SEDIMENT CONTROL ACTION PLAN
BLACK GORE CREEK I-70 CORRIDOR

Prepared by

Colorado Department of Transportation

IN COOPERATION WITH

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EXECUTIVE SUMMARY

This Sediment Control Action Plan (SCAP) provides an analysis of sediment control for the Black Gore Creek section of the Vail Pass corridor along Interstate Highway 70 (I-70) in Colorado. Due to erosion and winter traction sanding operations, sediment controls are needed to decrease water quality impacts to near-by surface waters from I-70 operations. The Black Gore Creek I-70 corridor lies entirely within the White River National Forest in Eagle County, west of the Denver Metropolitan Area. Eagle County has experienced significant growth over past twenty-five years creating more traffic demand on the I-70 corridor. In addition, the growth of interstate traffic, particularly truck traffic, in the mountains west of Denver is noteworthy. These factors have created their own set of travel conditions, demand patterns, and maintenance needs that differ significantly from other portions of the state because I-70 provides excellent winter access to and through these areas.

The Black Gore I-70 corridor is a steep high elevation mountain corridor that receives significant snowfall during the winter months and is subject to extreme weather conditions. The I-70 mountain corridor in this area is sensitive to winter maintenance issues due to its unique characteristics such as high elevation snowfall, steep gradient mountain passes, areas susceptible to avalanches, its proximity to many of the state's most popular ski areas, as well as the amount of traffic that it carries.

Excessive sediment loading has been occurring over the twenty years of I-70 operation in the Black Gore Creek corridor. Sedimentation is caused by both cut and fill slope erosion and winter maintenance practices, when I-70 is sanded for traction to maintain safety for the traveling public. This material, collectively referred to as sediment, is transported into the natural environment from the I-70 right-of-way by surface water runoff, depositing into streams, lakes, and wetlands. Excessive sediment loading can impair water quality, increase nuisance nutrient concentrations, reduce fish habitat, and inundate wetland vegetation. This situation is largely due to inadequate source controls and drainage problems along I-70. Sediment controls are referred to as Best Management Practices (BMP's) under the Clean Water Act. Implementation of sediment control BMP's can reduce the amount of sediment loading in receiving waters. Additional controls and drainage improvements are required to reduce the sediment loading from I-70. Therefore, the focus of this SCAP is related primarily to drainage improvements and sediment source controls along the Black Gore Creek I-70 corridor.

In November 2000, development of this SCAP was approved by the Transportation Commission to determine planning strategies for controlling sedimentation from I-70, including the identification of potential implementation scenarios and cost estimates for consideration. Extensive analysis was required to assess these needs, and this SCAP is the most comprehensive examination of I-70 of its type completed to date.

This SCAP is a planning document that includes relevant background information, an evaluation of I-70 sediment sources, volume estimates, hydraulic/drainage analysis, and maintenance practices to develop a source control strategy. Both structural and non-structural sediment control BMP's are proposed. To assist in the planning and decision making process, four implementation scenarios with cost estimates have been developed: (1) Existing Maintenance Program (baseline); (2) Enhanced Maintenance Program; (3) Capital Construction and Maintenance Program; and (4) Prioritized Capital Construction and Maintenance Program.

A great deal has been learned in the Straight Creek I-70 Corridor to help address the sedimentation over the past ten years, contributing to the proposed solutions put forth in this SCAP. Currently, Black Gore Creek has no sediment source controls in place. The strategy adopted for this planning document is focused on source control. Investigative data, field studies, and observations indicate that presently, the majority of sediment transported to Black Gore Creek is accumulated traction sand that is applied to I-70 during winter maintenance operations. Annual applications currently average approximately 15,000 tons/year on Black Gore Creek (CDOT, 2001). About 10 percent of the residual sand is collected annually under routine maintenance operations (ditch cleaning). The remaining 90 percent either remains on the shoulders of I-70, or is transported in surface water runoff to receiving streams. The area included in this SCAP is the highway shoulder and median, extending to approximately 30-feet on either side of the edge of pavement. Any work beyond the highway corridor 30-foot zone will need to be addressed in a separate study.

In recent years, there has been an increased focus on environmental facets of routine CDOT maintenance practices. Operational BMP's for sediment control are relatively new to the CDOT maintenance program. A major portion of this SCAP is dedicated to maintenance practices and operations. Since the completion of I-70, the focus of maintenance operations has been on maintaining the highway surface. The higher level of maintenance work to meet the growing needs was not anticipated at the time of I-70 construction. Public expectations for maintaining I-70 to a certain level have increased accordingly. The scenarios presented in this plan would require significant additional resources for I-70 maintenance to provide the same level of service to the traveling public and adequately address the sedimentation problem. This would indicate that additional resources, as well as changes in policies and priorities, are required to meet all the needs. It is clear that maintenance forces are under-staffed and under-funded at the current time to adequately clean-up traction sand and sediment material. It is estimated for Control Scenario 1 that approximately $40,000 to $80,000 is spent annually on the Black Gore Creek corridor, within existing budget allotments, to conduct maintenance activities related to traction sand and sediment removal, hauling, and disposal.

At this time, funding options for implementing Control Scenarios 2, 3 or 4 have not been identified. To adequately control sediment in the Black Gore Creek corridor utilizing non-structural methods including an enhanced maintenance program, it is estimated that approximately $200,000 to $500,000 is needed annually. In order to construct adequate source controls along the corridor, the estimated cost is $20 million. Full structural controls would require approximately $400,000 to 600,000 annually for routine maintenance. These estimates were based on experience with existing sediment and erosion controls in other areas of I-70, hydrologic analysis, and the Maintenance Management System (MMS).

New and innovative ideas are brought forth in this SCAP to identify and address current and future needs. The measures being proposed will significantly intercept the flow of sediment material from I-70 into the natural environment of Black Gore Creek. Additional hydraulic analysis and design will be necessary prior to implementation of the scenarios presented. However, this plan lays the groundwork for retrofitting I-70 with the necessary measures needed. Although it is noted that Black Gore Creek will ever be a pristine stream, it is recognized that the stream system will recover once the constant inundation of sediment material is arrested, thereby allowing for water quality improvements over time.

1.0 INTRODUCTION AND PURPOSE

This Sediment Control Action Plan (SCAP) was undertaken by the Colorado Department of Transportation (CDOT) to develop a strategy for addressing sediment loading from Interstate 70 (I-70) in the Black Gore Creek corridor. The Black Gore Creek corridor is located within the White River National Forest in Eagle County, Colorado, where I-70 follows Black Gore Creek for approximately ten miles from the Summit/Eagle County line (summit of Vail Pass) to the Town of Vail (Figure 1). CDOT operates I-70 in this area under a U.S. Forest Service easement.

Development of the SCAP was approved by the Colorado Transportation Commission (TC) in November 2000 to plan strategies for controlling sedimentation from I-70, including identification of potential implementation scenarios and cost estimates for TC consideration. The Black Gore Creek watershed is of particular interest because construction and operation of I-70 through this area created unique circumstances associated with high traffic volumes, steep slopes and highway grades, extreme winter weather conditions, winter maintenance operations (including traction sanding), and other characteristics that have contributed to accelerated sediment loading within an otherwise pristine mountain environment. The construction and operation of I-70 through the Black Gore Creek watershed has formed a new landscape that has forever altered the natural environment.

I-70 is a major route through Colorado; serving both the eastern plains and the western slope and is the only east-west interstate highway route through Summit and Eagle counties. Traffic along I-70 through the mountains has been increasing at a rate of approximately 5% every year since it was completed in the 1970's. Recent traffic counts from I-70 at the Eisenhower/Johnson Memorial Tunnel show traffic volume greater than 30,000 vehicles per day. Numerous recreational areas, including some of the most popular ski resorts in the state, are located within Summit and Eagle counties. These areas have experienced significant residential, economic, and recreational growth over the past twenty-five years. This factor has created its own set of travel conditions, demand patterns, and maintenance needs that differ significantly from other portions of the state because I-70 provides excellent winter access to and through these mountain areas.

Although highway maintenance is a year-round activity, the I-70 mountain corridor is extremely sensitive to winter-related maintenance issues due to its unique characteristics such as high elevation snowfall, steep gradient mountain passes, areas susceptible to avalanches, its proximity to many of the state's most popular ski areas, as well as the amount of car and truck traffic that it carries. In the I-70 mountain corridor, winter weather is an important factor where snow and ice on the roadway regularly causes conditions that reduce speeds and can adversely impact capacity.

A study of this magnitude has not been undertaken since the construction of I-70. This SCAP provides the first attempt to fully assess and identify potential measures that could be utilized to help control sedimentation from the highway, as well as an analysis of maintenance operations as they relate to sedimentation. In order to develop the SCAP, an extensive assessment and analysis of the Black Gore Creek I-70 corridor was required. This includes an analysis of relevant background information, evaluation of sediment sources, hydraulic/drainage analysis, sediment volume estimates, development of a sediment control strategy, and recommended potential structural and non-structural BMP's for sediment control. Four implementation scenarios with cost estimates were developed to assist with the planning and decision-making process as part of this SCAP: (1) Existing Maintenance Program (baseline); (2) Enhanced Maintenance Program; (3) Capital Construction & Maintenance Program; and (4) Prioritized Capital Construction & Maintenance Program.

1.1 Implementation of the SCAP

Because of the complexities and potential costs associated with implementing the various aspects of this SCAP, it must be emphasized that the SCAP is a planning document only. Further design and hydraulic analysis will be necessary prior to implementation. No funding sources for full or partial implementation of this SCAP have yet been identified. The rationale of the SCAP was to provide the analysis needed to develop concepts, methods, and potential costs for controlling sedimentation originating from I-70 in the Black Gore Creek corridor. Due to these factors, it is important to understand the scope of this document and its limitations. A Glossary of Terms has been included in the report that will aid in interpretation of the terminology used. A chronology for the Black Gore Creek I-70 corridor has been developed to assist with historical perspective.

Development of the SCAP was a voluntary effort on the part of CDOT and was not undertaken as part of any mandate or regulatory requirement. Actions taken by CDOT regarding unregulated nonpoint source issues are not incorporated into the Department's routine planning and project development process. Such actions are initiated on a case-by-case basis, as funding becomes available. No funding mechanism has yet been identified to implement this SCAP. It is anticipated that further clearances and coordination with the U.S. Forest Service and resource agencies will be required prior to implementation of the SCAP.

CDOT Region 1 has been proactive over the years with addressing nonpoint source highway-related water quality issues, and has collaborated with local stakeholders and other agencies through the State's Nonpoint Source program (NPS). The NPS program remains voluntary under the Clean Water Act (CWA). Much has already been accomplished in the Straight Creek and other highway corridors using this approach. Region 1 takes non-regulated nonpoint source issues very seriously and has an active water quality program dedicated solely to this issue. Within this program, the Region interacts with various agencies and entities to facilitate communication with local watershed groups and other interested parties to enhance and improve both the regulatory (those projects requiring NPDES permits) and the nonpoint source (non-regulatory) water quality and erosion control programs.

The Region 1 boundaries include the following watershed areas: Cherry Creek, Chatfield, Upper South Platte, Dillon, Republican River, Fraser River, Clear Creek, Upper Blue River, Bear Creek, Black Gore, and Straight Creek, among others. Therefore, the implementation of projects and funds for erosion control and water quality issues, particularly those that are unregulated, remain highly competitive among all the various stakeholders and local entities. The Region-wide program tries to take a balanced approach and works closely with the State's Nonpoint Source program to ensure that steps taken to address the highway related issues are in keeping with the appropriate goals and priorities as established within the State's overall program. Although the SCAP was completed specifically for the Black Gore Creek I-70 corridor, it could have application elsewhere as a tool for evaluating and assessing nonpoint source issues along other high elevation highway corridors.

Currently, a Programmatic Environmental Impact Statement (PEIS) is underway to address transportation issues in the I-70 mountain corridor. Should the SCAP be implemented prior to selected alternative(s) identified in the PEIS, sediment control BMP's would be incorporated as part of the new highway design. However, all of the non-structural controls and many of the structural controls proposed in this SCAP would not be affected by the reconstruction of I-70, although they need to be considered in such efforts.

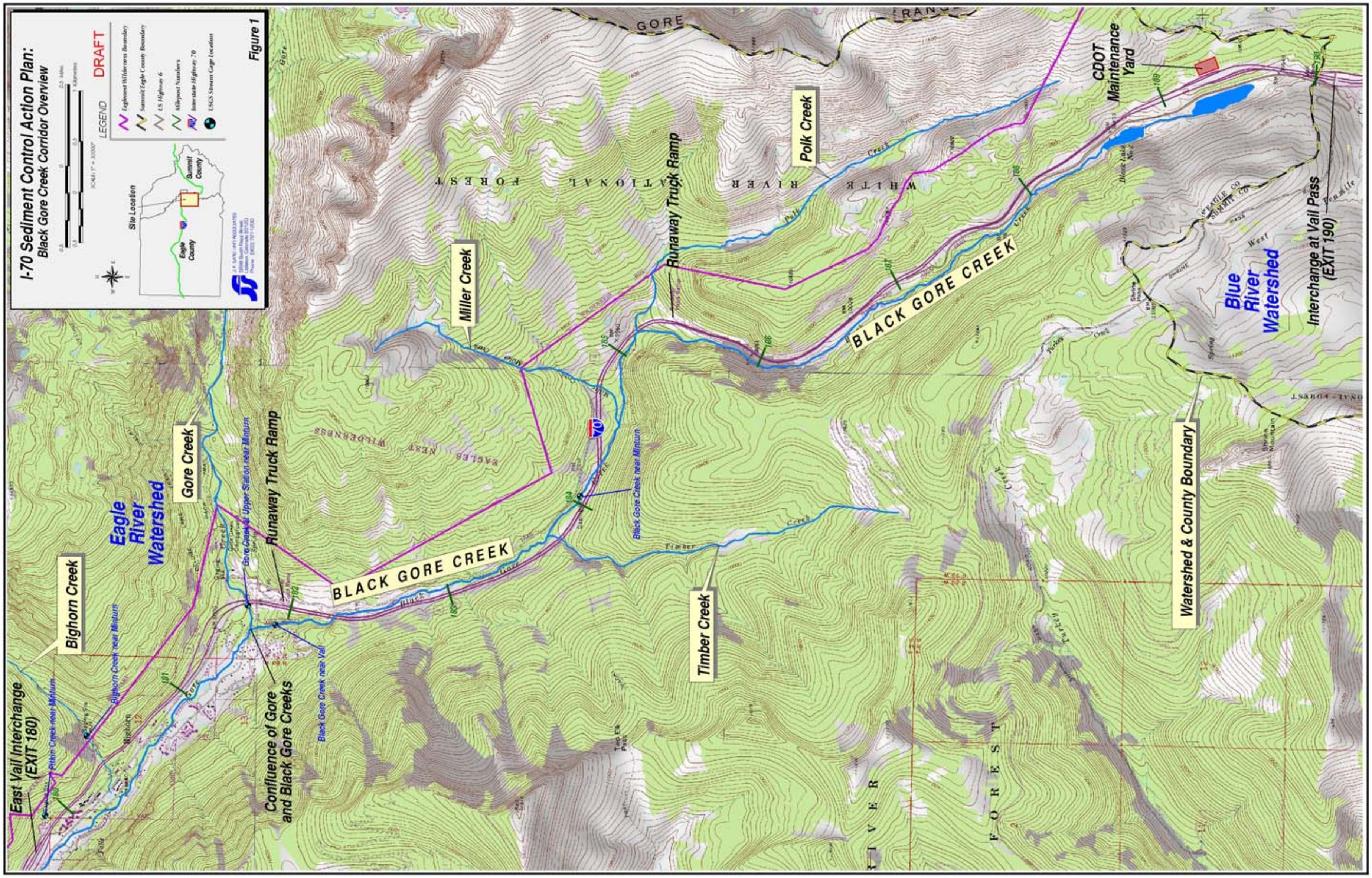

I-70 Sediment Control Action Plan:
Black Gore Creek Corridor Overview
DRAFT
LEGEND
Figure 1
Site Location
Eagle County
Summit County
BLACK GORE CREEK
Miller Creek
Runaway Truck Ramp
Polk Creek
CDOT Maintenance Yard
Interchange at Vail Pass (EXIT 190)
Blue River Watershed
Watershed & County Boundary
Timber Creek
Gore Creek
Eagle River Watershed
Bighorn Creek
East Vail Interchange (EXIT 180)
Confluence of Gore and Black Gore Creeks
Black Gore Creek near Vail
Black Gore Creek near Minturn
GORE RANGE

FIGURE 1

2.0 BLACK GORE CREEK I-70 CORRIDOR

The Black Gore Creek basin is located within the Upper Colorado River Basin and lies in the subalpine vegetation region. The basin originates near timberline at an elevation of 12,000 feet above sea level. The lowest elevation of the basin is located at 8,700 feet above sea level near East Vail. The basin itself encompasses an area approximately 8 miles long and 2.5 miles wide and consists of rugged terrain (see Figure 1).

During the 1970's, the Colorado Division of Highways (now the Colorado Department of Transportation) was granted approval to construct I-70 over Vail Pass. I-70 was not the first major highway through this area, as U.S. 6 was the first federal highway constructed along a virgin alignment through the Black Gore Creek watershed. In order to satisfy federal design standards at the time, I-70 was constructed as a four-lane divided highway containing two lanes of one-way traffic each direction, completed in 1978. The Black Gore Creek I-70 corridor is eight miles long beginning at Vail Pass and continuing down to the Town of East Vail, where Black Gore Creek confluences with Gore Creek.

I-70 was constructed on grades up to 7% using cut and fill methods. In some areas, highway construction resulted in steep cut and fill slopes that are on average 40% steeper than the natural slopes, with some near the angle of repose. Due to the high altitude and extreme weather conditions, unvegetated and highly erodable cut and fill slopes, and the use of traction sand/salt mixture during the winter months to maintain safety along I-70, accelerated sediment loading has occurred within the corridor.

An Environmental Impact Statement (EIS) was completed for the I-70 Vail Pass corridor during the 1970's. The EIS did not address the potential for accelerated sedimentation because such impacts were not predicted at the time. A chronology of activities associated with the development of I-70 in relation to sediment control in the Black Gore Creek corridor is provided at the end of this section.

Major factors that are generally associated with the severe erosion, stream sedimentation, and damage to the aesthetic and natural values along the Black Gore Creek I-70 corridor include: 1) on-site soil loss from landslide areas; 2) inadequate drainage control system; 3) unstable cut and fill slopes; 4) failure to establish and maintain adequate vegetation on disturbed areas; 5) lack of adequate sediment control structures; and 6) and ongoing traction sand loading from winter maintenance operations.

2.1 WATERSHED DESCRIPTION

The headwaters of Black Gore Creek originate near the summit of Vail Pass on the southeast. I-70 parallels Black Gore Creek and the creek flows northwest for approximately eight miles to its confluence with Gore Creek near East Vail (see Figure 1). The Black Gore Creek I-70 corridor as defined in this SCAP extends from the summit of Vail Pass to East Vail approximately ten miles long. I-70 is a four lane divided highway through the Black Gore Creek watershed constructed on grades up to 7%.. Prior to construction of I-70, U.S. 6 was the primary highway used to access the Vail Valley from the east.

Former U.S. Highway 6 is adjacent to I-70 in the upper portion of the watershed near Vail Pass, and downstream of Polk Creek for a distance of approximately 3.5 miles.

The Black Gore Creek I-70 corridor ranges in elevation from 10,700 feet above sea level on Vail Pass to around 8,700 feet above sea level at the confluence with Gore Creek, and has a drainage area of approximately 20 square miles. The I-70 corridor is largely comprised of sub-alpine forest and bisects five ecosystems including Engelmann Spruce-Subalpine fir, lodgepole-aspen, shrub, wet meadow, and dry meadow. Soils are primarily residual-type derived from parent sandstone and mudstone rock of the Maroon Formation, which is highly erodable material that remains in colloidal suspension when mixed with water (USFS, 1980). I-70 was constructed through two miles of landslide deposits from approximately milepost 186.5 to 188.5 (USGS, 2001a).

The mean annual precipitation (1961-90) at the Vail Mountain Snowtel station is 34 inches, with the maximum snow water equivalent occurring in April at an average of 24 inches (NRCS, 2002). These data show that over 50 percent of the annual precipitation is in the form of snow at higher elevations such as Vail Pass. The average annual precipitation along the I-70 corridor ranges from approximately 25 inches in East Vail to 40 inches on Vail Pass, an increase of 60 percent over a distance of 10 miles (CCC, 1984).

Elevation and season determine the type and temporal distribution of precipitation in the Black Gore Creek watershed. Precipitation is relatively evenly distributed throughout the year in Vail, whereas precipitation is greater during the winter months on Vail Mountain (Figure 2). The Town of Dillon is also shown for comparison. The mean annual precipitation in Vail (8,500 ft-MSL) is 22 inches and on Vail Mountain (10,300 ft-MSL) is 34 inches. Monthly mean temperatures for Vail are shown in Figure 3, and precipitation is dominated by snowfall when temperatures are below freezing during winter (November through March). At the higher elevations, snowfall can occur any time of the year due to the lower temperatures. Snow accumulates in the Black Gore Creek watershed from November through April each year, especially above 9,000 ft-MSL. The seasonal distribution of precipitation plays a dominant role in the hydrology of Black Gore Creek.

The hydrology of Black Gore Creek is dominated by the annual cycle of snowmelt runoff (Figure 4). Peak streamflow resulting from snowmelt occurs in May or June each year, followed by lower flows through the fall and winter months. Mean streamflow in Black Gore Creek ranges from less than 20 cubic feet per second (cfs) from late summer through early spring (August through April), to 90 cfs in June (USGS, 2001). Streamflow generally recedes during the summer months, with short-term fluctuations caused by rainfall-runoff events. Black Gore Creek is a gaining stream, that is, streamflow increases with distance downstream from tributary inflows. Several tributaries enter Black Gore Creek from the north and south through study area. Elevated bridge crossings were required for the construction of I-70 traversing Polk Creek, Miller Creek, Timber Creek, and at two locations over Black Gore Creek.

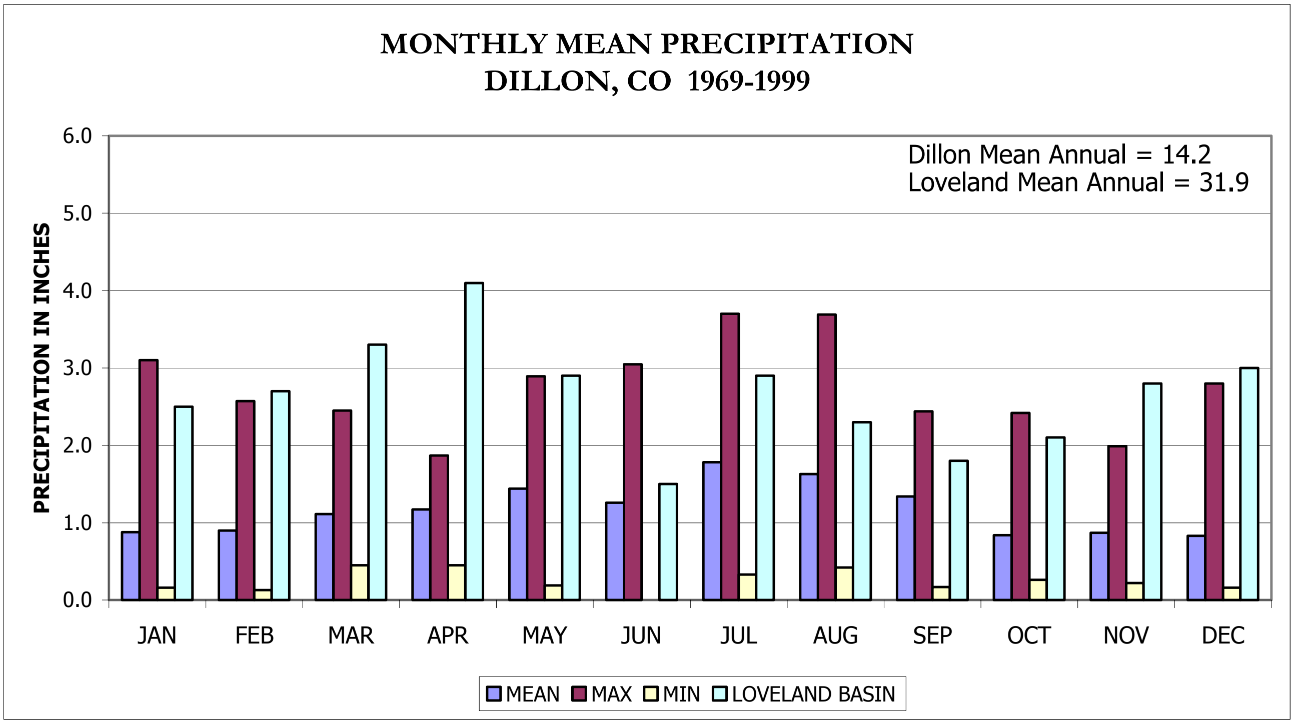
The narrow Black Gore Creek gorge and valley area occupied by I-70 contains limited quantities of ground water in the form of alluvial aquifers. Bedrock is shallow in most areas, which limits the depth of alluvium and associated ground water volume. A large proportion of ground water occurs in fractured sandstone aquifers, which play an important role in sustaining streamflow during dry periods.

Cut and fill construction methods were used to build I-70 through the steepland areas of the Colorado Mountains. In many areas, these cuts intercept and expose shallow ground water that reports in the form of springs. Most ground water springs are ephemeral, flowing only during the snowmelt period, but some are perennial (flowing year-round). These springs are visible along the I-70 road cuts in the Black Gore Creek corridor, particularly in spring and summer. Where ground water flows are intercepted by I-70, they are routed to surface drainage features along the corridor. Conversely, the fill slopes have buried many former ground water springs. In this manner, highway construction altered the hydraulic route by which groundwater enters Black Gore Creek in certain areas.

Black Gore Creek is a high mountain stream that flows through steep gorges and narrow valleys, with an average gradient of about five percent. The stream and floodplain have been constricted by highway fill material in some areas, but for the most part Black Gore Creek has not been significantly channelized by the construction of I-70. The longest set of channel alterations were required in the lower portion of Black Gore Creek between mileposts 182.5 and 182.7, where five drop structures and one stream sediment pond were installed during I-70 construction.

A CDOT maintenance facility is located on the north (westbound) side of I-70 at the summit of Vail Pass. Rest area facilities are located on both sides of I-70 in this area, along with a bike path (old U.S. 6) and two small water supply reservoirs on the south (eastbound) side of I-70. These reservoirs are referred to as Black Lake and Black Lake No. 2 Black Lake has a storage capacity of approximately 360 acre-feet (Hydrosphere, 1991).

The Black Lakes are located on U.S. Forest Service land, managed by the Colorado Division of Wildlife (CDOW), and are utilized by the Eagle River Water and Sanitation District for water supply purposes. CDOW provides a put-and-take trout fishery at the lakes that are stocked with trout on a regular basis. The Lakes are operated by the Eagle River Water & Sanitation District to meet minimum streamflow requirements in Gore Creek for snowmaking purposes at the Vail Ski Area. Gore Creek is a source of water supply for Vail Ski Area and the Town of Vail (see Figure 1). Black Lake water is released during the winter months to meet minimum instream flows. The construction and operation of Black Lakes and U.S. 6 has permanently altered the hydrologic and geomorphic condition of Black Gore Creek in this area.


