Technical Memorandum

To:	WRIA 35 Planning Unit		
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CC:	Ben Floyd		
Date:	March 17, 2005	Job No:	22604

RE: WATER STORAGE AVAILABILITY AND NEEDS ASSESSMENT

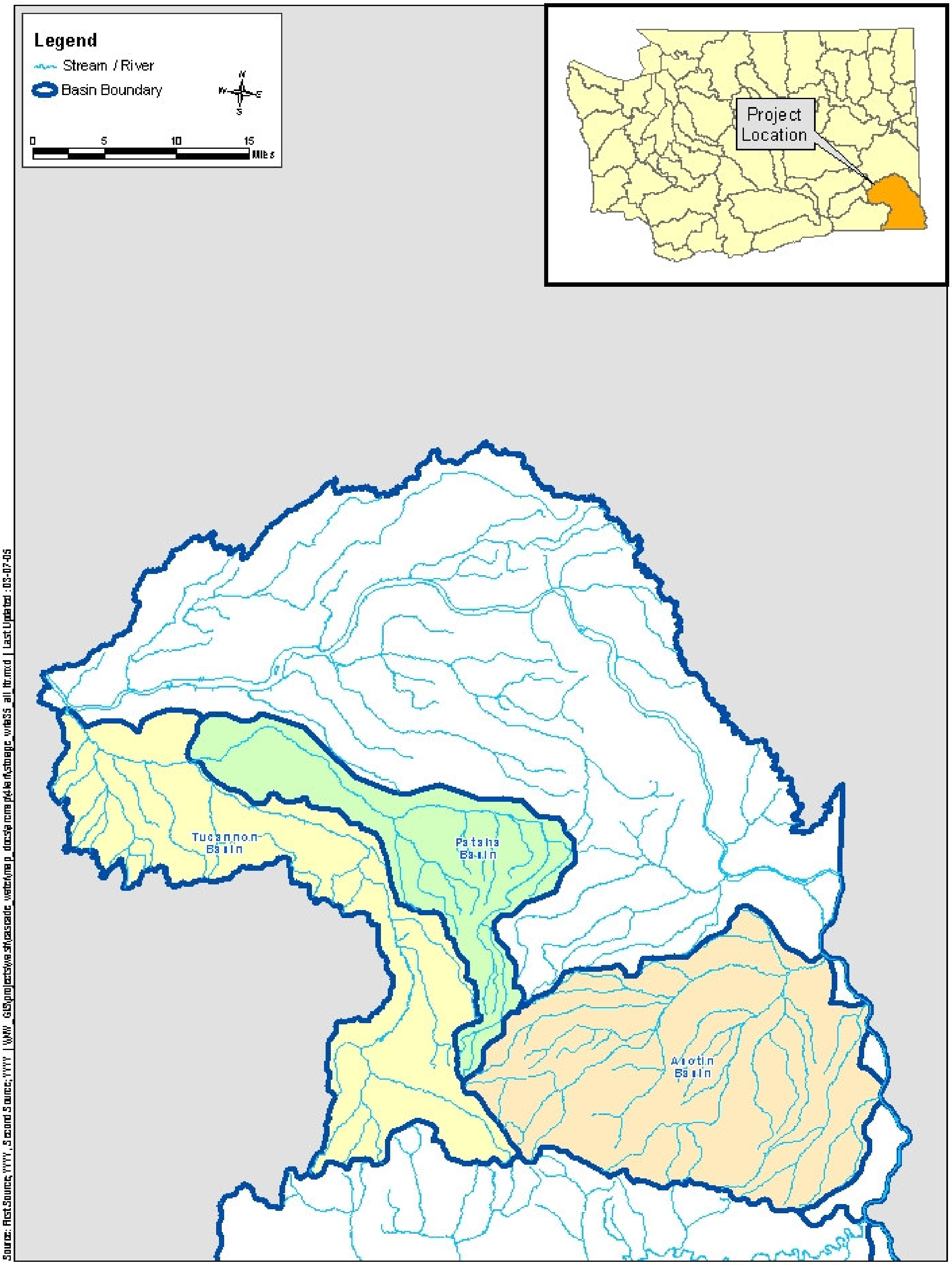
1.0 INTRODUCTION

This technical memorandum describes a screening-level analysis of water storage needs and options in the Pataha Creek, Asotin Creek and Tucannon River subbasins located in Water Resource Inventory Area (WRIA) 35. The WRIA 35 Planning Unit is exploring storage options that could supplement streamflow to better meet water demands for water supply, water quality and habitat. The entire study area is shown on Figure 1 and the project area at each subbasin is shown on Figures 2 through 4.

The general hydrology of the basin is described in the Phase II, Level 1 Watershed Assessment for WRIA 35. Streamflow reaches a peak in spring and early summer due to snow melt in the uplands and is reduced during summer and early fall. Irrigation is the largest component of water use in the watershed and is greatest during summer. Fish species require adequate flow, temperature and water quality at various life cycle stages. Elevated water temperature combined with low flow can serve as a limiting factor for fish growth and survival.

This memo describes the analysis of:

- Water storage needs for principal water use categories (irrigation, fish habitat and instream flow)
- Evaluation of water storage alternatives
- Evaluation of locations in basins where water storage projects could be beneficial



WRIA 35 Study Area

FIGURE 1

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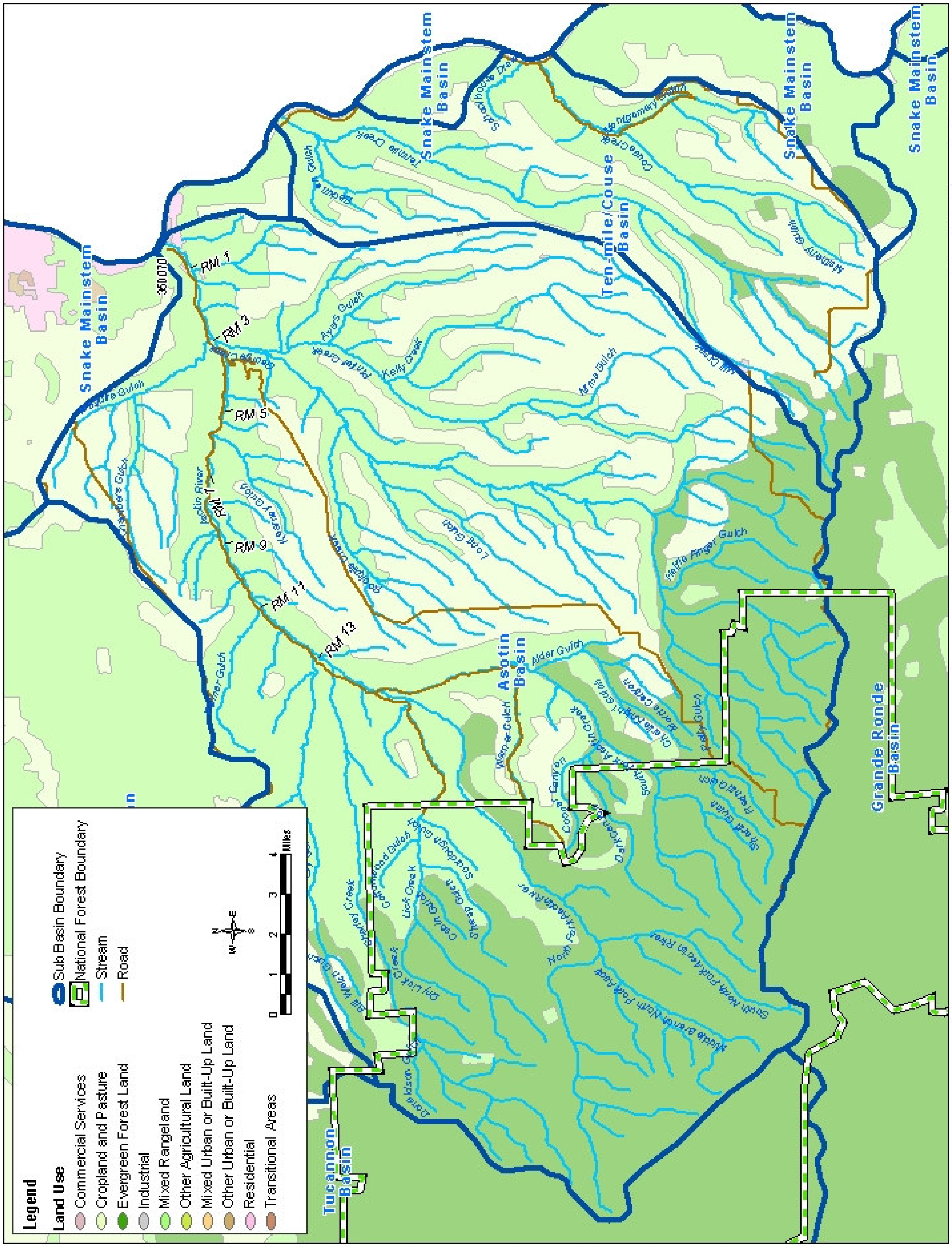

Asotin Creek Study Area

FIGURE 2

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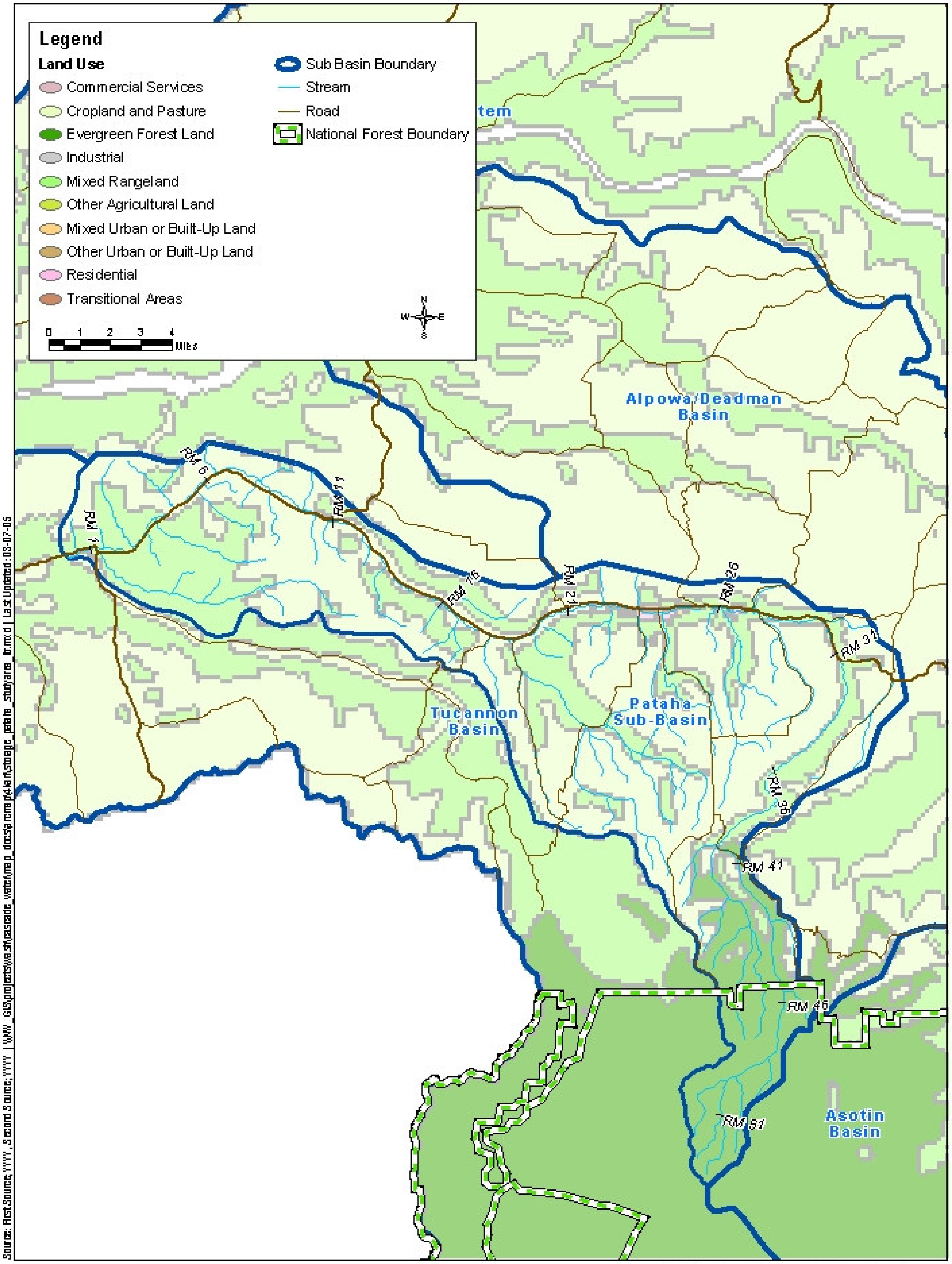

