WWE

MEMORANDUM

To: Big Dry Creek Watershed Association Board of Directors

From: Wright Water Engineers, Inc.
Jane Clary

Date: March 14, 2006

Re: Big Dry Creek Water Quality Summary for 2005

This memorandum summarizes the water quality monitoring program conducted by the Big Dry Creek Watershed Association during 2005, including these topics:

- Data summary and comparison to stream standards
- Key Constituents of Interest
  - Bacteria
  - Selenium
  - Iron
  - Others
- Flow Conditions
- Quality Assurance/Quality Control

Data Summary and Comparison to Stream Standards

During 2005, the cities of Broomfield, Northglenn, Thornton and Westminster (Cities) worked together to collect water quality and flow data along the main stem of Big Dry Creek (Figure 1). Water quality samples were analyzed for a variety of constituents, resulting in over 4,000 records being added into the Big Dry Creek Watershed Association (BDCWA) database. Metals were monitored on a quarterly basis with the exceptions of iron and selenium, which were monitored monthly. All other constituents were monitored on a monthly basis. The Cities also helped to fund operation of the U.S. Geological Survey (USGS) gauging station at Westminster behind Front Range Community College. Key findings related to the 2005 data are the subject of this memorandum.

Four summary tables and multiple figures are attached to this memorandum providing key supporting information for purposes of this water quality assessment, including:

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- Table 1 identifies the Colorado Water Quality Control Commission (CWQCC) stream standards on Segment 1 of Big Dry Creek, the frequency with which standards were exceeded and whether the stream attained the standard for each constituent.

- Table 2 provides a summary of the numbers of samples collected and the average, minimum and maximum concentrations for each constituent at each monitoring location. The relevant regulatory statistic (e.g., 85th percentile) for constituents with stream standards is also provided.

- Table 3 provides a compilation of data for constituents that exceeded the stream standard on any sampling occasion.

- Table 4 provides a summary of the duplicate sample analyses conducted during 2005 for purposes of quality assurance (QA).

Attainment of stream standards is evaluated based on comparison of specific statistical values to chronic stream standards and determining whether acute standards are exceeded in any samples. For most constituents, the relevant statistic for comparison to the chronic standard is the 85th percentile value. Exceptions include use of the 50th percentile value for metals with standards in the total recoverable form, the geometric mean for *E. coli* and fecal coliform, and the 15th percentile value for dissolved oxygen (DO) and the lower acceptable range for pH. (*It should be noted that from a regulatory perspective, five years of data would be used in such a comparison*.)

In keeping with the Colorado Water Quality Control Division's (CWQCD's) current wastewater discharge permits for Broomfield and Westminster, a hardness value of 256 mg/L was used to calculate the hardness-based stream standards. The CWQCD used a value of 359 mg/L for the city of Northglenn's permit. The mean hardness value for the stream as a whole during 2005 was 341 mg/L. Figure 2 shows relatively high hardness values upstream of the wastewater discharges, as well as in the lower portion of the creek in the agricultural area.

Segment 1 (the main stem) of Big Dry Creek is listed on the 2006 303(d) List for Colorado for non-attainment of stream standards for fecal coliform, *E. coli* and selenium. Each of these constituents has a temporary modification to the stream standard currently in place. Additionally, a portion of the stream downstream of the Weld County line is listed on the Monitoring and Evaluation (M&E) portion of the 303(d) list for total recoverable iron. Based on review of the 2005 BDCWA data set, Segment 1 of Big Dry Creek does not attain the currently assigned acute or chronic standards for dissolved selenium at bdc1.5. Although the stream segment as a whole attained the temporarily modified chronic stream standard for dissolved selenium, it did not meet the underlying chronic standard at any monitoring location on the stream. Although the overall stream segment met both the underlying and temporarily modified bacteria and *E. coli* standards, several individual monitoring locations (i.e., bdc1.5, bdc2.0 and bdc6.0) exceeded the underlying standard. One location on the stream, bdc6.0, does not meet the stream standard for total recoverable iron; however, the stream as a whole meets the standard. All other constituents attained the stream standards during 2005.

