Chatfield Watershed Authority

Water Quality Assessment of the
"Massey Draw Watershed and Ecosystem Improvements Pilot Project"

And
Authority Proposed Expanded Post-Construction Monitoring Program

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Authority Interest and Participation

The Massey Draw Watershed and Ecosystem Improvements Pilot Project completed channel improvements in the section of Massey Draw from Wadsworth to C-470 (June 30, 2005; Jefferson County Section 319 Report). This small drainage gulch discharges into the northwest corner of the reservoir near the boat launching area. The Massey Draw drainage forms the northeast boundary of the Chatfield Watershed. The project installed three enhanced drop structures, contoured eroded banks, made selected wetland and riparian habitat improvements, and included vegetation of trees, shrubs and groundcover. The project was designed to reduce sediment and nutrient loading into Chatfield Reservoir caused by serve erosion. The vegetation and riparian improvements incorporate water quality mitigation features, which allow nature vegetation to help reduce nutrient loads carried in Massey Draw runoff.

The Authority became involved in the project to provide limited water quality assessment of the project for both pre-construction and post-construction periods beginning in late 2002 and has continued data collection through the current year. Field parameters included specific conductance, pH, and temperature and dissolved oxygen. Laboratory analysis included nitrate-nitrogen, total phosphorus, total suspended solids, and limited ammonia-nitrogen and ortho-phosphorus. Sample sets were collected for both wet and dry-weather conditions. The monitoring protocols for the Massey Draw monitoring program are consistent with the

Authority's Quality Assurance Project Plan (Chatfield Authority January 2003). The Authority is responsible for quality control and quality assurance of the data.

The 2002-through late 2004 data set characterizes the pre-construction water quality conditions. Beginning in 2005, the monitoring information was obtained to characterize both the effectiveness of the pilot project and the efficiency in nutrient and sediment reduction from the combined set of restoration practices. While the project is complete, the Authority has not obtained enough information to assess the projects effectiveness or efficiency. The Authority has committed to limited additional monitoring through 2006. However, the Authority is no longer convinced that this limited one-year of post-construction data will be sufficient to draw a definitive conclusion.

Authority Reporting and Fact Sheet

The Authority will include the fact sheet in Appendix A in the Chatfield Watershed Authority 2005 Annual Report. The Authority will continue to provide an update on the Massey Draw in each annual report. The Authority will incorporate monitoring data from Massey Draw into the Authority Master Data set (Excel Spreadsheet) for monthly posting on the Authority Web Site **[wwwchatfieldwatershed.org]** and for annual transmittal to the Water Quality Control Division. The Authority will work with the Colorado Monitoring Council to get all Authority data into STORET by 2007.

Pre-Construction Monitoring Assessment

The Chatfield Watershed Authority (Authority) estimates that this project will reduce many tons per year of sediment transport from reaching the reservoir and could reduce up to 2,000 pounds of nonpoint source total phosphorus per year. The Authority recognizes the natural variability in nutrient loading and realizes this load reduction could vary from 500 to 3,500 pounds per year depending on hydraulic loading conditions. The total suspended sediments during storm events ranged from 236 to 475 mg/l with an average concentration of 326 mg/l. Storm events in Massey Gulch can produce runoff of 100 cfs or more. A 100 cfs runoff event had the potential to generate about 88 tons of suspended sediment loads per day. The annual average stream flow is about 1.0 cfs with a 100-year event resulting in a flow over 3,500 cfs. Generally, the area experiences 2-4 larger runoff events per year. Typical suspended sediment loading from the gulch averaged 0.05 to 1 tons per day during more normal runoff. Without accounting for storm generated sediment load, Massey Draw typically produced 15 tons of suspended sediment loads per year. It is safe for the

Authority to estimate that the total suspended sediment load from Massey Draw generally exceeded 150 tons per year. This sediment loading is evident in Chatfield Reservoir where a large sediment delta formed at the discharge of Massey Draw into the reservoir. The pilot project was designed to reduce the peak storm event suspended sediment loading by eliminating major erosional sources (Table 1). On June 27, 2004, Massey Draw experienced a 10-year flood event that caused significant bank erosion and sediment transport. This was over a 100 cfs event as seen in the figure to the right.

