E. COLI TOTAL MAXIMUM DAILY LOAD FOR CROW CREEK, LARAMIE COUNTY, WYOMING

Topical Report RSI-2280

prepared for

Wyoming Department of Environmental Quality
Water Quality Division
122 West 25th Street
Herschler Building 4-W
Cheyenne, Wyoming 82002

September 2013

RESPEC
CONSULTING & SERVICES

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Topical Report RSI-2280

by

Cory S. Foreman
Seth J. Kenner
Eric L. Krantz
Cindie M. McCutcheon

RESPEC
P.O. Box 725
Rapid City, South Dakota 57709

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Wyoming Department of Environmental Quality
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Total Maximum Daily Load Summary	
Waterbody Name/Description	Crow Creek (from Roundtop Road to directly downstream of the confluence with Dry Creek)
Assessment Unit I.D.	Reach_01 (WYSP101900090107_02 through WYSP101900090107_05 and approximately 3 miles of WYSP101900090107_1)[a]
Length of Impaired Waterbody	13.6 miles (21.8 kilometers)
Size of Watershed	434.1 square miles (1,124.3 square kilometers)
Size of Project Area	257.5 square miles (666.9 square kilometers)
Size of Impairment Watershed	95.6 square miles (247.6 square kilometers)
Location	10-digit Hydrologic Unit Code: 1019000902
Impaired Designated Use(s)	Primary contact recreation
303(d) Listing Parameter	Fecal coliform bacteria (Total Maximum Daily Load [TMDL] is in terms of *E. coli*)
Cycle Most Recently Listed	2012 Wyoming Integrated Report
Total Maximum Daily Load Priority Ranking	2010 (Wyoming Priority Rankings are TMDL Dates)
Total Maximum Daily Load Criteria Threshold Values	Indicator Name: *E. coli* bacteria Threshold Values: A geometric mean of at least five samples obtained during separate 24-hour periods over a 30-day period 126 organisms per 100 milliliters (org/100 mL) from May through September (summer recreation season) and 630 org/100 mL from October through April (winter recreation season)
Analytical Approach	Load Duration Curves and **HSPF** modeling

TMDL Component (cfu[b] × 10^9/day)		**Flow Zone**									
		High		**Moist**		**Midrange**		**Dry**		**Low**	
		> 106 cfs		**106–53 cfs**		**53–45 cfs**		**45–37 cfs**		**< 37 cfs**	
LA		122		44		17		10		4	
WLA	**MS4**	485	404	225	144	136	55	115	34	94	13
	PSA		81		81		81		81		81
MOS		143		39		10		14		16	
TMDL		750		308		163		139		114	

(a) Refer to Appendix A for further information on segmentation of Crow Creek

(b) cfu = colony-forming units

Total Maximum Daily Load Summary	
Waterbody Name/Description	Crow Creek (from Missile Road [Highway 217] upstream to directly downstream of the confluence with Dry Creek)
Assessment Unit I.D.	Reach_02 (WYSP101900090203_01 and approximately 6.4 miles of WYSP101900090107_01)[(a)]
Length of Impaired Waterbody	16.2 miles (26.1 kilometers)
Size of Watershed	434.1 square miles (1,124.3 square kilometers)
Size of Project Area	257.5 square miles (666.9 square kilometers)
Size of Impairment Watershed	35.5 square miles (91.9 square kilometers)
Location	10-digit Hydrologic Unit Code: 1019000905
Impaired Designated Use(s)	Primary contact recreation
303(d) Listing Parameter	Fecal coliform bacteria (Total Maximum Daily Load [TMDL] is in terms of *E. coli*)
Cycle Most Recently Listed	2012 Wyoming Integrated Report
Total Maximum Daily Load Priority Ranking	2010 (Wyoming Priority Rankings are TMDL Dates)
Total Maximum Daily Load Criteria Threshold Values	Indicator Name: *E. coli* bacteria Threshold Values: A geometric mean of at least five samples obtained during separate 24-hour periods over a 30-day period 126 organisms per 100 milliliters (org/100 mL) from May through September (summer recreation season) and 630 org/100 mL from October through April (winter recreation season)
Analytical Approach	Load Duration Curves and **HSPF** modeling

TMDL Component (cfu[(b)] × 10^9/day)	**Flow Zone**				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 84 cfs	**84–28 cfs**	**28–20 cfs**	**20–11 cfs**	**< 11 cfs**
LA	564	196	74	45	17
WLA	0	0	0	0	0
MOS	153	42	11	14	16
TMDL	717	238	85	59	33

(a) Refer to Appendix A for further information on segmentation of Crow Creek
(b) cfu = colony-forming units

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1.0 INTRODUCTION

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency (EPA) Water Quality Planning and Management Regulations (40 CFR 130) requires states to develop Total Maximum Daily Loads (TMDLs) for waterbodies not meeting applicable water-quality standards or guidelines for the protection of designated uses under technology-based controls. TMDLs specify the maximum pollutant amount a waterbody can receive and still meet water-quality standards. Based on a calculation of the total allowable load, TMDLs allocate pollutant loads to sources and incorporate a margin of safety (MOS). TMDL pollutant load reduction goals for significant sources provide a scientific basis for restoring surface water quality by linking the development and implementation of control actions to the attainment and maintenance of water-quality standards and designated uses.

The intent of this report is to clearly identify the components of a TMDL, support and document adequate public participation, and facilitate the EPA review. This TMDL was developed according to Section 303(d) of the federal Clean Water Act and EPA guidelines and addresses the *E. coli* impairment in the Crow Creek Watershed. The impaired waterbodies are classified as Class 2AB and 2C in the Wyoming Water Quality Assessment and Impaired Waters List [Wyoming Department of Environmental Quality, 2008a]. Dry Creek and Clear Creek, which are tributaries to the mainstem-impaired waterbodies, are classified as Class 3B in the Wyoming Water Quality Assessment and Impaired Waters List [Wyoming Department of Environmental Quality, 2008a].

Multiple other TMDLs are being developed for Crow Creek, including selenium and sediment TMDLs. The 2009 assessment of Crow Creek by the Wyoming Department of Environmental Quality (WDEQ) monitoring group assessed all designated uses of Crow Creek except for the scenic value. The scenic value was not assessed, because the state of Wyoming currently does not have a methodology to assess it. The suite of TMDLs (*E. coli*, sediment, and selenium) addresses the achievement of all assessed designated uses of Crow Creek and, together, will allow for the achievement of the water-quality standards.

The Wyoming Department of Environmental Quality [2007] states that:

> Class 2AB waters are those known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water use is otherwise attainable. Class 2AB waters include all permanent and seasonal game fisheries and can be either “cold water” or “warm water” depending on the predominance of cold-water or warm-water species present. All Class 2AB waters are designated as cold-water game fisheries unless they are identified as a warm-water game fishery by a “ww” notation in the “Wyoming Surface Water Classification List.” Unless it is shown otherwise, these waters are presumed to have sufficient water quality and quantity to support drinking water supplies and are

protected for that use. Class 2AB waters are also protected for nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value uses.

Class 2C waters are those known to support or that have the potential to support only nongame fish populations or spawning and nursery areas at least seasonally (including their perennial tributaries and adjacent wetlands). Class 2C waters include all permanent and seasonal nongame fisheries and are considered "warm water." Uses designated on Class 2C waters include nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value.

Class 3B waters are tributary waters (including adjacent wetlands) that do not support fish populations or drinking water supplies and where those uses are not attainable. Class 3B waters are intermittent and ephemeral streams with sufficient hydrology to normally support and sustain communities of aquatic life, including invertebrates, amphibians, or other flora and fauna that inhabit waters of the state at some stage of their life cycles. In general, Class 3B waters are characterized by frequent linear wetland occurrences or impoundments in, or adjacent to, the stream channel over its entire length. Such characteristics will be a primary indicator used in identifying Class 3B waters.

Modeling bacteria concentrations and developing TMDLs for the entire watershed will provide a framework for the WDEQ and watershed managers on which to base management decisions. TMDLs will also provide reasonable assurance that bacteria impairments will be addressed by continued best management practice (BMP) implementation and that future impairments will be readily addressed with an in-place model and TMDL. Furthermore, the TMDLs will protect the designated uses and will not impair or threaten other designated uses assigned to these waterbodies.

1.1 CLEAN WATER ACT SECTION 303(D) LISTING INFORMATION

This TMDL project was initiated before finalizing the 2010 integrated report [Wyoming Department of Environmental Quality, 2010], and it is, therefore, based on the 2008 integrated report impairments. In the 2008 integrated report, two stream segments on Crow Creek downstream of the confluence of North Fork and Middle Fork Crow Creek were listed as nonsupportive of recreational use because of elevated *E. coli* concentrations. The first 2008 303(d) listed segment, WYSP101900090107_01, was defined as Crow Creek from Dry Creek upstream an undetermined distance above Roundtop Road. The second 2008 303(d) listed segment, WYSP101900090203_01, was defined as Crow Creek from Dry Creek an undetermined distance downstream. Designated uses and causes of impairment from the 2008 integrated report are shown in Table 1-1. An additional *E. coli* impairment exists in the 2008 integrated report on the North Branch North Fork Crow Creek (WYSP101900090104_01), but was not addressed in this TMDL. Similarly, an additional *E. coli* impairment was added to the 2010

integrated report on the Middle Fork Crow Creek (WYSP101900090101_01), which was also not addressed in this TMDL.

Table 1-1. 2008 303(d) Impaired Waterbodies Summary

I.D.	Class	Location	Uses	Cause	Source	List Date
WYSP101900090107_01	2AB	From Dry Creek upstream an undetermined distance above Roundtop Road	Recreation	*E. coli*	Stormwater	1996
WYSP101900090203_01	2C	From Dry Creek an undeter-mined distance downstream	Recreation	*E. coli*	Unknown	1996

In the 2010 integrated report, the impairment was changed from *E. coli* to fecal coliform, and the two 2008 segments were joined (WSP101900090107_01) and given an upstream endpoint (Roundtop Road) and a downstream endpoint (Missile Road-Hwy 217) [Wyoming Department of Environmental Quality, 2010]. For the purposes of this TMDL, the impaired stream segments from the 2008 integrated report will be used with the upstream and downstream endpoints designated in the 2010 integrated report. These segments are referred to as Reach_01 (defined as Crow Creek from Roundtop Road to directly downstream of the city below the confluence with Dry Creek (including Dry Creek Watershed) and Reach_02 (defined as Crow Creek from immediately downstream of the confluence with Dry Creek to Missile Road [Hwy 217]). The drainage area directly contributing to Reach_01 is approximately 95.6 square miles and the area directly contributing to Reach_02 is approximately 35.5 square miles. The drainage area above Reach_01 within the project area is approximately 51.3 square miles, and the drainage area above the project area (North Fork and South Fork Crow Creek) is approximately 176.6 square miles. Therefore, the cumulative drainage area at the endpoint of Reach_01 is 323.5 square miles, and the cumulative drainage area at the endpoint of Reach_02 is 359.0 square miles. Approximately 75.1 square miles of the project area are located below the endpoint of Reach_02 above the Wyoming/Colorado border. Figure 1-1 depicts a map of the project area and specific reaches, and Table 1-2 lists reach delineations as determined by the WDEQ for the purposes of this TMDL document. The project area for this document, shown in Figure 1-1, is defined as the area draining to Crow Creek from the confluence of North Fork Crow Creek and Middle Fork Crow Creek to the Wyoming/Colorado state line. Through discussions with the WDEQ on addressing bacteria impairments, it was decided that the TMDL would be calculated using *E. coli* concentrations instead of fecal coliform for the following two reasons: (1) almost all historic data collection in Crow Creek was for *E. coli* (fecal coliform sample collection was discontinued in 2004), and (2) the current bacteria standard in Wyoming is for *E. coli*; there is not a standard for fecal coliform. Fecal coliform data were not used in the TMDL calculation.

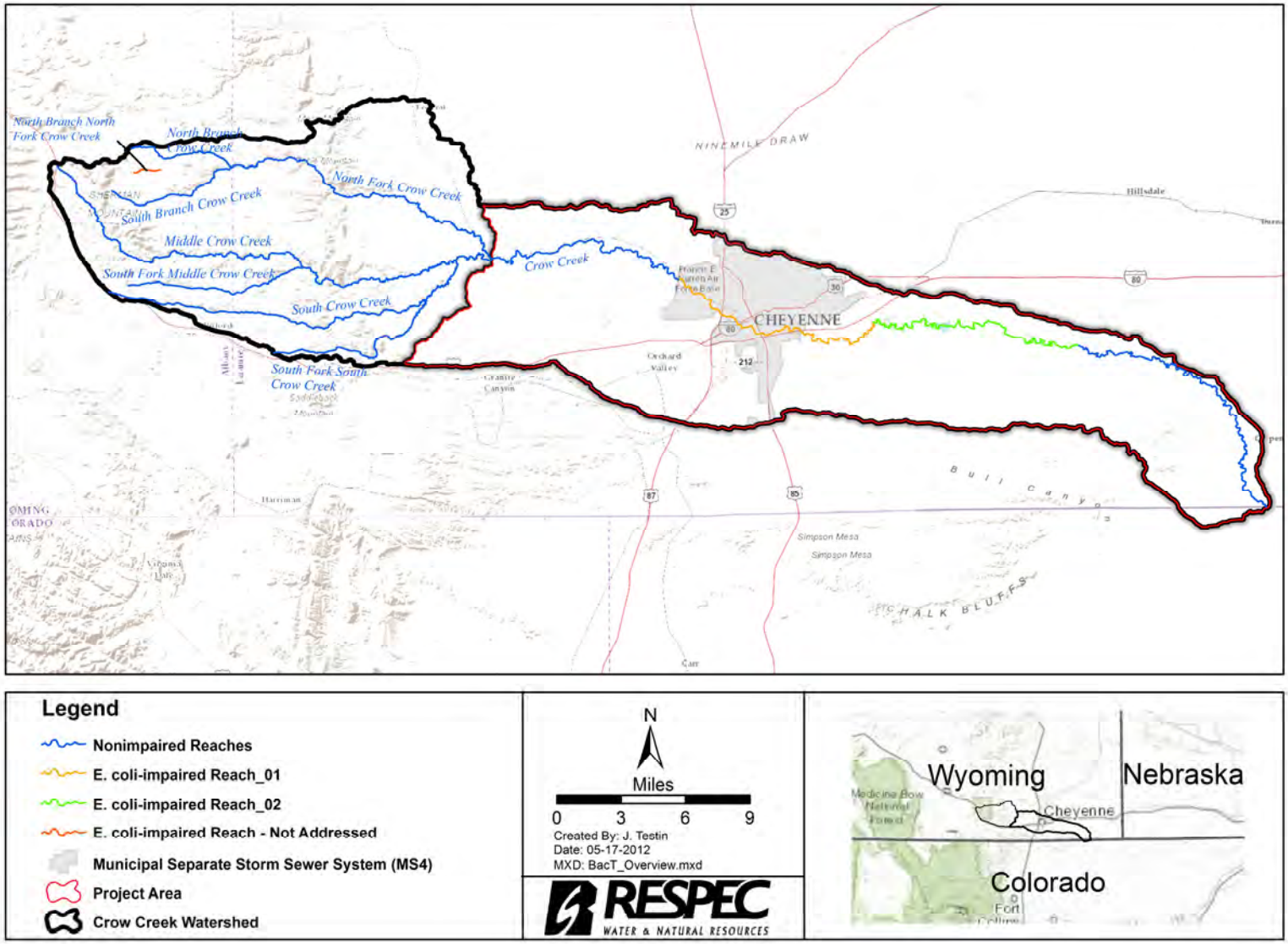

Figure 1-1. Crow Creek Project Area and *E. coli*-Impaired Reaches.

Table 1-2. *E. coli*-Impaired Reach Definitions

Wyoming Department of Environmental Quality Reach	Reach I.D.	Miles	Upstream Endpoint	Downstream Endpoint
WSP101900090107_01	Reach_01	13.6	Roundtop Road	Immediately downstream of confluence with Dry Creek
WYSP101900090203_01	Reach_02	16.2	Immediately downstream of confluence with Dry Creek (endpoint of Reach_01)	Missile Road (Hwy 217)

The Wyoming 2012 303(d) list changed dramatically from the 2010 list. It was broken from a single reach (from Missile Road upstream to Roundtop Road) impaired for fecal coliform to six reaches. One was impaired for fecal coliform and the rest were changed back to *E. coli* impairments. Bacteria-impaired reaches from the 2012 303(d) list are listed below from upstream to downstream:

- From Happy Jack Road Upstream to Roundtop Road (*E. coli*)
- From Morrie Avenue upstream to Happy Jack Road (*E. coli*)
- From Morrie Avenue to a point 0.7 mile downstream (*E. coli*)
- From 0.7 mile below Morrie Avenue downstream to the inlet of Hereford Reservoir #1 (*E. coli*)
- From the inlet of Hereford Reservoir #2 upstream to the outlet of Hereford Reservoir #1 (fecal coliform)
- From Missile Road (Hwy 217) upstream to the outlet of Hereford Reservoir #2 (*E. coli*).

TMDL Reach_01 includes the 2012 303(d) listed segments WYSP101900090107_05 (from Happy Jack Road upstream to Roundtop Road), WYSP101900090107_04 (from Morrie Avenue upstream to Happy Jack Road), WYSP101900090107_03 (from Morrie Avenue to a point 0.7 mile downstream), WYSP101900090107_02 (from 0.7 mile below Morrie Avenue downstream to the inlet of Hereford Reservoir #1), and approximately 3 miles of WYSP101900090107_01 (from the inlet of Hereford Reservoir #2 upstream to the outlet of Hereford Reservoir #1). TMDL Reach_02 includes approximately 6.4 miles of the 2012 303(d) listed segment WYSP101900090107_01 as well as segment WYSP101900090203_01 (from Hereford Reservoir #2 downstream to Missile Road). Additional information on the segmentation of Crow Creek is provided in Appendix A.

Reaches were broken differently for this TMDL, because Reach_01, which falls above the natural breakpoint at the Dry Creek confluence, contains all of the municipal separate storm sewer system (MS4) and wastewater treatment plant (WWTP) discharges; whereas, Reach_02 is

much less developed. Also, individual TMDLs and Load Duration Curves (LDCs) for each of the six 2012 listed segments (some of which are very short) were not ideal for this TMDL because they lack sufficient flow data, water-quality data, and unique sources within each segment. One of the six 2012 segments listed for *E. coli* was listed for a selenium impairment in 2012 (WYSP101900090107_02), and three of the six 2012 segments were listed for sediment impairments in 2012 (WYSP101900090107_02, WYSP101900090107_03, and WYSP101900090107_04). These impairments are being addressed in two separate TMDL documents (a Crow Creek Selenium TMDL and a Crow Creek Sediment TMDL).

The *E. coli*-impaired reaches have a primary contact recreation designated use. For primary contact recreation waterbodies, the summer recreation season criterion, applicable from May 1 through September 30, is defined as a geometric mean of 126 organisms per 100 milliliters (org/100 mL) based on a minimum of five samples collected during separate 24-hour periods for any 30-day period. From October 1 through April 30, the winter recreation season criteria apply, which are defined as a geometric mean of 630 org/100 mL based on a minimum of five samples obtained during separate 24-hour periods for any 30-day period. Three different units are used throughout this report to keep consistency with criteria, data, and regulations. The standards are written in units of org/100 mL, *E. coli* data are generally reported in most probable number per 100 milliliters (mpn/100 mL) or colony-forming units per 100 milliliters (cfu/100 mL), and the TMDL was written in cfu/100 mL. These units are analogous. These criteria apply to Crow Creek, Dry Creek, and Clear Creek in the project area; however, the criteria do not apply to storm drains in the city of Cheyenne.

According to the Wyoming Department of Environmental Quality [2007], "a single sample maximum value may be used to post recreational use advisories in public recreation areas and to derive single sample maximum effluent limitations on point-source discharges." The document also states "an exceedance of the single sample maxima shall not be cause for listing a waterbody on the State 303(d) list or development of a TMDL or watershed plan." The single sample maximum concentrations depend on whether or not the recreational use for the waterbody is a high-use swimming area; a moderate-use, full-body-contact area; a lightly used, full-body-contact area; or an infrequently used, full-body-contact area. However, because exceedance of the single sample maxima cannot cause a 303(d) impairment, the TMDL focuses on the geometric mean criterion and does not address the single sample maximum. Other applicable water-quality standards in these Class 2AB and Class 2C stream segments are summarized in *Water Quality Rules and Regulations* [Wyoming Department of Environmental Quality, 2007].

1.2 WATERSHED CHARACTERISTICS

The Crow Creek Watershed (Hydrologic Unit Code [HUC] 10190009) is located in Laramie County in the southeastern part of Wyoming. The headwaters of Crow Creek originate in Albany County. Crow Creek begins at the confluence of North Fork Crow Creek and Middle Fork Crow Creek approximately 8.5 miles west of Cheyenne, Wyoming. Crow Creek flows east

to southeast to its confluence with the South Platte River in Colorado. The project area for this TMDL study is in the Crow Creek Watershed near Cheyenne (Figure 1-1).

The Crow Creek project area is represented by suburban, urban, industrial, and grazing areas in and around the city of Cheyenne. Water quality is suspected to be influenced by urban stormwater runoff, water treatment facilities, and industrial facilities. Above and below the project area, land use is primarily characterized by dryland farming, irrigated farming, industry, livestock grazing, and small housing developments. Water-quality influences in the project area are grazing, irrigation, small housing developments, industry, and stormwater carryover [Laramie County Conservation District, 2008].

1.2.1 Land Cover/Land Use

A summary of land cover/land use was completed using the 2001 National Land Cover Dataset (NLCD). The NLCD is a 16-category multilayer land cover classification dataset derived from Landsat imagery and ancillary data that provides consistent land cover data for all 50 states [Multi-Resolution Land Characteristics Consortium, 2001]. As shown in Figure 1-2, approximately 81 percent of the land cover/land use of the Crow Creek Watershed project area consists of herbaceous grasslands with the remaining areas consisting of cultivated crops, developed land, and other small land uses. Land use for the Crow Creek Watershed project area is provided in Table 1-3. Cheyenne is the only large urban area in the watershed with a population of 60,000 and an incorporated area of approximately 45 square miles.

1.2.2 Precipitation

Precipitation varies throughout the state of Wyoming but is generally consistent throughout the Crow Creek project area. Typically, annual precipitation is between 13 and 17 inches per year and is illustrated in Figure 1-3. A majority of the precipitation generally occurs in the spring and early summer months.

1.2.3 Irrigation

The largest consumptive use of water (approximately 80 to 85 percent) in Wyoming is from agricultural irrigation, and the primary source is surface water. Irrigation waters from surface sources in the watershed are mainly from South Crow Creek via the Gilchrist #4 Diversion (14 miles west of Cheyenne), which has a permitted conveyance of 37.5 cubic feet per second (cfs). A number of smaller irrigation diversions are also in the watershed [Wyoming State Water Plan Platte River Basin Water Atlas, 2010].

1.2.4 Geology and Soils

The study area is located in the Denver Basin immediately east of the Laramie Mountains. In general, this area consists almost entirely of Tertiary- and Quaternary-age deposits. These deposits were derived from sediment that was eroded off the Laramie Mountains after the mountains were uplifted as part of the Laramide orogeny approximately 60 million years ago. The bedrock geology is displayed in Figure 1-4.

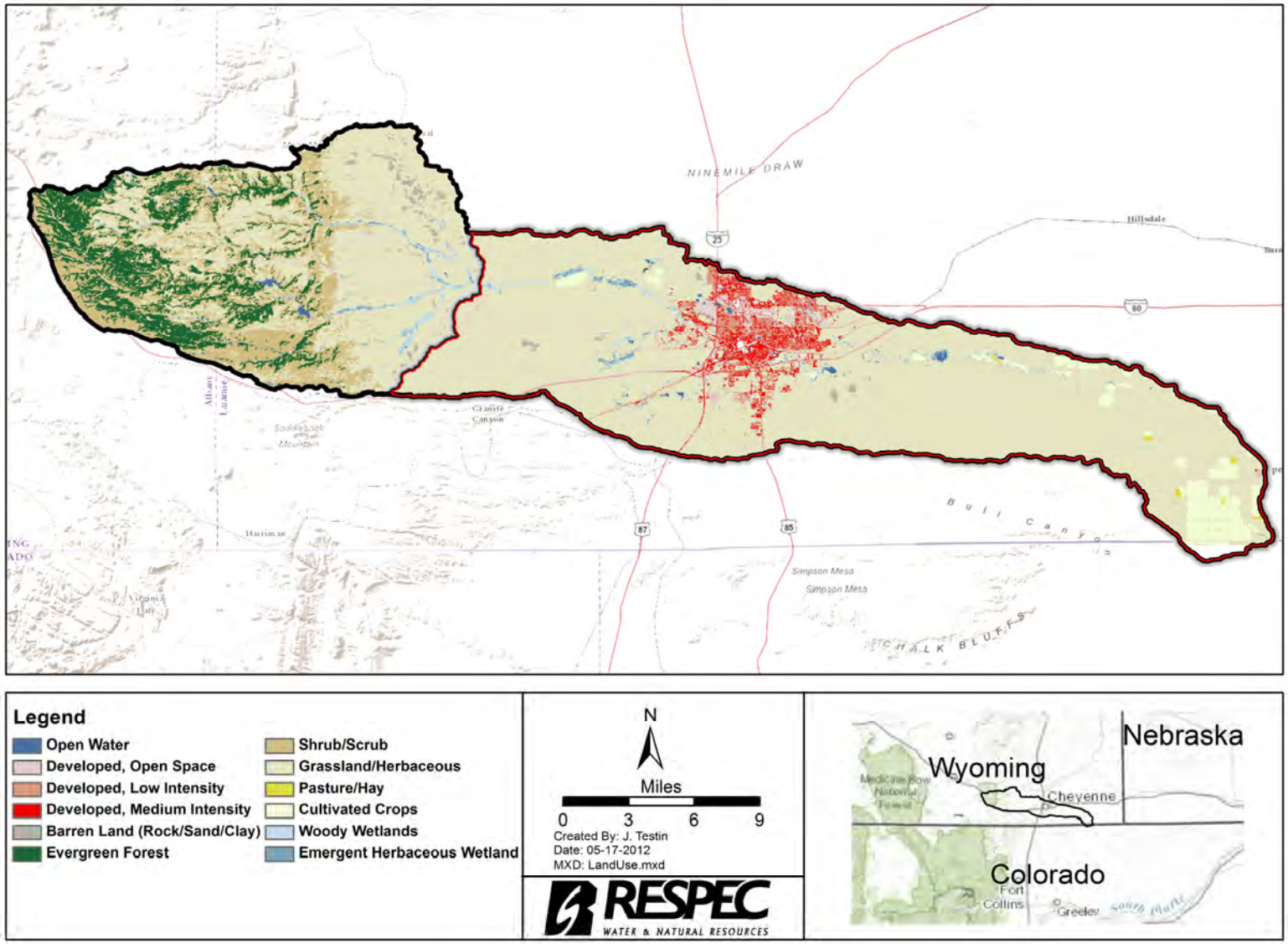

Figure 1-2. Predominant Land Cover/Land Use.

Table 1-3. Land Use by National Land Cover Dataset Category in the Project Area

NLCD Land Use Category	Area (mi^2)	Percent of Total
Grassland, Herbaceous	208.5	80.9
Cultivated Crops	12.5	4.9
Developed, Low Intensity	11.5	4.4
Developed, Open Space	9.7	3.8
Developed, Medium Intensity	6.9	2.7
Other	8.4	3.3
Total	**257.5**	**100**

Approximately 90 percent of the watershed is underlain by the Ogallala Formation (Tmu) deposited in the Upper Miocene. These rocks primarily consist of light-colored claystone, sandstone, and gravel conglomerate. Additionally, several volcanic ash deposits are in the upper sequences of the Ogallala Formation. The formation was deposited in a complex, alluvial sequence with inherent heterogeneity, although most clasts are locally derived.

Two small areas of exposed Tertiary White River Formation (Twr) exist at the east and west ends of the watershed. The White River Formation is predominantly composed of pale-to-white, tuffaceous claystone and sandstone. Thin Quaternary alluvial and gravel deposits (Qt) are also present at the easternmost edge of the watershed.

Soil properties were also examined, because soil type can affect hydrologic processes such as infiltration, surface runoff, interflow, groundwater storage, and deep groundwater losses. Of the available soil data, an approximated 87 percent of the watershed is classified with a hydrologic soil group (HSG) of B, which is characterized as having a moderately low runoff potential. The soil erodibility factor (kfact) was largely unavailable for the watershed. The area-weighted kfact of available data was 0.25, which indicates that the soils are moderately susceptible to detachment.

