I-70 Mountain Corridor PEIS Water Resources Technical Report

August 2010

This page intentionally left blank.

Table of Contents

List of Figures

List of Tables

Section 1. Purpose of the Report

This *I-70 Mountain Corridor PEIS Water Resources Technical Report* supports the information contained in **Chapter 3, Section 3.4** of the *I-70 Mountain Corridor Programmatic Environmental Impact Statement (PEIS)*. It identifies:

- Description of the water resources in the Corridor.
- Methods used to identify water resources and to determine potential impacts of alternatives including changes in water quality regulations and Total Maximum Daily Load (TMDL) requirements.
- Coordination with local, state, and federal agencies.
- Consequences of the Action and No Action Alternatives evaluated in the I-70 Mountain Corridor PEIS, including impacts on water resources resulting from changes in operations or chemical conditions.
- Considerations for Tier 2 Processes.
- Proposed mitigation for water resources.

Section 2. Background and Methodology

This section of the *I-70 Mountain Corridor PEIS Water Resources Technical Report* provides background information about water resources in the Corridor. This section provides information about the major water resources issues for the Corridor that were evaluated by the PEIS; the summary of major issues is intended to provide a context for the analysis. More specific water resources background information is provided in **Section 4**, Affected Environment. A summary of relevant water resources regulations is also included, as well as other water resources planning studies that have relevance to the PEIS. Finally, a discussion is provided about the methodology for analysis of water resources for the PEIS.

The I-70 Mountain Corridor crosses four watersheds. From west to east the watersheds include:

- Eagle River
- Blue River
- Clear Creek
- Bear Creek

The Corridor includes 11 identified waterways adjacent to the I-70 highway (from west to east):

- Eagle River
- Gore Creek
- Black Gore Creek
- West Tenmile Creek
- Tenmile Creek
- Straight Creek
- Upper/Middle/Lower Clear Creek
- Beaver Brook
- Mount Vernon Creek

The Corridor also includes two reservoirs along the way (Lake Dillon and Georgetown Reservoir). **Figure** 1shows the watersheds and stream segments within the I-70 Mountain Corridor. Also shown are stream flow directions and mile post references along the I-70 highway that identify locations.

2.1 Major Water Resources Issues for the Corridor

Water resources issues within the Corridor area were identified through the collection of available data and information, as well as public and agency coordination. Water resource data were acquired generally through federal, state, and local agency coordination. Furthermore, some water resource information was gathered through the development of various programs designed to assemble the data necessary for describing existing conditions and evaluating potential impacts, but were not available through other sources.

In particular, CDOT established three Corridor-specific programs to gather information on water resources within the Corridor, as follows:

1. A program entitled Stream and Wetland Ecological Enhancement Program (SWEEP) to develop mitigation strategies and identify water-related issues, with immediate attention given to the Clear Creek watershed
2. The I-70 Storm Water Quality Monitoring Program to sample and quantify existing impacts
3. The *Sediment Control Action Plan (SCAP) for Black Gore Creek and Straight Creek* (CDOT, May 2002 and CDOT, May 2002a) to develop mitigation strategies for these two streams that are listed for TMDL classification purposes as water quality impaired streams from I-70

The information gathered as part of the Corridor-specific programs is discussed in **Section 4**, Affected Environment. The following subsections provide an overview of the major water resources issues that are evaluated by this Technical Report. These issues include:

1. Highway Runoff and Winter Roadway Maintenance Activities
2. Historic Mining
3. Water Quality Impaired Streams, Stream Classifications, and Standards
4. Spills and Hazardous Materials Transport
5. Development and Urbanization
6. Channelization and Stream Flow
7. Regulations

2.1.1 Highway Runoff and Winter Roadway Maintenance Activities

Highway maintenance activities are known to increase sediment from the traction sand application and contaminants from deicers, such as sodium chloride and magnesium chloride, in runoff to adjacent waterways. This occurs when snowmelt and rainfall runoff events drain from the highway and shoulder areas into waterways and streams. To assess the impacts of highway runoff on receiving streams, a monitoring program has been conducted since 2000 with the latest report in 2010 for direct snowmelt and stormwater runoff from the I-70 highway, as well as in adjacent runoff-impacted streams. In **Table 1**, the pollutant constituents (suspended solids, phosphorus, chloride, copper, and zinc) have been identified in water quality monitoring as priority pollutants associated with the operation of the I-70 highway due to their potential toxicity or threat to aquatic habitat or public water supplies. Although other constituents/pollutants are identified in urban highway runoff (FHWA, 1990), they are considered secondary pollutants in the I-70 Mountain Corridor and were not studied for the PEIS.

Figure 1. Watersheds and Stream Segments within the I-70 Mountain Corridor

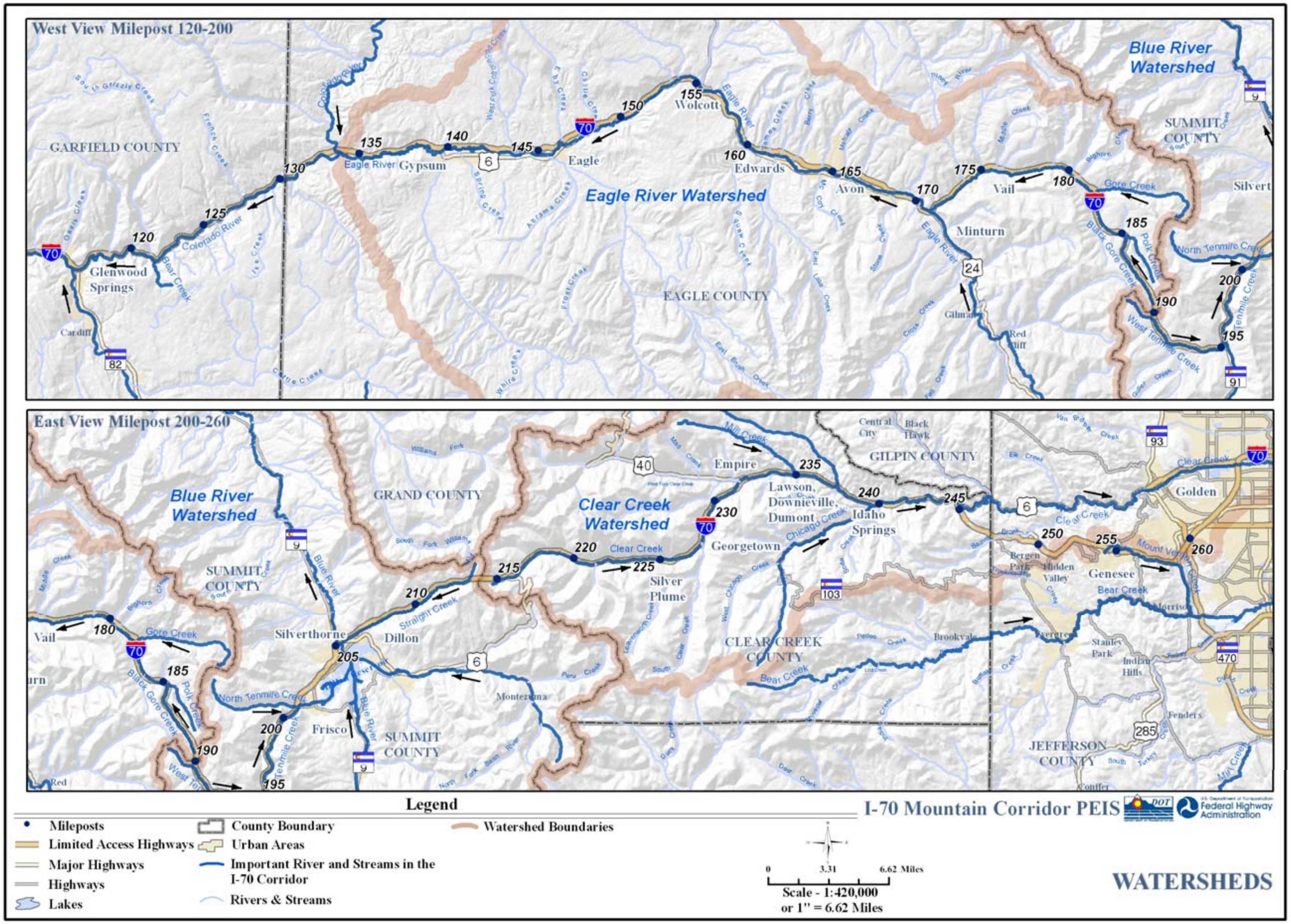


Table 1. Highway Runoff Pollutants of Concern in the Corridor

Pollutant	Source
Total suspended solids (TSS)	Pavement wear, slope erosion, vehicle and tire wear deposition, the atmosphere (air), and maintenance activities (sand and highway structural erosion)
Phosphate phosphorus	Atmosphere, particulates (sediment from sand and erosion associated with the transportation system), and fertilizer application
Chloride (sodium chloride, magnesium chloride)	Sodium chloride rock salt mixed with traction sand and liquid magnesium chloride deicers applied directly to the highway to melt snow and ice
Copper	Metal plating, bearing and brushing wear, moving engine parts, brake lining wear, fungicides, and insecticides
Zinc	Tire wear, motor oil, and grease

Source: Driscoll, 1990

2.1.2 Historic Mining

The discovery of gold in the mid-1800s brought an onslaught of human activity to the Corridor area, particularly east of the Continental Divide. Many of these activities occurred along rivers and streams. Placer mining (removal of alluvial or glacial deposits and associated metals from streams) was the original type of mining that took place within these drainages and has resulted in the removal of stream substrate and the relocation of stream channels. Most of the former mining operations (including Placer) have produced mine waste, including mill tailings. Although there is little mining activity in the area today, rainwater still leaches residual metals out of old tailings/waste rock piles and from bedrock exposed in the mine drainage tunnels.

Historic mining activities have affected streams in the Roaring Fork, Eagle River, Blue River, Clear Creek, Arkansas River Headwaters, and South Platte Headwaters sub-basins. However, some of the most substantial impacts have occurred along Clear Creek immediately adjacent to the I-70 highway. In addition, the I-70 highway construction activities have played a role in the exposure and disturbance of mine waste and mineralized rock. Mine adits (a horizontal entrance to a mine in the side of a hill) that underlie the I-70 highway may contain contaminated water.

Historic mining activities have affected streams in the Eagle River, Blue River, Clear Creek, and South Platte Headwaters sub-basins. Some of the most substantial mining impacts have occurred along Clear Creek immediately adjacent to the I-70 highway. In addition, the I-70 highway construction activities have played a role in the exposure and disturbance of mine waste and mineralized rock.

2.1.3 Water Quality Impaired Streams, Stream Classifications, and Standards

The Colorado Water Quality Control Commission (WQCC) has classified streams and developed standards to protect these resources. With the exception of Mount Vernon Creek and Clear Creek below Idaho Springs, all of the streams in the Corridor are classified for water supply, aquatic life, recreation, and agricultural uses. Mount Vernon Creek and Lower Clear Creek are designated as use-protected due to the aquatic life warm 2 classifications and heavy metals contamination, respectively. Numeric water quality standards are in force to protect designated uses. These stream segments require special consideration for potential additional impacts from I-70 Mountain Corridor alternatives.

Several streams adjacent to the I-70 highway have been identified as water quality impaired streams. Segments identified as impaired are those in which one or more classification or standard has not, or may not be, fully achieved. As necessary for the protection of the water resource, TMDLs are established to set the maximum amount of pollutant that may be allowed while still complying with water quality standards.

Total Maximum Daily Loads are implemented and regulated through the issuance of permits for point sources (such as wastewater treatment plants) and through the use of best management practices for nonpoint sources (such as highway runoff). A discussion of the streams adjacent to the Corridor with established TMDLs is provided in Section 2.2

2.1.4 Spills and Hazardous Materials Transport

Spills resulting from I-70 highway crashes have previously affected adjacent waterways, many of which have designated uses for aquatic life and water supplies. The greatest potential for impacts is from large trucks that transport hazardous materials. Because the I-70 highway is located immediately adjacent to streams throughout the Corridor, the entire Corridor is a sensitive or priority area with respect to both water supply and environmental protection against hazardous waste spills. Transportation-related spills are directly related to traffic crashes. An analysis of crashes, crash locations, and reported spills indicates that the greatest number of crashes involving trucks occurs in only about 25 percent of the Corridor. The segments of the I-70 highway with multiple incidents involving spill volumes from 100 to more than 1,000 gallons are shown in **Table 2**. These crash-prone areas are in steep, narrow sections of the I-70 highway in very close proximity to streams. About 84 percent of the hazardous materials transported through the Corridor are flammable liquids.

Table 2. Frequency of Hazardous Waste Spills within the Corridor 1992–2002

Receiving Stream (West to East Along Corridor)	Milepost Locations (General Locations)	Number of I-70 Highway Spills 100 to >1,000 Gallons	Substance
Colorado River[a]	mp 122–125 (Glenwood Canyon)	6	Petroleum/paint
Eagle River	mp 157 (10 miles west of Avon)	2	Petroleum
Gore Creek	mp 176 (Vail)	1	Petroleum
Black Gore Creek[a]	mp 185–191 (Vail Pass)	3	Petroleum
West Tenmile Creek	mp 194 (Copper Mountain)	1	Petroleum
Tenmile Creek	mp 199 (2 miles west of Frisco)	1	Petroleum
Straight Creek[a]	mp 208–212 (west of Silverthorne)	2	Petroleum
Clear Creek above Silver Plume	mp 216–225 (EJMT to Silver Plume)	2	Petroleum
Clear Creek, Silver Plume – Idaho Springs	mp 234 (Lawson)	1	Petroleum
Clear Creek, Idaho Springs – US 6 interchange[a]	mp 242–244 (Idaho Springs)	3	Petroleum/asphalt
Mount Vernon Creek[a]	mp 257–259 (Genesee)	4	Petroleum/caustic/acid

Source: National Response Center, 2002

.[a] *Locations that have 200 percent the truck crash rate of other Corridor areas.*

The National Response Center data show that every stream in the Corridor has received a major hazardous waste spill from the I-70 highway within the last 10 years. The greatest number of large petroleum spills has occurred in the Colorado River, followed by Mount Vernon Creek. Spills in these areas have occurred within a 2-mile segment of the I-70 highway, indicating highly crash-prone areas for trucks. Other areas within the Corridor that had at least three large petroleum spills were Black Gore Creek, Straight Creek, and Lower Clear Creek (milepost 233 to milepost 246). The streams in these areas are immediately adjacent to the I-70 highway, resulting in very high potential for transport of hazardous substances into waterways. Note that a large percentage of spill incidents occur on US 6 at Loveland Pass, for which the receiving waters are Clear Creek on the east and the Snake River/Dillon Reservoir on the west.

For a more detailed discussion of the effects of spills and hazardous materials transport, see the *I-70 Mountain Corridor PEIS Water Resources Technical Report* (CDOT, August 2010).

2.1.5 Development and Urbanization

The Corridor area has undergone considerable growth and development because of the construction of the I-70 highway, primarily during the 1960s. Continued growth in area population and in tourism is expected in the future. These influences have resulted in increased sedimentation, alterations in the water quality, and changes in the morphology (channelization) of rivers, streams, and wetlands within the Corridor. Development factors that affect water resources include runoff and hydrologic modification of stream channels, eutrophication, and water supply/drinking water development.

Runoff

As a stream basin becomes more urbanized and impervious cover (such as parking lots, roadways, driveways, and buildings) replaces natural vegetation, the volume of stormwater runoff is likely to increase, ultimately affecting the stability and characteristics of the nearby stream channel. In addition, runoff from urban/developed areas is likely to contain pollutants that can affect the water quality of streams. The most common pollutants and their sources include:

- Excess fertilizers and pesticides from commercial and residential areas
- Oil, grease, and toxic chemicals from urban runoff and energy production
- Sediment from unprotected construction sites and eroding stream banks
- Sediment and salts from winter highway maintenance
- Bacteria and nutrients from pet wastes and faulty septic systems

Sediment from construction sites is by far the predominant contributor of runoff pollutants from development and urbanization.

Excess nutrients can trigger eutrophication — a complex degradation of a water resource (including streams and lakes). Typically, the controlling nutrient for plant growth is phosphorus. When phosphorus levels increase, there is a corresponding increase in aquatic plant growth. When this increased aquatic plant biomass dies, it decays and consumes dissolved oxygen in the water causing decreased oxygen in the water and a negative impact on other types of aquatic life. Eutrophication is the disruption of the natural capacity of a water resource to balance the chemical and biological processes occurring within it.

Phosphorus loads that occur in stormwater runoff can, with other natural and anthropogenic sources of phosphorus, contribute to eutrophication. Stormwater runoff occurs as periodic spikes, where phosphorus and other pollutants increase dramatically for a few hours and then decrease to ambient levels. The nature of the receiving water can determine the potential for eutrophication. In fast-moving streams, the phosphorus peak acts as a “slug” and passes before the resident aquatic life can absorb it and has a resulting increase in biomass. In lakes, however, phosphorus is dissipated only by settling out or by being consumed by plants. Phosphorus "slugs," which are relatively benign in rivers and streams, can flow to lakes or reservoirs and take months to dissipate. The eutrophication risk to these lakes and reservoirs can be quantified based on total volume, surface area, depth, and residence time of the water, as well as the total nutrient loading to the lake. As appropriate, Tier 2 processes will include a detailed analysis of the eutrophication risk for possible impacts on lakes and reservoirs. Lake Dillon has been affected by nutrients from point and nonpoint sources in the watershed, causing concern about eutrophication and the need for wastewater treatment facility effluent limits.

Water Use and Drinking Water

Additional water use to accommodate population growth and recreation (snowmaking and golf course irrigation) might decrease stream flows and groundwater reservoirs, creating conditions that could cause greater concentrations of pollutants and disturb the aquatic environment.

Fifty-four drinking water entities are located within the PEIS project area. Of these, 17 have surface water intakes, 6 have groundwater intakes that are under the influence of surface water (alluvial aquifers), and 31 have groundwater intakes. Intake locations are not shown on the Tier 1 PEIS maps for security reasons. Impacts on these intakes will be considered in Tier 2 processes. Impacts on water supplies due to proximity or configuration of a project alternative would be mitigated in consultation with the affected drinking water treatment plants, watershed groups, and the Colorado Department of Public Health and Environment (CDPHE).

Intakes for public water supplies in the immediate vicinity of the I-70 highway might be affected by sediment, deicers, and other constituents contained in highway runoff. Deicers and other constituents in highway runoff might also affect alluvial wells associated with Corridor streams.

Watersheds in the Corridor area supply the predominant amount of municipal water to the Front Range area. These diversions can affect local streams by decreasing their ability to dilute contaminants and by threatening instream flows that support aquatic habitat and recreational use. Nutrient (phosphorus and ammonia) loading from various sources, including WWTPs, can affect Corridor streams and reservoirs and may be a factor in lake eutrophication.

Wastewater treatment plants discharge treated water to streams. Although the treated water must meet standards for pollutants, these standards are partially based on a stream's capacity to dilute a certain amount of these pollutants. Decreased stream flow and nonpoint source contaminants have the potential to increase the impacts of wastewater discharges. Growth will make it necessary to increase facility capacities.

Water Availability to Support Future Growth

Appendix A provides a compilation of available water resources information to provide an overview of the potential of water availability to influence future growth in the Corridor. Tabulated data for existing and future projected water supply needs in the Corridor were evaluated using existing information from multiple water planning agencies. The information **Appendix A** indicates that water resources (including quantity and quality issues) and associated infrastructure, including water treatment and wastewater treatment, are likely to influence future land development patterns in watersheds intersecting the Corridor.

2.1.6 Channelization and Stream Flow

The natural pattern that a stream takes is affected by soils, vegetation, climatic conditions, and geology. Human activities can disturb these natural stream processes and alter patterns of flooding, erosion/deposition, habitat diversity, water quality characteristics, sediment, and other aspects of the ecological system. As areas become more urbanized and impervious cover (parking lots, roadways, driveways, and building rooftops) replaces natural vegetation, the volume of stormwater runoff increases, ultimately affecting the nearby stream channel.

In general, Corridor streams do not exhibit consistent flow characteristics and slightly meandering, generally lower gradient reaches are interspersed between steeper bedrock and boulder-controlled reaches. Unlike lowland streams, there is an indeterminate relationship between channel size and flow conditions. In Straight Creek and Black Gore Creek, for example, there is no consistent increase in channel size in the downstream direction, and neither bed material size nor channel slope diminish in a systematic fashion in the downstream direction, as is the case in lowland streams.

Several areas of localized channel disturbances related to construction and operation of the I-70 highway have affected the local morphology of streams. These areas are located along Clear Creek, Straight Creek, Black Gore Creek, and to a lesser extent Tenmile and Gore creeks. Up to 35 percent of the channelization caused by construction of the I-70 highway occurs in the Clear Creek watershed. Most of Lower Clear Creek is constrained naturally in a narrow valley or canyon environment with bedrock control. However, the construction of US 6/US 40 and the I-70 highway has resulted in additional channel constriction/channelization, streambank erosion, changes in the natural stream gradient, and channel scour and depositional areas. While flooding is generally not a concern in the Corridor, seasonal high water from snowmelt can create flooding issues, particularly along Clear Creek where increased channelization has occurred. Further information about the floodplains in the Clear Creek Sub-Basin is presented in **Section 4**, Affected Environment. Transmountain diversions of additional water into the Clear Creek Basin may have also caused channel erosion and hydrologic modifications by increasing flows beyond historic levels.

Review of historical photographs indicates that Lower Clear Creek once exhibited sinuosity (meandering) between the sides of the canyon and within the narrow valley areas. However, historical photographs also indicate that heavy sediment loads, likely caused by excessive deposition of mine waste, once caused braided channel conditions in the Idaho Springs area. Thus, at least on a localized level, the morphology of Lower Clear Creek has changed both spatially and temporally as a result of human activities in the basin.

2.2 Water Resources Regulations

Although several regulatory statutes are applicable to the water resources of the Corridor, the Clean Water Act (CWA) of 1977 and its various regulatory subsections probably have the greatest influence on the activities taking place within the Corridor. Other regulations applicable to the water resources of the Corridor include the CDPHE, Water Quality Control Commission (WQCC) State Water-Quality Standards (CRS 1973, 25-8-101, as amended); the Safe Drinking Water Act (SDWA) of 1974, as amended in 1984 and 1996; and the Source Water Assessment and Protection (SWAP) program (amendment to the SDWA). **Table 3** summarizes these regulations.

Table 3. Water Resources Regulations

Regulation	Designation	Explanation	Governing Entity
Clean Water Act (CWA)	208	Provisions for nonpoint source pollution	CDPHE/Water Quality Control Division (WQCD); EPA
	301	Requirement for state certification for water quality protection under the federal CWA	
	303(d)	Identification of water quality threatened or impaired waters; may require establishment of TMDLs	
	314	Lake protection	
	319	Provision for full disclosure of water quality impacts	

Regulation	Designation	Explanation	Governing Entity
	402(p)	Municipal and industrial stormwater discharge; CDOT construction and operations are covered under industrial discharge	
Safe Drinking Water Act (SDWA)		Provision for protection of drinking water sources and human health; CDPHE has established Colorado Primary Drinking Water Regulations (5 CCR 1003-1)	CDPHE/ WQCD; EPA
SDWA SWAP program amendment		Provision for state assessment of potential water quality issues for public water supplies	
Colorado Standards/Colorado Water Quality Control Act	CRS 1973, 25-8-101	Specification for classifications and numeric standards for surface water in Colorado in compliance with the CWA	WQCC; WQCD

2.2.1 Clean Water Act

Under the CWA, the Environmental Protection Agency has established a framework for protecting and improving the nation's water quality. This framework includes numerous sections and subsections designed to identify and regulate both point and nonpoint sources of pollution. Section 402(p) of the CWA establishes a framework for regulating municipal and industrial stormwater discharges. Section 208 of the CWA addresses water quality provisions for nonpoint source pollution. Section 303(d) of the CWA requires states to identify waters that do not or are not expected to meet water quality standards with technology-based controls alone. Section 303(d) of the CWA requires states to identify waters that are not expected to meet the national goal of "fishable or swimmable" and to develop total maximum daily loads (TMDLs) for them, with oversight from Environmental Protection Agency. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, as well as an allocation of that amount to the pollutant's sources.

Water quality limited segments (or *impaired* segments) are those in which one or more classification or standard is not, or may not be, fully achieved. These waters are prioritized based on the risks to human health and aquatic life, and, if necessary, TMDLs are established to set the maximum amount of pollutant that may be allowed while still complying with water quality standards.

The TMDL status has changed for several I-70 Corridor streams in the last several years, as outlined by some of the recent changes bulleted below. **Table 4** provides a summary of these conditions and statuses.

- The lower Eagle River (along the I-70 highway) was removed from the TMDL list due to changes in the manganese standard.
- The trace metal TMDL for Clear Creek was finalized in August 2008.
- A draft TMDL was proposed to Colorado Department of Public Health and Environment (CDPHE) for Black Gore Creek related to sediment impairment from the I-70 highway.
- A 2008 compliance evaluation of the Straight Creek I-70 Sediment TMDL by the United States Forest Service (USFS) and Environmental Protection Agency concluded that Straight Creek is not meeting the water quality goals set forth in the TMDL. As noted in the evaluation, high variability of some physical parameters makes finding any trends, toward or away from the goals, difficult.

Total Maximum Daily Loads

The TMDL process is designed by the Federal Water Pollution Control Act (a part of the "Clean Water Act") to ensure that all sources of pollutant loading are accounted for when devising strategies to meet water quality standards. The TMDL is an estimate of the greatest amount of a specific pollutant that a water body or stream segment can receive without violating water quality standards. The TMDL process is a method of analyzing pollution sources and allocating responsibility among those sources. TMDLs are implemented through the issuance of permits for point sources and the use of best management practices for nonpoint sources. Streams within the Corridor that have been listed on 303(d) as water quality limited and that are subject to TMDL analysis are listed in **Table 4**. Clear Creek and the Eagle River are undergoing TMDL analysis for metals related to historic mining or geologic sources. The TMDL listing for Black Gore Creek and Straight Creek were established based on sedimentation from I-70 highway runoff (CDPHE, 2002b).

All streams in the I-70 Corridor have specific use classifications. Numeric water quality standards are in place to protect those designated uses as described in the PEIS.

Straight Creek and Black Gore Creek have been placed on the 303(d) list of water quality impaired streams for sediment related to runoff from the I-70 highway. Hence, CDPHE has completed the TMDL for Straight Creek and proposed a TMDL for Black Gore Creek (see **Table 4**). Specific stream water quality targets or goals are set forth in these TMDLs. Monitoring and evaluation are required to determine whether TMDL goals are being met so that the streams can be removed from impaired status (303[d] list).

Examples of data parameters required for these TMDLs include:

- Maintenance (cleanup) requirements
- Stream channel deposition metrics
- Water quality sampling for chemical and physical constituents
- Sediment loading analysis
- Sediment budget
- Fish age and population surveys
- Aquatic insect sampling and identification (macroinvertebrates)

Colorado Department of Public Health and Environment have developed and finalized new stream sediment deposition guidance (CDPHE, 2005). This guidance outlines methodology and metrics for the determination of sediment impaired streams. Although this is not a regulation, it is useful for assessing sedimentation problems associated with the I-70 highway in the context of other mountain streams.

The trace-metal TMDL for Lower Clear Creek (Segment 2 Silver Plume and Segment 11 Golden) that was developed in response to historic mining discharge from the nearby Superfund site may be applied to specific trace metal discharge limits for water treatment plants, including the Eisenhower-Johnson Memorial Tunnels. In addition to the existing wastewater discharge permit, CDOT recently applied for a subterranean discharge permit for the Eisenhower-Johnson Memorial Tunnels. These permit requirements and the associated Clear Creek TMDL will limit the amount of metal pollutants that can be discharged from facilities. Although highway-related trace metal discharge is not seen as an issue on the I-70 highway at this stage, the limit may also apply to metal pollutants from the roadway in the future.

Table 4. Listed Corridor Streams

Stream Segment Description	Pollutant or Condition	Priority Ranking	TMDL Process Status	Completion Date
Clear Creek from Silver Plume to Argo Tunnel (Segment 2)	Copper, lead, zinc	High	Final Draft TMDL	August 2008
Clear Creek from Argo Tunnel to Golden (Segment 11)	Cadmium, lead, zinc	High	Final Draft TMDL (Iron and manganese delisted, copper standard in attainment as of 2004)	August 2008
Straight Creek (entirety; Blue River Segment 18)	Sediment	Medium	Final	June 2000
Black Gore Creek (entirety; Eagle River Segment 6)	Sediment	High	In Review	Unknown; listed September 2002
Eagle River from Gore Creek to Colorado River (Segment 9)	Manganese	Low	Removed from the 303(d) list June 2004	

Source: CDPHE, 2008

The TMDLs require evaluation of the physical and chemical impacts on the aquatic environment caused by the operation and maintenance of the I-70 highway. The current TMDL data collection and evaluation is underfunded and inconsistent, making it difficult to quantify improvements and assess if water quality goals are being met. A coherent monitoring and evaluation plan is needed for the I-70 highway along with consistent annual funding. Furthermore, nonparametric analysis is needed to address high annual variability when seeking trends.

2.2.2 Water Quality Control Commission Standards

The CDPHE WQCC promulgates regulations under the Colorado Water Quality Control Act (CRS 1973, 25-8-101, as amended June 2002) specifying classifications and numeric water quality standards for Colorado by river basin. In addition to these numeric standards, anti-degradation standards have been identified to maintain the quality and functions of high-quality waters of Colorado (CDPHE, 2000a). The CDPHE Water Quality Control Division (WQCD) carries out water quality programs daily within the statutory and regulatory framework.

Application of the anti-degradation standard is based on three stream-segment classifications: *outstanding waters*, *intermediate-quality waters*, and *use-protected waters.* For streams designated as *outstanding waters*, no degradation is allowed. *Outstanding waters* are maintained and protected at their existing quality. Anti-degradation standards do not apply to stream segments designated as *use-protected.* The quality of waters designated as *use-protected* may be altered if applicable water quality classifications and standards are maintained. Waters not designated as *outstanding* or *use-protected* are referred to as *reviewable waters*. No degradation of *reviewable waters* is allowed except when necessary to accommodate important economic or social development. Two stream segments within the immediate vicinity of the I-70 highway are designated *use-protected waters:* Clear Creek between Idaho Springs and Golden, and Mount Vernon Creek. The WQCC has determined that these waters do not warrant the special protection provided by the *outstanding waters* designation or the anti-degradation review process. The remaining streams within the Corridor are designated as *reviewable waters.*

With the exception of Mount Vernon Creek and Clear Creek below Idaho Springs, all of the streams in the Corridor are classified for *water supply, aquatic life cold 1, recreation,* and *agricultural* uses. Numeric water quality standards apply for protection of these designated uses.

2.2.3 Potential Future Regulatory Requirements

Recent evaluation of Straight Creek noncompliance with that TMDL suggests that monitoring and assessment is an iterative process that will require modification of water quality parameter goals and objectives over time. Data need to be collected consistently and results evaluated routinely to determine if the proper metrics are being measured, and if not, what adjustments may be appropriate. The TMDL parameters for Straight Creek and Black Gore Creek will require modification in the future to ensure that the proper metrics are monitored to assess compliance with the TMDL goals.

Preliminary data indicate that Upper Clear Creek suffers from similar sedimentation and chemical impacts from the I-70 highway and US 6 highway runoff. A SCAP will be necessary to address the sedimentation issue. It is possible that the Upper Clear Creek reach will also be listed as a water quality impaired stream due to the I-70 highway sediment and will require a TMDL in the future.

It is anticipated that CDPHE will disseminate information about the final development and implementation of the first ever stream temperature and phosphorus regulations for Clear Creek and other streams in the I-70 Mountain Corridor in 2010 and 2011. Stream temperature can be influenced by highway runoff under certain conditions. It has been documented that particulate phosphorus is associated with sediment runoff from I-70. These new regulations will limit the amount of I-70 pollutant allowed for these parameters in the future.

2.3 Water Resources Planning and Projects

Section 208 of the CWA requires regional water quality management planning as an important approach to protecting water quality. The designated 208 Planning Agency develops certified regional water quality management plans. Public participation is part of the 208 process and allows collaboration with public and private sectors. The Northwest Colorado Council of Governments (NWCCOG) has been the designated Regional Water Quality Planning Agency (208 Planning Agency) for Eagle, Grand, Jackson, Pitkin, and Summit counties since February 1976. The region includes the Upper Colorado Watershed that contains the Eagle River and Blue River watersheds. The 1996 Colorado River 208 Plan was updated in 2002 and received WQCC, Governor, and United States Environmental Protection Agency Region VIII approval.

The Upper Clear Creek Watershed Association is the 208 Planning Agency for Clear Creek from the headwaters to the City of Golden.

A number of water resources planning documents have been prepared, as well as other recent studies. This section provides an overview of these projects, starting first with a summary of basin-specific planning projects, summarized for each of the Sub-Basins within the Corridor, and then with more specific information about some of the planning projects with greater applicability to the PEIS.

2.3.1 Basin Specific Planning Projects

Colorado Headwaters Sub-Basin

Numerous existing water quality projects primarily focus on issues in the upper portion of the basin as summarized below.

Clinton Reservoir Agreement. An agreement between the Denver Water Department and numerous “Western Slope Parties” enables additional flows in the Fraser River using Clinton Reservoir (in the Tenmile drainage of the Blue River watershed).

Berthoud Pass sediment control projects. CDOT has begun a slope stabilization project on the north side of Berthoud Pass. In addition, the USFS and CDOT cooperated in a project at the base of the pass that minimizes snow storage immediately adjacent to the Fraser River and provides vegetative stabilization of the stream bank in the vicinity of the bottom switchback.

The NWCCOG is using an Environmental Protection Agency grant to implement a project designed to reduce the sediment load in the upper Fraser River.

Three Lakes Clean Watershed Assessment Grant. In 2000, Grand County was awarded an Environmental Protection Agency grant to perform a "Clean Lakes Assessment" of Grand Lake, Shadow Mountain, and Granby reservoirs.

Sheephorn Creek riparian improvement project. The goal of this project is to reduce stream bank cutting on a 0.25 mile section of Sheephorn Creek and increase sub-surface water in a meadow area on Piney Peak Ranch in Grand County about 18 miles southwest of Kremmling.

Shadow Mountain Reservoir delta formation. In 1999, the Shadow Mountain Homeowners Association was awarded an Environmental Protection Agency grant to assess and provide direction regarding sediment deposition at the mouth of the Colorado River as it enters Shadow Mountain Reservoir.

Grand County Water Information Network. The mission of the network (which provides online data) is to coordinate and consolidate water quality monitoring and costs of water quality monitoring in Grand County.

Eagle River Sub-Basin

NWCCOG has been the designated Regional Water Quality Planning Agency (208 Planning Agency) for Eagle, Grand, Jackson, Pitkin, and Summit counties since February 1976. The region includes the Eagle River watershed. The 1998 208 Plan was updated in 2002 and received WQCC, Governor, and Environmental Protection Agency Region VIII approval. Major projects and groups concerned with water resource issues in the Eagle River sub-basin are listed below.

Eagle Mine site remedial action plan and record of decision. These documents list ongoing cleanup activities associated with the Eagle Mine Superfund site.

Vail nonpoint source management plan. This plan was completed based on stormwater permit requirements for large municipalities and recommends various management practices based on collected data.

Milk and Alkali Creek drainage project. In 1989, the WQCD provided nonpoint source pollution control funding for placement of structural sediment controls.

Black Lakes enlargement project. The Black Lake Reservoirs are located at the headwaters of Gore Creek. These two reservoirs have a combined capacity of 300 acre-feet and are used by the town of Vail to augment stream flows in Gore Creek and replace water diverted for snowmaking.

Eagle River watershed plan. The project was initiated by the Minturn town manager in 1994 and includes water quantity, wildlife, recreation, and land use issues.

Gore Creek partnership. A number of entities in the Gore Creek watershed joined together in 1995 to develop a monitoring program, database, and a water quality management program.

Eagle River watershed council. The group, officially formed in 2000 and funded by Environmental Protection Agency, currently provides ongoing coordination and implementation of watershed improvement and protection projects within the Eagle River drainage. Major projects include the cleanup of Black Gore Creek, spearheaded by the Black Gore Steering Committee and the Watershed Council.

Black Gore Creek steering committee. The group was established by Eagle County and NWCCOG to address sediment impacts on Black Gore Creek. Sand-control projects are ongoing on Vail Pass, including the recently constructed CDOT sand shed and the related improvements to drainage problems in the Black Gore headwaters, including Black Gore Lakes.

USGS retrospective analysis. The USGS has been contracted to develop a water quality database, design and implement a long-term monitoring program, and conduct a comprehensive retrospective analysis of data for the Eagle River watershed.

Blue River Sub-Basin

The NWCCOG has been the designated Regional Water Quality Planning Agency (208 Planning Agency) for Eagle, Grand, Jackson, Pitkin, and Summit counties since February 1976. The region includes the Blue River watershed. The 1998 208 Plan was recently updated in 2002 and received WQCC, Governor, and Environmental Protection Agency Region VIII approval.

Town of Frisco stormwater project. The project implemented structural controls to reduce phosphorus concentrations in stormwater runoff from the town of Frisco to Dillon Reservoir.

Town of Dillon stormwater project. The project implemented structural controls to reduce phosphorus concentrations in stormwater runoff from the town of Dillon to Dillon Reservoir.

Town of Breckenridge Blue River restoration. The project rechannelized and lined 2000 linear feet of the Blue River (previously disturbed by placer mining).

Town of Breckenridge stormwater quality enhancement project. The project improved storm sewers within the river corridor.

Division of Minerals and Geology Peru Creek project. The project reduced metal loading in the Snake River from historic mining.

Snake River Watershed Task Force. This group was established in 1999 to improve water quality in the Snake River watershed.

Division of Minerals and Geology French Gulch project. The project reduced metal loading in French Gulch from historic mining.

Summit Water Quality Committee. The Summit Water Quality Committee monitors water quality in the Upper Blue River tributary to Dillon Reservoir and manages the phosphorus control program defined in regulations adopted by the WQCC.

Summit Water Quality Committee Straight Creek sediment investigation project. The project coordinates monitoring and studies for sediment control in Straight Creek.

CDOT Straight Creek sediment retention project. CDOT activities include those associated with structural and nonstructural controls to reduce sediment loadings to Straight Creek.

South Blue River Regional Wastewater Reclamation Facility. The project will allow abandonment of old WWTPs and conversion of septic systems to central sewer.

NWCCOG biological restoration goals for French Gulch and Peru Creek. This was a 1994 Environmental Protection Agency grant for protection of aquatic environments affected by acid mine drainage.

NWCCOG Blue River Restoration Master Plan. This was a 1999 Environmental Protection Agency grant for plan development for a 2-mile segment of the Blue River between Breckenridge and Dillon Reservoir.

Climax Mine Revegetation Biosolids Partnership. This studied the use of biosolids and wood waste for mine land reclamation.

Clear Creek Sub-Basin

The Upper Clear Creek Watershed Association (UCCWA) is the designated 208 Planning Agency and is responsible for implementing point and nonpoint source controls in the Upper Clear Creek watershed, located between Eisenhower-Johnson Memorial Tunnels and Golden.

In response to a request of the Standley Lake cities (Northglenn, Thornton, and Westminster) to establish water quality standards and resulting control regulations for Standley Lake, an agreement was developed between 23 entities in the Clear Creek basin to address water quality issues (specifically phosphorus) related to Standley Reservoir. The parties to the agreement adopted a narrative standard only for Standley Lake, with options to adopt a numeric total phosphorus effluent limitation of 1.0 mg/L (for example, the Bear Creek Reservoir Regulation) if substantial progress was not made by the Upper Clear Creek basin dischargers in reducing their portion of nutrient loading to Clear Creek (Clear Creek/Standley Lake Watershed Agreement). A desired total phosphorus goal for the prevention of plant nuisances in streams or other flowing waters not discharging to lakes or impoundments is 0.1 mg/L (EPA 1986). CDOT is party to the Clear Creek/Standley Lake Watershed Agreement.

2.3.2 TMDL Monitoring Results 1992 to 2006 – Straight Creek, Colorado, Final Report (Completed May 2007)

This document assesses water quality improvement in Straight Creek, Colorado, between 1992 and 2006. The purpose of the assessment is to assist Environmental Protection Agency in measuring progress toward attainment of standards in streams on the 1998/2000 303(d) list of impaired waters. The assessment objectives were as follows:

1. Verify if the I-70 highway sediment control practices have attained the targets listed in the Straight Creek TMDL
2. Determine if conditions are improving toward attainment of the TMDL targets
3. Ascertain if sediment control practices have attained the Colorado sediment deposition standard (CDPHE 2005)

Under an interagency agreement with Environmental Protection Agency, USFS was responsible for compiling existing data from physical and biological monitoring and for analyzing the data. The conclusions of findings indicated that habitat and biological conditions in Straight Creek have not attained the TMDL targets even though many of the required sediment control practices have been completed. Pebble counts collected over the past 14 years show that sediment control has not been effective at meeting the target for median particle size. The TMDL target for five age classes of brook trout has been attained in one out of two reaches; however, neither site can be used to assess the effectiveness of sediment control best management practices because they are influenced by untreated sand input from the I-70 highway. A simple nonparametric analysis by CDOT, comparing averaged aquatic life support categories for 1992–1998 versus 1999–2006, indicates improvement over time (see **Table 8** in the USFS TMDL Monitoring Results 1992 to 2006, Straight Creek, CO, Final Report, 2007).

2.3.3 Upper Clear Creek Watershed Plan (Completed February 2006)

The Upper Clear Creek Watershed Plan is a compendium of mining-related trace metals data with comparisons to water quality standards. The stated goal of the plan is to provide a basic framework for the development of nonpoint source controls such that currently applicable or ultimate stream standards for key trace metals of concern can be met. An extensive compilation and assessment of stream flow and trace-metals data from several sources was completed to quantify the nonattainment of current stream standards and to estimate improvements related to ongoing Superfund and mine waste remediation (TDS 2006).

2.3.4 Energy Development Water Needs Assessment, Phase I Report (Completed September 2008)

The Energy Development Water Needs Assessment estimates the water supply needed to support the extraction and production of natural gas, coal, uranium, and oil shale in northwest Colorado. The investigation is led by the Colorado and Yampa River Basin Roundtables and funded by the Colorado Department of Natural Resources and the Colorado Water Conservation Board under House Bill 05-1177. These roundtables are seeking to use data and information from this study, in conjunction with the Statewide Water Supply Initiative and other appropriate sources, to assist with the development of a basin-wide consumptive and nonconsumptive water supply needs assessment (URS 2008).

2.3.5 Phase II Upper Colorado River Study, Final Report (Completed May 2003)

The Upper Colorado River Basin Study (UPCO) was initiated in 1998 to identify and investigate water quantity and quality issues in Grand and Summit counties. Phase I of UPCO was the development of the Scope of Work for Phase II. The primary goal identified for Phase II was to develop the information and analytical tools necessary to understand existing hydrology and water quality conditions in the area and how increased water diversions may have an impact on those conditions. This information supports discussions and negotiations among the stakeholders as they seek solutions to current and future water supply, reservoir level, instream flow, and water quality issues (HRC 2003).

The UPCO evaluations indicate a need for additional water supplies in Grand and Summit counties for existing and future municipal demands. These evaluations also show a need for instream flows to support the area's recreational uses and maintain low-flow levels used to determine waste load allocations for wastewater treatment plants. Information was used to evaluate the impact on stream flow and lake levels that go beyond the municipal and domestic water demands of the area. Results indicate Denver Water's future demands for water supplies are approximately 10 times greater (100,000 acre-feet/year) than Summit County's future water demands (10,000 acre-feet/year). Average annual shortages projected by Denver Water's existing hydrologic and water rights model (referred to as the Platte and Colorado Simulation Model [PACSM]) indicate that shortages in Summit County will amount to only about 2 percent of the future Denver Water demand. Instream flows, reservoir levels, and wastewater treatment plant low-flow levels were all below optimum for the future water demand scenarios in Summit County (HRC 2003).

2.3.6 Water Availability Study of the Colorado River and Tributaries, Proposed August 2008

The Water Availability Study of the Colorado River and Tributaries provides information to Colorado River water users and other stakeholders regarding water availability in the river and in its Colorado tributaries (CWCB 2008). The Colorado Water Conservation Board conducted the study under House Bill 08-1346. Phase I of the study helps the State address the following questions:

1. What is a reasonable base of existing uses to consider in the Colorado River Water Availability Study?
2. How does historical hydrology in the last 70 to 90 years compare to a longer hydrologic trace that was developed based on tree ring analysis?
3. What is a reasonable projection for hydrology as affected by climate change?
4. Based on evaluations of previous investigations of Colorado River Compact entitlements, and considering current information, how much water would Colorado be entitled to under the Compacts?

2.3.7 Memorandum of Agreement on Management of Mine-Related Materials in the Interstate 70 Mountain Corridor

CDPHE recommended that CDOT's materials handling plan be formalized into a Memorandum of Agreement among CDOT, Environmental Protection Agency, and CDPHE (with involvement of the Solid Waste and CERCLA programs).

Following the completion of the Draft PEIS, meetings were held with CDPHE, CDOT, and FHWA representatives involved with the preparation of a Memorandum of Agreement. A draft Memorandum of Agreement was prepared and reviewed for legality in relationship with existing legislation. Following reviews, it was determined that the Memorandum of Agreement would not add anything to the overall regulatory process and would only add another layer of procedures that for all intents would be redundant. As a result, CDOT and FHWA determined that a Memorandum of Agreement will not be included in the Final PEIS or Record of Decision.

2.4 Methodology

This section provides a discussion on the methodology used for analysis of water resources in the Corridor, specifically, the use of the FHWA Stormwater Runoff Model and the BASINS Model. Results from these analyses are presented in Section 5, Environmental Consequences.

2.4.1 FHWA Stormwater Runoff Model

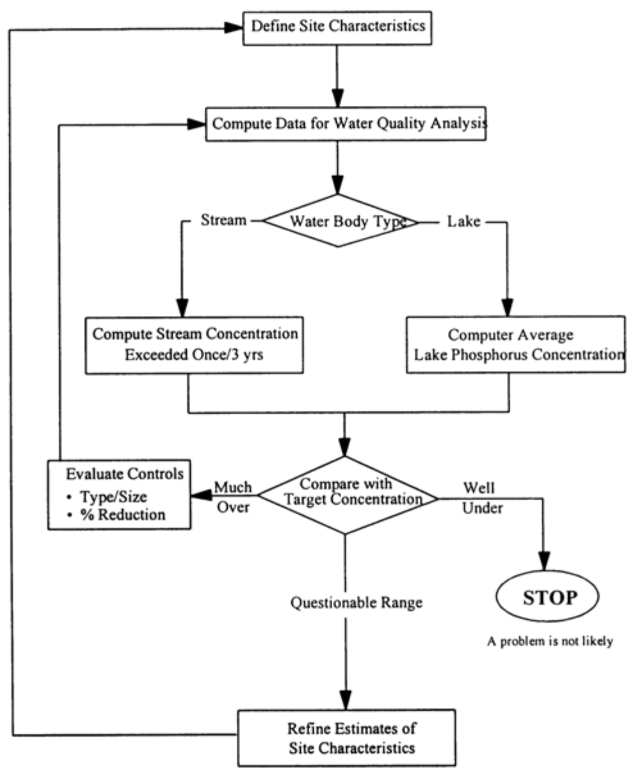
A water quality model developed and supported by the Federal Highway Administration (FHWA) has been used in the direct impact assessment to determine potential changes in stream water quality related to the alternatives under consideration. The model is the software implementation of FHWA-RD-006/009, "Pollutant Loadings and Impacts from Highway Stormwater Runoff" (Driscoll et al. 1990). The software characterizes highway runoff pollutant loads and predicts the resulting impacts on stream water quality. The general procedure employed by the model for evaluating water quality impacts from highway runoff is shown in **Figure 2**. The FHWA study and resulting software are based on analysis of 993 individual storm events at 31 highway runoff sites in 11 states. The water quality characteristics of the storm events populate a database that is accessed by the software. Site-specific data can also be used in the model, as was the case in this I-70 impact assessment. This I-70 impact assessment used the site-specific Corridor water quality data discussed above for model inputs. Site-specific runoff concentrations overcome many of the drawbacks related to using national data from averaged mostly humid climates.

It is important to note that the FHWA model does not take into account the background levels of pollutants in subject streams. The percentage increases are only the increase in pollutant loading directly due to the alternative presented. In areas where mining has historically occurred, highway runoff concentrations of copper and zinc are often quite small compared to the background levels found in the streams. The model cannot effectively evaluate the complex mechanisms that govern the chemical and physical interactions between highway runoff pollutants and the receiving water. For this and other reasons discussed above, the FHWA model is intended only to act as a screening model. In the Tier 2 processes for this project, it is expected that a more detailed analysis will be considered to evaluate impacts on areas where water quality concerns require increased scrutiny.

The procedure employed for this analysis is a probabilistic dilution model developed and applied in the Environmental Protection Agency's Nationwide Urban Runoff Program (NURP). It permits the user to compute the magnitude and frequency of occurrence of instream concentrations of a pollutant under the variable and intermittent discharges that are produced by stormwater and snowmelt runoff.

This interactive computer program allows the user to estimate the water quality changes that will be produced by stormwater runoff from a specific highway site, evaluate whether or not the resulting water quality conditions can be considered to cause a problem (as indicated by the exceedance of water quality standards, aquatic life criteria, or target concentrations), and when appropriate, to examine the extent to which selected control measures can be expected to mitigate any adverse impacts.

Figure 2. General Procedure Used with FHWA Model (Driscoll et al. 1990)



The input parameters required in the model include drainage areas, stream flow for the watershed, rainfall characteristics, pollutant concentrations in the runoff, and instream target concentrations to be used for comparison of exceedance frequency. The model outputs are frequency of storm events exceeding specified target concentrations and once in 3-year stream concentrations.

The FHWA highway runoff model has been used as a screening tool for various transportation alternatives. Instream concentration estimates are based, in part, on the following assumptions:

- The model uses precipitation in the form of rainfall, not snow.

- The road surface drains to one point in the stream; there are no intervening features, natural or constructed, between the highway runoff and natural waterways that might decrease impacts on stream water quality.
- Any intervening soils between the highway discharge culvert and the stream are saturated, causing all of the highway runoff to flow to the receiving stream.
- The receiving streams are chemically the equivalent of distilled water.
- All dissolved metals that are in highway runoff remain dissolved in the receiving waterway.

Many of these assumptions may not be true for the Colorado Rocky Mountains. The soils usually are not saturated; highway runoff is dispersed; and some runoff does not flow directly into the stream or lake. The assumption that all dissolved metals from highway runoff will remain dissolved is particularly unlikely for copper. Sediment control structures that have been or will be built are expected to remove substantial amounts of total metals and particulate phosphorous. While the FHWA model may predict mixing of runoff volumes with receiving streams well, a more rigorous assessment of the geochemical behavior of metals and phosphorous may be necessary at the Tier 2 level of study. The current analysis focuses on the relative impacts of different transportation alternatives and in different watersheds, not on prediction of stream concentrations.

For highway discharges to flowing streams, which are the most common water body receiving highway discharges in the Corridor, the potential toxic effect on aquatic biota in mountain streams is more properly associated with dissolved phosphorous, especially orthophosphorous. The average dissolved phosphorous in highway runoff from the I-70 highway is less than 1/20 of the total phosphorous (0.04 mg/L versus 0.90 mg/L; Clear Creek Consultants, Inc. 2002; update 2004).

Consideration of possible water quality impacts on Corridor lakes and reservoirs was considered to be outside the scope of this PEIS and would be deferred to the Tier 2 level of study. For highway discharges to lakes, methods could be employed to predict whether phosphorus discharged by highway stormwater is likely to contribute substantially to eutrophication.

Hydrologic Drainage Areas

The Corridor was divided into 11 sub-basin areas that correspond to specific watersheds along the highway from west to east. These sub-basins are listed in **Table 5**. For each sub-basin, the highway length and width were used to calculate the total impervious surface area and the total disturbed area (including cut-and-fill slopes). The total watershed drainage area is also used in the stream runoff calculations. The area values were developed for each project alternative (the alternatives are described in Section 3).

