Big Dry Creek
Watershed Management Plan

Prepared for

The Big Dry Creek Watershed Association
Cities of Broomfield, Northglenn & Westminster
US Department of Energy Rocky Flats Field Office

Prepared by

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July 2002

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With the Support of

The U.S. Environmental Protection Agency

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EXECUTIVE SUMMARY

This Watershed Management Plan (Plan) has been developed to provide a comprehensive framework for the activities of the Big Dry Creek Watershed Association. This Plan condenses the findings of over five years worth of work by the Watershed Association and has been developed to conform to the requirements of the U.S. Environmental Protection Agency's Watershed Restoration Action Strategy (WRAS) guidelines. A broad range of topics is covered including targeting (characterizing) current watershed conditions, identifying measures to protect and restore the watershed, and identifying the methods used to evaluate the watershed and activities of the Watershed Association.

Key findings and recommendations of this Plan include:

1. As a result of the diligent efforts of the Watershed Association, many aspects of Big Dry Creek are relatively well characterized. The on-going water quality, flow and biological monitoring program continues to provide up-to-date information on watershed conditions that can be used to target and prioritize future actions in the watershed.

2. Based on water quality data collected to date, wastewater discharges to the creek appear to be adequately controlled by the Colorado Discharge Permit System.

3. Hydrologic modification of the creek from increased stormwater flows related to urbanization will require continued attention by local governments and the Watershed Association. In both the urban and agricultural portions of the watershed, specific areas have been identified that would benefit from stream restoration activities.

4. Local government enforcement of existing stormwater ordinances relating to detention of stormwater flows and erosion and sediment controls at construction sites is critical to protecting Big Dry Creek water quality and habitat. In general, the local governments are believed to have appropriate ordinances in place for new development and redevelopment of existing areas.

5. Stormwater flows and pollutant contributions have not been well characterized, relative to the strong base of information associated with ambient stream conditions. This is an area of additional study that the Watershed Association may want to consider.

6. Based on analysis of the last five years of data, Big Dry Creek meets existing stream standards for all constituents. Although the stream meets Recreation Class 2 fecal coliform and *E. coli* standards, it would have considerable difficulty meeting Recreation Class 1 standards in the event that the stream is reclassified.

7. Considerable data have been collected on erosion and sedimentation issues in the agricultural portion of the watershed. Sufficient information is believed to have been developed to support local landowners in obtaining funding to help stabilize portions of the streambank. Based on information provided by the Natural Resources Conservation Service, it is critical that the landowner initiates the cost-share program application process. The Watershed Association can provide the landowners with good information to help facilitate this process.

8. The Phase II stormwater regulation emphasizes the watershed approach and collaborative efforts to reduce pollution associated with stormwater discharges. The Watershed Association should meet with local government staff and managers responsible for implementation of the Phase II permits in the near future to determine what role the Watershed Association will play in helping the cities to meet the requirements of the regulation.

9. The Watershed Association should continue its public education efforts such as development of a watershed educational video, newsletters and other products. It is important that the Watershed Association work with local governments to take advantage of existing communication pathways to broaden its audience. For example, the Watershed Association should consider providing short articles for distribution to local governments for inclusion in local newsletters and utility bills.

10. The current monitoring and evaluation process used to evaluate the mission and goals, monitoring program, and water quality and biological data should be continued.

1.0 INTRODUCTION

This Watershed Management Plan (Plan) has been developed for the stakeholders of the Big Dry Creek watershed to facilitate coordinated efforts to understand, protect and improve Big Dry Creek. This Plan builds upon efforts that began in 1997 when the cities of Broomfield, Northglenn and Westminster and Rocky Flats Environmental Technology Site (Rocky Flats) entered into an agreement to work together to better understand conditions in Big Dry Creek. Since that time, the initial stakeholders group has expanded to include citizens and representatives from local, state and federal agencies, resulting in the Big Dry Creek Watershed Association (Watershed Association). This Plan integrates the key findings of studies and activities completed during the last five years into one concise document for easy reference by stakeholders. The Plan is organized to be consistent with state and U.S. Environmental Protection Agency (EPA) guidelines for a Watershed Restoration Action Strategy (WRAS).

In keeping with WRAS guidelines, this document is divided into three parts with the following contents:

- Phase I— Targeting: This involves defining the boundaries of the watershed, identifying the environmental goals related to the chemical, physical, and/or biological characteristics of the watershed, and identifying non-point sources of pollution and the relative contribution of those sources. This Plan expands the targeting task to also consider point sources of pollution such as wastewater and stormwater.

- Phase II— Restoration: This involves identifying the lead agencies and funding needs for maintenance, monitoring, and evaluation of the stream; developing and implementing a process for interagency and stakeholder involvement; coordinating with other water quality related initiatives; and identifying, scheduling, and implementing restoration measures to improve water quality and natural resource goals. Since inception of the Watershed Association in 1997, many of these tasks have been completed—this Plan serves to provide better documentation of these activities.

- Phase III— Evaluation: This involves monitoring and evaluating progress toward goals and reiterating the strategy, as necessary, to reflect accomplishments and progress. This Plan documents and improves upon the evaluation process that the Watershed Association has been following for the past five years.

2.0 PHASE I: TARGETING

2.1 Watershed Characterization

2.1.1 *Location*

The Big Dry Creek basin originates in unincorporated Jefferson County at the mouth of Coal Creek Canyon at an elevation of approximately 8,000 feet above sea level. The total drainage area is approximately 110 square miles. The headwaters area is located approximately 5 miles west of Rocky Flats, 10 miles south of the City of Boulder, 20 miles northwest of the City of Denver, and 10 miles west of the City of Westminster. The basin drains easterly from the headwaters area across Rocky Flats, where several tributaries including Walnut Creek, Woman Creek, and Upper Big Dry Creek form. The basin is significantly influenced by Standley Lake reservoir located in the upper basin, as well as by discharges from the Broomfield and Westminster municipal wastewater treatment plants (WWTPs) in the central portion of the basin. Stormwater runoff in the urbanized portion of the basin and ditch diversions also significantly influence the stream. Below Standley Lake, Big Dry Creek flows in a northeasterly direction approximately 33 miles to its confluence with the South Platte River near Fort Lupton in Weld County. Interstate 25 roughly divides the watershed between urban and agricultural land uses with agricultural uses dominating east of I-25. The confluence marks the downstream end of Segment 15 of the South Platte, which is identified as an impaired stream segment on Colorado's 303(d) list. The Big Dry Creek basin is outlined in Figure 1 along with the municipalities and counties comprising the watershed. Significant portions of the watershed are currently undergoing or have recently undergone rapid urban development, transitioning from predominantly agricultural uses to include a mixture of residential, commercial and industrial uses.

2.1.2 *Soils/Geology*

Previous studies sponsored by the Watershed Association included characterization of soils and geologic conditions with regard to potential sources of increased sediment loading (i.e., particularly erosion-prone) and/or sources of naturally elevated iron concentrations (WWE 2000). Some of the highlights of these findings include:

1. Loess-type soil deposits are mapped along the majority of the creek's tributary area. These deposits are wind-deposited, unconsolidated materials that are typically erodible.

2. There are no mapped faults in the study area based on available geologic mapping, which is available for most of the basin with the exception of the Eastlake Quadrangle. Coal mining influences exist to the north of the creek system; however, coal mining in the Broomfield area is vertical shaft, not open-pit with associated waste piles.

3. There is the potential for fracture porosity influence into the stream system where bedrock units (Denver, Dawson, Arapahoe) are located adjacent to the creek, as is the case in several locations. Bedrock shale zones mapped in the study area naturally contain iron, and discharges from the shallow bedrock aquifers may represent one source of naturally occurring iron, in addition to the soils along the creek channel. Marine shales may also be sources of naturally occurring selenium.

4. Soils in the vicinity of the creek are generally alkaline (high pH). Some of these soil units have visible lime streaks that are identified as being corrosive. Although the high pH soils could potentially influence the pH of surface water in Big Dry Creek, which in turn could influence the toxicity of certain constituents, the pH of surface waters in Big Dry Creek does not vary significantly and is within a reasonable range of 7.5 to 8.1 throughout the stream reach.

2.1.3 *Hydrology*

The hydrology of Big Dry Creek is significantly influenced by irrigation releases from Standley Lake, runoff from storm events, discharges from WWTPs, diversions to irrigation ditches and irrigation return flows. Big Dry Creek has not experienced a "natural" flow regime in roughly 100 years since Standley Lake was constructed in the early 1900s. In addition, significant population growth in the central portion of the watershed during the latter portion of the twentieth century has resulted in increased base flows from wastewater discharges and increased storm runoff from increased impervious area. The hydrologic regime of Big Dry Creek is complex because of the significant inflows and diversions from the creek. See Section 2.3.2 of this Plan for a gross hydrologic balance for the creek.

2.1.4 *Channel Character*

The main stem of Big Dry Creek below Standley Lake dam to the confluence with the South Platte River can generally be described as a well defined, meandering channel. The upper 8 miles of the channel between Standley Lake and the Broomfield WWTP can be generally characterized as a transitional foothills-plains stream type, with the lower portion of the stream characterized as a plains stream type (Aquatics Associates 1999).

Transitional foothills-plains stream characteristics include a diminishing gradient, with rubble and gravel settling out and sand becoming a key constituent of stream substrate. These streams are usually restricted to a single channel and shaded by riparian vegetation. Pools, riffles and runs are present in these streams (Propst 1982). In the transitional foothills-plains segment of Big Dry Creek between Standley Lake and the Broomfield WWTP, the stream banks are well vegetated with grasses, willows, cottonwood and Russian olive trees. The streambed consists of small cobble interspersed with gravel and sand in riffle areas, and sand and silt in pool and run areas. In addition, large cobble, small boulders and large woody debris are also present at a few locations in the stream, but are not widespread. The stream meanders through open space and residential areas (Aquatics Associates 1999). In this segment, the stream channel varies from being shallow to being deeply incised with steep cut banks as high as 25 feet in the Westminster Open Space and below the WWTP discharges. Some portions of the bed and banks are experiencing erosion, as discussed in more detail in Section 2.3.5 of this Plan.

Plains stream characteristics include shifting channels, eroding banks and bar migration. Point bars create temporary, quiet pools in their lee. In this type of transient system, there is little structural stability (Propst 1982). Below the Broomfield WWTP in the plains portion of Big Dry Creek, the stream bank is covered with overhanging grasses and the streambed is primarily sand and silt. East of I-25, similar conditions exist with the channel being more channelized and of uniform width and depth. Some areas of embedded cobble are present in areas where bridges cross the stream (Aquatics Associates 1999). Erosion of the streambed is minor in this segment, as is bank erosion, with the exception of localized areas where cattle drink from and cross the creek or on the outside bends of stream meanders.

Overall, the streambed slopes from Standley Lake to the confluence with the South Platte River are relatively mild, less than 0.35 percent, with the exception of slopes ranging from 0.5 to 2.0 percent from just below the dam to approximately 104th Avenue. The natural channel slope is affected by several grade control structures that exist along the creek such as bridges, diversion structures, and riprap weirs (WWE 2000). The stream has a concave profile from Standley Lake to approximately 104th Avenue, indicating that the stream has downcut over time. This would be expected because of the construction and long-term placement of the dam creating Standley Lake. From 104th Avenue to 128th Avenue, the slope remains fairly constant at approximately 0.34 percent. From 128th Avenue to just above the confluence with the South Platte, the slope also remains relatively constant at 0.24 to 0.21 percent. The slope decreases to 0.12 percent just prior to the confluence (WWE 2000).

Between 112th to 120th Avenues, an increased slope followed by a decreased slope downstream to approximately 128th Avenue is present. This change in slope is indicative of a bed lowered by erosion with deposition of sediments downstream. If the bed is actively eroding and downcutting, the downcutting will continue to move upstream. This downcutting process would be expected to occur over a long-range time scale of anywhere from five to more than 20 years in the absence of grade control structures (WWE 2000).

2.1.5 *Land Use*

Land use in the watershed can be broken into roughly three categories: Rocky Flats in the headwaters, urbanized areas in the central portion of the watershed and agricultural use in the lower watershed. These land uses are further discussed below.

<u>Rocky Flats Environmental Technology Site</u>

Rocky Flats is owned by the U.S. Department of Energy (DOE) and operated by Kaiser-Hill. The site's historical mission was the development and fabrication of nuclear weapons components from radioactive and non-radioactive materials. Rocky Flats covers almost 10 square miles in Jefferson County, with the developed plant site, or Industrial Area, comprising roughly 0.65 square miles in the center of the property. The remainder of the site includes a buffer zone of approximately 9 square miles. In 1989, the site was placed on the "Superfund"

National Priorities List for cleanup of the site-wide radiological and chemical contamination that occurred during active operation of the plant. In January 1992, the decision to halt the production of nuclear weapons components was announced. Rocky Flats is currently in transition to decontamination and decommissioning (D&D) for site closure in 2006.

The cleanup of Rocky Flats is expected to result in significant long-term improvements in the watershed of Big Dry Creek with respect to quantities and types of hazardous materials present. However, during cleanup and D&D there will be significant materials handling and removal activities that may potentially impact water quality. Nonetheless, during the active cleanup period, which is currently underway, water quality is required to attain all classified uses except drinking water supply.

Rocky Flats is a significant feature in the watershed because the headwaters of several tributaries to Big Dry Creek are located there, including Woman Creek, Walnut Creek, and Upper Big Dry Creek. These drainages generally traverse the plant from west to east, as shown in Figure 1. The majority of the Industrial Area drains to Walnut Creek, and the majority of discharges from Rocky Flats have historically been made to Walnut Creek. Woman Creek contains much less of the Industrial Area drainage. The flows in Walnut Creek are expected to be reduced following the closure of Rocky Flats (Kaiser-Hill 2002).

Upon closure of the site, including the roughly 6,000-acre buffer zone, Rocky Flats will become a national wildlife refuge with the Industrial Area becoming reclaimed grassland. Roughly the western third of Rocky Flats is covered by the xeric tallgrass prairie, which is one of fewer than 20 such sites worldwide and perhaps the largest remnant in the United States (RFCAB 2000). DOE is now in the process of drafting the Rocky Flats Stewardship Strategy, which will include the overall goals and policies for long-term stewardship at the site (DOE 2002).

Urban Growth and Development

The central portion of the watershed, roughly between Standley Lake and I-25, has experienced significant urbanization in recent years. Figure 2 shows existing municipal and county boundaries in the watershed. This development is primarily within the cities of Broomfield and Westminster, as well as portions of Thornton and Arvada. The portion of the watershed upstream of Standley Lake is anticipated to be largely undeveloped based on the wildlife refuge designation of Rocky Flats. East of I-25 in Weld County, it is anticipated that urban growth may spread, but currently this area remains primarily agricultural. Denver Regional Council of Governments (DRCOG) estimates the current and projected population growth within the watershed as summarized in Table 1. These data are estimated based on the Transportation Analysis Zones data set and do not include the agricultural area in Weld County (DRCOG 2002b).

Table 1

Estimated Population Growth in Big Dry Creek Watershed

	1990	2001	2005	2010	2015	2020	2025
Population	71,871	122,223	134,575	146,357	161,156	173,988	196,548
Households	24,520	43,555	48,446	53,540	59,521	65,078	74,236
Employment	23,546	41,966	51,949	61,740	66,278	70,717	73,025

Agriculture

Agricultural activities focused east of I-25 primarily include corn, alfalfa and winter wheat crops and pastureland for both beef and dairy farming. Watershed-related issues of concern to landowners and farmers in the agricultural area include flooding, sediment loads, stream stability, and salinity. The Natural Resources Conservation Service (NRCS) has reported that livestock grazing with uncontrolled access to Big Dry Creek has contributed to serious soil erosion and reduced water quality in some areas where the stream flows through agricultural lands. The NRCS has also reported that upstream urban growth has resulted in more frequent flooding in these downstream rural areas (Rogers 1997). These findings have been confirmed by follow-up studies sponsored by the Watershed Association (WWE 2000; Gossenauer and Wachob 2001).

2.1.6 *Water Supply*

The cities and counties located within the Big Dry Creek watershed boundaries rely on a variety of water sources. The cities are primarily served by water stored in Carter Lake and Standley Lake or supplied by the Denver Water Board. For the most part, farmers in the county areas rely on well water for domestic purposes and the Farmer's Reservoir and Irrigation Company (FRICO) water released from Standley Lake for irrigation purposes.

Until August 1997, the City of Broomfield's primary water supply was based on raw water stored in Great Western Reservoir. Due to concerns regarding the possibility of contamination of the supply from upstream Rocky Flats, an agreement was reached between DOE and the city of Broomfield to replace the Great Western Reservoir source. The replacement water originates from the western slope of Colorado and is transported through the Colorado-Big Thompson (CBT)/Windy Gap system under management of the Northern Colorado Water Conservancy District. The water is stored on the east slope in Carter Lake in Larimer County. The water is then conveyed in 33 miles of pipeline to the relatively new Broomfield Water Treatment Facility. The facility's current capacity has recently been expanded from 8 to 20 million gallons per day (mgd). To supplement the CBT water source, the city purchases approximately 40 percent of its drinking water from the Denver Water Board, which delivers water to its municipal customers from its Moffat, Foothills and Marston treatment facilities, which are supplied by Denver's extensive Moffat and South Platte collection systems. All of Broomfield's water, whether CBT or Denver water, originates from surface water sources located outside of the Big Dry Creek watershed (City of Broomfield 2002).

Broomfield is in the process of equipping Great Western Reservoir to store reclaimed wastewater to irrigate golf courses and other large landscaped areas. Due to water rights constraints, the reuse water project will be limited to about 6 mgd (Black and Veatch 2000).

Standley Lake is the sole-source municipal water supply for the cities of Westminster and Northglenn and a major water supply source for the city of Thornton. Water stored in Standley Lake originates as runoff from snowmelt and rain and travels down Clear Creek and through a network of canals and ditches to Standley Lake, where it is stored until needed (City of Northglenn 2002).

FRICO provides the primary source of irrigation water used by farmers in the watershed. This water is stored in Standley Lake and released to Big Dry Creek for delivery to the downstream farms. This water is then diverted and distributed via various canals and ditches.

2.1.7 *Wastewater Discharges*

Four WWTPs discharge treated effluent into the Big Dry Creek watershed including Rocky Flats and the cities of Broomfield, Westminster and Northglenn. The three municipal discharges are permitted by the Colorado Department of Public Health and Environment Water Quality Control Division (CWQCD), and Rocky Flats is permitted by the EPA, since it is a federal facility. Each of the WWTP facilities is described below. Wastewater discharge permit limits are discussed in Section 2.2.2 of this Plan.

Rocky Flats

Rocky Flats has its own WWTP located on the plant site at Building 995. The WWTP discharges to Pond B-3, located in the South Walnut Creek drainage. Water subsequently flows to Ponds B-4 then B-5, prior to discharge off-site (Figure 3).

The design hydraulic capacity of the WWTP is 0.5 mgd; however, the plant typically treats less than 0.2 mgd (Fiehweg 2002). The WWTP treatment process consists of an activated-sludge system, tertiary treatment for phosphorus removal and sand filtration for solids removal (Fiehweg 1998). Under a National Pollutant Discharge Elimination System (NPDES) Federal Facility Compliance Agreement between EPA and DOE in 1991, the plant has been upgraded in many ways, including the addition of almost one million gallons of storage for influent and effluent streams, a change in disinfectant from chlorine to ultraviolet (UV) light, the addition of mechanical sludge dewatering, and other process upgrades and improvements (Fiehweg 2002).

The Rocky Flats WWTP operations are strictly regulated under its NPDES permit, DOE orders, and other regulatory criteria. An internal waste stream (IWS) monitoring program is in place to regulate the types of waste discharged to the WWTP. Internal waste streams are non-process, non-domestic wastewaters compatible with the conventional treatment processes used in Building 995. The IWS program is similar to pretreatment programs found at most municipal wastewater facilities. Potential wastewater streams must be approved before discharge may begin, and records are kept of volumes, dates of discharge and any pertinent information about the source of the water. In some cases, chemical analyses are required as part of the approval process (Fiehweg 1998).

In addition, fairly continuous monitoring is conducted at the influent to the WWTP to detect spills or discharges into the sanitary sewer system that could cause operational upsets of the WWTP. This monitoring includes real-time continuous measurements of pH and conductivity, lower explosive limit (LEL) monitoring of the atmosphere above the headworks and visual inspection for unusual conditions (Fiehweg 1998).

On May 1, 2001, the renewal of the Rocky Flats NPDES permit was completed following an 11-year permit renewal process. The process began in December 1988 when Rocky Flats applied for renewal of the existing permit, which had been issued in 1984. The reapplication was timely, but difficulties with the renewal resulted in EPA issuing an administrative extension of the 1984 permit until renewal was possible. Over the 11 years it took to renew the permit, a variety of proposals were considered. The final form of the permit is quite different than the 1984 version. The new document regulates only one NPDES outfall, the Rocky Flats WWTP. New effluent limitations and monitoring requirements were written into the permit, reflecting major changes in Colorado water quality regulations enacted in the 16 years since the last permit was written. New stormwater requirements were also added to the permit, requiring Rocky Flats, as a site with industrial activity, to comply with the Phase I stormwater regulations of 1992 (Fiehweg 2002).

Rocky Flats continues to submit monthly monitoring reports to various government agencies summarizing the previous month's performance and compliance with discharge limitations. Effluent is also monitored under the Rocky Flats Cleanup Agreement (RFCA) to measure radionuclides. RFCA was modified to establish a "Point of Evaluation" at the WWTP outfall, with results reported in accordance with RFCA requirements (Fiehweg 2002).

