Recommendation for Hamilton Ponds Sediment Control Plan
Technical Brief
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Revised June 18, 2010

Background

In the late 1980s, a consortium of numerous state, federal, and local agencies known as the Trinity River Basin Fish and Wildlife Task Force constructed 3 sediment detention ponds at the mouth of Grass Valley Creek (GVC). These ponds were intended to capture sand and very fine gravel derived from decomposed granite in the GVC watershed, where extensive logging in the preceding decades had greatly accelerated erosion and sediment production. The ponds were one component of a multi-pronged effort to reduce sediment delivery from GVC to the Trinity River, where the salmon fishery was impaired due to excessive sandy material in the gravel substrate.

The oldest of these 3 ponds, Wellock Pond was constructed at the mouth of GVC in 1984. Wellock Pond was re-excavated to some extent in 1986 and in 1995, but has otherwise not been regularly maintained. As originally constructed, Wellock Pond was a long, narrow deepening of the GVC channel. Over time, it has partially filled with fine sediment and presently appears as a deep section of slack-water near the creek mouth. Two additional ponds, Upper and Lower Hamilton Ponds, were excavated on GVC about a quarter of a mile upstream from the mouth in 1988 and 1989, respectively. These ponds are roughly circular in shape, with mean diameters of between 200 and 300 feet. Since their construction, both of these ponds have been periodically dredged to maintain sediment storage capacity.

The purpose of this technical brief is to evaluate the need for continued dredging of the Hamilton Ponds and to make recommendations for their future management from a geomorphic perspective. Continued dredging has become somewhat controversial, due to recent recognition that the ponds provide habitat for Coho Salmon and Pacific Lamprey. In addition, the benefit to the Trinity River fishery from pond dredging may no longer justify the cost of around $50,000 per year for ongoing operation and maintenance of the ponds. The full scope of sediment reduction efforts in GVC included the 1992 construction of Buckhorn Dam (a large sediment detention reservoir located in the upper part of the GVC basin), land buy-outs to retire and restore timber lands, road decommissioning, and an upland revegtation program. Together with construction of the ponds and some additional pool dredging in the mainstem Trinity River, more than $46 million in 2002 dollars (not counting ongoing operations and maintenance) has been expended to control sediment deliveries from GVC (Trso 2004). It is possible that these restoration efforts have reduced sediment production in the GVC watershed to the extent that the quantity of sediment captured in the ponds no longer constitutes a significant threat to the health of the Trinity River fishery. In addition to any actual sediment reduction, the impact of GVC sediments on the Trinity River has been substantially reduced by the implementation of annual flow releases from Lewiston Dam, which have greatly increased the capacity of the river to flush sandy sediments from the stream bed.

Trend in Sediment Delivery to Hamilton and Wellock Ponds

A major question in the evaluation of GVC sediment management strategies is whether the quantity of sand and fine gravel delivered to the Trinity River is declining over time. These are the sizes of greatest consequence to the Trinity fishery because it is primarily the sand fraction that infiltrates the gravel bed of the Trinity River, thereby decreasing bed permeability and the survival of salmonid eggs buried in the substrate. Silt and clay fractions of the sediments delivered to the river are of less concern for this analysis because these size fractions are readily transported downstream, and so do not normally accumulate in the stream bed. In addition, the ponds are ineffective for trapping these smaller particles, further eliminating their consideration from an analysis of pond maintenance requirements.

The magnitudes of sediment fluxes are notoriously difficult to measure directly. A large proportion of sediment transport in GVC occurs episodically during winter storm events which can occur at any time of day or night and may last only a few hours. It is virtually impossible to sample transport during more than a tiny fraction of these events. In addition, sand-sized sediments can be transported over a wide range of flows. This means that significant transport can be sustained over long time periods, so that a comprehensive sampling plan would require nearly continuous sampling for weeks or even months.