One proposed regulatory change that is likely to affect Big Dry Creek in coming years is Colorado's adoption of EPA's *1999 Update of Ambient Water Quality Criteria for Ammonia*, which would shift the ammonia standard from the unionized form to the total ammonia form. The standard is calculated based on temperature and pH and would affect both discharge permit limits and the in-stream standard.

As a general note, the Big Dry Creek monitoring program is an ambient-based program. Nine of the twelve sampling dates occurred during dry weather conditions, with three sampling events following mild storms in April, May and June. Precipitation recorded at Broomfield through the Urban Drainage and Flood Control District (UDFCD) Flood Alert System on these dates ranged from 0.28 to 0.31 inches.

Selenium

Dissolved selenium concentrations during 2005 exceeded the underlying chronic stream standard of 4.6 µg/L at all locations on the creek, based on comparison of the 85th percentile value at each monitoring location to the stream standard as shown in Figure 3. The 85th percentile value met the temporary modification to this standard of 11 µg/L, which was assigned by the CWQCC in 2004, at all locations except bdc1.5. Two exceedances of the acute dissolved selenium standard also occurred at bdc1.5 during December and February. In the December sample, both the sample and its duplicate showed identical values of 20 µg/L. During 2003 and 2004, similar trends were present on the stream. Figures 4a and 4b demonstrate seasonal variation in selenium concentrations during 2005 with lower concentrations during the irrigation season (April-October) and higher concentrations during the non-irrigation season (November-March). Monitoring location bdc1.5 is located just downstream of Front Range Community College, upstream of both the wastewater discharges and agricultural influences.

During the fall of 2005, the BDCWA worked to develop a better understanding of selenium sources in the watershed. The underlying data and results of this analysis are contained in a separate 40+ page technical memorandum that addresses geologic sources, Rocky Flats data, surface water and groundwater samples, biological data and other issues. (This document is currently under review by the BDCWA Board of Directors.) Excerpts providing a few of the basic findings of this work based on data available from 2003 through October 2005, which are presented in more detail in the technical memorandum and not repeated herein, include the following:

- *There is not a statistically significant upstream to downstream trend for selenium concentrations. However, the highest concentrations are consistently recorded upstream of the wastewater treatment plants. There is a statistically significant difference between locations upstream of the WWTPs relative to downstream, with the upstream locations being higher; however, Least Significant Difference analysis refined this conclusion by showing that the mean concentration for bdc1.5 was significantly different from other*

locations on the creek, but that there was not a significant difference among the means for the other locations.

- *Seasonal variation in selenium concentrations is statistically significant based on analysis of the irrigation (April through October) versus non-irrigation (November through March) season. During the irrigation season, mean selenium concentrations were 5.1 µg/L, and during the non-irrigation season, they were 8.5 µg/L. This trend is most evident at the three monitoring locations (bdc0.5, bdc1.0, bdc1.5) between Standley Lake and the Broomfield WWTP and is less evident at the stations below the Broomfield and Westminster WWTP discharges (bdc2.0 through bdc6.0). During the irrigation season, stations upstream of the WWTPs averaged 4.4 µg/L and stations downstream averaged 5.6 µg/L. During the non-irrigation season, stations upstream averaged 11.2 µg/L and stations downstream averaged 6.7 µg/L. During the irrigation season, the upstream sites benefit from the diluting flows released from Standley Lake. During the non-irrigation season, there is typically very little flow in the creek at the upstream monitoring locations and selenium concentrations increase significantly. This seasonal trend is less defined below the WWTPs due to the more consistent flows in the creek from the wastewater discharges. (However, in the future, the reuse programs being implemented by both cities could alter this trend.)*

- *Closely related to seasonal variation is the relationship between flow and selenium. As would be expected, flows during the irrigation season are roughly double the non-irrigation season flows on average. Flows downstream of the WWTPs are higher than above the WWTPs. This difference is most pronounced during the non-irrigation season. In general, lower flows have higher selenium concentrations. However, there is significant variation in selenium concentrations at low flows (e.g., at very low flows, there can be very high and very low selenium). Due to this variation, flow alone is not a strong predictor of selenium concentration. If flows are grouped into roughly 5 cfs ranges and plotted against selenium, some of this variability is removed and a stronger relationship is apparent (r^2=0.61). Nonetheless, there are clearly other variables influencing selenium concentration in addition to flow (i.e., flow does not fully explain selenium concentrations).*

