DRAFT

M & T / Llano Seco Fish Screen Facility
Short-Term/Long-Term Protection Project

Conceptual Model and Project Proposal
Technical Review of Project Alternatives
Recommendation of Preferred Alternative
Preferred Alternative Conceptual Model / Project Proposal Recommendation

April 24 – 25, 2006
Llano Seco Ranch Headquarters
Chico, CA

M I N U T E S

Monday
April 24, 2006

Met at Llano Seco Ranch Headquarters, Chico, CA

Attendees:

Burt Bundy, Manager, Sacramento River Conservation Area Forum
Stacy Cepello, Environmental Scientist, California Dept. of Water Resources
Yantao Cui, Research Scientist, Hydrology/Geomorphology
Dennis Dorratcague, MWH Americas
Kevin Foerster, Project Leader, Sacramento National Wildlife Refuge Complex
Jim Gaumer, Engineer, M&T Chico Ranch
Virginia Getz, Regional Biologist, Ducks Unlimited
Michael Harvey, Principal Geomorphologist, Mussetter Engineering, Inc.
Les Heringer, Manager, M&T Chico Ranch
Eric Larsen, Research Scientist Geology
Chris Leininger, Project Development, Ducks Unlimited, Inc.
Tracy McReynolds, Assoc. Fishery Biologist, Region 2, Calif. Dept. of Fish & Game
Tamara Miller, PE, City of Chico
Kelley Moroney, Refuge Manager, Sacramento Valley National Wildlife Refuge Complex
Jon Mulder, Engineering Geologist, Calif. Dept of Water Resources
Robert Mussetter, Principal Engineer, Mussetter Engineering, Inc.
Vickie Newlin, Sacramento Valley Regional Coordinator, California Bay-Delta Authority
Chris Petersen, Principal Hydrologist, MWH Americas
Bruce Ross, Engineering Geologist, California Dept. of Water Resources
Neil Schild, Principal Engineer, MWH Americas
David Sieperda, Manager, Rancho Llano Seco
Richard Thieriot, Shareholder, RanchoLlano Seco
Paul Ward, Association Fishery Biologist, Region 2, California Department of Fish and Game
Olen Zirkle, Manager, Conservation Programs, Ducks Unlimited, Inc.

Introductions - Workshop Facilitator – Olen Zirkle, Mgr., Conservation Programs, Ducks Unlimited, Inc.

Olen opened the meeting with a welcome and introductions.

Project Review: Steering Committee Charge, Goals and Objectives, Progress to Date.

See attached Steering Committee Charge, Goals and Objectives.
Olen gave a brief project update that explained the process to date (See http://dev.ducks.org/conservation/Projects/Western/MandT/mt.asp)

TECHNICAL REVIEW UPDATE

Eric Larsen, PhD, Research Scientist Geology
Future Meander Bend Migration and Floodplain Development Patterns

Executive Summary

The issue being investigated
This report describes analyses to study the meander migration patterns 50 years into the future near River Miles 200 to 191 of the Sacramento River. Previous studies have been done at this location to document the channel dynamics near the locations of the M&T pumping plant (Larsen and Cui 2004); Larsen 2005). The current report describes work that extends the previous work.

The previous studies analyzed the meander migration dynamics 50 years into the future starting with a channel location in 1997 and reported migration tendencies with a simulation of proposed groins in place. The work described in the current report developed and used new data, consisting of a 2004 channel centerline, and also simulated migration for 50 years into the future with and without simulation of the placement of groins proposed in 2005. An additional scenario (Scenario 5) shows the patterns of migration with the placement of an additional groin (called extended groins in this report) near the pump. In addition, simulations were performed with bank restraint removed near the location of the State Park upstream from the M&T pump site.

The methods and model used and key assumptions
The details of modeling techniques, the background on the meander migration model, and key assumptions are not repeated in this report and can be found in previous reports (Larsen and Cui 2004; Larsen 2005). In this report, the current calibration of the model, and five modeling scenarios, are described.

Results
For each of the five scenarios, maps were produced that show the migration patterns 50 years into the future, with channel locations at 5-yr increments. Graphs of rate of land reworked were also produced for each scenario at each bend. The patterns of land reworked were similar for

scenarios 1 and 2. Simulations 3 and 4 show that there is significant area of land reworked at the State Park site, if the existing bank restraint near the Park is removed. Scenario 5 shows the pattern of land reworked with the extended groin scenario.

Conclusions regarding the issues at the M&T pumps

1. Simulations 1 and 2 suggest that, with the eight dike groin field, there will be continued pressure on the west bank near the pumping plant site. The flow patterns due to meander-bend-scale channel curvature and planform shape suggest that the forces will continue to be on the west bank, and may lead to continued pressure to erode downstream of the placement of the original eight dike groin field.
2. Simulations 1 (with no groins), 2 (eight dike groin field), and 5 (nine dike groin field), which show the channel migration, suggest that the placement of groins has little effect on the pattern or rate of meander-bend-scale migration of the bend downstream.
3. The meander modeling does not consider local affects of concentrated flows that may occur in the vicinity of the dikes as a result of the dike configuration.

Discussion Points:

- Model did not analyze variable hydrographs.
- Model added 9th dike scenario.
- No year-to-year variability)linear process).
- Used near bank velocity; 2-year peak flow.
- End point is the same for stream location.
- Resolution of the model does not accurately map hard points, e.g., river road.
- A more erodible unit was added near the pumping plant.
- Model uses a calibration unit that mixes dense forest and weeds together.
- The modeling should contain more accurate erosion fields.
- Model only shows patterns; Eric not comfortable in predicting definitive units of metric measurements.
- Will the model reach a useful conclusion regarding site specific river impacts with or without spur dikes?
- Lateral retreat of west bank.
- Very little effect on the river above and below project area.
- No method to predict point migration.
- Simulation of the groins as a hard point shows little difference in migration fields with and without dikes.
- Eric will rely on 2-D model to demonstrate flows.
- Questions regarding river impacts are too detailed for the capability of the model.
- Model assumes preserving river road.
- Moving river road over would gain riparian forest.

Mussetter Engineering

Two-dimensional Modeling to Evaluate Potential River Training Works at M&T Pumping Plant

Bob Mussetter, Principal Geomorphologist, MEI
Mike Harvey, Principal Geomorphologist, MEI

Executive Summary

The objective of this hydraulic and sediment-transport investigation of the Sacramento River between River Mile (RM) 192.5 and RM 194.4 (Figure 1.1) was to determine if spur dikes installed along the west bank of the river upstream of the M&T Ranch pumping plant inlets and fish screens (RM 192.75) could recreate hydrodynamic conditions that will permit sustainable operation of the pumps for the next 40 years.