Table 5. Hydrologic Drainage Areas[a] (Acres) Existing Conditions and Combination Alternative

Drainage Basin	Milepost	Watershed Name	Watershed Area	Area of I-70 Disturbance	I-70 Existing Impervious Surface	Combination Highway/Rail Impervious Surface	Percent Change Impervious	Watershed Yield (cfs/sq-mi)
Eagle River	176–182	Gore Creek	65,280	536	66	92	40%	1.38
	182–190	Black Gore	11,520	303	90	140	56%	1.38
Blue River	190–195	West Tenmile	11,520	238	59	79	34%	1.09
	195–201	Tenmile Creek	59,520	447	69	93	35%	1.09
	201–205	Blue River	6,400	144	45	68	51%	0.83
	205–214	Straight Creek	11,520	447	102	139	36%	0.83
Clear Creek	214–227	Upper Clear Creek	32,000	433	130	215	65%	0.96
	227–235	Middle Clear Creek	94,080	693	92	153	47%	0.99
	235–246	Lower Clear Creek	170,880	1025	122	253	107%	0.88
	246–255	Beaver Brook	23,680	271	143	175	22%	0.50
Platte River	255–260	Mount Vernon Creek	3,840	216	92	117	27%	0.50

[a] Surface areas are cumulative for streams in multiple watersheds.

cfs/sq-mi = cubic feet per second per square mile.

Areas were cumulative from upstream to downstream in multiple watersheds, such as Black Gore/Gore Creek and West Tenmile/Tenmile Creek. Clear Creek was subdivided into upper, middle, and lower to accommodate the major changes in water quality that are known to occur in the modeling effort. Note that most of these sub-basins do not correspond to stream segments as specified for Colorado water quality standards, and “Upper Clear Creek” in **Table 5** differs substantially from the UCCWA watershed delineation.

Hydrologic Input Parameters

Stream flow and rainfall data are required as model input parameters. Runoff flow rates and volumes, mass loading, and the ratio of runoff to stream flow are computed. The watershed yield was calculated for each I-70 watershed using long-term stream flow data from local stream gages (USGS, 2001). For ungauged watersheds, yields were estimated based on the gauge record from adjacent watersheds. A coefficient of variation of 2 was used in the stream flow estimate, as suggested for the Colorado region (Driscoll et al. 1990).

A large portion of the annual stream flow volume in Corridor streams is from snowmelt in May and June. Precipitation over the winter from October to April generally falls in the form of snow. The FHWA model does not provide an option for snowmelt modeling of contaminant transport. However, I-70 studies have documented that even though contaminant transport from the highway to the streams can occur year round, the majority of transport results from intense rainfall-runoff during the summer months (Clear Creek Consultants, Inc., 2002a).

Rainfall intensity and volume were taken from eight local rainfall intensity gauges operated between May and September in the Corridor as part of the baseline storm event/snowmelt water quality monitoring program. The period of record used from these gauges is 2001 to 2003. The rainfall depths from 131 storm events in the Corridor were used to compute a mean depth of 0.27 inches for the 1-hour duration. The 1-hour storm depth had a coefficient of variation of 0.52. The rainfall depths from 73 individual storms were used to compute an average storm depth of 0.49 inches for the Corridor. The average storm depth had a coefficient of variation of 0.5.

Each storm event selected for the rainfall analysis produced I-70 highway runoff to streams that were sampled for the monitoring program. The average duration between I-70 runoff events that produced enough water to cause a reasonable response in stream flow was about 14 to 21 days. Therefore, an average duration of 18 days between storm events was used in the model with a coefficient of variation of 0.5.

Pollutant Concentrations and Loading

The pollutant parameters analyzed in the impact analysis include TSS, total phosphorus, chloride, and dissolved forms of copper and zinc. Changes in predicted 3-year concentrations among alternatives are evaluated for each parameter.

For the evaluation of stream impacts resulting from highway runoff discharges, the intermittent exposure times are on the order of hours, and the soluble fraction of a toxic pollutant in the runoff is important. Trace metal water quality standards in Colorado are based on soluble concentrations in the water column. The fact that the particulate fraction (rather than soluble forms) constitutes the major component of most pollutants of interest in the runoff from highways emphasizes the importance of this distinction. For example, the average of dissolved phosphorous is only 4 percent of the average of total phosphorous in runoff (Clear Creek Consultants, Inc., 2002a).

Dissolved metal fractions were small and were generally near or below detection limits in FHWA research studies (Clear Creek Consultants, Inc. 2002a). This is the case for highway runoff sampling results within the Corridor with the exception of Lower Clear Creek, which intersects the mining district in Clear Creek County. Highway runoff in the mining-affected stream segments generally contained higher concentrations of soluble metals (Clear Creek Consultants, Inc., 2002a).

The site median and 85th percentile concentrations for 36 sampled I-70 highway snowmelt and rainfall-runoff events were computed for TSS, total phosphorus, chloride, dissolved copper, and dissolved zinc. For dissolved copper and zinc, the 85th percentile concentrations are used for all watersheds except Lower Clear Creek, where the median concentrations from a highly mineralized rock cut near Idaho Springs were used. This approach provides higher (more conservative) values for the analysis and is justified because of the limited number of available I-70 runoff samples. Traffic loads on the I-70 highway are high enough to qualify it as an “urban” highway in this model. Therefore, site-specific data were used in the model rather than national averages to provide most reliable site-specific estimates of the pollutant concentrations in the Corridor.

For lake eutrophication analysis, the distribution of the total phosphorus in runoff between soluble and particulate fractions is not important (FHWA-RD-88-006) because the time scale for this type of impact as determined by the hydraulic residence time is typically long. Particulate fractions that may settle out of the water column usually have ample time to decompose and recirculate to the water column. The toxicity of soluble phosphorus is not known but is generally believed to be low relative to heavy metals.

Model results from the FHWA Stormwater Runoff Model are presented in Section 5.1.

2.4.2 BASINS Model

Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) is a watershed model that integrates data and assessment tools in a customized GIS environment for performing water quality analysis (EPA, 2001). The GIS provides the integrating framework for BASINS by organizing spatial information, such as land use, highways, and point source discharge locations, so that it can be displayed as maps, tables, or graphics. Existing and future land use data from Clear Creek, Summit, and Eagle counties are used in the BASINS model to assess potential changes in annual phosphorus loading and cumulative impacts from alternatives. The BASINS model is used to assess changes in phosphorous loadings that are due *strictly* to changes in land use, based on county plans. The entire I-70 right-of-way was used to provide a conservatively large area that would incorporate all proposed alternatives to assess the I-70 land use component. Impacts from combined future land use and I-70 Mountain Corridor alternatives are shown in the *I-70 Mountain Corridor PEIS Cumulative Effects Technical Report*.

The BASINS model contains a suite of interrelated components for performing the various aspects of environmental analysis including databases, data assessment tools, and instream water quality and loading and transport models. Input parameters include GIS land use data, GIS watershed data, impervious terrain factors, event mean concentrations for different land use types, and point source facility locations and loads. PLOAD is a spatially distributed, lumped parameter watershed model that computes nonpoint source loads from different subwatersheds and land uses based on annual precipitation, land use, and best management practices. Input parameters include GIS land use data, GIS watershed data, impervious terrain factors, event mean concentrations for different land use types, and point source facility locations and loads. PLOAD is used as a screening tool for the cumulative water quality impacts analysis to estimate annual loading changes related to the I-70 highway and associated future land use changes.

The model input parameters were adjusted to represent conditions in the Corridor. The land use categories, impervious terrain factors, and event mean concentrations (EMC) used in the model are listed in **Table 6**. The same EMC values for each land use and cover type were used for Eagle River, Blue River, and Clear Creek to provide a consistent basis for comparison of the model results among Corridor watersheds. The total phosphorus EMC for the I-70 highway and other federal or state highways is based on site-specific data collected as part of the I-70 storm event/snowmelt water quality monitoring program and other studies (Clear Creek Consultants, Inc. 2002a). These data reflect the effects of traction sand use and highway runoff on stream water quality. The EMC values for undeveloped forested areas of the Corridor were taken from ongoing site-specific EMC studies (UCCWA 2002). Other EMC and percent impervious parameters were taken from suggested values provided in the BASINS model (EPA, 2001). Point discharge loads from 1999 wastewater treatment facility reports (the most recent data set provided in BASINS) and other data sources (UCCWA 2001) also were used in the loading analysis.

Model results from the BASINS Model are presented in Section 5.1.

Table 6. BASINS Input Data—Land Use and Cover Parameters

Land Use Code	Land Use and Cover Type	Percent Impervious	Total Suspended Solids (mg/L)	Total Phosphorus (mg/L)
9	Interstate Highway 70	65	520	0.56
10	Federal or State Highways	65	520	0.56
11	Residential	60	132	0.33
12	Commercial and Services	85	132	0.33
13	Industrial	70	132	0.33
14	Trans., Comm., Util.	65	520	0.56
15	Industrial and Commercial Complexes	75	132	0.33
16	Mixed Urban or Built-Up	25	78	0.28
17	Other Urban or Built-Up	25	78	0.28
21	Cropland and Pasture	2	78	0.28
22	Orch., Grov., Vnyrd., Nurs., Orn.	2	78	0.28
23	Confined Feeding Ops.	25	78	0.28
24	Other Agricultural Land	2	78	0.28
32	Shrub and Brush Rangeland	2	39	0.10
33	Shrub and Brush High Soil P	2	78	0.28
41	Deciduous Forest Land	2	26	0.05
42	Evergreen Forest Land	2	26	0.05
43	Mixed Forest Land	2	26	0.05
51	Streams and Canals	100	26	0.03
52	Lakes	100	26	0.03
53	Reservoirs	100	26	0.03
61	Forested Wetland	2	26	0.05
62	Nonforested Wetland	2	26	0.05
74	Bare Exposed Rock	100	39	0.10
75	Strip Mines	50	520	0.56
76	Developed Transitional	50	39	0.14
81	Shrub and Brush Tundra	2	26	0.05
82	Herbaceous Tundra	2	26	0.05
83	Alpine Transitional	10	26	0.05

Section 3. Description of Alternatives

This section summarizes the alternatives considered in the I-70 Mountain Corridor PEIS. A more complete description of these alternatives is available in **Chapter 2** of the PEIS and in the *I-70 Mountain Corridor PEIS Alternatives Screening and Development Technical Report* (CDOT, August 2010).

3.1 Minimal Action Alternative

The Minimal Action Alternative provides a range of local transportation improvements along the Corridor without providing major highway capacity widening or dedicated transit components. The Minimal Action Alternative includes elements of the Transportation System Management family and the Localized Highway Improvements family, including: transportation management, interchange modifications, curve safety modifications, and auxiliary lanes. These elements are also incorporated into the other Action Alternative Packages.

3.2 Transit Alternatives

Four Transit alternatives are considered in the PEIS as a reasonable range representing the Fixed Guideway and Rubber Tire Transit families:

- Rail with Intermountain Connection Alternative
- Advanced Guideway System Alternative
- Dual-Mode Bus in Guideway Alternative
- Diesel Bus in Guideway Alternative

3.2.1 Rail with Intermountain Connection

The Rail with Intermountain Connection Alternative would provide rail transit service between the Eagle County Regional Airport and C-470. Between Vail and C-470 the rail would be primarily at-grade running adjacent to the I-70 highway. The segment between Vail and the Eagle Count Airport would be constructed within the existing Union Pacific Railroad right-of-way. A new Vail Transportation Center, including new track, would be constructed between Vail and Minturn to complete the connection between the diesel and electric trains. This alternative also includes auxiliary lane improvements at eastbound Eisenhower-Johnson Memorial Tunnels to Herman Gulch and westbound Downieville to Empire and the other Minimal Action Alternative elements except for curve safety modifications at Dowd Canyon, buses in mixed traffic and other auxiliary lane improvements.

3.2.2 Advanced Guideway System

The Advanced Guideway System Alternative would provide transit service between the Eagle County Regional Airport and C-470 with a 24-foot-wide, 118 mile, fully elevated system. The Advanced Guideway System Alternative would use a new technology that provides higher speeds than the other Fixed Guideway Transit technologies studied for the PEIS. Any Advanced Guideway System would require additional research and review before it could be implemented in the Corridor. Although the Federal Transit Administration-researched urban magnetic levitation system is considered in the PEIS, the actual technology would be developed in a Tier 2 process. This alternative includes the same Minimal Action elements as described previously for the Rail with Intermountain Connection Alternative.

3.2.3 Dual-mode Bus in Guideway

This alternative includes a guideway located in the median of the I-70 highway with dual-mode buses providing transit service between the Eagle County Regional Airport and C-470. This guideway would be

24 feet wide with 3 foot high guiding barriers and would accommodate bidirectional travel. The barriers direct the movement of the bus and separate the guideway from general purpose traffic lanes. While traveling in the guideway, buses would use guidewheels to provide steering control, thus permitting a narrow guideway and providing safer operations. The buses use electric power in the guideway and diesel power when traveling outside the guideway in general purpose lanes. This alternative includes the same Minimal Action Alternative elements as described previously for the Rail with Intermountain Connection Alternative.

3.2.4 Diesel Bus in Guideway

This includes the components of the Dual-mode Bus in Guideway Alternative except that the buses use diesel power at all times.

3.3 Highway Alternatives

Three Highway alternatives are advanced for consideration in the PEIS as a reasonable range and representative of the Highway improvements, including Six-Lane Highway 55 mph, Six-Lane Highway 65 mph, and Reversible/HOV/HOT Lanes. The Highway alternatives considered both 55 and 65 mph design speeds to 1) establish corridor consistency and 2) address deficient areas within the Corridor. The 55 mph design speed establishes a consistent design speed throughout the Corridor, which currently does not exist. The 65 mph design speed further improves mobility and addresses safety deficiencies in key locations such as Dowd Canyon and the Twin Tunnels. Both the 55 mph and the 65 mph design speed options are augmented by curve safety improvements, but the 65 mph design speed constructs tunnels in two of the locations: Dowd Canyon and Floyd Hill/Hidden Valley.

3.3.1 Six-Lane Highway 55 mph Alternative

This alternative includes six-lane highway widening in two locations: Dowd Canyon and the Eisenhower-Johnson Memorial Tunnels to Floyd Hill. This alternative includes auxiliary lane improvements at eastbound Avon to Post Boulevard, both directions on the west side of Vail Pass, eastbound Frisco to Silverthorne and westbound Morrison to Chief Hosa, and the Minimal Action Alternative elements except for buses in mixed traffic and other auxiliary lane improvements.

3.3.2 Six-Lane Highway 65 mph Alternative

This alternative is similar to the Six-Lane Highway 55 mph Alternative; it includes the same six-lane widening and all of the Minimal Action Alternative elements except the curve safety modification at Dowd Canyon. The higher design speed of 65 mph alternatives requires the curve safety modifications near Floyd Hill and Fall River Road to be replaced with tunnels.

3.3.3 Reversible Lanes Alternative

This alternative is a reversible lane facility accommodating high occupancy vehicles and high occupancy toll lanes. It changes traffic flow directions as needed to accommodate peak traffic demands. It includes two additional reversible traffic lanes from the west side of the Eisenhower-Johnson Memorial Tunnels to just east of Floyd Hill. From the Eisenhower-Johnson Memorial Tunnels to US 6, two lanes are built with one lane continuing to US 6 and the other lane to the east side of Floyd Hill. This alternative includes one additional lane in each direction at Dowd Canyon. This alternative includes the same Minimal Action Alternative Elements as the Six-Lane Highway 55 mph Alternative.

3.4 Combination Alternatives

Twelve Combination alternatives, combining Highway and Transit alternatives are considered in the PEIS. Four of these alternatives involve the buildout of highway and transit components simultaneously. Eight alternatives include preservation options, the intent of which is to include, or not preclude, space for future modes in the I-70 Mountain Corridor. The Combination alternatives all include the Six-Lane Highway 55 mph Alternative for highway components.

Combination Rail and Intermountain Connection and Six-Lane Highway Alternative—This alternative includes the 55 mph six-lane highway widening between Floyd Hill and Eisenhower-Johnson Memorial Tunnels, the Rail and Intermountain Connection transit components, and most of the components of the Minimal Action Alternative. The exception is that only one of the Minimal Action auxiliary lane improvements (from Morrison to Chief Hosa westbound) is included.

Combination Advanced Guideway System and Six-Lane Highway Alternative—This alternative includes the 55 mph six-lane highway widening between Floyd Hill and Eisenhower-Johnson Memorial Tunnels and the Advanced Guideway System transit components. It includes the same Minimal Action Alternative elements as the Combination Rail and Intermountain Connection and Six-Lane Highway Alternative.

Combination Bus in Guideway (Dual-Mode) and Six-Lane Highway Alternative—This alternative the 55 mph six-lane highway widening between Floyd Hill and Eisenhower-Johnson Memorial Tunnels and the dual-mode bus in guideway transit components. It includes the same Minimal Action Alternative elements as the Combination Rail and Intermountain Connection and Six-Lane Highway Alternative.

Combination Bus in Guideway (Diesel) and Six-Lane Highway Alternative—This alternative includes the 55 mph six-lane highway widening between Floyd Hill and Eisenhower-Johnson Memorial Tunnels and the diesel bus in guideway transit components. It includes the same Minimal Action Alternative elements as the Combination Rail and Intermountain Connection and Six-Lane Highway Alternative.

Combination Rail & Intermountain Connection and Preservation of Six-Lane Highway Alternative—This alternative includes the Rail and Intermountain Connection Alternative and preserves space to construct the Six-Lane Highway 55 mph at a later point.

Combination Advanced Guideway System and Preservation of Six-Lane Highway Alternative—This alternative includes the Advanced Guideway System and preserves space to construct the Six-Lane Highway 55 mph at a later point.

Combination Bus in Guideway (Dual-Mode) and Preservation of Six-Lane Highway Alternative—This alternative includes the Combination Bus in Guideway (Dual-Mode) Alterative and preserves space to construct the Six-Lane Highway 55 mph at a later point.

Combination Bus in Guideway (Diesel) and Preservation of Six-Lane Highway Alternative—This alternative includes the Bus in Guideway (Diesel) Alternative and preserves space to construct the Six-Lane Highway 55 mph at a later point.

Combination Preservation of Rail and Intermountain Connection and Six-Lane Highway Alternative—This alternative includes the Six-Lane 55 mph Highway Alternative and also preserves space to construct the Rail and Intermountain Connection at a later point.

Combination Preservation of Advanced Guideway System and Six-Lane Highway Alternative— This alternative includes the Six-Lane 55 mph Highway Alternative and also preserves space to construct the Advanced Guideway System at a later point.

Combination Preservation of Bus in Guideway (Dual-Mode) and Six-Lane Highway Alternative— This alternative includes the Six-Lane Highway Alternative and also preserves space to construct the Bus in Guideway (Dual-Mode) at a later point.

Combination Preservation of Bus in Guideway (Diesel) and Six-Lane Highway Alternative—This alternative includes the Six-Lane Highway Alternative and also preserves space to construct the Bus in Guideway (Diesel) at a later point.

3.5 Preferred Alternative—Minimum and Maximum Programs

The Preferred Alternative provides for a range of improvements. Both the Minimum and the Maximum Programs include the Advanced Guideway System Alternative. The primary variation between the Minimum and Maximum Programs is the extent of the highway widening between the Twin Tunnels and the Eisenhower-Johnson Memorial Tunnels. The Maximum Program includes six-lane widening between these points (the Twin Tunnels and the Eisenhower-Johnson Memorial Tunnels), depending on certain events and triggers and a recommended adaptive management strategy.

3.6 No Action Alternative

The No Action Alternative provides for ongoing highway maintenance and improvements with committed funding sources highly likely to be implemented by the 2035 planning horizon. The projected highway maintenance and improvements are committed whether or not any other improvements are constructed with the I-70 Mountain Corridor project. Specific improvements under the No Action Alternative include highway projects, park and ride facilities, tunnel enhancements, and general maintenance activities.

Section 4. Affected Environment

This section provides an in depth discussion of water resources within the Corridor.

4.1 Stream Morphology and Basin Characteristics

4.1.1 Colorado Headwaters Sub-Basin

The Colorado Headwaters sub-basin drains 6,013 square miles and includes the contributions of the Blue River and Eagle River sub-basins. The major watersheds in the Colorado Headwaters sub-basin include the Colorado River, which originates in Rocky Mountain National Park; the Fraser River; Willow Creek; Williams Fork; Troublesome Creek; and Muddy Creek. The lower portion of the watershed includes parts of Routt (Rock Creek drainage), Eagle, and Garfield counties and ends at the confluence of the Roaring Fork and Colorado rivers in Glenwood Springs. Below the confluence of the Blue River, the Colorado River flows through a remote and rural area until it joins with the Eagle River at Dotsero and then parallels the I-70 highway for 25 miles to Glenwood Springs. The existing I-70 footprint is located immediately adjacent to the river in this segment.

In the immediate vicinity of the I-70 highway, the Colorado River channel changes from a meandering stream near Dotsero to a confined channel within the Glenwood Canyon. The dominant stream slope is generally less than 2 percent with substrate consisting predominantly of gravel near Glenwood Springs and boulder and cobble further upstream nearer its confluence with the Eagle River. The establishment of the I-70 highway through the Glenwood Canyon has minimally affected the morphology of the river.

Operation of the Shoshone pump-back storage facility located within the canyon, however, has resulted in dramatic stream flow fluctuations in the canyon. Additionally, the Glenwood Canyon area is going through the process of being designated as a Wild and Scenic River which would afford it protection under the Wild and Scenic Rivers Act.

4.1.2 Eagle River Sub-Basin

The Eagle River sub-basin is located almost entirely in Eagle County and encompasses 944 square miles (604,160 acres). The watershed includes several stream segments that come in close proximity to the I-70 highway. Black Gore Creek (Black Gore Creek sub-watershed) flows from its headwaters near the Summit County line (and Vail Pass) to its confluence with Gore Creek near the eastern edge of Vail. Gore Creek (Gore Creek watershed) flows through Vail to its confluence with the Eagle River at Minturn interchange. The Eagle River flows west through the Corridor from Minturn to its confluence with the Colorado River near Dotsero.

The Eagle River channel from the Minturn interchange downstream to its confluence with the Colorado River is of low sinuosity, low gradient, and generally exhibits a wide, shallow, entrenched channel with a bed consisting predominantly of cobble and gravel. The Eagle River differs from other rivers and streams within the Corridor because of its lower gradient and entrenched nature in most areas. The lower gradient tends to facilitate long-term deposition of sediment conveyed from tributaries to the Eagle River (such as Milk Creek, Muddy Creek, Alkali Creek, and Ute Creek).

The Gore Creek channel from its confluence with the Eagle River upstream to eastern Vail is of low sinuosity, low gradient, and has an entrenched channel (predominantly of cobble) and narrow floodplain. Gore Creek has experienced localized channel disturbance related to the construction and operation of the I-70 highway and development within the town of Vail. Gore Creek stream discharge is augmented by an estimated 500 acre-foot/year from the Eagle River for snowmaking. The Black Gore Creek channel is of very low sinuosity (nearly straight), narrow, and confined. The streambed is steep (4 to 10 percent slope) with cascading step pools and substrate consisting predominantly of bedrock, boulders, and cobble.

4.1.3 Blue River Sub-Basin

The Blue River sub-basin drains an area of 680 square miles from elevations reaching 14,270 feet along the southeastern perimeter to its confluence with the Colorado River south of Kremmling at an elevation of 7,400 feet. Most of the watershed is located within high relief, crystalline, and hard-sedimentary mountainous lands. The watershed includes several stream segments in the immediate vicinity of the I-70 highway. West Tenmile Creek (West Tenmile Creek sub-watershed) flows from west Summit County to Tenmile Creek (Tenmile Creek watershed) near Frisco. Tenmile Creek (Tenmile Creek and Dillon Reservoir watersheds) flows into Dillon Reservoir near Dillon and Silverthorne. The Blue River (Blue River in Dillon sub-watershed) flows from the Dillon Reservoir under the I-70 highway northward toward Green Mountain Reservoir.

West Tenmile Creek flows entirely within the immediate vicinity of the I-70 highway from its headwaters near Vail Pass to its confluence with Tenmile Creek, where it has been channelized by the development of the Copper Mountain Resort. The West Tenmile Creek is a high-gradient (2 to 4 percent), low sinuosity, narrow mountain stream with coarse substrate consisting primarily of boulders and cobble. The White River National Forest (WRNF), the I-70 highway, and Copper Mountain Resort dominate land use in West Tenmile Creek drainage.

Tenmile Creek is a high-gradient (2 to 4 percent), low sinuosity, narrow mountain stream with coarse substrate consisting primarily of boulders and cobble. Tenmile Creek has been channelized locally, particularly in areas near Wheeler Junction, by the construction of the I-70 highway. Land use in Tenmile Creek is dominated by mining, the WRNF, and the I-70 highway in the lower portion only.

Straight Creek originates at an elevation of 12,000 feet and flows west for 8 miles along the I-70 highway before its confluence with the Blue River in the town of Silverthorne. Straight Creek is a generally high gradient stream with coarse substrate consisting primarily of bedrock, boulders, and cobble. As the name implies, its channel is of very low sinuosity (essentially a straight stream) with a dominant slope of 4 to 10 percent. Straight Creek has been channelized locally by the construction of the I-70 highway and development within the town of Dillon.

4.1.4 Clear Creek Sub-Basin

the I-70 highway enters the Clear Creek watershed at the east portal of the Eisenhower-Johnson Memorial Tunnels and resides within the Clear Creek sub-basin to the base of Floyd Hill, a distance of nearly 30 miles. Elevations range from 11,100 feet at the Eisenhower-Johnson Memorial Tunnels to 7,500 feet at the junction of the I-70 highway and US 6 (west base of Floyd Hill). Clear Creek and the Clear Creek channel have been altered by mining activities, urbanization, railroads, and roadway construction. Most of the development is confined to the middle and lower portions of the watershed, whereas the upper portions of the watershed reside in relatively undisturbed Arapaho and Roosevelt National Forests (ARNF) land. The construction of US 6, US 40, and the I-70 highway resulted in additional channelization of Clear Creek along portions of its entire length, as did development in the towns of Silver Plume, Georgetown, and Idaho Springs.

More than 50 percent (16 miles) of Clear Creek has been channelized as a result of highway development, about 13 percent (4 miles) of the stream has been channelized as a result of ski resort and urban development, and 5 percent (1.5 miles) has been channelized as a result of mining. Channelization has reduced the overall meandering or sinuosity of the stream, which is an essential element in providing aquatic habitat and dissipating the stream's energy. Minor attempts to mitigate the effects of channelization have occurred over time by the addition of boulders and drop structures in the stream channel. The channelization of Clear Creek, however, has eliminated the floodplain and, as a result, contributes to the area of flooding in various municipalities, such as Silver Plume, Georgetown, and Idaho Springs. Channelization also altered the groundwater conditions adjacent to the stream by limiting seasonal flooding and potentially affecting groundwater recharge.

Figure 3 through Figure 7 show the Flood Hazard Zones within the Corridor for the Clear Creek Sub-Basin. In some locations and depending upon the improvements at that location, floodplain considerations may be important during Tier 2 processes, and floodplain analysis will be performed.

4.1.5 Upper South Platte River Sub-Basin

The Upper South Platte River sub-basin (HUC 4) includes the Trout/West Creeks watershed (HUC 5) and the Bear Creek sub-watershed (HUC 6). The Bear Creek watershed includes Mount Vernon Creek, which flows parallel to the I-70 highway from near Genesee Park east to near US 24. Land use consists of mixed rural residential and commercial development, as well as open space. Mount Vernon Creek is a high-gradient, narrow mountain stream with coarse substrate consisting primarily of bedrock, boulder, and cobble. Its channel is of very low sinuosity (nearly straight) with a dominant slope of 4 to 10 percent.

4.2 Water Use Information

This section provides an overview on the water use for the water resources sub-basins throughout the I-70 Corridor.

4.2.1 Colorado Headwaters Sub-Basin

Table 7 summarizes water resources data in the Colorado Headwaters sub-basin. Water diversions include more than 2.42 million acre-feet per year for irrigation and approximately 2.39 million acre-feet per year for industrial use (NWCCOG, 1996). Transbasin diversions to Front Range cities (Denver Water Department and Northern Colorado Water Conservancy District) and agricultural use are approximately 0.51 million acre-feet per year. The greatest expansion of industrial use in recent years has been for snowmaking at ski areas and for maintaining instream flows for other recreational uses, such as fishing and rafting.

4.2.2 Eagle River Sub-Basin

Table 8 summarizes water use for the Eagle River sub-basin. The watershed supplies substantial quantities of water to the Arkansas River basin and to the Front Range. In addition to the major reservoirs listed in **Table 8**, the Eagle River Water and Sanitation District operates two water supply reservoirs at the headwaters of Black Gore Creek: Black Gore Lake No. 1 and 2. Water stored in these lakes is used by Vail Associates for snowmaking at the Vail ski area and for public water supplies.

4.2.3 Blue River Sub-Basin

Table 9 provides water use information for the Blue River sub-basin. The watershed has substantial transbasin diversions to the Front Range, and Dillon Reservoir is operated by the Denver Water Department for municipal water supply. Straight Creek and tributary (Laskey Gulch) water is diverted for municipal and public water supplies by the town of Dillon and Dillon Valley public water systems. Colorado Department of Transportation also diverts water from upper Straight Creek for water supply at the Eisenhower-Johnson Memorial Tunnels facilities.

Figure 3. Flood Hazard Zones, Clear Creek Sub-Basin, Milepost 218 to Milepost 223

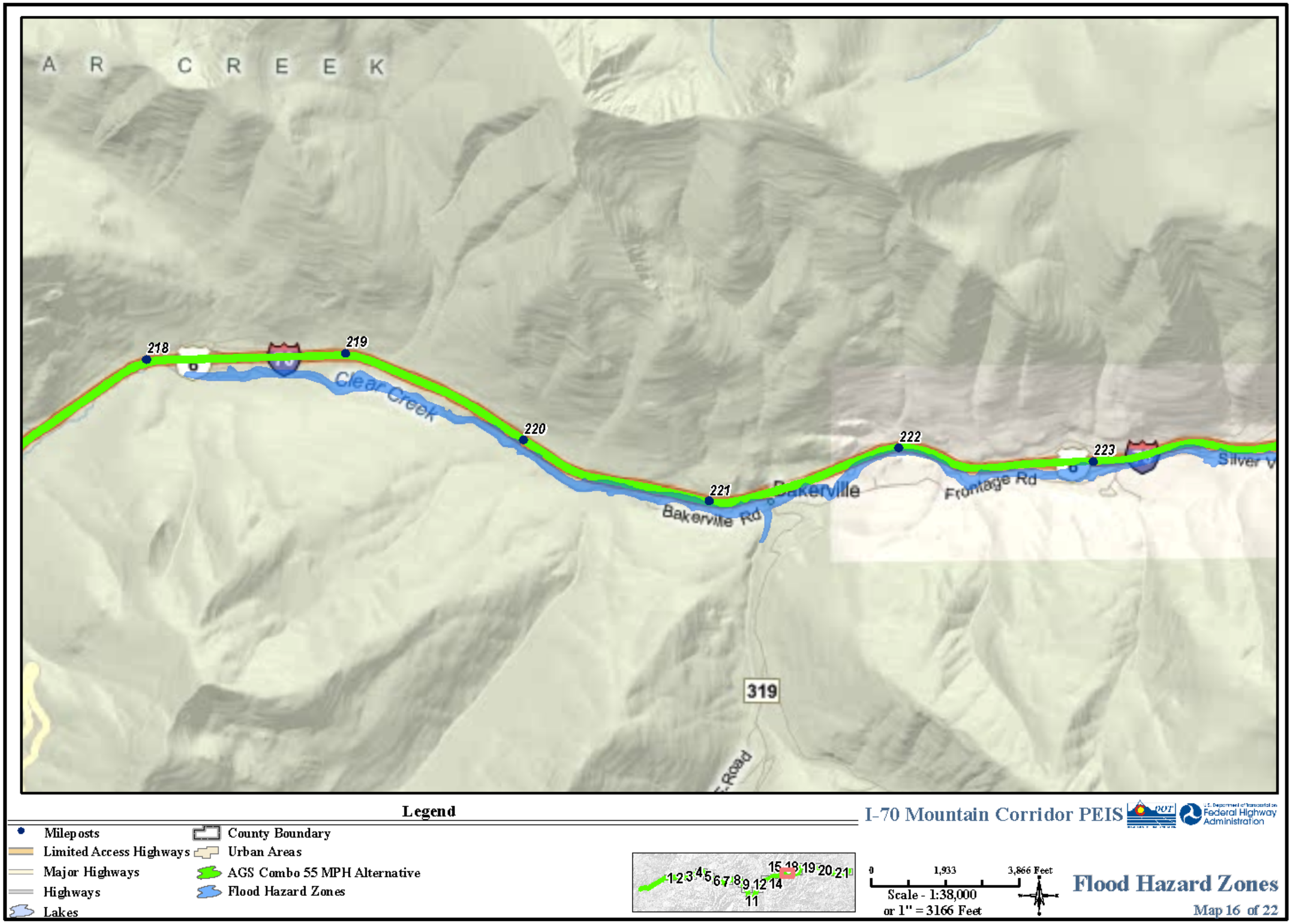


Figure 4. Flood Hazard Zones, Clear Creek Sub-Basin, Milepost 223 to Milepost 229

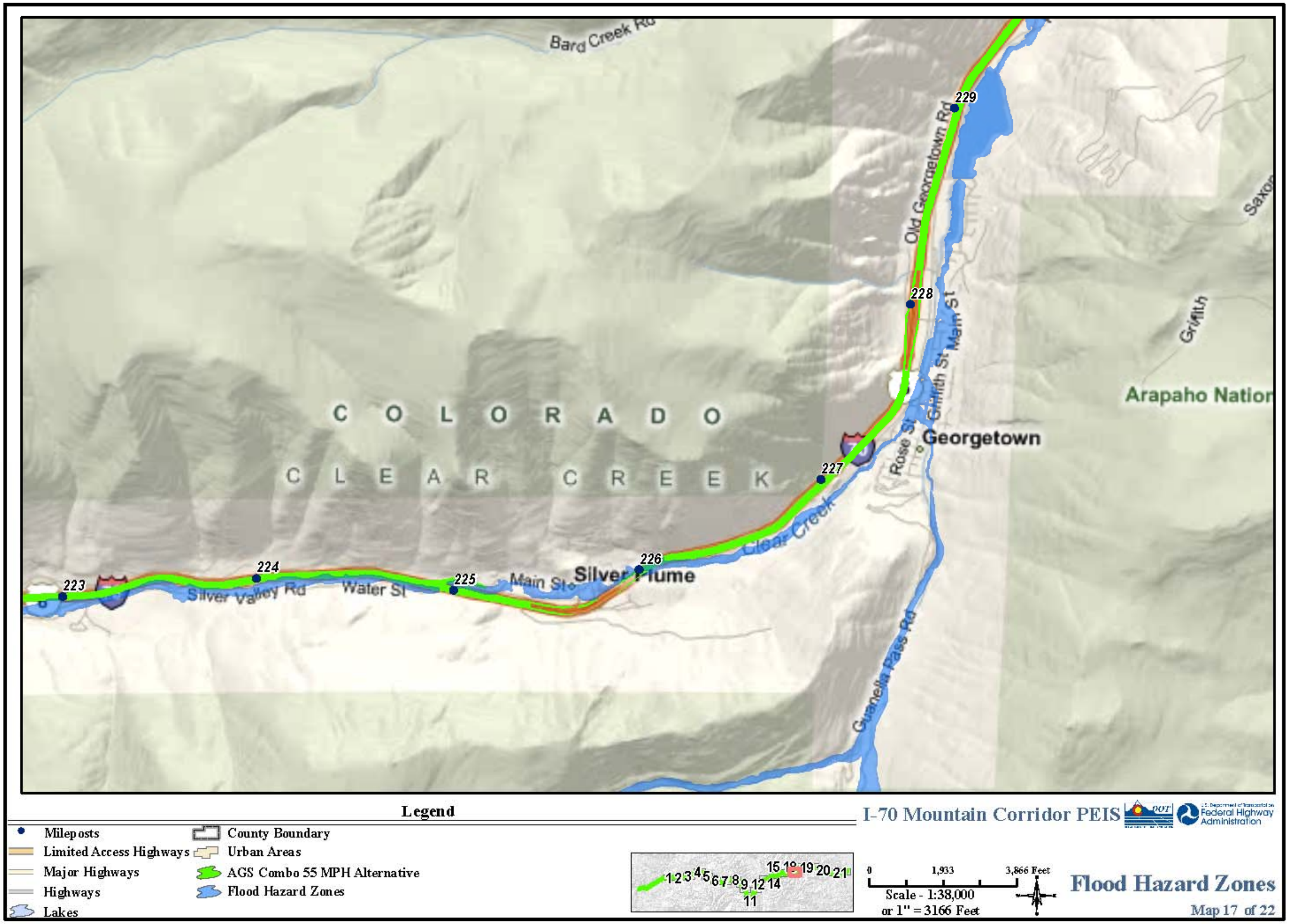


Figure 5. Flood Hazard Zones, Clear Creek Sub-Basin, Milepost 229 to Milepost 235

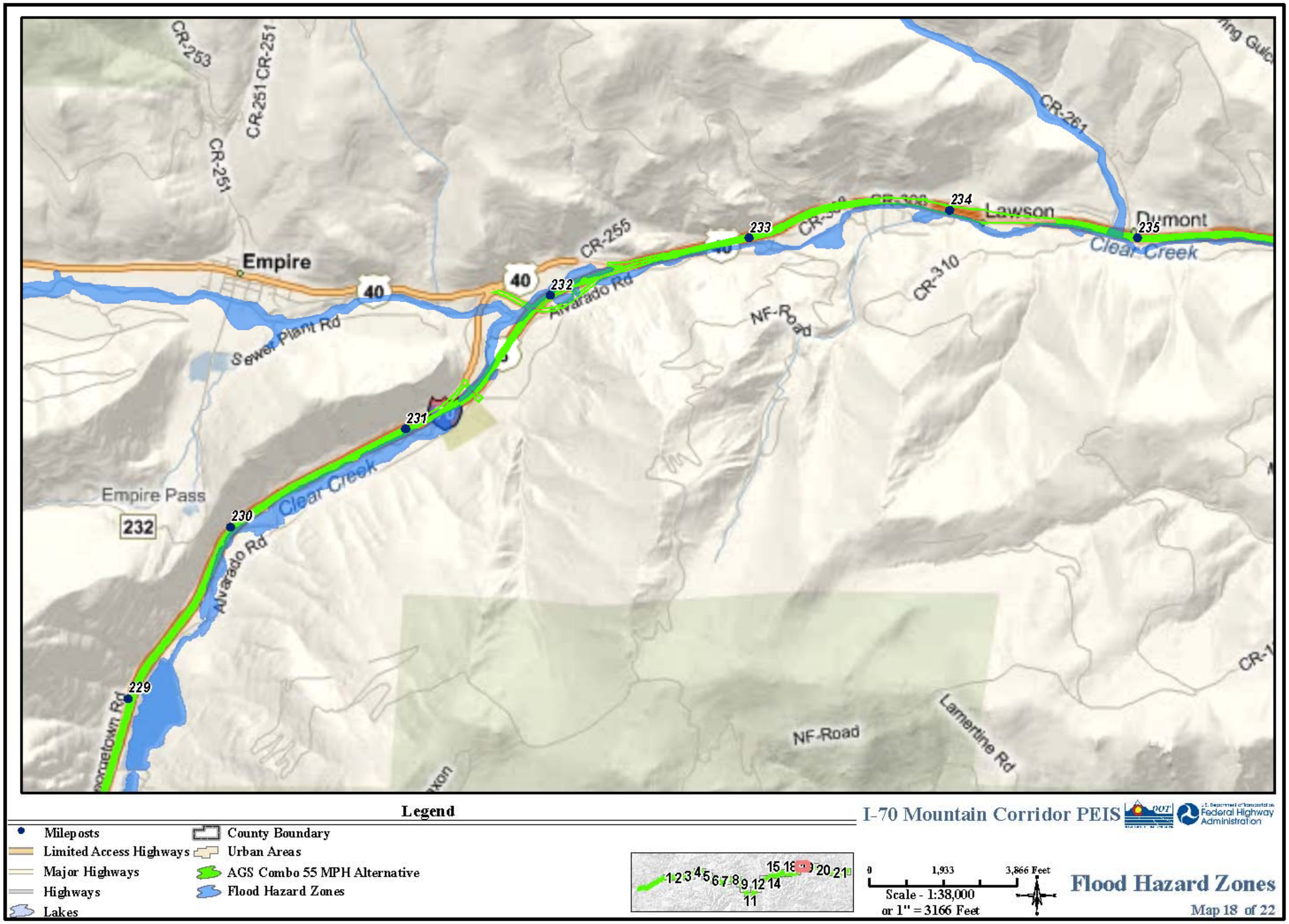


Figure 6. Flood Hazard Zones, Clear Creek Sub-Basin, Milepost 235 to Milepost 242

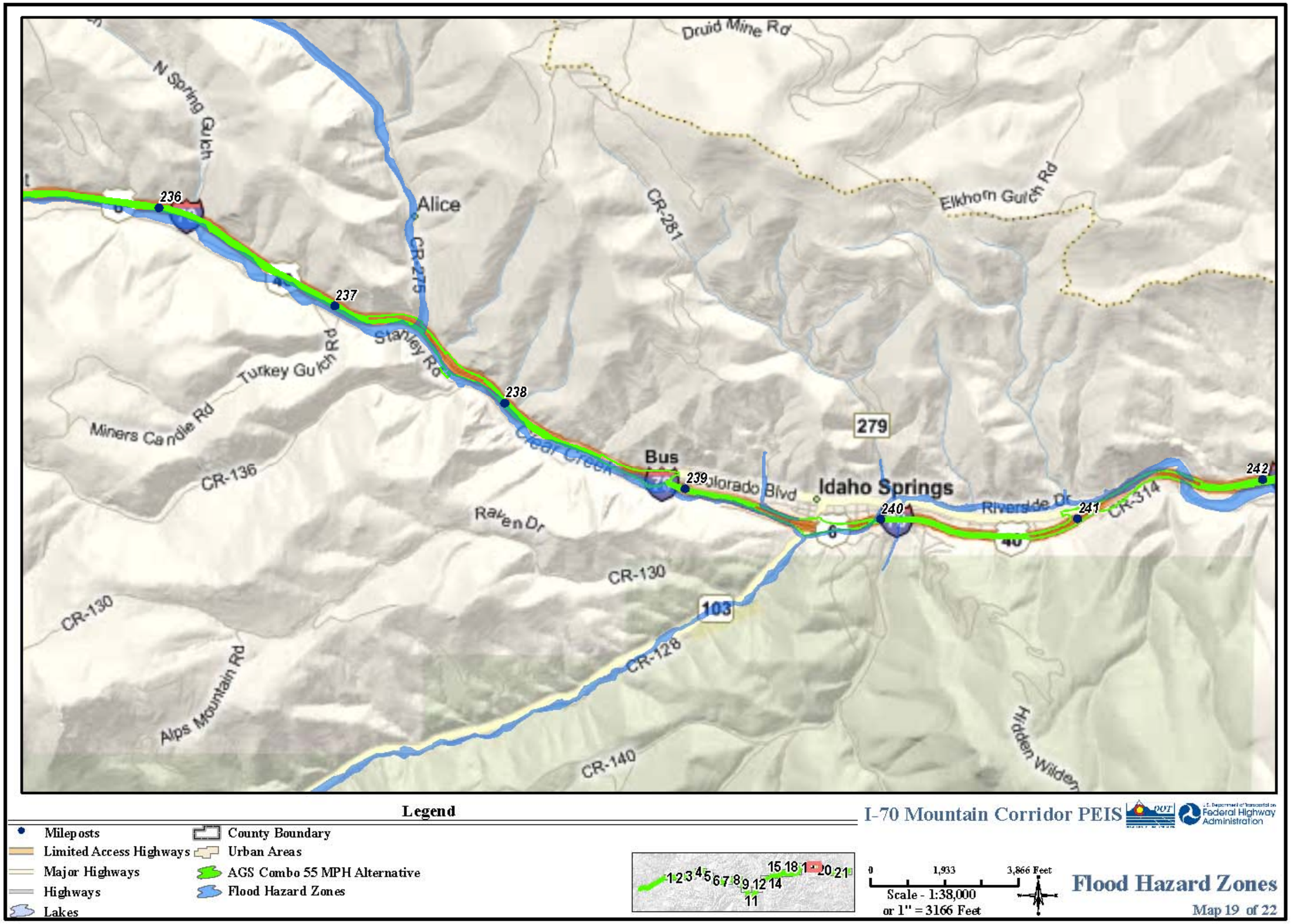


Figure 7. Flood Hazard Zones, Clear Creek Sub-Basin, Milepost 242 to Milepost 249

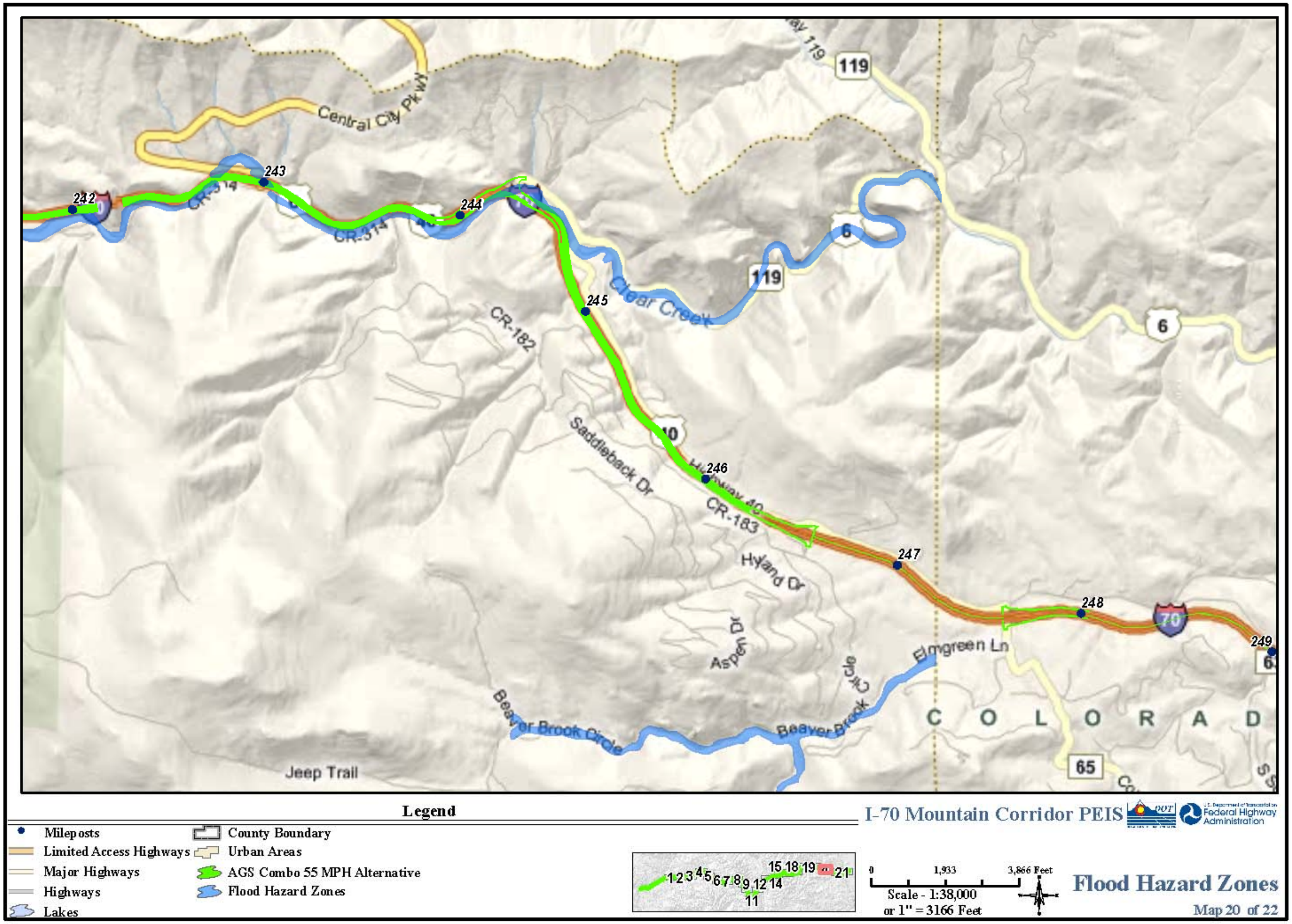


Table 7. Colorado Headwaters Sub-Basin[a] Overview

Transbasin Diversions						
Structure	**Receiving Basin**	**Average Annual Diversion (Acre-Feet)**				
Grand Ditch	South Platte	18,673				
Moffat Tunnel		57,450				
Alva Adams Tunnel		245,600				
Major Reservoirs						
Structure	**Operating Authority**	**Capacity (Acre-Feet)**				
Shadow Mountain / Grand Lake	Northern Colorado Water Conservancy District	18,400				
Lake Granby		539,760				
Williams Fork	Denver Water Department	—				
Wolford Mountain		60,000				
Communities in Upper Basin Area						
Winter Park	Fraser	Tabernash	Granby	Grand Lake	Hot Sulphur Springs	Kremmling
Communities in Lower Basin Area						
Radium	State Bridge	Bond	McCoy	Burns	Glenwood Springs	Dotsero

[a] Includes 59 drinking water systems (49 that rely on groundwater, 10 on surface water, with most of the population served by surface water and alluvial wells).

Table 8. Eagle River Sub-Basin Water Use Information

Transbasin Diversions		
Structure	**Receiving Basin**	**Average Annual Diversion (Acre-Feet)**
Columbine Ditch	Arkansas River	1,809
Ewing Ditch		1,155
Wurtz Ditch		2,930
Homestake Tunnel		24,965
Major Reservoirs		
Structure	**Operating Authority**	**Capacity (Acre-Feet)**
Homestake (Homestake Creek)	Aurora and Colorado Springs	44,360
Public Supply Watersheds (HUC 6)[a]		**Community Served**
Castle Creek, Hunter Creek, Maroon Creek		Avon
Brush Creek		Eagle

Transbasin Diversions	
Mosher Creek	Gypsum
Resolution Creek	Camp Hale
Fall Creek	Gilman
Cross Creek	Minturn
Turkey Creek	Redcliff
Beaver Creek	Beaver Creek Resort
Booth Creek, Gore Creek, Black Gore Creek, Mill Creek	Vail

[a] *Includes 27 drinking water systems (21 are groundwater and 6 are surface water, with surface water and alluvial wells serving most of the population).*

Table 9. Blue River Sub-Basin Water Use

Transbasin Diversions		
Structure	**Receiving Basin**	**Average Annual Diversion (Acre-Feet)**
Boreas Pass Ditch	Platte River	95
Vidler Tunnel		635
Roberts Tunnel		49,795
Hoosier Pass Tunnel	Arkansas River	9,209
Major Reservoirs		
Structure	**Operating Authority**	**Capacity (Acre-Feet)**
Dillon (Blue River)	Denver Water Department	262,200
Green Mountain (Blue River)	USDI Bureau of Reclamation	146,900
Public Supply Watersheds (HUC 6)[a]	**Area Served**	
Straight Creek	Dillon, Dillon Valley	
North Tenmile Creek	Frisco	
North Fork Snake River	Arapahoe Basin Ski Area	
North Fork Snake River	Loveland Pass Village	
North Fork Snake River	Keystone	
Lehman Gulch	Breckenridge Resort	
North Fork Cucumber Gulch	Blue River Water District	
North Fork South Barton Gulch		
Cucumber Gulch		
Indiana Gulch	Breckenridge	

Transbasin Diversions		
Structure	Receiving Basin	Average Annual Diversion (Acre-Feet)
West Tenmile Creek	Copper Mountain	
Morgan Gulch	Montezuma	

[a] *Includes 44 drinking water systems (more than 25 persons): 34 reliant on groundwater, 10 on surface water, with most of the population served by surface water.*

4.2.4 Clear Creek Sub-Basin

Water from Clear Creek has been put to many uses over the past 140 years. Historically, it was used for mining, agriculture, drinking-water supply, and industries, such as flourmills, breweries, and manufacturing. Today, it provides drinking water for more than 350,000 people and recreational opportunities for rafters, kayakers, and fishermen (CDPHE, 1997). The demand for Clear Creek water makes it one of the most over-appropriated streams in Colorado. Forty-six reservoirs are involved in the diversion and storage of Clear Creek water, the most notable within the Corridor being Georgetown Reservoir. Only about 20 percent of Clear Creek flows ever reach the mouth of Clear Creek at the South Platte River due to heavy demand in the Denver metropolitan area. Public water supply intakes operated on Clear Creek adjacent to the I-70 highway or immediately downstream include the Loveland Basin and Loveland Valley facilities, town of Silver Plume, city of Black Hawk, and city of Golden. Surface water in the watershed also supplies water to the town of Empire, city of Idaho Springs, and the town of Georgetown.

Wastewater treatment facilities that discharge directly to Clear Creek include Eisenhower-Johnson Memorial Tunnels (CDOT), Idaho Springs, Loveland Ski Area, Dumont, and Georgetown. Wastewater treatment facilities that discharge to Clear Creek tributaries include Black Hawk/Central City Sanitation District and Empire.