- *The highest in-stream concentrations of selenium are consistently present at station bdc1.5 near 120th and Federal, just downstream of Front Range Community College. Three[1] exceedences of the acute selenium standard have also occurred at this station, ranging from 19-20 µg/L, once per year. The entire stream segment between bdc1.0 and bdc1.5 is Westminster Open Space and is primarily unirrigated. Two groundwater monitoring wells located between Big Dry Creek and Front Range Community College show elevated dissolved selenium concentrations averaging from 34 to 92 µg/L. Three other wells in the same area have low concentrations of selenium. Available*

[1]An additional exceedance of the acute standard occurred in December 2005, bringing the total to four.

groundwater flow mapping available from Front Range Community College indicates that the direction of groundwater flow is to the northeast toward the creek. Surficial geology in this reach of stream consists primarily of alluvial deposits with the exception of several discontinuous outcrops of the Arapahoe Formation (TKda) bedrock on the south side of the stream, which may help to explain the large variation in groundwater concentrations in the five wells behind Front Range Community College. These bedrock outcrops and weathered materials originating from these outcrops are believed to be the naturally occurring source of selenium along Big Dry Creek.

- *In terms of trends over time, it is important to recognize that the data set only covers about two and a half years and differing months for these years. Comparison of August through October data, which are the three months common to all three years, did not show a statistically significant difference over time.*

- *Although the groundwater contribution to Big Dry Creek is not known to have been formally studied or defined, review of paired selenium and flow data between bdc1.0 and bdc1.5 indicate that for two-thirds of the year, flows are gained in this reach. For 20% of the year, there is no measured change, and during 14% of the year, flows are lost (possibly to diversions to Community College Pond). A clear trend between gains and losses and selenium concentrations in this reach is not apparent. For example, the largest flow gain does not show a corresponding large increase in selenium. The highest selenium concentrations occurred when there was no net change in flow. In other cases, flows were lost and large increases in selenium were observed. Presence or absence of irrigation flows appears to have a stronger relationship to selenium concentration than the gain/loss data available to date. (Additionally, because there are at least two flowing tributaries to the stream in this reach, gains can't be allocated between groundwater and surface water without additional field data.)*

- *Analysis of grab samples from the Broomfield and Westminster WWTPs show that these discharges average 4.01 µg/L and 3.47 µg/L, respectively. In several grab samples, the WWTPs have occasionally exceeded the instream standard with maximum concentrations of 6 µg/L. Other occasionally elevated concentrations have also been collected in wastewater composite samples collected by the cities as part of their discharge monitoring reports (DMRs). These relatively isolated elevated concentrations typically are associated with large precipitation events and are hypothesized to result from inflow/infiltration (I/I) into the sanitary sewer system during wet periods. Other potential contributions to the sanitary sewer system may be the result of basement sumps tied into the sanitary system. Either way, the source of the selenium would still be expected to be due to the naturally occurring geology and groundwater in the watershed. Additionally, the WWTP discharges do not contribute to the highest selenium concentrations in the stream, which are upstream of the WWTPs. For the most part, the WWTPs are expected to dilute instream selenium concentrations, rather than increase them.*

- *Based on exploration of water quality data from Big Dry Creek, ponds and reservoirs, groundwater, review of geologic conditions and review of Rocky Flats data, selenium is believed to be naturally occurring in the Big Dry Creek watershed. Available biological data show that fish continue to reproduce and live in Big Dry Creek despite selenium concentrations that exceed the stream standard throughout the creek. Because available data do not show a discernable relationship between ambient selenium concentrations and fish communities, it is unclear whether the fish communities would benefit from reduced selenium concentrations, even if it were possible to reduce the selenium concentrations. Aquatics Associates (2005) has stated that flow conditions, high turbidity and habitat preferences appear to be the predominant influences on the fish community.*

Future changes to selenium standards on Big Dry Creek are a long-range issue since the temporary modification for the selenium standard is in place until 2010. Revised selenium criteria, whatever they may ultimately be, would not be adopted into Colorado's Basic Standards until 2010 and would not be incorporated into Big Dry Creek's Stream Standards until 2014. EPA's revised criteria for selenium were issued in draft form in 2004 and are tentatively scheduled to be finalized in 2008. Selenium was listed as a "low priority" on the 2006 303(d) list. Nonetheless, because Big Dry Creek has a temporary modification in place, the BDCWA must work towards developing a better scientific understanding of sources and impacts of selenium on the creek. The monthly water quality monitoring data and fish tissue sampling help to support this effort. Other recommendations regarding identification of selenium sources are provided in the December 2005 technical memorandum regarding selenium.