Three specific questions were addressed by the study:

1. Will the spur dikes prevent further erosion of the west bank of the river that has retreated over 330 feet between 1996 and 2006, which is the primary cause of the problems at the M&T pumps,
2. Will the spur dikes stabilize the bank-attached bar on the east bank that has migrated downstream towards the pump inlets as the west bank has retreated, and
3. Will the spur dikes create sufficiently high velocities and shear stresses in the vicinity of the pumps during the range of flows when pumping generally takes place (4,000 to 14,000 cfs) to prevent sand accumulation around the fish screens and pump inlets?

An existing two-dimensional (2-D) hydrodynamic model RMA2) (MEI, 2005) was modified to represent the current (December 2005) bathymetry and topography of the site. Models were developed and run for a range of flows from 5,000 to 90,000 cfs for the following scenarios (Figures 3.1 and 3.2):

1. 2005 channel alignment and geometry for a baseline condition (Scenario 1)
2. An 8-dike configuration with dike height at two-thirds bank height (Scenario 2)
3. A 9-dike configuration with dike height at two-thirds bank height (Scenario 3)
4. An extended 9-dike configuration with the lower three dikes raised to full bank height (Scenario 4)

Incipient motion and sediment-transport analyses were conducted with output from the 2-D models and an average bar sediment gradation with a median (D_{50}) size of 39 mm and a D_{84} attached bar in December 2005. A sand size of 1 mm was used in the analysis of deposition potential around the fish screens and pump inlets. Cost estimates for permitting, construction, mitigation and operation and maintenance were developed for the three with-dike scenarios.

Based on the results of the analyses the following were concluded:

1. All of spur dike configurations will prevent further erosion of the west bank,
2. All of the spur dike configurations will prevent further downstream migration of the bank-attached bar located on the east bank upstream of the M&T pumps,

3. Only the extended and raised 9-dike configuration (Scenario 4) will prevent sand accumulation at the pump inlets during the range of river flows when pumping typically occurs,
4. If the dikes are constructed from rock, and full mitigation is required for the 3,200 feet of affected bankline, the costs for Scenarios 2, 3 and 4 are $7.9M, $8.7M and $13.4M, respectively.
5. If mitigation can be offset by removal of an equivalent length of existing bank protection on Golden State Island that is owned by the M&T Ranch, and the recovered rock is incorporated into the spur dikes, costs for Scenarios 2, 3 and 4 decrease to $5.1M, $5.5M and $10,2M, respectively.

Because spur dikes are not commonly used on the Sacramento River, there is little information available to assess their performance for river stabilization or their environmental impacts or benefits. A 5-year Adaptive Management Experiment is proposed to inform future use of these structures where infrastructure protection is required as envisaged in the House Bill 1086 process. The likely cost of the experiment is $345,000. Physical modeling of any selected dike scenario is highly recommended to validate the numerical model results at the fish screens and pump inlets. Physical modeling of a selected dike alternative could be conducted for approximately $190,000. Note: This figure was later revised: 2-D Model - $40K - $50K; Physical Model $400K - $500K.

Discussion Points:

- Used MEI (in-river) data and COE data (overbank) – all the same coordinates
- 3 gravel bar samples – 1 sample subsurface
- Added additional flow data – 90,000 = 2-yr flow probability.
- Duration curve was updated 50% level.
- Uncertainty in ability of dikes to control deposition / sand.
- Uncertainty associated with using shear stress as a predictor of sand deposition.
- Gravel bar will continue to move down river overtime regardless of dike option 1 or 2 (eight dikes or nine dikes).
- Only 9 dikes extended will prevent gravel bar deposition at pump location.
- Physical model important.
- Increased velocities creates erosion of the bar
- Rigid model – changing the bar will change the flow pattern.
- A physical model required.
- Model represents an incipient motion calculation not a transport model.
- Suggested that the shear stress is over used in the large-scale scenario.
- Velocity should be evaluated.
- How far is it necessary to extend 9th groin to achieve suitable velocities at the pumps?
- Problem occurs with the retreat of the west bank.
- As the west bank erodes, the bar grows and moves downstream.

- Review of CALTRANS Butte City Bridge dikes – they are performing well? Over topping of downstream dike has resulted in increased scour just upstream of the bridge abutment..
- Need better information regarding the dynamics of Big Chico Creek.

Dredging / Fish Screen Analysis
Dennis Dorratcague, Principal Engineer, MWH Americas

Executive Summary

A gravel bar is expanding and threatening to block the M & T intake on the Sacramento River at RM 192.7. To provide a reliable water supply to the intake, three options were chosen for further investigation. One of these is to excavate and maintain an open channel from the river to the intake. This report discusses the analysis of this option.
The location of the gravel bar was estimated for the next 40 years based on historical bar movement. The present river energy slope and gravel bar height were assumed to apply in the future. Three alternatives to maintain an open channel were developed. These were:

- A 400 cfs channel to the intake and a 250 cfs bypass channel from the intake back to the river. The 250 cfs provides a sweeping flow past the screens.
- A 150 cfs channel from the river to the intake with no bypass channel back to the river. This has a dead end area at the fish screens.
- A channel from the river to the intake with a flow velocity of 0.33 fps to allow juvenile fish the ability to return to the river.

Uniform flow was assumed to determine the size of the channels. The amount of excavation was calculated for each year in the future assuming that major channel excavation would take place once every three years on average.

The cost of each alternative consists of capital costs to purchase a high capacity, long reach excavator and fish screen modifications (Alternative 2 only). Annual costs consist of channel excavating, hauling, and spreading excavated material and obtaining permits once every five years. To determine first costs from annual costs, it was assumed that the cost of money (discount rate) equaled inflation.

Alternative 2 was not acceptable for fish protection since fish could be trapped at the end of the channel in front of the fish screen. Total present value costs for each alternative showed that Alternative 3 was least expensive. Alternative 3 appears to be the most attractive alternative, however excessive sedimentation in the channel from bedload across the bar is a problem for flows above about 100,000 cfs.

If the dredging alternative is to move forward, Alternative 1 is recommended for further study. Alternative 3 should also be analyzed to obtain a qualitative estimate of the amounts of sediment that must be removed to keep the channel open. See Section 5 for further discussion of the results, conclusions, and recommendations.

Discussion points:

Dredging Alternative #1

- Dredging ends at the pumps.
- Channel along edge of state park.
- Direct to river access.

