APPENDIX A

KLAMATH RIVER WATER QUALITY WORKSHOP NOTES

Klamath River
Water Quality Workshop
September 10-13, 2012
Sacramento, CA
Workshop Notes

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Introduction

The Klamath River Water Quality Workshop, held in Sacramento, California, September 10-13, 2012, included over 100 attendees representing roughly 13 federal and state (California, Oregon) agencies, multiple tribes, and several consulting firms, academic institutions, and utilities. The purpose of the workshop was to identify technologies and strategies that will provide a clear working framework to reduce nutrient and organic matter loads to the Klamath River and improve water quality conditions within the Klamath Basin. The workshop focus was on the Upper Klamath Basin including Upper Klamath Lake and its primary tributaries (Wood, Williamson, and Sprague Rivers) and the Keno Impoundment.

The workshop was funded by the California Coastal Conservancy, PacifiCorp, and the California State Water Boards Training Academy.

On Day 1, the Project Contract Team and invited speakers from United States Geologic Survey (USGS) presented both in-basin and out-of-basin background information, much of which was also detailed in the Pre-Workshop Information Packet (Stillwater Sciences 2012). On Day 2, participants broke into small working groups to evaluate several potential project types for nutrient and water quality improvements and engage in a design charrette involving a 20-year time horizon and $570 million of project implementation funding in the Klamath Basin. The results of this hypothetical exercise were presented at a working dinner on Day 2 to facilitate group information sharing. On Day 3, design charrette key themes were summarized and reviewed with the broader workshop group, followed by a four-member Expert Panel question and answer session on the key themes.

The following workshop notes provide documentation of the agenda, attendees, small group evaluation sessions, design charrettes, and expert panel discussion. A summary of the USGS technical presentations will be provided as an addendum to the workshop notes. Synthesis and application of the information contained within the workshop notes will be presented in the Final Workshop Report, which will also include a description of priority technological options that emerged from workshop discussions and potential benefits from sequencing or linking potential projects to improve Klamath Basin water quality.

Workshop Agenda

	Location	Moderator	Presenter(s)	Mins	Time		
Day 1 - September 11, 2012							
Welcome and Workshop Objectives	Byron Sher Hearing Room	Michael Bowen	Clayton Creager, Maia Singer	15	8:30 AM	-	8:45 AM
Setting the Stage							
Environmental Setting Overview	Byron Sher Hearing Room	Michael Bowen	Maia Singer, Eli Asarian, Jake Kann	60	8:45 AM	-	9:45 AM
Existing Example Large-Scale Projects			Maia Singer, Todd Osborne	45	9:45 AM	-	10:30 AM
Break - light refreshments provided				15	10:30 AM	-	10:45 AM
Expert Panel Presentations	Byron Sher Hearing Room	Michael Bowen	Tammy Wood, Stewart Rounds, Chauncey Anderson	60	10:45 AM	-	11:45 AM
Discussion of Restoration/ Rehabilitation Potential			Maia Singer, Pat Higgins	30	11:45 AM	-	12:15 PM
Lunch on your own				75	12:15 PM	-	1:30 PM
Project Evaluation Criteria	Byron Sher Hearing Room	Michael Bowen	Maia Singer	30	1:30 PM	-	2:00 PM
Candidate Water Quality Projects							
Wetland Restoration	Byron Sher Hearing Room	Maia Singer	Eli Asarian	75	2:00 PM	-	3:15 PM
Treatment Wetlands			Maia Singer				
Decentralized (Diffuse) Source Treatment Systems			Michael Ogden				
Break - light refreshments provided				30	3:15 PM	-	3:45 PM
Algae/Biomass Removal from the Water Column via Filtration	Byron Sher Hearing Room	Maia Singer	Todd Osborne	75	3:45 PM	-	5:00 PM
Sediment Removal (Dredging)			Todd Osborne				
Water Column Oxidation/ Sediment Sequestration (Phosphorus Inactivation)			Harry Gibbons				
Break - light refreshments provided				15	5:00 PM	-	5:15 PM
Open Session	Bryon Sher Hearing Room	Maia Singer	Interested Workshop Participants	45	5:15 PM	-	6:00 PM

Day 2 - September 12, 2012							
Brief Overview of Day 1	Byron Sher Hearing Room	Maia Singer	Maia Singer	15	8:30 AM	-	8:45 AM
Small Group Evaluation Sessions							
Application of Evaluation Criteria - 3 project types	Conference Rooms	Small Group Activity		90	8:45 AM	-	10:15 AM
Break - light refreshments provided				15	10:15 AM	-	10:30 AM
Application of Evaluation Criteria - 3 project types	Conference Rooms	Small Group Activity		90	10:30 AM	-	12:00 PM
Lunch on your own				75	12:00 PM	-	1:15 PM
Small Group Reporting	Byron Sher Hearing Room	Assigned by Small Groups		60	1:15 PM	-	2:15 PM
Small Group Design Charrette - Linking Multiple Projects for Basin-Scale WQ Improvements							
Design Planning	Conference Rooms	Small Group Activity		90	2:15 PM	-	3:45 PM
Break - light refreshments provided				30	3:45 PM	-	4:15 PM
Continued Design Planning and Prepare Reports	Conference Rooms	Small Group Activity		75	4:15 PM	-	5:30 PM
Break				60	5:30 PM	-	6:30 PM
Working Dinner - Hors d'oeuvres and main meal provided Small Group Design Charrette Reports	Citizen Hotel, Terrace Room, 7th Floor	Assigned by Small Groups		120	6:30 PM	-	8:30 PM

	Location	Moderator	Presenter(s)		Time		
Day 3 - September 13, 2012							
Summary of Small Group Report Consensus	Byron Sher Hearing Room	Maia Singer	Maia Singer	60	9:00 AM	-	10:00 AM
Expert Panel Discussion		Maia Singer	John Day, Larry Dunsmoor, Stewart Rounds, Dave Ferguson	30	10:00 AM	-	10:30 AM
Break - light refreshments provided				15	10:30 AM	-	10:45 AM
Expert Panel Discussion (cont.)	Byron Sher Hearing Room	Maia Singer	John Day, Larry Dunsmoor, Stewart Rounds, Dave Ferguson	30	10:45 AM	-	11:15 AM
Identify Next Steps for Project Development		Maia Singer	Group Discussion	45	11:15 AM	-	12:00 PM

Attendees List with Affiliations

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Day 2 – Small Group Evaluation Sessions: Application of Evaluation Criteria

Wetland Restoration/Treatment Wetlands/Diffuse Source Treatment Systems (WR/TR/DSTS)

Group 1 - WR / TR / DSTS

Technology/Measure: WETLAND RESTORATION						
Criterion - Use Quantitatve or H/M/L Rankings	UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Comments?	For detailed analysis, go to tab...
1. Effectiveness						
a. Total TN removed for project life (MT)		H (> 100 MT)	H (> 100 MT)		No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)		H (> 10 MT)	H (> 10 MT)		No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?	L-Indirect	H-Direct	H-Direct	L-Indirect	No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?	L-Indirect	H-Direct	H-Direct	L-Indirect	No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?	L-	M-Direct	M-Direct	L-	No	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?	L-	H-Direct	H-Direct	L-	No	Obj 2 - Water Quality
2. Cost (estimated)						
a. Total cost for project life		VH (> $100M)	VH (> $100M)		No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)		H (> $15/kg)	L (< $10/kg)		No	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)		M ($10 to $100/kg)	H (> $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges	L	L	L	L	No	Narrative Questions
4. Infrastructure challenges	L	L	L	L	No	Narrative Questions
5. Implementation timeframe	M	M	M	M	No	Narrative Questions
6. Energy Use	L	L	L	L	No	Narrative Questions
7. CO2 Loading	M	M	M	M	Yes	Narrative Questions
8. Compatability/synergy						
a. With other large-scale technologies considered	H	H	H	H	No	Narrative Questions
c. With ongoing or anticipated restoration measures	H	H	H	H	No	Narrative Questions
9. Risk of failure?	L	L	L	L	No	Narrative Questions
10. Need for further scientific study?	L	L	L	L	No	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace.

Objective 1: Reduce seasonal concentrations of nutrients

Technology/Measure: WETLAND RESTORATION

Criterion - Use Quantitative Rankings		UKL Tributaries (Wood, Sprague, Williamson)	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Lost river (existing wetland)	Line of Reasoning/Notes
General Costing Info	Wetland area (acres)	1000 (2 acres per mile)	10000	10000	260		calc area for the three UKL tribs (2 acres per mile), straights drain already has a wetland (wildlife refuge) and is gravity feed
General Costing Info	Project life (yrs)	100	100	100	100		
General Costing Info – Capital costs	Per unit area ($/acre) [a]	2000	$ 4,700	$4,700	2000		number for riverine system
General Costing Info – Capital costs	Sub-total capital costs		$ 47,000,000	$ 47,000,000			
General Costing Info – O&M costs	Per unit area ($/acre/yr) [b]		100	$ 100		$ 100	
General Costing Info – O&M costs	Annual ($/yr)		$ 1,000,000	$ 1,000,000		$ -	
General Costing Info – O&M costs	Sub-total O&M ($)		$ 100,000,000	$ 100,000,000		$ -	
General Costing Info	**Total cost for project life**		**$ 147,000,000**	**$ 147,000,000**		**$ -**	
Unit Removal - Zero Order	N removal rate (mg N/m2/d)		5	50		50	low n concentration reduce removal rate (first order)
Unit Removal - Zero Order	P removal rate (g P/m2/yr)		0.2	0.5		0.5	p removal driven by plant cover
Unit Removal - Zero Order	P "avoided" loading rate (g P/m2/yr)[c]		1.62	--		--	better definition and condition for p avoided
Unit Removal - Zero Order	Annual TN load removed (MT/yr)		74	739		0	
Unit Removal - Zero Order	Annual TP load removed (MT/yr)		66	20		0	
Unit Removal - Zero Order	**Total TN removed for project life (MT)**		**7,386**	**36,929**		-	
Unit Removal - Zero Order	**Total TP removed for project life (MT)**		**6,556**	**1,012**		-	
Unit Removal - Zero Order	**TN unit removal cost ($/kg)**		**$ 20**	**$ 4**		**#DIV/0!**	
Unit Removal - Zero Order	**TP unit removal cost ($/kg)**		**$ 22**	**$ 145**		**#DIV/0!**	

[a]Includes land acquisition and construction. Low end of per-acre land costs assumed to be $3,000 (i.e., mid-way between $700-750 cost for 1990s Wood River land acquisitions and the $5,000 current small-parcel estimate from Deas (2011). Lower estimate construction costs assumed to be $1,700/acre based on 2000-2010 construction costs for entire Williamson River Delta project (i.e., $10M/5,800 wetland acres = $1,700/acre) http://www.fws.gov/klamathfallsfwo/suckers/sucker_pub/oct08posters/RestoringWetlands-SternHendrickson.pdf. Higher estimate construction costs assumed to be $5,600/acre from Mahugh et al. (2009).

[b]O&M costs very low but unknown (no pumping/energy but: security, fencing, monitoring, etc.).

[c] Re-flooding north/west side of the Williamson River Delta (Tulana Farms) initially released 2 MT of phosphorus (Wong et al. 2011), whereas previous annual P export to lake was 21-25 MT (Synder and Morace 1997), indicating 21 MT reduced loading to the lake in the first year (and release of P should be lower than 2 MT in subsequent years). 21 MT/yr/3,200 acres=1.8 g P/m2/yr.

Comments: assume dams are removed,

Group 1 - WR / TR / DSTS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.							
Technology/Measure: WETLAND RESTORATION							
Criterion - Use Qualitative or H/M/L Rankings		**UKL Tributaries**	**Upper Klamath Lake**	**Link River Dam to Keno Dam**	**JC Boyle Dam to Iron Gate Dam**		**Line of Reasoning/Notes**
Dissolved Oxygen	Overall DO improvements	L	H	H	L		
	Direct or indirect effects?	Indirect	Direct	Direct	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall		
	Other						
pH	Overall pH improvements	L	H	H	L		
	Direct or indirect effects?	Indirect	Direct	Direct	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall		
	Other						
Temperature	Overall water temperature improvements	L	H	H	L		
	Direct or indirect effects?		Direct	Direct			
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall		
	Other		refugia (localized)				
TSS/Turbidity	Overall TSS/turbidity improvements	L	M	M	L		
	Direct or indirect effects?		Direct	Direct			
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall		
	Other						
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	L	H	H	L		
	Direct or indirect effects?		Direct	Direct			
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall		
	Other						

Comments: asumption scale changes sufficent to push eco system over tipping point (based on a mass balance approach), legacy issues addressed, the effectiveness of efforts in Link River depend on remediation of UKL problems, potential beaver role,

Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	L	
Are the infrastructure requirements for this technology high, medium, or low and why?	L	
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	
Is the energy use of this technology high, medium, or low and why?	L	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	M	greenhouse gas
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	L	
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	L	don't know
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	H	
Does this technology/measure provide an acceptable cost to benefit ratio?	M	depending on coorperation
Is this technology/measure a long-term solution or improvement?	H	
Are there readily identifiable legal constraints on this technology/measure?	L	
Are there readily identifiable political ramifications for this technology/measure?	H	
Are there likely to be unique opportunities for funding for this technology/measure?	M	
Will this approach create jobs? Of what sort?	L	
Are there identifiable social or cultural impacts from this technology/measure?	H	
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	H	
What is the potential for unintended consequences for this technology/measure?	L	

Group 1 - WR / TR / DSTS

Summary Criteria - please make entries in green shaded cells only.

Technology/Measure: TREATMENT WETLANDS

Criterion - Use Quantitatve or H/M/L Rankings	UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Comments?	For detailed analysis, go to tab...
1. Effectiveness						
a. Total TN removed for project life (MT)			H (> 100 MT)		No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)			H (> 10 MT)		No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?					No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?					No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?					No	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?					No	Obj 2 - Water Quality
2. Cost (estimated)						
a. Total cost for project life			H ($1M to $100M)		No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)			L (< $10/kg)		Yes	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)			M ($10 to $100/kg)		Yes	Obj 1 - Nutrients
3. Engineering challenges	H	H	H	H	Yes	Narrative Questions
4. Infrastructure challenges	H	H	H	H	Yes	Narrative Questions
5. Implementation timeframe	M	M	M	M	No	Narrative Questions
6. Energy Use	M	M	M	M	Yes	Narrative Questions
7. CO2 Loading					Yes	Narrative Questions
8. Compatability/synergy						
a. With other large-scale technologies considered	H	H	H	H	No	Narrative Questions
c. With ongoing or anticipated restoration measures	H	H	H	H	No	Narrative Questions
9. Risk of failure?	M	M	M	M	Yes	Narrative Questions
10. Need for further scientific study?	L	L	L	L	No	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace.

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.

Technology/Measure: TREATMENT WETLANDS

	Criterion - Use Quantitative Rankings	UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Lost River Basin (straights drain)	Line of Reasoning/Notes
General Costing Info	Wetland area (acres)			1600	0		
	Project life (yrs)		50	50		50	
	Capital costs: Per unit area ($/acre) [a]		$10,488	$10,488			$5-50k
	Capital costs: Sub-total capital costs		$ -	$ 16,780,800		$ -	
	O&M costs: Per unit area ($/acre/yr) [b]		$ 259	$ 260		$ 260	gravity feed vs pumping vary costs
	O&M costs: Annual ($/yr)		$ -	$ 416,000.00		$ -	
	O&M costs: Sub-total O&M ($)		$ -	$ 20,800,000		$ -	
	Total cost for project life		**$ -**	**$ 37,580,800**		**$ -**	
Unit Removal - First Order	Average flow (cfs)		70	70		70	
	Days operating per year		365	365		365	
	Mean inflow TN concentration (mg/L)		1.35	1.35		1.35	Mass loading 50 - 150 mg/m2/day
	Mean outflow TN concentration (mg/L)		0.14	0.14		0.14	Calcs needed
	Mean inflow TP concentration (mg/L)		0.41	0.41		0.41	Mass loading 1 - 1.5 g/m2/year
	Mean outflow TP concentration (mg/L)		0.16	0.16		0.16	Calcs needed
	Annual TN load removed (MT/yr)		76	76		76	this equation needs HRT, or calc out flow concentration
	Annual TP load removed (MT/yr)		16	16		16	
	Total TN removed for project life (MT)		**3800**	**3800**		**3800**	
	Total TP removed for project life (MT)		**800**	**800**		**800**	
	TN unit removal cost ($/kg)		**$ -**	**$ 10**		**$ -**	N-removal can be estimated using either 1st or zero order empirical models
	TP unit removal cost ($/kg)		**$ -**	**$ 47**		**$ -**	P-removal can be estimated using either 1st or zero order empirical models
Unit Removal - Zero Order	N removal rate (mg N/m2/d)		100	100		100	
	P removal rate (g P/m2/yr)		1.25	1.25		1.25	
	Annual TN load removed (MT/yr)		0	236		0	
	Annual TP load removed (MT/yr)		0	8		0	
	Total TN removed for project life (MT)		**-**	**11,817**		**-**	
	Total TP removed for project life (MT)		**-**	**405**		**-**	
	TN unit removal cost ($/kg)		**#DIV/0!**	**$ 3**		**#DIV/0!**	N-removal can be estimated using either 1st or zero order empirical models
	TP unit removal cost ($/kg)		**#DIV/0!**	**$ 93**		**#DIV/0!**	P-removal can be estimated using either 1st or zero order empirical models

[a]Includes land acquisition and construction. Per-acre capital costs based upon scale-dependent regression equation (Kadlec and Wallace 2009).

[b]O&M costs of $260/acre/yr are the average value from SFWMD (2004). O&M costs of $800/acre/yr are median value from Kadlec and Wallace (2009).

Comments: design to handle real time conditions, optimize for either P or N, removal rate calcs need to be revisited, refer to restore/constructed wetland for straights drain (o/m costs higher), must consider whose water it is (Rufuges may have senior rights), staging constructive wetland around UKL and transition into fully restored wetland (contiguous),

Group 1 - WR / TR / DSTS

Please make entries in green shaded cells only.		
Technology/Measure: TREATMENT WETLANDS		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	H	low compared to other tech (dredging)
Are the infrastructure requirements for this technology high, medium, or low and why?	H	site specific designs required, low compared to other tech (dredging)
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	
Is the energy use of this technology high, medium, or low and why?	M	depends on pumping costs, compared to what?
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)		needs study
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	M	invasive weeds
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	L	
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	H	
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	H	
Does this technology/measure provide an acceptable cost to benefit ratio?	M	don't like
Is this technology/measure a long-term solution or improvement?	H	
Are there readily identifiable legal constraints on this technology/measure?	M	water rights, ESA, NEPA
Are there readily identifiable political ramifications for this technology/measure?	H	
Are there likely to be unique opportunities for funding for this technology/measure?	H	
Will this approach create jobs? Of what sort?	M	
Are there identifiable social or cultural impacts from this technology/measure?	H	
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	H	
What is the potential for unintended consequences for this technology/measure?		see restoration
what is the potential for unintended benefits?	H	

Summary Criteria - please make entries in green shaded cells only.							
Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS							
Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions		**UKL Tributaries (per unit)**	**UKL Tributaries (per 50 units)**	**Other Potential Location**	**Comments?**	**For analysis, go to tab...**
1. Effectiveness						
a.	Total TN removed for project life (MT)	L (< 10 MT)	M (10 to 100 MT)		No	Obj 1 - Nutrients
b.	Total TP removed for project life (MT)	L (< 1 MT)	M (<1 to 10 MT)		No	Obj 1 - Nutrients
c.	Seasonal DO improvements - indirect or direct?	HDirect	HDirect	H-Direct	No	Obj 2 - Water Quality
d.	Seasonal pH improvements - indirect or direct?	HDirect	HDirect	H-Direct	No	Obj 2 - Water Quality
e.	Seasonal TSS/turbidity improvements - indirect or direct?	HDirect	HDirect	H-Direct	No	Obj 2 - Water Quality
f.	Seasonal Chl-a/algal toxin improvements - indirect or direct?	HDirect	HDirect	H-Direct	No	Obj 2 - Water Quality
2. Cost (estimated)						
a.	Total cost for project life	L (< $250K)	M ($250K to $1M)		No	Obj 1 - Nutrients
b.	Cost per unit N removal ($/kg)	M ($10 to $15/kg)	M ($10 to $15/kg)		No	Obj 1 - Nutrients
c.	Cost per unit P removal ($/kg)	H (> $100/kg)	H (> $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges		L	L	L	No	Narrative Questions
4. Infrastructure challenges		L	L	L	No	Narrative Questions
5. Implementation timeframe		L	L	L	No	Narrative Questions
6. Energy Use		L	L	L	No	Narrative Questions
7. CO2 Loading					Yes	Narrative Questions
8. Compatability/synergy						
a.	With other large-scale technologies considered	H	H	H	No	Narrative Questions
b.	With ongoing or anticipated restoration measures	H	H	H	No	Narrative Questions
9. Risk of failure?		L	L	L	No	Narrative Questions
10. Need for further scientific study?		L	L	L	Yes	Narrative Questions
Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. However, since these are small systems, it is not expected that the overall losses will be large. Additionally, at this scale, ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace.						

Group 1 - WR / TR / DSTS

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.						
Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS						
Criteria - Development of Cost Estimates			**UKL Tributaries (per unit)**	**UKL Tributaries (per 50 units)**	**Other Potential Location**	**Line of Reasoning/Notes**
General Costing Info	Wetland area (acres)		1	50		
	Project life (yrs)		10	10		highly variable
	Capital costs	Site survey	$ 1,500	$ 75,000		Could be Zero, Highly Variable
		Diversion box	$ 2,500	$ 125,000		Could be Zero, Highly Variable
		Level control	$ 3,000	$ 150,000		Could be Zero, Highly Variable
		Pumps	$ -	$ -		Could be Zero, Highly Variable
		Earthwork	$ 750	$ 37,500		Could be Zero, Highly Variable
		Planting	$ 3,000	$ 150,000		Could be Zero, Highly Variable
		Exclusion fencing @ $3 per foot	$ 2,505	$ 125,226.20		Could be Zero, Highly Variable
		Sub-total capital costs	$ 13,255	$ 662,726	$ -	Could be Zero, Highly Variable
	O&M costs	Per unit area ($/acre/yr)	$ 260	$ 13,000		
		Annual ($/yr)	$ 260	$ 13,000		
		Sub-total O&M ($)	$ 2,600	$ 130,000	$ -	
	Total cost for project life		**$ 15,855**	**$ 792,726**	**$ -**	
Unit Removal	N removal rate (mg N/m2/d)		100	100	100	Particulate removal (grazing), Tailwater
	P removal rate (g P/m2/yr)		1	1	1	Particulate removal (grazing), Tailwater
	Total TN removed for project life (MT)		**1**	**74**	-	
	Total TP removed for project life (MT)		**0.0**	**2.0**	-	
	TN unit removal cost ($/kg)		**$ 11**	**$ 11**	**#DIV/0!**	
	TP unit removal cost ($/kg)		**$ 392**	**$ 392**	**#DIV/0!**	

Comments: The cost estimates in column D are for a single 1-acre system. This technology has broader effects when many diffuse source wetlands are implemented in a single watershed, so cost estimates are provided for a larger number of systems are given in column E. highly variable inputs, spatial and temperal variability, target 1 - 2% of irrigated lands,

Objective 2: Improve overall water quality - please make entries in green shaded cells only.					
Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS					
Criteria - Use H/M/L Rankings and Narrative Descriptions		**UKL Tributaries (per unit)**	**UKL Tributaries (per 100 units)**	**Other Potential Location**	**Line of Reasoning/Notes**
Dissolved Oxygen	Overall DO improvements	H	H	H	
	Direct or indirect effects?	Direct	Direct	Direct	
	Season of greatest improvement	Late Winter - Fall	Late Winter - Fall	Late Winter - Fall	
	Other				
pH	Overall pH improvements	H	H	H	
	Direct or indirect effects?	Direct	Direct	Direct	
	Season of greatest improvement	Late Winter - Fall	Late Winter - Fall	Late Winter - Fall	
	Other				
Temperature	Overall water temperature improvements	n/a	n/a	n/a	study needed, groundwater connectivity?,
	Direct or indirect effects?	Direct	Direct	Direct	
	Season of greatest improvement	Late Winter - Fall	Late Winter - Fall	Late Winter - Fall	
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	H	H	H	
	Direct or indirect effects?	Direct	Direct	Direct	
	Season of greatest improvement	Late Winter - Fall	Late Winter - Fall	Late Winter - Fall	
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	H	H	H	
	Direct or indirect effects?	Direct	Direct	Direct	
	Season of greatest improvement	Late Winter - Fall	Late Winter - Fall	Late Winter - Fall	
	Other				

Comments: suggest design criteria, groundwater connectivity,

Group 1 - WR / TR / DSTS

Please make entries in green shaded cells only.		
Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	L	
Are the infrastructure requirements for this technology high, medium, or low and why?	L	
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	L	
Is the energy use of this technology high, medium, or low and why?	L	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)		**needs study**
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	L	**no**
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	L	**unknown, surface storage?**
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	H	
Does this technology/measure provide an acceptable cost to benefit ratio?	H	
Is this technology/measure a long-term solution or improvement?	H	
Are there readily identifiable legal constraints on this technology/measure?	L	
Are there readily identifiable political ramifications for this technology/measure?	L	
Are there likely to be unique opportunities for funding for this technology/measure?	H	
Will this approach create jobs? Of what sort?	L	
Are there identifiable social or cultural impacts from this technology/measure?	M	
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	M	
What is the potential for unintended consequences for this technology/measure?	L	
What is the potential for unintended benefits?	H	duck hunting

Group 2 - WR / TR / DSTS

Summary Criteria - please make entries in green shaded cells only.							
Technology/Measure: WETLAND RESTORATION							
Criterion - Use Quantitatve or H/M/L Rankings	**UKL Tributaries**	**Upper Klamath Lake**	**Link River Dam to Keno Dam**	**JC Boyle Dam to Iron Gate Dam**	**Comments?**	**For detailed analysis, go to tab...**
1. Effectiveness						
a. Total TN removed for project life (MT)		H (> 100 MT)	H (> 100 MT)		No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)		H (> 10 MT)	H (> 10 MT)		No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?	L-Indirect	L-Indirect			No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?	L-Indirect	L-Indirect			No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?	M-Direct	L-			No	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?	L-Indirect	L-			No	Obj 2 - Water Quality
2. Cost (estimated)						
a. Total cost for project life		VH (> $100M)	H ($1M to $100M)		No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)		L (< $10/kg)	L (< $10/kg)		No	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)		M ($10 to $100/kg)	M ($10 to $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges	L	L	L	L	No	Narrative Questions
4. Infrastructure challenges	L	L	L	L	No	Narrative Questions
5. Implementation timeframe	M	M	M	M	Yes	Narrative Questions
6. Energy Use	L	L	L	L	No	Narrative Questions
7. CO2 Loading	L	L	L	L	No	Narrative Questions
8. Compatability/synergy						
a. With other large-scale technologies considered	H	H	H	H	Yes	Narrative Questions
c. With ongoing or anticipated restoration measures	H	H	H	H	No	Narrative Questions
9. Risk of failure?	L	L	L	L	Yes	Narrative Questions
10. Need for further scientific study?	L	L	L	L	Yes	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace. Group comments and take away: Group felt there were many hundreds of acres in the upper basin that could be restored, with some emphasis on lakeshore restorations as a priority. Overall effectiveness is not high, but costs are low. Large scale in acres will deliver scaled benefits. If carefully executed, effectiveness could be enhanced.

Objective 1: Reduce seasonal concentrations of nutrients

Technology/Measure: WETLAND RESTORATION

Criterion - Use Quantitative Rankings			**UKL Tributaries**	**Upper Klamath Lake**	**Link River Dam to Keno Dam**	**JC Boyle Dam to Iron Gate Dam**	**Line of Reasoning/Notes**
General Costing Info	Wetland area (acres)		20000	15,000	3200	0	
	Project life (yrs)		50	50	50		
	Capital costs	Per unit area ($/acre) [a]	4700	$ 4,700	$4,700		
		Sub-total capital costs		$ 70,500,000	$ 15,040,000		$ seems low compared to Eli's initial spreadsheets
	O&M costs	Per unit area ($/acre/yr) [b]		100	$ 100		
		Annual ($/yr)		$ 1,500,000	$ 320,000		
		Sub-total O&M ($)		$ 75,000,000	$ 16,000,000		
	Total cost for project life			**$ 145,500,000**	**$ 31,040,000**		
Unit Removal - Zero Order	N removal rate (mg N/m2/d)			50	50		
	P removal rate (g P/m2/yr)			--	0.5		
	P "avoided" loading rate (g P/m2/yr)[c]			1.62	--		
	Annual TN load removed (MT/yr)			1108	236		
	Annual TP load removed (MT/yr)			98	6		
	Total TN removed for project life (MT)			**55,393**	**11,817**		
	Total TP removed for project life (MT)			**4,917**	**324**		
	TN unit removal cost ($/kg)			**$ 3**	**$ 3**		
	TP unit removal cost ($/kg)			**$ 30**	**$ 96**		

[a] Includes land acquisition and construction. Low end of per-acre land costs assumed to be $3,000 (i.e., mid-way between $700-750 cost for 1990s Wood River land acquisitions and the $5,000 current small-parcel estimate from Deas (2011). Lower estimate construction costs assumed to be $1,700/acre based on 2000-2010 construction costs for entire Williamson River Delta project (i.e., $10M/5,800 wetland acres = $1,700/acre) http://www.fws.gov/klamathfallsfwo/suckers/sucker_pub/oct08posters/RestoringWetlands-SternHendrickson.pdf. Higher estimate construction costs assumed to be $5,600/acre from Mahugh et al. (2009).

[b] O&M costs very low but unknown (no pumping/energy but: security, fencing, monitoring, etc.).

[c] Re-flooding north/west side of the Williamson River Delta (Tulana Farms) initially released 2 MT of phosphorus (Wong et al. 2011), whereas previous annual P export to lake was 21 25 MT (Synder and Morace 1997), indicating 21 MT reduced loading to the lake in the first year (and release of P should be lower than 2 MT in subsequent years). 21 MT/yr/3,200 acres=1.8 g P/m2/yr.

