Preliminary Drainage Report

Tailwaters at Stagecoach

Routt County, Colorado

Produced for:

Contour, LLC

440 Eagle Street

Minturn, CO 81645

Prepared by:

NKE Engineering

7638 S Crocker Ct

Littleton, CO 80120

Date: REV 1 - 10/08/2024

I. INTRODUCTION

A. PURPOSE

The purpose of this report is to document the existing drainage conditions for the Tailwaters Project (Project) in Routt County, Colorado and to present the preliminary basis, analysis and proposed drainage facilities for the project as a component of the Subdivision Preliminary Plan Application. The information provided in this report is based on Routt County Standards and constitutes a drainage study in accordance with the Subdivision Regulations of Routt County, Colorado (County). The preliminary design follows local and State guidelines and regulations to effectively manage stormwater runoff through conveyance, detention and water quality facilities.

B. PREPARED BY PROFESSIONAL ENGINEER

This report has been prepared by NKE Engineering, LLC, under the direction and supervision of William S. Otero, a professional engineer licensed in State of Colorado.

C. LOCATION

The Project is located approximately 20 minutes south of the Town of Steamboat within the Stagecoach Development Area in north central Colorado. As shown in Figure 1-1, the location of the Tailwaters Project and Property Boundary (i.e. Study Area). The Study Area is located directly adjacent to Little Morrison Creek on the east and approximately a half mile south of the Stagecoach Reservoir to the north. In addition, the Project is bordered to the west and south by County Roads 16 and 18A and the surrounding area consists primarily of rural housing and undeveloped land.

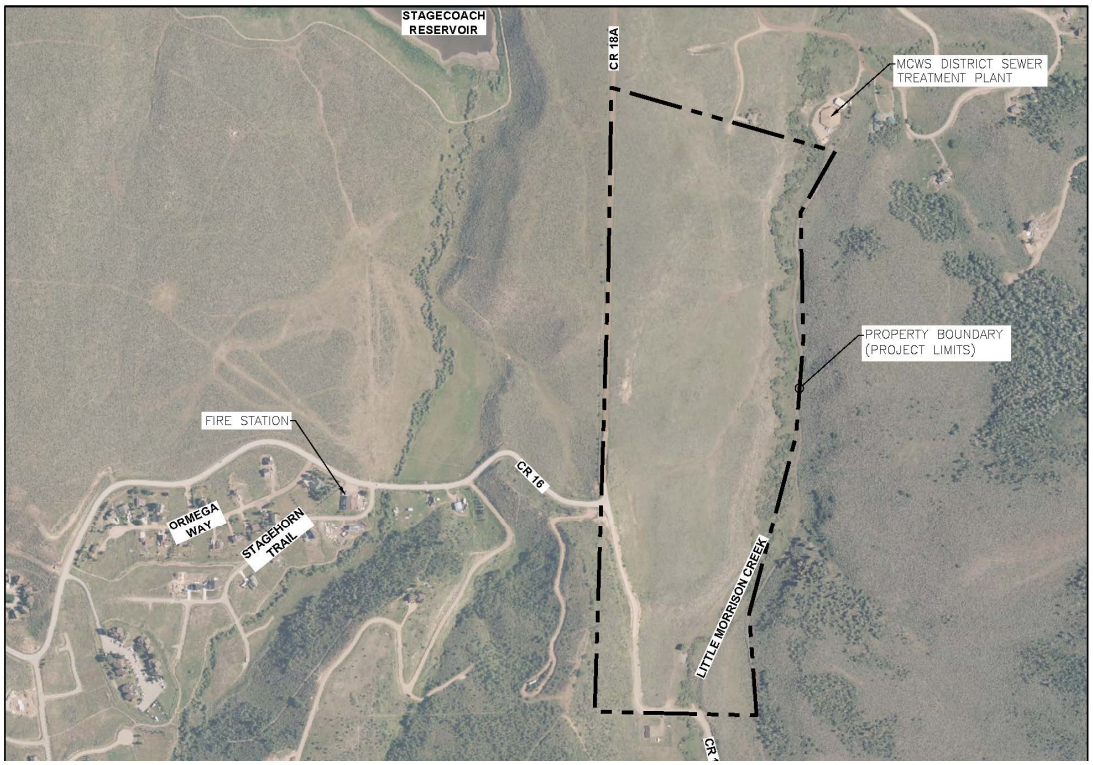


Figure 1 - Vicinity Map

D. PROJECT DESCRTIPTION

Appendix A, Figure 1 presents the overall Project Plan of the approximately 89.17 acres and proposed Project Phasing. The Applicant is looking to develop the Site with a mix of 200 residential units, a small neighborhood commercial area, and the necessary infrastructure improvements required to serve the Project. Currently, the anticipated elements of the Project include:

- A 4.11 (+/-) acre commercial zone or neighborhood marketplace to fulfill needs of the entire Stagecoach community which could include: community retail market, childcare, office space, restaurant, and four (4) live / work units.
- Approximately 156 single family and duplex lots on just under 36 acres of land with lot sizes as follows:
    - Twenty-four (24) lots, approximately one-quarter acre or larger in size, for single family homes (12% of the residential units).
    - Sixty-six (66) lots, that range from approximately 0.15 – 0.20 acres in size (6,500-8,700 s.f.), for single family homes (33% of the residential units).
    - Thirty-three duplex lots that would contain sixty-six (66) duplex units (33% of the residential units).
    - Forty (40) multi-family four plex townhome units on three separate lots containing a total of 2.96 – acres (20% of the residential units).
- New infrastructure: restructuring of County Road 16, internal circulation roads, electric, and new water/sewer lines per Morrison Creek Water and Sanitation District Standards.

II. STUDY AREA

A. PROPERTY DESCRIPTION AND SOIL TYPES

Appendix A, Figure 2 presents the Existing Conditions of the Study Area. As shown, the existing land cover of the Project Area includes predominately shrub grasslands, with some grasslands, riparian and wetlands located along the eastern edge of the Project area. The terrain in the area is generally gently sloped south to north at approximately a 3 to 4 percent grade, with two intermediate terraces consisting of slopes greater than 30 percent trending from west to east.

Appendix A, Figure 3 (including associated Legend) presents a general overlay of the soil types within the Project Area as described by the Natural Resources Conservation Service (NRCS) as Lintim Loam (western third), Vabem-Rabbitears Complex (central third) and Rabbitears Loam (eastern third). These soils are generally classified as gravelly clay loam, sandy loam, loamy sand, and silt loam. Hydrologically, these soils are described by the NRCS as follows:

- Lintim Loam – Well drained, slow permeability, and moderate to very high runoff
- Vabem-Rabbitears Complex – Well drained, moderately slow permeability
- Rabbitears Loam – Well drained, moderate permeability, and low runoff

For purposes of the described analysis, it was assumed that the site generally consists of well drained, moderate permeability and moderate runoff potential soils, generally classified by the NRCS as Type B and C soils.

B. OFFSITE BASINS

The off-site drainage is included in the basin delineation for those three sub-basins 8, 9 and 10 for which off-site flow contributes to surface hydrology. Based on the proposed Project, sub-basin 10 has no current development being proposed and sub-basins 8 and 9 predominately consist of slopes greater than 30% with the only development related activities being proposed is the requested restructuring of County Road 16.

C. MAJOR DRAINAGEWAYS

The Little Morrison Creek flows from the south to north through the Project and outfalls into the Stagecoach Reservoir located approximately a half a mile to the north of the Project Area (closest point). All existing eastern and southern surface drainage slope to and outfall into Little Morrison Creek.

III. EXISTING CONDITIONS

A. BASIN AND SUB-BASIN DESCRIPTION

Appendix A, Figure 4 presents the Existing Conditions Drainage Plan which includes the overall Project Area delineation into 10 sub-basins. The approximate Area and Impervious Percentage of each of the ten sub-basins used in the hydrology analysis of the current site conditions are presented in Figure 4 and listed in Table 1.

Sub-Basin	Area (acres)	Impervious Percentage
1	4.4	2
2	5.6	2
3	1.5	2
4	23.4	2
5	2.7	2
6	20.0	2
7	11.6	2
8	3.3	2
9	6.3	2
10	31.1	2

Table 1 - Sub-Basin Areas – Existing Conditions

B. EXISTING DRAINAGE CHARACTERISTICS

The drainage characteristics within the Study Area and associated sub-basins are shown in Appendix A, Figure 4. The arrows show the general flow direction of surface and shallow channel flows and outfalls for each sub-basin. The outfalls from the Project Area generally flow towards and into Little Morrison Creek as sheet flow or flow from shallow swales. With exception to three of the small sub-basins along the western edge of the project currently surface flow across CR 16 and 18A and the very northern edge of the Study Area which flows directly to adjoining properties.

