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MEMORANDUM

Project No.: 090045-001-05

April 26, 2010

To: Rick Roeder, Washington Department of Ecology Office of the Columbia River

cc: Dave McClure, Klickitat County; Adam Fyall, Benton County; Bruce Beauchene, City of Kennewick; WRIA 31 Planning and Advisory Committee

From: Tim Flynn and Steve Germiat, Aspect Consulting LLC
Bob Montgomery, David Rice, and Carmen Andonaegui, Anchor QEA LLC

Re: **Briefing Memorandum: WRIA 31 Water Storage Project**
Ecology Grant No. G0900153

This memorandum outlines the WRIA 31 Planning Advisory Committee's (PAC) preferred alternative for a water storage project to develop new supplies of water within WRIA 31. The WRIA 31 Planning Unit's vision for its Watershed Management Plan (WMP) includes the statement: "Implementation of this plan will provide dependable and high quality water supplies for our communities, economies, and natural environment". To that end, a high priority recommendation of the WMP is to develop water storage within WRIA 31 to address multipurpose water demands identified in the planning process. Identified strategies in the WMP consider both surface (e.g. surface reservoir) and groundwater (e.g. aquifer storage and recovery) storage to meet this need.

The area of WRIA 31 with the greatest total water demand, and which also could achieve the greatest economic growth if new water supplies were made available, is the Wood-Glade Planning Area – the broad agricultural center of the watershed. The Wood-Glade Planning Area is more commonly known by the local community as the Horse Heaven, an approximately 1,200 square mile area bounded by the crest of the Horse Heaven Hills on the north and east, the shoreline of the Columbia River on the south, and the Rock Creek watershed on the west.

There are many interruptible water rights within the Horse Heaven, comprising roughly 50,000 acre-feet/year in total. In addition, there has been substantial overdraft of groundwater supplies from the Wanapum Basalt aquifer system in the western portion of the area, requiring well deepening and greatly increasing pumping costs. Finally, potential changes in climate and/or agricultural markets may also reduce the viability of dry land farming, which may necessitate a transition toward additional irrigation. Any and all of these water-supply-related factors may threaten the viability of the region's existing agricultural economy. Surplus pump station and conveyance capacity also exists in WRIA 31, which could allow for cost effective expansion of irrigated agriculture if new water rights were made available through a storage project.

A water storage project may also provide opportunities to enhance streamflows in the WRIA's intermittent tributaries, some of which are designated as critical habitat. A source of additional cooler water in these tributaries may provide thermal refuge along the Columbia River mainstem, benefiting migrating salmonid stocks. It is possible that a water storage project in the Horse Heaven could help meet demands both within and beyond the geographic area that comprises WRIA 31.

Under its legislative mandate to "aggressively pursue the development of water supplies to benefit both instream and out-of-stream use", Ecology has provided funding from the Columbia River Basin Water Supply Development Account to the WRIA 31 PAC for a Pre-Feasibility Water Storage Assessment (Ecology grant G0900153) . The objective of the Pre-Feasibility Assessment is assess a range of applicable water storage alternatives to meet defined out-of-stream and instream demands, and select a preferred alternative that can move forward for feasibility study and conceptual design. The preferred water storage alternative presented here is the outcome of the WRIA 31 Pre-Feasibility Storage Assessment.

Following this introduction, the memorandum includes the following sections:

- Proposed Water Storage Project;
- Benefits of Project;
- Fatal Flaw Analysis;
- Planning-Level Project Cost Estimates

Proposed Water Storage Project

Following screening of numerous water storage alternatives, and extensive discussions and meetings with the PAC, a water storage subcommittee of the PAC, and other local stakeholders, the preferred WRIA 31 water storage project to be further evaluated in an FS consists of three primary elements, which are illustrated on Figure 1:

1. **Switzler Reservoir:** an in-channel reservoir in the lower reaches of Switzler Canyon, a tributary to McNary Pool, with an estimated total storage capacity of roughly 44,000 acre-feet;

2. **Alder Reservoir:** an in-channel reservoir in the lower reaches of Alder Creek, a tributary to John Day Pool, with an estimated total storage capacity of roughly 56,000 acre-feet; and

3. **Aquifer Storage and Recovery (ASR) in the western study area**. The annual storage capacity for ASR is unknown but, given exceptionally high well yields and groundwater declines of up to 250 feet, we expect that the Wanapum Basalt aquifer in the western part of the Horse Heaven can provide substantial subsurface storage capacity. The localized large water level declines appear to result, in part, from geologic structures creating groundwater flow barriers; these same barriers could be a

benefit for creating a viable subsurface reservoir. Overall, the western portion of the Horse Heaven appears to be a prime candidate for further evaluating the feasibility of applying ASR in the Columbia River Basalts, and using the stored water for irrigation supply.

Under the preferred project, Columbia River water would be diverted and pumped to storage in the surface and subsurface reservoirs predominantly during the non-irrigation season. For this, existing pump station and conveyance infrastructure would be used to the maximum extent practical in terms of physical suitability, cost effectiveness (compared to new construction), and owner willingness to participate.

During the irrigation season, water stored in the Switzler and Alder reservoirs would be released back to the Columbia River or directly pumped from the reservoir by nearby users. The stored water provides a new seasonal water supply to mitigate for interruptible water rights during drought years (sustaining current agriculture) and/or for new water rights (expanding the agricultural economy). Water released from the Alder reservoir would mitigate for diversions from John Day Pool or any downstream reach of the mainstem. Water released from the Switzler reservoir would mitigate for diversions from McNary Pool, John Day Pool, or any downstream reach of the mainstem.

The released water, drawn from the deepest part of each reservoir, would also augment instream flows below the reservoir for aquatic habitat benefit within the tributary stream and the mainstem. The release would be controlled so as to not erode or otherwise impact the stream channel below the reservoir, which may require releasing a portion of the water via pipeline back to the mainstem Columbia River, bypassing the stream channel.

During the irrigation season, the stored ASR water would be recovered (pumped) for beneficial use in one or more ways. The recovered water could be distributed directly to nearby farms, or potentially could be released back to the Columbia River via stream channel(s) (perhaps via the Alder reservoir) under the same mitigation concept as described for the surface reservoirs. If water were released from an ASR wellfield in the western study area, it would mitigate for diversions from John Day Pool or any downstream reach of the mainstem.

The preferred project would provide a substantial new water supply that can be accessed for out-of-stream or instream use anywhere within WRIA 31 or in WRIAs downstream of it, via diversion from the Columbia River (subject to economic constraints of pumping from the river to points of use). The project involves putting water into storage, and establishing mitigated water rights for use of the stored water. Distribution and use of the stored water, i.e. exercising the mitigation water rights, is outside of the project. However, there is surplus capacity in existing irrigation infrastructure within the watershed that could assist in distribution to new acreage. The details regarding administration of the storage project, including allocation of the stored water, would be defined as part of a subsequent feasibility study.

Benefits of Project

The WMP identifies four general priorities for developing additional water supplies that are applicable to the Horse Heaven:

1. Replacing non-sustainable groundwater withdrawals for irrigation;
2. "Shoring up" interruptible water rights;
3. Economic development principally through expansion of higher-value (irrigated) agriculture; and
4. Improving instream conditions for aquatic habitat.

Priorities 1 and 2 are aimed at sustaining the existing level of irrigated agriculture, whereas Priority 3 supports economic growth for the region. Priority 4 provides for instream benefits in balance with out-of-stream benefits achieved under the other three priorities, in accordance with the WMP.

