AECOM Environment

Submitted to:
Platte River Power Authority
Fort Collins, Colorado

Submitted by:
AECOM
Greenwood Village, Colorado
60514657
October 12, 2021

Solid Waste Disposal Facility Run-on and Run-off Control System Plan

Platte River Power Authority
Fort Collins, Colorado - Monofill

AECOM Environment

Submitted to:
Platte River Power Authority
Fort Collins, Colorado

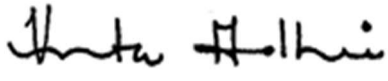
Submitted by:
AECOM
Greenwood Village, Colorado
60514657
October 12, 2021

Solid Waste Disposal Facility Run-on and Run-off Control System Plan - Monofill

Platte River Power Authority
Fort Collins, Colorado

Prepared By
Brian Long, P.E., Project Engineer

Reviewed By
Steve Walker, P.E., Senior Engineer



Approved By
Vasanta Kalluri, P.E., Senior Project Manager

Contents

1.0 Introduction 1-1
1.1 Background 1-1
1.2 Regulations 1-1
1.3 Purpose 1-1
2.0 Site Characterization 2-1
2.1 Site Hydrology and Hydrogeology 2-1
2.2 Site Soil 2-1
2.3 Current Conditions 2-2
3.0 Run-On and Run-Off Calculations 3-1
3.1 Drainage Basins 3-1
3.2 Curve Number Calculations 3-1
3.3 Run-Off Volume and Peak Discharge Calculations 3-1
4.0 Run-On and Run-Off Controls 4-1
4.1 Hamilton Reservoir 4-1
4.2 Run-on and Run-off Controls by Drainage Basin 4-1
4.2.1 Upper Sub-Basin 4-1
4.2.2 Lower Sub-Basin 4-1
4.2.3 Sub-Basin 1 4-2
4.2.4 Sub-Basin 2 4-2
4.2.5 Sub-Basin 3 4-2
4.2.6 Sub-Basin 4 4-2
4.2.7 Sub-Basin 5 4-2
4.2.8 Sub-Basin 6 4-3
5.0 Inspections and Maintenance of Run-On and Run-Off Controls 5-1
5.1 Inspections 5-1
5.2 Maintenance 5-1
6.0 Amendment, Recordkeeping, and Notification 6-1
6.1 Amendment of the Plan 6-1
6.2 Recordkeeping 6-1
6.3 Notification 6-1
7.0 Certification 7-1
8.0 References 8-1

List of Appendices

Appendix A Web Soil Survey Information

Appendix B Tables from Technical Release 55

Appendix C Supporting Calculations (Curve Numbers, Run-off Volume, Peak Discharge, Culvert Sizing, Drainage Channel Sizing)

Appendix D Weekly Inspection Report

List of Figures

Figure 1 Site Location Map

Figure 2 Solid Waste Disposal Facility Plan

Figure 3 Solid Waste Disposal Facility Drainage Sub-basins

Figure 4 Solid Waste Disposal Facility Soil Map

List of Acronyms

amsl	above mean sea level
CCR	coal combustion residuals
CDPHE	Colorado Department of Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm/sec	centimeters per second
H:V	horizontal to vertical
in/hr	inches per hour
NOAA	National Oceanic and Atmospheric Administration
Platte River	Platte River Power Authority
Rawhide	Rawhide Energy Station
RCRA	Resource Conservation and Recovery Act
TR-55	Technical Release 55
USDA	United States Department of Agriculture
USGS	United States Geological Survey
USEPA	Environmental Protection Agency

1.0 Introduction

This Run-on and Run-off Control System Plan has been prepared on behalf of Platte River Power Authority (Platte River) to meet the Coal Combustion Residuals (CCR) Regulations (Final CCR Rule) as detailed in 40 Code of Federal Regulations (CFR) 257.81. This section discusses site background, regulatory drivers, and purpose.

1.1 Background

Rawhide Energy Station (Rawhide) is a 4,560 acre facility located at 2700 East County Road 82 in Wellington, CO (**Figure 1**). Construction of Rawhide began in 1979 and it has operated as a coal-fired power plant since 1984. The primary land use on the Rawhide property is those related to utility service and electric generation.

Power generation at Rawhide produces CCR. Rawhide places these residuals in the Solid Waste Management Facility (also called the CCR Monofill), located in the northwest corner of the Rawhide site. The Rawhide materials currently authorized for placement in the CCR Monofill include the following:

- dry waste products (including fly ash) collected by the flue gas cleaning process,
- bottom ash removed from the bottom ash ponds,
- sludge from the phosphorous removal system sludge ponds, and
- inorganic construction wastes.

The location of the CCR Monofill is shown on **Figure 1**.

1.2 Regulations

The CCR Monofill is regulated by the Final CCR Rule promulgated by the United States Environmental Protection Agency (USEPA, 2015) under 40 CFR Part 257, Subtitle D of the Resource Conservation and Recovery Act (RCRA). The CCR Monofill is also regulated by the Colorado Department of Public Health and Environment (CDPHE) – Hazardous Materials and Waste Management Division under the Regulations Pertaining to Solid Waste Sites and Facilities (6 Code of Colorado Regulations 1007-2, Part 1) (Solid Waste Regulations) (CDPHE, 2015). Compliance with these regulatory requirements is described in the current Monofill Engineering Design and Operations Plan (EDOP). The disposal area is located within the boundaries established by the Platte River Certificate of Designation which covers the Northeast ¼ of Section 6, Township 10 North, Range 68 West, and the Southern ½ of Section 31, Township 11 North, Range 68 West, as shown on **Figure 1**. This Run-on and Run-off Control System Plan, however, was developed to meet only the requirements of the Final CCR Rule, as detailed in 40 CFR 257.81. Onsite run-on and run-off control procedures satisfy CDPHE Solid Waste Regulation requirements and are implemented on the site.

1.3 Purpose

The purpose of this Run-on and Run-off Control System Plan as follows.

1. Prevent run-on flow onto the active portion of the CCR Monofill during the peak discharge from a 24-hour, 25-year storm.
2. Collect and control run-off from the active portion of the CCR Monofill during the 24-hour, 25-year storm.
3. Document how the run-on and run-off control systems have been designed and constructed to meet 40 CFR 257.81.

2.0 Site Characterization

This section characterizes the site and includes a discussion of the site hydrology, hydrogeology, soil, and current conditions at the CCR Monofill.

2.1 Site Hydrology and Hydrogeology

As discussed in the most recent Annual Ash Monofill Inspection Report (AECOM, 2021), the geologic setting at Rawhide lies on the high plains located immediately east of the Colorado Front Range, where soil and bedrock units are incised by drainage from nearby mountains to the west, forming small, relatively minor valley and ridge topographic expressions. Elevations within the project area range from about 5,580 to 5,805 feet above mean sea level. The most distinctive topographic feature at Rawhide is a broad basin that occupies the center of the site and extends from northwest to southeast. Smooth ridges and rounded bluffs surround this basin and mark the transition to uplands that are 50 to 70 feet higher. It is within this basin that the site for the CCR Monofill was selected.

According to the United States Geological Survey (USGS) geologic map, bedrock at Rawhide consists of Cretaceous units including the Upper Pierre Shale Formation. Specifically, the majority of the Rawhide site lies on the Upper Pierre Shale Formation transition zone, the eastern extent of which transitions to the Lower Fox Hills Sandstone downslope and east of the Rawhide site. The Pierre Shale transition zone is described as shale with interbedded sandstones. The portions 600 feet below the contact with the Fox Hills sandstone are mapped by the USGS as being the most permeable within the unit, yielding 5 to 15 gallons per minute in wells. The Fox Hills Sandstone is described as a pale yellow, massive, silty, fine-grained sandstone with lenticular black shale partings but is not present on the Rawhide site.

The bedrock surface at the site is mapped as dipping east-southeast toward Hamilton Reservoir. The geologic map indicates bedrock bedding structure in the area striking roughly north-south with shallow dips 5 to 10 degrees to the east. The Rawhide site is considered to be in an area of overall minor seismicity.

The hydrogeology at Rawhide is discussed in the Engineering Report and Operational Plan (Platte River, 1980) and in the *Final Report Investigation of the Groundwater Monitoring Program for the Bottom Ash Disposal Site* (Lidstone & Anderson, 1989). Data indicates that a groundwater table exists within the Pierre Shale bedrock below the site and in surficial deposits along Coal Creek. The Lidstone & Anderson report explained depth to groundwater varied across the site from 11 to 67 feet and follows a general gradient to the south-southeast. The shallow water table was determined to be directly recharged by infiltration from precipitation and surface runoff.

The Lidstone & Anderson report concluded that sufficient data was collected on the groundwater beneath the Rawhide site to determine a mound has formed in the shallow fractured Pierre Shale Aquifer in the vicinity of Hamilton Reservoir. Hamilton Reservoir is a 500-acre dry-land construction reservoir of reclaimed wastewater from the City of Fort Collins which is used for cooling processes (previously referred to as the Cooling Pond in early reports). After a review of available documents on the current water levels within the area, it was concluded that the CCR Monofill is hydraulically upgradient of any groundwater mound that may be created by Hamilton Reservoir, and groundwater mounding associated with Hamilton Reservoir would not affect the overall performance of the CCR Monofill (AECOM, 2021).

Approximately two-thirds of the surface water at the Rawhide site drains to Hamilton Reservoir. Hamilton Reservoir is located on land that previously drainage to an unnamed tributary of Coal Creek, but this area no longer drains to this tributary. The remaining one-third of the surface water at the Rawhide site is drained by Coal Creek (as shown on **Figure 1**). Coal Creek flows intermittently depending on the amount of precipitation.

2.2 Site Soil

As discussed in the most recent Annual Ash Monofill Inspection Report (AECOM, 2021), soils at the site are mapped as Pleistocene pediment deposits consisting of arkosic sands and gravel with minor

amounts of red clay. More recent, relatively thin soils mantling the pediment deposits and bedrock in the area are likely wind-blown silts and clays.

According to the United States Department of Agriculture (USDA) Web Soil Survey (USDA, 2020), the CCR Monofill was constructed in areas consisting primarily of two soil types: Midway clay loam and Renohill-Midway clay loam. The Midway clay loam is well drained and the surface layer consists of clay loam, clay, silty clay loam to a depth of approximately four to 19 inches, under which is weathered bedrock. Permeability of the soil is moderately low to moderately high (0.06 to 0.20 inches per hour [in/hr]) and the available water storage capacity is moderate. The Renohill-Midway clay is well drained and the surface layer consists of clay loam, clay, and silty clay loam to a depth of approximately four to 27 inches, under which is weathered bedrock. Permeability of the soil is moderately low to moderately high (0.06 to 0.20 in/hr) and the available water storage capacity is moderate. Tests conducted on similar Rawhide site soils indicate a permeability of approximately 1×10^{-3} centimeters per second [cm/sec] to 1×10^{-8} cm/sec (Platte River, 1980). A printout showing the locations of each soil type from the Web Soil Survey and general information about each soil type is provided in **Appendix A**.

2.3 Current Conditions

The current CCR Monofill extent, along with topography provided by Platte River, is shown on **Figure 2**, and includes two adjoining cells. Cell 1 of the CCR Monofill has been filled and is currently inactive. Maximum side slopes are 4H:1V (Horizontal:Vertical). Cell 1 has been covered with a minimum two-foot thick earthen cover. The material used for the cover was obtained from the stripping actives conducted when the active area was prepared for the placement of solid waste. Cell 1 has also been drill seeded with a seed mix containing western wheatgrass, intermediate wheatgrass, blue gramma, buffalo grass, and little blue steam (Platte River, 1980). Although Cell 1 is currently covered with a thick stand of grass, it was never officially considered final closure by the State of Colorado. Per the Revised Design and Operations Plan for the Solid Waste Disposal Facility (Smith Geotechnical [Smith], 2007), Platte River stopped filling Cell 1 before it had reached the full extent authorized by the original Engineering Report and Operational Plan for the Solid Waste Disposal Facility (Platte River, 1980) to avoid disrupting the views of the neighbors. However, if additional storage capacity is needed in the future, filling operations may resume in Cell 1. If that were to occur, this plan will be updated at that time.