Comments:

Group 2 - WR / TR / DSTS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.						
Technology/Measure: WETLAND RESTORATION						
Criterion - Use Qualitative or H/M/L Rankings		UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	L	L			
	Direct or indirect effects?	Indirect	Indirect			
	Season of greatest improvement	Summer/Fall	Summer/Fall			
	Other					
pH	Overall pH improvements	L	L			not applicable in wetland itself
	Direct or indirect effects?	Indirect	Indirect			
	Season of greatest improvement					
	Other					
Temperature	Overall water temperature improvements	L	n/a			assuming in tribs less irrigation might decrease temps and veg might be denser providing shade
	Direct or indirect effects?	Indirect	Indirect			
	Season of greatest improvement					
	Other					
TSS/Turbidity	Overall TSS/turbidity improvements	M	L			
	Direct or indirect effects?	Direct				
	Season of greatest improvement					
	Other					
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	L	L			
	Direct or indirect effects?	Indirect				
	Season of greatest improvement					
	Other					
Comments:						

Please make entries in green shaded cells only.		
Technology/Measure: WETLAND RESTORATION		
Narrative Question	H/M/L	Narrative Response
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	L	
Are the infrastructure requirements for this technology high, medium, or low and why?	L	
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	based on number of acres, acquisition, permitting
Is the energy use of this technology high, medium, or low and why?	L	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	L	
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	fits with almost any other approach
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	already going on in Basin
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	L	might be site specific issues
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	H	might need water rights transfer. Could lead to instream leases
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	M	define global?
Does this technology/measure provide an acceptable cost to benefit ratio?	H	medium to high especially if you consider all beneficial uses and ecosystem services. Community is a big factor
Is this technology/measure a long-term solution or improvement?	H	
Are there readily identifiable legal constraints on this technology/measure?	L	water rights, permitting for restoration, ESA species, land taxes, cultural resources
Are there readily identifiable political ramifications for this technology/measure?	M	community acceptance - tax revenue, secondary ag economics, removing productive ag land, precidents set
Are there likely to be unique opportunities for funding for this technology/measure?	H	already established funding sources, diverse funding. OWEB, NFWF, NRCS, NGO's, NAWCA, Tribes, USFWS, private funds
Will this approach create jobs? Of what sort?	L	losses balance gains
Are there identifiable social or cultural impacts from this technology/measure?	H	loss of farm jobs, tribal cultural values improved
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	L	upstream of dams. Does address upstream conditions necessary for anadromous fish. Helps maintain higher summer base flows
What is the potential for unintended consequences for this technology/measure?	L	

Group 2 - WR / TR / DSTS

Summary Criteria - please make entries in green shaded cells only.

Technology/Measure: TREATMENT WETLANDS

Criterion - Use Quantitatve or H/M/L Rankings	UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Comments?	For detailed analysis, go to tab...
1. Effectiveness						
a. Total TN removed for project life (MT)			H (> 100 MT)		No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)			H (> 10 MT)		No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?			M-Indirect		No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?			L-Indirect		No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?			H-Direct		No	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?	H-Direct	H-Direct	L-Direct		No	Obj 2 - Water Quality
2. Cost (estimated)						
a. Total cost for project life			H ($1M to $100M)		No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)			L (< $10/kg)		Yes	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)			H (> $100/kg)		Yes	Obj 1 - Nutrients
3. Engineering challenges	M	M	M	M	Yes	Narrative Questions
4. Infrastructure challenges	M	M	M	M	Yes	Narrative Questions
5. Implementation timeframe	M	M	M	M	Yes	Narrative Questions
6. Energy Use	M	M	M	M	No	Narrative Questions
7. CO2 Loading	L	L	L	L	Yes	Narrative Questions
8. Compatability/synergy						
a. With other large-scale technologies considered	H	H	H	H	No	Narrative Questions
c. With ongoing or anticipated restoration measures	M	M	M	M	Yes	Narrative Questions
9. Risk of failure?	L	L	L	L	Yes	Narrative Questions
10. Need for further scientific study?	M	M	M	M	Yes	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace. Group comments and take aways: On farm ag return flow treatment /avoidance might be more feasible than treatment wetlands lower down in tributaries. Group was concerned that the model example was not entirely accurate, or tranportable as a template to other situations. Treatment wetlands are sui generis, dependent on flow, constituents of interest, and the goals for the project. These can be very effective, but tend to come at a high cost, which are hard to predict. Pilots are recommended. Water rights implications are high. Infrastructure limitations are a problem. Much discussion of whether these would be 'harvested' and the fate of the harvested mateial. O&M would have to increase accordingly.

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.

Technology/Measure: TREATMENT WETLANDS

Criterion - Use Quantitative Rankings			UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Line of Reasoning/Notes
General Costing Info		Wetland area (acres)	tens/hundreds	tens/hundreds	1600		opportunities in UKL tribs for all point source, not just ag run off, and around UKL for ag return flow. Modoc Point? Sevenmile?
		Project life (yrs)			50		
	Capital costs	Per unit area ($/acre) [a]			$17,500		costs likely much higher for a wetland this size. Modified costs.
		Sub-total capital costs			$ 28,000,000		
	O&M costs	Per unit area ($/acre/yr) [b]			$ 800		changed O&M to 800 because SFMWD reference is for large scale wetlands that require less $ per acre. Does not include harvest costs
		Annual ($/yr)			$ 1,280,000.00		
		Sub-total O&M ($)			$ 64,000,000		
		Total cost for project life			**$ 92,000,000**		
Unit Removal - First Order		Average flow (cfs)			70		
		Days operating per year			365		
		Mean inflow TN concentration (mg/L)			1.35		
		Mean outflow TN concentration (mg/L)			0.14		wetlands generate organic N so this number is too low. Can't remove this much N. use biochar?
		Mean inflow TP concentration (mg/L)			0.41		
		Mean outflow TP concentration (mg/L)			0.16		
		Annual TN load removed (MT/yr)			76		
		Annual TP load removed (MT/yr)			16		
		Total TN removed for project life (MT)			**3800**		
		Total TP removed for project life (MT)			**800**		
		TN unit removal cost ($/kg)			**$ 24**		N-removal can be estimated using either 1st or zero order empirical models
		TP unit removal cost ($/kg)			**$ 115**		P-removal can be estimated using either 1st or zero order empirical models
Unit Removal - Zero Order		N removal rate (mg N/m2/d)			500		
		P removal rate (g P/m2/yr)			1.5		
		Annual TN load removed (MT/yr)			1182		
		Annual TP load removed (MT/yr)			10		
		Total TN removed for project life (MT)			**59,086**		
		Total TP removed for project life (MT)			**486**		
		TN unit removal cost ($/kg)			**$ 2**		N-removal can be estimated using either 1st or zero order empirical models
		TP unit removal cost ($/kg)			**$ 189**		P-removal can be estimated using either 1st or zero order empirical models

[a] Includes land acquisition and construction· Per-acre capital costs based upon scale-dependent regression equation (Kadlec and Wallace 2009).

[b] O&M costs of $260/acre/yr are the average value from SFWMD (2004). O&M costs of $800/acre/yr are median value from Kadlec and Wallace (2009).

Comments: P removal rates predicted here are potentially much lower then indicated here because P uptake is high for first several years then levels off unless biomass is harvested which would greatly increase the O&M costs. Removal in the everglades was around 70% because the baseline concentrations were much lower to begin with so plant uptake of those rates was feasible. In the straits drain, P concentration is much higher, so high removal rates not feasible.

Group 2 - WR / TR / DSTS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.

Technology/Measure: TREATMENT WETLANDS

Criterion - Use Qualitative or H/M/L Rankings		UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements			M		
	Direct or indirect effects?			Indirect		
	Season of greatest improvement			Summer/Fall		
	Other					
pH	Overall pH improvements			L		
	Direct or indirect effects?			Indirect		
	Season of greatest improvement					
	Other					
Temperature	Overall water temperature improvements			L		
	Direct or indirect effects?			Direct		
	Season of greatest improvement					
	Other					
TSS/Turbidity	Overall TSS/turbidity improvements			H		
	Direct or indirect effects?			Direct		
	Season of greatest improvement					
	Other					
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	H	H	L		lake treatment focuses on algae removal, trib treatmend focuses on overall nutrient reduction. Reducing initial P input
	Direct or indirect effects?	Direct	Direct	Direct		
	Season of greatest improvement	Spring	Spring	Summer/Fall		
	Other					

Comments:

Please make entries in green shaded cells only.

Technology/Measure: TREATMENT WETLANDS

Narrative Question	H/M/L	Narrative Response
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	M	medium to low
Are the infrastructure requirements for this technology high, medium, or low and why?	M	needs are water, power, access
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	more than 10 if pilot projects implemented first
Is the energy use of this technology high, medium, or low and why?	M	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	L	some pumping and construction equipment, harvest
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	M	treatment versus natural wetlands competing for same land.
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	fish passage issues a concern, low if pilot project built first and wetland is sited correctly
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	M	need pilot studies in Klamath Basin.
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	H	need water right. Existing water rights best option. Non-consumptive right possible, although there is some consumptive use.
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	H	
Does this technology/measure provide an acceptable cost to benefit ratio?	M	costs are unsure
Is this technology/measure a long-term solution or improvement?		
Are there readily identifiable legal constraints on this technology/measure?		
Are there readily identifiable political ramifications for this technology/measure?		
Are there likely to be unique opportunities for funding for this technology/measure?		
Will this approach create jobs? Of what sort?		
Are there identifiable social or cultural impacts from this technology/measure?		
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?		
What is the potential for unintended consequences for this technology/measure?		

Group 2 - WR / TR / DSTS

Summary Criteria - please make entries in green shaded cells only.						
Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS						
Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions	**UKL Tributaries (per unit)**	**UKL Tributaries (per 50 units)**	**Other Potential Location**	**Comments?**	**For analysis, go to tab...**
1. Effectiveness					
a. Total TN removed for project life (MT)	L (< 10 MT)	H (> 100 MT)		No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)	L (< 1 MT)	M (<1 to 10 MT)		No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?	LIndirect			No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?	LIndirect			No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?	MDirect			No	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?	LIndirect			No	Obj 2 - Water Quality
2. Cost (estimated)					
a. Total cost for project life	L (< $250K)	M ($250K to $1M)		No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)	L (< $10/kg)	L (< $10/kg)		No	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)	H (> $100/kg)	H (> $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges	L	L	L	No	Narrative Questions
4. Infrastructure challenges	L	L	L	Yes	Narrative Questions
5. Implementation timeframe	L	L	L	No	Narrative Questions
6. Energy Use	L	L	L	No	Narrative Questions
7. CO2 Loading	L	L	L	No	Narrative Questions
8. Compatability/synergy					
a. With other large-scale technologies considered	H	H	H	Yes	Narrative Questions
b. With ongoing or anticipated restoration measures	H	H	H	No	Narrative Questions
9. Risk of failure?	M	M	M	Yes	Narrative Questions
10. Need for further scientific study?	M	M	M	Yes	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. However, since these are small systems, it is not expected that the overall losses will be large. Additionally, at this scale, ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace. Group comments and take aways: This approach is a low cost, readily funded, and fairly simple solution that should be pursued at the farm level. Where the target is a canal or more centralized source, complexity and cost increases. General concern about efficacy and long term maintenance at the farm level,and with unintended consequences.

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.

Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS

		Criteria - Development of Cost Estimates	**UKL Tributaries (per unit)**	**UKL Tributaries (per 50 units)**	**Other Potential Location**	**Line of Reasoning/Notes**
General Costing Info		Wetland area (acres)	1	50	**ubiqutous**	around Upper Klamath Lake and Lower Klamath Lake
		Project life (yrs)	15	15		Project life likely much shorter. Total rehab likely on a decadal scale
	Capital costs	Site survey	$ 1,500	$ 75,000		
		Diversion box	$ 2,500	$ 125,000		
		Level control	$ 3,000	$ 150,000		
		Pumps	$ -	$ -		
		Earthwork	$ 750	$ 37,500		
		Planting	$ 3,000	$ 150,000		
		Exclusion fencing @ $1.25 per foot	$ 1,044	$ 52,178		
		Sub-total capital costs	$ 11,794	$ 589,678	$ -	
	O&M costs	Per unit area ($/acre/yr)	$ 260	$ 13,000		
		Annual ($/yr)	$ 260	$ 13,000		Likely higher if maintenance is diligent.
		Sub-total O&M ($)	$ 3,900	$ 195,000	$ -	
		Total cost for project life	**$ 15,694**	**$ 784,678**	**$ -**	
Unit Removal		N removal rate (mg N/m2/d)	100	100	100	
		P removal rate (g P/m2/yr)	1	1	1	
		Total TN removed for project life (MT)	**2**	**111**	**#VALUE!**	
		Total TP removed for project life (MT)	**0.1**	**3.0**	**#VALUE!**	
		TN unit removal cost ($/kg)	**$ 7**	**$ 7**	**#VALUE!**	
		TP unit removal cost ($/kg)	**$ 259**	**$ 259**	**#VALUE!**	

Comments: The cost estimates in column D are for a single 1-acre system. This technology has broader effects when many diffuse source wetlands are implemented in a single watershed, so cost estimates are provided for a larger number of systems are given in column E. LAndowners might like because of treating their own problem

Group 2 - WR / TR / DSTS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.

Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS

Criteria - Use H/M/L Rankings and Narrative Descriptions		Tributaries (per unit)	UKL Tributaries (per 100 units)	Other Potential Location	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	L			
	Direct or indirect effects?	Indirect			
	Season of greatest improvement	Summer/Fall			
	Other				
pH	Overall pH improvements	L			
	Direct or indirect effects?	Indirect			
	Season of greatest improvement				
	Other				
Temperature	Overall water temperature improvements	L			
	Direct or indirect effects?	Indirect			
	Season of greatest improvement	Summer/Fall			
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	M			
	Direct or indirect effects?	Direct			
	Season of greatest improvement				
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	L			depends on source: canal has potential for direct benefits, tailwater mimimal and indirect
	Direct or indirect effects?	Indirect			
	Season of greatest improvement	Summer/Fall			
	Other				

Comments:

Please make entries in green shaded cells only.		
Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	L	
Are the infrastructure requirements for this technology high, medium, or low and why?	L	**Decentralized, minimal power and access issues.**
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	L	
Is the energy use of this technology high, medium, or low and why?	L	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	L	
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	**Easily used in tandem with other technologies, potential zero sum game for available funding.**
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	M	**risk of failure high, consequenses low**
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	M	**do we really know how effective this treatment is? Good KTAP project**
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	L	**maybe, depends on design. If no increase in cnsumptive use, no water right needed**
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	M	mainly TSS, some small nutrient improvement. Temp effects unknown. A global solution in the geographic sense, but no silver bullet.
Does this technology/measure provide an acceptable cost to benefit ratio?	M	sites specific
Is this technology/measure a long-term solution or improvement?	H	Effectiveness monitoring is recommended.
Are there readily identifiable legal constraints on this technology/measure?	M	creation of jurisdictional wetlands
Are there readily identifiable political ramifications for this technology/measure?	L	low if people feel they are taking fate in own hands, treating problem on own land
Are there likely to be unique opportunities for funding for this technology/measure?	H	local funding available
Will this approach create jobs? Of what sort?	L	
Are there identifiable social or cultural impacts from this technology/measure?	L	
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	L	indirect
What is the potential for unintended consequences for this technology/measure?	M	flooding downstream or adjacent neighbors, decrease in surface water availability, bugs, long term maintenance issues, the ducks don't come, beavers move in, endangered species move in. pesticides could concentrate at the site or move into ground water.

Group 3 - WR / TR / DSTS

Summary Criteria - please make entries in green shaded cells only.						
Technology/Measure: WETLAND RESTORATION						
Criterion - Use Quantitatve or H/M/L Rankings	**UKL Tributaries**	**Upper Klamath Lake**	**Link River Dam to Keno Dam**	**JC Boyle Dam to Iron Gate Dam**	**Comments?**	**For detailed analysis, go to tab...**
1. Effectiveness						
a. Total TN removed for project life (MT)	H (> 100 MT)	H (> 100 MT)	H (> 100 MT)		No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)	H (> 10 MT)	H (> 10 MT)	H (> 10 MT)		No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?	M-Indirect	M-Indirect	M-Indirect		No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?	M-Indirect	M-Indirect	M-Indirect		No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?	M-Direct	M-Direct	M-Direct		No	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?	M-Indirect	M-Indirect	M-Indirect		No	Obj 2 - Water Quality
2. Cost (estimated)						
a. Total cost for project life	H ($1M to $100M)	H ($1M to $100M)	H ($1M to $100M)		No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)	L (< $10/kg)	L (< $10/kg)	L (< $10/kg)		No	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)	M ($10 to $100/kg)	M ($10 to $100/kg)	M ($10 to $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges	L	L	L	L	Yes	Narrative Questions
4. Infrastructure challenges	L	L	L	L	No	Narrative Questions
5. Implementation timeframe	M	M	M	M	No	Narrative Questions
6. Energy Use	L	L	L	L	No	Narrative Questions
7. CO2 Loading	L	L	L	L	Yes	Narrative Questions
8. Compatability/synergy						
a. With other large-scale technologies considered	H	H	H	H	No	Narrative Questions
c. With ongoing or anticipated restoration measures	H	H	H	H	No	Narrative Questions
9. Risk of failure?	L	L	L	L	Yes	Narrative Questions
10. Need for further scientific study?	L	L	L	L	Yes	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace.

Objective 1: Reduce seasonal concentrations of nutrients						
Technology/Measure: WETLAND RESTORATION						
Criterion - Use Quantitative Rankings		**UKL Tributaries**	**Upper Klamath Lake**	**Link River Dam to Keno Dam**	**JC Boyle Dam to Iron Gate Dam**	**Line of Reasoning/Notes**
General Costing Info	Wetland area (acres)	5000	10000	10000		UKL-Target is emergent marsh habitat in late summer for suckers. UKL tributaries-adding wetlands to wood river & south fork of the Sprague is a focus (large source of P).
	Project life (yrs)	50	50	50		
	Capital costs: Per unit area ($/acre) [a]	$4,700	$ 4,700	$4,700		
	Capital costs: Sub-total capital costs	$ 23,500,000	$ 47,000,000	$ 47,000,000		
	O&M costs: Per unit area ($/acre/yr) [b]	$100	100	$ 100		
	O&M costs: Annual ($/yr)	$ 500,000	$ 1,000,000	$ 1,000,000		
	O&M costs: Sub-total O&M ($)	$ 25,000,000	$ 50,000,000	$ 50,000,000		
	Total cost for project life	**$ 48,500,000**	**$ 97,000,000**	**$ 97,000,000**		
Unit Removal - Zero Order	N removal rate (mg N/m2/d)	50	50	50		
	P removal rate (g P/m2/yr)	--	--	0.5		
	P "avoided" loading rate (g P/m2/yr)[c]	1.62	1.62	--		
	Annual TN load removed (MT/yr)	369	739	739		
	Annual TP load removed (MT/yr)	33	66	20		
	Total TN removed for project life (MT)	**18,464**	**36,929**	**36,929**		
	Total TP removed for project life (MT)	**1,639**	**3,278**	**1,012**		
	TN unit removal cost ($/kg)	**$ 3**	**$ 3**	**$ 3**		
	TP unit removal cost ($/kg)	**$ 30**	**$ 30**	**$ 96**		

[a] Includes land acquisition and construction. Low end of per-acre land costs assumed to be $3,000 (i.e., mid-way between $700-750 cost for 1990s Wood River land acquisitions and the $5,000 current small-parcel estimate from Deas (2011). Lower estimate construction costs assumed to be $1,700/acre based on 2000-2010 construction costs for entire Williamson River Delta project (i.e., $10M/5,800 wetland acres = $1,700/acre) http://www.fws.gov/klamathfallsfwo/suckers/sucker_pub/oct08posters/RestoringWetlands-SternHendrickson.pdf. Higher estimate construction costs assumed to be $5,600/acre from Mahugh et al. (2009).

[b] O&M costs very low but unknown (no pumping/energy but: security, fencing, monitoring, etc.).

[c] Re-flooding north/west side of the Williamson River Delta (Tulana Farms) initially released 2 MT of phosphorus (Wong et al. 2011), whereas previous annual P export to lake was 21-25 MT (Synder and Morace 1997), indicating 21 MT reduced loading to the lake in the first year (and release of P should be lower than 2 MT in subsequent years). 21 MT/yr/3,200 acres=1.8 g P/m2/yr.

Comments:

Group 3 - WR / TR / DSTS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.

Technology/Measure: WETLAND RESTORATION

Criterion - Use Qualitative or H/M/L Rankings		UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	M	M	M		
	Direct or indirect effects?	Indirect	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall		
	Other					
pH	Overall pH improvements	M	M	M		50 years into the future emergent marsh could have a larger effect on lake pH, moderate is a consevative estimate
	Direct or indirect effects?	Indirect	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall		
	Other					
Temperature	Overall water temperature improvements	M	M	M		
	Direct or indirect effects?	Indirect	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall		
	Other					
TSS/Turbidity	Overall TSS/turbidity improvements	M	M	M		
	Direct or indirect effects?	Direct	Direct	Direct		
	Season of greatest improvement	All	All	All		
	Other					
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	M	M	M		
	Direct or indirect effects?	Indirect	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall		
	Other					

Comments: Evaluations in the tributaries will effect water quality in tribs and UKL, so those were evaluated for both. Wetlands along link river dam to keno dam would need to be placed directly along the reach to have the highest impact. Wetlands around link river dam will have to be a combination of restored and treatment wetlands. Link river dam to Keno--WQ was evaluated for downstream effects.

Narrative Question	H/M/L	Narrative Response
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	L	**Some sites have the potential to carry higher engineering and design costs, due to hydrologic models, species inventory, levee breaching design, etc. But we feel that the cost is relatively low compared to other proposed technologies.**
Are the infrastructure requirements for this technology high, medium, or low and why?	L	
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	
Is the energy use of this technology high, medium, or low and why?	L	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	L	**This would be a very green option, where vegetation will take CO2 out of the atmosphere.**
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	**This is assumed that wetlands are build, operated, and maintained properly; with monitoring post-restoration.**
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	L	**There is a political need to educate public that this process is needed and will have positive wq outcomes. Research is needed to better understand wetland function and wq improvments with respect to lake level management.**
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?		
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?		
Does this technology/measure provide an acceptable cost to benefit ratio?		
Is this technology/measure a long-term solution or improvement?		
Are there readily identifiable legal constraints on this technology/measure?		
Are there readily identifiable political ramifications for this technology/measure?		Education in the klamath basin is needed to communicate the science ramifications of wetland restoration and WQ impacts.
Are there likely to be unique opportunities for funding for this technology/measure?		
Will this approach create jobs? Of what sort?		
Are there identifiable social or cultural impacts from this technology/measure?		
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?		
What is the potential for unintended consequences for this technology/measure?		

Group 3 - WR / TR / DSTS

Summary Criteria - please make entries in green shaded cells only.

Technology/Measure: TREATMENT WETLANDS

Criterion - Use Quantitatve or H/M/L Rankings	UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Comments?	For detailed analysis, go to tab...
1. Effectiveness						
a. Total TN removed for project life (MT)		H (> 100 MT)	H (> 100 MT)		No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)		H (> 10 MT)	H (> 10 MT)		No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?		M-Indirect	M-Indirect		No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?		M-Indirect	M-Indirect		No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?		H-Direct	H-Direct		No	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?		M-Indirect	H-Indirect		No	Obj 2 - Water Quality
2. Cost (estimated)						
a. Total cost for project life		VH (> $100M)	VH (> $100M)		No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)		L (< $10/kg)	L (< $10/kg)		Yes	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)		M ($10 to $100/kg)	M ($10 to $100/kg)		Yes	Obj 1 - Nutrients
3. Engineering challenges		M	M		No	Narrative Questions
4. Infrastructure challenges		M	M		No	Narrative Questions
5. Implementation timeframe		M	M		No	Narrative Questions
6. Energy Use		M	M		Yes	Narrative Questions
7. CO2 Loading		L	L		No	Narrative Questions
8. Compatability/synergy						
a. With other large-scale technologies considered		M	M		No	Narrative Questions
c. With ongoing or anticipated restoration measures		H	H		Yes	Narrative Questions
9. Risk of failure?		M	M		No	Narrative Questions
10. Need for further scientific study?		L	L		Yes	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace.

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.

Technology/Measure: TREATMENT WETLANDS

		Criterion - Use Quantitative Rankings	UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Line of Reasoning/Notes
General Costing Info		Wetland area (acres)	0	5000	5000		Target areas that have been diked and drained, but are subsided and will not resul in emergent marsh habitat.
		Project life (yrs)		50	50		
	Capital costs	Per unit area ($/acre) [a]		$10,488	$10,488		
		Sub-total capital costs		$ 52,440,000	$ 52,440,000		
	O&M costs	Per unit area ($/acre/yr) [b]		260	$ 260		
		Annual ($/yr)		$ 1,300,000.00	$ 1,300,000.00		
		Sub-total O&M ($)		$ 65,000,000	$ 65,000,000		
		Total cost for project life		**$ 117,440,000**	**$ 117,440,000**		
Unit Removal - First Order		Average flow (cfs)		150	70		
		Days operating per year		365	365		
		Mean inflow TN concentration (mg/L)		1.35	1.35		
		Mean outflow TN concentration (mg/L)		0.14	0.14		
		Mean inflow TP concentration (mg/L)		0.41	0.41		
		Mean outflow TP concentration (mg/L)		0.16	0.16		
		Annual TN load removed (MT/yr)		162	76		
		Annual TP load removed (MT/yr)		33	16		
		Total TN removed for project life (MT)		**8100**	**3800**		
		Total TP removed for project life (MT)		**1,650**	**800**		
		TN unit removal cost ($/kg)		**$ 14**	**$ 31**		N-removal can be estimated using either 1st or zero order empirical models
		TP unit removal cost ($/kg)		**$ 71**	**$ 147**		P-removal can be estimated using either 1st or zero order empirical models
Unit Removal - Zero Order		N removal rate (mg N/m2/d)		500	500		
		P removal rate (g P/m2/yr)		1.5	1.5		
		Annual TN load removed (MT/yr)		3693	3693		
		Annual TP load removed (MT/yr)		30	30		
		Total TN removed for project life (MT)		**184,644**	**184,644**		
		Total TP removed for project life (MT)		**1,518**	**1,518**		
		TN unit removal cost ($/kg)		**$ 1**	**$ 1**		N-removal can be estimated using either 1st or zero order empirical models
		TP unit removal cost ($/kg)		**$ 77**	**$ 77**		P-removal can be estimated using either 1st or zero order empirical models

[a] Includes land acquisition and construction. Per-acre capital costs based upon scale-dependent regression equation (Kadlec and Wallace 2009).

[b] O&M costs of $260/acre/yr are the average value from SFWMD (2004). O&M costs of $800/acre/yr are median value from Kadlec and Wallace (2009).

Comments:

Group 3 - WR / TR / DSTS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.						
Technology/Measure: TREATMENT WETLANDS						
Criterion - Use Qualitative or H/M/L Rankings		**UKL Tributaries**	**Upper Klamath Lake**	**Link River Dam to Keno Dam**	**JC Boyle Dam to Iron Gate Dam**	**Line of Reasoning/Notes**
Dissolved Oxygen	Overall DO improvements		M	M		There is some uncertainty on the magnitude of effect in UKL from well functioning treatment wetlands.
	Direct or indirect effects?		Indirect	Indirect		
	Season of greatest improvement		Summer/Fall	Summer/Fall		
	Other					
pH	Overall pH improvements		M	M		
	Direct or indirect effects?		Indirect	Indirect		
	Season of greatest improvement		Summer/Fall	Summer/Fall		
	Other					
Temperature	Overall water temperature improvements		L	L		
	Direct or indirect effects?		Indirect	Indirect		
	Season of greatest improvement		Summer/Fall	Summer/Fall		
	Other					
TSS/Turbidity	Overall TSS/turbidity improvements		H	H		
	Direct or indirect effects?		Direct	Direct		
	Season of greatest improvement		Summer/Fall	Summer/Fall		
	Other					
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements		M	H		
	Direct or indirect effects?		Indirect	Indirect		
	Season of greatest improvement		Summer/Fall	Summer/Fall		
	Other					
Comments: Siting of treatment wetlands needs to consider impacts on habitat quality (should avoid displacing habitat for sensitive species).						

Please make entries in green shaded cells only.		
Technology/Measure: TREATMENT WETLANDS		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	**M**	
Are the infrastructure requirements for this technology high, medium, or low and why?	**M**	
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	**M**	
Is the energy use of this technology high, medium, or low and why?	**M**	**Pumping of water has potental to require moderate energy levels**
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	L	
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	M	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	**assuming that these treatment wetlands do not replace habitat wetlands**
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	M	
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	L	**Pilot study needed to determine site specific removal efficiency.**
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?		
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?		
Does this technology/measure provide an acceptable cost to benefit ratio?		
Is this technology/measure a long-term solution or improvement?		
Are there readily identifiable legal constraints on this technology/measure?		
Are there readily identifiable political ramifications for this technology/measure?		
Are there likely to be unique opportunities for funding for this technology/measure?		
Will this approach create jobs? Of what sort?		
Are there identifiable social or cultural impacts from this technology/measure?		
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?		
What is the potential for unintended consequences for this technology/measure?		

Group 3 - WR / TR / DSTS

Summary Criteria - please make entries in green shaded cells only.						
Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS						
Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions		**UKL Tributaries (per unit)**	**UKL Tributaries (per 50 units)**	**Other Potential Location**	**Comments?**	**For analysis, go to tab...**
1. Effectiveness						
a.	Total TN removed for project life (MT)	L (< 10 MT)	H (> 100 MT)		No	Obj 1 - Nutrients
b.	Total TP removed for project life (MT)	L (< 1 MT)	H (> 10 MT)		No	Obj 1 - Nutrients
c.	Seasonal DO improvements - indirect or direct?				No	Obj 2 - Water Quality
d.	Seasonal pH improvements - indirect or direct?				No	Obj 2 - Water Quality
e.	Seasonal TSS/turbidity improvements - indirect or direct?				No	Obj 2 - Water Quality
f.	Seasonal Chl-a/algal toxin improvements - indirect or direct?				No	Obj 2 - Water Quality
2. Cost (estimated)						
a.	Total cost for project life	L (< $250K)	H ($1M to $100M)		No	Obj 1 - Nutrients
b.	Cost per unit N removal ($/kg)	L (< $10/kg)	L (< $10/kg)		No	Obj 1 - Nutrients
c.	Cost per unit P removal ($/kg)	H (> $100/kg)	H (> $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges					No	Narrative Questions
4. Infrastructure challenges					No	Narrative Questions
5. Implementation timeframe					No	Narrative Questions
6. Energy Use					No	Narrative Questions
7. CO2 Loading					No	Narrative Questions
8. Compatability/synergy						
a.	With other large-scale technologies considered				No	Narrative Questions
b.	With ongoing or anticipated restoration measures				No	Narrative Questions
9. Risk of failure?					No	Narrative Questions
10. Need for further scientific study?					No	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. However, since these are small systems, it is not expected that the overall losses will be large. Additionally, at this scale, ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace.

