Employing Innovative Data and Technology for Water Conservation Targeting and Planning in the Salinity and Selenium Affected Areas of the Lower Gunnison River Basin

A Conservation Innovation Grant (CIG) Project
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FINAL REPORT
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Protecting Western Colorado Water Since 1937

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LIST OF ACRONYMS

BSP-Basin States Program
CIG-Conservation Innovation Grant
CRWCD-Colorado River Water Conservation District
CSV-Comma Separated Value
CWA-Clean Water Act
CWCB- Colorado Water Conservation Board
DCD-Delta Conservation District
DOLA- Department of Local Affairs
DWR-Department of Water Resources
EC- Electrical Conductivity
EPA-Environmental Protection Agency
EQIP-Environmental Quality Incentives Program
ESRI-Environmental Sciences Research Institute
GBSTF-Gunnison Basin Selenium Task Force
GIS- Geographic Information System
HUC-Hydrologic Unit Code
KNWR- Kesterson National Wildlife Refuge
NIWQP- National Irrigation Water Quality Program
NPDES- National Pollutant Discharge Elimination System
NRCS-Natural Resources Conservation Service
PBO- Programmatic Biological Opinion
SAR-Sodium Absorption Rate
SCD-Shavano Conservation District
SMP- Selenium Management Program
SWDC-Southwest Data Center
SWSI- Statewide Water Supply Investigation
TA-Technical Assistance
TMDL-Total Maximum Daily Load
USDA-United States Department of Agriculture
USFWS-United States Fish and Wildlife Service
USGS-United States Geological Survey
USBOR-United States Bureau of Reclamation
USBR-United States Bureau of Reclamation
UVWUA- Uncompahgre Valley Water Users Association
WHIP-Wildlife Habitat Incentives Program
WQCC-Water Quality Control Commission

I. Executive Summary and Key Findings

Selenium and salinity are major water-quality concerns in the Lower Gunnison Basin. Numerous stream segments in the Lower Gunnison and Colorado River Basins are listed as impaired by selenium for aquatic wildlife uses under Section 303(d) of the Clean Water Act. The Lower Gunnison and Colorado Rivers serve as habitat to several endangered fish species and as such, are subject to a mandated selenium management plan under a recent US Fish and Wildlife biological opinion. Deep percolation of water through Mancos shale-derived soils via inefficient irrigation practices, domestic sewer leach fields, unlined ponds and earthen irrigation delivery systems have been shown to significantly contribute selenium and salinity loads to the lower Gunnison Basin. Salinity is a significant concern in the Upper Colorado River Basin where salt problems cause decreased agricultural productivity and significant economic impacts to downstream water users in Colorado and downstream states.

This project developed a comprehensive Geographic Information System (GIS) of water- quality, water-quantity and soil survey information. The GIS can be used by NRCS and by water- and land-use planners to target specific locations for cost-effective water conservation improvements to minimize deep percolation and contaminant loading.

This project compiled, digitized, mapped and analyzed available information on the location and extent of salinity control projects, soil-quality information with respect to selenium and salinity mobilization, water supply and water use information. In addition, water-quality and water-quantity information was compiled for Delta County and parts of Montrose and Gunnison Counties within the Delta and Shavano Conservation District service areas.

The results from the mapping project were used to characterize irrigation practices as well as selenium and salinity mobilization potential for water districts in Delta County and sub-watersheds in the entire Lower Gunnison Basin.

Key Findings

There are 183,539 acres of irrigated land in the Lower Gunnison Basin. Over 81% of the irrigated lands employ potentially inefficient irrigation techniques (*i.e.*, parcels irrigated by flood and furrow systems; see Table 2).

Seleniferous soils are significant in the study region. Soils with "very high" and "high" selenium mobilization potential cover over 20% of the basin (Table 2). Relative selenium mobilization potential was determined by special studies and techniques designed to test the relative amounts of extractable selenium concentrations present in soils. The subwatersheds with the highest selenium mobilization potential ranked in terms of irrigated acres on parcels classified with very high and high selenium soils are generally located in the northeastern portion of the Uncompahgre Valley (East Mesa, Outlet Uncompahgre River, unnamed HUC 140200050113, and Petrie Mesa). The sub-watersheds with the highest salt mobilization potential also generally occurred in the same area of the Uncompahgre Valley. In terms of relative rank of total saline acreage (strongly and moderately saline) the top saline subwatersheds include the un-named HUC 140200050113, Loutzenhiser Arroyo, Outlet Uncompahgre River, Peach Valley and Petrie Mesa.

Due to the large amount of irrigated land with high selenium and salt mobilization potential, as well as the large percentage (81%) of the irrigated lands utilizing potentially inefficient irrigation methods, the northeastern portion of the Uncompahgre Valley has the highest potential for improved irrigation efficiency through agricultural programs (*e.g.*, Environmental Quality Improvement Program [EQIP] and Colorado Basin States Program [BSP]).

Additionally, significant agricultural water shortages in the Lower Gunnison Basin have been observed that are attributed to lack of physical supplies and inefficient water uses. This project provides water resource planners with the ability to target areas and water districts with high potential for increasing irrigation system efficiencies while at the same time reducing deep percolation associated with selenium and salinity mobilization. Project results indicate that areas like the Paonia District, which has an identified 2030 water supply gap, could gain water supply benefits through cost effective irrigation efficiencies while limiting selenium and salt mobilization.

In general, project results indicate that traditional focus areas used by planners in local conservation district offices to target the implementation of conservation practices capture neither the full extent, nor the complex distribution of seleniferous and saline soils. The GIS coverages developed by this project more fully describe the nature, location and extent of these naturally occurring contaminant sources (Plate 1A.)

In order to maintain and leverage the results of this study, a plan to update and maintain the project database should be developed and implemented.

II. Introduction

A. Project Background

Selenium and salts naturally occur in high concentrations in soils derived from the Mancos Shale. These soils are common in the irrigated valleys of western Colorado such as those in the lower Gunnison and lower Colorado River basins. It has been found that previously unirrigated Mancos-derived soils can contain up to 34 times greater extractable selenium than irrigated Mancos-derived soils (Dave Dearstyne, Natural Resource Conservation Service [NRCS], personal communication, 2003).

Sources of selenium and salt mobilization in the study area (primarily focused on Delta and Montrose counties, Colorado) include leakage and seepage from the irrigation delivery systems and the application of irrigation water for agriculture, inefficient irrigation practices both agricultural and urban, septic systems and associated leach fields, and unlined ponds. Additional groundwater can oxidize selenium and dissolve salts making them more mobile. In turn, accretions to the groundwater system can cause springs, seeps and perennial flow in previously intermittent local surface streams and drains where they then carry these undesirable contaminants through subwatersheds into local waterways. This study focuses on the sources of deep percolation and related salinity and selenium mobilization.

Excess salinity can have potentially negative impacts including: decreased agricultural productivity, economic damage for downstream water users due to decreased agricultural production, corrosive effects and increased treatment costs. High selenium concentrations have been linked to decreased reproductive success of sensitive aquatic wildlife, including several endangered fish species native to the lower Gunnison and Colorado Rivers.

The project study area is sparsely populated (combined populations of Delta and Montrose are approximately 72,900 according to the Colorado Department of Local Affairs, [DOLA]). The City of Montrose and City of Delta are the major population centers in the basin, with approximately 17,834 and 8,325 residents respectively. The major population centers in Delta County, in order of size include Delta, Orchard City, Cedaredge, Paonia, Hotchkiss, and Crawford. Nearly half of the population lives in unincorporated areas. Delta County is forecasted to grow by 111% from 2000 to 2035 (DOLA, 2008).

Land use in the Lower Gunnison Basin is predominately forest and rangeland. Agriculture dominates the land use in the river valleys and flat-top mesas. Irrigation is used for various crops including pasture, hay, fruit, corn, alfalfa, and small grains. A majority of the irrigated land in the basin (81% according to study results) is supplied by flood and/or furrow irrigation systems.

The CIG project study, *Employing Innovative Data and Technology for Water Conservation Targeting and Planning in the Salinity and Selenium Affected Areas of the Lower Gunnison River Basin* ("Employing Innovative Data"), addresses three of the NRCS high priority natural resource concerns in Colorado: water resources, soil resources and wildlife habitat. The main objective of the study is to improve water resource management and related decision-making by employing innovative data and technology to address water-quantity and water-quality concerns in the Lower Gunnison River Basin. Project objectives are accomplished through the following four tasks (Colorado River Water Conservation District [CRWCD], 2005):

1.) Compiling, digitizing, mapping and analyzing water conservation practices in the study area to target conservation practices that reduce salinity and selenium concentrations and loading to Lower Gunnison River Basins;
2.) Compiling, mapping and analyzing soils information within the study area to help identify areas that have a high potential of contributing salinity and selenium to Lower Gunnison River Basins so that cost-effective implementation practices can be targeted and water-quality improved;
3.) Compiling, digitizing, mapping and analyzing water supply and water use information within the study area in order to assist local planners in identifying and addressing potential water-supply issues by targeting additional water conservation measures; and
4.) Compiling existing water-quality and water-quantity data within the study area into a common, comprehensive database to more effectively analyze and manage irrigation practices and water uses to limit impacts to domestic water supplies and agricultural production.

A.1. Water-Quality Summary of the Lower Gunnison River Basin

Selenium and salinity are the major water-quality concerns in the Lower Gunnison Basin. These constituents can be mobilized by the deep percolation of water from diverse sources such as leaking ponds, inefficient application of irrigation water, and leaking delivery systems. Excessive salinity can have potential negative impacts including decreased agricultural productivity and economic damage for downstream water users due to corrosive effects and increased treatment costs. High selenium concentrations have been linked to decreased reproductive success of sensitive aquatic wildlife, including several endangered fish species native to the Lower Gunnison and Colorado Rivers.

Salinity loading in the upper Colorado River basin cause significant economic impacts in downstream states, currently estimated at $383 million annually at 2008 salinity concentrations (United States Bureau of Reclamation [USBR], 2009). It is estimated that taxpayers contribute up to $20 Million dollars annually to control salinity in the Upper Colorado River Basin (USBR, 2004). The Colorado River Basin Salinity Control Forum estimates that by 2030 a target of 1.86 million tons per year of salt will need to be diverted from entering the Colorado River to remain in compliance with federal water-quality laws (USBR, 2009).