Dredging Alternative #2

- Does not meet project criteria.
- Uncertainty regarding benefit to City of Chico.
- Questions still remain about where the gravel is going to go over time and how much material will be deposited in the channels and where in order to know how much to dredge.
- Are there provisions for spring-run Chinook salmon to get in and out of Big Chico Creek?
- There is no provision in the report for Big Chico Creek.
- sediment transport and bed load in the river as it pertains to Big Chico Creek is important, in addition to the location and affect on the fish screens. It may cut through the gravel bar at some point and then the same issue arises regarding fish screen criteria and adult attraction. More information is needed to understand the stream dynamics on Big Chico Creek.
- Agreed that regardless of the dredging alternative, Big Chico Creek will remain a problem.
- There is enough flow from Big Chico Creek and the dredged channel to get back into the river and therefore there are attraction flows. However, if there is a dead-end channel and Big Chico Creek joins the dead-end channel, there are no bypass flows.

More discussions held regarding the future location of the mouth of Big Chico Creek and the impact on the gravel bar.

- Dredging Alternative 1 seems to meet the project criteria over the 40 year project life. There are similar back channels at various locations along the river that seem to maintain themselves.
- When the river comes up increased flows will come down the channel.
- Investigations were requested regarding changes that result from various increased river flows.
- In regard to bypass flows, based on the configuration of the fish screens, 250 cfs bypass flows may not be a requirement. The intake channel could theoretically be 170cfs.
- The intake consists of four cylindrical fish screens and the flow of water coming into the intake through the screens and piped through the levee. He agreed with Paul that the screens could be rearranged.
- There are serious concerns regarding the dredging of the channel around the fish screens without damaging the screens. The screens are below the water surface and working around them with any kind of equipment will damage the screens.
- It is impossible to clean around or underneath the screens. The key is to keep the sediment from settling there in the first place.

More discussions were held regarding channel configurations, deposition and type of sediment around the pumps and access issues to dredge deposition (excavator on a barge?). What do you do with the material? Agreed that this is a very difficult issue.

Discussions were held regarding the movement and ultimate length of the gravel bar and the potential of the low flow channel that used to exist in the riparian area to breach the gravel bar. Historically the channel flowed through the lands owned by the Reclamation Board.

Les described the location using a historical aerial photo.

More discussions were held regarding self-maintaining channels. No conclusions.

More discussions about bypass channels.

Stacy commented about self-maintaining channels under the right configurations. Channels found in the non-alluvial system like the Trinity (sediment input dependent) were old spawning channels engineered back in the 1980's. Where there is large sediment load, they tend to choke up pretty quickly.

More discussions were held regarding location and dynamics of Sacramento River channels.

Dennis reviewed the costs listed in the report and how the costs were compiled.

There were strong concerns and discussions regarding where to deposit the spoils or the recapture of the spoils.

Uncertainty regarding the probability of acquiring necessary permits to dredge in the river over a 40-year time period. There is strong sentiment to stay completely out of the river and this option requires yearly in-river maintenance as a sediment management issue. Discussion was held regarding similar situations on the river and potential law suits from third party impacts. The City of Chico may be in harms way due to sediment transport at a lower flow.

Sediment management results in higher costs than gravel reduction.

The question arises about the possibility of the dredged sediment becoming a point source problem due to the turbidity.

Paul commented that as long as its captured in the dry its not a problem. The question is how will it be viewed in future years. He commented that DFG is trying to look at these issues and maintain a consistent policy over the long-term and the project should assume some way to do this whatever the options.

There is a question whether the federal agencies will take the same position.

More discussions were held regarding Dredging Alternative #3, e.g., velocities, by pass flows, debris/sediment collection around the screens. Conclusion: any dead-end alternative will accumulate debris/sediment on the screen and not meet project criteria.

How would State Parks feel about a dredged channel through their park? No conclusion. Woody stated that State Parks has cooperated in the pas and he felt the agency would continue to cooperate in the future.

Dennis provided further discussions regarding implementation actions associated with the dredging alternative and associated costs / constraints.

More discussions on channel configurations for each alternative, especially the sheet-pile wall (not recommended).

Discussions were held regarding dragline vs clam shell. Contractor noted that clamshell will not work under the conditions at the pumping plant site.

Main question – how to keep the fish screens open as the gravel bar moves down but has yet to inundate the facility? Solution may be a on-call dredge on a barge. Suction dredging escalates costs. More discussions we held regarding appropriate equipment and approach.

Olen wrapped up the presentation with the following key points:

- Dredging option #1 – Channel along the east side is acceptable but needs further evaluation.
- Dredging option #2 – Maintaining same channel with a dead end and a channel out to the river. Discarded due to fishery issues.
- Dredging option #3 – high uncertainty about where the gravel will travel and how to deal with the sediment issues around the pumps, high O&M – not feasible. Agreed that the bar will continue to move down river and inundate the pumping facility.
- Large O&M associated with all alternatives and very difficult to assume by stakeholders.
- Where does the gravel bar travel over time and how much material is deposited in the channel?

It will be necessary to agree on the dynamics in order to associate costs.

Montgomery Watson Harza Americas

Ranney Collectors
Chris Petersen, Hydrogeologist, MWH Americas

Executive Summary

Survey Sonoma County Water Supply Operations
A review of the regional and local hydrogeology at the Sonoma County Water Agency (SCWA) and M&T sites shows that the two are drastically different (See report - Appendix A). At

SCWA, the alluvial aquifer is tightly bound at approximately 100 feet below ground surface and at the valley edges by nearly impermeable bedrock. The width of the valley is 800 to 4,000 feet. At M&T, the bounding depth is far enough away from the proposed wells to not pose a limitation to well yield. Permeable sediments extend to approximately 3,800 feet below ground surface. The width of the valley also does not pose a limitation on well yield with the nearest bounding bedrock unit outcropping approximately 14 miles to the east. It is recommended that a facility with more similar hydrogeologic conditions be used as a comparison to the proposed M&T site. Such a facility would be the Nearman Water Treatment Plant in Kansas City, Kansas. Here the geologic and river conditions are similar to the M&T site. More information on this site can be found in Appendix B, Survey Results of Collector Well Operators.

Another main difference between the SCWA distribution system and M&T is the mechanics of delivery. SCWA pressurizes their pipes and system to generate 500 feet of head prior to release into their distribution system. M&T requires the lift (no greater than 100 feet) to convey water to an open canal.