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.						
Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS						
Criteria - Development of Cost Estimates			**UKL Tributaries (per unit)**	**UKL Tributaries (per 2000 units)**	**Other Potential Location**	**Line of Reasoning/Notes**
General Costing Info		Wetland area (acres)	1	2000		
		Project life (yrs)	50	50		
	Capital costs	Site survey	$ 1,500	$ 3,000,000		
		Diversion box	$ 2,500	$ 5,000,000		
		Level control	$ 3,000	$ 6,000,000		
		Pumps	$ -	$ -		
		Earthwork	$ 750	$ 1,500,000		
		Planting	$ 3,000	$ 6,000,000		
		Exclusion fencing @ $1.25 per foot	$ 1,044	$ 2,087,103		
		Sub-total capital costs	$ 11,794	$ 23,587,103	$ -	
	O&M costs	Per unit area ($/acre/yr)	$ 260	$ 520,000		
		Annual ($/yr)	$ 260	$ 520,000		
		Sub-total O&M ($)	$ 13,000	$ 26,000,000	$ -	
	Total cost for project life		**$ 24,794**	**$ 49,587,103**	**$ -**	
Unit Removal	N removal rate (mg N/m2/d)		100	100	100	
	P removal rate (g P/m2/yr)		1	1	1	
	Total TN removed for project life (MT)		**7**	**14,772**	-	
	Total TP removed for project life (MT)		**0.2**	**404.7**	-	
	TN unit removal cost ($/kg)		**$ 3**	**$ 3**	**#DIV/0!**	
	TP unit removal cost ($/kg)		**$ 123**	**$ 123**	**#DIV/0!**	

Comments: The cost estimates in column D are for a single 1-acre system. This technology has broader effects when many diffuse source wetlands are implemented in a single watershed, so cost estimates are provided for a larger number of systems are given in column E.

Group 4 - WR / TR / DSTS

Summary Criteria - please make entries in green shaded cells only.							
Technology/Measure: WETLAND RESTORATION							
Criterion - Use Quantitatve or H/M/L Rankings		**UKL Tributaries**	**Upper Klamath Lake**	**Link River Dam to Keno Dam**	**JC Boyle Dam to Iron Gate Dam**	**Comments?**	**For detailed analysis, go to tab...**
1. Effectiveness							
a.	Total TN removed for project life (MT)		H (> 100 MT)	H (> 100 MT)		No	Obj 1 - Nutrients
b.	Total TP removed for project life (MT)		H (> 10 MT)	H (> 10 MT)		No	Obj 1 - Nutrients
c.	Seasonal DO improvements - indirect or direct?					No	Obj 2 - Water Quality
d.	Seasonal pH improvements - indirect or direct?					No	Obj 2 - Water Quality
e.	Seasonal TSS/turbidity improvements - indirect or direct?					No	Obj 2 - Water Quality
f.	Seasonal Chl-a/algal toxin improvements - indirect or direct?					No	Obj 2 - Water Quality
2. Cost (estimated)							
a.	Total cost for project life		H ($1M to $100M)	H ($1M to $100M)		No	Obj 1 - Nutrients
b.	Cost per unit N removal ($/kg)		L (< $10/kg)	L (< $10/kg)		No	Obj 1 - Nutrients
c.	Cost per unit P removal ($/kg)		M ($10 to $100/kg)	M ($10 to $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges		M	M	M	M	No	Narrative Questions
4. Infrastructure challenges		L	L	L	L	No	Narrative Questions
5. Implementation timeframe		M	M	M	M	No	Narrative Questions
6. Energy Use		L	L	L	L	No	Narrative Questions
7. CO2 Loading		M	M	M	M	Yes	Narrative Questions
8. Compatability/synergy							
a.	With other large-scale technologies considered	H	H	H	H	No	Narrative Questions
c.	With ongoing or anticipated restoration measures	H	H	H	H	Yes	Narrative Questions
9. Risk of failure?		M	M	M	M	Yes	Narrative Questions
10. Need for further scientific study?		H	H	H	H	No	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace.

Objective 1: Reduce seasonal concentrations of nutrients								
Technology/Measure: WETLAND RESTORATION								
Criterion - Use Quantitative Rankings			**UKL Tributaries**	**Upper Klamath Lake**	**Link River Dam to Keno Dam**	**JC Boyle Dam to Iron Gate Dam**	**Line of Reasoning/Notes**
General Costing Info	Wetland area (acres)		1000	4000	1000	270	Woods River considered UKL tributary. 300-400 additional acres in the Woods. UK Lake includes fringe wetlands around Agency Lake. Wetland acreage depends on land owner willingness to sell
	Project life (yrs)			50	50		Project life estimates should incorporate future changes associated with climate change
	Capital costs	Per unit area ($/acre) [a]		$ 4,700	$4,700		Cost estimates for the future are questionable and likely low
		Sub-total capital costs		$ 18,800,000	$ 4,700,000		
	O&M costs	Per unit area ($/acre/yr) [b]		100	$ 100		
		Annual ($/yr)		$ 400,000	$ 100,000		
		Sub-total O&M ($)		$ 20,000,000	$ 5,000,000		
	Total cost for project life			**$ 38,800,000**	**$ 9,700,000**		
Unit Removal - Zero Order	N removal rate (mg N/m2/d)			50	50		
	P removal rate (g P/m2/yr)			--	0.5		
	P "avoided" loading rate (g P/m2/yr)[c]			1.62	--		
	Annual TN load removed (MT/yr)			295	74		
	Annual TP load removed (MT/yr)			26	2		
	Total TN removed for project life (MT)			**14,772**	**3,693**		
	Total TP removed for project life (MT)			**1,311**	**101**		
	TN unit removal cost ($/kg)			**$ 3**	**$ 3**		
	TP unit removal cost ($/kg)			**$ 30**	**$ 96**		

[a]Includes land acquisition and construction. Low end of per-acre land costs assumed to be $3,000 (i.e., mid-way between $700-750 cost for 1990s Wood River land acquisitions and the $5,000 current small-parcel estimate from Deas (2011). Lower estimate construction costs assumed to be $1,700/acre based on 2000-2010 construction costs for entire Williamson River Delta project (i.e., $10M/5,800 wetland acres = $1,700/acre) http://www.fws.gov/klamathfallsfwo/suckers/sucker_pub/oct08posters/RestoringWetlands-SternHendrickson.pdf. Higher estimate construction costs assumed to be $5,600/acre from Mahugh et al. (2009).

[b]O&M costs very low but unknown (no pumping/energy but: security, fencing, monitoring, etc.).

[c] Re-flooding north/west side of the Williamson River Delta (Tulana Farms) initially released 2 MT of phosphorus (Wong et al. 2011), whereas previous annual P export to lake was 21-25 MT (Synder and Morace 1997), indicating 21 MT reduced loading to the lake in the first year (and release of P should be lower than 2 MT in subsequent years). 21 MT/yr/3,200 acres=1.8 g P/m2/yr.

Why not flood the refuge instead of purchasing new acreage for wetlands

Group 4 - WR / TR / DSTS

Please make entries in green shaded cells only.		
Technology/Measure: WETLAND RESTORATION		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	M	
Are the infrastructure requirements for this technology high, medium, or low and why?	L	
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	
Is the energy use of this technology high, medium, or low and why?	L	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	M	questions regarding methane production from wetlands
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	may be a competition for land between the different wetland solutions
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	M	uncertainty regarding phosphorus removal
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	H	
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	H	
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	M	
Does this technology/measure provide an acceptable cost to benefit ratio?	L	low for P removal, good for habitat
Is this technology/measure a long-term solution or improvement?	H	
Are there readily identifiable legal constraints on this technology/measure?	M	acquisition of land
Are there readily identifiable political ramifications for this technology/measure?	H	competition with ag
Are there likely to be unique opportunities for funding for this technology/measure?	M	other sources of funding besides P removal..
Will this approach create jobs? Of what sort?	M	initial construction
Are there identifiable social or cultural impacts from this technology/measure?	M	competition with ag, good for bird watchers and hunters
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	H	
What is the potential for unintended consequences for this technology/measure?	M	invasive species, bioaccumulation

Summary Criteria - please make entries in green shaded cells only.						
Technology/Measure: TREATMENT WETLANDS						
Criterion - Use Quantitatve or H/M/L Rankings	**UKL Tributaries**	**Upper Klamath Lake**	**Link River Dam to Keno Dam**	**JC Boyle Dam to Iron Gate Dam**	**Comments?**	**For detailed analysis, go to tab...**
1. Effectiveness						
a. Total TN removed for project life (MT)			H (> 100 MT)		No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)			H (> 10 MT)		No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?	M-Indirect	M-Indirect	M-Indirect	M-Indirect	No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?	M-Indirect	M-Indirect	M-Indirect	M-Indirect	No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?	H-Direct	H-Direct	H-Direct	H-Direct	No	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?	M-Indirect	H-Direct	H-Direct	H-Direct	No	Obj 2 - Water Quality
2. Cost (estimated)						
a. Total cost for project life			VH (> $100M)		No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)			L (< $10/kg)		Yes	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)			H (> $100/kg)		Yes	Obj 1 - Nutrients
3. Engineering challenges	M	M	M	M	Yes	Narrative Questions
4. Infrastructure challenges	M	M	M	M	Yes	Narrative Questions
5. Implementation timeframe	M	M	M	M	No	Narrative Questions
6. Energy Use	L	L	L	L	No	Narrative Questions
7. CO2 Loading	L	L	L	L	No	Narrative Questions
8. Compatability/synergy						
a. With other large-scale technologies considered	H	H	H	H	No	Narrative Questions
c. With ongoing or anticipated restoration measures	H	H	H	H	No	Narrative Questions
9. Risk of failure?	M	M	M	M	Yes	Narrative Questions
10. Need for further scientific study?	H	H	H	H	No	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace.

Group 4 - WR / TR / DSTS

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.

Technology/Measure: TREATMENT WETLANDS

Criterion - Use Quantitative Rankings			UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Line of Reasoning/Notes
General Costing Info	Wetland area (acres)		1000	4000	40000	270	We assumed some portion of the restored wetlands could be desinged as treatment wetlands. Klamath Straits Drain area (320 acres) has the greatest potential to intercept ag drainage prior to reaching the river. The estimate for Link River Dam to Keno is an estimate to treat the Klamath River based on CH2MHill's 2012 wetland study.
	Project life (yrs)		30	30	30	30	
	Capital costs	Per unit area ($/acre) [a]	$10,488	10488	$10,488	10488	
		Sub-total capital costs			$ 419,520,000		Unit cost may vary depending upon project size
	O&M costs	Per unit area ($/acre/yr) [b]	260	260	$ 260	260	
		Annual ($/yr)			$ 10,400,000.00		
		Sub-total O&M ($)			$ 312,000,000		
	Total cost for project life				**$ 731,520,000**		
Unit Removal - First Order	Average flow (cfs)		70	70	1097	70	
	Days operating per year		365	365	365	365	
	Mean inflow TN concentration (mg/L)		1.35	1.35	1.35	1.35	
	Mean outflow TN concentration (mg/L)		0.14	0.14	0.14	0.14	
	Mean inflow TP concentration (mg/L)		0.41	0.41	0.41	0.41	
	Mean outflow TP concentration (mg/L)		0.16	0.16	0.16	0.16	
	Annual TN load removed (MT/yr)				1185		
	Annual TP load removed (MT/yr)				245		
	Total TN removed for project life (MT)				**35550**		
	Total TP removed for project life (MT)				**7,350**		
	TN unit removal cost ($/kg)				**$ 21**		N-removal can be estimated using either 1st or zero order empirical models
	TP unit removal cost ($/kg)				**$ 100**		P-removal can be estimated using either 1st or zero order empirical models
Unit Removal - Zero Order	N removal rate (mg N/m2/d)				500		
	P removal rate (g P/m2/yr)				1.5		
	Annual TN load removed (MT/yr)				29543		
	Annual TP load removed (MT/yr)				243		
	Total TN removed for project life (MT)				**886,293**		
	Total TP removed for project life (MT)				**7,285**		
	TN unit removal cost ($/kg)				**$ 1**		N-removal can be estimated using either 1st or zero order empirical models
	TP unit removal cost ($/kg)				**$ 100**		P-removal can be estimated using either 1st or zero order empirical models

[a]Includes land acquisition and construction· Per-acre capital costs based upon scale-dependent regression equation (Kadlec and Wallace 2009).

[b]O&M costs of $260/acre/yr are the average value from SFWMD (2004). O&M costs of $800/acre/yr are median value from Kadlec and Wallace (2009).

Comments:

Objective 2: Improve overall water quality - please make entries in green shaded cells only.

Technology/Measure: TREATMENT WETLANDS

Criterion - Use Qualitative or H/M/L Rankings		UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	M	M	M	M	may release low DO water from wetland, but also removes nutrients
	Direct or indirect effects?	Indirect	Indirect	Indirect	Indirect	
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall	
	Other					
pH	Overall pH improvements	M	M	M	M	
	Direct or indirect effects?	Indirect	Indirect	Indirect	Indirect	
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall	
	Other					
Temperature	Overall water temperature improvements	L	L	L	L	
	Direct or indirect effects?	Direct	Direct	Direct	Direct	
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall	
	Other					
TSS/Turbidity	Overall TSS/turbidity improvements	H	H	H	H	
	Direct or indirect effects?	Direct	Direct	Direct	Direct	
	Season of greatest improvement	n/a	n/a	n/a	n/a	
	Other					
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	M	H	H	H	
	Direct or indirect effects?	Indirect	Direct	Direct	Direct	
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall	
	Other					

Comments:

Group 4 - WR / TR / DSTS

Please make entries in green shaded cells only.		
Technology/Measure: TREATMENT WETLANDS		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	M	At the larger scale, the engineering aspects are more complex and challenging
Are the infrastructure requirements for this technology high, medium, or low and why?	M	Depends on the location, water surface elevation and site charateristics
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	
Is the energy use of this technology high, medium, or low and why?	L	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	L	
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	M	Not much certainty about removal effectiveness and limited data on wetland performance in Klamath watershed
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	H	
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	H	
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	H	more of a global solution
Does this technology/measure provide an acceptable cost to benefit ratio?		???
Is this technology/measure a long-term solution or improvement?	H	
Are there readily identifiable legal constraints on this technology/measure?	M	willing land owners are needed
Are there readily identifiable political ramifications for this technology/measure?	H	taking land out of ag production
Are there likely to be unique opportunities for funding for this technology/measure?	M	carbon offsets, ecosystem services market
Will this approach create jobs? Of what sort?	M	initial construction, ongoing operation
Are there identifiable social or cultural impacts from this technology/measure?	H	conflicts with agriculture, land use and water use
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	H	compatible with dam removal, should improve downstream water quality
What is the potential for unintended consequences for this technology/measure?	M	possible export of nutrients, bioaccumulation

Summary Criteria - please make entries in green shaded cells only.						
Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS						
Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions		**UKL Tributaries (per unit)**	**UKL Tributaries (per 50 units)**	**Other Potential Location**	**Comments?**	**For analysis, go to tab...**
1. Effectiveness						
a.	Total TN removed for project life (MT)	L (< 10 MT)	H (> 100 MT)		No	Obj 1 - Nutrients
b.	Total TP removed for project life (MT)	L (< 1 MT)	H (> 10 MT)		No	Obj 1 - Nutrients
c.	Seasonal DO improvements - indirect or direct?	LIndirect	MIndirect	M-Indirect	No	Obj 2 - Water Quality
d.	Seasonal pH improvements - indirect or direct?	LIndirect	MIndirect	M-Indirect	No	Obj 2 - Water Quality
e.	Seasonal TSS/turbidity improvements - indirect or direct?	LDirect	HDirect	H-Direct	No	Obj 2 - Water Quality
f.	Seasonal Chl-a/algal toxin improvements - indirect or direct?	LIndirect	HDirect	H-Direct	No	Obj 2 - Water Quality
2. Cost (estimated)						
a.	Total cost for project life	L (< $250K)	H ($1M to $100M)		No	Obj 1 - Nutrients
b.	Cost per unit N removal ($/kg)	L (< $10/kg)	L (< $10/kg)		No	Obj 1 - Nutrients
c.	Cost per unit P removal ($/kg)	H (> $100/kg)	H (> $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges		L	L	L	Yes	Narrative Questions
4. Infrastructure challenges		L	L	L	No	Narrative Questions
5. Implementation timeframe		M	M	M	No	Narrative Questions
6. Energy Use		L	L	L	No	Narrative Questions
7. CO2 Loading		L	L	L	No	Narrative Questions
8. Compatability/synergy						
a.	With other large-scale technologies considered	H	H	H	No	Narrative Questions
b.	With ongoing or anticipated restoration measures	H	H	H	No	Narrative Questions
9. Risk of failure?		M	M	M	Yes	Narrative Questions
10. Need for further scientific study?		H	H	H	No	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. However, since these are small systems, it is not expected that the overall losses will be large. Additionally, at this scale, ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace.

Group 4 - WR / TR / DSTS

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.

Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS

Criteria - Development of Cost Estimates			**UKL Tributaries (per unit)**	**UKL Tributaries (per 50 units)**	**Other Potential Location**	**Line of Reasoning/Notes**
General Costing Info	Wetland area (acres)		1	50		
	Project life (yrs)		50	50		
	Capital costs	Site survey	$ 1,500	$ 75,000		
		Diversion box	$ 2,500	$ 125,000		
		Level control	$ 3,000	$ 150,000		
		Pumps	$ -	$ -		
		Earthwork	$ 750	$ 37,500		
		Planting	$ 3,000	$ 150,000		
		Exclusion fencing @ $1.25 per foot	$ 1,044	$ 52,178		
		Sub-total capital costs	$ 11,794	$ 589,678	$ -	
	O&M costs	Per unit area ($/acre/yr)	$ 260	$ 13,000		
		Annual ($/yr)	$ 260	$ 13,000		
		Sub-total O&M ($)	$ 13,000	$ 650,000	$ -	
	Total cost for project life		**$ 24,794**	**$ 1,239,678**	**$ -**	
Unit Removal	N removal rate (mg N/m2/d)		100	100	100	
	P removal rate (g P/m2/yr)		1	1	1	
	Total TN removed for project life (MT)		**7**	**369**	-	
	Total TP removed for project life (MT)		**0.2**	**10.1**	-	
	TN unit removal cost ($/kg)		**$ 3**	**$ 3**	**#DIV/0!**	
	TP unit removal cost ($/kg)		**$ 123**	**$ 123**	**#DIV/0!**	

Comments: The cost estimates in column D are for a single 1-acre system. This technology has broader effects when many diffuse source wetlands are implemented in a single watershed, so cost estimates are provided for a larger number of systems are given in column E.

Objective 2: Improve overall water quality - please make entries in green shaded cells only.

Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS

Criteria - Use H/M/L Rankings and Narrative Descriptions		**Tributaries (per unit)**	**UKL Tributaries (per 100 units)**	**Other Potential Location**	**Line of Reasoning/Notes**
Dissolved Oxygen	Overall DO improvements	L	M	M	other potential location may be Lost River basin, Shasta, Scott River
	Direct or indirect effects?	Indirect	Indirect	Indirect	
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	
	Other				
pH	Overall pH improvements	L	M	M	
	Direct or indirect effects?	Indirect	Indirect	Indirect	
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	
	Other				
Temperature	Overall water temperature improvements	L	L	L	
	Direct or indirect effects?	Direct	Direct	Direct	
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	L	H	H	
	Direct or indirect effects?	Direct	Direct	Direct	
	Season of greatest improvement	n/a	n/a	n/a	
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	L	H	H	
	Direct or indirect effects?	Indirect	Direct	Direct	
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	
	Other				

Comments:

Group 4 - WR / TR / DSTS

Please make entries in green shaded cells only.		
Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	L	**assumes small, localized, onfarm treatment wetlands**
Are the infrastructure requirements for this technology high, medium, or low and why?	L	
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	**M**	
Is the energy use of this technology high, medium, or low and why?	L	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	L	
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	M	**questions about long term maintenance**
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	H	
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	M	**convert existing water rights to include wetland function as a beneficial use appears to be a feasible way to deal with this**
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	M	
Does this technology/measure provide an acceptable cost to benefit ratio?	H	
Is this technology/measure a long-term solution or improvement?	H	questions about long term maintenance
Are there readily identifiable legal constraints on this technology/measure?	L	
Are there readily identifiable political ramifications for this technology/measure?	L	unless it is required
Are there likely to be unique opportunities for funding for this technology/measure?	M	carbon trading, habitat improvements, conservation practices
Will this approach create jobs? Of what sort?	L	
Are there identifiable social or cultural impacts from this technology/measure?	L	
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	H	
What is the potential for unintended consequences for this technology/measure?	L	invasive species,noxious weeds, mosquitoes, increased export if wetland is drained

Group 5 - WR / TR / DSTS

Technology/Measure: WETLAND RESTORATION							
Criterion - Use Quantitatve or H/M/L Rankings		**UKL Tributaries**	**Upper Klamath Lake**	**Link River Dam to Keno Dam**	**JC Boyle Dam to Iron Gate Dam**	**Comments?**	**For detailed analysis, go to tab...**
1. Effectiveness							
a.	Total TN removed for project life (MT)		H (> 100 MT)	H (> 100 MT)		No	Obj 1 - Nutrients
b.	Total TP removed for project life (MT)		H (> 10 MT)	H (> 10 MT)		No	Obj 1 - Nutrients
c.	Seasonal DO improvements - indirect or direct?	L-Indirect	M-Indirect	L-Indirect	L-Indirect	No	Obj 2 - Water Quality
d.	Seasonal pH improvements - indirect or direct?	L-Indirect	M-Indirect	L-Indirect	L-Indirect	No	Obj 2 - Water Quality
e.	Seasonal TSS/turbidity improvements - indirect or direct?		M-Direct			No	Obj 2 - Water Quality
f.	Seasonal Chl-a/algal toxin improvements - indirect or direct?		M-Indirect			No	Obj 2 - Water Quality
2. Cost (estimated)							
a.	Total cost for project life		VH (> $100M)	H ($1M to $100M)		No	Obj 1 - Nutrients
b.	Cost per unit N removal ($/kg)		L (< $10/kg)	L (< $10/kg)		No	Obj 1 - Nutrients
c.	Cost per unit P removal ($/kg)		M ($10 to $100/kg)	M ($10 to $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges		M	M	M	M	Yes	Narrative Questions
4. Infrastructure challenges		L	L	L	L	No	Narrative Questions
5. Implementation timeframe		H	H	H	H	No	Narrative Questions
6. Energy Use		L	L	L	L	No	Narrative Questions
7. CO2 Loading		L	L	L	L	No	Narrative Questions
8. Compatability/synergy							
a.	With other large-scale technologies considered	H	H	H	H	No	Narrative Questions
c.	With ongoing or anticipated restoration measures	M	M	M	M	No	Narrative Questions
9. Risk of failure?		L	L	L	L	No	Narrative Questions
10. Need for further scientific study?		M	M	M	M	Yes	Narrative Questions
Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace.							

Objective 1: Reduce seasonal concentrations of nutrients							
Technology/Measure: WETLAND RESTORATION							
Criterion - Use Quantitative Rankings			**UKL Tributaries**	**Upper Klamath Lake**	**Link River Dam to Keno Dam**	**JC Boyle Dam to Iron Gate Dam**	**Line of Reasoning/Notes**
General Costing Info	Wetland area (acres)		3000	12000	1400	270	Goal = Maximum acreage on Upper Klamath Lake. Intent for UKL tribs is for riparian plant restoration, not limited to wetland plant restoration. Refuge not included in UKL acreage number, nor is expansion of walking wetland program, although both of these areas should be promoted for this technology. For this technology, restored wetland corridors are best suited for non-lake reaches. Boyle reach acreage based on assumption of dam removal.
	Project life (yrs)		50	50	50	50	
	Capital costs	Per unit area ($/acre) [a]		$ 4,700	$4,700		
		Sub-total capital costs		$ 56,400,000	$ 6,580,000		
	O&M costs	Per unit area ($/acre/yr) [b]		100	$ 100		
		Annual ($/yr)		$ 1,200,000	$ 140,000		
		Sub-total O&M ($)		$ 60,000,000	$ 7,000,000		
	Total cost for project life			**$ 116,400,000**	**$ 13,580,000**		
Unit Removal - Zero Order	N removal rate (mg N/m2/d)			50	50		
	P removal rate (g P/m2/yr)			--	0.5		
	P "avoided" loading rate (g P/m2/yr)[c]			1.62	--		
	Annual TN load removed (MT/yr)			886	103		
	Annual TP load removed (MT/yr)			79	3		
	Total TN removed for project life (MT)			**44,315**	**5,170**		
	Total TP removed for project life (MT)			**3,934**	**142**		
	TN unit removal cost ($/kg)			**$ 3**	**$ 3**		
	TP unit removal cost ($/kg)			**$ 30**	**$ 96**		

[a] Includes land acquisition and construction. Low end of per-acre land costs assumed to be $3,000 (i.e., mid-way between $700-750 cost for 1990s Wood River land acquisitions and the $5,000 current small-parcel estimate from Deas (2011). Lower estimate construction costs assumed to be $1,700/acre based on 2000-2010 construction costs for entire Williamson River Delta project (i.e., $10M/5,800 wetland acres = $1,700/acre) http://www.fws.gov/klamathfallsfwo/suckers/sucker_pub/oct08posters/RestoringWetlands-SternHendrickson.pdf. Higher estimate construction costs

[b] O&M costs very low but unknown (no pumping/energy but: security, fencing, monitoring, etc.).

[c] Re-flooding north/west side of the Williamson River Delta (Tulana Farms) initially released 2 MT of phosphorus (Wong et al. 2011), whereas previous annual P export to lake was 21-25 MT (Synder and Morace 1997), indicating 21 MT reduced loading to the lake in the first year (and release of P should be lower than 2 MT in subsequent years). 21 MT/yr/3,200 acres=1.8 g P/m2/yr.

Comments:

Group 5 - WR / TR / DSTS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.

Technology/Measure: WETLAND RESTORATION

	Criterion - Use Qualitative or H/M/L Rankings	UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	L	M	L	L	Riparian corridors on non-lake reaches might eventually provide more shade.
	Direct or indirect effects?	Indirect	Indirect	Indirect	Indirect	
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall	
	Other					
pH	Overall pH improvements	L	M	L	L	
	Direct or indirect effects?	Indirect	Indirect	Indirect	Indirect	
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall	
	Other					
Temperature	Overall water temperature improvements	M	L	L	L	Riparian corridors on non-lake reaches might eventually provide more shade.
	Direct or indirect effects?	Direct	Indirect	Direct	Direct	
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall	
	Other					
TSS/Turbidity	Overall TSS/turbidity improvements		M			
	Direct or indirect effects?		Direct			
	Season of greatest improvement		Spring			
	Other					
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements		M			IMPORTANT NOTE: Nutrient removal and habitat benefits greatly depend on the design and operation of the wetlands (esp. considering seasonal pumping regimes).
	Direct or indirect effects?		Indirect			
	Season of greatest improvement		Summer/Fall			
	Other					

Comments:

Please make entries in green shaded cells only.

Technology/Measure: WETLAND RESTORATION

Narrative Question	H/M/L	Narrative Response
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	M	Maybe closer to HIGH?
Are the infrastructure requirements for this technology high, medium, or low and why?	L	
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	H	
Is the energy use of this technology high, medium, or low and why?	L	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	L	
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	M	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	M	For the size of these projects, pilot studies should be conducted! Revisiting results from monitoring of TNC project is also worthwhile.
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	H	Higher on non-lake reaches. Maybe higher for pump-driven designs, too.
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	H	
Does this technology/measure provide an acceptable cost to benefit ratio?		Refer to Obj 1 Sheet.
Is this technology/measure a long-term solution or improvement?	H	
Are there readily identifiable legal constraints on this technology/measure?	H	
Are there readily identifiable political ramifications for this technology/measure?	H	Everything in the Klamath is high!
Are there likely to be unique opportunities for funding for this technology/measure?	M	
Will this approach create jobs? Of what sort?	M	
Are there identifiable social or cultural impacts from this technology/measure?	M	
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	L	
What is the potential for unintended consequences for this technology/measure?	M	

Group 5 - WR / TR / DSTS

Criterion - Use Quantitatve or H/M/L Rankings	UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Comments?	For detailed analysis, go to tab...
Summary Criteria - please make entries in green shaded cells only.						
Technology/Measure: TREATMENT WETLANDS						
1. Effectiveness						
a. Total TN removed for project life (MT)			H (> 100 MT)		No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)			H (> 10 MT)		No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?	L-Indirect	L-Indirect	L-Indirect	L-Indirect	No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?	L-Indirect	L-Indirect	L-Indirect	L-Indirect	No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?	L-Direct	L-Direct	L-Direct	L-Direct	No	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?	n/a-n/a	L-Indirect	L-Indirect	L-Indirect	No	Obj 2 - Water Quality
2. Cost (estimated)						
a. Total cost for project life	H ($1M to $100M)		H ($1M to $100M)	H ($1M to $100M)	No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)	L (< $10/kg)		L (< $10/kg)	L (< $10/kg)	Yes	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)	L (< $10/kg)		H (> $100/kg)	L (< $10/kg)	Yes	Obj 1 - Nutrients
3. Engineering challenges	M	M	M	M	Yes	Narrative Questions
4. Infrastructure challenges	M	M	M	M	Yes	Narrative Questions
5. Implementation timeframe	M	M	M	M	No	Narrative Questions
6. Energy Use	L	L	L	L	No	Narrative Questions
7. CO2 Loading	L	L	L	L	No	Narrative Questions
8. Compatability/synergy						
a. With other large-scale technologies considered	H	H	H	H	No	Narrative Questions
c. With ongoing or anticipated restoration measures	M	M	M	M	No	Narrative Questions
9. Risk of failure?	L	L	L	L	Yes	Narrative Questions
10. Need for further scientific study?	L	L	L	L	No	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace.

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.

