



MEMORANDUM

Project No.: 030009-002-01

September 23, 2005

To: WRIA 31 Planning Unit

From: Steve Germiot, LHG, CGWP, and Timothy J. Flynn, LHG, CWGP

Re: **Preliminary Water Storage Assessment
Glade-Fourmile Subbasin, WRIA 31**

This memorandum provides our preliminary assessment of water storage concepts in the Glade-Fourmile subbasin of Water Resource Inventory Area 31 (WRIA31). The overriding objective of this assessment is to develop a preliminary understanding of the feasibility and constraints for applying water storage to meet current and future water demands in the major agricultural area of WRIA 31 (Glade/Fourmile subbasin). This water storage project was funded under Grant number G0500011 obtained by the WRIA 31 Planning Unit from the Washington State Department of Ecology (Ecology) under the Watershed Management Act.

Background

Agriculture is the primary economy for WRIA 31 as a whole. Accordingly, irrigation is the predominant water use in the WRIA, with the greatest concentration of irrigation usage occurring within the Glade-Fourmile subbasin (nearly 80% of total irrigation usage in WRIA 31). In portions of this subbasin near the Columbia River, surface water diversions from the Columbia River are the primary source of large irrigation supplies. Inland from the Columbia River, groundwater withdrawals from deep aquifers (Wanapum Basalt) are the main source. Aquifer water level declines exceeding a hundred feet or more are documented in some areas of this subbasin. In some cases, irrigation supply wells have been deepened multiple times to remain operable in response to declining water levels. This mining of the groundwater system is a consequence of groundwater withdrawal exceeding natural groundwater recharge to the Wanapum Aquifer. Under Chapter 173-531A WAC, 1.32 million acre-feet/ year of water is reserved from the John Day/McNary Pools reach of the Columbia River to provide a water supply for 330,000 acres of irrigation projected to be developed by the year 2020. Roughly 125,000 acre-feet/year (9.5%) of this reserve has been permitted. The state's permitting of additional water rights from this reserve was stopped in the 1990s, pending development of a comprehensive water management program for the Columbia River that would comply with federal requirements under the Endangered Species Act.

Storage of water from the Columbia River can be an important strategy for making water available to bring additional irrigable land in the Glade-Fourmile subbasin into production for high-value crops and thus support economic growth in this region. The Level 1 Assessment documents that all streams in WRIA 31 are ephemeral, and there is no source of water in WRIA 31 other than the Columbia River that would be practical for a storage project. Diverting water from the Columbia River for storage during the winter, when regional

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demands on the resource are lowest, represents one method to make additional water available for economic growth while reducing diversions in the summer when flows for fish are of greatest concern and reversing water level decline in aquifers of the subbasin.

Water storage can be accomplished using in-channel dams, off-channel impoundments/reservoirs, or subsurface storage in aquifers. As background, Attachment A provides a brief overview of conceptual water storage options (on-channel dam, off-channel impoundment, and ASR), including discussion of relative pros and cons of each and potentially applicable permitting requirements. Based on discussion with the WRIA Planning Unit, aquifer storage and recovery (ASR) was the initial focus of this assessment at the outset. Available hydrogeologic information assembled as part of the Level 1 Assessment indicates that productive aquifers exist within the Glade-Fourmile subbasin. Specifically, the Wanapum Basalt is known to provide high well yields for irrigation supply across this subbasin. Some portions of this aquifer have experienced large water level declines over time, demonstrating that, at a minimum, subsurface storage volume would be available by replenishing those declines. As such, it appears that ASR would be technically feasible, from a hydrogeologic standpoint, in this subbasin. Non-technical factors, including water rights and particularly cost, are expected to be the key factors determining whether ASR could be a feasible and practical water management strategy in this subbasin.

Discussions with Planning Unit over the course of the assessment suggested a preference for not discounting dams or off-channel storage opportunities in this subbasin (i.e., not focusing solely on ASR). Klickitat and Benton Counties have contracted with Nakaty Enterprises to review historically developed concepts for development of additional irrigated acreage within the Horse Heaven Hills region (which includes the Glade-Fourmile subbasin). Those concepts involve conveying water from the Columbia River to irrigable lands inland from the river, in some cases involving storage behind dams. A future phase of Nakaty Enterprises' assessment will be to evaluate applicability of those historical concepts to present conditions, and outline potential options for developing the John Day/McNary reserve (as per Chapter 173-531A WAC) for irrigation in the subbasin. The Nakaty Enterprises study represents a considerably broader assessment of regional development potential than the limited scope of this storage assessment; however, it does include some overlap with this assessment in terms of conceptual water conveyance and storage options.

Based on that parallel effort and discussion with the Planning Unit, this preliminary storage assessment thus changed in focus from evaluating feasibility and constraints of ASR to outlining conceptual water storage opportunities that can then be evaluated and developed in greater detail as appropriate during the Phase 3 Watershed Management Plan and Phase 4 implementation of that Plan. The planning-level cost estimates for diverting and conveying Columbia River water developed in this assessment could be applicable to any form of storage.

The remaining sections of this memorandum include a general overview of irrigable acres and irrigation water volumes, planning-level cost estimates for diversion and conveyance for moderate scale water storage projects (10 to 30 cubic feet per second [cfs]), followed by an outline of concepts for larger scale, regional water storage.

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Irrigable Acres and Water Volumes for Irrigation

Using satellite imagery and crop rotation records from 2001, IRZ Consulting estimated approximately 131,000 acres are being irrigated in the Glade-Fourmile subbasin: 11,000 acres (8%) of permanent crops (orchards and vineyards) and 120,000 acres (92%) of seasonal row crops (refer to Section 3.5.1 of the Level 1 Assessment). In the Level 1 Assessment, an annual irrigation water use of 492,000 acre-feet/year was estimated for the subbasin. This equates to an aggregate average water duty of 3.8 feet/year. The average annual water duty for permanent crops is on the order of 5 feet/year, whereas the typical seasonal crops (with cover crop) average about 2.8 feet/year. The 1.32 million acre-feet/year irrigation reserve from the John Day/McNary pools assumed irrigation of 330,000 acres, equating to an average water duty of 4 feet/year. Assuming this range of average water duties, each 1,000 acres of additional land to be irrigated would require roughly 3,000 to 5,000 acre-feet/year of additional water, depending on crop type.

The total area of the Glade-Fourmile subbasin is approximately 529,000 acres. The total number of irrigable acres within this subbasin is not known, but up to 400,000 acres has been estimated for the Horse Heaven Hills region including some area outside of this subbasin (Duane Unland, Nakaty Enterprises, personal communication June 2005).

Cost Estimate for Moderate-Scale Storage Project

Based on the general range of irrigation water volumes above, a planning-level cost estimate was developed assuming diversion and conveyance of 10 to 30 cfs of Columbia River water during the 5-month period of November through March (3,000 to 9,000 acre-feet, respectively), so that a storage reservoir would be full for an assumed start of irrigation in April. This range of water volumes is likely similar in scale to typical river diversions along the Columbia River currently pumping for irrigation in the summer (not for storage). This quantity is also within the range of typical ASR projects. Such a project might provide irrigation supply for one larger farm or a collection of smaller farms, and as such represents a moderate-scale storage project. It also assumes direct pumping uphill along the shortest pipeline alignment, with no benefit of gravity flow. We expect that a small- to moderate-sized project of this type also has little economy of scale, and therefore can represent a relatively high cost range in terms of cost per acre-foot of water. Much larger storage projects potentially take advantage of substantial economies of scale, and can thus be much more cost effective per acre-foot of water delivered. A preliminary concept for a large-scale, regional strategy to store/provide water for irrigation is discussed in a later section; however, costing such a preliminary concept is beyond the scope of this assessment.

We contracted with Anderson-Perry and Associates of La Grande, Oregon, to complete the planning-level cost estimate for diversion of Columbia River water (3,000 to 9,000 acre-feet/year [AFY]) from a location near Alderdale and conveyance of that water approximately 14 miles inland. All new construction is assumed.

For this planning-level estimate, the conceptual location chosen for a hypothetical storage project was chosen as with the area where very large groundwater level declines occur as a result of extensive irrigation pumping. Figure 1 shows locations for the conceptual river

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diversion, conveyance pipeline alignment, and storage project area assumed for this cost estimate. Based on the current distribution of irrigated agriculture in the subbasin, this 14-mile distance provides a reasonable maximum distance, and thus worst-case cost, for the purposes of this assessment. At the time of its development, the cost estimate was developed with the assumption of providing source water for an ASR system in this area – providing artificial recharge to stabilize and gradually reverse the aquifer overdraft. However, the type of diversion/conveyance system costed could be applicable to any type of storage facility (dam, off-channel impoundment, or ASR wellfield) with minor adjustments.

