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Shadow Mountain Bike Park

Phase I Drainage Report

November 2022

Prepared For:

Shadow Mountain Bike Park

Prepared By:

SE GROUP

PHASE I DRAINAGE REPORT

For

Shadow Mountain Bike Park

November 2022

Prepared For

Shadow Mountain Bike Park

Conifer, CO

Prepared By

SE Group

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I. General Location and Description

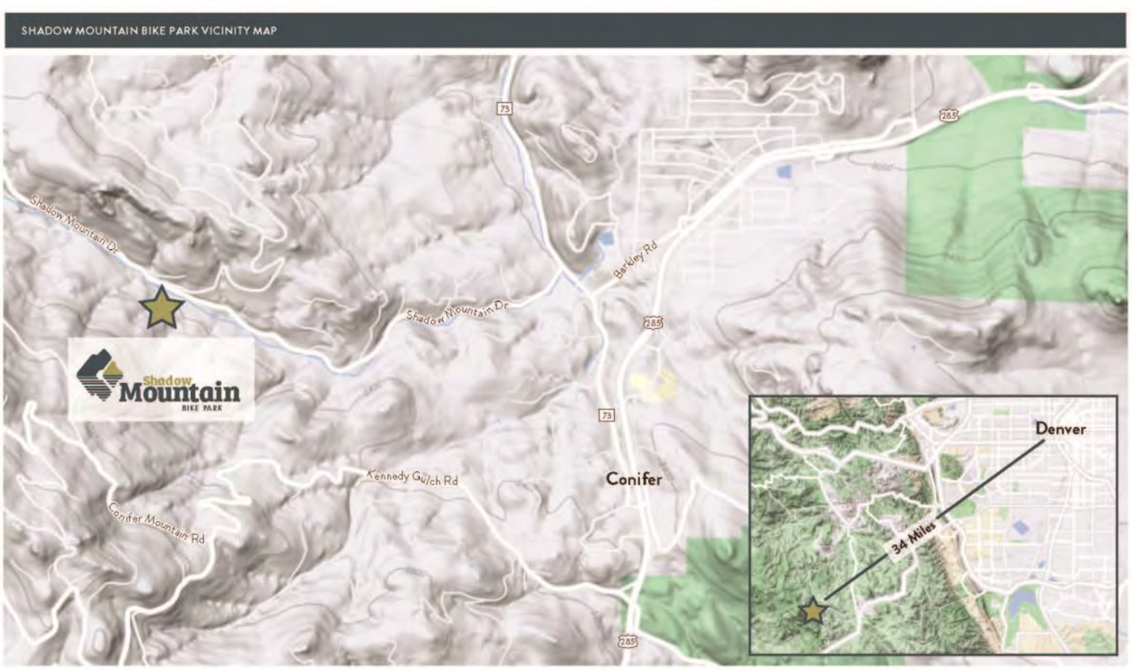
The Shadow Mountain Bike Park is to be designed in accordance with the Jefferson County Storm Drainage criteria. This report will review at a conceptual level the feasibility and design characteristics of the proposed development and is to accompany the project's Special Use Application materials. The Phase I Drainage Report is prepared in accordance with Jefferson County standards.

A. LOCATION

The Shadow Mountain Bike Park is proposed to be located at 29611 Shadow Mountain Drive in Conifer, CO. Conifer is an unincorporated community of Jefferson County, and the property is subject to the rules and regulations set by the County. The property is in Section 16, Township 6 South, Range 71 West of the 6th Principal Meridian, County of Jefferson, State of Colorado and is owned by the State Land Board. The property is comprised of approximately 306 acres of undeveloped land per County Assessor records, but the project is proposed only within the approximately 235-acre portion of the property south of Shadow Mountain Drive. It is proposed that the bike park would lease this southern portion of the property from the State Land Board and only develop and disturb a small fraction of the parcel.

The site is in a primarily rural, residential setting, bounded by residential neighborhoods along all property lines. The Conifer Senior High School and US Highway 285 are due east of the project. North Turkey Creek runs along the south side of Shadow Mountain Dr and bisects the front portion of the property; there are no exiting drainage facilities. The project site is about four (4) miles from downtown Conifer and approximately 34 miles from Denver.

Figure 1. Vicinity Map



The property falls within a Jefferson County Floodprone area as defined in the Floodplain Overlay District (Section 37) of the Zoning Resolution.

B. DESCRIPTION OF PROPERTY

The 235-ac portion of the property to be developed is located on an undeveloped hillside, sloping towards the North Turkey Creek and Shadow Mountain Dr. The northeastern portion of the site along Shadow Mountain Dr is relatively flat, from approximately 4% to 8%, as it extends from the roadway and then steepens up the mountain heading south-southwest, from 12% to 45%. The high point is in the southwestern most portion of the property at approximately 9250' and flows primarily due east-northeast into North Turkey Creek. The total vertical fall across the site is approximately 870 vertical feet. The flatter areas are predominantly meadows and grassy areas, and the hillside is primarily wooded. There are a series of low flow channels that bisect the property and flow into the North Turkey Creek. Throughout the site there are also wetlands on both the hillside and along the creek. The hillside is relatively consistent in grade with some knolls but no defined ridge. There are a series of small gullies formed by the low flow channels.

The property is in Zone X (unshaded) according to FIRM Map No 08059C0365F in Jefferson County, CO last revised February 5, 2014. Zone X (unshaded) is defined by FEMA as areas of minimal flood hazard, outside of the Special Flood Hazard Area (SFHA), and higher than the elevation of the 0.2-percent-annual-chance flood. A copy of the property FIRMette is included in Appendix A.

Shadow Mountain Bike Park is a lift-served mountain bike park. The facility would include driveway access from Shadow Mountain Dr, onsite vehicular parking and guest drop-off, a base lodge with guest services (food & beverage, restrooms, seating, and bike/equipment rentals), and a mid-mountain maintenance building area. All access into the property would be via a two-lane (single in/single out) culvert crossing over North Turkey Creek. Water would be supplied by a water well and sewage would be handled by an onsite septic system.

The driveway access, internal drives & walkways, landscaping, and parking space design are to comply with the standards outlined by the Jefferson County Section 14 – Off-Street Parking and Loading. The parking and access would create impacts to waters of the U.S., including wetlands located in this area. Permitting would be required with the U.S. Army Corps of Engineers to comply with the Clean Water Act and County regulations. The culvert crossing of North Turkey Creek is to be sized according to the criteria set in Chapter 11.5 Culvert Sizing of the Jefferson County Storm Drainage Design & Technical Criteria.

It is anticipated that mountain access be provided via a four-passenger chairlift to be constructed to transport guests and bikes to the top of the property for gravity flow and downhill trails. The proposed lift would include a bottom and top terminal building with an accessory lift attendant building; all lift infrastructure (terminals and towers) would comply with the height limit of 35-feet. The facility may provide, but would not be limited to, approximately 20 miles of trails. These trails would be primarily constructed of earthen materials, and would include wooden, steel and other materials. Vegetation removal would be necessary for the construction of the chairlift and trails. Industry trail design practices would be utilized for construction and maintenance of trails and the lift corridor.

A work road would be constructed from the main base area to the north to the location of a maintenance shop. The work road would also be constructed to the chairlift top terminal location providing construction and maintenance access, as well as emergency access through the bike park. The maintenance shop is likely to be located mid-mountain and constructed atop a hard, gravel surface. The approximate location is provided on the attached Drainage Map, but the final footprint and location is subject to change.

For all work within the Jefferson County Floodprone area, a Floodplain Development permit will be required to be approved prior to construction.

The maintenance access road and designated bike trails will likely cross the existing low flow channels within the site. Both the trails and road are to be routed and designed to minimize impacts to the channels and delineated wetland areas.

II. Drainage Basins and Sub-Basins

A. MAJOR BASIN DESCRIPTION

The proposed site is tributary to the North Turkey Creek and is part of the Turkey Creek Major Drainage Basin. The North Turkey Creek begins in the hillside above Shadow Mountain Dr, flows east-northeast alongside Rte. 285 and N. Turkey Creek Rd before its confluence with Turkey Creek. According to the Hydrologic Conditions and Assessment of Water Resources in the Turkey Creek Watershed completed in 2001, the site is entirely within the North Turkey Creek sub-basin. This sub-basin is designated as Subbasin K. Applicable sections of the report are included in Appendix B.

Subbasin K is approximately 4,800 acres and is largely undeveloped with areas of residential and limited commercial development, and some roadways, both gravel and paved county roads. The basin encompasses much of the unincorporated community of Conifer, including the commercial district along Rte. 285 and the Conifer High School; the basin does not include the Aspen Park area. Historically, flows start from the ridgeline along the southwest edge of the Major Basin and sheet flows or enters small drainageways to the north/northeast into North Turkey Creek. The basin also includes minor flows from the north of the creek. North Turkey Creek flows to the east and the Major Basin delineation ends at Route 70. The creek continues to flow north before its confluence with Turkey Creek. Slopes vary throughout the Major Basin ranging from steep slopes at upwards of 40-45% to flat grassy areas from 2-5%.

There are no existing major drainage facilities within the Major Basin.

Added imperviousness for the developed site is assumed to be negligible within the Major Basin because full spectrum detention is to be provided onsite and attenuated to historic levels. Thus, no negative impacts are anticipated to the North Turkey Creek major drainageway basin because all increases in site imperviousness, although very small, are treated and detained onsite.

The Major Basin follows Jefferson County zoning and is a mix of Mountain Residential (MR) & Suburban Residential (SR), Planned Development (PD), Commercial (C), and Agricultural (A) Districts. The property is zoned for A-2 Agricultural Two District. The project's proposed development would be defined as a Class III Commercial Recreational Facility and is thus subject to a Special Use/Rezoning review process before proceeding with the Site Development Plan process. The project aligns with the goals of the Conifer-285 Corridor Area Plan by providing an active recreational area that maintains the mountain community character.

There are no known irrigation facilities such as ditches that will or would be influenced by the North Turkey Creek in the vicinity of the property.

B. SUB-BASIN DESCRIPTION

Historically, the property drains into the North Turkey Creek via sheet flow or channelized flow in a series of low flow channels bisecting the hillside. Runoff largely flows to the east-northeast into the abutting property before entering the creek. The site is undeveloped with majority of the surface area covered by wooded areas and meadows along Shadow Mountain Drive.

The USDA Soils Survey states that the site is largely Legualt-Hiwan stony loamy sands, 5 to 15 and 5 to 30 percent slopes, or rock outcrop complex 30 to 50 percent slopes on the hillside and then Kittredge-Earcree complex, 9 to 20 percent slopes, along the street frontage. The stony loamy sands and rock outcrop complex are Hydrologic Soil Group (HSG) D and the Kittredge-Earcree complex is HSG B. Soils with a B HSG rating are in the above average soils class for infiltration and D HSG rating is the lowest group and has the least amount of runoff infiltration. According to the USDA, 95% of the property has a HSG D soils rating. A copy of the Soils Survey is provided in Appendix C.

The property is split into distinct developed areas that impact the existing property: the new mountain bike trails, the lift and associated terminal and tower structures, the maintenance building and access road, and base services and parking area. It is proposed that the trails, lift areas, access road, and maintenance building use stormwater best management practices to mitigate impacts. Runoff generated by the new base lodge and parking area is to be redirected to an onsite detention facility to treat and detain access flows prior to being released into the North Turkey Creek. The detention facility is to be designed per Jefferson County and Mile High Flood District (MHFD) standards; preliminary calculations are provided in this report. The site improvements will not alter the existing minor and major drainage patterns of the property and all flows will continue to enter the creek.

The section of North Turkey Creek that crosses the property is to remain functional and stay adequately protected during construction to the greatest extent possible. The proposed driveway crossing over the creek is to be designed and constructed per county and MHFD standards and best practices. The functionality and capacity of the existing drainageway is to be restored to the historic conditions.

III. DRAINAGE FACILITY DESIGN

The preliminary drainage facility design has been prepared in accordance with Jefferson County Storm Drainage Design & Technical Criteria and the latest MHFD Urban Storm Drainage Criteria Manuals (USDCM), Vol. I revised August 2018, Vol. II revised September 2017, and Vol. III revised January 2021 and MHFD design tools for Detention Design, v4.06 revised July 2022 and Rational Method revised May 2017.

A. GENERAL CONCEPT

Historically the runoff from the site is un-detained and directly discharging to North Turkey Creek. The developed site will produce a higher runoff volume due to increased imperviousness from the base lodge and parking area, and this runoff is to be detained to or below existing runoff rates per MHFD standard through the addition of storm sewer and the on-site full spectrum detention pond. All new onsite drainage facilities are to be encumbered by drainage easements per County regulations. Easement delineation and language to be provided within final construction documents.

There are flows that enter the site from the abutting properties to the west. All offsite flows are to be redirected around the proposed developed areas to the creek and not collected by the new drainage facilities.

The added imperviousness from the mountain bike trails, lift terminals, access road, and maintenance area are to be mitigated using Low Impact Development (LID) best practices and selection and sizing of stormwater BMPs that improve runoff quality and minimize impacts to the existing surfaces.

Surface disturbance from construction activities to be mitigated and controlled by temporary erosion control measures and follow a Grading, Erosion and Sediment Control Plan. The plan is to be provided as part of the final construction documents and reviewed during the Site Development Plan process.

1. *HYDROLOGIC CRITERIA*

The Rational Method (Q=CIA) is used to determine runoff peak discharges for the historic and developed site basins at given design points. The composite runoff coefficients (C) are calculated using site imperviousness and hydrologic soil type (HSG B & C/D) to define an area-weighted coefficient per basin. The rainfall intensity (I) in inches per hour are defined using the time of concentration (tc) and provided intensity-duration curve table provided within the County Storm Criteria Manual Chapter 5.4 for Jefferson County Rainfall Zone IIB. The Time-Intensity-Frequency curves for each zone were developed by distributing the one-hour point rainfall values using the factors obtained from the NOAA Atlas 14 for durations of less than one hour. The point rainfall values from Table 501 within the Criteria Manual are as follows:

Table 1: One-Hour Point Rainfall Values for Jefferson County Rainfall Zone IIB (in)

2-YR	5-YR	10-YR	50-YR	100-YR
[illegible]	1.19	1.39	1.93	2.20

Will need this to be discussed/analyzed in further detail at time of Phase III D.R. No updates needed at this time.

Each basin was evaluated based on area (A) in acres. Final peak discharge (Q) is defined in cubic feet per second (cfs). Post-development time of concentration calculations for each subbasin, corresponding rainfall intensities, and composite runoff coefficients for each sub-basin as calculated using the MHFD UD-Rational Method spreadsheet are provided in Appendix D.

The proposed base lodge and parking facilities are to disturb approximately 6.75 acres of historically undeveloped area:

- **Basin H:** The historic basin, labelled as Basin H is split into two sub-basins H1 and H2 for the HSG D and HSG B soils respectively.
- **Basin D:** The developed basin, labelled as Basin D, is split into two sub-basins D1 and D2 for the HSG and HSG soils respectively as well. Basin D represents all disturbed areas that are tributary to the proposed detention basin.
- **Basin OS:** All flows that cannot be conveyed to the basin are analyzed within the OS (offsite) basin. All soils within the Basin OS are HSG B.

Per Chapter 6 of the MHFD Urban Storm Drainage Criteria Manual (USDCM) Vol. I, Table 6-3, packed gravel surfaces are 40%, drive and walks are 90%, and roofs are 90% impervious. The proposed plaza area around the building and bottom lift terminal is likely to be a hardpacked dirt surface and is assumed 25% imperviousness.

The calculated peak flows for the minor storm event (5-year) and the major storm event (100-year) for the base lodge and parking area are as follows:

Table 2: Runoff Summary Table

Basin	Total Area (ac)	HSG	Imperviousness (%)	Q5 (cfs)	Q100 (cfs)
H1	2.74	D	2	0.43	7.68
H2	4.01	B	2	0.10	6.89
D1	2.74	D	43	2.98	11.06
D2	3.61	B	31	3.04	10.93
OS	0.40	B	2	0.56	0.81

The calculated release rates through the Rationals Method to be used as reference only. The final detention basin design and required release rates to be determined using the MHFD standards outlined below.

The proposed detention basin is to be designed to MHFD standards for an Extended Detention Basin (EDB). An EDB is proposed for the site in lieu of other drainage options, such as bioretention, because there is at least 5 acres of tributary area to the basin. The EDB is to be sized to store the tributary water quality control volume (WQCV), excess urban runoff volume (EURV), and 100-year storm event using the latest MHFD Detention Basin Design Workbook.

Preliminary calculations for basin storage are provided in Appendix E.

2. *HYDRAULIC CRITERIA*

Site runoff is proposed to be conveyed via sheet flow into a series of storm inlets and storm sewers before outfalling into the EDB. All site drainage design within the parking facilities to comply with the standards set by the Jefferson County Zoning Resolution, Section 14 – Off-Street Parking and Loading. Per the manual, sheet flow shall not exceed 200 feet, parking areas wider than 42 feet shall control concentrated flow via swales and/or underdrains, and no drainage from areas other than parking shall be diverted to and cross parking areas.

Final hydraulic design to be provided during the Site Development Plan process as part of a Phase III Drainage Report. The final storm sewer system is to be designed in accordance with MHFD USDCM Volume I Chapter 7 and sized accordingly. The storm sewer network is to be analyzed for the 5-year and 100-year storm events and is to include capacity, minimum and maximum velocity, and HGL considerations; it is the intent for the final storm sewer design to be sized so that the 100-year HGL remains below the finished grade. The storm inlets are to also be analyzed for the minor and major storm event to ensure adequate capacity and bypass in accordance with Chapter 7 design criteria.

