APPENDIX C – SUPPLEMENTAL INFORMATION ON EDT MODELING

Supplemental Information on EDT Modeling

Table C-1.

Aquatic and Riparian Habitat Factors Impacting Ahtanum Creek Watershed Spring Chinook Populations

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Ahtanum, Bachelor return - 42nd Avenue	∘	◯	•				●	•	●	●			•		●	⬤		●
Ahtanum, L. WIP Div - American Fuit Rd	∘	◯	•				●	•	●	•			•		●	⬤		●
Ahtanum, Marks Rd - Bach-Hat Div	∘	◯	•				●	•	●	•			•	•	●	⬤		●
Ahtanum, U. WIP Div - forks	◯	◯	•				•	•	●						●	●		●
NF Ahtanum, Mouth - RM 2.0	○	○	•				•	•	●						⬤	●		●
SF Ahtanum, Mouth - RM 2.0		○	•				•	•	●	•					⬤	●		●
Ahtanum, Mouth - Goodman Rd	∘	○	•				●	•	●	●					⬤	⬤		●
Ahtanum, 42nd Avenue - Hatton return		○	•				●	•	●	●			•		●	⬤		●
Ahtanum, Bach/Hat Div - U. WIP Div	∘	○	•				•	•	●	•				•	●	⬤		●
Ahtanum, Goodman Road - Bachelor return		∘	•				●	•	●	●			•		⬤	⬤		●
Ahtanum, Hatton return - L. WIP Div	∘	∘	•				●	•	•	•					●	⬤		●
Ahtanum, American Fruit Rd - Marks Rd		∘	•				●	•	●	•				•	●	⬤		●
Ahtanum, L. WIP Diversion Dam																		
Ahtanum, Bach/Hat Diversion Dam																		
Ahtanum, Upper WIP Diversion Dam																		
Yakima Benton to Powerplant														•	•	•		•
Yakima Chandler Bypass Reach									•					•	•	•		•
Yakima delta														•	•	•		•
Yakima delta to Horn Dam									•					•	•	•		●
Yakima Horn Dam to Benton											•			•	•	•		•
Yakima Prosser Dam to Satus									•		●		•	•	●	•		•
Yakima Satus to Toppenish	∘												•	●	●	•		⬤
Yakima SSide Dam to Ahtanum Cr			•				•	•	●		⬤			•	•	•		●
Yakima Toppenish to Sunnyside Dam	∘				•								•	•	•	•		⬤

Key to strategic priority (corresponding Benefit Category letter also shown)

A ◯ High; B ○ Medium; C ∘ Low; D & E (blank) Indirect or General

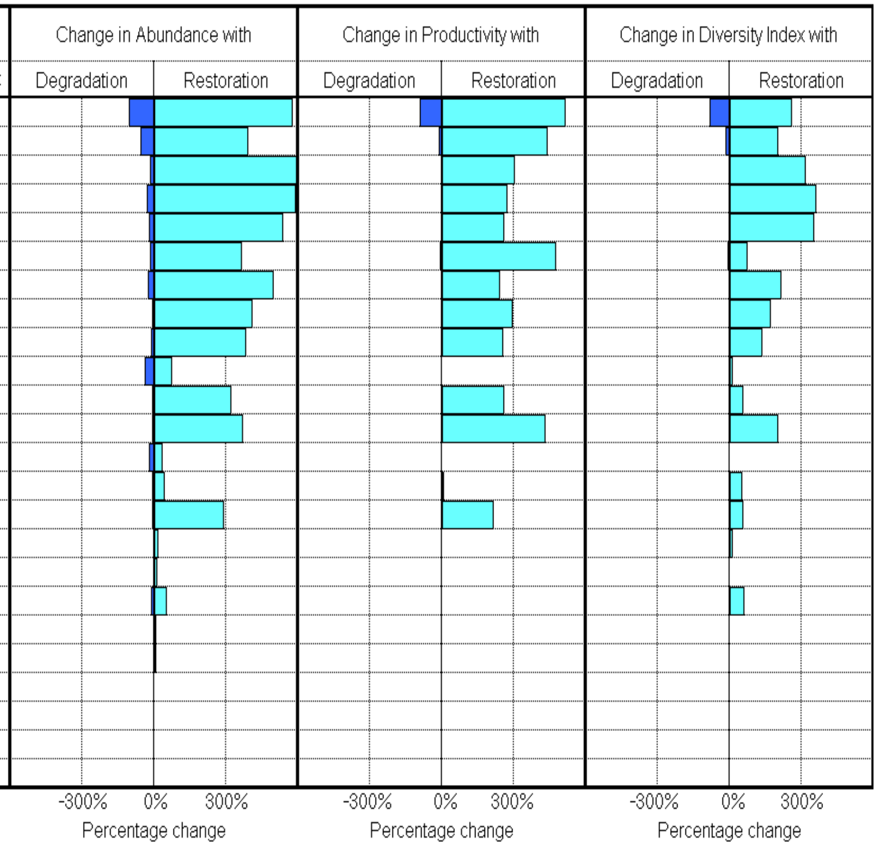
The factors are derived from the EDT model simulation.

Table C-1 displays the relative habitat restoration or protection benefits, and the degree of impact (high, medium, or low) on key habitat indicators for the Ahtanum Creek spring Chinook population based on the Ecosystem Diagnosis and Treatment (EDT) model analysis. Restoration/protection benefits and habitat impacts are evaluated based on the degree of habitat degradation from the historic base line and the relative importance of the specific reach for the population's life stages (migration, spawning, rearing, etc.).

Table C-2.

Relative Habitat Protection and Restoration Benefits for the Ahtanum Creek Watershed Spring Chinook Population for each of the EDT Model Reaches

Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
Ahtanum, U. WIP Div - forks	A	1	A	1
NF Ahtanum, Mouth - RM 2.0	B	2	B	5
Ahtanum, Marks Rd - Bach-Hat Div	C	5	A	2
Ahtanum, Bachelor return - 42nd Avenue	C	5	A	3
Ahtanum, L. WIP Div - American Fuit Rd	C	4	A	4
Ahtanum, Bach/Hat Div - U. WIP Div	C	3	B	7
Ahtanum, Mouth - Goodman Rd	C	7	B	7
Ahtanum, 42nd Avenue - Hatton return	D	8	B	6
Ahtanum, Hatton return - L. WIP Div	C	6	C	8
Yakima Toppenish to Sunnyside Dam	C	3	D	12
Ahtanum, American Fruit Rd - Marks Rd	D	8	C	9
SF Ahtanum, Mouth - RM 2.0	E	12	B	6
Yakima Satus to Toppenish	C	5	D	14
Yakima Prosser Dam to Satus	D	9	D	11
Ahtanum, Goodman Road - Bachelor return	E	11	C	10
Yakima Horn Dam to Benton	D	10	D	12
Yakima delta to Horn Dam	D	8	E	15
Yakima SSide Dam to Ahtanum Cr	D	10	D	13
Yakima Chandler Bypass Reach	E	11	E	16
Yakima Benton to Powerplant	E	12	E	17
Yakima delta	E	13	E	18
Ahtanum, L. WIP Diversion Dam	E	14	E	19
Ahtanum, Bach/Hat Diversion Dam	E	14	E	19
Ahtanum, Upper WIP Diversion Dam	E	14	E	19



Habitat restoration and protection values are based on the impact of current habitat conditions on population abundance, productivity, and capacity relative to historic habitat conditions.

Table C-2 displays the relative changes in key population performance indicators under habitat restoration or degradation for the Ahtanum Creek spring Chinook population. Abundance denotes the expected average number of returning adults; Productivity is an estimate of the maximum number of returning adults per spawning fish; and Diversity describes the proportion of life history patterns that are self-sustaining (that result in at least one returning adult per spawner). The restoration rank is based on the increase in the performance indicators the population would experience if the reach were restored to historical conditions. The preservation rank is estimated based on the change in the population's performance that would result if the reaches were thoroughly degraded.

Table C-3.

Aquatic and Riparian Habitat Factors Impacting Ahtanum Creek Watershed Summer Steelhead Populations

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
NF Ahtanum, Mouth - RM 2.0		A	B				C						C		A	B		B
NF Ahtanum, RM 2.0 - Nasty Cr	C	A	B				C		C				C		A	B		B
NF Ahtanum, Nasty Cr - Foundation Cr	C	A	B				C		C						A	B		B
NF Ahtanum, Foundation Cr - MF Ahtanum	B	A	B				C		C						A			B
NF Ahtanum, MF Ahtanum - McLain Canyon	A	A	C				C		C						A			B
NF Ahtanum, McLain Canyon - access limit	C	A	C				C		C				C		A	B		B
SF Ahtanum, Mouth - RM 2.0	A	A	C				C		C						A			B
SF Ahtanum, RM 2.0 - access limit	A	A	C				C		C				C		B	B		B
Ahtanum, Mouth - Goodman Rd		A	B				B	C	B				C		B	B		A
Ahtanum, Goodman Road - Bachelor return		B	B				C		C						A	B		B
Ahtanum, Bachelor return - 42nd Avenue	C	B	C				B		C	C			C	C	B	A		B
Ahtanum, 42nd Avenue - Hatton return	B	B	B				C		C	C			C	C	B	A		B
Ahtanum, Hatton return - L. WIP Div		B	C				C		C				C	C	B	A		B
Ahtanum, L. WIP Diversion Dam	B	B	C				C								A			B
Ahtanum, L. WIP Div - American Fuit Rd		C	B				C		B	B			C	C	A	A		B
Ahtanum, American Fruit Rd - Marks Rd		C	B				B		C	B			C	C	B	A		B
Ahtanum, Marks Rd - Bach-Hat Div		C	B				B		C	B			C	C	B	A		B
Ahtanum, Bach/Hat Diversion Dam		C	C				B		C	C			C	C	B	A		B
Ahtanum, Bach/Hat Div - U. WIP Div		C	B				C		C						A	B		B
Ahtanum, Upper WIP Diversion Dam		C	B				B		C						A	B		B
Yakima Prosser Dam to Satus	C	C			C				B		A			B	B	C		C
Yakima SSide Dam to Ahtanum Cr		C			C		C	C	B		A		C	B	C	C		C
Bachelor, Current adult rack - Spring Cr			B				C		B	B			C	C	A	A		B
Bachelor, potential rack just above Spring Cr																		
Bachelor, Spring Cr - Bach/Hat Div			B				C		C	C			C	C	B	A		B
Foundation, Mouth - access limit																		
Hatton Cr: Adult barrier at mouth																		
Hatton, mouth - Bach/Hat Div											A							
MF Ahtanum, Mouth - access limit			C				B		C	C			C	C	B	A		B
Nasty, Mouth - start of perennial flow																		
Nasty, start of perennial flow - access limit			B				B		B	C			C	C	B	A		B
Spring Cr, Mouth - access limit											A							
Yakima delta to Horn Dam			B				B		B	C			C	C	B	A		B
Yakima Chandler Bypass Reach									B	C				C	C	C		B
Yakima Benton to Powerplant									C					B	C	C		C
Yakima Chandler Bypass Reach					C				C				C	B	C	B		C
Yakima delta														B	C	C		C
Yakima delta to Horn Dam									C					B	C			B
Yakima Horn Dam to Benton											B			B	C	C		C
Yakima Satus to Toppenish					C				B					B	B	C		A
Yakima Toppenish to Sunnyside Dam					C				C					B	C	C		A

Key to strategic priority (corresponding Benefit Category letter also shown)

A High

B Medium

C Low

D & E Indirect or General

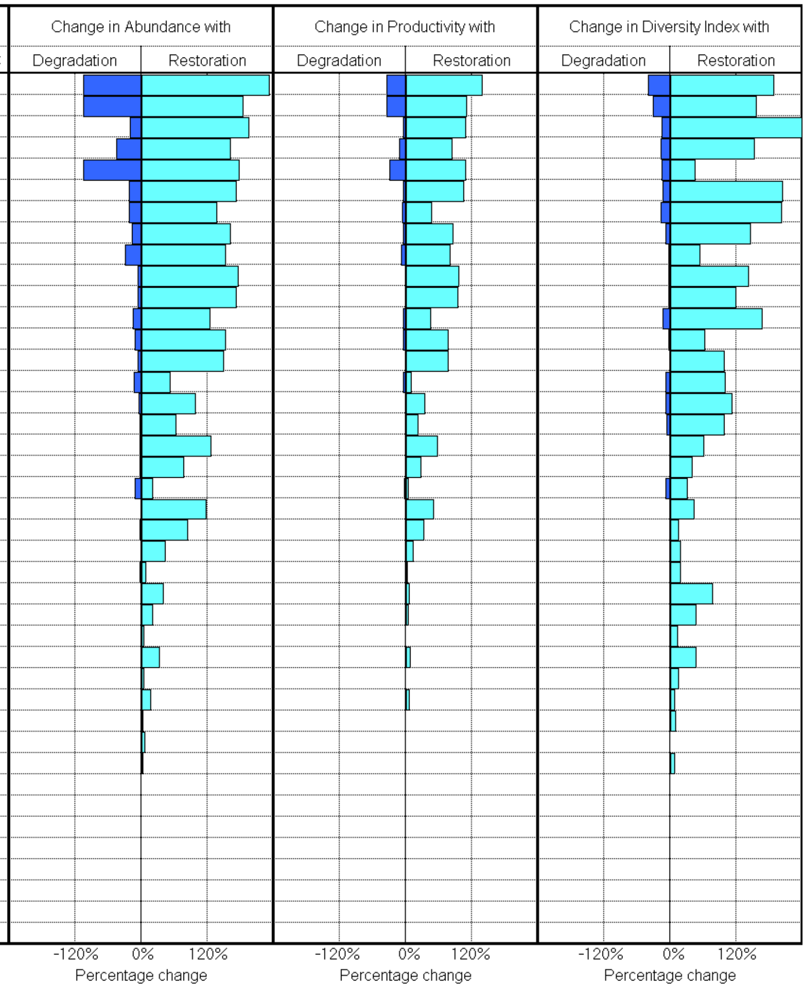
The factors are derived from the EDT model simulation.

Table C-3 displays the relative habitat restoration or protection benefits, and the degree of impact (high, medium, or low) on key habitat indicators for the Ahtanum Creek summer steelhead population based on the Ecosystem Diagnosis and Treatment (EDT) model analysis. Restoration/protection benefits and habitat impacts are evaluated based on the degree of habitat degradation from the historic base line and the relative importance of the specific reach for the population's life stages (migration, spawning, rearing, etc.).

Table C-4.