Pataha Creek Study Area

FIGURE 3

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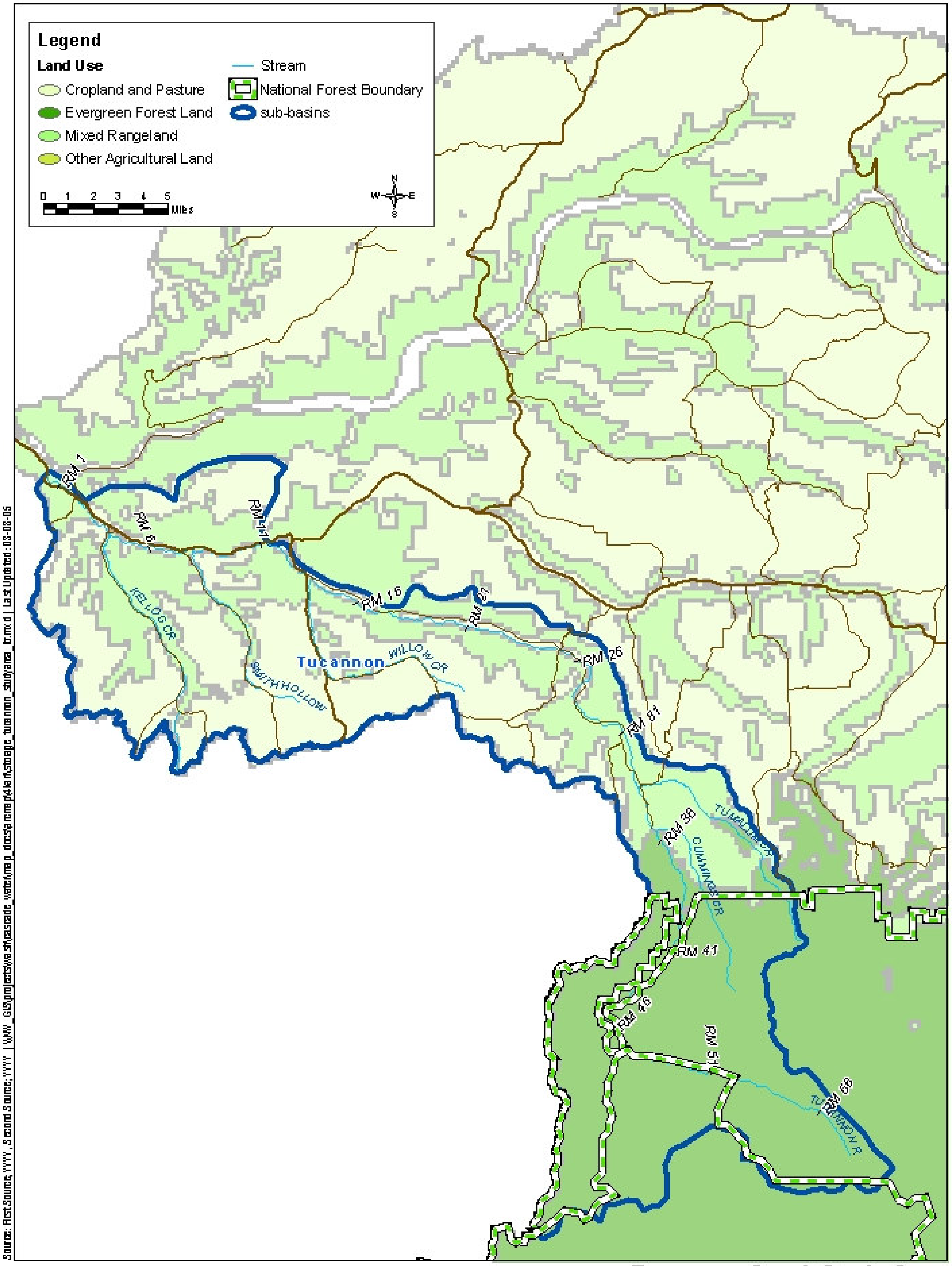

Tucannon Creek Study Area

FIGURE 4

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2.0 STORAGE NEEDS

This section describes water storage needs for Pataha Creek, Asotin Creek and the Tucannon River subbasins. Water demand is identified for the upper, middle and lower sections of each subbasin[1]. There are several needs that may be better met with the implementation of a storage alternative.

2.1 WATER USE

Table 1 presents the annual estimated water use and water rights for all water uses in acre feet per year, as well as the instantaneous use during the irrigation season based on irrigation occurring during a five month irrigation season. The average annual flow presented in the Table 1 represents the volume of water flowing past the indicated gage during one year as averaged over available historic records. The 'Ave flow during irrigation season' assumes irrigation occurs from May to September and values were calculated from averaged historic monthly flow values during these months.

Irrigation is the largest water use in WRIA 35, with some additional water demand from municipalities. Water demand in the Tucannon subbasin is the greatest of all of the subbasins. Estimated water use in the Tucannon subbasin (5389 afy) is more than ten times that in the Asotin subbasin (424 afy) and six times that in the Pataha subbasin (883 afy). The annual flow in Asotin Creek (74,287 afy) is approximately one half of the annual from in the Tucannon River (123,823 afy). However, the annual flow in Pataha Creek (8,954 afy) is only about seven percent of the flow in the Tucannon River. These results indicate that water demand is highest in the Tucannon River subbasin, lower in the Pataha Creek subbasin and least in the Asotin Creek subbasin.

2.2 STREAMFLOW COMPARED TO WATER USE

In WRIA 35 irrigation demand is highest at the end of summer when flow is the lowest. Figures A.1 to A.9 in Appendix A show the seasonal timing of demand and flows in the upper, middle and lower sections of each subbasin. Annual water rights and estimated annual demand are presented in cubic feet per second, with non-irrigation demands assumed to occur all year and irrigation demand assumed to occur over a five month period from May to September. Historic streamflows are presented at 90%, 50% and 10% exceedance levels for a range of flow. A 50% exceedance streamflow is that which

[1] This memo refers to upper, middle and lower portions of Asotin, Pataha and Tucannon subbasins. Definitions for this breakdown of the watershed are as follows:
Asotin: upper – RM 12.8 to end of streams; middle – RM 3.1 to RM 12.8 (including George Creek) ; lower – RM 0 to RM 3.1
Pataha: upper – RM 31.1 to RM 53.3; middle – RM 18.4 to RM 31.1; lower – RM 0 to RM 18.4
Tucannon: upper – RM 37.5 to RM 58.2; middle – RM 13.8 to RM 37.5; lower – RM 0 to RM 13.8

50% of the recorded flows have exceeded. Also included on the graphs are the instream flow requirements for fish habitat.

A summary of water availability in each subbasin on a reach by reach basis is presented in Tables B.1 to B.3. The breakdown of reaches in these tables corresponds to reaches described in the Phase II Level I Assessment. These tables provide more detailed information on stream gages, average flows, water rights, targeted fish species and any water right restrictions or closures on each reach. They show more specifically the location of demand and the corresponding average flows.

In many locations in the watershed the water demand is much lower than available flow. In these locations implementation of a water storage alternative would most likely not improve the ability to meet demands. There are some locations, however, where water demand is greater and additional storage would provide a benefit. These areas are discussed below.

2.2.1 Asotin Subbasin

Figures A.1 to A.3 show the streamflow, water demands and surface water source limitations in the Asotin subbasin. In the upper and middle sections all demands and surface water source limitations are met by the 90% exceedance flow at all periods of year (Figures A.1 and A.2). In the lower section of the subbasin the water use demands are met, but the surface water source limitation is not met by the lowest 10 percent of the streamflow on record from mid-May to mid-July (Figure A.3).

2.2.2 Pataha Subbasin

Pataha streamflow, demand and surface water source limitations are shown in Figures A.4 to A.6. In the upper section of the subbasin all water demands are less than exceedances (Figure A.4). In the middle section, however, the surface water source limitation of 10 cfs exceeds even the 10% exceedance flows from June through November, and exceeds the 50% exceedance flow through December (Figure A.5). In the lower section of the Pataha subbasin, combined water right allocations exceed the 50% exceedance flow and the estimated water demand exceeds the 90% exceedance flow during July and August (Figure A.6).

2.2.1 Tucannon Subbasin

Figures A.7 to A.9 show streamflow, water demand and instream flow recommendations in the Tucannon subbasin. Figure A.7 shows that all water rights and estimated demands are less than historic streamflow in the upper portion of the subbasin. In the middle section of the basin, water demand is less than available streamflow, but suggested optimal flow for fish habitat as quantified from weighted useable area (WUA) based on physical habitat modeling exceeds the 50% exceedance flow from July to January and exceeds the 90% exceedance flow in all months but April (Figure A.8). In the lower section of the subbasin the situation is similar; streamflow is sufficient to meet demands but does not meet the instream flow recommendation. The 90% exceedance flow is below the 50 cfs instream flow recommendation from mid-July to September while the optimal fish habitat flow quantified from weighted useable area based on physical habitat modeling is not met by the 50% exceedance flow from July to October and by the 90% flows from June to November (Figure A.9).

Table 1 Summary of Annual Water Right Allocation and Water Use

Subbasin	Sum of Water Right Allocations (Q_a)		Sum of Water Right Allocations + Claims (Q_a)		Estimated Annual Water Use[2]		Historic Streamflow				
	afy	cfs[a]	afy	cfs[a]	afy	cfs[a]	Gage Location	Average Annual Flow		Ave flow during irr season	Ave August flow
								afy	cfs	cfs	cfs
Asotin	808[2]	2.14	5300[2,3]	17.24	424	1.15	Asotin	74,287[4]	104.04	125.7	35.7
Pataha	1191[2]	2.95	NA	NA	883	1.62	At Tucannon R	8,954[5]	30.10	12.2	1.7
Tucannon	4,982[1]	16.94	29,557[1]	99.54	5,389	17.83	Starbuck	123,823[4]	416.18	183.2	60.7

Notes:

a - cfs values calculated from afy values, assuming irrigation use distributed evenly over 5 irrigation season

1 -Tucannon River Model Watershed Plan

2 - WRIA 35 Level 1 Assessment Report, original data compiled from NRCS 1995, DOE WRATS database,

Conservation Districts, and AgiMet ET data

3 - Asotin Creek Subbasin Summary

4 - USGS

5 - WSU

NA = Information is not available

Qa = Water right allocation, annual use limit

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2.3 SUMMARY OF WATER NEED COMPARED TO WATER AVAILABILITY

The water requirements for irrigation and fish habitat were compared with the available water on a seasonal basis and evaluated on a relative basis for each watershed. This information is summarized in Tables 2 to 4. The purpose of the tables is to summarize locations where storage alternatives could provide the most impact benefit. Information is presented to summarize the irrigation demands, the ability of the streamflow to meet these demands, the water right status, whether fish need are being met and, finally, if additional flow could provide significant benefits

2.3.1 Asotin Subbasin

Table 2 shows that the irrigation demand is low in the Asotin subbasin and is met by the streamflow. The streamflow recommendations for optimal fish habitat are not defined for Asotin basin but some surface water source limitations (SWSLs) exist on the middle and lower sections of the stream. These results indicate that additional flow would not provide a significant benefit in the upper section of the subbasin, but may provide a benefit in the middle and lower sections depending on fish habitat requirements.

2.3.2 Pataha Subbasin

Table 3 shows that the irrigation demand in the Pataha subbasin is medium in the middle section, medium in the lower section and low in the upper section. Streamflow is sufficient to meet irrigation demand in the upper two sections of the stream but not in the lower section. A surface water source limitation is noted in the middle portion of the subbasin, but fish habitat requirements are undefined. The results in the Table 3 indicate that additional flow would provide a benefit in the middle and the lower sections of the Pataha subbasin.

2.3.3 Tucannon Subbasin

Table 4 shows that irrigation demand is high in the lower section of the Tucannon subbasin and moderate in the middle section. Streamflow in Tucannon River is able to meet the irrigation demands in all areas of the subbasin. Streamflow is not sufficient to meet fish habitat flow, where optimal weighted useable area targets have been estimated from IFIM studies, and instream flow recommendations for water use in the middle and lower reaches For this reason, additional flow could provide a significant benefit in the middle and lower section of the Tucannon subbasin.

2.3.4 Summary

Tables 2 through 4 show that there is an opportunity to better meet water demand and to provide additional water for fish habitat, particularly in the middle and lower Pataha and Tucannon subbasins. In the Pataha subbasin supplemental flow would be most beneficial from June to December in the middle portion of the basin and in July and August in the lower portion. In the Tucannon subbasin supplemental flows are most needed in the middle portion of the basin during July through December and in the lower portion during July through October.

Table 2 Water Need Assessment for Asotin Subbasin

	Upper Asotin	Middle Asotin	Lower Asotin
Irrigation demand	Low	Low to medium	Low
Does streamflow always meet water demands?	Yes	Yes	Yes
Are water rights restricted or closed?	No	SWSL of 10 cfs I	SWSL of 70 cfs Apr-June, 15 cfs, July-Mar
Is streamflow sufficient for fish habitat?	Not defined[1]	Not defined[1]	Not defined[1]
Would additional flow provide a significant benefit?	No	Potentially yes	Potentially yes

1 - Instream flow studies have not been made available for the Asotin Creek subbasin

Table 3 Water Need Assessment for Pataha Subbasin

	Upper Pataha	Middle Pataha	Lower Pataha
Irrigation demand	Low to medium	Medium	Medium
Does streamflow always meet water demands?	Yes	Yes	No
Are water rights restricted or closed?	No	SWSL of 10 cfs	No
Is streamflow sufficient for fish habitat?	NA	NA	NA
Would additional flow provide a significant benefit?	No	Yes	Yes

Table 4 Water Need Assessment for Tucannon Subbasin

	Upper Tucannon	Middle Tucannon	Lower Tucannon
Irrigation demand	Low	Medium	High
Does streamflow usually meet water demands?	Yes	Yes	Yes
Are water rights closed or restricted?	Closed down to Cummings Cr	No	Instream Flow Recommendation of 50 cfs
Is streamflow sufficient for fish habitat?	NA	No	No
Would additional flow provide a significant benefit?	No	Yes	Yes

3.0 GENERAL SUBBASIN PHYSICAL CHARACTERISTICS

Tables C.1 to C.3 in Appendix C summarize the physical characteristics of each subbasin on a reach by reach basis. These tables summarize the watershed characteristics for each subbasin. This information will be used to help determine the optimal locations for specific storage alternatives.