1.3 SUMMARY OF AVAILABLE FLOW DATA

Figure 1-5 illustrates all of the monitoring sites throughout the project area and Figure 1-6 shows the monitoring sites within the city. The available U.S. Geological Survey (USGS) flow data are provided in Table 1-4. The associated project I.D. for each USGS I.D. is referenced in Table 1-4. The USGS collected daily average discharge (called out in the “type” column of Table 1-4) at Sites CRC100 and CRC300 from March 1994 through September 1996 and at Site CRC400 from October 1993 through the present. Any flow data collected by the USGS at other sites outside of the listed time periods were instantaneous samples. Beginning in 2010,

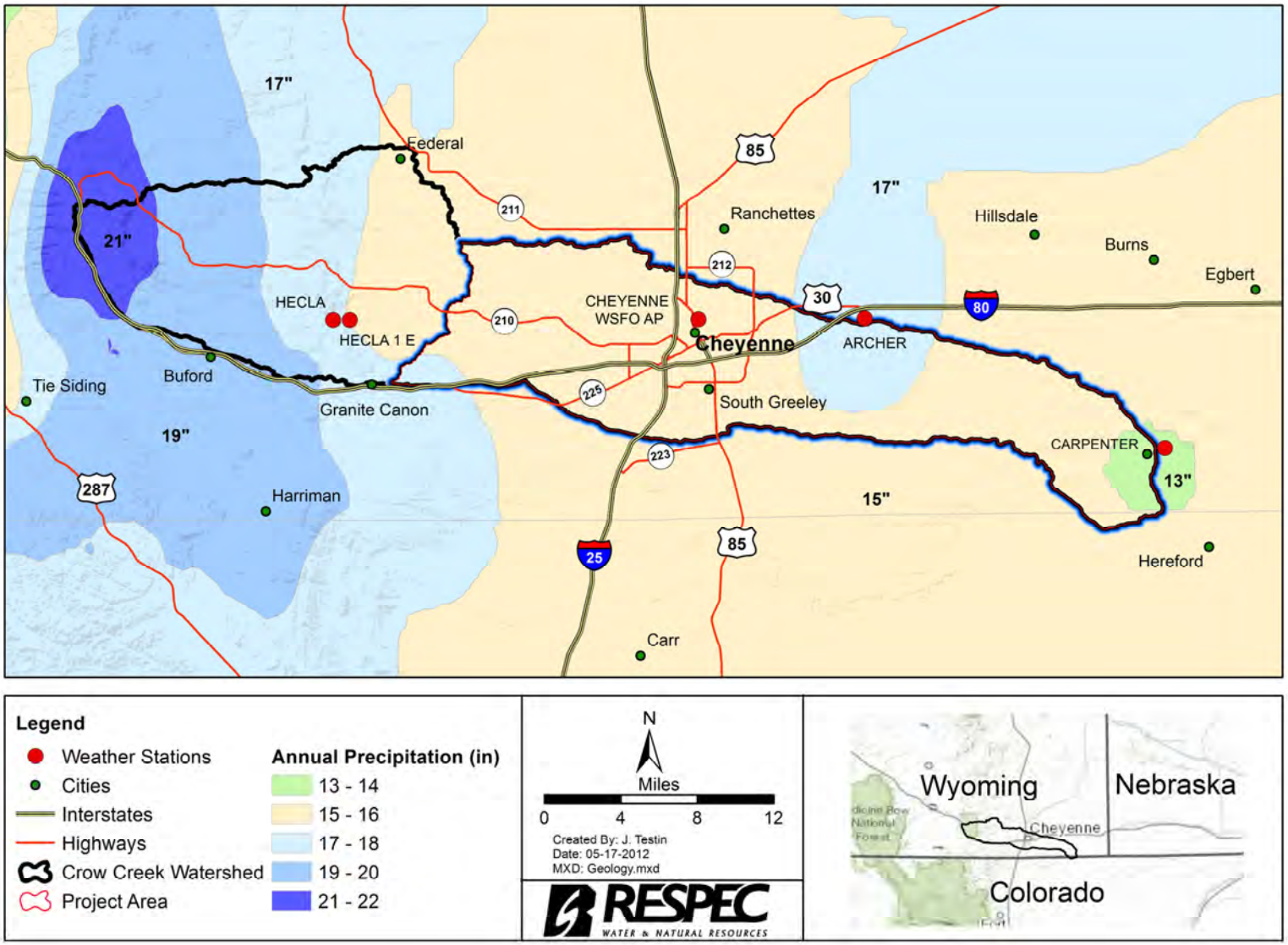

Figure 1-3. Average Annual Precipitation in the Project Area [Natural Resources Conservation Service, 2011].

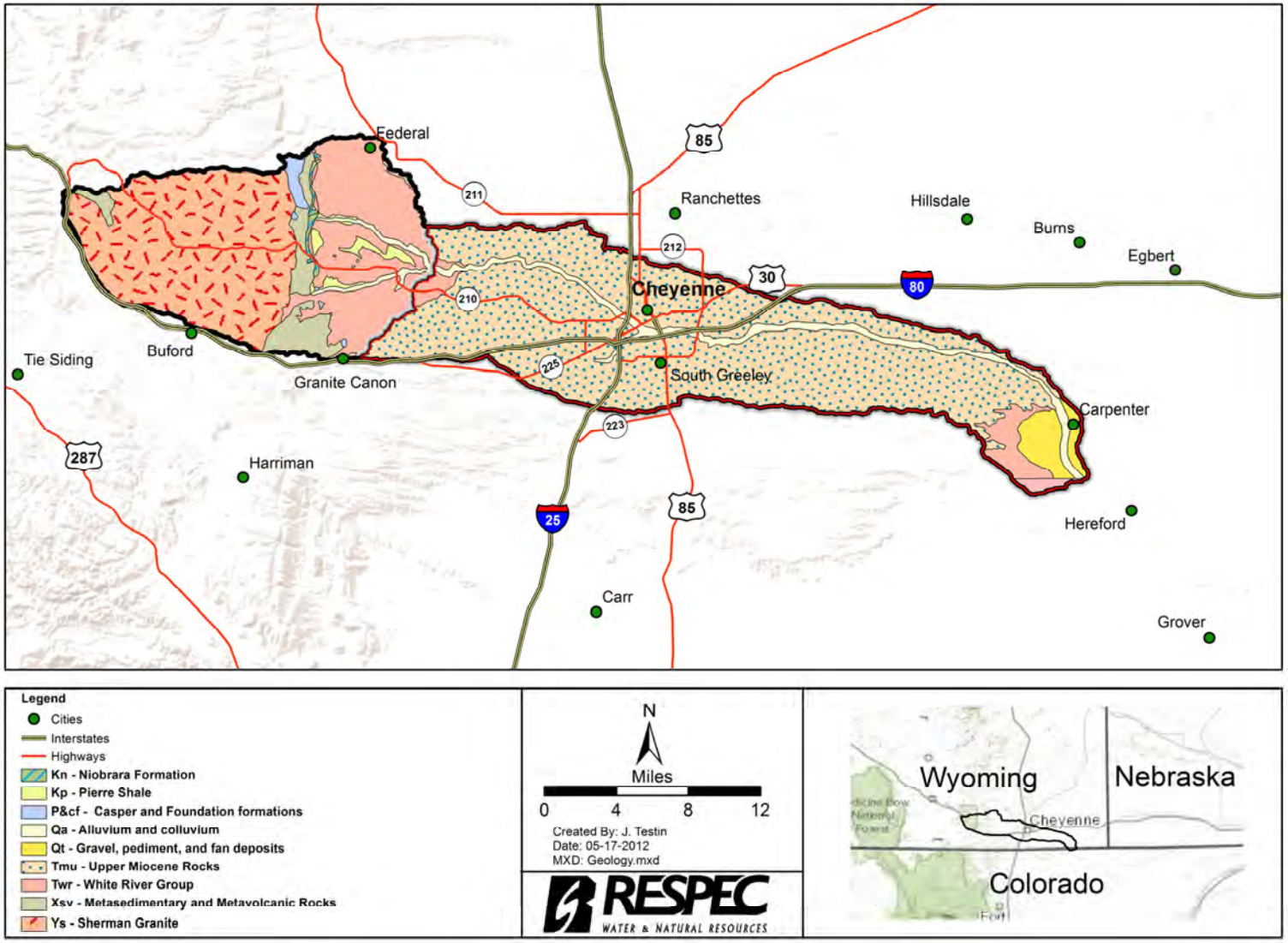

Figure 1-4. Bedrock Geology Distribution in the Crow Creek Watershed.

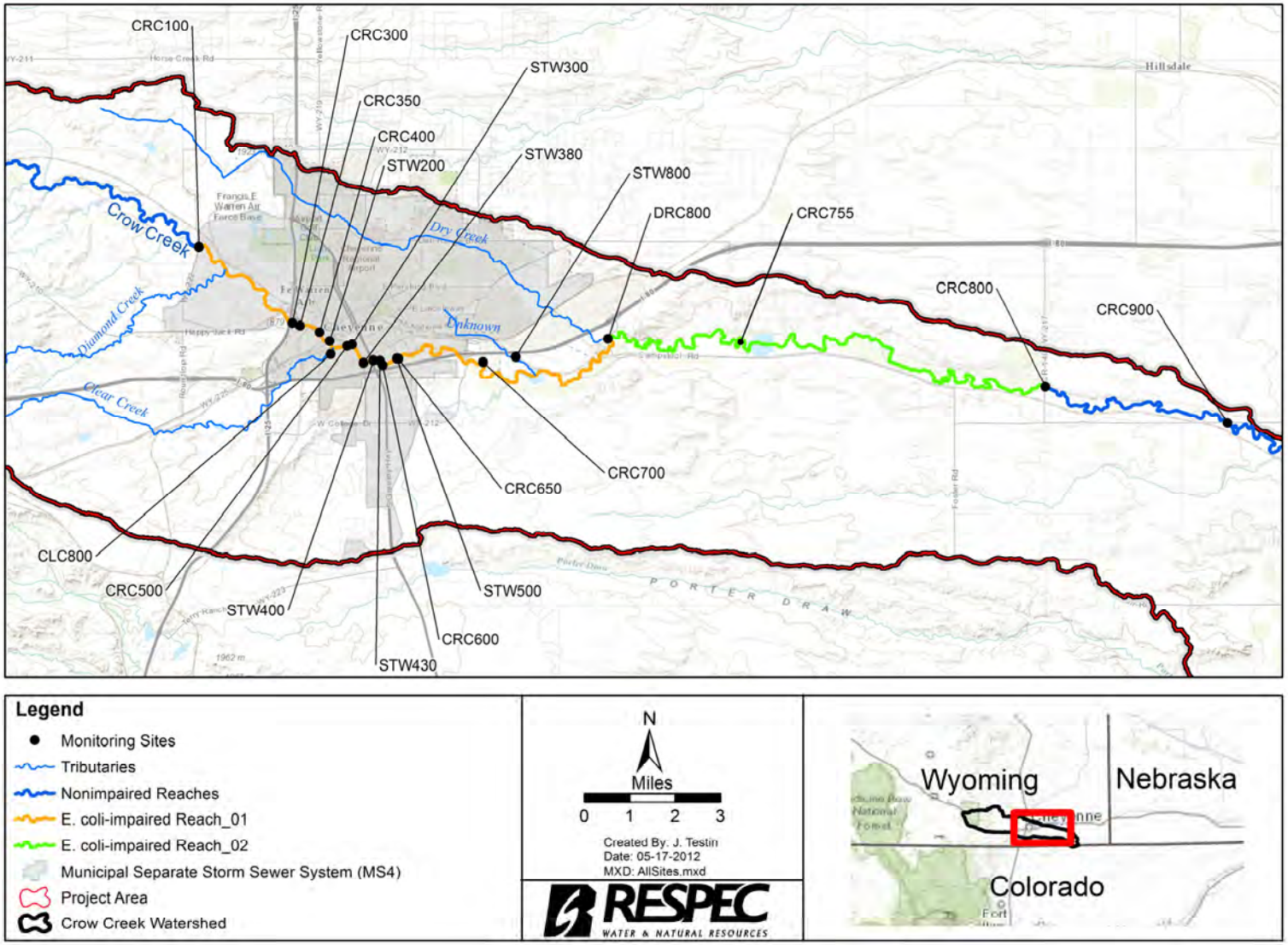

Figure 1-5. Crow Creek Monitoring Sites (Flow and *E. coli*) Including Tributaries and Stormwater Outfalls.

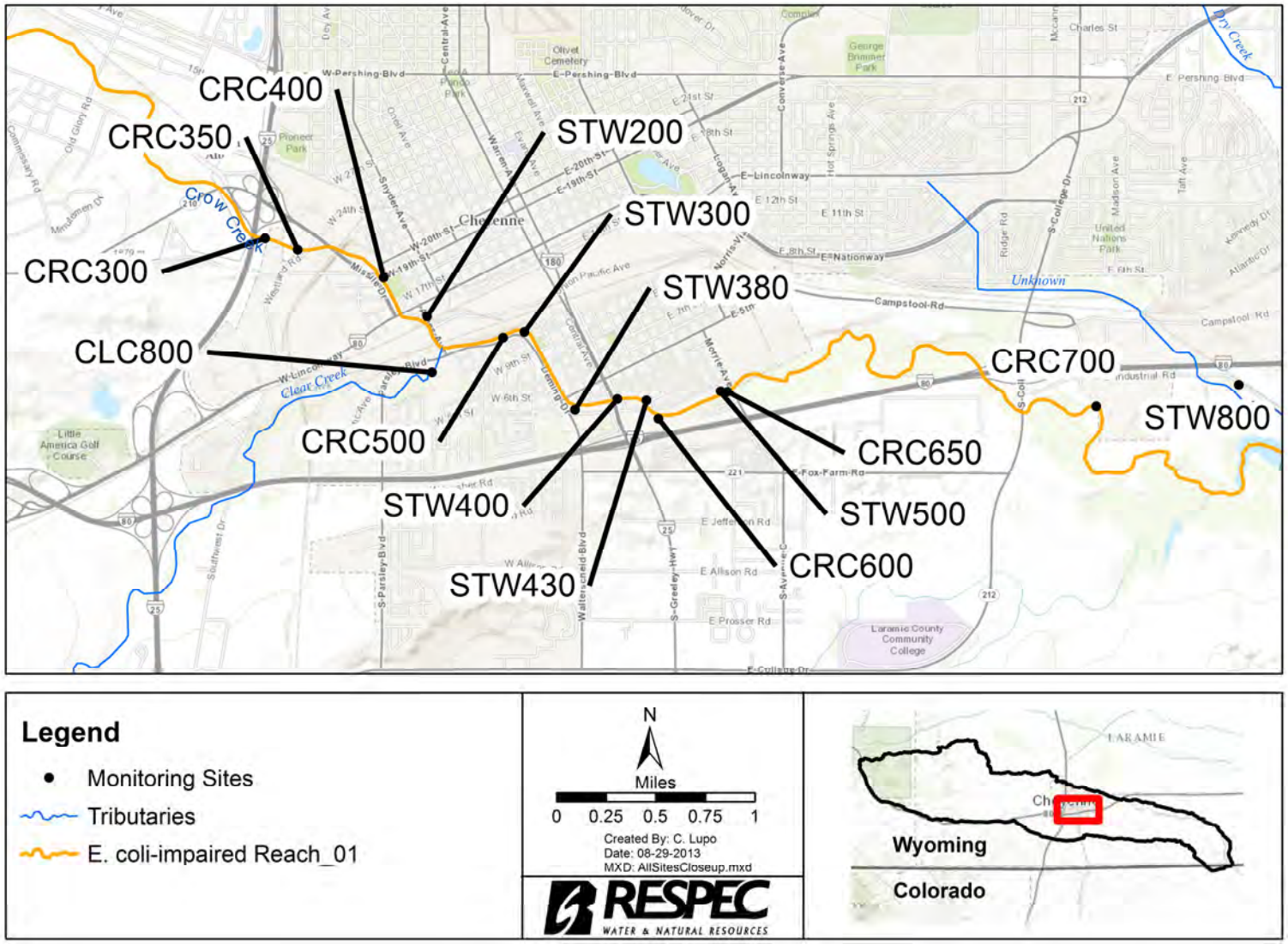

Figure 1-6. Crow Creek Monitoring Sites (Flow and *E. coli*) Including Tributaries and Stormwater Outfalls Throughout the City of Cheyenne, Wyoming.

RESPEC collected continuous discharge at 13 sites throughout the project area, as shown in Table 1-5. All discharge data were provided electronically and can be obtained from the WDEQ. The relative flow contribution (percent) throughout the project area is shown in Figure 1-7. This relative flow contribution was calculated as the percent of the flow volume at the most downstream site (CRC800) using daily average flow on days when all included sites had flow data available.

Table 1-4. Summary of U.S. Geological Survey Flow Data

Project I.D.	USGS I.D.	Type	Start Date	End Date	Number of Samples
CRC100	06755800	Daily average	03/21/1994	09/30/1996	925
		Instantaneous	06/16/1986	09/24/1992	33
CRC300	06755950	Daily average	03/21/1994	09/30/1996	925
		Instantaneous	05/27/1983	08/18/1994	76
CRC400	06755960	Daily average	10/01/1993	12/31/2011	6,663
CRC705	06756000	Instantaneous	11/02/1973	09/24/1992	98
CRC755	06756060	Instantaneous	11/01/1990	02/25/2010	79

Table 1-5. Summary of RESPEC Flow Data

Project I.D.	2010 Flow Data			2011 Flow Data		
	Start Date	End Date	Number of Samples	Start Date	End Date	Number of Samples
CRC100	05/20/2010	10/06/2010	39,984	04/07/2011	08/24/2011	40,000
CRC300	07/08/2010	10/07/2010	26,209	03/28/2011	09/26/2011	51,425
STW200	07/08/2010	10/07/2010	26,201	03/30/2011	07/24/2011	30,633
CLC800	05/20/2010	10/06/2010	39,985	04/07/2011	06/10/2011	18,445
CRC500	07/08/2010	10/07/2010	26,224	03/28/2011	09/26/2011	48,214
STW400	08/01/2010	10/07/2010	19,216	03/28/2011	09/26/2011	51,339
CRC600	07/04/2010	10/07/2010	27,543	03/28/2011	08/23/2011	39,823
STW500	07/08/2010	10/06/2010	23,899	03/29/2011	09/01/2011	38,964
CRC700	07/04/2010	10/06/2010	27,256	03/29/2011	09/26/2011	46,559
STW800	05/20/2010	10/06/2010	39,911	04/07/2011	08/24/2011	40,000
DRC800	07/08/2010	10/06/2010	25,265	03/29/2011	09/26/2011	41,188
CRC800	05/20/2010	10/06/2010	39,920	04/08/2011	09/27/2011	16,521
CRC900	05/20/2010	10/06/2010	39,906	04/08/2011	09/27/2011	16,522

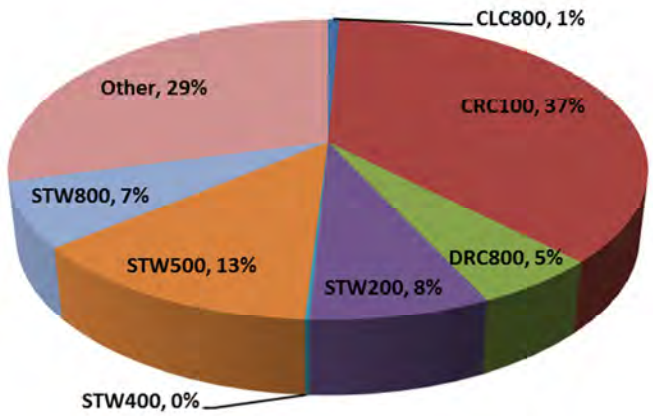

Figure 1-7. Relative Flow Contribution From Throughout the Project Area at the Most Downstream Site.

1.4 SUMMARY OF AVAILABLE WATER-QUALITY DATA

The Laramie County Conservation District (LCCD) began collecting fecal coliform grab samples from Crow Creek in the spring of 2001 and *E. coli* grab samples in the spring of 2002. The LCCD discontinued collecting fecal coliform samples after October 2004, but *E. coli* sample collection continued through 2011. During 2010, RESPEC collected *E. coli* and total coliform storm event and base flow samples at mainstem, tributary, and stormwater outlet sites on Crow Creek. All sampling sites with site I.D.s are shown in Figure 1-5, and sites within the city of Cheyenne are shown in Figure 1-6. Site descriptions, date ranges (2000 through 2011), and collection agencies (LCCD, RESPEC, USGS, or WDEQ) for data used in this TMDL analysis are provided in Table 1-6. All water-quality data were provided electronically and can be obtained from the WDEQ. Automated samplers were installed at Sites CRC300, CRC500, CRC600, CRC700, DRC800, STW200, STW300, and STW500. Site STW300 did not receive enough flow during storm events, so the automated sampler was relocated to Site STW400 in June 2010. Site DRC800 did not receive flow after July 12, 2010. RESPEC collected event grab samples by hand and representative flow-weighted composite samples using the automated samplers. Aliquots from automated samplers collected nearest in time to event grab samples were analyzed separately for comparison. Sample types are also listed in Table 1-6.

Data collected from May 1 through September 30 and from October 1 through April 30 from each project site were used to calculate geometric means for computing the percent of exceedance of the applicable criteria. Note that when replicate samples were taken (within 5 minutes of each other at the same site) for quality assurance/quality control (QA/QC) purposes, that only the first of the replicates were used to calculate geometric means. Also, although some sites did have *E. coli* data available, they did not have any geometric mean values, because no sets of five samples taken in separate 24-hour periods occurred within a 30-day window. An “N/A” qualifier in Table 1-6 indicates that there was insufficient data to calculate any geometric mean values. Table 1-7 provides the percent of exceedance of the summer recreation season criterion and concentration ranges. Table 1-8 provides the percent of exceedance of the winter recreational season criterion and concentration ranges.

Table 1-6. Summary of *E. coli* Data in the Crow Creek Total Maximum Daily Load Study Area (All Months, Replicates Not Used) (Page 1 of 3)

Segment	Monitoring Stations	Project I.D.[a]	Sampling Entity	First Sample Date	Last Sample Date	Total Number of Samples	Type(s)	Number of Grab Samples	Number of Flow-Weighted Composite Samples	Number of Aliquot Samples
Upstream	Roundtop Road	CRC100	LCCD	05/14/2002	09/01/2010	142	Grab	142	0	0
			RESPEC	05/09/2010	08/04/2010	9	Grab	9	0	0
Reach_01	F. E. Warren Air Force Base	CRC300	RESPEC	05/09/2010	08/05/2010	15	Grab, flow-weighted composite, aliquot	9	2	4
	County Road 51 (downstream of Little America drain)	CRC350	LCCD	04/26/2005	09/01/2010	119	Grab	119	0	0
	Martin Luther King Park	CRC400	LCCD	05/14/2002	09/01/2010	150	Grab	150	0	0
			RESPEC	05/09/2010	08/04/2010	8	Grab	8	0	0
	Capitol Basin Outfall	STW200	LCCD	04/23/2002	09/28/2011	34	Grab	34	0	0
			RESPEC	05/06/2010	07/13/2011	35	Grab, flow-weighted composite, aliquot	22	9	4
	Clear Creek at confluence	CLC800	LCCD	04/04/2011	09/28/2011	32	Grab	32	0	0
			RESPEC	05/06/2010	10/04/2011	22	Grab	22	0	0
	Deming Drive near O'Neil Avenue	CRC500	LCCD	05/14/2002	09/01/2010	149	Grab	149	0	0
			RESPEC	05/10/2010	08/05/2010	17	Grab, flow-weighted composite, aliquot	9	4	4
	South Park	STW380	LCCD	04/18/2011	06/27/2011	17	Grab	17	0	0
			RESPEC	05/12/2011	05/12/2011	1	Grab	1	0	0

Table 1-6. Summary of *E. coli* Data in the Crow Creek Total Maximum Daily Load Study Area (All Months, Replicates Not Used) (Page 2 of 3)

Segment	Monitoring Stations	Project I.D.[a]	Sampling Entity	First Sample Date	Last Sample Date	Total Number of Samples	Type(s)	Number of Grab Samples	Number of Flow-Weighted Composite Samples	Number of Aliquot Samples
Reach_01 (cont.)	"Other" U.P. Outfall west of Warren Avenue	STW400	LCCD	04/04/2011	06/20/2011	3	Grab	5	0	0
			RESPEC	05/12/2010	08/04/2011	12	Grab, flow-weighted composite, aliquot	7	5	0
	South 15th Drain at Evans and Second Street	STW430	LCCD	05/10/2011	05/16/2011	2	Grab	2	0	0
			RESPEC	05/12/2011	05/12/2011	1	Grab	1	0	0
	1st Street	CRC600	LCCD	04/26/2005	09/01/2010	119	Grab	119	0	0
			RESPEC	05/10/2010	08/05/2010	17	Grab, flow-weighted composite, aliquot	9	4	4
	Morrie Avenue Outfall	STW500	LCCD	04/04/2011	09/28/2011	31	Grab	31	0	0
			RESPEC	05/06/2010	08/04/2011	28	Grab, flow-weighted composite, aliquot	22	6	0
	Morrie Avenue	CRC650	LCCD	05/14/2002	12/13/2004	32	Grab	32	0	0
			WDEQ	10/01/2007	10/01/2007	1	Grab	1	0	0
	Crow Creek Water Reclamation Facility	CRC700	LCCD	05/14/2002	09/01/2010	144	Grab	144	0	0
			RESPEC	05/10/2010	08/05/2010	15	Grab, flow-weighted composite, aliquot	9	3	3
	E. Lincolnway Basin Drain	STW800	LCCD	04/04/2011	06/27/2011	21	Grab	21	0	0
			RESPEC	05/06/2010	05/12/2011	22	Grab	22	0	0
	Dry Creek at confluence[b]	DRC800	LCCD	05/02/2011	06/27/2011	17	Grab	17	0	0
			RESPEC	05/06/2010	08/04/2011	19	Grab, flow-weighted composite, aliquot	14	3	2

Table 1-6. Summary of *E. coli* Data in the Crow Creek Total Maximum Daily Load Study Area (All Months, Replicates Not Used) (Page 3 of 3)

Segment	Monitoring Stations	Project I.D.[a]	Sampling Entity	First Sample Date	Last Sample Date	Total Number of Samples	Type(s)	Number of Grab Samples	Number of Flow-Weighted Composite Samples	Number of Aliquot Samples
Reach_02	Crow Creek near Archer	CRC755	USGS	08/16/2000	03/17/2003	11	Grab	11	0	0
	Missile Road	CRC800	LCCD	04/23/2002	09/01/2010	154	Grab	154	0	0
			RESPEC	05/10/2010	08/04/2010	9	Grab	9	0	0
Downstream	State Section	CRC900	LCCD	04/16/2003	09/01/2010	87	Grab	87	0	0
			RESPEC	05/10/2010	08/04/2010	9	Grab	9	0	0

(a) Sites listed from upstream to downstream.

(b) In 2010, Dry Creek at DRC800 did not flow after July 12. Five additional samples were collected from a pool below the outfall but were not included in the analysis because no load could be associated with the samples.

Table 1-7. *E. coli* Percent Exceedance of the Summer Recreation Season Geometric Mean Criterion (126 mpn/100 mL) and *E. coli* Concentration Ranges for Project Sites in the Project Area (Grab Samples, May–September, Replicate Data Not Used)

Monitoring Stations[(a)]	Project I.D.[(a)]	Total Number of Samples	Geometric Mean Values	Geometric Mean Exceedances	Geometric Mean Percent Exceedance	Geometric Mean Concentration Range (mpn/100 mL)
Roundtop Road	CRC100	94	36	26	72	7–893
County Road 51 (upstream of Little America drain)	CRC300	9	0	N/A	N/A	N/A
County Road 51 (downstream of Little America drain)	CRC350	70	16	11	69	17–1,218
Martin Luther King Park	CRC400	90	31	28	90	15–1,486
Capitol Basin Outfall	STW200	48	49	49	100	1,341–12,062
Clear Creek at Confluence	CLC800	47	49	43	88	94–1,838
Deming Drive	CRC500	94	36	36	100	141–3,490
South Park	STW380	14	13	0	0	1–5
“Other” U.P. Outfall	STW400	8	0	N/A	N/A	N/A
South 15th Drain	STW430	3	0	N/A	N/A	N/A
1st Street	CRC600	80	34	32	94	28–2,256
Morrie Avenue Outfall	STW500	46	45	38	84	79–2,881
Morrie Avenue	CRC650	14	1	0	0	54
Crow Creek Water Reclamation Facility	CRC700	87	33	29	88	21–585
E. Lincolnway Basin Drain	STW800	34	34	23	68	26–1,059
Dry Creek at Confluence	DRC800	24	17	17	100	190–1,238
Crow Creek near Archer	CRC755	5	0	N/A	N/A	N/A
Missile Road	CRC800	94	36	26	72	17–624
State Section	CRC900	50	23	23	100	143–402

(a) Sites listed from upstream to downstream.
NA = not enough samples were collected in a 30-day period in order to calculate a geometric mean.

Table 1-8. *E. coli* Percent Exceedance of the Winter Recreation Season Geometric Mean Criterion (630 mpn/100 mL) and *E. coli* Concentration Ranges for Project Sites in the Project Area (Grab Samples, October–April, Replicate Data Not Used)

Monitoring Stations[a]	Project I.D.	Total Number of Samples	Geometric Mean Values	Geometric Mean Exceedances	Geometric Mean Percent Exceedance	Geometric Mean Concentration Range (mpn/100 mL)
Roundtop Road	CRC100	57	8	0	0	1–61
County Road 51 (downstream of Little America drain)	CRC350	49	8	0	0	8–168
Martin Luther King Park	CRC400	68	9	0	0	10–358
Capitol Basin Outfall	STW200	8	1	1	100	1,410
Clear Creek at confluence	CLC800	7	1	0	0	32
Deming Drive near O'Neil Avenue	CRC500	64	8	2	25	55–1,720
South Park	STW380	4	0	N/A	N/A	N/A
"Other" U.P. Outfall	STW400	2	0	N/A	N/A	N/A
1st Street	CRC600	48	7	0	0	73–611
Morrie Avenue Outfall	STW500	7	1	0	0	218
Morrie Avenue	CRC650	19	2	0	0	9–25
Crow Creek Water Reclamation Facility	CRC700	66	7	1	14	26–936
E. Lincolnway Basin Drain	STW800	8	1	0	0	32–32
Dry Creek at confluence	DRC800	7	0	N/A	N/A	N/A
Crow Creek near Archer	CRC755	6	0	N/A	N/A	N/A
Missile Road	CRC800	69	9	1	11	5–1,122
State Section	CRC900	46	5	0	0	13–32

(a) Sites listed from upstream to downstream.
NA = Not enough samples were collected in a 30-day period in order to calculate a geometric mean.