Technology/Measure: TREATMENT WETLANDS

		Criterion - Use Quantitative Rankings	UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Line of Reasoning/Notes
General Costing Info		Wetland area (acres)	200	0	250	250	Tribs = Seven Mile, West Canal; Link = Klamath Straits Drain, JC = Refer to Lyons et al. (2009). Acreage based on presumed treatment flows (i.e., 250 acres needed for 150 cfs.)
		Project life (yrs)	50		50	50	
	Capital costs	Per unit area ($/acre) [a]	11300		11300	11300	Unit cost based on Day 1 presentation.
		Sub-total capital costs	$ 2,260,000	$ -	$ 2,825,000	$ 2,825,000	
	O&M costs	Per unit area ($/acre/yr) [b]	$ 425		$ 425	$ 425	Unit cost based on Day 1 presentation. Return to check assumptions here. Cost may be offset by ecosystem services / commodities.
		Annual ($/yr)	$ 85,000.00	$ -	$ 106,250.00	$ 106,250.00	
		Sub-total O&M ($)	$ 4,250,000	$ -	$ 5,312,500	$ 5,312,500	
		Total cost for project life	**$ 6,510,000**	**$ -**	**$ 8,137,500**	**$ 8,137,500**	
Unit Removal - First Order		Average flow (cfs)	100		150	150	Design flow here, not necessarily average flow.
		Days operating per year	365		365	365	
		Mean inflow TN concentration (mg/L)					
		Mean outflow TN concentration (mg/L)					90% removal
		Mean inflow TP concentration (mg/L)					
		Mean outflow TP concentration (mg/L)					60% removal
		Annual TN load removed (MT/yr)			0		
		Annual TP load removed (MT/yr)			0		
		Total TN removed for project life (MT)			**0**		
		Total TP removed for project life (MT)			**0**		
		TN unit removal cost ($/kg)			**#DIV/0!**		N-removal can be estimated using either 1st or zero order empirical models
		TP unit removal cost ($/kg)			**#DIV/0!**		P-removal can be estimated using either 1st or zero order empirical models
Unit Removal - Zero Order		N removal rate (mg N/m2/d)			500		Default values here.
		P removal rate (g P/m2/yr)			1.5		
		Annual TN load removed (MT/yr)			185		
		Annual TP load removed (MT/yr)			2		
		Total TN removed for project life (MT)			**9,232**		
		Total TP removed for project life (MT)			**76**		
		TN unit removal cost ($/kg)			**$ 1**		N-removal can be estimated using either 1st or zero order empirical models
		TP unit removal cost ($/kg)			**$ 107**		P-removal can be estimated using either 1st or zero order empirical models

[a] Includes land acquisition and construction· Per-acre capital costs based upon scale-dependent regression equation (Kadlec and Wallace 2009).

[b] O&M costs of $260/acre/yr are the average value from SFWMD (2004). O&M costs of $800/acre/yr are median value from Kadlec and Wallace (2009).

Comments:

Group 5 - WR / TR / DSTS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.						
Technology/Measure: TREATMENT WETLANDS						
Criterion - Use Qualitative or H/M/L Rankings		UKL Tributaries	Upper Klamath Lake	Link River Dam to Keno Dam	JC Boyle Dam to Iron Gate Dam	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	L	L	L	L	
	Direct or indirect effects?	Indirect	Indirect	Indirect	Indirect	
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall	Keyed to when wetland plants are expected to grow.
	Other					
pH	Overall pH improvements	L	L	L	L	
	Direct or indirect effects?	Indirect	Indirect	Indirect	Indirect	
	Season of greatest improvement	Summer/Fall	Summer/Fall	Summer/Fall	Summer/Fall	Keyed to when wetland plants are expected to grow.
	Other					
Temperature	Overall water temperature improveme	n/a	n/a	n/a	n/a	Not enough residence time to register temperature changes.
	Direct or indirect effects?	n/a	n/a	n/a	n/a	
	Season of greatest improvement	n/a	n/a	n/a	n/a	
	Other					
TSS/Turbidity	Overall TSS/turbidity improvements	L	L	L	L	Based on characteristics of water to be treated at specified sites.
	Direct or indirect effects?	Direct	Direct	Direct	Direct	
	Season of greatest improvement	Spring	Winter	Winter	Winter	
	Other					
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	n/a	L	L	L	Low, due to project scale.
	Direct or indirect effects?	n/a	Indirect	Indirect	Indirect	
	Season of greatest improvement	n/a	Summer/Fall	Summer/Fall	Summer/Fall	
	Other					
Comments:						

Please make entries in green shaded cells only.		
Technology/Measure: TREATMENT WETLANDS		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	**M**	**M/L, really.**
Are the infrastructure requirements for this technology high, medium, or low and why?	**M**	**M/L, really.**
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	**M**	
Is the energy use of this technology high, medium, or low and why?	**L**	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	**L**	
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	M	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	L	
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	H	
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	M	
Does this technology/measure provide an acceptable cost to benefit ratio?		Refer to Obj 1 Sheet.
Is this technology/measure a long-term solution or improvement?	H	
Are there readily identifiable legal constraints on this technology/measure?	H	
Are there readily identifiable political ramifications for this technology/measure?	H	Everything in the Klamath is high!
Are there likely to be unique opportunities for funding for this technology/measure?	M	
Will this approach create jobs? Of what sort?	M	
Are there identifiable social or cultural impacts from this technology/measure?	L	
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	L	
What is the potential for unintended consequences for this technology/measure?	L	

Group 5 - WR / TR / DSTS

Summary Criteria - please make entries in green shaded cells only.						
Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS						
Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions		**UKL Tributaries (per unit)**	**UKL Tributaries (per 50 units)**	**Other Potential Location**	**Comments?**	**For analysis, go to tab...**
1. Effectiveness						
a.	Total TN removed for project life (MT)	L (< 10 MT)	H (> 100 MT)	#VALUE!	No	Obj 1 - Nutrients
b.	Total TP removed for project life (MT)	L (< 1 MT)	H (> 10 MT)	#VALUE!	No	Obj 1 - Nutrients
c.	Seasonal DO improvements - indirect or direct?	LIndirect	MIndirect		No	Obj 2 - Water Quality
d.	Seasonal pH improvements - indirect or direct?	LIndirect	LIndirect		No	Obj 2 - Water Quality
e.	Seasonal TSS/turbidity improvements - indirect or direct?	LDirect	MDirect		No	Obj 2 - Water Quality
f.	Seasonal Chl-a/algal toxin improvements - indirect or direct?	LIndirect	MIndirect		No	Obj 2 - Water Quality
2. Cost (estimated)						
a.	Total cost for project life	L (< $250K)	H ($1M to $100M)		No	Obj 1 - Nutrients
b.	Cost per unit N removal ($/kg)	L (< $10/kg)	L (< $10/kg)		No	Obj 1 - Nutrients
c.	Cost per unit P removal ($/kg)	H (> $100/kg)	H (> $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges		L	L	L	No	Narrative Questions
4. Infrastructure challenges		L	L	L	No	Narrative Questions
5. Implementation timeframe		L	L	L	Yes	Narrative Questions
6. Energy Use		L	L	L	No	Narrative Questions
7. CO2 Loading		L	L	L	No	Narrative Questions
8. Compatability/synergy						
a.	With other large-scale technologies considered	H	H	H	No	Narrative Questions
b.	With ongoing or anticipated restoration measures	H	H	H	No	Narrative Questions
9. Risk of failure?		L	L	L	No	Narrative Questions
10. Need for further scientific study?		L	L	L	Yes	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). This technology may result in some ET loss from wetlands, which could negatively impact surface water availability through increased consumptive use. However, since these are small systems, it is not expected that the overall losses will be large. Additionally, at this scale, ET losses in the wetlands may be smaller than ET losses from the grazed pasture or hayfields they replace.

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.						
Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS						
Criteria - Development of Cost Estimates			**UKL Tributaries (per unit)**	**UKL Tributaries (per 50 units)**	**Other Potential Location**	**Line of Reasoning/Notes**
General Costing Info		Wetland area (acres)	1	50	Lost River basin	Assume 2% of areas treated, per speaker's recommendation. Productive lands contributing to the Klamath Strait Drain appear to be appropriate sites for this technology, but may not be cost-effective. Moreover, it may not work within the confines of the BOR Klamath Project.
General Costing Info		Project life (yrs)	50	50		
General Costing Info	Capital costs	Site survey	$ 1,500	$ 75,000		
General Costing Info	Capital costs	Diversion box	$ 2,500	$ 125,000		
General Costing Info	Capital costs	Level control	$ 3,000	$ 150,000		
General Costing Info	Capital costs	Pumps	$ -	$ -		
General Costing Info	Capital costs	Earthwork	$ 750	$ 37,500		
General Costing Info	Capital costs	Planting	$ 3,000	$ 150,000		
General Costing Info	Capital costs	Exclusion fencing @ $1.25 per foot	$ 1,044	$ 52,178		
General Costing Info	Capital costs	Sub-total capital costs	$ 11,794	$ 589,678	$ -	
General Costing Info	O&M costs	Per unit area ($/acre/yr)	$ 260	$ 13,000		
General Costing Info	O&M costs	Annual ($/yr)	$ 260	$ 13,000		
General Costing Info	O&M costs	Sub-total O&M ($)	$ 13,000	$ 650,000	$ -	
General Costing Info		**Total cost for project life**	**$ 24,794**	**$ 1,239,678**	**$ -**	
Unit Removal		N removal rate (mg N/m2/d)	100	100	100	
Unit Removal		P removal rate (g P/m2/yr)	1	1	1	
Unit Removal		**Total TN removed for project life (MT)**	**7**	**369**	**#VALUE!**	
Unit Removal		**Total TP removed for project life (MT)**	**0.2**	**10.1**	**#VALUE!**	
Unit Removal		**TN unit removal cost ($/kg)**	**$ 3**	**$ 3**	**#VALUE!**	
Unit Removal		**TP unit removal cost ($/kg)**	**$ 123**	**$ 123**	**#VALUE!**	

Comments: The cost estimates in column D are for a single 1-acre system. This technology has broader effects when many diffuse source wetlands are implemented in a single watershed, so cost estimates are provided for a larger number of systems are given in column E.

Group 5 - WR / TR / DSTS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.

Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS

Criteria - Use H/M/L Rankings and Narrative Descriptions		Tributaries (per unit)	UKL Tributaries (per 100 units)	Other Potential Location	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	L	M		GENERAL NOTE: Greatest benefits to this technology would be realized if applied in the Sprague basin.
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
pH	Overall pH improvements	L	L		
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Temperature	Overall water temperature improvements	L	L		
	Direct or indirect effects?	Direct	Direct		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	L	M		
	Direct or indirect effects?	Direct	Direct		
	Season of greatest improvement	Spring	Spring		
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	L	M		
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				

Comments:

Please make entries in green shaded cells only.

Technology/Measure: DECENTRALIZED (DIFFUSE) SOURCE TREATMENT SYSTEMS

Narrative Question	H/M/L	Narrative Response
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	L	
Are the infrastructure requirements for this technology high, medium, or low and why?	L	
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	L	(per project)
Is the energy use of this technology high, medium, or low and why?	L	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	L	
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	L	Essentially LID technology, already well-researched.
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	L	
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	M	
Does this technology/measure provide an acceptable cost to benefit ratio?		Refer to Obj 1 Sheet.
Is this technology/measure a long-term solution or improvement?	H	
Are there readily identifiable legal constraints on this technology/measure?	L	
Are there readily identifiable political ramifications for this technology/measure?	M	
Are there likely to be unique opportunities for funding for this technology/measure?	M	
Will this approach create jobs? Of what sort?	L	
Are there identifiable social or cultural impacts from this technology/measure?	H	Technology has the potential to create landowner buy-in, education/outreach opportunities, enthusiasm for being part of the solution.
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	L	
What is the potential for unintended consequences for this technology/measure?	L	

Algal Biomass Removal/Sediment Removal/Water Column Oxidation-Sediment Sequestration (ABR/SR/WCO-SS)

Group 1 - ABR / SR / WCO-SS

Summary Criteria - Please make entries in green shaded cells only.						
Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION						
Criterion - Use Quantitatve and H/M/L Rankings		**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Comments?**	**For analysis, go to tab...**
1. Effectiveness						
a.	Total TN removed for project life (MT)	H (> 100 MT)			No	Obj 1 - Nutrients
b.	Total TP removed for project life (MT)	M (10 to 100 MT)			No	Obj 1 - Nutrients
c.	Seasonal DO improvements - indirect or direct?	L-Indirect	H-Indirect		No	Obj 2 - Water Quality
d.	Seasonal pH improvements - indirect or direct?	L-Indirect	H-Direct		No	Obj 2 - Water Quality
e.	Seasonal TSS/turbidity improvements - indirect or direct?	L-Direct	H-Direct		No	Obj 2 - Water Quality
f.	Seasonal Chl-a/algal toxin improvements - indirect or direct?	L-Direct	H-Direct		No	Obj 2 - Water Quality
2. Cost (estimated)						
a.	Total cost for project life	H ($1M to $100M)			No	Obj 1 - Nutrients
b.	Cost per unit N removal ($/kg)	L (< $10/kg)			No	Obj 1 - Nutrients
c.	Cost per unit P removal ($/kg)	M ($10 to $100/kg)			No	Obj 1 - Nutrients
3. Engineering challenges					No	Narrative Questions
4. Infrastructure challenges		H	H	H	Yes	Narrative Questions
5. Implementation timeframe		L	L	L	Yes	Narrative Questions
6. Energy Use		L	L	L	Yes	Narrative Questions
7. CO2 Loading		L	L	L	Yes	Narrative Questions
8. Compatability/synergy						
a.	With other large-scale technologies considered	H	H	H	Yes	Narrative Questions
b.	With ongoing or anticipated restoration measures	H	H	H	No	Narrative Questions
9. Risk of failure?		L	L	L	Yes	Narrative Questions
10. Need for further scientific study?		H	H		Yes	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support o aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). Could help with TMDL
potential incidental take concerns, but also clear benefit to ESA if successful so permit likely
Would be useful to have consistent units (moles, metric tons...)
Anywhere with pinch point and infrastructure could be candidate location.
Benefit to local economy (jobs) are good.
Viabiliby of use at large scalae is to find a use of biomass (or cheap disposal)

Objective 1: Reduce seasonal concentrations of nutrients - Please make entries in green shaded cells only.							
Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION							
Criterion - Use Quantitative Rankings				**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Line of Reasoning/Notes**
General Costing Info	Mole C per mole biomass			120			
	Mole N per mole biomass			16			
	Mole P per mole biomass			1			
	Barge filtration capacity (lbs wet weight/day)			200,000			
	Barge filtration capacity (lbs dry weight/day)			2,000			
	Project life (yrs)			10			
	Capital costs	Filtration barge ($)	$	250,000			
		Off-load vessel (tender) ($)	$	50,000			
		Sub-total capital costs	$	300,000			
	O&M costs	Fuel for barge and tender ($/day)	$	400			
		Maintenance for barge and tender ($/day)	$	125			
		Personnel ($/day)	$	400			
		Annual ($/yr)	$	337,625			
		Sub-total O&M ($)	$	3,376,250			
	Total cost for project life		**$**	**3,676,250**			
Unit Removal	Biomass removed (lbs/day)			2,000			
	Carbon removed (lbs/day)			1,699			
	Nitrogen removed (lbs/day)			264			
	Phosphorus removed (lbs/day)			37			
	Total TN removed for project life (MT)			**438**			
	Total TP removed for project life (MT)			**61**			
	TN unit removal cost ($/kg)		**$**	**8**			
	TP unit removal cost ($/kg)		**$**	**61**			

Comments:
Issues: Assume external load (40%) been addressed.
Not effective toward total load in UKL; disposal of biomass, energy costs.
Opportunities for biomass removal at Link at good to address OM input to Keno Reach

Group 1 - ABR / SR / WCO-SS

Objective 2: Improve overall water quality - Please make entries in green shaded cells only.					
Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION					
Criterion - Use Qualitative or H/M/L Rankings	**Klamath Lake/Eagle**	**Reservoir/Link River Dam/Keno Dam**	**Other**	**Line of Reasoning/Notes**
Dissolved Oxygen	Overall DO improvements	L	H		high rating has uncertainty depending on biomass removed (efficency/magnitude of project)
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement		Summer/Fall		
	Other				
pH	Overall pH improvements	L	H		depends on health of biomass (living and pH swings); high rating has uncertainty depending on biomass removed (efficency/magnitude of project)
	Direct or indirect effects?	Indirect	Direct		
	Season of greatest improvement		Summer/Fall		
	Other				
Temperature	Overall water temperature improvements	n/a	n/a		
	Direct or indirect effects?	n/a	n/a		
	Season of greatest improvement				
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	L	H		high rating has uncertainty depending on biomass removed (efficency/magnitude of project)
	Direct or indirect effects?	Direct	Direct		
	Season of greatest improvement		Summer/Fall		
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	L	H		high rating has uncertainty depending on biomass removed (efficency/magnitude of project)
	Direct or indirect effects?	Direct	Direct		
	Season of greatest improvement		Summer/Fall		
	Other				
Comments: Potential to return algal toxins and TP to waterbody with dewatering					

Please make entries in green shaded cells only.		
Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?		
Are the infrastructure requirements for this technology high, medium, or low and why?	H	**need pinch points**
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	L	**good immediate, short tem tool**
Is the energy use of this technology high, medium, or low and why?	L	**need motors etc**
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	L	**removed Caron but burns energy to run motors**
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	**esaily compatable with other technologies**
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	**Low at pinch points, but high in open water (UKL)**
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	H	**magnitude of biomass removal in UKL uncertain.** **Water quality after removal uncertain; are toxins, phos, etc released and returned to water?**
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	L	
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?		effect on WQ has uncertainties cause we don't have design information (Magnitude of project and location)
Does this technology/measure provide an acceptable cost to benefit ratio?		
Is this technology/measure a long-term solution or improvement?	L	
Are there readily identifiable legal constraints on this technology/measure?	H	potential incidental take concerns, but also clear benefit to ESA if successful so permit likely
Are there readily identifiable political ramifications for this technology/measure?		Depends on whose is paying
Are there likely to be unique opportunities for funding for this technology/measure?		
Will this approach create jobs? Of what sort?		
Are there identifiable social or cultural impacts from this technology/measure?		If we could turn the algae into a resource
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	H	Likely source of funding for this technology
What is the potential for unintended consequences for this technology/measure?		

Group 1 - ABR / SR / WCO-SS

Summary Criteria - please make entries in green shaded cells only.						
Technology/Measure: DREDGING						
Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions		**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Comments?**	**For detailed analysis, go to tab...**
1. Effectiveness						
a.	Total TN removed for project life (MT)	n/a	n/a	n/a	No	Obj 1 - Nutrients
b.	Total TP removed for project life (MT)	H (> 10 MT)	M (<1 to 10 MT)		No	Obj 1 - Nutrients
c.	Seasonal DO improvements - indirect or direct?	MIndirect	HIndirect		No	Obj 2 - Water Quality
d.	Seasonal pH improvements - indirect or direct?	MIndirect	HIndirect		No	Obj 2 - Water Quality
e.	Seasonal TSS/turbidity improvements - indirect or direct?	MIndirect	HIndirect		Yes	Obj 2 - Water Quality
f.	Seasonal Chl-a/algal toxin improvements - indirect or direct?	MIndirect	HIndirect		No	Obj 2 - Water Quality
2. Cost (estimated)						
a.	Total cost for project life	VH (> $100M)	H ($1M to $100M)		No	Obj 1 - Nutrients
b.	Cost per unit N removal ($/kg)	n/a	n/a	n/a	No	Obj 1 - Nutrients
c.	Cost per unit P removal ($/kg)	H (> $100/kg)	H (> $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges					No	Narrative Questions
4. Infrastructure challenges					No	Narrative Questions
5. Implementation timeframe					No	Narrative Questions
6. Energy Use					No	Narrative Questions
7. CO2 Loading					No	Narrative Questions
8. Compatability/synergy						
a.	With other large-scale technologies considered				No	Narrative Questions
c.	With ongoing or anticipated restoration measures				No	Narrative Questions
9. Risk of failure?					No	Narrative Questions
10. Need for further scientific study?					No	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses, including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake).
Want more data from Howard Bay to see if it should also be target area; Caladonia and Wokus Bay areas have Ag input to southern UKL.
Nancy Simon had maps of UKL showing contour maps of TP/Carbon/TN loads in sediments to inform discussion, but need more info for south UKL.
Concern with nesting habitat - would be further out into waterbody.
Goose Bay is Willimason delta - access available; high return on effort.
Shoal Water Bay and Ball Bay - access to landfill for dredged material.

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.						
Technology/Measure: DREDGING						
Criteria - Development of Cost Estimates			**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Line of Reasoning/Notes**
General Costing Info		Dredging area (acres)	57,328			
		Dredging depth (ft)	0.33			
		Dredging volume (yd3)	30,521,427	98,000		
		Depth of highest P concentration in sediments (cm)	10	10		
		Assumed concentration of P in sediments (mg/g dry weight)	0.6	0.6		From Simon et al. (2009)
	Capital & O&M costs	Hydraulic dredging unit cost ($/yd3)*	$ 15	$ 15		
		Hydraulic dredging cost	$ 457,821,408	$ 1,470,000	$ -	
		Total cost for project life	**$ 457,821,408**	**$ 1,470,000**	**$ -**	
Unit Removal		**Total TN removed (MT)**	**-**	**-**		
		Total TP removed (MT)**	**1,392**	**4.5**		
		Total TN removed for project life (kg)	-	-		
		Total TP removed for project life (kg)**	1,392,000	4,470	-	
		TN unit removal cost ($/kg)	-	-		
		TP unit removal cost ($/kg)**	**$ 329**	**$ 329**	**#DIV/0!**	

* Disposal cost not captured in the estimate of cost per unit removal.

** Estimates assume the same P-content of Keno Reservoir sediments as Upper Klamath Lake.

Comments:

Group 1 - ABR / SR / WCO-SS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.

Technology/Measure: DREDGING

Criteria - Use H/M/L Rankings and Narrative Descriptions		Lake, selected locations	Lake Ewauna/Keno Reservoir	Other Location	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	M	H		target high nutrient areas and expect localized biomass decrease
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
pH	Overall pH improvements	M	H		
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Temperature	Overall water temperature improvements				
	Direct or indirect effects?				
	Season of greatest improvement				
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	M	H		This is an assessment of long-term TSS/turbidity from decreased algae blooms rather than an assessment of short-term impacts due to dredging.
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	M	H		
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				

Comments:
Assumes localized dredging of UKL, not all of lake.
Suggest having pilot areas; chosen with fisheries people involved to assess effects/benefits.
Degree of biomass removal with targeted dredging is uncertain, especially how it shows with rotational dredging approach.
Slow process - so suggest doing rotatin program - do part of habitat each year, leaving other habitat areas unimpacted while doind dredging in pilot area.
Mechanics of doing dredging - pick as confined area as possible to do pilot study in west side embayment to understand hydrodynamics, etc

Summary Criteria - please make entries in green shaded cells only.

Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION

Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions		Upper Klamath Lake: whole lake alum treatment only	Lake Ewauna/Keno Reservoir: alum injection (includes oxygenation)	Copco 1 and Iron Gate Reservoirs	Comments?	For detailed analysis, go to tab...
1. Effectiveness						
a.	Total TN removed for project life (MT)	n/a	n/a	n/a	n/a	Obj 1 - Nutrients
b.	Total TP removed for project life (MT)	H (> 10 MT)	H (> 10 MT)		No	Obj 1 - Nutrients
c.	Seasonal DO improvements - indirect or direct?	HIndirect	HIndirect		Yes	Obj 2 - Water Quality
d.	Seasonal pH improvements - indirect or direct?	HDirect	HDirect		Yes	Obj 2 - Water Quality
e.	Seasonal TSS/turbidity improvements - indirect or direct?	HDirect	HDirect		No	Obj 2 - Water Quality
f.	Seasonal Chl-a/algal toxin improvements - indirect or direct?	HDirect	HDirect		No	Obj 2 - Water Quality
2. Cost (estimated)						
a.	Total cost for project life	VH (> $100M)	H ($1M to $100M)		No	Obj 1 - Nutrients
b.	Cost per unit N removal ($/kg)	n/a	n/a	n/a	n/a	Obj 1 - Nutrients
c.	Cost per unit P removal ($/kg)	H (> $100/kg)	M ($10 to $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges		L	L	L	Yes	Narrative Questions
4. Infrastructure challenges		M	M	M	Yes	Narrative Questions
5. Implementation timeframe		L	L	L	No	Narrative Questions
6. Energy Use		M	M	M	Yes	Narrative Questions
7. CO2 Loading					No	Narrative Questions
8. Compatability/synergy						
a.	With other large-scale technologies considered	M	M	M	Yes	Narrative Questions
c.	With ongoing or anticipated restoration measures	H	H	H	No	Narrative Questions
9. Risk of failure?		L	L	L	Yes	Narrative Questions
10. Need for further scientific study?		M	M	M	Yes	Narrative Questions

Comments: (is cell has alot more content than can be seen in view!!!!) Scroll down!
Oxygenation alone is doable in Keno Reservoir. For UKL, not good solution cause scale issue. Also capture of phosphaste relative to iron oxides. Oxygen alone not good apporach due to limited iron for phos sequestration; could be sufficient for ESA habitat.
Alum - Call for more information, and need for furhter understanding of technology; impacted ability to address technology potential. Need for more informtion on chemistry, scaling up to size of UKL. Pilot studies needed to determine dosage, and impact of high pH in watercolumn versus in pore water. Uncertainites relate to alum use (could change geochemistry for sediments, replace function of iron in trapping phos, humic and other ligand concentrations, uncertain),
There are other options we need to explore - PhosLock, BioChar, etc. Could we use BioChar as Ag soil amanedments to reduce runoff of nutrients.
Could genereating BioChar be done to produce electricity in basin and amend BioChar with algal biomass of soil amanedment.

Group 1 - ABR / SR / WCO-SS

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.

Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION

		Criteria - Development of Cost Estimates	Upper Klamath Lake: whole lake alum treatment only	Lake Ewauna/Keno Reservoir: alum injection (includes oxygenation)	Copco 1 and Iron Gate Reservoirs	Line of Reasoning/Notes
General Costing Info		Lake area (acres)	66000	n/a		
		Treated flow (MGD)	n/a	788		
		Alum dose required for lake (g/m2)	80	n/a		
		Alum dose required for injection (mg/L)	n/a	1.65		
		Daily area covered (acres/day)	150	n/a		
		Project life (years)	8	20		Project life for Upper Klamath Lake is estimated to be 8 to 15 years.
	Capital Costs	Alum Storage Facility ($)	incl in mobilization cc	$ 150,000		
		Mobilization ($)	$ 2,250,000	$ 741,772		Assume 8% of total project cost.
		Injection/aeration equipment	n/a	$ 4,000,000		
		Facilities building	n/a	$ 300,000		
		Sub-total Capital ($)	$ 2,250,000	$ 5,191,772	$ -	Alum injection costs are pro-rated over 20 years.
	O&M Costs	Alum cost ($/gal)	$ 1.20	$ 1.00		
		Sodium aluminate buffer cost ($/gal)	$ 2.20	$ 2.00		
		Injection equipment maintenance and replacement	n/a	$ 300		Alum injection assumes a 20 year life on equipment.
		Personnel ($/day)	n/a	$ 100		
		Annual ($/yr)	n/a	$ 4,080,000		
		Sub-Total O&M ($)	$ 177,750,000	$ 81,600,000		
		Total cost for project life	$ 180,000,000	$ 85,680,000		
Unit Removal		Days operating per year	200	200		
		Annual TP load removed (MT/yr)	70	89		
		Total TP removed for project life (MT)	560	1,771		
		Total TP removed for project life (kg) (over 10 year for UKL whole lake and 20 year operation alum injection)	699,791	1,770,909		
		TP unit removal cost ($/kg)	$ 257	$ 48		

Comments:

Objective 2: Improve overall water quality - please make entries in green shaded cells only.

Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION

	Criteria - Use H/M/L Rankings and Narrative Descriptions	Lake: whole lake alum treatment only	Lake Ewauna/Keno Reservoir: alum injection (includes oxygenation)	sequestiration above UKL (in water or soils)	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	H	H		
	Direct or indirect effects?	Indirect	Indirect		reduces biomass
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
pH	Overall pH improvements	H	H		
	Direct or indirect effects?	Direct	Direct		cause of reduced photosynthesis (and immediately buffer input)
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Temperature	Overall water temperature improvements	n/a	n/a		
	Direct or indirect effects?	n/a	n/a		
	Season of greatest improvement				
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	H	H		
	Direct or indirect effects?	Direct	Direct		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	H	H		
	Direct or indirect effects?	Direct	Direct		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				

Comments: Critical uncertainty is required biomass reduction, and agreement on what is target (Phosphorus?) and how much of a reduction is needed.
John Holz suggestions- Lake treatment in combination with installing aeration alum injection system. Floculated produce takes alage to bottom and binds with inorganic Phos on bottom; algae convert org. phos. to inorganic phos which is then bound by floculant. Concern is with total cost for fix requiring O&M every 10 yrs.
Treatement of entire lake is not needed; need better understanding of goal and how to use technology.
Oxygenation in Keno is short term fix, but also addressed BOD, pH and down river nutrient loads.

Group 1 - ABR / SR / WCO-SS

Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	L	**Low for lake, moderate for alum injection**
Are the infrastructure requirements for this technology high, medium, or low and why?	M	**for injection**
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	L	
Is the energy use of this technology high, medium, or low and why?	M	**transport of product to lake high, but boat application low**
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)		
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	M	**use with aeration etc.or as kick-start to treatment wetland effectivenes**
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	**Proven technoligy, just need to do it right.**
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	M	**Need agreement on magnitude of biomass reduction. Have to do pilot studies and dose calculations**
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	L	
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	H	
Does this technology/measure provide an acceptable cost to benefit ratio?		
Is this technology/measure a long-term solution or improvement?	M	10 yrs, but have to redo. Need to interact with external load control for long term fix.
Are there readily identifiable legal constraints on this technology/measure?		
Are there readily identifiable political ramifications for this technology/measure?	H	concern with stakeholders buy-in.
Are there likely to be unique opportunities for funding for this technology/measure?		
Will this approach create jobs? Of what sort?	M	Size of alum order could result in mfgr builiding plant in Kfalls or Yreka - jobs etc. Large potentalila benefits to improvement as related to clean water.
Are there identifiable social or cultural impacts from this technology/measure?		
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	H	
What is the potential for unintended consequences for this technology/measure?	L	Overdose inhances macrophyte growth - unlikely to so fully address TP control since open system

Group 2 - ABR / SR / WCO-SS

Summary Criteria - Please make entries in green shaded cells only.

Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION

Criterion - Use Quantitatve and H/M/L Rankings	Upper Klamath Lake	Lake Ewauna/Keno Reservoir	Other Location	Comments?	For analysis, go to tab...
1. Effectiveness					
a. Total TN removed for project life (MT)	H (> 100 MT)			No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)	M (10 to 100 MT)			No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?	L-Indirect			No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?	L-Indirect			No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?	L-Direct			No	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?	L-Direct			No	Obj 2 - Water Quality
2. Cost (estimated)					
a. Total cost for project life	H ($1M to $100M)			No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)	L (< $10/kg)			No	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)	M ($10 to $100/kg)			No	Obj 1 - Nutrients
3. Engineering challenges	L	L	L	Yes	Narrative Questions
4. Infrastructure challenges				Yes	Narrative Questions
5. Implementation timeframe	M	M	M	No	Narrative Questions
6. Energy Use	H	H	H	Yes	Narrative Questions
7. CO2 Loading	M	M	M	Yes	Narrative Questions
8. Compatability/synergy					
a. With other large-scale technologies considered	H	H	H	Yes	Narrative Questions
b. With ongoing or anticipated restoration measures	H	H	H	Yes	Narrative Questions
9. Risk of failure?	H	H	H	Yes	Narrative Questions
10. Need for further scientific study?	H	H		Yes	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake).

Objective 1: Reduce seasonal concentrations of nutrients - Please make entries in green shaded cells only.

Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION

		Criterion - Use Quantitative Rankings	Upper Klamath Lake	Lake Ewauna/Keno Reservoir	Other Location	Line of Reasoning/Notes
General Costing Info		Mole C per mole biomass	120			
		Mole N per mole biomass	16			
		Mole P per mole biomass	1			
		Barge filtration capacity (lbs wet weight/day)	200,000			
		Barge filtration capacity (lbs dry weight/day)	2,000	**100,000**		
		Project life (yrs)	10			
	Capital costs	Filtration barge ($)	$ 250,000			
		Off-load vessel (tender) ($)	$ 50,000			
		Sub-total capital costs	$ 300,000	**16,000,000**		
	O&M costs	Fuel for barge and tender ($/day)	$ 400			
		Maintenance for barge and tender ($/day)	$ 125			
		Personnel ($/day)	$ 400			
		Annual ($/yr)	$ 337,625			
		Sub-total O&M ($)	$ 3,376,250			
		Total cost for project life	**$ 3,676,250**			
Unit Removal		Biomass removed (lbs/day)	2,000			
		Carbon removed (lbs/day)	1,699			
		Nitrogen removed (lbs/day)	264			
		Phosphorus removed (lbs/day)	37			
		Total TN removed for project life (MT)	**438**			
		Total TP removed for project life (MT)	**61**			
		TN unit removal cost ($/kg)	**$ 8**			
		TP unit removal cost ($/kg)	**$ 61**			

Comments: 29 barges needed to reduce the P to the TMDL level. In column E we are basing the numbers based on Land Filtration, not the barge filtration. Land filtration is more risk for fish because of the narrow flows than with the barge filtration.

Group 2 - ABR / SR / WCO-SS

Objective 2: Improve overall water quality - Please make entries in green shaded cells only.					
Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION					
Criterion - Use Qualitative or H/M/L Rankings		**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Line of Reasoning/Notes**
Dissolved Oxygen	Overall DO improvements	L			Due to the number of barges needed to employ
	Direct or indirect effects?	Indirect			
	Season of greatest improvement	Spring			We would also inculde summer
	Other				
pH	Overall pH improvements	L			
	Direct or indirect effects?	Indirect			
	Season of greatest improvement	Spring			Same
	Other				
Temperature	Overall water temperature improvements	n/a			
	Direct or indirect effects?	n/a			
	Season of greatest improvement	None			
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	L			
	Direct or indirect effects?	Direct			
	Season of greatest improvement	Spring			Same
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	L			
	Direct or indirect effects?	Direct			
	Season of greatest improvement	Spring			Same
	Other				
Comments: These answers are dependent on how many barges are employed.					

Please make entries in green shaded cells only.		
Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	L	**The technologies are already exsisting for barge but would require engineering for the land system**
Are the infrastructure requirements for this technology high, medium, or low and why?		**L: barge; H: land**
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	
Is the energy use of this technology high, medium, or low and why?	H	**Mechanical needs**
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	M	**Burning gas; decay of algea; could compost or create biofuel; will depend on scale**
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	**Will work with other technologies (wetlands); not antagnistic with other technologies**
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	**""**
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	H	**Little confidence that all the algea could be harvested with barges. Risk for land system in M, more potential for downstream benefits.**
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	H	**For both systems**
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	L	**May need for land system**
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	L	The barges Only adressing the lake
Does this technology/measure provide an acceptable cost to benefit ratio?	L	~4 million per barge; need 29 barges; need cost info for land system
Is this technology/measure a long-term solution or improvement?	L	
Are there readily identifiable legal constraints on this technology/measure?	L	
Are there readily identifiable political ramifications for this technology/measure?	L	Barges already in place may be issue; may have positive effect
Are there likely to be unique opportunities for funding for this technology/measure?	M	May have private/publuc share
Will this approach create jobs? Of what sort?	H	
Are there identifiable social or cultural impacts from this technology/measure?	L	
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	L	Just UKL; undefined
What is the potential for unintended consequences for this technology/measure?		Shift to microsytices; potential on suckers; changing the food web; benthic make-up

Group 2 - ABR / SR / WCO-SS

Summary Criteria - please make entries in green shaded cells only.					
Technology/Measure: DREDGING					
Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions	**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Comments?**	**For detailed analysis, go to tab...**
1. Effectiveness					
a. Total TN removed for project life (MT)	n/a	n/a	n/a	No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)	H (> 10 MT)	M (<1 to 10 MT)		No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?	HIndirect			No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?	HIndirect			No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?	HIndirect			Yes	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?	HIndirect			No	Obj 2 - Water Quality
2. Cost (estimated)					
a. Total cost for project life	VH (> $100M)	H ($1M to $100M)		No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)	n/a	n/a	n/a	No	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)	H (> $100/kg)	H (> $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges	H	H	H	No	Narrative Questions
4. Infrastructure challenges	H	H	H	No	Narrative Questions
5. Implementation timeframe	M	M	M	No	Narrative Questions
6. Energy Use	H	H	H	No	Narrative Questions
7. CO2 Loading	H	H	H	Yes	Narrative Questions
8. Compatability/synergy					
a. With other large-scale technologies considered	H	H	H	Yes	Narrative Questions
c. With ongoing or anticipated restoration measures	H	H	H	No	Narrative Questions
9. Risk of failure?	H	H	H	Yes	Narrative Questions
10. Need for further scientific study?	H	H	H	Yes	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses, including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake).

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.						
Technology/Measure: DREDGING						
Criteria - Development of Cost Estimates			**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Line of Reasoning/Notes**
General Costing Info		Dredging area (acres)	57,328			
		Dredging depth (ft)	0.33			
		Dredging volume (yd3)	30,521,427	98,000		
		Depth of highest P concentration in sediments (cm)	10	10		
		Assumed concentration of P in sediments (mg/g dry weight)	0.6	0.6		From Simon et al. (2009)
	Capital & O&M costs	Hydraulic dredging unit cost ($/yd3)*	$ 15	$ 15		
		Hydraulic dredging cost	$ 457,821,408	$ 1,470,000	$ -	
		Total cost for project life	**$ 457,821,408**	**$ 1,470,000**	**$ -**	
Unit Removal		**Total TN removed (MT)**	-	-		
		Total TP removed (MT)**	**1,392**	**4.5**		
		Total TN removed for project life (kg)	-	-		
		Total TP removed for project life (kg)**	1,392,000	4,470	-	
		TN unit removal cost ($/kg)	-	-		
		TP unit removal cost ($/kg)**	**$ 329**	**$ 329**	**#DIV/0!**	

* Disposal cost not captured in the estimate of cost per unit removal.

** Estimates assume the same P-content of Keno Reservoir sediments as Upper Klamath Lake.

Comments: Using the assumed acres but cost could go down by using targeted dredging. Assuming dredging would take 5 years to do the whole lake. We question the cost of disposal of the sediment; may be contaminated (arsenic).

Group 2 - ABR / SR / WCO-SS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.					
Technology/Measure: DREDGING					
Criteria - Use H/M/L Rankings and Narrative Descriptions		**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Line of Reasoning/Notes**
Dissolved Oxygen	Overall DO improvements	H			Less P that can move to the water column; without removing the external loading the logentivity is questionable
	Direct or indirect effects?	Indirect			
	Season of greatest improvement	Summer/Fall			
	Other				
pH	Overall pH improvements	H			
	Direct or indirect effects?	Indirect			
	Season of greatest improvement	Summer/Fall			
	Other				
Temperature	Overall water temperature improvements	N/a			
	Direct or indirect effects?	n/a			
	Season of greatest improvement	n/a			
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	H			This is an assessment of long-term TSS/turbidity from decreased algae blooms rather than an assessment of short-term impacts due to dredging.
	Direct or indirect effects?	Indirect			
	Season of greatest improvement	Summer/Fall			
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	H			
	Direct or indirect effects?	Indirect			
	Season of greatest improvement	Summer/Fall			
	Other				
Comments: This rankings are under the assumption that external loading is being addressed.					

Please make entries in green shaded cells only.		
Technology/Measure: DREDGING		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	H	
Are the infrastructure requirements for this technology high, medium, or low and why?	H	
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	
Is the energy use of this technology high, medium, or low and why?	H	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	H	**Not very green**
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	**Sediment could be used in wetalnds and othe applications**
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	H	**The cost is high and the effect may not be big and this process will take a long time; loading from other sources that will reestablish the sediment**
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	H	**Effect on species; dredge fast enough that external loading is not an issue. Would be best after upstream technologies in place.**
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	L	
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	H	Not a global solution but adress multiple WQ parameters
Does this technology/measure provide an acceptable cost to benefit ratio?	L	
Is this technology/measure a long-term solution or improvement?	L	
Are there readily identifiable legal constraints on this technology/measure?	M	
Are there readily identifiable political ramifications for this technology/measure?	H	Endangered species
Are there likely to be unique opportunities for funding for this technology/measure?	L	
Will this approach create jobs? Of what sort?	H	Short term
Are there identifiable social or cultural impacts from this technology/measure?	L	
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	L	
What is the potential for unintended consequences for this technology/measure?	H	Invertabite species; arsenic; endangered species

Group 2 - ABR / SR / WCO-SS

Summary Criteria - please make entries in green shaded cells only.							
Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION							
Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions		**Upper Klamath Lake: whole lake alum treatment only**	**Lake Ewauna/Keno Reservoir: alum injection (includes oxygenation)**	**Copco 1 and Iron Gate Reservoirs**	**Comments?**	**For detailed analysis, go to tab...**
1. Effectiveness						
a.	Total TN removed for project life (MT)	n/a	n/a	n/a	n/a	Obj 1 - Nutrients
b.	Total TP removed for project life (MT)	H (> 10 MT)	H (> 10 MT)		No	Obj 1 - Nutrients
c.	Seasonal DO improvements - indirect or direct?	HIndirect	MDirect		No	Obj 2 - Water Quality
d.	Seasonal pH improvements - indirect or direct?	HIndirect	MIndirect		No	Obj 2 - Water Quality
e.	Seasonal TSS/turbidity improvements - indirect or direct?	MIndirect	HDirect		No	Obj 2 - Water Quality
f.	Seasonal Chl-a/algal toxin improvements - indirect or direct?	HIndirect	MDirect		No	Obj 2 - Water Quality
2. Cost (estimated)						
a.	Total cost for project life	VH (> $100M)	H ($1M to $100M)		No	Obj 1 - Nutrients
b.	Cost per unit N removal ($/kg)	n/a	n/a	n/a	n/a	Obj 1 - Nutrients
c.	Cost per unit P removal ($/kg)	H (> $100/kg)	M ($10 to $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges		H	H	H	No	Narrative Questions
4. Infrastructure challenges		H	H	H	Yes	Narrative Questions
5. Implementation timeframe		M	M	M	No	Narrative Questions
6. Energy Use		H	H	H	No	Narrative Questions
7. CO2 Loading		H	H	H	Yes	Narrative Questions
8. Compatability/synergy						
a.	With other large-scale technologies considered	H	H	H	No	Narrative Questions
c.	With ongoing or anticipated restoration measures	H	H	H	No	Narrative Questions
9. Risk of failure?		M	M	M	Yes	Narrative Questions
10. Need for further scientific study?		H	H	H	No	Narrative Questions
Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses, including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake).						

Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION						
Criteria - Development of Cost Estimates			**Upper Klamath Lake: whole lake alum treatment only**	**Lake Ewauna/Keno Reservoir: alum injection (includes oxygenation)**	**Copco 1 and Iron Gate Reservoirs**	**Line of Reasoning/Notes**
General Costing Info	Lake area (acres)		66000	n/a		
	Treated flow (MGD)		n/a	788		
	Alum dose required for lake (g/m2)		80	n/a		
	Alum dose required for injection (mg/L)		n/a	1.65		
	Daily area covered (acres/day)		150	n/a		
	Project life (years)		8	20		Project life for Upper Klamath Lake is estimated to be 8 to 15 years.
	Capital Costs	Alum Storage Facility ($)	incl in mobilization cc	$ 150,000		
		Mobilization ($)	$ 2,250,000	$ 741,772		Assume 8% of total project cost.
		Injection/aeration equipment	n/a	$ 4,000,000		
		Facilities building	n/a	$ 300,000		
		Sub-total Capital ($)	$ 2,250,000	$ 5,191,772	$ -	Alum injection costs are pro-rated over 20 years.
	O&M Costs	Alum cost ($/gal)	$ 1.20	$ 1.00		
		Sodium aluminate buffer cost ($/gal)	$ 2.20	$ 2.00		
		Injection equipment maintenance and replacement	n/a	$ 300		Alum injection assumes a 20 year life on equipment.
		Personnel ($/day)	n/a	$ 100		
		Annual ($/yr)	n/a	$ 4,080,000		
		Sub-Total O&M ($)	$ 177,750,000	$ 81,600,000		
	Total cost for project life		$ 180,000,000	$ 85,680,000		
Unit Removal	Days operating per year		200	200		
	Annual TP load removed (MT/yr)		70	89		
	Total TP removed for project life (MT)		560	1,771		
	Total TP removed for project life (kg) (over 10 year for UKL whole lake and 20 year operation alum injection)		699,791	1,770,909		
	TP unit removal cost ($/kg)		$ 257	$ 48		
Comments:						

Group 2 - ABR / SR / WCO-SS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.					
Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION					
Criteria - Use H/M/L Rankings and Narrative Descriptions		**Lake: whole lake alum treatment only**	**Lake Ewauna/Keno Reservoir: alum injection (includes oxygenation)**	**Copco 1 and Iron Gate Reservoirs**	**Line of Reasoning/Notes**
Dissolved Oxygen	Overall DO improvements	H	M		
	Direct or indirect effects?	Indirect	Direct		
	Season of greatest improvement	Summer/Fall	Summer/Fall		Including Spring
	Other				
pH	Overall pH improvements	H	M		
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Temperature	Overall water temperature improvements	n/a	n/a		Assuming the design of the air has post-construction cooling
	Direct or indirect effects?	n/a	n/a		
	Season of greatest improvement	n/a	n/a		
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	M	H		
	Direct or indirect effects?	Indirect	Direct		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	H	M		Distribution of Alum injection sites is dependent on local systems
	Direct or indirect effects?	Indirect	Direct		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Comments: We do not think this method will sustain itself because of external loading; and these rankings are based off of this. Will the N:P change? Effect vs. total lbs out. What needs to be done with the floc once it settles out? Where will the floc/sediment settle out; investigate floc transport and distribution. What will happen when we change the enviroenment? Will more microsyctin be produced? We think the same treatment and rankings as with Keno would be relatively the same at Copco; oxygen deplel_tion downstream may be solved from upstream treatments.					

Please make entries in green shaded cells only.		
Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	H	
Are the infrastructure requirements for this technology high, medium, or low and why?	H	**Multiple injection sites may be needed**
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	
Is the energy use of this technology high, medium, or low and why?	H	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	H	**Electric grid; transport**
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	M	**Would not be for whole lake; high as a whole lake treatment but low in Keno. Need to implement up stream tretament before implenting this technology. Operation has to stay continuous in order to be effective for DO**
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	H	
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	L	
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	H	Not global but adressing other WQ issues
Does this technology/measure provide an acceptable cost to benefit ratio?		Need more info
Is this technology/measure a long-term solution or improvement?	L	
Are there readily identifiable legal constraints on this technology/measure?	M	
Are there readily identifiable political ramifications for this technology/measure?	H	
Are there likely to be unique opportunities for funding for this technology/measure?	L	319?
Will this approach create jobs? Of what sort?	H	
Are there identifiable social or cultural impacts from this technology/measure?	M	
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	L	Better understand floc through the system
What is the potential for unintended consequences for this technology/measure?	M	Not sure how the downstream dynamics will be effected; algal dynamics. Never done this technology on a lake this big.

Group 3 - ABR / SR / WCO-SS

Summary Criteria - Please make entries in green shaded cells only.

Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION

Criterion - Use Quantitatve and H/M/L Rankings	Upper Klamath Lake	Lake Ewauna/Keno Reservoir	Other Location	Comments?	For analysis, go to tab...
1. Effectiveness					
a. Total TN removed for project life (MT)	M (10 to 100 MT)			No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)	H (> 10 MT)			No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?	H-Indirect			No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?	H-Direct			No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?	M-Direct			No	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?	H-Direct			No	Obj 2 - Water Quality
2. Cost (estimated)					
a. Total cost for project life	H ($1M to $100M)			No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)	M ($10 to $15/kg)			No	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)	M ($10 to $100/kg)			Yes	Obj 1 - Nutrients
3. Engineering challenges	L	L	L	Yes	Narrative Questions
4. Infrastructure challenges	H	H	H	Yes	Narrative Questions
5. Implementation timeframe	M	M	M	Yes	Narrative Questions
6. Energy Use	H	H	H	Yes	Narrative Questions
7. CO2 Loading	M	M	M	Yes	Narrative Questions
8. Compatability/synergy					
a. With other large-scale technologies considered	H	H	H	Yes	Narrative Questions
b. With ongoing or anticipated restoration measures	H	H	H	Yes	Narrative Questions
9. Risk of failure?	L	L	L	Yes	Narrative Questions
10. Need for further scientific study?	M	M		Yes	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake).

Objective 1: Reduce seasonal concentrations of nutrients - Please make entries in green shaded cells only.

Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION

		Criterion - Use Quantitative Rankings	Upper Klamath Lake	Lake Ewauna/Keno Reservoir	Other Location	Line of Reasoning/Notes
General Costing Info		Mole C per mole biomass	120			loss of intercellular const.
		Mole N per mole biomass	16			
		Mole P per mole biomass	1			
		Barge filtration capacity (lbs wet weight/day)	200,000			single vessel
		Barge filtration capacity (lbs dry weight/day)	2,000			
		Project life (yrs)	10			
	Capital costs	Filtration barge ($)	$ 250,000			
		Off-load vessel (tender) ($)	$ 50,000			
		Sub-total capital costs	$ 300,000			
	O&M costs	Fuel for barge and tender ($/day)	$ 400			
		Maintenance for barge and tender ($/day)	$ 125			
		Personnel ($/day)	$ 400			
		Annual ($/yr)	$ 92,500			
		Sub-total O&M ($)	$ 925,000			
		Total cost for project life	**$ 1,225,000**			
Unit Removal		Biomass removed (lbs/day)	2,000			
		Carbon removed (lbs/day)	1,699			
		Nitrogen removed (lbs/day)	264			
		Phosphorus removed (lbs/day)	37			
		Total TN removed for project life (MT)	**120**			
		Total TP removed for project life (MT)	**17**			
		TN unit removal cost ($/kg)	**$ 10**			
		TP unit removal cost ($/kg)	**$ 74**			based on this cost, per unit, 100,000 kg P in UKL, 5%/ yr over 10yrs

Comments:

Group 3 - ABR / SR / WCO-SS

Objective 2: Improve overall water quality - Please make entries in green shaded cells only.

Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION

Criterion - Use Qualitative or H/M/L Rankings		Upper Klamath Lake	Lake Ewauna/Keno Reservoir	Other Location	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	H			5% yr removal- consideration for other sites but focus on Eagle Ridge, direct effect noted for Lake Ewauna if instituted
	Direct or indirect effects?	Indirect			
	Season of greatest improvement	Summer/Fall			
	Other				
pH	Overall pH improvements	H			
	Direct or indirect effects?	Direct			
	Season of greatest improvement	Summer/Fall			
	Other				
Temperature	Overall water temperature improvements	n/a			
	Direct or indirect effects?	n/a			
	Season of greatest improvement	None			
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	M			
	Direct or indirect effects?	Direct			
	Season of greatest improvement	Summer/Fall			
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	H			
	Direct or indirect effects?	Direct			
	Season of greatest improvement	Summer/Fall			
	Other				

Comments:

Please make entries in green shaded cells only.

Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION

Narrative Question	H/M/L	Narrative Response
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	L	**There is existing technology . Assume no permits / regs - See Steve Kirk**
Are the infrastructure requirements for this technology high, medium, or low and why?	H	**Land based technology may be the prefered option. The barge option is consider to be low.**
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	**Land based technology may be the prefered option. The barge option is consider to be low.**
Is the energy use of this technology high, medium, or low and why?	H	**There maybe off-set options for energy production; algae as fuel. The land based system is assumed to be low E use; depending on the location gravity may be used pumping.**
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	M	**Algae harvesting maybe a green option depending on how the algae is used afeter harvesting. If the algae is burned then it is not a green option.**
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	**This technology does not conflict with other techs.**
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	**Not a large footprint of the technology. If the land based technology is sited on the ridge there is nothing there to conflict with the operation.**
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	**Would need to do proper modeling ahead of time to test feasaility - See Tammy Wood. Are we on target for 5% / year for 10 years? And does that yeild a benefit?**
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	M	**The tools exist and are currently being utilized, may need additional modeling.**
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	L	**If the technology is land based - H**
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	H	
Does this technology/measure provide an acceptable cost to benefit ratio?	H	
Is this technology/measure a long-term solution or improvement?	M	Over 10 year we may be able to re-set the system, it must be coupled with upstream BMPs
Are there readily identifiable legal constraints on this technology/measure?	H	May have ESA concerns, water rights, permitting
Are there readily identifiable political ramifications for this technology/measure?	H	Competition with current harvesters and farmers
Are there likely to be unique opportunities for funding for this technology/measure?	H	There may be cost off-sets; KlamTAP? There are markets that are currently available for algae (ferts, energy)
Will this approach create jobs? Of what sort?	H	There may be seasonal and high-tech opportunities for the community.
Are there identifiable social or cultural impacts from this technology/measure?	M	The score is based on a positive evaluation
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	H	The technology will reduce downstream loads, improving WQ for salmonids and allowing for upstream migration to the upper tribs
What is the potential for unintended consequences for this technology/measure?	L	Bycatch of suckers, perhaps? The technology would need to be screened.

Group 3 - ABR / SR / WCO-SS

Summary Criteria - please make entries in green shaded cells only.

Technology/Measure: DREDGING

Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions	Upper Klamath Lake	Lake Ewauna/Keno Reservoir	Other Location	Comments?	For detailed analysis, go to tab...
1. Effectiveness					
a. Total TN removed for project life (MT)	n/a	n/a	n/a	No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)	H (> 10 MT)	M (<1 to 10 MT)	H (> 10 MT)	No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?	MIndirect	MIndirect		No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?	MIndirect	MIndirect		No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?	MIndirect	MIndirect		Yes	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?	HIndirect	HIndirect		No	Obj 2 - Water Quality
2. Cost (estimated)					
a. Total cost for project life	VH (> $100M)	H ($1M to $100M)		No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)	n/a	n/a	n/a	No	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)	H (> $100/kg)	H (> $100/kg)		Yes	Obj 1 - Nutrients
3. Engineering challenges	H	H	H	Yes	Narrative Questions
4. Infrastructure challenges	H	H	H	Yes	Narrative Questions
5. Implementation timeframe	M	M	M	Yes	Narrative Questions
6. Energy Use	H	H	H	No	Narrative Questions
7. CO2 Loading	H	H	H	Yes	Narrative Questions
8. Compatability/synergy					
a. With other large-scale technologies considered	H	H	H	Yes	Narrative Questions
c. With ongoing or anticipated restoration measures	L	L	L	Yes	Narrative Questions
9. Risk of failure?	L	L	L	Yes	Narrative Questions
10. Need for further scientific study?	H	H	H	Yes	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses, including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake). We assume that the project, if properly implemented, would be a short-term project (~4 years).

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.

Technology/Measure: DREDGING

		Criteria - Development of Cost Estimates	Upper Klamath Lake	Lake Ewauna/Keno Reservoir	Other Location	Line of Reasoning/Notes
General Costing Info		Dredging area (acres)	6,000			Assume 10% area of the basin
		Dredging depth (ft)	1			
		Dredging volume (yd3)	9,680,000	98,000		
		Depth of highest P concentration in sediments (cm)	10	10		
		Assumed concentration of P in sediments (mg/g dry weight)	0.6	0.6		From Simon et al. (2009)
	Capital & O&M costs	Hydraulic dredging unit cost ($/yd3)*	$ 150	$ 150		Additional cost for off-set desposal, containments ponds, and testing for toxic materials
		Hydraulic dredging cost	$ 1,452,000,000	$ 14,700,000	$ -	
		Total cost for project life	**$ 1,452,000,000**	**$ 14,700,000**	**$ -**	
Unit Removal		**Total TN removed (MT)**	-	-		
		Total TP removed (MT)**	**211**	**2.1**		Changed the value based on targeted remove .3 meter depth and 6,000 mg/square meter
		Total TN removed for project life (kg)	-	-		
		Total TP removed for project life (kg)**	211,000	2,136	-	
		TN unit removal cost ($/kg)	-	-		
		TP unit removal cost ($/kg)**	**$ 6,882**	**$ 6,882**	**#DIV/0!**	**Check the formulas in this sheet!! Seems too high.**

* Disposal cost not captured in the estimate of cost per unit removal.

** Estimates assume the same P-content of Keno Reservoir sediments as Upper Klamath Lake.

Comments:

Group 3 - ABR / SR / WCO-SS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.					
Technology/Measure: DREDGING					
Criteria - Use H/M/L Rankings and Narrative Descriptions		Upper Klamath Lake	Lake Ewauna/Keno Reservoir	Other Location	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	M	M		Internal load are approx 61%
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
pH	Overall pH improvements	M	M		
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Temperature	Overall water temperature improvements	n/a	n/a		
	Direct or indirect effects?	n/a	n/a		
	Season of greatest improvement	n/a	n/a		
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	M	M		This is an assessment of long-term TSS/turbidity from decreased algae blooms rather than an assessment of short-term impacts due to dredging.
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	H	H		
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Comments:					

Please make entries in green shaded cells only.		
Technology/Measure: DREDGING		
Narrative Question	H/M/L	Narrative Response
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	H	Due to the land based system need to deposit sediment and permitting and toxic screening.
Are the infrastructure requirements for this technology high, medium, or low and why?	H	waste disposal; lots of land
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	2 - 10 years, mobilization and site selections, infastucture
Is the energy use of this technology high, medium, or low and why?	H	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	H	transport of material, but may be able to use the material as a soil admendment. The material would need testing.
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	Good fit, but the cost, permits and regs may be prohibative
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	L	See above
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	Risk of failure is dependant the effectivness of the pre-project site selection
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	H	Need modeling work and efficient site selection and testing of the material
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	L	
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	M	May address legacy sediments and internal load if the sites selection is accurate
Does this technology/measure provide an acceptable cost to benefit ratio?	L	The cost is high...without considering the externalities (toxins, off-site removal, trucking)
Is this technology/measure a long-term solution or improvement?	H	
Are there readily identifiable legal constraints on this technology/measure?	H	Permits and regs and possible regs for disposal
Are there readily identifiable political ramifications for this technology/measure?	H	
Are there likely to be unique opportunities for funding for this technology/measure?	L	
Will this approach create jobs? Of what sort?	L	
Are there identifiable social or cultural impacts from this technology/measure?	H	
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	H	
What is the potential for unintended consequences for this technology/measure?	H	Toxins for the material and off-site disposal

Group 4 - ABR / SR / WCO-SS

Reporting - 9-12-12

General Notes:

- Technologies are not a silver bullet, but rather assumed that any activities would be couched in a watershed scale effort to assure that any one activity would be benefiting by other activities (e.g. Upstream). Specifically that external reductions in P would be carried out in concert with these technologies.
- All activities would have a longer-term impact, i.e., it will take time, possibly a long time to arrive at improvement
- There was prodigious discussion on a wide range of topics in an effort to address elements of the workbook: basic assumptions, individuals experience, information gaps (to answer the questions at hand), etc.
- Everything in Upper Klamath Lake, unless noted. Spent less time on Keno.

In sum:

- algae removal - worth continuing to explore
- alum application - probably infeasible, but perhaps a pilot to explore methods
- oxygenation - not addressed
- dredging - largely infeasible

____

Algal Filtration:

Objective: reduce nutrients in Upper Klamath Lake, reduce oxygen demand below Link

Feasibility: Feasible, but many questions.

Effect: potentially high, but need more information (specific technical data)

##Upper Klamath Lake

Key questions/comments

- Once algae is removed, algae may replace it until sufficient P is removed from the system; so, may not see immediate impact.

- **Need to determine the amount of tons of P and N removed with per ton of algae removed to have an effect or desired effect

- May be an economic element when utilizing removed algae

- Question about potential to impact fish species with use of algae removal. - -

- Redo economic analysis once questions are answered.

- There is a need for a model for P in the system **A pilot study is recommended

Barge

- Questions about draft of barge and ability to filter/remove in shallow areas. - Question about how much a barge can collect in a day, hour, etc. Need to confirm that algae collected is not toxic to determine future use versus disposal.

-Target areas of greatest accumulation

- Estimated 20,000-25,000 tons wet algae per month in summer months in Upper Klamath Lake

- Data shows 30 metric tons of total P in Upper Klamath Lake outflow (monthly mean value for 1991-2010 period) in June and July.

- If 4 tons of P removed in season, not so great; however, if 40 tons of P removed, may be worth it. At peaks, data shows there is 100 metric tons of P in Upper Klamath Lake.

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- Technology while feasible, may not be implementable in some areas due to screening requirements associated with screening requirements, etc. (e.g., sucker larval stage); may work with barge at surface, but maybe not with screen of flow (or target time when larval suckers are no longer present – adaptive each year based on surveys).