Relative Habitat Protection and Restoration Benefits for the Ahtanum Creek Watershed Summer Steelhead Population for each of the EDT Model Reaches

Geographic Area	Protection benefit		Restoration benefit	
	Category/rank		Category/rank	
Ahtanum, U. WIP Div - forks	A	1	A	1
SF Ahtanum, RM 2.0 - access limit	A	1	A	2
NF Ahtanum, Nasty Cr - Foundation Cr	C	6	A	1
NF Ahtanum, MF Ahtanum - McLain Canyon	B	3	A	5
NF Ahtanum, McLain Canyon - access limit	A	2	A	7
NF Ahtanum, RM 2.0 - Nasty Cr	C	7	A	3
Ahtanum, Marks Rd - Bach-Hat Div	B	4	B	8
SF Ahtanum, Mouth - RM 2.0	C	8	A	6
MF Ahtanum, Mouth - access limit	B	5	B	10
Nasty, Mouth - start of perennial flow	D	12	A	4
NF Ahtanum, Mouth - RM 2.0	D	13	A	5
Ahtanum, L. WIP Div - American Fuit Rd	C	9	B	9
Ahtanum, Bach/Hat Div - U. WIP Div	D	11	B	10
NF Ahtanum, Foundation Cr - MF Ahtanum	D	13	B	10
Yakima Prosser Dam to Satus	C	10	C	15
Ahtanum, Bachelor return - 42nd Avenue	D	14	C	12
Ahtanum, Mouth - Goodman Rd	D	14	C	14
Foundation, Mouth - access limit	E	17	C	11
Ahtanum, Hatton return - L. WIP Div	E	15	C	16
Yakima Toppenish to Sunnyside Dam	D	11	D	22
Ahtanum, 42nd Avenue - Hatton return	E	24	C	13
Nasty, start of perennial flow - access limit	E	20	C	17
Ahtanum, American Fruit Rd - Marks Rd	E	19	D	20
Yakima Satus to Toppenish	E	16	E	23
Yakima SSide Dam to Ahtanum Cr	E	22	C	18
Yakima Horn Dam to Benton	E	21	D	21
Yakima Chandler Bypass Reach	E	18	E	25
Bachelor Cr: Adult barrier at mouth	E	25	D	19
Yakima delta to Horn Dam	E	20	E	24
Ahtanum, Goodman Road - Bachelor return	E	25	E	23
Yakima Benton to Powerplant	E	23	E	26
Hatton Cr: Adult barrier at mouth	E	25	E	27
Yakima delta	E	24	E	28
Ahtanum, L. WIP Diversion Dam	E	25	E	29
Ahtanum, Bach/Hat Diversion Dam	E	25	E	29
Ahtanum, Upper WIP Diversion Dam	E	25	E	29
Bachelor, Current adult rack - Spring Cr	E	25	E	29
Bachelor Cr.-2A(new adult rack)	E	25	E	29
Bachelor, Spring Cr - Bach/Hat Div	E	25	E	29
Hatton, mouth - Bach/Hat Div	E	25	E	29
Spring Cr, Mouth - access limit	E	25	E	29



Habitat restoration and protection values are based on the impact of current habitat conditions on population abundance, productivity, and capacity relative to historic habitat conditions.

Table C-4 displays the relative changes in key population performance indicators under habitat restoration or degradation for the Ahtanum Creek steelhead population. Abundance denotes the expected average number of returning adults; Productivity is an estimate of the maximum number of returning adults per spawning fish; and Diversity describes the proportion of life history patterns that are self-sustaining (that result in at least one returning adult per spawner). The restoration rank is based on the increase in the performance indicators the population would experience if the reach were restored to historical conditions. The preservation rank is estimated based on the change in the population's performance that would result if the reaches were thoroughly degraded.

Table C-5.

Aquatic and Riparian Habitat Factors Impacting Ahtanum Creek Watershed Coho Populations

Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Ahtanum, Bachelor return - 42nd Avenue	C	A	Low				Low	Low	Low	Medium					Medium	Low		Medium
Ahtanum, U. WIP Div - forks	A	A	Low				Low	Low	Medium						Medium	Low		Medium
Ahtanum, Mouth - Goodman Rd	C	B	Low				Low	Low	Medium	Medium					High	Low		Medium
Ahtanum, Hatton return - L. WIP Div	C	B	Low				Low	Low	Low	Low					Medium	Low		Medium
Ahtanum, L. WIP Div - American Fuit Rd	C	B	Low				Low	Low	Medium	Low					Medium	Low		Medium
Ahtanum, Marks Rd - Bach-Hat Div	B	B	Low				Low	Low	Medium	Low					Medium	Low		Medium
NF Ahtanum, Mouth - RM 2.0	C	C					Low	Low	Medium						Medium	Low		Medium
NF Ahtanum, RM 2.0 - Nasty Cr		C	Low				Low	Low	High						Medium	Low		Medium
NF Ahtanum, Nasty Cr - Foundation Cr		C	Low				Low	Low	High						Medium	Low		Medium
NF Ahtanum, Foundation Cr - MF Ahtanum		C	Low				Low	Low	Medium						Medium			Medium
SF Ahtanum, Mouth - RM 2.0		C	Low				Low	Low	High						Medium	Low		Medium
SF Ahtanum, RM 2.0 - access limit		C					Low		High						Medium			Medium
Ahtanum, Goodman Road - Bachelor return		C	Low				Low	Low	Low	Medium					High	Low		Medium
Ahtanum, 42nd Avenue - Hatton return		C	Low				Low	Low	Low	Medium					Medium	Low		Medium
Ahtanum, American Fruit Rd - Marks Rd		C	Low				Low	Low	Medium	Low					Low	Low		Medium
Ahtanum, Bach/Hat Div - U. WIP Div	C	C	Low				Low	Low	Medium	Low					Medium	Low		Medium
Nasty, Mouth - start of perennial flow		C	Low				Medium	Low	High						Medium	Medium		High
Yakima SSide Dam to Ahtanum Cr		C	Low		Low		Low	Low	High	Low	High			Low	Low	Low		Medium
NF Ahtanum, MF Ahtanum - McLain Canyon							Low	Low	High						Medium			Medium
Ahtanum, L. WIP Diversion Dam																		
Ahtanum, Bach/Hat Diversion Dam																		
Ahtanum, Upper WIP Diversion Dam																		
Bachelor Cr: Adult barrier at mouth											High							
Bachelor, Current adult rack - Spring Cr			Low				Low		Low	Low					Medium	Low		Medium
Bachelor, potential rack just above Spring Cr																		
Bachelor, Spring Cr - Bach/Hat Div			Low				Medium	Low	Medium	Low					Medium	Medium		High
Foundation, Mouth - access limit			Low				Low	Low	High						Medium			Medium
Hatton Cr: Adult barrier at mouth											High							
Hatton, mouth - Bach/Hat Div			Low				Medium	Low	Medium	Low					Medium	Medium		High
MF Ahtanum, Mouth - access limit							Low	Low	High						Medium			Medium
Nasty, start of perennial flow - access limit			Low				Low	Low	High						Medium			Medium
Spring Cr, Mouth - access limit			Low					Low	Low	Low					Low			Medium
Yakima Benton to Powerplant														Medium	Low			Low
Yakima Chandler Bypass Reach									High					Medium				Low
Yakima delta														Medium	Low			Low
Yakima delta to Horn Dam									Low					Medium	Low			Medium
Yakima Horn Dam to Benton											Medium			Medium	Low			Low
Yakima Prosser Dam to Satus					Low				High		Medium			Low	Low	Low		Medium
Yakima Satus to Toppenish					Low									Low	Medium	Low		High
Yakima Toppenish to Sunnyside Dam	C				Low				Low					Low	Low	Low		High

The factors are derived from the EDT model simulation.

Key to strategic priority (corresponding Benefit Category letter also shown)

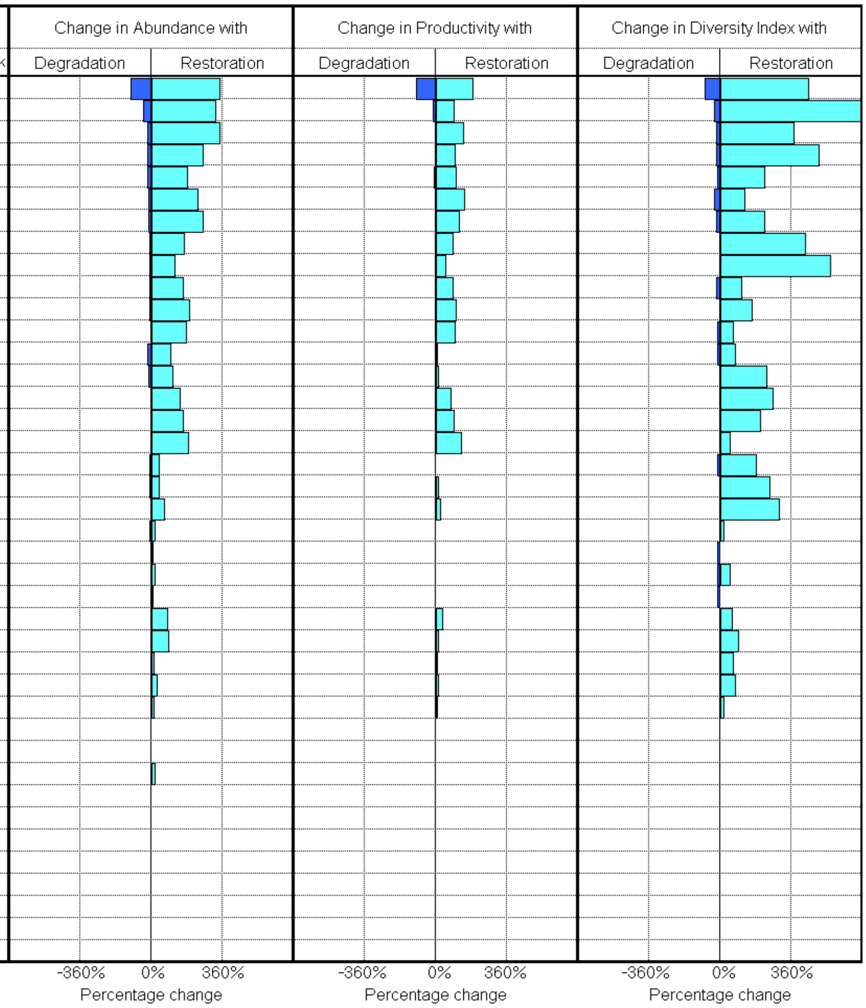
A	B	C	D & E
High	Medium	Low	Indirect or General

Table C-5 displays the relative habitat restoration or protection benefits, and the degree of impact (high, medium, or low) on key habitat indicators for the Ahtanum Creek coho population based on the Ecosystem Diagnosis and Treatment (EDT) model analysis. Restoration/protection benefits and habitat impacts are evaluated based on the degree of habitat degradation from the historic base line and the relative importance of the specific reach for the population's life stages (migration, spawning, rearing, etc.).

Table C-6.

Relative Habitat Protection and Restoration Benefits for the Ahtanum Creek Watershed Coho Population for each EDT Model Reach

Geographic Area	Protection benefit Category	Protection benefit rank	Restoration benefit Category	Restoration benefit rank
Ahtanum, U. WIP Div - forks	A	1	A	1
Ahtanum, Marks Rd - Bach-Hat Div	B	2	B	3
Ahtanum, Bachelor return - 42nd Avenue	C	5	A	2
Ahtanum, L. WIP Div - American Fuit Rd	C	3	B	4
NF Ahtanum, Mouth - RM 2.0	C	4	C	7
Ahtanum, Hatton return - L. WIP Div	C	5	B	6
Ahtanum, Mouth - Goodman Rd	C	7	B	5
NF Ahtanum, RM 2.0 - Nasty Cr	D	13	C	9
NF Ahtanum, Nasty Cr - Foundation Cr	D	13	C	10
Ahtanum, Bach/Hat Div - U. WIP Div	C	8	C	15
Ahtanum, 42nd Avenue - Hatton return	E	16	C	8
Ahtanum, American Fruit Rd - Marks Rd	D	12	C	14
Yakima Toppenish to Sunnyside Dam	C	6	D	21
Yakima SSide Dam to Ahtanum Cr	D	11	C	17
SF Ahtanum, Mouth - RM 2.0	E	16	C	13
NF Ahtanum, Foundation Cr - MF Ahtanum	E	18	C	12
Ahtanum, Goodman Road - Bachelor return	E	19	C	11
Yakima Prosser Dam to Satus	D	9	D	22
SF Ahtanum, RM 2.0 - access limit	E	15	C	18
Nasty, Mouth - start of perennial flow	E	17	C	16
Yakima Satus to Toppenish	D	10	E	25
Yakima delta to Horn Dam	D	12	E	26
Yakima Horn Dam to Benton	E	14	E	24
Yakima Chandler Bypass Reach	D	12	E	27
Nasty, start of perennial flow - access limit	E	20	D	20
Bachelor Cr: Adult barrier at mouth	E	22	D	19
NF Ahtanum, MF Ahtanum - McLain Canyon	E	19	D	23
Foundation, Mouth - access limit	E	21	D	22
MF Ahtanum, Mouth - access limit	E	20	E	24
Yakima Benton to Powerplant	E	16	E	28
Yakima delta	E	18	E	29
Hatton Cr: Adult barrier at mouth	E	22	E	26
Ahtanum, L. WIP Diversion Dam	E	22	E	30
Ahtanum, Bach/Hat Diversion Dam	E	22	E	30
Ahtanum, Upper WIP Diversion Dam	E	22	E	30
Bachelor, Current adult rack - Spring Cr	E	22	E	30
Bachelor, potential rack just above Spring Cr	E	22	E	30
Bachelor, Spring Cr - Bach/Hat Div	E	22	E	30
Hatton, mouth - Bach/Hat Div	E	22	E	30
Spring Cr, Mouth - access limit	E	22	E	30

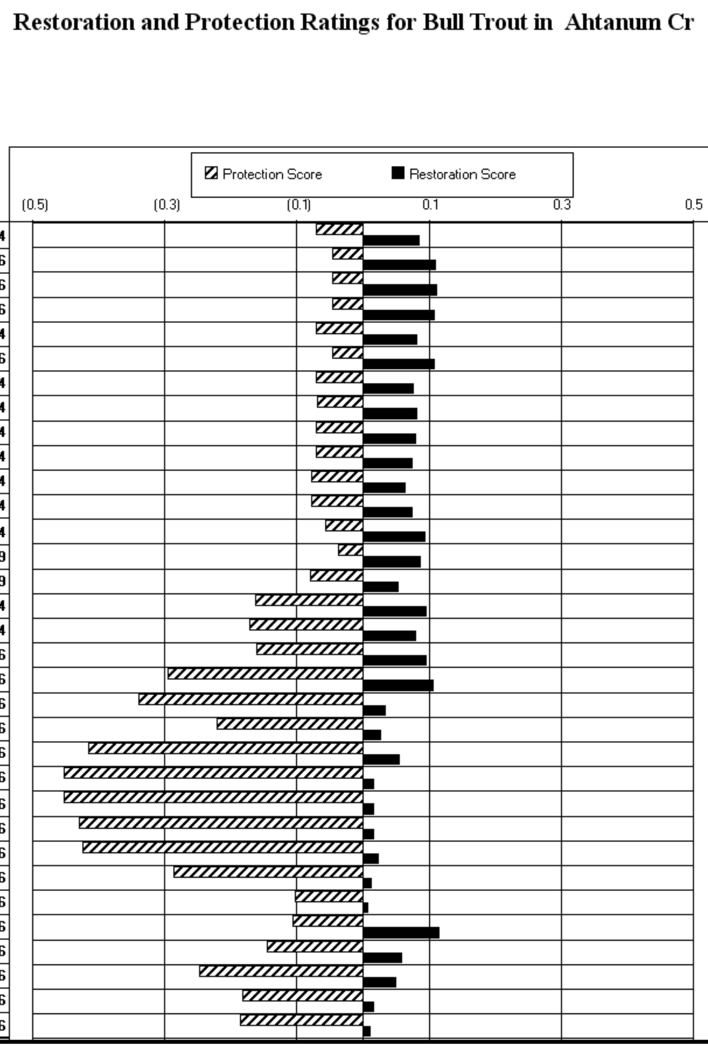


Habitat restoration and protection values are based on the impact of current habitat conditions on population abundance, productivity, and capacity relative to historic habitat conditions.

