Map Unit Properties Table

Age	Map Unit (Symbol)	Unit Description	Erosion Resistance	Paleontological Resources	Cultural Resources	Hazards	Mineral Resources	Suitability for Development	Other
QUATERNARY (Holocene)	Alluvium (Qal)	Unconsolidated sand, gravel and clay deposited by streams; includes Holocene stream deposits, Pleistocene glacial outwash, & locally, colluvium; up to several tens of feet thick.	Low	None	As part of the Great Sand Dunes eolian system archaeological program research, 67 prehistoric and historic sites were documented on the eastern side of GRSA	Flash flooding	None	Floodplain deposits	Recreation in Medano Creek
	Alluvial fan deposits (Qaf)	Poorly sorted, coarse sand & gravel deposited by distributary stream systems	Low	None		None	None	Cut by mountain front fault	
	Eolian sand (Qes)	Surficial deposits of well- sorted sand covered by sparse vegetation; thin and discontinuous, interspersed with alluvial sand & clay N of Deadman Creek.	Low	None		None	Placer gold, sand, magnetite	Unstable	Recreation popular on sand dunes
	Dune field (Qdf)	Wind- blown sand piled in various dune types.	Low	None		Burial	Placer gold, sand, magnetite	Unstable	
	Sandsheet (Qssh)	Unconsolidated sand	Low	None		None	None	Unstable	Hiking is a popular activity along mountain front
	Sabhka (Qsbk)	Clay and salt	Low	None		None	None	Wetland	
	Landslide deposits (Ql & Qls)	Angular rock debris of all sizes; forms hummocky topography; up to 100 ft (30 m) thick.	Low if disturbed by seismic activity or by construction	None		None	None	Low	
	Rockfall deposits (Qrf)	Accumulations of talus below large outcrops.	High	None		None	None	Low	
	Rock- glacier deposits (Qrg)	Angular blocks at base of steep slopes & valley floors; lobate & tongue- shaped; 32-100 ft (10- 30 m) thick.	High	None		None	None	Low	
QUATERNARY (Pleistocene)	Pinedale glacial deposits, undiff. (Qpu)	Gray stratified alluvium of boulders, cobbles, pebbles & sand; forms mostly undissected & coalescing fans; locally covered by thin deposits of eolian sand; thickness unknown, may be as much as 330 ft (100 m) thick.	High	Mammoth femur & bison phalange (Pinedale/Bull Lake?)	None documented	None	Sand & gravel	Limited aerial extent	
	Pinedale alluvial fan deposits (Qpf)	Boulders, cobbles, pebbles, sand; some boulders as much as 10 ft (3 m) in diameter.	High		None documented	None	Sand & gravel	Limited aerial extent	
	Pinedale lacustrine clay (Qpl)	Glacial lake clay above terminal moraine on Willow Creek; thickness unknown.	Low if disturbed		None documented	None	Clay	Low (clay)	
	Pinedale outwash deposits (Qpo)	Gray, well- washed, stratified alluvium of boulders, cobbles, pebbles, sand; below terminal moraines on South Colony Creek; about 26 ft (8 m) thick.	Sand will erode more quickly than boulders		None documented	None	Sand & gravel	Limited aerial extent	
	Pinedale till (Qpt)	Gray, unsorted, unstratified deposit of boulders, cobbles, pebbles, sand & clay; 50-100 ft (15- 30 m) thick.	Sand & clay will erode more quickly than boulders		None documented	None	Sand & gravel	Limited aerial extent	
	Pinedale & Bull Lake deposits, undiff. (Qpbu)	Boulders, cobbles, pebbles, sand	Variable		None documented	None	Sand & gravel	Limited aerial extent	
	Bull Lake alluvial fan deposits (Qbf)	Sorted, stratified alluvium of boulders, cobbles, pebbles, sand; forms dissected fans.	High except at times of intense runoff		None documented	None	Sand & gravel	Limited aerial extent	
	Bull Lake outwash deposits (Qbo)	Gray, sorted, stratified alluvium of boulders, cobbles, pebbles, sand; located in valleys below terminal moraines; thickness about 32 ft (10 m).	High except at times of intense runoff		None documented	None	Sand & gravel	Limited aerial extent	
	Bull Lake till (Qbt)	Yellow- gray, unsorted, unstratified compact deposit of boulders, cobbles, pebbles, sand & clay; 160 ft (50 m) thick on South Colony and Willow Creeks.	High		None documented	None	Sand & gravel	Limited aerial extent	
Unconformity									
TERTIARY (Oligocene/ Eocene)	Santa Fe Formation (Ts)	Tan, pink, buff, orange, brick red, light olive, and light gray to black stratified sand & gravel mostly from Precambrian and upper Paleozoic rocks; 1,300 ft (400 m) thick in subsurface.	High	None documented in GRSA	None documented	None	Methane in the (basin) overlying Alamosa Fm.	Limited aerial extent; wilderness	