The new permit also requires a variety of studies and special reports to the agencies, including an annual update of nutrient levels in Walnut Creek as it leaves Rocky Flats. The first annual report was prepared in 2001 and presented to the Watershed Association. The intent of this permit requirement is to provide on-going assessments of Walnut Creek and the impacts of the wastewater discharges, especially ammonia, to the environment. In 1995, the Colorado Water Quality Control Commission (CWQCC) agreed to remove the water quality standards for unionized ammonia from that portion of Walnut Creek downstream of Ponds A-4 and B-5 and west of Indiana Street, known as Segment 4b of Big Dry Creek (Figure 3). In order to continue the justification for the CWQCC's action, EPA included the annual reporting requirement in the permit (Fiehweg 2002).

It is important to note that the Rocky Flats WWTP will cease operation prior to site closure, which is currently scheduled for 2006 (Fiehweg 2002).

City of Broomfield

The City of Broomfield's WWTP is located at 12380 Lowell Boulevard in Broomfield. The current design hydraulic capacity of the facility is 5.4 mgd, with an organic loading capacity of 10,300 pounds of BOD a day. The facility currently discharges from outfall 001A to Big Dry Creek. The current treatment process consists of an aerated grit chamber, primary clarifiers, a flow-equalization basin, bio-tower, an activated-sludge system, and UV disinfection (CWQCD 1997b). Broomfield also has an approved industrial pretreatment program that has reduced the influent concentrations of copper by 88 percent, nickel by 96 percent and zinc by 32 percent since the program's inception in 1981 (Rutt 2001).

Due to significant growth in Broomfield and future growth projections, Broomfield has initiated a three-phase expansion of the facility. The first phase, scheduled to be on-line by 2003, will increase the plant capacity to 8 mgd. An expansion to 12 mgd is planned for 2006, followed by 16 mgd in 2020. In addition to meeting increased capacity requirements, upgrades to the treatment process include addition of biological nutrient removal through an integrated fixed film activated sludge (IFFAS) process. This process provides for carbonaceous biological oxygen demand (CBOD) removal, oxidation of ammonia to nitrate and bio-phosphorus uptake.

Denitrification is then achieved by recycling the nitrate-rich mixed liquor from the downstream end of the IFFAS basins to the upstream anoxic basins. A new UV disinfection building designed to meet the new more stringent *E. coli* effluent objectives will also replace the existing UV facility. Additional treatment facilities for the reclaimed water destined for reuse will include supplemental phosphorous and turbidity removal for the 6 mgd that can be pumped to Great Western or directly to reuse customers (Black and Veatch 2000). Reclaimed water is required to meet standards for the protection of public health (CWQCD 2000).

The reclaimed water program that is underway for Broomfield will reduce direct discharges to Big Dry Creek, primarily during the non-irrigation season of November to March, when the majority of the treated effluent will be pumped to Great Western Reservoir. During these winter months, the remaining approximately 0.4 to 0.5 mgd will be discharged directly to the stream. These reduced return flows are possible due to use of the Windy Gap/CBT water supply during the winter with less reliance on Denver Water. During the summer months, Broomfield will directly discharge approximately 80 percent of its effluent to Big Dry Creek in order to meet water rights obligations (i.e., Denver Water return flows) (Ramey 1999).

City of Westminster

The Westminster WWTP is located at 13150 North Huron Street and is called the "Big Dry Creek Wastewater Reclamation Facility." The facility is an activated biosolids system consisting of primary clarifiers, aeration basins, final clarifiers, chlorine contact basins, dechlorination and effluent equalization ponds. The permitted capacity of the facility is 9.2 mgd, with 6 mgd of the treated effluent eligible for reclaimed water irrigation usage (CWQCD 2000). The design capacity is 9.2 mgd, with 14,500 lbs of BOD for organic loading (CWQCD 1997a). During 2001, the city initiated a process to begin design for full build-out of the facility (Scott 2002). The facility discharges to Big Dry Creek at discharge points 002A, 003A, and 004A, to the Farmer's Highline Canal at discharge point 001A, and to a variety of reclaimed water irrigation sites from point 005A. Approximately 13 percent of the flows treated at the facility are of industrial origin, with the remaining 87 percent being of domestic origin (CWQCD 1997a). Westminster has an approved industrial pretreatment program.

During 2000, a significant wastewater reuse plan was initiated, which will nearly eliminate direct discharges to Big Dry Creek during the summer months. Wastewater reuse is planned for the months of April through October, with 95 to 99 percent of direct discharges to Big Dry Creek eliminated during the peak irrigation months of June through August (Settle 1999). The initial reuse program will include approximately 1,500 acre-feet/year, with roughly 2,600 acre-feet/year at full build-out (10-15 years out) (Scott 2002). Currently, the reclaimed water is used to irrigate large public turf areas such as golf courses, parks and greenbelts. Sites where reclaimed water is permitted for irrigation include Legacy Ridge Golf Course, Westminster City Park, Front Range Community College, Avaya, Westminster City Hall, Heritage Golf Course, Ryan Elementary School and Park, Sherwood Park, Cotton Creek Park, Westminster Boulevard, and the Big Dry Creek WWTP facilities (CDPHE 2000). Replacement water to fulfill water rights obligations occurs through return flows from the Metro WWTP on the South Platte River (Settle 1999).

City of Northglenn

The City of Northglenn's WWTP is located on 320 acres of land in Weld County at 5445 Weld County Road 2. The facility is permitted to discharge to Bull Canal (001A), Big Dry Creek (004A), and Thompson Ditch (005A). The hydraulic capacity is 6.5 mgd, with an organic capacity of 11,384 pounds of BOD a day; however, the plant currently treats an average of 3.5 mgd (City of Northglenn 2002). The treatment process is entirely biological, using an aeration system; however, a chemical building and chlorine contact chamber exist, if needed for additional treatment. After treatment, the water is stored in a 1.3 billion gallon reservoir, where it may be stored for up to 10 months. During the spring and summer, the reservoir water is discharged primarily to Bull Canal, where it is subsequently used for crop irrigation (City of Northglenn 2002). Some effluent is occasionally released to Big Dry Creek in response to water rights calls from FRICO, which occur very infrequently, on the order of every three years or so. Typically, these discharges occur at a rate of 5 cfs, for a total discharge of 80-100 acre-feet/year. In the future, if farmers were to sell water rights to cities in the area, this could result in Northglenn being required to increase discharges to Big Dry Creek; however, a timeline for flow-related changes is difficult to predict (Elliott 1999).

Approximately 10 percent of the wastewater treated at the WWTP is from commercial and industrial contributors. Northglenn has an approved industrial pretreatment program (CWQCD 1996).

2.2 Environmental Goals of Watershed

The environmental goals for the watershed can be categorized according to those prescribed by law through the CWQCC, regional goals by organizations such as the Urban Drainage and Flood Control District (UDFCD) and DRCOG and as goals developed voluntarily by the Watershed Association. The Watershed Association is committed to ensuring that water quality standards for the stream are met and that measures to protect the health of the aquatic community and riparian corridor are included in development, management, and land use decisions. Beyond meeting regulatory standards, the Watershed Association's goals include identifying and implementing measures to improve and protect stream conditions, and developing public education and involvement to provide a base of support for watershed protection. Because the current population within the drainage area is growing, public awareness and support will be key to maintaining and improving the conditions in the watershed. Goals are discussed below.

2.2.1 *State Stream Classifications*

The main stem of Big Dry Creek, which extends from the Standley Lake dam to the confluence with the South Platte River, is classified for protection of Aquatic Life Class 2, Recreation Class 2, and Agriculture use. The state's Water Body Identification (WBID) number for the main stem of Big Dry Creek is COSPBD01 (the South Platte Basin, Big Dry Creek Sub-basin, Stream Segment 1). Table 2 contains the classifications for segment 1, as well as the other segments in the watershed. These segments are also identified on Figure 3. Table 3 contains the numeric standards for these segments.

Table 2

Big Dry Creek Stream Classifications

Segment	Description	Classifications
Segment 1	Main stem of Big Dry Creek, including all tributaries, lakes, reservoirs and wetlands, from the source to the confluence with the South Platte River, except for the specific listing in Segments 2, 3, 4a, 4b, 5 and 6.	Aquatic Life Warm 2 Recreation 2 Agriculture
Segment 2	Standley Lake	Aquatic Life Warm 1 Recreation 1a Water Supply Agriculture
Segment 3	Great Western Reservoir	Aquatic Life Warm 2 Recreation 2 Water Supply Agriculture
Segment 4a	Main stem and all tributaries to Woman and Walnut Creeks from their sources to Standley Lake and Great Western Reservoir except for specific listings in Segments 4b and 5.	Aquatic Life Warm 2 Recreation 1a Water Supply Agriculture
Segment 4b	North and South Walnut Creek, from the outlet of ponds A-4 and B-5 to Indiana Street.	Aquatic Life Warm 2 Recreation 2 Water Supply Agriculture
Segment 5	Main stem of North and South Walnut Creek, including all tributaries, lakes, reservoirs, and wetlands, from their sources to the outlets of ponds A-4 and B-5 on Walnut Creek, and Pond C-2 on Woman Creek. All three ponds are located on Rocky Flats property.	Aquatic Life Warm 2 Recreation 2 Water Supply Agriculture
Segment 6	Upper Big Dry Creek and South Upper Big Dry Creek, from their source to Standley Lake.	Aquatic Life Warm 2 Recreation 2 Water Supply Agriculture

Table 3
CWQCC Stream Classifications and Water Quality Standards

REGION: 3 BASIN: Big Dry Creek Stream Segment Description	Desig	Classifications	NUMERIC STANDARDS: PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l			TEMPORARY MODIFICATIONS AND QUALIFIERS
1. Mainstem of Big Dry Creek, including all tributaries, lakes, reservoirs and wetlands, from the source to the confluence with the South Platte River, except for specific listing in Segment 2, 3, 4a, 4b, 5 and 6.	UP	Aq Life Warm 2 Recreation 2 Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=2000/100ml E.Coli=630/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=4.5	As(ac)=100(Trec) Be(ch)=100 Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS	Cu(ac/ch)=TVS Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	
2. Standley Lake.		Aq Life Warm 1 Recreation 1a Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.06 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS Be(ch)=4	See attached Table 2 for additional standards for segment 2. See * for narrative standard.
3. Great Western Reservoir.	UP	Aq Life Warm 2 Recreation 2 Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=2000/100ml E.Coli=630/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=2.7	As(ac)=100(Trec) Be(ch)=100 Cd(ac/ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS	Cu(ac/ch)=TVS Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	See attached Table 2 for additional standards for segment 3.
4a. Mainstem and all tributaries to Woman and Walnut Creeks from sources to Standley Lake and Great Western Reservoir except for specific listings in Segments 4b and 5.	UP	Aq Life Warm 2 Recreation 1a Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=200/100ml E.Coli=126/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10	As(ac)=50(Trec) Be(ch)=4 Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ac)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	See attached Tables 2 and 3 for additional standards for segment 4a.
4b. North and South Walnut Creek and Walnut Creek, from the outlet of ponds A-4 and B-5 to Indiana Street.	UP	Aq Life Warm 2 Recreation 2 Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=2000/100ml E.Coli=630/100ml	Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005 S=0.002 B=0.75	NO_2=0.5 NO_3=10	As(ac)=50(Trec) Be(ch)=4 Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Hg(ac)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	See attached Tables 2 and 3 for additional standards for segment 4b.
5. Mainstems of North and South Walnut Creek, including all tributaries, lakes, reservoirs and wetlands, from their sources to the outlets of ponds A-4 and B-5, on Walnut Creek, and Pond C-2 on Woman Creek. All three ponds are located on Rocky Flats property.	UP	Aq Life Warm 2 Recreation 2 Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=2000/100ml E.Coli=630/100ml	Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS Be(ch)=4	See attached Tables 2 and 3 for additional standards and temporary modifications for seg 5. Goal qualifier for all use classifications.
6. Upper Big Dry Creek and South Upper Big Dry Creek, from their source to Standley Lake.	UP	Aq Life Warm 2 Recreation 2 Water Supply Agriculture	D.O.=5.0 mg/l pH=6.5-9.0 F.Coli=2000/100ml E.Coli=630/100ml	NH_3(ac)=TVS NH_3(ch)=0.10 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.5 NO_3=10 Cl=250 SO_4=WS	As(ac)=50(Trec) Cd(ac/ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=WS(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ac/ch)=TVS Mn(ch)=WS(dis) Hg(ch)=0.01(Tot)	Ni(ac/ch)=TVS Se(ac/ch)=TVS Ag(ac/ch)=TVS Zn(ac/ch)=TVS	

*Narrative standard for Segment 2, Big Dry Creek, Standley Lake. The trophic status of Standley Lake shall be maintained as mesotrophic as measured by a combination of common indicator parameters such as total phosphorus, chlorophyll **a**, secchi depth, and dissolved oxygen. Implementation of this narrative standard shall only be by Best Management Practices and controls implemented on a voluntary basis.

The current use classifications are accepted by the Watershed Association as reasonable uses for the watershed. The stream generally attains the numeric standards associated with these designated uses as discussed in Section 2.3.1 of this Plan. One significant issue facing the watershed with regard to attainment of water quality standards is the possibility that the stream will be reclassified for Recreation Class 1a or 1b uses. A Use Attainability Analysis (UAA) sponsored by the city of Broomfield was conducted for the stream that concluded that Recreation Class 2 was the appropriate recreational classification for the stream (WWE 1999). The CWQCC accepted the finding of the UAA in the 2000 South Platte Water Quality Standards hearing; however, the EPA disapproved the classification (EPA 2001). Thus, it is uncertain which recreational usage classification will be in place for the stream in the future. Based on available data and land uses within the watershed, the Watershed Association believes that Big Dry Creek would have considerable difficulty meeting a Recreation Class 1 standard for *E. coli*/fecal coliform. For this reason, some discussion is devoted to this issue below based on the CWQCC's recently issued guidance regarding this issue (CWQCC 2001c).

Recreational Use Classification

Currently, for purposes of recreational usage classifications, the CWQCC divides the primary contact classification into two subcategories: "Class 1a" for waters with existing primary contact uses and "Class 1b" for potential primary contact uses. Class 2 is for secondary contact. The Basic Standards define waters suited for Class 1 recreational uses as follows:

> "These surface waters are suitable or intended to become suitable for recreational activities in or on the water when the ingestion of small quantities of water is likely to occur. Such waters include, but are not limited to, those used for swimming, rafting, kayaking, tubing, windsurfing and water-skiing. Waters shall be presumed to be suitable for Class 1 uses and shall be assigned a Class 1a or Class 1b classification unless a UAA demonstrates that there is not a reasonable potential for primary contact uses to occur in the water segment(s) in question within the next 20-year period."

Additionally, "Recreation Class 1a - Existing Primary Contact" waters are those in which primary contact uses have been documented or are presumed to be present. Waters for which no UAA has been performed demonstrating that a Recreation Class 2 classification is appropriate are assigned a Class 1a classification, unless a reasonable level of inquiry has failed to identify any existing Class 1 uses of the water segment (CWQCC 2001c).

"Recreation Class 1b - Potential Primary Contact" is assigned to water segments for which no UAA has been performed demonstrating that a Recreation Class 2 classification is appropriate, if a reasonable level of inquiry has failed to identify any existing Class 1 uses of the water segment (CWQCC 2001c).

"Recreation Class 2 - Secondary Contact" is assigned to surface waters that are not suitable or intended to become suitable for primary contact recreation uses, but are suitable or intended to become suitable for recreational uses on or about the water which are not included in the primary contact subcategory, including, but not limited to, wading, fishing and other streamside or lakeside recreation (CWQCC 2001c).

Reflecting the federal requirement that all waters be "suitable for recreation in and on the water," unless it is demonstrated that such uses are not attainable, the Basic Standards require that a Class 1a or 1b classification must be adopted for all surface waters unless a UAA demonstrates that primary contact uses are not attainable (CWQCC 2001c).

Table 4 presents the criteria for protection of recreational use classifications in Colorado.

Table 4

Criteria for Recreation Use Classifications
(organisms per 100 m/L, geometric mean)

	Class 1a Existing Primary Contact Use	**Class 1b Potential Primary Contact Use**	**Class 2 Primary Contact Use is Not Attainable**
E. coli	126	205	630
Fecal coliform	200	325	2000

Since completion of the UAA for Big Dry Creek in 1999, the CWQCD and EPA have developed more detailed draft guidance on what constitutes Class 1 recreational uses. This draft guidance recommends that streams be assigned a Recreation 1 classification if public access could result in children ingesting water from splashing or wading (CWQCD 2002). The public access areas of Big Dry Creek are primarily located in Westminster Open Space, which is posted to prohibit use of the creek for wading, swimming, etc.; nonetheless, the recent draft CWQCD guidance suggests that, even if the creek is posted to prohibit usage, the creek should be designated for Recreation Class 1 usage unless a fence precluding access is in place (CWQCD 2002). Given this draft guidance and EPA's disapproval of the classification, it is possible that Big Dry Creek may receive a Recreation Class 1a or 1b designation in the future. The final decision lies with the CWQCC, which considers recreational uses on a case-by-case basis and may or may not apply the draft CWQCD guidance to Big Dry Creek.

2.2.2 *Wastewater Discharge Permit Limits*

Wastewater discharges to the stream are permitted by the CWQCD for the cities of Broomfield, Westminster and Northglenn and by the EPA for Rocky Flats. During late 2001, as a result of the City of Broomfield's request for Preliminary Effluent Limits (PELs) from the state, the CWQCD conducted a water quality assessment for Big Dry Creek, resulting in calculation of new PELs for all three municipal discharges. These PELs take into account revisions to the stream standards based on the 1999 CWQCC hearings and ammonia modeling by the CWQCD's contractor. For purposes of the PELs, the CWQCD used a combined design discharge of 23.7 mgd (37 cfs) for the cities (CWQCD 2001b). This was based on a design flow of 8 mgd (12 cfs) for Broomfield, 9.2 mgd (14 cfs) for Westminster (located 2.9 miles downstream of the Broomfield discharge) and 6.5 mgd (10 cfs) for Northglenn (located 9.6 miles downstream of the Broomfield discharge). For purposes of calculating the new effluent limits, the chronic and acute low flows for Big Dry Creek were calculated and summarized in Table 5, indicating minimal dilution of wastewater discharges to the stream.

The Colorado Ammonia Model (CAM) was also run to determine ammonia limits for the municipal discharges, and steady-state, mass balance calculations were completed for conservative pollutants (CWQCD 2001b). The input data used in the ammonia modeling effort were provided by the Watershed Association and are considered to be of good reliability. Additionally, the new CAM is rigorous, with realistic assumptions. The model results require the municipal dischargers to provide full ammonia removal, as had been anticipated. However, the model indicates that the area of the stream that is impacted by high ammonia levels is relatively small, suggesting a much larger safety factor than previously assumed. The model results indicate that projected ammonia concentrations are not a significant factor with regard to aquatic life (Grimes 2001).

The preliminary effluent limits calculated during late 2001 are provided in Table 6, with the ammonia limits provided separately in Table 7. Since the PELs are not yet in effect as of the completion of this Plan, the current effluent limits for each facility, which will become obsolete over the next few years, are also summarized in Table 8. The previously discussed plant upgrades for Broomfield and Westminster and the current wastewater management strategy for Northglenn should enable these permit limits to be achieved.

Table 5

Annual Acute and Chronic Low Flows at Municipal WWTP Outfalls (CWQCD 2001b)

Municipal Discharge	Acute (1E3) Low Flow (cfs)	Chronic (30E3) Low Flow (cfs)
Broomfield	0.3	0.8
Westminster	2.1	2.4
Northglenn	1.0	1.0

Table 6

Preliminary Effluent Limits for Selected Constituents Based on CWQCD's 2001 Water Quality Assessment (CWQCD 2001)

Note: This table is subject to change based on finalization of the discharge permits.

Metals and Cyanide	**Standard Type**	**Discharge Limit (ug/L)**	**Northglenn Seasonal Discharge Limit (Jan-March) (ug/L)**	**Northglenn Seasonal Discharge Limit (Jan-March) (ug/L))**
Arsenic (Trec)	Acute	100	100	100
Cadmium	Acute	9.5	18	20
Cadmium	Chronic	3.5	6.1	6.6
Copper	Acute	27	47	52
Copper	Chronic	17	28	31
Cyanide (Free)	Acute	30	5	5
Iron (Trec)	Chronic	1000	1000	1000
Lead	Acute	143	270	299
Lead	Chronic	5.6	11	11.7
Manganese	Acute	3823	4714	4906
Manganese	Chronic	2112	2608	2710
Nickel	Acute	877	1475	1608
Nickel	Chronic	98	164	178
Selenium	Acute	18	4.6	4.6
Selenium	Chronic	4.6	4.6	4.6
Silver	Acute	7.3	20	23
Silver	Chronic	1.1	3.2	3.7
Zinc	Acute	220	369	403
Zinc	Chronic	220	374	407
Other				
E. coli (#/100 mL)		635		
Chlorine	Acute	19/22/21[1]		
Chlorine	Chronic	12/13/12[1]		

[1] For Broomfield/Westminster/Northglenn, respectively.