Link

Another location to consider would be Link Dam, where it would need to be done each year. Question about whether it makes sense to target area below Link Dam (screen outlet) due to oxygen problems, as an interim measure, recognizing also need to address source coming from Upper Klamath Lake (will take time). Recognize sensitivity of working in Link River corridor.

Summary:

Algal Filtration: Feasible, but many questions. Another location to consider would be Link Dam, where it would need to be done each year. Question about whether it makes sense to target area below Link Dam (screen outlet) due to oxygen problems, as an interim measure, recognizing also need to address source coming from Upper Klamath Lake (will take time). Recognize sensitivity of working in Link River corridor. 20,000-25,000 tons wet algae per month in summer months in Upper Klamath Lake. Question about the extent to which once algae is removed, whether more algae will replace it until sufficient P is removed from the system; so, may not see immediate impact. Questions about draft of barge and ability to filter/remove in shallow areas. Question about how much a barge can collect in a day, hour, etc. Need to confirm that algae collected is not toxic to determine future use versus disposal. Need to determine the amount of tons of P and N removed with per ton of algae removed. Data shows 30 metric tons of total P in Upper Klamath Lake outflow (monthly mean value for 1991-2010 period) in June and July. Need the P budget of lake. If 4 tons of P removed in season, not so great; however, if 40 tons of P removed, may be worth it. Target areas of greatest accumulation. At peaks, data shows there is 100 metric tons of P in Upper Klamath Lake. Suggest model be developed to see how algae removal over time would impact internal loads of P to system. Question about potential to impact fish species with use of algae removal. Redo economic analysis once questions are answered. Technology while feasible, may not be implementable in some areas due to screening requirements associated with screening requirements, etc. (e.g., sucker larval stage); may work with barge at surface, but maybe not with screen of flow (or target time when larval suckers are no longer present – adaptive each year based on surveys).

Oxygenation/Sediment Sequestration:

Objective: phosphorus reduction

Feasibility: Feasible, but many questions.

Effect: Modest, but may be minimal

Feasible, but may not be effective.

Key questions/comments:

- What is pH of sediment?
- What will happen to Al and resuspension potential? Wind driven system.
- Large scale concerns (rate of application, amount, persistence) Cultural/Social/Political issues of Al addition
    - Educational element, not only for cultural/social/political, but for effectiveness and expectation.
- Case studies: Big Bear (3000 acres), Grand Lake (10,000 acres)

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- May be worth conducting a pilot study on a small scale.

Summary:
Oxygenation/Sediment Sequestration: Concerned about introducing Al. What is pH of sediment? What will happen to Al and resuspension potential? May be worth conducting a pilot study on a small scale. Scale of problem is so large that it may not be workable. May not be socially or politically viable; in general, tribes do not support addition of chemicals to water. Not effective, at least visually, in Big Bear (potential case study). Importance of good education program for any technology to set expectations for community that benefits will take time (i.e., things will not happen immediately). Another case study is Grand Lake Saint Mary's (Ohio). Wind or currents in lakes that move sediments may make application of alum less beneficial because alum not remaining in place to capture releases from sediments.

__________________.

Dredging:
Objective: Phosphorus removal to reduce algal blooms, specifically the first bloom.
Feasibility: Infeasible
Effect: n/a

Generally had similar discussion as with alum treatment (spatial and temporal issues), costs, and effectiveness.

- could take decades to skim 10 cm out of the lake
- identified constraints/issues
    - ice,
    - fisheries impacts
    - depth
    - location
    - contaminants (would require sampling)
    - modifications Upper Klamath Lake storage under KBRA
- Just a giant effort and a partial dredging solution was not pursued because we felt unable to identify a "critical" area to have a desired effect.
- May be an application in Keno, but no objective - reason - was identified at this time. Keep on table for Keno to consider under potential future prescriptions.

Summary:
Dredging: Comments: If KHSA/KBRA implemented, would add an additional 90,000+ acre-feet of water or ~10 percent increase in area. Questions pertaining to reuse of dredged material. Goal would be to remove sufficient material to short circuit first algal bloom. Concerns about dredging Keno due to contaminants; would recommend testing to see if pesticides, arsenic, etc. are present and levels. Idea to potentially try on pilot basis in Howard Bay to see if improvement. At this point, group thinks this technology is infeasible. Organic matter coming out of Upper Klamath Lake needs to be addressed first because it overwhelms the rest of the watershed (e.g., Keno and beyond). Implemented, would add an additional 90,000+ acre-feet of water or ~10 percent increase in area. Questions pertaining to reuse of dredged material. Goal would be to remove sufficient material to short circuit first algal bloom. Concerns about dredging Keno due to contaminants; would recommend testing to see if pesticides, arsenic, etc. are present and levels. Idea to potentially try on pilot basis in Howard Bay to see if improvement. At this point, group thinks this technology is infeasible. Organic matter coming out of Upper Klamath Lake needs to be addressed first because it overwhelms the rest of the watershed (e.g., Keno and beyond).

Group 4 - ABR / SR / WCO-SS

Summary Criteria - Please make entries in green shaded cells only.					
Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION					
Criterion - Use Quantitatve and H/M/L Rankings	**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Comments?**	**For analysis, go to tab...**
1. Effectiveness					
a. Total TN removed for project life (MT)	H (> 100 MT)			No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)	M (10 to 100 MT)			No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?				No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?				No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?				No	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?				No	Obj 2 - Water Quality
2. Cost (estimated)					
a. Total cost for project life	H ($1M to $100M)			No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)	L (< $10/kg)			No	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)	M ($10 to $100/kg)			No	Obj 1 - Nutrients
3. Engineering challenges				No	Narrative Questions
4. Infrastructure challenges				No	Narrative Questions
5. Implementation timeframe				No	Narrative Questions
6. Energy Use				No	Narrative Questions
7. CO2 Loading				No	Narrative Questions
8. Compatability/synergy					
a. With other large-scale technologies considered				No	Narrative Questions
b. With ongoing or anticipated restoration measures				No	Narrative Questions
9. Risk of failure?				No	Narrative Questions
10. Need for further scientific study?				No	Narrative Questions

Comments: Feasible, but many questions. Another location to consider would be Link Dam, where it would need to be done each year. Question about whether it makes sense to target area below Link Dam (screen outlet) due to oxygen problems, as an interim measure, recognizing also need to address source coming from Upper Klamath Lake (will take time). Recognize sensitivity of working in Link River corridor. 20,000-25,000 tons wet algae per month in Summer months in Upper Klamath Lake. Question about the extent to which once algae is removed, whether more algae will replace it until sufficient P is removed from the system; so, may not see immediate impact. Questions about draft of barge and ability to filter/remove in shallow areas. Question about how much a barge can collect in a day, hour, etc. Need to confirm that algae collected is not toxic to determine future use versus disposal. Need to determine the amount of tons of P and N removed with per ton of algae removed. Data shows 30 metric tons of total P in Upper Klamath Lake outflow (monthly mean value for 1991-2010 period) in June and July. Need the P budget of lake. If 4 tons of P removed in season, not so great; however, if 40 tons of P removed, may be worth it. Target areas of greatest accumulation. At peaks, data shows there is 100 metric tons of P in Upper Klamath Lake. Suggest model be developed to see how algae removal over time would impact internal loads of P to system. Question about potential to impact fish species with use of algae removal. Redo economic analysis once questions are answered. Technology while feasible, may not be implementable in some areas due to screening requirements associated with screening requirements, etc. (e.g., sucker larval stage); may work with barge at surface, but maybe not with screen of flow (or target time when larval suckers are no longer present – adaptive each year based on surveys).

Group 4 - ABR / SR / WCO-SS

Objective 1: Reduce seasonal concentrations of nutrients - Please make entries in green shaded cells only.						
Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION						
Criterion - Use Quantitative Rankings			**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Line of Reasoning/Notes**
General Costing Info		Mole C per mole biomass	120			
		Mole N per mole biomass	16			
		Mole P per mole biomass	1			
		Barge filtration capacity (lbs wet weight/day)	200,000			
		Barge filtration capacity (lbs dry weight/day)	2,000			
		Project life (yrs)	10			
	Capital costs	Filtration barge ($)	$ 250,000			
		Off-load vessel (tender) ($)	$ 50,000			
		Sub-total capital costs	$ 300,000			
	O&M costs	Fuel for barge and tender ($/day)	$ 400			
		Maintenance for barge and tender ($/day)	$ 125			
		Personnel ($/day)	$ 400			
		Annual ($/yr)	$ 337,625			
		Sub-total O&M ($)	$ 3,376,250			
		Total cost for project life	**$ 3,676,250**			
Unit Removal		Biomass removed (lbs/day)	2,000			
		Carbon removed (lbs/day)	1,699			
		Nitrogen removed (lbs/day)	264			
		Phosphorus removed (lbs/day)	37			
		Total TN removed for project life (MT)	**438**			
		Total TP removed for project life (MT)	**61**			
		TN unit removal cost ($/kg)	**$ 8**			
		TP unit removal cost ($/kg)	**$ 61**			

Comments: Feasible, but many questions. Another location to consider would be Link Dam, where it would need to be done each year. Question about whether it makes sense to target area below Link Dam (screen outlet) due to oxygen problems, as an interim measure, recognizing also need to address source coming from Upper Klamath Lake (will take time). Recognize sensitivity of working in Link River corridor. 20,000-25,000 tons wet algae per month in Summer months in Upper Klamath Lake. Question about the extent to which once algae is removed, whether more algae will replace it until sufficient P is removed from the system; so, may not see immediate impact. Questions about draft of barge and ability to filter/remove in shallow areas. Question about how much a barge can collect in a day, hour, etc. Need to confirm that algae collected is not toxic to determine future use versus disposal. Need to determine the amount of tons of P and N removed with per ton of algae removed. Data shows 30 metric tons of total P in Upper Klamath Lake outflow (monthly mean value for 1991-2010 period) in June and July. Need the P budget of lake. If 4 tons of P removed in season, not so great; however, if 40 tons of P removed, may be worth it. Target areas of greatest accumulation. At peaks, data shows there is 100 metric tons of P in Upper Klamath Lake. Suggest model be developed to see how algae removal over time would impact internal loads of P to system. Question about potential to impact fish species with use of algae removal. Redo economic analysis once questions are answered. Technology while feasible, may not be implementable in some areas due to screening requirements associated with screening requirements, etc. (e.g., sucker larval stage); may work with barge at surface, but maybe not with screen of flow (or target time when larval suckers are no longer present – adaptive each year based on surveys).

Group 4 - ABR / SR / WCO-SS

Summary Criteria - please make entries in green shaded cells only.

Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION

Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions		Upper Klamath Lake: whole lake alum treatment only	Lake Ewauna/Keno Reservoir: alum injection (includes oxygenation)	Copco 1 and Iron Gate Reservoirs	Comments?	For detailed analysis, go to tab...
1. Effectiveness						
a.	Total TN removed for project life (MT)	n/a	n/a	n/a	n/a	Obj 1 - Nutrients
b.	Total TP removed for project life (MT)	H (> 10 MT)	H (> 10 MT)		No	Obj 1 - Nutrients
c.	Seasonal DO improvements - indirect or direct?				No	Obj 2 - Water Quality
d.	Seasonal pH improvements - indirect or direct?				No	Obj 2 - Water Quality
e.	Seasonal TSS/turbidity improvements - indirect or direct?				No	Obj 2 - Water Quality
f.	Seasonal Chl-a/algal toxin improvements - indirect or direct?				No	Obj 2 - Water Quality
2. Cost (estimated)						
a.	Total cost for project life	VH (> $100M)	H ($1M to $100M)		No	Obj 1 - Nutrients
b.	Cost per unit N removal ($/kg)	n/a	n/a	n/a	n/a	Obj 1 - Nutrients
c.	Cost per unit P removal ($/kg)	H (> $100/kg)	M ($10 to $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges					No	Narrative Questions
4. Infrastructure challenges					No	Narrative Questions
5. Implementation timeframe					No	Narrative Questions
6. Energy Use					No	Narrative Questions
7. CO2 Loading					No	Narrative Questions
8. Compatability/synergy						
a.	With other large-scale technologies considered				No	Narrative Questions
c.	With ongoing or anticipated restoration measures				No	Narrative Questions
9. Risk of failure?					No	Narrative Questions
10. Need for further scientific study?					No	Narrative Questions

Comments: Concerned about introducing Al. What is pH of sediment? What will happened to Al and resuspension potential? May be worth conduting a pilot study on a small scale. Scale of problem is so large that it may not be workable. May not be socially or politically viable; in general, tribes do not support addition of chemicals to water. Not effective, at least visually, in Big Bear (potential case study). Importance of good education program for any technology to set expectations for community that benefits will take time (i.e., things will not happen immediately). Another case study is Grand Lake Saint Mary's (Ohio). Wind or currents in lakes that move sediments may make application of alum less beneficial because alum not remaining in place to capture releases from sediments.

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.

Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION

Criteria - Development of Cost Estimates			Upper Klamath Lake: whole lake alum treatment only	Lake Ewauna/Keno Reservoir: alum injection (includes oxygenation)	Copco 1 and Iron Gate Reservoirs	Line of Reasoning/Notes
General Costing Info		Lake area (acres)	66000	n/a		
General Costing Info		Treated flow (MGD)	n/a	788		
General Costing Info		Alum dose required for lake (g/m2)	80	n/a		
General Costing Info		Alum dose required for injection (mg/L)	n/a	1.65		
General Costing Info		Daily area covered (acres/day)	150	n/a		
General Costing Info		Project life (years)	8	20		Project life for Upper Klamath Lake is estimated to be 8 to 15 years.
General Costing Info	Capital Costs	Alum Storage Facility ($)	incl in mobilization cc	$ 150,000		
General Costing Info	Capital Costs	Mobilization ($)	$ 2,250,000	$ 741,772		Assume 8% of total project cost.
General Costing Info	Capital Costs	Injection/aeration equipment	n/a	$ 4,000,000		
General Costing Info	Capital Costs	Facilities building	n/a	$ 300,000		
General Costing Info	Capital Costs	Sub-total Capital ($)	$ 2,250,000	$ 5,191,772	$ -	Alum injection costs are pro-rated over 20 years.
General Costing Info	O&M Costs	Alum cost ($/gal)	$ 1.20	$ 1.00		
General Costing Info	O&M Costs	Sodium aluminate buffer cost ($/gal)	$ 2.20	$ 2.00		
General Costing Info	O&M Costs	Injection equipment maintenance and replacement	n/a	$ 300		Alum injection assumes a 20 year life on equipment.
General Costing Info	O&M Costs	Personnel ($/day)	n/a	$ 100		
General Costing Info	O&M Costs	Annual ($/yr)	n/a	$ 4,080,000		
General Costing Info	O&M Costs	Sub-Total O&M ($)	$ 177,750,000	$ 81,600,000		
General Costing Info		Total cost for project life	$ 180,000,000	$ 85,680,000		
Unit Removal		Days operating per year	200	200		
Unit Removal		Annual TP load removed (MT/yr)	70	89		
Unit Removal		Total TP removed for project life (MT)	560	1,771		
Unit Removal		Total TP removed for project life (kg) (over 10 year for UKL whole lake and 20 year operation alum injection)	699,791	1,770,909		
Unit Removal		TP unit removal cost ($/kg)	$ 257	$ 48		

Comments:

Group 4 - ABR / SR / WCO-SS

Summary Criteria - please make entries in green shaded cells only.					
Technology/Measure: DREDGING					
Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions	**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Comments?**	**For detailed analysis, go to tab...**
1. Effectiveness					
a. Total TN removed for project life (MT)	n/a	n/a	n/a	No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)	H (> 10 MT)	M (<1 to 10 MT)		No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?	Indirect			No	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?				No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?				Yes	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?				No	Obj 2 - Water Quality
2. Cost (estimated)					
a. Total cost for project life	VH (> $100M)	H ($1M to $100M)		No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)	n/a	n/a	n/a	No	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)	H (> $100/kg)	H (> $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges	M	M	M	Yes	Narrative Questions
4. Infrastructure challenges	H	H	H	Yes	Narrative Questions
5. Implementation timeframe	M	M	M	No	Narrative Questions
6. Energy Use	H	H	H	No	Narrative Questions
7. CO2 Loading	H	H	H	No	Narrative Questions
8. Compatability/synergy					
a. With other large-scale technologies considered	M	M	M	Yes	Narrative Questions
c. With ongoing or anticipated restoration measures	L	L	L	No	Narrative Questions
9. Risk of failure?	H	H	H	Yes	Narrative Questions
10. Need for further scientific study?	L	L	L	No	Narrative Questions

Comments: If KHSA/KBRA implemented, would add an additional 90,000+ acre-feet of water or ~10 percent increase in area. Questions pertaining to reuse of dredged material. Goal would be to remove sufficient material to short circuit first algal bloom. Concerns about dredging Keno due to contaminants; would recommend testing to see if pesticides, arsenic, etc. are present and levels. Idea to potentially try on pilot basis in Howard Bay to see if improvement. At this point, group thinks this technology is infeasible. Organic matter coming out of Upper Klamath Lake needs to be addressed first because it overwhelms the rest of the watershed (e.g., Keno and beyond).

Objective 2: Improve overall water quality - please make entries in green shaded cells only.					
Technology/Measure: DREDGING					
Criteria - Use H/M/L Rankings and Narrative Descriptions		**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Line of Reasoning/Notes**
Dissolved Oxygen	Overall DO improvements				Effect on DO will vary due to frequency and amount dredged; external loading will bring back without additional maintenance. If knock down first bloom, assume High effect that year.
	Direct or indirect effects?	Indirect			
	Season of greatest improvement				
	Other				
pH	Overall pH improvements				
	Direct or indirect effects?				
	Season of greatest improvement				
	Other				
Temperature	Overall water temperature improvements				
	Direct or indirect effects?				
	Season of greatest improvement				
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements				This is an assessment of long-term TSS/turbidity from decreased algae blooms rather than an assessment of short-term impacts due to dredging.
	Direct or indirect effects?				
	Season of greatest improvement				
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements				
	Direct or indirect effects?				
	Season of greatest improvement				
	Other				
Comments:					

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Please make entries in green shaded cells only.		
Technology/Measure: DREDGING		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low	**M**	**Disposal and determining target location for dredging.**
Are the infrastructure requirements for this technology high, medium, or low and why?	**H**	**Takes land for disposal and barges/equipment for dredging.**
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	**M**	
Is the energy use of this technology high, medium, or low and why?	**H**	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	**H**	
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	M	**Maybe a good fit with other technologies; however, more questions arising due to howsediments become resuspended and move within the lake and ability of sediments to move with currents and wind action.**
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	L	
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	H	**You can do it, but the water quality improvement has a high risk of failure. The number of dredge days (one dredge) assumed to be 13,300 for the entire Upper Klamath Lake. (Assumes 30,000 cubic yards with a 12-hour day.) Can only be done for 100 days out of year due to weather constraints, fish species, etc.**
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	L	
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?		
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?		
Does this technology/measure provide an acceptable cost to benefit ratio?		
Is this technology/measure a long-term solution or improvement?		
Are there readily identifiable legal constraints on this technology/measure?		
Are there readily identifiable political ramifications for this technology/measure?		
Are there likely to be unique opportunities for funding for this technology/measure?		
Will this approach create jobs? Of what sort?		
Are there identifiable social or cultural impacts from this technology/measure?		
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate		
What is the potential for unintended consequences for this technology/measure?		

Group 5 - ABR / SR / WCO-SS

Summary Criteria - Please make entries in green shaded cells only.					
Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION					
Criterion - Use Quantitatve and H/M/L Rankings	**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Comments?**	**For analysis, go to tab...**
1. Effectiveness					
a. Total TN removed for project life (MT)	H (> 100 MT)			No	Obj 1 - Nutrients
b. Total TP removed for project life (MT)	M (10 to 100 MT)			No	Obj 1 - Nutrients
c. Seasonal DO improvements - indirect or direct?	L-Indirect	H-Indirect		Yes	Obj 2 - Water Quality
d. Seasonal pH improvements - indirect or direct?	L-n/a	L-n/a		No	Obj 2 - Water Quality
e. Seasonal TSS/turbidity improvements - indirect or direct?	L-Direct	H-Direct		No	Obj 2 - Water Quality
f. Seasonal Chl-a/algal toxin improvements - indirect or direct?	L-Direct	M-Direct		No	Obj 2 - Water Quality
2. Cost (estimated)					
a. Total cost for project life	H ($1M to $100M)			No	Obj 1 - Nutrients
b. Cost per unit N removal ($/kg)	L (< $10/kg)			No	Obj 1 - Nutrients
c. Cost per unit P removal ($/kg)	M ($10 to $100/kg)			No	Obj 1 - Nutrients
3. Engineering challenges	H	H	H	Yes	Narrative Questions
4. Infrastructure challenges	L	L	L	Yes	Narrative Questions
5. Implementation timeframe	M	M	M	Yes	Narrative Questions
6. Energy Use	M	M	M	Yes	Narrative Questions
7. CO2 Loading	L	L	L	Yes	Narrative Questions
8. Compatability/synergy					
a. With other large-scale technologies considered	H	H	H	Yes	Narrative Questions
b. With ongoing or anticipated restoration measures	H	H	H	Yes	Narrative Questions
9. Risk of failure?	M	M	M	Yes	Narrative Questions
10. Need for further scientific study?	L	L		Yes	Narrative Questions
Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses (Objective 3), including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake).					

Objective 1: Reduce seasonal concentrations of nutrients - Please make entries in green shaded cells only.							
Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION							
Criterion - Use Quantitative Rankings				**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Line of Reasoning/Notes**
General Costing Info		Mole C per mole biomass		120			
		Mole N per mole biomass		16			
		Mole P per mole biomass		1			
		Barge filtration capacity (lbs wet weight/day)		200,000			how much algea is in the lake? What is the daily algea production. How much algea is being exported into the Klamath rivers. How much peak needs to be removed from the first bloom to make an impact to the blue green algea. What is he removal objective?
		Barge filtration capacity (lbs dry weight/day)		2,000			
		Project life (yrs)		10			
	Capital costs	Filtration barge ($)	$	250,000			we are not just talking about barges, there are other filtration methods for algea that don't involve barges.
		Off-load vessel (tender) ($)	$	50,000			
		Sub-total capital costs	$	300,000			
	O&M costs	Fuel for barge and tender ($/day)	$	400			
		Maintenance for barge and tender ($/day)	$	125			
		Personnel ($/day)	$	400			
		Annual ($/yr)	$	337,625			
		Sub-total O&M ($)	$	3,376,250			
		Total cost for project life	**$**	**3,676,250**			
Unit Removal		Biomass removed (lbs/day)		2,000			
		Carbon removed (lbs/day)		1,699			
		Nitrogen removed (lbs/day)		264			How much N do you want remove?
		Phosphorus removed (lbs/day)		37			How much P do you want to remove?
		Total TN removed for project life (MT)		**438**			
		Total TP removed for project life (MT)		**61**			
		TN unit removal cost ($/kg)	**$**	**8**			
		TP unit removal cost ($/kg)	**$**	**61**			
Comments: there needs to be mutiple locations with both mobil and fix technologies for this to be effective. Need at least 1 fixed ttechnology to prevent algea getting into lake Ahwana. What is the reltative flow from A canal to the river? What is the cost profile of the land based system.							

Group 5 - ABR / SR / WCO-SS

Objective 2: Improve overall water quality - Please make entries in green shaded cells only.

Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION

Criterion - Use Qualitative or H/M/L Rankings		Upper Klamath Lake	Lake Ewauna/Keno Reservoir	Other Location	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	L	H		
	Direct or indirect effects?	Indirect	Indirect		indirect because we are not adding oxygen we are removing a demand.
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
pH	Overall pH improvements	L	L		
	Direct or indirect effects?	n/a	n/a		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Temperature	Overall water temperature improvements	L	L		
	Direct or indirect effects?	n/a	n/a		
	Season of greatest improvement	None	None		
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	L	H		How fast is the regrowth as it effect TSS and turbidity.
	Direct or indirect effects?	Direct	Direct		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	L	M		depends upon technology.
	Direct or indirect effects?	Direct	Direct		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				

Comments:

Please make entries in green shaded cells only.

Technology/Measure: ALGAE BIOMASS REMOVAL VIA FILTRATION

Narrative Question	H/M/L	Narrative Response
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	H	**Due to the amount of algea needed to be removed to make a significant change.**
Are the infrastructure requirements for this technology high, medium, or low and why?	L	**Existing infrastructure is in place to accomdate this technology.**
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	**Time for permitting and planning.**
Is the energy use of this technology high, medium, or low and why?	M	**Staging and locations for the algea use would most likely be within a 10 to 20 mile radius.**
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	L	**low for the filtration technology.**
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	H	**Yes, there are hybrids that could be utilized along with this technology to assist in lake improvements. For example wetland restoration.**
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	H	**Yes, there are hybrids that could be utilized along with this technology to assist in lake improvements. For example wetland restoration.**
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	M	**High if stand alone, medium if coupled with other technologies. The quantity you'd have to remove at link dam is much less than what you'd have to remove in the lake, so this technology may be better suited for link dam area.**
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	L	**Amount of scientific study is low but engineering may be high.**
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	L	**no. It is an export of what though.**
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?	L	Yes, it does assist with other water quality problems. No it isnt a global solution.
Does this technology/measure provide an acceptable cost to benefit ratio?		
Is this technology/measure a long-term solution or improvement?	L	It isnt a long term solution.
Are there readily identifiable legal constraints on this technology/measure?	L	no.
Are there readily identifiable political ramifications for this technology/measure?	L	no.
Are there likely to be unique opportunities for funding for this technology/measure?		yes.
Will this approach create jobs? Of what sort?		yes. A wide range, maitenance etc.
Are there identifiable social or cultural impacts from this technology/measure?		yes.
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?	L	lower nutrient loads going downstream would be a positive effect on downstream areas.
What is the potential for unintended consequences for this technology/measure?	H	everything has unintended consequences. Could result in a system wide change. If we remove one alega species it could create room for another.

Group 5 - ABR / SR / WCO-SS

Summary Criteria - please make entries in green shaded cells only.						
Technology/Measure: DREDGING						
Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions		**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Comments?**	**For detailed analysis, go to tab...**
1. Effectiveness						
a.	Total TN removed for project life (MT)	n/a	n/a	n/a	No	Obj 1 - Nutrients
b.	Total TP removed for project life (MT)	H (> 10 MT)	M (<1 to 10 MT)	H (> 10 MT)	No	Obj 1 - Nutrients
c.	Seasonal DO improvements - indirect or direct?	HIndirect	HIndirect		No	Obj 2 - Water Quality
d.	Seasonal pH improvements - indirect or direct?	HIndirect	HIndirect		No	Obj 2 - Water Quality
e.	Seasonal TSS/turbidity improvements - indirect or direct?	HIndirect	HIndirect		Yes	Obj 2 - Water Quality
f.	Seasonal Chl-a/algal toxin improvements - indirect or direct?	HIndirect	HIndirect		No	Obj 2 - Water Quality
2. Cost (estimated)						
a.	Total cost for project life	VH (> $100M)	H ($1M to $100M)		No	Obj 1 - Nutrients
b.	Cost per unit N removal ($/kg)	n/a	n/a	n/a	No	Obj 1 - Nutrients
c.	Cost per unit P removal ($/kg)	H (> $100/kg)	H (> $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges		L	L	L	Yes	Narrative Questions
4. Infrastructure challenges		M	M	M	Yes	Narrative Questions
5. Implementation timeframe		M	M	M	Yes	Narrative Questions
6. Energy Use		H	H	H	No	Narrative Questions
7. CO2 Loading		M	M	M	Yes	Narrative Questions
8. Compatability/synergy						
a.	With other large-scale technologies considered	L	L	L	No	Narrative Questions
c.	With ongoing or anticipated restoration measures	M	M	M	Yes	Narrative Questions
9. Risk of failure?		L	L	L	Yes	Narrative Questions
10. Need for further scientific study?		H	H	H	Yes	Narrative Questions
Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses, including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake).						

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.						
Technology/Measure: DREDGING						
Criteria - Development of Cost Estimates			**Upper Klamath Lake**	**Lake Ewauna/Keno Reservoir**	**Other Location**	**Line of Reasoning/Notes**
General Costing Info		Dredging area (acres)	57,328			
General Costing Info		Dredging depth (ft)	1			We need to further evaluate the depth. Group thinks more than .33 feet and is leaning more towards at least 1 foot.
General Costing Info		Dredging volume (yd3)	92,489,173	98,000		
General Costing Info		Depth of highest P concentration in sediments (cm)	10	10		
General Costing Info		Assumed concentration of P in sediments (mg/g dry weight)	0.6	0.6		From Simon et al. (2009)
General Costing Info	Capital & O&M costs	Hydraulic dredging unit cost ($/yd3)*	$ 15	$ 15		
General Costing Info	Capital & O&M costs	Hydraulic dredging cost	$ 1,387,337,600	$ 1,470,000	$ -	
General Costing Info		**Total cost for project life**	**$ 1,387,337,600**	**$ 1,470,000**	**$ -**	
Unit Removal		**Total TN removed (MT)**	-	-		
Unit Removal		**Total TP removed (MT)****	**1,392**	**1.5**		Is there a legacy for P in the sediments? How many years supply would there be if it were made avaiable. The size of the resivouir isn't as important as the release rate.
Unit Removal		Total TN removed for project life (kg)	-	-		
Unit Removal		Total TP removed for project life (kg)**	1,392,000	1,475	-	
Unit Removal		**TN unit removal cost ($/kg)**	-	-		
Unit Removal		**TP unit removal cost ($/kg)****	**$ 997**	**$ 997**	**#DIV/0!**	
* Disposal cost not captured in the estimate of cost per unit removal.						
** Estimates assume the same P-content of Keno Reservoir sediments as Upper Klamath Lake.						
Comments: Some of the P is stored in the iron in the sediments. How deep would you have to dredge for a P reduction?						

Group 5 - ABR / SR / WCO-SS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.

Technology/Measure: DREDGING

Criteria - Use H/M/L Rankings and Narrative Descriptions		Upper Klamath Lake	Lake Ewauna/Keno Reservoir	Other Location	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	H	H		huch does the sedimentry layer contribute to the nutrient load? This implies a whole lake treatment. If you can reduce the algea in the U.Klamath lake and its effective you can have a high effect to the Lake Ewauna/Keno Reservoir.
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
pH	Overall pH improvements	H	H		
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Temperature	Overall water temperature improvements	L	L		
	Direct or indirect effects?	na	na		
	Season of greatest improvement				
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	H	H		This is an assessment of long-term TSS/turbidity from decreased algae blooms rather than an assessment of short-term impacts due to dredging.
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	H	H		
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				

Comments: Our answeres for the Keno reach are assuming dredging in Upper Klamath Lake.