Selenium is an essential trace nutrient necessary for all life and serves important metabolic functions. However, at elevated levels it is known to have toxic effects to both fish and aquatic wildlife. Selenium concentrations in normal wildlife tissue range from about 2 parts-per-million (ppm) or less. Tissue and food item samples acquired in the Grand Valley and Lower Gunnison Basin were found to be above the threshold of toxicity for sensitive and moderately sensitive species (10 - 20 ppm tissue; 3- 5 ppm food items) (National Irrigation Water Quality Program [NIWQP], 1998).

In the early 1980's, an incident at the Kesterson National Wildlife Refuge (KNWR) in central California drew national attention to selenium. Environmental and cost concerns associated with selenium in the water prevented the USBR from transporting irrigation drainage water from the west side of the San Joaquin Valley to the San Francisco Bay. Much of the drain water came from agricultural lands overlaying Mancos shale soils. The USBR diverted much of the drainage water into a series of reservoirs (a.k.a. Kesterson Reservoir) in the hopes of evaporating a significant portion in order to reduce salt build-up from intensive irrigation. These reservoirs were eventually combined with surrounding grasslands and became known as the KNWR. The continual flow of irrigation drain water into the KNWR resulted in water column selenium concentrations of 15-350 ppb (Ohlendorf, H.M and Presser, T.S. , 1987). Eventually, deformities, reproductive failure, and mortality of aquatic birds were observed. Extensive collection of organisms eaten by birds at KNWR reflected biomagnifications of selenium in the food chain (Ohlendorf, H.M., et. al. 1986a).

In response, the National Irrigation Water Quality Program (NIWQP) was created by the Department of Interior in 1985 to study the effects of federal irrigation drainage projects on water resources, fish, and wildlife throughout the western United States. This program found that the Gunnison River Basin and Grand Valley ranked 4th in the nation for median surface water selenium concentrations, 2nd for sediment, and 1st for bird tissue concentrations (Butler, D.L., et al., 1996). More recent studies by the USGS (Butler, D.L. and Leib, K.J., 2002) found that 38% of the measurable selenium load in the Gunnison River near the town of Whitewater, Colorado is generated by the Lower Uncompahgre River watershed. This study also suggests that sub-basins on the east side of the Uncompahgre Valley (*e.g.*, Loutsenhizer Arroyo, Cedar Creek), may produce the majority of this selenium load due to the presence of highly seleniferous soils. Inefficient water use, particularly irrigation, on the east side of the Uncompahgre Valley exacerbates this problem. Selenium concentrations in Loutsenhizer Arroyo during low-flow periods in winter may run as high as 150 ppb, a significant departure from the 4.6 ppb State water quality standard (Ken Leib, USGS, personal communication, 2006).

In 1998, the State of Colorado, Water Quality Control Commission, designated many stream segments within the Gunnison River Basin as impaired due to elevated selenium under section 303(d) of the Clean Water Act. This listing action directly followed the implementation of reduced stream standards for selenium in the Gunnison basin hearings. In response to this listing, the Gunnison Basin Selenium Task Force (Task Force) was formed. The Task Force is a group of private, local, state, and federal interests committed to finding ways to reduce selenium in locally affected waterways, while maintaining the economic viability and lifestyle of the Lower Gunnison River Basin of western Colorado. The Task Force, through scientific studies and local experience, has found that deep percolation of water in areas with Mancos shale soils or geologic parent materials, whether in irrigation or domestic water systems, is the main cause of selenium loading to local waterways. In response, the Task Force formulated an action plan (Gunnison Basin & Grand Valley Selenium Task Force, 2009) to attain the State water-quality standard for selenium by minimizing deep percolation and promoting increased water use efficiency and water conservation.

An additional, compounding factor to the water-quantity and quality issues in the Lower Gunnison Basin is the high rate of population growth and the associated changes in land and water use. The Colorado DOLA projects the population of both Delta and Montrose County will double by the year 2035 (DOLA, 2009). The population growth and associated increase in demand for water not only presents challenges to water managers, it may counteract reduced salt and selenium loading benefits by increasing deep percolation from additional water uses such as unlined ponds, septic systems and irrigation in previously un-irrigated Mancos derived soils.

A.2. Water-Quantity Summary of the Lower Gunnison River Basin

Water is managed in the Gunnison Basin in a manner that meets many important human and environmental needs. The local economy, quality of life, recreational opportunities, and environment are all dependent on water availability. Prolonged drought conditions in the early 2000s, in conjunction with rapid growth, declining supplies and downstream compact obligations (*e.g.*, 1922 Colorado River and 1948 Upper Colorado River Compacts) have focused attention on the Gunnison Basin's limited water resources and the challenges associated with balancing multiple objectives and sometimes conflicting needs. In addition, the State of Colorado has completed several water availability investigations that have identified water supply 'gaps' throughout the study area (*e.g.*, Statewide Water Supply Investigation [SWSI].

The Lower Gunnison River Basin is approximately 3,749 square miles in size, ranging in elevation from over 14,000 feet in the San Juan Mountains to 4,550 feet at Grand Junction. Average annual precipitation varies from over 40 inches in the mountains to as little as 8 inches in the valleys (National Resources Conservation Service [NRCS], 2009). Temperatures generally vary inversely with elevation, and variations in the growing season follow a similar trend. The average growing season ranges from 64 days in Ridgway to over 180 days in Grand Junction. The watershed includes parts of Delta, Montrose, Ouray, Mesa and Gunnison Counties. Because annual and seasonal precipitation is subject to significant seasonal and year-to-year variability, successful agriculture requires supplemental water supplies. In response, extensive irrigation networks have been developed.

The Lower Gunnison River Basin is generally characterized by several high-elevation valleys situated at the eastern edge of the Colorado Plateau. It has diverse physiography characterized by flat top mesas, deep canyons and wide river valleys. The underlying deep bedrock in the region consists predominantly of crystalline and sedimentary rocks, with shallower alluvial deposits in the valleys. Weathering of these different geologic formations, particularly the Mancos Shale, are a significant source of salts and selenium.

The mainstem of the lower Gunnison River begins below the outlet of Crystal Dam, which is part of the Bureau of Reclamation's Wayne Aspinall Unit. The two largest tributaries to the Lower Gunnison River are the North Fork of the Gunnison River and Uncompahgre River. The North Fork joins the Gunnison River at Pleasure Park downstream of the Gunnison Gorge. Average annual flow of the North Fork at Leroux Creek below Hotchkiss (Department of Water Resources [DWR] gage NORLUXCO) is 256,284 acre-feet. The

Uncompahgre River enters the Gunnison River near the City of Delta. Average annual flow of the Uncompahgre near the confluence is 220,000 acre-feet (USGS gage 09149500). The average annual flow of the Gunnison River near Grand Junction is over 1.8 million acre-feet (USGS gage 09152500). It is estimated that approximately 60 percent of this flow is attributable to snowmelt runoff in May, June, and July.

The alluvial and bedrock aquifers of the Lower Gunnison Basin typically provide less than 1 percent of the water used. This relatively low rate of groundwater use is offset by extensive development and use of surface water in the basin. Saturated alluvial deposits form the most productive aquifers in the basin, with yields commonly ranging from 20 to 40 gpm (Apodaca et al. 1996). The majority of wells in the basin are located in the alluvial aquifers along the Uncompahgre and mainstem Gunnison Rivers.

The Lower Gunnison Basin has an expansive network of diversions and irrigation canals that supply water to the landscape for many uses. Water diversions from many of the small irrigation ditches average one or two thousand acre-feet per year. The largest diversion, the Gunnison Tunnel, diverts approximately 365,000 acre-feet per year from the Gunnison River (USBR, 2010) to supply irrigation water to the Uncompahgre River Basin. Most of the storage and irrigation infrastructure in the Lower Gunnison Basin was created by the USBOR. There are six USBOR projects in the Lower Gunnison Basin: Uncompahgre Project, Paonia Project, Dallas Creek Project, Bostwick Park Project, Fruitgrowers Project, and the Smith Fork Project. Local conservancy districts, ditch companies and water user associations are responsible for federal and private project operations and maintenance.

The USBR-sponsored Uncompahgre Project, which includes the Gunnison Tunnel, was developed over a hundred years ago and helps to irrigate over 76,000 acres of land with waters diverted from both the Gunnison and Uncompahgre Rivers in the Uncompahgre Valley (http://www.usbr.gov/projects/Project.jsp?proj_Name=Uncompahgre Project).This federal irrigation project generally supplies 60 inches of water per acre of land to the west side of the project each irrigation season and approximately 48 inches of water per acre of land each irrigation season to the east side on an average basis (Marc Catlin, UVWUA Manager, personal communication, 2004).

Consumptive water uses in the Lower Gunnison Basin include irrigation, municipal and industrial water use, and rural domestic water use. Irrigation provides the principal mechanism for consumptive use of water in the basin and accounted for 98% and 87% of water withdrawals in 2005 in Delta and Montrose Counties respectively. Approximately 1.3% and 13.1% of Delta and Montrose County water withdrawals were used for municipal supply. Rural domestic water deliveries totaled less than one percent of water withdrawals (Kenney et al., 2009).

Significant agricultural water shortages can occur in the Lower Gunnison Basin. Average annual shortages exceed ten percent in most of the basin, with the exception of the Uncompahgre Valley. By 2030, the gross Delta County demand is forecasted to have a shortfall of 500 AF (Camp Dresser McKee [CDM], 2004). Anticipated shortages in Delta County will occur in Paonia and in unincorporated areas. The shortages can generally be attributed to lack of physical supplies. The total irrigated land in the entire Gunnison basin in

2000 was estimated to be approximately 264,000 acres (CDM, 2004). This amount is predicted to decrease by 2,500 to 10,000 acres by 2030. The loss of irrigated land is predicted as a result of projected urbanization in the Uncompahgre Basin and agricultural transfers along the North Fork and Gunnison mainstem (CDM, 2004). Increasing system efficiencies as a selenium and salt reduction tool could potentially generate additional water supplies for water companies.

In addition, rapid growth in the basin, for example around the City of Montrose, has presented water managers with the major challenge of identifying new water supplies. Municipal and industrial water demands in Montrose County are expected to double (7,000 to 14,300 AF) from 2000 to 2030 while Delta County demands are expected to increase by 73% (6,400 to 11,100 AF). Although the majority of the demand may be met through existing supplies and transfer of agricultural water rights, the anticipated remaining gross water supply shortfall is 800 acre feet (CDM, 2004). Additional, increased water use efficiency and conservation practices can also provide potential solutions to help fill this water supply gap.