A cooperative effort known as SWEEP was conceived in the early stages of the PEIS by FHWA, CDOT, and various federal, state, county, and local agencies. The SWEEP identifies water-related issues associated with development along Clear Creek from the Eisenhower-Johnson Memorial Tunnels to Floyd Hill and provides an opportunity to minimize water resource-related impacts and improve the aquatic environment adjacent to the Corridor in conjunction with any potential future transportation actions. SWEEP completed a *Draft Inventory of I-70 Mountain Corridor Water Resource-Related Issues for Clear Creek* in February 2002 (J.F. Sato and Associates 2002). Since the initiation of SWEEP, agencies have met frequently to identify water resource and water quality related issues and potential mitigation strategies. A memorandum of understanding was developed between the agencies to outline the purposes of the program and initial mitigation strategy recommendations (CDOT, et al 2009).

4.2.5 Upper South Platte River Sub-Basin

Mount Vernon Creek is not used as a municipal or an industrial water supply source. The stream, however, flows to Bear Creek, a major tributary to the South Platte River, and as such provides surface water for downstream irrigation and industrial use. There is no known stream flow information for Mount Vernon Creek.

4.3 Stream Flow Information

Table 10 through Table 13 show historic stream flow data for waterways in the Colorado Headwaters, Eagle River, Blue River, and Clear Creek Sub-Basins, respectively.

Table 10. Average Stream Flows, Colorado Headwaters Sub-Basin (in cubic feet per second), HUC 14010001

USGS Gauge Location	Drainage Area (Square Miles)	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Colorado River near Granby	323	1908–2001	38.4	37.6	45.7	190	316	526	267	92.6	52.3	91.8	60.8	45.5
Fraser River at Winter Park	27.60	1910–2001	6.63	6.21	6.63	12.7	48.7	114	48.6	19.7	13	10.8	9.51	7.59
Colorado River near Dotsero	4,394	1940–2001	909	921	1,046	1,865	4,831	6,363	3,142	1,727	1,310	1,213	1,088	952

Table 11. Average Stream Flows, Eagle River Watershed (in cubic feet per second), HUC 14010003

USGS Gauge Location	Drainage Area (Square Miles)	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Eagle River near Minturn	186	1989–2001	28.5	28.1	33.8	92.1	413	534	203	88.3	55.9	46	38.8	31.3
Gore Creek at mouth near Minturn	102	1995–2001	20.2	19.3	28.8	73.4	462	684	203	71.8	41.4	39.8	28	23
Eagle River below Gypsum	944	1946–2001	182	175	190	351	1,350	2,291	1,008	387	269	261	242	199

Table 12. Average Stream Flows, Blue River Sub-Basin (in cubic feet per second), HUC 14010002

USGS Gauge Location	Drainage Area (Square Miles)	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
French Gulch at Breckenridge	10.9	1995–2001	1.92	1.81	1.92	3.39	21.9	47.3	19.3	9.45	6.16	4.64	3.21	2.47
Blue River near Dillon	121	1957–2001	26.3	24.2	23.7	40.2	180	343	205	106	68	51.8	38.7	31.3
Tenmile Creek below North Tenmile Creek at Frisco	93.30	1957–2001	17.2	17.6	19.6	38.5	257	479	195	74.8	44.8	32.5	25.2	19.8
Blue River below Dillon	335	1960–2001	76.4	78.4	82.4	132	333	751	444	251	163	121	101	85.8
Straight Creek below Laskey Gulch near Dillon	18.30	1986–2001	3.97	3.86	4.05	6.41	26.9	66.2	31.4	13	8.29	7.45	5.85	4.59

Table 13. Average Stream Flows, Clear Creek Watershed (in cubic feet per second), HUC 1019004

USGS Gauge Location	Drainage Area (Square Miles)	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
West Fork Clear Creek above mouth near Empire	57.6	1994–2001	16.3	15.1	15.3	23.2	136	363	219	97	47.1	31.3	24.9	19.8
Chicago Creek below Devil's Canyon near Idaho Springs	43.7	1994–2001	4.31	3.53	4.32	10.9	43.4	78.5	41.1	30.1	15.1	8.59	5.16	4.64
Clear Creek at Golden	400	1974–2001	45.1	43.5	44.8	75.9	326	783	469	217	129	86.1	63.8	51

4.4 Winter Maintenance

This section provides an overview of winter maintenance procedures, materials used for winter maintenance and usage trends with time, and the corresponding water quality trends in adjacent streams to the Corridor

4.4.1 Summary of Maintenance Procedures

Existing CDOT Maintenance Practices

Colorado Department of Transportation (CDOT) roadway and tunnel maintenance personnel are responsible for maintaining the operation capability of the I-70 highway system. In Colorado, snow and ice control is the highest priority of all the maintenance activities to protect the safety of the traveling public. As a key transportation corridor, the I-70 highway must remain safe and open as much as possible. In addition (and in conjunction with winter maintenance), CDOT maintenance staff are responsible for minimizing highway runoff pollutants. Such responsibilities require shoulder restoration, removal of excess traction sand from highways, maintenance of ditches and bridges, slope repair, and tunnel washing.

Winter Maintenance

In Colorado, snow and ice control is the highest priority of all the maintenance activities to protect the safety of the traveling public. Existing winter maintenance practices include the following:

- Snow is moved as far away from the highway template as possible in the high elevation areas of the Corridor.
- Once the snow is plowed to the shoulder during the initial snowstorm, it is later moved further off the shoulder using heavy equipment, such as loaders or bulldozers.
- Snow blowers are occasionally used to remove excess snow.
- Liquid deicers are used to reduce the quantity of salt/sand mixture used.

Colorado Department of Transportation uses various products and techniques for the most effective treatment of snow, slush, ice, and black ice. Products used include sand and salt, a sand/salt mixture, and various liquid anti-icers and deicers. Most of the chemical anti-icers and deicers applied by CDOT are mineral salt compounds in liquid form, such as magnesium chloride, that lower the freezing point of the moisture on the roadways. CDOT began using liquid road treatments in Glenwood Canyon during the late 1980s, and more broadly along the I-70 highway starting in the winter of 1995/1996 and has opted to increase their use as a result of their widespread benefits. Resulting reduction in the use of sand (reduced by an average of 50 percent) creates cleaner air and decreases the amount of sediment (from sand) in runoff to nearby streams.

Various factors are taken into account when deciding on a course of action to treat winter roadways. Product application combinations are chosen after maintenance workers evaluate many factors including air temperature, pavement temperature, humidity levels, dew point temperatures, exposure to solar radiation, type and rate of precipitation, weather forecast, weather radar data, and satellite data. Colorado Department of Transportation monitors road conditions using infrared sensors, thermal mapping, and road weather information systems. Colorado Department of Transportation continuously evaluates operation treatments before, during, and after a winter weather storm. Road treatments and applications are modified through all phases of a storm based on careful analysis of intensity, duration, and type of precipitation.

Deicers

Colorado Department of Transportation uses sand/salt mixtures to improve traction on the roadway and for winter deicing of highways. Sand/salt mixtures generally consist of rock salt (sodium chloride) mixed with sand (crushed aggregate and/or river sand). Mixtures generally range from 3 to 20 percent salt content. During the 1994/1995 winter season, CDOT used 98,000 tons of salt/sand mix on the I-70 highway from the Hogback to the Vail East Entrance interchange (79 miles).

Historical Usage

Historical usage (prior to 2001) indicates an average of 10,000 tons per year (1990/2001) of sand/salt mixture was applied to the 8-mile section of the I-70 highway along Straight Creek (CDOT, 2002). The average application rate was about 305 tons per mile per 12-foot lane. Runoff from the highway along this segment of the I-70 highway contributed about 2,700 tons of the sand/salt mixture into Straight Creek (CDOT, 2002). This reflects approximately 70 percent containment of the sand/salt mixture. Approximately 25 to 30 percent was collected and removed, and 40 to 50 percent was in storage within the system. More traction sand was required on Vail Pass, where about 12,000 tons per year (1990/2001) were applied to the 8-mile section between the top of the pass and the Black Gore Creek and Gore Creek confluence. The average annual application rate was 457 tons per mile per 12-foot lane. Runoff from the highway along this segment of the I-70 highway contributed about 5,000 tons of sand/salt mixture into Black Gore Creek (Fischel, 2001).

Liquid Deicers

Colorado Department of Transportation uses magnesium chloride and other chemical deicers to improve safety and reduce application of sand and salt mixtures. Colorado Department of Transportation uses magnesium chloride as its main chemical deicer for several reasons. In addition to reducing sand use, because it has a lower freezing point than salt (sodium chloride), less is needed to keep roads from freezing at lower temperatures (FHWA, 1996a; Blackburn et al., 2004). Magnesium chloride also sticks to the road better than salt and has a longer-lasting deicing effect. The California Department of Transportation reports that magnesium chloride can last several days, but salt must be reapplied daily (Xi and Xie, 2002). Calcium chloride, which is used for colder climates, such as Ontario, Canada, is reported to have a slimier consistency, to be more corrosive, and to be harder to mix and spread than magnesium chloride.

Magnesium chloride deicers generally consist of up to 30 percent magnesium chloride in water and a corrosion inhibitor to reduce the likelihood of metal corrosion. Laboratory tests indicate that magnesium chloride is less corrosive than calcium chloride or sodium chloride for steel and concrete (HITEC, 1999). Other studies show mixed results (Baroga, 2004; Xi and Xie, 2002). CDOT-funded research suggests that, in dry climates like Colorado, magnesium chloride is less corrosive than sodium chloride than in humid climates (Xi and Xie, 2002).

Summary of CDOT Maintenance Procedures

CDOT maintenance procedures are summarized in **Table 14**. These procedures are intended to provide safe travel conditions, maintain transportation system structures, and provide water quality controls, such as erosion prevention and drainage structure maintenance. Of particular interest to water resources in the Corridor are the use of winter maintenance materials and the effect of these materials on adjacent water quality.

Table 14. CDOT 1997 Manual of Maintenance Procedures Related to Water Resources

CDOT Major Program Area (MPA)	MPA Tasks	CDOT Procedure Topic	Manual Reference

Snow and Ice Control	■ Snow removal and storage
	  ■ Traction application (sanding and deicers)
	■ Ice control
	  ■ Snow fence maintenance and repair
	  ■ Avalanche control
		Snow and Ice Control	Chapter 9

		Abrasives and Deicing	Section 9.2, Procedural Directive 1055.2
		Ice Control	Section 9.3
		Snow Fence	Section 9.4
		Avalanche Management	Chapter 10
Roadway Surface	■ Blading ■ Restoring shoulders	Mudjacking and Base Stabilization	Section 4.6
		Unpaved Surfaces and Shoulders	Section 4.7
Roadside Facilities	■ Removal of excess highway sanding material ■ Maintenance of drainage structures ■ Maintenance of ditches ■ Slope repair ■ Litter and trash cleanup ■ Mowing ■ Sweeping ■ Sound barrier maintenance	Drainage Structures	Section 7.1
		Roadsides and Ditches (Paved and Unpaved)	Section 7.2
		Slopes	Section 7.3
		Streambeds and Wetlands	Section 7.4
		Paths and Trails	Section 7.5
		Fences	Section 7.6
		Litter Control	Section 7.7
		Sweeping	Section 7.8
		Rockrun and Mountainous Terrain Ditch Cleaning Procedures	Chapter 11
Roadside Appearance	■ Vegetation control ■ Bridge/structure maintenance and repair ■ Maintenance of deck expansion devices	Bridge Maintenance and Repair	Sections 5.1 and 5.2
		Waterways and Ditches	Pg. 5-3 to 5-5
		Timber Structures	Section 5.3
		Steel Structures	Section 5.4
		Concrete Structures	Section 5.5
		Roadside Vegetation Management	Chapter 16
Tunnel Maintenance	■ Tunnel snow removal and sanding ■ Tunnel washing	Tunnel Washing	Section 6.1

4.4.2 Winter Maintenance Material Usage

Initially, winter maintenance material usage data was available through 2001. Additional data from 2002 to 2008 have also been collected, and a noticeable change of material usage can be observed. Data have been obtained using the CDOT Materials Management System (MMS) and System Application and Products (SAP) record keeping systems. (Note: 2007 total solids data, including sand and solid salt, are considered unreliably low, possibly due to inaccurate reporting during the transition from MMS to SAP.) The data up through 2001 have been maintained in this *I-70 Mountain Corridor PEIS Water Resources Technical Report* to aid analysis and discuss data trends.

The Colorado Department of Transportation maintenance data suggest substantial changes in winter maintenance material usage for periods 2001-2008 as compared with usage prior to that time. **Table 15** shows the winter maintenance material usage data by I-70 watershed area updated for periods 2001–2008. Application rates and usage totals prior to and including year 2001) are shown in italics for comparison. **Table 16** shows the historical usage data compiled by fiscal year. A trend away from salt/sand toward more widespread use of sand/slicer mixture and liquid deicer salts is shown in **Table 16**, particularly in the higher elevation areas (for example, the east and west tunnel approaches to the Eisenhower-Johnson Memorial Tunnels and Vail Pass). This shift in materials has been measured in receiving stream water quality, particularly in Black Gore Creek and Straight Creek. Black Gore Creek data show a decreasing trend in sediment loading and an increase in chloride concentrations and loads in recent years. Straight Creek and Upper Clear Creek also show an increase in chloride concentrations and loads. Ice slicer has become the preferred solid deicer replacing rock salt in sand mixtures used in certain Corridor areas. **Figure 8** and **Figure 9** illustrate the data trend away from salt/sand to sand/slicer usage. According to maintenance, ice slicer is more concentrated than rock salt and its use provides a higher maintenance level of service for the traveling public.

Table 15. Impervious Surface Area and Total Solids (Sand and Salt) and Liquid Deicer 2001–2008 Average Material Usage and Application Rates

				Total Solids (sand & salt)			Liquid Deicer		
				2001 - 2008		*1996 - 2002*	*2001 – 2008*		*1996 - 2002*
Watershed	Begin-End Milepost	Existing Road Width (Feet)	Highway Surface Areas (Acres)	Usage (Tons/Year)	Application Rate (Tons/Acre)	Application Rate (Tons/Acre)	Usage (Gal/year)	Application Rate (Gal/Acre)	Application Rate (Gal/Acre)
Eagle River Dowds	169-171	48	12	1,548	129	129	28,648	2,387	141
Gore Creek	171-182	48	64	8,514	133	129	157,564	2,462	1,828
Black Gore Creek[1]	182-190	48	47	8,819	188	258	154,771	3,293	1,826
Gore Creek/Eagle River Total			**123**	**18,881**		**21,750**	**340,983**		**203,641**
West Tenmile	190-195	48	29	3,870	133	172	71,620	2,470	1,822
Tenmile Creek	195-201	48	35	4,644	133	172	85,944	2,456	1,833
Blue River	201-205	48	23	2,864	125	129	71,324	3,101	2,664
Straight Creek[2]	205-213	66	64	7,188	112	169	176,861	2,763	1,750
Blue River Total			**151**	**18,566**		**24,800**	**405,749**		**291,000**
Clear Creek (upper)	216-228	48	70	1,944	28	186	194,112	2,773	3,781
Clear Creek (middle)	228-233	48	29	810	28	138	80,880	2,789	2,200
Clear Creek (lower)	233-246	48	76	2,106	28	73	210,288	2,767	1,163
Clear Creek Total			**175**	**4,860**		**22,500**	**485,280**		**416,000**
Beaver Brook	246-255	72	79	2,070	26	57	102,276	1,295	1,566
Mount Vernon Creek	255-260	72	44	1,785	41	57	165,425	3,760	1,535
Upper South Platte			**123**	**3,855**		**7,000**	**267,701**		**190,000**
Total			**572**	**46,162**		**76,050**	**1,499,712**		**1,100,641**

Notes:

A "Watershed" is used as a general term to refer to specific stream reaches or drainage areas along I-70 but does NOT necessarily coincide with stream segments referred to in regulatory water quality designations.

Values in italics from years 1996 - 2002 are shown for comparison.

Source: CDOT Region 1 Maintenance; 2001-2008 average material application rates form Patrols 44, 43, 41, 45, 35 applied to watershed corridor length. Source of 1996 – 2002 data is also CDOT Region 1 Maintenance and the MMS database.

**Year 2007 solid volumes not used; possible under-reporting caused by transition from MMS to SAP.*

[1] Material volumes adjusted 56% of Patrol 44 totals to account for Black Gore corridor length/higher material usage

[2] Material volumes adjusted 64% of Patrol 43 totals to account for Straight Creek corridor length/higher material usage

Figure 10 shows the total solids (salt/sand, sand/slicer, solid deicer) application rate by fiscal year for each watershed. In the Black Gore and Straight Creek watersheds, the total solids usage (which by weight is primarily traction sand) is considerably lower than historical (pre-2001) usage.

Colorado Department of Transportation has increased the use of liquid deicers since 1996. **Figure 11**shows that liquid deicer usage varies from year to year according to winter weather conditions. Higher liquid deicer usage is reported to have started in FY-1997 in Black Gore Creek and in FY-2001 in Straight Creek (see **Table 16**). Patrol 35 (including Mount Vernon Creek) has shown a substantial increasing trend in liquid deicer use in recent years, when compared to that reported for FY-2001 and earlier.

Recent data for the Black Gore Creek and Straight Creek corridors indicate only about 50 percent of the total solid (salt/sand) use since 2002, when compared to the 1990–2000 average usage (see **Figure 8**). Patrol 35 between El Rancho and Hogback (Mount Vernon Creek) and Straight Creek shows an increasing data trend in liquid deicer use (see **Figure 11**).

Table 16. I-70 Winter Maintenance Materials Usage Data

Winter	FY	Milepost Range	Length (miles)	Solid Deicer/ice Slicer (tons)	Sand-Slicer Mix (tons)	Total Solids Sand & Salt (tons)	Rate (tons/mile)	MgCl Deicer (gal)	Caliper 1000 Deicer (gal)	Total Liquid Deicer (gal)	Rate (gal/mile)
Clear Creek											
Patrol 41 – Idaho Springs to Eisenhower Tunnel											
1999-2000	2000	216-241	25			10,701	428	385,975	0	385,975	15,439
2000-2001	2001	216-241	25			6,756	270	368,125	371,375	739,500	29,580
2001-2002	2002	216-241	25			3,563	143	210,547	241,040	451,587	18,063
2002-2003	2003	216-241	25			2,882	115	138,347	235,392	374,339	14,974
2003-2004	2004	216-241	25			3,952	158	86,582	164,523	251,105	10,044
2004-2005	2005	216-241	25			3,379	135	62,076	185,568	247,644	9,906
2005-2006	2006	216-241	25			4,510	180	0	459,007	459,007	18,360
2006-2007	2007*	216-241	25			803	32	45,842	210,157	255,999	10,240
2007-2008	2008	216-241	25			3,340	134	299,948	7,700	307,648	12,306
2001-2008 7-Year Average			**25**			**4,055**	**162**			**404,404**	**16,176**
Patrol 45 – El Rancho to Idaho Springs											
1999-2000	2000	241-252	11			3,471	316	101,700	0	101,700	9,245
2000-2001	2001	241-252	11			3,022	275	62,200	106,900	169,100	15,373
2001-2002	2002	241-252	11			3,064	279	62,000	90,000	152,000	13,818
2002-2003	2003	241-252	11			2,591	236	42,300	52,700	95,000	8,636
2003-2004	2004	241-252	11			2,298	209	61,100	42,500	104,600	9,509
2004-2005	2005	241-252	11			1,963	178	99,600	32,408	132,008	12,001
2005-2006	2006	241-252	11			3,255	296	45,300	27,800	73,100	6,645
2006-2007	2007*	241-252	11			560	51	68,407	13,574	81,981	7,453
2007-2008	2008	241-252	11			1,505	137	149,205	0	14,205	13,564
2001-2008 7-Year Average			**11**			**2,528**	**230**			**125,002**	**11,364**
Patrol 35 – Morrison to El Rancho											
1999-2000	2000	252-259	7			1,852	265	117,100	0	117,100	16,729
2000-2001	2001	252-259	7			6,782	969	69,400	108,000	177,400	25,343
2001-2002	2002	252-259	7			1,185	169	100,800	138,175	238,975	34,139
2002-2003	2003	252-259	7			1,613	230	71,550	140,160	211,710	30,244
2003-2004	2004	252-259	7			2,961	423	74,900	123,446	198,346	28,335
2004-2005	2005	252-259	7			2,200	314	66,450	129,921	196,371	28,053
2005-2006	2006	252-259	7			1,366	195	73,700	120,260	193,960	27,709
2006-2007	2007*	252-259	7			555	79	219,008	84,415	303,423	43,346
2007-2008	2008	252-259	7			1,366	195	404,422	0	404,422	57,775
2001-2008 7-Year Average			**7**			**2,496**	**357**			**231,598**	**33,085**
Straight Creek											
1990-1991	1991	205-213	8			14,000	1,750				
1991-1992	1992	205-213	8			12,000	1,500				
1992-1993	1993	205-213	8			12,500	1,563				
1993-1994	1994	205-213	8			8,000	1,000				
1994-1995	1995	205-213	8			7,000	875				
1995-1996	1996	205-213	8			13,000	1,625				
1996-1997	1996	205-213	8			9,500	1,188				
1997-1998	1998	205-213	8			6,000	750				
1998-1999	1999	205-213	8			9,000	1,125				
1999-2000	2000	205-213	8			10,292	1,287	64,732		64,732	8,091
2000-2001	2001	205-213	8			9,080	1,135	126,278	1,536	127,814	15,977
2001-2002	2002	205-213	8	448		5,597	700	207,005	26,400	233,405	29,176
2002-2003	2003	205-213	8	10	5,105	6,282	785	238,505	51,008	289,513	36,189
2003-2004	2004	205-213	8	353	753	5,679	710	71,796	116,205	188,002	23,500

Winter	FY	Milepost Range	Length (miles)	Solid Deicer/ice Slicer (tons)	Sand-Slicer Mix (tons)	Total Solids Sand & Salt (tons)	Rate (tons/mile)	MgCl Deicer (gal)	Caliper 1000 Deicer (gal)	Total Liquid Deicer (gal)	Rate (gal/mile)
2004-2005	2005	205-213	8	1,351	3,498	7,005	876	52,128	40,384	92,512	11,564
2005-2006	2006	205-213	8	1,887	4,267	8,987	1,123	19,456	41,088	60,544	7,568
2006-2007	2007*	205-213	8	929	29	1,815	227	1,110	86,912	88,.022	11,003
2007-2008	2008	205-213	8	398	4,911	7,688	961	228,187	18,048	246,235	30,779
2001-2008 7-Year Average			**8**			**7,188**	**899**			**176,861**	**22,108**
1991-2000 Average			**8**			**10,129**	**1,266**				
Black Gore Creek											
1989-1990	1990	182-190	8			12,400	1,550				
1990-1991	1991	182-190	8			1,3,221	1,653				
1991-1992	1992	182-190	8			11,855	1,482				
1992-1993	1993	182-190	8			15,106	1,888				
1993-1994	1994	182-190	8			12,971	1,621				
1994-1995	1995	182-190	8			14,727	1,841				
1995-1996	1996	182-190	8			23,458	2,932	17,730		17,730	2,216
1996-1997	1996	182-190	8			16,953	2,119	150,223		150,223	18,778
1997-1998	1998	182-190	8			13,878	1,735	68,181		68,181	8,523
1998-1999	1999	182-190	8			13,713	1,714	61,238		61,238	7,655
1999-2000	2000	182-190	8			20,115	2,514	64,047		64,047	8,006
2000-2001	2001	182-190	8			14,936	1,867	185,528		185,528	23,191
2001-2002	2002	182-190	8	773		7,154	894	247,099	45,382	292,481	36,560
2002-2003	2003	182-190	8	59	6,954	8,132	1,017	86,027	86,178	172,206	21,526
2003-2004	2004	182-190	8	577	990	6,292	787	67,084	88,683	155,767	19,471
2004-2005	2005	182-190	8	583	6,886	7,748	969	67,930	49,782	117,712	14,714
2005-2006	2006	182-190	8	479	9,076	9,555	1,194	23,069	84,958	108,027	13,503
2006-2007	2007*	182-190	8	1,006	585	2,233	279	52,921	11,645	64,566	8,071
2007-2008	2008	182-190	8	132	7,760	7,913	989	51,672	0	51,672	6,459
2001-2008 7-Year Average			8			**8,819**	**1,102**			**154,771**	**19,346**
1990-2000 Average			**8**			**15,309**	**1,914**				

Source: CDOT Region 1 Maintenance

Total solids includes sand and solid salt deicers

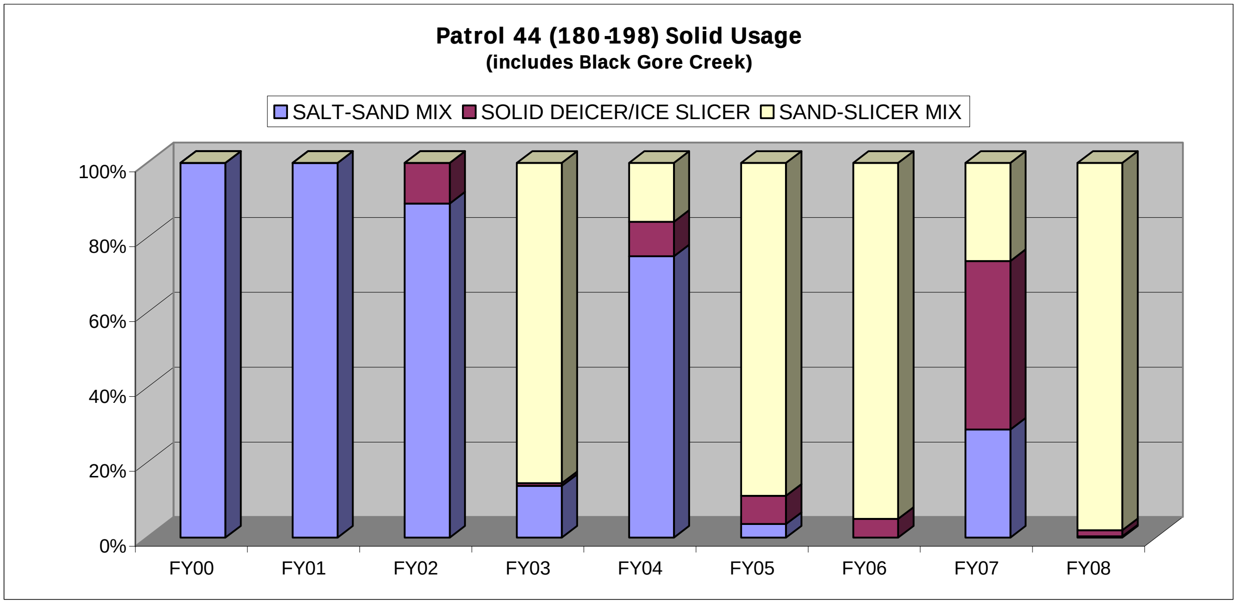
Notes:

**Year 2007 solid volumes not used; possible under-reporting caused by transition from MMS to SAP*

[1] Material volumes adjusted 64% of Patrol 43 totals to account for SC corridor length.

[2] Material volumes adjusted 56% of Patrol 44 totals to account for BG corridor length.

Figure 8. Materials Usage – Patrols 43 and 44



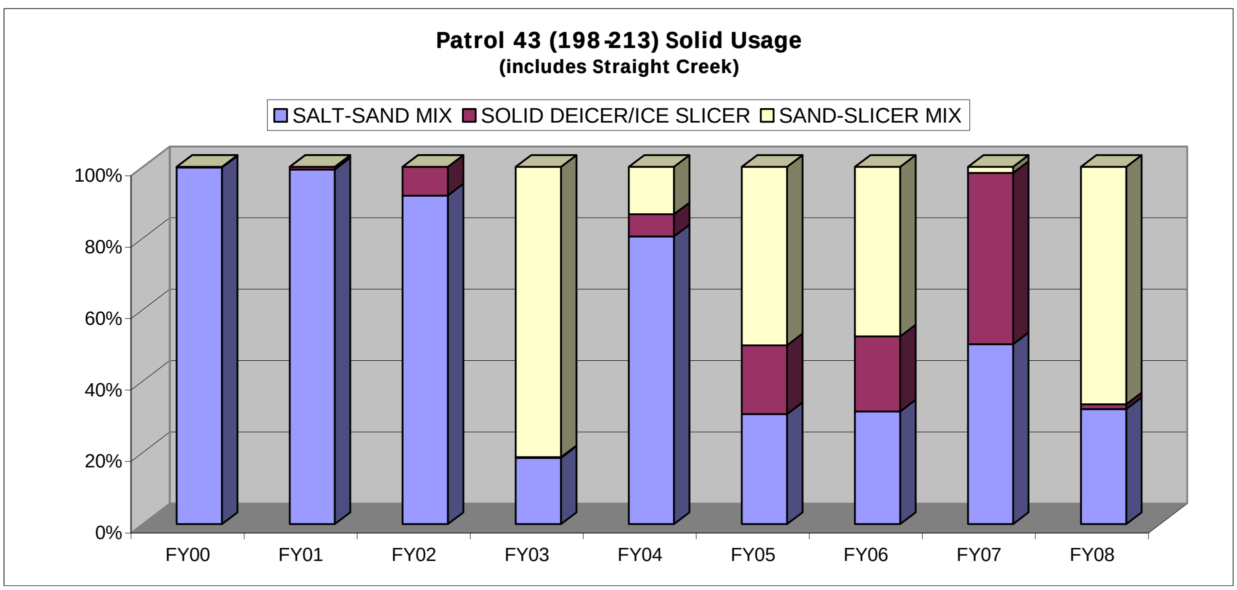
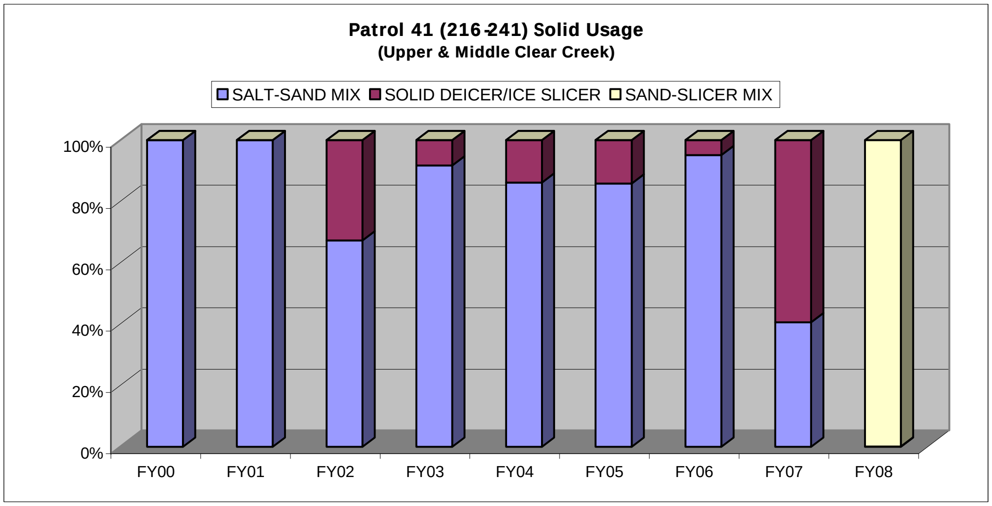
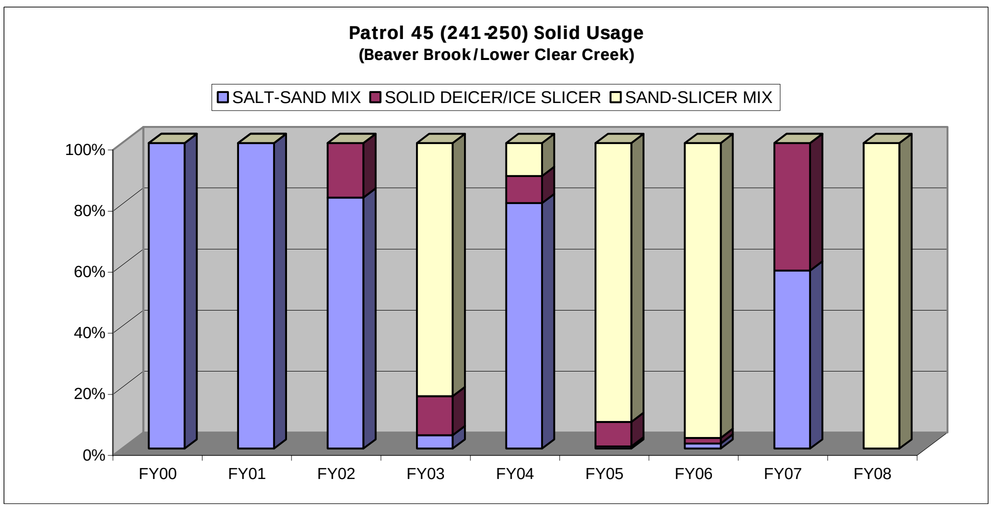


Figure 9. Materials Usage – Patrols 35, 41, and 45





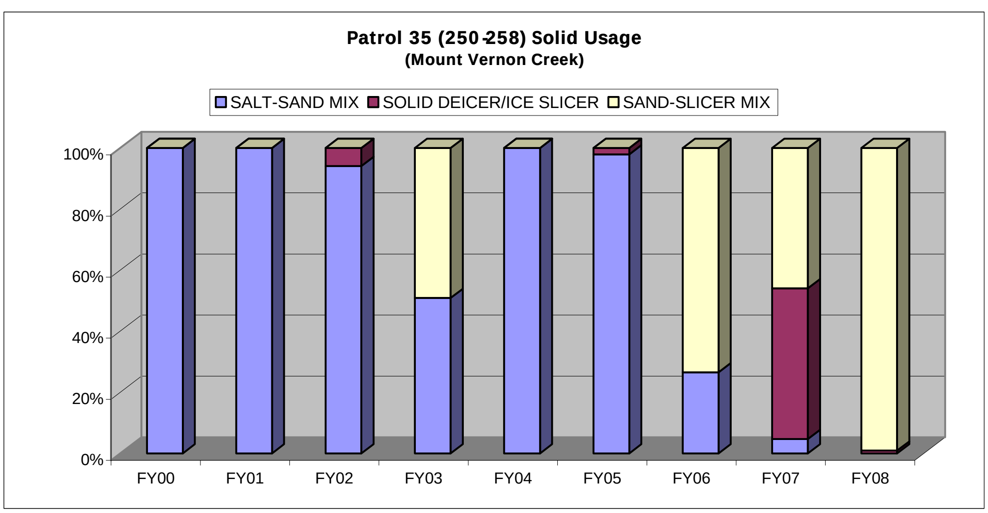
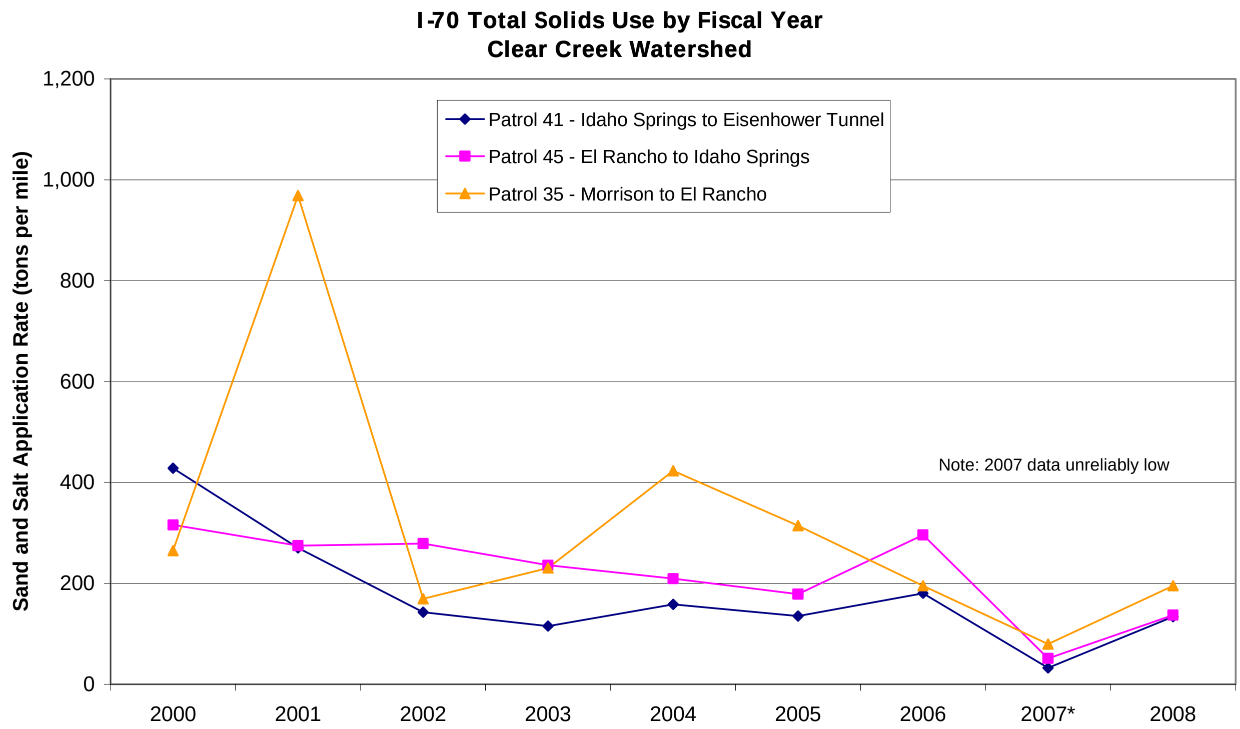


Figure 10. I-70 Total Solids Use (Sand and Salt) by Fiscal Year



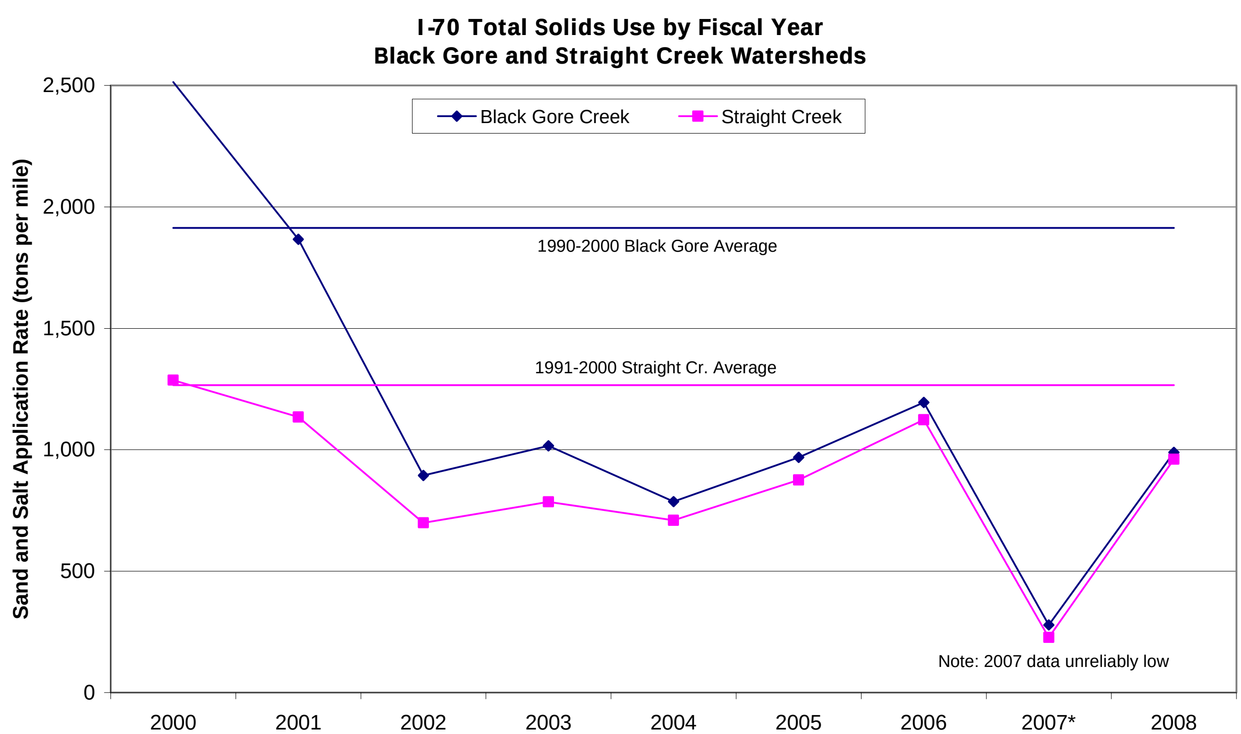
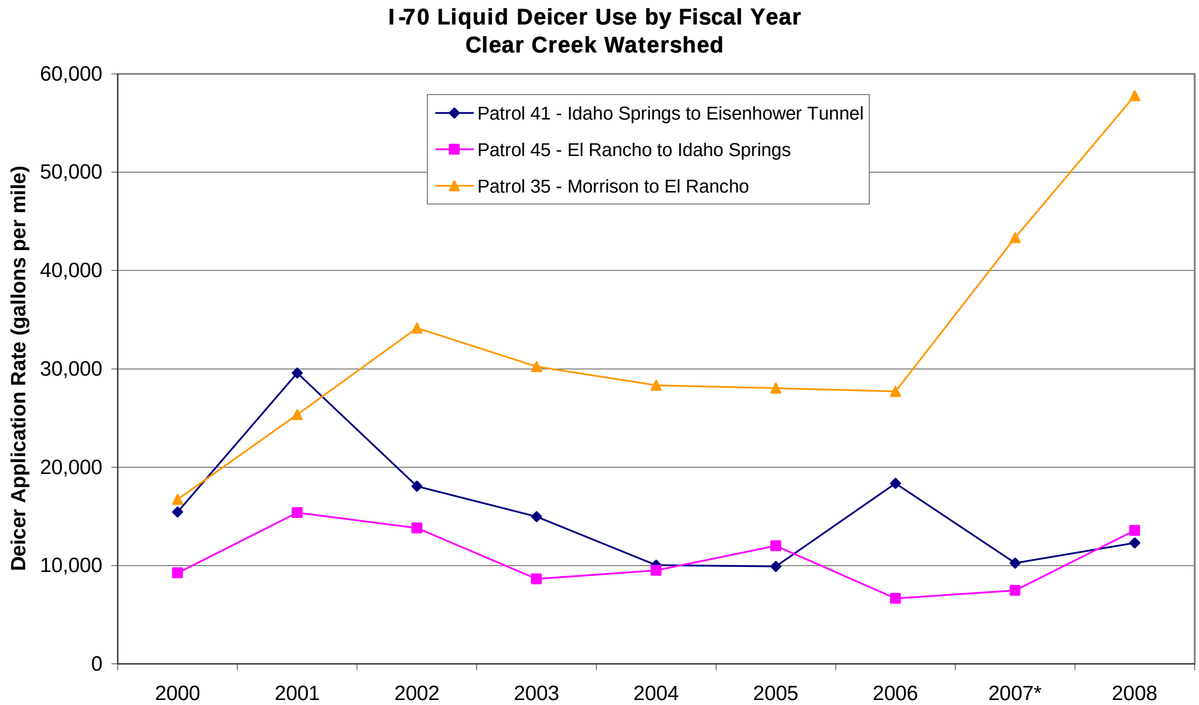
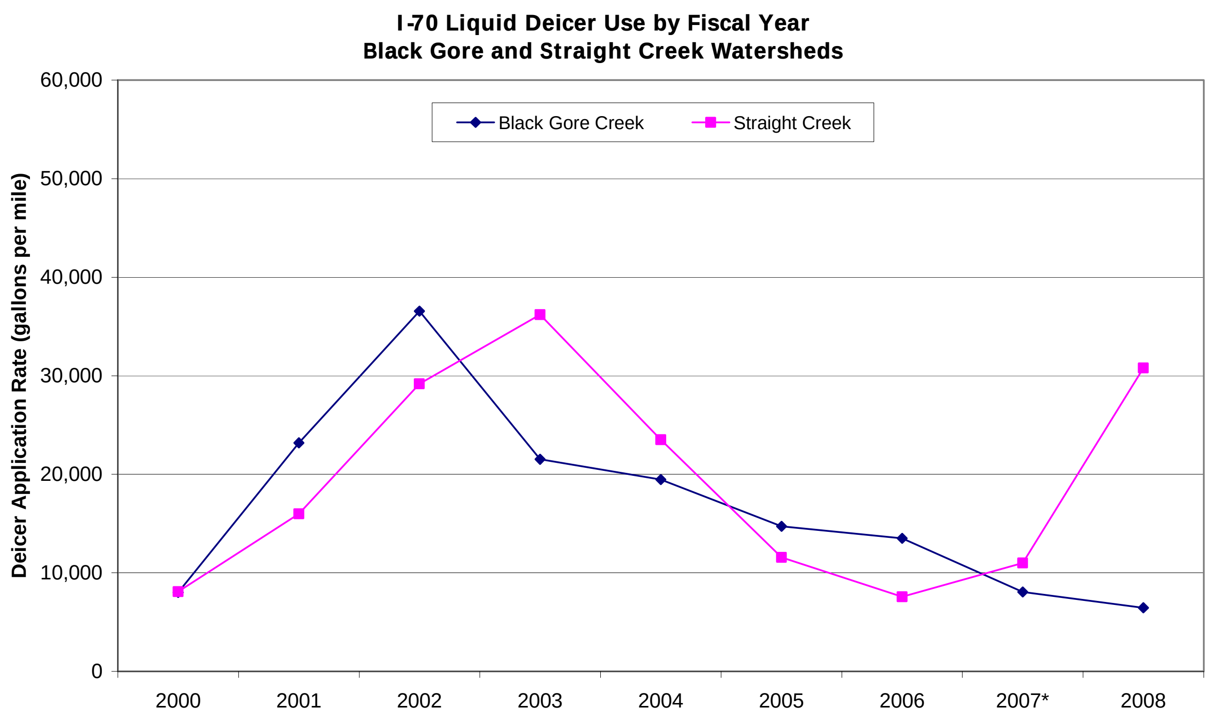


Figure 11. I-70 Liquid Deicer Use by Fiscal Year





Note: 2007 data unreliably low.

4.4.3 Highway Runoff and Water Quality

Highway Runoff

Highway runoff is a source of numerous pollutants as shown in **Table 17**, and pollutant concentrations are indicated to increase with the amount of traffic, based on a FHWA study (Driscoll et al. 1990). During peak travel periods, 75 to 85 percent of the Corridor carries more than 30,000 vehicles per day. During low travel periods, the portion of the Corridor that carries more than 30,000 vehicles per day changes to 3 percent (based on CDOT 2002 AADT data). Absence of leaded fuels has greatly decreased impacts of lead from highway runoff since this study was published.

Table 17. Highway Runoff — Typical Pollutants and Measured Concentrations (Driscoll et al., 1990)

Pollutant	Source	Highways with Fewer Than 30,000 Vehicles/Day[a]	Highways with More Than 30,000 Vehicles/Day[a]
Total suspended solids	Pavement wear, vehicles, the atmosphere, and maintenance activities	41	142
Volatile suspended solids	Various petroleum waste and residue	12	39
Total organic carbon	May be partially attributed to petroleum products	8	25
Chemical oxygen demand	Petroleum products	49	114
Nitrite and nitrate	Atmosphere and fertilizer application	0.46	0.76
Total Kjeldahl nitrogen	Atmosphere and fertilizer application	0.87	1.83
Phosphate phosphorus	Atmosphere, particulates (sediment), and fertilizer application	0.16	0.40
Copper	Metal plating, bearing and brushing wear, moving engine parts, brake lining wear, fungicides, and insecticides	0.022	0.054
Lead	Leaded gasoline from auto exhausts and tire wear	0.080	0.40
Zinc	Tire wear, motor oil, and grease	0.080	0.329

[a] *Event mean concentration in mg/L (Driscoll et al. 1990), mean for 31 sites nationwide)*

Highway maintenance activities are known to increase sediment (from traction sand application) and contaminants (from deicers) in runoff to adjacent waterways. Chemicals in deicers include major amounts of chloride, sodium, and magnesium. Currently used deicers may also contain minor or trace amounts of organic material (nitrogen, phosphorous, or carbon) and metals (copper, lead, zinc, arsenic, or cadmium). Sediments and chemicals in snowmelt and from storms are drained from the highway and shoulder areas toward waterways and streams.

Although small amounts of manganese in highway runoff can come from vehicle engine parts, it is not considered to be a substantial highway runoff pollutant. There is no aquatic life standard for manganese (EPA, 2002); the standard used is a secondary drinking water standard. However, manganese was included in the monitoring program because it is identified as a constituent/substance of concern associated with historic mining in specific areas of the Corridor. For example, in areas such as the Black Gore, West Tenmile, and Straight Creek watersheds, where water quality is not influenced by historic mining, stormwater runoff impacts remain below manganese standards. In contrast, stormwater runoff contributes to manganese standard exceedances in areas downstream of (and influenced by) historic mining: Eagle River, Tenmile Creek, and Clear Creek. Monitoring parameters for the 1 PEIS were selected based on issues of concern specific to the Corridor including sedimentation (phosphorus, total suspended solids or TSS), winter maintenance (sand and deicers – TSS, phosphorus, magnesium, sodium, chloride), and historic mining (copper, lead, zinc). Highway runoff pollutant indicators not included in PEIS monitoring—total nitrogen, volatile suspended solids, total organic carbon, nitrite/nitrate, and chemical oxygen demand—but will be further considered for possible study during Tier 2.

Recent Water Quality Trends

Recent data show that water quality in I-70 Corridor streams has changed in response to changes in winter maintenance material use. The stream water quality data collected from 2000 to 2003 have been updated through 2008 with data collected and analyzed by Clear Creek Consultants on behalf of CDOT (Clear Creek Consultants, 2010). **Table 15** provides a summary data comparison.

The I-70 highway runoff-sampling program was curtailed after 2004 at all stations except Station CC-231 (milepost 231.5). This station is operated for summer rainfall-runoff events only; highway snowmelt samples have not been collected since 2003. Available sample data from Station CC-231 collected from 2004 to 2008 have been compiled and incorporated into the mean values for highway runoff shown in **Table 18**.

Notable changes in mean stream concentration data show a decrease in suspended solids and phosphorus for Black Gore Creek and Straight Creek and an increase in chloride (sodium and magnesium) for Upper Clear Creek, Straight Creek, and Black Gore Creek. Recent data indicate that there has not been any substantial change in highway runoff water quality at Station CC-231. Analysis from the water quality monitoring results to include the more recent data for each stream are documented in the subsequent sections and summarized in **Table 18**.

Black Gore Creek

Recent data indicate that mean suspended solids and total phosphorus concentrations in Black Gore Creek samples are lower in 2004–2008 as compared to samples collected between 2000–2003.

- This trend is consistent with a substantial decrease in traction sand use in the Black Gore Creek corridor.
- Samples show that mean chloride (sodium and magnesium) concentrations have increased in Black Gore Creek from 2004–2008 as compared to 2000–2003 data (see **Table 18**).
- These findings are consistent with an increase in liquid and solid deicer salt use.

Polk Creek, a control stream used to approximate background stream water quality for high-elevation segments of the I-70 Mountain Corridor, showed little or no change in water quality parameters between 2000–2003 and 2008 (see **Table 18**).

The Black Gore Creek winter chloride concentrations are plotted in **Error! Reference source not found.**. Data in **Error! Reference source not found.** start in 2001 when monitoring began and include the time period October 15 to May 15 for each winter. Detailed information on the development of chloride data is provided in I-70 water quality evaluation reports (CDOT, 2008).

- Results show chloride concentrations exceeding water quality standards for several days each winter as a result of I-70 highway runoff. A trend line is plotted along with the 95 percent confidence interval.
- These data show an increasing trend in chloride concentrations in Black Gore Creek from 2001 to 2008.
- Trace metals copper, manganese, and zinc remain below established water quality standards.

