

# BCWA WORKING DOCUMENT

Date: January 5, 2011

Re: Adopted Bear Creek Watershed  
Association Surface Water Monitoring  
Program Version 2011.01



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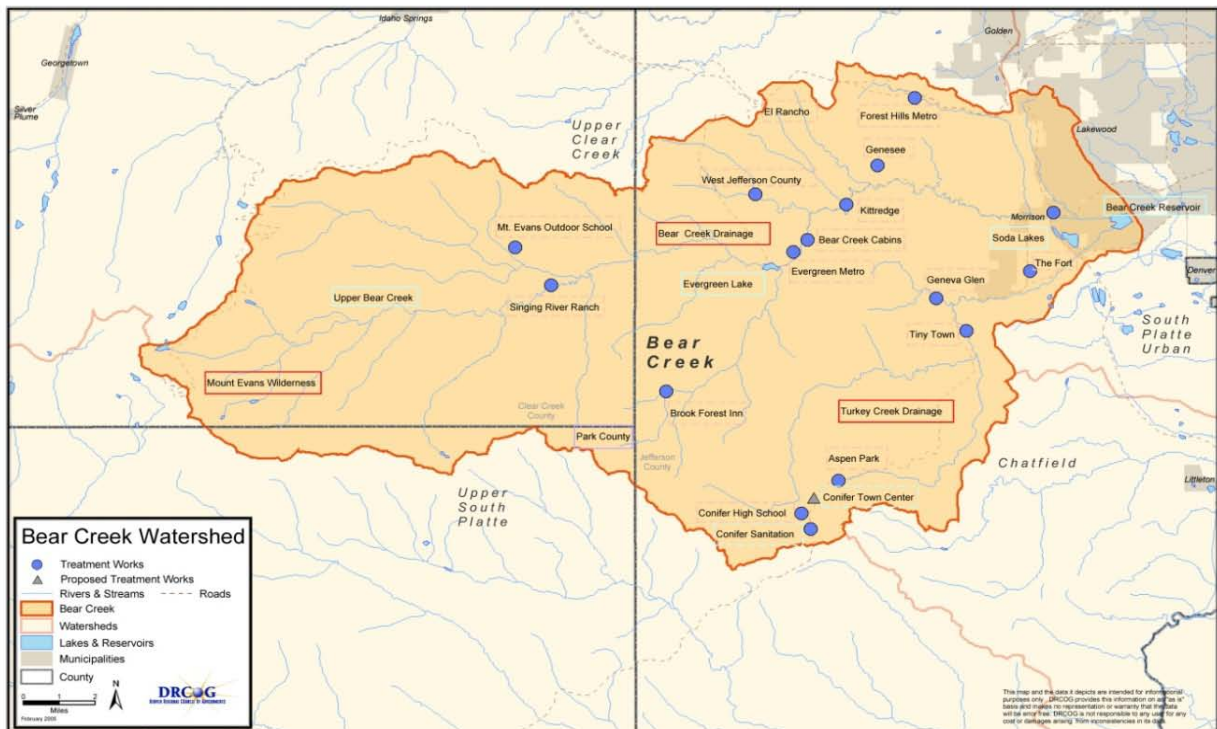
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## Bear Creek Watershed Monitoring Program

A generally continuous collection of surface quality data began in 1990 for the Bear Creek Watershed (Figure 1) and reservoir (Figure 2). Data collection includes specific chemical, physical and biological parameters. Data is collected monthly and bi-monthly at Bear Creek Reservoir and along Turkey Creek and Bear Creek. The Association meets water quality data sampling and analyses objectives established in the Bear Creek Reservoir Control Regulation # 74.



**Figure 1 Bear Creek Watershed**

The Bear Creek Watershed Association maintains four types of monitoring efforts to characterize water and environmental quality within the Bear Creek Watershed:

1. P1- Routine water quality monitoring at Bear Creek Reservoir (multiple vertical stations), Turkey Creek inflow to reservoir, Bear Creek inflow to reservoir, and reservoir discharge into lower Bear Creek. The P1 sites are long-term monitoring sites consistent with the intent of the monitoring program outlined in the Bear Creek Reservoir Control Regulation.
2. P2- Supplemental sampling of restoration or other project specific sites (e.g., Coyote Gulch in cooperation with the City of Lakewood). These types of monitoring efforts are for limited duration and for specific parameters of interest.
3. P3- Watershed surface water monitoring along Bear Creek and Turkey Creek drainages for site-specific characterizations (e.g., temperature trends, nutrient loading, flow studies). These are interim and long-term monitoring sites for watershed characterizations
4. P4- Supplemental environmental characterizations of Bear Creek watershed including, but not limited to macroinvertebrates, flow analysis, habitat characterizations, fishery

evaluations, system productivity, or other environmental factors that potentially affect fisheries or watershed health.

## **2011 Water Quality Monitoring Program and Quality Assurance Project Plan**

The contract laboratory for 2011 is GEI Consultants, Inc. / Chadwick Ecological Division.

The follow monitoring plan sections detail the 2011 reservoir and watershed monitoring programs as approved by the BCWA Board and accepted by the Water Quality Control Division staff (WQCD). This monitoring plan remains consistent with the quality assurance goals of the previously adopted Association QAPP (Bear Creek Watershed Association, 2006). However, this monitoring plan is the working version. The 2011 monitoring program version 2011.01 adapted from the last version of the 2010.02 monitoring plan. The 2010 monitoring program included changes to Bear Creek Control Regulation #74 and updated standards and classifications in Regulation #38.

Changes, updates, major continuation studies and monitoring program elements of the 2011 monitoring program include:

- Additional temperature probes for new stream segments. Temperature data loggers in Bear Creek Segment 1b above and below the Ward Ditch. Logger location on Cub Creek near Brookforest Inn, site 35 and lower Cub Creek, site 50. Include these sites for seasonal chemistry.
- Temperature Logger profile of Bear Creek Reservoir at Site 40 will begin in January 2011 with buoy placement and probes attached at ice-off (April-December, first week): ½ m, 1m, 1 ½m, and 2m. Field probe measurements year-round at site 40 with profile interval of ½ m, 1m, 1 ½m, 2m, 2 ½m, 3m, 3 ½ m, 4m, 5m, 6m, 7m, 8m, 9m, 10m, and 11m. Similar profile pattern used at other reservoir sites.
- Temperature Logger profile for Genesee Reservoir with single chemistry set taken off dam face with profile interval of: ½ m, 1m, 1 ½m, and 2m. Field probe measurements during July, August and September off dam face with profile interval of ½ m, 1m, 1 ½m, 2m, 2 ½m, 3m, 3 ½ m, 4m, 5m, and 10m.
- Temperature Logger profile for Evergreen Lake at ice-off (April-May) through November 1: ½ m, 1m, 1 ½m, and 2m. Field probe measurements during July, August and September at ½ m, 1m, 1 ½m, 2m, 2 ½m, 3m, 3 ½ m, 4m, 5m, and 6m.
- Maintain all other existing temperature data logger locations and seasonal monitoring periods with temperature logger placement adjust to temperature seasons as shown in Appendix C.
- Recognize growing season for data collection as July, August and September. Adjust watershed chemistry analyses to focus primarily on the period of July to September. Additional chemistry data maybe collected on an as needed basis.
- Monitoring sites maintained for Summit Lake in the Mount Evans Wilderness (segment 8), in upper segment 7 below Summit Lake and middle segment 7 at Bear Tracks for the July,

August and September months. The Bear Tracks monitoring station is a reference station and is proposed for fishery, Macroinvertebrate, and habitat surveys in 2011.