Using accepted hydrologic criteria and current site conditions for the Study Area, which will be further detailed in Section VI and per Routt County Standards, the Rational Method was used to calculate the Peak Outflows for the 5-year storm event, which will be used for sizing the structures for controlling stormwater runoff, 25-year storm event to be considered in sizing of and any necessary drainage easements, and the 100-year storm event being used to describe the general site conditions during major events (planning). The results of these calculations are shown in Table 3-2.

Sub-Basin	Peak Outflow from Basin (cfs)		
	5-Year	25-Year	100-Year
1	2.7	11.3	12.2
2	2.8	11.5	14.2
3	1.1	4.4	4.8
4	11.5	46.4	60.4
5	1.8	7.7	8.6
6	6.0	23.8	33.9
7	8.0	32.6	36.8
8	1.9	7.9	10.0
9	3.7	14.9	19.2
10	16.8	67.8	90.8

Table 2 - Rational Method Results for Existing Conditions

IV. PROPOSED CONDITIONS

A. PROPOSED LANDUSES AND CHANGES IN BASIN CONDITIONS

Based on the Project Plan presented in Appendix A, Figure 1 the land uses for the Proposed Conditions vary from essentially undeveloped areas of open space to differing levels of residential development and a small neighborhood commercial area near the proposed entrance. Overlaying these proposed land uses over the Project Area and associated sub-basins creates varying levels of imperious area created by the placement of dwellings, roads, trails and commercial structures and supporting parking, as shown on Appendix A, Figure 5 and listed in Table 3.

Sub-Basin	Area (acres)	Impervious Percentage
1	4.4	45
2	5.6	35
3	1.5	70
4	23.4	60
5	2.7	40
6	20.0	65
7	11.6	15
8	3.3	2
9	6.3	2
10	31.1	2

Table 3 - Sub-Basin Areas – Proposed Conditions

B. PROPOSED DRAINAGE CHARACTERISTICS

Based on the proposed basin conditions presented in Figure 5, the basins areas, imperious percentages and intensity of the differing levels of storm events, hydrologic calculations were performed and the results of the Rational Method analysis are presented in Table 4. Runoff quantity and quality from the Project Area based on the calculated changes from historic/existing conditions will be managed based on County standards. In basins that will be developed, runoff quantity will be managed to prevent peak flows from exceeding the pre-development peak flows for the 5-year and 100-year storm events.

Sub-Basin	Peak Outflow from Basin (cfs)		
	5-Year	25-Year	100-Year
1	6.1	15.9	15.5
2	6.2	16.6	18.5
3	3.8	7.8	6.4
4	36.1	83.8	91.7
5	4.7	14.2	8.9
6	23.7	53.1	67.0
7	20.6	48.4	38.8
8	2.3	8.8	9.9
9	4.4	16.7	19.1
10	17.9	67.8	90.8

Table 4 - Rational Method Results for Proposed Conditions

V. DRAINAGE PLAN

A. GENERAL CONCEPTS

As presented on Figure 5, the general concept for managing surface water drainage and water quality based on the site conditions and proposed land uses will be to convey water through enhanced grass swales/channels and grass lined roadside ditches to either the primary Detention Basin 1 located in the central area of the Project Plan or enhanced water quality areas designed to assist in the management of sediment removal while slowing the peak outflows. In the terraced areas (i.e. area predominately consisting of slopes greater than 30 percent) and low-lying areas directly adjacent to the creek, enhancing plantings and re-working surface soils to increase permeability may be required to assist in managing runoff prior to entering individual residential lots and prior to discharging to Little Morrison Creek.

B. CONVEYANCE OF SURFACE DRAINAGE

All proposed internal roads and along County Roads 16 and 18A within or adjoining the Project Area are designed with either grass lined roadside ditches or enhanced grass swales/channels to both convey collected surface water and manage peak flows via the use of shallow slopes, enhanced plantings and the placement of ditch checks when the Froude number is greater than 0.8 (i.e. typically where ditch bottom slopes are greater than 3.5 percent).

The typical grass lined roadside ditch (see Typical Drainage Details and Sections in Engineering Plans) are 6 to 8 feet wide at the top, with a 1 foot wide bottom and 2:1 side slopes. Based on this typical design:

- Slope: 2.0 to 3.0%
- Depth: 2 ft
- Manning's n: 0.04 (grass lined)

The normal depth, velocity and Froude number at the 5-year storm event were calculated at approximately 0.78 ft, 3.4 fps and 0.8. See Appendix B for calculations.

The typical enhanced grass swale/channel (see Typical Drainage Details and Section in the Engineering Plans) are 16 to 20 feet wide at the top, with and 8 foot wide bottom and 4:1 side slopes. Based on this typical design:

- Slope: 2.5 to 3.5%
- Depth: 2.5 ft
- Manning's n: 0.04 (grass lined)

The normal depth, velocity and Froude number at the 5-year storm event for a minor and major channel were calculated at approximately 0.309 ft, 2.45 fps, and 0.83 and 0.703 ft, 3.947 fps and 0.93. See Appendix B for calculations.

C. CULVERTS

Per County standards, drainage system will be designed to convey the 5-year storm, with the culverts at a maximum of 80 percent full.

The typical culverts (see Typical Drainage Details and Sections in Engineering Plans) are minimum of 18-inch CMP and placed at all locations where the conveyance crosses a road and paved trail. Based on a typical design:

- HY-8 Analysis
- Slopes: 1.0 to 5.0%
- Inlet Controlled – partial full pipe for analyzed flows
- CMP w/ Flared End Sections
- Assumed range of flows (-25 to +50%) for 5-year event of the upstream basin at proposed full build-out

The outlet velocities and depth of flow were calculated to sure the culverts as design would have outlet velocities greater than 2% and the depths were below the maximum of 80% full. See Appendix B for calculations. Final design for each culvert will be provided at final design.

D. MANAGEMENT OF PEAK FLOW AND WATER QUALITY

1. Detention Basin

A detention basin is proposed in the central area of the Project Area. The location of the basin was selected based on the downstream proximity to the sub-basins (5 and 6) with the proposed highest impervious area due to a high residential density and neighborhood commercial area of the proposed Development Plan.

The basin area was analyzed for both the minor (5-year) and major (100-year) storm events. See preliminary calculations in Appendix B and the results summarized in this section. The Top Surface Area of the proposed basin covers approximately 0.85 acres with an estimated depth of 4.5 feet. The discharge is located to the north with an approximate invert elevation of the outlet (i.e. culvert) being 7292 feet. Based on these preliminary calculations, using the FAA Method, and the preliminary design:

- Inflow Volumes (Minor and Major): 15,195 cubic-ft and 47,797 cubic ft
- Outflow Volumes (Minor and Major): 1,156 cubic-ft and 8,673 cubic-ft
- Required Storage (Minor and Major): 0.32 acre-ft and 0.90 acre-ft
- Percent Full (Minor and Major): 11 and 31

The Water Quality Capture Volume (WQCV) was also calculated and added to the Required Storage presented above. Based on the calculations using the Impervious percentage from Sub-basins 5 and 6 at 50% (average), the Required Storage for Quantity and Quality (Minor and Major) equate to 0.74 acre-ft and 1.31 acre-feet and the Percent Full (Minor and Major) equate to 26% and 46%.

Final capacity of the basin will be determined at Final Plan, with the depth and ultimate configuration being set based on the surrounding land uses.

2. Enhanced Grass Swales/Channels

A description, schematic details, design criteria and documented effectives for these permanent BMPs and conveyance structures are provided in Appendix C – Example BMPs.

As previously discussed, the Project Area consists of undulating terrain from south to north and intermediate terraces from west to east. All modified surface water conveyance to Little Morrison Creek will be through Enhanced Grass Swales/Channels. When the Enhanced Grass Swales/Channels are in areas of slopes greater than 3.5%, further erosion control BMPs (i.e. enhanced plantings, riprap and ditch checks) will be placed to further assist in managing runoff prior to offsite discharge. In addition, Filter Strips and Terraced Filters Strips with enhanced plantings and energy dissipators will be constructed at all outfalls/offsite discharge locations to further assist in permanent water quantity and quality management.

Based on the calculated Normal Depths and the typical design of these structures, which are wider, shallower slopes and enhanced plantings, these enhanced channels will not only be used to convey collected surface water runoff, but also provide linear storage of almost 50% of their total capacity. Therefore, further reducing the peak flows 5-year and 100-year storm events.

3. Water Quality BMPs

Examples of potential BMPs to be used are presented in the Appendix. Preliminary selection and locations of primary pre and post BMPs are presented on the provided Proposed Drainage and Grading Plans and final selections will be determined during final design.