The planning-level cost estimate assumed two methods of river water diversion: a conventional surface water diversion and a Ranney collector. For the option of subsurface storage via ASR, the state's antidegradation policy under the Ground Water Quality Standards (WAC 173-200-30) requires that the quality of the source water to be recharged (stored) must not degrade the quality of groundwater in the storage aquifer such that its highest beneficial use (presumed as drinking water) is degraded. Turbidity and bacteria in the river water to be stored, if untreated, could degrade groundwater quality; turbidity and bacteria could also rapidly clog the ASR well during recharge. Consequently, the cost estimate included a membrane filtration plant in combination with the surface water diversion, to allow treatment of the diverted surface water to meet drinking water standards for turbidity and bacteria (complying with the Surface Water Treatment Rule). Such filtration plants are expensive. Anderson-Perry assumed costs of \$1.8 million and \$5.0 million for constructing filtration plants capable of treating 10 cfs and 30 cfs flow rates, respectively.

A second set of costs was also prepared assuming the source water is shallow groundwater withdrawn from a Ranney collector, a type of well completed in overburden (gravels) along the river banks. It is constructed with a central large-diameter caisson from which multiple lateral collectors extend outward into the gravels of the river bed. The Ranney collector offers the advantage of producing groundwater that has been filtered naturally in the river bed sediments, therefore it is assumed that secondary filtration is not required to meet drinking water standards. For example, the City of Kennewick uses a pair of large capacity Ranney collectors in the Columbia River gravels as a primary water supply source, with chlorine disinfection only. The Ranney collector is estimated to be more expensive than a conventional surface water diversion structure, but less expensive than that diversion structure with the necessary water filtration (treatment) plant to meet water quality standards. However, water quality testing would be required to demonstrate that the natural river bank filtration was adequate to meet water quality standards.

In the case of above-ground storage, treatment of the source water should not be necessary. Because Anderson-Perry's cost estimate is itemized, the cost of the filtration plant can be excluded for the assumption of above-ground storage supplied from a conventional surface water diversion. For this planning-level cost estimate, we assume water to be stored subsurface (ASR) would be withdrawn from the Columbia River gravels using a Ranney collector, whereas water to be stored in surface reservoirs would be diverted from the Columbia River using a conventional diversion structure. Water filtration is assumed to not be necessary in either case.

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In addition to the river diversion or Ranney collector, the major capital elements of the cost estimate include mobilization, highway and railroad crossings (with traffic control), equalization storage tankage and pump station, and conveyance piping. The cost estimate assumes easements can be obtained for pipeline construction. The 10 cfs option includes 24-inch diameter piping, whereas the 30 cfs option includes 36-inch piping. In both options, three different types of piping are assumed along the 14-mile alignment based on water pressures in the pipe during conveyance. Anderson-Perry assumed that the first approximately 1 mile of the pipeline is welded steel piping because of the high fluid pressures generated when lifting the water from river elevation out of the gorge. The next 9 miles of pipeline, where pressures are reduced, is assumed to be ductile iron piping. The final 4 miles of pipeline, in which pressures are still lower, are assumed to be PVC. Based on the surface geologic map (Figure 1), it is assumed that approximately 4 miles of the pipeline alignment is trenched in rock (requiring blasting), and approximately 10 miles is in unconsolidated material (requiring conventional excavation). The cost estimates include sales tax, design/construction engineering, administration, and legal fees assumed to be 20% of the construction cost, and a 15% construction contingency. A copy of Anderson-Perry's cost estimate, which includes additional details regarding costing assumptions, is included as Attachment B to this memorandum.

Table 1 presents planning-level cost estimates for the 10 cfs scenario (3,000 acre-feet stored over 5 months). Estimates are provided both for an assumed ASR project in which source water is withdrawn using a Ranney collector to provide natural water quality filtration, and for an assumed surface storage project in which source water is diverted via surface water diversion without treatment.

Note that, for this very long alignment, the pipeline costs (including costs to cross drainages) are roughly 60% of the estimated total construction cost. For comparison, Table 1 also includes the estimated costs assuming an alignment half as long (approximately 7 miles). For an assumed 7-mile alignment, the pipeline cost is roughly 45% of the estimated total construction cost. Consideration should be given to utilizing/upgrading existing conveyance system already in place, given the high capital costs. However, upgrading of existing conveyance for year-round operation (e.g., winterizing valves etc.) may be cost effective.

Table 2 provides the same cost estimate information as in Table 1, except for the 30 cfs scenario (9,000 acre-feet stored over 5 months).

Cost for 10 cfs/3000 AFY Storage Scenario

Under the 10 cfs/3,000 acre-feet scenario, and the full 14-mile conveyance distance, the planning-level costs for water diversion and conveyance components only are approximately \$19.7 million for ASR and \$18.8 million for surface storage (Table 1). The lower estimate cost for surface storage is a result of the lower cost of a river diversion relative to a Ranney collector. For ASR, the cost for ASR wells would be additional. We assume a planning-level cost of \$200,000 for each ASR well capable of recharging and recovering 1,000 to 1,200 gpm (with pump and ancillary piping). Assuming 10 cfs could be handled with four such ASR wells, the estimated cost for an ASR option is increased \$800,000 to \$20.5 million.

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There is a wide range of potential surface reservoir options for storing 3,000 acre-feet (980 million gallons) of water. The scope and costs for such options have not been developed for this preliminary assessment; however, we expect that ballpark costs would exceed \$10 million when land acquisition and the rigorous level of permitting are considered in addition to construction costs. Consequently, we expect that the estimated cost for a surface storage option would be \$30 million or greater.

Assuming a 7-mile conveyance distance, estimated diversion/conveyance costs are \$14.6 million and \$13.7 million for ASR and surface storage, respectively (Table 1). In other words, reducing the alignment length by 50% reduces costs by roughly 25% (diversion structure etc. are fixed costs). Adding costs for assumed ASR wells raises the ASR cost to roughly \$15.4 million. We expect that the estimated cost for a surface storage option would be \$25 million or greater.

We also coordinated with Klickitat PUD for planning-level power costs to run the pump station, with 4,800-horsepower pump, continuously for an assumed 5-month period in the winter (November-March). Given the assumed pump horsepower and continuous pumping, the PUD calculated estimated power costs for each month based on numbers of on-peak and off-peak hours and their irrigation rate. Monthly electric costs range month to month, with the highest rates occurring in the winter months when operation of this system would be planned. The estimated monthly electrical costs range from about \$152,000 in December to \$111,000 in March, with a total cost of approximately \$658,000 over the 5-month storage season.

Cost for 30 cfs/9,000 AFY Storage Scenario

Under this higher flow scenario, and the full 14-mile conveyance distance, the planning-level costs for water diversion and conveyance are approximately \$30.5 million for ASR and \$27.0 million for surface storage (Table 2). Assuming 30 cfs could be handled with 12 ASR wells (at \$200,000 each); the estimated cost for an ASR option is increased to roughly \$33 million. The ballpark cost for a potential surface reservoir capable of storing 9,000 acre-feet (2,900 million gallons) of water would likely exceed \$25 million when land acquisition and permitting are considered with construction costs. Consequently, we expect that the estimated cost for a surface storage option would exceed \$50 million.

Assuming a 7-mile conveyance distance, estimated diversion/conveyance costs are \$22.6 million and \$19.0 million for ASR and surface storage, respectively (Table 2). Adding costs for assumed ASR wells raises the ASR cost to roughly \$25 million. We expect that the estimated cost for a surface storage option would exceed \$44 million.

Summary of Costs

The planning-level costs for storage of 3,000 to 9,000 acre-feet of water, assuming all new construction, are very high in terms of dollars per acre-foot of water delivered. The costs per acre-foot of water are summarized below.

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Estimated Costs per Acre-Foot of Water Stored

Distance Inland from River	10 cfs/3000 AFY		30 cfs/9000 AFY	
	ASR	Surface Storage	ASR	Surface Storage
14 miles	\$7,100	\$10,200	\$3,700	\$5,600
7 miles	\$5,400	\$8,600	\$2,900	\$5,000

As described above, there is considerable uncertainty in costs for constructing large-scale surface storage reservoirs (in-channel dam or off-channel impoundment) to store these assumed volumes of water; this creates considerable uncertainty in unit costs for the surface storage option irrespective of storage volume. In addition, there may be considerable siting and permitting constraints that need to be addressed.