Table 7

Preliminary Effluent Limits for Total Ammonia (mg/L) for Municipal Discharges to Big Dry Creek (CWQCD 2001b)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Westminster and Broomfield												
Chronic	6.0	13.0	9.0	6.8	8.6	7.8	6.3	5.6	6.2	5.9	4.8	5.2
Acute	9.0	17	11	11	18	18	20	18	18	13	7.2	8.1
Northglenn												
Chronic	12	12	6.5	5.2	5.2	5.7	6	4.7	4.7	5.5	5.7	8.4
Acute	13	17	10	10	14	15	15	13	13	11	8.9	13

Table 8

Existing Municipal WWTP Discharge Permit Effluent Limits Big Dry Creek Watershed

Effluent Parameter	**City of Broomfield** CO-0026409 (001A)	**City of Northglenn** CO-0036757 (004A)	**City of Westminster** CO-0024171 (002A, 003A, 0004A, 005A)
FLOW, MGD	5.4[a]	0.79-11.84[e] (tiered IWC)	9.2 [a] (6.0 at 005A)
BOD, mg/L	25/40 [b]	30/45 [b]	30/45 [b]
TSS, mg/L	30/45 [b]	30/45 [b]	30/45 [b]
Fecal Coliform Bacteria #/100 mL	2,404/4,808 [b]	2,000/4,000 [b]	2,000/4,000 [b] (excluding 005A)
Total Residual Chlorine, mg/L	0.5 [c]	0.5 [c]	0.5 [c]
pH, su	6.5-9.0 [c]	6.5-9.0 [c]	6.5-9.0 [c] 6.0-9.0 [c] (at 005A)
Oil and Grease, mg/L	10 [c]	10 [c]	10 [c]
Dissolved Oxygen, mg/L	4.2 (min) [c]	5.0 (min) [c]	4.3 (min) [c]
Turbidity, NTU			3.0/5.0[f] (at 005A)
E. coli, #/100 mL			2.2/23[b] (at 005A)
Whole Effluent Toxicity (WET), Acute	IWC=80.8%/ 50% [d]	tiered IWC, see Table 9	
Whole Effluent Toxicity, Chronic		No Statistical Difference	No Statistical Difference relative to IWC of 82%

See Table Notes Next Page

Table Notes:

[a]30-day average.

[b]30-day average/7-day average.

[c]Daily maximum or range.

[d]WET testing is whole effluent toxicity testing. The standard is applied to individual toxicity tests showing toxicity at a concentration less than or equal to the identified In-stream Waste Concentration (IWC) or 50 percent species mortality in any sample.

[e]See Table 9 for specific IWCs according to month.

[f]30-day average/daily maximum.

With regard to Northglenn's discharge, chronic WET test requirements are applied because WET testing data for the previous permit period indicated reoccurring toxicity to fathead minnows at approximately 50 percent effluent dilution. The city attributes the toxicity to ammonia. The chronic WET limit became effective January 1, 1999. In order to meet WET limits, the city selected a tiered in-stream wasteload concentration (IWC) approach that enables the city to vary its discharges to Big Dry Creek by using other discharge points and 4,000 acre-feet of effluent storage capacity. The formula for calculating the IWC is:

IWC = [Facility Flow/(Stream Chronic Low Flow + Facility Flow)] x 100 percent.

The IWC varies based on the flows in Big Dry Creek, as shown in Table 9.

Table 9

Existing Permitted Northglenn Effluent Discharge (mgd) to Big Dry Creek Based On In-stream Wasteload Concentrations (IWC)

Month	Chronic Low Flow 30E3, cfs	Outfall 04AX IWC = 55 percent	Outfall 04BX IWC = 40 percent	Outfall 04CX IWC = 20 percent
April	4	3.16	1.72	0.65
May through September	1	0.79	0.43	0.16
October	8	6.32	3.44	1.29
November	15	11.84	6.46	2.42
December through March	14	11.05	6.03	2.26

The effluent limits for the Rocky Flats WWTP discharge are summarized in Table 10.

Table 10

Rocky Flats Effluent Limitations (CO-0001333) - Outfall STP1

Effluent Characteristic	30-Day Avg.	7-Day Avg.	Daily Max.	Practical Quantification Limit (PQL)
Flow, MGD	0.5	N/A	N/A	
pH, s.u.	N/A	N/A	6.5-9.0	
$CBOD_5$, mg/L - (Carbonaceous BOD_5)	8.0	N/A	20	
Total Suspended Solids, mg/L	15	N/A	25	
Fecal Coliforms, no./100 mL	200	400	N/A	
Oil and Grease, mg/L	N/A	N/A	10	
Nitrite as Nitrogen, mg/L	N/A	N/A	(4.5)	
Total Phosphorus, mg/L	8	N/A	12	
Chromium, TR, ug/L	N/A	N/A	50	
Chromium, Hexavalent, Dissolved, ug/L	11	N/A	16	
Silver, Potentially Dissolved, ug/L	0.6	N/A	3.8	
Gross Alpha, pCi/L	11	N/A	N/A	
Gross Beta, pCi/L	19	N/A	N/A	
Benzene, ug/L	(5)	N/A	N/A	1.0
Carbon tetrachloride, ug/L	(5)	N/A	N/A	1.0
Dichloroethane, 1,2-, ug/L	(5)	N/A	N/A	1.0
Dichloroethylene, 1,1-, ug/L	(7)	N/A	N/A	1.0
Dichloroethylene, 1,2-, ug/L	70	N/A	N/A	1.0
Tetrachloroethylene, ug/L	(5)	N/A	N/A	1.0
Trichloroethane 1,1,1-, ug/L	200	N/A	N/A	
Trichloroethylene, ug/L	(5)	N/A	N/A	

2.2.3 *Local and Regional Drainage and Floodplain Management*

Stormwater drainage within the watershed is one of the key issues that has been a recurring topic of discussion at Watershed Association meetings. Current goals associated with floodplain management, stormwater drainage management and stormwater quality are summarized below.

Floodplain

The 100-year floodplain for Big Dry Creek, as calculated and delineated by the Federal Emergency Management Agency (FEMA), is shown on Figure 4 to the Weld County line. In the agricultural areas, the floodplain is one-half mile or more wide. Within the UDFCD planning area, the floodplain is generally uninhabited except for a few homes and farm buildings. Stormwater management for Big Dry Creek within the UDFCD boundaries places primary emphasis on keeping development out of the floodplain through floodplain regulation (Muller 1989). Muller (1989) provides a synopsis of planning for Big Dry Creek as follows:

> "It is planned that the channel of Big Dry creek be maintained in its present and natural state. This involves maintenance of the meandering channel pattern, with relatively steep side banks along the normal flow channel. The increasing development in upstream areas will result in greater and more frequent flood flows passing through the channel, in addition to greater sustained low flows. These flows will increase the rate of channel bank erosion. It is anticipated that general degradation of the channel bed will be relatively minor, because the channel is already at a very flat slope. It is considered necessary that some controls be placed along the channel so that bank erosion is not allowed to continue unchecked."

Drainage planning within the UDFCD boundaries is relatively coordinated and based on consistent criteria and standards. One of the challenges facing the watershed is that the UDFCD boundary stops at the Weld County line, so the lower portion of the watershed is not necessarily managed in accordance with UDFCD policies.

Drainage

An important factor influencing the amount of sediment loading and erosion in Big Dry Creek is stormwater management policy in jurisdictions tributary to the creek. Over the last several years, representatives of the cities have spoken to the Watershed Association about requirements and practices that are in place in their jurisdictions.

During August 1999, UDFCD and the cities of Broomfield and Westminster were contacted to determine what stormwater control measures were in place and/or being planned for areas along Big Dry Creek (Urbonas 1999; Allen 1999; Beissel 1999). At that time a stormwater master plan was being developed for the main stem of Big Dry Creek in the Westminster area with typical measures such as grade controls, drop structures and development-related detention ponds. No regional detention or retention facilities were planned. Instead, the primary management approaches focused on each developer being responsible for implementing stormwater detention practices that address both quantity and quality in accordance with the UDFCD *Storm Drainage Criteria Manual* (UDFCD 2001). The areas included in the plan relative to Big Dry Creek were the Civic Park area in the vicinity of 120th/Federal, Quail Creek east of I-25, and McKay Lake west of I-25 near 140th (Beissel 1999).

With regard to implementation of structures identified in previous master drainage plans (WWE 1989; Muller 1987) within the UDFCD planning area, recommended measures are believed to have been implemented as development has occurred (Beissel 1999).

Northeast of 160th Avenue, which corresponds to the Weld County line, no master drainage plans are in place. This portion of the basin is predominantly agricultural. Farmers and landowners in this area have indicated that high flows and flooding have increased in recent years with property damage resulting (Brow 2001, Chikuma 2001, Howard 2001, Marrs 2001, Rosenbrock 2001, Wright 2001). During 2002, the practicality of a regional detention facility was informally discussed as a potential option to help alleviate some of this flooding. Conceptual-level discussions among city, WWE and UDFCD staff indicated that this was unlikely to be a practical solution to the flow problem, due partly to the size of the facility that would be required to manage the flows, land constraints and high costs relative to the benefits achieved (WWE 2002).

Policies regarding stormwater quality and quantity are summarized in various city and county codes, but generally follow the guidance contained in the UDFCD *Storm Drainage Criteria Manual* (Volumes 1 through 3) (UDFCD 1999 and 2001), providing a reasonable level of consistency among the various jurisdictions (City of Northglenn 1982; City of Northglenn 1979; Jefferson County 1996a&b; Adams County 1989; Adams County 2000; O'Neil 2000; City of Thornton 1996a&b; City of Broomfield 1995; City of Westminster 1987, 1995 and 1998). Some of the common principles among the various jurisdictions include:

- Permanent stormwater quality management is required for new developments to maintain and enhance the quality of water discharged into storm drainage systems. New developments are required to release only historic stormwater runoff levels, with any increases of this amount being detained on the development site by detention or other stormwater management facilities. Design and technical criteria for these facilities exist in the form of drainage criteria manuals.

- Storm drainage master plans and outfall systems plan requirements are contained in reports issued by UDFCD.
- Measures to prevent erosion and the loss of sediment and other pollutants from construction sites before, during and after construction are required.
- For both construction and post-construction, temporary and permanent BMPs must be implemented to achieve a reduction in the pollutant loading of stormwater runoff.
- Open space acquisitions along drainageways, including Big Dry Creek and Walnut Creek, and other areas have been included as goals for both the cities of Broomfield and Westminster. Westminster's goal is to preserve 15 percent open space (City of Westminster 1998). Broomfield's goal is to preserve approximately 44 percent open space and park and recreation areas for the future developed portion of Broomfield.

In addition to local requirements, the CWQCD currently requires that any construction project disturbing over five acres must obtain a CDPS construction permit with requirements for a stormwater management plan with erosion and sediment control components. Under the Phase II stormwater regulations, construction projects disturbing over one acre will be required to obtain a permit.

The extent to which local and state requirements are enforced is unknown. Several watershed residents have noted examples of inadequate erosion and sediment control practices in some of the areas tributary to the creek. Due to the rapid growth that the area is experiencing, it is anticipated that staffing for enforcement may be limited in some cases.

2.2.4 *Stormwater Quality*

Over the next few years, under the Phase II stormwater regulation requirements, the Big Dry Creek urbanized areas operating municipal separate storm sewer systems (MS4s) will be required to implement six minimum control measures to reduce impacts of stormwater discharges on receiving waters. These six minimum measures include:

- Public education and outreach
- Public participation and involvement
- Illicit discharge detection and elimination
- Construction site runoff control
- Post-construction site runoff control
- Pollution prevention and good housekeeping (EPA 2000).

The schedule for this process is contained in Table 11.

Table 11

Phase II Stormwater Regulation Implementation Schedule

Activity	Date/Deadline
Division notifies initial Phase II MS4 operators of need to apply	December 2001 – June 2002
Division drafts MS4 general permit	July 2002 – October 2002
Division issues MS4 general permit	February 2003
Application deadline for Phase II MS4s	March 10, 2003
MS4 operators complete implementation of six minimum measures	March 9, 2008

Although most of the six minimum measures are in place to some extent in the watershed, more intentional efforts will be required as the full force of the Phase II regulation comes into place.

Stormwater engineers from each city and county in the watershed have been participating on a Task Force to help CWQCD develop Colorado's version of the Phase II regulation.[2]

While each of the municipalities within the Big Dry Creek Watershed will be required to obtain their own permit, an opportunity exists for the Watershed Association to assist the cities in fulfilling some of these goals. In fact, the CWQCD strongly supports cooperation between permit holders in complying with the six minimum measures. Part 61.8(11)(a)(vii) of the regulation allows for a permittee to rely on another entity to implement all or part of a minimum control measure to comply with the permit. However, the permittee must still make sure that the requirements of the minimum control measure are met and is liable if they are not. In particular, the CWQCD encourages permittees to enter into partnerships with other governmental entities to fulfill the public education minimum control measure's requirements, in part because it is generally more cost-effective to use an existing local program, or develop a new program linked to a regional or statewide education program. Furthermore, the CWQCD states that "Participation in watershed-based organizations facilitates both intergovernmental and non-governmental coordination, and can often provide an educational opportunity for the participants in those groups" (CWQCD 2001a). In Section 3.2 of this Plan, several ways that the Watershed Association can help the municipalities in this effort are discussed.

2.2.5 *Reduction in Erosion and Sediment Loading*

In both the urban and agricultural portions of Big Dry Creek, significant erosion has occurred at multiple locations, resulting in degraded streambanks and increased sediment loading to the stream in certain areas. In addition to anecdotal evidence of erosion in both the urban (Cline 2002, Mahan 2002, Aquatics Associates 2002) and agricultural areas (Brow 2001, Chikuma 2001, Howard 2001, Marrs 2001, Rosenbrock 2001, Wright 2001), two studies have been sponsored by the Watershed Association that documented and confirmed these reports (WWE 2000; Gossenauer and Wachob 2001). The results of these studies are discussed in Section 2.3.5

[2] For more information on the Phase II regulation, including the six minimum measures, see EPA's fact sheet series obtainable over the Internet at www.epa.gov/owm/sw/phase2.

of this Plan. Environmental goals relating to reduction in erosion and sediment loading focus on the following areas:

- Stabilizing areas identified as experiencing accelerated erosion. If key areas are stabilized, a reduction in sediment loading of roughly 10-20 percent could be realized.
- Implementing proper erosion and sediment control BMPs at construction sites.
- Implementing/enforcing local and regional detention requirements for stormwater at new development and redevelopment sites.

2.3 Baseline Data

Since 1988, the cities of Broomfield, Northglenn, and Westminster have been conducting a voluntary combined water quality monitoring program on Big Dry Creek through an intergovernmental agreement. The current monitoring program includes eight locations as shown on Figure 1. Additionally, biological data have been collected for benthic macroinvertebrates and fish since 1997 at five of the eight monitoring locations. Habitat assessments have been conducted in conjunction with the biological data collection. Two artificial substrate studies have also been conducted to help isolate the relative contributions of water quality versus habitat with regard to the benthic macroinvertebrate community. Additionally, the cities have helped to fund operation of the U.S. Geological Survey (USGS) gaging station at Westminster behind Front Range Community College. The USGS also measures flow at the gaging station near Fort Lupton. Key findings related to available data are discussed below.

2.3.1 *Water Quality*

As part of the voluntary monitoring program conducted by the cities of Broomfield, Northglenn and Westminster, water quality samples are collected and analyzed for a variety of constituents, typically resulting in over 4,000 water quality data points being added into the Watershed Association database each year. Metals are monitored on a quarterly basis with the exceptions of iron and selenium, which are monitored monthly. All other constituents are monitored on a monthly basis.

The data collected each year are analyzed annually to determine whether the stream is attaining CWQCC stream standards based on comparison of the appropriate statistics to the chronic stream standards and determining whether any exceedances of acute standards have occurred. 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 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.

For purposes of calculating hardness-based metals standards, a value of 250 mg/L was used until 2002, when the value was changed to 256 mg/L to be consistent with the CWQCD's approach used to calculate preliminary effluent limits for discharges in the central portion of the stream (CWQCD 2001).

During the last five-year evaluation period (1997 through 2001), Big Dry Creek has attained the existing stream standards based on the evaluation protocols established by the CWQCD. Nonetheless, there are several constituents that the Watershed Association closely monitors because of exceedances of the standards or because of concerns raised by others. These constituents include fecal coliform, *E. coli*, unionized ammonia, total iron, TSS and flow. During 2000 and 2001, cyanide and mercury were also closely monitored due to some elevated concentrations that have been attributed to laboratory procedural problems. Table 12 summarizes the results of the data evaluation conducted during 2001. Additional discussion for key constituents over the past five years is also provided.

Table 12
Comparison of Big Dry Creek 2001 Water Quality Data to CWQCC Stream Standards

Parameter		Stream Standard	Unit	# of Exceedances (2001)[3]	# of Samples (2001)	% Occurrence of Exceedances (2001)[4]	# Days Standard Exceeded (2001)	Does 85th (or 50th) Percentile Value for 2001 Exceed Standard?[4]	Comment
Physical and Biological									
DO		5	mg/L	0	87	0%	0	No	
pH		6.5-9.0	SU	0	87	0%	0	No	
Fecal Coliform		2000	#/100mL	14	89	16%	5	No	Geometric mean of 332/100 mL does not exceed the standard.
E. Coli		630	#/100mL	35	88	40%	9	No	Geometric mean of 429/100 mL does not exceed the standard.
Ammonia	acute	TVS	mg/L	0	85	0%	0	No	
Ammonia	chronic	0.1	mg/L	1	85	1%	1	No	Exceedance occurred on 8/9/01 at bdc5.0 at 0.125 mg/L
Chlorine	acute	0.019	mg/L	NA	0	NA	NA	NA	
Chlorine	chronic	0.011	mg/L	NA	0	NA	NA	NA	
Cyanide		0.005	mg/L	0	23	0%	0	No	All values below detection limits of 0.002 to 0.005 mg/L.
Sulfide		0.002	mg/L	NA	0	NA	NA	NA	
Boron		0.75	mg/L	0	93	0%	0	No	
Nitrite		4.5	mg/L	1	86	1%	1	No	Elevated value at bdc2.0 due to 10.91 mg/L value in Broomfield effluent on 1/18/01.
Metals (Dissolved unless otherwise noted)[2]									
Arsenic (Trec	Acute	100	ug/L	0	93	0%	0	No	All values below detection limits of 0.001 mg/L.
Beryllium	chronic	100	ug/L	NA	0	NA	NA	NA	
Cadmium	Acute	12	ug/L	0	31	0%	0	No	All values below detection limits of 0.001 mg/L.
Cadmium	Chronic	4.5	ug/L	0	31	0%	0	No	All values below detection limits of 0.001 mg/L.
Chromium III	Acute	1230	ug/L	0	31	0%	0	No	All values below detection limits of 0.001 mg/L.
Chromium III	Chronic	160	ug/L	0	31	0%	0	No	All values below detection limits of 0.001 mg/L.
Chromium VI	Acute	16	ug/L	0	31	0%	0	No	All values below detection limits of 0.001 mg/L.
Chromium VI	Chronic	11	ug/L	0	31	0%	0	No	All values below detection limits of 0.001 mg/L.
Copper	Acute	33	ug/L	0	31	0%	0	No	
Copper	Chronic	20	ug/L	0	31	0%	0	No	
Iron (Trec)	Chronic	1000	ug/L	35	93	38%	9	No	
Lead	Acute	177	ug/L	0	31	0%	0	No	All values below detection limits of 0.002 mg/L.
Lead	Chronic	6.9	ug/L	0	31	0%	0	No	All values below detection limits of 0.002 mg/L.
Mercury (tot)	Acute	0.01	ug/L	1	31	3%	1	No	All values below detection limits of 0.0002 mg/L, except bdc6.0 on 9/13/01 at 0.00025 mg/L. This may be within range of lab error.
Manganese	Acute	4083	ug/L	0	31	0%	0	No	
Manganese	Chronic	2256	ug/L	0	31	0%	0	No	
Nickel	Acute	1037	ug/L	0	31	0%	0	No	
Nickel	Chronic	115	ug/L	0	31	0%	0	No	
Selenium	Acute	18	ug/L	0	93	0%	0	No	
Selenium	Chronic	5	ug/L	0	93	0%	0	No	
Silver	Acute	10	ug/L	0	31	0%	0	No	All values below detection limits of 0.001 mg/L.
Silver	Chronic	1.6	ug/L	0	31	0%	0	No	All values below detection limits of 0.001 mg/L.
Zinc	Acute	260	ug/L	0	31	0%	0	No	
Zinc	Chronic	262	ug/L	0	31	0%	0	No	

[1]Based on data collected at all sampling locations along Segment 1 of Big Dry Creek.
[2]Hardness value of 256 mg/L used to calculated table value standards based on the hardness value used by CDPHE in calculating effluent limits for the cities of Broomfield and Westminster.
A hardness value of 337 mg/L was used by CDPHE for the city of Northglenn.
[3]Includes multiple exceedances that occurred on the same day at different stations for some parameters.
[4]The 85th percentile value is used by the CWQCC to assess whether streams attain water quality standards. The 50th percentile value is used for metals with standards in the total form. The geometric mean is used for fecal coliform and E. coli. The 15th percentile is used for DO and the lower pH boundary.
For regulatory purposes, the last five years of data would be included in calculating the 85th and 50th percentile values.