MONTHLY MEAN PRECIPITATION
DILLON, CO 1969-1999
Dillon Mean Annual = 14.2
Loveland Mean Annual = 31.9
PRECIPITATION IN INCHES
6.0
5.0
4.0
3.0
2.0
1.0
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MEAN
MAX
MIN
LOVELAND BASIN

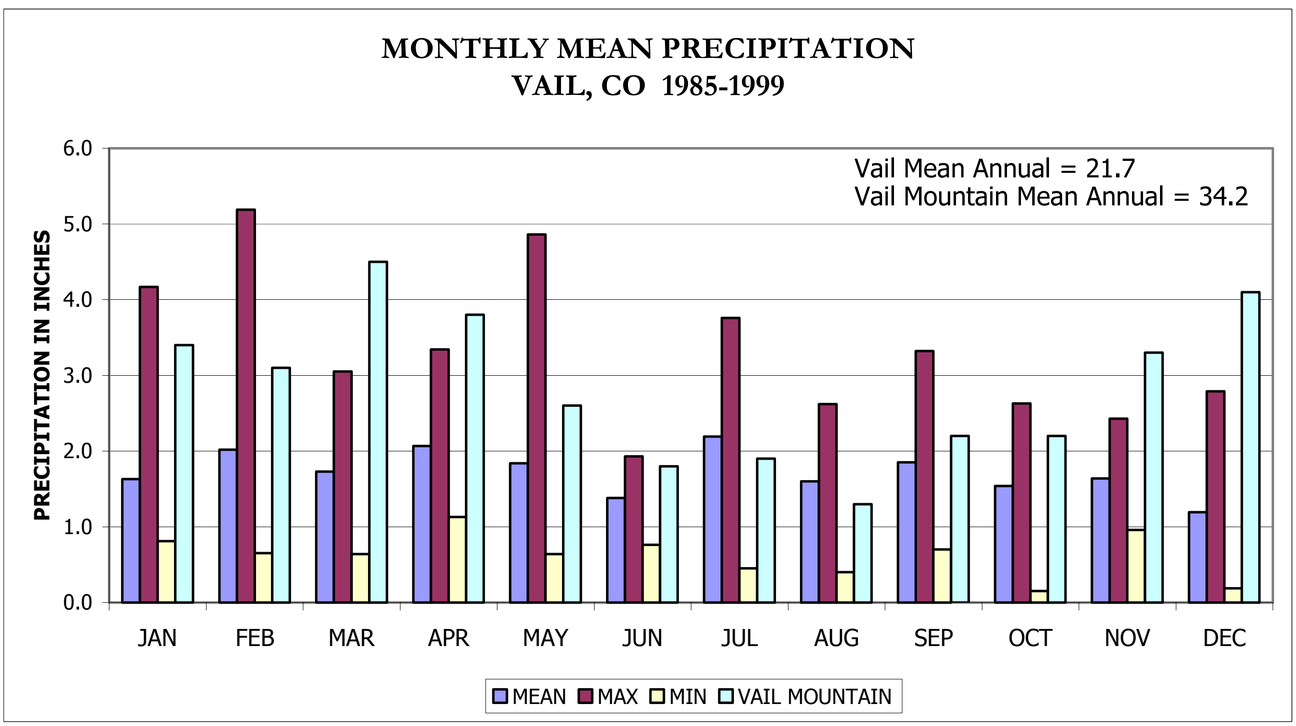
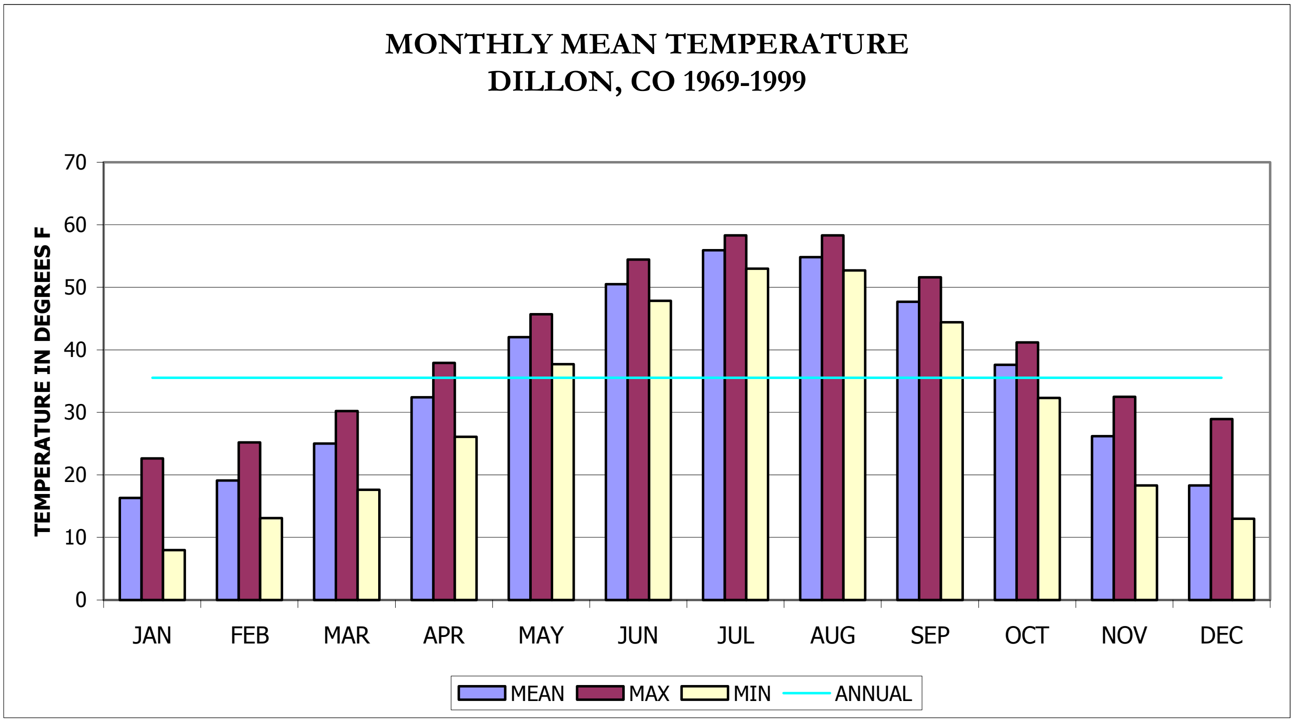

MONTHLY MEAN PRECIPITATION
VAIL, CO 1985-1999
Vail Mean Annual = 21.7
Vail Mountain Mean Annual = 34.2
PRECIPITATION IN INCHES
6.0
5.0
4.0
3.0
2.0
1.0
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MEAN
MAX
MIN
VAIL MOUNTAIN

FIGURE 2


MONTHLY MEAN TEMPERATURE
DILLON, CO 1969-1999
TEMPERATURE IN DEGREES F
70
60
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
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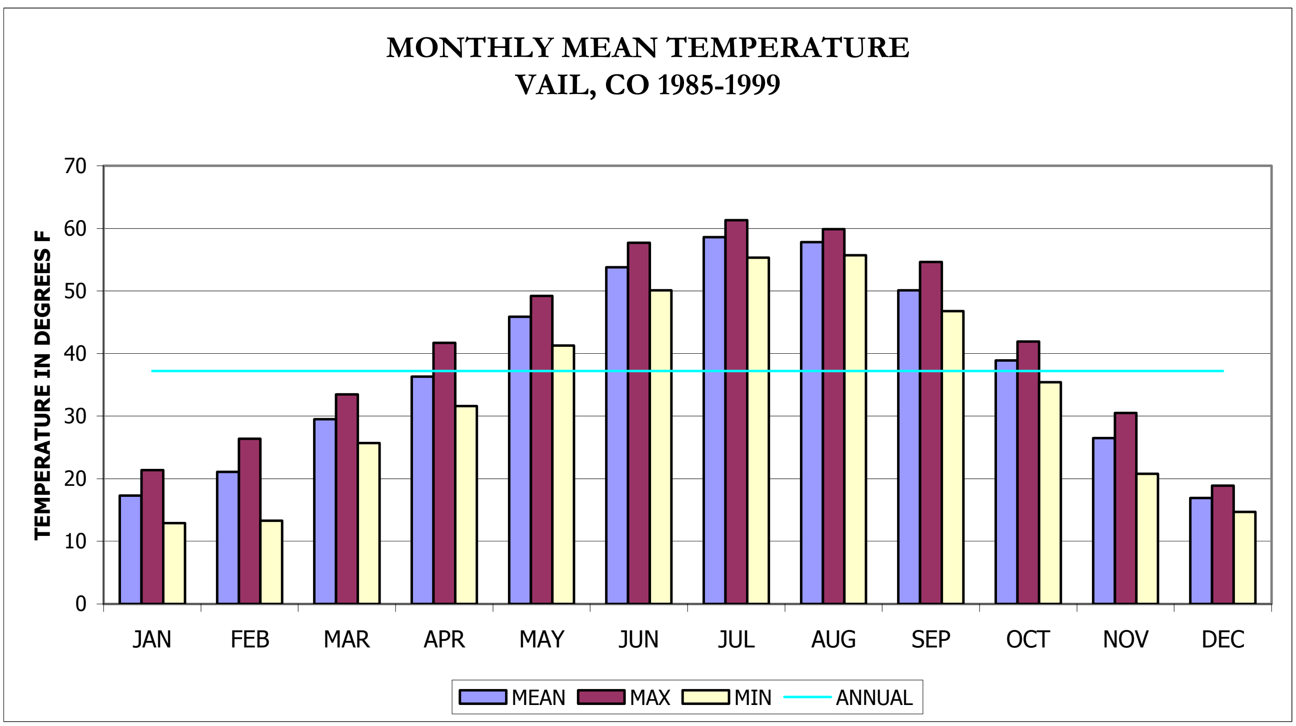
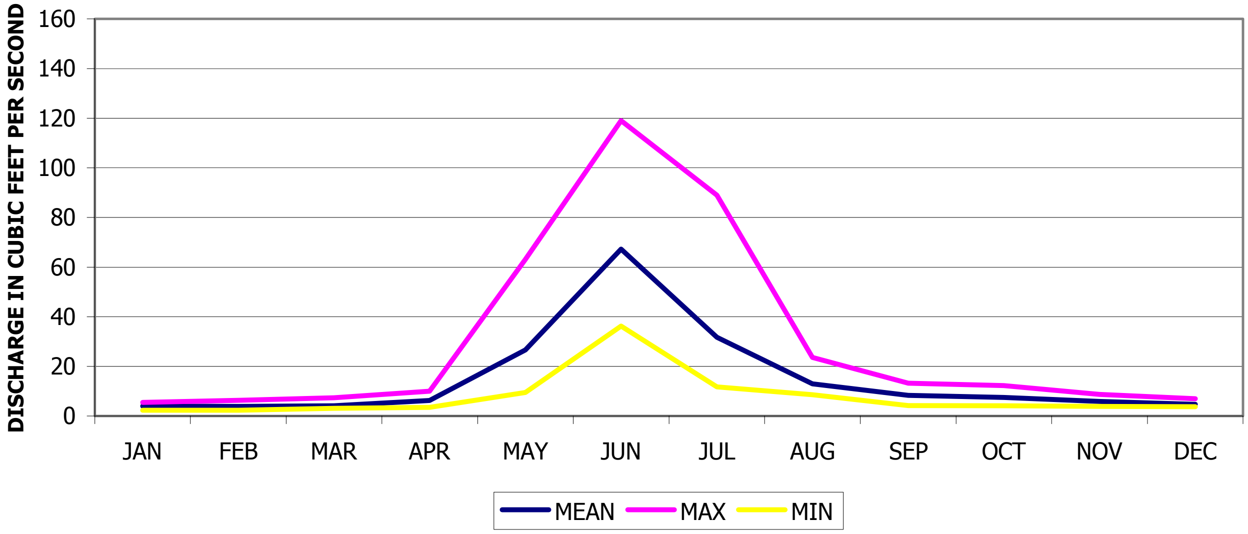

MONTHLY MEAN TEMPERATURE
VAIL, CO 1985-1999
TEMPERATURE IN DEGREES F
70
60
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MEAN
MAX
MIN
ANNUAL

FIGURE 3

STRAIGHT CREEK MONTHLY MEAN DISCHARGE
Below Laskey Gulch Near Dillon, CO 1987-2000
Drainage Area = 18.3 sq-mi



BLACK GORE CREEK MONTHLY MEAN DISCHARGE
Above Timber Creek Near Vail, CO 1948-2000
Drainage Area = 12.6 sq-mi

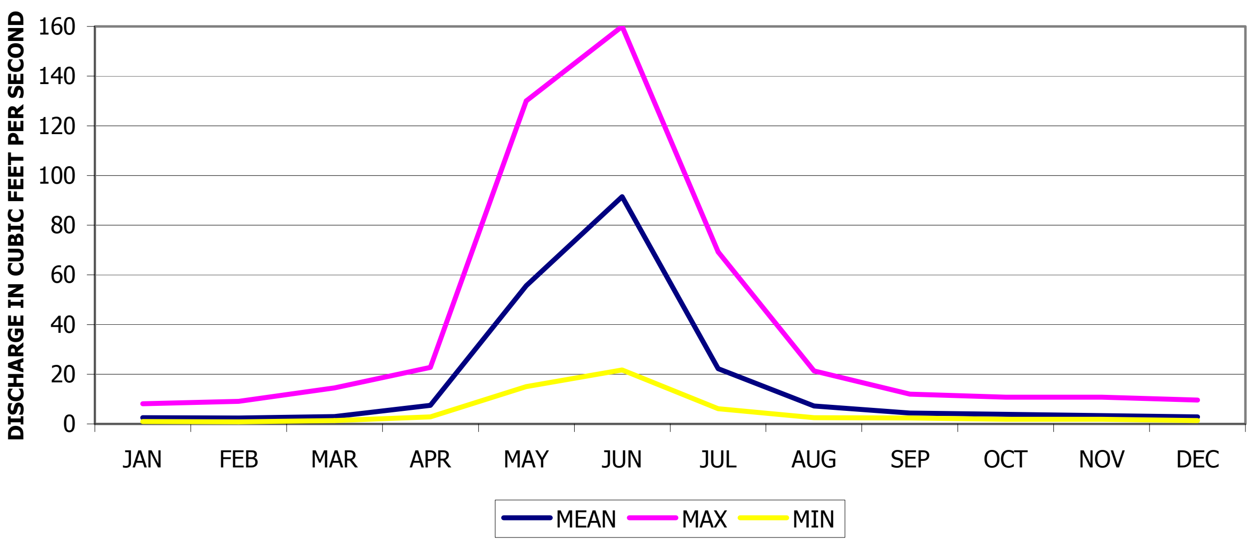


FIGURE 4

2.2 AFFECTS OF I-70

The Black Gore section of the I-70 corridor carries a significant portion of both intrastate and interstate traffic. The Vail Valley has experienced significant growth since the completion of I-70. Vail and other ski areas in the vicinity are popular destination resorts. In the year 2005, Vail is projecting over 1,700,000 annual skier visits, with a peak day demand of 23,000 skiers (Hydrosphere, 1991). This is expected to increase at an average rate of 2-3 percent per year for the next twenty years. This portion of I-70 is also experiencing increasing commercial truck traffic. The chain law is invoked when needed to help control semi-trucks during adverse winter weather conditions.

Due to heavy interstate traffic during the winter, a salt/sand mixture is used, along with chemical deicers, to maintain safety and traffic flow on I-70. Over the years, the local entities and the traveling public has increasingly demanded that this section of highway remain open at all costs, requiring extensive efforts by CDOT maintenance to accommodate this demand. The salt/sand mixture is stockpiled at the Vail maintenance yard for use in the corridor. Recently, chemical deicer tanks were placed at the maintenance yard and a new sand shed was installed for storing the salt/sand mixture during the winter season.

Unlike the Straight Creek corridor, the Black Gore Creek corridor of I-70 was constructed after the National Environmental Policy Act (NEPA) was passed in 1969, requiring an EIS that was completed 1972. Because the topography is generally not as steep as the Straight Creek corridor where massive cut and fill construction techniques were required, the Black Gore Creek corridor has not been subjected to the same slope erosion problems that have plagued Straight Creek. In addition, revegetation efforts on Black Gore were started immediately following construction. These factors resulted in lower slope erosion rates following construction of I-70 in the Black Gore Creek corridor.

The impacts of I-70 within the corridor on Black Gore Creek and Black Lakes have resulted from winter maintenance operations, when the highway surface is sanded to maintain safety for the traveling public. Assessments have indicated deposition of excessive sediment into the environment of Black Gore Creek. Approximately 15,000 tons of traction sand/salt mixture is applied annually to I-70 between the summit of Vail Pass and the confluence of Black Gore and Gore Creeks to maintain vehicle mobility during winter (Table 1). An estimated 5,000 tons of traction sand is delivered annually to Black Gore Creek (Lorch, 1998). Excessive sedimentation has resulted in potential impairment to water quality and aquatic life uses in Black Gore Creek.

Black Gore Creek also carries substantial sediment loads naturally, especially during spring runoff and rainstorms. However, the full extent of impacts from sedimentation on the natural environment has not yet been fully determined. This would likely require a large-scale watershed analysis and a continuous stream monitoring program for sediment. In 1999, the Black Gore Creek Steering Committee was developed to bring together local entities, state, and federal agencies to begin planning efforts to address the sediment and water quality issues occurring in Black Gore Creek. The Committee has been active in seeking funding, identifying issues and research needs, exploring approaches to assessing the water quality in Black Gore Creek, and developing methods for addressing the sedimentation issues.

Table 1
Winter Maintenance Materials Usage Data
I-70 Black Gore Creek Corridor

Winter	FY	Patrol (milepost)	Length (miles)	Sand/Salt Mixture (tons)	Application Rate (tons/mile)	Liquid Deicer MgCl (gal)	Application Rate (gal/mile)
1989-1990	1990	180-190	10	12,400	1,240		
1990-1991	1991	180-190	10	13,221	1,322		
1991-1992	1992	180-190	10	11,855	1,186		
1992-1993	1993	180-190	10	15,106	1,511		
1993-1994	1994	180-190	10	12,971	1,297		
1994-1995	1995	180-190	10	14,727	1,473		
1995-1996	1996	180-190	10	23,458	2,346	17,730	1,773
1996-1997	1997	180-190	10	16,953	1,695	150,223	15,022
1997-1998	1998	180-190	10	13,878	1,388	68,181	6,818
1998-1999	1999	180-190	10	13,713	1,371	61,238	6,124
1999-2000	2000	180-190	10	20,115	2,012	NA	NA
2000-2001	2001	180-190	10	14,936	1,494	248,475	24,848
1989-2001	**Average**		**10**	**15,278**	**1,528**		

Source: CDOT Maintenance

Due to the complexities of source and depositional areas within the Black Gore Creek I-70 corridor, three distinct impact "Zones" have been identified in the SCAP: Zone 1 - I-70 Immediate Travel Corridor; Zone 2 - Adjoining Slopes and Valley Area; and Zone 3 - Receiving Water Body and Riparian Corridor. These impact zones are illustrated in Figure 5. The SCAP exclusively addresses Zone 1, the I-70 Immediate Travel Corridor.

Zone 1 includes that area approximately 30 feet either side of the actual travel surfaces. This is the originating sand source area that is accessible and that CDOT maintenance forces typically maintain. Zone 2 includes the area of adjoining slopes or valleys extending from the outer edge of Zone 1 to the edge of the receiving water body or riparian corridor (Zone 3). Zone 3 includes Black Lakes, Black Gore Creek, and the riparian zone.

The limitation to maintain a 30' width from the edge of pavement for Zone 1 is primarily based on access and maintenance needs. However, this is only an approximation being used for planning purposes. The actual width of Zone 1 will vary throughout the I-70 corridor. This is particularly true in those locations where the bike path is situated near the roadway, and in other areas that are routinely maintained by CDOT maintenance forces. Therefore, the actual area within Zone 1 will vary and the 30' is an average distance that is used as a reference to help distinguish between the different areas within the corridor and for source control and cost estimating purposes.

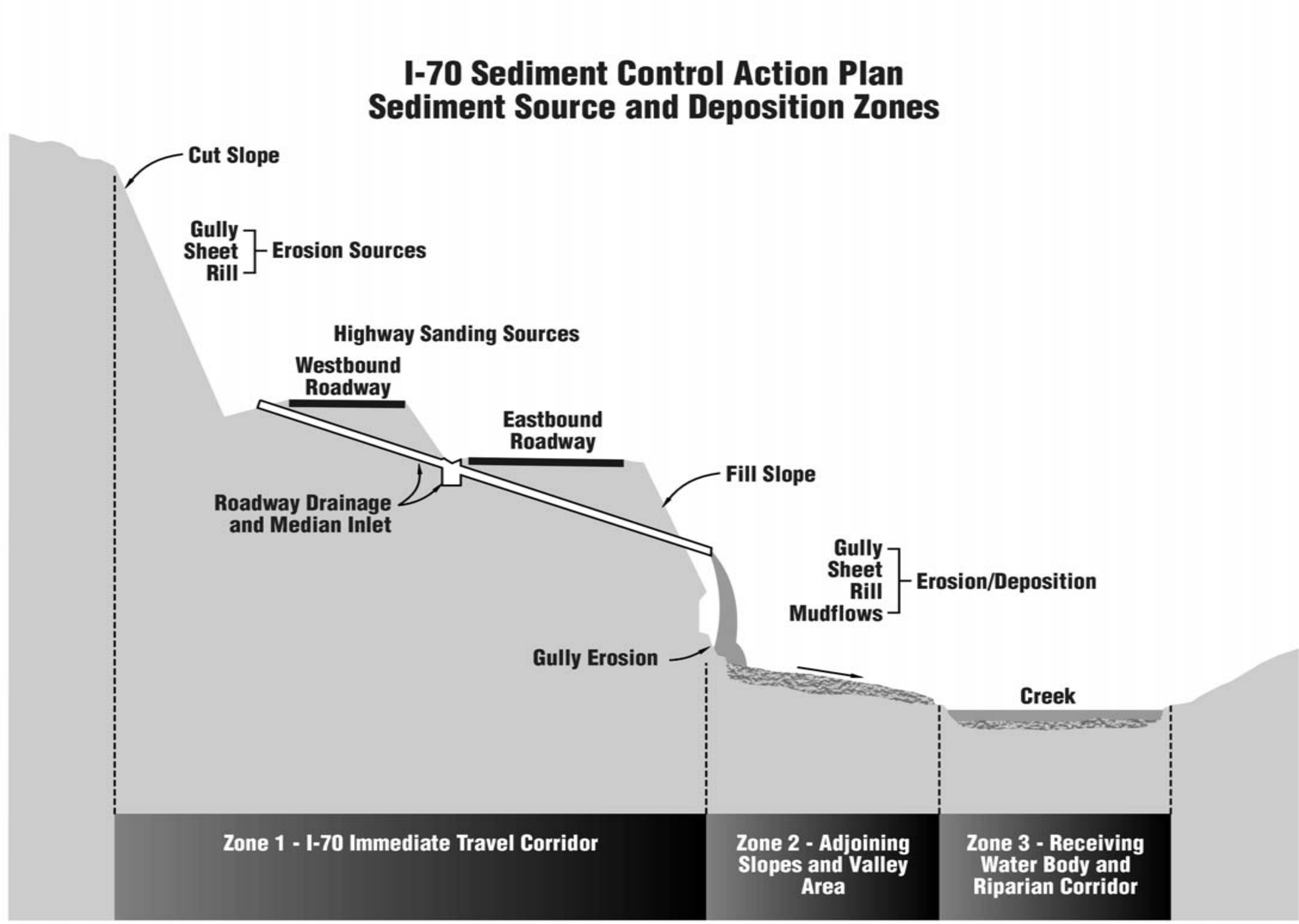

I-70 Sediment Control Action Plan
Sediment Source and Deposition Zones
Cut Slope
Gully
Sheet
Rill
Erosion Sources
Highway Sanding Sources
Westbound Roadway
Eastbound Roadway
Fill Slope
Roadway Drainage and Median Inlet
Gully
Sheet
Rill
Mudflows
Erosion/Deposition
Gully Erosion
Creek
Zone 1 - I-70 Immediate Travel Corridor
Zone 2 - Adjoining Slopes and Valley Area
Zone 3 - Receiving Water Body and Riparian Corridor

FIGURE 5

CDOT recognizes the need for sediment controls at the source. Source controls are imperative to the eventual recovery of Black Gore Creek. It is important to arrest future deliveries of highway sand to the affected areas before undertaking any cleanup of historical sand accumulation in Zones 2 or 3. The analogy being: "first stop the bleeding", or stabilize the situation at the source.

Black Gore Creek is tributary to Gore Creek, creating concerns about the potential effects that sediment loading from the Black Gore Creek corridor may have on Gore Creek, a gold medal trout fishery. Gore Creek is very important to the economic vitality of the Vail Valley. To date, little work has been done in Gore Creek to assess sediment transport and stream channel stability to adequately determine the current condition of the stream and establish future goals. This should be done as part of an overall watershed planning process. It is believed that once sediment source controls are implemented along the Black Gore Creek corridor, future potential impacts to Gore Creek from I-70 would be greatly reduced.

A comprehensive watershed analysis suggests a watershed approach to addressing the overall issue with regard to the entire Gore Creek watershed. A watershed approach to managing both point and nonpoint sources could be beneficial in implementing cost effective management strategies for protecting water resources, forest lands, and the environment. This type of plan would consider the watershed as a whole, incorporating all activities that may impact the uses and quality of the water resource including local initiatives and concerns regarding watershed management. A watershed analysis should focus on resource restoration. Resource restoration is a process that attempts to reduce or eliminate existing impacts on beneficial uses and is utilized to solve problems that are occurring due to past or present activities. In this case, it may be appropriate to determine a general endpoint as part of the restoration plan, e.g., reduced sediment loading and improved fish habitat. This focuses the planning and management on exploring how much improvement is feasible, with respect to the problems identified, rather than on achieving a precise defined level of water quality.

Black Gore Creek, like many similar mountain streams, carries substantial sediment load naturally especially during spring runoff and rainstorms. It has the ability to move large amounts of sediment, and has apparently been doing so. Further sampling and analysis of the sediment loading will be necessary in order to gain a better understanding of current and future stream conditions. The effects of I-70 in the Black Gore Creek corridor on the surrounding areas and stream systems will therefore require further study and analysis.

2.3 LITERATURE REVIEW

A literature review was conducted as part of the SCAP to identify and assess previous research, studies, and known information to determine the body of knowledge existing about the Black Gore Creek I-70 corridor, particularly with respect to remedial efforts identified or undertaken.

Limited highway-related environmental research or data collection has been conducted in the Black Gore Creek I-70 corridor. The only research conducted to date is entitled, Transport and Aquatic Impacts of Highway Traction Sand and Salt near Vail Pass, Colorado, (Lorch, 1998). The objectives of this study were to 1) estimate inputs and hillslope storage of traction sand applied to I-70, 2) identify the dominant erosion processes on cut and fill slopes along I-70, 3) evaluate sediment transport from cutslopes, fillslopes and road surfaces, 4) estimate relative sediment inputs from different road segments and discharge locations, 5) estimate background erosion and sediment yield, 6) compare bedload transport, suspended sediment and chloride concentrations to two tributaries unaffected by I-70 operations, and 7) compare stream morphology and aquatic habitat to two control streams. The Lorch study concluded that the long-term reduction of traction sand inputs will require the interception of sand being delivered to the system by highway runoff.

I-70 also follows Gore Creek through the Vail Valley to its confluence with the Eagle River at Dowds Junction. A study conducted by the Northwest Colorado Council of Governments concluded that the land use contributing the largest amount of pollutants to Gore Creek was residential (39% of the land use in Vail falls within this category). Although I-70 contributed the highest mean suspended solids concentrations, mean nutrient and trace metal concentrations and loads were greater in commercial and residential runoff during this study (NWCCOG, 1995).