	Granite & granodiorite (Tgr)	Small irregularly shaped intrusions; tan to light- gray; leucocratic, medium- to coarse- grained; seriate; nonfoliated; plagioclase, microcline, & quartz in subequal amounts with 1%- 5% biotite; accessory minerals include magnetite & apatite.	High	None	None documented	None	None	None - in Preserve & wilderness	
	Andesite (Ta)	Andesitic lahar, biotite latite, & dense hornblende- pyroxene andesite.	High	None	None	None	Hornblende, pyroxene, biotite	None - in Preserve & wilderness	
	Mafic volcanic rocks (Tmv)	Black, vesicular, porphyritic olivine basalt; composed of several flows; rests unconformably on Sangre de Cristo Formation; 250 ft (75 m) thick	High	None	None documented	None	None	None - in Preserve & wilderness	
	Felsic dikes (Tf)	Light- gray to white, fine- grained, felsic dike as much as 10 ft (3 m) wide; composed of microphenocrysts of quartz, feldspar & sparse biotite in groundmass of same minerals.	Phenocrysts will weather more quickly than groundmass	None	None documented	None	Feldspar, quartz	None - in Preserve & wilderness	
	Mafic dikes (Tm)	Dark gray- green to black, aphanitic to medium- grained; generally massive, locally porphyritic; nonfoliated; as much as 10 ft (3 m) wide.	High	None	None documented	None	None	None - in Preserve & wilderness	
Unconformity									

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UPPER JURASSIC	Morrison Formation (Jm)	Interbedded gray to brown shale, gray to brown sandstone, & minor gray, fine-grained limestone. 250 ft (75 m) thick.	Shale has low resistance	None documented in GRSA	None documented	None	None documented	None - in Preserve & wilderness	Known for dinosaur fossils & uranium
MIDDLE JURASSIC	Entrada Sandstone (Je)	Thin- bedded, white to tan, friable quartz sandstone, fine- to medium- grained, well- sorted, well- rounded & frosted. 39 ft (12 m) thick.	Friable surface grains, otherwise high	None documented in GRSA	None documented	None	None documented	None - in Preserve & wilderness	Most widespread preserved eolianite in western US
Unconformity									
UPPER PENNSYLVANIAN/PERMIAN	Sangre de Cristo Formation Undivided (PPNsu)	Red arkosic sandstone, conglomeratic sandstone, siltstone, shale, minor limestone; cross- bedding in sandstone; ripple marks, cross- laminations, mudcracks, raindrop impressions, burrows in siltstone & shale; thin limestone is unfossiliferous, marine limestone contains bryozoan fossils; max exposed thickness of about 4,600 ft (1,400 m) at Horn Peak.	Feldspars and limestone will erode more quickly than quartz sandstone	Bryozoan fossils in marine limestone beds on Music Creek	None documented	Rockfall?	None documented	None - in Preserve & wilderness	
	Sangre de Cristo Formation Crestone Member (PPNsc)	Red conglomerate, conglomeratic sandstone, & minor siltstone & shale; boulders & cobbles of Early Proterozoic gneiss, syenite & quartz. monzonite; sandstone is horizontally laminated & cross- bedded; exposed between Sand Creek Thrust and Little Sand Creek Thrust; 6,500 ft (2,000 m) thick.	Variable	Crinoid columns, brachiopods, sponge spicules, bryozoans; *Eomarginifera* sp & fusulinids found in biohermal units; trunks of *Calamites* in clastic beds	None documented	Rockfall?	None documented	None - in Preserve & wilderness	Mountain biking, rock climbing, caving at higher elevations
	Sangre de Cristo Formation Lower Member (PPNsl)	Red arkosic sandstone, conglomeratic sandstone, siltstone, & shale; sandstone cross- bedded; siltstone & shale contain ripple marks, cross- lamination & sparse mudcracks; conformably overlies Minturn Fm.; interfingers with overlying Crestone Conglomerate Member; thickens northward; thickness about 2,000 ft (600 m) west of Rito Alto Peak.	High	None documented	None documented	Rockfall?	None documented	None - in Preserve & wilderness	