B.) Project Grant Sponsor

Colorado River Water Conservation District: (Colorado River District or CRWCD; www.coloradoriverdistrict.org): The CRWCD served as the applicant, grant sponsor and project manager and as such, was fiscally responsible for the CIG project, managing funds, processing financial documents, coordinating activities, analyzing results, providing GIS support and developing project reports. The CRWCD is a water planning and policy agency responsible for the Colorado River and its tributaries within the CRWCD boundary which includes all or parts of 15 counties in northwestern and west-central Colorado.

The CIG project was directed by Mr. David A. Kanzer, P.E., Senior Water Resources Engineer, for the CRWCD. Mr. Kanzer is a registered in Colorado as a Professional Engineer, and he specializes in Gunnison Basin water resource issues. Questions regarding the CIG project can be directed to his office (Phone: 970-945-8522 or Email: dkanzer@crwcd.org).

C.) Project Collaborators

Altria Foundation: Altria provided a grant award of $20,000 to Painted Sky Resource Conservation and Development in support of the project ($18,000 went directly to the CIG project while $2,000 went to Painted Sky for administrative overhead). A project summary report was created for the foundation and is provided in Appendix A.

Delta Conservation District (DCD): The portion of the Lower Gunnison Basin watershed of interest for this project was limited to the DCD which contains all of Delta County and portions of Montrose and Gunnison Counties. The DCD assisted in Task 1 to identify conservation practices, EQIP targeting, and soil mapping. They also managed and paid the two GIS technicians responsible for researching and digitizing information on water conservation practices, acquiring information on domestic water supply data, and database development. The DCD also serves as the location for the local GIS database. An MOU between the DC and CRWCD was executed to provide the legal framework for the exchange and protection of data under applicable federal laws and is included in Appendix B. The MOU defines the roles and responsibilities of these two entities.

Delta County (DC): The DC GIS Department assisted in the completion of Task 3 (development of the Domestic Water Supply GIS). They provided work space for the CIG GIS technician, assisted in acquiring and providing information on water supplies, and contributed $20,000 in cash support for Tasks 3 and 4. DC was interested in water-quantity and water-quality data for the area, especially with respect to oil and gas development impacts and related water-quality and water supply and demand issues.

Gunnison Basin Selenium Task Force (GBSTF): The GBSTF is a voluntary group of public, private, local, regional, state, and federal interests committed to finding ways to reduce selenium in locally affected waterways while maintaining the economic viability and lifestyle of the Lower Gunnison River Basin. Members of the GBSTF provided technical expertise, monitoring and evaluation of the project, and a forum for education and outreach. The watershed coordinator for the GBSTF assisted with grant administration, facilitation, coordination, and project reporting.

Natural Resource Conservation Service (NRCS): The NRCS soil scientists provided extensive technical assistance on Task 2 (soil sampling and mapping). NRCS also assisted in coordination efforts with both the Delta and Shavano Conservation Districts. In addition, the State NRCS office served as grant administrator and provided technical support, as necessary.

Shavano Conservation District (SCD): The SCD was added to the CIG project spatial extent area in 2008 due to project efficiencies and remaining funds in Task #1 as originally proposed. Additional data was collected on water conservation practices in the SCD area. An MOU between the DCD and SCD was executed to provide the legal framework for the exchange and protection of data under applicable federal laws and is included in Appendix C. The MOU defines the roles and responsibilities of these two entities.

Southwest Data Center (SWDC): The SWDC provided valuable GIS technical support to the database design and project team. Since 2008, the SWDC changed operations due to financial and administrative issues and was no longer involved in the project after that time.

U.S. Geological Survey (USGS): The USGS provided water-quantity, quality, GIS, and database support for the project. In particular, the USGS was the technical lead for Task 4 (water quality database development for the DC area) of the project.

D.) Current federal programs addressing water-quality and water-quantity concerns in the Lower Gunnison River Basin

"The Colorado River drains 246,000 square miles (approximately 157 million acres) of the western United States and Mexico while providing water to some 7.5 million people within its own basin and supplies wholly or in part the water needs of an additional 25.4 million people outside the basin through trans-basin diversions. The United States Government and the seven basin states have long recognized the importance of the river and its tributaries to the survival of the region. From the headwater states of Colorado, Utah, Wyoming, and New Mexico, to its terminus in the Gulf of California, the river's water increases in salinity. It is estimated that the river carries an average salt load of nine million tons annually. In 1972 the Clean Water Act mandated efforts to maintain water quality standards in the United States. During the same time Mexico and the United States were discussing the increasing salinity of the Colorado River and the economic and environmental impacts the added salinity was having on downstream users. In 1973 the seven Basin states formed the Colorado River Basin Salinity Control Forum and directed it to control salt contributions to the river from manmade sources as a condition for continued development of compact-apportioned water. In 1998 an agreement was signed by the US Bureau of Reclamation and the Colorado River Basin Salinity Forum to provide funds to cost share with water users in the upper basin states of Colorado, Wyoming, and Utah that would parallel the federal USDA's efforts to reduce salt contributions to the river from irrigation" (http://www.colorado.gov/cs/Satellite?c=Page&cid=1178305661561&pagename=Agriculture-Main%2FCDAGLayout).

At this time there are no federal funding programs specifically dedicated to selenium control. There are several specific federal funding programs described below that address salinity control:

The **Environmental Quality Incentives Program (EQIP)** was reauthorized in the Farm, Conservation, and Energy Act of 2008 (2008 Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land (***on-farm***).

The **Basin States Program (BSP)** administered by the Colorado State Conservation Board provides financial assistance of up to 75% to landowners in order to improve the efficiency of irrigation systems on their land in western Colorado through their Farm Assistance funds. Farm Assistance funds are also known as Financial Assistance (FA) or cost-share funds. FA funds are made available to participating individuals and entities owning and/or operating irrigated land or providing irrigation water to land, as a direct payment to implement the Basin States Salinity Control Program. The funds can therefore be used for ***on-farm*** and ***near-farm*** projects. By implementing the program, rural landowners can help to reduce the amount of salt entering the Colorado River (Colorado BSP Policy) http://www.colorado.gov/cs/Satellite/Agriculture-Main/CDAG/1183672493429?rendermode=preview*)*.

The BSP program also offers Technical Assistance (TA) to perform technical implementation work to meet the goals of the Salinity Control Act. The purpose of the TA funds is to accelerate the implementation of existing EQIP and BSP contracts. TA funds reside with the USBR and are requested on a reimbursement basis by the State of Colorado for disbursement to the Conservation Districts (CDs) in accordance with a federal contract agreement. CDs must use TA funds to support employees to provide technical assistance to BSP and EQIP cost-share programs. Irrigation related, water conservation and water-use efficiency, and water-quality activities may be considered as supporting the goals of the Salinity Control Program (Colorado BSP Policy, http://www.colorado.gov/cs/Satellite/Agriculture-Main/CDAG/1183672493429?rendermode=preview).

The State of Colorado, in conjunction with the U.S. Environmental Protection Agency (EPA), addresses water-quality concerns and regulates water users in the Lower Gunnison River Basin pursuant to the United States Clean Water Act (CWA). "Section 303(d) of the CWA requires States to submit to the U. S. Environmental Protection Agency (EPA) every two years, a list of water bodies that are water-quality impaired. A water-quality impaired segment does not meet the standards associated with its assigned use classification. This list of impaired water bodies is referred to as the "303(d) List" (Colorado Department of Public Health and Environment [CDPHE], 2009). In November of 2009, the Colorado Water Quality Control Division released the Public Notice Draft of the Total Maximum Daily Load (TMDL) for selenium in the Lower Gunnison River Basin. Twelve separate river reaches were assessed, and load allocations for point source dischargers were developed.

Although the TMDL has not been formally adopted by the Water Quality Control Commission, the official decision-making regulatory body, as of March 31, 2010, the publication of the Public Notice draft TMDL provides draft guidance and raises the funding priority of the basin with respect to competitive funding under section 319 of the CWA.

An additional federal regulatory decision related to selenium, the Lower Gunnison Programmatic Biological Opinion (PBO) (USBR, 2009b), was released on December 4, 2009 by the U.S. Fish and Wildlife Service. The PBO mandates several actions related to selenium control, including the creation of a Selenium Management Program (SMP). The SMP is to be developed amongst stakeholders and accepted by the USFWS within two years or by a target date of December, 2011.

The selenium data, spatial information and conclusions developed as part of this report will serve as the foundation for the SMP and will be instrumental in the development of remediation options.

III. Project Need, Goals, Objectives and Tasks

A. Project Need and Goal

This project addresses three high priority natural resource concerns of the NRCS in Colorado:

1. *Water Resources:* By developing the GIS database tool for implementing targeted water resource planning. This tool can be used to specifically address declining water supplies, increasing water demands and salinity and selenium loading concerns while maintaining agricultural productivity and ensuring long term water security;

2. *Soil Resources:* By enhancing the use of local soil resource geodatabases, planners can proactively and comprehensively address the accumulation of salts and selenium so that environmental enhancement can occur coincidently with enhanced agricultural production; and

3. *Wildlife Habitat:* By developing a tool which can be used to a.) Create an incentive system that promotes the conservation of species at risk (*i.e.*, conservation of native endangered fish species in the Colorado and Gunnison Rivers); and b.) Promote the improvement of wildlife habitat in riparian corridors through reduction of salinity and selenium as an impact to aquatic resources.

In addition, the project effectively leverages significant current and historical federal investments in environmental enhancement and protection (through EQIP, Wildlife Habitat Incentives Program [WHIP], Salinity Control projects) in the area. The project will also help local, state and federal officials more efficiently target future water conservation practice investment.

The information developed by the *Employing Innovative Data* project will be used as the foundation for the development of innovative approaches to anticipate and address water-quality and quantity issues specifically related to salinity and selenium. By developing and implementing an innovative, comprehensive Geographic Information System (GIS) of water-quantity and water-quality information, water conservation targeting and planning can be enhanced. Comprehensive planning, in particular, will benefit tremendously.