The NWCCOG study states that nutrient, dissolved, and suspended solids concentrations have gotten worse in Gore Creek due to the increases in pollutants from storm water runoff. Water quality standards in Gore Creek could be exceeded, resulting in impacts to the aquatic community. Best management practices to control non-point sources of pollutants were recommended that provide water quality protection while balancing economic and political considerations. These include regular collection of road sanding materials, sweeping of paved parking lots before they are washed, and water quality controls for new commercial parking facilities.

The USGS conducted an assessment of historical water quality for the Gore Creek watershed (USGS, 2001a). This study concluded that suspended sediment is not a major water quality concern in Gore Creek. Rock salt and magnesium chloride applied to I-70 are primary sources for some of the dissolved solids affecting specific conductance in Black Gore and Gore Creeks. Past exceedences of aquatic life stream standards for trace metals such as cadmium, copper, and manganese were attributed to soil disturbance and natural geochemical properties of the Gore Creek watershed. Historically, manganese concentrations in Black Gore Creek were elevated or exceeded stream standards. Concentrations were attributed to the sedimentary geology of the area and were likely exacerbated by land disturbance during the construction of I-70 during the early 1970's.

Since the 1970's, ammonia concentrations have decreased and nitrate concentrations have increased in Gore Creek because of changes in wastewater treatment methods. Recent total phosphorous concentrations were elevated when compared to the USEPA recommended level of 0.10 mg/l for control of eutrophication in flowing water. The lower four miles of Gore Creek have been designated a Gold Medal Fishery in recognition of the high recreational value and the productive brown trout community. The productivity of the fishery was attributed to the responses of the algal and macroinvertebrate communities to increased nutrient availability (USGS, 2001a). However, the NWCCOG reported bacterial infections of trout in this reach of Gore Creek under conditions of low flow, high temperature, and catch and release fishing (NWCCOG, 1998).

The CDPHE , Water Quality Control Division, developed a data summary for the Black Gore Creek synoptic water quality and macroinvertebrate sampling that was conducted in 2000. The draft copy of this study was provided to members of the Black Gore Creek Technical Committee, but was not yet finalized and available for public review.

A Black Gore Creek Pebble Count Monitoring Report was produced by the White River National Forest based on late summer 2001 measurements (USFS, 2002). Substrate pebble counts and channel cross section measurements were taken at three locations on Black Gore Creek and with two reference streams. The middle Black Gore station had a greater accumulation of fine gravels and sands than other monitoring reaches sampled.

Data collected for Black Gore Creek and selected tributaries as part of the I-70 Runoff Event Baseline Water Quality Monitoring Program conducted by CDOT in 2000 and 2001 has been evaluated and used in this SCAP. A data evaluation report is being prepared.

2.4 BLACK GORE CREEK MONITORING

This section describes stream monitoring efforts undertaken for the Black Gore Creek watershed.

2.4.1 Stream Monitoring Efforts

Stream chemistry, biological, or habitat data for Black Gore Creek is limited. Water quality sampling in Black Gore Creek was conducted near Vail by the USGS sporadically from 1974 to 1979, and above Timber Creek in 1996. Stream chemistry sampling was also conducted in Black Gore Creek from 1988 to 1990 for an Environmental Assessment for the proposed enlargement of Black Lake.

Fish shocking was conducted in Black Gore Creek in 1999 by CDOW near the USGS gaging station. At that time, brook, rainbow, cutthroat, and brown trout were found in Black Gore Creek. Sculpin were also found to exist just above the old treatment plant near the confluence with Gore Creek.

Black Gore Creek has been sampled by CDPHE on two separate field surveys during the spring and fall of 2001. Four sites were sampled along the mainstem of the stream for field water quality parameters (flow, temperature, dissolved oxygen concentration, pH, and conductivity), and benthic macroinvertebrates. However, additional data are needed to more accurately assess the current stream conditions.

In order to obtain more data, a Technical Committee within the Black Gore Creek Steering Committee has been formed and is working on developing a comprehensive monitoring program for Black Gore Creek. CDOT participates on the Technical Committee.

2.4.2 CDOT I-70 Baseline Runoff Event Water Quality Monitoring

An I-70 runoff event baseline monitoring program was initiated by CDOT in conjunction with the I-70 PEIS in August 2000 (CCC/JFSA, 2000). The objective of the monitoring program is to develop baseline information to assess the effects of snowmelt and rainfall runoff associated with I-70 on receiving stream water quality. The monitoring program began on Black Gore Creek in September 2000 at the end of the runoff season, and was continued throughout the 2001 monitoring season from March to September. Results from the 2000 monitoring program are limited to one rainfall-runoff event and are provided in a data summary report (CCC/JFSA, 2001). A 2001 monitoring report is being prepared.

The monitoring season extends about seven months over the spring and summer along the I-70 corridor (March to September). Melting of the accumulated winter snowpack generates snowmelt runoff in spring, whereas monsoon moisture produces rainfall runoff in July and August each year. The I-70 storm water monitoring program utilized automated storm water sampling with following general components:

1) Assessment of I-70 runoff water quality affects to receiving streams using automated monitoring systems at selected locations throughout the I-70 mountain corridor
2) Highway culvert drainage automated monitoring stations representing rainfall-runoff from the paved surface, shoulder, and median of I-70; and
3) Snowmelt-event sampling representing runoff from the paved surface, shoulder, and median of I-70

As part of the CDOT storm water monitoring program, snowmelt and rainfall-runoff event water quality monitoring was conducted in Black Gore Creek above Timber Creek in 2001. This monitoring station is below Polk Creek about mid-way between the headwaters and the mouth (milepost 184.2). A second monitoring station was added in 2001 on Polk Creek to measure background sediment transport conditions. Snowmelt samples were collected from the shoulder of I-70 in the Black Gore Creek corridor in April 2001. The constituents tested include suspended solids, magnesium, sodium, chloride, total and dissolved phosphorous, and the dissolved metals arsenic, copper, manganese, and zinc. Water quality results from the Black Gore Creek I-70 corridor monitoring program for Black Gore Creek, Polk Creek, Miller Creek, and I-70 snowmelt-runoff are summarized in Table 2.

Table 2
Black Gore Creek and Tributaries
Snowmelt/Storm Event Water Quality Data 2000-2001 (mg/l)

	Suspended Solids	Phosphorous Total	Chloride	Sodium Dissolved	Magnesium Dissolved	Copper Dissolved	Manganese Dissolved	Zinc Dissolved
Black Gore Creek								
No.Samples	63	54	63	48	54	52	52	52
Range	<5-2600	<0.01-3.1	6.4-250	4-140	2.2-12	<0.002-0.003	<0.005-0.024	<0.005-0.016
Mean	240	0.18	43.2	22.7	5.1	<0.002	<0.005	<0.005
Std.Dev.	550	0.49	47.2	26.6	2.3			
Polk Creek								
No.Samples	3	3	3	3	3	3	3	3
Range	<5	<0.02	1.2	1.7-1.8	3.9	<0.002	<0.003	0.003-0.016
Miller Creek								
No.Samples	1	1	1	1	1	1	1	1
Value	<5	<0.01	1.0	1.9	1.8	<0.001	<0.005	<0.005
I-70 Snowmelt Runoff MP 185-187								
No.Samples	3	3	3	3	3	3	3	3
Range	460-6,700	0.02-0.34	74-470	37-180	5.9-46	<0.005	0.007-0.130	<0.005-0.010

The results of the stormwater monitoring program are preliminary since they reflect only one full monitoring season of data (2001). Additional data, obtained over several more years, is needed to more fully assess stormwater runoff quality along the Black Gore Creek I-70 corridor. However, the data obtained to date indicate a large variation in water quality constituent concentrations. For many constituents tested the sample standard deviation was close to or greater than the mean, suggesting that the effects of I-70 runoff on Black Gore Creek water quality can be significant under certain conditions.

I-70 Runoff Water Quality Results (shoulders and median)

Preliminary 2001 results show that suspended solids concentrations in highway runoff from the I-70 shoulders ranged from 460 to 6,700 mg/l and total phosphorous ranged from 0.02 to 0.34 mg/l. There was a positive correlation between suspended sediment and total phosphorous, indicating that phosphorous is associated with particulate material. The higher concentrations were associated with road sand transported in runoff. Comparisons of the preliminary I-70 runoff sampling results with those reported for urban highways show that the Black Gore Creek I-70 corridor has greater than average suspended solids and total phosphorous concentrations (FHWA, 1996).

Although both were not measured in the previously mentioned studies, sodium and chloride concentrations measured in 2001 were above background levels in I-70 runoff. Highway snowmelt-runoff sample results indicate elevated chloride concentrations (470 mg/l) in I-70 runoff to Black Gore Creek. Lorch concluded that high chloride concentrations in I-70 runoff, plus the congruent timing of chloride concentrations in I-70 stormwater and stream samples, indicate that highway sources were directly responsible for the high chloride concentrations observed in Black Gore Creek.

Sand containing 5% salt (NaCl) is applied to I-70 as a treatment to maintain mobility during winter. The higher sodium-chloride concentrations were likely associated with the road sand/salt mixture that accumulates along the shoulders and median of I-70 and is transported in runoff. Although liquid magnesium-chloride deicer is used in certain areas of the Black Gore Creek I-70 corridor, data show that water chemistry is dominated by sodium-chloride. The highest concentrations were measured in snowmelt runoff. The availability of these constituents for transport in runoff is the likely result of the average application of 1,500 tons of road sand/salt mixture per mile during each winter season (see Table 1).

Black Gore Creek Water Quality Results

Preliminary 2000-2001 results indicate low or non-detectable dissolved trace metal concentrations in Black Gore Creek during snowmelt or rainfall-runoff event conditions. No exceedences of water quality standards for trace metals were measured for the 52 samples collected (see Table 2). Low concentrations of dissolved manganese and zinc were detected that could be related to natural geologic sources or I-70 runoff. In fact, sample results from a 7-September 2001 rainfall-runoff event on Polk Creek, a background tributary unaffected by I-70, showed the same maximum dissolved zinc concentration (0.016 mg/l) as Black Gore Creek.

Samples collected from Polk Creek and Miller Creek, two background tributaries to Black Gore Creek, show metal chemistry dominated by magnesium with low sodium and chloride concentrations. In contrast, Black Gore Creek chemistry is dominated by sodium chloride, which is the likely result of salt used on I-70 during winter. Mean concentrations of sodium chloride in Black Gore Creek were at least one order of magnitude greater than background tributaries.

The 2001 streamflow hydrograph for Black Gore Creek is plotted in Figure 6, along with conductivity. These data show an inverse relationship between flow and conductivity. Conductivity is an indicator of dissolved solids including sodium-chloride. During early spring (April) when streamflow is low, conductivity values are high. Significant dilution takes place in May and June as flow volumes increase, resulting in lower conductivity. Conductivity increased slightly in July following peak flows but remained low to moderate through the summer. Large spikes in conductivity, some exceeding the early spring values, were measured in October and November 2001 following snowmelt-runoff events when sand/salt mixtures or chemical deicers were applied to I-70.

Sodium and chloride concentrations in Black Gore Creek show the same temporal trend as conductivity, and storm water quality results indicate a positive correlation between conductivity and sodium-chloride concentrations. The maximum chloride concentration measured in Black Gore Creek during 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 I-70 were about 1 mg/l. USGS water quality data collected between 1974 and 1979 for Black Gore Creek near the mouth indicated chloride concentrations ranging from about 1 to 21 mg/l, with the highest concentrations during the early snowmelt period in March and April.

An estimated 5,000 tons of traction sand is delivered to Black Gore Creek each year through the primary mechanisms of snowmelt and rainfall runoff, and highway maintenance/snow removal, resulting in elevated suspended solids concentrations under certain conditions. Suspended solids results from the 2000-2001 storm water/snowmelt event samples from Black Gore Creek show a mean concentration of 240 mg/l suspended solids with a standard deviation of 550 mg/l. The large deviation indicates highly variable water quality conditions associated with runoff events, with results showing suspended solids concentrations ranging from less than 5 to 2,600 mg/l (see Figure 6).

2.4.3 Stream Monitoring Data Needs

The implementation of source controls in this corridor is not dependant on water quality or biological monitoring results. Source controls are necessary regardless of the condition of the stream. Once source controls are in place along the corridor, the stream condition should improve significantly. However, additional baseline information is required to adequately characterize the aquatic biological and water quality attributes of Black Gore Creek. Monitoring of suspended solids (TSS) for in-stream improvements before and after source controls are implemented is also necessary to determine BMP effectiveness and to assess stream conditions and improvements over time. Other research needs may include stream physical and aquatic biological parameters. CDOT's continued participation in a stream monitoring program for Black Gore Creek to collect data related to sedimentation is useful and necessary. An overall stream monitoring program will be further developed as a separate plan with the basic components described below.

Baseline Stream Monitoring

A continuation of the current CDOT baseline runoff event water quality monitoring program is proposed as part of this SCAP to establish baseline sediment and salt loading conditions to Zone 3 of the Black Gore Creek I-70 corridor prior to implementation of the proposed BMP's. Baseline information is required to measure the future effects of sediment control BMP's. Additional baseline information is also necessary to adequately characterize the aquatic biological attributes of Black Gore Creek including fish populations, macroinvertebrates, and habitat conditions. These data can be used to assess the overall biological health of Black Gore Creek and to direct any future efforts toward improvements.

The baseline stream monitoring program would incorporate the existing baseline event water quality monitoring, selected sediment deposition or habitat metrics, and aquatic biological components to provide the following data and information about Black Gore Creek:

- Obtain baseline highway-related water quality data for the Black Gore Creek area
- Establish background sediment loading conditions for the Black Gore Creek watershed

- Evaluate the effects and trends of winter maintenance and materials use (e.g. salt/sand and liquid deicers) on Black Gore Creek water quality
- Characterize the principal aquatic biological components and overall health of Black Gore Creek
- Identify data needs or deficiencies, including sediment deposition and biological components
- Provide a baseline for future I-70 construction or improvement alternatives
- Contribute to the efforts of the Black Gore Steering Committee to monitor and evaluate stream conditions

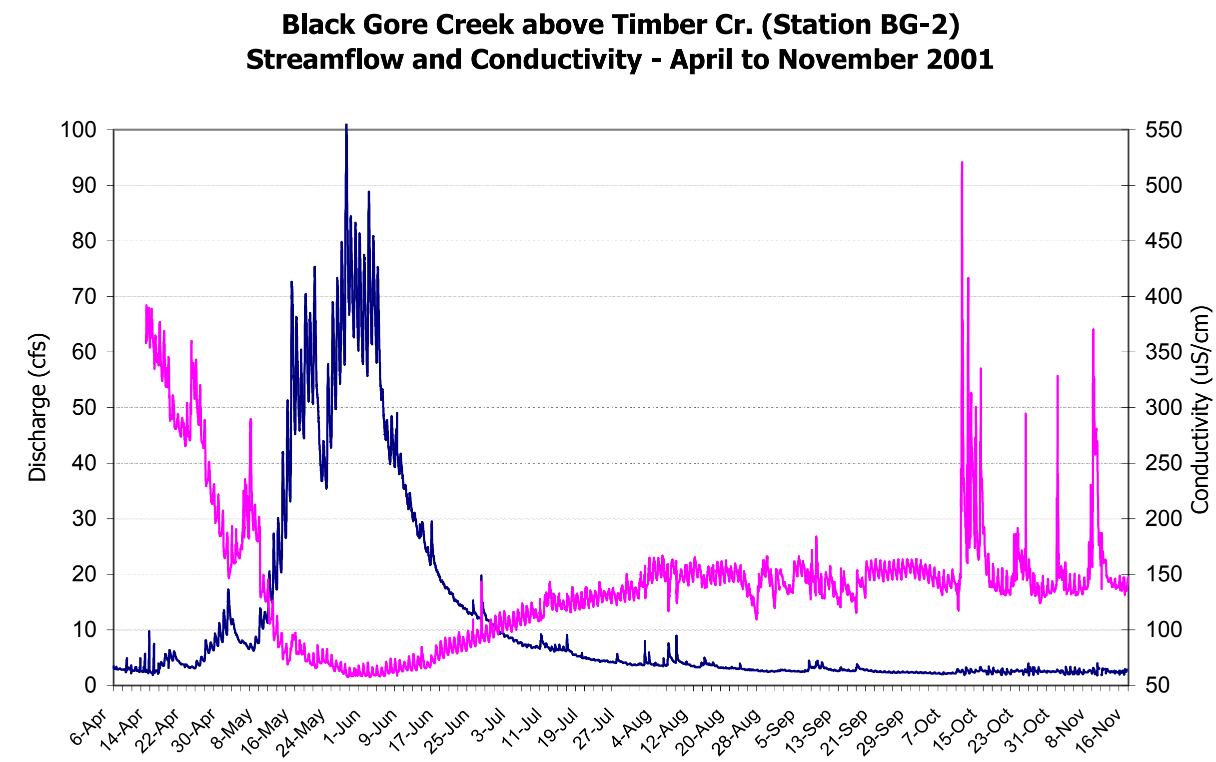
Long-Term Stream Monitoring of Sediment Control BMP Effectiveness

In order to assess BMP effectiveness, a long term stream monitoring program is needed. Because of the extensive deposits of sediment material in the Black Gore Creek corridor (Zones 2 and 3), it will take time to measure improvements in water quality. However, if source controls are fully implemented, the annual transport and deposition of sediment to Black Gore Creek will be largely eliminated. Once the annual sediment source is controlled, areas will begin to stabilize and improvements in the stream system can be effectively measured through a monitoring program. The following information would be derived from the long-term stream monitoring program:

- Monitor and evaluate the effectiveness of BMP’s and improving trends
- Evaluate the effects and trends of winter maintenance and materials use (e.g. salt/sand and liquid deicers) on Black Gore Creek water quality
- Provide the data necessary for strategy and management decisions regarding Black Gore Creek water quality and aquatic resource protection

In order to assess sediment control BMP effectiveness for example, a water quality monitoring program has been initiated on Hoop Creek near Berthoud Pass. CDOT has been conducting water quality monitoring in Hoop Creek associated with implementation of sediment control BMP’s on U.S. Highway 40. Preliminary results suggest a decrease in suspended sediment load in this basin. Suspended sediment concentration data are also used to track changes in total phosphorous concentrations associated with the sediment. Dissolved solids related to the use of road salt are also monitored to assess the affects of winter highway maintenance practices.

A long-term stream monitoring program for sediment would include both storm event/snowmelt water quality and biological components. These components should be integrated into a monitoring plan that specifies the objectives, scope of work, methodology, and reporting requirements. The parties responsible for conducting the various aspects of the monitoring program would be defined, and costs for implementing the program would need to be determined.


Black Gore Creek above Timber Cr. (Station BG-2)
Streamflow and Conductivity - April to November 2001
Discharge (cfs)
Conductivity (uS/cm)
6-Apr
14-Apr
22-Apr
30-Apr
8-May
16-May
24-May
1-Jun
9-Jun
17-Jun
25-Jun
3-Jul
11-Jul
19-Jul
27-Jul
4-Aug
12-Aug
20-Aug
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31-Oct
8-Nov
16-Nov

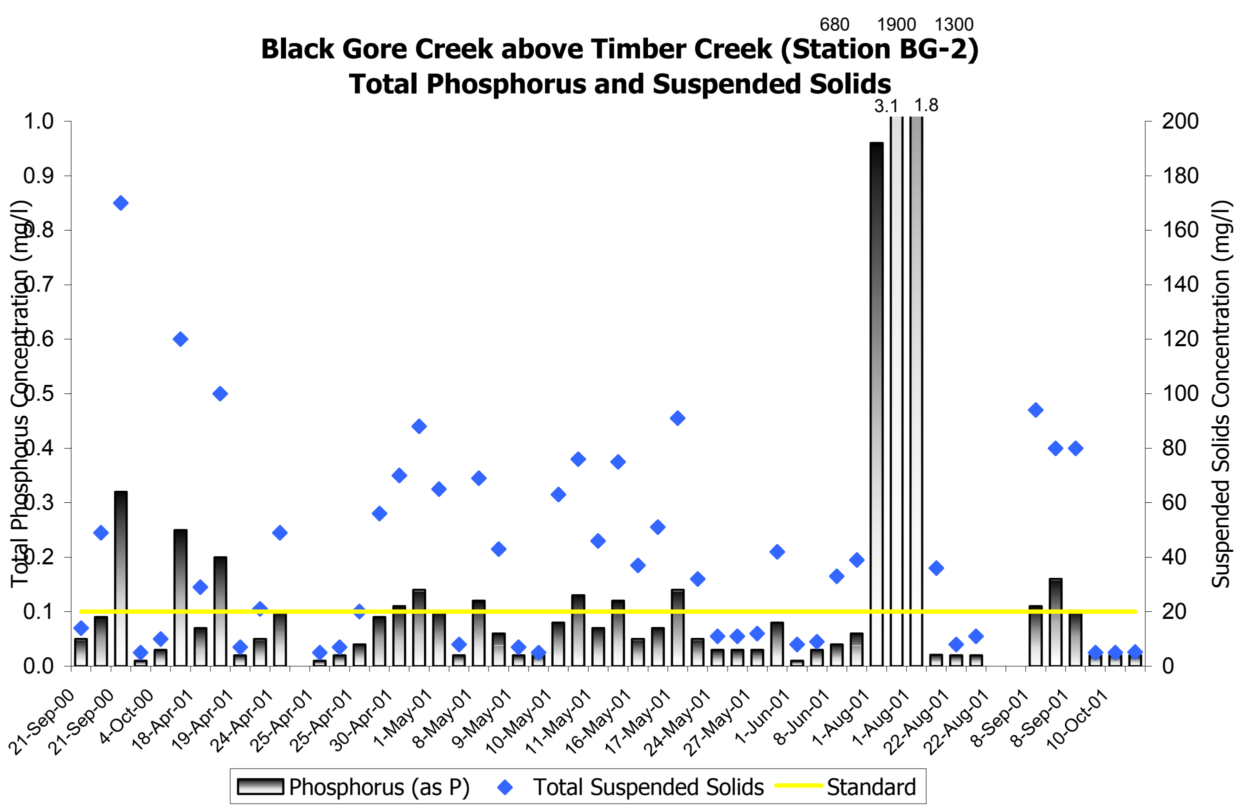
680
1900
1300
Black Gore Creek above Timber Creek (Station BG-2)
Total Phosphorus and Suspended Solids
3.1
1.8
Total Phosphorus Concentration (mg/l)
Suspended Solids Concentration (mg/l)
21-Sep-00
21-Sep-00
4-Oct-00
18-Apr-01
19-Apr-01
24-Apr-01
25-Apr-01
25-Apr-01
30-Apr-01
1-May-01
8-May-01
9-May-01
10-May-01
11-May-01
16-May-01
17-May-01
24-May-01
27-May-01
1-Jun-01
8-Jun-01
1-Aug-01
1-Aug-01
22-Aug-01
22-Aug-01
8-Sep-01
8-Sep-01
10-Oct-01
Phosphorus (as P)
Total Suspended Solids
Standard

FIGURE 6

2.5 RECONNAISSANCE AND MAPPING

A reconnaissance of the Black Gore Creek section of I-70 was conducted in 2001 as part of this SCAP to assess sedimentation conditions and to identify potential locations for sediment structures and drainage improvements along I-70. Winter maintenance practices were also evaluated during several visits to the area in 2000-2001. The reconnaissance was integrated with the CDOT storm water monitoring program in which snowmelt and rainfall runoff conditions were monitored during 2000-2001. A Field Observation or "Matrix Table" of potential sediment control BMP's developed in 1999 (Hirsch, 1999) was verified and expanded for this plan.

Detailed field notes and photo documentation of conditions along I-70 were taken as part of the 2001 reconnaissance efforts. Potential sediment control measures were evaluated primarily based on experience that CDOT has developed on Straight Creek and Berthoud Pass. Several interviews and site visits were conducted with CDOT maintenance personnel and engineers involved with previous sediment control projects on high elevation highways in Colorado. Involvement and participation in meetings and activities covering issues undertaken by the Black Gore Steering Committee and CDOT also provided valuable information for the development of this plan. The following general observations were made during the reconnaissance visits and monitoring in the Black Gore Creek I-70 corridor:

- Cutslopes on the uphill side of I-70 are generally steeper than original slopes in order to construct a flat roadbed. This has resulted in accelerated slope erosion in some areas.
- Fillslopes below the road prism primarily consist of the materials removed from cutslopes, and are generally steeper than the original slopes. Cut and fill slopes were limited to 2:1 gradient because successful revegetation of steeper slopes was considered unlikely (U.S. DOT, 1972).
- The eastbound and westbound lanes are often grade-separated to reduce cutslope and fillslope angles. (A detailed survey of cut and fill slope properties along I-70 in Black Gore Creek is provided in Lorch, 1998).
- Drainage is primarily to the outside shoulder in each lane direction, except on curves where the highway is super elevated for high-speed traffic safety. The super-elevated condition has created drainage capacity problems where there is no median/culvert drain and all four lanes drain to one shoulder.
- Runoff from the cutslopes, median, and highway generally drains into ditches and through approximately 60 cross culverts to Black Gore Creek. Rundowns are not present at several locations resulting in severe gully erosion on certain fillslopes
- In areas where a Type 4 (Jersey) barrier is adjacent to the edge of pavement, runoff water concentrates and reports at the end of the barrier wall, causing severe shoulder and fillslope gully erosion.
- The Type 4 (Jersey) barriers are beginning to disintegrate from over 20 years of weathering and require replacement in many areas.

- Excess snow/sand material is moved long distances (greater than 30 feet) from the edge of highway with heavy equipment to maintain ample snow storage capacity along I-70. This material is wasted in forested areas, meadows, and over fillslopes.
- Large deposits of road sand have accumulated behind Type 4 barriers and beneath bridge guardrails.
- Culvert inlets are plugged with excessive sediment in certain shoulder and median areas.
- Sheet flow from the paved surfaces of the highway generates rill erosion and transport of the sand accumulated on the unpaved shoulders.
- The used road sand particle size and shape result in high mobility and sediment transport on the generally steep gradients found in the study area.
- The water quality in Black Gore Creek (dissolved and suspended solids) responds rapidly to runoff from I-70.

Based on the site reconnaissance, a narrative description of proposed sediment control measures has been developed according to milepost for both the westbound and eastbound directions of I-70. These results cover milepost 190 (Vail Pass) to 180 (East Vail), beginning at the summit of Vail Pass and continuing in a westerly direction to East Vail. The proposed treatment descriptions are provided in Appendix A, along with corresponding photographs of the treatment areas throughout the I-70 corridor in Appendix A-1 and A-2.

Up to date engineering drawings for the Black Gore Creek basin are limited. The only drawings found were as-constructed hand markups developed in the late 1970's. No computer-generated engineering drawings are available. Fortunately, an aerial photo survey of I-70 was conducted in 2000 as part of the I-70 Programmatic Environmental Impact Statement (PEIS). These digital images were developed in an ArcView GIS system and the Black Gore Creek sediment control treatment features were mapped on the 2000 aerial photo base of I-70. Several map scales were evaluated to determine the optimum resolution and coverage for this plan, resulting in a set of 13, 1:300 scale maps that are shown in Appendix B.

The mileposts (MP) indicated as red dots on these maps are based on external references and do not necessarily reflect the same milepost markers found along the highway. The highway reference markers may have changed since construction, whereas the computer-generated points on the maps are accurate depictions of the relative distances. These maps show the cutslope treatments with a green line and fillslope treatments with an orange line. Sediment basins are shown as triangles and below-grade sediment traps are shown as red cross-hatched lines. Clean tributary flows are shown in blue and culvert rundowns are shown in purple. Culvert inlets are shown as open squares.

