appears to be a reasonable conclusion given the size of the withdrawal relative to flows in the Columbia River. At the time of modeling, the withdrawal by the Black Rock pumping plant was assumed to be 6,000 cfs. That amount has since been reduced to 3,500 cfs. Also note that water would be pumped from the Columbia River for Black Rock reservoir primarily during fall and winter, when the flows are low, and the temperatures are declining. For these reasons, a new model was not constructed for the study, and the results of the two models available were determined to be adequate to address this issue.

In the Yakima River, USGS model results (Voss, 2007) indicate there would be no significant changes in water temperatures under this alternative compared to the No Action Alternative (figure 4.12), which is consistent with previous temperature modeling conducted for the Yakima River (Vaccaro, 1986).

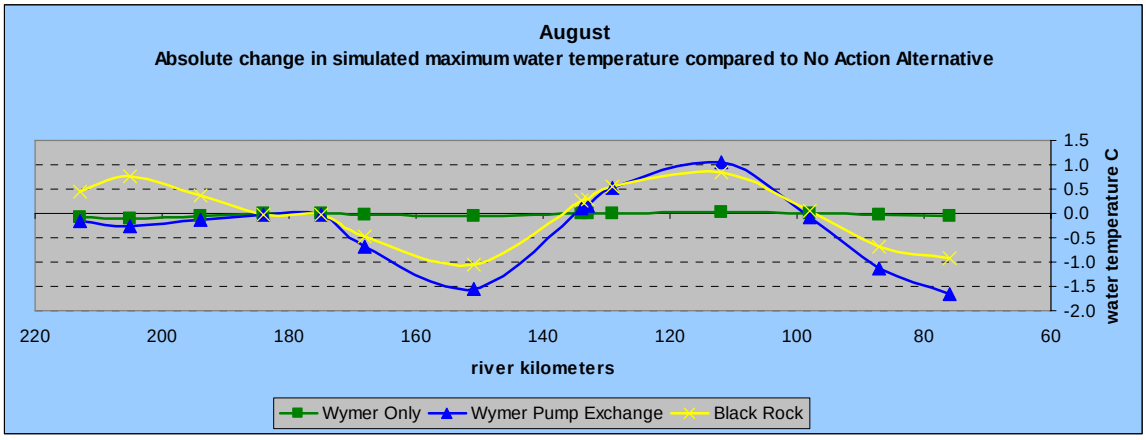


Figure 4.12 Modeled August absolute change in maximum water temperatures for Wymer Dam and Reservoir, Wymer Dam Plus Yakima River Pump Exchange, and Black Rock Alternatives compared to the No Action Alternative. Note: 1 °C = 1.8 °F.

Higher flows during summer in the lower river should provide improved water quality conditions relative to nutrients, DO, and DDT. The water used to augment flows would come from reservoir releases higher in the valley where water quality is better. At the Parker gage, flows would be 3 to 4 times higher, so a water quality improvement would be expected. Lower in the river, the flows would also be increased; therefore, concentrations of nutrients could possibly be reduced.

The western boundary of the Hanford Site is approximately 5 miles from the proposed Black Rock reservoir. From 1943 to 1989, Hanford's principal mission was the production of weapons-grade plutonium. To produce this material, uranium metal was irradiated in production reactors. The uranium metal was cooled, and then treated through chemical separations in a reprocessing plant.

From this process, a large amount of waste was produced and stored in tanks, or disposed of in cribs and trenches. In some cases, chemicals and radionuclides from this material have leaked or were discharged to the ground. The cleanup of the contamination present at the site is being done under the Resource Conservation and Recovery Act or Comprehensive Environmental Response Compensation and Liability Act, depending on the particular process or unit being addressed.

The proposed Black Rock reservoir could affect the existing groundwater contamination at the Hanford Site in a number of ways. For example, seepage from the Black Rock reservoir would increase the groundwater flow in the aquifer under the reservation. Increased groundwater flow has the potential to increase

the movement of contaminants from the central part of the site, referred to as the Central Plateau. Such an increase in groundwater flow has the potential to change containment plume shapes, travel times, and peak concentrations. The hydraulic conductivity distribution is different beneath the eastern and western portions of the Central Plateau, so it is likely that an increase in groundwater flow would have a differential impact across the site.

Seepage from Black Rock reservoir also has the potential to raise the water table level beneath the Hanford Site. Raising the water table would have the potential to mobilize contaminants currently in the soil, as well as shorten the travel time of contaminants through the vadose zone. The Department of Energy is investigating this contaminant mobilization at the Hanford Site, along with contaminant travel time toward the river. At present, it appears that there could be impacts to deep vadose zone contamination at a minimum, and those remediation technologies and programs either currently implemented or under development at the Hanford Site could be significantly impacted by seepage from the Black Rock reservoir.

DOE issued a Notice of Intent (*Federal Register*, 2006) for the Tank Closure and Waste Management EIS, which is evaluating treatment, storage and closure options for tanks and other units around the Hanford Site. In this EIS, DOE intends to include an analysis of the potential impacts to groundwater beneath the Hanford Site as a result of seepage from the Black Rock reservoir.

4.6.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

There would be short-term impacts to water quality from instream and near-stream construction activities for the Wymer pumping plant on the Yakima River. The required instream work may cause local, temporary increases in turbidity during installation and removal of coffer dams. These increases would likely be most intense near the construction activity itself and would decrease over time and distance.

Care would also have to be taken with flows in Lumuma Creek during dam construction. A coffer dam and one or more temporary bypass channels would have to be constructed to route the flowing water away from any construction activity. Rerouting the stream to the bypass may create a minor amount of sediment that would settle out before it reaches the Yakima River.

Long-Term Impacts

Under the Wymer Dam and Reservoir Alternative, there would be no effect, either adverse or beneficial, on water quality in the Columbia River.

In the Yakima River, USGS model results indicate there would be no significant changes in water temperatures under this alternative compared to the No Action

Alternative (figure 4.12), which is consistent with previous temperature modeling conducted for the Yakima River (Vaccaro, 1986).

For the proposed Wymer reservoir, CE-QUAL-W2 temperature modeling results indicated that during June and July in wet, average, and dry years, Wymer dam release temperatures would be cooler than those of the Yakima River. During late August in wet and average years, Wymer reservoir releases would approach Yakima River temperatures. During late August in dry years, Wymer reservoir releases would be warmer than those of the Yakima River. At low Wymer reservoir elevations during September, warm surface waters could be discharged to the Yakima River. Therefore, minimal discharges are anticipated during September in dry years.

Little change would be expected in other Yakima River water quality parameters as a result of releases from Wymer reservoir. During dry years, bottom releases from Wymer reservoir could potentially affect Yakima River water quality. Therefore, stagnant water quality conditions in the lower layers of Wymer reservoir could be minimized by mixing water quality releases from upper outlets with potentially poor water quality from the lower outlet.

4.6.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Construction impacts for Wymer reservoir would be the same as for the Wymer Dam and Reservoir Alternative. Additionally, there would be short-term impacts to water quality from instream and near-stream construction activities for the Yakima River pump exchange (pumping plant #1) on the Columbia River. The required instream work may cause local, temporary increases in turbidity during installation and removal of coffer dams. These increases would likely be most intense near the construction activity itself and would decrease over time and distance. Given the slow-moving nature of the river at this location, turbidity would be expected to be confined near the site of the construction.

Long-Term Impacts

Under the Wymer Dam Plus Yakima River Pump Exchange Alternative, there would be no effect, either adverse or beneficial, on Columbia River water quality.

Effects on Wymer reservoir and Yakima River temperatures would be the same as under the Wymer Dam and Reservoir Alternative.

In the mid and lower Yakima River, the higher summer flows at Parker would provide water quality improvements as a result of dilution. The flow increase is only about two-thirds of that expected under the Black Rock Alternative, so while water quality benefits are anticipated, they are not expected to be as prevalent as under the Black Rock Alternative.

4.6.2.6 Mitigation

Contributing sediment from construction activities (such as staging areas and temporary access roads) would need to be prevented. The contractor would be required to use silt curtains, settling ponds, and other measures to prevent construction site runoff. Waste water associated with construction activities, such as dewatering excavations, washing equipment or wet sawing, would be kept from directly discharging into surface waterways. Complying with State and local water quality permits would provide the necessary water quality protection.

As mitigation for warm-water releases from Wymer reservoir, releases would be maximized and made as early as possible in a dry water year to minimize the potential for warm water releases later in the summer when the Yakima River and Wymer reservoir would be warmer.

4.6.2.7 Cumulative Impacts

Planned development in the basin could have an adverse effect on water quality. The additional development would result in more water use and the returns of more used water could impact the area's streams and river. While some of the return flows would come through municipal water treatments facilities, they would add pollutants to the system. This increase in wastewater from residential and other developments could offset some of the benefits expected under the Black Rock and Wymer Dam Plus Yakima River Pump Exchange Alternatives. Because there are no expected water quality impacts associated with the No Action or Wymer Dam and Reservoir Alternatives, there would be no cumulative impacts.

4.7 Vegetation and Wildlife

4.7.1 Affected Environment

Vegetation issues of concern involve the loss of shrub-steppe associated with the development of facilities under some of the alternatives and effects to riparian and wetland habitat along the river corridor as a result of changes in flows. The loss of shrub-steppe is also an issue for wildlife, as it could be affected by its loss. Movement corridors for some species may also be affected with the development of some of the facilities.

Shrub-steppe communities were historically a dominant vegetation type in eastern Washington, and have been extensively studied (Yakima Subbasin Fish and Wildlife Planning Board, 2004). The shrub-steppe vegetation type is a mixture of woody shrubs, grasses, and forbs generally dominated by Wyoming big sagebrush and bluebunch wheatgrass in east-central Washington (Daubenmire, 1970). Environmental factors such as elevation, aspect, soil type, proximity to water, and others contribute to an individual site's vegetation diversity potential. For example, at higher elevations and on north-facing slopes, three-tip sagebrush and

Idaho fescue may dominate, while on ridge tops with shallow soils, rigid sagebrush and Sandberg's bluegrass and/or bluebunch wheatgrass may dominate (Yakima Subbasin Fish and Wildlife Planning Board, 2004). Rabbitbrush may be common on recently burned sites. Other grasses and shrubs that may be scattered throughout dominant stands of Wyoming big sagebrush and bluebunch wheatgrass include needle and thread, Thurber's needle grass, Indian rice grass, squirreltail, Cusick's bluegrass, short-spine horsebrush, antelope bitterbrush, spiny hopsage, and basin sagebrush (Crawford and Kagan, 2001). More alkaline sites may support black greasewood, basin wild rye, and inland saltgrass (Daubenmire, 1970). Estimates of historic vegetation cover on undisturbed sites range from 5- to 30-percent shrub cover and from 69- to 100-percent bunchgrass cover.

Agricultural, residential, and urban development over the past century have changed the landscape drastically, resulting in large losses of shrub-steppe habitat. Approximately 40 percent of the estimated 10.4 million acres of the shrub-steppe vegetation type that existed in Washington before the 1800s remains today (Dobler et al., 1996). This residual habitat continues to be threatened by continued loss/conversion of habitat; declines in vegetative diversity; reduction of microbiotic crusts, which are an indicator of undisturbed habitat and prevent the influx of exotic species (i.e., cheatgrass); and isolation of habitat (Service, 2007b). The further loss of habitat and the degradation of remaining shrub-steppe can be attributed to increased fragmentation, varying fire management practices, competition with exotic and invasive species, overgrazing from livestock, off-road vehicle use, and overall conversion and development (Crawford and Kagan, 2001). In the Yakima River basin, three large properties remain that continue to support large blocks of shrub-steppe: the YTC, a portion of the Yakama Reservation, and the Fitzner-Eberhardt Arid Lands Ecology (ALE) Reserve located on Hanford Reach National Monument, managed by the U.S. Fish and Wildlife Service (Yakima Subbasin Fish and Wildlife Planning Board, 2004). Table 4.19 presents the shrub-steppe acreage under each alternative area (Service, 2007b). More detailed treatment of this vegetation type is found in the Yakima Subbasin Plan (Yakima Subbasin Fish and Wildlife Planning Board, 2004), and the numerous references cited within that report.

Table 4.19 Shrub-steppe habitat at major facility sites (acres)

Location	Shrub-steppe habitat
Black Rock site	3,539 acres
Wymer site	1,055 acres
Other facilities – SR-24 Road relocation and access road to Priest Rapids to pumping plant	330 acres
Total affected area	4,924 acres

4.7.1.1 Wildlife

Several wildlife species utilize and exist within the remaining shrub-steppe habitats. The affected areas for these species and their habitat includes not only the footprint of the proposed Black Rock and Wymer dams and reservoirs but also the ancillary facilities, i.e., pipeline construction and alignment; pumping plants; access roads; staging areas; realignment of SR-24 and utilities; and potential recreational development in adjacent areas where they occur in shrub-steppe (Reclamation, 2004e).

The following section provides a general analysis of wildlife known to occur or have the potential to occur within the affected areas of both Black Rock and Wymer dam and reservoir sites.

An abundance of diverse wildlife inhabits and utilizes shrub-steppe communities in the region. Table 4.20 presents a list of the known wildlife species within the affected areas (both Black Rock and Wymer dam and reservoir sites), as well as a partial list of potential wildlife species that may occur.

Both habitat generalists and shrub-steppe obligates occupy the Black Rock and Wymer dam and reservoir sites. The U.S. Fish and Wildlife Service lists core habitat for the following species within the Black Rock site: short-eared owls (*Asio flammeus)*, burrowing owl (*Athene cunicularia)*, long-billed curlew *(Numenius americanus)*, ferruginous hawk (*Buteo regalis*), loggerhead shrike (*Lanius ludovicianus*), sage thrasher (*Oreoscoptes montanus*), greater sage-grouse (*Centrocerus urophasianus*), Townsend ground squirrel (*Citellus townsendi*), black-tailed jackrabbit (*Lepus californicus*), Merriam's shrew (*Sorex merriami*), mule deer (*Odocoileus hemionus*), pallid bat (*Antrozous pallidus*) and small-footed myotis (*Myotis subulatus*) (Reclamation, 2007b). Peripheral habitat exists for the white-tailed jackrabbit (*Lepus townsendii*) and Rocky Mountain elk (*Cervus canadensis*).

The Wymer site provides core habitat for bighorn sheep (*Ovis canadensis*), Townsend ground squirrel, golden eagle (*Aquila chrysaetos*), ferruginous hawk, short-eared owl, long-billed curlew, loggerhead shrike, sage sparrow (*Amphispiza belli*), brewer's sparrow (*Spizella breweri*), sage thrasher, greater sage-grouse, black-tailed jackrabbit, Merriam's' shrew, mule deer, pallid bat, and small-footed myotis. Peripheral habitat exists for the white-tailed jackrabbit. Other species that may live in the diverse habitats within the affected areas include the coyote (*Canus latrans*), badger (*Taxidea taxus*), western kingbird (*Tyrannus verticalis*), western meadowlark (*Sturnella neglecta*), mourning dove (*Zenaida macroura*), western rattlesnake (*Crotalus virdis*), Great Basin spadefoot toad (*Spea intermontana*), and northern sagebrush lizard (*Sceloporus graciosus*) (Service, 2007).

Table 4.20 Known and potential wildlife species within affected shrub-steppe habitats

	Federal ESA Candidate Species, State-listed (Threatened)	"Species of Concern" by Washington State	Known to exist/ utilize shrub-steppe: Black Rock site	Have potential to exist/utilize shrub-steppe: Black Rock site	Known to exist/ utilize shrub-steppe: Wymer site	Have potential to exist/ utilize shrub-steppe: Wymer site
Birds						
Greater sage-grouse	x	x	x		x	
Brewer's sparrow			x		x	
Ferruginous hawk	State-listed only	x	x		x	
Burrowing owl		x	x			x
Prairie falcon				x		x
Golden eagle		Candidate		x	x	
Short-eared owl				x		x
Long-billed curlew			x		x	
Red-tailed hawk				x		x
Sage sparrow		x		x	x	
Chukar				x		x
Loggerhead shrike		x	x		x	
Northern shrike				x		x
Sharp-tailed grouse		x		x		x
Western kingbird				x	x	
Grasshopper sparrow				x		x
Sage thrasher		x	x		x	
Northern harrier				x		x
Swainson hawk				x		x
Rough-legged hawk				x		x
American kestrel				x		x
Common nighthawk				x		x
Common poorwill						x
Western meadowlark			x		x	
Vesper sparrow				x		x
Lark sparrow				x		x
Mourning dove				x		x
Mammals						
Townsend's ground squirrel		x	x		x	
Black-tailed jackrabbit		x	x		x	
White-tailed jackrabbit		x	x		x	
Mule deer			x		x	
Bighorn sheep			n/a		x	
Coyote			x		x	
Merriam's shrew		x	x		x	
American badger			x		x	
Rocky Mountain elk			x	x	n/a	
Pallid bat			x		x	
Small-footed myotis			x		x	
Reptiles and amphibians						
Northern sagebrush lizard		x		x		x
Western rattlesnake				x		x
Great Basin spadefoot toad				x		x

4.7.1.2 Movement Corridors

Valleys are often used as movement corridors for numerous land animals. This is especially true for species with relatively large home ranges such as deer and elk. This section addresses the issue of movement corridors in the area.

Movement corridors are crucial to wildlife and may be seasonal, depending on the species. The primary function of a corridor is to connect two areas of habitat and encourage migration and dispersal into these areas. Wildlife movement is essential to healthy wildlife populations because it does the following: provides connectivity and, thereby, genetic variation and biodiversity between differing populations and habitats; connects isolated habitats and may allow recolonization of extirpated species; provides varying habitats for migration patterns, e.g., foraging, nesting, brood-rearing, wintering, and mating; encourages plant propagation; allows populations to move in response to habitat changes, e.g., fires; and can provide habitat for "corridor dwellers," species that live within corridors for extended periods (Beier and Loe, 1992).

The loss of movement corridors would further isolate and fragment vegetative and wildlife species' populations, as well as substantially decrease and/or eliminate suitable habitats. A large reservoir can be a major barrier for some species including elk, deer, and greater sage-grouse in the Yakima River basin.

Evidence has shown that elk have historically occupied the shrub-steppe habitats of the Columbia River Basin (McCorquodale, 1985). In recent times, elk were first observed in the Rattlesnake Hills in 1972 and are believed to come from the Yakima elk herd west of the Hanford Reach National Monument (McCorquodale et al., 1988; Eberhardt et al., 1996). The Rattlesnake Hills elk herd utilizes the Fitzner-Eberhardt ALE Reserve within the Hanford Site and has grown considerably throughout its history.

The ALE Reserve encompasses more than 127 square miles and is designated a Research Natural Area and a National Environmental Research Park. The majority of the Rattlesnake Hills elk are found within the ALE year-round, but some have moved to adjacent areas as the population has grown and disturbance to habitat from fire has pushed them westward. Most of the land surrounding the ALE Reserve is privately owned, but also includes the Saddle Mountain Wildlife Refuge, Wahluke Wildlife Area, and the YTC. The population has grown extensively over the years. Presently, elk are being managed by the Washington Department of Fish and Wildlife through hunting, trapping, and relocations because of crop damage complaints from private landowners (Tsukamoto, 2000).

The Rattlesnake Hills elk herd demonstrates distinct seasonal migration patterns and is concentrated within two areas, the Hanford ALE Reserve and the YTC. The elk usually winter in the ALE Reserve and then move out into adjacent lands in the spring and summer. The Cold Creek Valley within the ALE Reserve is the main area of distribution and runs along State Route 240. Elk are frequently

observed next to the western and southern boundaries of the ALE, on the Rattlesnake Hills and Yakima Ridge, and onto the southeastern portion of the YTC (Tsukamoto, 2000). They also move across the Columbia River towards the Saddle Mountain Wildlife Refuge and Wahluke Wildlife Area.

The YTC supports a small population of elk that migrate northwest from the ALE Reserve and south from the Colockum and Quilomene Wildlife Areas. The geography indicates that the Rattlesnake Hills elk probably cross the Black Rock Valley or move along the Yakima Ridge into the YTC (Tsukamoto, 2000). Neither the Yakima nor the Colockum herds have been observed within the Wymer area or in the areas directly east of the Yakima River (Stephenson, 2007).

4.7.1.3 Black Cottonwoods

Cottonwood reproduction has been identified as a key issue for the Yakima River basin by many recent studies and documents, mainly because black cottonwoods (*Populus balsamifera ssp. trichocaepa*) are the dominant plant species in lowland riparian forests of the Yakima River basin and are considered essential to the integrity of Yakima River riparian systems (Jaimeson and Braatne, 2001; Biology Technical Work Group, 2004; Braatne et al., 2007; Reclamation, 2002a; Yakima Subbasin Fish and Wildlife Board, 2004). As a dominant riparian plant species, black cottonwoods interact with other river system components, both physical and biological (Fierke and Kauffman, 2005). While hydrologic and sedimentary processes drive the creation and destruction of cottonwood habitat, the trees, in turn, modify physical river processes through increased channel and floodplain roughness, increased bank stability, and inputs of large woody debris (Montgomery, et al., 2003). Black cottonwoods also influence aquatic ecosystems through exchanges of nutrients, species, and energy. Because dominant riparian species such as black cottonwoods can be seen as integral components of the river system, it follows that changes in cottonwood recruitment can affect salmonid species both directly and indirectly in both the short and long terms (Naiman and Latterell, 2005).

Black cottonwoods range from northern California to the timberline in Alaska and grow mostly in riparian zones (DeBell, 1990). Their reproduction, growth, and mortality are closely linked to river processes (Auble and Scott, 1998). Other processes, such as grazing by native ungulates and cattle, fire, insect predation, and disease, have also been linked to black cottonwood ecology.

Seedling reproduction in black cottonwoods is thought to be the usual means of new stand establishment, and occurs in periodic pulses on many Western rivers. Black cottonwoods can also reproduce extensively by root sprouting and other clonal means; however, the relationship between riverflows and asexual reproduction is not well understood. Therefore, only sexual reproduction is considered here.

Mortality appears to be driven by floods, which undercut trees by sediment scour during channel avulsions and migration (Lytle and Merritt, 2004). Rapid declines in water table levels have also been shown to cause early mortality in cottonwoods (Rood, et al., 1995).

River Flows and Cottonwood Seedling Reproduction

The life history of riparian cottonwoods is tightly bound to riverflow dynamics. Much research has been conducted on the relationship between riverflow and cottonwood seedling reproduction, and several models have been published that describe this relationship for the semiarid Western United States (Lytle and Merritt, 2004; Mahoney and Rood, 1998). In general, a sequence of events spanning several years is thought to be necessary for abundant seedling production, beginning with a flood of at least a 5-year recurrence interval that scours or deposits sediments to produce bare, open sites. Also required is a 1.5-to-2-year recurrence (bank full flow) spring snowmelt flood that coincides with the June seed release period of cottonwoods on the Yakima River. This flow level moistens the surface of bare nursery sites and recharges shallow groundwater. Wind- and water-borne seeds, produced in vast quantities, then land on these sites and germinate. A gradual recession of the snowmelt flood, at a rate not more than about 1 inch of river stage per day, allows growing seedling roots to keep in contact with the capillary fringe of the groundwater. Survival after recession is favored by adequate summer base flows. Finally, a period of 2 to 5 years with low to moderate flows enables seedlings and juveniles to avoid being scoured or buried as would happen in large floods. These particular flow sequences occur episodically and result in a punctuated, rather than continuous, cohort recruitment process for cottonwoods. See figure 4.13.

Current Conditions

Large areas of cottonwood forest are found on alluvial segments of the Yakima River and the Naches River. These include the Easton, Cle Elum, Kittitas, Union Gap, Lower Naches, and Wapato floodplains. For the sake of brevity, the Easton, Cle Elum, and Umtanum floodplains are considered as a group and termed the upper reaches or floodplains, while the Union Gap, Lower Naches, and Wapato floodplains are considered individually. Several observations apply to all floodplains. The most general effect of current river operations is to reduce the volume of total annual discharge; simply put, the Yakima River has become a smaller stream. On average, smaller flows would reduce the potential size of riparian forests. Current Yakima Project operations also affect cottonwood reproduction most directly through the attenuation of fall and spring floods, which reduces the potential spatial extent of cohort recruitment. Indeed, several studies have documented a river-wide paucity of young cottonwood stands on the Yakima River. The identified causes of the poor reproduction are altered riverflows in addition to physical changes to floodplains such as levees, channelization, and gravel mining. These physical impediments to cottonwood reproduction would have to be addressed to realize the full potential of any

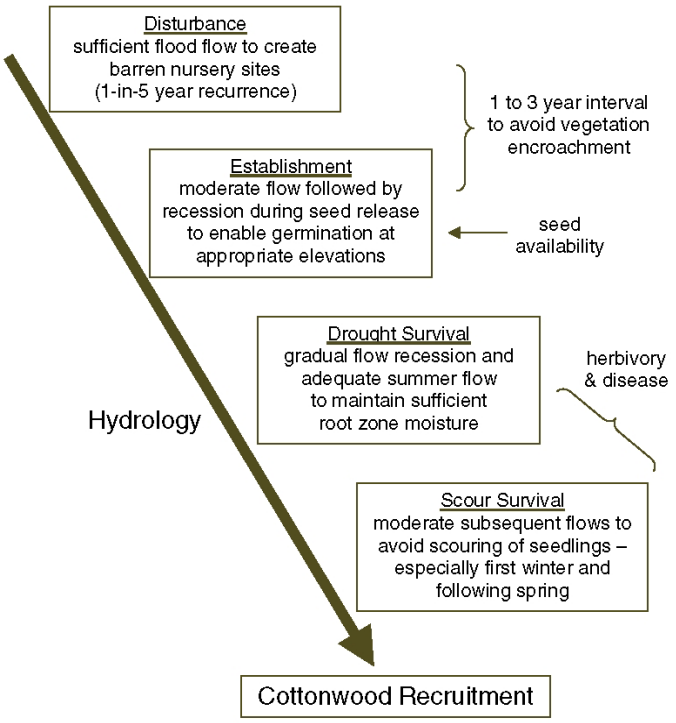


Figure 4.13 Conceptual model of flows for successful black cottonwood reproduction by seed (Braatne et al., 2007).

benefits associated with the Joint Alternatives. The Wapato and Union Gap floodplains have been identified as having greater restoration potential because of greater floodplain connectivity and complexity; hydrologic improvement might be expected to show relatively better results in these areas (Stanford et al., 2002).

Upper Floodplains (Easton, Cle Elum, and Kittitas).—River operations for the Yakima Project create reduced spring flows and very high summer base flows. As a result, cottonwood seedlings of the year are probably scoured each summer and relatively few young cottonwoods occur. However, some forest stands remain, most likely because of periodic large spring floods that provide recruitment sites beyond the reach of summer flow levels.

Lower Naches.—This floodplain has a flow pattern that is fairly close to natural flow, with the exception of fall high water caused by the flip-flop operation. Spring flows average substantially greater than the flip-flop surge, meaning that some seedlings most likely establish at high enough elevations to avoid being scoured in the fall. In general, seedling reproduction is probably occurring at higher rates on this reach than on mainstem Yakima River floodplains.

Union Gap.—Spring flows are reduced and summer flows are somewhat elevated in this reach. These flow alterations are not nearly as dramatic as those in the

upper floodplains, however, and periodic spring floods still generate pulses of cottonwood reproduction. High summer flows may raise the lower elevational limit of establishment, but most likely do not scour the bulk of seedlings of the year.

Wapato.—Cottonwood reproduction on this floodplain is limited by flow regulation. Spring flows are substantially reduced, spring recession rates are extremely rapid, and summer base flows average less than half of estimated natural flow. The combined effect of these conditions is limited opportunities for germination and high mortality of seedlings that do establish.

4.7.1.4 Wetlands

The single feature that most wetlands share is soil or substrate that is at least periodically saturated or covered with water. The National Wetlands Inventory (NWI) classification system (Cowardin et al., 1979) identifies wetlands and deepwater habitats. The NWI had identified 43,695 acres of wetlands within the Yakima River basin, including 20,040 acres of herbaceous wetlands, 20,044 acres of scrub-shrub and forested wetlands, and 3,611 acres of unvegetated wetlands.

Because of the affected area's semiarid environment, wetlands are extremely important to many species of wildlife as they provide some of the best vegetative growth for food and cover, invertebrate production and water. Recognition of the value of wetlands has historically focused on waterfowl populations. The Service (2007b) estimated that up to 300,000 ducks wintered on the Yakama Indian Reservation in the 1960s. Tens of thousands of waterfowl can still be found in the lower basin in winter and during migration. Several species of waterfowl also use these wetlands for nesting and brood rearing. Sandhill cranes (*Grus canadensis*) and swans (*Cygnus species*) historically nested in the basin, and could return if wetland restoration and enhancement efforts were to continue (Service, 2007b).

Wetlands in the affected area provide functions beyond fish and wildlife habitat. They provide both consumptive and nonconsumptive recreational uses, groundwater recharge, flood control (i.e., floodwater storage) and improvement of water quality as important functions. Wetlands in Washington have declined 30 percent, with the loss of freshwater wetlands estimated at 25 percent (Service, 2007b). Losses have been attributed to agriculture conversion; filling for solid waste disposal; road construction and commercial, residential, and urban development; construction of dikes, levees, and dams for flood control, water supply, and irrigation; discharges of materials; hydrologic alteration by canals, drains, spoil banks, roads and other structures; and groundwater withdrawal. Aside from direct loss of wetland, many wetlands have been reduced in quality from the above factors.

Black Rock Reservoir Site

Analysis of wetlands at the Black Rock site was confined to that area found within the footprint of the proposed dam, impounded reservoir (at maximum pool elevation) site and the indirect impact area around the perimeter of the dam and reservoir (0.31 mile [1/2 kilometer] wide). The Black Rock Valley is located in a semiarid environment; the primary drainage in the affected area is considered an intermittent/ephemeral watercourse tributary to the lower Yakima River subbasin. Although the plant community has been altered for agricultural purposes, it is unlikely that there were any wetlands historically found in the affected area. In fact, the only wetlands identified through analysis are relatively small in area (0.9 acre) and created by an impounded pond. They are not considered a natural occurrence (Reclamation, 2007b).

Wymer Reservoir Site

Wetlands in the Wymer reservoir site are found exclusively in the riparian zone in both Lmuma Creek and an unnamed tributary in the proposed impoundment area. Seeps were observed in the riparian corridor of Lmuma Creek. The riparian/ wetland plant community has been significantly degraded due to extensive past and ongoing livestock grazing; as such, these provide minimal value functioning habitat for wildlife. Remnant vegetation in the riparian/wetlands area included some cottonwood, willow, and black hawthorn. Some emergent vegetation was also observed. Even though the flow of Lmuma Creek is not regulated, there was no evidence of cottonwood recruitment, apparently a result of livestock grazing (Service, 2007b).

Wymer Reservoir Site Plus Yakima River Pump Exchange

Wetland and riverine habitats at the reservoir site are described above. Wetlands that may be present along the alignment for the pump exchange/pipeline were not included in this analysis due to lack of spatial data. They may be present at the site of the Yakima River siphon and at crossings of any irrigation delivery or drainage features along the pipeline through the irrigated portions of the valley.

4.7.2 Environmental Consequences

4.7.2.1 Methods and Assumptions

Shrub-Steppe Habitat

Many wildlife species dependent on shrub-steppe habitat would potentially be affected by the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives. This assessment is limited to the footprint and directly adjacent areas of the proposed reservoirs and ancillary facilities.

Shrub-steppe vegetation and wildlife impacts, species identification, and habitat requirements were based upon and evaluated using available literature and personal communication.

An assessment of the quality of the shrub-steppe habitat at the Black Rock and Wymer dam and reservoir sites was also performed using the U.S. Fish and Wildlife Service's Habitat Evaluation Procedures (HEP). HEP uses habitat units (HU) as the currency for addressing ecological losses or gains associated with any project development and implementation. HUs for a given species are the product of habitat quantity (acres) and habitat quality estimates. Habitat quality estimates are provided by a Habitat Suitability Index (HSI). HSI values range from 0.0 to 1.0 and are a projection of a given habitat parcel's ability to provide the life requisites of a given species. An HSI = 1.0 indicates essentially optimum habitat condition for the species in question. HSI values for a given species are determined on the basis of quantifiable habitat features (e.g., vegetation height, tree canopy cover, distance to water), which are known to be required for the success of that species. For this study, the Brewer's sparrow was used to estimate the quality of the habitat for shrub-steppe species.

Habitat and associated wildlife were first evaluated by identifying the areas that would be directly and indirectly affected by each storage alternative. Wildlife impacts are based on documented utilization by wildlife and estimated changes in their habitats.

Shrub-steppe habitat and wildlife assessments were based on the following premise:

- Impacts related to any loss of shrub-steppe habitat and subsequent habitat fragmentation would adversely affect shrub-steppe wildlife species and vegetation.

Habitat fragmentation can be defined as "the discontinuity, resulting from a given set of mechanisms, in the spatial distribution of resources and conditions present in an area at a given scale that affects occupancy, reproduction, or survival in a particular species" (Franklin et al., 2002). In this analysis the fragmentation of habitat for elk and deer is measured by reduced habitat area and presence of barriers for migration/dispersal. This, in turn, may lead to habitat isolation (Davidson, 1998).

Movement Corridors

Movement corridors are important aspects of resident and migratory wildlife and vegetation (Beier and Loe, 1992). This analysis specifically evaluated the Rocky Mountain elk as species that could be affected by the construction of the proposed dams and reservoirs.

Movement corridor delineation for Rocky Mountain elk is based upon the information provided in The *Rattlesnake Hills (Hanford) Elk Strategic Management Plan* (Tsukamoto, 2000); telemetry data and observations from the Hanford ALE Reserve regarding movement off the reserve; personal communication with elk biologist Jim Stephenson of the Yakama Nation; occurrence of shrub-steppe vegetation from aerial photographs; and topography of ridgelines and valleys where elk have been observed to frequent and move through.

Black Cottonwoods

Riverflows in the semiarid Western United States tend to follow strong seasonal patterns, and their hydrographs can be dissected into yearly repeating elements known as hydrograph components (Trush, McBain, and Leopold, 2000). For example, the Yakima River reliably experiences a small-to-moderate spring flood caused by melting snow in April through June, which gradually recedes to a stable summer base flow from July through September. Large floods may happen in the spring because of high snowmelt volume but more often occur following fall or winter storms (Reclamation, 2002). In turn, cottonwoods have evolved life history adaptations that are tightly linked to these recurring patterns, collectively termed the natural flow regime (Karrenberg et al., 2002; Lytle and Poff, 2004). Those hydrograph components important to cottonwood reproduction are the spring snowmelt flood, snowmelt recession, summer base flow, and fall/winter floods. They can be analyzed to assess the effects of the proposed alternatives on cottonwood recruitment, a procedure termed hydrograph components analysis (RMC Water and Environment and McBain & Trush, 2007). See table 4.21 for the biological relevance of each selected hydrograph component. In addition to focusing on individual components of hydrographs, a key aspect of the hydrograph components analysis is that different classes of water years have different functions. Thus, the same hydrograph component in a wet versus a dry year might provide a different function for cottonwood seed reproduction. Hydrograph components used were fall/winter flood peaks, spring snowmelt flood peaks and timing, and summer base flow average stage. Snowmelt flood recession, while important to cottonwood seed reproduction, was not used because of limitations in the modeled flow data.

After hydrograph components were defined and extracted from Yak-RW output, the data were summarized for each alternative at each floodplain. For example, the median value for the fall/winter flood peak during the period of study (water years 1981 to 2005) was calculated for each alternative. The absolute value of the difference between these median values and the median value for the modeled unregulated flow was then calculated, giving the percent difference from estimated unimpaired riverflow conditions. This process was repeated for each hydrograph component for each floodplain under each alternative. Because of model errors and errors in the underlying streamflow measurements, this method can only provide a rough estimate of the differences between alternatives in relation to cottonwood seeding reproduction success. See table 4.21.

Table 4.21 Significance of hydrograph components for cottonwood reproduction for water year types

Hydrograph component	Timing	Water year type	Biological function for cottonwood recruitment
Fall/winter flood	November-March	Wet	Creates large bare nursery sites for seedlings by major scouring or deposition; causes channel avulsion. Woody debris recruited from floodplains provides sheltered nursery sites on bars.
		Average	Minor scour and deposition create small nursery sites.
		Dry	No scour of seedlings allows for survival of seedlings from previous years.
Spring snowmelt peak flow	April-June	Wet	Scour and deposition; broad wetted band on bare sites allows for potentially large numbers of cottonwood seedlings to germinate.
		Average	Some bare sites wetted, moderate to small numbers of seedlings germinate.
		Dry	No scour of seedlings allows for survival of seedlings from previous years. No recruitment of seedlings of the year.
Spring snowmelt recession	June-August	Wet	Gradual recession far into summer allows growing seedling roots to maintain contact with receding capillary fringe; large numbers survive the first summer.
		Average	Gradual recession ends mid-summer, some seedlings of the year survive.
		Dry	Recession ends early in the summer, no same year seedling survival. Seedlings from previous years survive.
Spring snowmelt timing	June	Wet	Needs to be synchronized with seed release in order for seeds to land on moist nursery sites.
		Average	Needs to be synchronized with seed release in order for seeds to land on moist nursery sites.
		Dry	Not important since no seedling of the year survival is expected.
Summer base flow	August-October	Wet	High base flow promotes high survival of seedlings of year, growing season may be prolonged.
		Average	Moderate base flow allows some survival of seedlings of year, prevents stress to existing seedlings and juveniles.
		Dry	Low base flow prevents survival of seedlings of the year, causes drought stress and mortality for established seedlings and juveniles.

Adapted from RMC Water and Environment and McBain & Trush, 2007.

Wetlands

Wetlands were evaluated using the wetland delineations that were available for the construction and impoundment sites. Where wetlands existed within the construction or impoundment footprint, they were presumed to be lost with implementation of the alternative.

Flows were also evaluated to determine if wetlands associated with the river corridor would be affected by the flow changes. If spring or summer flows were to decline, it was assumed that wetlands associated with the river would be adversely impacted. If those flows were to increase, benefits were assumed.

Impacts to black cottonwoods were also examined to determine if the effects were negative or positive. Impacts to wetlands were assumed to have the same trend.

4.7.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Shrub-Steppe Habitat.—Under the No Action Alternative, existing management and recovery efforts for shrub-steppe habitat and existing wildlife would continue. Some shrub-steppe habitat would continue to suffer degradation from grazing, conversion to agriculture, or development. The susceptibility for fire and subsequent invasion of exotic species (i.e., cheatgrass) would also be a major concern.

A Memorandum of Understanding (MOU) was signed in 2006 among Federal, Tribal, State, and private agencies within Yakima, Benton, Grant, and Kittitas Counties to establish a partnership dedicated to conserve shrub-steppe and rangelands surrounding and connecting the YTC, Hanford Reach National Monument, the Yakama Reservation, and the Washington Department of Fish and Wildlife's Wildlife Areas (MOU, 2006). To date, the partnership, named the South-Central Washington Shrub Steppe/Rangeland Conservation Partnership, is acquiring a conservation easement for a property located within the Rattlesnake Hills, south of Moxee (Burkepile, 2007). This partnership would have the ability to work with landowners to protect shrub-steppe habitat and potentially restore these areas. The U.S. Fish and Wildlife Service estimates there are 6,591 acres of shrub-steppe and 5,059 acres of grassland (including Conservation Reserve Program lands) within the Black Rock footprint and .31 mile (0.5 kilometer) buffer that have the potential to be protected from future degradation and development. The Wymer footprint and buffer consists of 3,634 acres of shrub-steppe and 996 acres of grassland that have the potential for restoration and protection.

Movement Corridors.—Existing movement corridors and habitat would continue to be used by shrub-steppe wildlife. This alternative would coincide with the South Central Washington Shrub Steppe/Rangeland Conservation Partnership objectives and recovery efforts for the greater sage-grouse, to decrease fragmentation of populations and habitat. It would also allow for potential re-introductions and larger species dispersal into surrounding shrub-steppe habitat. Other wildlife, such as the Rattlesnake Hills elk herd, would also be able to utilize existing corridors along the Black Rock Valley and Yakima Ridge to reach the YTC from the Hanford ALE Reserve.

Black Cottonwoods.—Under the No Action Alternative, negligible changes in cottonwood reproduction would occur in comparison to the current condition. Flows in the upper reaches and the Union Gap reach would remain lower in the spring and higher in the summer than estimated unregulated conditions. In the Lower Naches River, the flip-flop surge would remain, and in the Wapato floodplain, spring floods are truncated and summer base flow, while marginally higher, would not be expected to increase seedling survival.

Wetlands.—In the event that this alternative is selected, water conservation measures would continue to be researched and implemented as part of the Yakima River Basin Water Enhancement Project authorized by Congress with Public Law 96-162 on December 28, 1979 (Reclamation, 1996). Water conservation measures may have an adverse impact on existing wetlands in the area because, as water delivery systems are made to be more efficient, wetlands that have been created by seepage from existing delivery systems would likely be reduced, or dry up all together.

4.7.2.3 Black Rock Alternative

Construction Impacts

Wildlife would be most affected by noise and increased traffic caused by construction and maintenance concentrated primarily at the damsite.

Long-Term Impacts

Shrub-Steppe Habitat.—The Black Rock Alternative would affect, both directly and indirectly, shrub-steppe habitat within the Black Rock Valley and adjacent lands. These impacts would result from the construction and use of the dam, reservoir, access roads, State Route 24 realignment, and recreational development. The proposed reservoir includes the following approximate habitat acreage: 3,539 acres of shrub-steppe, 113 acres of grassland, 3,771 acres of Conservation Reserve Program lands, 1,126 acres of agricultural croplands, 113 acres of developed land (i.e., residential), and some acreage of other habitat types (Service, 2007a).

After conducting a HEP analysis using the Brewer's sparrow as a model, it was determined that 1,692 habitat units for the sparrow would be completely lost in

the footprint of the reservoir and dam. The total area to be lost to reservoir inundation and the dam is about 8,700 acres. The relatively low number of habitat units for Brewer's sparrow at the site, relative to the number of acres, suggests it provides marginal habitat for the sparrow and other shrub-steppe species that it was intended to represent. If the entire site is used to estimate the number of habitat units, then the average value of the habitat, on a scale from 0.0 to 1.0, is about 0.2. If the agricultural and developed lands are omitted, then the value is slightly higher at about 0.23. This indicates that the lands within the reservoir and dam footprint are of relatively low value for shrub-steppe species. This may be largely due to the fact that less than half of the site is actually in shrub-steppe.

Indirect impacts could also occur at the site as a result of some increase in activity associated with operations and maintenance and recreation. Indirect adverse effects could include degradation of habitat adjacent to the site through introduction of nonnative invasive plants, increased development in the areas adjacent to the proposed reservoir, and increased fire danger. Given the modest level of recreational enhancement proposed and the disturbed nature of much of the site today, these indirect impacts are not expected to be significant.

This alternative would not significantly affect migration of the Rattlesnake Hills elk herd because they still have the potential to move from Hanford's ALE Reserve into the YTC along the Yakima Ridge, northeast of the reservoir. Elk have been observed within the Rattlesnake Hills and may be most affected by the southern realignment of the highway and utilities, as well as the associated recreational development.

Black Cottonwoods.—This alternative would improve cottonwood reproduction by seed in several, but not all, reaches as compared to the No Action Alternative. In the upper reaches, few changes would occur because summer flow remains high; thus, recruitment would continue at current low levels. In the Union Gap reach, spring flows would be higher, which would spur increased germination; late summer flows, however, are not much reduced, so the risk of scour remains. Thus, reproduction would increase moderately. The Wapato reach hydrograph shows both higher spring flows and much higher summer base flows, however, moving it closer to estimated natural conditions. These changes would be expected to lead to more frequent and larger (more seedlings) recruitment events. For the Naches River reach, a small reduction in the September flow surge caused by the flip-flop operation may spare some newly established seedlings from scouring, but would most likely not change reproduction dynamics. Even though cottonwood reproduction would be noticeably improved on only the Wapato and Union Gap floodplains, this would be a large overall improvement in cottonwood forest trends because these two river segments currently support the largest stands of cottonwood forest in the Yakima River basin.

Wetlands.—During an average water year, water releases associated with the Black Rock Alternative would increase flow and availability of water in the Yakima River (Wapato reach) during the mid-summer growing season. In some cases, this would double or triple the flows available under the No Action Alternative, but not reaching the peak flows that occur under the natural flow regime. These flows would probably result in the redistribution and a slight or moderate increase in area of palustrine emergent (PEM) and palustrine scrub-shrub (PSS) wetlands in the Wapato reach. Higher up in the basin, in the Cle Elum reach, releases from Cle Elum Lake would be less under this alternative, reducing scour of wetlands during the mid-summer growing season. PSS and PEM class wetlands would probably benefit under this alternative (Reclamation, 2007b).

The 0.9 acre of palustrine wetlands would be inundated by the proposed reservoir and permanently lost as habitat (Service, 2007b). Seepage from Black Rock reservoir and dam would provide subsurface and possibly surface flows that would likely create a wetland plant community in the presently intermittent Dry Creek downstream from the dam. This would create several miles of riparian and wetland habitat along the creek. If not managed specifically for wildlife habitat (i.e., to provide a plant community with native plant species), this area would likely attract invasive plant species such as Russian olive and other nonnative wetland vegetation with minimal habitat value. Fluctuations in the water level in Black Rock reservoir would not be conducive to growth of water-dependent shoreline plant community. The reservoir would generally be full or nearly so through the early part or the growing season, but the water surface elevation would decline rapidly in July and August. The west end of the reservoir pool has a very shallow slope, and a portion of this slope would likely become vegetated with some kind of wetland or riparian vegetation. In the upper end of Potholes Reservoir, near Moses Lake, which also has an extensive summer drawdown, an extensive area of shrub-scrub and forested wetlands exists. It is difficult to predict how much of the upper end of Black Rock reservoir would be vegetated.

4.7.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Similar to the Black Rock Alternative, wildlife would be most affected by noise and increased traffic caused by construction and maintenance of the reservoir and dam. However, the dam would be located near SR-821, which already creates some disturbance related to traffic in the area. Bighorn sheep may also avoid the area during the winter if construction occurs at that time.

Long-Term Impacts

Shrub-Steppe Habitat.—The Wymer Dam and Reservoir Alternative would have direct and indirect impacts on shrub-steppe vegetation and wildlife within the Lmuma Creek drainage. Many of the impacts would be similar to those described

for the Black Rock Alternative and include: inundation of shrub-steppe habitat; impacts to movement corridors; possible exotic plant species invasion; possible increase in fire susceptibility; and indirect impacts associated with the construction of facilities.

Habitat acreage within the footprint includes the following: 1,055 acres shrub-steppe habitat; 167 acres grassland; 62 acres barren land; 50 acres riparian area; 30 acres of cliff/canyon; 11 acres of agricultural cropland; 7 acres developed land; 6 acres forest habitat; 4 acres wetlands (Service, 2007b). Wildlife species known or that have the potential to use this area are included in table 4.20.

The HEP conducted at this site using Brewer's sparrow as the indicator species found that 378 habitat units that exist within the footprint of the reservoir and dam would be lost. The total area to be lost to reservoir inundation and the dam is about 1,400 acres. Of this total, about 1,200 provide habitat suitable for Brewer's sparrow. The relatively low number of habitat units for Brewer's sparrow at the site, relative to the number of acres, suggests it provides marginal habitat for the sparrow and other shrub-steppe species that it was intended to represent. If the entire site is used to estimate the number of habitat units, then the average value of the habitat, on a scale from 0.0 to 1.0, is about 0.27. If the lands not suitable for Brewer's sparrow are omitted, then the value is slightly higher—about 0.32. This indicates that the lands within the reservoir and dam footprint are of relatively low value for shrub-steppe species.

Indirect impacts could also occur at the site as a result of some increase in activity associated with operations and maintenance and recreation. Indirect adverse effects could include degradation of habitat adjacent to the site through introduction of nonnative invasive plants, increased development in the areas adjacent to the proposed reservoir, and increased fire danger. Currently, there is a fairly high level of recreational use occurring in the Yakima River Canyon just downstream from the damsite. Given the modest level of recreational enhancement proposed, the disturbed nature of much of the reservoir area today, and the existing level of recreational use in the area, these indirect impacts are not expected to be significant.

Elk movements within the Wymer reservoir vicinity would not be affected. Elk that are west of the Yakima River do not usually cross over, and the Rattlesnake Hills elk herd tends to stay in the YTC's southeastern portion or move north on the eastern side. There is migration southward from the Colockum and Quilomene elk herds, but there is little evidence that these herds move into the Wymer area.

Black Cottonwoods.—The Wymer Dam and Reservoir Alternative would result in only negligible changes in the floodplain flow patterns and would not have an effect on cottonwood reproduction as compared to the No Action Alternative.

Wetlands.—Under the Wymer Dam and Reservoir Alternative, flows in the Wapato reach would continue as under existing conditions. PEM and PSS class wetlands would not be affected; however, the degradation of palustrine forested (PFO) wetlands would continue due to the continuing lack of cottonwood recruitment. Eighty-three acres of palustrine (unclassified) wetlands would be inundated by the reservoir and permanently lost as habitat (Service, 2007b). Seepage from Wymer reservoir and dam would provide subsurface and possible surface flows that would likely expand the riparian and wetland plant community in Lmuma Creek downstream from the dam. Fluctuation in the water level in Wymer reservoir would not be conducive to the growth of water dependent shoreline plant community. Thus, no viable lakeshore fringe habitat value can be expected around the perimeter of the reservoir.

4.7.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Construction impacts for Wymer reservoir would be the same as for the Wymer Dam and Reservoir Alternative. In addition, there would be effects associated with the construction of the pump exchange system and location of the pipeline and pumping plants.

Long-Term Impacts

Shrub-Steppe Habitat.—The direct and indirect impacts regarding this alternative generally would be similar to those described for the Wymer Dam and Reservoir Alternative. Some additional losses of shrub-steppe habitat may occur if the buried steel pipeline and two of the pumping stations are located in such habitat. Based on the location described for the pipeline at this time, the losses would be very minor.

Movement Corridors.—Elk movement corridors would not be affected beyond the impacts discussed for the Wymer Dam and Reservoir Alternative.

Black Cottonwoods.—The pump exchange component of this alternative would have very similar effects on floodplain hydrographs and, thus, similar effects on cottonwood reproduction as under the Black Rock Alternative. Recruitment would be expected to increase moderately in the Union Gap reach and substantially on the Wapato floodplain, while no large changes would occur in other floodplains. This would be an overall improvement for cottonwood forests on the Yakima River because of the large spatial extent of cottonwood stands on the Union Gap and Wapato floodplains.

Wetlands.—Under the Wymer Dam Plus Yakima River Pump Exchange Alternative, summer flows downstream from Parker would be significantly higher than under the No Action Alternative. This flow scenario would probably result in the redistribution and a slight increase in area of PEM and PSS wetlands in the Wapato reach. Similar to the Wymer Dam and Reservoir Alternative, 83 acres of

palustrine (unclassified) wetlands would be inundated by the reservoir and lost (Service, 2007b). Seepage from Wymer reservoir and dam would provide subsurface and possibly surface flows that would likely expand the riparian and wetland plant community in Lmuma Creek downstream from the dam. At present, overgrazing by livestock is the most detrimental effect to the riparian plant community. Fluctuation in the water level in Wymer reservoir would not be conducive to the growth of water dependent shoreline plant community. Thus, no viable fringe habitat value can be expected around the perimeter of the reservoir.

4.7.2.6 Mitigation

Potential mitigation measures for either the Black Rock or Wymer Dam and Reservoir Alternative include the following:

- Create wetland and riparian habitats. This would entail constructing dikes in shallow water areas within the reservoir and maintaining adequate water levels for the production of wetland/riparian vegetation.
- Establish a wildlife management area adjacent to the reservoir in areas that would be able to provide suitable wildlife habitat.
- Install artificial perches on selected areas adjacent to the new reservoir to provide perches for raptors.
- Create, restore, and/or protect the amount of shrub-steppe habitat that would lead to production of a similar number of habitat units elsewhere within the Yakima River basin.
- Conduct plant surveys for threatened and endangered species, and protect any species discovered.

In addition to these mitigation measures, potential mitigation measures for the Wymer Dam Plus Yakima River Pump Exchange Alternative could include the following:

- Bury pipelines underground and restore native vegetation along the pipeline corridor. Develop a vegetation maintenance and monitoring plan.
- Locate any aboveground structures in areas that would cause minimal disturbance to wildlife and associated habitats.

4.7.2.7 Cumulative Impacts

Shrub-Steppe Habitat and Wildlife Movement Corridors

Shrub-steppe habitat in eastern Washington has been significantly altered by agricultural, residential, and urban development over the past century. There are three large areas of shrub-steppe remaining in the Yakima River basin, two are on

public lands, the YTC and the Hanford Reach National Monument, and the third is on the Yakama Reservation. These large blocks are protected from future residential and urban development. Management efforts are occurring or in the process of being implemented at these three remaining sites to preserve, restore, and increase shrub-steppe habitat and connectivity. Both the South Central Washington Shrub Steppe/Rangeland Conservation Partnership and Washington's Greater Sage-Grouse Recovery Plan seek to implement these objectives for the remaining tracts of shrub-steppe (Stinson et al., 2004). Currently, the partnership is acquiring a conservation easement for a private property located within the Rattlesnake Hills, south of Moxee (Burkepile, 2007).

Outside of these areas, the residual habitat and the wildlife that subsists within it continue to be threatened by urban and residential development and habitat fragmentation where shrub-steppe occurs on private land. While development to date has been primarily in the valley bottom where irrigated agriculture is dominant, shrub-steppe habitat is being lost to development in some places such as the north slope of the Moxee Valley, the north end of the Yakima River canyon south of Ellensburg, and near Richland and Kennewick. Losses of shrub-steppe habitat at either the Black Rock or Wymer sites would exacerbate these ongoing losses.

Black Cottonwoods

Riparian vegetation in alluvial basins in the Storage Study area has been significantly changed by human actions since at least the mid 19th century. Both upland and lowland watersheds have been dramatically altered by logging, infrastructure development, land clearance for agriculture, urban development, changing fire regimes, and beaver trapping (Eitemiller et al., 2000; McIntosh et al., 2000; Ring and Watson, 1999; Wissmar et al., 1994). Furthermore, direct changes to floodplains and channels have been dramatic since the early 1900s. Irrigation diversions, storage dams, and channel confinement have altered inter-annual and seasonal flow patterns, reduced total annual discharge, severed the connections between channel and floodplain, and changed geomorphic processes (Snyder et al., 2002). These direct changes have had negative consequences for cottonwood seed reproduction (Braatne et al., 2007). Overall, cottonwood forests have a diminished extent, older age structure, reduced diversity, less frequent stand recruitment, and altered species composition as compared to pre-European conditions.

Future actions that have the potential to affect black cottonwood recruitment include the Wapato Irrigation Project (WIP) conservation measures, planned growth in the Yakima River basin, and some Washington Department of Transportation (WDOT) projects.

The WIP conservation measures will add to instream flow levels in the Wapato reach of the Yakima River during summer months (irrigation season). Increased

summer base flows would benefit cottonwood reproduction as already explained. The volume to be added by the WIP conservation measures is likely to be small, perhaps on the order of 50 to 100 cfs during an average irrigation season (Crane, 2007). Such a small change would not significantly affect reproduction dynamics from the effects already described for each alternative. Growth in population and water demand has been forecast and incorporated in the modeled flow data; therefore, it has already been accounted for in the analysis. WDOT projects may have localized affects on flow but are not expected to affect flow or cottonwood reproduction dynamics over a river reach or valley segment scale. In summary, none of the reasonably foreseeable future actions would likely have any significant effect on cottonwood forest dynamics.

Wetlands

Cumulative impacts from other projects would most likely be beneficial or insignificant. The water conservation projects that increase flows in the rivers would benefit vegetative growth in the wetlands. Any projects that would have an impact to wetlands would be mitigated in order to minimize impacts by State and Federal agencies.

4.8 Anadromous Fish

4.8.1 Affected Environment

4.8.1.1 Columbia River

Extent of Affected Area

The areas of interest include the lower Priest Rapids Lake and the downstream segment of the Columbia River, including the Hanford reach, and extending to include the confluence of the Yakima River with the Columbia River (figure 2.2 in chapter 2).

Priest Rapids Dam is located at RM 397 on the Columbia River. The lake behind the dam is approximately 18 river miles long. The 7 river miles immediately upstream of the dam is like a lake, with slower currents and deeper water depths, while the uppermost 11 river miles of the pool is more like a river, with a faster current and shallower water depths.

The Hanford reach of the Columbia River extends approximately 62 river miles from the mouth of the Yakima River (RM 335) to Priest Rapids Dam (RM 397). The Hanford reach is the last remaining free-flowing portion of the Columbia River within the United States; however, flows are subject to daily fluctuations resulting from hydroelectric power generation at Priest Rapids Dam.

A more indepth description of the Hanford reach and Priest Rapids Lake can be found in Grant County PUD's *Final Environmental Impact Statement, Priest Rapids Hydroelectric Project, Washington* (FERC, 2006).

Status and Distribution

Spring and summer Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), steelhead (*O. mykiss*) and sockeye salmon (*O. nerka*) migrate through the Hanford reach and downstream from Priest Rapids Dam, destined to upriver subbasins (i.e., Wenatchee, Entiat, Methow, and Okanogan); fall Chinook spawn, rear, and begin their seaward migration within Hanford reach and, to some extent, in Priest Rapids Lake (FERC, 2006).

Anadromous Salmonids Status

Table 4.22 shows the 10-year average (1997-2006) of anadromous salmonid adult counts downstream from Priest Rapids Dam.

