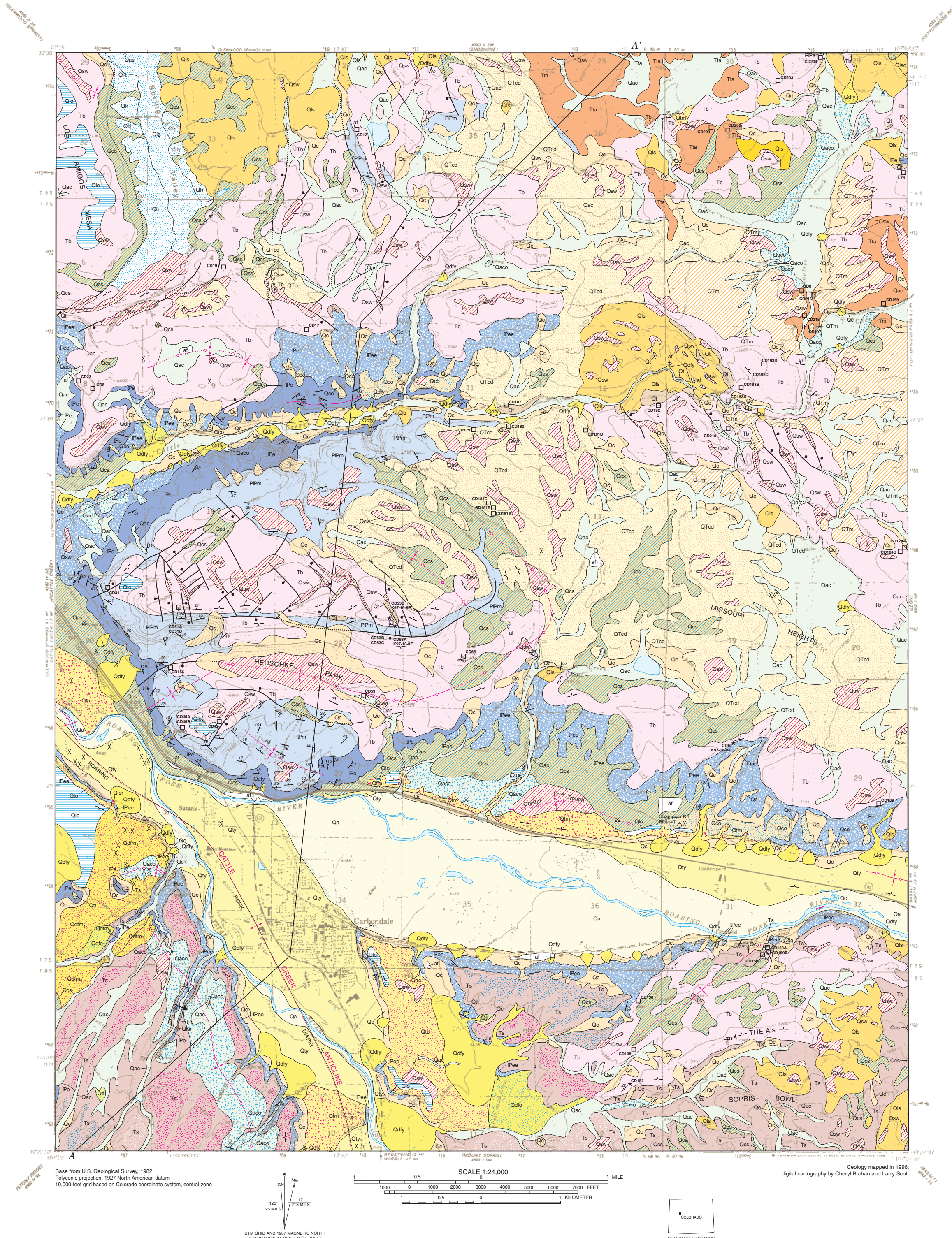
APPENDIX A: CARBONDALE AND LEON GEOLOGIC MAPS



Base from U.S. Geological Survey, 1982
Polyconic projection, 1927 North American datum
10,000-foot grid based on Colorado coordinate system, central zone

SCALE 1:24,000

Geology mapped in 1996;
digital cartography by Cheryl Brchan and Larry Scott

CONDENSED DESCRIPTION OF MAP UNITS

The complete description of map units and references is in the accompanying booklet.

SURFICIAL DEPOSITS

HUMAN-MADE DEPOSITS

af — **Artificial fill (latest Holocene)**

ALLUVIAL DEPOSITS—Sediments deposited in stream channels, flood plains, glacial outwash terraces, and sheetwash areas

Qa — **Stream-channel, flood-plain, and low-terrace deposits (Holocene and late Pleistocene)**—Mostly poorly sorted, clast-supported gravel in a sandy or silty matrix. Includes terraces up to about 12 ft above modern river level

Qsw — **Sheetwash deposits (Holocene and late Pleistocene)**—Pebbly silty sand, sandy silt, and clayey silt deposited in ephemeral and intermittent stream valleys, on gentle hillslopes, and in basinal areas

Qty — **Younger terrace alluvium (late Pleistocene)**—Mostly poorly sorted, clast-supported, locally bouldery, pebble and cobble gravel in a sand and silt matrix. Deposited as glacial outwash. Underlies terraces 14–45 ft above modern stream level. May include fine-grained overbank deposits

Qtm — **Intermediate terrace alluvium (late Pleistocene)**—Deposits texturally and depositionally similar to younger terrace alluvium (Qty). Underlies terraces 55–110 ft above modern streams

Qto — **Older terrace alluvium (late middle Pleistocene)**—Deposits texturally and depositionally similar to younger terrace alluvium (Qty). Clasts slightly to moderately weathered. Underlies terraces 160–200 ft above modern streams

MASS-WASTING DEPOSITS—Sediments on valley sides, valley floors, and hillslopes transported and deposited primarily by gravity

Qlsr — **Recent landslide deposits (latest Holocene)**—Includes active and recently active landslides with fresh morphological features. Heterogeneous unit consisting of unsorted, unstratified gravel, sand, and silt

Qc — **Colluvium (Holocene and late Pleistocene)**—Ranges from unsorted, clast-supported, pebble to boulder gravel in a sandy silt matrix to matrix-supported gravelly, clayey, sandy silt. Usually coarser grained in upper reaches of colluvial slopes and finer grained in distal areas

Qt — **Talus (Holocene and late Pleistocene)**—Angular, cobbly and bouldery rubble derived from outcrops of basalt or basalt-rich collapse debris (QTcd)

Qls — **Landslide deposits (Holocene and Pleistocene)**—Includes various types of landslide deposits. Consists of unsorted, unstratified gravel, sand, silt, clay, and rock debris. Ranges from recently active landslides to long-inactive Pleistocene landslides

Qco — **Older colluvium (Pleistocene)**—Texturally similar to colluvium (Qc), but found on drainage divides, ridge lines, and dissected hillslopes. Generally not subject to future deposition.

Qlso — **Older landslide deposits (Pleistocene)**—Landslide deposits dissected by erosion lacking distinctive landslide geomorphology. Similar in texture to landslide deposits (Qls)

ALLUVIAL AND MASS-WASTING DEPOSITS—Sediments in debris fans, stream channels, flood plains, and hillslopes along tributary valleys

Qdfy — **Younger debris-flow deposits (Holocene and late Pleistocene)**—Poorly sorted to moderately well-sorted, matrix- and clast-supported deposits ranging from gravelly clayey silt to sandy, silty, cobbly, pebbly, and bouldery gravel. Fan heads tend to be bouldery, while distal fan areas are finer grained. Includes debris-flow, hyperconcentrated-flow, fluvial, and sheetwash deposits on active fans and in some drainage channels

Qac — **Alluvium and colluvium, undivided (Holocene and late Pleistocene)**—Moderately well-sorted to well-sorted, stratified, interbedded sand, pebbly sand, and sandy gravel to poorly sorted, unstratified or poorly stratified, clayey, silty sand, bouldery sand, and sandy silt

Qcs — **Colluvium and sheetwash deposits, undivided (Holocene and late Pleistocene)**—Consists of colluvium (Qc) on steeper slopes and sheetwash deposits (Qsw) on flatter slopes. Mapped where contacts between the two types of deposits are very gradational and difficult to locate

Qdfm — **Intermediate debris-flow deposits (Holocene? and late Pleistocene)**—Similar in texture and depositional environment to younger debris-flow deposits (Qdfy), but found 20–100 ft above Edgerton Creek. Numeric subscripts on unit symbol indicate relative ages of deposits, with $Qdfm_1$ being older than $Qdfm_2$. Generally not subject to future deposition except during unusually large events or when drainage channels plug with debris and are overtopped

Qaco — **Older alluvium and colluvium, undivided (Pleistocene)**—Deposits texturally and depositionally similar to alluvium and colluvium (Qac) that underlie terraces and hillslopes above the floor of tributary valleys. Includes locally derived sediments and the Lava Creek B volcanic ash that were deposited within a large subsidence trough developed in oldest terrace alluvium (Qtt) southwest of Carbondale

Qdfo — **Older debris-flow deposits (Holocene? and Pleistocene)**—Remnants of inactive debris fans found on mesas and adjacent to stream drainages 20–160 ft above nearby streams. Similar in texture and genesis to younger debris-flow deposits (Qdfy)

EOLIAN DEPOSITS–sediments deposited by wind

Qlo — **Loess (late and middle? Pleistocene)**—Slightly clayey, sandy silt and silty, very fine to fine sand deposited by wind on level to gently sloping surfaces. Usually unstratified, friable, and plastic or slightly plastic when wet

LACUSTRINE DEPOSITS

Ql_2/Ql_1 — **Lacustrine deposits (Holocene and Pleistocene)**—Stratified deposits of medium- to dark-gray, organic-rich, silty clay and silt, yellow-brown clayey silt, and medium-red-brown, well-sorted, fine to coarse sand deposited in Spring Valley. Locally includes thick deposits of Lava Creek B ash. Numeric subscripts indicate relative ages of deposits. Ql_1 deposits are older than and lie 20–40 ft above Ql_2

UNDIFFERENTIATED SURFICIAL DEPOSITS

Q — **Surficial deposits, undifferentiated (Quaternary)**— Shown only on cross section. May include any of the above surficial deposits

ALLUVIAL, MASS-WASTING, LACUSTRINE, AND DELTAIC DEPOSITS

QTm — **Sediments of Missouri Heights (early Quaternary and/or late Tertiary)**—Locally derived gravel, sand, silt, and clay deposited in the Missouri Heights-Cottonwood Pass region in alluvial, mass-wasting, and either lacustrine or deltaic environments. Deposited in areas topographically lowered by collapse or subsidence related to dissolution or flow of salt deposits in the underlying Eagle Valley Evaporite. Overlies Miocene basaltic rocks (Tb) and Pliocene trachyandesitic rocks (Tta). Typically is less deformed than underlying rocks

COLLAPSE DEPOSITS

QTcd — **Collapse deposits (Pleistocene and late Tertiary)**—Heterogeneous deposits of slightly to highly deformed bedrock and overlying undeformed to moderately deformed surficial deposits. Locally includes large intact blocks of basalt (Tb) that are lowerd by collapse. Several flows in these blocks were geochemically analyzed. Formed in response to differential collapse resulting from dissolution of underlying evaporite

BEDROCK

Tta — **Trachyandesite undifferentiated (Pliocene)**—Multiple flows of basaltic trachyandesite and trachyandesite. Contains varying amounts of quartz, sanidine, and plagioclase xenocrysts

Tb — **Basalt (Miocene)**—Multiple flows of basalt, basaltic andesite, and basaltic trachyandesite. Petrographically most flows are olivine basalt; many are porphyritic. Groundmass predominantly plagioclase and pyroxene. Phenocrysts chiefly olivine and occasionally plagioclase. May contain rare xenocrysts or xenoliths of quartz and quartzite. Locally includes slightly indurated sediments

Ts — **Sedimentary deposits (Miocene)**—Mostly fluvial, clast-supported, silty, sandy pebble and cobble gravel, but locally contains silty and sandy deposits of probable alluvial and/or colluvial origin. Locally slightly to moderately indurated. Patterns indicate a younger erosion surface is present on the unit. Thin mantle of younger sediments locally underlies these erosion surfaces. Upper pattern indicates erosion surface is of late middle Pleistocene age; middle pattern indicates a middle and early? age; lower pattern indicates early Pleistocene and/or late Tertiary age

PPm — **Maroon Formation (Lower Permian? and Upper Pennsylvanian)**—Red beds of sandstone, conglomerate, mudstone, siltstone, and shale and minor, thin beds of gray limestone. Top of formation not exposed in quadrangle

Pe — **Eagle Valley Formation (Middle Pennsylvanian)**—Reddish-brown, gray, reddish-gray, and tan siltstone, shale, sandstone, gypsum, and carbonate rocks which are gradational between and intertonguing with the Maroon Formation and Eagle Valley Evaporite

Pee — **Eagle Valley Evaporite (Middle Pennsylvanian)**—Evaporitic sequence of gypsum, anhydrite, and halite interbedded with marine mudstone, fine-grained sandstone, thin carbonate beds, and black shale. Commonly intensely folded, faulted, and ductily deformed

MAP SYMBOLS

Contact—Dashed where approximately located; queried where very uncertain

Diapiric contact—Contact between evaporitic formations and overlying formations where the evaporitic rocks are intrusive or piercing into the overlying formations. Teeth are on the intrusive side of the contact