Fecal Coliform

Over the past five years, 36 of 465 fecal coliform samples exceeded the stream standard. During 2001, fecal coliform concentrations met stream standards in 84 percent of the samples collected, which represents a 10 percent decrease in the number of samples meeting standards during 1994 through 2000. During 2001, 14 out of 89 samples exceeded the standard; however, the geometric mean value for segment 1 was 332/100 mL, which did not exceed the 2,000/100 mL standard based on the current Recreation Class 2 stream classification. Figure 5 plots the annual geometric mean fecal coliform concentrations for 1993 through 2001. Several important observations relevant to the fecal coliform data set include:

- The highest concentrations are typically present during the warm summer temperatures and the fall. During cooler months, the concentrations are lower.

- Elevated fecal coliform concentrations do not appear to be related to point source (wastewater) discharges from Broomfield and Westminster. For example, during 2001, on days where the stream exceeded the standard, the fecal coliform concentrations were lower in the effluent than in the stream.

- An upstream to downstream or other geographic trend is not apparent. Elevated concentrations have occurred at both the upstream-most location below Standley Lake dam, in the developed portion of the watershed and in the agricultural area. During 2001, the standard was exceeded most frequently between 120th Avenue and I-25. Much of Big Dry Creek in this area is located in Westminster Open Space.

- Neither an increasing nor decreasing trend over time for the watershed as a whole is apparent, based on the data plotted in Figure 5. For example, at bdc1.5 in the upper watershed, concentrations have increased, while in the agricultural area (bdc4.0 through bdc6.0), the fecal coliform concentrations during the last three years were generally lower than during 1993 to 1995. At other locations, concentrations have increased then decreased over time or may demonstrate no clear pattern.

- In the event that the recreational standard applied to Segment 1 of Big Dry Creek is changed to Recreation Class 1a or 1b, the majority of the monitoring locations would not meet the stream standard, with the possible exception of bdc1.0.

<u>E. coli</u>

Currently, a dual standard for fecal coliform and *E. coli* is in place 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 Watershed Association began collecting *E. coli* data during 2000, with the first full year of *E. coli* data available for 2001. Out of 150 samples collected to date, 51 have exceeded the standard. During 2001, *E. coli* concentrations met stream standards in 60 percent of the samples collected. This represents a 13 percent decrease in *E. coli* samples meeting the 630/100 mL standard compared to the data collected between April and December of 2000, where 73 percent of the samples attained the standard. Nonetheless, the geometric mean for Segment 1 as a whole was 429/100 mL, which did not exceed the 630/100 mL Recreation Class 2 standard. As was the case during 2000, the geometric mean concentrations at stations bdc2.0 (below the Broomfield WWTP) and bdc4.0 (at York Street) were above the Recreation Class 2 standard as shown in Figure 6.

Based on review of this data set the following observations are relevant:

- The stream standard was exceeded most frequently during the summer months of June and July and during November. Elevated concentrations were spread throughout the year.

- Elevated *E. coli* concentrations do not appear to be related to point source (wastewater) discharges from Broomfield and Westminster. On the two days that effluent grab samples from effluent discharges exceeded the standard, samples from upstream of the discharges were already well above the standard.

- An upstream to downstream or other geographic trend was not apparent for any particular sampling event. Elevated concentrations occurred throughout the watershed at both the upstream-most location below Standley Lake dam, in the developed portion of the watershed and in the agricultural area.

- For both the *E. coli* and the fecal coliform data, the lowest concentrations were at bdc1.0, but even at this location, the standard was exceeded by both parameters on a least one day.

- EPA's disapproval of the Recreation Class 2 standard for Big Dry Creek also impacts the relevant *E. coli* standard for Big Dry creek, potentially reducing it to 126/100 mL. This Recreation Class 1a standard for *E. coli* has also been provided on Figure 6 for purposes of comparison. If this standard is adopted for Big Dry Creek, only bdc1.0 would meet the *E. coli* standard based on available data.

Unionized Ammonia

Ironically, the water quality constituent that led to the Watershed Association's formation, unionized ammonia, has not been a problem in the watershed. Although the chronic ammonia standard has been exceeded a few times, the 85th percentile value is well below the stream standard. During the last five years, out of 461 samples, 9 exceedances have occurred, with the 85th percentile value of 0.02 mg/L well below the standard. Unionized ammonia concentrations are generally lower during the irrigation season (April-September), with higher concentrations occurring during the winter months (October-March). Figure 7 plots the average monthly unionized ammonia concentrations for the last five years.

Iron

Total iron concentrations have frequently exceeded the total recoverable iron standard of 1 mg/L, with 91 out of 219 samples over the past five years exceeding the standard. Nonetheless, the 50th

percentile value for iron during this period was below the stream standard. The annual mean concentrations of total recoverable iron at each monitoring location are graphically depicted in Figure 8. During 2001, total recoverable iron exceeded the stream standard in 38 percent of the samples collected (i.e., 35 out of 93 samples), but as was the case in 2000, the 50th percentile value attained the stream standard. During 2000, the stream standard was exceeded in 17 of 63 samples, or roughly 27 percent of the time. During 1999, iron had exceeded stream standards in 56 percent of the samples, comparable to findings during 1994-1998 when the total recoverable iron standard was exceeded in 62 percent of the samples.

A few relevant observations with regard to iron include:

- Total recoverable iron concentrations are well correlated with TSS concentrations. Dissolved iron concentrations are relatively low.

- Total recoverable iron concentrations are highest during the summer months of May through August. These are the months with the highest in-stream flows and storm events.

- Elevated total recoverable iron concentrations are not attributable to point sources. Iron concentrations in the Broomfield and Westminster effluent discharges are typically one-third or less than the in-stream concentrations downstream of their discharges.

- Average total recoverable iron concentrations generally increase in a downstream direction with concentrations in the downstream agricultural areas being roughly ten times the average in the upstream area below Standley Lake.

One of the concerns with iron relative to aquatic life is that, in an oxidized state, it will settle and cover stream bottoms, thereby impacting bottom-dwelling invertebrates, plants, or incubating fish eggs (EPA 1976). This type of influence on aquatic life would be consistent with the general impacts of TSS in Big Dry Creek.

Although sources of iron in Big Dry Creek have not been studied, it is noteworthy that iron is the fourth most abundant, by weight, of the elements that make up the earth's crust. It is an important component of many soils, particularly clay soils, and can be present naturally in waters in varying quantities depending on the geology of the area and other chemical components of the waterway. Significant anthropogenic sources of iron have not been identified in the Big Dry Creek watershed. Based on NRCS soil surveys, clayey soils are increasingly present along the creek in the lower portion of the watershed (WWE 1998). Prime iron pollution sources are industrial wastes, mine drainage waters and iron-bearing groundwaters (EPA 1987). In "Urban Runoff Quality in the Denver Region" (DRCOG 1983), findings of a three-year study of urban runoff in the Denver area found that total iron standards were exceeded 51 percent of the time during ambient conditions and 100 percent of the time during storm conditions along the South Platte River at 50th Avenue. Given this information, in conjunction with the strong correlation between iron and TSS, it is hypothesized that the iron concentrations in Big Dry Creek are related to naturally occurring iron in soils along the creek. Further testing is being completed during the summer of 2002 to evaluate this hypothesis (Larsen 2002).

TSS

Although a numeric standard is not in place for TSS, the Watershed Association closely monitors TSS concentrations as a general water quality indicator. As shown in Figure 9, TSS concentrations increase from upstream to downstream, roughly ten-fold. The highest TSS concentrations typically occur during June and July, which are expected to be due to increased flows and storm events.

Based on an analysis of macroinvertebrate data in 1999, sites with high TSS generally had lower quality health index scores for benthic and fish communities. TSS concentrations were correlated to several habitat parameters that were also strongly correlated with aquatic community health as follows:

- Embeddedness of bottom substrate increased as TSS concentrations in the stream increased.
- Percent of substrate less than 2 mm (sand or smaller) increased as TSS concentrations increased.
- Channel alteration would be expected to be associated with increased TSS concentrations.

- Total habitat health scores decreased with increased TSS.

Given the interrelationship between TSS and habitat, it is likely that TSS affects aquatic communities along the creek. The effects of sediment on aquatic life have been widely observed and extensively presented in the literature, including guidance from the CWQCC (1998). In addition, TSS is strongly correlated with total recoverable iron concentrations (and likely other water quality parameters), which may affect aquatic communities (WWE 1999).

With regard to a frame of reference for TSS concentrations and impacts on aquatic life, the American Fisheries Society quotes a National Academy of Sciences (NAS 1973) study as follows:

> The combined effect of color and turbidity should not change the compensation point more than 10 percent from its seasonally established norm, nor should such a change place more than 10 percent of the biomass of photosynthetic organisms below the compensation point and aquatic communities should be protected if the following maximum concentrations of suspended solids exist:

High level protection	25 mg/L
Moderate protection	80 mg/L
Low protection	400 mg/L
Very low protection	over 400 mg/L

Additional data presented indicate that a limit of 100 mg/L non-filterable residue (suspended, settleable solids) for fresh and estuarian waters should prevent mortality of fish, zooplankton and benthic animals. However, some American Fisheries Society reviewers indicated 100 mg/L as being too restrictive (American Fisheries Society 1979).

The NAS (1973) quotes the European Inland Fisheries Advisory Commission (1965) as follows:

> "There is not evidence that concentrations of suspended solids less than 25 mg/L have any harmful effects on fisheries; it should usually be possible to maintain good or moderate fisheries in waters that normally contain 25 to 80 mg/L TSS; other factors being equal, however, the yield of fish from such waters might be somewhat lower than from those in the preceding category; waters normally containing from 80 to 400 mg/L TSS are unlikely to support good freshwater fisheries, although fisheries may sometimes be found at the lower conditions within this range; only poor fisheries are likely to be found in waters that normally contain more than 400 mg/L TSS."

The USGS's study of sediment issues in the South Platte was also reviewed for relevant information. The USGS review of sediment data in the South Platte River Basin between 1980-1992 found that most sediment enters the South Platte during snowmelt runoff from March to June. Runoff from intense rainfall was also identified as a source of sediment, but less so than for snowmelt events. The study also determined that suspended sediment in urban land use areas has more silt and clay sized particles than suspended sediment in agricultural areas, which has more sand-sized particles (USGS 1999).

Given this background, TSS concentrations in Big Dry Creek are within an acceptable range for supporting moderate fisheries to at least as far east as I-25. In the agricultural areas in the vicinity of monitoring locations bdc5.0 and bdc6.0, an expected moderate to low level of protection is provided to fisheries (WWE 2000).

Metals and Cyanide

The stream generally attains metal standards with the exception of iron. In a few cases for mercury and cyanide, laboratory procedural problems are expected to have been responsible for detectable or elevated values. To address these concerns, the monitoring laboratory, method and/ or sample collection frequency have been modified to ensure that accurate results are being provided. Selenium is also being closely watched because during 1999 and 2000, several exceedences of the dissolved selenium standard were identified. No exceedances of the dissolved selenium standard occurred during 2001, even with the sampling frequency increased from quarterly to monthly.

2.3.2 *Flow*

The discussion of flows in Big Dry Creek is divided into two subsections: 1) characterization of flow regime and 2) summary of inflows and outflows to provide a gross hydrologic balance.

Flow Regime

The USGS (supported in part by parties to the Watershed Association) maintains two stream gages on the creek that provide daily flow measurements. One is located behind Front Range

Community College in Westminster (#06720820) with a drainage area of 44 square miles and the other is located further downstream near Fort Lupton (#06720990) with a drainage area of 107 square miles. Figure 10 shows the monthly variability in stream flows at these gages during 2001, and Figure 11 shows the annual variability over the last 10 years.

Flows at the Westminster gage are generally low (less than 5 cfs) for roughly half of the year, corresponding to the fall and winter months. Flows are higher during April through October, reflecting influences of irrigation releases from Standley Lake and runoff from summer thunderstorm events. At the Fort Lupton gage, flows are higher, but exhibit a similar pattern as the Westminster gage.

A comparison of the data set over time was completed by Gossenauer and Wachob (2001), who examined various summary statistics for the gages for the period of record. The Westminster gage data was examined in two increments: 1988-1994 and 1995-2000. For the Fort Lupton gage, the time period of 1992-1994 was compared to 1995-2000. This comparison indicated increases in peak flows and average flows, with a more distinct trend present at the Westminster gage relative to the Fort Lupton gage.

Table 12

Comparison of Flow Summary Statistics at the Westminster and Fort Lupton USGS Gages

Westminster	88-94	95-00
Average annual peak (cfs)	182	402
Average daily flow (cfs)	13.6	23.9
Average mean annual flow (cfs)	13.6	23.3
Average monthly mean flow (cfs)	13.4	24.3

Fort Lupton	92-94	95-00
Average annual peak (cfs)	269	351
Average daily flow (cfs)	37.2	41.2
Average mean annual flow (cfs)	38.1	43.3
Average monthly mean flow (cfs)	37.2	41.1

Gossenauer and Wachob (2001) completed an additional analysis of the peak flows, indicating that peak flows have increased in both frequency and magnitude. Table 13 summarizes the number of times that the flow rate exceeded the 95th percentile flow per one hundred days, indicating increases at both gages after 1994. At the Westminster gage, the increase was nearly 500 percent. At the Fort Lupton gage, it was a 140 percent increase. The disparity between gages is attributed to several factors. The Fort Lupton gage is farther down in the watershed, allowing for significant losses from the channel to irrigation diversions, seepage to the banks, losses to overbank flows (if any), and greater rainfall infiltration rates in the lower portion of the watershed. In addition, data from the Westminster gage begins at an earlier date. Since the data contains more early-time (less developed watershed) data, it better reflects the initial condition of the watershed. The lack of older data at the Fort Lupton gage may increase the 95th percentile flow, reducing the number of exceedance occurrences. Even taking these factors into account, there is still an increase in flow "flashiness" throughout the watershed.

Table 13

Increases in Peak Flow Occurrences

Number of Flows Exceeding 95th Percentile			
Westminster 95th: 67 cfs			
	Total	**87-94**	**95-00**
N days:	254	64	190
per 100 days:	5.8	**2.4**	**10.7**
Fort Lupton 95th: 109.7 cfs			
	Total	**92-94**	**95-00**
N days:	121	32	89
per 100 days:	3.7	**2.9**	**4.1**

Summary of Inflows and Outflows

In order to understand the flow regime of Big Dry Creek, a "gross" hydrologic balance was developed by WWE (2000) as shown in Table 14. Although this table has not been updated to include data for 2000 and 2001, it nonetheless provides an overview of the key measured inflows to and outflows from Big Dry Creek in order to understand key influences on stream conditions. Supporting hydrologic data for this table are available in WWE (2000). (Note: only readily available measured flows were included in this table; a more complete hydrologic balance for Big Dry Creek could be developed in the future, including calculations for stormwater and groundwater flows along with updates to measured flows.)

Key measured inflows to Big Dry Creek include:

- Releases from Standley Lake for downstream farmers. The majority of the water stored in Standley Lake is diverted from the Clear Creek watershed, and to a lesser extent, the Coal Creek watershed. The majority of the releases from Standley Lake are subsequently diverted from the creek at Bull Canal.

- Wastewater discharges from the cities of Westminster, Broomfield and Northglenn.

- Discharges to Walnut Creek from the Rocky Flats Site, as measured at gage GS03 at Indiana Street.

- Discharges from Woman Creek Reservoir, which collects flows from the Woman Creek drainage. Woman Creek flows are also measured at GS01 at Indiana Street upstream of Woman Creek Reservoir.

Stormwater flows to Big Dry Creek have not been measured; however, stormwater is known to significantly contribute to flows in Big Dry Creek. Stormwater flow volumes in the drainage have been observed by watershed residents to have increased in recent years as development in the central portion of the Big Dry Creek drainage has rapidly occurred. Even with detention of stormwater in these developed areas to reduce peak flows, the increased and prolonged flow volumes have been reported by downstream watershed residents, several of whom have reported property damage during high flow events. Master drainage plans also confirm that increasing development in the upstream areas will result in greater and more frequent flood flows passing through the channel (Muller 1989).

Table 14
Summary of Key Measured Inflows and Outflows to Big Dry Creek
(WWE 2000)

Description of Inflow/Outflow	Approximate Volume (acre-feet/year)	Comment
Inflows Upstream of USGS Gauge at Front Range Community College		
Walnut Creek	200	Flows measured at GS03 at Indiana Street between 1993-1997, excluding Water Year (WY) 1995, which totaled 1,405 acre-feet. Majority (60% or more) of discharges occurred in April and May.
Woman Creek/Woman Creek Reservoir	116	Discharges to Woman Creek, which are subsequently routed to Walnut Creek measured 362 AF between October 1998 and July 1999. Flows measured at GS01 upstream of Woman Creek Reservoir averaged 116 AF/YR during 1993-1997, excluding WY 1995, which was an extremely wet year with 905 AF measured.
Standley Lake	9,220	Discharges to Big Dry Creek during 1993-1998.
Stormwater Flows	See comments.	Undefined from tributary areas to Big Dry Creek below Standley Lake and to Walnut Creek below Great Western Reservoir. Based on net difference of flows at Westminster Gauge, may be estimated at 2,960 acre-feet/year or more.
Groundwater Flows	See comments.	Undefined. May be significant in areas with lawn and agricultural irrigation.
Diversions		
No major diversions upstream of Westminster Gauge		
Subtotal of Flows Upstream of USGS Westminster Gauge	**9,536**	Average flows measured at the USGS Front Range Community College Gauge in Westminster averaged **12,735 AF**, excluding 1995-1996 because complete data set not available for these two years.
Inflows Below USGS Gauge at Front Range Community College		
Broomfield WWTP Discharge	4,930	Permitted capacity is 6,049 AF/YR. When reuse program is implemented, flows expected to decrease by roughly 2,000 AF/YR by 2003 and 3,200 AF/YR thereafter. However, increased flows associated with growth will counterbalance to some extent.
Westminster WWTP Discharge	6,440	Permitted capacity is 7,841 AF/YR. When reuse program is implemented, flow expected to decrease by roughly 1,200- 1,500 AF/YR with up to 3,000 AF/YR at full build-out; however, increased flows associated with growth will counterbalance to some extent.
Northglenn WWTP Discharge	90	Northglenn rarely discharges to Big Dry Creek, instead it usually discharges to the Bull Canal. When it does discharge to Big Dry Creek, it is usually along the order of 80-100 acre-feet/year.
Stormwater Flows	See comments.	Expected to be significant.
Irrigation Return Flows	See comments.	Expected to be significant.
Ditch Overpass Spills (Brantner and Brighton Ditches)	See comments.	Reported to be significant during certain storm events.
Groundwater Flows	See comments.	Undefined. May be significant in areas with lawn and agricultural irrigation.
Subtotal of Measured Inflows To Big Dry Creek Between Westminster Gauge and Fort Lupton Gauge	**11,460**	
Diversions Below USGS Gauge at Front Range Community College		
Community College Lake	70	Only recorded during 1994. (71 acre-feet reported by Water Commissioner)
City Park Pond	100	Only recorded during 1994-1997. (Average of 101 acre-feet/yr reported by Water Commissioner)
Thornton Golf Course	160	Only recorded during 1993-1997. (Average of 159 acre-feet/yr reported by Water Commissioner)
Bull Canal/Whipple Ditch	9,540	Majority of flows released from Standley Lake diverted at Bull Canal. Whipple Ditch flow only recorded during 1996-1997 with an average of 324 acre-feet/yr reported by Water Commissioner.
German Ditch	2,090	Average of 2,085 acre-feet/year reported by Water Commissioner for 1993-1997.
Big Dry Creek Ditch/Thompson Ditch	1,120	Average of 1,123 acre-feet/year reported by Water Commissioner for 1993-1997.
Yoxall Ditch	710	Average of 706 acre-feet/year reported by Water Commissioner for 1993-1997.
Subtotal of Diversions Downstream of Westminster Gauge	**13,790**	
Subtotal of Net Measured Flows Above USGS Fort Lupton Gauge	**7,206**	Average flows measured at the Fort Lupton Gauge averaged **29,580 AF/YR**.
Difference Between Net Measured Inflow & Outflows Relative to Measured Flows at Fort Lupton Gauge	**22,374**	Based on this difference, stormflows, irrigation return flows and groundwater are expected to contribute at least this difference to Big Dry Creek.

Notes:
This summary table is intended to provide a "gross" understanding of the relative inflows/outflows to Big Dry Creek.
Data presented in this table have been collected over varying time periods; therefore, the influence of "wet" and "dry" years may be significant.
Ditch diversions are based on measured flows from the District 2 Water Commissioner. Legal water rights may be greater than measured diversions.
Additional diversions from Big Dry Creek occur below the Fort Lupton USGS gauge at the Lupton Bottoms Ditch.
During 1999, these diversions were roughly 6,822 AF.

Wastewater discharges to the creek have also increased in recent years in response to development. Although wastewater flows are expected to increase as the basin continues to grow, wastewater reuse programs will have a counter-effect as more wastewater is land-applied rather than directly discharged to the stream. This reduction in relatively "sediment hungry" base flows (i.e., water with low sediment concentration) should help to reduce erosion along the creek (Pemberton 1999). More detail on wastewater discharges is provided in Sections 2.1.7 and 2.2.2 of this Plan.

Measured outflows from Big Dry Creek are primarily irrigation diversions to the following ditches or locations:

- Community College Lake, near Front Range Community College
- City Park Pond in Westminster
- Bull Canal, located near 128th and Huron St. (also diverts flows for the Whipple Ditch)
- Thornton Golf Course
- German Ditch, located near 136th and Washington Street
- Thompson Ditch (also Big Dry Creek Ditch) Diversion, located near Weld County Rd. 2
- Yoxall Ditch Diversion, Weld County Road 4
- Lupton Bottoms Diversion, east of Weld County Road 23.