Based on these planning-level cost estimate, we conclude that relatively small-scale storage projects would be economically infeasible for the agricultural industry without considerable public sector funding. Nonetheless, these estimates show an economy of scale in moving from a 3,000 AFY to 9,000 AFY storage project (costs per acre-foot of water are reduced 40 to 50%). Therefore, it is appropriate and necessary to look at possible concepts for much larger, regional-scale storage projects that provide sufficient economy of scale and/or include a combined utility (e.g. power generation) to potentially be economically viable.

Preliminary Concepts for Regional-Scale Water Storage

This section outlines preliminary concepts for irrigation water supply and storage on the regional scale being developed independent of this assessment by Nakaty Enterprises Inc. As stated above, Benton and Klickitat Counties have contracted with Nakaty Enterprises to help assess options for development of the John Day/McNary pools reserve. Because the counties are initiating governments for WRIA 31 watershed planning, it is appropriate to integrate that work into this assessment, and into future planning efforts as appropriate. While Nakaty Enterprises’ assessment is much broader in scope than this preliminary storage assessment, it does provide some useful concepts for water conveyance and storage that can overlap with this assessment. Mr. Duane Unland of Nakaty Enterprises presented a brief overview of some regional concepts at the April 2005 WRIA 31 Planning Unit meeting. We had additional discussion with Mr. Unland in a meeting on June 3, 2005. That information provides the basis of this section. We understand that Nakaty Enterprises will be preparing a Phase 3 report, under their contract with the counties, that outlines in greater detail the preliminary concepts outlined here.

Historically, several assessments have been conducted to evaluate feasibility of irrigation development across Horse Heaven Hills region, which includes the Glade-Fourmile subbasin of WRIA 31. These historical studies are summarized in Nakaty Enterprises (2005). Most notably, the Agricultural Research Center from Washington State University was contracted by Horse Heaven Irrigation Inc. to complete a multidisciplinary assessment of irrigation

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development potential of the Horse Heaven Hills region (WSU 1970). That broad-based study included assessment of irrigation potential, irrigation water requirements and costs, economics of expanding cultivation of various crop types, potential co-development of water storage with power development and recreation, as well as institutional alternatives for regional resource development. In that study, the concept for delivering irrigation water was diversion from John Day and McNary Pools with conveyance through an extensive series of irrigation canals. Diversion from the Yakima River and pumping over the Horse Heaven Hills crest was also considered for supplying higher elevation areas.

The WSU (1970) report outlined five different variations on the diversion and canal systems, termed Concepts A through E. The various canal concepts all had specific advantages and disadvantages, and all included dammed surface reservoirs for storage (typically within Glade Creek and Fourmile Canyon). Concept B was estimated to have the lowest cost; however, it relied on conveying Yakima River water to lands between elevations of 1,200 and 1,600 feet. The study recognized that it may not be possible to permit such an inter-basin transfer, and it certainly would not be allowed today. The next lowest cost option, Concept A, relied entirely on diversion from McNary Pool just upstream of the McNary Dam. Water would be pumped to a pair of dammed reservoirs in Fourmile Canyon, from which it would flow by gravity through a series of canals and be pumped to a canal at 1,400-foot elevation. For reference, a copy of WSU's (1970) schematic representation of Concept A is included as Attachment C to this memorandum. This regional canal network was laid out based on topography, thus the sketch (Attachment C) could be useful in understanding possibilities for canal systems for water conveyance and/or storage in the Glade-Fourmile subbasin.

The irrigation infrastructure/engineering and associated costs from that 1970 study are now out of date, but the concept of delivering irrigation water from the Columbia River via a regional canal system remains intriguing. A significant factor in future costs for any irrigation project is electric power costs. We understand that electric costs may increase dramatically after 2007 when the Bonneville Power Administration renegotiates its current contracts with utilities.

Recognizing the dramatic changes in irrigation engineering and economics since the 1970 study, Nakaty Enterprises has begun formulating preliminary concepts for supplying irrigation water across the Horse Heaven Hills region. While these preliminary concepts are to be developed in more detail in Nakaty Enterprises' future work, some general elements of the preliminary concepts at this time include:

- Water volumes via the canal system would be large, on the order of 1,000 to 1,300 cfs. Such large-scale projects can have large-scale economy of scale and thus the potential for delivering affordable irrigation water.
- Irrigation water would be pumped from McNary Pool during the winter months into an extensive network of canals, similar to that proposed in the WSU (1970) report. The canal network itself provides the potential for very large storage volumes. A main canal running to the west near the 1000-foot elevation contour is initially considered. A canal at 1,000-foot elevation is shown on the schematic drawing of the WSU (1970) Irrigation

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Concept A (Attachment C). Smaller canals leading from the main canal would then serve individual irrigation operations. A booster pump station could also pump water to a higher elevation (1,500-foot) canal to allow storage within a prospective high elevation dammed reservoir in the incised upper reaches of Glade Creek (T7N R23E). The lower end of this incised reach is shown in the upper left corner of Figure 1.

- Canal construction has improved considerably in the recent past. It is now possible to cut and line canals in a single process, which makes them an increasingly more cost effective than pipelines.
- It may be possible to integrate power generation, via wind turbines and/or low head hydroelectric, with irrigation water supply, through development of a combined water and power utility. The generalized concept is that the wind turbines could provide peak load power on demand, and off-peak power to pump water to storage in canals or other reservoirs. If the high-elevation reservoir described above were constructed for water storage, it may be possible to also generate power from turbines when the stored water is conveyed downslope in canals. The long-term revenue from power generation could help defray capital costs of the project.
- A regional-scale project would require a much greater level of centralized planning and organization than the moderate-scale project described above. Nakaty Enterprises' preliminary concept is that a combined water and power utility would be the institutional entity to construct and operate such a system. A combination of private and public sector investment would likely be needed to fund such a project.

As previously noted, conveyance costs represent a significant component of a storage project cost. It may be possible to make use of existing irrigation infrastructure to offset costs associated with storing water for irrigation supply. For example, there are numerous existing river diversions and distribution pipelines in WRIA 31 used to pump Columbia River water several miles inland for irrigation. We are uncertain whether it is technically or logistically feasible to use these existing systems to pump water from the river in the winter, when they're not in use for conventional irrigation supply. Most if not all of the existing infrastructure (piping, valves, etc.) was designed for use in the summer. It is not designed to operate in cold winter weather when its potential use for filling storage reservoirs would be desired. We are uncertain whether it is practical to replace cold-sensitive items (like valves) to allow operating the systems year-round, but this could be evaluated. Evaluation of feasibility and cost to winterize existing water conveyance systems was beyond the scope of this preliminary assessment, but could be completed as a follow-on to this assessment. An additional constraint to using existing infrastructure is that much of it was historically designed to minimize capital (construction) costs and did not consider high power costs. Therefore, the existing pump/piping systems are not hydraulically efficient, resulting in high operating costs. This will increase in importance if/when electric power costs increase substantially after 2007, and may require re-engineering of existing systems.

Clearly, considerable additional study would be required to evaluate the technical challenges of a regional-scale project in terms of irrigation water supply and possible integration with

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power generation, as well as the economic viability and funding alternatives required for a project of this magnitude. Additional discussion of regional-scale concepts for water storage and irrigation supply is appropriate in Phase 3 watershed planning for WRIA 31.

References

Aspect Consulting and WPN 2004. *Level 1 Watershed Assessment, WRIA 31 (Rock-Glade Watershed)*. November 12, 2004.

Nakaty Enterprises 2005. *Draft Phase II Historical Review, Benton - Klickitat County Study of the John Day-McNary Water Reserve*. Prepared in cooperation with IRZ Consulting and Pacific Northwest Consulting. May 21, 2005.

Washington State University (WSU) 1970. *Horse Heaven Hills Irrigation and Development Potential*. WSU College of Agriculture. December 1970.