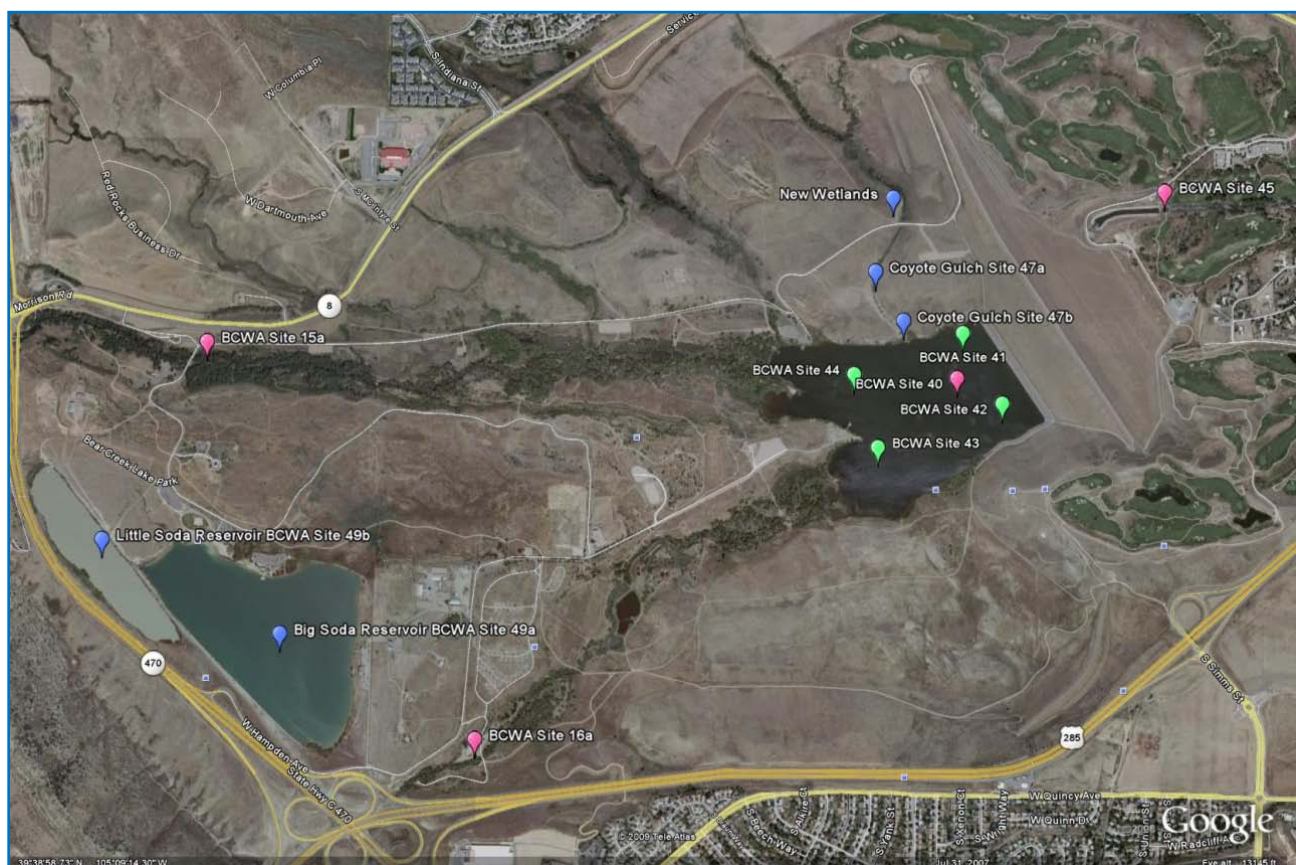
- Increase monitoring for Evergreen Lake chemistry to obtain samples at -1 meter and +1 meter in water column, and adjust position of temperature data loggers in water column. Track temperature against new standard and DO compliance in central pool of Evergreen Lake. No Association ammonia and TIN monitoring for Evergreen Lake. Included Evergreen Lake in the high quality water study for drinking water reservoirs. Association will collect data consistent with protection of a major drinking water supply system.
- Total nitrogen sampling for Summit lake (Site 37), segment 7 (Site 36), Bear Tracks (Site 38), below Bear Creek Reservoir at Site 45, Bear Creek Reservoir from May through November at the surface and bottom sites (sites 40a and 40c), inputs into the reservoir at sites 15a and 16a will be included in the 2011 monitoring program.
- Added stream staff gages at Singing River, Brookforest Inn, Little Cub at Mouth, Bear Creek Cabins and Turkey Creek. Daily and weekly reading taken at gages and compared against field measurements of flow to produce flow curves. Looking to expand program in 2011 and include more citizen involvement.
- Work with the City of Lakewood to closely monitor dissolved oxygen in water column and adjust the operation of the reservoir aeration system on a weekly basis to maintain DO standards, while minimizing aeration operations. This requires addition vertical probe sampling in the July to September period to monitor DO levels in the water column at site 40.
- Continue sediment and nutrient internal loading studies in Bear Creek Reservoir.
- Maintain photographic points for critical segments and conditions. Document dewatering of Bear Creek Segment 1b below both the Arnett-Harriman and Ward ditches.
- Continue special study of E. coli on Kerr/Swede Gulches. E. coli sampled year-round from 2010-2015 with field data and nutrient sampling from April-October.
- Continue special study on Coyote Gulch.
- Begin special study with Evergreen High School for Wilmont Creek, which is tributary to Evergreen Lake.
- Appendix A contains the 2011 monitoring sites with the BCWA site identifiers, data logger location and chemistry-monitoring sites by new stream segment descriptions.
- Maintain reference sites for segments (Appendix A)
- Appendix B in the back of the monitoring plan shows the general location of watershed sampling locations. An atlas of larger scale maps maintained on Association web site ([www.bearcreekwatershed.org](http://www.bearcreekwatershed.org)).
- Appendix C shows watershed temperature standards.

## P1 - Routine Monitoring Program

The routine monitoring program (P1) focuses on Turkey Creek drainage and Bear Creek drainage inputs and discharge from Bear Creek Reservoir (Figure 2) into lower Bear Creek with a central pool characterization of the reservoir near the dam (Site 40). In Figure 3, the outlet structure is near site 41 with Bear Creek inflow near site 44 and Turkey Creek inflow near site 43. The reservoir chemistry and biological characterization occurs at site 40.

Vertical probe samples at 1-meter intervals measured at sites 40, 41, 42, 43, and 44 beginning at -1-m. The current monitoring program optimizes data generation to evaluate reservoir inflow loading, trophic state changes within the reservoir, and reservoir outflow; while minimizing monitoring cost.

The Association measures flow in Bear Creek and Turkey Creek during sampling events. The Association also estimates discharge flows from Bear Creek reservoir for sampling events. The U.S. Army Corps of Engineers maintains records of flow inputs and discharge for the reservoir system.



**Figure 2 Bear Creek Reservoir and Dam**



**Figure 3 Reservoir Monitoring Stations; Site 2 is the Routine P1 station**

### 2011 routine P1 sampling sites

The four 2011 P1 routine watershed-monitoring stations, including the reservoir station, are:

1. Mainstem of Turkey Creek prior to discharge into Bear Creek Reservoir, within Bear Creek Park, adjacent to the City of Lakewood Maintenance Yard;
2. Mainstem of Bear Creek prior to discharge into Bear Creek Reservoir, within Bear Creek Park, adjacent to the bridge at the western edge of the park;
3. Tail-water discharge from Bear Creek Reservoir in the concrete channel that starts the lower Bear Creek; and
4. Bear Creek Reservoir, center of main pool and supplemental vertical profile stations 40, 41, 42, 43, and 44

Field Sampling Management: Russell Clayshulte, Association Manager; Field Assistance from Lakewood, Mike Towner.

### 2011 routine P1 Sampling Parameters and Methods

Table 1 shows water quality monitoring parameters for the P1 sampling sites. Table 2 lists methods of analyses and detection limits. Laboratory analyses performed by GEI Consultants, Inc. / Chadwick Ecological Division. Samples delivered to GEI Consultants, Inc. / Chadwick

Ecological Division within 2 hours of final sample collection. The phytoplankton samples are a composite of the top 1-meter of the water column. The reservoir bottom sample taken at approximately 10 meters depth, which is + 1m above the bottom. Care used not to disturb bottom sediments where the sample is collected. The top samples represent a composite water sample from -0.75m to -1.25m, as collected in a vertical Van Dorn sampler. Field probe measurements year-round at site 40 with profile interval of ½ m, 1m, 1 ½m, 2m, 2 ½m, 3m, 3 ½ m, 4m, 5m, 6m, 7m, 8m, 9m, 10m, and 11m. Similar profile pattern used at other reservoir sites.