E. PHASING AND DRAINAGE DURING CONSTRUCTION

BMPs will be used to control site runoff during construction, likely including check dams in existing surface water channels, sediment ponds properly placed to support continued sediment removal, silt fence, and vehicle tracking control implemented per requirements in County standards.

VI. CONCLUSIONS

A. COMPLIANCE WITH STANDARDS

Based on documented County Standards, this Preliminary Drainage analysis and approach are believed to be in General conformance. Based on the design concepts and parameters presented in this report and to be implemented and integrated into the final design, the proposed drainage facilities will be adequate for the population density and type of development proposed in the Project Area.

B. SUMMARY OF CONCEPT

The drainage plan consists of hydrologic modeling for both existing and proposed development conditions, the 10 sub-basins comprising the Project Area were modeled to estimate runoff quantities for two levels (Minor and Major) of storms.

C. PROTECTION TO EXISTING SITE

Based on this preliminary analysis, Peak flows from the developed basins can be managed to pre-development flows for the 5-year and 100-year storm events. The structural controls will also greatly limit increases in stormwater runoff pollutants loads resulting from the development. These controls will also potentially reduce volumes of runoff.

D. MEASURES FOR ADEQUATE DRAINAGE AND ENHANCEMENTS TO STORMWATER QUALITY

The design addresses structures to control stormwater runoff quantity and quality, including detention, enhanced conveyance channels and water quality BMPs. Preliminary sizes and locations of these structures and areas requiring possible enhanced plantings are presented in the attached Appendix A and supporting Engineering Plans (separated cover). The design for water quality BMPs will be completed at final design. However, in any case adequate provision for storm water will be provided onsite and in no case will development of the site be allowed to affect the location of discharge, magnitude, depth and velocity of drainage flows upstream or downstream from the development except as otherwise allowed by the County regulations.

E. EFFECTS OF PROJECT ON NEARBY PROPERTIES

The Project will have no adverse impact on the base flood elevation on the Little Morrison Creek. However, it should be noted that by the project replacing the damaged culverts on the south end of the

project, the flow conditions of the creek will be enhanced. The Project is not anticipated to have any impact on water quality.

F. STANDARD FORMS

To be completed with final design.

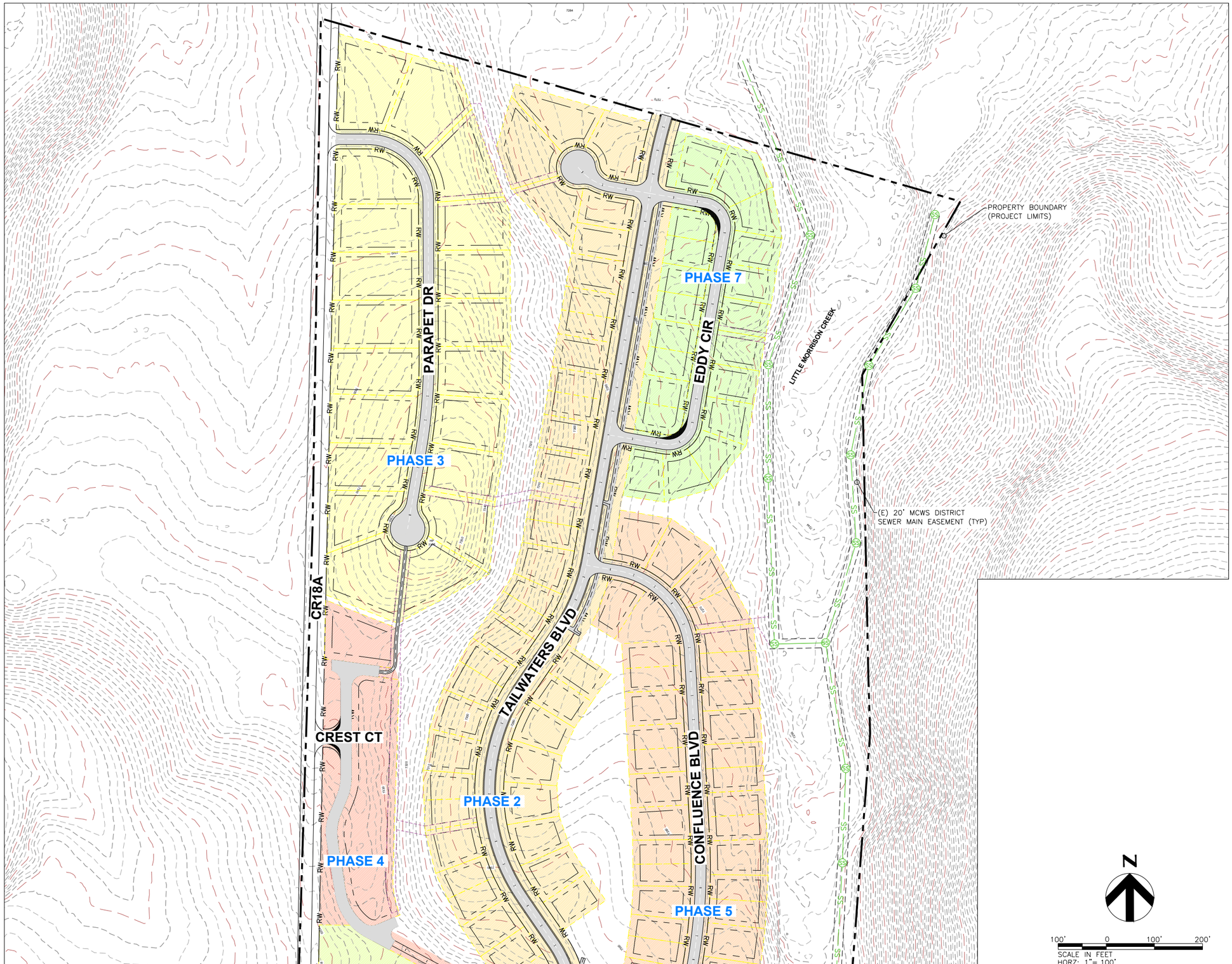
VII. LIST OF REFERENCES

City of Steamboat Springs, Colorado, Engineering Standards, Chapter 5 – Drainage Standards, Revision July 2019.

Mile High Flood District, Urban Storm Drainage Criteria Manual Volume 3, Calculating the WQCV and Volume Reductions, Revision October 2019.

Stagecoach Community Plan, Routt County, Colorado, Adopted March 16, 2017.

APPENDIX A – FIGURES



OWNER:

TAILWATERS AT STAGECOACH, LLC

PLANNER:

CONTOUR DESIGN COLLECTIVE
164 Railroad Ave
Minturn, CO 81645
(970) 239-1485

ARCHITECT:

LANDSCAPE ARCHITECT:

NOT FOR CONSTRUCTION

ENGINNER:

NKE
7638 S Crocker Ct
Littleton, CO 80120
(970) 445-8810

COLORADO REGISTERED WILLIAM S OTERO 32163 PROFESSIONAL ENGINEER
10/09/24

ISSUE	DATE	DESCRIPTION
3	10/09/24	COUNTY PLAN COMMENTS
2	08/23/24	DRAINAGE PLAN UPDATE
1	07/19/24	PRELIMINARY PLAN UPDATE
0	01/11/24	PRELIMINARY PLAN SUBMISSION

DRAWN BY: S. OTERO

SHEET TITLE:

MASTER PLANS (NORTH)

SHEET NUMBER:

FIGURE 1

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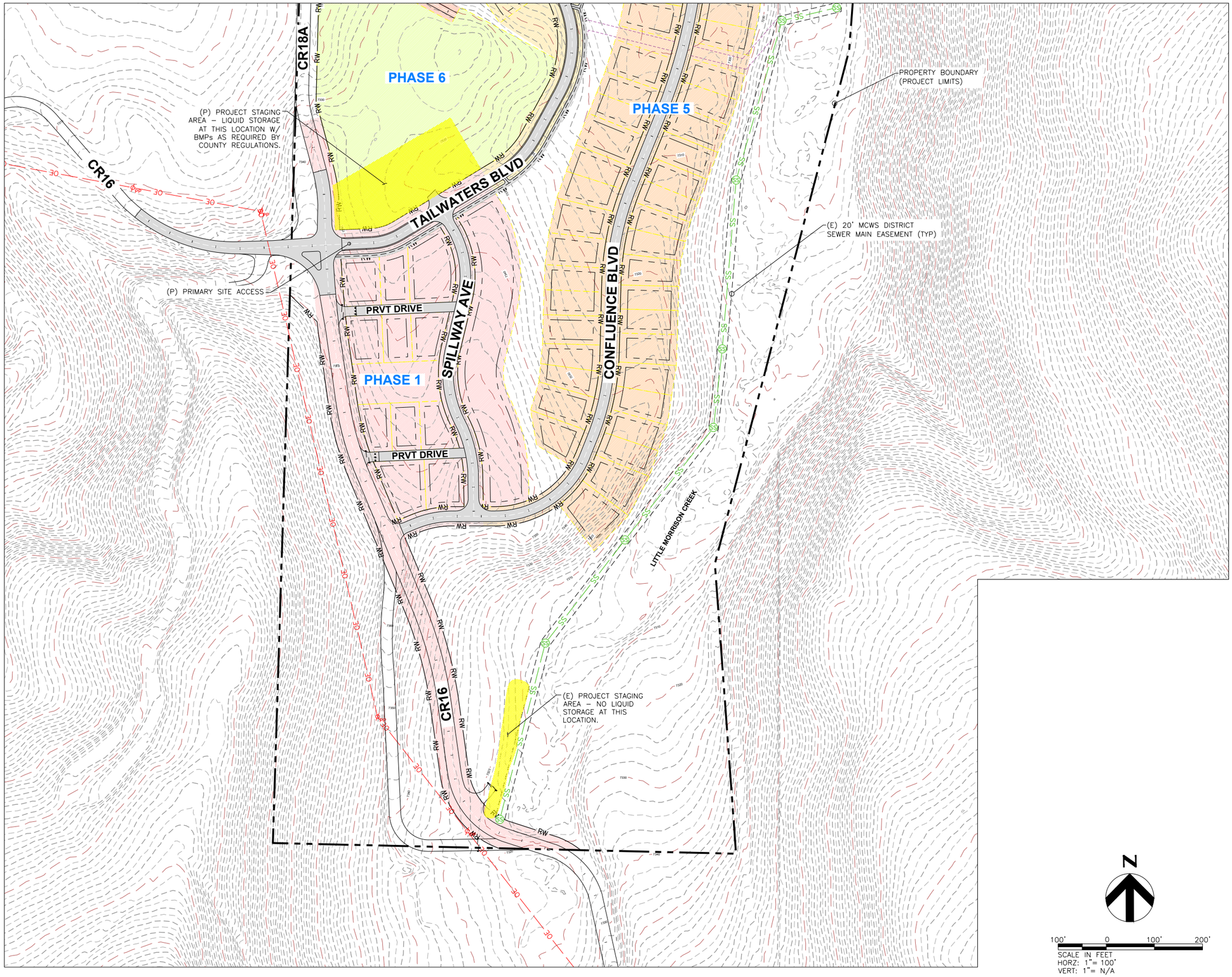
PLOTTED BY: SAM OTERO
PLOT STYLE: 8140CAD_MSTANDARD.CTB



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DRAWN BY: S. OTERO

SHEET TITLE:

MASTER PLAN (SOUTH)

SHEET NUMBER:

FIGURE 1

NOTE: NO EXIST. UNDERGROUND UTILITIES ARE LOCATED WITHIN PROJECT LIMITS, EXCEPT EXIST. MCWS DISTRICT SEWER AS SHOWN.

(E) PROPERTY BOUNDARY (PROJECT LIMITS)

CR-18A

TP-11

TP-11

TP-10

TP-9

TP-8

LITTLE MORRISON CREEK

(E) MCWS DISTRICT SEWER MAIN (20' EASEMENT CENTERED ON ALIGNMENT SHOWN)

(E) APPROX. EDGE OF SURVEYED WETLANDS (TYP.)

TP-5	TEST PIT LOCATIONS
	EXIST. SLOPES >30%
	BARE GROUND (EXIST. COUNTY ROADS)
	GRASSLAND
	SHRUB GRASSLAND
	RIPARIAN
	APPROX. EDGE OF SURVEY WETLANDS

NOTES:
1. FOR PROJECT SURVEY CONTROLS, SEE PLAT SHEETS 1 THROUGH 5.

N

100' 0 100' 200'
SCALE IN FEET
HORZ: 1"= 100'
VERT: 1"= N/A

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PLOT STYLE: 8140CAD_MSTANDARD.CTB

OWNER:

TAILWATERS AT STAGECOACH, LLC

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DRAWN BY: S. OTERO

SHEET TITLE:

EXIST. CONDITIONS (NORTH)

SHEET NUMBER:

FIGURE 2

NOTE: NO EXIST. UNDERGROUND UTILITIES ARE LOCATED WITHIN PROJECT LIMITS, EXCEPT EXIST. MCWS DISTRICT SEWER AS SHOWN.

CR-18A

CR-16

CR-16

TP-1

TP-2

TP-3

TP-4
NOTE: LOCATED OUTSIDE EXIST. ROAD FILL SLOPE

TP-5

TP-6

TP-7

(E) MCWS DISTRICT SEWER MAIN (20' EASEMENT CENTERED ON ALIGNMENT SHOWN)

(E) PROPERTY BOUNDARY (PROJECT LIMITS)

LITTLE MORRISON CREEK

(E) APPROX. EDGE OF SURVEYED WETLANDS (TYP.)

(E) PROJECT STAGING AREA

TP-5 TEST PIT LOCATIONS

EXIST. SLOPES >30%

BARE GROUND (EXIST. COUNTY ROADS)

GRASSLAND

SHRUB GRASSLAND

RIPARIAN

APPROX. EDGE OF SURVEY WETLANDS

NOTES:
1. FOR PROJECT SURVEY CONTROLS, SEE PLAT SHEETS 1 THROUGH 5.

N

100' 0 100' 200'
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DRAWN BY: S. OTERO

SHEET TITLE:

EXIST. CONDITIONS (SOUTH)

SHEET NUMBER:

FIGURE 2

Soil Map—Routt Area, Colorado, Parts of Rio Blanco and Routt Counties

106° 50' 52" W
106° 49' 55" W
40° 16' 37" N
40° 15' 28" N
343000
343200
343400
343600
343800
344000
344200
4460100
4459800
4459600
4459700
4459500
4459100
4458900
4458800
4458700
4458600
4458300
4458100
4459300
4459100

Little Morrison Creek
County Road 18a
Uncompahgre Rd
Shoshone Way
Arapahoe Rd
Navahoe Trl
Apache Trl
Barr Trl
County Road 76
County Road 16

W
50C
88F
AW
68D
49A
80D
124
68C
66D
139
78D

Soil Map may not be valid at this scale.

Map Scale: 1:2,710 if printed on D portrait (22" x 34") sheet.

N

0 40 80 160 240 Meters

0 100 200 400 600 Feet

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

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: Routt Area, Colorado, Parts of Rio Blanco and Routt Counties
Survey Area Data: Version 13, Aug 23, 2023

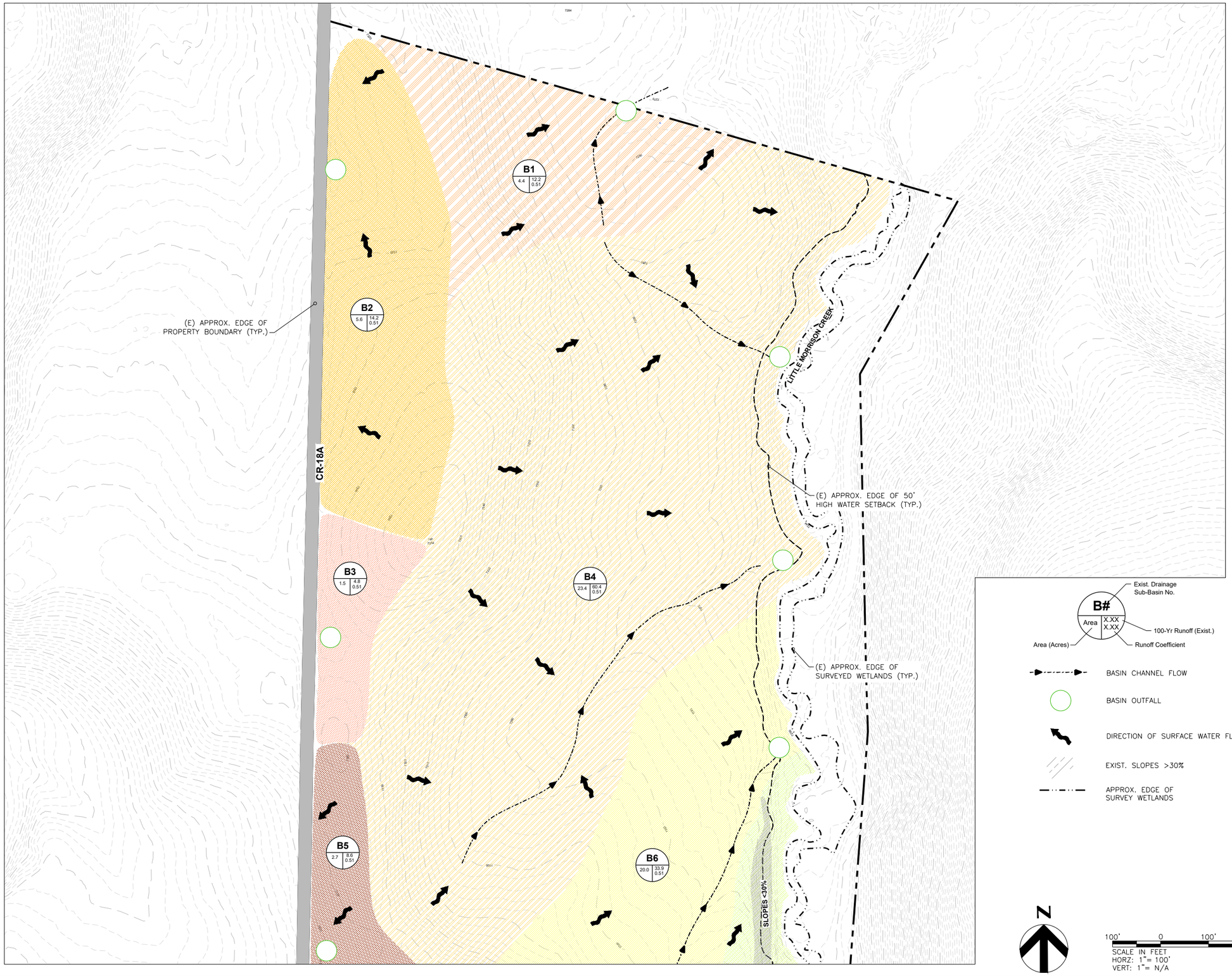
Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 2, 2021—Aug 25, 2021