Table C-6 displays the relative changes in key population performance indicators under habitat restoration or degradation for the Ahtanum Creek coho population. Abundance denotes the expected average number of returning adults; Productivity is an estimate of the maximum number of returning adults per spawning fish; and Diversity describes the proportion of life history patterns that are self-sustaining (that result in at least one returning adult per spawner). The restoration rank is based on the increase in the performance indicators the population would experience if the reach were restored to historical conditions. The preservation rank is estimated based on the change in the population's performance that would result if the reaches were thoroughly degraded.

Table C-7.

A Description of the Relative Protection and Restoration Priorities for Ahtanum Creek Bull Trout Population Reaches

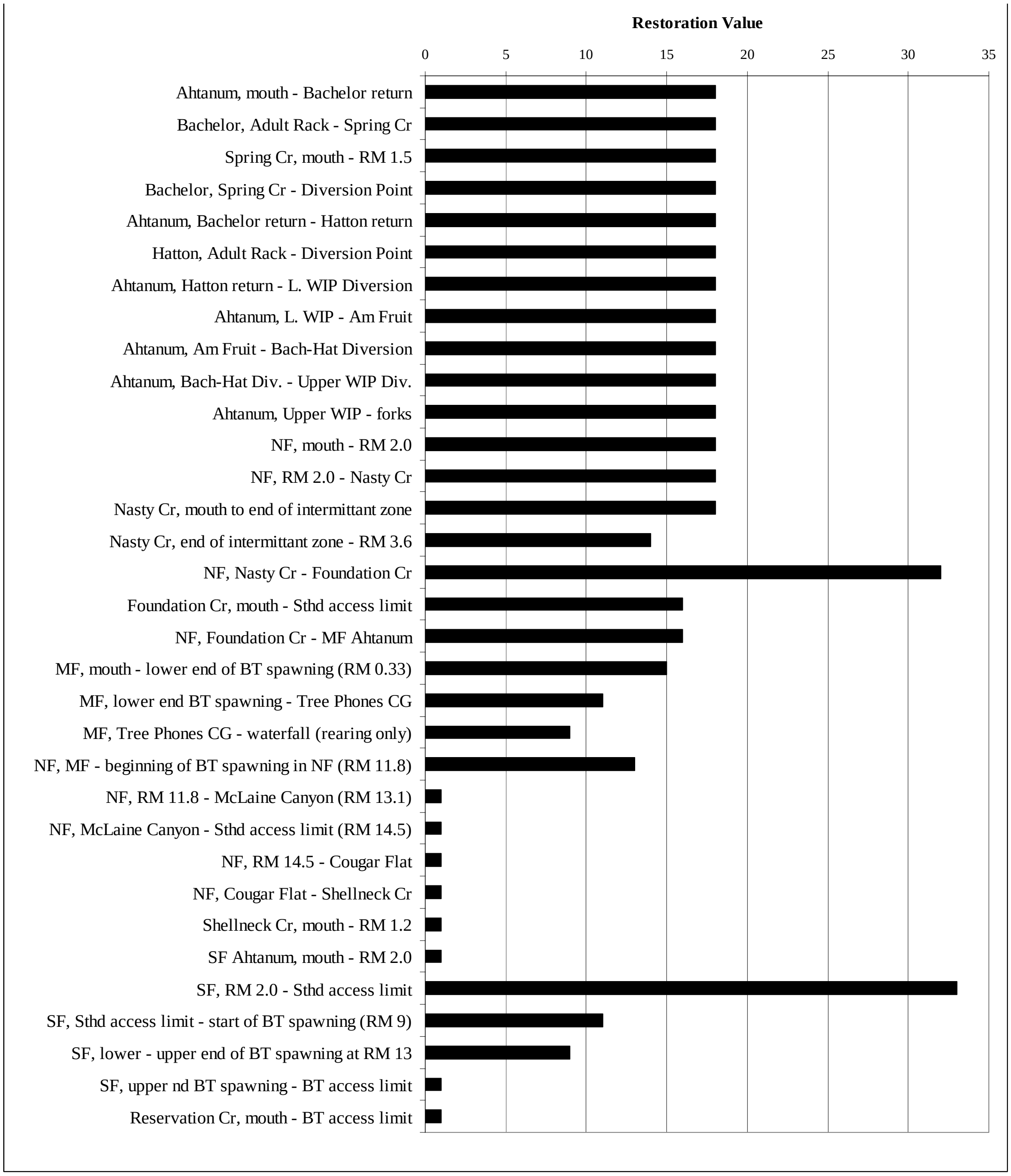


Reach Name	Protection Confidence	Restoration Confidence
Ahtanum, mouth - Bachelor return	1.24	0.87
Bachelor, Adult Rack - Spring Cr	0.86	0.68
Spring Cr, mouth - RM 1.5	0.86	0.68
Bachelor, Spring Cr - Diversion Point	0.86	0.68
Ahtanum, Bachelor return - Hatton return	1.24	0.87
Hatton, Adult Rack - Diversion Point	0.86	0.68
Ahtanum, Hatton return - L. WIP Diversion	1.24	0.87
Ahtanum, L. WIP - Am Fruit	1.24	0.87
Ahtanum, Am Fruit - Bach-Hat Diversion	1.24	0.87
Ahtanum, Bach-Hat Div. - Upper WIP Div.	1.24	0.87
Ahtanum, Upper WIP - forks	1.24	0.87
NF, mouth - RM 2.0	1.24	0.87
NF, RM 2.0 - Nasty Cr	1.24	0.87
Nasty Cr, mouth to end of intermittant zone	0.99	0.74
Nasty Cr, end of intermittant zone - RM 3.6	0.99	0.74
NF, Nasty Cr - Foundation Cr	1.24	0.87
Foundation Cr, mouth - Sthd access limit	1.24	0.87
NF, Foundation Cr - MF Ahtanum	1.36	0.93
MF, mouth - lower end of BT spawning (RM 0.	1.36	0.93
MF, lower end BT spawning - Tree Phones C	1.36	0.93
MF, Tree Phones CG - waterfall (rearing only)	1.36	0.93
NF, MF - beginning of BT spawning in NF (R	1.36	0.93
NF, RM 11.8 - McLaine Canyon (RM 13.1)	1.36	0.93
NF, McLaine Canyon - Sthd access limit (RM	1.36	0.93
NF, RM 14.5 - Cougar Flat	1.36	0.93
NF, Cougar Flat - Shellneck Cr	1.36	0.93
Shellneck Cr, mouth - RM 1.2	1.36	0.93
SF Ahtanum, mouth - RM 2.0	1.36	0.93
SF, RM 2.0 - Sthd access limit	1.36	0.93
SF, Sthd access limit - start of BT spawning (F	1.36	0.93
SF, lower - upper end of BT spawning at RM 1	1.36	0.93
SF, upper nd BT spawning - BT access limit	1.36	0.93
Reservation Cr, mouth - BT access limit	1.36	0.93

The scores were derived from the QHA process.

Table C-7 displays the relative importance of the Ahtanum Creek bull trout reaches for protection and restoration. The length of the bar corresponds to the reach's relative restoration or protection value weighted by its potential importance to bull trout. The protection and restoration confidence scores reflect the relative certainty of the ratings based on the local expert knowledge of habitat conditions for the specific reach. The higher the confidence score, the greater the confidence in the relative score of habitat protection or restoration conditions for the reach.

Table C-8.
A relative restoration of water temperature restoration priorities for Ahtanum Creek bull trout population reaches

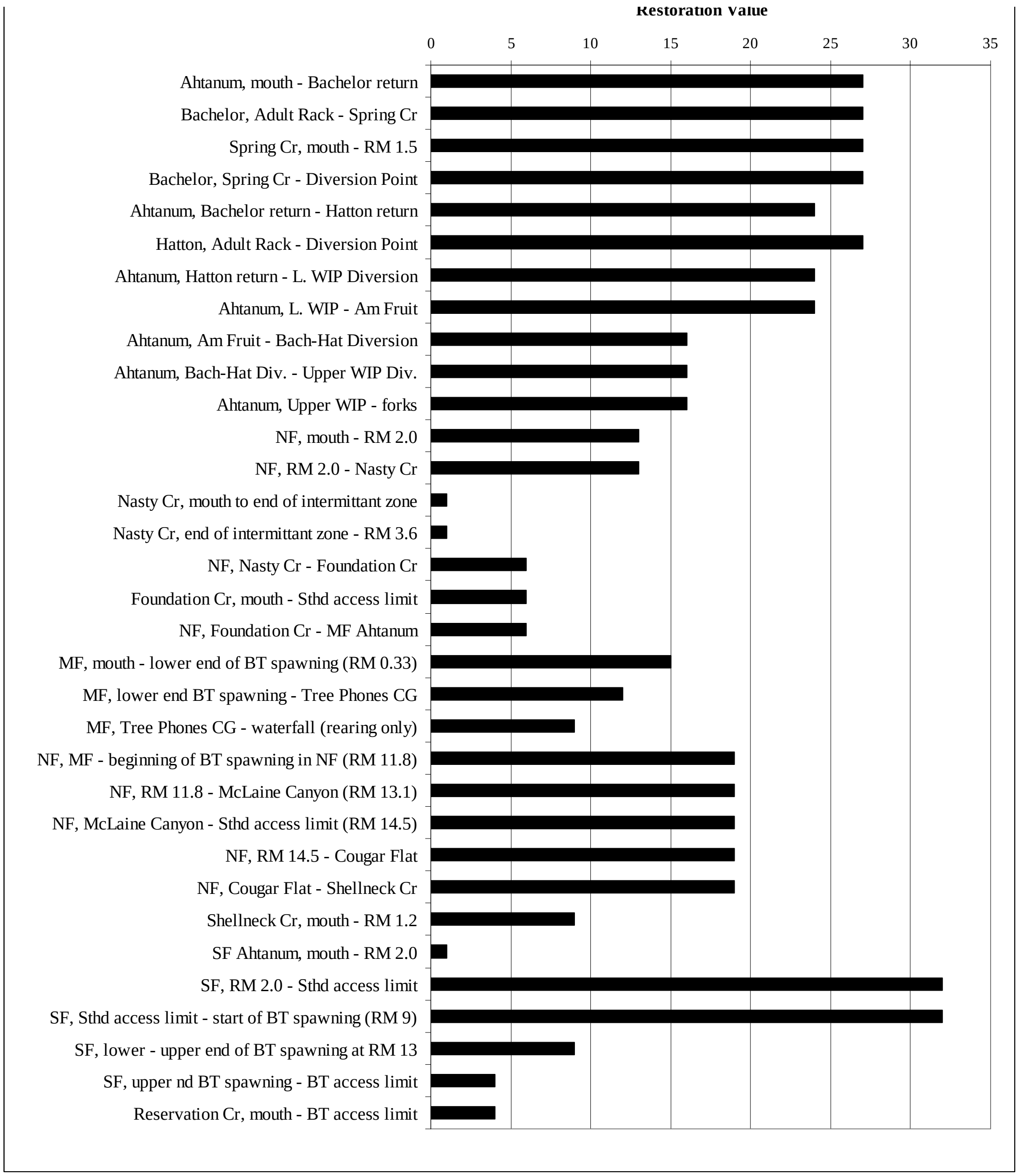


The length of the bar corresponds to the degree of degradation of the attribute weighted by its potential importance to bull trout. The relative rankings were derived from the QHA process.

Table C-8 displays the distribution of water temperature limiting conditions across all the bull trout reaches within Ahtanum Creek Watershed. The length of the bar corresponds to the degree of degradation of the attribute weighted by its potential importance to bull trout. The larger the bar, the greater the reach's restoration value for temperature.

Table C-9.

Relative Restoration of Water Pollution Restoration Priorities for Ahtanum Creek Bull Trout Population Reaches

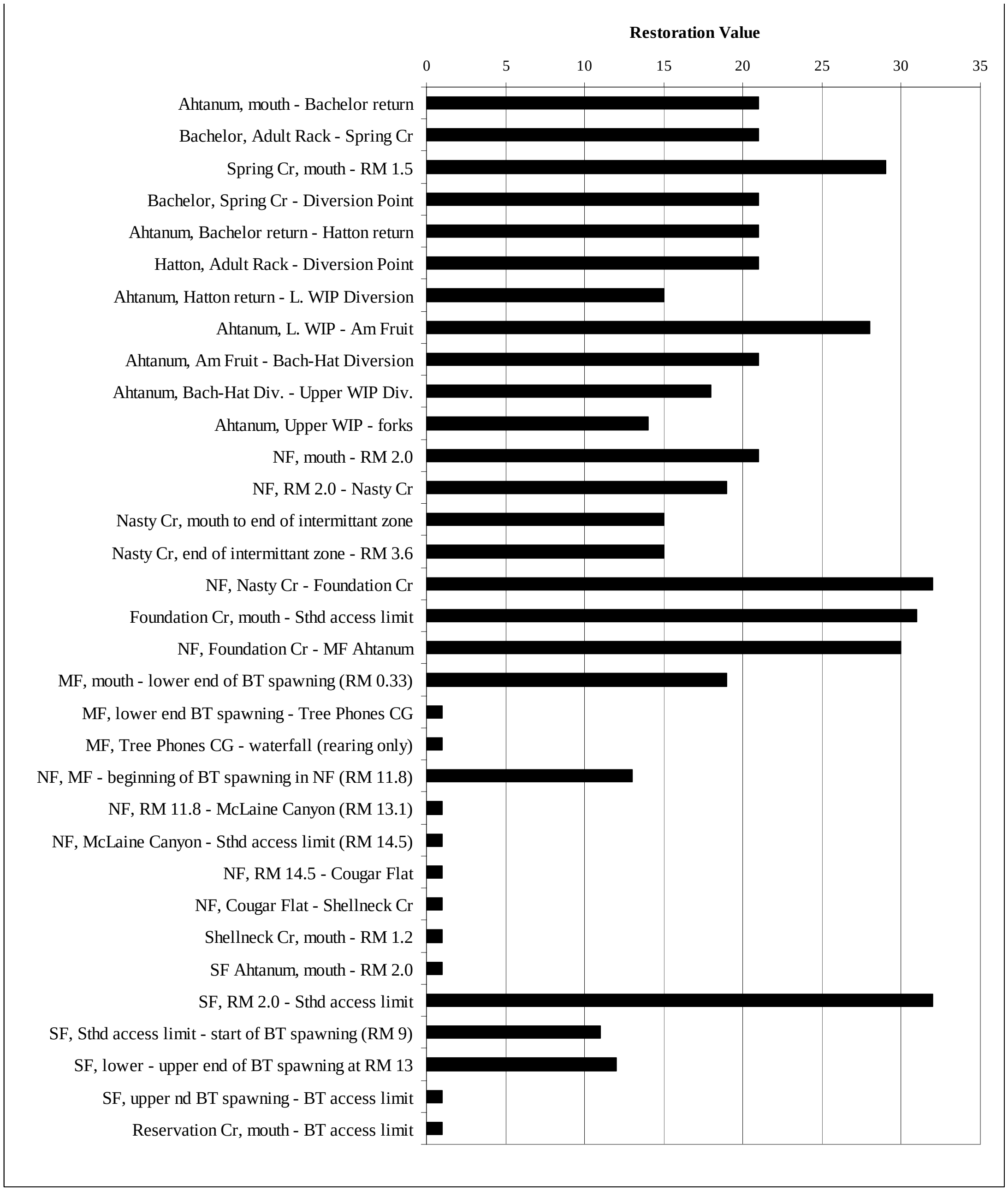


The length of the bar corresponds to the degree of degradation of the attribute weighted by its potential importance to bull trout. The restoration value scores were derived from the QHA process.