**Table 1      Routine Monitoring Parameters**

<b>Parameter (units)</b>	<b>Bear &amp; Turkey Creek Inflows, Site 15a and 16a</b>	<b>Reservoir Sites</b>	<b>Reservoir Outflow, Site 45</b>
<b>Physical/Field</b>			
Flow/ Discharge (cu m/s)	X		X
Specific Conductance (umhos/cm)	X	(Profiles at sites 40, 41, 42, 43, and 44)	X
Secchi (meters)		(Sites 40, 41, 42, 43, and 44)	
Dissolved Oxygen (mg/l)	X	(Profile sites 40, 41, 42, 43, and 44)	X
Temperature (C)	X (Data Loggers)	(Profile at sites 40, 41, 42, 43, and 44)	X
Total Suspended Sediments (mg/l)	X	(Site 40; laboratory)	X
Turbidity (NTU)	X	X (-1m)	X
pH (standard unit)	X	(Profile at sites 40, 41, 42, 43, and 44 )	X
<b>Biological (Site 40 only)</b>			
Chlorophyll a (ug/l)		X (-1m)	
Phytoplankton (July, August, September only; six sample sets)		(top 1-meter water column, a composite)	
<b>Nutrients (Reservoir Site 40 only)</b>			
Nitrate + Nitrite (ug/l)	X	X (top, lower)	X
Total Dissolved Phosphorus (ug/l)	X	X (top, lower)	X
Total Phosphorus (ug/l)	X	X (top, lower)	X
Total Nitrogen	X	X (top, lower), May-Nov	X

**Table 2      Methods and detection limits for laboratory analyses.**

<b>Analyte</b>	<b>Method*</b>	<b>Detection limit</b>
Total Suspended Solids	2540 D	4 mg/L
Total Dissolved Solids	2540 C	4 mg/L
Chlorophyll	10200 H (modified)	0.1 mg/m3
Total Dissolved phosphorus	4500-P G	2 µg/L
Total Phosphorus	4500-P G	2 µg/L
Nitrate+Nitrite	4500-NO3 I	2 µg/L
Total Nitrogen	4500 TN	2 ug/l

## **P1 Routine Sampling Frequency**

P1 sites sampled monthly in January, February, March, April, May, June, October, November, and December. Growing season samples taken twice in July, August, and September.

## **Laboratory QA/QC Protocols for Nutrient Analyses**

Equipment calibrations performed each time new standards are prepared (minimum of once per week). If the r-value of the standard curve is less than 0.999, the instrument is recalibrated or standards are remade. Replicates run on each sample analyzed and the percent difference must be within 10% if the resultant concentration is above the minimum detection limit. If results of analyses of replicate samples are not within 10% of one another, samples placed in a clean test tube and reanalyzed.

During analysis, check standards are analyzed between every 5 samples (or 10 replicates). The check standards consist of one high range standard, one mid range standard, and the zero (blank). Check standards analyzed before and after each group of samples must be within 10% of the theoretical value. If standards are outside of this range, samples and standards are placed in clean test tubes and reanalyzed to try to determine the source of the problem. Sample values are not accepted until the problem has been resolved and all check standards pass the QC criteria. One matrix spike is run for every 10 samples analyzed. The percent recovery for matrix spikes must be  $\pm 20\%$ .

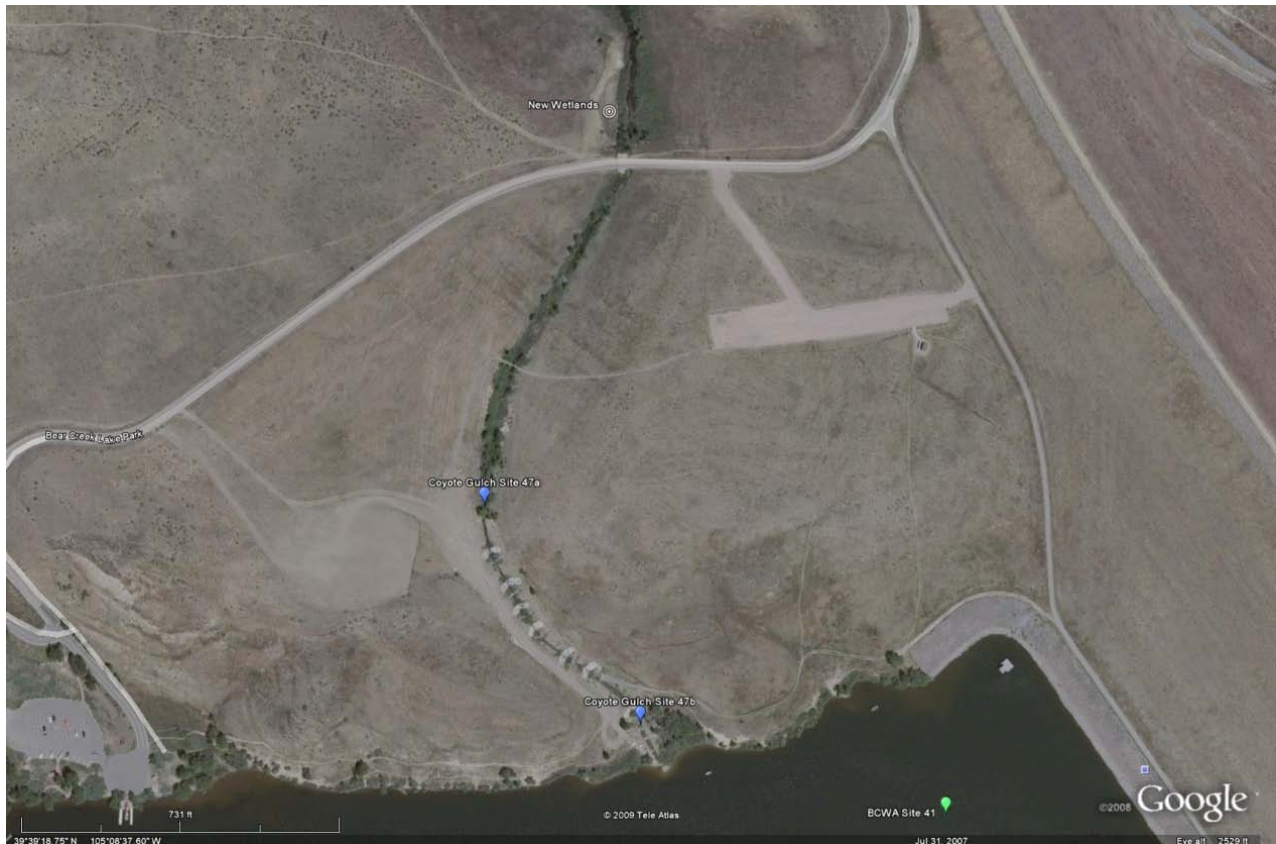
After sample analyses a final QC check performed to determine if all parameters measured agree. Final analyses for each sample compared to ensure that concentrations of total phosphorus  $\geq$  total dissolved phosphorus  $\geq$  orthophosphate and that the concentration of total nitrogen  $\geq$  total dissolved nitrogen  $\geq$  nitrate/nitrite and ammonia. If parameters do not agree, samples are reanalyzed.

## **P-1 and Reservoir Sampling Dates 2011**

- January 24, February 28, March 28, April 25, May 23, June 27, July 11/25, August 8/22, September 12/26, October 24, November 28, December 5

## **P2 - Supplemental Water Quality Characterizations in Bear Creek Watershed** **Coyote Gulch**

The Association coordinates with the City of Lakewood a sampling program on Coyote Gulch in the Bear Creek Park. The monitoring is done at two sampling sites: above the restoration project, and at the discharge into the reservoir (Figure 4). The City of Lakewood collects the chemistry data for total phosphorus and nitrate-nitrogen. The Association takes monthly flow measurements to determine nutrient loading. The Association also collects data for temperature, pH, specific conductance and Dissolved Oxygen. Data results incorporated into the Association monthly and annual data summaries. The Association has pre-construction and post-construction loading data.



**Figure 4 P-4 Coyote Gulch Sampling Sites**

### Kerr and Swede Gulch

Swede Gulch is listed on the 303(d) list as a low priority for E. coli. There is a discrepancy in the naming of the Swede/Kerr Gulch system. The United States Geological Survey maps used by the Division suggest that the mainstem is Swede Gulch. The Colorado Department of Transportation has maintained for decades an informational sign at the mouth of the gulch listing the gulch as Kerr Gulch. The locals also have identified the mainstem as Kerr Gulch with Swede Gulch as an upstream tributary. As such, the mainstem is Kerr/Swede Gulch with the western gulch upstream of the upper confluence as Kerr Gulch and the eastern tributary as Swede Gulch (Figure 5). The Division and Association agree this area maybe a good candidate to understand the impact of septic systems to the water quality in tributaries.