Attachments

Table 1 – Planning-Level Cost Estimates for Diversion and Conveyance of 10 cfs

Table 2 – Planning-Level Cost Estimates for Diversion and Conveyance of 30 cfs

Figure 1- Conceptual Water Storage Locations

Attachment A - Overview of Conceptual Water Storage Options

Attachment B - Planning-Level Cost Estimate prepared by Anderson-Perry and Associates

Attachment C – Schematic of Horse Heaven Hills Irrigation Concept A from WSU (1970)

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Table 1 - Planning-Level Cost Estimates for Diversion and Conveyance of 10 cfs

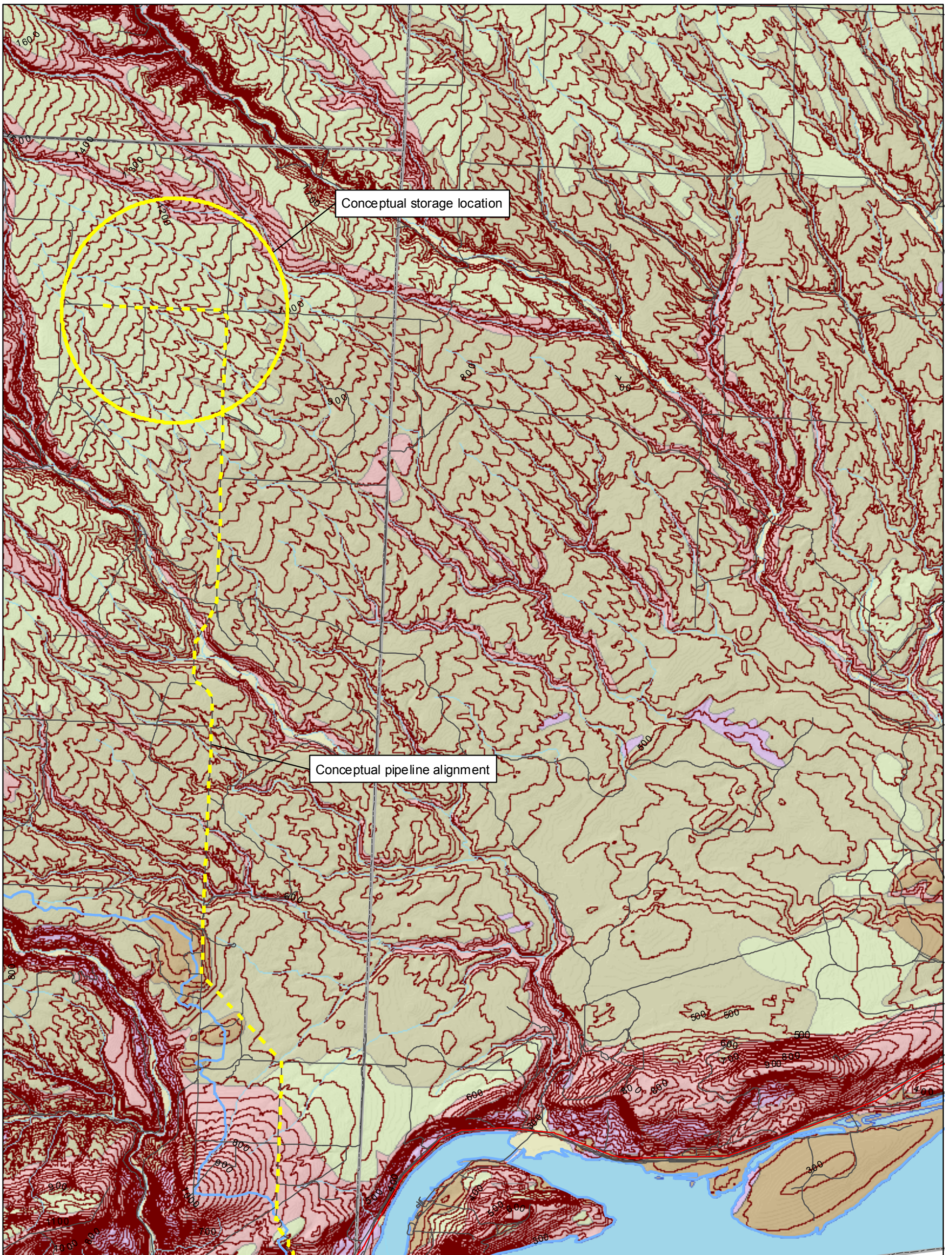
Unit	Diversion with Ranney Collector (for ASR)						Diversion with Surface Water Diversion (for Surface Storage)					
	14-mile Conveyance			7-mile Conveyance			14-mile Conveyance			7-mile Conveyance		
	Unit Cost	Number	Cost	Unit Cost	Number	Cost	Unit Cost	Number	Cost	Unit Cost	Number	Cost
Mobilization	\$695,000	1	\$695,000	\$695,000	1	\$695,000	\$695,000	1	\$695,000	\$695,000	1	\$695,000
Traffic Control	\$200,000	1	\$200,000	\$200,000	1	\$200,000	\$200,000	1	\$200,000	\$200,000	1	\$200,000
Diversion Structure	\$1,000,000	1	\$1,000,000	\$1,000,000	1	\$1,000,000	\$360,000	1	\$360,000	\$360,000	1	\$360,000
Equalization Storage	\$2,500,000	1	\$2,500,000	\$2,500,000	1	\$2,500,000	\$2,500,000	1	\$2,500,000	\$2,500,000	1	\$2,500,000
Pump Station	\$800,000	1	\$800,000	\$800,000	1	\$800,000	\$800,000	1	\$800,000	\$800,000	1	\$800,000
RR Crossing	\$125,000	1	\$125,000	\$125,000	1	\$125,000	\$125,000	1	\$125,000	\$125,000	1	\$125,000
Highway Crossing	\$125,000	1	\$125,000	\$125,000	1	\$125,000	\$125,000	1	\$125,000	\$125,000	1	\$125,000
36-in Welded Steel (rock)	\$175	5,500	\$962,500	\$175	5,500	\$962,500	\$175	5,500	\$962,500	\$175	5,500	\$962,500
36-in Ductile Iron (rock)	\$135	15,000	\$2,025,000	\$135	15,000	\$2,025,000	\$135	15,000	\$2,025,000	\$135	15,000	\$2,025,000
36-in DI (soft)	\$95	33,500	\$3,182,500	\$95	16,750	\$1,591,250	\$95	33,500	\$3,182,500	\$95	16,750	\$1,591,250
36-in PVC (soft)	\$85	21,000	\$1,785,000	\$85	0	\$0	\$85	21,000	\$1,785,000	\$85	0	\$0
Drainage Crossings (minor)	\$20,000	19	\$380,000	\$20,000	10	\$190,000	\$20,000	19	\$380,000	\$20,000	10	\$190,000
Misc. Piping	\$100,000	1	\$100,000	\$100,000	1	\$100,000	\$100,000	1	\$100,000	\$100,000	1	\$100,000
Construction Subtotal			\$13,880,000			\$10,313,750			\$13,240,000			\$9,673,750
sales tax (7%)			\$971,600			\$721,963			\$926,800			\$677,163
Contingency (15%)			\$2,082,000			\$1,547,063			\$1,986,000			\$1,451,063
Design/Admin/Legal (20%)			\$2,776,000			\$2,062,750			\$2,648,000			\$1,934,750
	Rounded total: \$19,710,000			Rounded total: \$14,646,000			Rounded total: \$18,801,000			Rounded total: \$13,737,000		

Surface water diversion assumes diversion to surface storage only; no treatment assumed.