Table C-9 displays the distribution of water pollution limiting conditions across all the bull trout reaches within Ahtanum Creek Watershed. The length of the bar corresponds to the degree of degradation of the attribute weighted by its potential importance to bull trout. The larger the bar, the greater the reach's restoration value for water pollution.

Table C-10.

A Relative Restoration of Habitat Diversity Restoration Priorities for Ahtanum Creek Bull Trout Population Reaches



The length of the bar corresponds to the degree of degradation of the attribute weighted by its potential importance to bull trout. The restoration value scores were derived from the QHA process.

Table C-10 displays the distribution of habitat diversity limiting conditions across all the bull trout reaches within Ahtanum Creek Watershed. The length of the bar corresponds to the degree of degradation of the attribute weighted by its potential importance to bull trout. The larger the bar, the greater the reach's restoration value for habitat diversity.

Table C-11. Assumptions Used to Develop Restoration Scenarios

Reach	Problems	Restoration Measures	Comments
NF Ahtanum: McLain Canyon to access limit	Few problems except for road-related sediment delivery to downstream reaches. Local biologists report good habitat complexity, cool water temperatures and stable banks and stream bed. A protection area.	Relocation of ~1 mi of NF road ("relocation" defined as > 200 ft from stream).	Can use DNR 1998 Watershed Analysis to calculate precise mileage of roads to be relocated/decommissioned.
NF Ahtanum: MF Ahtanum to McLain Canyon	Major road-related sediment delivery area, with relatively minor local problems related to confinement & high temperature.	Relocation of NF road from MF to McLaine Canyon (entire reach)	
MF Ahtanum	Streamside roads & recreationists/campground contribute substantial sediment to lower watershed, but cause only modest problems locally. Largest local problems are riparian degradation and high temperature.	Relocate ~2.5 miles of streamside road, relocate campground, cottonwood/willow riparian plantings (entire reach)	Width of planted corridor and density of plantings within corridor remain to be defined. Mileage of planting can be estimated from Terraserver aerial photos. Fencing considered necessary only on grazed areas or areas of heavy recreational use.
NF Ahtanum: Foundation Cr to MF Ahtanum	Important restoration reach. Land uses and bridge confine channel, insufficient LWD and road with 100-200 ft of stream entire length of reach (local and downstream sediment source). In descending order of severity, major problems are: confinement (roads, bridges), high temp, obstructions; lack of LWD; riparian degradation.	Road relocation entire reach; LWD addition; riparian planting (exclosures); weir fishways at problematic bridges (bull trout problems).	Objective of LWD addition is to add 1 piece of LWD per channel width on average throughout the wood-deficient reach provided it is not a natural transport reach.
Foundation Creek	Suffers from same problems as "NF, Foundation to MF", but problems are more severe. Most severe is road-related confinement; high temp next; habitat complexity (LWD) next; & riparian degradation next.	Road relocation for all but lower 0.7 mi; fenced riparian planting entire reach (grazing); LWD addition; bank stabilization.	
NF Ahtanum, Nasty Cr to Foundation Creek	Major impact to incubation primarily from local sedimentation (bank sloughing) with significant contributions by high temp, bed scour & lack of spawning gravel. Causes: primarily road/bridge confinement, riparian degradation, lack of LWD.	Major addition of LWD (perhaps 2 pc/CW); limited road relocation (only where fill slopes would be OK); riparian planting	Use DNR Watershed Analysis to identify road section to relocate.
Nasty Creek	Lower portion dries up; upper portion primarily impacts incubation because of sediment, bed scour/bank instability, high temp and lack of spawning gravels. Road within floodplain entire length.	Very difficult and expensive fix. There could be some benefit from LWD addition, there are a couple of places where side channels could be enhanced or created, but even those are pretty difficult spots.	4th top restoration potential reach for steelhead
NF Ahtanum, RM 2.0 to Nasty Creek	Loss of alluvial fan area/function causing scour/bank sloughing where confined (NF road, John Cox & Shaw diversions) & routing increased bedload downstream. Channelization below NF road to Shaw-Knox increases energy and sediment transport downstream. Result is major impact to incubation primarily from sedimentation with significant impacts from temperature and scour/fill.	Rework NF bridge/John Cox diversion: change grade control structures at bridge/diversion to allow bedload movement downstream. Consolidate John Cox/Shaw Knox to eliminate need for channelization below NF Bridge; relocate ~ 1 mi of road within 200 ft of stream; riparian plantings in devegetated areas (as per aerials).	3rd top restoration potential for steelhead

Table C-11. Assumptions Used to Develop Restoration Scenarios (continued)

Reach	Problems	Restoration Measures	Comments
NF Ahtanum, mouth to RM 2.0	Problems like reach above.	Actions for reach above affect this reach as well. Within this reach, more emphasis on riparian planting.	Respective restoration potential for steelhead, coho and spring Chinook: 5th, 7th, 5th
SF Ahtanum, RM 2.0 to steelhead/coho access limit	Large amounts of new angular bedload coming off the South Facing hills, severely impacting coho & steelhead incubation from sedimentation. To some degree, this is natural, but it is exacerbated by floodplain roads.	Relocate roads within 100 ft of stream.	2nd top restoration potential reach for steelhead. Very little published habitat data for SF.
SF Ahtanum, mouth to RM 2.0	Confinement by residential uses; considerable riparian damage from residential development, some from grazing. Major sediment impact to incubation for coho & steelhead; substantial temperature impact to steelhead incubation. Lack of spawning gravel for both species.	Fenced riparian plantings, decommissioning/relocation of ~1 mi of road (not the SF Road), perhaps the hydraulic reconnection of 3 NF-to-SF distributaries (creating fry rearing habitat, lessening scour problems because of increased conveyance capacity).	5th top restoration potential reach for steelhead. Very little published habitat data for SF.
Ahtanum Creek, upper WIP to forks.	Channel constriction at Herke causes aggradation upstream, instability in the constriction itself, increased erosion downstream & massive erosion & riparian degradation in the adjacent floodplain. Riparian degradation more severe than any other reach of drainage. Upstream of the Narrows the channel has lost sinuosity/gone through regrade due to increased bedload from upstream. The reach immediately above the Narrows is a significant upwelling area. Steelhead incubation severely impacted by temperature and sediment, less impact from scour/fill. Coho sub-yearling and winter rearing severely impacted by low habitat diversity (primarily lack of LWD) and lack of key habitat (pools, off-channel habitat). Spring Chinook adult holding compromised by excessive temperature and lack of key habitat (pools); & incubation compromised by sediment.	1) Rework Herke reach: Build Herke a new, longer bridge, and re-meander channel through Herke area and upstream (decreases scour/bank sloughing). The real cause of scour/bank sloughing is loss of area on the alluvial fan, which shifts deposition downstream. Fixing the NF bridge helps some but really need to recover floodplain from ~John Cox to the forks. 2) Addition of large quantities of LWD (2 pc/CW) really helps habitat complexity, pool formation & sediment storage. The area ~ from the Mission to Herkes has significant upwelling of cool groundwater & addition of structural complexity from LWD would be very beneficial. 3) Yakama Nation has identified 1.1 mi of side channel that could be reconnected here (juvenile rearing habitat). 4) Riparian planting/fencing urgently needed throughout reach, but especially in upper half. 4) Rework Herke's as above; 2) major fenced riparian planting; 3) retrofit upper WIP diversion to allow BH to be used as flood control channels & to allow bedload to move into BH.	Number 1 restoration reach for spring Chinook, coho and steelhead. Note: 3.1 mi riparian fencing already installed by Yakama Nation, 0.8 mi of side channel just re-connected.

Table C-11. Assumptions Used to Develop Restoration Scenarios (continued)

Reach	Problems	Restoration Measures	Comments
Ahtanum Creek, Bachelor-Hatton Diversion to upper WIP Diversion	Chronic channel instability/channel widening/aggradation & associate severe riparian degradation caused partly by upstream actions on Herke, partly by grazing, &partly by the WIP and Bachelor/Hatton diversions themselves. Impacts steelhead incubation (mainly high temperature, but also sediment & scour/fill); coho sub-yearling rearing (lack of pool/off-channel habitat, high temp) & incubation (sediment, scour/fill), and spring Chinook adult holding (pools & temp) & spawning (temperature). Temperature impacts dominate.	1)	Restoration potential for steelhead and spring Chinook = 10th & 7th, respectively. Yakama Nation recently fenced 1.6 mi of riparian corridor here.
Ahtanum Creek, American Fruit to Bachelor-Hatton Diversion	Reach suffers from 1) high temperatures and low flows (temp driven partly by low flow, partly by lack of shading, partly by temp of incoming water); 2) channel instability caused by 3500 ft of channelization/leveeing upstream of Diversion 14 (950 ft above Am Fruit Rd); 3) bed aggradation above confinement caused by Diversion 14 (950 ft above Am Fruit Rd) and erosion below Div 14; 4) channel incision below Lynch Lane 5) Levees, old roads & groins that prevent access to floodplain on the Reservation side, forcing creek toward Hatton channel; 6) few pools, little LWD. Severe impacts to steelhead incubation from temp, major impacts from sediment & scour/fill; Severe impacts to coho sub-yearling rearing from lack of key habitat (pools/off-channel habitat) & scour/fill, low flow, food and habitat diversity, and to coho winter rearing because of low habitat complexity (LWD) and lack of pools/off-channel habitat; and severe impacts to spring Chinook adult holding & spawning because of temperature, with lesser but large impacts from low flow, low habitat complexity (LWD) and low key habitat (pools).	1) Increase flow (probably impossible w/o Pine Hollow); 2) Continue floodplain/riparian restoration at and below the mission; 3) Purchase property from Am Fruit Rd to 3500 ft above Div 14 to re-meander channel & add LWD (to create pools) & to regrade banks to eliminate incision and increase bank stability (reduce sediment input).	Restoration potential for steelhead, coho and spring Chinook, respectively, 8th, 3rd, 2nd. Yakama Nation recently constructed 0.34 mi of fenced riparian in reach.
Ahtanum Creek, Lower WIP to American Fruit Road	1) Channel straightening throughout all but ~ 1 mi has resulted in major incision/bank instability, floodplain disconnection and loss of riparian vegetation; 2) Critically low flows in this reach; 3) excessive temperatures (shading & flow related).	1) Raise the channel back up through engineered re-meandering and grade control (made easier by a lack of residential development through altered sections). This would obviously require purchase of property; 2) Riparian planting/fencing; 3) Addition of LWD throughout re-meandered reach (1 pc/CW).	Restoration potential for steelhead, coho and spring Chinook, respectively, 9th, 4th, & 4th. Yakama Nation recently constructed 0.34 mi of fenced riparian in reach.

Table C-11. Assumptions Used to Develop Restoration Scenarios (continued)

Reach	Problems	Restoration Measures	Comments
Ahtanum Creek, Hatton return to Lower WIP	1) Although channel stability is generally good, the riparian zone is virtually denuded in about 60-70% of reach. 2) Low flows 3) The channel is straightened and incised for About over about a 1,000 ft section upstream of 62nd. 4) High temperatures due to lack of shading, low flow & temp of incoming water. These conditions have severe impacts on steelhead incubation (mainly temperature, but large impacts from scour/fill & sediment as well) and sub-yearling rearing (low flow, temperature & lack of pools); main coho impact is to sub-yearling rearing (lack of pools, low flow & temperature) and main impact to spring Chinook is to (mainly lack of pools and temperature but also large impact of low flow)	1) Main action is to plant riparian; 2) Install LWD (1 pc/CW); 3) Re-meander lower 1,000 ft	Restoration potential for reach for coho & spring Chinook is 6th & 8th, respectively.
Ahtanum Creek, Bachelor return to Hatton return	1) Low flows 2) Riparian zone damage, partially due to low flows (channel denuded for a 1/2 mi section below Hatton return) 3) High temperatures (due to riparian damage, low flows, temperature of incoming water) 4) Incision/channelization at Emma Lane/42nd. Impacts to steelhead: severe impacts to incubation from temperature with lesser but still major impacts from scour/fill and sediment. Impacts to coho: major impacts to sub-yearling rearing from lack of pools with lesser but still large impacts from low flow and temperature. Impacts to spring Chinook: Major impacts to adult holding from low flow, lack of habitat complexity, high temperature and lack of pools.	1) Riparian plantings, especially in upper half mile; 2) Remeander at Emma Lane; 3) Add LWD (1 pc/CW); 4) increase flows (impossible without Pine Hollow)	Restoration potential for reach for coho & spring Chinook is 2nd & 3rd, respectively.
Ahtanum Creek, mouth to Bachelor return	1) Low flows (but not so low as upstream, because of groundwater upwelling and Marquis ditch inflow from Wide Hollow Cr) 2) Extensive channelization alongside Fulbright Park 3) Channel aggradation and associated sediment problems from the mouth to the Ag Museum bridge. 4) Severe riparian vegetation damage in the lower 1/2 and upper 1/4 of the reach and an associated lack of LWD & pools. 5) High temperatures (although impact is mitigated by Marquis ditch inflow and groundwater upwelling). Impacts to steelhead: severe impacts to incubation from sediment & temperature, with lesser but still large impacts from scour/fill. Impacts to coho: Major impact to sub-yearling rearing from lack of pools, habitat complexity & temperature, as well as major impacts to incubation from sediment and scour/fill. Impacts to spring Chinook: Major impacts to adult holding from low flow, low habitat complexity (LWD), high temperature and lack of pools, as well as severe impacts to incubation from sediment and lesser but still major impacts from temperature.	1) Re-meander creek along Fulbright Park 2) Take out adult rack at mouth of Bachelor Cr, replace it just upstream of Spring Cr (allows use of cool lower Bachelor and Spring Cr) 3) riparian plantings throughout 3/4 of reach 4) Add LWD throughout reach (1 pc/CW)	Restoration potential for reach for coho & spring Chinook is 5th & 7th, respectively.