Cell 2 adjoins immediately on the west side of Cell 1 and is currently in the process of being filled (filling operations began in 2008). Solid waste placement started in the southernmost part of Cell 2 behind a containment dike and progressively moves north in the area planned to receive solid waste. The completed portion of Cell 2 has some mature grass, some newly planted areas, some newly-covered (two-foot soil cover) and unseeded areas, and some graded and uncovered ash (recently placed).

Both Cell 1 and the completed portion of Cell 2 are graded in a manner that discourages surface ponding on the CCR Monofill and minimizes infiltration. Run-off moves by overland flow and is either captured by depressions located outside the boundary of the CCR Monofill or flows downstream to Hamilton Reservoir.

To reduce fugitive dust due to vehicle travel or winds, a water truck is used at the facility to wet down the disposal area, unpaved roads, stockpiles, and traveled areas. Dust control will be in accordance with the Fugitive Dust Control Plan for Rawhide Energy Station (Platte River, 2017).

AECOM performed a stability inspection of the CCR Monofill in March 2016 and presented the results of a stability analysis within a May 6, 2016 letter to Platte River (AECOM, 2016). The results of the stability analysis show that the calculated factors of safety meet or exceed the minimum recommended factor of safety for global embankment stability.

According to information provided by Platte River, the estimated total volume in the CCR Monofill as of December 31, 2020 was 2,631,786 cubic yards (AECOM, 2021). Additional documentation from Platte River indicated that 22,822 tons were placed between January and June 2021. At a projected 2021 CCR disposal rate of 56,391 tons per year or 4,699 tons per month, and a density equivalent to 1.0125 tons per cubic yard, the current estimated volume contained in the CCR Monofill (by end of October 2021) is approximately 2,673,000 cubic yards.

3.0 Run-On and Run-Off Calculations

The standard engineering methods provided in USDA's Technical Release 55 *Urban Hydrology for Small Watersheds* (TR-55) (USDA, 1986) were used to determine drainage basins and compute curve numbers, run-off volumes, and peak discharges for each drainage basin.

3.1 Drainage Basins

The CCR Monofill area, as well as areas up-gradient of the CCR Monofill, has been divided into six drainage sub-basins as shown on **Figure 3**. The drainage sub-basins were developed by evaluating the topography, determining general flow directions, and bounding each basin along the drainage divide.

3.2 Curve Number Calculations

A curve number is an empirical parameter used in hydrology to determine the approximate amount of direct run-off from a rainfall event in a particular area. Determination of curve numbers depend on the watershed's soil and cover conditions which TR-55 represents as hydrologic soil group, cover type, and hydrologic conditions. Curve numbers range from 30 to 100 with lower numbers indicating low run-off potential and larger numbers indicating increasing run-off potential.

The majority of each drainage sub-basin is categorized as Pasture/Grassland/Range (as identified based on site observations and aerial photography). This cover type is used for open range areas surrounding the CCR Monofill and for areas of the CCR Monofill that have been filled, covered with two feet of soil, and are already well-vegetated resembling the surrounding areas. This includes all of Cell 1 and a portion of Cell 2. These areas were evaluated to be in good condition based on approximate percent of ground cover (greater than 75%) with the exception of a small portion in sub-basin 4 where vegetation is still being established within Cell 2 (observed to be in poor condition based on less than 50% ground cover). A small portion of sub-basin 2 (25 percent representing the gravel pit located northeast of Cell 1), sub-basin 3 (5 percent representing the active face in Cell 2), sub-basin 5 (45 percent representing un-seeded or newly seeded areas within Cell 2), and sub-basin 6 (45 percent representing un-seeded or newly seeded areas within Cell 2) are categorized as newly graded areas.

The USDA Web Soil Survey (USDA, 2020), as discussed above, was used to determine hydrologic soil group (A, B, C, or D) which is based primarily on soil texture. Group A soils (i.e. sand, loamy sand, or sandy loam) have low run-off potential and high infiltration rates while Group D soils (i.e. clay, clay loam and silty clay) have high run-off potential and low infiltrations rates. **Figure 4** shows the approximate locations of each soil type within the CCR Monofill area.

Table 2-2 from TR-55 (provided within **Appendix B**) was then used to determine curve numbers for each land cover scenario. An area-weighted average curve number calculation for each drainage basin is provided within **Appendix C**. The weighted average provides an overall curve number applicable to each drainage basin.

3.3 Run-Off Volume and Peak Discharge Calculations

Run-off volumes and peak discharges were calculated based on the 25-year, 24-hour storm event for each drainage basin per the methods provided in TR-55. The 25-year, 24-hour rainfall is 3.25 inches as determined with the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 precipitation frequency estimator (NOAA, 2014). Calculations are provided within **Appendix C**. The curve number, flow length, slope, and Manning's roughness coefficient were the primary input parameters used for each drainage basin. Flow length and slope were determined using topographic information provided by Platte River and USGS. Manning's roughness coefficient was determined using Table 3-1 from TR-55 (provided within **Appendix B**). An area-weighted average Manning's value was calculated (similar to the curve number calculations) for each drainage basin as provided within **Appendix C**.

4.0 Run-On and Run-Off Controls

As required by 40 CFR 257.81, run-on from the 24-hour, 25-year storm is diverted around the CCR Monofill as described in this section. Also as required by 40 CFR 257.81, 24-hour, 25-year run-off from the active portions of the CCR Monofill (active portion considered to be the open face of Cell 2 where CCR is currently being placed) is collected and controlled down-gradient of the CCR Monofill at Hamilton Reservoir and handled in accordance with the surface water requirements under 40 CFR 257.3-3.

4.1 Hamilton Reservoir

Hamilton Reservoir is located just downstream of the CCR Monofill as shown on **Figure 2**. Hamilton Reservoirwas constructed to serve the cooling and service water requirements of a coal-fired generating unit at the site. The reservoir was designed to capture a drainage area of 2.5 square miles and contain approximately 13,600 acre-feet of water with a normal operating elevation of approximately 5670 feet above mean sea level (amsl). Monthly meteorological data (rainfall at 593 acre feet per year), in addition to evaporation and exfiltration, were taken into account during design (Black & Veatch, 1978). The pond was furthermore designed to be a zero-discharge facility according to Platte River.

4.2 Run-on and Run-off Controls by Drainage Basin

Existing run-on and run-off controls for each drainage sub-basin are described within the following sections.

4.2.1 Upper Sub-Basin

The Upper Sub-Basin includes the open/range run-on area northwest of the CCR Monofill. This area flows to the southeast and is then directed to the south based on review of an October 2016 survey that was completed around the area of monitoring well ASH-01-OLD as shown on **Figure 2**. Run-off leaving the Upper Sub-Basin combines with flows from the Lower Sub-Basin as discussed below.

4.2.2 Lower Sub-Basin

The Lower Sub-Basin includes the open/range run-on area west of the CCR Monofill. Run-off from this area flows to the southeast and joins with the outflow from the Upper Sub-Basin prior to flowing through a constructed diversion channel that runs along the western edge of Cell 2. The grass-lined diversion channel was designed to pass the 100-year, 24-hour storm flow (253 cubic feet per second [cfs]) from areas upstream of the CCR Monofill as documented in the Revised Design and Operations Plan (Smith, 2007). This flow is greater than the flow currently estimated for the 25-year, 24-hour storm (95 cfs for the Upper Sub-Basin plus the Lower Sub-Basin per the calculations within **Appendix C**). The diversion channel was also designed to be permanent (remaining after final closure of the CCR Monofill).

The diversion channel was constructed as documented within the 2009 Construction Report (Smith, 2009). The channel was constructed with a trapezoidal cross section with 3H:1V side slopes, a 30-foot bottom width, a depth of approximately 1.5 feet, and a maximum grade of approximately 1.25 percent. The peak velocity within the diversion channel was estimated to be 4.95 feet per second (Smith, 2009). The location of the diversion channel is shown on **Figure 2**.

As indicated by the calculations within **Appendix C**, the diversion channel is sufficiently sized to pass the 25-year, 24-hour storm for the purpose of this Run-on and Run-off Control System Plan at a flow depth of approximately 0.9 feet.

The diversion channel conveys run-on around the CCR Monofill and outlets into a well-vegetated area just down-gradient of Cell 2 of the CCR Monofill. From here, water will sheet flow to the southeast until it is captured by the downstream Hamilton Reservoir as shown on **Figure 3.**

4.2.3 Sub-Basin 1

Sub-Basin 1 includes the open/range area just north of Cell 2 plus the very north end of Cell 1. This is a closed area meaning that based on review of the provided topography, run-off does not leave this sub-basin but instead will temporarily pond until water either infiltrates or evaporates. A site visit during August 2021 indicated that a permanent pond does not exist in this area.

According to the calculations within **Appendix C**, the run-off volume from the 25-year, 24-hour storm event is approximately 3.2 acre-feet, which would fill the depression to an elevation of approximately 5748 feet amsl. As evident on the topography, the extent of such a pond is outside the approximated limits of the CCR Monofill and run-on is controlled and prevented based on the nature of the topography in this area.

4.2.4 Sub-Basin 2

Sub-Basin 2 includes the open/range area and the gravel pit located just northeast of Cell 1. Based on review of the provided topography, this is a closed area and run-off does not leave this sub-basin but instead will temporarily pond within the gravel pit until water either infiltrates or evaporates. A site visit during August 2021 indicated that a permanent pond does not exist in this area.

According to the calculations within **Appendix C**, the run-off volume from the 25-year, 24-hour storm event is approximately 1.4 acre-feet, which would fill the depression to an elevation of approximately 5737 feet amsl. As evident on the topography, the extent of such a pond is outside the approximated limits of the CCR Monofill and run-on is controlled and prevented based on the nature of the topography in this area.

4.2.5 Sub-Basin 3

Sub-Basin 3 includes the west half of Cell 1, the unfilled portion of Cell 2, and the active face within Cell 2. Based on review of the provided topography, this is a closed area and run-off does not leave this sub-basin but instead will temporarily pond at the base of the active face water either infiltrates or evaporates. A site visit during August 2021 indicated that a permanent pond does not exist in this area.

According to the calculations within **Appendix C**, the run-off volume from the 25-year, 24-hour storm event is approximately 8.1 acre-feet, which would fill the depression to an elevation of approximately 5713 feet amsl. Ponding within Sub-Basin 3 from the 25-year, 24-hour storm event will remain within the unfilled portion of Cell 2.

4.2.6 Sub-Basin 4

Sub-Basin 4 includes the open/range area to the east of Cell 1 along with the east half of Cell 1. Run-off from these areas flows through a drainage channel located just east of Cell 1 and then through an existing 24-inch culvert located at the south end of Cell 1 (as shown on **Figure 2**). The drainage channel, as currently designed and installed, is sufficient to route the run-off from a 25-year, 24-hour storm event according to the calculations within **Appendix C**. The culvert, as currently designed and installed, will route the majority of the 25-year, 24-hour storm event according to the calculations within **Appendix C**. The remainder of the run-off, however, is anticipated to back-up within the drainage channel until the culvert can eventually drain the area. Run-on to the CCR Monofill is not anticipated based on review of the provided topography and the calculated run-off volume from this basin. The culvert routes run-off into a well-vegetated area just down-gradient of Cell 1. From here, water will sheet flow to the southeast until it is captured by the down-stream Hamilton Reservoir as shown on **Figure 3**.