The driveway culvert crossing at North Turkey Creek is to be designed and constructed in accordance with the Criteria Manual Chapter 11, specifically complying with 11.5.1 Culverts within Drainageways; final calculations and details to be provided during the Site Development Plan process. The culvert is to be designed to the minimum design standard set by the Criteria because the crossing remains outside of the 100-year floodplain. If only a small increase in culvert size is required to prevent overtopping, then a larger culvert is to be proposed. Final culvert sizing is to require additional major basin flow analysis using the Colorado Urban Hydrograph Procedure (CUHP) to establish the 10-year and 100-year flows within the creek.

B. SPECIFIC DETAILS

The EDB is to be designed to MHFD standard and include forebays at entering storm sewer outfalls, trickle channels, outlet structure, and an emergency overflow embankment. Each structure within the basin is to be designed and sized with calculations, design considerations, and construction details provided in the construction documents. The basin is also to be designed to maintain vegetation and have max 3:1 to 4:1 side slopes planted with turf grass that allows for consistent coverage and a mowable surface. Detailed access is also to be provided into the basin which may include a stabilized path to the internal structures or a detailed maintenance plan for sediment removal within the outlet structure, micropool, forebays, etc. The final basin footprint is to be as naturally and aesthetically shaped as possible with the outlet structure remaining as hidden from the right of way as possible and not deter its functionality.

The preliminary volume calculations and water surface elevations are as follows:

Table 3: Preliminary Basin Summary

Drainage Area (ac)	Required WQCV (ac-ft)	Required 100-year Volume (ac-ft)	Required Total Basin Volume (ac-ft)	Volume Provided (ac-ft)	100-yr Release Rate (cfs)
6.35	0.095	0.184	0.440	0.578	7.9

PERMANENT STORMWATER BMPS & MAINTENANCE

EDBs have low to moderate maintenance requirements with potentially significant maintenance required every 15-25 years. The proposed site EDB is to be maintained routinely per MHFD Vol III recommendations. Routine maintenance includes debris and litter removal, mowing and plant care, sediment removal, and erosion and structural repairs. Native grass and other drought tolerant plantings may be proposed to maintain effective vegetation without requiring permanent irrigation facilities.

The mountain bike trails are to be routinely inspected and maintained to ensure functionality and limit erosion and sediment travel downstream. Temporary erosion control measures to be implemented during active construction may include sediment fencing or sediment control logs, sediment basins, temporary rock check dams, and stabilized construction entrances. Permanent structures may include bridge crossings or cross culverts at existing seasonal waterways, ditch turnouts or constructed filter berms, and drainage swales.

IV. CONCLUSION

The Shadow Mountain Bike Park is to comply with the design criteria set by Jefferson County. This Phase I Drainage Report reviews at a conceptual review the feasibility and design characteristics of the proposed bike park development.

A. COMPLIANCE WITH STANDARDS

The proposed drainage facilities for the development of Shadow Mountain Bike Park are to be designed in accordance with Jefferson County rules and regulations including the criteria set by the Storm Drainage Design & Technical Criteria and the Zoning Resolution. Per County recommendations, the facilities are to follow design criteria and recommendations set by the MHFD within the USDCM Criteria Manuals.

B. DRAINAGE CONCEPT

The proposed drainage facilities at the base area are to be designed for full spectrum detention and will thus not have a negative impact on downstream properties and the existing North Turkey Creek functionality. The project is to be subject to a sitewide Grading, Erosion and Sediment Control Plan that will dictate temporary construction stormwater BMPs and construction practices to protect the area during active earthwork and construction. The bike trails, lift areas, access road, and maintenance area are to be constructed with stormwater BMPs to provide permanent solutions erosion and sediment control. All proposed improvements are to be adequately maintained to ensure functionality.

V. REFERENCES

Storm Drainage Design & Technical Criteria, Jefferson County. Revised December 2019.

Zoning Resolution, Jefferson Country. Published June 2022.

Conifer/285 Corridor Area Community Plan, Jefferson County. September 2003.

Hydrologic Conditions and Assessment of Water Resources in the Turkey Creek Watershed, Jefferson, Colorado, 1998 – 2001. US Geological Survey, Water-Resources Investigations Report 03-4034. Published 2003.

Urban Storm Drainage Criteria Manual, Vol. 1: Management, Hydrology and Hydraulics, Revised August 2018.

Urban Storm Drainage Criteria Manual, Vol. 2: Structures, Storage and Recreation. Revised September 2017.

Urban Storm Drainage Criteria Manual, Vol. 3: Stormwater Best Management Practices (BMPs). Revised January 2021.

FIRM Flood Insurance Rate Map, Map Number 08059C0365F, Jefferson County, Colorado. Federal Emergency Management Agency. Revised February 5, 2014.

United States Department of Agriculture, Natural Resources Conservation Service. Custom Soil Resource Report.

APPENDICES

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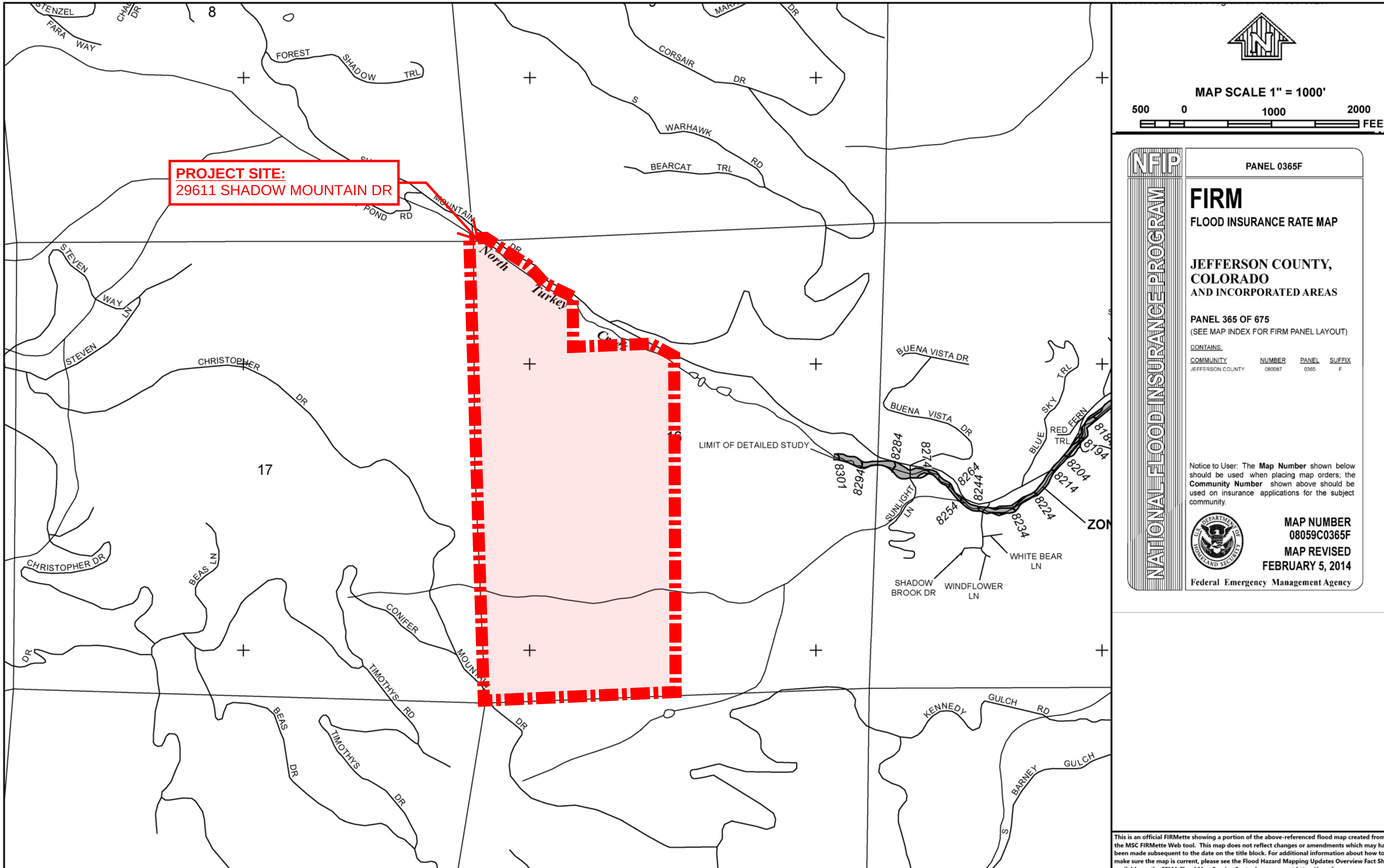
APPENDIX B – REDACTED MAJOR DRAINAGEWAY PLAN
APPENDIX C – SOILS SURVEY
APPENDIX D – SITE SUB-BASIN RATIONAL CALCULATIONS
APPENDIX E – PRELIMINARY DETENTION BASIN CALCULATIONS

DPE – GENERAL LOCATION MAP
DPP – DEVELOPED DRAINAGE PLANS



PROJECT SITE:
29611 SHADOW MOUNTAIN DR
MAP SCALE 1" = 1000'
500
0
1000
2000
FEET
NFIP
NATIONAL FLOOD INSURANCE PROGRAM
PANEL 0365F
FIRM
FLOOD INSURANCE RATE MAP
JEFFERSON COUNTY, COLORADO
AND INCORPORATED AREAS
PANEL 365 OF 675
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)
CONTAINS:
COMMUNITY NUMBER PANEL SUFFIX
JEFFERSON COUNTY 080087 0365 F
Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.
MAP NUMBER
08059C0365F
MAP REVISED
FEBRUARY 5, 2014
Federal Emergency Management Agency
This is an official FIRMette showing a portion of the above-referenced flood map created from the MSC FIRMette Web tool. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For additional information about how to make sure the map is current, please see the Flood Hazard Mapping Updates Overview Fact Sheet available on the FEMA Flood Map Service Center home page at https://msc.fema.gov.
8
17
FOREST
SHADOW TRL
CORSAIR DR
WARHAWK RD
BEARCAT TRL
POND RD
MOUNTAIN DR
North Turkey Creek
STEVEN WAY
STEVEN LN
CHRISTOPHER DR
CHRISTOPHER DR
BEAS LN
CONIFER
TIMOTHYS RD
TIMOTHYS DR
BEAS DR
BUENA VISTA DR
BUENA VISTA DR
LIMIT OF DETAILED STUDY
SUNLIGHT LN
SHADOW BROOK DR
WINDFLOWER LN
WHITE BEAR LN
BLUE SKY TRL
RED FERN TRL
8301
8294
8284
8274
8264
8254
8244
8234
8224
8214
8204
8194
ZON
KENNEDY GULCH RD
BARNEY GULCH
FARA WAY

Hydrologic Conditions and Assessment of Water Resources in the Turkey Creek Watershed, Jefferson County, Colorado, 1998–2001

By Clifford R. Bossong, Jonathan Saul Caine, David I. Stannard, Jennifer L. Flynn, Michael R. Stevens, and Janet S. Heiny-Dash

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U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 03–4034

SHADOW MOUNTAIN BIKE PARK - PHASE I DRAINAGE REPORT

Only sections of this report as they apply to the project site for the proposed Shadow Mountain Bike Park are included to be used as reference only. A full report can be located at https://pubs.usgs.gov

Prepared in cooperation with the
JEFFERSON COUNTY PLANNING AND ZONING DEPARTMENT

Denver, Colorado
2003

U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, Secretary

U.S. GEOLOGICAL SURVEY
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Denver Federal Center
Denver, CO 80225

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

Multiply	By	To obtain
	Length	
inch	2.54	centimeter (cm)
inch	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
acre	0.004047	square kilometer (km^2)
square mile (mi^2)	2.590	square kilometer (km^2)
square mile (mi^2)	640	acre
	Volume	
liter (L)	0.2642	gallon
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [(ft^3/s)/mi^2]	0.01093	cubic meter per second per square kilometer [(m^3/s)/km^2]
gallon per minute (gal/min)	0.06309	liter per second (L/s)
	Power	
watt	1	joules per second

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F = 1.8 (°C) + 32

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C = (°F – 32) / 1.8

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929. Horizontal is referenced to the North American Datum of 1927.

Elevation, as used in this report, refers to distance above or below NGVD29. NGVD29 can be converted to the North American Vertical Datum of 1988 by using the the National Geodetic Survey Conversion Utility available at URL http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Additional Abbreviations

mL	milliliter
m^2/m^3	square meter per cubic meter
$g\ m^{-2}\ s^{-1}$	gram per square meter per second
Wm^{-2}	watt per square meter
kPa	kilopascal
J	joule
min	minute

GLOSSARY OF SELECTED TERMS

The following terms are defined as they are used in this report.

Aperture.—The width of individual fracture openings in rock. Aperture is measured across the fracture, perpendicular to the fracture length.

Base flow.—Streamflow that emanates from ground water contained in a conceptual base-flow reservoir that exists in the subsurface. It is base flow that typically sustains streamflow during rainless periods.

Brittle structures.—Fractures, joints, and faults in rocks that are the result of brittle rather than ductile deformation.

Contemporary.—This term is used in this report to indicate data that were collected as part of this study, or to indicate methods that were applied to data that were collected for this study.

Evapotranspiration.—The process of moisture moving from the surface and near-surface areas of the Earth to the atmosphere; it is the sum of evaporation from wet surfaces (leaves, wet soils and rock, surface-water bodies, for example), sublimation from snow or ice, and transpiration, which is water evaporated from plant stomates.

Fracture set.—A group of fractures that have a set of properties such as orientation or length, or both, that are similar.

Fracture network.—A group of fracture sets that comprise all of the fractures in a volume of rock.

Fracture porosity.—Porosity resulting from open fractures, faults, or cracks.

Ground water.—As used in this report, water in the subsurface under water-table conditions. Some unknown amount of ground water is not asscoaited with local streamflow. As used in this report, ground water represents the contents of interflow and base-flow reservoirs and additional unaccounted for ground water that is not associated with local streamflow.

GSNK.—Ground water that percolates to a conceptual area of the watershed that is not available to support local streamflow.

Hydrologic response unit (HRU).—A land surface with similar slope and aspect properties defined for modeling surface and near-surface hydrologic processes.

Interflow.—Streamflow that emanates from ground water in direct response to precipitation or snowmelt, or both, that is contained in a conceptual interflow reservoir in the subsurface. Interflow may consist of streamflow contributions from subsurface areas that are saturated or perched, or some combination of both.

Interflow and base-flow reservoirs.—Conceptual subsurface portions of the watershed used for accounting purposes in runoff modeling.

Overland flow.—That part of precipitation that passes over the surface of the land and into the nearest surface-water body without first passing beneath the surface. Generally in direct response to precipitation.

Potential porosity.—An estimate of porosity made on the basis of mathematical characterizations of outcrop fracture measurements extrapolated to rock groups.

Recharge.—As used in this report, water added to the subsurface below the soil zone; it is the residual of precipitation, evapotranspiration, and overland flow. Recharge supports interflow, base flow, and underflow.

Rock group.—An assemblage of mappable rock types aggregated into a group on the basis of similarities.

Transmissivity.—Rate of movement of a volume of fluid through a medium. Units of measurement are L2/T, where L is length and T is time.

Underflow.—Ground water that leaves the watershed by means other than streamflow or evapotranspiration.

Hydrologic Conditions and Assessment of Water Resources in the Turkey Creek Watershed, Jefferson County, Colorado, 1998–2001

By Clifford R. Bossong, Jonathan Saul Caine, David I. Stannard, Jennifer L. Flynn, Michael R. Stevens, *and* Janet S. Heiny-Dash

Abstract

The 47.2-square-mile Turkey Creek watershed, in Jefferson County southwest of Denver, Colorado, is relatively steep with about 4,000 feet of relief and is in an area of fractured crystalline rocks of Precambrian age. Water needs for about 4,900 households in the watershed are served by domestic wells and individual sewage-disposal systems. Hydrologic conditions are described on the basis of contemporary hydrologic and geologic data collected in the watershed from early spring 1998 through September 2001. The water resources are assessed using discrete fracture-network modeling to estimate porosity and a physically based, distributed-parameter watershed runoff model to develop estimates of water-balance terms.

A variety of climatologic and hydrologic data were collected. Direct measurements of evapotranspiration indicate that a large amount (3 calendar-year mean of 82.9 percent) of precipitation is returned to the atmosphere. Surface-water records from January 1, 1999, through September 30, 2001, indicate that about 9 percent of precipitation leaves the watershed as streamflow in a seasonal pattern, with highest streamflows generally occurring in spring related to snowmelt and precipitation. Although conditions vary considerably within the watershed, overall watershed streamflow, based on several records collected during the 1940's, 1950's, 1980's, and 1990's near the downstream part of watershed, can be as high as about 200 cubic feet per second on a daily basis during spring. Streamflow typically recedes to about 1 cubic foot per second or less during rainless periods and is rarely zero. Ground-water level data indicate a seasonal pattern similar to that of surface water in which water levels are highest, rising tens of feet in some locations, in the spring and then receding during rainless periods at relatively constant rates until recharged. Synoptic measurements of water levels in 131 mostly domestic wells in fall of 2001 indicate a water-table surface that conforms to topography. Analyses of reported well-construction records indicate a median reported well yield of 4 gallons per minute and a spatial distribution for reported well yield that has relatively uniform conditions of small-scale variability. Results from quarterly samples collected in water year 1999 at about 112 wells and 22 streams indicate relatively concentrated calcium-bicarbonate to calcium-chloride type water that has a higher concentration of chloride than would be expected on the basis of chloride content in precipitation and evapotranspiration rates. Comparison of the 1999 data to similar data collected in the 1970's indicates that concentrations for many constituents appear to have increased. Reconnaissance sampling in the fall of 2000 indicates that most ground water in the watershed was recharged recently, although some ground water was recharged more than 50 years ago. Additional reconnaissance sampling in the spring and fall of 2001 identified some compounds indicative of human wastewater in ground water and surface water.