Table 2 - Planning-Level Cost Estimates for Diversion and Conveyance of 30 cfs

Unit	Diversion with Ranney Collector (for ASR)						Diversion with Surface Water Diversion (for Surface Storage)					
	14-mile Conveyance			7-mile Conveyance			14-mile Conveyance			7-mile Conveyance		
	Unit Cost	Number	Cost	Unit Cost	Number	Cost	Unit Cost	Number	Cost	Unit Cost	Number	Cost
Mobilization	\$1,100,000	1	\$1,100,000	\$1,100,000	1	\$1,100,000	\$1,100,000	1	\$1,100,000	\$1,100,000	1	\$1,100,000
Traffic Control	\$200,000	1	\$200,000	\$200,000	1	\$200,000	\$200,000	1	\$200,000	\$200,000	1	\$200,000
Diversion Structure	\$3,000,000	1	\$3,000,000	\$3,000,000	1	\$3,000,000	\$475,000	1	\$475,000	\$475,000	1	\$475,000
Equalization Storage	\$2,500,000	1	\$2,500,000	\$2,500,000	1	\$2,500,000	\$2,500,000	1	\$2,500,000	\$2,500,000	1	\$2,500,000
Pump Station	\$1,255,000	1	\$1,255,000	\$1,255,000	1	\$1,255,000	\$1,255,000	1	\$1,255,000	\$1,255,000	1	\$1,255,000
RR Crossing	\$150,000	1	\$150,000	\$150,000	1	\$150,000	\$150,000	1	\$150,000	\$150,000	1	\$150,000
Highway Crossing	\$150,000	1	\$150,000	\$150,000	1	\$150,000	\$150,000	1	\$150,000	\$150,000	1	\$150,000
36-in Welded Steel (rock)	\$245	5,500	\$1,347,500	\$245	5,500	\$1,347,500	\$245	5,500	\$1,347,500	\$245	5,500	\$1,347,500
36-in Ductile Iron (rock)	\$220	15,000	\$3,300,000	\$220	15,000	\$3,300,000	\$220	15,000	\$3,300,000	\$220	15,000	\$3,300,000
36-in DI (soft)	\$155	33,500	\$5,192,500	\$155	16,750	\$2,596,250	\$155	33,500	\$5,192,500	\$155	16,750	\$2,596,250
36-in PVC (soft)	\$135	21,000	\$2,835,000	\$135	0	\$0	\$135	21,000	\$2,835,000	\$135	0	\$0
Drainage Crossings (minor)	\$20,000	19	\$380,000	\$20,000	10	\$190,000	\$20,000	19	\$380,000	\$20,000	10	\$190,000
Misc. Piping	\$100,000	1	\$100,000	\$100,000	1	\$100,000	\$100,000	1	\$100,000	\$100,000	1	\$100,000
Construction Subtotal			\$21,510,000			\$15,888,750			\$18,985,000			\$13,363,750
sales tax (7%)			\$1,505,700			\$1,112,213			\$1,328,950			\$935,463
Contingency (15%)			\$3,226,500			\$2,383,313			\$2,847,750			\$2,004,563
Design/Admin/Legal (20%)			\$4,302,000			\$3,177,750			\$3,797,000			\$2,672,750
Rounded total:			\$30,544,000			\$22,562,000			\$26,959,000			\$18,977,000

Surface water diversion assumes diversion to surface storage only; no treatment assumed.



Conceptual storage location

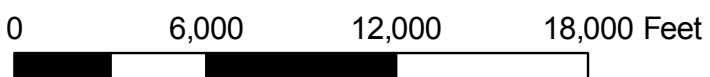
Conceptual pipeline alignment

Conceptual location for river diversion / Ranney collector

Lithology (DNR 1:100K mapping)

- Fill
- Flood Deposits - Sand & Silt (Quaternary)
- Flood Deposits - Gravel (Quaternary)
- Loess (Quaternary)
- Misc. Unconsolidated (Quaternary)
- Alluvium (Quaternary)
- Saddle Mountain Basalt (Miocene)

- Contours (25 foot)
- Contours (100 foot)
- Roads
- State Routes (WSDOT)
- Delineated Subbasins (Aspect Consulting)
- Counties (WSDOT)
- Waterbodies (Ecology)
- Watercourses (Ecology)



Conceptual Water Storage System Locations
 WRIA 31 Water Storage Assessment
 Glade/Fourmile Subbasin

DATE	January 2005	PROJECT NO.	030009
DESIGNED BY	GJC	PROJECT NO.	030009
CHECKED BY	GJC	REV. NO.	1
APPROVED BY	ACM		

ATTACHMENT A

Overview of Conceptual Water Storage Options

Attachment A

Overview of Conceptual Water Storage Options

There are multiple methods that can be used to store water, depending on site-specific conditions. This section provides a brief overview of three conceptual storage options potentially applicable to the Glade-Fourmile subbasin of WRIA 31. The most basic division of storage options is whether the water is stored above ground in a constructed surface water reservoir or underground in a naturally occurring aquifer. This screening assessment includes evaluation of two concepts using surface storage (on-channel dam; off-channel impoundment) and one using subsurface storage (aquifer storage and recovery, or ASR). These three conceptual storage opportunities are outlined briefly below in terms of the relative pros and cons in terms of permitting, construction, operation/maintenance, and cost, as well as data gaps to be addressed if further evaluation of a storage option were considered.

On-Channel Dam

There are currently more than 1,100 surface water dams in Washington State that store more than 10 acre-feet of water, with about 380 dams used primarily for water supply storage (Ecology 2001). On-channel dams and reservoirs are sited on major streams and can be filled directly by flow from the upstream watershed, or can be filled from source outside the stream's drainage area as would be the case for the Glade-Fourmile subbasin. The stored water can be conveyed directly from the reservoir via pipes or canals for irrigation use. It can also be released downstream for downstream uses. On-channel dams are typically constructed in deeply incised channels. Because the resulting reservoir is relatively deep with small surface area, it helps maintain the stored water at lower temperature than a shallow off-channel reservoir of comparable volume. If a particular stream is fish-bearing, fish passage can be engineered into the design of a dam. The potential pros and cons of an on-channel dam for application to irrigation water supply include:

Pros

- Likely amenable for greatest storage volumes.
- Likely has lower cost per volume of water stored than off-channel storage.

Cons

- Dam locations limited to non-fish-bearing waters, which may greatly limit feasible locations.
- Greatest permitting difficulty of the conceptual options considered here.
- Stored water lost to evaporation and subsurface seepage.
- Sedimentation behind dam.

Data Gaps

If further evaluation of this storage opportunity is warranted, information to consider can include:

- Accurately define fish-bearing/valuable habitat stream reaches to eliminate those reaches that are not permissible options for an on-channel dam

September 23, 2005

- Dam siting evaluation of prospective on-channel storage sites including land ownership, valley topography (reservoir volume to surface area ratio), geology, habitat potentially flooded, access and existing infrastructure, etc.
- Estimate storage volumes for variable sizes of dams at a prospective site, relative to water volumes considered feasible for storage there based on water rights and other considerations.
- Evaluate changes necessary in existing water rights and other permitting requirements specific to the project.
- Evaluate potential for impacts to the environment or other water rights.
- If a site appears feasible for permitting of a dam, estimate planning-level costs and prospective funding options.

Off-Channel Impoundment

Off-channel impoundments are sited outside the main stream valley, completely off-stream or possibly on an intermittent stream. This can include irrigation canals. Water to fill an off-channel reservoir can be diverted by gravity or pumping from downslope. Examples of off-channel impoundments include natural topographic depressions (not stream valleys) that either naturally retain water or can be dammed to do so, as well as constructed ponds, basins, or tanks. The potential pros and cons of an off-channel impoundment for application to irrigation water supply include:

Pros

- Generally flexible in terms of location and sizing. Can be located and sized to meet a range of irrigation needs.
- Relatively little instream impact, thus easier to permit than on-channel dam.
- Could be engineered to include wetlands or other habitat elements, thus providing environmental mitigation benefit.

Cons

- Likely involves greatest land area and surface disruption.
- Likely has higher cost per volume of water stored than on-channel storage.
- If open reservoir, stored water is lost to evaporation and, if unlined, to subsurface seepage.
- Sedimentation of impoundment.

Data Gaps

If further evaluation of this storage opportunity is warranted, information to consider can include:

- Quantify volumes and timing of excess water potentially available for storage by establishing and continuously monitoring stream gages at prospective dam sites.

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- For prospective sources of excess winter water, evaluate timing of fish use and habitat value of the streams to determine window in which diversion could be permitted;
- Because of the potentially large land requirements, define land ownership around streams representing prospective excess water sources and evaluate viability of land acquisition.
- Siting evaluation of prospective off-channel storage sites, including field inspection to evaluate topography, geology, existing infrastructure and access, etc.
- Evaluate changes necessary in existing water rights and other permitting requirements specific to the project.
- Evaluate potential for impacts to the environment (SEPA) or other water rights.
- Evaluate funding options.

Aquifer Storage and Recovery (ASR)

Water can be stored underground, where an aquifer serves as a subsurface reservoir. Aquifer storage and recovery (ASR) refers to temporarily storing water in an aquifer for later recovery and use. In the 2000 session, the Washington State Legislature expanded the definition of “reservoir” in RCW 90.03.370 to include “any naturally occurring underground geological formation where water is collected and stored for subsequent use as part of an underground artificial storage and recovery project.” In March 2003, Ecology adopted WAC 173-157, which establishes the standards for review of applications for ASR projects and standards for mitigation of potential adverse impacts to groundwater quality or the environment. In central and eastern Washington, the cities of Kennewick, West Richland, Walla Walla, and Yakima are all evaluating the feasibility of ASR to help meet future water demands.

