Soils of Wyoming

A Digital Statewide Map at 1:500,000-Scale

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Background

The Soils Map of Wyoming is intended to depict process-based soil categories found in Wyoming. Representative soils in the mapping units for this map are classified at the family level of *Soil Taxonomy* (Soil Survey Staff 1975; Soil Survey Staff 1998). Technical soil terminology follows definitions in the *Glossary of Soil Science Terms* (Soil Science Society of America 1997). The map was primarily generated for a statewide study of ground-water vulnerability to contamination from pesticides. In that context, it was to be used to assist in the generation of an estimated surficial aquifer recharge map and to serve as one of the individually rated layers required within a DRASTIC-based (Aller et al. 1987) aquifer sensitivity analysis (Hamerlinck and Arneson 1998).

This map provides a generalized description of soils within the state of Wyoming. Soils are highly variable, both on a regional basis (plains, mountains, basins) and locally, with changes in topography (northern versus southern slopes, side slopes versus ridge crest or foot slope positions), vegetation, climate, and geology. This map should be used for broad scale planning and general assessment of large areas of land. It should not be used for site specific interpretations such as site selection for an underground fuel storage tank or the development of management plans for individual farm fields. Such site intensive land uses require much more detailed soils information than is provided by this map.

The Soils Map of Wyoming and the generalized soils maps of the Wyoming counties are derived based on the five soil forming factor model first proposed in its entirety by the Russian soil scientist Doukachev in the 1880s. This model was introduced broadly to American soil scientists by Hans Jenny (Jenny 1941). The five factors of soil formation are soil parent material, climate, biota, topography, and time. As Hudson (1992) pointed out, soil surveying is an activity that conforms well to the theories of paradigm-based science. During detailed soil surveys, field mapping is based on the projection of soil map unit concepts onto the landscape, after which map unit composition and boundary placement are subject to immediate field checking in the form of soil pit excavation(s). Generalized soils maps are often based on either a process of consolidation of detailed soils maps, or on projection of limited data from direct observation across a broad area through use of soil-landscape models. In the United States, the model used to describe soil-landscape relationships is most commonly the soil forming factor model. The maps for this project were prepared using current understanding of soil-landscape models and available data in the form of published soil surveys, maps, and re-

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ports of the Natural Resource Conservation Service (NRCS), the Forest Service (FS), the Bureau of Land Management (BLM), and numerous theses and scientific papers published by the Wyoming Agricultural Experiment Station and the University of Wyoming.

The soil map presented here differs from the STATSGO map developed by the NRCS (National Cartographic and GIS Center 1998) in several ways. The STATSGO maps were developed by generalizing existing detailed soil surveys and were prepared on a 1:250,000-scale topographic map base. The mapping units in the STATSGO map contain from 1 to 21 components, and the soils components are represented at the series level. The STATSGO map provides a somewhat more detailed description of the soils in the state, with consequent complexity in interpretations. The detailed maps from which the STATSGO map was generalized were produced by numerous scientists over a 30-year time span. The surficial geology map of the state and the state bedrock geology map were not available in electronic format when these maps were produced and the original mapping was done on aerial photographs.

The scale of 1:500,000 used for this map was specified by the larger Wyoming Ground-Water Vulnerability Mapping Project (Hamerlinck and Arneson 1998). The maps are based on a simplification of the five soil forming factor model. Climate is proxied by elevation. This was derived from the 3-arc-second USGS Digital Elevation Model (DEM) for the state. There is a strong correspondence between elevation and precipitation in the state, and temperature regimes can generally be characterized by elevation. Vegetation is also closely tied to elevation through its effect on precipitation and temperature. Three temperature regimes are mapped in Wyoming: cryic in the higher mountains; frigid in the foothills, the high plains along the Rocky Mountain front, low mountains, and high intermountain basins; and mesic in lower elevation basins and the Great Plains (See Appendix for definitions of temperature regimes). There are small areas of a fourth temperature regime (pergelic) at elevations above 10,000 feet in the state's highest mountains. Soil parent material is derived from the digital version of the state geology map (Green and Drouillard 1994) and the state surficial geology map by Case, Arneson, and Hallberg (1998). Vegetation is inferred from climate, slope, and parent material. Time, or soil age, is inferred from elevation and surficial geology. The topographic factor is inferred from elevation, surficial geology and bedrock geology. The analysis of these layers was conducted using ARC/INFO Geographic Information System software on a Silicon Graphics UNIX workstation.

The boundary between cryic and frigid temperature regimes is at approximately 7,800 feet elevation in the southern half and at 7,500 feet in the northern half of the state. The boundary between mesic and frigid temperature regimes ranges between 5,000 feet in the northern part of the state and 6,500 feet in the southern part. Small areas of pergelic temperature regime exist above 10,000 feet in the highest mountains (Beartooths, Absarokas, Tetons, Bighorns, Wind Rivers, Snowy Range, Sierra Madre). Age relationships of mountainous surfaces are controlled by slope gradient and glacial history. Slopes with steep gradient (greater than 25%) are commonly occupied by Entisols

(Cryorthents) and Inceptisols (Dystrocryepts). Glacial deposits of Pinedale age usually are occupied by Inceptisols under forest (Dystrocryepts) and Mollisols under grasslands (Haplocryolls). Soils will be Humic Dystrocryeptss above 9,500 feet under alpine turf. Soils in riparian areas in the mountains are typically Entisols (Cryofluvents) or Inceptisols (Cryaquepts) with small areas of organic soils (Histisols). Glacial deposits of Bull Lake age or older are commonly occupied by Alfisols (Haplocryalfs) under continuous forest or Mollisols (Haplocryolls) under grassland. Non-glaciated surfaces with gradients less than 15% are usually Haplocryalfs under forest or Haplocryolls under grass.

In foothills and lower mountains, steep south-facing slopes are commonly occupied by Entisols (Torriorthents) and Inceptisols (Ustochrepts). Hillslopes under sagebrush and grasses are frequently Mollisols, most commonly without argillic (clay accumulation) horizons. Where grassland is intermingled with forest, the grassland sites are often on either warmer aspects or finer textured (less rocky) soils. Mountain mahogany (*Cercocarpus montanus*) is a reliable indicator of high coarse fragment contents and of a deep rooting environment, albeit in fractured bedrock or skeletal materials.

In foothill settings, Idaho fescue (*Festuca idahoensis*) and Ponderosa pine (*Pinus ponderosa*) are generally indicators of the break between frigid and cryic temperature regimes. Cacti grow at high elevations on dry slopes and indicate that the aridic moisture regime extends into areas with cryic soil temperature regime. Aspect effects are strong in this elevation zone, and it is not uncommon to have cool Alfisols (Haplocryalfs) on north facing canyon walls matched by noticeably warmer (frigid), dry Entisols (Torriorthents) on south facing canyon walls.