Table 18. Mean Stream Concentrations to Correlation Winter Maintenance Material Usage with Water Quality along I-70 Corridor

Stream	Number of Samples	Suspended Solids (mg/L)				Total Phosphorus (mg/L)			
	2000-2008	2000-2003	2004-2008	% Change	2000-2008	2000-2003	2004-2008	% Change	2000-2008
Standard		*NA*				*0.10-1.0**			
Upper Clear Creek	122-128	195	209	7%	201	0.18	0.44	143%	0.26
Middle Clear Creek	30-38	11			10	0.03			0.03
Lower Clear CC-3	25-32	221			221	0.33			0.33
Lower Clear CC-4	35-52	264			264	0.44			0.44
Straight Creek	122-133	191	116	-39%	160	0.14	0.14	-2%	0.14
West Tenmile Cr.	44-45	31			31	0.05			0.05
Black Gore Creek	127-152	345	189	-45%	292	0.27	0.16	-41%	0.23
Polk Creek	36-38	42			34	0.04			0.04
Miller Creek	1	<5			<5	<0.01			<0.01
I-70 Runoff	65-72	1,067			953	0.90			0.87

Stream	Number of Samples	Sodium-Chloride (meq/L)				Magnesium-Chloride (meq/L)			
	2000-2008	2000-2003	2004-2008	% Change	2000-2008	2000-2003	2004-2008	% Change	2000-2008
Standard		*NA*				*NA*			
Upper Clear Creek	122-128	2.03	2.53	25%	2.14	1.68	2.07	24%	1.77
Middle Clear Creek	30-38	0.64			0.59	0.78			0.74
Lower Clear CC-3	25-32	0.79			0.79	0.65			0.65
Lower Clear CC-4	35-52	0.81			0.81	0.63			0.63
Straight Creek	122-133	1.95	2.95	51%	2.36	1.54	2.20	43%	1.80
West Tenmile Cr.	44-45	0.79			0.73	0.69			0.64
Black Gore Creek	127-152	2.85	3.82	34%	3.20	2.13	2.81	32%	2.36
Polk Creek	36-38	0.09			0.09	0.31			0.31
Miller Creek	1	0.11			0.11	0.18			0.18
I-70 Runoff	65-72	9.74			6.95	7.60			5.19

Mean Concentrations (mg/L)

Stream	Number of Samples	Hardness as CaCO3		Copper Dissolved		Manganese Dissolved		Zinc Dissolved	
	2000-2008	2000-2006	2000-2008	2000-2003	2000-2008	2000-2003	2000-2008	2000-2003	2000-2008
Standard		*NA*		*0.007*		*0.05*		*0.065*	
Upper Clear Creek	122-128	64	62	<0.005	<0.005	0.027	0.030	0.009	0.010
Middle Clear Creek	30-38	58	58	<0.005	<0.005	0.007	0.008	0.080	0.080
Lower Clear CC-3	25-32	65	65	0.006	0.006	0.221	0.221	0.120	0.120
Lower Clear CC-4	35-52	61	61	0.006	0.006	0.154	0.154	0.097	0.097
Straight Creek	122-133	63	63	<0.005	<0.005	0.009	0.010	0.011	0.012
West Tenmile Cr.	44-45	73	73	<0.005	<0.005	0.005	0.005	0.010	0.010
Black Gore Creek	127-152	97	97	<0.005	<0.005	0.017	0.025	0.010	0.010
Polk Creek	36-38	46	45	<0.005	<0.005	0.016	0.011	0.007	0.008
Miller Creek	1	NA	NA	<0.001	<0.001	<0.005	<0.005	<0.005	<0.005
I-70 Runoff	65-72	NA	NA	0.012	0.012	0.48	0.50	0.16	0.16

West Tenmile Creek

Sampling in West Tenmile Creek was curtailed in 2006 due to budget constraints. However, stream conductivity and temperature monitoring have continued to provide information on chloride trends.

- Mean concentration data updated through 2006 do not show substantial differences from the 2000–2003 data (**Table 18**). This stream is farther away from the I-70 highway and seems to be buffered by ground between I-70 runoff discharges and the channel. Water quality parameter concentrations are generally lower than those of Black Gore Creek or Straight Creek.
- The West Tenmile Creek winter (October 15 to May 15) chloride concentrations are plotted in **Error! Reference source not found.**. Data in **Error! Reference source not found.** start in 2002 when monitoring began and include the time period October 15 to May 15 for each winter. Results show concentrations were consistently below water quality standards in West Tenmile Creek.
- A trend line is plotted along with the 95 percent confidence interval. These data show an increasing trend in chloride concentrations in West Tenmile Creek from 2002 to 2008, although the increase is smaller than those in Black Gore Creek.

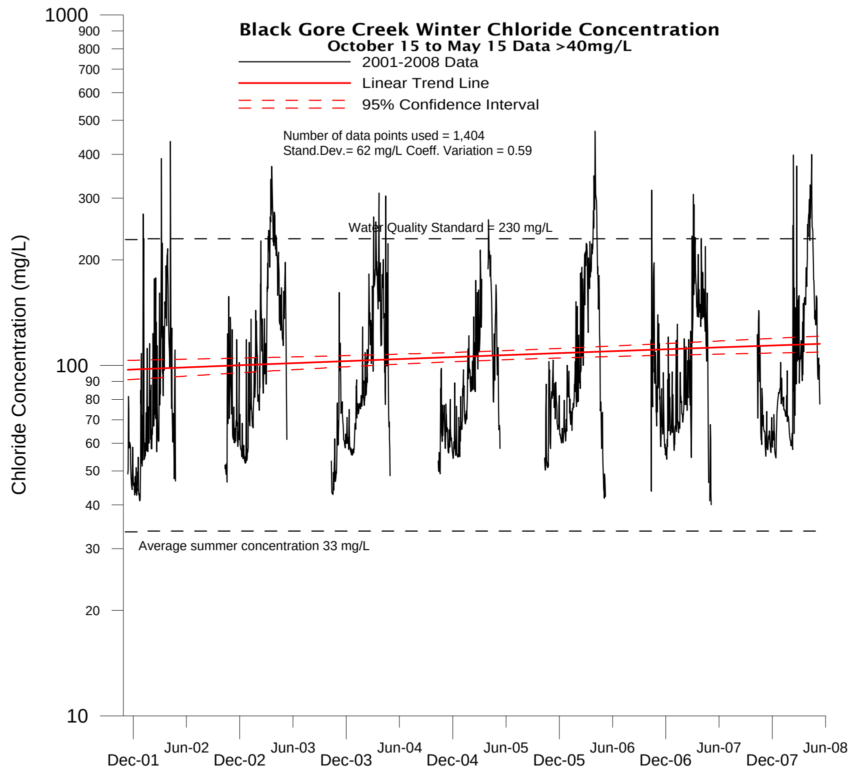
Straight Creek

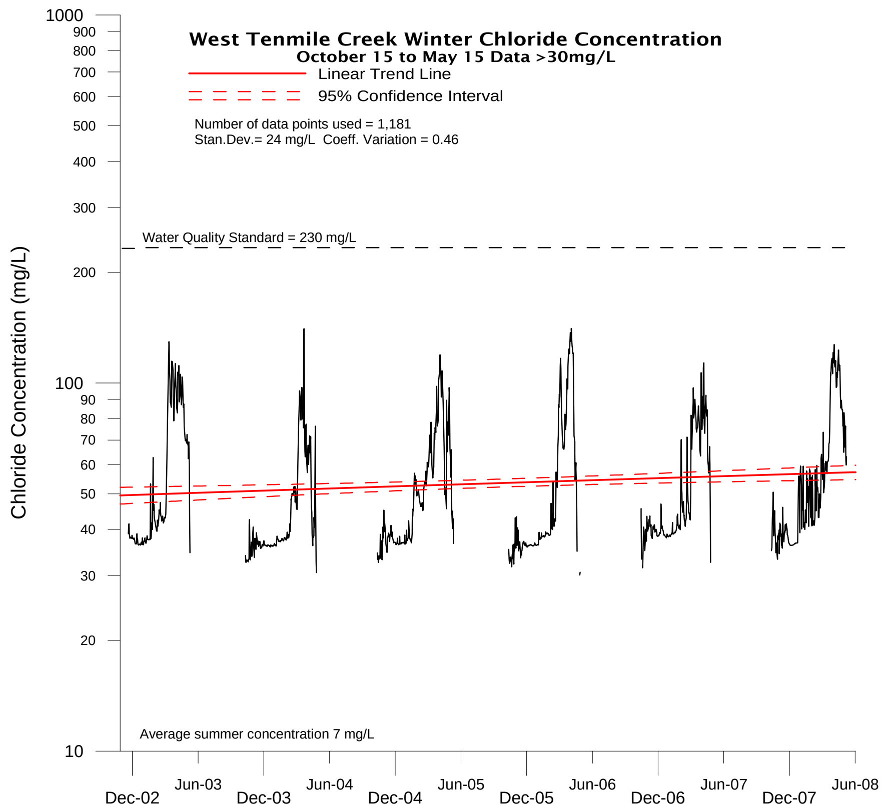
Recent data for Straight Creek show the following:

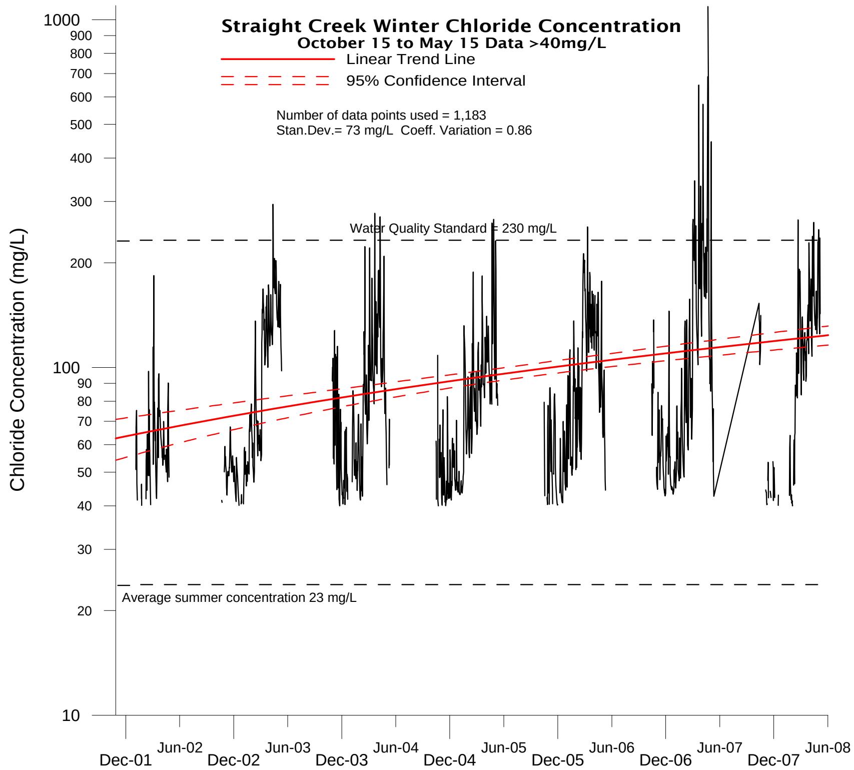
- Mean suspended solids concentrations in Straight Creek samples are lower in 2004-2008 as compared to samples collected between 2000–2003. This trend is consistent with a decrease in traction sand use in the Straight Creek corridor.
- Samples show that mean chloride (sodium and magnesium) concentrations have increased in Straight Creek from 2004–2008 as compared to 2000–2003 data (see **Table 18**). This is consistent with a substantial increase in liquid and solid deicer salt use.
- The Straight Creek winter chloride concentrations are plotted in **Error! Reference source not found.**. Data in **Error! Reference source not found.** start in 2001 when monitoring began and include the time period October 15 to May 15 for each winter. Results show concentrations exceeding water quality standards for several days each winter as a result of I-70 runoff. A trend line is plotted along with the 95 percent confidence interval. These data show an increasing trend in chloride concentrations in Straight Creek from 2001 to 2008.
- Trace metals copper, manganese, and zinc remain below established water quality standards.

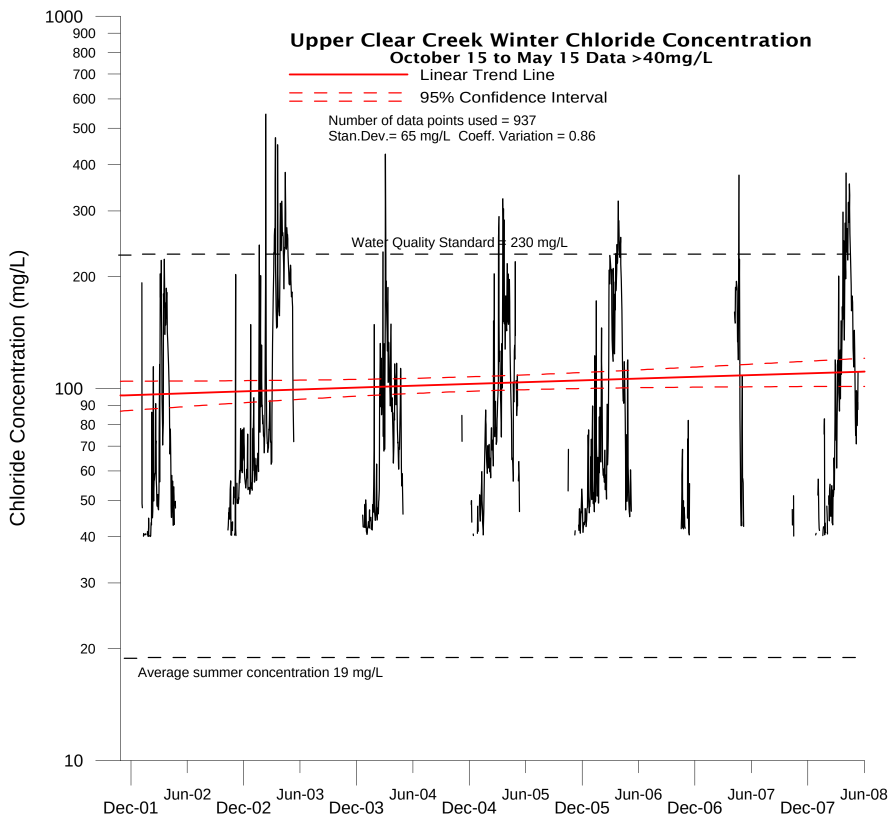
The Colorado Department of Transportation and White River National Forest developed a Supplemental Information Report for lower Straight Creek as a supplement to the *1993 Environmental Assessment and Finding of No Significant Impact* developed for the cleanup of I-70 sedimentation in Straight Creek.

Figure 12. Winter Chloride Concentrations






Straight Creek Winter Chloride Concentration
October 15 to May 15 Data >40mg/L
Linear Trend Line
95% Confidence Interval
Number of data points used = 1,183
Stan.Dev.= 73 mg/L Coeff. Variation = 0.86
Water Quality Standard = 230 mg/L
Average summer concentration 23 mg/L
Chloride Concentration (mg/L)
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
Dec-01
Jun-02
Dec-02
Jun-03
Dec-03
Jun-04
Dec-04
Jun-05
Dec-05
Jun-06
Dec-06
Jun-07
Dec-07
Jun-08


Upper Clear Creek Winter Chloride Concentration
October 15 to May 15 Data >40mg/L
Linear Trend Line
95% Confidence Interval
Number of data points used = 937
Stan.Dev.= 65 mg/L Coeff. Variation = 0.86
Water Quality Standard = 230 mg/L
Average summer concentration 19 mg/L
Chloride Concentration (mg/L)
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
Dec-01
Jun-02
Dec-02
Jun-03
Dec-03
Jun-04
Dec-04
Jun-05
Dec-05
Jun-06
Dec-06
Jun-07
Dec-07
Jun-08

Upper Clear Creek

Recent data for Upper Clear Creek show the following:

- Mean suspended solids and total phosphorus concentrations in Upper Clear Creek samples are higher in 2004–2008 as compared to samples collected between 2000–2003.
- Samples show that mean chloride (sodium and magnesium) concentrations have increased in Upper Clear Creek from 2004–2008 as compared to 2000–2003 data. This is consistent with an increase in liquid and solid deicer salt use.
- The Upper Clear Creek winter chloride concentrations are plotted in **Figure 12**. Data in **Figure 12** start in 2001 when monitoring began and include the time period October 15 to May 15 for each winter. Results show concentrations exceeding water quality standards for several days each winter as a result of I-70 runoff. A trend line is plotted, along with the 95 percent confidence interval. These data show a slight decrease in chloride concentrations in Upper Clear Creek from 2001 to 2008.
- Trace metals copper, manganese, and zinc remain below established water quality standards.

Lower Clear Creek

Sample data collection was curtailed at the three Lower Clear Creek monitoring stations after 2005 due to budget constraints. These stations included Middle Clear Creek Station CC-2 (milepost 230) and Lower Clear Creek Stations CC-3 (milepost 242) and CC-4 (milepost 244). However, any sample data collected after 2003 are included in the 2000–2008 statistical summaries (**Table 18**).

- Results through 2005 indicate there were no substantial changes in highway-related water quality in these locations since the Draft PEIS analysis (CDOT 2008).

4.4.4 Environmental Effects of Deicers on Water Quality

In preparation for increased use of magnesium chloride deicers on roadways at high elevations, CDOT initiated environmental investigations focused on the effects of deicers on water quality and aquatic ecosystems in 1996 (see references in **Table 19**). A 1999 study (Lewis, 1999) included analysis of water quality and aquatic communities, as well as biotoxicity testing in relation to magnesium chloride deicer. As a result of some of these studies, CDOT tightened its restrictions (limits on content of constituents including lead, zinc, cadmium, and phosphorus) on deicer supplies. Since 1997, CDOT has developed an interest in other types of deicers that may give better performance in the coldest weather. The 2001 study (Lewis, 2001) included two chloride-based deicers (Caliber M1000 and Caliber M2000) for environmental effects. Another study (Fischel 2001) evaluated deicers based on a review of the literature. In this study, deicers were generally divided into three categories: chloride-based deicers, acetate-based deicers, and sand. A comparison of these deicers is summarized in **Table 20**.

Table 19. References for Deicers

Studies Funded by, Action Plans for, or Operating Guides for the Colorado Department of Transportation
CDOT. 2002a. *Sediment Control Action Plan, Straight Creek I-70 Corridor.* Prepared in cooperation with Clear Creek Consultants, Inc. and J.F. Sato and Associates. May.
CDOT. 2002b. *Sediment Control Action Plan, Black Gore Creek I-70 Corridor.* Prepared in cooperation with Clear Creek Consultants, Inc. and J.F. Sato and Associates. May.
CDOT. 2003. *Colorado Department of Transportation Anti-icing and Deicing Standard Operating Guide, Part II.*
Clear Creek Consultants, Inc. 2001. *Data Summary report—2000, I-70 PEIS Storm Water Quality Monitoring.* Prepared for J.F. Sato and Associates. February.
Clear Creek Consultants, Inc. 2002a. *Data Summary Report—2001, I-70 PEIS Storm Water Quality Monitoring.* Prepared for J.F. Sato and Associates. December.
Fischel, M. 2001. *Evaluation of Selected Deicers Based on a Review of the Literature.* Report No. CDOT-DTD-R-2001-15. October.
Lewis, W.M. 1999. *Studies of Environmental Effects of Magnesium Chloride Deicer in Colorado*. Report No. CDOT-DTD-R-99-10. November.
Lewis, W.M. 2001. *Evaluation and Comparison of Three Chemical Deicers for Use in Colorado*. Report No. CDOT-R-2001-17. August.
Peterson, C., and N. Trahan. 2004. *Factors Impacting the Health of Roadside Vegetation.* Study No. 41.70, Progress Report for 4/01/04–6/30/04. 5 pages.
Xi, Y., and Z. Xie. 2002. *Corrosion Effects of Magnesium Chloride and Sodium Chloride on Automobile Components.* Report No. CDOT-DTD-R-2002-4. May.
Other Studies and Publications
Baroga, E.V. 2004. *Washington State Department of Transportation's 2002–2003 Salt Pilot Project.* Transportation Research Circular No. E-C063. June.
Blackburn, R.O., D.E. Amsler, Sr., and K.M. Bauer. 2004. *Guidelines for Snow and Ice Control Materials and Methods.* Transportation Research Circular No. E-C063. June.
Environment Canada. 2000. *Canadian Environmental Protection Act. 199 Priority Substance List Assessment Report—Road Salts.* Draft for public comments. Internet website http://www.ec.gc.ca/ceeb1/eng/public/road_salts.html. August.
FHWA. 1996a. *Manual of Practice for an Effective Anti-Icing Program: a Guide for Highway Winter Maintenance Personnel.* Publication No. FHWA-RD-95-202.
Highway Innovative Technology Evaluation Center. 1999. *Summary of Evaluation Findings for the Testing of Ice Ban@: Technical Evaluation Report for the Civil Engineering Research Foundation.* Report No. 40410. September.
Stidger, R.W. 2002. *The State of the State's Anti-icing Technology, Better Roads.* Vol. 72, No.4.
United States Environmental Protection Agency. 1988. *Ambient Water Quality Criteria for Chloride-1988.* Office for Research and Development. Environmental Research Laboratory. Duluth, Minnesota. EPA 440588001.
Upper Clear Creek Watershed Association. 2003. *Total Phosphorous Loadings Comparisons, Upper Clear Creek Watershed.* Project No. 9622-98. Technical memorandum to Rick Fendel, UCCWA Chairman, from Tim Steele, TDS Consulting, October 24 (revised November 12).

Table 20. Comparison of General Deicer Classes (Fishcel 2001)

Deicer	Water Quality	Aquatic Life	Corrosion	Cost
Chloride-based deicers	Can increase salinity in streams and lakes; corrosion inhibitors can contain high levels of nutrients; deicers may contain small amounts of metals	Acute toxicity to aquatic life is generally low	Highly corrosive unless corrosion inhibitors are included; some deicers contain corrosion inhibitors with high levels of phosphorus, ammonia, and nitrates, which can potentially cause oxygen depletion of surface water	Low
Acetate-based deicers	Can cause depletion of oxygen in water	Moderately toxic to aquatic algae	Not corrosive to metals in vehicles, bridges, and utilities	High
Sand	Causes water pollution via sedimentation — increased TSS	Sediment can impact aquatic life	Not corrosive to metals in vehicles, bridges, and utilities	Low to moderate

The 2001 study (Lewis, 2001) of chloride-based deicers for environmental effects indicated that some contain substantial amounts of phosphorus, ammonia, or organic matter. The use of phosphorus raises concerns about elevated concentrations and loads in Corridor streams. The ammonia contained in some deicers can cause aquatic toxicity, while excessive organic carbon is a potential source of oxygen depletion (Lewis, 2001). Because chemical deicers are applied in large quantities, CDOT has developed specifications that limit concentrations of rust-inhibiting chemicals in the raw product (CDOT, 2003). These specifications prompted vendors to change their formulas to meet the lower phosphorous and ammonia requirements. **Table 21** shows typical stream concentrations in relation to concentrations present in magnesium chloride deicer.

Colorado Department of Transportation-funded research indicates that the application of a magnesium chloride deicer having a chemical composition and application rate similar to those of 1997-1998 is unlikely to cause or contribute to environmental damage, assuming a median expected dilution of 1:500 prior to exit from the roadway. This is a very reasonable assumption because the measured dilution was 1:600 to 1:47,000 in samples taken next to sprayed roadways (Lewis 1999). However, the environmental safety of magnesium chloride deicer depends on low concentrations of contaminants and avoidance of rust/corrosion inhibitors with high phosphorus contents (Lewis 1999).

Table 21. Typical Stream Concentrations and Magnesium Chloride Deicer Concentrations (Lewis 1999)

Deicer Chemicals	Typical Stream Concentration (mg/L)	1997-1998 Magnesium Chloride Deicer Range (mg/L)
Major Ions		
Calcium	20	<100–2,200
Magnesium	3.5	80,000
Sodium	3.5	1,900–2,900
Chloride	4	230,000
Nutrients		
Total Phosphorus	0.015	7.5–17.6
Ammonia	2.3	3.4-5.3

Deicer Chemicals	Typical Stream Concentration (mg/L)	1997-1998 Magnesium Chloride Deicer Range (mg/L)
Metals (Dissolved)		
Copper	N/A	0.1–0.6
Zinc	N/A	<2
Cadmium	N/A	<0.01-0.01

Colorado Department of Transportation has funded deicer studies (Peterson and Trahan 2004) that focus on five objectives:

1. To assess the extent and mode of roadside vegetation exposure to deicers in areas with sand/salt and/or liquid applications
2. To evaluate impacts of deicer applications on photosynthesis and leaf level gas exchange in the field over time and in relation to road treatment type
3. To expand current laboratory studies to investigate and compare the effects of various sand/salt mixtures and liquid deicers on plant growth, photosynthesis, and seed germination
4. To quantify leaf water status in conifer trees within designated plots to account for the presence of drought stress before onset of treatments and during the treatment period
5. To assess several other factors potentially harmful to roadside vegetation including pollution, nutrient availability, disease, and insect impacts in areas where deicer stress may be a concern

Environmental Impacts of Deicer Components

CDOT also researched the potential effects on aquatic environments through which deicers are transported after leaving the highway (Lewis 1999 and 2001), and the effects on vegetation (Peterson and Trahan 2004). The following discussion of environmental effects by deicer component and water quality parameter is based on CDOT and other research. Several other states use magnesium chloride liquids with various kinds of corrosion inhibitors for anti-icing or deicing: Alaska, Arizona, California, Idaho, Indiana, Maryland, Montana, Nebraska, Oregon, Rhode Island, Washington, and Wisconsin (Stidger, 2002; Xi and Xie, 2002; HITEC, 1999), but CDOT-funded research provides the most site-specific information regarding deicers used in mountain environments.

Chloride

The chloride ions in magnesium chloride and sodium chloride deicers increase the salinity of the soil near the roadways where they are applied and have the potential to increase the salinity of rivers, streams, and lakes. Background concentrations of chlorides in Colorado mountain streams are generally low (2 to 3 mg/L). However, concentrations may increase substantially during snowmelt runoff events in streams adjacent to roadways where winter maintenance activities have occurred. Concentrations in flowing streams will generally decrease substantially due to dilution, and most aquatic animals can tolerate exposures exceeding normal levels by 10 to 100 times or more without any harmful effects (Lewis 2001). Maximum chloride concentrations measured in Corridor streams receiving runoff from the I-70 highway ranged from about 200 to 300 mg/L in 2001-2002 (Clear Creek Consultants, Inc. 2002a). The domestic drinking water quality standard for chloride in Corridor area streams is 250 mg/L. Environmental Protection Agency (2000) has also set chloride standards of 860 mg/L (acute) and 230 mg/L (chronic) for aquatic life. Chloride concentrations in I-70 snowmelt runoff samples (undiluted) ranged from 48 to 720 mg/L with an 85th percentile concentration of 550 mg/L (Clear Creek Consultants, Inc. 2002a). The 85th percentile concentration is important because it is the basis of comparison with water quality standards. For storm events, the acute standard for aquatic life is the appropriate basis of comparison.

Some of the discussion surrounding the water quality effects of deicer usage was based on earlier (pre-2001) studies. For example, the Lewis (1999) study was published before highway runoff water quality data were available for I-70 Corridor streams. The 1999 study estimated that stream chloride concentrations could increase by as much as 5 times from snowmelt runoff events. Subsequent CDOT data show that increases in chloride concentrations of more than 100 times are common each winter. More recent maintenance data show that deicer application rates have increased in many areas, and stream data indicate that the chronic aquatic life chloride standard (230 mg/L) is exceeded every year in high-elevation streams receiving I-70 runoff. The *I-70 Mountain Corridor PEIS Biological Resources Technical Report* addresses the effects of winter maintenance on roadside vegetation. Although the effects of high salt concentrations on aquatic biota in streams adjacent to the I-70 highway are not known at this time, the issue is addressed in the *I-70 Mountain Corridor PEIS Biological Resources Technical Report* (CDOT, August 2010).

Chloride-based deicers have been shown to have some adverse effects on terrestrial vegetation. Damage to vegetation from deicing salts has been reported to a distance of 100 to 650 feet (Lewis 2001). Most of the impacts of chloride deicers on vegetation occur near roadsides receiving heavy treatment of deicers. The vegetation that is most sensitive to the effects of chlorides includes native grass species, wetland species, and pine and Douglas-fir trees. Conifers, in general, are more sensitive to salt injury than deciduous trees (Lewis 2001). Chloride concentrations less than 70 mg/L are safe for all plants; concentrations between 70 and 140 mg/L will result in some damage to sensitive vegetation; concentrations between 140 and 350 mg/L will result in some damage to moderately tolerant plants; and concentrations greater than 350 mg/L can cause severe vegetation damage.

The trend in water quality reflects CDOT's maintenance practice of less traction sand and more liquid and solid deicer salts. This change has resulted in higher chloride loading and a similar or slightly lower sediment loading since 2002. The sodium and magnesium chloride used in liquid and solid deicers are highly soluble; therefore, the concentration in the runoff is high. The in-stream chloride concentration is the greatest in February, March, and April, when flows are low and there is little dilution from snowmelt. Conversely, the chloride concentration is lowest in May and June due to greater runoff flows and dilution of the chloride.

The chloride from rock salt is still a contributing factor to chloride entering the streams. However, the change to ice-slicer may have resulted in higher stream chloride concentrations. Salt washes out of the sand very quickly. The sand can be picked up, but there is no proven method for removing the salt before it is washed out of the sand. Sand is needed for traction and will, therefore, continue to be a concern for water quality.

The chloride concentrations are the greatest in Black Gore Creek, ranging from 50 to 400 mg/L, and in Upper Clear Creek below Herman Gulch, ranging from 30 to 400 mg/L. There is a slight increasing trend in concentration in these watersheds. The chloride concentrations in Straight Creek range from 30 to 250 mg/L, but the increasing trend is much higher than in either Black Gore Creek or Upper Clear Creek. The chloride concentrations in West Tenmile Creek are much lower than those of the other streams with a high in the early spring months of around 100 mg/L. The West Tenmile Watershed is larger than Black Gore Creek, which provides a greater dilution factor, and the stream is a much further distance from the I-70 highway.

Magnesium and Sodium

Sodium in salt deicers can affect soil by reducing permeability and aeration, leading to increased runoff. Magnesium is a natural component of soil and tends to increase soil stability and permeability. Sodium can depress calcium and magnesium levels in water, reducing hardness; this tends to increase environmental stress to aquatic life. There are no listed water quality standards for sodium and magnesium in Corridor-area surface water. Standards are not required because these inorganic parameters are not known to affect water quality (and water uses) at levels generally found in streams. Toxicity studies indicate that chloride associated with magnesium is more toxic to aquatic life than chloride associated with sodium (EPA, 1986). However, several factors offset this effect. As temperatures drop from freezing (32°F) to 20°F (common in Colorado), less magnesium chloride relative to sodium chloride achieves the same results (Blackburn et al., 2004). The level of dilution has been calculated at 500-fold and measured at 600 to 47,000 for the I-70 highway (Lewis, 1999), and these deicers are not indicated to have adverse impacts on aquatic life in streams at existing application levels and stormwater conditions. Use of salt with sand raises the peak concentrations of sodium in stream waters from the range of 2 to 5 mg/L to the range of 20 to 50 mg/L. These concentrations are not considered to be environmentally damaging (Lewis 1999).

Nutrients and Organics

Magnesium chloride deicers may contain small amounts of ammonia, nitrates, and phosphorus. The organic corrosion inhibitors present in some chemical deicers have the potential to cause oxygen depletion of streams near the roadways where the deicers are applied and can result in mortality of fish and other aquatic organisms. Substances with a high biological oxygen demand (BOD) have the potential to reduce oxygen levels substantially. Phosphorus raises concerns about elevated concentrations and loads in Corridor streams. Ammonia raises concerns about aquatic toxicity, while excessive organic carbon and phosphorus are potential sources of oxygen depletion. However, deicers used by CDOT are required to meet strict nutrient concentrations to minimize these potential contaminants (CDOT 2003). Thus, the magnesium chloride deicers that CDOT uses have low BOD, as compared to other deicers (particularly acetate-based deicers) that can have as much as 180 times the BOD (Lewis, 2001 and 1999).

An assessment of potential I-70 liquid deicer effects on Clear Creek's total phosphorus loading was recently performed by the Upper Clear Creek Watershed Association (UCCWA 2003). Results indicate that for the 2000-2001 season, CDOT's use of deicers on the I-70 highway contributed an estimated (maximum) total phosphorus loading to upper watershed streams of 173 pounds per year. The relative I-70 highway contribution as compared to Upper Clear Creek waste water treatment plants (WWTPs) annual total phosphorus loads was found to be 3.3 percent. For the 2002-2003 season, the I-70 highway total phosphorus load contribution was an estimated 96 pounds per year (probably due to below-normal snow events). The I-70 highway contribution as compared to annual WWTP loads was 1.9 percent for the 2002-2003 season (highway loadings were annualized, even though deicer application is during a shorter season). An estimated 8,920 pounds per year is the mean annual total phosphorus load for Clear Creek at Kermitt's (monitoring site CC-4), and 11,228 pounds per year is the comparable load for Clear Creek near Golden (monitoring site CC-6). Both estimates are for a 1995-2003 water-year period of record.

Metals

The corrosion inhibitors in the magnesium chloride deicers vary depending on the brand of deicer used. Magnesium chloride deicers may contain small amounts of copper, lead, zinc, arsenic, and cadmium. However, deicers used by CDOT are required to meet certain specifications to minimize these potential contaminants (CDOT, 2003). CDOT studies (Lewis, 1999) indicate that stream samples from sites that are unaffected by mine drainage (mainstem of Straight Creek and Laskey Gulch) show that the application of magnesium chloride deicer has no detectable effect on the concentrations of cadmium, copper, and zinc. Mine drainage causes consistent exceedances of standards on Upper Clear Creek and lower North Clear Creek. The amounts of metals transported in watersheds that are either affected or unaffected by mine drainage far exceed the amounts that are added to roadways with magnesium chloride deicer (Lewis, 1999).

Aquatic Toxicity

Organic materials are expected components of deicers due to rust/corrosion inhibitors and can induce total oxygen demands that might affect the aquatic environment. However, studies indicate that with dilution of deicer before entering streams, organic materials would present no environmental threat (Lewis, 1999).

Toxicity testing indicates that various kinds of organisms differ in their sensitivity to magnesium chloride deicer (Lewis 1999). The most sensitive kinds of organisms included in these tests begin to show observable effects at 0.05 to 0.1 percent magnesium chloride deicer during exposures ranging from 48 to 168 hours. Because of the presence of melt water, magnesium chloride deicer applied to roadways is diluted to approximately 0.2 percent before leaving the roadway, and an additional amount (to less than 0.1 percent) within short distances (for example, 20 yards) of the roadway. Addition of magnesium chloride raised the concentrations of magnesium in streams by as much as five times above baseline concentrations of 2 to 3 mg/L. Winter concentrations were most strongly affected because stream discharge is low during winter, and thus dilutes the magnesium less than during spring. Even though changes in concentration were substantial, they fell well within the natural range of magnesium concentrations in Colorado waters and raise no specific environmental concerns.

Terrestrial Animal Toxicity

Use of sodium chloride increases the potential for roadkills when birds or mammals try to lick the salt off the roads. Magnesium chloride or calcium chloride are not attractive to animals, and thus are less likely to cause roadkills (Environment Canada 2000).

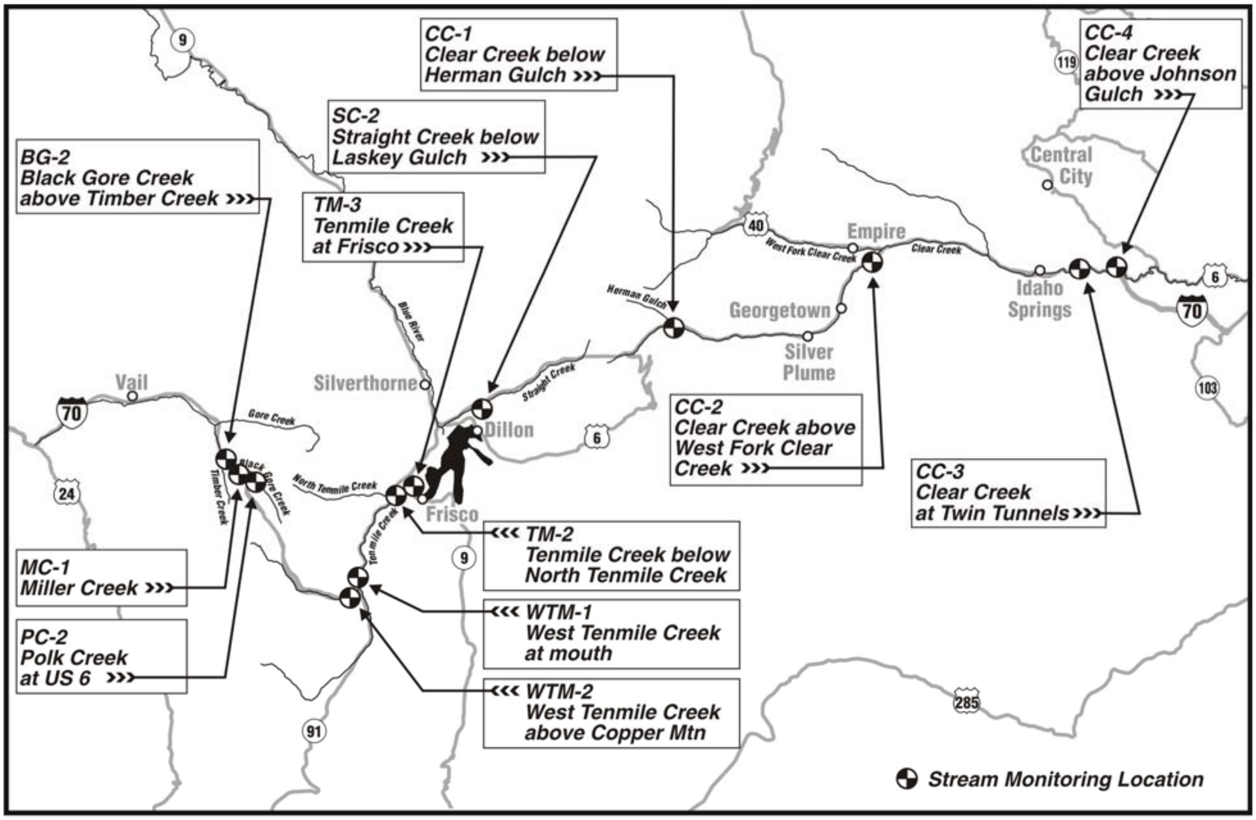
4.5 Water Quality Monitoring

The I-70 storm event/snowmelt water quality-monitoring program was established in 2000 to define baseline water quality conditions in Corridor streams. This program was designed to monitor stream water quality during periods of I-70 stormwater and snowmelt runoff. The monitoring network includes automated sampling in the Black Gore Creek watershed (two stations), West Tenmile Creek, Straight Creek, and Clear Creek watersheds (four stations). Two automated I-70 culvert runoff-monitoring stations are also operated to measure highway runoff water quality. These stormwater sampling sites are shown on **Figure** 13. Snowmelt runoff from the I-70 highway was sampled at 24 initial locations during the spring of 2001 to provide diagnostic information on water quality conditions. These highway sample locations ranged from milepost 185 in the Black Gore Creek watershed to milepost 254 in the Mount Vernon Creek watershed (Clear Creek Consultants, Inc. 2002a). Additional highway runoff samples were collected during a snowmelt event in the eastern Corridor in May 2002. This monitoring program provides site-specific water quality data related to the I-70 highway for use in establishing the instream effects of I-70 runoff within the Corridor. The monitoring program is limited by the frequency of highway runoff from rainfall or snowmelt events. As such, it is anticipated that several years of event monitoring will be required to determine stream water quality effects and to measure water quality changes in relation to sediment control measures implemented on the I-70 highway.

These activities and programs were developed as part of this PEIS because very little information was available to assess impacts on water resources from the construction and operation of the I-70 highway. For example, no comprehensive inventory of Clear Creek had been conducted to evaluate the effects of the I-70 highway. There were no highway water quality data related to the I-70 highway or its impacts on stream water quality within the Corridor before this study. This information provides the basis for evaluating impacts related to the alternatives proposed in this PEIS. The level of detail provided by these programs is appropriate for establishing the primary issues and locations of potential impacts.

As noted in **Section 4.4.3**, the I-70 highway runoff sampling program was curtailed after 2004 at all stations except CC-231 (milepost 231.5). This station is operated for summer rainfall-runoff events only; highway snowmelt samples have not been collected since 2003. Available sample data from CC-231 collected from 2004–2008 have been compiled and incorporated into the mean values for highway runoff. Recent water quality monitoring data (e.g. collected between 2004 and 2008) show that water quality in I-70 Corridor streams has changed in response to the changes in winter maintenance material use (Clear Creek Consultants, 2010).

Figure 13. Stream Monitoring Locations



The water resources inventory, *An Inventory of Corridor Water Resource-Related Issues for Clear Creek* (J.F. Sato and Associates, 2002), consisted of both existing and new information. Existing information on climate, stream flow, water supplies, regulations, and water quality was gathered from databases, Corridor studies, and available I-70 water research. New information related to the I-70 highway was gleaned from the Sediment Control Action Plan (SCAP), SWEEP, and the water quality-monitoring program.

Agencies and local interest groups providing information and data on water resources within the Corridor included the following:

- United States Fish and Wildlife Service
- United States Environmental Protection Agency
- Upper Clear Creek Watershed Association
- Black Gore Creek Steering and Technical Committees
- Colorado Division of Wildlife
- Straight Creek Cleanup Committee
- United States Army Corps of Engineers
- Clear Creek County

- Colorado Department of Public Health and Environment
- United States Forest Service (Arapaho and Roosevelt National Forests)
- United States Department of Agriculture (Natural Resource Conservation Service)
- United States Geologic Service
- Trout Unlimited
- SWEEP Committee

4.5.1 Colorado Headwaters Sub-Basin

The Colorado River between the towns of Glenwood Springs and Dotsero represents the largest single source of dissolved solids in the Upper Colorado River basin (NWCCOG, 1996). This area contributes 17 percent of the dissolved sodium and 38 percent of the chloride loads leaving the Upper Colorado River basin. Most of this dissolved solids load is contributed by very saline thermal springs between Glenwood Springs and Dotsero.

Major point source discharges in the Upper Colorado River watershed include municipal and domestic wastewater treatment plants. The Two Rivers Village project in the Dotsero area, just below the confluence with the Eagle River, is the only point source discharge in the immediate Corridor vicinity and has been granted site approval for a 0.15 million gallon per day facility (1,500 population equivalents). Most wastewater facilities are located in the upper watershed and are associated with population areas, such as Granby, Winter Park, Fraser, Kremmling, and Hot Sulphur Springs. Seven wastewater facilities in the watershed have ammonia discharge limits.

Transbasin diversions have impacts on water quality in the watershed, including decreased dilution flows, decreased spring runoff flushing flows that move accumulated sediments that affect fish spawning habitat, decreased aquatic life habitat, and increased stream temperature (NWCCOG, 2002).

4.5.2 Eagle River Sub-Basin

Ranching, logging, and mining were the dominant activities in the watershed from the late 1800s to the 1970s; and historic mining at Climax, Gilman, and Red Cliff have affected water quality. More recently, water quality and morphology of the Eagle River have been affected by various influences related to residential and commercial development in the areas of Vail, Eagle-Vail, Avon, Edwards, and the town of Eagle. The *Eagle River Water Quality Management Plan* (NWCCOG, 2002) states that water quality in the Eagle River from Gore Creek to its confluence with the Colorado River is affected by wastewater discharges, irrigation return flows, mineralized groundwater seepage, and runoff from highly erodible soils.

Two wastewater facilities discharge into the Eagle River downstream from Avon and Edwards. This portion of the river is water quality limited with load allocations requiring advanced wastewater treatment for ammonia removal for discharge at the Upper Eagle Valley. The CDOW (1996) indicated that effluent from existing WWTPs discharge nitrogen and phosphorus to the Eagle River and that too much nutrient enrichment will result in degradation of the aquatic community and a gradual decline in the fishery value of the river.

A major source of chloride in groundwater exists from geology immediately downstream of Edwards, and a substantial source of sediment and dissolved solids comes from Milk, Alkali, and Ute creeks near Wolcott (NPS, 1996). Suspended sediment concentrations as high as 12,000 milligrams per liter (mg/L) have been measured by the BLM during spring runoff, and the *1987 Colorado Nonpoint Source Assessment Report* (CDPHE, 1988) implicated these creeks as substantial sources of sediment to the Eagle River (NWCCOG, 1998).

Gore Creek

The Colorado WQCC has established classifications and standards for one segment of Gore Creek in the Corridor project area (Segment 8, Black Gore Creek to the Eagle River), and the lower 4 miles of Gore Creek have been designated a Gold Medal fishery in recognition of the creek's high recreational value and the productive brown trout community.

Water resource-related issues within the Gore Creek drainage include sedimentation from construction of residential and commercial developments within the Vail Valley and winter maintenance activities associated with the I-70 highway. Although I-70 runoff has contributed suspended solids to the stream, suspended sediment is not considered a major water quality concern in Gore Creek (USGS 2001), and nutrient and trace metal concentrations in stream loads are generally attributed to commercial and residential runoff (NWCCOG, 1995). However, rock salt and magnesium chloride associated with I-70 maintenance are primary sources for some of the dissolved solids affecting specific conductance in Gore and Black Gore Creeks.

Aquatic life standards have been exceeded for trace metals, such as cadmium, copper, and manganese, and are attributed to natural sources in the Gore Creek watershed (NWCCOG, 2002). Gore Creek is a water quality limited segment with load allocations requiring advanced wastewater treatment for ammonia removal for discharge at Vail. Other issues related to water quality include the application of fertilizers within the Vail Valley.

Black Gore Creek

Black Gore Creek is protected for water supply and aquatic life uses and is part of Colorado WQCC Segment 6 of the Eagle River watershed (see **Table 22**). Land use in the Black Gore Creek watershed is dominated by the WRNF and the I-70 highway. The only other development occurs near the headwaters of the watershed and includes Black Gore Reservoirs and the CDOT maintenance facility near the summit of Vail Pass. The I-70 segment that parallels Black Gore Creek is a steep high elevation mountain corridor that receives substantial snowfall during the winter months and is subject to extreme weather conditions. This area is sensitive to winter maintenance issues due to its unique characteristics, such as high elevation snowfall, steep gradient mountain passes, and areas susceptible to avalanches, its proximity to many of the state's most popular ski areas, as well as the amount of traffic that is carries. Excessive sediment loading has been occurring over the 20 years of I-70 operation in the watershed. Sedimentation is caused by both cut-and-fill slope erosion and winter maintenance practices.

Table 22. Impaired Waters, Eagle River Watershed, HUC 14010003

Water Body	Segment/ID	Pollutant or Condition	Sources	TMDL Project Status	Projected Completion Date
Eagle River—Belden to Gore Creek	5 (COUCEA05)	Zinc, manganese, copper	Mining	Cadmium delisted; zinc and manganese pending	June 2006
All tributaries—source or bridge at Belden to Lake Creek or to Belden—Black Gore Creek	6 (COUCEA06)	Sediment	Road runoff	TMDL development	Unknown
Cross Creek—source to Eagle River	7 (COUCEA07)	Zinc, manganese, copper		Cadmium delisted; zinc and manganese pending	June 2006

Water Body	Segment/ID	Pollutant or Condition	Sources	TMDL Project Status	Projected Completion Date
Eagle River—Gore Creek to Colorado River	9 (COUCEA09)	Manganese	Mining	Pending	June 2006

Bold = Segments in immediate vicinity of I-70, CDPHE, 2002a (2004 updates).

Based on prior usage, approximately 15,000 tons of traction sand/salt mixture has been historically applied annually to the I-70 highway between the summit of Vail Pass and the confluence of Black Gore and Gore creeks to maintain mobility during winter. This practice has resulted in an estimated yearly delivery of 3,600 tons of sediment to Black Gore Creek (Lorch, 1998). Sedimentation from I-70 traction sand has resulted in impacts on water quality, aquatic life, and the water supply reservoirs. Black Gore Creek (Eagle River Segment 6) is classified as impaired and was listed for TMDL development in September 2002 due to sediment loads in I-70 runoff.

Specific conductance is generally three to five times higher in Black Gore Creek than in Gore Creek, and water quality standards for manganese and copper have been exceeded in the past. These metal contaminants are associated with local rock mineralogy (Lorch, 1998). However, land disturbance from I-70 construction during the early 1970s has also contributed to manganese concentrations.

CDOT completed a SCAP for the Black Gore Creek corridor in May 2002. The SCAP provides an analysis of existing sediment conditions and controls and presents options for sediment control improvements and long-term structural controls. A covered sand storage structure was installed at the CDOT maintenance facility on Vail Pass to control sediment runoff in this area.

Data and Trends

The following sections summarize water quality data for rivers and streams that intersect or parallel the Corridor. Data tables list measurements made between 2000 and 2003 during storm or snowmelt runoff events associated with the Snowmelt/Storm Event Baseline I-70 Monitoring Program. These event samples differ from ambient (nonstormwater runoff) water quality data, when streams are not receiving highway runoff. These data reflect moderate runoff event impacts on stream concentrations of potential highway-related pollutants.

Eagle River

Ambient (nonstormwater runoff) water quality data from 14 samples collected from the Eagle River at Gypsum throughout 2000 indicate that concentrations of all regulated parameters were either at or below established water quality standards (USGS, 2000). The *Eagle River Watershed Plan*, developed in 1994, however, states that dissolved solids and nutrient concentrations have increased in Gore Creek between 1979 and 1991 due to development in the Vail area and that these trends are most likely occurring in all the developing areas of the Eagle River watershed (NPS, 1996). Growth and development in Eagle County are associated with numerous possible nutrient sources, including increased WWTP effluent and increased stormwater runoff from impervious surfaces (such as parking lots) and development/construction sites.

Gore Creek

Since the 1970s, ammonia concentrations have decreased, and nitrate concentrations have increased in Gore Creek because of changes in wastewater treatment methods. Increases in nutrients and dissolved and suspended solids in Gore Creek are more generally due to the increases in pollutants from stormwater runoff. There is concern that water quality standards in Gore Creek could be exceeded, resulting in impacts on the aquatic community and the Gold Medal fishery.

Black Gore Creek

In September 2000, CDOT began collecting snowmelt and rainfall-runoff water quality data in Black Gore Creek above Timber Creek. Results from this monitoring program are summarized in **Table 23** and discussed below.

Table 23. Snowmelt/Stormwater Quality Data for Black Gore Creek Above Timber Creek Near Vail

	Suspended Solids	Phosphorus Total	Chloride	Sodium Dissolved	Magnesium Dissolved	Copper[a] Dissolved	Manganese Dissolved	Zinc[a] Dissolved
Standards	None	0.1–1.0[b]	250	None	None	0.010	0.05	0.093
Black Gore Creek (BG-2 on Figure 13)								
Samples	99	90	99	84	90	88	88	88
Range	<5–4650	<0.01–3.2	6.4–250	4–140	2.2–16.5	0.001–0.010	<0.003–0.413	<0.003–0.020
Mean	345	0.27	57	28.5	6.3	<0.005	0.017	<0.010
Polk Creek (18 samples) (PC-2 on Figure 13)								
Range	<2–146	<0.01–0.12	<1.0–1.2	0.9–2.0	1.9–4.5	<0.005	<0.003–0.196	<0.003–0.016
Mean	42	0.04	1.0	1.5	3.4	<0.005	0.016	<0.010
Miller Creek (1 sample) (MC-1 on Figure 13)								
Value	<5	<0.01	1.0	1.9	1.8	<0.001	<0.005	<0.005

Notes: Drinking water standard for chloride. Aquatic life criteria for chloride are 860 mg/L acute, 230 mg/L chronic (EPA 2002). For years 2000 to 2003, data are measured in mg/L.

[a] Copper and zinc standards are acute, based on 92 mg/L average hardness for Black Gore Creek samples.

[b] Range from recommended Environmental Protection Agency stream standard for minimizing lake eutrophication to wastewater effluent limitation.

Metals and Chloride

Black Gore Creek chemistry is dominated by sodium chloride, which is the likely result of salt used on the I-70 highway during winter. Large spikes in conductivity (an indicator of dissolved solids including sodium chloride) were measured in October and November 2001 following snowmelt runoff events when sand/salt mixtures and chemical deicers were applied to the I-70 highway. The maximum chloride concentration measured in 2001 was 250 mg/L, which is equivalent to the drinking water standard. Chloride concentrations in background tributaries within the watershed that are unaffected by the I-70 highway were about 1 mg/L. Aquatic life criteria for chloride are 860 mg/L acute and 230 mg/L chronic (EPA, 2002). Water quality standards for trace metals were not exceeded.

Suspended Solids and Phosphorus

Suspended solids concentrations from 2000/2001 stormwater/snowmelt runoff samples collected in Black Gore Creek ranged from less than 5 to 2,600 mg/L. Total phosphorus is positively correlated with suspended solids, with higher values associated with high particulate material. The highest total phosphorus concentration was 3.1 mg/L, which corresponded to 4,650 mg/L suspended solids. The mean total phosphorus concentration in Black Gore Creek under snowmelt and storm runoff conditions was 0.27 mg/L.

4.5.3 Blue River Sub-Basin

Mineral exploration for gold and silver occurred in the Blue River sub-basin from the mid-1860s to 1905. Water quality impacts resulting from historical mining have affected four segments (designated as "use impaired") within the sub-basin (see **Table 24**). Straight Creek (Segment 18) is listed due to sediment impacts from the I-70 highway. Blue River Segment 1 is included on the CDPHE (2002a) list requiring monitoring and evaluation for cadmium and zinc.