3.1 ASOTIN SUBBASIN

Deciduous forest and shrubland cover most of the uplands in the Asotin subbasin, with shrubland and pastures comprising the lower portion of the basin. Land ownership varies in the subbasin but, in general, the upper portion of the subbasin consists of Federal and State land and the lower portion of the subbasin is in private ownership. The geology in the Asotin subbasin consists mainly of Grande Ronde Basalt along the stream valley and Saddle Mountain Basalt on the edges of the valley and in the uplands. Alluvial deposits are along the valley; the thickness of alluvial deposits inverse downstream as the valley floor branches. Deep valleys comprise the upper portion of the subbasin. The lower and middle portion is not as steep as the upper portion. Precipitation ranges from ten to twenty inches per year, with higher precipitation occurring in the upper portion of the subbasin.

Sedimentation basins can be found in the George Creek drainage area. There are also riparian wetlands in the middle and lower portion of the basin, along Asotin Creek on the stretch from the North and South Forks to George Creek.

3.2 PATAHA SUBBASIN

The land use in the Pataha subbasin ranges from deciduous forest in the upper portion, and agriculture and scrubland in the middle and lower portion, with residential land use near Pomeroy. The Forest Service and State owns most of the deciduous forest land, while other land is owned privately. Wanapum Basalt lies under most of the subbasin with Grande Ronde Basalt in the stream valley. Alluvial deposits are along the valley; the thickness of alluvial deposits inverse downstream as the valley floor branches. The topography ranges from hills and deep valleys in the upper portion to moderately sloped land in the middle and lower portion of the subbasin. Average precipitation in the subbasin is 12 to 14 inches per year in the lower subbasin, increasing to 18 to 30 inches in the upper subbasin.

There are no known existing storage structures in the Pataha subbasin and minimal riparian wetlands.

3.3 TUCANNON SUBBASIN

Deciduous forest covers most of the area upstream of Tumalum Creek and shrubland and pasture covers the area downstream. The Forest Service owns much of the area down to Cummings Creek, with State ownership dominating between Cummings and Tumalum Creek and private ownership further downstream. The geology of the subbasin consists of mainly Grande Ronde Basalt upstream of Tumalum Creek and along the river valley downstream of this location, with Wanapum Basalt in areas further from the river in this downstream portion. The topography is hilly to moderately sloped in the upper and middle portion of the basin and relatively flat valley in the lower portion. Average annual precipitation ranges from 10 to more than 30 inches, with average precipitation least at the lowest portion of the subbasin and greatest in the uplands.

There are storage structures existing in the upper and middle portions of the Tucannon subbasin. Washington Department of Fish and Wildlife operate fish ponds in the area along the Tucannon River from Little Tucannon to Tumalum Creek. Water is stored during peak flow periods and released during low flow periods. There are also small sediment basins located along the river in the reach between Tumalum Creek and Willow Creek which trap sediment and can store water for a limited time.

4.0 STORAGE ALTERNATIVES

This section describes the water storage alternatives recommended for consideration by members of the Planning Unit. Each alternative is presented with a short description followed by a comparison of major advantages and disadvantages. The storage alternatives information is presented in Table 5.

1. New Reservoirs

Off-channel surface water reservoirs could be constructed in upland areas, such as in tributary canyons or in suitable lowland areas. Water could be conveyed and stored in reservoirs during peak flows and released during dry periods when additional streamflow or water supply is needed. Water storage reservoirs would require significant engineering, permitting, and construction effort and associated costs. Reservoirs can store a large volume of water late into the summer when streamflow is lowest and the water release rate can be controlled so that water is provided when flow is most needed.

Advantages:
Ability to store a large volume of water
Well-controlled rate of release

Disadvantages:
High cost
Significant permitting and construction requirements
High land use requirements and difficult site selection
Possibility for increase of water temperatures
Potential water quality issues

2. In-Channel Storage

Water could be stored directly in the river valley through a variety of methods. Run of the river reservoirs could be use to store water upstream at high-flow periods with releases made according to decisions based on downstream needs. Potential in-stream habitat degradation and sedimentation issues would raise significant permitting obstacles. Also, much of the land in the upper portion of the watersheds is in state or federal ownership. However, a relatively large volume of water could be stored and released during low-flow periods. Other structures, such as grade control, could slow down the flow of water from upstream to downstream so that water remains in the stream for a longer period of time and low flow periods can be delayed. This option can create similar problems to a run of the river reservoir and also has a much lower storage capacity. Other options may be available for in-channel storage depending on the location and river characteristics.

Advantages:
Able to store water and release it during low-flow periods in a controlled manner

Disadvantages:
Permitting may be difficult
Degradation of in-stream habitat
Grade control cannot store much water
Sedimentation issues
High permitting, construction, and maintenance requirements
High cost

3. Modify Existing WDFW Ponds

Existing off-channel reservoirs or ponds could potentially be expanded to increase water storage capacity. Because the conveyance and water storage system is already in place, modification of an existing reservoir may offer a less costly option than construction of a new reservoir. In addition, purchase of new land may not be required or may be minimized. The permitting process could also be reduced.

Advantages:
Lower cost than new construction
Ability to store a large volume of water

Disadvantages:
Engineering, permitting and construction requirements
High cost
Current uses may not be compatible with increased water storage
Potential water quality issues

4. New Riparian Storage or Farm Field Flooding Storage

This category includes storing surface water close to the river within the riparian zone. Water could be diverted during peak flow periods and stored in a location close to the stream. The stored water may be released later in the year to supplement low flow and provide improved habitat for fish and other water users. Options under this category could include modifying existing levees and flooding fields. The farm fields located near a stream may provide possible sites for water storage spreading techniques. Water could be delivered to agricultural land during high flow spring runoff. Existing levees could be modified with a weir or other type of release structure. Water from the stream could potentially overflow onto the farm fields during peak flow periods and infiltrate into the ground. This water could drain through the soil and slowly seep into the stream.

Advantages:
Relatively low-cost
Source of water supply nearby
Potential riparian habitat benefits

Disadvantages:
High cost
Significant land requirements
Decreased agricultural production
Alteration of riparian habitat
Seepage losses
Not able to store water though summer

5. New or Modified Riparian Wetlands

Wetlands can serve water storage units while providing additional benefits such as reduced flood peaks, water quality improvement, and increased aquatic habitat. This alternative includes expansion of existing wetlands or construction of new wetlands in the riparian zone. Riparian wetlands could be expanded to increase the potential water storage volume or a new wetland could be constructed as an additional storage site. Water that is released or overflows into a wetland during peak flow periods may remain for some time, although the amount of water stored and the rate of release would be dependent on the ability to capture and store water while minimizing seepage losses. Infiltration of water from the wetland may increase aquifer storage, providing more summer baseflow. Diverting streamflow to wetlands may require a diversion structure, modification of existing wetlands and alteration of existing levees. Although wetlands provide many benefits, the storage capacity is not as great as a reservoir of the same area and there is less control over the rate of release of water back into the stream.

Advantages:
Improved aquatic habitat
Water quality benefits
Potentially minimal additional land requirements for existing wetlands

Disadvantages:
Water storage volume may be limited
Rate of release is difficult to control
Permitting requirements for wetland modification

6. Modification of Existing Sediment Basins

Sediment basins trap sediment entering a stream from uplands or tributary valleys and, as a secondary result, can slow water flow though the basin into the stream. Sediment basins in the valley are designed to hold water only long enough for sediment to filter out and would need to be modified to serve as storage facilities. Sediment basins could be improved, expanded or constructed in new areas to store water. Other modifications may increase the sediment filtration efficiency and/or decrease the rate of water release so that stored water could provide supplemental flows longer into the low-flow period. Sediment basins improve water quality by reduction of sediment and do not require a large area of land or high construction costs. They do, however, require regular maintenance to achieve optimal operation and to maintain water quality.

Advantages:
Improves water quality
Possibility of using existing structures

Disadvantages:
Control of flow release timing may be difficult
Regular maintenance required
May be difficult to incorporate infiltration

7. Aquifer Storage

Aquifer Recharge Aquifer storage can be used to infiltrate and store water in aquifers during a high-flow period. Water is diverted from the stream, conveyed to an infiltration pond and allowed to infiltrate into the alluvial aquifer. The water may be stored in the aquifer for some time before it flows back to the stream. The aquifer serves as an underground reservoir that provides baseflow to streams. Aquifer storage options may include enhanced infiltration or direct recharge of aquifers from recharge ponds or wells, although the technical issues and permitting requirements are more substantial for the latter option.

It also may be possible to enhance infiltration to aquifers from alternative land-use practices. Enhanced infiltration could include employing no-till farming techniques to decrease runoff and increase infiltration or using other methods to reduce runoff.

Alternative Source for Irrigation The basalt aquifer could potentially be used as an irrigation source in place of surface water, although the depth to water and pumping cost is unknown. If artesian conditions are present, this could eliminate the need for pumping.

Direct Stream Augmentation It may be possible to supplement streamflow with water pumped directly from the basalt aquifer. If low-temperature groundwater is available, ground water could be used to lower water temperatures.

New Water Supply Groundwater supply may be available for increased industrial, municipal and agricultural water supply.

Advantages:
High water quality
Low land cost
Able to store large quantities of water

Disadvantages:
Benefit to stream dependent on release rate
Ability to implement dependent on geologic factors

5.0 EVALUATION OF STORAGE ALTERNATIVES

This section presents an evaluation of each of the storage alternatives presented above. A description of implementation requirements is provided and the alternatives are compared as part of the process to determine the feasibility of each of the storage alternatives.

5.1 EVALUATION OF ALTERNATIVES

A screening-level evaluation was completed for each of the alternatives. The basis for the screening-level evaluation is presented on Table 5. The table summarizes requirements for location, funding, feasibility studies, design, construction, maintenance, permitting and possible impacts. The specific evaluation of each storage alternative is presented below:

1. New Reservoirs

Description
Construction of a new reservoir in the upper or middle part of the watershed.

Potential Benefit
New reservoirs are able to store large volumes of water. They allow controlled release of stored water to supplement streamflow or to meet irrigation demand when the need is greatest.

Evaluation Criteria

- The size of reservoirs necessary to augment streamflow to any meaningful flow rate would be very large. A minimal flow augmentation target of 10 cfs over 4 months would require 2,400 acre-feet of storage. This corresponds to 60 acres with a 40-foot deep reservoir or 120 acres with a 20-foot deep reservoir.
- Land acquisition costs for 60 to 120 acres range from $120,000 to $240,000, assuming $2,000/acre.
- Construction costs for impoundment berms, spillway, liners, diversion intake, etc. would be significant. Impoundments and spillways would be required to meet Ecology Dam Safety regulations.
- Engineering studies would require between 10 to 20 percent of construction costs.
- Permitting studies would require between 10 to 20 percent of construction costs.

- It is not possible to locate new reservoirs in Federal or State land ownership areas without approval by those agencies and a significant consultation and permitting process. Approval would be difficult.
- A permit would not be possible through USACE and/or EPA unless a significant need was demonstrated.
- A long-term commitment would be required for maintenance to comply with periodic Dam Safety review.
- Construction of a new reservoir may be possible if there is a local sponsor with a demonstrated water demand requirement willing to provide the funding necessary for permitting, design studies and construction.
- The entire reservoir water column would heat up in the summer as the reservoir would be fully mixed. Water released to the stream would be warm.

Potential Limitations

- Requires commitment by local agencies to sponsor a project.
- Geologic suitability of proposed reservoir sites is unknown.
- Water temperature may exceed water quality standards, limiting the benefit of the water for in-stream uses.

2. In-Channel Storage

Description

Construction of new in-channel low-head structures or small in-channel upland reservoirs.

Potential Benefit

Water storage in upper portion of watershed.

Evaluation Criteria

- In-channel low-head structures will not store much water and would create negative impacts to instream aquatic habitat.
- Small upland reservoirs will likely not store enough water to augment streamflow sufficiently to improve fish habitat. The Evaluation Criteria for small upland reservoirs are similar to those presented above in the analysis for New Reservoirs

Potential Limitations

- Permitting limitations removes in-channel low-head structures from further consideration.

- Other limitations are identical to New Reservoirs, described above.

3. Modify Existing WDFW Ponds

Description

Modify the existing WDFW Ponds in the Upper Tucannon River watershed to increase storage capacity

Potential Benefit

Store water in existing reservoirs, potentially expanding the reservoir size to store additional water.

Evaluation Criteria

- There are two or three small ponds owned and operated by WDFW on the upper Tucannon. The levees of these ponds may be raised to increase water storage.
- Levees and spillway may not meet Ecology Dam Safety requirements. A total redesign/rehabilitation of these structures would entail significant costs.
- Permitting would be more feasible than a new reservoir given the current footprint.
- Water storage quantities may be limited. Assuming total pond sizes are 10 acres, 40 foot levees (which is already unreasonably high) would allow 400 acre-foot of water storage. This would yield a streamflow supplement of approximately 1.7 cfs over a 4-month period.
- Temperature would be an issue of concern. A reservoir of the size proposed would be fully mixed and would significantly heat up in the summer, making it very difficult to return cool to the stream.
- Nutrients would also be a potential issue if the ponds are fish rearing continues in the ponds.