Historically, salinity and selenium remediation projects have been implemented on an ‘ad-hoc’ basis. The results of this project and attendant databases should enable planners to utilize the set of available tools for specific targeting and location of the most cost effective remediation projects and to discourage undesirable development projects that could increase salinity and selenium loading.

This report aggregates available historical information on the location and extent of salinity control projects. These data, when analyzed spatially and temporally, greatly improve the understanding of the dynamics of contaminant mobilization. The data should also be used by planners to target areas where future water conservation improvements can be implemented that will minimize deep percolation and contaminant mobilization. Planners can also utilize this report to aid in ongoing efforts to understand and predict the effects of changing land use on salinity and selenium loading.

Recent experience indicates that land use development in seleniferous and saline areas that have not been previously irrigated (*e.g.*, Montrose Arroyo and Devil's Thumb Golf Course) can significantly increase contaminant loading. Scientific data has proven that traditional salinity control-type projects like piping and lining of earthen water delivery systems and implementing higher efficiency irrigation systems (*e.g.* on-farm sprinklers) directly reduce deep percolation, and therefore are effective means of reducing selenium and salt loading to local watersheds (Butler, 2001).

Increased irrigation efficiency methods that represent Best Management Practices (BMPs) should be implemented on a large scale to reduce undesirable chemical constituent mobilization. Additional site-specific information is needed, however, to optimally locate BMPs for maximum cost effectiveness (USBR, 2006). Data from this study should be used to ensure that unnecessary contaminant loading can be prevented through implementation of BMPs. This approach will allow growth and development to occur without adverse impacts.

When the spatial data regarding salinity and selenium from this report are combined with water supply and demand information (section C.2) additional targeting of infrastructure improvement can be implemented in a more optimal way. For example, planners and designers will be able to concentrate resource conservation efforts on seleniferous and saline areas to encourage, or even require, as appropriate, the implementation of conservation measures and/or BMPs. This is especially true where water availability and uses are high. Implementation of such BMP's can effectively reduce excessive deep percolation and undesirable contaminant mobilization while allowing critical water uses and water-dependent lifestyles (*e.g.*, rural housing developments, landscaping, and small acreage agricultural production) to continue.

Finally, project results will further define changes in land use (*e.g.*, number of acres under different irrigation methods, areas affected by urbanization and changes to water service areas). Such data should help relate changes in observed salinity and selenium loading to land use change. These data can, in turn, can be incorporated into the development of more accurate and appropriate regulatory processes (*e.g.*, Total Maximum Daily Loads [TMDL], National Pollutant Discharge Elimination System [NPDES] permits, etc.) as well as in the development and implementation of BMPs, land-use planning, selenium management programs and other important decision-making processes.

B. Project Objective

The primary objective of the *Employing Innovative Data* project is to improve water-resource management (specifically addressing water-quality and water-quantity concerns) by identifying high priority areas for targeted BMPs in the Lower Gunnison River Basin. Missing soil and irrigation practice information was developed and incorporated into a comprehensive spatial database. These data were analyzed by sub-watershed and water district to help plan activities to reduce salinity and selenium mobilization. Water conservation practices (*e.g.* EQIP and Salinity Control Projects), soils data, water supply and water use and water-quality data were combined into seamless map coverage to meet the project objectives. The project area was originally limited to the Delta Conservation District service area which includes Delta County and parts of Montrose and Gunnison Counties, but was later expanded to include most of the Shavano Conservation District in Montrose and north Ouray Counties.

C. Summary of Tasks & Products

Task 1: The first task involved mapping and digitizing readily available water conservation practices within the study area. The data consisted of NRCS and Colorado State Conservation Board (CSCB) funded projects (EQIP and BSP, respectively).

Products: A comprehensive GIS that includes data from over 600 digitized contracts, that inventoried a significant portion of existing conservation practices useable to target areas for additional conservation practices to reduce deep percolation and therefore salinity and selenium concentrations and loading to the Uncompahgre, Lower Gunnison, and Colorado Rivers. (See *Plate 1B: Selenium Mobilization Potential in Soils with Irrigated Acreage and NRCS Practices* (NOT for public distribution); *Plate 4B: Selenium Mobilization Potential with EC in Soils with Irrigated Acreage, NRCS Practices and Sub-watershed Boundaries* (NOT for public distribution).

Task 2: The second task compiled and analyzed soils information within the study area with respect to selenium mobilization potential and salinity characteristics (electrical conductivity (EC)). The data collection effort was primarily focused on the Leroux Creek Watershed which is classified as water-quality impaired due to elevated selenium under Section 303(d) of the Clean Water Act. Soil samples were collected via hand augur and analyzed for extractable selenium at the laboratory. These soil selenium data were then correlated across the entire NRCS Paonia soil survey such that the final product coverage, when combined with the previously correlated NRCS Ridgway soil survey, yielded a seam-less selenium soil coverage across a broad geographical area from the north end of Ouray County through central Montrose County and almost all of Delta County.

Products: A comprehensive soil selenium GIS database used to identify and target areas that have a high potential of contributing salinity and selenium to the Uncompahgre, Lower Gunnison, and Colorado River Basins. By identifying high selenium and salinity loading areas, future conservation practices can be targeted and implemented more effectively. (See *Plate 1A: Selenium Mobilization Potential in Soils with Irrigated Acreage* - public); *Plate 2A - Selenium Mobilization Potential with EC in Soils with Irrigated Acreage (public)*; *Plate 2C - Selenium Mobilization Potential in Soils with Irrigated Acreage and Orthophoto (Public)*; *Plate 4C – Selenium Mobilization Potential with EC in Soils with Irrigated Acreage and Subwatershed Boundaries and Orthophoto (Public).*

Task 3: This task compiled and analyzed water supply and water use information within the study area including irrigation companies, domestic water suppliers, water wells, subdivisions, water rights and other water users, in Delta County.

Products: A comprehensive domestic water supply GIS that contains the location and attributes associated with water providers and users in Delta County that can be used by planners to address potential water supply and demand issues. The water supply and demand information can be used to target future water conservation practices where the economic value of the water supply can be tied to the targeted water conservation measures to maximize the cost-benefit ratio and to maximize public water supply benefits. (See *Plate 3A: Delta County Water Companies with Selenium Mobilization Potential with EC in Soils with Irrigated Acreage (Public).*

Task 4: The fourth and final task compiled existing water-quality and quantity data (*e.g.*, USGS, Colorado School of Mines, Delta County, State of Colorado) within the study area into a common, comprehensive database.

Products: A comprehensive GIS useable by local planners to effectively analyze and manage irrigation practices and water uses to limit impacts on domestic water supplies and agricultural production. The results of this task should be closely coordinated with other related and/or planned water resource studies and efforts. Data from this task are now publicly available on the following USGS website location: http://rmgsc.cr.usgs.gov/cwqdr/default.aspx?project=SoPiceance

IV. Project Methods

The achievement of the project objectives relied heavily on the use of GIS software and techniques. For all of the tasks, the project utilized ESRI products (ArcView and ArcGIS) to build "geodatabases". These geodatabases serve as the repository for spatial data and serve as the foundation for all of the associated water resource analyses. The *Employing Innovative Data* project commenced the Spring of 2006 and was completed March 31, 2010.

It should be noted that due to *federal privacy laws*, information gathered under Task 1 is protected and cannot be distributed to the general public. All data and figures related to NRCS conservation practices aggregated under this task necessitate NRCS permission and/or formal agreement to view and/or utilize. In addition, all figures using this information are clearly marked **"Not For Public Distribution"**.

A. Task 1 Methods, Results and Conclusions: Mapping and Digitizing Water Conservation Practices

A.1. Task 1 Methods

To perform the first task of ***digitizing and mapping water conservation practices***, the River District was required to utilize an NRCS or DCD employee authorized to examine EQIP and Salinity Control files to extract only the publicly accessible data. The GIS technicians were paid using project grant funds.

All pertinent NRCS and BSP contract data was extracted from readily available post-1996 to 2007 NRCS files to define the extent of water conservation practices that were applied through these cost share programs. Pertinent contract data (date, size, type of improvement, etc.) were then captured and digitized into a local ArcGIS ® compatible database that resides at the DCD office. It is estimated that over 400 contract files from the DCD and over 200 files from SCD were examined for implemented water conservation practices.

Data regarding conservation practices in the project area are not comprehensive and are limited to only readily available records obtained from DCD and SCD active and inactive files. These available data do not include *all* irrigation and conservation measures that were implemented by NRCS. The data from this task may include data as far back as 1996 and in some cases up to contract year 2007. Additionally, there are conservation practices that were installed before and after these dates and practices that were installed by private individuals; these data are outside the scope of this study.

All potentially sensitive and private information in the files is protected and will not be publicly released.

A.1.2 GIS Database Local, Maintenance and Project Issues

The original intent of the project was for all digitized contract data from this project to reside on the regional NRCS database in Fort Collins, Colorado. Such data would then be available to be extracted from this master database for use by local NRCS and conservation district planners and engineers. Unfortunately, the development of a revised "Customer Service Toolkit" to allow this type of data extraction was indefinitely delayed due to budgetary constraints. Due to this un-resolvable circumstance that arose during the project period with regard to the State of Colorado NRCS database retrieval/input process, the successful upload and download of important contract data was prevented.

A "workaround" for the problem was arranged. Two separate databases were maintained with one regional master database residing on the NRCS computer in Fort Collins and one local database residing in the DCD office. Because budgetary issues prevented download of previously uploaded project data from the regional database the project relied upon redundant data storage in both locations. All data analyses were based upon the local geodatabase.

At the time of project completion, no additional information was available regarding plans to complete the development of a revised data extraction tool for local planners. It is still hoped and strongly recommended that a revised data extraction tool can be developed to allow certified NRCS and conservation district employees to download data from the regional database to perform watershed-based planning and design. Such a tool will eliminate duplication of effort and would make upkeep and maintenance of conservation practice data more efficient. Additionally such a procedure would provide benefits to all users of the regional NRCS database and better enable future targeting efforts for conservation practices.

Unless the revised data extraction tool is developed, it is unlikely that the methods developed in this project for compiling and uploading digitized water conservation practices at the local office level will be employed in the future.

A.1.3 Creating Geodatabase Layers

A geodatabase was set-up to accommodate individual layers or feature classes for the DCD and SCD projects. Procedures for creating the geodatabases are attached in Appendix D. Three feature classes were included within the database including: 1) structures for water control, 2) pipelines (conveyance, gated, lined concrete ditches and drains, and 3) NRCS irrigation systems and irrigation water management indicated by polygons.