APPENDIX D – SURFACE WATER ANALYSIS OF RESERVOIR OPERATIONS

Surface Water—Analysis of Reservoir Operations

This appendix includes the information on the analysis conducted on the reservoir operations. The analysis was conducted using the flow routing model developed for the *Ahtanum Creek Watershed Assessment*, Golder Associates (2004). The model uses GoldSim software to evaluate the impacts of a proposed reservoir on surface water supply and instream flows. The model simulates flows through reaches of the watershed based on the following:

- Surface water flows – The model routes historical average daily stream flows (1947-1984) for the North and South Forks of Ahtanum Creek from the upper watershed to the mouth of the mainstem creek, under a variety of user input conditions. The model period of record (1947-1984) was chosen based on the availability of weather data used to simulate local runoff to the lower Ahtanum Creek system.
- Runoff – Each reach of the creek modeled is assigned a tributary area and a curve number based on ground cover. The model then applies the Natural Resource Conservation Service (formerly Soil Conservation Service) curve number method and weather data to calculate the runoff that enters the stream in each reach.
- Groundwater – The interaction between the surface water in Ahtanum Creek and groundwater is simulated as a gain or loss in each reach. Each reach was assigned a loss or gain based on stream flow measurements and calibration of the flow routing model. The model also calculates gains or losses in Bachelor and Hatton Creeks and makes an allowance for return flows from Bachelor and Hatton Creeks to the mainstem. However, conveyance of irrigation water through a piped system would significantly reduce flows in Bachelor and Hatton Creeks and minimize their impact on the overall water budget.
- Irrigation diversions – A crop water model was developed that calculates surface water demand for both the AID and WIP based on a variety of user input crop and irrigation parameters. The crop model is linked to the flow routing model, so that demands are calculated and applied to the routing model.
- Instream flow targets – The flow routing model enables the user to specify instream flow targets for the North Fork and mainstem of the Ahtanum Creek. The routing model gives priority to maintaining these flows when filling and releasing water from the proposed reservoir.
- Storage – The flow routing model has the ability to simulate storage of water in a 24,000-acre-foot off-stream reservoir in Pine Hollow. The user specifies whether the reservoir is to be used for a particular scenario. The model assumes that the reservoir will be supplied through an expanded (160-cfs capacity) Johncox Ditch. Diversion of flow from the North Fork to fill the reservoir is limited by maintenance of instream flow targets and channel-forming flows. The routing model specifies maintenance of a 350-cfs channel-forming flow, meaning that diversion to the reservoir is interrupted if the average daily flow in the North Fork exceeds 350 cfs for period of 1 to 6 days so that the channel-forming flows remain in the stream. Water is withdrawn from the reservoir to maintain instream flow targets specified for the mainstem of the Ahtanum Creek and meet surface water demand calculated for the AID and WIP. Withdrawals are limited by a maintaining a 2,000 acre-feet minimum reservoir volume for dead storage as outlined in the *Ahtanum Creek Watershed Assessment* (Golder, 2004) and other previous studies.

Alternative 2 was evaluated using the flow routing model to simulate the following conditions:

- The reservoir would provide all out-of-stream water use within the reservoir service area for the entire irrigation season.
- There would be no individual creek diversions within the reservoir service area.
- Water from the reservoir would be used to augment flow in Ahtanum Creek when natural flows cannot meet target flows.
- The WIP canals would be lined or piped.
- All water from the reservoir would be delivered through a piped system.

Several scenarios were evaluated that included variations of the following parameters:

- Irrigation Demand – The *Ahtanum Creek Watershed Assessment* (Golder, 2004) estimated that between groundwater and surface water supplies, a total of 46,400 acre-feet was required to adequately irrigate the current (2002) crop acreages. This level of demand was established as the current, or baseline demand condition. If conservation measures are implemented, as specified for Alternative 2, efficiencies would reduce the total amount of water required to irrigate the same crop acreage to approximately 33,100 acre-feet. That level of demand was evaluated by the routing model to determine the long-term impacts of Alternative 2 on surface water supply and flows. Different ratios of groundwater and surface water demand were evaluated. Based on the storage capacity of the reservoir and the assumption that most of the surface water demand will shift to the summer when supplied by a reservoir, it was estimated that 19,600 acre-feet of the total 33,100 acre-feet of water needed would be supplied by surface water.
- Instream flow targets – Alternative 2 assumes that water from the reservoir would be used to augment stream flow in Ahtanum Creek when natural flows cannot meet target flows. A variety of instream flow targets were evaluated. The evaluation included analysis of historical flows and comparison of historical flow statistics to previous instream flow target recommendations. Different instream flow targets were also evaluated with the routing model. Based on input from the Ahtanum Core Group, the analysis ultimately focused on the ability of the reservoir to maintain instream flow targets in the North Fork and mainstem of the Ahtanum Creek equal to those flows recommended by Simmons (USFWS, 1993) developed with the Instream Flow Incremental Methodology (IFIM) ; those instream flow targets are shown below in Table D-1.

Table D-1. Ahtanum Creek Instream Flow Targets

Location	**Monthly Instream Flow Target (cfs)**											
	Jan	**Feb**	**Mar**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
North Fork	20	20	30	70	110	80	20	20	20	20	20	20
Mainstem	25	30	50	90	140	100	20	20	25	25	25	25

Note: Based on IFIM Methodology (Simmons, 1993)

The results of the evaluation of Alternative 2 using the flow routing model are shown in Table D-2 and Figures D-1 and D-2. Table D-2 summarizes the instream flow targets and distribution of demands assumed for the scenario that provided the most beneficial results, based on the demand conditions and instream flow targets noted previously. Also listed, for comparison, are the results of evaluations completed for the *Ahtanum Creek Watershed Assessment* (Golder, 2004) to evaluate natural flow conditions, current flow conditions, and flow conditions resulting from use of the proposed reservoir to supply surface water demand and augment instream flows after July 10.

The evaluation results indicate the following:

- Improvements in efficiency resulting from conservation measures, including installation of a piped distribution system and more efficient on-farm irrigation systems, could reduce the total amount of water needed annually to approximately 33,100 acre-feet. This represents a reduction of approximately 29 percent in the total annual demand of 46,400 acre-feet that was estimated as the current (2002) demand condition in the *Ahtanum Creek Watershed Assessment* (Golder, 2004). This also represents an increase in on-farm efficiency from approximately 70 percent to 82 percent, and an increase in conveyance efficiency from approximately 75 percent to 95 percent.
- Installation of a "smart" diversion and upgrade of the capacity of Johncox to 160 cfs would allow the diversion of streamflow from the North Fork to the proposed Pine Hollow Reservoir. As shown in Figure D-1, approximately 17,000 acre-feet per year could be diverted on average from the North Fork of Ahtanum Creek while meeting in-stream flow targets and channel maintenance flow criteria.
- Assuming that 19,600 acre-feet of that total demand is surface water demand, a 24,000-acre-foot reservoir will have the capacity to meet the surface water demand and supplement instream flows to meet the IFIM instream flow target with a reliability of approximately 72 percent. The reliability represents the percentage of days that the reservoir would be able to supply surface water demand for irrigation and meet instream flow requirements under the natural surface flow and weather conditions defined for the model period (1947-1984). The results indicate that a 24,000 acre-foot reservoir would, on average, be able to yield approximately 15,000 acre-feet of surface water for irrigation and instream flow supplement. The 15,000 acre-foot yield is less than the estimated 17,000 acre-foot diversion described above because of conveyance losses estimated for deliveries in an upgraded Johncox Ditch and seepage and evaporation losses from the reservoir. The estimated 15,000 acre-foot yield supports the conclusion made during the evaluation of reservoir sizing outlined in the *Pine Hollow Reservoir Project Overview* (Dames & Moore, 2000).
- Evaluation of different scenarios indicated that greater reliability would result from application of lower instream flow targets. For example, reducing the instream flow target to a constant year-round 20 cfs for the North Fork and 25 cfs for the mainstem would increase the reliability of the reservoir from 72 percent to 80 percent. The change would also increase the amount of flow available from the reservoir, on average, from approximately 15,000 acre-feet to more than 16,000 acre-feet annually. This is shown in Figure D-3. Greater reliability would also result from shifting more of the overall demand to groundwater to reduce surface water demand.

Table D-2. Alternative 2 – Flow Routing Model Analysis Results

Model Scenario	ISF Target		Crop Water Model									Demand On Proposed Reservoir[3] (AF)	Demand Supplied By Proposed Reservoir[4] (AF)	Reservoir Reliability[5]	Flow Occurrences					
			Surface Water			Groundwater			TOTAL						North Fork		A. Cr. R2[6]		A. Cr. R5[7]	
	N Fk (cfs)	Aht. Cr. (cfs)	Apr-Jun Demand (AF)	Jul-Oct Demand (AF)	Total Demand (AF)	Apr-Jun Demand (AF)	Jul-Oct Demand (AF)	Total Demand (AF)	Apr-Jun Demand (AF)	Jul-Oct Demand (AF)	Total Demand (AF)				Days <20 cfs	Days >350 cfs	Days <20 cfs	Days >350 cfs	Days <20 cfs	Days >350 cfs
ACWA - Natural	N/A	N/A	0	0	0	0	0	0	0	0	0	0	0	N/A	14.2%	1.7%	6.4%	3.8%	23.4%	3.2%
ACWA - Current	IFIM[1]	0	13,800	4,600	18,400	17,700	10,300	28,000	31,500	14,900	46,400	0	0	N/A	18.9%	1.6%	8.0%	3.5%	40.3%	1.9%
ACWA - Demand C	IFIM[1]	35[2]	14,800	10,500	25,300	22,200	7,000	29,200	37,000	17,500	54,500	10,500	10,500	96%	14.4%	1.3%	3.5%	2.0%	10.8%	1.9%
EIS Alternative 2	IFIM[1]	IFIM[1]	9,100	10,700	19,800	10,700	2,600	13,300	19,800	13,300	33,100	19,800	15,000	72%	14.4%	1.1%	5.9%	1.5%	27.5%	1.5%

NOTES:

ACWA=*Ahtanum Creek Watershed Assessment* (Golder, 2004)

Model Scenario Description:

- ACWA – Natural simulates the natural stream flows that would have occurred during the model period (1947-1984) if the streams had not been regulated by irrigation diversions.
- ACWA – Current simulates the stream flows that would have occurred during the model period (1947-1984) under current (2002) cropping and irrigation demands.
- ACWA Demand C – simulates the stream flows that would have occurred during the model period (1947-1984) under a higher level of surface water demand defined in the ACWA. Surface water demands would be met by the reservoir after July 10.
- EIS Alternative 2 – simulates the stream flows that would have occurred during the model period (1947-1984) under the 2002 cropping and irrigation demands with conservation measures implemented and a portion of the surface water demand shifted to the late summer.

1) Indicates that IFIM Analysis (Simmons, 1993) recommendations were used as target flows.

2) 35 cfs was used as target flow to dictate reservoir withdrawals from Jul-Oct. During the rest of the year the target was set at 0 cfs.

3) Indicates the level of surface water demand that the scenario assumes will be provided by the proposed Pine Hollow Reservoir.

4) Indicates the level of surface water demand that can actually be provided by the reservoir under each scenario according to the routing model.

5) The reliability represents the percentage of days during the model period (1947-1984) that the reservoir was able to supply surface water demand[3] for irrigation and meet instream flow requirements. The ACWA – Demand C model scenario has a very high reliability as only demands occurring after July 10 were supplied by the reservoir.

6) A. Cr. R2 represents the flow in Ahtanum Creek at a point just below the proposed inflow from Pine Hollow Reservoir and upstream of the current WIP and AID diversions.

7) A. Cr. R5 represents the flow in Ahtanum Creek at a point near American Fruit Road. Low flows would typically occur in the late summer and early fall.