Survey Results of Collector Well Operators

Based on geological and hydrogeological information collected in the survey presented in Appendix B, the Nearman Water Treatment Plant program in Kansas City, Kansas is most similar to the proposed Project. The Nearman Water Treatment Plant has two collector wells with 14 laterals each. Each collector well supplies approximately 25 MGD. The alluvial aquifer is semi-confined with cobbles, gravels, sands, silts, and clays. The Missouri River is approximately 100 feet from the well caissons and the caissons are spaced 1,000 feet apart from each other.

Other projects that may have similar characteristics are the following:

1. City of Cedar Rapids, Iowa
2. Olathe District, Kansas
3. City of Lincoln, Nebraska
4. Humboldt Bay Municipal Water District, California

We can expect the Project collector well system to operate much like these projects if we assume that the data is accurate and conditions at the site are similar.

Meeting Minutes from Three Conference Calls

Three conference calls were conducted with Matt Reed (Ranney Division), Dan McManus (Department of Water Resources), and MWH staff. During these calls, the following were discussed;

- various locations for multiple Ranney Wells,
- types of fuel for pumping,
- alternatives of conveying the water to the canal,
- water conservation, and
- operation of the wells.

Discussions concluded that geologic conditions would be favorable to locate one well near the canal in Llano Seco Ranch. Information regarding energy costs and fuel types were discussed and results are presented in Appendix E. Two alternatives for conveyance of water from the wells to the canal at M&T Ranch were discussed; utilization of the existing sump and pipe system from the wells, or construction of a conveyance to the canal from the wells. The alternative utilizing the existing system was favored, but would require additional lifting costs from the sump. The favored water conservation alternative is to line the existing canal between Big and Little Chico Creeks to reduce losses from seepage along that section. It was also discussed that the wells may not incur operational costs as high as estimated because the maximum allocation may not be necessary 12 months of the year.

Refine Well Yield – Groundwater vs. River

Based on the evaluated simulations, it is not expected that river migration will substantially affect yield capacity and operation of one to four collector wells operating at 24.25 MGD each, spaced 1,500 to 2,00 feet between well caissons, and with 200 foot long laterals placed at 95 feet bgs.

Energy Requirements of the Ranney Well Water Supply

The proposed M&T Chico Ranch/Rancho Llano Seco Ranney Well Option includes construction of four wells for pumping of water to the existing M&T/Llano Seco Pumping Plant. The issue that is memorandum evaluates is the comparative cost of energy for alternative energy sources and initial planning to reduce the reoccurring costs associated with pumping of the raw water from the Sacramento River to the existing M&T/Llano Seco Pumping Plant. The means and methods used for evaluation involved standard hydraulic engineering including the Energy Equation of Pipe Flow and Hazen Williams Equation for Friction Head Loss to estimate system losses and total dynamic head for pumping power requirements. The system pumping power requirements were converted into costs per year based on cost per unit energy for the various alternative energy sources. The results of the evaluation showed that natural gas is the most economical source of energy based on the market conditions for energy sources evaluated. The sources evaluated included electricity , diesel fuel, natural gas and gasoline. The conclusions of this Technical Memorandum include a recommendation for using pipe material and sizes most suitable for lowering the energy costs in concert with utilizing natural gas as an economical source of power for the proposed well pumps.

Maintenance Costs

The proposed M&T Chico Ranch/Rancho Llano Seco Ranney Well Option, if constructed would add pumps, motors, valves and controls as maintenance items that would require consideration related to manpower, schedule and annual budgeting. The issue evaluated in this Technical Memorandum was the annual costs associated with development of this proposed construction option. Experience and standards of the industry were used as the means and methods for the estimate of annual maintenance costs for the M&T Chico Ranch/Rancho Llano Seco Ranney Well Option. The results of the evaluation provided an estimate of the anticipated maintenance costs in terms of a conceptual level analysis. The estimate is approximately $162,125/year for maintenance of the facilities.

Discussion points:

- River migration will not significantly affect the collectors due to the transmissivity of the aquifer.
- This condition will affect deep groundwater wells located on the M&T Ranch.
- Redevelopment of the wells is a major cost.
- Ranney Collectors lose capacity over time that raises the costs.
- Significant leap from test well to 150 cfs capacity for collectors.
- Recommends one well to test the information to design expansion.
- Stakeholders cannot afford the cost of the water.

Lunch

Complete Decision Matrix for all Alternatives

The Steering Committee discussed the information presented in the above-mentioned reports to refine an understanding and develop a preferred alternative that will possibly protect threatened and endangered fish populations from entrainment while meeting pumping requirements for adjacent agriculture, managed wetlands (state, federal and private) and the City of Chico Wastewater Treatment Facility, and have no significant impacts on the Sacramento River meander. The Steering Committee was charged with utilizing the current information to better understand what system-wide influence to the river meander may occur from any one or a combination of identified actions relevant to management needs, while at the same time, meeting the following project criteria: fish screen criteria; pumping requirements, engineering and economic feasibility.

The discussions addressed the following questions:

- What is the rate and uncertainty associated with river meander and sediment deposition at the project site?
- What is the realm of possible alternative means to meet the water requirements of the beneficiaries?
- What are the current fish screen criteria and can these criteria be changed to accommodate innovative solutions?
- What are the uncertainties associated with the simultaneous interaction between river meander, pumping plant capacity and fish screen protection?

Please refer to Attachment A – Decision Matrix.

Tuesday
April 25, 2006

Met at Llano Seco Ranch Headquarters, Chico, CA

Attendees:

Burt Bundy, Manager, Sacramento River Conservation Area Forum
Stacy Cepello, Environmental Scientist, California Dept. of Water Resources
Yantao Cui, Research Scientist, Hydrology/Geomorphology
Dennis Dorratcague, MWH Americas
Kevin Foerster, Project Leader, Sacramento National Wildlife Refuge Complex
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Neil Schild, Principal Engineer, MWH Americas
David Sieperda, Manager, Rancho Llano Seco
Richard Thieriot, Shareholder, RanchoLlano Seco
Paul Ward, Association Fishery Biologist, Region 2, California Department of Fish and Game
Olen Zirkle, Manager, Conservation Programs, Ducks Unlimited, Inc.

Olen Zirkle **–** Welcome & Introductions
Workshop Recap – Monday

Olen reviewed the project conceptual model that was designed to guide the Steering Committee on choosing the preferred alternative that will be a long-term solution. The model directs the decision to meet fish screen criteria, pumping requirements and river meander as well as being engineering and economically feasible.