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
49A	Slocum loam, gravelly substratum, 0 to 3 percent slopes	34.3	6.9%
50C	Lintim loam, 3 to 12 percent slopes	108.3	21.9%
66D	Foidel loam, 15 to 25 percent slopes	14.0	2.8%
68C	Rabbitears loam, 3 to 12 percent slopes	55.3	11.2%
68D	Rabbitears loam, 12 to 25 percent slopes	23.9	4.8%
78D	Frisco, very stony-Dorpat complex, 3 to 25 percent slopes	2.7	0.5%
80D	Foidel loam, 5 to 25 percent slopes	40.5	8.2%
88F	Inchau-Jerry complex, 25 to 50 percent slopes	30.7	6.2%
124	Vabem-Rabbitears complex, 25 to 65 percent slopes	170.0	34.4%
139	Maciver stony loam, 3 to 25 percent slopes, extremely stony	3.2	0.6%
AW	Venable, mucky peat, 0 to 3 percent slopes, frequently flooded	2.2	0.4%
W	Water	8.8	1.8%
Totals for Area of Interest		**493.8**	**100.0%**



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PLOTTED BY: SAM OTERO
PLOT STYLE: 81140CAD_WSTANDARD.CTB

OWNER:

TAILWATERS AT STAGECOACH, LLC

PLANNER:

CONTOUR DESIGN COLLECTIVE
164 Railroad Ave
Minturn, CO 81645
(970) 239-1485

ARCHITECT:

LANDSCAPE ARCHITECT:

NOT FOR CONSTRUCTION

ENGINNER:

NKE 7638 S Crocker Ct
Littleton, CO 80120
(970) 445-8810

COLORADO REGISTERED
WILLIAM S. OTERO
32163
10/09/24
PROFESSIONAL ENGINEER

ISSUE	DATE	DESCRIPTION
3	10/09/24	COUNTY PLAN COMMENTS
2	08/23/24	DRAINAGE PLAN UPDATE
1	07/19/24	PRELIMINARY PLAN UPDATE
0	01/11/24	PRELIMINARY PLAN SUBMISSION

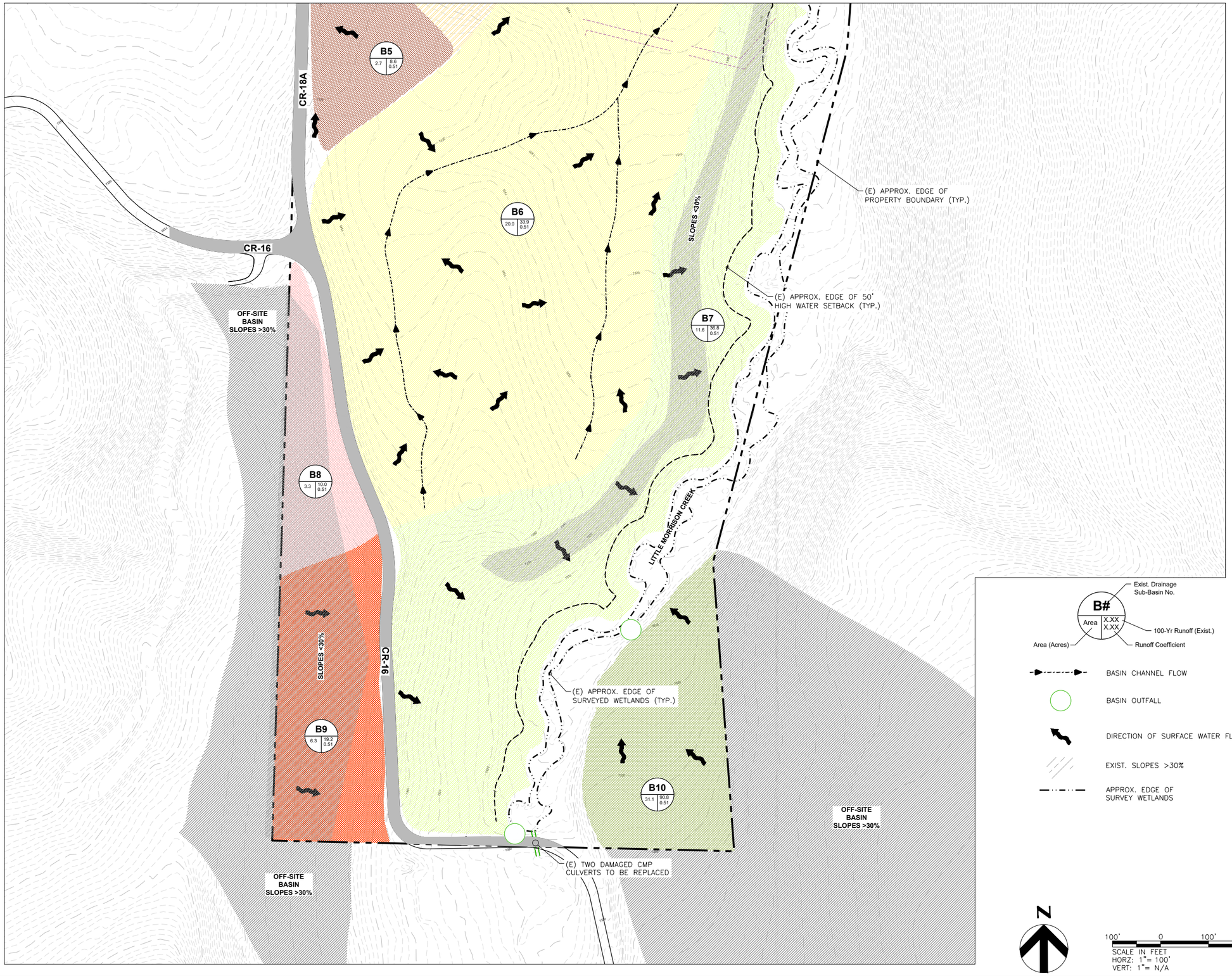
DRAWN BY: S. OTERO

SHEET TITLE:

EXIST. CONDITIONS MASTER DRAINAGE (NORTH)

SHEET NUMBER:

FIGURE 4



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PLOTTED BY: SAM OTERO
PLOT STYLE: 8140CAD_MSTANDARD.CTB

OWNER:

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STAGECOACH, LLC

PLANNER:

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Minturn, CO 81645
(970) 239-1485

ARCHITECT:

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0	01/11/24	PRELIMINARY PLAN SUBMISSION