Future land surveys will be required as specific projects are undertaken to construct BMP's along the I-70 corridor.

Black Gore Creek Chronology
I-70 Related Activities

May 1996:	Brian Lorch field work on sedimentation study
Sept. 1998:	Lorch report
April 1999:	First meeting of Black Gore Steering Committee
Summer 1999:	Field survey and sediment matrix completed by CDOT (Hirsch) to identify locations for potential BMP's to address sediment loading
Nov. 2 1999:	Completion of matrix table of potential sediment control treatments
June 2000:	Field trip held by Black Gore Steering Committee for elected officials along the Black Gore corridor
July 2000:	Wetland mitigation site clean-up cooperative project CDOT and Eagle River Sanitation District. $15,764 total cost estimate
Sept. 2000:	Pebble counts conducted
Nov. 2000:	Transportation Commission granted additional maintenance funds of $150,000 for Straight Creek and Black Gore Creek sand clean-up for FY 02 (available July 01)
April 2001:	Macroinvertebrate and chemistry samples obtained for Black Gore Creek by CDPHE
Summer 2001:	Begin development of three-year monitoring program, identify reference stream and determine biological protocols and water quality objectives by Black Gore Technical Committee
Fall 2001:	Sand Shed at Vail Pass Rest Area completed
July 2001:	Initiation of Sediment Control Action Plan by Clear Creek Consultants for CDOT
October 2001:	Vail maintenance yard cooperative project to fix drainage problems
April 2002:	Transportation Commission Briefing for Sediment Control Action Plan
May 2002:	Completion of the Sediment Control Action Plan by CDOT

3.0 ENVIRONMENTAL CONSIDERATIONS AND REQUIREMENTS

This section provides a summary of relevant water quality regulations and environmental requirements.

3.1 WATER QUALITY REGULATIONS

Under the Federal Clean Water Act of 1977 (CWA), and the Colorado Water Quality Control Act (CWQCA), Colorado has instituted various programs to protect state surface waters. Water quality standards and classifications have been developed by the Colorado Water Quality Control Commission (WQCC) and are implemented by the Water Quality Control Division of the Colorado Department of Public Heath and Environment (CDPHE).

Pollutants that affect water resources are divided into point and nonpoint sources of pollution. Water resources may include public water supplies, fisheries, wetlands, recreational uses, wildlife, aquatic habitat, and other functions of the stream system. Pollutants from point and nonpoint sources can include nutrients, sediments, pesticides, acid mine drainage, toxic waste, herbicides, fertilizers, petroleum and many other forms of pollutants. Point sources are direct discharges to a water body from a single source such as water treatment plants or industrial facilities. Nonpoint sources originate from diffuse sources of pollutions such as urbanization, agriculture, mining, roadways, and construction sites. Point sources are regulated under the CWA, whereas nonpoint sources remain largely unregulated.

In the Black Gore Creek I-70 corridor, it is recognized that the primary nonpoint pollutant of concern is sediment that originates along I-70 from cut and fill slopes, and the sand/salt mixture applied during winter maintenance operations. Although there are natural background sediment sources, there are essentially no other anthropogenic sources of sediment loading to Black Gore Creek other than I-70. To date, sediment loading beyond natural background levels has been occurring since operations began on I-70 without adequate source control.

In Colorado, there are currently no numeric standards for sediment, but narrative standards do apply as follows (WQCC, 1999b): “state surface waters shall be free from substances attributable to human-caused point source or nonpoint source discharge in amounts, concentrations or combinations which: “can settle to form bottom deposits detrimental to the beneficial uses. Depositions are stream bottom buildup of materials which include but are not limited to anaerobic sludges, mine slurry or tailings, silt or mud” (Reg. No. 31, 31.1.1(1)(a)(I)). To help address this, the State has developed the “Provisional Implementation Guidance for Determining Sediment Deposition Impacts to Aquatic Life in Streams and Rivers (WQCC 1998a). This guidance requires that both habitat and aquatic life must be demonstrated to be impaired before a stream is considered impaired by sediment.

Black Gore Creek has been placed on the State’s monitoring and evaluation list under provisions of Section 303(d) of the CWA. Under Section 303(d), the State is required to identify stream segments not meeting water quality standards and those streams are placed on the 303(d) list. Once listed, a Total Maximum Daily Load (TMDL) is developed for that stream segment. A TMDL is part of a plan to address water quality problems and identifies the action needed to restore and protect the water resource. Additional data is needed to further assess the biological condition of Black Gore Creek before it is placed on the State's 303(d) list. The WQCD has not yet documented impairments to habitat or aquatic life in Black Gore Creek. However, it is generally believed through observation that in Black Gore Creek, accelerated sediment loading has impaired aquatic life and potentially impacted water supplies.

3.1.1 Best Management Practices (BMP's) for Nonpoint Source Control

Under the CWA, BMP's are measures used to address nonpoint sources of pollution. BMP's are essentially structural or nonstructural measures undertaken to help reduce or prevent the pollution of surface waters. In the case of highway construction and operation, BMP's include maintenance practices as well as measures for the control of erosion and sedimentation, and for the treatment of stormwater runoff. Structural BMP's are those that require construction of a specific measure, such as a sediment trap or detention basin. Nonstructural BMP's do not typically require construction; for example, revegetation and maintenance training programs.

BMP's are also divided into temporary and permanent. Temporary BMP's are used to control erosion and runoff during construction activities. Permanent BMP's are implemented for use after construction activities are completed. The SCAP identifies permanent BMP's that can potentially be implemented along the I-70 corridor. These include sediment basins and revegetation efforts, for example.

When used for sediment control, BMP's also have the added potential of capturing highway runoff. Quantification of highway runoff, or nonpoint source pollution loads, is not a routine activity within highway planning and design procedures at this time. Highway runoff is difficult to assess since it can contain various pollutants from a variety of sources. However, since runoff can contain residual chemicals left behind on the roadway, it is believed that some of this material can potentially be captured and properly disposed of along with the sediment material.

This SCAP develops an analysis and recommendation of BMP's that can be utilized to directly address sedimentation. Retrofitting BMP's along a highway corridor is expensive and challenging, particularly in the mountainous environment.

3.2 CDOT Environmental Process

Within the CDOT process of developing projects, environmental clearances are required to comply with the National Environmental Policy Act (NEPA), and are completed during the project design phase. These clearances may include hazardous waste, water quality, wetlands, Threatened & Endangered Species (T&E), history, archaeology, and others. Any construction work conducted by CDOT has to be approved by the Federal Highway Administration (FHWA). Appropriate permits are obtained prior to construction.

It is recognized that implementation of any portion of the SCAP would benefit the Black Gore Creek I-70 corridor. In developing the SCAP, certain environmental issues have been identified which will require additional coordination with the appropriate agencies. These include :

1) NEPA documentation
2) Wildlife and threatened & endangered species issue consultations
3) Aesthetic values
4) Wetland & riparian area identification
5) Remediation of valley and stream/water body corridors

3.3 NEPA DOCUMENTATION

With the exception of the EIS prepared for construction of I-70, NEPA documentation has not been completed for the Black Gore Creek corridor. Within the Black Gore Creek I-70 corridor the level of NEPA requirements will be determined in consultation with the Forest Service and FHWA prior to design and construction of BMP measures. There are specific NEPA requirements for "federal actions", and some of the likely treatment locations are outside the I-70 easement on National Forest Service land. NEPA will need to be satisfied prior to design and construction of some proposed BMP measures. Other BMP's, especially those within the immediate travel corridor, may not require NEPA evaluation. The level of documentation will not be known until the detailed scope of projects is clearly identified. Environmental documentation is generally not required for routine maintenance work along I-70. Many of the non-structural BMP's proposed in this SCAP fall into this category. CDOT and Forest Service officials are coordinating to make these determinations on a case-by-case basis.

The only precedent for NEPA documentation required for sediment impacts and implementing BMP's in the I-70 mountain corridor is Straight Creek. An Environmental Assessment (EA) was completed in 1992 by the Forest Service for the S*traight Creek Watershed Improvements Project,* to enable sediment control measures to be implemented within the Straight Creek I-70 corridor. A Decision Notice and Finding of No Significant Impact (FONSI) was completed in 1993. The selected remedy (Alternative Three) and mitigation measures in the EA included the following:

- Construction of sediment basins
- Completion of an access road to maintain the basins
- Resource enhancement measures; and
- Providing recreational use along the Straight Creek access road

The EA for Straight Creek stressed the need for the implementation of source control measures. The FONSI states that, "This alternative will effectively resolve the current problems of increased sediment loading into Straight Creek, unregulated recreation use, and resource damage to the existing road and degraded water quality." It is not known at this time if the Straight Creek EA will need to be updated as the SCAP for that corridor is implemented.

3.4 WILDLIFE AND THREATENED & ENDANGERED (T&E) SPECIES

Wildlife and T&E species issues have been identified, prompting initial discussions with the US Fish & Wildlife Service (USF&W) regarding the implementation of the SCAP and it's potential impacts on wildlife. The lynx is a known T&E species in the area of Black Gore Creek and at least one kill on I-70 has been recorded within the corridor. The boreal toad may also be an issue in the I-70 corridor. Katos Pond on Gore Creek near East Vail, for example, contains boreal toad that will need to be further examined for potential sediment impacts.

The level of environmental documentation that may be required for the protection of T&E species will be determined with the USF&W prior to implementation of BMP's. Further discussions with the USF&W, Colorado Division of Wildlife, and U.S. Forest Service pertaining to wildlife and T&E will be required prior to project implementation in the corridor.

3.5 AESTHETIC VALUES, WETLAND & RIPARIAN AREAS

Other environmental concerns, such as aesthetic values, must also be considered. The Black Gore Creek I-70 corridor is located in scenic areas where aesthetic values are important. The U.S. Forest Service and other interested parties will be consulted regarding this matter prior to implementation of projects. Additionally, clearances will be needed for any potential wetland impacts, tree removal, or disturbance of riparian or other natural areas. Permits, such as Section 404 and 402 permits, will be determined on a project-specific basis before construction activities commence. CDOT coordinates the permitting process with the appropriate regulatory agencies.

3.6 CDOT EXPERIENCE WITH THE STRAIGHT CREEK I-70 CORRIDOR

The strategy used on the Straight Creek I-70 corridor over the last ten years has been to gain control of the sediment loading to the extent possible with the limited funding. Any available funding has gone towards addressing the problem and not with additional studies or monitoring efforts. It is acknowledged that Straight Creek may never again be a pristine mountain stream; however, the stream will support a fishery. Improvements will occur when adequate structural controls, including slope repair and revegetation, are implemented to further address the sedimentation problem.

Within the Straight Creek Valley, only minimal attempts have been made to address the inundation of sediment material into the riparian and wetland areas. It has long been the strategy within this corridor to undertake restoration projects in the natural environment only where feasible and practicable. The philosophy being that over time, the riparian zone will repair itself as sediment deposition stabilizes and as the stream moves the remaining sediment through the system. It has been acknowledged by natural resource experts that more harm could be done to the riparian zone and stream by undertaking extensive clean-up efforts, and that the stream system will recover when adequate source controls are implemented. Although this strategy takes a long period to achieve, it is thought to be the better alternative in the end to protect the natural environment.

In the Straight Creek corridor, any projects undertaken beyond Zone 1 have been coordinated with and approved by the Forest Service. Certain site-specific projects have been undertaken by the Forest Service and CDOT within the Straight Creek Valley to re-establish wetland areas and undertake wetland restoration projects.

3.7 REMEDIAL MEASURES CONSIDERED FOR THE BLACK GORE CREEK I-70 CORRIDOR

It is anticipated that the strategy for Black Gore Creek will be similar to Straight Creek due to limited access to depositional areas, the sensitivity of the forest, receiving waters, and riparian areas. Because this will require participation and further decision-making by the Forest Service and the appropriate agencies regarding how the natural areas located beyond Zone 1 of the I-70 Corridor are addressed, further analysis will be required. A collaborative effort will be needed between the Forest Service, the resource agencies, and other stakeholders in order to assess remedial actions and determine the most appropriate course of action to be taken. It would be premature on CDOT 's behalf to draw conclusions at this time regarding the remedial actions needed in those areas beyond Zone 1 of the I-70 Corridor.

Preliminary discussions have occurred regarding the course of action to be taken in the Black Gore corridor Zones 2 and 3. Possible remedial projects have been identified during these discussions. However, no decisions have yet been made regarding specific remedial measures to be taken since additional analysis is needed. Examples of potential remediation projects are summarized below.

Bridge Crossings

The bridge crossings at Polk Creek, Miller Creek, and Black Gore Creek, where traction sand is regularly deposited around the abutments at the base of the bridges, has been mentioned as an excellent location for remedial efforts. Several treatment methods have been considered for dealing with this sediment material, i.e., remediate the sediment in place by capping it on a regular basis, attempt to remove it on a regular basis, and/or try to restore the surrounding area.

This SCAP proposes installation of retaining walls beneath the bridges to prevent migration of sand directly into the streams, with scheduled inspection and removal of accumulated sand. However, further analysis and extensive coordination with professional biologists and hydrologists will be needed to determine the correct remedies at the bridge crossings. Maintenance practices will also be considered to reduce plow cast in the bridge areas.

Sediment Pond in Lower Black Gore Creek

A site that has been identified as being a potential candidate for remediation is located in the Black Gore Creek stream channel near the bottom of Vail Pass, where a sediment pond was installed during I-70 construction. The pond has filled with sediment and therefore has functioned somewhat as a catch basin. However, it has not been maintained because it was constructed as a catchment basin during construction and not as a permanent sediment collection facility. The Colorado Division of Wildlife stocked the pond with rainbow trout into the early 1980's, until the pond began to fill with sediment and stocking was ceased. The preliminary discussions concerning the eventual functionality of this site have centered on developing the pond into a permanent sediment collection facility or creating a wetland that could function as a filter and capture sediment material that is in the stream channel. However, experience on the Fraser River has demonstrated that maintaining in-stream sediment ponds is difficult due to drainage problems and is only marginally effective.

Black Lakes

Black Lakes have also been discussed as a potential area to consider remedial efforts. The exact nature of the remedial efforts has not yet been determined. It is anticipated that once source control measures within Zone 1 are fully implemented above the Black Lakes, this will alleviate concerns about continuous sediment loading into the lakes. Although the lakes may be viewed as excellent BMP's by reducing sediment loading into Black Gore Creek, this is in conflict with their current purpose of storing water. The dialogue regarding the Black Lakes will require further consultations with the Eagle River Water & Sanitation District, the Colorado Division of Wildlife, as well as other stakeholders.

Other Considerations

Other considerations include developing a remedial action plan by the Black Gore Creek Steering Committee that would incorporate Zones 2 & 3. With the limited funding available, a comprehensive planning process for all of Black Gore Creek may not be advisable at this time. However, more specific remedial actions taken within Zones 2 and 3 could be identified. With the limited resources available it is generally thought that any funding received should go directly to addressing the source of the problem and not with conducting further studies or activities in Zones 2 or 3. It has been demonstrated that much can be achieved with a collaborative approach to undertake cost-effective cooperative projects designed to address specific nonpoint source problems, such as highway traction sand.

It is important to note that although source controls are needed in Zone 1 as funding is available, this does not preclude remedial actions from being taken in the other zones anytime, as part of an iterative process. Remedial actions in Zones 2 and 3 should be given further consideration by stakeholders and the Black Gore Creek Steering Committee since these efforts would require significant input from biologists and hydrologists from the various agencies, including the U.S. Forest Service, the Colorado Department of Public Health & Environment, EPA, the Colorado Division of Wildlife and others who already participate on the Black Gore Creek Steering Committee. This type of collaborative effort is needed in order to adequately determine the appropriate courses of action beyond Zone 1.

A comprehensive analysis of the entire Gore Creek Watershed could be undertaken in the future by an appropriate watershed entity formed to develop strategies for protecting Gore Creek. At this time, no such entity exists. An analysis would need to incorporate all the point and nonpoint sources within the watershed in order to identify remedial actions needed to address impacts to mainstem Gore Creek from urbanization, sewage treatment plants, ski areas, snowmaking, stormwater runoff, and all other potential contaminant sources. In order to develop this type of planning effort, all potentially affected stakeholders would need to be part of the planning process.

4.0 CDOT MAINTENANCE PROGRAM

Roadway and tunnel maintenance personnel are responsible for maintaining the operational capability of the I-70 highway system. The purpose of highway maintenance is to preserve and keep all roads, roadsides, structures and miscellaneous facilities in as close to their original or improved condition as possible. The maintenance employee's primary duty is to keep all highways that are open to traffic in as safe and usable condition, as available resources allow. In Colorado, snow and ice control is the highest priority of all the maintenance activities in order to protect the safety of the traveling public. The operational capability of a highway system can be greatly diminished by such things as roadway surface deterioration, snow and ice, poor lighting, and inadequate lane demarcation.

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Within CDOT, the state is divided into six engineering regions and nine maintenance sections. Each engineering region has project development (preconstruction and construction) responsibilities and maintenance sections. Region 1 encompasses twelve counties from the Kansas Line to the summit of Vail Pass on I-70, excluding the Denver metropolitan area (Figure 7). Region 3 encompasses thirteen counties including I-70 from the Utah State line to the summit of Vail Pass. Engineering Regions 1 and 3 boundaries meet at the Vail Pass summit. Maintenance Section 5 includes Vail Pass within Region 1 and maintenance Section 2 is in Region 3. Maintenance Sections 5 and 2 meet at the East Vail Interchange (Figure 8). The Maintenance Sections are further divided into Foreman Areas. The Paul Foreman Area maintains all of the state highways within Summit County, and a significant portion of state highways in Clear Creek, Grand, and Eagle Counties, including I-70 from Idaho Springs to East Vail, Berthoud Pass (SH 40) from Empire Junction to Winter Park, SH 9 south of Breckenridge to the Grand County Line, and Loveland Pass (US 6).

4.1 PAUL FOREMAN AREA

The Paul Foreman Area is divided into work groups called patrols. These patrols perform maintenance on specific roadway sections in the Paul Area. This includes Patrol 44 that covers I-70 from Officer's Gulch to East Vail, including the Black Gore Creek portion of the I-70 corridor.

When fully staffed, the Paul Area has 38 full-time maintenance workers (FTE), 3 supervisors, 1 heavy equipment operator and 4 heavy equipment mechanics. In the winter months, 38 part-time workers (PPT's) are hired to assists for winter maintenance operations. These people are accountable for all the maintenance on 784 lane miles of state highways consisting of high mountainous terrain. This SCAP covers only a small portion of I-70 within the total Paul Area.

Public pressure is being placed on the CDOT maintenance to meet customer needs with increased traffic volumes, limitations on resources, and greater expectations. Not only does the Paul Area contain some of the most heavily traveled portions of the interstate system within the state, these personnel maintain the roadway network that service some of the most popular ski areas in the state during the winter months.

FIGURE 7
CDOT TRANSPORTATION REGIONS

FIGURE 8
CDOT MAINTENANCE SECTIONS

The routine maintenance of these corridors has focused primarily on maintaining the roadway surface. When I-70 was first constructed, the higher level of maintenance work needed to meet the growing needs was not anticipated. Public expectations for maintaining I-70 to a certain level have increased significantly since the completion of I-70. The scenarios presented in this SCAP would require significant additional resources for roadway maintenance in order to provide the same level of service to the traveling public.

4.2 MAINTENANCE ACTIVITIES AND FUNDING MECHANISM

Maintenance personnel are responsible for a number of tasks and activities. These activities are divided into Major Program Areas (MPA's) and are funded according to established targets. CDOT uses a system of budgeting for maintenance based on Maintenance Levels of Service (MLOS) and MPA's. The Transportation Commission has established targets for the level of service for each MPA. The target rate drives the funding for the activities in each MPA. The rating ranges from "A+" being the top of the scale to "F-" being the bottom. For example, if an MPA is targeted at an A level of service, it will receive more funding than if it is targeted at a C level of service. Maintenance equipment, building maintenance, and sand shed allocations are managed separately. Routine maintenance activities under the current MLOS program will continue to be accomplished with existing personnel. The Maintenance MPA's are further defined below:

Snow & Ice Control: snow removal, traction application (sanding & deicers), ice control, snow fence maintenance & repair, avalanche control, chain station operations, snow removal (special equipment), etc.

Roadway surface: patching, seal coating, blading, restoring shoulders, crack sealing, etc. Traffic services:

Traffic Services: installation, maintenance and installation of signs, maintenance and installation of guardrail, pavement striping, etc.

Roadside Facilities: maintenance of drainage structures, maintenance of ditches, slope repair, litter & trash clean-up, mowing, sweeping, sound barrier maintenance, etc.

Roadside Appearance: vegetation control, bridge/structure maintenance & repair, maintenance of deck expansion devices, etc.

Tunnel Maintenance: tunnel operations, tunnel snow removal & sanding, auto extrication & fire fighting, tunnel washing, maintenance and mechanical operations, electrical & electronic warning systems, etc.

In order to track the management of maintenance expenditures, the Maintenance Management System (MMS) is used statewide by each CDOT Region. The MMS is a computer program designed to track materials, equipment, and labor expended on highway maintenance activities. This system provides information regarding the efficiency and effectiveness of resources used, and is used to plan for activities and associated future costs. With this system, field personnel report their maintenance activities and inventories, which are then entered into a computer database.

Although sand clean-up can fall into many MPA's, such as Traffic Services for guardrail work or Roadway Surface for ditch cleaning, the majority of the environmental clean-up work falls under the Roadside Facilities MPA. Roadside Facilities typically includes mowing, fence repair, litter and debris control, sweeping, drainage structure maintenance, rock runs, slope repair, and streambed maintenance. These are considered routine maintenance activities.

Maintaining BMP's, collecting and hauling material, and data collection and reporting are all part of the environmental requirements, but these are not considered routine maintenance activities. Implementation of this SCAP as a part of "routine" operations within the context of the activities performed by maintenance personnel would require an entirely new focus and prioritization of maintenance operations under MLOS. In order to accomplish this, the extra work must be fully integrated into the maintenance program.

The clean-up of sand and sediment from the highway corridor is conducted through ditch cleaning, guard rail cleaning, sweeping, and other related activities as work designated under Roadside Facilities. In Region One, maintenance must budget for these activities among twelve counties. Since the beginning of the MLOS program in FY2000, the MLOS for Roadside Facilities has been set at Level B. This has determined funding levels for this program area, including sand clean-up and other "environmental-related work" such as erosion and drainage control, constructing boreal toad habitat, maintaining sediment ponds, collecting and reporting data, and other similar activities.

The MLOS system was implemented largely to improve accountability and is tied to the annual budgeting process. Maintenance funds are limited since they are made up entirely of state funds and must cover a wide variety of activities within a given maintenance area. Winter operations to maintain the safety of the traveling public and the roadway surface remain two of the highest maintenance priorities where large portions of the funds are allocated. Maintenance staffing, equipment needs, and annual maintenance priorities are established by CDOT management, the Transportation Commission and state law, and are all tied closely to the MLOS system.

The relatively new environmental-related maintenance activities, such as additional sand clean-up beyond the routine work and implementing and maintaining source controls, are not funded or accounted for within the current system. There is no new source of funding, nor have changes been made in the MLOS to provide additional resources for addressing these environmental components. The demand placed on existing maintenance forces to meet the full responsibility of the maintenance activities alone is worth noting. For maintenance personnel, it is additional burden on their already taxed resources to address these relatively new environmental concerns, which is additional labor intensive work that requires specialty equipment and is expensive.

CDOT is receiving considerable pressure to increase the level of sediment control and clean-up, particularly in these two segments of the I-70 mountain corridor, but in others as well. Within the Paul Area alone, maintenance is required to address sediment related and water quality related problems that exist on Berthoud Pass from Empire to Winter Park, along the Clear Creek corridor of I-70, through the Dillon Valley, as well as the Straight Creek and Black Gore Creek I-70 corridors. With the TMDL on Straight Creek, new requirements are expected of maintenance forces to accomplish work that is beyond the routine work established in the MLOS. A more extensive maintenance program is needed if the demands of the public are to be met to address the highway related water quality issues.

The majority of the roadway surface treatments such as paving and seal coating are done in July and August when temperatures for these activities are optimum. The shoulder and ditch cleaning, and rock removal are performed primarily during May, June and September. The snow begins falling in September and roadside work becomes very sporadic in October. Additionally, maintenance must repair safety devices, perform structure work, slope repair, vegetation management, and many other required activities within the short summer months.

In FY 2000, the Transportation Commission began to fund an additional $150,000 for maintenance to conduct sediment related clean-up activities. The funds were split between both the Straight Creek and Black Gore Creek I-70 corridors. Although this additional funding certainly has helped, it is inadequate to address the problem on an annual basis. The options for maintenance are large increases in overtime, adding FTE's, or contracting out more maintenance related work such as paving or sand clean-up.

With the extra $75,000 for sand clean-up on Vail Pass in the summer of 2001, a contract was released to remove sand along a two mile stretch of I-70 near Vail Pass. An estimated 7,889 tons (5,844 cu-yds) of sand and sediment were removed from Zone 1 between mileposts 185 and 190 (CDOT, 2001). The total for this removal effort included machine sweeping, drainage structures, ditch cleaning, and removal of accumulated sand behind barriers. Of this, approximately 54 percent (4,290 tons) was removal of sand that had accumulated behind Type 4 "Jersey" barriers adjacent to I-70. The cost for this work was $50,000 plus another $20,000 set aside for constructing and reseeding the sand disposal berm in Vail.

Many maintenance activities, such as laying asphalt, sand cleanup under guardrails, or dredging sediment ponds are very labor intensive. For example, when a maintenance patrol lays asphalt, it requires nearly the entire allotment of people in that foreman's area. These workers are therefore not available for dredging sediment ponds, although both activities must be accomplished during the summer months. The approach over the last several years has been to leave one patrol intact to do extra environmental clean-up work, while all the other patrols perform the paving. This is accomplished using the gang maintenance approach as much as possible between areas. For example, one year the Straight Creek patrol is left intact to clean sand, and the next year Black Gore Creek. Berthoud Pass generally has some people working on environmental clean-up work as well. This restricts the efforts of the Clear Creek, Loveland Pass, and Highway 9 crews to conduct their other routine maintenance activities and try to accomplish extra environmental work on their highway segments.

The maintenance patrols make an effort to sweep after snow events whenever possible during winter, spring and summer operations. Due to lack of specialized equipment, adverse weather conditions, and extreme temperature fluctuations during late winter and spring, it is often not possible to sweep after every storm event. The area only has one broom that is used to sweep Straight Creek, Vail, Silverthorne, Frisco, and Dillon. Since snow and ice control is the highest priority for maintenance crews, they must respond quickly. When snowstorms are predicted, the affected patrols are preparing for adverse weather conditions by making sure all snow removal equipment is in good working order, important safety matters are addressed, and existing snow is pushed back to ensure adequate room for additional accumulations.

Due to the cap on FTE's in the Department, maintenance cannot hire additional front-line personnel to perform any additional tasks. With the current allotment of funds in the maintenance budget for this work, maintenance forces can continue to maintain the shoulders, ditches, drainage structures, and eroded areas to the extent possible, but are typically unable to undertake more activities. At the current time, for example, if roadway resurfacing has been identified as a high priority for the Paul Area within a given season, this type of work must be done during summer and utilizes all of the presently available resources.

Staffing levels for front-line maintenance employees have basically remained the same since the number of allowable FTEs was reduced in the mid-1980's. Historically, the FTE count was augmented during the winter months with temporary help. However, these workers were not covered by state benefits and were paid hourly, making it difficult to retain adequate temporary help. By 1995, it became necessary for the Department to take extreme measures to hire maintenance workers to work during the winter months in the high country. In order to attract seasonal workers, temporary positions were converted to permanent part-time (PPT) positions and paid on adjusted high-cost pay. A PPT is ½ of an FTE and is fully covered by all state personnel rules applicable to full time employees.