The Division and Association agree there is a water quality problem that requires further investigation. The Association commits to a 5-years monitoring program to evaluate E. coli on Kerr/Swede Gulch (confluence with Bear Creek, below confluence of Swede Gulch and just upstream of confluence on Kerr Gulch) and lower Swede Gulch. The Association will monitor E. coli at 4-sites (Figure 5) from January (provided winter flows) through December over a 5-year period. The Association will also collect data for temperature, pH, specific conductance and Dissolved Oxygen using the field probe. The Association established GPS coordinates at selected sites and begin special monitoring program in May 2010. The Association is using the wastewater treatment plant laboratories for the E. coli analyses. Periodically, the Association will collect duplicates for analyze at an outside laboratory.

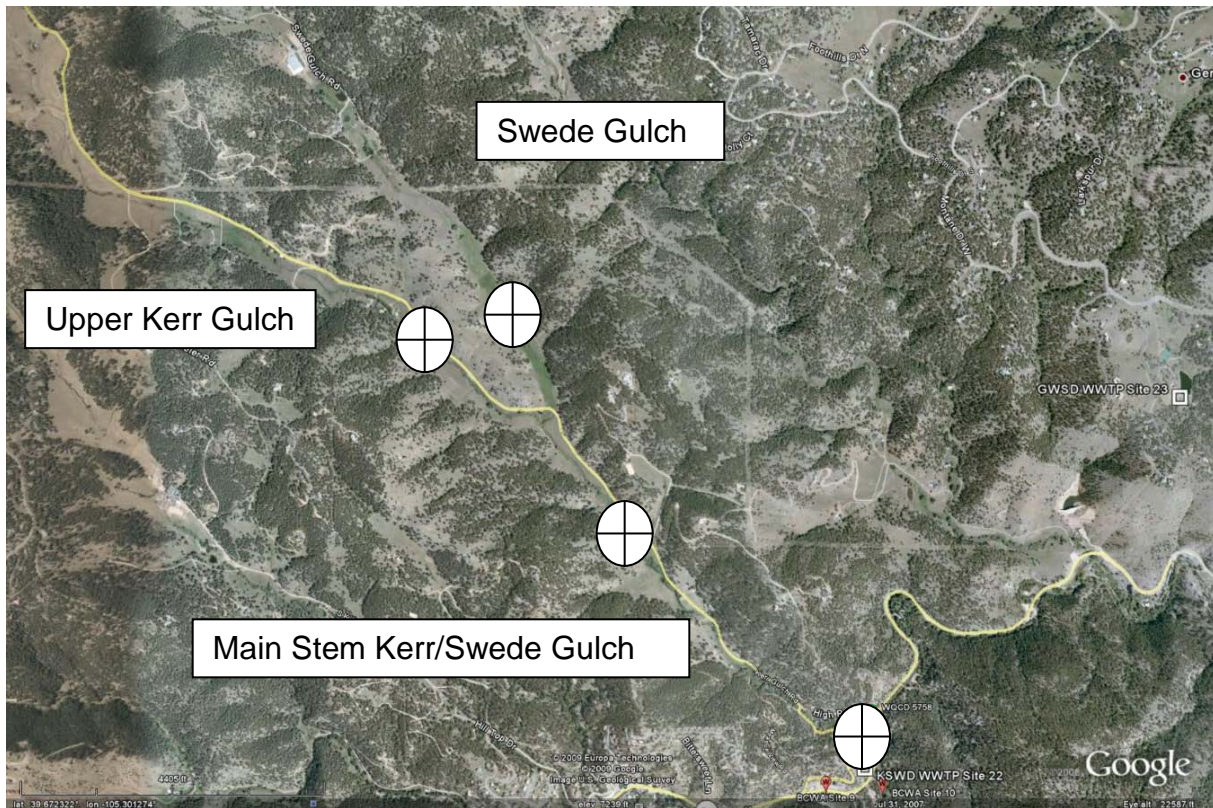


Figure 5 P-4 Kerr/Swede Gulch Sampling Sites

## P2 - Bear Creek Reservoir Sediment Study

### Sediment Survey Questions

1. What is the distribution of phosphorus in bottom sediments and is this phosphorus load evenly distributed across the reservoir bottom?
2. Do aeration operations affect to release of total phosphorus from bottom sediments?
3. Is the internal loading of phosphorus showing trends over time, temporal?
4. Is there a reliable method to determine if internally phosphorus loading is decreasing over time?
5. What is the potential annual contribution of phosphorus into the water column and when does this nutrient transfer occur?
6. Is the high organic build-up in the reservoir inlets affecting the amount of available phosphorus for transfer into the water column?
7. How does water-column phosphorus chemistry relate to sediment chemistry?

### Sediment Survey Design

#### Survey Duration: Annually for 5-years

- October 2009 – obtained preliminary core samples at multiple sites

- August 2010, 2011, 2012 and 2013 (During operation of aeration system)

Survey Types: Stratified and Single-stage

Discrete dredge samples from each of three reservoir zones; Central pool, Turkey Creek inlet and Bear Creek inlet using three fixed transects (Figure 6). Field sampled in August. Bottom samples obtained with a petite Ponar sampler. Two dredge drops made at each site resulting in 1.5 to 3 liters of bottom mud. GPS coordinates were taken at each site. The locations in figure 6 are estimates. Two samples were bagged from the composite mud sample at the site

One bag of sample was used for analyses and the second sample retained for future reference. The contents of the sample were placed in a pie tin. Samples were dried at 105 degrees C in an oven for 24 to 48 hours.

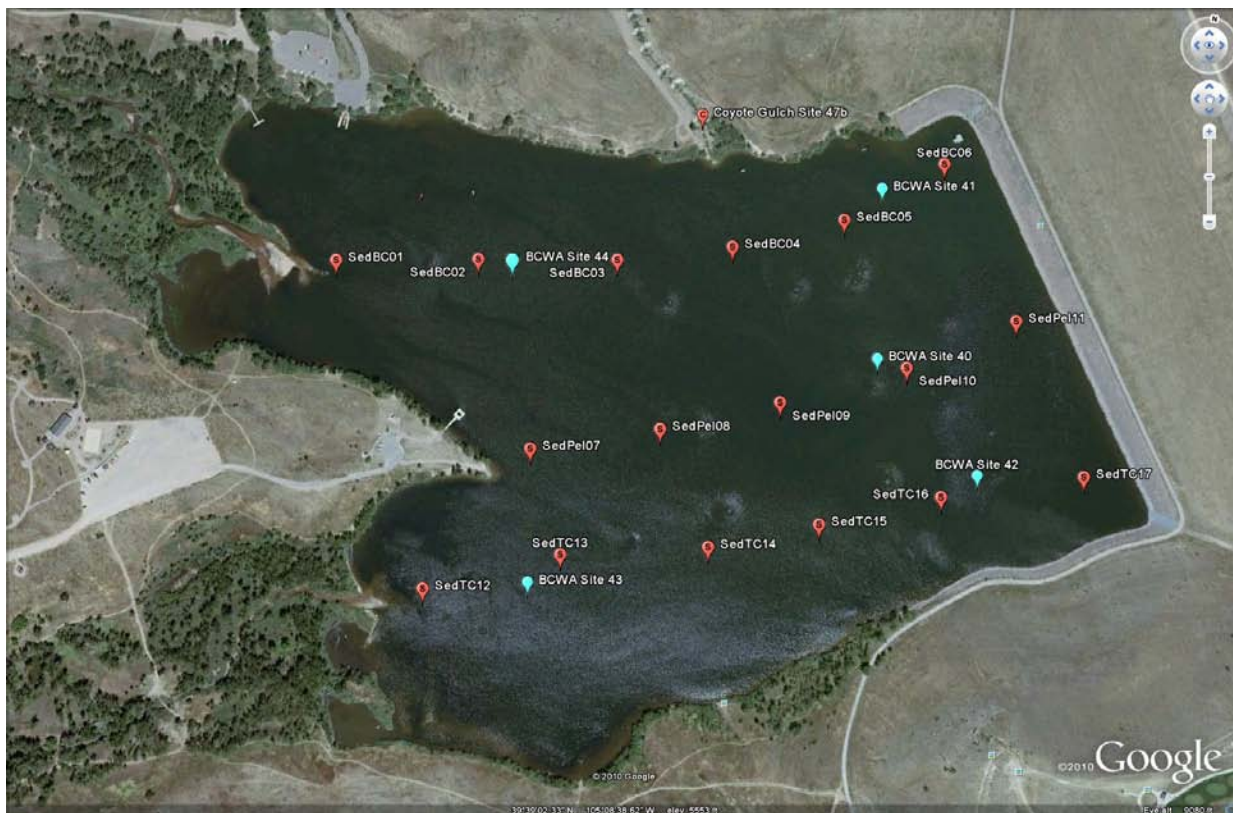


Figure 6 Sediment transects and approximate sampling sites

Total Organic Matter

An about 5 gram sample of the dried sediment was weighed, ashed in a muffle furnace at 550 degrees C for 1 hour and reweighed. The total organic matter (TOC) is volatilized and the percent difference is calculated to determine the estimated percentage of TOC .