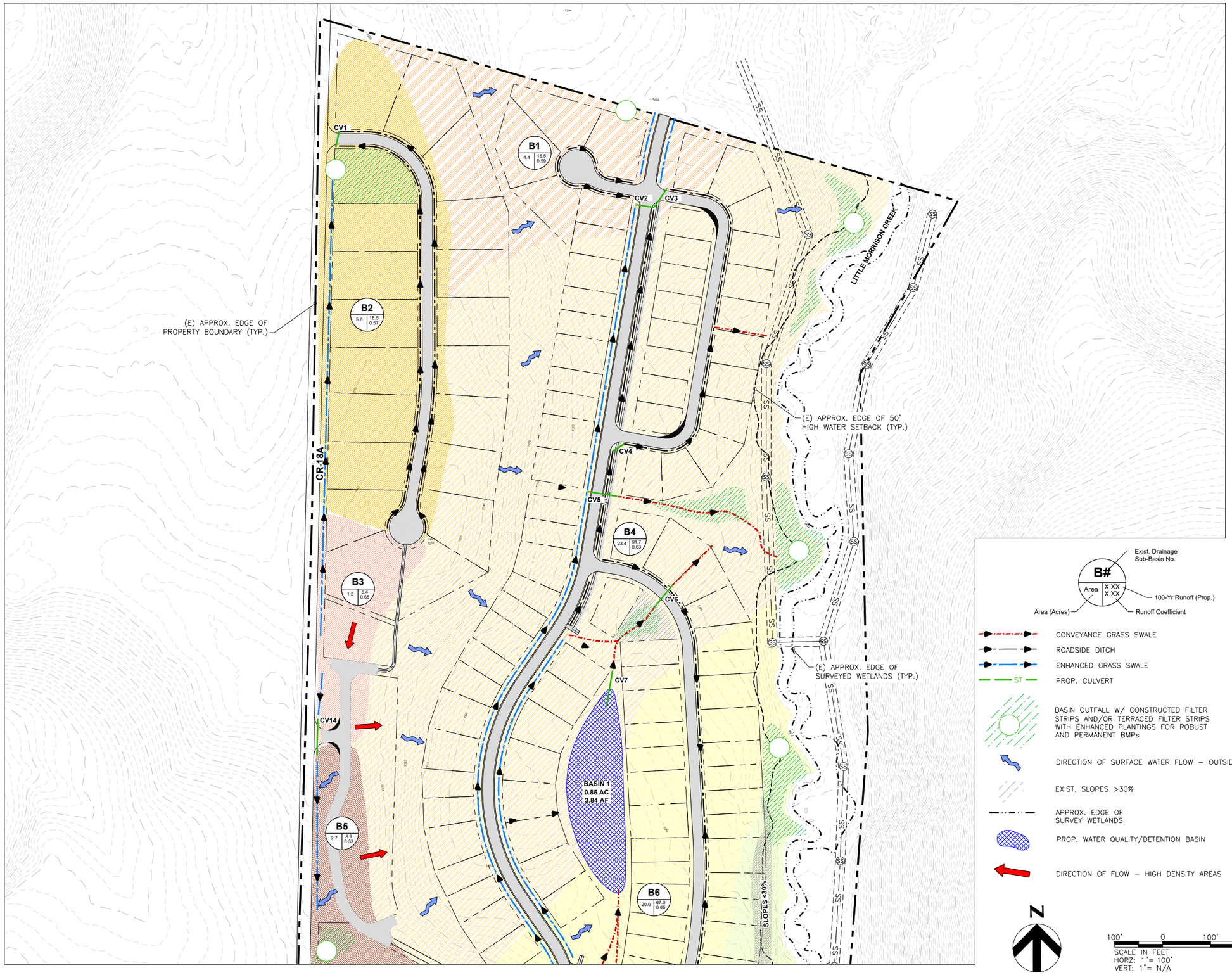
DRAWN BY: S. OTERO

SHEET TITLE:

EXIST. CONDITIONS MASTER DRAINAGE (SOUTH)

SHEET NUMBER:

FIGURE 4



OWNER:

TAILWATERS AT
STAGECOACH, LLC

PLANNER:

CONTOUR
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Minturn, CO 81645
(970) 239-1485

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LANDSCAPE ARCHITECT:

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COLORADO REGISTERED
William S Otero
WILLIAM S. OTERO
32163
10/09/24
PROFESSIONAL ENGINEER

ISSUE	DATE	DESCRIPTION
3	10/09/24	COUNTY PLAN COMMENTS
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1	07/19/24	PRELIMINARY PLAN UPDATE
0	01/11/24	PRELIMINARY PLAN SUBMISSION

DRAWN BY: S. OTERO

SHEET TITLE:

PROP. CONDITIONS MASTER DRAINAGE (NORTH)

SHEET NUMBER:

FIGURE 5

FILE NAME: N:\PROJECTS\BATTLE MOUNTAIN\STAGECOACH\MASTER PLANS\TAILWATERS_PROP_DRAINAGE.DWG
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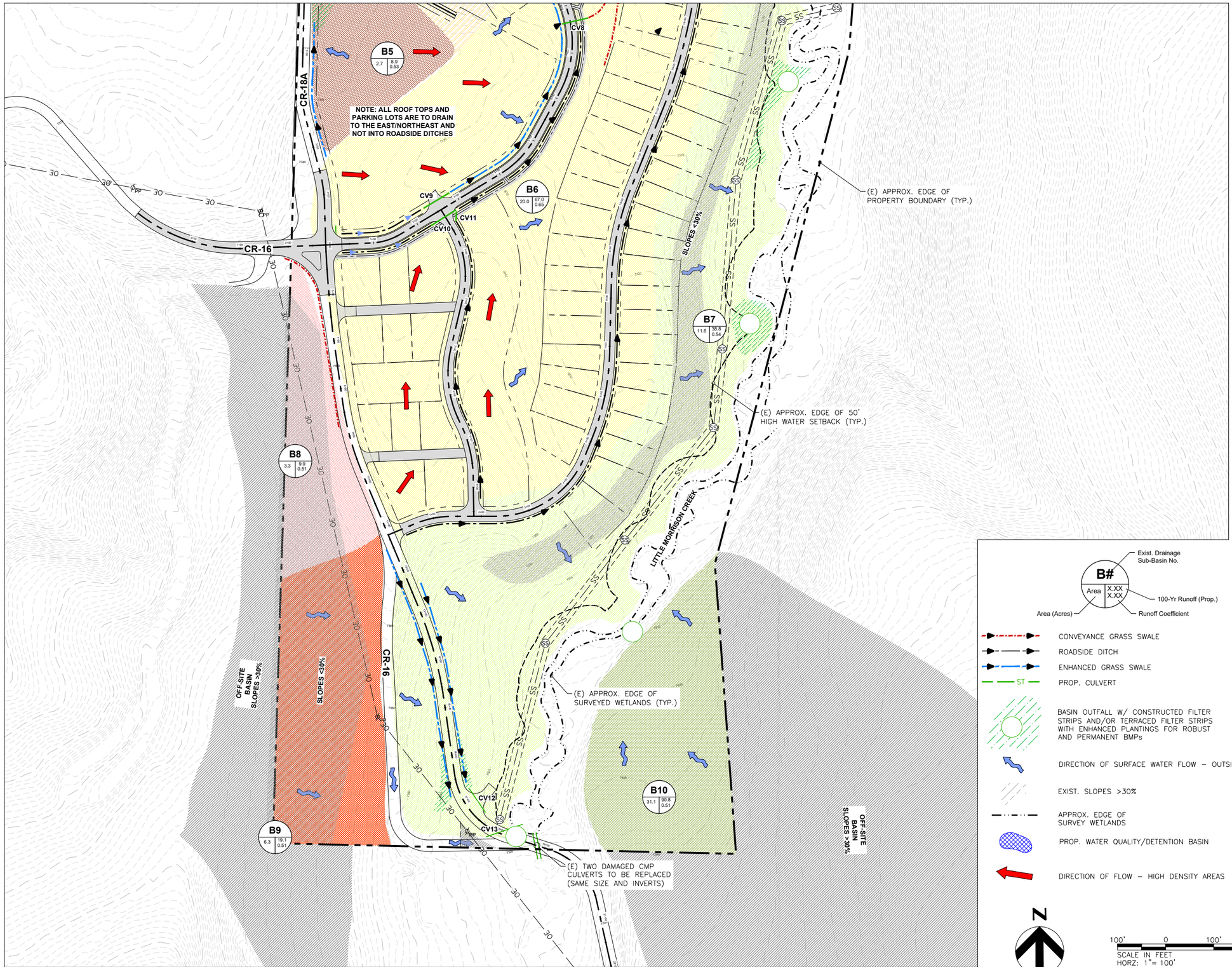
PLOT STYLE: 8140CAD_WSTANDARD.CTB



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PLOTTED BY= SAM OTERO
PLOT STYLE= 8140CAD_MSTANDARD.CTB

OWNER:

TAILWATERS AT STAGECOACH, LLC

PLANNER:

CONTOUR DESIGN COLLECTIVE
164 Railroad Ave
Minturn, CO 81645
(970) 239-1485

ARCHITECT:

LANDSCAPE ARCHITECT:

NOT FOR CONSTRUCTION

ENGINNER:

NKE 7638 S Crocker Ct
Littleton, CO 80120
(970) 445-8810

COLORADO REGISTERED WILLIAM S. OTERO 32163 10/09/24 PROFESSIONAL ENGINEER

ISSUE	DATE	DESCRIPTION
3	10/09/24	COUNTY PLAN COMMENTS
2	08/23/24	DRAINAGE PLAN UPDATE
1	07/19/24	PRELIMINARY PLAN UPDATE
0	01/11/24	PRELIMINARY PLAN SUBMISSION

DRAWN BY: S. OTERO

SHEET TITLE:

PROP. CONDITIONS MASTER DRAINAGE (SOUTH)

SHEET NUMBER:

FIGURE 5

APPENDIX B – Hydrologic and Hydraulic Calculations

HYDROLOGY CALCULATIONS

Sources: City of Steambot Springs - Engineering Standards, Revision July 2019
NOAA Atlas 14 (Station ID 05-7936)

Sub-Basin	I	P_1	$T_d=T_c$	T_c	T_i	T_t	C_{100}	L_o	S		Q	C_{100}	I	A	T_t	V	K	S_w	Notes
Existing Conditions - 100-year Event																			
B1	5.43	1.79	12.87	12.87	12.01	0.86	0.51	300	0.04	70	12.2	0.51	5.43	4.4	0.86	1.36	7	0.04	Overland Shallow Channel(s)
B2	4.97	1.79	14.96	14.96	10.33	4.63	0.51	300	0.06	474	14.2	0.51	4.97	5.6	4.63	1.71	7	0.06	Overland Shallow Channel(s)
B3	6.22	1.79	10.00	9.02	9.02	0.00	0.51	277	0.08		4.8	0.51	6.22	1.5				0.08	
B4	5.06	1.79	14.51	14.51	8.91	5.59	0.51	300	0.09	715	60.4	0.51	5.06	23.4	5.59	2.13	7	0.09	Overland Shallow Channel(s)
B5	6.22	1.79	10.00	10.25	10.11	0.14	0.51	300	0.06	15	8.6	0.51	6.22	2.7	0.14	1.76	7	0.06	Overland Shallow Channel(s)
B6	3.32	1.79	27.44	27.44	10.68	16.76	0.51	300	0.05	1633	33.9	0.51	3.32	20	16.76	1.62	7	0.05	Overland Shallow Channel(s)
B7	6.22	1.79	10.00	9.01	8.25	0.77	0.51	300	0.12	110	36.8	0.51	6.22	11.6	0.77	2.40	7	0.12	Overland Shallow Channel(s)
B8	5.92	1.79	11.00	11.00	8.15	2.85	0.51	300	0.12	590	10.0	0.51	5.92	3.3	2.85	3.45	10	0.12	Channels to Gravel Road (~40% Imperviousness for <5% of area)
B9	5.96	1.79	10.85	10.85	7.69	3.16	0.51	300	0.14	715	19.2	0.51	5.96	6.3	3.16	3.77	10	0.14	Channels to Gravel Road (~40% Imperviousness for <5% of area)
B10	5.73	1.79	11.68	11.68	7.18	4.50	0.51	300	0.18	795	90.8	0.51	5.73	31.1	4.50	2.95	7	0.18	Large Off Property Basin - min. contribution to on-site Sub-Basin
Proposed Conditions - 100-year Event																			
B1	5.98	1.79	10.79	10.79	10.39	0.40	0.59	300	0.04	70	15.5	0.59	5.98	4.4	0.40	2.92	15	0.04	Overland Shallow Channel(s)
B2	5.79	1.79	11.43	11.43	9.27	2.16	0.57	300	0.06	474	18.5	0.57	5.79	5.6	2.16	3.66	15	0.06	Overland Shallow Channel(s)
B3	6.22	1.79	10.00	6.38	6.38	0.00	0.68	277	0.08		6.4	0.68	6.22	1.5				0.08	
B4	6.22	1.79	10.00	9.71	7.10	2.61	0.63	300	0.09	715	91.7	0.63	6.22	23.4	2.61	4.56	15	0.09	Overland Shallow Channel(s)
B5	6.22	1.79	10.00	9.77	9.72	0.05	0.53	300	0.06	15	8.9	0.53	6.22	2.7	0.05	5.04	20	0.06	Overland Shallow Channel(s)
B6	5.16	1.79	14.03	14.03	8.17	5.87	0.65	300	0.05	1633	67.0	0.65	5.16	20	5.87	4.64	20	0.05	Overland Shallow Channel(s)
B7	6.22	1.79	10.00	8.22	7.86	0.36	0.54	300	0.12	110	38.8	0.54	6.22	11.6	0.36	5.13	15	0.12	Overland Shallow Channel(s)
B8	5.90	1.79	11.05	11.05	8.20	2.85	0.51	300	0.12	590	9.9	0.51	5.90	3.3	2.85	3.45	10	0.12	Channels to Gravel Road (~40% Imperviousness for <5% of area)
B9	5.95	1.79	10.90	10.90	7.73	3.16	0.51	300	0.14	715	19.1	0.51	5.95	6.3	3.16	3.77	10	0.14	Channels to Gravel Road (~40% Imperviousness for <5% of area)
B10	5.73	1.79	11.68	11.68	7.18	4.50	0.51	300	0.18	795	90.8	0.51	5.73	31.1	4.50	2.95	7	0.18	Large Off Property Basin - min. contribution to on-site Sub-Basin

Sub-Basin	I	P_1	$T_d=T_c$	T_c	T_i	T_t	C_5	L_o	S		Q	C_5	I	A	T_t	V	K	S_w	Notes
Existing Conditions - 5-year Event																			
B1	3.86	0.82	4.99	4.99	4.13	0.86	0.16	300	3.78	70	2.7	0.16	3.86	4.4	0.86	1.36	7	0.04	Overland Shallow Channel(s)
B2	3.15	0.82	8.18	8.18	3.55	4.63	0.16	300	5.94	474	2.8	0.16	3.15	5.6	4.63	1.71	7	0.06	Overland Shallow Channel(s)
B3	4.47	0.82	3.10	3.10	3.10	0.00	0.16	277	7.94		1.1	0.16	4.47	1.5					
B4	3.06	0.82	8.66	8.66	3.06	5.59	0.16	300	9.26	715	11.5	0.16	3.06	23.4	5.59	2.13	7	0.09	Overland Shallow Channel(s)
B5	4.28	0.82	3.62	3.62	3.48	0.14	0.16	300	6.35	15	1.8	0.16	4.28	2.7	0.14	1.76	7	0.06	Overland Shallow Channel(s)
B6	1.87	0.82	20.43	20.43	3.67	16.76	0.16	300	5.38	1633	6.0	0.16	1.87	20	16.76	1.62	7	0.05	Overland Shallow Channel(s)
B7	4.29	0.82	3.60	3.60	2.83	0.77	0.16	300	11.71	110	8.0	0.16	4.29	11.6	0.77	2.40	7	0.12	Overland Shallow Channel(s)
B8	3.68	0.82	5.67	5.67	2.82	2.85	0.16	300	11.91	590	1.9	0.16	3.68	3.3	2.85	3.45	10	0.12	Channels to Gravel Road (~40% Imperviousness for <5% of area)
B9	3.64	0.82	5.82	5.82	2.66	3.16	0.16	300	14.19	715	3.7	0.16	3.64	6.3	3.16	3.77	10	0.14	Channels to Gravel Road (~40% Imperviousness for <5% of area)
B10	3.38	0.82	6.97	6.97	2.47	4.50	0.16	300	17.72	795	16.8	0.16	3.38	31.1	4.50	2.95	7	0.18	Large Off Property Basin - min. contribution to on-site Sub-Basin
Proposed Conditions - 5-year Event																			
B1	4.23	0.82	3.78	3.78	3.38	0.40	0.33	300	3.78	70	6.1	0.33	4.23	4.4	0.40	2.92	15	0.04	Overland Shallow Channel(s)
B2	3.80	0.82	5.21	5.21	3.05	2.16	0.29	300	5.94	474	6.2	0.29	3.80	5.6	2.16	3.66	15	0.06	Overland Shallow Channel(s)
B3	4.96	0.82	1.93	1.93	1.93	0.00	0.51	277	7.94		3.8	0.51	4.96	1.5					
B4	3.88	0.82	4.90	4.90	2.29	2.61	0.40	300	9.26	715	36.1	0.40	3.88	23.4	2.61	4.56	15	0.09	Overland Shallow Channel(s)
B5	4.60	0.82	2.75	2.75	2.68	0.07	0.37	300	6.35	15	4.7	0.37	4.60	2.7	0.07	3.78	15	0.06	Overland Shallow Channel(s)
B6	2.78	0.82	10.46	10.46	2.64	7.82	0.43	300	5.38	1633	23.7	0.43	2.78	20	7.82	3.48	15	0.05	Overland Shallow Channel(s)
B7	4.69	0.82	2.53	2.53	2.18	0.36	0.38	300	11.71	110	20.6	0.38	4.69	11.6	0.36	5.13	15	0.12	Overland Shallow Channel(s)
B8	4.09	0.82	4.21	4.21	2.79	1.42	0.17	300	11.91	590	2.3	0.17	4.09	3.3	1.42	6.90	20	0.12	Channels to Gravel Road (~40% Imperviousness for <5% of area)
B9	4.09	0.82	4.21	4.21	2.63	1.58	0.17	300	14.19	715	4.4	0.17	4.09	6.3	1.58	7.53	20	0.14	Channels to Gravel Road (~40% Imperviousness for <5% of area)
B10	3.39	0.82	6.94	6.94	2.44	4.50	0.17	300	17.72	795	17.9	0.17	3.39	31.1	4.50	2.95	7	0.18	Large Off Property Basin - min. contribution to on-site Sub-Basin