Table 24. Impaired Waters—Blue River Watershed, HUC 14010002

Water Body	Segment/ID	Pollutant or Condition	Sources	TMDL Project Status	Projected Completion Date
Blue River—French Gulch to 0.5 mile below SCR3	2a (COUCBL02a)	Cadmium, copper, zinc	Mining	Data collection ongoing	June 2004
Blue River—0.5 mile below SCR3 to Swan River	2b (COUCBLO2a)	Copper	Mining	Data collection ongoing	
Snake River—source to Dillon Reservoir	6 (COUCBL02)	Cadmium, copper, lead, manganese, zinc, pH	Mining	Data collection ongoing	June 2006
Peru Creek—source to Snake River	7 (COUCBL07)	Cadmium, copper, lead, manganese, zinc, pH	Mining	Data collection ongoing	June 2006
French Gulch—below Lincoln to Blue River	11 (COUCBL11)	Cadmium, zinc, pH	Mining	Data collection ongoing	June 2004
All tributaries to Blue River—Dillon Reservoir to Green Mountain Reservoir (Straight Creek—source to Blue River)	**18 (COUCBL18)**	**Sediment**	**Road runoff**	**TMDL available**	**August 2000**

Bold = Segments in immediate vicinity of I-70, CDPHE 2002a (2004 updates)

Blue River

The Blue River from Dillon Dam to the confluence with the Colorado River below Kremmling (Segment 17) is designated a Gold Medal trout fishery. The segment passes under the I-70 highway near milepost 205. The Silverthorne/Dillon Joint Sewer Authority water treatment plant (WTP) discharges to the lower Blue River at the north end of the town of Silverthorne. Ammonia toxicity from wastewater effluent is a concern, along with maintenance of instream flow due to increased pressure for diversions due to growth. Downstream from the Dillon-Silverthorne WWTP discharge, concentrations of total cadmium, lead, and zinc have exceeded standards for aquatic life, and dissolved manganese has exceeded water supply stream standards (Deacon and Mize, 1997). Gravel mining operations adjacent to the Blue River have been sources of substantial suspended and dissolved solids.

Dillon Reservoir and Tributaries

Dillon Reservoir and its tributaries (Blue River Segment 3) have been classified for aquatic life, recreation, and water supply use. Phosphorus loads from WWTPs and nonpoint sources are cited as major problems impacting Dillon Reservoir, resulting in accelerated eutrophication conditions in the lake. Phosphorus wasteload allocations have been in place for the upper Blue River watershed since 1984 (WQCC Regulation No. 71). The control regulation established a phosphorus load allocation for the dischargers upstream of Dillon Reservoir. Wastewater treatment plants located upstream of Dillon Reservoir include the Snake River WTP, the Frisco Sanitation District WTP, and numerous facilities operated by the Breckenridge Sanitation District.

The WQCD has indicated that discharges to Dillon Reservoir will be evaluated for effluent limits for ammonia when permits are renewed. The concern with respect to ammonia is its un-ionized form, due to its toxicity to fish. Initial concentrations, temperature, pH, and mixing are the key elements in determining the amount of un-ionized ammonia that could be toxic to fish.

West Tenmile Creek and Tenmile Creek

The WQCC has established classifications and standards for one segment (14) of Tenmile Creek in the immediate vicinity of the I-70 highway, which includes West Tenmile Creek (see **Table 25**). CDOT operates a wastewater treatment facility at the Vail Pass Rest Area under CDPS Permit No. CO-0042731 that discharges effluent to shallow groundwater in West Tenmile Creek. The original facility was constructed in 1980 and upgraded in 1991 and 1998 to mitigate surface discharges from a failed leach field. Both nitrates and phosphorus are a concern for the discharge from this facility (CDPHE, 1998). The facility has recently been fitted with further mechanical treatment and a new leach field to comply with the effluent limitation of 3.9 pounds of phosphorus per year (0.11 mg/L) to meet Dillon Reservoir Control Regulations (CDPHE WQCC Regulation No. 71).

The Copper Mountain Consolidated Metropolitan District WTP discharges to Tenmile Creek, just above the confluence with West Tenmile Creek. Elevated metal and sulfate levels in Tenmile Creek, partially sourced from the Climax Mine, are also a concern.

Straight Creek

Straight Creek is a tributary to the Blue River in Silverthorne and is classified for drinking-water supply and aquatic life uses (Segment 18 on **Table 25**). CDPHE included Straight Creek on the Colorado 1998 303(d) list for aquatic life use impairment by sediment. Excess sediment in Straight Creek impairs the Class 1 coldwater aquatic life use, increases the maintenance necessary at the drinking-water system's intakes and plants, and has the potential to impact the Gold Medal fishery of the Blue River. Land use in the watershed is dominated by the WRNF and the I-70 highway, with the exception of the lower 2 miles where residential development has taken place near the town of Silverthorne.

More than 20 years of erosion of cut-and-fill slope—primarily as a result of ineffective surface runoff disposal—and annual application of 10,000 to 20,000 tons of sand and fine gravel for winter sanding operations on the I-70 highway have led to severe sedimentation problems on Straight Creek (RCE et al. 1993). Sedimentation has affected the morphology of Straight Creek in localized areas where excessive deposition has occurred. Other sources of pollution in the Straight Creek watershed are associated with urban development in the towns of Dillon and Silverthorne.

In response to a USDA Forest Service 1990 Environmental Assessment (EA), CDOT initiated the Straight Creek Erosion Control Project and installed sediment basins, concrete valley pan drains, and culvert rundowns in the Straight Creek watershed to control highway runoff during 1993. A Sediment Pond Maintenance Plan was also developed that specified pond sizes, locations, and inspection and clean-out frequency (CDOT 1993).

In 1993, the Summit Water Quality Committee investigated highway-related sediment effects in the upper 5.7 miles of Straight Creek. An analysis of the sediment basins constructed as part of the Straight Creek Erosion Control Project was conducted to determine the volume of sediment captured and the sediment removal efficiency of the sediment basins in 1995 (CDOT, 1996). The results indicated that for the period 1993–1994, 5,337 tons of road sand were applied to the I-70 highway between Eisenhower-Johnson Memorial Tunnels and Silverthorne, and 587 tons (435 cubic yards) were collected by the seven basins that were operational during that period (CDOT 1996). Assuming all sediment collected was originally road sand, 11 percent of the road sand was collected in the seven sediment basins. Based on more recent analyses (CDOT, 2001), this efficiency has remained relatively constant since 1994.

Colorado Department of Transportation completed a SCAP for the Straight Creek corridor in May 2002. The SCAP provides an analysis of existing sediment conditions and controls and presents options for sediment control improvements and long-term structural controls. Numerous sediment basins and sediment control structures exist along this segment of the I-70 highway. However, most of these structures require maintenance (dredging of accumulated sediment in many cases) to function properly.

Data and Trends

West Tenmile Creek and Tenmile Creek

Baseline snowmelt-runoff, water quality conditions were measured in both West Tenmile and Tenmile creeks on April 18, 2001, as part of the CDOT stormwater monitoring program (**Table 25**). Early snowmelt water samples were collected from West Tenmile and Tenmile creeks at their confluence and from Tenmile Creek downstream at Frisco. Sample results from April 2001 indicate that Tenmile Creek water quality is influenced by upstream sources unrelated to the I-70 highway. Metal concentrations for magnesium, manganese, and zinc were much greater in Tenmile Creek compared to West Tenmile Creek, likely the result of extensive mine tailing deposits in upper Tenmile Creek. Concentrations decreased or remained the same in Tenmile Creek from Wheeler Junction to Frisco, indicating minimal contribution of these metals from I-70 runoff. Highway snowmelt-runoff samples collected from the I-70 highway in Tenmile Creek in April 2001 indicate low or undetectable trace metal concentrations but elevated sodium, chloride, suspended solids, and total phosphorus concentrations.

Table 25. West Tenmile/Tenmile Creek Water Quality Data, 2000–2003 (mg/L)

	Suspended Solids	Phosphorus Total	Chloride	Sodium Dissolved	Magnesium Dissolved	Copper [a] Dissolved	Manganese Dissolved	Zinc[a] Dissolved
Standards	None	0.1–1.0[b]	250	None	None	0.010	0.05	0.093
West Tenmile above Copper Mountain[c] (WTM-2 on Figure 13)								
Samples	28	28	28	28	28	28	28	28
Range	<5–128	<0.01–0.17	2–59	1.3–23	0.9–4.5	<0.001–<0.010	<0.005–0.013	<0.005–0.030
Mean	31	0.05	16.9	7.3	2.6	<0.010	0.005	0.012
West Tenmile Creek at Mouth[b] (WTM-1 on Figure 13)								
Samples	21	24	N/A	N/A	N/A	N/A	N/A	N/A
Range	<5–14	0.004–0.022	N/A	N/A	N/A	N/A	N/A	N/A
West Tenmile Creek at Mouth (April 2001) (1 sample)								
Value	26	0.06	43	15	3.8	<0.001	0.013	<0.005
Tenmile Creek below North Tenmile Creek (April 2001) (1 sample) (TM-2 on Figure 13)								
Value	<5	0.02	11	24	13	0.002	1.1	0.077
Tenmile Creek at Frisco (April 2001) (1 sample) (TM-3 on Figure 13)								
Value	<5	<0.01	16	19	11	<0.001	0.48	0.089

	Suspended Solids	Phosphorus Total	Chloride	Sodium Dissolved	Magnesium Dissolved	Copper [a] Dissolved	Manganese Dissolved	Zinc [a] Dissolved
Standards	None	0.1–1.0 [b]	250	None	None	0.010	0.05	0.093

[a] *Copper and zinc standards are acute, based on 150 mg/L hardness. Hardness for West Tenmile Creek is 150 and for Tenmile is 200. The lower hardness is used to compute acute standards because these standards are more restrictive.*

[b] *Range from recommended Environmental Protection Agency stream standard for minimizing lake eutrophication to wastewater effluent limitation.*

[c] *Drinking water standard for chloride. Aquatic life criteria for chloride are 860 mg/L acute, 230 mg/L chronic (EPA 2002)*

Source: Clear Creek Consultants. 2004.

Compared to mainstem Tenmile Creek, the suspended solids, total phosphorus, and chloride concentrations were higher in West Tenmile Creek at the confluence. The April 2001 sample was influenced by runoff from the Copper Mountain Resort, as well as the I-70 highway. These results show distinctly different water chemistry between Tenmile and West Tenmile creeks.

Water quality monitoring results (1999/2000, Copper Mountain) from West Tenmile Creek indicate that concentrations of total phosphorus were low above the Copper Mountain development. The same study indicated that the greatest phosphorus concentrations at the mouth of West Tenmile Creek occurred during early spring runoff. The April 2001 snowmelt runoff sample results also indicate elevated concentrations of suspended solids and phosphorus during this period. There is no indication that aquatic life criteria were approached according to the monitoring data collected to date at Tenmile Creek.

Straight Creek

Metals and Chloride

Stormwater quality data representing runoff conditions include diurnal snowmelt during April and May and rainfall-runoff from July through September. CDOT collected runoff samples as part of the I-70 runoff event baseline water quality monitoring (**Table 26**).

Table 26. Straight Creek Below Laskey Gulch (SC-2 on Figure 13) Snowmelt/Stormwater Quality Data, 2000–2001 (mg/L)

	Suspended Solids	Phosphorus Total	Chloride	Sodium Dissolved	Magnesium Dissolved	Copper [a] Dissolved	Manganese Dissolved	Zinc [a] Dissolved
Standards	None	0.1–1.0 [b]	250 [c]	None	None	0.008	0.05 [c]	0.074
Samples	79	76	79	71	73	68	68	68
Range	<5–3,550	<0.01–1.68	7.6–145	5–51	1.6–14.2	<0.002–0.002	<0.005–0.042	<0.005–0.030
Mean	191	0.14	41	18.3	4.6	<0.005	0.009	<0.01

[a] *Copper and zinc standards are acute, based on 58 mg/L hardness measured in Straight Creek samples.*

[b] *Range from recommended Environmental Protection Agency stream standard for minimizing lake eutrophication to wastewater effluent limitation.*

[c] *Drinking water standard for chloride. Aquatic life criteria for chloride are 860 mg/L acute, 230 mg/L chronic (EPA 2002).*

Source: Clear Creek Consultants, Inc. 2002a.

Sodium and chloride concentrations were relatively high in April and May (possibly associated with roadway deicers) and dropped to normal levels during summer thunderstorms in June and July. Ambient (nonrunoff conditions) water quality data collected at the mouth of Straight Creek between 1985 and 1989 show mean chloride concentrations ranging from 4 to 16 mg/L (SWQC 1991). These data indicate that most of the chloride associated with the I-70 highway is transported during snowmelt and rainfall-runoff conditions. Diurnal snowmelt and stormwater sample results for 2001 indicate low or nondetectable trace metal concentrations in Straight Creek above Silverthorne.

Suspended Solids and Phosphorus

Straight Creek TSS and phosphorus concentrations measured in 2001 were positively correlated indicating the presence of particulate phosphorus. Average total phosphorus concentrations in runoff samples were relatively low through the early spring and summer (<0.1 mg/L). The maximum concentration was measured during July and August rainfall-runoff events with 1.68 mg/L total phosphorus and 3,550 mg/L TSS. The mean total phosphorus was 0.14 mg/L while the dissolved phosphorus concentrations were less than 0.04 mg/L in all samples.

Monitoring of ambient water quality conducted at the mouth of Straight Creek from 1985 to 1989 by the Summit Water Quality Committee (SWQC 1991) showed mean concentrations of suspended solids ranging from 9 to 13 mg/L and total phosphorus ranging from 0.01 to 0.02 mg/L. These data indicate that suspended solids and phosphorus concentrations are typically low in Straight Creek under nonstormwater runoff conditions.

4.5.4 Clear Creek Sub-Basin

The lower segments of Clear Creek within the study corridor have myriad land use conditions and contaminant sources that contribute to water quality changes. Numerous tributaries and mine waste piles contribute substantial metal loads to Clear Creek, particularly during local snowmelt and rainfall-runoff conditions. Superfund remedial actions, along with the implementation of the Clear Creek Watershed Management Agreement, have resulted in improvements in Clear Creek water quality. Nonpoint sources, however, remain the top priority for cleanup in the Superfund study area (UCCWAG 2000). Environmental Protection Agency and CDPHE have yet to complete all of the remedial actions planned for the Superfund site, some of which are planned for areas within these affected stream segments.

Wastewater treatment plants that discharge nutrients directly to Clear Creek adjacent to the I-70 highway are located at the Eisenhower-Johnson Memorial Tunnels, Loveland Ski Area, Georgetown, Dumont, and Idaho Springs. Three municipal WWTPs discharge to Clear Creek in the lower portion of the study area. CDOT operates a wastewater treatment facility at the east portal of the Eisenhower-Johnson Memorial Tunnels facility under CDPS Permit No. CO-0026069. This permit allows discharge of treated wastewater to Clear Creek at the design capacity of 0.072 million gallons per day. Other WWTPs in the Clear Creek watershed discharge to Clear Creek tributaries and include Empire and the Black Hawk/Central City Sanitation District.

Table 27 lists four stream segments in the Clear Creek watershed that have been designated as *impaired*. Two segments (2 and 11) are in the immediate vicinity of the I-70 highway and are listed due to historic mining impacts.

Table 27. Impaired Waters—Clear Creek Watershed, HUC 1019004

Water Body	Segment/ID	Pollutant or Condition	Sources	TMDL Project Status	Projected Completion Date
Clear Creek - I-70 bridge at Silver Plume to Argo Tunnel	**2 (COSPCL02)**	**Copper, zinc**	**Mining**	**Draft TMDL**	**June 2002**
South Fork Clear Creek	3a (COSPCL03)	Zinc	Mining	—	—

Water Body	Segment/ID	Pollutant or Condition	Sources	TMDL Project Status	Projected Completion Date
West Fork Clear Creek	5 (COSPCL05)	Copper	Mining	—	—
Fall River and tributaries	9 (COSPCL09)	Copper	Mining	Pending	—
Clear Creek—Argo Tunnel to Farmers Highline Canal	**11 (COSPCL11)**	**Zinc, cadmium, copper**	**Mining**	**Iron and manganese delisted**	**June 2004**
North Clear Creek and tributaries—lowest water supply intake to Clear Creek	13 (COSPCL13)	Cadmium, manganese, zinc, copper, aquatic life	Mining	Pending CERCLA cleanup	June 2006

Bold = Segments in immediate vicinity of I-70, CDPHE 2002a (2004 updates)

Data and Trends

As part of the Clear Creek/Standley Lake Watershed Agreement since 1994, the Upper Clear Creek Watershed Association (UCCWA) developed and implemented an ambient water quality monitoring program for Clear Creek (CDOT is a party to the agreement). One goal established for the monitoring program was to evaluate nutrient loading from point and nonpoint sources in the watershed. The monitoring program includes four surface WTP and WWTPs on mainstem Clear Creek in the Corridor area. Sampling is conducted 8 months each year for nutrients and metals. Environmental Protection Agency and the UCCWA have also been conducting joint monitoring of Clear Creek since 1994 in association with Superfund activities. As part of the joint monitoring effort, an analysis of trace metals data was conducted and reported in 2001 (UCCWA 2001).

A summary analysis of Clear Creek water quality data is provided in the following sections. For discussion purposes, data are separated into ambient data, which generally represent nonstormwater runoff data collected by UCCWA from 1994 to 2001, and diurnal snowmelt/ stormwater runoff data collected by CDOT (Clear Creek Consultants, Inc., 2002a).

Metals (Ambient and Stormwater Data)

In September 2000, CDOT began collecting stormwater quality data representing runoff conditions, diurnal snowmelt during April and May, and project area from June through September as part of the I-70 runoff event baseline water quality monitoring (**Table 28**).

Upper Clear Creek

The most widespread land disturbances in the watershed above Bakerville are the I-70 highway, US 6, and Loveland Ski Area. Dissolved zinc is typically the principal indicator of water quality changes in streams affected by mining in the Clear Creek watershed. Because very few mining sources are located above Bakerville, dissolved zinc concentrations in stream samples are generally low and meet drinking water standards. Existing data, however, indicate an increasing trend in zinc and magnesium concentrations starting in 1997.

Water quality data collected by CDOT in May 2001 from the Eisenhower-Johnson Memorial Tunnels seepage flows indicate low concentrations of the total metals arsenic, cadmium, copper, lead, mercury, and zinc. However, it is not known if these metal concentrations vary seasonally with changing flow rates (0.3 to 1.5 cubic feet per second as measured by Coors Brewing Company). CDPHE does not require metals discharge monitoring at the CDOT Eisenhower-Johnson Memorial Tunnels treatment plant.

The 2001 trace metals data for Station CC-1 (below Herman Gulch) indicate that dissolved copper and zinc concentrations were within water quality standards and were similar to ambient concentrations reported by UCCWA for Bakerville in 2001. However, dissolved manganese concentrations exceeded the drinking water standard of 0.05 mg/L in several stormwater samples collected at the same station during 2001.

As might be expected due to the higher elevations and the associated increase in winter maintenance activities, the highest sodium, chloride, and magnesium concentrations were measured in Upper Clear Creek. Sodium, chloride, and magnesium trends include high concentrations in April and May and lower concentrations during summer and fall. The high concentrations of sodium chloride and magnesium chloride are believed to be associated with snowmelt runoff from the I-70 highway.

Table 28. Clear Creek Snowmelt/Stormwater Quality Data, 2000–2003 (mg/L)

	Suspended Solids	Phosphorus Total	Chloride	Sodium Dissolved	Magnesium Dissolved	Copper Dissolved[a]	Manganese Dissolved	Zinc Dissolved[a]
Standards	None	0.1–1.0[b]	250[c]	None	None	0.008	0.05 [c]	0.075
Clear Creek below Herman Gulch (CC-1 on Figure 13)								
Samples	89	87	91	85	85	85	85	85
Range	<5–7730	<0.01–4.3	4.1–210	2.5–56.5	1.5–15	<0.001–0.003	<0.003–0.35	<0.003–0.16
Mean	195	0.18	44.8	17.5	5.0	<0.005	0.027	0.009
Clear Creek above West Fork (CC-2 on Figure 13)								
Samples	33	33	33	25	28	28	28	28
Range	2–100	0.01–0.18	2.6–42	2.6–16	3.1–9.4	<0.001–0.002	<0.003–0.018	0.039–0.18
Mean	11	0.03	12.2	6.7	5.3	<0.005	0.007	0.078
Clear Creek at Twin Tunnels (CC-3 on Figure 13)								
Samples	25	24	25	18	21	21	21	21
Range	<5–2000	0.02–3.2	3.7–27	5.2–25	2.7–7.9	0.004–0.012	0.046–0.60	0.040–0.34
Mean	281	0.41	10.5	14.5	5.2	0.009	0.277	0.139
Clear Creek above Johnson Gulch (CC-4 on Figure 13)								
Samples	44	40	44	27	31	31	31	31
Range	<5–2700	0.02–5.2	3.5–29	5.5–26	2.7–8.1	0.003–0.011	<0.005–0.60	0.020–0.31
Mean	300	0.52	9.9	14.3	4.9	0.008	0.176	0.105

[a] Copper and zinc standards are acute, based on 59 mg/L average hardness measured at Upper Clear Creek Station CC-1. The lower hardness is used to compute acute standards because these standards are more restrictive.

[b]Range from recommended Environmental Protection Agency stream standard for minimizing lake eutrophication to wastewater effluent limitation.

[c] Drinking water standard for chloride. Aquatic life criteria for chloride are 860 mg/L acute, 230 mg/L chronic (EPA 2002).

Middle Clear Creek

Dissolved zinc data in the middle (Clear Creek above West Fork) and lower (Clear Creek below Idaho Springs) segments show a strong seasonal fluctuation in dissolved zinc related largely to changes in stream flow (dilution). The October data for Middle Clear Creek appear to indicate a decreasing trend in dissolved zinc concentrations since 1995. This improving trend in Middle Clear Creek may be transferred downstream through the system, as shown in the data for Lower Clear Creek that indicate a similar decreasing trend since 1995 (UCCWA 2001).

A water quality study of Georgetown Lake, immediately downstream from the town of Georgetown, was conducted in 1998 by the USGS in cooperation with the Environmental Protection Agency (USGS 2000). This study concluded that the lake effectively removes certain metals and sediment from Clear Creek. Average concentrations of dissolved sodium, magnesium, and manganese were lower in Clear Creek below the lake (Station CC-2) as compared to Upper Clear Creek (Station CC-1). Chloride concentrations were also much lower below Georgetown Lake (Station CC-2) compared to Upper Clear Creek at Herman Gulch (Station CC-1). Concentrations of dissolved copper and zinc, however, increase with distance downstream as a result of historic mining influences.

Lower Clear Creek

Dramatic increases in average trace metal concentrations occur in Lower Clear Creek between Empire Junction and Idaho Springs. Study results indicate large increases in dissolved copper, manganese, and zinc concentrations in this area, which is consistent with ambient data collected in the same stream area for the Superfund site.

Stormwater results from a paired set of stations designed to monitor I-70 runoff effects between Twin Tunnels (Station CC-3) and Floyd Hill (Station CC-4) indicate that average dissolved metal concentrations remain approximately the same in this segment of Clear Creek during stormwater runoff conditions. Considering multiple point and nonpoint metal source contributions in Lower Clear Creek, the concentrations of dissolved sodium, magnesium, and chloride are higher in Upper Clear Creek near Herman Gulch (Station CC-1) during runoff conditions. Metal concentrations in Lower Clear Creek are dominated by historic mining influences, and it is difficult to segregate any influence I-70 runoff may have on metals (Clear Creek Consultants, Inc. 2000).

Suspended Solids and Phosphorus (Ambient and Stormwater Data)

Clear Creek at Bakerville (CC-05) includes wastewater discharges from plants at the Eisenhower-Johnson Memorial Tunnels and Loveland Ski Area. Clear Creek above West Fork (CC-25) includes discharge from Georgetown’s wastewater plant, whereas Clear Creek below Idaho Springs (CC-40) includes discharges from the Dumont and Idaho Springs plants. These ambient data show generally low phosphorus concentrations (<0.04 mg/L) in Clear Creek since monitoring began in 1994.

However, samples collected during stormwater runoff events indicate generally higher total phosphorus and suspended solids concentrations in Clear Creek when compared to ambient data. Phosphorus and suspended solids concentrations are highest below the Twin Tunnels sampling point and lowest at the West Fork sampling point. High concentrations in the upper watershed (mean of 0.11 mg/L) reflect the influence of winter highway maintenance activities, and concentrations in the lower watershed reflect the influence of historic mining (in addition to winter maintenance activities). As previously discussed, Georgetown Lake apparently captures sediment and influences concentrations at the West Fork sampling point. The highest mean concentration of phosphorus is 0.6 mg/L and is associated with the Kermitt’s sampling point. Specific sources of suspended solids and phosphorus in Lower Clear Creek are likely to include nonpoint runoff from the I-70 highway, commercial facilities, historic mining, and natural sources.

4.5.5 Upper South Platte River Sub-Basin

Possibly the most relevant water quality regulation in the context of the I-70 highway is the Bear Creek Watershed Control Regulation No. 74 (5-CCR-1002-74, 1998). This control regulation covers all tributaries in the Bear Creek watershed including Mount Vernon Creek. Bear Creek Reservoir has a very high level of nutrients that cause algal blooms in the growing season, and the reservoir is characterized as eutrophic to hypertrophic. During summer stratification, the concentration of dissolved oxygen approaches zero throughout the hypolimnion (20 to 46 feet; 6 to 14 meters depth). These low-oxygen conditions have eliminated most of the coldwater habitat for aquatic life in the months of July, August, and September. Potential for recreation on and in the lake is limited under present conditions (CDPHE 1998b).

The total waste-load allocation for all point source dischargers of phosphorus in the Bear Creek watershed is 5,255 pounds total phosphorous per year, and point-source discharge of total phosphorus cannot exceed 1.0 mg/L (CDPHE 1998b). Nonpoint sources of phosphorus to Bear Creek Reservoir are estimated to be 50 percent or more of the annual load to the reservoir. The Bear Creek Basin Clean Lakes study (CDPHE Regulation No. 74, 5 CCR 1002-74, September 2001 update) indicated that there is a substantial nonpoint source loading of nutrients in the basin in areas where there are only very small wastewater point sources or no point-source discharges. For example, data indicate that runoff from the I-70 highway in Mount Vernon Canyon may be a nonpoint source of phosphorus to Bear Creek (Clear Creek Consultants, Inc. 2002a).

Upper South Platte Watershed/South Platte River Headwaters

The Corridor does not directly traverse the WQCD Upper South Platte Watershed/South Platte River Headwaters sub-basin. However, general water quality information is presented because the watershed, located in Park County, has the potential to be influenced indirectly by I-70 Mountain Corridor alternatives. Sixteen segments of the watershed have been designated and classified by WQCD. One segment (1b) includes wilderness area tributaries and is designated as *outstanding waters*. Six segments are *use-protected*.

Table 29 lists *impaired* waters for the Upper South Platte River watershed. Mining and roadway runoff are presented as sources of use impairment and are associated with the following pollutants: sediment, zinc, cadmium, lead, iron, manganese, and copper.

Table 29. Impaired Waters—Upper South Platte River Watershed

Water Body	Segment/ID	Pollutant or Condition	Sources	TMDL Project Status	Projected Completion Date
South Platte River—sources to North Fork	1 (COSPUS01A)	Sediment	Road runoff	TMDL available	June 2002
Mosquito Creek—source to Middle Fork	2 (COSPUS02B)	Zinc, cadmium, lead	Mining	TMDL available	August 2000
South Mosquito Creek—above Mosquito Creek	2 (COSPUS02C)	Cadmium, iron, zinc, manganese	Mining	TMDL available	August 2000
South Platte River tributaries—Tarryall Creek to North Fork	3 (COSPUS03)	Sediment	Road runoff	Pending Forest Service assessment	June 2004
North Fork and tributaries—source to South Platte River	4 (COSPUS04)	Aluminum, copper, zinc	Mining	Pending cadmium, iron, lead delisting	Submitted June 2002
Geneva Creek—Scott Gomer Creek to North Fork	5 (COSPUS05)	Copper, zinc	Mining	Pending	June 2008

Section 5. Environmental Consequences

5.1 Modeling Results

5.1.1 FHWA Stormwater Runoff Model Results

The FHWA model provides an estimate of the stream concentration occurring on average of once in three years to evaluate the significance of highway stormwater discharge. Because the absolute numbers are uncertain (see **Section 2.4.1**), the results are instead used to compare potential changes from existing conditions. This provides a relative comparison (in percentage change) between the various alternatives and the No Action Alternative.

The model also produces the mean runoff flow resulting from the event. The concentration values are specified as the maximum 1-hour average with a 3-year return period. The event flow was combined with the runoff concentration to calculate the event load in pounds. The purpose of the load calculation is to incorporate the increase in runoff volume resulting from additional impervious surfaces into the impact analysis. The load assumes a 1-hour duration, which is reasonable for most runoff events in the Corridor. *The emphasis is the relative change from existing conditions rather than the load value.* Therefore, the percentage change in constituent loading from existing conditions is the primary analysis method for quantifying potential impacts from various I-70 Mountain Corridor alternatives.

The model results for project alternative affected areas (see individual milepost-delineated segments) are presented in terms of increases (from existing I-70 conditions) in instream pollutant concentrations and loads. It is important to differentiate between the percent increases reported for specific areas of project alternative effects, and the summarized load increase results by watershed and the entire Corridor. The summarized results were calculated based on a mileage-weighted average (in load increases) for watershed areas along segments of the I-70 highway. Therefore, the summarized results indicate percentage changes in these areas only, not for entire watersheds or the entire Corridor length (termini). The summary percentage increases were specifically calculated for use in the comparison of alternatives.

A ranking of alternatives was developed for each watershed by using the percentage increase in stream *loading* (concentration times flow) for the 3-year storm event. The results for each watershed, along with an overall Corridor-wide ranking, are shown in **Table 29**.

The FHWA model results are consistent with current water-quality data for the Corridor streams in terms of both physical and chemical conditions. Results indicate that the stream chloride and dissolved copper and zinc concentrations resulting from highway runoff exceed water quality standards once in 3-years under existing conditions. Dissolved metal concentrations are greater in middle and lower Clear Creek than in other corridor streams. These concentrations increase for each I-70 expansion alternative. The increase is proportional to the amount of impervious surface associated with each alternative. For example, the minimal action alternative shows about a 2 to 5 percent increase in stream concentrations from existing conditions. The 6-lane widening with rail alternative could result in about a 3 to 9 percent increase in stream concentrations. Results indicate that potential increases in stream concentrations would be less that 12 percent for any of the proposed alternatives in the corridor.

Larger increases are predicted for constituent loading because the increase in highway runoff volume is combined with the potential concentration increases. The weighted percentage load increase from existing conditions for each alternative in each sub-basin is provided in **Table 29**. A ranking of alternatives was developed for each watershed by using the percentage increase in stream loading. A load increase of less than 10 percent was considered negligible (rank 1), 10-20 percent low (rank 2), 30-40 percent moderate (rank 4), and greater than 50 percent high impact (rank 6). Intermediate rankings were also incorporated. The results for each watershed along with an overall corridor-wide ranking are shown in **Table 30**.

Table 30. FHWA Highway Storm-Water Runoff Model Once In 3-Year Stream Concentrations and Loads

Alternative	Eagle River Average Loading Increase	Eagle River Ranking	Blue River Average Loading Increase	Blue River Ranking	Clear Creek Average Loading Increase	Clear Creek Ranking	Corridor Average Loading Increase	Corridor Ranking
Minimal Action	14%	2	0%	1	6%	1	7%	1
Rail	38%	4	30%	4	37%	4	35%	4
AGS	15%	2	11%	2	16%	2	17%	2
Bus	0%	1	4%	1	23%	3	9%	1
6-Lane Widening	0%	1	0%	1	27%	3	9%	1
Reversible Lanes	0%	1	0%	1	39%	4	13%	2
6-Lane/Rail	21%	3	8%	1	56%	6	28%	3
6-Lane/AGS	9%	1	2%	1	30%	4	14%	2
6-Lane/Bus	0%	1	4%	1	45%	5	17%	2

These results show a broad range of potential water quality impacts that are dependent on location and alternative. The highest localized water quality impacts would be for the combination 6-lane/rail alternative in Clear Creek. Clear Creek is impacted by more of the proposed alternatives than any other watershed. This is not surprising because the upper, middle, and lower sub-basins of Clear Creek would experience the largest increases in impervious surface (**Table 5**). The highest localized water quality impacts would be for the Combination Six-Lane Highway with Rail and Intermountain Connection Alternative in Clear Creek. Clear Creek would be affected by more of the proposed alternatives than any other watershed. The percentage increase in constituent loading is expected to be negligible (<10%) in the Blue River for several of the alternatives. The greatest potential water quality impact on a corridor-wide basis would be the rail alternative, which would have a moderate water quality impact in all watersheds.

The FHWA model features a highway treatment option whereby subroutines allow the user to select a type of control device and arrive at an estimate of the reduction in pollutant discharges it will provide. The SCAP developed for the Black Gore Creek and Straight Creek corridors rely extensively on detention dry basins for sedimentation (Clear Creek Consultants, Inc. 2002a). These sediment control devices, or structural best management practices, are effective in reducing suspended solids and total phosphorus in highway discharges. Phosphorus removal is related because more than 90 percent is associated with particulate matter and sediment.

Removal efficiency for similarly sized and spaced (every 0.3 miles) sediment basins as established in the SCAPs, sediment production rates from traction sanding, and site values for the runoff characteristics were combined in the FHWA model to estimate long-term average mass removal. This treatment was applied to existing conditions to assess the potential for reductions in TSS and phosphorus.

Model results for the mitigation analysis indicate that long-term reductions in highway runoff suspended solids and total phosphorus concentrations ranging from 30 to 70 percent are possible with appropriately implemented best management practices. The results for total phosphorus are similar to those for suspended solids because these parameters are positively correlated. These model results are consistent with reductions of up to 80 percent estimated in the SCAPs for Black Gore and Straight Creek.

The water quality modeling analysis for various I-70 alternative scenarios was last revised in October 2006. In light of recent changes in winter maintenance products and the resultant water quality changes, a review of the updated stream water quality data was performed. This review indicates that the highway runoff median and stream target concentrations used in the model were conservatively high enough to incorporate recent changes. For example, the site median chloride (210 mg/L) and stream target (860 mg/L) are consistent with any recent changes that have been measured. Any new data collected starting in 2002 falls within the ranges used for the original model input for the water quality parameters evaluated. Updated stream data shows that concentrations remain less than those predicted by the model.

The impervious surface associated with each project alternative has changed only minimally from previous model runs. Because the impacts are proportional to the impervious surface, the percentage increases in winter maintenance materials would remain unchanged, as well as the direct impacts on stream water quality. These are discussed further in Section 5, Environmental Consequences.

Further Tier 2 analysis of the various Action Alternatives may be warranted with respect to mitigation that would result in potential reductions to stream concentrations of priority constituents. Particular focus will be paid to control of sediments and related total phosphorous. Tier 2 processes may also include mitigation plans for metals removal, particularly in the Clear Creek watershed.

5.1.2 BASINS Model Results

All land use and cover types have the potential to produce at least small amounts of phosphorus loading. Highly developed or disturbed areas generally produce greater phosphorus loading to receiving streams. The phosphorus load is expressed in units of total pounds per year and in pounds per acre per year. The total load is generally proportional to the size of the drainage basin because all land use and cover types produce at least minor amounts of total phosphorus. However, the units are normalized as pounds per acre per year for comparison among the three Corridor watersheds. Both the existing (2000) and future (2025) annual phosphorus loading conditions are provided by HUC-6 watersheds in **Table 31, Table 32, and Table 33** for all land use and cover types. The locations of these HUC-6 watersheds and the BASINS results are provided by watershed in the *I-70 Mountain Corridor PEIS Cumulative Impacts Technical Report* (CDOT, August, 2010).

The total phosphorus loading contributed by the I-70 highway was calculated for each of the three river basins as shown in **Table 31, Table 32, and Table 33**. The I-70 influence area includes the entire potential disturbance zone including pavement, shoulders, and cut-and-fill slope areas. Note that the basin areas are defined specifically for the modeling study and are not necessarily equivalent to the entire HUC 4 sub-basin area.

Eagle River Watershed

BASINS model results for the Eagle River watershed are provided in **Table 31**. The I-70 highway contributes about 9 percent of the total phosphorus of the evaluated watershed area. Figure 4-10 and Figure 4-11 in Chapter 4 show results in pounds per acre by HUC-6 watershed for existing and planned land use, respectively. Developed areas along the I-70 highway indicate the greatest existing total phosphorus in pounds per acre. The Vail area (watershed codes 31 and 34) indicates the greatest existing phosphorus contribution from land use (0.35 to 0.449 lb/acre). The Eagle and Avon/Minturn areas (watershed codes 32, 24, 7, and 29) indicate phosphorus contributions from 0.25 to 0.349 lb/acre.

Phosphorus loads in the evaluated Eagle River watershed are expected to increase by 34 percent according to planned land use data. The greatest increase in phosphorus loading is associated with the

Avon/Minturn/Vail area along the I-70 highway (grid codes 23, 24, and 32) at levels greater than 0.45 lb/acre. Watersheds along SH 131 (grid codes 1 and 13) are also expected to increase (to 0.25-0.249 and 0.35-0.449 lb/acre categories).

Table 31. BASINS—Total Phosphorus (TP) Load—Eagle River Watershed in Eagle County

HUC-6 Sub-Basin Name	Grid Code	Drainage Area (acres)	Existing TP Load (lb/yr)	Existing TP Load (lb/ac/yr)	Future Land Use TP Load (lb/yr)	Future Land Use TP Load (lb/ac/yr)
Game Creek	48	2,698	343	0.13	436	0.16
Eagle River above Minturn	50	12,936	1,776	0.14	2,169	0.17
Two Elk Creek	51	10,069	401	0.04	460	0.05
Grouse Creek	53	6,737	577	0.09	588	0.09
Turkey Creek	57	18,601	624	0.03	717	0.04
Cross Creek	59	22,021	1,711	0.08	1,871	0.08
Fall Creek	68	6,950	271	0.04	271	0.04
Eagle River above Redcliff	71	2,614	140	0.05	282	0.11
Homestake Creek	72	31,293	1,638	0.05	2,152	0.07
Resolution Creek	77	7,450	332	0.04	332	0.04
Eagle River above Pando	80	6,300	906	0.14	945	0.15
East Fork	81	11,797	721	0.06	773	0.07
Yoder Gulch	82	2,463	115	0.05	115	0.05
South Fork	83	11,997	904	0.08	981	0.08
Upper Homestake Creek	84	9,221	549	0.06	549	0.06
Total Upper Eagle River		**163,146**	**11,007**	**0.07**	**12,641**	**0.08**
Buffehr Creek	16	2,715	126	0.05	203	0.07
Red Sandstone Creek	17	8,685	307	0.04	315	0.04
Middle Creek	18	3,785	128	0.03	131	0.03
Spraddle Creek	19	1,304	67	0.05	82	0.06
Booth Creek	20	3,889	400	0.10	404	0.10
Pitkin Creek	21	3,350	164	0.05	189	0.06
Bighorn Creek	22	2,890	214	0.07	332	0.11
Middle Gore Creek	31	5,527	1,980	0.36	2,310	0.42
Gore Creek Around West Vail	34	5,801	2,045	0.35	2,439	0.42
Upper Gore Creek	36	9,133	1,154	0.13	1,198	0.13
Mill Creek	42	4,813	1,523	0.32	1,523	0.32
Black Gore Creek	46	12,512	1,481	0.12	1,498	0.12
Total Gore Creek		**64,403**	**9,590**	**0.14**	**10,624**	**0.16**
Buffehr Creek	16	1	4	3.10	4	3.10

HUC-6 Sub-Basin Name	Grid Code	Drainage Area (acres)	Existing TP Load (lb/yr)	Existing TP Load (lb/ac/yr)	Future Land Use TP Load (lb/yr)	Future Land Use TP Load (lb/ac/yr)
Red Sandstone Creek	17	3	9	3.10	9	3.10
Middle Creek	18	2	6	3.10	6	3.10
Spraddle Creek	19	4	13	3.10	13	3.10
Booth Creek	20	2	8	3.10	8	3.10
Pitkin Creek	21	2	5	3.10	5	3.10
Bighorn Creek	22	2	7	3.10	7	3.10
Middle Gore Creek	31	231	716	3.10	716	3.10
Gore Creek Around West Vail	34	170	528	3.10	528	3.10
Upper Gore Creek	36	7	22	3.10	22	3.10
Black Gore Creek	46	311	964	3.10	964	3.10
Total I-70 Gore Creek		**735**	**2,282**	**3.10**	**2,282**	**3.10**
Ute Creek	8	3,216	258	0.08	312	0.10
Red Canyon Creek	9	3,666	169	0.05	742	0.18
Berry Creek	10	3,829	268	0.07	294	0.08
June Creek	11	3,950	258	0.07	314	0.08
Metcalf Creek	12	2,784	350	0.13	916	0.33
Eagle River above Wolcott	13	7,736	1,657	0.21	3,005	0.39
Buck Creek	14	2,995	156	0.05	406	0.14
Nottingham Gulch	15	2,256	92	0.04	226	0.10
Eagle River around Wilmore	23	3,917	872	0.22	1,927	0.45
Eagle River above Edwards	24	4,830	1,534	0.32	2,690	0.50
Eagle River below Avon	30	2,827	979	0.35	2,293	0.68
Eagle River above Avon	32	7,125	2,178	0.31	3,282	0.46
Squaw Creek	33	11,116	1,226	0.11	3,316	0.30
Lake Creek	38	31,359	2,833	0.09	4,230	0.13
McCoy Creek	41	2,971	144	0.05	1,065	0.33
Beaver Creek	45	9,387	1,384	0.15	1,959	0.21
Stone Creek	47	2,726	236	0.09	265	0.10
Total Middle Eagle River		**106,690**	**14,595**	**0.14**	**27,242**	**0.27**
Red Canyon Creek	9	1	4	3.10	4	3.10
Berry Creek	10	16	50	3.10	50	3.10
June Creek	11	3	10	3.10	10	3.10
Metcalf Creek	12	4	13	3.10	13	3.10
Eagle River above Wolcott	13	117	363	3.10	363	3.10

HUC-6 Sub-Basin Name	Grid Code	Drainage Area	Existing TP Load	Existing TP Load	Future Land Use TP Load	Future Land Use TP Load
		(acres)	(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)
Buck Creek	14	2	5	3.10	5	3.10
Nottingham Gulch	15	1	4	3.10	4	3.10
Eagle River around Wilmore	23	67	208	3.10	208	3.10
Eagle River above Edwards	24	77	240	3.10	240	3.10
Eagle River below Avon	30	60	185	3.10	185	3.10
Eagle River above Avon	32	151	469	3.10	469	3.10
Eagle River above Minturn	50	1	4	3.10	4	3.10
Total I-70 Middle Eagle River		**501**	**1,554**	**3.10**	**1,554**	**3.10**
Alkali Creek	1	20,270	3,251	0.16	5,459	0.27
Milk Creek	2	11,882	1,279	0.11	1,410	0.12
Eby Creek	3	10,228	1,632	0.16	1,920	0.19
Muddy Creek	4	8,572	455	0.05	536	0.06
Cottonwood Creek	5	11,165	1,852	0.17	2,015	0.18
Castle Creek	6	2,719	506	0.19	687	0.25
Eagle River above Eagle	7	15,827	4,120	0.26	4,849	0.31
Warren Gulch	25	4,892	402	0.08	490	0.10
Eagle River above Dotsero	26	10,204	2,415	0.24	2,614	0.26
Road Gulch	27	3,034	506	0.17	586	0.19
Bizarro Gulch	28	4,210	657	0.16	657	0.16
Eagle River above Gypsum	29	20,400	5,870	0.29	7,099	0.34
Brush Creek above Eagle	35	10,105	1,137	0.11	1,725	0.17
Lower Gypsum Creek	37	11,743	1,434	0.12	2,993	0.25
Abrams Creek	39	9,748	595	0.06	694	0.07
Third Gulch	40	5,871	327	0.06	374	0.06
Salt Creek	43	13,698	672	0.05	2,108	0.15
Spring Gulch	44	5,827	352	0.06	391	0.07
Brush Creek around Skim Milk	49	4,516	460	0.10	579	0.13
Bruce Creek	52	2,950	148	0.05	586	0.20
Old Mans Gulch	54	3,183	141	0.04	141	0.04
Frost Creek	55	2,438	90	0.04	90	0.04
Middle Gypsum Creek	56	5,879	294	0.05	383	0.07
Fish Pond Gulch	58	1,779	65	0.04	65	0.04
Beecher Gulch	60	3,331	116	0.03	118	0.04
East Brush Creek	61	20,810	949	0.05	1,014	0.05

HUC-6 Sub-Basin Name	Grid Code	Drainage Area	Existing TP Load	Existing TP Load	Future Land Use TP Load	Future Land Use TP Load
		(acres)	(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)
Miller Gulch Creek	62	2,515	125	0.05	133	0.05
Gould Creek	63	1,879	61	0.03	61	0.03
Lower West Brush Creek	64	8,185	544	0.07	570	0.07
Upper Gypsum Creek	65	6,329	287	0.05	339	0.05
Yates Gulch	66	1,530	73	0.05	73	0.05
Cherry Creek	67	2,633	248	0.09	248	0.09
Erickson Creek	69	1,707	97	0.06	110	0.06
Upper Gypsum Creek	70	9,058	346	0.04	346	0.04
Sourdough Creek	73	3,400	249	0.07	249	0.07
White Creek	74	2,788	137	0.05	137	0.05
McAllister Gulch	75	1,825	66	0.04	82	0.05
Red Creek	76	5,270	190	0.04	190	0.04
Upper West Brush Creek	78	8,328	638	0.08	638	0.08
Antones Cabin Creek	79	4,052	145	0.04	145	0.04
Total Lower Eagle River		**284,782**	**32,933**	**0.09**	**42,908**	**0.11**
Milk Creek	2	0.2	1	3.10	1	3.10
Eby Creek	3	5	16	3.10	16	3.10
Cottonwood Creek	5	12	37	3.10	37	3.10
Castle Creek	6	15	48	3.10	48	3.10
Eagle River above Eagle	7	323	1,001	3.10	1,001	3.10
Eagle River above Dotsero	26	303	939	3.10	939	3.10
Road Gulch	27	8	25	3.10	25	3.10
Bizarro Gulch	28	13	40	3.10	40	3.10
Eagle River above Gypsum	29	228	706	3.10	706	3.10
Total I-70 Lower Eagle River		**907**	**2,814**	**3.10**	**2,814**	**3.10**
Total Eagle River Watershed		**621,164**	**74,774**	**0.12**	**100,064**	**0.16**
Percent Increase					**34%**	
Total I-70		**2,143**	**6,650**	**0.01**	**6,650**	**0.01**
I-70 Percent of Total			**8.9%**		**6.6%**	

Note: I-70 contributions are broken out separately, are included in the watershed total, and do NOT change between existing and future TP loads.

Blue River Watershed

BASINS model results for the Blue River watershed are provided in **Table 32**. The I-70 highway contributes about 5 percent of the total phosphorus of the evaluated watershed area. Developed areas along the I-70 highway, SH 9, and SH 91 indicate the greatest existing total phosphorus in pounds per acre. The Silverthorne, Breckenridge, and mine tailings ponds (Robinson and Tenmile) areas (watershed codes 26, 39, and 51) indicate the greatest existing phosphorus contribution from land use (greater than 0.45 lb/acre). Areas upstream of Dillon, Silverthorne, and Blue River (watershed codes 29, 32 and 56) indicate phosphorus contributions from 0.35 to 0.449 lb/acre.

Phosphorus loads in the Blue River watershed are expected to increase by about 7 percent according to planned land use data. The greatest increase in phosphorus loading is associated with the Dillon/Frisco area along the I-70 highway (grid codes 29 and 28) at levels from 0.35-0.449 lb/acre. The watershed in the area of Blue River along SH 9 (grid code 56) is also expected to increase (to greater than 0.45 lb/acre).

Table 32. BASINS—Total Phosphorus (TP) Load—Blue River Watershed in Summit County

HUC-6 Sub-Basin Name	Grid Code	Drainage Area (acres)	Existing TP Load (lb/yr)	Existing TP Load (lb/ac/yr)	Future Land Use TP Load (lb/yr)	Future Land Use TP Load (lb/ac/yr)
Lower Blue River	1	30,799	3,833	0.12	3,833	0.12
Beaver Creek	2	6,576	479	0.07	479	0.07
Spruce Creek	3	7,038	590	0.08	590	0.08
Spring Creek	4	2,374	209	0.09	209	0.09
Deep Creek	5	7,377	288	0.04	288	0.04
Green Mountain Reservoir	6	22,497	3,375	0.15	3,375	0.15
Elliott Creek	7	9,516	358	0.04	358	0.04
Cataract Creek	8	9,696	531	0.05	531	0.05
Otter Creek	9	4,951	180	0.04	180	0.04
Black Creek	10	11,672	1,234	0.11	1,234	0.11
Total Lower Blue River		**112,496**	**11,077**	**0.08**	**11,077**	**0.08**
Brush Creek	11	5,253	484	0.09	484	0.09
Pass Creek	12	5,590	277	0.05	276	0.05
Middle Blue River	13	18,211	3,967	0.22	4,093	0.22
Squaw Creek	14	3,165	170	0.05	170	0.05
Slate Creek	15	10,512	1,065	0.10	1,065	0.10
Harrigan Creek	16	2,674	100	0.04	100	0.04
Acorn Creek	17	5,123	313	0.06	310	0.06
Quaking Aspen Creek	18	1,845	126	0.07	126	0.07
Boulder Creek	19	6,415	897	0.14	907	0.14
Rock Creek	20	9,967	1,355	0.14	1,355	0.14
Big Gulch	21	1,637	259	0.16	259	0.16
Pioneer Creek	22	1,565	178	0.11	178	0.11
Bushee Creek	23	4,129	149	0.04	149	0.04
Maryland Creek	24	2,040	87	0.04	87	0.04

HUC-6 Sub-Basin Name	Grid Code	Drainage Area (acres)	Existing TP Load (lb/yr)	Existing TP Load (lb/ac/yr)	Future Land Use TP Load (lb/yr)	Future Land Use TP Load (lb/ac/yr)
Total Middle Blue River		**78,125**	**9,426**	**0.09**	**9,559**	**0.09**
Willow Creek	25	8,622	891	0.10	950	0.11
Blue River in Dillon	26	6,912	3,963	0.57	5,426	0.79
Straight Creek	27	12,644	2,473	0.20	2,492	0.20
Salt Lick Gulch	28	2,946	1,132	0.38	1,166	0.40
Total Blue River at Silverthorne		**31,124**	**8,458**	**0.31**	**10,034**	**0.37**
Blue River in Dillon	26	37	125	3.39	125	3.39
Straight Creek	27	407	1,377	3.39	1,377	3.39
Salt Lick Gulch	28	64	217	3.39	217	3.39
Dillon Reservoir	29	98	333	3.39	333	3.39
Total I-70 Blue River		**606**	**2,052**	**3.39**	**2,052**	**3.39**
Dillon Reservoir	29	12,542	4,089	0.33	4,419	0.35
Frey Gulch	30	1,545	108	0.07	122	0.08
North Fork Snake River	31	10,190	1,773	0.17	1,782	0.17
Lower Snake River	32	5,394	2,048	0.38	2,181	0.40
Keystone Gulch	41	5,998	224	0.04	224	0.04
Middle Snake River	42	5,282	308	0.06	480	0.09
Jones Gulch	43	1,746	68	0.04	78	0.04
Peru Creek	44	9,655	461	0.05	461	0.05
Upper Snake River	46	9,713	691	0.07	691	0.07
Total Snake River above Dillon		**49,522**	**5,683**	**0.11**	**6,020**	**0.12**
Meadow Creek	33	3,337	333	0.10	333	0.10
North Tenmile Creek	34	7,723	404	0.05	404	0.05
Uneva Lake	35	1,976	257	0.13	257	0.13
Lower Tenmile Creek	36	3,423	1,043	0.30	1,044	0.30
Officers Gulch	37	2,182	231	0.11	231	0.11
West Tenmile Creek	48	16,721	3,462	0.21	3,502	0.21
Middle Tenmile Creek	49	10,438	1,788	0.17	1,839	0.18
Searle Gulch	50	3,526	275	0.08	275	0.08
Upper Tenmile Creek	51	6,803	9,781	1.44	9,781	1.44
Clinton Creek	52	5,143	584	0.11	584	0.11
Total Tenmile Creek above Frisco		**61,270**	**18,157**	**0.27**	**18,249**	**0.27**
Meadow Creek	33	28	94	3.39	94	3.39

HUC-6 Sub-Basin Name	Grid Code	Drainage Area	Existing TP Load	Existing TP Load	Future Land Use TP Load	Future Land Use TP Load
		(acres)	(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)
North Tenmile Creek	34	12	41	3.39	41	3.39
Uneva Lake	35	11	37	3.39	37	3.39
Lower Tenmile Creek	36	206	696	3.39	696	3.39
Officers Gulch	37	21	70	3.39	70	3.39
West Tenmile Creek	48	300	1,015	3.39	1,015	3.39
Total I-70 Tenmile Creek		**577**	**1,953**	**3.39**	**1,953**	**3.39**
Miners Creek	38	4,461	489	0.11	571	0.13
Blue River at Gold Hill	39	5,446	2,799	0.51	3,484	0.64
Soda Creek	40	5,500	548	0.10	812	0.15
Swan River	45	23,952	2,230	0.09	2,990	0.12
Barton Gulch	47	5,066	728	0.14	1,091	0.22
Cucumber Creek	53	2,099	449	0.21	643	0.31
Sawmill Gulch	54	1,520	424	0.28	484	0.32
French Gulch	55	7,102	1,232	0.17	1,629	0.23
Blue River at Breckenridge	56	10,423	4,428	0.42	4,870	0.47
Lehman Gulch	57	1,717	427	0.25	427	0.25
Spruce Creek	58	3,996	229	0.06	229	0.06
Indiana Creek	59	5,496	261	0.05	261	0.05
Pennsylvania Creek	60	2,767	187	0.07	187	0.07
McCullough Gulch	61	3,048	170	0.06	170	0.06
Monte Cristo Creek	62	3,674	424	0.12	424	0.12
Upper Blue River	63	2,291	428	0.19	428	0.19
Total Blue River above Dillon		**88,557**	**15,453**	**0.18**	**18,699**	**0.21**
Total Blue River Watershed		**434,819**	**76,348**	**0.18**	**82,062**	**0.19**
Percent Increase					**7%**	
Total I-70		**1,183**	**4,005**	**0.01**	**4,005**	**0.01**
I-70 Percent of Total			**5.2%**		**4.9%**	

Note: I-70 contributions are broken out separately, are included in the watershed total, and do NOT change between existing and future TP loads.