Diversion data for 1993 through 1999 were summarized in WWE (2000) and have not been reproduced in this report.

2.3.3 *Aquatic Life*

An aquatic monitoring program was initiated in 1997 by the cities of Broomfield, Westminster and Northglenn to document the abundance and distribution of fish and aquatic macroinvertebrate populations along Big Dry Creek. Since that time, the program has expanded to include locations on Walnut Creek just upstream of the confluence with Big Dry Creek and on Walnut Creek on the Rocky Flats property. The program has also expanded to include artificial substrate samplers to help differentiate impacts on aquatic life from habitat limitations versus water quality.

The original purpose of the biological monitoring program was to develop an understanding of the aquatic community in Big Dry Creek in order to determine whether an unionized ammonia stream standard of 0.06 mg/L was necessary to protect aquatic life in the stream, particularly the Johnny darter. Concerns over the unionized ammonia standard were raised by the Colorado Division of Wildlife (CDOW) in the 1996 CWQCC stream standard hearings for Big Dry Creek. In order to make the determination of whether a lower stream standard for unionized ammonia was warranted, it was necessary to first document the characteristics of the aquatic community and identify and explore factors such as habitat and water quality that influence the aquatic community (WWE 1999).

For more detail on the findings of aquatic life analysis, these reports should be obtained:

- Aquatics Associates, 1998. Interim Report Results of Aquatic Monitoring Program in Big Dry Creek, 1997. Prepared for the Cities of Broomfield, Northglenn and Westminster, Colorado. June.

- Aquatics Associates, 1999. Interim Report Results of Aquatic Monitoring Program in Big Dry Creek, 1998. Prepared for the Cities of Broomfield, Northglenn and Westminster, Colorado. December.

- Aquatics Associates, 1999. Physical Habitat Assessment Results for Big Dry Creek, Spring 1997. Prepared for the Cities of Broomfield, Northglenn and Westminster, Colorado.

- Aquatics Associates, 2002. Interim Report Results of Aquatic Monitoring Program in Big Dry Creek, 1999-2001. Prepared for the Cities of Broomfield, Northglenn and Westminster, Colorado. *(Note: Not Yet Complete—Anticipated to be Released in the Summer of 2002; some findings have been incorporated into this Plan based on personal communication with Tami Schneck of Aquatics Associates.)*

- Exponent, 1998. Lower Walnut Creek Aquatic Sampling, Spring 1998. Prepared for Kaiser Hill Company, LLC.

- Greystone Consulting, 1998. October 1998 Fish Sample Data for Big Dry Creek (spreadsheet).

- Wright Water Engineers, 1999. Integrated Analysis of Habitat, Macroinvertebrate, Fish, Flow and Selected Water Quality Parameters on the Main Stem of Big Dry Creek. October.

Highlights of the macroinvertebrate, fish, habitat and artificial substrate studies are provided below. Final reports for the aquatic data for 1999 through 2001 were not available at the time this report was completed; therefore, a comprehensive discussion of these data was not possible.

<u>Macroinvertebrate Data</u>

Macroinvertebrate data have been collected in the spring and fall of each year since 1997 following EPA's Rapid Bioassessment Protocol III (RBP) with the exception of the spring of 1999 when data were not collected. The most recent findings for 2001 are summarized in Table 15.

A review of the benthic macroinvertebrate data collected in Big Dry Creek from 1997-2001 indicate the predominant factors affecting the numbers and kinds (i.e., density and species composition) of macroinvertebrates are physical habitat and fluctuating flow conditions, especially at sites bdc2.0 through bdc6.0 downstream from the WWTPs. While slight deteriorations in water quality also undoubtedly influence the community's species composition at downstream sites, the scarcity of riffle habitats with cobble substrates and the predominately channelized streambed of shifting silt and sand substrates are also major contributing factors. Additionally, fluctuating flows caused by irrigation activities in the downstream sections of Big Dry Creek and the ongoing bank erosion also adversely influence the benthic community (species composition and fluctuating densities) (Aquatics Associates 2002).

Overall, the macroinvertebrate community is dominated by tolerant midge larvae (Diptera: Chironomidae), with the relative abundance of this group tending to increase at the downstream stations. Sensitive groups were mainly represented by mayflies, which were generally more abundant at the upstream sites (bdc0.5 through 1.5C). The number of mayfly taxa and their abundance decreased dramatically at downstream sites, typical of plains-type streams which are characteristically low in gradient with predominately shifting silt and sand substrates. Occasionally, aquatic worms (Oligochaeta) were present in very high numbers, especially at sites bdc2.0 and bdc3.0, which are situated immediately downstream from the WWTPs. The proliferation of aquatic worms is likely due to nutrient rich conditions (dissolved and fine particulate organic matter), with density fluctuations also attributable to changing substrate conditions at the time of sampling (i.e., shifting silt and sand) (Aquatics Associates 2002).

Generally fewer taxa were collected at the downstream sites. Site bdc6.0 typically had the fewest taxa. Densities were generally variable with no distinct upstream versus downstream trends. Temporal and spatial variations in densities are often influenced by the naturally occurring patchy distribution that is typical of many macroinvertebrate species, as well as flow and substrate conditions (Aquatics Associates 2002).

RBP analyses indicate that downstream sites showed varying levels of impact compared to the upstream reference sites (bdc0.5, 1.5, 1.5C). Site bdc6.0 appeared to be most affected as it was "moderately impaired" on 12 of 21 occasions during the 1999-2001 period compared to nine occasions at site bdc2.0, and four and five occasions at sites bdc3.0 and bdc5.0, respectively (Aquatics Associates 2002).

Table 15
MACROINVERTEBRATE DATA SUMMARY
BIG DRY CREEK AND WALNUT CREEK
2001 Summary of Rapid Bioassessment Protocol III Results

	Study Site								Walnut Creek		
	BDC-0.5	**BDC-1.0**	**BDC-1.5**	**BDC-1.5C**	**BDC-2.0**	**BDC-3.0**	**BDC-5.0**	**BDC-6.0**	**D2**	**W1**	**W2**
Spring 2001- Kick Samples											
BDC-0.5 to downstream sites											
Total Score	44	30	34	24	8	10	16	20	28	32	40
Percent of Reference Score	100	68	77	55	18	23	36	45	64	73	91
Biological Condition Category	ref. site	slight	slight	slight	moderate-severe	moderate	moderate	moderate	slight	slight	nonimpaired
BDC-1.5 to downstream sites											
Total Score			44	38	14	14	20	20			
Percent of Reference Score			100	86	32	32	45	45			
Biological Condition Category			ref. site	nonimpaired	moderate	moderate	moderate	moderate			
BDC-1.5C to downstream sites											
Total Score				44	14	18	20	22			
Percent of Reference Score				100	32	41	45	50			
Biological Condition Category				ref. site	moderate	moderate	moderate	moderate			
Fall 2001- Kick Samples											
BDC-0.5 to downstream sites											
Total Score	46	42	44	46	22	42	38	20	32	44	44
Percent of Reference Score	100	91	96	100	48	91	83	43	70	96	96
Biological Condition Category	ref. site	nonimpaired	nonimpaired	nonimpaired	moderate	nonimpaired	nonimpaired	moderate	slight	nonimpaired	nonimpaired
BDC-1.5 to downstream sites											
Total Score			46	46	26	40	40	22			
Percent of Reference Score			100	100	57	87	87	48			
Biological Condition Category			ref. site	nonimpaired	slight	nonimpaired	nonimpaired	moderate			
BDC-1.5C to downstream sites											
Total Score				46	28	42	40	20			
Percent of Reference Score				100	61	91	87	43			
Biological Condition Category				ref. site	slight	nonimpaired	nonimpaired	moderate			
Fall 2001 Artificial Substrates											
BDC-1.5 to downstream sites											
Total Score			42		38	32	24	16			
Percent of Reference Score			100		90	76	57	38			
Biological Condition Category			ref. site		nonimpaired	slight	slight	moderate			

Analysis of spring and fall 2001 data for Walnut Creek upstream of its confluence with Big Dry Creek shows that site D2 was slightly impaired in both seasons; whereas site W1 was slightly impaired in the spring, but not impaired in the fall. Site W2 was not impaired in either the spring or fall (Aquatics Associates 2002).

The slight impairment at site D2 in both spring and fall is most likely due to extremely low base flows and periodic relatively high flows related to the intermittent discharges from Rocky Flats. At site W1, the slight impairment may likely be due to the stress of the winter low flow and temperature conditions, while by the fall these conditions have become suitable for the establishment of a balanced macroinvertebrate community. Flow, habitat, and water quality conditions at site W2 appear to be sufficiently suitable for sustaining a healthy benthic community during all seasons.

Habitat

Physical habitat assessment data were collected by Aquatics Associates following the methods in EPA's (1989) Rapid Bioassessment Protocols in spring of 1997 and 1999 (Aquatics Associates 1999)[3]. Habitat assessment results for 1997 indicated that there were measurable differences in habitat quality at sites upstream and downstream of the WWTPs, with habitat scores at the upper three monitoring locations (bdc0.5, 1.0 & 1.5B) being higher than the habitat scores at the lower four stations. Differences in channel morphology, flow and substrate composition between sites upstream and downstream of the Broomfield WWTP largely accounted for differences in habitat quality. At the upstream monitoring locations, a diversity of riffle, run and pool macro-habitats and substrates were present, with habitat quality being limited primarily by flow conditions during the low flow period and increased runoff during storm events (Aquatics Associates 1999).

The downstream stations (bdc2.0 through bdc6.0) showed decreased habitat quality attributable to the absence or limited availability of riffle and pool macro-habitats, poor substrate quality with the predominance of shifting sand and silt substrates and the lack of larger substrates that

[3] Habitat data for 1999 had not yet been summarized in a report at the time that this Plan was completed.

provide cover for fish and macroinvertebrates. Flow fluctuations and interruptions such as stream dewatering and excessive turbidity associated with irrigation activities were associated with unstable conditions that adversely affect habitat quality in these areas (Aquatics Associates 1999).

Based on analysis of macroinvertebrate and habitat data available for 1997 and fish data for 1998, overall habitat quality was well correlated with the overall health of the benthic macroinvertebrate and fish communities. Monitoring locations with low embeddedness, low channel alteration, high pool/riffle and run/bend ratios, and good bottom substrate and available cover generally had higher benthic and fish scores. Sites with low percentages of sand and fine sediment generally had higher benthic invertebrate community index (ICI) scores, while sites with higher percentages of cobble and large substrate generally had higher fish index of biotic integrity (IBI) scores. The fish community (as measured by the IBI) was not as strongly correlated to overall habitat quality, although the fish community was generally better where habitat was better.

<u>Artificial Substrate Study</u>

The artificial substrate study was conducted based on analysis of the biological data in 1999 (WWE 1999). In this analysis, it was difficult to distinguish between the effects of water quality and habitat on aquatic life since both tend to decrease in a downstream direction as the health of the aquatic communities generally decrease. The water quality parameters analyzed were highly correlated to several habitat parameters. For example, average ammonia concentrations were well correlated to total habitat quality and most of the habitat parameters (WWE 1999). The 2000 and 2001 artificial substrate studies were performed to isolate the relative impacts of water quality and habitat on the benthic community (Aquatic Associates 2002).

Artificial substrate data for the fall 2001 samples collected on Big Dry Creek are presented in Table 15 using bdc1.5 as the reference site. The artificial substrate (Hester-Dendy) samples indicate the benthic community was not impaired at site bdc2.0, while sites bdc3.0 and bdc5.0 were slightly impaired. The greatest degree of impairment was evident at site bdc6.0, which was moderately impaired (Aquatic Associates 2002).

Integration of the artificial substrate study with the RBP results indicates that at bdc2.0, habitat conditions may be the primary cause of impairment. At this site, substrate conditions, with no cobble or riffle habitat, are very poor for colonization of aquatic insects. The silt and mud substrates at this site favor the more tolerant aquatic worms and midges (Aquatic Associates 2002).

At site bdc6.0, even with an artificial substrate provided, a moderate degree of impairment was present, consistent with the kick samples. These findings suggest that impairment at this site is probably due to multiple factors such as fluctuating flows, excessive turbidity, predominance of shifting sand and silt substrates, and water quality (Aquatic Associates 2002).

An artificial substrate study was also completed during the fall of 2000. In this study, the downstream benthic community was much more similar to that of the upstream sites once the artificial habitat was provided. The implication of this finding is that the aquatic community in the lower watershed is more likely to be limited due to habitat conditions than water quality conditions (Aquatic Associates 2002).

<u>Fish</u>

Fish data were collected and summarized generally following standard EPA protocols as described in the Rapid Bioassessment Protocols V (EPA 1998). During the spring and fall of 1997, fish species collected in Big Dry Creek included the longnose dace, creek chub, fathead minnow, sand shiner, goldfish, white sucker, longnose sucker, black bullhead, yellow bullhead, brook stickleback, largemouth bass, green sunfish, bluegill, pumpkinseed, yellow perch, Johnny darter and mosquitofish. Species abundance and distribution during 1997 was largely dependent on the different habitat preferences of the species and the different habitat conditions encountered in the transitional foothills-plains and plains reaches of Big Dry Creek (Aquatics Associates 1998).

Based on the spring and fall 1997 and fall 1998 fish data, Johnny darter presence in Big Dry Creek was most strongly correlated with several habitat parameters. Specifically, Johnny darter presence was higher in areas with low embeddedness, low percent substrate less than 2 mm (sand or smaller) and good bottom substrate/available cover. Johnny darter presence was not significantly correlated with the water quality parameters evaluated, including unionized ammonia (WWE 1999).

Additional fish were collected in both the fall of 1999 and the fall of 2000. Although a report summarizing the fish data was not available at the time of this report, a few key points identified by Aquatic Associates at the July 18, 2001 Watershed Association meeting included:

- Fish distribution and abundance appeared to be most affected by flow and habitat conditions. Findings were similar between 1999 and 2000.

- The most common species were the white sucker and the fathead minnow. The longnosed dace was the only intolerant species present.

- Johnny darters were present at the upstream monitoring locations, as has been the case in previous years. Reasons for the absence of Johnny darters at the lower sites are believed to include the lack of still water, lack of sandy areas adjacent to clean cobble, and turbidity.

- On Walnut Creek, six fish species were present, which is typical for headwaters streams. Low flows and stream size limit the species and abundance of fish.

2.3.4 *Wildlife*

Under the federal Endangered Species Act, the Preble's Meadow Jumping Mouse is listed as a threatened species by the U.S. Fish and Wildlife Service (USFWS). The mouse has been documented to live in the riparian area along Woman Creek in the upper portion of the Big Dry Creek watershed. Past studies of relative abundance have indicated fewer than 100 individuals on Woman Creek (RFCAB 2000). The mouse is found in all major drainages at Rocky Flats, as well as in off-site locations. Additionally, the Bald Eagle is also found at Rocky Flats and in the Standley Lake area. Other species of special concern (but not listed) with habitat at Rocky Flats include the Eastern Short-Horned Lizard, the Northern Leopard Frog, the Western Burrowing Owl and the Loggerhead Shrike. Additionally, there are several endangered, threatened or candidate species with potential habitat at Rocky Flats, including the Colorado Butterfly Plant, the Whooping Crane, the Piping Plover and the Black-Footed Ferret (RFCAB 2000).

2.3.5 *Stream Geomorphology*

During 1998-1999, non-point sources of pollution, particularly erosion and sedimentation, were identified as an area in need of more study with regard to developing an overall understanding of water quality conditions in Big Dry Creek. In response to this need, an engineering stream survey of Big Dry Creek, including both field and office research, was conducted by Wright Water Engineers (WWE) under a 319 grant to identify key areas subject to erosion and sedimentation and other non-point sources of pollution. Aerial photography, videography and interviews with watershed residents and city staff were used to focus on portions of Big Dry Creek that were believed to be of highest priority with regard to erosion and sedimentation. Based on these activities, the goals of the study were:

- To determine whether Big Dry Creek was experiencing excessive erosion and sedimentation and to assess general channel stability,

- To identify sources of erosion/sedimentation and non-point source pollution problems on the creek, and

- To propose potential solutions for identified non-point source problems on Big Dry Creek.

Based on field surveys and evaluation of available data, some of the key conclusions regarding the geomorphology of Big Dry Creek in the WWE (2000) report included:

- As a whole, the main stem of Big Dry Creek is not experiencing excessive sedimentation and erosion; however, there are localized areas in both the urban and agricultural areas where erosion is occurring and where improvements can be made.

- Big Dry Creek is now a perennial stream that is subject to erosion of outside bends of the channel. The creek has some extreme bends with several ox-bow type meander patterns. Bank erosion, as evidenced by exposed sediments, was present on the almost vertical banks that are typical of outside bends in a meandering channel. This condition prevails throughout the creek. As sediments are eroded in the upstream portion of the creek, erosive potential is actually reduced in the downstream portion of the creek as the eroded bank sediment is carried in suspension, thereby reducing the tractive forces of the flowing water and subsequent bank line erosion.

- Although erosion of the bare stream banks appears to be a dramatic loss of topsoil, the erosion of most bank lines actually appeared to be minor. In particular, the natural erosion process within open space areas did not appear to be excessive. There were, however, a few cases of more accelerated rates of erosion either caused by fallen trees or by movement of riprap, which had originally been placed along the bank, into the active stream.

- Extent of bank erosion was estimated based on review of the aerial video and is summarized in Table 16 below. The overview indicates, that at a macro-level, Big Dry Creek is experiencing relatively low rates of erosion, as evidenced by roughly 80 percent of the banks being vegetated. Of the remaining 20 percent of banks that are denuded to some extent, 13 percent show low erosion potential, 6 percent show moderate erosion potential and only 1 percent show heavy erosion potential. It should be noted that most of the areas showing heavy erosion potential are concentrated in the area between Highway 36 and Sheridan, where the steep cut banks are located. Review of aerial photos and geologic data in this area indicate that these banks are actually relatively stable, even though they are steep and unvegetated.

Table 16

Portions of Big Dry Creek With Bare Banks Susceptible to Erosion

Reach Description	Reach Length (ft)	# of Meanders	% of Meanders Showing Various Levels of Erosion Susceptibility			
			No Significant Erosion Evidence (Well vegetated banks)	Low Erosion Potential (<5 ft of bare banks)	Moderate Erosion Potential (5-10 ft of bare banks)	Heavy Erosion Potential (>10 ft of bare banks)
Standley Lake Dam to Wadsworth	5,900	35	94	6		
Wadsworth to Hwy 36	9,600	34	73	9	18	
Hwy 36 to Sheridan	12,600	33	67	3	9	21
Sheridan to 120th/Federal	10,400	43	86	5	7	2
120th/Federal to 128th	12,000	34	94	6		
128th to I-25	8,000	38	73	16	11	
I-25-144th	12,300	44	75	20	5	
144th-160th (Hwy 7)	19,200	118	60	28	12	
160th (Hwy 7) to WCR 23 & 8	56,500	270	83	13	4	
WCR 23 & 8 to Confluence w/South Platte	23,000	100	95	5		
Totals	**169,500**	**749**	**80**	**13**	**6**	**1**

Specific areas experiencing erosion and sedimentation are discussed in Section 2.4 of this Plan.

As a follow-up to the WWE (2000) report, the Watershed Association collaborated with two Colorado State University (CSU) engineering students who completed more detailed evaluations of several parcels in the agricultural portion of the watershed (Gossenauer and Wachob 2001). These students interviewed several landowners along the creek, documented conditions on their properties and provided recommendations to mitigate the problems. The common concerns of most of the landowners were loss of property to erosion, an increase in the rate of erosion, increases in the flow rate and occurrence of high flow events, loss of infrastructure from heightened flows, and the high cost of even simple bank stabilization techniques such as riprap.

The study results identified accelerated erosion present at several locations studied, primarily along bends with naturally high banks, sites with significant cattle impacts, or points where infrastructure such as bridges and headgates are present. In some cases, the erosion appeared to be due to increased peak flows and significant fluctuations in flow conditions. In other cases, impacts appeared to be due to a combination of increased flows exacerbated by cattle impacts.

Many landowners have one or two especially troublesome points of erosion along their reach of stream (Gossenauer and Wachob 2001).

Gossenauer and Wachob (2001) further characterized the influence of the significant variations in the flow regime of Big Dry Creek on the stream channel. Variable flows cause increased bank erosion by preventing the stream from reaching a state of equilibrium. At low flows, the banks dry out. As a higher flow progresses down the channel, water moves into the pore spaces in the soil, the tension in the pore spaces is reduced, and the soil becomes less cohesive (Bledsoe 2001). The now weakened bank is subjected to greater hydraulic forces and a flow that lacks sediment (Knighton 1998). In order to balance the sediment transport capacity of the high flow, sediment is removed from the banks of the stream. This relationship is known as Lane's Balance. As sediment is removed from the bank, surface erosion, undercutting and sloughing can occur. As the flow recedes, the banks dry again, and the cycle repeats itself (Knighton 1998). Thus, peak flows associated with a highly variable flow will be more erosive than a peak flow associated with a consistent flow regime. The more flashy, or variable, a flow is, the more destructive it is to the streambanks. Analysis of Big Dry Creek flow data indicates that the flow regime has changed to become more variable, and more likely to cause erosion. It also indicates that the flow in the upper (more urbanized) portion of the watershed is more variable than the lower portion (Gossenauer and Wachob 2001).