A.1.3.a. Structures for Water Control (NRCS Practice Code 587)

Structures for water control are defined as *a structure in a water management system that conveys water, controls the direction or rate of flow, maintains a desired water surface elevation or measures water*. Each point in the feature class also includes how many structures were installed, latitude, longitude and the date applied.

A.1.3.b. Pipelines (Practice Code varies by feature class, see below)

Pipeline features are defined as *a pipeline and appurtenances installed in an irrigation system* and are indicated by five different types of lines representing conveyance, gated, lined concrete ditches, and drains:

a.) **Irrigation water conveyance –** plastic pipelines
  i.) High pressure, underground plastic pipelines (Practice Code 430DD)

ii.) Low pressure, underground plastic pipelines (Practice Code 430EE)

b.) **Irrigation water conveyance** - steel pipeline (Practice Code 430FF)

c.) **Irrigation water conveyance** - high pressure, rigid gated pipeline (Practice Code 430HH)

d.) **Ditch and canal lining, plain concrete** (Practice Code 428A) - A fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch or irrigation canal or lateral

f.) **Subsurface drain** (Practice Code 606) - A conduit, such as corrugated plastic tubing, tile or pipe installed beneath the ground to collect or convey drainage water. Attribute tables for pipelines include applied amount in feet, latitude, longitude and applied date.

A.1.3.c. NRCS Irrigation Systems

NRCS irrigation systems are indicated by polygons. Attributes associated with this feature class include: planned amount, applied amount, latitude, longitude, applied date, lifespan, and practice code. Four of the many different types of irrigation systems have been recognized and predominate in the project results and are defined as follows:

a.) **Micro-irrigation system** (Practice Code 441) – An irrigation system for distribution of water directly to the plant zone by means of surface or subsurface applicators.

b.) **Irrigation sprinkler system** (Practice Code 442) – An irrigation system in which all necessary equipment and facilities are installed for efficiently applying water by means of nozzles operated under pressure.

c.) **Irrigation system** (Practice Code 443) – A surface and subsurface system in which all necessary water control structures have been installed for the efficient distribution of water by surface means, such as furrows, borders, contour levees, or contour ditches or by subsurface means.

d.) **Irrigation water management** (Practice Code 449) – The process of determining and controlling the volume, frequency and application rate of irrigation water in a planned, efficient manner (http://efotg.nrcs.usda.gov/references/public/GA/GA449_Irrigation_Water_Management_CPS_Final.pdf).

A.1.3.d Irrigated Acreage Information

The base data related to irrigated acreage and irrigation method used for the project originated from the Colorado Division of Water Resources (CODWR). In conjunction with the Colorado Water Conservation Board (CWCB), these data were digitized by water division and are publicly available at http://cdss.state.co.us/DNN/GIS/tabid/67/Default.aspx. These data include information regarding parcel size, location, irrigation method, and crop type. It is updated every five years. The data coverage used in this project was from the most recent available information (2005, released February 2010). This information was collected by air photo interpretation and verified by water commissioners in the field, but is subject to significant uncertainty and in some cases, inaccuracies. This project updated and corrected irrigation method data using the digitized contract information from the NRCS district offices where available, in the project area.

In the analysis of the two irrigation method data sets (NRCS and CODWR), the data sources were combined and "cross-walked" or combined such that the irrigation methods were consistent (*i.e.*, terminology and definitions used for irrigation methods and practices). Where NRCS contract information was available for specific parcels, it was deemed more accurate and it was used to super-cede, or overwrite the CODWR irrigation methods. This combined data coverage served as the base information upon which all the statistical analysis was performed.

The spatial extent of the 2005 irrigated acreage coverage is depicted in Figure 2.

Due to privacy concerns of the NRCS, the improved irrigation methods data garnered from the NRCS contracts under Task 1 are protected and proprietary and cannot be shared with the public. The updated information and spatial GIS coverages are provided to the NRCS in a separate **Appendix E – marked not for public distribution.**

A.1.4 GIS Query Tool

A specialized integrated query engine was developed by the project sub-contractor, Spatial Cybernetics, to extract and analyze results from the database. This query tool was created using PostgreSQL, a public domain open source object-relational database system (www.postgresql.org). The integrated query engine created a series of summary tables by desired parameter and/or combination of parameters and by location. The draft documentation that describes the query engine that was developed as part of this project is included in Appendix F. Because the query tool is still being developed and is a work in progress, the documentation is subject to change.

Two types of spatial queries were created to analyze the multiple layers of map data. The primary spatial query related the parameters of interest (selenium mobilization potential, soil salinity and irrigation method) to the hydrological unit code (HUC), or sub basin, of interest. The second type of spatial query used to analyze the multiple layers of map data was related to water district or water company. This is discussed in more detail in section C.2.

A.1.5 Analysis of Watersheds Using Hydrologic Units

A hydrologic unit is an area that receives surface water directly from upstream areas to form a drainage area generally characterized by a single outlet point. Hydrologic units can be considered synonymous with watersheds when their boundaries include all the source area contributing surface water to a single defined outlet point. The U.S. Geological Survey delineated hydrological units in the United States using a national standard hierarchical system based on surface hydrologic features and classified them into four types of hydrologic units. The NRCS further delineated, numbered and named hydrologic units on a smaller scale (fifth and sixth levels).

Each hydrologic unit is identified by a unique **hydrologic unit code (HUC)** consisting of two to twelve digits based on six levels of classification:

- 2-digit HUC first-level (region)
- 4-digit HUC second-level (sub-region)
- 6-digit HUC third-level (accounting unit)
- 8-digit HUC fourth-level (cataloguing unit)
- 10-digit HUC fifth-level (watershed)
- 12-digit HUC sixth-level (sub-watershed)

(http://www.nrcs.usda.gov/programs/rwa/Watershed_HU_HUC_WatershedApproach_defined_6-18-07.pdf)

There are ninety-five 12-digit HUCs and four 8-digit HUCs that make up the project study domain. Figures 1 and 1A shows the distribution of these HUCs and the names of each. Each of these HUCs was analyzed for irrigated acres, mobilization potential and were summarized separately. ArcGIS compatible shape files were then generated for each of the HUCs. These data are archived in Appendix G.

A.2 Task 1 Results

Geodatabase layers were used to create maps showing implemented water conservation practices in both the DCD and SCD areas using ESRI ® ArcGIS 9.2. Plate 1B shows the general location of all available and mapped NRCS applied conservation practices for both conservation districts. (This figure is protected and is not to be distributed outside of the NRCS to the public – see below.)

It should be noted that due to federal privacy laws, information gathered under this task is protected and cannot be distributed to the general public. All data and figures related to NRCS conservation practices aggregated under this task necessitate NRCS permission and/or formal agreement to view and/or utilize. In addition, all figures developed using this information are clearly marked "Not For Public Distribution."

The results for all 95 HUCs and 50 water companies in the study area are independently summarized and ranked by number of irrigated and total acres of very high and high selenium mobilization potential as well as by strongly and moderately saline soils. In addition, the study area was analyzed, summarized and HUCs ranked by where these contaminant mobilization attributes intersected. Specifically, results were calculated and tabulated where irrigated and total acres of very high and high selenium mobilization potential and strongly and moderately saline soils overlapped.

The detailed results are archived and are included in Appendices G and I: *Results of Spatial Query Analyses by HUC (and water company) for Selenium and Salinity* . In addition, these results are summarized in the tables listed below:

Table 1. Selenium mobilization potential ranked by ranked sub-watershed (12-digit HUC)
Table 2. Selenium mobilization potential ranked by cataloguing unit (8-digit HUC)
Table 3. Selenium mobilization potential ranked by Water Company
Table 4. Salt mobilization potential ranked by sub-watershed (12-digit HUC)

Table 5. Salt mobilization potential ranked by cataloguing unit (8-digit HUC)
Table 6. Salt mobilization potential ranked by Water Company
Table 7. Water supply and gap summary
Table 8. Combined selenium and salt mobilization potential ranked by sub-watershed (8-digit HUC)
Table 9. Combined selenium and salt mobilization potential ranked by watershed (12-digit HUC)
Table 10. Combined selenium and salt mobilization potential ranked by Water Company

These tables reflect the distribution of the implemented irrigation and water conservation practices both by the NRCS and other parties. Specifically, the tables summarize the number of acres under different soil conditions (selenium and salinity potential mobilization) and relate these parcels to potentially inefficient irrigation practices (those fields identified as being irrigated by flood and furrow).

Figures 1-9 illustrate the spatial extent of the data coverages of concern that were used to develop the above mentioned tables and related analyses.

Figure 1 depicts the location and names of the 8- and 12–digit Hydrologic Unit Codes;
Figure 2 depicts the spatial extent of the Colorado Division of Water Resource 2005 irrigated parcels;
Figure 3 depicts the extent and nature of selenium mobilization potential;
Figure 4 illustrates the nature and extent of the soil salinity as represented by Electrical Conductivity;
Figure 5 shows the nature and extent of the possible presence of Mancos Shale underlying the surficial soils;
Figure 6 depicts the nature and extent of NRCS contracted water conservation practices (**NOT for Public Distribution**);
Figure 7 shows the extent of NRCS contracted practices on top of the 2005 irrigated parcels (**NOT for Public Distribution**);
Figure 8 depicts the extent and nature of selenium mobilization potential along with the nature and extent of the possible presence of Mancos Shale underlying the surficial soils
Figure 9 shows the generalized location and extent of Delta County water companies and service areas

A more detailed discussion of these results as they relate to Tasks 2 and 3 can also be found in the subsequent sections B.2 and C.2.

A.3 Task 1 Discussion & Conclusions

This task confirms the value of maintaining an accurate database of water conservation practices and how such a database can be essential to successful future planning. Tabular and spatial results demonstrate that although much has been implemented by the NRCS and CD offices, there is significant potential to improve irrigation efficiencies and to affect additional contaminant control. In addition, the results indicate that previous federal investment in conservation efforts have not necessarily targeted the areas with the greatest irrigation inefficiencies or the areas with the salinity and selenium mobilization potential and therefore have not necessarily maximized the associated environmental benefits.