One final note with regard to selenium data analyzed during 2005 is that 95 samples were analyzed by a contract laboratory using ICP-MS EPA 200.8 methodology, and a subset of these samples (n=35) was analyzed by the Broomfield Wastewater Treatment Facility's laboratory using ICP EPA 200.7 methodology. The larger data set analyzed by the contract laboratory was used for purposes of data interpretation in this memorandum. The mean and maximum concentrations reported for the samples analyzed using both methods were identical. The 85th percentile value using Broomfield's ICP analysis was 9 ug/L, which was slightly higher than the contract laboratory's 8 ug/L value. On average, the variation between the two methods was 0.8 ug/L or about 16 percent.

Bacteria

Currently, a dual standard for fecal coliform and *E. coli* is in place for Segment 1 based on changes to the Basic Standards in 2001. *E. coli*, which is a subset of fecal coliform, is believed to be a better predictor of potential human health impacts from waterborne pathogens. In the next triennial review, the CWQCC anticipates moving to *E. coli* as the sole pathogen indicator. The dual standards are established as an interim transitional step. However, in the event of a conflict between the fecal coliform and *E. coli* data, the *E. coli* data will govern (CWQCC 2001a). The BDCWA now has six years of *E. coli* data, so primary emphasis regarding trend analysis in this memorandum is focused on *E. coli*. Additionally, *E. coli* and fecal coliform trends from 2000-

2005 appear to be comparable, as shown in Figure 5. Based on review of geometric mean concentrations from 2000-2005, the following observations are noteworthy:

- Geometric mean concentrations for both *E. coli* and fecal coliform are consistently the lowest in grab samples from the Broomfield and Westminster WWTP effluent. For the six-year time period, wastewater grab samples were well below the stream standard. For this reason, elevated geometric mean concentrations at in-stream locations below the discharges cannot be attributed to WWTP discharges during the vast majority of the sampling events. (Note: There may be occasionally elevated concentrations in the WWTP discharges that may cause corresponding elevated concentrations in the stream, but this is not the primary cause of elevated bacteria.)

- The highest concentrations of both *E. coli* and fecal coliform are present at bdc2.0, below the Broomfield WWTP. Monitoring station bdc6.0 in the agricultural area upstream of the confluence with the South Platte River also has concentrations above stream standards for both *E. coli* and fecal coliform.

- During 2005, geometric mean concentrations of fecal coliform were below the underlying stream standard at all locations except bdc2.0 and bdc6.0 (Figure 6). Concentrations at bdc1.5 also approached the stream standard. All locations met the temporarily modified standard of 380/100 mL during 2005.

- During 2005, geometric mean concentrations of *E. coli* were below the underlying stream standard at all locations except bdc1.5, bdc2.0 and bdc6.0 (Figure 7). All locations met the temporarily modified standard of 401/100 mL during 2005.

- For most locations on the stream, *E. coli* concentrations are about one-quarter to one-half of those measured during drought conditions in 2002, with the exception of bdc.1.5, which appears to be less variable over time.

- Seasonal variation is evident (Figure 8) for the six-year *E. coli* data set, with geometric mean concentrations above the underlying stream standard during April through November and above the temporarily modified standard for June through October. Although bdc6.0 also exhibits a seasonal trend, concentrations in the winter months still remain above the underlying stream standard at this location (Figure 9).