The preferred storage project is large – roughly 100,000 acre-feet of storage estimated – and can meet at least three of the four WMP priorities. The identified project benefits are briefly summarized as follows:

1. **Sustain existing groundwater-supplied irrigation** by using ASR and potentially source exchange (using stored surface water in lieu of groundwater) to reverse the ongoing groundwater overdraft. Both storage methods would reduce the net groundwater withdrawal from the Wanapum aquifer: ASR by increasing aquifer recharge and source exchange by reducing groundwater withdrawal. In both cases, the net volume of groundwater withdrawal from the aquifer is brought back toward balance with the volume of natural recharge to the aquifer. At this point, ASR is assumed to occur in the western Horse Heaven where large declines have occurred. If ASR is successful there, it could be evaluated for expansion throughout WRIA 31 and more broadly within the Columbia River basin.

2. **Address interruptible water rights** by providing mitigation water to offset (1:1) consumptive use under those rights during times when Columbia River instream flow minimums are not met. Based on the Department of Ecology's Water Right Tracking System (WRTS), we estimate that WRIA 31 water rights interruptible under Chapter 173-563 WAC total roughly 50,000 acre-feet/year. In addition, the Quad Cities water right is an interruptible permit (96,619 acre-feet/year) subject to instream flow minimums dictated by the National Marine Fisheries' (NMFS) biological opinion (BiOp). The proposed storage project is large enough to address all WRIA 31 water rights interruptible as per Chapter 173-563 WAC, plus provide mitigation water (from Switzler reservoir) for a portion of the Quad Cities water right.

3. **Achieve regional economic development** by making available new irrigation water supplies that would allow additional higher-value crop acreage to be brought into production. Economic growth in WRIA 31 will be achieved largely through growth

in agriculture, specifically higher-value crops that rely on irrigation. The Horse Heaven supports a diverse range of crops, and is Washington's newest American Viticultural Area (AVA). There are tens of thousands of irrigable acres in the Horse Heaven that could be brought into production if additional water was available at a reasonable cost. The economic benefit to the state from expanded agricultural development in the Horse Heaven is uncertain, but was previously assessed in Washington State University's 1970 multidisciplinary study entitled "Horse Heaven Hill Irrigation and Development Potential". The study concluded that the Horse Heaven contains about 10% of all irrigable land in the state, and estimated that gross agricultural income could increase by more than $60 million/year for partial irrigation expansion to more than $600 million/year for irrigation of all irrigable acres. Further employment in the region would also be achieved with introduction of processing plants and supporting service and trade businesses. WSU's 1970 study, while outdated now and evaluating larger-scale irrigation expansion than the preferred project by itself would provide for, nonetheless provides useful perspective on the magnitude of economic benefit to the state from agricultural development in the Horse Heaven.

4. **Improving aquatic habitat** within the lowermost reaches of Alder Creek and Switzler Canyon, downstream of the proposed reservoirs, including creating thermal refuge for migrating salmonids in the mainstem. Construction of in-channel storage reservoirs could provide year-round flow in the lowermost reaches of these naturally intermittent streams, and the release quantity and timing could be controlled to optimize habitat benefit. Subject to natural constraints, in-channel habitat improvements could also be designed and constructed to establish channel gradients, meander configurations, and instream structure conducive to successful juvenile salmonid rearing and adult spawning habitat downstream of the reservoir. In addition, the released water would marginally improve instream flows in the mainstem Columbia River during the critical months of July and August.

5. **Maximizing use of existing irrigation infrastructure** to most cost effectively bring new acreage into production of high-value crops. Discussions with irrigators across the watershed confirm that existing river pump station/conveyance systems have surplus capacity now, or that additional capacity could be added at relatively low incremental cost. While this project only addresses making available new water rights by placing water in storage, it appears that economic development by exercising those new rights could be accomplished cost effectively. How the new water supply would be allocated could be complicated, and therefore would be a topic for a subsequent feasibility study.

Fatal Flaw Analysis

Based on the available information assembled during the Pre-Feasibility Assessment, no fatal flaws are currently identified for the preferred storage project. Because of additional time and effort spent working with stakeholders to establish the preferred storage alternative, the level of detailed evaluation anticipated in the Ecology grant has not been completed. However, analysis of potential fatal flaws has been completed, focusing on water availability from the Columbia River, permitting (e.g., habitat), and geologic suitability of the two surface reservoir sites, as presented below.

The fatal flaw analysis did shape the preferred storage alternative, most importantly by reducing the proposed size of the Alder reservoir from that initially considered by the Bureau of Reclamation (Reclamation) in their 2005 appraisal evaluation of Columbia River mainstem off-channel storage options (330,000 acre-feet). The main dam for the reservoir initially proposed by Reclamation would have been positioned at river mile 1, and would therefore inundate all but the lower mile of Alder Creek including the area of perennial flow supplied by a major spring ("Sally Spring") as well as several miles of Six Prong Creek, a major tributary to Alder Creek which reportedly contains 18 acres of wetlands. The reservoir initially proposed by Reclamation would also inundate and require relocation of a couple miles of Alderdale Road and several miles of a regional natural gas pipeline, which would further increase permitting challenges, project costs, and potentially public resistance to the project. Because of anticipated difficulty and costs to mitigate for expected habitat impacts, and relocate substantial portions of major utilities, it was therefore decided to include in the preferred storage alternative a smaller (56,000 acre-feet) version of the Alder reservoir, with the main dam located further upstream to reduce impacts and mitigation costs.

Water Availability to Store

In the preferred project, Columbia River water would be diverted and pumped to storage in the surface and subsurface reservoirs predominately during the non-irrigation season (assumed to be November 1 to March 31). An analysis was completed to determine the amount of Columbia River water that would be available for pumping during the non-irrigation season.

For this analysis, Columbia River water is assumed to be available after instream flows are met. Minimum instream flows have been set by the State of Washington for the Columbia River for use in protecting instream values and regulating water rights. Those flows are described in chapter 173-563 WAC, which was implemented in 1980. Target flows were also agreed upon by federal agencies as part of the 2004 BiOp for the Federal Columbia River Power System (FCRPS). The target flows facilitate spawning and downstream passage of juveniles and accommodate returning adult salmon and steelhead. These flows are tabulated in Table 1.

Due to the dates Columbia River water is assumed to be diverted by the preferred project, the Bonneville BiOp target flows control the water available for pumping. For this preliminary analysis, it was assumed that the highest BiOp flow target (160,000 cfs) is required for the duration of the time pumping to storage will take place (November 1 to March 31). It was also assumed that all other Columbia River water demand requirements have already been met and have been removed from the observed flow below Bonneville Dam. Figure 2 and Table 2 show the estimated volumes of water available in the Columbia River from November 1 to March 31 based on the average flow measured below Bonneville Dam from 1971 to 2000.

Permitting

Implementation of a water storage project, particularly one involving in-channel reservoirs, would involve substantial project review including an environmental impact statement (EIS) and would require multiple permits. For a project to be permittable, adverse environmental impacts would need to be fully mitigated to achieve a net environmental benefit, particularly in terms of instream habitat function and value.

Environmental

Instream habitat conditions in Alder Creek and particularly in Switzler Canyon are not well documented. Landowner permission was not granted to collect instream habitat information in Alder Creek during the 2009 WRIA 31 instream habitat assessment, and Switzler Canyon was not surveyed. Both drainages are intermittent, excluding the lower mile of Alder Creek in which a small volume of perennial flow is sustained by a spring (Sally Spring). Potential salmonid spawning and rearing habitat has been reported in Alder Creek from its mouth upstream to Six Prong Creek. In 2005, NOAA Fisheries designated habitat in the lower three miles of Alder Creek as critical habitat for the recovery of Mid-Columbia Steelhead; Switzler Canyon was not designated as such. Alder Creek is also considered by the Interior Columbia Basin Technical Recovery Team (ICTRT) to provide spawning habitat for the Umatilla Steelhead Distinct Population Segment (DPS); Switzler Canyon was not so designated. Known presence of steelhead in Alder Creek and Switzler Canyon has not been documented. Steelhead adults have reportedly been observed in the lower 1.5 miles of Alder Creek.