This effort helped alleviate the immediate staffing shortages, but did not solve the problem during the winter months. By FY 2000, many maintenance positions remained vacant. At that time, some of the PPT positions were converted to FTE positions in order to find workers. Since maintenance has a cap on allowable FTE's, an exchange was made of two PPT positions for every one FTE. Now, instead of having two plow drivers to plow Vail Pass or Straight Creek on a cold snowy winter night, there is now only one. However, this FTE now works year round and is available during the summer months.

In order to accomplish what is being requested of maintenance forces during the summer months to clean-up sediment material, maintain BMP's, and other environmental-related activities along the I-70 mountain corridor, the maintenance program will require a new approach and philosophy regarding maintenance priorities and responsibilities. Sediment control needs to become as high a priority under the MLOS program during the summer months, as snow and ice control is during the winter months. Responsibilities within the current MPA's would need to be expanded to include resources for accomplishing these additional activities.

5.0 BMP DESIGN ANALYSIS FOR SEDIMENT CONTROL

This section develops the basis for sediment source identification, volume estimates, control strategies, preliminary hydraulic and drainage analysis, BMP design, proposed structural and nonstructural BMP's, and proposed maintenance program requirements for the Black Gore Creek I-70 corridor. The BMP's proposed in this SCAP were developed largely on previous CDOT experience and research in implementing BMP's at high altitudes, both successes and failures. It is important to remember that this is a planning level document only. Further site-specific analysis, design, and cost estimates will be required prior to implementation of specific sediment control measures.

To date, no sediment control BMP's have been implemented along the Black Gore Creek I-70 corridor. However, several cooperative projects have been undertaken between CDOT and the Eagle River Water and Sanitation District near the top of Vail Pass near Black Lakes, including improvements to the CDOT maintenance yard and sand storage facility. Two new projects have been authorized for the Black Gore Creek I-70 corridor including a transportation enhancement project and a Section 319 project. These projects will involve removal of accumulated sand and construction of sediment control BMP's based on recommendations made in this SCAP. It is anticipated that these sediment control projects will be constructed during 2002.

5.1 SOURCE VERSUS DEPOSITIONAL AREAS

Studies of Black Gore Creek have indicated that I-70 traction sand is the primary source of sediment loading to Black Gore Creek. Approximately 15,000 tons of this material is applied to the highway surface each year. Most of this material is plowed off the highway with snow, depositing on the shoulders until surface water runoff becomes available to transport the sand. Thus, the mobilization of sand to receiving waters is dependent on the surface water hydrology.

Data indicate that two primary hydrologic conditions mobilize sediment; snowmelt runoff and rainfall runoff. Snowmelt along I-70 in Black Gore Creek extends over a period of several weeks beginning in March and substantially ending in May. During this extended snowmelt period a significant amount of snowmelt infiltration can occur along the shoulders of I-70. This results in generally lower runoff volumes in early spring than might be experienced during summer thunderstorm runoff events. Thus, the erosive energy (water velocity) available to mobilize sediment is generally lower during snowmelt periods than following intense rainstorm events. The data collected to date support this hypothesis, indicating the maximum sediment loads in Black Gore Creek occur following intense summer rainfall-runoff events.

The primary strategy of this Plan is to capture the highway sediment before it has an opportunity to leave Zone 1 (approximately 30' each side of I-70). To reduce the potential for off-site transport and deposition, the sediment must be controlled in this area. Data indicate that most of the initial deposition of sand occurs in Zone 1, e.g. the snowplow cast is on average about 10 feet. The hydraulic distance to Black

Gore Creek is only a few hundred feet down steep fillslopes in many areas, and sediment is lost to the riparian zone if it is not collected near the highway. It is therefore essential to gain control of sediment at the source before it is transported beyond the highway template.

Highway sediment is deposited on hillslopes, in forested and wetland areas, and along the banks of Black Gore Creek in several areas (Lorch, 1998). Sand deltas have formed at many locations where drainage from I-70 enters Black Gore Creek and the Black Lakes. Mineral sediments carried in I-70 runoff continue to bury organic soils in wetlands. Drop structures installed in Black Gore Creek during construction of I-70 to stabilize the channel and prevent downcutting have filled with sediment and several sediment basins used during construction of I-70 along the corridor have also filled with sediment.

An Eagle River Water & Sanitation District wetland mitigation site located just west of Black Lake No.2 had to be remediated in 1999 due to the continued inundation of roadway sediment, and this encroachment continues each year. These visual indicators of the impacts further illustrate the need for implementing source controls along the highway template to reduce sediment transport into the natural environment. Otherwise, areas receiving runoff downstream from the I-70 template will continue to be inundated.

5.2 SEDIMENT SOURCE ESTIMATES

An average of 15,000 tons of traction sand is applied to I-70 between mileposts 180 (East Vail) and 190 (Vail Pass) based on the past 12 years of record (1990-2001). Maximum application rates were reported at about 23,000 tons in winter 1995-1996 (see Table 1). Cut and fill slopes along I-70, and natural sources also contribute sediment to Black Gore Creek through erosion processes. However, revegetation success has been good since construction of I-70, and studies indicate that these sources are negligible by comparison and that traction sand is the primary source of sediment in Black Gore Creek.

Sediment from I-70 is contributed to Black Gore Creek throughout its length to varying degrees. Sand application rates during most winter storms are non-linear over the 10-mile Black Gore Creek segment of I-70; rather sand is applied according to specific traction needs based on roadway snow and ice conditions. Specific areas that typically require more traction sand include the Narrows (approximately milepost 184.5 to 186.5), bridge crossings, and higher elevation zones. The Narrows coincide with the highest gradient section of I-70, requiring additional traction sand application to maintain traffic mobility.

Precipitation increases with elevation by approximately 60 percent from East Vail to Vail Pass. With the exception of specific areas (the Narrows), traction sand usage also generally increases with elevation and snowfall. For sediment control design purposes, a conservative approach was used to estimate the volume of traction sand used by factoring in these potential differences in sand application rates within the corridor.

It is assumed that sand cleanup is only feasible after snow has melted (May), resulting in one full winter season of sand usage that would need to be captured. The sand application rate used as the design criteria in this study assumes the average total of 15,000 tons per year for lower Black Gore Creek (below Polk Creek bridge) and 22,500 tons per year for upper Black Gore Creek (Polk Creek to Vail Pass). These criteria incorporate the maximum annual sand application rates at higher elevations (including the narrows), and the average rate for lower elevations.

These design criteria assume a “worst case” scenario for annual sediment control needs, such as that experienced for the winter 1995-1996. Because sand usage during most years will be less than this estimate, the sediment collection structures specified in this plan may require less frequent cleaning. Further, the uncertainties regarding the volume of cut slope and other sediment produced annually demands that sediment collection structures be sized for adequate storage capacity.

5.3 SEDIMENT CONTROL STRATEGY

In the Black Gore Creek study corridor, the temporary structural sediment controls used during construction of I-70 were not designed as permanent structures and have been abandoned. The annual sedimentation caused by traction sand usage was not anticipated to be a significant source of sediment transport at the time of construction. The only permanent method of controlling sediment on Black Gore Creek has been through revegetation to prevent erosion. This Plan proposes other permanent sediment control measures along I-70, as well as a more intensive maintenance program as the primary solution to sediment transport.

Several sediment control measures are considered in this study including both structural and non-structural controls. Structural sediment controls include features that are placed in the drainage pathway to dissipate hydraulic energy and settle solid material. This includes hydraulic control of highway runoff to reduce erosion of cut and fill slopes. Non-structural sediment controls include revegetation to prevent soil erosion and other maintenance BMP’s. A proactive maintenance program involving BMP’s such as utilization of controlled snow storage areas, chain law enforcement, and scheduled sand cleanup activities including sweeping and removal is integrated into this plan.

The primary sediment control strategies in this plan include:

- Bypass clean tributary water to prevent contamination by highway runoff
- Minimize the volume of water requiring treatment
- Maximize sediment capture volumes
- Removal of sand stored within Zone 1
- Reduce the size and number of vehicle turnouts and/or implement erosion control BMP’s
- Reduce cutslope and fillslope erosion
- Reduce rill erosion along shoulders
- Improve highway drainage network
- Contain sand below bridges where feasible to prevent migration to streams
- Maximize vegetation cover necessary to prevent erosion
- Provide controlled snow/sand storage areas

- Develop a preventative maintenance program (Sediment Maintenance Program)

Highway drainage design plays a major role in the sediment control strategy. Several areas exist along I-70 where the original drainage design is inadequate, or the drainage system has been altered by sedimentation to the extent that it no longer functions properly. This can and has resulted in massive rill and gully erosion where runoff is concentrated on the highway shoulders and steep gradients in unstable soil. There are several locations in the Black Gore Creek I-70 corridor where large gullies have formed, particularly in fillslope areas, as a result of improper drainage. Rill formation is common in shoulder areas where highway runoff sheet flow is concentrated in unconsolidated sediments. In some areas, culverts are plugged with sediment and no longer function, resulting in concentration of large flow volumes that exceed downstream drainage system capacity.

By incorporating drainage design considerations, this SCAP also serves to resolve many of the drainage problems currently experienced in the Black Gore Creek I-70 corridor. Because hydraulic energy must be dissipated to control sediment, runoff water must be managed in a controlled manner through adequate drainage design.

Paving of the shoulder areas, installation of "valley pan" drains, and concrete guardrail placed to control highway runoff have all proven to be effective methods of controlling erosion along I-70. An experimental erosion control project conducted on Straight Creek in 1979 by the Colorado State University Research Institute and the Federal Highway Administration found that Type 4 (Jersey barrier) guardrail and valley gutter drains at the top of the fillslope were treatments that worked well in controlling runoff and reducing erosion (FHWA, 1980). A 1990 study by the U.S. Forest Service on Straight Creek concluded that revegetation, coupled with construction of a collection ditch (valley gutter) had stopped the majority of erosion on test fillslopes (CDOT, 1992).

Vegetation has the ability to bind soil particles, provide organic enrichment, and maintain soil moisture. Adequate vegetation cover is widely recognized as a key element in stabilizing soil and preventing erosion. Most of the areas disturbed by I-70 construction have been successfully revegetated. However, vegetation in many areas remains under stress due to annual smothering by highway traction sand. An annual revegetation program for the hillslope areas along I-70 is proposed as part of this SCAP in an effort to improve and maintain adequate vegetation cover to prevent soil loss.

A preventative maintenance program is proposed to control annual sediment transport and to remove accumulated sand. A cleanup and disposal plan will be required as part of the maintenance program. These aspects will be integrated into a Sediment Maintenance Plan as described in Section 5.6.

Based on past research and experience in high elevation snowfall traction sanding areas in Colorado, the following primary sediment control measures are proposed for the Black Gore Creek I-70 corridor:

- Basins and traps to capture sediment
- Paving of shoulder areas to reduce rill erosion and provide a durable surface for cleaning

- Valley pan drains to control and route highway runoff
- Knee walls to prevent cut slope erosion
- Type 7 concrete guardrail to reduce migration of sediment from fillslopes
- Controlled snow storage/sand deposition areas
- Revegetation program
- Maintenance BMP's
- Sediment Maintenance Program

5.4 HYDRAULIC/DRAINAGE ANALYSIS

The hydrology of the Black Gore Creek watershed, described in Section 2.1, is dominated by the annual cycle of snowmelt runoff. The winter snowpack effectively stores water for release to streams during spring and summer when daily temperatures increase. This phenomenon drives the hydrology of Black Gore Creek, including both surface and ground water flows that intercept I-70 within the corridor. Other factors that influence the natural hydrology include the Black Gore Lake storage reservoirs and increased impervious surfaces resulting from highway and parking area development.

Significant drainage problems were identified as part of the site reconnaissance. It is noted that overall, the drainage design for I-70 was probably adequate when constructed. However, the drainage system has been significantly altered from sand deposition along the shoulders of I-70. In some areas, the shoulder slopes to drainage ditches were originally 6:1 and are now 10:1 from sediment infilling. Thus, drainage improvements are needed to reduce transport of deposited material and to provide adequate runoff conveyance. Present-day drainage and erosion problems occur primarily at 1) shoulder and cutslope areas, 2) the terminus of Jersey barriers where runoff is concentrated along the roadway with no inlet drains, 3) areas where the inlet drains are plugged with sediment, 4) areas where culvert cross drains daylight on fillslopes with no erosion protection or energy dissipation, and 5) median areas where flow is concentrated for long distances.

One of the most problematic drainage areas is the "narrows" where all four lanes of I-70 appear to be super-elevated to the westbound shoulder (approximate milepost 186.0 to 186.4). This area also coincides with one the highest gradient segments of I-70, a snowslide zone, and the largest single highway cut into the Maroon sandstone formation, which is subject to regular mass wasting. Highway runoff appears to concentrate on the westbound shoulder at the toe of this cutslope, mobilizing large amounts of both highway sand and natural material eroded from the sandstone cliffs. This area was identified previously as having the single largest source contribution of sediment load to Black Gore Creek (Lorch, 1998).

The I-70 highway cut bisects several tributary streams that flow perpendicular to the highway. Several ephemeral tributaries and ground water springs that flow only during the spring and early summer were also intercepted during construction. The highway was designed to allow passage of these tributary flows through culvert cross drains. The culvert inlets and cross drains for perennial tributaries were generally in good condition. Each of the major tributary flows were identified and mapped for this study.

A primary objective of this plan is to separate the clean tributary flows from highway runoff flows to the extent practical. The objective is to 1) keep clean tributary water from becoming contaminated with highway runoff and sediment, 2) reduce the volume of water requiring treatment, and 3) maintain sediment basins as dry as possible between runoff events to improve trap efficiency and facilitate cleaning. All of the largest existing clean tributary culverts will remain at their present locations and the only alteration proposed is to extend the existing culvert inlets upstream as needed to collect the tributary flow before it reaches the shoulder of I-70.

Highway runoff will be routed in a concrete channel past clean tributary inlets and into sediment control structures before release to Black Gore Creek. Runoff water will be conveyed through existing culvert cross drains wherever possible. Culvert rundowns with energy dissipation will be installed where necessary to eliminate hillslope erosion and stabilize fillslopes.

5.4.1 Assumptions

Since highway runoff will be re-routed past clean culvert inlets into sediment basins or traps before being released through cross drains, the hydraulic (flow) length between cross drains could increase in certain areas. Therefore, it was necessary to re-evaluate the hydrologic design for I-70 drainage structures to determine conveyance needs based on CDOT hydrologic design criteria. A "worst case" scenario was evaluated assuming a maximum hydraulic length between cross drains to assess potential "fatal flaws" in the sediment control design in terms of hydraulic conveyance. The following assumptions were used in the hydraulic analysis.

1) No off-site area contributes to highway runoff flows. The only drainage area considered was that from the roadway and paved shoulders. The off-site flows are clean water tributaries conveyed through existing cross culverts under I-70 and via slope drains to the valley floor.

2) A maximum longitudinal grade of 7% along the roadway and 2% roadway cross slope. This would create a worst case for velocity in the V-ditches and gutter pans. A slope of 1% was also evaluated to determine maximum carrying capacity.

3) Contributing area is the traveling roadway and paved shoulder. The contributing area used for I-70 along Vail Pass (Black Gore Creek) was two 12-ft traveling lanes in the east and west direction with an average 15-ft paved shoulder.

4) Conveyance structures include paved V-ditches along the cut slopes and concrete valley pans along the fill section. Cross slopes were modeled for 8:1 to 12:1 (horizontal to vertical).

5) Cross drain structure inlets are CDOT Type C and D for the paved V-ditches and vane grates in the concrete valley pans. In addition to the vane grates, slotted drains may be used to increase hydraulic efficiency. These inlets are shown in CDOT's Standard Plans-M&S Standards.

6) There are instances where V-ditch flows will be bypassed over major tributary cross culverts. These tributary culverts will be extended back into the slope for a short distance and similar cross culvert inlets will be used.

The design criteria used in the hydrologic analysis include the following:

- The 2-yr rainfall frequency depth was used in the preliminary design since the structures proposed for erosion and sediment control are integrated with the existing I-70 storm drain system. As per CDOT Drainage Manual the 2 to 5 yr rainfall frequency is typically used for storm drainage design.

- Rainfall intensity was determined from NOAA Atlas 2 "Precipitation Frequency Atlas of the Western United States-Volume III-Colorado. Rainfall amounts for Vail Pass were slightly higher than for Straight Creek.

- Minimum freeboard requirements were evaluated to determine the degree of safety necessary to prevent overtopping of the conveyance structures. The freeboard will vary depending on location.

- The Rational Method was used to estimate peak flows. All drainage areas met the criteria of less than 160 acres for use of this method. The runoff coefficient used was the 2-yr value for paved streets of 0.87 from Urban Drainage Flood Control District's "Urban Storm Drainage Criteria Manual". The time of concentration method used was that outlined in the CDOT Drainage Manual Chapter 7 - Hydrology.

5.4.2 Results

Hydraulic lengths ranging from 0.1 to 1.0 mile were evaluated to estimate peak highway runoff flow volumes that could be generated between I-70 culvert inlets. These estimates represent one lane direction, either eastbound or westbound (Table 3).

Most of the cross culverts draining I-70 are 24-inches in diameter or larger. The full-flow capacity for a 24-inch CMP is about 22 cfs at one percent slope. It was conservatively assumed that the total flow at the point where drainage from both the eastbound and westbound lanes combines in the 24-inch culvert drain should not exceed 10 cfs. Therefore, the maximum allowable distance between sediment collection and cross drain structure inlets is approximately 0.4 miles in the Black Gore Creek I-70 corridor. Highway runoff water would not be conveyed any farther than this distance before being collected at sediment control structure inlets for discharge via cross culverts and rundowns.

Table 3
Black Gore I-70 Culvert Design Peak Flows (cfs)
Each Lane Direction

Distance (miles)	2-year	5-year
0.1	1.1	1.8
0.2	2.0	3.2
0.3	2.8	4.5
0.4	**3.4**	5.4
0.5	4.5	7.2
0.6	4.7	7.5
0.7	5.2	8.4
1.0	6.6	10.4

Several variables associated with design flows for the different conveyance structures were evaluated. The parameters that were fixed were slope at 0.07 ft/ft and a peak discharge of 3.4 cfs per lane direction. Side slopes of the conveyance structures were varied from 8:1 to 12:1 (horizontal to vertical). The resulting estimates for water depth, velocity and top width are shown in Table 4.

Table 4
Black Gore I-70 Hydraulic Conveyance Structure Estimates

Cross Slope (h:v)	Longitudinal Slope (ft/ft)	Peak Flow (cfs)	Flow Depth (ft)		Flow Velocity (ft/s)		Flow Top-Width (ft)	
			Asphalt V-ditch	Concrete Valley Pan	Asphalt V-ditch	Concrete Valley Pan	Asphalt V-ditch	Concrete Valley Pan
12:1	0.07	3.4	0.30	0.20	6.5	6.0	3.5	5.2
10:1	0.07	3.4	0.32	0.20	6.7	6.2	3.2	4.7
8:1	0.07	3.4	.035	0.30	7.0	6.6	2.8	4.1
10:1	0.01	3.4	0.46	0.30	3.3	3.0	4.6	6.7

The hydraulic design assumptions and variables used in this analysis are considered to be conservative but appropriate for planning purposes. According to CDOT hydraulics section, these results indicate that there should be no drainage issues that would present a problem for future design and construction of the proposed sediment control measures.

5.5 PROPOSED STRUCTURAL CONTROL MEASURES

Several permanent sediment collection structure designs have been used by CDOT in an effort to capture highway sand in the Colorado Rocky Mountains. On Straight Creek, earthen sediment basins are used at the toe of the I-70 fillslope to capture sediment. Along I-70 near the west portal of the Eisenhower Tunnel, a series of concrete above-grade sediment traps are utilized to capture traction sand. On U.S. 40 Berthoud Pass east, below grade concrete sediment traps have been installed in the highway template to capture road sand because the steep topography and grades do not allow sufficient space for conventional earthen sediment basins.

All of these sediment control features have in common a drainage network that routes sediment-laden water into collection structures that dissipate energy to settle solid material. Thus, runoff controls are an integral part of the structural sediment control design. Another important structural aspect is the combined need to reduce erosion of unprotected soil and to provide a durable surface from which cleanup activities can take place without causing damage to the vegetated slopes or highway template.

The I-70 roadway and shoulder vary considerably throughout the Black Gore Creek I-70 corridor, making a single sediment control design solution impractical. A safety "clear zone" of 30 feet from the edge of pavement is recommended wherever possible along I-70 due to the high-speed design of the highway. In many areas the clear zone is less than 30 feet because of the steep mountainous topography, and concrete "Jersey" barriers or steel guardrails are required in narrow locations within the corridor. Since the sediment should be controlled as close to the highway source as possible, the type and location of sediment control structures must be carefully considered.

5.5.1 Runoff and Erosion Control Structures

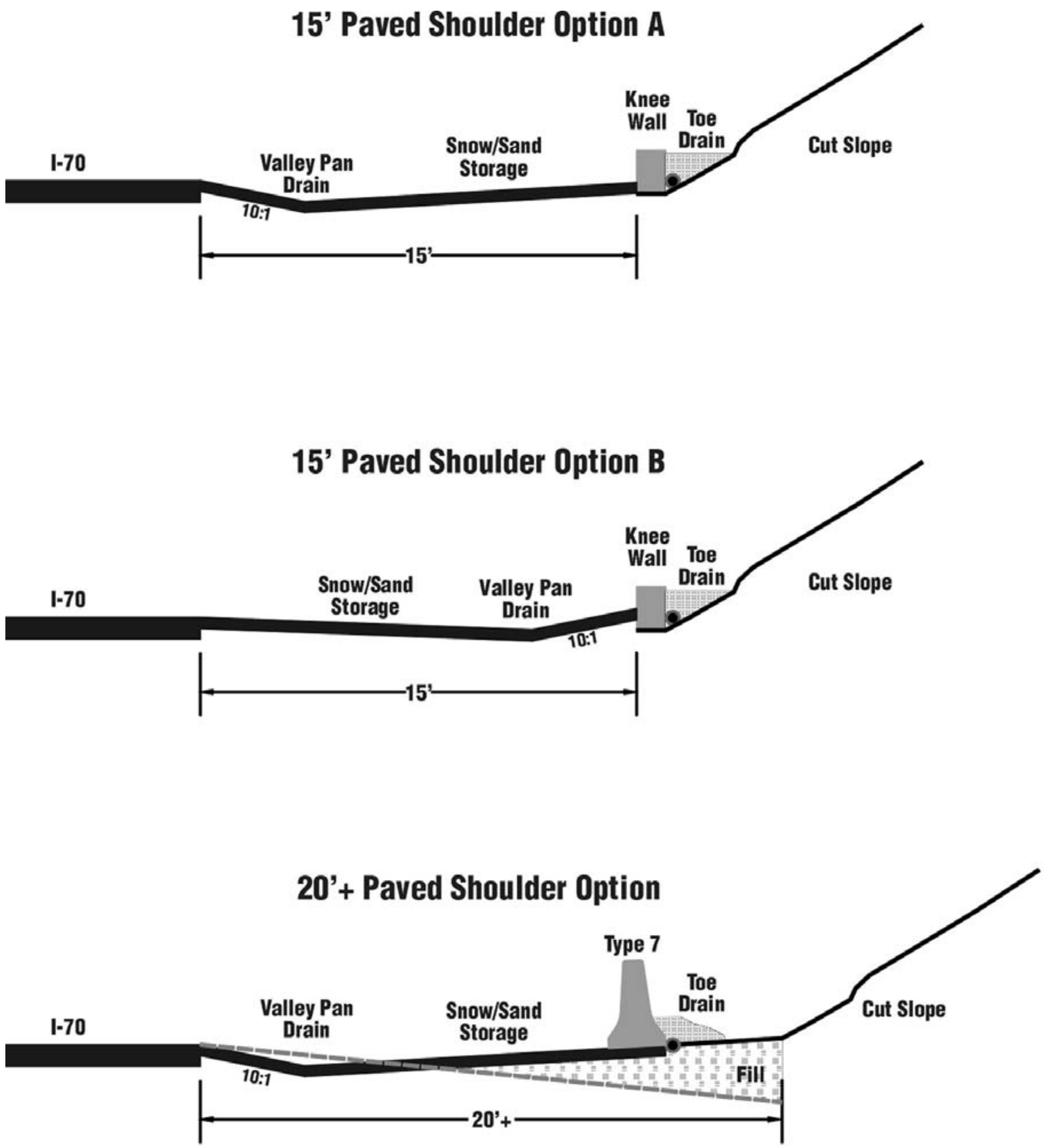
Permanent non-erodable surfaces are proposed for the conveyance of I-70 runoff to sediment collection structures. The highway shoulder in both cutslope and fillslope areas will be paved to a distance of approximately 15 feet from the edge of the highway. Concrete valley pan drains will be used to convey highway runoff. Drop inlet drains will be used below the outfall of sediment collection features to capture and route highway runoff water through existing cross drain culverts beneath I-70. Rundown culverts will be installed at fillslope locations for runoff conveyance to Black Gore Creek. Energy dissipaters will be used at the outlet of culvert rundowns where necessary to prevent erosion.

Typical highway sections for two cutslope and two fillslope treatments are shown in Figures 9 and 10. The shoulder widths on I-70 are not uniform and the typical configurations shown will vary considerably in many areas. However, for planning purposes it is necessary to establish an average condition. A site-specific analysis will be required before final design and construction.

