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Memorandum

To: CCBWQA Technical Advisory Committee

CC: Chuck Reid, Manager, Jim Swanson, Capital Projects Consultant

From: William P. Ruzzo, P.E.

Date: September 4, 2013

Re: West Shade Shelter Shoreline Stabilization PRF – Water Quality Analysis

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An analysis was conducted to identify and quantify water quality benefits associated with shoreline stabilization at the West Shade Shelter (Project) recreation site in Cherry Creek State Park. See Figure 1 for the location of the Project.

RESULTS AND CONCLUSIONS

The results of analysis showed that the conceptual stabilization plan developed for the West Shade Shelter Project will:

1. Minimize the direct discharge of parking lot pollutants including total phosphorus and sediment into Cherry Creek Reservoir.

2. Minimize shoreline erosion which discharges sediment and attached pollutants into Cherry Creek Reservoir.

3. As measured by the pound of total phosphorus immobilized or otherwise removed, the projected annual cost of the Project is 410 $/lb. This annualized cost compares favorably with other projects funded by the Authority which have ranged from $100 to $2,200 dollars/lb.

RECOMMENDATION

It is recommended that the West Shade Shelter Shoreline Stabilization Project be considered a PRF and be included in the Authority's 5-year CIP beginning in 2014. The first step would be to have prepared a more detailed alternatives analysis and preliminary design to confirm technical feasibility and to better define all project costs.

BACKGROUND

Forces from wind, wave, ice, storm runoff, and recreation users cause surface soils to become "detached", particularly along the shoreline, causing soil movement (sediment) and

eventual discharge into the Reservoir. Sediment is a pollutant that impacts aquatic habitats. Sediment and storm runoff also include other pollutants, primarily phosphorus and nitrogen that promote algae growth. Algae negatively impacts beneficial uses of the reservoir, such as fishing, swimming, and boating. Shoreline stabilization reduces the quantity of pollutants that enter the reservoir through techniques that:

a. Uses rock or other non-erodible materials to protect shorelines, which prevent or minimize the amount of erosion that can occur and, therefore, the discharge of pollutants to the Reservoir.

b. Uses vegetation to reinforce the soil matrix, protect the soil surface from erosive forces of precipitation, and filters sediment from storm runoff, thereby immobilizing and trapping pollutants, preventing them from entering the Reservoir.

c. Encourages infiltration of storm water which reduces runoff volume and, therefore, quantities of pollutants entering the reservoir related to surface runoff.

In addition, when recreation activities are focused adjacent to the shoreline, such as the West Shade Shelter, parking lots, formal and social trails, shelters, and other ancillary facilities increase and concentrate storm runoff resulting in the discharge of other pollutants (sediment, nutrients, pesticides, oil/grease)[1] into the Reservoir. Best management practices (BMPs) to minimize pollutant discharges from these activities use sedimentation, filtration, and infiltration techniques described above to immobilize and trap sediment before entering the Reservoir.

The Water Quality Control Commission (Commission) previously established a chlorophyll *a* standard as a measure of algae in the reservoir to protect the beneficial uses of the reservoir. The Commission also established a total maximum annual load (TMAL) for phosphorus as a goal meant to achieve the chlorophyll *a* standard, which was lifted in 2008. Whereas currently Cherry Creek Reservoir does not have a TMAL, the Commission continued a standard for chlorophyll *a* and required a concentration-based management strategy for phosphorus control in the basin[2]. Therefore, controlling nutrient concentrations and loads to the Reservoir was established as the watershed management strategy.

PROJECT HISTORY

Shoreline stabilization projects were some of the earliest pollutant reduction facilities (PRFs) constructed by the Authority beginning with the East Shade Shelter and East Boat Ramp in 1996 then followed by Tower Loop and Dixon Grove projects in 1999 (see Figure 1). During the 2005 annual inspection of PRF's in the Park[3], extensive erosion was observed along the shorelines in the west Park area. These observations resulted in identification of

[1] Kadlec and Knight.1996. *Treatment Wetlands.* CRC Press LLC, p22.

[2] CDPHE Water Quality Control Commission 2012. *Cherry Creek Reservoir Control Regulation.* 5 CCR 1002-72 @72.3

[3] William P. Ruzzo, PE, LLC April 25, 2005. *Annual Inspection of PRF's at Cherry Creek State Park*

reservoir shoreline stabilization by the Authority in 2006 as a general category of potential PRFs for the capital improvement program (CIP). The 2007, 5-year CIP identified the shoreline at Mountain, Lake, and Cottonwood trail recreation sites as specific projects. Stabilization of the Mountain and Lake Loop shoreline areas was completed in the summer of 2013. It is unknown why the West Shade Shelter shoreline was not specifically identified as well.