Table 4.22 10-year anadromous salmonid adult counts downstream from Priest Rapids Dam (1997-2006)

Species	10-year average fish count (1997-2006)	10-year range in fish counts (1997-2006)
Spring Chinook	17,852	4,186 - 52,120
Summer Chinook	50,400	13,922 - 96,167
Fall Chinook	33,702	11,266 - 54,453
Coho	2,896	19 - 11,186
Sockeye	55,683	10,769-124,943
Steelhead	12,838	5,837-29,963

Peak migration for adult anadromous salmonids through the Hanford reach and Priest Rapids Dam is April through November, while juveniles migrate downstream April through August though peak migration occurs April through June (table 4.23) (FERC, 2006).

Table 4.23 Summary of the upstream (adults) and downstream (juveniles) migration timing for anadromous salmonids in the Hanford reach and at Priest Rapids Dam.

Species/run	Upstream migration timing	Downstream migration timing
Spring Chinook	Upstream migration timing	April through June
Summer Chinook	Mid-May to mid-August	June through August
Fall Chinook	Mid-June to mid-August	June through August
Coho	Mid-August through November	April through June
Steelhead	September through November	April through June
Sockeye	July through November	April through June

4.8.1.2 Yakima River

Extent of Affected Area

The areas of interest include the existing and proposed reservoirs within the basin and the mainstem of the Yakima, Naches, and Tieton Rivers from headwater reservoirs to the confluence of the Yakima River with the Columbia River (figure 2.1 in chapter 2).

Distribution of Steelhead and Salmon

Spring and fall Chinook, coho, and steelhead currently reside in the Yakima River basin, while summer Chinook and sockeye have been extirpated. Coho were extirpated in the 1970s but were reintroduced in the mid-1980s. Spring Chinook spawn and rear as juveniles in the Bumping, American, upper Yakima, and Naches Rivers. Fall Chinook generally spawn and rear as juveniles in the Yakima River downstream from the Naches River to the mouth of the Yakima River. Steelhead spawn and rear as juveniles in many of the tributaries to the Yakima and Naches Rivers, including the mainstem of the Naches and upper Yakima (upstream of Roza Diversion Dam) Rivers. Coho (reintroduced) spawn and rear primarily in the Wapato and Ellensburg reaches of the Yakima River and in the lower Naches River downstream from the Tieton River. Some coho spawning and rearing is known to occur in Ahtanum, Cowiche, Taneum, Wilson, Reecer, and Big Creeks in the Yakima River; and Nile as well as Pileup Creeks and the North Fork of the Little Naches River in the Naches subbasin.

Anadromous Fish Status

The discussion of anadromous salmonid life histories is limited to spring Chinook and steelhead in this section. See an indepth discussion of spring and fall Chinook, coho and steelhead, their life history, and demographics in the Habitat Limiting Factors, Yakima River Watershed Final Report Haring (2001).
Table 4.24 provides annual Yakima salmon and steelhead adult counts at Prosser Diversion Dam.

Table 4.24 Annual Yakima salmon and steelhead adult counts at Prosser Diversion Dam (RM 47)

Year	Spring Chinook	Fall Chinook	Coho	Year	Steelhead
1997	3,173	1,120	1,312	1997-98	1,113
1998	1,903	1,148	4,679	1998-99	1,070
1999	2,781	1,896	3,943	1999-00	1,611
2000	19,101	2,293	6,216	2000-01	3,089
2001	23,265	4,311	5,046	2001-02	4,525
2002	15,099	6,241	818	2002-03	2,235
2003	6,957	4,875	2,354	2003-04	2,755
2004	15,289	2,947	2,389	2004-05	3,451
2005	8,758	1,942	3,115	2005-06	2,005
2006	6,314	1,528	4,510	2006-07	1,537
10-year average	10,264	2,830	3,438	10-year average	2,339

Salmon and steelhead were once abundant in the Yakima River basin, but native populations of sockeye, coho, and summer Chinook have been extirpated. Sockeye were historically present in many natural lakes within the basin, including Keechelus, Kachess, Cle Elum, and the smaller lakes upstream of Cle Elum and Bumping Lakes (Reclamation, 1999). Sockeye disappeared from the Yakima River basin with the construction of dams for storage reservoirs. Anadromous fish currently using the basin include steelhead, spring and fall Chinook, and coho (reintroduced). Anadromous fish spawn and the resulting young fish rear in the basin, juvenile fish migrate to the ocean to become adults, and adults return to spawn. While there are differences in the resource requirements for various species and life stages, there are also similarities, and the summer steelhead is used below to represent the general habitat requirements of anadromous fish in the Yakima River basin. Spring Chinook, because of the interest in the flip-flop operation, is also addressed.

Steelhead.—Steelhead are found in greatest abundance in Satus, Toppenish, Naches, and upper Yakima, and Ahtanum watersheds. Steelhead enter the Yakima River in greatest numbers September through November and then again in February through April (Haring, 2001). The majority of adults spend the winter months holding in deep, slow pools in the Yakima River in the vicinity of Satus Creek, though some move into the Naches and upper Yakima Rivers. Adults spawn March through June, with early spawning occurring in Satus and Toppenish watersheds and late spawning occurring in the Naches and upper Yakima watersheds. The majority of spawning occurs in tributaries rather than the mainstem of the Naches and upper Yakima Rivers. Similar to other salmon species, steelhead require small gravels free of fine sediment for successful egg incubation and hatching. Fry emerge from the gravel from May into July, with Satus and Toppenish fry emerging beginning in May, and Naches and upper Yakima fry emerging in June and July. Like all salmon species, emergent steelhead fry require shallow and very slow-velocity water, preferably with associated cover to avoid predators. As young steelhead grow in size, they seek deep and faster velocity water with associated cover that provides both protection from predators and resting areas. Yakima River basin steelhead spend from 1 to 3 years living in freshwater before they begin their seaward migration. April is the peak outmigration month at the Chandler Juvenile Monitoring Facility located at Prosser Diversion Dam (RM 47). As with other salmon species, steelhead rely on spring freshets to successfully move them downriver through the Yakima River into the Columbia River.

Spring Chinook.—The upper Yakima, Naches River subbasin, and American River spawning groups comprise the Yakima River basin spring Chinook population. About 60-70 percent of the population returns to the upper Yakima (Keechelus Dam to Ellensburg) and Cle Elum Rivers annually. Adult spring Chinook return to the Yakima River beginning in late April through June and swim upstream to their spawning areas. However, spawning does not occur

until August (American River) and September (Naches and upper Yakima). Pre-spawning adults require deep holding pools with adequate overhead cover and water that is cool and well oxygenated. Females typically build their spawning nests near the streambank, close to cover, in water 12 to 30 inches deep with moderate velocities. Successful egg incubation and fry emergence requires spawning gravels that are relatively free from fine sediments which can impede water percolation through the spawning nest and entomb emergent fry. Emergent spring Chinook fry seek out quiet, shallow waters with instream cover near the shoreline, which afford a hospitable rearing environment. As the juveniles increase in size, they move into deeper, faster water—preferably with instream cover such as a log jam or overhanging vegetation along the bank margin. The combination of faster water with resting areas created by the instream cover allows juveniles to dart into the current to capture drifting insects and then return to the area of low velocity. A portion of the juveniles will slowly move downstream from the time of emergence throughout the summer. With onset of cooler water temperatures in the fall, a more pronounced downstream movement of juveniles begins in late September and can extend through the winter. It is thought that most of these fall-winter moving juveniles spend the winter in deep, quiet water with overhead cover in the lower Naches and Yakima (upstream of Prosser Diversion Dam) Rivers. After spending 1 year in fresh water, spring Chinook begin their seaward migration, with the majority passing Prosser Diversion Dam (RM 47) in April. Returning adults can spend from 1 to 3 years in the ocean before returning as a spawning adult to the Yakima River basin.

4.8.1.3 Habitat Conditions for Anadromous Fish

Habitat is defined as ". . . the combination of resources (like food, cover, water) and the environmental conditions (temperature, precipitation, presence or absence of predators and competitors) that promotes occupancy by individuals of a given species (or population) and allows those individuals to survive and reproduce. . ." (Morrison et al., 1978).

Numerous instream and floodplain elements of habitat (e.g., substrate, large woody debris [LWD], pool frequency and quality, off-channel areas, and refugia) combine to produce habitat heterogeneity and are vital to the production and maintenance of native fish assemblages (Everest et al., 1985; Bjornn and Reiser, 1991; Karr, 1991; Spence et al., 1996; National Research Council [NRC], 1996; NOAA Fisheries, 1996). The interaction of these habitat elements, combined with streamflow and other physicochemical determinants, produce a complex mosaic under which native aquatic species assemblages evolved and live.

Flow/Hydrology

The results of other studies suggest that the natural, unregulated flow regime of the Yakima River and its tributaries was the master variable that nourished the distribution and abundance of riverine species and sustained the ecological

integrity of the ecosystem via physicochemical processes that provide riverine structure and function (Leopold et al., 1964; Schlosser, 1985; Resh et al., 1988; Allan, 1995; Power et al., 1995; Stanford et al., 1996; Poff et al., 1997).

Flow variability provides ecological benefits to floodplain ecosystems and the terrestrial and aquatic organisms that depend upon them (Williams and Hynes, 1977; Chapman et al., 1982; Poff and Ward, 1989; Closs and Lake, 1996). The natural timing of variable flows provides numerous environmental cues for fish to spawn, hatch eggs, rear, move to off-channel floodplain habitats for feeding or reproduction, and migrate upstream or downstream, etc. (Seegrist and Gard, 1972; Montgomery et al., 1983; Nesler et al., 1988; Junk et al., 1989; Welcomme, 1992; Naesje et al., 1995; Sparks, 1995; Trepanier et al., 1996, Poff et al., 1997).

Under the current condition, riverflows are substantially altered as a result of storing water in the reservoirs in the winter and diverting water in the spring, summer, and fall to meet entitlements, primarily for irrigation. Flow regimes that deviate substantially from the natural condition, as is currently the case in the Yakima River basin, are well understood to produce a diverse array of ecological consequences (Hill et al., 1991; Ligon et al., 1995; Richter et al., 1996; Stanford et al., 1996). While a range of flows is vital to the structure and function of aquatic ecosystems, stable base flows are important in supporting high growth rates for fish that are timed with periods of high ecosystem production (i.e., late spring through early fall; Binns and Eiserman, 1979; Poff and Ward, 1989; Stanford et al., 1996).

Thus, natural streamflow variability has a controlling effect on the biology of native aquatic species assemblages, and the physical and chemical ecosystem attributes upon which they depend for survival. Current conditions have inverted and truncated the natural flow regime, producing river systems that are out of phase with their natural runoff regimes.

Temperature

Perhaps no other environmental factor has a more pervasive influence on salmonids and other aquatic biota than temperature (Brett, 1956; Hynes, 1970; Spence et al., 1996). Temperature influences all aspects of fish life, as well as those of the macroinvertebrates (Sweeney and Vannote, 1986; Bjornn and Reiser, 1991) and primary producers (algae, bacteria, etc.) that dwell within the stream and serve as food for fish (Hynes, 1970). The majority of aquatic organisms are cold-blooded, meaning that their body temperatures and metabolic demands are determined by the temperature of the environment in which they live.

Slight changes in stream temperatures that differ from the natural condition can alter the processes listed above, and most often adversely affect native aquatic species assemblages (Groot et al., 1995; Spence et al., 1996; McCullough, 1999). Quantitatively defining the effects of temperature on key biological functions is essential for understanding how temperature contributes to fish success, how it

places species at risk, and how moderating and controlling the thermal regime can contribute to recovering impaired populations (McCullough, 1999; Sullivan et al., 2000). However, it is a widely held view that high water temperatures are one of the most harmful environmental variables affecting salmonid extent, biomass, and survival (Spence et al., 1996).

Dams, riparian vegetation removal, water withdrawal and regulation, irrigated agriculture, channel engineering (e.g., straightening, channelization, diking, revetments, etc.), urbanization, increasing impervious surfaces, and floodplain development alter the factors that drive stream temperature (Poole and Berman, 2001). All of these factors occur in the Yakima River basin to some extent and have altered the temperature regime from the predevelopment, natural condition. Water temperature, especially in the lower Yakima River, has consistently been acknowledged as a factor affecting salmonids, especially during some life stages. High temperatures at the mouth of the Yakima River may affect anadromous fish, including migrating smolts and adults. In the upper parts of the basin, bottom draw release structures like those used at Keechelus, Kachess, Cle Elum, Rimrock, and Bumping Dams provide thermally homogeneous, cold discharge to the Yakima, Kachess, Cle Elum, Tieton, and Bumping Rivers, which may interfere with certain aspects of salmonid ecology in the Yakima River basin (e.g., migration cues, spawn timing, and growth).

Sediment

Suspended sediment is a naturally variable phenomenon in riverine ecosystems, and increased concentrations above background levels are most strongly correlated with erosional processes and elevated discharge observed during spring runoff, or discrete precipitation events. Heavy loads of suspended sediments directly impact salmonids through their avoidance of impacted habitats, mortality (in extreme cases), a skewed distribution of prey species within the habitat, reduced feeding and growth, and reduced tolerance to disease (Waters, 1995). Sediment and bedload movement occur naturally. It is acknowledged that sediment (fine sediments to cobble) transport is beneficial to the ecological health of a river system (Poff et al., 1997). However, irrigated agricultural activities have altered the timing, volume, and magnitude of sediment movement in the river by modifying the magnitude and timing of riverflows.

Large Woody Debris

In recent years, the relationship between LWD (loosely defined as trees greater than 4 inches in diameter, greater than 6 feet long, with or without the root wad attached), riparian vegetation, and fish habitat has received much emphasis in the Pacific Northwest. Flow regime alteration by impoundment and diversion can affect the cycling of organic and inorganic materials, including LWD. Numerous authors have described the interactions between LWD and stream ecosystems (Bisson et al., 1987; Sedell et al., 1988; Bilby and Bisson, 1998). Additionally, the influence of LWD on channel morphology (Keller and Swanson, 1979; Lisle,

1986; Bilby and Ward, 1991; Montgomery et al., 1996) and its importance to the ecology of native aquatic species assemblages in the Pacific Northwest (Abbe and Montgomery, 1996; Naiman et al., 1992; 1998; McIntosh et al., 1994; Naiman and Décamps, 1997) has also been documented and analyzed. LWD is an important element in the creation of complex habitats and pools.

Recruitment of LWD has likely been affected by many human activities in the Yakima River basin. First, headwater source areas were removed from the river continuum by construction of the storage dam embankments on the Yakima, Kachess, Cle Elum, Tieton, and Bumping Rivers. Natural lakes on all these streams, except the Tieton, may have acted to some extent as LWD "traps" before the dams were built. Farther down the system, diversion structures may impede the transport of LWD though, to large extent, LWD is simply passed over these structures as part of operations. Secondly, flow regulation and extraction has contributed to impaired floodplain function along alluvial reaches of the river (Snyder and Stanford, 2001). Cottonwoods (*Populus spp*.) are a primary species along the alluvial floodplain reaches of the Yakima River basin. Their growth and survival are important to the aquatic ecosystem. The status of cottonwoods in the Yakima River basin is discussed further in the "Vegetation and Wildlife" section of this chapter.

Channel Condition and Dynamics

Truncation of flood peaks by capturing them in reservoirs reduces the duration, magnitude, and spatial extent of floodplain inundation. This not only alters the quantity, quality, and timing of groundwater discharge to the river but also diminishes the availability, extent, and temporal duration of off-channel habitats for anadromous and resident fish. Among the myriad habitat attributes of these floodplain ecosystems, off-channel areas provide complex, diverse habitats for cold water fishes. Flood flows form and maintain the channel network including side channels. In turn, side channels and sloughs provide a large area of edge habitat and slower water velocities favored by early salmonid life stages (Pringle et al., 1988; Naiman et al., 1988; Stanford and Ward, 1993; Arscott et al., 2001). Spring brooks receiving discharging groundwater provide low-velocity, thermally moderate, food-rich habitat for juvenile fish. For salmonids in the Yakima River basin, these side-channel complexes likely help to increase productivity, carrying capacity, and life history diversity by providing suitable habitat for all life stages in close physical proximity (Ring and Watson, 1999; Snyder and Stanford, 2001).

Floodplain disconnection combined with flow regulation has reduced river floodplain interactions in the Yakima River basin. Of particular importance has been the loss of habitat complexity, including connectivity between off-channel and mainstream habitats, which directly relates to the ability of the ecosystem to support salmonid populations, including steelhead and bull trout. Flood control dikes and levees and railroad and highway construction have disrupted the lateral connectivity between wetted areas that occurred historically (Eitemiller et al.,

2002). This deprivation of lateral connectivity has resulted in loss of habitat, reduced vertical connectivity, loss of or changes in nutrient flux, and reduction in the tempering affect of groundwater on stream temperature. The result has been a significant loss, compared to pristine conditions, of horizontal and vertical connectivity, diminished habitat heterogeneity through the loss of off-channel habitat, and a general loss of ecosystem function.

Habitat Alterations

Alterations in the aquatic ecosystem have affected the habitat of anadromous fish in the Yakima River basin. In its most basic form, regulation alters streamflow volume, sediment transport, floodplain connectivity, and water temperature.

The Yakima River basin has experienced well over 100 years of Euro American development, with a marked increase seen after the advent of storage reservoirs and watercourse (e.g., canals, drains, ditches, laterals) development in the early twentieth century. Consequently, there is a long history of forest practices and floodplain development for irrigated agriculture, urban centers, roadways, railways, and housing (McIntosh et al., 1994; Reclamation, 2000). As development progressed, so did the magnitude and extent of floodplain revetments (e.g., levees, road and railway prisms, riprap, etc.) intended to protect local infrastructure. However, floodplain activities and revetments have armored, shortened, realigned, and simplified many miles of mainstem and tributary habitat in the Yakima River basin (Dunne and Leopold, 1978; Snyder and Stanford, 2001; Braatne and Jamieson, 2001). Consequently, channel form and processes have been altered (Leopold et al., 1964), and the potential for normal riparian processes (e.g., shading, bank stabilization, and LWD recruitment) to occur is diminished (Ralph et al., 1994; Young et al., 1994; Fausch et al., 1994; Dykaar and Wigington, 2000). Ultimately, the once diverse and extensive assemblage of riparian and aquatic habitats in the Yakima River and its tributaries has become simplified (Stanford et al., 1996; Ring and Watson, 1999).

As a result of irrigation development in the Yakima River basin, including development of the Yakima Project, runoff in the system has become highly regulated for multiple purposes. Regulation of streamflow—whether that regulation is for flood control, irrigation, or for some other purpose—alters the physical environment of the system (Collier et al., 1996; Stanford et al., 1996; Poff et al., 1997; Friedman et al., 1998).

4.8.2 Environmental Consequences

As discussed, flow is an important variable affecting many aspects of habitat suitability for anadromous fish. Consequently, the various alternatives being considered could affect anadromous fish primarily by altering habitat quantity

and quality as a consequence of changing the flow regime in various parts of the basin and at various times. These flow changes drive most of the following anadromous fish effects analysis.

Two of the alternatives also change the source of the water for some of the basin's irrigation. This potentially affects the homing of anadromous fish into the Yakima River basin and is also an important part of this analysis.

4.8.2.1 Methods and Assumptions

Columbia River

An issue identified by the Biology Technical Work Group (2004) was the potential effects of water withdrawal from Priest Rapids Lake to fill Black Rock reservoir on anadromous fish spawning and rearing habitat, fry and juvenile stranding, and passage and migration.

The report by Anglin et al. (2006) discussing the effects of hydropower operations on the Hanford reach fall Chinook population was used to assess the potential effects of water withdrawal from Priest Rapids Lake on anadromous fish spawning, rearing and stranding. Specifically, Anglin et al. (2004) provide information on changes in fall Chinook spawning and rearing habitat and in juvenile stranding as a function of river discharge.

The *Assessment of the Effects of the Yakima Basin Storage Study on Columbia River Fish Proximate to the Proposed Intake Locations* (Reclamation, 2008b) examined the effects of the Black Rock pumping station located at Priest Rapids Lake on anadromous and resident fishes residing in or migrating through the pool. The report also provides a list of fish species documented to reside in or migrate through the Priest Rapids Lake.

Yakima River

RiverWare and Flow Data—Most of the indicators for anadromous fish link at some point to the flow data generated from the Yak-RW model. Results at critical locations in the river system are discussed in the "Water Resources" section. The Yak-RW model is a riverflow model used to estimate daily average streamflow at several locations throughout the Yakima River basin, plus estimate daily irrigation diversions and estimate daily reservoir storage volume by reservoir for each alternative. A detailed description of the Yak-RW model is found in the *System Operations Technical Document* (Reclamation, 2008c).

Temperature.—There were no substantial differences in water temperature between the Joint Alternatives and the No Action Alternative for the Yakima River stream reaches between Roza and Prosser Diversion Dams, which was the modeled reach, as shown in the "Water Quality" section. Because there were no substantive differences in water temperature between alternatives, this topic is not

discussed further for the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives.

Indicator 1: Summer Rearing Habitat in the Easton and Ellensburg Reaches for Spring Chinook and Steelhead Fry and Yearlings.—

Description.—Typically, in unregulated streams, low streamflows occur in the summer after the spring snowmelt, resulting in the creation of more pool habitat preferred by juvenile salmonids. In the upper Yakima River, storage releases for irrigation delivery result in high flow levels and associated water velocities which reduce the amount of suitable rearing habitat. This results in fish occupying unfavorable habitats that decrease juvenile survival. Consequently, the river environment is not capable of supporting a larger fish population.

This indicator quantifies the difference in the amount (acres) and percent in juvenile spring Chinook and steelhead summer rearing habitat relative to the No Action Alternative for the Easton and Ellensburg reaches, which represent the upper Yakima River where high summer flows occur in important salmonid rearing areas. Of the five reaches that were modeled to describe the flow to fish habitat relationship, these two reaches were selected for this indicator because they are located in the upper Yakima River where high summer flows occur.

Method.—The DSS model for the Easton and Ellensburg reaches was used to estimate the amount (acres) and difference in summer rearing habitat for the spring Chinook and steelhead fry and yearling life stages for each of the three alternatives compared to the No Action Alternative.

Estimated daily average streamflows for each alternative are supplied as output from the Yak-RW model. The relationship between habitat quantity and streamflow for each species and lifestage requires output from the two-dimensional hydraulic flow models that were developed for the Easton, Ellensburg, Union Gap, Wapato, and lower Naches River reaches.

A detailed description of the DSS model and its development for the Yakima River basin is found in the USGS draft Open File Report 2008 (forthcoming) (Bovee et al., 2008).

Two-Dimensional Hydraulic Model Description.—This study used the SRH-W (formerly GSTAR-W) and the River2D two-dimensional hydraulic models to characterize the riverflow conditions over a range of streamflows in the Easton, Ellensburg, Union Gap, Wapato, and lower Naches River reaches. A description of the SRH-W model is found on Reclamation's Web site at: http://www.usbr.gov/pmts/sediment/model/srh2d/index.html and a description of for the University of Alberta's River2D model is found at: http://www.river2d.ualberta.ca/description.htm.

Hydraulic models are physical models that describe how flow moves through a channel based on its configuration, slope and the amount of discharge. For this analysis, the river channel bathymetry (the three-dimensional contour of the wetted river channel) was measured primarily using an aerial topography mapping system (LIDAR) supplemented in some locations with traditional surveys and hydroacoustic mapping. Using the channel shape data, the two-dimensional hydraulic model estimates channel width, water depth and velocity, and water surface elevation at points throughout the modeled reach arranged in a grid pattern. These physical parameters were later used to characterize fishery habitat (e.g., pool, riffle, glide).

Development of the two-dimensional hydraulic model for the Easton, Ellensburg and lower Naches River reaches is discussed by Hilldale and Mooney (2007e) in Technical Series No. TS-YSS-12. Development of the two-dimensional hydraulic model for the Union Gap and Wapato reaches is discussed in Appendix 1 of Bovee et al. (2008).

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers for Yearling Steelhead and Spring Chinook.—

Description.—Unnatural and relatively sudden changes in streamflow and elevation can disrupt the habitats of both fishes and aquatic insects.

The first measurement for this indicator is the average rate of change in daily streamflow between pre- and post-flip-flop for the Easton, Ellensburg, and lower Naches River reaches. This measurement provides a method to determine how significant the average rate of change in daily streamflow might be in terms of spatial change in habitats for juvenile salmonids. The greater the rate of change in average daily streamflow, the greater the potential for habitat disruption.

The second measurement for this indicator is the pre- and post-flip-flop average median streamflows for the Easton, Ellensburg, and lower Naches River reaches. This measurement provides some context for what the daily streamflows were just prior to and after flip-flop and the absolute change in magnitude in streamflows pre- and post-flip-flop.

Method.—The Yak-RW model was used to estimate the daily median streamflow for the Easton, Ellensburg, and lower Naches River reaches for each alternative. These flows were used to calculate the average rate of change in streamflow and the absolute change in the magnitude of flows between pre- and post-flip-flop.

The average rate of change in daily streamflow between pre- and post-flip-flop was calculated by taking the difference in the average median flow for the pre (August 1-15) and post (September 14-28) flip-flop periods. The difference in average median flow between pre- and post-flip-flop was divided by 30 days, the

numbers of days from the start to the completion of the flip-flop operation, to determine the average daily rate of change in flow during the flip-flop operation.

The change in the magnitude of streamflows for the Easton, Ellensburg, and lower Naches River reaches was calculated as the difference between the average median streamflows for pre- and post-flip-flop. The pre- and post-flip-flop periods were August 1-15 and September 14-28, respectively.

Indicator 3: Spring Flow Downstream from the Parker Gage.—

Description.—The reduction in the magnitude, frequency, and runoff pattern of spring freshets that smolts rely on for their seaward migration causes increased migration time and exposure to predators, an environment more conducive for predators, and body chemistry issues related to delayed migration into saltwater. This decreases survival rates to the Columbia River.

Method.—This indicator measures the volume (acre-feet) of water that flows downstream from the Parker gage during the spring season of March through June based on average daily flows generated by the Yak-RW model. For the No Action Alternative, the spring season water volume is compared to the desired target volume and is expressed as a percentage how much it is above or below the target volume. The three Joint Alternatives are compared to the No Action Alternative in a similar fashion.

The spring freshet runoff pattern, as opposed to the runoff quantity, for the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives is qualitatively compared to the No Action Alternative and is ranked as “no change” or “improved.”

This indicator provides a way to gauge what the potential change in smolt survival might be by comparing the percent change in spring flows under an alternative to the No Action Alternative.

Indicator 4: July-September Flow Downstream from the Parker Gage.—

Description.—Reduced summer flows in the Wapato floodplain, considered some of the best salmonid habitat that remains in the basin, is an issue because of reduced availability of summer rearing habitat. Of concern is the loss of off-channel and side-channel habitat.

Method.—The indicator is the amount of coho summer yearling habitat (acres) in the Wapato reach. The DSS model was used to estimate the average amount of habitat in the Wapato reach for the summer period of July through September. Total habitat quantity and how it compares to the No Action Alternative was recorded. The coho summer yearling life stage was selected

because juvenile coho are present in the Wapato reach during the summer and readily use pool and side-channel habitat for summer rearing.

Indicator 5: Estimated Anadromous Fish Population Size.—

Description.—The projected numerical response of the anadromous fish populations to the three alternatives compared to the No Action Alternative provides a way to estimate the anadromous fishery benefits.

Method.—The EDT model provides estimates of population size and productivity for salmon and steelhead based on the quantity and quality of habitat within a watershed. On the basis of the quantity and quality of habitat, the EDT model tracks population survival by life stage. Survival rates remain static across alternatives for all lifestages that occur outside of the Yakima River basin (e.g., lower Columbia River, Columbia River estuary, and ocean). Therefore, any observed differences in population size between alternatives are due to differences in habitat quantity and quality within the Yakima River basin specific to each alternative.

Output from the Yak-RW (daily flow) and the two-dimensional hydraulic habitat models provided input for the EDT flow and habitat attributes for each alternative. Information pertaining to the relative change in daily maximum water temperature between alternatives generated by the USGS-Tacoma's water temperature model was used for stream reaches from Roza to Prosser Diversion Dams. (See the "Water Quality" section for a model description.)

This analysis used the EDT model in conjunction with the AHA model to compare change in average annual escapement of steelhead and spring Chinook between alternatives based on a 100-year simulation which takes into account fluctuations in ocean survival. Fish escapement numbers are inclusive of both natural and hatchery fish populations.

A disparity occurs in the escapement numbers for coho between observed (table 4.25) and those estimated by the EDT and AHA models. This disparity occurs because the EDT model estimates population equilibrium abundance; meaning the population is approaching full capacity for current habitat conditions. The Yakima coho population is relatively new, being reintroduced in the mid-1980s and has not fully expanded into all potential reaches in the basin.

Indicator 6: False Attraction.—

Description.—Because the Storage Study is currently in a planning feasibility phase, it was deemed prudent to initially address the issue of false attraction through a literature review and expert opinion. Reclamation's Technical Service Center secured the expertise of Dr. Andrew Dittman with NOAA Fisheries, Northwest Fisheries Science Center, and Dr. Thomas Quinn,

University of Washington, School of Aquatic and Fishery Sciences, to assist in assessing the possible outcomes of false attraction associated with the Storage Study. A complete discussion of their work can be found in Technical Series No. TS-YSS-13 entitled, *Assessment of the Effects of the Yakima Basin Storage Study on Columbia River Fish Proximate to the Proposed Intake Locations* (Reclamation, 2008b).

Method.—Dittman and Quinn identified four primary questions to be evaluated regarding the issue of false attraction for the Storage Study: For both the Yakima and Columbia Rivers, how does the infusion of Columbia River water into the Yakima River affect the homing/straying patterns of:

- Salmon that migrated to sea before the diversion was completed and thus were not exposed to an admixture of Yakima-Columbia River water prior to returning as adults?

- Salmon that migrated to sea after the diversion was completed and thus were exposed to an admixture of Yakima-Columbia river water prior to returning as adults?

They identified two issues that could influence the effect of Columbia River water entering the Yakima River on Yakima returning adult salmon. These issues were: the proportion of Columbia River water entering the Yakima River through the irrigation system; and to what extent is the chemical signature of the Columbia River water lessened as it is exchanged through seepage through the soil? Dittman and Quinn had no way to quantify this influence. In general, it is assumed that both a smaller proportion of Columbia River water and/or increased exposure of this water to Yakima River basin soils will decrease the risk of false attraction for Yakima returning adult salmon.

They suggest there is likely to be a decreased risk of false attraction for Yakima returning adult salmon that, as juveniles, were incubated, hatched, and reared on Yakima River water after the diversion of Columbia River water commenced (termed first-generation fish), as opposed to returning adults that, as juveniles, incubated, hatched, and reared on Yakima River water prior to the influence of Columbia River water (termed second-generation fish), but return after the diversion of Columbia River water commenced.

For salmon returning to rivers upstream of the Yakima River confluence (i.e., Wenatchee and Methow) for both before and after the release of Columbia River water into the Yakima River basin, Dittman and Quinn suggest that the risk of false attraction by these salmon populations would be less than compared to the false attraction risk for Yakima returning adults to the Yakima River described above. Their rationale was that Columbia River water entering the Columbia River at the Yakima River confluence would be sufficiently modified in terms of

the chemical signature that returning adults would be seeking as a homing queue. They suggest the greatest risk would be to the first-generation fish compared to the second-generation fish.

4.8.2.2 Summary of Impacts

Columbia River

The amount of change in fall Chinook spawning habitat in the Hanford reach due to power generation is expected to be much greater than that which may result from the maximum withdrawal of 3,500 cfs from Priest Rapids Lake to fill Black Rock reservoir. For example, riverflows on the Hanford reach in 2004 measured at White Bluffs (RM 370) during the peak fall Chinook spawning period (November 4-14) fluctuated from a low of approximately 50,000 cfs to a high of 160,000 cfs (Anglin et al., 2006), which is several times greater than the water withdrawal associated with the filling of Black Rock reservoir. In addition, the water withdrawal pumping schedule adheres to the spawning flow requirements dictated by the Vernita Bar Agreement approved by FERC in 1980.

Nugent et al. (2002a, 2002b, 2002c) report that during the period of fall Chinook emergence and rearing, the Priest Rapids Dam tailrace can fluctuate up to 6.9 feet (2.1 meters) per hour and 13.1 feet (4 meters) per day in a 24-hour period. Fluctuations in river stage occur in the Hanford reach year-round as a result of power generation. The effect on habitat for juvenile anadromous salmonids and stranding would likely overshadow the small decrease in the amount of available habitat in the Hanford reach as a consequence of pumping 3,500 cfs from the Priest Rapids Lake based on the juvenile fall Chinook habitat to river discharge relationship defined by Anglin et al. (2006). Furthermore, pumping from Priest Rapids Lake occurs only when there is water available above the established flow targets downstream from Priest Rapids Dam. In conclusion, water withdrawal from the Priest Rapids Lake is not expected to have a substantive change in habitat availability or a change in the risk for stranding for juvenile anadromous salmonids residing in the Hanford reach.

In all likelihood, the Priest Rapids Lake elevation would remain unchanged to maintain optimal pool elevation for power generation. Therefore, there are no anticipated impacts to anadromous fish residing in the lake.

If river outflow at Priest Rapids Dam is reduced by the amount of water withdrawn by pumping into Black Rock reservoir (maximum 3,500 cfs) to maintain pool elevation, it is not expected to affect anadromous adult fish migrating downstream from Priest Rapids Dam.

The maximum amount of water that is pumped from the Priest Rapids Lake is 3,500 cfs. This amount of pumping equates to approximately 2.2 percent of the riverflows in September and October to 4.7 percent in June. The quantity of water pumped on a monthly basis is presented in chapter 2. The greatest pumping

occurs in September, October, and June, and the least amount occurs in February, March, and December. The pump intake channel (depicted in chapter 2) is approximately 3,600 feet upstream of the dam on the right bank and is approximately 2,400 feet long before reaching the fish screens and fish bypass system. The screens are designed to meet Washington State Department of Fish and Wildlife screen criteria.

It is not likely that many anadromous salmonid smolts would become entrained into the pump intake channel because their outmigration behavior is to follow the thalwag where the river current is the fastest. Typically, smolts do not outmigrate near shore where the current is slow, which is where the entrance to the pump intake channel is located. Additionally, the approximate average monthly percent of water being pumped from the Columbia River is April, 0.2 percent; May, 0.2 percent; and June, 1.2 percent.

Similarly, entrainment of juvenile salmonids rearing in the lake is expected to be minimal because of their preference for habitat that consists of a shear zone (slow-moving water that transitions to faster moving water that provides both resting and drift insect feeding habitat) that would be nonexistent in the pump intake channel. Furthermore, no water withdrawal occurs in July and August, and the approximate average monthly percent of water being pumped in September is 5 percent.

No significant mortality is expected of juvenile anadromous salmonids in association with the fish screens because the State's fish screening criteria are designed to safely pass juvenile salmonids. However, the potential exists for increased predation of juvenile salmonids that are entrained into the pump intake channel and use the fish bypass system back into the Columbia River where predators typically congregate.

Yakima River

Table 4.25 summarizes the effects of the alternatives on the selected indicators for spring Chinook and steelhead.

4.8.2.3 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Under the No Action Alternative, the flow regime is about the same as under the current condition. Winter and spring flows throughout the systems are essentially unchanged as a result of water conservation. Summer flows increase slightly in some reaches, mostly downstream from Parker, as water that currently is released

Table 4.25 Summary of impacts on the selected indicators for spring Chinook and steelhead

Resource indicator	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
	Area (acres)	Area (acres) and percent change relative to the No Action Alternative		
High summer flows in the upper Yakima and Cle Elum Rivers (acres of available habitat)				
Easton reach				
Steelhead fry habitat	4.1	4.4 7.3%	4.4 7.3%	4.3 5.5%
Steelhead yearling habitat	57.9	63.9 10.4%	58.6 1.7%	58.7 1.3%
Spring Chinook fry habitat	2.5	2.4 -4.0%	2.5 0.0%	2.5 0.0%
Spring Chinook yearling habitat	47.9	52.6 9.8%	49.3 2.9%	49.0 2.3%
Ellensburg reach				
Steelhead fry habitat	2.2	2.1 -4.5%	2.1 -4.5%	2.1 -4.5%
Steelhead yearling habitat	20.2	26.1 29.2%	20.5 1.5%	20.6 2.3%
Spring Chinook fry habitat	1.7	1.8 5.9%	1.8 5.9%	1.8 4.5%
Spring Chinook yearling habitat	14.9	14.6 -2.0%	13.8 -7.4%	14.5 -2.4%
Rate of change flip-flop (average cfs per day August 15 to September 14)				
Easton reach	-8 cfs	-4 cfs	-7 cfs	-6 cfs
Ellensburg reach	-78 cfs	-51 cfs	-58 cfs	-57 cfs
Lower Naches River reach	34 cfs	20 cfs	37 cfs	36 cfs
Reduced spring freshets downstream from the Parker gage (percentage difference in spring season flow between the alternative and flow objective; if >=0 then target flow reached)				
Stream runoff timing	-7% Not applicable	29% Improved	-10% No change	11% No change
Summer flows downstream from the Parker gage (acres of available habitat)				
Coho yearling habitat				
Total	63.7	64.7 1.5%	63.7 -0.1%	66.4 4.1%
Mainstem	56.7	44.2 -22.0%	56.7 -0.2%	41.8 -26.2%
Side channel	7.0	19.8 184.9%	7.0 0.6%	23.6 239.7%
Average annual fish escapement (includes harvest) numbers (natural + hatchery)				
Spring Chinook	7,189	9,066	7,294	8,428
Fall Chinook	6,893	11,128	7,112	9,321
Coho	8,475	10,242	8,591	9,392
Steelhead	2,700	4,067	2,724	3,338

from storage and diverted downstream for irrigation remains instream to meet the higher flow objectives. Because the conservation is achieved by improving efficiency, which reduces return flow, the effects are limited to the reaches where conservation occurs. Downstream from those reaches, there is no effect. The magnitude of the streamflow changes varies by reach. At the Parker gage, the increase is estimated at 136 cfs in average or wet years and about 90 cfs in dry years. Because the flow regimes under this alternative are essentially the same as under the current condition, the indicators linked to flows generally reflect conditions that currently exist.

Indicator 1: Summer Rearing Habitat in the Easton and Ellensburg Reaches for Spring Chinook and Steelhead Fry and Yearlings.—The habitat quantity amounts for each reach and species/life stage are presented in table 4.25. These values are essentially the same as under the current condition. Only habitat changes near or greater than 10 percent are discussed in the text, but all values are presented in table 4.25.

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers for Yearling Steelhead and Spring Chinook.— Flows decrease in the Easton reach at an average rate of 8 cfs per day during the flip-flop period from mid-August to mid-September. At the same time, flows in the Ellensburg reach decrease at an average rate of 78 cfs per day, while flows in the lower Naches River increase at an average rate of 34 cfs per day (table 4.25).

The average difference in flow between pre- and post-flip-flop is Easton: -245 cfs; Umtanum: -2,354 cfs; and lower Naches: +1,016 cfs.

Indicator 3: Spring Flow Downstream from the Parker Gage.—Median spring season (March-June) flow downstream from the Parker gage under the No Action Alternative is 2,274 cfs, or 291 cfs greater than under the current condition (1,983 cfs). This greater spring flows downstream from the Parker gage is considered beneficial because it could improve anadromous salmon smolt outmigration survival through the middle and lower Yakima River.

The spring seasonal flow volume is 7 percent below the flow volume objective (chapter 2), and the stream runoff pattern is the same as under the current condition.

Indicator 4: July-September Flow Downstream from the Parker Gage.— The median July through September flow downstream from the Parker gage under the No Action Alternative is 642 cfs, or 333 cfs greater than under the current condition (309 cfs). However, based on the flow-to-habitat relationship for coho yearlings, the result is a net decrease of approximately 4.8 acres in the amount of available summer rearing habitat (figure 4.14). This decrease is the result of habitat loss in the main channel (7.9 acres) as channel velocity increases and as a result of increased flow that is not compensated for by an equal increase

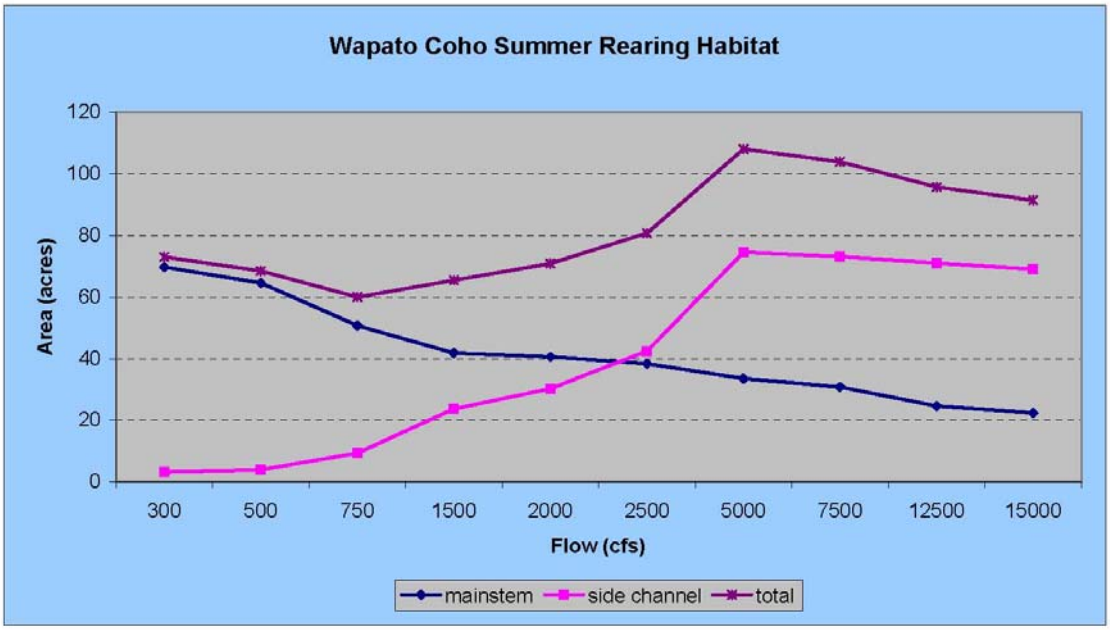


Figure 4.14 Relationship of coho summer yearling habitat amount to flow for the Wapato reach.

in side-channel habitat (3.1 acres) because the flow threshold that results in the watering-up of side channels has not been realized. Overall, the amount of habitat begins to increase again at 750 cfs; and the amount of habitat (73 acres) at 300 cfs is nearly the same as at 2,000 cfs (72.5 acres). However, the percent of side-channel habitat increases from approximately 4 percent at 300 cfs to 44 percent at 2,000 cfs. This may suggest that overall habitat quality is improved since presumably side-channel habitat is of greater quality than mainstem habitat for juvenile rearing salmonids.

Indicator 5: Estimated Anadromous Fish Population Size.—A summary of the average annual escapement for spring and fall Chinook, coho, and steelhead under the No Action Alternative is presented in table 4.26. These escapement estimates include the contribution of hatchery produced fish. The EDT and AHA models estimated average annual escapement under the No Action Alternative as follows:

- Spring Chinook: 7,189
- Fall Chinook: 6,893
- Coho: 8,475
- Steelhead: 2,700

Table 4.26 Estimates of average annual spring Chinook, fall Chinook, coho, and steelhead total recruitment, harvest, escapement, and percent increase in total escapement under Joint Alternatives compared to No Action Alternative based on results from the All H Analyzer model. Estimates include both natural and hatchery produced fish based on a 100-year model simulation.

Resource indicator	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Spring Chinook				
Total recruitment				
Absolute estimate	9,591	12,048	9,729	11,209
Change compared to No Action Alternative		2,457	138	1,618
Harvest				
Absolute estimate	2,402	2,982	2,435	2,781
Change compared to No Action Alternative		580	33	379
Escapement				
Absolute estimate	7,189	9,066	7,294	8,428
Change compared to No Action Alternative		1,877	105	1,239
Percent increase in total escapement compared to No Action Alternative				
		26	2	17
Fall Chinook				
Total recruitment				
Absolute estimate	11,093	17,908	11,445	15,000
Change compared to No Action Alternative		6,815	352	3,907
Harvest				
Absolute estimate	4,200	6,780	4,334	5,680
Change compared to No Action Alternative		2,580	133	1,479
Escapement				
Absolute estimate	6,893	11,128	7,112	9,321
Change compared to No Action Alternative		4,235	219	2,428
Percent increase in total escapement compared to No Action Alternative				
		61	3	35
Coho				
Total recruitment				
Absolute estimate	11,461	13,850	11,618	12,702
Change compared to No Action Alternative		2,389	157	1,241

Table 4.26 Estimates of average annual spring Chinook, fall Chinook, coho, and steelhead total recruitment, harvest, escapement, and percent increase in total escapement under Joint Alternatives compared to No Action Alternative based on results from the All H Analyzer model. (continued)

Resource indicator	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Coho (continued)				
Harvest				
Absolute estimate	2,986	3,608	3,027	3,309
Change compared to No Action Alternative		623	41	323
Escapement				
Absolute estimate	8,475	10,242	8,591	9,392
Change compared to No Action Alternative		1,767	116	918
Percent increase in total escapement compared to No Action Alternative				
		21	1	21
Steelhead				
Total recruitment				
Absolute estimate	3,096	4,663	3,124	3,827
Change compared to No Action Alternative		1,567	28	731
Harvest				
Absolute estimate	396	596	399	489
Change compared to No Action Alternative		200	4	94
Escapement				
Absolute estimate	2,700	4,067	2,724	3,338
Change compared to No Action Alternative		1,367	24	638
Percent increase in total escapement compared to No Action Alternative				
		51	1	24

Indicator 6: False Attraction.—The existing Yakima River water supply would be used under the No Action Alternative; therefore, no false attraction issue is associated with an out-of-basin water supply mixing with Yakima River water.

4.8.2.4 Black Rock Alternative

Construction Impacts

Construction impacts to fishery resources would occur during the construction of the intake to Priest Rapids pumping plant and the fish bypass pipe outlet, but the

overall impact is anticipated to be minor relative to the quality and amount of aquatic habitat found within the Columbia River. Impacts resulting from construction activities (installation and removal of coffer dams and dewatering the coffer dams) may also alter aquatic conditions by temporarily increasing sedimentation (turbidity), but these impacts are anticipated to be temporary.

Long-Term Impacts

Differences in flow in the Yakima River under the Black Rock Alternative (compared to the No Action Alternative) are the greatest of any Joint Alternative. Spring flows are greater throughout the system, while summer flows in the mid- and lower Yakima River are significantly greater as a result of being able to meet higher flow objectives at the Parker gage because of an increase in available water supply for instream flow augmentation. Summer and early fall flows in the upper Yakima River basin are less, as water previously released for diversion by Roza and Sunnyside Irrigation Districts is now provided from Black Rock reservoir. Winter flows are also higher throughout the basin as a result of improved carryover and a reduced volume that needs to be stored each winter. These changes in the flow regime generally would benefit anadromous fish.

Indicator 1: Summer Rearing Habitat in the Easton and Ellensburg Reaches for Spring Chinook and Steelhead Fry and Yearlings.—In the Easton reach, steelhead and spring Chinook yearling habitat are 10.4 percent and 9.8 percent greater, respectively, than under the No Action Alternative (table 4.25). In the Ellensburg reach, the amount of steelhead yearling habitat is 29.2 percent greater than under the No Action Alternative.

Of the three alternatives, the Black Rock Alternative provides the greatest amount of steelhead and spring Chinook summer rearing habitat in the Easton reach, which would potentially equate to an improvement in juvenile survival and the ability to accommodate more summer rearing fish. For similar reasons, of the three Joint Alternatives, the Black Rock Alternative appears most beneficial to steelhead yearlings in the Ellensburg reach.

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers for Yearling Steelhead and Spring Chinook.—The average rate of change in daily flow during the flip-flop operation in the Easton reach is -4 cfs; the average rate of change in daily flow is -51 cfs in the Ellensburg reach and +20 cfs in the lower Naches River (table 4.25).

Thus, for the Easton reach, there is essentially no change in the average rate of change in daily flow during the flip-flop operation compared to the No Action Alternative. For the Ellensburg reach, the average rate of change in daily flow is 35 percent less, the best of the three Joint Alternatives. For the lower Naches River reach, the rate of increase in flow is 41 percent less than under the No Action Alternative, the best of the three Joint Alternatives.

These differences represent an improvement in both the Ellensburg and lower Naches River reaches for fish compared to the No Action Alternative. While the specific biological implications are difficult to measure, the reduction in the rates of change should translate into less stranding of both fish and aquatic invertebrates in the Ellensburg reach that need to move to adjust to the change, and less spatial disruption to desired habitat (i.e., the change in location of desired habitat in a relatively short period of time) in the lower Naches River reach.

Indicator 3: Spring Flow Downstream from the Parker Gage.—The spring seasonal flow is 29 percent above the flow volume objective, while the No Action Alternative is 7 percent below the flow volume objective (table 4.25). These results represent a more than 500-percent improvement in the spring seasonal flow compared to the No Action Alternative. There is also an improvement in the stream runoff pattern compared to the No Action Alternative, as the high flows continue into April, May, and June when most smolt migration is occurring, which should increase overall smolt outmigration survival.

Indicator 4: July-September Flow Downstream from the Parker Gage.—The median July-September flow past Parker for Black Rock is 1,301 cfs compared to 642 cfs under the No Action Alternative. These greater flows would result in 1.5 percent more total coho summer yearling habitat (64.7 acres under the Black Rock Alternative compared to 63.7 acres under the No Action Alternative) (figure 4.14). The reduction in mainstem habitat is nearly equal to the increase in side-channel habitat.

Indicator 5: Estimated Anadromous Fish Population Size.—The EDT and AHA models estimated average annual escapement under the Black Rock Alternative as follows:

- Spring Chinook: 9,066
- Fall Chinook: 11,128
- Coho: 10,242
- Steelhead: 4,067

Rationale for Flow Versus Fish Abundance

The fishery models (EDT and AHA) estimated increases of approximately 20 to 60 percent in anadromous fish population sizes under the Black Rock Alternative compared to the No Action Alternative. Of all the Joint Alternatives, the Black Rock Alternative results in the greatest modification of the current flow regime in the Yakima River basin. One finding suggests that, in many cases, there was not a significant change (increase or decrease) in the amount of fishery habitat even when flow differences were fairly substantial. For example, for the Ellensburg floodplain, there is generally not a substantial change in the amount of spring

Chinook and steelhead fry and summer rearing habitat between the Black Rock Alternative and the No Action Alternative (table 4.27).

Table 4.27 Summary of spring Chinook and steelhead fry and summer rearing habitat area (acres) in the Ellensburg floodplain and the July and August median flow for the No Action and Black Rock Alternatives

Species/Lifestage	No Action Alternative	Black Rock Alternative
Spring Chinook fry habitat (acres)	1.7	1.8 (5.9% increase)
Spring Chinook summer rearing habitat (acres)	14.9	14.6 (2.0% decrease)
Steelhead fry habitat (acres)	2.2	2.1 (4.5% decrease)
Steelhead summer rearing habitat (acres)	20.2	26.1 (29.2% increase)
July median flow (cfs)	3,500	2,700 (23% decrease)
August median flow (cfs)	3,960	2,500 (37% decrease)

It is important to recognize that the Joint Alternatives do not increase or improve the existing habitat conditions in the basin, but only modify how the existing habitat is utilized by changes to the flow regime. Furthermore, the effects of the Joint Alternatives are limited to the stream reaches downstream from the five major storage reservoirs and would not affect habitat conditions in the tributaries.

On a much larger geographic scale, fisheries habitat conditions have significantly changed through decades of development, both within the Yakima basin and downstream, that preclude achieving near historic anadromous fish populations through actions provided by the Joint Alternatives or any other suite of realistic actions. For example, Eitemiller et al. (2002) investigated the historic size of the seven largest floodplains in the Yakima River basin (i.e., Easton, Cle Elum of the Yakima River, Kittitas, Selah, lower Naches, Union Gap and Wapato) and concluded that approximately 15 to 43 percent habitat remains, depending on the floodplain. Changes in habitat conditions (e.g., hydropower development and loss of estuary habitat) in the Columbia River have reduced smolt and adult migration survival from historic levels which further reduce the potential to achieve near historic anadromous fish run sizes in the Yakima River basin.

Indicator 6: False Attraction.—Under the Black Rock Alternative, Columbia River water would be pumped from the Priest Rapids Lake into the Black Rock reservoir and released into Roza and Sunnyside Canals during the irrigation season. In wet years, the amount of water put into Sunnyside canal is less (median = 847 cfs) than in average and dry water years (median = 928 cfs).

The monthly median amount of operational spill of Black Rock reservoir water from Roza and Sunnyside Canals ranges from 2.2 cfs in March to 30.4 cfs in August. The percent of Black Rock reservoir water mixed in the Yakima River water at the Kiona-Benton gage (RM 29.9) ranges from 0.05 to 1.6 percent (table 4.28).

Table 4.28 Percent of Black Rock reservoir water mixed with Yakima River water at the Kiona Benton gage (RM 29.9) by month during the irrigation season as a result of direct operational spill from Roza and Sunnyside Canals

Month	Kiona-Benton Gage Monthly Median Flow (cfs)	Total monthly median Roza and Sunnyside Canal operational spill of Black Rock reservoir water (cfs)	Percent of Black Rock reservoir water mixed with Yakima River water (cfs) at Kiona-Benton Gage
March	4,507	2.2	0.049
April	5,162	17.5	0.34
May	4,933	24.4	0.49
June	4,428	29.0	0.65
July	1,932	30.1	1.53
August	1,845	30.4	1.62
September	1,939	24.5	1.25
October	2,206	20.9	0.94

Under laboratory conditions, Fretwell (1989) investigated the behavioral response of sockeye salmon to their home water source in comparison to their home water source mixed with an increasing percent of a nonhome water source. He found that if the home water source were made up of more than 10 percent of a nonhome water source, fish began to discriminate between the two water sources and selected their home water source more frequently than the water source comprised of both water sources. This study suggests that the sockeye did not discriminate between the home and nonhome water sources based on the behavioral response to a water source preference.

Most adult anadromous fish migration into the Yakima River basin occurs outside of the summer months—between September and June—when the amount of Black Rock reservoir water mixed in the Yakima River water is generally 1 percent or less. Based on these findings, the potential for false attraction resulting from direct operational spill of mixed Yakima and Black Rock reservoir water appears to be minimal.

4.8.2.5 Wymer Dam and Reservoir Alternative

Construction Impacts

Construction impacts to fishery resources would occur during the construction of the intake to Wymer pumping plant and fish bypass pipe outlet (installation and removal of coffer dams and dewatering the coffer dams), but the overall impact is anticipated to be minor relative to the quality and amount of aquatic habitat found within the Yakima River system. Impacts resulting from construction activities (installation and removal of coffer dam and dewatering the coffer dam) in and around Lmuma Creek may also alter aquatic conditions in Lmuma Creek and the Yakima River by temporarily increasing sedimentation (turbidity), but these impacts are anticipated to be temporary.

Long-Term Impacts

Winter flows from Cle Elum Lake to the Wymer site are greater under this alternative as winter flows are "bypassed" through Cle Elum Lake to be stored in Wymer reservoir. This "bypass" more than doubles flows in the Cle Elum River. During the summer months, flows in the upper Yakima River are lower, as some of the irrigation needs in the middle basin are met by releases from Wymer reservoir. Summer flows are about 600 cfs less.

Indicator 1: Summer Rearing Habitat in the Easton and Ellensburg Reaches for Spring Chinook and Steelhead Fry and Yearlings.—Less summer flows in the upper Yakima River basin result in slightly more fry and yearling habitat for both steelhead and Spring Chinook than under the No Action Alternative in the Easton reach. However, the increases do not exceed 10 percent for either species or life stage. In the Ellensburg reach, habitat for steelhead yearlings and spring Chinook fry is greater and steelhead fry and spring Chinook yearling habitat is less than under the No Action Alternative. Again, all differences are less than 10 percent (table 4.25).

Because the percent change in habitat values are all less than 10 percent compared to the No Action Alternative, no effect on the biological response of steelhead or spring Chinook upper Yakima River population is expected compared to the No Action Alternative.

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers for Yearling Steelhead and Spring Chinook.—The average rate of change in daily flow during the flip-flop operation for Easton is -7 cfs. The average rate of change in daily flow is -58 cfs in the Ellensburg reach and +37 cfs in the lower Naches River reach. These changes represent a decline in the rate of change in flow of about 26 percent for the Ellensburg reach, and an increase in the rate of change in flow of 9 percent for the lower Naches River reach compared to the No Action Alternative (table 4.25).

These results represent an improvement in the Ellensburg reach (third best) and a slight worsening condition in the lower Naches River reach (third best) for fish compared to the No Action Alternative. While the specific biological implications are difficult to measure, the reduction in the rates of change in flow in the Ellensburg reach should translate into less stranding of both fish and aquatic invertebrates for reasons similar to those stated under the Black Rock Alternative. Even though the rate of change in flow increases somewhat in the lower Naches River reach, this is not expected to result in any biological change compared to the No Action Alternative for steelhead and spring Chinook in the Naches River basin.

Indicator 3: Spring Flow Downstream from the Parker Gage.—The spring seasonal flow is 10 percent below the flow volume objective, or about the same as under the No Action Alternative. The stream runoff pattern is the same as under

the No Action Alternative. No effect on steelhead or spring Chinook smolt survival is expected because there is virtually no difference in the flow volume objective or in the spring runoff pattern.

Indicator 4: July-September Flow Downstream from the Parker Gage.—The median July-September flow downstream from the Parker gage under the Wymer Dam and Reservoir Alternative is 644 cfs, compared to 642 cfs under the No Action Alternative. This difference in flow does not result in a significant change in the total amount of coho summer yearling habitat compared to the No Action Alternative and, therefore, no effect on the survival or rearing capacity for anadromous fish in the Wapato reach is expected compared to the No Action Alternative.