Stormwater discharges regulated by the National Pollutant Discharge Elimination System (NPDES) must be addressed by the MS4 portion of the wasteload allocation (WLA) component of this TMDL. Urban stormwater monitoring data collected in the storm drainage network in the Cheyenne area were used to evaluate *E. coli* loads from the city of Cheyenne MS4. Stormwater monitoring sites are labeled as "STW ###."

A majority of the LCCD data were collected specifically for calculating geometric means with sets of five samples collected during separate 24-hour periods for 30-day periods. Table 1-9 provides the number of geometric means available, the number of geometric means exceeding the specified criteria, and the percent exceedance of LCCD *E. coli* data (2002–2011, replicates not used).

Table 1-9. *E. coli* Geometric Mean Data From Laramie County Conservation District (2002–2011, Replicate Data Not Used)

Project I.D.	Laramie County Conservation District Sampling					
	(May–September)			(October–April)		
	Geometric Means	Geometric Means Exceeding 126 µg/L	Exceedance (%)	Geometric Means	Geometric Means Exceeding 630 µg/L	Exceedance (%)
CRC100	19	9	47	8	–	0
CRC350	16	11	69	8	–	0
CRC400	16	13	81	9	–	0
CRC500	19	19	100	8	–	25
CRC600	17	15	88	7	–	0
CRC650	1	—	0	2	–	0
CRC700	16	12	75	7	1	14
CRC800	19	9	47	9	1	11
CRC900	6	6	100	5	–	0

Automated water-quality sampling devices were installed at STW300, STW400, and STW500 to collect composite samples and at STW200 to collect composite samples and single aliquots. Grab samples during storm events were also collected. The entire MS4 drains into Reach_01. The MS4 permit is a municipal stormwater discharge permit that authorizes the discharge of stormwater from MS4s. For the Crow Creek TMDL, the MS4 refers to stormwater runoff from the boundary of the city of Cheyenne into Crow Creek, as determined by the 2000 Decennial Census conducted by the U.S. Census Bureau [Wyoming Department of Environmental Quality, 2008b]. This boundary includes the city of Cheyenne MS4, the Laramie County MS4, the F. E. Warren Air Force Base MS4, and the Wyoming Department of Transportation–Cheyenne MS4.

Boxplots showing the range of *E. coli* concentrations (measured in mpn/100 mL) at each site during various flow conditions were created using available data from mainstem and secondary

sites. Secondary sites consist of tributary and stormwater sites. Boxplots were evaluated for the summer recreation season in which a majority of the exceedances occur. Boxplot trends are discussed in the following sections. Note that stormwater drains do not currently have set bacteria criteria.

1.4.1 Summary of *E. coli* Data

All data collected during the summer recreational season (grab samples, May–September, replicates not used) at mainstem sites and secondary sites are shown in the first set of boxplots in Figure 1-8. Mainstem sites are shown in the top portion of Figure 1-8, and tributary sites are shown in the bottom portion of the figure. For reference, sites are listed in order from upstream to downstream in Table 1-6. Mainstem Site CRC100 (Crow Creek at Roundtop Road) marks the beginning of Reach_01 and represents bacteria concentrations coming into the project area. The median concentration increases threefold when the creek enters the city near F. E. Warren Air Force Base at CRC300. From this point, the concentration remains fairly constant until the influence from the Capitol Basin Outfall (STW200) reaches CRC500. At CRC500, the *E. coli* median concentration is increased by four times the upstream concentration at CRC400. CLC800 (Clear Creek) also influences the median concentration at CRC500; however, the median concentration at CLC800 is one-fourth of the concentration from STW200, and one-eighth of the flow contribution at CLC800 is one-eighth of the flow contribution from STW200; both of these facts show that the relative impact of Clear Creek is much less than the contribution from the Capitol Basin storm drain. Therefore, CLC800 has a much smaller loading impact on bacteria at CRC500 than STW200. From this point, the median concentration slowly decreases through the city despite influences from multiple stormwater outfalls. Both STW200 and STW500 (Morrie Avenue Outfall) have a continuous base flow; whereas, other stormwater outfalls are more flashy and have no flow at times. The base flow and bacteria concentrations at the Morrie Avenue Outfall are significantly lower than the concentrations at the Capital Basin Outfall, and, therefore, its bacteria load contribution does not cause a substantial increase in the median concentration at CRC600. Note that all secondary sites, except one, have data with median values higher than the summer recreation season criterion of 126 org/100 mL. Downstream of the city, median concentrations remain fairly constant.

Base flow is defined as the portion of flow that is not from melting snow or precipitation runoff, and event flow is defined as the portion of flow that is from melting snow or precipitation. Flow type (base versus event) was recorded as a part of the RESPEC and LCCD bacteria data sampling protocols; thus, boxplots could be created for these samples to show concentration trends for each flow type. Base flow trends at mainstem sites (upper boxplots) and secondary sites (lower boxplots) for the summer recreational season (grab samples, May–September, replicates not used) are shown in Figure 1-9. Again, concentrations increase at the F. E. Warren Air Force Base at CRC300 before spiking from the large influence from Capitol Basin. CLC800 also influences the median concentration but to a much smaller degree, because (1) the median concentration at CLC800 is less than one-fourth of the concentration at STW200 during base flow, and (2) CLC800 has a far smaller flow contribution to Crow Creek than

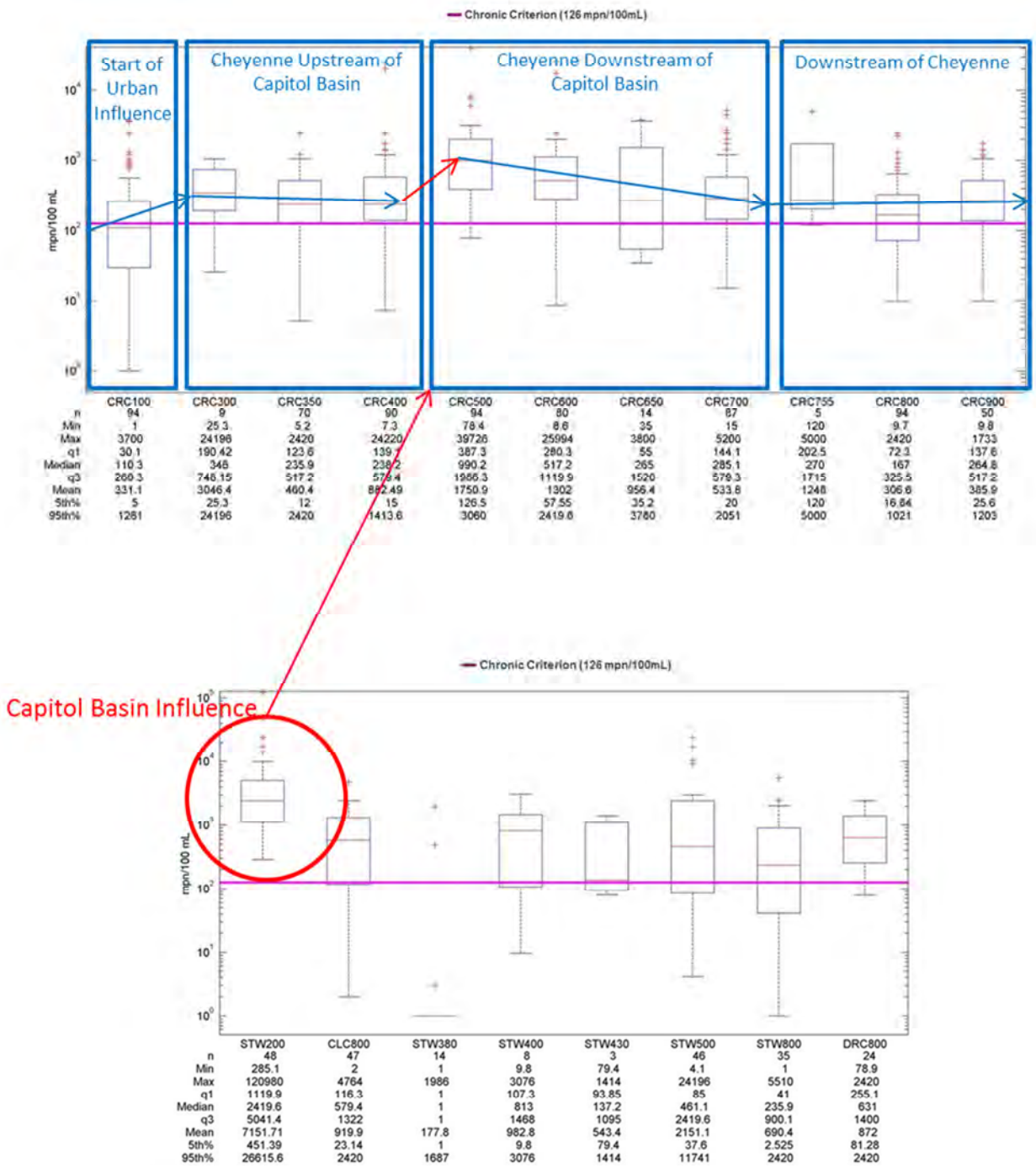

Figure 1-8. *E. coli* Boxplots for **Base Flow and Event Flow** Samples (Grab Samples, May–September, Replicates Not Used) Combined From the Mainstem (Upper Boxplots), Tributary, and Stormwater Sites (Lower Boxplots) in the Project Area.

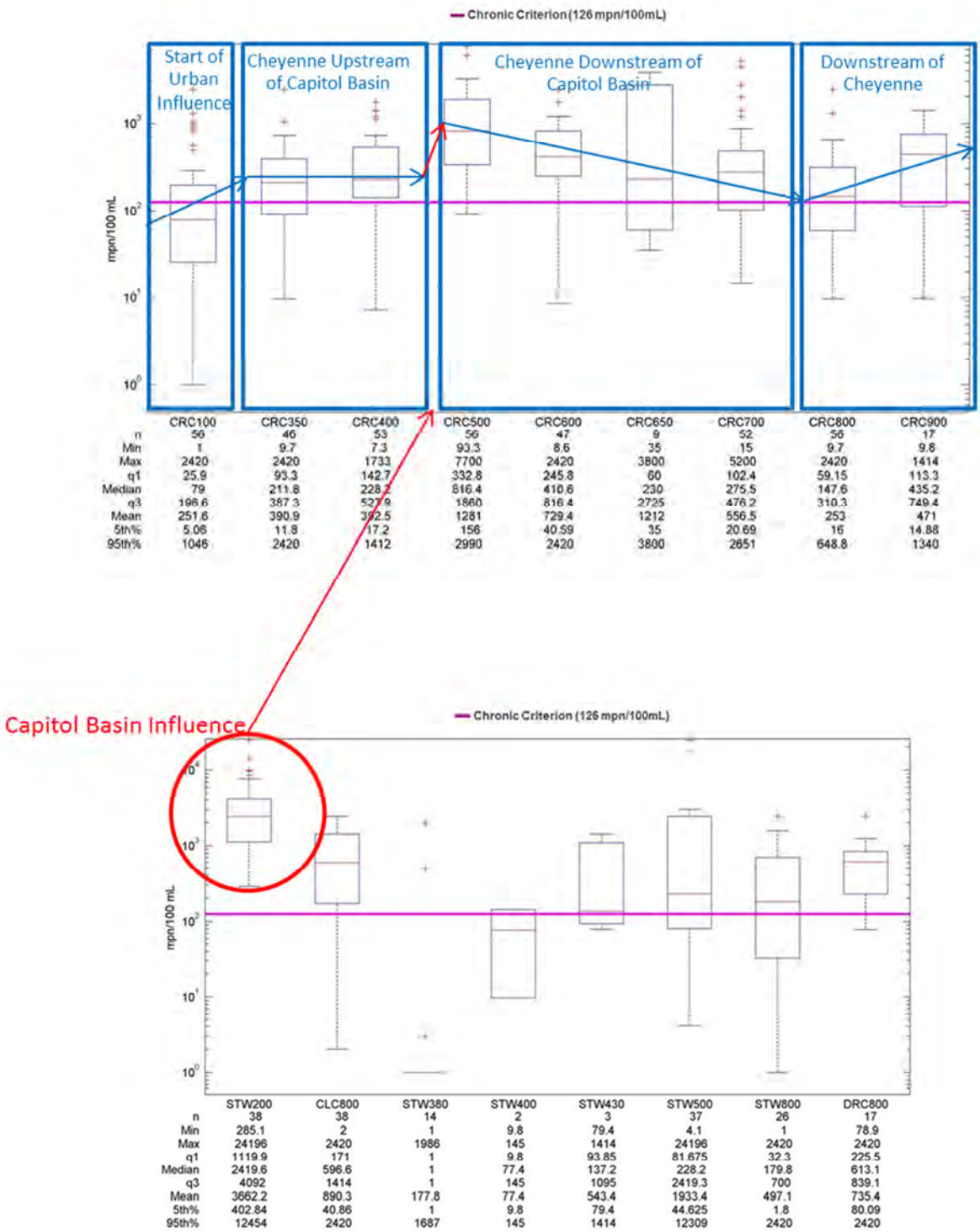

Figure 1-9. *E. coli* Boxplots for **Base Flow** Samples (Grab Samples, May–September, Replicates Not Used) From the Mainstem (Upper Boxplots), Tributary, and Stormwater Sites (Lower Boxplots) in the Project Area.

STW200. Therefore, CLC800 has a much smaller loading impact on the bacteria concentration at CRC500. High concentrations during base flows from the stormwater outfalls are a likely indicator of cross connections with sewer lines throughout the city. Again, the *E. coli* concentration gradually decreases through the city downstream of the Capitol Basin influence. A second spike occurs during base flow between CRC800 and CRC900, which does not occur during event flows. This spike indicates direct defecation from the livestock or wildlife that are present in this stretch of the reach.

Event flow trends at mainstem sites (upper boxplots) and secondary sites (lower boxplots) are provided in the boxplots in Figure 1-10. Event flow trends are similar to base flow trends. Concentrations increase from the beginning of the city at the F. E. Warren Air Force Base at CRC300 before they spike from the large influence from Capitol Basin at CRC500. From CRC500, concentrations gradually decrease through the city.

Overall, the Capitol Basin Outfall (STW200) is the largest contributor to the *E. coli* impairment in Crow Creek during both base flow (likely from cross connections with sewer lines) and event flow.

1.4.2 Summary of Available Point-Source Data

Monthly average and daily maximum bacteria data from the two Wyoming Pollutant Discharge Elimination System- (WYPDES-) permitted facilities, the Dry Creek WWTP (WY0022934), and the Crow Creek WWTP (WY0022381) are available from January 2001 through the present [Coleman, 2012]. These data are summarized in Table 1-10. Fecal coliform sampling was discontinued in 2009 when *E. coli* sampling began. Over these 8 years (2001 through 2009), the Crow Creek facility exceeded the specified daily maximum fecal coliform limit six times (7 percent of the daily maximum samples) and never exceeded the monthly average limit. The Dry Creek facility exceeded the specified daily maximum limit twice (3 percent of the daily maximum samples) and never exceeded the monthly average limit. Daily maximum concentrations from the Dry Creek and the Crow Creek facilities remain fairly low with overall average and median *E. coli* concentrations below 35 mpn/100 mL and 20 mpn/100 mL, respectively.

1.4.3 Quality Assurance Reporting

All project data collection followed the QA/QC procedures for field sampling [Wyoming Department of Environmental Quality, 2011]. QA/QC sample sets were collected as part of the bacteria monitoring effort. QA/QC samples consisted of field replicates and blanks. Field replicate samples were independent samples that represented the parameters of interest for which a second sample was collected in the same way with the same equipment as close in time and space to the previous sample as was practicable. No marks were used to differentiate the sample from the regular sample. The locations and dates of the replicate sample and the regular or routine sample were recorded. Relative percent difference (RPD) was calculated for each replicate sample pair as follows:

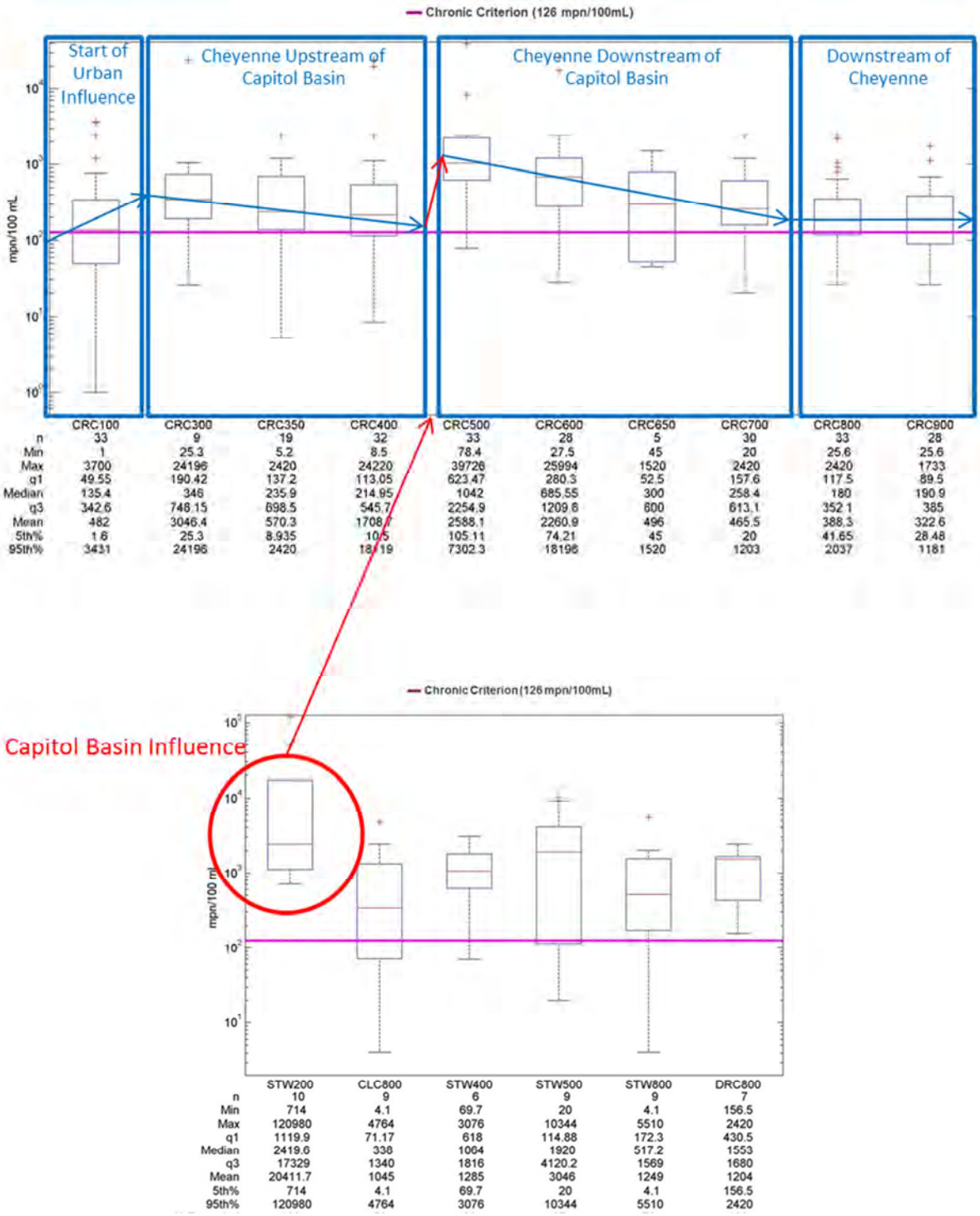

Figure 1-10. *E. coli* Boxplots for **Event Flow** Samples (Grab Samples, May–September, Replicates Not Used) From the Mainstem Sites (Upper Boxplots), Tributary, and Stormwater Sites (Lower Boxplots) in the Project Area.

Table 1-10. Bacteria Data Summary From Crow Creek and Dry Creek Wastewater Treatment Plants

Water Reclamation Facility	Bacteria Type	Recreation Season	Statistical Measure	Permit Limit	Number of Measurements	Mean Concentration	Exceedances
Crow Creek	*E. coli* (mpn/ 100 mL)	Summer	Daily Maximum	576	19	34.0	0
			Monthly Average	126	14	9.4	0
		Winter	Daily Maximum	630	28	32.2	0
			Monthly Average	630	21	7.6	0
	Fecal coliform (mpn/ 100 mL)	Summer	Daily Maximum	400	31	255.7	5
			Monthly Average	200	31	46.6	0
		Winter	Daily Maximum	400	52	122.7	1
			Monthly Average	200	51	23.2	0
Dry Creek	*E. coli* (mpn/ 100 mL)	Summer	Daily Maximum	576	19	4.3	0
			Monthly Average	126	14	0.7	0
		Winter	Daily Maximum	630	27	3.8	0
			Monthly Average	630	21	0.7	0
	Fecal coliform (mpn/ 100 mL)	Summer	Daily Maximum	400	30	52.9	0
			Monthly Average	200	28	8.4	0
		Winter	Daily Maximum	400	45	51.0	2
			Monthly Average	200	44	3.5	0

$$\mathrm{RPD} = \left(\left|\mathrm{S} - \mathrm{R}\right|\right) \Big/ \left(\left(\mathrm{S} + \mathrm{R}\right)/2\right) \times 100 \tag{1-1}$$

where:

S = Sample

R = Replicate.

For *E. coli* replicate samples, the average RPD was 25 percent, the median RPD was 17 percent, the minimum RPD was 0 percent, and the maximum RPD was 162 percent. At low concentrations, the RPD is not an accurate method for comparing replicates, and it is at these low concentrations where the highest RPDs occur. Because *E. coli* is typically more variable in nature, it should have an RPD of less than 40 percent. Less variable parameters would be expected to have an RPD of less than 20 percent. Differences between replicate and routine samples may be caused by the contamination of sample bottles, a laboratory error, the inherent variability of the laboratory method, or stream variability. For the sampling on Crow Creek, the variation between samples is likely because of the highly variable nature of *E. coli* and not differences in how each sample was collected or analyzed.

Field blanks are created at the sampling site. The WDEQ *Manual of Standard Operating Procedures for Sample Collection and Analysis* [Wyoming Department of Environmental Quality, 2011] states that "The purpose of a field blank is to establish that a sample is not being contaminated by conditions associated with the collection or custody of a sample or by cross-contamination during sampling or shipping." Examples of potential field contamination sources are: ambient air pollution, sample collection equipment, sample collection procedures, storage and transport conditions, and the filter and/or filtering equipment.

Field blanks were collected during regular sampling activities at random sites during the base flow sample collection and during storm events. Field blanks were used to determine if the procedures used for equipment decontamination and sample collection, storage, and transport were sufficient to ensure the integrity of the samples. Field blanks were collected, stored, and shipped with other samples. All field blanks (n = 133) collected for this project were measured as nondetects for *E. coli*.

2.0 SIGNIFICANT SOURCES

Bacteria sources in the Crow Creek project area are a factor of both point-source and nonpoint-source pollution. WYPDES point sources include WWTPs and the MS4, and nonpoint sources consist primarily of sources that can be transported through washoff. Other nonpoint sources include septic systems and direct defecation from livestock and wildlife.

2.1 POINT SOURCES

Two WYPDES-permitted point sources with *E. coli* permit limits are located in the Crow Creek project area and are listed in Table 2-1 and illustrated in Figure 2-1. These permitted point sources include the Dry Creek WWTP (WY0022934) and the Crow Creek WWTP (WY0022381). Both treatment plants are located in Reach_01. The Cheyenne Parks and Recreation Department (WY0094617), the Cheyenne Board of Public Utilities Water Treatment Plant (WY0031721), the Frontier Oil Refinery (WY0000442), Pilot Travel Centers (WY0033944), the Wyoming Air National Guard (WY0056731 and WY0028576), and the Cheyenne Rail Yard Union Pacific Railroad (WY0000647) are also located in the project area, but they do not have *E. coli* permit limits and are not considered potential sources of bacteria. From May to September, the *E. coli* daily maximum and geometric mean effluent limits are 576 cfu/100 mL and 126 cfu/100 mL, respectively, for both the Dry Creek and Crow Creek facilities. From October to April, the daily maximum and geometric mean effluent *E. coli* limits are 630 cfu/100 mL. Measured daily maximum concentrations from the two facilities remain fairly low with averages and median values below 35 cfu/100 mL and 20 cfu/100 mL, respectively. The current MS4 permit (WYR04-0000) was issued on December 1, 2008, and will expire on September 30, 2013 [Sahl, 2012].

Table 2-1. Wyoming Pollutant Discharge Elimination System Concentration Point-Source Permit Limits in the Crow Creek Project Area

Point Sources	Reach	Average Effluent Flow (cfs)	Design Flow (cfs)	*E. coli* Permit Limits (May–September)		*E. coli* Permit Limits (October–April)	
				Daily Maximum (cfu/100 mL)	Geometric Mean (cfu/100 mL)	Daily Maximum (cfu/100 mL)	Geometric Mean (cfu/100 mL)
Dry Creek WWTP, WY0022934	01	9	16	576	126	630	630
Crow Creek WWTP, WY0022381	01	5	10	576	126	630	630

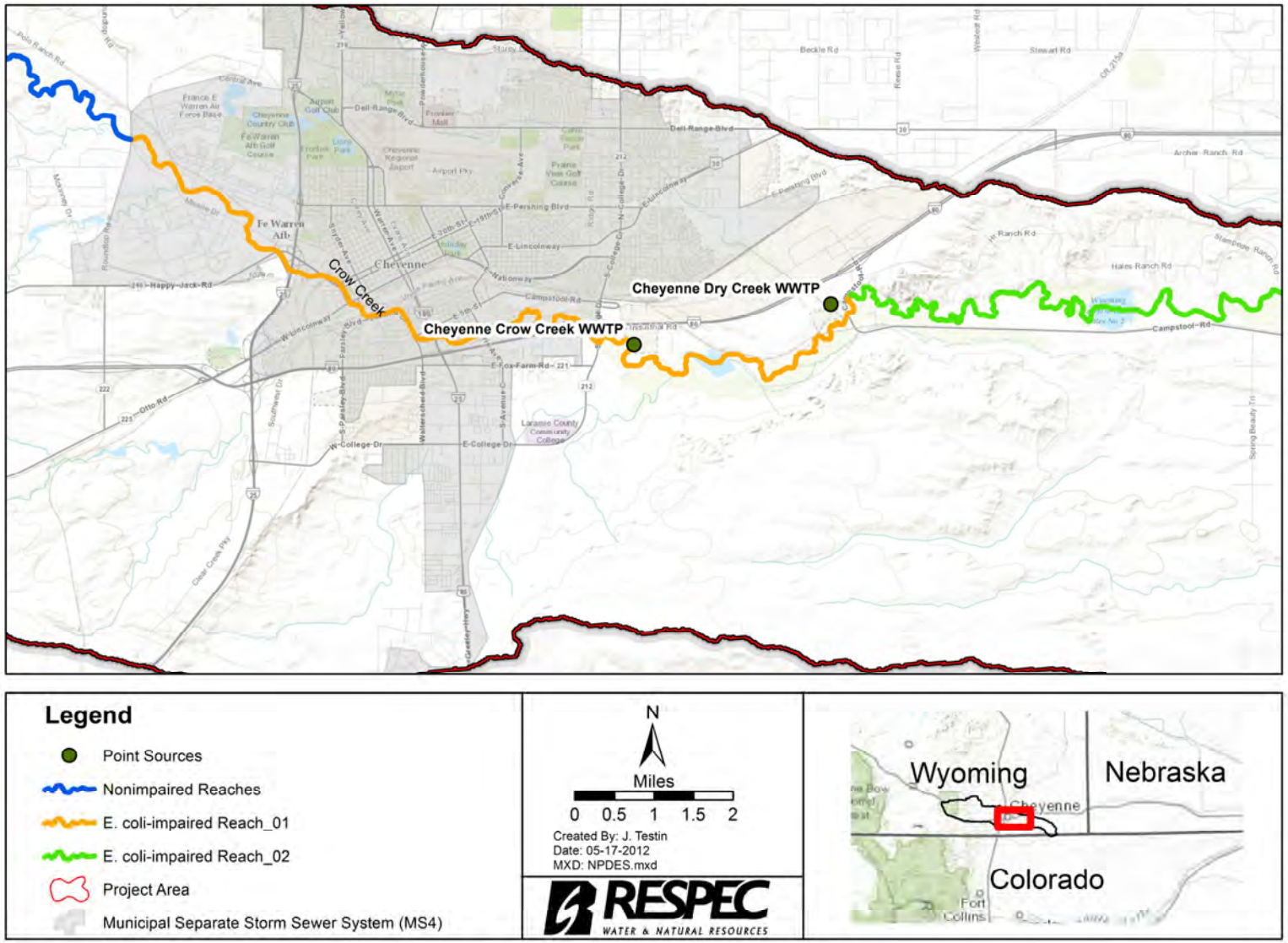

Figure 2-1. Wyoming Pollutant Discharge Elimination System Point Sources Including the Municipal Separate Storm Sewer System in the Crow Creek Project Area.