- Cursory statistical analyses were conducted to determine if there was any obvious pattern with regard to bacteria and temperature, total suspended solids (as a surrogate for stormwater conditions) and flow. Because of the notorious temporal and spatial variability in bacteria data and the fact that the data set is not normally or even log-normally distributed, these types of analyses were not very helpful. For the 2000-2005 data set (n=511), *E. coli* and TSS were positively correlated (r=0.41). *E. coli* and temperature also showed a weak positive correlation (r=0.14). Additional non-parametric data analysis could be helpful but was not conducted within the scope of this memorandum. Scatter plots (Figure 10) of the data, however, suggest that stormwater

flows during the April, May and June sampling events may have contributed to elevated bacteria concentrations in the upper watershed at locations that typically have lower concentrations. Summer temperatures are expected to contribute to elevated bacteria conditions at multiple locations on the stream.

A field investigation and/or sanitary survey focused on locations bdc1.5, bdc2.0 and bdc6.0 would be helpful in identifying potential sources at these particularly elevated locations. Based on land use information, elevated concentrations at bdc6.0 would be expected to be associated with agricultural land use such as cattle grazing. Concentrations at bdc1.5 could be associated with wildlife and dogs in the open space area. Potential sources at bdc2.0 are unclear. At all of these locations, it is important to rule out sanitary sources such as failing septic systems or illicit connections to the storm sewer system. In 2003, City of Broomfield staff confirmed that a camp located near bdc2.0 was not on septic system, but was instead connected to the Westminster sewer system. Information on conducting a sanitary survey was provided in a technical memorandum summarizing WWE's analysis of water quality in 2001 (WWE 2002).

Bacteria in Stormwater

The BDCWA does not currently have a wet-weather monitoring program in place, but national and local stormwater data show that bacteria concentrations in stormwater runoff are typically high. For example, the U.S. Geological Survey (USGS) and the Urban Drainage and Flood Control District (UDFCD) recently released *Summary and Evaluation of the Quality of Stormwater in Denver, Colorado, Water Years 1998-2001* (Scientific Investigations Report 2005-5150) by Clifford Bossong, Michael Stevens, John Doerfer and Ben Glass. The report contains sampling and analysis results for multiple constituents at a network of five monitoring stations in the metro Denver area, with three on the South Platte River and two on tributary streams (Sand Creek and Tollgate Creek). The data set covers a four-year period from 1998-2001, including fecal coliform and *E. coli* sample analyses. The overall finding with regard to the 34 bacteria samples collected is that no *E. coli* or fecal coliform sample results during storm flow conditions meet the CDPHE stream standards. Bacteria are elevated in both the rising and falling limbs of the hydrograph, with mean bacteriological concentrations roughly 25 times the stream standard. The table below summarizes the results of the bacteriological samples collected at all five locations. (Samples collected at individual monitoring locations can be obtained in the report from http://pubs.usgs.gov/sir/2005/5150/.)

***E. coli* and Fecal Coliform Concentrations in Five Denver-area In-stream Monitoring Locations under Storm Flow Conditions**
(Data Source: USGS/UDFCD 2005)

Constituent (#/100 mL)	Hydrograph Position	Number of Samples	Mean	Median	Standard Deviation	Min	Max
E. coli	All samples	34	2,900	2,000	2,500	170	7,900
	Rising limb	16	2,850	2,000	2,300	170	7,900
	Falling limb	18	2,950	2,150	2,730	330	7,900
Fecal coliform	All samples	34	5,490	3,300	7,400	330	35,000
	Rising limb	16	5,050	3,300	5,850	330	24,000
	Falling limb	18	5,880	3,300	8,710	330	35,000

Iron

Total recoverable iron concentrations during 2005 attained the stream standard of 1 mg/L based on the 50th percentile value for the overall stream. Nonetheless, about 25 percent of the samples collected (i.e., 24 out of 95 samples) exceeded the standard, with the elevated concentrations generally corresponding to storm events during April, May and June (Figure 11), with concentrations increasing in a downstream direction during these storm events. As shown in Figure 12, total recoverable iron and total suspended solids both increase in a downstream direction and are well correlated to each other, as has been the case in previous years.