CONCEPTUAL PLAN

In late 2012, the Authority was approached by University of Denver professor Charles Chase who teaches a graduate level class in landscape design to see if the Authority had another project that his students could use as a case study. Professor Chase's students previously provided assessment of the 12-Mile Dog Park reach of Cherry Creek that became the starting point for the analysis, design, and eventual construction of the stabilization in the reach[4]. Working with Professor Chase, I was a student advisor from January through July 2013 providing information and guidance on the problems and potential solutions for the West Shade Shelter project area. The result of the student's efforts is provided in their master's program report[5] and is the basis for the conceptual plan use for this water quality analysis.

Presented on Figure 2 is the conceptual plan for the Project area, which consists of the following components:

1. Capture of storm runoff from the parking lot and directing it eastward toward a porous landscape detention (PLD).

2. Construction of armored jetty's at strategic locations to stabilize the shoreline.

3. Reconstruction and relocation of formal and social trails to minimize erosion caused by pedestrian access over grassed areas and steep banks.

Tim Metzger, Park Manager, was interviewed by the students to get Park's perspective and general requirements before developing the conceptual plan. Mr. Metzger was provided a copy of the student's final report for review and responded favorably to the project (see Appendix B).

WATER QUALITY ANALYSIS

Evaluation of the water quality benefits associated with the West Shade Shelter Shoreline Stabilization project requires an analysis of parking lot runoff and shoreline erosion. Calculations of pollutant loads and estimates of load reductions due to implementation of the BMPs described above are provided in Appendix A. Procedures, data, and assumptions used for these calculations are described below.

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[4] Phase I was completed in early 2013 and Phase II is scheduled to begin construction in late 2013

[5] Silbernagel, Kara and White, Hunter August 2013. *West Shade Shoreline Stabilization Cherry Creek State Park*

Parking Lot Runoff. Phosphorus and sediment loads from the parking lot are estimated by multiplying the event mean concentrations (EMC, in mg/l) times the mean annual storm runoff (see Appendix A, sheet 2/3) which resulted in an annual total phosphorus (TP) load of 2.3-lbs and 1,562-lbs of sediment (TSS).

Proposed modifications to the parking lot would direct the 2-year storm event to an infiltration type BMP called a porous landscape detention (PLD) located east of the parking lot. Criteria for design and evaluation for PLD's is provided in Volume 3 of the Urban Storm Drainage Criteria Manual[6].

The ability of the PLD, as designed using Authority criteria, to immobilize TP and TSS is believed to be very good and estimated to prevent ~80% of the pollutants from reaching the Reservoir. Two similar PLDs were constructed at the Mountain and Lake Loop projects and included a different filtering media than recommended in Volume 3. The Authority also had installed monitoring locations at the PLDs to collect data, although no results are available as of the date of this report.

Shoreline Erosion. Phosphorus and sediment loads from shoreline erosion were calculated by using the median concentration of TP in the soils and an estimate of the erosion that had occurred along the shoreline. Calculations are shown in Appendix A sheet 3/4.

The Authority has sampled and tested for TP in a number of soils from stream banks, shorelines, and detention ponds, which are shown in Table 1 below in mg/kg and pounds per ton of sediment. The median of 9-sample locations with 3 or more samples each was calculated to be 1.3-lbs/ton.