Indicator 5: Estimated Anadromous Fish Population Size.—The EDT and AHA models estimated average annual escapement under the Wymer Dam and Reservoir Alternative as follows:

- Spring Chinook: 7,294
- Fall Chinook: 7,112
- Coho: 8,591
- Steelhead: 2,724

Indicator 6: False Attraction.—A minimal potential exists for false attraction to occur at the confluence of Lmuma Creek, which would receive the outflow from the Wymer reservoir. The water supply for the reservoir is both skimmed Yakima River water, along with Cle Elum Lake water released during the winter months, and should have a similar chemical signature as the river water steelhead and salmon have imprinted to. In most years (except in prorated water years), reservoir releases would occur in July and August, and the number of adult steelhead and salmon migrating through this reach of the river would be minimal at that time. Some late arriving spring Chinook could be affected.

4.8.2.6 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

In addition to the construction impacts for Wymer reservoir discussed for the Wymer Dam and Reservoir Alternative, construction impacts to fishery resources would occur during construction of the intake to pumping plant #1 and the pipeline crossings under the Yakima River and various roads and waterways. The impacts of crossing the Yakima River and roads and waterways (installation and removal of coffer dams and dewatering the coffer dams) are anticipated to be minor relative to the quality and amount of aquatic habitat found within the Yakima River system. Impacts resulting from construction activities may

also alter aquatic conditions by temporarily increasing sedimentation (turbidity), but these impacts are anticipated to be temporary.

Long-Term Impacts

Winter flows from Cle Elum Lake to Wymer reservoir are greater under this alternative as winter flows are "bypassed" through Cle Elum Lake to be stored in Wymer reservoir. This "bypass" more than doubles flows in the Cle Elum River. In the spring and summer, flows are greater in the middle and lower basin as water available for diversion at Roza and Parker is left in the river as some of the irrigation demand is met by the exchange. The flow objective at Parker increases from about 640 cfs to 1,500 cfs. During the summer months, flows in the upper Yakima River are less, as some of the irrigation needs in the middle basin are met by releases from Wymer reservoir. Summer flows are about 600 cfs less than under the No Action Alternative.

Indicator 1: Summer Rearing Habitat in the Easton and Ellensburg Reaches for Spring Chinook and Steelhead Fry and Yearlings.—There are no significant differences (>10 percent change) between this alternative and the No Action Alternative for either of the species and life stages for the Easton or Ellensburg reaches. As under the Wymer Dam and Reservoir Alternative, habitat is generally better for steelhead and spring Chinook in the Easton reach, while results are mixed for the Ellensburg reach (table 4.25).

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers for Yearling Steelhead and Spring Chinook.—The average rate of change in daily flow during the flip-flop operation for the Easton reach is -6 cfs. The average rate of change in daily flow is -57 cfs in the Ellensburg reach and +36 cfs in the lower Naches River reach. In the Ellensburg reach, the rate of change in daily flow is about 27 percent less than under the No Action Alternative; in the lower Naches River reach, the rate of change is 6 percent greater (table 4.25).

For the three Joint Alternatives, these results represent the third best improvement in the Ellensburg reach (and comparable to the Wymer Dam and Reservoir Alternative) of the three Joint Alternatives and the second best improvement in the lower Naches River reach (and comparable to the Wymer Dam and Reservoir Alternative) compared to the No Action Alternative. While the specific biological implications are difficult to measure, the reduction in the rates of change in flow in the Ellensburg reaches should translate into less stranding of both fish and aquatic invertebrates for reasons similar to those stated under the Black Rock Alternative. A reduction in the rate of increase in flow in the lower Naches River reach may decrease the potential for juvenile steelhead and salmon to be displaced from their rearing habitats.

Indicator 3: Spring Flow Downstream from the Parker Gage.—The spring seasonal flow is 11 percent above the flow volume objective, an improvement (19 percent) compared the No Action Alternative, which is 7 percent below the

objective. The stream runoff pattern is the same as under the No Action Alternative. Overall smolt outmigration survival should be better under this alternative.

Indicator 4: July-September Flow Downstream from the Parker Gage.—The median July-September flow downstream from the Parker gage under the Wymer Dam Plus Yakima River Pump Exchange Alternative is 1,505 cfs, compared to 642 cfs under the No Action Alternative. These greater flows result in a 4.1-percent increase in the amount of coho summer yearling habitat compared to the No Action Alternative. The reduction in mainstem habitat (14.8 acres) is offset by an increase of 16.7 acres of side-channel habitat. Though the overall increase in the amount of habitat is small compared to the No Action Alternative, the shift towards a greater percentage in the side channels may be of greater habitat quality compared to mainstem habitat.

Indicator 5: Estimated Anadromous Fish Population Size.—The EDT and AHA models estimated average annual escapement under the Wymer Dam Plus Yakima River Pump Exchange Alternative as follows:

- Spring Chinook: 8,428
- Fall Chinook: 9,321
- Coho: 9,392
- Steelhead: 3,338

Indicator 6: False Attraction.—The Wymer Dam Plus Yakima River Pump Exchange Alternative would use Columbia River water pumped in the vicinity of the Yakima River confluence, which would occur during the irrigation season and would be pumped into the Roza and Sunnyside Canals. A maximum of 1,040 cfs of Columbia River water would be exchanged between Roza and Sunnyside during the irrigation season. Potential false attraction issues on the Yakima and mid-Columbia (upstream of the Yakima River) salmon populations discussed in "Methods and Assumptions" would be further reduced because the pumping plant would be located immediately downstream from the Yakima River confluence; thus, the pumped water would be an admixture of Yakima and Columbia River water.

The monthly median operational spill of Columbia River water from Roza and Sunnyside canals ranges between 10.5 cfs in June through August to 13.7 cfs in April. The mixture of Columbia River water to Yakima River water at the Kiona-Benton gage ranges from 0.27 to 0.72 percent (table 4.29). As discussed for the Black Rock Alternative, most adult anadromous fish migration into the Yakima River basin occurs outside of the summer months—between September and June—when the amount of Columbia River water mixed in the Yakima River water is generally 1 percent or less.

Table 4.29 Percent of Columbia River water mixed with Yakima River water at the Kiona Benton gage (RM 29.9) by month during the irrigation season as a result of direct operational spill from Roza and Sunnyside Canals

Month	Kiona-Benton gage monthly median flow (cfs)	Total monthly median Roza and Sunnyside Canal operational spill of Black Rock reservoir water (cfs)	Percent of Columbia River water to Yakima River water (cfs) at Kiona-Benton gage
March	4,507	12.2	0.27
April	5,162	13.7	0.27
May	4,933	12.2	0.25
June	4,428	10.5	0.24
July	1,932	10.5	0.54
August	1,845	10.5	0.57
September	1,939	13.9	0.72
October	2,206	14.6	0.66

Based on these findings, the potential for false attraction resulting from direct operational spill of mixed Yakima and Columbia River water appears to be minimal.

4.8.2.7 Mitigation

The following measures will be implemented to reduce short-term impacts of construction activities to anadromous fish:

- Implement construction Best Management Practices (BMPs) to avoid and minimize potential construction impacts, including erosion and sedimentation, accidental and incidental discharge of pollutants (Spill Prevention, Containment, and Control Plan), and dewatering and discharge of dewatering water.

- Prior to complete dewatering of coffer dams, fishery personnel will salvage all fishes using the most appropriate capture gear and methods.

- Provide treatment of construction dewatering discharges, such as sediment removal or filtration, as necessary, before the release of such water to wetlands or streams.

4.8.2.8 Cumulative Impacts

While there are some short-term minor adverse impacts to anadromous fish from construction activities under the Joint Alternatives, for the most part, the impacts under those alternatives are, in the long term, beneficial. Those benefits could be diminished by some of the other actions that are reasonably likely to occur. In particular, the future growth in the area may affect anadromous fish both directly and indirectly. As Lackey et al. (2006) have pointed out, future population growth in the Pacific Northwest and the development and use of scarce natural

resources that accompanies it will diminish populations of wild salmonids. While laws and regulations, like the Shorelines Management Act, the Hydraulic Project Approval Act, and the Endangered Species Act are in place to try to minimize or at least manage some of the direct impacts of development on salmonids and their habitat, continued development in the Yakima River basin would likely erode some of the benefits of the alternatives considered here.

Cumulative impacts could also occur from the implementation of fish enhancement projects as part of the BPA Fish and Wildlife Program or through other fish enhancement programs such as the State of Washington's Salmon Recovery Funding Board. Funds from both of these programs have been used in the Yakima River basin to restore and enhance anadromous fish habitat and this is expected to continue in the future. In the *Yakima Subbasin Plan* (Yakima Subbasin Fish and Wildlife Planning Board, 2004) estimates of potential anadromous fish populations were made using EDT presuming improvements in habitat made under the *Yakima Subbasin Plan*. The estimates were made looking forward 30 years with the assumption that funding was not limited but that the actions contemplated met some test of reasonableness given current conditions. This exercise also took into account future development and actually decreased habitat values in areas where development was likely to be focused. Spring Chinook abundance estimates increased by about 60 percent over estimates under current conditions while fall Chinook and coho abundance estimates increased by about 35 percent. The flow improvements contemplated under the Joint Alternatives would enhance these projected increases, in some cases in an additive fashion but in other cases by multiplying the benefits to be achieved by the habitat enhancement projects. For example, by improving flow conditions in the basin under the Joint Alternatives they work in concert with the habitat enhancements to grow more smolts in the basin and then improve their survival out of the basin magnifying the benefit of the habitat enhancement.

4.9 Resident Fish

4.9.1 Affected Environment

4.9.1.1 Columbia River

The extent of the affected area in the Columbia River for the Storage Study is described in the "Anadromous Fish" section. A total of 38 resident species are known to reside in the Hanford reach and/or the Priest Rapids Lake (Pfeifer et al., 2001) and are grouped as native game fish, native nongame fish, introduced (nonnative) game fish, and introduced nongame fish. They are listed, along with their type and relative abundance, in table 4.30.

Important resident fish that prey on juvenile salmonids are northern pikeminnow, walleye, and small mouth bass. Walleye and small mouth bass are also important to recreational fisheries.

Table 4.30 Resident fishes sampled in the Priest Rapids Project area during multiple year surveys (Source: Pfeifer et al., 2001)

Common name	Scientific name	Species category	General abundance
White Sturgeon	*Acipenser transmontanus*	Native game fish	Common
Bull trout native	*Salvelinus confluentus*	Game fish	ESA threatened, rare
Rainbow trout	*Oncorhynchus mykiss*	Native game fish	Common
Cutthroat trout	*Oncorhynchus clarki*	Native game fish	Uncommon
Brown trout	*Salmo trutta*	Introduced game fish	Uncommon
Mountain whitefish	*Prosopium williamsoni*	Native game fish	Common
Lake whitefish	*Coregonus clupeaformis*	Native game fish	Rare
Northern pikeminnow	*Ptychocheilus oregonensis*	Native nongame fish	Abundant
Peamouth	*Mylocheilus caurinus*	Native nongame fish	Abundant
Chiselmouth	*Acrocheilus alutaceus*	Native nongame fish	Abundant
Redside shiner	*Richardsonius balteatus*	Native nongame fish	Abundant
Longnose dace	*Rhinichthys cataractae*	Native nongame fish	Common
Speckled dace	*Rhinichthys osculus*	Native nongame fish	Common
Leopard dace	*Rhinichthys falcatus*	Native nongame fish	Rare
Carp	*Cyprinus carpio*	Introduced nongame fish	Common
Tench	*Tinca tinca*	Introduced nongame fish	Uncommon
Bridgelip sucker	*Catostomus columbianus*	Native nongame fish	Abundant
Largescale sucker	*Catostomus macrocheilus*	Native nongame fish	Abundant
Longnose sucker	*Catostomus catostomus*	Native nongame fish	Common
Channel catfish	*Ictalurus punctatus*	Introduced game fish	Common
Black bullhead	*Amiurus melas*	Introduced game fish	Uncommon
Burbot	*Lota lota*	Native game fish	Rare
Three-spined stickleback	*Gasterosteus aculeatus*	Native nongame fish	Abundant
Sandroller	*Percopsis transmontana*	Native nongame fish	Rare
Largemouth bass	*Micropterus salmoides*	Introduced game fish	Common
Smallmouth bass	*Micropterus dolomieu*	Introduced game fish	Common
Black crappie	*Pomoxis nigromaculatus*	Introduced game fish	Common
White crappie	*Pomoxis annularis*	Introduced game fish	Common
Bluegill	*Lepomis macrochirus*	Introduced game fish	Uncommon
Pumpkinseed	*Lepomis gibbosus*	Introduced game fish	Uncommon
Torrent sculpin	*Cottus rhotheus*	Native nongame fish	Common
Prickly sculpin	*Cottus asper*	Native nongame fish	Common
Walleye	*Stizostedion vitreum*	Introduced game fish	Common
Yellow perch	*Perca flavescens*	Introduced game fish	Common

Grant County PUD documented the capture of one juvenile bull trout in November during an intensive fishery survey in 1999 (FERC, 2006).

White sturgeons are known to spawn in July in the tailrace of Wanapum and Priest Rapids Dams and farther downstream in the Hanford reach. A total of 230 fish were sampled between the three locations in a census study conducted in 2000 (FERC, 2006).

4.9.1.2 Yakima River

The areas of interest include the existing and proposed reservoirs within the basin and the Yakima, Cle Elum, Naches, Tieton and Bumping Rivers from headwater reservoirs to the confluence of the Yakima River with the Columbia River. (See frontispiece map.)

Description and Distribution

Resident native salmonids that currently exist in streams and lakes of the upper Yakima River basin include bull trout (*Salvelinus confluentus*), westslope cutthroat trout (*Oncorhynchus clarki*), rainbow trout (*Oncorhynchus mykiss*), kokanee (*Oncorhynchus nerka*), mountain whitefish (*Prosopium williamsoni*), and pygmy whitefish (*Prosopium coulteri*) (Pearsons et al., 1998; WDFW, 1998). Eastern brook trout (*Salvelinus fontinalis*), a nonnative (introduced), salmonid is also present. Of these species, those of special concern include bull trout (federally threatened), westslope cutthroat trout, and pygmy whitefish (State sensitive). Although bull trout tend to exhibit several different life history strategies, they are included in the resident fish analysis.

At least in the Yakima River basin, westslope cutthroat appear to be fairly abundant and widely distributed, particularly in the upper reaches (higher elevations) of tributaries to Keechelus Lake and the Yakima River. Cutthroat, as well as other resident salmonid species, provide recreational angling opportunities throughout the upper basin. Resident rainbow trout and mountain whitefish angling in the upper Yakima River and in the lower reaches of tributary streams is extremely popular. In fact, the trout fishery in the upper Yakima River is considered one of the best “blue ribbon” catch-and-release fisheries in Washington State.

Thirty-seven resident nonsalmonid species are present in the Yakima River basin (Pearsons et al., 1998). The most abundant nonsalmonids in the upper Yakima River basin are speckled dace *(Rhinichthys osculus*), longnose dace (*Rhinichthys cataractae*), redside shiners (*Richardsonius balteaus*), northern pikeminnow (*Ptychocheilus oregonensis*), largescale suckers (*Catostomus macrocheilus*), bridgelip suckers (*Catostomus columbianus*), and several sculpin species, including mottled, torrent, piute, and shorthead sculpins (*Cottus sp*.). Although these nonsalmonid species do not receive the notoriety of salmonids (trout, salmon, and steelhead) or other lower river nonsalmonid game fish (such as bass

and catfish) they are nevertheless an important component of the aquatic environment. Most serve as forage for other game and food fish. Burbot (*Lota lota*) is an important game fish present in Keechelus Lake.

Two other species, although not as abundant as those listed above, but important due to their status, are the mountain sucker (*Catostomus platyrhynchus*) (a State candidate species) and the Pacific lamprey (*Lampetra tridentata*) (a Federal species of concern). Mountain suckers occur within the basin, and it is possible that lamprey do as well, although few have been observed in the Yakima River. Although not listed, numerous fish species inhabiting the mid to lower zones of the Yakima River may potentially be impacted by the proposed Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives. For a complete fish species list for the Yakima River basin, refer to Pearsons et al. (1998).

Habitat Conditions

Habitat conditions for native resident fish in the river segments downstream from the storage dams are identical to those discussed in the "Anadromous Fish" section. Unlike anadromous fish, resident fish are also present in the storage reservoirs, which are part of the area affected by the proposed alternatives. Reservoir operations may affect resident fish by affecting the productivity of the reservoirs for fish and their food base and by affecting access from the reservoir to tributary spawning streams.

Annual drawdown of the basin reservoirs, which is part of the routine operation and maintenance of the Yakima Project, could affect reservoir aquatic productivity. Existing data suggest that the Yakima River basin reservoirs have limited nutrients, especially phosphorus and trace elements (Flagg et al., 2000; Hiebert, 1999; Mongillo and Faulconer, 1982). Based on the information available, all of the reservoirs are oligotrophic (lacking plant nutrients and usually containing plentiful amounts of DO without stratification). Studies by Mongillo and Faulconer integrated many limnological factors to determine the fish-producing potential of the reservoirs. The studies were conducted in the presence of what would have been routine operations at the time. Their analysis suggested that flushing rates may be removing phosphorus from the reservoirs (Mongillo and Faulconer, 1982), that there was a significant relationship between zooplankton production and fish catch per unit effort, and that lake levels, if held higher, might enhance benthic invertebrate production.

Generally, time is an important factor for the effectiveness of lake processes (stratification, sedimentation, population growth, etc.); adequate time under relatively stable conditions is required for the ecosystem to function adequately (Wetzel, 1990). One common effect of an annual drawdown is to reduce the time available to complete population growth (e.g., phytoplankton, zooplankton),

and this can result in reduced diversity of biota and the favoring of biota with broad physiological tolerances (Wetzel, 1990).

Drawdown also impacts the littoral zone, the area between the high and low water marks, which is often important to several aspects of fish production. In 1981, Washington Department of Game wrote a report to Reclamation for the Yakima River Basin Water Enhancement Project (Washington Department of Game, 1981). The biologists reported:

> *All reservoirs in the basin are seasonally drafted to meet irrigation needs. The decrease in reservoir surface area has an adverse impact on primary productivity reducing the food supply for fish. The major source of productivity in most reservoirs is phytoplankton, which thrive in the upper photic zone of the pool. As reservoir levels decrease through the summer, primary production and resultant food supplies decline. Because of inadequate food supplies, fish populations in reservoirs are maintained at artificially low levels. In addition, a low water level in fall limits the habitat available for shoal spawning species.*

Reservoir elevations may affect the ability of species which rear in the reservoir but spawn in the tributaries to move from one to the other. The access problem is a function of both tributary streamflow and reservoir elevation and occurs mainly in the fall and early winter when reservoirs are low as are flows in the tributaries. As the reservoirs are drawn down, the exposed stream channels on the reservoir bottoms may be ill-defined as they flow across the exposed sediments. Much of what little water is present may seep into the ground because the sediments are permeable; consequently, the stream may become too shallow for passage. In some years (e.g., 1996), when the reservoir and streamflows were low some streams became disconnected completely from the reservoirs. Years when flows and reservoir elevations are higher present less of a problem.

4.9.2 Environmental Consequences

4.9.2.1 Methods and Assumptions

Columbia River

The Biology Technical Work Group (2004) identified two issues that pertain to resident fish in the affected area of the Columbia River. The first issue is the potential effects of water withdrawal from Priest Rapids Lake to fill Black Rock reservoir on the spawning and rearing habitat of resident fish.

The relationship between the Hanford reach juvenile fall Chinook habitat area to river discharge (Anglin et al., 2006) was used as an indicator to evaluate the potential affects of pumping Columbia River water from Priest Rapids Lake on resident fish residing in the Hanford reach. Because of the large number of

resident fish that reside in the affected area and lack information pertaining to the relationship of habitat area to river discharge specific to these resident species, the habitat-area-to-river-discharge relationship for juvenile fall Chinook was used as a surrogate.

The second issue was to evaluate the potential effects on resident fish mortality at the pump intake site of pumping Columbia River water from Priest Rapids Lake to fill Black Rock reservoir.

This issue was evaluated in qualitative terms, factoring in the pump intake location, screen design, pumping schedule, and quantity of water pumped, as was discussed for anadromous fish.

Yakima River

There was no appreciable change in water temperature in the modeled reach (Roza Diversion Dam to Prosser Diversion Dam) during the irrigation season between the Joint Alternatives and the No Action Alternative ("Anadromous Fish" section). Thus, no change is expected in the biological consequence of water temperatures to resident fishes for the Joint Alternatives compared to the No Action Alternative.

Indicator 1: Summer Rearing Habitat in the Easton, Ellensburg, and Lower Naches River Reaches for Rainbow Trout and Bull Trout

See the "Anadromous Fish" section for a complete description of this indicator. The methods and assumptions are the same, except that the fry and subyearling life stage time periods for rainbow trout and bull trout differ from the steelhead and spring Chinook because of differences in their life cycles. Few records exist of bull trout spawning or fry/juvenile rearing in the three reaches evaluated for this indicator. The lifestage time periods used to estimate the amount of fry and subyearling habitat in the Easton, Ellensburg, and lower Naches River reaches were as follows:

- Rainbow trout fry - July 1 through August 30
- Rainbow trout subyearling - September 1 through September 30
- Bull trout subyearling - June 1 through September 30

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers

This indicator applies similarly to anadromous and resident fishes. A complete description of this indicator is discussed in the "Anadromous Fish" section.

Indicator 3: Reservoir Operations

The reservoir operations indicator applies to bull trout spawners in Kachess, Keechelus, and Rimrock Lakes. This indicator has two components. The first component counts the average annual number of days access from the reservoir to spawning tributary is impeded for bull trout spawners due to low reservoir

volume. Critical passage due to reservoir volume is influenced by the amount (cfs) of tributary inflow. For the same reservoir volume, bull trout passage generally improves as tributary inflow increases. To account for this tributary influence on passage (Thomas and Bovee, 2007) lookup tables were developed for each of the three reservoirs that were used in the DSS model to track this indicator. These lookup tables are based on multiple field observations by Thomas and Bovee (2007) spanning several years, where the number of spawning nests (redds) in the reservoir tributaries were counted and loosely correlated to reservoir volume and the amount of tributary inflow.

The critical bull trout spawner migration time period was defined as July 15-September 15 (Thomas and Bovee, 2007).

The second component is a measure of the median Kachess, Keechelus, and Rimrock Lake elevation during the bull trout spawning migration period of July 15 - September 15 when they migrate from the reservoirs into the tributaries.

The first component of the reservoir operations indicator is calculated by the DSS model with input of daily reservoir elevation from the Yak-RW model for the hydrologic period of 1981-2005. The DSS model counts the number of days for each year in the hydrologic period that reservoir elevation is below the critical threshold volume for each of the three reservoirs from July 15-September 15 and is recorded as the average number of days annually the critical threshold volume is not exceeded. This indicator was calculated for all four alternatives; the percent difference between each Joint Alternative and the No Action Alternative was also calculated.

The second component of the reservoir operations indicator calculates the median reservoir elevation for Kachess, Keechelus, and Rimrock Lakes based on estimated daily reservoir elevations for the 1981-2005 hydrologic period provided as output from the Yak-RW model.

4.9.2.2 Summary of Impacts

Columbia River

Much of the discussion for anadromous fish in section 4.8 applies to resident fish and is not discussed further here. The only difference identified was the potential for entrainment of newly emergent resident fry through the fish screens; this potential does not exist for anadromous salmonids. The State's criterion is a 3/32-inch mesh size opening for all screens designed to preclude entrainment of juvenile salmonids. Many of the resident warm water species have fry that hatch at approximately 15 millimeters or less in length (salmon and steelhead fry are approximately 20-25 millimeters at emergence), which would result in entrainment into the intake pipe to Black Rock reservoir until they grow to a size comparable to anadromous salmonids. While some fish would be actively drawn into the Priest Rapids pumping plant, intake screening would restrict entrainment.

Yakima River

Table 4.31 summarizes the effects of the alternatives on the selected indicators for rainbow trout and bull trout.

Table 4.31 Summary of impacts on the selected indicators for rainbow trout and bull trout

Resource Indicator	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Summer flows in the upper Yakima and lower Naches Rivers (acres of available habitat)				
Easton reach				
Rainbow trout fry habitat	5.2	5.5 5.8%	5.4 3.8%	5.5 5.8%
Rainbow trout yearling habitat	57.2	63.2 10.5%	57.9 -3.8%	54.6 -4.5%
Bull trout yearling habitat	61.9	66.1 6.8%	62.9 1.6%	62.8 1.5%
Ellensburg reach				
Rainbow trout fry habitat	2.5	2.4 -4.0%	2.4 -4.0%	2.4 -4.0%
Rainbow trout yearling habitat	19.9	25.7 28.9%	20.3 -20.1%	17.0 -9.5%
Bull trout yearling habitat	20.5	20.3 -1.0%	20.3 -1.0%	2.3 -1.0%
Lower Naches River reach				
Rainbow trout fry habitat	4.3	4.2 -0.8	4.3 0.0%	4.3 0.0%
Rainbow trout yearling habitat	45.9	47.2 2.9%	48.1 0.2%	46.0 0.1%
Bull trout yearling habitat	64.8	65.0 0.3%	64.8 0.0%	64.6 -0.3%
Bull trout spawner upmigration at reservoirs (inseason days impeded)				
Kachess Lake	18	15 -16.7%	18 0.0	17 -5.5%
Keechelus Lake	37	38 2.7%	37 0.0%	37 2.7%
Rimrock Lake	3	3 0.0%	1 -66.6%	1 -66.6%
Average minimum and maximum reservoir elevation during bull trout spawning migration: July 15 – September 15 (feet)				
Kachess Lake	2,248.4 2,202.4 - 2,262.0	2,253.1 2,206.0 - 2,262.0	2,249.3 2,201.0 - 2,262.0	2,249.7 2,202.4 - 2,262.0
Keechelus Lake	2,467.3 2,427.5 - 2,513.3	2,466.6 2,427.6 - 2,514.4	2,467.6 2,427.5 - 2,514.9	2,468.0 2,427.5 - 2,514.9
Rimrock Lake	2,909.9 2,869.8 - 2,927.8	2,906.2 2,839.8 - 2,927.7	2,912.3 2,872.4 - 2,927.8	2,911.7 2,868.0 - 2,927.8

4.9.2.3 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Indicator 1: Resident Fish Impacts.—The habitat quantity amounts for each reach and species/life stage are presented in table 4.31. These values are essentially the same as under the current condition.[6]

Only habitat changes near or greater than 10 percent are discussed in the text, but all values are reported in table 4.31.

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers.—The results are the same as discussed for anadromous fish, and results are shown in table 4.25.

No change is expected in the biological consequence to resident rainbow trout and bull trout under the No Action Alternative compared to the current condition.

Indicator 3: Reservoir Operations.—The average annual number of days with a critical threshold reservoir volume for bull trout spawners under the No Action Alternative is Kachess Lake, 18 days; Keechelus Lake, 37 days; and Rimrock Lake, 3 days (table 4.31).

The average reservoir elevations for the period coinciding with bull trout spawner migration for all the alternatives are presented in table 4.31. The average reservoir elevation for the No Action Alternative are Kachess Lake, 2,248.4 feet; Keechelus Lake, 2,467.3 feet; and Rimrock 2,909.9 feet.

4.9.2.4 Black Rock Alternative

Construction Impacts

Construction impacts would be the same as discussed in the "Anadromous Fish" section.

Long-Term Impacts

Indicator 1: Resident Fish Impacts.—Compared to the No Action Alternative, flows changes in the Yakima River are the greatest under this alternative. Spring flows are greater throughout the system, while summer flows in the mid- and lower Yakima River are significantly greater as a result of a higher flow objective

[6] The DSS model was not run for the RiverWare current flows; therefore, the only way to compare and thus make this statement is by comparison of flows between the current condition and No Action Alternative.

at the Parker gage. Summer and early fall flows in the upper Yakima River basin are less, as water previously released for diversion by Roza and Sunnyside Irrigation Districts is now provided from Black Rock reservoir. Winter flows are also higher throughout the basin as a result of improved carryover and a reduced volume that needs to be stored each winter.

Generally there is no substantive difference in the amount of fry and yearling habitat between the Black Rock and the No Action Alternatives in the Easton reach (table 4.31). The only exception is an increase (10.5 percent) in the amount of rainbow trout yearling habitat. In the Ellensburg reach, the only substantive change in habitat quantity is the nearly 30-percent increase in rainbow trout yearling habitat compared to the No Action Alternative. There are no changes 10 percent or greater in the lower Naches River reach.

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers.—The results are the same as discussed for anadromous fish, and results are shown in table 4.25.

The results represent an improvement in both the Ellensburg and lower Naches River reaches for fish compared to the No Action Alternative. While the specific biological implications are difficult to measure, the reduction in the rates of change should translate into less stranding of both fish and aquatic invertebrates in the Ellensburg reach that need to move to adjust to the change, and less spatial disruption to desired habitat (i.e., the change in location of desired habitat in a relatively short period of time) in the lower Naches River reach.

Indicator 3: Reservoir Operations.—The average annual number of days with a critical threshold reservoir volume for bull trout spawners under the Black Rock Alternative is Kachess Lake, 15 days; Keechelus Lake, 38 days; and Rimrock Lake, 3 days; compared to 18, 37, and 3 days, respectively, under the No Action Alternative (table 4.31).

The average reservoir elevations under the Black Rock Alternative are Kachess Lake, 2,255.3 feet; Keechelus Lake, 2,466.6 feet; and Rimrock Lake, 2,906.2 feet (table 4.31). Average reservoir elevation is higher in Kachess Lake (+4.7 feet) and lower in Keechelus Lake (-0.7 feet) and Rimrock Lake (-3.7 feet) than under the No Action Alternative. No effects on bull trout spawner migration are expected as a result of these differences in average reservoir elevations compared to the No Action Alternative.

4.9.2.5 Wymer Dam and Reservoir Alternative

Construction Impacts

Construction impacts would be the same as discussed in the “Anadromous Fish” section.

Long-Term Impacts

Indicator 1: Resident Fish Impacts.—Winter flows from Cle Elum Lake down to the Wymer site are greater under this alternative as winter flows are "bypassed" through Cle Elum Lake to be stored in Wymer reservoir. This "bypass" more than doubles flows in the Cle Elum River. During the summer months, flows in the upper Yakima River are lower as some of the irrigation needs in the middle basin are met by releases from Wymer reservoir. Summer flows are about 500-600 cfs less.

There are no substantive differences of 10 percent or greater in the amount of rainbow trout and bull trout habitat between the Wymer Dam and Reservoir and the No Action Alternatives in the Easton reach (table 4.31).

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers.—The results are the same as discussed for anadromous fish, and the results are presented in table 4.25.

The results represent an improvement in the Ellensburg reach (third best) and a slight worsening condition in the lower Naches River reach (third best) for fish compared to the No Action Alternative. While the specific biological implications are difficult to measure, the reduction in the rates of change in flow in the Ellensburg reach should translate into less stranding of both fish and aquatic invertebrates for reasons similar to those presented for the Black Rock Alternative. Even though the rate of change in flow is somewhat greater in the lower Naches River reach, it is anticipated this would not result in any biological change compared to the No Action Alternative for rainbow trout and bull trout in the Naches River basin.

Indicator 3: Reservoir Operations.—The average annual number of days with a critical threshold reservoir volume for bull trout spawners is Kachess Lake, 18 days; Keechelus Lake, 37 days; and Rimrock Lake, 1 day (table 4.31). Under this alternative, the number of critical passage days is the same for Kachess and Keechelus Lakes and two days less for Rimrock Lake than under the No Action Alternative.

The average reservoir elevation is Kachess Lake, 2,249.3 feet; Keechelus Lake, 2,467.6 feet; and Rimrock Lake, 2,912.3 feet (table 4.31). Average reservoir elevation is higher in Kachess Lake (+0.9 feet), Keechelus Lake (+0.3 feet), and Rimrock Lake (+1.8 feet) than under the No Action Alternative. No effects on bull trout spawner migration are expected as a result of these differences in average reservoir elevations compared to the No Action Alternative.

4.9.2.6 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Construction impacts would be the same as discussed in the "Anadromous Fish" section.

Long-Term Impacts

Indicator 1: Resident Fish Impacts.—Winter flows from Cle Elum Lake to the Wymer site improve under this alternative as winter flows are "bypassed" through Cle Elum Lake to be stored in Wymer reservoir. This "bypass" more than doubles flows in the Cle Elum River. In the spring and summer, flows are greater in the middle and lower basin as water available for diversion at Roza and Parker is left in the river as some of the irrigation demand is met by the exchange. The flow objective at the Parker gage increases from about 640 cfs to 1,500 cfs. During the summer months, flows in the upper Yakima River are lower as some of the irrigation needs in the middle basin are met by releases from Wymer reservoir. Summer flows are about 1,000 cfs less.

There are no substantive changes of 10 percent or greater in the amount of rainbow trout and bull trout habitat between this alternative and the No Action Alternative in the Easton reach (table 4.31).

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers.—The results are the same as discussed for anadromous fish, and the results are shown in table 4.25.

For the three Joint Alternatives, these results represent the third best improvement in the Ellensburg reach (and comparable to the Wymer Dam and Reservoir Alternative) and the second best improvement in the lower Naches River reach (and comparable to the Wymer Dam and Reservoir Alternative) compared to the No Action Alternative. While the specific biological implications are difficult to measure, the reduction in the rates of change in flow in the Ellensburg reaches should translate into less stranding of both fish and aquatic invertebrates for reasons similar to those presented for the Black Rock Alternative. A reduction in the rate of increase in flow in the lower Naches River reach may decrease the potential for juvenile rainbow trout and bull trout to be displaced from their rearing habitats.

Indicator 3: Reservoir Operations.—The average annual number of days with a critical threshold reservoir volume for bull trout spawners is nearly the same as under the Wymer Dam and Reservoir Alternative.

The average reservoir elevation for Wymer Dam and Reservoir Alternative is Kachess Lake, 2,249.7 feet; Keechelus Lake, 2,468.0 feet; and Rimrock Lake, 2,911.7 feet (table 4.31). Average reservoir elevation is higher in Kachess Lake (+1.3 feet), Keechelus Lake (+0.7 feet), and Rimrock Lake (+1.8 feet) than under

the No Action Alternative. No effects on bull trout spawner migration are expected as a result of these differences in average reservoir elevations compared to the No Action Alternative.

4.9.2.7 Mitigation

Mitigation would be the same as discussed in the "Anadromous Fish" section.

4.9.2.8 Cumulative Impacts

Cumulative impacts on resident fish would be similar to those described for anadromous fish. Future growth and development in the basin will likely diminish the benefits of the Joint Alternatives for resident fish in the affected stream reaches. The benefits foreseen at the reservoirs as a result of higher reservoir elevations would not likely be diminished by growth. Most of the land surrounding the reservoirs is public land and not subject to the same development pressures as private lands located elsewhere in the basin.

Implementation of habitat enhancement projects for anadromous fish would also benefit native resident fish. The EDT modeling done for anadromous fish as part of the subbasin planning process (Yakima Subbasin Fish and Wildlife Planning Board, 2004) also included steelhead. Because of difficulties using the EDT model to evaluate only steelhead, the modeling was done for both steelhead and rainbow trout (the nonanadromous form of steelhead) combined. This analysis indicated a better then four-fold increase in abundance for steelhead/rainbow over the current condition. As with anadromous fish, the improvements under the Joint Alternatives would work in concert with these habitat improvements to further boost resident fish numbers.

4.10 Aquatic Invertebrates

4.10.1 Affected Environment

Invertebrate responses to regulated river systems are often complex and variable. Invertebrates are a major part of the food resource for fishes, and changes in invertebrate communities may result in changes in condition of fish communities (Waters, 1982; Bowlby and Roff, 1986; Wilzbach et al., 1986). Invertebrates, like other aquatic organisms, respond to changes in water quality, food abundance, and other habitat parameters (Ward, 1976; Armitage, 1984; Armitage et al., 1987). Many habitat parameters affecting the distribution and/or abundance of aquatic invertebrates are affected by flow regime (Statzner et al., 1988), and the effects of change in flow are thus the focus of this resources assessment.

This analysis of aquatic invertebrate communities is based on studies from other river systems and site-specific sampling within the Yakima River basin. Sites sampled in 2002-04 include areas downstream from storage reservoirs:

Keechelus, Kachess, Cle Elum, Bumping, Clear, and Rimrock (Tieton) Lakes; downstream from diversion dams (Easton and Roza); and in unregulated tributaries (Bumping, Cle Elum, Cooper, Gold Creek, Deep Creek, Indian Creek, South Fork Tieton Creek, and Waptus) (Nelson, 2004; Nelson, 2005). Sampling in the lower portion of the Yakima River was conducted in 2006 in the Union Gap/Wapato reach. Study results are summarized in the following sections, and additional details are in Nelson (2004).

4.10.1.1 Flow Magnitude and Timing

Aquatic invertebrates appear to be adapted to flow fluctuations within a range of what can be considered normal conditions. For example, Morgan et al. (1991) found that invertebrate density doubled if flows were generally held within a range of about one to three times the base flow. However, under extreme flood conditions—28 to 60 times the base flows—benthic biomass can be reduced between 75 to 95 percent within the first few miles downstream and a reduction of between 40 to 60 percent (compared to undisturbed areas) can be detected 12 to 25 miles downstream (Moog, 1993). In general, flood flows need to exceed about 20 times the median flow to have significant effects on invertebrate abundance and taxonomic richness 3 to 4 weeks after a flood event (Quinn and Hickey, 1994).

However, artificially high flows at unseasonable times may have a major effect on benthic composition. The length of time that biota are exposed to high flows also likely plays a role in the amount of community resiliency that is exhibited, with short-term (pulse) alterations less damaging than long-term (press) alterations. This may explain some of the variance in invertebrate assemblages downstream from Yakima Project reservoirs and may play a role in the low richness values relative to other Reclamation reservoirs (Nelson, 2004). Macroinvertebrate communities downstream from Cle Elum Lake and Bumping Lake appeared, however, to recover relatively quickly, with distance and time, from dam-induced impacts (Nelson, 2004).

Arango (2001) determined that the flip-flop operation affected the insect community in an upper Yakima River riffle near the town of Ellensburg. It appeared that some insects were stranded as the water level was lowered in the Yakima River, while other insects entered the drift. Standing crop, however, doubled in samples collected in the river. The study suggested that a major portion of the invertebrate community is successful in moving down the drying bank and back into the wetted area.

4.10.1.2 Recovery from Regulation

The benthic communities downstream from Cle Elum Lake and Bumping Lake appeared to recover from dam-induced impacts within a relatively short distance (1.5 to 5.9 miles) downstream from dams (Nelson, 2004). However, the

hyporheic invertebrate community may be more impacted by river regulation than macroinvertebrates associated with surface substrates (Nelson and Bowen, 2004), and the recovery distances downstream from dams for this portion of the macroinvertebrate community remains unstudied.

4.10.1.3 Lateral Connectivity/Backwater Effects

Backwaters in natural systems often function as macroinvertebrate refugia from extreme flows. Backwaters accumulate macroinvertebrates during spates, and lateral heterogeneity of stream channels is an important element of stream restoration (Negishi et al., 2002). Floodplain production of invertebrates can be orders of magnitude higher than that produced in the river channel (Gladden and Smock, 1990) and result in enhanced growth and survival of salmonids (Sommer et al., 2001). However, this may not always be the case, and Naches River invertebrate drift biomass and the abundance of benthos preferred by salmonids decreased in a season with higher flows, suggesting that invertebrates may have been flushed out of backwaters (Reclamation, unpublished data). Differences between studies may be the result of variable responses to differences in flow duration (e.g., pulse vs. press disturbances).

Stanford et al. (2002) emphasized the importance of flow for maintaining off-channel environments in the Yakima River system, and it was suggested that these areas are often dewatered because of reduced base flows. Productivity decreases in benthic invertebrates caused by flow alterations likely to impact the quality of salmonid food resources. Presence of coarse-particulate-organic-matter (CPOM) has been found to be positively correlated with aquatic invertebrate biomass in upstream portions of the Yakima River basin (Nelson, 2005) and CPOM is associated, to a large degree, with riparian trees. Leaf fall in the autumn provides a large input of CPOM, with much of this linked to black cottonwoods, which then enters the main channel directly through leaf fall and via connection with side channels and floodplain inundation.

4.10.1.4 Relationship to Discharge and Project Facilities

It is likely that aquatic invertebrate distribution in the Yakima Project area is related to discharge, and, therefore, the potential for community changes resulting from altered flows is high. Alternatives that shift flows from what were the historic normative flows should have the greatest adverse effect on macroinvertebrate communities. However, despite some of the extreme alterations already present in the system, there is a great diversity and abundance of macroinvertebrates at some sites downstream from dams in the Yakima Project area.

Yakima Project facilities and their operations have variable effects on aquatic invertebrates, with variability likely related to the degree of resulting flow alteration as compared to the natural flow regime. For example, taxa richness

values downstream from diversion dams were similar to those obtained from unregulated tributaries, and much higher than those obtained below storage reservoirs (Nelson, 2004). Macroinvertebrate communities downstream from Cle Elum Lake and Bumping Lake appear to recover from dam-induced effects with distance downstream and season.

4.10.2 Environmental Consequences

As discussed in detail in this section, the analysis of alternatives based on hydrology suggests that the Black Rock Alternative would result in major positive changes in macroinvertebrate assemblages in the Wapato reach of the Yakima River and major changes of an indeterminate nature in the Cle Elum River. It appears that the Wymer Dam and Reservoir Alternative would have few effects, and that the Wymer Dam Plus Yakima River Pump Exchange Alternative may result in only minor to moderate positive changes in the Wapato reach.

4.10.2.1 Methods and Assumptions

Impact assessment for aquatic invertebrate communities that may be affected by the proposed alternatives was based on studies from other river systems and site-specific sampling within the Yakima River basin. Study results are summarized in the following sections and additional details can be found in Nelson (2004), and in the "Aquatic Ecosystem Evaluation" report developed for the Storage Study (Reclamation, 2008a).

Reclamation scientists have been sampling aquatic invertebrates at Yakima River basin sites for several years, but this has occurred mostly in the upper part of the basin. Sites sampled in 2002-04 include areas downstream from storage reservoirs (Keechelus, Kachess, Cle Elum, Bumping, Clear, and Rimrock [Tieton] Lakes); downstream from diversion dams (Easton and Roza); and in unregulated tributaries (Bumping, Cle Elum, Cooper, Gold Creek, Deep Creek, Indian Creek, South Fork Tieton Creek, and Waptus) (Nelson, 2004; Nelson, 2005). Sampling was conducted in 2006 at six sites in the Union Gap and Wapato reaches using the same methods as presented in Nelson (2004). These data indicated that Ephemeroptera Plecoptera and Trichoptera (EPT) and taxa richness were similar between Union Gap/Wapato sites (EPT = 12.5 $\pm$ 1.5 [95-percent confidence interval]), taxa richness = 23.3 $\pm$ 6.0 (95-percent confidence interval) and unregulated tributaries (n = 30) (EPT = 15.3 $\pm$ 1.8 (95-percent confidence interval), taxa richness = 22.7 $\pm$ 2.4 (95-percent confidence interval) and abundance values were higher at sites in the lower reaches (lower reach abundance = 504 $\pm$ 315 [95-percent confidence interval]) individuals/sample, unregulated tributaries abundance = 252 $\pm$ 90 (95-percent confidence interval) individuals/sample, but had overlapping confidence intervals. Taxa richness refers to the total number of taxa sampled at sites, while EPT richness depends on the number of taxa within the disturbance sensitive insect orders of Ephemeroptera, Plecoptera, and Trichoptera.

Yakima River basin reservoirs/diversions were compared to 15 other Reclamation reservoirs with similar water quality parameters through a percentile ranking mechanism based on taxa (same classification level) and EPT richness (Nelson, 2004). Richness scores from the 15 Reclamation reservoirs are categorized from low to high value and Yakima sites compared based on percentiles: ≥ 75 percent is high; > 50 to 75 percent is moderately high; > 25 to 50 percent is moderately low; and ≤ 25 percent is low.

The focus in this analysis is largely on three reaches and includes the Cle Elum River, Kittitas (Ellensburg) and Wapato (Parker) reaches of the Yakima River. Hydrographs for these reaches are presented in chapter 2. Changes in macroinvertebrate assemblages are likely to occur under conditions that alter the timing and/or magnitude of flows, and these alterations may vary in different reaches of the same river. Macroinvertebrate data are relatively common for the Cle Elum River, largely absent for the Kittitas reach, and limited for the Wapato reach. A variety of metrics, including EPT and taxa richness along with macroinvertebrate functional feeding groups, were used to estimate effects related to hydrographs for these three reaches. It should be recognized that hydrological responses and macroinvertebrates to a river section may be variable under similar flows and the conclusions are not intended to be very specific.

4.10.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Under the No Action Alternative, flows are little changed from the current condition. Yakima Project facilities and their operations have variable effects on aquatic invertebrates under the No Action Alternative, with variability likely related to the degree of resulting flow alteration as compared to the natural flow regime. For example, taxa richness values downstream from diversion dams were similar to those obtained from unregulated tributaries and much higher than those obtained downstream from storage reservoirs (Nelson, 2004). Flows from diversions typically resemble run-of-the-riverflows and may thus be more similar to historic hydrology. Clear Lake and Rimrock Lake differed from other reservoirs by exhibiting high taxa richness values. Clear Lake flows are similar to natural flows and are typically surface withdrawals, while large substrate downstream from Rimrock Lake may provide a more stable habitat for invertebrates. It should also be noted that sampling at Rimrock Lake occurred in August, almost a year after—and before—the initiation of annual high flows associated with flip-flop operations. Macroinvertebrate communities downstream from Cle Elum Lake and Bumping Lake appear to recover from dam-induced effects with distance downstream and season.

When compared among themselves based on aquatic invertebrate richness, Yakima River basin reservoirs and diversions can be ranked from highest to lowest as: Rimrock = Roza = Clear Lake = Easton > Kachess = Bumping > Cle Elum = Keechelus (Nelson, 2004). The high late-summer flows from Cle Elum Lake (chapter 2) are likely responsible for the low macroinvertebrate rankings downstream from this reservoir in August/September.

Despite alterations in the basin, there is a great diversity and abundance of macroinvertebrates at some sites downstream from dams in the Yakima Project area. For example, high-quality resilient invertebrate communities exist in the upper Yakima River basin under the altered flow regimes associated with flip-flop operations (Cuffney et al., 1997; Stanford et al., 2002; Nelson, 2004; Reclamation, unpublished data). Limited data appear to indicate some impairment to aquatic invertebrates in downstream sites. Cuffney et al. (1997) describe sites along the mainstem Yakima River between Umtanum and Parker as containing moderately impaired communities. Conditions that may have influenced the macroinvertebrate communities included municipal wastewater discharges, irrigation return flows, and hydrological alterations caused by water diversions. Water diversions in conjunction with enrichment from wastewater discharges may result in major alterations of invertebrate communities (Suren et al., 2003). It is possible that, in the lower portion of the Yakima Project area, water diversions result in more easily detected consequences on the invertebrate community than the alterations in flow timing that presently occur in the upper part of the project under flip-flop operations. However, recent data collection indicates that metrics from macroinvertebrate samples collected from the Union Gap and Wapato reaches have values similar to those from unregulated tributaries. It should be noted that some investigators (Paller et al., 2006) have found that macroinvertebrate taxa richness increases with growing stream width. This appears not to be the case at Union Gap and Wapato, and taxa richness equivalent to upstream sites may be indicative of impacts.

Differences in flow objectives (table 2.7) for the No Action Alternative (similar to current flows) suggest that upstream reaches during spring flows at Kittitas (decreased by 8 percent) are less altered than those in the Wapato reach, which are decreased by 38 percent. This alteration from unregulated flow would be expected to affect in-channel invertebrates, but would also affect floodplain aquatic invertebrates and CPOM production from black cottonwoods. The No Action Alternative would likely result in diminished production of CPOM over time because of the low cottonwood seedling recruitment that presently occurs on some of the reaches.

4.10.2.3 Black Rock Alternative

Construction Impacts

Construction-related impacts are anticipated to be minimal and isolated to areas adjacent to or immediately downstream from any new intake or outlet structures.

Long-Term Impacts

The Black Rock Alternative appears to result in the most normative/unregulated flow regime (chapter 2) at the three reaches. In the Cle Elum River, the Black Rock Alternative would shift high flows from summer to early spring (chapter 2). These high flows, however, would be much lower than unregulated flows (chapter 2) and even lower than the current high flows (around 13 times lower in some cases). At present, the macroinvertebrate community recovers from the impacts of regulation at about 6 miles downstream from the dam, and, in the absence of large flows in July-September, this recovery distance may decrease and result in community assemblages found immediately downstream from the dam becoming more like those found at downstream stations (Nelson, 2004), at least in the short term. Because of the presence of Cle Elum Lake, communities would still be altered with a larger presence of collector-filterers closer to the reservoir. Collector-filterers are animals with anatomical structures (setae or fans) or secretions that sieve particulate matter from suspension. In the absence of near normative high flows at any time of the year, there is a concern that finer substrates may become more common in the Cle Elum River downstream from the dam. This could have a large impact on the macroinvertebrate community because fine sediment deposition has been correlated with lower benthos abundance and changes in composition from EPT to burrowing midges and oligochaetes (Waters, 1995). The overall lower flows that would occur under the Black Rock Alternative would also likely result in the retention of more CPOM in the Cle Elum River. This could result in an abundance of shredders (organisms that process large pieces of decomposing plant matter) and collector-gatherers (organisms that feed primarily on deposited fine particulate organic matter) in what would become a largely low-flow environment with larger amounts of CPOM.

In the Ellensburg reach of the Yakima River, summer flows would still be relatively high under the Black Rock Alternative, but would become more like unregulated conditions during spring runoff. Because of the high summer flows, it is likely that the macroinvertebrate community would be mostly unchanged in this reach under the Black Rock Alternative.

The Wapato reach shows higher spring and summer flows (around 4-5 times greater than under the No Action Alternative) under the Black Rock Alternative, which results in a flow regime more similar to unregulated conditions. Despite these current alterations, the macroinvertebrate community in this reach and the Union Gap reach just upstream contain assemblages that have richness and abundance values similar to those in upstream unregulated tributaries ("Methods

and Assumptions"). The higher summer base flows may expand the river channel area and increase channel production for a given reach. The Black Rock Alternative, because of higher spring flows, may result in more floodplain inundation for a longer period of time. This could have a large impact on invertebrate production in these areas. It has also been suggested that there would be an improvement in cottonwood forest trends in this reach of the Yakima River ("Vegetation and Wildlife") which could maintain or increase CPOM production. It is unclear whether the increased (relative to the No Action Alternative) winter time flows under this alternative would flush CPOM from this reach.

Abundance of hyporheic invertebrates in sample wells in the Wapato reach was low relative to other sites in the Yakima River basin (Stanford et al., 2002). It is possible that the greater base flow under the Black Rock Alternative could increase the interaction between surface water and groundwater in this reach, resulting in increased invertebrate production in the hyporheic. Much of this invertebrate biomass would eventually make its way back to the main channel, resulting in increased productivity under the Black Rock Alternative.

4.10.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Construction-related impacts are anticipated to be minimal and isolated to areas adjacent to or immediately downstream from any new intake or outlet structures.

Long-Term Impacts

Hydrology under the Wymer Dam and Reservoir Alternative is grossly similar to the No Action Alternative for the Cle Elum River (chapter 2), with the exception of slightly greater (< 2 times) winter flows. Thus, major effects on macroinvertebrate assemblages are unlikely. The major impact from the high late season flows would be the likely driver under this alternative.

Changes in hydrology in the Ellensburg reach under the Wymer Dam and Reservoir Alternative would also be limited and would still retain the flattened spring runoff peak and summertime maximum flows. It would be expected that macroinvertebrate assemblages would be similar to those under the No Action Alternative.

The Wymer Dam and Reservoir Alternative hydrology in the Wapato reach appears to be similar to the No Action Alternative and, therefore, it is not expected that there would be any observable effects on the macroinvertebrate community.

4.10.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Construction-related impacts are anticipated to be minimal and isolated to areas adjacent to or immediately downstream from any new intake or outlet structures.

Long-Term Impacts

Hydrology under the Wymer Dam Plus Yakima River Pump Exchange Alternative is grossly similar to the No Action Alternative for the Cle Elum River (chapter 2) and thus would be unlikely to result in major effects on the macroinvertebrate assemblages. The timing of flows late in the season would be largely unchanged from the No Action Alternative.

Changes in hydrology in the Ellensburg reach under this alternative would also be limited and would still retain the flattened/depressed spring runoff peak and summertime maximum flows. It would be expected that macroinvertebrate assemblages would be similar to those under the No Action Alternative.

The Wymer Dam Plus Yakima River Pump Exchange Alternative would result in greater base flows in the late summer and early fall in the Wapato reach. Spring flows are approximately 2 times greater, which may result in some increased flooding of the riparian area. Effects on the macroinvertebrate community under this alternative would be less than those expected under the Black Rock Alternative but could be expected to be altered in the direction of the Black Rock Alternative. This would include changes caused by increased channels width, hyporheic exchange, and CPOM introduction to the reach from black cottonwoods.

4.10.2.6 Mitigation

No mitigation would be required because impacts to aquatic invertebrate populations are anticipated to be minor or, in the long term, potentially beneficial.

4.10.2.7 Cumulative Impacts

Impacts to aquatic invertebrates under the Joint Alternatives are largely beneficial, except for potential minor impacts associated with short-term construction activities. The beneficial impacts associated with the Joint Alternatives to a large extent stem from changes in the flow regime, modifying it to more closely resemble the natural flow regime. None of the actions that are reasonably foreseeable would significantly alter the flow regime, so they should not offset the benefits to aquatic invertebrates that are projected under the Joint Alternatives. Some of the fisheries enhancement projects to be carried out under the BPA Fish and Wildlife Program or through other fish enhancement programs such as the State of Washington's Salmon Recovery Funding Board could provide very localized improvements in aquatic invertebrate populations, but, from a basinwide perspective, they would not be significant.

4.11 Threatened and Endangered Species

4.11.1 Affected Environment

Reclamation evaluated special status species potentially occupying or using the Storage Study area. Columbia River species selection was confined to the river channel only within Priest Rapids Lake and the Hanford reach downstream. In the Yakima River basin, only Benton, Kittitas, and Yakima Counties were addressed. Although the basin includes a narrow strip of northern Klickitat County (including the headwaters of Status Creek), no facilities would be constructed and/or operated that would affect resources in Klickitat County.

As in other sections addressing both Columbia River and Yakima River basin locations, the Columbia River is addressed first, followed by Yakima River species. Anadromous fish are treated first, followed by other species.

4.11.1.1 Columbia River

Four anadromous salmonids inhabit or migrate through the Columbia River reaches that may be affected by the Joint Alternatives. These species include: spring, summer, and fall Chinook; summer steelhead; coho; and sockeye. Only fall Chinook are known to spawn in the Columbia River reaches within the study area (FERC, 2006). Upper Columbia River steelhead and Upper Columbia River spring Chinook migrate through this area and are federally listed species under ESA.

Upper Columbia River Steelhead (*O. mykiss*)

The Upper Columbia River steelhead was listed as endangered on June 13, 2007, by court decision. Critical habitat for the Upper Columbia River steelhead was designated on September 2, 2005 (*Federal Register*, 2005). Upper Columbia River steelhead include fish from the mainstem Columbia River and its tributaries upstream of the confluence of the Columbia and Yakima Rivers.

Steelhead life history and ecological considerations are discussed under Middle Columbia River steelhead, and are not repeated here. Steelhead do not spawn in the Columbia River reaches potentially affected by the proposed alternatives, but do migrate through the reaches as adults on their way to spawning streams, and as juveniles on their way to the Pacific Ocean (FERC, 2006). Most steelhead adults pass Priest Rapids Dam during August and September, while most smolts migrate downstream from Priest Rapids Dam in May (range is late April through early June).

The average number of adult steelhead passing Priest Rapids Dam from 1960 to 2004 was 11,379 fish (range from 2,462 in 1975, to 34,589 in 1985; FERC, 2006). Prior to 1960, steelhead were counted upstream at Rock Island Dam. Counts from 1933 to 1959 ranged between 2,600 and 3,700 fish. Hatchery production in

the 1960s increased run size to about 6,700 fish. Adult steelhead counts at Priest Rapids for the period 2003-2005 were 17,652; 18,727; and 13,449, respectively (FERC, 2006).

Upper Columbia River Spring Run Chinook Salmon

Three different runs of adult Chinook salmon pass Priest Rapids Dam. Adult Chinook returning from April 17 through June 13 are "spring" Chinook, adults returning from June 14 through August 13 are "summer" Chinook, and adults returning from August 14 through November 15 are "fall" Chinook (FERC, 2006). Only spring Chinook are federally listed under ESA. The Upper Columbia River spring Chinook salmon, a State candidate species, was federally listed as endangered June 28, 2005 (*Federal Register*, 2005). Critical habitat for this species was designated on September 2, 2005 (*Federal Register*, 2005).

Spring Chinook life history and ecological considerations are discussed in the "Anadromous Fish" section under "Middle Columbia River Spring Run Chinook" and are not repeated here. Spring Chinook do not spawn in the Columbia River reaches potentially affected by the proposed alternatives, but do migrate through the reaches as adults on their way to spawning streams, and as juveniles on their way to the Pacific Ocean (FERC, 2006).

The average annual return of spring Chinook for the period 1960 to 2004 is 13,067 fish (with a range from 51,133 in 2001 to 1,130 fish in 1995; FERC, 2006). Adult spring Chinook counts at Priest Rapids in 2004 and 2005 were 14,541 and 14,663, respectively.

Spring Chinook juveniles outmigrate through the Middle Columbia River in April through June, with peak numbers passing Wanapum and Priest Rapids Dams in mid- to late-May (FERC, 2006).

Additional detail on the affected environment of anadromous fish is found in the "Anadromous Fish" section.