Figure D-1.
Alternative 2 – North Fork Flows and Diversion to Reservoir

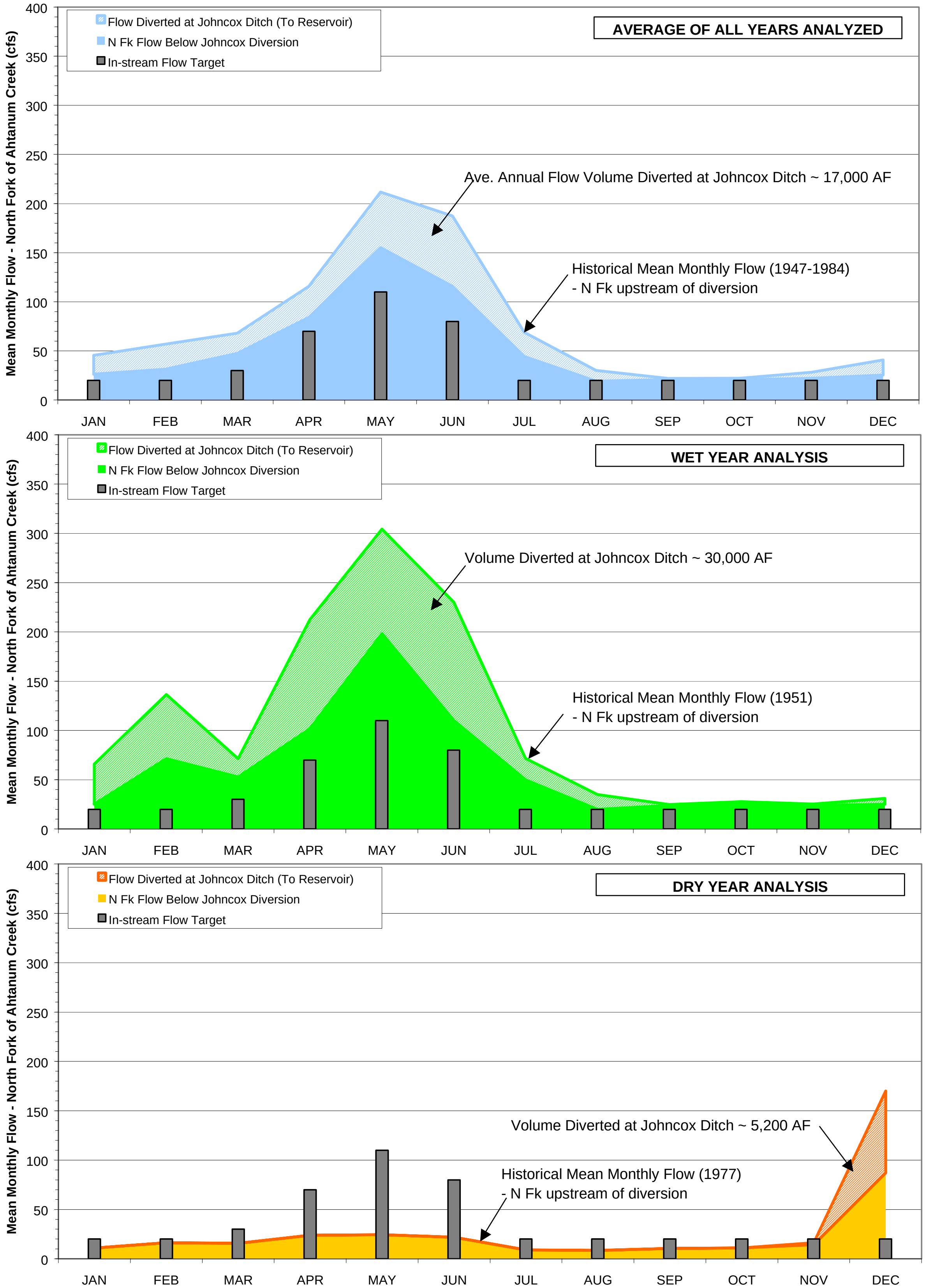
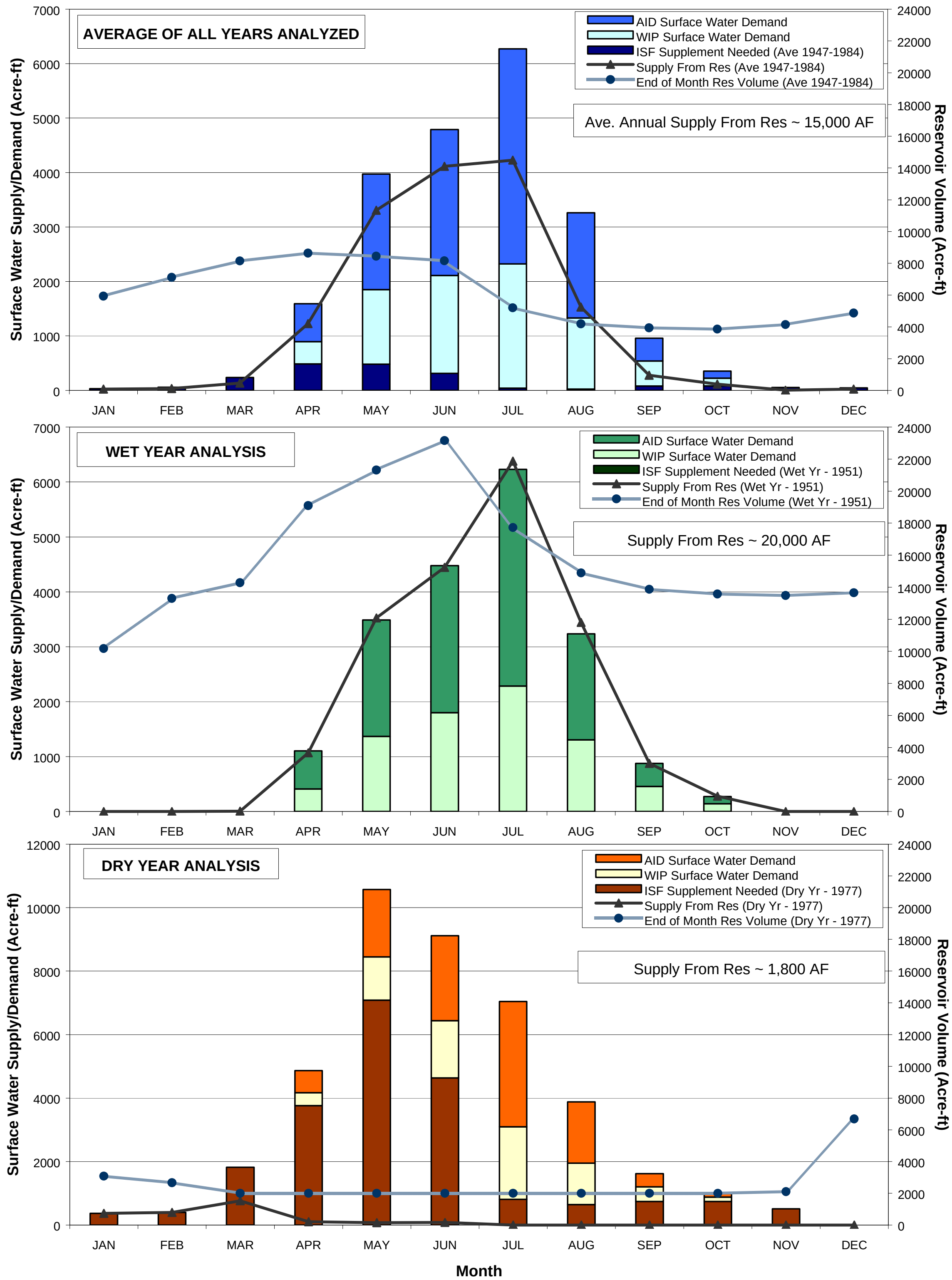
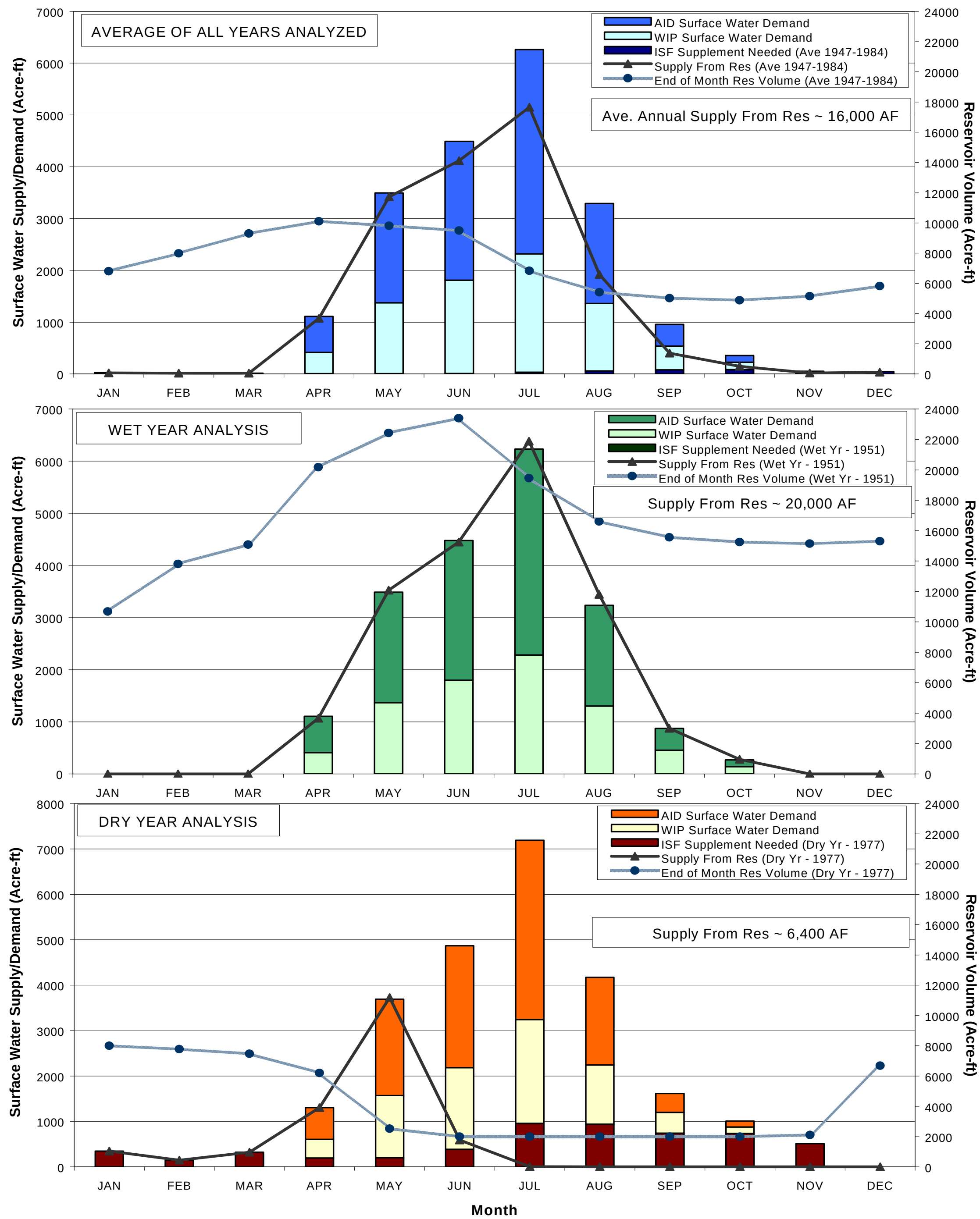


Figure D-2.
Alternative 2 – Surface Water Demand vs. Supply From Reservoir



NOTES:
1) WIP and AID Surface Water Demand calculated by crop water model based on providing surface water to acreages and crop types that are currently served by surface water (Estimated 11,100 acres served partially or exclusively by surface water). Calculated demand applied to all years within the model period of record.
2) ISF Supplement Needed calculated by flow routing model as difference between modeled flow in Ahtanum Creek and in-stream flow target.
3) Supply From Reservoir, Flow Into Reservoir, and End of Month Reservoir Volumes also calculated by flow routing model.

Figure D-3.
Alternative 2 – North Fork Flows and Diversion to Reservoir
(Instream Flow Targets Reduced to 20 cfs year-round on N. Fork and 25 cfs year-round on mainstem)



NOTES:
1) WIP and AID Surface Water Demand calculated by crop water model based on providing surface water to acreages and crop types that are currently served by surface water (Estimated 11,100 acres served partially or exclusively by surface water). Calculated demand applied to all years within the model period of record.
2) ISF Supplement Needed calculated by flow routing model as difference between modeled flow in Ahtanum Creek and in-stream flow target.
3) Supply From Reservoir, Flow Into Reservoir, and End of Month Reservoir Volumes also calculated by flow routing model.

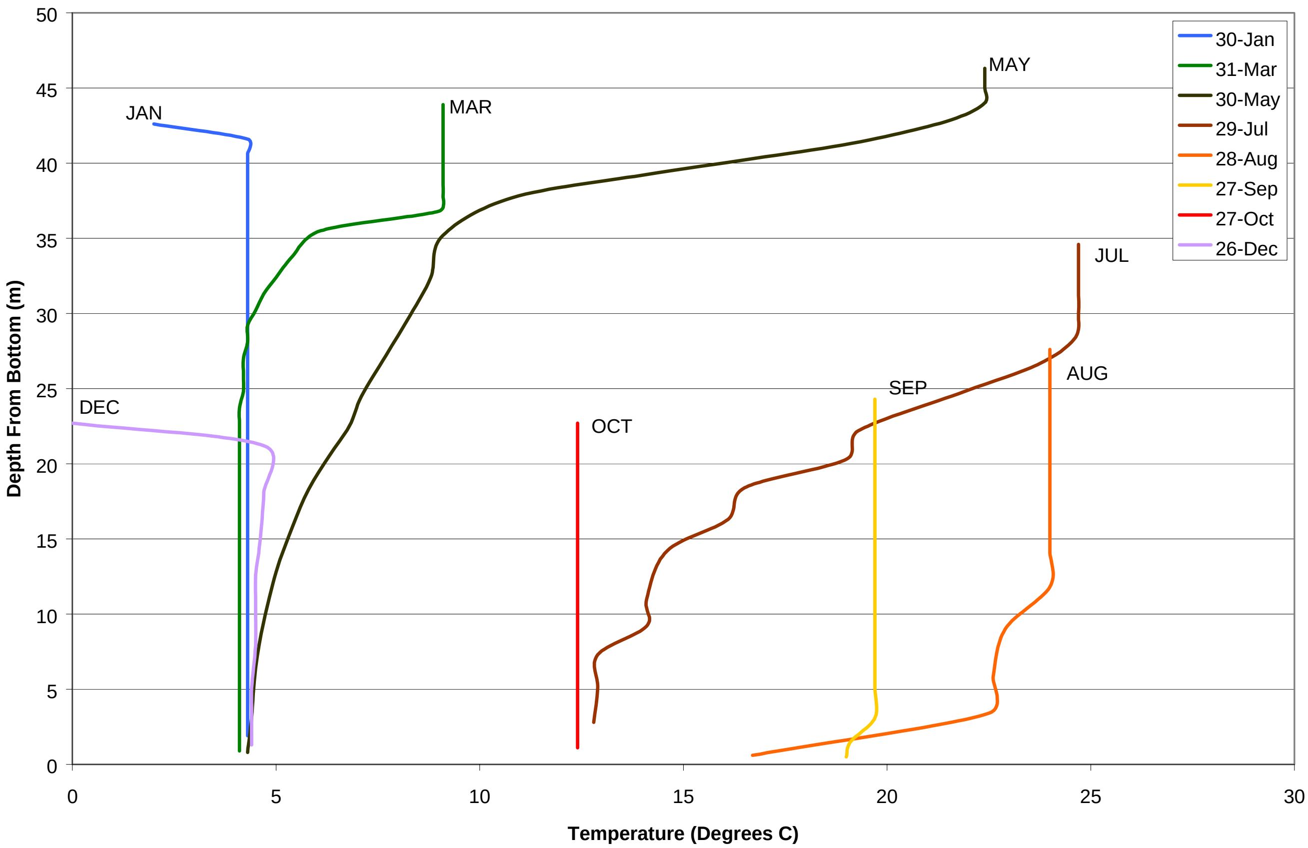
- In general, reliability of surface water supply is currently lowest during the late summer and early fall when stream flows are low. Currently, AID cannot divert water from the creek after July 10, and irrigators have to rely on other sources of water for irrigation during the late summer and early fall. The WIP diverts flow for irrigation throughout the summer, but the reliability of diversions is limited by the flow in the creek. Under Alternative 2, both AID and WIP would divert water for irrigation between April and October directly from the reservoir.
- On average, the reservoir would be able to augment instream flow and provide surface water to meet most of the demand for surface water in the AID and WIP during the spring and early summer. During the late summer and early fall, the reservoir would be drawn down and would not be able to supply as much of the irrigation demand.
- During a wet year, the reservoir would remain nearly full and be able to supply all surface water demands. Very little supplementation of natural instream flows would be required to meet instream flow targets.
- During a very dry year, the reservoir would be drawn down throughout most of the year and would have very little capacity to meet irrigation demands or supplement instream flows on the mainstem of Ahtanum Creek. As evaluated, the reservoir would provide limited benefit to surface water supply during a drought year. If the very dry year was preceded by a wetter than average year, some carry over storage would be available during the early part of the year to augment instream flows and supply irrigation.
- On average, use of the reservoir to maintain instream flow targets in the North Fork and supplement instream flows in the mainstem of the Ahtanum Creek would reduce the number of days with low flow below the point of discharge from the reservoir. Under current conditions, average daily flow in the mainstem of the Ahtanum Creek below the AID and Upper WIP diversions falls below 20 cfs on approximately 40.3 percent of the days during the model period. Alternative 2 could reduce that number to approximately 27.5 percent. Analysis indicated that under natural flow conditions, without any diversions, that number would be approximately 23.4 percent.