4.2.7 Sub-Basin 5

Sub-Basin 5 includes the majority of the filled portion of Cell 2. Run-off from this area flows south over the perimeter road and to the southeast until it is captured by the down-stream Hamilton Reservoir as shown on **Figure 3**.

4.2.8 Sub-Basin 6

Sub-Basin 6 includes a portion of the filled Cell 2. Run-off from this area flows south then through an existing 18-inch culvert located at the south end of Cell 2 (as shown on **Figure 2**). The culvert, as currently designed and installed, will sufficiently route the 25-year, 24-hour storm event according to the calculations within **Appendix C**. The culvert routes run-off into a well-vegetated area just down-gradient of Cell 1. For here, water will sheet flow to the southeast until it is captured by the down-stream Hamilton Reservoir as shown on **Figure 3**.

5.0 Inspections and Maintenance of Run-On and Run-Off Controls

5.1 Inspections

Throughout operation, the CCR Monofill is inspected weekly by a qualified person for condition of vegetation, appearance of actual or potential slope distress, and general landfill conditions. The run-on and run-off control system is one of the items inspected each week. Inspections are documented on a weekly inspection report (provided as **Appendix D**).

The CCR Monofill is also inspected annually during operations by a qualified professional engineer to ensure that the design, construction, operation, and maintenance of the CCR Monofill are consistent with recognized and generally accepted good engineering standards. The inspection includes visual observation of the CCR Monofill, including observation of any structural weakness, erosion control measures, and observation of the run-on and run-off controls (including drainage channels and culverts). The qualified professional engineer prepares an annual inspection report in accordance with 40 CFR 257.84 to document the inspection and make maintenance recommendation. Noted deficiencies or releases identified during the inspection are remedied as soon as feasible. The most recent annual inspection was conducted in November 2021 and is documented in a report completed by AECOM in January 2021. (AECOM, 2021).

5.2 Maintenance

Erosion rills/gullies/channels will be repaired by tracking a bulldozer up and down the slopes (in areas that have not yet been seeded), hand raking (for small areas), or by grading or backfilling (for larger areas). Storm water may be redirected by construction of temporary berms. Erosion control blankets or wattles may be placed on slopes as needed. The use of riprap or other forms of armoring may be evaluated for use in drainage channels and on steep slopes. Re-seeding bare areas or application of soil amendments may be used to promote vegetation growth.

Eroded drainage channels and culvert inlet/outlets will be graded and repaired as necessary to return the controls to design conditions. Ponding within drainage channels will be repaired/graded such that positive grade is maintain. Debris/sediment/vegetation blocking drainage channels and/or culverts will be removed. Crushed culverts or otherwise mal-functioning culverts will be replaced or repaired as needed to maintain design capacity.

6.0 Amendment, Recordkeeping, and Notification

6.1 Amendment of the Plan

As required by 40 CFR 257.81(c)(2), Platte River may amend this Run-on and Run-off Control System Plan provided the revised plan is placed in the facility's operating record. Platte River will amend this plan whenever there is a change in conditions that would substantially affect the plan.

As required by 40 CFR 257.81(c)(4), Platte River will revise this Run-on and Run-off Control System Plan every five years. The date of completing the initial plan is the basis for establishing the deadline to complete the first subsequent plan. Platte River may complete any required plan prior to the required deadline provided that Platte River places the completed plan into the facility's operating record within a reasonable amount of time. In all cases, the deadline for completing a subsequent plan is based on the date of completing the previous plan. Any amendment of this plan will be certified by a qualified professional engineer.

6.2 Recordkeeping

Platte River will maintain their files with Run-on and Run-off Control System Plans (this version plus subsequent revisions), inspections, maintenance, and other pertinent documents within the facility's operating record for a period of at least five years in accordance with 40 CFR 257.105.

6.3 Notification

Platte River will notify CDPHE whenever the Run-on and Run-off Control System Plan (along with subsequent updates), inspection reports, and/or documentation of maintenance has been placed in the operating record in accordance with the notification requirements specified in 40 CFR 257.106.

7.0 Certification

Certification Statement 40 CFR § 257.81(c)(5) – Solid Waste Management Unit Run-on and Run-off Control System Plan, Fort Collins, Colorado

CCR Unit – Platte River Power Authority, CCR Monofill

I, Steve Walker, being a Registered Professional Engineer in good standing in the State of Colorado, do hereby certify, to the best of my knowledge, information, and belief, that the information contained in this certification has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the information contained in the Solid Waste Management Unit Run-on and Run-off Control System Plan dated October 11, 2021 meets the requirements of 40 CFR § 257.81.

Steve Walker
Printed Name

October 11, 2021
Date

8.0 References

AECOM, 2016. Platte River Power Authority – Rawhide Residual Solid Waste Ash Monofill Stability Evaluation. May 6, 2016.

AECOM, 2021. Annual Ash Monofill Inspection Report, Platte River Power Authority, Rawhide Station. January 2021.

Black & Veatch, 1978. Cooling Pond Management Study. Platte River Power Authority Rawhide Project Unit 1. Black & Veatch 1978.

CDPHE, 2021. Hazardous Materials and Waste Management Division. 6 Code of Colorado Regulations 1007-2, Part 1, Regulations Pertaining to Solid Waste Sites and Facilities, Effective January 14, 2021.

Lidstone & Anderson, 1989. Investigation of the Ground-Water Monitoring Program for the Bottom Ash Disposal Site. March, 1989.

NOAA, 2014. NOAA Atlas 14 Point Precipitation Frequency Estimates: CO. US Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Office of Water Prediction. Available online at http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=co. Page last modified August 27, 2014. Accessed September 28, 2021.

Platte River, 1980. Engineering Report and Operational Plan for the Solid Waste Disposal Facility. Rawhide Energy Project. Platte River Power Authority. December, 1980.

Platte River, 2017. Fugitive Dust Control, Compliance Monitoring, and Documentation for Fugitive Particulate Emission Sources. Rawhide Energy Station. Platte River Power Authority. November, 2017.

Smith, 2007. Revised Design and Operations Plan for the Solid Waste Disposal Facility. Rawhide Energy Station. Smith Geotechnical. November, 2007.

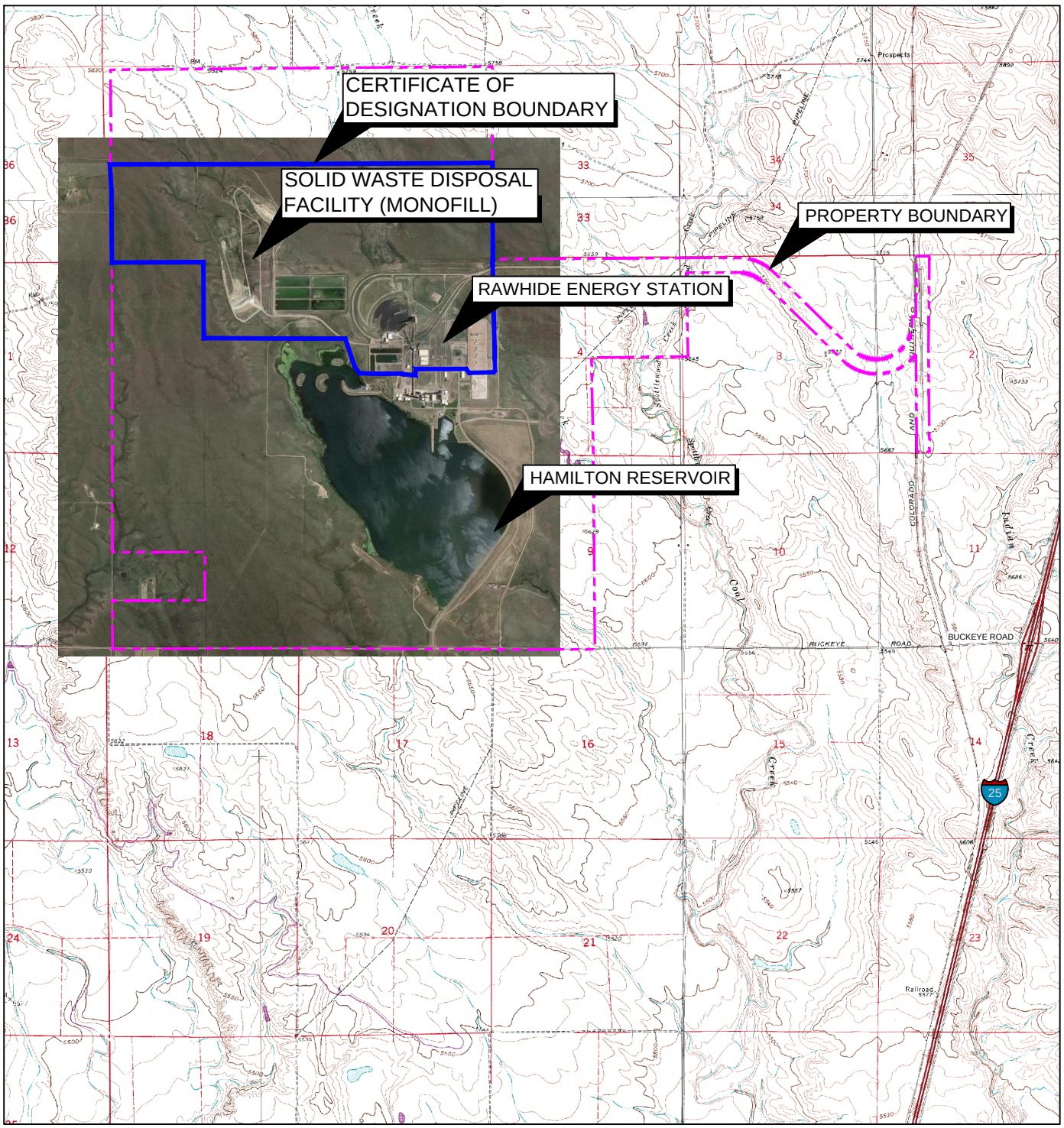
Smith, 2009. Construction Report for The Solid Waste Disposal Facility, Rawhide Energy Station Monofill Expansion. Smith Geotechnical. November, 2009.

USDA, 1986. Urban Hydrology for Small Watersheds, Technical Release 55. Natural Resources Conservation Service – Conservation Engineering Division, United States Department of Agriculture. June, 1986.

USDA, 2020. Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Published June 9, 2020. Accessed September 28, 2021.

USEPA, 2018. 40 CFR Parts 257 and 261 Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule. Federal Register, 80 FR 21468, April 17, 2015, as amended at 83 FR 36452, July 30, 2018

Figures



Solid Waste Disposal Facility
Run-On and Run-Off Control System Plan

SITE LOCATION MAP

Platte River Power Authority, Fort Collins CO
Project No.: 60514657 Date: 10/07/21

Figure: 1

Last saved by: BRIAN.LONG(2021-09-29) Last Plotted: 2021-09-29
Filename: \\NA.AECOMNET.COM\LFS\AMER\DENVER-USDEN06\DCS\PROJECTS\ENV\PRPA\60629643_2020_ASH_DESIGN\900-CAD-GIS\910-CAD\916-SKETCHES\RUN-ON RUN-OFF FIGURES\RES-RUNON-RUNOFF PLAN_2_SWDF PLAN.DWG
Project Management Initials: Designer: BCL Checked: SCW Approved: VK ANSI B 11" x 17"

NOTES:
1. TOPOGRAPHY INSIDE OF TOPO BOUNDARY BASED ON SURVEY PROVIDED BY NORTHERN ENGINEERING, DATED JULY 07, 2021. SURVEY CONDUCTED IN STATE PLANE COORDINATE SYSTEM USING US SURVEY FOOT.
2. TOPOGRAPHY OUTSIDE TOPO BOUNDARY GENERATED FROM USGS DEM MODEL.
3. THE LIMITS OF CELL 2A ARE APPROXIMATE. THE AREA IS CURRENTLY BEING FILLED, PROGRESSING NORTHWARD.