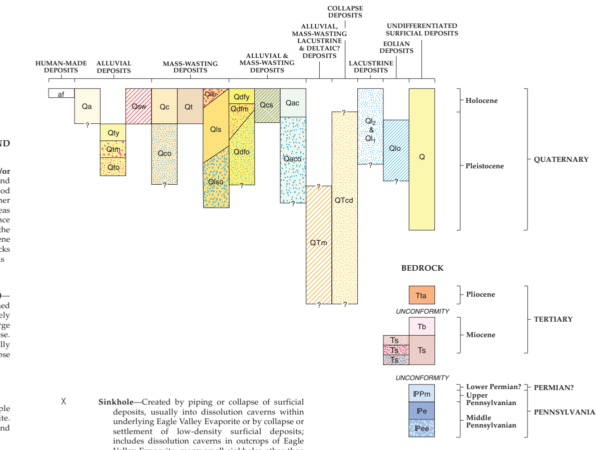
Fault—Dashed where approximately located; dotted where concealed; bar and ball on downthrown side; includes faults related to dissolution and flowage of evaporite

Anticline—Showing axial trace; dashed where approximately located; dotted where concealed; arrow on end of axis indicates direction of plunge

Syncline—Showing axial trace; dashed where approximately located; dotted where concealed; these structures may be synclinal sags, but they lack supportive evidence for this origin

Synclinal sag or subsidence trough—Showing axial trace of synclinal sag or subsidence trough related to evaporite tectonism; synclinal sags occur in bedrock, subsidence troughs are in river terraces and overlying deposits; dashed where approximately located; dotted where concealed; limbs of synclinal sags and subsidence troughs may be faulted; closed and nearly closed depressions in collapse debris (QTcd), which likely are at least in part sags or troughs, are not mapped

CORRELATION OF MAP UNITS



X — **Sinkhole**—Created by piping or collapse of surficial deposits, usually into dissolution caverns within underlying Eagle Valley Evaporite or by collapse or settlement of low-density surficial deposits; includes dissolution caverns in outcrops of Eagle Valley Evaporite; many small sinkholes other than those shown on the map are probably present in the quadrangle

Strike and dip of beds—Angle of dip shown in degrees; most attitudes in basalt and terrace deposits were measured on top of apparent surface

23 — **Inclined beds**

Vertical beds

Inclined beds—Showing approximate attitude of surface on terraces and basalt flows as determined from stereoscopic models set on a Kelsh PG-2 plotter; dip between 0 and 30

65 — **Strike and dip of foliation or flow layering in volcanic rocks**—Angle of dip shown in degrees

Zone of shearing and bleaching

Gravel pit

CD42 — **Location and identification number of rock sample with geochemical analysis (Unrah and others, 2001; Budahn and others, 2002). See table 1 and Appendix A in booklet**

CD53D — **Location and identification number of rock sample with geochemical analysis (Unrah and others, 2001; Budahn and others, 2002) and $^{40}Ar/^{39}Ar$ age date (Kunk and others, 2002). See Table 1 and Appendix A in booklet**

Outcrop of Lava Creek B volcanic ash—Ash correlated by Izett and Wilcox (1982)

A———A′ **Alignment of cross section**

Oil or gas exploration test hole—Plugged and abandoned; operator, well name, and total depth shown

ACKNOWLEDGEMENTS

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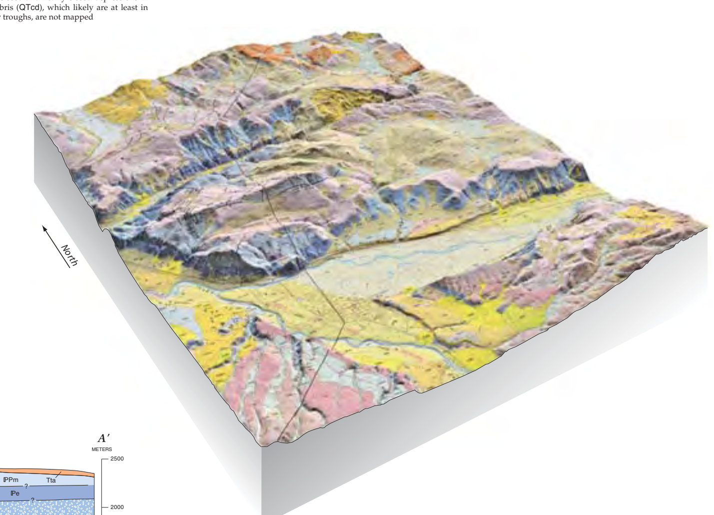
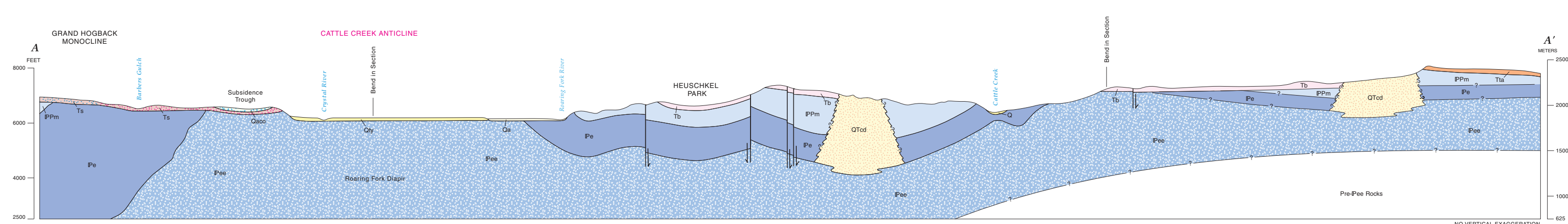




GEOLOGIC MAP OF THE CARBONDALE QUADRANGLE, GARFIELD COUNTY, COLORADO

By Robert M. Kirkham and Beth L. Widmann
2008

Bill Ritter Jr., Governor
State of Colorado

Harris D. Sherman, Executive Director
Department of Natural Resources

Vincent Matthews
State Geologist and Director
Colorado Geological Survey

Base from U.S. Geological Survey, 1987
Polyconic projection, 1927 North American datum
10,000-foot grid based on Colorado coordinate system, central zone

UTM GRID AND 1987 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24,000

QUADRANGLE LOCATION

Geology mapped in 1997
Digital map prepared by Cheryl Brchan and Larry Scott

CONDENSED DESCRIPTION OF MAP UNITS

The complete description of map units and references is in the accompanying booklet.

SURFICIAL DEPOSITS

HUMAN-MADE DEPOSITS

af — **Artificial fill (latest Holocene)**

ALLUVIAL DEPOSITS

Qa — **Modern stream-channel, flood-plain, and low-terrace deposits (Holocene and late Pleistocene)**—Mostly poorly sorted, clast-supported gravel in a sandy or silty matrix. May locally include clayey deposits in some subsidence troughs. Includes terraces up to about 12 ft above modern river level

Qsw — **Sheetwash deposits (Holocene and late Pleistocene)**—Pebbly silty sand, sandy silt, and clayey silt deposited in ephem-eral and intermittent stream valleys, on gentle hillslopes, and in basins

Qty — **Younger terrace alluvium (late Pleistocene)**—Mostly poorly sorted, clast-supported, locally bouldery, pebble and cobble gravel in a sand and silt matrix. Deposited as glacial outwash. Underlies terraces 15 to 52 ft above modern stream level. May include fine-grained overbank deposits

Qtm — **Intermediate terrace alluvium (late Pleistocene)**—Deposits texturally and depositionally similar to younger terrace alluvium (Qty). Underlies terraces 55 to 100 ft above modern streams

Qtt — **Oldest terrace alluvium (middle and early? Pleistocene)**—Deposits texturally and depositionally similar to younger terrace alluvium (Qty). Clasts moderately to highly wea-thered. A single small terrace remnant in the southeast corner of the quadrangle that is about 380 to 400 ft above the Frying Pan River

QTg — **High-level gravel (early Pleistocene and/or late Tertiary)** —Chiefly clast-supported, sandy, silty, cobble and pebble gravel occurring on a subtle ridge line about 1 mi east of El Jebel and about 1,300 to 1,350 ft above the Roaring Fork River. Clasts are moderately to very highly weathered

QTm — **Sediments of Missouri Heights (early Quaternary and/or late Tertiary)**—Locally derived gravel, sand, silt, and clay deposited in the Missouri Heights area in alluvial and colluvial environments. May include pediment deposits derived from and deposited on the sediments of Missouri Heights in area between Spring Park Reservoir and Cattle Creek. Deposited in topographic depressions created by evaporite tectonism. Overlies Miocene basaltic rocks (Tb). Typically is less deformed than underlying rocks. Occurs about 1,000 to 1,650 ft above the Roaring Fork River

MASS-WASTING DEPOSITS

Qlsr — **Recent landslide deposits (latest Holocene)**—Includes a recently active landslide near the northeast corner of the map with very fresh morphological features. Hetero-geneous unit consisting of unsorted, unstratified rock debris, sand, and silt

Qc — **Colluvium (Holocene and late Pleistocene)**—Ranges from un-sorted, clast-supported, pebble to boulder gravel in a sandy silt matrix to matrix-supported gravelly, clayey, sandy silt. Usually coarser grained in upper reaches of colluvial slope and finer grained in distal areas

Qt — **Talus (Holocene and late Pleistocene)**—Angular, cobbly and bouldery rubble derived from outcrops of basalt, trachy-andesite, sandstone, or basalt-rich landslide deposits

Qbf — **Boulder-field deposits (Holocene and late Pleistocene)**—Angular boulders and cobbles of basalt with little or no matrix on moderate to steep slopes. Commonly has an undulatory surface suggestive of flowage as a rock glacier or related to periglacial processes

Qls — **Landslide deposits (Holocene and Pleistocene)**—Includes various types of landslide deposits. Consists of unsorted, unstratified gravel, sand, silt, clay, and rock debris

Qco — **Older colluvium (Pleistocene)**—Texturally similar to colluvium (Qc), but found on drainage divides, ridge lines, and dissected hillslopes

Qlso — **Older landslide deposits (Pleistocene)**—Landslide deposits dissected by erosion and lacking distinctive landslide geomorphology. Similar in texture to landslide deposits (Qls)

ALLUVIAL AND MASS-WASTING DEPOSITS

Qdfy — **Younger debris-flow deposits (Holocene and late Pleistocene)**—Poorly sorted to moderately well-sorted, matrix- and clast-supported deposits ranging from gravelly clayey silt to sandy, silty, cobbly, pebbly, and bouldery gravel. Fan heads tend to be bouldery, while distal fan areas are finer grained. Includes debris-flow, hyper-concentrated-flow, fluvial, and sheetwash deposits on active fans and in some drainage channels. Numeric subscripts indicate relative ages of younger debris-flow deposits in the southwest corner of the quadrangle. Deposits labeled $Qdfy_1$ are younger than and derived from deposits labeled $Qdfy_2$

Qac — **Alluvium and colluvium, undivided (Holocene)**— Moderately well-sorted to well-sorted, stratified, interbedded sand, silt, pebbly sand, and sandy gravel to poorly sorted, unstratified or poorly stratified, clayey, silty sand, bould-ery sand, sandy silt, and silty clay

Qcs — Colluvium and sheetwash deposits, undivided (Holocene and late Pleistocene)—Consists of colluvium (Qc) on steeper slopes and sheetwash deposits (Qsw) on flatter slopes. Mapped where contacts between the two types of deposits are very gradational and difficult to locate. May locally include lacustrine deposits in large subsidence troughs

Qaco — **Older alluvium and colluvium, undivided (Pleistocene)**—Deposits texturally and depositionally similar to alluvium and colluvium (Qac) that underlie terraces and hillslopes ranging from about 10 to 60 ft above the floor of tributary valleys

Qcso — **Older colluvium and sheetwash deposits, undivided (Pleistocene)**—Deposits texturally and depositionally similar to colluvium and sheetwash (Qcs) that underlie surfaces 20 to 160 ft above adjacent stream beds

Qdfo — **Older debris flow-deposits (Pleistocene)**—Remnant of an inactive debris fan on a ridge line about 80 to 120 ft above the adjacent stream bed near the southeast corner of the quadrangle. Similar in texture and genesis to younger debris-flow deposits (Qdfy)

SINTER DEPOSITS

Qtu — **Tufa (Holocene and late Pleistocene?)**—Low-density, porous, calcium carbonate deposits precipitated from a mineral spring along the Basalt Mountain Fault immediately north of Cattle Creek

UNDIFFERENTIATED SURFICIAL DEPOSITS

Q — **Surficial deposits, undivided (Quaternary)**—Shown only on cross section

COLLAPSE DEPOSITS

QTcd — **Collapse deposits (Quaternary and late Tertiary)**—Heterogenous deposits of moderately to highly deformed bedrock and overlying undeformed to moderately deformed surficial deposits within the Carbondale Collapse Center. Locally includes large but displaced blocks of volcanic rocks. Formed in response to differential collapse resulting from dissolution and flow of underlying evaporite

BEDROCK

Tsp — **Trachyandesite of Spring Park (Pliocene)**—Medium-gray basaltic flows from an eruptive center about 0.5 mi east of the dam for Spring Park Reservoir. Petrographically the unit is xenocrystic olivine basalt, while geochemically it is a basaltic trachyandesite. Groundmass predominantly plagioclase and pyroxene. Contains sparse phenocrysts of mainly olivine and rare plagioclase. Locally contains abundant xenocrysts of quartz, sanidine, and plagioclase. Included in compositional group 6b′ of Budahn and others (2002). $^{40}Ar/^{39}Ar$ of 2.90 ± 0.02 Ma (Kunk and others, 2002)

Tspc — **Cinder deposits of Spring Park (Pliocene)**—Red and red-brown scoriaceous, unconsolidated cinder deposits associated with an eroded eruptive center about 0.5 mi east of the dam for Spring Park Reservoir. Petrographically the rock is olivine basalt with locally abundant xenocrysts of quartz, sanidine, and plagioclase. Geochemically these rocks are basaltic trachyandesite and are included in compositional group 6b′ of Budahn and others (2002). $^{40}Ar/^{39}Ar$ of 2.96 ± 0.02 Ma (Kunk and others, 2002)