The modeling results indicate that flow conditions under Alternative 2 would compare favorably against current flow conditions. The evaluation that was described in the *Ahtanum Creek Watershed Assessment* (Golder, 2004) suggested that the reservoir could operate at an even higher reliability under a scenario where surface water demands and instream flow supplement would only be supplied by the reservoir from July to October. That scenario assumed that the annual surface water demand would be approximately 25,300 acre-feet and that overall demand would be approximately 54,500 acre-feet. Those demands are higher than those supplied under Alternative 2 and would result from irrigation of higher value crops. Of the 25,300 acre-feet surface water demand, only 10,500 acre-feet would be supplied by the reservoir. The scenario presented in the *Watershed Assessment* also assumed that the surface water demand before July would be met by diversions from the creek. Although that scenario would result in a higher reliability for the reservoir, it would not supply as much surface water from the reservoir as would be provided by the reservoir under Alternative 2. That scenario does not sufficiently evaluate the ability of the mainstem to meet surface water demand before July while diverting water from the North Fork to fill the reservoir. In addition to evaluating the impact that

Alternative 2 could have on the quantity of surface water flow and supply, a model was developed to evaluate the impact that Alternative 2 would have on surface water temperatures. The model was developed using the CE-QUAL-R1 model developed by the U.S. Army Corps of Engineers. The model has the capability of simulating the vertical distribution of temperature throughout a reservoir and the outflow temperature from the reservoir. The simulation requires input of flow data, incoming water temperature data, geometry of the reservoir and outlet, and weather data. A year of flow data selected as typical from the flow routing model was used as inflow for the temperature model. Recent water temperature measurements taken along the North Fork of Ahtanum Creek were used to generate a curve representing typical inflow temperatures. The proposed geometry of the reservoir was input as described in the *Pine Hollow Reservoir Project Overview* (Dames & Moore, 2000). It was assumed that the reservoir would have a common outlet at a point near the base of the dam. A year of weather data were also assembled and input.

Figure D-4 illustrates temperature profiles that were generated by the model of the proposed reservoir through a typical year. The temperature standard for streams with salmon and trout spawning, core rearing, and migration (formerly Class AA waterbody) is 16 degrees Celsius (°C). Results of the modeling indicate temperatures exceeding 16° C will occur for releases from the reservoir in August and September. Since modeling was performed for a typical year, release temperatures would exceed temperature standards earlier during a dry year with less water in the reservoir and later during a wet year. State water quality standards allow the target temperature criteria for streams to be the natural temperature plus 0.3° C. Reservoir releases may be managed to meet that criteria; however, because Ahtanum Creek temperatures typically exceed 16° C during the summer, releases could not be made in August and September to prevent an increase in stream temperatures. However, it would be the decision of resource agencies whether or not water is released from the reservoir into the stream when it exceeds the temperature criteria.

Figure D-4. Simulated Monthly Temperature Profiles – Pine Hollow Reservoir



APPENDIX E – ECONOMIC MODELING

Economic Modeling

This Appendix describes the methods by which the total regional economic impacts are projected from the initial direct effects of the project, including the input/output modeling, data adjustments, and localizing impacts. The economic analysis of direct and indirect impacts is included.

Baseline Projections

Input-Output Models

An input-output model simulates the relationships of an economy. These relationships, or linkages, are measured by the dollar value of purchases or sales among the various industrial and commercial sectors. Thus the model links the microeconomics of diverse businesses to the total interactions of the local economy. Economists have used the input-output analysis for 40 years to evaluate changes in inter-industry flows of goods and services and resulting changes in output, employment, and income.

The input-output model is based upon a specification of production relationships within an economy; such a specification shows the magnitude of each industry's purchases from other industries. These production relationships are combined with measures (regional purchase coefficients) that reflect the extent of local purchases in each input category. Any direct expenditure can be multiplied by the coefficient of the affected industry to find the first round of indirect effects. In turn, this first round will generate other rounds of indirect effects that can be determined in a similar manner to direct effects. Subsequent rounds of indirect spending eventually become negligible for the various categories, which allows for a determination of total indirect impact. A similar iterative process using household incomes provides an estimate of induced effects. Totals of direct, indirect, and induced effects enable calculation of a multiplier.

The primary strength of the input-output model is its level of detail, which allows for estimates of industry-specific impacts. There are several non-survey models and modeling services available for use when time and financial constraints preclude obtaining full survey data.

The models are relatively inexpensive and are considered to be reasonably accurate. One widely used non-survey model is the U.S. Forest Service IMPLAN (Impact Analysis for Planning) model, which adapts a national input-output table to the local economy by using national production coefficients and local levels of sectorial employment and final demand. After consideration of the advantages and shortcomings of a number of non-survey input-output models, the IMPLAN coefficients were selected for this project that were derived in the analysis of a similar project for Yakima County (Mack and Robison, 1995; Bruckner, Hasting and Latham, 1987).

Direct expenditures from the various categories of activities were programmed into the input-out model in order to generate indirect and induced impacts. These are various categories of construction and operation and maintenance. The generation of estimates for the expenditures requires adjustments for time, function, and geography. As sufficiently detailed construction cost estimates were not available, data from 30 Bureau of Reclamation projects constructed in the region since 1984 were used to apportion total cost estimates into detailed IMPLAN sectors. In addition, regional contractors were consulted to determine likely sources of subcontractor activities. These contractors were: Mountain States Construction of Sunnyside, George A. Grant of the Tri-Cities, Pellinger Enterprises of the Tri-Cities, MRM Construction of Ellensburg, and Kiewitt-Pacific Company of Concord, California. Detailed estimates of these expenditures were obtained from the consultants who developed the plans for the *Ahtanum Creek Watershed Assessment* (Golder, 2004).

Data Adjustment

The analysis began with estimates of direct spending for subcomponents of each alternative from the *Ahtanum Creek Watershed Assessment* (Golder, 2004). These data were adjusted for a number of local factors before the input-output analysis coefficients were applied. First, expenditures for each alternative were calculated for each year of the 2007 to 2040 period; the *Ahtanum Creek Watershed Assessment* (Golder, 2004) was the preliminary source of costs. All values were adjusted for inflation and stated in 2004 dollars. For simplicity, these data were aggregated into four time periods--the years surrounding 2010, 2020, 2030, and 2040. The results are shown in Tables E-1 through E-5 below. The tables detail aggregated expenditures for Alternatives 2, 3, and 4, respectively. There are two tables for Alternatives 2 and 3, with a high and a low estimate for each. These ranges reflect the relatively broad range of values derived for habitat enhancement and stream channel improvements, as calculated in the *Ahtanum Creek Watershed Assessment* (Golder, 2004). Because the magnitude of the range was significant, separate calculations were made for each rather than creating a single value by averaging.

Table E-1. Alternative 2 Activity Timeline: Low Range of Estimates Direct Spending in Thousands of 2004 dollars

	2010	2020	2030	2040	Total
Construction					
Reservoir	$81,996				$81,996
Pressurized Pipe	22,856				22,856
Farm Connections	29,212				29,212
Farm Improvements	399	1,197	1,064		2,660
Habitat	2,624	3,936			6,560
Stream Channel Improvements	3,240	4,860			8,100
Operation and Maintenance	2,164	4,863	4,869	4,869	16,765
Farm Profits	21,728	48,888	48,888	48,888	168,392
Net Downstream Flows	3,584	8,064	8,064	8,064	27,776
Totals	$167,803	$71,808	$62,885	$61,821	$364,317

*Time intervals
2010 Denotes activities from 2007-2013 inclusive
2020 Denotes activities from 2014-2022 inclusive
2030 Denotes activities from 2023-2031 inclusive
2040 Denotes activities from 2032-2040 inclusive

Table E-2. Alternative 2 Activity Timeline: High Range of Estimates Direct Spending in Thousands of 2004 dollars

	2010	2020	2030	2040	Total
Construction					
Reservoir	$81,996				$81,996
Pressurized Pipe	22,856				22,856
Farm Connections	29,212				29,212
Farm Improvements	399	1,197	1,064		2,660
Habitat	4,264	6,396			10,660
Stream Channel Improvements	6,436	9,654			16,090
Operation and Maintenance	2,164	4,863	4,869	4,869	16,765
Farm Profits	21,728	48,888	48,888	48,888	168,392
Net Downstream Flows	3,584	8,064	8,064	8,064	27,776
Totals	$172,639	$79,062	$62,885	$61,821	$376,407

*Time intervals 2010 Denotes activities from 2007-2013 inclusive
2020 Denotes activities from 2014-2022 inclusive
2030 Denotes activities from 2023-2031 inclusive
2040 Denotes activities from 2032-2040 inclusive

Table E-3. Alternative 3 Activity Timeline: Low Range of Estimates Direct Spending in Thousands of 2004 dollars

	2010	2020	2030	2040	Total
Construction					
Farm Improvements	$399	$1,197	$1,064		$2,660
Habitat	2,624	3,936			6,560
Stream Channel Improvements	3,240	4,860			8,100
Totals	$6,263	$9,993	$1,064	$0	$17,320

*Time intervals 2010 Denotes activities from 2007-2013 inclusive
2020 Denotes activities from 2014-2022 inclusive
2030 Denotes activities from 2023-2031 inclusive
2040 Denotes activities from 2032-2040 inclusive

Table E-4. Alternative 3 Activity Timeline: High Range of Estimates Direct Spending in Thousands of 2004 dollars

	2010	2020	2030	2040	Total
Construction					
Farm Improvements	$399	$1,197	$1,064		$2,660
Habitat	4,264	6,396			10,660
Stream Channel Improvements	6,436	9,654			16,090
Totals	$11,099	$17,247	$1,064	$0	$29,410

*Time intervals 2010 Denotes activities from 2007-2013 inclusive
2020 Denotes activities from 2014-2022 inclusive
2030 Denotes activities from 2023-2031 inclusive
2040 Denotes activities from 2032-2040 inclusive

Table E-5. Alternative 4 Activity Timeline:
Direct Spending in Thousands of 2004 dollars

	2010	2020	2030	2040	Total
Construction					
Reservoir	$81,996				$81,996
Pressurized Pipe	22,856				22,856
Farm Connections	29,212				29,212
Farm Improvements	399	1,197	1,064		2,660
Operation and Maintenance	2,164	4,863	4,869	4,869	16,765
Farm Profits	21,728	48,888	48,888	48,888	168,392
Net Downstream Flows	3,584	8,064	8,064	8,064	27,776
Totals	$161,939	$63,012	$62,885	$61,821	$349,657

*Time intervals	2010	Denotes activities from 2007-2013 inclusive
	2020	Denotes activities from 2014-2022 inclusive
	2030	Denotes activities from 2023-2031 inclusive
	2040	Denotes activities from 2032-2040 inclusive

As noted in Tables E-1 through E-5, construction activities in the first period are, in aggregate, the most significant expenditures across the 35 years of the analysis. The “operation years,” after construction is completed in 2010, have significantly less financial magnitude than do the construction years. The largest “activities” listed during the operations years are farm profits and net downstream flows. For different reasons each of these two sources of economic flows will be segregated from the more traditional analysis and presented in a later section. Farm profits will be treated separately because they are highly speculative and depend solely upon the manner in which the reservoir and conveyance components are financed. As explained in Golder (2004), profits will be negative unless the preponderance of capital cost is borne by entities other than the farmer. The federal or state government would likely be the institutions looked to for bearing much of the capital cost. Because of the responsibility for capitol costs of the projects is unknown, farm profits should not be a component of the main body of the analysis. This is particularly the case because of their magnitudes. At $5.3 million per year, if this analysis were to include these speculative profits, they would dwarf those categories of economic flows that are far more probable.

Similarly, the question of the value of net downstream flows has also resulted in their segregation from the major body of the analysis. This is because the value of the flows and their impact upon the local economy would depend upon their use, and this has not been fully determined. That is, allocation of the flows to an easily quantified use such as agriculture would have more quantifiable local economic impact than their allocation to a less easily quantifiable use, such as the enhancement of fish runs, even if the value, or benefit, of the two uses is the same. Even if the increase in return flows do increase fish population in a quantifiable and predictable manner, the most common means of assigning value is through surveying or imputing recreational values. Because steelhead are a listed species, they would not be subject to sport fishing. Therefore, there would be no associated recreational value for increases in steelhead.

Note that in absence of farm profits and increases in downstream flows, the remaining expenditures during the operational period are very small compared to those of the construction period, as shown in Tables E-1 through E-5. Activities associated with habitat and stream channel improvements will require a ten-year period to complete, and accordingly stretch across the 2010 and 2020 periods. The nature of work involved with this category combines some activities that are clearly construction oriented, such as moving access roads, with activities that are very labor intensive and so resemble operations and maintenance functions. For these reasons, habitat and stream channel improvements appropriately are stretched across both the construction and the operations periods.

One other potential source of impacts deserves discussion, impacts from recreation. At the time of this analysis there is not sufficient information on the planned operations and management of the reservoir and the results of habitat improvements to be able to estimate recreational impacts with any degree of confidence. It is expected that non-motorized recreational boating and some fishing will be permitted on the reservoir. However, the intent of agencies involved with stocking the reservoir for sport fisheries is not known, nor are the explicit plans for the timing of or the degree of reservoir drawdown. Similarly, as reservoir management policies are unknown, the nature and extent of a warm water fishery of bass or blue gills in the reservoir are beyond comfortable speculation. Those recreational impacts that may result from the habitat improvements are likely to be very small. This is primarily because steelhead are a listed species, and any sport fishery for steelhead within the timeframe of the analysis is highly unlikely. Furthermore, the steepness of the reservoir banks may prevent access once the draw-down period begins. This factor, coupled with the very short period that the reservoir would be full as well as the restrictions against motorized boating, would likely limit boating recreation significantly. Accordingly, no attempt to estimate recreational impacts can be prudently made at this juncture.

Localizing Impacts

All spending was adjusted for the degree that local industries could provide inputs; this created two scenarios involving whether a local or outside contractor would receive the bid to construct the reservoir and install the pressurized pipe and the farm connections. Table E-6 shows estimates of the degree to which local contractors and suppliers would be involved under the assumption that the primary construction contracts were granted to local firms or to outside firms. Typically, the patterns of local spending and incomes are sensitive to that choice. Because the difference between the choice of contractors was only 3 percent, this EIS analysis used the assumption of an out of area contractor. A 3 percent lower estimate was built into the analysis.

Table E-6. Assuming Outside and in-Region Contractors

	Out-of-Region Contractor	**In-Region Contractor**
Description	Yakima	Yakima
Dimension Stone	100%	100%
New Utility Structures	100%	100%
New Highway and Streets	40%	100%
Concrete Block & Brick	100%	100%
Ready-Mixed Concrete	100%	100%
Fabricated Metal Structures	60%	80%
Wholesale Trade	60%	60%
Eating and Drinking	100%	100%
Miscellaneous Retail	90%	100%
Insurance Agents & Brokers	40%	100%
Hotels & Lodging Places	100%	100%
Computer & Data Processing Svcs.	25%	80%
Auto Repair & Services	80%	80%
Engineering & Architectural Svcs.	35%	70%
Accounting & Auditing	15%	60%
Management & Consulting Svcs.	27%	70%
Research, Development, Testing	35%	70%
Other Gov't Enterprises	100%	100%

A second paring of expenditures involved the critical question of the percentage of expenditures that result in local incomes. In order to calculate direct income impacts, expenditures for each industry were adjusted for the percent of incomes derived from each dollar of expenditures. This was based upon the number of supplier and contractor inquiries that were explained above.

Direct Impacts

Tables E-7 and E-8 show the allocation of expenditures into specific sectors of the local economy for the construction period and the operations period, respectively. As explained above, this allocation of the total direct expenditures shown in Tables E-7 through E-8 into specific economic sectors was based upon the estimates in Golder (2004) combined with experiences with similar projects in the region. In addition to allocating expenditures into economic sectors, the tables also show the results of adjusting for an out of area contractor availability, as explained in the section above.