MIDDLE PENNSYLVANIAN	Minturn Formation (PNm)	Gray & red arkosic sandstone, conglomerate, siltstone, shale, and minor marine limestone; occurs in thrust plates west of Mosca Pass; max thickness about 6,500 ft (2,000 m) at Middle fork of Taylor Creek. PNmu: upper part; PNmumls: marker limestone PNmcls: crinoidal silty limestone, about 755 ft (230 m) below top of unit; 39- 52 ft (12- 16 m) thick. PNmush: shale & siltstone member PNmols: oolite limestone PNmt: main turbidite member; upward- fining units of sandstone, siltstone, & shale PNmbls: biohermal limestone unit PNml: lower part PNmq: quartzose red- beds; arkosic & quartzose sandstone & siltstone	High	Abundant crinoid columnals, brachiopods, sponge spicules, bryozoans	None documented	Rockfall?	Siltstone & shale in upper part is radioactive & copper-bearing; gypsum near Arkansas River Valley	None - in Preserve & wilderness	
Unconformity									
MISSISSIPPIAN, DEVONIAN, ORDOVICIAN	Sedimentary rocks, undifferentiated (MDOr)	Leadville Limestone (Lower Mississippian): Dark gray cherty massive dolomitic limestone; locally contains limestone breccia; 230 ft (70 m) thick. Chafee Group, Dyer Dolomite (Mississippian- Devonian): Yellow- gray cherty dolomite; 100 ft (30 m) thick. Chafee Group, Parting Quartzite (Mississippian- Devonian): Gray, massive quartzite and dolomite; 50 ft (15 m) thick. Fremont Dolomite (Upper Ordovician): Dark- gray, coarsely crystalline dolomite; 230 ft (70 m) thick.	High	None documented	None documented	Rockfall?	Chert in Dyer Dolomite	None - in Preserve & wilderness	

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MIDDLE ORDOVICIAN	Harding Sandstone (Oh)	Pale- red, thin- bedded quartzite; 100 ft (30 m) thick.	High	None documented	None documented	Rockfall?	None documented	None - in Preserve & wilderness	
LOWER ORDOVICIAN	Manitou Limestone (Om)	Dark- gray, fine- grained, cherty dolomitic limestone; 200 ft (60 m) thick.	High	None documented	None documented	Rockfall?	None documented	None - in Preserve & wilderness	
Unconformity									
MIDDLE PROTEROZOIC	Quartz Monzonite (Yqm)	Stock of gray to pink, medium- grained, equigranular, leucocratic, quartz monzonite, N of Willow Creek; 35% plagioclase, 30% microcline, 30 % quartz, 2%- 5% biotite & magnetite; locally small pegmatite dikes; extensively altered to chlorite, epidote, & muscovite; located along the Sangre de Cristo fault near Crestone; 1.45 billion years old. Vein quartz (Yqmqz)	High	None	None documented	Rockfall?	Microcline, plagioclase feldspar, quartz, biotite, sphene, magnetite	None - in Preserve & wilderness	
Unconformity									
LOWER PROTEROZOIC	Pegmatite (Xp)	Coarse- grained igneous rock; interlocking crystals; composition of granite	High	None	None	None	Feldspar, qtz, muscovite	None- in Preserve & wilderness	High altitude recreational activities (i.e., horse riding, hiking, climbing)
	Tonalite gneiss (Xto)	White to light- gray- green, buff- weathering; 60% plagioclase, 30% quartz, 8% mafic minerals, 2 % or less potassium feldspar; porphyroblastic with aggregates of mafic minerals as much as 0.6 inches (1.5 cm) across; groundmass grain size generally 3- 4 mm; weak foliation; original mafic minerals thoroughly altered to epidote, chlorite, & muscovite; K- feldspar increases near major faults; contains numerous mafic dikes as much as several tens of feet across; dikes most abundant near contact with metadiorite (Xdi); contact with metadiorite is interlayered & metadiorite xenoliths occur in tonalite gneiss near contact; located near southern end of Sangre de Cristo wilderness area.	Plagioclase will erode faster than quartz	None	None documented	Rockfall?	Plagioclase, quartz, magnetite, apatite, sphene	None - in Preserve & wilderness	
	Metagabbro (Xg)	Metamorphosed gabbro	High	None	None	Unknown	Unknown	Low	
	Quartz diorite (Xqd)	Plagioclase, quartz, & hornblende or biotite; accessory apatite, zircon, & opaque oxides.	High	None	None documented	Unknown	Unknown	None - in Preserve & wilderness	
	Diorite (Xdi)	Dark- green to dark- gray, fine- to medium- grained, seriate to equigranular, locally foliated hornblende diorite; 50- 705 euhedral to subhedral hornblende, 30%- 50% plagioclase, up to 5 % quartz as inclusions in plagioclase; quartz averages about 1% of rock; accessory minerals (about 2% of rock) are magnetite, sphene, & apatite; extensively altered to sericite, chlorite, epidote; locally injected by numerous interconnecting veins of leucocratic biotite granodiorite to tonalite.	Alteration of dark minerals	None	None documented	Unknown	Unknown	None - in Preserve & wilderness	