Tcc — **Trachyandesitic flows of Cattle Creek (Pliocene)**—Medium- to dark-gray basaltic trachyandesite and trachybasalt flows along Cattle Creek between Shippes Draw and Sleepy Creek. Contains varying amounts of quartz and sanidine xenocrysts. Included in compositional group 6c of Budahn and others (2002). $^{40}Ar/^{39}Ar$ of 3.09 ± 0.02 Ma (Kunk and others, 2002)

Tccc — **Trachyandesite cinder deposits of Cattle Creek (Pliocene)**—Dark-gray to black, scoriaceous, cinder deposit exposed in cinder quarries along Cattle Creek between Shippes Draw and Sleepy Creek. Petrographically this deposit is a xenocrystic olivine basalt; geochemically it is basaltic trachyandesite. Included in compositional group 6c of Budahn and others (2002). $^{40}Ar/^{39}Ar$ of 3.01 ± 0.01 Ma (Kunk and others, 2002)

Tta — **Trachyandesitic flows, undifferentiated (Pliocene)**—Multiple flows of basaltic trachyandesite, trachyandesite, and trachybasalt. Contains varying amounts of quartz, sanidine, and plagioclase xenocrysts

Tsb — **Sediments of Basalt Mountain (Pliocene or Miocene)**—Chiefly medium-red-brown, weakly indurated, pebble and cobble gravel in a sandy or silty matrix. Locally bouldery. Deposited over basalt flows on northern edge of Basalt Mountain shield volcano by ancestral Cattle Creek

Tb — **Basaltic flows (Miocene)**—Multiple flows of basalt, basaltic andesite, and basaltic trachyandesite. Petrographically most flows are olivine basalt; many are porphyritic. Groundmass predominantly plagioclase and pyroxene. Phenocrysts chiefly olivine and occasionally plagioclase. May contain rare xenocrysts or xenoliths of quartz and quartzite. Locally includes slightly indurated sediments. Included in compositional groups 1b, 1c, 2b′, 4b, and 4b′ of Buhdan and others (2002). $^{40}Ar/^{39}Ar$ age dates range from 7.75 ± 0.03 Ma to 10.84 ± 0.06 Ma.

Ts — **Sedimentary deposits (Miocene)**—Mostly fluvial, clast-supported, silty, sandy pebble and cobble gravel but locally contains silty and sandy deposits of probable alluvial and/or colluvial origin. Locally slightly to moderately indurated

Km — **Mancos Shale (Upper Cretaceous)**—Light- to dark-gray, carbonaceous, silty to sandy shale and thin bentonite beds, gray limestone, and light- to medium-gray, grayish-yellow-weathering, clayey sandstone. Includes the Fort Hays Limestone Member, a thick-bedded, coarse-grained, gray limestone

Kd — **Dakota Sandstone (Lower Cretaceous)**—Light-gray to tan, medium- to very coarse-grained, quartzose sandstone and conglomeratic sandstone interbedded with carbonaceous siltstone, sandstone, and shale. May include Burro Canyon Formation in southern part of quadrangle

Jm — **Morrison Formation (Upper Jurassic)**—Pale-green, greenish-gray, and maroon variegated siltstone and claystone, buff to tan sandstone, and gray limestone. A thick-bedded, coarse-grained, oolitic, tan- and white-weathering, medium-dark-gray limestone at the base of the formation overlies the Entrada Sandstone

Je — **Entrada Sandstone (Upper Jurassic)**—Light-gray, tan, and white, medium- to very fine-grained, well-sorted sand-stone with large-scale crossbedding. Weakly to mod-erately indurated

₮c — **Chinle Formation (Upper Triassic)**—Thin, even-bedded, and structureless beds of dark-reddish-brown, orangish-red, and purplish-red, calcareous siltstone and mudstone and scattered thin lenses of light-purplish-red and gray lime-stone and limestone-pebble conglomerate. Locally in-cludes a thin, basal conglomeratic sandstone

₮Psb — **State Bridge Formation (Lower Triassic and Permian)**—Reddish-orange, grayish-red, and pale-reddish-pink silty sandstone, clayey siltstone, arkosic sandstone, and conglomeratic sandstone. Includes lenses of sandy dolo-mite and limestone of the South Canyon Creek Dolomite Member that are up to 18 inches thick and occur about 200 ft above the base of the formation. Sandstone beds are well sorted, equigranular, and have rounded to sub-rounded sand grains with a high degree of sphericity

₮Pcs — **Chinle and State Bridge Formations, undivided (Triassic and Permian)**

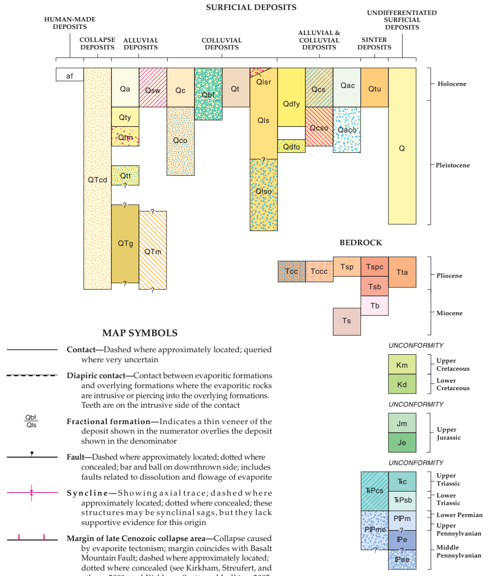
PIPm — **Maroon Formation (Lower Permian? and Upper Pennsylvanian)**—Red beds of sandstone, conglomerate, mudstone, siltstone, and shale and minor, thin beds of gray limestone

IPe — **Eagle Valley Formation (Middle? Pennsylvanian)**—Reddish-brown, gray, reddish-gray, and tan siltstone, shale, sandstone, gypsum, and carbonate rocks which are gradational between and intertonguing with the Maroon Formation and Eagle Valley Evaporite

PIPme — **Maroon and Eagle Valley Formations, undivided (Lower Permian and Upper and Middle? Pennsylvanian)**

IPee — **Eagle Valley Evaporite (Middle Pennsylvanian)**—Evaporitic sequence of gypsum, anhydrite, and halite interbedded with mudstone, fine-grained sandstone, thin carbonate beds, and black shale. Commonly intensely folded, faulted, and ductily deformed

CORRELATION OF MAP UNITS



MAP SYMBOLS

Contact—Dashed where approximately located; queried where very uncertain

Diapiric contact—Contact between evaporitic formations and overlying formations where the evaporitic rocks are intrusive or piercing into the overlying formations. Teeth are on the intrusive side of the contact

Qbf/Qls — **Fractional formation**—Indicates a thin veneer of the deposit shown in the numerator overlies the deposit shown in the denominator

Fault—Dashed where approximately located; dotted where concealed; bar and ball on downthrown side; includes faults related to dissolution and flowage of evaporite

Syncline—Showing axial trace; dashed where approximately located; dotted where concealed; these structures may be synclinal sags, but they lack supportive evidence for this origin

Margin of late Cenozoic collapse area—Collapse caused by evaporite tectonism; margin coincides with Basalt Mountain Fault; dashed where approximately located; dotted where concealed (see Kirkham, Streufert, and others, 2001; and Kirkham, Scott, and Judkins, 2002, for description of collapse)

Synclinal sag or subsidence trough—Showing axial trace of synclinal sag or subsidence trough related to evaporite dissolution and/or flowage; synclinal sags occur in bedrock, subsidence troughs are found on river terraces; dashed where approximately located; dotted where concealed; limbs of synclinal sags and subsidence troughs may be faulted; closed and nearly closed depressions in collapse debris (QTcd), which likely are at least in part sags or troughs, are not mapped

Sinkhole—Created by piping or collapse of surficial deposits, usually into dissolution caverns within underlying Eagle Valley Evaporite or by collapse or settlement of low-density surficial deposits; includes dissolution caverns in outcrops of Eagle Valley Evaporite; "x" denotes one or more small sinkholes; many small sinkholes other than those shown on the map are probably present in the quadrangle

55 — **Strike and dip of beds**—Angle of dip shown in degrees; most attitudes in basalt were measured on top of apparent surface

Inclined beds—Showing approximate attitude of surface on basalt flows as determined from stereoscopic models set on a Kelsh PG-2 plotter; dip between 0° and 30°

65 — **Strike and dip of foliation in extrusive flow rocks**—Includes measurements on flows within collapse debris (QTcd). Angle of dip shown in degrees

Linear ridge within landslide on west side of Basalt Mountain— Ridge is underlain by tilted slump blocks of basalt that range from nearly intact to very rubbly flows

Linear swale of uncertain origin along the Basalt Mountain Fault

Approximate boundary of a subsidence trough developed in surficial deposits—Resultant from collapse into voids created by dissolution or flowage of underlying evaporitic rocks. Queried where very approximate

Approximate boundary of a lava-filled crater at the crest of Basalt Mountain—Exposed part of crater has been filled with two thick, ponded lava flows. The lower flow averages about 200 to 250-ft thick and the upper flow averages about 40 to 50-ft thick

Adit

Gravel pit

Cinder quarry

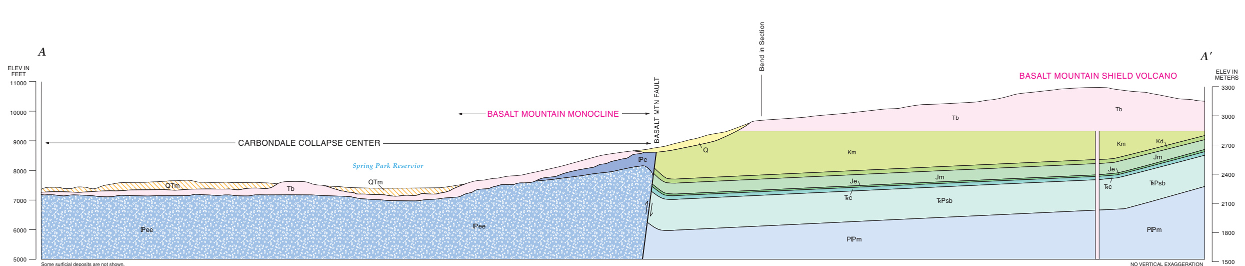
L-23 — **Location and identification number of geochemical rock sample—(Table l and Appendix A in booklet; Unruh and others, 2001; Budahn and others, 2002)**

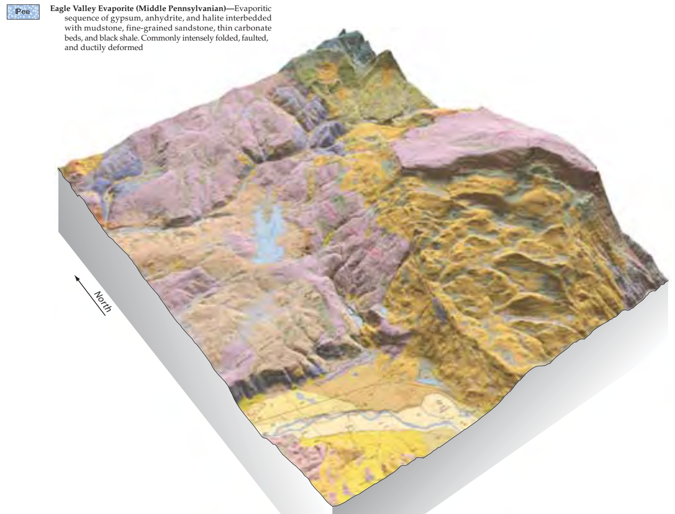
L-39 — **Location and identification number of rock sample with geochemical analysis (Unruh and others, 2001; Budahn and others, 2002) and $^{40}Ar/^{39}Ar$ age date (Kunk and Snee, 1998; Kunk and others, 2001). See Table 1 and Appendix A in booklet**

A ——— A′ — **Alignment of cross section**

ACKNOWLEDGEMENTS

This geologic map was funded in part by the U.S. Geological Survey National Geologic Mapping Program and by State of Colorado General Funds and Colorado Department of Natural Resources Severance Tax Operational Funds.