Olen reviewed the Steering Committee membership, including the stakeholder and the technical experts. He reiterated the responsibility of the technical experts to synthesize all the technical information into a recommendation that meets the criteria set forth in the conceptual model. He also explained that the recommendation must meet stakeholder requirements of long-term economic feasibility in order to have a viable solution.

Discussion was held regarding the public role in the project during the NEPA and CEQA process to provide environmental and social input for the technical and economical recommendation for the project. It was the sense of the committee that social/political issues would be left to the political process and would not be part of the Steering Committee deliberations.

The group discussed the history of the original proposal and agreed that alternatives will drop off the preferred list as each alternative is ranked for meeting the criteria established in the conceptual model.

It was agreed that each alternative should have a thorough discussion in the technical memorandum describing the reasons that the alternative was recommended and why it may or may not meet the long-term solution goal.

Discussion was held regarding the CBDA budget for the project and project implementation. CBDA last notified DU that $12 million had been allocated for the project together with other project budgets. Olen explained that subsequent proposals for the project will be resubmitted to CBDA or other entity (yet to be determined) for review and approval.

Olen then led the discussion through a review of the information that was compiled in the decision matrix for further contributions and comments.

Additional comments were made by Yantao regarding additional information for O&M and costs for dredging and by Dennis regarding the cost of the low-approach fish screens (see attached respective memos).

It was agreed that there is uncertainty regarding hauling of the spoils in the dredging alternative and assumptions are necessary based on experience and estimated cost increases.

Bob compared the 1997 topography of the gravel bar with the post-2001 dredging and the 2005 topography. He compared the areas in each cross section. He explained that the bar has built up approximately 5 feet. More discussion held regarding the movement of the bar and the lack of accretion and that it was a huge sink due to a reduction of transport rate and the ongoing migration of the west bank.

Mike reviewed photos of the CALTRANS Butte City Bridge dikes and the erosion problems at the abuttments and not at the dikes. Mike explained that dikes are categorized as a flexible revetment. When they are constructed it is expected that they will have some adjustment. CALTRANS dikes are atypical with sheet pile down the core.

Bob commented that the sheet pile defeats the purpose of the dikes.

Mike commented that the basis for the argument for one-to-one mitigation for rock is the reduction of soft bank and that must be mitigated. With dikes, there is flexibility seen in the soft bank between the dikes with sediment deposition and revegetation. Spur dikes do not represent a solid full-bank revetment.

Les commented that the high flows this year has increased the potential for a 2006 dredging.

The comment was made that the river is continuing to move west and now flows over an increased area allowing for a wider area for deposition, the formation of the middle-channel bar and the need for an updated survey.

The group still raised the question of in-river movement of the bar as the west bank moves.

Projects costs were revised based on more input from the group.

There is consensus that there must be another dredging no matter what the preferred alternative to keep the project operating.

Discussion was held concerning the potential for a self-mitigating project where rock is put in and rock is taken out and potential mitigation sites / costs.

Uncertainty was raised concerning the need and location of the 9th dike.
Bob explained that the dikes work as a field and isolating one dike over another has significant consequences to the whole system. The design is to ensure that all the dikes work sufficiently to solve the problem. The physical modeling will be able to reduce uncertainty and provide required information for appropriate engineering design.

More discussions were held regarding the uncertainty of mitigation costs.

Discussions were held concerning the interim project and the necessity to dredge in order to keep the pumps and fish screens functioning. It was again reiterated that if rock is put in the river for the interim project, the rock would be removed if the long-term solution is a non-goal alternative. The group agreed that it would take a minimum of 5 years to implement a long-term solution.

There was debate concerning the necessity of the interim solution to protect the pumps and fish screens until a long-term solution was approved and implemented. The discussion ended with agreement that the interim project was to protect the function of the pumping facility and maintain options for selecting a final alternative.

Break

Olen began the discussions by reviewing the fundamental questions goals and ojectives listed in the project charge.

Primary Project Goal

- To protect the existing M&T/Llano Seco fish-screen facility and its beneficiaries while investigating and identifying a technically and economically feasible long-term solution to adapt the fish-friendly pumping facility to the lateral migration of the Sacramento River.

Study Objectives

- To obtain an authoritative and unbiased description of the state of scientific knowledge related to the Sacramento River meander, fish screen and pumping plant technology by convening a multidisciplinary team of experts in the fields of fluvial geomorphology, hydrologic modeling, fish screen and pumping plant technology.

- To provide an opportunity for stakeholders and scientists to test and refine an understanding and potential for unintended effects between managing the natural riverine system, fisheries requirements and pumping requirements.

- To conduct an exhaustive literature search, fill identified data gaps and conduct modeling to provide important data essential in answering specific questions that support a strong research approach in accomplishing the primary project goal.

- To determine performance measures/indicators that will guide the long-term solution in meeting the primary project goal.

- To fully document the investigative process of determining, identifying and justifying the long-term solution that will meet the primary goal of the project.

Current Working Hypotheses and Investigative Approaches. It is possible to protect threatened and endangered fish populations from entrainment while meeting pumping requirements for adjacent agriculture, managed wetlands - state, federal and private) and the City of Chico Wastewater Treatment Facility, and have no significant impacts on the Sacramento River meander.

Olen reminded the group that there is a short-term solution and a long-term solution and that the group must stay focused on each separately while at the same time discussing the cross-over points.

Olen posed the question that if the spur dike alternative was not chosen that the interim project (bioremediation) would not move forward.

Mike commented that it was possible to withdraw the bioremediation if the project is prepared to dredge multiple times to keep the pumping plant operational and the west bank does not necessarily need to be held if dikes are not an option. The bank needs to be preserved if the project needs constructable dikes. Mike reiterated that the cost to put temporary rock on the west bank is not that costly. Mike suggested that it be clarified in the matrix.

It was agreed that if the west bank project is withdrawn a higher cost is associated with dredging.

Olen continued the discussion on the matrix.

Dennis commented that it would be necessary to dredge immediately after a high-water event in the winter and the question arises can that be permitted in a timely manner to meet the immediate need?

Discussions were held regarding the window of opportunity and the associated constraints.

Les emphasized that GCID cannot dredge until after April 1 and that constraint would be applicable to this project.

Discussions were held regarding the potential inundation rate of deposition to a dredged channel.

Jim emphasized that the deep sink is associated within the proposed channel area and must fill before a channel will deliver water to the pumps and no solution to that issue has been discussed.

Les commented that now there exists a low estuary and that will soon fill in around the fish screens. Les agreed that is would take a long time to fill. Les explained that if the pumping plant were farther upstream, they would have a significant amount of deposition underneath the screens.