Table 1 Pre-construction Total Suspended Solids Loading Under Various Flow Conditions

Flow	TSS (Mg/l)	Tons TSS/hour	Tons TSS/day
1 cfs (daily average)	16.6 (non-storm)	0.002	0.04
10 cfs (common)	32 (elevated runoff)	0.04	0.9
100 cfs (2-4 per year)	326 (Measured)	3.65	88
3,500 cfs (100-year)	475 (estimate)	186.31	4,472

The Authority predicted that runoff from the Massey draw system was a potential source of total phosphorus loading to the reservoir. In 1992, Woodward Clyde estimated that the Massey Draw drainage could produce up to 7,000 pounds of total phosphorus on an annual basis (Woodward-Clyde Consultants 1992: *Nonpoint Source Management Plan for Chatfield Reservoir*). The total phosphorus load measured in 2003 under various load conditions predicted Massey Draw in the lower reach would transport about 1,000 pounds of total phosphorus per year. However, it is noted that a single large storm event could transport over 10,000 pounds of total phosphorus per event. Consequently, the Authority estimates a wide range of annual total phosphorus from 850-7,000 pounds. Massey Draw has a high potential for nonpoint source total phosphorus loading (Table 2).

The project design could potentially reduce this total phosphorus load by as much as 50% per annum. Based on the 2003 data sets, the reduced total phosphorus load (minus very large events) would range from 425 to 500 pounds. Additionally, the project has the potential to reduce the nitrate-nitrogen loading reaching the reservoir (Table 3) and, as such, serves as a nutrient best management practice. Consequently, the Authority needs sufficient post-construction data to determine the effectiveness of a stream restoration effort. The Authority anticipates that this information is transferable to other stream restoration projects in predicting the total phosphorus reduction potential.

Table 2 Pre-construction Total Phosphorus Loading Under Various Flow Conditions

Flow	Total Phosphorus (Mg/l)	Pounds TP/hour	Pounds TP/day
1 cfs (daily average)	0.161 (non-storm)	0.04	0.9
10 cfs (common)	0.22 (elevated runoff)	0.5	12
100 cfs (2-4 per year)	0.32 (Measured)	7.2	172
3,500 cfs (100-year)	0.532 (estimate)	417	10,016

Table 3 Pre-construction Nitrate-Nitrogen Loading Under Various Flow Conditions

Flow	Nitrate-Nitrogen (Mg/l)	Pounds N/hour	Pounds N/day
1 cfs (daily average)	0.75 (non-storm)	0.2	4
10 cfs (common)	1.8 (elevated runoff)	4	97
100 cfs (2-4 per year)	5.9 (Measured)	132	3,174
3,500 cfs (100-year)	8.3 (estimate)	6,511	156,269

BMP Effectiveness Evaluation

The Massey Draw monitoring data is tabulated and summarized in Appendix B. Table 4 shows a summary of the pre-construction and limited post-construction data collected by the Authority. While the post-construction averages show some improvement, there is insufficient information to make a determinative statement about either effectiveness or efficiency of the project.

Table 4 Summary of the pre-construction and post-construction data

	Pre-Construction				Post-Construction			
	Average	N	Minimum	Maximum	Average	N	Minimum	Maximum
Specific Conductance (uS/cm)	633	6	107	1,040	827	9	108	1,650
Nitrate Nitrogen (ug/l)	2,737	10	596	8,265	1.8	9	0.7	2.64
Total Phosphorus (ug/L)	161	10	2	532	141	9	29	388
pH (standard unit)	7.7	6	7.42	7.92	7	6	6.1	8.2
Total Suspended Sediments (mg/L)	120	9	8.4	475	41	9	1.4	151
Temperature (Degrees C)	14.5	6	7.2	21.1	14.6	9	8.9	21

The Authority interest is in validating the effectiveness and efficiency of the restoration best management practices. Particularly of interest is the total phosphorus reduction potential from the pilot project. Although the post-construction data set from 2005 doesn't account for complete stabilization of the project site due to revegetation, it can provide an indication of expected conditions. The total suspended sediment loading for normal or near normal runoff conditions appears little changed from pre-construction conditions. However, there is a marked decrease in suspended sediment loading during stormwater runoff events as shown in the Table 5.