GEOLOGIC MAP OF THE LEON QUADRANGLE, EAGLE AND GARFIELD COUNTIES, COLORADO

By Robert M. Kirkham, Beth L. Widmann, and Randall K. Streufert

2008

Bill Ritter Jr., Governor
State of Colorado

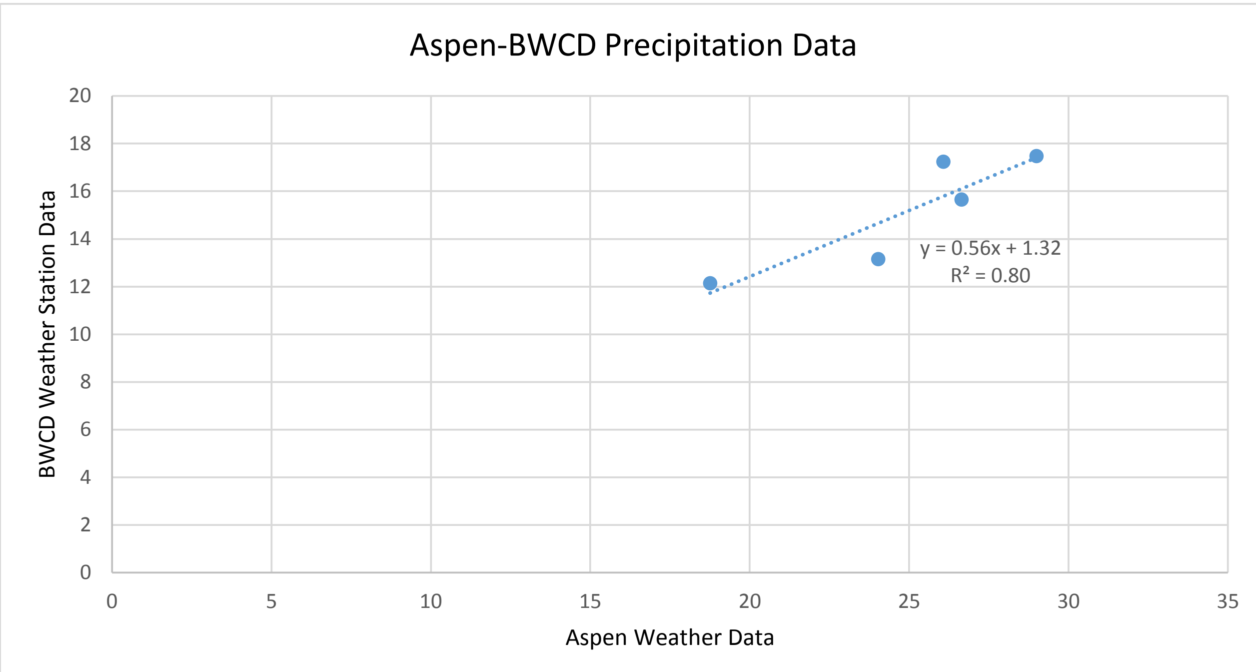
Harris D. Sherman, Executive Director
Department of Natural Resources

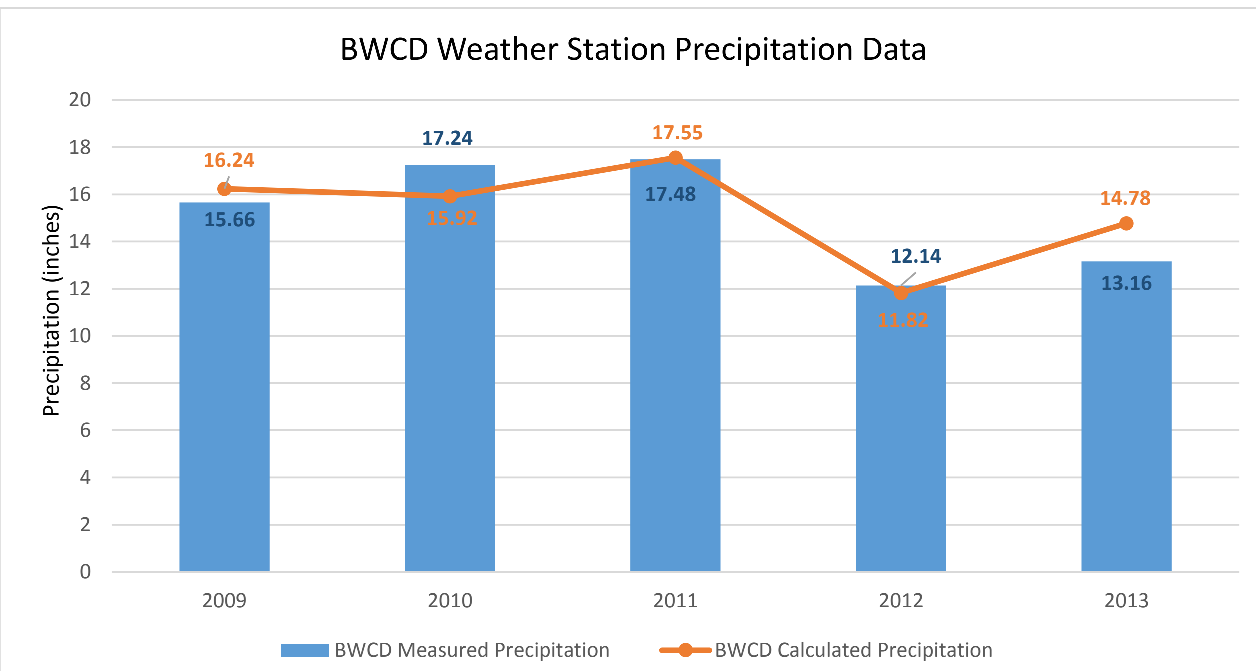
Vincent Matthews
State Geologist and Director
Colorado Geological Survey

APPENDIX B: PRECIPITATION ANALYSIS RESULTS

Total Annual Precipitation Data

Water Year	Weather Station BWCD	Weather Station Aspen	BWCD Calculated	Percent Difference
2009	15.66	26.64	16.24	103.7%
2010	17.24	26.07	15.92	92.3%
2011	17.48	28.99	17.55	100.4%
2012	12.14	18.76	11.82	97.4%
2013	13.16	24.03	14.78	112.3%
			Ave.	101.2%

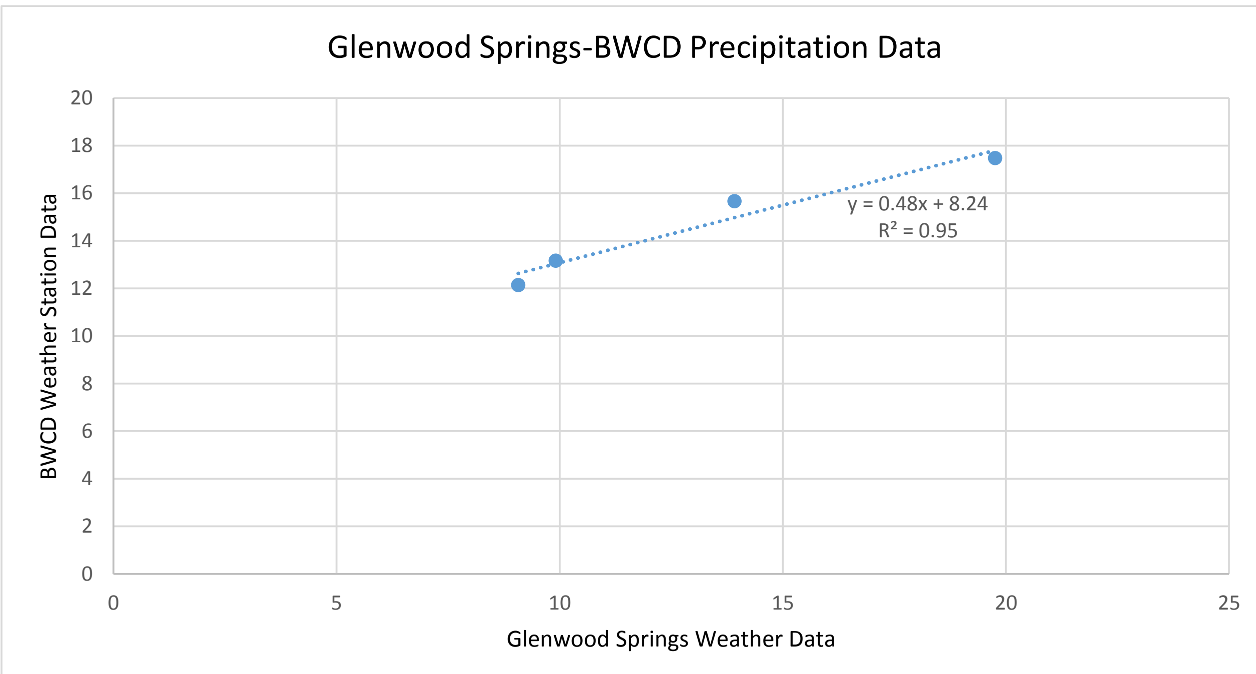


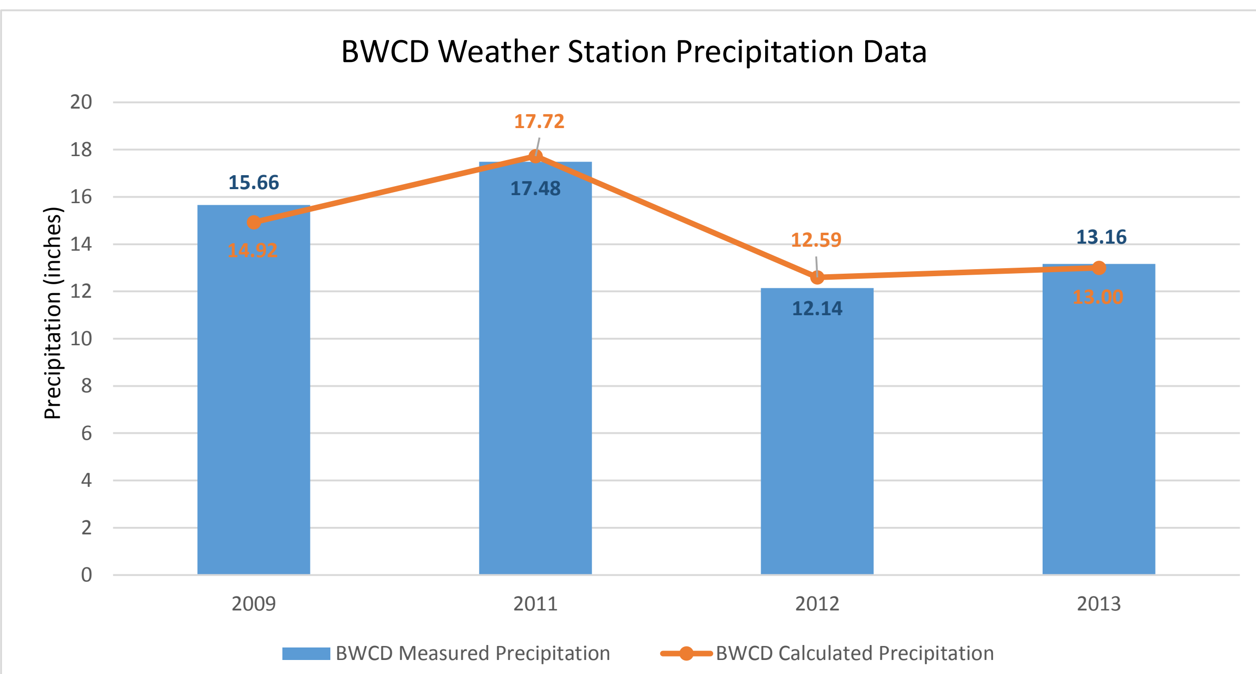


Total Annual Precipitation Data

Water Year	Weather Station BWCD	Weather Station Glewood	BWCD Calculated	Percent Difference
2009	15.66	13.92	14.92	95.3%
2011	17.48	19.76	17.72	101.4%
2012	12.14	9.07	12.59	103.7%
2013	13.16	9.91	13.00	98.8%
			Ave.	99.8%

*2010 Outlier data removed





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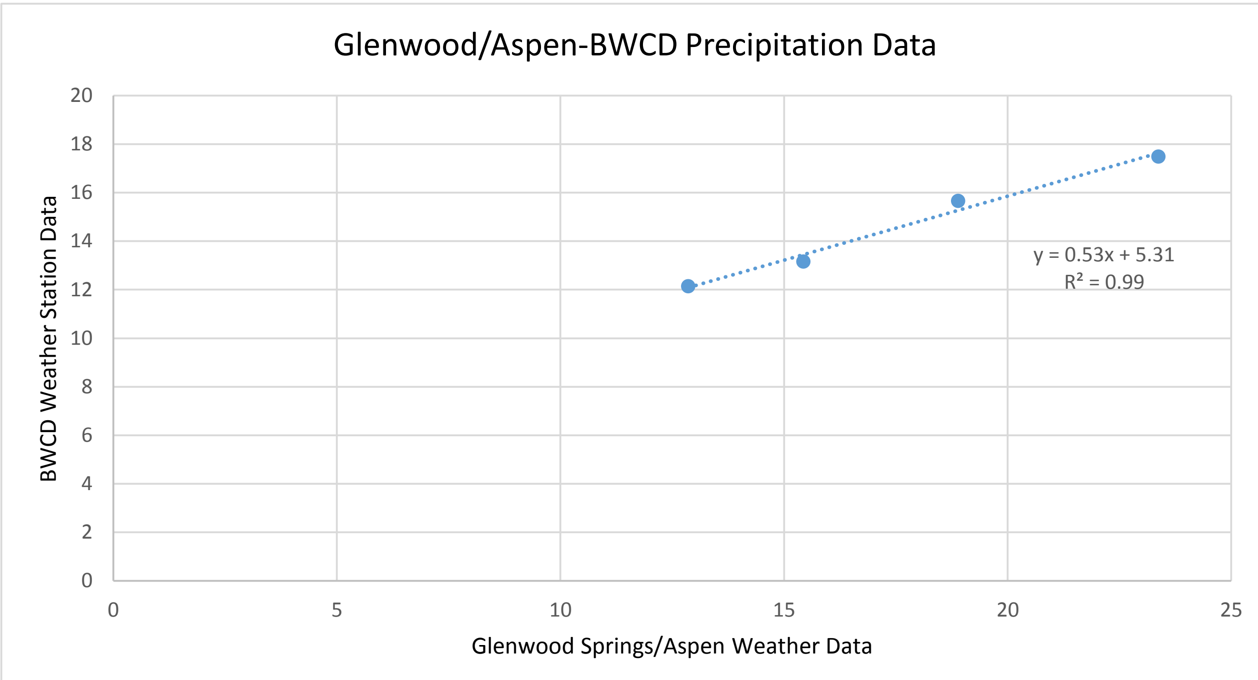
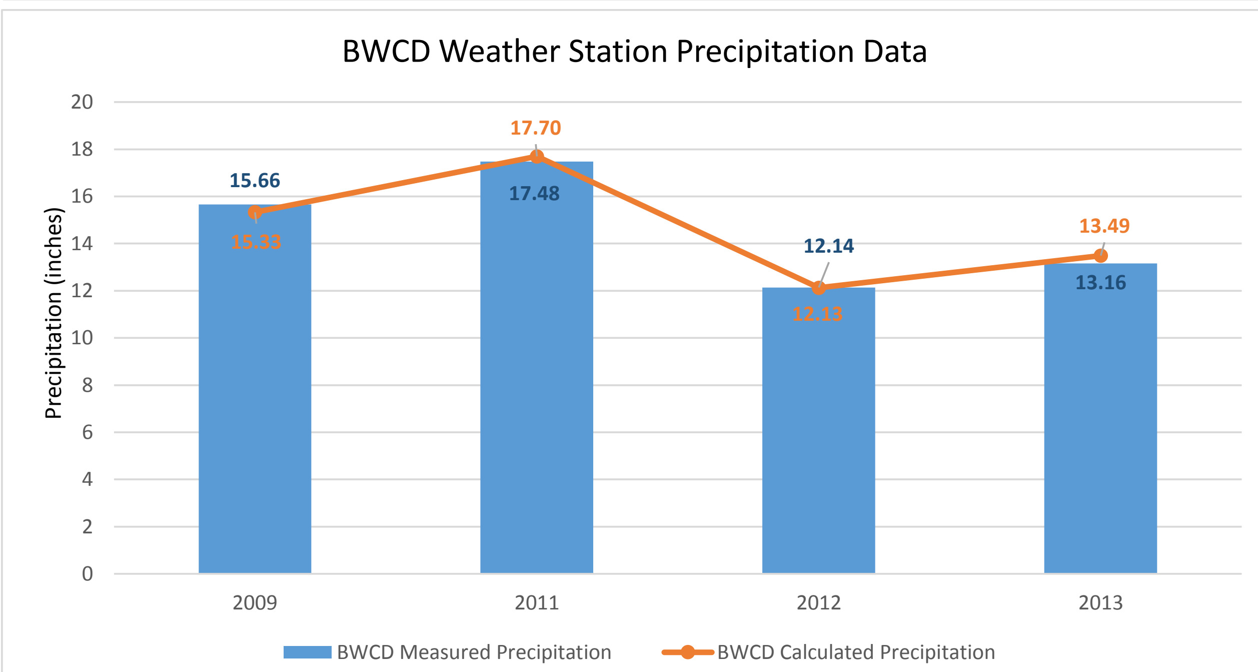
Total Annual Precipitation Data