2.4 Problem Identification/Pollution Sources

2.4.1 *Non-point Sources*

Currently, Big Dry Creek attains numeric stream standards (WWE 2002); however, the aquatic community in portions of the watershed is considered to be slightly to moderately impaired (Aquatics Associates 2002). Additionally, the possibility exists that the bacteriological standards for the stream may be lowered, making attainment of fecal coliform and *E. coli* standards difficult to obtain. The chemical, biological and flow data, combined with anecdotal evidence from residents and city staff, suggest several sources of non-point source impacts including hydrologic modification associated with urban development, bacterial contributions, and agricultural operations.

Table 17 contains a summary of non-point sources of pollution identified in previous studies sponsored by the Watershed Association (WWE 1999; Gossenauer and Wachob 2001). Additional discussion of these areas is provided below.

Hydrologic Modification

Watersheds that transition from urban to agricultural regions along their courses are especially susceptible to bank erosion (FISRWG 1998). Variability of flow caused by increased impervious surface area upstream and greater base flows from WWTP effluent can contribute to this problem. In addition, urban outflow is often high in energy and intensity but carrying little sediment. That is, the sediment carrying capacity of the flow is greater than the available sediment load. In an agricultural area, the inverse is true. The banks are often stabilized only by grass, and can be subject to impacts from livestock, resulting in a relatively large amount of sediment available for transport (Novotny and Olem 1994). As the flow moves down the watershed, the high energy, clear flow removes sediment from the channel boundaries. The result is decreased streambank stability, erosion and loss of formerly usable land (Gossenauer and Wachob 2001).

Table 17 (part 1)
Areas in Need of Stream Stabilization on Big Dry Creek Identified in (WWE 2000)

Item	Current Problem Area	Proposed Solution	Stream Reach Length (ft)	Urban or Rural (U or R)	Estimated Annual Sediment Yield (cubic yards)	Rough Cost Estimate	Supporting Cost Data[1]	Potential Teaming Partners/Funding Sources	Priority
1	Lack of erosion and sediment control measures at construction sites.	Education of developers regarding implementation of ESC measures, enforcement of ordinances requiring implementation of ESC measures.	N/A	U	Not Estimated	Low $5,000-$10,000		Cities, Developers, 319 grant	High
2a	112th Avenue area bank erosion, extends upstream and downstream for roughly 2 mile reach.	Vegetative stabilization of bare toes of slopes may include willow plantings and other revegetation and/or use of geotextiles.	1000 (eroding bends only)	U	370	Low to Medium (depends on length, $10,000 to $40,000)	$0.25-$0.75/sq. ft.	City of Westminster, GOCO, 319 grant	Medium
2b	120th Avenue area bank erosion.	Provide bank stabilization through regrading of bank and use of retaining wall or riprap.	200	U	74	Medium to High $47,000 to $52,000	200 L.F. @ $235-260/L.F.	City of Westminster, GOCO, 319 grant	Medium
3	General area of high cut banks in the area between 104th and 128th Avenue. Potential future source of bank erosion, channel incision, and sediment loading. (General stream reach, see items 5a and 5b for more short-term problems.)	Unless piping, gullying or sloughing of the banks occurs, there is no needed immediate action. Bank protection and "laying back" the high cut banks as development occurs along the channel should be a requirement of the Cities for developers.	1000 (eroding bends not previously included)	U	185	Medium to High (depends on length)	$40-$50/L.F.	Private Developers, City of Westminster, City of Broomfield, GOCO	Low Presently/ High Future
4	Cattle trampling stream banks causing bank failure and sediment loading.	Alternatives such as providing off-stream water, providing stable access points, changing the location of salt and mineral blocks, providing gate access to pasture locations away from the riparian corridor, etc.	1300 (x 2)	R	147	Medium $29,000-40,000	1/4 mile both sides of stream @ $11-15/L.F.	Landowners, NRCS, CSU Cooperative Extension Service	Medium
5	Return flows from an alfalfa field near Colorado Blvd. eroding bank.	Provide bank stabilization by controlling return flow, regrading bank and revegetating.	120	R	62	Medium $28,000 to $31,000	120 L.F. @ $235-260/L.F.	Private Landowner, 319 grant, NRCS	Medium
6	Fallen trees in stream which can redirect flows, causing erosion. (144th Ave.; Broomfield WWTP; Col. Blvd.)	Either alter location of trees in stream to minimize erosion or remove trees from the stream. (Fallen trees provide benefit to aquatic life in the form of habitat.)	150	R	28	Low $400/tree	$400/tree	Landowners, Cities, Counties	Medium
7	Eroding bank and flow alignment problems upstream of the Washington Street bridge.	Remove the concrete riprap that has moved away from the left bank. The right bank should be laid back by grading and lined with riprap to prevent additional erosion.	100	R	22	Medium $23,500-26,000	100 L.F. @ $235-260/L.F.	City of Thornton, Adams County, Adjacent landowner(s)	Medium
8	Road base erosion at higher flows at the Weld County Road 21 bridge over Big Dry Creek.	Replace the eroded material with a graded fill, which will not erode at the higher flows. Possible realignment of the channel upstream where flows are not directed into the problem area under the bridge.	200	R	22	High $77,000	Road Base 500 C.Y. @ $60/C.Y. Riprap 200 L.F. @ $235/L.F.	Weld County	Medium
9a	Plugged culvert under Weld County Road 4 on tributary inflow and problems with Yoxall Ditch "sand out" near culvert.	Replacement of the Weld County Road 4 culvert and regrading and stabilization of adjacent ditch.	60	R	7	Medium $12,500-17,500	50-70 L.F. @ $250/L.F.	Weld County and Adjacent Landowner	Medium
9b	Yoxall Ditch diversion structure severely damaged in Apri 1998 storm event.	Engineered diversion structure and headgate for the diversion.	Point	R	Not Applicable	High $70,000	Based on Thompson Ditch cost	Ditch company, farmer(s) served by the diversion, NRCS EQUIP	Medium
10	Inadequate or lack of riprap protection around Lupton Bottoms diversion structure.	Protect the structure by placement of graded riprap.	500	R	Not Applicable/ Future Concern	High $118,000-130,000	500 L.F. @ $235-260/L.F.	Ditch companies, NRCS EQUIP	Medium to Low

[1]Costs are rough, ballpark estimates for purposes of macro-level decision making.
Actual costs may vary significantly and more detailed budgeting should be conducted prior to conducting activity.
[2]Sediment loads are estimated based on 1 foot/year lateral erosion, except at the Alfalfa field at Colorado where 2 feet/year was used. Sediment load esimations are for prioritizing activities onl

Table 17 (part 2)
Areas in Need of Stream Stabilization on Big Dry Creek Identified in (Gossenauer and Wachob 2001)

Item	Current Problem Area	Proposed Solution	Stream Reach Length (ft)	Urban or Rural (U or R)	Estimated Annual Sediment Yield (cubic yards)	Rough Cost Estimate	Supporting Cost Data[1]	Potential Teaming Partners/Funding Sources	Priority
11	Gary Howard Property: Yoxall Ditch Headgate--flows threaten headgate, frequent dredging. (Sites 6, 10, 11) (Also see Part 1 of this table).	Bank reshaping, toe stabilization (e.g., riprap), upper bank revegetation and exclusionary fencing (at some locations). Additional structural solutions needed at bridges and headgate. Also consider buffer installation/CRP program.	50-150 ft	Rural	Not Estimated	Bank Stabilization: Low $5,000-$10,000; Structure (bridge, headgate) Stabilization: High	Not Included	Landowners, NRCS, CSU Coop. Ext. Service, 319 grant	Medium
12	Barry Marrs Property: severe bank erosion, fences and cropland threatened by washouts. Some cattle grazing. (Sites 7, 8 and 9)							Landowners, NRCS, CSU Coop. Ext. Service, 319 grant	Medium
13	Dorothy Brow Property: bank erosion and high flows threaten bridge (Site 12)							Landowners, NRCS, CSU Coop. Ext. Service, 319 grant	Medium
14	Don and Barbara Rosenbrock Property: bank erosion and high flows threaten bridge and out-building (Site 13)							Landowners, NRCS, CSU Coop. Ext. Service, 319 grant	Medium
15	Wright Property: bank erosion and cattle impacts.							Landowners, NRCS, CSU Coop. Ext. Service, 319 grant	Medium
16	Tom Chikuma Property: bank erosion and bridge overtopping during high flows. Loss of cropland. (Site 15)							Landowners, NRCS, CSU Coop. Ext. Service, 319 grant	Medium

[1]Costs are rough, ballpark estimates for purposes of macro-level decision making.
Actual costs may vary significantly and more detailed budgeting should be conducted prior to conducting activity.

In the agricultural area, hydrologic modification is compounded by the use of creek bottom areas as pastureland. In these bottomlands, the slightly terraced banks, presence of trees, and possibility of inundation make cultivating the land difficult. At the same time, the continuous water source, shade and protection afforded by trees and shrubs, and abundant grass make it an ideal pasture. Grazing cattle in the unplowed bottomlands can be a financially attractive supplement to dry-land farming (Gossenauer and Wachob 2001). However, cattle can have injurious consequences if not managed well (Erhart and Hansen 1997). Cattle traffic, as well as grazing down beneficial plants, can accelerate erosion (FISRWG 1998).

Gossenauer and Wachob (2001) reported that erosion is occurring in varying degrees throughout the lower reach of the watershed. Erosion is most severe in areas of high banks, on the outside of tight bends with poor vegetation. Where the creek flows through areas of low banks, wide meanders, and well-established, healthy vegetation, erosion was minimal. All observed erosion was lateral. It was usually limited to one side of the creek at a time, generally the outside of a bend. On the inside of the bend, deposition of sediment was present at nearly every site of significant erosion. Places where the bank had eroded to form a sharp bank over 6 feet in height were not uncommon, but erosion was usually not continuous along an entire reach. Typically, the affected length was about 50 feet. On the reaches examined, there were no headcuts or areas of severe bed erosion. Several examples of significant bank erosion include banks 10 feet high and over 140 feet in length. Landowners commented that those banks have not historically been so large, and that the cut banks are increasing in size at much greater than historical rates (Gossenauer and Wachob 2001).

Although significant erosion was found both where cattle were grazed intensively and in areas that had seen little or no grazing in recent times, those areas demonstrating the most bank erosion were also subject to impacts from cattle. Cattle trails often crossed affected banks, increasing the breakdown of the bank. Vegetation was generally thinner in grazed areas, leading to more soil exposed to water at high flows. The significant presence of cattle decreased streambank stability at nearly every site where grazing was intensive (Gossenauer and Wachob 2001).

Non-point Sanitary Sources

Throughout the watershed, elevated concentrations of fecal coliform and *E. coli* have been documented via the in-stream monitoring program. The source of these bacteria has not been determined. Because the bacteria levels in the municipal WWTP discharges are significantly lower than what is found in the creek, further exploration of sources of these bacteria is needed. The area below Standley Lake and upstream of the Broomfield WWTP has several large parcels of land with barnyard animals. Further exploration of whether these lots are on septic systems is warranted.

Agricultural Sources

In the agricultural portion of Big Dry Creek, impacts to the watershed include erosion related to hydrologic modification, as previously discussed. While some portions of the watershed are primarily impacted by the changes in hydrology, in several areas this problem is exacerbated by grazing in bottomlands. Cattle paths accelerate erosion by destabilizing the soil. Worn paths from frequent traffic concentrate runoff from storms, leading to greater erosion in certain areas. On side slopes, cattle paths can lead to loosening of the soil and breakdown of the soil on the bank (FISRWG 1998). Steep slopes heighten instability of the soil, multiply the effects of cattle walking across the bank, and decrease the potential for revegetation (Gossenauer and Wachob 2001).

Heavy cattle traffic also inhibits the growth of plants that would otherwise stabilize banks. Compacted soil makes it more difficult for most plants to become established. Young plants and shoots also cannot become established where frequent traffic prevents growth. In most cases (on flat, dry ground) these concerns do not pose much of a problem. Plants are able to grow and mature even in the presence of moderately intensive grazing. It is in bottomlands that the cattle impacts combine with frequently wetted soils, steeply sloped banks, and erosion from the creek to exacerbate erosion problems (FISRWG 1998). Table 17 identifies the agricultural properties identified by both WWE (2000) and Gossenauer and Wachob (2001) that would benefit from stream stabilization activities.

2.4.2 *Point Sources*

Construction Sites

In guidance for the Phase II stormwater regulation, EPA states that sediment runoff rates from construction sites are typically 10 to 20 times greater than those of agricultural lands and 1,000 to 2,000 times greater than those of forested lands. During a short time period, construction sites can contribute more sediment to streams than what can be deposited naturally during several decades (EPA 2000). Based on anecdotal evidence from both residents of the watershed and city staff, erosion and sediment control measures are not believed to be practiced at construction sites at a level that is deemed to be adequately protective of Big Dry Creek. Although erosion and sediment control ordinances are in place throughout the watershed, these ordinances do not appear to be being followed. Under the Phase II stormwater regulation, construction sites of one acre or more will require stormwater discharge permits. Currently, state regulations require permits for areas disturbing five or more acres.

Wastewater Discharges

Wastewater discharges to the stream are believed to be adequately managed through permits. See Section 2.1.7 and 2.2.2 for more discussion on wastewater discharges. The primary dischargers to Big Dry Creek, the cities of Broomfield and Westminster, are both in the process of improving their treatment processes. With these improvements and assuming compliance with the CDPS permits, it is expected that potential adverse impacts from wastewater discharges will be adequately controlled.

Stormwater Discharges

Increased volumes and peak flows associated with runoff from impervious areas within the developed portion of the watershed are adversely impacting the streambanks in both the urban and agricultural areas. The impacts of stormwater discharges have been discussed in Sections 2.3.2 and 2.3.5.

3.0 PHASE II: RESTORATION

3.1 Watershed Association Organization Structure and Lead Agencies

Currently, the Watershed Association's organizational structure is based on a signed intergovernmental agreement between the cities of Broomfield, Westminster and Northglenn and DOE. These entities are considered to be the "lead agencies" for the Watershed Association. The Watershed Association also includes representatives of a variety of federal, state, county and local governments, as well as citizens. The involvement of these parties is voluntary. Some of the agencies providing technical support, financial assistance, or in-kind services include EPA, CDPHE/WQCD, NRCS, DOE, CDOW, USFWS, UDFCD and DRCOG.

For the last several years, the Watershed Association has considered the formation of a nonprofit organization and has even developed draft articles and bylaws. However, the effort has "stalled out" due in part to the fact that the written intergovernmental agreement has functioned acceptably for the primary financially contributing entities (cities of Broomfield, Northglenn and Westminster and DOE). Since each of the involved parties is already tax-exempt, the development of the non-profit has been less urgent. Grants received by the "Watershed Association" are typically awarded to one of the steering committee entities who administers the grant on behalf of the Watershed Association. For example, the city of Northglenn administered the initial Regional Geographic Initiative grant, the city of Broomfield administered a 319 grant, and the city of Westminster has administered grants from DOE and EPA. For non-grant-funded activities, the selected contractor invoices each entity separately for their respective portion of the project.

3.1.2 *Mission and Goals*

The Watershed Association's initial vision for its mission and goals has been largely unchanged since its development in 1997. The mission and goals have been evaluated on roughly an annual basis to ensure that the Watershed Association's activities are consistent with these goals. The mission of the Watershed Association is to develop a sound scientific understanding of water quality, flow, aquatic life, and habitat conditions in the Big Dry Creek Watershed for the purposes of: (1) environmentally responsible decision-making with regard to land and stream uses and (2) identifying measures to improve and protect stream conditions.

The goals of the Watershed Association include three broad categories: (1) public education and involvement, (2) monitoring and study, and (3) protecting, preserving and restoring water quality, aquatic life, and habitat. Specific objectives relating to these goals are identified below.

Public Education and Involvement

- Provide a forum for entities interested in Big Dry Creek to cooperatively and constructively discuss water quality, flow, and habitat-related issues.

- Develop a web page and other communication means that can be readily accessed by interested parties for information pertinent to Big Dry Creek.

- Develop a broad base of support for the Watershed Association including, but not limited to, wastewater dischargers, water suppliers, farmers, developers, planners, students, teachers, public agencies, business/industry, community groups, park and open space users, and other interested citizens.

- Promote responsible land development practices in the rapidly urbanizing watershed consistent with local, state, and federal regulations.

- Inform and educate watershed residents on stream-related environmental issues and measures they can take to improve and protect water quality, aquatic life, and habitat.

Monitoring and Study

- Reinforce the use of sound science in evaluating watershed conditions and decision making.

- Develop and maintain a user-friendly comprehensive water quality database on Big Dry Creek to be used for scientifically sound water quality related decisions and public education.

- Integrate future watershed studies with existing programs and the many historical studies conducted in the watershed.
- Maintain awareness and involvement in water quality monitoring and habitat preservation programs such as those currently in place at Rocky Flats and Standley Lake.
- Maintain and improve the Big Dry Creek water quality and biological monitoring program conducted by the Cities of Broomfield, Northglenn, and Westminster.
- Develop an understanding of stormwater impacts to Big Dry Creek that is consistent with federal stormwater regulations and requirements.
- Develop an understanding of groundwater quality and groundwater-surface water interactions along the main stem of Big Dry Creek.

Protect, Preserve and Restore Water Quality, Aquatic Life, and Habitat

- Protect and preserve water quality, aquatic life, and aquatic habitat.
- Prioritize watershed management goals and coordinate related watershed activities to maximize environmental benefits.
- Support existing and future efforts to preserve riparian habitat and open space in the watershed.
- Identify areas in need of and suitable for stream restoration and habitat protection and projects.
- Develop an understanding of impacts of agricultural activities east of Interstate 25 on water quality, and work with the NRCS through established communication channels to implement any needed measures/practices to improve water quality.
- Continue to monitor and understand the South Platte Segment 15 total maximum daily load (TMDL) process.

During the most recent re-evaluation of goals by stakeholders in November 2001, all of the goals were retained; however, some were of higher priority than others. Additionally, the priorities of the Watershed Association vary to some extent based on the "I-25" line, with upstream stakeholders more interested in water quality and monitoring type issues and downstream stakeholders more interested in flooding and erosion of property. The goals with the lowest priority focus on the web site, groundwater issues, and the South Platte Segment 15 TMDLs (WWE 2001).

3.1.3 *Funding Strategy*

The funding strategy to-date has relied heavily on federal grants and voluntary contributions by the municipalities discharging wastewater to Big Dry Creek. For some time, the Watershed Association has recognized that a baseline operating budget is necessary that is not dependent on competitive grants. A baseline budget has been developed to cover the following activities: routine monitoring, data analysis and reporting, watershed coordination, and special projects. Table 18 contains the budget based on FY2001 costs.

Table 18

Big Dry Creek Watershed Baseline Annual Budget

Description	**Total**
Basic Operations	
Watershed Association meetings (4) and Committee meetings (2)	$ 3,960
Newsletters (1)/Web site updates	$ 3,300
Database management (load data, basic queries)	$ 1,478
Annual data summary/analysis/follow-up	$ 2,475
Coordination	$ 3,696
Contingency for Unexpected Items (15 percent)	$ 2,236
Subtotal for General Operations	**$ 17,145**
Monitoring Program (does not include Rocky Flats)	
Water Quality Monitoring Main Stem	$ 55,610
Biological Monitoring: Walnut Creek	$ 7,207
Biological Monitoring: Big Dry Creek Macroinvertebrate (2x/year) and fish (1x/year)	$ 44,330
Biological Monitoring: Big Dry Creek Artificial Substrate (1x/year)	$ 2,610
USGS Gage at Westminster (cost-share)	$ 5,400
Subtotal for Monitoring	**$ 115,157**
Other Restoration Activities Not Included/Case Specific	
Total Estimated Budget	**$ 132,302**

For the most part, routine monitoring is covered by contributions from the cities and DOE. Approximately half of the Watershed Association meetings/coordination and data analysis are covered by a grant from DOE. The remainder of the costs to date have been covered by grants. To reduce reliance on grants, there have been discussions regarding mechanisms to fairly allocate funding among interested parties. These methods can generally be categorized into wastewater discharge percentage and land area percentage, as well as considerations regarding ability to pay. For example, Watershed Association dues for a municipality would be assessed on a different scale than for an individual farmer. The following recommended dues structure for basic operations, excluding monitoring, includes these sources:

- Wastewater Discharging City: $2,500/year
  (totals $7,500/year for Broomfield/Westminster/Northglenn)

- Land-based City/County (comprising 5 percent or more of land area in watershed): $1,000 to $2,500/year
  (note: goal to have at least two contributing land-based entities by end of 2002; discussions have been initiated with Weld County and Thornton)

- Rocky Flats: $8,000/year

Based on this approach, an operating budget of $17,500 to $20,500 per year would be achieved. In the absence of a non-profit corporation, these "dues" would have to be based on separate invoices to the participating governments for specific tasks. Until a non-profit organization is formed, the administrative costs associated with handling smaller dues for individual memberships (e.g., $25 to $100) is not cost-effective. Other organizations such as the Colorado Watershed Assembly assess individual memberships for their non-profit organizations at $25 for individual membership, $50 for an organization membership and rely on other tax-deductible contributions for operations.