Bull Trout

The bull trout, a State candidate species, was federally listed as threatened in the Columbia and Klamath River basins in 1998.

Bull trout exhibit four life history types in Washington: anadromous, adfluvial (downstream migration to lakes), fluvial (downstream migration to larger rivers), and resident (Wydoski and Whitney, 2003). The resident, fluvial, and adfluvial forms occur in the study area. Resident fish complete their entire life cycle in the streams (or nearby) in which they spawn and rear, while fluvial forms mature in their natal streams, but then move to large streams and rivers after maturation. Adfluvial bull trout rear from 1 to 4 years in their natal stream then migrate to lakes, but return to natal streams to spawn.

Bull trout are native to the Pacific Northwest and are found from the California-Oregon border east to Nevada, north through western Montana and western Alberta, westward through British Columbia, and north to at least 60 degrees north latitude in Alaska (Wydoski and Whitney, 2003). Bull trout occur in the Yukon River drainage and may occur further north. In the mid-Columbia River region of Washington, some 16 subpopulations of bull trout occur in the Yakima, Wenatchee, Entiat, and Methow River basins (FERC, 2006). Historically, subpopulations were more numerous and distribution covered a larger area and included the Columbia River mainstem. Information for the mainstem is limited. However, bull trout are believed to be extirpated from the Hanford reach and are exceedingly rare in the Priest Rapids and Wanapum Lakes.

4.11.1.2 Yakima River Basin

The initial group of federally threatened or endangered species from the three-county Yakima River basin and State-listed threatened or endangered species identified as being potentially affected by the proposed project include the gray wolf, Canada lynx, grizzly bear, marbled murrelet, and northern spotted owl. These species are associated with forest resources high in the basin on lands that may be in proximity to Reclamation's storage reservoirs or other Yakima Project facilities. In 2000, Reclamation concluded—in another study—that operations of project facilities would not result in alterations to habitat resources important to these species (Reclamation, 2000). Reclamation believes that similar circumstances exist with this study, i.e., habitat resources potentially used by these species would not be affected, and these species are not considered further. Four additional species—the pygmy rabbit, the greater sandhill crane, the mardon skipper, and the basalt daisy—have historically occurred, or currently occur, within the three-county study area, but are unlikely to be affected by the proposed alternatives. These four species are briefly addressed but are not carried into the analyses.

Middle Columbia River Steelhead (*O. mykiss*)

Spawning Habitat.—Within the Yakima River basin, wild adult steelhead returns have averaged 1,818 fish (range 505 to 4,491) over brood years 1985-2006 as monitored at Prosser Diversion Dam (RM 47.1; brood year 2006 data from Yakima-Klickitat Fisheries Program (Yakama Nation, 2006). The relative number and timing of wild adult steelhead returning during the fall and winter-spring migration periods varies from year to year (Reclamation, 2000; NPPC, 2001).

Minimal numbers of adult steelhead pass Prosser Diversion Dam during July and August, with numbers beginning to increase in September. Peak passage timing upstream of Prosser Diversion Dam occurs in October and November when a combined 50 percent of the steelhead run occurs at this location. Steelhead abundance over Prosser Diversion Dam declines slightly in December and early-January due to the onset of cold water temperatures. However, adult migration

resumes in February through April, coincident with the spawning run. Adult steelhead migration is essentially completed at Prosser Diversion Dam by early April.

Most adult steelhead over-winter in the Yakima River between Prosser (RM 47.1) and Sunnyside Diversion Dams (RM 103.8) before moving upstream into tributary or mainstem spawning areas (Hockersmith et al., 1995). The Yakima River upstream of Prosser Diversion Dam is known to be occupied by steelhead as well as resident rainbow trout and provides important habitat for adult steelhead migration and holding, as well as for juvenile rearing for this species. In addition, the upper sections of the Yakima River and the entire Naches River basin contains important spawning habitat for steelhead and rainbow trout (Campton and Johnson, 1985; NPPC, 2001).

Hockersmith et al. (1995) identified the following spawning populations within the Yakima River basin: upper Yakima River upstream of Ellensburg, Teanaway River, Swauk Creek, Taneum Creek, Roza Canyon, mainstem Yakima River between the Naches River and Roza Diversion Dam, Little Naches River, Bumping River, Naches River, Rattlesnake Creek, Toppenish Creek, Marion Drain, and Satus Creek. Of 105 radio-tagged fish observed from 1990 to 1992, Hockersmith et al. (1995) found that well over half of the spawning occurred in Satus and Toppenish Creeks (59 percent), with a smaller proportion in the Naches River drainage (32 percent), and the remainder in the mainstem Yakima River downstream from Wapato Dam (4 percent), mainstem Yakima River upstream of Roza Diversion Dam (3 percent), and Marion Drain (2 percent), a Wapato Irrigation Project drain tributary to the Yakima River. Yakima River basin steelhead spawn in intermittent streams, mainstem and side-channel areas of larger rivers, and in perennial streams up to relatively steep gradients (Hockersmith et al., 1995; Pearsons et al., 1996). Within the Naches River basin, most steelhead spawning (85 percent) occurred in the Naches River mainstem, primarily from RM 2.7 (Cowiche Creek confluence) to the Little Naches River, with the remainder distributed in lower reaches of the Bumping River, Little Naches River, and Rattlesnake Creek (Cramer et al., 2003). Electrophoretic analyses have identified four genetically distinct spawning populations of wild steelhead in the Yakima River basin: the Naches, Satus, Toppenish, and upper Yakima stocks (Phelps et al., 2000).

Typically, steelhead spawn earlier at lower, warmer elevations than higher, colder waters. Overall, most spawning is completed from January through May (Hockersmith et al. 1995), although steelhead have been observed spawning in the Teanaway River (RM 176.1), a tributary to the upper Yakima River into July (Pearsons, 2007). From radio tagging data and records of the first observations of steelhead fry, steelhead spawn in the lower Naches (below Tieton) and its tributaries from early March through mid-May. In the upper Naches, the spawning period is from late March through late May. In the higher

elevation tributaries of the upper Naches (the Little Naches River, Bumping River, Rattlesnake Creek), spawning occurs from late April through late May, peaking in early May.

Hatching and Rearing Habitat.—Steelhead eggs take about 30 days to hatch at 50 °F and another 2 to 3 weeks before fry emerge from the gravel. However, time required for incubation varies significantly with water temperature. Fry emergence typically occurs between mid- to late May and early July, depending on time of spawning and water temperature during incubation.

Juvenile steelhead use tributary and mainstem reaches throughout the Yakima and Naches River basins as rearing habitat until they begin to smolt and emigrate from the basin. Smolt emigration begins in November, peaking between mid-April and May. Busack et al. (1991) analyzed scale samples from smolts and adult steelhead and found that the smolt transformation typically occurs after 2 years in the Yakima system, with a few fish maturing after 3 years and an even smaller proportion reaching the smolt stage after 1 year.

Steelhead Distribution.—The Yakima River upstream of Roza Diversion Dam is known to be occupied by steelhead as well as resident rainbow trout and provides important habitat for migration and spawning, as well as for juvenile rearing for this species. Although adult run sizes upstream of Roza Diversion Dam are not large, they constitute an important part of the overall Middle Columbia River steelhead ESU. Since 1985, steelhead abundance in the upper Yakima River upstream of Roza Diversion Dam has averaged about 85 to 108 returning adults, depending on the data source and period of record analyzed (Yakama Nation, 2006; University of Washington, 2006; Haring 2001). Figure 4.15 shows the total steelhead run size for the upper Yakima River stock and the number of adults passing Roza Diversion Dam for the years 1985 to 2007 from these various data sources.

Data provided in figure 4.15 indicates some level of inconsistency in data records for the upper Yakima River stock abundance and fish ladder counts at Roza Diversion Dam. Most of these inconsistencies occurred as a result of inadequate monitoring of fish passage at the dam or because of lack of record keeping related to steelhead passage. However, the data from 2001 to the present are considered to be the most accurate because of more detailed record keeping and specific monitoring activities for anadromous steelhead passage at Roza Diversion Dam.

Specific information regarding steelhead distribution within the upper Yakima River has not been well understood in this area, despite the early radio-tracking work of Hockersmith et al. (1995). However, recent steelhead radio-tracking studies in the upper Yakima River basin (upstream of Roza Diversion Dam), conducted by Reclamation and the Yakama Nation have provided detailed information on the distribution patterns of adult steelhead (Reclamation, 2003d).

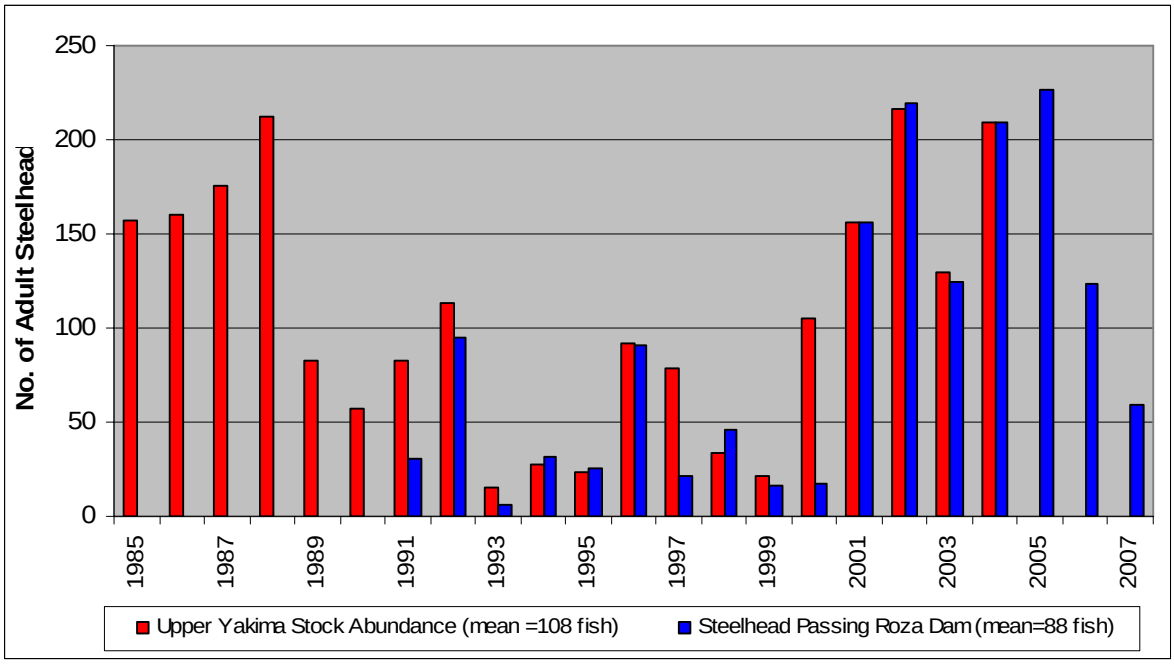


Figure 4.15 Abundance of the Upper Yakima River stock and total number of steelhead passing Roza Diversion Dam between 1985 and 2007.

Sources: University of Washington (2006) and Haring (2001).

These recently completed studies show that tagged steelhead are migrating to and spawning in the Yakima River mainstem as well as major tributary systems of the upper Yakima River (Reclamation, 2003d; Reclamation, 2005).

In 2002-2003, approximately 34 of 75 (45 percent of the total) radio-tagged wild steelhead remained in the mainstem Yakima River between Roza Diversion Dam and Easton, while 24 (32 percent) migrated into the Teanaway River, 9 (12 percent) were tracked into Swauk Creek, and 1 (2 percent) moved about 2.5 miles up Taneum Creek. The remaining seven fish (9 percent) tagged in 2002-2003 were tracked to other Yakima River tributaries (Reclamation, 2003d). Results of steelhead radio tracking in 2003/2004 indicate that 51 percent of tagged steelhead remained in the mainstem river between Roza Diversion Dam and Easton, while 38 (32 percent), 9 (7 percent), and 7 (6 percent) used the Teanaway River, Swauk Creek, and Taneum Creek, respectively (Reclamation, 2005).

Critical Habitat.—The final rule designating critical habitat for 12 evolutionarily significant units (ESUs) of west coast salmon and steelhead in Washington, Oregon, and Idaho was published in the *Federal Register* on September 2, 2005, and became effective on January 2, 2006 (*Federal Register*, 2006). Critical habitat designated for Middle Columbia River steelhead in the Yakima River

basin included the entire mainstem Yakima River from the confluence with the Columbia River to the upstream limits of migration at storage dams or tributary headwater streams.

Critical habitat for steelhead in the Yakima River and tributaries consists of primary constituent elements (PCE) that support steelhead spawning, freshwater rearing, and migration habitat (NOAA Fisheries, 2004; *Federal Register*, 2005). NOAA Fisheries has determined that critical habitat PCEs for steelhead spawning, rearing, and migration exist in the upper Yakima and Naches Rivers as well as several tributaries, and that these PCEs are currently providing an acceptable level of protection that will contribute to the conservation of steelhead populations in this area (NOAA Fisheries, 2004).

Bull Trout

The U.S. Fish and Wildlife Service identified 22 recovery units within the Columbia River Distinct Population Segment (Service, 2002). The Yakima River basin was designated as the Middle Columbia River recovery unit. For recovery purposes, the Service has identified a single core area (Yakima River basin) within the Middle Columbia Recovery unit encompassing a majority of the basin and its tributaries.

Bull trout have some of the most demanding habitat requirements of any native trout species mainly because they require water that is especially cold and clean. As a result, water temperature is a critical habitat characteristic for bull trout. Bull trout have demonstrated a unique adaptation for spawning, incubating, and rearing in colder water than salmon and steelhead. This adaptation has allowed this species to survive in habitat areas that may be unsuitable for most other species of fish. Ratliff and Howell (1992) note that in many of the cold streams where bull trout spawn, they are the only fish present. McPhail and Murray (1979) demonstrated that survival of bull trout eggs was 80-95 percent to hatching at temperatures of 36-40 °F (2-4 ºC) and dropped to 0-20 percent at temperatures of 46-50 °F (8-10 ºC). Buchanan et al. (1997) report observations from throughout Oregon and the published literature, and conclude that, while optimum temperatures for juvenile growth are between 40-50 °F (4-10 ºC), the optimum for adult bull trout is near 54-59 °F (12-15 ºC). Temperatures above 59 ˚F (15 ºC) exceed bull trout physiological preferences and are, therefore, thought to limit their distribution (Fraley and Shepard, 1989).

Bull trout reach sexual maturity after 4 or more years and live up to 10-12 years. They typically spawn during September through November, in relatively cold streams that are clean and free of sediment. The incubation period for bull trout is extremely long, and young fry may take up to 225 days to emerge from the gravel (Craig, 1997; Service, 1998; *Federal Register*, 1998). Because of this long incubation period, eggs are particularly vulnerable to siltation problems and bed load movement in rivers and streams where spawning occurs. Any activity that

causes erosion, increases siltation, removes stream cover, or affects water flow or temperature affects the number of bull trout that hatch and their ability to survive to maturity (Knowles and Gumtow, 1996).

Bull trout exhibit both migrant and resident life history strategies. After rearing as juveniles for 2-4 years in their natal streams (Meehan and Bjornn, 1991), migrant bull trout emigrate to larger rivers or lakes, whereas resident fish complete their entire life cycle within their natal stream. Migrant forms, both fluvial and adfluvial, grow rapidly, often reaching over 20 inches in length and 2 pounds by the time they are 5-6 years old. Migratory bull trout live several years in larger rivers or lakes, where they grow to a much larger size than resident forms before returning to tributaries to spawn. Growth differs little between forms during their first years of life in headwater streams, but diverges as migratory fish move into larger and more productive waters (Rieman and McIntyre, 1993).

Yakima River basin studies indicate that bull trout typically occur in the upper reaches of several tributaries, in small populations that are mostly isolated from each other (Goetz, 1994; Wissmar and Craig, 1998; WDFW, 1998). Studies have indicated that bull trout are most likely to occur, and to be strong in cold, high elevation, low- to mid-order watersheds with low road density (Rieman et al., 1997; Goetz, 1994; MacDonald et al., 1996).

In the 1998 final listing rule (*Federal Register*, 1998), the Service identified eight bull trout subpopulations in the Yakima River basin: (1) Ahtanum Creek, (2) Naches River, (3) Rimrock Lake, (4) Bumping Lake, (5) North Fork Teanaway River, (6) Cle Elum Lake, (7) Kachess Lake; and (8) Keechelus Lake. At the time of listing, only the Rimrock Lake subpopulation was considered stable. The remaining subpopulations were classified as depressed and declining. The population status for the Naches River subpopulation was classified as unknown. With the exceptions of Rimrock Lake and the Naches River, the remaining subpopulations were considered to be at risk of extirpation.

The WDFW recognizes nine bull trout stocks in the Yakima River basin. Eight of these stocks are consistent with the subpopulations identified by the Service in the final listing rule. However, they also include one (Yakima River) that was not recognized by the Service at the time of listing. The Service now concurs with the presence of nine populations. Redd counts for some of these stocks have been conducted annually since 1984 (table 4.32).

One or more local populations may exist within each stock (WDFW, 1998). A local population represents a group of bull trout that spawn within a particular stream or portion of a stream system. Thus, a local population is considered the smallest group of fish that represent an interacting reproductive unit. Gene flow may occur between local populations but is assumed to be infrequent compared to that among individuals within a local population. There are presently 13 local

Table 4.32 Annual redd counts since 1993 for eight local bull trout populations in the Yakima River basin (data from WDFW). The average number of redds counted in the index areas along with the standard deviation (SD) is given at the bottom.

Survey year	Ahtanum Creek	Rattlesnake Creek	American River	South Fork Tieton River	Indian Creek	Deep Creek	Box Canyon Creek	Gold Creek
1993	9			38	140	45	4	11
1994	14	4		167	179	12	11	16
1995	6	26		95	201	101	4	13
1996	5	38	25	233	193	46	8	51
1997	7	46	24	177	193	126	10	31
1998	5	53	31	142	212	98	16	36
1999	7	44	30	161	205	107	17	40
2000	11	45	44	144	226	147	10	19
2001	20	57	36	158	117	51	14	15
2002	17	69	27	141	100	120	15	31
2003	12	54	30	190	101	57	8	9
2004	8	32	40	180	50	97	19	20
2005	6	15	35	205	91	73	8	7
2006	7	40	55	189	106	95	8	8
Avg.	9.6	40.2	34.3	158.6	151.0	83.9	10.8	21.9
SD.	4.7	17.7	9.2	47.9	56.3	37.6	4.7	13.6

populations that have been identified in the Yakama River basin (WDFW, 1998; Service, 2002). Other local populations may exist that are as yet unrecognized. For example, as recently as 2002, a juvenile bull trout was captured by Yakama Nation fisheries personnel in a tributary to Cowiche Creek (Anderson, 2002) and 13 bull trout were observed in the North Fork Tieton River during a comprehensive snorkel census in 2004.

The main migration period for fluvial adult bull trout in the Naches River occurs between May and October, with peak upstream movement occurring in July, and peak downstream movement occurring in September to October (Mizell, 2006).

The early part of this time period is coincident with both water temperature and day length increases and with the early onset and preparation for spawning by adult fish. The later part of this active migration period relates to the downstream movement of post-spawn adults as they return to winter and spring holding habitats in the mainstem of the Naches River. Subadult bull trout are also known to have increased migration activity during this late-spring to early-summer period; however, this behavior is not related to spawning. Adult bull trout that have been radio-tagged as part of the WDFW bull trout telemetry study in the Yakima River basin have been tracked throughout the Naches River mainstem during the active migration period. However, the majority of radio-tagged bull trout have remained near the city of Naches and have only occasionally migrated as far as the city of Yakima. A few fish have migrated into the Yakima River where they have held in suitable habitat for a short time (a few days to weeks)

before migrating back to the mainstem Naches River. Prior to the onset of spawning, adult bull trout in the mainstem Naches migrate upstream to spawning areas in several tributaries of the upper Naches River basin.

During the winter and spring periods (roughly November through May), adult and subadult bull trout hold or overwinter in the mainstem Naches River. The winter and spring is characterized by a period of relative inactivity by bull trout. Overwintering adults and subadults tend to congregate in highly selective pool habitats that may be used year after year by the same fish (Mizell, 2006). Preferred pool overwintering habitats that are used by radio-tagged bull trout occur in the mainstem Naches River from the Wapatox Diversion Dam (RM 17) to the town of Cliffdell (RM 36) (Mizell, 2006).

Greater Sage-Grouse

The greater sage-grouse is State-listed as threatened and is a Federal candidate for listing under the ESA. The current range of the greater sage-grouse includes portions of eastern Montana, Wyoming, northwestern Colorado, Utah, southern Idaho, northeastern California, southeastern Oregon, and central Washington. In Washington, sage-grouse formerly ranged from the Columbia River north to Oroville, west to the foothills of the Cascades, and east to the Spokane River. Sage-grouse in Washington are currently restricted to three isolated populations. The largest population (estimated at about 600 birds) is located on mostly private land in Douglas and Grant Counties. A second population of 300-400 birds occurs on the YTC in Kittitas and Yakima Counties (Schroeder and Vander Haegen, 2006), and a third population of 25-30 birds occurs within the Yakama Indian Reservation (Shroeder et al., 2000; Burkepile, 2007). Data from radio-tagged sage-grouse show that they use habitat in the Black Rock and Wymer reservoir sites (Livingston, 2007). See figures 4.16 and 4.17. Habitat fragmentation in the area has adversely impacted the species as have loss of shrub-steppe habitat from fires, overgrazing, military practices in the YTC, conversion to cropland, invasion of exotic species, and additional development (Stinson, et al., 2004).

The Washington Sage-Grouse working group, an interagency technical group, has developed recovery objectives and delineated management units for the sage-grouse. The Black Rock site lies within the Rattlesnake Hills Management Unit, and the Wymer site lies within the Umtanum Ridge Management Unit. Telemetry data indicates these units are utilized by greater sage-grouse from the YTC. The Rattlesnake Hills Unit is designated as both a potential corridor and habitat for future reintroductions. The northeastern section may allow greater sage-grouse movement between the YTC and the Hanford ALE Reserve (located within the Hanford Management Unit). Sage-grouse were probably extirpated from the Hanford Management Unit due to catastrophic fires in 1981 and 1984, although there has been telemetry data of individual birds since 1998 indicating movement out of the YTC (Stinson et al., 2004). The possible use area and movement

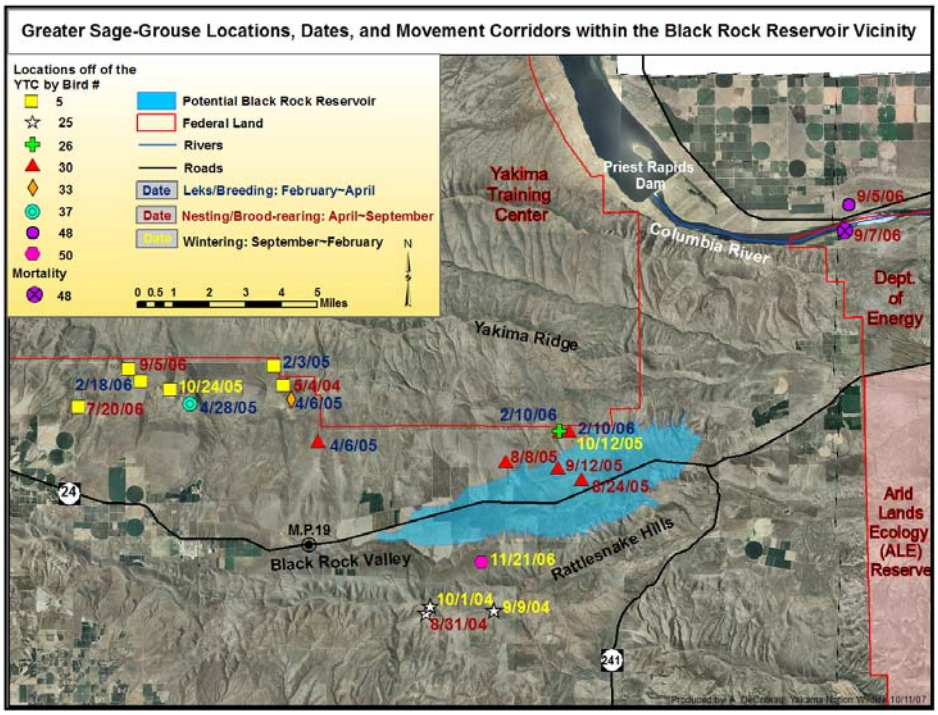


Figure 4.16 Greater sage-grouse locations, dates, and movement corridors within the Black Rock reservoir vicinity.

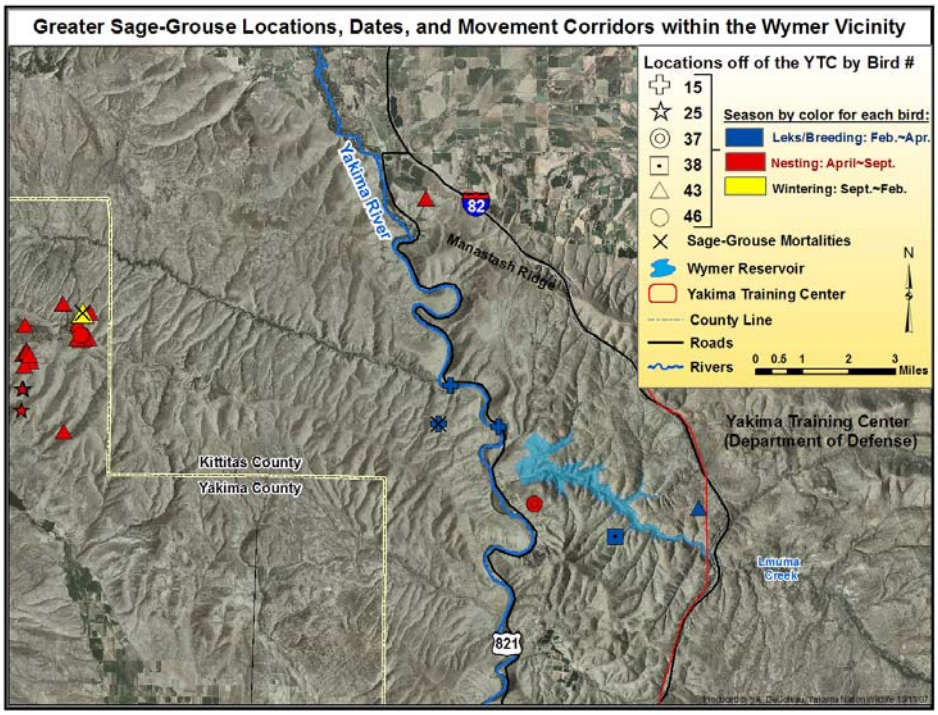


Figure 4.17 Greater sage-grouse locations, dates, and movement corridors within the Wymer site vicinity.

corridor for greater sage-grouse extends from shrub-steppe lands east of the Columbia River, along Priest Rapids Lake and the Hanford reach, west across the Hanford Site, ALE, and the YTC, to the upper end of the Moxee Valley and the shrub-steppe-covered hills west of the Yakima River in the Wenas, Umtanum, and Manastash Creek drainages. To the north, it extends up to the irrigated lands in the Ellensburg Valley. Along the southern edge, it extends from the Rattlesnake Hills west along Ahtanum Ridge, across the Yakima River, and along the ridge to shrub-steppe lands on the Yakama Nation.

Ferruginous Hawk

The ferruginous hawk is a State threatened species and a species of concern under ESA. This species breeds from southeastern Alberta, southern Saskatchewan, and southwestern Manitoba south through eastern Washington, eastern Oregon, and Nevada to Arizona and New Mexico. The range also extends eastward into Utah, Colorado, Wyoming, Idaho, Montana, the Dakotas, and western Nebraska, Oklahoma, and Texas.

In Washington, the range of the ferruginous hawk coincides with the remaining shrub-steppe communities in the eastern part of the State. This species is believed to depend on native prairie systems of the Great Plains and Great Basin. The decline of shrub-steppe prey, such as black-tailed jackrabbits and Washington ground squirrels, has likely contributed to the listing of the ferruginous hawk as threatened in Washington (Watson and Pierce, 2000).

Ferruginous hawks use open grasslands for both nesting and hunting prey. In winter (September through February), this species leaves Washington and generally moves east in search of more abundant prey (Watson and Pierce, 2000). Small- to medium-sized mammals comprise 80-90 percent of their prey. The YTC, Hanford Reach National Monument, and sage-brush-dominated areas on the Yakama Nation lands provide potential habitat resources for this species.

Ute Ladies'-tresses

Ute ladies'-tresses (*Spiranthes diluvialis*), a perennial orchid, was federally listed as threatened in 1992 (Service, 1992). It is also a State threatened species. In 1996, a population was found along the upper Snake River in southeastern Idaho. In 1997, another population was found in Okanogan County, the only known population in Washington (Service, 2007c). Prior to these discoveries, it was known only from a few locations in Montana, Colorado, Wyoming, and Nebraska. Ute ladies'-tresses is a wetland and riparian species found in springs, wet meadows, river meanders, and floodplains from 1,500 to 7,000 feet elevation (Service, 1995).

This species has not been found in the Yakima Project, though no formal surveys have been conducted with the exception of a wetland site downstream from Keechelus Reservoir in the upper river (Reclamation, 1999).

This species occurs in full sunlight to partially shaded sites in early- to mid-seral communities subject to flooding or periodic inundation. Beaked spikerush (*Eleocharis rostellata*) appears to be the dominant species in habitat occupied by Ute ladies'-tresses and is a good indicator throughout its range. Other species commonly associated with the orchid include creeping bentgrass (*Agrostis stolonifera*), Baltic rush (*Juncus balticus*), long-styled rush (*Juncus longistylis*), and scouring rush (*Equisetum laevigatus*). Other common associates include rushes (*Juncus spp.*), paint-brushes (*Castilleja spp.*), thinleaf alder saplings (*Alnus incana*), narrowleaf cottonwood saplings (*Populus angustifolia*), sweet clover (*Melilotus spp)*, willow saplings *(Salix spp.*), sedges (*Carex spp.*), red clover (*Trifolium praetense*), and western goldenrod (*Solidago spp*).

Umtanum Wild Buckwheat

Umtanum wild buckwheat is a State endangered species and a Federal candidate species. This species is endemic to a very narrow range in Benton County. It is currently only known from one ridgeline in the Columbia Basin physiographic province, most of which recently burned in a wildfire (WDNR et al., 1997). The only known population occurs at elevations ranging from 1,100 to 1,320 feet on flat to gently sloping microsites near the top of the steep, north-facing basalt cliffs overlooking the Columbia River. It is apparently restricted to the exposed top of one particular basalt flow (the Lolo Flow). Approximately 5,000 plants grow interruptedly in a narrow band 1.6 miles long and less than 98 feet wide in the Hanford Site. This species' restriction to exposures of one particular basalt flow may suggest a dependent relationship with the chemical composition of that flow. The relatively high water-holding capacity of the substrate has also been suggested as an important factor. The overall vegetation cover is quite low.

The area occupied is being considered for a change in ownership or management responsibility. Public access could accompany such a change. Off-road vehicle use, livestock grazing, and increased risk of wildfire are potentially significant threats (Reveal et al., 1995).

Pygmy Rabbit - Greater Sandhill Crane - Mardon Skipper - Basalt Daisy

The pygmy rabbit, the greater sandhill crane, the mardon skipper, and the basalt daisy have historically occurred, or currently occur, within the three-county study area, but are unlikely to be affected by the proposed alternatives. These four species are briefly addressed below but are not carried into the analyses.

The pygmy rabbit is a species with endangered status in the State of Washington, and under ESA and was initially evaluated for potential effects from the proposed action. The pygmy rabbit was thought to have been extirpated from Washington in the mid-1900s, but some small populations were relocated in 1979. Extensive surveys in 1987 and 1988 located five small populations in southern Douglas County (WDFW, 1995). A sixth population was located in 1997, but between 1997 and 2000, five of the six populations disappeared (Hays, 2001). The

Washington Department of Fish and Wildlife initiated a pygmy rabbit captive breeding program in 2001 and released captive-bred rabbits at a Douglas County site in the spring of 2007. No animals have been detected since 2004, indicating that the pygmy rabbit in Washington may be extirpated from the wild (Service, 2007a). This species is not considered further.

The sandhill crane has been listed as endangered in Washington since 1981 (Littlefield and Ivey, 2001), but there is no listing status for sandhill cranes under ESA. This species was also initially evaluated for potential effects from the proposed project. A small number of greater sandhill cranes nest in Klickitat and Yakima Counties, and 20,000 plus lesser sandhill cranes stop in eastern Washington during migration. Sandhill cranes that breed in the study area (Yakima County) are part of the Central Valley population that winters in California's Central Valley and nests in California, Nevada, Oregon, Washington, and British Columbia (Littlefield and Ivey, 2001). The lesser sandhill cranes that stop in eastern Washington during migration belong to the Pacific Flyway population. Cranes that breed in Yakima County use an area some distance from project facilities and would not be affected by any proposed operation changes. Therefore, habitat resources potentially used by this species would not be affected, and greater sandhill cranes are not considered further.

The mardon skipper is a small northwestern butterfly currently found at only four small geographically distinct areas in Washington, Oregon, and California. This species is federally listed as endangered and is a State candidate for listing. In Washington, the mardon skipper occurs in a small number of sites in the Puget Prairie and South Cascades (Potter et al., 1999). Active sites within the South Cascades are known from southwestern Yakima and northwestern Klickitat Counties. In the South Cascades, mardon skippers are found in open grassland sites within the Ponderosa pine savanna woodland at elevations ranging from 1,900 to 5,100 feet. All known occupied sites are on U.S. Forest Service or Yakama Nation lands. Mardon skippers are closely associated with sites supporting native bunch grass such as Idaho fescue. Skippers that occur in Yakima County use areas some distance from project facilities and would not be affected by any proposed operation changes. Therefore, habitat resources potentially used by this species would not be affected, and mardon skippers are not considered further.

The basalt daisy is State-listed as threatened and as a candidate for Federal listing under the ESA. The basalt daisy, a small daisy, is found in the steep cliffs above Selah Creek and within the Yakima River Canyon. It is unlikely that habitat resources potentially used by this species would be affected by the proposed alternatives, and the basalt daisy is not considered further.

The bald eagle was removed from Federal Endangered Species protection on June 28, 2007, but the species remains protected under the Bald and Golden Eagle Protection Act, the Migratory Bird Treaty Act, and remains State-listed as

threatened. Bald eagles occur in the Yakima River basin along the shores of lakes, reservoirs, and streams. Suitable habitat includes areas that are close to water and provide a suitable food resource such as anadromous or resident fish, waterfowl, or carrion. Three nests have been reported in the Yakima River basin that are at, or near, Reclamation facilities: one at Cle Elum Lake, one at Rimrock Lake, and one in the Yakima River Canyon near Roza Diversion Dam (Reclamation, 2000).

Bald eagle wintering sites typically occur in the vicinity of concentrated food resources such as anadromous fish spawning areas, waterfowl concentration areas, or sources of mammalian carrion such as ungulate winter ranges. Other important wintering habitat features include perch sites and communal roost sites. The birds do not arrive until late December or, more typically, early January. Mid-winter bald eagle surveys were conducted in Washington, including the Yakima River area, from the winter of 1981-82 to the winter of 1988-89 (Stinson et al., 2001). During this period, the Yakima River counts varied from a high of 39 to a low of 3 with a mean of 23.9 (Stinson et al., 2001). The 2002 Christmas Bird Count for the Tri-Cities tallied 16 bald eagles, compared to 34 in 2001. The overall trend for these counts is quite erratic from year to year (Audubon Society, 2002).

The Hanford reach of the Columbia River has been monitored for wintering bald eagles since 1960 (Caldwell et al., 2000). Wintering bald eagles have generally increased during the early study period, reaching a high in 1989 of 58. The number of eagles declined through the 1990s. In 2000, 26 eagles were counted wintering along the Hanford reach. Caldwell et al. (2000) indicate that the bald eagle numbers generally track changes in the number of returning fall Chinook salmon, a major fall and winter food source. Fall Chinook redds counted in the Hanford reach increased during the 1960s through 1980s until reaching a high of about 9,000 in 1989. Redd counts dropped during the early 1990s to about one-third of the 1989 peak. In 2000, about 5,507 redds were counted. It is likely that bald eagle use in the nearby lower Yakima River would follow a similar trend. Due to its removal from Federal Endangered Species protection the bald eagle is not discussed further.

The remaining seven species (table 4.33) are addressed below or in other sections of this Draft PR/EIS.

4.11.2 Environmental Consequences

4.11.2.1 Methods and Assumptions

The issues, indicators, methods, and assumptions previously described in the “Anadromous Fish” and “Resident Fish” sections are the same for the threatened and endangered salmonids: threatened and endangered stocks

Table 4.33 State and federally listed endangered or threatened species that may occur within the Yakima River basin, and may be affected by the project

Species	State of Washington status	Federal ESA status
Upper Columbia River steelhead	Species of Concern	Endangered
Upper Columbia River spring Chinook	Species of Concern	Endangered
Middle Columbia River Steelhead Bull trout	Candidate for Listing Candidate for Listing	Threatened Threatened
Greater sage-grouse Ferruginous hawk	Threatened Threatened	Candidate for Listing Species of Concern
Ute Ladies'-tresses Umtanum wild buckwheat	Not Listed Candidate for Listing	Threatened Endangered

of steelhead and Chinook salmon and bull trout. The following is a summary of the indicators and methods used in the analysis of impacts.

- Early life-stage survival as measured by a difference (acres and percent) in steelhead summer rearing habitat compared to the No Action Alternative for the Easton and Ellensburg reaches. The DSS, SRH-W, and River2D models were used to quantify these changes.

- Restoration of more natural flows as measured by a comparison of the average median streamflows and rate of change in daily flow in the Easton, Ellensburg, and the lower Naches River reaches for pre- and post-flip-flop operations. The Yak-RW model was used to estimate the daily median streamflows for the Easton, Ellensburg, and lower Naches River reaches.

- Success of seaward migration as measured by the volume of water (March through June) measured at the Parker gage. The spring freshet runoff for the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives was qualitatively compared to the No Action Alternative and ranked as "worse," no change," or "improved."

- Fish population: The EDT, Yak-RW, and USGS temperature models were used to estimate limiting factors and fish population numbers by species.

- False attraction of spawning runs caused by the diversion of Columbia River water to the Yakima River. The methods were derived from the Technical Series No. TS-YSS-13 entitled, *Assessment of the Effects of the Yakima Basin Storage Study on Columbia River Fish Proximate to the Proposed Intake Locations* (Reclamation, 2008b). The analysis is based on the timing of the fishes' interaction prior to or post diversion, the

percentage of native versus diverted flows, and the chemical signature of the diverted flows after seepage through Yakima River basin soils.

- The ability of bull trout, residing in reservoirs, to access spawning streams. The first component of this indicator is the average annual number of days access from the reservoir to spawning tributary is impeded by low reservoir volume and tributary inflows. The second component is the average pool elevation in Kachess, Keechelus, and Rimrock Lakes during bull trout spawning migration (July 15-September 15). This indicator is described in detail in the "Resident Fish" section.

The greater sage-grouse analysis focuses on changes in acres of shrub-steppe habitat, movement corridors, and exposure to West Nile virus. Movement corridor delineation for the greater sage-grouse was evaluated based on the following: telemetry data of collared birds off of the YTC; topography of area dependent on ridgelines and valleys where greater sage-grouse are most likely to occur or travel through; and occurrence of shrub-steppe vegetation based upon aerial photographs, which excludes agricultural and residential lands. Sage-grouse do not usually occur within or along riparian zones. The methodology for evaluating the risk of West Nile virus is described in detail in the "Public Health" section. The analysis of movement corridors is described in the "Vegetation and Wildlife" section.

The Ute Ladies'-tresses analysis is based on instream flows and riparian flooding discussed in the black cottonwood reproduction section. Both black cottonwood and Ute Ladies'- tresses reproduction are assumed to benefit from the early succession conditions created by riparian flooding.

The ferruginous hawk and Umtanum wild buckwheat analysis is based on changes in acreage to shrub-steppe habitat.

4.11.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Middle Columbia River Steelhead and Bull Trout in the Yakima River.—The flow regime under the No Action Alternative is about the same as under the current condition, suggesting the indicators linked to flow generally reflect conditions that currently exist. The EDT and AHA models estimated average annual escapement of 2,362 for steelhead under the No Action Alternative.

The average annual number of days with a critical threshold reservoir volume for bull trout spawners under the No Action Alternative is Kachess Lake, 18 days; Keechelus Lake, 37 days; and Rimrock Lake, 3 days.

Median reservoir elevations under the No Action Alternative are Kachess Lake, 2,248.4 feet; Keechelus Lake, 2,467.3 feet; and Rimrock Lake, 2,909.9 feet. Additional detail is provided in the "Anadromous Fish" and "Resident Fish" sections.

Greater Sage-Grouse, Ferruginous Hawk, and Umtanum Wild Buckwheat.— These protected species have been combined in the analysis because they would be impacted by the same habitat and disturbance issues associated with the Joint Alternatives. The No Action Alternative would have no impact on greater sage-grouse, ferruginous hawk, and Umtanum wild buckwheat because the quality and quantity of their primary habitat would be unaltered. Existing management and recovery efforts for shrub-steppe habitat and existing wildlife would continue, including the Washington State Recovery Plan for the Greater Sage-Grouse (Stinson, et al., 2004), the Conservation Reserve Program conservation of habitat (Vander Haegen et al., 2004); and possible reintroductions.

Ute Ladies'-tresses.—Greater instream flows would improve riparian habitat associated with Ute Ladies'-tresses. However, the unknown presence of the plant in the study area and the small increase in overbank flooding associated with greater instream flows suggest a negligible improvement for the species.

4.11.2.3 Black Rock Alternative

Construction Impacts

The greatest construction impacts would be for greater sage-grouse because they tend to be in the Black Rock Valley area for foraging from July-September, although most of the grouse located by radio telemetry were not near the damsite. Relocating SR-24 could result in sage-grouse leaving the site during construction (Burkepile, 2007.)

Construction of the Black Rock pumping plant on the Priest Rapids Lake would have minor effects to upper Columbia River steelhead and spring Chinook. A small area of the pool would be isolated during construction and migrating smolts or returning adults would not have access to that area.

Long-Term Impacts

Middle Columbia River Steelhead and Bull Trout in the Yakima River.—Flow changes in the Yakima River (compared to the No Action Alternative) are the greatest of any Joint Alternative. These changes in the flow regime are generally beneficial to anadromous fish.

Early Life-Stage Survival.—In the Easton reach, habitat for steelhead is 10.4 percent greater than under the No Action Alternative. In the Ellensburg reach, the amount of steelhead yearling habitat is 29.2 percent greater than under the No Action Alternative.

Restoration of More Natural Flows.—The Black Rock Alternative provides greater natural flows and better habitat than the No Action Alternative. The lower average rates of change in daily flow would result in less fish and aquatic invertebrate stranding and more stable desired habitat.

Success of Seaward Migration.—Spring seasonal flows are 29 percent above the target flows, compared to 7 percent below the target flows under the No Action Alternative (table 4.25), which represents a more than 500-percent improvement in the spring seasonal flow compared to the No Action Alternative. The stream runoff pattern also is better than under the No Action Alternative, as the high flows continue into April, May, and June when most smolt migration is occurring. These greater flows should increase overall smolt outmigration survival.

Fish Population.—The EDT and AHA models estimated average annual escapement of 4,067 for steelhead under the Black Rock Alternative, compared to 2,700 under the No Action Alternative, or a 50.6-percent increase.

False Attraction.—Under the Black Rock Alternative, Columbia River water would be pumped from the Priest Rapids Lake into the Black Rock reservoir and released into Roza and Sunnyside Canals during the irrigation season.

The monthly median amount of operational spill of Black Rock reservoir water from Roza and Sunnyside Canals ranges from 2.2 cfs in March to 30.4 cfs in August, and the percent of Black Rock reservoir water mixed in the Yakima River water at the Kiona-Benton gage (RM 29.9) ranges from 0.049 to 1.62 percent (table 4.34).

Fretwell (1989) investigated, under laboratory conditions, the behavioral response of sockeye salmon to their home water source in comparison to their home water source mixed with an increasing percent of a nonhome water source. He found that when the admixture of nonhome water source exceeded 10 percent, fish began to discriminate between the two water sources and selected their home water source more frequently. This study suggests that the sockeye did not discriminate between the home and nonhome water sources based on the behavioral response to a water source preference. As noted previously, the peak adult steelhead migration occurs in October and November, with a second run in February. Based on these findings, the potential for false attraction resulting from direct operational spill of mixed Yakima and Black Rock reservoir water appears to be minimal.

Table 4.34 Percent of Black Rock reservoir water mixed with Yakima River water at the Kiona-Benton gage (RM 29.9) by month during the irrigation season as a result of direct operational spill from Roza and Sunnyside Canals

Month	Kiona-Benton gage monthly median flow (cfs)	Total monthly median Roza and Sunnyside Canal operational spill of Black Rock reservoir water (cfs)	Percent of Black Rock reservoir mixed with Yakima River water (cfs) at Kiona-Benton gage
March	4,507	2.2	0.049
April	5,162	17.5	0.34
May	4,933	24.4	0.49
June	4,428	29.0	0.65
July	1,932	30.1	1.53
August	1,845	30.4	1.62
September	1,939	24.5	1.25
October	2,206	20.9	0.94

Bull Trout Spawning.—The stream access thresholds and reservoir elevations associated with the Black Rock Alternative are about the same as those for the No Action Alternative. There is no biologically distinguishable difference in bull trout access to streams during the spawning migration between the No Action Alternative and the Black Rock Alternative.

Upper Columbia River Steelhead and Spring Chinook.—Impacts to fish in the Columbia River would occur from the pumping plant in the Priest Rapids Lake. There should be no impacts to these species from pumping water out of the Columbia River as the pump intake would be screened to State specifications to prevent entrainment of fish.

Greater Sage-Grouse.—The issues associated with the Black Rock Alternative as they may affect greater sage-grouse include the following:

- Loss of habitat that would adversely impact movement, dispersal, reintroduction and feeding
- Exposure to West Nile virus resulting in direct and indirect mortality
- Construction disturbance
- The proposed reservoir includes 3,539 acres of shrub-steppe, 113 acres of grassland, and 3,771 acres of Conservation Reserve Program lands, considered important for the continued survival of greater sage-grouse in central Washington (Service, 2007b). The Black Rock Alternative would inundate about 13.5 square miles of the Black Rock Valley, which would no longer available as habitat. The highway and utilities relocation south of the proposed reservoir would impact a movement and potential

dispersal corridor considered important for sage-grouse recovery (Livingston, 2007). Impacts would include loss of shrub-steppe habitat and the potential for greater mortality from vehicles. The location of the reservoir in the middle of three localized populations and the small, fragmented nature of the central Washington population suggest that the habitat losses from the proposed alternative would have an adverse impact on greater sage-grouse.

Inundation by the reservoir would impact the greater sage-grouse population in the YTC by reducing available shrub-steppe habitat and placing an impediment to their dispersal and movement in the Black Rock Valley. Currently, greater sage-grouse can move through a "corridor" that stretches in an arc about 27 miles from the head of the Moxee Valley through the Black Rock Valley to the Columbia River near the SR-24 Vernita Bridge (figure 4.16). This area provides a potentially important corridor between the Hanford Site, the YTC, and Rattlesnake Hills, which are the largest remaining shrub-steppe habitats left in Washington. The existing corridor extends in a general east-west direction, and the long axis of the approximately 9-mile-long Black Rock reservoir would be oriented the same way. Presuming that greater sage-grouse could not fly over the reservoir, which would be more than a mile wide in places, it would block about one-third of the existing corridor. There would still be a corridor about 2½-3 miles wide at the west end of the reservoir, and one about 14 miles wide at the east end where habitat suitable for movement would exist. For comparison purposes, the identified corridor connecting the Rattlesnake Hills to Ahtanum Ridge is less than a mile wide in some spots and, for several miles, only about 2 miles wide. Black Rock reservoir and dam then would not prevent greater sage-grouse from moving from the YTC to the ALE and Rattlesnake Hills, but it would be a significant impediment. Birds approaching the reservoir from the YTC would have to move east or west to get around it.

Greater sage-grouse are susceptible to mortality from West Nile virus (Walker et al., 2007; Naugle et al., 2004). Research has shown West Nile virus reduced survival by an average of 25 percent and put small fragmented populations, like those in the study area, at risk of extinction (Naugle et al., 2004). Black Rock reservoir's proximity to the YTC, Yakama Nation, and Hanford sage-grouse populations increases their risk of exposure to West Nile virus. The effect of this exposure risk is unknown because of the climate, water management, and epidemiology variables that affect mosquito vector introduction, reproduction, and dispersion. These factors are discussed in detail in the "Public Health" section. Research recommends "…eliminating mosquito breeding habitat in anthropogenic water sources …" (Walker et al., 2007). This alternative would not increase the sage-grouse's susceptibility to West Nile virus more than the current condition because the population of the mosquito-carrying the virus would not increase. Also see the "Public Health" section. The direct and indirect loss and

disturbance of habitat and mortality resulting from exposure to West Nile virus suggest that the impact of the Black Rock Alternative would be moderate.

Ferruginous Hawk and Umtanum Wild Buckwheat.—The issues associated with the Black Rock Alternative as they may affect ferruginous hawk and Umtanum wild buckwheat include the following:

- Loss of shrub-steppe habitat
- Construction disturbance

The proposed reservoir includes 3,539 acres of shrub-steppe (Service, 2007b), inundating about 13.5 square miles of the Black Rock Valley. The highway and utilities relocation south of the proposed reservoir and land use changes associated with development surrounding the reservoir would also reduce available habitat and make the remaining habitat more susceptible to potential invasion of exotic species and fire. The unlikely occurrence of buckwheat in the area and the ranging ability of the ferruginous hawk would suggest insignificant impacts. Construction noise, increased traffic, and ground disturbance would have a short-term adverse impact on the ferruginous hawk. The risk to Umtanum wild buckwheat is low because it is unlikely to occur in the study area because of its specialized basalt flow, ridge-top habitat.

The direct and indirect loss of habitat and construction disturbance on ferruginous hawk and Umtanum wild buckwheat would be low.

Ute Ladies'-tresses.—Impacts under this alternative would be largely confined to those associated with changes in Yakima River flows. The Black Rock site is currently shrub-steppe and does not provide suitable habitat for this species.

The change in riverflows to a more unregulated-like pattern would generally be beneficial to this species. As discussed in the "Vegetation and Wildlife" section relative to black cottonwood reproduction, the higher spring flows on floodplains in the middle reaches of the river would create more seasonally flooded habitat where Ute Ladies'-tresses might survive. As with black cottonwoods, the potential increase in habitat would be confined to the Wapatox, Union Gap, and lower Naches River reaches. This possible benefit is tempered by the fact that the known populations of Ute-Ladies'-tresses have been found at elevations several hundred feet higher than elevations in the middle reaches of the Yakima River.

4.11.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Construction activities would disturb sensitive fauna and potentially alter sage-grouse movement corridors. Construction noise and increased traffic would have short-term adverse impacts on sage-grouse foraging from July-September (Burkepile, 2007).

Long-Term Impacts

Middle Columbia River Steelhead and Bull Trout in the Yakima River.—

Early Life-Stage Survival.—The Wymer Dam and Reservoir Alternative would increase fry and yearling habitat in the upper Yakima River basin compared to the No Action Alternative. However, these improvements are below the threshold of biological response (table 4.33).

Restoration of More Natural Flows.—The average rate of change in daily flows is better in the Ellensburg reach and slightly worse in the lower Naches River reach under this alternative than under the No Action Alternative. As a result, fish and aquatic invertebrate stranding would be reduced in the Ellensburg reach. Changes in the lower Naches River are below the threshold of biological response and would not result in any adverse change compared to the No Action Alternative.

Success of Seaward Migration.—Spring seasonal flows under this alternative are essentially the same as under No Action Alternative (table 4.25). No effect on steelhead smolt survival is expected because there is virtually no difference in target flows or in the spring runoff pattern.

Fish Population.—The EDT and AHA models estimated average annual escapement of 2,724 for steelhead under the Wymer Dam and Reservoir Alternative, compared to 2,700 under the No Action Alternative, or a 0.9-percent increase.

False Attraction.—The potential of false attraction at the confluence of Lmuma Creek is minimal, because in most years (except in prorated water years) July and August reservoir releases would occur when the number of migrating adult steelhead in this reach is minimal.

Bull Trout Spawning.—The stream access thresholds and reservoir elevations associated with the Wymer Dam and Reservoir Alternative are about the same as under the No Action Alternative. There is no biologically distinguishable difference in bull trout access to streams during the spawning migration under the Wymer Dam and Reservoir Alternative and the No Action Alternative.

Greater Sage-Grouse.—The issues associated with the Wymer Dam and Reservoir Alternative as they may affect greater sage-grouse include the following:

- Loss of habitat that would adversely impact movement, dispersal, reintroduction, and feeding
- Exposure to West Nile virus resulting in direct and indirect mortality

The proposed reservoir includes 1,055 acres of shrub-steppe habitat; 167 acres of grassland; 62 acres of barren land; 50 acres of riparian area; 30 acres of cliff/canyon; 11 acres of agricultural cropland; 7 acres of developed land; 6 acres of forest habitat; 4 acres of wetlands (Service, 2007b). The location of the reservoir in the movement corridor of the local populations and the small, fragmented nature of the Central Washington population suggests that the habitat losses from the proposed alternative would have an adverse impact on the greater sage-grouse.

Movement corridors and habitat for the greater sage-grouse would be directly affected by the Wymer Dam and Reservoir Alternative (figure 4.17). The corridor through the Yakima River Canyon is about 14 miles wide, north to south. The long axis of the reservoir is oriented east and west so it obstructs very little of the corridor. Greater sage-grouse moving from the YTC to the west or back could easily circumvent the reservoir by moving either north or south.

As discussed for the environmental consequences of the Black Rock Alternative, greater sage-grouse are susceptible to mortality from West Nile virus (Walker et al., 2007 and Naugle et al., 2004). The construction of Wymer reservoir in proximity to the YTC, Yakama Nation, and Hanford sage-grouse populations would increase their risk of exposure to West Nile virus. The impact of this increased exposure risk is unknown because of the climate, water management, and epidemiology variables that affect mosquito vector introduction, reproduction, and dispersion. These factors are discussed in detail in the "Public Health" section.

Ferruginous Hawk and Umtanum Wild Buckwheat.—These two protected species have been combined in the analysis because they are impacted by the same habitat and disturbance issues associated with the Joint Alternatives. Neither species is likely to occur in the study area because of its steep slopes and canyon habitats. The Wymer Dam and Reservoir Alternative is unlikely to affect either the ferruginous hawk or Umtanum wild buckwheat.

Ute Ladies'-tresses.—This alternative would not significantly affect the frequency or extent of riparian flooding in the study area. Lmuma Creek is generally incised and the area is grazed. There is little riparian zone and few, if any, seasonally flooded areas that might provide habitat for this species. Therefore, the Wymer Dam and Reservoir Alternative is unlikely to impact Ute Ladies'-tresses.

4.11.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Construction impacts to fish in the Columbia River would be the same as for the Black Rock Alternative, except the area disturbed by pumping plant construction

would be in the McNary pool near the mouth of the Yakima River. Impacts to greater sage-grouse would be the same as for the Wymer Dam and Reservoir Alternative.

Long-Term Impacts

Upper Columbia River Steelhead, Upper Columbia River Spring Run Chinook Salmon, and Bull Trout in the Columbia River.—Impacts to fish in the Columbia River would occur from the pumping plant on the river. There should be no impacts to these species from pumping water out of the Columbia River as the pump intake would be screened to State specifications to prevent entrainment of fish.

Middle Columbia River Steelhead and Bull Trout in the Yakima River.—There are no substantive differences (10 percent or greater) between this alternative and No Action Alternative for either species. As under the Wymer Dam and Reservoir Alternative, habitat for steelhead in the Easton reach is generally better, while results are mixed in the Ellensburg reach.

Restoration of More Natural Flows.—The Wymer Dam Plus Yakima River Pump Exchange Alternative represents the best improvement in the Ellensburg reach of the Joint Alternatives and the second best improvement in the lower Naches River reach compared to the No Action Alternative. This is expected to reduce fish and aquatic invertebrate stranding in the Ellensburg reach and improve juvenile steelhead rearing habitats.

Success of Seaward Migration.—Spring seasonal flows are 11 percent above the target flows, compared to 7 percent below the target flows under the No Action Alternative (table 4.25), which represents a more than 250-percent improvement in the spring seasonal flow compared to the No Action Alternative. The stream runoff pattern is similar to the No Action Alternative. Though the stream runoff pattern remains unchanged, the increase in spring flows should increase overall smolt outmigration survival.

Fish Population.—The EDT and AHA models estimated average annual escapement of 3,338 for steelhead under the Wymer Dam Plus Yakima River Pump Exchange Alternative compared to 2,700 under the No Action Alternative, or a 23.6-percent increase.

False Attraction.—Under the Wymer Dam Plus Yakima River Pump Exchange Alternative, Columbia River water in the vicinity of the Yakima River confluence would be pumped during the irrigation season into the Roza and Sunnyside Canals. A maximum of 1,040 cfs Columbia River water would be exchanged between the Roza and Sunnyside Irrigation Districts during the irrigation season. The pumping plant would be located immediately downstream from the Yakima River confluence; thus, the pumped water would be an admixture of Yakima and Columbia River water.

On a monthly median basis, the amount of operational spill of Columbia River water from Roza and Sunnyside Canals ranges from 10.5 cfs in June-August to 13.7 cfs in April. The mixture of Columbia River water to Yakima River water at the Kiona-Benton gage ranges from 0.27 to 0.72 percent (table 4.35).