Water Year	BWCD	Aspen Glewood	BWCD Calculated	Percent Difference
	Weather Station			
2009	15.66	18.90	15.33	97.9%
2011	17.48	23.37	17.70	101.2%
2012	12.14	12.86	12.13	99.9%
2013	13.16	15.44	13.49	102.5%
			Ave.	100.4%

*2010 Outlier data removed





Aspen Weather Station Data

Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1980	2.25	2.00	1.79	2.11	2.54	2.63	2.08	1.26	0.52	1.17	0.85	1.61	20.80
1981	1.38	1.45	0.28	0.89	3.64	1.63	3.45	0.71	2.35	1.38	1.56	2.03	20.75
1982	1.23	3.53	2.6	0.83	3	1.61	2.05	1.02	1.69	0.95	3.35	1.58	23.44
1983	2.39	0.92	0.47	1.6	3.68	2.8	4.75	0.89	0.82	1.78	0.61	1.75	22.46
1984	5.05	4.88	0.64	1.78	4.07	2.71	1.45	4.35	3.2	3.46	1.14	5.47	38.20
1985	1.5	3.1	0.33	2.4	4.1	2.75	2.3	1	2.43	0.61	5.08	3.2	28.80
1986	4.3	0.89	1.79	2.11	1.3	2.63	1.54	1.63	2	2.45	2.95	0.75	24.33
1987	0.15	0.85	1.55	2.5	2.11	1	1.45	2.53	1.25	2.09	0.62	1.4	17.50
1988	1.62	2.17	2.55	0.95	1.56	1.21	1.95	1.86	0.84	0.75	1.85	0.22	17.53
1989	3.6	1.54	1.5	3.78	3.2	2.21	1	0.4	1.73	1.19	0.99	0.44	21.58
1990	2	2.00	0.86	1.17	1.82	3.8	0.9	0.5	2.3	0.99	1.78	3.42	21.54
1991	2.5	1.81	1.35	1.22	3.23	3.28	1.39	2.22	1.45	1.59	1.7	2.2	23.94
1992	1.76	0.56	1.19	0.98	3.52	1.46	3.09	0.89	1.89	1.73	1.91	0.98	19.96
1993	4.01	1.43	1.67	4.08	2.54	3.43	2.43	1.13	1.64	1.82	1.99	2.71	28.88
1994	2.25	1.49	0.98	2.97	1.62	2.55	1.08	0.83	0.32	1.71	1.01	2.05	18.86
1995	3.06	2.00	1.71	3.84	5.54	3.26	5.41	2.4	2.77	1.46	2.09	1.43	34.97
1996	1.87	2.00	2.54	4.73	2.54	3.12	1.31	1.2	1.8	0.56	2.32	3.55	27.54
1997	3.03	2.82	3.4	1.58	1.93	3.67	2.64	1.2	0.4	1.78	2.62	3.3	28.37
1998	1.89	0.99	1.77	2.54	3.16	3.05	0.56	1.34	4.26	1.1	0.98	1.94	23.58
1999	3.31	1.79	2.58	2.55	1.45	3.88	3.72	1.08	2.63	2.75	2.67	1.49	29.90
2000	0.42	1.24	2.31	2.3	2.81	1.69	2.04	1.06	1.79	1.8	2.01	0.5	19.97
2001	2.42	1.28	0.78	1.21	1.67	2.59	2.74	1.6	2.29	2.97	2.12	1.03	22.70
2002	2.39	1.29	1.71	1.39	2.2	1.42	0.21	0	1.69	1.22	3.29	1.8	18.61
2003	2.55	1	0.55	1.62	2.97	2.47	2.91	1.35	0.49	0.9	2.7	0.5	20.01
2004	3	2.3	1.91	2.37	0.89	1.73	1.03	1.59	1.35	0.79	2.59	1.69	21.24
2005	2.99	1.3	3.89	1.98	1.68	2.48	1.3	1.76	1.84	2.12	2.65	3.51	27.50
2006	2.41	2.69	2.75	1.14	2.15	0.99	1.06	0.3	3.54	1.52	2.74	2.56	23.85
2007	2.65	1.41	1.93	2.11	1.85	1.78	2.03	0.87	3.74	1.2	2.74	2.95	25.26
2008	0.46	5.28	4.24	3.16	3.55	2.51	2.56	0.6	0.9	1.52	0.83	0.71	26.32
2009	2.12	4.62	2.85	1.27	2.63	2.84	2.54	1.47	2.06	1.06	1.42	1.76	26.64
2010	1.37	1.91	0.86	2.48	2.25	3.97	1.7	1.55	1.92	4.92	0.71	2.43	26.07
2011	2.39	2.56	1.84	2.74	2.89	6.38	2.47	0.81	3.17	0.85	0.92	1.97	28.99
2012	1.71	0.76	2.38	1.64	0.55	1.76	1.07	1.26	2.39	2.29	1.45	1.5	18.76
2013	0.44	2.11	1.22	1.67	1.83	3.99	2.41	0.12	2.41	2.08	4.27	1.48	24.03
Average	2.25	2.00	1.79	2.11	2.54	2.63	2.08	1.26	1.94	1.66	2.02	1.94	24.20

Notes:

The 1980-2013 average was used in months with missing data

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Glenwood Springs Weather Station Data

Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1980	1.29	1.21	2.65	2.73	1.78	0.47	2.41	0.05	1.97	0.90	1.92	2.57	19.94
1981	0.86	0.90	0.73	1.16	2.01	1.15	1.76	1.42	2.59	1.53	1.47	4.02	19.60
1982	0.98	2.16	2.60	0.69	2.83	0.37	1.53	0.48	0.79	1.14	4.40	1.86	19.83
1983	1.28	0.51	0.55	1.59	1.61	2.41	3.61	2.80	1.54	1.42	0.49	1.44	19.25
1984	2.69	3.61	0.42	0.23	1.33	1.97	2.33	0.98	1.63	2.02	0.66	4.21	22.07
1985	0.75	2.14	1.00	1.16	3.24	3.13	1.67	1.13	1.76	1.23	3.61	2.48	23.30
1986	2.06	1.81	0.58	1.93	1.63	1.53	1.73	0.89	0.99	0.85	3.09	2.41	19.50
1987	2.89	0.56	1.22	1.15	1.00	1.33	1.73	0.46	1.55	1.07	1.22	1.77	15.95
1988	1.33	1.53	2.49	0.81	0.97	0.93	1.73	0.22	0.25	2.51	2.16	0.27	15.20
1989	1.91	1.01	1.34	2.79	0.65	1.09	0.38	0.37	0.80	1.25	1.89	1.73	15.21
1990	0.67	0.62	0.34	0.57	1.02	1.63	1.13	0.86	1.89	0.61	1.45	2.74	13.53
1991	1.15	1.09	0.77	0.20	2.03	1.03	0.82	2.75	0.86	1.21	1.30	1.50	14.71
1992	0.98	0.38	0.35	1.16	1.27	0.08	2.82	0.38	1.17	1.13	1.61	1.71	13.04
1993	2.03	0.51	1.61	2.65	2.60	3.00	3.58	1.07	0.50	1.55	1.08	1.74	21.92
1994	0.67	0.40	0.25	1.23	0.38	1.55	0.41	0.77	0.65	1.29	1.60	2.89	12.09
1995	2.48	1.09	1.51	2.54	1.67	1.81	5.82	1.90	2.04	0.88	1.81	1.15	24.70
1996	2.55	2.81	4.44	2.72	0.67	1.96	1.21	0.74	1.18	0.30	2.92	2.33	23.83
1997	1.61	2.52	3.84	0.40	0.77	1.84	2.36	1.32	1.65	1.67	4.03	2.82	24.83
1998	1.39	0.80	2.19	1.44	2.05	1.82	0.44	2.23	2.11	1.79	1.35	2.67	20.28
1999	0.56	0.61	0.97	0.91	0.60	3.97	3.39	1.02	0.50	1.98	2.28	0.45	17.24
2000	0.13	0.99	1.99	0.10	1.10	0.36	1.08	0.85	0.75	1.14	0.64	0.10	9.23
2001	0.79	1.20	0.55	0.89	1.00	1.05	1.65	0.60	1.05	1.13	1.70	1.74	13.35
2002	1.25	1.15	0.19	0.31	0.61	1.24	0.00	0.00	0.45	0.73	3.49	1.91	11.33
2003	1.66	0.38	0.00	0.83	0.79	0.88	3.39	0.47	0.69	1.19	2.26	0.00	12.54
2004	0.88	1.15	0.34	0.42	0.77	2.84	0.82	1.14	0.27	0.00	1.62	1.28	11.53
2005	1.30	1.12	1.20	0.98	1.21	1.54	0.62	0.89	0.00	0.77	2.91	1.60	14.15
2006	1.25	0.83	0.93	0.11	3.11	1.59	0.81	0.34	1.16	2.85	1.46	3.82	18.26
2007	0.92	0.30	0.51	0.67	0.70	0.38	0.24	0.23	0.00	1.18	2.88	0.70	8.71
2008	0.88	0.61	1.75	1.61	1.73	0.92	1.52	0.32	0.49	0.75	1.49	0.19	12.26
2009	1.00	1.38	0.84	0.93	0.43	0.89	3.00	1.85	0.66	0.77	1.15	1.02	13.92
2010	0.70	1.32	0.69	0.98	0.00	1.55	0.38	0.85	1.08	1.58	0.81	1.66	11.60
2011	0.83	1.35	0.31	0.86	1.73	3.83	2.74	0.66	3.28	1.61	1.10	1.46	19.76
2012	0.40	0.12	0.76	1.21	0.35	1.43	0.18	0.19	1.87	1.22	1.00	0.34	9.07
2013	0.26	0.76	0.93	0.10	1.36	1.23	1.45	0.00	0.66	1.18	1.43	0.55	9.91
Average	1.25	1.14	1.20	1.12	1.32	1.55	1.73	0.89	1.14	1.25	1.89	1.74	16.22

Notes:

The 1980-2013 average was used in months with missing data

When data from the NOAA weather station was missing, available data from Weather Underground South Glenwood Springs Data was used

BWCD Weather Station Data

Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
2008										0.92	0.94	0.57	
2009	0.78	2.79	1.31	0.98	1.59	2.03	2.03	1.74	1.06	0.25	0.08	1.02	15.66
2010	0.13	1.89	1.22	1.84	1.06	2.54	1.03	1.54	1.41	1.73	0.84	2.01	17.24
2011	1.09	0.82	1.03	1.43	1.53	3.12	2.05	0.55	1.93	0.88	1.27	1.78	17.48
2012	1.18	0.27	1.17	1.45	0.73	1.19	0.64	0.22	2.26	1.35	1.24	0.44	12.14
2013	1.10	1.54	1.34	0.19	0.77	1.32	1.41	0.01	1.09	0.31	2.52	1.56	13.16
Average	0.86	1.46	1.21	1.18	1.14	2.04	1.43	0.81	1.55	0.90	1.19	1.36	15.14

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APPENDIX C: IRRIGATION DIVERSION RECORDS