Table 1 – **Measured Soil Phosphorus Data**

Results reported as mg/kg or %	Samples By	Lab	Range		Average	Unit	Note
Cherry Creek stream bed measurements	Halepaska		310	580		mg/kg	
Watershed Soil Measurements	Halepaska		0	3.9	1.5	mg/kg	
Soil Measurements	CSU Extension		1	60	8	mg/kg	
Shoreline Bank measurements	CH2MHill				2	lbs/cy	
Cherry Creek Bed measurements at Arapahoe Rd	TetraTech		10.5	41.4	14.7	mg/kg	
Cottonwood\Peoria Sediment Pond	GEI		640	810	743	mg/kg	Extrac P = 3 mg/kg
Cottonwood @ Easter Avenue, stream bank composites	Ruzzo	ACZ labs	431	910	573	mg/kg	
Cottonwood @ Easter Avenue, stream bed composites	Ruzzo	ACZ labs			516	mg/kg	
Cherry Creek @ 12-Mile House	CTL Thompson	ACZ labs	290	590	406	mg/kg	
Mountain/Lake Loop Shoreline	MEC	ACZ labs	3400	14300	9340	mg/kg	data questionable
E470 SFB Segment 1	Ruzzo	ACZ labs	350	510	420	mg/kg	
Piney Creek @ Saddle Rock GC	Toering/Adam	ACZ labs	390	650	533	mg/kg	
Cottonwood Wetlands PRF	Ruzzo	ACZ labs	720	773	744	mg/kg	
Sterne Lake sediment	Conklin	Midwest Labs	483	698	551	mg/kg	
Converted to lbs/ton							
Cherry Creek stream bed measurements	Halepaska		0.6	1.2		lbs/ton	
Watershed Soil Measurements	Halepaska		0.0	0.0	0.0	lbs/ton	
Soil Measurements	CSU Extension		0.0	0.1	0.0	lbs/ton	
Shoreline Bank measurements	CH2MHill				1.9	lbs/ton	
Cherry Creek Bed measurements at Arapahoe Rd	TetraTech		0.0	0.1	0.0	lbs/ton	
Cottonwood\Peoria Sediment Pond	GEI		1.3	1.6	1.5	lbs/ton	
Cottonwood @ Easter Avenue, stream bank composites	Ruzzo	ACZ labs	0.9	1.8	1.1	lbs/ton	
Cottonwood @ Easter Avenue, stream bed composites	Ruzzo	ACZ labs			1.0	lbs/ton	
Cherry Creek @ 12-Mile House	CTL Thompson	ACZ labs	0.6	1.2	0.8	lbs/ton	
Mountain/Lake Loop Shoreline	MEC	ACZ labs	6.8	28.6	18.7	lbs/ton	data questionable
E470 SFB Segment 1	Ruzzo	ACZ labs	0.7	1.0	0.8	lbs/ton	
Piney Creek @ Saddle Rock GC	Toering/Adam	ACZ labs	0.8	1.3	1.1	lbs/ton	
Cottonwood Wetlands PRF	Ruzzo	ACZ labs	1.4	1.5	1.5	lbs/ton	
Sterne Lake sediment	Conklin	Midwest Labs	1.0	1.4	1.1	lbs/ton	

[6] UDFCD November 2010. *Urban Storm Drainage Criteria Manual Volume 3 – Best Management Practices*

To estimate the erosion rate along the shoreline, the Authority used survey data at the Mountain and Lake Loop project taken three years apart. The original topo survey was prepared for the preliminary and final design phases of the project. However the project was delayed from preliminary to final design about a year and a half and additional shoreline erosion had taken place during this period. Therefore a second topo survey was prepared along the shoreline to determine the change in pay quantities for construction due to the additional erosion. Comparison of the two surveys showed that 1225-cubic yards had eroded along 1250-feet of shoreline in 3-years, which resulted in an erosion rate of 0.33-cy/yr/foot of shoreline.

For estimating erosion at the West Shade Shelter project, it was reasoned that the shoreline would likely not continue to erode at this rate and a more conservative value of 0.1-cubic yards per year per foot was believed a reasonable assumption. Then using the median TP concentration of 1.3-lbs/ton, 1,000-feet of shoreline, and an erosion rate of 0.1 cy/yr/ft, the annual erosion was calculated to be 100-cy containing 140-lbs of TP.

Again for conservatism, it was reasoned that the shoreline erosion control measures would not be 100% effective over the life of the project perhaps due in part to extreme weather related events and general recreational use. Therefore, the "effectiveness" of shoreline erosion measures to reduce erosion and TP was assumed to be 90% such that the annual reduction in TP due to shoreline stabilization is 126-lbs.

Project Costs

The final step in the analysis was to estimate total project costs, annualized the costs, and then determine annual water quality benefits, which are shown in Table 2 below.

Table 2 – **Project Cost Estimate**

Item	Description	Unit	Quantity	Unit Cost	Cost
1	Stabilization Measures	1	ea	$ 492,000	$ 492,000
2	Trails	0.25	mile	$ 70,000	$ 17,500
3	Parking lot repairs	1	LS	$ 50,000	$ 50,000
4	Contingency	20%	%	$ 509,500	$ 101,900
Total	Capital				$ 661,400
5	Technical Feasibility	1	ea	$ 55,000	$ 55,000
6	Final Design	1	ea	$ 90,000	$ 90,000
7	Construct. Mgmt	1	ea	$ 150,000	$ 125,000
8	Administration	3%	%	$ 661,400	$ 19,842
Total					$ 289,842
Total	(rounded)				***$ 951,200***
	Annualized (4% @ 35-years)				***50,965***
	Annual O&M				***1,000***
	Total Annual Cost				***51,965***
	Parking Lot TP reduction (lbs)				1.9
	Shoreline TP reduction (lbs)				126
	Cost per pound of Total P reduction				***410***

The total project costs with contingency and including design, bidding, and construction services is $951,200. At 4% over 35-years[7], the annualized cost is $51,965 which includes minor maintenance. The annual cost per pound of TP immobilized is projected to be $410, which is below the suggested $600 per pound upper threshold limit[8].

Appendices A – Water Quality Benefit Calculations

B – Supplemental Information

[7] CCBWQA June 16, 2011. *Stream Reclamation Water Quality Benefit Evaluation Interim Status Report.*
[8] IBID.