B. Task 2 Methods, Results and Conclusions: Compiling and Analyzing Selenium and Salinity Soil Information

B.1.Task 2 Methods

The second task of compiling and analyzing selenium and salinity soil information within the study area was accomplished in conjunction with NRCS soil scientists. Because selenium data is not normally incorporated into standard soil surveys, special studies and techniques were required to determine the relative amounts of extractable selenium concentrations present in soils. This data collection effort was primarily focused on the Leroux Creek Watershed, wholly within the NRCS Paonia Soil Survey area, which is classified as water-quality impaired due to elevated selenium under Section 303(d) of the Clean Water Act.

The Paonia, Colorado soil survey (CO679) which covers the northern portion of the project study area, including the North Fork of the Gunnison River watershed and sub-basins including the previously mentioned Leroux Creek watershed, was compared to soils that were mapped and characterized as part of the Ridgway Colorado Soil Survey (CO677) project and previously correlated to relative selenium soil levels (http://websoilsurvey.nrcs.usda.gov/app/).

Soil scientist, Dave Dearstyne, previously developed a qualitative approach that correlates physical soil characteristics, parent-material types, irrigated versus non-irrigated conditions, residual versus alluvial soil types, moisture levels and related conditions to relative selenium levels in the landscape. This approach was used in the adjacent Ridgway Soil Survey and proved to be very effective. Analogies were drawn from the comparisons and sites were utilized to sample and to ground truth correlations and findings (For more information see the “Summary Report on Leroux Creek Soil Selenium Data” in Appendix H).

Soils were sampled to an approximate depth of 48-60 inches below the surface. Up to two soil samples were collected from each point location. A total of 41 samples for selenium analysis were obtained and sent to the USBR laboratory for preparation and subsequent analysis by the U.S. Geological Survey lab in Denver for soluble selenium.

The laboratory soluble selenium soil data for the Paonia soil survey was compared to the soluble selenium data that was obtained in the Ridgway soils survey and previously correlated based upon physical characteristics such as texture, color, content, parent materials and water applied. The correlated data was then imported into the geodatabase and plotted on a map with a view extent that covered both the Paonia and Ridgway soil surveys (broad geographical area from the north end of Ouray County through central Montrose County and almost all of Delta County (see Plate 1A: Selenium Mobilization Potential in Soils with Irrigated Acreage [Public]).

Additionally, this project quantified the distribution of saline soils throughout the study area. Although water-quality monitoring throughout the Upper Colorado River basin, including the Lower Gunnison Basin, provides information on the mass of salts entering the river system, there is a need to understand the spatial variability of the source of the salts in the surficial soils. To do this, digital soil survey information was acquired from the NRCS regarding electrical conductivity (EC). Electrical conductivity is a measure of the concentration of water-soluble salts in soils. It is used to indicate saline soils. It is defined as “the electrolytic conductivity of an extract from saturated soil paste, expressed as millimhos per centimeter at 25 degrees Celsius NRCS1993).

This attribute is typically recorded as three separate values in the soil survey database (for three layers in the soil profile). A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property and this project, the representative value is used and is depicted on Plate 4A. This value was extracted from Soildatamart (http://soildatamart.nrcs.usda.gov) and was provided by NRCS GIS technician, Rich Swanson. Figure 4 also depicts the soil salinity distribution of the study area.

It should be recognized that these soil EC data do not fully cover the project study area and the results based upon this soil parameter may not be fully indicative of salinity conditions in the project area. Therefore, it is essential to note that the salinity results discussed in the following section are limited and provide a ‘proof of concept” rather than an exhaustive analysis.

It is anticipated that additional digital soil information for the project area, such as EC, will be made available in late 2010 (Dearstyne, personal communication, 2010). At that time it will be necessary to re-run the spatial analysis to obtain more complete and representative results.

According to Steve Park, the Colorado NRCS State Soil Scientist (personal communication, 2008), other additional soil properties can and should be used as soil salinity indicators:

- Low saturated conductivity (Ksat)
- Depth to water table
- Drainage class
- Parent material, should be combined with underlying geology information where available to describe influence of underlying materials
- pHs - values greater than 8.4 typically indicate the possibility of both sodium and other salts
- Gypsum content
- Sodium adsorption ration (SAR), may be a better indicator than pH of the potential for overall salinity problems

On a qualitative basis, the study investigated the attribute of parent material and/or the underlying geological information as it may relate to selenium and salinity potential mobilization. Figures 5 and 8 depict the areal extent of the cretaceous Mancos Shale geological formation throughout the study area. It can be seen that the Mancos Shale is prevalent and extensive throughout the study area below the surface. The figure also illustrates areas where the Mancos Shale is at the surface, where shading is absent (*i.e.,* on the east side of the Uncompahgre Valley).

B.2. Task 2 Results

The two USDA, NRCS Soil Surveys of the project study area (Paonia; NRCS CO679 and Ridgway; NRCS CO677) cover most of the Shavano and Delta Conservation Districts. Soil Map Unit data from these two surveys were used to develop relative selenium rankings for each soil map unit as previously discussed in section B1. Maps showing the distribution of selenium mobilization potential for the combined survey areas can be seen in Plate 1A and on Figures 3 and 8.

The specially developed and customized integrated query engine that was created by project sub-contractor, Spatial Cybernetics, was used to analyze the GIS data by sub-watershed (12 digit HUC). The significant features of each HUC were queried by attribute, and/or combination of attributes, analyzed and summarized.

The results for all 95 HUCs in the study area are summarized and ranked by number of irrigated and total acres of very high and high selenium mobilization potential and strongly and moderately saline soils. The detailed results are archived and are included in Appendix G: Results of Spatial Query Analyses by HUC for Selenium and Salinity (Disc 1). The results are organized by folder name and by individual HUC. These folders contain GIS compatible shape files (*e.g.,* geometry and tabular attribute information) and summary information regarding the acreage and related percentage by area using soils information (*e.g.*, selenium mobilization potential and electrical conductivity) by irrigation methods in Comma Separated Value (CSV) files.

In addition, these results are summarized for the top ranked subwatersheds based upon selenium and salinity mobilization potential in Tables 1-9 (listed below):

Table 1. Selenium mobilization potential ranked by ranked sub-watershed (12-digit HUC)
Table 2. Selenium mobilization potential ranked by cataloguing unit (8-digit HUC)
Table 3. Selenium mobilization potential ranked by Water Company
Table 4. Salt mobilization potential ranked by sub-watershed (12-digit HUC)
Table 5. Salt mobilization potential ranked by cataloguing unit (8-digit HUC)
Table 6. Salt mobilization potential ranked by Water Company
Table 7. Water supply and gap summary
Table 8. Combined selenium and salt mobilization potential ranked by sub-watershed (8-digit HUC)
Table 9. Combined selenium and salt mobilization potential ranked by watershed (12-digit HUC)
Table 10. Combined selenium and salt mobilization potential ranked by Water Company

These tables reflect the distribution of the implemented irrigation and water conservation practices both by the NRCS and other parties. Specifically, the tables summarize the number of acres under different soil conditions (selenium and salinity potential mobilization) and relate these parcels to potentially inefficient irrigation practices (those fields identified as being irrigated by flood and furrow).

Figures 1-9 illustrate the spatial extent of the data coverages of concern that were used to develop the above mentioned tables and related analyses.

Figure 1 depicts the location and names of the 8- and 12–digit Hydrologic Unit Codes;
Figure 2 depicts the spatial extent of the Colorado Division of Water Resource 2005 irrigated parcels;
Figure 3 depicts the extent and nature of selenium mobilization potential;
Figure 4 illustrates the nature and extent of the soil salinity as represented by Electrical Conductivity;
Figure 5 shows the nature and extent of the possible presence of Mancos Shale underlying the surficial soils;
Figure 6 depicts the nature and extent of NRCS contracted water conservation practices (**Not for Public Distribution**);
Figure 7 shows the extent of NRCS contracted practices on top of the 2005 irrigated parcels (**Not for Public Distribution**);
Figure 8 depicts the extent and nature of selenium mobilization potential along with the nature and extent of the possible presence of Mancos Shale underlying the surficial soils; and
Figure 9 shows the generalized location and extent of Delta County water companies and service areas.

Selenium:
In general, the results from this task indicate that the greatest number of irrigated acres that overlie seleniferous soils occur in the northeastern portion of the Uncompahgre Watershed. Specifically Table 1 depicts the sub-watersheds with the highest selenium mobilization potential by irrigated acres. The two HUCs with the most significant selenium mobilization potential (*i.e.,* classified as having very high and high selenium soils and significant irrigated acreage) are East Mesa (140200060604) and Outlet Uncompahgre River (140200060605) depicted on Figure 1. Together these HUCs have over 11,000 acres of irrigation on areas with significant selenium mobilization potential and approximately 19,500 acres that are irrigated with potentially inefficient systems (*i.e.,* classified as using flood and furrow systems).

The results summarized in Table 1 also suggest that the two HUCs that make up the commonly named ‘Loutsenhizer Arroyo’ basin: Loutsenhizer (140200060605) and East Mesa (140200060604) have significant selenium mobilization potential. Nearly ninety percent of the 10,205 irrigated acres employ “potentially inefficient” irrigation techniques. In addition, the analysis indicates that there are approximately 43,000 total acres classified with respect to selenium mobilization within the two HUCs. Of this total acreage, over 55% are classified as “Very High Selenium” and 32% are classified as “High Selenium”.

When the selenium results are examined on a larger watershed basis and ranked for number of irrigated acres on seleniferous soils, it can be seen in Table 2 that the greatest potential for selenium mobilization appears to be located in the Uncompahgre Basin, followed by the lower Gunnison, the North Fork basin and lastly the lower Gunnison Tributaries.

Salinity:
Like soil selenium levels, the distribution of soil salinity is difficult to fully and accurately quantify. Although the results for soil salinity are based upon an incomplete EC data coverage (as previously discussed in Section B.1) for the project study area, it can be seen in Table 4 that in relative terms, the most saline soils in the study area are located in the northeastern portion of the Uncompahgre Valley. This is shown on Plate 4A and Figure 4. The HUCs with the highest salt mobilization potential are unnamed HUC (140200050113), Loutsenhizer Arroyo (140200060605) and Outlet Uncompahgre River (140200060606).

Additionally, Table 5 shows that, in relative terms, when the salinity results are assessed on a larger watershed basis and ranked for number of irrigated acres on saline soils, the greatest potential for salt mobilization appears to be located in the Uncompahgre Basin, followed by the Lower Gunnison, the Lower Gunnison Tributaries and lastly the North Fork basin.