Table E-7. Construction Period Expenditures, Earnings, and Jobs by Sector for Alternatives 2, 3, and 4. Expenditures and Earnings in Thousands of 2004 Dollars.

	Alternative 2						Alternative 3						Alternative 4		
	High			Low			High			Low					
Description	Expenditures	Earnings	Jobs	Expenditures	Earnings	Jobs	Expenditures	Earnings	Jobs	Expenditures	Earnings	Jobs	Expenditures	Earnings	Jobs
Dimension Stone	$ 667.18	$ 266.87	8	$ 645.28	$ 258.11	7	$ 50.26	$ 20.11	1	$ 28.36	$ 11.34	0	$ 618.73	$ 247.49	7
Sand & Gravel	326.22	130.49	4	315.52	126.21	4	24.58	9.83	0	13.87	5.55	0	302.53	121.01	3
New Utility Structures	8,254.52	3,301.81	93	7,983.57	3,193.43	90	621.86	248.74	7	350.91	140.36	4	7,655.02	3,062.01	86
New Highway & Streets	564.05	225.62	6	545.54	218.21	6	42.49	17.00	0	23.98	9.59	0	523.09	209.23	6
Concrete Block & Brick	418.83	167.53	5	405.08	162.03	5	31.55	12.62	0	17.80	7.12	0	388.41	155.36	4
Ready-Mixed Concrete	1,831.06	732.43	21	1,770.96	708.38	20	137.94	55.18	2	77.84	31.14	1	1,698.08	679.23	19
Fabricated Metal Structures	1,452.22	580.89	16	1,404.55	561.82	16	109.40	43.76	1	61.74	24.69	1	1,346.75	538.70	15
Wholesale Trade	27.78	11.11	0	26.87	10.75	0	2.09	0.84	0	1.18	0.47	0	25.76	10.31	0
Eating and Drinking	181.00	72.40	2	175.06	70.02	2	13.64	5.45	0	7.69	3.08	0	167.86	67.14	2
Miscellaneous Retail	392.10	156.84	4	379.23	151.69	4	29.54	11.82	0	16.67	6.67	0	363.62	145.45	4
Insurance Agents & Brokers	163.32	65.33	2	157.96	63.18	2	12.30	4.92	0	6.94	2.78	0	151.46	60.58	2
Hotels & Lodging Places	277.82	111.13	3	268.70	107.48	3	20.93	8.37	0	11.81	4.72	0	257.64	103.06	3
Computer & Data Process Svcs.	104.18	41.67	1	100.76	40.30	1	7.85	3.14	0	4.43	1.77	0	96.61	38.65	1
Auto Repair & Services	94.29	37.72	1	91.19	36.48	1	7.10	2.84	0	4.01	1.60	0	87.44	34.98	1
Engineering & Architectural Svcs	240.88	96.35	3	232.97	93.19	3	18.15	7.26	0	10.24	4.10	0	223.39	89.35	3
Accounting & Auditing	88.71	35.48	1	85.80	34.32	1	6.68	2.67	0	3.77	1.51	0	82.27	32.91	1
Management & Consulting Svcs.	309.70	123.88	3	299.54	119.81	3	23.33	9.33	0	13.17	5.27	0	287.21	114.88	3
Research, Development, Testing	298.34	119.33	3	288.54	115.42	3	22.48	8.99	0	12.68	5.07	0	276.67	110.67	3
Other Government Enterprises	534.59	213.83	6	517.04	206.82	6	40.27	16.11	0	22.73	9.09	0	495.76	198.30	6
Total	$ 16,226.81	$6,490.72	183	$ 15,694.16	6,277.66	177	$ 1,222.46	$488.98	14	$ 689.82	$275.93	8	$ 15,048.29	$6,019.32	170

Table E-8. Operations Period Expenditures, Earnings, and Jobs by Sector for Alternatives 2, 3, and 4. Expenditures and Earnings in Thousands of 2004 Dollars.

	Alternative 2						Alternative 3						Alternative 4		
	High			Low			High			Low					
Description	**Expenditures**	**Earnings**	**Jobs**	**Expenditures**	**Earnings**	**Jobs**	**Expenditures**	**Earnings**	**Jobs**	**Expenditures**	**Earnings**	**Jobs**	**Expenditures**	**Earnings**	**Jobs**
Dimension Stone	$ 12.19	$ 4.88	0	$ 9.50	$ 3.80	0	$ 6.78	$ 2.71	0	$ 4.10	$ 1.64	0	$ 6.25	$ 2.50	0
Sand & Gravel	12.19	4.88	0	9.50	3.80	0	6.78	2.71	0	4.10	1.64	0	6.25	2.50	0
New Utility Structures	12.19	4.88	0	9.50	3.80	0	6.78	2.71	0	4.10	1.64	0	6.25	2.50	0
New Highway & Streets	14.63	5.85	0	11.40	4.56	0	8.14	3.26	0	4.91	1.97	0	7.49	3.00	0
Maintenance & Repair	451.02	180.41	7	351.61	140.64	5	250.93	100.37	4	151.52	60.61	2	231.07	92.43	3
Concrete Block & Brick	12.19	4.88	0	9.50	3.80	0	6.78	2.71	0	4.10	1.64	0	6.25	2.50	0
Ready-Mixed Concrete	12.19	4.88	0	9.50	3.80	0	6.78	2.71	0	4.10	1.64	0	6.25	2.50	0
Fabricated Metal Structures	7.31	2.93	0	5.70	2.28	0	4.07	1.63	0	2.46	0.98	0	3.75	1.50	0
Wholesale Trade	65.82	26.33	1	51.32	20.53	1	36.62	14.65	1	22.11	8.85	0	33.72	13.49	0
Eating and Drinking	12.19	4.88	0	9.50	3.80	0	6.78	2.71	0	4.10	1.64	0	6.25	2.50	0
Miscellaneous Retail	10.97	4.39	0	8.55	3.42	0	6.10	2.44	0	3.69	1.47	0	5.62	2.25	0
Insurance Agents & Brokers	4.88	1.95	0	3.80	1.52	0	2.71	1.09	0	1.64	0.66	0	2.50	1.00	0
Hotels & Lodging Places	12.19	4.88	0	9.50	3.80	0	6.78	2.71	0	4.10	1.64	0	6.25	2.50	0
Computer & Data Process Svcs.	3.05	1.22	0	2.38	0.95	0	1.70	0.68	0	1.02	0.41	0	1.56	0.62	0
Auto Repair & Services	9.75	3.90	0	7.60	3.04	0	5.43	2.17	0	3.28	1.31	0	5.00	2.00	0
Engineering & Architectural Svcs	4.27	1.71	0	3.33	1.33	0	2.37	0.95	0	1.43	0.57	0	2.19	0.87	0
Accounting & Auditing	1.83	0.73	0	1.43	0.57	0	1.02	0.41	0	0.61	0.25	0	0.94	0.37	0
Management & Consulting Svcs.	3.29	1.32	0	2.57	1.03	0	1.83	0.73	0	1.11	0.44	0	1.69	0.67	0
Research, Development, Testing	4.27	1.71	0	3.33	1.33	0	2.37	0.95	0	1.43	0.57	0	2.19	0.87	0
Other Government Enterprises	426.64	170.65	6	332.60	133.04	5	237.36	94.95	3	143.33	57.33	2	218.58	87.43	3
Total	$ 1,093.04	$ 437.22	16	$ 852.13	$340.85	12	$ 608.13	$ 243.25	9	$ 367.22	$146.89	5	$ 560.01	$224.00	8

TableE-7 shows this allocation for Alternatives 2, 3 and 4 during the construction years. The expenditures in these tables are normalized to show average expenditures for a typical year in the construction period. Since Alternatives 2 and 3 have high and low ranges of estimates that derive from the Golder (2004) estimates for habitat and stream channel improvements, a high and a low allocation are shown in the table for both Alternative 2 and Alternative 3. As seen in the table, adjusting for the high and low estimates makes considerably more difference than does allocating for local versus out of area contractors. Although almost an order of magnitude smaller, expenditure proportions for Alternative 3 closely parallel those of the two reservoir-building alternatives. This is because of the amount of material moving associated with changes in road routings and bank alterations. The two reservoir-building alternatives, 2 and 4 show significant expenditures in the categories of Utility Structures, Streets (roads), Concrete, and Metal Structures.

Table E-7 also portrays earnings flows and job creation during the construction period for each of the alternatives. The earnings flows were derived from expenditures, based upon a number of telephone inquiries of providers and suppliers in each sector to determine the expenditure to earnings conversion factors. Employment impacts by sector for the construction period, noted on the table as "Jobs," were derived in a similar manner, depending upon the earnings/job relationship for each sector. Clearly, the preponderance of jobs is generated in the construction sectors. The other sectors that would experience significant job impacts are in project management and consulting services. Spillover of job creation into other service sectors is primarily due to the retail support of new workers. The high level of activities under the sector "Other government enterprises" occurs because irrigation district employment falls under that category. Again, because of the lesser magnitude of expenditures associated with Alternative 3, earnings flows are accordingly smaller.

Direct expenditures, earnings and jobs for the post construction operations period are detailed by sector in Table E-8. The table portrays the sectorial impacts for each of the alternatives for a typical year in the post-constructive period. Impacts in all categories are far less than those in the typical construction year, particularly after farm profits and downstream flows have been segregated out, leaving only this most probable, but minor set of expenditures, earnings, and jobs. Unlike the direct expenditures in the construction period that differed by an order of magnitude among the alternatives, the operations period manifests an approximately equal distribution of impacts across the three alternatives. Because the operations period is very labor intensive, most of the impacts fall into the categories of Maintenance and Repair and Other Government Enterprises (irrigation district employment). As expected, the number of jobs created is small, ranging from 8 to 16.

Direct and Total Impacts

Table E-9 summarizes the aggregated direct and total impacts for each alternative for a typical year in the construction phase. As for direct impacts, each entry is a column aggregation of all sectors shown in the previous impact tables (Tables E-7 and E-8) Because of its inclusiveness of activities, Alternative 2 will have the greatest direct impacts in terms of expenditures, earnings and jobs. This is particularly the case when the high estimate for habitat and stream channel improvements is used as part of Alternative 2. The direct jobs created by the reservoir-related alternatives, ranging from 170 to 183, are reasonable in comparison to similar projects.

Table E-9 also shows aggregations of total income and total job impacts in the construction phase. The total impacts represent the sum of direct impacts plus the indirect impacts. Indirect impacts are the result of the multiplier effects; they arise from the circulation and recirculation of incomes and expenditures throughout the local economy. For the construction period the income multiplier ranges as high as 1.75, depending upon sector. For example, the $6.019 million of direct earnings associated with Alternative 4 are coupled with $4.514 million of indirect and induced earnings generated to become the $10.533 million total earnings shown Table E-9 as total earnings impacts of Alternative 4.

Table E-9. Construction Period Annual Impact for a Typical Year 2007-2015, in Thousands of 2004 Dollars, Jobs. Margined for Out of Area Contractor

	Direct Impacts			Total Impacts	
Alternative 2					
High	Expenditures	Earnings	Jobs	Earnings	Jobs
	$ 16,226.81	$ 6,490.72	183	$11,358.76	311
Low	$ 15,694.16	$ 6,277.66	177	$10,985.91	301
Alternative 3					
High	Expenditures	Earnings	Jobs	Earnings	Jobs
	$ 1,222.46	$ 488.98	14	$ 806.82	22
Low	$ 689.82	$ 275.93	8	$ 455.28	13
Alternative 4					
	Expenditures	Earnings	Jobs	Earnings	Jobs
	$ 15,048.29	$ 6,019.32	170	$10,533.81	289

Table E-10 portrays a parallel set of outcomes for the typical operations year, after construction is completed. Again both direct and total impacts are shown for each alternative. Although the multipliers are smaller, total impacts still reflect a range of 8 to 14 jobs. These total impacts include the effects of operation expenditures that cycle and recycle through the economy plus the induced effects of the recycling the spending of operations-related incomes.

Table E-10. Operations Period Impact for a Typical Year 2014 – 2040, in Thousands of 2004 Dollars, Jobs. Margined for Out of Area Contractor

	Direct Impacts			Total Impacts	
	Alternative 2				
High	Expenditures	Earnings	Jobs	Earnings	Jobs
	$ 1,093.04	$ 437.22	16	$ 699.55	24
Low	$ 852.13	$ 340.85	12	$ 545.36	19
	Alternative 3				
High	Expenditures	Earnings	Jobs	Earnings	Jobs
	$ 608.13	$ 243.25	9	$ 357.58	13
Low	$ 367.22	$ 146.89	5	$ 215.92	8
	Alternative 4				
	Expenditures	Earnings	Jobs	Earnings	Jobs
	$ 560.01	$ 224.00	8	$ 362.88	14

Tables E-11 and E-12 show the impact of assuming that capital costs of the reservoir and the delivery systems are assumed by an outside institution, and that, accordingly, all gains resulting from changes in cropping patterns accrue as farm profits. Thus, for each alternative, the tables reflect the combination of undertaking the alternative plus the impact of additional incomes that result from the significantly increased farm profits, $5.3 million dollars per year in 2003 dollars. The assumption of farm profits not only raises the earnings columns for Alternatives 2 and 4, but, because of the induced effects of these higher earnings, raises the total earnings impacts as well. This has a marked effect in the operations period because of the magnitude of these farm earnings relative to earnings associated with operation of the reservoir, delivery, and habitat improvements.

Table E-11. Construction Period Annual Impact for a Typical Year 2007-2015, in Thousands of 2004 Dollars, Jobs. Margined for Out of Area Contractor Assuming Farm Profits.

	Direct Impacts			Total Impacts	
	Alternative 2				
High	Expenditures	Earnings	Jobs	Earnings	Jobs
	$ 16,226.81	$11,922.72	336	$20,864.76	572
Low	$ 15,694.16	$11,709.66	330	$20,491.91	562
	Alternative 3				
High	Expenditures	Earnings	Jobs	Earnings	Jobs
	$ 1,222.46	$ 488.98	14	$ 806.82	22
Low	$ 689.82	$ 275.93	8	$ 455.28	13
	Alternative 4				
	Expenditures	Earnings	Jobs	Earnings	Jobs
	$ 15,048.29	$11,451.32	323	$20,039.81	549

Table E-12. Operations Period Impact for a Typical Year 2014-2040, in Thousands of 2004 Dollars, Jobs. Margined for Out of Area Contractor Assuming Farm Profits.

	Direct Impacts			Total Impacts	
Alternative 2					
High	Expenditures	Earnings	Jobs	Earnings	Jobs
	$1,093.04	$5,869.22	213	$9,390.75	324
Low	$ 852.13	$5,772.85	210	$9,236.56	319
Alternative 3					
High	Expenditures	Earnings	Jobs	Earnings	Jobs
	$ 608.13	$ 243.25	9	$ 357.58	13
Low	$ 367.22	$ 146.89	5	$ 215.92	8
Alternative 4					
	Expenditures	Earnings	Jobs	Earnings	Jobs
	$ 560.01	$ 224.00	8	$ 362.88	14