Grain Size Distribution

A mechanical sieve “sandshaker” was used to determine the percentage distribution of selected grain sizes in the dried bottom sediments. The dried sediment was re-loosened into a sandy silt material. All bottom sediment material was less than U.S. Standard sieve 10 (0.08 inches) in diameter. As such all reservoir sediment ranges from coarse sand to clay size. The Sieve distribution used is shown in the following Table.

Grain-Size Term	ASTM No.	Mesh Opening (in)	Sieve Designation
Very Coarse and Coarse Sand	25	0.026	26 OPN
Medium Sand	60	0.009	9 OPN
Fine Sand	120	0.0046	46 OPN
Very Fine Sand	200	0.0029	29 OPN
Silt and Clay	<200		

**Total Phosphorus**

**Extraction Procedure - Distilled Water**

1. Weigh 4 g of wet mud into 125 ml bottle with lid.
2. Add 20 mL of distilled water and shake manually over a one hour period.
3. Centrifuge at 3,500 rpm for 15 minutes.
4. Filter the solution through a 0.7 µm membrane filter.
5. Use 5 ml for analysis; retain remainder for dilution, if appropriate.

**Analysis**

Determine total phosphorus as water extractable P in wet mud using HACH method 8190 PhosVer 3 with acid persulfate digestion Test “N Tube method measured with a Hach DR2010 spectrophotometer at 890 nm.

Sediment Survey Data obtain from U.S. Army Corps of Engineers (2001) with new survey data from 2009 available later this year. Association will work to get the Corps to do a more detailed bathymetric survey of reservoir within next couple of years.

**P3 - Seasonal and Off-Season Watershed Monitoring Programs**

The Bear Creek Watershed Association conducts seasonal (April – September) and off-season (October- May) monitoring programs in cooperation with Water Quality Control Division, Evergreen Trout Unlimited, and Colorado Division of Wildlife. These P3 monitoring programs focus on characterizing water quality of surface waters in the Turkey Creek and Bear Creek drainages of the watershed. Table 4 shows monitoring and reference stations. Table 5 lists monitoring parameters for watershed stream segments. Table 6 lists monitoring parameters for watershed lakes/reservoirs.

**Table 3 2011 Monitoring Stations**

Site ID	Site Location by Stream Segment	2011 April-October		2011-12 Cold Season Nov-Mar	Reference
		Data Logger	Chemistry	Data Logger	Site
<b>Segment 1a</b>					
Site 1a	Above Singin' River Ranch complex	x	x		R
Site 2	Above Evergreen Lake at Clear Creek County line	x			
Site 3a	Above Evergreen Lake at CDOW Site	x	x	x	
<b>Segment 1b</b>					
Site 15a	Bear Creek Segment 1b at the USGS gaging station within Bear Creek Park	x	x	x	R

Site ID	Site Location by Stream Segment	2011 April-October		2011-12 Cold Season Nov-Mar	Reference
		Data Logger	Chemistry	Data Logger	Site
Site 27a	Morrison above Ward Ditch	x			
Site 27bc	Morrison Below Ward Ditch	x			
Site 24	Morrison WWTP Eff	x	x	x	
<b>Segment 1c</b>					
Site 40	Bear Creek Reservoir	x	x	x	R
<b>Segment 1d</b>					
Site 4a	Evergreen Lake Surface, profile station	x			R
Site 4b	Evergreen Lake Profile Station, 1.5m	x	x		
Site 4e	Evergreen Lake Profile Station, 4.5m	x	x		
<b>Segment 1e</b>					
Site 5	Above EMD WWTP, at CDOW downtown site	x	x	x	R
Site 8a	Bear Creek Cabins at CDOW Site	x	x	x	
Site 9	O'Fallon Park, west end at CDOW Site	x	x	x	
Site 12	Lair o' the Bear Park, at CDOW site	x	x	x	
Site 13a	Below Idledale, Shady Lane CDOW site	x	x	x	
Site 14a	Morrison Park west end at CDOW Site	x	x	x	R
Site 20	EMD WWTP Eff	x	x	x	
Site 21	WJCMD WWTP Eff	x	x	x	
Site 22	KSWD WWTP Eff	x	x	x	
Site 23	GWSD WWTP Eff	x	x	x	
<b>Segment 2</b>					
Site 45	Lower Bear Creek, below reservoir concrete trace/ weir (Plunge pool)	x	x	x	R
<b>Segment 3</b>					
Site 25	Vance Creek (Mt. Evans Wilderness)	x	x		R
<b>Segment 4a</b>					
Site 47a	Upper Coyote Gulch		x		
Site 47b	Lower Coyote Gulch, reservoir		x		R
<b>Segment 5</b>					
Site 26	Cub Creek, Upstream of Hwy 73 bridge, south of EMD WTP	x			
Site 50	Cub Creek, Upstream Cub Creek Park	x	x		R
Site 35	Cub Creek @ Brookforest Inn	x	x		R
<b>Segment 6a</b>					
Site 16a	Turkey Creek within Bear Creek Park at old USGS gage	x	x	x	R
Site 18	South Turkey Creek Aspen Park Metropolitan District	x	x		
<b>Segment 6b</b>					
Site 19	North Turkey Creek Flying J Ranch Bridge	x	x		R
<b>Segments 7 and 8</b>					
Site 37	Summit Lake outfall, Mainstem from Lake at first ripples (Segment 7)		x		R
Site 36	Summit Lake outfall (Mount Evans Wilderness) (Segment 8)		x		R
Site 38	Bear Creek at Bear Tracks, Bridge		x		R

Site ID	Site Location by Stream Segment	2011 April-October		2011-12 Cold Season Nov-Mar	Reference
		Data Logger	Chemistry	Data Logger	Site
	(Segment 7)				
<b>Segment 10</b>					
Site 39	Genesee Reservoir Profile	x	x		R

**Table 4 Watershed Monitoring Parameters**

Field Data	Laboratory Analyses	Calculation
Temperature (discrete field probe & continuous data loggers)	Nitrate+Nitrite-Nitrogen	
Dissolved Oxygen	Total Ammonia	
Specific Conductivity	Total Phosphorus	Total Inorganic Nitrogen
pH	Total Nitrogen (Selected Sites)	
Turbidity (NTU)		

**Table 5 Watershed Lakes/Reservoir Monitoring Parameters**

Field Data	Laboratory Analyses
Temperature (field probe, 1/2-m intervals in central pool)	Nitrate+Nitrite-Nitrogen
Dissolved Oxygen (field probe, 1/2-m intervals in central pool)	Total Phosphorus
Specific Conductivity (field probe, 1/2-m intervals in central pool)	Total Nitrogen (-1m)
pH (field probe, 1/2-m intervals in central pool)	

Sample Periods: Seasonal Monitoring July- September; cold-season Monitoring November to April

Field Sampling Management: Russell Clayshulte, Association Manager; Tony Langowski, Field Manager

**Seasonal Temperature Datalogger Monitoring Locations**

Continuous temperature measurements taken by loggers every half-hour, May 1-October 15.