Selenium and Salinity:
This project also examined the combined salt and selenium mobilization potential at the 12-digit HUC scale for the entire study area of the lower Gunnison Basin. The results for the Lower Gunnison Basin are shown on Table 8. It can be seen that the basin can be characterized as having 37,124 irrigated acres on very high to high selenium mobilization potential soils and 2,145 irrigated acres on potentially high salt mobilization potential soils (Table 1). However, the spatial analysis of those irrigated areas where high selenium and high salinity intersect is limited by the availability of salinity data. Therefore the results are limited and not fully representative for this analysis. However, for purposes of relative comparison, the study results are educational and significant.

The HUCs with the most significant combined selenium and salt mobilization potential (irrigated acres on very high to high selenium potential mobilization and strongly to moderately saline soils) generally occurred in northeastern Montrose and south central Delta Counties, in and around the federal Uncompahgre Project, as shown on Table 9. The following subwatersheds had the highest combined selenium and salt mobilization potential: The unnamed HUC (140200050113), East Mesa (HUC 140200060604) and Outlet Uncompahgre River (HUC 140200060606). This is shown in Table 9.

B.3. Task 2 Discussion and Conclusions
Irrigation water lost to deep percolation by “potentially inefficient” irrigation systems that are located on soils with high selenium or salt mobilization potential can significantly contribute to contaminant loading. Therefore, areas with high contaminant mobilization potential that employ such “potentially inefficient” irrigation systems should be targeted for irrigation efficiencies. The project results strongly suggest that in particular areas like the East Mesa, the Loutzenhizer Arroyo, Uncompahgre River Outlet and sub-watersheds should be targeted for irrigation efficiencies to maximize environmental benefits.

As previously discussed in B.1 Methods Section, it should be recognized that the soil EC data do not fully cover the project study area and the results based upon this soil parameter may not be fully indicative of salinity conditions in the project area. Therefore, it is essential to note that the salinity results discussed in the following section are limited and provide a ‘proof of concept" rather than an exhaustive analysis. When additional EC data becomes available, it will be necessary to re-run the spatial analysis to obtain more complete and representative results.

With over 80% percent of all agricultural lands (148,420 acres) in the basin employing potentially inefficient irrigation techniques (those parcels classified as being irrigated with flood and furrow systems), it is important to carefully target expensive irrigation improvements in areas that will result in the maximum environmental return. By performing spatial analysis that quantifies areas that have multiple potential contaminants (*i.e.*, both high selenium and salt mobilization potential) increases the planner's ability to maximize the cost-benefit ratio of targeted water conservation practices.

C. Task 3 Methods, Results and Conclusions: Compiling and Analyzing Water Supply and Demand Information with respect to Soil Characteristics

C.1. Task 3 Methods

To adequately assess where and how water use is occurring in Delta County, task three ***compiled and analyzed water supply and demand information*** from water users and suppliers within the study area. The GIS data related to Delta County water supplies was acquired through water provider surveys sent to domestic and irrigation water providers and archived into a geodatabase to enable spatial analysis with GIS tools. Data on domestic water well water-quality information was obtained from the Delta County GIS and Health Departments and was cross-referenced with well information from the Colorado Department of Water Resources where available and appropriate. The base survey data acquired under this project served as the foundation for additional subsequent investigations performed by the Gunnison Basin Roundtable and consulting firm, CDM, under a CWCB Task Order.

Agricultural water use was extrapolated based on municipal and industrial (M&I) water use data. In some instances, water users have been known to use domestic supplies for irrigation. The basic assumption in this study was that there are no restrictions on domestic water use, and therefore, all water supplies can be used for irrigation.

The base map extent was from the project area that includes Colona, Colorado in the south to Crawford, Colorado in the east and Leroux Creek in the north and Delta, Colorado in the northwest. These data provide the foundation to relate water supply issues such as quantity and quality to water demands for local and regional planning purposes in Delta and possibly Montrose Counties. Prior to the project, there was no comprehensive database that described water uses by type, extent, and/or spatial distribution.

The water supply and demand information obtained for this task were combined with soils information and spatially analyzed to determine where water availability is high and seleniferous and saline soils predominate. This type of analysis is crucial to focusing limited financial resources towards improving water systems for the maximum value (*e.g.*, cost-benefit ratio) to realize potential water savings through implementation of BMPs. Well-targeted BMPs can also maximize environmental benefits (*e.g.*, reducing selenium and salinity loads) while at the same time increasing water efficiencies.

C.2. Task 3 Results

The water companies that provide domestic water service in Delta County, Colorado were surveyed and are delineated on Figure 9. It can be seen that 50 separate service areas exist with many areas reliant upon cisterns and wells.

Each of the service areas were analyzed with respect to soil attributes within their boundaries. The results of these analyses are summarized and listed in Table 3 (by selenium potential mobilization), Table 6 (by salinity potential mobilization) and Table 10 (ranked by combined selenium and salinity potential mobilization).

Individual tables and GIS compatible shape files have been created for each of the 50 water companies in the study area that detail the soils and irrigation methods employed by company and district members. The tables are compiled and archived in Appendix J and are attached on the study Disc 1. The results are organized by folder and named by individual water company. In these folders reside GIS compatible shape files (geometry and tabular attribute information) and summary tables in CSV format files.

In terms of water quantity, there is limited water supply information at the water district level. Survey results from Task 3 and other studies are summarized on Table 7. These results indicate that Tri-County Water, the largest regional water provider, does not anticipate a gap in water supplies. However, firm water supplies in other service areas, like the Surface Creek Valley, may not be enough during drought conditions and water providers could face a cumulative supply gap of 1992 AF (CDM, 2009). Surface Creek Valley water districts include the Upper Surface Creek Domestic Water Users Association, Coalby Domestic Water Company, Town of Orchard City, Town of Cedaredge, domestic and household wells. Results indicate that only Coalby Domestic Water Company has sufficient water and may even have surplus water supply (184 AF) (CDM, 2009 Appendix C1). Results also indicate that the selenium mobilization potential in this water service area may not be significant (less than 50 irrigated acres). Increased water efficiencies gained from selenium and/or salinity control projects could improve water supplies in areas that may be facing future water supply shortages.

C.3. Task 3 Discussion and Conclusions

There are six water districts in Delta County that have significant selenium mobilization potential (over 100 irrigated acres): Tri-County, Cathedral, Bone Mesa, Gunnison Valley Domestic Pipeline, Crawford Mesa Water, and West Ext. as shown on Table 3. With the exception of Cathedral, generally 45-96% of the irrigated lands in these districts utilize potentially inefficient methods (*i.e.*,, furrow and flood). Resource managers should focus best management practices for selenium reduction and water use efficiency practices in these districts.

The results from Task 3 also suggest that salt mobilization potential (EC values greater than 8 millimhos/cm or µS/cm) from water districts in Delta County varies greatly from water company to water company. Although the EC data coverage is limited spatially, only a few districts, including Tri-County and Cathedral, had over 150 irrigated acres on land with high salt mobilization potential. Paonia, Deutsch Domestic, Fruitland Domestic Water, Crawford Mesa Water, South Lamborn Mesa, and Crawford each had over 20 irrigated acres of high salt mobilization potential (Table 6).

The water districts that have both a high selenium and salt mobilization potential also include Tri-County and Cathedral (Table 10). Unfortunately, due to the limited data available regarding intersected selenium and salinity mobilization potential, Table 10 may not be representative of local conditions. So, although irrigation practices in the Cathedral District are largely unclassified, it might be assumed that the majority are potentially inefficient, like many of the surrounding districts.

In general, the set of tools developed by this project should be used to address water supply and demand issues as well as salinity and selenium loading concerns. By examining selenium and salt mobilization potential, irrigation techniques and gaps in water supplies, planners can identify which water companies and or sub-watersheds have the most potential for efficiency improvements. This valuable information can be used to maintain agricultural productivity and ensure long term water security.

Future evaluations of localized supply gaps, similar to the synopsis of Surface Creek Valley water providers, are needed to better identify which providers could most increase their water supplies by addressing irrigation efficiencies. The supply data that is currently available is sparse and for some providers, contradictory (Table 7). For example, the 2004 SWSI report (CDM, 2004) identified future gap of 300 AF for the Town of Paonia. In contrast, the 2007 Water Providers survey (GBRT Appendix A, 2009) indicated that current supplies (279 MG) are more than adequate to meet forecasted 2030 demands (140 MG).

As previously mentioned, this report assumed that there are no restrictions on domestic water use, and therefore, it was assumed that all available water supplies could be used for irrigated agricultural purposes. In many cases, water users have been known to use domestic supplies for irrigation. Because of this simplifying assumption, it should be recognized that the project analysis may overestimate water use and contaminant mobilization. A more detailed evaluation of water availability for deliveries from ditch companies is recommended to further target districts or watersheds for irrigation-based efficiencies for more accurate results and planning purposes.

D. Task 4 Methods, Results and Conclusions: Compiling Water-Quality Data into a Comprehensive Publicly Available Database

D.1. Task 4 Methods

The final task of ***compiling water-quality data*** involved acquiring data from the study area from various sources and studies including, but not limited to USGS, Colorado School of Mines, Delta County, and the State of Colorado Department of Public Health.

Data was compiled into a comprehensive digital database in conjunction with the Southern Piceance Water-quality Database Development. The northern end of the grant study area was coincident with this project effort.

These water-quality data combined with the information developed in Tasks 1through 3 provided a robust data set for assessing water-quality conditions, identification of data gaps, planning water-conservation projects and for determining the effects of remediation.

D.1.1. Methods for the Development of the Common Data Repository and Water Resource Assessment for the Southern Piceance Basin, Western Colorado

The Southern Piceance Common Data Repository project kicked off during June 2008. Since the project started, the Data Repository got an initial redesign to help increase its utility. Once the Data Repository redesign was complete, data sources were contacted. Data was also cross-walked to the Repository design. The database and web interface are available at: http://rmgsc.cr.usgs.gov/cwqdr/default.aspx?project=SoPiceance. Additional data analysis and report writing is underway by the USGS. Regional monitoring strategies will be based on information learned during data analysis and conclusions of report writing.