To mitigate for lost habitat as a result of in-channel reservoir construction and inundation, and to achieve a net benefit for aquatic species, the project could include habitat improvements downstream of the reservoirs. In addition to flow augmentation, habitat improvement projects could include construction of channel meanders, revegetation, and features such as side channels and instream structure to create habitat complexity. In this way, the quantity of habitat lost as a result of inundation could be replaced and the quality of habitat in the mile or more of channel downstream of the reservoirs could be markedly improved. As part of the permitting process, resource agencies and tribal governments would be consulted regarding habitat-related actions. No fatal flaw is identified at this time regarding environmental permitting.

Water Rights/Dam Safety

No fatal flaws are identified with respect to water right permits or dam safety permits for the project. The preferred project would require a new primary water right to seasonally divert Columbia River water to the storage reservoirs (surface and subsurface [ASR]). The permit would identify the points of diversion, the use of storage, and would authorize beneficial use of the stored water. A reservoir permit to store water in each reservoir would also be required.

For the project to be viable, it would only pump water into storage when Columbia River water is available for diversion, it would not impair existing water rights or instream flows and would fully mitigate for adverse environmental impacts, and it would not be contrary to the public interest. At this point, it is expected that, through communications with Ecology, resource agencies, and tribal governments, this can be accomplished. Therefore, no fatal flaw is identified for obtaining necessary water rights for the project.

The surface reservoirs would be designed to comply with dam safety requirements, thus obtaining a Dam Safety Permit is not considered a fatal flaw for the project.

Geologic Suitability for Reservoirs

Based on available information, no fatal flaws are identified with respect to geologic suitability of the in-channel reservoir sites, but more detailed site-specific assessment of each reservoir site is warranted in a feasibility study. Likewise, more detailed hydrogeologic assessment is warranted to ascertain the technical feasibility for ASR and potentially site prospective ASR wells. Pertinent information regarding suitability of surface reservoir sites is presented below.

Alder Reservoir

Within the area of the proposed Alder reservoir, the Alder Creek canyon is incised through bedrock predominantly consisting of the Pomona member of the Saddle Mountains Basalt (per DNR 1:100,000 geologic mapping). Overlying the Pomona member, the younger Elephant Mountain member of the Saddle Mountains occurs around the perimeter of the reservoir's lower extent. Within the reservoir footprint, the basalt members are comprised of one or more individual basalt flows separated by permeable interflow zones that typically transmit water readily. The available geologic mapping is not detailed enough to identify individual flows and interflows within each basalt member. At a minimum, an interflow zone exists at the contact between basalt members.

Regionally, the two basalt members are separated by the Selah sedimentary interbed, which can vary from fine-grained siltstone to more coarse-grained sandstone and conglomerate. However, no sedimentary interbed units (Ellensburg Formation) are mapped on the valley walls in or around the Alder reservoir area. A veneer of recent alluvium is present along Alder Creek in the valley bottom. On the uplands outside of the reservoir footprint, the bedrock is overlain by geologically younger Touchet Beds (silt and sand) and Pasco Gravel.

Of particular note within the reservoir footprint are the mass wasting (landslide) deposits mapped across larger areas of the valley walls. The Selah interbed is probably responsible for the extensive low-angle landside deposits. These sedimentary interbeds can contain a high clay/silt content and can be unstable when saturated. Driller's logs for wells closest to the Alder reservoir indicate the interbeds are predominantly clay, sometimes referenced as "caving". Although the landslides may have originated during extensive wetter climates (early Holocene), they are a potential issue for reservoir construction.

No geologic folds or faults are mapped in the immediate vicinity of the reservoir, but thrust faults are extensively mapped elsewhere in the Columbia Hills south of the reservoir. Regional studies suggest that some of the faults in the Yakima Fold Belt remain active (Holocene age with potential to reactivate).

Switzler Reservoir

Within the area of the proposed Switzler reservoir, Switzler Canyon is incised through geologically older basalt bedrock than observed in Alder Creek. The valley bottom is incised into the Frenchman Springs Member of the Wanapum Basalt, which is overlain unconformably by the Umatilla Member of the Saddle Mountains Basalt. The intervening Pomona and Elephant Mountain Members of the Saddle Mountains Basalt are not mapped, which if accurate indicates an erosional unconformity in the geologic record. The available geologic mapping is not detailed enough to identify individual flows and interflows within each basalt member but, at a minimum, an interflow zone exists at the contact between basalt members.

No sedimentary interbeds are mapped between the basalt members. Driller's logs for the few wells drilled near Switzler Canyon indicate sedimentary interbeds are present, but they are thinner and less prevalent than observed in wells within the Alder Creek drainage. Outside of the canyon, the uplands are capped with loess (wind-blown silt), a small area of which lies within the reservoir footprint. The mapping indicates no significant alluvium in the valley bottom, and only one small area of landslide deposits on the eastern valley wall.

No geologic structures (folds or faults) are mapped in the vicinity of the Switzler reservoir, but smaller-scale structures (unmapped) are possible given the geologic complexity of the region.

Hydrogeologic Suitability for ASR

Available hydrogeologic information assembled during the watershed planning process indicates that highly productive aquifers exist within the western portion of the Horse Heaven, where ASR is proposed as part of the preferred storage project. Specifically, the Wanapum Basalt aquifer is known to supply very high well yields (2000+ gpm) for irrigation supply across this area. Over the past 30 years, the Wanapum Basalt aquifer in this area has experienced large water level declines (up to 250 feet), which has necessitated well deepening and increased pumping costs. The USGS' 1996 modeling study of the Horse Heaven inferred, based on mapping of water levels and geologic contacts, that there are geologic faults, oriented northeast-southwest, that act as subsurface barriers to lateral groundwater flow in the basalt aquifers. Such faults are not mapped by DNR. The location of the inferred barrier faults, which would divide the Wanapum aquifer into "blocks", is consistent with the pattern of groundwater level declines observed. Without such barriers, we expect that groundwater would flow more readily in the aquifer toward the pumping centers and dampen the magnitude of drawdown.

The large water level declines indicate that, at a minimum, a substantial subsurface storage volume would be available by replenishing those declines. The same barriers that appear to limit groundwater replenishment to the pumping centers should help form an effective subsurface reservoir in which to store artificially recharged water. The highly productive aquifer in this area should be capable of high rates of groundwater recharge and recovery. As such, it appears that ASR would be technically feasible, from a hydrogeologic standpoint, in the western Horse Heaven.

The greatest aquifer depletion in the western Horse Heaven occurs over a relatively wide area, spanning about 5 to 18 miles from the Columbia River. Pumping river water to the higher elevation areas at distance from the river, for direct use or for ASR, is likely not economical currently. However, if the fault-bounded Wanapum aquifer block concept is proven, it may be possible to recharge the aquifer block at a lower elevation location nearer the river, where conveyance and injection of river water would be more economical, and achieve a water level increase (pressurization) throughout the block including at greater distances from the river. Groundwater within an aquifer block should be able to flow laterally toward pumping wells within the same block, so recharging a block should slow or potentially reverse further water level decline in response to the current rate of withdrawal. Since an aquifer block would represent a distinct body of public groundwater, the recharge and recovery could occur at different locations in the block, subject to approval by Ecology.

A Ranney well would be constructed in the Columbia River gravels as the supply source for water to be stored in an ASR project. In addition to providing high capacity, the Ranney well provides for filtration through the gravels to remove suspended sediment and bacteria necessary to avoid ASR well clogging and meet groundwater quality standards for injection without additional treatment (disinfection). The City of Kennewick, an initiating government for WRIA 31 watershed planning process, operates Ranney wells for part of its water supply and has considerable knowledge regarding their water quality performance.