Potential Limitations

- Requires willingness of WDFW to partner.
- Dam Safety requirements for impoundment beams / spillway.
- Potential for warm water temperature in the reservoir and possible impacts to river water temperature.
- Potential for nutrient and sediment impairments to water quality from reservoir if reservoirs are used for aquaculture.

4. Riparian Zone or Farm Field Flooding

Description

Storage of water during the spring freshet within the riparian zone or on farm fields. Water is distributed through levee breaks or from temporary diversions.

Potential Benefit

Water is stored within the riparian zone or on farm fields during the spring freshet.

Evaluation Criteria

- New riparian zone or farm field flooding would involve disruption of levees (levee breaks) and flooding of land. Flooding would need to be contained to specific properties. This would require extensive flood studies, including re-mapping of the floodplain, and USACE/FEMA approval. It would also require levees constructed on adjacent properties to avoid flooding of agricultural lands, homes, roads, etc.
- Stored water volume is constrained by area of land available.
- Ponding of water in the spring may cause increased water temperature.
- Habitat benefits would be limited and may actually be destructive.
- May affect drainage in adjacent agricultural land.
- Not possible in middle and lower Pataha due to incision of channel.

Potential Limitations

- Requires support of local sponsor.
- Issues related to possible effects on adjacent agricultural land.
- Acquisition of land for flooding.
- Potential for damage to roads, fields, homes, etc. from flooding.

5. New or Modified Wetlands

Description

Construct new wetlands near the stream or modify existing wetlands to increase water storage capacity.

Potential Benefit

Potential for habitat improvements and limited potential for water storage.

Evaluation Criteria

- Construction of a new wetland requires land acquisition, preferably close to the stream.
- Wetlands can improve riparian habitat.
- Modification of existing wetlands may require difficult permitting.
- Stored water volume is constrained by area of land available.
- Hardened structures are required for significant water storage (levees, spillways, etc), which increases costs and permitting requirements.
- Wetland storage may increase temperature of the water during summer.
- Wetlands filter out nutrients and sediment from the water. However, nutrient loading is not a significant problem in these streams.
- Minimal regular maintenance required.

Potential Limitations

- Requires support of local sponsor.
- Water storage capacity limited by area of land.
- Possible increases in water temperature.
- Difficult permitting for wetland modification.

6. Modify Existing Sediment Basins

Description

Modify existing sediment basins for the purpose of additional water storage and/or water infiltration to groundwater.

Potential Benefit

Potential for increased water storage and increased removal of suspended sediment.

Evaluation Criteria

- Current sediment basins are designed to trap sediment. This limits size and water infiltration capacity. Sediment basins would either need to be significantly enlarged to store sufficient water, or regularly maintained to remove sediments to allow infiltration of water.
- Combining sediment removal with water storage could degrade water quality.

- Sizing would need to follow general guidelines for water demand as described above for New Reservoirs.

Potential Limitations

- This option would require the support of a local sponsor.
- Limited infiltration of water through sediment basin / higher ongoing maintenance requirements due to trapped sediments.
- Possible water quality issues due to sediments in stored water.

7. Aquifer Storage (and other groundwater alternatives)

Potential Benefit

Aquifer storage or other ground water alternatives offer several possibilities to supplemental streamflow and to meet water supply demand.

Description

Aquifer Recharge: Water could be infiltrated into the alluvial aquifer through infiltration basins. This method could infiltrate water to the aquifer which may supplement streamflow during the late spring and summer. It also may be possible to enhance infiltration to aquifers from alternative land-use practices. Enhanced infiltration could include employing no-till farming techniques to decrease runoff and increase infiltration or using other methods to reduce runoff.

Alternative Source for Irrigation: This option includes providing a replacement for irrigation supply from surface water to groundwater (likely basalt aquifer water). This would allow more water to remain in the stream during critical low flow periods.

Direct Stream Augmentation: Water could be pumped from the basalt aquifer to the stream to supplement streamflow and decrease stream temperature during summer months.

New Water Supply: A regional groundwater study could provide information on new water supply possibilities for municipal or agricultural purposes. The regional ground water study would provide information on locations and aquifer target depths, water quality, water temperature, production rates. Test wells could be installed which could be used to supplement supply or streamflow for one of the above options.

Evaluation Criteria

- Preliminary evaluation of the Tucannon and Pataha basins indicate that the alluvial valley-fill deposits may only be about 40 to 50 ft thick. This may not be sufficient to infiltrate groundwater in sufficient quantities.

- Detailed studies are required to evaluate aquifer characteristics, water quality and sediment control.
- The depth to water in the basalt aquifer and pumping cost are unknown at this time.
- Artesian conditions could eliminate the need for pumping, thus reducing costs.
- Basalt water quantity and quality are unknown, but it could potentially provide a major source of water supply.
- A small municipal wellfield would be necessary to bring down high temperatures in Tucannon River or Pataha Creek. It may be possible to do a lot more for less costs with riparian shading.

Potential Limitations

- The first three options (Aquifer Recharge, Alternative Source, and Direct Stream Augmentation) require a local sponsor.
- The alluvial aquifer deposits may not be deep enough to store a significant volume of water.
- Geophysics and/or exploratory drilling would be helpful but would require a large portion of the total water storage budget.
- The water temperature and water quality of the basalt aquifer is not known.

5.2 Summary of Alternative Feasibility

The following section summarizes the feasibility of the seven alternatives below.

New Reservoirs	Unlikely
In-Channel Storage	Unlikely
Modify Existing WDFW Ponds	Difficult
Riparian Zone or Farm Field Flooding	Difficult
New or Modified Wetlands	Possible
Modify Existing Sediment Basins	Difficult
Aquifer Storage (all groundwater alternatives)	Possible

"Unlikely" to Implement

The following alternatives would be unlikely to implement for the following reasons:

- *New Reservoirs* appear unfeasible due to their high cost as well as high construction requirements and difficult permitting process. A new reservoir would require a local sponsor with funding for design studies, permitting, construction and maintenance and operation. Increasing water temperature could be an issue.

- *New In Channel Storage* appears unfeasible due to possible aquatic habitat impacts, complicated permitting, high construction requirements and the inability to store a significant volume of water.

"Difficult" to Implement

The following alternatives would be difficult to implement for the following reasons:

- *Modifying WDFW Ponds* requires significant construction efforts but slighter easier permitting than new reservoirs; possible temperature and water quality problems. However the volume of water that could potentially be stored is minimal.
- *Modifying Existing Sediment basins* require regular maintenance and large land area; could increase filtration of sediments but has the possibility for water quality problems. Also, significant land areas and infrastructure would be required to store a significant quantity of water.
- *Riparian Zone or Farm Field Flooding* remains a feasible option with water storage located close to the stream, but has high land and construction requirements with the possibility for flooding concerns makes this option difficult to implement. Detailed studies would be necessary to evaluate drainage and flooding impacts.

"Possible" to Implement

The following alternatives would be possible to implement for the following reasons:

- *Wetlands* may have minimal storage capacity but require little maintenance and have potential for enhancing the riparian habitat. However, the potential to store large volumes of water in a wetland is limited, unless significant investments can be made in embankments and earthwork to pond water. Additionally, storage of large volumes of water with little riparian tree shading may increase mainstem river water temperatures. It may be possible to construct a combined wetland-ground water recharge system to overcome some of these difficulties.
- *Aquifer Storage* may also be considered an appropriate choice due to the possibilities it offers for supplementing streamflow or water supply but there are many unknowns at this time. Additional evaluation is required to determine the feasibility of this alternative.

Table 5 Storage Alternative Design, Construction and Maintenance Requirements

	Alternative	Land Requirements	Geologic Requirements	Engineering Studies	Scientific Studies	Construction Requirements	Infrastructure Requirements	Permitting Requirements	Maintenance Requirements	Cost	Ecological Impacts	Potential for Riparian/Aquatic Habitat Enhancement
1	New reservoirs	Medium to high	Seismic risk, geotechnical, leakage, groundwater impacts	Civil, geotechnical, hydraulic	Biological, hydrogeological, hydrologic, sedimentation	High	Channel, impoundment, levees, spillway	High	Medium to high	High	Effects terrestial habitat	Low
2	In-channel storage	Medium	NA	Civil, geotechnical, hydraulic	Biological, hydrological, sedimentation	High	Impoundment, spillway	High	Medium	Medium to high	Effects aquatic habitat	Low
3	Modify existing WDFW ponds	Low	Seismic risk, geotechnical, leakage, groundwater impacts	Civil, geotechnical, hydraulic	Biological, hydrogeological, hydrologic, sedimentation	Medium to high	Depends	Medium	Medium to high	Medium	Depends	Medium to high
4	Riparian zone or farm field flooding storage	Medium to high	Seismic risk, geotechnical, leakage, groundwater impacts	Civil, geotechnical, hydraulic	Biological, hydrogeological, hydrologic	Medium to high	Diversion, conveyance channel, minor impoundment, spillway	Medium to high	Medium	Medium to high	Modifies some riparian land, may provide new aquatic habitat	Medium to low
5	New or modified wetlands	Medium to high	NA	Civil, geotechnical, hydraulic	Biological, hydrological, hydrogeological	Medium	Diversion, conveyance channel, levees	Medium	Low	Low to Medium	May enhance wetland habitat	High
6	Modify existing sediment basins	High	NA	Civil, geotechnical, hydraulic	Biological, hydrologic, sedimentation	Low to medium	Modified embankments	Medium	Medium to high	Low to medium	Some minor land and riparian disturbance	Medium to low
7	Aquifer storage	Low	Geological/hydrogeological characterization, storage capacity, flow paths & discharge points	Civil, hydraulic, geotechnical	Hydrogeological, hydrological	Low to medium	Diversion, conveyance channel, infiltration ponds	Medium	High	Low to medium	Minor	Low

6.0 CONCLUSIONS

The purpose of this preliminary storage analysis is to present the Planning Unit with a summary of the storage needs of the watershed and to offer a list of possible storage alternatives from which to choose some for more detailed assessment. The following summarize findings from this preliminary analysis:

- In general all water demands and instream flow requirements are met in the Asotin subbasin. The exception is in the lower section of the subbasin where the 10% exceedance flows are insufficient in June and July for meeting the surface water source limitation.

- All water demands are met in the upper Pataha subbasin. The surface water source limitation is not met by even the highest flows over several months in the middle portion of the subbasin. In the lower portion of the subbasin 50% exceedance flows are insufficient for meeting full water rights and 90% exceedance are insufficient for meeting estimated water use in the later summer months.

- Pataha Creek water quality and water supply could be improved by supplemental flow in the middle and lower portions from June through October.

- All water demands are met in the upper Tucannon subbasin. The 50% exceedance flows are insufficient for meeting optimal fish habitat flow as quantified from weighted useable area based on physical habitat modeling for the late summer and fall months in the middle portion of the subbasin. Optimal fish habitat needs for flow are not met in the lower portion of the subbasin by the 50% exceedance flows in the late summer and early fall and are not met by the 90% flows from June to November. The instream flow recommendation for this portion of the basin is also not met by 90% flows from July to September.

- Tucannon River habitat and water supply could be improved by supplemental flow in the middle and lower portions from July to September.

- Of the seven types of storage alternatives considered for preliminary assessment, two were determine to be difficult to implement: new upland reservoirs and in-channel structures. The remaining five, new or modified wetlands, modification of existing reservoirs, aquifer storage, modification of existing sediment basins and riparian zone water storage, may be feasible depending on site specific conditions.

7.0 NEXT STEPS

1) Obtain input from the Planning Unit.

2) Complete a more detailed analysis and investigations in the locations determined to be of highest priority for selecting a water storage site.

3) Determine which storage alternative best meets the storage requirements for the watershed.

4) Using the preferred alternative(s), test one or two sites for feasibility.

8.0 REFERENCES

Columbia Conservation District 1997. Tucannon River Model Watershed Plan.

HDR/EES 2005. WRIA 35 Middle Snake River Watershed Level 1 Assessment Report.

Northwest Planning Council 200l. Asotin Creek Subbasin Summary. Stacey Stovall, ed. Bradley Johnson, Subbasin Team Leader.

Pomeroy Conservation District 1998. Pataha Creek Model Watershed Plan.

Washington State University 2001. Pataha Creek Water Quality Report 1999 - 2001.

Washington State University 2001. Tucannon River Water Quality Monitoring Report April 1999 – March 2001.