	Mafic intrusive rocks (Xm)	Dark gray- green to black, aphanitic to coarse- grained, basaltic & gabbroic dikes & sills; generally massive, locally porphyritic; subequal amounts of plagioclase & hornblende with 5%- 10% opaque minerals; pyroxene- & olivine- bearing varieties occur locally; nonfoliated; sharp contacts with host rocks; map units may include mafic intrusive rocks of Tertiary age.	Mafic igneous rocks will erode faster than felsic igneous rocks	None	None documented	Unknown	Plagioclase, olivine, augite	None - in Preserve & wilderness	
	Quartz Monzonite (of Music Pass) (Xqm)	Gray to pink, coarse- grained, foliated, quartz monzonite porphyry; white to pink, subhedral, microcline phenocrysts 25%- 45%; groundmass is about 60% plagioclase, 20% quartz, 20% biotite, up to 1% sphene and magnetite; foliation locally well developed; boudinage of microcline phenocrysts accompanies increased foliation intensity, particularly near contacts of unit; faulted contacts with Paleozoic sedimentary rocks; intrudes Xgn, Xlgn, & Xq; mafic pods & large mafic xenoliths common locally.	Biotite & feldspars will erode faster than quartz	None	None documented	Unknown	Microcline	None - in Preserve & wilderness	

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LOWER PROTEROZOIC	Quartzite (Xq)	Black & gray to purple & white, layered quartzite breccia; blocks of layered quartzite range from mm to tens of meters across; matrix is crushed quartzite with minor iron oxide & muscovite; numerous fractures crisscross blocks; 90%- 95% quartz, 3%- 8% opaque minerals, minor muscovite & biotite; opaque minerals include magnetite, specular hematite, earthy hematite; opaque minerals define layers in blocks probably reflecting original bedding; occurs as a narrow, fault-bounded 328- ft (100 m) wide layer between PPNsc & Xqm & as scattered, poorly exposed xenoliths within quartz monzonite.	High	None	None documented	Unknown	Colored quartz	None - in Preserve & wilderness	High altitude recreational activities (i.e., horse riding, hiking, climbing)
	Syenite & Monzonite (Xsm)	Reddish- tan, medium- to coarse- grained porphyry stock; nonfoliated to weakly foliated; subhedral microcline phenocrysts; 50%- 80% microcline, up to 35% plagioclase, 1%- 5% quartz, & up to 10% biotite with minor muscovite, zircon, & sphene; moderate alteration of plagioclase & biotite; fault contact with Paleozoic sedimentary rocks; interlayered with Xgn.	High	None	None documented	Unknown	Microcline	None - in Preserve & wilderness	
	Leucocratic gneiss (Xlgn)	80% of unit white to medium gray, light- pink to light- gray weathering; 30% quartz, 30% microcline; 35 % plagioclase, 4% biotite; variably massive, laminated and layered; foliated; locally migmatitic; locally has porphyroblasts of feldspar up to 2 inches (5 cm); 20% of unit is gray gneiss with composition of granodiorite; 40% plagioclase, 25% quartz, 20% microcline, 15% mafic minerals; original mafic minerals commonly altered to chlorite; complexly interlayered with light- colored gneiss; quartz veins & pods & small pegmatites common.	Biotite & feldspars will erode faster than quartz	None	None documented	Unknown	Quartz, microcline, plagioclase	None - in Preserve & wilderness	
	Hornblende gneiss (Xhgn)	Schistose to massive, fine- to medium- grained quartz- plagioclase- hornblende gneiss; dominantly a well- foliated, laminated gneiss having sharply bounded, continuous, dark- and light- colored layers 1- 5 mm thick.	Hornblende & plagioclase erodes faster than quartz	None	None documented	Unknown	Unknown	None - in Preserve & wilderness	
	Mixed gneiss (Xgn)	Mafic & felsic gneiss & micaceous schist; pink, gray & black; layered, laminated, & foliated; layers discontinuous, rarely traceable more than 0.3 miles (0.5 km); contains leucocratic, biotite- quartz- plagioclase- microcline gneiss & hornblende-bearing varieties of leucocratic gneiss interlayered with mafic quartz- plagioclase-hornblende gneiss; locally includes fine- to coarse- grained, weakly foliated to nonfoliated alaskitic gneiss; all varieties in this unit are extensively altered to chlorite, epidote, & sericite; dikes & sills ranging in composition from aplite & pegmatite to basalt cut the unit; exposed along west side of Sangre de Cristo Range for about 60 miles (100 km).	Dark minerals will erode faster than lighter minerals	None	None documented	Unknown	Unknown	None - in Preserve & wilderness	