- Site 1a At Singing River Ranch on Upper Bear Creek
- Site 38 Bear Creek at Bear Tracks, Bridge
- Site 25 Vance Creek below Mt Evan Wilderness Area
- Site 2 Above Evergreen Lake at Clear Creek County line
- Site 3a Above Evergreen Lake at Keys-on-the-Green, CDOW Site
- Site 4 Evergreen Lake, at dam (1/2m, then at 1-meter intervals)
- Site 35 Cub Creek at Brookforest Inn
- Site 50 Cub Creek Upstream Cub Creek Park
- Site 5 Above EMD WWTP effluent, CDOW Downtown Site
- Treatment Plant EMD WWTP effluent
- Site 8 Bear Creek Cabins, CDOW Site
- Treatment Plant WJCMD WWTP effluent
- Site 9 O’Fallon Park (west end, CDOW Site)
- Treatment Plant KSWD WWTP effluent

Treatment Plant	GWSD WWTP effluent
Site 12	Lair o' the Bear, CDOW Site
Site 13a	Below Idledale (at Idledale at Shady Lane, CDOW Site)
Site 14a	Morrison Park (west end of town, CDOW Site)
Site 15	Bear Creek Segment 1b at Gaging Station in Bear Creek Park
Sites 27a & 27b	Morrison above and below the Ward Ditch
Site 16	Turkey Creek within Bear Creek Park (Lakewood)
Site 19	North Turkey Creek Flying J
Site 18	South Turkey Creek
Treatment Plant	Morrison Wastewater Treatment Plant Effluent
Site 40	Bear Creek Reservoir
Site 45	Below Bear Creek Reservoir

### Seasonal Monthly Manual Monitoring Locations

Field sample for pH, DO, Temperature, Conductivity (Field Probe), Nitrate+Nitrite-Nitrogen, Total Ammonia, Total Inorganic Nitrogen (TIN) (Calculation), Total Phosphorus (Laboratory), July-September

Site 1a	At Singing River Ranch on Upper Bear Creek
Site 25	Vance Creek below Mt Evan Wilderness Area
Site 3a	Above Evergreen Lake at Keys-on-the-Green, CDOW Site
Site 4b & 4e	Evergreen Lake, at dam (Note; no Ammonia or TIN in 2010)
Site 5	Above EMD WWTP effluent, CDOW Downtown Site
Site 8a	Bear Creek Cabins, CDOW Site
Site 9	O'Fallon Park (west end, CDOW Site)
Site 12	Lair o' the Bear, CDOW Site
Site 13a	Below Idledale (at Idledale at Shady Lane, CDOW Site)
Site 14a	Morrison Park (west end of town, CDOW Site)
Site 18	South Turkey Creek
Site 19	North Turkey Creek Flying J
Site 35	Cub Creek at Brookforest Inn
Site 36	Summit Lake
Site 37	Upper Segment 7
Site 38	Bear Creek at Bear Tracks, Bridge
Site 39	Genesee Reservoir
Site 50	Cub Creek Upstream Cub Creek Park
Site 52	Kerr/Swede Gulch Confluence (Annual Monitoring, April- October)
Site 53	Kerr/Swede Gulch Riefenberg (Annual Monitoring, April-October)
Site 54	Kerr Gulch (Annual Monitoring, April- October)
Site 55	Swede Gulch (Annual Monitoring, April-October)

### Evergreen Lake Monitoring

Evergreen Lake has a temperature data logger string near the dam structure with data probes suspended at -1/2m, -1m, -2m, -3m, and -4m. Profile data collected in July, August, and September for Temperature, DO, specific conductance, pH and Turbidity at 0m, -1m, -2m, -3m, and -4m. Chemical analyses include Nitrate+Nitrite-Nitrogen, Total Nitrogen, and Total Phosphorus and Total Dissolved Phosphorus. Water sampled at -1m and +1m in water column.

A total depth and Secchi reading collected. Chlorophyll maybe sample, if appropriate. An additional vertical profile maybe taken in mid lake, as appropriate.

### Genesee Reservoir Monitoring

Genesee Reservoir will have a temperature data logger string near the dam structure with data probes suspended at ½ m, 1m, 1 ½m, and 2m from April through December (or earlier if limited by ice). July- September chemistry sampling in reservoir Nitrate+Nitrite-Nitrogen, Total Nitrogen, and Total Phosphorus and Total Dissolved Phosphorus.

### Off-Seasonal Temperature Datalogger Monitoring Locations

Continuous measurements every half-hour, November 15 to April 15

Site 3	Above Evergreen Lake at Keys-on-the-Green, CDOW Site
Site 5	Above EMD WWTP effluent, CDOW Downtown Site
Site 8	Bear Creek Cabins, CDOW Site
Site 9	O'Fallon Park (west end, CDOW Site)
Site 12	Lair o' the Bear, CDOW Site
Site 13a	Below Idledale (at Idledale at Shady Lane, CDOW Site)
Site 14	Morrison Park (west end of town, CDOW Site)
Site 15	Bear Creek Segment 1b at Gaging Station in Bear Creek Park
Site 16	Turkey Creek within Bear Creek Park (Lakewood)

### Stream Monitoring Plan Details

- The Association in cooperation with Evergreen Metropolitan District (EMD) have primary responsible for sampling and data collection.
- EMD, West Jefferson County Metropolitan District (WJCMD), Kittredge Sanitation and Water District (KSWD), Genesee Water and Sanitation District (GWSD), the Town of Morrison, Conifer High School, Conifer Metropolitan District, and Aspen Park Metropolitan District will provide effluent data collected at their respective WWTP's, including analytical results; and /or assistance with special monitoring.
- City of Lakewood assists with sampling on Coyote Gulch, Bear Creek Reservoir, and P1 sites.
- Interval frequency for temperature dataloggers is every half-hour (48 per day). The dataloggers in wastewater plant discharges will be field-downloaded every 30 days, while dataloggers located in the stream will be field-downloaded as needed.
- Seasonal manual pH, Temperature, DO, Specific Conductivity, Nitrate-nitrogen, Total Ammonia, Total Inorganic Nitrogen and Total Phosphorus data collected at selected temperature datalogger locations. Manual monitoring performed in the morning, beginning at approximately 07:00 in Evergreen and ending at approximately 16:00. Monthly monitoring provides a check on integrity of dataloggers. Scheduled stream sampling day will generally coincide with effluent sampling performed by WWTP.

- WWTP effluent data collected as part of the typical plant process control performed daily. Effluent pH/Temperature/DO recorded and ammonia sampling performed in accordance with the requirements of each WWTP discharge permit. Total ammonia analyzed for WWTP effluents by the method allowing for the lowest detection limit.
- USGS flow measurement obtained at gages above Evergreen Lake and above the Town of Morrison. Weekly gage graphs downloaded and printed.
- Daily weather data (High/low temperature, precipitation) from the NWS station at the EMD WWTP obtained on a monthly basis.
- Calibrations of portable equipment documented prior to each use and Certificates of Calibration for all equipment obtained. NIST certifications and Certifications of Compliance obtained for each temperature datalogger used in the study.
- GPS points maintained for all new sampling and monitoring locations.

### Data Management

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- Special monitoring data resides in two locations (EMD server and Association Manager).
- The Association uses a sampling and data collection manager to assist with special monitoring effort.
- The Association incorporates data into a data report, at the conclusion of the study. Electronic data files transmitted to the Water Quality Control Division, Colorado Division of Wildlife and Evergreen Trout Unlimited after the Association Board has approved the study report.
- Sampling and Monitoring Plan summaries provided at BCWA monthly meetings, which are open to the public.

### Watershed Sampling Dates 2011

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- July 7, Aug 11, Sept 8
- Loggers in field late April for May 1, 2011 start time; loggers retrieved third week in October.

### P-4 Annual Colorado Division of Wildlife Fishery Sites, WQCD Macroinvertebrates, and BCWA Flow Analyses

The Colorado Division of Wildlife (CDOW) has monitored fish populations in the watershed from 1988 through 2010. Prior to 2005, there were five monitoring sites. In 2010, there were ten survey sites (Table 6). In 2011, Bear Track site 38 will be included in survey. All of the CDOW survey sites incorporated in the Association monitoring network.

**Table 6 Colorado Division of Wildlife Fish Survey Sites**

<b>Stream Segment</b>	<b>CDOW Fishery Reference Sites</b>
Segment 3	(9) Vance Creek
Segment 1a	(1) Keys on the Green, (8) Singing River Ranch
Segment 1e	(2) Little Bear Evergreen, (3) Bear Creek Cabins, (4) O'Fallon Park, (5) Lair O' the Bear, (6) Idledale, (7) Morrison Park
Segment 5	(10) Lower Cub Creek
Segment 7	Bear Tracks (Site 38)
Segment 6b	Pack-back surveys (not reference sites)

These reference sites have coordinated chemistry, biological, physical data collection. This mixed data analysis establishes reference conditions for four stream segments in the watershed.

### CDOW Fish Population Surveys

The CDOW surveys fish populations in September. The survey determines young of the year and adult size classes, species present, total biomass of fish by species and total pounds per acre by species. The Association assists the CDOW with fish sampling. The CDOW provides raw and processed data to the Association for the annual data report.