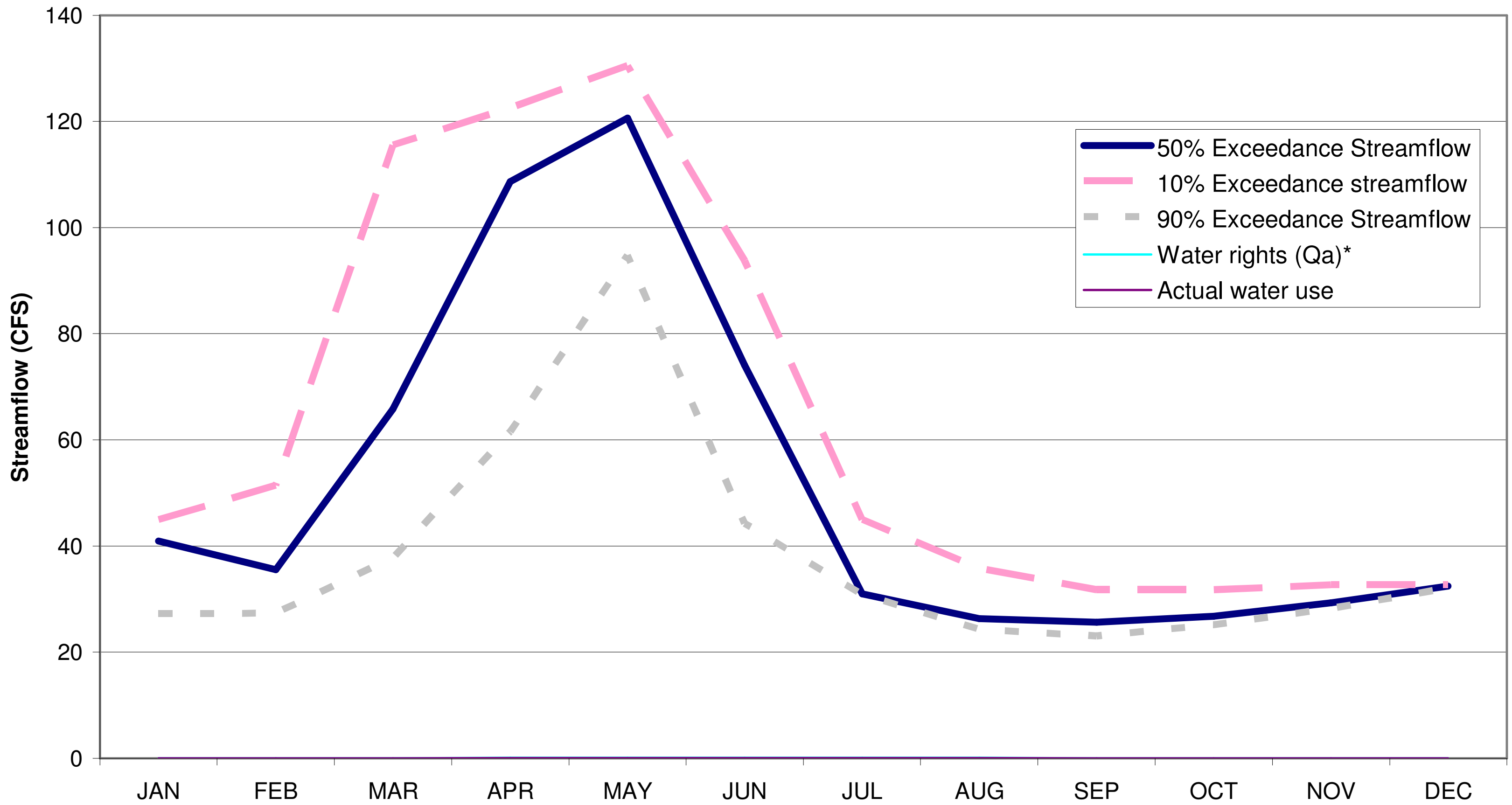
Washington Department of Ecology 1995. Initial Watershed Assessment Tucannon River Watershed.

WA Department of Ecology 2005. River and Stream Water Quality Monitoring Website. http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html.

APPENDIX A

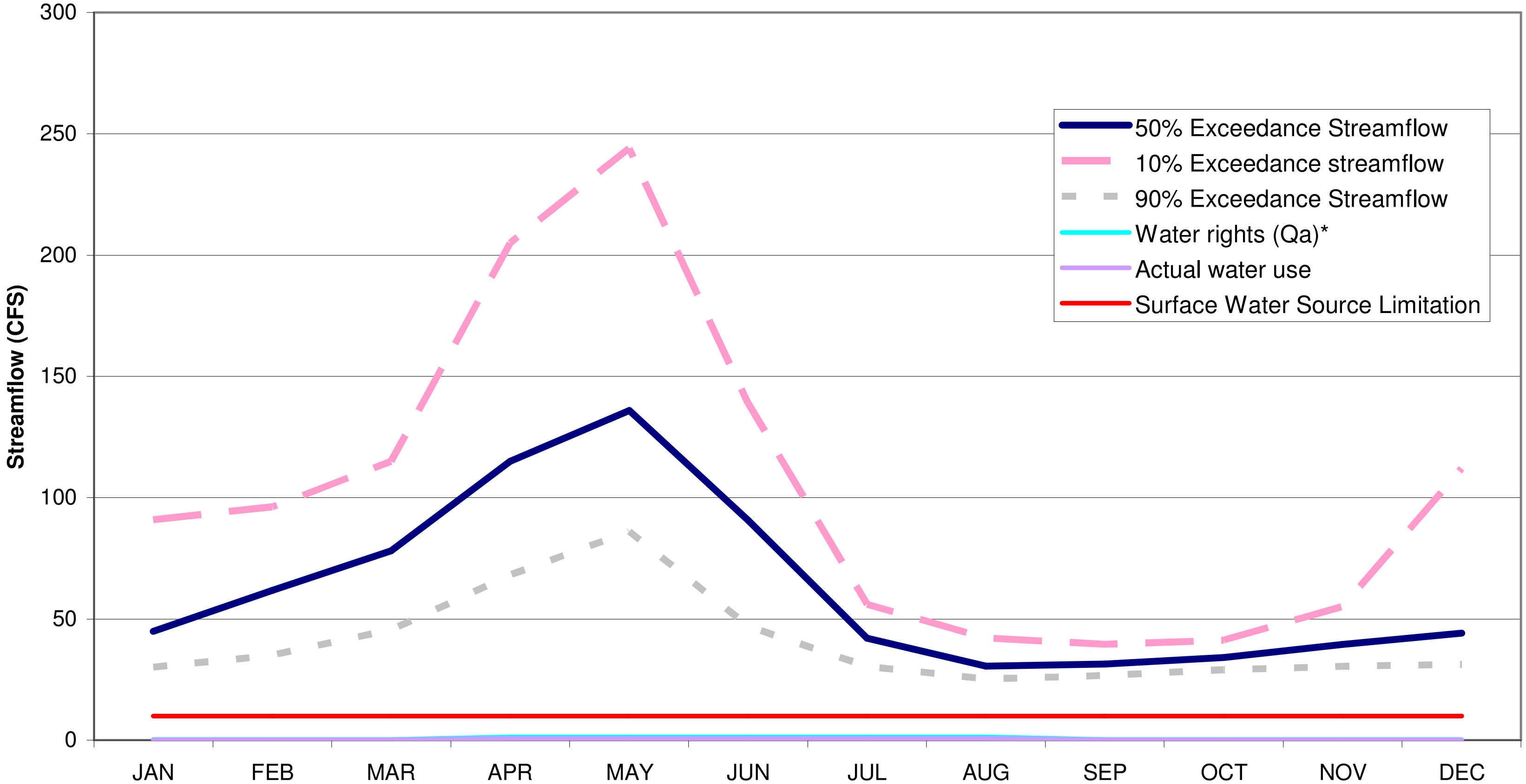
WATER QUANTITY SUMMARY GRAPHS

Figure A.1
UPPER ASOTIN SUBBASIN STREAMFLOW AND WATER USE
USGS Gage 13334450, Gauging period 1/2001 to current



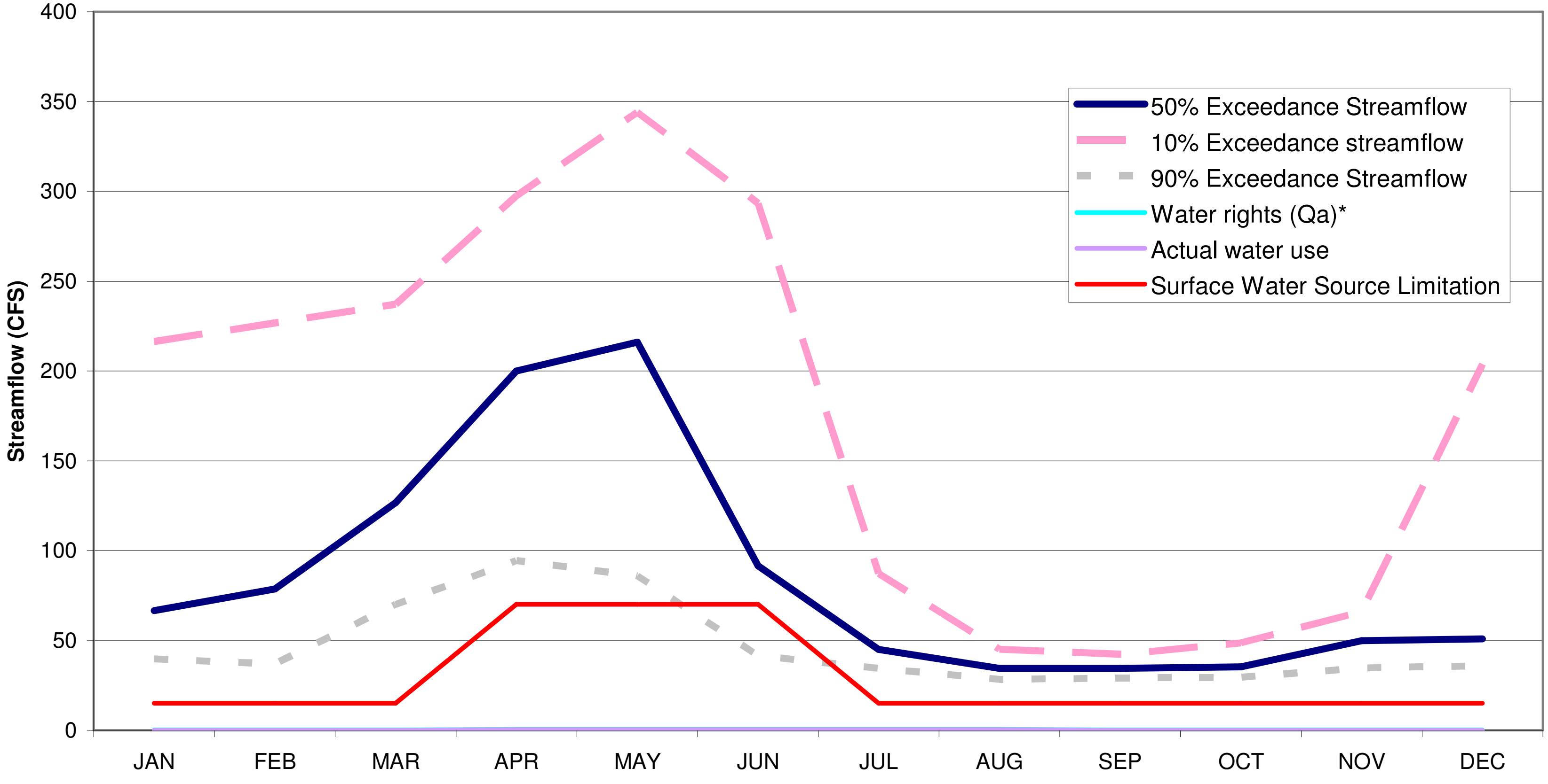
Note: *Annual water rights (Qa) are distributed over a 5-month irrigation season.

Figure A.2
MIDDLE ASOTIN SUBBASIN STREAMFLOW AND WATER USE
USGS Gage 13334500, Gauging period 10/1928 to 11/1959



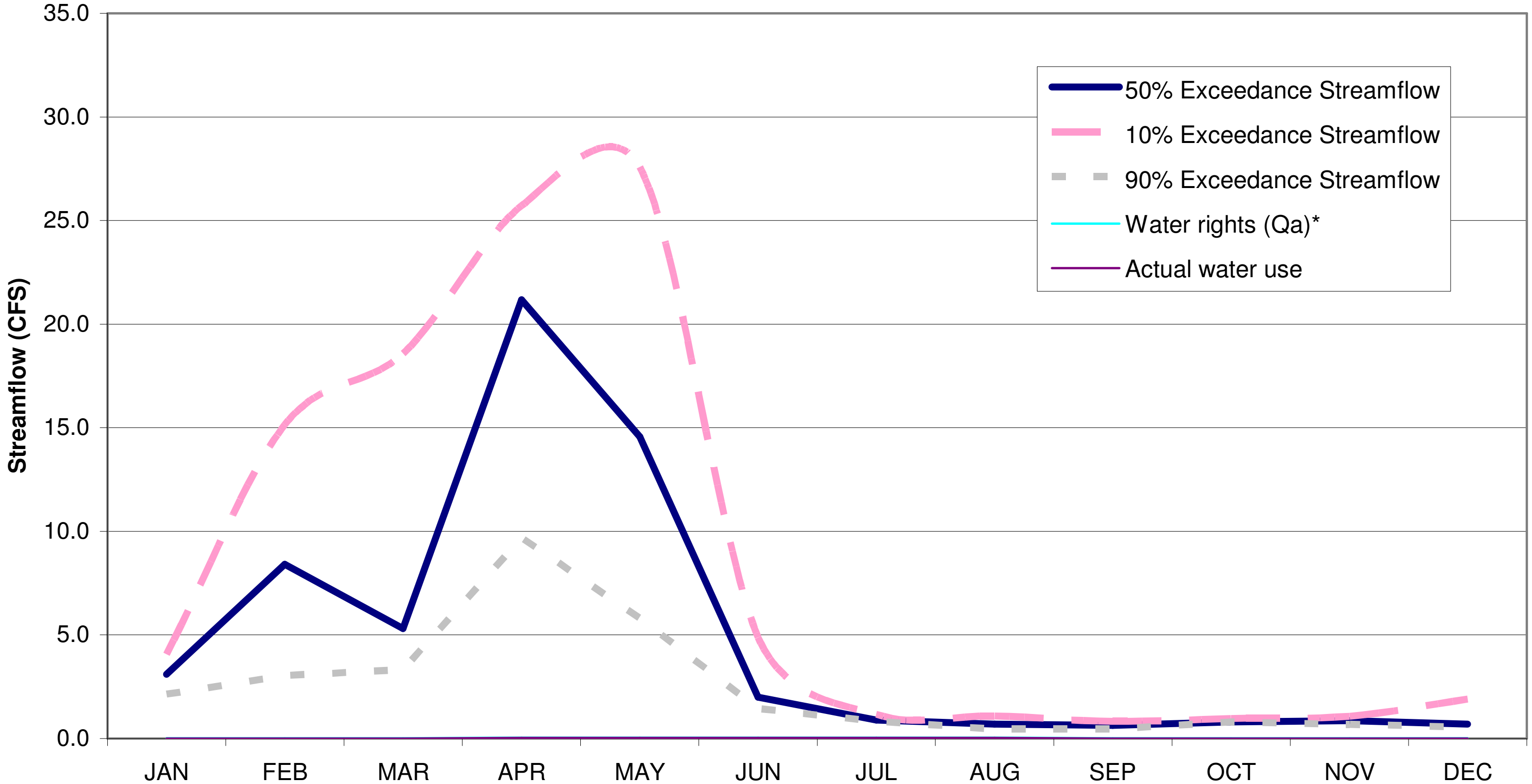
Note: *Annual water rights (Qa) are distributed over a 5-month irrigation season.