Table 5 Pre-Construction and Post-construction Comparison of Total Suspended Sediment Concentrations

Flow	Pre-Construction TSS (Mg/l)	Post-Construction TSS (Mg/l)	Delta Change
1 cfs (daily average)	16.6 (non-storm)	20 (non-storm)	-20%
10 cfs (common)	32 (elevated runoff)	41 (elevated runoff)	-28%
100 cfs (2-4 per year)	326 (Measured)	118 (Measured)	64%
3,500 cfs (100-year)	475 (estimate)	150 (estimate)	68%

The total phosphorus loading for normal or near normal runoff conditions appears slightly decreased from pre-construction conditions, but the data range is quite variable. However, there is no marked decrease in total phosphorus loading during stormwater runoff events as shown in the Table 6. In terms of nitrates, the normal flow loads appear little changed while there is a potential for substantial nitrogen reduction during higher flow events (Table 7). This is due in part to the reduction of sediment transport associated with erosion.

Table 6 Pre-Construction and Post-construction Comparison of Total Phosphorus Concentrations

Flow	Pre-Construction Total Phosphorus (Mg/l)	Post-Construction Total Phosphorus (Mg/l)	Delta Change
1 cfs (daily average)	0.161 (non-storm)	0.072	55%
10 cfs (common)	0.22 (elevated runoff)	0.132	40%
100 cfs (2-4 per year)	0.32 (Measured)	0.388	-21%
3,500 cfs (100-year)	0.532 (estimate)	0.5	6%

Table 7 Pre-Construction and Post-construction Comparison of Nitrate-Nitrogen Concentrations

Flow	Pre-Construction Nitrate-Nitrogen (Mg/l)	Post-Construction Nitrate-Nitrogen (Mg/l)	Delta Change
1 cfs (daily average)	0.75 (non-storm)	1.6 (non-storm)	-113%
10 cfs (common)	1.8 (elevated runoff)	2 (elevated runoff)	-11%
100 cfs (2-4 per year)	5.9 (Measured)	1.5 (Measured)	75%
3,500 cfs (100-year)	8.3 (estimate)	5 (estimate)	40%

The educational and recreational aspects of the project with easy area access, walking trail, interpretive signs and benches has been very successful. The Authority manager interviewed a number of people using the facility at various times since the project was complete. The response has been over whelming positive. On one site visit, the manager noted over 20 people using the trail system with several stopped to read the signs. The area is popular for jogging, biking, dog walking, reading and access to Chatfield State Park. The area is now an attractor for small hawks and an owl.

Proposed Post-Construction Monitoring Program

Preferred Authority Post-Construction Monitoring Period

Several important factors affect the Authority's determination of an adequate monitoring period:

1. While the project was completed in the first part of 2005, the vegetation plantings weren't complete until the summer of 2005. Pre-construction monitoring will begin in earnest in 2006

2. Planting should be established for at least one-year before water quality results can begin to be definitive of restoration conditions.

3. The sampling period should include a range of hydrology conditions.

The Massey Draw post-construction (Beginning Spring 2005) period should extend through the fall of 2010. The most intense sampling would be in 2006-2007 with a reduced monitoring frequency from 2008-2010. This would result in about 100 paired sample sets.

The Authority has agreed to conduct 4-6 sample sets in Massey Draw during the 2006 monitoring period. The Authority will compile the one-year post-construction data set and incorporate into the Authority data management system. Additional funding support will allow the Authority to evaluate the project and made a more definitive statement about the effectiveness and efficiency of the restoration effort. The Authority proposes an expanded monitoring program operated at cost by Authority membership with an Authority in-kind match. The total funding required for these monitoring, analyses, and reporting program is $11,440 with a minimum Authority in-kind match of $9,000 over a five-year period.

Sample Sites

Massey Draw sampling is done at two locations with a paired sampling protocol:

1. Massey Draw below Wadsworth and after culvert;

2. Massey Draw at C-470 before entering culvert under highway.

Sample Parameters, Frequency and Conditions

Sampling will be done for both wet and dry-weather conditions. Generally data collection will be evenly spaced sampling sets. The Authority will target getting data from at least one storm event per year. The Authority will collect flow information that can be used to predict average daily flow, small storm events, and larger storm events. The Authority will consult with the *Urban Drainage and Flood Control Distinct* on flow

conditions within the gulch under different storm loadings. The monitoring parameters and sample frequency are shown in Table 8.