Depending on the water source used to recharge an aquifer for ASR, the source water may require some degree of water quality treatment prior to its storage. At a minimum, the recharged water must have minimal turbidity to avoid clogging the ASR well and the aquifer around the well. In addition, recharge water quality cannot exceed applicable groundwater quality standards, or degrade ambient groundwater quality in the storage aquifer. Typically in ASR applications, a greater volume of water is recharged to the aquifer for storage than is subsequently withdrawn for beneficial use, because some recharge water is “lost” to mixing with the ambient groundwater. This can lead to an increase in the volume of groundwater in the storage aquifer through successive ASR cycles. As is the case for a surface water reservoir, ASR requires a primary water right to divert the source water (often already permitted), a reservoir permit (the ASR permit), and, if the primary water right does not specify the intended beneficial use, a secondary permit to use the stored water. The potential pros and cons of ASR for application to irrigation water supply include:

Pros

- Can be easier and less expensive to permit than surface reservoirs, particularly dams.
- Less land required and less surface disruption than surface reservoir systems.

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- Because the volume of water recovered is typically less than the volume stored, allows for gradual replenishment of aquifer.
- Range of uses is versatile – same as for any groundwater withdrawal.

Cons

- Source water may require water quality treatment prior to storage.
- Requires significant pilot testing to demonstrate feasibility.
- Considerable operation and maintenance (O&M) effort to ensure appropriate timing and volumes of storage and recovery, ensure ASR well doesn't clog, etc.
- Limited to areas with appropriate hydrogeologic setting in proximity to available surplus surface water for storage.

Data Gaps

If further evaluation of this storage opportunity is warranted, information to consider can include:

- Evaluate hydrogeologic suitability for ASR in areas where property ownership might allow for ASR.
- Determine availability and capacity of primary water rights for the source water that would allow for additional diversion in the winter season.
- Evaluate changes necessary in existing water rights and other permitting requirements specific to the project.
- Evaluate water quality compatibility between prospective surface water source and groundwater in storage aquifer.
- Evaluate land ownership, access and existing infrastructure, and potential for impacts to the environment (SEPA) or other water rights.
- Evaluate cost for diverting and conveying source water to ASR well(s), as well as funding options.

Permitting

Regulatory review and approval of prospective water storage projects can involve multiple permits. An overview of some of the major permits and approvals that may be required for a water storage project is provided below (modified from Ecology 2001).

Environmental Review

Water storage projects that require local, state, or federal approval require environmental review under the State Environmental Policy Act (SEPA) and/or the federal National Environmental Policy Act (NEPA). Environmental review is not a permit per se, but is intended to ensure that environmental values are considered during decision-making by government agencies. This review involves identifying and evaluating probable effects to the

September 23, 2005

environment. Water storage projects can require environmental review in the form of a SEPA checklist or environmental impact statement (EIS).

JARPA Permits

Numerous permits may be required for any water storage project that involves working in or near state waters (in-channel dam). These permits are typically applied for through the Joint Aquatic Resource Permits Application (JARPA). A Hydraulic Project Approval (HPA) from the Washington Department of Fish and Wildlife (WDFW) is required for any project that includes construction or other work that will use, divert, obstruct, or change the natural flow or bed of any fresh or salt water of the state. Any project involving placement of a structure within waters of the U.S. would require an Army Corps of Engineers 404 permit. Any instream diversion structure would need to comply with WDFW regulations to ensure fish are not trapped or otherwise harmed by it.

Fish and Wildlife Mitigation Policy

WDFW has a formal policy related to mitigation that may be applicable to proposed water storage projects. The policy is applied by WDFW when issuing or commenting on environmental permits. The stated goal of the policy is to achieve no loss of habitat function and value. It lists the guiding principles for making decisions on appropriate mitigation activities, required elements of mitigation plans and appropriate legal documentation.

State Water Rights/Reservoir Permits

Under the Washington Water Code, there are three possible authorizations required for storage projects:

- A water right permit or certificate is required to divert or withdraw water to an off-channel reservoir (surface or subsurface). On-channel reservoirs do not require this authority.
- A reservoir permit or certificate is required to impound and store water if the reservoir is storing more than 10 acre-feet in volume or if it is 10 or more feet deep at its deepest point.
- A secondary permit(s) may be necessary for using reservoir water outside the reservoir. A secondary permit to beneficially use stored water is not required where an existing water right for the source of the stored water authorized the beneficial use. Note that storage, by itself, is not a beneficial use of water. When practical, the authorizations to divert or withdraw public waters, to store water within a reservoir, and to use stored water outside the reservoir are combined into a single document.

Note that the Washington Water Code provides for expedited processing of water right applications for certain types of water storage proposals (RCW 90.03.370[1][b]).

Dam Safety Permit

A Dam Safety Construction Permit is required from the Department of Ecology's Dam Safety Office before constructing or modifying any dam or controlling works that can store

September 23, 2005

10 or more acre-feet of water. Ecology also inspects the construction of all dams to reasonably secure safety of life and property.

ATTACHMENT B

**Planning-Level Cost Estimate
Prepared by Anderson-Perry and
Associates Inc.**



April 6, 2005
Job No. 1199-177

Steve Germiot
Aspect Consulting, LLC
179 Madrone Lane North
Bainbridge Island, Washington 98110

RE: WRIA 31 Watershed Planning Services (030009)
Planning Level Cost Estimate

Dear Mr. Germiot:

Pursuant to our scope of services for the conceptual ASR system location, we have developed planning level cost estimates for a 10 cfs and 30 cfs supply facility. This letter report describes the data used for the estimate, discusses the route selected, details the overall improvements, presents some construction observations, and gives the estimated cost for the 10 cfs and 30 cfs supply options.

The following data was utilized to develop the planning level cost estimates:

- Site location provided by Aspect Consulting, LLC.
- Site visit (accessible portions of the route).
- Estimated unit cost of pipe provided by United Pipe & Supply and Northwest Pipe Company.
- Estimated pump cost from Sulzer Pumps (formerly Paco Pump).
- Estimated membrane filtration cost from W.H. Rielly.
- Estimated cost of Ranney collector from a past project along the Columbia River.
- Estimated cost for railroad and highway crossings from past projects.
- Estimated cost for pipeline construction from past projects and contractor input by R&G Excavating, Inc.
- Elevation data for the site from USGS topographic maps.

Route. After reviewing the site map provided and a USGS map of the area, the conceptual location of the diversion was shifted to the east about 2 miles. This site appears to be a better location for the facility and avoids the Windy Road route of Alderdale Road adjacent to Alderdale Creek (refer to Figure 1). Additionally, there may be alluvium deposits adjacent to the Columbia River at the adjusted site for a Ranney collector, if that option were chosen.

CONSULTING ENGINEERING • SURVEYING • MATERIALS TESTING

LA GRANDE, OR 97850-0939
1901 N. FIR ST.
P.O. BOX 1107
(541) 963-8309
FAX: (541) 963-5456

WALLA WALLA, WA 99362-0032
214 E. BIRCH
P.O. BOX 1687
(509) 529-9260
FAX: (509) 529-8102

BAKER CITY, OR 97814-2621
BASCHE-SAGE PLACE
2101 MAIN, Suite 207
(541) 523-5211
FAX: (541) 523-9275

From the adjusted diversion location, the pipeline would cross the railroad track and highway and follow a ravine around Golgotha Butte. Once around Golgotha Butte, the pipeline would veer back to Alderdale Road through primarily agricultural land. Right-of-way would need to be obtained from the Columbia River to the intersection with Alderdale Road. Except for drainage crossings, the pipeline could be constructed within the roadside ditch adjacent to the asphalt pavement within Alderdale Road. Temporary construction easements may need to be obtained because of the minimum width between the asphalt and the adjacent fence line, which is assumed to be the right-of-way location. At each of the drainage crossings, the pipeline will either need to be constructed within the roadway pavement or constructed outside the roadway in the new right-of-way.

Project Improvements. Project improvements include the water supply system, for which there are two options, and the pipeline to the ASR site. One water supply option is to obtain Columbia River water using a river intake, followed by membrane filtration to meet water quality standards, equalizing storage for satisfactory pump operation, ending with a pump station to pump the water to the site. The other water supply option would be to construct a Ranney collector, followed by equalizing storage for satisfactory pump operation, ending with a pump station.