In Wyoming, high basins present a mixture of old, tilted sedimentary rock, which is Cretaceous in age or older, along with younger Tertiary, Pleistocene, and Holocene sediments. Often, the Cretaceous and older rock will occur in bands along basin margins with younger sediments showing varying degrees of incision by erosion in basin centers. A quick view of a topographic map will usually provide ready separation of these two zones. Because basins are drier than mountains, vegetation cover may be limited on some slopes in the basins (many of the south aspects) where plant cover is too sparse to prevent erosion. Associations of soils include Entisols (Torriorthents) on slopes of 15% or more and on south and west facing slopes, while on low-relief surfaces the soils will be Aridisols, usually either Haplocalcids, Haplocambids, or Haplargids on most Cretaceous-age parent materials. On Tertiary parent materials high in clay, the soils may be a complex of Aridisols, some of which are strongly affected by sodium (Haplargids and Natrargids). On stabilized sand dunes, the soils are Entisols (Torripsamments). On playas with clayey textures and clay dunes frequently associated with them, soils are commonly salt-affected Aridisols (Calcigypsids or Gypsisalids). Soils along ephemeral channels are usually Entisols (Torrifluvents) on surfaces younger than approximately 6,000 years old, with wet Mollisols (Haplaquolls) occurring along streams with permanent high water tables. Early Holocene surfaces are commonly occupied by moderately developed Inceptisols (Haplocambids or Haplocalcids),

depending upon soil texture and source of carbonates. Many high basins of Wyoming had permafrost environments during the Late Pleistocene, and these old surfaces are often covered with low-relief mounds. The soils are typically Aridisols with clay enriched subsoils (Haplargids) on intermound areas and Aridisols with only moderate development (Haplocambids) on mound areas.

Along the eastern edge of the Rocky Mountains there is a band of mounded topography similar in origin to mounds in the high basins. These mounds are commonly occupied by Mollisols with very thick organic matter enriched surface layers (A horizons) (pachic subgroups), while the intermound areas are occupied by similar soils but with thinner surface horizons (typic subgroups). Riparian areas are occupied by wet Mollisols (Haplaquolls) and Entisols (Fluvents). Further from the mountain front, soils are sandy-textured Entisols (Torripsamments) on old dunes, shallow to moderately deep Entisols (Torriorthents) on Tertiary materials that are either very sandy or very clayey in texture, and a mixture of Entisols (Fluvents) and Mollisols (Haplaquolls) along riparian areas. For many landscapes with coarser textured Tertiary materials (e.g., Arikaree formation), ridges and even cliffs and mesas on the landscape are common; these are supported by conglomerate layers. The Tertiary White River formation is highly erodible and may include badland areas. The Green River Basin in the southwestern corner of the state contains a large exposure of Tertiary sedimentary rock, which controls landscape topographic features and soils. There are several large dune fields in the state with west to east axes, resulting from wind corridors. Playas occur locally in both basin and plains landscapes; some are saline and others are periodic, temporary freshwater wetlands.

The Black Hills have a typical Laramide mountain structure. However, uplift in the Black Hills was not as high as for the Rocky Mountains, and the surface of the range is still largely mantled by sedimentary rocks of Tertiary and older ages. The range was not glaciated and the soils atop the Black Hills are a mosaic of Alfisols (Eutraboralfs) and Mollisols (Argiustolls).

The Wyoming Range and Overthrust Belt along the western boundary of the state are the product of very old mountain building events and present soil parent materials of immense geologic complexity. Ridges and valleys often result from differential resistance to weathering in folded sedimentary rocks of Tertiary, Cretaceous, and older ages.

Overall, because of the relatively harsh climate in the state, soils in Wyoming show a close relationship to geologic parent materials and vegetation communities under which they form. Landscape stability and age relationships are also quite important in understanding soil occurrence throughout the state.

Soil Map Unit (SMU) Descriptions: Soils Map of Wyoming

Soil Zone 1: Yellowstone National Park Area. Mountains and high plateau. Cryic, udic, and aquic.

WY01: Typic Dystrocryepts-Typic Haplocryalfs, loamy-skeletal, mixed; and Histic Cryaquepts, fine-loamy over sandy or sandy-skeletal, mixed. Under continuous coniferous forest (Lodgepole Pine, Englemann Spruce, Subalpine Fir, and Douglas Fir), soils on geologic parent materials and surfaces that are older than Pinedale are typically Haplocryalfs. The Yellowstone Plateau area was heavily glaciated during the Pinedale (Wisconsin) glaciation and most surfaces are of Late Pinedale or Holocene age. On these younger parent materials and/or surfaces, the dominant soils are Dystrocryepts. Cryaquepts occur in riparian areas. Inclusions may include Typic Cryofluvents along small channels and Cryofibrists in depressions in Pinedale moraines and along low-gradient segments of streams. Typic Haplocryolls and Humic Dystrocryepts may occur in small openings in the forest.

WY02: Typic Haplocryolls, fine-loamy; and Histic Cryaquepts, fine-loamy over sandy or sandy-skeletal. Haplocryolls occur in mountain meadows, which are predominately on south and west facing slopes, and are often on finer textured parent materials than surrounding forest soils. Cryaquepts occur along riparian areas.

WY03: Typic Cryorthents and Humic Dystrocryepts, loamy-skeletal; and Histic Cryaquepts, fine-loamy over sandy or sandy-skeletal. Topography for this unit is irregular, with Humic Dystrocryeptss occurring under grass or grass with scattered trees on small benches and low gradient segments of the slope. Cryorthents are on very steep slopes and around the base of rock outcrops. Cryaquepts occur along riparian areas.

Soil Zone 2: Absaroka Volcanics. Mountains. Cryic, udic, and aquic.

WY03: Typic Cryorthents and Humic Dystrocryepts, loamy-skeletal; and Histic Cryaquepts, fine-loamy over sandy or sandy skeletal. Soils are similar to those in Soil Zone 1, except the mineralogy reflects volcanic parent materials.

WY04: Typic Cryorthents, loamy-skeletal; rock outcrop; and Histic Cryaquepts, fine-loamy over sandy or sandy-skeletal. Thin Cryorthents and bedrock outcrops dominate this landscape. In narrow riparian areas between steep slopes, Cryaquepts have developed in accumulations of fine materials weathered from the surrounding uplands.

WY05: Histic Cryaquepts, fine-loamy over sandy or sandy-skeletal; and Humic Dystrocryepts, loamy-skeletal. In alpine settings, the soils over most of the landscape are an association of Cryaquepts in riparian areas and Humic Dystrocryepts, with moderately deep profiles, on uplands. Umbric epipedons contain 6 to 8% organic matter and are typically 25 to 50 cm thick.

Soil Zone 3: Middle Rocky Mountains. Cryic, udic, and aquic.

WY06: Typic Haplocryalfs, Typic Dystrocryepts, and Typic Haplocryolls, loamy-skeletal; and Histic Cryaquepts, fine-loamy over sandy or sandy-skeletal. On stable slopes which are older than Pinedale (Late Wisconsin), the predominate soils are

Haplocryalfs. Dystrocryepts occur on slopes greater than 40% and on Pinedale and younger surfaces (Pinedale tills and holocene surfaces). Haplocryolls occur under mountain meadow vegetation and are most common on south-facing slopes. Cryaquepts are found along narrow riparian areas.

WY07: Typic Haplocryolls, fine-loamy; Chromic Haplocryerts, fine; and Histic Cryaquepts, fine-loamy. These soils occur on Mesozoic-age bedrock with the Haplocryerts predominating on marine shales. Dominant vegetation is grass or forest with thin canopy coverage and clusters of aspen in wet areas. Cryaquepts predominate in riparian areas.

WY08: Rock outcrop and Lithic Cryorthents, loamy-skeletal. These residual landscapes present a rugged appearance with 50 to 60% of the area covered by rock outcrop. The thin Cryorthents occur intermingled with the bedrock.