3.1.4 *Stakeholder Involvement Process*

As previously noted, the Watershed Association began as a partnership among the cities of Broomfield, Northglenn and Westminster, and Rocky Flats, all of which operate domestic WWTPs discharging to Big Dry Creek. In keeping with the watershed approach to providing integrated water quality management, the Partnership expanded the interest base and formed the Watershed Association, with individuals representing municipalities, federal, state, and local agencies, water providers, and agricultural interests. One of the three goals laid out in the Watershed Association's mission and goals statement is public education and involvement. Toward this goal, the Watershed Association holds regular meetings, provides public presentations, distributes a newsletter, and has developed a web site.

3.1.5 *Key Organizations/Water Quality Initiatives and Relationship to Watershed Association*

There are a number of initiatives being implemented in the Big Dry Creek watershed to varying degrees. The Watershed Association and its member entities participate in and support these initiatives. Key organizations and initiatives are discussed below.

Cities of Westminster, Broomfield and Northglenn

As noted throughout this Plan, the cities of Westminster, Broomfield and Northglenn have been the primary local governments supporting the efforts of the Watershed Association. These entities have provided and continue to provide both in-kind and cash contributions to the Watershed Association. As the three wastewater dischargers on the main stem of Big Dry Creek, these entities are key players on the Watershed Association steering committee, providing critical guidance and support. Additionally, the cities of Broomfield and Westminster have significant land areas tributary to the creek, providing a good opportunity to coordinate efforts related to the Phase II stormwater regulation.

Rocky Flats Environmental Technology Site

Also as noted throughout this Plan, DOE and its contractors at Rocky Flats have also provided critical financial, technical and other in-kind support for the activities of the Watershed Association. Rocky Flats is a key feature influencing the watershed in the headwaters area upstream of Standley Lake. Activities and water quality protection efforts at Rocky Flats directly influence water quality and quantity in Walnut Creek, which is tributary to Big Dry Creek. Additionally, the planned future use of Rocky Flats as a wildlife refuge is an amenity to the watershed as a whole.

Standley Lake Cities

The Standley Lake Cities include the cities of Westminster, Northglenn and Thornton. The activities of these cities to protect the source waters of Standley Lake are important to the water quality of Big Dry Creek. Because this group has been in place for nearly a decade, the Watershed Association has not included source water protection for Standley Lake in its mission and goals. Additionally, the city staff participating in the Big Dry Creek Watershed Association are also active in the Standley Lake group, providing updates and communication regarding Standley Lake, as needed.

The Standley Lake Cities are participating in the state's Source Water Assessment Program (SWAP), which is designed to protect public drinking water supplies by delineating the drinking water source area, conducting an inventory of potential sources of contamination within the source area and determining the susceptibility of the public water supply to these potential sources. It is the responsibility of the state to ensure that these assessments are completed for all public water supplies by 2003 (CDPHE 2000).

Based on discussions during the summer of 2001, it is not anticipated that the Watershed Association will take on issues related to Standley Lake under SWAP since an effective organization is already in place. (Note: with regard to the city of Broomfield's drinking water supply, it is piped into the basin from Carter Lake; therefore, SWAP does not impact Broomfield's water supply within the basin.)

Upper Clear Creek Watershed Association

The activities of the Upper Clear Creek Watershed Association (UCCWA) are of interest to the Big Dry Creek watershed because they influence the quality of water transported to Standley Lake. Pollutants from the Clear Creek watershed transported to Standley Lake may originate from WWTP discharges, stormwater runoff, mine drainage and various non-point sources. The 1993 Upper Clear Creek Watershed Agreement contains provisions for implementation of BMPs and other measures to protect water quality in Clear Creek, the ditches that transport Clear Creek water and in the land areas adjacent to Standley Lake (WWE 1998). Northglenn and Westminster city staff on the Big Dry Creek steering committee are also active in UCCWA.

Milton Reservoir/Barr Lake Watershed Association

During 2002, the groundwork was laid for formation of the Barr Lake and Milton Reservoir Watershed Association. Water for Milton Reservoir is diverted from the South Platte River below the confluence with Big Dry Creek. Both reservoirs are considered to be hyper-eutrophic and are expected to be included on the next 303(d) list due to exceedances of the pH standard. The watershed association will conduct modeling activities to develop a thorough understanding of the physical and biological conditions in the reservoirs and intends to develop a credible water quality database, identify data gaps, continue monitoring, and develop tools (models) to evaluate the lakes.

Water Rights Owners/Ditch Companies/State Engineer's Office.

The flows in Big Dry Creek are strictly regulated by the State Engineer's Office under Colorado Water Law. Currently, the Water Commissioner with jurisdiction over Big Dry Creek is Bob Stahl, who has provided the Watershed Association with diversion data for the creek on a regular basis. Some of the ditches diverting water from Big Dry Creek include the Bull Canal, Whipple Ditch, Thompson Ditch, German Ditch, Yoxall Ditch and the Lupton Bottoms diversion. Flows are returned to the creek via municipal wastewater discharges and agricultural runoff. FRICO is the largest ditch company in the watershed, controlling approximately 40,000 acre-feet of water stored in Standley Lake, approximately three quarters of which is used for municipal purposes with the remaining quarter used for agricultural purposes.

Downstream Land Owners/Agricultural Users

Downstream landowners along Big Dry Creek, who are primarily crop farmers, are welcomed participants in the Watershed Association. The primary concerns of these landowners relate to increased flows in Big Dry Creek resulting in streambank erosion, damage to bridges and ditch headgates and restricted property access during high flows (Rosenbrock, Marrs, Howard, Wright, Brow 2001). Roughly a dozen landowners have either attended Watershed Association meetings from time-to-time or participated in special studies sponsored by the Watershed Association. Approximately 40 landowners are on the Big Dry Creek mailing list and receive updates on activities of the Watershed Association, educational information on conservation practices and grant opportunities.

Denver Regional Council of Governments

Under state and federal statutes, DRCOG is responsible for regional water quality planning in the Denver area. In this capacity, DRCOG prepares and updates the Clean Water Plan. This is the management plan for achieving water quality standards pursuant to sections 208, 303(d) and 305(b) of the federal Clean Water Act. The region's goal is to "restore and maintain the chemical and physical integrity, in order to assure a balanced ecological community, in waters associated with the region." The Big Dry Creek watershed is one of the eleven designated watersheds recognized by the Clean Water Plan. Additionally, DRCOG received a grant from EPA during 2000 to help provide background and communication for cities and towns affected by the Stormwater Phase II rule. The project includes activities such as an informational web site, a series of case studies, a practical procedure manual for local governments affected by Phase II, and a series of training workshops (DRCOG 2002a). Each of the municipalities and counties in the Big Dry Creek watershed, with the exception of Weld County, and Rocky Flats are members of DRCOG.

Urban Drainage and Flood Control District

The cities and counties in the watershed, with the exception of Weld county, are also members of UDFCD, which is the regional agency responsible for urban drainage and flood control in the Denver metro area. The UDFCD sponsors master drainage plans, outfall systems planning and flood hazard area delineations, a number of which have been completed over the years for the Big Dry Creek watershed. The UDFCD's *Urban Storm Drainage Criteria Manual,* Volumes 1 through 3, provides critical, standardized guidance to local governments for planning, construction and maintenance of stormwater quantity and quality control structures.

UDFCD staff have also taken a lead role on the Phase II task force responsible for developing the Phase II stormwater rule and guidance for Colorado (Doerfer 2002). Volume 3 of the *Urban Storm Drainage Criteria Manual* provides information on both structural and non-structural BMPs for stormwater.

Given the impact of storm flows in the watershed, UDFCD is an important technical resource for the watershed. Any activities related to stormwater and drainage control should be coordinated not only with the relevant local government, but also with UDFCD. Additionally, UDFCD has stormwater outfall maps, which are critical to Phase II stormwater permits, available to member governments (Doerfer 2002).

Colorado Division of Wildlife

As previously noted in this Plan, one of the key factors in the development of the Watershed Association was CDOW's concerns regarding water quality impacts, particularly ammonia, on the Johnny darter. Several CDOW staff members are included on the Watershed Association's mailing list and are kept apprised of activities of the Watershed Association although they do not routinely attend meetings. Additionally, the CDOW Riverwatch coordinator is included on the mailing list and is important with regard to the Watershed Association developing relationships with the schools that may be active in the Riverwatch program sponsored by CDOW. Some of the mid-1990s data contained in the Watershed Association database was obtained from CDOW and the Riverwatch program.

Colorado Water Quality Control Division

The CWQCD is an important participant in the Watershed Association as the agency responsible for issuing wastewater discharge permits, stormwater discharge permits under the Phase II regulation and determining whether the creek attains stream standards established by the CWQCC. In the event that Big Dry Creek were to be required to implement TMDLs in the future, this is the agency that would take the lead in such an effort. Additionally, the CWQCD has provided technical and financial support to Big Dry Creek through the 319 non-point source grant program. The Watershed Association provides the CWQCD with data and results of water quality analyses on a periodic basis for purposes of the state's water quality assessments and development of effluent limits for discharge permits.

U.S. Environmental Protection Agency

The EPA has been instrumental in helping the Watershed Association get started through grant funding under the Regional Geographic Initiative program and other programs, as well as through input and guidance from its technical staff. EPA also has considerable educational resources available through its web site that provide guidance for the Watershed Association.

Natural Resources Conservation Service

The NRCS is a critical partner for the Watershed Association given its technical expertise with regard to conservation in agricultural areas and as a source of cost-share funds for projects in the agricultural area. The NRCS promotes the creation of buffer zones along the creek bank and helps to provide cost-sharing mechanisms for such efforts. The objectives of the NRCS are to implement conservation practices to reduce soil erosion, improve riparian wildlife habitat, improve water quality, and improve pasture, cropland and livestock health and productivity (Rogers 1997). The NRCS, primarily through the Brighton and metro Denver field offices, has provided the Watershed Association with technical assistance regarding water quality and stream stability issues in the lower watershed. The NRCS staff also have provided linkage to landowners in the watershed who have historically been interested in conservation practices. NRCS is a potential source of funding to the landowners in the lower watershed through a variety of programs as discussed in Section 3.2.2 of this Plan.

U.S. Fish and Wildlife Service

The USFWS has interfaced with the Watershed Association primarily through its role working with DOE regarding the long-term plans for a national wildlife refuge at Rocky Flats.

U.S. Army Corps of Engineers

The Watershed Association has not directly interfaced with the USACE, but in the event that on-the-ground stream restoration activities are undertaken, it may be necessary to obtain a disturbance permit from the USACE.

South Platte CURE

The South Platte Cooperative for Urban River Evaluation (SPCURE) was formed in 1999 to develop TMDLs on Segments 14 and 15 of the South Platter River. Big Dry Creek marks the downstream end of Segment 15 of the South Platte River. The Big Dry Creek Watershed

Association is considered an ex-officio member of SPCURE and periodically attends SPCURE meetings. To date, the activities of SPCURE have not affected the Big Dry Creek watershed.

North Front Range Water Quality Planning Association

The North Front Range Water Quality Planning Association (NFRWQPA) is the designated Section 208 water quality planning organization for Larimer and Weld counties. Similar to DRCOG, it is responsible for preparing the area-wide water quality management plan for its area. DRCOG and NFRWQPA have a memorandum of understanding between the two agencies to work together on overlapping issues, such as the Big Dry Creek watershed.

Colorado Watershed Assembly

The Colorado Watershed Assembly was formed in 2000 to support watershed organizations throughout the state. The Colorado Watershed Assembly is perceived as a technical and educational resource for the Watershed Association.

Non-profit Organizations

A variety of non-profit organizations exist in Colorado that may provide both financial and technical assistance to the Watershed Association. Some of these include the Natural Heritage Foundation, the Nature Conservancy, Great Outdoors Colorado (GOCO), the League of Women Voters and others. These nonprofit organizations should be explored as future sources of support for the Watershed Association.

3.2 Measures to Improve Water Quality and Achieve Natural Resource Goals

In addition to its critical role with regard to monitoring and evaluating conditions in the watershed, the Watershed Association can play several important roles to improve water quality and achieve natural resource goals, including public and intergovernmental education and facilitation of cooperative efforts in the urban and agricultural areas. These are discussed in more detail below.

3.2.1 *Public and Intra-governmental Education*

Currently, educational activities focused on by the Watershed Association include a regular informational newsletter, a video, a web site and other educational efforts. Table 19 contains a schedule of activities that should be considered by the Watershed Association.

Table 19

Educational Activities Schedule

Activity	Date
Newsletter Summarizing Water Quality	Annually (Summer)
Educational Video	Summer 2002
Web site updates	Bi-annually (summer and winter)
Coordinate with Municipal and County Staff Responsible for Phase II Stormwater Rule	Summer/Fall 2002
Presentations on Activities of the Watershed Association: Rocky Flats Data Exchange Meeting Standley Lake Cities Local Governments (City Council, etc.)	Annual Briefings/Presentations
Watershed Association Meetings	Quarterly

Additional detail on some of these efforts include:

- Newsletters—The Watershed Association issues one or more newsletters each year providing an update on Watershed Association activities and measures that can be taken to improve conditions in the watershed. For example, one newsletter each year summarizes the findings of the water quality and biological data analysis. Other newsletters have targeted specific demographic groups within the watershed such as providing grant information to the agricultural community or providing information on urban runoff issues to the municipalities.

- Web Site—Currently, the Watershed Association has several "pages" on the city of Broomfield's web site where information on the Big Dry Creek watershed is posted. More information on ways citizens can help protect the Big Dry Creek watershed can be posted on this web site.

- Video—Under a grant from EPA and contributions from the cities of Broomfield, Westminster and Northglenn and DOE, an educational video characterizing the watershed, describing key watershed issues and identifying ways that residents can protect water quality in Big Dry Creek is currently being developed. Approximately 24 copies of the video will be available to local governments and schools in the watershed. Additionally, compressed DVD clips will be available for posting on the web site or inclusion in PowerPoint presentations. The video is anticipated to be completed during the summer of 2002.

In addition to the educational efforts already underway, one of the key roles that the Watershed Association can play in the coming years is to help the communities within the watershed educate the public and local government staff on water quality and stormwater issues. Properly managed stormwater can help to minimize or avoid problems with erosion, flooding, and damage to natural drainage features such as streams, wetlands, and lakes, as well as protect wildlife habitat in these natural features (EPA 2002).

It is important that the Watershed Association host a meeting of the local government staff responsible for implementation of the Phase II Stormwater Rule to ensure that local communities are aware that the Watershed Association can help facilitate these efforts. Initial steps by the watershed in 1999, under a 319 grant, included development of an educational notebook on non-point source and stormwater pollution, which was distributed to representatives of each local government within the watershed. As part of this notebook, brochures on several water quality BMPs were developed and included.

For purposes of establishing a framework for discussion at such a meeting, it is important to have a general understanding of what EPA and the state expect to see in a good stormwater program. In 2002, the EPA issued "Measurable Goals Guidance for Phase II Small MS4s" to assist local governments in developing measurable goals for various activities under the Phase II Stormwater Rule.

EPA recommends several key components be included in a stormwater management program:

- Governmental coordination

• Legal authority and comprehensive planning

• Funding and staffing

• Public education and participation

• BMP selection

EPA's description of these elements puts significant emphasis on a coordinated approach within and among local governments that incorporates both location-specific and watershed-wide goals. Assessing the impacts of cumulative pollutant loadings using indicators, trend data, and other means is identified as an essential part of this process (EPA 2002). Additionally, EPA considers development of a watershed association a "measurable goal" under the Phase II rule. Given that the Watershed Association is already working on some of these issues, it could be advantageous to the Phase II municipalities to consider using the Watershed Association as a "vehicle" to meet some of their goals under the Phase II program.

One of the key areas that the Watershed Association can be of assistance is with regard to public outreach and education on stormwater impacts. Representative activities, based on the EPA guidance, could include:

- Classroom stormwater education—including development of curricula for students and teacher training.

- Distribution of targeted stormwater guidance/brochures to business owners and operators.

- Development of a "green certification" program for businesses that adhere to a prescribed set of water quality protection practices or BMPs. Such a program is in place in Boulder (Kaufman 2002). Additionally, a guidance manual for landscape contractors and other Green Industry professionals in Colorado has recently been developed (WWE 2002).

- Development of pamphlets and short articles to be included in local newsletters and utility bills. (Note: During 1999, the Watershed Association worked to have several key brochures developed by the UDFCD reproduced for local governments. Adequate support was not present at the time, but may be present in the future as the Phase II permits come into place.)

- Provide training and information on appropriate lawn and garden practices to minimize pollution. Once again, the Green Industry BMP Manual is an excellent tool for local governments (WWE 2002).

- Identify areas within the watershed in need of pet waste management ordinances or signage alerting owners to pickup after their pets. This may become increasingly important due to bacteria levels in the watershed.

- Continue to hold watershed stakeholder meetings where stormwater protection practices are discussed. Consideration could be given to holding a Watershed Association meeting in the evening in a larger meeting facility. A PowerPoint presentation and the watershed video could be shown, in effect developing a stormwater education curriculum targeted to the specific concerns in Big Dry Creek.

- Work with volunteer organizations such as the Boy Scouts on storm drain stenciling programs. On several occasions, Boy Scout troops have contacted the Watershed Association for potential Eagle Scout projects.

3.2.2 *Facilitation of Cooperative Efforts in Agricultural Area*

The agricultural areas within Big Dry Creek are an asset to the watershed for many reasons (e.g., wildlife corridor, stormwater attenuation); however, in several locations the stream channel is experiencing degradation due to hydrologic modification compounded by cattle trampling the stream banks in some areas. Water quality data for TSS and bacteria also indicate some impacts in the agricultural area.

As previously noted, the Gossenauer and Wachob (2001) study focused on specific portions of the agricultural portion of the watershed, which had been identified through landowners in Watershed Association meetings and in the WWE (2000) study. Based on the findings of these studies, a two-fold approach is needed to stabilize banks including toe slope stabilization combined with protection of the upper portion of bank. In most cases, a combination of riprap placement, bank reshaping, vegetation planting, and exclusionary fencing are needed. Additionally, bank stabilization measures, repairs to roads and culverts, and improvements to ditch diversion structures should be constructed to be stable during the 25-year design storm event (WWE 1999). The Gossenaur and Wachob (2001) and WWE (2000) reports should be referenced for detail on suggested measures and details for specific sites. These reports can be used to support Watershed Association efforts to facilitate cost-share applications for landowners in the agricultural area, as discussed below.

The Watershed Association has been working with the NRCS Brighton Office for the last several years on trying to identify appropriate programs for Big Dry Creek landowners. The NRCS assists private landowners with conservation concerns including soil erosion, water quantity and quality, agronomic issues, wildlife habitat, wetlands, grazing management, nutrient management, pest control, riparian areas, and other related natural resource issues. Most recently, the NRCS reviewed the WWE (2000) and Wachob and Gossenaur (2001) reports. After their review, the NRCS provided suggestions on several cost-share programs believed to be of potential relevance to landowners with eroding property along Big Dry Creek. One critical aspect with regard to these grants is that they must be initiated by the landowners along the creek. The NRCS programs are setup only for voluntary participation and have no regulatory authority. Some of the programs have cost-share incentives, but most of the work is with landowners who request their expertise in proper installation of conservation practices. The NRCS also provides information and education to landowners as to the benefits of conservation practices both environmentally and economically (NRCS 2002).

Some of the potentially appropriate NRCS cost-share programs are listed below with brief descriptions, who is eligible, what the requirements are, how to apply, and current status of the program.

- Environmental Quality Incentives Program (EQIP)—This is a cost-share program in which the government will share up to 75 percent of the cost of installing approved conservation practices to address issues or concerns of landowners or operators. It is a competitive program in which environmental benefit points are assigned, depending on the practices to be applied, and compared to the dollars requested from the government. The proposals with the highest environmental benefits per dollar spent are accepted into the program.

To be eligible for EQIP, the landowner or operator must be considered an agricultural producer as determined by Farm Services Agency (FSA). This program requires the producer to enter into a five- to ten-year contract with the NRCS. Currently, in Colorado, the five conservation issues under which a producer can sign up include water quality, soil erosion, grasslands, wildlife, and animal waste management. Each issue is given an equal portion of the funding allotted to Colorado. Contracts with the best environmental benefits for each issue are accepted until the funds are fully allocated.

The 2002-year signup has been completed, and the official signup for 2003 will be in the fall of 2002, although producers can signup at any time. Funding for the program will depend on the 2002 Farm Bill.

- Conservation Reserve Program (CRP)—This program is designed to take highly erodible land out of production and re-seed it with permanent vegetation. Producers who sign up for this program also compete based on the environmental benefit points associated with their proposal. If selected, the costs associated with the establishment of permanent vegetation receive a 50 percent government cost share. In addition, the government will then provide rental payments for each year of the required 10-year contract. The rental payments cannot exceed the established rental rate which is based on the soil type for the county.

  Landowners or operators may signup land for CRP. The operators must show control of the land for the 10-year contract. The land must be cropland and must have produced a crop two out of the previous five years as determined by FSA. The soil within the land offered into the program must meet a minimum erodibility index. There is a limit on the number of acres that can be enrolled in CRP for any county; currently neither Adams nor Weld counties have reached the maximum acreage.

  There are currently no plans to have a 2002 CRP signup. Again, limited funding from Congress has restricted this program. If funding levels are increased within the 2002 Farm Bill, a signup may be possible in the fall of 2002.

- Continuous Conservation Reserve Program (CCRP)—This program targets the installation of buffers to improve water quality and wildlife habitat. Practices include field buffers, riparian buffers, grassed waterways, field windbreaks and other related practices. This program is not competitive like EQIP or CRP. The government will cost-share the cost of practice installation up to 90 percent. Like CRP, a rental payment will be made each year for the acreage in the contract. The length of the contract can be from 10 to 15 years. There are also some incentive payments for specific practices.