Outcrop fracture measurements were used to estimate potential porosities in three rock groups (metamorphic, intrusive, and fault zone) that have distinct fracture characteristics. The characterization, assuming a uniform aperture size of 100 microns, indicates very low potential fracture porosities, on the order of hundredths of a percent for metamorphic and intrusive rocks and up to about 2 percent for fault-zone rocks. A fourth rock group, Pikes Peak Granite, was defined on the basis of weathering characteristics. Short-term continuous and synoptic measurements of streamflow were used to describe base-flow characteristics in areas of the watershed underlain by each of the four rock groups and are the basis for characterization of base flow in a physically based, distributed-parameter watershed model.

The watershed model, the Precipitation-Runoff Modeling System (PRMS), was used to characterize hydrologic conditions on the basis of precipitation and air temperature in 112 hydrologic response units for which physical characteristics were derived from mostly digital data. The watershed model also was used to characterize hydrologic conditions in subsurface portions of the watershed that are associated with streamflow. The model was conditioned, using a relatively small set of parameters, to match measurements of watershed and intrawatershed streamflow and point measurements of evapotranspiration, air temperature, and soil moisture. Results from the watershed model provide simulated estimates for water-balance terms in a contemporary simulation (January 1, 1999, through September 30, 2001) using precipitation and adjusted temperature data from within the watershed, and in a long-term simulation (October 1, 1948, through September 30, 1999) using precipitation and temperature data from near the watershed. The results of both simulations indicate that, on a watershed scale, base-flow reservoirs consistently contain about enough water to cover the watershed with 0.1 to 0.2 inch of water. The long-term simulations indicate that during a year with about 14 inches of precipitation, the watershed base-flow reservoir may have about a –0.06 inch change in contents during periods with relatively small amounts of recharge. The results from watershed simulations also indicate that contents of base-flow reservoirs vary within the watershed; base-flow reservoirs contain little or no recoverable water for significant portions of many years in about 90 percent of the watershed. In areas where base-flow reservoirs contain no water, the only source of water for wells is water that has percolated to relatively deep parts of the system that are not associated with local streamflow; water withdrawn under these conditions will need to be replaced before base flow can resume. Estimates of the amount of water withdrawn by wells in 2001 in the Turkey Creek watershed are equal to a watershed depth of about 0.43 to 0.65 inch (about 0.0012 to 0.0018 inch per day).

INTRODUCTION

Water quality, water quantity, and population growth in the foothill portions of Jefferson County are of concern to the Jefferson County Board of County Commissioners and the Planning and Zoning Department. The Planning and Zoning Department desires to meet the needs of current residents for adequate supplies of good quality water and to prepare for the projected growth and demands on the water resource from future development. The Turkey Creek watershed is representative of the foothills portions of Jefferson County. Contemporary (2001) population in the Turkey Creek watershed is estimated at 11,064 residents with projected population growth, using a 2-percent per year rate, at 13,186 residents in 2010, and 15,313 residents in 2020 (Jefferson County Planning and Zoning Department, written commun., 2001).

Water supply in the foothills portions of Jefferson County is typically derived from domestic wells developed in the fractured crystalline rocks. There are many anecdotal reports of wells “going dry” or requiring modifications to maintain production, and the prospect of continued development raises some questions regarding water supply. In addition, domestic water is treated in individual sewage-disposal systems (ISDS) and returned to the local system as ISDS effluent from leach fields, and this has raised some concerns regarding the quality of water.

An understanding of hydrologic processes, especially those related to ground water, is a fundamental step in assessing contemporary (2001) quality and quantity of ground water. Together, the U.S. Geological Survey (USGS) and Jefferson County undertook a cooperative study of hydrologic conditions and assessment of water resources in Turkey Creek watershed beginning in 1998.

Purpose and Scope

The purpose of this report is to describe contemporary (2001) hydrologic conditions and to provide a hydrologic assessment of water resources in the Turkey Creek watershed. Hydrologic conditions are described on the basis of evapotranspiration, surface water, ground water, and water quality. In addition, a description of rock-fracture characteristics based on outcrop-scale measurements is included. The watershed assessment includes estimates of fracture porosity and a characterization of water-balance terms using a watershed precipitation-runoff model.

The scope of the study includes historical climatologic data collected by study-area residents, contemporary data collected during the study from 1998 to 2001, and historical data from agencies such as the Colorado Climate Center, State Engineers Office (SEO), and the USGS. Various methods, including geologic mapping and precipitation-runoff modeling, were used to assess water resources in the study area.

Location and Setting

The study area is the 47.2-mi^2 Turkey Creek watershed (fig. 1), in Jefferson County southwest of Denver, Colo., in the foothills of the Front Range Section of the Southern Rocky Mountains physiographic province (Fenneman, 1931). Included in the study area are many developed areas such as Conifer, Aspen Park, and Indian Hills. It is estimated that there are about 4,900 households in the study area, or, on average, about one household for every 6 acres (Jefferson County Planning and Zoning Department, written commun., 2001). About 62 percent of households in the watershed are single-family detached homes.

The watershed topography is mostly steep and often rocky with elevations ranging from about 10,500 ft in the southwestern part of the watershed to about 6,000 ft at the mouth of Turkey Creek canyon where the stream exits the foothills. Numerous bedrock outcrops in the study area border relatively gentle, open parks, such as Aspen Park, and stream valleys, such as North and South Turkey Creeks. Bedrock consists of fractured igneous and metamorphic crystalline rocks of Precambrian age that are extensively deformed. A more detailed geologic description is presented in the “Geologic Framework” section.

Previous Investigations

Several previous studies have been done on the chemical quality and physical quantity of the water resource in the Turkey Creek watershed. Snow (1968, 1972) and Waltz (1972) discussed the importance of fractured-bedrock aquifer characteristics in influencing the ground-water flow regime. Hofstra and Hall (1975a, 1975b) collected, compiled, and analyzed water-quality data for Phase I of an investigation to determine the effects of development on the water availability, water quality, and controlling factors in several mountain communities. Phase II of that investigation (Hall and Johnson, 1979) indicated that, although water quality was degrading, it was still acceptable for drinking. Seasonal fluctuations in water levels were observed (Hall and Johnson, 1979), and over a 3-year period there was an overall decline in water levels that may reflect short-term climatological factors or increased withdrawal from ground water. Recent work by Bruce and McMahon (1997) and Stevens and others (1997) provides water-quality data from the Turkey Creek watershed and other Front Range mountainous settings that can be compared to the results of this study.

Acknowledgments

The authors thank various local, State, and Federal agencies for their cooperation in providing information and data that were used in preparing this report, specifically the Colorado Department of Public Health and Environment; Colorado Division of Water Resources; Jefferson County Board of Commissioners; Jefferson County Planning and Zoning Department;

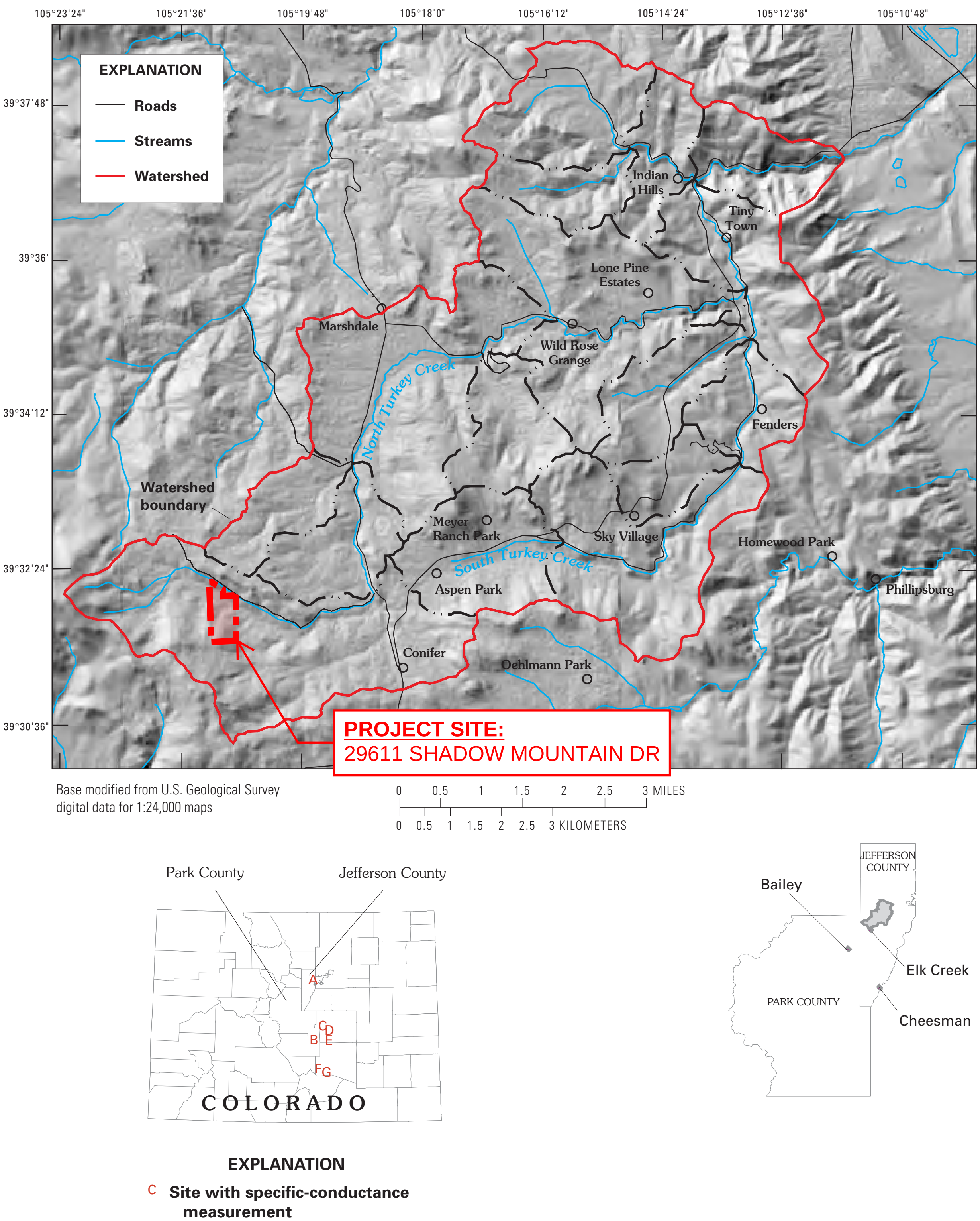


Figure 1. Location of Turkey Creek watershed in Jefferson County, Colorado; identifier and locations for sites with specific-conductance measurement; and location of Bailey, Cheesman, and Elk Creek climatologic monitoring stations.

members of the Mountain Ground-Water Resource Study Steering Committee; and the U.S. Environmental Protection Agency, Region VIII. Thanks also to Stephanie R.A. Tomusiak, Department of Geological Sciences, University of Colorado, Boulder, for her contributions to the fracture-data collection, analyses, and modeling efforts. Field assistance for outcrop measurements of fracture characteristics was provided by Ari Menitove, Jessica Beck, Sonya Cadle, Ben Glass, David Gardner, and Jared Lewis. Special appreciation also is expressed to Dick Burrows and Dorothy Hatch, dedicated volunteers that made monthly water-level measurements throughout the watershed during the study, as well as individuals who collected precipitation data, and homeowners who allowed various activities on their property such as water-level measurements, precipitation measurements, access to outcrops for fracture measurements, access to stream-sampling sites, and ground-water sample collection.

GEOLOGIC FRAMEWORK

A compilation of existing USGS geologic quadrangle maps for the Turkey Creek watershed shows a complex arrangement of Precambrian-age crystalline metamorphic and intrusive rock types (fig. 2 and table 1; Char, 2000, modified from Sheridan and others, 1972; Bryant and others, 1973; Scott, 1972; Bryant, 1974). Figure 3 is a simplified version of the geology shown in figure 2 and the rock types in table 1, produced by combining individual rock types into rock groups. Rock groups were identified on the basis of lithologic similarity, structural history, and geologic setting. For each rock group it is assumed that (1) ground-water flow and storage predominantly occurs in fracture networks, and that (2) because each rock group is composed of similar rock types that have a similar geological history and response to brittle deformation, they will exhibit similar hydrogeological properties (for example, porosity). Three important rock groups that contain subgroups were used to aid in establishing a geologic and hydrologic framework model. The rock groups are (1) metamorphosed and foliated gneisses and schists, referred to as the “metamorphic rock group;” (2) large-scale intrusive quartz monzonites found in plutons and consisting mostly of the Silver Plume Quartz Monzonite, referred to as the “intrusive rock group;” and (3) major fault zones that cut all rock types, referred to as the “fault-zone rock group” (fig. 3). Further division of the metamorphic and intrusive rock groups results in three subgroups: (1a) amphibolites, calc-silicates, and quartzites, (2a) the Pikes Peak Granite, and (2b) granitic pegmatite dikes that cross-cut the metamorphic and intrusive rock groups (table 1). The metamorphic, intrusive, and fault-zone rock groups plus subgroup 2a (the Pikes Peak Granite) are collectively referred to as the “four rock groups” in this report; group 1a is included in the metamorphic rocks and group 2b is included in the intrusive rocks.

The major rock types include approximately 1.7-billion-year-old gneisses and schists (metamorphic rocks). These rocks are typically well layered due to original compositional variations and metamorphic processes (Bryant, 1974; Bryant and others, 1975). They are part of the Turkey Creek Formation and are similar to the rocks in the Idaho Springs Formation (Lickus and LeRoy, 1968). The metamorphic rocks are intruded or cut by the approximately 1.4-billion-year-old Silver Plume Quartz Monzonite, which is a rock type similar to granite (intrusive rocks) (Bryant, 1974). These intrusive rocks are heterogeneously distributed in the watershed. The intrusive bodies range in size from small, dikelike features 50–100 ft long to large and irregular plutonlike bodies with large apophyses miles long. Pegmatitic dikes also cut the intrusive rocks. The pegmatites are highly irregular in shape and size and are less than a few feet to several miles long.

The major geologic structures in the watershed include folds and fault zones. The layering in the metamorphic rocks is generally steeply to moderately tilted and generally strikes northwest to southeast. This tilting is associated with the proximity of the observed outcrops to the limbs of several regional scale folds (Bryant and others, 1973). Many local- to outcrop-scale folds and highly contorted layering zones are present throughout the watershed.

A variety of brittle fault structures or fault zones are present in the watershed (fig. 3), and the Appendix contains a detailed discussion of these features. Brittle fault zones are in the form of unusually wide fracture networks (tens of feet to greater than miles wide) where most of the zone is composed of open fractures with little offset on them and a few discrete fractures where most of the offset has occurred. Other brittle fault zones are relatively narrow (a few feet wide) fault breccia zones that have anastomosing and discrete fractures where motion has taken place and where fracture networks have been mineralized with quartz, calcite, and other associated minerals.