WY42: Typic Hapludolls and Typic Hapludalfs, loamy-skeletal, mixed, frigid. These soils occur in the foothills along the flank of the higher mountains and represent a transition from the basins to the higher mountains. Hapludolls are common on south- and west-facing slopes; Hapludalfs predominate on north-facing slopes and on both canyon walls of narrow canyons.

Soil Zone 4: Bighorn Basin. Intermountain Basin. Mesic, aridic.

WY09: Typic Haplargids and Typic Haplocalcids, fine-loamy over sandy or sandy-skeletal, mesic; and Typic Torriorthents, fine-loamy and coarse-loamy, mesic. Aridisols occur on colluvial and alluvial landscapes, while Entisols occur on residual landscapes.

WY10: Typic Torripsamments, mesic. These soils are on stabilized dunes. They show little horizon development; thin A horizons are the most apparent change from the parent material (stabilized dune sand).

WY11: Calcic Haplosalids, fine, mesic. These soils are associated with marine shales and occur in topographic depressions where run-off water from the surrounding landscape accumulates and evaporates concentrating salt.

WY12: Typic Torriorthents, loamy, mesic; and rock outcrop. These soils form in a variety of sedimentary parent materials which are exposed along the perimeter of the basin. Soils are shallow or moderately deep to soft bedrock.

WY13: Typic Torriorthents, fine, mesic; and rock outcrop. These soils form over fine-textured Cretaceous bedrock. Outcrops of shale occur as small badlands; outcrops of coarser textured rock support long, narrow ridges with finer textured soils along the flanks.

WY14: Typic Haplargids and Typic Natrargids, fine-loamy or coarse-loamy, mesic. These soils occur on low-gradient colluvial slopes (less than 15%) and reflect the texture of the underlying bedrock as well as the effects of slope processes.

WY15: Typic Torrifluvents, sandy-skeletal, mesic; and Typic Haplocambids, fine-loamy over sandy or sandy-skeletal, mesic. These soils occur on Holocene-age terraces and slopes along small streams. The Torrifluvents occupy the first and second terraces above the modern channel.

Soil Zone 5: Powder River Basin. Northern Great Plains. Mesic, aridic.

WY16: Ustic Haplargids, Ustic Haplocalcids,

and Aridic Haplustolls, fine-loamy, mesic; and Torriorthents, loamy-skeletal, mesic. These soils have formed from a variety of parent materials on Pleistocene and Holocene surfaces, weathered from Tertiary and other bedrocks. The Haplargids and Haplocalcids occur across broad expanses of the landscape. The Torriorthents occur along eroded drainage ways and around rock outcrops. The Haplustolls occur where snow accumulation significantly enhances soil water.

WY17: Typic Torriorthents, loamy-skeletal, mesic; and rock outcrop. These stony soils occupy ridge crests where coal bed fires have created clinker. The soils tend to be much coarser than the soils on the adjacent lower slopes and contain hard clasts.

WY18: Typic Torriorthents and Entic Haplustolls, fine-loamy, mesic. These soils occur on reconstructed landscapes that have been disturbed by mining. The occurrence of mollic epipedons is a function of reclamation practices and is not necessarily tied to topography or potential productivity.

WY19: Typic Haplogypsids, fine, mesic. These soils occur in clayey playas where gypsum has accumulated in sufficient quantity to qualify as a gypsic horizon.

WY42: Typic Hapludolls and Typic Hapludalfs, loamy-skeletal, mixed, frigid. These soils are similar to those in Soil Zone 3. They occur in foothills along the margin of the Powder River Basin.

Soil Zone 6: Black Hills. Mountains. Frigid, udic, and ustic.

WY20: Typic Hapludalfs and Typic Argiudolls, fine-loamy; and Typic Haplaquolls, fine, frigid. The Hapludalfs support open to dense stands of Ponderosa Pine. The Argiudolls occur under moist meadows, while the Haplaquolls occur along narrow riparian areas.

WY21: Ustic Haplocambids and Ustic Torriorthents, fine, frigid; and rock outcrop. These clayey soils are derived from acid shales and show little profile development. The Haplocambids occur on low-gradient surfaces. Torriorthents occur intermingled with areas of shale outcrop in badlands-type topography.

WY22: Typic Argiudolls and Typic Haplaquolls, fine-loamy, frigid. These soils occur in moist meadows along riparian areas in the mountains. The Haplaquolls have accumulated greater amounts of organic matter due to their high water table.

WY43: Ustic Haplargids and Ustic Haplocambids, fine and fine-loamy, mesic. These soils have weathered from interbedded sandstones, siltstones, and shales. The Haplargids are on low-gradient slopes (less than 15%); the Haplocambids are on steeper slopes.

Soil Zone 7: Southeast Wyoming. Northern Great Plains. Frigid and mesic, aridic.

WY10: Typic Torripsamments as in Zone 4, except soil temperature regime is frigid.

WY23: Typic Argiustolls, fine-loamy; and Typic Argiustolls, fine-loamy over sandy or sandy-skeletal, mixed, frigid. These soils occur on Tertiary and Pleistocene parent materials (mostly alluvial fan deposits of Tertiary age, or local alluvium of Pleistocene age.)

WY24: Ustic Haplocambids and Ustic Torriorthents, fine, frigid. These moderately and weakly developed soils occur on gentle to

steep slopes over the Tertiary White River formation. Profile development is shallow or moderately deep.

WY25: Ustic Torriorthents and Aridic Ustochrepts, loamy-skeletal, frigid. These soils occur along the front of the Laramie Range and the Hartville uplift. The Ustochrepts support scattered stands of Ponderosa Pine. Soils are shallow or moderately deep and coarse textured.

WY26: Ustic Torriorthents and Ustic Haplocambids, fine, frigid. These soils have developed on Cretaceous-age bedrock (shale) and are moderately deep or shallow. The Haplocambids are on low-gradient fans and slopes; Torriorthents occur on steeper slopes (greater than 15%).

WY27: Typic Torrifluvents and Typic Haplaquolls, fine-loamy over sandy or sandy-skeletal, mixed, frigid. These soils occur along riparian areas with the Torrifluvents developing along channels scoured by flooding and the Hapliquolls developing on low-gradient channel sections where vegetation is well established and high water tables occur during most of the year.

WY44: Ustic Haplargids and Ustic Torrifluvents, fine-loamy over sandy or sandy-skeletal, mixed, mesic. These soils occur on alluvium and slopes of Pleistocene and Holocene age over a variety of bedrocks. The Torrifluvents occur on the active floodplain; Haplargids occur on more stable landscape segments.

Soil Zone 8: Medicine Bow and Laramie Mountains. Mountains. Cryic, udic, and aquic.

WY28: Typic Haplocryalfs and Typic Dystrocryepts, loamy-skeletal, mixed; and Typic Haplocryolls, fine-loamy, mixed. Haplocryalfs occur under forest on till parent materials older than Pinedale (140,000 years old and older) and on non-glaciated land forms where the slope gradient is less than approximately 10%. Dystrocryepts occur under forest on till of Pinedale age and on slopes (>10%) that were unstable during the Pinedale glaciation. Haplocryolls occur under grasses and shrubs on west and south aspects and in dry parks on Tertiary-age parent materials.