Conclusion from Fatal Flaw Analysis

No fatal flaws are currently identified with the WRIA 31 preferred water storage project. However, a more detailed feasibility study is necessary to better define the technical, permitting, and economic feasibility of the project.

Planning-Level Project Cost Estimates ($/Acre-Foot Stored)

A planning level opinion of the probable capital costs associated with the preferred water storage project was developed in terms of 2010 dollars/acre-foot of annual storage capacity. An opinion of long-term project costs, including power costs (for pumping), operations and maintenance costs, and loan repayment was also developed in terms of 2010 dollars/acre-foot of annual storage capacity. The planning level opinion of probable costs only addresses placing water into storage; it does not include pumping and delivery improvements needed to distribute water from the Columbia River or storage locations to irrigators for use.

Project capital costs were evaluated in two ways. First, the project costs were evaluated assuming that existing irrigation systems would be used, to the extent possible, for pumping and conveyance of water from the Columbia River to surface water storage and ASR locations. This assumes that operators of suitable existing irrigation systems would make their systems available to pump water to storage during the non-irrigation season as part of the preferred project, which is not known at this preliminary stage[a]. Therefore, project costs

[a] As part of the pre-feasibility study, initial discussions have been held with existing irrigators (river pumpers) regarding the project and potential of use of existing infrastructure to reduce capital costs. While there has been interest in the project, there has been no commitment by any irrigator to participate in the

were also evaluated assuming that all new pumping and conveyance facilities would be installed to deliver water from the Columbia River to storage locations.

The planning-level costs conservatively assume that the surface reservoirs are filled entirely with water pumped from the Columbia River. Capture of natural stream discharge in each stream is not considered, which may slightly overstate pumping costs. It is likely that only flood water could be captured and retained in a reservoir as most flow entering the reservoir would likely need to be released to maintain downstream hydrologic conditions. Natural discharge contribution to each reservoir would be evaluated as part of a feasibility study.

Table 3 provides a summary of the costs of each component of the preferred water storage project. The following summarizes the facilities and improvements identified for each component of the preferred water storage project and the key assumptions used to develop the preliminary opinion of costs for the project. The approximate locations of existing river pump stations and mainline piping from the pump stations considered in this cost analysis are shown on Figure 1.

West Surface Storage (Alder Reservoir)

As was noted previously, surface water storage would be created in the western study area by constructing a dam across the lower portion of Alder Creek. The proposed storage reservoir would have an estimated capacity of approximately 56,000 acre-feet and would have a high water surface elevation (WSEL) of approximately 680 feet. The reservoir would be filled by pumping and conveying water from the Columbia River, John Day pool.

The following conveyance and pumping improvements were identified, assuming that existing irrigation pumping and conveyance systems can be used to the extent possible to deliver water from the Columbia River to the proposed reservoir:

- Winterization and retrofit of the existing 100 Circles (ConAgra) Pump Station. Existing information indicates that the pump station can deliver approximately 185 cfs with 14,000 horsepower of pumping installed.
- Winterization and retrofit of the existing 66-inch diameter transmission pipeline from the 100 Circles (ConAgra) Pump Station. Existing information indicates that the 66-inch transmission line extends north nearly 1 mile from the pump station.
- Installation of more than 35,000 feet of new 72-inch diameter transmission pipeline from the ConAgra system to the Alder reservoir.
- Installation of nearly 22,000 feet of 48-inch transmission pipeline in lower Alder Creek Canyon to deliver water from the reservoir to the Columbia River. In order to drain the reservoir over 6 months time, an average flow of 154 cfs would need to be

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project, should it proceed to construction and operation. Because use of existing infrastructure would reduce project costs, we present here assumptions for integrating existing infrastructure solely for cost comparison against all new construction.

conveyed from the reservoir to the Columbia River. A portion of this water could be conveyed through lower Alder Creek. However, it is expected that most would need to be conveyed in a pipeline to prevent erosion and scour of the Alder Creek channel downstream of the reservoir.

The following conveyance and pumping improvements were identified for delivery of water from the Columbia River to the proposed Alder reservoir if existing irrigation pumping and conveyance systems are not used:

- Installation of a new 13,500-horsepower pump station on the Columbia River near its confluence with Alder Creek to deliver up to 190 cfs to the reservoir.

- Installation of nearly 22,000 feet of 84-inch transmission pipeline in lower Alder Creek as a common inlet/outlet between the Columbia River and the reservoir.

Key assumptions used to develop costs for the Alder reservoir component of the preferred project include:

- Storage costs include an earth-fill embankment dam (approximately 200 feet tall), related site work, local piping and conveyance facilities, and a spillway channel.

- For the scenario that assumed use of existing irrigation facilities for pumping and conveyance, an allowance of $100,000 was included for winterization/retrofit of transmission piping and valves and an allowance of $1,000,000 was included for winterization/retrofit of the existing 100 Circles pump station.

- An allowance of 10% of the construction subtotal was provided for mobilization.

- Allowances were also provided for environmental mitigation (10% of the construction total); contingency (30% of the construction total); and engineering, permitting, and administration (15% of the construction total).

- Annual operations and maintenance costs (not power) were assumed to be 2% of the total capital cost for the reservoir project.

- Power costs were estimated based on rates from the Benton PUD, Schedule 72 (Large Agricultural Irrigation without Annual Facilities Charge). 2010 rates were used. No escalation was assumed for the opinion of cost in Table 3. On-peak irrigation rates were used. Actual pumping costs may be lower if off-peak rates are applied to nighttime pumping.

- Long-term costs would include repayment of capital costs based on a 50-year loan repayment schedule at an annual interest rate of 4%.

- Costs include pumping, storage, and conveyance facilities needed to deliver, store, and release water to the Columbia River. Costs do not include pumping and conveyance improvements needed to deliver water from the Columbia River or storage reservoir to irrigators for use.

ASR in Western Study Area

ASR wells constructed in the western study area would initially be designed to deliver up to 5,000 acre-feet annually from the Columbia River to the Wanapum Basalt aquifer for subsurface storage.

The following conveyance and pumping improvements were identified, assuming that existing irrigation conveyance systems can be used to the extent possible to deliver water from the Columbia River to the proposed ASR wellfield:

- Winterization and retrofit of the Mercer irrigation distribution system. Existing information indicates that the Mercer system includes a looped network of 18-inch diameter to 30-inch diameter pipelines. The most northern and western portions of the system are not looped and included smaller (12-inch diameter to 24-inch diameter) pipelines.

- Installation of more than 9,000 feet of 24-inch pipeline to increase the transmission capacity at the north end of the Mercer irrigation system.

- Installation of nearly 14,000 feet of 30-inch transmission pipeline to convey water from the Mercer system to the ASR wellfield.

- Installation of a Ranney well designed to deliver up to 20 cfs of filtered groundwater from the Columbia River Gravels near the location of the Mercer pump station to the proposed ASR wellfield.

The following conveyance and pumping improvements were identified for delivery of water from the Columbia River to the proposed ASR wellfield if existing irrigation conveyance systems are not used:

- Installation of a Ranney well designed to deliver up to 20 cfs of filtered groundwater from the Columbia River Gravels near the location of the Mercer pump station to the proposed ASR wellfield.

- Installation of nearly 54,000 feet of 30-inch transmission pipeline from the Ranney well to the proposed ASR wellfield.

Key assumptions used to develop costs for the ASR component of the preferred project include:

- An ASR wellfield consisting of 10 ASR wells, each capable of delivering 500 acre-feet annually to the subsurface reservoir.

- For the scenario that assumed use of existing irrigation facilities for conveyance, an allowance of $150,000 was included for winterization/retrofit of transmission piping and valves.