Cut Slope Treatments

Permanent structural treatments to control erosion and to convey runoff in cutslope areas of I-70 are:

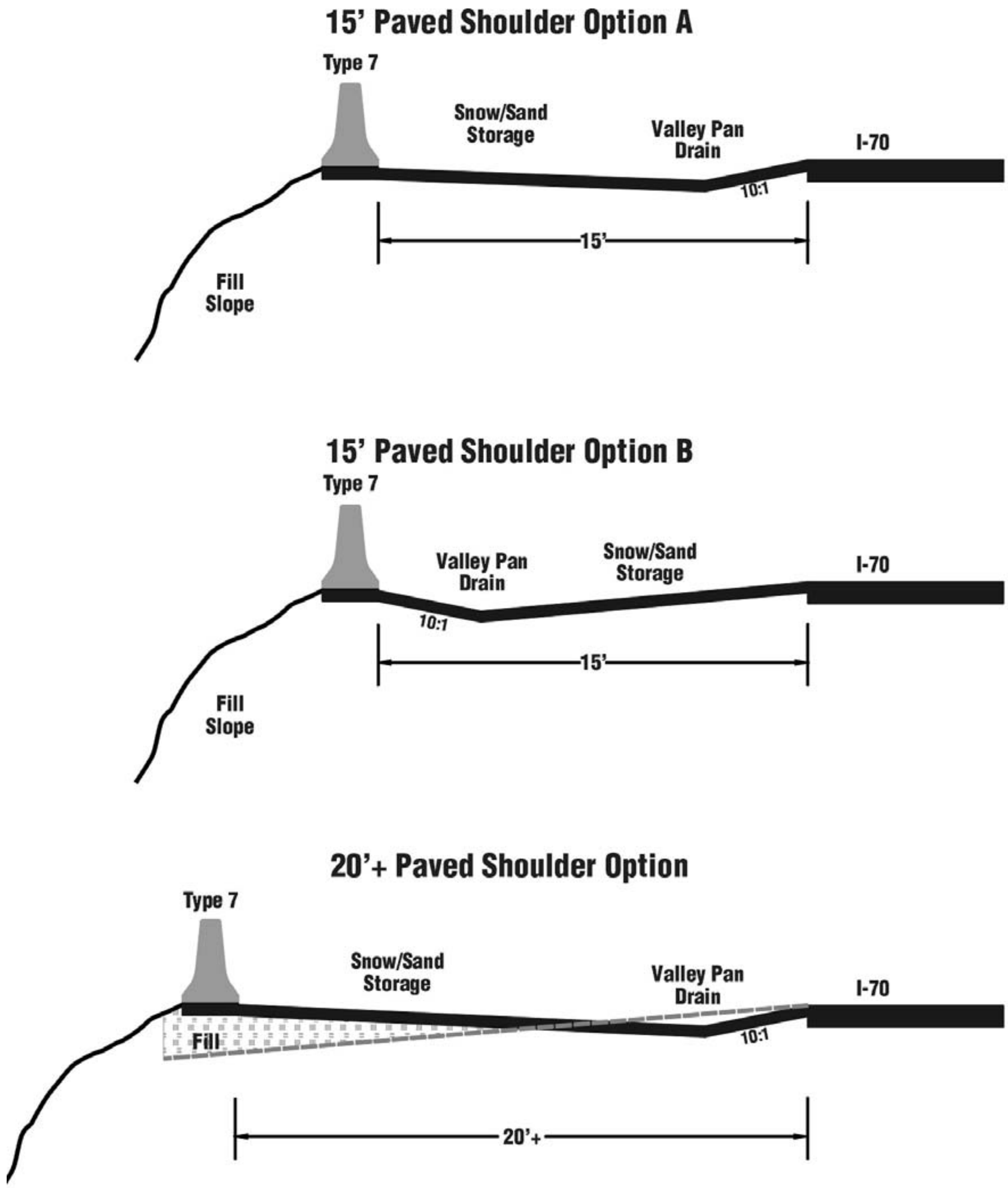
- Pave shoulder to an average distance of approximately 15 feet from the edge of highway
- Cross culvert extension for clean tributary flows
- Knee wall at toe of cutslope (approximately 18-inch high concrete)
- 6-inch perforated underdrain behind knee wall in high seepage areas
- Concrete valley pan drain (approximately 7 feet wide)
- 8-inch perforated underdrain beneath valley pan
- Sediment basins or below-grade sediment traps
- Inlets to existing cross culverts



I-70 Sediment Control Action Plan
Typical Cut Slope Shoulder Sections

03/05/02

FIGURE 9



I-70 Sediment Control Action Plan
Typical Fill Slope Shoulder Sections

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FIGURE 10

The typical section for cut slopes assumes a total paved distance of approximately 15 feet from the edge of highway. The valley pan drain will occupy approximately 7 feet, while approximately 8 feet is utilized for snow/sand storage. The eight foot paved section is designed for easy access with a sweeping machine (broom) to collect accumulated sediment. The knee wall at the toe of the cut slope will prevent undercutting of the slope and provide a durable surface for cleaning.

In areas of high spring flows or ground water seepage, a perforated underdrain will be installed behind the knee wall to collect and convey clean water flows to the nearest clean water tributary inlet. The culvert inlets at clean water tributaries will be extended up the slope above the invert of the valley pan drain to separate clean tributary flows from highway runoff. The knee wall seep collection drains will be routed to clean tributary culvert inlets.

Valley pan drains will be used to convey highway runoff to sediment collection structures. An underdrain will be installed beneath the valley pan to collect subsurface water in areas with high subsurface water. The subsurface water will be routed to clean tributary culvert inlets.

Three alternatives are considered for cutslope areas where the highway shoulder is greater than approximately 30 feet wide and the space is not used for drainage control and sediment collection structures. These include; 1) backfilling the unused area with used road sand and regrading/revegetation to extend the slope to the knee wall/valley pan drain, 2) installation of Type 7 barrier (34-inch tall) instead of the knee wall (18-inch tall) and utilizing the area for seasonal snow/sand storage, or 3) installation of a revegetated earth berm and utilizing the area for seasonal snow/sand storage.

Fill Slope Treatments

Permanent structural treatments to control erosion and to convey runoff in fillslope areas of I-70 are:

- Paved shoulder to an average distance of approximately 15 feet from the edge of highway
- Type 7 barrier at crest of fillslope (approximately 34-inch high concrete)
- Concrete valley pan drain (approximately 7 feet wide)
- Sediment basins or below-grade sediment traps
- Inlet to existing cross culverts
- Culvert rundown with energy dissipation

The typical section for fill slopes assumes a total paved distance of approximately 15 feet from the edge of highway. The valley pan drain will occupy approximately 7 feet, while approximately 8 feet is utilized for snow/sand storage. The eight foot paved section is designed for easy access with a sweeping machine (broom) to collect accumulated sediment. The Type 7 barrier will be installed on the crest of the fillslope to prevent migration of sand.

In fillslope areas where at least 8 feet of width is available behind existing concrete barriers, a snow/sand storage zone will be constructed by installing both a Type 7 barrier and a retaining wall as shown in

Figure 11. This type of configuration will be effective in trapping sand and is feasible in many areas of the Black Gore Creek I-70 corridor where concrete (Jersey) barriers already exist.

Where snow storage is required, selected fillslope areas with greater than approximately 30 feet of shoulder width will be paved and utilized for seasonal snow/sand storage. Valley pan drains will be used to convey shoulder snowmelt and highway runoff to sediment collection structures. Highway runoff will be separated from clean tributary culverts wherever possible.

Several areas along the Black Gore Creek I-70 corridor do not fall into specific cut or fill slope categories, but are considered a combination of the two. Some of these areas have at least 30 feet of shoulder width from the edge of the highway that is relatively level. If this space is not required for sediment collection structures but seasonal snow/sand storage is required, they will be paved to a maximum distance of 30 feet and a Type 7 barrier will be installed at the edge of the pavement to prevent migration of sand. If seasonal snow/sand storage is not required, these areas will be treated with 8 feet of pavement and an 18-inch tall knee wall at the edge of pavement to reduce sand migration from the highway template. In all cases a valley pan drain will be used to route snowmelt and highway runoff to the nearest sediment collection structure.

5.5.2 Sediment Collection Structure Preliminary Design

The primary constraints that determined the type and location of sediment collection structures in the study area were physiography, accessibility, safety, hydrology, and sediment volume generated. The potential locations for sediment control structures were identified through the site reconnaissance described in Section 2.2. In contrast to I-70 on Straight Creek and US40 on Berthoud Pass, the topography along I-70 west of Vail Pass offers many suitable locations for conventional sediment basins. There are small depressions along I-70 that are sufficiently outside of the safety "clear zone" to allow installation of a series of small earthen dams for use as sediment detention basins. Sediment basins are the most commonly used off-site control (Haan, 1983).

Sediment collection structures currently in use on Straight Creek were evaluated with respect to these constraints and their effectiveness in trapping sediment to determine if similar designs may be appropriate for use in the Black Gore Creek I-70 corridor. Alternative sediment collection structures evaluated included conventional earthen sediment basins, above-grade concrete traps, below-grade concrete traps, and snow storage areas. The following sand volume assumptions were used to establish the initial structure design requirements for the Black Gore Creek I-70 corridor.

1) A total sand application of 7,500 tons/year for the lower five miles of the corridor (MP 180-185); equivalent to 556 cubic-yards per mile or 56 cu-yds/tenth-mile for each lane direction.
2) A total sand application of 15,000 tons/year for the upper five miles of the corridor (MP185-190); equivalent to 1,112 cubic-yards per mile or 112 cu-yds/tenth-mile for each lane direction.

FIGURE 11
PARALLEL SNOW STORAGE

3) The average storage volume for sediment basins installed at the toe of the I-70 fillslope on Straight Creek is 139 cu-yds (CDOT, 1996). Reasonable sizing for a small sediment basin is 20-ft x 40-ft (60 cu-yds); large sediment basin is 30-ft x 68-ft (150 cu-yds).
4) Below-grade traps specified at 8-ft x 50-ft with 4-ft depth flat bottom (59 cu-yds).
5) 80 percent trapping efficiency for a rectangular shaped basin.

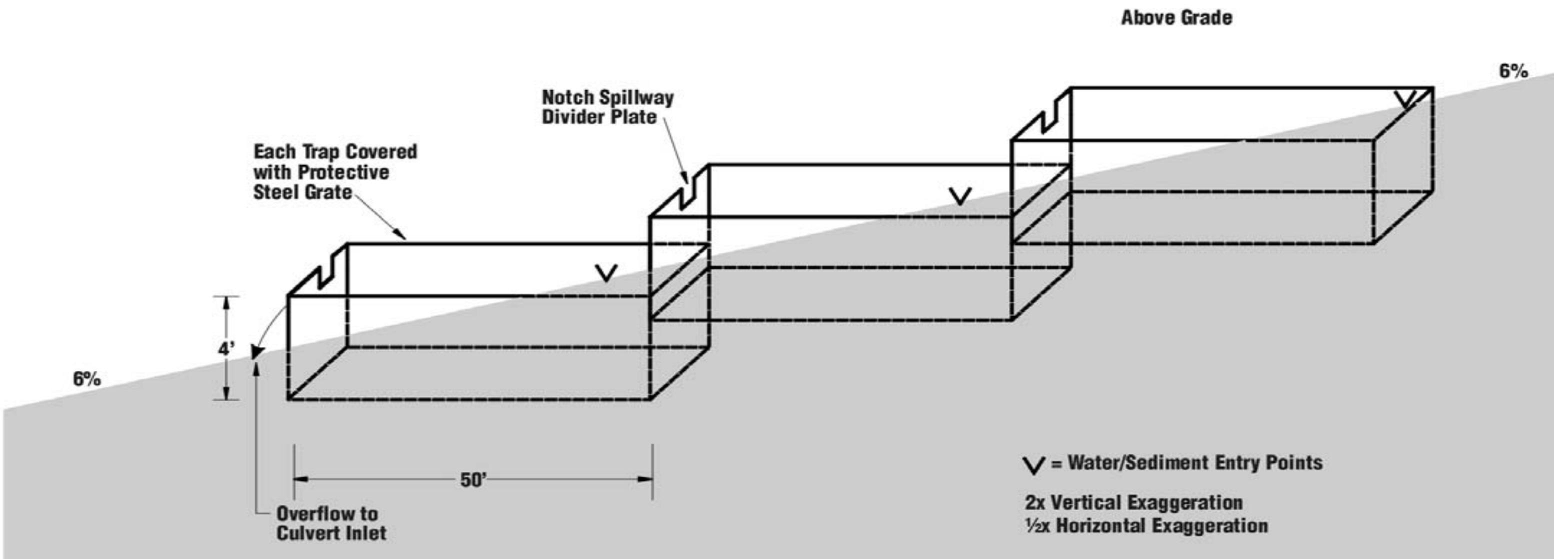
The above assumptions were used to develop the estimates of spacing requirements for sediment collection structures along I-70. These assumptions result in a reasonably conservative approach to sediment collection in the Back Gore Creek I-70 corridor. During a "worst case" snowfall/sand usage year such as 1996, many of the sediment collection structures would be filled with sand in one season and would require cleanout. In an average year, many of the collection structures would only partially fill after one season and cleanout may only be required every two or three years. Therefore, a conservative initial design is appropriate to ensure efficient capture of sediment under a range of potential conditions.

The principal type of sediment collection structure proposed in this study can be generally categorized as a detention dry basin (FHWA, 1996). Detention dry basins are depressed basins or traps designed to remove particulate pollutants and to reduce maximum (peak) runoff flows. Nutrients, heavy metals, toxic materials, and oxygen-demanding substances associated with sediment particles are also removed. These sediment basins are designed to temporarily store a portion of the highway runoff following a snowmelt or storm water runoff event.

The largest constraints with respect to sediment collection structure design for the Black Gore Creek I-70 corridor are access and space. The nature of the topography and highway safety issues dictate the type and location of potential structures that can be used. Based on these considerations, two types of collection basins are proposed in this study, including below-grade sediment traps and sediment basins. Typical diagrams of these structures are provided in Figures 12 and 13, respectively.

The below-grade traps are rectangular shaped concrete vaults that are installed in series below or partially below grade. The dimension of each trap is 8 feet wide, 4 feet deep, and 30 to 50 feet long depending on slope gradient conditions. A perforated steel plate is used at the outlet end to allow accumulated water to seep out between runoff events. Highway runoff water enters the trap near the upstream end and passes through the length of the trap. Excess runoff spills over the steel end plate and into the next downstream trap or culvert inlet.

The sediment basins are rectangular-shaped earthen basins specified in series where space allows. Two sizes are proposed; a small basin 20 feet wide, 4 feet deep at the dam, and 40 feet long; and a large basin 30 feet wide, 4 feet deep at the dam, and 68 feet long. Sediment basins will be designed with a reinforced spillway structure to pass the design storm. If possible, the bottom of the basin will be constructed in natural soil to promote infiltration of water between runoff events. In some cases it may be necessary to line the bottom of the basin with asphalt or concrete to provide a durable surface for cleaning. For lined



I-70 Sediment Control Action Plan
Typical Below-Grade Sediment Traps
6% Shoulder Grade

03/05/02

FIGURE 12

FIGURE 13
TYPICAL SEDIMENT BASIN

basins, a trickle tube pipe will be installed through the face of the dam to promote drainage of water between runoff events.

5.5.3 Sediment Collection Efficiency

The water quality benefits of any sediment collection structure increases by extending the detention time. To maximize the detention time and trap efficiency the sediment collection structures are placed in series wherever possible. In this fashion, the sediment trap efficiency is optimized and finer particle sizes can be settled before the water is released to Black Gore Creek.

Utilizing the traction sand usage assumptions described earlier, the volume of sediment generated per tenth of a mile of highway was calculated for both the westbound and eastbound lane directions of I-70. The location, type, and number of sediment collection structures was determined according to space constraints and the sediment volume estimates. Collection structure treatments included large basins (150 cu-yd), small basins (60 cu-yds), and below-grade traps (59 cu-yds).

Using a trap efficiency of 80 percent, the ratio of theoretical sediment volume captured versus volume generated was computed. For purposes of this plan, this ratio can be considered a margin of safety. Values greater than 1 indicate the specified number and placement of collection structures should be adequate to theoretically collect all of the sediment generated. Results are provided in the structure estimates table in Appendix B.

In most areas a safety factor of 1 or greater was achieved, indicating that most of the applied sand would be collected if transported into the collection structures. In some areas, a combination of basins and below grade traps is used. It is believed that this analysis provides a conservative approach, and that the number of collection structures estimated may be the maximum required since not all of the sediment will be transported into the structures. However, as stated earlier it is impossible to accurately determine the volume of sediment that will enter the basins, so added capacity will only result in less frequent clean out requirements.

Collection structures were designed to capture the maximum amount of sediment while passing the design storm. Since no effluent standard is applicable, the effluent concentration is not predicted. However, the trapping efficiency of the proposed collection structures was determined to provide a theoretical basis for estimation of the volume of sediment collected. The factors which control sediment transport through a collection structure are the:

- Physical characteristics of the sediment
- Hydraulic characteristics of the basin
- Inflow sedigraph
- Inflow hydrograph
- Basin geometry
- Chemistry of the water and sediment

Sediment basin shape has a strong influence on how effectively the volume is utilized in sedimentation. It is assumed in most analysis that some areas of the basin are bypassed and is therefore totally ineffective in the settling process (Haan, 1983). This is referred to as dead storage. Some examples of sediment basins with dead storage volumes can be found on Straight Creek, where the basins had to be constructed perpendicular to steep slopes and hence the flow path through the basin is shortened. In order to minimize dead storage, the EPA recommends that the ratio of average length of flow path to effective width of the basin be greater than 2.0. Therefore, all sediment basins and traps proposed in this study are rectangular-shaped with length/width ratio of at least 2.0.

The settling velocities of sand sized and larger particles are determined by using the size of sieve openings and calculating the settling velocity. Studies of road sand particle size from I-70 on Straight Creek (CDOT, 1996) indicate that the diameter of 85 percent of all stockpiled road sand, used sand on shoulder, and cut slope soil was greater than fine sand size (0.25mm). Studies of road sand from I-70 on Black Gore Creek (Lorch, 1998) indicate that 90 percent of the particles were greater than medium sand size. Thus, for purposes of determining collection structure trap efficiency, 85 percent of all source material is assumed to be greater than fine sand size.

An analysis of the trapping efficiency for the rectangular basins proposed in this study was made using settling velocities assuming steady state inflow and outflow conditions. Discrete particle settling is assumed for the road sand. An average rectangular-shaped basin size of 10-ft x 50-ft x 4-ft depth was used in the analysis conservatively assuming a peak flow of 5 cfs. Assuming a specific gravity of 2.65, the fall velocity would range from 0.1 ft/s for a 0.25mm (fine sand) particle to 2 ft/s for a 8mm diameter particle (fine gravel). Based on the trajectory of particles through the settling basin, the critical settling velocity was calculated to be 0.01 ft/s, which is the velocity that will just allow the particle to settle to the bottom in its trajectory through the flow length of the basin.

This analysis indicates that 90 percent of all particles in the size range measured for I-70 sand on Black Gore Creek and Straight Creek will be settled in a 50-ft long basin. In fact, particles as small as 0.08mm (very fine sand) would be captured at the critical settling velocity in a 50-ft long basin assuming a steady state flow of 5 cfs. The minimum basin size required to achieve settling of 0.08mm (very fine sand) and larger particles would be 8-ft x 30-ft x 2-ft depth at a peak flow rate of 5 cfs. Therefore, the sediment basins proposed in this study are designed to capture at least 90 percent of the stockpiled (road) sand, used shoulder sand, and cut slope soil particles with a 10-fold factor of safety.

The size distribution of inflowing sediment is the single most important factor determining the trap efficiency of a sediment basin. This analysis indicates that under steady state flow conditions over 90 percent of the sediment would be trapped. However, factors such as turbulence, non-steady flow conditions, and high flow velocity will reduce trap efficiency. Considering that all of these conditions are likely to be encountered on the steep gradients and highway runoff conditions found in the study area, the theoretical trap efficiency was conservatively reduced from 90 percent to 80 percent. CDOT (1996) estimated that, based on measured particle size distributions, about 78 percent of the source material should be intercepted and captured by the sediment basins on Straight Creek.

Based on the above analysis and assumptions, about 80 percent of the material that enters the proposed sediment collection structures will be captured. This does not include sand that bypasses the collection structures or is deposited in other locations along I-70. Some of this extraneous sediment will be removed through maintenance BMP's, while a portion will be transported from the I-70 template and permanently lost to the environment. Because of the highly variable nature of topographic, sand usage, and runoff conditions along I-70, it is impossible to accurately quantify the total volume of sediment that will be removed. Therefore, for purposes of this study it is estimated that at least 50 to 80 percent of the traction sand applied annually to Black Gore Creek I-70 corridor could potentially be collected and removed if full structural controls and a rigorous maintenance program were in place.

5.6 PROPOSED NON-STRUCTURAL CONTROL MEASURES

Various non-structural control measures exist that can be utilized for roadways. Some of these include maintenance BMP's, seeding & slope stabilization, roadside swales, drainageway protection, slope drains, terracing slopes, porous pavement, implementation of the chain-law, training of construction and maintenance personnel, phasing project activities, proper material storage practices, and other measures. Revegetation and maintenance practices are the primary non-structural control measures discussed in this SCAP. However, this does not preclude the use of other measures that should be evaluated and utilized along the corridor.

5.6.1 Re-vegetation

Establishment of vegetation and stabilization of slopes to prevent soil loss were difficult challenges faced during the construction of I-70. Steep slopes, a short growing season, and highly erodible soils are encountered at the high elevations of the Black Gore Creek I-70 corridor. These factors continue to make high altitude revegetation efforts challenging. Topsoil was placed on all slopes following I-70 construction, along with commercial fertilizer at a rate of 350 pounds per acre (lbs/ac). Straw mulch and jute netting were used to hold soil in place. Original seeding rates used during construction along the I-70 Black Gore Creek corridor were 40 lbs/ac of the following seed mix:

Streambank Wheatgrass – 7 lbs/ac
Western Wheatgrass – 4 lbs/ac
Kentucky Bluegrass – 3 lbs/ac
Smooth Brome – 5 lbs/ac
Timothy – 4 lbs/ac
Red Fescue – 3 lbs/ac
Meadow Foxtail – 4 lbs/ac
Slender Wheatgrass – 5 lbs/ac
White Dutch Clover – 1 lbs/ac
Alisike Clover – 3 lbs/ac

The revegetation program for Vail Pass was successful and has required minimal maintenance. However, vegetation adjacent to the highway continues to be buried annually with traction sand and is under considerable stress in many areas. Fillslope and cutslope areas also receive sand annually and vegetation covers is less than optimal in many areas. Many of these areas will begin to stabilize after sediment control structures are in place and maintenance practices are modified under the SMP.

Areas disturbed by installation of any new sediment collection structures, as well as areas where sand is removed, will need to be revegetated. The criteria for vegetation cover establishment will be determined through negotiations between CDOT and the U.S. Forest Service. Experience from revegetation efforts on Straight Creek and Berthoud Pass will greatly assist CDOT and the Forest Service in selecting successful seed mixes and cover criteria for the Black Gore Creek I-70 corridor.

This SCAP recommends that an annual revegetation monitoring program be undertaken by CDOT. This program would include an annual vegetation cover survey and a report to be developed that identifies problem areas, recommends solutions, and proposes any actions needed to improve vegetation cover. It is undetermined at this time if the annual revegetation program will be administered as a maintenance program or as part of a construction program. A vegetation monitoring plan will be developed that includes the following components:

- Agreed upon seed mixes and soil amendments
- Vegetation cover criteria for different slope aspect and soil types
- Establishment of vegetation reference areas along the two I-70 study corridors
- Approximate transect monitoring locations
- Schedule for annual cover surveys
- Reporting requirements

5.6.2 Proposed Maintenance BMP's

Maintenance will play an integral role in sediment control on I-70 as part of this SCAP. Currently, there is no maintenance plan that specifically deals with the removal of excess highway sanding material (see Section 4.0). Excess highway sand is cleaned up according to the availability of labor resources and funding which is highly variable from year to year. Sediment clean-up volumes for the Black Gore Creek I-70 corridor have not been recorded prior to year 2000, except the more routine activities such as removal of sand from ditches and drainage structures. In the year 2000, a new MMS acronym, SCL (sand clean-up), was added to the MMS system, allowing those maintenance activities directly related to sand clean up to be more closely monitored.

Sweeping is accomplished as time allows, and after sand pick-up work can be performed along the shoulders and median areas. The sand pick-up schedule at the higher elevations generally occurs between May and September when maintenance forces are able to clean ditches and guardrail. Due to the need for maintenance personnel during the winter months, and since the state fiscal year ends on June 30, vacations for maintenance personnel are taken before the end of June for those who must take their time, or throughout the rest of the summer months for all others. There are presently few maintenance crews fully staffed during May and June.

Sediment Maintenance Program

An important recommendation of this SCAP is the development of a Sediment Maintenance Program (SMP), as part of implementation. The SMP will specify procedures for sediment collection and, at a minimum, would specify critical periods in the schedule for inspection and maintenance requirements. Accumulated sediment would be removed and disposed of according to the SMP. Installation of permanent sediment collection structures will require a routine inspection and maintenance program for the cleanup and removal of accumulated sediment. This program will need to include an annual inspection program to assess the integrity and condition of sediment control BMP's and other drainage treatments. The following components should be included in the SMP:

1) Sediment control BMP structure and drainage inspection schedule
2) Sediment removal and disposal plan
3) Implementation schedule and requirements for routine maintenance BMP's (e.g. annual sweeping schedule, guardrail and ditch cleaning, chain law enforcement, etc.)
4) Snow removal and disposal techniques
5) Location and utilization of controlled snow storage areas
6) Revegetation program
7) Maintenance training program
8) Documentation, data collection, and reporting requirements

As part of the SMP, a training module covering specific aspects of sediment control would need to be incorporated into the existing CDOT snow and ice training program. This training module would cover sediment control issues related to winter maintenance such as the use of controlled snow storage areas, snowplow cast zones, snow blowing, snow removal from bridges, and winter sweeping.

I-70 Immediate Travel Template Depositional Area Sand Cleanup (Zone 1)

There is uncertainty regarding the exact volume of sand deposited along the I-70 template in the Black Gore Creek corridor. The deepest deposits are found immediately behind Type 4 barriers that act as sediment traps. In these areas, annual deposition rates are too great for vegetation to become well established. In other locations, the sand depths are highly variable and much of the material has either been integrated into the shoulder, removed by ditch cleaning, or washed away downslope. Vegetation has established to varying degrees in these areas. To prevent further disturbance to vegetation and subsequent erosion, areas with well established vegetation or areas beyond approximately 30 feet from the edge of I-70 will not be disturbed except where necessary to install sediment collection structures.

Several areas adjacent to I-70 along the Black Gore Creek corridor serve as effective sand traps. Sand material accumulates each year in the same areas (typically behind Type 4 barriers or guardrails) and migrates slowly downslope. Runoff water is often not available to transport the sand in these areas and material can accumulate for many years. The 2001 removal activity for sand accumulated behind Type 4 barriers along the eastbound lane of I-70 (0.92 miles) resulted in removal of 4,663 tons (3,454 cu-yds) per mile. The sand volume accumulated within Zone 1 was estimated for this plan based on the following general areas of both the eastbound and westbound shoulders of I-70:

- Behind Type 4 (Jersey) barriers
- The Narrows (MP 185.5 to 186.3)
- Bridge approaches and abutments
- Beneath Polk, Miller, and upper Black Gore Creek I-70 bridges
- Along shoulder areas

CDOT estimates resulting from removal of about one mile of the deep deposits found behind Type 4 (Jersey) barriers indicate approximately 3,500 cu-yds of sand per mile in these areas. Less than the total bi-directional lane miles have deep sand deposits behind Type 4 barriers or guardrails. There are about 4 to 5 lane miles of Type 4 barrier along I-70 in the Black Gore Creek study area. However, CDOT believes that substantial sand volume is also stored in shoulder areas in the Black Gore Creek I-70 corridor.

To develop estimates of the Zone 1 cleanup volume, it is conservatively assumed that 10 bi-directional lane miles in the Black Gore Creek I-70 corridor have deposits at the rate of 5,000 cu-yds per mile. This translates to 20 miles x 5,000 cu-yds/mile = 100,000 cu-yds. The Black Gore Creek I-70 corridor also has three bi-directional bridges crossing Polk Creek, Miller Creek, and upper Black Gore Creek. Sand has deposited at the abutments of these bridges and along the length of each side of the bridge, except in areas were the streams have washed the material away. There is an estimated 6,000 cu-yds of sand deposited at each of the three bridge crossings (total both directions), or a total of 18,000 cu-yds. Therefore, the total amount of sand deposited within Zone 1 is conservatively estimated to be about 120,000 cu-yds.

In areas beyond 30 feet from the travel lane that are easily accessible, some sand deposits will also be removed. This includes areas that receive annual I-70 sand loads along the bike path or U.S. Highway 6 that are easily accessible with heavy equipment with minimal disturbance to the environment. Certain cutslope areas (e.g. The Narrows) having large deposits of natural sediment that are easily accessible will also be cleaned of sand deposits and prepared for permanent BMP’s.

Removal of sand material within Zone 1 would be prerequisite to installation of the permanent sediment control measures proposed in Scenarios 3 and 4 in this plan. Many of these deposition zones are areas where sediment has accumulated from routine winter maintenance practices, indicating good potential for future sand traps. This plan proposes removal of the existing Type 4 barriers and accumulated sand, paving to the crest of the fillslope, and installation of new barriers and valley pan drains. Thus, removal of the Zone 1 sand deposited immediately adjacent to I-70 is part of the proposed plan.