WY29: Histic Cryaquepts and Typic Cryaquolls, fine-loamy over sandy or sandy-skeletal, mixed. These are poorly drained soils along riparian areas. Only A horizon thickness is different between the two soils (thicker in the Mollisols). Depth to water table in the profile varies from 0 to 50 cm over the course of the summer.

WY30: Typic Dystrocryepts and Lithic Cryorthents, loamy skeletal, mixed; and rock outcrop. These soils are found at high elevations and on very resistant parent materials. They are on eroding slopes or the youngest tills in the region (Neoglacial).

WY31: Typic Dystrocryepts and Typic Cryorthents, loamy skeletal, mixed. This unit occurs on Triassic, Permian, and Cretaceous sedimentary rock along the flanks of the mountain range. The soils are moderately deep or shallow.

WY32: Typic Dystrocryepts, loamy-skeletal, mixed; and rock outcrop. These soils occur on Precambrian granitic parent materials. The Inceptisols are mostly moderately deep with less than 12% clay in their thin B horizons (Bw). The rock outcrops take the form of rounded boulders and sheets of rock.

WY45: Typic Hapludalfs and Aridic Haplustepts, loamy-skeletal, mixed, frigid.

These soils occur along the base of the mountain ranges in the region and support open stands of Ponderosa Pine as well as other conifers. The Hapludalfs are on low-relief slopes and nearly level surfaces. The Haplustrepts are on slopes greater than 15% and on the narrow valley floors of canyons.

Soil Zone 9: Laramie and Wind River Basins. Intermountain Basins. Frigid, aridic.

WY09: Ustic Haplargids and Ustic Haplocalcids, fine-loamy over sandy or sandy-skeletal, frigid; and Ustic Torriorthents, fine-loamy and coarse-loamy, frigid. In this region, the soils in this unit have frigid temperature regimes. These soils occur on old alluvial terraces along major rivers. Soils younger than mid-Pleistocene age are an association of Haplargids and Haplocalcids. On older landscapes, Haplocalcids predominate. Torriorthents occur along south-facing terrace scarps; textural family is determined by underlying bedrock.

WY10: Typic Torripsamments, frigid. These soils on stabilized dunes show little profile development but are quite productive under native rangeland.

WY33: Lithic Torriorthents, loamy-skeletal, frigid; and rock outcrop. These soils occur along both sides of bedrock outcrops that form ridges along the flanks of the basins. The rock outcrop is usually sandstone or limestone.

WY34: Ustic Haplargids and Ustic Natrargids, fine-loamy, frigid. These soils occur as an association on residual landscapes and in local colluvium derived from Tertiary-age parent materials. Natrargids show less productivity under sagebrush and grass than Haplargids.

WY35: Typic Natrargids and Typic Torriorthents, fine, frigid. These soils occur on landscapes underlain by Triassic and Cretaceous bedrock (shales). The Torriorthents occur in a badlands type topography, while the Natrargids occur on small, local alluvial fans at the foot of badland scarps, and on low-gradient slopes.

WY36: Ustic Torriorthents and Ustic Haplocalcids, coarse-loamy, frigid. These soils occur on calcareous sandstone of Permian age (redbeds). Haplocalcids occur on low gradient slopes; Torriorthents on slopes greater than 10%.

WY37: Typic Petrocalcids and Ustic Calciargids, fine-loamy over sandy or sandy-skeletal, frigid. These soils occur on the highest terraces along major streams where the surfaces are mid-Pleistocene age or older. On some surfaces, the petrocalcic horizon of the Palecalcids is nearly continuous; on other surfaces, Palecalcids and Haplocalcids occur as a complex.

WY38: Ustic Haplocambids and Ustic Haplargids, coarse-loamy, frigid. These soils occur as a complex on late-Pleistocene age terraces along major streams, and on slopes of less than 15% gradient of the same age.

WY44: Ustic Haplargids and Typic Torrifluvents, fine-loamy over sandy or sandy-skeletal, mixed, mesic. These soils occur below 5,000 feet in elevation in a relatively small area in the Wind River Basin. The Haplargids occur on alluvial terraces; the Torriorthents occur along the scarp slopes.

Soil Zone 10: Green River Basin. Intermountain Basin. Frigid, aridic.

WY06: Typic Haplocryalfs, Typic Dystrocryepts, and Typic Haplocryolls, loamy-skeletal, mixed; and Histic Cryaquepts, fine-loamy over sandy or sandy-skel-

etal, mixed. These soils are similar to those in the same unit in Soil Zone 3. They are confined to the highest elevations of this region.

WY10: Typic Torripsamments, frigid. These soils are very similar to Torripsamments in other areas of the state, except they are intermingled with active dunes.

WY11: Typic Haplosalids, fine, frigid. These Haplosalids occur in saline playas and are similar to those of this unit in Zone 4, except they are frigid.

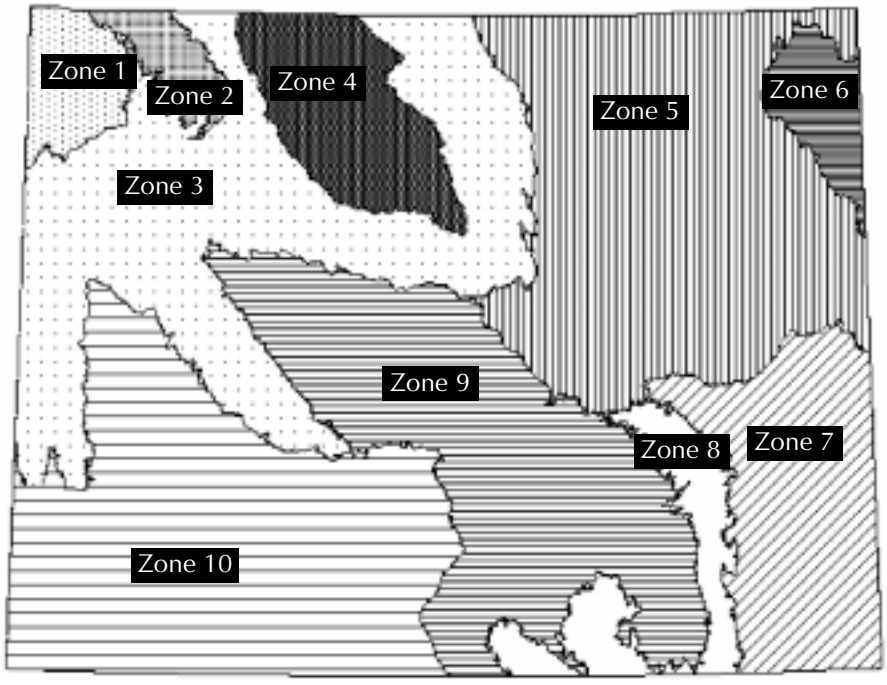
WY17: Rock outcrop and Typic Torriorthents, loamy-skeletal, mixed, frigid. These soils are similar to those in Zone 5, except the coarse fraction of the soil consists of clasts of the local bedrock, rather than clinker.

WY39: Ustic Haplargids, Ustic Haplocambids, and Ustic Natrargids, fine-loamy, mixed, frigid. On Tertiary parent materials along the flank of the Wyoming Range uplift, the soils are found in an association reflecting slope position and parent material sodium content. The Haplargids occur on stable, low-gradient slopes. Haplocambids are on steeper slopes, and Natrargids occur on fans where erosional processes have accumulated high-sodium materials.