  Land is considered eligible if it is cropland and has produced a crop two out of the previous five years, or if it is marginal pastureland. There are no erodibility index requirements. If the producer and land are eligible, and the practice is feasible, then the land is accepted into the program.

  Currently there is a national push from Washington, D.C., to install two million miles of buffers nation wide. Funding for this program is currently available and signups can be taken at anytime.

- Wetland Reserve Program (WRP)—This program is directed to the enhancement, restoration or creation of wetlands. In this program, installation of practices is cost-shared up to 75 percent. Contracts can be ten years, thirty years or perpetual in length. The ten year contract only cost shares the practices installed. The thirty year contract cost shares practices and pays a percentage of the value of the land as is. The perpetual contract cost shares practices and pays for the full value of the land as is. The thirty-year and perpetual contracts are easements.

  The land must be considered a wetland according to the Army Corps of Engineers definition to be eligible. Some uplands can be included in the contract for diversity. Landowners or operators with control of the land for the length of the contract may apply.

  Funding for WRP has been very good in the past. Although funding has diminished in the last few years, there is still funding available for 2002. Signups can be taken at any time, but will be held until an actual signup is announced. Even though there is funding available for 2002 year, previous signups already in will probably use all that money.

- Emergency Watershed Program (EWP)—This program is specifically targeted for repair of structural practices associated with agriculture immediately after a flood event. It can also be used in emergency circumstances to stabilize structures in imminent danger during a flood event. Once again, this is a cost-share program in which the government provides 75 percent of costs to repair or stabilize damaged structures.

  The landowner or structure owner can apply for EWP within 60 days after a documented flood event. The applicant must have a sponsor such as their Soil Conservation District to guarantee owner share of the payment. In emergency circumstances, the owner can hire an available contractor for stabilization purposes. For repair work, a bid package is prepared and public notice published for contractors to bid on. Work must be done in a scheduled time frame. This program is handled out of the NRCS state office, which would need to be contacted with regard to availability of funds, which are typically available as the need arises after floods.

- Emergency Watershed Program Easement (EWPE)—This is a pilot program under EWP in which the program pays the value of the land where flooding has occurred frequently in the past, resulting in a 99-year perpetual easement. The land in the easement would not be eligible for government programs in the future. The purpose of this program is to eliminate repeated government payments for crop loss or structure damage where frequent flooding occurs.

- Farmland Protection Program (FPP)— This program is designed to help government entities protect prime farmland from development and maintain open space. The government entity applying for funds must already have an existing open space program with funding in place. Funding for this program has not been good. In past years this program has either not been funded or only limited funding was made available. Although the FFP was funded for 2002, the funding is very limited.

- Resource Conservation and Development (RC&D)—This is a unique program that is led by local volunteer councils to help people care for and protect their natural resources. The RC&D program includes these purposes: to promote conservation, development and utilization of natural resources; to improve the general level of economic activity; and to enhance the environment and standard of living in all communities. RC&D is a way for people to work together to plan and carry out activities that will make their areas a better place to live. The program identifies and solves problems in rural communities that include human, economic and environmental issues. The RC&D program is administered by NRCS, which along with other USDA agencies makes available technical and financial assistance to operate and maintain RC&D areas.

  Currently, a goal of the USDA is to have all counties in the United States covered under an RC&D area. Presently, however, the area of the Big Dry Creek watershed is not covered. NRCS is currently undertaking the necessary steps to form an RC&D for the Front Range area. Unfortunately, this is not a very speedy process and could take as long as two or more years to be approved.

3.2.3 *Facilitation of Cooperative Efforts in Urban Area*

The key activities needed in the urban area include streambank stabilization, characterization and reduction of bacterial pollution sources, and education related to stormwater pollution prevention. The educational portion has been previously discussed under Section 3.2.1 and is not repeated below. Similarly, characterization of bacterial pollution sources is discussed in Section 3.2.4.

As discussed in Section 2.3.2, flows measured at the Westminster gage have significantly increased over the last 10-15 years. As part of the WWE (2000) study, several locations were identified as experiencing accelerated erosion. As part of its regular monitoring activities, Watershed Association staff can help alert appropriate jurisdictions of areas that need attention to prevent property and structural damage, habitat degradation and water quality decline. One course of action is for the relevant jurisdiction to work with the UDFCD to correct the problem. In other cases, it may be helpful to obtain a grant from an organization such as GOCO. In any case, good communication with the appropriate municipal and county staff is necessary for effective action to occur. Table 17 identifies several key locations in the urban area that would benefit from stream stabilization and restoration. The table also provides a suggested solution and rough cost estimate.

3.2.4 *Characterization and Reduction of Bacteriological Contributions*

The Watershed Association should work to further characterize bacteriological conditions in Big Dry Creek. Sources of these bacteria are believed to be non-point source in nature, which are not regulated by the discharge permit system like point sources. In "Draft Implementation Guidance for Ambient Water Quality for Bacteria—1986" (EPA 2000), the EPA recommends that a sanitary survey be conducted in areas where elevated bacteria levels are identified. EPA's guidance states the following:

> A sanitary survey is an examination of a watershed to determine if unauthorized sanitary discharges are occurring from sources such as failed septic tank leach fields or cesspools, sewage leakage from broken pipes, sanitary sewer overflows from hydraulically overloaded sewers, or overflows from storm sewers that may contain illegal sanitary sewer connections. The survey should use available public health and public works department's records to identify where such septic tanks and sewer lines exist so that observations are focused in the right places. A sanitary survey might also use dyes or other tracers in both dry and wet weather to see if unauthorized discharges are occurring from septic tanks and sewers. In addition, EPA recommends that sanitary surveys identify other possible sources, including confined animal areas, wildlife watering points and recreation spots, such as dog running/walking areas, since these are also sources of fecal pollution.

Additionally, the Watershed Association may want to expand its monitoring program to include sampling of runoff from various land uses to better identify sources of the elevated concentrations of fecal coliform and *E. coli*.

Once key sources of the bacteria are identified, the Watershed Association should work to reduce these contributions where possible. In the event that Big Dry Creek is reclassified to

Recreation Class 1 uses, it is improbable that any location on the stream will meet the significantly lower stream standards for fecal coliform and *E. coli* under current watershed conditions. If this is the case, the Big Dry Creek Watershed Association will face a significant challenge in working to help the watershed meet this standard. One role that the Watershed Association could play would be in identification of best management practices (BMPs) that could be implemented to reduce contributions of these bacteria to the stream. A simple example would be educating residents on the importance of picking up and disposing of dog waste.

In the event that the stream standard is not attained for fecal coliform or other water quality constituents, the watershed may be subject to the Total Maximum Daily Load (TMDL) process. A TMDL is the maximum amount of a pollutant that a water body can receive and still meet water quality standards. The TMDL is the sum of the allowable load of a single pollutant from all contributing point and non-point sources, including a margin of safety, background conditions and seasonal variation considerations to ensure that the water body can meet the water quality standards. If a stream does not meet its designated water quality standards and becomes listed on the state's "303(d) list," then the process of allocating pollutant loads to sources under a TMDL must be scheduled (EPA 2000). The "303(d) list" of impaired waters is required to be generated by states every two years. Currently, Big Dry Creek is not on the state's 303(d) list and therefore is not subject to the TMDL process; however, this could change in the future, depending on revisions to the stream classifications to Big Dry Creek.

4.0 PHASE III: EVALUATION

Perhaps one of the most successful aspects of the Watershed Association has been its ongoing commitment to monitoring conditions in the watershed in order to provide a scientifically sound basis for decision making and prioritizing actions. The monitoring program, Watershed Association database and evaluation strategy are discussed below.

4.1 Monitoring Program

The monitoring program in the watershed includes both the main stem of Big Dry Creek and Walnut Creek. Additionally, DOE monitors conditions on the Rocky Flats property and the Standley Lake Cities monitor conditions in Standley Lake. The Big Dry Creek main stem and Walnut Creek monitoring programs are discussed below.

4.1.1 *Main Stem of Big Dry Creek*

Table 19 summarizes the locations of the monitoring program in place on Big Dry Creek. Table 20 summarizes the constituents monitored, sampling frequency and test methods used.

Table 19
Big Dry Creek In-stream Monitoring Program 2002

Location (Upstream to Downstream)		Flow	Water Quality	Biological/ Artificial Substrate	Habitat
Site #	**Location**				
0.5	Old Wadsworth Boulevard	**X**	**X**		
1.0	112th and Big Dry Creek	**X**	**X**		
1.5	120th and Big Dry Creek	X	**X**	**X (reference)**	**X**
10.0	Broomfield WWTP		**X**		
2.0	128th and Big Dry Creek	**X**	**X**	**X**	**X**
11.0	Westminster WWTP		**X**		
3.0	I-25 and Big Dry Creek	**X**	**X**	**X**	**X**
4.0	York St. and Big Dry Creek		**X**		
12.0	Northglenn WWTP (rarely discharges/rarely monitored)		**X**		
5.0	Weld County Road 4	**X**	**X**	**X**	**X**
6.0	Weld County Road 23	**X**	**X**	**X**	**X**

Brief descriptions of these monitoring locations include the following:

- bdc0.5: Located in Church Ranch Open Space, downstream from Old Wadsworth Boulevard. This site is the upstream-most aquatic monitoring location along the main stem of Big Dry Creek and is relatively free from anthropogenic influences. For this reason, bdc0.5 was initially used as the "reference" station for purposes of comparing downstream conditions and calculating various metrics which are part of the EPA's Rapid Bioassessment Protocols (EPA 1998).

- bdc1.0: Located downstream of 112th Avenue, also located in a transitional foothills plains stream type.

- bdc1.5B: Located downstream of 120th Avenue, also located in a transitional foothills plains stream type. Slightly further downstream, bdc1.5C was added as a reference site for the biological monitoring because it was considered to be more appropriate as a plains stream reference site.

- bdc2.0: Located upstream from 128th Avenue and downstream of the Broomfield WWTP discharge. This is the first monitoring station located in the reach designated as a plains stream.

- bdc3.0: Located at Interstate 25 and downstream from the Westminster WWTP. This station is located in a channelized reach of Big Dry Creek categorized as a plains stream.

- bdc5.0A/5.0B: Located downstream from Weld County Road 4 in an agricultural area.

- bdc6.0: Located near Wattenberg and Weld County Road 23, upstream from the bridge on Weld County Road 8 in a stream reach also categorized as a channelized plains stream.

Table 20

Big Dry Creek Monitoring Constituents, 2002				
CONSTITUENT/ACTIVITY	FREQUENCY (events/year)	NUMBER OF LOCATIONS	METHOD DESCRIPTION	METHOD NUMBER
Field Measurements				
Flow (Continuous, USGS Contract)	1	2	USGS Gaging Stations	USGS Gaging Stations
Flow (concurrent with WQ sampling)	12	7	Manual field measurments	
pH	12	10	Field meter/Potentiometric	EPA 150.1
Dissolved Oxygen	12	10	Field meter/Membrane Electrode	SM 4500-O G
Temperature	12	10	Field meter/Thermometric	SM 2550
Conductivity	12	10	Field conduuctivity meter	SM 2510 B
Nutrients\Demand				
Biochemical Oxygen Demand	12	10	5-Day BOD Test	SM 5210 B
Phosphorus, Total	12	10	Ascorbic Acid	SM 4500-P E
Orthophosphate	12	10	Automated Ascorbic Acid	EPA 365.1
Ammonia, Total	12	10	Flow Injection Analysis	SM 4500-NH3 H
Ammonia, Unionized	12	10	Calculation	
Nitrate + Nitrite	12	10	Automated Cd Reduction	SM 4500-NO3- F
Nitrite	12	10	Automated Cd Reduction	EPA 353.2
Inorganic/Physical				
Alkalinity	12	10	Titration	SM 2320 B
Turbidity	12	10	Nephelometric	EPA 180.1
Total Suspended Solids	12	10	Gravimetric	SM 2540 D
Total Dissolved Solids	12	10	Gravimetric	EPA 160.1
Total Organic Carbon	12	10	UV-Persulfate	SM 5310 C
Sulfate	12	10	Gravimetric	SM 4500-SO_4^{2-} D
Chloride	12	10	Titration	SM 4500-Cl D
Cyanide, Free	4	10	(Contract)	EPA 335.2
Boron	12	10	ICAP	EPA 200.7
Metals				
Arsenic, total	4	10	GFAA	EPA 200.9
Cadmium, dissolved	4	10	ICAP	EPA 200.7
Calcium, dissolved	12	10	EDTA Titration	SM 3500-Ca D
Chromium (III + IV), dissolved	4	10	ICAP	EPA 200.7
Copper, dissolved	4	10	ICAP	EPA 200.7
Iron, total recoverable and dissolved	12	10	Direct AA	EPA 200.2, SM 3111 B
Magnesium, dissolved	12	10	Direct AA	SM 3111 B
Manganese, dissolved	4	10	ICAP	EPA 200.7
Mercury, Total	4	10	Cold vapor (Contract)	EPA 245.1
Molybdenum, dissolved	4	10	ICAP	EPA 200.7
Nickel, dissolved	4	10	ICAP	EPA 200.7
Lead, dissolved	4	10	ICAP	EPA 200.7
Potassium, dissolved	12	10	Direct AA	SM 3111 B
Selenium, dissolved	12	10	GFAA	EPA 200.9
Silver, dissolved	4	10	ICAP	EPA 200.7
Sodium, dissolved	12	10	Direct AA	SM 3111 B
Zinc, dissolved	4	10	ICAP	EPA 200.7
Hardness, total	12	10	Calculated	SM 2340 B
Biological				
Chlorophyll a	12	10	Spectrophotometric	SM 10200 H
Fecal Coliform	12	10	Membrane Filtration	SM 9222 D
E. coli	12	10	Enzyme Substrate (Colilert)	SM 9223
Fish Population	1	7		RBP
Invertebrates	2	7		RBP, WQF95
Habitat Assessment (Qualitative)	2	7		RBP
Habitat Assessment (Quanitative)	1	7		RBP
Special Studies	1	7		RBP
Artificial Substrates (Invertebrates)	1	6	Hester Dendy Samplers	

Additionally, the Cities of Broomfield, Northglenn, and Westminster have also conducted an aquatic monitoring program since 1997 to document the abundance and distribution of fish and benthic macroinvertebrate populations and to describe the physical habitat at select locations in Big Dry Creek. Objectives of this monitoring program included establishing a database that can ultimately be used to determine appropriate surface water quality standards for Segment 1 of Big Dry Creek and document the effects of potential influences in water quality on the aquatic community. Under the current program, benthic macroinvertebrates are collected in the spring and fall of each year, fish are collected in the fall and habitat data are collected in the spring. Aquatic Associates is the contractor responsible for these activities. The results of the monitoring program to date were discussed in Section 2.3.

4.1.2 *Walnut Creek*

Following the same protocols for biological monitoring as are used on Big Dry Creek, three locations are monitored on Walnut Creek, including:

- D2: downstream from Great Western Reservoir.
- W1: Walnut Creek Open Space, downstream from Wadsworth Blvd.
- W2: Downstream from riprap structure along Highway 36 and east of Church Ranch Blvd.

4.1.3 *Rocky Flats*

Rocky Flats maintains an extensive monitoring program in accordance with the Rocky Flats Clean Up Agreement. These activities are conducted separately from the Watershed Association; however, subsets of these monitoring activities are made available to the Watershed Association for inclusion in the Watershed Association database.

Most of the surface water monitoring is conducted under the Integrated Monitoring Plan (IMP) which describes the various monitoring programs, identifies the analytes of interest, and establishes decision rules using the EPA Data Quality Objective protocols. Water quality data are used for a number of purposes, including permit compliance, gauging the safety of stormwater releases from the Site, and evaluation of remediation efforts (Fiehweg 2002).

In 1999, DOE also expanded monitoring activities at Rocky Flats to include biological monitoring on Walnut Creek. The monitoring is being conducted by Aquatics Associates, the same firm responsible for monitoring on the main stem of Big Dry Creek. The aquatic monitoring program documents existing conditions, the abundance and distribution of fish and benthic macroinvertebrate populations, and physical habitat at select locations in onsite Rocky Flats drainages (Woman Creek, Walnut Creek and Rock Creek). Objectives of the monitoring program are to establish a database that can be used to determine the overall aquatic ecosystem diversity, the appropriate surface water quality standards for Segments 4 and 5 of Big Dry Creek, and document the possible effects of site closure on the aquatic community. Data from the monitoring activities will be combined into a database to provide a more integrated picture of the overall watershed, particularly as the site approaches closure and transition to a wildlife refuge. The data will be used to determine existing conditions, assess the extent and potential causes of aquatic impairment, and appropriate water quality standards for the entire Big Dry Creek watershed (Stover 2002).

Fish and benthic macroinvertebrate sampling and an assessment of physical habitat were performed at onsite locations in the fall of 2001. The fall 2001 biological sampling and physical habitat assessment will establish onsite baseline conditions. In future years, habitat assessments to update the baseline will be conducted during the spring. Biological samples will be collected at ten locations during the spring, summer, and fall. The sampling dates will be consistent with previous sampling efforts for data comparability. The results of biological and physical habitat monitoring conducted in 2001 will be summarized and presented in one report. The scope of work for biological monitoring at Rocky Flats can be obtained for more detail on study methods, which are consistent with the approach being used on the main stem of Big Dry Creek. It is intended that the aquatic monitoring program will continue on an annual basis through Site Closure from 2001 to 2006; however, continuation of the work is dependent upon future funding (Stover 2002).

4.1.4 *Watershed Association Database and Data Analysis*

Data collected under the cities' monitoring program are entered into a master database following QA/QC by the steering committee. This database is currently in Microsoft Access. On an annual basis, the water quality data are retrieved from the database and compared to CWQCC stream standards to assess whether the stream is attaining stream standards. Trends regarding water quality and flow are identified and discussed in an annual technical memorandum presented at a Watershed Association meeting and are subsequently summarized in a Watershed Association newsletter.

Additionally, data stored in the Watershed Association database have been provided to the CWQCD on several occasions in support of development of the state's 303(d) list and development of preliminary effluent limits for municipal wastewater discharges in the watershed.

4.2 Strategy for Monitoring Progress, Revising Plan and Identifying Future Actions

On an annual basis, the Watershed Association reviews and discusses the following:

- Mission and goals—Is the Association on track with defined mission and goals? Have goals changed? Have priorities changed?
- Monitoring program—Are monitoring constituents, frequencies or methods appropriate?
- Water quality data analysis results—Do results indicate a source of pollution that needs to be identified and mitigated? Are additional analyses needed and is QA/QC adequate?
- Special projects—Based on the results and discussion of the issues, are special projects or studies needed? Should specific grants be pursued?

Each Watershed Association meeting includes follow-up written meeting minutes to help the group track its process. In most years, funding permitting, one or more written documents is prepared that can also be used as a tool to track progress.

5.0 CONCLUSIONS/RECOMMENDATIONS

Key findings and recommendations of this Plan include:

1. As a result of the diligent efforts of the Watershed Association, many aspects of Big Dry Creek are relatively well characterized. The on-going water quality, flow and biological monitoring program continues to provide up-to-date information on watershed conditions that can be used to target and prioritize future actions in the watershed.

2. Based on water quality data collected to date, wastewater discharges to the creek appear to be adequately controlled by the Colorado Discharge Permit System.

3. Hydrologic modification of the creek from increased stormwater flows related to urbanization will require continued attention by local governments and the Watershed Association. In both the urban and agricultural portions of the watershed, specific areas have been identified that would benefit from stream restoration activities.

4. Local government enforcement of existing stormwater ordinances relating to detention of stormwater flows and erosion and sediment controls at construction sites is critical to protecting Big Dry Creek water quality and habitat. In general, the local governments are believed to have appropriate ordinances in place for new development and redevelopment of existing areas.

5. Stormwater flows and pollutant contributions have not been well characterized, relative to the strong base of information associated with ambient stream conditions. This is an area of additional study that the Watershed Association may want to consider.

6. Based on analysis of the last five years of data, Big Dry Creek meets existing stream standards for all constituents. Although the stream meets Recreation Class 2 fecal coliform and *E. coli* standards, it would have considerable difficulty meeting Recreation Class 1 standards in the event that the stream is reclassified.

7. Considerable data have been collected on erosion and sedimentation issues in the agricultural portion of the watershed. Sufficient information is believed to have been developed to

support local landowners in obtaining grants to help stabilize portions of the streambank. Based on information provided by the NRCS, it is critical that the landowner initiates the grant application process. The Watershed Association can provide the landowners with a good base of information to help facilitate this process.

8. The Phase II stormwater regulation emphasizes the watershed approach and collaborative efforts to reduce pollution associated with stormwater discharges. The Watershed Association should meet with local government staff and managers responsible for implementation of the Phase II permits in the near future to determine what role the Watershed Association will play in helping the cities to meet the requirements of the regulation.

9. The Watershed Association should continue its public education efforts such as development of a watershed educational video, newsletters and other products. It is important that the Watershed Association work with local governments to take advantage of existing communication pathways to broaden its audience. For example, the Watershed Association should consider providing short articles for distribution to local governments for inclusion in local newsletters and utility bills.

10. The current monitoring and evaluation process used to evaluate the mission and goals, monitoring program, water quality and biological data should be continued.

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FIGURES