### WQCD Macroinvertebrate and Habitat Sampling

The reference sites in Table 1 sampled for macroinvertebrates, physical habitat (modified Rapid Bioassessment Protocol) and streambed characterization (modified Wolman Pebble Count). The WQCD's procedure on physical habitat is a visual assessment of the quality of the instream and riparian habitat that influences the structure and function of the aquatic community in a stream. Parameters are ranked as optimal, suboptimal, marginal, or poor based on a 4-point scale, with 4 being the best possible (optimal) conditions and one representing the worst (poor) conditions.

Macroinvertebrate samples collected at the nine CDOW fish survey sites along Bear Creek: Morrison (west end), Idledale, Lair o' the Bear Park, O' Fallon Park, Bear Creek Cabins, Main Street Evergreen (across from the Little Bear), above Evergreen Lake upstream of the USGS gaging station, at the Singing River Ranch (Lost and Found), and at Vance Creek. The cooperative macroinvertebrate sampling is done by the Association in September with analyze done by the WQCD. Sample collection done by the state timed-kick net methodology protocol.

### BCWA Stream Flow Supplemental Data

The Association uses a portable velocity meter to spot check estimated flows at CDOW fish survey sites and all watershed-monitoring sites. A stream cross-section is measured for flow depth and mid-water column instant velocity. Data is processed in a spreadsheet to estimate stream velocity. The flow measurements match closely (2-10%) with the USGS measured flows at Keys on the Green and Morrison gaging stations.

**BCWA Stream Flow Supplemental Flow Gaging Sites**

The Association installed stream staff gages at Singing River Ranch, Brookforest Inn, Mouth of Cub Creek, Bear Creek Cabins, lower Bear Creek below the reservoir and Turkey Creek. Manual flow measurement will be taken and a flow curve developed for these sites. In 2011, the Association will install several additional gages along Bear Creek.

**BCWA Stream Temperature Standards**

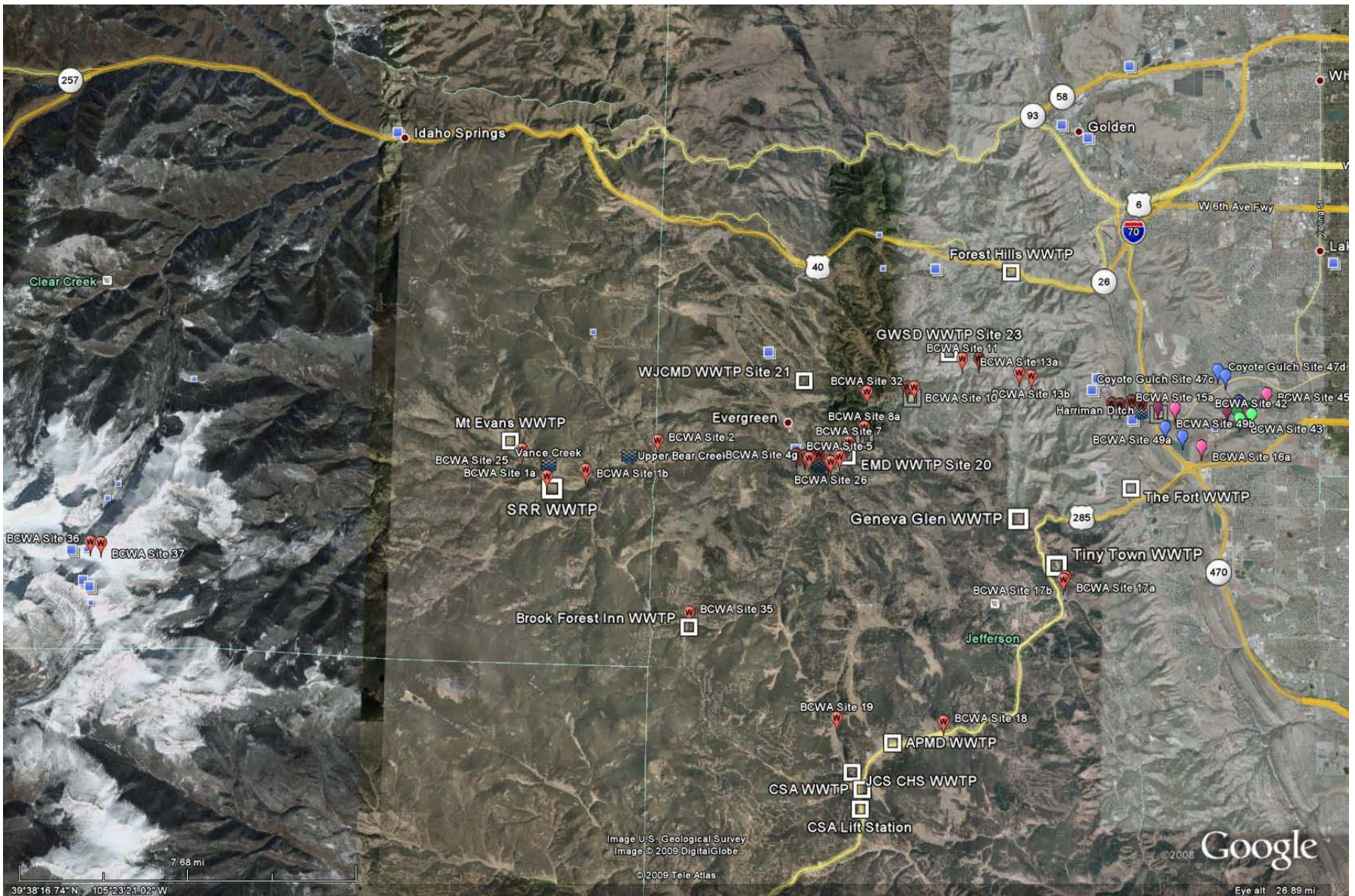
Table 7 following Appendix B list the adopted temperature standards by segments. These standards are use to determine temperature monitoring periods by segments.

**Appendix A - BCWA Monitoring Stations by Watershed Stream Segments**

BCWA Site ID	Site Location by Stream Segment	2011 Monitoring May-October		2011-12 Off-season	Reference
		Data Logger	Chemistry	Data Logger	Site
<b>Segment 1a</b>					
Site 1a	Above Lost and Found (Singin' River Ranch) complex	x	x		R
Site 1b	Below West Bryant Singin' River Ranch-Williams Property				
Site 2	Above Evergreen Lake at Clear Creek County line	x			
Site 3a	Above Evergreen Lake at CDOW Site	x	x	x	
Site 3b	Above Evergreen Lake at Lake House Bridge				
<b>Segment 1b</b>					
Site 15a	Bear Creek Segment 1b at the USGS gaging station within Bear Creek Park	x	x	x	R
Site 15b	Bear Creek Segment 1b above inlet to reservoir				
Site 24	Morrison WWTP Eff	x			
Site 27	Morrison above outfall				
Site 27a	Morrison above Ward Ditch	x (new)			
Site 27b	Morrison below Ward Ditch	x(new)		x	
<b>Segment 1c</b>					
Site 40a	Bear Creek Reservoir; central pool; 1m	x	x	x	R
Site 40b	Bear Creek Reservoir central pool; 5m				
Site 40c	Bear Creek Reservoir central pool; 10m		x		
Site 41	Bear Creek Reservoir outlet (profile)		x		
Site 42	Bear Creek Reservoir SE corner (profile)		x		
Site 43	Bear Creek Reservoir Turkey Creek inlet (profile)		x		
Site 44	Bear Creek Reservoir Bear Creek inlet (profile)		x		
<b>Segment 1d</b>					
Site 4a	Evergreen Lake Surface, profile station	x			R (Profile)
Site 4b	Evergreen Lake Profile Station, 1m	x	x		
Site 4c	Evergreen Lake Profile Station, 2m	x			
Site 4d	Evergreen Lake Profile Station, 3m	x			
Site 4e	Evergreen Lake Profile Station, 4 m	x	x		