Seasonal Cleanup Needs

The timing of sand cleanup is critically dependent on the season of the year because sediment transport is dependent on hydrology. Sediment is transported away from the highway template by surface water runoff in spring (snowmelt) and summer (rainstorms). If sand is readily available, these conditions will serve as the sediment transport mechanism. However, if sand is removed to the extent practical before transport can occur, sediment loading to receiving streams will be substantially reduced. As stated in Section 5.5, it is estimated that at least 50 to 80 percent of the road sand applied annually could be captured and removed through the combined implementation of permanent sediment collection structures and maintenance sweeping and removal efforts. Using an average of 15,000 tons per year total application for the 10-mile corridor, average annual capture and removal would be approximately 7,500 to 12,000 tons annually.

Sediment transport by surface water runoff that occurs during snowmelt and rainfall periods determines the timing required for maintenance and removal of accumulated sediment in Zone 1. Although snowmelt can occur any time during the winter, temperatures are typically too low to generate large runoff volumes. Hence, sediment transport is generally low during winter. The period in which the majority of snowmelt occurs is from March through May each year, during which time enough meltwater volume is generated to provide higher flow velocities and sediment transport energy. It has been observed that the used traction sand along I-70 is typically rounded and has a tendency to be mobilized with relatively low flow velocity. This high mobility factor, combined with the relatively steep gradients along I-70 results in potentially large sediment transport rates during the spring snowmelt period.

Major sediment transport occurs as a result of summer rainstorm events. The summer monsoon rainfall period in the study area is from June through August each year. The highest sediment transport rates in Black Gore Creek have been measured as a result of July rainfall runoff events. The erosive energy of raindrop impact and potential flow volume is greater than that of snowmelt, resulting in greater potential for mobilization of sediment accumulated along I-70.

Sand is deposited annually along the highway shoulders, but large amounts are also entrained in snow stored along the highway each winter. Large volumes of snow/sand mixture accumulate along I-70 as a result of winter snow removal activities. When the snow melts in April and May it can mobilize the sand in runoff. If it were feasible to remove the snow/sand mixture late in the season when snow volumes were relatively low, for example in April, this would reduce the sediment transport to receiving streams. Some high elevation mountain towns utilize controlled snow storage areas that allow snow to melt with minimal transport of contaminants. However, it is unlikely that sufficient permanent storage areas could be secured for the large volume of snow/sand that is typically present along the two high-elevation I-70 study corridors in April.

In some areas the I-70 snow piles do not fully melt until May. Melting typically takes place first near the road surface and shoulders where solar heating is greatest, and on south-facing slopes. Accumulated traction sand is transported in snowmelt water from shoulder areas. However, the runoff water typically concentrates in rills and gullies, leaving large deposits of traction sand in shoulder areas (see photos in Appendix A-1 and A-2). This plan proposes to pave these shoulder areas and route the runoff to valley pan drains and sediment collection structures.

Observations of paved shoulder areas on Straight Creek indicate that large deposits of road sand can remain on the paved surface immediately following the snowmelt period. To maximize the sediment control effectiveness, sand accumulated on the paved shoulder areas must be removed by sweeping or other methods immediately following snowmelt from the highway shoulder. This should be accomplished by May 15 each year. The timing for sweeping and removal is critical because rainfall can occur in May or June, and rainfall-runoff is very effective at washing the accumulated sand off the shoulders (e.g., Straight Creek). Early spring sweeping and removal on a rigorous schedule will result in less mobilization and will lower sediment transport volumes. At a minimum, the SMP to be developed will specify this critical period in the schedule for inspection and maintenance requirements.

There are two critical periods when inspections, maintenance, and sediment removal are required for sediment collection structures and depositional areas to ensure adequate volume is maintained to capture sediment. Inspection and removal from structures should take place following the two major sediment transport periods:

1) June - following snowmelt in late spring but before monsoon thunderstorms in July
2) September - following the summer monsoon rainfall period but before the onset of winter weather

Removal of sediment from structures in June will help ensure that collection structures and depositional areas are maintained with adequate capacity to capture sediment transported during the summer monsoon rainfall runoff period. Sediment removal in September will help ensure that collection structures and depositional areas are maintained with adequate capacity to capture sediment transported during the winter and early spring snowmelt runoff period.

Sand Disposal

One of the largest challenges faced by CDOT is securing long-term disposal sites for used traction sand and other sediment generated along the highway. Unfortunately, there is no market that has yet been identified for used traction sand. CDOT research has indicated that the angularity of the sand grains is lost once the sand is applied to the highway and pulverized by vehicle traffic, resulting in poor traction characteristics. Haul distances for this type of solid waste also must be kept to a minimum to control costs.

The functionality of used sand for purposes of disposal or reuse becomes problematic. The mixture used by CDOT on state highways, including the Interstate system, is purchased as a mixture of salt and sand from qualified sand and gravel companies, in accordance with specifications established by CDOT.

Gravel companies bid on contracts let by each Region, generally on an annual basis. Due to various reasons, these companies do not want the used sand returned to them for disposal.

It is not practical for the used sand to be recycled since it has been pulverized after being on the road and therefore, no longer meets the required specification. Additionally, it would take a large amount of space and labor to sift through the material that would need to be collected for recycling. After being on the roadway surface, the material also becomes contaminated with impurities from litter, natural sediment, chemicals, petroleum hydrocarbons, and other types of pollutants that mix with the salt/sand mixture. Without adequate storage facilities, the only other alternative is to haul the material annually to disposal sites willing to take the material. This means of sand removal and disposal could potentially become cost prohibitive.

Practical alternatives for the disposal of used sand material are extremely limited. However, several communities adjacent to I-70 are realizing the advantages of sound berms to reduce highway noise. Currently, the disposal of some accumulated sediment material from the Black Gore Creek I-70 corridor is used for the construction of berms along I-70 in Vail and surrounding areas. This could provide adequate disposal for the immediate future. However, additional sites will be needed in the near future. CDOT personnel in Region 3 have indicated that additional permanent disposal sites are readily available in the Vail and Eagle River Valleys downstream of Black Gore Creek.

Preliminary research by CDOT into sand disposal options for the Black Gore Creek section of I-70 indicate that the sand berm currently under construction in West Vail has an estimated capacity of 12,000 cubic yards, of which 5,000 cu-yds (6,750 tons) remains open. However, estimates indicate that 120,000 cu-yds (162,000 tons) may be removed from existing depositional areas along the I-70 template as part of this SCAP. An additional 5,556 cu-yds (7,500 tons) may be captured annually for disposal. Clearly, substantial permanent disposal areas will be needed before this SCAP can be implemented. This will require an active approach in identifying sand disposal sites in advance, before significant volumes of traction sand can be removed from the highway and an effective sediment control program can be implemented.

As described in Section 5.5, the cross sections at certain locations along I-70 may require infilling of material near the toe of cutslopes or the crest of fillslopes to accommodate drainage design. Depending on the suitability of sand for use as a fill material, it may be possible to utilize these areas as permanent sand disposal sites. In this fashion, the sand removal BMP's specified in Control Scenario 2 may be integrated into certain fill requirement needs for Control Scenario 3 or 4. This option would be particularly useful for disposal of the sand accumulation in both study corridors.

Equipment

The equipment required to remove sediment from Zone 1 consist primarily of mechanical sweepers/brooms, front-end loaders, graders, and haul trucks. The sediment collection structures will likely require cleaning with a track hoe (excavator), or vacall truck. There are several advantages offered by a vacall truck including a reduction in manpower and the ability to remove sediment when it is saturated with water. CDOT equipment needs will depend on whether or not the equipment will be purchased or leased. The estimated equipment needs and costs are included in the various Scenarios presented in this SCAP.

Snow Removal and Storage

The current CDOT snow removal practice involves moving snow as far away from the highway template as possible in the high elevation areas of the I-70 corridor, including Straight Creek and Black Gore Creek. Once snow is plowed to the shoulder with snow plow trucks during the initial snowstorm, it is later moved further off the shoulder using heavy equipment such as loaders or bulldozers. The maximum extent of plow cast is typically 10 to 20 feet, whereas snow is often moved beyond the plow cast zone during subsequent removal operations in certain areas. The main purpose of this practice is to allow sufficient space for new snow storage as the winter progresses. Further, CDOT has determined that after snow is moved once, it is more difficult to move the second time due to consolidation processes that occur in the snowpack.

As described in earlier sections of this plan, snowfall is generally proportional to elevation with the highest amounts above 9,500 feet. Locations above 9,500 feet on west Vail Pass and the west approach to the Eisenhower Tunnel require substantial snow storage areas to maintain a clear zone along I-70 during winter. Unfortunately, storage space is limited due to the steep nature of the topography. The snow removed from the highway includes a mixture of traction sand/salt. Therefore, large deposits of traction sand remain in snow storage areas following snowmelt.

Even without the advantage provided by structural controls, there are opportunities to reduce migration and transport of traction sand that result from snow storage practices. In some areas, traction sand deposits are 30 feet or more from the edge of the highway, well beyond the extent to which plow trucks cast snow during initial removal operations. Wide shoulders beyond the clear zone are cleared in these areas during winter that are not utilized. Even though vegetation is smothered each year, sand deposits are diffuse and even structural controls would only be marginally effective and difficult to maintain in these areas.

Two situations are common in snow storage zones along I-70 including 1) snow is moved off the highway shoulder into forested areas to distances of 30 feet or more from the edge of pavement sometimes resulting in large expanses of excess snow storage capacity, and 2) snow is dumped over the crest of fillslopes even when large snow storage areas remain open. One reason for these procedures is to maintain substantial snow storage capacity at all times. Another is to provide adequate drainage to ensure melting snow does not reach the travel portion of the highway where it could re-freeze. However, if adequate capacity is available late in the winter (for example in April), and proper drainage controls are in place, there is probably no need to dump the snow over hillslopes because the storage capacity is not likely to be reached before winter's end and drainage onto the roadway would not occur.

In some areas it may be possible to limit the distance by which snow/sand is moved away from the highway shoulder. This would require structural controls in combination with a change in maintenance procedures and techniques involving designation of an initial limit to the distance snow could be moved off the shoulder. For example, a maximum distance of 30 feet from the edge of pavement could be designated as the limit for snow removal. If the snow pile became too large and the drainage was affecting safety on I-70, maintenance forces could mobilize heavy equipment to reduce the height of the snow pile. Likewise, snow could remain on the highway template within 30 feet of the edge of pavement, and could be dumped over the hillslope only if maximum storage capacity was reached. Once the snow/sand is dumped over the hillslope it is impossible to recover the sand or to establish a permanent vegetation cover in the fillslope areas buried by sand each year.

Any of these changes in snow/sand storage practices would 1) reduce the extent of sand deposition and facilitate cleanup efforts, 2) reduce the migration and transport of sand into receiving streams, and 3) improve vegetation cover and the success of revegetation and slope stabilization efforts. Any changes in current maintenance practices would likely require both a training program and an active management strategy. Judgment would have to be applied on the ground regarding when and where to move snow if this were determined to be a feasible BMP for sediment control.

Finally, snow blowers are used occasionally to remove excess snow along the Black Gore and Straight Creek I-70 corridors. This maintenance practice results in dispersing the sand that is entrained in the snow over wide areas, to distances of 100 feet or more from the highway. Snow blowing disperses the sand, possibly resulting in lower accumulation depths in certain areas. However, the sand eventually accumulates in forested areas far from the highway where removal is no longer feasible. Therefore, careful consideration should be given to these factors before this snow removal technique is used. Snow blowing criteria will be developed as part of the SMP.

Liquid Deicer Program

During the 1994-95 winter season, traction sand usage was reduced along the I-70 west corridor in an effort to decrease the amount of the salt/sand mixture applied. This action resulted in numerous road closures that season. In the spring of 1996, CDOT began the experimental use of liquid de-icers to reduce the quantity of salt/sand mixture used in the I-70 mountain corridor while maintaining efficiency and safety during the winter. Since that time, the use of liquid de-icers has been increasing since they have helped to keep I-70 open, while maintaining the safety of the traveling public. Traction sand is still required to accompany the chemicals used since a certain amount of traction is still required.

It has been demonstrated that there is a direct correlation between the amount of salt/sand mixture applied to the roadway and the severity of a given winter season. Therefore, the amount of material applied varies from year to year. Although, salt/sand usage along I-70 west has decreased overall, due primarily to better housekeeping and management practices over the years, the average (mean) has remained relatively constant, while the use of liquid deicers has increased dramatically.

Liquid deicers are becoming more commonplace at the higher elevations, when used in conjunction with traction sand material. At this time, the most common liquid deicer is Magnesium Chloride. When liquid deicers are applied to dry pavement prior to a snow event, it is called anti-icing. The intent is to create a barrier between the road surface and the snow and ice. This prevents ice from bonding to the asphalt and this material works to a certain surface temperature. When the road surface drops below that temperature, it is not longer effective. An advantage of anti-icing is that once the temperature begins to rise again, the snow and ice plow off the road easily because it has not bonded to the pavement. This notably reduces the time to dry pavement.

Deicing is a procedure where liquid deicers are applied to the road surface while a snow event is in progress. This is done in an effort to keep the road surface wet for a longer period of time. The liquid deicers reduce the freezing temperature of water to a certain point, when they lose their effectiveness. It is at this point that maintenance crews select one of two options: 1) switch to a different type of deicer with a lower freezing point, or 2) begin the application of traction sand.

Even with the increased usage of liquid deicers, some amount of traction on the roadway is still necessary due to snow-pack build-up, ice, and refreezing, especially with the steep grades that exist on Vail Pass and Straight Creek. Therefore, although there have been recent reductions in sand usage, this is very weather dependant and traction sand will continue to be used in the I-70 mountain corridor into the foreseeable future.

6.0 BLACK GORE CREEK SEDIMENT CONTROL SCENARIOS

The SCAP includes four scenarios for consideration by the Transportation Commission and CDOT management. These Scenarios include: (1) Existing Maintenance Program (baseline); (2) Enhanced Maintenance Program; (3) Capital Construction and Maintenance Program; and (4) Prioritized Capital Construction and Maintenance Program. Each Scenario includes BMP items and estimated costs that were developed for planning purposes only and therefore may not be all- inclusive. The costs do not, for example, include potential costs associated with environmental clearances or permitting since these cannot be accurately identified at this time but would have to be determined on a project-specific basis.

6.1 SEDIMENT CONTROL SCENARIO 1 - EXISTING MAINTENANCE PROGRAM (BASELINE)

Sediment Control Scenario 1 assumes a continuation of the existing CDOT maintenance program with no additional enhancements or funding for sand cleanup. This was deemed important to include in the SCAP since all other control scenarios will require significant maintenance resources and policy changes within the existing maintenance program in order to implement.

Control Scenario 1 assumes that the routine maintenance practices such as ditch cleaning (including limited sand and sediment removal, rockfall removal, etc.) will be accomplished within existing budgets using existing personnel. Shoulder, ditch cleaning, and rock removal are primarily performed during the months of May, June, and September. High priority activities such as paving and other roadway activities must also be accomplished during the summer months due to the short summer season. Additional work for environmental purposes such as sand removal, constructing boreal toad habitat, maintaining sediment ponds, tracking & reporting data, and other activities within the Paul Area can currently be accomplished only as staffing and resources allow.

Cost Summary

With the current allotment of funds in the maintenance budget for roadside appearance, the service provided will remain the same or possibly decrease. Maintenance forces will continue to maintain the shoulders, ditches, drainage structures, and eroded areas to the extent possible with existing maintenance forces and funding. The culverts along the corridor are aging and will require repairs and replacement that may also need to be funded out of the roadside appearance budget.

It is estimated that approximately $40,000 to $80,000 will continue to be spent annually on sediment removal activities in the Black Gore Creek I-70 corridor (excluding the extra $75,000 provided by the Transportation Commission in FY 01-03).

6.2 SEDIMENT CONTROL SCENARIO 2 – ENHANCED MAINTENANCE PROGRAM (NON-STRUCTURAL CONTROLS)

It is apparent from the analysis conducted for this SCAP that a more aggressive maintenance program is needed to better control the sediment at the source, to collect sediment material more frequently, and to establish and utilize long-term disposal areas. In order to more fully develop this program, Sediment Control Scenario 2 assumes an enhanced maintenance program, but with no new structural controls along I-70. Instead, Scenario 2 emphasizes the use of maintenance BMP's, cleanup requirements, revegetation, and other non-structural controls. Routine repair or replacement of existing drainage structures, such as culverts and inlets, is presumed as part of regularly funded maintenance activities.

Scenario 2 requires additional equipment, staff, and funding to improve current maintenance operations beyond the "routine" operations, practices, and policies under MLOS. This scenario requires that maintenance increase the use of maintenance BMP's (i.e., sweeping, guardrail and ditch cleaning, annual sediment removal, revegetation, etc.), collecting and hauling material on a routine basis, developing and implementing a sediment maintenance program as a part of "routine" operations, and providing an improved MMS system for data collection and retrieval needs, among others.

Control Scenario 2 assumes that the maintenance BMP measures specified in Section 5.6 will be implemented to the extent possible but with no new structural controls. This scenario includes removal of the estimated 120,000 cu-yds of sand accumulated in Zone 1 of the Black Gore Creek I-70 corridor.

Without structural drainage controls such as sediment basins, there are few practical means of sediment control during the March-April snowmelt period. However, maintenance BMP's such as removal and sweeping could play a major role in sediment control if a strict schedule is adhered to. For example, during most years snow/sand removal and sweeping activities could begin in April at the lower elevations of both the Straight Creek and Black Gore Creek. These cleanup activities would begin at lower elevations proceeding to progressively higher elevations by May. This would assure that sand accumulated in shoulder and in snow storage areas would be removed before May 15, after which time rainfall events would start to occur that mobilize the sand.

This sand removal maintenance BMP could result in effective sediment control because a large portion of the annual sand deposits that are normally mobilized during summer (June-July) rainfall-runoff events would be removed from the system by May 15. During summer rainfall-runoff events residual material is mobilized, some of which is transported into receiving streams while a portion is re-deposited along the highway template. Therefore, a secondary period when sediment removal and sweeping should take place is in the fall (September) following the summer rainfall season. This second annual cleanup will assure that the highway shoulders and drainage networks are free of sediment buildup before the next winter season begins, minimizing source areas.

It is anticipated that CDOT will need to utilize contractors for hand-work and seasonal work to conduct these annual cleanup activities. This can provide many benefits including:

- Elimination of internal schedule conflicts associated with CDOT winter maintenance forces
- Rapid response and timely cleanup
- Mobilization of sufficient labor resources and heavy equipment to complete the task quickly

A Sediment Maintenance Program (SMP) will be developed as part of Scenario 2 that specifies a schedule and scope of work for annual sediment cleanup activities, as described in Section 5.6.

CDOT records indicate that about 3,600 tons of sediment was removed from the I-70 Black Gore Creek corridor during 2001, of which approximately 2,600 tons were from ditch cleaning, 900 tons from drainage features, and 100 tons from sweeping. It is unknown what percentage of this material was annual sand versus previous deposits. However, these results suggest that it may be possible to remove at least a total of 3,750 tons of the average annual 15,000 tons of sand applied each year through maintenance BMP's. This translates to about 25 percent of the average annual input in the Black Gore Creek I-70 corridor.

Based on the information obtained during the development of the SCAP, it is conservatively assumed that the utilization of non-structural maintenance BMP's under Control Scenario 2 would be capable of capturing and removing at least 25 percent of the average annual sand applied to Zone 1 of the Black Gore Creek I-70 corridor. Therefore, permanent disposal facilities would be required to accommodate these annual sediment volumes. This will require an ongoing effort by CDOT, local agencies, and communities to identify and secure more permanent sediment disposal sites for at least 20 years into the future.

The replacement and cleaning of highway drainage features such as culvert inlets, culverts, and installation of erosion protection measures at culvert inlets and outfalls are routine maintenance activities carried out by CDOT. These activities are included in Control Scenario 2 because of their importance in facilitating sediment control. Several culvert inlets are buried or plugged in the Black Gore I-70 corridor. These conditions cause runoff to concentrate in downstream areas, producing excessive flow velocities, erosive energy, and sediment transport.

The integrity of the existing drainage system is evaluated by CDOT maintenance as part of routine sediment control BMP's to identify problem areas and solutions. In some instances the existing inlets or culverts may be damaged and require replacement. Cost estimates for routine replacement of drainage structures are included. However, major structural control improvements such as culvert rundowns and sediment basins are not included as part of Control Scenario 2.

Several pieces of equipment are presently owned and utilized by CDOT to remove accumulated traction sand and roadcut sediments from the I-70 corridor. These generally include graders, front-end loaders, track loaders and/or bulldozers, mechanical sweepers, and tandem dump trucks. Since most of the shoulder areas of I-70 where excess traction sand accumulates are unpaved, the typical procedure is to grade the excess sediment into a windrow for removal by loaders and trucks. It is assumed under Control

Scenario 2 that this will continue to be the primary method of sand cleanup. There is no effective mechanical method for removing sand from beneath guardrails, so these areas are typically cleaned by hand. This procedure will probably need to continue until such time the guardrails can be replaced with improved structural controls.

Sediment Control Scenario 2 consists of the following maintenance BMP items:

- Removal of 120,000 cu-yds of sand accumulated in Zone 1
- Development of a Sediment Maintenance Program with resource allocation and schedule
- Maintenance training for improved snow removal and storage practices
- Annual inspection and removal of sediment deposited in existing basins
- Semi-annual ditch cleaning/removal of traction sand accumulated within 30 feet of the edge of pavement (May and September)
- Sediment disposal program
- Revegetation program
- Vegetation monitoring program
- Stream monitoring program
- Drainage system repairs
- Vacall truck and other necessary equipment
- Hiring of up to 6 additional CDOT FTE's (or equivalent contracting)

The estimated cost for Control Scenario 2 is summarized in the following table. This estimate indicates approximately $500,000 would be required annually to fully implement Control Scenario 2. Approximately $4,400,000 would be required for removal and disposal of the sediment accumulated in Zone 1, purchase equipment, and develop the SMP.

6.2.1 Control Scenario 2 - Lite

As an option for consideration, selected key components of Scenario 2 could be implemented in the short-term to reduce costs while still removing up to 25 percent of the annual sand input. This approach would incorporate any new structural BMP's as they come on line such as those being installed in 2002. Scenario 2 Lite would include the following priority components for an estimated annual cost of $197,000.

- Development of a Sediment Maintenance Program with resource allocation and schedule ($10K)
- Maintenance training for improved snow removal and storage practices ($5K)
- Annual inspection and removal of sediment deposited in existing basins and Semi-annual ditch cleaning/removal and disposal of traction sand accumulated within 30 feet of the edge of pavement (May and September) ($97K)
- Sediment disposal program ($15K)

- Revegetation and monitoring program ($25K)
- Stream monitoring program ($25K)
- Drainage system repairs ($20K)

Control Scenario 2 Lite incorporates the priority components required to establish sediment maintenance BMP's as routine practice within the CDOT maintenance program. It is also important to establish a sediment maintenance program early in the process before structural controls are installed to improve effectiveness. This alternative also provides the essential funding needed for removal of annual sand inputs. Monitoring programs and a sediment disposal program would be formally started to assess trends and data needs. Given the limited funding potential at this time, Control Scenario 2 Lite provides a cost effective alternative for immediate implementation.

Control Scenario 2 Cost Summary
Black Gore Creek

BMP Item	Units (cu-yds)	Cost/Unit	Estimated Cost	Assumptions/Notes
Capital Expenditure				
Sediment Deposition Removal	120,000	$35	$4,200,000	Incremental removal of sediment stored on I-70 template - assumes 12,000 cu-yds/year for 10-years
Equipment Purchase			$225,000	One broom and vacuum truck - assumes equipment not leased, design life 20-years, 50/50 split with Straight Cr.
Sediment Maintenance Program Development			$15,000	SMP will be collaborative effort with CDOT maintenance and environment - assumes 50/50 split with Straight Cr.
Capital Total			**$4,440,000**	
Annual Costs				
Winter Maintenance Sediment Control Training			$5,000	Training at Maintenance Training Academy - assumes 50/50 split with Straight Cr.
Annual Sand Removal and Ditch Cleaning	2,778	$35	$97,230	Pickup, hauling, dumping, (optional contracting), traffic control, seasonal work – 25% of average annual sand (3,750 tons/1.35 ton/cu-yd)
Sediment Disposal and Reclamation Program			$30,000	Includes stockpiling, forming, topsoil, reseeding, drainage controls, identification and permitting of disposal areas
Re-vegetation Program			$35,000	Annual re-seeding and soil amendment, cover surveys, and reporting
Stream Monitoring & Reporting			$30,000	Assumes stream monitoring of improvements at four stations, coordination for aquatic biology surveys, etc.
Temporary Drainage System BMP’s			$35,000	Drop inlet protection and cleaning, culvert maintenance
Annual Equipment Lease			$72,000	Annual lease of loader/haul truck/track hoes assumes 6 units @ $2,000/month = $12,000/month split 50/50 Straight
Maintenance Environmental Specialist	1 FTE	$50,000	$50,000	Technical support at Jr. Foremen level to oversee and manage environmental activities and reporting
Maintenance Labor Needs	5 FTE	$30,000	$150,000	Labor at M-1 level for sediment maintenance program (optional contracting)
Annual Total			**$504,230**	

6.3 SEDIMENT CONTROL SCENARIO 3 – CAPITAL CONSTRUCTION AND MAINTENANCE PROGRAM

Control Scenario 3 integrates full structural sediment and erosion controls, non-structural controls, and an enhanced maintenance BMP program. It assumes that all control measures outlined in Section 5 would be implemented in the Black Gore Creek I-70 corridor, including:

- Basins and traps to capture sediment
- Paving of shoulder areas to reduce rill erosion and provide a durable surface for cleaning
- Valley pan drains to control and route highway runoff
- Knee walls to prevent cut slope erosion
- Type 7 concrete guardrail to reduce migration of sediment from fillslopes
- Controlled snow storage/sand deposition areas

The following maintenance BMP's outlined for Control Scenario 2 would also be included:

- Removal of 120,000 cu-yds of sand deposits in Zone 1
- Development of a Sediment Maintenance Program with resource allocation and schedule
- Maintenance training for improved snow removal and storage practices
- Semi-annual sweeping and ditch cleaning/removal of traction sand accumulated within 30 feet of the edge of pavement (May and September)
- Annual inspection and removal of sediment deposited in sediment basins and traps
- Sediment disposal program
- Revegetation program
- Vegetation monitoring program
- Stream monitoring program
- Drainage system repairs
- Vacall truck and other necessary equipment

Detailed capital construction costs are provided in Appendix C and are summarized in the following table, along with the annual maintenance costs. The capital construction costs for the structural BMP's proposed for the Black Gore Creek I-70 corridor is approximately $20,000,000. The non-structural BMP's including maintenance would require approximately $580,000 annually. This cost estimate includes the following contingency components:

- Traffic control – 10%
- Incidentals – 20%
- Inflation – 10%
- Preliminary Engineering – 5%
- CE Costs – 17.5%

For estimating purposes, it is assumed that sediment would be removed from the collection structures twice each year as outlined in Section 5.6. The frequency of cleaning will also be dependent on weather conditions, sand usage, basin collection efficiency, and the effectiveness of the maintenance BMP's. The SMP will specify maintenance procedures, including a collection structure inspection schedule, from which the results will ultimately be used to determine the frequency of cleaning.

Many of the existing sediment basins (and WesTraps) in the Straight Creek area are continually saturated with water from perennial flows, making it very difficult to remove accumulated sediment. Under these conditions the material is the consistency of soup, making removal inefficient and loss of material during transport problematic. The structural drainage control design proposed for Control Scenario 3 will resolve this problem in most areas by routing clean perennial flows away from sediment basins to clean tributaries.