WY40: Ustic Haplocambids and Ustic Torriorthents, coarse-loamy, mixed; and Typic Torrifluvents, loamy-skeletal, mixed, frigid. This landscape has shallow and moderately deep Haplocambids and Torriorthents occurring on slopes along ephemeral channels and Torrifluvents along gully bottoms.

WY41: Aridic Haplustolls and Ustic Haplocambids, fine-loamy, frigid. These soils are on Tertiary age parent materials along the edges of the basins under sagebrush-grasslands. The Haplustolls are on sites with extra moisture, which promotes greater productivity.

Rationale for Soil Map Units



This map shows the 10 soil zones used in the Digital Soils Map of Wyoming.

Zone 1: This zone features high mountains that were heavily glaciated. The most common well-drained forest soils are Dystrocryepts. Haplocryalfs occur on older till parent material (Bull Lake till of 140,000 years plus age) and on low-relief surfaces. Soils along riparian areas are Cryaquepts, with inclusions of Histisols. The default mapping unit (WY01) is the most extensive unit. Along the larger alluvial areas, the soils are affected by a high water table (WY02), with some inclusions of Cryofluvents. At high elevations, in the rugged, glaciated peaks and ridges, the soils are Cryorthents and Humic Dystrocryepts, with extensive areas of rock outcrop and talus (WY03).

Zone 2: This zone includes extensive areas of glaciated extrusive volcanic mountains. The default soil mapping unit is WY03. The very highest ridges and peaks, with very thin and patchy soil cover, comprise WY04. Larger alluvial valley floors, including old terraces, are occupied with a complex of Cryaquepts and Humic Dystrocryepts (WY05).

Zone 3: This extensive unit is comprised of high mountains that were heavily glaciated. The landscape is largely occupied by Dystrocryepts and Haplocryalfs under continuous forest, with Haplocryolls under grass and shrubs in parks or openings in the forest. These parks are more common on dry (south and west) aspects than on north-facing slopes. Cryaquepts occur along the streams. This is soil mapping unit WY06. At lower elevations (below 8,000 feet), the temperature regime is frigid, and the landscape is occupied by WY42. On Cretaceous shales, soil textures are much finer and the mapping unit is WY07. At highest elevations, on glaciated peaks and ridges, the soils are thin and patchy, with large areas of rock outcrop (WY08).

Zone 4: In this intermountain basin environment, the default mapping unit is a complex of Haplargids and Haplocalcids on low-gradient surfaces, and Torriorthents on sloping surfaces (WY09). Psamments occur on stabilized dunes (WY10) and gypsum-affected and soluble salt-affected soils occur on playas (WY11). Where bedrock is exposed along ridges, the soils are Torriorthents with fine texture on Cretaceous shales (WY13) and loamy texture over other bedrocks (WY12). Footslopes occupied by local colluvium/alluvium are occupied by Haplargids and Natrargids, depending upon the sodium content of the parent material (WY14), and the alluvial valley floors in this arid setting are occupied by Torrifluvents and Haplocambids, with the latter on the older Holocene surfaces.

Zone 5: The default soil mapping unit for this landscape is a complex of Haplocalcids and Haplargids, with Mollisols (Haplustolls) on the more favorable sites. Above 5,000 feet elevation, the soil temperature regime is frigid and the soils are a complex of Hapludolls and Hapludalfs, the latter under Ponderosa Pine and Douglas Fir. Special landscape components include playas (WY19), mined land (WY18), and karst topography (WY17).

Zone 6: The Black Hills support an association of Mollisols (Argiudolls) under grasslands and Alfisols (Hapludalfs) under forests. Many soils are fine textured (fine or fine-loamy families). Below 5,000 feet in elevation, the soils are similar to those in the Powder River Basin (Haplocambids and Haplargids). Along streams, the soils are Haplaquolls and Fluvents.

Zone 7: The landscape in southeastern Wyoming is dominated by extensive outcrops of Tertiary-age parent materials. Above 6,500 feet in elevation, the soils are Argiudolls and Hapludolls, except for areas where the White River formation is exposed; here the soils are shallow Entisols and Aridisols. Highest elevations in the area support Inceptisols under forest and Mollisols under grass.

Zone 8: The Medicine Bow Mountains are occupied by an association of Haplocryalfs and Dystrocryepts on forested sites. The Haplocryalfs occur on low-relief surfaces of Bull Lake or older age. Dystrocryepts occur under forest on Pinedale glacial deposits and on steep slopes of all ages. Grassy openings in the forest and sage-grasslands in the foothills are typically occupied by Typic Haplocryolls. Alpine areas are occupied by a complex of Humic Dystrocryepts and Cryorthents. Riparian areas are usually occupied by Cryaquepts, with a few Histisols present.

Zone 9: The Laramie and Wind River Basins are rimmed with upturned Cretaceous and older sedimentary rock. Soils developed on these parent materials are typically an association of Natrargids and Torriorthents. The interiors of the basins are filled with alluvial sediments of Tertiary and Pleistocene age. Soils on older alluvial surfaces (700,000 years and older) are usually dominated by calcium accumulations (Petrocalcids and Haplocalcids) while younger, low-relief surfaces are occupied by Haplargids (Pleistocene surfaces) or Haplocambids (Holocene surfaces). A complex of Natrargids and Haplargids occupies broad uplands developed in Tertiary-age parent materials. Riparian areas often contain Haplaquolls, and steep scarps are typically occupied by Torriorthents.

Zone 10: The landscape in this extensive basin environment is dominated by the broad exposure of Tertiary shales and sandstones, many of which are noted for their rich fossil record. Soils on the tertiary bedrock are an association of Haplocambids and Torriorthents, with Fluvents along ephemeral channels and Mollisols on favorable sites. The zone contains Psamments on stabilized sand dunes and salinized soils in playas. Sodium-affected soils (Natrargids) occur on alluvial fans on high-sodium parent materials, and an association of Haplocryolls, Dystrocryepts, and Haplocryalfs occur above 7,800 feet in elevation. Uplifted areas of cretaceous and older rock add to the complexity of the area.

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Appendix I

Soil Moisture and Soil Temperature Regimes

Soil moisture and soil temperature regimes are defined in terms of field measurements and are important characteristics of soils. Besides the direct effect of climate, they are also influenced by such factors as slope, aspect, plant cover, permeability, and water table. These regimes are used at different levels of taxonomy to define the classes of soils. For some soils, these climatic-related criteria define classes of orders, suborders, and great groups as indicated by formative elements of many soil names used in the legend. Soil moisture and soil temperature regimes are used as one basis for separating different map units. Therefore, the legend is presented under subheadings that group the units according to ranges of soil moisture and temperature. Brief definitions of the temperature and moisture regimes in Wyoming are given below; the complete definitions are given in Soil Taxonomy (Soil Survey Staff 1975; Soil Survey Staff 1998).