Please make entries in green shaded cells only.

Technology/Measure: DREDGING

Narrative Question	H/M/L	Narrative Response
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	L	been applied in many other places and is known technooogy. Though this may be the largest lake this technology is used on.
Are the infrastructure requirements for this technology high, medium, or low and why?	M	would require lots of trucking trips to export the dredge. Where do you dispose of the dredge soils? Need to know if the dredge could be hazzardous.
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	permitting could take a few years to resolve. ACOE permit.
Is the energy use of this technology high, medium, or low and why?	H	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	M	Depends on where the energy is obtained. Move the dredge can be CO2 intensive.
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	L	
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	M	spoils can be used to assist in remidating the subsidance.
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	how much of the lake would have to be dredged for this to be effective? Need to understand the adequate depth. If you don't complete the entire job the risk can be high but if done right the risk is low. Also depends on if this is a political question or scientific. If you reduced bloom by 50% scientifically its good but politically?public perception it could be viewed as low
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	H	there is a need for further scientific research to collect more data.
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?	L	no
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?		yes
Does this technology/measure provide an acceptable cost to benefit ratio?		This is a costly treatment option. How long would the improved effect last in relation to the cost of the activity? What is the maintenance?
Is this technology/measure a long-term solution or improvement?		
Are there readily identifiable legal constraints on this technology/measure?		
Are there readily identifiable political ramifications for this technology/measure?		
Are there likely to be unique opportunities for funding for this technology/measure?		
Will this approach create jobs? Of what sort?		
Are there identifiable social or cultural impacts from this technology/measure?		
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?		
What is the potential for unintended consequences for this technology/measure?		Are there other contamients in the sediments?

Group 5 - ABR / SR / WCO-SS

Summary Criteria - please make entries in green shaded cells only.

Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION

Criterion - Use a Combination of Quantitatve and H/M/L Rankings and Narrative Descriptions		Upper Klamath Lake: whole lake alum treatment only	Lake Ewauna/Keno Reservoir: alum injection (includes oxygenation)	Copco 1 and Iron Gate Reservoirs	Comments?	For detailed analysis, go to tab...
1. Effectiveness						
a.	Total TN removed for project life (MT)	n/a	n/a	n/a	n/a	Obj 1 - Nutrients
b.	Total TP removed for project life (MT)	H (> 10 MT)	H (> 10 MT)		No	Obj 1 - Nutrients
c.	Seasonal DO improvements - indirect or direct?	HIndirect	HDirect		No	Obj 2 - Water Quality
d.	Seasonal pH improvements - indirect or direct?	HIndirect	HIndirect		No	Obj 2 - Water Quality
e.	Seasonal TSS/turbidity improvements - indirect or direct?	HIndirect	HIndirect		No	Obj 2 - Water Quality
f.	Seasonal Chl-a/algal toxin improvements - indirect or direct?	HIndirect	HIndirect		No	Obj 2 - Water Quality
2. Cost (estimated)						
a.	Total cost for project life	VH (> $100M)	H ($1M to $100M)		No	Obj 1 - Nutrients
b.	Cost per unit N removal ($/kg)	n/a	n/a	n/a	n/a	Obj 1 - Nutrients
c.	Cost per unit P removal ($/kg)	H (> $100/kg)	M ($10 to $100/kg)		No	Obj 1 - Nutrients
3. Engineering challenges		L	L	L	Yes	Narrative Questions
4. Infrastructure challenges		L	L	L	No	Narrative Questions
5. Implementation timeframe		M	M	M	Yes	Narrative Questions
6. Energy Use		M	M	M	No	Narrative Questions
7. CO2 Loading		L	L	L	Yes	Narrative Questions
8. Compatability/synergy						
a.	With other large-scale technologies considered	M	M	M	Yes	Narrative Questions
c.	With ongoing or anticipated restoration measures	M	M	M	Yes	Narrative Questions
9. Risk of failure?		L	L	L	Yes	Narrative Questions
10. Need for further scientific study?		L	L	L	No	Narrative Questions

Comments: It is assumed that improvements to water quality in the Klamath Basin will improve support of beneficial uses, including support of aquatic habitat (e.g., support for increased sucker recruitment in Upper Klamath Lake).

Objective 1: Reduce seasonal concentrations of nutrients - please make entries in green shaded cells only.

Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION

		Criteria - Development of Cost Estimates	Upper Klamath Lake: whole lake alum treatment only	Lake Ewauna/Keno Reservoir: alum injection (includes oxygenation)	Copco 1 and Iron Gate Reservoirs	Line of Reasoning/Notes
General Costing Info		Lake area (acres)	66000	n/a		
		Treated flow (MGD)	n/a	788		
		Alum dose required for lake (g/m2)	80	n/a		work would need to be done to fully know the load does. Need to also be aware of the pH in the lake. There may be some concerns about the water collumn pH being above 9.5
		Alum dose required for injection (mg/L)	n/a	1.65		
		Daily area covered (acres/day)	150	n/a		
		Project life (years)	8	20		Project life for Upper Klamath Lake is estimated to be 8 to 15 years.
	Capital Costs	Alum Storage Facility ($)	incl in mobilization cc	$ 150,000		
		Mobilization ($)	$ 2,250,000	$ 741,772		Assume 8% of total project cost.
		Injection/aeration equipment	n/a	$ 4,000,000		
		Facilities building	n/a	$ 300,000		
		Sub-total Capital ($)	$ 2,250,000	$ 5,191,772	$ -	Alum injection costs are pro-rated over 20 years.
	O&M Costs	Alum cost ($/gal)	$ 1.20	$ 1.00		
		Sodium aluminate buffer cost ($/gal)	$ 2.20	$ 2.00		
		Injection equipment maintenance and replacement	n/a	$ 300		Alum injection assumes a 20 year life on equipment.
		Personnel ($/day)	n/a	$ 100		
		Annual ($/yr)	n/a	$ 4,080,000		
		Sub-Total O&M ($)	$ 177,750,000	$ 81,600,000		
		Total cost for project life	$ 180,000,000	$ 85,680,000		
Unit Removal		Days operating per year	200	200		
		Annual TP load removed (MT/yr)	70	89		
		Total TP removed for project life (MT)	560	1,771		
		Total TP removed for project life (kg) (over 10 year for UKL whole lake and 20 year operation alum injection)	699,791	1,770,909		
		TP unit removal cost ($/kg)	$ 257	$ 48		

Comments: Is this a continous treatment with Keno?

Group 5 - ABR / SR / WCO-SS

Objective 2: Improve overall water quality - please make entries in green shaded cells only.

Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION

Criteria - Use H/M/L Rankings and Narrative Descriptions		Lake: whole lake alum treatment only	Lake Ewauna/Keno Reservoir: alum injection (includes oxygenation)	Copco 1 and Iron Gate Reservoirs	Line of Reasoning/Notes
Dissolved Oxygen	Overall DO improvements	H	H		if it were effective in algea control.
	Direct or indirect effects?	Indirect	Direct		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
pH	Overall pH improvements	H	H		
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Temperature	Overall water temperature improvements	n/a	n/a		
	Direct or indirect effects?				
	Season of greatest improvement				
	Other				
TSS/Turbidity	Overall TSS/turbidity improvements	H	H		
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				
Chlorophyll-a / algal toxins	Overall chl-a/algal toxin improvements	H	H		
	Direct or indirect effects?	Indirect	Indirect		
	Season of greatest improvement	Summer/Fall	Summer/Fall		
	Other				

Comments:

Please make entries in green shaded cells only.		
Technology/Measure: OXYGENATION/SEDIMENT SEQUESTRATION		
Narrative Question	**H/M/L**	**Narrative Response**
Considerations for Summary Criteria		
Are the engineering and design requirements for this techology high, medium, or low and why?	L	**Need to work out potential dosing and pH**
Are the infrastructure requirements for this technology high, medium, or low and why?	L	
Is the implementation timeframe for this technology generally high (>10 yrs), medium (2-10 yrs), or low (< 2 yrs) and why?	M	**On low end of range**
Is the energy use of this technology high, medium, or low and why?	M	
Is the CO2 loading of this technology high, medium, or low and why? (How "green" is this technology/measure?)	L	**Transport**
Is the 'fit' of this technology with other large-scale technologies being considered high, medium, or low? Is there a hybrid of several options that makes sense?	M	**medium with the exception of dredging.**
Is the 'fit' of this technology with other ongoing or anticipated restoration measures high, medium, or low?	M	**except for dredging.**
Is the risk of failure with this technology high, medium, or low and why? (i.e., if the money is spent for implementation, does failure mean zero WQ improvements are realized, or just somewhat less than anticipated)?	L	**low if designed correctly. If effect is just a percentage of what was expected we would want it to be used in conjuction with other treatment techniques with the exception of dredging.**
Is the need for further scientific study of this technology prior to implementation in the Klamath Basin high, medium, or low and why?	L	
Additional Considerations		
Does this technology require that a water right be obtained for consumptive or non-consumptive use?		**no**
Does this technology/measure address multiple water quality problems? Is it a more or less of a global solution?		yes but not a global solution.
Does this technology/measure provide an acceptable cost to benefit ratio?		yes. It has in past uses but the group has some disagreement.
Is this technology/measure a long-term solution or improvement?	M	Lakes need to be redosed every 10 years (typically)
Are there readily identifiable legal constraints on this technology/measure?		no.
Are there readily identifiable political ramifications for this technology/measure?		yes there can be political and public education issues.
Are there likely to be unique opportunities for funding for this technology/measure?		no
Will this approach create jobs? Of what sort?		minimal.
Are there identifiable social or cultural impacts from this technology/measure?		no.
How will this technology interact with dam removal, should there be an affirmative Secretarial Determination on the removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams?		no interaction.
What is the potential for unintended consequences for this technology/measure?	H	don't know future implications of this project. Could have economic consequences.

Day 2 – Small Group Design Charrette: Linking Multiple Projects for Basin-Scale Water Quality Improvements

Group 1

Combination of Technologies

- Algal Biomass Removal:
    - Modeling and Pilot study of algal biomass removal in Upper Klamath Lake and Link River (Pilot Study C)
    - Divert algal biomass at A Canal (removal at A Canal – Flotation
- Dredging:
    - No Dredging
    - No Alum or Aeration in Upper Klamath Lake
- Aeration/oxygenation Sediment Sequestration:
    - Aeration and alum use below Link River Dam
- Restored and Diffuse Treatment Wetlands:
    - Some diffuse wetland restoration in riparian corridors of upper Sprague
    - Pasture-level wetlands in 2% of irrigated agriculture
    - Divert water into Lower Klamath NWR from Klamath Straits Drain and/or Klamath River via ADY Canal
    - Wetland restoration at Miller Island – Improve connectivity to Keno Reservoir
- Treatment Wetlands:
    - Potential for treatment wetlands at lower end of Sprague, lower Wood and lower Seven Mile (LIDAR use for identifying sites)
    - Williamson is lower priority due to existing functional marsh
    - Treatment wetlands at Barnes Ranch, Agency Lake Ranch, Caledonia Ranch, Wocas Marsh, Lower Klamath Lake,

Design/ Planning Component	Program Year																				Est. Cost ($M)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
BMP Imp.																					50
Effect. Monit. & Assess.																					20
Aeration/Alum Injection Below Link River Dam																					70
Modeling/ Mechanism Study:																					1
Pilot Study A: Treatment Wetland																					25
Pilot Study B: Restored Wetlands																					10
Pilot Study C: Algal Biomass Removal																					2
AM Decision Point 1 (pilot studies)																					--
Project A: Treatment Wetlands (137,000 acres)																					275
Project B: Restored and Diffuse Wetlands (50,000																					107
Project C: Algal Biomass Removal at UKL and Link																					10
AM Decision Point 2+																					--
Program Total																					570

Maia Singer:
Decision point color matches project color

Measurable WQ Imprv.	Program Year																				Est. % Red. t=20
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
TN																					
TP																					
D.O.																					
pH																					
Turbidity/TSS																					
Chl-a																					
Algal toxins																					
Other																					

Group 2

Assumptions/ Considerations/ Guiding Principles

1. Geographic area begins at headwaters and extends to Keno Dam
2. Assume that dams are still in place.
3. Assume that 28.5 mil has same buying power over 20 year span (2012 dollars)
4. Climate change will affect project cost, land use, efficacy, etc. over time. Project selections must have longevity in the face of climate change/ Resiliency to survive future climate change, land use change, needs of fish
5. Phasing- organize projects into short term vs. long term solutions. Need to consider near term, mid term and long term aspects of projects
6. Consider/ design for implications beyond 20 years (i.e.: 20 years is in the short term). Divide design sections into geographic areas and short/mid/long term solutions
7. Allocate funds according to magnitude of problem within geographic area
8. Some activities are urgently needed to keep threatened species alive to see the future
9. Based on current knowledge - without additional information
10. Present technology and energy costs
11. Wetlands = treatment wetlands

Geographic Area #1: Main tribs

1. Williamson River
2. Sprague River
3. Wood River

Geographic Area #2: Upper Klamath Lake

Geographic Area #3: Keno Reach and Lost River System

Treatment Opportunities in Area #1

- Williamson River - water quality good. Well- vegetated. No treatment technologies needed. Not as much potential for treatment opportunities and P reduction.
- Wood and Seven Mile - naturally occurring high P in Wood subbasin aquifers. Wetlands for nutrient removal. Discussed the general possibility of opportunities for treatment wetlands that will transition into habitat wetland system (for all geographic areas). Focus on the removal of phosphorus. Seven Mile: diffuse wetlands.
- Sprague River -restore temp in Sprague (for sucker fish and anadromous fish requirements). Have farmers use well rather than spring water. Reconnect spring system. Get cold groundwater recharge back into the system. Change in point of diversion. Control juniper encroachment at springs and seeps. (Modification of hydrology is a technology that has not been discussed at workshop, but is important and a recommendation.) Biomass of juniper has the potential for use as biochar/ energy production ($225/acre to remove juniper) Riparian corridor management. Riparian/ wetland restoration/ management. Diffuse wetlands. Channelization in N & S forks—reconnection, restore natural channel. Irrigation system- improved management. Improve BMPs.

Treatment Opportunities in Area #2

- Dredging in areas of high sediment—to remove P and to create wetlands (15,000 ac of lake bottom) and create wetlands (dredging: $5-15 y3). Remove material to create wetland berms around Agency Lake Ranch parcel. Dredging 15,000 ac of lake bottom will cost between $40- 120 mil. Passive approach also discussed (no dredging, only wetland restoration). 10,000 acres likely for potential treatment sites in this area.

- Alum discussed- looked at as a potential short term solution. Large lake scale precedents have proven relatively unsuccessful. Better for downstream? Pilot scale project?
- A $30 mil investment (initial investment) to remove algae was discussed, but group decided that money is better invested in wetland restoration. Algae removal is an area for further research. Pilot scale project?

Treatment Opportunities in Area #3

Keno Reservoir

- $30 million- alum micro floc treatment discussed as water flows into Keno Reservoir (Link River). Or pilot project scale?
- Pilot project to examine feasibility of algae removal in Keno Reservoir.
- Oxygenation in Keno Reservoir: possible short term solution, but probably not feasible as a long term solution.

Lost River System

- Improve effluent/ return flows through wetland treatment. Water from agricultural areas currently flowing into Keno Reach diverted to wildlife refuge. Feasibility study? May be infeasible due to Oregon water laws.
- Treatment wetlands—salinity issues.
- Discussed the purchase of land/water rights along Straights Drain for potential treatment sites.
- Net 20 year costs (summary):
- 2000 ac in Sprague for riparian rest. ($40 mil)
- 5000 ac berm wetlands ($250 mil)
- 10,000 ac wetlands built on hydric soils ($100 mil)
- oxygenation below lake ($30 mil)
- Add an additional ___ for pilot testing on harvesting, biomass removal,
- 5000 acres of juniper removal - ($2 mil)
- Reserve funds for water rights along Lost River system ($10 mil)

RESOURCE ALLOCATION PLAN		Acres	Funding
Reserve fund to buy water rights			$10,000,000
BMPs - improved nutrient management			$5,000,000
Williamson River	No action		$0
Wood River	Wetland Restoration	1600	$24,000,000
Sprague River	Reconnect Springs		$2,000,000
	Restore Natural Channel		$5,000,000
	Riparian Wetlands	500	$5,000,000
	Wetland Restoration	1500	$18,000,000
	Remove Juniper	8000	$2,000,000
Upper Klamath Lake	Wetland Restoration	10000	$140,000,000
	Berm-ed Wetland Creation	5000	$250,000,000
	Research - Algal Harvesting		$1,000,000
Keno Reach	Oxygenation (w/o alum treatment)		$30,000,000
	Wetland Restoration	500	$7,000,000
	Research pilot - alum treatment		$500,000
	Research pilot - biomass removal		$500,000
			$500,000,000

Group 3

- A design process that identifies goals, and actions to achieve them, first might be a better approach. (More focused approach)
- An approach that uses pilot projects and adaptive management in the first years is likely to have benefits for the long term effort.
- Public outreach and buy-in will be important for the success of any project.
- River restoration (riparian, wetlands, and nutrient reductions) on Upper Klamath Lake tribs, primarily the Sprague, should be a component of any strategy.
- Long term solution depends on success of efforts to control loads in Upper Klamath Lake tribs.
- Data gap: Can A canal fish screens be designed to allow BGA cells to pass, but not fish?
- A major uncertainty is how long will it take for phosphorous concentrations to come to an equilibrium following reductions of phosphorous inputs from upstream.
- Gene: injection of alum and oxygen at link river, and perhaps at another site downstream, would be effective downstream of Upper Klamath Lake, but would require injections every year. Major cultural concerns would need to be addressed.
- Gene: the amount of internal phosphorous loading to Upper Klamath Lake may be attributed to algae die-off from the previous year.
- A watershed restoration plan, and model, that organizes all the efforts is missing but necessary.
- Develop a watershed plan that develops hypotheses for phosphorous removal strategies, and provides a framework to assess effectiveness of strategies for adaptive management.
- The concentration of phosphorous at Link River is the metric to track success of efforts upstream.
- Deas: Getting Lake Euwana to act as an aerobic system (24 miles of process) would solve a lot of the habitat issues (and others).
- Use Wood River as a demonstration of how upstream improvements can be implemented and effective, and implement similar projects on the Sprague. Implement oxygenation and algae removal (or other appropriate measures) at link river dam to affect improvements downstream of the dam.
- General strategy: Control nutrient loads upstream for long-term through wetland and riparian restoration, remove algae at Link Dam to address short-term, and research in-lake phosphorous dynamics and alum injection at Link River to evaluate other opportunities.
- Potential wetland acreage: 3200 wood, 24000-31000 Williamson, 43000 Sprague.

Design/ Planning Component	Program Year																				Est. Cost ($M)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
BMP Imp.																					50
Effect. Monit. & Assess.																					20
Planning																					
Develop a Watershed Plan																					10
BOD control at Link River																					
Link River algae removal/oxygenation design																					2
Link River algae removal/oxygenation construction																					20
Link River algae removal																					25
Link RiverOxygenation																					10
External P input control																					
Wetland restoration in upper basins																					150
Pilot projects																					15
Landowner incentives																					45
																					--
Outreach/Research																					
UKL Phosphorous dynamics																					15
Algae removal pilot on West side of UKL																					10
Alum injection outreach																					10
Program Total																					382
Overhead, unanticipated costs																					565.36

Group 4

- Not using TMDL load allocations for this exercise.

Individual Group Member Combo of Technologies

- Straits stream, riverine and the Sprague (riparian corridor improvements/reveg/hydromodification), Wood River Wetland (not breaching the levee).
- Wetlands, Floodplain (be aware of spatial/temporal scales – might be good long-term cost option)
- Wetland restoration (important long-term option to get out of managed area), technology provides short term options and can work in specific places, algae removal fixed location over barges, Straits Drain (good target for treatment wetland)
- Fixed structure at dam outlet --> biofuels and soil amendment which can lead to positive public acceptance
- Leave some areas alone. Look to established federal lands for functional wetlands. Supporting restoration on the upper lake. Recirculation of Klamath straits discharge above the drain in wildlife refuge.
- Wetland (provide good long-term option). Not alum dosing in the lake.
- Start at the headwaters. Sprague restoration is an important component, Lake fringe wetlands, access of wetlands for juvenile suckers and recruitment is important, need short-term options for suckers while wetlands get established over 20 years.
- Incentive companies to remove algae.
- Removal of algae in Keno Straits/Link River with a fixed structure. Phosphorous credits/offsets through algae removal after proof of project.
- Start at the headwaters (hydromod in the upper tributaries). Possible pilot dredging and alum to test short-term options.
- EPA's Walking Wetlands expansion, Rotational Grazing, irrigation efficiency grants (conserve water instream), and improving farming techniques.

Combination of Technologies

Focus on long-term restoration starting at headwaters and moving to Upper Klamath Lake using passive restoration (for cost saving with conservation easements).

- Riverine/Riparian Restoration
    - Use of conservation easements
    - Sprague
    - Williamson and willing landowners
- Wetland restoration
    - North side of Agency Lake and $4.5M for acquisition.
- Treatment Wetland
    - Straits Drain (preferred in the existing USFW Wildlife Refuge after feasibility study)
    - Lake Ewauna
- Diffuse Return Flow Treatment
    - Bioswales
- EPA's Walking Wetlands expansion, Rotational Grazing, irrigation efficiency grants (conserve water instream), and improving farming techniques.

Short-term measures for target treatment

- Algal Filtration

- Pinch-point land facility at Link Dam - start with a pilot test to explore commodity of bi-products and potential phosphorus credits/offsets.
- Offsite Alum Treatment and pilot test.

Design/ Planning Component	Program Year																				Est. Cost ($M)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
BMP Imp.																					50
Effect. Monit. & Assess.																					20
Link River Algae Harvest - Pilot & Implementation																					50
Humate for AFA Control - Pilot																					0.5
Feasibility Treatment at Straits Drain																					9
Riverine/Riparian Restoration																					100
Diffuse Return Flow Treatment																					25
Water Efficiency																					25
Wetland Restoration/Habitat																					140.5
Treatment Wetland (2)																					150
AM Decision Points																					--
Program Total																					570

Measurable WQ Imprv.	Program Year																				Est. % Red. t=20
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
TN																					
TP																					
D.O.																					
pH																					
Turbidity/TSS																					
Chl-a																					
Algal toxins																					
Other																					

Group 5

Key Ideas:

- Recognize importance of addressing the source of the problems/prevention as opposed to use of large-scale technologies. Potential to devote more $50 million allocated for BMPs. $50 million for BMPs should be targeted at removal of nitrogen; the removal of this should be verified with monitoring, etc.
- Need to look at addressing more than nutrients, recognizing upcoming TMDLs for other constituents such as pesticides, arsenic, etc. Recognize additional benefits such as habitat and wildlife.
- Importance of looking for opportunities to find additional revenues or benefits from technologies being used. Use grants or potential to sell algae to supplement the $500M allocated for this project.
- Need clear goals/vision. May not want to tie to TMDLs. Recognize that the TMDLs in Oregon are contentious and under revision at this point. Likely to be changed again with more litigation.
- Focus on more sustainable alternatives that have lower operations and maintenance costs. Our design focuses on the use of wetlands as opposed to dredging, oxygenation, or the addition of chemicals to the system. Recognize that other technologies could be brought into the mix through the adaptive management process if endangered species or other needs arise and need to be addressed in short term/more immediately.

Project Design:

- Wetlands:
  - Use a combination of all three types of wetlands (diffuse/restoration/treatment) with focus on removal of phosphorus.
  - Recognize the importance of locations in ability to maximum water quality benefits.
  - Objective to restore 20 percent of natural function in each sub-basin.
  - Importance of focusing money in Upper Basin where benefits may be more readily achieved early in the process (less controversy than some other areas and may not require water right revisions)
  - Other key areas for wetlands include:
    - Around Upper Klamath Lake; and
    - Klamath Strait's Drain (treatment wetland before water re-enters Klamath River; also potential for use of a carbon filter).
  - $50 million for diffuse wetlands over 20 years, with $2.5 million/year.
  - $202 million for a combination of restoration and treatment wetlands for Years 1-5
    - Identify and purchase three key properties in each basin and conversion to wetland; and
    - Associated studies.
- **Algal Filtration/Removal:**
  - Pilot study to screen the outlet of Upper Klamath Lake (at Link River Dam) and deliver algae to A Canal or spoil site (allow for dewatering and subsequent dispose or re-use of material – possible source of funding).
    - $3 million in Year 1;
    - $7-10 million for ongoing operations and maintenance; and
    - $5-10 million to implement in Years 3-5 or sooner if designed and pilot shows benefits for larger scale.

- **Adaptive Management:**
    - Annual review of data and status of system. Includes report. Allows opportunity for changes to policy/plan if necessary (e.g., fish kill, etc.).
    - Not less than every five years, overall (comprehensive) review of policy, funding, assessment of meeting goals, funding allocations, etc.
    - Multi-stakeholder process that is not run by any one agency. Desire to ensure continuity. Promote transparency (similar to KBMP model).
    - $1 million/year for database and infrastructure that supports this process. Data integration into CEDEN/SWAMP.
    - $208 million remaining at Year 5 (first adaptive management meeting). Will determine future uses of funding at this point in time with considerations for O&M over future 15 years.

Summary of Money:

Year	Amount	Purpose
1-5	$202M	Wetlands (Treatment & Restoration, including land acquisition)
1-5	$20 M	Algal Filtration/Removal
1-20	$50 M ($2.5 M/year)	Diffuse Wetlands
1-20	$20 M ($1M/year)	Adaptive Management (Stakeholder, Infrastructure, Data)
*Leaves $208 million. Use of remaining funds will be determined through adaptive management process. Also need to recognize the potential for additional revenue from other sources (e.g., grants, sale of algae, etc.).		

Group 6

Important Group Comments Regarding Design:
The group emphasized the importance of adaptive management to evaluate the impact of the different treatment options. The final design and budget recognizes that we need immediate action in order to prevent the loss of the native fish populations within the basin.