Table 4.35 Percent of Columbia River water mixed with Yakima River water at the Kiona Benton gage (RM 29.9) by month during the irrigation season as a result of direct operational spill from Roza and Sunnyside Canals

Month	Kiona-Benton gage monthly median flow (cfs)	Total monthly median Roza and Sunnyside Canal operational spill of Black Rock reservoir water (cfs)	Percent of Columbia River water to Yakima River water (cfs) at Kiona-Benton gage
March	4,507	12.2	0.27
April	5,162	13.7	0.27
May	4,933	12.2	0.25
June	4,428	10.5	0.24
July	1,932	10.5	0.54
August	1,845	10.5	0.57
September	1,939	13.9	0.72
October	2,206	14.6	0.66

Based on these findings and the fact that the bulk of the adult steelhead migration occurs from October through February, the potential for false attraction resulting from direct operational spill of mixed Yakima and Columbia River water appears to be minimal.

Bull Trout Spawning.—The stream access thresholds and reservoir elevations associated with the Wymer Dam Plus Yakima River Pump Exchange Alternative are about the same as under the No Action Alternative. There is no biologically distinguishable difference in bull trout access to streams during the spawning migration between the Wymer Dam Plus Yakima River Pump Exchange Alternative and the No Action Alternative.

Greater Sage-Grouse.—The type, magnitude, and duration of the impacts associated with this alternative are the same as under the Wymer Dam and Reservoir Alternative. The steep topography of Wymer reservoir suggests that mosquito populations carrying the West Nile virus would not become established and become a risk to greater sage-grouse. Habitat loss, disturbance of movement and risk of exposure to the West Nile virus suggest that the impact of the Wymer Dam Plus Yakima River Pump Exchange Alternative would be slight.

Ferruginous Hawk and Umtanum Wild Buckwheat.—These two protected species have been combined in the analysis because they are impacted by the same habitat and disturbance issues associated with the Joint Alternatives.

Neither species is likely to occur in the study area because of its steep slopes and canyon habitats. The Wymer Dam Plus Yakima River Pump Exchange Alternative is unlikely to affect either the ferruginous hawk or Umtanum wild buckwheat.

Ute Ladies'-tresses.—The Wymer Dam Plus Yakima River Pump Exchange Alternative would not significantly change the frequency or extent of riparian flooding in the study area. Therefore, the alternative is unlikely to affect Ute Ladies'-tresses.

4.11.2.6 Mitigation

Black Rock Alternative

Mitigation measures under the Black Rock Alternative could include the following:

- Perform botanical surveys in areas proposed for disturbance and relocation of sensitive species.
- Establish a wildlife management area adjacent to the reservoir.
- Bury pipelines underground and restore native vegetation along the corridor.
- Compensate for shrub-steppe losses by converting agricultural lands to shrub-steppe or enhancing degraded shrub-steppe habitat adjacent to the study area or at an offsite location where it would be more beneficial.
- Control nonnative invasive plant species.

Wymer Dam and Reservoir Alternative

Mitigation measures under the Wymer Dam and Reservoir Alternative would be the same as under the Black Rock Alternative.

Wymer Dam Plus Yakima River Pump Exchange Alternative

Mitigation measures under the Wymer Dam Plus Yakima River Pump Exchange Alternative would be the same as under the Black Rock Alternative.

4.11.2.7 Cumulative Impacts

Cumulative impacts with respect to bull trout and steelhead would be similar to those described in the "Anadromous Fish" section. Cumulative impacts for terrestrial species would be similar to those discussed in the "Vegetation and Wildlife" section.

4.12 Recreational Resources

4.12.1 Affected Environment

4.12.1.1 Recreation Setting

Washington provides a diverse array of recreation settings from designated wilderness areas to urban greenways. Within the Yakima River basin, the recreation opportunities are largely found in developed and rural natural settings.

Recreationists are attracted to the basin by the quality of the scenery, water, and recreation opportunities. Primary recreation activities include fishing the reservoirs and rivers for cold-water species; whitewater boating and kayaking; motorized boating; and other related activities such as camping, hiking, picnicking, and wildlife viewing.

All six reservoirs within the study area—Bumping, Rimrock, Cle Elum, Kachess, Keechelus, and Clear Lakes—are located on the eastern slopes of the Cascade Mountains (figure 4.18). The rugged mountain terrain and coniferous forests create magnificent scenic settings. Camping, swimming, boating, picnicking, and fishing are available at all reservoirs. Picnic sites and campgrounds are close to, or exceed, capacity on summer weekends and exceed capacity on holiday weekends (Novitsky, 2005).

The Easton Diversion Dam area has a State park with facilities for camping, swimming, and boat launching and mooring. Recreational use is heavy. The reservoir also has a good fishery.

The five primary rivers within the basin that supply recreation opportunities are the Tieton, Naches, Cle Elum, Bumping, and Yakima Rivers. Although there are other smaller flat-water lakes and rivers in the basin that offer similar types of water-based recreation activities, the only water bodies discussed in this section and this report are the ones specifically mentioned above.

The Yakima River has a national reputation for its high-quality fly fishing, one of the fastest growing activities on the river. The Yakima River is also considered a "blue ribbon" trout stream (Yakima Valley Visitors and Convention Bureau, 2005). The prime periods for fishing the river are February through May and September and October, although fishing occurs on the river throughout the year.

The Naches and Tieton Rivers do not provide the quality of fishing found in the Yakima River. The Naches does not because of limited access, and the Tieton does not because of its small stream size, swift water, woody debris, and cloudiness of the water. The Tieton River has regionally acclaimed whitewater rafting during a 3-week period (flip-flop) in September. The rapids during that time are rated as Class III (Fairfield, 2005). There is very little rafting on the Naches River, because of limited access due to private land ownership on adjacent lands.

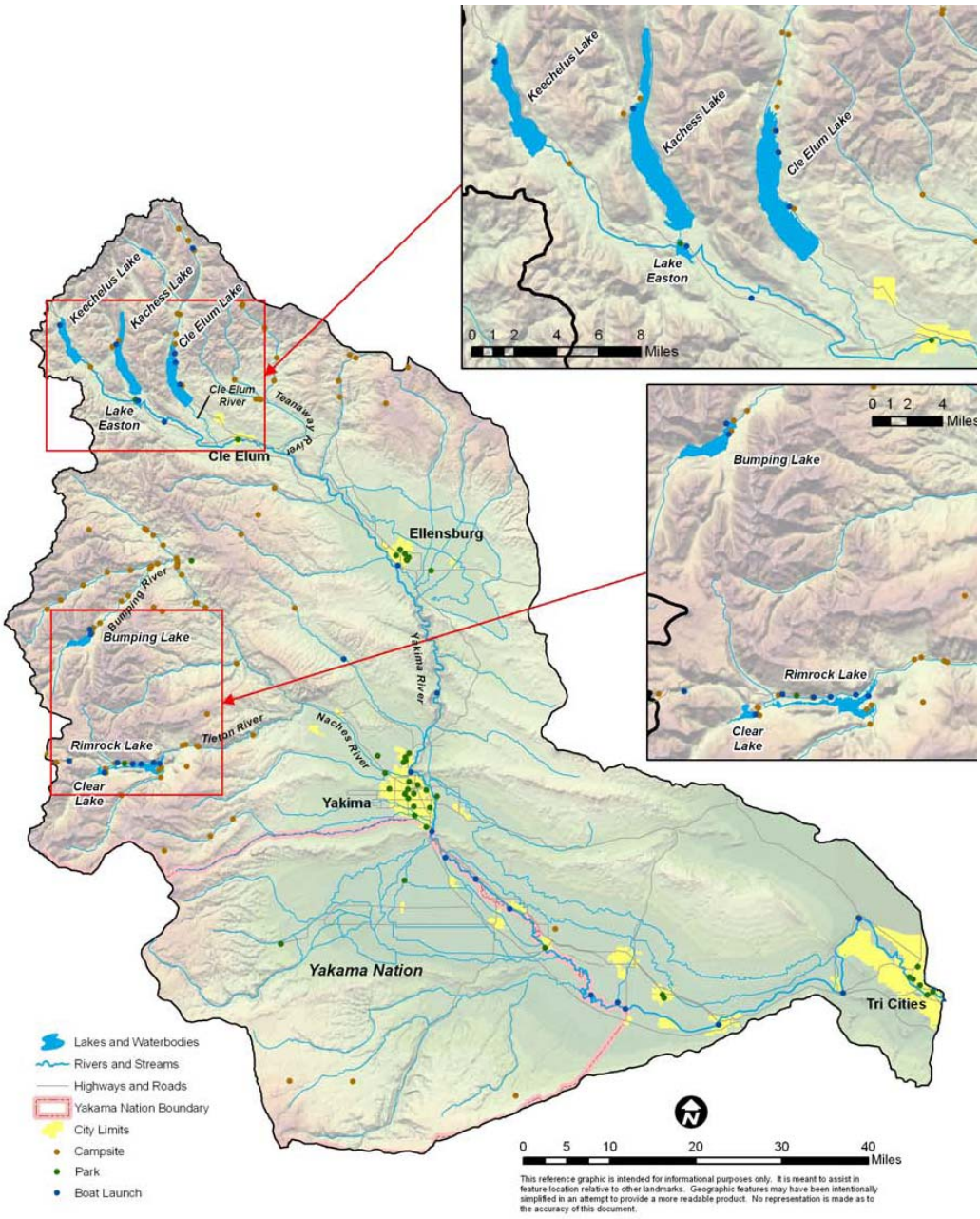


Figure 4.18 Yakima River basin recreation access points and recreation areas.

The Yakima River basin also has a Pacific Northwest regional reputation for motorized recreation opportunities associated with trail bikes, all-terrain vehicles (ATV), jeeps, and snowmobiles, primarily on U.S. Forest Service lands on the west side of the basin.

4.12.1.2 Current Recreation Visitation

Table 4.36 presents the estimated visitation to the key reservoirs and rivers in the Yakima River basin.

Table 4.36 Estimated 2006 annual visitation to key reservoirs and rivers in the Yakima River basin

Reservoir	Number of annual visitors
Keechelus Lake	660
Kachess Lake	17,292
Cle Elum Lake	6,996
Rimrock Lake	10,824
Clear Lake	4,620
Bumping Lake	7,524
Lake Easton	19,260
River	**Number of annual visitors**
Yakima River	18,000
Tieton River	8,844
Naches River	3,696
Bumping River	5,016
Cle Elum River	5,280

4.12.2 Environmental Consequences

This section describes the effects of implementation of the Joint Alternatives on recreation, including drawdown and recreation use at proposed reservoirs. This section also describes effects on recreation at existing reservoirs and on rivers. See chapter 2 for details of estimated changes in recreation under the Joint Alternatives.

4.12.2.1 Methods and Assumptions

The following assumptions were used in assessing the effects of all Joint Alternatives on recreation.

The likely future recreation situation for the Wymer Dam and Reservoir Alternative and Wymer Dam Plus Yakima River Pump Exchange Alternative would be the same.

Recreation visitation was estimated on the basis of (1) current visitation at the existing reservoirs in the basin, (2) current visitation to three State parks in comparable settings near Yakima, and (3) the findings reported in the *Recreation Demand and User Preference Analysis* (Reclamation, 2007f) which includes projected changes in population and demographics.

A recreation managing partner would enter into a cooperative agreement with Reclamation for the design, development, and management of recreation facilities. It is expected that these managing partners would add facilities, programs, and services, which would meet the demand of the recreating public and attract more visitation.

Likely managing partners include the Washington State Parks Commission or counties where the reservoirs would be located.

Local, county, and State tourism organizations are expected to promote and market the availability of any new reservoir site as a new recreation opportunity.

The recreation situation described is confined to Reclamation's geographical boundaries and does not describe nearby future land use changes or residential and commercial development that may occur.

A fish-stocking program (for the new reservoirs) would be prepared and implemented by the Washington Department of Fish and Wildlife.

Drawdown can change the type, amount, and quality of recreation opportunities. It is recognized that as one type of recreation opportunity may be displaced by a certain water level, another opportunity may be afforded or enhanced.

At the existing reservoirs, changes which could affect recreation were only projected to occur at Cle Elum and Kachess Lakes.

4.12.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

Effects on recreation at Cle Elum, Bumping, Rimrock, Keechelus, Kachess, Easton, and Clear Lakes and on riverine recreation would be the same as under current conditions.

4.12.2.3 Black Rock Alternative

Construction Impacts

There would be no construction impacts to existing recreation resources under the Black Rock Alternative.

Long-Term Impacts

Black Rock reservoir would be approximately 8,720 water surface acres at full pool (13.6 square miles), about 10 miles long, and more than 1 mile wide at its

widest point. The west end of Black Rock reservoir would be within 20 miles of Yakima, while the east end would almost reach the Benton County line. Access would be from State Routes 24 and 241. Ten miles of SR-24 would be submerged and, thus, provide boat ramp access from the west.

The reservoir would be elongated, open, and have few coves or arms. The south and southeast side of the Black Rock reservoir would be steep with tall hillsides, providing good vistas of the lake and surrounding landscape but with limited or no safe access. The north and west sides of the reservoir would be a rolling, flat terrain of dryland grasses and few trees.

The open exposure of the reservoir along with westerly winds coming down the valley would make for cool breezes for some recreationists but dangerous winds and wave-action for others.

Table 4.37 presents the recreation setting for Black Rock reservoir, including the startup years and the long-term operation. It is assumed that a managing partner would assume recreation management from Reclamation and provide the recreation facilities, programs and services to meet the public demand. Table 4.38 presents projections of recreation use at Black Rock reservoir by activity.

Table 4.37 Recreation setting at Black Rock reservoir

Recreation setting	Initial startup (5 years) following reservoir completion	Post-initial startup years (beyond first 5 years) following reservoir completion
Management	Reclamation	Primary recreation manager (e.g., Yakima County Parks, Washington State Parks)
Facilities	Day-use Minimal facilities for resource protection and public safety No fees or entrance station Minimal security Parking lot 1 boat ramp (old Highway 24) Regulatory and directional signage Vehicular access of drawdown shoreline Portable toilets No utilities	Day and overnight facilities Boat marina (rentals and short term slips) Concessioned services Developed campground, picnic area, trails, and toilets 2 boat ramps Fee-based Entrance station Security Utilities Interpretive signage Controlled shoreline access and boating capacity Wakeless zones
Projected annual visitation	250,000 - 304,000	400,000 - 700,000
Projected annual change in visitation	5-percent increase due to new location, marketing and media attention, improving fishery	5-percent increase in early facility buildout, similar to population growth in subsequent years

Table 4.38 Recreation use at Black Rock reservoir

Primary activities	Primary visitation period	Percent of total annual visitation	Annual visitation estimate in initial startup years	Annual visitation estimate after initial startup years	Additional descriptors of visitation
Boat fishing	Spring and fall	25%	62,500-76,000	100,000-175,000	50% of boat fishers are local; 50% are nonlocal
Shoreline fishing	May-July	10%	25,000-30,400	40,000-70,000	Predominantly local residents; popular activities among the increasing senior and Hispanic population in basin.
Swimming	June-August	15%	37,500-45,600	60,000-105,000	
Picnicking	June-August	15%	37,500-45,600	60,000-105,000	
Water skiing, wakeboarding, jet skiing	June-August	25%	62,500-76,000	100,000-175,000	70% local; 30% from out of the basin
Walking	Spring and fall	3%	7,500-9,100	12,000-21,000	Local residents
Wildlife viewing	Spring and fall	3%	7,500-9,100	12,000-21,000	Local residents
Horseback riding	Spring and fall	2%	5,000-6,100	8,000-14,000	Local residents
OHV riding	July-August	2%	5,000- 6,100	8,000-14,000	Local residents
			250,000-304,000 annual visitors	400,000-700,000 annual visitors	Visitation would increase approximately 5% per year for the first 10 years and then stabilize similar to the rate of population growth in the Yakima area.

[1] Annual visitation numbers assume a fish-stocking program for the reservoir. Visitation could be substantially lower if no fish-stocking program were implemented.

[2] A comparison of the recreation setting in the initial years of reservoir completion versus later years is provided in table 4.37.

Effects on Reservoir Recreation.—

Drawdown of Black Rock Reservoir.—Black Rock reservoir would reach full pool in February-March and low pool in August. There would be about a 20-percent reduction in the available water surface acres for recreationists as a result of this drawdown. Conversely, this drawdown would provide considerable shoreline acreage for associated land-based activities later in the summer months, such as off-highway vehicle (OHV) and ATV use on the north and west shores.

Kachess Lake.—At Kachess Lake, a water level below 2,256 feet could affect recreation. In wet years, the Black Rock Alternative would have little effect compared to the No Action Alternative, while in average water years, the only effect occurs in August when the elevation of Kachess Lake remains at or above 2,256 feet, improving recreation in that month. The biggest effect occurs early in the recreation season (June, July) in dry years when Kachess water levels are higher than under the No Action Alternative. Under these conditions, recreation needs would be better met and would result in 17,220 more visitor days in dry years. Also in dry years, the Black Rock Alternative would allow boat launching for approximately 2.5 months or approximately 75 days from mid-May through July, whereas the No Action Alternative would allow boat launching for only a few days in mid-June.

Cle Elum Lake.—Cle Elum Lake recreation visitors, on average, prefer medium to high water levels, somewhere between an elevation of 2,200 and 2,237 feet. Water levels generally fall within the range under both the Black Rock and No Action Alternatives. In dry years, however, July and May water levels fall below that range under the Black Rock Alternative.

Effects on Riverine Recreation.—

Yakima River.—Under this alternative, Yakima River flows are within or close to the preferred medium flow range for recreation. In average water years, these flows would result in about 7,260 more visitor days from July to mid-August and October than under the No Action Alternative. These estimates are based on the average monthly visitation and visitor projections of increased visits if users' preferred flows were met.

Tieton River.—For the Tieton River, flows under the Black Rock Alternative range from about 1,000 to 1,250 cfs, which are at the lower end of, but still within, visitors' preferred flows for this river. The effect on recreation would occur during flip-flop, when flows would be about 350 cfs less in a wet year, 550 cfs less in an average year, and 250 cfs less in a dry year. These lower flows would occur at a crucial time for rafters and rafting companies, and would affect rafting companies and rafters and kayakers seeking whitewater. More importantly, from a visitor-day measurement standpoint, flows for all recreationists, including rafters, would be below their desired levels a week earlier in late September and early October than under the No Action Alternative. This week could represent a potential loss of about 1,000 visitors.

4.12.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

There would be no impacts to existing recreation resources during construction of the Wymer dam and reservoir.

Long-Term Impacts

Wymer reservoir would be approximately 1,390 water surface acres at full pool (2+ square miles), about 4 miles long, and ½-mile wide in the dam area. The west end of Wymer reservoir would almost abut SR-821, while the east end would reach Interstate 82. Access would be from SR-821. There would be no interstate access or anticipated signage.

While Wymer would be a relatively small reservoir, the topography of rolling, steep hillsides with canyons would provide with numerous coves and arms for recreationists to enjoy. The topography and lake configuration would provide water recreationists protection from winds, but shoreline use would be limited by the steep terrain and large projected drawdown.

Table 4.39 provides a description of the recreation setting that is projected at the Wymer Reservoir. It is assumed that a managing partner would take over the development and management of recreation facilities, programs and services. Table 4.40 projects the primary recreation opportunities at Wymer, primary season and level of use, and estimated annual visitation.

Table 4.39 Recreation setting at Wymer reservoir

Recreation setting	Initial startup (5 years) following reservoir completion	Post-initial startup years (beyond first 5 years) following reservoir completion
Management	Reclamation	Primary recreation manager (e.g., Yakima County Parks, city of Yakima's parks and recreation department, and Washington Parks Commission)
Facilities	Day-use only Human-powered boating only Minimal facilities for resource protection and public safety No fees or entrance station Minimal security Small parking lot 1 boat ramp Shoreline access for nontrailered boats Regulatory and directional signage Portable toilets No utilities	Day-use only Human-powered boating only Developed picnic and toilet facilities Designated trails Fee-based Entrance station Security Utilities (water and lighting) Small parking lot 1 boat ramp Shoreline access for nontrailered boats Interpretive signage Designated trail
Projected annual visitation	40,000-45,300	70,000-200,000
Projected annual change in visitation	Annual increase in visitation would approximate the rate of population change in basin (i.e., estimated 3 percent)	

Table 4.40 Recreation use at Wymer reservoir

Primary activities	Primary visitation Period	Percent of total annual visitation	Annual visitation estimate in initial start-up years	Annual visitation estimate after initial start-up years	Additional descriptors of visitation
Canoe, kayak, and small sailboats	May-July	20%	8,000-9,000	14,000-40,000	Wymer reservoir would be a small reservoir with considerable water level fluctuation. It would be popular as a summer reservoir for locals to enjoy human-powered recreation activities.
Boat fishing	Spring and fall	10%	4,000-4,500	7,000-20,000	
Shoreline fishing	May-July	25%	10,000-11,300	17,500-50,000	
Swimming	June- August	15%	6,000- 6,800	10,500-30,000	
Picnicking	June-August	15%	6,000- 6,800	10,500-30,000	
Walking	Spring and fall	10%	4,000-4,500	7,000-20,000	
Wildlife viewing	Spring and fall	5%	2,000-2,300	3,500-10,000	
			40,000-45,200 annual visitors	70,000-200,000 annual visitors	Visitation would increase similar to the rate of population growth in the Yakima area

Effects on Reservoir Recreation.—

Drawdown of Wymer Reservoir.—Wymer reservoir would reach a full pool of some 1,300 water surface acres in May-June, and a low pool of 600+ water surface acres in August-September. There would be about a 50-percent reduction in the available water surface acres for recreationists. Conversely, this drawdown would provide more shoreline acreage for associated land-based activities later in the summer months, such as OHV and ATV use.

Kachess Lake.—No impacts to recreation would occur under this alternative at Kachess Lake in wet, average or dry conditions.

Cle Elum Lake.—Effects on recreation use at Cle Elum Lake would be relatively slight under this alternative. In wet years, the boat launches at the lake would still be useable in August, in contrast to the No Action Alternative. Conversely, under the Wymer Dam and Reservoir Alternative in a dry year, the elevation of the lake would fall below the preferred elevation range of between 2,200 and 2,237 feet in June. Under the No Action Alternative, the elevation would be within the preferred range.

Effects on Riverine Recreation.—

Yakima River.—Under this alternative, Yakima River flows during the recreation season are about the same as under the No Action Alternative, except from the end of June to the end of August, when they are about 500 to 1,000 cfs

lower than under the No Action Alternative. As a result, flows are within or close to the preferred medium flow range for recreation and, thus, are better for recreation than under the No Action Alternative. These flows would result in about 3,631 more visitor days from July to mid-August and October (average water years) than under the No Action Alternative. These estimates are based on the average monthly visitation and visitor projections of increased visits if users' preferred flows were met.

Tieton River.—Under this alternative, Tieton River flows are virtually the same as under the No Action Alternative; thus, no effect on recreation is expected.

4.12.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

There would be no impacts to existing recreation resources during construction of the Wymer dam and reservoir.

Long-Term Impacts

Impacts would be the same as for the Wymer Dam and Reservoir Alternative. Opportunities for new recreation would be the same as under the Wymer Dam and Reservoir Alternative.

Effects on Reservoir Recreation.—

Drawdown of Wymer Reservoir.—Effects on Wymer reservoir drawdown would be the same as under the Wymer Dam and Reservoir Alternative.

Kachess Lake.—There would be no effects on recreation at Kachess Lake under this alternative, compared to the No Action Alternative, except in dry years. Reservoir elevations are higher in dry years, which would provide a better recreation experience in May, June, and July. As a result of these higher elevations, the boat launch would be useable for about 50 days in June and July in dry years compared to only a few days under the No Action Alternative. The only other impact would occur in average years in June, when reservoir elevations are higher than under the No Action Alternative, decreasing the quality of the recreation experience as less "beach" would be exposed.

Cle Elum Lake.—As discussed previously, Cle Elum Lake users prefer water surface elevations in the range of 2,200 and 2,237 feet. In wet years, elevations are within this range in June under this alternative, whereas they are below the range under the No Action Alternative. Elevations remain high in wet years into August, which would allow boat launching. Under No Action, elevations are too low in August for launching in wet years. No other impacts to recreation were identified at Cle Elum Lake under other water year types in any part of the recreation season.

Effects on Riverine Recreation.—Effects on riverine recreation would be the same as under the Wymer Dam and Reservoir Alternative.

4.12.2.6 Mitigation

No mitigation would be required.

4.12.2.7 Cumulative Impacts

Regional, State, and local area population will continue to grow by approximately 1.5 to 2.5 percent annually. The increase in population within the prime recreation market area of the Yakima River basin (i.e., Washington, Oregon, Idaho, British Columbia, and California) will be greater than national averages and ensure continued increases in outdoor recreation participation on public lands and waters. National, State, regional, and local participation rates in outdoor recreation will continue to increase among all ages, income, and ethnic groups. On average, State park visitation in eastern Washington increased 2 percent annually from 2000 to 2005. Water resources will continue to be a prime attraction for day-use and overnight outdoor recreation participants. People will continue to seek opportunities to enjoy the outdoors and to experience a natural setting in contrast to their daily work and living environments. It is reasonable to project a 2- to 3-percent average annual increase in outdoor recreation demand for the Yakima River basin over the next 20 years.

4.13 Land Use and Shoreline Resources

This section addresses the following aspects of land use and shoreline resources in the study area:

- Land ownership/land status
- Existing land or shoreline uses
- Consistency with relevant city, county, State, or Federal land use and shoreline management plans, programs, and policies

These aspects are addressed relative to the direct physical development and operation of facilities associated with the Joint Alternatives, for which specific land areas and/or requirements have been identified.

4.13.1 Affected Environment

4.13.1.1 No Action Alternative

The No Action Alternative includes conservation-oriented system improvements, including pumping plants and pipelines, at various locations in the Yakima Valley region. These improvements are associated with existing approved programs and

orient predominantly to existing facilities; none are being or would be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis is required for these actions, appropriate documentation of the directly affected land/shoreline use environment will be prepared separately, apart from the Storage Study process.

4.13.1.2 Black Rock Alternative

Dam and Reservoir

The site of the proposed Black Rock dam and reservoir is the Black Rock Valley, located in eastern Yakima County, Washington. Land in the valley is privately owned. No substantial State or Federal landholdings exist. The YTC borders the valley to the north. The general setting and proposed location of the reservoir (as well as appurtenant facilities) is shown in chapter 2.

The land area that would be affected by the proposed dam and reservoir is held by relatively few (approximately 20) landowners, with holdings ranging in size from 120 to several thousand acres.

Land use in the Black Rock Valley is primarily open habitat and rangeland, with limited areas of irrigated pasture and other crops in the western end of the valley. Within the potential area of influence of the reservoir, the only developed land uses are three residences and a hunting club in the valley itself, and a roadside café and one residence approximately 1 mile east of the damsite.

Land use planning in the Black Rock Valley is under the jurisdiction of Yakima County. All land in and around the proposed Black Rock dam and reservoir site is designated "agriculture" in the county's comprehensive plan and zoning. The county's "Plan 2015" describes the agriculture designation as "lands primarily devoted to or important for the long-term commercial production of horticultural, viticultural, floricultural, dairy, apiary, vegetable, or animal products…Generally lands in Yakima County zoned Exclusive or General Ag can be considered resource lands of long-term commercial significance" (Yakima County, 1998a).

Appurtenant Facilities

Intake/Inflow System.—The only substantial surface land area associated with the Black Rock intake/inflow system would be the site of the intake and fish screen facility. An access road (approximately 10 miles) and a new transmission line (approximately 6 miles to intake and fish screen facility site) would also be necessary.

The intake and fish screen facility itself would be located on the southwest shore of Priest Rapids Lake, approximately 3,600 feet upstream of Priest Rapids Dam. The facility would be on land owned by the Grant County PUD as part of the Priest Rapids hydroelectric project. The site and surrounding land is currently undeveloped except for a small marina facility used by PUD personnel.

The only developed use in the vicinity of the intake and fish screen site, other than the industrial facilities of the hydroelectric project, is a small Wanapum village approximately 1 mile to the southeast, immediately downstream from Priest Rapids Dam, on the south side of the Columbia River.

The access road to the intake and fish screen facility site would be developed on an abandoned railroad right-of-way (ROW) along the south side of the Columbia River from SR-24 to the southeast. The transmission line would also be constructed on the south side of the river, from the Bonneville Power Administration's Midway Substation located 4 miles west of SR-24. Both the access road and transmission line routes pass through predominantly undeveloped private land, with isolated instances of irrigated agriculture; involved lands are within Yakima and Benton Counties, and are designated/zoned by the counties as "agriculture." Both the access road and the transmission line would also pass adjacent to (south of) the Wanapum village noted above.

Inflow conveyance from the intake and fish screen facility to Black Rock reservoir would be a tunnel under land within the YTC. The only surface facility associated with this tunnel would be a 22-foot-diameter surge/vent shaft connecting the tunnel with the ground surface approximately three-quarters of a mile south-southwest of the intake facility. This vent would be on steep terrain within the YTC, near the YTC's easternmost boundary.

From the standpoint of land use planning and shoreline resources management, the site of the intake and fish screen facility is (1) addressed in Grant County PUD's *Priest Rapids/Wanapum Land Use Plan*, which designates the site as wildlife area (Grant County PUD, 1992), and (2) subject to review and permitting pursuant to the State Shoreline Management Act (SMA). In the latter regard, all lakes and reservoirs in the state over 20 acres in surface area are formally designated as "shorelines of the State." Implementation of the Black Rock intake and fish screen facilities would be considered "substantial development" under the SMA, and a Substantial Development Permit would be required. SMA consistency review and issuance (if appropriate) of a Substantial Development Permit would be accomplished by Yakima County.[7] Relevant policies/provisions of the SMA governing this review and issuance of the required permit include (Ecology, 2007d):

- **Encourage water-dependent uses**: "uses shall be preferred which are consistent with control of pollution and prevention of damage to the natural environment, or are unique to or dependent upon use of the states' shorelines..." (generally, nonwater/shoreline-dependent uses are to be avoided unless there is no feasible alternative).

[7] In partnership with the State Department of Ecology, local counties and cities implement the SMA through required Shoreline Master Programs.

- **Protect shoreline natural resources**, **including:** "...the land and its vegetation and wildlife, and the waters of the state and their aquatic life..." (with an emphasis on restoring priority habitats and species, and specific policy of no net loss of ecological functions necessary to sustain shoreline natural resources).

- **Promote public access**: "the public's opportunity to enjoy the physical and aesthetic qualities of natural shorelines of the state shall be preserved to the greatest extent feasible consistent with the overall best interest of the state and the people generally."

Outflow/Delivery System.—All outflow and delivery facilities would be located west of the Black Rock reservoir site on private lands within Yakima County. In all cases, except where noted, surface facilities (sites and conveyance routes) would involve land currently characterized as large lot ownership, used for agricultural production, and designated/zoned "agriculture" by Yakima County. (See previous discussion under "Dam and Reservoir.")

The following overviews of the land use setting for elements in the outflow/delivery system use the proposed location of the Black Rock outlet facility as a reference point. This facility would be located on the south side of SR-24, east of Moxee, approximately 3,000 feet east of Beane Road and immediately east of the Roza Canal.

Outflow Conveyance.—From the proposed Black Rock reservoir to a point approximately 3,000 feet northeast of the Black Rock outlet facility (the first distribution element in the delivery system), the outflow conveyance from Black Rock reservoir would be via a tunnel. With the exception of a 40-foot-diameter surge/vent shaft, this tunnel would not involve surface land use/disturbance. The surge/vent shaft would be located approximately 3.4 miles northeast of the Black Rock outlet facility on land currently in open habitat/rangeland use. The final 3,000 feet of the conveyance would involve a buried pipeline passing through agricultural lands.

Black Rock Outlet Facility and Powerplant (and point of delivery for the Roza Division).[8]—At present, the site of this facility is in irrigated agriculture. All surrounding use is agricultural.

Sunnyside Powerplant and Bypass.—This facility would be located on land currently in orchard use on the north side of the Sunnyside Canal, immediately east of its Konnowac Pass Road crossing, approximately ¾ mile north of Yakima Valley Highway. All surrounding use is also agricultural.

[8] Delivery of water to the Roza Division would be accomplished at the site of the Black Rock outlet facility, via connection with the adjacent Roza Canal.

Delivery System for Sunnyside Division.—The delivery of water to the Sunnyside Division would be via a new pipeline, approximately 6.4 miles long, connecting the Black Rock outlet facility with the Sunnyside powerplant and bypass facility. The conceptual alignment of this pipeline passes through a combination of large-lot agricultural and currently undeveloped land.

4.13.1.3 Wymer Dam and Reservoir Alternative

Dam and Reservoir

The location of the proposed Wymer dam and reservoir is the Lmuma Creek watershed/basin, tributary to the Yakima River, located in southern Kittitas County, Washington. The site spans the basin from the Yakima River and SR-821 on the west to Interstate 82 (I-682) on the east. The general setting and proposed location of the reservoir (as well as appurtenant facilities) is shown in chapter 2.

Land in the Lmuma Creek basin is primarily privately owned by one family. Approximately 320 acres of State ownership (Departments of Natural Resources and Transportation) are located in the northern part of the basin, and Federal ownership (YTC) begins in the extreme eastern part of the basin, immediately east of I-82.

Land use in the Lmuma Creek basin is open habitat and rangeland. There are no developed uses.

Land use planning in the area is under the jurisdiction of Kittitas County. All land in and around the dam and reservoir site is designated "rural" in the *County Comprehensive Plan*, with a zoning designation of "forest and range." The forest and range zone in intended "to provide for areas of Kittitas County wherein natural resource management is the highest priority and where subdivision and development of lands for uses and activities incompatible with resource management are discouraged" (Kittitas County, 1992).

Appurtenant Facilities

The import and export conveyances (pipelines, tunnels, and modified Lmuma Creek channel) for the Wymer Dam and Reservoir Alternative follow the Lmuma Creek corridor approximately 4,700 feet from the proposed damsite, southwest to the site of the pumping plant, air chamber, and switchyard along the Yakima River. Land crossed by these conveyances, as well as the land on which the pumping plant, air chamber and switchyard would be located next to the river, is all privately owned and involves the same family who holds most of the Lmuma Creek basin in which the dam and reservoir would be located. Outside of privately held land in this area are State (Departments of Natural Resources and Fish and Wildlife) and Federal (Bureau of Land Management [BLM]) holdings.

Current use of the land on which the Wymer facilities would be located (conveyances east of SR-821 and the pumping plant west of the highway) is primarily irrigated agriculture, with a family residence present in the area east of the highway. Surrounding State and Federal lands are open space, habitat areas, with no developed recreation or other facilities.

Land use planning jurisdiction, as well as assigned use designations, for involved private land are the same as described for the dam and reservoir (Kittitas County; Forest and Range). State and Federal lands are managed as open space, habitat, and recreation, as part of the BLM-administered Yakima Canyon Scenic and Recreation Highway.

In addition to the above land-use planning context, the Yakima River in this area is formally designated a "shoreline of the State" pursuant to the State's SMA. Similar to the Black Rock intake and fish screen facility discussed previously, the Wymer facilities along the river would be considered "substantial development," and an SMA Substantial Development Permit would be required. SMA consistency review and issuance (if appropriate) of a Substantial Development Permit would be accomplished by Kittitas County.[9] (See discussion under Black Rock appurtenant facilities for further perspective.)

4.13.1.4 Wymer Dam Plus Yakima River Pump Exchange Alternative

The affected environment of the Wymer dam component of this alternative is presented in the previous section. The following discussion focuses on the land and shoreline use setting for the Yakima River pump exchange component of this alternative.

The 56 miles of underground pipeline comprising the Yakima River pump exchange component of this alternative would span portions of five local Washington jurisdictions: city of Richland (7 miles), city of Kennewick (1 mile), city of West Richland (4 miles), Benton County (24 miles), and Yakima County (20 miles). The three pumping plants that are the only major surface facilities associated with the alternative would be located in Richland (pumping plant #1), Benton County (pumping plant #2), and Yakima County (pumping plant #3). Chapter 2 maps illustrate the general locations of pump exchange facilities, including the conceptual pipeline alignment and pumping plant sites[10].

With the exception of crossings at State and interstate highways, the Yakima River, and elements of the Roza and Sunnyside Irrigation District systems, all

[9] In partnership with Ecology, local counties and cities implement the SMA through required Shoreline Master Programs.

[10] More detailed mapping of the conceptual pipeline route and the location of the pumping plants is available for review in Reclamation's *Appraisal Assessment of the Yakima River Pump Exchange Alternative Delivery System for Roza and Sunnyside Valley Irrigation Districts* (Reclamation, 2006).

land in the corridor through which the pump exchange would pass is privately owned, with land use planning and shoreline management jurisdiction held by the local cities and counties.

Land use character along the proposed pipeline corridor is urban in the cities of Kennewick, Richland, and West Richland, and rural/agricultural in both Benton and Yakima Counties.

Additional perspectives on existing and planned land use along the corridor are presented in the following text, by local jurisdiction.

City of Richland.—The Columbia River intake and pumping plant #1 facilities of the Yakima River pump exchange component of this alternative would be located in the southwesternmost portion of the city's Richland Wye Master Plan area. The proposed site and immediate surroundings of the intake and pumping plant are currently undeveloped, but are designated "commercial recreation" in the Wye Master Plan, with a designation of "waterfront" on the overlying Comprehensive Plan. In addition, the Columbia River in this area is a designated water of the State, pursuant to the SMA. The intake and pumping plant #1 facilities would be considered "substantial development" under the SMA, and, thus, would be subject to obtaining a Substantial Development Permit. (See discussion of the Black Rock appurtenant facilities for further perspective.)

Outside the Wye area, the proposed pump exchange corridor follows existing linear facilities, primarily a railroad ROW and Keene Road. A substantial proportion of the land along this corridor is currently undeveloped. However, urban development is present on one or both sides of the pipeline corridor. Developed uses along the corridor are generally consistent with the city's Comprehensive Plan and include high- and low- density residential, commercial, and limited examples of industrial. In terms of relative proportion (both existing and planned), low-density residential uses predominate.

City of Kennewick.—One mile of the pump exchange pipeline, approximately 1 mile west of pumping plant #1, would pass through land under city of Kennewick jurisdiction. This area of Kennewick is predominantly developed in a combination of residential and commercial uses. Also relevant is that the city's Columbia Park planning area is immediately southeast of and adjacent to Richland's Wye planning area along the Columbia River shore. Columbia Park lands, adjacent to the site of the proposed intake and pumping plant #1 facilities, are currently used as a campground, but are designated for future resort hotel, public park, and habitat/buffer uses.

City of West Richland.—The pipeline corridor, centered on Keene Road, would pass through the southwest portion of West Richland. Land in the corridor is approximately 50-percent developed in a combination of residential and commercial uses. The city's Comprehensive Plan designates lands in the area as

low-, medium-, and high-density residential; commercial, and light industrial, with low- and medium-density residential predominating.

Benton and Yakima Counties.—Beyond the city of West Richland, the pump exchange corridor would predominantly pass through existing irrigated agricultural lands, with associated residences and appurtenant structures, in Benton and Yakima Counties. The primary exception to this is approximately 10 miles of open, undeveloped land in Benton County. No substantial instances of residential or other urban development are present in the corridor. Both counties designate all land in the corridor as "agriculture."

Regarding shoreline management, the pipeline would cross the Yakima River in Benton County, north of Benton City. The Yakima River in the affected area is a designated "water of the State" under the SMA, and the pipeline crossing would be considered "substantial development." Thus, a Substantial Development Permit would be required. (See discussion of the Black Rock appurtenant facilities for further perspective.)

4.13.2 Environmental Consequences

4.13.2.1 Methods and Assumptions

The land use and shoreline resources impact analysis was conducted using existing published information, supplemented by limited field reconnaissance. Primary sources of information for existing land ownership and use included mapping available at the respective county and city Web sites and available aerial photography.

As discussed previously, the following indicators were selected to evaluate land use and shoreline resources impacts:

- Changes in land ownership/land status
- Changes in land or shoreline uses, and compatibility with surrounding uses
- Consistency with relevant city, county, State, or Federal land use/management plans and policies

In reviewing the analysis, the following points are of particular relevance:

- The proposed locations of and plans for facilities associated with the alternatives, including appurtenant facility development sites and conveyance alignments, are derived from Reclamation's appraisal-level assessments. Some facility locations (especially siting of structures) and substantial distances of the conveyance alignments are preliminary and subject to adjustment based on further study. Thus, the impacts reported

herein for these facilities should be viewed as illustrative or prototypical, with site or alignment adjustments considered an important source of mitigation action. Further insight from this perspective is provided where relevant on a facility-specific basis.

- No construction plans have been prepared for facilities associated with the Joint Alternatives. Given this, potential short-term construction-phase impacts on existing land uses during construction (for example, road detours, extent of construction ongoing at any given time, or construction traffic patterns) cannot be specifically addressed.

4.13.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

As noted previously, conservation-related system improvements associated with the No Action Alternative are part of other approved programs and orient predominantly to existing facilities; none are being or will be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis is required for these actions, appropriate documentation of land ownership changes, impacts on existing land use, or conflicts/inconsistencies with relevant land use plans or programs will be prepared separately, apart from the Storage Study process.

4.13.2.3 Black Rock Alternative

Construction Impacts

Construction impacts would include temporary impacts to existing land uses (for example, to agricultural production and/or access).

Long-Term Impacts

Dam and Reservoir.—Development of the proposed Black Rock dam and reservoir (including necessary borrow and stockpile areas) would involve Federal acquisition of approximately 13,000 acres of private land in Black Rock Valley. The preliminary boundary of the acquisition area is shown on figure 4.19. This acquisition would involve all or a portion of the holdings of approximately 20 landowners.

The acquired land would be converted from predominantly open habitat and rangeland uses to dam and outlet works, reservoir pool, and shoreline management uses. Shoreline management is expected to include reservoir-oriented recreation facilities (e.g., day and overnight use sites, boat ramp(s). (See the “Recreation” section.)

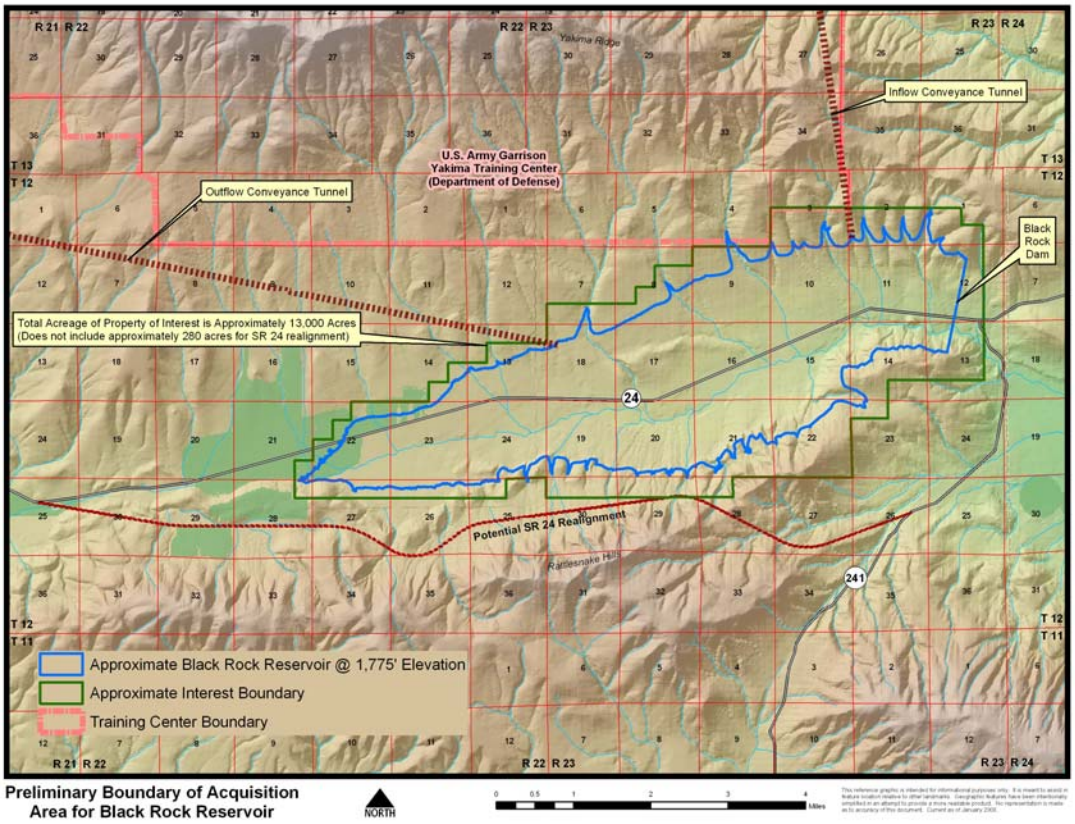


Figure 4.19 Preliminary boundary of acquisition area for the Black Rock Alternative.

In terms of impacts on existing developed uses:

- One existing residence and a hunting club location would be displaced (inundated by the reservoir).
- Two other residences, associated with agricultural use in the western end of the reservoir area, would not be inundated, but a substantial portion of the associated landholding would need to be acquired, thus making uncertain the viability of continued agricultural operations.
- Two electric transmission lines and one buried fiber optic cable which traverse the valley in an east-west direction would require relocation.
- SR-24 would need to be rerouted. (See the "Transportation" section.)
- The roadside café and nearby residence located east of the damsite would likely be indirectly impacted by this alternative because of incompatibility between these uses and the development and operation of Black Rock dam.

From the standpoint of land use planning, the dam and reservoir are not anticipated by or consistent with the current Yakima County comprehensive plan or zoning. However, development of Black Rock dam and reservoir would involve removing associated land from Yakima County jurisdiction; thus, county plans and designations for the land would no longer be relevant.

Appurtenant Facilities.—

Intake/Import System.—Development of the Priest Rapids intake and fish screen facility would require Federal control (fee title or other appropriate land interest) of approximately 24 acres of Grant County PUD land on the southwest shore of Priest Rapids Lake. Structures above ground surface would include a pumping plant 56 feet high and an electrical switchyard with towers up to 104 feet high. The facility site would involve approximately 2,400 feet of shoreline near the dam. Use of this shoreline land would change from general wildlife area to developed project facilities.

This change in use would not be significant. No existing PUD facilities would be displaced. The 24 acres withdrawn from wildlife use would be minor in context with the overall lake environment, and all new facilities would be compatible in character with existing hydroelectric project infrastructure.

From the standpoint of shoreline management pursuant to the SMA, the intake and fish screen facilities are undoubtedly "water dependent." Beyond this, the conceptual nature of facility plans and designs at this point in the planning process precludes a detailed assessment of response to SMA policies and provisions. (See "Mitigation.")

Development of the access road and transmission line to the intake and fish screen facility would require acquisition of associated easements/rights-of-way, but would not involve (1) direct impact to or displacement of any developed land uses[11] or (2) inconsistencies with existing county plans or zoning.

With one exception, development (boring) of the inflow tunnel from the intake facility to the reservoir would not involve changes in land use along the tunnel route. Material excavated for the tunnel would be used in the dam embankment. The exception to this is the surge/vent shaft, which would require dedication of an 80 x 80-foot, fenced site where the shaft reaches the land surface in the YTC; this requirement is not expected to have a significant impact on YTC uses or activities.

Outflow/Delivery System.—The following discussions focus on potential long-term impacts from facility development on land ownership and existing land use. Also, project facilities would be generally consistent with the intent of the

[11] See the "Transportation" and "Visual Quality" sections for discussions of adjacency impacts of the road and transmission line on the existing Wanapum village.

Yakima County's agriculture land use designation, given that the facilities are similar to other local and regional irrigation infrastructure on which the region depends.

Outflow Conveyance.—Development and operation of a buried pipeline for the westernmost 3,000 feet of the conveyance would involve long-term use impacts to a 150-foot-wide corridor of predominantly agricultural land. Reclamation would acquire a ROW or easement along this corridor, and future use within it would be restricted. It is likely that agricultural uses could continue after construction is completed. However, no permanent structures would be permitted, and any permitted use would be subject to disruption in the event of a pipeline repair or replacement requirement.

The preliminary alignment shown in the appraisal assessment report for Black Rock would cross several parcels of land at an angle, and not along property lines, essentially dividing the parcels into two parts. It would also come in close proximity to, if not displace, at least one existing residence. These impacts would be locally significant (to individual landowners).

With one exception, construction (boring) of the outflow tunnel from the reservoir to the tunnel portal (at the beginning of the pipeline described above) would not involve land use impacts or changes along the tunnel route. All material excavated for the tunnel would be used in construction of the dam. The exception to this is the surge/vent shaft. Where this shaft reaches the land surface, Reclamation would need to acquire and fence an 80 x 80-foot site, as well as access to the site for construction, operation, and maintenance. Given that the land on which the shaft site would be located and through which the access road would be routed is currently undeveloped, open habitat/rangeland, no significant impact on existing uses occur.

Black Rock Outlet Facility and Powerplant (and point of delivery to Roza Canal for the Roza Division).—This facility would require Federal acquisition of approximately 5.7 acres of private agricultural land; no existing residences would be affected. The facility would include a 45-foot-high structure, a service yard, and an electrical switchyard with towers up to 104 feet high. The overall site would be fenced (7-foot chain link). Power to the facility is expected to be provided via a new wood pole transmission line from the existing Roza pumping plant #3 switchyard; this line could require acquisition of an easement or ROW along existing roads/property lines on private land. (No specific alignment studies for this line have been done to date.)

Overall, the facility would involve introduction of an industrial use in a predominantly agricultural area. However, such facilities are not uncommon in the area given current irrigation infrastructure.

Sunnyside Powerplant and Bypass.—This facility would require Federal acquisition of approximately 2 acres of private agricultural land. No existing residences would be affected. The facility would include powerplant and bypass structures (35 and 18 feet high, respectively), a service yard, and an electrical switchyard with towers up to 104 feet high. The overall site would be fenced (7-foot chain link). Power to the facility is expected to be provided via a new wood-pole line from the BPA line about 1 mile to the southwest. This line could require acquisition of an easement or ROW along existing roads/property lines on private land. (No specific alignment studies for this line have been done to date.)

The general impacts of the facility would be the same as that described for the Black Rock outlet facility.

Delivery System for Sunnyside Division.—Development and operation of 6.4 miles of buried pipeline connecting the Black Rock outlet facility with the Sunnyside powerplant and bypass facility would involve long-term use impacts to a 120-foot-wide corridor of predominantly agricultural land. Reclamation would acquire a ROW or easement along this corridor, and future use within it would be restricted. It is likely that agricultural uses could continue after construction is completed. However, no permanent structures would be permitted, and any permitted use would be subject to disruption in the event of a pipeline repair or replacement requirement.

Preliminary alignment studies show the pipeline facility would cross several agricultural parcels at an angle and/or not along property lines, thus dividing the parcels into two parts, and come close to, if not displacing, at least one residence. These impacts would be locally significant (to individual landowners).

4.13.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Construction impacts would include temporary impacts to existing land uses (for example, to agricultural production and/or access).

Long-Term Impacts

Dam and Reservoir.—Development of Wymer dam and reservoir would involve Federal acquisition of approximately 4,000 acres of private land in the Lmuma Creek basin. The preliminary boundary of the acquisition area is shown on figure 4.20. This acquisition would involve two members of the same family. The land would be converted from open habitat and rangeland uses to dam and outlet works, reservoir pool, and shoreline management uses. Shoreline management is expected to include reservoir-oriented recreation facilities (e.g., day use sites, boat ramp(s). (See the “Recreation” section.) At the easternmost extent of the reservoir, the high water line would extend approximately 2,500 feet

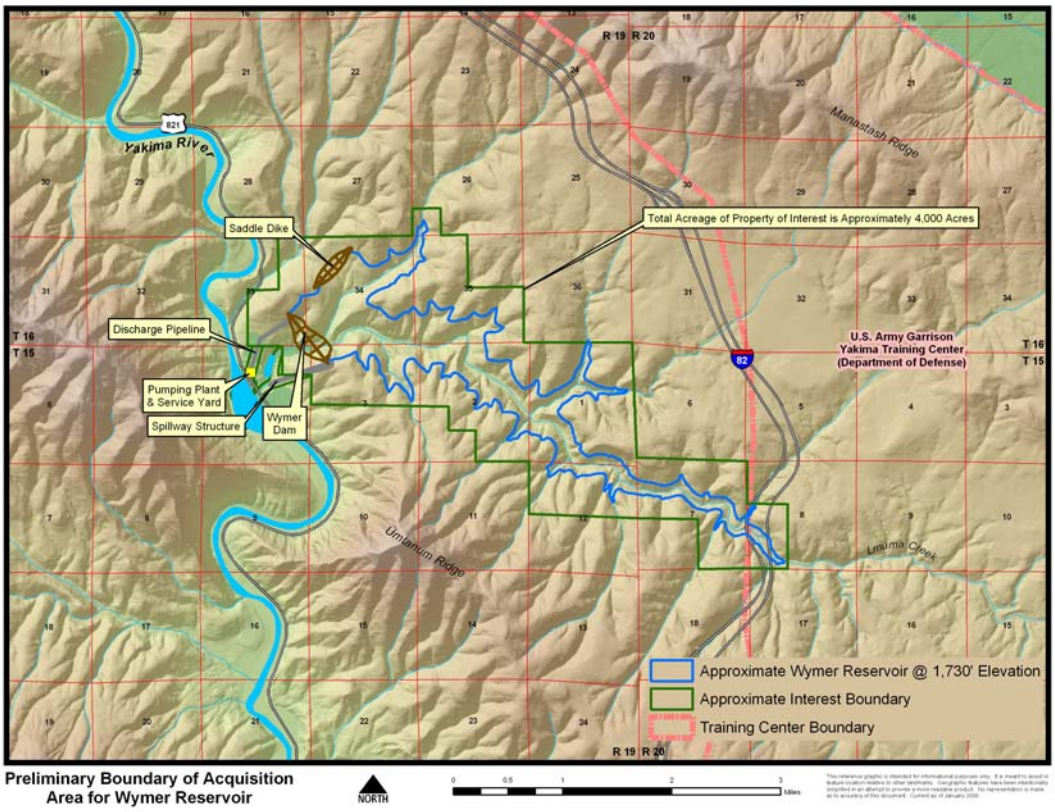


Figure 4.20 Preliminary boundary of acquisition area for Wymer Dam and Reservoir Alternative.

into the YTC; appropriate coordination among Federal agencies would be required, but no major incompatibilities would be created. No other landowners (private or public) and no developed uses would be affected.

From the standpoint of land use planning, it is uncertain whether Kittitas County would consider the dam and reservoir consistent with the intent of the Forest and Range zoning designation. However, development of Wymer dam and reservoir would involve removing associated land from Kittitas County jurisdiction, thus making county plans and designations for the land no longer relevant.

Appurtenant Facilities.—Development of appurtenant facilities would require the following:

- Pumping plant, air chamber, and switchyard: Federal acquisition of approximately 6.8 acres of private agricultural land along the Yakima River, including approximately 100 feet of shoreline.

- Import conveyance (pipeline): Federal control of (via acquisition, easement, or ROW) and construction within a 100-foot-wide corridor

of agricultural land approximately 4,700 feet long from the dam to the pumping plant, and crossing SR-821.

- Outlet conveyance: Federal control and modification of the Lmuma Creek channel from the dam to the Yakima River.

- Electric transmission line: Federal control of (via acquisition, easement, or ROW) and construction of a transmission line within a 100-foot-wide corridor of land approximately 5 miles long from the pumping plant to an existing Bonneville Power Administration transmission line located to the west. No routing studies for this line have been conducted to date.

With the exception of the SR-821 ROW (State Department of Transportation) and transmission line ROW (route and associated land ownership not determined), all land on which appurtenant facilities would be located is owned by one family. The import conveyances would be underground, and the transmission line would be above ground; thus, long-term use of associated land could include continued agriculture with appropriate restrictions and conditions related to the potential for repair/replacement access. Whether the landowner's residence in the area immediately east of SR-821 would need to be relocated has not been determined. Use of the land on which the pumping plant, air chamber, and switchyard would be constructed would be changed from irrigated agriculture to project facilities.

These changes in use could be locally significant (especially if the landowner's residence would be displaced), but would not be significant in the broader context of Yakima Canyon. In the latter regard, the commercial/industrial nature of the pumping plant, air chamber, and switchyard facilities would be similar to those associated with Roza Diversion Dam approximately 5 miles to the south and private commercial uses one mile to the north.

From the standpoint of land use planning, it is uncertain whether Kittitas County would consider project facilities consistent with the intent of the Forest and Range zoning designation in the area, or if the BLM would consider these facilities compatible with the Scenic and Recreational Highway. However, as noted above, the Wymer facilities would be similar in nature to existing development upstream and downstream along the river.

From the standpoint of shoreline management (pursuant to the SMA), the Yakima River intake, pumping plant, and outlet facilities are undoubtedly "water dependent." Beyond this, the conceptual nature of facility plans and designs at this point in the planning process precludes a meaningful assessment of response to SMA policies and provisions. (See "Mitigation.")

4.13.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

In addition to the construction impacts described for the Wymer Dam and Reservoir Alternative, impacts would occur all along the pipeline route, impacting existing land uses and requiring significant under-crossings of waterways and roads.

Long-Term Impacts

The environmental consequences of the Wymer dam component of this alternative are the same as for the Wymer Dam and Reservoir Alternative. This section discusses the Yakima River pump exchange component of the alternative.

Development of the pump exchange component of this alternative would require Reclamation to acquire the following land interests from private owners:

- **Pipeline:** Approximately 56 miles of easement or ROW would need to be acquired. This easement or ROW would typically be 200 feet wide. Land use within the easement/ROW would be restricted for the life of the project. It is likely that agricultural, recreational, or other nonstructural uses could continue after construction is completed. However, existing structures would be removed, no new permanent structures would be permitted, and any permitted use would be subject to disruption in the event of a pipeline repair or replacement requirement.