D.1.1.a. Objectives

The objectives of the water-quality Data Repository were to:

- Develop a web-accessible common data repository that provides energy operators, researchers, consultants, agencies, and interested stakeholders equal access to the latest information;
- Evaluate existing water-resources data for uniformity (aggregate sites, combine parameters, etc.);
- Perform and publish a baseline assessment of available water-resources data; and
- Reduce duplication of effort by developing regional monitoring strategies that economically fill data gaps while still meeting regulatory requirements.

D.2. Task 4 Results

This project helped support database loading activities for the southern most portion of the Southern Piceance Study area. As of 2009, the entire study area included the following data:

- National Water Information System (NWIS): To date 47,819 NWIS records for 2320 sites in the Southern Piceance study area, 559 of which lie within Delta County. Agencies include U.S. Geological Survey, U.S. Forest Service, and U.S. Environmental Protection Agency

- U.S. Environmental Protection Agency STORET (short for STOrage and RETrieval): To date, 37,665 STORET records for 63 sites in Delta County have been compiled. Agencies include Colorado Department of Public Health and Environment (49 sites), Colorado River Watch, and U.S. Environmental Protection Agency National Asbestos Registry System (NARS).

- Local data sets were evaluated, including Delta County data. Local data also included industry data. Evaluation of local datasets included identification of all local datasets, conducting a data interview to determine the extent and purpose of data, cross-walking of local datasets of Repository design, and finally, loading the local datasets.

D.3. Task 4 Discussion and Conclusions

Although this task differs in scope and content from the previous tasks, it can potentially tie together the related water-quality and quantity data developed through this project.

The Common Data Repository can act as a first stop when identifying and quantifying selenium concentration data in Delta County, and will facilitate understanding selenium compliance issues. For example, planners interested in the potential impact of water-quality and quantity on water resources can extract and analyze data from the data repository. Managers and planners also can use the Common Data Repository for building predictive models that look at projected development in Delta County.

Various studies and efforts specific to Delta County will benefit from the comprehensive inventory and assessment of water-quality data. Future studies and even past projects can benefit from, and contribute data to, the Common Data Repository. For example, data generated from the USGS Rogers Mesa Ground Water Sustainability Study (Watts, 2008) and related water-quality data for the Rogers Mesa area will be added to the repository to help future investigations.

Additional concerns such as issues related to oil and gas development in Delta County can be investigated. Baseline information collected as part of this project and others can be used to estimate the potential impact of energy development (*e.g.,* oil, natural gas, and coal bed methane) activities on water resources and water quality.

Lastly, all data repository partners benefitted from an economy of scale, as each partner contributed a portion to this multi-million dollar project. Benefits of this larger project include a publically available web interface, online relational database, comprehensive data compilation, USGS report, and regional monitoring strategies. Because the overall Southern Piceance Study Area covers a large area in Western Colorado, it was useful to leverage this CIG project effort. By doing so, it ensured that water resource data from the Lower Gunnison River Basin was included as part of this larger assessment.

The relational water-quality data base is publicly accessible via a website interface at: (http://rmgsc.cr.usgs.gov/cwqdr/default.aspx?project=SoPiceance).

V. Outreach and Education

Public outreach activities for the *Employing Innovative Data* project during the grant contract period included:

- Presented project up-dates, reports, and technical review sessions for mapping and analytical products during regularly scheduled meetings of the Gunnison Basin/Grand Valley Selenium Task Forces;
- Presented results of Task 3 to Delta County Commission;
- Presented CIG project highlights during multiple STF and CRWCD public presentations (*e.g.*, 2009 Colorado Watershed Assembly Conference, Gunnison Basin Roundtable Selenium Presentation, CRWCD Quarterly Board Meetings, Montrose County Planning Commission Presentation, Colorado Basin Salinity Control Forum workgroup meetings and the "Climbing the Selenium Summit" public education forum);
- Public selenium and soils maps were distributed to Montrose County for use in their master plan update process; and
- Presented draft final results at a special joint meeting of the Grand Valley Selenium Task Force and Grand Valley Wise Water Use Council.

Post project (*i.e.*,, after grant contract period) outreach and education activities are scheduled to include:

- The development of a "Project Highlight" web page on the STF website (www.seleniumtaskforce.org) for this project which will include access to the final project report, selenium maps, and a link to the USGS data repository;
- Presentation of the project final results at the April 15th STF meeting in Delta, Colorado;
- Publicize through local media outlets – (*e.g.*, using press releases, interviews, and potential fact sheets);
- Collaboration with CSU Cooperative Extension (*e.g.*, in conjunction with local "Tri-River" water resource specialist and agronomist);
- Potential presentation and workshops with local conservation districts (*e.g.*, in conjunction with local Irrigation Water Management specialists and to the Board of Supervisors); and
- Publicize results on other applicable web sites (*e.g.*, CRWCD; www.ColoradoRiverDistrict.org, NRCS, CSU, etc.)

VI. CIG Project Financial Reporting

A. Original Project Budget Proposal

The *Employing Innovative Data* CIG project was awarded $75,000 by the NRCS. The project proposed to match the NRCS funding with $46,250 of cash funding from the Altria Foundation ($20,000) and Delta County, Colorado ($26,250). The project proponents (CRWCD) and local supporters (STF, Delta County, and Delta and Mesa Conservation Districts) pledged additional in-kind match of $57,250. The total project budget was estimated at $178,500 (see Project Budget Summary Proposal below).

Project Budget Summary Proposal:

CIG Project Funding:	$ 75,000
Cash Match:	$ 46,250
In-Kind:	$ 57,250
Total Project Budget:	$178,500

B. Final Project Budget Summary

When all invoices have been paid and all accounts reconciled, it is anticipated that the total NRCS reimbursement requests will total $75,000. Total cash match contributed to the project was $40,000. This included $20,000 from the Altria Foundation (including $2,000 administrative overhead to Painted Sky Resource Conservation and Development) and $20,000 from Delta County. The CRWCD contributed in-kind services in the amount of $73,275 including support of Selenium Task Forces' activities (see Final Project Budget Summary below). In-kind match activities included (but is not limited to) GIS support, data management and analysis, computer time, printing costs, map and figure development, technical assistance, administrative overhead, and project management. The final calculated total budget for the CIG project is $188,275, which is only slightly above (+5%) the original estimate.

Final Project Budget Summary:

CIG Award:	$ 75,000
Cash Match:	$ 40,000
In-Kind:	$ 73,275
Total Project Budget:	$188,275
(Additional Federal Contributions	$ 5,380)*

* USGS match from CRWCD cooperative program, not included as in-kind, nor total project cost (if included grand total = ***$193,655***)

VII. Concluding Remarks and Potential Future Steps

The integrated data and analysis products developed by this project and described in this document are only as good the ever-changing data upon which they are based. Therefore, it is important to recognize that this study represents a ‘snapshot’ in time and is essentially a “work in progress.” In other words, this project acts as a framework that will serve the reader and/or user best if it is continually refined and updated with spatial data layers or map data coverages that reflect the constant changes in local land and water uses.

Immediately after the final report is printed and the data archived, additional data will become available. Therefore if this project is to be a living document and effective tool, it must continue to function and grow as conditions change and as new data become available.

As changes occur in the study domain, additional queries and spatial analyses should be executed. This will help verify assumptions and will help calibrate the analytical results against available monitoring data of soils and water. The “integrated query engine” should be employed to analyze different groups of data as they become available for the study area. For example, it is anticipated that the soil salinity data coverage, as represented by electrical conductivity (EC), will be expanded when the NRCS digital product becomes available in winter 2010-11. When available, these data should be re-analyzed with the query tool to refine the preliminary results of salt mobilization potential and the relationship of salinity to selenium and irrigation practices.

It is incumbent upon entities responsible for land use planning (NRCS, counties, etc.) to maintain, update and make available parcel, land use and conservation practice information so that the query engine can be employed to provide the most up-to-date information. The clearly described procedures developed in this project provide the framework to ensure that the database can remain comprehensive and complete. Regular database updates should include recently installed water conservation practices and changes due to urbanization.

For best results, it is recommended that the data development and upload procedures developed in this project be adopted as a standard operating procedure by the NRCS. In addition, such procedures should be employed to describe and inventory conservation practices that have been applied by agencies other than NRCS and/or landowners and to inventory land use changes that have occurred since this project was completed (March 2010).

For additional planning purposes it is strongly encouraged and recommended that the following agencies coordinate and pool appropriate data coverage and utilize the developed tools and data from this project. This includes but is not limited to: local conservation districts, the NRCS, the Colorado Division of Water Resources, Gunnison Basin Roundtable, CRWCD, Selenium Task Force, Delta, Montrose, Ouray and Gunnison counties, and the USBOR.

The results of such future analyses will help further target areas for water conservation practices that can control both salt and selenium while helping to improve water use efficiency. Such strategic targeting should be used, as some have said, to not only effectively control “two contaminants for the price of one,” but also to stretch valuable limited water resources in water short areas.

Furthermore, the analytical toolset developed by this project can and should be utilized to further regional objectives. For example, this tool and related data could be used to comprehensively identify regions where site-specific conservation measures such as pressurized sprinklers could be employed as a system. In fact, a coalition of parties under the umbrella of the Selenium Task Force are currently developing specific spatial data related to topographic elevations and potential hydraulic pressures as part of a broad system optimization review and assessment. With such spatial data, the query engine can specifically locate parcels that meet threshold criteria such as desired hydraulic pressures and soil conditions. Such identified areas for potential sprinkler implementation would not require costly pumping and unnecessary energy consumption and would eliminate undesirable contaminant-laden runoff and loading.

Other future possible enhancements of the project and uses of the GIS developed for this project include temporal analysis. To date this tool has been used for spatial analysis only. With additional information and minor enhancements, this tool can be used to quantify the effect of changing land use on selenium and salinity loading. Temporal analysis could also be utilized to try to link age and initialization of water infrastructure improvements to observed loads of salt and selenium at gage locations. Although such investigations are outside the scope of this report, it is believed that this would be an excellent use of the data and query engine.

The wish list and potential applications for the data analysis tool don't stop there. With additional resources, this analysis tool and query engine could be hosted on a publicly available computer server and enhanced with a web-based interface to give greater public access. For example, it is possible this query engine could add value to the existing NRCS Soildatamart website: http://soildatamart.nrcs.usda.gov. Such an approach could not only lead the way to greater access, but it also could make this tool available for regional analysis (*i.e.*, on a major watershed basis).

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