Overall Comments:

- Importance of adaptive management – recognition of potential failures
- Holistic approach absolutely necessary – no one technology or approach will solve the problem
- Value of pilot projects above and beyond efficacy
    - Particularly diffuse wetlands
    - Ability to use pilot projects for education of the public
    - Education as part of the solution
- Riparian restoration
- Ability and room for coordination of different projects
    - Riparian corridor necessary
    - Department of Agriculture is looking into compliance solution
- Stream morphology
    - Stream network has been significantly altered
    - Water table has been lowered as part of irrigation and stream channelization
    - Wetland creation may be easier with the use of beaver dams
        - Concern – beaver considered nuisance species
        - Concern – migratory fish
- Wetlands
    - Lakeshore wetlands have been altered too extensively to use passive wetland restoration
- Overall basin
    - Treat tributaries first to get the most cost effective solution
    - AFA bloom spurs the *Microcystis* bloom
    - P not evenly distributed throughout Upper Klamath Lake
- Treatment Options/Discussion
    - Dredging
        - Concern: prohibitive costs
        - Concern: sediment disposal
        - Could the dredged sediments be used in wetland restoration
    - Constructed wetland
        - Alum application to limit P with wetland creation
    - Adaptive management
    - Limited activities because of the scale of the issue and cost limitations
    - Can we harvest at a rate that can compete with the AFA blooms
    - Pilots needed for wetlands/riparian restoration? Knowledge exists, may not be necessary
    - Concentrate on downstream benefit
    - Internal P cycling within Upper Klamath Lake – not a single source within Upper Klamath Lake
        - Major hot spots may benefit from dredging
            - Need data regarding mass balance model
        - P sediment hotspot map – the values are relative with the lake
    - Legacy P in the sediment of Upper Klamath Lake?
        - If yes: alum may be a potential solution

        - If no (the P flushes out with the blooms): alum treatment may not be effective
    - Keno
        - Removal of algal biomass prior to entering Keno
        - Limited resiliency within the lake
    - Fish protection
        - Upper basin morphology is too altered for endangered fish species
        - Easements for riparian areas
        - Reconnect floodplain - incised banks
        - Time may not be an option in order to protect the fisheries
            - Perhaps need a major action in order to protect the endangered fish
            - Short term actions necessary to protect fisheries
        - When are the effects of long term projects going to be realized
    - Floodplain reconnection
        - Channel reconstruction
        - Not a BMP -->
    - Unknown P reduction
        - Currently there is no P goal, so it is difficult to evaluate potential actions for efficacy
        - In-lake mesocosom to evaluate the water column P concentration necessary to prohibit AFA bloom
    - Costs Estimates
        - Not helpful in isolation
        - Dredging costs should be higher than workshop spreadsheets
        - Actual channel reconstruction:
            - Lower Wood River: $1 million/mile
            - Sprague: $250,000/mile
        - Riparian restoration
            - $200-$250/foot
    - P & N Benefits
        - Riparian restoration calculations currently unknown but available
    - Land Acquisition
        - Removal of tax base concern for local government
        - Benefit of having possession of the land for management
        - Concern of taking agricultural land out of production
            - Potential of wetland with biomass that could be hayed →still working land
- Managed wetlands around Upper Klamath Lake for the biomass haying
    - Certain managed wetlands around Upper Klamath Lake will temporarily drained 2-3 times during the growing season in order to harvest wetland plant species which can be used for hay
    - Assumptions are that the area will have to be drained for a short time period: 1-2 weeks, to allow for the haying. During this time, it is assumed that the land will not dry out sufficiently to cause additional nutrient loading
    - The wetland species that is able to tolerate the inundation and can be harvested for hay will require additional investigation

Design/ Planning Component	Program Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Est. Cost	Comments
BMP Imp.																					50	
Effect. Monit. & Assess.																					20	
UKL P Modeling																					0.5	Additional P modeling for UKL is necessary to inform the specifics of many other actions
Floodplain Restoration																					90	Priority is the South Fork Sprague. Other systems have potential as well, for a total of 90 miles of stream restoration
Land Acquisition around UKL																					50	Purchase of an estimated 10,000ac around UKL
Managed Wetlands around UKL	P	P	P	P	P																1	The initial 5 years will involve the implementation of a pilot program to determine feasibility and efficacy. The management option involved the haying of wetland biomass. Details in the Notes section.
Managed Soil Accretion Wetlands	P	P	P	P	P																1	The initial 5 years will involve the implementation of a pilot program to determine feasibility and efficacy. The management strategy involves the accretion of soil within these wetlands to sequester organic mater and nutrients.
Habitat Wetlands	P	P	P	P	P																1	The initial 5 years will involve the implementation of a pilot program to determine feasibility and efficacy. Habitat restoration with very little management necessary
UKL & Agency Alum Treatment	P					Adpt Mgt D					Adpt Mgt D										241	Initial Alum treatment, then evaluate the impact of the treatment to determine whether an additional application is necessary or if Keno would benefit from an Alum application. Pilot project to demonstrate efficacy.
Keno Alum Treatment						Adpt Mgt D	?														68	After the initial UKL alum application the management group will determine whether a Keno alum treatment is necessary. If not, then the management group can decide the best place to spend the additional funds.
Managed/Habitat Wetlands around Keno - TBD after adaptive mngt decision						Adpt Mgt D															40	After the initial work, determine the necessary wetland actions that are needed to help treat Keno.
Public Outreach																					8	Public outreach to support restoration efforts and encourage the local community to participate in the restoration of the Klamath Basin.
Program Total																					570	

	Implementation and maintenance
P	Pilot project stage
D	Adaptive Management Decision Point

Group 7

Objectives

- KSD/FERC- getting salmonids into upper basin/ beneficial uses
- Not necessarily the attainment of TMDL
- Accountability by milestones/measurable progress/goals
- Restoring function is key
- Nutrient reduction in the Upper Klamath Lake, CNP control d/s
- Expand program to 50+ yrs, spend $ in first 20 yrs
- New $, other ongoing processes continue (TMDL, DMA's, BMP's, restoration)

Technologies

- Wetland Restoration
- Treatment Wetlands
- Diffuse (decentralized) treatment systems
- Gravity fed raceways downstream of Link Dam, adjacent to Keno to remove algae and nutrients (CNP)
- Sediment dredging
- Algal filtration

Land Acquisition for Wetland Technologies

- 15,000 acres = $60MM (at an average price of $4000/acre; combination of lakefront/riverfront and pasture land); $40MM to convert to some combination of wetland treatment/natural wetlands and O/M; **$100MM TOTAL**
- U/s of lake, diffuse wetlands are 3% of the 150k acres, 4,500ac. Purchase Cost =$3,000/ac for a total purchase price of $13.5MM; construction costs @ $10,000/acre= construction total cost $45MM; **$58.5MM TOTAL**
- Assuming willing landowner

Gravity Fed Raceways: downstream of Link Dam, adjacent to Keno to remove algae and nutrients (CNP)

- Treating 25% of flow and total load, 129M gallons of treated water/daily =60 acres needed ($5,000/acre, $300k total)
- Water rights issue? Minimal consumptive loss
- Potential adverse issue with *Microcystis* in late summer, pilot study needed
- Potential economic benefit from algal harvesting
- 32 MT N/yr removed, 3200MT of wet biomass/yr
- Cost of OM, Construction, Pilot Study ($10M) (50yrs)= $65M
- Timeframe, immediately implemented

Pilot Projects in Upper Klamath Lake

- Algal removal via barges =$37M using 10 barges/yr, 9MM kg/yr (100 days/year)
- Explore feasibility of dredging P hotspots, and use dredged material to offset subsidence
    - Target Goose Bay (10,000acres at 10cm depth=$53MM Total cost for dredging)

Additional Approaches

- $20M for watershed restoration/watershed health in Sprague
- KSD
- Tule Lake
- Sprague River Riparian wetlands

- Water conservation and efficiency in irrigation project
- Additional monitoring

Cost Summary

Est. Cost	Design/Planning Component
100MM	Upper Klamath Lake wetland restoration
65MM	Algal removal in Keno (raceways)
60MM	Upstream of Upper Klamath Lake diffuse (decentralized) treatment systems
100MM	Upper Klamath Lake treatment including feasibility studies and research (hotspots and algal biomass removal)
20MM	Sprague River Restoration
Total $300MM	

Group 8

Lingering Questions/Needs

- Need more information about mass balance of nutrients (P) in the various portions of the system. This is not part of our budget, we are assuming that this information gap is being filled elsewhere (we are simply identifying it here).
- Need modeling of algal bloom dynamics so that we know the role of flow, temperature, nutrients, wind circulation, etc. and their effects on Nutrient dynamics.
- Need modeling conducted that describes sucker survival and recruitment in the Lake. What will it take for the suckers to successfully recruit juveniles?
- Models of Keno and Upper Klamath Lake should be applied to get an idea of how much Nutrient removal we need to get a response in the system.
- There will be a need to outreach and education about the need for nutrient decreases, large scale watershed technologies to decrease nutrient loads, etc.
- Need to better understand the costs of dredging, and the benthic/fish community to understand if a pilot project would be advisable.
- Questions about alum treatments at pH of 9 and higher.

Group System Design

- All agree that one component of our project will be restoring fringe wetlands around Upper Klamath Lake (wetland restoration). Land acquisition the main cost. 4000 acres ($45 million…this includes an initial investigation where restoration has already taken place historically and the results of restoration efforts)
- All agree to spend BMP ($50 million) & Monitoring monies over the entire 20 years ($20 million).
- Education/Outreach ($5 million).
- Considered $ for landowner incentives
- All agree that we need pilot projects involving the creation of diffuse wetlands and have incentives for installation in key locations (pilot for 3 years, 5-10 projects $1.5 million). The pilot projects can tell us how much nutrient removal will occur from these diffuse wetlands. South Fork Sprague is the recommended implementation location.
- Full diffuse wetland treatment system development in the basin - after/if pilot program proves successful ($30 million, this anticipates that there will be other funding sources for the creation of diffuse wetlands).
- Treatment wetland pilot projects to help determine additional treatment wetland sizing and placement in the system (three (3) 50 acre wetlands…ideas for pilot:
    - Williamson
    - Wood
    - Keno: Rat Club [upstream of straits drain] and Miller Island Wildlife Area.
- Full construction of 4000 acres of treatment wetlands (around Keno, Wood/Williamson, and Lower Klamath Lake)
- Algae removal $20 million (5000 kg/yr of TP removal) in the Eagle Ridge Trench

    - Need to consider some type of biomass removal at Link (group didn't have time to discuss in detail)
  - Analysis and engineering analysis of aeration of Keno Reservoir (no cost estimates yet).
  - Alum application:
    - If the following questions are addressed then proceed with pilot project for alum: 1) high pH (9+) does not result in toxicity, 2) benthic community is studied and low effects determined, 3) benthic fish (suckers) will not be adversely affected
    - If the above questions are answered do a pilot projects at location TBD in Upper Klamath Lake, with further implementation TBD
- Dredging pilot project (suction dredging our preference). Suggest putting sediment into subsidence areas. South end of lake suggested (Cove Point?).
    - Idea: dredge and then apply alum to the slurry to make sure it doesn't re-mobilize back into the lake.
- Biochar pilot project.

Group 9

How to approach the problem:

- Interim measures evolving to longer term solutions
- How can we make greater strides over a shorter term to protect beneficial uses?
- Fix external load first

How many tons do we need to sequester (load)? Long term TMDL as measured at Stateline:

3M lbs/yr N
Target: 1.1M lbs/yr Reduction 1.875 M lbs/yr
717K lbs/yr P
Target: 90Klbs/yr P Reduction 675K lbs/yr

	Tribs to Upper Klamath Lake	Upper Klamath Lake	Keno
Short term	Diffuse wetland treatment-beyond the scope of a couple of pilot projects Wetland restoration		
Long Term			

Priorities (tentative):

- Klamath Straights Drain (KSD) water can be run through wetlands to remove P; may be able to run through Klamath River Lower National Wildlife Refuge
- BioChar mixed with silage (but what to do with it?) could be applied to KSD or Seven Mile Canal as a pilot study; can make it out of algal biomass; or use alum as soil amendment (PAM)
- HL or need to take additional measures in Keno Reservoir to achieve WQ goals in nearer future for the 20 year program until the 50-year reduction of external loads is fully realized. Accelerate diffuse treatment wetlands.

Ideas around the room:

- Need better handle on numbers and cycling; not paralysis by analysis; i.e., in Wood River, can make some strides with diffuse wetland treatment where can get good bang for buck. Sprague River watershed is also important in case salmonid habitat can be utilized; Upper Klamath Lake opportunities should be pursued since there is a good probability of success (low risk with good results); serious short term problems (consider alum treatment in Keno Reservoir as there may be salmon in this reach within 7 yrs so that salmon don't need to be trucked to spawning habitat); along Keno Reservoir, need to put in treatment wetlands that could evolve to restored wetlands; treatment wetlands for agricultural returns; algae removal may not be effective/nor dredging
- Need to look at LIDAR coverage in the Upper Basin to identify best locations for diffuse treatment wetlands. Wood River has better opportunities than Sprague River; best hope in riparian restoration; Sprague River sediment budget high in certain stretch and needs reconstruction; need to deal with Sprague levees since they prevent sediment from settling in floodplain; alum treatment could be done in Upper Klamath Lake that could give positive results in Keno (93-130M$) two large scale alum treatments in the lake; why not use LKL wildlife preserve for treatment but would need plumbing changes; divert from UK to reserve to get benefit of existing wetland treatment; without alum might need dredging and biomass removal. Biomass removal doesn't address internal loading

- Alum treatment could be a powerful short term fix; Upper Klamath Lake or Keno? Maybe both? Then longer term treatments. Concerned about net long term nutrient reduction with wetlands. Harvest for silage to increase nutrient reductions. Is there a wetland crop? Dredged material: can it be fed back into system to build up subsidence areas?
- Restore habitat for nutrient reduction and to create habitat; P sequestration but concerned about the pH with creating chemical toxicity from the aluminum; or can we use calcium as an alternative (or lanthanum); would need a lot of design work and a pilot study; if you don't treat the lake then you aren't dealing with the fish issue in the lake. Trap and haul as objectionable, need a shorter term solution with oxygenation when the fish need to pass. Stop draining inundated wetlands; leave it flooded once it is flooded (walking wetlands may mobilize nutrients). Dredging too expensive; removing algal biomass not realistic. Dosing of the sediment to deal with internal load; might have to do it every 10 years along with tons of restoration
- Concerns with alum use and possibility for floc impacting aquatic life; holistic enhancements
- External loading dealt with in 50 year plan; positive approach to utilize existing wetland; and create habitat but want to get immediate benefits as well; algal filtration and biomass removal at dams or canals/pinch-points; aeration oxygenation to address temporary impairments so trap and haul doesn't have to go on for years after removing dams; need to address internal load of the lake. Pilot studies in limited areas or hot spots; wetlands around Upper Klamath Lake perimeter where opportunity exists.
- Problems with legacy load and hydraulic modifications; restoration needs to be a major component but unfortunately may be politically infeasible due to constraints with changing land use; agricultural drainage collected into treatment wetlands/diffuse treatment; big question with BMPs: do they work? Needs to have monitoring (needs greater investment and try to educate and outreach to community)
- Focus of restoring ecosystem function on a larger scale rather than little diffuse systems. How is hydroperiod affecting function of wetlands that are being restored (hasn't been addressed so can't show if restoring them is a benefit to improving water quality). Two stage ditches with an internal terrace between the system that traps sediment and denitrifies; studies done so far show lag in P retention so will need some pilot studies for alum or other short term methods
- Ag expertise not represented here so missing some of the needed input; sodium aluminate can be enemy to irrigated agricultural, so sodium budget needs to be considered (this could be changed to K); 1-2 acre wetlands may not work over long term and may not be maintained; targeted design wetlands with reality check of getting acreage in the right places to cut external load. Algal filtration viewed with skepticism. Reservations about wetland restoration vs. treatment: not a great track record with restoration but better removal with treatment wetlands based on historical; targeted wetlands downstream of Link could give some improvement but probably can't get the needed acreage.

Pilot Projects:

A Upper watershed strategies
   - Treatment wetlands needs 4–5 yrs to see benefits
   - Wood River watershed is high priority and amenable to treatment wetland approach
   - Dispersed wetlands treatment siting and design is needed

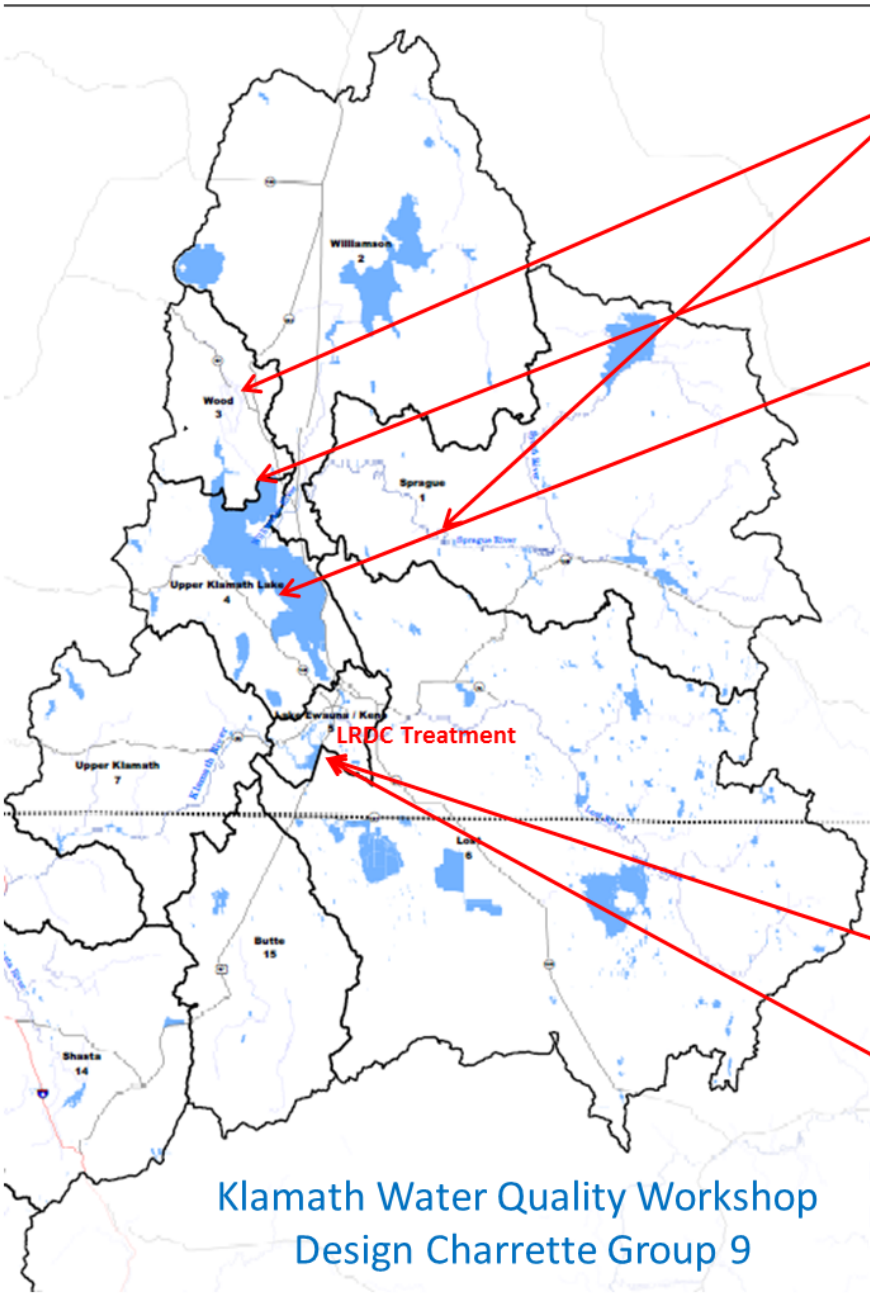
B Restored wetlands on prioritized basis = 1-1.5 g P/m2/yr = 10.5 lb/acre/yr = 10 lbs/acre/yr;

C Intervention: short term and long term needed

D Treatment: alum and/or biochar

Design/ Planning Component	Program Year																				Est. Cost
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
BMP Imp.																					50
Effect. Monit. & Assess.																					20
UKL Pilot and Intervention 1					X																130
UKL Intervention 2 or Keno fix if alum # 1 fails															x						100
UKL Upper Watershed rehabilitation	Plan	Plan																			80
UKL marginal wetlands	plan	plan	plan	plan																	50
Wood R treat wetlands																					30
Wood R wetland O/M																					1.5
Straits Drain wetland planning	plan	plan	plan	plan																	1
Straight Drain alum injection/treatment	plan	plan																			
AM Decision Point 1: Straights drain implementation									x												--
Straits Drain implementation																					82
Contingency Fund																					25
Program Total																					570

X= start to see water quality benefit



1) Upper Watershed Strategies (diffuse & riparian corridor)
$80 million (capital & O&M)

2) Restore historic wetlands $50 million

3) Intervention (p sequestration)
$130 million – pilot + Treatment #1
$100 million – Treatment 2 **(or Keno Fix)**

Working Assumptions

- ✓ Models to refine nutrient targets
- ✓ Improve walking wetland – e.g., Don't drain - fill
- ✓ Ag water conservation
- ✓ Targeted BMPs (?)
- ✓ Biochar (wetlands / soil amendment ?)

4) Treatment wetland – KSD pilot
$90 million

5) Keno intervention (habitable for fish passage) alum / oxygenation (?)

Contingency fund $50 million

Group 10

Concept: focus most money on what we know will work but save some money for pilot studies where there is uncertainty

Project 1: Treat Tailwater

- Pilot Project to establish Diffuse Treatment Systems with willing landowners (use small wetland to treat agricultural tailwater on farm-by-farm basis). May inform development of BMPs Manual by year 4; total cost over 20 years: $500,000 x 5 = $2,500,000

Project 2: Algal Filtration

- Feasibility study and development of P transport model – how much algae do we need to remove? Are there markets for the harvested material? Need economic study. Results of studies by year 2. Cost for studies: $500,000 Assume studies lead to clear plan to build off channel filtration plant that costs $30 million to build by end of year 6 with annual O and M of $3 million; implement years 6-20. $84 million total. Costs possibly offset by marketing material as fertilizer.
- See decrease in total and P and magnitude of blooms by year: 15.

Project 3: Alum Feasibility – $500,000; complete in year one.

Project 4: Treatment and Restored Wetlands

- Objective i. Treatment Wetlands on Klamath Refuge (assumes KBRA implement restores refuge wetlands 48-64 taf water goes there); Develop program that starts treatment wetland with long term goal of achieving a restored wetland. Would absolutely not affect leased lands consistent with KBRA.
- Objective ii. Combine our efforts with the Water Rights Retirement Program in the KBRA (designed to retire use of 30 taf) to identify lands upstream of Upper Klamath Lake to convert to treatment wetlands. Caledonia Marsh, Barnes Ranch, Agency Ranch, key areas.
- Objective iii. Klamath Straits Drain – develop treatment wetlands
- Objective iv. Lake Ewauna – develop treatment wetlands

Timeline

Year 1 – feasibility studies and design project: $500,000 per each = $2,000,000
Years 2 to 6 – permitting, land acquisition = $150,000,000
Years 7 to 20 – implementation = $173,000,000

Invest $100,000,000 into a trust account for management into perpetuity. Involve Warren Buffet.

Effectiveness Monitoring

What is the focus of our project?

Treatment Options

3 Wetlands	5, 5,7,6,8,6,7,7,5,7 = 62
1 Treatment wetlands	7,7,7,5,5,10,9,5,8,10 = 73
4 Diffuse treatment systems	3,7,3,6,2,0,7,5,7,8 = 48
2 Algal filtration	4,6,7,8,8,10,5,5,6 (PILOT), 5 (pilot) = 64
6 Sediment dredging	1,3,0,2 ,0,0,0,0,1,2 = 9
5 sequestration of P	7,6,3,2,1,(land) 5,5,8, (land) 5, 5 = 47

IDEA: P trading and capping. Buy P by the pound.

Day 3 –Design Charrette Key Themes

The following key themes were developed on the morning of Day 3 by the Project Contract Team lead, Maia Signer. The Final Workshop Report will present a synthesis of the workshop, so the below key themes represent only a first cut at the key themes.

- General passion for WQ and habitat improvements in the basin
- Creative thinking is needed
- Multiple technologies/approaches – no one fix
- We are in this for the long haul – 20 years isn't enough, perhaps a 50-year time horizon
- Amount of funding needed
    - Easy to spend the first $100-300M
    - Given information gaps, harder to justify $500M
    - More important to get it right then spend a lot of money trying big installations
- Need targets – not necessarily TMDLs, but need a goal
- Short-term and long-term measures needed
    - Short-term suggestions
        - Treat symptoms now where unacceptable
            - Keno Reservoir oxygenation (w/alum or w/out alum)
        - Get pilot studies going
            - Algal biomass removal
            - Diffuse wetlands
            - Targeted dredging
            - Alum application
    - Long-term suggestions
        - Imperative to consider climate change
        - Treat source rather than symptoms
        - Low energy use systems preferred (i.e., wetlands)
- Locations
    - Wood & Sprague River watersheds
    - Williamson River lower priority
    - Keno Reach
    - KSD
    - Lost River watershed
- Large-scale nutrient removal technologies/approaches
    - Need more than $50M for BMPs
    - Wetland restoration
        - All types of wetlands included (habitat-focused, managed, treatment, diffuse source), distinction not important
        - Mainly around Upper Klamath Lake and in Keno Reach (including KSD)
        - Mixed application in tributaries to Upper Klamath Lake
    - Alum
        - Sensitivities around alum application
        - Pilot studies/further research on how it will work in Upper Klamath Lake/Keno
        - Concern about high pH
        - Public outreach
    - Dredging
        - Targeted areas in Upper Klamath Lake

        - Pilot studies needed
        - Want to re-use that material in the basin if possible, so need to study implications for P-release
- More scientific studies needed in the following areas:
    - Upper Klamath Lake P-dynamics
    - How much algae needs to be removed to have an affect on Keno D.O. and internal P recycling in Upper Klamath Lake
- Riparian restoration is critical to restoring function

Other ideas:

- Other TMDLs beyond nutrients
- Need modeling conducted that describes sucker survival and recruitment in the Lake. What will it take for the suckers to successfully recruit juveniles?
- Reconnect springs
- Juniper removal
- Biochar applications possible
- Energy costs are rising, be mindful of consequences
- Invest $$$$ into a trust account for management into perpetuity. Find wealthy benefactors to fund this ☺

Day 3 – Expert Panel Discussion

Format: Expert Panel members each had 5 minutes to respond to the synthesis of Day 2 Key Themes from the Design Charrettes. During the Expert Panel response period, other workshop participants wrote questions on small sheets of paper, which were then collected and sorted into topic areas. Twenty-six questions were submitted, falling into the following topic areas, which generally aligned with the expertise of one of the Expert Panel members:

- Agriculture - Dave Ferguson
- Scientific Understanding/Nutrients/Algal Dynamics - Stewart Rounds
- Hydrology/Fisheries/Wetland Management around Upper Klamath Lake - Larry Dunsmoor
- Broad Approach Themes - John Day

Three of the questions were repetitious, so 23 questions were read to the Expert Panel members.

Questions/Brief Summary of Responses:

1. *Where does the panel believe we stand as far as data/science in the basin? Do we have (1) enough data/science to move to an implementation program, (2) just enough data to start implementing but need more to implement full scale, or (3) not have enough to do anything yet?*

   Stewart: We need to start now to address critical water quality problems and learn as we go, i.e., adaptive management.
   John: Start now and remove distinction between wetland technologies.
   Dave: There are tried and true measures in place (i.e., BMPs), we should move forward with BMPs; for big removal projects, we need more information before wholesale implementation.
   Larry: Would instead pose a question in response - is our understanding of fundamental processes being strategically brought to bear across landscape to problem solve? I think the answer is “no” and we need to do this.

2. *There has been a lot of attention paid to algal biomass filtration. What is your view of the role/importance of dissolved nutrients?*

   Stewart: Upper Klamath Lake is a coupled system and dissolved nutrients are important as well as particulate/total nutrients.

3. *Do you see any fatal flaws in any proposed activity?*

   John: proposing a program that becomes unaffordable due to inevitably increasing energy costs.
   Stewart: any proposed activity has flaws and need to be considered for tweaking (i.e., dredging Keno Reach not a good idea).
   Larry: noticed a lot of discussion of half-way measures discussed at the workshop, these don’t go far enough and doing so may divert funds from a better overall solution.
   Dave: fatal flaws may be in developing projects without consulting landowners. Suggest bringing conceptual plans to landowners early in the process. To keep the momentum going, we need conceptual plans in next 1-2 years. Then conduct landowner outreach prior to installation of projects.

4. *Notwithstanding funding issues what is the likelihood of a timeline for achieving >50%BMPs (e.g. riparian fencing) in places like South Fork Sprague?*

   Dave: Not withstanding funding issues, we’ve seen similar projects achieved in 20 yrs.

5. *Don't the rights of private property ownership come with a responsibility to protect public trust?*
   Dave: the answer to this question depends on your political views.
   Larry: this is an ideological question and regardless of the answer, I'm most interested in practical solutions.

6. *Can you get cooperation of landowners if there is no specter of enforcement of environmental laws?*
   Dave: Response "yes", limited amount of regulation is good push but the market drives behavior in many cases (for example, organic hay production near Upper Klamath Lake has been largely market driven).

7. *Will structured engineering assistance focus the behavior of professional agriculture practitioners?*
   Dave: that is one of the roles of NRCS, however, it is up to willing landowners to accept new practices.

8. *What are the three knowledge gaps we need to address in the Klamath Basin?*
   John: we need to look at the sustainability of approaches given that energy costs will no longer be low.
   Stewart: the physiology of AFA is still not well understood; additional studies may provide clues about controls on bloom dynamics.

9. *What are the three actions/activities/projects that need to be done next in the basin?*
   John: there are several scenarios which I will leave to the local experts, but I emphasize that there are real limitations on resources (funding) and sustainability is key.
   Dave: we need to provide a common message throughout the basin regarding management approaches.
   Larry: we need to decide what to do about Upper Klamath Lake internal P-loading in the near term- what can we do to deal with this problem now? There are still knowledge gaps for each of the major intervention techniques. We need to implement the settlement agreements.
   Stewart: we need to develop a comprehensive basin plan that states our vision for water quality and habitat improvements in the basin.

10. *How do the Florida/Chesapeake programs collaborate and coordinate at the basin level and across agencies/organizations?*
    John: expert workshops such as this and development of a lot of published literature.

11. *Although wetland restoration is generally accepted as critically important for habitat and water quality improvements, these kinds of projects take a long time and don't help immediately in emergency WQ/habitat conditions. How can we balance the need for solutions now?*
    John: again, there are several scenarios for the near-term solutions which I will leave to the local experts, but I emphasize that there are real limitations on resources (funding) and sustainability is key. Wetlands are low energy use and provide habitat benefits as well as water quality improvement.

12. *Nancy Simon stated that the dominant composition of the sediment in Upper Klamath Lake was diatom frustules. If so, shouldn't we expect the lake to respond reasonably quickly to reductions in external loads?*
    Stewart: Agreed that the response time is a critical piece of information.

Nancy: We do not know the response of diatoms, a form of algae, to reductions in external nutrient (phosphorus) loads because a major limiting nutrient for diatoms is silica.

13. *Are we as a group over-estimating and over relying on wetlands to reduce loads and impact water quality? What does the science say? Won't they have reduced effectiveness in the future and possibly even become a source of P to the system?*

    John: Wetlands are proven in this regard. There are many other regions, watersheds where wetlands have been in place for a >20yrs and they are still functioning with respect to P removal.

14. *Other than mention of the two endangered fish species and the two algal bad actors, there was little discussion of a vision for the target community and ecosystem structure for Upper Klamath Lake. Do we need a more explicit vision? Do we need to think more about the importance of food web interactions?*

    Stewart: more diversity in the algal community should be the target. In other words, replacing the monoculture in Upper Klamath Lake.

15. *How do we get landowners to embrace restoration?*

    Dave: proper incentives and meeting landowners where they are at in life. Also suggest development of conceptual plans that are shown to landowners in the early stages of projects to help them understand and get onboard.

16. *Is enough known about the target nutrient and nutrient ratios needed to eliminate AFA blooms and avoid triggering MSE blooms? Has enough information been extracted from case studies of shallow lake restoration and switching between alternate stable states?*

    Stewart: Our goal should be to control AFA and MSE rather than eliminate the blooms. Upper Klamath Lake is a coupled system and we need to understand how the dynamic can change.

17. *How do we plan for an ecological threshold (cliff) if we don't know where it is?*

    Stewart: We need to make incremental progress, use adaptive management.

18. *Not a new question really an emphasis of earlier question, how much algae needs to be removed to affect subsequent blooms?*

    Stewart: This is something we can work on, study, I don't have the answer now, but it is an important question.

19. *Do we have a good understanding of agricultural water management practices in the area?*

    Larry: Yes. We have good data on hydrology in the basin and we basically understand agricultural practice with respect to water management. There are some gaps in our understanding of shallow groundwater interactions with agriculture.

    Dave: Yes we do, but we find that when actually designing irrigation systems or practices related to irrigation, there are often management factors that don't necessarily fall within the norm.

20. *Do you feel it is necessary to do a mass balance analysis to discern the area that needs to be restored to wetlands?*

    Stewart: the magnitude of the response to wetland restoration should be quantitative, so a mass balance could be informative.

21. *We've lost over 50% of Lost River suckers and as much as 80% of shortnose suckers in Upper Klamath Lake since 2000. To what extent does the threat of extinction for these species drive priority setting in the Klamath Basin restoration? (As compared to e.g., salmon rehabilitation in the upper basin)?*

    Larry: An enormous amount – restoration of these species was an important driver of KBRA. We won't be able to recover these species without a multifaceted approach like KBRA.

22. *Recognizing Dave Ferguson's point about meeting landowners needs and John Day's point that large federal funds won't materialize, how do we generate local support and or funds for restoration that isn't perceived as threatening? KBRA may have had that intent but it felt exclusive and federally driven to many in the basin.*

    Larry: As Dave said previously, we need to meet landowners where they are at and offer good incentives. KBRA is not a federally driven agreement – it was developed by many people who understand and work with local/regional issues.

23. *Shouldn't areas purchased for wetland restoration around Upper Klamath Lake and Agency Lake be used for that purpose instead of water storage to help suppress BGA?*

    Larry: Yes, ultimately wetlands should be restored rather than used for pumped water storage, but the inherent assumption in this question seems to be that wetlands are the silver bullet for solving Upper Klamath Lake water quality problems related to algal blooms. The benefit of restored wetland areas is that by acquiring properties and changing their management, we stop the cycle of oxidation of nutrients and pump-off/release of these nutrients to the lake. This is the critical long-term process that needs to be fixed to help the lake's water quality.