- An allowance of 10% of the construction subtotal was provided for mobilization.

- Allowances were also provided for environmental mitigation (10% of the construction total); contingency (30% of the construction total); and engineering, permitting and administration (15% of the construction total).

- Annual operations and maintenance costs were assumed to be 5% of the total capital cost for the ASR project. The operations and maintenance of an ASR wellfield were assumed to be more intensive that the operations and maintenance of surface storage, so a larger percentage was used.

- Power costs were estimated based on rates from the Benton PUD, Schedule 72 (Large Agricultural Irrigation without Annual Facilities Charge). 2010 rates were used. No escalation was assumed for the opinion of cost in Table 3. On-peak irrigation rates were used. Actual pumping costs may be lower if off-peak rates are applied to nighttime pumping.

- Long-term costs would include repayment of capital costs based on a 50-year loan repayment schedule at an annual interest rate of 4%.

- Costs include pumping, storage, and conveyance facilities needed to deliver water from the Columbia River to the ASR facility. Costs do not include pumping and conveyance improvements needed to deliver water from the Columbia River or the ASR facility to irrigators for use.

East Surface Storage (Switzler Reservoir)

As was noted previously, surface water storage would be created in the eastern study area by constructing a dam across Switzler Canyon. The proposed storage reservoir would have a capacity of approximately 44,000 acre-feet and would have a high WSEL of approximately 780 feet. The reservoir would be filled by pumping and conveying water from the Columbia River, McNary pool.

The following conveyance and pumping improvements were identified, assuming that existing irrigation pumping and conveyance systems can be used to the extent possible to deliver water from the Columbia River to the proposed reservoir:

- Winterization and retrofit of the existing Easterday/Berrian, Easterday/Premier, and Easterday/Denhoed Pump Stations. Existing information indicates that the Easterday pump stations can deliver approximately 59 cfs, 29 cfs, and 57 cfs, respectively.

- Winterization and retrofit of the existing transmission pipelines from each of the Easterday pump stations. Existing information indicates that the transmission pipelines that would be needed are typically 36-inch diameter.

- Installation of more than 23,000 feet of new 48-inch diameter transmission pipeline from the Easterday/Berrian and Easterday/Denhoed systems to the reservoir site in Switzler Canyon.

- Installation of approximately 2,000 feet of new 36-inch diameter transmission pipeline from the Easterday/Premier system to the reservoir site in Switzler Canyon.

- Installation of approximately 8,500 feet of 36-inch transmission pipeline in lower Switzler Canyon to deliver water from the reservoir to the Columbia River. In order to drain the reservoir over 6 months time, an average flow of 121 cfs would need to be conveyed from the reservoir to the Columbia River. A portion of this water could be conveyed through lower Switzler Canyon. However, most would likely need to be conveyed in a pipeline to prevent erosion and scour of Switzler Canyon downstream of the reservoir.

The following conveyance and pumping improvements were identified for delivery of water from the Columbia River to the proposed reservoir if existing irrigation pumping and conveyance systems are not used:

- Installation of a new 11,500-horsepower pump station on the Columbia River near its confluence with Switzler Canyon to deliver up to 150 cfs to the reservoir.

- Installation of approximately 8,500 feet of 60-inch transmission pipeline in lower Switzler Canyon as a common inlet/outlet between the Columbia River and the reservoir.

Key assumptions used to develop costs for the Switzler Reservoir component of the preferred project include:

- Storage costs include an earth-fill embankment dam (approximately 335 feet tall), related site work, local piping and conveyance facilities, and a spillway channel.

- For the scenario that assumed use of existing irrigation facilities for pumping and conveyance, an allowance of $120,000 was included for winterization/retrofit of transmission piping and valves and an allowance of $1,000,000 was included for winterization/retrofit of the existing pump stations.

- An allowance of 10% of the construction subtotal was provided for mobilization.

- Allowances were also provided for environmental mitigation (10% of the construction total); contingency (30% of the construction total); and engineering, permitting and administration (15% of the construction total).

- Annual operations and maintenance costs were assumed to be 2% of the total capital cost for the reservoir project.
- Power costs were estimated based on rates from the Benton PUD, Schedule 72 (Large Agricultural Irrigation without Annual Facilities Charge). 2010 rates were used. No escalation was assumed for the opinion of cost in Table 3. On-peak irrigation rates were used. Actual pumping costs may be lower if off-peak rates are applied to nighttime pumping.
- Long-term costs would include repayment of capital costs based on a 50-year loan repayment schedule at an annual interest rate of 4%.
- Costs include pumping, storage, and conveyance facilities needed to deliver, store and release water to the Columbia River. Costs do not include pumping and conveyance improvements needed to deliver water from the Columbia River or storage reservoir to irrigators for use.

Summary of Planning-Level Project Costs

Table 3 summarizes the planning-level opinion of probable costs for the preferred storage project. The estimated total capital costs of the preferred storage project (three reservoirs storing 105,000 acre-feet) range from approximately $3,600 per acre-foot if existing pumping and conveyance facilities can be used to deliver water from the Columbia River to the storage facilities, to $5,300 per acre-foot if all new conveyance and pumping facilities are installed. The total annual long-term costs, including power costs, operating and maintenance costs, and loan repayment range from approximately $300 per acre-foot annually if existing pumping and conveyance facilities can be used to deliver water from the Columbia River to the proposed storage facilities, to $400 per acre-foot annually if all new conveyance and pumping facilities are installed.

Proposed Feasibility Study

A feasibility study is necessary to better define the technical, permitting, and economic feasibility of the preferred storage project. Primary issues to be addressed in a feasibility study include but are not limited to:

In-Channel Reservoirs

- Land ownership and acquisition, geologic/geotechnical suitability, existing infrastructure potentially affected within the project area;
- Instream habitat impacts/mitigation;
- Natural stream discharge as contribution to reservoir filling;
- Stream channel geomorphology and sediment transport potential, downstream of reservoir;

- Permitting.

ASR

- Verify presence/absence of inferred hydraulic barriers in basalt aquifer caused by geologic faults;
- Assess whether recharging the aquifer near the river would create groundwater mounding upgradient where significant depletion has occurred;
- Assess locations in Columbia River gravels to site a Ranney well for source water, including exploratory drilling and testing, and the suitability of source water provided by Ranney wells for injection as part of an ASR program for irrigation (compliance with Ground Water Quality Standards);
- Assess establishment of a Ground Water Management Area within which the groundwater's highest beneficial use is irrigation supply via ASR;
- If the findings from the tasks above suggest that ASR is feasible, develop an ASR pilot test plan and apply for a preliminary permit to drill and test an ASR well.

Administration of Storage System

- Work with stakeholders to define a preferred administrative system for constructing and operating the storage project, and permitting use of the new water supply made available (e.g., allocation for interruptible water rights [infrequently needed] versus other demands).

Refined Project Cost Estimates

- Using the collective information gathered in the feasibility study tasks, propose a refined concept for the preferred storage project with associated costs estimates (capital costs and annual operation and maintenance).

Regional Economic Evaluation

- Evaluate regional economic effects of increased irrigated agriculture in Horse Heaven, including potential for competitive disadvantage to existing farmers.

Closing

The WRIA 31 PAC believes that, based on information developed in the WRIA 31 Pre-Feasibility Storage Assessment, the preferred water storage project alternative may be a viable means to achieve out-of-stream and instream benefits within WRIA 31 in accordance with the WRIA 31 Watershed Management Plan. No fatal flaws are identified with the preferred project at this point, but the PAC recognizes that considerable additional information must be developed before the true project feasibility – technical, permitting, and economic – is understood with confidence. The PAC is interested in discussing the project further with Ecology's Office of the Columbia River, including potential for funding to conduct a feasibility study.