Figure A.3
LOWER ASOTIN SUBBASIN STREAMFLOW AND WATER USE
USGS Gage 13335050, Gauging period 10/1988 to 9/1989; 4/1991 to 9/2002



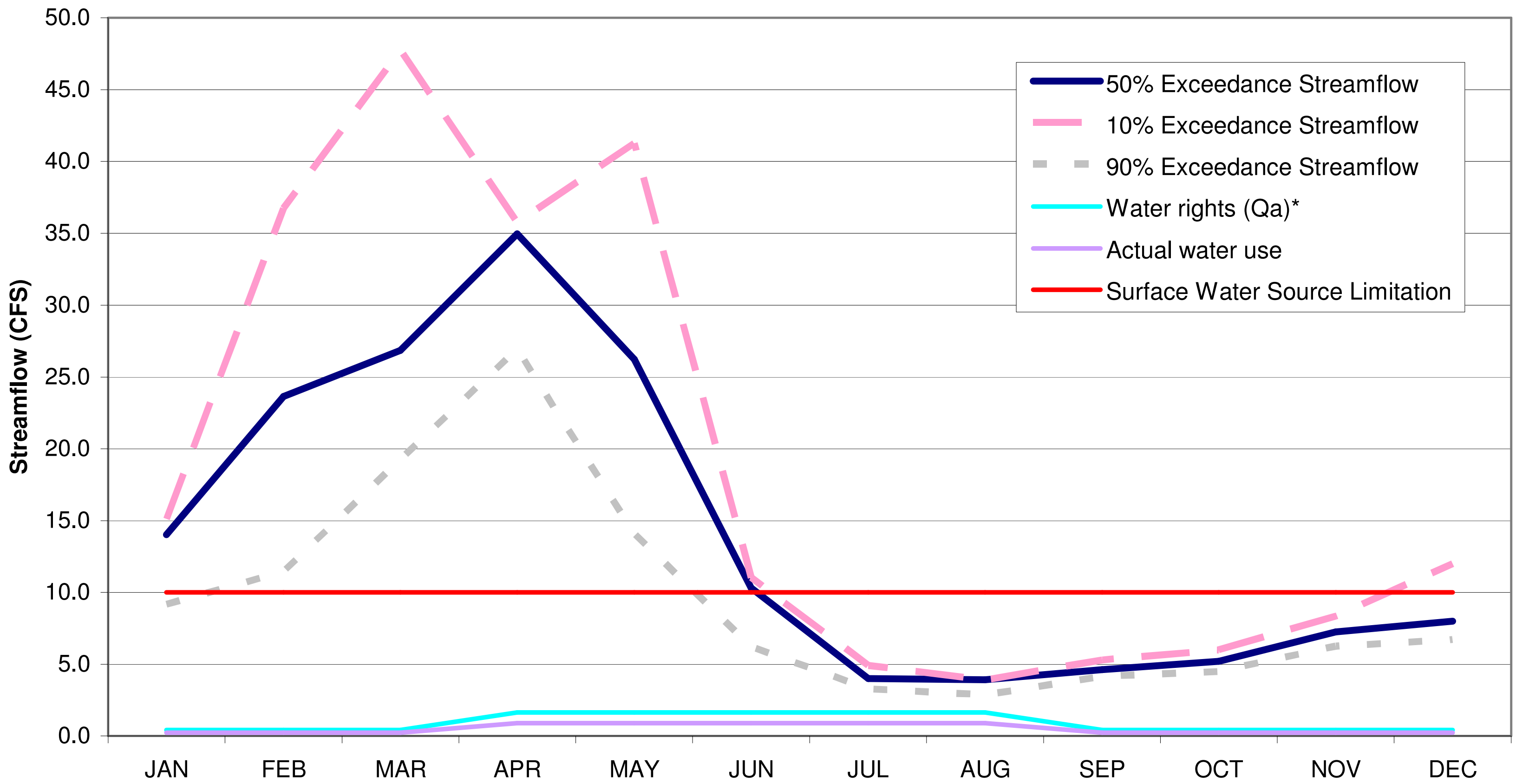
Note: *Annual water rights (Qa) are distributed over a 5-month irrigation season.

Figure A.4
UPPER PATAHA SUBBASIN STREAMFLOW AND WATER USE
WSU Monitoring Station Pataha 5
Gauging period 9/1998 to 6/2001; 2/2003 to 11/2003



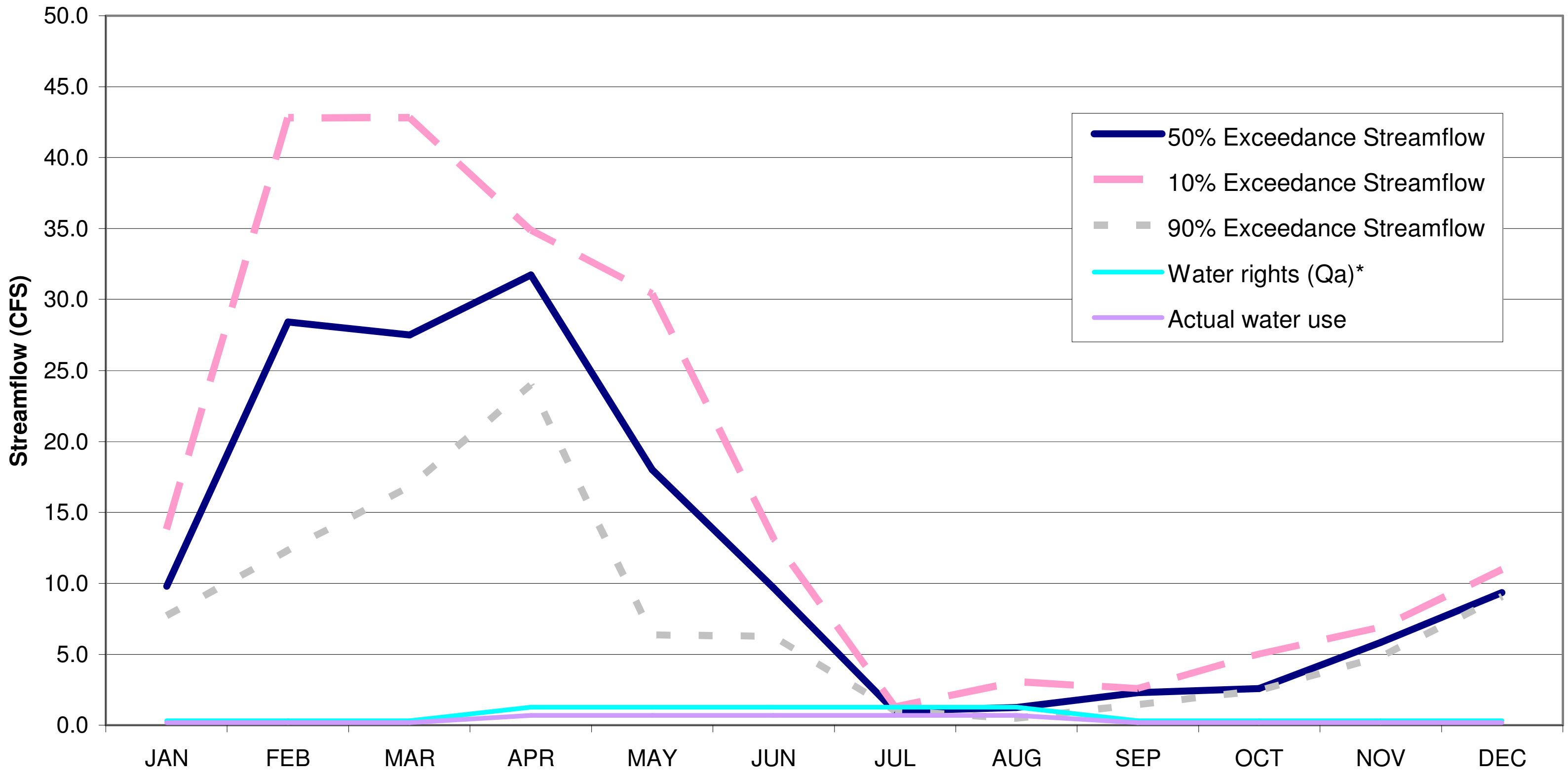
Note: *Annual water rights (Qa) are distributed over a 5-month irrigation season.

Figure A.5
MIDDLE PATAHA SUBBASIN STREAMFLOW AND WATER USE
WSU Monitoring Station Pataha 3
Gauging period 9/1998 to 6/2001; 2/2003 to 11/2003



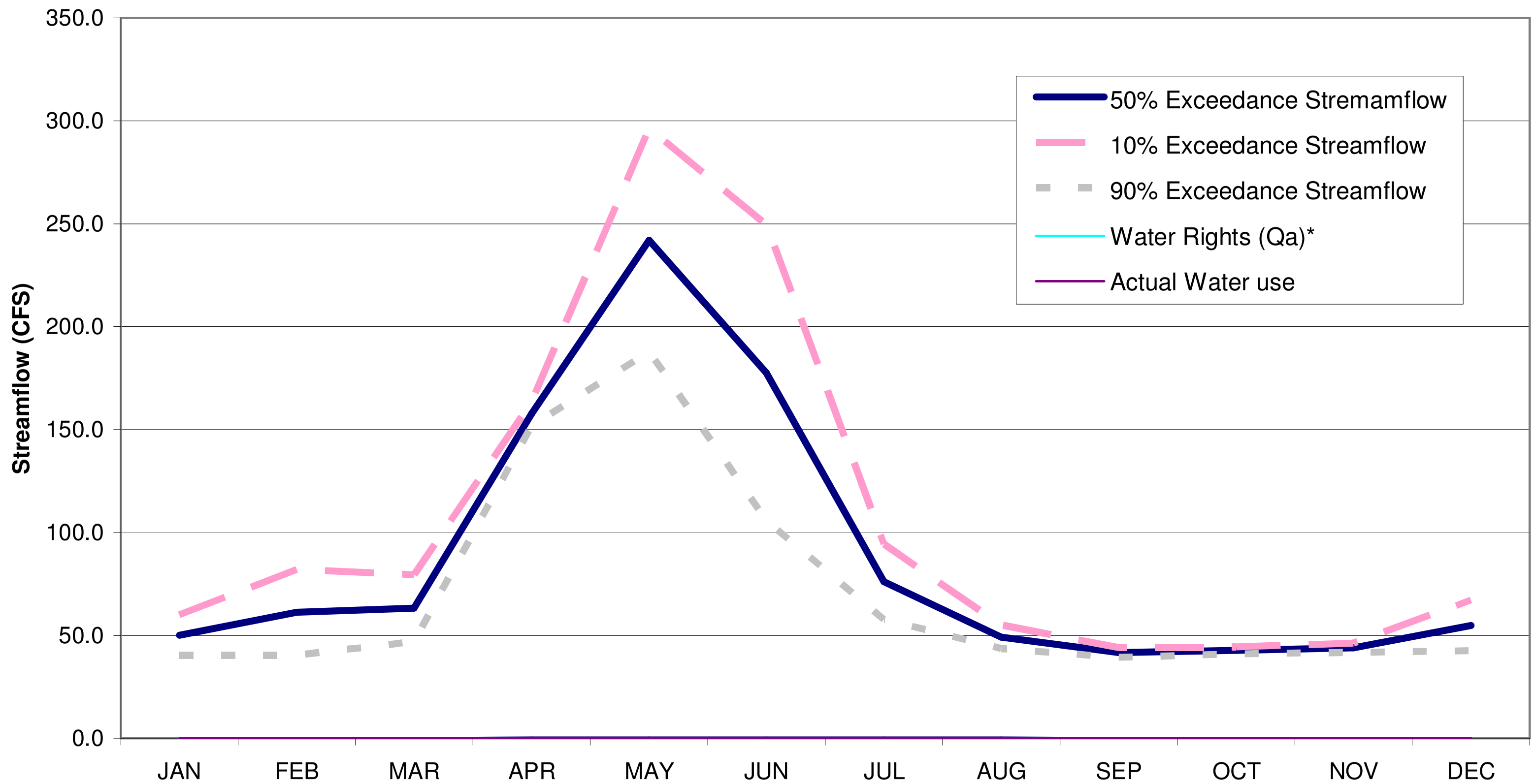
Note: *Annual water rights (Qa) are distributed over a 5-month irrigation season.