Discussions were then held regarding these issues.

Jim commented to be responsible the group should design the long-term solution around the worst-case scenario. Jim explained that the dredging option should be mindful of what the river did in the 1930's that would create the condition of no bypass flows that would eliminate alternative #1.

Eric suggested that his modeling did not show that that scenario would likely take place.

Les and Jim strongly disagreed and reiterated that there is certainly proof that the river relocated in the 1930's.

Bob believed that the river could actually take the 1930 meander pattern especiallysince there is development of the bar in the middle of the river. He felt that the continued buildup of the bar would put pressure on the right bank. In that case, the river could take the flow path seen in the 1930s and the pump area will be completely abandoned.

Discussions were regarding this issued and the group agreed that this scenario could indeed exist. Eric commented that he did not model this potential river change and that it could take decades. He recommended that the channel be opened up at the mouth of Big Chico Creek.

Dennis reiterated that the project life was indeed based on four decades – originally 50 years less the 10-year study and development process.

The group further discussed the attributes of the #1 dredging alternative. It appeared to be feasible from an engineering standpoint.

Stacy suggested that the physical modeling be initiated as soon as possible to provide timely answers for the environmental documentation and a 30% design.

Bob commented that he agreed that the modeling should be conducted for the both the spur dikes and the dredging in hopes that more detailed analysis will provide a solution that suggest one or a combination of alternatives.

Paul commented that any additional analysis must come out of the funding slated for this project.

Olen brought consensus to the following action:

The Ranney Collectors were not an option. There was consensus for the Spur Dikes and the #1 Dredging Alternatives and modeling (physical and numerical) should be conducted to refine the options be eliminating key uncertainties and risks.

Stacy commented that he felt the modeling would provide assurance regarding the potential for another 1930 scenario.

Dennis commented that the dredging alternative has not had the same level of analysis as the spur dike option. At this point, the dredging option has made assumptions on wild guesses where the gravel bar is moving and how to get water to it. He suggested that, permitting aside, water can be kept going to the plant and intake with a 2 to 3 day interruption. Now the permitting issue is the real question mark. He questioned the validity of the present ranking based on the permitting questions. A significant uncertainty remains concerning the regulatory window of opportunity for dredging in the river.

Paul commented (with the exception of having the planform) that if the project is talking about removing a plug in the dredged channel a permit can be issued at any time by DFG to remove the plug if that's the issue. A different question arises if the project works in the river.

Dennis revisited the dredging scenario. Paul commented that as long as the removal did not take place in the open river channel, DFG could approve the work in a timely manner.

Les commented on an existing permit that does not state that a live river is involved and NOAA Fisheries will not allow work until April 1. In addition, there would be an annual permit for State Parks.

Paul argued that the permitting would not be insurmountable and could be done. Green Sturgeon is problem for the future. Decisions must be made on what we know today.

The group agreed to leave the question mark in the matrix regarding permitting.

Eric questioned the need for additional dredging if the west bank is not protected.

Bob explained that there is significant potential for additional sedimentation that may result from the river moving into the west bank. Bob also commented that any of the three dredging option do not qualify as a long-term solution due to the movement of the west bank. Recent history shows that the bank is eroding even if the modeling suggests that the erosion is a slow process. The river has to accommodate the bar build up somehow. One possibility is that it will move farther and farther to the right side and maybe cut across to the next bend downstream. To have any kind of certainty with this in-river solution, you have to make sure that the river stays by the pumps. With the dredging alternative, Bob was not convinced that that certainty exists.

Mike commented if the river continues to widen out there will be more deposition.

Dennis commented that he had not captured the costs of potential clean-up action around the pumping plant due to sedimentation. There are no costs for divers, suction dredges, etc. designed around that uncertainty.

Les emphasized that bypass flows remains a significant uncertainty.

Dennis emphasized that was the reason for two channels; one channel to direct the flow to the screen and one channel to take the flow away from the screen.

More discussion were held regarding the 30 foot deep hole that currently exists on the upstream side of the pumps and how the channel alternative will accommodate that existing condition, the migration of Big Chico Creek and meeting sweeping flow requirements with channel flow rather than river flow.

Dennis commented that his information is based on the present size of the screen. He suggested that the approach could be altered by rearranging the screens (with money) to decrease the channel size from the river down to the screens in addition to decreasing the bypass channel.

Les commented that it may not be a channel at some point due to the movement of the mouth of Big Chico Creek similar to the configuration when the pumps where at the old location.

More discussions were held regarding the channel location, channel acceptance by state parks, mitigation measures and required bypass flows.

Les strongly emphasized that there is a lot of unknowns that the stakeholders may not have the capacity to deal with 30 years down the road.

Eric commented that to allow river meander other areas must be sacrificed in reference to impacts to the State Parks. In order to meet the goal of allowing the river not to be constrained we have to give up some other environmental issues in other places. If we want to meet big goals, we can't do them all.

Paul commented that hydraulic standards for fish screens have changed the whole dynamic for past maintenance options of other diversions over the last ten years and if not for that we would not be here today.

Final Selection of Preferred Alternative by Experts

Dredging Alternative #1 – further discussion regarding flat plate screens.

Discussion was held regarding the feasibility of flat plate fish screens in the event that a dead-end channel is created. The construction costs were very roughly estimated between $5 and $7 million with a significant O&M costs. A trash-rake cleaner would be necessary to keep such a large fish screen free of debris and will be costly to maintain.

Paul Ward explained that the screen surface must equal 450 sq ft. and the channel capacity has to meet that same screen velocity.

Dennis commented that the fish screen will be faced with the issue of somehow mechanically removing debris and protection from winter flows. The problem arose from not having a clear drawing to even represent the construction of Dredging Alternative #3. Costs are impossible to estimate without a more definite design.

Discussions on capital costs for dredging alternatives.

Yantao – prudent to dredge on a regular basis rather than wait for a crisis. Yantao made the assumption that 150,000 cubic yards would be dredged every 5 years. Using a 7 to 8 mile haul = about $16 per yard. $3.5 / yard - assume a 40 year life, no haul - dredge 7 times for every alternative. No haul = $3.67M With haul = $16.8M

Jim commented that if that river moves any further to the west there would not be any bypass flows. He strongly emphasized that it is not possible to dredge a feasible water-deliver channel to the pumping facility due to the deep hole that exists in the river along the east side. Fill would have to be placed in the river to raise the channel in that area. In addition, a pad would have to be constructed out in the river to place equipment in the appropriate location for effective gravel extraction. In his expert opinion, dredging is not a feasible alternative.