Missouri Heights Park Ditch Diversion Records

Diversion Summary in Acre Feet

YEAR	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1994	0	0	0	0	0	0	136	301	244	66	81	39	**867**
1995	0	0	0	0	0	0	72	246	366	191	99	233	**1207**
1996	0	0	0	0	0	0	26	236	163	186	127	209	**947**
1997	27	0	0	0	0	0	127	242	139	402	351	381	**1669**
1998	0	0	0	0	0	0	246	295	173	234	282	0	**1231**
1999	0	0	0	0	0	0	44	130	122	162	110	25	**592**
2000	0	0	0	0	0	0	86	93	63	53	57	75	**428**
2001	0	0	0	0	0	0	167	84	141	152	134	139	**816**
2002	0	0	0	0	0	4	85	40	14	17	22	11	**193**
2003	0	0	0	0	0	0	162	136	79	20	23	23	**444**
2004	0	0	0	0	0	34	205	93	42	15	60	69	**517**
2005	0	0	0	0	0	0	234	223	169	36	90	8	**761**
2006	0	0	0	0	0	0	165	183	151	101	127	73	**801**
2007	0	0	0	0	0	0	17	91	98	64	32	24	**327**
2008	0	0	0	0	0	0	48	220	163	131	35	89	**687**
2009	0	0	0	0	0	0	117	256	185	31	159	0	**747**
2010	0	0	0	0	0	0	27	277	149	62	107	184	**805**
2011	0	0	0	0	0	0	0	142	166	98	89	0	**495**
2012	0	0	0	0	0	76	141	156	37	74	61	61	**605**
2013	0	0	0	0	0	0	104	90	70	45	54	64	**426**
1994-2008 Average	**2**					**3**	**121**	**174**	**142**	**122**	**109**	**93**	**766**
2009-2013 Average						**15**	**78**	**184**	**121**	**62**	**94**	**62**	**616**

Note: Diversions were reduced to 26.6% (133 acres out of 500 acres) of total diversions to account for only diversions that irrigated fields within the Missouri Heights Study Area

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Missouri Heights C and M Ditch Diversion Records

Diversion Summary in Acre Feet

YEAR	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1994	0	0	0	0	0	0	359	318	139	29	123	121	**1088**
1995	53	0	0	0	0	0	353	477	169	226	156	152	**1587**
1996	0	0	0	0	0	0	41	448	220	148	65	116	**1037**
1997	71	0	0	0	0	0	177	264	189	84	0	0	**784**
1998	0	0	0	0	0	0	311	408	358	162	86	0	**1326**
1999	0	0	0	0	0	99	487	405	235	144	141	62	**1572**
2000	0	0	0	0	0	0	166	268	106	21	10	17	**587**
2001	0	0	0	0	0	0	204	284	120	72	55	5	**739**
2002	0	0	0	0	0	24	235	117	0	0	0	0	**375**
2003	0	0	0	0	0	0	413	336	191	18	0	0	**957**
2004	0	0	0	0	0	69	482	308	71	1	0	0	**932**
2005	0	0	0	0	0	0	426	533	223	101	0	0	**1283**
2006	0	0	0	0	0	0	534	349	170	69	0	0	**1122**
2007	0	0	0	0	0	0	497	380	133	53	39	30	**1131**
2008	0	0	0	0	0	0	205	454	223	72	63	0	**1017**
2009	0	0	0	0	0	0	619	302	221	146	32	0	**1320**
2010	0	0	0	0	0	0	80	379	237	160	34	0	**890**
2011	0	0	0	0	0	0	0	328	276	44	106	0	**754**
2012	0	0	0	0	0	31	233	81	0	0	0	0	**345**
2013	0	0	0	0	0	0	380	380	68	0	0	0	**828**
1994-2008 Average	**8**					**13**	**326**	**356**	**170**	**80**	**49**	**33**	**1036**
2009-2013 Average						**6**	**263**	**294**	**160**	**70**	**34**	**0**	**827**

Note: Diversions were reduced to 63.6% (260 acres out of 409 acres) of total diversions to account for only diversions that irrigated fields within the Missouri Heights Study Area

Missouri Heights Needham Ditch Diversion Records

Diversion Summary in Acre Feet

YEAR	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1994	0	0	0	0	0	0	509	537	172	151	168	173	**1709**
1995	92	0	0	0	0	0	410	918	521	371	175	259	**2745**
1996	0	0	0	0	0	0	276	903	334	172	200	170	**2055**
1997	132	0	0	0	0	7	501	595	430	222	224	238	**2350**
1998	46	0	0	0	0	0	457	831	616	181	199	314	**2644**
1999	59	0	0	0	0	256	920	902	212	170	165	171	**2855**
2000	163	0	0	0	0	0	752	529	170	175	184	233	**2205**
2001	0	0	0	0	0	0	432	648	176	173	150	178	**1757**
2002	0	0	0	0	0	20	223	160	151	117	125	18	**814**
2003	0	0	0	0	0	0	427	732	110	224	247	253	**1994**
2004	0	0	0	0	0	0	699	620	181	150	141	147	**1937**
2005	48	0	0	0	0	0	0	935	466	190	265	336	**2241**
2006	0	0	0	0	0	0	971	675	173	175	169	211	**2373**
2007	0	0	0	0	0	0	920	753	331	204	187	196	**2592**
2008	0	0	0	0	0	0	623	845	634	182	165	153	**2603**
2009	0	0	0	0	0	0	932	904	441	192	175	183	**2827**
2010	0	0	0	0	0	0	502	798	205	182	185	154	**2026**
2011	0	0	0	0	0	0	0	572	666	373	200	148	**1959**
2012	0	0	0	0	0	0	402	165	170	170	165	139	**1211**
2013	0	0	0	0	0	0	456	578	171	168	141	77	**1591**
1994-2008 Average	**36**					**19**	**541**	**706**	**312**	**190**	**184**	**203**	**2192**
2009-2013 Average							**458**	**603**	**331**	**217**	**173**	**140**	**1923**

Note: Diversions were reduced to 92.3% (687 acres out of 744 acres) of total diversions to account for only diversions that irrigated fields within the Missouri Heights Study Area

Missouri Heights Monarch Ditch Diversion Records

Diversion Summary in Acre Feet

YEAR	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1994	0	0	0	0	0	0	222	170	0	0	0	0	**391**
1995	0	0	0	0	0	0	0	79	128	0	0	0	**207**
1996	0	0	0	0	0	0	40	110	0	0	0	0	**150**
1997	0	0	0	0	0	0	175	95	8	0	0	0	**278**
1998	0	0	0	0	0	0	28	43	9	0	0	0	**80**
1999	0	0	0	0	0	0	76	124	0	0	0	0	**200**
2000	0	0	0	0	0	0	97	30	0	0	0	0	**127**
2001	0	0	0	0	0	2	125	176	73	16	5	0	**397**
2002	0	0	0	0	0	3	67	0	0	0	0	0	**70**
2003	0	0	0	0	0	0	129	163	0	0	0	0	**292**
2004	0	0	0	0	0	0	111	108	0	0	0	0	**219**
2005	0	0	0	0	0	0	72	101	0	0	0	0	**172**
2006	0	0	0	0	0	0	74	176	0	0	0	0	**249**
2007	0	0	0	0	0	0	97	193	148	0	0	0	**437**
2008	0	0	0	0	0	0	31	176	128	19	0	0	**353**
2009	0	0	0	0	0	0	65	153	57	0	0	0	**274**
2010	0	0	0	0	0	0	31	151	31	0	0	0	**213**
2011	0	0	0	0	0	0	0	123	38	0	0	0	**160**
2012	0	0	0	0	0	0	6	0	0	0	0	0	**6**
2013	0	0	0	0	0	0	94	126	0	0	0	0	**220**
1994-2008 Average						**0**	**89**	**116**	**33**	**2**	**0**		**241**
2009-2013 Average							**39**	**110**	**25**				**174**

Note: Diversions were reduced to 50% (2.5 cfs out of 5.0 cfs) of total diversions to account for only diversions that irrigated fields within the Missouri Heights Study Area

Missouri Heights Mountain Meadow Ditch Diversion Records

Diversion Summary in Acre Feet

YEAR	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1994	115	148	148	134	148	143	1948	253	0	0	0	0	**3038**
1995	66	62	62	56	40	621	2512	3009	1472	8	0	0	**7906**
1996	101	105	105	98	135	800	2938	1313	0	0	0	0	**5595**
1997	60	62	62	56	33	238	2641	1675	181	0	0	0	**5005**
1998	0	0	0	0	454	1579	2376	1984	123	0	0	0	**6515**
1999	0	0	0	0	464	687	2050	895	0	0	0	0	**4096**
2000	0	0	0	0	119	1436	2602	196	0	0	0	0	**4354**
2001	0	0	0	0	165	1081	2781	544	0	0	0	0	**4569**
2002	0	0	0	0	173	754	0	0	0	0	0	0	**927**
2003	0	0	0	0	20	1301	3158	699	0	0	0	0	**5178**
2004	0	0	0	0	286	1053	1102	14	0	0	0	0	**2455**
2005	0	0	0	0	79	1821	3195	1657	0	0	0	0	**6752**
2006	0	0	0	0	167	2381	2348	286	0	0	0	0	**5182**
2007	0	0	0	0	654	1839	1817	0	0	0	0	0	**4310**
2008	0	0	0	0	0	716	2504	2776	449	0	0	0	**6445**
2009	0	0	0	0	0	127	3300	1717	170	0	0	0	**5314**
2010	0	0	0	0	0	0	945	1537	0	0	0	0	**2482**
2011	0	0	0	0	0	193	1477	1617	279	0	0	0	**3566**
2012	0	0	0	0	0	0	0	0	0	0	0	0	**0**
2013	0	0	0	0	386	646	1661	232	0	0	0	0	**2925**
1988-2008 Average	**23**	**25**	**25**	**23**	**196**	**1097**	**2265**	**1020**	**148**	**1**	**0**	**0**	**4822**
2009-2013 Average					**77**	**193**	**1477**	**1020**	**90**	**0**	**0**	**0**	**2857**

Note:

1: All of the diversions from the Mountain Meadow Ditch irrigated fields are located in Missouri Heights, so no reduction was take

2: Mountain Meadow Ditch diversions equal total diversions minus reservoir releases.

3: Per water commissioner comments, the 2009-2013 average was used in April and May 2011, due to lack of diversion records

Missouri Heights Spring Park Reservoir Diversion Records

Diversion Summary in Acre Feet

YEAR	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1994	0	0	0	0	0	0	1446	530	601	442	0	0	**3018**
1995	0	0	0	0	0	0	1203	3009	1490	792	470	41	**7005**
1996	0	0	0	0	0	0	2908	1313	649	704	188	59	**5822**
1997	0	0	0	0	0	0	1373	1440	805	531	0	0	**4149**
1998	0	0	0	0	0	0	1206	1294	481	603	190	83	**3856**
1999	0	0	0	0	14	305	419	573	565	399	104	324	**2703**
2000	0	0	0	0	0	79	988	657	639	194	0	109	**2666**
2001	0	0	0	0	0	0	1079	480	553	449	250	104	**2915**
2002	0	0	0	0	0	373	240	20	0	0	0	0	**633**
2003	0	0	0	0	0	59	698	369	0	0	0	0	**1126**
2004	0	0	0	0	0	0	679	14	0	0	0	0	**693**
2005	0	0	0	0	0	0	1686	1206	0	0	0	0	**2892**
2006	0	0	0	0	0	59	1458	286	0	0	0	0	**1804**
2007	0	0	0	0	0	0	0	0	0	0	0	0	**0**
2008	0	0	0	0	0	0	331	1853	232	0	0	0	**2416**
2009	0	0	0	0	0	0	649	844	555	959	431	0	**3438**
2010	0	0	0	0	0	0	0	1195	428	527	423	0	**2573**
2011	0	0	0	0	0	0	0	1617	831	916	835	111	**4310**
2012	0	0	0	0	0	0	791	0	0	0	0	0	**791**
2013	0	0	0	0	0	0	2	746	1187	151	0	0	**2086**
1994-2008 Average						**58**	**1048**	**870**	**401**	**274**	**80**	**48**	**2780**
2009-2013 Average							**289**	**880**	**600**	**511**	**338**	**22**	**2640**

Note:

1: All of the diversions from the Mountain Meadow Ditch irrigated fields are located in Missouri Heights, so no reduction was taken.

2: Sprink Park Reservoir Diversions equal Mountain Meadow Ditch diversions minus diversions from cattle creek, Equals direct flow plus releases.

APPENDIX D: ACZ WATER QUALITY LAB RESULTS

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Inorganic Analytical Results

Resource Engineering, Inc.
Project ID: 033-8.1.5
Sample ID: HART WELL

ACZ Sample ID: ***L73595-01***
Date Sampled: *12/17/08 15:30*
Date Received: *12/18/08*
Sample Matrix: *Ground Water*

Metals Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Calcium, dissolved	M200.7 ICP	40.3			mg/L	0.2	1	12/22/08 20:01	ear
Magnesium, dissolved	M200.7 ICP	22.8			mg/L	0.2	1	12/26/08 15:17	ear
Potassium, dissolved	M200.7 ICP	0.9	B		mg/L	0.3	2	12/22/08 20:01	ear
Sodium, dissolved	M200.7 ICP	49.9			mg/L	0.3	2	12/22/08 20:01	ear

Wet Chemistry

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Alkalinity as CaCO3	SM2320B - Titration								
Bicarbonate as CaCO3		237			mg/L	2	20	12/20/08 0:00	abm
Carbonate as CaCO3		7	B		mg/L	2	20	12/20/08 0:00	abm
Hydroxide as CaCO3			U		mg/L	2	20	12/20/08 0:00	abm
Total Alkalinity		244		*	mg/L	2	20	12/20/08 0:00	abm
Cation-Anion Balance	Calculation								
Cation-Anion Balance		0.8			%			12/30/08 0:00	calc
Sum of Anions		6.0			meq/L	0.1	0.5	12/30/08 0:00	calc
Sum of Cations		6.1			meq/L	0.1	0.5	12/30/08 0:00	calc
Chloride	SM4500Cl-E	11		*	mg/L	1	5	12/26/08 12:41	aml
Conductivity @25C	SM2510B	515			umhos/cm	1	10	12/20/08 3:01	abm
Hardness as CaCO3	SM2340B - Calculation	194			mg/L	1	7	12/30/08 0:00	calc
Lab Filtration	SM 3030 B			*				12/18/08 13:28	gkj
Lab Filtration & Acidification	SM 3030 B			*				12/18/08 14:22	kah
Nitrate as N, dissolved	Calculation: NO3NO2 minus NO2	0.42			mg/L	0.02	0.1	12/30/08 0:00	calc
Nitrate/Nitrite as N, dissolved	M353.2 - Automated Cadmium Reduction	0.42			mg/L	0.02	0.1	12/18/08 18:40	pjb
Nitrite as N, dissolved	M353.2 - Automated Cadmium Reduction		U	*	mg/L	0.01	0.05	12/18/08 18:40	pjb
pH (lab)	SM4500H+ B								
pH		8.4	H		units	0.1	0.1	12/20/08 0:00	abm
pH measured at		23.0			C	0.1	0.1	12/20/08 0:00	abm
Residue, Filterable (TDS) @180C	SM2540C	360			mg/L	10	20	12/19/08 16:02	jlf
Sulfate	SM4500 SO4-D	40	B		mg/L	10	50	12/18/08 14:31	kah
TDS (calculated)	Calculation	316			mg/L	10	50	12/30/08 0:00	calc
TDS (ratio - measured/calculated)	Calculation	1.14						12/30/08 0:00	calc
Turbidity	M180.1 - Nephelometric	6.8		*	NTU	0.1	0.5	12/18/08 13:04	gkj

** Please refer to Qualifier Reports for details.*

ACZ Laboratories, Inc.