Attachments

Table 1 – Instream Flows Set by WAC 173-563 and the 2004 Biological Opinion

Table 2 – Estimated Average Columbia River Water Available

Table 3 – Opinion of Probable Costs of Preferred Storage Alternative

Figure 1 – Preferred Storage Alternative

Figure 2 – Columbia River Average (1971-2000) Flow Below Bonneville Dam (Nov 1-Mar 31)

S:\WRIA 31\Phase 4\HHH storage\Deliverables\Briefing Memo to PAG Apr 2010\Briefing Memo WRIA 31 Water Storage Project - 4-26-10 draft.doc

Table 1

Instream Flows Set by WAC 173-563 and the 2004 Biological Opinion

Date	Chief Joseph		Wells & Rocky Reach		Rock Island & Wanapum		Priest Rapids			McNary			John Day		Bonneville	The Dalles	
	WAC 173-563		WAC 173-563		WAC 173-563		WAC 173-563		2004 BiOp	WAC 173-563		2004 BiOp	WAC 173-563		2004 BiOp	WAC 173-563	
	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)	Flow Objective (kcfs)	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)	Flow Objective (kcfs)	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)	Flow Objective (kcfs)	Min. Q_i (kcfs)	Min. Avg. Weekly Flows (kcfs)
Jan	10	30	10	30	10	30	50	70	--	20	60	--	20	60	?[b]	20	60
Feb	10	30	10	30	10	30	50	70	--	20	60	--	20	60	?[b]	20	60
Mar	10	30	10	30	10	30	50	70	--	50	60	--	50	60	?[b]	50	60
Apr 1-2	20	50	20	50	20	60	50	70	--	50	100	--	50	100	?[b]	70	120
3-9	20	50	20	50	20	60	50	70	--	50	100	--	50	100	?[b]	70	120
10-15	20	50	20	50	20	60	50	70	135	50	100	220-260[a]	50	100	?[b]	70	120
16-25	20	60	30	60	30	60	50	70	135	70	150	220-260[a]	70	150	?[b]	70	160
26-30	20	90	50	100	50	110	50	110	135	70	200	220-260[a]	70	200	?[b]	70	200
May	20	100	50	115	50	130	50	130	135	70	220	220-260[a]	70	220	?[b]	70	220
Jun 1-15	20	80	50	110	50	110	50	110	135	70	200	220-260[a]	70	200	?[b]	70	200
16-20	10	60	20	80	20	80	50	80	135	50	120	220-260[a]	50	120	?[b]	50	120
21-30	10	60	20	80	20	80	50	80	135	50	120	220-260[a]	50	120	?[b]	50	120
Jul 1-15	10	60	20	80	20	80	50	80	--	50	120	200	50	120	--	50	120
16-31	10	90	50	100	50	110	50	110	--	50	140	200	50	140	--	50	140
Aug	10	85	50	90	50	95	50	95	--	50	120	200	50	120	--	50	120
Sep	10	40	20	40	20	40	36	40	--	50	60	--	50	85	--	50	90
Oct 1-15	10	30	20	35	20	40	36	40	--	50	60	--	50	85	--	50	90
16-31	10	30	20	35	20	40	50	70	--	50	60	--	50	85	--	50	90
Nov	10	30	10	30	10	30	50	70	--	50	60	--	50	60	125-160[b]	50	60
Dec	10	30	10	30	10	30	50	70	--	20	60	--	20	60	?[b]	20	60

NOTES:

Abbreviations: Min = Minimum; Qi = instantaneous flow; Avg. = Average; WAC = Washington State Administrative Code; kcfs = thousand cubic feet per second

a. Objective varies according to water volume forecasts.

b. Objective varies based on actual and forecasted water conditions. The dates to which this flow objective applies include 11/1 to emergence (spring season) which may vary each year.

c. The 2004 Biological Opinion was issued by NMFS regarding the Federal Columbia River Power System (FCRPS). The data in the table is from Bureau of Reclamation, Bonneville Power Administration, and U.S. Army Corps of Engineers (Action Agencies). 2004. Final Updated Proposed Action for the FCRPS Biological Opinion Remand. November 24, 2004.

Source: Final Programmatic Environmental Impact Statement for the Columbia River Water Management Program

Table 2
Estimated Average Columbia River Water Available

Month	Volume Available (million acre-feet)
November	0
December	0.51
January	1.62
February	2.11
March	3.32
Total	**7.55**

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Table 3

Opinion of Probable Costs of Preferred Storage Alternative

WRIA 31 Water Storage Pre-Feasibility Assessment

ITEM	IF EXISTING CONVEYANCE AND PUMPING SYSTEMS ARE USED				IF ALL NEW CONVEYANCE AND PUMPING SYSTEMS ARE USED			
	WEST SURFACE STORAGE	WEST ASR	EAST SURFACE STORAGE	TOTAL	WEST SURFACE STORAGE	WEST ASR	EAST SURFACE STORAGE	TOTAL
Storage Included:								
Description	Lower Alder Reservoir	ASR	Switzler Reservoir		Lower Alder Reservoir	ASR	Switzler Reservoir	
Annual Storage Capacity (Acre-feet)	55,800	5,000	44,400	105,200	55,800	5,000	44,400	105,200
Transmission/Distribution Pipelines Included:								
Description	Ex. 100 Circles + New Pipelines to Reservoir	Ex. Mercer + New Pipelines to Reservoir	Ex. Easterday + New Pipelines to Reservoir		All New Pipelines	All New Pipelines	All New Pipelines	
Pipeline Sizes (In)	66" to 72"	18" to 36"	36" to 48"		84"	30"	60"	
Pumping Included:								
Description	Ex. 100 Circles Pump Station	New Ranney Well	Ex. Easterday Pump Stations		New Pump Station	New Ranney Well	New Pump Station	
Power Required (HP)	14,000	3,500	12,000	29,500	13,500	2,000	11,500	27,000
Capital Costs:								
Storage Improvements	$ 67,298,000	$ 5,000,000	$ 95,430,000	$ 167,728,000	$ 67,298,000	$ 5,000,000	$ 95,430,000	$ 167,728,000
Transmission and Distribution Improvements	$ 21,108,000	$ 2,699,000	$ 6,225,000	$ 30,032,000	$ 11,825,000	$ 6,456,000	$ 3,400,000	$ 21,681,000
Pumping Improvements	$ 1,000,000	$ 5,000,000	$ 1,000,000	$ 7,000,000	$ 59,400,000	$ 5,000,000	$ 50,600,000	$ 115,000,000
Construction Subtotal	**$ 89,406,000**	**$ 12,699,000**	**$ 102,655,000**	**$ 204,760,000**	**$ 138,523,000**	**$ 16,456,000**	**$ 149,430,000**	**$ 304,409,000**
Moblization/Demoblization (10%)	$ 8,940,600	$ 1,269,900	$ 10,265,500	$ 20,476,000	$ 13,852,300	$ 1,645,600	$ 14,943,000	$ 30,440,900
Construction Total	**$ 98,346,600**	**$ 13,968,900**	**$ 112,920,500**	**$ 225,236,000**	**$ 152,375,300**	**$ 18,101,600**	**$ 164,373,000**	**$ 334,849,900**
Environmental Mitigation (10%)	$ 9,834,660	$ 1,396,890	$ 11,292,050	$ 22,523,600	$ 15,237,530	$ 1,810,160	$ 16,437,300	$ 33,484,990
Contingency (30%)	$ 29,503,980	$ 4,190,670	$ 33,876,150	$ 67,570,800	$ 45,712,590	$ 5,430,480	$ 49,311,900	$ 100,454,970
Engineering, Permitting and Administration (15%)	$ 14,751,990	$ 2,095,335	$ 16,938,075	$ 33,785,400	$ 22,856,295	$ 2,715,240	$ 24,655,950	$ 50,227,485
Subtotal - Capital Cost	**$ 152,437,000**	**$ 21,652,000**	**$ 175,027,000**	**$ 349,116,000**	**$ 236,182,000**	**$ 28,057,000**	**$ 254,778,000**	**$ 519,017,000**
Sales Tax	$ 10,670,590	$ 1,515,640	$ 12,251,890	$ 24,438,120	$ 16,532,740	$ 1,963,990	$ 17,834,460	$ 36,331,190
Land Acquisition	$ 4,210,000	$ 10,000	$ 444,000	$ 4,664,000	$ 4,210,000	$ 10,000	$ 444,000	$ 4,664,000
Total Capital Cost	**$ 167,318,000**	**$ 23,178,000**	**$ 187,723,000**	**$ 378,219,000**	**$ 256,925,000**	**$ 30,031,000**	**$ 273,056,000**	**$ 560,012,000**
Total Capital Cost ($/Acre-foot)	**$ 2,999**	**$ 4,636**	**$ 4,228**	**$ 3,595**	**$ 4,604**	**$ 6,006**	**$ 6,150**	**$ 5,323**
Long Term Costs:								
Annual Pumping Power Costs (2010 Rates)	$ 1,813,000	$ 453,000	$ 1,554,000	$ 3,820,000	$ 1,748,000	$ 259,000	$ 1,489,000	$ 3,496,000
Annual Operating and Maintenance (O&M) Costs	$ 3,346,360	$ 1,158,900	$ 3,754,460	$ 8,259,720	$ 5,138,500	$ 1,501,550	$ 5,461,120	$ 12,101,170
Subtotal - Pumping + O&M Costs	**$ 5,159,360**	**$ 1,611,900**	**$ 5,308,460**	**$ 12,079,720**	**$ 6,886,500**	**$ 1,760,550**	**$ 6,950,120**	**$ 15,597,170**
Subtotal - Pumping + O&M Costs ($/Acre-foot)	**$ 92**	**$ 322**	**$ 120**	**$ 115**	**$ 123**	**$ 352**	**$ 157**	**$ 148**
Amortized Annual Cost	$ 7,788,686	$ 1,078,941	$ 8,738,543	$ 17,606,170	$ 11,959,910	$ 1,397,949	$ 12,710,812	$ 26,068,671
Amortized Annual Cost ($/Acre-foot)	$ 140	$ 216	$ 197	$ 167	$ 214	$ 280	$ 286	**$ 248**
Total Annual Long-Term Cost	**$ 12,948,000**	**$ 2,691,000**	**$ 14,047,000**	**$ 29,686,000**	**$ 18,846,000**	**$ 3,158,000**	**$ 19,661,000**	**$ 41,666,000**
Total Annual Long-Term Cost ($/Acre-foot)	**$ 232**	**$ 538**	**$ 316**	**$ 282**	**$ 338**	**$ 632**	**$ 443**	**$ 396**