The CWQCD has placed Segment 1 of Big Dry Creek on the Monitoring and Evaluation List because one location on the stream, bdc6.0, does not meet the stream standard. As shown in Figure 13, the 50th percentile value for 2001 through 2005 at bdc6.0 is 1.4 mg/L, exceeding the stream standard. Although the highest concentrations (5-13 mg/L) over the past five years at bdc6.0 occurred during the April to July time period and are believed to be associated with sediment loads associated with summer storm events and irrigation activities, concentrations at this site are elevated above the standard throughout all months of the year, even in the absence of these activities, as shown in Figure 14. The stream in the lower watershed is actively eroding and has multiple unstable banks, exacerbated by the severe storm events during 2004. Several parcels of land (e.g., Wright, Rosenbrock, Chikuma) upstream of bdc6.0 were visited during 2005, with active bank erosion evident. Iron that naturally occurs in the streambanks is expected to be the probable source of elevated iron in the lower watershed.

Other Constituents

Ammonia

Unionized ammonia concentrations were well below stream standards in 2005, as shown in Figure 15. Like 2003 and 2004, the stream continued to show an improvement in unionized ammonia conditions in the creek relative to 2002, when the 85th percentile value exceeded the chronic standard and several exceedences of the acute standard occurred. During 2002, several of these exceedances were attributed to operational challenges during the Broomfield WWTP plant expansion and upgrade, which is now complete. The 2003 through 2005 data are relatively consistent with Big Dry Creek data prior to 2002, which indicated very few unionized ammonia concentrations above the stream standard.

Although the unionized concentrations of ammonia are low, the total ammonia concentrations were elevated at bdc2.0 during January and February of 2005, as shown in Figure 16. As previously noted, total ammonia stream standards are also expected in the future. Since this area has lower aquatic community health, as well as elevated bacteria, potential sanitary sources should be explored in this area.

Nitrate

Although Big Dry Creek does not have a drinking water classification or a corresponding in-stream nitrate standard, the Middle South Platte River Segment 1 downstream of Big Dry Creek has a drinking water classification and a nitrate standard of 10 mg/L. This standard is applied based on a single day combined total of nitrite and nitrate at the point of intake to the domestic water supply. Figure 17 provides a scatter plot of nitrate grab samples collected at the farthest downstream sampling point (bdc6.0) in the Big Dry Creek monitoring program. The scatter plot indicates that over the past five years, nitrate grab samples reached or exceeded 10 mg/L seven times at this location, or in about 12 percent of the samples. From another perspective, Figure 18 shows that, at the confluence with the South Platte River, Big Dry Creek average nitrate concentrations were below 10 mg/L with an average concentration of 6.8 mg/L over the last five years. Figure 18 shows that grab samples from the Broomfield (bdc10.0) and Westminster (bdc11.0) wastewater discharges are higher than the downstream drinking water standard; however, dilution from stream flows and natural losses associated with the nitrogen cycle result in lower concentrations at the confluence with the South Platte River. Additionally, no samples from Northglenn's WWTP effluent were included in the 2005 analysis because Northglenn did not discharge to Big Dry Creek in 2005 during BDCWA sampling events, but this may change in the future and could influence concentrations at bdc6.0.

BDCWA anticipates the need to protect the downstream drinking water classification to be an issue in the future; therefore, nitrate concentrations along Big Dry Creek will continue to be examined and modeling will likely be required to determine Big Dry Creek's contribution to nitrate concentrations at the "point of compliance" on the South Platte River.

Others

In previous annual data analysis memoranda, cyanide, mercury, lead and zinc had been specifically commented on due to some elevated concentrations detected prior to 2001 (some of which were believed to be laboratory issues). For both 2005 and the last five years, there have been no elevated concentrations of these constituents, so no specific comments on these constituents are warranted in this memorandum.

Flow

Annual average instantaneous flow measurements collected by the Big Dry Creek cities during monthly sampling since 1997 are provided in Figure 19. These data suggest that streamflows remain roughly comparable to the drought conditions in 2002 upstream of the Westminster WWTP. Downstream of the Westminster WWTP, there is less variation. Care must be taken when drawing conclusions based on comparison of average flows because during high flow conditions, field staff do not measure flows for safety reasons. Nonetheless, the low flows at the upstream monitoring locations could influence poor aquatic life conditions reported by Aquatics Associates at bdc2.0.