Clear Creek Watershed

BASINS model results for the Clear Creek watershed are provided in **Table 33**. The I-70 highway contributes about 6 percent of the total phosphorus of the evaluated watershed area. Figure 4-14 and Figure 4-15 in Chapter 4 show results in pounds per acre by HUC-6 watershed for existing and planned land use, respectively. Developed areas along the I-70 highway and along SH 93 in the area of Black Hawk and Central City and areas of historic mining areas indicate the greatest existing total phosphorus in pounds per acre. The Georgetown and Black Hawk/Central City areas (grid codes 12 and 8) indicate the greatest existing phosphorus contribution from land use (greater than 0.45 lb/acre). The Idaho Springs area (grid code 16) indicates phosphorus contributions from 0.35 to 0.449 lb/acre.

Phosphorus loads in the Clear Creek watershed are expected to increase by about 28 percent according to planned land use data. The greatest increase in phosphorus loading is associated with the Idaho Springs area along the I-70 highway (grid code 16) at levels greater than 0.45 lb/acre. Watershed areas between Idaho Springs and Georgetown (grid code 11) and along SH 119 downstream of Black Hawk (grid code 7) are also expected to increase (to from 0.35-0.449 lb/acre).

Table 33. BASINS—Total Phosphorus (TP) Load—Clear Creek Watershed Above Golden, CO

HUC-6 Sub-Basin Name	Grid Code	Drainage Area	Existing TP Load	Existing TP Load	Future Land Use TP Load	Future Land Use TP Load
		(acres)	(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)
Clear Creek Headwaters to South Fork	23	30,515	6,144	0.20	6,655	0.22
South Clear Creek	21	19,065	2,401	0.13	2,401	0.13
Total Upper Clear Creek		**49,579**	**8,545**	**0.16**	**9,056**	**0.17**
Total I-70 Upper Clear Creek	**23**	**453**	**1,532**	**3.39**	**1,532**	**3.39**
West Fork Clear Creek	9	29,302	4,874	0.17	5,323	0.18
Bard Creek	13	7,258	1,100	0.15	1,231	0.17
Total West Fork Clear Creek		**36,559**	**5,974**	**0.16**	**6,554**	**0.18**
Clear Creek South Fork to West Fork	12	5,233	3,133	0.60	4,534	0.87
Clear Creek West Fork to Fall River	11	7,125	1,908	0.27	2,660	0.37
Mill Creek	6	5,567	510	0.09	677	0.12
Trail Creek	14	2,367	258	0.11	280	0.12
Fall River	5	14,771	1,957	0.13	2,174	0.15
Total Middle Clear Creek		**35,062**	**7,766**	**0.24**	**10,325**	**0.33**
Fall River	5	2	6	3.39	6	3.39
Mill Creek	6	0.4	1	3.39	1	3.39
Clear Creek West Fork to Fall River	11	145	490	3.39	490	3.39
Clear Creek South Fork to West Fork	12	164	557	3.39	557	3.39
Total I-70 Middle Clear Creek		**311**	**1,054**	**3.39**	**1,054**	**3.39**
West Chicago Creek	20	8,866	522	0.06	522	0.06
Chicago Creek Headwaters to West Chicago Creek	22	9,637	1,043	0.11	1,689	0.18
Barbour Fork Creek	15	9,098	1,668	0.18	2,141	0.24
Chicago Creek West Chicago Creek to Mouth	18	12,149	2,510	0.21	2,670	0.22
Clear Creek Fall River to North Clear Creek	16	12,094	5,351	0.44	9,970	0.82
Total Lower Clear Creek		**51,844**	**11,095**	**0.20**	**16,993**	**0.30**
North Clear Creek Headwaters to Chase Gulch	1	15,380	2,245	0.15	2,245	0.15
Fourmile Gulch	2	1,000	183	0.18	183	0.18
Smith Hill Gulch	3	2,937	87	0.03	87	0.03
Chase Gulch	4	2,671	237	0.09	237	0.09
North Clear Creek Chase Gulch to Mouth	7	8,832	2,526	0.29	3,771	0.43
Eureka Gulch	8	2,252	1,338	0.59	1,338	0.59

HUC-6 Sub-Basin Name	Grid Code	Drainage Area (acres)	Existing TP Load (lb/yr)	Existing TP Load (lb/ac/yr)	Future Land Use TP Load (lb/yr)	Future Land Use TP Load (lb/ac/yr)
Russell Gulch	10	5,333	1,395	0.26	1,401	0.26
Total North Fork Clear Creek		**38,406**	**8,011**	**0.23**	**9,262**	**0.25**
Clear Creek North Clear Creek to Beaver Brook	17	25,696	6,811	0.27	8,028	0.31
Clear Creek Beaver Brook to South Table Mount	19	13,882	1,503	0.11	1,885	0.14
Total Lower Clear Creek US 6		**39,578**	**8,313**	**0.19**	**9,913**	**0.22**
Barbour Fork Creek	15	1	4	3.39	4	3.39
Clear Creek Fall River to North Clear Creek	16	299	1,012	3.39	1,012	3.39
Clear Creek North Clear Creek to Beaver Brook	17	276	936	3.39	936	3.39
Total I-70 Lower Clear Creek		**577**	**1,952**	**3.39**	**1,952**	**3.39**
Total Clear Creek Watershed		**378,853**	**81,416**	**0.21**	**103,870**	**0.27**
Percent Increase					**27.6%**	
I-70 Total		**1,340**	**4,538**	**0.01**	**4,538**	**0.01**
I-70 Percent of Total Watershed			**5.6%**		**4.4%**	

Note: I-70 contributions are broken out separately, are included in the watershed total, and do NOT change between existing and future TP loads.

Land development includes rural, urban, and commercial growth, as well as highway expansion. Model results indicate that the highest phosphorus loads occur in developed areas. These results are corroborated by water quality studies conducted in the Eagle River and Blue River watersheds (NWCCOG, 1995; Deacon et al. 1999; Clear Creek Consultants, Inc., 2002a; SWQC, 1991). Additional development is expected to exacerbate phosphorus loading unless effective mitigation measures are taken.

BASINS model results were compared to site-specific watershed data collected as part of the I-70 monitoring program to determine the reasonableness of the runoff and EMC values used in the model.

- A measured storm event on August 1, 2001, produced 233 lb/day of total phosphorus load from Black Gore Creek. This runoff event represented approximately 16 percent of the total annual Black Gore Creek phosphorus load predicted by the model.
- A measured storm event on July 7, 2001, produced 722 lb/day total phosphorus load from Straight Creek. This runoff event represented approximately 29 percent of the total annual Straight Creek phosphorus load predicted by the model.
- A storm event measured at Upper Clear Creek Station CC-1 on July 10, 2001, produced 1,522 lb/day total phosphorus load. This runoff event represented approximately 100 percent of the total annual phosphorus load predicted by the model for Upper Clear Creek.
- A storm event measured at Lower Clear Creek Station CC-4 on July 13, 2001, produced 11,456 lb/day total phosphorus load. This runoff event also represented almost 100 percent of the total annual phosphorus load predicted by the model for Lower Clear Creek.

These data suggest that a relatively large percentage of the annual load can be produced by only a few storm runoff events. However, because most of the available stream water quality data is for ambient conditions (nonstorm runoff), there are limited stormwater quality data available to corroborate the model results. Model results suggest that the runoff and EMC values used in the model may be too low for the Clear Creek watershed, resulting in the BASINS model under predicting the annual total phosphorus load. Because of the relatively large volume of unconsolidated mine waste in the watershed and associated higher potential for sediment mobility, the EMC, impervious terrain factors, or land cover types may need to be adjusted if the BASINS model is used to predict phosphorus loads as a water quality management tool. Nonetheless, the phosphorus loads estimated by the watershed model are considered reasonable for use in comparing relative differences between watershed areas and for assessing future changes in water quality according to land use.

Although the BASINS model provides total phosphorus loading predictions, these results are more valuable when used as screening information to assess the:

- Relative contribution of phosphorus loads from urban and rural areas
- Relative contribution of phosphorus loading from the I-70 highway
- General geographic areas where existing and future phosphorus loading is prevalent
- Potential percentage change in phosphorus loading from existing (2000) to future (2025) conditions

5.2 Direct Impacts

Direct impacts on water resources related to the Action Alternatives include:

- Increases in impervious surface area/roadbed expansion,
- New construction disturbances,
- Stream channelization,
- Impedance or blockage of cross-slope streams,
- Impacts from disturbance of historic mine waste materials, and impacts from transportation system operations and maintenance.

The Action Alternatives directly affect water resources through the introduction of sediments and other contaminants into the stream channels, as well as by physically affecting stream length by placing the road or its supports next to or in the stream channel. Changes in impervious surface and roadbed expansion are considered permanent impacts, whereas construction impacts are considered temporary. Construction impacts are discussed in **Section 5.4**.

5.2.1 Winter Maintenance Impacts to Water Quality

Winter maintenance calculations assume that the average application rate per unit area for sand and chemical deicers remains the same for all alternatives. This assumption is based on existing data that incorporate historic weather conditions and maintenance procedures for both four-lane and six-lane I-70 highway segments (Straight Creek and Mount Vernon/Beaver Brook). Although No Action projects would include some additional sand and deicer usage, such amounts are considered minimal in comparison with the Action Alternatives. The increase in material usage reflects the increase in the number of highway lanes and quantity of impervious surface in the guideway for the Dual-Mode or Diesel Bus in Guideway alternatives. Traction sand would be applied for the Rail with IMC; however, the amount used would be very minimal because it would be applied on the rail directly in front of the wheels as needed. No traction sand would be required for the AGS because it would be powered by a magnetic levitation system. Both the Rail with IMC and AGS alternatives are estimated to use the same amount of sand and deicer as their Minimal Action components. Although the absolute material volumes may change, these changes are proportional to the surface disturbance of the alternative. The percentage change from existing conditions (**Table 34**) will remain the same for each previously evaluated alternative.

Table 34summarizes winter maintenance impacts by alternative and watershed.

Table 34. Summary of Winter Maintenance Impacts

Alternative	Minimal Action	Rail with IMC/AGS	Dual-Mode or Diesel Bus in Guideway	6-Lane Highway 55 mph	6-Lane Highway 65 mph	Reversible/ HOV/HOT Lanes	Combination 6-Lane Highway/Rail or AGS	Combination 6-Lane Highway with Dual-Mode or Diesel Bus in Guideway
Eagle River Watershed (Eagle County Airport to Summit County Line, mp 133–190)								
Sand	19%	8%	4%	19%	17%	19%	19%	19%
Deicer	18%	11%	5%	18%	15%	18%	18%	18%
Blue River Watershed (Eagle County Line to EJMT, mp 190–213)								
Sand	6%	6%	6%	7%	7%	7%	7%	7%
Deicer	6%	6%	24%	8%	8%	8%	8%	24%
Clear Creek Watershed (EJMT to Genesee, mp 213–255)								
Sand	44%	8%	8%	62%	58%	72%	62%	62%
Deicer	28%	8%	73%	45%	41%	54%	45%	103%
Upper South Platte River Watershed (Genesee to C-470, mp 255–260)								
Sand	14%	3%	3%	14%	14%	14%	14%	14%
Deicer	14%	3%	44%	14%	14%	14%	14%	50%
Corridor Total								
Sand	23%	8%	7%	28%	27%	32%	28%	29%
Deicer	19%	8%	39%	26%	24%	30%	26%	55%

Denotes percentage increases from existing I-70 impervious surface and sand and deicer application amounts. The Rail with IMC alternative would use minimal amounts of sand and is estimated to be the same as its Minimal Action components. The AGS alternative would not require the use of sand or deicer and would be the same as its Minimal Action components.

5.2.2 Highway Runoff

Increased impervious surface could lead to increased runoff, affecting stream water quality and associated TMDL exceedances, public water supplies, fisheries, stream morphology, and wastewater treatment plant discharge permits. Any project alternative that would result in a potential increase in stream exceedance of water quality target goals, even if relatively minor, could be in direct conflict with existing or draft TMDLs. Areas of potential concern include existing impaired segments resulting from I-70 runoff (Black Gore Creek, Straight Creek, and Upper Clear Creek), and impaired segments resulting from historic mining in Lower Clear Creek that could be affected by construction disturbance of mining waste and mineralized rock, as well as the long-term operation of the transportation corridor. For the purposes of this analysis, Clear Creek is separated into upper, middle, and lower stream reaches as defined by the I-70 highway mileposts in **Table 15**.

Impacts from highway runoff are estimated by quantifying increased impervious surface area and winter maintenance material usage (increases in sand and liquid deicer). Highway stormwater runoff and associated increases in water quality pollutant concentrations, as well as loads in streams are quantified using the FHWA water quality model (see **Section 5.1** for a discussion of the FHWA stormwater model).

Notable differences in water quality impacts among Action Alternatives include:

- The elevated Advanced Guideway System Alternative results in fewer water quality impacts than the Rail with Intermountain Connection or Bus in Guideway alternatives. There is little additional impervious pavement and pier construction for the Advanced Guideway System Alternative, which requires less excavation that might loosen sediments.
- The Bus in Guideway alternatives result in fewer impacts than the Rail with Intermountain Connection Alternative because it is largely contained in the median (a previously disturbed area) and requires minimal excavation.
- The Highway alternatives have similar overall impacts due to comparable footprints. However, the Highway alternatives have more impacts on historic mine heavy metal sources that could be released into the waterways than just the Advanced Guideway System Alternative. These alternatives likely have fewer impacts compared to the Rail with Intermountain Connection Alternative because they will require more cuts into mine waste areas and mineralized rock by the roadway along the Middle and Lower Clear Creek stretches to accommodate the wider footprint. The strategy for winter maintenance of these lanes minimizes the additional deicers needed for the additional roadway.
- The Combination Six-Lane Highway with Rail and Intermountain Connection Alternative probably has the greatest direct impacts on water quality because of its greater impervious surface and potential to disturb historic mine waste materials because of its footprint width.
- The Combination Six-Lane Highway with Advanced Guideway System (Preferred Alternative Maximum Program) best meets the project's purpose and need and still has a limited footprint due to the Advanced Guideway System being on piers among the other Combination alternatives.

Sediment control structures that have been or will be built are expected to remove substantial amounts of total metals and particulate phosphorous. While the FHWA stormwater model may be a good predictor of mixing runoff volumes with receiving streams, a more rigorous assessment of the geochemical behavior of metals and phosphorous may be necessary at Tier 2. The current analysis focuses on the relative impacts of I-70 Mountain Corridor alternatives in different watersheds, not on the prediction of stream concentrations.

Runoff Monitoring Program to Estimate Future Impacts

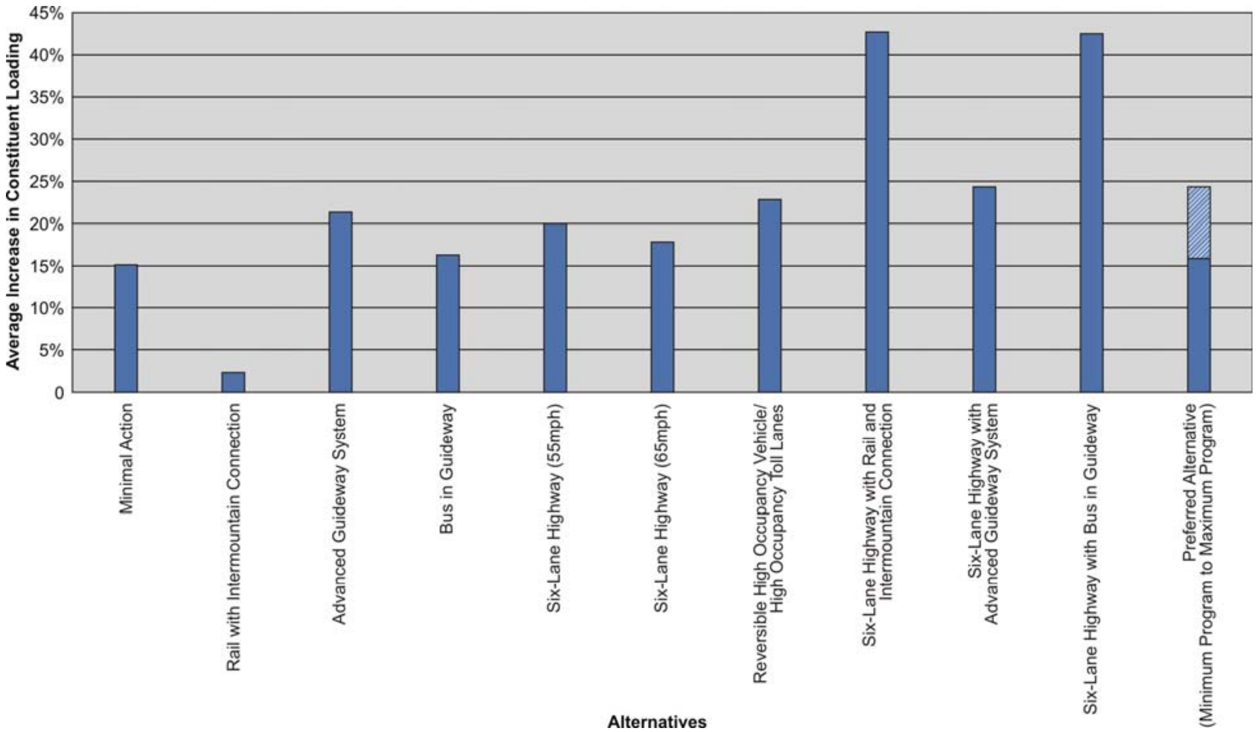
At the request of the CDPHE and the Environmental Protection Agency, a monitoring program conducted since 2000 measured actual direct snowmelt and stormwater runoff contaminants from the I-70 highway and their impacts on receiving streams. The data are explained in the *Data Evaluation Report Interstate 70 Mountain Corridor, Storm Event/Snowmelt Water Quality Monitoring 2000-2006* (Clear Creek Consultants, Inc. 2008). In addition, the results are described in the *Water Quality Modeling, I-70 PEIS Direct Impact Analysis* (Clear Creek Consultants, Inc., 2010), which includes 2010 updates to the monitoring data. The selected pollutants monitored include:

- Suspended solids (such as sediments that can carry other pollutants);
- Phosphorus (found in sediment and winter maintenance materials used on the I-70 highway and in fertilizers); and
- Chloride (from rock salt and liquid magnesium chloride deicers);
- Copper (from moving engine parts, brake linings and fungicides/insecticides); and
- Zinc (from tire wear, motor oil and grease).

The monitoring of existing conditions provides an estimate for future impacts from additional roadway capacity improvements. Current CDOT maintenance data indicates a major change in winter maintenance material usage in the recent years: there is a trend away from sand/salt toward more widespread use of sand/slicer mixture (a solid deicer that is more concentrated than rock salt) and liquid deicer salts. This shift decreases sediment and phosphorus loading in the high-elevation streams receiving I-70 highway runoff and increases chloride concentrations and loads in recent years exceeding the long-term aquatic life chloride standard.

Error! Reference source not found. shows the result of a sediment stream loading model run for the performance of the Preferred Alternative compared to the other alternatives being considered in this document. The adaptive management approach to implementation of the Preferred Alternative allows some or all of the components of the Preferred Alternative to be built as funding allows and as improvements are needed for the Corridor. Therefore, a range of impacts is shown on **Figure 14** for the Preferred Alternative. The No Action Alternative does not have sediment and hydrologic mitigation associated with it. The other Action Alternatives do have mitigation strategies, but the No Action Alternative still causes a continuing impact on water quality over time. The Minimal Action Alternative shows more of an impact on sedimentation than the Minimal Program for the Preferred Alternative because the Minimum Program for the Preferred Alternative does not include some of the improvements in the Minimal Action Alternative; that is, it does not include the Idaho Springs interchanges, Fall River Road curve, and the Empire to Downieville eastbound auxiliary lane improvements planned for Clear Creek County.

Figure 14. Predicted Corridor Stream Loading Impacts by Alternative



**Stream water quality loading increases were calculated using the FHWA water quality model. The load changes were based on stream concentrations and highway runoff from impervious surfaces. Although the No Action Alternative does not show an increase with regard to what is built for the project, there are indirect increases from land use changes and population growth that cause an increase in sediment loading. None of these columns include mitigation as part of the measure, which greatly reduces the sediment loading of any Action Alternative including the Preferred Alternative. Mitigation is not be included for the No Action Alternative and likely has a higher sediment loading after mitigation is considered over all of the Action Alternatives.*

Bar Chart Source: Clear Creek Consultants, Inc., 2010 and Clear Creek Consultants, Inc., 2004

5.2.3 Historic Mining

Possible disturbance of historic mine waste is discussed in the *I-70 Mountain Corridor PEIS Regulated Materials and Historic Mining Technical Report* (CDOT, August 2010). Tier 2 processes will be necessary to identify specific water quality impacts from disturbance of historic mine waste and associated avoidance/mitigation measures. Sediment control structures that have been or will be built are expected to remove much of total metals and particulate phosphorous.

5.2.4 Development and Urbanization

In all watersheds, the Corridor footprint and roadside cut and fill estimates of the Action Alternatives amount to less phosphorus loads on the system than any of the planned development land use categories; however, they amount to 12 percent to 30 percent of the total phosphorus loads expected at that time in the Corridor. Most of the impacts on water quality in Corridor streams are the result of planned urban and rural development, increasing point and nonpoint source loads of total phosphorus. For information on Cumulative Effects of actions planned in the area on water quality, see the *I-70 Mountain Corridor PEIS Cumulative Effects Technical Report* (CDOT, August 2010).

Combination alternatives (including the Preferred Alternative) are expected to distribute induced growth equally between the above transit and highway distribution scenarios that results in increased pressure on areas planned for rural development.

5.2.5 Channelization and Stream Flow

Channelizing, moving, or placing piers in the waterway also have an impact on water resources. **Table 35** lists these impacts by alternative and watershed. **Table 35** shows that the impacts resulting from the Preferred Alternative (Minimum Program of Improvements) are less than the impacts for the Minimal Action Alternative. The primary differences between the stream channel impacts from the footprint of these alternatives are to Clear Creek within Clear Creek County. The Minimal Action Alternative shows more of an impact on stream length than the Minimal Program for the Preferred Alternative because the Minimum Program for the Preferred Alternative does not include some of the improvements in the Minimal Action Alternative. It does not include the Idaho Springs interchanges, Fall River Road curve, and the Empire to Downieville eastbound auxiliary lane improvements planned for Clear Creek County. As a result, there is 0.4 miles less impact on stream channels. These impacts are based on the overall footprint area of alternatives and do not assume any mitigation or avoidance potential.

Table 35.Summary of Stream Channel Impacts (Miles)

Alternative	Clear Creek Watershed	Blue River Watershed	Eagle River Watershed	Total Impacts
No Action	0.0	0.0	0.0	0.0
Minimal Action	3.0	0.3	0.7	4.0
Rail with IMC	5.0	0.6	0.7	6.3
AGS	3.8	0.3	0.5	4.6
Dual-Mode Bus in Guideway	4.0	0.5	1.1	5.6
Six-Lane Highway (55 mph)	4.9	0.3	0.7	5.9
Six-Lane Highway (65 mph)	5.2	0.3	0.3	5.8
Reversible/HOV/HOT Lanes	5.5	0.3	0.7	6.5
Combination Six-Lane Highway with Rail and IMC	6.8	0.6	1.2	8.6
Combination Six-Lane Highway with AGS	6.5	0.3	0.9	7.7
Combination Six-Lane Highway With Diesel Bus in Guideway	6.2	0.5	1.2	7.9
Preferred Alternative[1]	2.6 to 6.8	0.3 to 0.3	0.7 to 0.9	3.8 to 7.7

[1]The Preferred Alternative is presented as a range because the adaptive management component allows it to be implemented based on future needs and associated triggers for further action. Chapter 2, Section 2.7 of the PEIS describes the triggers for implementing components of the Preferred Alternative.

Key to Abbreviations/Acronyms:
AGS = Advanced Guideway System HOT = High Occupancy Toll
HOV = High Occupancy Vehicle IMC = Intermountain Connection

Notable differences in stream length impacts among Action Alternatives include:

- The elevated Advanced Guideway System Alternative results in fewer water quality impacts than the Rail with Intermountain Connection or Bus in Guideway alternatives because there is little additional impervious pavement and pier construction for the Advanced Guideway System, which requires less of a footprint than either of the other alternatives.
- The Bus in Guideway alternatives results in fewer impacts than the Rail with Intermountain Connection Alternative because it largely is contained in the median (a previously disturbed area) and requires minimal expansion to the outside of the I-70 highway where the streams are located.
- The Highway alternatives have similar overall impacts due to comparable footprints.
- The Combination Six-Lane Highway with Rail and Intermountain Connection Alternative probably has the greatest direct impacts on stream lengths because of its footprint width.
- The Combination Six-Lane Highway with Advanced Guideway System (Preferred Alternative Maximum Program) best meets the project's purpose and need and still has a limited footprint due to the Advanced Guideway System being on piers among the other Combination alternatives. Additionally, although not specifically calculated for this alternative, there are better opportunities to minimize direct impacts on the stream because the impacts calculated in Tier 2 processes are more related to pier placement than to roadway width.

5.3 Indirect Impacts

Indirect water quality impacts are related to the induced growth that the completed project will bring to the area and include:

- The increase in impervious area causing additional runoff,
- Increased importation of water adding an unnatural volume to the waterways below, and
- Increased use of fertilizers and other chemicals that can be a source of contamination.

The No Action Alternative is expected to have the fewest indirect impacts, with the Minimal Action Alternative expected to have the next fewest indirect impacts. However, neither of these alternatives meets the purpose and need for the project.

Alternatives that include tunnels (Transit, Highway, and Combination) have considerable potential for indirect impacts related to highway operation and maintenance activities, as well as construction disturbance of geological substrate that could release pollutants into the waterways.

The Combination alternatives have the greatest amount of indirect impacts through induced growth, partly because of their effectiveness at moving more people through the Corridor.

Indirect water quality impacts from possible induced growth are more localized to areas of Eagle and Summit counties and vary with specific alternatives. Transit alternatives (including the Preferred Alternative with the adaptive management approach) may induce growth in urban areas with transit centers, including Eagle, Avon, Vail, Dillon, and Silverthorne, and increase stormwater runoff, phosphorus loading and sedimentation from these areas. Highway and Combination alternatives may induce more dispersed growth in rural areas, possibly leading to the greatest cumulative impacts on water quality from new development activities.

Coordination with planners in Garfield, Eagle, and Summit counties resulted in the following assumptions regarding the distribution of induced growth as it relates to the alternatives being considered:

- Transit alternatives (including the Preferred Alternative) concentrate induced growth in urban areas surrounding transit centers in areas of existing or planned urban development.
- Highway alternatives distribute growth based on existing trends for urban/rural development in each county, resulting in increased densities in rural areas of the Eagle and Blue River watersheds.
- Combination alternatives (including the Preferred Alternative Maximum Program of Improvements [Maximum Program]) are expected to distribute induced growth equally between the above Transit and Highway distribution scenarios, also resulting in increased pressure on areas planned for rural development.

The water resources indirect analysis included a cumulative water quality impact assessment using the BASINS model for each of the three major Corridor watersheds. The year 2000 land use was used to define the existing condition, while year 2025 land use projected by each county was used to evaluate changes.

The impact of planned land use on water quality is based on the potential for transportation alternatives to induce growth and development. Increased growth and development of cities generally result in an increase in impervious surfaces, which, in turn, can increase runoff and contamination of water bodies.

The BASINS model is used to assess changes in phosphorous loadings that are directly related to changes in land use based on county plans. Total phosphorous loads are expected to increase by 34 percent in the

Eagle River Watershed, by 7 percent in the Blue River Watershed, and by 28 percent in the Clear Creek Watershed as a result of planned land use to 2025. It is not anticipated at this time that county planning has developed substantially different projections beyond 2025 to warrant new modeling.

Figure 15 and **Figure 16** show the relative contributions to phosphorous loading in the three watersheds based on existing development, planned development, and the I-70 Corridor. **Figure 15** indicates total phosphorous loads resulting from existing development (2000 era), planned development through 2025, and the I-70 highway in terms of pounds of phosphorous per year. In **Figure 16**, the same information is presented as a percentage of total phosphorous loads resulting from development and the I-70 Corridor. Note that the Eagle and Blue Rivers lie within the Upper Colorado River basin, while Clear Creek falls in the South Platte River basin.

Most of the cumulative impacts on water quality in Corridor streams will be the result of planned urban and rural development, which increases both point and nonpoint source loads of total phosphorus. Impacts from the existing I-70 highway are generally included in the changes from existing to planned development in the BASINS modeling study.

Secondary water quality impacts from possible induced growth, which would be more localized to areas of Eagle and Summit counties, would vary with specific alternatives. Transit alternatives (including the Minimum Program) may induce growth in urban areas with transit centers, including Eagle, Avon, Vail, Dillon, and Silverthorne. Highway and Combination Highway/Transit alternatives may induce some amount of dispersed growth in rural areas, possibly leading to the greatest cumulative impacts on water quality from new development activities (including possible induced growth).

Figure 15. Water Quality Affected Environment, Total Phosphorus Loads

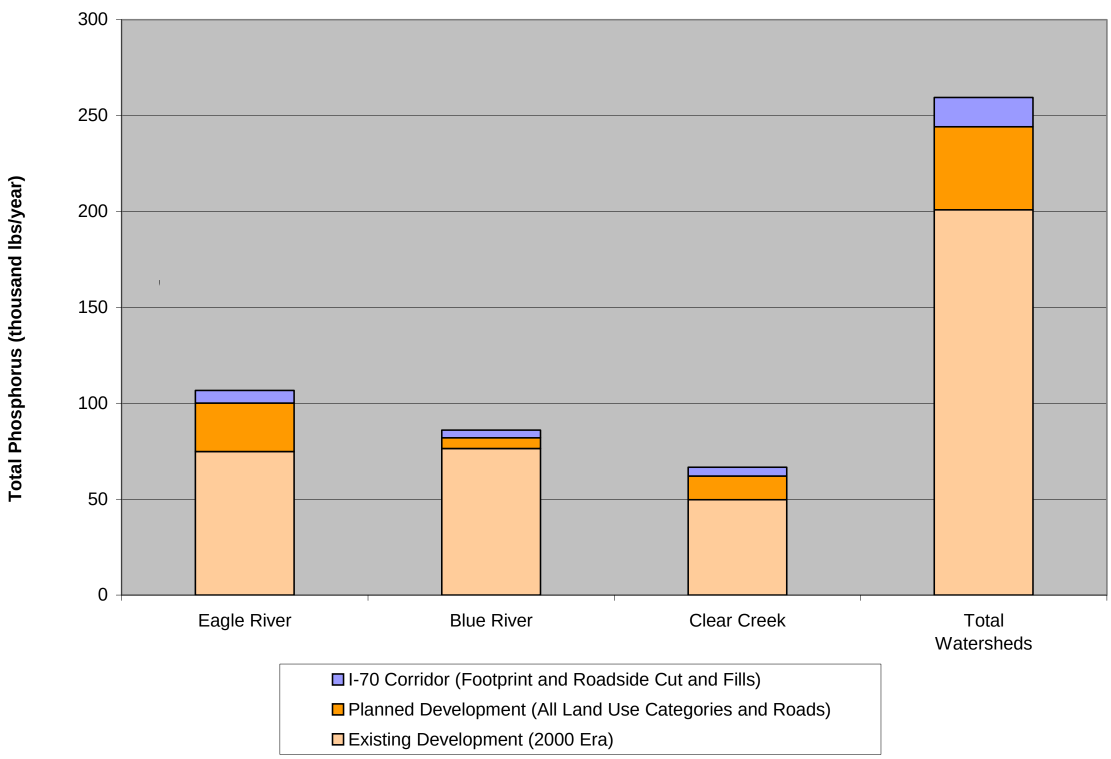
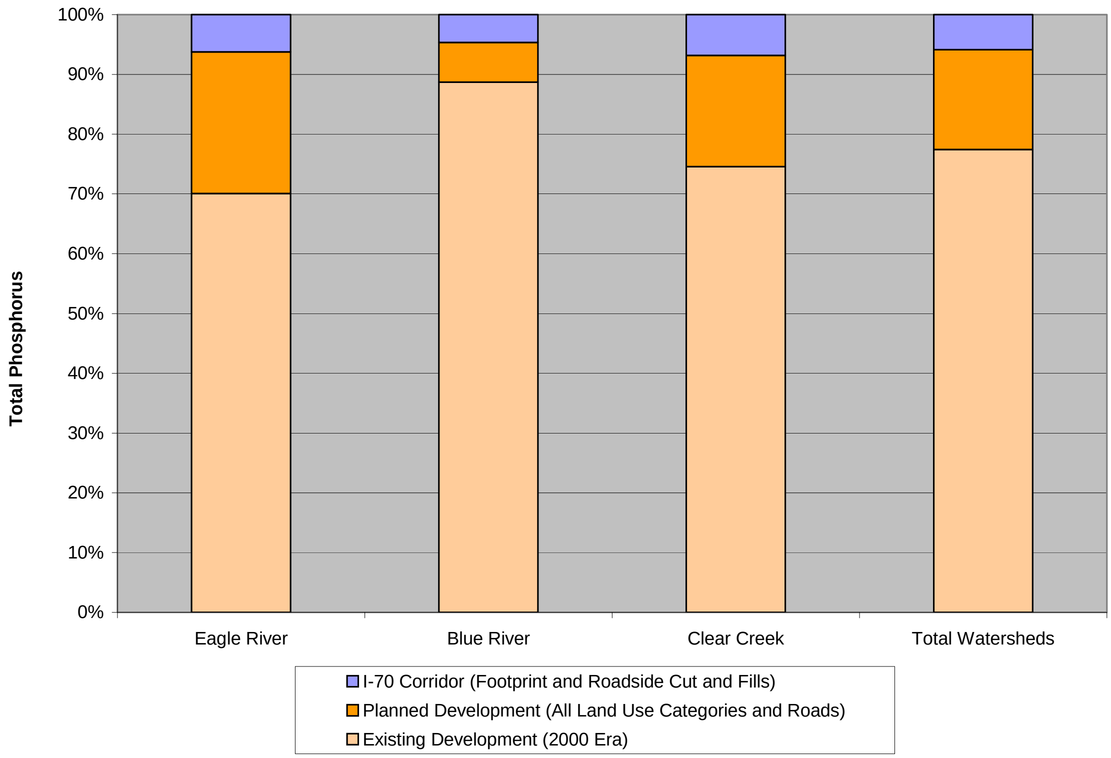


Figure 16. Water Quality Affected Environment, Percentage of Total Phosphorus Loads



5.3.1 Construction Impacts

Construction disturbance constitutes temporary sedimentation impacts on streams and water bodies caused by work that may be required in the stream and temporary crossing of the streams during construction activities. The use of best management practices along the edge of the streams will minimize other sediments from entering the stream from adjacent earth-moving activities. In some areas, such as along Lower Clear Creek where heavy metals are natural in the soil, these construction-related earth moving activities release these metals into the sediments so that temporary heavy metal loads could enter the stream with the other sediments from the project. Having equipment working so close to, and possibly working within, the streams may temporarily release oils and other petroleum products into the waters. Stormwater runoff from freshly poured concrete areas could temporarily slightly increase the alkalinity of the stream (this is the opposite of acidity). Although the project design minimizes permanent impacts on stream channels, project footprints might require additional channelization of the stream banks or pier placement for bridges within the stream flow.

5.3.2 Impacts in 2050

By 2050, streams could receive higher than-normal flows due to increased water importation and increased stormwater runoff due to increased impervious surface, caused by land use changes and population growth in the area. These changes in natural flows of the creeks and rivers may increase water scour of the waterways further adding sediment and soil minerals to the waterways system while not allowing these sediments and nutrients to settle out. Climate change could also have a negative impact on water resources by contributing to deforestation already started by the mountain pine beetle epidemic. The loss of trees could increase sedimentation of aquatic habitat along the Corridor during rain and snow-melt events due to lack of vegetative cover that holds the soil in place. Existing Sediment Control Action Plans for Black Gore and Straight Creeks do not protect all of the areas from increased sedimentation that could be affected by the alternatives. Implementation of Action Alternatives includes sediment control through the SWEEP program and also helps to address and correct the impacted hydrologic system of the watershed. Over time, the Action Alternatives improve water resources by helping the waterways manage sedimentation from some natural or man-made events in the Corridor. For more on cumulative effects, see the *I-70 Mountain Corridor PEIS Cumulative Effects Technical Report* (CDOT, August 2010).

Section 6. Tier 2 Considerations

In Tier 2 processes, it can be determined whether a stream channel will be affected by the proposed alignment and what kinds of mitigations could offset this impact. Likewise, the placement of permanent water quality features such as catchment basins could benefit the Corridor by repairing stream health and minimizing impacts of the projects.

Some of the water quality impacts cannot be further assessed until the transportation mode is selected and the pier placement or roadway cuts are identified. Therefore, the following information is more appropriate to investigate in Tier 2 processes:

- Reservoir impact analysis from phosphorus concentrations in highway runoff impacts water quality.
- A decreased in stream flow caused by drought conditions lowers the stream's ability to dilute contaminants and might lower the amount of acceptable pollutants allowed in the stream.
- Further analysis of permanent stormwater best management practices along the Corridor could verify that potential reductions to stream concentrations of priority constituents could be achieved by the alternatives beyond existing annual conditions.
- Floodplain analysis, in compliance with 23 CFR 650, will be conducted during Tier 2 processes.
- Potential water quality issues arising from disturbance of mine tailings and therefore, metal loading, will be covered in the Regulated Materials and Historic Mining analysis during the Tier 2 process.
- Tier 2 processes will evaluate and identify permanent mitigation measures for specific issues and could include structural controls (beyond the Black Gore Creek and Straight Creek Sediment Control Action Plan and the Clear Creek Sediment Control Action Plan that is currently under development).
- Tier 2 processes will include specific identification of stream disturbance during construction, including construction disturbance areas, channelized segments, pier placement, and structural modifications (for example, embankment walls, cantilevered sections, or elevated structural segments and bridges). The USACE requires compliance with the Clean Water Act that requires Section 404 permitting of temporary and permanent impacts on stream flow and channels.
- Tunnel discharges are typically considered point source discharges under the Clean Water Act, requiring one or more National Pollutant Discharge Elimination System permits. Further study will be necessary during Tier 2 processes to identify if any new tunnels will require National Pollutant Discharge Elimination System permits and/or water treatment systems. Water rights issues must also be considered in the context of water law for new groundwater discharges.
- Impacts associated with washout of sand onto bike paths will be addressed in Tier 2 processes.
- Impacts from Straight Creek runoff on the Blue River will be addressed in Tier 2 processes. These were not monitored for this analysis.
- The lead agencies will specify how the SWEEP Memorandum of Understanding mitigation strategies will be incorporated in the project design that will be detailed in the Tier 2 process.

More detailed site-specific studies may be required as new I-70 development projects are identified. For example, detailed mapping of stream channel and quantification of wetland features will be necessary to establish appropriate mitigation on a project-specific basis (Tier 2). Coring and sampling of the metal content of existing roadbed material will be required before major reconstruction of the I-70 highway to determine appropriate control strategies and to prevent release of toxic materials into the environment. This level of analysis is deferred until such time as project details are defined during Tier 2 and environmental clearances are necessary for specific areas.

Section 7. Mitigation

Local watershed initiatives would be incorporated into project alternative mitigation strategies, and mitigation would consider the goals of the local watershed planning entity. Best management practices implemented along the Corridor, for example, can be designed to address individual watershed entity concerns. In some cases, a monitoring program could be implemented to provide timely information needed for ongoing management and improvements of the watershed.

Increased impervious surface would have an impact on winter maintenance activities and stormwater runoff. Best management practices, highway maintenance strategies, and drainage/sediment control structures would be implemented as appropriate to minimize impacts from winter maintenance and increased stormwater. Methods of capturing and reducing the amount of salt/sand applied to the Corridor include structural sediment control and retrieval, automated deicing systems, solar snow storage zones, and porous pavement (CDOT, 2002; CDOT 2002a). Additional discussion of winter maintenance mitigation is provided in **Section 7.1**.

In Tier 2 processes, steps will be taken to safeguard intakes for public water supplies (includes alluvial wells associated with Corridor streams) in the immediate vicinity of the I-70 highway from sediment, deicers, and other constituents contained in highway runoff.

The Sediment Control Action Plans developed for the Black Gore Creek and Straight Creek I-70 corridors rely extensively on detention basins for the collection of sediment (CDOT 2002a; CDOT 2002b). These sediment control devices, or structural best management practices, are effective in reducing suspended solids and total phosphorus in highway discharges. Many of the sediment control measures specified in the SCAPs have already been successful in reducing sediment loads from the I-70 highway. Reductions have been measured in Straight Creek and Black Gore Creek. When the SCAPs are fully implemented, sediment load reductions of up to 80 percent are possible (CDOT, 2002; CDOT, 2002a). However, load reductions would be highly variable due to factors such as runoff distribution, drainage control, sand applications, maintenance procedures, and best management practices design. It is assumed that full implementation of SCAPs could occur in a more timely fashion with the development of an alternative than with the No Action Alternative. Tier 2 processes will evaluate and identify permanent mitigation measures for specific issues, including structural controls (beyond the Black Gore Creek and Straight Creek SCAPs).

Construction impacts would primarily be mitigated through the implementation of appropriate best management practices for erosion and sediment control according to the CDOT *Erosion Control and Storm Water Quality Guide* (CDOT, 2002b). According to the guide, a stormwater management plan (SWMP) must be developed before commencing with any major construction project that specifies water quality protection best management practices. Both structural and nonstructural control measures are described in the document to reduce water quality impacts from areas disturbed by construction. The SWMP may include monitoring of erosion and water quality during and after construction. Soil stabilization and revegetation measures are commonly employed to reduce long-term impacts from construction disturbance. Drinking water sources and special considerations such as instream flow requirements for fisheries will be evaluated in light of the I-70 highway construction requirements during Tier 2.

Construction disturbance would constitute temporary impacts on streams, whereas project alternative footprints could require permanent impacts such as channelization or pier placement for bridges. Tier 2 processes will include specific identification of stream disturbance during construction, including construction disturbance areas, channelized segments, pier placement, and structural modifications (for example, embankment walls, cantilevered sections, or elevated structural segments and bridges). The United States Army Corps of Engineers would require Clean Water Act (CWA) 404 permitting temporary and permanent impacts on stream flow and channels. New construction in areas that have been disturbed previously by the existing I-70 highway would provide opportunities for stream restoration measures that could improve stream environments and aquatic habitat. Stream restoration measures might include bank stabilization, the creation of drop structures (used to create riffle and pool areas), and revegetation of barren areas.

The initial construction of the I-70 highway through Corridor valleys resulted in the blockage or obstruction of numerous tributary streams. Many of the tributaries are ephemeral, flowing only after precipitation events. In some areas along the Corridor, these tributaries drain unconsolidated geologic materials that are subject to severe erosion and sediment or debris transport. Typical measures taken to convey tributary flows include installation of cross-drain culverts beneath the I-70 highway.

In the Clear Creek Watershed where these tributaries drain mine waste, the I-70 highway can serve as an effective sediment dam that reduces metal loading. These tributaries are prevalent along the I-70 highway between Idaho Springs and Silver Plume. If additional sediment control structures are installed and maintained in these areas, net cumulative improvements to water quality through reduced sediment metal loading could be realized.

Effective hydraulic design and maintenance measures would minimize impacts from tributary hydraulic disruption. For some alternatives, it may be possible to mitigate existing hydraulic problems, resulting in overall improvements to the transportation system and decreased environmental impacts.

Tunnel discharges are typically considered point source discharges under the CWA, requiring one or more National Pollutant Discharge Elimination System (NPDES) permits. This is presently the case for the I-70 Eisenhower-Johnson Memorial Tunnels, which requires a subterranean discharge permit. Further study will be necessary at Tier 2 to identify if any new tunnels will require NPDES permits and/or water treatment systems. Water rights issues must also be considered in the context of Colorado water law for new groundwater discharges.

The impaired waters under discussion are headwater streams that are worthy of protection for multiple uses, where ongoing monitoring for TMDL evaluation is essential. The true water quality impacts associated with the I-70 highway can be assessed only with a regular, long-term monitoring and evaluation program for physical, chemical, and aquatic life parameters. Information gathered from ongoing monitoring will enable CDOT to assess its winter maintenance practices and its effects on sediment loading and contaminants from liquid and solid salt deicers in streams adjacent to the I-70 highway. Monitoring should include the following:

- Annual fish and aquatic macroinvertebrate sampling at selected locations in each stream system. Changes will be evaluated over time with respect to the overall health of the aquatic system, relationship between biological and other factors, effects of changes in material usage, and compliance with regulations.
- Continuous stream gauging to determine the relationship with stream flow that directly affects water quality and aquatic biota.

- Continuous water quality monitoring using automated probes and focused seasonal sampling (similar to what is currently being conducted).
- Monitoring to evaluate compliance with TMDLs, stream standards, and regulations for protection of aquatic life and water supplies.

As a result of an increased use of chloride-based solid and liquid deicers, streams adjacent to the I-70 highway are currently receiving increasing chloride levels. These changes are likely to continue as different materials are used to maintain the roadway. Ongoing stream monitoring and evaluation will provide the data necessary to assess current and future impacts on water quality and will enable CDOT to assess its winter maintenance practices and resulting changes in sediment and contaminant loading in streams adjacent to the I-70 highway. Implementation of TMDL-required best management practices and funding of required monitoring and assessments will provide the information needed to assess overall stream health and should eventually result in the delisting of the water quality impaired streams in compliance with the CWA.

Colorado Department of Transportation Maintenance will continue to research alternative deicers and traction materials, as well as methods and their potential impacts on the adjacent environment. CDOT will also develop long-term directions to address the issue of increased contaminants in runoff to adjacent waterways. Updates from the Mitigation Issue Task Force and the SWEEP Committee will track these developments.

In addition, the phased approach of the Preferred Alternative allows for ongoing opportunities to avoid and minimize environmental impacts, establish effective mitigation, and employ context sensitive solutions.

7.1 Potential Winter Maintenance Mitigation Measures

CDOT’s winter maintenance group met on July 13, 2009, to discuss winter maintenance and water quality trends. The purpose of this meeting was to initiate possible future adjustments to winter maintenance practices in the Corridor that maintain a balance between driver safety and the influence of deicing salt/sand materials on the environment. The following notes indicate the strategies under discussion.

7.1.1 Trends in Water Quality

The trend in water quality reflects CDOT’s maintenance practice of less traction sand and more liquid and solid deicer salts. This change has resulted in higher chloride loading and a similar or slightly lower sediment loading since 2002. The sodium and magnesium chloride used in liquid and solid deicers are highly soluble and, therefore, the concentration in the runoff is high. The instream chloride concentration is the greatest in February, March, and April when flows are low and there is little dilution from snow melt. Conversely, the chloride concentration is the lowest in May and June due to greater runoff flows and dilution of the chloride.

The chloride from rock salt is still a contributing factor to chloride entering the streams. However, the change to ice slicer may have resulted in higher stream chloride concentrations. Salt washes out of the sand very quickly. Even though sand can be picked up, there is no proven method for removing the salt before it is washed out of the sand. Sand is needed for traction and will, therefore, continue to be a concern for water quality.

The chloride concentrations are the greatest in Black Gore Creek, ranging from 50 to 400 mg/L, and in Upper Clear Creek below Herman Gulch, ranging from 30 to 400 mg/L. There is a slight increasing trend in concentrations in these watersheds. The chloride concentrations in Straight Creek range from 30 to 250 mg/L, but the increasing trend is much higher than those reported in either Black Gore Creek or Upper Clear Creek. The chloride concentrations in West Tenmile Creek are much lower than those of the other streams and show a high in the early spring months of around 100 mg/L. The West Tenmile Watershed is larger than the Black Gore Creek Watershed, which provides a greater dilution factor, and the stream is a much further distance from the I-70 highway.

7.1.2 Operational Mitigation Measures

- **Early Closure –** Due to public safety concerns, Corridor communities and emergency response agencies increasingly support early road closure if a storm is expected to be severe. This would reduce overall material use since no material would be applied until the storm plays out. Operational efficiency can also be achieved by clearing snow and applying chemicals before opening the road where traffic interferes with maintenance operations.
- **Speed Management –** Use signage to control speed in difficult driving conditions and to reduce speeds approaching areas where traffic begins to back up.

7.1.3 Management of Sand and Deicer Materials

Based on Maintenance staff comments, the top three factors for controlling use of sand and deicers were (1) heavy traffic, (2) training/education, and (3) experience.

- **Heavy Traffic –** The general philosophy has been to keep the road open. Possible mitigation measures would include early road closure.
- **Training/Education –** Frequently, some operators tend to use more material than is needed, and material application is sprayed outside the travel lane. Due to high workloads for Maintenance staff, training must be short and focused. Discussion must balance keeping the roadway safe versus reducing use of deicers.
- **Experience –** Difficulty in keeping experienced Maintenance staff is the result of low pay (relative to adjacent municipalities), long hours, and perceived lack of respect from other CDOT staff. Turnover rates in the mountains are exceedingly high. Inexperienced operators tend to use far more material than experienced ones. Reduction in turnover will substantially reduce winter maintenance material use.

Possible mitigation measures would include initial planning for snowstorm events. The following variables were discussed in the meeting:

- It is possible to manage the amount of sedimentation by picking up and disposing of used traction sand; however, it is not possible to manage salt going into the stream except for percentage and type of salt used in the mix.
- Ice slicer is more concentrated than rock salt; therefore, consideration should be given to the type of salt used in salt/sand mixes.
- Liquid magnesium chloride can be more effective than solid salt but does not work in all conditions.
- Because chloride concentration varies among the different salt products, some type of conversion table would be useful for determining how much of a product is needed.

7.1.4 Other Management Considerations

- Additional weather stations are needed to determine the application amount. Problems exist with receiving weather signals in parts of the Corridor. Also, conditions vary substantially with elevation, even along a few miles of roadway. Drivers tend to spread materials to address the worst possible weather along a patrol length. More weather stations (and automated equipment) would allow the operators to vary materials usage within their patrols.

- Automated systems need to be installed on more equipment for operators to respond to differing weather conditions within their patrols. Currently, only 10 percent of the equipment used in the Corridor is automated. The other 90 percent of operators have to stop, leave the truck cab, walk to the back, and change the spreader/sprayer volume manually—all in the middle of snowstorms or blizzards. It is more efficient (and safer) for operators to set volumes to the largest amount needed and keep driving. Automated equipment would also help less experienced operators control materials use.
- Calibrated spreaders would eliminate guesswork.
- Consistent data are needed on truckloads to determine the effectiveness of the program. Driver fills out a logbook but it is based on his estimate rather than on any direct measurement. This has led to some differences between what is placed and what is reported in the SAP system. Because TMDLs are based on sand usage, consistent data are critical to meeting regulations. An automatic data recorder could be used for bucket loader size. A scale for the loader buckets would provide a better means for tracking material usage. A weight scale could be used for the truck; however; this option needs to consider the conditions of the truck and material being loaded when either is covered with snow or frozen material.
- Contractor removal of the sand has proven to be very expensive. Cost-benefit of increasing CDOT maintenance sand cleanup costs needs to be evaluated as a tradeoff against contractor costs.
- Options need to be evaluated consistently for net present value.