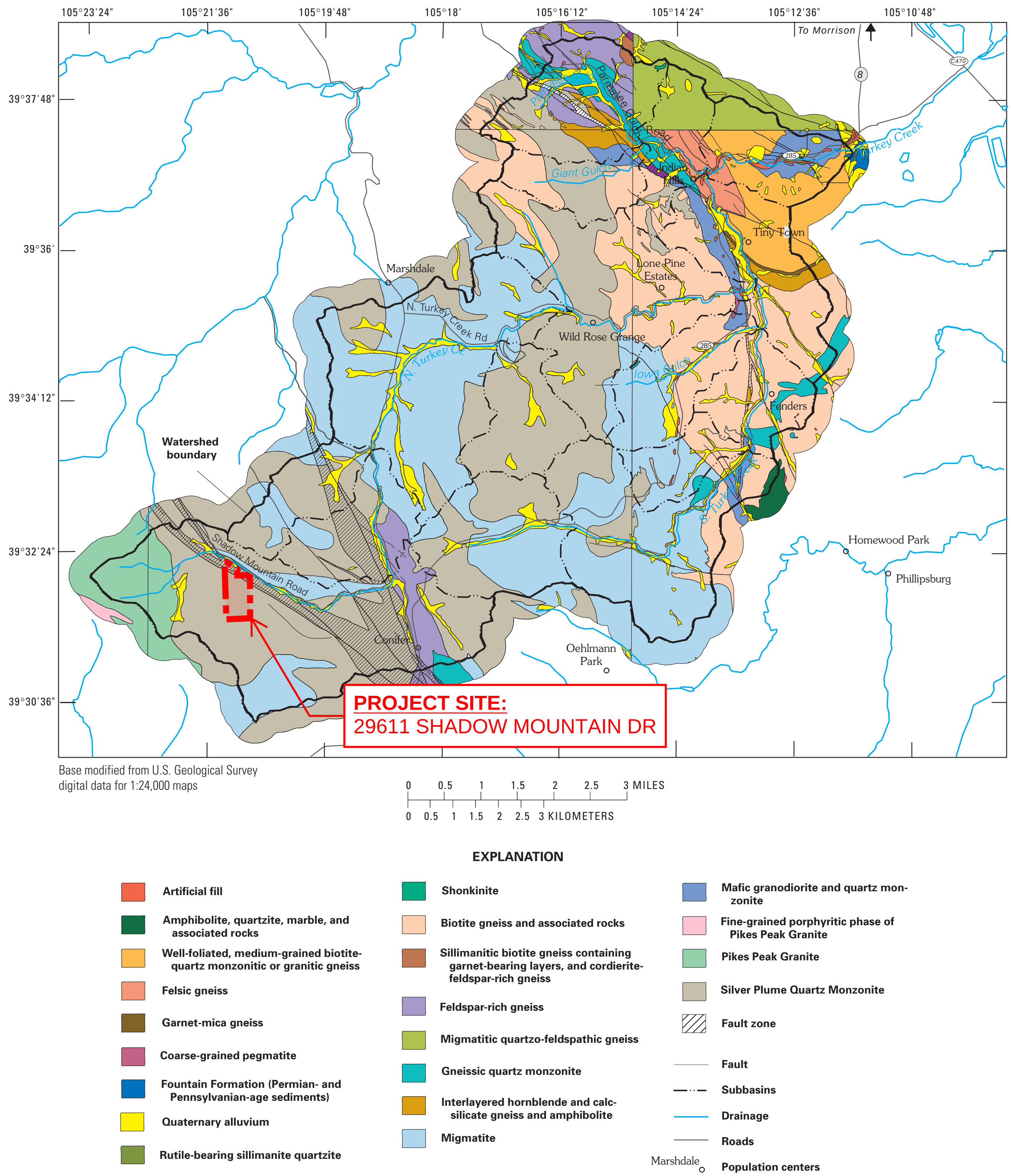


Figure 2. Compilation of parts of the existing Evergreen, Indian Hills, Morrison, Conifer, and Meridian Hills U.S. Geological Survey Geologic Quadrangle Maps.

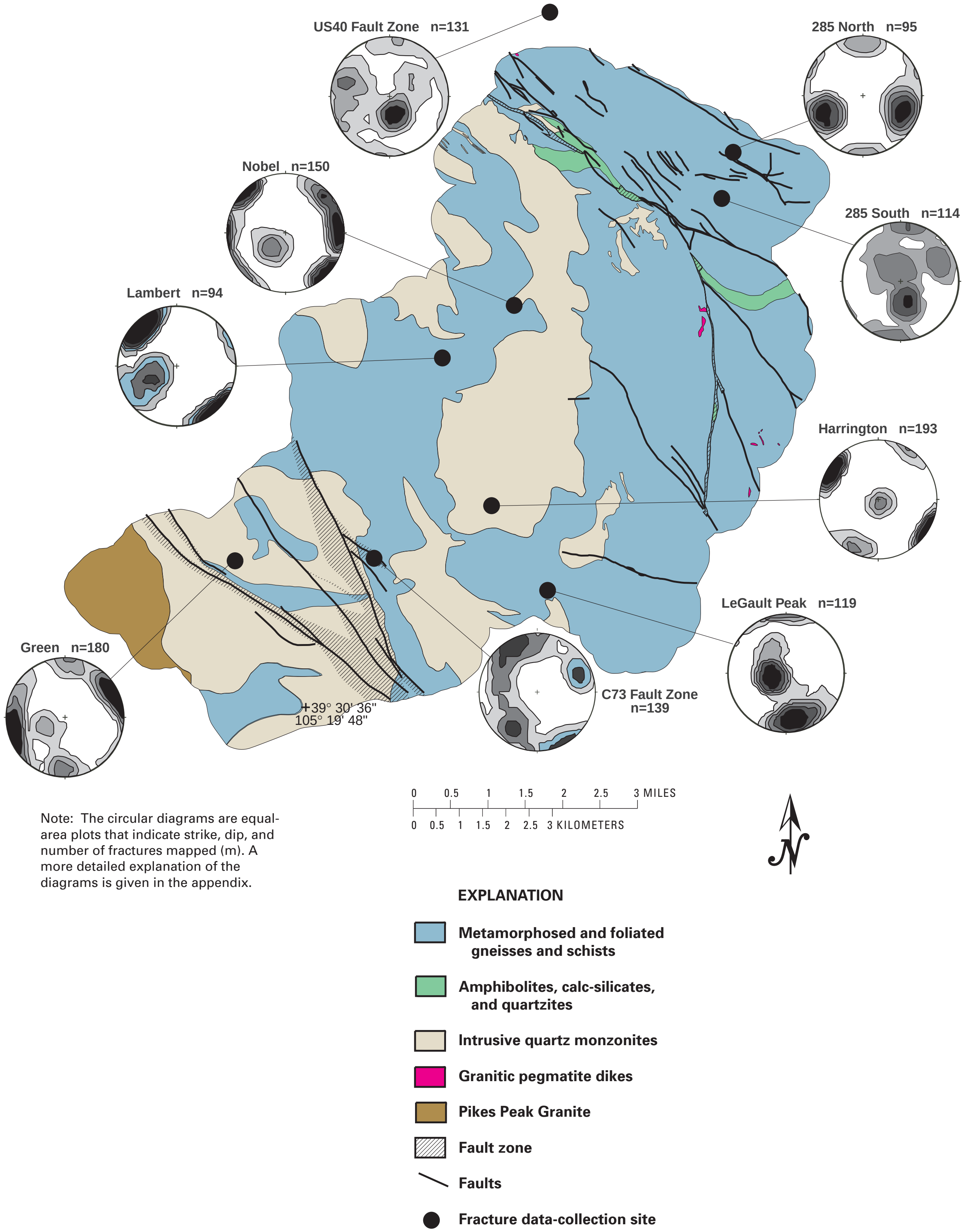


Figure 3. Simplified geologic map, locations of outcrops where fracture characteristics were measured or observed, and fracture-orientation data for measurements at each location.

Table 1. Individual rock types assigned to rock groups in the Turkey Creek watershed

[Individual rock types taken from the explanation in figure 2 are assigned to rock groups based on lithologic similarity, structural history, and geologic setting. The groups include (1) metamorphosed and foliated gneisses and schists; (1a) amphibolites, calc-silicates, and quartzites; (2) large-scale intrusive quartz monzonites found in plutons and consisting mostly of the Silver Plume Quartz Monzonite; (2a) Pikes Peak Granite and other granites; (2b) granitic pegmatites; and (3) major fault zones that cut all rock types. NP indicates rock types not present in the study area and Quaternary-age deposits have not been included. Y indicates Precambrian-age rocks that formed between 1.04 and 1.44 billion years ago, and X indicates rocks between 1.71 and 1.75 billion years old for this area. All other units are undated Precambrian-age rocks unless otherwise stated. The following is from Char, 2000, modified from Sheridan and others, 1972; Bryant and others,1973; Scott, 1972; and Bryant, 1974]

Rock type name	Rock group assignment
Shonkinite	NP
Fountain Formation (Permian and Pennsylvanian-age sediments)	NP
Pikes Peak Granite	2a
Silver Plume Quartz Monzonite	2
Fine-grained porphyritic phase of Pikes Peak Granite	2a
Granitic rock	2a
Coarse-grained pegmatite	2b
Mafic granodiorite and quartz diorite	2
Gneissic granodiorite and quartz monzonite	1
Gneissic quartz monzonite	1
Migmatitic quartzo-feldspathic gneiss	1
Migmatite	1
Amphibolite, quartzite, marble, and associated rocks	1a
Amphibolite	1a
Biotite gneiss and associated rocks	1
Sillimanitic biotite gneiss containing garnet-bearing layers, and cordierite-feldspar-rich gneiss	1
Interlayered hornblende and calc-silicate gneiss and amphibolite	1a
Feldspar-rich gneiss	1
Garnet-mica gneiss	1
Well-foliated, medium-grained biotite-quartz monzonitic or granitic gneiss	1
Felsic gneiss	1
Rutile-bearing sillimanite quartzite	1a
Fault zone	3

The Colorado Rocky Mountain Front Range has a long and complex geologic history and associated brittle deformation. There are at least three generations of brittle deformation associated with the Precambrian rock in the watershed: (1) early Paleozoic-age burial and late Paleozoic-age Ancestral Rocky Mountain uplift, (2) mid- to late Mesozoic-age burial and late Mesozoic-age to early Cenozoic-age Laramide uplift, and (3) late Cenozoic-age volcanism, uplift, and possible extension (for example, Sonnenberg and Bolyard, 1997). This protracted geologic history and the response of the various rock types to deformation led to the complex joint (fractures with no shearing motion along them) and fault patterns that are observed today. The Turkey Creek watershed represents a relatively undeformed portion of the Front Range relative to areas to the north in the Colorado Mineral Belt (Tweto and Sims, 1963).

Quaternary-age alluvium in the Turkey Creek watershed is sparse and is present primarily along stream channels and in open areas locally known as parks (fig. 2). The dominant soil types (stony loams to rock outcrops) are generally thin (about 2 to 3 ft thick), have generally low water availability, have moderate to high permeability, and are on moderate to steep slopes (U.S. Department of Agriculture, 1980). In addition, locally derived, very near-surface, bedrock weathering may be hydraulically significant. Thicker zones of weathered bedrock exist predominantly where there are coarse-grained intrusive rocks, especially overlying the Pikes Peak Granite. Significant areas of weathered bedrock also occur where there are metamorphic rocks that are dominantly composed of hornblende and a variety of amphiboles. Field observations and anecdotal information from water-well drillers indicate that weathered bedrock is rare to absent except in the southwestern part of the watershed where the Pikes Peak Granite crops out (fig. 2). Weathering probably extends to depths of about 10 ft or less and is nonuniformly distributed where the Pikes Peak Granite crops out and in particular where it has been glaciated.

Surficial deposits of alluvium and soils are thin and not present everywhere in the Turkey Creek watershed; although the surficial deposits contain water, most wells in the watershed are completed in the crystalline bedrock and most water used for domestic supply in the watershed is withdrawn from the crystalline bedrock. The crystalline bedrock has very low primary, or intergranular, porosity; rather, open space that may contain water in the crystalline rocks consists mostly of fractures and fracture networks. The fractured bedrock aquifer system in the Turkey Creek watershed is the fractures and fracture networks in the crystalline rocks.

DATA COLLECTION AND METHODS

Data used as part of this study are described in this section. Data collected in previous USGS studies and data compiled or collected by other agencies are referred to as “historical data,” and data collected as part of this study, beginning in 1998 and continuing through September 2001, are referred to as “contemporary data.” Some of the methods used in analyzing these data also are described in this section. Detailed descriptions of specialized methods used in developing estimates of fracture-network porosity, measurements of evapotranspiration, and characterization of spatial characteristics for some well-construction records are described in the Appendix. The preferred system of units for reporting in this report is the English inch-pound system; however, some data, such as those related to energy measures and rock fractures, are described in metric units as this is a standard and accepted practice.

Historical Data

Much data for the Turkey Creek watershed collected as part of previous studies or maintained by agencies other than the USGS were used in this study. These data provide some descriptions of historical climatologic, streamflow, ground-water level, and water-quality conditions in or around the watershed. The data also include well-construction records available from the Colorado State Engineer’s Office (SEO) and miscellaneous data available from the Jefferson County Planning and Zoning Department including summaries of U.S. Census Bureau information, projections of population growth, locations of occupied households, some historical land-use classifications, and digital orthophoto imagery.

The Colorado Climate Center, in cooperation with the National Weather Service, maintains climatologic records for many locations in Colorado (Colorado Climate Center, 2002). Records for precipitation and daily air temperature extremes from three stations—Bailey (station 50454), Cheesman (station 51528), and Elk Creek (station 52633)—were used as part of this study (fig. 1). In addition, a detailed precipitation record covering more than 40 years (1956–99) was available from John and Marguerite Schoonhoven of Flying J Ranch (RG12 in table 2). Several other intermittent and short-term records of snowfall and temperature were available from various sources.

Historical records include those collected previous to this study and consist of data from two stream gages on Turkey Creek in the vicinity of the present gage (06710992, fig. 4). A summary for time-series data indicating periods of record for stream gages and other data is presented in table 2. Some historical records, from the late 1980’s, of surface-water discharge, or streamflow, in the Turkey Creek watershed are available from the Automatic Data Processing System (ADAPS) part of the National Water Inventory System (NWIS) (Bartholoma, 1997). NWIS is a computer system established by the USGS to manage and provide some analytical capabilities for a wide variety of hydrologic information; ADAPS addresses continuous records of many hydrologic data, including surface-water records. Additional historical records of streamflow from the 1940’s and 1950’s are not included in the NWIS but have been compiled in publications (U.S. Geological Survey, 1942–53).

Table 2. List of sites with time-series records

[Note: primary identifier, U.S. Geological Survey (USGS) station identification number or National Weather Service (NWS) station number; identifier type refers to source for identifier (1 - USGS, 2 - Colorado Climate Center, 3 - State Engineers Office); Local identifier, local identifier used by this study; Location, latitude and longitude in nad27; Elevation, feet above NGVD29; Type, defines type of data collected at site (1 - total daily precipitation [a - tipping bucket, b - weighing bucket], 2 - daily minimum and maximum air temperature, 3 - mean daily discharge, 4 - soil moisture, 5 - solar radiation, 6 - evapotranspiration, 7 - daily mean diversion, 8 - intermittent or monthly depth-to-water measurements, 9 - mean daily depth to water); --, not applicable]

Identifier							
primary	type	local	Location	Elevation	Type	Period of record	Site name
DISCHARGE AND DIVERSIONS							
06710992	1	--	393703 1051324	6420	3	April 13, 2001 - continuing	Turkey Creek near Indian Hills
06710995	1	SWA01	393713 1051141	6040	3	April 1, 1998 - April 13, 2001	Turkey Creek at mouth of Canyon near Morrison
06711040	1	--	393827 1050934	5635	3	June 19, 1942 - September 30, 1953	Turkey Creek above Bear Creek Lake near Morrison
06711000	1	--	393809 1051003	--		April 25, 1986 - September 30, 1989	Turkey Creek near Morrison
393203105221600	1	STR-1	393203 1052216	9100	3	April 10, 2001 - August 1, 2001	North Turkey Creek upper tributary above Aspen Park
393210105205500	1	STR-2	393210 1052055	8435	3	April 10, 2001 - August 1, 2001	North Turkey Creek above Warhawk near Aspen Park
393141105200500	1	STR-3	393141 1052005	8350	3	April 17, 2001 - August 1, 2001	North Turkey Creek tributary above Aspen Park
393443105165800	1	STR-4	393443 1051658	7615	3	April 13, 2001 - August 1, 2001	North Turkey Creek tributary near Gartner Drive near Aspen Park
--	3	head 12	393714 1051155	6115	7	-- - --	Headgate Independent Highline # 12
--	3	head 27	393714 1051141	6015	7	-- - --	Headgate Bergen # 27
CLIMATOLOGIC							
393213105142100	1	RG1	393213 1051421	7460	1a	December 1, 1998 - September 30, 2001	RG1
393145105195900	1	RG2	393145 1051959	8250	1a	no record	RG2
393204105141700	1	RG3	393204 1051417	7900	1a	December 1, 1998 - September 30, 2001	RG3
393404105182701	1	RG4	393404 1051822	7820	1a	December 1, 1998 - September 30, 2001	RG4
393143105135600	1	RG5	393143 1051356	8480	1a	December 1, 1998 - September 30, 2001	RG5
393459105170300	1	RG6	393459 1051703	7560	1a	December 1, 1998 - September 30, 2001	RG6
393552105144201	1	RG7	393552 1051442	7480	1a	December 1, 1998 - September 30, 2001	RG7
393700105114500	1	RG8	393700 1051145	6040	1b,2	August 28, 1998 - September 30, 2001	RG8/AT1
393423105131000	1	RG9	393423 1051310	7160	1b	September 23, 1998 - September 30, 2001	RG9
393249105181900	1	RG10	393248 1051819	8240	1b	February 2, 1999 - September 30, 2001	RG10
393340105201500	1	RG11	393340 1052015	8180	1b	November 25, 1998 - November 23, 20011	RG11
--	1	RG12	393237 1051912	7980	1,2	January 1, 1956 - December 30, 1999	RG12
50454	1	RG13	392421 1052822	7730	11,2	August 1, 1948 - December 31, 1997	Bailey
51520	2	RG14	391313 1051640	6890	11,2	August 1, 1948 - June 30, 2000	Cheesman
52633	2	RG15	392953 1052000	8440	11,2	August 1, 1948 - September 30, 1951	Elk Creek
--	2	RG16	393227 1051925	8180	1a,2, 4,5,6	February 3, 1999 - December 31, 2001	RG16/ *ET* Forest site/ *ET* Tower
--	2	RG17	393429 1051638	7770	1a,2, 4,5,6	June 2, 2000 - December 31, 2001	RG17/ *ET* Meadow site
--	2	RG18	393429 1051638	7770	1b	December 6, 2000 - September 30, 2001	RG18/ *ET* Forest site
--	2	AT2	393104 1052109	9760	2	April 1, 2001 - September 30, 2001	Elk Creek Fire Station at Conifer Mountain
--	2	AT3	393304 1051621	8200	2	March 23, 2001 - September 30, 2001	North Meyer Ranch Park
--	2	AT4	393223 1051624	8200	2	March 23, 2001 - September 30, 2001	South Meyer Ranch Park
DEPTH TO WATER							
393821105161001	1	MH1	393820 1051612	7310	8	September 5, 1973 - February 14, 1983	MH1
						August 25, 1998 - continuing	
					9	May 23, 2001 - September 30, 2001	
393604105132100	1	MH2	393604 1051321	6900	8	November 4, 1998 - continuing	MH2
393513105181300	1	MH3	393513 1051813	7751	8	July 9, 1998 - continuing	MH3
393459105165701	1	MH4	393459 1051657	7672	8	December 3, 1998 - continuing	MH4
393350105184401	1	MH5	393350 1051844	7900	8	September 5, 1973 - February 14, 1983	MH5
						August 25, 1998 - continuing	
					9	May 23, 2001 - September 30, 2001	
393348105171400	1	MH6.1	393348 1051714	8375	8	December 3, 1998 - continuing	MH6.1
393344105171400	1	MH6.2	393344 1051714	8352	8	December 3, 1998 - continuing	MH6.2
393342105171500	1	MH6.3	393342 1051715	8340	8	December 3, 1998 - continuing	MH6.3
39333210515 800	1	MH7	393332 1051508	8337	8	December 3, 1998 - continuing	MH7
393301105150201	1	MH8	393301 1051532	8050	8	September 6, 1973 - February 14, 1983	MH8
						July 9, 1998 - continuing	
					9	May 23, 2001 - September 30, 2001	
393121105110600	1	MH9	393121 1051106	6720	8	September 6, 1973 - February 14, 1983	MH9
						August 25, 1998 - September 30, 2001	
392958105164601	1	MH10	392958 1051646	7950	8	September 6, 1973 - February 14, 1983	MH10
						August 25, 1998 - September 30, 2001	
393112105182100	1	MH11	393112 1051821	8477	8	June 18, 1998 - continuing	MH11
393143105195400	1	MH12	393143 1051954	8187	8	July 10, 1998 - continuing	MH12
393717105145300	1	MH13	393717 1051453	7279	8	May 11, 1999 - continuing	MH13

