Yantao Cui, Ph.D., Hydraulic Engineer

Memorandum

To: Olen Zirkle, Ducks Unlimited

From: Yantao Cui, Ph.D., Hydraulic Engineer

CC: Steering Committee Members

Date: 3/4/2005

Re: Dredging near M&T Intake on the Sacramento River

Introduction: The M & T / Llano Seco Fish Screen Facility Short-Term/Long-Term Protection Project Technical Review and Recommendation Workshop reconvened on the 16th to 18th, January 2005. One of the proposed actions at the end of the workshop is to evaluate the potential feasibility of dredging a channel toward M&T intake across the gravel bar, including an evaluation of the potential rate of dredging with the river meandering model of Eric Larsen. Here in this memorandum I argue that dredging a channel through the gravel bar toward M&T intake will be a high risky operation in solving sedimentation problem with M&T intake even on a short-term basis, and the best short-term solution is to continue to dredge the gravel bar, whenever it is deemed necessary. I further caution that Eric Larsen's model is not appropriate to come up with a potential dredging rate as pointed out by Eric Larsen himself during the workshop.

General discussion on dredging: It might be helpful if we first discuss two types of diversion operations: those connecting the main water body with a cannel and those located directly at the main water body. The ACID Sacrament River intake was once located in the open water and is currently connected to the river through a cannel following the cutoff event on the Sacrament River near the intake. A schematic sketch of a water intake with a cannel connecting to the main water body is shown in Figure 1.

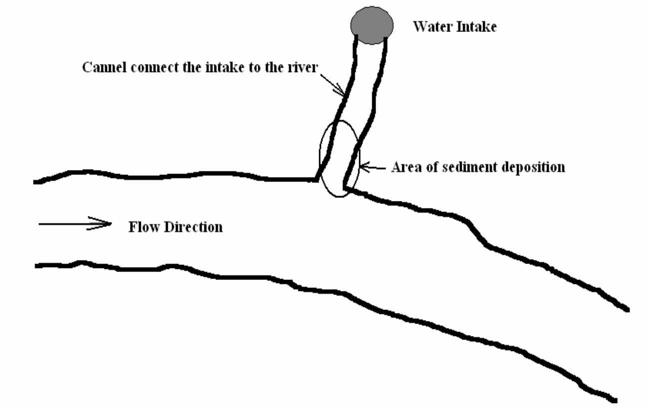

Figure 1. A schematic diagram of a water intake connected to the main water body with a cannel. The oval indicates the primary area of sediment deposition that may need to be frequently dredged.

In the case of Figure 1, the area of sediment deposition is usually limited to the cannel, and the majority of the sediment deposit occurs in a short section within the cannel near the river (and sometimes in the main water body at the entrance to the cannel) as shown in the oval area in Figure 1. In cases like this, the amount of sediment deposit is usually limited and the sedimentation process is usually relatively slow. Because of the relatively slow and small amount of sediment deposition, using dredging as the way to keep the intake open to the river is generally an excellent option, and in the majority of the cases, the best option.

To have a general discussion for the cases where intakes are located in the main water bodies is more difficult because each case is different and has to be dealt differently. The factors that need to be taken into consideration include: (a) where the intake is located; (b) what is contributing to the sedimentation process near the intake; (c) what is the potential rate of sedimentation; (d) what are the consequences and risks involved with the sedimentation process; (e) what is the engineering cost and environmental impact of the dredging operation; (f) what other options exist and what are the associated economic and environmental impact, *etc.* A single factor or a combination of a few of them may decide whether dredging is a viable option to keep the intake under operational conditions. Because of the site specifics, we cannot suggest that dredging is an acceptable option at M&T site based on the fact that there are other intakes that are successfully maintained by dredging. Instead, we have to look at the specific factors that are contributing to the sedimentation problem near the intake at the M&T site. Below I will discuss the implications of dredging the gravel bar and dredging a channel toward M&T intake.

Dredge the gravel bar vs. dredging a channel across the gravel bar toward the intake as short-term options: As the steering committee had agreed upon, the continued downstream migration of the gravel bar on the east side of the river upstream of the M&T intake associated with the continuous erosion of the west bank is the primary cause of the sedimentation problem at the M&T intake. Based on evaluation of sediment transport processes in the Sacramento River near M&T intake, Stillwater Sciences (2001) suggested that dredging the gravel bar would be the best short-term solution before a long-term solution can be identified and implemented. Following Stillwater Sciences (2001) suggestion, approximately 189,000 tons of sediment was dredged from the gravel bar in the following winter, and the pump intake has been operational ever since, in part because the river experienced only relatively dry hydrologic conditions since the dredging operation.

Here it is useful to discuss how dredging the gravel bar will protect the intake. To do that, I adapted an existing numerical model (Cui et al. 2003) to demonstrate the fluvial process following dredging. The model is one dimensional, and thus, does not provide the lateral variations observed in the river. In addition, the processes of river meander and bar migration are not built into the model. That is, model results demonstrate fluvial process following dredging in an otherwise equilibrium system. The results of this demonstrative run are shown in Figure 2 below. Figure 2 demonstrate that the dredging slot creates a sink area for sediment deposition. As a result, the intake area experiences degradation because upstream sediment supply is trapped within the dredging slot.

It needs to be reiterated that the demonstration in Figure 2 does not include the effects from river meander and gravel bar migration, and thus, the actual filling of the dredging slot should be faster.

Figure 2. Simulated results, showing changes in bed elevation, as a demonstration of the functionality of dredging gravel bar upstream of the intake.

Dredging a channel across the gravel bar toward the channel, on the other hand, functions completely differently from dredging the gravel bar to create a dredging slot. Instead of attempting to intercept sediment with a dredging slot, this option tries to keep adequate water to flow to the intake through a dredged channel. In order to have adequate water flow to the intake, the channel must be maintained at certain depth at all times. Figure 3 demonstrates the fluvial process following the initial dredging of the channel. Please note that all the parameters used to produce the results in Figure 3 are identical to the run shown in Figure 2, except that dredging slot is replaced with a narrow channel toward the intake. In addition, the horizontal and vertical scales between Figures 2 and 3 are also identical.

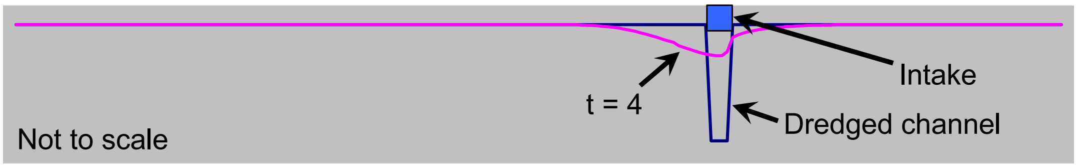

Figure 3. Simulated results, showing changes in bed elevation, as a demonstration of the fluvial process following the dredging of a channel toward the intake.

It can be seen from Figure 3 that the dredged channel will loss its depth in a much shorter time (please note the time difference between Figures 2 and 3) than filling the dredging slot in case of dredging gravel bar, indicating that we can reasonably expect that the dredged channel will have to be maintained (dredged) frequently.

Using Larsen model for dredging rate estimate: Finally I caution the use of Larsen's river meander model for estimating the potential rate of dredging, especially when a dredging channel is suggested as shown in Figure 3. Figure 3 demonstrated that short-term local fluvial process dominates the refilling of the channel, and a long-term, large-scale model such as Larsen's meandering model will not provide adequate estimate for the potential rate of dredging.

I have planned to do some estimate on potential dredging rate but, with careful considerations, realized that the current understanding in sediment transport theories does not provide adequate support for such an estimate.

References

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