For these reasons, monitoring the rate of accumulation of sediments in the ponds themselves is by far the most accurate way to assess sediment delivery from the watershed. This is most easily accomplished by keeping track of the volumes of materials dredged from the ponds, which trap virtually all of the sand and fine gravel delivered from the watershed. However, making the most of this approach requires accurate and reliable record keeping. The available record of sediment accumulation and dredging at the mouth of GVC is less than perfect. Dredge quantities over the 20-plus years since the ponds were first constructed are scattered through a large number of different documents that sometimes give conflicting numbers. The primary sources of the reported quantities are frequently unknown, and in some of the years for which no quantities are available there can be no assurance that in fact no dredging took place. When dredging was performed it is uncertain whether the dredged sediments were delivered to the ponds in the same year they were dredged, or whether they were delivered in a previous year. In some years when particularly large dredge totals were recorded, it is possible that the reported quantities represent enlargement of the excavation rather than simply removing fill to restore the original pond capacity. In general, the existing dredge records are inadequate for assessing these possibilities with confidence.

Despite these deficiencies, the dredge record provides the best approximation of the sand and gravel flux from GVC. A recent compilation of these records is given in Table 1, along with a few topographic surveys documenting pond fill volumes. A time series of sediment delivery to the ponds since 1986 was reconstructed from these data as follows: In the absence of any other information, it was assumed that the material dredged from the ponds represent delivery in the winter prior to the dredging. Where fill estimates are available, they are assigned to the delivery for the correct year and subtracted from future dredge volumes. This slightly improves the temporal resolution of reconstructed record of sediment delivery.

Year	Dredge (yards)	Fill (yards)	Source	Notes
1984			DWR 1994	Wellock pools constructed
1985	0		Trso 2004 and DWR 1994	
1986	30000		Trso 2004 and DWR 1994	Wellock pond dredged
1987	0		Trso 2004 and DWR 1994	
1988	0		Trso 2004 and DWR 1994	Upper Hamilton constructed
1989	4300		Trso 2004 and DWR 1994	Lower Hamilton constructed
1990	0		Trso 2004 and DWR 1994	
1991	0		Trso 2004 and DWR 1994	
1992	6600		Trso 2004	Hamilton only, DWR 1994 reported 5000
1993	6048		Trso 2004	Hamilton only
1994	0		Trso 2004	
1995	53600		Trso 2004	48000 from Hamilton, 5600 from Wellock*
1996	0		Trso 2004	
1997	13000		Trso 2004	
1998	34700	14000	Trso 2004	Ponds full, 14000 tons spilled to river
1999	0		Trso 2004	
2000	No data	2930	GMA survey (fill)	
2001	No data	1140	GMA survey (fill)	
2002	6200	1120	RCD pers. com. (dredge) GMA survey (fill)	
2003	2900		RCD pers. com. (dredge) GMA survey (fill)	
2004	3700	7080	RCD pers. com. (dredge) GMA survey (fill WY2003-04)	
2005	3650	1500	RCD pers. com. (dredge) GMA survey (fill)	
2006	9200	4740	RCD pers. com. (dredge) GMA survey (fill)	
2007	11700		RCD Report	
2008	0		RCD Report	
2009	0		RCD Report.	

Table 1: Dredge and fill records for Hamilton and Wellock Ponds. GMA refers to Graham Matthews and Associates; RCD refers to the Trinity County Resource Conservation District. *Wellock pond has not been dredged since 1995.

The rate of sediment delivery to the ponds is necessarily tied to the stream flow in GVC. Most of the pond filling occurs during wet years with large water discharges from GVC, whereas relatively little sediment is transported into the ponds during dry years when stream flows are low. Stream flow in GVC was assessed in terms of both the total acre-feet of runoff from the watershed and the annual peak water discharge (Q_p) attained at the USGS stream gage near Lewiston. Flow records prior to water year 2005 were synthesized by correlating records from the historical gage at Fawn Lodge with records from the existing gage near Lewiston over the year when both gages were in operation. After evaluating both approaches, it was decided to rely primarily on Q_p to quantify the potential for sediment to be transported from the watershed into the ponds.