Soil Moisture Regimes

The amounts and seasonal incidence of water that enter the soil profile and percolate through, or are held and used by plants, are important properties of the soil affecting its use. Through geologic time, it has been a controlling determinant of processes that have formed the soil. The moisture regimes generally are related to climate and usually are estimated from climatic data. The definitions, however, are given in terms of long-term average seasonal soil moisture conditions within an upper portion of the profile called the **soil moisture control section**. The control section is intended to indicate equivalent amounts of soil moisture, and its upper and lower boundaries vary with soil water holding capacity. It is roughly between depths of 10 and 30 cm (4 and 12 in) for most soils, and at greater depths for moderately coarse and coarse textured soils. The moisture regimes are generally definitive criteria of the higher categories of soil taxonomy and are indicated by formative elements in names of many of the great groups. The aridic moisture regime is one of the criteria that defines the Aridisol Order.

The aridic, ustic, udic, aquic, and xeric moisture regimes are recognized in Wyoming. Abbreviated definitions of the moisture regimes as they apply in Wyoming are given in the following paragraphs. In these definitions, reference is to moisture levels within the control section. “Dry” means too dry for most plant growth, or above 15 bars moisture tension; “moist” means soil water present at less than 15 bars tension; “prolonged summer dry period” means the control section is dry for more than 45 consecutive days after June 21; “saturated” means the profile is subject to a high water table for a significant part of the year; “warm enough for plant growth” means above 5°C at a soil depth of 50 cm; “above 8°C” refers to temperatures at this same depth. The moisture regimes describe the moisture conditions that prevail in most years (6 out of 10 for xeric soils; 7 out of 10 for others).

Soils with the **aridic** (or **torric**) soil moisture regime are dry more than half of the time when they are warm enough for plant growth and are never moist in any part for 90 con-

secutive days when they are warmer than 8°C. Aridic soils are described here as arid and semiarid. They generally have annual precipitation of less than 36 cm (14 in.). These soils are too dry for annual cropping and many require irrigation for crop production. "Torri-" is a formative element indicating aridic great groups of orders other than Aridisols (e.g., Entisols-Torriorthents).

Soils of the **aquic** soil moisture regime are saturated by a seasonal or permanent high water table and subject to reducing conditions reflected by mottled and grayish subsoil colors (called redoximorphic features). When the whole soil (from the surface down) is saturated for sufficient time, aquic suborders are used. Aquic subgroups are used for soils when saturated conditions prevail lower in the profile. When the water table in the soil is contiguous with the ground water table, the soil is said to have "endosaturation." When the water table in the soil is perched above a non-saturated layer (within 2 meters of the surface), the soil is said to have "episaturation." When a soil has a water table as the result of irrigation or other human activity, the soil is said to have "antric saturation." Except for Aridisols, aquic suborder classes are used in all orders in Wyoming. These classes are designated by the formative element "aqu-" in the name. Such soils are commonly described as wet.

Soils of the **udic** soil moisture regime are usually moist. They are not dry in any part for as long as 90 cumulative days and do not have a prolonged summer dry period. They are never wet except for short periods. These soils have sufficient moisture for annual cropping or good forest and range production. They are commonly described as humid. Nearly all soils with udic moisture regimes in Wyoming are in mountains and most are cold. The formative element "ud-" does not appear in group names of these cold soils (e.g., Haplocryalfs). Temperature is given precedence.

Soils with a **ustic** soil moisture regime are dry in some or all parts for 90 or more cumulative days but not dry in all parts more than half of the time when they are warm, and they do not have a prolonged summer dry period. These soils have limited soil moisture, but the moisture normally occurs mainly during the growing season. They are described as semiarid or sub-humid. In years of average or above average rainfall with favorable distribution, these soils can be annually cropped. "Ust-" is the formative element used in ustic great groups of Entisols and Inceptisols.

Soil Temperature Regimes

Soil temperature regimes are defined in relation to the mean summer soil temperatures and the mean annual soil temperatures measured at a depth of 50 cm (20 in) or at the contact with bedrock, if shallower. Only the frigid, cryic, and mesic temperature regimes occur extensively in Wyoming. The formative element "bor-" is used in frigid or cryic Mollisols suborders (except Aquolls) and Alfisol suborders (except Aqualfs); "cry-" is used in names for cryic great groups of all orders in Wyoming except Aridisols.

The **frigid** soil temperature regime has mean annual soil temperatures below 8°C (47°F) but above 0°C (32°F). The Borolls are suborders of Mollisols, and Boralfs are suborders of Alfisols that are frigid or colder. In other suborders and orders, frigid temperatures are recognized at the family level. Frigid soils are described as cool.

The **cryic** soil temperature regime also has mean annual soil temperatures between 0°C and 8°C (32°F and 47°F), but, in addition, cool summer temperatures. Specifically, mean summer soil temperatures (June, July, and August) are below 15°C (59°F). They are below 8°C (47°F) if a surface organic layer (forest floor) is present and below 13°C (55°F) if the soil is saturated and has no surface organic layer. These somewhat complicated limits are designed to group equivalent soil temperatures that differ because of the insulating effect of surface organic layers or the extra heat absorption by excess water. Cryic soils are described as cold.

The **mesic** soil temperature regime has mean annual soil temperatures between 8°C (47°F) and 15°C (59°F). This temperature regime is typical of the middle latitudes, including the midwest corn belt. Major areas of soils with mesic temperature regimes occur in the Bighorn Basin and in eastern Wyoming from the Black Hills (low elevations) to the Colorado state line. Smaller areas occur around Casper and Rock Springs.

In addition to the three temperature regimes discussed above, which occur extensively in Wyoming, the following temperature regimes are recognized:

Pergellic: Mean annual soil temperature (MAST) <0°C (32°F). Permafrost occurs in moist soils with this temperature regime. Patterned ground is common as a result of frost action. In Wyoming, small areas at high elevations in the alpine have this temperature regime.

Thermic: MAST is >15°C (59°F) but <22°C (72°F) and the difference between mean summer and mean winter soil temperatures at 50 cm is 5°C.

Hyperthermic: MAST is >22°C (72°F) and the difference between mean summer and mean winter soil temperatures is >5°C.

The pergellic regime is typical of Arctic and Antarctic regions. The thermic regime is typical of the cotton belt in the United States, and the hyperthermic zone is typical of the tropics. The prefix "iso-" is used with mesic, thermic, and hyperthermic regimes when the difference between mean summer and mean winter soil temperatures at 50 cm is <5°C (9°F).

Appendix II

Descriptions of the Soil Orders

Alfisols: Alfisols are light colored, slightly to moderately acid soils with brownish subsoil horizons of clay accumulation. They are somewhat leached, but they are usually moderate to high in bases. Alfisols have formed under coniferous or mixed forests with moderately low to high precipitation and cool or cold climates (frigid Udalfs and Cryralfs). They are primarily on mountains and foothills or in forested intermountain valleys. In western Wyoming valleys, some Alfisols are dry for extended periods of the summer, though moist most of the year (Xeralfs).

Aridisols: Aridisols are light colored soils of dry regions that are depleted of plant-available soil moisture for most of the summer. They are unleached and are alkaline in reaction. Some Aridisols have developed horizons of clay accumulation (Argids), mainly on older and more stable surfaces. These may also be sodium affected. Others have only some redistribution of clay and weak-to-strong accumulations of calcium carbonate or more soluble salts (Calcids, Gypsids, Cambids). Aridisols are common in the Wyoming plains and basins. They have shrub-grass or shortgrass prairie vegetation with a few juniper and stunted Ponderosa Pine in places. In Wyoming, many Aridisols are considered to be intergrading to Mollisols with somewhat more available moisture than typical and are dry-farmed in some areas (e.g., Ustic Haplargids).