The pipeline from the diversion to the ASR site would be constructed with three different types of pipe material depending on the location along the route. Next to the river and up to the ridge line, the pipeline would be constructed of epoxy lined and coated steel pipe. Steel pipe is required at this location because the pipeline pressure will be approximately 300 to 450 psi. Beyond this point, ductile iron pipe would be used until the pipeline pressure reaches approximately 160 psi, then C905 PVC pipe would be used for construction up to the ASR site.

Construction Observation. As shown on the map provided by Aspect Consulting, subsurface material adjacent to the Columbia River and around Golgotha Butte contains Saddle Mountain basalt. We have assumed trench excavation in this area would be difficult and would require blasting and/or hard excavation with specialized equipment. With the exception of one drainage, all other trench excavation was assumed to occur within sand and silt deposit materials.

Cost Estimates. Tables 1 and 2 provide the planning level cost estimates for the project. For a 30 cfs supply, the estimated cost ranges between \$30.5 million to \$34.2 million. For the 10 cfs supply, the estimated cost ranges between \$19.7 million and \$21.4 million. The length of pipeline work has a great deal to do with the construction cost. Over 60 percent of the cost is associated with pipeline work. Additionally, the amount of water supply has a substantial bearing on the total estimate construction cost. It should also be noted that the cost per cfs is lower for the 30 cfs supply than for the 10 cfs supply.

Mr. Steve Germiot
Aspect Consulting, LLC
April 6, 2005
Page -3-

Thank you for giving us the opportunity to work on this project. If you have any questions, please feel free to contact me at (541) 963-8309.

Sincerely,

ANDERSON-PERRY & ASSOCIATES, INC.

By 
Robin Harris, P.E.

RH/dl

Enclosure

cc: File 1199-177-02 (w/encl.)

COST ESTIMATE - 10 CFS SUPPLY
WRIA 31 WATER STORAGE ASSESSMENT PLANNING
WATER INTAKE AND TRANSMISSION PLANNING LEVEL
April 2005

NO.	ITEM	UNIT	UNIT PRICE	AMOUNT	TOTAL PRICE
Ranney Collector Option					
1	Mobilization	L.S.	\$ 695,000	All Req'd	\$ 695,000
2	Project Safety/Traffic Control	L.S.	200,000	All Req'd	200,000
3	Ranney Collector	L.S.	1,000,000	All Req'd	1,000,000
4	Equalization Storage	L.S.	2,500,000	All Req'd	2,500,000
5	Pump Station	L.S.	800,000	All Req'd	800,000
6	Railroad Crossing	L.S.	125,000	All Req'd	125,000
7	Highway Crossing	L.S.	125,000	All Req'd	125,000
8	24-inch Steel Pipeline (Rock Excavation)	L.F.	175	5,500	963,000
9	24-inch DI Pipeline (Rock Excavation)	L.F.	135	15,000	2,025,000
10	24-inch DI Pipeline	L.F.	95	33,500	3,183,000
11	24-inch PVC Pipeline	L.F.	85	21,000	1,785,000
12	Drainage Crossings (Minor)	Each	20,000	19	380,000
13	Miscellaneous Piping	L.S.	100,000	All Req'd	100,000
Planning Level Construction Cost Estimate					\$ 13,881,000
Sales Tax (7%)					\$ 971,700
Contingency (15%)					\$ 2,082,200
Design and Construction Engineering, Administration, Legal (20%)					\$ 2,776,200
					\$ 19,711,100

Exclusions: Well for injection; right-of-way; power service; operation, maintenance, and replacement; asphalt restoration.

NO.	ITEM	UNIT	UNIT PRICE	AMOUNT	TOTAL PRICE
Membrane Filtration Option					
1	Mobilization	L.S.	\$ 755,000	All Req'd	\$ 755,000
2	Project Safety/Traffic Control	L.S.	200,000	All Req'd	200,000
3	River Intake	L.S.	360,000	All Req'd	360,000
4	Membrane Filtration Plant	L.S.	1,800,000	All Req'd	1,800,000
5	Equalization Storage	L.S.	2,500,000	All Req'd	2,500,000
6	Pump Station	L.S.	800,000	All Req'd	800,000
7	Railroad Crossing	L.S.	125,000	All Req'd	125,000
8	Highway Crossing	L.S.	125,000	All Req'd	125,000
9	24-inch Steel Pipeline (Rock Excavation)	L.F.	175	5,500	963,000
10	24-inch DI Pipeline (Rock Excavation)	L.F.	135	15,000	2,025,000
11	24-inch DI Pipeline	L.F.	95	33,500	3,183,000
12	24-inch PVC Pipeline	L.F.	85	21,000	1,785,000
13	Drainage Crossings (Minor)	Each	20,000	19	380,000
14	Miscellaneous Piping	L.S.	100,000	All Req'd	100,000
Planning Level Construction Cost Estimate					\$ 15,101,000
Sales Tax (7%)					\$ 1,057,100
Contingency (15%)					\$ 2,265,200
Design and Construction Engineering, Administration, Legal (20%)					\$ 3,020,200
TOTAL PLANNING LEVEL ESTIMATE					\$ 21,443,500

Exclusions: Well for injection; right-of-way; power service; operation, maintenance, and replacement; asphalt restoration.