2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Inorganic Analytical Results

Resource Engineering, Inc.

Project ID: 033.8.1.5

Sample ID: PIETSCH WELL

ACZ Sample ID: ***L72807-02***

Date Sampled: *10/31/08 15:00*

Date Received: *11/03/08*

Sample Matrix: *Ground Water*

Metals Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Calcium, dissolved	M200.7 ICP	0.4	B		mg/L	0.2	1	11/13/08 17:42	aeh
Magnesium, dissolved	M200.7 ICP	0.3	B		mg/L	0.2	1	11/13/08 17:42	aeh
Potassium, dissolved	M200.7 ICP	0.3	B		mg/L	0.3	2	11/13/08 17:42	aeh
Sodium, dissolved	M200.7 ICP	115			mg/L	0.3	2	11/13/08 17:42	aeh

Wet Chemistry

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Alkalinity as CaCO3	SM2320B - Titration								
Bicarbonate as CaCO3		218			mg/L	2	20	11/06/08 0:00	abm
Carbonate as CaCO3		4	B		mg/L	2	20	11/06/08 0:00	abm
Hydroxide as CaCO3			U		mg/L	2	20	11/06/08 0:00	abm
Total Alkalinity		221			mg/L	2	20	11/06/08 0:00	abm
Cation-Anion Balance	Calculation								
Cation-Anion Balance		1.0			%			11/18/08 0:00	calc
Sum of Anions		5.0			meq/L	0.1	0.5	11/18/08 0:00	calc
Sum of Cations		5.1			meq/L	0.1	0.5	11/18/08 0:00	calc
Chloride	SM4500Cl-E	5			mg/L	1	5	11/11/08 13:14	jjg
Conductivity @25C	SM2510B	440			umhos/cm	1	10	11/06/08 20:42	abm
Hardness as CaCO3	SM2340B - Calculation	2	B		mg/L	1	7	11/18/08 0:00	calc
Lab Filtration	SM 3030 B			*				11/03/08 12:29	abm
Lab Filtration & Acidification	SM 3030 B			*				11/03/08 16:44	abm
Nitrate as N, dissolved	Calculation: NO3NO2 minus NO2	0.43			mg/L	0.02	0.1	11/18/08 0:00	calc
Nitrate/Nitrite as N, dissolved	M353.2 - Automated Cadmium Reduction	0.43	H	*	mg/L	0.02	0.1	11/04/08 18:39	pjb
Nitrite as N, dissolved	M353.2 - Automated Cadmium Reduction		UH	*	mg/L	0.01	0.05	11/04/08 18:39	pjb
pH (lab)	SM4500H+ B								
pH		8.3	H		units	0.1	0.1	11/06/08 0:00	abm
pH measured at		22.0			C	0.1	0.1	11/06/08 0:00	abm
Residue, Filterable (TDS) @180C	SM2540C	300			mg/L	10	20	11/04/08 15:33	abm
Sulfate	SM4500 SO4-D	20	B		mg/L	10	50	11/10/08 12:31	abm
TDS (calculated)	Calculation	278			mg/L	10	50	11/18/08 0:00	calc
TDS (ratio - measured/calculated)	Calculation	1.08						11/18/08 0:00	calc
Turbidity	M180.1 - Nephelometric		UH	*	NTU	0.1	0.5	11/04/08 9:56	kah

Inorganic Analytical Results

Resource Engineering, Inc.
Project ID: 033.8.1.5
Sample ID: ELMORE WELL

ACZ Sample ID: ***L72807-01***
Date Sampled: *10/31/08 13:45*
Date Received: *11/03/08*
Sample Matrix: *Ground Water*

Metals Analysis

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Calcium, dissolved	M200.7 ICP	47.4			mg/L	0.2	1	11/13/08 17:39	aeh
Magnesium, dissolved	M200.7 ICP	29.9			mg/L	0.2	1	11/13/08 17:39	aeh
Potassium, dissolved	M200.7 ICP	2.2			mg/L	0.3	2	11/13/08 17:39	aeh
Sodium, dissolved	M200.7 ICP	21.9			mg/L	0.3	2	11/13/08 17:39	aeh

Wet Chemistry

Parameter	EPA Method	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Alkalinity as CaCO3	SM2320B - Titration								
Bicarbonate as CaCO3		250			mg/L	2	20	11/06/08 0:00	abm
Carbonate as CaCO3			U		mg/L	2	20	11/06/08 0:00	abm
Hydroxide as CaCO3			U		mg/L	2	20	11/06/08 0:00	abm
Total Alkalinity		252			mg/L	2	20	11/06/08 0:00	abm
Cation-Anion Balance	Calculation								
Cation-Anion Balance		-0.9			%			11/18/08 0:00	calc
Sum of Anions		5.9			meq/L	0.1	0.5	11/18/08 0:00	calc
Sum of Cations		5.8			meq/L	0.1	0.5	11/18/08 0:00	calc
Chloride	SM4500Cl-E	9			mg/L	1	5	11/11/08 13:13	jjg
Conductivity @25C	SM2510B	489			umhos/cm	1	10	11/06/08 20:34	abm
Hardness as CaCO3	SM2340B - Calculation	241			mg/L	1	7	11/18/08 0:00	calc
Lab Filtration	SM 3030 B			*				11/03/08 12:27	abm
Lab Filtration & Acidification	SM 3030 B			*				11/03/08 16:35	abm
Nitrate as N, dissolved	Calculation: NO3NO2 minus NO2	3.35			mg/L	0.06	0.3	11/18/08 0:00	calc
Nitrate/Nitrite as N, dissolved	M353.2 - Automated Cadmium Reduction	3.35	H	*	mg/L	0.06	0.3	11/04/08 19:05	pjb
Nitrite as N, dissolved	M353.2 - Automated Cadmium Reduction		UH	*	mg/L	0.01	0.05	11/04/08 18:37	pjb
pH (lab)	SM4500H+ B								
pH		8.3	H		units	0.1	0.1	11/06/08 0:00	abm
pH measured at		22.0			C	0.1	0.1	11/06/08 0:00	abm
Residue, Filterable (TDS) @180C	SM2540C	310			mg/L	10	20	11/04/08 15:33	abm
Sulfate	SM4500 SO4-D	20	B		mg/L	10	50	11/10/08 12:28	abm
TDS (calculated)	Calculation	295			mg/L	10	50	11/18/08 0:00	calc
TDS (ratio - measured/calculated)	Calculation	1.05						11/18/08 0:00	calc
Turbidity	M180.1 - Nephelometric	0.3	BH	*	NTU	0.1	0.5	11/04/08 9:56	kah

** Please refer to Qualifier Reports for details.*

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Inorganic Analytical Results

Resource Engineering, Inc.
Project ID: 033-8.1.6
Sample ID: HART WELL

ACZ Sample ID: ***L15739-01***
Date Sampled: *11/22/13 10:30*
Date Received: *11/25/13*
Sample Matrix: *Ground Water*

Metals Analysis

Parameter	EPA Method	Dilution	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Calcium, dissolved	M200.7 ICP	1	41			mg/L	0.2	1	12/03/13 13:58	aeb
Magnesium, dissolved	M200.7 ICP	1	21			mg/L	0.2	1	12/03/13 13:58	aeb
Potassium, dissolved	M200.7 ICP	1	1.4	B		mg/L	0.3	2	12/03/13 13:58	aeb
Sodium, dissolved	M200.7 ICP	1	48.7			mg/L	0.3	2	12/03/13 13:58	aeb

Wet Chemistry

Parameter	EPA Method	Dilution	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Alkalinity as CaCO3	SM2320B - Titration									
Bicarbonate as CaCO3		1	229			mg/L	2	20	12/04/13 0:00	khw
Carbonate as CaCO3		1	9	B		mg/L	2	20	12/04/13 0:00	khw
Hydroxide as CaCO3		1		U		mg/L	2	20	12/04/13 0:00	khw
Total Alkalinity		1	238			mg/L	2	20	12/04/13 0:00	khw
Cation-Anion Balance	Calculation									
Cation-Anion Balance			0.8			%			12/09/13 15:32	calc
Sum of Anions			5.9			meq/L	0.1	0.5	12/09/13 15:32	calc
Sum of Cations			6			meq/L	0.1	0.5	12/09/13 15:32	calc
Chloride	SM4500Cl-E	1	10		*	mg/L	1	5	12/05/13 15:46	mpb
Conductivity @25C	SM2510B	1	552			umhos/cm	1	10	12/04/13 20:15	khw
Hardness as CaCO3	SM2340B - Calculation		189			mg/L	1	7	12/09/13 15:32	calc
Lab Filtration (0.45um filter)	SOPWC050	1							12/04/13 10:48	abm
Lab Filtration (0.45um) & Acidification	M200.7/200.8	1							12/02/13 10:46	mfm
Nitrate as N, dissolved	Calculation: NO3NO2 minus NO2		0.42	H		mg/L	0.02	0.1	12/09/13 15:32	calc
Nitrate/Nitrite as N, dissolved	M353.2 - Automated Cadmium Reduction	1	0.42	H	*	mg/L	0.02	0.1	11/26/13 22:49	pjb
Nitrite as N, dissolved	M353.2 - Automated Cadmium Reduction	1		UH	*	mg/L	0.01	0.05	11/26/13 22:49	pjb
pH (lab)	SM4500H+ B									
pH		1	8.3	H		units	0.1	0.1	12/04/13 0:00	khw
pH measured at		1	22			C	0.1	0.1	12/04/13 0:00	khw
Residue, Filterable (TDS) @180C	SM2540C	1	340			mg/L	10	20	11/27/13 13:35	mss3
Sulfate	D516-02 - Turbidimetric	1	38.0		*	mg/L	1	5	12/05/13 18:12	mpb
TDS (calculated)	Calculation		305			mg/L	10	50	12/09/13 15:32	calc
TDS (ratio - measured/calculated)	Calculation		1.11						12/09/13 15:32	calc
Turbidity	M180.1 - Nephelometric	1	0.2	BH	*	NTU	0.1	0.5	12/02/13 14:21	dcw

Arizona license number: AZ0102

ACZ Laboratories, Inc.
2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Inorganic Analytical Results

Resource Engineering, Inc.

Project ID:	033-8.1.6
Sample ID:	PIETSCH WELL
ACZ Sample ID:	***L15739-02***
Date Sampled:	*11/22/13 13:45*
Date Received:	*11/25/13*
Sample Matrix:	*Ground Water*

Metals Analysis

Parameter	EPA Method	Dilution	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Calcium, dissolved	M200.7 ICP	1	35.7			mg/L	0.2	1	12/03/13 14:01	aeb
Magnesium, dissolved	M200.7 ICP	1	26.9			mg/L	0.2	1	12/03/13 14:01	aeb
Potassium, dissolved	M200.7 ICP	1	2.7			mg/L	0.3	2	12/03/13 14:01	aeb
Sodium, dissolved	M200.7 ICP	1	14.6			mg/L	0.3	2	12/03/13 14:01	aeb

Wet Chemistry

Parameter	EPA Method	Dilution	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Alkalinity as CaCO3	SM2320B - Titration									
Bicarbonate as CaCO3		1	192			mg/L	2	20	12/04/13 0:00	khw
Carbonate as CaCO3		1	7	B		mg/L	2	20	12/04/13 0:00	khw
Hydroxide as CaCO3		1		U		mg/L	2	20	12/04/13 0:00	khw
Total Alkalinity		1	200			mg/L	2	20	12/04/13 0:00	khw
Cation-Anion Balance	Calculation									
Cation-Anion Balance			1.1			%			12/09/13 15:32	calc
Sum of Anions			4.6			meq/L	0.1	0.5	12/09/13 15:32	calc
Sum of Cations			4.7			meq/L	0.1	0.5	12/09/13 15:32	calc
Chloride	SM4500Cl-E	1	6		*	mg/L	1	5	12/05/13 15:47	mpb
Conductivity @25C	SM2510B	1	434			umhos/cm	1	10	12/04/13 20:24	khw
Hardness as CaCO3	SM2340B - Calculation		200			mg/L	1	7	12/09/13 15:32	calc
Lab Filtration (0.45um filter)	SOPWC050	1							12/04/13 10:51	abm
Lab Filtration (0.45um) & Acidification	M200.7/200.8	1							12/02/13 10:46	mfm
Nitrate as N, dissolved	Calculation: NO3NO2 minus NO2		0.31	H		mg/L	0.02	0.1	12/09/13 15:32	calc
Nitrate/Nitrite as N, dissolved	M353.2 - Automated Cadmium Reduction	1	0.31	H	*	mg/L	0.02	0.1	11/26/13 22:50	pjb
Nitrite as N, dissolved	M353.2 - Automated Cadmium Reduction	1		UH	*	mg/L	0.01	0.05	11/26/13 22:50	pjb
pH (lab)	SM4500H+ B									
pH		1	8.4	H		units	0.1	0.1	12/04/13 0:00	khw
pH measured at		1	21			C	0.1	0.1	12/04/13 0:00	khw
Residue, Filterable (TDS) @180C	SM2540C	1	270			mg/L	10	20	11/27/13 13:36	mss3
Sulfate	D516-02 - Turbidimetric	1	20.4		*	mg/L	1	5	12/05/13 18:12	mpb
TDS (calculated)	Calculation		228			mg/L	10	50	12/09/13 15:32	calc
TDS (ratio - measured/calculated)	Calculation		1.18						12/09/13 15:32	calc
Turbidity	M180.1 - Nephelometric	1	0.2	BH	*	NTU	0.1	0.5	12/02/13 14:22	dcw

Arizona license number: AZ0102

** Please refer to Qualifier Reports for details.*

ACZ Laboratories, Inc.