Dennis commented that the proposed dredging would be conducted in the same manner as in the past (dredge the end and the side of the bar). Dennis also questioned the build out of the bar and as a result the reduction of sweeping flows. Does that mean there should be longer screen?

More discussions about modified screens.

Paul suggested retrofitting current screen with a flat plate screen that comes up to the levee height would be a problem.

Questions that remain:

- Economics of dredging
- Cost of dredging

Questions that remain will be answered with the modeling.

Uncertainties that will be unanswered, e.g., long-term behavior of the river during dredging

Water supply would be compromised if dredging is impossible due to high flows – timing issue
Permitting will be a constraint
Water supply reliability is significantly reduced with the dredging alternative

Consensus of the Steering Committee – move forward on the following two options:

- Spur Dikes (alternative configurations)

- Dredging #1

Phase II – further analysis will determine the most suitable solution.

Recommendation:

Proposal will describe project concept and propose an analysis of two preferred alternatives to determine the best long-term solution. Proposal will include environmental documentation process and final design of the range of possible alternatives.

A matrix was developed to list uncertainties and associated approaches to reduce these uncertainties.

Key Uncertainties:

Permitting
Consultation with regulatory agencies will answer some of the questions.
Redirected Flow
Uncertain concerning redirected flow as a result of spur dike configurations will be answered with physical model.
Social and Economic Impacts
These issues will be addressed within the NEPA/CEQA process.

Proposed location of some of the spur dikes is on federal refuge lands. These lands were purchased to let the river meander. It is critical that a thorough discussion be held weighing the benefits/costs to place rock on refuge land that was purchased for a different purpose.

Sacramento River Area Forum (SB1086 process) must weigh in on the project. This discussion should be in the proposal introduction and describe how the proposal is meeting the policies outlined in the SB1086 Handbook.
For example, "rock will be considered on the river where appropriate.

Larger dike extending out into the middle of the river will have issues.

Consider a one to one mitigation by taking off an equivalent amount of rock to match the rock going into the river.

Identify potential removal sites, e.g., Llano Seco site, M&T Golden State Island, USFWS Phelan Island.

Recommendation made to review and incorporate the current FWS assessment of potential rock removal sites along the river.

Under the dredging #1 alternative, there is a critical uncertainty regarding Butte Creek water availability during dredging and negative impacts on the Butte Creek watershed.

Recommendation: project would gain more physical processes downstream from rock removal than upstream.

Group consensus agreed that there is a significant uncertainty regarding costs and permitting for the dredging alternative.

Important to focus on identifying and analyzing sites for rock removal and assess feasible mitigation opportunities.

Yantao commented that physical modeling will be qualitative and not quantitative.

Bob commented that the model will however reduce uncertainty.

Dennis commented that the model will provide sufficient information to make some engineering assumptions.

It was agreed that physical and numerical modeling should be conducted to advance an understanding that will provide an important basis for choosing the final technical alternative. The model will provide information to conduct an engineering analysis.

Eric again reiterated the importance of listing the recommendation of one to one mitigation of removing rock downstream to advance the acceptance of the spur dike alternative.

Les commented that he was very involved in the SB 1086 process from the beginning and one of the things that landowners, cities and other people with infrastructure asked was that the meander be limited where appropriate and if this isn't an appropriate place on the river to limit meander than there is none. There is M&T utility and the City of Chico. If the group cannot come to agreement that this is an appropriate place to limit the meander than everything that the participants worked in the SB 1086 process was a waste of time.

Eric argued that he felt that this project was to determine whether this is an appropriate place or not.

Les strongly disagreed and referred Eric to the handbook.

Les commented that the dredging alternative comes with a significant amount of risk for the water users who rely on the water on a continual basis.

Bruce commented that he needed more information to provide assurance that the dike configurations would in fact limit the migration of the gravel bar. In addition, Bruce would like to insure that the shear stress for sand removal at low flows and dredging alternative questions would be answered by conducting a physical model.

Les had strong concerns regarding the significant margin of uncertainty associated with permitting on a year-to-year basis with the dredging alternative.

Bruce commented that he had strong concern that the modeling process should reduce the uncertainties about the spur dike alternatives due to the $7 million dollar cost.

Olen commented that the three dredging alternatives will require some fish screen modifications and those costs should be included in the dredging report.

Discussions regarding dredging costs, equipment and fish screen modifications.

Olen led the discussions to rank each alternative according to the flow chart (conceptual mode) for meeting fish screen criteria, pumping requirements, river meander, engineering feasibility and economics.

Tamara questioned whether each yes in the matrix ranked equally.

Discussions continued regarding the weight of river meander and fish screens as it applied to the City of Chico.

Olen posed the question that the Ranney Collectors are disqualified due to economics – too expensive (capital costs and operating costs).

Discussion about complete ranking of Ranney Collectors for every criteria on the flow chart, e.g., fish screen criteria, pumping requirements, river meander, engineering feasibility and economics.

Attention was given to the economic criteria and the ability of the stakeholders to pay the cost of the water and the willingness of the agencies to pick up the capital costs.

More discussions were held regarding burden of costs, long-term funding and funding cap.

It was agreed that the funding cap placed on the project by CBDA was $12 million\. Due to this restriction, Ranney Collectors were rejected.

Discussions were held regarding feasible O&M costs that the stakeholder could bear. Kevin Foerester emphasized that the O&M costs are significantly higher for the ranches than for FWS. Tripling the cost of water for the refuge is not as significant as tripling the cost for the ranches and the Committee should recognize the difference is scale.

It was recognized that all the alternatives would bear the burden of current O&M costs associated with pumping and delivering water ($11/AF).

More discussions were held regarding the assessment of costs and feasibility evaluation for each alternative in the matrix.

It was recognized that there was no way to amortize river meander.

It was agreed that the uncertainties with each alternative would serve to significantly weight the alternatives.

After much discussion is was agreed that the following two alternatives ranked at the top:

Spur Dikes (yet to be determined configuration)

- Meets economic feasibility
- Uncertainty of solving the problem is relatively low
- Resolve uncertainties by modeling

Dredging Alternative #1

- Economic feasibility – OK
- Uncertainty of qualifying as a long-term solution is significantly high.

Discussions held regarding approach to reduce uncertainties for both alternatives to find the best technical long-term alternative.

- Committee agreed to recommend concurrently conducting more refined investigations to reduce the uncertainties in order to more confidently recommend the most feasible and permanent of the two alternatives.