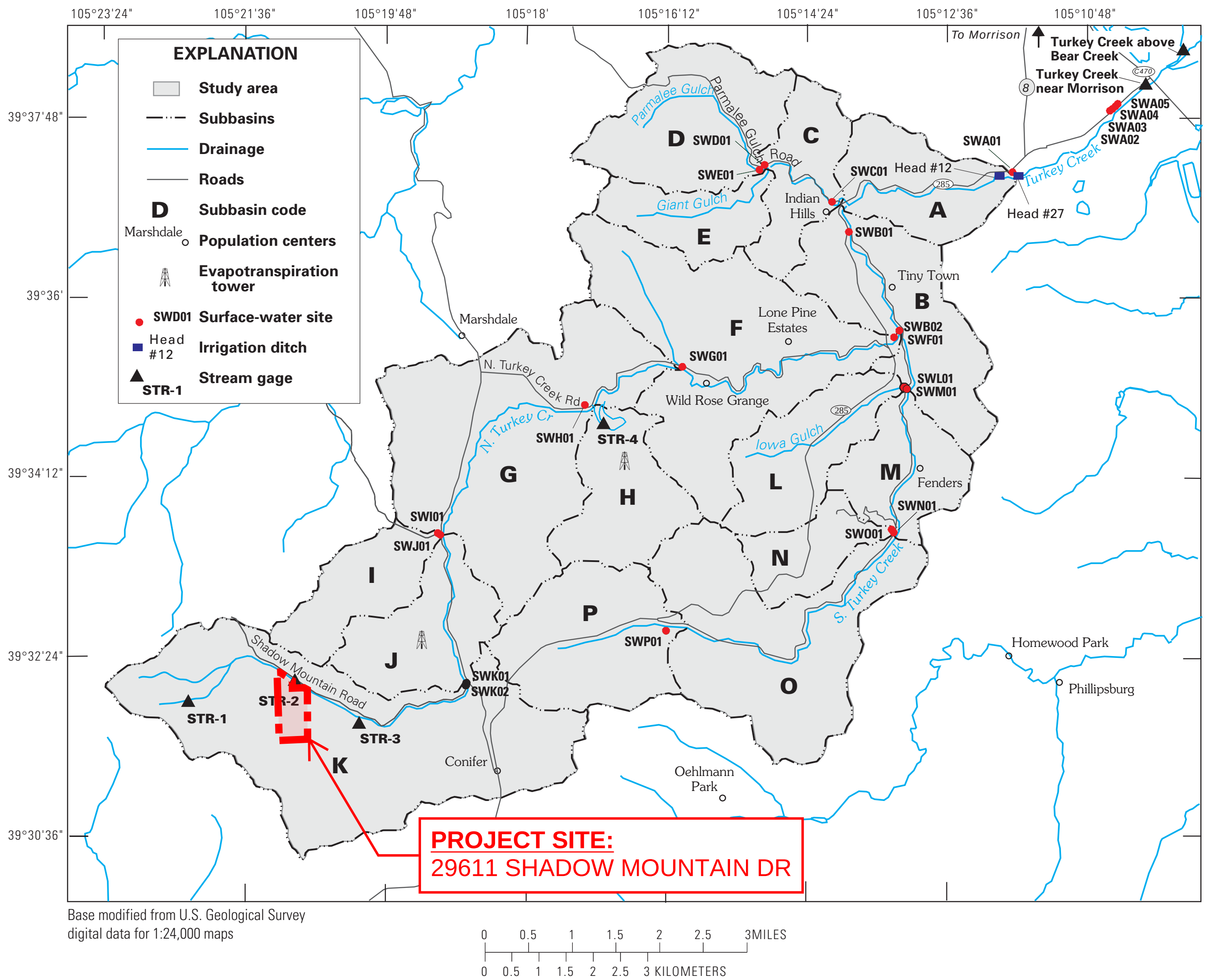


Figure 4. Locations of surface-water streamflow measurement and sampling sites, stream gages, and irrigation ditches.

Two stream gages on Turkey Creek were operated by the USGS at various times previous to this study. Station 06711040, Turkey Creek above Bear Creek Lake near Morrison, about 1.5 mi downstream from the present gage (station 06710992) (fig. 4), has data available from April 25, 1986, through September 30, 1989. Station 06711000, Turkey Creek near Morrison, about 1 mi downstream from the present gage, has data available from June 19, 1942, through September 30, 1953. Diversions from Turkey Creek upstream from these stations complicate streamflow records. Although streamflow records at these stations have an acceptable level of accuracy, they are not representative of stream regulation that occurs upstream from the gages. Regulation activity typically consists of diversions. The water diverted from streams is not measured at the gages; consequently, the gage record is "low biased," or consistently less than the sum of measured streamflow and the diversion, during times of diversion. Regulation also may include addition of water to streams. Records for diversions from the Independent Highline and Bergen ditches (fig. 4) are available from the SEO; other records from potential additional diversions or additions are not available.

The SEO is responsible for issuing permits for well construction in Colorado. As part of the permitting process, many well-construction details are obtained by the SEO and retained in their files. Many of these data, such as legal description, drillers' logs, and well-completion diagrams, are only available in paper format or scanned images of original paper copies. However, some data are available electronically as digital records. The SEO has about 3,300 digital well records with construction details on file for the Turkey Creek watershed. About 1,100 of those wells, referred to in this report as “permitted wells,” have defined locations that are shown in figure 5. The digital data describe reported well yield, total depth, and depth to water.

Water-quality data from previous studies were available for use in this study. Most of these data were collected in the 1970’s as part of the work by Hofstra and Hall (1975a) and Hall and others (1981). Bruce and McMahon (1997) also collected water-quality data from a number of wells in Front Range settings, a few of which are in the watershed. In addition, Bruce and McMahon (1997) and Stevens and others (1997) collected water-quality data from wells completed in fractured rocks in other Front Range areas that can be compared to data collected during this study. All of these data include analyses for many water-quality properties and constituents addressed by this study as well as other constituents that are useful to this study. The locations for samples collected during previous studies in the Turkey Creek watershed are shown in figure 6. Univariate statistics for water-quality properties and constituents including major ions and some nutrients collected in previous studies are listed in table 3.

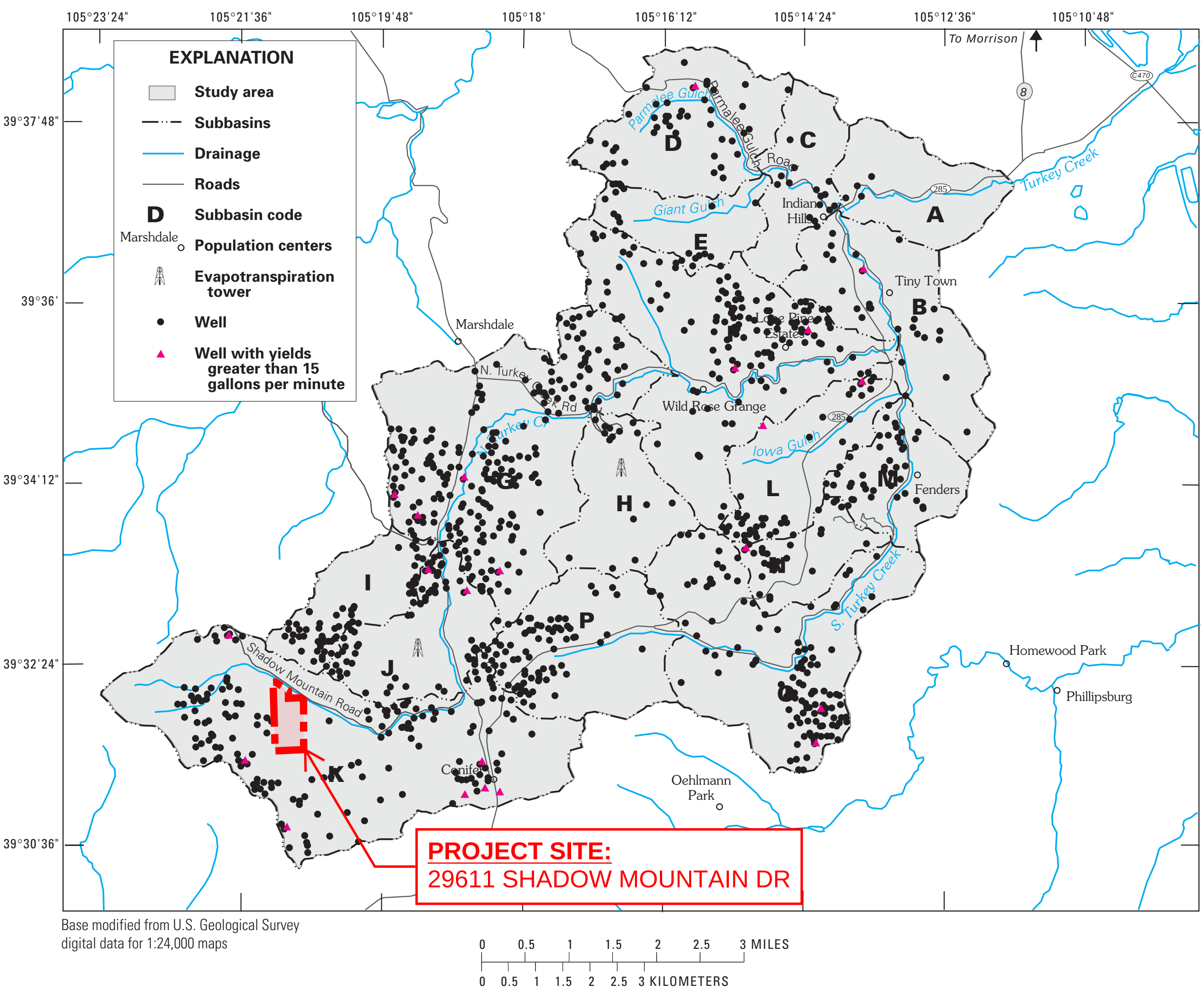


Figure 5. Locations of permitted wells from the State Engineers Office.

United States Department of Agriculture

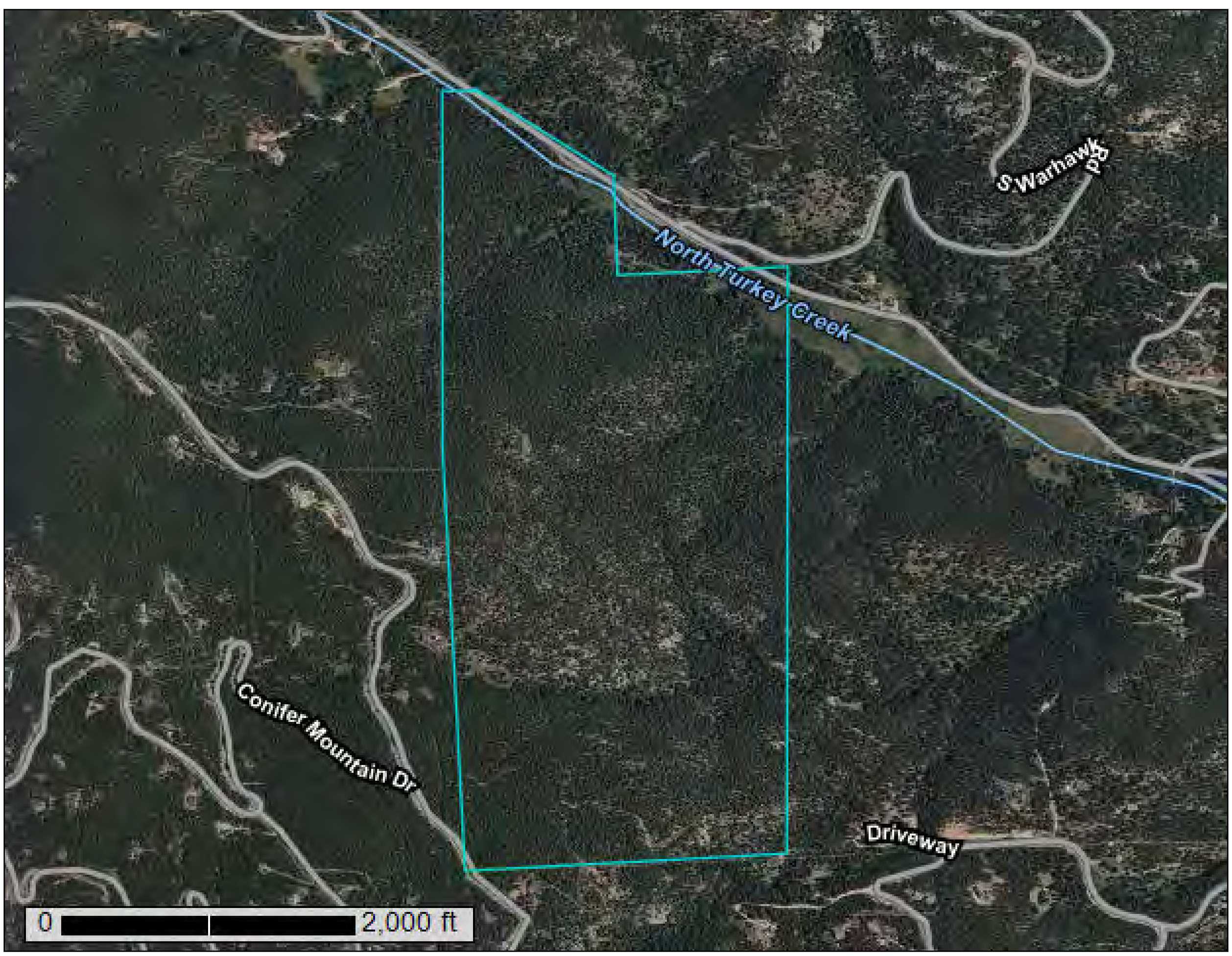
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties

Shadow Mountain Bike Park



September 16, 2022

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

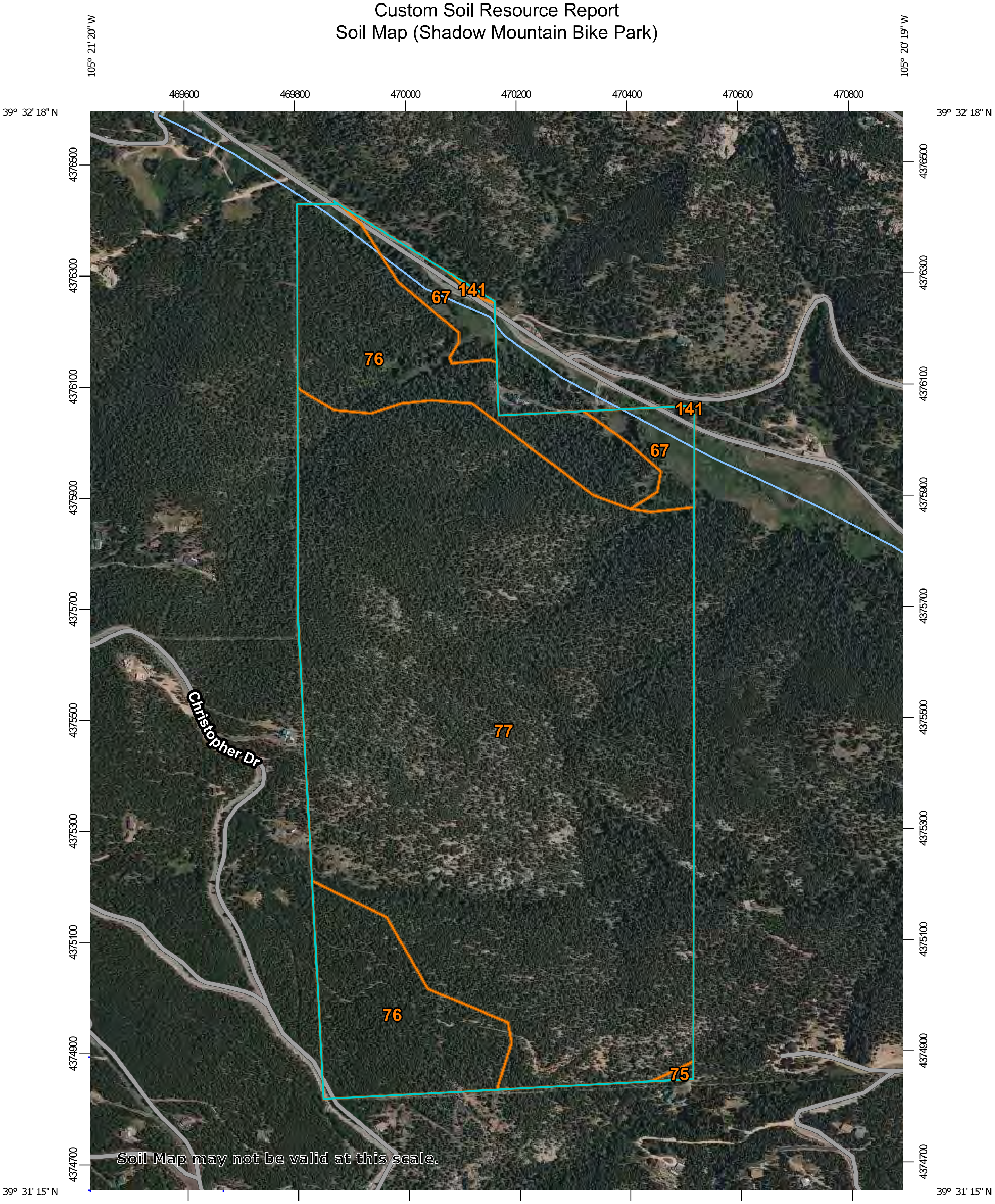
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

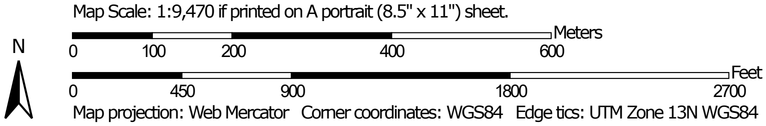
Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map (Shadow Mountain Bike Park)



Map Scale: 1:9,470 if printed on A portrait (8.5" x 11") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties
Survey Area Data: Version 16, Aug 31, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 1, 2020—Jul 2, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND	MAP INFORMATION
	imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend (Shadow Mountain Bike Park)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
67	Kittredge-Earcree complex, 9 to 20 percent slopes	10.1	4.2%
75	Legault-Hiwan stony loamy sands, 5 to 15 percent slopes	0.3	0.1%
76	Legault-Hiwan stony loamy sands, 15 to 30 percent slopes	48.5	20.3%
77	Legault-Hiwan-Rock outcrop complex, 30 to 50 percent slopes	179.8	75.3%
141	Rogert, very stony-Herbman-Rock outcrop complex, 30 to 70 percent slopes	0.2	0.1%
Totals for Area of Interest		**238.9**	**100.0%**

Map Unit Descriptions (Shadow Mountain Bike Park)

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Golden Area, Colorado, Parts of Denver, Douglas, Jefferson, and Park Counties

67—Kittredge-Earcree complex, 9 to 20 percent slopes

Map Unit Setting

National map unit symbol: jppt
Elevation: 7,600 to 9,500 feet
Mean annual precipitation: 17 to 20 inches
Mean annual air temperature: 41 to 43 degrees F
Frost-free period: 55 to 75 days
Farmland classification: Not prime farmland

Map Unit Composition

Kittredge and similar soils: 45 percent
Earcree and similar soils: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kittredge

Setting

Landform: Mountain slopes, terraces
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Mountainbase, tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium and/or colluvium derived from igneous and metamorphic rock

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 29 inches: sandy clay loam
H3 - 29 to 60 inches: sandy loam

Properties and qualities

Slope: 9 to 20 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: R048AY222CO - Loamy Park
Hydric soil rating: No

Description of Earcree

Setting

Landform: Alluvial fans
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Noncalcareous, gravelly and loamy alluvium and/or colluvium derived from igneous and metamorphic rock

Typical profile

H1 - 0 to 11 inches: gravelly sandy loam
H2 - 11 to 60 inches: gravelly sandy loam

Properties and qualities

Slope: 9 to 20 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: R048AY222CO - Loamy Park
Hydric soil rating: No

Minor Components

Cryofluvents

Percent of map unit: 3 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R048AY010UT - Wet Fresh Streambank (Willow)
Hydric soil rating: No

Urban land

Percent of map unit: 3 percent
Hydric soil rating: No

Rogert

Percent of map unit: 3 percent
Landform: Ridges
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Troutdale

Percent of map unit: 3 percent
Landform: Mountain slopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex, linear
Across-slope shape: Linear
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Venable

Percent of map unit: 3 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R048AY241CO - Mountain Meadow
Hydric soil rating: Yes

75—Legault-Hiwan stony loamy sands, 5 to 15 percent slopes

Map Unit Setting

National map unit symbol: jpq3
Elevation: 7,600 to 10,000 feet
Mean annual precipitation: 17 to 20 inches
Mean annual air temperature: 41 to 43 degrees F
Frost-free period: 55 to 75 days
Farmland classification: Not prime farmland

Map Unit Composition

Legault and similar soils: 45 percent
Hiwan and similar soils: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Legault

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Acidic, gravelly, stony, and sandy residuum weathered from igneous and metamorphic rock

Typical profile

H1 - 0 to 2 inches: gravelly loamy sand
H2 - 2 to 14 inches: very gravelly loamy sand
H3 - 14 to 18 inches: weathered bedrock

Properties and qualities

Slope: 5 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 0.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: D
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Description of Hiwan

Setting

Landform: Mountain slopes, ridges
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Mountainflank, crest
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Acidic, stony, gravelly, and sandy residuum weathered from igneous and metamorphic rock

Typical profile

H1 - 0 to 1 inches: very gravelly loamy sand
H2 - 1 to 15 inches: very gravelly loamy sand
H3 - 15 to 19 inches: unweathered bedrock

Properties and qualities

Slope: 5 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 0.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: D
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Minor Components

Earcree

Percent of map unit: 3 percent
Landform: Drainageways
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Grimstone

Percent of map unit: 3 percent
Landform: Mountain slopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Peeler

Percent of map unit: 3 percent
Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Ecological site: F048AY908CO - Mixed Conifer
Other vegetative classification: ABLA-PIEN/VASC (subalpine fir, Engelmann's spruce, grouse whortleberry) (null_6)
Hydric soil rating: No

Rock outcrop

Percent of map unit: 3 percent
Landform: Mountain slopes, ridges
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Free face, mountainflank, side slope, crest, free face
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Hydric soil rating: No

Herbman

Percent of map unit: 2 percent
Landform: Mountain slopes
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Mountaintop, mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Urban land

Percent of map unit: 1 percent
Hydric soil rating: No

76—Legault-Hiwan stony loamy sands, 15 to 30 percent slopes

Map Unit Setting

National map unit symbol: jpq4
Elevation: 7,600 to 10,000 feet
Mean annual precipitation: 17 to 20 inches
Mean annual air temperature: 41 to 43 degrees F
Frost-free period: 55 to 75 days
Farmland classification: Not prime farmland

Map Unit Composition

Legault and similar soils: 45 percent
Hiwan and similar soils: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Legault

Setting

Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: Acidic, gravelly, stony, and sandy residuum weathered from igneous and metamorphic rock

Typical profile

H1 - 0 to 1 inches: gravelly loamy sand
H2 - 1 to 13 inches: very gravelly loamy sand
H3 - 13 to 17 inches: weathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 0.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Description of Hiwan

Setting

Landform: Mountain slopes, ridges
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Mountainflank, crest
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Acidic, stony, gravelly, and sandy residuum weathered from igneous and metamorphic rock

Typical profile

H1 - 0 to 1 inches: very gravelly loamy sand
H2 - 1 to 15 inches: very gravelly loamy sand
H3 - 15 to 19 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 0.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: D
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Minor Components

Grimstone

Percent of map unit: 3 percent
Landform: Mountain slopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Rock outcrop

Percent of map unit: 3 percent
Landform: Mountain slopes, ridges
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Mountainflank, free face, side slope, crest, free face
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Hydric soil rating: No

Peeler

Percent of map unit: 3 percent
Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Ecological site: F048AY908CO - Mixed Conifer
Other vegetative classification: ABLA-PIEN/VASC (subalpine fir, Engelmann's spruce, grouse whortleberry) (null_6)
Hydric soil rating: No

Earcree

Percent of map unit: 3 percent
Landform: Drainageways
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Herbman

Percent of map unit: 2 percent
Landform: Mountain slopes
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Mountaintop, mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Urban land

Percent of map unit: 1 percent
Hydric soil rating: No

77—Legault-Hiwan-Rock outcrop complex, 30 to 50 percent slopes

Map Unit Setting

National map unit symbol: jpq5
Elevation: 7,600 to 10,000 feet
Mean annual precipitation: 17 to 20 inches
Mean annual air temperature: 41 to 43 degrees F
Frost-free period: 55 to 75 days
Farmland classification: Not prime farmland

Map Unit Composition

Legault and similar soils: 35 percent
Hiwan and similar soils: 30 percent
Rock outcrop: 20 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Legault

Setting

Landform: Ridges, mountain slopes
Landform position (three-dimensional): Mountainflank, crest
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Acidic, gravelly, stony, and sandy residuum weathered from igneous and metamorphic rock

Typical profile

H1 - 0 to 1 inches: gravelly loamy sand
H2 - 1 to 13 inches: very gravelly loamy sand
H3 - 13 to 17 inches: weathered bedrock

Properties and qualities

Slope: 30 to 50 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 0.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Description of Hiwan

Setting

Landform: Mountain slopes, ridges
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Mountainflank, crest
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Acidic, stony, gravelly, and sandy residuum weathered from igneous and metamorphic rock

Typical profile

H1 - 0 to 1 inches: very gravelly loamy sand
H2 - 1 to 15 inches: very gravelly loamy sand
H3 - 15 to 19 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 50 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 0.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Description of Rock Outcrop

Setting

Landform: Mountain slopes, ridges
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Mountainflank, free face, side slope, crest, free face
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Igneous and metamorphic rock

Typical profile

H1 - 0 to 60 inches: unweathered bedrock

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Grimstone

Percent of map unit: 3 percent
Landform: Mountain slopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Herbman

Percent of map unit: 3 percent
Landform: Mountain slopes
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Mountaintop, mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Rogert

Percent of map unit: 3 percent
Landform: Mountain slopes
Landform position (two-dimensional): Shoulder, backslope

Landform position (three-dimensional): Upper third of mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

Peeler

Percent of map unit: 3 percent
Landform: Mountain slopes
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Ecological site: F048AY908CO - Mixed Conifer
Other vegetative classification: ABLA-PIEN/VASC (subalpine fir, Engelmann's spruce, grouse whortleberry) (null_6)
Hydric soil rating: No

Tolvar

Percent of map unit: 3 percent
Landform: Mountain slopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: F048AY908CO - Mixed Conifer
Hydric soil rating: No

141—Rogert, very stony-Herbman-Rock outcrop complex, 30 to 70 percent slopes

Map Unit Setting

National map unit symbol: 2tz4y
Elevation: 7,590 to 10,000 feet
Mean annual precipitation: 17 to 23 inches
Mean annual air temperature: 37 to 43 degrees F
Frost-free period: 25 to 75 days
Farmland classification: Not prime farmland

Map Unit Composition

Rogert, very stony, and similar soils: 45 percent
Herbman and similar soils: 30 percent
Rock outcrop: 15 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rogert, Very Stony

Setting

Landform: Ridges, mountain slopes
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Mountaintop, upper third of mountainflank
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Colluvium over residuum weathered from igneous and metamorphic rock

Typical profile

A - 0 to 8 inches: very cobbly sandy loam
C - 8 to 16 inches: very gravelly sandy loam
R - 16 to 79 inches: bedrock

Properties and qualities

Slope: 30 to 70 percent
Surface area covered with cobbles, stones or boulders: 2.0 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.01 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.0 inches)

Interpretive groups

Land capability classification (irrigated): 7e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: R048AY237CO - Stony Loam
Hydric soil rating: No

Description of Herbman

Setting

Landform: Mountain slopes, ridges
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Mountaintop, mountainflank, crest
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Colluvium over residuum weathered from igneous and metamorphic rock

Typical profile

A - 0 to 4 inches: very gravelly sandy loam
AC - 4 to 14 inches: very gravelly sandy loam
Cr - 14 to 79 inches: bedrock

Properties and qualities

Slope: 30 to 70 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.00 to 0.28 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.2 inches)

Interpretive groups
Land capability classification (irrigated): 7e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: R048AY237CO - Stony Loam
Hydric soil rating: No

Description of Rock Outcrop

Setting
Landform: Mountain slopes, ridges
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Mountainflank, free face, side slope, crest, free face
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Rock outcrops, talus, and large boulders of igneous and metamorphic rock

Interpretive groups
Land capability classification (irrigated): 8
Land capability classification (nonirrigated): 8
Hydric soil rating: No

Minor Components

Troutdale
Percent of map unit: 3 percent
Landform: Ridges, mountain slopes
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Mountainflank, crest
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Ecological site: R048AY228CO - Mountain Loam
Hydric soil rating: No

Kittredge
Percent of map unit: 3 percent
Landform: Alluvial fans, mountain slopes
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Mountainbase
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R048AY228CO - Mountain Loam
Hydric soil rating: No

Sprucedale
Percent of map unit: 2 percent
Landform: Ridges, mountain slopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Mountaintop, mountainflank, side slope, crest

Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Ecological site: R048AY228CO - Mountain Loam
Hydric soil rating: No

Pettingell

Percent of map unit: 2 percent
Landform: Mountain slopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Ecological site: R048AY237CO - Stony Loam
Hydric soil rating: No

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Calculation of Peak Runoff using Rational Method

Designer: Olivia Dawson, P.E.
Company: SE Group
Date: 11/2/2022
Project: Shadow Mountain Bike Park
Location: 29611 Shadow Mnt Dr Conifer, CO

Version 2.00 released May 2017

Cells of this color are for required user-input
Cells of this color are for optional override values
Cells of this color are for calculated results based on overrides

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_i^{0.33}}$$

$$t_t = \frac{L_t}{60K\sqrt{S_t}} = \frac{L_t}{60V_t}$$

$$\text{Computed } t_c = t_i + t_t$$

$$\text{Regional } t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$$

$t_{minimum}$ = 5 (urban)
$t_{minimum}$ = 10 (non-urban)

$$\text{Selected } t_c = \max\{t_{minimum}, \min(\text{Computed } t_c, \text{Regional } t_c)\}$$

Select UDFCD location for NOAA Atlas 14 Rainfall Depths from the pulldown list OR enter your own depths obtained from the NOAA website (click this link)

	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
1-hour rainfall depth, P1 (in) =	0.85	1.19	1.39		1.93	2.20	

	a	b	c
Rainfall Intensity Equation Coefficients =	28.50	10.00	0.786

$$I(in/hr) = \frac{a * P_1}{(b + t_c)^c}$$

$$Q(cfs) = CIA$$

Subcatchment Name	Area (ac)	NRCS Hydrologic Soil Group	Percent Imperviousness	Runoff Coefficient, C 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
H1	2.74	D	2.00	0.01	0.05	0.15	0.33	0.40	0.49	0.59
H2	4.01	B	2.00	0.01	0.01	0.07	0.26	0.34	0.44	0.54
D1	2.74	D	43.0	0.32	0.39	0.45	0.56	0.61	0.66	0.72
D2	3.61	B	31.0	0.21	0.24	0.31	0.44	0.50	0.57	0.65
OS	0.40	B	2.0	0.01	0.01	0.07	0.26	0.34	0.44	0.54

Subcatchment Name	Overland (Initial) Flow Time: Overland Flow Length L_i (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Overland Flow Slope S_i (ft/ft)	Overland Flow Time t_i (min)	Channelized (Travel) Flow Time: Channelized Flow Length L_t (ft)	U/S Elevation (ft) (Optional)	D/S Elevation (ft) (Optional)	Channelized Flow Slope S_t (ft/ft)	NRCS Conveyance Factor K	Channelized Flow Velocity V_t (ft/sec)	Channelized Flow Time t_t (min)
H1	230.00	8432.97	8390.54	0.184	10.97	5.00			0.010	5	0.50	0.17
H2	500.00	8405.21	8371.58	0.067	23.41	5.00			0.010	2.5	0.25	0.33
D1	300.00	8432.97	8389.33	0.145	9.24	5.00			0.010	10	1.00	0.08
D2	200.00	8379.40	8368.23	0.056	12.45	185.00	8389.33	8379.40	0.054	20	4.63	0.67
OS	200.00	8378.00	8369.00	0.045	16.91	5.00			0.010	2.5	0.25	0.33