Notes:

1) Annual Operating and Maintenance Costs Estimated at 2% and 5% of Total Capital Cost for surface and aquifer storage alternatives, respectively.

2) Rates from Benton PUD Schedule 72: Large Agricultural Irrigation Without Annual Facilities Charge (2010 On-peak Rates Used, No escalation assumed).

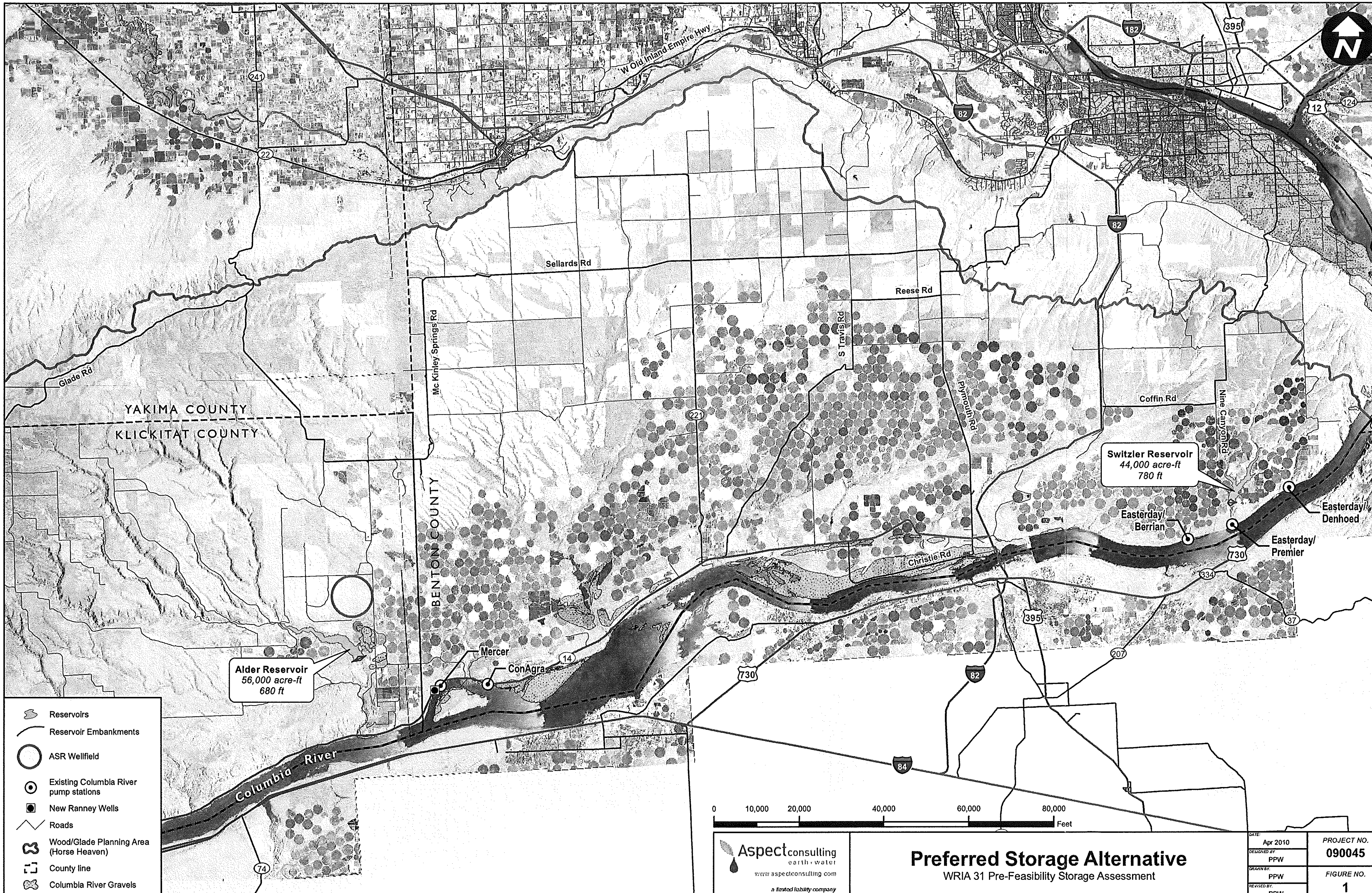

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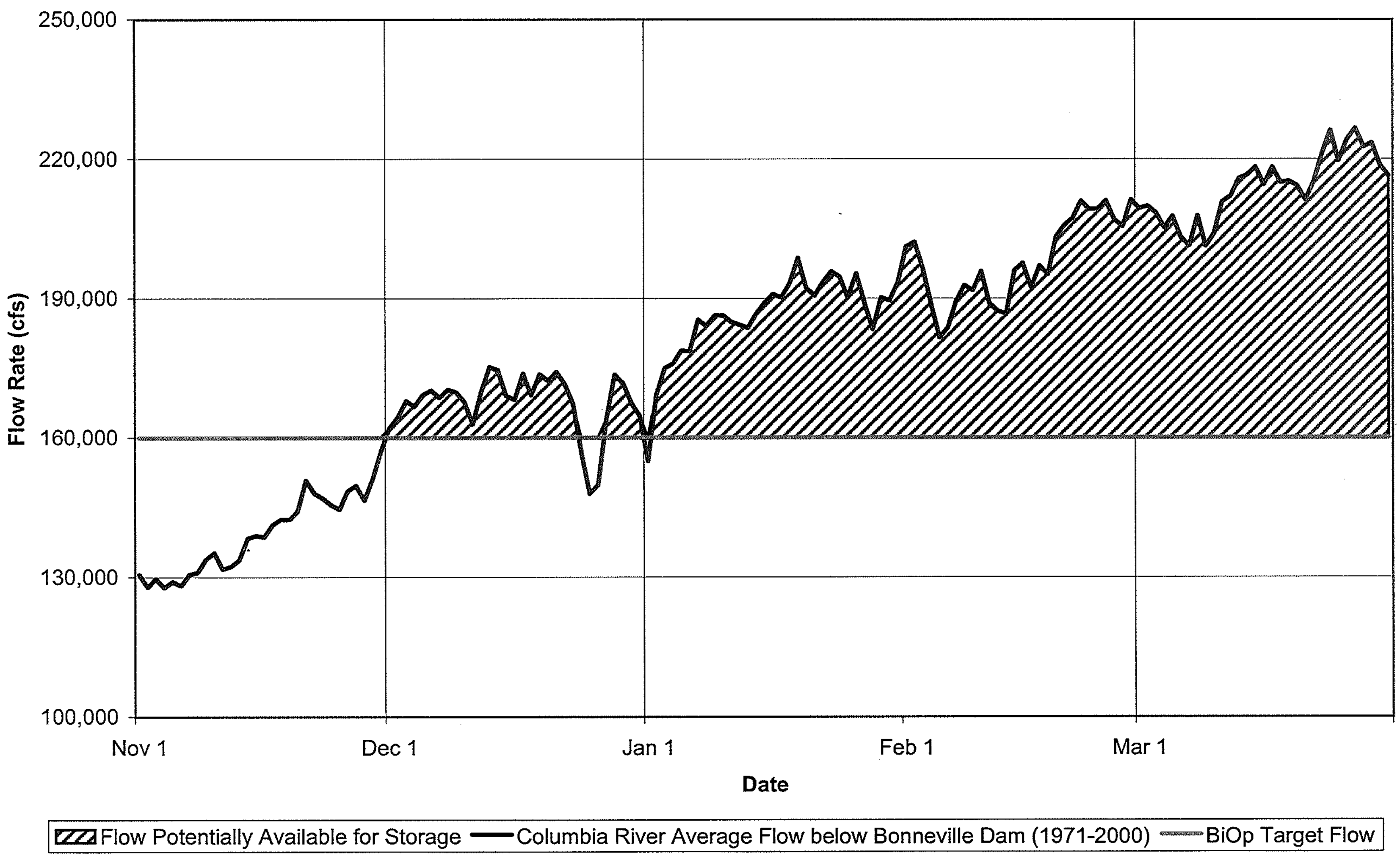
Figure 2
Columbia River Average (1971-2000) Flow below Bonneville Dam (Nov 1-Mar 31)



Planning-Level Cost Estimates to Place Water Into Storage
WRIA 31 Preferred Storage Alternative

ITEM	SCENARIO 1 WINTERIZE/USE EXISTING INFRASTRUCTURE				SCENARIO 2 ALL NEW INFRASTRUCTURE			
	Alder Reservoir	Western ASR	Switzler Reservoir	Total Project	Alder Reservoir	Western ASR	Switzler Reservoir	Total Project
Annual Storage Capacity (Acre-feet)	55,800	5,000	44,400	105,200	55,800	5,000	44,400	105,200
Capital Costs								
Total $	$ 167,318,000	$ 23,178,000	$ 187,723,000	$378,219,000	$ 256,925,000	$ 30,031,000	$ 273,056,000	$560,012,000
Amortized Total $/Year[1]:	$7,788,700	$1,078,900	$8,738,500	$17,606,100	$11,959,900	$1,397,900	$12,710,800	$26,068,600
Amortized Capital Costs:								
$/Acre-foot in Storage	$ 140	$ 216	$ 197	$ 167	$ 210	$ 280	$ 290	$ 250
$/Acre @ 1.5 foot/year	$ 209	$ 324	$ 295	$ 251	$ 315	$ 420	$ 435	$ 375
$/Acre @ 3.5 foot/year	$ 489	$ 755	$ 689	$ 586	$ 735	$ 980	$ 1,015	$ 875
Annual Operational Costs								
Pumping Power[2]								
Total $	$ 1,813,000	$ 453,000	$ 1,554,000	$ 3,820,000	$ 1,748,000	$ 259,000	$ 1,489,000	$ 3,496,000
$/Acre-foot in Storage	$ 32	$ 91	$ 35	$ 36	$ 31	$ 52	$ 34	$ 33