7.1.5 Maintenance of Future Auxiliary Lanes

In areas where auxiliary lanes are planned (**Table 36**), CDOT Maintenance has suggested that at times the fast lane would be plowed with little or no sand or deicer material applied. Material would be applied to the other two lanes to keep them open to vehicles that cannot handle snow conditions or to drivers who prefer to take less risk because of the road conditions. Therefore, adding a third lane may not result in a direct correlation for an additional 33 percent of sand or deicer material. Depending on how the roadway is maintained, the actual factor may be closer to a 10 percent increase.

Table 36. Proposed Auxiliary Lane Locations

Location	Eastbound	Westbound
West Vail Pass	mp 180–190	mp 180–190
Frisco to Silverthorne	mp 203–205	
EJMT	mp 216–218.5	mp 216–221
Empire to Downieville	mp 232–234	mp 232–234
Mount Vernon Canyon		mp 252–258

7.2 Mitigation Commitments

The Colorado Department of Transportation will incorporate the following strategies to minimize and avoid potential environmental impacts on water resources from the proposed project.

- Water quality and water resource mitigation strategy recommendations from the *Draft Stream and Wetland Ecological Enhancement Program (SWEEP) Memorandum of Understanding* (CDOT, et al 2009) (but may be modified in the final Memorandum of Understanding) are adopted by the lead agencies for this Programmatic Environmental Impact Statement. The Colorado Department of Transportation is leading the primary effort to initiate the SWEEP, facilitating open discussions and working relationships to accomplish stream mitigation goals and providing technical support and funding mechanisms. These mitigation strategies include, but are not limited to, sedimentation control and stream restoration measures.

- The lead agencies will work cooperatively with various local, state, and federal agencies and local watershed groups to avoid further impacts on and possibly improve Clear Creek water quality, including management of impacted mine waste piles and tunnels within the Corridor and through the use of appropriate best management practices during storm water permitting.
- Local watershed initiatives will be incorporated into site-specific Action Alternative mitigation strategies, and mitigation will consider the goals of the local watershed planning entity. Detention basins for the collection of sediment as outlined in the Sediment Control Action Plans developed for the Black Gore Creek and Straight Creek corridors (the Clear Creek Sediment Control Action Plan is under development) will be part of the mitigation strategy for this Corridor. Sediment Control Action Plans could be implemented concurrently with development of an Action Alternative and will consider drinking water source protection.
- The Colorado Department of Transportation will mitigate construction impacts primarily through the implementation of a Stormwater Management Plan that proposes appropriate best management practices for erosion and sediment control according to the *CDOT Erosion Control and Storm Water Quality Guide* (CDOT, 2002b). Appropriate water quality protection best management practices must be in place to protect water quality before construction begins and remain until the site is stabilized and vegetation has regrown.
- Efforts will be included in further design phases to minimize impacts on water quality and other water resources by refining placement of roadway and road piers to avoid impacts when feasible.

Section 8. References

Baroga, E.V. 2004. *Washington State Department of Transportation's 2002–2003 Salt Pilot Project.* Transportation Research Circular No. E-C063. June.

Blackburn, R.O., D.E. Amsler, Sr., and K.M. Bauer. 2004. *Guidelines for snow and ice control materials and methods.* Transportation Research Circular No. E-C063. June.

Clear Creek Consultants, Inc. 2000. *Interstate 70 Mountain Corridor Runoff Event Baseline Water Quality Monitoring Plan*. Prepared for J.F. Sato and Associates and CDOT. July.

—. 2001. *Data Summary Report—2000, I-70 PEIS Storm Water Quality Monitoring.* Prepared for J.F. Sato and Associates. February.

—. 2002a. *Data Summary Report—2001, I-70 PEIS Storm Water Quality Monitoring*. Prepared for J.F. Sato and Associates. December.

—. 2002b. Information collected from CDOT Maintenance personnel and the MMS database system for winter maintenance activities from 1996 to 2002.

—. 2004. *Water Quality Modeling, I-70 PEIS Direct Impact Analysis*. February.

—. 2010. *Water Quality Modeling, I-70 PEIS Direct Impact Analysis (Addendum)*. March.

Colorado Department of Public Health and Environment (CDPHE). 1988. *1987 Colorado nonpoint source assessment report.* CDPHE Water Quality Control Division.

Colorado Department of Public Health and Environment (CDPHE). 1997. *State of the watershed report, Clear Creek.* USEPA Region 8.

—. 1998. *Colorado Wastewater Discharge Permit System Number CO-0042731 Second Renewal*. Summit County, CDOT Vail Pass Rest Area, Water Quality Control Division.

—. 2000a. *State of Colorado Source Water Assessment and Protection Program Plan.* CDPHE Water Quality Control Division. May.

—. 2002a. *Classification and Numeric Standards South Platte River Basin*, Regulation No. 38. *Classification and Numeric Standards Upper Colorado River Basin* Regulation No. 33, 2. CDPHE Water Quality Control Commission.

—. 2002b. *Status of water quality in Colorado* surface water assessment. CDPHE Water Quality Control Commission.

—. 2005. *Implementation Guidance for Determining Sediment Deposition Impacts to Aquatic Life in Streams and Rivers*. May.

—. 2008. Water Quality Control Commission. 5 CCR 1002-93. Regulation #93. Section 303(d) List Water-Quality-Limited Segments Requiring TMDLs. March.

Colorado Department of Transportation (CDOT). 1993. *Sediment Pond Maintenance.* Straight Creek Erosion Control Project STE(CX) 070-3(197).

—. 1996. *Efficiency of the Sediment Basins Constructed as Part of the Straight Creek Erosion Control Project.* Final report. January.

—. 2001. *Eisenhower/Johnson Memorial Tunnels, total flow during spring runoff.* Datasheets.

—. 2002. *Sediment Control Action Plan, Straight Creek I-70 Corridor*. Prepared in cooperation with Clear Creek Consultants, Inc. and J.F. Sato and Associates. May.

—. 2002a. *Sediment Control Action Plan, Black Gore Creek I-70 Corridor*. Prepared in cooperation with Clear Creek Consultants, Inc. and J.F. Sato and Associates. May.

—. 2002b. *Erosion Control and Stormwater Quality Guide*.

—. 2003. *Colorado Department of Transportation Anti-Icing and Deicing Standard Operating Guide, Part II.*

—. 2004. *Data evaluation report, interstate 70 storm event/snowmelt water quality monitoring, 2002-2003.* Clear Creek Consultants, Inc. and J.F. Sato and Associates (for CDOT Region 1). August.

—. 2008. *Data Evaluation Report, Interstate 70 Mountain Corridor Storm Event/Snowmelt Water Quality Monitoring 2000-2006*. Prepared in cooperation with Clear Creek Consultants, Inc. and J.F. Sato & Associates, January.

CDOT, FHWA, USFWS, USFS, BLM, CDOW, Clear Creek County, Clear Creek Watershed, UCCWA, and Trout Unlimited. 2009. Draft Stream and Wetland Ecological Enhancement Program (SWEEP) Memorandum of Understanding. November 11.

Colorado Water Conservation Board (CWCB). 2008. Senate Bill 07-122: Exhibit A, Water Availability Study of the Colorado River and Tributaries Phase 1 Scope of Work. August.

Deacon, J.R., and Mize, S.V. 1997. *Effects of water quality and habitat on composition of fish communities in the upper Colorado river basin.* USGS. 1997.

Driscoll, E.D., P.E. Shelley, and E.W. Strecker. 1990. *Pollutant loadings and impacts from highway stormwater runoff*. FHWA final report FHWA-RD-88-006, 61 pages.

Environment Canada. 2000. *Canadian Environmental Protection Act. 199 Priority Substance List Assessment Report—Road Salts.* Draft for public comments. Internet website http://www.ec.gc.ca/ceeb1/eng/public/road_salts.html. August.

Federal Highway Administration (FHWA). 1990. *Analytical Investigation of Pollutant Loadings and Impacts from Highway Stormwater Runoff: Research Report.* FHWA-RD-88-008. US Department of Transportation, Federal Highway Administration, Washington, DC.

FHWA. 1996a. *Manual of Practice for an Effective Anti-Icing Program: A Guide for Highway Winter Maintenance Personnel.* Publication No. FHWA-RD-95-202.

Fischel, M. 2001. *Evaluation of Selected Deicers Based on a Review of the Literature*. Report No. CDOT-DTD-R-2001-15. October.

Highway Innovative Technology Evaluation Center. 1999. *Summary of Evaluation Findings for the Testing of Ice Ban@: Technical Evaluation Report for the Civil Engineering Research Foundation.* Report No. 40410. September.

Hydrosphere Resource Consultants (HRC), Inc. 2003. *Upper Colorado River Basin Study Phase II Final Report*. May.

J.F. Sato and Associates. 2002. *Draft - An inventory of I-70 Mountain Corridor Water Resource-Related Issues for Clear Creek.* Prepared for CDOT. February.

Lewis, W.M. 1999. *Studies of Environmental Effects of Magnesium Chloride Deicer in Colorado*. Report No. CDOT-DTD-R-99-10. November.

Lewis, W.M. 2001. *Evaluation and Comparison of Three Chemical Deicers for Use in Colorado*. Report No. CDOT-R-2001-17. August.

Lorch, B. 1998. *Transport and Aquatic Impacts of Highway Traction Sand and Salt Near Vail Pass, Colorado*. Colorado State University, Department of Earth Resources—Watershed Sciences.

National Response Center. 2002. Internet database http://www.nrc.uscg.mil/nrchp.html.

NPS. 1996. *Eagle River Watershed Plan*. NPS River, Trails, and Conservation Assistance Program.

NWCCOG. 1995. *Vail Nonpoint Source Water Quality Management Plan*.

—. 1996. *Regional Water Quality Management Plan*.

—. 1998. *Eagle River Water Quality Management Plan*. April.

—. 2002. *Final Eagle River Water Quality Management Plan*. December.

Peterson, C., and N. Trahan. 2004. *Factors Impacting the Health of Roadside Vegetation*. Study No. 41.70, Progress Report for 4/01/04–6/30/04. 5 pages.

Resource Consultants and Engineers, Inc. (RCE), et al. 1993. *Draft Report, Straight Creek Sedimentation Investigation.* December.

Stidger, R.W. 2002. *The State of the State's Anti-Icing Technology, Better Roads.* Vol. 72, No.4.

SWQC. 1991. *Water Quality Monitoring of Straight Creek from 1985 to 1989.* Monitoring report.

TDS Consulting Inc. (TDS). 2006. *Upper Clear Creek Watershed Plan Revised Final Report*. Prepared for the Upper Clear Creek Watershed Association on Behalf of the Colorado Department of Public Health and Environment, Water Quality Control Division, and the United States Environmental Protection Agency. February.

Upper Clear Creek Watershed Association (UCCWA). 2000. *UCCWAG Technical Final Report*.

—. 2001. *Clear Creek Watershed Management Agreement 2000 annual report.*

—. 2002. *Water Quality Data FROM Ongoing Studies in the Clear Creek Watershed.* Data made available to Clear Creek Consultants, Inc. 2002.

United States Environmental Protection Agency. 1988. *Ambient Water Quality Criteria for Chloride-1988.* Office for Research and Development. Environmental Research Laboratory. Duluth, Minnesota. EPA 440588001.

—. 2001. *Better assessment science integrating point and nonpoint sources (BASINS) version 3.0, user's manual.* EPA 823-B-01-001. June 2001

—. 2002. *Revision of national recommended water quality criteria.*

United States Forest Service (USFS). 2007. *TMDL Monitoring Results 1992 to 2006, Straight Creek, CO, Final Report.* USEPA IAG No.: DW-12-95394501-0, USFS IAG No.: 06-IA-11020000-032. Submitted by: Gregory J. Laurie, White River National Forest, Silverthorne, CO. May.

United States Geologic Service (USGS). 2000. *Effect of Georgetown Lake on the water quality of Clear Creek, Georgetown, Colorado, 1997–98.* USGS water-resources investigations report 00-4109.

—. 2001. *Gore Creek watershed, Colorado—assessment of historical and current water quantity, quality, and aquatic ecology, 1968–98.* USGS water-resources investigations report 99-4270.

Upper Clear Creek Watershed Association. 2003. *Total phosphorous loadings comparisons, upper Clear Creek watershed.* Project No. 9622-98. Technical memorandum to Rick Fendel, UCCWA Chairman, from Tim Steele, TDS Consulting, October 24 (revised November 12).

URS. 2008. *Energy Development Water Needs Assessment (Phase I Report)*. Prepared for Colorado, Yampa, and White River Basin Roundtables. September.

Xi, Y., and Z. Xie. 2002. *Corrosion Effects of Magnesium Chloride and Sodium Chloride on Automobile Components*. Report No. CDOT-DTD-R-2002-4. May.

This page intentionally left blank.

One appendix supports the *I-70 Mountain Corridor PEIS Water Resources Technical Report*:

Appendix A provides a compilation of available water resources information to provide an overview evaluation of the potential of water availability to influence future growth in the Corridor, and to supplement the induced growth analysis contained in **Chapter 3, Section 3.7**, Land Use and Right of Way, and **Chapter 4**, Cumulative Impacts, of the PEIS, as well as those supporting technical reports: *I-70 Mountain Corridor PEIS Land Use Technical Report* and *I-70 Mountain Corridor PEIS Cumulative Impacts Technical Report*. Tabulated data for existing and future projected water supply needs in the Corridor were evaluated using existing information from multiple water planning agencies. The land use analysis used the Oregon Department of Transportation *Guidebook for Evaluating the Indirect Land Use and Growth Impacts of Highway Improvements* (2001) as a guide, and that book recommends that a variety of different factors be considered to determine whether they would constrain or encourage additional growth. The ones discussed in the land use analysis are public policy, geography, the large amount of public lands, and water availability. The analysis remains a valid discussion of the influence of water availability on growth despite the fact that the data are old. The intent of the analysis is not to provide a quantitative discussion, which requires current projections and modeling, but to provide a representation of the water availability factors that could influence growth in the Corridor. The analysis may exaggerate the issue because 2002. Because the recent economic downturn has resulted in relatively flat growth through the latter half of the decade, and the 2002 drought is represented in the data analyzed, the data still remain a fairly accurate characterization of water resources in the Corridor.

This page intentionally left blank.

Appendix A. Overview of Water Availability and Growth

This page intentionally left blank.

Table of Contents

List of Charts

List of Tables

This page intentionally left blank.

A. Overview of Water Availability and Growth

A.1 Water Availability and Growth

A compilation of available water resources information was performed to evaluate the potential of water availability to influence future growth in the Corridor. Although tabulated data for existing and future projected water supply needs are available for the major water basins in the Corridor (South Platte River and Colorado River basins) from the Colorado Water Conservation Board (CWCB), more detailed CWCB tabulated water data are not currently available for the specific Corridor area. No single source of comprehensive and consistent water resources information is available for the area of interest. Therefore, information was gathered from numerous sources including Denver Regional Council of Governments (DRCOG), Northwest Colorado Council of Governments (NWCCOG), individual water and sanitation districts, Corridor conservation districts, Corridor communities and counties, Colorado Division of Water Resources (DWR), US Environmental Protection Agency (EPA), and US Geological Survey (USGS), in an effort to obtain the most detailed and up-to-date data available for this analysis.

Although the information provided in this report is a composite of numerous sources and methodologies, it contains the best data available at the present time. The focus of the report is not to rely on quantitative data regarding water resources availability in the Corridor area, but rather to determine if any general indicators and issues may be discerned. The CWCB is in the process of conducting a *Colorado Drought and Water Supply Assessment* to determine whether Colorado has enough water to meet its existing and future needs. Recent CWCB assessment activities include a scope of work for the *Statewide Water Supply Initiative* (CWCB 2003). The work includes development of project objectives, performance of statewide and basin inventories, alternatives identification and evaluation, and implementation strategies.

The information in this report indicates that water resources (including quantity and quality issues) and associated infrastructure, including water treatment and wastewater treatment, are likely to influence future land development patterns in watersheds intersecting the Corridor. Water resource factors that may influence growth and development in the Corridor include water rights appropriations (water available for use), water quality issues, and public water infrastructure, including treatment plants, public supply systems, and wastewater treatment facility infrastructure. These factors are interrelated on many levels, and the findings of this report are summarized below. Because data were obtained from numerous sources, various discrepancies exist. However, such discrepancies do not overshadow support for the major conclusions of this report.

A.1.1 Water Shortage Indicators

- The recent *Upper Colorado River Basin Study* (Hydrosphere Resource Consultants, 2003) indicates a need for additional water supplies in Grand and Summit counties for existing and future municipal demands, as well as instream flows to support the area's recreational uses and maintain low-flow levels used to determine waste load allocations for wastewater treatment plants (WWTP).
- Under future conditions, nearly 66 percent of providers in Summit and Grand counties are expected to have demands that exceed their current water rights and/or water availability (Hydrosphere Resource Consultants 2003). The largest shortages are predicted for the Fraser River upstream of Tabernash, Blue River upstream of Dillon Reservoir, Snake River upstream of Dillon Reservoir, and Tenmile Creek upstream of Dillon Reservoir.
- Mountain communities (including Georgetown), as well as rural well users, in Clear Creek County encountered problems meeting existing water needs during the drought of 2002. County assistance was provided during the summer to meet minimum demands. The county is pursuing

avenues to obtain water rights and develop new storage facilities to meet future needs (Clear Creek County, 2002).

- Although existing water storage capacity in the Eagle River watershed is generally adequate to satisfy current water supply augmentation requirements, an additional 7,500 acre-feet of in-basin storage is believed necessary for environmental purposes and for water supply use associated with future growth (Eagle River Assembly, 2000).
- Many communities along the Corridor (including Silverthorne, Breckenridge, Minturn, Vail, Fraser, Frisco, Dillon, Empire, Georgetown, and Idaho Springs) indicate they have a sufficient supply for currently planned development according to community and county plans. However, none of these communities indicate they have an abundant supply for any additional (beyond planned development) future development. Water supply planning has not been performed for unlimited growth. In addition, drought conditions, such as those of 2002, were generally not incorporated into these community plan water supply projections.
- Increasing groundwater depletions as a result of residential development may affect stream flow because groundwater discharge generally supplies 25 percent of the surface flow in the Corridor area (NWCCOG, 2002b).
- During or beginning in the year 1999, the state of Colorado has been experiencing a significant drought cycle, and water supply is an existing concern for the Corridor area. Most Corridor communities have implemented water conservation measures. The 2002 water year was the driest on record, breaking records set in the 1977 drought (DWR, 2002a).
- Based on an increase in Corridor population from 119,306 (2000) to 216,581 (2025) (Garfield, Eagle, Summit, and Clear Creek counties), and an annual residential per capita water use of 73,000 gallons (CWCB, 2002a), and accounting for tourism, an additional 27,000 to 30,000 acre-feet of water per year will be required in the Corridor.
- In response to the 2002 drought, CWCB and many other entities are conducting studies (both independent and cooperative) to determine the status of Colorado’s water resources for existing and future demands.
- Streams in the Corridor area are currently over appropriated, and increased water diversions to meet increased demands are unlikely (DWR, 2002a).
- Although it is too soon to determine specific impacts, climate change (global warming) is likely to affect Colorado’s water supply.

A.1.2 Water Quality Issues

- Low instream flows caused by drought and/or seasonal fluctuations are less capable of diluting pollutants from various sources such as WWTP discharges or historic mining sites. As a result, public water supplies might be affected and wastewater treatment systems might require upgrades to meet more stringent discharge limits. Such upgrades might require costly state-of-the-art treatment technologies.
- Many wastewater treatment facilities operating in Corridor-intersecting watersheds are dealing with capacity and water quality issues (NWCCOG 2002b, c, d, e). To meet regulatory water protection standards, many of these facilities have permitted discharge limits for ammonia and/or phosphorus. Future facility expansions might face more stringent water quality standards because receiving streams will be affected by increasing nonpoint source pollution, various water protection standards, and instream flow requirements.
- Many water supply sources, both in the Colorado River basin and in the Clear Creek watershed, are adversely affected by historic mining activities. Water supply sources in portions of these basins must address heavy metals contamination and acidic water from mine waste (EPA, 1997).

- Drought conditions affect water quality by elevating contaminant concentrations due to low-flow conditions. The increased level of contaminants might affect public water supplies at stream intakes and treatment requirements at wastewater treatment facilities.
- The reduction or alteration of river and stream flows (from agricultural, municipal, hydropower, snowmaking, and golf course use) can result in fish kills (from concentrated pollutants and/or elevated water temperatures), degraded water quality, reduced wildlife habitat, reduced natural scenic value of rivers and streams, and affected recreational opportunities, and have far-reaching economic, social, and quality of life impacts (Trout Unlimited, 2002).
- Water rights diversions that are senior to instream flow rights have left several miles of the Colorado River in Glenwood Canyon dry for up to 12 weeks a year (Trout Unlimited, 2002).
- Diversions for snowmaking and other uses at Snowmass Creek can drop winter flows to 4 cubic feet per second or lower. This is lower than the CWCB instream minimum flow of 7 to 12 cubic feet per second. Biological studies found that these low flows can drop velocity in the stream below levels needed for successful trout spawning (Trout Unlimited, 2002).

A.1.3 Water Policy Issues

- Growth in Colorado has resulted in increased competition for limited water supplies between the municipal, agricultural, and environmental sectors. The ability of Western Slope headwater communities to meet future growth needs is affected by Front Range diversions, senior or conditional water rights held by parties outside the local water resource area, and instream flow requirements (NRLC, 2001).
- Overlapping water supply and water quality issues are often in conflict because state law primarily guides the former while federal law (Clean Water Act and Endangered Species Act) dominates the latter. The assertion that *"Colorado…water quality issues are independent of, and therefore properly subservient to, the right to use the waters of the state"* is being challenged on several fronts. At the current time, water quality issues such as maintenance of instream flows and water quality protection standards are often of equal prominence (NRLC, 2001).
- The Recovery Implementation Program for Endangered Fish Species in the Upper Colorado basin includes a commitment to manage and protect instream flows needed to recover the endangered fish in accordance with the state laws and property rights. The CWCB makes the conservative assumption that all future water development will likely occur under water rights that will be junior in priority to the endangered fish recovery instream water rights (CWCB 1995).

Based on available information for the Corridor area, watersheds intersecting the Corridor are already under stress due to growth, both within the Corridor area and outside (due to transbasin diversions to the Front Range). There is evidence to indicate that future development in the Corridor will be influenced by available water rights, instream flow requirements, and water quality standards. While many water and wastewater facility providers in the Corridor area are generally meeting current and planned development needs, most of these districts have not documented water supply and/or wastewater facility capacities for more significant growth (beyond planned development or buildout conditions). More definitively, a recent NWCCOG study (2002a) indicates a significant number of water providers in the Corridor area have existing and future projected "baseline buildout" (beyond planned development or buildout conditions) water supply shortages. Water quality within the Corridor has the potential to be significantly affected by water supply diversions, nonpoint source pollutants, drought periods, and wastewater effluent. Many Corridor wastewater facility capacities are already limited by nutrient discharge limits to meet federal and state water quality protection requirements.

Management measures are not currently in place for Corridor communities to effectively deal with these complex interrelated water and growth issues, and future water availability will be based on the evolution of water management strategies and the interplay of state and federal water laws. Instream flow and water quality are significant factors that affect recreational resources and quality of life in the Corridor area. Local and statewide entities currently face the prospect of balancing these factors with water supply issues. The specific influences that water resources will have on future land development in the Corridor area, or vice versa, are difficult to predict. Although some Corridor communities have planned for a certain amount of growth, existing water supply infrastructure is not in place to meet projected growth in the Corridor (as a whole). Corridor water providers must obtain new supplies and new water right allocations, acquire additional storage, and/or implement conservation/efficiency management measures to accommodate future growth.

A.1.4 Evaluation Overview

This evaluation report is divided into sections that discuss water availability, water quality, water policy, and Colorado drought conditions. A summary of regulatory and planning entity roles as related to Colorado water resources is presented in this introduction. The quantities of water available for all uses in Colorado are determined by appropriated water rights. All of the water in Corridor streams is currently appropriated for use by various entities. The Colorado DWR administers and enforces all surface and affected by rights throughout the state of Colorado and enforces interstate compacts. DWR also monitors stream levels, collects water data, and provides resources for water quantity analyses. The USGS also monitors and reports stream flow and groundwater data for numerous stations throughout Colorado. They also conduct water investigations and generate water hydrology and quality reports for specific Colorado study areas.

The CWCB is the state executive branch agency responsible for state water policy and planning. The CWCB's mission is to promote the protection, conservation, and development of Colorado's water resources and to minimize the risk of flood damage. Its major programs include Water Supply Protection, Water Supply Planning and Finance, Conservation and Drought Planning, Flood Protection, Instream Flow and Natural Lake Protection, and Water Information. Instream flows are maintained for environmental, aesthetic, scenic, and recreational purposes as appropriated water rights by CWCB.

The Colorado Water Quality Control Commission (WQCC) is the administrative agency responsible for developing specific state water quality policies, in a manner that implements the broader policies set forth by the Legislature in the Colorado Water Quality Control Act. The Colorado WQCC oversees the implementation of the federal Clean Water Act in Colorado and adopts water quality classifications and standards for surface and ground waters of the state, as well as various regulations aimed at achieving compliance with those classifications and standards. The Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Division (WQCD) is the agency responsible for implementing and enforcing the regulations adopted by the Colorado WQCC, as well as applicable regulations adopted by the State Board of Health. The WQCD regulates the discharge of pollutants into state waters and enforces the state regulations governing public water supplies. At the federal level, EPA is also involved in the protection of water quality under authority of the Clean Water Act and the Endangered Species Act.

NWCCOG is a voluntary association of county and municipal governments that work together on a regional basis to provide regional planning. The NWCCOG Watershed Services Program provides expertise in water quality planning, regulatory monitoring, and technical assistance. NWCCOG is the designated regional water quality management agency and completes and updates a water quality management plan for EPA in compliance with Section 208 of the Clean Water Act. NWCCOG serves 25 member jurisdictions in a five-county region including Eagle County and the towns of Avon, Basalt, Eagle, Gypsum, Minturn, Red Cliff and Vail; Grand County and the towns of Fraser, Granby, Grand Lake, Hot Sulphur Springs, Kremmling, and Winter Park; Jackson County and the town of Walden;

Pitkin County and the city of Aspen; and Summit County and the towns of Breckenridge, Dillon, Frisco, Montezuma, and Silverthorne.

Denver Regional Council of Governments (DRCOG) is the metropolitan areawide water quality management agency. As a regional planning agency, DRCOG is responsible for preparing and adopting a regional plan that provides a road map to address future growth and development. Growth concerns top the region's list of issues. *Metro Vision 2020*, the regional plan for the future, charts a preferred course for the region through core elements such as extent of urban development, urban centers, a balanced multimodal transportation system, open space, environmental quality, and freestanding communities. DRCOG and its local governments establish a cost-efficient WWTP system so that the region's growing population can be assured of clean water through the *Clean Water Plan* (part of *Metro Vision 2020)*.

A.1.5 Water Supply Issues

Colorado Climate/Water Cycle

Colorado is a semiarid state that receives an average of only 17 inches of precipitation per year with 75 percent of the total surface runoff derived from snowmelt. During the winter, snowfall accumulates from October to April, acting as a frozen reservoir, and is by far the primary source of Colorado's water supply. The snowpack begins to melt in April, causing stream levels to rise, peak in June, and again reach base flow conditions in August/September (see **Chart A-1 and Chart** A-2). Reservoir storage, which primarily takes place between April and July, is a critical factor to Colorado water supply providers and is closely monitored. These reservoirs, totaling more than 1,900 statewide, can store 8.85 million acre-feet of water. However, winter snowpack ultimately determines how much water will be available for recreation, industry, farming, drinking, and other uses.

Water providers use snowpack data to project future water supply (reservoir levels) so that preparations can be made for possible shortages. Low-quantity snowpack accumulation during drought episodes is generally predicted to cause lower reservoir levels (and a diminished water supply source). However, the warm spring of 2002 has shown that predictions based solely on snowpack accumulation are not always representative of future conditions, and other factors, including evaporation and infiltration, must also be considered.

The timing of peak water demand relative to water supply is also a major factor in Colorado. The major uses of water in the Corridor area are crop and pasture irrigation, domestic, and recreational (ski area snowmaking) and golf course irrigation. These uses vary from month to month, with peak cumulative demand taking place in August and September, when late irrigation use occurs. This time period also coincides with the lowest stream flows. Water use for snowmaking also occurs during low stream flow conditions. Reduced stream flows and water demands can adversely affect aquatic habitat and water quality.

A. Overview of Water Availability and Growth

Chart A-1. Average Stream Flow List One (Period of Record)

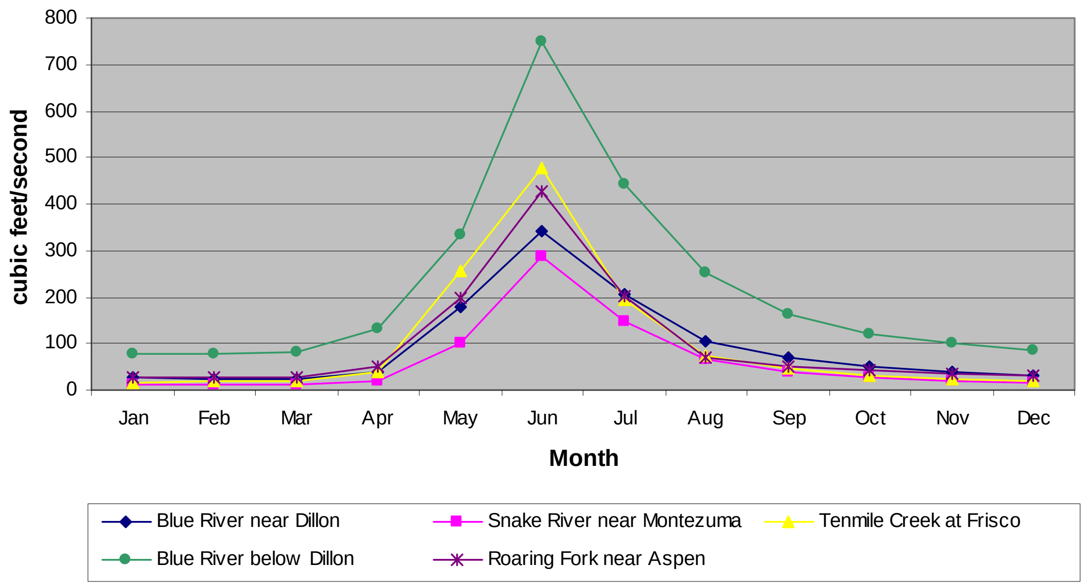
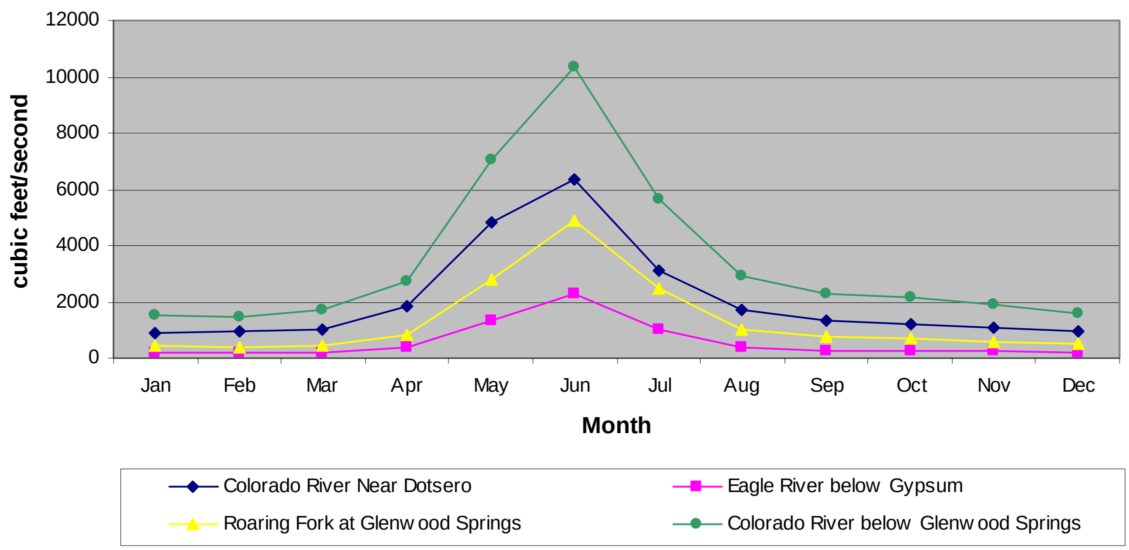


Chart A-2. Average Stream Flow List Two (Period of Record)



Recent studies indicate that global warming might affect regional and local water cycles. Although the specific cause(s) of global warming continue to be debated, most scientists agree that the phenomenon of global warming is presently impacting the Earth. Such impacts include:

- Mountain glaciers are melting at rates unprecedented in recorded history.
- Arctic ice thickness has declined considerably from levels recorded in the mid-twentieth century.
- Permafrost in the Alaskan arctic is beginning to thaw.
- Mean sea level has risen between 10 and 20 centimeters since the 1890s.
- The US has, on average, warmed by two-thirds of a degree C since 1900.

Research in California mountain environments (Gleick, 2000) indicates that watersheds with a substantial snowpack in winter will experience major changes in the timing and intensity of runoff if average temperatures continue to rise. Reductions in spring and summer runoff, increases in winter runoff, and earlier peak runoff are common responses to rising temperatures.

An examination of 2002 peak flows for Corridor streams indicates that early peak runoff occurred during the 2002 drought (see **Chart A-3 through Chart** A-5). During the warm spring of 2002, peak flows consistently occurred near June 1 or late May, approximately 2 weeks earlier than the period of record average – June 15. The 2002 warm spring also increased snowpack evaporation and increased high altitude runoff infiltration (water lost to the soil/ground), decreasing the amount of runoff available to reservoirs and streams. Specific impacts from global warming are variable and difficult to predict, and national and global impacts may not be evident in more localized areas and during smaller timeframes. Early peak flows have occurred throughout Colorado's period of record, and this report does not intend to imply a direct cause/effect relationship with global warming. However, the global warming issue and its potential impacts are additional factors that might affect Colorado's water supply and are included here for completeness.

In addition, climate changes have the potential to alter water quality by changing temperatures, flows, runoff rates, and timing, and by changing the ability of watersheds to assimilate wastes and pollutants. Lakes are also sensitive to changes in climate, with even small changes in climate producing large changes in lake levels and salinity. If average air temperatures continue to increase, fewer lakes and streams in high-latitude areas will freeze to the bottom and the number of ice-free days will increase, leading to increases in nutrient cycling and productivity. Other effects of increased temperature on lakes could include higher thermal stress for coldwater fish, improved habitat for warm water fish, increased productivity and lower dissolved oxygen, and degraded water quality.

Chart A-3. Beaver Creek at Avon

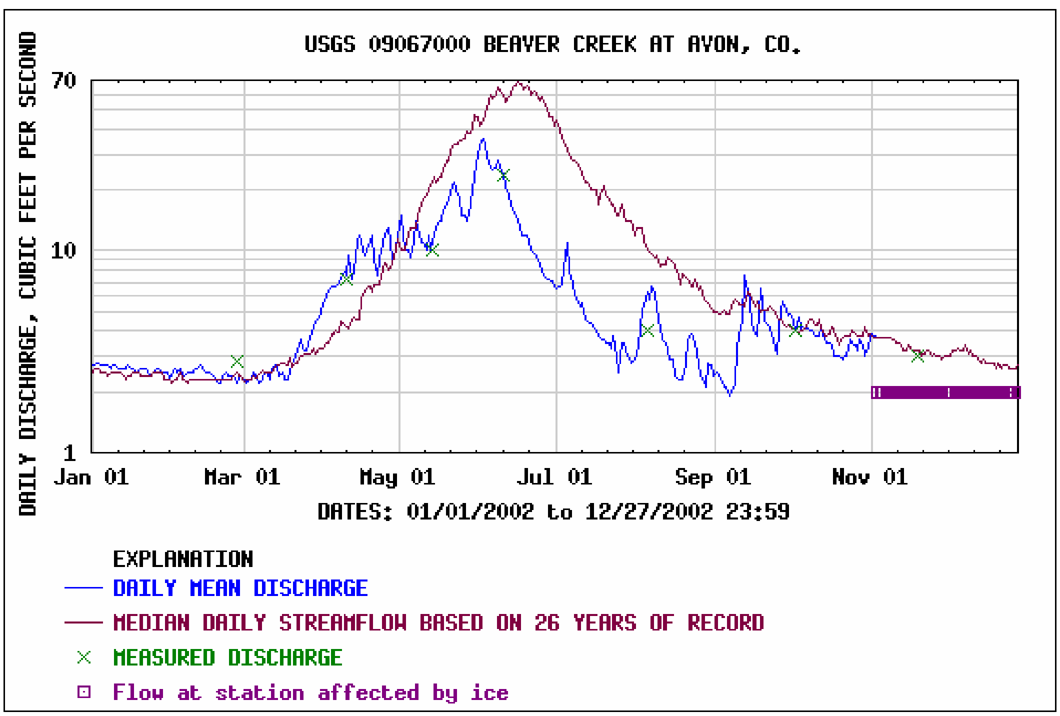


Chart A-4. Eagle River Below Gypsum

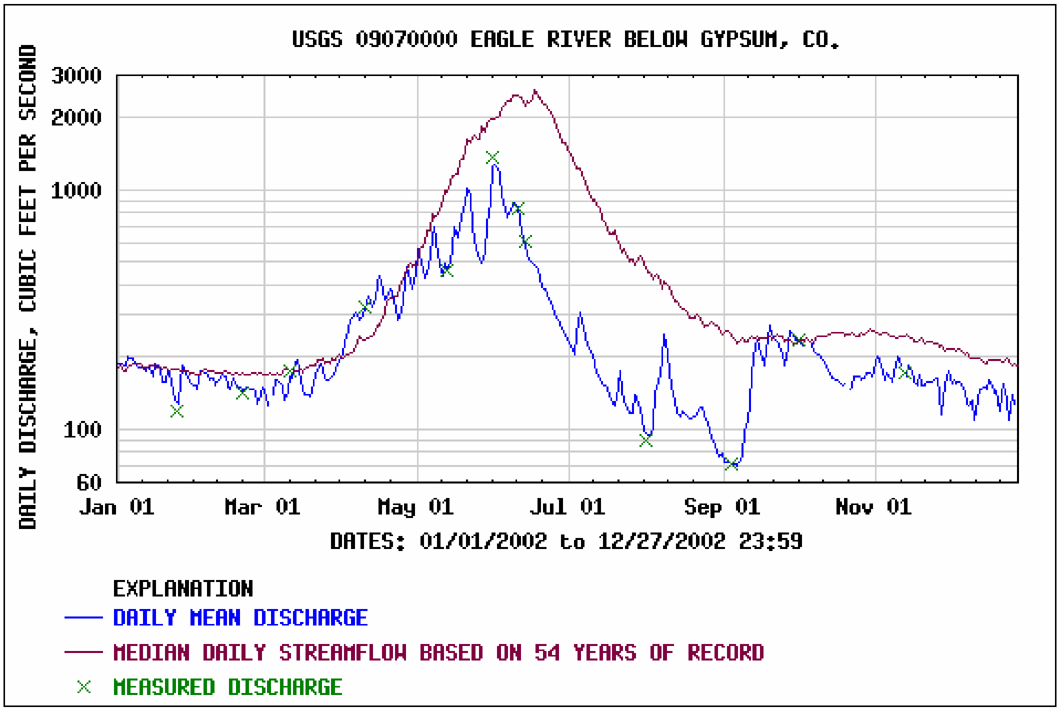
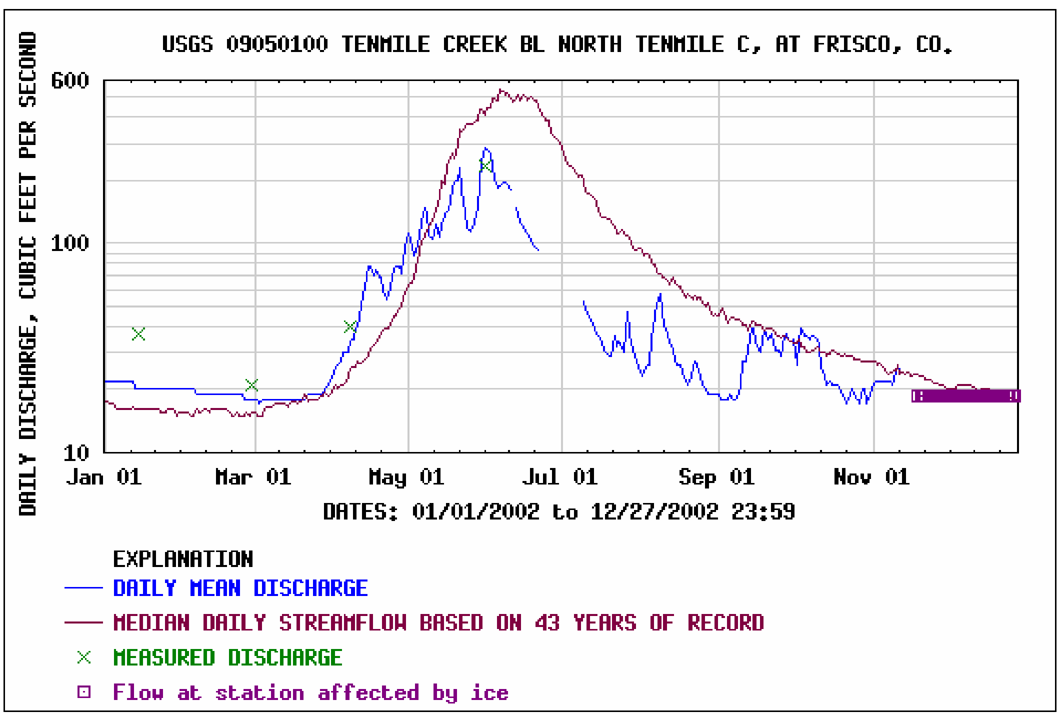


Chart A-5. Tenmile Creek below North Tenmile Creek at Frisco



Water Use and Water Demand Projections

The Colorado River Compact and the Upper Colorado River Compact entitle Colorado to the beneficial consumptive use of 51.75 percent of the total water available to the Upper Colorado River basin. These compacts and water laws are further discussed under **Section A.1.7** in this Appendix. The native supply in the Colorado River basin (for use by Colorado) is estimated at 3.0 million to 3.8 million acre-feet, and total consumptive use in the mainstem is about 1.2 million acre-feet, of which about 600,000 acre-feet is in the form of exports to other river basins. CWCB indicates that exports will reach about 900,000 acre-feet in 2030 and predicts that municipal consumptive use will increase slightly, but remain under 100,000 acre-feet, and irrigation consumptive use will remain constant, somewhere under 500,000 acre-feet.

More than 90 percent of water used in Colorado through human activities occurs in agriculture (NRLC, 2001). Agricultural water use in Colorado is not expected to increase and is likely to decrease slightly in coming decades as a result of increased irrigation efficiencies and additional agricultural-to-urban water transfers. **Table A-1** lists projected water supply needs for 2030 in the two major river basins that intersect the Corridor (Colorado and South Platte basins) according to CWCB (2002b).

Table A-1. Colorado River Basin and South Platte River Basin Water Demand Projections

Entity	Water Demands			Existing Water Supply		Additional Water Needed
	1990	2010	2030	Avg Annual Yield	Dry Year Yield	2030
Colorado River Basin						
City of Aspen	4,113	7,336	N/A	7,287	6,656	680
Clifton Water District	3,187	4,575	7,140	14,400	14,400	0
Ute Water Conservancy District	6,800	11,500	19,900	41,000	24,000	0
Other basin entities (55% of basin population)	N/A	N/A	N/A	N/A	N/A	300
Total	N/A	N/A	N/A	N/A	N/A	980
South Platte River Basin						
City of Aurora	39,000	61,800	75,000	63,000	N/A	12,000
City of Boulder	19,800	24,900	29,200	N/A	41,330	0
City of Englewood	8,212	10,100	11,000	10,100	10,100	1,000
City of Fort Collins	31,000	39,000	48,000	68,000	35,000	13,000
City of Loveland	8,990	12,973	20,684	23,053	15,460	5,300
Denver Water Board	249,000	325,000	376,000	375,000	345,000	31,000
East Cherry Creek Valley W&S District	2,802	10,823	15,540	11,870	11,870	3,700
East Larimer County Water District	3,000	4,000	6,000	4,200	3,500	2,500
Lefthand WSD (Niwot)	4,550	9,750	11,050	7,273	4,789	6,300
Other basin entities (15% of basin population)	N/A	N/A	N/A	N/A	N/A	11,200
Total	N/A	N/A	N/A	N/A	N/A	86,000

Source: Colorado Water Conservation Board, March 2002.
Note: All measurements in acre-feet.
Legend:
N/A = Not available.

Projections for individual counties or watersheds were not available from the CWCB. Based on the existing dry year water supply, a shortage of 980 acre-feet is projected for the year 2030 in the Colorado

River basin, and a shortage of 86,000 acre-feet is projected for the South Platte River basin. Population statistics for water demand projections were obtained from the Colorado Department of Local Affairs 2001 *Preliminary Population Projections*.

Five level 4 watersheds intersect the Corridor as shown on Map 3.10-1 in the Resource Maps section, and a summary of water use information is provided in **Table A-2**. These five watersheds from east to west are Clear Creek, Blue River, Eagle River, Upper Colorado, and Roaring Fork. According to USGS (1990) and NWCCOG (2002 a ,b, c, d ,e) data, watershed populations served by surface water versus groundwater are comparable, except for the Clear Creek watershed, where 99 percent of the population is served by surface water. The Clear Creek watershed is the only watershed of the group that drains east of the Continental Divide. Most of the public water supply systems are served by groundwater sources. All significant groundwater sources (wells for public systems) in the Corridor are alluvial sources directly associated with adjacent streams (see **Table A-6 through Table** A-9).

Table A-2. Water Use: Level 4 Watersheds Intersecting the Corridor

Watershed Name	Description	Major Reservoirs	1990 Total Consumptive Use (MGD)a	Population % Served by Surface Water and No. of Public Water Systems Served	Population % Served by Groundwater and No. of Public Water Supply Systems Served
Roaring Fork	Drains northwest from Aspen to Glenwood Springs where it joins the Colorado	Ruedi Reservoir	46.01	50% and 8 [b]	50% and 39 [b]
Colorado Headwaters (Upper Colorado)	Drains southwest from Granby to Glenwood Springs	Numerous	56.18	55% and 10 [b]	45% and 49 [b]
Eagle	Drains west-northwest from Vail, through Minturn, Eagle, Avon, to join the Colorado	Homestake Reservoir	25.48	52% and 6 [b]	48% and 21 [b]
Blue	Drains south-southeast through Silverthorne, Frisco, and Breckenridge	Green Mountain, Dillon	12.24	42% and 10[b]	58% and 34 [b]
Clear Creek	Drains east through Golden to join the South Platte	Georgetown, numerous	17.62	99% and 14[a]	<1% and 9 [a]

Legend:
MGD = million gallons per day.
[a] = USGS 1990.
[b] = NWCCOG 2002.

Estimates of additional water demand, based on projected Colorado Department of Local Affairs (DOLA) populations, were performed to provide a general idea of the amount of additional water (beyond the amount currently used) necessary to accommodate such growth. (The calculations performed in these estimates are fairly simple and are not intended as a rigorous analysis of future water demand.) Due to the significant tourist and second homeowner population in the Corridor, an effort was also made to account for this additional "transient" population (beyond the residential projections). **Table A-3** and

Table A-4 contain these estimates, which are based on percentage of tourism employment by county and percentage of transient water populations by county, respectively. The estimated additional annual water demand is generally higher using the transient percentage; however, the results of the two methods are within the same range for the most part. Overall, additional water demand for the Corridor ranged from 27,156 to 30,049 acre-feet, while additional water demand for the entire nine-county Corridor area ranged from 46,828 to 54,571 acre-feet.

Table A-3. Estimated Future Water Demand Based on Percent Transient Population Served

County	2000 Population (DOLA)	2000 Estimated Population Served Including Transient Population[a]	2025 Projected Population (DOLA)	2025 Estimated Population Served Including Transient Population[a]	Additional 2025 Water Demand: Residential[b]	Additional 2025 Water Demand (with Tourism)[b]
Corridor Counties						
Summit	23,705	29,631	42,561	65,118	4,224	6,087
Garfield	44,219	55,274	80,879	90,584	8,213	13,016
Eagle	42,027	52,534	76,081	95,101	7,629	8,583
Clear Creek	9,355	11,694	17,060	25,078	1,726	2,362
Total	**119,306**	**149,133**	**216,581**	**275,882**	**21,793**	**30,049**
Other Counties in Corridor Area						
Gilpin	4,775	5,969	7,175	12,413	538	991
Grand	12,535	15,669	25,598	42,493	2,927	4,468
Lake	7,825	9,781	18,458	28,979	2,382	3,341
Park	14,679	18,349	56,100	92,565	9,280	12,953
Pitkin	14,943	18,679	23,719	34,630	1,966	2,770
Total All Counties	**174,063**	**217,579**	**347,631**	**486,961**	**38,886**	**54,571**

Legend:

a = *Projected populations added to projected population multiplied by the percent transient population served (additional population from tourism is calculated as a year-round quantity); transient includes hotels, gas stations, and restaurants according to EPA Water Provider database.*

b = *Additional as compared to the year 2000; uses a per capita number of 200 gallons/day for resident population and 100 gallons/day for transient population.*

Table A-4. Estimated Future Water Demand Based on Percent Tourism Employment

County	2000 Census Population	2000 Estimated Peak Population[a]	2025 Projected Population (DOLA)	2025 Estimated Population Including Tourism[b]	Additional Annual Water Demand, Resident Only (AF)[c]	Additional Annual Water Demand with Tourism (AF)[d]
Corridor Counties						
Summit	23,705	132,748	42,561	238,342	4,224	6,653
Garfield	44,219	61,907	80,879	113,231	8,213	8,624
Eagle	42,027	100,865	76,081	182,595	7,629	8,964
Clear Creek	9,355	11,694	17,060	21,325	1,726	1,780
Total	**119,306**	**307,213**	**216,581**	**557,696**	**21,793**	**26,084**
Other Counties in Corridor Area						
Gilpin	4,775	38,678	7,175	58,118	538	1,015
Grand	12,535	32,591	25,598	66,555	2,927	3,512
Lake	7,825	11,738	18,458	27,688	2,382	2,531
Park	14,679	27,890	56,100	106,590	9,280	10,324
Pitkin	14,943	35,116	23,719	55,740	1,966	2,298
Total All Counties	**174,063**	**453,225**	**347,631**	**905,161**	**38,886**	**46,681**

Legend:

AF = Acre-feet.

a = Estimated peak population includes tourists and second homeowners. Estimates are based on estimates provided by Summit County, the 1999 tourist industry employment percentage for counties, and 2000 census industry sector employment percentages for counties (counties with high retail sales/service sectors rated higher peak populations than counties with high construction/real estate sectors).

b = Peak population includes population from tourists and second homeowners, which was multiplied by an arbitrary factor of 0.25 to obtain a year-round representation. Generally assumes that 25 percent of the additional peak population contributes to year-round service demands, specifically water demand.

c = Assumes per capita use of 200 gallons/day (the Colorado Front Range average provided by CWCB).

d = Additional as compared to the year 2000; uses a per capita number of 200 gallons/day for resident population and 100 gallons/day for transient population.

Table A-5 provides total water demand estimates.

Table A-5. Estimated Total Water Demand

County/Subarea	2000 Water Demand	2025 Water Demand
Garfield	10,402	19,026
Eagle	11,063	20,028
Summit	8,365	15,018
Clear Creek	2,161	3,942
Corridor Counties	**31,991**	**58,075**
Gilpin	2,019	3,034
Grand	3,370	6,882
Lake	1,863	4,394
Park	3,659	13,982
Pitkin	3,913	6,211
All Counties	**46,814**	**93,496**

Notes: All measurements in acre-feet. Tourism is considered based on methodology in Table A-4.

More recent and/or detailed water availability/use information for these watersheds was obtained from the following organizations: Corridor conservation districts, Corridor community and county plans, EPA, DRCOG, and NWCCOG. Water availability data are presented and discussed by watershed in the following sections.