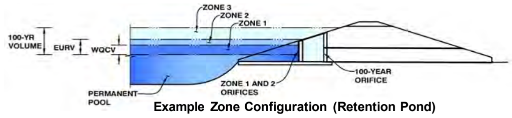
Subcatchment Name	Time of Concentration: Computed t_c (min)	Regional t_c (min)	Selected t_c (min)	Rainfall Intensity, I (in/hr) 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr	Peak Flow, Q (cfs) 2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
H1	11.14	25.75	11.14	2.20	3.08	3.60		5.00	5.70		0.06	0.43	1.45		5.52	7.68	
H2	23.75	25.75	23.75	1.52	2.13	2.49		3.46	3.95		0.05	0.10	0.73		4.71	6.89	
D1	9.32	18.75	9.32	2.36	3.31	3.86		5.37	6.12		2.09	3.49	4.74		8.90	11.06	
D2	13.12	21.73	13.12	2.05	2.87	3.36		4.66	5.31		1.57	2.49	3.72		8.43	10.93	
OS	17.24	25.75	17.24	1.80	2.53	2.95		4.10	4.67		0.01	0.01	0.09		0.56	0.81	

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)

Project: **Shadow Mountain Bike Park**

Basin ID: **Developed Drainage Plan Basin**



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	EDB			
Watershed Area =	6.35	acres		
Watershed Length =	700	ft		
Watershed Length to Centroid =	350	ft		
Watershed Slope =	0.060	ft/ft		
Watershed Imperviousness =	40.00%	percent		
Percentage Hydrologic Soil Group A =	0.0%	percent		
Percentage Hydrologic Soil Group B =	65.0%	percent		
Percentage Hydrologic Soil Groups C/D =	35.0%	percent		
Target WQCV Drain Time =	40.0	hours		
Location for 1-hr Rainfall Depths = User Input				

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.095	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.256	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 0.85 in.) =	0.149	acre-feet	0.85	inches
5-yr Runoff Volume (P1 = 1.19 in.) =	0.251	acre-feet	1.19	inches
10-yr Runoff Volume (P1 = 1.39 in.) =	0.330	acre-feet	1.39	inches
25-yr Runoff Volume (P1 = 1.69 in.) =	0.507	acre-feet		inches
50-yr Runoff Volume (P1 = 1.93 in.) =	0.624	acre-feet	1.93	inches
100-yr Runoff Volume (P1 = 2.2 in.) =	0.785	acre-feet	2.20	inches
500-yr Runoff Volume (P1 = 3.14 in.) =	1.271	acre-feet		inches
Approximate 2-yr Detention Volume =	0.143	acre-feet		
Approximate 5-yr Detention Volume =	0.231	acre-feet		
Approximate 10-yr Detention Volume =	0.297	acre-feet		
Approximate 25-yr Detention Volume =	0.352	acre-feet		
Approximate 50-yr Detention Volume =	0.374	acre-feet		
Approximate 100-yr Detention Volume =	0.440	acre-feet		

Define Zones and Basin Geometry

Zone 1 Volume (WQCV) =	0.095	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.161	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.184	acre-feet
Total Detention Basin Volume =	0.440	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	
Initial Surcharge Area (A_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	**user**	acre-feet

Depth Increment = ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	40	0.001		
8372	--	0.33	--	--	--	50	0.001	15	0.000
8378	--	6.33	--	--	--	8,331	0.191	25,158	0.578
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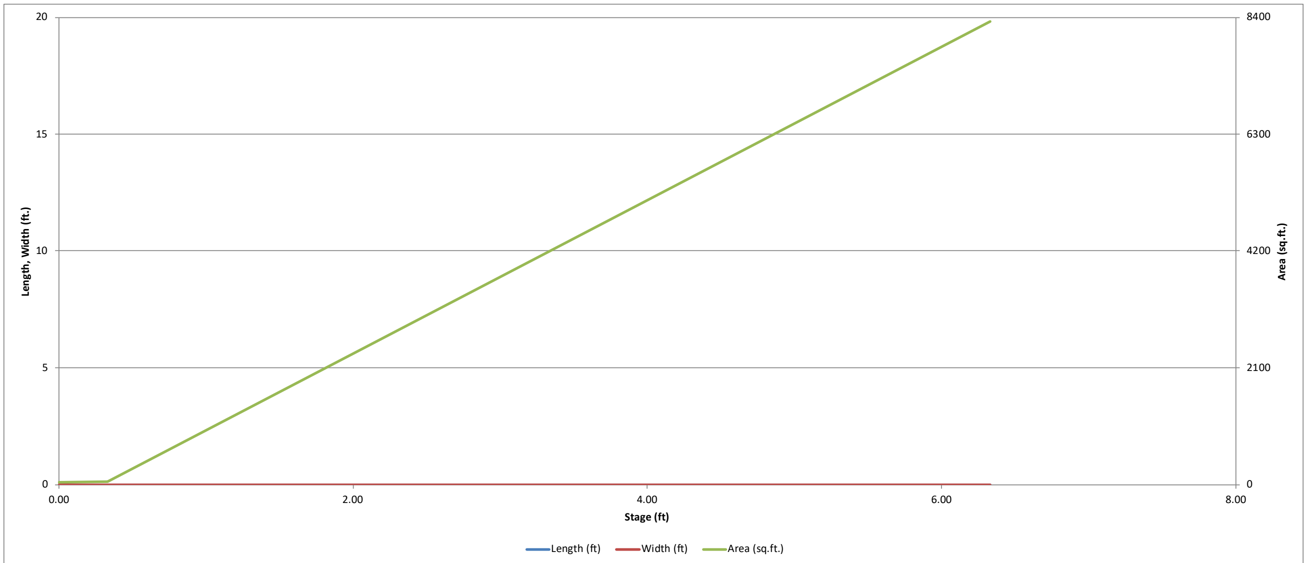
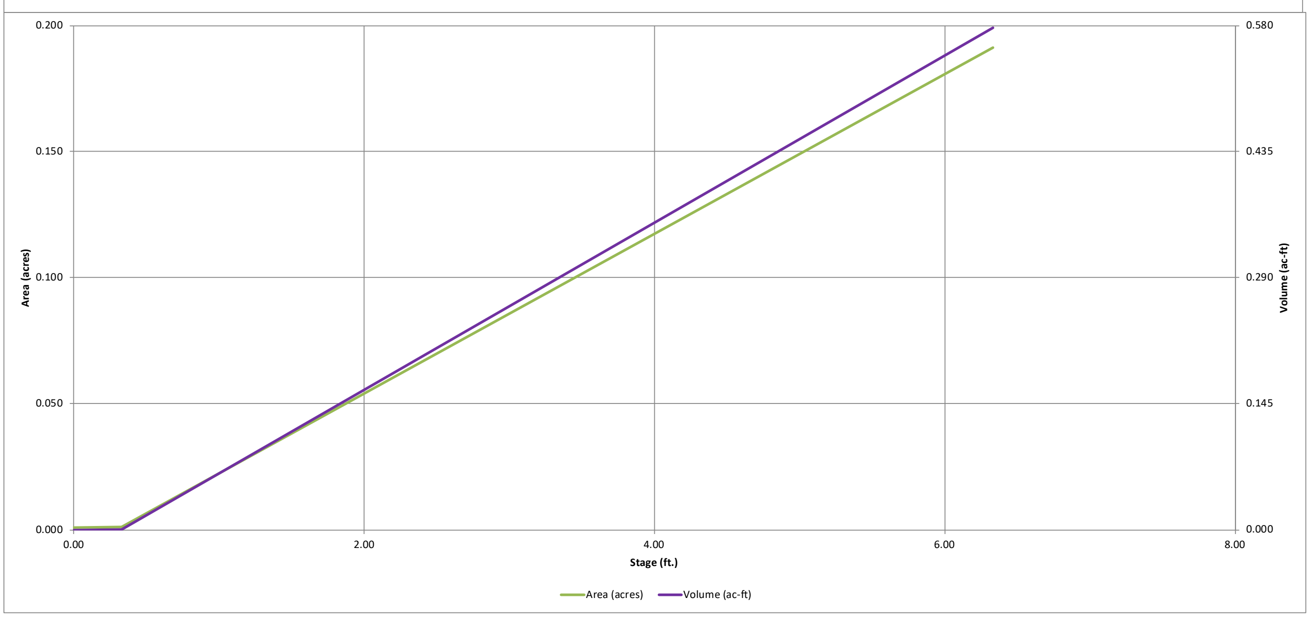
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)

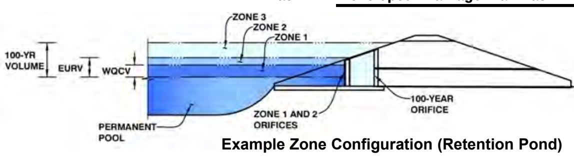




DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Project: **Shadow Mountain Bike Park**
Basin ID: **Developed Drainage Plan Basin**



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	2.75	0.095	Orifice Plate
Zone 2 (EURV)	4.32	0.161	Circular Orifice
Zone 3 (100-year)	5.56	0.184	Weir&Pipe (Restrict)
Total (all zones)		0.440	

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth =	N/A	ft (distance below the filtration media surface)
Underdrain Orifice Diameter =	N/A	inches

Calculated Parameters for Underdrain

Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Centroid =	N/A	feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Centroid of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	2.75	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	11.00	inches
Orifice Plate: Orifice Area per Row =	0.37	sq. inches (diameter = 11/16 inch)

Calculated Parameters for Plate

WQ Orifice Area per Row =	2.569E-03	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	0.92	1.83					
Orifice Area (sq. inches)	0.37	0.37	0.37					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

	Zone 2 Circular	Not Selected	
Invert of Vertical Orifice =	2.75	N/A	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	4.32	N/A	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =	2.17	N/A	inches

Calculated Parameters for Vertical Orifice

	Zone 2 Circular	Not Selected	
Vertical Orifice Area =	0.03	N/A	ft^2
Vertical Orifice Centroid =	0.09	N/A	feet

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir and No Outlet Pipe)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	4.32	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	3.00	N/A	feet
Overflow Weir Grate Slope =	4.00	N/A	H:V
Horiz. Length of Weir Sides =	4.00	N/A	feet
Overflow Grate Type =	Close Mesh Grate	N/A	
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	5.32	N/A	feet
Overflow Weir Slope Length =	4.12	N/A	feet
Grate Open Area / 100-yr Orifice Area =	16.33	N/A	
Overflow Grate Open Area w/o Debris =	9.78	N/A	ft^2
Overflow Grate Open Area w/ Debris =	4.89	N/A	ft^2

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

	Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	2.50	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	18.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	6.70		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	0.60	N/A	ft^2
Outlet Orifice Centroid =	0.33	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	1.31	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	5.40	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	30.00	feet
Spillway End Slopes =	4.00	H:V
Freeboard above Max Water Surface =	0.60	feet

Calculated Parameters for Spillway

Spillway Design Flow Depth=	0.29	feet
Stage at Top of Freeboard =	6.29	feet
Basin Area at Top of Freeboard =	0.19	acres
Basin Volume at Top of Freeboard =	0.57	acre-ft

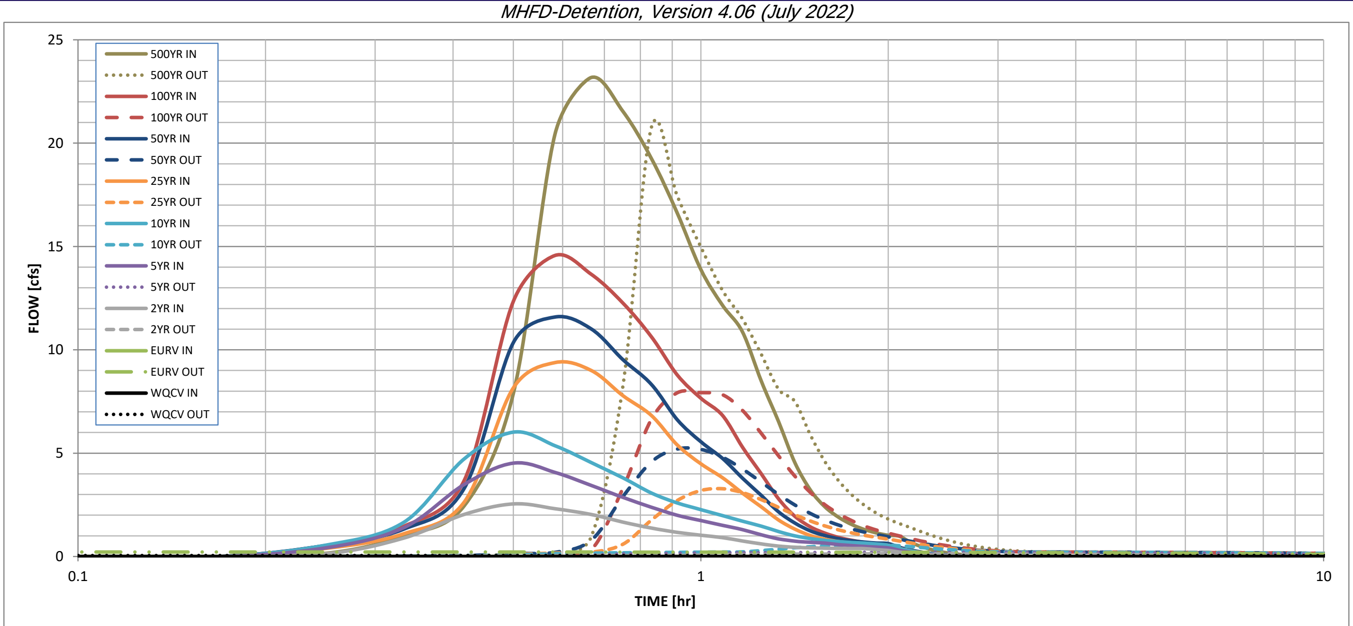
Routed Hydrograph Results

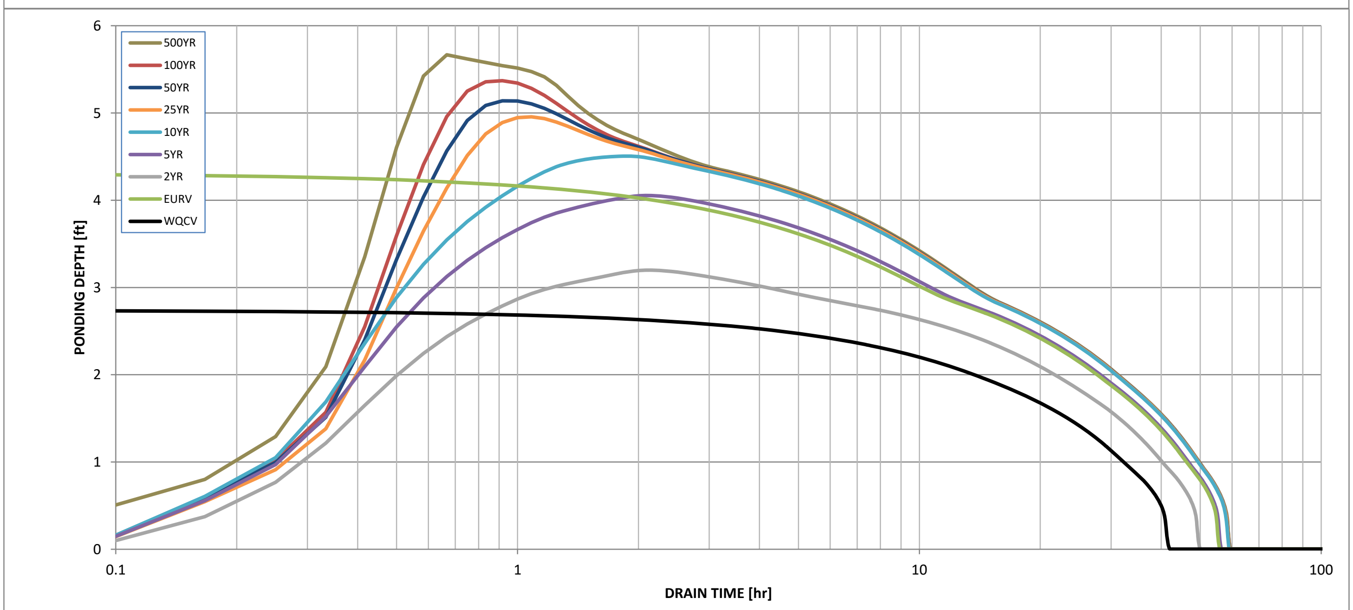
The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