In addition to the point sources and the general MS4 permit, there is also a Large Construction General Permit (LCGP), a Small Construction General Permit (SCGP), a Mineral Mining General Permit (MMGP), and an Industrial General Permit (IGP). The Wyoming LCGP was renewed May 9, 2011, and will expire March 15, 2016. This permit covers all construction projects that disturb 5 or more acres and smaller projects that are part of a common plan of sale or development that will disturb 5 or more acres. The Wyoming SCGP recently expired but has been administratively extended. The SCGP covers all construction projects that disturb at least 1 acre and less than 5 acres. Projects smaller than 1 acre will require coverage if they are part of a common plan of sale or development that will disturb between 1 and 5 acres. The Wyoming MMGP was renewed on April 1, 2012, and will expire March 31, 2017. The MMGP covers all mines, regardless of size, except metal ore mines and coal mines. The Wyoming IGP expires on August 31, 2012, and is currently being rewritten. This permit will cover manufacturing, transportation, junk and salvage yards, metal ore mining, and coal mining in addition to other categories [Sahl, 2012]. It is assumed that the LCGP, SCGP, MMGP, and IGP do not have a large impact on bacteria concentrations.

In reviewing available data and communicating with state and local authorities, stormwater outflows, which are from the MS4, were determined to be the primary source of bacteria in the Crow Creek Watershed. Likely sources of bacteria in stormwater outflows include humans, domestic animals, and urban wildlife. In general, human bacterial sources in urban settings can include cross connections between sanitary sewers and storm drain systems, overflows from sanitary sewer systems, and wet weather discharges from centralized wastewater collection and treatment plants. The city of Cheyenne has investigated cross connections and is in the process of removing identified cross connections in the distribution system. Pet wastes could be a contributor to bacteria in Crow Creek. Pet waste may not be properly disposed of along the stream and in the stormwater drainage network. It can also be washed off during precipitation events. According to a Source Water Protection Practices Bulletin from the U.S. Environmental Protection Agency [2001], pets are significant contributors to bacterial contamination.

2.2 NONPOINT SOURCES

Upstream and downstream of the city of Cheyenne, runoff from livestock operations and/or agricultural runoff contribute to nonpoint bacteria loads. Wildlife and septic systems are also likely nonpoint sources of bacteria in the watershed.

2.2.1 Humans

Outside the city limits, septic systems are a potential human source of bacteria loads, because much of the land beyond the city limits is rural. Septic systems were estimated using county population, urban population, and average household size from the 2010 Census. It was assumed that, if a household was in an area without a WWTP, the household had a septic system. Using this assumption with the 2010 Census data, the number of septic systems in

Laramie County was estimated to be approximately 7,900, and the number of septic systems in the project area was estimated to be approximately 1,500. The ratio between the project area and Laramie County was estimated based on areas of nonurban land.

2.2.2 Livestock

Manure from livestock is a potential source of bacteria entering the stream. Livestock in Laramie County is predominantly cattle. Other livestock in Laramie County include sheep, horses, poultry, goats, and pigs. For 10 years, it was a common practice in the project area to allow a large group of goats to graze in the riparian areas of the MS4 to control noxious, invasive weeds. However, this practice is no longer occurring in the project area [Mitchell, 2011]. Livestock counts in Laramie County from the 2007 Census of Agriculture are summarized by acre of agricultural land in Table 2-2 with the estimated bacterial contribution per animal per day [Wagner and Moench, 2009]. The number of hogs and pigs in Laramie County are unknown but considered insignificant, and, therefore, hogs and pigs are not included in Table 2-2. Livestock contribute bacteria loads to Crow Creek directly by defecating in the stream and indirectly by defecating on pastures or cropland, which can be washed off during precipitation events.

Table 2-2. Laramie County Livestock Estimates

Laramie County Livestock	Animals in County[(a)]	Animals per Acre of Agricultural Land[(b)]	Estimated Watershed Population	Fecal Coliform per Animal (cfu/day)	Fecal Coliform in Watershed (cfu/day)
Cattle and Calves	83,438	0.0292	7,274	8.55×10^{9}	6.22×10^{13}
Goats	692	0.0002	60	4.32×10^{9}	2.59×10^{11}
Horses and Ponies	3,485	0.0012	304	3.64×10^{8}	1.11×10^{11}
Poultry	1,241	0.0004	108	3.34×10^{8}	3.61×10^{10}
Sheep and Lambs	16,938	0.0059	1,477	5.80×10^{10}	8.57×10^{13}

(a) From U.S. Department of Agriculture [2007].
(b) From Wagner and Moench [2009].

2.2.3 Natural Background/Wildlife

Wildlife in the watershed is a natural background source of bacteria. Similar to livestock, wildlife, including waterfowl, small mammals living near the stream or in the City's stormwater system, and large game species, contribute bacteria loads to Crow Creek directly by defecating while wading or swimming in the stream and indirectly by defecating on lands that are washed off during precipitation events. The herds in the Crow Creek area include the Iron Mountain Pronghorn herd (approximately 19,000 pronghorn), the Iron Mountain Elk herd (approximately

3,000 elk), and the Laramie Mountain Mule Deer herd (approximately 22,000 mule deer) [Creekmore, 2012].

2.3 SOURCE ASSESSMENT MODELING RESULTS

An **HSPF** model application was developed for the project area to determine the contribution of *E. coli* bacteria from identified sources and to evaluate different scenarios of implementing BMPs to control these sources. The Crow Creek drainage basin was represented in the model using 39 subwatersheds and one boundary condition, which represented the confluence of North Fork Crow Creek and Middle Fork Crow Creek. **HSPF** is a comprehensive watershed model of hydrology and water quality that includes modeling both land surface and subsurface hydrologic and water-quality processes and is linked and closely integrated with corresponding stream and reservoir processes. **HSPF** is considered a premier, high-level model among those currently available for comprehensive watershed assessments. Since the model is continuous, the framework can be used to determine the critical environmental conditions (e.g., flow-variable, seasonal) for the impaired segments by providing continuous flow and load predictions at any point in the system. For the Crow Creek TMDL project, it was proposed that bacteria loading from nonpoint-source runoff be simulated using event mean concentrations (EMCs) in the project area. EMCs use discharge data from a storm event to composite samples based on flow volume to create a single representative sample. Results from the composite sample analysis yield the EMC. **HSPF** is capable of simulating the fate and transport of bacteria in a variety of ways. Furthermore, unlike other watershed-scale models, **HSPF** can include subsurface concentrations in addition to surface concentrations where appropriate. In terms of water-quality modeling, using EMCs allows a more streamlined conceptual framework and could potentially reduce compounded uncertainty from the inclusion of other models. An EMC inherently accounts for the physical, biological, and chemical processes that occur over and in land segments, and, thus, it eliminates using another model to simulate those processes and predict a concentration or load to receiving waterbodies.

The EMCs used in the bacteria model were developed from the 2010 stormwater data. Isco samplers were set up at sites identified as having relatively uniform land uses (e.g., residential, commercial, industrial, and recreational). This method allowed for the development and application of land use-specific EMCs in the model. Stage and discharge data from each event were used to composite samples based on flow volume, which resulted in a single sample for each event. Results from the composite sample analysis yielded land use-specific EMCs for bacteria. EMCs were applied to the surface outflow and fate and transport processes in the reaches that were simulated within the modeled system.

2.3.1 Model Methods

The primary components of developing an **HSPF** model application include:

- Collecting and developing time-series data.

- Characterizing and segmenting the watershed.
- Calibrating and validating the model.

The watershed model was first set up and calibrated to predict the range of flows that have historically occurred throughout the watershed, including the stormwater system, to assist in developing the LDCs. Subsequently, the watershed model application was used to predict bacteria loadings. The modeling period was from 1995 through 2010.

2.3.1.1 Collecting and Developing Time-Series Data

Data requirements for developing and calibrating an **HSPF** model application are both spatially and temporally extensive. Data used in developing the model application included:

- Meteorological time series.
- Stream flow and water-quality boundary conditions.
- Channel geometry.
- Point-source loads (Crow Creek and Dry Creek WWTPs).

Precipitation, potential evapotranspiration, air temperature, wind speed, solar radiation, dew-point temperature, and cloud cover data were collected in order for **HSPF** to calculate hydrology (including snow processes).

An iterated boundary condition was used at the confluence of North Fork and Middle Fork Crow Creek to account for stream flow and water-quality constituents from areas that were not modeled in this application. Water-quality time series at the boundary conditions were developed using estimated flags and measured *E. coli* concentrations and **LOADEST**, which is a program for estimating constituent loads in streams and rivers using regression models. The output was a continuous, daily time series of *E. coli* load based on the relationship between discharge and bacteria concentrations that was used as input into the model.

Observed flow and water-quality data are needed to compare and calibrate with simulated results. Continuous stream flow from USGS gaging stations and water-quality data from various monitoring sites were used to calibrate the model to existing, observed conditions. Data (2002 through 2010) summarized in Table 1-6 were used to calibrate the **HSPF** model application.

2.3.1.2 Characterizing and Segmenting the Watershed

The purpose of segmenting a watershed for use in a watershed model is to divide the project area into individual land and channel segments, or pieces, that are assumed to demonstrate relatively homogeneous hydrologic, hydraulic, and water-quality behavior. The segmentation provides the basis for assigning similar or identical input and/or parameter values or functions to where they can be applied logically to all portions of a land area or channel length contained in a model segment. Since **HSPF** and most watershed models differentiate between land and channel portions of a watershed and each is modeled separately, each watershed undergoes a

segmentation process to produce separate land and channel segments that are linked together to represent the entire watershed area.

The river reach segmentation requires considering river travel time, riverbed slope continuity, a temporal and spatial cross section, morphologic changes or obstructions, the confluence of tributaries, TMDL reach endpoints, and the calibration and verification of gage locations for flow and bacteria. The municipal boundary and sewer shed were also used to accurately represent the MS4 in Cheyenne, Wyoming. Once the segmentation was finalized, each reach segment was analyzed to compute the tributary areas of the land use categories and the hydraulic characteristics of the reach. The reach hydraulic behavior is specified in an FTABLE, which is an expanded rating curve that contains the reach surface area, volume, and discharge as functions of depth. FTABLEs were developed for each reach segment using cross-sectional data from previous Crow Creek projects (1988–2009). Unsurveyed tributaries were assigned the geometry of hydraulically similar channels.

Land segmentation was used to assign unique parameters to areas of land in the **HSPF** model application. For the land segmentation, subbasins were delineated to capture hydrologic and water-quality variability. Land segmentation was based on the boundaries defined by meteorological characteristics and land use. Land use and land cover affect the hydrologic and water-quality response of a watershed. The land use and land cover affect infiltration, surface runoff, and water losses from evaporation or transpiration by vegetation. The movement of water through the system is affected significantly by vegetation (e.g., crops, pasture, or open) and associated characteristics. Land use clearly impacts the rate of accumulation of pollutants, such as bacteria. The 2001 NLCD was integrated with a higher resolution land cover of the city of Cheyenne. The resulting land cover categories were aggregated into seven model categories (residential, commercial, industrial, park, rangeland and pasture, forest, and cropland) by combining hydrologically similar land cover categories to reduce complexity. The urban categories were divided into pervious and impervious areas based on an estimated percentage of effective impervious area. The term “effective” implies that the impervious region is directly connected to a local hydraulic conveyance system (e.g., open channel and river), and the resulting overland flow will not run onto pervious areas and will not have the opportunity to infiltrate along its respective overland flow path before reaching a stream or waterbody.

2.3.1.3 Calibrating and Validating the Model

Hydrology

Once the initial model was developed, the calibration and validation process took place. The principal time-series data used for hydrologic calibration included the long-term data from the USGS Gage 06755960 (CRC400) and 13 of the monitoring sites in 2010 shown in Figure 1-5. For this project, the entire simulation period (1995 through 2010), excluding 1995, was used in the calibration of the model. The initial year (1995) was simulated so the model could adjust to existing conditions. This period had exceptionally wet years in the late 1990s to extreme drought conditions in the 2000s, which made it an ideal calibration and validation period, because the model response could be validated during both wet and dry periods.

Hydrologic calibration is an iterative process intended to match simulated flow to observed flow by methodically adjusting model parameters. Water-quality simulations are highly dependent on the hydrology process. Therefore, water-quality calibration cannot begin until the hydrology calibration is considered acceptable. **HSPF** hydrologic calibration is divided into the following four sequential phases of adjusting appropriate parameters to improve performance:

- Annual runoff
- Seasonal or monthly runoff
- Low- and high-flow distribution
- Individual storm hydrographs.

By iteratively adjusting specific calibration parameter values within accepted ranges, the simulation results are improved until an acceptable comparison of simulated results and measured data is achieved. The procedures and parameter adjustments involved in these phases are more completely described in Donigian et al. [1984] and Lumb et al. [1994].

Bacteria

HSPF divides runoff into three components called surface runoff, interflow, and groundwater. Surface runoff represents the first flush and rising limb of a hydrograph. Interflow is the sustained storm flow that is just below the ground surface that represents the falling limb of a hydrograph. Groundwater is deeper subsurface flow that recedes slowly and represents base flow. *E. coli* EMCs were derived from observed data collected during storm events and base flow and different gaging stations below critical geographical areas. The EMCs differed between surface runoff, interflow, and groundwater based on the observed concentrations representing a range of storm intensities. EMCs also differed between geographical areas based on the observed concentrations at the respective downstream gage stations. EMCs for each runoff component and geographical area were calibrated concurrently to accurately represent the different concentrations present in the three flow components at each geographical area. This EMC application method allows the allocation of sources associated with each runoff component and the land use distributions in the geographical areas. Another critical calibration parameter is the in-stream *E. coli* decay rate, which was calibrated in congruence with the EMCs to create continuity in the in-stream *E. coli* concentrations calibrated throughout the simulated watershed.

Sources were allocated to direct and indirect categories using the loadings calculated within each runoff component. Direct sources are simulated by the groundwater runoff component, which can represent contributions of *E. coli* from direct deposition from wildlife or livestock, bacteria from failing septic systems, leaking wastewater collection system infrastructure, or cross connections between sanitary and storm sewer lines. Direct sources could also represent other mechanisms that are difficult to quantify explicitly, including resuspension of bacteria associated with sediment and illicit discharges. Some direct sources, such as WWTPs, were explicitly represented, because the data were available. Indirect sources were simulated with a

combination of interflow and surface runoff components and represent the bacteria washoff from land surfaces. Indirect sources were also allocated to land use categories using the indirect loadings and the land use area distributions within the geographical areas.

2.3.2 Model Results

The modeled hydrology performance was evaluated using a "weight-of-evidence" approach based on criteria developed from over 30 years of modeling experience with HSPF. This approach uses a variety of graphical comparisons and statistical tests, including annual and monthly runoff errors, low-flow and high-flow distribution errors, and storm volume and peak flow errors. More weight was given to the performance of the USGS gage, because it provides continuous daily flow for the entire model simulation period; whereas, the other gages provided data for less than a full year in 2010 only. The performance criteria are described in more detail in Donigian [2002].

The model application simulates hydrology above Capitol Basin at USGS Gage 06755960 very well with daily and monthly coefficients of determination (r^2) of 0.91 and 0.97, respectively. A review of the data gages downstream of Capitol Basin and the city of Cheyenne shows the performance of the model is good to excellent with the r^2 values ranging from 0.73 to 0.99. Figures 2-2 and 2-3 are flow time-series plots comparing observed and simulated data during 2010 at CRC100 and CRC400, respectively. For the performance of the *E. coli* calibration, a visual evaluation, ensuring that the model simulations are representing the pattern of the data, was used because the EMC method of representing *E. coli* represents the average trends based on flow. Using statistics alone would be misleading, because the variability in *E. coli* is not represented as well with this method. Figures 2-4 and 2-5 illustrate the simulated and observed concentrations of *E. coli* upstream and downstream of Capitol Basin, respectively. Observed data are shown as blue circles and the simulated results are represented with a solid red line.

2.3.3 Source Assessment

In an urban environment, it is difficult to predetermine nonpoint bacteria-loading sources using observed data, which are often limited. The calibrated model application is highly effective in quantifying load contribution from a variety of point and nonpoint sources in a watershed and can help quantify source contributions when limited, paired flow and concentration data are available.

For this project, source assessment modeling results were summarized using the following categories: urban areas, cross connections, nonurban areas, and point sources. A time series of average daily loads by source from the model application occurring on each date from 1995 through the end of September 2010 was created. The graph provided in Figure 2-6 represents source load allocation at the endpoint of Reach_01 throughout the recreation season. Contributions to Reach_01 were mainly from the MS4 (46.8 percent) and MS4 cross connections (48 percent). Figure 2-7 represents load contributions to Reach_02; 97 percent of the load originates from upstream Reach_01 versus 3 percent from local sources.

RSI-1939-12-011

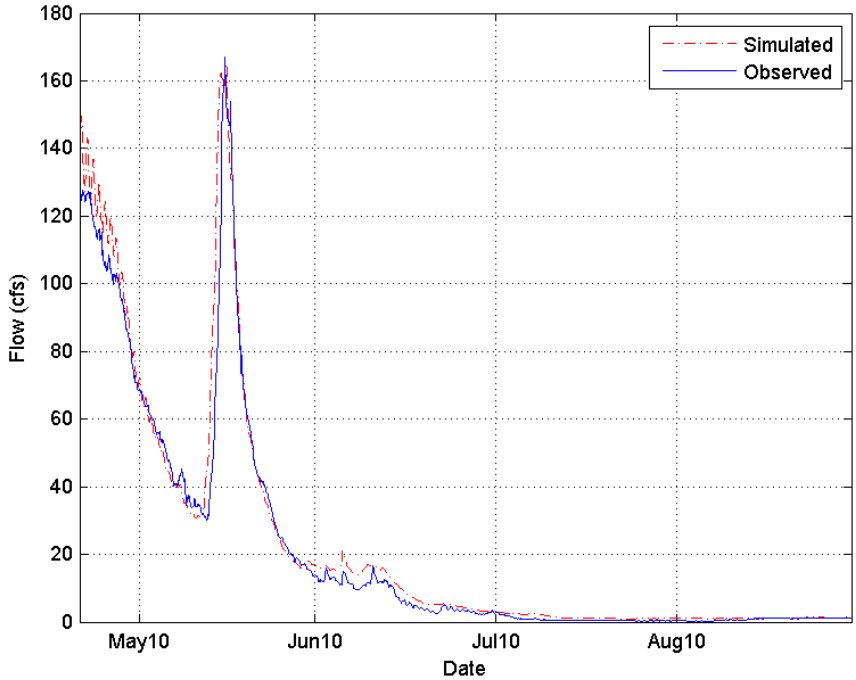

Figure 2-2. Simulated and Observed Discharge at CRC100 During 2010.

RSI-1939-12-012

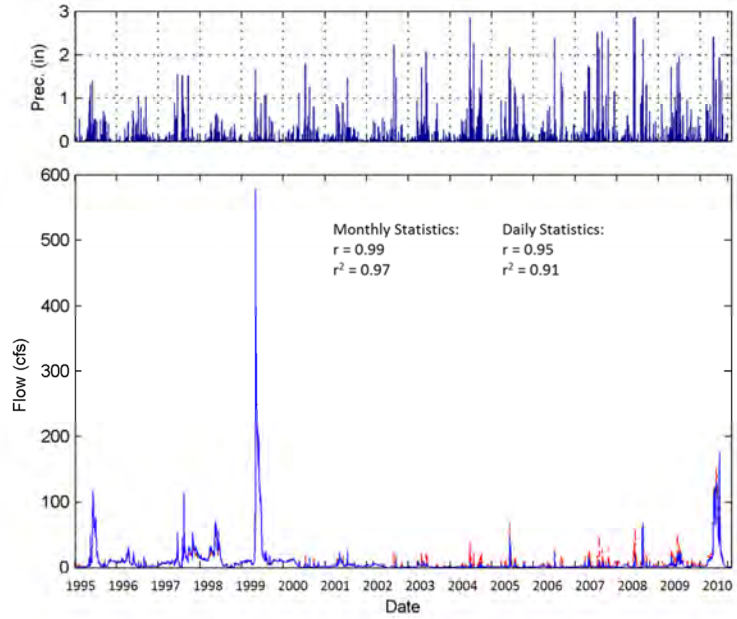

Figure 2-3. Simulated and Observed Discharge at CRC400 During the Model Simulation Period.

RSI-1939-12-013

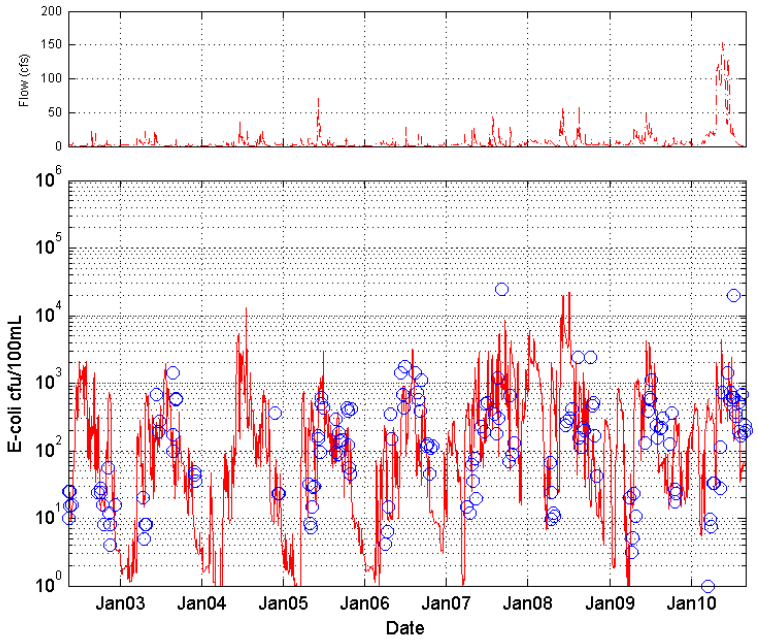

Figure 2-4. Simulated and Observed *E. coli* Concentrations Above Capitol Basin.

RSI-1939-12-014

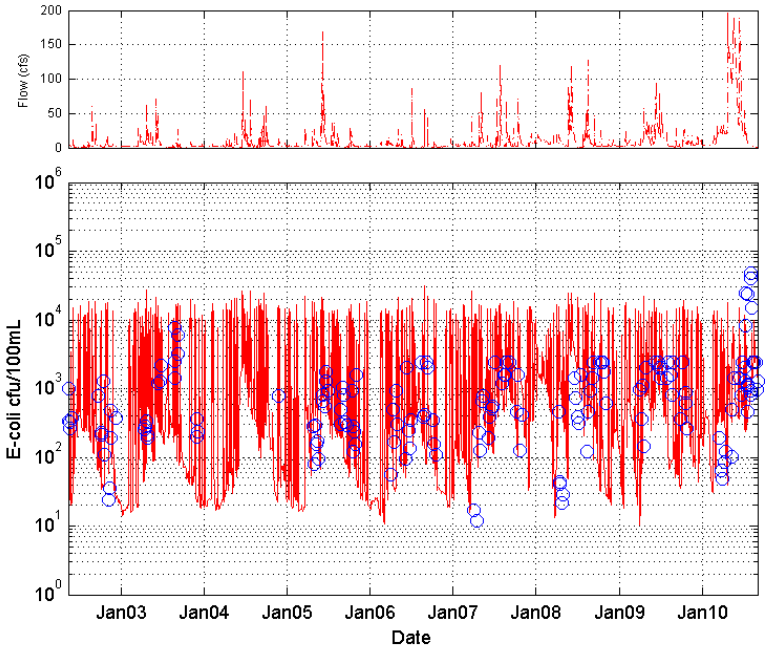

Figure 2-5. Simulated and Observed *E. coli* Concentrations Below Capitol Basin.

RSI-1939-12-015

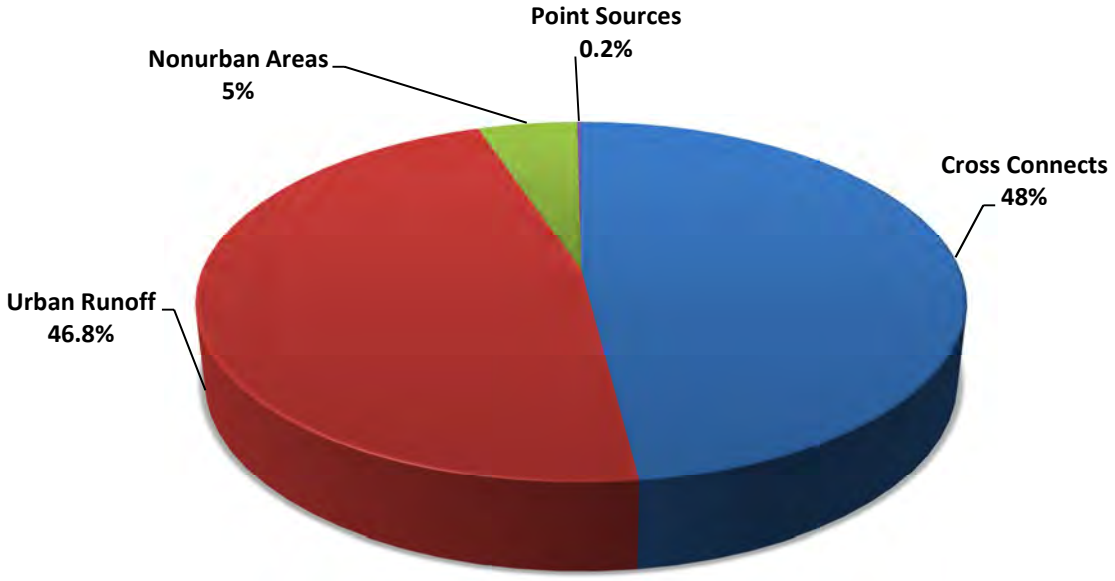

Figure 2-6. Load-Based Source Assessment Modeling Results for the Recreation Season in Reach_01 of the Crow Creek Project Area.

RSI-1939-12-016

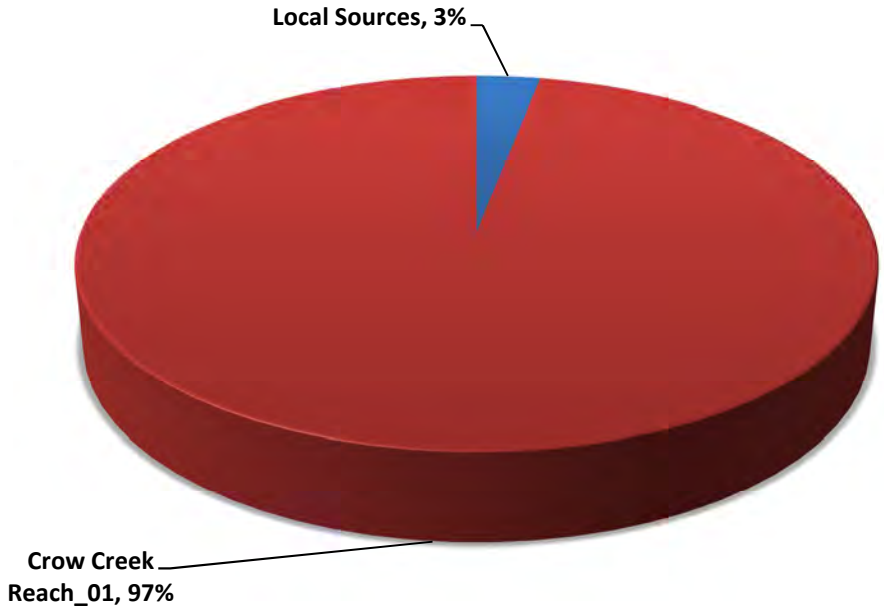

Figure 2-7. Load-Based Source Assessment Modeling Results for the Recreation Season in Reach_02 of the Crow Creek Project Area.

The model was also used to locate source contributions from the basins in the city shown in Figure 2-8. Figure 2-9 illustrates the source allocation by city basin, in which Capitol Basin has the highest contributions of bacteria (63 percent) and is followed by Holiday Basin (16 percent) at the endpoint of Reach_01. All other source contributions were less than 10 percent.

A loadograph is commonly used to visualize long-term loading. Values plotted in the loadograph, shown in Figure 2-10, were calculated by averaging MS4 loads for Reach_01 on each day of the year from 1995 to 2010. Modeled MS4 loads (maroon lines on the loadograph) were developed as the product of the modeled MS4 flows and the EMCs. The in-stream, criteria-based load (from the MS4 capped at the in-stream criterion applicable to Crow Creek [blue line on the loadograph]) was developed as the product of the modeled MS4 flows and the Crow Creek geometric mean *E. coli* criterion of 126 org/100 mL. The *E. coli* water-quality standard of 126 org/100 mL is not written for the MS4 flows from the city of Cheyenne. However, if the same standards were applied to the MS4 flows, the average required reduction in bacteria loads from the city (calculated using the loadograph values) would be over 99 percent in Reach_01. Load reductions required are fairly consistent with the concentration data from tributaries and stormwater sites collected in Reach_01 (discussed in Section 1.4.1). The average median event concentration from the tributary and stormwater sites in Reach_01 was 1,302 mpn/100 mL, which indicates a required reduction of approximately 90 percent.