- **Pumping Plants:** Fee title to required lands for development of project surface facilities would need to be acquired. Approximate land area requirements are:

  - **Intake and pumping plant #1:** 16 acres

  - **Pumping plant #2:** 53 acres (16 for structures and yard; 37 for overflow reservoir

  - **Pumping plant #3:** 40 acres (12 for structures and yard; 28 for overflow reservoir)

- **Transmission Lines to Pumping Plants:** Easement or ROW (width not specified to date) for new transmission lines to supply power to the pumping plants. Land use within this easement/ROW would be restricted for the life of the project (in similar fashion to that described above for the pipeline). Preliminary studies specify the following requirements:

  - **Intake and pumping plant #1:** One-half mile of 500-kV line
  - **Pumping plant #2:** 1.5 miles of 230-kV line
  - **Pumping plant #3:** 3 miles of 115-kV line

Also, the pipeline would require numerous crossings of other infrastructure facilities and waterways, necessitating coordination and permitting from involved State and/or Federal agencies. Required crossings include, but are not limited to, those presented in table 4.41 (based on preliminary inventory of major facilities, and not including utility lines, other pipelines, minor waterways/drainages, etc.).

Table 4.41 Pump exchange pipeline crossings of rivers, waterways, highways, and roads

Feature	Crossings
Rivers and waterways	
- Yakima River	1
- Roza ID wasteway	1
- Sunnyside Canal	3
- Other waterways	6
Highways and roads	
- Interstate highways (I-182 in Richland)	1
- State Routes (240, 224, 225 and 241)	4
- Arterial highways (in Richland)	4
- Local roads	45-50

Overall, this alternative would have significant impacts on land use within the required easements/ROW and on surface facility sites. Long-term impacts would include restriction of allowable uses within the pipeline easement/ROW and changes in land use at the pumping plant sites.

From the standpoint of shoreline management (pursuant to the SMA), both the intake and pumping plant #1 facilities on the Columbia River and the Yakima River pipeline crossing can certainly by considered "water dependent" given the purpose of the project/alternative. Beyond this, the conceptual nature of facility plans and designs at this point in the planning process precludes a meaningful assessment of response to SMA policies and provisions. (See "Mitigation.")

Overviews of potentially significant long-term impact on land use within affected jurisdictions are provided below.

City of Richland.—Approximately 16 acres (including approximately 200 feet of Columbia River/McNary pool shoreline) designated "commercial recreation" in the city's Wye Master Plan would be used instead for the industrial facilities associated with intake and pumping plant #1. Project facilities may also have a wider impact because of incompatibilities with planned commercial recreation uses in the surrounding area; this is especially the case with the transmission line necessary to supply the pumping plant.

Beyond the Wye area, after the I-182 crossing near Columbia Center Boulevard, a substantial proportion of the land along the proposed pipeline corridor is currently

undeveloped, especially on the north side of Keene Road (where the preliminary alignment of the pipeline has been shown). However, there are several instances of residential subdivisions abutting the pipeline route. There is at least one instance of high-density development built across the preliminary pipeline route. There are several crossings through commercial development, especially near roadway intersections. It is likely that at least some residential and/or commercial land uses would be displaced by pipeline construction.

City of Kennewick.—Most land along the proposed pipeline route through Kennewick (1 mile long) is developed, with residential uses on the north and commercial uses on the south. Construction here would likely result in displacement of structures.

Another potential impact on Kennewick is incompatibility between the intake and pumping plant #1 facilities and both existing (campground) and park/resort hotel (planned) uses in the city's Columbia Park, immediately to the southeast.

City of West Richland.—Land along the proposed pipeline route within West Richland is more than 50 percent developed, primarily in low-density residential uses. It is unlikely that the pipeline could be implemented without some displacement of existing residences.

Benton and Yakima Counties.—The preliminary route shown for the pipeline primarily follows existing roads through irrigated agricultural areas in these two counties. As such, there are many instances of existing residences within 200 feet of the roads. These residences would be displaced if the pipeline were developed according to the preliminary alignment.

Land on which pumping plant # 2 and pumping plant # 3 and their associated overflow reservoirs and transmission lines would be located is currently in agricultural use. This use would be displaced by project facilities.

4.13.2.6 Mitigation

Black Rock Alternative

Land acquisition requirements and associated land use impacts associated with Black Rock dam and reservoir would be long-term and unavoidable. Mitigation would focus exclusively on (1) compensating impacted landowners at fair market value according to established Federal regulations, guidelines, and procedures and (2) relocating/rerouting existing utility and transportation infrastructure. In the latter regard, as shown conceptually in chapter 2 and described further in the "Transportation" section, SR-24 is proposed to be rerouted along the south side of the reservoir. The impacted transmission lines and fiber optic cable would be relocated/reconstructed along the new SR-24 alignment.

Land and easement/ROW acquisition, as well as short- and long-term land use impacts associated with appurtenant facilities of the Black Rock Alternative, would be largely unavoidable. Mitigation would focus primarily on compensating impacted landowners at fair market value according to established Federal guidelines, standards, and procedures. Additional mitigation potential, to be explored during more detailed studies (especially for conveyance routes), would include the following:

- Minimize construction-phase disruption to existing land uses (especially related to construction duration and access/circulation).
- Avoid dislocation of or significant proximity impacts on existing residences or other major structures to the maximum extent feasible.
- Align conveyances along existing roads and/or property lines to the maximum extent feasible.
- In response to SMA policies and as part of obtaining the required Substantial Development Permit, design shoreline facilities at Priest Rapid Lake to (1) protect shoreline natural resources (including response to the no net loss policy) and (2) promote public access to the maximum extent feasible.

Wymer Dam and Reservoir Alternative

Land use impacts associated with Wymer dam and reservoir would be long-term and unavoidable. Mitigation would focus exclusively on compensating impacted landowners at fair market value according to established Federal regulations, standards, and procedures

Land and easement/ROW acquisition, as well and use impacts associated with appurtenant facilities of the Wymer Dam and Reservoir Alternative, would be largely unavoidable. Mitigation would focus primarily on compensating the impacted private landowners at fair market value according to established Federal guidelines, standards, and procedures. Additional mitigation potential, to be explored during more detailed studies would include the following:

- Avoid dislocation of the existing residence east of the State highway, if feasible.
- Work with the landowner to accommodate agriculture in conveyance and transmission corridors, if desired.
- In response to SMA policies and as part of obtaining the required Substantial Development Permit, design shoreline facilities to (1) protect shoreline natural resources (including response to the no net loss policy) and (2) promote public access to the maximum extent feasible.

- Use architectural treatments and landscape screening to blend facilities with the surrounding landscape. (See the "Visual Quality" section.)

Wymer Dam Plus Yakima River Pump Exchange Alternative

Land and easement/ROW acquisition, and associated short- and long-term land use impacts from pipeline, pumping plant and transmission line facilities of the Yakima River pump exchange component would be largely unavoidable. However, more detailed studies of pipeline and transmission line routing options should explore opportunities for avoiding direct, dislocation impacts on existing residences and business to the maximum extent feasible. For example, in the rural/agricultural lands of Benton and Yakima Counties, routing of the pipeline on/near property lines or on quarter- or half-section lines (rather than immediately along roads) in some areas may offer the opportunity to avoid dislocation impacts to residences and minimize construction-phase access disruptions. Such detailed routing studies should also seek opportunities to minimize long-term impacts on existing developed uses in the urban environments of Richland, Kennewick, and West Richland.

- Beyond such site/alignment adjustments during detailed planning, mitigation for land use and ownership impacts would focus primarily on compensating impacted landowners at fair market value according to established Federal guidelines, standards and procedures.

- Regarding shoreline resources, siting and design of the intake and pumping plant #1 facilities and the Yakima River pipeline crossing should seek to (1) protect shoreline natural resources (including response to the no net loss policy) and (2) promote public access to the maximum extent feasible. Consideration and adoption of potential responses in these regards would be part of the Substantial Development Permit process.

4.13.2.7 Cumulative Impacts

The Black Rock Alternative would have only minor cumulative impacts relative to local- or county-scale land ownership, existing land uses, or applicable land use plans and policies. Cumulative impacts would be associated predominantly with appurtenant facilities and would take the form of an incremental addition in the number of industrial/infrastructure facilities present in the context of rural environments. In the area of the intake facilities near Priest Rapids Dam, this change would primarily be an addition to already existing facilities and uses (i.e., no other, similar facilities are planned). In the area of the outlet and distribution facilities (rural Yakima County) it can be expected that continuing urban development will also bring instances of this type of development over time.

The appurtenant facilities (pumping plant, switchyard, etc.) of the Wymer Dam and Reservoir Alternative would add cumulatively to the number of locations

within Yakima Canyon where developed industrial/commercial land uses occur in the context of a primarily undeveloped river canyon, a canyon environment designated as "rural" by Kittitas County. This cumulative "land use compatibility" impact will be in relation to existing developed facilities such as Roza Diversion Dam; no additional, similar types of development are known to be planned within the canyon.

The Wymer Dam Plus Yakima River Pump Exchange Alternative would have only minor cumulative impacts relative to local- or county-scale land ownership, existing land uses or applicable land use plans and policies. Cumulative impacts would be associated predominantly with pumping plant # 2 and pumping plant # 3 and would take the form of an incremental addition in the number of industrial/ infrastructure facilities present in the context of rural environments in Benton and Yakima Counties. This change would primarily be an addition to already existing facilities and uses (i.e., no other, similar facilities are known to be planned in the locally affected environment).

4.14 Socioeconomics (Regional Economy)

This section presents estimates of the regional economic impacts resulting from changes in construction expenditures, gross farm income, and recreational expenditures for each Joint Alternative as compared to the No Action Alternative. The regional economic impact analysis comprises the RED account. The NED account compares the alternatives from a national perspective, while the RED account measures the effect of the alternatives on the region's local economy.

The RED analysis includes not only the initial or direct impact on the primary affected industries, but also the secondary impacts resulting from those industries providing inputs to the directly affected industries as well. This analysis also includes the changes in economic activity stemming from household spending of income earned by those employed in the sectors of the economy impacted either directly or indirectly. These secondary impacts are often referred to as "multiplier effects."

The NED economic benefits are not used directly in the RED analysis; only the physical changes are carried over from the NED analysis. For example, changes in agricultural water supply may result in a change in crop acreages, which subsequently results in a change in gross farm income. The change in gross farm income reflects the direct economic impact in the RED analysis, which after being run through the regional economic model, generates the secondary or multiplier effects. The NED benefits analysis uses net farm income as defined by the *P&Gs* as the estimate of agricultural benefits.

See chapter 2 for further explanation on the difference between the NED and RED accounts.

4.14.1 Affected Environment

The study area encompasses Kittitas, Yakima, Benton, and Franklin Counties. Ellensburg, Yakima, and the Tri-Cities (Richland, Pasco, and Kennewick) are the largest cities located within the study area. The Yakima River basin includes all of these counties except for Franklin County. Franklin County is included because the Tri-Cities are located in both Benton and Franklin Counties.

The common measures of regional economic impacts are output, employment, and labor income. Table 4.42 presents these measures for the four-county area for the year 2004. These measures are discussed below.

Table 4.42 Regional employment, output, and labor income, Kittitas, Yakima, Benton, and Franklin Counties (2004)

Sector category	Output		Employment		Labor income	
	$ million	% Total	Number of jobs	% Total	$ million	% Total
Agriculture, forestry, fish and hunting	$2,944	11.1%	39,059	15.8%	$1,023	10.7%
Mining	$7	Less than 1	51	Less than 1	$2	Less than 1
Utilities	$173	0.7%	357	0.1%	$32	0.3%
Construction	$1,486	5.6%	13,439	5.4%	$607	6.4%
Manufacturing	$4,803	18.1%	15,457	6.2%	$766	8.0%
Wholesale trade	$877	3.3%	7,745	3.1%	$330	3.5%
Transportation and warehousing	$655	2.5%	6,891	2.8%	$283	3.0%
Retail trade	$1,481	5.6%	23,485	9.5%	$602	6.3%
Information	$535	2.0%	2,839	1.1%	$127	1.3%
Finance and insurance	$736	2.8%	4,831	2.0%	$212	2.2%
Real estate and rental	$789	3.0%	5,623	2.3%	$157	1.6%
Professional: scientific and technical services	$1,791	6.8%	15,832	6.4%	$1,062	11.1%
Management of companies	$141	0.5%	918	0.4%	$61	0.6%
Administrative and waste services	$2,181	8.2%	13,958	5.6%	$832	8.7%
Educational services	$108	0.4%	2,653	1.1%	$49	0.5%
Health and social services	$1,772	6.7%	24,411	9.9%	$928	9.7%
Arts: entertainment and recreation	$184	0.7%	4,028	1.6%	$65	0.7%
Accommodation and food services	$697	2.6%	14,835	6.0%	$231	2.4%
Other services	$879	3.3%	14,252	5.8%	$298	3.1%
Government	$4,29	16.2%	37,020	14.9%	$1,874	19.6%
Total	$26,532	100.0%	247,684	100.0%	$9,541	100.0%

Source: 2004 IMPLAN data files, including U.S. Bureau of Economic Analysis, U.S. Bureau of Labor, and Census.

4.14.1.1 Employment

Employment measures the number of jobs related to the sector of the economy. In the study area, activities related to agricultural production generate the largest number of jobs (15.8 percent of total regional employment) in the study area. Government related jobs rank second in terms of overall number of jobs in the study area (14.9 percent of total regional employment).

4.14.1.2 Output

Output, or industry output, represents the value of production of goods and services produced by business within a sector of the economy. The manufacturing sectors produce the highest level of output in the study area (18.1 percent of the total regional output). The vast majority of the manufacturing output stems from activities in the food processing related industries. The government sectors generate the second highest level of output within the study area (16.2 percent of total regional output). The agricultural production sectors rank third in level output (11.1 percent of the total regional output).

4.14.1.3 Labor Income

Labor income is the sum of Employee Compensation and Proprietor Income. The government sectors generate the largest portion of labor income in the region (19.6 percent of the total regional labor income). The sectors related to providing professional related services rank second (11.1 percent of the total regional labor income). Ranking third, closely behind professionally related services, are the sectors related to agricultural production (10.7 percent of the total labor income).

4.14.1.4 Irrigated Agriculture

As discussed previously, activities related to agricultural production contribute the largest number of jobs to the region. The agricultural sector ranks third in terms of labor income and industry output. These jobs are primarily related to irrigated agricultural production, including livestock, and food processing. Production agriculture is widely diversified in the region. The area is well known for tree fruit (apples, pears, and cherries), vegetable (sweet corn, potatoes, and asparagus), grape (wine and juice), as well as hay and grain (timothy hay, alfalfa hay, pasture, and wheat) production.

Table 4.43 presents gross on-farm income for each crop grown on Yakima Project lands. Gross on-farm income is calculated by multiplying together acres, yields, and prices for each crop. These data are taken from the Yakima Agricultural Impact Model discussed in chapter 2.

The gross on-farm income from crops grown on Yakima Project lands generates 12,321 total jobs, $391.4 million in labor income, and $1,097.3 million in output in the study area. These data are estimated using the IMPLAN modeling package discussed in section 4.14.2.1.

Table 4.43 Gross on-farm income by crop

Crops	Output ($ million)
Vegetables	
Asparagus	$17
Sweet Corn	$10
Potato	$3
Fruits	
Cherries	$68
Pears	$28
Apples	$342
Other	
Mint	$8
Hops	$86
Concord Grapes	$36
Wine Grapes	$41
Timothy Hay	$13
Alfalfa	$32
Silage	$9
Grains	
Wheat	$7
Total	$700

Source: Reclamation's Yakima Agriculture Impact Model.

4.14.1.5 Recreation

Recreation expenditures generate output, labor income, and employment in the study area. A recreation survey was conducted to gather information at existing reservoir and river sites within the region. Estimates of visitation, nonlocal recreator visitation percentages (see "Methods and Assumptions" for a discussion of the logic for focusing on nonlocal recreation expenditures), and expenditures per visit were obtained from the survey. Because changes in recreation activity related to the proposed alternatives were estimated to occur at only four sites (i.e., Kachess Lake, Cle Elum Lake, Yakima River, and Tieton River), the description of current regional recreation expenditures also focuses on those sites. Obviously, the proposed Black Rock and Wymer reservoirs are not part of the current condition.

Table 4.44 presents information on current in-region recreational expenditures by nonlocal recreators by site. Summing across all four sites, nearly 70 percent of the visitation reflects nonlocal recreators. Average in-region expenditures per visit by nonlocal recreators ranges from a low of $49.02 at Kachess Lake to a high of $133.09 at Cle Elum Lake. The current total in-region expenditures by nonlocals at these sites were estimated at nearly $3 million.

Table 4.44 Current in-region recreation expenditures by nonlocal recreators by site

Site	Visitation	Nonlocal percentage	Nonlocal visitation	Average in-region expenditures per visit	Current total in-region expenditures ($ thousands)
Kachess Lake	17,668	.86	15,194	$ 49.02	$ 744.8
Cle Elum Lake	8,976	.663	5,951	133.09	792.0
Yakima River	18,900	.5	9,450	88.47	836.0
Tieton River	9,108	.78	7,104	85.24	605.5
Combined	54,652		37,699		$2,978.3

4.14.2 Environmental Consequences

At the regional level, all of the alternatives would result in positive economic output, as compared to the No Action Alternative. The most significant effect would result from construction activities. However, expenditures related to OM&R, recreation expenditures, and agricultural production also would affect the regional economy.

4.14.2.1 Methods and Assumptions

The modeling package used to assess the regional economic effects stemming from construction, irrigated agriculture, and recreation for each alternative is IMPLAN (IMpact Analysis for PLANning). IMPLAN is an economic input-output modeling system that estimates the effects of economic changes in an economic region.

Input-output models measure commodity flows from producers to intermediate and final consumers. Purchases for final use (final demand) drive the model. Industries produce goods and services for final demand and purchase goods and services from other producers. These other producers, in turn, purchase goods and services. This buying of goods and services (indirect purchases) continues until leakages from the region (imports and value added) stop the cycle.

These indirect and induced effects (the effects of household spending) can be mathematically derived using a set of multipliers. The multipliers describe the change of output for each and every regional industry caused by a $1 change in final demand for any given industry.

IMPLAN data files are compiled from a variety of sources for the study area, including the U.S. Bureau of Economic Analysis, the U.S. Bureau of Labor, and the U.S. Census Bureau. This analysis uses 2004 IMPLAN data for Washington's Benton, Yakima, Kittitas, and Franklin Counties, which comprise the study area for the RED analysis.

Construction

The construction-related expenditures associated with each of the alternatives were placed into categories that represent different sectors of production in the economy. The construction expenditures that are made inside the study region were considered in the regional impact analysis. Construction expenditures made outside the four-county area were considered "leakages" and would have no impact on the local economy.

The RED study assumed that the workforce would move to the region and spend their wages inside the area during the construction period. This analysis also assumed that the vast majority of the construction expenditures will be funded from sources outside the four-county study area. Money from outside the region that is spent on goods and services within the region would contribute to regional economic impacts, while money that originates from within the study region is much less likely to generate regional economic impacts. Spending from sources within the region represents a redistribution of income and output rather than an increase in economic activity.

For the purpose of the Storage Study, the total construction costs were used to measure the overall regional impacts. These overall impacts would be spread over the construction period and would vary year-by-year proportionate to actual expenditures.

Operation, Maintenance, and Replacement

Expenditures that are made inside the study region related to OM&R will also generate a positive economic output to the regional economy. Estimating regional impacts resulting from OM&R expenditures is difficult because they occur during different periods of time. For example, expenditures related to operations and maintenance occur annually, whereas replacement expenditures occur periodically based on the replacement schedule.

This analysis quantifies annual impact resulting from annual costs related to operation and maintenance. The analysis does not quantify the positive impacts resulting from replacement costs given they are spread out over the entire study period. Like the construction-related expenditures, O&M expenditures made inside the study area associated with each alternative were placed into categories related to the each sector of the economy and run through IMPLAN to estimate impacts to the regional economy.

Irrigated Agriculture

Regional economic impacts are realized in drought years when proration levels drop below 70 percent. To estimate the regional impacts in each of these years, the YAI model was used to estimate the changes in gross on-farm between the No Action Alternative proration level and the proration level achieved by each alternative. No regional economic impacts accrue when the proration levels are

above 70 percent for a given alternative. Table 4.45 presents the gross on-farm income by IMPLAN sector (incremental to the No Action Alternative) for each year the proration levels drop below 70 percent for each alternative.

Table 4.45 Gross on-farm income (incremental to the No Action Alternative) by IMPLAN sector

Year	Grains	Other	Fruits	Vegetables
Black Rock Alternative				
1987	556,579	17,232,110	16,043,770	1,129,626
1992	428,138	13,255,040	12,347,810	868,943
1993	685,021	21,206,100	19,804,730	1,393,283
1994	1,840,993	55,196,340	88,008,910	4,932,981
2001	1,113,159	34,101,480	43,542,390	2,964,663
2005	1,070,345	32,796,050	41,392,080	2,821,306
Wymer Dam and Reservoir Alternative				
1987	171,255	5,302,016	4,939,123	347,577
1992	256,883	7,953,024	7,408,685	521,366
1993	470,952	14,578,580	13,630,830	958,812
1994	85,628	2,086,366	6,944,756	32,920
2001	642,207	19,520,940	29,959,800	2,008,826
2005	171,255	5,221,744	8,601,246	573,428
Wymer Dam Plus Yakima River Pump Exchange Alternative				
1987	171,255	5,302,016	4,939,123	347,577
1992	256,883	7,953,024	7,408,685	521,366
1993	470,952	14,578,580	13,630,830	958,812
1994	85,627	2,086,367	6,944,756	32,920
2001	642,208	19,520,940	29,959,800	2,008,828
2005	171,255	5,221,744	8,601,246	573,428

The change in gross on-farm income summarized in table 4.45 was used in the IMPLAN model to estimate total employment, output, and labor income associated with the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Exchange Alternatives.

This analysis measures regional economic impacts stemming from production agricultural. Industries related to production agriculture are not the only industries dependent on irrigation in a regional economy. Other industries depend on inputs of irrigated crops in their production process, for example the livestock and food processing industries.

Recreation

Regional economic impacts associated with changes in recreation activity within the region were estimated for both the proposed reservoirs and existing reservoirs and rivers. Estimates of changes in visitation by site were obtained from the recreation analysis. Given that the proposed Black Rock and Wymer reservoirs are obviously not a part of the No Action Alternative, the estimates of visitation for these proposed reservoirs reflect the full change in visitation as compared to the No Action Alternative.

In regional economic impact analyses of recreation, the assumption is typically made that the majority of impacts are generated by expenditures made inside the region by nonlocal recreators. Local recreators are generally assumed to spend the majority of their recreation expenditures within the region, regardless of the alternatives under consideration, implying they would generate little by way of additional regional economic activity. As a result, the analysis focuses on in-region expenditures by nonlocal recreators.

Given that in-region nonlocal recreator expenditures per visit vary by site, the survey was conducted across all the existing reservoirs and rivers within the region. Survey questions asked recreators to estimate their total expenditures for the current visit, the portion of those expenditures incurred within the local region, and the breakdown of expenditures into various expenditure categories (e.g., lodging, food, gas, etc.). This later piece of information was necessary to help subdivide the expenditures across the economic sectors included in the IMPLAN model. These data were used by IMPLAN to estimate output, labor income, and employment, relative to the No Action Alternative, stemming from recreational expenditures for each alternative.

4.14.2.2 No Action Alternative

The No Action Alternative provides the basis of comparison for changes in employment, output, and labor income under the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives.

4.14.2.3 Black Rock Alternative

Construction Impacts

Regional economic impacts related to construction expenditures, incremental to the No Action Alternative, for each Joint Alternative, are presented in table 4.46. The employment, output, and income generated from each alternative's expenditures are compared to the overall regional economy. The estimated impacts are representative of the entire construction period. These impacts would not occur each year; they vary year by year proportionate to annual expenditures. The majority of the employment, output, and income

Table 4.46 Total regional economic impacts stemming from construction activities

	Employment[1]		Output ($ million)[2]		Income ($ million)[3]	
	Total	Percent of the total regional economy	Total	Percent of the total regional economy	Total	Percent of the total regional economy
Regional economy	247,684		$26,532		$9,540	
Black Rock Alternative	18,667	7.5%	$2,100	7.9%	$710	7.4%
Wymer Dam and Reservoir Alternative	5,677	2.2%	$613	2.3%	$216	2.3%
Wymer Dam Plus Yakima River Pump Exchange Alternative	15,539	6.3%	$1,732	6.5%	$589	6.2%

[1] Employment is measured in number of jobs.

[2] Output represents the dollar value of industry production.

[3] Income is the dollar value of total payroll (including benefits) for each industry in the region plus income received by self-employed individuals located within the region.

impacts are due to the expenditures of the wages earned by the workforce involved in the construction project and the construction activities.

The total number of jobs during the approximate 10-year construction period, 18,668, includes 8,181 jobs in the construction sector. Thus, assuming a 10-year construction period, an average of about 820 of the 1,870 average annual jobs would be directly related to construction and include onsite and offsite labor. The 8,181 direct construction jobs would be about 3 percent of the regional 2004 employment, while the total number of jobs, 18,668, would be less than 8 percent. The average annual direct and average annual total number of jobs, 820 and 1,870, respectively, would be less than 1 percent of the regional 2004 employment.

The 2004 population of the four-county region was estimated to be 475,400. The total number of jobs associated with this alternative would be an increase of about 4 percent, while the direct construction jobs would be an increase of about 2 percent. The average annual direct and average annual total number of jobs would be less than ½ of 1 percent of the regional population.

In 2000, the region had a total of 167,696 housing units, of which 7.5 percent or 12,615 were vacant. The number of housing units in 2006 was estimated to be about 185,000, an increase of 17,300 units, with about 14,000 vacant units. The housing unit estimates include mobile homes but do not include the numerous motels, recreational vehicle (RV) parks, and similar facilities located within the four-county region.

The specific skills and numbers of the construction workforce would change during the construction period. It is likely some jobs may last for a few weeks or

months, while others could last for one or more years. A few workers may elect to commute to the worksites associated with this alternative from outside the four-county region. Others may choose to stay in the region in temporary quarters, e.g., motels, RV parks, during the work week and return to their permanent residence on weekends. Some may relocate alone or with family to the region, renting or purchasing housing. Regardless, adequate housing would likely be available within the four-county area. With the construction workforce dispersed throughout the four-county area, it is unlikely any community would be overwhelmed with an influx of workers.

Long-Term Impacts

O&M Activities.—Regional economic impacts stemming from O&M activities, incremental to the No Action Alternative for each alternative, are presented in table 4.47. The employment, output, and income generated from each alternative's O&M are compared to the overall economy. These impacts are assumed to occur on an annual basis. Like the construction impacts, the majority of the O&M impacts are due to the expenditures of the wages earned by the workforce involved in O&M-related activities.

Table 4.47 Annual regional economic impacts stemming from O&M activities

	Employment (number of jobs)		Output ($ millions)		Income ($ millions)	
	Total	% of total regional economy	Total	% of total regional economy	Total	% of total regional economy
Regional Economy	247,684		26,532		9,540	
Black Rock Alternative	33	Less than 1	4	Less than 1	1.1	Less than 1
Wymer Dam and Reservoir Alternative	9	Less than 1	1.1	Less than 1	0.314	Less than 1
Wymer Dam Plus Yakima River Pump Exchange Alternative	119	Less than 1	11.8	Less than 1	4.8	Less than 1

Irrigated Agriculture.—Table 4.48 presents the regional economic impacts for the Black Rock Alternative for each year of the 25-year period of record (1981-2005) that the proration level falls below 70 percent. Also presented in the table is a comparison to the total regional impacts stemming from the gross on-farm income generated on the Yakima Project lands (table 4.48).

Table 4.48 Regional economic inputs stemming from irrigated agriculture

Year	Output ($ million)	Percent of Yakima Project	Labor income ($ million)	Percent of Yakima Project	Employ-ment	Percent of Yakima Project
Black Rock Alternative						
2005	$121.2	11.1%	$42.2	10.8%	1,330	10.8%
2001	$126.9	11.6%	$44.2	11.3%	1,394	11.3%
1994	$234.1	21.3%	$82.6	21.1%	2,608	21.2%
1993	$66.4	6.1%	$22.7	5.8%	716	5.8%
1992	$41.4	3.8%	$14.1	3.6	447	3.6
1987	$53.9	4.9%	$18.4	4.7	580	4.7
Wymer Dam and Reservoir and Wymer Dam Plus Yakima River Pump Exchange Alternatives						
2005	$22.8	2.1%	$8.0	2%	254	2.1%
2001	$81.3	7.4%	$28.6	7.3%	902	7.3%
1994	$14.5	1.3%	$5.3	1.4%	169	1.4%
1993	$45.7	4.2%	$15.6	4%	493	4%
1992	$24.9	2.3%	$8.5	2.2%	268	2.2
1987	$16.8	1.5%	$5.7	1.5%	179	1.5

Recreation.—Recreation expenditures (the expenditures used in IMPLAN were incremental to the No Action Alternative) related to the proposed Black Rock reservoir stimulate $23.6 million of output, $9.2 million in labor income, and 360 jobs annually. Recreation expenditures at existing recreation sites generate a small amount of regional economic impacts ($0.14 million of output, $0.07 million of labor income, and 2 jobs). The majority of the regional impacts stemming from expenditures at the proposed reservoir and existing sites occur in the Accommodation and Food Service and the Retail Trade sectors. Table 4.49 summarizes these results. Also presented in the table is a comparison to the total regional impacts stemming from total recreation expenditures from existing sites (table 4.49).

4.14.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Regional economic impacts related to construction expenditures for the Wymer Dam and Reservoir Alternative are presented in table 4.46.

Table 4.49 Regional economic impacts stemming from recreation expenditures

Recreation	Black Rock Alternative	Percent of the current condition	Wymer Dam and Reservoir Alternative	Percent of the current condition	Wymer Dam Plus Yakima River Pump Exchange Alternative	Percent of the current condition
Existing sites						
Output/sales ($ million)	$ 0.14	5.2 %	$ 0.05	1.9 %	$ 0.09	3.3 %
Labor income ($ million)	$ 0.07	5.8 %	$ 0.02	1.7 %	$ 0.04	3.3 %
Employment	2	4.6 %	1	2.3 %	1	2.3 %
Proposed sites						
Output/sales ($ million)	$ 23.6	Not applicable[1]	Not applicable[2]	Not applicable	Not applicable	Not applicable
Labor income ($ million)	$ 9.2	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Employment	360	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

[1] The proposed Black Rock reservoir is not included in the current condition; therefore, no comparisons were made.

[2] Recreators at Wymer reservoir are assumed to be from the local area; therefore, no regional impacts were generated.

The total number of jobs during the approximate 10-year construction period, 5,677, includes 2,521 jobs in the construction sector. Thus, assuming a 10-year construction period, an average of about 250 of the 570 average annual jobs would be directly related to construction and include onsite and offsite labor. The 2,521 direct construction jobs would be about 1 percent of the regional 2004 employment, while the total number of jobs, 5,677, would be about 2 percent. The average annual direct and average annual total number of jobs, 250 and 570, respectively, would be less than 3/10 of 1 percent of the regional 2004 employment.

The total number of jobs associated with this alternative would be an increase in regional population of less than 2 percent, while the direct construction jobs would be an increase of about ½ of 1 percent. The average annual direct and average annual total number of jobs would be about 1/10 of 1 percent of the regional population. Other effects would be as described for the Black Rock Alternative.

Long-Term Impacts

O&M Activities.—Table 4.47 presents the regional economic impacts stemming from O&M activities for the Wymer Dam and Reservoir Alternative.

Irrigated Agriculture.—Table 4.48 presents the regional economic impacts for the Wymer Dam and Reservoir Alternative and the Wymer Dam Plus Yakima River Pump Exchange Alternative for each year the proration level falls below 70 percent.

Recreation.—It was assumed that recreators at the proposed Wymer reservoir are residents of the regional study area; thus, their recreational expenditures would not create regional economic impacts to the region. The Wymer Dam and Reservoir Alternative would generate a small amount of recreation expenditures at existing sites, as presented in table 4.49. Regional economic impacts stemming from recreational expenditures at existing sites stimulates $0.05 million in output, $0.02 million in labor income, and one job. As under the Black Rock Alternative, most of the regional impacts occur in the Accommodation and Food Services and Retail Trade sectors of the economy.

4.14.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Regional economic impacts related to construction expenditures for the Wymer Dam Plus Yakima River Exchange Alternative are presented in table 4.46.

The total number of jobs during the approximate 10-year construction period, 15,539, includes 6,776 jobs in the construction sector. Thus, assuming a 10-year construction period, an average of about 680 of the 1,550 average annual jobs, would be directly related to construction and include onsite and offsite labor. The 6,776 direct construction jobs would be slightly less than 3 percent of the regional 2004 employment, while the total jobs, 15,539, would be about 6 percent. The average annual direct and average annual total number of jobs, 680 and 1,550, respectively, would be less than 1 percent of the regional 2004 employment.

The total number of jobs associated with this alternative would be an increase in regional population of about 3 percent, while the direct construction jobs would be an increase of about 1 percent. The average annual direct and average annual total number of jobs would be less than ½ of 1 percent of the regional population. Other effects would be as described for the Black Rock Alternative.

Long-Term Impacts

O&M Activities.—Table 4.47 presents the regional economic impacts stemming from O&M activities for the Wymer Dam Plus Yakima River Pump Exchange Alternative.

Irrigated Agriculture.—The regional economic impacts are the same as for the Wymer Dam and Reservoir Alternative (table 4.48).

Recreation.—Like the Wymer Dam and Reservoir Alternative, regional economic impacts related to the Wymer Dam Plus Yakima River Pump Exchange

Alternative are related to recreational expenditures at existing recreational sites. Regional economic impacts related to recreational expenditures are small ($0.09 million output, $0.04 million in labor income, and 1.4 jobs). Like both the Black Rock and Wymer Dam and Reservoir Alternatives, most of the regional impacts occur in the Accommodation and Food Services and Retail Trade sectors. These results are summarized in table 4.49.

4.14.2.6 Mitigation

Mitigation measures may have impacts to the regional economy due to activities related to construction.

4.14.2.7 Cumulative Impacts

No cumulative impacts are expected.

4.15 Public Services and Utilities

This analysis of public services and utilities analysis addresses the affected environment and environmental consequences of the Joint Alternatives from the perspectives of the following:

- Public services
  - Law enforcement
  - Fire protection
  - Emergency medical/transportation
- Utilities
  - Electricity
  - Natural gas
  - Telecommunications
  - Water supply (domestic and irrigation)
  - Wastewater management

These are addressed from the standpoint of potential for short- or long-term impact on local systems (levels of service, response time, access, etc.) and/or infrastructure serving populated areas in/near which facilities would be developed. For analysis of potential impact to major/regional utility infrastructure (such as, high voltage transmission lines, pipelines, and/or cable installations); see the “Land Use and Shoreline Resources” section.

4.15.1 Affected Environment

4.15.1.1 No Action Alternative

The No Action Alternative includes conservation-oriented water supply system improvements, including pumping plants and pipelines, at various locations in the Yakima Valley region (Kittitas, Yakima, and Benton Counties). These improvements are associated with existing approved programs and orient predominantly to existing facilities; none are being or would be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis is required for these actions, appropriate documentation of the directly affected public services and/or utilities environment would be prepared separately, apart from the Storage Study process.

4.15.1.2 Black Rock Alternative

With only minor exceptions, all facilities associated with the Black Rock Alternative would be located in Yakima County, Washington. Public services and utilities in the general areas of Yakima County where Black Rock facilities would be developed are provided by:

- **Law Enforcement:** Yakima County Sheriff
- **Fire Protection:** Local Yakima County Fire Protection Districts (multiple)
- **Emergency Medical/Transportation:** Primarily local Yakima County Fire Protection Districts
- **Electrical Power:** Pacific Power & Light Company and Benton County Rural Electric Association
- **Natural Gas:** Cascade Natural Gas Corporation
- **Telecommunications:** Several companies, including Qwest
- **Water Supply:** Domestic supply—predominantly from individual wells; irrigation supply—individual wells and local irrigation district surface deliveries
- **Wastewater Management:** Individual septic tank and leach field installations

4.15.1.3 Wymer Dam and Reservoir Alternative

All facilities associated with the Wymer Dam and Reservoir Alternative would be located in southern Kittitas County, Washington. Public services and utilities in the general area of the county where Wymer facilities would be developed are provided by:

- **Law Enforcement:** Kittitas County Sheriff
- **Fire Protection:** Kittitas County Fire Department
- **Emergency Medical/Transportation:** Kittitas County Fire Department
- **Electrical Power:** Kittitas County Public Utility District
- **Natural Gas:** No developed system in the study area
- **Telecommunications:** Several companies, including Qwest
- **Water Supply:** Domestic supply—individual wells; irrigation supply—individual wells and Yakima River
- **Wastewater Management:** Individual septic tank and leach field installations

4.15.1.4 Wymer Dam Plus Yakima River Pump Exchange Alternative

The affected environment of the Wymer dam component of this alternative is presented in the previous section. The following presents the public services and utilities setting for the Yakima River pump exchange component of this alternative.

Facilities associated with the Yakima River pump exchange would be located in Yakima County, Benton County, and the cities of Richland and West Richland, Washington. The general public services and utilities setting for Yakima County is presented above (related to the Black Rock Alternative). A comparable overview of service and utility provision in Benton County and incorporated Richland and West Richland is provided below.

- **Law Enforcement:** Benton County Sheriff, Richland Police Department, West Richland Police Department
- **Fire Protection:** Benton County Fire Protection Districts (multiple) and Richland Fire Department
- **Emergency Medical/Transportation:** Primarily Benton County Fire Protection Districts (multiple), and Richland Fire Department
- **Electrical Power:** Benton County Public Utility District, Benton Rural Electric Association, and City of Richland
- **Natural Gas:** Cascade Natural Gas Corporation (Richland/West Richland area; no service in rural Benton County)
- **Telecommunications:** Several companies, including Qwest

- **Water Supply:** Rural Benton County—domestic supply—primarily individual wells, with irrigation supply from individual wells and local irrigation district surface deliveries; cities of Richland and West Richland—all service through city-owned systems

- **Wastewater Management:** Rural Benton County—individual septic tank and leach field installations; cities of Richland and West Richland—city-owned systems

4.15.2 Environmental Consequences

4.15.2.1 Methods and Assumptions

Potential for adverse effects to public services and utilities is based on analysis of the following indicators:

- **Long-term** increases in demand for services or utilities to a point where existing capacity (ability to serve) would be exceeded, thus causing service shortfalls unless capacity is expanded. This indicator is expressed in one or more of the following terms:

  - Exceeding established local standards for police, fire, or emergency service personnel-to-population ratio (e.g., personnel per 1,000 population). This measure can also sometimes be expressed in terms of vehicles or equipment.

  - Exceeding established local standards for police, fire, or emergency medical service response time.

  - Inability of local utilities/utility systems to provide adequate service to proposed facilities (electric power, telecommunications, water supply or wastewater management).

- **Short-term** (construction-phase) disruption of services or utilities to an extent that would impose unacceptable health and safety risk or additional cost on affected residents/landowners. This indicator is expressed in such terms as:

  - Blocking/disruption of efficient access by police, fire, or emergency service personnel.

  - Disruption of electrical, telecommunications, water or sewer service.

  - Requirements for relocation of local electrical, telecommunications, water or sewer service facilities.

For this Draft PR/EIS, analysis and discussion of potential for public service and utility impacts are generalized and qualitative. Direct consultation with potentially affected service/utility providers has not been conducted; instead, such consultation is included as a primary mitigation action should any of the alternatives be selected for development. This approach is considered appropriate for the following reasons:

- With the exception of electrical power, none of the Joint Alternatives would introduce a substantial new long-term demand for public service or utilities. This is because the Joint Alternatives do not involve increases in local population (i.e., the primary source of demand for most services and utilities).

- Potential for short-term impacts can only be generally addressed because:

  - The proposed locations, plans, and designs for facilities associated with the alternatives, especially appurtenant facility development sites and conveyance alignments, are derived from Reclamation's appraisal-level assessments. Some facility locations and substantial distances of the conveyance alignments are preliminary and subject to adjustment based on further study. Thus, site or alignment adjustments are considered an important source of mitigation action during more detailed planning.

  - No detailed construction plans have been prepared for facilities associated with the alternatives. Thus, detailed analysis of potential for short-term impacts (as described above) is not possible. Instead, as with actual facility location/alignment, avoidance or mitigation of potential for short-term service/utility disruptions would be an important concern during detailed planning.

4.15.2.2 No Action Alternative

As noted previously, conservation-related system improvements associated with the No Action Alternative are part of other approved programs and orient predominantly to existing facilities; none are being or will be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis is required for these actions, appropriate documentation of potential for public service and/or utility impacts would be prepared separately, apart from the Storage Study process.

4.15.2.3 Black Rock Alternative

Construction Impacts

Public Services.—Short-term impacts to these services can be expected in all areas involved with facility construction (i.e., intake/inflow facilities, dam and

reservoir, outflow and distribution facilities); such impacts would be primarily in the form of access disruptions. With proper construction-phase planning, these impacts are not expected to be significant. (See "Mitigation.")

Utilities.—Short-term impacts to local utility services can be expected on adjacent/surrounding lands in all areas involved with facility construction, especially related to the outlet and distribution facilities located in rural residential and agricultural areas. Such impacts would be primarily in the form of temporary service interruptions and requirements for infrastructure relocations (e.g., power, telecommunications or water supply lines, septic tanks or leach fields). Until more detailed construction-phase planning occurs, it is not possible to determine if potential for such impacts would be significant.

Long-Term Impacts

Public Services.—Development of the Black Rock Alternative would not result in a significant long-term increase in demand for police, fire protection, or emergency medical/transportation services.

Utilities.—Development of the Black Rock Alternative would result in a long-term increase in demand for electrical power, specifically associated with intake/import facilities at Priest Rapids Lake, and the Black Rock outlet facility/pumping plant and Sunnyside pumping plant/bypass in eastern Yakima County. In each case, as noted in "Land Use and Shoreline Resources" (section 4.13), power supply to these facilities is expected to be drawn directly from existing Bonneville Power Administration transmission lines, and no constraint on the availability of necessary power has been recognized to date.

Two existing overhead 115-kilovolt powerlines on H frame-type wood poles supports and a buried fiber optic line along existing SR-24 would need to be relocated along new SR-24 alignment.

Other perspectives on long-term utility service demand at/from Black Rock facilities include:

- Telecommunication system connections would be required at all major facility sites. Where land-line connections are not readily available, wireless systems could be used.

- Water supply and wastewater management would be provided via independent, onsite systems (e.g., water supply wells, septic tank/leach field or other independent wastewater management system).

- No connections to natural gas distribution systems would be required. If gas energy is needed, onsite systems (i.e., propane) would be used.

4.15.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Public Services.—Minor, short-term access disruptions may occur during construction (i.e., along SR-821). However, with proper construction-phase planning, such impacts can likely be avoided. (See "Mitigation.")

Utilities.—Short-term impacts to utility services (e.g., temporary service interruptions and requirements for infrastructure relocation) may occur for the one local resident in the immediate study area. However, with proper construction-phase planning, such impacts can likely be avoided. (See "Mitigation.")

Long-Term Impacts

Public Services.—Development of the Wymer Dam and Reservoir Alternative would not result in a significant long-term increase in demand for police, fire protection, or emergency medical/transportation services.

Utilities.—Development of the Wymer Dam and Reservoir Alternative would result in a long-term increase in demand for electrical power, associated with the pumping plant and other intake/outlet facilities along the Yakima River. As noted in the "Land Use and Shoreline Resources" section, power supply to these facilities is expected to be drawn directly from an existing Bonneville Power Administration transmission line, and no constraint on the availability of necessary power has been recognized to date.

Other perspectives on long-term utility service demand at/from Wymer facilities include:

- Telecommunication system connections would be required at facility sites. Where land-line connections are not readily available, wireless systems could be used.
- Water supply and wastewater management would be via independent, onsite systems (e.g., water supply wells, septic tank/leach field, or other independent wastewater management system).
- If gas energy is needed, onsite systems (i.e., propane) would be used.

4.15.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

The environmental consequences of the Wymer dam component of this alternative are addressed in the previous section for the Wymer Dam and Reservoir Alternative. This section discusses the Yakima River pump exchange component of the alternative.

Construction Impacts

Public Services.—Short-term impacts to these services can be expected in all areas involved with facility construction (i.e., pumping plant sites and pipeline alignments); such impacts would be primarily in the form of access disruptions. With proper construction-phase planning, these impacts are not expected to be significant. (See "Mitigation.")

Utilities.—Short-term impacts to local utility services can be expected on adjacent/surrounding lands in all areas involved with facility construction (i.e., pumping plant sites and pipeline alignments). Such impacts would be primarily in the form of temporary service interruptions and requirements for infrastructure relocations (e.g., power, telecommunications or water supply lines, sewer lines, septic tanks or leach fields). Until more detailed construction-phase planning occurs, it is not possible to determine if potential for such impacts would be significant.

Long-Term Impacts

Public Services.—Development of the Yakima River pump exchange would not result in a significant long-term increase in demand for police, fire protection, or emergency medical/transportation services.

Utilities.—Development of the Yakima River pump exchange would result in a long-term increase in demand for electrical power, associated with pumping plants. Power supply to these plants is expected to be drawn from existing transmission lines near the facility sites, and no constraint on the availability of necessary power has been recognized to date.

Other perspectives on long-term utility service demand at/from the Yakima River pump exchange facilities include:

- Telecommunication system connections would be required at each pumping plant site. Where land-line connections are not readily available, wireless systems could be used.

- Water supply and wastewater management would be provided (1) at pumping plant #1 by the city of Richland, and (2) at pumping plants #2 and #3 via independent, onsite systems (e.g., water supply wells, septic tank/leach field, or other independent wastewater management system).

- If gas energy is needed, pumping plant #1 may be serviced via the local Cascade Natural Gas Corporation system. Onsite systems (i.e., propane) are an option at all three plant sites.

4.15.2.6 Mitigation

Long-term provision of all necessary public services and utilities for project facilities can be ensured by proper coordination and planning with involved service/utility providers. No significant, residual long-term impacts are expected.

Mitigation planning related to potential for short-term, construction-phase impacts on public services and utilities should also be rooted in close coordination with involved service providers, as well as with potentially impacted local residents/landowners. In this regard, the following objectives should be met during detailed implementation planning (resulting in no significant residual impacts):

- Retain appropriate access throughout construction zones and throughout the construction period for law enforcement, fire protection, and emergency medical/transportation service providers.
- Where local utility system connections/installations would be impacted by construction activities, plan for and implement alternative/relocated connections and facilities prior to construction (i.e., avoid service disruptions).
- Either accomplish the above two measures at no cost to affected service providers and/or residents and landowners or provide compensation to offset additional costs incurred.

4.15.2.7 Cumulative Impacts

There would be no significant cumulative impacts on public service or utilities.

4.16 Transportation

Transportation analysis addresses the affected environment and environmental consequences of the alternatives from the perspectives of road/highway and railroad transportation facilities in and serving the areas where alternative project facilities would be located. No air or navigable waterway transportation systems or facilities would be involved or impacted by any of the alternatives.

4.16.1 Affected Environment

4.16.1.1 No Action Alternative

The No Action Alternative includes conservation-oriented system improvements, including pumping plants and pipelines, at various locations in the Yakima Valley region. These improvements are associated with existing approved programs and orient predominantly to existing facilities; none are being or will be constructed under the auspices of the Storage Study. To the extent that NEPA

or SEPA analysis is required for these actions, appropriate documentation of the directly affected transportation environment will be prepared separately, apart from the Storage Study process.

4.16.1.2 Black Rock Alternative

Dam and Reservoir

The site of the proposed Black Rock dam and reservoir is the Black Rock Valley, located in eastern Yakima County, Washington. State Route 24 crosses this valley in an east-west direction and is the only paved roadway present. There are no rail facilities in the valley.

SR-24, a two-lane roadway, is a major transportation and shipping link between the Yakima Valley (city of Yakima and Moxee City) to the west and the Hanford Site to the east, the Tri-Cities area to the southeast, and central Columbia Basin towns and cities to the northeast.

Major SR-24 connections are Interstate Highway 82 in the Yakima Valley to the west of Black Rock Valley and SR-240 and 241 east of the valley.

Within the Black Rock Valley, SR-24 provides access, via unpaved roads, to private landholdings north and south of the highway.

Appurtenant Facilities

Intake/Inflow Conveyance System.—The Priest Rapids intake and fish screen facility and the northern portal for the flow conveyance tunnel to Black Rock reservoir would be located on Grant County PUD lands along the southwest shore of Priest Rapids Lake approximately 0.7 miles northwest of Priest Rapids Dam. Current access to the facility site is via Dam Road (across Priest Rapids Dam) from SR-243 east of the lake. On and around the site itself, the only access route is an unpaved road used by the PUD.

New access to the intake and fish screen facility site would be developed as part of the Black Rock Alternative. The new access route would be approximately 10 miles long, from SR-24 to the southeast, along the south side of the Columbia River, and connecting with existing access roads southwest of the existing Wanapum village and Priest Rapid Dam and leading to the facility site on the southwest shore of Priest Rapids Lake. Most of the new route would be built within an existing, abandoned railroad ROW through predominantly undeveloped land along Midway Substation and Priest Rapids Roads.

Related to the inflow conveyance tunnel connecting the Priest Rapids intake facility with the reservoir, surface access would be required only to the vent shaft site, located in the YTC approximately 0.75 mile south/southwest of the intake facility. No routing studies for this access have been conducted

to date; however, it is likely that existing unpaved roads within the Training Center can be used for most of the required distance.

Outflow Conveyance/Delivery System.—All transportation facilities within the settings of the Black Rock outflow/delivery system are roads and highways. No railroads or railroad rights-of-way would be affected.

Outflow Conveyance.—The eastern portal of the Black Rock outflow conveyance would be located in Black Rock Valley. Access for construction of this portal would be from SR-24. (See "Dam and Reservoir" above.) The western tunnel portal, vent shaft, and 3,000-foot pipeline components of the conveyance in the would be accessed regionally from SR-24 approximately 3 miles east of Moxee City; several two-lane local roads would also likely be used for access to various parts of these western outflow facilities (e.g., Smith, Deeringhoff, and Den Beste Roads).

Black Rock Outlet Facility and Powerplant.—The site of this facility is immediately adjacent to (and access to the site would be from) SR-24 east of Moxee City, roughly 3,000 feet east of Beane Road.

Sunnyside Powerplant and Bypass.—This facility would be located adjacent to and east of Konnowac Pass Road in Yakima County, approximately 1 mile north of Yakima Valley Highway. Access to the facility would be via Konnowac Pass Road, a two-lane facility that connects with SR-24 on the north and the Yakima Valley Highway and I-82 on the south.

Delivery System for Sunnyside Division.—The 6.4 miles of pipeline comprising this conveyance would be routed from the Black Rock outlet facility to the Sunnyside powerplant and bypass facility generally paralleling (but not adjacent to) (1) the Roza Canal for the northern two thirds of the route and (2) Konnowac Pass Road for the southern one third. Access for construction, operation, and maintenance would be primarily from two-lane local roads (e.g., Beane, Desmarais) in the north, and Konnowac Pass Road in the central and southern portions of the route.

4.16.1.3 Wymer Dam and Reservoir Alternative

Regional and local access to the proposed Wymer dam and reservoir site, as well as sites and alignments of all appurtenant facilities, would be exclusively via SR-821, a two-lane roadway in Yakima Canyon, southern Kittitas County. The easternmost extent of the reservoir pool at high water would pass under I-82, but no access to project facilities is proposed from this location, either for construction or long-term operation. There are no public roads present in the Lmuma Creek basin, where Wymer dam and reservoir would be built; nor are there any rail facilities. The only access present is an unpaved, private ranch road. In terms of appurtenant facilities, the pumping plant would be built west

of and adjacent to SR-821; the subsurface discharge pipelines would cross under SR-821 heading eastward to the damsite.

4.16.1.4 Wymer Dam Plus Yakima River Pump Exchange Alternative

The affected transportation environment for the Wymer dam component of this alternative was presented under "Wymer Dam and Reservoir Alternative." The following discussion focuses on transportation setting for the Yakima River pump exchange component.

The transportation environment, through which the 56 miles of underground pipeline comprising the Yakima River pump exchange component of this alternative would pass, includes (1) the regional highway and local road systems in the urban environments of southern Richland and West Richland and (2) the main regional highway and the rural road systems of the Yakima Valley in Benton and Yakima Counties. An active Union Pacific rail line in southern Richland would also be effected (Trumbull, 2007).

Perspectives on the transportation environment for individual local jurisdictions along the project corridor are provided below.

City of Richland

Major highway access routes to and around project facilities in Richland include (from east to west): SR-240, Columbia Center Boulevard, Leslie Road, Keene Road, I-182, and Bombing Range Road. Neighborhood- or development-specific local road systems are also present within the general pipeline corridor.

In terms of specific facility siting and pipeline routing, the intake and pumping plant #1 site would likely be accessed via Columbia Center Boulevard, north of SR-240. The pipeline from that site would be (1) within or immediately adjacent to the ROW of a Union Pacific Railroad line north of Gage Boulevard, from Columbia Center Boulevard to Leslie Road and (2) immediately adjacent to (conceptually shown on the north side of) Keene Road from Leslie Road to the city limits northwest of I-182, near the intersection of Bombing Range Road. In the latter regard, access roads to several developed areas connect with Keene Road.

City of Kennewick

The 1 mile of pipeline though north Kennewick would be within or immediately adjacent to railroad ROW noted above for Richland. No major transportation facilities in Kennewick would be affected beyond the facilities noted above for areas adjacent to Richland (e.g., SR-240).

City of West Richland

Regional access to the pipeline route in West Richland would be from I-182 in Richland to the south and SR-224 from Benton City to the west. Within West

Richland, the corridor would follow (pipeline conceptually shown on the north side of) Keene Road, from the southeast city limits near Kennedy Road to the northwest city limits near West Van Giesen Street (SR-224). At present, very few local and no major roads intersect Keene Road along this corridor.

Benton and Yakima Counties

Through affected portions of Benton and Yakima Counties, from West Richland to the pipeline terminus near Sunnyside, regional access is provided by I-82 connecting the Tri-Cities area with Yakima. All pipeline and pumping plant facilities in the two counties would be through the corridor of agricultural land north of I-82, and would be accessed primarily by the rural, local road system throughout the area. Three State routes intersect the pipeline alignment: SR-224 and SR-225 near Benton City and SR-241 near Sunnyside.

4.16.2 Environmental Consequences

4.16.2.1 Methods and Assumptions

Transportation impact analysis was conducted using existing published information (city and county maps and aerial photography), supplemented by limited field reconnaissance.

The following indicators were selected to evaluate transportation impacts:

- Long-term: Route (road or railroad) closures and/or relocations
- Short-term (construction-phase):
  - Route crossings (i.e., traffic disruptions and detours)
  - Disruptions to rail traffic during construction within the ROW
  - Land parcel access disruption (i.e., where construction parallels existing public roads)
  - Increased traffic (construction workers and material/equipment hauling)
  - Increased road repair/maintenance requirements due to increased heavy load movements

Of particular relevance in reviewing the analysis are the following points:

- Given the nature of the facilities associated with the Joint Alternatives, the highest potential for significant transportation-related impacts would occur during the construction phase (i.e., traffic and transportation requirements/ impacts would be relatively minor during project operations and maintenance).

- No construction plans have been prepared for facilities associated with the alternatives. Consequently, no detailed analysis is possible of construction-phase impacts such as material haul routes, construction traffic volumes, increased road repair and maintenance requirements, frequency and length of detours, etc. Impact analysis is, therefore, general and programmatic.

- The locations of and plans for facilities associated with the alternatives are derived from Reclamation's appraisal-level assessments. Many appurtenant facility locations (especially siting of structures) and substantial distances of the conveyance alignments are preliminary and subject to adjustment based on further study. Thus, the transportation impacts reported herein should be viewed as illustrative or prototypical, with site or alignment adjustments considered an important source of mitigation action. Further insight from this perspective is provided where relevant on a facility-specific basis.

4.16.2.2 No Action Alternative

As noted previously, conservation-related system improvements associated with the No Action Alternative are part of other approved programs and orient predominantly to existing facilities; none are being or will be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis is required for these actions, appropriate documentation of impacts on transportation systems and facilities will be prepared separately, apart from the Storage Study process.

4.16.2.3 Black Rock Alternative

Construction Impacts

Dam and Reservoir.—Construction of Black Rock dam would have significant construction-phase impacts on the regional highway system. All materials and personnel necessary for construction would use the State routes within and surrounding the Black Rock Valley (i.e., SRs 24, 240, and 241). Traffic, especially heavy vehicle use, would increase significantly, with corresponding increases in highway maintenance requirements. On a localized basis, these impacts would be the greatest for the Black Rock Alternative.

Appurtenant Facilities.—Construction impacts would be short-term and would involve (in some cases, significant) increases in material/equipment hauling and construction personnel-related traffic, increases in road maintenance and repair requirements, and localized detours.

Related to the intake/inflow system:

- Construction-phase impacts would center on the Priest Rapids intake and fish screen facility and northern portal of the inflow tunnel. Regionally, SRs 24, 240, and 243 would be most impacted, with the highest increases in traffic and heavy load movement likely to occur on SRs 240 and 24 from the Tri-Cities area to the south. Locally, construction traffic would use the new access road to the facility site from SR-24; this traffic may temporarily disrupt circulation in/around the Wanapum village immediately southwest of Priest Rapids Dam, but would otherwise not substantially affect local routes or facilities.

- Access to the vent shaft site on the YTC would require coordination between agencies, but should not result in any significant disruption of existing Training Center access or circulation patterns.