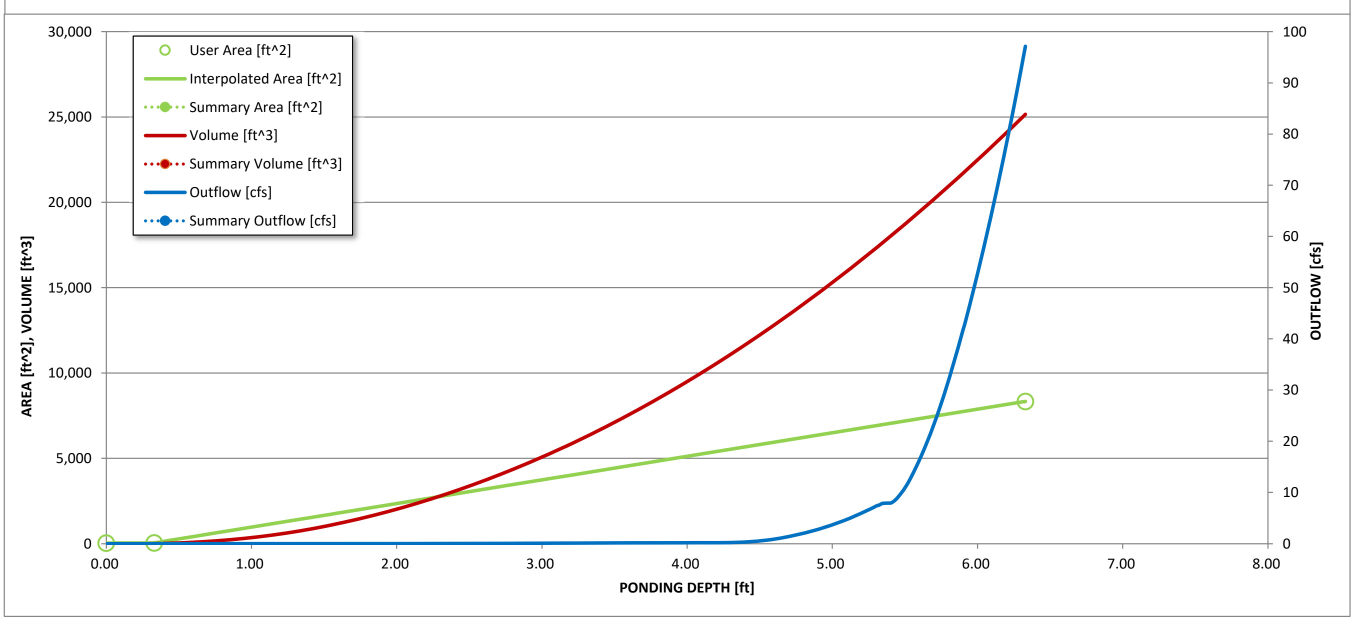
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	N/A	N/A	0.85	1.19	1.39	1.69	1.93	2.20	3.14
CUHP Runoff Volume (acre-ft) =	0.095	0.256	0.149	0.251	0.330	0.507	0.624	0.785	1.271
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.149	0.251	0.330	0.507	0.624	0.785	1.271
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.1	0.9	1.9	4.9	6.5	8.5	14.8
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.01	0.14	0.30	0.77	1.02	1.35	2.34
Peak Inflow Q (cfs) =	N/A	N/A	2.5	4.5	6.0	9.4	11.6	14.6	23.2
Peak Outflow Q (cfs) =	0.0	0.2	0.1	0.2	0.6	3.3	5.2	7.9	20.8
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.2	0.3	0.7	0.8	0.9	1.4
Structure Controlling Flow =	Plate	Overflow Weir 1	Vertical Orifice 1	Vertical Orifice 1	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1	Outlet Plate 1	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.0	0.3	0.5	0.8	0.8
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	38	47	44	47	48	45	43	41	34
Time to Drain 99% of Inflow Volume (hours) =	**40**	52	47	53	54	53	51	50	47
Maximum Ponding Depth (ft) =	2.74	4.32	3.20	4.05	4.50	4.96	5.14	5.37	5.67
Area at Maximum Ponding Depth (acres) =	0.08	0.13	0.09	0.12	0.13	0.15	0.15	0.16	0.17
Maximum Volume Stored (acre-ft) =	0.095	0.257	0.133	0.224	0.281	0.344	0.371	0.407	0.457

DETENTION BASIN OUTLET STRUCTURE DESIGN

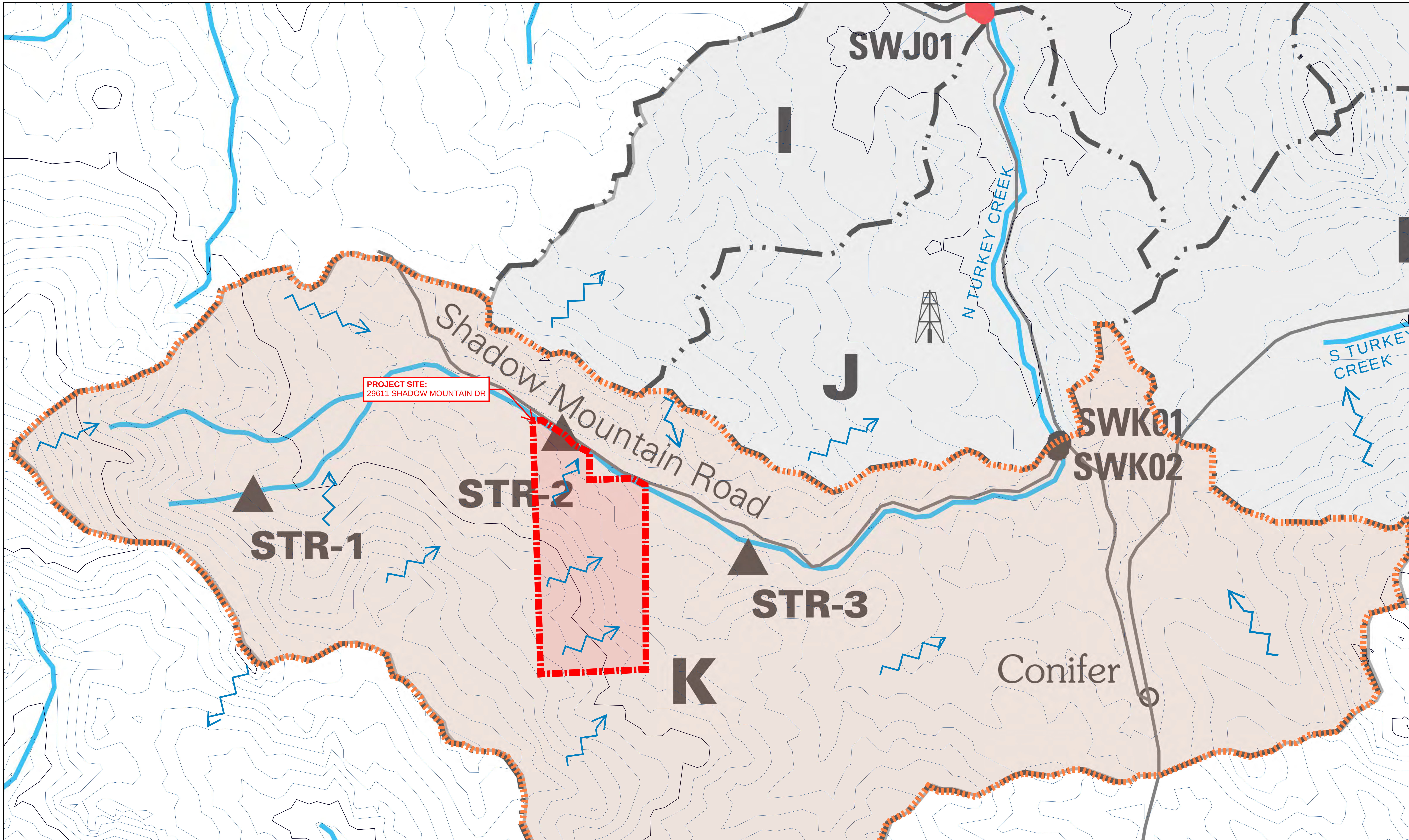
MHFD-Detention, Version 4.06 (July 2022)







S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			



GENERAL NOTES:

1. MAJOR BASIN DELINEATION, SUB-BASIN K, RETRIEVED FROM THE HYDROLOGIC CONDITIONS AND ASSESSMENT OF WATER RESOURCES IN THE TURKEY CREEK WATERSHED DATED 2003.
2. THE PROPERTY IS IN ZONE X (UNSHADED) ACCORDING TO FIRM MAP NO 08059C0365F LAST REVISED FEB 5, 2014.

SE GROUP
323 West Main Street, Suite 202
Frisco, CO 80443
tel: 970.668.3398
www.segroup.com

SHADOW MOUNTAIN BIKE PARK

CONIFER, COLORADO

Not For Construction

ISSUE
SCHEMATIC DESIGN

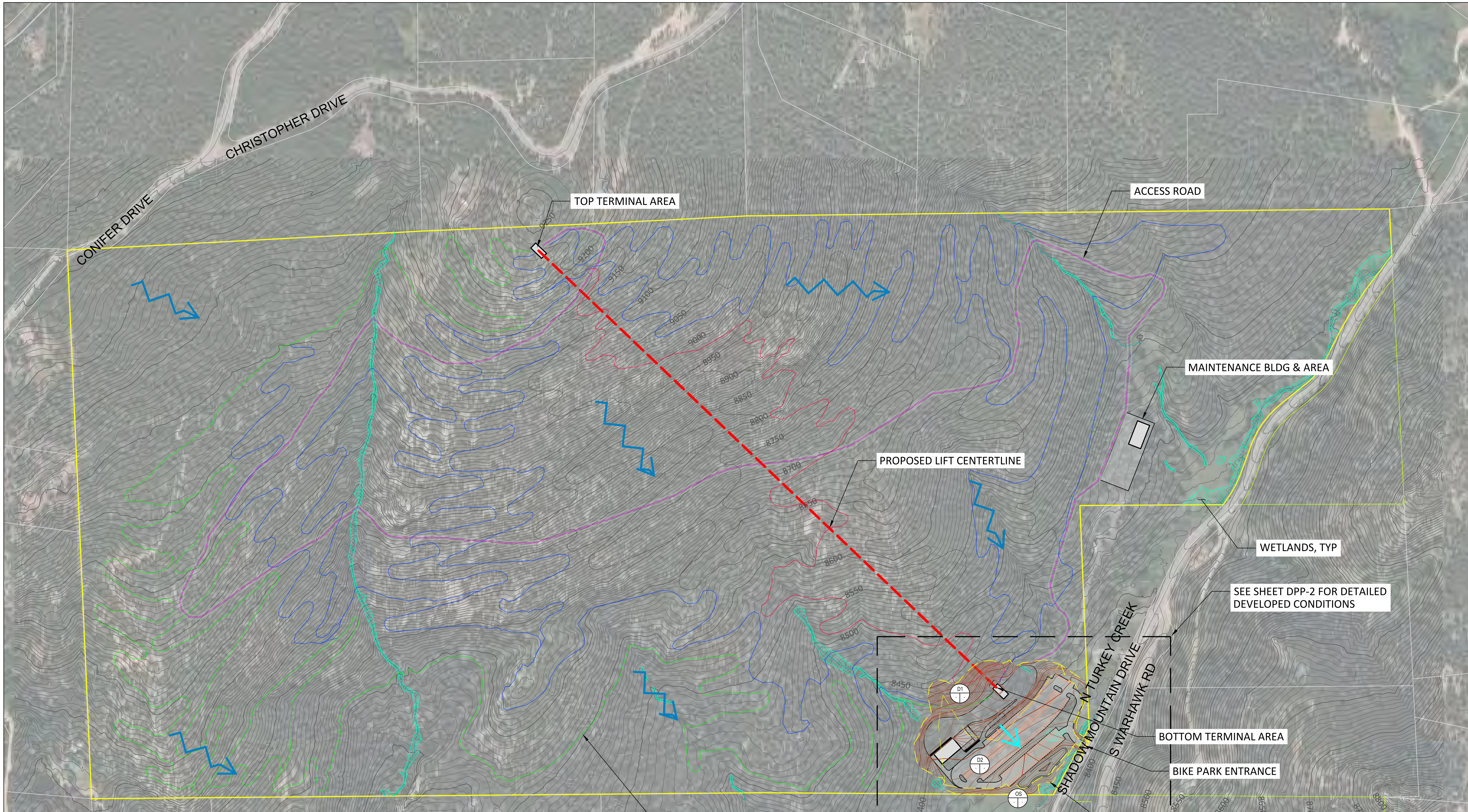
RELEASE DATE
November 22

REVISIONS

PROJECT NO.	22089001
MADE BY	OD
REVIEWED BY	OD

GENERAL LOCATION MAP

DPE



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2. WETLANDS SURVEY DATED 10/31/22 BY PEAK ECOLOGICAL.
3. PARCEL DATA INCLUDING PROPERTY LINE DATA RETRIEVED FROM JEFFERSON COUNTY ON 8/21/27.
4. CONTOUR DATA RETRIEVED FROM JEFFERSON COUNTY ON 10/17/22.
5. FINAL SITE DESIGN, INCLUDING MNT BIKE TRAIL, LIFT TERMINAL, ACCESS ROAD, MAINTENANCE YARD, AND PARKING FACILITY DESIGN, ARE SUBJECT TO CHANGE AND ARE TO BE USED AS REFERENCE ONLY.

LEGEND:

- EXIST CONTOURS
- PROPOSED CONTOURS
- PROPERTY LINE
- WETLANDS & STREAMS
- LIFT CENTERLINE
- ACCESS ROAD
- EXTREMELY DIFFICULT MNT BIKE TRAIL
- MOST DIFFICULT MNT BIKE TRAIL
- MORE DIFFICULT MNT BIKE TRAIL
- EASIER MNT BIKE TRAIL

DRAINAGE LEGEND:

- HISTORIC DRAINAGE
- DEVELOPED DRAINAGE
- DRAINAGE BASIN BOUNDARY
- DRAINAGE BASIN

0 200' 400'
GRAPHIC SCALE: 1" = 200ft
CONTOUR INTERVAL: 5'

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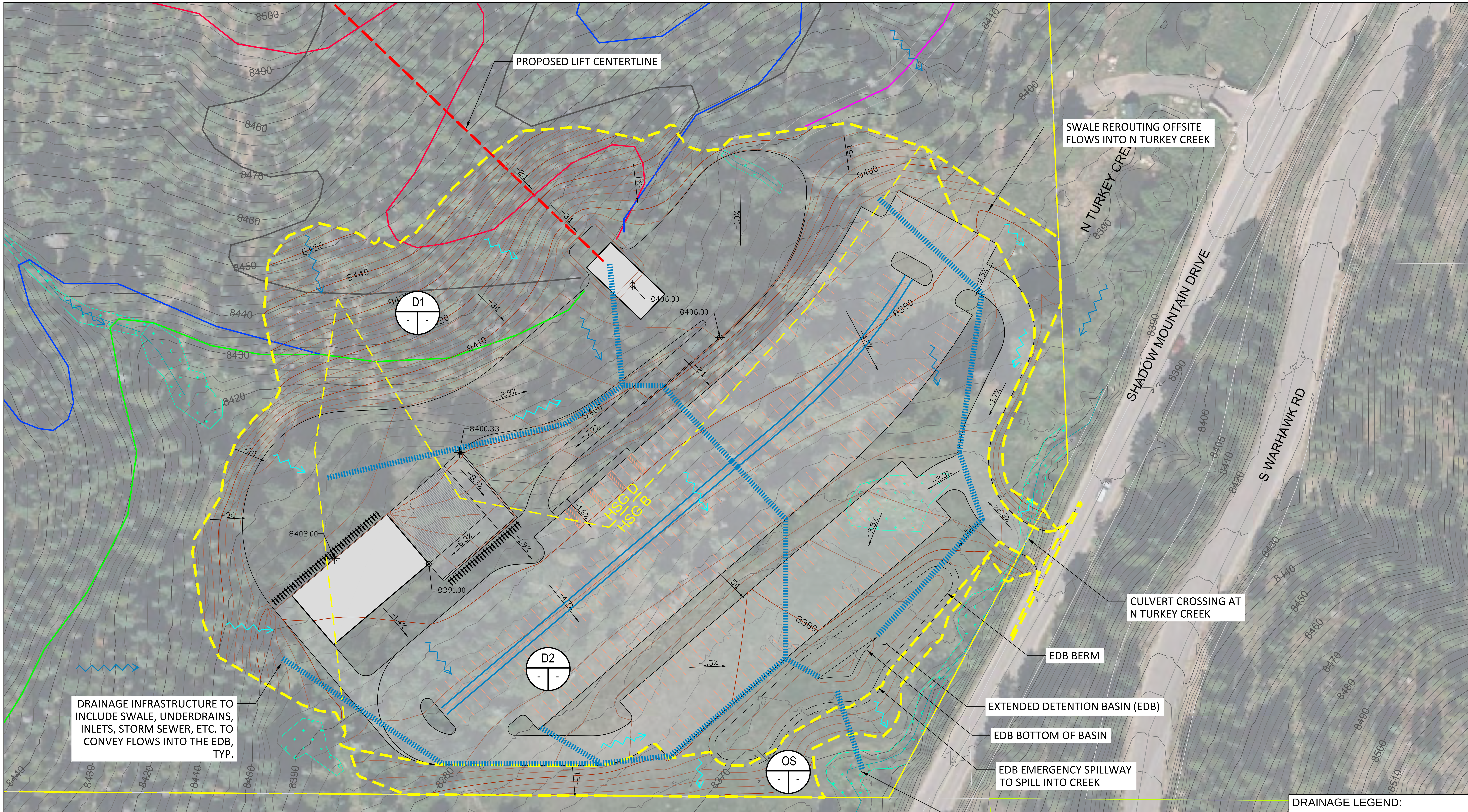
DEVELOPED DRAINAGE CONDITIONS

DPP-1



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DPP-2