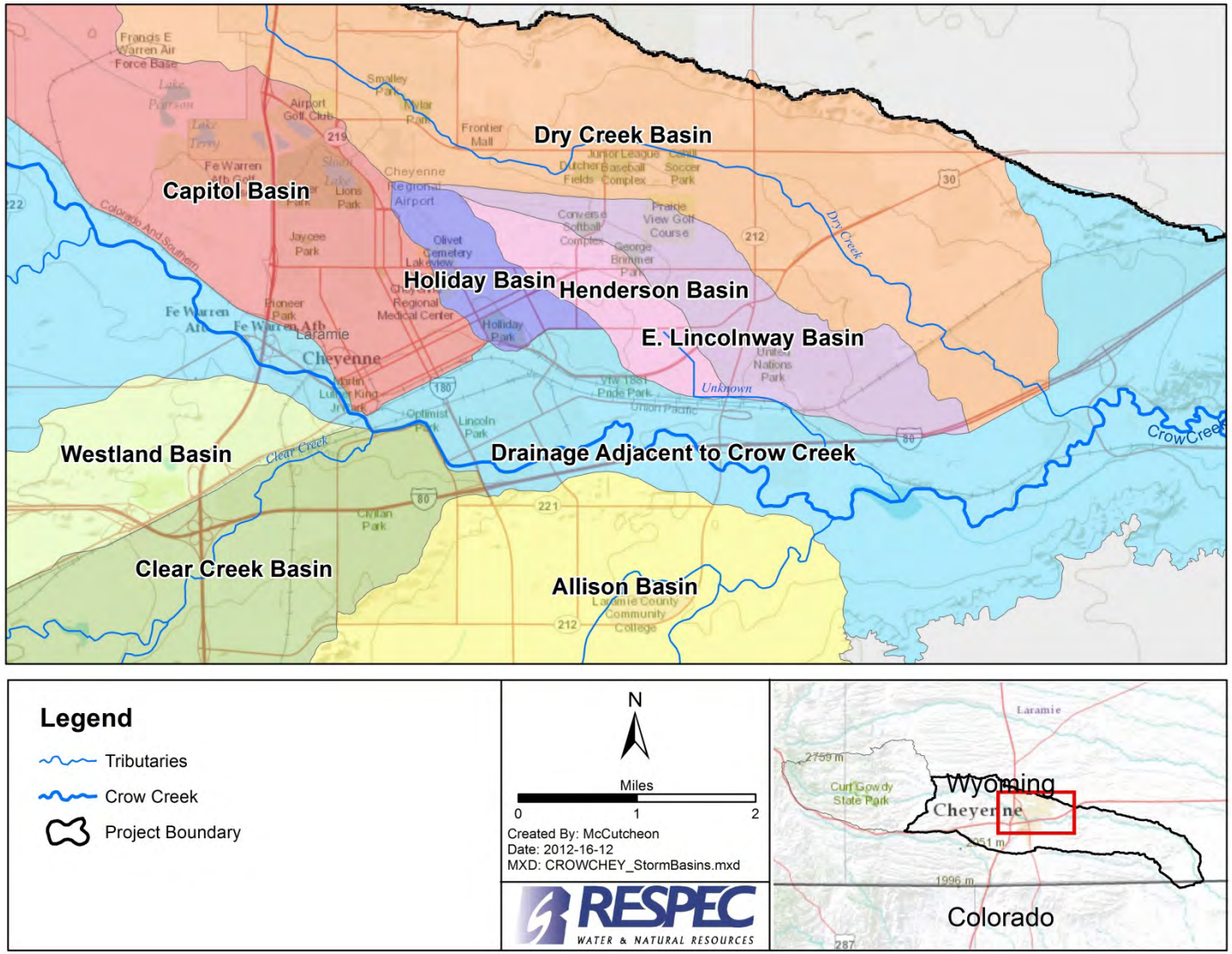

Figure 2-8. Cheyenne Drainage Basins in the Crow Creek Project Area.

RSI-1939-12-018

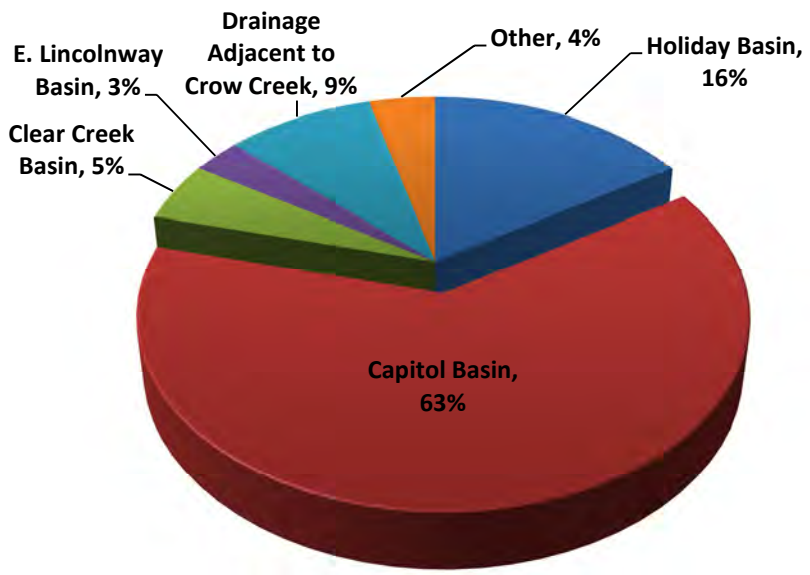

Figure 2-9. Source Assessment Modeling Results by Drainage Basin for the Recreation Season in the Crow Creek Project Area.

RSI-1939-12-019

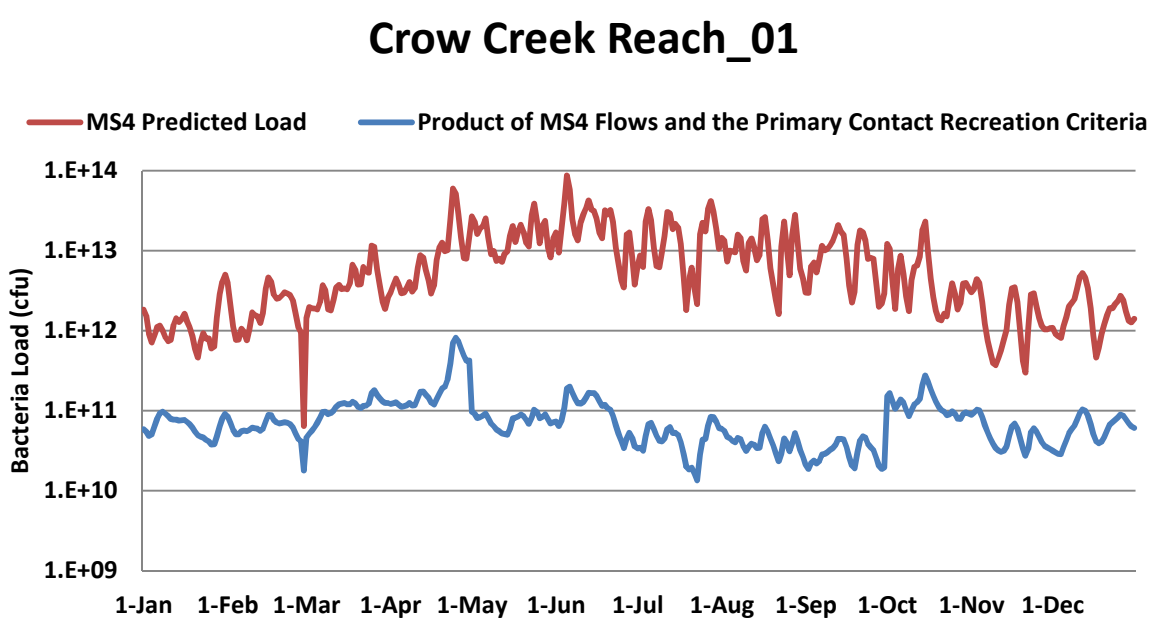

Figure 2-10. Time Series of Average Daily Municipal Separate Storm Sewer System Load and the Product of Municipal Separate Storm Sewer System Flows and the Applicable Contact Recreation Criterion in Reach_01.

3.0 TOTAL MAXIMUM DAILY LOAD AND ALLOCATIONS

The LDC is a dynamic expression of the allowable daily load for any given flow in each specified season. The TMDL was developed using the LDC approach, which results in a flow-variable target that considers the entire flow regime in the summer recreation season (May 1–September 30) and the entire flow regime in the winter recreation season (October 1–April 30). To aid in interpreting and implementing each TMDL, the TMDL and LDC flow intervals were grouped into five flow zones: high flows (0–10 percent), moist conditions (10–40 percent), midrange flows (40–60 percent), dry conditions (60–90 percent), and low flows (90–100 percent), as per guidance provided by the U.S. Environmental Protection Agency [2007].

To aid in prioritizing implementation, load allocations were calculated for each of the five flow zones using summer and winter recreation criteria. This TMDL is written on the geometric mean during the summer and winter recreation seasons because "an exceedance of the single sample maxima shall not be cause for listing a waterbody on the state 303(d) list or development of a TMDL" [Wyoming Department of Environmental Water Quality, 2007].

TMDL tables were constructed for each reach using simulated flows and bacteria concentrations. The summer recreation season TMDL tables in this chapter are in effect from May 1 through September 30, and the winter recreation season TMDL tables are in effect from October 1 through April 30. Only data from each applicable time period were used to develop the TMDL allocations and load reduction goals. Exceedances of the summer recreation season criterion do occur in the reach upstream of Reach_01 and the reach downstream of Reach_02. Therefore, the contribution from the upstream reach was considered in the source assessment and the restoration strategy. Methods used to calculate both Reach_01 and Reach_02 TMDL allocations are discussed in detail in this chapter. In addition, a schematic of the project area explaining the calculation equations for Reach_01 is provided in Figure 3-1. A schematic is not included for Reach_02. Detailed discussions on each of the equations shown in Figure 3-1 are provided in the following sections.

3.1 LOADING CAPACITY

The TMDL (loading capacity) is the sum of the load allocation (LA), the WLA, and the MOS, as shown in Equation 3-1:

$$TMDL = LA + WLA + MOS \tag{3-1}$$

E. coli bacteria-loading capacities are generally calculated as the product of the 95th percentile flow in each flow zone, the applicable criterion, and a unit conversion factor. However, flows at the endpoint of Reach_01 (below Dry Creek) have historically fallen below (as low as 2.5 cfs) the

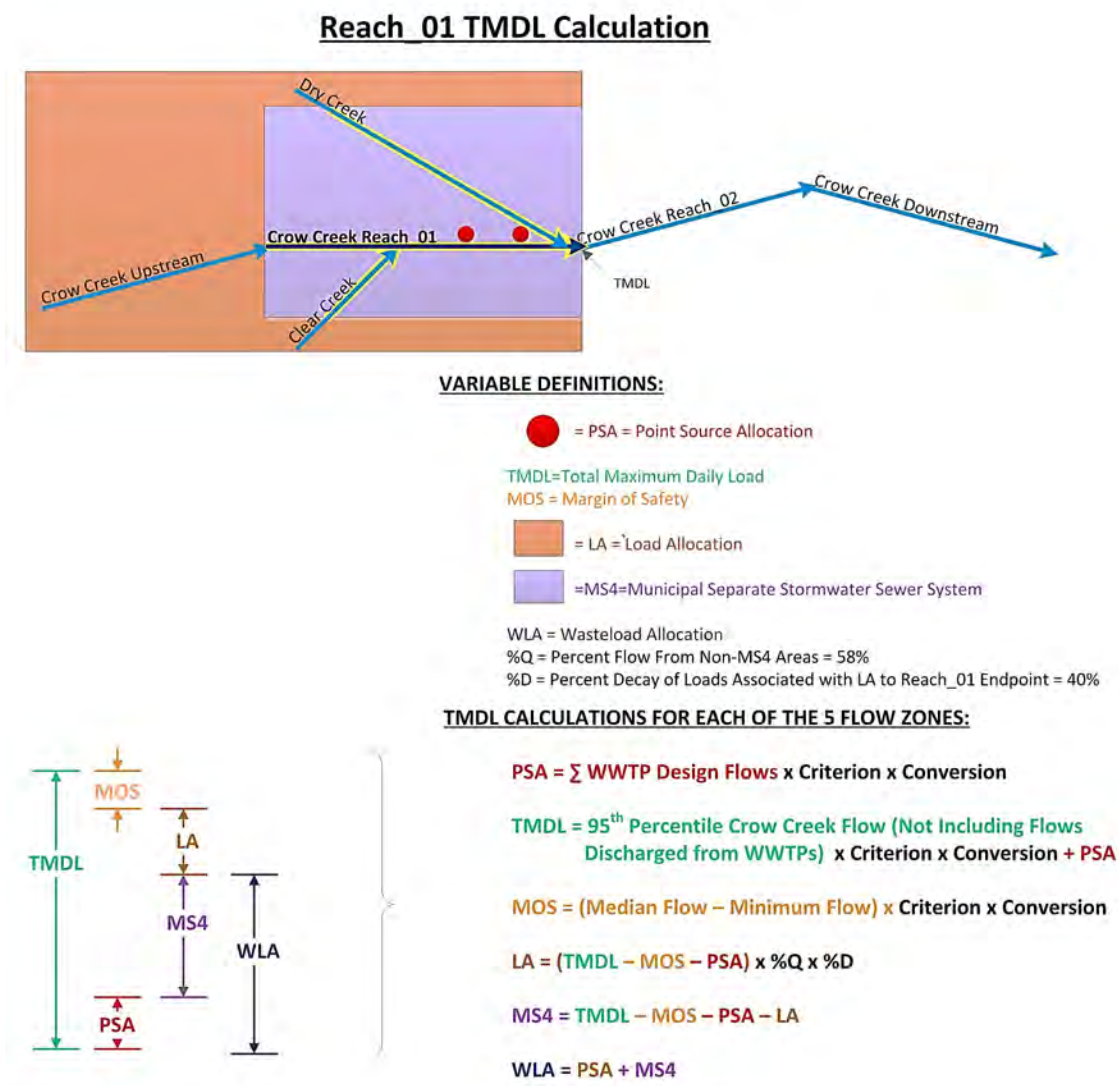

Figure 3-1. Schematic of the Project Area Explaining the Calculation Equations for Reach_01.

sum of the design flows from the Crow Creek WWTP and the Dry Creek WWTP (approximately 26 cfs). The accepted method for calculating a point-source allocation (PSA) is to multiply the design flow of a facility, the water-quality criterion, and a conversion factor. The calculation of the conversion factor is shown in Equation 3-2. Because the flow from the WWTPs has the potential to be far higher than those occurring in the midrange, dry, and low flow zones, the 95th percentile of flows in Crow Creek (without the flows discharged from the WWTPs) in each flow zone were increased by the sum of the WWTP design flows to create the final LDC for Crow Creek to be used in the calculation of the TMDL. By using the flows in Crow Creek with the actual WWTP flows removed, before the generation of the LDCs, the WWTPs are not accounted for twice in the final calculations of the loading capacity or the subsequent allocation of the WLA. Additionally, the PSA was added to the current load, and, therefore, maintains the needed load reductions in the TMDL table as originally calculated as the difference between the current load and the allowable load based on the Crow Creek flows. The loading capacities in each flow zone were calculated as the product of the following three numbers: (1) the sum of the 95th percentile of Crow Creek flows and the design flows, (2) the applicable criterion, and (3) a unit conversion factor.

$$\frac{C\,\text{mpn}}{100\,\text{mL}} \times \frac{Q\,\text{ft}^3}{1\,\text{s}} \times \frac{86{,}400\,\text{s}}{1\,\text{d}} \times \frac{28{,}317\,\text{mL}}{1\,\text{ft}^3} \times \frac{1}{10^9} = C \times Q \times 0.0245 \frac{\text{mpn} \times 10^9}{\text{day}} \tag{3-2}$$

where:

C = Concentration
Q = Flow
L = Load

3.2 MARGIN OF SAFETY

An explicit MOS identified using a duration curve framework is an unallocated load intended to account for uncertainty. An explicit MOS was calculated as the difference between the loading capacity at the midpoint of each of the five flow zones and the loading capacity at the minimum flow in each zone. A substantial MOS is provided using this method, because the loading capacity is typically much less at the minimum flow of a zone as compared to the midpoint [U.S. Environmental Protection Agency, 2007]. Because the allocations are a direct function of flow, accounting for potential flow variability is an appropriate way to address the MOS.

3.3 LOAD ALLOCATION

The LA represents the load allowed from nonpoint sources accounting for uncertainty in the loading capacity, and it is generally calculated as the loading capacity minus the WLA and the MOS. Flow contributions to the endpoint of Reach_01 include the MS4, the flow from upstream

of Reach_01, and the local flow from outside of the MS4. The non-MS4 flow contributions were calculated using the HSPF model by "disconnecting" the MS4 flows and calculating the percent difference in flows with and without the MS4 flows. The HSPF model determined that the MS4 contributed approximately 42 percent of the flow at the endpoint of Reach_01, and the reach upstream of Reach_01 contributed the remaining 58 percent. In addition, the HSPF model determined that approximately 40 percent of the load from the reach upstream of Reach_01 reaches the endpoint of Reach_01 because of decay. Therefore, the LA for Reach_01 was calculated to be 23.2 percent (58 percent × 40 percent) of the difference between the TMDL, the MOS, and the PSA. By accounting for the decay of the allowable upstream load, the MS4 is allocated a higher load that is equal to the upstream load decay while still setting targets in line with the TMDL. Reach_02 has no point sources and zero direct MS4 influence; therefore, the LA of Reach_02 was simply calculated as the TMDL minus the MOS.

3.4 WASTELOAD ALLOCATION

The WLA is the sum of the PSAs and the MS4 loads in each reach. The PSA is calculated as the product of the design flow, the applicable criterion, and a unit conversion factor. The equation used to calculate the MS4 is shown in Equation 3-3:

$$\text{MS4} = \text{Load From MS4} = \text{TMDL} - \text{MOS} - \text{LA} - \text{PSA} \tag{3-3}$$

Two applicable point sources of *E. coli* bacteria (Crow Creek WWTP and Dry Creek WWTP) discharge directly to Reach_01 of Crow Creek. No bacteria point sources exist upstream of Reach_01 or in Reach_02. The PSAs for these point sources, provided in Table 3-1, were calculated as the product of a specified criterion (summer or winter recreation season criterion), the facility design flow, and a unit conversion factor. The design flows for Crow Creek WWTP and Dry Creek WWTP are 10 cfs and 16 cfs, respectively. If both of the WWTPs were flowing at their design flow, the flow in Crow Creek at the Reach_01 endpoint would be approximately 26 cfs. The MS4 for Reach_01 was calculated as the difference between the loading capacity, the MOS, the LA, and the PSA.

One permitted concentrated animal feeding operation (CAFO) is located in the Crow Creek project area. However, this permitted CAFO is downstream of the impaired reach near Carpenter, Wyoming. The CAFO is not allowed to discharge, except in the case of a catastrophic storm event that causes an overflow from the runoff and/or wastewater control structure.

3.5 LOAD DURATION CURVES

E. coli LDCs were constructed for both impaired segments in the Crow Creek project area for both the summer and winter recreation seasons. LDCs include the loading capacity curve

Table 3-1. Crow Creek *E. coli* Wyoming Pollutant Discharge Elimination System Waste Load Allocations, Expressed as Loads

2012 Impaired Segment of Crow Creek	Project Reach	Permittee	Permit Number	Load Type	Summer Recreation Season (cfu × 10^9/day)	Winter Recreation Season (cfu × 10^9/day)
WYSP101900090107_02, WYSP101900090107_03, WYSP101900090107_04, WYSP101900090107_05	Reach_01	Crow Creek WWTP	WY0022381	PSA	31	155
		Dry Creek WWTP	WY0022934	PSA	50	250
		Cheyenne MS4	WYR04-0000	MS4	Flow Zone Variable (13–404)[(a)]	Flow Zone Variable (63–823)[(a)]
		F.E. Warren Air Force Base MS4				
		Laramie County MS4				
		Wyoming Department of Transportation (WDOT) MS4				
WYSP101900090107_01, WYSP101900090203_01	Reach_01 and Reach_02	Crow Creek WWTP	WY0022381	PSA	0	0
		Dry Creek WWTP	WY0022934	PSA	0	0
		Cheyenne MS4	WYR04-0000	MS4	0	0
		F.E. Warren AFB MS4				
		Laramie County MS4				
		WDOT MS4				

(a) Tables 3-3 through 3-6 contain MS4 load allocations for each flow zone.

(shown as a green line in Figures 3-2 through 3-5), which is constructed using the product of a running 30-day average simulated flow, the applicable criterion (summer or winter recreation season criterion), and a unit conversion factor. Because the Wyoming Water Quality Standards state that "an exceedance of the single sample maxima shall not be cause for listing a waterbody on the State 303(d) list or development of a TMDL watershed plan" [Wyoming Department of Environmental Quality, 2007], no single sample maximum TMDL tables are included in this document. The sum of the two PSAs in Reach_01 is shown as a dashed tan line, and the WLA, which includes both PSAs and the MS4, is shown as a purple line in the Reach_01 LDCs in Figures 3-2 and 3-3. The space between the purple line and the dashed tan line represents the MS4 loads. There is no WLA in Reach_02; therefore, there are no PSA or WLA lines in the Reach_02 LDCs. The PSAs are consistent across all flow zones, while the MS4 load varies depending on flow contribution from the MS4 area. The points plotted in each LDC are loads calculated by multiplying the observed geometric mean *E. coli* concentrations by the 30-day average simulated flow and a unit conversion factor. Because there are no geometric mean data at the endpoint of Reach_01, and because the stream conditions change rapidly at stormwater inflows, no observed geometric mean points are included on the Reach_01 LDCs, and existing loads are based on calibrated, simulated results. Boxplots of the geometric mean data are also included in each flow zone. Both the plotted, single points and the boxplots of loads show characteristics of the water-quality impairment. Loads that plot above the curve exceed the water-quality criteria, and while those below the curve are in compliance.

The locations of the water-quality monitoring sites, from which observed data were collected on Crow Creek, are shown in Figure 1-5. Because a monitoring site is not located at the endpoint of Reach_01, there are no observed points on the Reach_01 LDCs, and simulated loads were used to represent reductions needed. In addition, stormwater outfall impacts on concentrations at each monitoring site throughout the reach limit the simulation results at the endpoint of Reach_01. Geometric means of observed bacteria data from CRC800 are shown in Reach_02 LDCs. Because the geometric mean data were limited in the low flow zone in Reach_02, simulated loads were used to represent reductions needed. Water-quality monitoring sites and flow-monitoring sites used to develop the LDCs are shown in Table 3-2. LDCs based on the summer recreation season criterion and winter recreation season criterion for Reach_01 and Reach_02 are shown in Figures 3-2 through 3-5.

In the summer recreation season, exceedances of the criterion occurred during all flow conditions in both segments (Reach_01 and Reach_02). Bacteria loads exceeding the criterion in the higher flow zones generally reflect potential, indirect source contributions, such as stormwater runoff or other nonpoint-source load contributions. Bacteria loads exceeding the criterion in the lower flow zones generally indicate potential direct-source load contributions or sources in close proximity to the stream, such as failing septic systems, cross connections, or livestock in the stream channel [U.S. Environmental Protection Agency, 2007].

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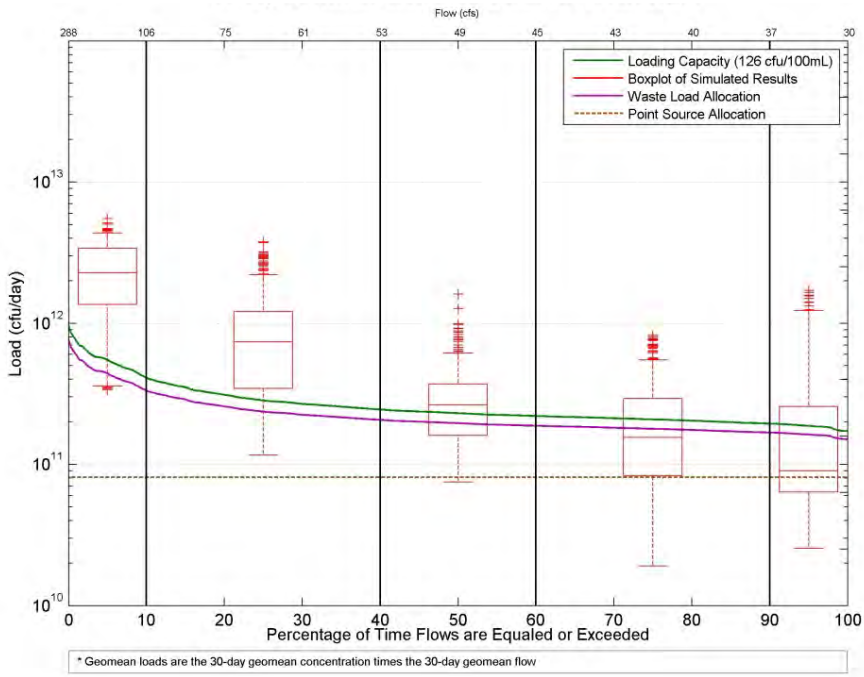

Figure 3-2. Reach_01 Load Duration Curve Representing Allowable Geometric Mean *E. coli* Loads Based on **Summer Recreation Season** Criterion.

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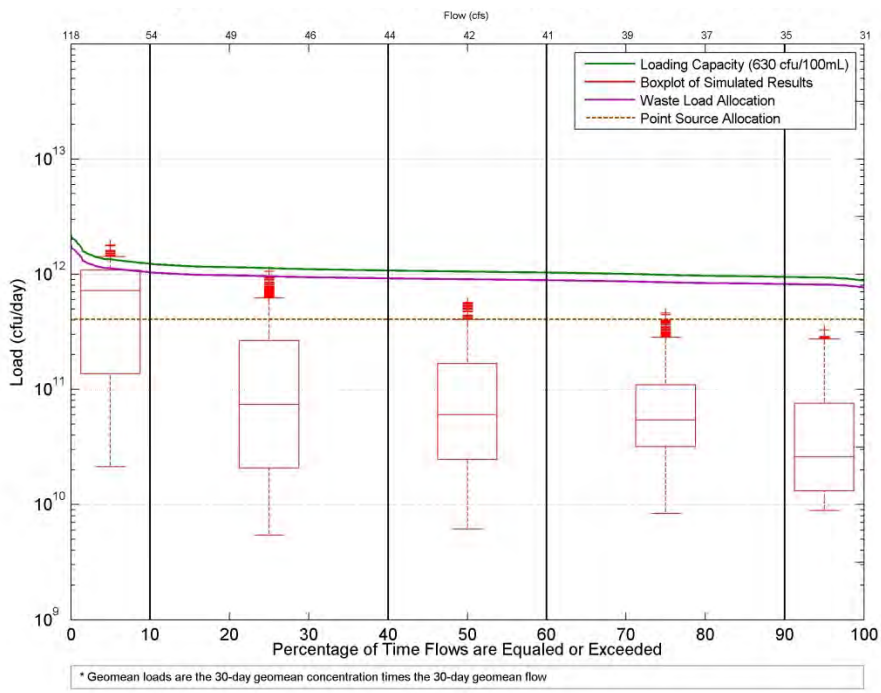

Figure 3-3. Reach_01 Load Duration Curve Representing Allowable Geometric Mean *E. coli* Loads Based on **Winter Recreation Season** Criterion.

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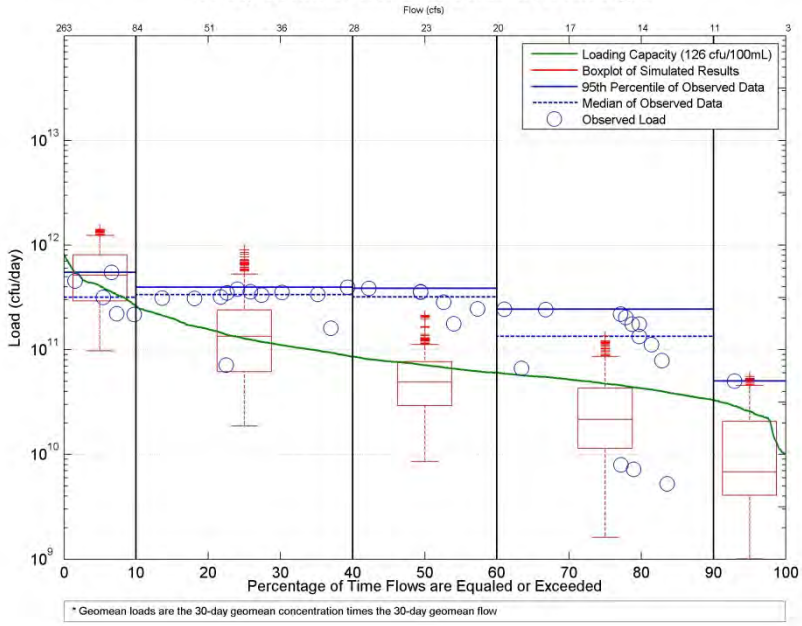

Figure 3-4. Reach_02 Load Duration Curve Representing Allowable Geometric Mean *E. coli* Loads Based on **Summer Recreation Season** Criterion.

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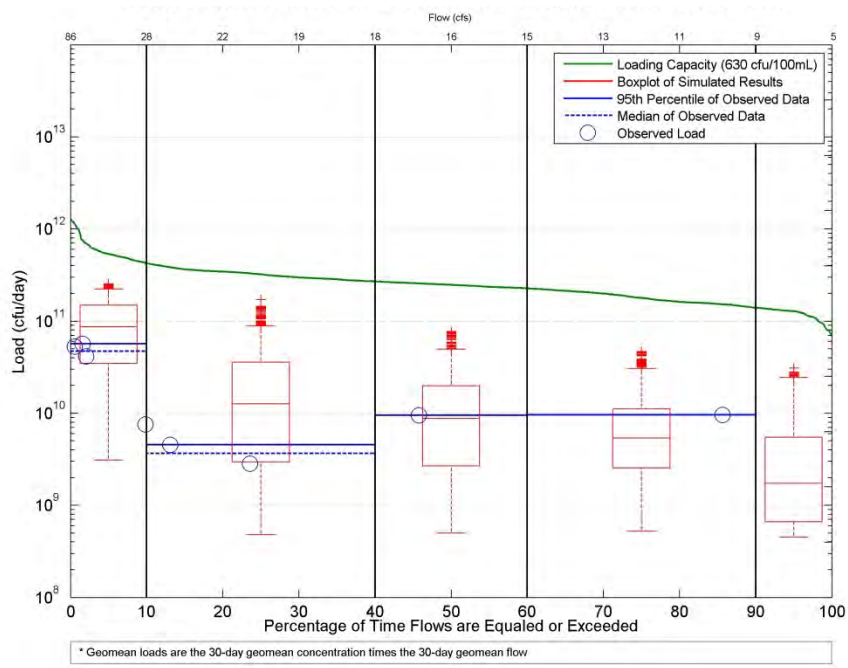

Figure 3-5. Reach_02 Load Duration Curve Representing Allowable Geometric Mean *E. coli* Loads Based on **Winter Recreation Season** Criterion.