Table 8 Monitoring Parameters and Paired Sets

Parameter	2006	2007	2008	2009	2010
	Number of Paired Sample Sets				
Field					
Specific Conductance (umhos/cm)	12	12	8	8	6
pH	12	12	8	8	6
Temperature (Celsius)	12	12	8	8	6
Turbidity Tubes	12	12	8	8	6
Flow (cfs)	12	12	8	8	6
Total Dissolved Solids (mg/l)	12	12	8	8	6
Laboratory					
Total Suspended Solids (mg/l)	12	12	8	8	6
Total Phosphorus (ug/l)	12	12	8	8	6
Nitrate-Nitrogen (mg/l)	12	12	8	8	6
Total	**108**	**108**	**72**	**72**	**45**

Quality Assurance and Quality Control

The monitoring protocols for the Massey Draw monitoring program will be consistent with the Authority's Quality Assurance Project Plan (Chatfield Authority January 2003) and as amended from time-to-time by the Authority in cooperation with the Water Quality Control Division (Division). The Authority is responsible for quality control and quality assurance of the data.

Monitoring Costs

Cost of monitoring, analyses, data management and reporting are shown in Table 9.

Table 9 Five-Year Monitoring, Analyses and Reporting Costs

Monitoring Task	Cost Basis	NPS Funding 5-year Cost	Authority In-Kind Match
Field Sampling	Cost per sample	1,840	1,800
Laboratory Analysis	Cost per sample	2,400	
Sample, Analysis, Data Base & Reporting	32 hrs/ year	7,200	7,200
Total		11,440	9,000
			$20,440

Data Management

Authority data is maintained in a master Excel spreadsheet, posted on the Authority Wed site and annually provided to the Division. The Authority will work with the Colorado Monitoring Council to upload all Authority water quality data into the Environmental Protection Agency STORET system by 2007.

Appendix A: Chatfield Authority Fact Sheet - Massey Draw Restoration Project

Problem: Massey Draw drains directly into Chatfield Reservoir. This gulch has been extensively developed and urbanized within the upper portions and now delivers year-round flow (1 to 10 cubic feet per second per day) to the Chatfield Reservoir. A 100-year event can produce over 3,500 cfs flow. The lower portions of Massey Draw are subject to flooding, which has caused severe erosion and sediment transport. A 1992 special nonpoint source study by the Chatfield Authority estimated this entire drainage system could contribute over 7,000 pounds of total phosphorus to the reservoir on an annual basis. The sediment transport characterized by total suspended solids data suggests the drainage system could contribute 100s of tons of suspended sediment on an annual basis. Increased downstream erosion has exacerbated this sediment loading problem in recent years. Additionally, the drainage system is a source of nitrate-nitrogen that contributes to the eutrophication of Chatfield Reservoir.

Project: In 2004-05, the Massey Draw Watershed and Ecosystem Improvements Pilot Project constructed three enhanced drop structures, added wetlands and riparian habitat improvements to a portion of Massey Draw between Wadsworth and C-470. The restoration effort corrected severe bank and channel erosion. The project is designed to reduce total phosphorous and sediment loading entering the reservoir. The project provides information and education opportunities, and demonstrates how erosion control practices can be naturally and aesthetically incorporated into a restoration effort while remaining practical.

Stakeholders: A diverse group of stakeholders implemented the project: Jefferson County, Urban Drainage & Flood Control District, and Lockheed Martin provided funding with support from Chatfield Watershed Authority, the United States Army Corps of Engineers, the Denver Botanic Gardens/Chatfield Nature Preserve, Roxborough Park District, and Volunteers for Outdoors Colorado (VOC), Colorado State Parks and the Denver Regional Council of Governments.