BCWA Site ID	Site Location by Stream Segment	2011 Monitoring May-October		2011-12 Off-season	Reference
		Data Logger	Chemistry	Data Logger	Site
site 4f	Evergreen Lake inlet #1				
site 4g	Evergreen Lake inlet #2				
site 4h	Evergreen Lake inlet #3				
<b>Segment 1e</b>					
Site 5	Above EMD WWTP, CDOW site	x	x	x	R
Site 6	Above EMD WWTP effluent				
Site 7	Below EMD WWTP effluent	x	x		
Site 8a	Bear Creek Cabins at CDOW Site	x	x	x	
Site 8b	Below Bear Creek Cabins WQCD site				
Site 9	O'Fallon Park, west end at CDOW Site	x	x	x	
Site 10	O'Fallon Park above KSWD WWTP effluent				
Site 11	Lair o' the Bear Park, west end above GWSD WWTP effluent				
Site 12	Lair o' the Bear Park, at CDOW site	x	x	x	
Site 13a	Below Idledale, Shady Lane at CDOW site			x	
Site 13b	Below Idledale, at Baker Bridge				
Site 14a	Morrison Park west end at CDOW Site	x	x	x	R
Site 14b	Above Morrison at DWR gage, Morrison				
Site 14c	Above Harriman Diversion, Morrison				
Site 20	EMD WWTP Eff	x			
Site 21	WJCMD WWTP Eff	x			
Site 22	KSWD WWTP Eff	x			
Site 23	GWSD WWTP Eff	x			
Site 29	Welch Avenue Bridge				
Site 30	West End Idledale at Little Park				
<b>Segment 2</b>					
Site 45	Lower Bear Creek, below reservoir concrete trace/ weir (Plunge pool)	x	X		R
Site 46	Lower Bear Creek at Sheridan				
<b>Segment 3</b>					
Site 25	Vance Creek (Mt. Evans Wilderness drainage)	x	X		R
<b>Segment 4a</b>					
Site 33	Myers Gulch				
Site 34	Mt Vernon Drainage, Morrison				
Site 47a	Upper Coyote Gulch		x		
Site 47b	Lower Coyote Gulch, discharge into reservoir		x		R
Site 47c	Coyote Gulch at Morrison Road				
Site 47d	Coyote Gulch above Morrison Road (Green Mountain Subdivision)				
Site 48a	Lakewood Park Tributary C (Coyote Crossing)				
Site 48b	Lakewood Park Tributary D (Rooney Gulch)				
<b>Segment 5</b>					
Site 26	Cub Creek, Upstream of Hwy 73 bridge, south of EMD WTP	x			

BCWA Site ID	Site Location by Stream Segment	2011 Monitoring May-October		2011-12 Off-season	Reference
		Data Logger	Chemistry	Data Logger	Site
Site 35	Cub Creek, Upstream @ Brookforest Inn	x	x		R
Site 50	Cub Creek, Upstream Cub Creek Park	x	x		R
Site 52	Kerr/ Swede Mouth		x		
Site 53	Kerr/Swede at Riefenberg		x		
Site 54	Swede Gulch near mouth		x		
Site 55	Kerr Gulch above confluence with Swede		x		
Site 31	Kerr Gulch				
Site 32	Troublesome Gulch, mouth				
<b>Segment 6a</b>					
Site 16a	Turkey Creek within Bear Creek Park at old USGS gage	x	x	x	R
site 16b	Turkey Creek within Bear Creek Park at inlet to reservoir				
Site 17a	Near confluence of North and South Turkey Creeks, above confluence on NTC				
Site 18	South Turkey Creek Aspen Park Metropolitan District	x	x		
Site 28	Parmalee Gulch, mouth				
<b>Segment 6b</b>					
Site 17b	Confluence of North and South Turkey Creeks, above on NTC	x			
Site 19	North Turkey Creek Flying J Ranch Bridge	x	x		R
Site 51	North Turkey Creek at Dankes Road	x			
<b>Segments 7 and 8</b>					
Site 37	Mainstem from Lake at 1/4 mile (Segment 7)		x		R
Site 36	Summit Lake outfall (Mount Evans Wilderness) (Segment 8)		x		R
Site 38	Bear Creek at Bear Tracks, bridge (Segment 7)		x		
<b>Segment 10</b>					
Site 39	Genesee Reservoir	X (profile)	x		none
<b>Segment 11</b>					
Site 49a	Soda Lakes, Big (Profile Center)				
Site 49b	Soda Lakes, Little (Profile Center)				
<b>Segment 12</b>					
<b>No sites</b>					



**Appendix B - Watershed Sampling Sites**

**Appendix C - Adopted Temperature Standards**

Seg	Segment	Standard	Month	STANDARD (°C)		Month	STANDARD (°C)	
				(MWAT)	(DM)		(MWAT)	(DM)
1a	Mainstem of Bear Creek from the boundary of the Mt. Evans Wilderness area to the inlet of Evergreen Lake	T=TVS(CS-I) °C	June-Sept	17.0	21.2	Oct-May	9.0	13.0
1b	Mainstem of Bear Creek from Harriman Ditch to the inlet of Bear Creek Reservoir	T=TVS(CS-II) °C, April-Oct; T(WAT)=19.3 oC	April-Oct	19.3	23.8	Nov-Mar	9.0	13.0
1c	Bear Creek Reservoir.	T=TVS(CLL) °C; April-Dec; T(WAT)=23.3oC	April-Dec	23.3	23.8	Jan-Mar	9.0	13.0
1d	Evergreen Lake.	T=TVS(CLL) °C	April-Dec	18.2	23.8	Jan-Mar	9.0	13.0
1e	Mainstem of Bear Creek from the outlet of Evergreen Lake to the Harriman Ditch.	T=TVS(CS-II) °C; April-Oct; T(WAT)=19.3 oC	April-Oct	19.3	23.8	Nov-Mar	9.0	13.0
2	Mainstem of Bear Creek from the outlet of Bear Creek Reservoir to the confluence with the South Platte River.	T=TVS(WS-II) °C	March-Nov	27.5	28.6	Nov-Mar	13.7	14.3
3	All tributaries to Bear Creek, including all wetlands, from the source to the outlet of Evergreen Lake, Except for specific listings in Segment 7.	T=TVS(CS-I) °C	June-Sept	17.0	21.2	Oct-May	9.0	13.0
4a	All tributaries to Bear Creek, including all wetlands, from the outlet of Evergreen Lake to the confluence with the South Platte River, except for specific listings in Segments 5, 6a, and 6b.	T=TVS(WS-I) °C	March-Nov	24.2	29	Dec-Feb	12.1	14.5
5	Swede, Kerr, Sawmill, Troublesome, and Cold Springs Gulches, and mainstem of Cub Creek from the source to the confluence with Bear Creek.	T=TVS(CS-II) °C	April-Oct	18.2	23.8	Nov-Mar	9.0	13.0
6a	Turkey Creek system, including all tributaries and wetlands, from the source to the inlet of Bear Creek Reservoir, except for specific listings in Segment 6b.	T=TVS(CS-II) °C	April-Oct	18.2	23.8	Nov-Mar	9.0	13.0
6b	Mainstem of North Turkey Creek, from the source to the confluence with Turkey Creek.	T=TVS(CS-I) °C	June-Sept	17.0	21.2	Oct-May	9.0	13.0
7	Mainstem and all tributaries to Bear Creek, including wetlands, within the Mt. Evans Wilderness Area.	T=TVS(CS-I) °C	June-Sept	17.0	21.2	Oct-May	9.0	13.0
8	Lakes and reservoirs in the Bear Creek system from the sources to the boundary of the Mt. Evans Wilderness area.	T=TVS(CL) °C	April-Dec	17.0	21.2	Jan-Mar	9.0	13.0
9	Lakes and reservoirs in the Bear Creek system from the boundary of the Mt. Evans Wilderness area to the inlet of Evergreen Lake.	T=TVS(CL) °C	April-Dec	17.0	21.2	Jan-Mar	9.0	13.0
10	Lakes and reservoirs in drainages of Swede Gulch, Sawmill Gulch, Troublesome Gulch, and Cold Springs Gulch from source to confluence with Bear Creek.	T=TVS(CL) °C	April-Dec	17.0	21.2	Jan-Mar	9.0	13.0
11	Lakes and reservoirs in the Bear Creek system from the outlet of Evergreen Lake to the confluence with the South Platte River, except as specified in Segments 1c, 10, and 12; includes Soda Lakes.	T=TVS(CL) °C	April-Dec	17.0	21.2	Jan-Mar	9.0	13.0
12	Lakes and reservoirs in the Turkey Creek system from the source to the inlet of Bear Creek Reservoir	T=TVS(CL) °C	April-Dec	17.0	21.2	Jan-Mar	9.0	13.0