IMAGE SOURCE: Bing Maps, 2017
IMAGE DATE: 09/07/16

ASH-01 OLD
GRAVEL PIT
COMPLETED CELL 1
FUTURE CELL 2B
DRAINAGE CHANNEL
CELL 2A
ACTIVE FACE
DRAINAGE CHANNEL
12" STEEL CULVERT
16" CONCRETE CULVERT
ASH-03
ASH-04
ASH-05

LEGEND
- MONITORING WELL (ASH-03)
- SURFACE WATER FLOW DIRECTION
- DRAINAGE CHANNEL
- APPROX. CELL LIMITS
- CULVERT LOCATION
- EXISTING GROUND SURFACE CONTOUR (FT. AMSL)
- MAJOR CONTOUR
- MINOR CONTOUR
- CONTOUR INTERVAL = 2'

N
150 0 300
1"=300'

Solid Waste Disposal Facility
Run-On and Run-Off Control System Plan

SOLID WASTE DISPOSAL FACILITY PLAN

AECOM

Platte River Power Authority, Fort Collins CO
Project No.: 60514657 Date: 09/29/21

Figure: 2

Last saved by: BRIAN.LONG(2021-09-29) Last Plotted: 2021-10-07
Filename: \\NA.AECOMNET.COM\LFS\AMER\DENVER-USDEN06\DCS\PROJECTS\ENV\PRPA\60629643_2020_ASH_DESIGN\900-CAD-GIS\910-CAD\916-SKETCHES\RUN-ON RUN-OFF FIGURES\RES-RUNON-RUNOFF PLAN_3_SWDF DRAIN SUB BASIN.DWG
Project Management Initials: Designer: BCL Checked: SCW Approved: VK ANSI B 11" x 17"

LEGEND

- DRAINAGE SUB-BASIN
- MONITORING WELL (ASH-03)
- SURFACE WATER FLOW DIRECTION
- DRAINAGE CHANNEL
- APPROX. CELL LIMITS
- CULVERT LOCATION

EXISTING GROUND SURFACE CONTOUR (FT. AMSL)

- MAJOR CONTOUR
- MINOR CONTOUR

CONTOUR INTERVAL = 2'

UPPER
7,777,624 sqft
178.5 acre

1
2,220,731 sqft
51.0 acre

LOWER
3,827,410 sqft
87.9 acre

2
859,821 sqft
19.7 acre

3
2,861,487 sqft
65.7 acre

4
1,920,902 sqft
44.1 acre

5
593,470 sqft
13.6 acre

6
154,966 sqft
3.6 acre

ASH-01 OLD
ASH-04
ASH-03
ASH-05

GRAVEL PIT
COMPLETED CELL 1
FUTURE CELL 2B
ACTIVE FACE
CELL 2A
DRAINAGE CHANNEL
TOPO BOUNDARY LINE (SEE NOTE)
12" STEEL CULVERT
16" CONCRETE CULVERT
HAMILTON RESERVOIR

5840 5830 5830 5830 5820 5810 5800 5790 5830 5820 5810 5800 5790 5780 5770 5770 5770 5760 5750 5740 5770 5760 5750 5750 5740 5720 5710 5700 5690 5680

N

350 0 700

1"=700'

NOTES:
1. TOPOGRAPHY INSIDE OF TOPO BOUNDARY BASED ON SURVEY PROVIDED BY NORTHERN ENGINEERING, DATED JULY 07, 2021. SURVEY CONDUCTED IN STATE PLANE COORDINATE SYSTEM USING US SURVEY FOOT.
2. TOPOGRAPHY OUTSIDE TOPO BOUNDARY GENERATED FROM USGS DEM MODEL.
3. THE LIMITS OF CELL 2A ARE APPROXIMATE. THE AREA IS CURRENTLY BEING FILLED, PROGRESSING NORTHWARD.

IMAGE SOURCE: Bing Maps, 2017
IMAGE DATE: 09/07/16

Solid Waste Disposal Facility
Run-On and Run-Off Control System Plan

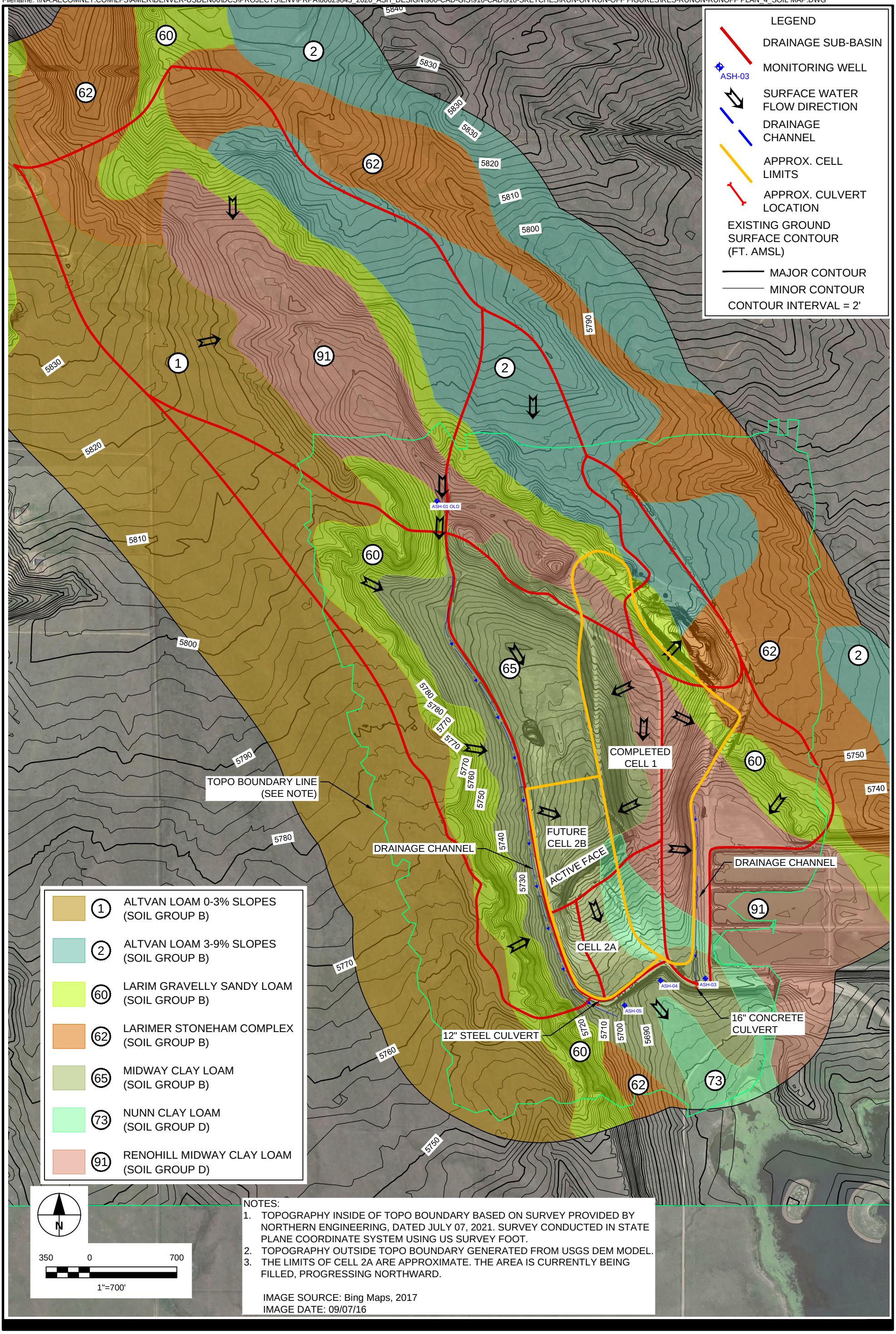
Platte River Power Authority, Fort Collins CO
Project No.: 60514657 Date: 10/07/21

SOLID WASTE DISPOSAL FACILITY
DRAINAGE SUB-BASINS

AECOM

Figure: 3

Last saved by: BRIAN.LONG(2021-09-29) Last Plotted: 2021-09-29
Filename: \\NA.AECOMNET.COM\LFS\AMER\DENVER-USDEN06\DCS\PROJECTS\ENV\PRPA\60629643_2020_ASH_DESIGN\900-CAD-GIS\910-CAD\916-SKETCHES\RUN-ON RUN-OFF FIGURES\RES-RUNON-RUNOFF PLAN_4_SOIL MAP.DWG
Project Management Initials: Designer: BCL Checked: SCW Approved: VK ANSI B 11" x 17"



Solid Waste Disposal Facility
Run-On and Run-Off Control System Plan

Platte River Power Authority, Fort Collins CO
Project No.: 60514657 Date: 09/29/21

SOLID WASTE DISPOSAL FACILITY
SOIL MAP

AECOM

Figure: 4

Appendix A
Web Soil Survey Information

United States Department of Agriculture

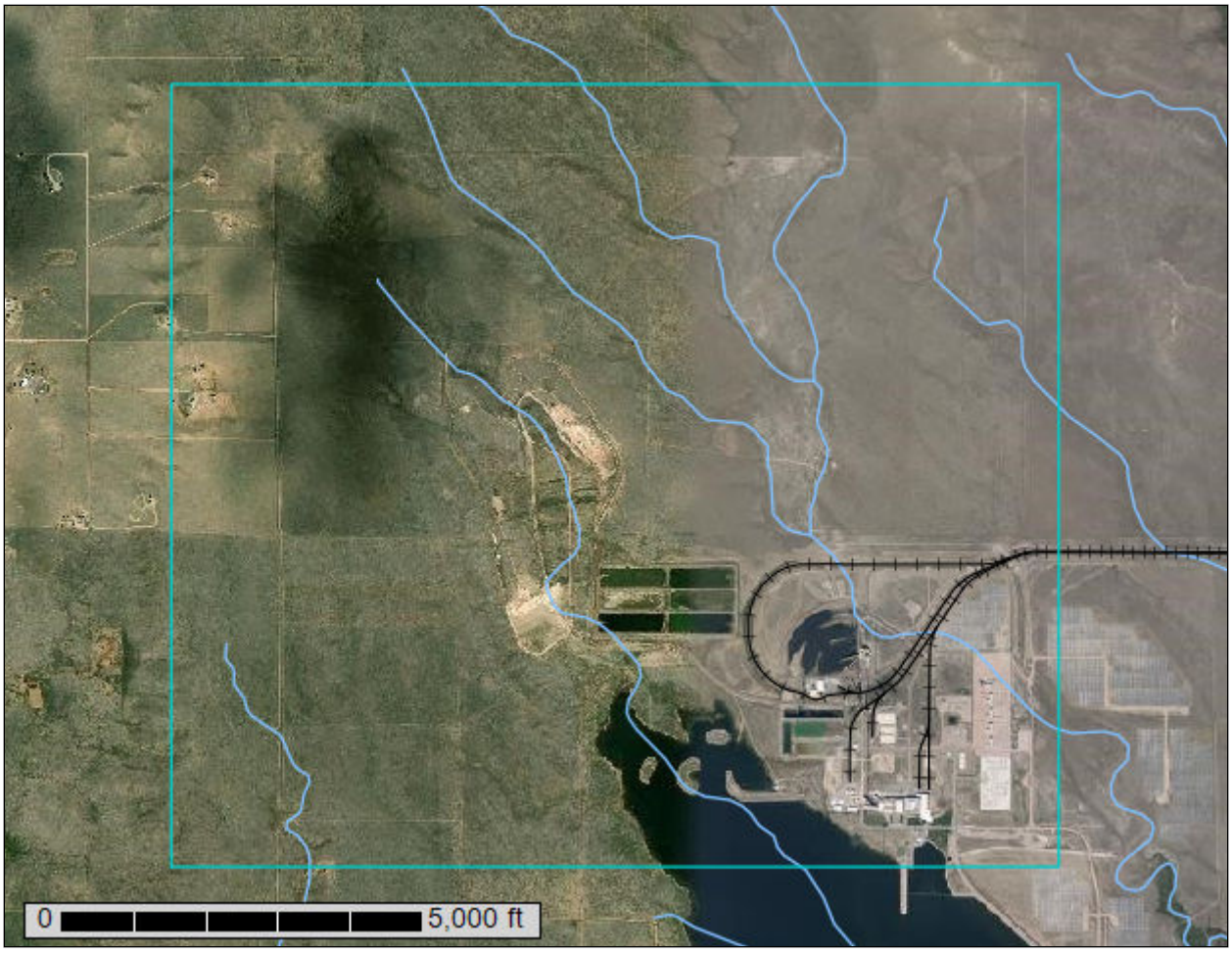
NRCS

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 Larimer County Area, Colorado