Table 3-2. Water-Quality Monitoring Sites and Flow-Monitoring Sites From Which Data Were Used to Develop Load Duration Curves

Reach	*E. coli* Sites Used	Flow Sites Used
Reach_01	Simulated bacteria directly downstream of Dry Creek confluence	Simulated flow directly downstream of Dry Creek confluence
Reach_02	CRC800	Simulated flow at CRC800

3.6 TOTAL MAXIMUM DAILY LOADS

The baseline load conditions (cfu × 10^9/day) were calculated by using the product of the simulated 30-day geometric mean of *E. coli* concentrations at reach endpoints, the 30-day average of simulated flow (cfs) at reach endpoints, and the unit conversion factor provided in Equation 3-2 (0.0245) for both Reach_01 and Reach_02. The 95th percentile of the range of these estimates in each flow zone was defined as the baseline load.

Tables 3-3 and 3-4 present load allocations for Reach_01 based on summer and winter recreation season criteria, respectively. Tables 3-5 and 3-6 present the same information for Reach_02. The PSAs from Reach_01 are described in Table 3-1. In Reach_01, reductions are required in all flow zones during the summer recreation season but are not required during the winter recreation season. Greater load reductions are required in the upper flow zones for Reach_01 through the city where loads are the highest, which supports the idea that stormwater sources are a key concern in this system. In Reach_02, reductions are required in all flow zones during the summer recreation season but are not required during the winter recreation season.

The flow-weighted percent reductions for all flow zones combined, that are required to meet the TMDL based on the summer recreation season water-quality criterion, were 74 percent in Reach_01 and 47 percent in Reach_02.

Table 3-3. Crow Creek *E. coli* Bacteria Total Maximum Daily Load Based on the Summer Recreation Season Criterion for Reach_01

TMDL Component (cfu × 10^9/day)		Flow Zone									
		High		Moist		Midrange		Dry		Low	
		> 106 cfs		106–53 cfs		53–45 cfs		45–37 cfs		< 37 cfs	
LA		122		44		17		10		4	
WLA	MS4	485	404	225	144	136	55	115	34	94	13
	PSA		81		81		81		81		81
MOS		143		39		10		14		16	
TMDL		750		308		163		139		114	
Current Load[(a)]		3,635		1,571		284		213		198	
Load Reduction		2,885		1,263		121		74		84	
% Load Reduction		79		80		43		35		42	
Overall Reduction Required = 74%											

(a) Current load is the 95th percentile of the geometric mean-simulated *E. coli* load for each flow zone.

Table 3-4. Crow Creek *E. coli* Bacteria Total Maximum Daily Load Based on the Winter Recreation Season Criterion for Reach_01

TMDL Component (cfu × 10^9/day)		Flow Zone									
		High		Moist		Midrange		Dry		Low	
		> 54 cfs		54–44 cfs		44–41 cfs		41–35 cfs		< 35 cfs	
LA		248		82		58		44		18	
WLA	MS4	1,231	823	677	272	597	192	548	143	468	63
	PSA		405		405		405		405		405
MOS		116		53		21		39		60	
TMDL		1,592		812		676		631		546	
Current Load[(a)]		1,026		292		157		89		68	
Load Reduction		0		0		0		0		0	
% Load Reduction		0		0		0		0		0	
Overall Reduction Required = 0%											

(a) Current load is the 95th percentile of the geometric mean-simulated *E. coli* load for each flow zone.

Table 3-5. Crow Creek *E. coli* Bacteria Total Maximum Daily Load Based on the Summer Recreation Season Criterion for Reach_02

TMDL Component (cfu × 10^9/day)	Flow Zone				
	High	Moist	Midrange	Dry	Low
	> 84 cfs	84–28 cfs	28–20 cfs	20–11 cfs	< 11 cfs
LA	564	196	74	45	17
WLA	0	0	0	0	0
MOS	153	42	11	14	16
TMDL	717	238	85	59	33
Current Load[(a)]	1,236	557	113	87	46
Load Reduction	519	319	28	28	13
% Load Reduction	42	57	25	31	29
Overall Reduction Required = 47%					

(a) Current load is the 95th percentile of the geometric mean-simulated *E. coli* load for each flow zone.

Table 3-6. Crow Creek *E. coli* Bacteria Total Maximum Daily Load Based on the Winter Recreation Season Criterion for Reach_02

TMDL Component (cfu × 10^9/day)	Flow Zone				
	High	Moist	Midrange	Dry	Low
	> 28 cfs	28–18 cfs	18–15 cfs	15–9 cfs	< 9 cfs
LA	1,048	356	249	187	83
WLA	0	0	0	0	0
MOS	111	53	22	39	58
TMDL	1,159	409	271	226	141
Current Load[(a)]	222	90	50	31	24
Load Reduction	0	0	0	0	0
% Load Reduction	0	0	0	0	0
Overall Reduction Required = 0%					

(a) Current load is the 95th percentile of the geometric mean-simulated *E. coli* load for each flow zone.

4.0 SEASONALITY

Monthly precipitation, stream flow, and *E. coli* concentration in Crow Creek showed seasonal variation. Precipitation at the Cheyenne airport (1990 through 2011) was used to calculate minimum, maximum, and average monthly precipitation. As shown in Figure 4-1, the average monthly precipitation is generally the highest in May, June, and July (2.3 inches).

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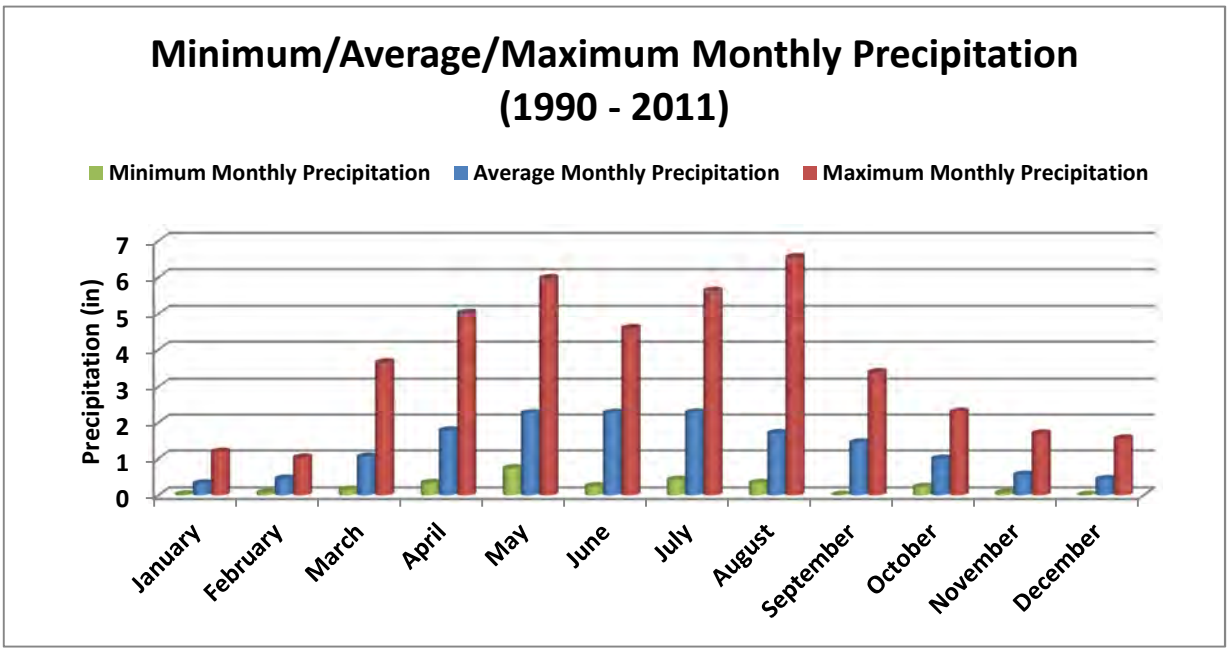

Figure 4-1. Minimum, Maximum, and Average Monthly Precipitation at the Cheyenne, Wyoming, Airport.

A boxplot of flow data at CRC400 is provided in Figure 4-2. Flows were typically highest during spring and summer months and lowest during the fall months. The maximum average flows occurred in May, and the minimum average flows occurred in September.

Available *E. coli* grab sample data (replicates not used) for mainstem project sites were used to create monthly boxplots as provided in Figure 4-3, and to calculate monthly median bacteria concentrations, as provided in Figure 4-4. The boxplots indicate that the higher average and median bacteria concentrations occurred in the spring and summer months. The highest mean bacteria concentration occurred in July (2,293 mpn/100 mL). Because higher flows and bacteria concentrations occur during the spring and summer months, bacteria loads are highest during the spring and summer months.

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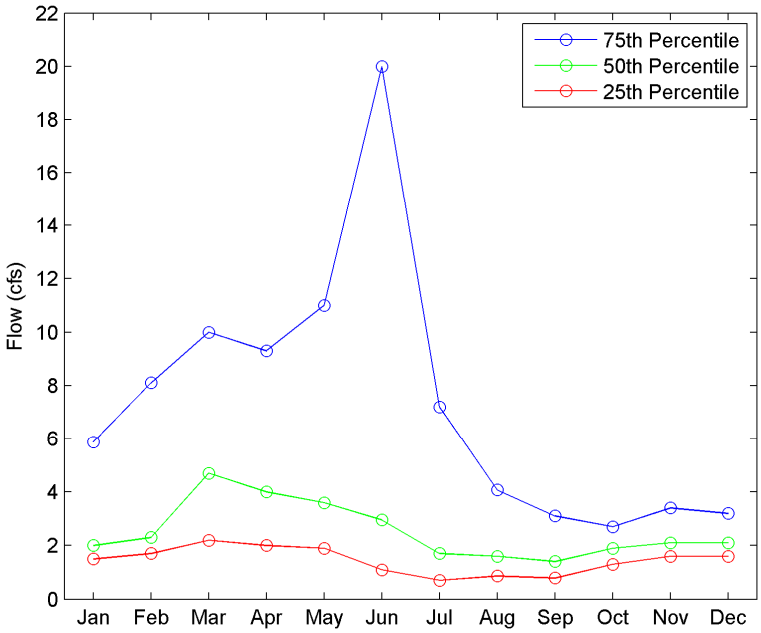

Figure 4-2. Monthly Flow at CRC400.

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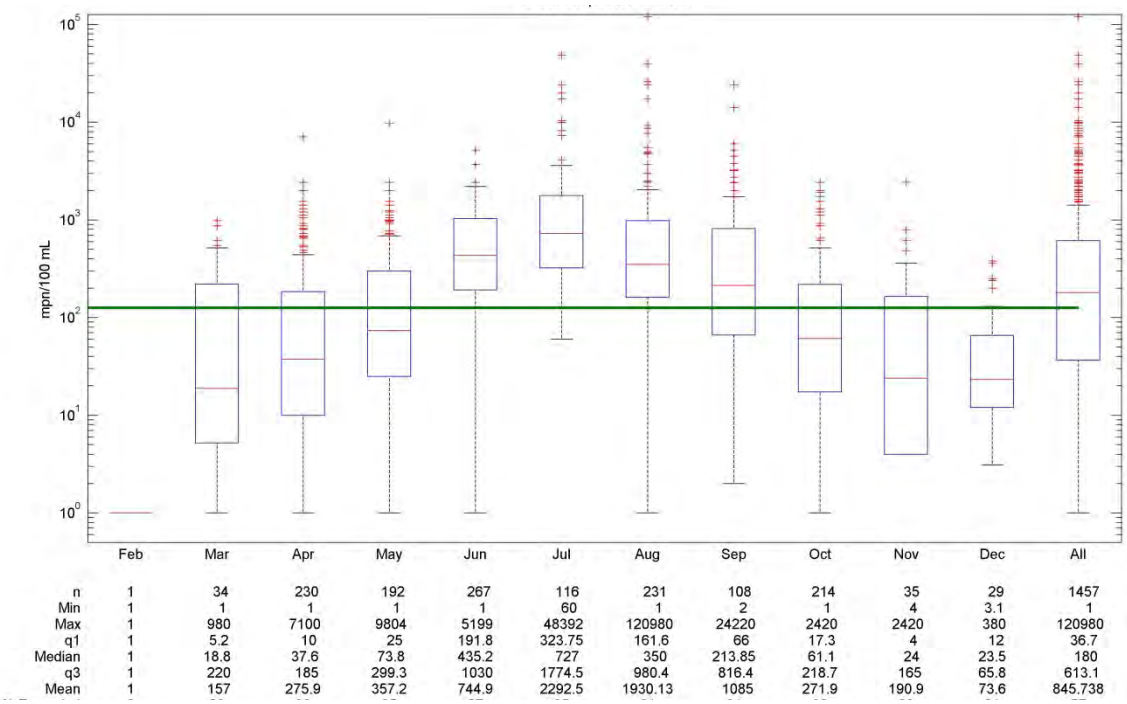

Figure 4-3. Monthly Boxplots of *E. coli* Concentrations From All Available *E. coli* Data.

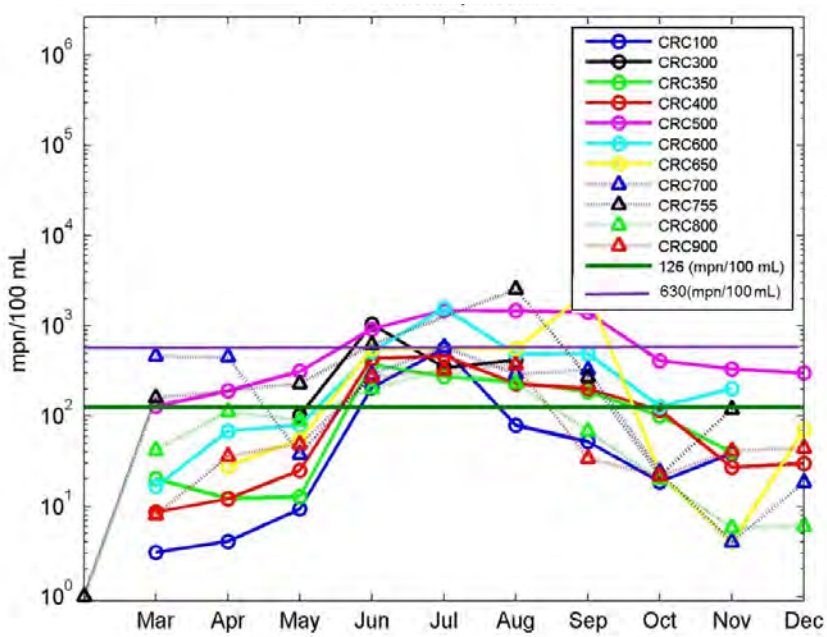

Figure 4-4. Monthly Median *E. coli* Concentrations From All Available *E. coli* Data.

Short-duration, high-intensity rainstorms are common during the summer months. These localized summer storms can cause significant runoff and increased bacteria concentrations for a relatively short period of time while only slightly increasing stream flows. However, by using the LDC approach to develop the TMDL allocations, seasonal variability in flows and *E. coli* loads are taken into account, because stream flow and bacteria delivery to the stream are related to seasonal changes in precipitation. This *E. coli* bacteria TMDL is seasonal, because the summer recreation season criterion (126 org/100mL) from May 1 through September 30 is lower (i.e., more protective) than the winter recreation season criterion (630 org/100mL) from October 1 through April 30. Summer is also a critical period because of seasonal differences in precipitation patterns and land uses. Typically, livestock are allowed to graze along the streams during the summer months. High-intensity rainstorm events are common during the summer and, combined with the peak in bacteria sources, they produce a significant amount of *E. coli* load because of bacterial washoff from the watershed. The high-intensity rainstorm events would also have a large effect on the bacteria in stormwater runoff from the city.

5.0 PUBLIC PARTICIPATION

Efforts to facilitate public education, review, and comment with developing the Crow Creek *E. coli* TMDL included presentations to local groups in the watershed on the findings of the assessment, a feature photograph in a local media publication, and a 30-day public notice period for public review and comment of the draft TMDL document. All input, comments, responses, and suggestions from public meetings and the public notice period were addressed or were taken into consideration in developing the TMDL. Throughout the project, monthly meetings were held among the WDEQ, the city of Cheyenne, the LCCD, and the TMDL consultants. The public notice was published in the *Wyoming Tribune Eagle* on June 3, 2013. The draft Crow Creek *E. coli* TMDL report was made available at the Laramie County Public Library in Cheyenne, was available from the Laramie County Conservation District, and was available for download from the internet (*http://deq.state.wy.us/wqd/watershed/TMDL/TMDL.htm*). The document was also made available through the WDEQ's website. After comments were received, two meetings were held with stakeholders to review. Comments received during the public comment period and responses to those comments are presented in Appendix B. Table 5-1 lists specific announcements and events. A photograph of a sampling site and field crew and a brief project summary were published on the front page of the *Wyoming Tribune-Eagle* on August 12, 2010.

Table 5-1. Crow Creek Public Outreach Announcements and Events

Date	Outreach	Description
08/19/2009	Crow Creek Watershed meeting/tour	Transition from watershed planning to TMDL development
09/08/2009	WDEQ press release on TMDLs	Reviewed and provided comments to Mr. Eric Hargett, WDEQ
10/20/2009	Wyoming Game and Fish projects for Crow Creek	Coordinated with Wyoming Game and Fish for delaying fish projects until after TMDL
02/2010	Newspaper insert on water quality	*Wyoming Tribune-Eagle* and *Pine Bluffs Post*
02/2010	*Crow Creek Connection* (Winter 2010)	TMDL and water-quality update to Crow Creek Watershed Committee
04/29/2010	Open-house announcement on website	Announcement provided by RESPEC
05/11/2010	Newspaper insert on water quality	Delivered supply of extra newspapers to Laramie County Planning Office
06/15/2010	Public meeting hosted by RESPEC	Direct mailing to landowners on or near Crow Creek; meeting held at Laramie County Library
08/12/2010	*Wyoming Tribune-Eagle* article	A photograph of a sampling site and field crew and a brief project description were published on the front page
09/21/2010	Crow Creek Watershed meeting/tour	Update on TMDL and projects with watershed committee members
01/18/2011	Stakeholder meeting hosted by RESPEC	Meeting held at Laramie County Library
02/2011	Newspaper insert on water quality	*Wyoming Tribune-Eagle* and *Pine Bluffs Post*
6/3/2013–7/3/2013	TMDL public notice	Public notice of TMDL was published in the *Wyoming Tribune Eagle*. The draft Crow Creek *E.coli* TMDL report was available at the Laramie County Public Library in Cheyenne, was available from the Laramie County Conservation District, and was available for downloaded from the internet.
7/8/2013	Stakeholder meeting	Review comments from TMDL public notice
8/29/2013	Stakeholder meeting	Review public comments from TMDL public notice

6.0 MONITORING STRATEGY

During and after implementing management practices, monitoring will be necessary to ensure the attainment of the TMDLs. Stream water-quality monitoring should be continued at the LCCD ambient water-quality monitoring stations in the project area (provided in Table 1-6) and at the stormwater sites. In addition, a monitoring station should be added directly downstream of Dry Creek to further understand bacteria loads from the city of Cheyenne. Both event flow and base flow should be monitored. Additional monitoring and evaluating efforts should be targeted to ensure the implemented BMPs are effective. Monitoring locations should be based on the locations and types of BMPs installed.

The WDEQ will use this monitoring strategy to reevaluate the TMDL as the implementation proceeds. This will occur at a minimum of every 5 years as outlined in the WDEQ TMDL work plan [Wyoming Department of Environmental Quality, 2008c]. The WDEQ will notify the EPA, and a new public review will be made available if any changes or adjustments are needed after the reevaluation.

7.0 RESTORATION STRATEGY

A variety of BMPs could be considered in developing a water-quality management implementation plan in the project area. Management scenarios were only evaluated for the summer recreation season, because there was no reduction required for the winter recreation season. While several types of control measures are available for reducing *E. coli* bacteria loads, the practicable control measures discussed below are recommended to address the identified sources in the Crow Creek project area. Based on water-quality monitoring and **HSPF** model results, there is reasonable assurance that the recommended control measures to be implemented in Crow Creek would reduce loads by 95 percent in Reach_01 and by 96 percent in Reach_02. Specific details on the suite of BMPs, represented in the model scenarios, to be implemented in the Crow Creek project area, which incorporate the EPA's 9 Key Elements for Watershed Planning, are included in the *Crow Creek Implementation Plan* [McCutcheon, 2013].

The six management scenarios that were simulated for each bacteria-impaired reach using the **HSPF** model include incorporating the following:

1. Agricultural BMPs (90 percent removal) *upstream* of CRC100
2. Compliance with the summer recreation season criterion at CRC100
3. Cross-connection repair in the city of Cheyenne
4. An *E. coli* reduction of 90 percent on 100 percent of the MS4
5. Reach_01 compliance with summer recreation season criterion (for evaluation of Reach_02)
6. Agricultural BMPs (90 percent removal) *downstream* of CRC100.

Modeled percent exceedance of the summer recreation season criterion, individual load reduction results, and cumulative load reduction results are presented in the first, second, and third rows, respectively, of each reach's TMDL endpoint in Table 7-1. Reach_01 and Reach_02 reductions showing the percent exceedance and cumulative reduction for each scenario are illustrated in Figures 7-1 and 7-2, respectively. Percent reductions were calculated for the summer recreation season (May 1 through September 30) in Crow Creek.

Agricultural BMPs include grazing management and conservation buffers. Model results show that implementing agricultural BMPs upstream of the city of Cheyenne (Scenario 1) would result in a 4 percent load reduction for Reach_01 and a 4 percent load reduction for Reach_02.

Although *E. coli* loads at CRC100 are lower than loads throughout the city of Cheyenne, this site does occasionally exceed the criterion. Model results indicate that compliance of the summer recreation season criterion (126 org/100 mL) at CRC100 (Scenario 2) would result in a 1 percent load reduction for Reach_01 and a 1 percent load reduction for Reach_02.

Table 7-1. Summary of Load and Exceedance Reductions for *E. coli* Best Management Practices Summer Recreation Season

	Baseline	Scenario 1 (90% Load Reduction on Agriculture Land Upstream of CRC100)[a]	Scenario 2 (CRC100 at Summer Recreation Season Criterion 126 org/100 mL)	Scenario 3 (Repair of Cross Connections in Cheyenne)	Scenario 4 (*E. coli* Reductions of 90% on 100% of the MS4)	Scenario 5 (Reach_01 Compliance With Summer Recreation Season Criterion [126 org/100 mL)	Scenario 6 (90% Load Reduction on Agriculture Land Downstream of CRC100)[b]
Crow Creek (TMDL Endpoint of Reach_01)							
Modeled % Exceedance (Summer Recreation Season)[c]	92	92	87	79	16	16	1
Individual BMP % Load Reduction[d]	—	4	1	49	39	0	2
Cumulative BMP % Load Reduction	—	4	5	54	93	93	95
Crow Creek (TMDL Endpoint of Reach_02)							
Modeled % Exceedance (Summer Recreation Season)[c]	36	33	31	12	2	2	0
Individual BMP % Load Reduction[d]	—	4	1	48	37	2	4
Cumulative BMP % Load Reduction	—	4	5	53	90	92	96

(a) Agriculture BMPs for Scenario 1 were on lands within the project area boundary west of Cheyenne local to Crow Creek.

(b) Agriculture BMPs for Scenario 6 were on lands within the project area boundary east of Cheyenne local to Crow Creek.

(c) Modeled percent exceedance represents the percentage of geometric means that exceeded the summer recreation season criterion of 126 mpn/100 mL based on the results of the HSPF model application.

(d) Individual Load Reduction is the reduction in average annual load that corresponds to a single BMP (not cumulative BMP effects).

RSI-1939-12-029

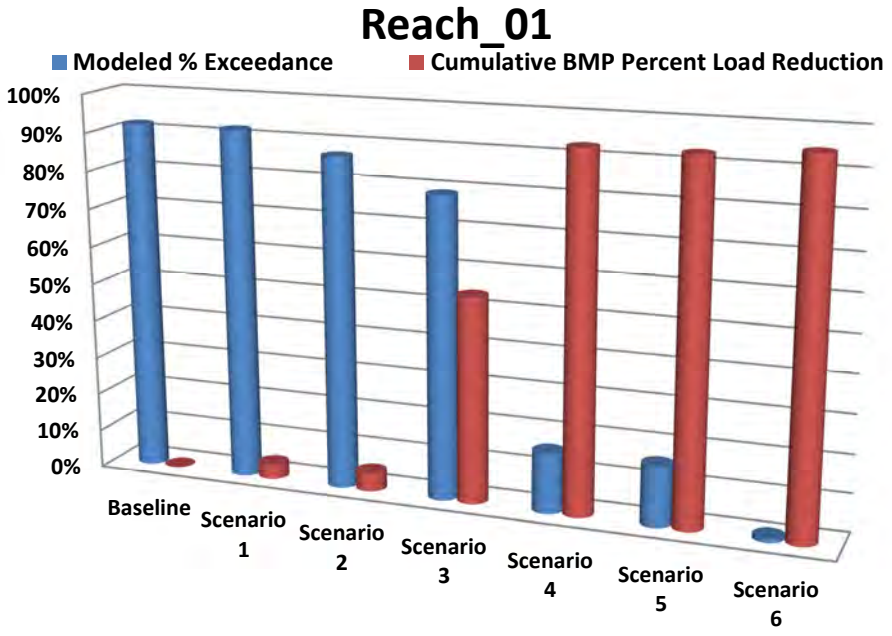

Figure 7-1. Percent Exceedance and Load Reduction for Each Scenario in Reach_01.

RSI-1939-12-030

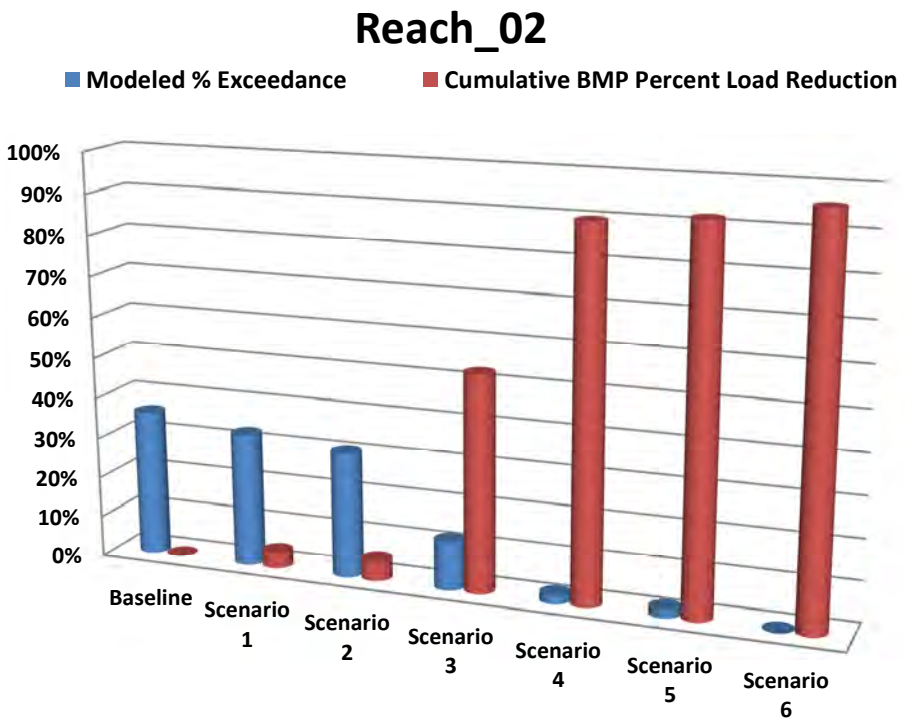

Figure 7-2. Percent Exceedance and Load Reduction for Each Scenario in Reach_02.

The repair of cross connections between sanitary sewers and storm drain systems throughout the city of Cheyenne is in progress. The model shows that the repair of all cross connections in the city of Cheyenne (Scenario 3) would result in a load reduction of 49 percent and 48 percent for Reach_01 and Reach_02, respectively.

The observed *E. coli* data suggest that the MS4 is a large contributor to *E. coli* in Reach_01. The simulation of *E. coli* reductions of 90 percent on 100 percent of the MS4 (Scenario 4) resulted in a load reduction of 39 percent in Reach_01 and a load reduction of 37 percent in Reach_02. The largest percent decrease in exceedance of the summer recreation season criterion in Reach_01 would occur from Scenario 4 (63 percent). Example BMPs that could be implemented in the MS4 area include, but are not limited to, pet waste programs, wet detention basins at the end of stormwater outfalls, or UV treatment of enclosed stormwater pipes.

Scenario 5 was evaluated for Reach_02 only. The model indicated that compliance with the summer recreation season criterion at the endpoint of Reach_01 (Scenario 5) would result in a 2 percent load reduction at the endpoint of Reach_02. Because loads would be significantly reduced by the MS4 load reduction scenario (Scenario 4) and this scenario (Scenario 5), in Reach_02 it can be assumed that if Reach_01 is in compliance, Reach_02 should also be in compliance.