For the outflow/delivery system, the focus of construction-phase traffic would be on (1) SR-24 from Yakima through Moxee City and (2) Konnowac Pass Road from SR-24 on the north and Sunnyside (via Yakima Valley Highway) on the south. Facility-specific perspectives include:

- Construction traffic impacts would focus on SR-24 from Yakima related to the western end of the outflow conveyance (including the vent shaft and the 3,000-foot pipeline), the Black Rock outlet facility, and the northern half of the Sunnyside delivery pipeline. The outflow pipeline would require temporary detour/reroute of SR-24 while the line is installed under the highway. Construction traffic impacts and temporary disruptions of access routes would also occur on the local road systems adjacent to SR-24.

- Construction traffic impacts associated with much of the Sunnyside Division pipeline and the Sunnyside powerplant and bypass facility will focus on Konnowac Pass Road, which would be crossed twice by the pipeline. Local disruption of access to properties and local road detours would also occur on both sides of Konnowac Pass Road.

Long-Term Impacts

Dam and Reservoir.—Construction of Black Rock dam would involve rerouting of an approximately 15-mile stretch of SR-24 in the Black Rock Valley, from a point approximately 10 miles east of Moxee City to the current interconnection with SR-241 east of the damsite. As shown conceptually in "Land Use and Shoreline Resources" (section 4.13), the new alignment is proposed to be on higher-elevation terrain on the south side of the valley and would connect with SR-241 approximately 4 miles south of the existing SR-24/241 intersection (thus, making a approximately 4-mile distance of SR-241 also part of SR-24).

Overall, the new SR-24 route would be approximately 2.5 miles longer than the current alignment. It would also involve steeper grades/lower speeds in the eastern portion of the route. Preliminary alignment studies for the new route indicate that design speed would be 70 miles per hour (mph) for much of the route (like the existing highway), but along the easterly 3 miles before the new SR-241 connection, design speed would be 50 mph, with 7-percent grades. In addition to these slower speeds and higher gradients, Washington Department of Transportation has noted that the southern alignment for a SR-24 reroute would involve slope aspects disadvantageous to winter travel (i.e., reduced exposure to the sun and consequent slower snowmelt) when compared with a route along the northern part of the valley. For these reasons, WDOT has expressed a preference for rerouting SR-24 along the north side of the proposed reservoir (McCartney, 2007). Current residents in Black Rock Valley have also indicated this northerly route preference (Reclamation, 2004a). However, the southerly route is proposed by Reclamation primarily due to cost concerns (i.e., a northern route would involve bridging several tributary canyons, and recreation facilities requiring access at the reservoir would be sited primarily on the southeast shore).

Appurtenant Facilities.—No long-term road closures or realignments would be required as a result of building Black Rock appurtenant facilities.

4.16.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Significant construction-phase traffic and repair/maintenance impacts would occur along SR-821, which would be the only available route for import of materials and equipment and access by construction personnel. It is uncertain what proportion of these impacts would occur north of the project site (i.e., to/from Ellensburg) compared to south of the site (i.e., to/from the Selah and Yakima areas).

State Route 821 would also be directly affected by construction of the discharge pipeline for this alternative, which would pass directly under the highway. Short-term reroute/detour around a local portion of the highway would likely be required while the conveyance under-crossings are constructed. It is unlikely that any temporary closures of the highway would be required as this work is accomplished.

As noted in section 4.16.1.3, the easternmost extent of the reservoir at high water in this alternative would pass under the I-82 bridges at Lmuma Creek, inundating the bridge piers. Preliminary plans for the Wymer Dam and Reservoir Alternative include provision for reinforcement and protection of the bridge piers to avoid any significant impact from reservoir inundation. These measures could be accomplished without significant disruption to traffic on the highway.

Long-Term Impacts

Development of the Wymer Dam and Reservoir Alternative would not involve long-term relocation or closure of any roadways.

4.16.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

The transportation consequences of the Wymer dam component of this alternative were addressed previously, under "Wymer Dam and Reservoir Alternative." This section discusses the Yakima River pump exchange component of the alternative.

Construction Impacts

Overall, construction-phase impacts would be greater for this alternative than for any other alternative being considered; this conclusion relates specifically to the following parameters:

- Level of urban and rural development present within or adjacent to the construction corridor (i.e., related to impacts from increased traffic and disruptions to circulation and access). See the "Land Use and Shoreline Resources" section for an overview of land and development conditions along the pipeline route.
- Number and length of highways and other roads impacted.
- Length of rail line disruption (i.e., this is the only alternative that would impact rail infrastructure).
- Geographic extent of impact (i.e., 56 miles of construction, overall, in four local jurisdictions).

A preliminary inventory of road crossings necessary in this alternative includes the following:

- Interstate 182 in Richland
- State Route 240 in Richland
- State Route 224 west of West Richland
- State Route 225 north of Benton City
- State Route 241 northwest of Sunnyside
- Several arterial roads in Richland, including Columbia Center Boulevard, Leslie Road, Queensgate Drive, and Bombing Range Road
- 45-50 local roads in Benton and Yakima County

Approximately 2 miles of active rail line would also be disrupted during construction within the Union Pacific Railroad ROW.

In addition, the preliminary alignment for the exchange pipeline shows many miles of construction parallel with, and adjacent to, existing roadways, including Keene Road in Richland, and many local collector and rural roads in Benton and Yakima Counties. While direct impact on existing roads in these "parallel" situations would likely be minimal (i.e., construction limited to the construction pipeline ROW), temporary disruption of access (e.g., driveways) to adjacent land parcels may be widespread.

As noted previously, no construction phasing plans or specification of construction traffic routes have been prepared, nor have specific construction methods and techniques been selected for implementation of the pipeline.

For road crossings, boring methods would be used under major highways, such as I-182 and SR-240 in Richland; in such cases, significant facility closures or detours would not be necessary. However, most crossings would be constructed using cut-and-cover methods, necessitating temporary closures and/or detours.

Where roads are paralleled, preliminary planning indicates that access would be along the construction route, rather than using/impacting the adjacent roadway.

In all cases, as construction proceeds, increased local traffic would occur and road maintenance and repair requirements would increase (especially along equipment and material haul routes).

Long-Term Impacts

Development of the Yakima River pump exchange component of this alternative would not require any long-term relocations or closures of roadways or rail lines. All impacts would be during the construction phase.

4.16.2.6 Mitigation

Black Rock Alternative

Long-term impacts associated with relocation of SR-24 and significant construction-phase traffic and road impacts are largely unavoidable under this alternative. Efforts to mitigate impacts should focus on the following:

- Further discussion with the State Department of Transportation and local residents to explore the feasibility of relocating SR-24 to the north versus south side of Black Rock Valley, as a means of mitigating design speed, gradient, winter travel and local parcel access concerns associated with proposed route.

- Potential adjustment of new conveyance pipeline routes to minimize necessary road crossings and other disruptions to local traffic patterns and access routes.

- Coordination with State and local transportation agencies and potentially impacted neighborhoods and landowners, as appropriate, in preparing construction transportation management plans. Objectives would include:

    - Specifying material haul routes and construction traffic patterns which minimize local traffic impacts.

    - Phasing construction to minimize the duration of necessary temporary road closures and detours.

Wymer Dam and Reservoir Alternative

Significant construction-phase traffic and road impacts to SR-821 are largely unavoidable with development of this alternative. More detailed planning should address questions of haul route and overall traffic direction and magnitude (i.e., east versus west) and, thus, potential traffic and road impacts in Ellensburg, Selah, or Yakima. Coordination with the State Department of Transportation would be required to properly plan for construction on and any potential traffic flow disruptions along SR-821.

Wymer Dam Plus Yakima River Pump Exchange Alternative

Significant construction-phase traffic and road impacts are largely unavoidable with development of this alternative. Efforts to mitigate impacts should focus on the following:

- Close coordination with involved transportation agencies in obtaining necessary permits and preparing plans and schedules for crossings of highways and roads.

- Close coordination and cooperation with involved railroad companies related to construction with the rail ROW.

- Potential adjustment of pipeline route to minimize necessary road crossings and other disruptions to local traffic patterns and access routes.

- Coordination with involved transportation agencies and potentially impacted neighborhoods and landowners, as appropriate, in preparing construction transportation management plans. Objectives would include the following:

    - Specifying material haul routes and construction traffic patterns which minimize local traffic impacts.

- Phasing construction to minimize the duration of necessary temporary road closures and detours.

4.16.2.7 Cumulative Impacts

Short-term cumulative impacts could occur during construction with any of the Joint Alternatives. Specifically, it is possible that construction of proposed facilities could occur coincident with other development activities in local areas, thus cumulatively increasing the number or intensity of traffic impacts, road detours, etc. The potential for this type of short-term cumulative impact would be highest (by a wide margin) with the Wymer Dam Plus Yakima River Pump Exchange Alternative, given the length of required pipelines through urban, suburban and rural development areas (particularly in the urban environments of Richland and West Richland). Such impacts could be avoided or mitigated by proper coordination among involved government entities.

None of the alternatives would result in significant long-term cumulative transportation impacts.

4.17 Air Quality

4.17.1 Affected Environment

This section describes the area studied for the air quality analysis, as well as the regulatory and environmental setting. The regulatory setting is described in terms of Federal, State, and local requirements. The environmental setting is described in terms of air pollutant sources and existing concentrations. The air quality impact analysis evaluates existing conditions and impacts to Kittitas, Benton, and Yakima Counties, where the Joint Alternatives would generate emissions.

The Federal Clean Air Act has set National Ambient Air Quality Standards (NAAQS) that define levels of air quality that are necessary to protect the public health (primary standards) and the public welfare (secondary standards). Areas where the measured concentrations of a pollutant are above the primary and secondary NAAQS are identified as nonattainment areas. The Clean Air Act requires that Federal activities may not cause or contribute to new violations of air quality standards, exacerbate existing violations, or interfere with timely attainment or required emission reductions towards attainment (40 CFR 93.150).

In addition to ambient air quality standards, the EPA has established standards for the Prevention of Significant Deterioration (PSD) of air quality. PSD standards provide maximum allowable increases in concentrations of pollutants for areas already in compliance with NAAQS. Regulated pollutants that most commonly lead to source-wide PSD applicability include particulate matter, sulfur dioxide, and nitrogen oxides. The PSD standards are expressed in allowable increments in atmospheric concentrations of these specific pollutants (40 CFR 52). The EPA

has established NAAQS for ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, inhalable particulate matter, fine particulate matter, and lead. The Federal Clean Air Act requires States to classify air basins as either attainment or nonattainment with respect to these air pollutants. Counties or regions designated as nonattainment areas for one or more pollutants must prepare a State Implementation Plan (SIP) that demonstrates how the area will achieve attainment by federally mandated deadlines. Section 176(c) of the Clean Air Act requires any entity of the Federal Government that engages in, supports, or in any way provides financial support for, licenses, or permits or approves any activity, to demonstrate that the action conforms to the applicable SIP required under Section 110(a). According to EPA guidance, before any approval is given for a proposed action, the regulating Federal agency must determine the regional significance of the action and its general conformity on a pollutant-by-pollutant basis. If the emissions are determined to be *de minimis*, no further analysis is required. However, if the conformity regulations apply, then an evaluation must be conducted.

The Washington Department of Ecology (2002b) identified ambient air quality standards for total suspended particulates, lead, particulate matter, sulfur dioxide, carbon monoxide, ozone, and nitrogen dioxide. In 1994, the EPA, the Washington Department of Ecology, Benton County, and Franklin County signed a Memorandum of Agreement to study the area's air quality problems and develop controls over urban fugitive dust sources (fugitive dust is generally defined as particulate matter nominally 10 microns or less" [PM10]). The Washington Administrative Code regulates fugitive dust sources. According to this regulation, "the owner or operator of a source of fugitive dust shall take reasonable precautions to prevent fugitive dust from becoming airborne and shall maintain and operate the source to minimize emissions" (Ecology, 2000c). Typical construction or water delivery projects are regulated if they emit or have the potential to emit at least 250 tons per year of any regulated pollutant (Ecology, 2003a). The Washington Department of Ecology exempts internal combustion engines that propel or power vehicles from PSD emissions regulations (2002b).

Air quality in Yakima, Kittitas, and Benton Counties in south-central Washington are well within most of these standards for pollutants. Air quality in the study area occasionally exceeds the 24-hour PM10 standard (Mann, 2003). Most exceedances are from windblown dust from area agricultural fields (BCAA, 1996) followed by windblown dust from open lands, outdoor and agricultural burning, woodburning stoves and fireplaces, wildfires, industrial sources, and motor vehicles (BCAA, 2003). Local air pollutant emissions are limited to windblown dust from agricultural operations and tailpipe emissions from vehicular traffic along State highways and local roads. Between 1993 and 2002, the PM10 standard was exceeded in the Tri-Cities area 11 times, or about an average of once a year (Mann, 2003). In the eight occurrences since 1998, five were agricultural

dust, two were wildfire smoke and ash, and one was construction dust. The Washington Department of Ecology has identified the study area as having attainment status.

Dust originating from the Black Rock and Wymer reservoir drawdown zones is a concern for air quality and public health. Dispersion of dust into the atmosphere is a function of wind speed, duration and direction of wind, intensity of atmospheric turbulence, and mixing depth. Conditions likely to increase dispersion are most common in the summer when the reservoir pool is declining and an unstable atmosphere exists, about 56 percent of the time. Atmospheric conditions in summer are favorable to dispersion. Less-favorable conditions occur in all seasons from about sunset to about an hour after sunrise as a result of temperature inversions and shallow mixing layers. Occasionally, in winter months, poor dispersion conditions are associated with stagnant air in stationary high-pressure systems. The prevailing surface winds in the area are from the northwest and occur most frequently during the winter and summer. Winds from the southwest also occur frequently. During the spring and fall, there is an increase in winds from the southwest and a corresponding decrease in winds from the northwest. Though data for the presence of fine-grain sediments in the Black Rock and Wymer reservoir drawdown zone and site-specific wind data are lacking, the Hanford data (Neitzel, 2005) suggests that the conditions (wind speed, duration, direction, and atmospheric turbulence) favor dust dispersion that would be problematic for public health and air quality.

4.17.2 Environmental Consequences

4.17.2.1 Methods and Assumptions

This section describes the methodology used to develop the emission inventories and comparison of the analysis results to the significance and conformity thresholds. Construction emissions are not available for the Draft PR/EIS. In general, they are estimated from emission models and spreadsheet calculations, depending on the source type and data availability. Dispersion models are also used to estimate the dissipation and movement of emissions. The following sources and activities are typically analyzed for emissions, demolition, drilling and blasting; grading; onsite and offsite construction equipment and haul truck emissions; onsite processing and concrete batch plants; asphalt paving; and offsite worker vehicle trips to and from the site.

Long-term air quality impacts associated with emissions known to contribute to global warming are evaluated qualitatively.

4.17.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

Population growth in the Tri-Cities and Yakima areas would increase air pollution associated with tailpipe emissions, but these emissions would not likely endanger Benton, Yakima, Kittitas and Franklin Counties' attainment status. Overall, there would likely be little or no effect on air quality in the study area. Area agricultural activities and natural events such as wildfires would continue to cause occasional exceedances in fugitive dust ambient air quality standards at a rate of about one per year.

4.17.2.3 Joint Alternatives

Construction Impacts

Vehicle emissions and dust associated with either Black Rock or Wymer reservoir construction would result in short-term impacts ranging from moderate to severe.

A comparison of alternatives would need to consider the amount of material moved and the number of pieces of equipment used in the peak day and peak year of construction activity. The major sources of volatile organic compounds (VOC), carbon monoxide (CO), and nitrogen oxide (NO_x) emissions are expected to be the onsite construction equipment and haul trucks with nonroad equipment engines, which are not subject to stationary source permitting requirements. The various Joint Alternatives would require varying levels of construction with heavy machinery and equipment. Typical construction activities would include excavation, earthwork, trenching, tunneling, boring, and jacking. Most trenching work would involve very little stationary equipment and would be complete at any one location within a few weeks. Some trenching activities would occur very near residential areas.

Air quality impacts associated with the constructing the proposed pumping facilities, pipelines, and reservoir would vary. The primary type of air pollution during construction would be combustible pollutants from equipment exhaust and fugitive dust particles from disturbed soils becoming airborne. Any adverse impacts from combustible pollutants and fugitive dust (PM10) would be temporary in nature and minor. The construction activity best management practices would help maintain PM10 emissions compliance with the 24-hour average criterion.

Long-Term Impacts

Dust and other airborne particulates originating from the drawdown zone of the reservoirs may be a chronic contribution to PM10 levels, particularly at the Black Rock site which is expected to be more susceptible to wind.

4.17.2.4 Mitigation

Emissions from offroad construction equipment and particulate concentrations are expected to exceed the general conformity *de minimis* thresholds for each year of construction. Therefore, additional mitigation would need to be applied to the emission sources. Such mitigation would include:

- Use of emulsified or aqueous diesel fuel.
- Use of equipment with engines that incorporate exhaust gas recirculation systems.
- Installation of a lean NO_x catalyst in the engine exhaust system.
- Wet suppression and soil stabilization.
- Wind fencing around the active area.
- Paving onsite roadways.
- Truck wheel washing facilities at site exits on public roadways.
- Maintaining minimal truck bed freeboard or covering haul truck beds.
- Compliance with all local, State and Federal air quality regulations.

4.17.2.5 Cumulative Impacts

All the reasonably foreseeable projects could affect air quality. Each project would be expected to incorporate all feasible mitigation measures recommended by local regulatory agencies in proportion to the severity of the impact to reduce project-specific construction or operation effects.

4.18 Noise

4.18.1 Affected Environment

Noise has long been accepted as a byproduct of urbanization but only recently has it received much social attention as a potential environmental hazard. Noise is generally defined as unwanted or objectionable sound. Excessive or sustained noise can contribute to both temporary and permanent physical impairments,

such as hearing loss and increased fatigue, as well as stress, annoyance, anxiety, and other psychological reactions in humans.

4.18.1.1 Noise Measurement Scales

Noise levels are measured on a logarithmic scale because of physical characteristics of sound transmission and reception. Noise energy is typically reported in units of decibels (dB). Noise levels diminish, or attenuate, as distance to the source increases.

Community noise levels are typically measured in terms of the A-weighted decibel (dBA), which measures the noise energy emitted from a noise source. The A-weighted frequency scale correlates noise or sound to the hearing range of the human ear, and ranges from 1.0 dBA at the threshold of hearing to 140 dBA at the threshold of pain. Table 4.50 provides examples of common noise levels and their effects on the human ear. Table 4.51 provides the recommended noise levels of various land use types.

Table 4.50 Common noise levels and their effects on the human ear (EPA, 1986)

Source	Decibel level (dBA)	Exposure concern
Soft whisper	30	Normal safe levels.
Quiet office	40	
Average home	50	
Conversational speech	66	
Busy traffic	75	May affect hearing in some individuals depending on sensitivity, exposure length, etc.
Noisy restaurant	80	
Average factory	80 to 90	
Pneumatic drill	100	Continued exposure to noise over 90 dB may eventually cause hearing impairment.
Automobile horn	120	
Jet plane or gunshot blast	140	Noises at or over 140 dB may cause pain.

Table 4.51 Recommended land use noise levels (Housing and Urban Development [HUD], 1991)

Land use category	Noise Levels (dBA)			
	Clearly acceptable	Normally acceptable	Normally unacceptable	Clearly unacceptable
Residential	< 60	60 - 65	65 - 75	> 75
Commercial, retail	< 65	65 - 75	75 - 80	> 85
Commercial, wholesale	< 70	70 - 80	80 - 85	> 85
Manufacturing	< 55	55 - 70	70 - 80	> 80
Agricultural, farming	< 75	> 75	N/A	N/A
Natural recreation areas	< 60	60 - 75	75 - 85	> 85
Schools	< 60	60 - 65	65 - 75	> 75
Playgrounds	< 55	55 - 65	65 - 75	> 75

4.18.1.2 Current Noise Environment

The study area for noise is defined as the immediate vicinity of the proposed pumping plant locations, the proposed pipeline alignment, and the proposed reservoir locations. These areas include the project construction area as well as nearby agricultural, commercial, industrial, recreational, and residential areas. Currently, existing noise levels are attributable to motor vehicles, industrial and commercial operations, railroad transportation, and agricultural operations.

4.18.1.3 Applicable Laws, Ordinances, Regulations, and Standards

The construction and operation of new facilities under the Joint Alternatives are outside the city limits and their jurisdiction. The sites are not regulated by any county ordinances, regulations or standards. Further, construction activities are excluded from Washington Department of Ecology noise ordinances (Ecology, 2000).

4.18.1.4 Ambient Noise Levels

Vehicular Noise

The primary noise source in the study area is motor vehicle traffic on highways and major arterials. The interstate highway produces the loudest noise in the area. Other arteries that pass through and adjacent to some of the pipeline alignment also generate moderate noise levels during daytime hours.

Railroad Traffic Noise

Railroad traffic constitutes an occasional but less intrusive element to the noise environment.

Stationary Source Noise

Stationary noise sources in the area include grading and construction activity, power tools, and mechanical equipment, such as heating and air conditioning units, fans, and compressors. Industrial noise in the area includes loading and transfer noise, outdoor warehousing operations, and unscreened commercial and industrial activities.

4.18.2 Environmental Consequences

Noise impacts were derived by identifying features of the various alternatives that would create noise at each of the project sites and by evaluating the sites' proximity to and effect on identified sensitive receptors. Noise impacts from construction, operation, and maintenance of the Joint Alternatives would be localized, most often in remote areas, and temporary in nature. During reservoir construction, use of the area by wildlife would be disrupted.

4.18.2.1 Methods and Assumptions

The degree to which noise affects the human environment depends on the affected area's land use category, the A-weighted decibel of the noise, and the corresponding recommended land use noise levels. This study used the categories, assignments, and acceptability ratings to determine potential impacts in the study area.

4.18.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

The cities of Richland and Kennewick would likely continue to experience population growth and urbanization. Traffic on major highways and arterials would continue to increase and produce additional noise. The current commercial and industrial growth in and around the cities of Kennewick and Richland would also increase localized noise levels.

4.18.2.3 Black Rock Alternative

Construction Impacts

There would be noise during construction; however, the construction areas are localized in remote areas. Wildlife use of the area would be disrupted.

Long-Term Impacts

The Black Rock pumping plant at Priest Rapids Dam would be located in an unpopulated area with few receptors and an existing background noise level.

4.18.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

There would be noise during construction; however, the construction areas are localized in remote areas. Wildlife use of the area would be disrupted.

Long-Term Impacts

The Wymer pumping plant would be located in an area with minimal background noise and is frequented by summer recreators. The pumping plant has been designed below ground with low profile pumps in order to minimize disturbance.

4.18.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

There would be noise during construction; however, the construction areas are located in developed or remote areas. Wildlife use of the area would be disrupted.

Long-Term Impacts

The pumping plants for the Wymer Dam Plus Yakima River Pump Exchange Alternative would be located in an areas with existing background noise from highways, railroads, and urban development.

4.18.2.6 Mitigation

The project would comply with all local, State, and Federal noise regulations.

4.18.2.7 Cumulative Impacts

All the reasonably foreseeable projects could affect noise quality. However, all noise impacts are expected to be short term and in compliance with all county noise abatement regulations.

4.19 Visual Resources

4.19.1 Affected Environment

4.19.1.1 No Action Alternative

The No Action Alternative includes conservation-oriented system improvements, including pumping plants and pipelines, at various locations in the Yakima Valley region. These improvements are associated with existing approved programs and orient predominantly to existing facilities; none are being or would be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis would be required for these actions, appropriate documentation of the directly affected visual environment would be prepared separately, apart from the Storage Study process.

4.19.1.2 Black Rock Alternative

The visual setting for the Black Rock Alternative is characterized by three geographically distinct landscapes, associated with the three major elements of the alternative:

- Priest Rapids Lake and Dam area and downstream Columbia River corridor (proposed location of the intake, fish screen and inflow tunnel portal and vent facilities and the access road and transmission line serving these facilities)

- Black Rock Valley and the surrounding area (proposed location of the dam and reservoir)
- Rural/agricultural Yakima County, generally north, east, and south of Moxee City (proposed location of the project outflow and distribution facilities)

Priest Rapids Lake and Dam Area and Downstream Columbia River

The proposed site of the Black Rock intake and fish screen facility and northern inflow tunnel portal is on the southwest shore of Priest Rapids Lake, approximately 0.7 mile upstream and northwest of Priest Rapids Dam. Public views of the site are generally from (1) from SR-243, Orchard Drive, and the small community of Desert Aire to the northeast, at a distance of approximately 2 miles, (2) Dam Road on the approach to Priest Rapids Dam from SR-243, and (3) the lake surface (i.e., while boating on the lake).

From these viewpoints, the visual setting of the facility site is characterized as a narrow, gently sloping, and sparsely vegetated bench of open land along the southwest lakeshore, with steeply rising mountains as a backdrop. The site is part of a broad vista, undeveloped except for the Priest Rapids hydroelectric project facilities to the south. Within this vista, with the exception of the more proximate views available to boaters and those approaching the dam, the site is seen from across the lake and at a distance, with desert scrubland or agricultural fields along the northeast shore of the lake in the foreground.

The vent shaft site required along the inflow tunnel alignment would be located approximately ¾ mile beyond, and in the mountains that represent the backdrop to, the intake and fish screen facility. If this site is visible to the public (uncertain given the small size and low height of the facility, the absence of specific site location data and the steep/rough nature of the terrain), the viewpoints would be the same as those described above for the intake and fish screen facility.

The access road and transmission line serving the intake and fish screen facility would be sited on the south side of the Columbia River west of SR-24. The primary views of the corridor through which these facilities would be routed are (1) from SR-243, at distances ranging from 0.8 to 2 miles, and (2) the Wanapum village south of Priest Rapids Dam, with the corridor immediately adjacent. The visual setting of the corridor from SR-243 viewpoints consists of a steep mountain backdrop, with a combination of river shore, river channel, and open desert scrubland in fore- and middle-ground. Several instances of irrigated agriculture and existing power system facilities (e.g., transmission lines and the BPA Midway Substations) also are present in middle-ground views. The setting from viewpoints in the Wanapum village includes the proposed road and transmission line corridor in the immediate foreground with a steep mountain backdrop rising from as close as 1,000 feet beyond.

Black Rock Valley

Black Rock Valley, where Black Rock dam, reservoir and associated facilities (including recreation) would be located, is a broad, east-west oriented desert valley. It is characterized predominantly by an open scrubland/grassland valley floor flanked by basalt mountains and hills along the northern and southern margins. With the exception of SR-24, which traverses the center of the valley, and a few farms/ranches in the west, the setting provides a perceived "natural" landscape, with a relatively limited built environment.

Public views of Black Rock Valley are predominantly from SR-24. All other access within the valley is via unpaved roads, typically used by the few residents and other landowners.

Externally, the eastern end of the valley (proposed location of Black Rock dam) is visible from farms and ranches in the Dry Creek Valley to the southeast and from a roadside café and residence immediately to the east.

Rural/Agricultural Yakima County

The setting of the proposed outlet and distribution facilities/systems of the Black Rock Alternative is characterized largely by irrigated agriculture and other large lot rural development (e.g., rural residential). Local agriculture includes a mixture of orchards, vineyards, and row/field crops. Agricultural infrastructure (canals and appurtenant facilities) is strongly in evidence. Structures are generally residential and farm-oriented.

Public viewpoints from which the locations of Black Rock facilities would be visible are generally along the local road system, especially SR-24 and Konnowac Pass Road. Facility sites and alignments would also be visible from numerous private residences in the area.

4.19.1.3 Wymer Dam and Reservoir Alternative

From visual resources standpoint, the affected environment for the Wymer Dam and Reservoir Alternative is primarily Yakima Canyon, along SR-821, north of Selah and south of Ellensburg. It is only within Yakima Canyon where facilities associated with this alternative would be visible to the public. While the dam and reservoir would be located in the Lmuma Creek basin (tributary to Yakima Canyon to the east), that entire basin is privately owned, with no public access, no existing residents, and very limited public viewpoints from surrounding areas. The only other location from which portions of this alternative would be seen is from I-82, where the narrow, easternmost arm of the reservoir pool would be crossed by the highway and would be visible to motorists.

Yakima Canyon is generally narrow and meandering, with the Yakima River corridor dominating the canyon bottom and steep-to-gently-rolling basalt hills rising high on both sides. Much of the canyon is undeveloped, presenting a

natural desert canyon landscape, with riparian vegetation along the river and low-growing scrubland/grassland on the hillsides. Evidence of human development is present, however, including Roza Diversion Dam and associated infrastructure, instances of irrigated agriculture (with associated residences and other buildings) and canyon-oriented recreational sites and businesses (for example, a river rafting company) where the canyon widens. SR-821 through the canyon is designated a State Scenic Byway and BLM Scenic and Recreational Highway.

Public viewpoints in the canyon are from the highway and the river (i.e., rafters and kayakers).

4.19.1.4 Wymer Dam Plus Yakima River Pump Exchange Alternative

The affected environment of the Wymer dam component of this alternative was presented under "Wymer Dam and Reservoir Alternative." The following discussion focuses on the visual setting for the Yakima River pump exchange component of this alternative.

The visual setting of the 56 miles of underground pipeline and three pumping plants comprising the Yakima River pump exchange component of this alternative is characterized by two broad landscape categories:

- Urban/suburban environments of Richland and West Richland, and
- Open and agricultural landscapes in rural Benton and Yakima Counties, north of I-82, between West Richland and Sunnyside

Urban/Suburban Richland and West Richland

The visual setting in Richland and West Richland is typical of small to moderate sized cities. The "cityscapes" where pump exchange facilities would be located include residential developments of varying densities, commercial sites and complexes, limited industrial development, and associated infrastructure (e.g., road systems, utility lines). Where the pipeline would be routed through this setting, public views of the facility corridor are generally short-range, from adjacent roadways, residences and businesses.

The intake and pumping plant #1 facilities of this alternative would be located along the Columbia River shore in a partially developed, flatland linear park between the river to the north and SR-240 to the south. The area immediately west of the facility site is undeveloped, with commercial development occurring 1/4 to 1/2 mile further west. The area east of the facility site is currently developed park with a campground. Public views of the facility site are from SR-240 along the southern site boundary, from the river and West Pasco to the north, and from within the shoreline park.

Rural Benton and Yakima Counties

West of the Richland/West Richland, the landscape through which the pump exchange pipeline would be routed and within which pumping plants #2 and #3 would be sited is characterized largely by irrigated agriculture and other large lot rural development (e.g., rural residential). The agriculture is a mixture of orchards, vineyards, and row/field crops. Agricultural infrastructure (canals and appurtenant facilities) is strongly in evidence. Structures are generally residential and farm-oriented. Limited instances of open desert hillsides also occur along the pipeline route in Benton County.

Public viewpoints from which the pipeline route and the sites of the pumping plants would be seen are the local roads, residences, and farms along the facility corridor. Relevant views in this setting are generally dominated by surrounding agriculture, often with open hillsides as a backdrop.

4.19.2 Environmental Consequences

4.19.2.1 Methods and Assumptions

Visual resources impact analysis focuses on (1) the extent to which facilities and actions of the alternatives would result in a long-term change in the visual character of landscapes/locations in which they would be located (e.g., landscape form, line, color, and/or texture) and (2) the extent to which these changes would be visible to/experienced by the general public or existing residents.

For the purpose of this Draft PR/EIS, the primary visual resources indicator is a distinct, fundamental, and/or widespread change in the visual character of the subject landscape, with this change visible to the general public or local residents. Significant visual quality effects can be either positive (e.g., restoration of a damaged natural landscape) or adverse (e.g., major introduction of contrasting, developed facilities in an otherwise natural landscape). This analysis focuses on identifying the potential for significant adverse visual resources impacts.

4.19.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

As noted previously, conservation-related system improvements associated with the No Action Alternative are part of other approved programs and orient predominantly to existing facilities; none are being or would be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis would be required for these actions, appropriate documentation of visual impacts would be prepared separately, apart from the Storage Study process.

4.19.2.3 Black Rock Alternative

Construction Impacts

No construction-related impacts to visual resources are anticipated under this alternative.

Long-Term Impacts

Priest Rapids Lake and Dam Area and Downstream Columbia River.— Development of the intake and fish screen facility and northern inflow tunnel portal along the southwest shore of Priest Rapids Lake would introduce a substantial new industrial facility in the context of the existing Priest Rapids Dam hydroelectric project. Development would include a large pumping plant structure 56 feet high and an electric switchyard complex with towers up to 104 feet high. Although these facilities would be visibly separate from the existing Priest Rapids hydroelectric facilities, they would be consistent in character with the existing development. Considering this similarity in appearance with existing structures and the fact that the overall complex of facilities would be viewed predominantly from 2 miles or more away (e.g., the SR-243 corridor), the overall long-term visual resources impact is not expected to be significant.

As noted in discussion of the affected environment, it is uncertain whether the vent shaft along the inflow tunnel alignment beyond the intake and fish screen facility would be visible from public viewpoints. Thus, the potential for visual impact from this facility cannot be determined.

With one exception, development of the access road and transmission line serving the intake and fish screen facility would not represent a significant visual impact. For the most part (i.e., from SR-243 viewpoints), the new facilities would be introduced into a visual environment already containing several similar facilities. The exception to this would be at the location of the Wanapum village. While this village is located in a setting containing hydroelectric facilities, including existing roads and transmission lines, the new, large transmission line (500 kV) would be placed immediately adjacent to the village, and would intervene between village residences and the nearby mountain face. This impact would be locally significant.

Black Rock Valley.—Introduction of the Black Rock dam and reservoir would significantly and irrevocably affect the visual character of the Black Rock Valley. Within the valley itself, and along the rerouted SR-24 in the hills south of the valley floor ("Transportation"), the landscape would change from one dominated by open desert scrub/range land to one dominated by a working reservoir. This change would be perceived as either neutral or positive by some and as adverse by others. The degree of positive versus negative viewer reaction would likely vary by perceived opportunity (e.g., access for various types of recreation and

similar pursuits), as well as by season, as the reservoir is drawn down (revealing large expanses of barren mudflats) and refilled.

External to the Black Rock Valley, construction of the Black Rock dam would have a significant adverse impact on the visual environment from viewpoints immediately east of the dam (i.e., the café and residence); the view westward from these viewpoints would change from an open valley landscape to the face of the dam and associated outlet works. A limited number of existing farm residents in the Dry Creek Valley to the southeast would also see the dam as a significant new feature in the local visual environment.

Rural/Agricultural Yakima County.—Most of the outlet and distribution facilities of the Black Rock Alternative would be underground pipelines, with the only surface manifestation being management of land use and land cover within the associated easement or ROW. Management of the easement/ROW corridor would include prohibition of permanent structures, but landscape plantings, agriculture in some form, and/or restored natural vegetation (as appropriate to the environment along the route) would characterize the corridor after construction. Given the open, agricultural and otherwise sparsely developed character of the landscape through which these pipelines would be routed, their long-term visual impact would be minimal.

Exceptions to the above are the Black Rock outlet and powerplant and the Sunnyside powerplant and bypass facilities. Both of these facilities would be industrial in character, involving relatively large structures, an electrical switchyard, other work yards, and a new electric transmission line serving the facility site.

Structures at the Black Rock outlet and powerplant facility would include a 45-foot-high building and switchyard towers up to 104 feet in height. The overall site would be fenced (7-foot chain link). Power to the facility is expected to be provided via a new wood pole transmission line from the existing Roza powerplant switchyard.

At the Sunnyside powerplant and bypass site, structures would include buildings 18 and 35 feet high, with switchyard towers up to 104 feet high. The overall site would be fenced (7-foot chain link). Power to the facility is expected to be provided via a new wood pole transmission line from an existing BPA line 1 mile to the southwest.

The visual impact of these facilities may be significant on a local scale (i.e., to existing residents in the immediate vicinity of the sites and along the transmission line routes). At this scale, the facilities would be generally out of character with the rural, agricultural, residential nature of the local areas, and could interfere with view corridors or vistas from local residences.

Outside of this local perspective, however, major structures/facility sites would all be located along existing major roads, in a broader environment containing numerous other examples of similar infrastructure associated with irrigated agriculture and power transmission; in this context, the long-term visual impact would not be significant.

4.19.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

No construction-related impacts to visual resources are anticipated under this alternative.

Long-Term Impacts

Construction of the pumping plant, power system (switchyard and transmission line), air chamber, and other facilities, as well as the outlet channel would introduce substantial new manmade facilities/features in predominantly undeveloped Yakima Canyon. The most prominent of the facilities would include the pumping plant (39 feet high) and the switchyard (which would include 80-foot-high towers). These facilities would be on a site currently in irrigated (center-pivot system) agriculture between SR-821 and the river. The outlet channel from the dam would be a constructed/engineered conveyance with several drop structures, replacing the existing Lmuma Creek channel and crossing under SR-821 to the Yakima River.

These facilities, at least prior to mitigation, would represent a significant visual impact in the context of the largely undeveloped, scenic Yakima Canyon corridor. While the new facilities may be somewhat similar in character to those at Roza Diversion Dam (located 5 miles to the south) and not unlike the buildings and outdoor equipment storage of the river boating business one mile to the north, they would be more prominent, visible, and concentrated.

Related to the dam and reservoir, the top of Wymer Dam would be visible to motorists along an approximately one half mile stretch of SR-821; the saddle dike north of the dam would not be visible from the highway. The view of the dam would be fleeting (available for less than a minute) and would only be noticed if motorists look eastward up Lmuma Creek immediately opposite the site of the pumping plant complex. Nonetheless, this visibility of the dam would add to the significance of impact from this alternative on the Yakima Canyon corridor.

Other relevant perspectives on potential visual impacts of this alternative include the following:

- The import conveyance of the Wymer Dam and Reservoir Alternative would be underground between the dam and pumping plant and, thus, would not affect the visual environment.

- Where I-82 crosses the easternmost arm of the reservoir, motorists would see the reservoir at high water for a matter of seconds. When reservoir storage is being used, this view would be of the drawdown zone. Overall, this change from an intermittent drainage channel to the narrow upper arm of an active reservoir would not be significant.

4.19.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

No construction-related impacts to visual resources are anticipated under this alternative.

Long-Term Impacts

Visual resource impacts of the Wymer dam component of this alternative were discussed under "Wymer Dam and Reservoir Alternative." The following discussion focuses on the Yakima River pump exchange component of this alternative.

With the exception of the three pumping plant sites and the transmission lines associated with them, this alternative is comprised of underground pipelines; the only surface manifestation would be a managed corridor of land along the easement or ROW. Management of the easement/ROW corridor would include prohibition of permanent structures, but landscape plantings, agriculture in some form, and/or restored natural vegetation (as appropriate to the environment along the route) would characterize the corridor after construction. Given the open, agricultural, and otherwise sparsely developed character of the landscape through which these pipelines would be routed, their long-term visual impact would be minimal.

At the sites of each of the three pumping plants, a new industrial facility would be introduced. In the generally urban environment of Richland where pumping plant #1 would be located, this addition to the visual environment would not be significant, except for users of the shoreline park immediate adjacent (both existing and planned). See the "Land Use and Shoreline Resources" section.

Pumping plants #2 and #3, however, would be located in agricultural settings and, without mitigation, would represent significant visual impact to their local surroundings. The facilities would each involve relatively large structures, an electrical switchyard, air chambers, an overflow reservoir, and a new electric transmission line.

At pumping plant #2, facilities would include buildings of 20 and 40 feet in height, switchyard towers 80 feet high, and six 40-foot-high air chambers. Overall site size would be 53 acres, with 16 used for the above facilities and 37 acres used for the overflow reservoir. A new 1.5-mile 230-kV transmission line would also be needed.

At pumping plant #3, facilities would be somewhat smaller, with structures up to 20 and 40 feet high, 50-foot towers in the switchyard, and 25-foot-high air chambers. Site size would be 40 acres, with 12 acres used for the above facilities and 28 acres used for the overflow reservoir. Three miles of new 115-kV transmission line would be needed.

4.19.2.6 Mitigation

Black Rock Alternative

Available mitigation for visual impacts of Black Rock facilities focuses on (1) architectural treatments and landscape screening at the intake and fish screen, Black Rock outlet/powerplant and Sunnyside powerplant/bypass facilities, and (2) vegetation restoration and management in the pipeline and transmission line easements/ROW.

In the first regard, selection of building exterior colors that blend with the surrounding environment and planting of appropriate landscape screening could substantially reduce the contrast of the facility to the surrounding landscape. Such measures could reduce long-term visual impacts to an insignificant level. The same mitigation measures may also be applicable to outlet works and other appurtenant facilities at Black Rock dam.

In the pipeline and transmission line easements/ROW, restoration and long-term maintenance of vegetation consistent with the surrounding environment would serve to minimize adverse visual impact.

However, some visual impacts associated with this alternative are not subject to mitigation. Most significantly, the impact of Black Rock dam and reservoir on the Black Rock Valley and the impact of Black Rock dam on viewpoints from the east and southeast are not mitigable. It is also unlikely that any meaningful mitigation is available for the visual impact of the required 500-kV transmission line on the Wanapum village near Priest Rapids Dam.

Wymer Dam and Reservoir Alternative

Available mitigation for visual impacts of the Wymer Dam and Reservoir Alternative focuses on architectural treatment and landscape screening at the pumping plant facility complex and potential for landscape screening along the outlet channel. Selection of building/structure exterior color(s) that blend with the surrounding environment and planting of appropriate landscape screening could substantially reduce the contrast of the facility with the surrounding landscape. It is uncertain whether such measures could reduce the level of visual impact overall to an insignificant level.

Wymer Dam Plus Yakima River Pump Exchange Alternative

As with similar facilities associated with the Black Rock and Wymer Dam and Reservoir Alternatives, available mitigation would focus on architectural treatments and landscape screening at the pumping plant facility sites. Dependent of the proximity of proposed facilities to existing residences and the effectiveness of mitigation measures, impact could be reduced to insignificant levels (i.e., if new facilities are not close to existing residences, do not block important vistas or sight lines, and screening is implemented that provides sufficient height and density).

In the pipeline and transmission line easements/ROW, restoration and long-term maintenance of vegetation consistent with the surrounding environment would serve to minimize adverse visual impact.

4.19.2.7 Cumulative Impacts

Appurtenant facilities of the Black Rock Alternative would add cumulatively to the number of industrial/infrastructure facilities present in the context of rural environments. In the area of the intake facilities near Priest Rapids Dam, this change would primarily be an addition to already existing facilities and uses (i.e., no other, similar facilities are planned). In the area of the outlet and distribution facilities (rural Yakima County) it can be expected that continuing urban development would also bring instances of this type of development over time.

For the Wymer Dam and Reservoir Alternative, the appurtenant facilities (pumping plant, switchyard, etc.) would add cumulatively to the number of industrial/commercial elements present in the primarily natural, undeveloped visual context of Yakima Canyon. This cumulative visual impact would be in relation to existing developed facilities such as Roza Diversion Dam and commercial recreation businesses; no additional, similar types of development are known to be planned within the Canyon.

For the Wymer Dam Plus Yakima River Pump Exchange Alternative, pumping plants #2 and #3 would represent incremental/cumulative additions to the number of industrial/infrastructure facilities present in the context of rural environments in Benton and Yakima Counties. This change would primarily be an addition to already existing facilities and uses (i.e., no other, similar facilities are known to be planned in the locally affected environment).

4.20 Historic Properties

The legislative and regulatory basis for the identification, evaluation, protection, and management of historic resources in Federal undertakings is based on the National Historic Preservation Act of 1966, as amended (NHPA), and its implementing regulations at 36 CFR 800. Historic resources—also known as

cultural resources – includes districts, buildings, sites, structures, or objects possessing historical, architectural, archeological, cultural, traditional or scientific significance to broad themes in American history and culture. American Indian Tribal and cultural history is an important component of historic resources.

NHPA requires that Federal agencies complete field inventories and evaluations to identify sites or properties that may be eligible for listing in the *National Register of Historic Places* (*National Register*); and, then ensure those resources "are not inadvertently transferred, sold, demolished, substantially altered, or allowed to deteriorate significantly." Historic resources that meet *National Register* criteria are referred to as "Historic Properties." Further, the regulations at 36 CFR 800 define a consultation process for ensuring compliance with the NHPA. The consultative parties include the State Historic Preservation Officer (SHPO), the President's Advisory Council on Historic Preservation (ACHP), and Tribal governments with cultural and legal interests in the area of the undertaking.

4.20.1 Affected Environment

4.20.1.1 Columbia River Reaches and Yakima River Basin

The following discussion pertains to all of the Joint Alternatives.

Relevant to understanding the human history and land use in the Yakima River basin is the federally recognized Yakama Nation, which consists of 14 Tribes and Bands that were combined socially and politically following the Walla Walla Treaty of June 9, 1855. The areas covered by all Joint Alternatives are in the territory ceded in the 1855 Treaty. The Yakama Nation governing Tribal Council, located at the Yakama Nation Reservation headquarters at Toppenish, speaks for and manages the interests of the constituent 14 Tribes and Bands.

At least as early as 8,000 years ago, the ancestral inhabitants of today's Yakama Nation, Confederated Tribes of the Colville Reservation, Confederated Tribes of the Umatilla Reservation, and the Wanapum band developed a thriving native economy based on the natural richness and bounty of the Columbia Plateau. In precontact times, the Yakama and neighboring groups consisted of small, politically autonomous, yet closely related, bands, which lived in permanent winter villages located on major watercourses. The villages were essentially autonomous, although each group as a whole shared a common culture, maintained inter-village kinship ties, shared subsistence resources, and were engaged in frequent social interaction with one another.

Historians and anthropologists suggest that the traditional arrangement of autonomous villages was altered to a certain degree with the introduction of the horse in the 1700s, which gave the people greater ability to access more distant resources and interact with more distant groups. These more distant contacts included encounters with people living in the Plains region. As a result of this

interaction with Plains groups, the Yakama and related peoples adapted tipis, Plains clothing styles, and a Plains-like pattern of social organization by establishing a war chief and an incipient Tribal framework in which villages became more closely aligned.

Settlement centered on winter villages located in sheltered areas along the shores of rivers. The largest of these villages among the Kittitas and Yakima could have as many as 500 residents housed in circular-shaped houses with conical roofs. About 2,000 people typically inhabited one village of the Lower Yakima, known as tsíkik 'spring.' From these villages, subsistence forays extended into the surrounding areas to fish, gather, and hunt. The foods processed from these subsistence activities were stored at the villages for the winter. In addition to residential structures, villages also contained menstrual huts, sweat huts, food caches, and burial grounds.

The proposed locations of the Joint Alternatives are situated in areas where there is a high potential for both historic and prehistoric resources. A records and literature review was conducted for lands associated with each of the Joint Alternatives. A 1-mile radius study area around both the proposed Black Rock and Wymer reservoirs and along the alignments for the tunnels and pipelines associated with them and a 1/2-mile corridor study area along the pipeline route for the Wymer Dam Plus Yakima River Pump Exchange Alternative were used for this review. As a result of this review, a total of 102 cultural resources have been identified and recorded, of which 76 are prehistoric, 26 are historic, and one is a site with both prehistoric and historic components. Among these, only five resources have been determined eligible for NRHP listing: a historic structure known as the Mattoon Cabin (45YA360) and a historic structure known as the Sawyer Mansion (45YA361), both located within the 1/2-mile study corridor for the Yakima River pump exchange pipeline boundaries; two precontact lithic material sites (45YA91 and 45YA94) located within the study area along the Black Rock reservoir outflow tunnel; and one precontact feature (45YA96), also located in the study area along the Black Rock reservoir outflow tunnel. In addition to the previously recorded archaeological sites, one archaeological district (Tri-Cities Archaeological District) transects the 1/2-mile study area along the Yakima River pump exchange pipeline corridor. This district is National and State Register listed and contains a combined 30 historic and prehistoric sites. One of these sites, 45BN52, is located within the 1/2-mile study area used for the Yakima River pump exchange pipeline corridor.

While there are only five resources that have been determined eligible for listing in the NRHP, the eligibility status of the majority of cultural resources (97 totals) has not been determined. These sites include 11 precontact camp sites, 37 precontact lithic material sites, 2 precontact burial sites, 10 precontact isolates, 1 precontact feature site, 3 precontact cairn sites, 6 precontact talus pit sites, 1 precontact house pit/depression site, 2 precontact petroglyph sites, 7 historic objects sites, 2 historic hydroelectric sites, 1 historic agriculture site, 8 historic

refuse scatter/dump sites, 1 historic bridge site, 2 historic structure sites, 1 historic homestead site, 1 historic isolate, and 1 historic agriculture/lithic material site.

Given the abundance of previously recorded resources within the area, the construction of the proposed reservoirs and pipelines could potentially affect significant archaeological sites. This is most apparent in the study area along the Black Rock reservoir inflow tunnel alignment, where there are 42 previously recorded historic and prehistoric resources within an area of 11,345.75 acres. This is in sharp contrast to the study area along the Yakima River pump exchange pipeline corridor, which encompasses a total area of 24,335.46 acres and contains a combined seven prehistoric and historic resources in addition to an archaeological district.

The limited records and known historic resources inventory for the Joint Alternatives indicates that there is a high potential for historic resources. The individual size of each of the Joint Alternatives and associated impacts, the relationship of these alternatives to the Columbia and Yakima Rivers and Indian ceded lands, the Holocene geomorphology, and the high site density in nearby locales are indicators of a high level of complexity in the cultural and historic resources. In addition, these factors predispose either alternative to a high level of interest and scrutiny from Indian Tribes, State and Federal partners and reviewers, the professional historic preservation community, and the public.

4.20.2 Environmental Consequences

4.20.2.1 Methods and Assumptions

Methods to identify and evaluate historic resources include Class I inventories and Class III field surveys. The Class I inventory is a planning tool that involves a literature review and development of a low-level probability model for the occurrence of different kinds of sites and resources. The Class III survey is a complete field survey of project lands to identify unrecorded sites and resources.

The Class I inventory suggests that there are varieties of such resources in lands that would be affected under the Joint Alternatives; these resources span the long time depth of human occupation in the Columbia Plateau.

The Class III survey, which identifies historic resources and related discoveries, will occur after an alternative is selected and an area of potential effect (APE) can be defined. Class III surveys must await identification of a preferred alternative because Class III survey is predicated on the premise that a range of historic resources will be encountered, some of which will require additional investigations to evaluate their significance. Of those evaluated, a subset will be determined significant and eligible for the *National Register*. These eligible sites

will require mitigation, which will be determined through consultation with Washington Department of Archaeology and Historic Preservation (DAHP) and American Indian Tribes.

4.20.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

There would be no long-term impacts on historic properties under the No Action Alternative.

4.20.2.3 Joint Alternatives

Construction Impacts

Impacts to historic resources are, by their nature, not short-term or transitory. Once adversely impacted by construction activities, an historic resource cannot be returned to its preconstruction condition. As a result, all potential impacts to historic resource are long-term in nature and are discussed in the following section.

Long-Term Impacts

A Class III survey to identify historic resources in lands involved in any of the Joint Alternatives would only occur if one of them were selected; therefore, the numbers and kinds of historic resources are not yet known. At the current stage of project development, the assumption is that historic resources would be identified through a Class III survey, and some would require additional investigations to determine eligibility to the *National Register*. Further, some of these investigated resources would be determined eligible, and a round of consultations would proceed to develop mitigation measures.

4.20.2.4 Mitigation

Mitigation of historic resources is data recovery or archeological excavation, preservation, conservation, and interpretation of significant historic properties from direct and indirect impacts from a construction project. Specific mitigation measures cannot be developed and implemented until after a preferred alternative has been selected, and a Class III field survey has been conducted and reported; the Class III survey for any of the Joint Alternatives can be reasonably estimated to take at least 1 year.

A typical scenario for mitigation of a group of historic resources would be as follows:

- Identify the significant historic properties that cannot be avoided during project construction and development.

- Consult with the SHPO and ACHP that historic properties are eligible for the NRHP. Consultation may also occur with American Indian Tribes, other Federal agencies, and public entities.

- Develop Memorandum of Agreement (MOA) among Reclamation, SHPO, and ACHP over mitigation measures. MOA signatories may also include Tribes, other Federal agencies, and public entities.

- The MOA will include a research and data recovery plan, stipulations for permanent storage and curation of recovered material, and provisions for sharing the results of the data recovery phase with the public; for example, interpretive facilities. The goal is to identify and implement a range of measures to record and preserve, in some manner, the record of historic resources affected by the project. Mitigation of historic properties can involve data recovery, or large-scale archeological excavations, a program of monitoring of project effects, development of interpretive facilities and public educational opportunities, or a mix of those measures.

- The MOA may also include goals for long-term historic properties management and monitoring.

- The period for developing, implementing and completing mitigation measures could take an estimated 2 years for any of the Joint Alternatives. However, certain activities could last for many years, if not decades, beyond completion of the alternative. Museum storage and curation costs, monitoring activities, and management of historic resources in the development footprint not impacted directly by project construction, are examples of some common long-term activities which have attendant costs.

4.20.2.5 Cumulative Impacts

The assumption is that historic resources would experience unavoidable physical effects under implementation of any of the Joint Alternatives. These effects cannot be quantified until a Class III survey is conducted. Nevertheless, some general statements can be made that suggest cumulative effects to historic resources could be severe, particularly with respect to the Black Rock and Wymer Dam and Reservoir Alternatives, and less so in the case of the Yakima River pump exchange component of the Wymer Dam Plus Yakima River Pump Exchange Alternative.

Historic resources, as records of an array of human culture and knowledge at different points in time, are nonrenewable. Consequently, it is axiomatic that once a historic property is gone, another one cannot be grown to take its place.

Even though the aim of archeological investigations is to be able to re-create a site or historic property in the laboratory, it is also desirable to preserve a portion of the site for the future when advances in analytical methods and techniques may yield additional significant knowledge. For example, archeological sites contain evidence of environmental and climatic change, some of which is at a molecular level, the understanding of which depends on analytical tools that are not widely available or adapted to archeological applications yet.

4.21 Indian Sacred Sites

4.21.1 Affected Environment

See the "Historic Properties" section for a discussion of the affected environment of Indian sacred sites.

4.21.2 Environmental Consequences

4.21.2.1 Methods and Assumptions

Executive Order (EO) 13007, signed by President Clinton on May 24, 1996, instructs Federal land managers to accommodate access to, and protect the physical integrity of, sites of religious and spiritual significance to American Indians. The intent of EO 13007 is to memorialize the protection of the religious freedom of all American citizens. The sites subject to EO 13007 are those that are recognized by an American Indian Tribe through its government as a religious site, in contrast to sites significant to an individual. EO 13007 leaves open the method to learn if access to sacred sites will be impaired, except that knowledge of such sites should come from authoritative sources, such as from, or on behalf of, a Tribal Government. The Storage Study team chose to ask the Yakama Nation through stipulations in an interagency agreement for a spectrum of resource information bearing on the lands affected by the Storage Study, including cultural, traditional, and sacred sites.

Because the Joint Alternatives all lie in Yakama-ceded lands, the Storage Study team assumed sacred sites exist because of the land use history. The Storage Study team has been informed by the Yakama Nation Cultural Resources Program that sacred sites are known; however, identification and location are, at present, knowledge reserved by the Tribe. Whether access to, or physical integrity of, sacred sites would be affected by development of any Joint Alternatives is not known. EO 13007 directs Federal agencies to accommodate access to sacred sites in project planning through a good faith effort to learn of sites locations.

4.21.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

Official Tribal sources advise that sacred sites exist, although their locations and numbers have not been disclosed. If the No Action Alternative is selected, access to, and physical integrity of, sacred sites could, in the abstract, be adversely affected. However, the lands in question would remain privately owned; therefore, EO 13007, which applies to Federal land, would afford no protection.

4.21.2.3 Black Rock Alternative

The presence of sacred sites in the Black Rock reservoir site has not been disclosed at this time.

4.21.2.4 Wymer Dam and Reservoir Alternative

The presence of sacred sites in the Wymer reservoir site has not been disclosed at this time.

4.21.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

The presence of sacred sites in lands affected by this alternative has not been disclosed at this time.

4.21.2.6 Mitigation

Mitigation to offset project impacts to access to sacred sites has few precedents or standard treatments. Any focus on American Indian sacred sites is complicated by the very nature of the discussion, which is perceived by some, if not most, American Indian Tribes as outside the greater public sphere. EO 13007 allows Government-to-Government consultation between a Federal agency and the affected Tribes, which will occur if mitigation in this particular category is at issue if one of the Joint Alternatives is selected.

4.21.2.7 Cumulative Impacts

The cumulative impacts depends on knowledge of Indian sacred sites within the footprints of the Joint Alternatives, and if access would also be affected. Preliminary information confirms sites exist, particularly in the Black Rock and Wymer reservoir alternatives. However, affected Tribal Governments have chosen not to disclose site-specific information.

Assuming sacred sites are identified, addressing cumulative effects also depends on an understanding of each site in relationship to its religious and cultural

context. For example, loss of access to a site significant to Tribal members would obviously evoke a sense of loss. In the case where a sacred site is involved which obtains significance as a member of a network of sacred sites, loss of access conceivably has an even greater effect.

In some circumstances, access to sacred sites may not be impeded by development of one of the Joint Alternatives; however, the altered landscape can conceivably diminish the "sacredness" of the site in question.

4.22 Indian Trust Assets

Indian trust assets (ITA) are legal interests in property held in trust by the United States for Indian Tribes or individuals. Examples of trust assets are lands, minerals, hunting and fishing rights, and water rights. The United States has a trust responsibility to protect and maintain rights reserved by or granted to Indian Tribes or Indian individuals by treaties, statutes, and Executive orders, which are sometimes further interpreted through court decisions and regulations. This trust responsibility requires Reclamation to take all actions reasonably necessary to protect trust assets.

4.22.1 Affected Environment

As discussed earlier, several Tribes have interests in the areas associated with the potential Black Rock Alternative, Wymer Dam and Reservoir Alternative, and the Wymer Dam Plus Yakima River Pump Exchange Alternative. The dams, reservoirs, and other facilities are within lands ceded by the Yakama under the June 9, 1855, Treaty with the Yakama. This treaty reserved the Yakama Reservation and reserved to the Yakama the exclusive right of taking fish in the streams running through and bordering the reservation and at all other usual and accustomed stations in common with citizens of the United States, and the privilege of hunting, gathering roots, and pasturing their stock on open and unclaimed lands in common with citizens. Most of the lands to be acquired for the Joint Alternatives are in private ownership.