It is a well-known principal of sediment transport theory that sediment transport capacity increases roughly as the square of shear stress (Yang 1996). Although the relationship between shear stress and water discharge depends on channel geometry and channel network organization, sediment rating relations developed for several Trinity River tributaries indicate that sediment transport scales in a similar manner with stream flow

(Gaeuman 2008). Thus, it is theoretically sound to expect the sediment delivery rate to the ponds to scale with Q_p^a, where the exponent a is about 2, rather than linearly with Q_p. A close correspondence between the normalized cumulative total sediment delivery over time to the GVC ponds and the normalized cumulative sum of Q_p^2 (Figure 1) supports this expectation. That is, the slope of the cumulative curve for sediment delivery increases/decreases when the slope of the cumulative curve for Q_p^2 increases/decreases.

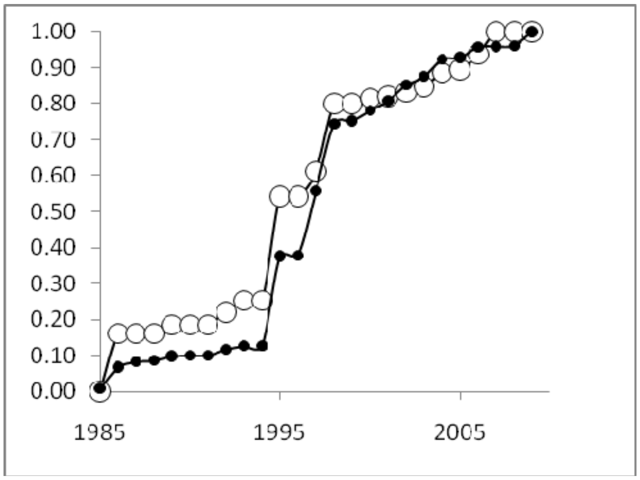

Figure 1: Normalized cumulative total sediment delivery over time (open circles) and the normalized cumulative sum of Q_p^2 (filled circles) from 1986 through 2009.

Because hydrology is such a critical factor in determining the sediment delivery rate, changes in the potential for sediment delivery at the ponds cannot be adequately evaluated by considering raw delivery estimates alone. The potential for delivery is instead evaluated here by comparing the rates at which the sediment and summed peak flows accumulate through time. Figure 2 shows the ratio of the normalized cumulative sediment delivery to the normalized cumulative sum of Q_p^2.

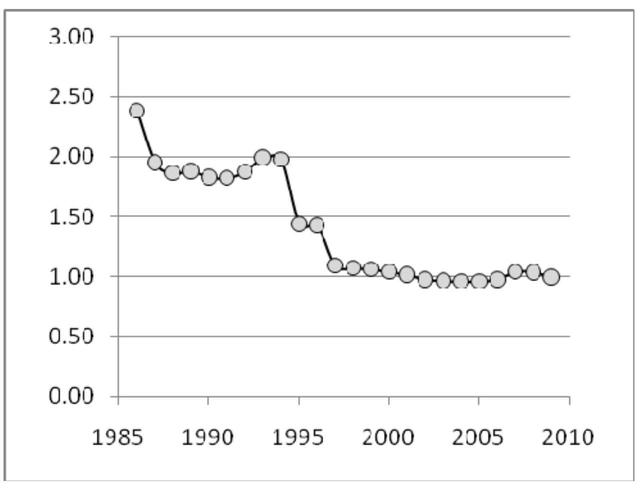

Figure 1: Ratio of the normalized cumulative total sediment delivery to the normalized cumulative sum of Q_p^2 from 1986 through 2009.

It can be seen that the delivered sediment accumulated at about double the relative rate that the sum of Q_p^2 accumulated between 1986 and 1994. Q_p^2 accumulated rapidly after 1994, and by 1998 had attained a proportion of the total sum similar to that of the delivered sediment. Since 1998, both the delivered sediment and the sum of Q_p^2 have been accumulating in similar proportions.