Entisols: Entisols are very young soils. Some are developing in recently deposited parent materials, while others are on steep slopes, are actively eroding, and show little, if any, alteration or development of horizons. Entisols can be in any climate and may be alkaline or acid in reaction. Those developing in recent alluvial deposits are stratified (Fluvents) or wet (Aquents). Most are on steep and very steep slopes (Orthents), and some are on sandy, often wind-reworked materials (Psamments).

Histisols: Histisols are organic soils formed in bogs, wet meadows, and some backwater floodplain areas with a high water table. They include the peat and muck soils. These soils are of minor extent in Wyoming and are mostly found at high elevations.

Inceptisols: Inceptisols include light colored soils (Ochrepts) that have had slight to moderate alteration during formation. They lack horizons of clay accumulation but have subsoil horizons differentiated by color, structure, and some leaching of carbonates. Inceptisols occur under cool and cold temperatures and moderately low to high precipitation. They have formed either under grass or forest vegetation and are alkaline or acid in reaction. They are common in the forested mountains of Wyoming.

Inceptisols in the Wyoming mountains have formed under the influence of high precipitation, cold temperatures, and coniferous forest. They are common on Late Wisconsin (Pinedale) and younger surfaces. Some Inceptisols along streams and in wet mountain meadows have high water tables and mottled grayish subsoils (Aquepts).

Mollisols: Mollisols are dark colored, base-rich soils formed under grass and, in some places, under open forest vegetation. They

may or may not have subsoil horizons of clay accumulation. Typically, they have prismatic and blocky subsoil structure. Most have lower subsoil horizons of calcium carbonate accumulation. Some are calcareous to the surface, and some are sodium affected. Mollisols occur under moderate to low precipitation and cool to cold temperatures (frigid Udolls and Cryolls) throughout Wyoming. Generally, the Mollisols of foothills and mountains with moderate precipitation have a relatively thick, nearly black surface horizon and are deeply leached of carbonates. Those formed on the plains and in basins under low precipitation are associated with Aridisols. They usually have thinner and lighter colored surface horizons and are less deeply leached of carbonates. Mollisols of low-lying areas with high water tables have mottled or grayish subsoils (Aquolls). In western Wyoming valleys, some Mollisols are dry for extended periods of time in the summer, though moist most of the year (Xerolls).

Spodosols: Spodosols are light colored, acid, brownish soils found occasionally under coniferous forests in the Wyoming mountains. Precipitation is relatively high and temperatures are cold. They are characterized by having brownish or reddish brown, loamy or sandy, thin subsoil horizons with amorphous humus, aluminum, and iron accumulation. Typically, these soils have a thin, light gray subsurface horizon beneath a dark organic duff layer of decomposing plant litter. Spodosols are common in the taiga of Eurasia and North America but are rare in the Rockies.

Vertisols: Vertisols are very clayey soils that have deep, wide cracks when dry, and that swell tightly when wet. Expanding clays of this type are common in intermountain basins in Wyoming in clayey soils derived from shale. Vertisols have "slickensides" and wedge-shaped peds. Many soils that are vertic intergrades in other orders also occur.

Andisols: Andisols are soils which have developed on rather young (geologically) volcanic ejectra (ash, cinders, pumice, etc.). They typically have low bulk densities compared to other mineral soils (0.4 to 0.9 g cm^{-3}). These soils are often fertile, with high water-holding capacities and are highly productive for forestry and crops. They may be thixotropic, however, and generally have poor engineering properties. They are common in the Pacific Northwest but rare in Wyoming (some are found in the Yellowstone Park area).

Other Orders

Ultisols, Oxisols, and Gelisols: These are the remaining three soil orders. Soils in these orders are not recognized in Wyoming, although soils fitting these concepts developed in what is now Wyoming under previous climatic (tropical) conditions. Some of the red colors seen in the Wyoming badlands are relict Ultisols, dating from a time and climate when crocidiles and flamingos lived in what is now Wyoming.

Ultisols are forest soils similar to Alfisols except they are more highly leached. Base saturation is low (<35%) and the argillic or kandic horizon is normally dominated by 1:1 (Kaolinitic) type clays. Ultisols are common in the southeastern United States, in the Pacific Northwest, and in the tropics. A few Ultisols occur in Wyoming, but the combination of argillic horizons and < 35% base saturation is rare.

Oxisols are soils of great age found on stable land surfaces in the tropics and subtropics. They are highly leached and contain mostly iron and aluminum sesquioxides and 1:1 type silicate clays in the clay particle size fraction. In the United States, oxisols occur only in Hawaii and Puerto Rico. Relicts of oxisols have been identified in California and Texas, representing past tropical climates.

Gelisols are soils with permafrost (i.e., pergellic temperature regimes). Gelisols are common in the arctic and antarctic regions, and they also occur at high elevation in the northern and central Rocky Mountains. Plant root growth in Gelisols is restricted to the active layer, the shallow surface layer that thaws during the growing season. Gelisols are sensitive to disturbance since removal of the vegetation canopy or soil litter layer may result in thawing of the permafrost layer.

APPENDIX III

Soil Data Layer – Decision Rules

The state was divided into 10 soil zones based on geologic province.

1. Yellowstone National Park area: mountains, cryic, udic.
2. Absaroka Volcanics: mountains, cryic, udic.
3. Middle Rocky Mountains: cryic, udic.
4. Bighorn Basin: intermountain basin, mesic, aridic.
5. Powder River Basin, Northern Great Plains: mesic, aridic.
6. Black Hills: mountains, frigid, ustic.
7. Southeast Wyoming: Northern Great Plains: frigid, aridic.
8. Medicine Bow and Laramie Mountains: mountains, cryic, udic.
9. Laramie and Wind River Basins: Wyoming basin, frigid, aridic.
10. Green River Basin: Wyoming basin, frigid, aridic.

The soils in each zone were assigned to particular combinations of surficial geology and bedrock. Surficial geology units were grouped into three major types, with four special categories. A third classification element is elevation. Throughout most of Wyoming, the break between frigid and cryic temperature regimes occurs at approximately 7,800 feet. The break between mesic and frigid occurs at 5,000 feet in northern Wyoming and at 6,500 feet in southern Wyoming.

Landforms (from Surficial Geology Map of Wyoming 25 Element Classification; Case, Arneson, and Hallberg 1998):

Residual: aR, bi, bdi, mi, tre, ri, ui, Ri, Ki, ki, xi, Ti.

Alluvial: Ai, ai, ti, tdi, oai.

Colluvial: fi, fdi, li, sci.

Special: eolian (ei); glacial (gi); playas (pea); mined (Mi)

Bedrock geology (Love and Christiansen 1985) was either keyed on the first letter of the code from the state bedrock geology map, or an individual unit is named specifically.

Key to the Wyoming State Soils Mapping Units (SMU)

Water: major lakes (Yellowstone Lake, Teton Lake) and reservoirs.

Soil Zone 1:

Default SMU is Dystrocryepts-Haplocryalfs, loamy-skeletal, mixed; and Cryaquepts, fine-loamy over sandy or sandy-skeletal, mixed (WY01).

If landform is Alluvial, then SMU is Haplocryolls, fine-loamy, mixed; and Cryaquepts, fine-loamy over sandy or sandy-skeletal, mixed (WY02).