Roaring Fork Watershed

The three major rivers in the watershed, the Roaring Fork, the Crystal, and the Frying Pan, contribute about 54 percent, 32 percent, and 14 percent of the flow in the watershed, respectively. Stream flows in the Roaring Fork watershed are affected by diversions that transport water out of the basin to the Arkansas River via the Frying Pan-Arkansas Project. The Ruedi Dam and Reservoir, the only major water storage facility in the watershed, was built in 1968 to facilitate the operation of the Frying Pan-Arkansas project. Transbasin diversions are about 15 percent of the Roaring Fork River flow. Most of the population and principal economic activities in the watershed center on the Aspen and Glenwood Springs areas. The Glenwood Springs water system capacity was reported to be operating at 83 percent in 1994 (Glenwood Springs, 1996). The 1996 *Land Use Plan* also states that the system requires infrastructure upgrades to provide future needs. According to CWCB (2002a), Aspen will require an additional 680 acre-feet of water by 2030.

Upper Colorado Watershed

Upper Colorado River basin water diversions include more than 2.42 million acre-feet per year for irrigation and about 2.39 million acre-feet per year for industrial use (NWCCOG, 1998). Transmountain diversions to Front Range cities and agricultural use are about 0.51 million acre-feet per year. The greatest expansion of industrial use in recent years has been for snowmaking at ski areas, and there has been increasing pressure from environmental organizations, Colorado Division of Wildlife (CDOW), CWCB, and other entities to maintain instream flows for other recreational uses such as fishing and rafting.

Water supply information for 11 providers in the Upper Colorado watershed was obtained from the *Upper Colorado River Basin Study Phase II Draft* and *Final* Reports (NWCCOG, 2002a and Hydrosphere Resource Consultants, 2003) as shown in **Table A-6.** The sponsoring parties of the study include Grand County, Summit County, the Colorado River Conservation District, Middle Park Water Conservancy District, Denver Water, the Northern Colorado Water Conservancy District, and the NWCCOG Water Quality/Quantity Committee. The Phase II study is based on 1947–1991 stream flow data and up-to-date water use data available from the sponsoring parties, and uses a generally accepted (and commonly used) hydrologic model (NWCCOG, 1998). Individual water suppliers, communities, and counties provided future water use data based on projected population growth, zoning, and planned development documented in community plans. Existing water shortages are reported for Winter Park Recreation and Wastewater and Sanitation District (WS&D) and Grand County W&SD. Future maximum water shortages are projected for six additional providers including Hot Sulphur Springs, town of Kremmling, Winter Park Recreation (snowmaking), Silver Creek Resort, town of Granby, and town of Fraser. Grand County W&SD is projected to require an additional 977 acre-feet for future buildout (planned development). Future shortages for the watershed are estimated at 1,127 acre-feet.

The *Final Phase II* study reports that current water demands in Grand County are 3,100 acre-feet, and future demands will reach 14,200 acre-feet. About 70 percent of future demands are in the Fraser River basin. Water supply sources for this area include surface water diversions from the Fraser River and its tributaries, as well as alluvial wells. Total future maximum annual shortage for Grand County is 2,369 acre-feet (dry year for projected buildout/planned development).

Table A-6. Upper Colorado Watershed Public Water Supply Current Status and Future Projections

Provider	System Source	Existing Shortages	Future Maximum Shortages	Projected Capacity (Other Data)
Columbine Lake WD	Surface water: Tonahutu Creek, groundwater: 1 alluvial well	0	0	N/A
Town of Grand Lake	Groundwater: 1 alluvial well, surface water: Tonahutu Creek	0	7	N/A.
Hot Sulphur Springs	Surface water: Colorado River	0	44	N/A.
Town of Kremmling	Surface water: Sheep Creek and Colorado River	0	18	N/A
Winter Park Recreation & W&SD	Surface water: Fraser River, Groundwater: alluvial wells with augmentation	2	204	Buildout water usage requires a substantial increase in storage capacity (1998)
Winter Park Recreation (snowmaking)	Exchange from Denver's Vasquez Canal with Clinton Reservoir augmentation	0	70	N/A
Grand County W&SD	Surface water: Little Vasquez Creek and Vasquez Creek with augmentation	1	1,903	N/A.
Winter Park West W&SD	Groundwater: 7 alluvial wells	0	23	N/A
Silver Creek Resort	Groundwater: alluvial wells	0	68	N/A
Town of Granby	Surface water: Fraser River with augmentation	0	5	N/A
Town of Fraser	Groundwater: 2 alluvial wells, surface water: St. Louis Creek with augmentation	0	27	Substantial quantity available according to 1981 *Community Plan;* capacity to serve 25,000 residents (6,250 households)

Note: All measurements in acre-feet.
Legend:
Shading = Water shortages.
** = Dry year with projected buildout/planned development.*

The *Phase II* study (2003) also presents possible solutions for meeting the projected water shortages. Solutions in Grand County consist of bypass arrangements with Denver Water, collection system extension, additional in-basin storage that may require pumping from downstream locations, reduction of instream flow (certain locations, specific time of year), additional conservation measures, wastewater treatment consolidation with pumpback, new intake facilities, and additional reservoir releases during low-flow periods.

Two ongoing Environmental Impact Statement (EIS) projects in the Upper Colorado River watershed include the *Moffat Collection System EIS* (Denver Water proposal to increase yield for the Moffat Collection System, US Army Corps of Engineers 2003) and the *Windy Gap Firming Project EIS* (Northern Water Conservancy District proposal to increase deliveries from the existing Windy Gap Project, NWCD 2004). Implementation of either or both of these projects could further affect water resources along the Fraser River due to the increased diversions to the Front Range. Such impacts could include decreased stream flows, increased effluent treatment demands on local wastewater treatment facilities (impacts on the ability of existing facilities to meet discharge limits), and decreased water supply resources for local mountain communities.

Eagle River Watershed

There are six water storage facilities in the Eagle River basin: Homestake, Climax, Black Lakes, Nottingham Lake, Sylvan Lake, and Lede Reservoir. Homestake delivers water to the cities of Aurora and Colorado Springs and augments flows in the Eagle River during dry periods. Sylvan Lake provides water to the town of Eagle. The other storage facilities are used for recreation and industry and to augment Eagle River low flows. In a 1994 report by the Eagle River Assembly, it was estimated that an additional 3,300 to 4,000 acre-feet of water was required for storage and release into the Eagle River during dry periods to meet instream flow levels (Eagle River Assembly 2000). The report also states that future projections for buildout plans (planned development) will require an additional 5,200 to 6,500 acre-feet to meet instream flow based on water supply projections and existing dry period requirements. The June 2000 report update indicates the following recent developments:

> *"Growth and development have continued at a rapid rate within the Eagle River watershed and in particular along the Eagle River corridor. This growth has increased local water demands for municipal and commercial purposes. …Residential and commercial growth has continued to displace previously irrigated pastureland. The loss of flood-irrigated land may result in diminished late summer flows of the Eagle River by reducing irrigation return flow.*
>
> *Historic stream flow data through 1999 suggests that instream flow deficits from Minturn to Dotsero can be expected to occur one out of every 5 to 10 years. The Eagle River reach between Beaver Creek and Lake Creek (Avon gage) may be expected to record instream deficits in one out of every two years.*
>
> *Eagle Park Reservoir, Homestake Reservoir, and Black Lakes Reservoir provide storage for in-basin use. Over 2,500 acre-feet of storage water is currently available from these facilities during dry years. This existing storage is generally adequate to satisfy current water supply augmentation requirements.*
>
> *Additional in-basin storage is desirable for environmental purposes and for water supply use associated with future growth. An additional storage yield of 7,500 acre feet or more would be beneficial for these environmental and water supply purposes."*

Information from community plans indicate that communities in the Eagle River watershed are generally capable of meeting planned development needs (see

Table A-7). However, several communities, including Gypsum and Vail, are dealing with water supply issues, and Wolcott would require the creation of a public supply system if future development occurs (Wolcott Advisory Group, 1992). Gypsum is working to develop raw water storage according to the 1999 *Foundation Plan*, and an additional supply may be required to supply a future projected population of 9,000 residents (Eagle River Assembly, 2000). Vail's projected buildout/planned development demand will be 84 percent of existing water rights according to the 1994 *Environmental Strategic Plan*.

Table A-7. Eagle River Watershed Public Water Supply Current Status and Future Projections

Provider	System Source	Projected Capacity (Other Data)
Avon	Hunter Creek, Castle Creek, Maroon Creek	N/A
Eagle	N/A	Current capacity can serve an additional 4,000 residents according to the 1996 *Community Plan*. The plan also recommends securing additional water rights to meet future buildout. An additional 200 acre-feet of storage may be required to supply a future projected population of 9,800 residents (Eagle River Assembly [ERA] 2000).
Edwards	N/A	Latest Sub-Area Master Plan, August 1985.
Gypsum	Gypsum Creek, Mosher Spring	Gypsum is working to develop raw water storage according to the 1999 *Foundation Plan*. An additional 50 acre-feet may be required to supply a future projected population of 9,000 residents (ERA 2000).
Minturn	N/A	Existing water rights are adequate to meet future needs according to 1998 *Community Plan*.
Vail	7 drinking water wells (Gore Creek Alluvium)	Projected buildout demand will be 84% of existing water rights according to 1994 *Environmental Strategic Plan*. Increased diversions to the Front Range could significantly affect water availability.
Wolcott	Private wells and small community systems	Significant development would require creation of a public water supply and distribution system according to the 1992 area community plan.

Growth and development concerns in the watershed are discussed in the 1996 Eagle River Watershed Plan (Eagle County). The plan states that "…local land use planning and water planning efforts must identify critical thresholds for growth" and "…planning efforts should provide specific recommendations for directing growth and development based on critical natural and man-made thresholds, particularly water availability." The plan also recommends investigation of growth management tools such as evaluation of water use proposals in light of whether they contribute to minimum instream flow deficits; acquisition of lands for open space to reduce the rate of in-basin water consumption; and the granting of water taps or building permits in increments based on estimated water supply thresholds or adopted land use policies for growth. The Eagle County Master Plan (1996) also discusses growth and development concerns:

> *"There are municipalities, water districts and private developers in the Eagle River Basin which have insufficient legal water supplies for existing or future water demands.…To avoid adverse impacts on priority users downstream, these water users must obtain approval of a water augmentation plan, typically by using water from the Green Mountain Reservoir. While this water protects the rights of users downstream, this water does not flow through the Eagle River and, therefore, does not address minimum flow and water quality deficits within Eagle County."*

Blue River Watershed

Water supply information for 17 providers serving the Blue River watershed was obtained from the *Upper Colorado River Basin Study Phase II Draft* and *Final* Reports (NWCCOG, 2002a and Hydrosphere Resource Consultants, 2003) as shown in **Table A-8**. The sponsoring parties of the study include Grand County, Summit County, the Colorado River Conservation District, Middle Park Water Conservancy District, Denver Water, the Northern Colorado Water Conservancy District, and the NWCCOG Water Quality/Quantity Committee. The *Phase II* study is based on 1947–1991 stream flow data and up-to-date water use data available from the sponsoring parties and uses a generally accepted (and commonly used) hydrologic model (NWCCOG, 1998). Individual water suppliers, communities, and counties provided future water use data based on projected population growth, zoning, and planned development documented in community plans.

Table A-8. Blue River Watershed Public Water Supply Current Status and Future Projections

Provider	System Source	Existing Shortages	*Future Maximum Annual Shortages	Projected Capacity (Other Data)
Alpensee Water District	Groundwater — wells, and augmentation	N/A	N/A	3 taps online; buildout at 57 taps; 285,000 gallon storage tank
Arapahoe Basin snowmaking	Surface water: North Fork and Snake River	0	330	N/A
Town of Breckenridge	Surface water: Goose Pasture Tarn (Blue River), Barton Gulch with augmentation from Green Mountain Reservoir, Windy Gap and Clinton Reservoir	0	0	The 1998 Water Master Plan indicates sufficient supply for buildout but recommends infrastructure improvements for storage, water treatment capacity, and fire protection. Information updated in May 2002 indicates 516 single-family equivalents are available outside master plan boundaries.
Town of Breckenridge golf course	Surface water: Swan River with augmentation from Green Mountain and Clinton Reservoirs	7	88	N/A
Breckenridge Ski Area	Surface water: Blue River and groundwater with augmentation from reservoirs	0	24	N/A
Buffalo Mountain Metro District	Four alluvial wells along Blue River			2,218 taps online; buildout at 2,444 taps
Copper Mountain W&SD (Consolidated Metro District)	Groundwater: 3 alluvial wells, surface water: West Tenmile Creek with augmentation	46	282	1,600 taps online; buildout at 3,344 taps; substantial augmentation is required to supply buildout taps
Copper Mountain Incorporated	Surface water: Tenmile and West Tenmile Creeks and groundwater wells with augmentation from reservoirs	6	99	N/A
Eagles Nest	Town of Silverthorne and 2 alluvial wells with augmentation	0	3	N/A
East Dillon Water District	Groundwater: 10 alluvial (Soda Creek) wells with augmentation	1	106	1,350 taps online; buildout at 1,800 taps
Dillon Valley Metro District	Surface water: Straight Creek and Laskey Gulch with augmentation	0	7	989 taps online; buildout at 1,008 taps; building 0.5 million gallon storage tank in 2003
Town of Dillon	Surface water: Straight Creek and Laskey Gulch with augmentation	0	0	N/A
Town of Frisco	Surface water: North Tenmile Creek, groundwater: 5 alluvial wells with augmentation	0	0	72% capacity in 1998
Hamilton Creek Metro District	Groundwater: 2 wells			77 taps online; buildout at 125 taps; 200,000 gallon storage tank

Provider	System Source	Existing Shortages	*Future Maximum Annual Shortages	Projected Capacity (Other Data)
Keystone-Montezuma Domestic	Future groundwater: 4 alluvial wells, surface water: Snake River with augmentation	0	11	N/A
Keystone Mountain snowmaking	Surface water: Snake River with Clinton Reservoir augmentation	27	668	N/A
Keystone Gulch	*Information not available.*	0	11	N/A
Keystone Ranch	Groundwater: 4 alluvial wells, surface water: Reynolds Reservoir with augmentation	0	6	N/A
Mesa Cortina W&SD	Groundwater: 3 wells, also buy from Buffalo Mountain MD	N/A	N/A	202 taps online; buildout at 252 taps; 300,000 gallon storage tank
Town of Silverthorne	Surface water: Blue River, groundwater: 6 alluvial wells with augmentation	0	0	Additional 11,250 residential taps
Snake River WD	Groundwater: alluvial wells with augmentation	1	239	3,600 taps online; buildout at 5,200 taps
Swan's Nest Metro District	N/A	N/A	N/A	138 planned condos, all sold but no taps yet
Timber Creek Estates	N/A	N/A	N/A	5 taps online; buildout at 79 taps; 60,000 gallon underground vault
Willow Brook Metro District	Acquired from outside provider (Silverthorne)	N/A	N/A	41 taps online; buildout at 57 taps

Note: All measurements in acre-feet.
Legend:
Shading = Water shortages.
** = Dry year with projected buildout/planned development.*
N/A = Not available.

Existing shortages are reported for six providers including the town of Breckenridge Golf Course, Copper Mountain W&SD, Copper Mountain Inc. (snowmaking), East Dillon Water District, Keystone Mountain Snowmaking, and Snake River WD. Although Dillon Reservoir is adjacent to Dillon, the reservoir is owned by the city and county of Denver and provides water to the Denver metropolitan area. Projected future maximum shortages are reported for the previously named providers and for Arapahoe Basin snowmaking, Breckenridge Ski Area, and Keystone Resort snowmaking. Total existing shortages and total future shortages for the watershed are 88 acre-feet and 518 acre-feet, respectively. Although the model indicates communities will have sufficient water supplies to meet future needs, recreational providers have significant projected shortages. Water rights for recreational supplies are generally junior (due to their later date of appropriation) to both community supplies and instream flow requirements, which might account for the higher recreational shortages. The modeling study may be considered conservative because it uses 1947–1991 stream flow data, and 2002 stream flow levels have set new low records.

The *Final Phase II* study reports that current water demands in Summit County are 8,000 acre-feet, and future demands will reach 17,900 acre-feet. About 25 percent of future demands are in the Upper Blue River area above Dillon. The remaining future demands are primarily in the Silverthorne, Eagles Nest, and Mesa Cortina areas. Water supply sources for these areas are Blue River surface water diversions and alluvial wells. Total future maximum annual shortage for Summit County is 1,900 acre-feet (dry year for projected planned development/buildout).

Clear Creek Watershed

Clear Creek is one of the most over appropriated streams in Colorado, with 46 reservoirs that involve diversion and storage (EPA, 1997). About 40 percent of Clear Creek's annual flow is used in-basin (with some returned to the watershed), and another 40 percent is diverted out of the watershed. Only about 20 percent of Clear Creek flows ever reach its confluence with the South Platte River due to heavy demand in the Denver metropolitan area.

A water supply shortage of 11,200 acre-feet is projected in the year 2030 for 15 percent of the South Platte River basin (CWCB, 2002b). This 15 percent includes all water supply providers located in the Upper Clear Creek watershed. Although data available from various community plans indicate supplies for communities including Empire, Georgetown, and Idaho Springs are sufficient to meet 2020 needs (see **Table A-9**), recent discussions with Clear Creek County officials (Clear Creek County, 2002) indicate otherwise. The recent drought conditions have forced some of these communities to buy water from other providers to meet existing minimum demands, and the county is pursuing avenues to obtain water rights and develop new storage facilities to meet future needs. Rural water supplies in the county primarily consist of domestic wells. Some of these wells have gone dry during the drought, and residents have required water resources assistance from the county.

Table A-9. Clear Creek Watershed Water Supply Information

Provider	System Source	Projected Capacity
Arvada	Clear Creek watershed surface water	N/A
Black Hawk	Clear Creek watershed surface water	N/A
Central City	Clear Creek watershed surface water	N/A
Consolidated Mutual Water Company	Clear Creek watershed surface water	N/A
Coors Brewing Company	Clear Creek watershed surface water	N/A
Empire	Mad Creek	More than sufficient to meet 2020 demands according to 1995 *Comprehensive Plan*
Georgetown	Clear Creek watershed surface water	Water system has kept pace with development and is in good standing according to 2000 *Comprehensive Plan*
Golden	Clear Creek watershed surface water	N/A
Idaho Springs	Chicago & Soda Creeks (tributaries to Clear Creek)	More than sufficient to meet 2020 demands including planned development according to 2001 revised *Comprehensive Plan*
Northglenn	Clear Creek watershed surface water	N/A
Public Service Company	Clear Creek watershed surface water	N/A
Silver Plume	Clear Creek watershed surface water	N/A
Thornton	Clear Creek watershed surface water	N/A
Westminster	Clear Creek watershed surface water	N/A

Legend:
Shading = Providers/communities in the Corridor area.
N/A = Not available.

A.1.6 Water Quality Issues

Information and data for the Upper Clear Creek watershed were obtained from the Upper Clear Creek Watershed Advisory Group, EPA, and DRCOG. Information and data for the Colorado River basin watersheds were obtained from NWCCOG watershed and water quality management plans. These data are presented and discussed for the five Corridor watersheds in the following sections.

Roaring Fork Watershed

Information for 18 WWTPs in the Roaring Fork watershed was obtained from the *Water Quality Management Plan* (NWCCOG, 2002e) as shown in **Table A-10**. Five facilities in the watershed have ammonia discharge limits. Capacity expansion is underway at the Mid-Valley facility and is planned and/or necessary for the Aspen and Redstone facilities.

Table A-10. Roaring Fork Watershed Wastewater Treatment Facility Information

Treatment Plant	Controlling Entity	Current Hydraulic Capacity (MGD)	Capacity and Water Quality Notes
Aspen WWTF[b]	Aspen Consolidated Sanitation District (SD)	3.0	Expansion needed to 4.5 MGD
Snowmass WWTF[a]	Snowmass W&SD	3.2	Recently completed expansion; ammonia discharge limits
Aspen Village WWTF	Aspen Village HOA	0.051	Monthly groundwater monitoring
Woody Creek WWTF	Woody Creek MHP	0.032	Discharge to groundwater
Lazy Glen WWTF[a]	Lazy Glen HOA/Basalt SD	0.045	Past permit compliance problems
Sopris Village	Sopris Village HOA	0.05	N/A
Ranch at Roaring Fork	Ranch at Roaring Fork HOA	0.10	N/A
Basalt WWTP	Basalt SD	0.8	N/A
Mid-Valley WWTP[b]	Mid-Valley Metro Dist.	0.5	Expansion underway; ammonia discharge limit
Redstone WWTF	Redstone W&SD	0.05	80% capacity in 1997
Carbondale WWTF	Town of Carbondale	0.995	N/A
Aspen Glen WWTF	Roaring Fork W&SD	0.107	N/A
Mountain Meadows WWTF[a]	Mountain Meadows HOA	0.01	Failed leach field; under enforcement order
Spring Valley WWTF[a]	Spring Valley SD	0.052	Ammonia and chlorine discharge limits
H Lazy F WWTF	H Lazy F MHP	0.04	N/A
El Rocko WWTF[a]	El Rocko MHP	0.01	Flows have exceeded hydraulic capacity; poor operation and maintenance record
Ski Sunlight WTF[a]	Ski Sunlight, Inc.	0.03	Ammonia discharge limits
Glenwood Springs[a]	City of Glenwood Springs	2.3	Ammonia discharge limits

Legend:
[a] = Facility is dealing with water quality issues.
[b] = Facility is dealing with capacity and water quality issues.
N/A = Not available.
MGD = millions of gallons per day.

Water quality concerns for the watershed are similar to those of the Eagle and Blue River watersheds and include salinity and ammonia concentrations as related to stream flow (and capability of the streams to dilute contaminants). Stream flows (hydrology factors related to water quality) in the Roaring Fork watershed are affected by diversions that transport water out of the basin to the Arkansas River via the Frying Pan-Arkansas Project. In 2001, the Roaring Fork Conservancy issued the *Roaring Fork Watershed State of the River Report*. The report states that the major issues regarding water quality are wastewater treatment discharges, stormwater runoff, and erosion and sediment loading. Additional water resource-related concerns include filling of the floodplain and channel, degradation and removal of natural vegetation, and increased recreational use. Specific pollutants of concern include sediment, nutrients, bacteria, dissolved metals, and salts.

Upper Colorado Watershed

Information from 11 WWTPs in the Upper Colorado watershed was obtained from the watershed *Water Quality Management Plan* (NWCCOG, 2002d) as shown in **Table A-11**. Seven facilities in the watershed have ammonia discharge limits. Three Lakes, Winter Park, and Tabernash have either recently expanded or are currently expanding facility capacity. Two Rivers Village is a planned facility.

Table A-11. Upper Colorado Watershed Wastewater Treatment Facility Information

Treatment Plant	Controlling Entity	Existing Hydraulic Capacity (MGD)	Capacity and Water Quality Notes
Three Lakes WWTF[c]	Three Lakes W&SD	2.0	Ammonia discharge limits, capacity has been increased recently
Winter Park WWTF[c]	Winter Park W&SD	0.45	Chlorine disinfection and ammonia discharge limits, capacity has been increased recently
Grand County #1 WWTF[b]	Grand County #1 W&SD	0.995	Problems meeting ammonia discharge limits; plans to consolidate with Fraser WWTF in near future
Fraser WWTF[b]	Fraser SD	1.0	Ammonia discharge limits, need for capacity expansion in near future
Tabernash WWTF[c]	Tabernash Meadows W&SD	0.2	Ammonia discharge limits; currently expanding the facility to 0.2
Young Life WWTF[b]	Young Life Camp	0.034	Ammonia discharge limits
Snow Mountain Ranch[a]	YMCA of the Rockies	0.22	Capacity was recently expanded
Granby WWTF[b]	Granby SD	0.995	Ammonia discharge limits; running below half capacity
Hot Sulphur Springs WWTF	Town of Hot Sulphur Springs	0.09	Compliance schedule for inflow/infiltration studies
Kremmling WWTF	Kremmling SD	0.17	Monitoring required by permit
Two Rivers Village[a]	N/A	0.15	Proposed facility; 1,500 population equivalents

Legend:

[a] = Facility is dealing with capacity issues.

[b] = Facility is dealing with water quality issues.

[c] = Facility is dealing with capacity and water quality issues.
N/A = Not available.
MGD = millions of gallons per day.

Water quality concerns in the watershed are similar to those described for meeting ammonia discharge limits in the Eagle River watershed. Transbasin diversion impacts on water quality are also a major concern as discussed below:

> *"The major water diverters from this watershed are the Denver Water Department and the Northern Colorado Water Conservancy District. Approximately one third of the annual streamflow in the upper Colorado River watershed is diverted out of the drainage. The withdrawal of this amount of water from the streams in the watershed has impacts on water quality including: decreased dilution flows; decreased spring runoff flushing flows which move accumulated sediments that impact fish spawning habitat; decreased aquatic life habitat; increased stream temperature and other water quality concerns associated with changes in channel morphology, and loss of high quality headwaters with low pollutant concentrations."*

Two ongoing EIS projects in the Upper Colorado River watershed include the *Moffat Collection System EIS* (Denver Water proposal for additional transmountain diversions through the Moffat Tunnel to Gross Reservoir, Denver Water 2004) and the *Windy Gap Firming Project EIS* (Northern Water Conservancy District proposal to increase deliveries from the existing Windy Gap Project, NCWCD 2004). Implementation of either or both of these projects could further affect water resources along the Fraser River due to the increased diversions to the Front Range. Such impacts could include decreased stream flows, increased effluent treatment demands on local wastewater treatment facilities (impacts on the ability of existing facilities to meet discharge limits), and decreased water supply resources for local mountain communities.

Eagle River Watershed

Information for nine WWTPs in the Eagle River watershed was obtained from the watershed *Water Quality Management Plan* (NWCCOG, 2002c) (see **Table A-12**). The Vail and Edwards facilities are operating under ammonia discharge limits. Facility expansions are needed and/or planned for the Red Cliff, Red Sky Ranch, Gypsum, and Two Rivers Village facilities. Vail, Avon, and Edwards WWTPs have installed advanced treatment systems to decrease ammonia concentrations.

Table A-12. Eagle River Watershed Wastewater Treatment Facility Information

Treatment Plant	Controlling Entity	Current Hydraulic Capacity (MGD)	Capacity and Water Quality Notes
Red Cliff WWTP[a]	Town of Red Cliff	0.07	Currently at peak capacity, looking at economics to upgrade the facility
Vail WTP[b]	ERW&SD	2.7	Excess flow transferred to Avon; ammonia discharge limits
Avon WTP	ERW&SD	4.3	Projected to meet needs through 2015
Edwards WTP[b]	ERW&SD	1.92	Can serve a population of 24,500; ammonia discharge limits
Red Sky Ranch[a]	Holland Creek Metro District	0.027	Currently near peak capacity
Eagle WTP	Town of Eagle	0.546	Currently running at 53% capacity
Gypsum WTP[a]	Town of Gypsum	0.96	Potential expansion to 2.0
Dotsero Mobile Home Park (MHP)	Dotsero MHP	0.002	N/A
Two Rivers Village[a]	Two Rivers Village District	0.150	Proposed for development community

Legend:
[a] = Facility is dealing with capacity issues.
[b] = Facility is dealing with water quality issues.
N/A = Not available.
MGD = millions of gallons per day.

Several issues of water quality concern within the watershed are discussed in the *Management Plan*, including wastewater facility ammonia removal:

> *"Continuing to provide for an adequate level of ammonia removal to avoid ammonia toxicity problems in Gore Creek and the upper Eagle River is a current problem. Although current levels of wastewater treatment are adequate to meet existing water quality standards, decreased levels of stream flow due to upstream water development projects may require higher levels of treatment to maintain existing water quality levels in the upper Eagle River."*

The impact of diversions affecting hydrological change and water quality is also a concern discussed in the *Management Plan*. Existing transbasin diversions account for about 6 percent of the total stream flow in the watershed. Transbasin diversion activities during low-flow and drought periods have the potential to increase the concentration of pollutants (through a reduction in the amount of dilution flows in the Eagle River), including ammonia and chlorine at existing point source discharges. While the cleanup of the Eagle mine has reduced metals concentrations in the river, significant environmental pressures remain. According to investigations performed by CDPHE, metals concentrations in the upper Eagle River would be increased as a result of diversions from the Homestake II project and could affect downstream public drinking water supplies (NWCCOG, 2002c). Available data suggest that the Eagle River is of poorest quality during low-flow periods, particularly during the late summer months. Low stream flow, coupled with high air temperatures, can significantly elevate water temperatures.

Blue River Watershed

Information for 14 WWTPs in the Blue River watershed is available from the watershed *Water Quality Management Plan* (NWCCOG 2002b) as shown in **Table A-13**. The Iowa Hill, Farmers Korner, and Vail Pass facilities are removing ammonia and/or phosphorus to meet discharge limits. The Copper Mountain facility has reached 95 percent capacity and currently removes ammonia and phosphorus to meet discharge standards. The Frisco, Snake River, and Blue River facilities are planning facility expansions to meet future development plans and are removing phosphorus before discharge.

Table A-13. Blue River Watershed Wastewater Treatment Facility Information

Treatment Plant	Controlling Entity	Current Hydraulic Capacity (MGD)	Capacity and Water Quality Notes
Blue River Treatment Plant	Joint Sewer Authority	1.5	N/A
South Blue River[a]	Breckenridge Sanitary District[d]	0.012	May expand to 0.3 MGD
McDill Placer	Breckenridge Sanitary District[d]	0.02	N/A
Skiers Edge	Breckenridge Sanitary District[d]	0.014	N/A
Valley of the Blue	Breckenridge Sanitary District[d]	0.004	N/A
Iowa Hill[b]	Breckenridge Sanitary District[d]	1.5	Ammonia limits; ammonia and phosphorus removal
Farmers Korner[b]	Breckenridge Sanitary District[d]	1.5	Ammonia limits
Vail Pass[b]	CDOT	0.012	Phosphorus removal
Copper Mountain[c]	Copper Mountain Consolidated Metro District	0.7	Plant has reached 95% capacity and expansion is planned to 1.6 MGD. 2,100 SFE online; buildout at 4,400 SFE (with expansion); phosphorus and ammonia removal; phosphorus allocation
Frisco[c]	Frisco Sanitation District	1.2	1.65 capacity upgrade will buildout; phosphorus removal and allocation
Arapahoe Basin	Dundee Realty	0.035	N/A
Keystone Summit House	Keystone Resorts	0.021	N/A
Snake River[c]	Summit County	1.5	6,000 taps online; buildout at 10,400 taps; phosphorus and ammonium discharge limits
Blue River[a]	Silverthorne/Dillon Joint Sewer Authority	4.0	7,400 taps online; buildout at 10,000 taps; phosphorus removal

Legend:

[a] = Facility is dealing with capacity issues.

[b] = Facility is dealing with water quality issues.

[c] = Facility is dealing with capacity and water quality issues.

[d] = 13,500 Single Family Equivalent (SFE) online; buildout at 15,000 SFE.
N/A = Not available.
MGD = millions of gallons per day.

Several issues of water quality concern are discussed in the *Management Plan*, including the impact of wastewater effluent on reservoir water quality. Although current levels of wastewater treatment in the watershed are adequate to meet existing water quality standards, decreased levels of stream flows due to upstream water development projects may require higher levels of treatment to maintain existing water quality in the Blue River. Nutrient enrichment from phosphorus sources (partially from wastewater treatment facility discharges) is contributing to potentially excessive algal growth in Dillon and Green Mountain reservoirs. Excessive algal growth alters lake/reservoir water quality conditions so that oxygen is not available to fish, among other effects. These concerns are further described in the *Management Plan*:

> *"Existing wastewater treatment levels have been based on meeting water quality standards under existing hydrologic conditions. Changes in the operations of the reservoirs to increase system yields, including reduction in residence times, second fill rights, and routing of new sources of nutrients to Dillon and Green Mountain Reservoirs, have the potential to modify future wastewater treatment requirements to maintain the same level of water quality. The concern is that discharge permit limits can be made more stringent to meet instream water quality standards, when actual discharge quantities have not changed. For example, plants discharging to Dillon Reservoir could have significantly more stringent permit limits, and thus increased treatment costs, as a result of changes to Dillon Reservoir operations."*

In 1993 the Summit Board of County Commissioners passed a resolution approving a *Water Quality Mitigation Plan*, primarily to deal with phosphorus impacts on Dillon Reservoir. The plan placed a significant responsibility for man-made nonpoint source phosphorus loading to Dillon Reservoir on septic systems. Nonpoint source water quality issues in streams and lakes in the Blue River watershed include the effects of both existing and inactive mining activities; urban and construction activities (including septic systems), agricultural activities (specifically silvicultural), and hydrologic modifications.

Other water quality concerns in the watershed are directly related to transbasin and in-basin diversions. One issue is the impact that existing water development projects have had on water salinity levels. Diversion of snowmelt, which is generally very low in salinity high in the watershed, results in less dilution of downstream salinity inputs. Dillon Reservoir transbasin diversions are expected to increase and might result in the water quality issues described below:

> *"Wastewater treatment levels for the Silverthorne/Dillon treatment plant downstream of Dillon Reservoir may also be affected by changes in the operational hydrology which are currently being planned. Existing treatment levels are determined, in part, by the one-day in three-year low flow event. With consistently lower stream flows, average concentrations of pollutants will increase and the flow available for dilution will also decrease. Because ambient conditions are considered in effluent permit discharge limitations, more stringent permit limits could result from increased average concentrations of pollutants even though flow levels are not below the permit's low flow criteria."* (NWCCOG, 2002b)

In-basin diversions, although not on the scale of transmountain diversions, also affect water quality in the Blue River because the lower stream flows resulting from these diversions diminish the stream's ability to dilute these pollutant sources. Diversions for snowmaking affect water quality because they occur during the time of lowest stream flows, when the streams are least able to meet fishery flow requirements as determined by CDOW and CWCB instream flow levels. In addition, the Upper Blue River basin is experiencing increasing groundwater depletions as a result of residential development, which may, in turn, affect stream flow because groundwater systems contribute about 25 percent of surface water flow in the watershed area.

Upper Clear Creek (Within the Clear Creek Watershed)

The water quality evaluation is limited to the Upper Clear Creek watershed because the entire Clear Creek watershed covers a much larger region beyond the Corridor area of interest. A major water quality issue in the Upper Clear Creek watershed is the impact of historic mining on surface and groundwater. Although CDPHE and EPA, through the Superfund program, have regulated the cleanup of substantial contamination in the area, tailings, mine waste, and their contaminant impacts remain in some locations. Contaminants include metals and acidic water conditions. Manganese has been a concern of the municipalities that use Clear Creek for drinking water because water treatment is necessary and expensive (EPA, 1997).

Information was available for 12 WWTPs in the Upper Clear Creek watershed (see **Table A-14**). The Loveland Ski Area facility has implemented two primary programs to reduce ammonia and phosphorus loadings. The CDOT Eisenhower Tunnel facility has worked to improve the functioning of the plant in an effort to treat/control/contain hazardous spills and to enhance nutrient removal. The Black Hawk wastewater facility is being moved about 5 miles downstream on North Fork Clear Creek to have the space to accommodate increased capacity and advanced treatment. As a result, wastewater that currently enters North Fork at the south end of Black Hawk will be piped to the plant and will re-enter the stream 5 miles downstream. Because the existing plant effluent has neutral pH and lower metals content, this change may affect both the quantity and quality of water that flows between Black Hawk and the new plant location because the effluent would no longer serve to dilute the polluted stream flow.

Table A-14. Upper Clear Creek Watershed Wastewater Treatment Facility Information

Treatment Plant	Controlling Entity	Current Hydraulic Capacity (MGD)	Capacity and Water Quality Notes
Black Hawk/Central City[a]	Black Hawk/Central City Sanitation District	1.125	New plant is under construction to meet future needs
CDOT Eisenhower	N/A	0.072	N/A
Central Clear Creek	N/A	0.1	Expected to reach 95% capacity in 2015
Clear Creek Convenience	N/A	0.002	N/A
Loveland Ski Area[b]	Clear Creek Skiing Corporation	0.03	Ammonia and nitrogen concentrations are an issue
Cyprus Amax Materials	N/A	N/A	N/A
Town of Empire	N/A	0.06	N/A
Town of Georgetown	N/A	0.58	WWTP improvements and modifications were made in 1996
Town of Idaho Springs	N/A	0.6	N/A
Mount Vernon Country Club	N/A	0.007	N/A

Treatment Plant	Controlling Entity	Current Hydraulic Capacity (MGD)	Capacity and Water Quality Notes
Reverend's Ridge Campground	N/A	0.0155	N/A
Schwayder Camp WWTF[a]	N/A	0.002	0.009 MGD needed in 2020
St. Mary's Glacier	N/A	0.03	N/A

Legend:
a = Facility is dealing with capacity issues.
b = Facility is dealing with water quality issues.
N/A = Not available.
MGD = millions of gallons per day.

DRCOG is the Denver metropolitan-areawide water quality management agency and has put together a *Clean Water Plan* (1998). The plan addresses water quality concerns in the governing region (which includes the Upper Clear Creek watershed) and states that *"nutrient management, phosphorus and nitrogen, is a national priority with proposed changes to stream standards expected within two years."* In response, DRCOG has initiated a utility planning program to address this issue and other wastewater management needs. Any proposed WWTPs in the Clear Creek watershed fall under this program. As part of the planning program, DRCOG assesses the need for a wastewater treatment system based on growth and development, which has been approved for local governments and is consistent with DRCOG's *Metro Vision 2020 Plan*. According to the assessment, the primary goal of a proposed facility is to provide reasonable, feasible, and economical wastewater service to any particular area. Consideration is also given to the impact the treatment system will have on receiving waters, the ability to meet water quality standards, and the impact a discharge may have on downstream dischargers.

A.1.7 Colorado Water Policy Issues

Colorado's water is managed according to a legal principle known as the "Appropriation Doctrine," which uses the concept of "first in time, first in right." This means that the first person who claims the right to water has the right to use that water before anyone else (called a senior water right), whether they are upstream or downstream. A few subtle changes have been made over time:

- The person who owns water rights owns only the right to use the water, not the water itself.
- To hold a water right, water must be put to beneficial use, such as for agriculture, industry, domestic use, or other purposes.
- The owner of a water right cannot alter the diversion or use of the water if it will harm a current downstream user, regardless of who owns the most senior water right.

In times of drought, when river flow is low, the Appropriation Doctrine does not require conservation and still holds that the most senior water rights be completely fulfilled before other water rights holders.

Appropriation of water in the Colorado River is subject to the 1922 Colorado River Compact, which divided the U.S. portion of the Colorado River into two basins: the Upper and the Lower basins. The division is at Lee's Ferry, Arizona. A total of 20 million acre-feet of water were allocated to seven US states and to Mexico, and each US state was awarded 7.5 million acre-feet of water. Evaporation and leaks in dams and diversions remove around 2.5 million acre-feet per year, which theoretically leaves a total of 17.5 million acre-feet for use. However, the original agreement assumed total use of the water and did not account for minimum stream flows to support wildlife, fish, and habitat. In addition, studies of tree rings by University of Arizona scientists show that over time the river flow averages about 13 million acre-feet of water per year (7 million acre-feet less than the Compact total). Some states in the Upper basin (including Colorado) have not yet reached their maximum allocation.

The NRLC, housed with the University of Colorado School of Law, performed a study in 2001 that focused on water and growth in Colorado. The study is based on interviews with about 70 key Colorado water leaders, as well as an extensive review of recent water studies and legal documents. The resulting report (NRLC, 2001) describes existing water problems and water development strategies for coping with future growth including development of new surface and groundwater sources, reallocation of supplies from agriculture to municipal use, and conservation and efficiency management measures.

According to the NRLC study, water development is not a necessary precursor to growth and is not necessarily a deterrent to growth. However, growth in Colorado has resulted in increased competition for limited water supplies between the municipal, agricultural, and environmental sectors. The ability of Western Slope headwater communities to meet future growth needs is affected by Front Range diversions and instream flow requirements.

> *"The challenge faced by headwater communities is, arguably, even greater than that faced by Front Range cities in some cases. Rapidly growing Summit County, for example, has a physical abundance of water, but most is unavailable for local use due to senior or conditional rights held by parties outside the County.*
>
> *Instream flow requirements can impair the ability of headwater communities to meet growing demands for resorts and recreational industries."* (NRLC, 2001)

The NRLC study also discusses the interplay of water supply and water quality issues in Colorado. Overlapping water supply and water quality issues are often problematic because state law primarily guides water supply while federal law dominates water quality issues. The assertion that *"Colorado…water quality issues are independent of, and therefore properly subservient to, the right to use the waters of the state"* is being challenged on several fronts (NRLC, 2001). At the current time, water quality issues such as maintenance of instream flows and water quality protection standards are often of equal prominence.

The CWCB issued the *Colorado River Compact Water Development Projection—Final Report* in November 1995. The report discusses water availability as related to water rights issues and instream flow requirements. Upper limits for future development (and instream flow management) of water resources in the Colorado River basin based on the state's remaining Compact entitlement must fall within the total state consumptive use apportionment of 3.079 to 3.855 million acre-feet. The following excerpts demonstrate some of the water development and water quality issues:

> *"A conservative assumption should be made in which all future water development may occur under water rights which will be junior in priority to the endangered fish recovery instream water rights.*
>
> *The Recovery Implementation Program for Endangered Fish Species in the Upper Colorado Basin includes a commitment to manage and protect instream flows needed to recover the endangered fishes in accordance with the state laws and property rights and to date, has been successful as a cooperative means of meeting the regulatory requirements of the Endangered Species Act."*

A.1.8 Colorado Drought Conditions

Single season droughts with precipitation of 75 percent or less of the average for 1 to 3 months in a row occur nearly every year in Colorado. Ninety-three percent of the time at least 5 percent of the state is experiencing drought at a 3-, 6-, 12-, or 24-month time scale. However, drought rarely encompasses the entire state. Short-term droughts (3-month duration) have covered as much as 80 percent of the state and longer-duration droughts (2 to 4 years) have reached about 70 percent of the state. **Table A-15** shows prominent dry and wet cycles in Colorado from 1890 to 1999.

Table A-15. Prominent Dry and Wet Periods, Colorado 1890–1999

Dry Periods		Wet Periods	
Dates	Duration (years)	Dates	Duration (years)
1893 to 1905	12	1905 to 1931	26
1931 to 1941	10	1941 to 1951	10
1951 to 1957	6	1957 to 1959	2
1963 to 1965	2	1965 to 1975	10
1975 to 1978	3	1979 to 1996	17

Source: Colorado Water Resources Research Institute, 2000.

Colorado's drought of 1976–77 was the driest winter in recorded history at that time, for much of Colorado's high country and Western Slope, and had serious consequences for the ski industry. Another drought cycle, from fall 1980 to summer 1981, also generated costly impacts on the ski industry and initiated a huge investment in snowmaking equipment. The 2002 water year was the driest on record, breaking records set in the 1977 drought. Some river basins fell below 10 percent of their normal water capacity.

On April 22, 2002, Governor Bill Owens requested, in a letter to the Colorado Water Availability Task Force, that Colorado's *Drought Mitigation Response Plan* be activated to address statewide drought conditions. The Task Force put together a document to assess drought issues and make recommendations in May 2002. Primary concerns include:

- **Critical drinking water supply shortage.** This is an extreme public safety issue in that fire protection systems are generally tied to drinking water supply systems.
- **Risks to public water systems and increased operational costs.** Drought-induced low flows, especially downstream from a WWTP, would increase water temperatures, nutrient concentrations, and algal blooms causing operational issues, potential fish kills, and nuisance concerns affecting downstream public water systems.

The Task Force is in the process of assessing existing Colorado water supplies and compiling short and long-term drought strategies. As the agency responsible for regulating water supply issues, DWR provides drought status updates to the public and to government entities. August 2002 drought update reports are available for the major Colorado water basins and are briefly discussed below.

The Colorado Front Range did not experience significant drought impacts during the summer of 2003. Late winter and spring precipitation in the mountains and along the Front Range provided adequate water for various uses (including public supplies) to reservoirs and streams. However, efforts to assess water supplies and to plan for future supplies are continuing, most recently in the completion of a scope of work for the *Statewide Water Supply Initiative* (CWCB, 2003).

Colorado River Basin Drought Update

Most municipal water districts in the Colorado River basin have outdoor watering restrictions in place, and many have initiated higher restrictions during the summer of 2002. The DWR update for the basin reports that storage in Green Mountain, Ruedi, and Williams Forks reservoirs was 49 percent of normal at the end of July 2002. Reservoir storage for the entire basin, as of August 1, 2002, was 50 percent of average. The update also reports that a landslide at Green Mountain Reservoir has led the Bureau of Reclamation to increase the dead storage pool by 20,000 acre-feet. The landslide event has significantly reduced the amount of replacement water for water users, particularly for water users within the basin. The August 2002 DWR presentation *Streamflow Information and Drought Impacts* indicates that *"…stream flow continues to decline in the Colorado River Basin and the Fraser River near Granby may dry up soon and the Eagle River may lose its exchange potential from the main stem…winter snowmaking may be limited by available water rights and by augmentation water requirements…the March 1, 2003 forecast for reservoir storage in the basin is very bleak."*

South Platte River Basin Drought Update

According to the DWR update, cities in the South Platte River basin continue to follow water conservation plans, and many cities have been looking to purchase additional water supplies, including transbasin supplies. As of August 2002, South Platte Reservoir storage was at 53 percent of the normal average, and Denver has begun to drain Antero to consolidate supplies in Cheesman Reservoir to reduce evaporation losses and to provide a mix of in-basin and transbasin supplies for water quality purposes. By bringing down water from Antero, Denver hopes to dilute the amount of ash (from the Hayman burn area runoff) in the raw water supply. Releases from Antero are anticipated in September 2002, followed by potential Eleven Mile releases for the same reasons.

Tourism and Drought

Tourism is one of the most important economic sectors in Colorado, with certain regions of the state more dependent on tourism and, consequently, more affected by drought. The part of the state most dependent on tourism is Region 12, which includes Eagle, Grand, Jackson, Pitkin, and Summit counties. Drought has the potential to affect tourism (and has affected tourism during past droughts) by a decline in the following activities:

- Skier visits (due to lack of snow)
- Hunting (due to loss of habitat caused by potential wildfires, as well as possible decline in herd size from lack of precipitation in the graze land)
- Fishing and rafting (due to lower stream levels)
- Outdoor recreation (due to fire bans and lack of interest in camping without campfires; access to camping areas also may decrease from wildfires)
- Resort visits (due to water restrictions and decreased watering of golf courses)
- Touring and parks visits (due to forest fires)

A.1.9 Conclusions

The information in this report indicates that water resources (including quantity and quality issues) and associated infrastructure, including water treatment and wastewater treatment, are likely to influence future land development patterns in watersheds intersecting the Corridor. Water resource factors that may influence growth and development in the Corridor include water rights appropriations (water available for use), water quality issues, and public water infrastructure, including treatment plants and public supply systems, and wastewater treatment facility infrastructure. These factors are interrelated on many levels.

Based on available information for the Corridor area, watersheds intersecting the Corridor are already under stress due to growth, both within the Corridor area and outside (due to transbasin diversions to the Front Range). There is evidence to indicate that future development in the Corridor will be influenced by available water rights, instream flow requirements, and water quality standards. While many water and wastewater facility providers in the Corridor area are generally meeting current and planned development needs, most of these districts have not documented water supply and/or wastewater facility capacities for more significant growth (beyond planned development or buildout conditions). More definitively, a recent water supply study (NWCCOG, 2002a and Hydrosphere Resources Consultants, 2003) indicates that a substantial number of water providers in the Corridor area have existing and future projected water supply shortages (based on planned development). Water demand estimates based on projected population growth and tourism in the Corridor, indicate that substantial additional water will be required by 2025 and/or buildout (of planned development) conditions. In many cases, existing infrastructure is not planned or in place to meet these demands.

In addition, water quality within the Corridor has the potential to be significantly affected by drought and low stream flow periods, nonpoint source pollutants, and wastewater effluent. Many Corridor wastewater facility capacities already are limited by nutrient discharge limits to meet federal and state water quality protection requirements.

Management measures are not currently in place for Corridor communities to effectively deal with these complex interrelated water and growth issues, and future water availability will be based on the evolution of water management strategies and the interplay of state and federal water laws. Instream flow and water quality are significant factors that affect recreational resources and quality-of-life in the Corridor area. Tourism, a major economic driver for the Corridor, as well as the state, was severely affected by drought during the summer of 2002. Local and statewide entities are currently faced with the prospect of balancing these factors with water supply issues. The specific influences that water resources will have on future land development in the Corridor area, or vice versa, are difficult to predict. Corridor water providers must obtain new supplies and new water right allocations, acquire additional storage/infrastructure, and/or implement conservation/efficiency management measures in an effort to accommodate future growth. **Table A-16** summarizes the findings of the water resources analysis. The table shows water availability factors and the findings in relation to meeting water demand in the Corridor. The factors are associated with high, medium, or low likelihood with respect to their issues.

Table A-16. Summary of Findings

Water Resources Are Available to Accommodate Growth Beyond Buildout Conditions	Potential to Acquire Additional Water Resources								Interrelated Issue Impacts				Public Concerns	Overall Rating
	Storage	Groundwater	Surface Water	Water Rights	Management Measures	Transbasin Sources	Forest Management	Cloud Seeding	Drought Will Not Affect the Water Supply	Drought Will Not Affect Tourism and Recreational Use	Global Warming Will Not Affect Colorado's Water Supply	Water Quality Will Not Affect the Water Supply	Water Supply Issues and Related Issues Are Not Public Concerns	Water Will Be a Limiting Factor in Relation to Growth Beyond Buildout
L	L	M	L	M	M	L	M	M	L	L	M	L	L	H
Data from numerous sources indicate that the Corridor area will be facing water shortage issues at and before buildout. Growth during the 1990s occurred during a wet cycle when an abundant water supply was taken for granted. Most water providers in Colorado did not anticipate the current drought cycle. The drought situation has demonstrated that many providers are not prepared for extended drought conditions and has brought water shortage issues to the forefront.	Although there is the potential to acquire additional water storage, there are no planned projects and such projects require years of study and environmental clearance. New storage in the Corridor area is unlikely for 2025. In addition, storage is dependent on sufficient runoff, and significant drought episodes can make storage a moot point.	Deep mountain aquifers cannot produce sufficient water for large supplies. Alluvial aquifers are constrained by surface water rights. Limited groundwater development is possible but is not a long-term solution because aquifers must be replenished by precipitation/ infiltration.	Surface water sources are already over-appropriated. Significant new surface water supplies are not available.	A limited amount of water rights might be available via reallocation (such as from agricultural to municipal use). However, reallocation from agricultural use is limited by the water rights of downstream users (due to return flow requirements) and environmental factors (such as protection of habitat).	Conservation, water reuse, and other measures might provide limited water resource protection but will not contribute considerably to the water supply. In addition, many of these measures are constrained by the water rights of downstream users (required return flows).	Although there is the potential to acquire water from areas outside the Corridor (from Colorado's remaining allocation of Colorado River water), there are no planned projects and these projects would require years of study. A new project (such as the "Big Straw") is unlikely for 2025. In addition, such projects are constrained by water compacts, environmental requirements, water quality issues, and natural hydrologic conditions.	Although a small-scale study indicates thinning of forest vegetation might increase that runoff, the degree of success using this method depends on many complex factors and is uncertain. For example, drought conditions might actually decrease the amount of runoff.	Cloud seeding is under consideration due to the existing drought and is an option to augment Colorado's water supply. However, it depends on appropriate atmospheric conditions (precipitation conditions must already be present) and is, therefore, not dependable. Cloud seeding is not expected to be a significant contributor to Colorado's additional water demands.	Drought is a regular (and natural) occurrence in Colorado. At least 5 percent of the state is experiencing drought at a 3-, 6-, 12-, or 24-month timescale, 93% of the time. Five major droughts of 2 to 12 years' duration have occurred during the last 100 years in Colorado. Drought affects water storage (reservoirs) and stream flow, which are Colorado's two primary water sources.	Drought has affected the tourism industry and recreational use in Colorado and will do so in the future.	Although the causes of global warming are still under debate, the phenomenon is not. Some evidence suggests that warmer winters and springs have decreased mountain runoff from snow pack. The complete ramifications of global warming in relation to the Rocky Mountain water cycle are not yet fully evident.	Lower flow, resulting from drought or normal low stream flow (including impacts from diversions) results in higher concentrations of pollutants. Nonpoint source pollutants and wastewater effluent have affected water supplies and aquatic habitat. Instream flow rights influence stream diversions for other uses.	High-quality, flowing water is a major component of aesthetic appeal and recreational use in the Corridor. Protection of these resources is part of most community plans. Existing residents in Colorado do not want to sacrifice their water supply to accommodate new residents.	None of the components examined in this table indicate the availability of water for growth beyond projected growth and planned development. The components, however, indicate a high likelihood that water supply will be a limiting factor in relation to future Corridor growth.

Legend:
H = High likelihood.
M = Medium likelihood.
L = Low likelihood.