These results can be interpreted as follows: In the late 1980s and early 1990s, a large amount of excess sediment was available for immediate transport in the GVC system. After 1994, the Trinity region experienced a period of unusually wet weather. Water year 1995 and 1998 were classified as extremely wet, and 1996, 1997, 1999, and 2000 were all classified as wet. By the end of that wet period, much of the sediment that was readily available for transport in GVC had been flushed out of the system, and the magnitude of the sediment delivery potential to the Trinity River declined. Between 1985 and 1999 an average of 10,140 yards of sand and fine gravel were delivered to the mouth of GVC each year, whereas the average delivery for the years 2000 through 2009 is just 3,735 yard per year.

Pond Delivery Rates Compared with Previous Estimates

When converted to tons per year (1.5 tons per yard), the dredge and fill records indicate that sand and gravel delivery to the Hamilton and Wellock Ponds averaged 15,210 t/yr prior to 2000 and 5,600 t/yr since 2000. Independent estimates of sediment production in the GVC watershed could provide a rough check on whether the above analysis is at all realistic.

As is typically the case with such figures, previously computed estimates of sediment production in the basin are extremely variable. Various reports of total sediment production in the basin compiled by Trso (2004) range from 16,690 t/yr to 230,000 t/yr, with an average of about 70,000 t/yr. Estimates reported by the same agency (NRCS in particular) can vary wildly from one document to the next, and in some cases different figures are reported within the same document. Among the more believable estimates is that of GMA (2001), which reported about 62,000 t/yr of total sediment production in the GVC watershed for the period 1980-2000. Back-calculations from yields of sand and gravel reported by Trso (2004), as well as explicit statements in the text, indicate that it has been common to assume that sand and gravel constitute about 45% to 55% of the total sediment yield in the GVC basin. Adopting a proportion of sand/gravel to silt/clay of 50% and recognizing that 46% of the GVC basin is upstream from Buckhorn Dam, the GMA figure implies a delivery rate for sand and gravel at the pond site of about 15,500 t/yr. This is essentially identical to the pre-2000 figure derived from the dredge records.

Pond Delivery Rates Compared with Trinity River Transport

Although the quantities of sand and fine gravel that could potentially be delivered to the Trinity River from GVC have apparently declined in recent years, the relatively small loads could very well remain large enough to be harmful to the Trinity River fishery. The magnitude of the present delivery potential relative to the quantities that the river can be expected to accommodate is evaluated by considering the loads of sand and fine gravel that the river has actually transported in recent years. A continuous record of bedload and suspended load sediment transport in the Trinity River is available at two sampling locations that are relevant to this discussion (Trinity River at Limekiln Gulch [TRLG] and Trinity River near Douglas City [TRDC]) since 2004. A record since 2006 is available at a third relevant site (Trinity River near Grass Valley Creek [TRGVC]). Table 2 lists annual loads of sand and fine gravel (t/yr) computed by GMA at those locations during those years.

	2004	2005	2006	2007	2008	2009	Average
TRGVC							
Bedload < 8 mm	na	na	3280	444	1260	542	921
Susp. Load 0.5-4 mm	na	na	2790	341	822	0	659
Total Load 0.5-8 mm	na	na	6070	785	2082	542	1580
TRLG							
Bedload < 8 mm	1649	1314	6660	278	1330	236	1911
Susp. Load 0.5-4 mm	359	747	*31100	206	893	57	5560
Total Load 0.5-8 mm	2008	2061	37760	484	2223	293	7472
TRDC							
Bedload < 8 mm	3754	5064	12700	733	2510	882	4274
Susp. Load 0.5-4 mm	1698	1960	31100	1660	2830	472	6620
Total Load 0.5-8 mm	5452	7024	43800	2393	5340	1354	10894

Table 2: Trinity River sand and fine gravel loads computed for 3 sampling locations by GMA. All figures in tons. *GMA reported 111,690 tons based on extrapolation of turbidity records to estimate suspended sand concentration between samples. This method is inappropriate for sand fractions and resulted in an unrealistically large load. The load estimate from TRDC, which is downstream and should transport larger loads, was substituted in its place.