Although Scenarios 1 through 5 would result in load reductions of 93 percent in Reach_01 and 92 percent in Reach_02, further load reductions could be achieved through agricultural BMPs downstream of CRC100 (Scenario 6). Scenario 6 would result in a 2 percent load reduction and a 4 percent load reduction for Reach_01 and Reach_02, respectively. Although the load is highly driven by the MS4, the large reduction in percent exceedance that would occur because of the agricultural BMPs suggests that agricultural BMPs would need to be implemented in addition to the MS4-related BMPs for the stream to be in compliance with the water-quality standards.

The largest, modeled decreases in the load during the summer recreation season were caused by a 90 percent removal of bacteria on 100 percent of the MS4 in Reach_01 (Scenario 4) and the removal of cross connections in Reach_02 (Scenario 5). This decrease indicates that *E. coli* removal in runoff from the city and the repair of cross connections would have a large impact on load reduction and on overall *E. coli* concentrations.

Cumulatively, the implementation of all six scenarios would decrease the exceedance of the summer recreation season criterion from baseline conditions of 92 percent exceedance to 1 percent exceedance in Reach_01 and from baseline conditions of 36 percent exceedance to 0 percent exceedance in Reach_02. Thus, there is reasonable assurance that the cumulative implementation of Scenarios 1 through 6 would be an effective way to achieve maximum *E. coli* reduction in Crow Creek throughout the project area. Note that Laramie County sponsored a Section 319 wetland project in 2010 with the goal of improving water quality in lower Dry

Creek. This project is expected to help trap sediment and other pollutants associated with urban runoff. Cheyenne began fixing cross connections in 2010.

With proper planning between state and local regulatory agencies, organizations, and stakeholders; BMP implementation; and access to adequate financial resources, the exceedance of the *E. coli* standards in the Crow Creek project area can be substantially decreased.

8.0 REASONABLE ASSURANCE

There is reasonable assurance that the model results adequately represent reductions in *E. coli* levels that can be realized through the recommended BMPs. In addition, the goals this TMDL established for Crow Creek can be met with proper planning between state and local regulatory agencies, organizations, and stakeholders; BMP implementation; and access to adequate financial resources. The summary of BMP modeling scenarios conducted during this TMDL assessment provides reasonable assurance that the water-quality standards will be met for the two Crow Creek reaches. The simulated **HSPF** model application of BMP scenarios reduced the modeled percent exceedance from 92 percent to 1 percent in Reach_01 and from 36 percent to 0 percent in Reach_02. Wyoming water-quality standards state that one exceedance of the criteria every 3 years on average should not result in unacceptable effects on freshwater aquatic organisms and their uses. A 1 percent exceedance is in line with the acceptable one exceedance every 3 years [Wyoming Department of Environmental Quality, 2007].

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APPENDIX A

CROW CREEK 303(D) LIST SEGMENTATION EVOLUTION AND CORRELATION TO THE 2013 *E. COLI* TOTAL MAXIMUM DAILY LOAD DOCUMENT

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CROW CREEK 303(D) LIST SEGMENTATION EVOLUTION AND CORRELATION TO THE 2013 *E. COLI* TOTAL MAXIMUM DAILY LOAD DOCUMENT

The segmentation of Crow Creek on the State's 303(d) list changed during the listing periods of 2008, 2010, and 2012. The Crow Creek *E. coli* Total Maximum Daily Load (TMDL) project started in 2009 and was initially based on the 2008 303(d) listed segmentation, which was subsequently further refined based on given, defined endpoints in the 2010 303(d) list. For the 2012 303(d) list, the segmentation of Crow Creek was redefined to include six segments to more accurately reflect surface water classification and sources of pollution and to align with water-quality sample reaches used by the Wyoming Department of Environmental Quality's (WDEQ's) Surface Water Monitoring group and the Laramie County Conservation District (LCCD). A description of the segmentation process for listing purposes on Crow Creek is contained in the 2012 Integrated Report under the description of the Crow Creek Subbasin which begins on page 86, and the Summary of 303(d) List Changes, which begins on page 116. The evolution of the segmentation of Crow Creek is illustrated in Figure A-1.

At the time of the 2012 303(d) list publication, the Crow Creek *E. coli* TMDL project was complete. The **HSPF** model incorporated 39 reaches along the project study area and already accounted for changes in the surface water classification, land use, pollutant sources, and water-quality sampling. Individual TMDLs and Load Duration Curves (LDCs) for each of the six 2012 listed segments (some of which are very short) were not ideal for this TMDL, because sufficient flow data, water-quality data, and unique sources within each segment were lacking. In addition, evaluating pollution reduction scenarios based on the original two impaired segments, because they represented two different implementation environments (Reach_01 is an urbanized environment driven primarily by point sources of pollution whereas Reach_02 is a rural environment with nonpoint sources of pollution) was logical. The correlation between this *E. coli* TMDL document and the current 2012 303(d) list is provided in Table A-1.

Two additional segments of Crow Creek are listed for *E. coli* impairment: WYSP101900090101_01 (Middle Fork Crow Creek) and WYSP101900090104_01 (North Branch North Fork Crow Creek). These segments were not included in this TMDL analysis and will be addressed at a future date.

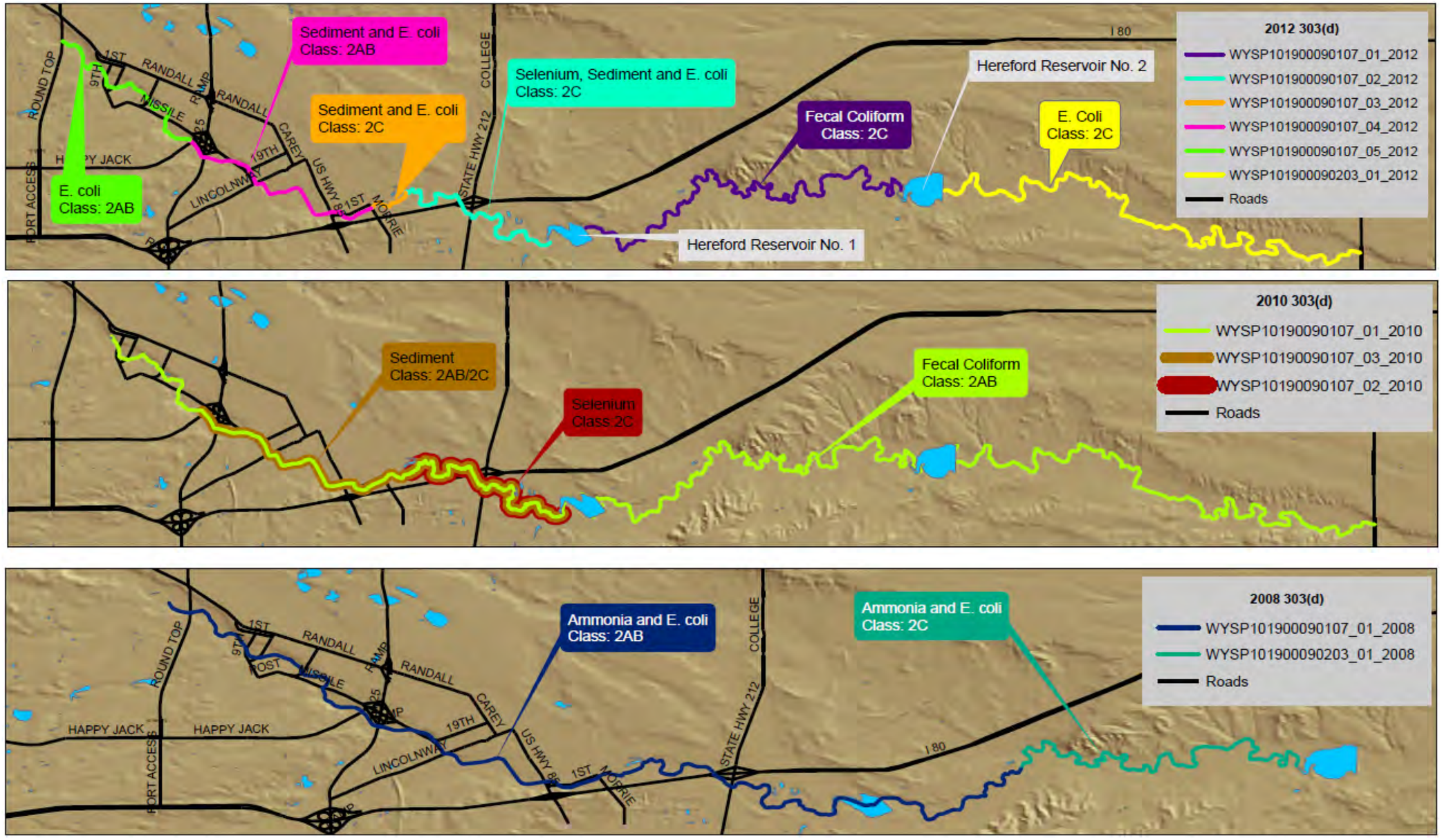

Figure A-1. Crow Creek 303(d) List Segmentation Changes During 2008, 2010, and 2012.

Table A-1. Summary of Load and Exceedance Reductions for *E. coli* Best Management Practices Summer Recreation Season

2012 303(d) List					2013 *E.coli* TMDL Document			
305(b) Identifier	**Class**	**Impairment**	**Location**	**Miles**	**TMDL Report Identifier**	**Location**	**Miles**	**Corresponding 305(b) Identifier**
WYSP101900090107_05	2AB	*E. coli*	From Happy Jack Road upstream to Roundtop Road	3.1	Reach_01	From Roundtop Road to directly downstream of the confluence with Dry Creek.	13.6	All of WYSP101900090107_05, WYSP101900090107_04, WYSP101900090107_03, WYSP101900090107_02 and approximately 3 miles of WYSP101900090107_01.[(b)]
WYSP101900090107_04	2AB	*E. coli*	From Morrie Avenue upstream to Happy Jack Road	3.4				
WYSP101900090107_03	2C	*E. coli*	From Morrie Avenue to a point 0.7 miles downstream[(a)]	0.7				
WYSP101900090107_02	2C	*E. coli*	From 0.7 miles below Morrie Avenue[(a)] downstream to the inlet of Hereford Reservoir #1	3.7				
WYSP101900090107_01	2C	Fecal Coliform	From the inlet of Hereford Reservoir #2 upstream to the outlet of Hereford Reservoir #1	9.4	Reach_02	From Missile Road (HWY 217) upstream to directly downstream of the confluence with Dry Creek.	16.2	Approximately 6.4 miles of WYSP101900090107_01 and all of WYSP101900090203_01.[(b)]
WYSP101900090203_01	2C	*E. coli*	From Missile Road (HWY 217) upstream to the outlet of Hereford Reservoir #2	10.1				

(a) 0.7 miles downstream of Morrie Avenue is the approximate location of the point of discharge from Frontier Refinery.

(b) A difference of 0.6-miles exists between the sum of miles of the 2012 listed 303(d) segments and the sum of miles for Reach_01 and Reach_02 from the TMDL document. This difference is attributed to increasing precision of the database used to delineate the 2012 303(d) listed segments as opposed to the database used to delineate the 2008 303(d) listed segments (which the TMDL document was initially based upon).

APPENDIX B

PUBLIC COMMENTS AND RESPONSES

Department of Environmental Quality

To protect, conserve and enhance the quality of Wyoming's environment for the benefit of current and future generations.

Matthew H. Mead, Governor

Todd Parfitt, Director

September 4, 2013

Mike Vinson and Rob Geringer
City of Cheyenne – Engineering Department
2101 O'Neil Avenue
Cheyenne, WY 82001

Dear Mr. Vinson and Mr. Geringer,

The Wyoming Department of Environmental Quality (WDEQ) would like to thank you for submitting comments on the Crow Creek TMDLs for *E.coli*. These comments have been reviewed and this letter documents the responses addressing them. The responses are as follows:

1. This TMDL is based on the classification of Crow Creek through the area as either Class 2AB or 2C. We are not in agreement with these classifications.
    a. *Surface water classifications are defined in Chapter 1 of Wyoming's Water Quality Rules and Regulations (Chapter 1) [http://soswy.state.wy.us/Rules/RULES/6547.pdf] under Section 4 and Appendix A. Specific stream classifications are found in the Wyoming Surface Water Classification List [http://deq.state.wy.us/wqd/watershed/surfacestandards/Downloads/Standards/2-3648-doc.pdf]. As outlined in these documents, the classification of Crow Creek is based on the presence of game fish (2AB) and nongame fish (2C) in a Wyoming Game and Fish database submitted to the Wyoming Department of Environmental Quality in June 2000. Once a surface water body has been classified, modifications to the classifications must be made through a Use Attainability Analysis (UAA), defined on page 1-8 and Sections 33 and 34 of Chapter 1. The procedures for conducting a UAA are contained in Wyoming's Implementation Policies [http://deq.state.wy.us/wqd/watershed/surfacestandards/Downloads/Standards/Policies_Final_Ag_rev.pdf]. However, this Total Maximum Daily Load (TMDL) project did not identify any data that suggested that the designated uses assigned to Crow Creek were unattainable. As such, this project does not impact the surface water classification of Crow Creek.*
2. Figure 1-5 is at a scale such that the locations of the monitoring sites between Interstate 25 (I-25) and approximately Morrie Avenue are unclear. An additional figure that is a blow-up of this area would be helpful.
    a. *Response: An expanded figure of this section of stream was added to the figure.*
3. In Figure 1-5 Monitoring Sites STW380 and STW430 are labeled twice.

a. *Response: This was corrected*

4. Deming Drive parallels Crow Creek for over a mile. References to the Deming Drive Monitoring Site (CRC500) need to be more specific, perhaps referencing a cross street.
   a. *Response: Table 1-6 was changed to state: Deming Avenue near O'Neil Avenue.*
5. The difference between Monitoring Site "Other" U.P. Outfall (STW400) and South 15th Drain (STW430) is unclear. There is an outfall west of Warren Avenue that drains Interstate 180 to approximately 9th Street, and there is an outfall at approximately 2nd Street and Evans Avenue. Please clarify.
   a. *Response: Table 1-6 was changed to state "West of Warren Avenue" for STW400 and "Evans and Second Street" for STW430*
6. What does N/A mean in Tables 1-7 and 1-8?
   a. *Response: A clarifier was added to the bottom of these tables stating that the N/A refers to the fact that not enough samples were ever collected in a 30-day period in order to calculate of geometric mean of samples.*
7. The seventh sentence of Section 1.4.1 (page 20) states "... one-eighth of the flow concentration at CLC800 is from STW200." This implies Monitoring Site CLC800 is on Crow Creek mainstem instead of Clear Creek. Please clarify.
   a. *Response: this statement was modified to read: "the flow contribution at CLC800 is one-eighth of the flow contribution from STW200; both of these facts show that the relative impact of Clear Creek is much less than the contribution from the Capitol Basin storm drain."*
8. Figures 1-7, 8 & 9 refer to monitoring station CRC 100 as the Start of the City. The City limits western boundary along Crow Creek is at the eastern Right-of-Way of I-25. Roundtop Road is approximately 2.7 miles (as the crow flies) west of the Cheyenne City Limits. The reach between Roundtop Road and I-25 is the Air Force Base. The Start of City should be CRC300.
   a. *Response: This was changed to read "start of urban influence"*
9. Why doesn't Table 3-1 agree with Table 2-1?
   a. *Response: Table 2-1 gives concentration limits in terms of mpn/100mL while Table 3-1 gives daily load limits given as mpn/day. The heading on Table 2-1 was changed to "Concentration Point Source Permit Limits" and Table 3-1 was changed to "Point Source Allocations, expressed as loads".*
10. Table 7-1 refers to the scenarios as Best Management Practices. With the exception of Scenario 3 these appear to be goals. Please clarify.
    a. *Response: Many of the BMP scenarios are more accurately described as milestones for BMP implementations to outline what types of reductions are needed to meet the TMDL, to identify areas and types of BMPs to evaluate for future implementation. Details for BMPs are shown in the implementation plan. Table 7-1 gives the reduction needed from BMPs and the associated reductions on the TMDL endpoints.*
11. Page 57, the end of the first paragraph refers to the report *Crow Creek Implementation Plan* [Krajewski, 2013]. Section 9.0 References refers to the same report but with a date of 2012. Are these the same report or are there two? Is this report available?

a. *Response: The date was changed to 2013. The implementation plan will be sent to the city as soon as it becomes available.*

12. Section 7.0 is based on the Krajewski report (see 11 above). We are uncomfortable with this TMDL report, which has significant impacts to the City of Cheyenne, referencing another report that is unavailable for review.
    a. *Response: The implementation plan will be sent to the city as soon as it becomes available. The TMDL is independent of the Implementation Plan; the implementation adds detail to the TMDL.*
13. The units used in this report appear to be all over the board. Consistency would be nice, as well as some discussion.
        i. *Response: Both cfu and mpn are analogous reporting numbers for bacteria concentrations. The term cfu (colony forming units) are often reported with EPA method 9222, a membrane filter technique using a manual count. The term mpn is often reported for EPA Method 9223 for E. coli Analysis which is a statistical probability method. We used mpn (most probable number) for the purposes of reporting the observed results since those are the units reported to us by the lab, while we used cfu for simulated result since we are reporting colony numbers versus a statistical probability. Additionally, colonies or CFU were listed to be consistent with the units that were originally reported as part of the project (e.g discussing WWTP limits).*
    a. The summaries on pages i and ii state the Threshold Values are 126 organisms per 100 milliliters (org/mL). Then below in the table it is mpn x 10^9/day, where mpn appears to be defined without the 10^9 Scientific Notation.
        i. *Response – the 10^9 is part of the value of the load, not part of the units; it is defined in the upper left corner of the table which applies to all values in the table. Water quality standards are defined with units of concentration of organisms/100mL while loads are expressed as organisms per day.*
    b. Tables 1-7/8 – mpn/mL
        i. *Response: These tables are reporting water quality results which were originally reported as mpn/100mL.*
    c. Figures 1-7/8/ &9 – Assumed mpn/mL, but not stated.
        i. *Response: units are defined on the y-axis.*
    d. Table 1-10 – colonies/mL
        i. This table is reporting data originally reported in mpn so the table was changed to the units of MPN.
    e. Table 2-1 – mpn/mL
        i. These are permitted limits so the units were changed to cfu
    f. Table 2-2 – cfu/day
        i. This table does not list concentrations in a water sample, but lists the contribution of bacteria contributed by animal group. This was also done because it is consistent with the numbers that were reported.

g. Figures 2-4/5 – cfu/100mL
    i. Since these are simulated results which output as cfu, no change was made.
h. Figure 2-10 – mpn, but the scale does not appear to match the data
    i. *Response: this is a timeseries plot on a daily timestep – the units were changed to cfu, the scale does match the data. .*
i. Table 3-1 – mpn/day, but includes the Scientific Notation
    i. The units were changed to cfu, as reported in the point permits. Because the scientific notation changes between different cells (i.e. 10^{10} vs 10^{11}), the scientific notation is given in the table.
j. Figures 3-2/3/4 & 5 – cfu/day
    i. This plot shows simulated results, so no change was made
k. Tables 3-3/4/5 & 6 – mpn x 10^9/day, but appears to be just mpn
    i. These tables were changed to cfu/day
l. Figures 4-3 & 4 – mpn/100mL
    i. These are water quality results that were reported as mpn.
m. Table 7-1 – mpn/100mL
    i. This was changed to org/100mL since it is referencing the cirterion

(2nd round of comments from the City of Cheyenne…)

<u>Source Assessment</u>

1. Understanding the source assessment is important to the City, especially in reference to how these sources are represented in the HSPF model. Specifically, the City requests the following clarifications on the source assessment:
    a. Cross connections were identified as 48% of the bacteria load in Reach 1. How were these represented in the model and what was the basis for including these in the HSPF model?
        i. The TMDL sources were broken out by land use type and the MS4 area was one of these categories. The MS4 source assessment was subdivided between urban runoff and cross connects. This was based on the calibration of the model to the observed data. Essentially when baseflow was occurring with high concentrations of bacteria at a time period when no rainfall runoff was occurring, this was assumed to be cross connects. The remaining portion was allocated to urban runoff.
        ii. Figure 2-6 was changed to say "Urban Runoff" versus "Urban Areas".
    b. Domestic animals, livestock, and wildlife are all mentioned as sources in the Crow Creek watershed; it would be helpful to describe how these are represented in the HSPF model.
        i. *Response: Based on how the Crow Creek HSPF model was constructed, the HSPF model does not quantify the contributions from individual animal groups.*

Bacteria loads from individual animal groups were incorporated into the EMC's represented in the model.

c. Goats were identified as having been present in the riparian areas of the MS4 for weed control. Considering that (i) the reference cited that about 1,100 goats were used in this area (vs. 692 total County population shown in Table 2-2) and (ii) they were present during the sampling period but as of 2011 are no longer being utilized, how was this accounted for in the analysis?
    i. Response: The 1100 goats were brought in from outside of the county and were therefore not accounted for in the county ag statistics.
    ii. *Response: The TMDL assessment period was from 1995-2010; during this time goats were present and need to be listed as a potential source. In section 2.2.3 on page 30 it was stated that this practice was discontinued in 2011. As stated previously contribution from animals groups are not quantified as part of this assessment.*

d. Urban sources are identified as the primary source to Crow Creek; how are these sources included in the assessment (i.e. where is the urban bacteria coming from)?
    i. *Response: These are concentrations originating from the urban area. Figure 2-9 quantifies the contributions from the source areas (by stormwater basin) within the MS4. A more detailed assessment of sources within these basins was not completed as part of this project. Within any of these basins, sources can include but are not limited to small mammals living in the stormwater system, runoff of accumulated bacteria from urban wildlife or pet waste, or growth in the storm drain system.*

e. Although urban bacteria sources are varied, with numerous potential sources, the City recognized that geese are potentially a bacteria source. Were these accounted for in the analysis?
    i. *Response: These were implicitly accounted for in the calibration process of the model. However the model was not built in a way to quantify the sources from individual animal groups.*

f. The City requests a map be included of any sources used for model input. Mapping of these sources would be very useful to the City for planning and BMP purposes.
    i. *Response: Figure 2-9 identifies the level of detail that could be identified with the current model application. Often times TMDLs will report to the land use type, (e.g. residential, industrial, commercial for an urban area), but with the diverse nature of land uses within each of the basins in Cheyenne, this was not possible with any level of confidence. The implementation plan will discuss types of BMPs that could be implemented in the urban area.*

<u>Model Calibration and Data</u>

2. The following questions are intended to provide specific requests for assisting the City in better understanding the results. By providing the additional detail on the calibration of the model and

the figures used to represent the model output the City will have a better understanding of how sources were identified.

a. The calibration presented in the report only focuses on the 2010 data, and City would like some discussion of calibration over multiple years. It would be helpful if all years used for calibration were presented and/or included in an appendix.
    i. *Response: The model simulation period is 1995 -2010. The model was calibrated from 1996-2010. Figure 2-3 was changed to show the calibration for the entire calibration period.*

b. The bacteria calibration needs more clarification, especially how sources are represented and what factors were used to match modeled data to monitored data. For instance, was the model calibrated by adjusting Event Mean Concentrations (EMCs) or die-off coefficients? Additional text discussions on the basis of changes would be helpful.
    i. *Response: We added additional text to the bacteria calibration section in Section 2.3.1.3 to address the above comments.*

c. It would be helpful to have more text clarification for Figures 3-2 through 3-5. Based on our understanding of these plots, it appears that the modeled output (box and whisker) does not match the observed median loads of the graph (Figure 3-4). The plots also appear to be missing data based on earlier tables that suggest there are over 1,000 water quality samples in Reach_01 and 250 in Reach_02. A description of excluded data would assist understanding of the output. For example, why are there no observed data included for Reach_01?
    i. *Response: If data is not shown on the LDC, it just indicates that no observed data was collected in that specific model reach. In the case of the Crow Creek TMDL endpoints, data was collected a short distance upstream or downstream of the end points providing the high level of confidence in the calibrated results at the end point; however this data was not collected in the modeled reach and therefore not shown on the LDCs.*
    ii. *Often times boxplots do not necessarily match exactly with the observed points on a LDC because the boxplots represent all simulated days in a flow zone, while the observed plots are only a handful of days. These differences are to be expected and are analyzed and addressed in the calibration process.*

3. A description of how the fate and transport of bacteria was accounted for in the model would be useful.
    i. *Response: We added additional text to the bacteria calibration section in Section 2.3.1.3 to address the above comments.*

<u>Event Mean Concentrations (EMCs) and Monitoring</u>

4. More descriptions would be helpful on how the EMCs were developed for the urban areas? Were they means or medians?
    i. *Response: The last paragraph on Page 31 was modified to the following:*

The EMCs used in the bacteria model were developed from the 2010 stormwater data. ISCO samplers were set up at key stormwater outfalls to Crow Creek. This dataset allowed for the development and application of EMCs in the model. Stage and discharge data from each event were used to composite samples based on flow volume, which resulted in a single ***flow weighted composite*** *sample for each event. EMCs were applied to the surface outflow and fate and transport processes in the reaches were simulated within the modeled system.*

5. More detail is needed on the land use for each of the monitored subwatersheds and whether these subwatersheds included any cross connections. This information will assist in a better understanding for the implications of the EMCs selected.
    i. *Response: Cross connects locations were not specifically identified as part of this project.*
6. Please provide an appendix with the monitoring approach and procedures for bacteria sampling. Utilizing automated sampling is typically problematic for bacteria due to the short laboratory hold time for the sample (<24hours) and the need to autoclave (sterilize) sample bottles and tubing between events.
    i. *Response: All sampling followed WDEQ's Manual of Standard Operating Procedures for Sampling Collection and analysis [http://deq.state.wy.us/wqd/watershed/Downloads/QA/12-0698-JAC-SOP_July2012.pdf] Escherichia Coli & Total Coliform Bacteria Colilert – Defined Enzyme Substrate Method (pgs. 63-68). The WDEQ's SOP manual is referred to under Section 1.4.3 and 9.0 References. QA/QC methods included running blanks with the ISCO samplers. Using an ISCO sample is an approved method for collecting data for TMDLs. Previous projects that RESPEC has been involved in have investigated the possibility of adding bias to bacteria data from using ISCO's and found that the results are consistent with in-stream concentrations.*

Allocation Process

7. The allocation process needs clarification especially as it relates to the MS4 allocation. The following specific questions are intended to streamline the response to comments.
    a. A TMDL has a margin of safety (MOS), and the report shows the City has an unfair burden with being 100% of the MOS. Please describe the justification for this allocation.
        i. *The margin of safety is calculated based on the flow variability of the stream. It is calculated independent of any allocations assigned to the city and is not taken away from the city's portion of the allocation.*
    b. The MOS process used in the TMDL appears over protective for the TMDL and does not specifically address variability in the data set. Since all of the MOS is taken from the City allocation, this results in an undue burden on the City. We suggest considering a straight 5 percent reduction in each of the flow zones.
        i. *Response: Within the TMDL, the method of the margin of safety accounts for variability of allowable loads within a flow zone. This does not add an excessive*

MOS for this TMDL. Typically explicitly defined MOS's range from 10% to as high as 20%. The range of the MOS's for this TMDL by flow regime is 6% to 19% with a weighted average of 13%.

c. It doesn't appear the HSPF model was used to estimate urban area flows to calculate the MS4 allocation. Please describe the methodology of excluding the model.
    i. *Response: the HSPF flows were used to estimate the flow percent of the flow contribution that the MS4s provides to Crow Creek. This was used to determine allowable load coming for upstream of the city and then calculates decay to this allowable load. Any decay accounted for was added to the MS4 allocation implying that the city can discharge higher than the criteria and still meet the TMDL.*

d. The process used for allocating the loads needs more detail especially for the LA to fully understand how they were developed. Sections 3.3 and 3.4 are difficult to follow and need a more detailed, step by step description of the process would clarify how they were developed.
    i. *Response: Figure 3-1has a simplified bullet list outlining the process of calculating the TMDL.*

Restoration Strategy

The restoration strategy, especially the management scenarios used, needs more clarification. The City believes this section is critical to assist responsible parties in meeting water quality standards. Following are some specific questions on the Restoration Strategy section.

8. The source assessment concluded that the majority of bacteria in Reach_01 (Figure 2-6) is almost 95% from urban areas yet 2 of the 6 scenarios focus on agricultural BMPs. Please explain why there is not as much focus on urban BMPs.
    a. Response: Scenarios 3, 4, &5 were used to evaluate the impacts urban BMP's could have on water quality at the TMDL endpoints. Detailed BMPs are not required as part of a TMDL document. We chose to leave it general since the TMDL document gets approved by the EPA. If details are added it could be interpreted as a requirement for implementation which is not the desired outcome of the TMDL. More details are present in the implementation plan. Ag BMPs were evaluated since it is often times easier/less costly to get reductions from ag areas than urban areas.

9. There appears to be a conflict since scenario 6 (agricultural BMPs below CRC 100) appears to meet necessary reductions. This is in conflict if 95% of the load is from urban areas.
    a. Response: The reductions reported in Table 7-1 are cumulative. Scenario six only results in a 2% reduction at the endpoint of Reach 1 and a 4% reduction at the end point of Reach 2.

10. Scenario 3 relies heavily upon cross connection repair, and as noted prior, City requests information on this source. Please describe how this is accounted for in the HSPF model.

a. Response: See previous comment on Cross Connection calculations (Source Assessment Response 1a.).