Figure A.6
LOWER PATAHA SUBBASIN STREAMFLOW AND WATER USE
WSU Monitoring Station Pataha 1
Gauging period 9/1998 to 5/2001; 2/2003 to 11/2003



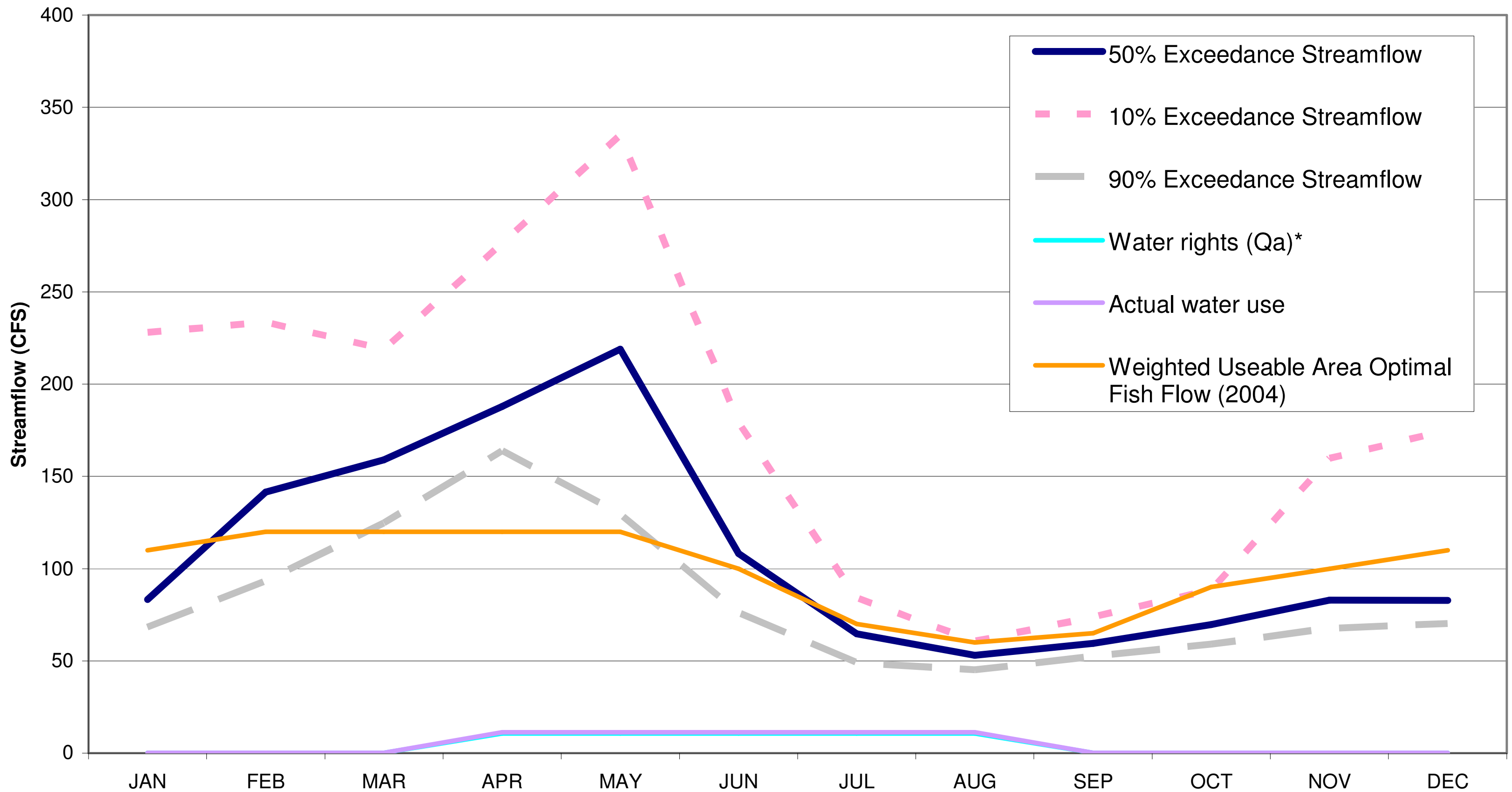
Note: *Annual water rights (Qa) are distributed over a 5-month irrigation season.

Figure A.7
UPPER TUCANNON SUBBASINSTREAMFLOW AND WATER USE
WSU Monitoring Site Tucannon 9 , Gauging period 4/1999 to 3/2001



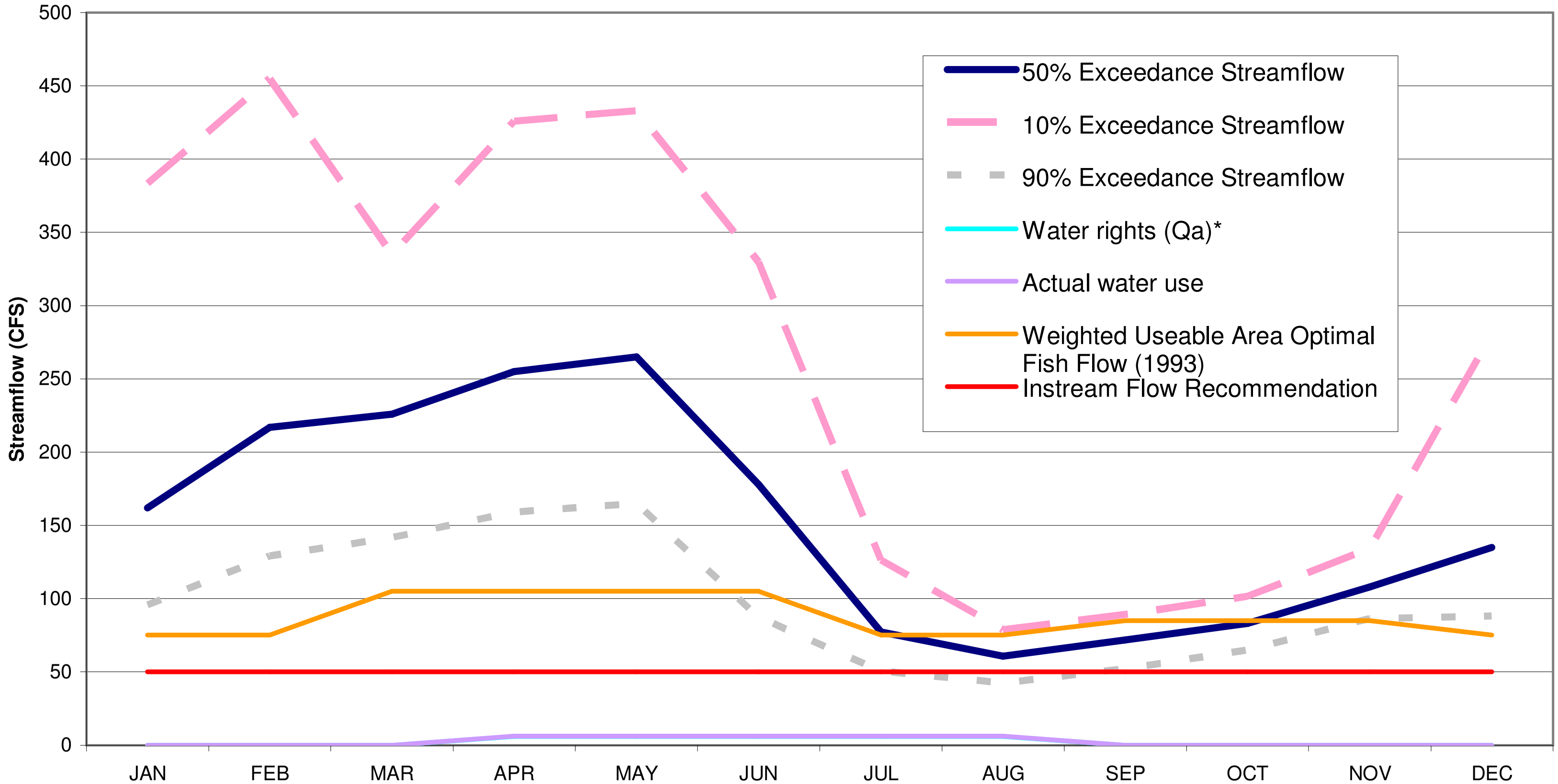
Note: *Annual water rights (Q_a) are distributed over a 5-month irrigation season.

Figure A.8
MIDDLE TUCANNON SUBBASIN STREAMFLOW AND WATER USE
USGS Gage 1334400, Gauging period 10/1913 to 6/1915; 3/1924 to 9/1930



Note: *Annual water rights (Q_a) are distributed over a 5-month irrigation season.

Figure A.9
LOWER TUCANNON SUBBASIN STREAMFLOW AND WATER USE
USGS Gage 13344500
Gauging period 10/1914 to 10/1917; 10/1928 to 9/1931; 10/1958 to 12/1990; 9/1994 to 10/2003



Note: *Annual water rights (Q_a) are distributed over a 5-month irrigation season.

APPENDIX B

WATER QUANTITY SUMMARY TABLE

Table B.1 Summary of Asotin Creek Subbasin Water Quantity

River Reach	River Section	River Miles	Streamflow Gages[1,2,3]	Average Streamflow (cfs)[1-4]	Water Right Allocation (afy)[5]	Target Fish Species[6]	Water Right Restrictions and/or Closures[3]
N Fork from headwaters to Asotin Cr	Upper	RM 14.1 to end of N Fork	No gage, info from WSCC report	Summer = 20	SW Rights = 9 GW Rights = 0	Spring Chinook, Summer Steelhead, Bull Trout	-
S Fork from headwaters to Asotin Cr	Upper	RM 14.1 to end of S Fork	No gage, info from WDFW spot records	25.3 after rain in June, 2.9 in late summer	SW Rights = 15 GW Rights = 0	Summer Steelhead	-
Asotin Cr from N and S Forks to Charley Cr	Upper	RM 12.8 to RM 14.1	USGS 13334450 (2001-now)	Late summer=25-30 Mean = 50 Mar-June = 70-120	SW Rights = 0 GW Rights = 0	Spring Chinook, Summer Steelhead	-
Charley Cr from headwaters to Asotin Cr	Upper	RM 12.8 to end of Charley Cr	None	Unknown	SW Rights = 0.5 GW Rights = 0	Summer Steelhead	-
Asotin Cr from Charley Cr to George Cr	Middle	RM 3.1 to RM 12.8	USGS 13334500 (1928-59) USGS 13334700 (1959-82,1989-96)	Late summer=30-45 Mean = 70 Mar-June = 75-155	SW Rights = 221 GW Rights = 48	Spring Chinook, Summer Steelhead	SWSL of 10 cfs
George Cr and tributaries	Middle	RM 3.1 to end of George Cr.	No gage, info from estimates btwn gages and WDFW reports	Late summer=0-2 Mean = 20 Feb-June = 40-70	SW Rights = 87 GW Rights = 505	Summer Steelhead	-
Astoin Cr from George Cr to Snake R	Lower	RM 0 to RM 3.1	USGS 13335050 (1988-89, 1991-02) 1 Ecology gage w only 3 readings	Late summer=35-50 Mean = 100 Mar-June = 130-210	SW Rights = 115 GW Rights = 57	Spring Chinook, Summer Steelhead	SWSL of 70 cfs Apr-June & 15 cfs July-Mar

Data Sources:

1 - USGS

2 - WA Department of Ecology

3 - WRIA 35 Level 1 Assessment Report

4 - Washington Department of Fish and Wildlife

5 - DOE WRATS database

6 - Asotin Creek Subbasin Summary

Table B.2 Summary of Pataha Creek Subbasin Water Quantity

<table>
<tr><th>River Reach</th><th>River Section</th><th>River Miles</th><th>Streamflow Gages[1,2,3]</th><th>Average Streamflow (cfs)[1-4]</th><th>Water Right Allocation (afy)[5]</th><th>Target Fish Species</th><th>Water Right Restrictions and/or Closures[3]</th></tr>
<tr><td>Pataha Cr from headwaters to Dry Pataha Cr</td><td>Upper</td><td>RM 40.1 to RM 53.3</td><td>WSU Pataha 5 (1998-01, 2003)</td><td>Late summer=0.6-1
Mean = 5
Feb-May = 9-20</td><td>SW Rights = 13
GW Rights = 0</td><td rowspan="7">NA</td><td rowspan="7">SWSL of 10 cfs at Tatman Gulch</td></tr>
<tr><td>Pataha Cr rom Dry Pataha Cr to Sweeney Gulch</td><td>Upper</td><td>RM 31.1 to RM 40.1</td><td>None</td><td>Unknown</td><td>SW Rights = 0
GW Rights = 39</td></tr>
<tr><td>Pataha Cr from Sweeney Gulch to Balmaier Gulch</td><td>Middle</td><td>RM 27.0 to RM 31.1</td><td>None</td><td>Unknown</td><td>SW Rights = 461
GW Rights = 1820</td></tr>
<tr><td>Pataha Cr from Balmaier Gulch to Tatman Gulch</td><td>Middle</td><td>RM 18.4 to RM 27.0</td><td>Ecology 35F100 (new)</td><td>Unknown</td><td>SW Rights = 59
GW Rights = 305</td></tr>
<tr><td>Pataha Cr from Tatman Gulch to Dry Hollow Gulch, upper portion</td><td>Lower</td><td>RM 10 to RM 18.4</td><td>WSU Pataha 3 (1998-01, 2003)</td><td>Late summer=3.5-5.2
Mean = 14
Feb-May = 24-32</td><td rowspan="2">SW Rights = 402
GW Rights = 382</td></tr>
<tr><td>Pataha Cr from Tatman Gulch to Dry Hollow Gulch, lower portion</td><td>Lower</td><td>RM 1.3 to RM 10</td><td>WSU Pataha 1 (1998-01, 2003)</td><td>Late summer=1.1-3.5
Mean = 12.5
Feb-May = 18-30</td></tr>
<tr><td>Pataha Cr from Dry Hollow Cr to Tucannon R</td><td>Lower</td><td>RM 0 to RM 1.3</td><td>Ecology 35F050 (2004-now)</td><td>Unknown</td><td>SW Rights = 0
GW Rights = 0</td></tr>
</table>

Data Sources:

1 - USGS

2 - WA Department of Ecology

3 - WRIA 35 Level 1 Assessment Report

4 - Washington Department of Fish and Wildlife

5 - DOE WRATS database

Table B.3 Summary of Tucannon River Subbasin Water Quantity

River Reach	River Section	River Miles	Streamflow Gages[1-4]	Average Streamflow (cfs)[1-3,5]	Water Right Allocation (afy)[6]	Studies of Target Fish Species[7,8]	Water Right Restrictions and/or Closures[3,7,8]
Tucannon R from headwaters to Panjab Cr	Upper	RM 47.0 to RM 58.2	None	NA	SW Rights = 0 GW Rights = 0		Closure
Tucannon R from Panjab to Little Tucannon	Upper	RM 45.0 to RM 47.0	WSU Tucannon 9 (1999-01)	Aug-Oct = 42.7-49.3 Mean = 88.4 Apr-June = 158-242	SW Rights = 0 GW Rights = 0		
Tucannon R from Little Tucannon to Cummings Cr	Upper	RM 375. to RM 45.0	None	NA	SW Rights = 37 GW Rights = 1440		
Tucannon R from Cummings Cr to Tumalum Cr	Middle	RM 33.4 to RM 37.5	WSU Tucannon 6 (1999-01)	Aug-Oct = 50-60.5 Mean = 115.6 Apr-June = 151-284	SW Rights = 46 GW Rights = 18		NA
Tucannon R from Tumalum Cr to Willow Cr	Middle	RM 13.8 to RM 33.4	USGS 13344000 (1913-30) Ecology 35B150 (1996-97) WSU Tucannon 4 (1998-01)	Aug-Oct = 53-72 Mean = 125.3 Mar-June = 129-234	SW Rights = 1379 GW Rights = 141	IWUA 2004 Feb-May = 120 Aug = 60	Marengo WUA study, not yet enforced
Tucannon R from Willow Cr to Pataha Cr	Lower	RM 11.3 to RM 13.8	None	NA	SW Rights = 0 GW Rights = 0		NA
Tucannon R from Pataha Cr to Kellogg Cr	Lower	RM 4.0 to RM 11.3	USGS 13344500 (1914-17,1928-31,1958-90,1994-02)	Aug-Oct = 61-83 Mean = 171.8 Mar-June = 202-296	SW Rights = 732 GW Rights = 615		Instream flow recommendation of 65 cfs in June-Aug and 100 cfs Mar-June
Tucannon R from Kellogg Cr to Snake R	Lower	RM 0 to RM 4.0	Ecology 35B060 (1973-74,1977-92,1994-02)	Aug-Oct = 67-80 Mean = 164.7 Apr-June = 230-278	SW Rights = 70 GW Rights = 779	WUA 1995 June-Aug = 65 Mar-June = 100	Instream flow recommendation of 50 cfs

Data Sources:

1 - USGS

2 - WA Department of Ecology

3 - WRIA 35 Level 1 Assessment Report

5 - Washington Department of Fish and Wildlife

6 - DOE WRATS database

7 - Initial Watershed Assessment Tucannon

APPENDIX C
WATERSHED PHYSICAL CHARACTERSTICS

Table C.1 Summary of Asotin Creek Subbasin Characteristics

River reach	Land Use[3,6]	Land Ownership[5]	Geology[3,7]	Topography[5,11]	Precip (in/yr)[2,3]	Aquifer Characteristics	Potential Aquifer Depth	Temp prob-lems? [1-4,9,11]	Peak TSS (mg/l)[3,8-10]	% Canopy[5]	Riparian wetlands?[11]	Existing Storage Structures[5,11]
Asotin Cr from N and S Forks to Charley Cr	Deciduous forest and shrubland	State and private	Grande Ronde Basalt	Valley	14-16	Alluvial vally fill (pebble, cobble, boulder) at variable presence; Columbia River basalt aquifer underlying the entire area	where alluvial is present it is a few feet to a few tens of feet down; basalt at 50-150 ft below surface	Listed	<10	50	Some	No
Asotin Cr from Charley Cr to George Cr	Shrubland and pastures	Private w some blocks of state land	Grande Ronde and Wanapum Basalt along river valley; Saddle Mountain Basalt on top	Flat with hills to both sides	12-16			Often	10	37-79		
Astoin Cr from George Cr to Snake R		Private		Relatively flat	10-14			Listed	80+		No	
N Fork from headwaters to Asotin Cr			Grande Ronde					Listed	?	68-75+		No
S Fork from headwaters to Asotin Cr		Federal, state and private						Listed	50	58-65		
Charley Cr from headwaters to Asotin Cr		Federal, private and state			14-28			Listed	2000+ during a storm	65		
George Cr and tributaries	Shrubland, pastures & fallow	Private w few blocks of state land	Grande Ronde Basalt along river valley; Saddle Mountain Basalt further out	Valley	12-20			Listed	?	?	?	Sedimentation basins

<u>Data Sources:</u>
1 - USGS
2 - WA Department of Ecology
3 - WRIA 35 Level 1 Assessment Report
4 - Washington Department of Fish and Wildlife
5 - Asotin Creek Subbasin Summary
6 - National Resource Conservation Service & Department of Ecology
7 - Drost and Whiteman, 1986
8 - Asotin County Conservation District
9 - WSU
10 - US Forest Service
11 - Site investigation

Note: temperature concerns in WRIA 35 are most likely due to natural or ambient air conditions

Table C.2 Summary of Pataha Creek Subbasin Characteristics

<table>
<tr><th>River reach</th><th>Land Use[2,3]</th><th>Land Ownership[4]</th><th>Geology[2,5]</th><th>Topography[8]</th><th>Aquifer Characteristics</th><th>Potential Aquifer Depth</th><th>Precip (in/yr)[1,2]</th><th>Temp problems?[1,2,6,7]</th><th>Peak TSS (mg/l)[1,2,6,7]</th><th>Riparian wetlands?[8]</th><th>Existing Storage Structures[8]</th></tr>
<tr><td>Pataha Cr from headwaters to Dry Pataha Cr</td><td rowspan="2">Deciduous forest</td><td>Forest Service</td><td rowspan="7">Grande Ronde Basalt along river; Wanapum Basalt elsewhere</td><td>Hills and narrow valleys</td><td rowspan="2">alluvial, rare and if present thin and discontinuous</td><td rowspan="2">alluvial just a few feet, basalt at less than 200 ft</td><td>18-30+</td><td>Listed</td><td>most often well below standard</td><td rowspan="7">Minimal</td><td rowspan="7">No known structures</td></tr>
<tr><td>Pataha Cr rom Dry Pataha Cr to Sweeney Gulch</td><td rowspan="6">Private with some blocks of State land</td><td>Very narrow valley</td><td>16-18</td><td>Listed</td><td>6 of 70 samples exceed standard</td></tr>
<tr><td>Pataha Cr from Sweeney Gulch to Balmaier Gulch</td><td>Agricultural and scrubland</td><td>Moderate slope</td><td rowspan="5">alluvial (pebble, cobble, boulder, gravel) variable and perhaps very thin; underlying basalt aquifer widespread extensive, some capable of 500+ gpm per well</td><td rowspan="5">alluvial at less than 10 - 40 or 50 ft, occasional absent where bedrock highs are present; basalt at less than 200 ft</td><td rowspan="2">14-16</td><td rowspan="2">Listed</td><td rowspan="2">exceeds standard 3 of 9 months</td></tr>
<tr><td>Pataha Cr from Balmaier Gulch to Tatman Gulch</td><td rowspan="4">Agricultural and scrubland; residential at Pomeroy</td><td rowspan="4">Flat valley</td></tr>
<tr><td>Pataha Cr from Tatman Gulch to Dry Hollow Gulch, upper portion</td><td rowspan="3">12-14</td><td rowspan="3">Listed</td><td rowspan="3">most often well below standard</td></tr>
<tr><td>Pataha Cr from Tatman Gulch to Dry Hollow Gulch, lower portion</td></tr>
<tr><td>Pataha Cr from Dry Hollow Cr to Tucannon R</td></tr>
</table>

Data Sources:

1 - WA Department of Ecology

2 - WRIA 35 Level 1 Assessment Report

3 - National Resource Conservation Service & Department of Ecology

4 - Tucannon Subbasin Summary

5 - Drost and Whiteman, 1986

6 - WSU

7 - US Forest Service

8 - Site investigation

Note: temperature concerns in WRIA 35 are most likely due to natural or ambient air conditions

Table C.3 Summary of Tucannon River Subbasin Characteristics

<table>
<tr><th>River reach</th><th>Land Use[2,6]</th><th>Land Ownership[5]</th><th>Geology [2,7]</th><th>Topography [10]</th><th>Precip (in/yr)[1,2]</th><th>Aquifer Characteristics</th><th>Potential Aquifer Depth</th><th>Temp problems? [1-4,8,9]</th><th>Peak TSS (mg/l)[1-3,9]</th><th>% canopy cover[5]</th><th>Riparian wetlands?[10]</th><th>Existing Storage Structures[10]</th></tr>
<tr><td>Tucannon R from headwaters to Panjab Cr</td><td rowspan="4">Deciduous forest</td><td rowspan="3">Forest Service</td><td rowspan="4">Grande Ronde Basalt</td><td rowspan="3">Hills and steep valleys</td><td>30+</td><td>thin to nonexisteant alluvial</td><td></td><td>Often</td><td>Well below standard</td><td>43</td><td rowspan="4">No</td><td rowspan="2">No</td></tr>
<tr><td>Tucannon R from Panjab to Little Tucannon</td><td>22-24</td><td rowspan="2">alluvial aquifer (peb, cob, boul, gravel), undofined, locally absent when bedrock highs are present</td><td rowspan="2">10s of thick ft</td><td>No</td><td>Well below standard</td><td>17</td></tr>
<tr><td>Tucannon R from Little Tucannon to Cummings Cr</td><td>14-22</td><td>Listed</td><td>Well below standard</td><td>15-49</td><td rowspan="2">WDFW Ponds</td></tr>
<tr><td>Tucannon R from Cummings Cr to Tumalum Cr</td><td>State</td><td>Valley begins to widen</td><td>14-16</td><td rowspan="5">alluvial aquifer is thicker and more extensive in valley (bc larger valley) as you move downstream, bedrock highs are fewer, same materials, aquifer widespread</td><td rowspan="5">alluvial is less than 20 feet deep where present, basalt within 200 feet</td><td>Listed</td><td>Well below standard</td><td>13</td></tr>
<tr><td>Tucannon R from Tumalum Cr to Willow Cr</td><td rowspan="4">Shrub land and pasture</td><td rowspan="4">Private</td><td rowspan="4">Grande Ronde Basalt along river; Wanapum Basalt elsewhere</td><td>Moderate to flat</td><td>12-16</td><td>Listed</td><td>Well below standard</td><td>1-81</td><td>Yes</td><td>Sediment basins</td></tr>
<tr><td>Tucannon R from Willow Cr to Pataha Cr</td><td rowspan="3">Relatively flat valley</td><td rowspan="2">12-14</td><td>Listed</td><td>Well below standard</td><td>56</td><td rowspan="3">NA</td><td rowspan="3">No</td></tr>
<tr><td>Tucannon R from Pataha Cr to Kellogg Cr</td><td>Listed</td><td>Well below standard</td><td>60</td></tr>
<tr><td>Tucannon R from Kellogg Cr to Snake R</td><td>10-12</td><td>Listed</td><td>Some exceedance recorded</td><td>30</td></tr>
</table>

Data Sources:

1 - WA Department of Ecology
2 - WRIA 35 Level 1 Assessment Report
3 - WSU
4 - Washington Department of Fish and Wildlife
5 - Tucannon Subbasin Summary
6 - National Resource Conservation Service & Department of Ecology
7 - Drost and Whiteman, 1986
8 - Columbia Conservation District
9 - US Forest Service
10 - Site investigation

Note: temperature concerns in WRIA 35 are most likely due to natural or ambient air conditions