PRPA Rawhide Energy Station

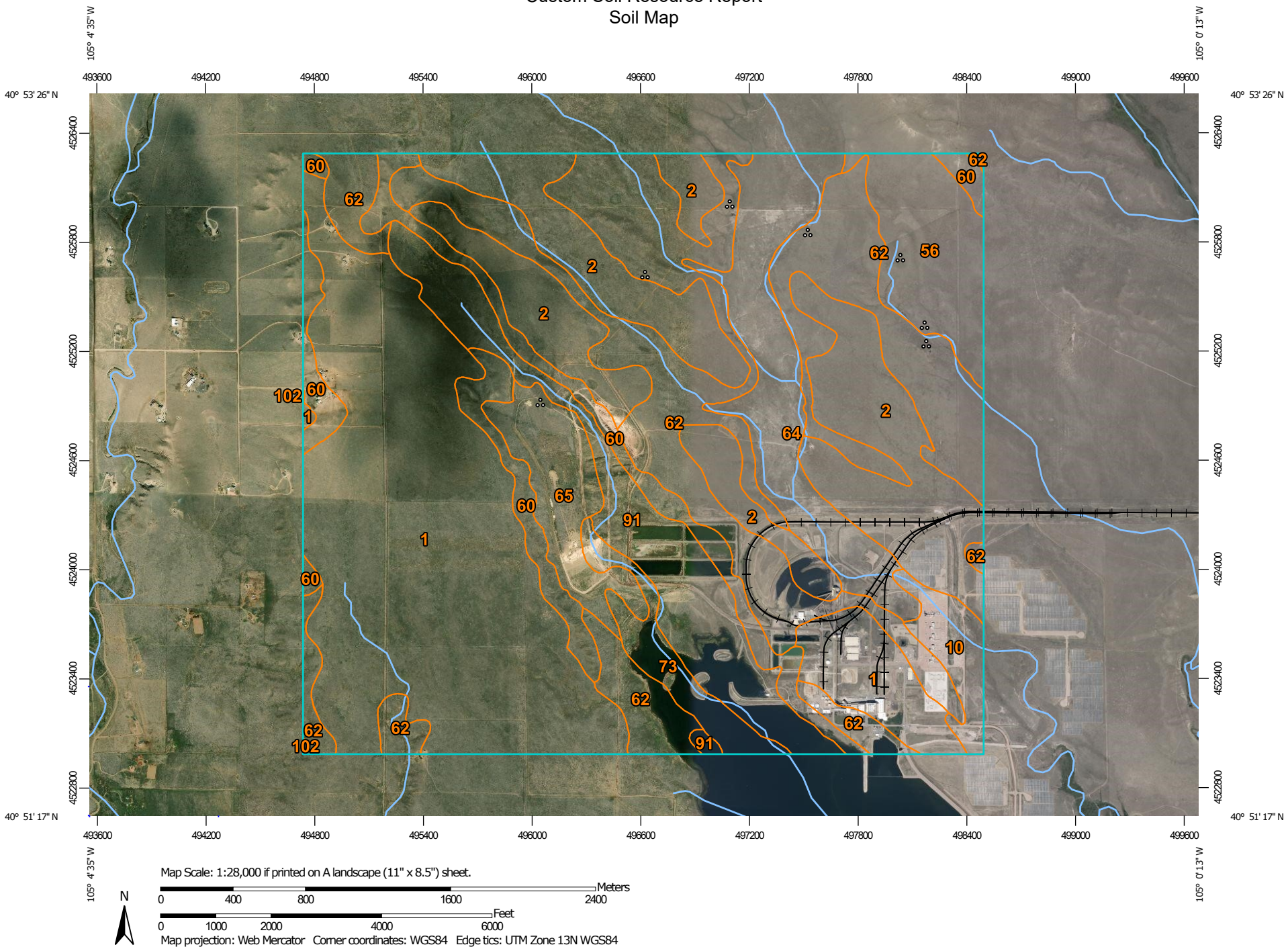


September 28, 2021

Contents

Preface..... 2
Soil Map..... 5
Soil Map.....6
Legend.....7
Map Unit Legend..... 8
Map Unit Descriptions..... 8
Larimer County Area, Colorado..... 11
1—Altvan loam, 0 to 3 percent slopes.....11
2—Altvan loam, 3 to 9 percent slopes.....12
10—Bainville-Keith complex, 2 to 9 percent slopes..... 13
56—Kim-Thedalund loams, 3 to 15 percent slopes..... 15
60—Larim gravelly sandy loam, 5 to 40 percent slopes.....17
62—Larimer-Stoneham complex, 3 to 10 percent slopes..... 18
64—Loveland clay loam, 0 to 1 percent slopes.....20
65—Midway clay loam, 5 to 25 percent slopes.....22
73—Nunn clay loam, 0 to 1 percent slopes.....23
91—Renohill-Midway clay loams, 3 to 15 percent slopes.....24
102—Stoneham loam, 3 to 5 percent slopes..... 26

Custom Soil Resource Report
Soil Map



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.

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: Larimer County Area, Colorado
Survey Area Data: Version 15, Jun 9, 2020

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

Date(s) aerial images were photographed: Sep 20, 2015—Aug 10, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Altvan loam, 0 to 3 percent slopes	844.6	27.4%
2	Altvan loam, 3 to 9 percent slopes	526.0	17.1%
10	Bainville-Keith complex, 2 to 9 percent slopes	53.0	1.7%
56	Kim-Thedalund loams, 3 to 15 percent slopes	140.1	4.6%
60	Larim gravelly sandy loam, 5 to 40 percent slopes	202.6	6.6%
62	Larimer-Stoneham complex, 3 to 10 percent slopes	695.6	22.6%
64	Loveland clay loam, 0 to 1 percent slopes	213.8	6.9%
65	Midway clay loam, 5 to 25 percent slopes	109.2	3.5%
73	Nunn clay loam, 0 to 1 percent slopes	66.6	2.2%
91	Renohill-Midway clay loams, 3 to 15 percent slopes	226.6	7.4%
102	Stoneham loam, 3 to 5 percent slopes	0.6	0.0%
Totals for Area of Interest		**3,078.9**	**100.0%**

Larimer County Area, Colorado

1—Altvan loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: jptq
Elevation: 5,200 to 6,200 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 48 to 50 degrees F
Frost-free period: 135 to 150 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Altvan and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Altvan

Setting

Landform: Hummocks, benches, terraces
Landform position (three-dimensional): Side slope, crest, base slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium

Typical profile

H1 - 0 to 7 inches: loam
H2 - 7 to 17 inches: clay loam, loam, sandy clay loam
H2 - 7 to 17 inches: loam, fine sandy loam, silt loam
H2 - 7 to 17 inches: gravelly sand, gravelly coarse sand, coarse sand
H3 - 17 to 36 inches:
H3 - 17 to 36 inches:
H3 - 17 to 36 inches:
H4 - 36 to 60 inches:
H4 - 36 to 60 inches:
H4 - 36 to 60 inches:

Properties and qualities

Slope: 0 to 3 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): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water supply, 0 to 60 inches: Very high (about 16.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B

Ecological site: R067XY002CO - Loamy Plains
Hydric soil rating: No

Minor Components

Stoneham
Percent of map unit: 6 percent
Hydric soil rating: No

Keith
Percent of map unit: 5 percent
Hydric soil rating: No

Larimer
Percent of map unit: 4 percent
Hydric soil rating: No

2—Altvan loam, 3 to 9 percent slopes

Map Unit Setting
National map unit symbol: jpvq
Elevation: 5,200 to 6,200 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 48 to 50 degrees F
Frost-free period: 135 to 150 days
Farmland classification: Farmland of statewide importance

Map Unit Composition
Altvan and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Altvan

Setting
Landform: Benches, fans, terraces
Landform position (three-dimensional): Side slope, base slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium

Typical profile
H1 - 0 to 7 inches: loam
H2 - 7 to 17 inches: clay loam, loam, sandy clay loam
H2 - 7 to 17 inches: loam, fine sandy loam, silt loam
H2 - 7 to 17 inches: gravelly sand, gravelly coarse sand, coarse sand
H3 - 17 to 36 inches:
H3 - 17 to 36 inches:
H3 - 17 to 36 inches:
H4 - 36 to 60 inches:
H4 - 36 to 60 inches:

H4 - 36 to 60 inches:

Properties and qualities

Slope: 3 to 9 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 (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water supply, 0 to 60 inches: Very high (about 16.0 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: R067XY002CO - Loamy Plains
Hydric soil rating: No

Minor Components

Larimer

Percent of map unit: 8 percent
Hydric soil rating: No

Stoneham

Percent of map unit: 7 percent
Hydric soil rating: No

Larim

Percent of map unit: 5 percent
Hydric soil rating: No

10—Bainville-Keith complex, 2 to 9 percent slopes

Map Unit Setting

National map unit symbol: jptr
Elevation: 5,600 to 6,400 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 47 to 50 degrees F
Frost-free period: 135 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Bainville and similar soils: 50 percent
Keith and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bainville

Setting

Landform: Benches
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Material weathered from shale and siltstone

Typical profile

H1 - 0 to 5 inches: silt loam
H2 - 5 to 24 inches: silt loam, clay loam
H2 - 5 to 24 inches: weathered bedrock
H3 - 24 to 28 inches:

Properties and qualities

Slope: 3 to 9 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: 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
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Hydric soil rating: No

Description of Keith

Setting

Landform: Terraces
Landform position (three-dimensional): Side slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Weathered from colluvium derived from siltstone

Typical profile

H1 - 0 to 5 inches: clay loam
H2 - 5 to 16 inches: silty clay loam
H3 - 16 to 60 inches: silt loam

Properties and qualities

Slope: 2 to 5 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 (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches

Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Available water supply, 0 to 60 inches: High (about 10.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Larim

Percent of map unit: 8 percent
Hydric soil rating: No

Epping

Percent of map unit: 7 percent
Hydric soil rating: No

56—Kim-Thedalund loams, 3 to 15 percent slopes

Map Unit Setting

National map unit symbol: jpx0
Elevation: 4,800 to 5,600 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 48 to 50 degrees F
Frost-free period: 135 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Kim and similar soils: 45 percent
Thedalund and similar soils: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kim

Setting

Landform: Fans, valley sides
Landform position (three-dimensional): Base slope, side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium

Typical profile

H1 - 0 to 7 inches: loam
H2 - 7 to 60 inches: loam, clay loam, sandy clay loam
H2 - 7 to 60 inches:

H2 - 7 to 60 inches:

Properties and qualities

Slope: 3 to 7 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 (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very high (about 26.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: R067XY002CO - Loamy Plains
Hydric soil rating: No

Description of Thedalund

Setting

Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Material weathered from sandstone and shale

Typical profile

H1 - 0 to 4 inches: loam
H2 - 4 to 33 inches: clay loam, loam, sandy clay loam
H2 - 4 to 33 inches: weathered bedrock
H2 - 4 to 33 inches:
H3 - 33 to 37 inches:

Properties and qualities

Slope: 7 to 15 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well 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
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very high (about 15.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: R067XY002CO - Loamy Plains

Hydric soil rating: No

Minor Components

Renohill
Percent of map unit: 10 percent
Hydric soil rating: No

Midway
Percent of map unit: 9 percent
Hydric soil rating: No

Aquic haplustolls
Percent of map unit: 1 percent
Landform: Swales
Hydric soil rating: Yes

60—Larim gravelly sandy loam, 5 to 40 percent slopes

Map Unit Setting
National map unit symbol: jpx5
Elevation: 4,800 to 6,300 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 47 to 49 degrees F
Frost-free period: 135 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition
Larim and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Larim

Setting
Landform: Terraces, benches, fans
Landform position (three-dimensional): Side slope, base slope, riser
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium

Typical profile
H1 - 0 to 4 inches: gravelly sandy loam
H2 - 4 to 15 inches: very gravelly sandy clay loam, very gravelly clay loam
H2 - 4 to 15 inches: very gravelly loamy sand, very gravelly sand
H3 - 15 to 60 inches:
H3 - 15 to 60 inches:

Properties and qualities
Slope: 5 to 40 percent
Depth to restrictive feature: More than 80 inches

Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
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: B
Ecological site: R049XB215CO - Gravelly Foothill
Hydric soil rating: No

Minor Components

Midway

Percent of map unit: 8 percent
Hydric soil rating: No

Tassel

Percent of map unit: 7 percent
Hydric soil rating: No

62—Larimer-Stoneham complex, 3 to 10 percent slopes

Map Unit Setting

National map unit symbol: jpx7
Elevation: 4,800 to 5,800 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 48 to 50 degrees F
Frost-free period: 135 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Larimer and similar soils: 35 percent
Stoneham and similar soils: 25 percent
Minor components: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Larimer

Setting

Landform: Benches, fans, terraces
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Linear
Across-slope shape: Linear

Parent material: Alluvium

Typical profile

H1 - 0 to 7 inches: fine sandy loam
H2 - 7 to 22 inches: loam
H3 - 22 to 30 inches: gravelly sandy clay loam, gravelly loam, sandy clay loam
H3 - 22 to 30 inches: very gravelly sand, very cobbly sand, very gravelly loamy sand
H3 - 22 to 30 inches:
H4 - 30 to 60 inches:
H4 - 30 to 60 inches:
H4 - 30 to 60 inches:

Properties and qualities

Slope: 5 to 10 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 (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 9.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: R067XY002CO - Loamy Plains
Hydric soil rating: No

Description of Stoneham

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed alluvium and/or eolian deposits

Typical profile

H1 - 0 to 4 inches: loam
H2 - 4 to 10 inches: clay loam, sandy clay loam, loam
H2 - 4 to 10 inches: loam, clay loam, sandy clay loam
H2 - 4 to 10 inches: sandy loam, gravelly sandy loam
H3 - 10 to 14 inches:
H3 - 10 to 14 inches:
H3 - 10 to 14 inches:
H4 - 14 to 60 inches:
H4 - 14 to 60 inches:

Properties and qualities

Slope: 3 to 5 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): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very high (about 14.7 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: R067XY002CO - Loamy Plains
Hydric soil rating: No

Minor Components

Cushman

Percent of map unit: 20 percent
Hydric soil rating: No

Fort collins

Percent of map unit: 8 percent
Hydric soil rating: No

Larim

Percent of map unit: 7 percent
Hydric soil rating: No

Satanta

Percent of map unit: 5 percent
Hydric soil rating: No

64—Loveland clay loam, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: jpx9
Elevation: 4,800 to 5,500 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 48 to 50 degrees F
Frost-free period: 135 to 150 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Loveland and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Loveland

Setting

Landform: Flood plains, stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

H1 - 0 to 15 inches: clay loam
H2 - 15 to 32 inches: clay loam, silty clay loam, loam
H2 - 15 to 32 inches: very gravelly sand, gravelly sand, gravelly coarse sand
H2 - 15 to 32 inches:
H3 - 32 to 60 inches:
H3 - 32 to 60 inches:
H3 - 32 to 60 inches:

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: OccasionalNone
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very high (about 16.7 inches)

Interpretive groups

Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Aquolls

Percent of map unit: 5 percent
Landform: Swales
Hydric soil rating: Yes

Poudre

Percent of map unit: 5 percent
Hydric soil rating: No

65—Midway clay loam, 5 to 25 percent slopes

Map Unit Setting

National map unit symbol: jpxb
Elevation: 4,800 to 5,800 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 48 to 50 degrees F
Frost-free period: 135 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Midway and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Midway

Setting

Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Material weathered from shale

Typical profile

H1 - 0 to 4 inches: clay loam
H2 - 4 to 19 inches: clay, clay loam, silty clay loam
H2 - 4 to 19 inches: weathered bedrock
H2 - 4 to 19 inches:
H3 - 19 to 23 inches:

Properties and qualities

Slope: 5 to 25 percent
Depth to restrictive feature: 6 to 20 inches to paralithic bedrock
Drainage class: Well 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
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 15 percent
Maximum salinity: Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 15.0
Available water supply, 0 to 60 inches: Moderate (about 7.9 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D

Ecological site: R067BY045CO - Shaly Plains
Hydric soil rating: No

Minor Components

Renohill
Percent of map unit: 10 percent
Hydric soil rating: No

73—Nunn clay loam, 0 to 1 percent slopes

Map Unit Setting
National map unit symbol: 2tlng
Elevation: 4,100 to 5,700 feet
Mean annual precipitation: 14 to 15 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 135 to 152 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition
Nunn and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Nunn

Setting
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Pleistocene aged alluvium and/or eolian deposits

Typical profile
Ap - 0 to 6 inches: clay loam
Bt1 - 6 to 10 inches: clay loam
Bt2 - 10 to 26 inches: clay loam
Btk - 26 to 31 inches: clay loam
Bk1 - 31 to 47 inches: loam
Bk2 - 47 to 80 inches: loam

Properties and qualities
Slope: 0 to 1 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 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

Calcium carbonate, maximum content: 7 percent
Maximum salinity: Nonsaline (0.1 to 1.0 mmhos/cm)
Sodium adsorption ratio, maximum: 0.5
Available water supply, 0 to 60 inches: High (about 9.1 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: R067BY042CO - Clayey Plains
Hydric soil rating: No

Minor Components

Heldt

Percent of map unit: 10 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R067BY042CO - Clayey Plains
Hydric soil rating: No

Wages

Percent of map unit: 5 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R067BY002CO - Loamy Plains
Hydric soil rating: No

91—Renohill-Midway clay loams, 3 to 15 percent slopes

Map Unit Setting

National map unit symbol: jpy8
Elevation: 4,800 to 5,600 feet
Mean annual precipitation: 13 to 15 inches
Mean annual air temperature: 48 to 50 degrees F
Frost-free period: 135 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Renohill and similar soils: 55 percent
Midway and similar soils: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Renohill

Setting

Landform: Ridges
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Material weathered from sandstone and shale

Typical profile

H1 - 0 to 7 inches: clay loam
H2 - 7 to 19 inches: clay loam, clay
H2 - 7 to 19 inches: clay loam
H3 - 19 to 27 inches: unweathered bedrock
H4 - 27 to 31 inches:

Properties and qualities

Slope: 3 to 9 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well 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
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Hydric soil rating: No

Description of Midway

Setting

Landform: Ridges
Landform position (three-dimensional): Crest
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Material weathered from shale

Typical profile

H1 - 0 to 4 inches: clay loam
H2 - 4 to 19 inches: clay, clay loam, silty clay loam
H2 - 4 to 19 inches: weathered bedrock
H2 - 4 to 19 inches:
H3 - 19 to 23 inches:

Properties and qualities

Slope: 9 to 15 percent
Depth to restrictive feature: 6 to 20 inches to paralithic bedrock
Drainage class: Well 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
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 15 percent
Maximum salinity: Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 15.0
Available water supply, 0 to 60 inches: Moderate (about 7.9 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: R067BY045CO - Shaly Plains
Hydric soil rating: No

Minor Components

Ulm

Percent of map unit: 10 percent
Hydric soil rating: No

Heldt

Percent of map unit: 5 percent
Hydric soil rating: No

102—Stoneham loam, 3 to 5 percent slopes

Map Unit Setting

National map unit symbol: 2x0j1
Elevation: 3,500 to 6,500 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 46 to 54 degrees F
Frost-free period: 115 to 155 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Stoneham and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Stoneham

Setting

Landform: Low hills, interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear

Across-slope shape: Linear
Parent material: Mixed alluvial and/or eolian tertiary aged pedisediment

Typical profile

Ap - 0 to 4 inches: loam
Bt - 4 to 9 inches: clay loam
Btk - 9 to 13 inches: clay loam
Bk1 - 13 to 18 inches: loam
Bk2 - 18 to 34 inches: loam
C - 34 to 80 inches: loam

Properties and qualities

Slope: 3 to 5 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): 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
Calcium carbonate, maximum content: 12 percent
Maximum salinity: Nonsaline to very slightly saline (0.1 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 0.5
Available water supply, 0 to 60 inches: High (about 9.1 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: C
Ecological site: R067BY002CO - Loamy Plains
Hydric soil rating: No

Minor Components

Satanta

Percent of map unit: 5 percent
Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R067BY002CO - Loamy Plains
Hydric soil rating: No

Kimst

Percent of map unit: 5 percent
Landform: Interfluves, low hills
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R067BY002CO - Loamy Plains
Hydric soil rating: No

Weld

Percent of map unit: 5 percent

Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R067BY002CO - Loamy Plains
Hydric soil rating: No

Appendix B
Tables from Technical Release 55

Table 2-2a Runoff curve numbers for urban areas [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area [2/]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5/]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1/]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2/]	Hydrologic condition [3/]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition, and I_a=0.2S

[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c Runoff curve numbers for other agricultural lands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2/]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3/]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4/]	48	65	73
Woods—grass combination (orchard or tree farm). [5/]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6/]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4/]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.

2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

3 *Poor*: <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

4 Actual curve number is less than 30; use CN = 30 for runoff computations.

5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d Runoff curve numbers for arid and semiarid rangelands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition [2/]	A [3/]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

1 Average runoff condition, and I_a, = 0.2S. For range in humid regions, use table 2-2c.
2 Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.
3 Curve numbers for group A have been developed only for desert shrub.