Under their 1855 Treaties, the Confederated Tribes and Bands of the Yakama Reservation, Washington, the Confederated Tribes of the Umatilla Indian Reservation, Oregon, the Confederated Tribes of the Warm Springs Reservation of Oregon and the Nez Perce Tribe of Idaho have exclusive fishing rights. Court decisions and cases have confirmed Tribal treaty fishing rights and the extent of those rights.

Potential Indian trust assets of concern for this action include water rights, fishing rights, and hunting and gathering privileges.

4.22.2 Environmental Consequences

This section identifies potential impacts to potential ITAs under the Joint Alternatives.

4.22.2.1 Methods and Assumptions

The resources sections of this document were reviewed to identify impacts potentially affecting ITAs.

4.22.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

The water rights of the Yakama Nation would continue as affirmed by the Washington State Superior Court handling the Yakima River basin adjudication. The numbers of anadromous fish in the Yakima and Columbia River systems would not increase. Terrestrial resource trends would continue.

4.22.2.3 Black Rock Alternative

Construction Impacts

No construction impacts to ITAs have been identified.

Long-Term Impacts

No adverse impacts to water rights, fishing rights, or hunting and gathering privileges, the ITAs of concern for this action, have been identified.

The increases in harvestable anadromous fish identified in chapter 2, Section 2.7, "Economic and Financial Analysis," would facilitate the exercising of Tribal fishing rights by members of area Tribes. It would also contribute to maintaining or increasing subsistence fishing.

4.22.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

No construction impacts to ITAs have been identified.

Long-Term Impacts

No adverse impacts to water rights, fishing rights, or hunting and gathering privileges, the ITAs of concern for this action, have been identified.

The increases in harvestable anadromous fish identified in chapter 2, Section 2.7, "Economic and Financial Analysis" section would facilitate the exercise of

Tribal fishing rights by members of area Tribes. The increases would also contribute to maintaining or increasing subsistence fishing.

4.22.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

No construction impacts to ITAs have been identified.

Long-Term Impacts

No adverse impacts to water rights, fishing rights, or hunting and gathering privileges, the ITAs of concern for this action, have been identified.

The increases in harvestable anadromous fish identified in chapter 2, Section 2.7, "Economic and Financial Analysis," would facilitate the exercising of Tribal fishing rights by members of area Tribes. It would also contribute to maintaining or increasing subsistence fishing.

4.22.2.6 Mitigation

No mitigation would be required.

4.22.2.7 Cumulative Impacts

No cumulative impacts have been identified.

4.23 Public Health

4.23.1 Affected Environment

4.23.1.1 Hazardous and Toxic Materials

The acquisition of residential, agricultural, or industrial property has inherent risks of the property containing solid wastes and hazardous and toxic materials. In order to avoid acquiring real property that is contaminated, it is required under *Reclamation Manual*, *Directives and Standards*, that an Environmental Site Survey be completed prior to any acquisition.

Septic Systems

Larger cities and towns in the Storage Study area have sanitary wastewater treatment plants. In areas outside town or city limits, most homes are on septic systems. When properly operating, septic systems treat bacteria and filter nutrients from the water within the confines of the treatment system. Under certain conditions, such as high water table and poor soil conditions, septic systems do not operate properly and could result in sanitary wastes being discharged into groundwater or, more commonly, into surface water. These conditions may require the closure or relocation of these systems to protect both groundwater and surface water.

Building Materials

Buildings, such as residences and outbuildings located on properties to be acquired, may require removal or demolition. Buildings older then 20 years have the potential of containing hazardous materials such as lead-based paint, asbestos-containing materials, polychlorinated bi-phenols (PCB), and mercury. These materials are known to be hazardous to human health and the environment. All of these materials when used for the intended purpose are considered safe if they are not disturbed or damaged. If a structure is to be removed or demolished, testing will be completed to determine the presence any of these hazards. Based on the test results, the appropriate method of disposal will then be determined, if it is necessary at all.

4.23.1.2 Public Health (West Nile Virus) and Mosquitoes

Mosquitoes belong to the insect order *Diptera*. Mosquito mouthparts form a long, piercing-sucking proboscis with which females obtain a blood meal needed for egg production. Nectar is the main food source for male mosquitoes. Four distinct stages make up the life cycle of the mosquito: egg, larva, pupa, and adult. Larval and pupal stages are typically aquatic. Biting mosquitoes can become a serious nuisance to people recreating in areas with nearby mosquito populations. They may also be a health concern where transmission of disease agents, which are often maintained in bird populations, from mosquitoes to humans occurs.

Successful disease transmission requires several generations to increase the size of the adult mosquito population and amplify the virus within the bird population (e.g., Madder et al., 1983), which then will increase the likelihood of transmission to humans. Optimal conditions for development of high densities of adult mosquitoes are large water surfaces and long periods of time (Tadzhieva et al., 1979). Timing of availability of breeding areas is likely important and Madder et al. (1983) found that *Culex pipiens* and *Cx. restuans* egg production declined in late summer. Length of time that mosquito production areas are available is also critical. Minimum mean time for embryonic, larval, plus pupal development time (*Culex* species) was about 8 days at a high temperature of 86 °F (30 °C) (Madder et al., 1983). The Washington State Department of Health (2002) suggests that water that stands for greater than 10 days is needed for production of *Culex tarsalis*. In a study by Williams et al. (1993) it took about 2 days for first instar larvae to appear in newly filled pool areas.

The association of dams with mosquito and human health problems has long been documented (World Health Organization [WHO], 2000) and the Tennessee Valley Authority (TVA) made recommendations for limiting mosquito production in impoundments (Cooney, 1976). Cooney (1976) listed a number of measures to help control mosquitoes in TVA facilities: (1) monitoring of mosquito populations; (2) the application of approved insecticides when levels reach a nuisance threshold; (3) implementation of an effective water-level management scheme; (4) maintenance of effective internal drainage; (5) control of marginal

vegetation; and (6) operation of dewatering projects for mosquito control. Gartrell et al. (1972) suggested that dewatering areas controls mosquito production in the spring and summer. Water-level management destroys mosquito eggs and larvae by stranding them onshore or drawing them into open water where they are exposed to predators (Snow, 1956). Reservoir drawdowns during the summer and fall of at least 20 feet were effective in providing mosquito control in TVA reservoirs (Hess and Kiker, 1943) by decreasing marginal vegetation. Mosquito production is often highest in shallow, stagnant waters with dense, emergent vegetation. Wind-swept shorelines lacking vegetation and pools containing fish and other mosquito larvivores are not conducive to mosquito production (e.g., Pratt and Moore, 1993).

Mosquito-Borne Disease

Several arthropod-borne viruses associated with mosquitoes are found in Washington State. The Washington State Department of Health (2002) lists western equine encephalitis and St. Louis encephalitis as being diseases relevant to Washington State. Both of these viruses are maintained in a mosquito-bird-mosquito cycle and *Culex tarsalis* is a principal vector. These traits are shared to a great degree with the newly emergent (in the Western hemisphere) West Nile virus.

History, Origin, and Status of West Nile Virus

West Nile virus is a typically mosquito-borne virus indigenous to Africa, Asia, Europe, and Australia (Campbell et al., 2002). West Nile virus was recently introduced to North America and first detected in 1999 in New York City. The virus spread across the United States by 2002 (Centers for Disease Control [CDC], 2002). The virus is maintained in nature in a mosquito-bird-mosquito transmission cycle primarily involving *Culex* spp. mosquitoes (CDC, 2002). A large number of bird species can become infected with West Nile virus. Many groups of birds, such as doves (columbiform) and quails (galliform), become infected but do not die (Reisen, 2004); highest mortality rates were found in passerines in a laboratory study (Komar et al., 2003). Members of the crow family (*Corvideae*) are the most susceptible to death from West Nile virus (Crane, 2003). Susceptibility to West Nile virus is variable, and groups that are reported to be resistant to mortality such as the galliforms may contain members that are highly susceptible to mortality following infection, such as the greater sage-grouse (*Centrocercus urophasianus*) (Naugle et al., 2004).

In the United States, most human infections with West Nile virus occur in summer or early fall (Campbell et al., 2002) and coincide with high abundance of adult *Culex* mosquitoes (Kulasekera et al., 2001). Mosquito feeding preferences can increase or decrease the potential of mosquitoes for transmitting the virus to humans. Opportunistic feeders that feed on both mammals and birds are best for bridging West Nile virus from birds to humans and other mammals. Goddard et al. (2002) suggested that a suite of *Culex* species is important for maintaining and

bridging West Nile virus in wetland ecosystems in California. While mosquito genera other than *Culex* may be susceptible to West Nile virus infection, they are often found to be uninfected in nature (Reisen, 2004). Transmission of West Nile virus is most intense when initially arriving in a geographic area. West Nile virus will decline to a lower level after susceptible wild birds have either died or recovered and developed immunity to reinfection. Transmission of West Nile virus to humans requires a reservoir of infected, viremic animals (mostly birds) from which mosquitoes carry the virus to people (Crane, 2003).

To prevent West Nile virus infection in humans, extensive early season larval control has been recommended because it prevents the buildup of mosquito populations (CDC, 2001).

4.23.2 Environmental Consequences

4.23.2.1 Methods and Assumptions

Hazardous and Toxic Materials

As property is identified for acquisition, an Environmental Site Survey will be conducted.

Mosquitoes

The key to estimating impacts to human health from mosquitoes is related to understanding the relationship between mosquito life history characteristics and the physical and biological environment. Conditions that create shallow, warm, stagnant water in conjunction with emergent vegetation should be avoided to prevent public health concerns. Biological needs for virus transmission also include resident birds in high densities (typically found at roosting sites) for virus amplification.

This analysis focused on the mosquito vector *Culex tarsalis* and the disease agent West Nile virus. Other disease agents of public health concern are maintained in a similar *Culex tarsalis*-bird-*Culex tarsalis* cycle and responses to alternatives would be grossly similar. Water-level management conditions which would potentially create mosquito habitat were examined, with slopes from 0 to 3 percent (obtained via GIS) considered as areas conducive to shallow water pooling and mosquito habitat. Other considerations were proximity of roosting sites for birds, potential for shoreline vegetation, and water surface disturbance from wind. This assessment is limited spatially to areas associated with the proposed reservoirs.

4.23.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

Hazardous and Toxic Materials.—There would be no impacts because no property would be acquired.

Mosquitoes.—West Nile virus is presently expanding in the United States and will likely increase. Climatic conditions may be associated with the spread of West Nile virus; in California, West Nile virus introduction coincided with above average temperatures and anomalous rainfall events (Reisen, 2004) that apparently benefited *Culex* populations. Similar conditions may allow for expansion in Washington State independent of any of the alternatives. Other disease agents of concern in Washington State would likely maintain infection cycles similar to past conditions.

4.23.2.3 Black Rock Alternative

Construction Impacts

Hazardous and Toxic Materials.—For all construction activities associated with the Joint Alternatives, the contractor(s) must comply with Reclamation Safety and Health Standards. In doing so, the contractor(s) will be responsible for ensuring that all work under contract meets or exceeds Occupational Safety and Health Administration (OSHA) standards. These standards outline the requirements for proper handling, storage, and disposal of hazardous materials and wastes.

Mosquitoes.—Construction activities often alter drainage patterns and can leave tire ruts in the soil which may fill with water from rainfall or seepage in wet areas, creating mosquito breeding sites. In some cases, equipment that is left at constructions sites, or tarpaulins used to cover equipment may retain water that could also be used by mosquitoes for rearing.

Water should be removed from depressions and abatement strategies should be implemented during and after construction to minimize the creation of areas where water pools for extended periods of time (>7 days).

Long-Term Impacts

Hazardous and Toxic Materials.—As property is identified for acquisition, an Environmental Site Survey would be conducted. Any materials or potential effects of hazardous substances that could be exposed to higher levels of surface water or groundwater would be removed prior to final implementation. This may include the removal of: solid wastes, underground storage tanks, septic systems, any building structures, and/or other appropriate remedial action. The closer to human habitation or developed areas, the greater the possibility in finding hazardous wastes and/or contaminates. The Black Rock study area contains mostly undeveloped land or farmland, which minimizes the potential for hazardous findings.

All operational facilities associated the Black Rock Alternative would comply with all environmental regulations pertaining to hazardous waste management issues such as storage, disposal, inspection, recordkeeping and reporting associated with operating the facilities. Each facility, such as the powerplants, the pumping plant, and the dam would have a Spill Prevention Control and Countermeasure (SPCC) plan. The SPCC would detail measures to be in place to prevent spills of hazardous or dangerous materials and petroleum products and measures to control a spill should one occur.

Any hazardous materials and wastes associated with acquiring property would be remediated, and any related to construction activities would cease upon completion of the project; therefore, there would be no long-term impacts on public health.

Mosquitoes.—Operation of Black Rock reservoir would result in a drawdown beginning in April and refilling in September. (See chapter 2 for drawdown curve.) It is estimated that from about March to the beginning of June, 30 acres of previously inundated land would be exposed. This would increase to approximately 100 acres for the months of June to the beginning of August. The majority of this potential mosquito habitat would likely drain into the reservoir or dry quickly; however, any pool areas that remain could produce *Culex* mosquitoes. Arguments against increased mosquito production under this scenario include the historic use of dewatering reservoirs in the spring and summer for mosquito control (Gartrell et al., 1972). Snow (1956) noted that drawdown water-level management destroys mosquito eggs and larvae by stranding them onshore or drawing them into open water where they are exposed to predators. Reservoir drawdowns during the summer and fall of at least 20 feet were effective in providing mosquito control in TVA reservoirs (Hess and Kiker, 1943) by decreasing marginal vegetation. A temporary water-level drawdown in Minnesota wetlands also reduced densities of mosquito larvae (*Coquillettidia perturbans*) which did not recover until 4 years later (Batzer and Resh, 1992). The timing of the drawdown at Black Rock may also disrupt mosquito production. Drawdown during the spring would likely destroy egg rafts and early stages of larval mosquitoes. Inundation in the late summer may not allow enough time for populations of *Culex* mosquitoes to recover to levels needed for disease transmission. Mosquitoes that would be produced would likely be flood-water mosquitoes (e.g., *Aedes*) and not the *Culex* species typically associated with West Nile virus.

Terrestrial vegetation could create variance in landscape topography and impact drainage in the drawdown area. Vegetation would also provide structure and an organic food base for mosquito larvae when water levels increase at other times of the year. While some perennial marginal vegetation may be decreased under these conditions, annual weedy vegetation or exotic grasses could invade exposed mud flats and result in favorable conditions for larval mosquitoes upon refilling, at least until drawdown once again occurs. If drawdown levels vary between

years, vegetation that is produced in 1 year could remain partially inundated in the next year and provide high-quality mosquito habitat. While many fluctuating reservoirs have shorelines that are devoid of vegetation, others may contain large stands of exotics such as reed canary grass (McKay and Renk, 2002). Responses of vegetation to drawdown areas likely depend upon drawdown timing (which seeds are present in the environment), the drawdown rate and its influence on soil moisture, and the type of substrate (whether it is rocky or fine substrate) (e.g., Auble et al., 2007).

Domestic livestock and wild ungulates should also be kept away from the drawdown area because of enrichment of the area with animal manure and the creation of hoof prints that retain water, both factors that would favor mosquito production.

Black Rock reservoir would be both filled and drained via pipeline and would be isolated in shrub-steppe habitat away from other riparian areas (nearest riparian area is the Columbia River approximately 5 miles away). Riparian corridors are important for dispersion of *Cx. tarsalis*, probably because of the presence of prey and higher humidity that is important for avoiding desiccation. The shrub-steppe habitat associated with Black Rock reservoir also lacks the elevated vegetation commonly used by West Nile virus-susceptible birds for roosting and nesting and which *Cx. tarsalis* has been found to be attracted to in California (Reisen, 2004). However, other birds associated with shrub-steppe habitat, such as sage-grouse, may be atypical but competent amplifying agents for West Nile virus (Walker et al., 2007).

Data from the Hanford Meteorology Station east of the Black Rock site capture the general climatic conditions for the region (Neitzel, 2005). Prevailing surface winds are from the northwest and are most frequent in the winter and summer. Monthly average wind speed at 50 feet above the ground averages 6 to 7 mph in the winter and 8 to 9 mph during the spring and summer. Summertime drainage winds from the northwest frequently exceed speeds of 30 mph. Wind gusts greater than or equal to 25 mph occur on an average 20 days per year in June and July.

Wind speed slows near the ground surface, and average wind speed of 9 mph at 50 feet during the summer was used to calculate the approximate wind speed at 5-foot elevation from the following equation: $v_2 = v_1 \text{ x } (h_2/h_1)^n$ where v_1 is the known (reference) wind speed at height h_1 above ground, v_2 is the speed at a second height h_2, and n is the exponent determining the wind change caused by surface roughness (www.energy.iastate.edu). The exponent used (0.10) was the one pertaining to a smooth surface. Calculations suggest that spring/summer wind speed over the Black Rock site might be in the range of 7 mph and would be approximately 5 on the Beaufort wind scale, resulting in moderate wave action (www.spc.noaa.gov/faq/tornado/beaufort.html).

It should be recognized that this is a rough estimate of possible conditions on the ground at the Black Rock site, but it does suggest that there is a possibility for wave action on the reservoir during mosquito production periods. Pratt and Moore (1993) indicate that wind-swept shorelines are not conducive to production of mosquito larvae. Turbidity associated with windy shorelines and fine sediments may also create difficulties for mosquito survival because of the ingestion of large volumes of nonnutritive soil particles (Ye-Ebiyo et al., 2003). Wind would also increase the drying rate of exposed mudflats, decreasing the lifespan of potential isolated pool areas.

Operation and the physical placement of Black Rock reservoir indicates that relatively few mosquitoes would be produced, and limited transmission of West Nile virus would result from this facility, especially if vegetation does not invade the drawdown area. The low amount of emergent vegetation, limited roosting sites for bird congregations, timing of the drawdown, and winds associated with the area all argue against increases in *Culex* mosquito populations.

- Following completion of project construction, to ensure there are no long-term adverse impacts from mosquitoes, Reclamation will:
- Perform management and maintenance activities necessary to control mosquito populations.
- Regularly consult with local health departments and mosquito and abatement districts to identify mosquito management problems, mosquito monitoring and abatement procedures, and opportunities to adjust water management practices to reduce mosquito production during problem periods.

4.23.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Hazardous and Toxic Materials.—Construction impacts would be the same as under the Black Rock Alternative.

Mosquitoes.—Construction impacts would be the same as under the Black Rock Alternative.

Long-Term Impacts

Hazardous and Toxic Materials.—Impacts would be similar to those described for the Black Rock Alternative.

Mosquitoes.—Releases from Cle Elum Lake and flows in the Yakima River would be used to fill Wymer reservoir between November 1 and May 31. Water would be released from Wymer reservoir only in July and August, and the

drawdown would expose approximately 35 acres of potential pool area. This area would remain exposed through October. Drawdown elevations are presented in chapter 2.

Reservoir drawdowns that occur in late summer likely have negative impacts to mosquito production. Withdrawal of water from potentially vegetated shorelines would decrease mosquito populations and mitigate against any potential production from drawdown pools. Colonization of isolated pools in late July and August occurs at a time when egg production by females is beginning to decrease and the time needed to achieve multiple generations, which would lead to high adult densities, is unavailable. August is also the time of year when rapid evaporation of pools would take place because of high air temperatures.

Refill of the reservoir beginning in November would gradually fill the reservoir through the end of May. It seems likely that this pattern of filling and drawdown would drastically decrease the likelihood of vegetation being present along the shoreline of the reservoir and would diminish problems with mosquitoes.

4.23.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Hazardous and Toxic Materials.—Construction impacts would be the same as under the Black Rock Alternative.

Mosquitoes.—Construction impacts would be the same as under the Black Rock Alternative.

Long-Term Impacts

Hazardous and Toxic Materials.—Impacts would be similar to those described for the Black Rock Alternative.

Mosquitoes.—Impacts would be the same as under the Wymer Dam and Reservoir Alternative.

The Yakima River pump exchange component of this alternative would not result in any areas conducive to shallow water pooling and mosquito habitat, and therefore, would not result in any increase in *Culex* mosquito populations.

4.23.2.6 Mitigation

Hazardous and Toxic Materials

As property is identified for acquisition, Reclamation would conduct an Environmental Site Survey. Remediation for any materials or potential effects of hazardous substances will be conducted prior to final implementation. For all constructed facilities, Reclamation will comply with environmental regulations pertaining to hazardous waste management and develop a SPCC where required.

Mosquitoes

Reclamation will:

- Conduct baseline mosquito surveillance and control program, including a monitoring program for mosquito larvae.
- Ensure final design of project facilities are designed in consultation with experts in mosquito biology and control to prevent as much mosquito production as possible and to facilitate proper functioning and maintenance in the future. Appropriate operations and maintenance provisions will include considerations for routine monitoring and control of mosquito populations.
- Consult and coordinate with local health departments and mosquito and abatement districts about mosquito control measures during design, implementation, and operations phases of the project.
- Prepare a mitigation monitoring plan to ensure that the proposed mitigation measures are implemented.

The construction contractors will be required to:

- Develop and implement mosquito abatement measures including stormwater management, reducing opportunities for mosquito breeding habitats in construction materials and facilities, management of vegetation that may be conducive to mosquito habitat, site maintenance to prevent topographical depressions and ponding, monitoring, and adult mosquito control.
- Consult with local health departments and mosquito and abatement districts to discuss design or control measures to inhibit mosquito breeding and stormwater practices.
- Monitor access routes to detect formation of undrained depressions in tire ruts. Backfill access-related shallow depressions or incise narrow drainages so they do not impound small, sheltered areas of standing water.
- Ensure any artificial depressions capable of holding water for a period greater than 7 days are rectified by filling, draining or other treatment to prevent the creation of mosquito breeding sites.
- Optimize drainage.
- Keep discharge of test water to a practical minimum and prevent long-term pooling.

- Avoid water storage open to ingress of insects wherever possible. When open storage is necessary, the duration will be kept to a minimum and assure proper mosquito control treatment.

- Inform workers during the worker education program of the potential for increases in mosquito breeding populations and of the appropriate precautions to take to protect their health including requiring personnel to wear long sleeve shirts and long trousers and use insect repellent. Provide insect repellent.

4.23.2.7 Cumulative Impacts

Cumulative impacts are those environmental consequences that result from the incremental effects of an activity when added to other projects. Although it is unlikely that large increases in mosquito populations will occur with individual project reservoirs, the underlying result of these projects would be the ability to irrigate crops even during dry years. Mosquitoes are often associated with agriculture and irrigation (Lawler and Lanzaro, 2005); therefore, the increased ability to irrigate would increase cumulative mosquito numbers over periods that include both wet and dry years.

4.24 Environmental Justice

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," dated February 11, 1994, requires agencies to identify and address disproportionately high and adverse human health or environmental effects of their actions on minorities and low-income populations and communities as well as the equity of the distribution of the benefits and risks. Environmental Justice addresses the fair treatment of people of all races and incomes with respect to actions affecting the environment. Fair treatment implies that no group should bear a disproportionate share of negative impacts.

4.24.1 Affected Environment

4.24.1.1 Black Rock Alternative

Yakima County Census Tract 17, which includes the area around the Black Rock dam and reservoir site and the Grant County Census Designated Place (CDP) of Desert Aire, which is immediately across Priest Rapids Lake from the Black Rock pumping plant, were selected for the immediate study area. Table 4.52 provides the numbers and percentages of population for the total racial minority population which includes six minority racial categories: Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, Some Other Race, and Two or More Races and the Hispanic or Latino

Table 4.52 Race and ethnicity

Subject	Study area		Yakima County		Washington	
	Number	Percent	Number	Percent	Number	Percent
Total population	7,668	100.0	222,581	100.0	5,894,121	100.0
Racial minorities	1,768	23.1	76,576	34.4	1,072,298	18.2
Hispanic or Latino (of any race)	1,976	25.8	79,905	35.9	441,509	7.5

population, a minority ethnic group for the Black Rock study area, Yakima County, and the State of Washington. Table 4.53 provides income, poverty, unemployment, and housing information for the same geographic areas.

Table 4.53 Income, poverty, unemployment, and housing

Subject	Study area		Yakima County	Washington
	Census Tract 17	Desert Aire CDP		
Income				
Median family income	$45,015	$36,971	$39,746	$53,760
Per capita income	$16,441	$18,719	$15,606	$22,973
Percent below poverty level				
Families	6.6	4.9	14.8	7.3
Individuals	11.7	6.5	19.7	10.6
Percent unemployed	11.3	13.8	11.1	6.2
Percent of Housing				
Occupants per room – 1.01 or more	8.0	17.2	14.2	2.7
Lacking complete plumbing facilities	0.4	3.2	1.4	0.5

In comparison to Yakima County, the study area has a smaller percentage of total racial minority and ethnic (Hispanic or Latino) populations. The percentages of racial minorities and ethnic populations for the study area and the county are greater than for the State.

Additional potentially affected minority populations include members of the Yakama Nation and downstream Indian Tribes. While Census data are available for recognized Indian reservations, specific data for Tribal members are not. Tribal members may be affected regardless of whether or not they reside on their reservations.

Low-income populations are identified by several socioeconomic characteristics. As categorized by the 2000 Census, specific characteristics include income (median family and per capita), percentage of the population below poverty (families and individuals), unemployment rates and substandard housing.

Median family income for Census Tract 17 is greater than Desert Aire and the County, but less than for the State. Desert Aire has per capita income higher than Census Tract 17 and the county but less than for the State. Compared to Yakima County, the study areas have lower percentages of families and individuals below the poverty level.

Other measures of low income, such as unemployment and substandard housing, also characterize demographic data in relation to environmental justice. The 2000 unemployment rates for the study area and Yakima County were higher than the State's 6.2 percent rate. Substandard housing units are overcrowded and lack complete plumbing facilities. The percentage of occupied housing units with 1.01 or more occupants per room in the study area and county was greater than the percentage for the State. The percentage of housing units lacking complete plumbing facilities in Census Tract 17 was lower than Desert Aire, the county, and the State, while the percentages for Desert Aire and Yakima County were greater than for the State.

4.24.1.2 Wymer Dam and Reservoir Alternative

Kittitas County Census Tract 9757, which includes the area around the proposed Wymer dam and reservoir site, was selected for the immediate study area. Table 4.54 provides the numbers and percentages of population for the total racial minority population, which includes six minority racial categories: Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, Some Other Race, and Two or More Races and the Hispanic or Latino population, a minority ethnic group for the Wymer study area, Kittitas County, and the State of Washington. Table 4.55 provides income, poverty, unemployment, and housing information for the same geographic areas.

In comparison to the State of Washington and Kittitas County, the local study area has a smaller percentage of racial minorities and a greater ethnic population percentage.

Table 4.54 Race and ethnicity

Subject	Study area		Kittitas County		Washington	
	Number	Percent	Number	Percent	Number	Percent
Total population	3,361	100.0	33,362	100.0	5,894,121	100.0
Racial minorities	268	8.0	2,745	8.2	1,072,298	18.2
Hispanic or Latino (of any race)	301	9.0	1,668	5.0	441,509	7.5

Table 4.55 Income, poverty, unemployment, and housing

Subject	Study area: Census Tract 9757	Kittitas County	Washington
Income			
Median family income	$40,357	$46,057	$53,760
Per capita income	$20,399	$18,928	$22,973
Percent below poverty level			
Families	10.4	10.5	7.3
Individuals	13.3	19.6	10.6
Percent unemployed	7.1	9.1	6.2
Percent of housing			
Occupants per room – 1.01 or more	1.7	1.6	2.7
Lacking complete plumbing facilities	1.0	0.8	0.5

Additional potentially affected minority populations include members of the Yakama Nation and downstream Indian Tribes. While census data are available for recognized Indian reservations, specific data for Tribal members are not. Tribal members may be affected regardless of whether or not they reside on their reservations.

Median family income for Census Tract 9757 is less than for the County and the State. The study area's per capita income is higher than for Kittitas County but less than for the State. Compared to Kittitas County, the study area has lower percentages of families and individuals below the poverty level.

The 2000 unemployment rates for the study area and Kittitas County were higher than the State's 6.2-percent rate. The percentage of occupied housing units with 1.01 or more occupants per room in the study area and County was less than the percentage for the State. The percentage of housing units lacking complete plumbing facilities in Census Tract 9757 was greater than for the County and the State.

4.24.1.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

The pipeline associated with this alternative crosses Benton County and part of Yakima County. The Benton County Census County Divisions (CCD) of Benton City, Northwest Benton, and Richland-Kennewick and the Yakima County CCD of Sunnyside approximate the area to be traversed. Table 4.56 provides the numbers and percentages of population for the total racial minority population which includes six minority racial categories: Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, Some Other Race, and Two or More Races and the Hispanic or Latino population, a minority ethnic group for the Wymer pipeline area, county, and the State of Washington. Table 4.57 provides income, poverty, unemployment, and housing information for the same geographic areas.

Table 4.56 Race and ethnicity

Subject	Benton City CCD		Northwest Benton CCD		Richland-Kennewick CCD		Benton County	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total population	5,494	100.0	11,877	100.0	124,238	100.0	142,475	100.0
Racial minorities	731	13.3	2,915	24.5	15,716	12.6	19,596	13.8
Hispanic or Latino (of any race)	960	17.5	4,116	34.7	12,400	10.0	17,806	12.5

Subject	Sunnyside CCD		Yakima County		Washington	
	Number	Percent	Number	Percent	Number	Percent
Total population	45,291	100.0	222,581	100.0	5,894,121	100.0
Racial minorities	21,484	47.4	76,576	34.4	1,072,298	18.2
Hispanic or Latino (of any race)	27,054	59.7	79,905	35.9	441,509	7.5

Table 4.57 Income, poverty, unemployment, and housing

Subject	Benton City CCD	Northwest Benton CCD	Richland-Kennewick CCD	Benton County
Income				
Median family income	$45,872	$43,225	$55,954	$54,146
Per capita income	$16,971	$15,073	$22,149	$21,301
Percent below poverty level				
Families	9.6	13.5	7.1	7.8
Individuals	12.7	15.9	9.6	10.3
Percent unemployed	6.7	5	3.9	4.1
Percent of housing				
Occupants per room – 1.01 or more	5.0	4.4	2.8	3.0
Lacking complete plumbing facilities	1.3	0.8	0.3	0.4

Subject	Sunnyside CCD	Yakima County	Washington
Income			
Median family income	$35,086	$39,746	$53,760
Per capita income	$12,375	$15,606	$22,973
Percent below poverty level			
Families	19.5	14.8	7.3
Individuals	25.7	19.7	10.6
Percent unemployed	9.0	6.9	6.2
Percent of housing			
Occupants per room – 1.01 or more	7.9	14.2	2.7
Lacking complete plumbing facilities	0.8	1.4	0.5

In Benton County, the Northwest Benton CCD has the highest percentage of racial minorities. The percentages of racial minorities in the CCDs and in Benton County are lower than for Yakima County and the State. The percentage of racial minorities in the Sunnyside CCD is higher than for Yakima County and more than twice the State percentage. The percentages of the Hispanic or Latino populations in the Benton City CCD and Northwest Benton CCD—17.5 and 34.7, respectively—are greater than the percentages for Benton County and the State, which are 12.5 and 7.5 percent respectively. The percentage of the Hispanic or Latino populations in the Sunnyside CCD, 59.7, is greater than for the County, 35.9 percent and the State, 7.5 percent.

Additional potentially affected minority populations include members of the Yakama Nation and downstream Indian Tribes. While Census data are available for recognized Indian reservations, specific data for Tribal members are not. Tribal members may be affected regardless of whether or not they reside on their reservations.

Median family and per capita incomes in Benton City CCD and Northwest Benton CCD are less than for Benton County and the State. Richland-Kennewick CCD's median family income is greater than for the County and the State. Its per capita income is greater than for the County but less than for the State. Median family income and per capita income in the Sunnyside CCD are less than in Yakima County and the State.

The percentages of families and individuals below poverty are higher in Benton CCD and Northwest Benton CCD than for Benton County and the State. The percentages of families and individuals in the Richland-Kennewick CCD are lower than for Benton County and the State. The percentages of families and individuals below poverty in the Sunnyside CCD and Yakima County are more than twice the State percentages of families and individuals below poverty.

The 2000 unemployment rates for the Benton City CCD, Northwest Benton CCD, Benton County, Sunnyside CCD, and Yakima County were higher than the State's 6.2-percent rate.

The percentages of occupied housing units with 1.01 or more occupants per room in the Benton City CCD, Northwest Benton CCD, Benton County, Sunnyside CCD, and Yakima County are greater than for the State. Percentages of housing lacking complete plumbing facilities in Benton City CCD, Northwest Benton CCD, Sunnyside CCD, and Yakima County are greater than for the State.

4.24.2 Environmental Consequences

4.24.2.1 Methods and Assumptions

Construction of the alternatives would most directly impact those living, recreating, or pursuing other activities in the immediate areas. To the extent these are minority and/or low-income populations, there is potential for disproportionate adverse impacts.

Environmental justice issues are focused on environmental impacts on natural resources (and associated human health impacts) and potential socioeconomic impacts. In addition to the identification of minority and/or low-income populations in the study areas, the following issues were evaluated to determine potential impacts:

- Are affected resources used by minority or low-income populations?
- Are minority or low-income populations disproportionately subject to adverse environmental, human health, or economic impacts?
- Do the resources affected by the project support subsistence living?

Environmental resources potentially used by minority groups in the study area are terrestrial- and aquatic-related resources. Members of the Yakama Nation and other Tribes outside the immediate area may currently use these resources and would be expected to do so in the future. They may use these resources disproportionately to the total population. The subsistence level of use of renewable natural resources (such as fish, wildlife, and vegetation) by the Yakama Nation or other Tribes in the construction areas and downstream has not been quantified.

4.24.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

No adverse impacts would occur under this alternative.

4.24.2.3 Black Rock Alternative

Construction Impacts

Minor, temporary construction-related impacts to aquatic-related resources have been identified.

Long-Term Impacts

The immediate study area potentially affected by implementation of this alternative has lower percentages of minority and low-income populations than Yakima County. There would be no disproportionate adverse impact to those populations; everyone in the area, especially nearest the construction areas, would be equally affected.

No adverse human health impacts to any human population have been identified.

Other than minor, temporary construction impacts, no adverse impacts to aquatic-related resources have been identified.

While permanent adverse impacts to terrestrial resources have been identified, and wildlife would be affected, there are only limited hunting opportunities in the area for game species, e.g., elk or deer. Thus, the potential impact to subsistence would be negligible.

Overall, potential adverse impacts to minority and low-income populations would be negligible.

4.24.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Minor, temporary construction-related impacts to terrestrial- and aquatic-related resources potentially used for subsistence have been identified.

Long-Term Impacts

The immediate area potentially affected by implementation of the alternative has lower percentages of minority and low-income populations than Kittitas County. There would be no disproportionate adverse impact to those populations; everyone in the area, especially nearest the construction areas, would be equally affected.

No adverse human health impacts to any human population have been identified.

Other than minor, temporary construction impacts, no adverse impacts to terrestrial- and aquatic-related resources have been identified.

This alternative would not have potential adverse impacts to minority and/or low-income populations.

4.24.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Minor, temporary construction-related impacts to terrestrial- and aquatic-related resources potentially used for subsistence have been identified. This alternative

could potentially have disproportionately adverse construction impacts to minority and/or low-income populations.

Long-Term Impacts

Much of the pipeline corridor has high percentages of minority and low-income populations. The actual alignment of the pipeline could disproportionately affect minority and low-income populations.

No adverse human health impacts to any human population have been identified.

Other than minor, temporary construction impacts, no adverse impacts to terrestrial- and aquatic-related resources potentially used for subsistence have been identified.

4.24.2.6 Mitigation

No mitigation would be required for either the Black Rock or Wymer Dam and Reservoir Alternative because no adverse impacts to minority and/or low-income populations have been identified.

The pipeline associated with the Wymer Dam Plus Yakima River Pump Exchange Alternative should be aligned to avoid areas of minority and/or low-income populations.

4.24.2.7 Cumulative Impacts

No cumulative impacts have been identified.

4.25 Unavoidable Adverse Impacts

Unavoidable significant adverse impacts are defined as those that meet the following two criteria:

- There are no reasonably practicable mitigation measures to eliminate the impacts; and
- There are no reasonable alternatives to the proposed project that would meet the purpose and need of the action, eliminate the impact, and not cause other or similar significant adverse impacts.

All the Joint Alternatives involve some in-water construction work at the associated pumping plants. For the Wymer Dam and Reservoir Alternative, the pumping plant is on the Yakima River. For the Wymer Dam Plus Yakima River Pump Exchange Alternative there are two pumping plants, one on the Yakima River and one on the Columbia River. The Black Rock Alternative has one pumping plant on the Columbia River. Construction of all of these pumping

plants involves the installation and removal of coffer dams and dewatering of a small area of the riverbed. These actions would have minor, short-term impacts on aquatic resources at the sites.

Construction of facilities under any of the Joint Alternatives would result in unavoidable impacts associated with the land committed to those facilities. The most significant impacts would be associated with the construction of the dam and reservoir, which are features of all three Joint Alternatives. At Black Rock reservoir, about 8,700 acres of existing vegetation would be lost to dam and reservoir construction, including more than 3,600 acres of shrub-steppe and grassland and several other nonnative cover types. These losses are unavoidable. Nearly 350 acres of other land would be occupied by other project facilities, with the biggest loss of about 280 acres associated with the relocation of SR-24. At the Wymer dam and reservoir site, the losses would total about 1,400 acres, with about 1,200 acres of shrub-steppe and grassland, 54 acres of riparian/wetland habitat, and a variety of other cover types. The same losses would occur under the Wymer Dam Plus Yakima River Pump Exchange Alternative, along with additional losses associated with the pump exchange pumping plants and pipeline. The pipeline would be buried, but installation of it would result in the disturbance of nearly 1,400 acres. The final route has not been determined in detail, but it would extend through urban and rural setting, likely affecting a variety cover types including agriculture and developed land.

Construction of the dams and reservoir may also lead to unavoidable impacts to historic resources. The historic resources present at the damsites would need to be recorded and placed in a repository, if warranted. The Black Rock dam and Wymer dam and saddle dike sites would unavoidably destroy any historic resources present in those areas.

The Joint Alternatives all involve the impoundment of water. Seepage would occur in the vicinity of the dams and reservoirs. Design features would be included in the dams and saddle dike to minimize or control and collect the seepage, but local groundwater tables would be affected, and there is no way to absolutely prevent the seepage from occurring.

With respect to land use and shoreline resources, adverse unavoidable impacts would occur with the Wymer Dam Plus Yakima River Pump Exchange Alternative. It would adversely affect ongoing land uses along the pipeline corridor while it is under construction. These impacts could include the need to relocate residences or other facilities depending upon the final route selected. Uses on the corridor would also be limited to accommodate the need for operation and maintenance access once the pipeline is in place.

The Black Rock Alternative would affect transportation by requiring the need to relocate SR-24. Transportation would also be temporarily affected under all the Joint Alternatives, as some of the proposed pipelines involve construction under

existing roads. The Black Rock Dam and Reservoir Alternative would involve two significant crossings, one of a State route. Minimal impacts would occur with the Wymer Dam and Reservoir Alternative, which involves a single road crossing, while more significant temporary impacts would occur with the Wymer Dam Plus Yakima River Pump Exchange Alternative, which involves multiple road crossings, including a crossing of Interstate 182 and several State routes.

Because all of the Joint Alternatives involve significant amounts of construction activity, they would all result in some short-term increase in construction-related noise and some effects to air quality. Since the sites are, for the most part, in either remote or rural areas, the impacts associated with these increases are not expected to be significant.

The construction of the dams and reservoirs under the Joint Alternatives would alter the visual landscape, and these changes are unavoidable. Black Rock dam and reservoir would be visible from SR-24 and SR-241 and Wymer reservoir would be visible from SR-821 and I-90. For Black Rock dam and reservoir, the changes would dominate the viewscape from vantage points to the east and southeast of the dam and reservoir. For Wymer dam and reservoir, the change in the visual environment will be less striking because the dam and reservoir would be visible from relatively short stretches of SR-821 and I-90, respectively.

4.26 Relationship Between Short-Term and Long-Term Productivity

NEPA requires considering "the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity"(40 CFR 1502.16). Long-term productivity refers to the capability of the land to provide market outputs and amenity values for future decades. The quality of life for future generations is linked to the capability of the land to maintain its productivity.

All Joint Alternatives would implement ground-disturbing activities that would produce short-term effects to soil, water quality, and habitat while providing the long-term benefits in terms of higher instream flows in the Yakima River, improved irrigation and municipal water supply, recreation, and hydropower.

4.27 Irreversible and Irretrievable Commitments of Resources

An irreversible commitment is a permanent resource loss, including the loss of future options. These commitments are removed by an alternative without the option to renew these resources (such as spent time and money). These

commitments usually apply to nonrenewable resources, such as minerals, or to factors that are renewable only over long periods, such as soil productivity. Table 4.58 presents a summary of these commitments.

Table 4.58 Irreversible commitments

Commitment	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Materials, labor, and energy needed to construct the project represented by total project cost	4,500,000,000	1,050,000,000	4,100,000,000
Materials, labor, and energy consumed in maintenance and operation of the project annually represented by total annual O&M	60,170,000	2,980,00	38,013,000
Flow uses during construction	Coffer dams and other temporary disturbances	Coffer dams and other temporary disturbances	Coffer dams and other temporary disturbances

An irretrievable commitment is the loss of use or production of a natural resource for some time. These commitments are used by an alternative. For example, if suitable wildlife habitat being used for a reservoir, habitat growth, or productivity is lost while the land is a reservoir, but at some point in time could be revegetated. These commitments would include any constructed feature of an alternative for the life of that constructed feature. Table 4.59 presents a summary of irretrievable commitments.

Table 4.59 Irretrievable commitments

Commitment	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Direct land uses (total acreages for reservoirs, canals, pumping plants, switchyards, and other above-ground features)	13,000 acres	4,050 acres	1,470 acres
Indirect land uses (total acreages for borrow pits, fill disposal sites, excavation sites and other temporary construction features)	Undetermined at this time	Undetermined at this time	Undetermined at this time
Flow uses during operation	Flows would be diverted from the Columbia River	Flows would be diverted from the Yakima River.	Flows would be diverted from the mouth of the Yakima River rather than from upstream of the Yakima River.

4.28 Environmental Commitments

This list includes the environmental commitments made in the project plan and Draft PR/EIS. Reclamation has the primary responsibility to ensure these commitments are met if an action is implemented.

4.28.1 General

Application would be made to the U.S. Army Corps of Engineers for a permit or an exemption under Section 404 of the Clean Water Act before commencing any work at the damsites, pumping plant intakes, fish bypass outlets, and contractor use areas, as necessary. If necessary, Reclamation would also obtain a Section 401 water quality certification from the Washington State Department of Ecology. A hydraulic project approval permit would be obtained from the Washington State Department of Fish and Wildlife, and any necessary stormwater discharge permits would be acquired. The contractor would be supplied copies of the permits and the associated conditions they would be required to adhere to throughout construction.

All construction activities would comply with applicable EPA, OSHA, and State requirements on quality and control of runoff from the construction site, sediment control, noise control, and safety.

4.28.2 Groundwater Resources

Measures to minimize the impacts from the Black Rock reservoir seepage to the Hanford Site would include blanketing, cutoff walls, grout curtains, drainage tunnels and wells. Some measures would be used to control the direction of the groundwater flow and others would be used to remove and transport the groundwater to a location away from the Hanford Site.

Blanketing would be placed on the south reservoir rim upstream of the dam. The blanket could consist of impervious soils, shotcrete, or geomembrane. Tunnels and drain holes would be placed in the south abutment of the dam. The water collected from these features would be contained in pipelines and not allowed to seep back into the groundwater. A cutoff wall would be located downstream from Black Rock reservoir to block groundwater that has not been collected by the features in the right abutment. This cutoff wall could be up to 400 feet deep and would be underground. Wells would be placed downstream from this structure to collect and deliver the seepage to a location away from the Hanford Site. Other wells would be located downstream from the cutoff wall to collect any groundwater flows that moved around the wall and were not collected by the right abutment features. The wells would be placed such that this groundwater would be pumped from the ground and collected into pipeline or canals to convey it away from the Hanford Site. All groundwater collected by

these features would be conveyed away from the Hanford Site and would be available for consumptive uses such as drinking water, irrigation, and even to supplement streamflows.

4.28.3 Water Quality

Construction activities (such as staging areas and temporary access roads) would be performed in manners that would prevent sedimentation. The contractor would be required to use silt curtains, settling ponds, and other measures to prevent construction site runoff. Wastewater associated with construction activities, such as dewatering excavations, washing equipment or wet sawing, would be kept from directly discharging into surface waterways. Complying with State and local water quality permits would provide the necessary water quality protection.

4.28.4 Vegetation and Wildlife

4.28.4.1 Black Rock Alternative and Wymer Dam and Reservoir Alternative

Wetland and riparian habitats would be created. This would entail constructing dikes in shallow water areas within the reservoir and maintaining adequate water levels for the production of wetland/riparian vegetation.

Wildlife management areas would be established adjacent to the reservoir in areas that would be able to provide suitable wildlife habitat.

Artificial perches would be installed on selected areas adjacent to the new reservoir to provide perches for raptors.

Shrub-steppe habitat would be created, restored, and/or protected such that the amount of shrub-steppe habitat would lead to production of a similar number of habitat units elsewhere within the Yakima River basin.

Plant surveys for threatened and endangered species would be conducted, and any species discovered would be protected.

Areas disturbed by construction activities would be revegetated.

4.28.4.2 Wymer Dam Plus Yakima River Pump Exchange Alternative

Pipelines would be buried underground, and native vegetation along the pipeline corridor would be restored. Vegetation maintenance and monitoring plans would be developed.

Any above-ground structures would be located in areas that would cause minimal disturbance to wildlife and associated habitats.

Areas disturbed by construction activities would be revegetated.

4.28.5 Anadromous and Resident Fish

The following measures would be implemented to reduce short-term impacts of construction activities to fishery resources:

- Implement construction BMPs to avoid and minimize potential construction impacts, including erosion and sedimentation, accidental and incidental discharge of pollutants (Spill Prevention, Containment, and Control Plan), and dewatering and discharge of dewatering water.
- Prior to complete dewatering of coffer dams, fishery personnel would salvage all fishes using the most appropriate capture gear and methods.
- Provide treatment of construction dewatering discharges, such as sediment removal or filtration, as necessary, before the release of such water to wetlands or streams.
- Comply with applicable Federal, State, and local environmental regulations to mitigate potential impacts to sensitive areas, including streams, buffers, and wetlands.
- Restore disturbed areas to the maximum extent possible.
- Construction work windows for special-status fish would be followed as required by State and Federal agencies such as Washington Department of Fish and Wildlife, NOAA Fisheries, and/or the U.S. Fish and Wildlife Service to avoid critical periods (i.e., breeding/spawning, migration).

4.28.6 Threatened and Endangered Species

4.28.6.1 Black Rock Alternative

Mitigation measures under the Black Rock Alternative could include the following:

- Perform botanical surveys in areas proposed for disturbance and relocation of sensitive species.
- Establish a wildlife management area adjacent to the reservoir.
- Bury pipelines underground and restore native vegetation along the corridor.
- Compensate for shrub-steppe losses by converting agricultural lands to shrub-steppe or enhancing degraded shrub-steppe habitat adjacent to the study area or at an offsite location where it would be more beneficial.
- Control nonnative invasive plant species.

4.28.6.2 Wymer Dam and Reservoir Alternative

Mitigation measures under the Wymer Dam and Reservoir Alternative would be the same as under the Black Rock Alternative.

4.28.6.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

Mitigation measures under the Wymer Dam Plus Yakima River Pump Exchange Alternative would be the same as under the Black Rock Alternative.

4.28.7 Land Use and Shoreline Resources

4.28.7.1 Black Rock Alternative

Impacted landowners would be compensated at fair market value according to established Federal regulations, guidelines, and procedures.

Additional mitigation potential, to be explored during more detailed studies (especially for conveyance routes), would include the following:

- Avoid dislocation of, or significant proximity impacts on, existing residences or other major structures to the maximum extent feasible.
- Align conveyances along existing roads and/or property lines to the maximum extent feasible.
- Minimize construction-phase disruption to existing land uses (especially related to construction duration and access/circulation).

4.28.7.2 Wymer Dam and Reservoir Alternative

Impacted private landowners would be compensated at fair market value according to established Federal guidelines, standards, and procedures. Additional mitigation potential, to be explored during more detailed studies (especially for conveyance routes), would include the following:

- Avoid dislocation of the existing residence east of the State highway, if feasible.
- Work with the landowner to accommodate agriculture in conveyance and transmission corridors, if desired.
- Use architectural treatments and landscape screening to blend facilities with the surrounding landscape. (See the “Visual Quality” section.)

4.28.7.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

More detailed studies would be conducted of pipeline and transmission line routing options exploring opportunities for avoiding direct or dislocation impacts

on existing residences and businesses to the maximum extent feasible. Such detailed routing studies would also seek opportunities to minimize long-term impacts on existing developed uses in the urban environments of Richland, Kennewick, and West Richland. Beyond such site/alignment adjustments during detailed planning, mitigation would focus primarily on compensating impacted landowners at fair market value according to established Federal guidelines, standards, and procedures.

4.28.8 Public Services

Mitigation for short-term, construction-phase impacts on public services and utilities would involve close coordination with involved service providers, as well as with potentially impacted local residents/landowners. In this regard, the following objectives would be met during detailed implementation planning (resulting in no significant residual impacts):

- Retain appropriate access throughout construction zones and throughout the construction period for law enforcement, fire protection and emergency medical/transportation service providers.
- Where local utility system connections/installations would be impacted by construction activities, plan for and implement alternative/relocated connections and facilities prior to construction (i.e., avoid service disruptions).
- Either (1) accomplish the above two measures at no cost to affected service providers and/or residents and landowners or (2) provide compensation to offset additional costs incurred.

4.28.9 Transportation

4.28.9.1 Black Rock Alternative

Further discussion with the State Department of Transportation and local residents would be done to explore the feasibility of relocating SR-24 to the north versus south side of Black Rock Valley, as a means of mitigating design speed, gradient, winter travel and local parcel access concerns associated with proposed route.

Potential adjustment of new conveyance pipeline routes to minimize necessary road crossings and other disruptions to local traffic patterns and access routes would be considered.

Coordination with State and local transportation agencies and potentially impacted neighborhoods and landowners would be done in preparing construction transportation management plans. Objectives would include:

- Specifying material haul routes and construction traffic patterns which minimize local traffic impacts.
- Phasing construction to minimize the duration of necessary temporary road closures and detours.

4.28.9.2 Wymer Dam and Reservoir Alternative

More detailed planning would be done to address questions of haul route and overall traffic direction and magnitude (e.g., east versus west) and, thus, potential traffic and road impacts in Ellensburg, Selah, or Yakima. Coordination with the State Department of Transportation would be required to properly plan for construction on, and any potential traffic flow disruptions along, SR-821.

4.28.9.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

Efforts to mitigate impacts would focus on the following:

- Close coordination with involved transportation agencies in obtaining necessary permits and preparing plans and schedules for crossings of highways and roads.
- Close coordination and cooperation with involved railroad companies related to construction within the railroad ROW.
- Potential adjustment of pipeline route to minimize necessary road crossings and other disruptions to local traffic patterns and access routes.
- Coordination with involved transportation agencies and potentially impacted neighborhoods and landowners, as appropriate, in preparing construction transportation management plans. Objectives would include the following:
    - Specifying material haul routes and construction traffic patterns which minimize local traffic impacts.
    - Phasing construction to minimize the duration of necessary temporary road closures and detours.

4.28.10 Air Quality

Emissions from off-road construction equipment and particulate concentrations are expected to exceed the General Conformity *de minimis* thresholds for each year of construction. Therefore, additional mitigation would be applied to the emission sources. Such mitigation would include:

- Use of emulsified or aqueous diesel fuel.

- Use of equipment with engines that incorporate exhaust gas recirculation systems.
- Installation of a lean NO_x catalyst in the engine exhaust system.
- Wet suppression and soil stabilization.
- Wind fencing around the active area.
- Paving onsite roadways.
- Truck wheel washing facilities at site exits on public roadways.
- Maintaining minimal truck bed freeboard or covering haul truck beds.
- Compliance with all local, State, and Federal air quality regulations.

4.28.11 Visual Resources

4.28.11.1 Black Rock Alternative

Available mitigation for visual impacts of Black Rock facilities would focus on (1) architectural treatments and landscape screening at the intake and fish screen, Black Rock outlet/powerplant, and Sunnyside powerplant/bypass facilities, and (2) vegetation restoration and management in the pipeline and transmission line easements/ROW.

In the first regard, building exterior colors that blend with the surrounding environment and planting of appropriate landscape screening would be done. The same mitigation measures would also be applicable to outlet works and other appurtenant facilities at Black Rock dam.

In the pipeline and transmission line easements/ROW, vegetation consistent with the surrounding environment would be used and maintained.

4.28.11.2 Wymer Dam and Reservoir Alternative

Treatments similar to those for the Black Rock facilities in terms of building colors and landscaping would be used.

In the pipeline and transmission line easements/ROW, vegetation consistent with the surrounding environment would be used and maintained.

4.28.11.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

Treatments similar to those for the Black Rock facilities in terms of building colors and landscaping would be used.

In the pipeline and transmission line easements/ROW, vegetation consistent with the surrounding environment would be used and maintained.

4.28.12 Historic Properties

Mitigation of historic resources is data recovery or archeological excavation, preservation, conservation, and interpretation of significant historic properties from direct and indirect impacts from a construction project. Specific mitigation measures cannot be developed and implemented until a preferred alternative is selected and a Class III field survey has been conducted and reported. The Class III survey for any of the Joint Alternatives can be reasonably estimated to take at least 1 year.

A typical scenario for mitigation of a group of historic resources would be as follows:

- Identify the significant historic properties that cannot be avoided during project construction and development.
- Consult with the SHPO and ACHP that historic properties are eligible for the NRHP. Consultation may also occur with American Indian Tribes, other Federal agencies, and public entities.
- Develop an MOA among Reclamation, SHPO, and ACHP over mitigation measures. MOA signatories may also include Tribes, other Federal agencies, and public entities.
- The MOA will include a research and data recovery plan, stipulations for permanent storage and curation of recovered material, and provisions for sharing the results of the data recovery phase with the public; for example, interpretive facilities. The goal is to identify and implement a range of measures to record and preserve in some manner the record of historic resources effected by the project. Mitigation of historic properties can involve data recovery, or large-scale archeological excavations, a program of monitoring of project effects, development of interpretive facilities and public educational opportunities, or a mix of those measures.
- The MOA may also include goals for long-term historic properties management and monitoring.

The period for developing, implementing and completing mitigation measures can take an estimated 2 years for any of the Joint Alternatives. However, certain activities may last for many years, if not decades, beyond completion of the Alternative. Museum storage and curation costs, monitoring activities, and management of historic resources in the development footprint not

impacted directly by project construction, are examples of some common long-term activities which have attendant costs.

4.28.13 Indian Sacred Sites

Mitigation to offset project impacts to access to sacred sites has few precedents or standard treatments. Any focus on American Indian sacred sites is complicated by the very nature of the discussion, which is perceived by some, if not most, American Indian Tribes as outside the greater public sphere. EO 13007 allows Government-to-Government consultation between a Federal agency and the affected Tribe(s), which will occur if mitigation in this particular category is at issue if one of the Joint Alternatives is selected.

4.28.14 Public Health

4.28.14.1 Hazardous and Toxic Materials

As property is identified for acquisition, Reclamation would conduct an Environmental Site Survey. Remediation for any materials or potential effects of hazardous substances would be conducted prior to final implementation. For all constructed facilities, Reclamation would comply with environmental regulations pertaining to hazardous waste management and develop a SPCC where required.

4.28.14.2 Mosquitoes

Reclamation would:

- Conduct baseline mosquito surveillance and control program, including a monitoring program for mosquito larvae.
- Ensure final design of project facilities are designed in consultation with experts in mosquito biology and control to prevent as much mosquito production as possible and to facilitate proper functioning and maintenance in the future. Appropriate operations and maintenance provisions would include considerations for routine monitoring and control of mosquito populations.
- Consult and coordinate with local health departments and mosquito and abatement districts about mosquito control measures during the design, implementation, and operations phases of the project.
- Prepare a mitigation monitoring plan to ensure that the proposed mitigation measures are implemented.

The construction contractors would be required to:

- Develop and implement mosquito abatement measures for control including stormwater management, reducing opportunities for mosquito-breeding habitats in construction materials and facilities, management of vegetation that may be conducive to mosquito habitat, site maintenance to prevent topographical depressions and ponding, monitoring, and adult mosquito control.

- Consult with local health departments and mosquito and abatement districts to discuss design or control measures to inhibit mosquito-breeding and stormwater practices.

- Monitor access routes to detect formation of undrained depressions in tire ruts. Backfill access-related shallow depressions or incise narrow drainages so they do not impound small, sheltered areas of standing water.

- Ensure any artificial depressions capable of holding water for a period greater than 7 days are rectified by filling, draining, or other treatment to prevent the creation of mosquito-breeding sites.

- Optimize drainage.

- Keep discharge of test water to a practical minimum and prevent long-term pooling.

- Avoid water storage open to ingress of insects wherever possible. When open storage is necessary, the duration would be kept to a minimum and ensure proper mosquito-control treatment.

- Inform workers during the worker education program of the potential for increases in mosquito breeding populations and of the appropriate precautions to take to protect their health, including requiring personnel to wear long sleeve shirts and long trousers and use insect repellent. Provide insect repellent.