If landform is Ri, then SMU is Cryorthents and Humic Dystrocryepts, loamy-skeletal, mixed; and Cryaquepts, fine-loamy over sandy or sandy-skeletal, mixed (WY03).

Soil Zone 2:

Default SMU is WY03.

If landform is Residual, then SMU is Cryorthents, loamy-skeletal, mixed; rock outcrop; and Cryaquepts, fine-loamy over sandy or sandy-skeletal, mixed (WY04).

If landform is ai or ti, then SMU is Cryaquepts fine-loamy over sandy or sandy-skeletal, mixed; and Humic Dystrocryepts, loamy-skeletal, mixed (WY05).

Soil Zone 3:

Default SMU is Haplocryalfs, Dystrocryepts, and Haplocryolls, loamy-skeletal, mixed; and Cryaquepts, fine-loamy over sandy or sandy-skeletal, mixed (WY06).

If elevation is less than 7,800 ft, SMU is Hapludolls and Haplboralfs, loamy-skeletal, mixed (WY42).

If bedrock is any K-- unit (Cretaceous) and elevation is greater than 7,800 ft, then SMU is Haplocryolls, fine-loamy, mixed; Haplocryerts, fine, smectitic; and Cryaquepts, fine-loamy, mixed (WY07).

If landform is Residual, Bedrock is other than K, and elevation is greater than 7,800 ft, SMU is rock outcrop and Cryorthents, loamy-skeletal , mixed (WY08).

Soil Zone 4:

Default SMU is Haplargids and Haplocalcids, fine-loamy over sandy or sandy-skeletal, mixed, mesic; and Torriorthents, fine-loamy and coarse-loamy, mixed, mesic (WY09).

If landform is ei, SMU is Torripsamments, mesic (WY10).

If landform is pea, SMU is Haplosalids, fine, smectitic, mesic (WY11).

If landform is Residual, SMU is Torriorthents, loamy, mixed, mesic; and rock outcrop (WY12).

If landform is Residual and Bedrock is any K-- unit, SMU is Torriorthents, fine, mixed, mesic; and rock outcrop (WY13).

If landform is Colluvial, SMU is Haplargids and Natrargids, fine-loamy or coarse-loamy, mixed, mesic (WY14).

If landform is ai, SMU is Torrifluvents, sandy-skeletal, mixed, mesic and Haplocambids, fine-loamy over sandy or sandy-skeletal, mixed, mesic (WY15).

Soil Zone 5:

Default SMU is Haplargids, Haplocalcids, and Haplustolls, fine-loamy, mixed, mesic; and Torriorthents, loamy-skeletal, mixed, mesic (WY16).

If elevation is greater than 5,000 ft, SMU is WY42.

If landform is ki, SMU is Torriorthents, loamy-skeletal, mixed, mesic; and rock outcrop (WY17).

If landform is Mi, SMU is Torriorthents and Haplustolls, fine-loamy, mixed, mesic (WY18).

If landform is pea, SMU is Haplogypsids, fine, smectitic, mesic (WY19).

Soil Zone 6:
Default SMU is Haplargids and Haplocambids, fine and fine-loamy, mixed, mesic (WY43).

If elevation is greater than 5,000 ft, Default SMU is Hapludalfs and Argiudolls, fine-loamy, mixed, frigid; and Haplaquolls, fine, mixed, frigid (WY20).

If landform is Alluvial and elevation is greater than 5,000 ft, SMU is Argiudolls and Haplaquolls, fine-loamy, mixed, frigid (WY22).

If landform is Alluvial, SMU is WY15

If bedrock is any K-- unit, SMU is Haplocambids and Torriorthents; fine, mixed, mesic; and rock outcrop (WY21).

Soil Zone 7:
Default SMU is Argiudolls, fine-loamy, mixed, frigid; and Argiudolls, fine-loamy over sandy or sandy-skeletal, mixed, frigid (WY23).

If landform is ei, SMU is WY10.

If bedrock is Twr, SMU is Haplocambids and Torriorthents, fine, mixed (WY24).

If elevation is less than 6,500 ft, SMU is WY44.

If bedrock is any P--- unit (Permian and Pennsylvanian), SMU is Torriorthents and Haplustepts, loamy-skeletal, mixed, frigid (WY25).

If bedrock is any K--- unit, SMU is Torriorthents and Haplocambids, fine, mixed, frigid (WY26).

If landform is ai, SMU is Torrifluvents and Haplaquolls, fine-loamy over sandy or sandy-skeletal, mixed, frigid (WY27).

Soil Zone 8:
Default SMU is Haplocryalfs and Dystrocryepts, loamy-skeletal, mixed; and Haplocryolls, fine-loamy, mixed (WY28).

If elevation is less than 7,800 ft, SMU is Hapludalfs and Haplustepts, loamy-skeletal, frigid. (WY45).

If landform is Alluvial, SMU is Cryaquepts and Cryaquolls, fine-loamy over sandy or sandy-skeletal, mixed (WY29).

If bedrock is Ys or Yla, SMU is Dystrocryepts and Cryorthents, loamy skeletal, mixed; and rock outcrop (WY30).

If bedrock is any K--, P-- or Tr-- (Triassic) unit, SMU is Dystrocryepts and Cryorthents, loamy-skeletal, mixed (WY31).

If bedrock is Wgn, SMU is Dystrocryepts, loamy-skeletal, mixed; and rock outcrop (WY32).

Soil Zone 9:
Default SMU is WY09. (Note: In this region, this unit is frigid.)

If landform is ei, SMU is WY10.

If elevation is greater than 7,800 ft, SMU is WY31.

If elevation is less than 5,500 ft, SMU is Haplargids and Torrifluvents, fine-loamy over

sandy or sandy-skeletal, mixed, mesic (WY44).

If bedrock is Wgn, SMU is Torriorthents, loamy-skeletal, mixed, frigid; and rock outcrop (WY33).

If bedrock is any T-- (Tertiary) unit, SMU is Haplargids and Natragids, fine-loamy, mixed, frigid (WY34).

If bedrock is Tr-- or K--, SMU is Natrargids and Torriorthents, fine, mixed, frigid (WY35).

If bedrock is P--, SMU is Torriorthents and Haplocalcids, coarse-loamy, mixed, frigid (WY36).

If bedrock is Qt, SMU is Petrocalcids and Calciargids, fine-loamy over sandy or sandy-skeletal, mixed, frigid (WY37).

If bedrock is Qa, SMU is Haplocambids and Haplargids, coarse-loamy, mixed, frigid (WY38).

Soil Zone 10:

Default SMU is Haplargids, Haplocambids, and Natrargids, fine-loamy, mixed, frigid (WY39).

If landform is ei, SMU is WY10.

If elevation is greater than 7,800 ft, SMU is WY06.

If elevation is less than 6,500ft,. SMU is WY44.

If bedrock is Tw, Tgw or Tgrw, SMU is Hapludolls and Haplocambids, fine-loamy, mixed, frigid (WY41).

If landform is Residual, SMU is WY17.

If landform is Colluvial and Bedrock is T--, SMU is Haplocambids and Torriorthents, coarse-loamy, mixed, frigid; and Torrifluvents, loamy-skeletal, mixed, frigid (WY40).

If landform is pea, SMU is WY11.

If landform is Alluvial, SMU is WY27.