Control Scenario 3 proposes that a vacall truck be used to clean sediment basins and traps, as well as any future sediment basins. A vacall truck could provide the most efficient and cost effective method for removing sediment from collection basins because they can be accessed for cleaning remotely without entering the basin with heavy equipment. This would be particularly useful for the small basins associated with this SCAP. A labor cost savings may be realized with a vacall truck since only one or two operators are required. It is assumed that a vacall truck cannot be leased, but will have to be purchased. Equipment costs are included as part of Control Scenario 3.

The annual volume of sediment captured and removed will be approximately 50 to 80 percent of the sand applied, or an average total of 7,500 to 12,000 tons (5,556 to 8,889 cu-yds) for Zone 1 of the Black Gore Creek I-70 corridor. The sediment removal and disposal cost is estimated at $35 per cubic yard, regardless if the source is from sediment collection basins, snow storage areas, or sweeping.

Control Scenario 3 Cost Summary
Black Gore Creek

BMP Item	Units (cu-yds)	Cost/Unit	Estimated Cost	Assumptions/Notes
Capital Construction				
Full Build-Out of Structural BMP's			$19,832,000	Installation of all required structural sediment source controls and drainage improvements
Sediment Deposition Removal	120,000	$35	$4,200,000	One-time cost for removal of sand deposits down to design grade on I-70 template
Equipment Purchase			$225,000	One broom and vacuum truck - assumes equipment not leased, design life 20-years, 50/50 split with Straight Cr.
Sediment Maintenance Program Development			$15,000	SMP will be collaborative effort with CDOT maintenance and environment - assumes 50/50 split with Straight Cr.
Capital Total			**$24,272,000**	
Annual Costs				
Winter Maintenance Sediment Control Training			$5,000	Training at Maintenance Training Academy - assumes 50/50 split with Straight Cr.
Annual Sand Removal and Ditch Cleaning	5,556	$35	$194,460	Pickup, hauling, dumping, (optional contracting), traffic control, seasonal work – 50% of average annual sand (7,500 tons/1.35 ton/cu-yd)
Sediment Disposal and Reclamation Program			$30,000	Includes stockpiling, forming, topsoil, reseeding, drainage controls, identification and permitting of disposal areas
Re-vegetation Program			$35,000	Annual re-seeding and soil amendment, cover surveys, and reporting
Stream Monitoring & Reporting			$30,000	Assumes stream monitoring of improvements at four stations, coordination for aquatic biology surveys, etc.
Sediment Collection/Drainage System BMP's			$50,000	Collection structure monitoring and maintenance, repairs, performance evaluations, assumes 0.25% of capital
Annual Equipment Lease			$36,000	Annual lease of loader/haul truck/track hoes assumes 3 units @ $2,000/month = $6,000/month split 50/50 Straight
Maintenance Environmental Specialist	1 FTE	$50,000	$50,000	Technical support at Jr. Foremen level to oversee and manage environmental activities and reporting
Maintenance Labor Needs	5 FTE	$30,000	$150,000	Labor at M-1 level for sediment maintenance program (optional contracting)
Annual Total			**$580,460**	

6.4 SEDIMENT CONTROL SCENARIO 4 – PRIORITIZED CONSTRUCTION AND MAINTENANCE PROGRAM

Control Scenario 4 presumes a phased approach to sediment control according to priority needs and the availability of funding. This control scenario integrates the components of Scenarios 2 and 3 into prioritized capital improvement and maintenance needs based on specific problem areas identified in the Black Gore Creek I-70 corridor.

This scenario assumes that the enhanced maintenance program (Scenario 2) will be implemented and capital construction will be phased over a period of 10 years according to priority areas identified in the SCAP. Using a 10 percent annual capital expenditure of the total estimate of approximately $20,000,000 in today's dollars, the total annual capital construction budget of $2,000,000 would be allocated. The capital cost estimates are the same as Control Scenario 3 (see Appendix C). The annualized costs are shown in the following table for Control Scenario 4.

As the structural source control measures are brought on line, the maintenance program would need to be phased-in accordingly. This would be outlined in the Sediment Maintenance Program (SMP). The components of the SMP are described in Section 5.6 and summarized with costs in Control Scenario 2. This information is integrated into Control Scenario 4 to provide an enhanced maintenance program that would be implemented in conjunction with prioritized capital construction.

Additional maintenance resources would be needed as the additional sediment collection structures are brought on-line and the SCAP is fully implemented. Sediment removal and disposal would also increase accordingly from about 25 percent of the annual sand input initially, up to about 80 percent of the annual sand input after all structural controls are installed. For estimating purposes the annual maintenance costs assume that full structural controls are in place.

Control Scenario 4 Cost Summary
Black Gore Creek

BMP Item	Units (cu-yds)	Cost/Unit	Estimated Cost	Assumptions/Notes
Capital Construction				
Phased Build-Out of Structural BMP's			$1,983,000	Assumes 10% of total build-out of all required structural sediment source controls and drainage improvements
Sediment Deposition Removal	120,000	$35	$4,200,000	One-time cost for removal of sand deposits down to design grade on I-70 template
Equipment Purchase			$225,000	One broom and vacuum truck - assumes equipment not leased, design life 20-years, 50/50 split with Straight Cr.
Sediment Maintenance Program Development			$15,000	SMP will be collaborative effort with CDOT maintenance and environment - assumes 50/50 split with Straight Cr.
Capital Total			**$6,423,000**	
Annual Costs				
Winter Maintenance Sediment Control Training			$5,000	Training at Maintenance Training Academy - assumes 50/50 split with Straight Cr.
Annual Sand Removal and Ditch Cleaning	5,556	$35	$194,460	Pickup, hauling, dumping, (optional contracting), traffic control, seasonal work - 50% of average annual sand (7,500 tons/1.35 ton/cu-yd)
Sediment Disposal and Reclamation Program			$30,000	Includes stockpiling, forming, topsoil, reseeding, drainage controls, identification and permitting of disposal areas
Re-vegetation Program			$35,000	Annual re-seeding and soil amendment, cover surveys, and reporting
Stream Monitoring & Reporting			$30,000	Assumes stream monitoring of improvements at four stations, coordination for aquatic biology surveys, etc.
Sediment Collection/Drainage System BMP's			$50,000	Collection structure monitoring and maintenance, repairs, performance evaluations, assumes 0.25% of capital total
Annual Equipment Lease			$36,000	Annual lease of loader/haul truck/track hoes assumes 3 units @ $2,000/month = $6,000/month split 50/50 Straight
Maintenance Environmental Specialist	1 FTE	$50,000	$50,000	Technical support at Jr. Foremen level to oversee and manage environmental activities and reporting
Maintenance Labor Needs	5 FTE	$30,000	$150,000	Labor at M-1 level for sediment maintenance program (optional contracting)
Annual Total			**$580,460**	

Areas along the Black Gore Creek I-70 corridor have been prioritized according the sediment loading conditions. Areas having the greatest sediment load and direct transport pathway to receiving waters are first in priority, followed by progressively lower impact zones. The only quantitative loading data available is from Lorch (1998), where the largest load source to Black Gore Creek was identified as the "Narrows" area (milepost 186). Observations during water quality monitoring (including data) and reconnaissance in 2001 have also been used to assess loading conditions for prioritization. As described in Section 2.0, the higher elevation zones typically receive the greatest snowfall and sanding volumes and these areas are some of generally the highest priority for sediment control. The following criteria were used to establish priority areas for sediment control in Zone 1 of the Black Gore Creek I-70 corridor.

- Elevation zone and high traction sand usage areas
- High gradient areas of I-70 where heavy traction sanding is required
- Areas with direct sediment transport to streams with little or no storage (proximity of I-70)
- Drainage problem areas including cutslope and fillslope erosion
- Areas in close proximity to I-70, providing good access for installation and maintenance of structural BMP's with minimal disturbance to adjacent lands

Based on these criteria, the following table was developed listing areas in order from highest priority for treatment in Zone 1.

Prioritized Capital Construction
Black Gore Creek Area
Control Scenario 4

Priority Ranking	Milepost Length	Description
1	185.3-186.3 1.0-mi.	Narrows section – high sediment transport from road sand and erosion of rock cuts, steep gradient, drainage problems, direct pathway to Polk/Black Gore Cr.
2	186.3-187.0 0.7-mi.	High sediment transport from road sand, long steep gradient, drainage problems
3	187.0-188.0 1.0-mi.	High sediment transport from road sand, steep gradient, drainage problems, large sediment deposits on shoulder
4	184.4-185.3 0.9-mi.	High sediment transport from road sand, bridge crossings and direct transport pathway to Miller/Black Gore Cr., median drainage/erosion problems
5	189.0-189.9 0.9-mi.	High sand usage and transport – tributary to Black Gore Lake No. 1 and riparian wetland
6	188.0-189.0 1.0-mi.	High sand usage and transport – tributary to Black Gore Lake No. 2 and riparian wetland
7	183.2-183.7 0.5-mi.	Direct sediment transport to Black Gore Cr., wetland springs, and west Tributary
8	182.5-183.2 0.8-mi.	Moderate sediment transport, shoulder sand deposition, median drainage/erosion problems, Black Gore Cr. bridge crossing
9	183.7-184.4 0.7-mi.	Moderate sediment transport, shoulder sand deposition, Black Gore/Timber Cr. bridge crossings
10	182.0-182.5 0.5-mi.	Moderate sediment transport, shoulder sand deposition, median drainage/erosion problems, Black Gore/Gore Cr. Bridge crossings
11	180.0-182.0 2.0-mi.	Moderate sediment transport, no direct pathway to receiving streams, residential area

7.0 SUMMARY AND RECOMMENDATIONS

This SCAP sets forth the technical analysis and basis for future actions that address sediment control related to highway operation and maintenance in the Black Gore Creek I-70 corridor. This is considered a planning document only, but provides the guidance necessary for implementation of sediment controls. Additional design and hydraulic analysis will be necessary to fully implement this SCAP. A shift in CDOT policy and priorities, particularly with respect to maintenance operations, will be necessary before effective actions can be taken.

In the Black Gore Creek I-70 corridor, no permanent structural measures have been installed to control sediment loading caused by traction sanding. Slope erosion along this section of I-70 was not as a significant problem as it has been along Straight Creek or Berthoud Pass due to differences in topography and construction requirements. However, active erosion does continue to occur on some slopes in the Black Gore Creek corridor. The primary source of sediment in Black Gore Creek is traction sand. It is estimated that approximately 120,000 cubic yards of used traction sand is in “temporary storage” adjacent to I-70 along the shoulders. A portion of this material continues to migrate from I-70 to the forest and ultimately Black Gore Creek. It is estimated that with structural controls, at least 50 to 80 percent of the annual traction sand applied could be removed with the proposed control measures in place along I-70. Ongoing monitoring of the structural and non-structural BMP’s, vegetation, and water quality is needed.

Different sediment control scenarios for potential implementation were developed in order to provide a range in costs, including Scenario (1) Existing Baseline Condition, (2) Enhanced Maintenance Program, (3) Capital Construction and Maintenance Program, and (4) Prioritized Capital Construction and Maintenance Program. These control scenarios take into consideration the existing conditions and requirements needed to address all matters related to CDOT operations in the corridor.

The SCAP provides information for CDOT management and decision-makers regarding the current condition and future needs along the corridor. The SCAP focuses on implementing corrective measures along the I-70 corridor to help address sediment loading at the source. Once the source in Zone 1 is under control, it is believed that recovery in the areas beyond the highway will occur over time. Impacts from I-70 sedimentation beyond the immediate highway corridor (Zones 2 and 3) are recognized. However, further consultation and coordination with the appropriate agencies, entities, stakeholders, and experts is needed prior to evaluating remedial efforts affecting the forest or stream riparian corridors.

Currently, no funding stream has been identified or policy modifications made to the existing system that would allow for partial or full implementation of this SCAP. Maintenance operations, in particular, will need to be reviewed and policy decisions made before this plan is implemented. It is not practicable or prudent to allocate resources for construction of sediment control structures without an adequate maintenance program to maintain them on a routine basis. The ability within the current maintenance program to provide the necessary resources to conduct annual sediment clean-up of this corridor is limited. Maintenance personnel do what they can with available resources, but are currently taxed with conducting their routine duties. This SCAP identifies these deficiencies within the current system.

There is no doubt the cost of cleanup, implementing source control measures, providing for adequate maintenance, and other related costs along this corridor from over twenty years of operations will be significant. When the interstate system was designed and constructed, permanent source controls and the control of highway drainage and the potential impacts were not known or considered. Therefore, the current roadway configuration will require retrofitting to include the necessary controls and ongoing maintenance to ensure effectiveness and efficiency.

A summary of recommendations from this SCAP is presented below. These have been identified for review and consideration through the examination and analysis of research, policies, field surveys, data, and other information obtained and developed for this SCAP. This list reflects the most imperative needs identified, but may not be entirely complete.

1) Pursue funding for capital construction of sediment control structures
2) Increase funding to this Maintenance MPA or create a new MPA to address sediment maintenance needs
3) Initiate specialized training programs for sediment maintenance
4) Implement policy changes in maintenance operations regarding priorities
5) Implement BMP monitoring and maintenance program
6) Implement annual revegetation program
7) Support an ongoing stream monitoring program related to sediment data collection
8) Restructure the MMS to include environmental data

7.1 RESEARCH CONCEPTS FOR CONSIDERATION

Although I-70 was never designed to control sediment loading to receiving streams from traction sand, the issues identified in this SCAP warrant additional research and considerations for both structural and non-structural sediment control methods for the I-70 mountain corridor. Conventional methods for maintaining mobility in high-elevation mountain environments include snow removal and traction sanding. These methods are costly in terms of labor and equipment resources, and pose many safety hazards and environmental consequences. Potential concepts that warrant research involving other options for maintaining mobility on I-70 during winter are provided below.

Future Highway Design Structural Sediment Controls

Future I-70 design in the mountain corridor should incorporate sediment control and collection structures within the template, particularly in high-elevation zones and sensitive aquatic environments. Sediment basins are proven to provide many water quality benefits by controlling particulate contaminant transport. Many of the structures proposed in this plan have proven constructability and maintainability, and would not be a significant cost factor if integrated into the highway design. Examples of this can be found on the U.S. Highway 40 Berthoud Pass East project where sediment control structures (below-grade traps) and snow storage areas were incorporated into highway design and reconstruction.

Automated Liquid De-icing Systems

Automated liquid de-icing systems are commonly used in new bridge construction in cold environments to reduce ice formation. I-70 in Glenwood Canyon has such a system that is effective under certain conditions. These systems can reduce or eliminate the need for traction sanding. There are many locations along the I-70 Black Gore Creek and Straight Creek corridors where an automated de-icing system could be effective in reducing traction sand usage.

The dissolved solids in runoff associated with liquid deicers (commonly magnesium chloride) can affect water quality in receiving streams. However, if a system was designed to capture and recycle or dispose of the excess deicer runoff, the environmental benefits over traction sand may be warranted. A pilot study and monitoring program should be considered to determine the feasibility of this technology for use in the I-70 Black Gore Creek and Straight Creek corridors.

Solar Snow Storage Zones

A major issue with snow removal from I-70 in high elevation areas is snow disposal. Removed snow is typically stored in large piles along the shoulder of I-70, or is wasted over fill slopes. This snow contains traction sand and other particulate contaminants from the highway that have detrimental effects on vegetation, slope stability, and water quality. The excessive buildup of this material is a major operational, safety, and maintenance concern for CDOT and requires substantial labor and equipment resources to manage.

There are several snow storage zones utilized along the Straight Creek and Black Gore Creek corridors that are on south-facing slopes with excellent solar exposure. A portion of the snow stored in these areas can melt and consolidate, but ambient temperatures are typically too low during winter to melt enough snow to prevent excessive accumulation of the material removed from the highway. However, if the ground surface in these areas could be maintained just above the freezing point during the daytime (i.e., >32 degrees F), it may be possible to melt enough snow to prevent excessive buildup. This would eliminate the need for large snow storage zones and wasting over fill slopes, and melt water would be released at a slow rate thereby minimizing sediment and particulate transport.

It may be feasible to construct a solar heating system that would melt snow at the crest of certain fill slopes that have south exposures with solar gain. This concept is similar to solar hot water systems in common use today for residential and commercial applications. Further research into the feasibility of such a system and a pilot study is warranted for use in selected snow storage areas along I-70.

Porous Pavement

Pavement reduces infiltration of water and promotes rapid runoff, potentially increasing the erosive energy of water. Porous pavement, grasspave, and other paving products are commercially available that allow infiltration of water while controlling soil erosion.

It is anticipated that various products and treatments can be evaluated on an experimental basis. For example, these treatments could be implemented in selected areas to control runoff and erosion from I-70 parking areas, pull-offs, maintenance yards, and other similar areas.

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GLOSSARY/TERMINOLOGY

CDOT Terminology:

Colorado Department of Transportation (CDOT): State of Colorado agency charged with management of the state transportation system; including the construction, operation and maintenance of the state's highways

Enhancement funds: federal TEA-21 funds granted to state's for certain types of environmental projects

Fiscal Year (FY): the 12-month period for which the use of state funds is planned; the Colorado state fiscal year is July 1 – June 30.

Milepost (MP): original point based on roadway when CDOT first installed mileposts; designated on the roadway by "milepost markers", now referred to as reference posts

Region: One of six engineering regions in the state that are responsible for construction, right-of-way acquisition, environmental clearances, design and maintenance of state highways within their designated areas

State Transportation Improvement Program (STIP): Statewide, six-year listing of transportation projects eligible for federal funding

TEA – 21: Current federal transportation legislation

Transportation Commission (TC): An 11-member citizen board appointed by the governor that provides guidance to the Colorado Department of Transportation

Transportation Planning Region (TPR): local planning entity responsible for determining transportation priorities within a given area of the state.

Agencies:

Colorado Department of Public Health & Environment (CDPHE): The state agency for public health and environmental programs

Colorado Division of Wildlife (CDOW): State agency responsible for wildlife management

Federal Highway Administration (FHWA): responsible agency for federal highway programs

U.S. Army Corps of Engineers (COE): federal agency that oversees waters of the U.S.

U.S. Forest Service (USFS): federal land agency responsible for management of forest lands in the U.S.

Water Quality Control Commission (WQCC): A 9-member citizen board appointed by the governor that develops state water quality control policy and regulates pollutant sources

Water Quality Control Division (WQCD): a division of the Colorado Department of Public Health and Environment (CDPHE) responsible for the implementation of water quality programs and regulations established by the WQCC and through state and federal law

CDOT Maintenance Terms:

Accomplishment Unit: the unit of measure used to describe the quantity of work performed for each activity, e.g., cubic yards, linear feet, plow miles, etc.

Acronym: a three-letter code used in the MMS system to allow for tracking of various types of activities

Activity Report: CDOT Form #909, "Green Sheet", that records (maintenance) work accomplished in the field. Information from the Green Sheets is entered into the MMS System

Anti-icer: any anti-icing agent used to create a barrier between the roadway surface and snow & ice build-up; occurs before a snow event

De-icer: any anti-icing agent used to improve traction on the roadway surface; usually occurs during a snow event

Foreman's Area: area maintained by more than one maintenance patrol

Haul: the average one-way distance from the material source or stockpile to the work site on the highway

Liquid de-icers: chemical de-icing and anti-icing agents produced in liquid form; e.g., magnesium chloride

Magnesium Chloride: brine from the Great Salt Lake used as a liquid de-icing and anti-icing agent

M-1: refers to job classification of Highway Maintenance Worker I

M-2: refers to job classification of Highway Maintenance Worker II (the senior worker on a patrol)

Maintenance Management System (MMS): a computerized maintenance program used to track expenditures and work activities

Major Program Area (MPA): maintenance program used by the Transportation Commission to allocate funding for maintenance of state highways

Patrol: the smallest maintenance organizational unit, headed by a senior worker (M-2)

Section: refers to a maintenance section, the largest highway maintenance organizational unit headed by a Maintenance Superintendent

Sediment Maintenance Plan (SMP): In the SCAP, a program to be developed to assist maintenance forces with sediment clean-up activities and routine maintenance of sediment control structures

Traction sand/salt mixture: mixture purchased annually to be used on state highways to provide traction for vehicles during the winter months

Environmental/Water Resource Terms:

Aesthetic quality: a concept pertaining primarily to desirable visual values and with judgments concerning beauty. In highway design, it related highway landscape and planting design to nature, natural objects and other amenities

Aquatic life: wildlife living, growing on, in, or adjacent to water

Augmented flow: the increased volume of water entering a channel from diversion of surface water, water from another steam or watershed, or from waters withdrawn or collected upstream and released after use.

Best Management Practices (BMP's): schedules of activities, prohibitions of practices, maintenance procedures, and other management practices utilized to prevent or reduce the pollution of waters of the U.S. in accordance with the Clean Water Act

Channel: a natural stream that conveys water; a ditch or channel excavated for the flow of water

Clean Water Act (CWA): the federal law that directs national water quality policy. It is intended to address water pollution in the United States

Drainage: the removal of excess water or groundwater from land by means of surface or subsurface drains

Drainage basin: a geographical area or region defined by hydrologic boundaries

Ecosystem: living organisms and the nonliving environment interacting in a given area. The complex of a community and its environment functioning as an ecological unit in nature. Small part of a larger life system, but large enough to be comprehended and analyzed

Environmental Protection Agency (EPA): Federal regulatory agency responsible for national environmental programs

Erosion: the process whereby soil materials are detached and transported by water, wind, ice or gravity

Headwater: the source of a stream; the water upstream from a structure or point on a stream

Intermittent stream: a stream or potion of a stream that flows only in direct response to precipitation

National Environmental Policy Act (NEPA): Requires environmental documentation based on anticipated level of impact to the environment by federally funded projects

Nonpoint Source Pollution (NPS): pollution that enters a water body from diffuse sources, e.g., highways, agricultural areas, urban areas, mine sites, etc.

Nonstructural controls: controls that do not require construction and are used to prevent nonpoint source pollution from entering near-by receiving streams; e.g., training, maintenance practices, etc.

Perennial stream: a stream that maintains water in its channel throughout the year

Point Source: pollution originating from a specific point, e.g., a pipe

Runoff: that portion of precipitation that flows from a drainage area on the land surface, in open channels, or in a water conveyance system or stream

Section 319 of the Clean Water Act: Allows for grants to be given to address nonpoint source pollution

Section 303(d) of the Clean Water Act: Requires that pollutants of concern be addressed in stream segments not meeting their beneficial uses

Sediment: solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its origin by air, water, snow, gravity, or ice, and has come to rest on the earth's surface either above or below sea level

Sheet flow: water, usually storm runoff, flowing in a thin layer over the ground surface

Shoulder: the portion of a roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses

Stormwater: roadway runoff, snowmelt runoff, surface runoff and drainage

Structural Controls: controls constructed on the ground to decrease or eliminate nonpoint source pollution from entering near-by receiving streams

Surface water: all water the surface of which is exposed to the atmosphere

Suspended Solids: solids either floating or suspended in water

Total Maximum Daily Load (TMDL): Total load of pollutant, both point or nonpoint allowed in a stream segment

Water Quality: a term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose or use e.g., drinking water, agricultural uses, recreational uses, etc.

Water Resources: the supply of groundwater and surface water in a given area; defined as those resources dependant on or resulting from specific stream systems or other water bodies; aquatic-dependant communities, recreation, wetlands, riparian areas, floodplains, stream hydrology, and other stream communities

Watershed: drained by a river system. Alternatively, the area from which water reaches a specific point on a river or tributary

Wetland: an ecosystem that depends on constant or recurrent shallow inundation or saturation at or near the surface of the substrate

Engineering/Hydraulic Terms:

Clear Zone: area along a highway corridor that is kept clear of obstructions; provides a recovery area for vehicles leaving the traveled way

Corridor: a strip of land between two termini within which traffic, topography, environment, and other characteristics are evaluated for transportation purposes

Culvert: a closed conduit, other than a bridge, which conveys water carried by a natural channel or water transversely under the roadway

Culvert rundowns: water conveyance culverts that continue down a slope

Cut: portion of land surface or areas from which earth has been removed or will be removed by excavation; adjacent embankments or fill areas

Cut-and-fill: process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas

Detention basins: depressed basins or traps designed to remove particulate pollutants and to reduce maximum (peak) runoff flows

Ditch: an open drain for carrying surplus surface or groundwater flow

Fillslope: highway embankment; opposite to the cut slope

Gaging station: where measurements of discharge are made on a stream channel

Grade: the slope of a road, channel; or natural ground

Gradient: change of elevation, velocity, pressure, or other characteristics per unit length; slope

Hydraulic: the motion of fluid media

Hydrology: the scientific study of water

Hydrologic studies: a step required prior to the hydraulic design of a highway drainage structure. Such studies are necessary for determining the rate of flow, runoff, or discharge that the drainage facility will be required to accommodate.

Infiltration rate: a soil characteristic determining or describing the rate at which water can enter the soil under specific conditions including the presence of an excess of water

Jersey barriers: short concrete walls used as traffic barriers along a highway, used as a BMP in this application

Knee wall: short barrier used along a cut slope to help prevent undercutting of the slope; used as a BMP

Non-structural controls: BMP's that do not typically require construction, e.g., seeding, training, maintenance practices, etc.

Outfall: the point, location, or structure where wastewater or drainage discharges from a drain to a receiving body of water

Overland flow: waters derived from rain or snow that diffuse themselves over the land surface

Peak discharge: the maximum instantaneous flow from a given runoff condition at a specific location

Porous Pavement: a pavement through which water can flow at significant rates

Riparian: pertaining to anything connected with or adjacent to the banks of a stream or other body of water

Sediment: fragmentary solid material that originates from weathering of rocks or other particulate sources and is transported by, suspended in, or deposited by water

Sediment traps: constructed above grade or below grade to collect sediment material for temporary storage

Sediment basins: depressions used to collect sediment material; used for sediment collection and temporary storage

Slope: Degree of deviation of a surface from the horizontal; measured as a numerical ratio, percent, or in degrees

Slope Stabilization: providing adequate measures, vegetative and/or structural, that will reduce movement or prevent erosion from occurring

Soil: the unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants

Structural controls: relating to something constructed; constructed BMP's used to control runoff or soil erosion

Superelevation: the raised portion of highway above the normal cross slope to prevent a vehicle from sliding outward, or counteracting all the centrifugal force of a vehicle traveling at an assumed speed

Suspended load: sediment that is supported by the upward components of turbulent currents in a stream and that stays in suspension for an appreciable length of time.

Toe of Slope: where the slope stops or levels out. The bottom of the slope

Type 4 Guardrail: 34-inch tall concrete barrier typically used for temporary construction purposes

Type 7 Guardrail: 34-inch tall concrete barrier

Westrap: type of check dam/weir structure constructed out of concrete

V-ditch: paved ditch along a roadway used to channelize runoff

Valley Pan Drains: drains installed along the ditch to drain runoff to a particular point

APPENDIX A

SEDIMENT CONTROL TREATMENTS

BLACK GORE CREEK I-70 CORRIDOR

APPENDIX A-1

BLACK GORE CREEK I-70 CORRIDOR

EASTBOUND PHOTOS – VAIL PASS TO EAST VAIL

APPENDIX A-2

BLACK GORE CREEK I-70 CORRIDOR

WESTBOUND PHOTOS – VAIL PASS TO EAST VAIL

APPENDIX B

SEDIMENT CONTROL STRUCTURE ESTIMATES
AND MAPS

BLACK GORE CREEK I-70 CORRIDOR

APPENDIX C

I-70 SEDIMENT CONTROL ACTION PLAN

BLACK GORE CREEK COST ESTIMATE – 2002