According to the dredge and fill records, an average of annual delivery of about 7,000 t/yr of sand and fine gravel were delivered to the Trinity River at the mouth of GVC during the period 2004-2009. Data compiled since 2006 at TRLG shows that the ponds capture 4 or 5 times the load transported at that location, which is located a short distance upstream from GVC. The fact that the record at TRGVC lacks data for 2004 and 2005 underscores this result, because the record begins with the extremely wet year of 2006 when large amount of sand were input to the upper river from major landslides in the Lowden burn area near Lewiston. If the earlier years were available at TRGVC, the average loads would undoubtedly be significantly smaller than the 1,580 tons shown in the table, and the relative magnitude of GVC deliveries would be even greater. However, field observation has shown that the spring flow releases are effective in cleaning sand from the bed in the upper river, indicating that the releases are capable of transporting much larger loads of sand than are supplied to the river in that area.

At TRLG, which is located about 6 river miles downstream from GVC, the average load (adjusted as described in the table caption) is about 7,400. This is about equal to the estimated load captured in the ponds, suggesting that the sand load at TRLG would approximately double if pond dredging were discontinued. In this reach too, field observation indicates that the flow releases are capable of transporting more sand than is supplied to the river. Whether doubling the loads input to this stretch of the river would significantly impact substrate quality is uncertain. However, it would result in loads larger than are presently measured at TRDC, where the effect of increasing sand loads on the bed surface are apparent (see below).

TRDC is downstream from 2 major sources of sand and fine gravel – Indian Creek and Weaver Creek. These additional inputs can be observed to have an effect on the bed composition in the Douglas City area, where runs and riffle heads often contains 10% or more of sand cover following the flow release when similar facies in the Lewiston area usually contain only traces of sand. The sand loads computed for TRDC are larger than the estimated deliveries to the mouth of GVC, but not my much. Eliminating the GVC ponds would likely increase sand and fine gravel loads at TRDC by a factor of about 1.6, and could result in a similar increase in the percent sand cover on the bed surface. Whether this would be detrimental for salmon spawning is a biological question.

Conclusions and Recommendations

It is clear that dredging of Wellock Pond is unnecessary. It has not been dredged since 1995 with no ill effect, as the capacity of the other ponds is sufficient to control sediment delivered from GVC.

The potential sediment deliveries from GVC have declined to as little as a third of the delivery potential that existed when the ponds were constructed. With this decline in mind, it is suggested that the continued maintenance of both Hamilton Ponds is unnecessary. Either of the two ponds has the capacity to impound all the sediment delivered from GVC in most years, as well as the capacity to capture the majority of the sediment delivered even in very wet years. Some spillage from full ponds in very wet years would probably not significantly harm the Trinity River fishery, since large flow releases during very wet years have proved to be effective in flushing sand from the system.

However, the magnitude of the present delivery potential is still large enough that failure to maintain at least one pond would likely produce a noticeable increase in the percent of sand on the bed surface and in the substrate downstream from GVC. It is suggested that under a no-dredge option the substrate characteristics in the reaches between GVC and Indian Creek would assume characteristics similar to those presently observed downstream from Weaver Creek. Whether that magnitude of change would be biologically meaningful is beyond the scope of this brief.

With these considerations in mind, it is recommended that one or the other of the Hamilton Pond (probably the upper one) be dredged as needed to maintain a storage capacity of at least 7,500 yards (about twice the average delivery since 2000) for another 3-5 years. The other pond can be managed to provide habitat for various species of interest. During this time, it will be important to maintain accurate records of dredge volumes and pond topography so that any continued decreases in the sediment delivery potential can be identified with more confidence than is currently possible. At the end of that time period, the need for continued dredging should be re-assessed. It is likely that dredging can be safely discontinued in the not-too-distant future.

References

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