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n [1/]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2/]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3/]	
Light underbrush	0.40
Dense underbrush	0.80

1 The n values are a composite of information compiled by Engman (1986).

2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

3 When selecting n , consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

Appendix C
Supporting Calculations

NOAA Atlas 14, Volume 8, Version 2
Location name: Wellington, Colorado, USA*
Latitude: 40.8698°, Longitude: -105.0424°
Elevation: 5707.98 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.235** (0.188-0.297)	**0.284** (0.226-0.358)	**0.374** (0.297-0.473)	**0.460** (0.363-0.584)	**0.594** (0.460-0.797)	**0.710** (0.532-0.958)	**0.837** (0.604-1.15)	**0.977** (0.675-1.38)	**1.18** (0.780-1.70)	**1.35** (0.861-1.95)
10-min	**0.345** (0.275-0.434)	**0.415** (0.331-0.524)	**0.548** (0.435-0.693)	**0.674** (0.532-0.855)	**0.870** (0.673-1.17)	**1.04** (0.780-1.40)	**1.23** (0.885-1.69)	**1.43** (0.988-2.02)	**1.73** (1.14-2.49)	**1.97** (1.26-2.85)
15-min	**0.420** (0.335-0.530)	**0.507** (0.404-0.639)	**0.668** (0.531-0.845)	**0.821** (0.648-1.04)	**1.06** (0.821-1.42)	**1.27** (0.951-1.71)	**1.50** (1.08-2.06)	**1.75** (1.21-2.46)	**2.11** (1.39-3.04)	**2.40** (1.54-3.47)
30-min	**0.560** (0.447-0.707)	**0.675** (0.538-0.851)	**0.889** (0.706-1.12)	**1.09** (0.863-1.39)	**1.42** (1.10-1.90)	**1.69** (1.27-2.29)	**2.00** (1.44-2.75)	**2.34** (1.61-3.29)	**2.83** (1.87-4.07)	**3.23** (2.06-4.66)
60-min	**0.682** (0.544-0.860)	**0.827** (0.659-1.04)	**1.10** (0.875-1.39)	**1.36** (1.08-1.73)	**1.78** (1.38-2.39)	**2.13** (1.60-2.89)	**2.53** (1.83-3.49)	**2.97** (2.05-4.18)	**3.60** (2.38-5.19)	**4.12** (2.64-5.96)
2-hr	**0.803** (0.646-1.00)	**0.979** (0.787-1.22)	**1.31** (1.05-1.64)	**1.63** (1.30-2.05)	**2.14** (1.67-2.85)	**2.58** (1.95-3.45)	**3.06** (2.23-4.19)	**3.60** (2.51-5.03)	**4.38** (2.93-6.26)	**5.02** (3.24-7.19)
3-hr	**0.872** (0.705-1.08)	**1.07** (0.860-1.32)	**1.43** (1.15-1.78)	**1.78** (1.43-2.23)	**2.34** (1.84-3.11)	**2.83** (2.15-3.77)	**3.36** (2.47-4.58)	**3.96** (2.78-5.51)	**4.82** (3.25-6.87)	**5.54** (3.60-7.89)
6-hr	**1.03** (0.840-1.26)	**1.24** (1.01-1.52)	**1.64** (1.33-2.02)	**2.03** (1.64-2.51)	**2.65** (2.10-3.48)	**3.19** (2.45-4.21)	**3.79** (2.81-5.11)	**4.46** (3.16-6.15)	**5.43** (3.69-7.67)	**6.24** (4.10-8.82)
12-hr	**1.25** (1.03-1.52)	**1.46** (1.20-1.78)	**1.87** (1.53-2.28)	**2.27** (1.85-2.78)	**2.91** (2.33-3.77)	**3.47** (2.69-4.53)	**4.08** (3.06-5.45)	**4.77** (3.42-6.52)	**5.78** (3.97-8.08)	**6.61** (4.39-9.26)
24-hr	**1.48** (1.23-1.78)	**1.72** (1.42-2.07)	**2.17** (1.79-2.61)	**2.59** (2.13-3.14)	**3.25** (2.62-4.15)	**3.82** (2.99-4.92)	**4.45** (3.35-5.86)	**5.14** (3.71-6.94)	**6.14** (4.26-8.49)	**6.96** (4.67-9.66)
2-day	**1.68** (1.41-2.00)	**1.99** (1.67-2.37)	**2.54** (2.12-3.03)	**3.03** (2.51-3.63)	**3.76** (3.03-4.70)	**4.36** (3.42-5.52)	**5.00** (3.79-6.47)	**5.68** (4.13-7.56)	**6.65** (4.64-9.07)	**7.42** (5.03-10.2)
3-day	**1.84** (1.54-2.17)	**2.17** (1.82-2.56)	**2.74** (2.30-3.25)	**3.26** (2.71-3.88)	**4.01** (3.25-4.98)	**4.63** (3.65-5.82)	**5.28** (4.03-6.80)	**5.98** (4.37-7.90)	**6.96** (4.89-9.44)	**7.74** (5.28-10.6)
4-day	**1.96** (1.66-2.31)	**2.31** (1.94-2.72)	**2.90** (2.44-3.43)	**3.43** (2.87-4.07)	**4.20** (3.42-5.20)	**4.84** (3.83-6.05)	**5.51** (4.22-7.05)	**6.22** (4.57-8.18)	**7.21** (5.09-9.74)	**8.01** (5.49-10.9)
7-day	**2.27** (1.93-2.64)	**2.66** (2.26-3.10)	**3.32** (2.81-3.89)	**3.90** (3.28-4.58)	**4.74** (3.87-5.79)	**5.41** (4.32-6.70)	**6.12** (4.71-7.75)	**6.86** (5.07-8.93)	**7.88** (5.61-10.6)	**8.69** (6.01-11.8)
10-day	**2.54** (2.17-2.94)	**2.97** (2.53-3.44)	**3.69** (3.14-4.29)	**4.31** (3.64-5.04)	**5.20** (4.26-6.30)	**5.90** (4.72-7.25)	**6.63** (5.13-8.35)	**7.39** (5.49-9.56)	**8.43** (6.02-11.2)	**9.24** (6.43-12.5)
20-day	**3.31** (2.85-3.79)	**3.83** (3.30-4.39)	**4.69** (4.02-5.39)	**5.40** (4.61-6.24)	**6.39** (5.27-7.62)	**7.16** (5.78-8.66)	**7.93** (6.19-9.85)	**8.72** (6.53-11.1)	**9.76** (7.04-12.8)	**10.6** (7.43-14.1)
30-day	**3.92** (3.39-4.46)	**4.51** (3.90-5.14)	**5.47** (4.72-6.26)	**6.26** (5.37-7.19)	**7.33** (6.07-8.66)	**8.14** (6.60-9.77)	**8.94** (7.01-11.0)	**9.75** (7.34-12.3)	**10.8** (7.83-14.1)	**11.6** (8.20-15.4)
45-day	**4.64** (4.04-5.24)	**5.33** (4.63-6.03)	**6.43** (5.57-7.30)	**7.31** (6.30-8.34)	**8.48** (7.05-9.93)	**9.36** (7.62-11.1)	**10.2** (8.03-12.4)	**11.0** (8.34-13.8)	**12.1** (8.79-15.6)	**12.8** (9.14-16.9)
60-day	**5.22** (4.56-5.87)	**5.99** (5.23-6.75)	**7.22** (6.28-8.15)	**8.18** (7.09-9.29)	**9.45** (7.88-11.0)	**10.4** (8.47-12.3)	**11.3** (8.90-13.7)	**12.1** (9.19-15.1)	**13.1** (9.62-16.9)	**13.9** (9.94-18.3)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical

Curve Numbers used for Run-on and Run-off Control System Plan

UPPER BASIN:

Soil Map Unit	Map Unit Name	Hydrologic Soil Group	Cover Description	Percent of Area	Area (acres)	Curve Number	Manning
1	Altvan loam, 0 to 3% slopes	B	Pasture/Grassland/Range, Good	25%	44.6	61	0.13
2	Altvan loam, 3 to 9% slopes	B	Pasture/Grassland/Range, Good	25%	44.6	61	0.13
60	Larim gravelly sandy loam, 5 to 40% slopes	B	Pasture/Grassland/Range, Good	15%	26.8	61	0.13
62	Larimer-Stoneham complex, 3 to 10% slopes	B	Pasture/Grassland/Range, Good	10%	17.9	61	0.13
65	Midway clay loam, 5 to 25% slopes	D	Pasture/Grassland/Range, Good	0%	0.0	80	0.13
91	Renohill-Midway clay loams, 3 to 15% slopes	D	Pasture/Grassland/Range, Good	25%	44.6	80	0.13
				100%	178.5	**65.8**	**0.13**

LOWER BASIN:

Soil Map Unit	Map Unit Name	Hydrologic Soil Group	Cover Description	Percent of Area	Area (acres)	Curve Number	Manning
1	Altvan loam, 0 to 3% slopes	B	Pasture/Grassland/Range, Good	35%	30.8	61	0.13
2	Altvan loam, 3 to 9% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
60	Larim gravelly sandy loam, 5 to 40% slopes	B	Pasture/Grassland/Range, Good	35%	30.8	61	0.13
62	Larimer-Stoneham complex, 3 to 10% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
65	Midway clay loam, 5 to 25% slopes	D	Pasture/Grassland/Range, Good	30%	26.4	80	0.13
91	Renohill-Midway clay loams, 3 to 15% slopes	D	Pasture/Grassland/Range, Good	0%	0.0	80	0.13
				100%	87.9	**66.7**	**0.13**

SUBBASIN 1:

Soil Map Unit	Map Unit Name	Hydrologic Soil Group	Cover Description	Percent of Area	Area (acres)	Curve Number	Manning
1	Altvan loam, 0 to 3% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
2	Altvan loam, 3 to 9% slopes	B	Pasture/Grassland/Range, Good	40%	20.4	61	0.13
60	Larim gravelly sandy loam, 5 to 40% slopes	B	Pasture/Grassland/Range, Good	25%	12.7	61	0.13
62	Larimer-Stoneham complex, 3 to 10% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
65	Midway clay loam, 5 to 25% slopes	D	Pasture/Grassland/Range, Good	0%	0.0	80	0.13
91	Renohill-Midway clay loams, 3 to 15% slopes	D	Pasture/Grassland/Range, Good	35%	17.8	80	0.13
				100%	51.0	**67.7**	**0.13**

SUBBASIN 2:

Soil Map Unit	Map Unit Name	Hydrologic Soil Group	Cover Description	Percent of Area	Area (acres)	Curve Number	Manning
1	Altvan loam, 0 to 3% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
2	Altvan loam, 3 to 9% slopes	B	Pasture/Grassland/Range, Good	50%	9.9	61	0.13
60	Larim gravelly sandy loam, 5 to 40% slopes	B	Pasture/Grassland/Range, Good	10%	2.0	61	0.13
62	Larimer-Stoneham complex, 3 to 10% slopes	B	Pasture/Grassland/Range, Good	10%	2.0	61	0.13
65	Midway clay loam, 5 to 25% slopes	D	Pasture/Grassland/Range, Good	0%	0.0	80	0.13
91	Renohill-Midway clay loams, 3 to 15% slopes	D	Pasture/Grassland/Range, Good	5%	1.0	80	0.13
NA	NA	D	Newly Graded Areas	25%	4.9	94	0.05
				100%	19.7	**70.2**	**0.11**

SUBBASIN 3:

Soil Map Unit	Map Unit Name	Hydrologic Soil Group	Cover Description	Percent of Area	Area (acres)	Curve Number	Manning
1	Altvan loam, 0 to 3% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
2	Altvan loam, 3 to 9% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
60	Larim gravelly sandy loam, 5 to 40% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
62	Larimer-Stoneham complex, 3 to 10% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
65	Midway clay loam, 5 to 25% slopes	D	Pasture/Grassland/Range, Good	90%	59.1	80	0.13
91	Renohill-Midway clay loams, 3 to 15% slopes	D	Pasture/Grassland/Range, Good	5%	3.3	80	0.13
NA	NA	D	Newly Graded Areas	5%	3.3	94	0.05
				100%	65.7	**80.7**	**0.13**

SUBBASIN 4:

Soil Map Unit	Map Unit Name	Hydrologic Soil Group	Cover Description	Percent of Area	Area (acres)	Curve Number	Manning
1	Altvan loam, 0 to 3% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
2	Altvan loam, 3 to 9% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
60	Larim gravelly sandy loam, 5 to 40% slopes	B	Pasture/Grassland/Range, Good	25%	11.0	61	0.13
62	Larimer-Stoneham complex, 3 to 10% slopes	B	Pasture/Grassland/Range, Good	25%	11.0	61	0.13
65	Midway clay loam, 5 to 25% slopes	D	Pasture/Grassland/Range, Good	5%	2.2	80	0.13
91	Renohill-Midway clay loams, 3 to 15% slopes	D	Pasture/Grassland/Range, Good	45%	19.8	80	0.13
				100%	44.1	**70.5**	**0.13**

SUBBASIN 5:

Soil Map Unit	Map Unit Name	Hydrologic Soil Group	Cover Description	Percent of Area	Area (acres)	Curve Number	Manning
1	Altvan loam, 0 to 3% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
2	Altvan loam, 3 to 9% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
60	Larim gravelly sandy loam, 5 to 40% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
62	Larimer-Stoneham complex, 3 to 10% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
65	Midway clay loam, 5 to 25% slopes	D	Pasture/Grassland/Range, Good	30%	4.1	80	0.13
91	Renohill-Midway clay loams, 3 to 15% slopes	D	Pasture/Grassland/Range, Good	0%	0.0	80	0.13
65	Midway clay loam, 5 to 25% slopes	D	Pasture/Grassland/Range, Poor	25%	3.4	89	0.13
NA	NA	D	Newly Graded Areas	45%	6.1	94	0.05
				100%	13.6	**88.6**	**0.09**

SUBBASIN 6:

Soil Map Unit	Map Unit Name	Hydrologic Soil Group	Cover Description	Percent of Area	Area (acres)	Curve Number	Manning
1	Altvan loam, 0 to 3% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
2	Altvan loam, 3 to 9% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
60	Larim gravelly sandy loam, 5 to 40% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
62	Larimer-Stoneham complex, 3 to 10% slopes	B	Pasture/Grassland/Range, Good	0%	0.0	61	0.13
65	Midway clay loam, 5 to 25% slopes	D	Pasture/Grassland/Range, Good	30%	1.1	80	0.13
91	Renohill-Midway clay loams, 3 to 15% slopes	D	Pasture/Grassland/Range, Good	0%	0.0	80	0.13
65	Midway clay loam, 5 to 25% slopes	D	Pasture/Grassland/Range, Poor	25%	0.9	89	0.13
NA	NA	D	Newly Graded Areas	45%	1.6	94	0.05
				100%	3.6	**88.6**	**0.09**

Run-off and Peak Discharge Calculations

	Sub Basin	Upper	Lower	1	2	3	4	5	6
	Area (ft^2)	7,777,624	3,827,410	2,220,731	859,821	2,861,487	1,920,902	593,470	154,966
	Area (acres)	178.5	87.9	51.0	19.7	65.7	44.1	13.6	3.6
Am	Area (square miles)	0.279	0.137	0.080	0.031	0.103	0.069	0.021	0.006
	Storm Event	25yr, 24hr	25yr, 24hr	25yr, 24hr	25yr, 24hr	25yr, 24hr	25yr, 24hr	25yr, 24hr	25yr, 24hr
P	Design rainfall (inches)	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25
P	2-yr, 24-hr rainfall (inches)	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72
CN	Curve Number CN	65.8	66.7	67.7	70.2	80.7	70.5	88.6	88.6
S	Potential Max Retention (inches)	5.21	4.99	4.78	4.25	2.39	4.18	1.29	1.29
Ia	Initial Abstraction (inches)	1.04	1.00	0.96	0.85	0.48	0.84	0.26	0.26
Q	Run-off (inches)	0.66	0.70	0.74	0.87	1.49	0.88	2.09	2.09
Q	**Run-off (acre-ft)**	**9.78**	**5.12**	**3.16**	**1.43**	**8.14**	**3.24**	**2.37**	**0.62**
L	Total Flow Length (ft)	4500	6120	2340	1675	3075	2725	525	560
L	Sheet Flow Length (ft)	100	100	100	100	100	100	100	100
L	Concentrated Flow Length (ft)	4400	2695	2240	1575	2975	1295	425	460
L	Channel Flow Length (ft)	0	3325	0	0	0	1330	0	0
s	Total Slope (ft/ft)	0.022	0.017	0.032	0.035	0.028	0.029	0.042	0.039
s	Sheet Flow Slope (ft/ft)	0.020	0.010	0.010	0.040	0.060	0.020	0.050	0.050
s	Concentrated Flow Slope (ft/ft)	0.022	0.025	0.033	0.034	0.027	0.054	0.040	0.037
s	Channel Flow Slope (ft)	0.000	0.011	0.000	0.000	0.000	0.005	0.000	0.000
n	Manning coefficient for sheet flow	0.13	0.13	0.13	0.11	0.13	0.13	0.09	0.09
Tt	Sheet Flow Travel Time (hrs)	0.199	0.262	0.262	0.132	0.125	0.199	0.106	0.106
V	Concentrated Flow Average Velocity (ft/s)	2.38	2.56	2.95	2.99	2.63	3.75	3.23	3.10
Tt	Concentrated Flow Travel Time (hrs)	0.513	0.292	0.211	0.146	0.314	0.096	0.037	0.041
a	Cross-Sectional Flow Area of Channel (ft^2)	NA	29.2	NA	NA	NA	18.3	NA	NA
pw	Wetted Perimeter of Channel (ft)	NA	65.4	NA	NA	NA	62.5	NA	NA
n	Manning coefficient for open channel flow	NA	0.030	NA	NA	NA	0.030	NA	NA
V	Channel Flow Average Velocity (ft/s)	0.00	3.10	0.00	0.00	0.00	1.59	0.00	0.00
Tt	Channel Flow Travel Time (hrs)	0.000	0.298	0.000	0.000	0.000	0.233	0.000	0.000
Tc	Total Time of Concentration (hrs)	0.71	0.85	0.47	0.28	0.44	0.53	0.14	0.15
	Ia/P	0.32	0.31	0.29	0.26	0.15	0.26	0.08	0.08
qu	Unit peak Discharge (csm/in)	350	320	470	620	550	440	925	900
	Percentage of Pond or Swamp (%)	0	0	0	0	0	0	0	0
Fp	Pond Adjustment Factor	1	1	1	1	1	1	1	1
qp	**Peak Discharge (cfs)**	**64.2**	**30.7**	**27.8**	**16.6**	**84.0**	**26.8**	**41.1**	**10.4**

Fill in these cells (non-highlighted cells are calculated)

Culvert Sizing

	Q	Required Diameter	Required Diameter	Area	Slope	Length	Vert. Drop	Velocity	mannings	constant				notes
	cfs	ft	inches	ft^2	ft/ft	ft	ft	ft/s						
CULV 4	26.8	2.08	25	3.4	0.0096	49	0.47	7.9	0.012	0.216				existing concrete culvert, 24" diameter, length = ~49', elevation drop = 0.47'
CULV 6	10.4	1.27	16	1.3	0.0202	41	0.83	8.2	0.012	0.216				existing metal culvert, ~18" diameter, length = ~41', elevation drop = 0.83'

*Uses mannings equation solved for diameter, assumes full flow

Channel Sizing

	Q	Top Width	Depth	Side slope	Bot Width	Area	wet P	Hyd Radius	Slope	Length	Vert. Drop	Velocity	mannings	notes
	cfs	ft	ft	ft/ft	ft	ft^2	ft	ft	ft/ft	ft	ft	ft/s		
CHANNEL LOWER	94.9	35.4	0.9	0.33	30.0	29.24	65.42	0.45	0.0125	3600	45.0	3.25	0.030	earth channel, weedy (vert drop should equal 45)
CHANNEL 4	26.8	33.5	0.6	0.33	30.0	18.34	63.49	0.29	0.0045	1330	6.0	1.46	0.030	earth channel, weedy (vert drop should equal 7)

*Uses mannings equation for open channel flow

Pond Sizing

	Required Volume	Required Volume	Approx. Pond Elevation
	acre-ft	ft^3	ft amsl
POND 1	3.2	137,591	5748

	Required Volume	Required Volume	Approx. Pond Elevation
	acre-ft	ft^3	ft amsl
POND 2	1.4	62,151	5737

	Required Volume	Required Volume	Approx. Pond Elevation
	acre-ft	ft^3	ft amsl
POND 3	8.1	354,793	5701

Appendix D
Weekly Inspection Report

Platte River Power Authority

CCR Landfill
Weekly Inspection Report

Name of CCR Landfill: _____ **Qualified Inspector:** _____
Date: _____ **Time:** _____
Owner: _____ **Weather:** _____
Operator: _____ _____

I. Perimeter Slope

1. How would you describe the vegetation on the crest and side slopes? (Check all that apply)

___ Recently Mowed
___ Overgrown (Greater than 6-in.)
___ Good Cover
___ Sparse
___ Paved
___ Gravel

Other (describe): _____

2. Are there any areas of hydrophilic (lush, water-loving) vegetation? ___ Yes ___ No
If 'Yes', describe (size, location, severity, etc.) _____

3. Are there any trees or other undesired vegetation on the slope? ___ Yes ___ No
If 'Yes', describe (type of vegetation, size, location, etc.) _____

4. Is there an access ramp up the side slope or a road around the perimeter slope? ___ Yes ___ No
If 'Yes', describe (good condition, numerous cracks, newly paved, stone uniformly distributed, etc.) _____

5. Are there any depressions, ruts, or holes on the access ramp or road? ___ Yes ___ No
If 'Yes', describe (size, location, etc.) _____

6. Are there any cracks, sloughs, bulges, or indications of slope distress? ___ Yes ___ No
If 'Yes', describe (length and width, location and direction of cracking, slough, or distress, etc.) _____

7. Do any wet areas indicate seepage through the slope? ___ Yes ___ No
If 'Yes', describe (size, location, etc.) _____

8. Are there any active seeps (flowing water) from the slope of the slope? ___ Yes ___ No
If 'Yes', describe (size, location, flow quantity and color, etc.) _____

9. Are there any active seeps or wet areas at the toe of the slope? ___ Yes ___ No
If 'Yes', describe (size, location, etc.) _____

10. Other observations on the perimeter slope (changes since last inspection, etc.): _____

Platte River Power Authority

CCR Landfill
Weekly Inspection Report

Name of CCR Landfill: _____ **Qualified Inspector:** _____
Date: _____ **Time:** _____

II. Stormwater Conveyance

1. Is stormwater being properly diverted by the existing infrastructure? ___ Yes ___ No
   If 'Yes', describe (size, location, etc.) _____

2. Is the stormwater infrastructure in good condition? ___ Yes ___ No
   If 'No', describe (Is there any erosion in or around the structures, signs of leakage or movement, etc?).

III. Landfill Conditions

1. Describe operations in the landfill (disposal, reclamation, general operational activities): _____

2. Are any stormwater controls obstructed? ___ Yes ___ No
   If 'Yes', describe (type of debris, reason for obstruction, etc.) _____

3. Are there indications of erosion on the landfill slopes? ___ Yes ___ No
   If 'Yes', describe what type and its condition (rill, gully, dimensions, etc.) _____

4. Do conditions exist that may require additional dust controls? ___ Yes ___ No
   If 'Yes', describe (location, appropriate dust control measures, etc.) _____

5. Other observations around the landfill (changes since last inspection, etc.): _____

IV. Repairs, Maintenance, Action Items

1. Has any routine maintenance been conducted since the last inspection? ___ Yes ___ No
   If 'Yes', describe. _____

2. Have any repairs been made since the last inspection? ___ Yes ___ No
   If 'Yes', describe. _____

Platte River Power Authority

CCR Landfill
Weekly Inspection Report

Name of CCR Landfill: _____ **Qualified Inspector:** _____
Date: _____ **Time:** _____

3. Are there any areas of potential concern? ___ Yes ___ No
If 'Yes', describe. _____

4. Has this inspection identified any need for repair or maintenance? ___ Yes ___ No
If 'Yes', describe and state the urgency of maintenance. "Urgent" for maintenance that should be conducted as soon as possible, "Moderate" for maintenance that should be conducted within three months, and "Not Urgent" for maintenance that can be conducted in a year. _____

V. Photographs

Photographs can be taken of notable features. List of photographs:

	Location	Direction of Photo	Description
i.			
ii.			
iii.			
iv.			
v.			
vi.			
vii.			
viii.			
ix.			
x.			