2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

Inorganic Analytical Results

Resource Engineering, Inc.

Project ID: 033-8.1.6

Sample ID: ELMORE WELL

ACZ Sample ID: ***L15739-03***

Date Sampled: *11/22/13 14:30*

Date Received: *11/25/13*

Sample Matrix: *Ground Water*

Metals Analysis

Parameter	EPA Method	Dilution	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Calcium, dissolved	M200.7 ICP	1	46.8			mg/L	0.2	1	12/03/13 14:04	aeb
Magnesium, dissolved	M200.7 ICP	1	28.4			mg/L	0.2	1	12/03/13 14:04	aeb
Potassium, dissolved	M200.7 ICP	1	2.3			mg/L	0.3	2	12/03/13 14:04	aeb
Sodium, dissolved	M200.7 ICP	1	22.2			mg/L	0.3	2	12/03/13 14:04	aeb

Wet Chemistry

Parameter	EPA Method	Dilution	Result	Qual	XQ	Units	MDL	PQL	Date	Analyst
Alkalinity as CaCO3	SM2320B - Titration									
Bicarbonate as CaCO3		1	226			mg/L	2	20	12/04/13 0:00	khw
Carbonate as CaCO3		1	6	B		mg/L	2	20	12/04/13 0:00	khw
Hydroxide as CaCO3		1		U		mg/L	2	20	12/04/13 0:00	khw
Total Alkalinity		1	232			mg/L	2	20	12/04/13 0:00	khw
Cation-Anion Balance	Calculation									
Cation-Anion Balance			0.9			%			12/09/13 15:32	calc
Sum of Anions			5.6			meq/L	0.1	0.5	12/09/13 15:32	calc
Sum of Cations			5.7			meq/L	0.1	0.5	12/09/13 15:32	calc
Chloride	SM4500Cl-E	1	11		*	mg/L	1	5	12/05/13 15:47	mpb
Conductivity @25C	SM2510B	1	527			umhos/cm	1	10	12/04/13 20:32	khw
Hardness as CaCO3	SM2340B - Calculation		234			mg/L	1	7	12/09/13 15:32	calc
Lab Filtration (0.45um filter)	SOPWC050	1							12/04/13 10:53	abm
Lab Filtration (0.45um) & Acidification	M200.7/200.8	1							12/02/13 10:47	mfm
Nitrate as N, dissolved	Calculation: NO3NO2 minus NO2		2.81	H		mg/L	0.06	0.3	12/09/13 15:32	calc
Nitrate/Nitrite as N, dissolved	M353.2 - Automated Cadmium Reduction	3	2.81	H	*	mg/L	0.06	0.3	11/27/13 2:02	pjb
Nitrite as N, dissolved	M353.2 - Automated Cadmium Reduction	1		UH	*	mg/L	0.01	0.05	11/26/13 22:51	pjb
pH (lab)	SM4500H+ B									
pH		1	8.3	H		units	0.1	0.1	12/04/13 0:00	khw
pH measured at		1	21			C	0.1	0.1	12/04/13 0:00	khw
Residue, Filterable (TDS) @180C	SM2540C	1	330			mg/L	10	20	11/27/13 13:38	mss3
Sulfate	D516-02 - Turbidimetric	1	23.1		*	mg/L	1	5	12/05/13 18:12	mpb
TDS (calculated)	Calculation		285			mg/L	10	50	12/09/13 15:32	calc
TDS (ratio - measured/calculated)	Calculation		1.16						12/09/13 15:32	calc
Turbidity	M180.1 - Nephelometric	1	0.1	BH	*	NTU	0.1	0.5	12/02/13 14:23	dcw

Arizona license number: AZ0102

APPENDIX E: BLANEY-CRIDDLE CALCULATIONS

Title: Missouri Heights Groundwater Study

Crop Consumptive Use Estimate, Modified Blaney-Criddle methodology (S.C.S. Technical Release 21)
enter data in shaded cells
Crop = BLUEGRASS (utilizes Pochop Borelli & Burman's temperature and growth stage coefficients and elevation factors)

Climate Data source: BWCD Weather Station

	Month #	Day #	Date
Start of Growing Season =	4	27	117
End of Growing Season =	10	11	284
Season Length (inclusive) =	168	days	

Latitute (deg.min) = 39.43 — 39.72 Decimal Degrees

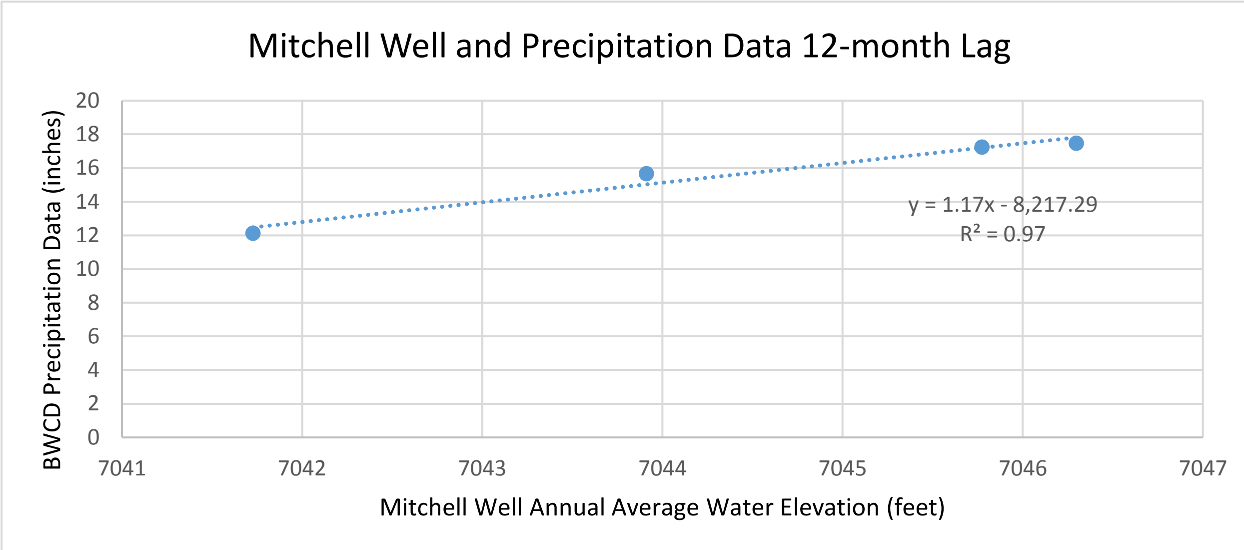
Depth of Application (in) = 1

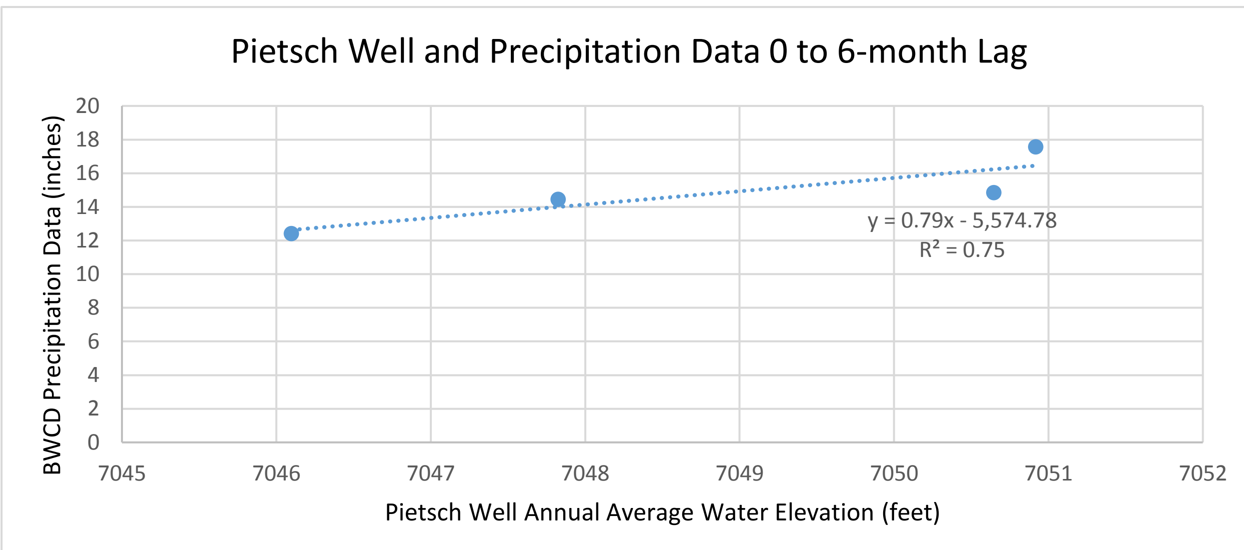
Elevation (ft) = 6700
Elevation Factor = 1.07 (+2.865% per 1,000 ft above 4,429 ft)

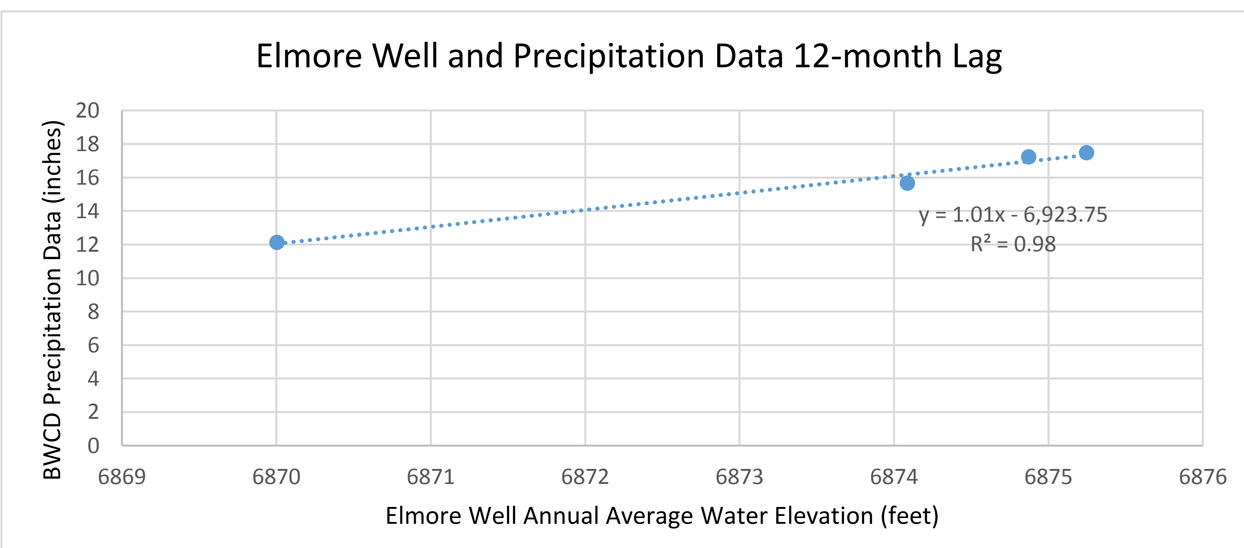
Month	Temp (^oF)	Precip. (in.)
Jan	21.9	1.2
Feb	24.2	1.2
Mar	35.0	1.1
Apr	41.2	2.0
May	50.5	1.4
Jun	61.4	0.8
Jul	65.5	1.6
Aug	63.5	0.9
Sep	56.0	1.2
Oct	43.2	1.4
Nov	32.9	0.9
Dec	22.9	1.5
Annual		15.14

Growing Period	Avg. Period Temp (^oF)	% Daylight	(t*p)/100	Kt	Growth Stage Coefficient Kc	Consumptive Crop Demand (in.)	Period Precip. (in.)	Period Effective Precip. (in.)	Consumptive Irrigation Requirment (in.)	Consumptive Irrigation Requirment (ft.)
Jan										
Feb										
Mar										
Apr	45.2	1.24	0.56	0.80	0.97	0.46	0.27	0.10	0.36	0.03
May	50.5	10.01	5.06	0.82	1.00	4.39	1.43	0.83	3.57	0.30
Jun	61.4	10.02	6.15	0.85	1.10	6.14	0.81	0.52	5.61	0.47
Jul	65.5	10.19	6.68	0.87	1.06	6.52	1.55	1.00	5.52	0.46
Aug	63.5	9.56	6.07	0.86	0.98	5.44	0.90	0.56	4.88	0.41
Sep	56.0	8.37	4.69	0.83	0.97	4.04	1.19	0.68	3.36	0.28
Oct	47.4	2.83	1.34	0.81	0.89	1.03	0.48	0.22	0.80	0.07
Nov										
Dec										
Annual						28.02	6.64	3.92	24.10	2.0

APPENDIX F: PRECIPITATION LAG RESULTS







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