11. Scenario 4 is also presented as meeting standards, which is a reduction in urban source areas. It appears the conclusion is reached that either agricultural BMPs or urban BMPs both meet the same goal given the difference in loads it is unclear how this is possible.
    a. Response: The reductions reported in Table 7-1 are cumulative. Scenario 4 only results in a 39% reduction in loads at the TMDL endpoint.

12. Some description of how a 90% reduction in urban areas can be achieved is needed. The City is interested if specific BMPs were modeled? If not, what BMPs does the DEQ suggest will be effective in bacteria reductions?
    a. Response: Specific BMPs were not modeled. Specific BMPs that could be used are described further in the implementation plan that will be provided when it becomes available.

We hope that our meeting on August 29th, 2013 helped to clarify many of these comments and we appreciate you taking time to discuss this project further. As discussed during the August 29th meeting, if you have additional comments after reviewing these responses, please provide them to the WDEQ no later than September 20, 2013. The WDEQ will submit this document for final approval to the EPA with the revisions stated herein. For questions or additional information, please contact Brianna Forrest at: (307) 777-7096.

Sincerely,

Brianna Forrest

Brianna Forrest
Natural Resources Analyst
TMDL Program

9/4/2013
Date

BF/rm/13-0840

Department of Environmental Quality

To protect, conserve and enhance the quality of Wyoming's environment for the benefit of current and future generations.

Matthew H. Mead, Governor

Todd Parfitt, Director

September 4, 2013

Matt Ley
Laramie County Conservation District
11221 US Hwy 30
Cheyenne, WY 82001

Dear Mr. Ley,

The Wyoming Department of Environmental Quality (WDEQ) would like to thank you for submitting comments on the Crow Creek TMDLs for *E.coli*. These comments have been reviewed and this letter documents the responses addressing them. The responses are as follows:

Page 2, Section 1.1; Page 6, Section 1.2 as well as throughout the documents entirety

> **Page 2**, "...downstream of the confluence of the North Fork and South Fork Crow Creek..."
>
> **Page 6**, "The headwaters of Crow Creek originate in Albany County. Crow Creek begins at the confluence of North Fork Crow Creek and South Fork Crow Creek approximately 8.5 miles west of Cheyenne, Wyoming."

Comment: The North Fork Crow Creek and the South Fork Crow Creek do not flow into each other as both streams form separate confluences with the Middle Fork Crow Creek. The above statement should be corrected to say that Crow Creek begins at the confluence of North Fork Crow Creek and the Middle Fork Crow Creek. The error should be corrected throughout the document's entirety.

Response: This statement was modified throughout the document to reflect the confluence with the middle fork.

Page 4, Figure 1-1 Crow Creek Project Area and *E.coli*-Impaired Reaches.

Comment: We feel that the map may be misleading as it does not include the Middle Fork Crow Creek and North Branch North Fork of Crow Creek as also being impaired stream reaches. Even though these stream segments are not part of this TMDL, they should not be listed as non-impaired reaches.

Response: The map was revised to show the impairment on North Branch North Fork Crow Creek; the map shows the 2008 impairment status of the Crow Creek watershed. At the time of this assessment only the North Branch North Fork Crow Creek was listed as impaired; Middle Fork Crow Creek was not listed as impaired until 2010. A sentence was added stating that the North Branch North Fork Crow Creek have impairments that were not addressed in this TMDL study.

Page 5, Section 1.1, *E.coli*-Impaired Reach Definitions

Comment: We feel that the reach definitions for this TMDL are inappropriate as both Reach_01 and Reach_02 are divided by large irrigation reservoirs. These reservoirs are designed and managed for irrigation purposes resulting in very little, if any, water being released directly back into Crow Creek during the summer irrigation season. Water that does make its way back to the creek does so predominately through subsurface flow resulting in drastically different water quantity and quality characteristics above and below the impoundment. The main purpose of utilizing different reach segments is to attempt to limit variability within segments making comparisons between segments more meaningful. As this document states on pages 32-33, "*The purpose of segmenting a watershed is to divide the project area into individual land and channel segments, or pieces, that are assumed to demonstrate relatively homogenous hydrologic, hydraulic, and water-quality behavior. The segmentation provides the basis for assigning similar or identical input and/or parameter values or functions to where they can be applied logically to all portions of a land area or channel length contained in a model segment.*" We view the documents assumption of analogous conditions above and below these reservoirs as being flawed. These reach definitions represent a primary component to the basis of this TMDL, a basis, that due to this inaccuracy, we feel effects the usefulness of the entire document. We request RESPEC address this concern or provide documentation as to why their assumptions are valid.

Response: On page 32-33 the report is describing the segmenting of the watershed for modeling purposes; the segments for the HSPF model are not the same as the reaches used by the WDEQ for listing an impairment. In total there are 39 defined reaches segmented within the Crow Creek HSPF watershed model. The above statement was describing the watershed model segments, and is therefore valid. The segments were broken at each of the reservoirs, with the reservoirs modeled as standalone reaches, to accurately reflect their hydrological and water quality condition. The first sentence on section 2.3.12 on page 32 has been modified to read "the purpose of segmenting a watershed ***for use in a watershed model*** *is to divide....."*

Page 5, Section 1.1, last paragraph

> **Page 5,** "The *E.coli*-Impaired segment of Crow Creek is assumed to be a high-use swimming area and has a single sample *E.coli* maximum concentration of 235 mpn/100 mL."

Comment: While we understand that this information came out of a 2007 WDEQ report, we are unsure how accurate the statement truly is. Furthermore, if this segment of Crow Creek is an actual high-use swimming area, why does DEQ not "post recreational use advisories in public recreation areas" as this stream segment routinely exceeds the single sample maximum value?

Response: The sentence on page 5 that states "The E. coli-impaired segment of Crow Creek is assumed to be a high-use swimming area and has a single sample E. coli maximum concentration of 235 mpn/100 mL during the summer recreation season" was removed from the document since it was not relevant or used during the TMDL analysis.

In Laramie County, such public advisories are typically posted by the local Department of Health.

Page 6, Section 1.2.1 Land Cover/Land Use

> **Page 6**, "A summary of land cover/land use was completed using the 2001 National Land Cover Dataset (NLCD). The NLCD is a 21-category multilayer land cover classification dataset derived from Landsat imagery and ancillary data that provides consistent land cover data for all 50 states [Multi-Resolution Land Characteristics Consortium, 2001]."

Comment: The 2001 NLCD was actually a 16-category land cover classification scheme not a 21 (http://www.mrlc.gov/nlcd2001.php). Furthermore, it may be useful to examine the 2006 NLCD to see what the percent change in land cover the area has experienced over the 5-year period.

Response: the statement was modified to state 16-category land cover classification scheme. The 2006 NLCD was not used because at the time this project was initiated the 2006 NLCD was not published; the 2006 NLCS was not published until 2011.

Page 6: Section 1.2.2 Precipitation

> **Page 6**, "Maximum precipitation generally occurs in the spring and early summer months"

Comment: Maximum precipitation should be changed to "A majority of precipitation..." Additionally, a citation should be provided for this section.

Response: The word "maximum" was changed to "majority". A citation was added for the high plains regional climate center.

Page 6, Section 1.2.3 Irrigation

> **Page 6**, "The largest consumptive use of water (approximately 80 to 85 percent) in Wyoming is from agricultural irrigation, and the primary source is surface water."

Comment: What bearing does the percent of agricultural consumptive use of water across the entire state of Wyoming have on a document that's focused solely on the Crow Creek Watershed? A watershed specific value should be used here. Furthermore, the document fails to address that the vast majority of irrigation in the Crow Creek Watershed is derived from groundwater pumping and center pivot irrigation.

Response: The sentence cited is a general statement describing the importance of irrigation in Wyoming and is used as a justification for having an irrigation section in the report. The irrigation section describes the surface water irrigation structures that are applicable to the project area. A detailed assessment of the irrigation in the watershed was not included in this assessment. The hydrology model incorporated irrigation implicitly though the calibration process.

Page 8, Section 1.2.4 Geology and Soils

Comment: This section does not address soils at all. Information on predominant soil types should be included and citations should be provided for all statements.

Response: A paragraph was added describing the soils hydrologic soil group and the soil erodibility factors, which are the 2 properties most commonly used for watershed modeling using HSPF.

Page 9, Figure 1-3. Average Annual Precipitation in the Project Area

Comment: The figure legend should only include precipitation values actually found in the map. Additionally, a base layer showing roads and cities should be added and the overlap between weather station labels and the project boundary should be fixed.

Response: The legend was corrected and the labels were shifted to eliminate overlaps. Roads and cities layers were added.

Page 10, Figure 1-4. Bedrock Geology Distribution in the Crow Creek Watershed.

Comment: A base layer showing roads and cities should be added to this map.

Response: Roads and cities layers were added.

Page 14, 17 and 18, Table 1-6, 1-7 and 1-8

Comment: The document incorrectly refers to "Little America" as "Super America" for CRC300 and CRC350.

Response: This word "Super" was replaced with "Little".

Page 19 as well as throughout the document, Replicate *E.coli* samples.

Comment: With regards to LCCD *E.coli* samples and replicates, even if the replicate data was not used they were still collected and we would like it to be reflected that way throughout the manuscript. We request replacing "No Replicates" with "Replicate Data Not Used."

Response: The phase "No Replicates" was changed to "Replicates not used".

Page 20, Section 1.4.1

Comment: We feel that this section is somewhat confusing and could be improved, especially since this is what the entire TMDL is based upon. The associated figures should also be improved to better highlight each specific trend that is described in the text.

Response: A reference was added to the previous map of site locations, which was modified to add a zoomed in section of the city. It was edited to remove some of the acronyms to make it easier to follow. Additional arrows were added to the figures to help identify the locations of the outfalls.

Page 23, Section 1.4.2 Summary of Available Point-Source Data

Comment: Citations should be provided for all statements.

Response: A citation was added for the source of the data. No citations are required for the statements about the data since they are based on the analysis completed as part of this project.

Page 26, Section 1.4.3 Quality Assurance Reporting

> **Page 26**, "For *E.coli* replicate samples, the average RPD was 25 percent, the median RPD was 17 percent, the minimum RPD was 0 percent, and the maximum RPD was 162 percent. At low concentrations, RPD is not an accurate method for comparing replicates, and it is at these low concentrations where the highest RPDs occur. Because *E.coli* is typically more variable in nature, it should have an RPD of less than 40 percent. Less variable parameters would be expected to have an RPD of less than 20 percent. Less variable parameters would be expected to have an RPD of less than 20 percent."

Comment: Citations must be provided for all of these statements. We believe than an average project relative percent difference (RPD) of 25% between sample duplicates seems rather high especially since the replicate values are not being utilized to account for this variation. An average RPD of 25% indicates that the overall precision of this data is very low and that any model generated using this data should have decreased confidence associated with it. While the large number of samples (n) helps account for this lack of confidence we believe that a caveat should be provided detailing the limitations of this data.

Response: While the RPD are in fact high, they are in a range that indicates the values are valid. The nature of bacteria is that it is highly variable, which is reflected in the RPD data. Just because it is variable does not mean it is not valid data. Using bacteria data of this nature for use in watershed modeling calibration is a commonly accepted practice in bacteria TMDLs.

Page 26, Section 1.4.3 Quality Assurance Reporting

> **Page 26**, "Small differences between replicate and routine samples may be caused by the contamination of sample bottles, a laboratory error, the inherent variability of the laboratory method, or stream variability."

Comment: We would argue that an average RPD of 25% is not a "small difference." We suggest that this statement be removed as the variation between samples is likely due to the highly variable nature of *E.coli* and not differences in how each sample was collected or analyzed.

Response: The word "small" was removed from this sentence. A sentence was added after the above referenced sentence: "For the sampling on Crow Creek the variation between samples is likely because of the highly variable nature of E.coli and not differences in how each sample was collected or analyzed.

Page 26, Section 1.4.3 Quality Assurance Reporting, last paragraph

Comment: The paragraph fails to describe what a field blank actually is.

Response: The text from the WDEQ SOP was added "Field blanks are created at the sampling site. The purpose of a field blank is to establish that a sample is not being contaminated by conditions associated with the collection or custody of a sample or by cross-contamination during sampling or shipping. Examples of potential field contamination sources are: ambient air pollution, sample collection equipment, sample collection procedures, storage and transport conditions, and the filter and/or filtering equipment."

Page 27, Section 2.1 Point Sources

Comment: Provide citations for all statements in this section.

Response: An additional citation for [Sahl, 2012] was added to the second paragraph. The permits are identified by their permit numbers which are available on the WDEQ website.

Page 30, Section 2.2.2 Domestic Animals

> **Page 30**, "Pet wastes could be a contributor to bacterial in Crow Creek. Pet waste may not be properly disposed of along the stream and in the stormwater drainage network. It can also be washed off during precipitation events. According to a Source Water Protection Practices Bulletin from the Environmental Protection Agency [2001], pets are significant contributors to bacterial contamination."

Comment: We request that the statement "Pet wastes could be a contributor to bacteria in Crow Creek" to be changed to "Pet waste is a contributor of bacteria to Crow Creek, although the exact amount is unknown."

Response: We have no direct evidence that pet wastes contribute so the statement was left as "could". The subheadings in section 2.2 are a list of possible source of contaminations that could be used as guidance for future investigations.

Page 30, Section 2.2.4 Natural Background/Wildlife

Comment: While waterfowl and other big game species do contribute bacteria to Crow Creek, we believe small mammals living adjacent to the creek as well as within the cities stormwater drainage infrastructure are another significant source that is largely unmentioned in this document. We feel more attention should be focused on these sources. Additionally, we are unsure how relevant the big game herd population numbers are to this TMDL as these animals are located primarily on the western side of the county, having little influence in the urban area.

Response: The statement about waterfowl and large game species was modified to read: "including waterfowl, small mammals living near the stream or in the City's stormwater system, and large game species. Exact populations of wildlife were not used in the TMDL analysis; the TMDL analysis was based on Event Mean Concentrations.

Page 31, Section 2.3 Source Assessment Modeling Results

Comment: Citations should be provided for all statements. We feel that this section says a lot of the HSPF model without actually telling us anything.

Response: The level of detail provided in this section is appropriate for a TMDL. If there are specific questions on HSPF, it might be more appropriate to discuss directly. Calibration figures for both hydrology and bacteria are provided in the TMDL report.

Page 35, Section 2.3.2 Model Results

> **Page 35**, "More weight was given to the performance of the USGS gage because it provides continuous daily flow for the entire model simulation period; whereas, the other gages provided data for less than a full year in 2010 only."

Comment: We feel that this data may be misleading and that a caveat be listed with this statement. 2010 represented an above average year for precipitation and surface water runoff within the Crow Creek watershed (http://waterdata.usgs.gov/wy/nwis/uv?site_no=06755960). Any data collected and used solely from 2010 may severely skew the model results regardless of any additional weight placed on the complete USGS gage data set.

Response: The HSPF model was calibrated for the entire modeling period (1995-2010). While 2010 was a wet year, the simulated results were only compared to the in-stream flows that year, to ensure that the model was predicting the runoff and resulting streamflow was associated with the precipitation from 2010. By calibrating the model for the entire period of record using the USGs, limited bias should be involved from the 2010 data. The data collected in 2010 was collected to augment the historical data that was available for the modeling period.

Page 35, Section 2.3.2 Model Results

> **Page 35**, "For the performance of the *E.coli* calibration, a visual evaluation was used because the EMC method of representing *E.coli* represents the average trends based on flow. Using statistics would be misleading, because the variability in *E.coli* is not represented as well with this method."

Comment: How does this technique not install bias into the model? Please provide a citation explaining why this is an acceptable technique.

Response: The calibration process using EMC's has evolved on several past similar projects; it is a practice that is widely accepted and has been used on numerous past approved TMDL's that RESPEC has been involved in the statement above was modified to the following: "For the performance of the E.coli calibration, a visual evaluation, ***ensuring that the model simulations are representing the pattern of the data****, was used because the EMC method of representing E.coli represents the average trends based on flow. Using statistics* ***alone*** *would be misleading, because the variability in E.coli is not represented as well with this method."*

Page 42, 46 and 49. General comment on use of simulated flows and simulated bacteria concentrations.

> **Page 42**, "TMDL tables were constructed for each reach using simulated flows and bacteria concentrations."
>
> **Page 46**, "Because there are no geometric mean data at the endpoint of Reach_01 and because the stream conditions change rapidly at stormwater inflows, no observed geometric mean points are included on the Reach_01 LDCs, and existing loads are based on calibrated, simulated results."
>
> **Page 46**, "Because the geometric mean data were limited in the low flow zone in Reach_02, simulated loads were used to represent reductions needed."
>
> **Page 49**, Table 3-2

Comment: It concerns the district that even though several years of data were collected from several different entities across numerous sites within the study area that only simulated bacteria and flow data was used to calculate the load reduction requirements in Reach_01. Additionally, it appears only one actual data site (CRC800) was used in conjunction with the simulated data for the Reach_02 calculations. While we understand that the actual data was used to calibrate the HSPF model, we question the overall accuracy of the simulated data, especially since a majority of the data was collected during the above average 2010 water year.

Response: All data was used to calibrate the model; based on the model calibration there is a fairly high level of confidence of the simulated results at the TMDL endpoints. The majority of bacteria data was collected by the Laramie County Conservation District, dating back to 2002. If data is not shown on the LDC, it just indicates that no observed data was collected in that specific model reach. In the case of the Crow Creek TMDL endpoints, data was collected a short distance downstream of the end points providing the high level of confidence in the calibrated results at the end point. The model provides outputs on a continuous time simulation during all flow ranges throughout the impaired reaches. The model results are the basis for the Load Duration Curves.

Page 42, 44 and 45 as well as data in Table 3-3 through 3-6. General comment on the flow zone ranges for TMDL requirements.

> **Page 42 and 44**, "However, flows at the endpoint of Reach_01 (below Dry Creek) have historically fallen below (as low as 2.5 cfs) the sum of the design flows from the Crow Creek WWTP and the Dry Creek WWTP (approximately 26 cfs). The accepted method for calculating a point source load allocation (PSA) is to multiply the design flow of a facility, the water-quality criterion, and a conversion factor. The calculation of the conversion factor is shown in Equation 3-2. Because the flow from the WWTPs has the potential to be far higher than those occurring in the midrange, dry and low flow zones, the 95th percentile flows in each flow zone were increased by the sum of the WWTP design flows."

Page 45, "The design flows for Crow Creek WWTP and Dry Creek WWTP are 10 cfs and 16 cfs, respectively. If both of the WWTPs were flowing at their design flow, the flow in Crow Creek at the Reach_01 endpoint would be approximately 26 cfs."

Comment: The flow zone values found in Tables 3-3 through 3-6 seem extremely high. We questions the accuracy of these values since it was based on data collected during the above average 2010 water year. Also, it seems inappropriate to calculate the flow zone based on the "designed flows" of the WWTP facilities. These facilities have historically operated only around 20-40% of their "designed flows" and we believe including their full "designed flow" will result in an overestimation of the flow zone ranges for the TMDL. We request RESPECT justify these flow values and explain why they are an accurate and correct representation of the range of streamflow within the Crow Creek Watershed.

Response: Because the TMDL is defining the load that is allowed in to the stream we have to set a number based on what is allowed to be discharged from the WWTP's, not what has historically been discharged. The only method to set a WLA number that was under the TMDL was to add the flow to each individual bin. We are currently reviewing this methodology with the EPA; if a better methodology is agreed upon we will modify the document accordingly.

Page 54, Section 4.0 Seasonality

Page 54, "Summer is also a critical period because of seasonal differences in precipitation patterns and land uses. Typically, livestock are allowed to graze along the streams during the summer months. High-intensity rainstorm events are common during the summer and, combined with the peak in bacteria sources, they produce a significant amount of *E.coli* load because of bacterial washoff from the watershed."

Comment: We question the accuracy of this statement and request a citation be provided. In our experience, there is actually very little livestock grazing that occurs along the streams during the summer as a majority of these pastures represent summer hay ground that are only actively grazed during the winter months.

Response: The statement about livestock is a general statement that is generally expected across the west where extensive off-site watering does not exist. The word "typically" was used to state that this is a common situation but exceptions can always be found. Some grazing, even if limited does occur in the summer; furthermore livestock grazing in the winter and spring can be a source of bacteria during the summer months. This statement was discussed with the Technical Steering Committee members during our regular meeting, of which both the LCCD and the City of Cheyenne participated in. This statement was based on input from these committee members.

Page 55, Section 5.0 Public Participation

Page 55, "Throughout the project, monthly meetings were held among the WDEQ, the City of Cheyenne, the LCCD, and the TMDL consultants."

Comment: We feel that the level of public participation mentioned in this section is greatly embellished as there have been no monthly meetings or communication of any kind between RESPECT and LCCD for over a year. We request that statements made in this section be corrected.

Response: Monthly meetings were held through the project when work was actively being completed. Once the draft document was submitted to the WDEQ in the summer of 2012, regular meetings were no longer held; the last full team meeting was on February 9th, 2013. Members that were on the invite list for these meetings included:

- *Barb Sahl (WDEQ)*
- *Leah Coleman (WDEQ)*
- *David Waterstreet (WDEQ)*
- *Don Newton/Kevin Hyatt (WDEQ)*
- *Mike Wachtendonk/Brianna Forrest (WDEQ)*
- *Eric Hargett (WDEQ)*
- *Marcia Porter (WDEQ)*
- *Gene MacDonald (Ayres Associates)*
- *Doug Vetter (City of Cheyenne)*
- *Liberty Blaine (LCCD)*
- *Cory Foreman (RESPEC)*
- *Eric Krantz (RESPEC)*

Additional stakeholder meetings were held as part of the TMDL review process during the months of July and August 2013.

Page 57 through 60, Section 7.0 Restoration Strategy

> **Page 57**, "Agricultural BMPs include grazing management and conservation buffers. Model results show that implementing agricultural BMPs upstream of the city of Cheyenne (Scenario 1) would result in a 4 percent load reduction for Reach_01 and a 4 percent load reduction for Reach_02."

Comment: We are unsure how relevant this scenario is as there is very little livestock grazing that occurs along the creek during the summer recreation season. We request a citation be provided detailing the basis for this statement.

Response: This statement is a direct result of work completed on this project; no citation is required. Bacteria sources can be from direct defecation to the stream, as well as from accumulation within the watershed The agricultural BMP's represented were aimed at treating the delivery of bacteria to the stream. These practices would also reduce bacteria delivery from non-agricultural animals as well. Some examples of types of BMP's we were referring to include, but are not limited to, grazing management, riparian buffers, and/or off-channel watering.

> **Page 57**, "Although *E.coli* loads at CRC100 are lower than loads throughout the city of Cheyenne, this site does occasionally exceed the criterion. Model results indicate that compliance of the summer recreation season criterion (126 mpn/100 mL) at CRC100 (scenario 2) would result in a 1 percent load reduction for Reach_01 and a 1 percent load reduction for Reach_02."

Comment: How exactly will this reduction be accomplished? This statement does not have an attainable or meaningful BMP associated with it. We recommend RESPECT remove the statement or provide an actual achievable practice that could be used to meet the intended load reduction.

Response: The BMP scenario referred to above is a milestone for implementation; (i.e. if the stream were meeting the criteria upstream, what are the impacts to the TMDL endpoint). More detailed information on potential BMPs are included in the implementation plan. The statement above is accurate; it is talking about needed reductions and the potential reductions that are achievable through BMP implementation. No changes were made to this statement

> **Page 60**, "The repair of cross connections between sanitary sewers and storm drain systems throughout the city of Cheyenne is in progress. The model shows that the repair of all cross connections in the city of Cheyenne (Scenario 3) would result in a load reduction of 49 percent and 48 percent for Reach_01 and Reach_02, respectively."

Comment: What is this information based upon? Is there any information available on how widespread the cross-connections are and if fixing them will have as significant of an impact as the model says it will? We feel that if cross-connections were as prevalent as this document suggests that the *E.coli* numbers would be drastically higher and that raw sewage would be readily visible along the creek. Please provide a citation.

Response: Cross connections were located by the City of Cheyenne during this project period. As part of this TMDL project we did not perform an assessment the City's sewer system to estimate the number of cross connects; we only estimated the amount of bacteria originating from cross connects, based on the patterns of the observed data. Even one cross connect, if it is dumping directly to the stream, could contribute a large percentage of the load to a stream the size of Crow Creek. In general cross connections were estimated within the model by evaluating the pattern of data, specifically concentrations in base flows.

> **Page 60**, "The observed *E.coli* data suggest that the MS4 is a large contributor to *E.coli* in Reach_01. Simulation of *E.coli* reductions of 90 percent on 100 percent of the MS4 (Scenario 4) resulted in a load reduction of 39 percent in Reach_01 and a load reduction of 37 percent in Reach_02. The largest percent decrease in exceedance of the summer recreation season criterion in Reach_01 would occur from Scenario 4 (63 percent)."

Comment: Again, how exactly will this reduction be accomplished? This statement does not have any attainable or meaningful BMPs associated with it. We recommend removing the statement or providing actual useful practices that could be used to meet the intended load reduction across the entire MS4 area.

Response: The BMP scenario referred to above is a milestone for implementation; (i.e. what is the needed reduction to meet the TMDL). The implementation plan will describe in more detail the specific BMPs. The following statement was added at the end of the second paragraph on Page 60, to describe some types on BMP's that could be implemented in the MS4 area : Example BMP's that could be

implemented in the MS4 area include, but are not limited to pet waste programs, wet detention basins at the end of stormwater outfalls, or UV treatment of enclosed stormwater pipes. Ultimately it is up to the WYPDES program in the WDEQ to set requirements for the MS4 permit for the city of Cheyenne. This TMDL was kept somewhat general so that conflicts between the TMDL, the City of Cheyenne, and WYPDES did not occur.

> **Page 60**, "Scenario 5 was evaluated for Reach_02 only. The model indicated that compliance with the summer recreation season criterion at the endpoint of Reach_01 (Scenario 5) would result in a 2 percent load reduction at the endpoint of Reach_02. Because loads would be significantly reduced in Reach_02 by the MS4 load reduction scenario (Scenario 4) and this scenario (Scenario 5), it can be assumed that if Reach_01 is in compliance, Reach_02 should also be in compliance."

Comment: Again, how exactly will this reduction be accomplished? This is only a statement as it does not have any attainable or meaningful BMPs associated with it. We recommend removing the statement or provide a series of actual practices that could be used to bring reach 1 and 2 into compliance.

Response: See previous response.

> **Page 60**, "Although Scenarios 1 through 5 would result in load reductions of 93 percent in Reach_01 and 92 percent in Reach_02, further load reductions could be achieved through agricultural BMPs downstream of CRC100 (Scenario 6). Scenario 6 would result in a 2 percent load reduction and a 4 percent load reduction for Reach_01 and Reach_02, respectively. Although the load is highly driven by the MS4, the large reduction in percent exceedance that would occur because of the agricultural BMPs suggests that agricultural BMPs would need to be implemented in addition to the MS4-related BMPs for the stream to be in compliance with the water-quality standards."

Comment: Again, we are unsure how relevant this scenario is as there is very little livestock grazing that occurs along the creek during the summer recreation season. A majority of the agricultural ground adjacent to Crow Creek in Reach 1 and 2 are used for summer hay ground that is not actively grazed until winter. We feel the logic these statements are based upon is flawed and we request the statements either be removed or a citation be provided detailing the basis for them.

Response: See the first response to the comment for Section 7.0 the restoration strategy.

We hope that our meeting on August 29th, 2013 helped to clarify many of these comments and we appreciate you taking time to discuss this project further. As discussed during the August 29th meeting, if you have additional comments after reviewing these responses, please provide them to the WDEQ no later than September 20, 2013. The WDEQ will submit this document for final approval to the EPA with the revisions stated herein. For questions or additional information, please contact Brianna Forrest at: (307) 777-7096.

Sincerely,

Brianna Forrest

Brianna Forrest
Natural Resources Analyst
TMDL Program

9/4/2013
Date

BF/rm/13-0841

Department of Environmental Quality

To protect, conserve and enhance the quality of Wyoming's environment for the benefit of current and future generations.

Matthew H. Mead, Governor

Todd Parfitt, Director

September 16, 2013

Matt Ley
Laramie County Conservation District
11221 US Hwy 30
Cheyenne, WY 82001

Dear Mr. Ley,

Following are two revisions to our responses to the comments submitted by the Laramie County Conservation District during the public comment period for the Crow Creek *E.coli* TMDL document. Only the part of the response which requires revision is referenced in this letter.

Comment addressing page 6, section 1.2.2 Precipitation

Response 9/4/2013: A citation was added for the high plains regional climate center.

Revised Response 9/16/2013: The source of the data for the precipitation map was not the high plains regional climate center. The source of data for the precipitation map is as follows:

> **Natural Resources Conservation Service, 2011.** "Natural Resource Conservation GeoSpatial Data Gateway 1981-2010 Annual Average Precipitation by State," retrieved October 20, 2011, from *http://datagateway.nrcs.usda.gov/GDGOrder.aspx*

This citation has been included into the Crow Creek E.coli TMDL document.

Comment addressing page 20, section 1.4.1 Summary of *E.coli* Data

Response 9/4/2013: Additional arrows were added to the figures to help identify the locations of the outfalls.

Response 9/16/2013: A sentence was added that stated "For reference, sites are listed in order from upstream to downstream in Table 1-6."

We feel these revisions still address the original comments satisfactorily and the purpose of this letter is to indicate what you can expect to see in the final document. Thank you again for your involvement on the Crow Creek *E.coli* TMDL document.

Sincerely,

Brianna Forrest

9/16/2013
Date

Brianna Forrest
Natural Resources Analyst
TMDL Program
BF/rm/13-0871