The available USGS flow data for the Westminster and Fort Lupton gauges through 2005 are shown in Figures 20 through 21. During 2005, average daily flows at the Westminster gauge ranged from 1 cfs to 224 cfs with an average of 21 cfs. Flows measured at the Westminster gage suggest gradual recovery from drought conditions. (Note: this observation is inconsistent with the BDCWA instream monitoring program flow data presented above.) Average daily flows for the Fort Lupton gauge data ranged from 2 cfs to 325 cfs with an average of 32 cfs. Average flows during 2005 were somewhat lower than during 2003 and 2004, though still somewhat higher than 2002. During 2005, there were several high flow events associated with storms, as shown on Figure 21. On October 11, storm flows measured at the USGS gage at Fort Lupton were 325 cfs, which exceeded the 268 cfs value reported during the July 24, 2004 storm that caused concerns from downstream landowners in 2004. Per correspondence during 2005 with USGS staff, the Fort Lupton gage has some accuracy issues, so the relative difference between the flow events is uncertain.

Quality Assurance/Quality Control

During 2005, quality control (QC) measures were followed for the sampling program in accordance with the Big Dry Creek Sampling and Analysis Plan (BDCWA 2003). Under this program, field blanks are analyzed for the full suite of constituents in March, a full set of duplicate analyses are completed in September, and during June and December, field duplicates are analyzed for four locations (bdc1.5, bdc2.0, bdc3.0 and bdc5.0) for constituents of concern (selenium, *E. coli*, ammonia and iron). This plan was followed except that the scheduled June duplicate sample analysis was only completed for *E. coli*; however, the July sample included duplicates for the remaining constituents of concern, compensating for the June omission.

Table 4 summarizes analysis of field blank and duplicate samples for 2005. Analysis of relative percent difference (RPD) for the sample duplicates shows acceptable accuracy with a few exceptions. The samples analyzed generally showed less than 5 percent variability. For constituents that showed greater variability, the magnitude was typically comparable or less than the laboratory detection limit, making the variability insignificant. For constituents such as *E. coli* and turbidity, greater variability was typically measured, which is characteristic of these types of analyses. The following three constituents had higher RPDs and will continue to be tracked next year:

- Zinc had a large RPD (88%) in the September duplicate analysis. Follow-up by Broomfield staff indicated that elevated zinc is observed frequently in a lot of the IPP blanks (field and equipment). Some powdered latex gloves also contain zinc, which could be a source. Another hypothesis included the sample bottles or autosampler tubes themselves. Given that zinc is not a constituent of concern on Big Dry Creek and that elevated zinc was not detected in 2005, this is not an issue of concern at this time.

- One of the three total recoverable iron sample pairs had an RPD of 21%. The source of the total recoverable iron variation is hypothesized to be lack of homogeneity in samples containing suspended solids.

- Dissolved manganese had a moderately high RPD of 33% in September. The source of the manganese variation is unknown, but dissolved manganese is not a constituent of concern on the creek.

Field blank analyses were within acceptable concentrations with the exception of boron and zinc. The explanation regarding zinc (above) also applies to the field blanks. With regard to boron, the City of Westminster is following up with the contract laboratory to determine possible sources of contamination. Per David Carter, the contract laboratory reported that this has been an issue in the past.

Recommendations

1. The Big Dry Creek Watershed Association should closely follow on-going selenium studies conducted by the CWQCD and other groups throughout the state, particularly along the Front Range. The BDCWA should complete review of the draft selenium analysis memorandum completed in the fall of 2005 by WWE and determine a course of action.

2. The BDCWA should continue to monitor *E. coli* and fecal coliform conditions along the creek and participate in regional efforts to better understand non-point sources of bacteria and potential methods to address these sources. Given the high priority status of bacteria on the 303(d) list, the BDCWA should begin formulating a plan to identify sources of bacteria in the watershed. At a minimum, reconnaissance level field investigations at bdc1.5, bdc2.0 and bdc6.0 could be helpful. A sanitary survey, as recommended by WWE (2002) could also be beneficial. Additionally, the BDCWA may benefit from development of a "white paper" that summarizes some of the data requirements and approaches used to develop bacteria TMDLs

in other parts of the U.S. This information could be helpful in shaping source identification and data collection activities.

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TABLES

FIGURES