$/Acre @ 1.5 foot/year	$ 49	$ 136	$ 53	$ 54	$ 47	$ 78	$ 50	$ 50
$/Acre @ 3.5 foot/year	$ 114	$ 317	$ 123	$ 127	$ 110	$ 181	$ 117	$ 116
O&M[3]								
Total $	$ 3,346,000	$ 1,159,000	$ 3,754,000	$ 8,259,000	$ 5,139,000	$ 1,502,000	$ 5,461,000	$ 12,102,000
$/Acre-foot in Storage	$ 60	$ 232	$ 85	$ 79	$ 92	$ 300	$ 123	$ 115
$/Acre @ 1.5 foot/year	$ 90	$ 348	$ 127	$ 118	$ 138	$ 451	$ 184	$ 173
$/Acre @ 3.5 foot/year	$ 210	$ 811	$ 296	$ 275	$ 322	$ 1,051	$ 430	$ 403
Total Operational (Power + O&M)								
Total $	$ 5,159,000	$ 1,612,000	$ 5,308,000	$ 12,079,000	$ 6,887,000	$ 1,761,000	$ 6,950,000	$ 15,598,000
$/Acre-foot in Storage	$ 92	$ 322	$ 120	$ 115	$ 123	$ 352	$ 157	$ 148
$/Acre @ 1.5 foot/year	$ 139	$ 484	$ 179	$ 172	$ 185	$ 528	$ 235	$ 222
$/Acre @ 3.5 foot/year	$ 324	$ 1,128	$ 418	$ 402	$ 432	$ 1,233	$ 548	$ 519
Total Long-Term Annual Costs (Amortized Capital + Operational)								
Total $	$ 12,948,000	$ 2,691,000	$ 14,047,000	$ 29,686,000	$ 18,847,000	$ 3,159,000	$ 19,661,000	$ 41,667,000
$/Acre-foot in Storage	$ 232	$ 538	$ 316	$ 282	$ 338	$ 632	$ 443	$ 396
$/Acre @ 1.5 foot/year	$ 348	$ 807	$ 475	$ 423	$ 507	$ 948	$ 664	$ 594
$/Acre @ 3.5 foot/year	$ 812	$ 1,884	$ 1,107	$ 988	$ 1,182	$ 2,211	$ 1,550	$ 1,386

29% estimated savings by integrating existing infrastructure to extent practical

Notes:

1) Amortization of capital costs assumes 50 year loan at 4% interest.

2) Power rates from Benton PUD Schedule 72: Large Agricultural Irrigation Without Annual Facilities Charge (2010 On-peak Rates Used, No escalation assumed).

3) Annual O&M Costs estimated at 2% and 5% of Total Capital Cost for surface and aquifer storage alternatives, respectively.