It was agreed that the Ranney Collectors did not rank as a feasible long-term solution.

Discussions were held regarding the social and environmental aspects associated with the Spur Dike and Dredging options.

Eric Larsen strongly recommended that the long-term solution be designed to give back to the environment whatever impact is associated with the most feasible alternative.

Paul Ward emphasized that decisions that DFG was willing to make may be contradicted by another agency and acknowledged that other agencies were not present for input.

Les reminded the group that the project life is 50 years and maintaining an institutional memory with participating regulatory agencies for that period of time is impossible.

The Committee agreed to move ahead with the Spur Dike and Dredging Alternatives and reduce the uncertainties of each through additional refined modeling as part of a Phase II project which would also include 30% engineering and environmental documentation for the preferred alternative.

Bob Mussetter commented that even if the level of uncertainty can be reduced for the dredging alternative, there still remains the high level of uncertainty with future on-going permitting over the life of the project. This aspect creates a greater burden than the technical merit of the

alternative and is a significant risk that cannot be reduced but has the recognized potential to increase.

Discussions were held regarding the potential for relaxed permitting.

Les commented that the current technical information provided by the experts regarding the Spur Dikes significantly gave the ranch more certainty that the dredging alternative.

More discussions were held regarding the problem of the on-going reoccurrence of obtaining dredge permits through the life of the long-term solution (50 years). Policies change in that length of time and significantly raised the level of uncertainty each year. Conditions for the permit will change over time.

Olen conclude this round of discussion by bringing the group to consensus regarding the following recommended alternatives:

Spur Dikes (configuration yet to be determined by modeling)

Dredging Alternative #1 (refined modeling and cost evaluation)

Discuss Preferred Alternative Proposal Framework

Steering Committee began to collectively contribute to writing text for the Phase II Project Proposal.

PROPOSAL

Comments:

- Uncertainty regarding future river migration under the dredging alternative.
- Uncertainty regarding water supply while dredging is being implemented.
- Uncertainty regarding timing issue associated with getting in the river due to species requirements.
- Dredging alternative must take the approach that dredging is possible at all times.
- Uncertainty regarding river flow that constrains necessary dredging.
- Water supply reliability for dredging is significantly reduced as compared to Spur Dikes.
- All alternatives should be clearly described to help CBDA understand the ranking of the preferred alternative.
- All uncertainties should be adequately addressed by technical modeling or thorough narrative discussion.
- Clarify third-party impacts by each alternative or other redirected impacts.
- Environmental impacts will be reviewed in NEPA and CEQA process.
- Clear descriptions of benefits and costs is critical for participating agencies to make an informed decision to put rock on property that was acquired to let the river meander.
- Thorough discussion of the SB 1086 process and accepted guidelines to inform policy makers in Sacramento about necessary protections using rock.

- Consideration should be given regarding the participating of the Reclamation Board in approving an acceptable alternative.
- Important to include one-to-one mitigation of rock in the river (e.g., Kopta Slough) – the project will put rock on and take rock off somewhere else.
- Identify potential sites for mitigation in order to inform CBDA of the proposal approach and design.
- Kelley – Phase II proposal that has similarities to the Princeton-Glenn-Codora project and not reinvent the wheel.
- Key uncertainty is the water dedication in Butte Creek that has a potential significant impact under the endangered species act that has a value of greater than or maybe equal to the dredging.

Olen clarified that a recommendation will be drafted and sent out to the Steering Committee members for editing and refinement. Once the recommendation is completed a draft proposal describing the concept for Phase II (modeling the two alternatives, reduction and resolution of the uncertainties, selection of the long-term solution, environmental documentation process with final design) of the project will be submitted to the committee for review and comment. The proposal will need to be completed as soon as possible.

It was agreed that the draft documents would be compiled at DU and distributed to the Steering Committee members for review and comment. Follow-up discussions would be conducted by e-mail and phone due to lack of funding.

Workshop was adjourned.

(See attached Excel file (9Alternative_Sum 4-25-2006 Decision.xls as Attachment A)

Alternatives	Fish Screen	Pumping Requirements	River Meander	Engineering Feasibility (Y, N, ??)	Economic Feasibility (x$1,000) (2006 dollars)		Benefits City of Chico	Uncertainties/Clarifications	O & M Cost ($ per Ac-ft)
					CAP	O&M			
Spur Dikes (8)	**Y**	**Y**	**N**	**Y**	**$7,350**	**$784**	**Y**	# and design of dikes depends on results of physical modeling; bio-remediation not included in costs	$0.65
Spur Dikes (9)	**Y**	**Y**	**N**	**Y**	**$8,050**	**$884**	**Y**	# and design of dikes depends on results of physical modeling; bio-remediation not included in costs	$0.74
Spur Dikes (9x)	**Y**	**Y**	**N**	**Y**	**$11,610**	**$2,024**	**Y**	# and design of dikes depends on results of physical modeling; bio-remediation not included in costs	$1.69
Dredging (1)	**Y**	**Y ?**	**Y**	**Y**	**$4,000**	**$4,200**	**N**	permits (costs), state parks, schedule of removal, frequency of removal, access to remove material near screen; screen cost included ($3,000,000); no mitigation cost included	$3.50
Dredging (3)	**Y ?**	**Y ?**	**Y**	**Y**	**$4,300**	**$2,326**	**N**	permits (costs), screen modifications, capacity?schedule of removal, frequency of removal, access to remove material near screen; screen cost included ($3,000,000); no mitigation cost included	$1.94
Dredging (GB)	**Y**	**Y**	**Y**	**Y**	**$6,000**	**$12,000**	**N**	permits (costs), Impact of river migration, rate of channel fill, response of other cases, assumes dropping gravel in river; screen cost included ($3,000,000); no mitigation cost included	$10.00
Collector Well (1)	**Y**	**N**	**Y**	**Y**	**$6,637**	**$12,120**	**N**	assumes yield of 10,000AF/y	$30.30
Collector Well (2)	**Y**	**N**	**Y**	**Y**	**$13,274**	**$24,249**	**N**	assumes yield of 20,000AF/y	$30.31
Collector Well (3)	**Y**	**Y ?**	**Y**	**Y**	**$19,911**	**$33,627**	**N**	assumes yield of 30,000AF/y	$28.02
Collector Well (4)	**Y**	**Y**	**Y**	**Y**	**$26,548**	**$43,024**	**N**	assumes yeild of 40,000AF/y	$26.89
No Action	**N**	**N**	**Y**	**Y**			**N**	Where/How would we get replacement water??	