Project Status: Improvements to the channel and three drop structures were completed in the beginning of 2005. New wetland and riparian habitat was established, along with >100 plantings of Cottonwoods, willows and small shrubs by June 2005. Informational signs, viewing sites, benches & educational opportunities are being extensively used by the public. The project turned an eye-sore into asset and a water quality problem into a solution. Measurable sediment, nitrogen and phosphorus reduction effectiveness and efficiency testing of the restoration best management practices is scheduled through the 2006 data collection season. However, the Authority predicts that it will take several additional years of Authority post-construction data collection to fully evaluate the project. The Authority is exploring options for additional funding to continue data collection and analyses.

Water Quality Monitoring: The Authority pre-construction monitoring program gathered background information to characterize natural runoff and stormwater loading in lower Massey Draw prior to discharge into the Chatfield State Park. Pre-construction estimates by the Authority suggest restoration of lower Massey Draw could reduce over 500 pounds per year of total phosphorus from reaching Chatfield Reservoir based on average daily flows without accounting for storm runoff loadings. The project should also reduce nitrogen and sediment loading, and related urban stormwater pollutants. The Authority collected limited water quality data in Massey Draw from 2003 through 2005, with an expectation to gather information for about one-years after project completion (2006). The Massey Draw monitoring program is incorporated into the Authority's standard monitoring program. Pre-construction data and preliminary post-construction data are shown below:

	Pre-Construction				Post-Construction			
	Average	N	Minimum	Maximum	Average	N	Minimum	Maximum
Specific Conductance (uS/cm)	633	6	107	1,040	827	9	108	1,650
Nitrate Nitrogen (ug/l)	2,737	10	596	8,265	1.8	9	0.7	2.64
Total Phosphorus (ug/L)	161	10	2	532	141	9	29	388
pH (standard unit)	7.7	6	7.42	7.92	7	6	6.1	8.2
Total Suspended Sediments (mg/L)	120	9	8.4	475	41	9	1.4	151
Temperature (Degrees C)	14.5	6	7.2	21.1	14.6	9	8.9	21

Appendix B – Massy Draw Data

Massey Draw Data

Parameter	5/21/03	7/27/03	7/27/03	7/27/03	3/24/04	4/27/04	7/14/04	7/26/04	8/20/04	9/21/04	Pre-Construction			
		Storm-event									Avg	N	Min	Max
Specific Conductance (uS/cm)					160	907	107	1040	606	980	633	6	107	1040
Nitrate-Nitrogen (ug/l)	936	8265	4093	3719	596	1471	1828	1965	1643	2857	2737	10	596	8265
Total Phosphorus (ug/L)	40	2	426	532	18	81	62	62	167	220	161	10	2	532
pH (standard unit)					7.42	7.55	7.81	7.92	7.67	7.58	7.66	6	7.42	7.92
Total Suspended Sediments (mg/L)		267	475	236	8.6	32	16	8.4	14.4	20	120	9	8.4	475
Temperature (Degrees C)					7.2	11.1	19	21.1	16.1	12.3	14	6	7.2	21.1

		Construction Complete					Planting Complete							
	1/26/05	3/9/05		3/29/05		5/31/05	7/8/05		8/4/05		Post-Construction			
Site	@ C-470	Below Wadsworth	@ C-470	Below Wadsworth	@ C-470	@ C-470	Below Wadsworth	@ C-470	Below Wadsworth	@ C-470	Avg	N	Min	Max
Specific Conductance (uS/cm)	137	1200	1480	1430	1650	778	138	108	309	352	758	10	108	1650
Nitrate-Nitrogen (mg/l)		2.5	1.59	1.77	1.66	0.737	2.64	2.51	1.48	1.51	2	9	0.74	2.64
Ammonia Nitrogen (ug/l)	25					98					62	2	25	98
Total Phosphorus (ug/l)	45	67	45	56	51	157	101	29	379	388	132	10	29	388
Ortho Phosphorus (ug/l)	16		16		3	83		20	10		25	6	3	83
Total Suspended Sediments (mg/L)		1.4	10.6	7.9	26.6	19.1	24.8	5.7	151	118	41	9	1.4	151
pH	6.3	7.9	6.1	7.6	8.2		7.3	7.4			7	7	6.1	8.2
Temperature (Degrees C)	2.3	8.9	10.5	10.2	11	16.7	21	18.1	17.7	17.3	13	10	2.3	21
Dissolved Oxygen (mg/l)	14.31	13.77	14.92	12.18	11.38	8.48								