COST ESTIMATE - 30 CFS SUPPLY
WRIA 31 WATER STORAGE ASSESSMENT PLANNING
WATER INTAKE AND TRANSMISSION PLANNING LEVEL

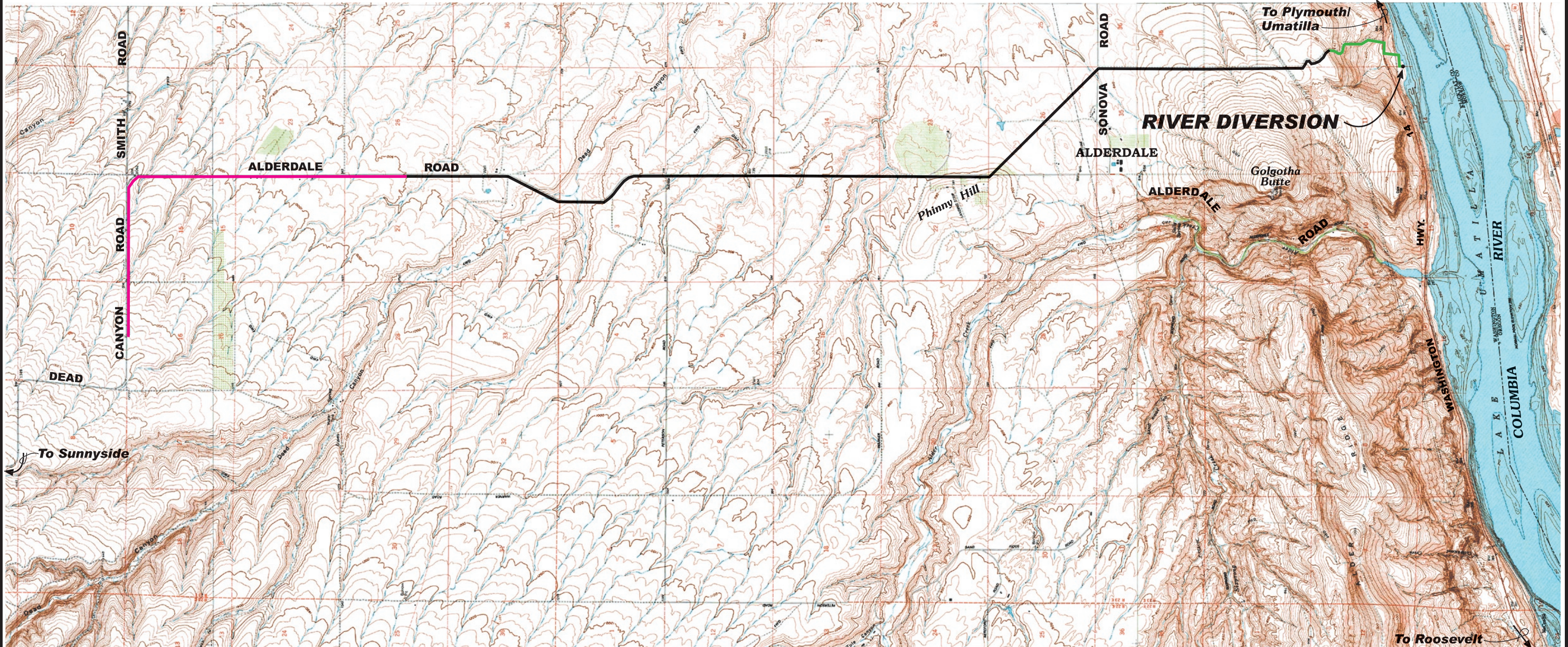
April 2005

NO.	ITEM	UNIT	UNIT PRICE	AMOUNT	TOTAL PRICE
Ranney Collector Option					
1	Mobilization	L.S.	\$ 1,100,000	All Req'd	\$ 1,100,000
2	Project Safety/Traffic Control	L.S.	200,000	All Req'd	200,000
3	Ranney Collector	L.S.	3,000,000	All Req'd	3,000,000
4	Equalization Storage	L.S.	2,500,000	All Req'd	2,500,000
5	Pump Station	L.S.	1,255,000	All Req'd	1,255,000
6	Railroad Crossing	L.S.	150,000	All Req'd	150,000
7	Highway Crossing	L.S.	150,000	All Req'd	150,000
8	36-inch Steel Pipeline (Rock Excavation)	L.F.	245	5,500	1,348,000
9	36-inch DI Pipeline (Rock Excavation)	L.F.	220	15,000	3,300,000
10	36-inch DI Pipeline	L.F.	155	33,500	5,193,000
11	36-inch PVC Pipeline	L.F.	135	21,000	2,835,000
12	Drainage Crossings (Minor)	Each	20,000	19	380,000
13	Miscellaneous Piping	L.S.	100,000	All Req'd	100,000
Planning Level Construction Cost Estimate					\$ 21,511,000
Sales Tax (7%)					\$ 1,505,800
Contingency (15%)					\$ 3,226,700
Design and Construction Engineering, Administration, Legal (20%)					\$ 4,302,200
					\$ 30,545,700

Exclusions: Well for injection; right-of-way; power service; operation, maintenance, and replacement; asphalt restoration.

NO.	ITEM	UNIT	UNIT PRICE	AMOUNT	TOTAL PRICE
Membrane Filtration Option					
1	Mobilization	L.S.	\$ 1,200,000	All Req'd	\$ 1,200,000
2	Project Safety/Traffic Control	L.S.	200,000	All Req'd	200,000
3	River Intake	L.S.	475,000	All Req'd	475,000
4	Membrane Filtration Plant	L.S.	5,000,000	All Req'd	5,000,000
5	Equalization Storage	L.S.	2,500,000	All Req'd	2,500,000
6	Pump Station	L.S.	1,255,000	All Req'd	1,255,000
7	Railroad Crossing	L.S.	150,000	All Req'd	150,000
8	Highway Crossing	L.S.	150,000	All Req'd	150,000
9	36-inch Steel Pipeline (Rock Excavation)	L.F.	245	5,500	1,348,000
10	36-inch DI Pipeline (Rock Excavation)	L.F.	220	15,000	3,300,000
11	36-inch DI Pipeline	L.F.	155	33,500	5,193,000
12	36-inch PVC Pipeline	L.F.	135	21,000	2,835,000
13	Drainage Crossings (Minor)	Each	20,000	19	380,000
14	Miscellaneous Piping	L.S.	100,000	All Req'd	100,000
Planning Level Construction Cost Estimate					\$ 24,086,000
Sales Tax (7%)					\$ 1,686,000
Contingency (15%)					\$ 3,612,900
Design and Construction Engineering, Administration, Legal (20%)					\$ 4,817,200
TOTAL PLANNING LEVEL ESTIMATE					\$ 34,202,100

Exclusions: Well for injection; right-of-way; power service; operation, maintenance, and replacement; asphalt restoration.



VICINITY MAP

PROJECT LOCATION

LEGEND

-  PVC PIPELINE
-  D.I. PIPELINE
-  WELDED STEEL PIPELINE

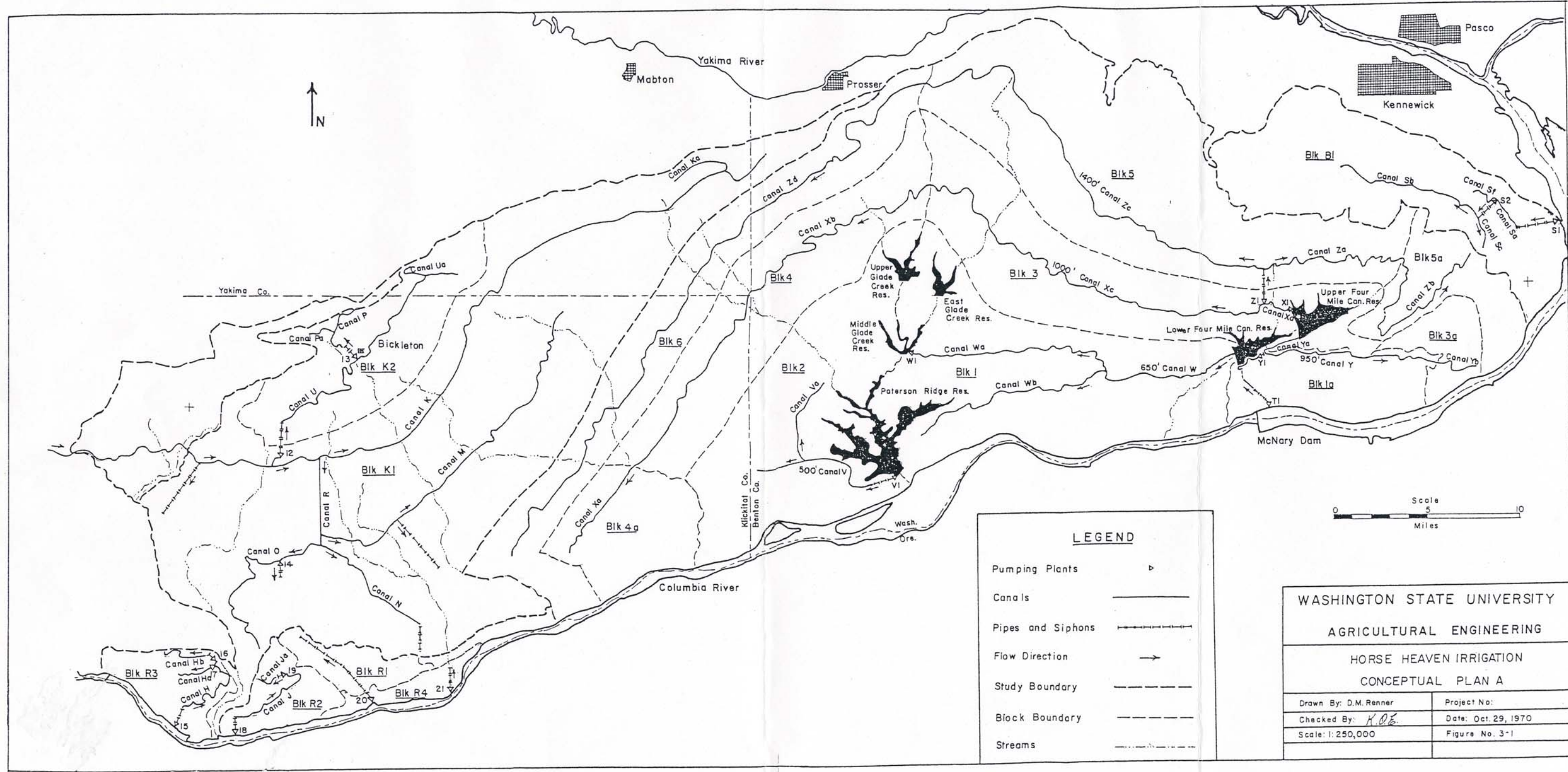


ASPECT CONSULTING LLC
 WRIA 31 WATER STORAGE ASSESSMENT
 PROJECT LOCATION MAP

FIGURE
 1

ATTACHMENT C

**Schematic of Horse Heaven Hills
Irrigation Concept A from WSU (1970)**



LEGEND	
Pumping Plants	▶
Canals	—
Pipes and Siphons	—+—+—+—+—
Flow Direction	→
Study Boundary	- - - - -
Block Boundary	- - - - -
Streams	~ ~ ~ ~ ~

WASHINGTON STATE UNIVERSITY	
AGRICULTURAL ENGINEERING	
HORSE HEAVEN IRRIGATION	
CONCEPTUAL PLAN A	
Drawn By: D.M. Renner	Project No:
Checked By: K.O.E.	Date: Oct. 29, 1970
Scale: 1:250,000	Figure No. 3-1