UPDATED: 10/8/2024

Sub-Basin	I	P_1	T_d=T_c	T_c	T_i	T_t	C_{25}	L_o	S		Q	C_{25}	I	A	T_t	V	K	S_w	Notes
Existing Conditions - 25-year Event																			
B1	6.78	1.34	4.02	4.02	3.16	0.86	0.38	300	3.78	70	11.3	0.38	6.78	4.4	0.86	1.36	7	0.04	Overland Shallow Channel(s)
B2	5.40	1.34	7.35	7.35	2.72	4.63	0.38	300	5.94	474	11.5	0.38	5.40	5.6	4.63	1.71	7	0.06	Overland Shallow Channel(s)
B3	7.78	1.34	2.37	2.37	2.37	0.00	0.38	277	7.94		4.4	0.38	7.78	1.5					
B4	5.21	1.34	7.94	7.94	2.35	5.59	0.38	300	9.26	715	46.4	0.38	5.21	23.4	5.59	2.13	7	0.09	Overland Shallow Channel(s)
B5	7.49	1.34	2.80	2.80	2.66	0.14	0.38	300	6.35	15	7.7	0.38	7.49	2.7	0.14	1.76	7	0.06	Overland Shallow Channel(s)
B6	3.14	1.34	19.58	19.58	2.81	16.76	0.38	300	5.38	1633	23.8	0.38	3.14	20	16.76	1.62	7	0.05	Overland Shallow Channel(s)
B7	7.40	1.34	2.94	2.94	2.17	0.77	0.38	300	11.71	110	32.6	0.38	7.40	11.6	0.77	2.40	7	0.12	Overland Shallow Channel(s)
B8	6.30	1.34	5.01	5.01	2.16	2.85	0.38	300	11.91	590	7.9	0.38	6.30	3.3	2.85	3.45	10	0.12	Channels to Gravel Road (~40% Imperviousness for <5% of area)
B9	6.21	1.34	5.20	5.20	2.04	3.16	0.38	300	14.19	715	14.9	0.38	6.21	6.3	3.16	3.77	10	0.14	Channels to Gravel Road (~40% Imperviousness for <5% of area)
B10	5.73	1.34	6.39	6.39	1.89	4.50	0.38	300	17.72	795	67.8	0.38	5.73	31.1	4.50	2.95	7	0.18	Large Off Property Basin - min. contribution to on-site Sub-Basin
Proposed Conditions - 25-year Event																			
B1	7.32	1.34	3.06	3.06	2.66	0.40	0.49	300	3.78	70	15.9	0.49	7.32	4.4	0.40	2.92	15	0.04	Overland Shallow Channel(s)
B2	6.49	1.34	4.60	4.60	2.44	2.16	0.46	300	5.94	474	16.6	0.46	6.49	5.6	2.16	3.66	15	0.06	Overland Shallow Channel(s)
B3	8.37	1.34	1.59	1.59	1.59	0.00	0.62	277	7.94		7.8	0.62	8.37	1.5					
B4	6.57	1.34	4.42	4.42	1.81	2.61	0.55	300	9.26	715	83.8	0.55	6.57	23.4	2.61	4.56	15	0.09	Overland Shallow Channel(s)
B5	8.22	1.34	1.77	1.77	1.70	0.07	0.64	300	6.35	15	14.2	0.64	8.22	2.7	0.07	3.78	15	0.06	Overland Shallow Channel(s)
B6	4.68	1.34	9.90	9.90	2.08	7.82	0.57	300	5.38	1633	53.1	0.57	4.68	20	7.82	3.48	15	0.05	Overland Shallow Channel(s)
B7	7.98	1.34	2.10	2.10	1.74	0.36	0.52	300	11.71	110	48.4	0.52	7.98	11.6	0.36	5.13	15	0.12	Overland Shallow Channel(s)
B8	7.02	1.34	3.58	3.58	2.16	1.42	0.38	300	11.91	590	8.8	0.38	7.02	3.3	1.42	6.90	20	0.12	Channels to Gravel Road (~40% Imperviousness for <5% of area)
B9	7.00	1.34	3.62	3.62	2.04	1.58	0.38	300	14.19	715	16.7	0.38	7.00	6.3	1.58	7.53	20	0.14	Channels to Gravel Road (~40% Imperviousness for <5% of area)
B10	5.73	1.34	6.39	6.39	1.89	4.50	0.38	300	17.72	795	67.8	0.38	5.73	31.1	4.50	2.95	7	0.18	Large Off Property Basin - min. contribution to on-site Sub-Basin

UPDATED: 10/8/2024

HYDRUALICS AND VOLUME CALCULATIONS

Sources:
City of Steambot Springs - Engineering Standards, Revision July 2019
Mile High Flood District - Urban Storm Drainage Criterial Manual Volume 3, Revision October 2019

DETENTION BASIN SIZING

Allowable Release Rate				
	Minor	0.10	25	2.5
	Major	0.54	25	13.5
C				
5 Yr	Minor	0.42		
100 Yr	Major	0.55		
Intensity				
	Minor	3.14		
	Major	5.37		
Inflow Volume				
	Minor	15,195	ft^3	
	Major	47,797	ft^3	
Outflow Volume				
	Minor	1,156	ft^3	
	Major	8,673	ft^3	
Required Storage				
	Minor	14,038	0.32	AF
	Major	39,125	0.90	AF

BASIN 1

Top Surface Area		0.85		
Bottom Surface Area		0.64		
		4.5		Depth of Basin
100 Yr	1.41	31%		Full at Major Storm
5 Yr	0.51	11%		Full at Minor Storm

WQCV

WQCV	0.20	(watershed-inches)	
Required Storage	0.42	AF	
Required Storage (Quanity and Quality)			
Minor	0.74	AF	
Major	1.31	AF	
	2.06	46%	Full at Major Storm
	1.16	26%	Full at Minor Storm

ENHANCED GRASS SWALE/CHANNEL

B1/B2	Normal Depth	0.309	ft
7 fps	Velocity	2.456	fps
	Froude #	0.83	
	Critical Depth	0.274	ft
	Critical Velocity	2.806	fps
	Froude #	1	
B4/B6	Normal Depth	0.703	ft
30 fps	Velocity	3.947	fps
	Froude #	0.932	
	Critical Depth	0.674	ft
	Critical Velocity	4.161	fps
	Froude #	1	

ROADSIDE DITCHES

Average Slope	0.25	
	Range (0.65 - 0.05)	
Manning's n	0.04	GRASS LINED
Normal Depth	0.78	AVERAGE DICTH DEPTH 2 FT
Velocity	3.445	
Froude #	0.868	

CULVERTS

CULVERT	LENGTH (FT)	INVERT IN	INVERT OUT	SIZE (IN)	OUTLET VELOCITY (FPS)	Depth (FT)	NOTES
1	35	7309.5	7309.0	18	2.87	0.23	CR18A ROADSIDE DITCH AT PARAPET DR ENTRANCE
2	35	7279.5	7279.0	18	2.48	0.45	
3	45	7279.0	7278.5	18	3.92	0.79	
4	30	7290.0	7289.0	18	3.04	0.22	
5	65	7290.0	7284.0	24	2.39	0.61	TAILWATERS BLVD CROSSING
6	65	7284.0	7280.0	18	4.71	0.51	OUTLET CONTINUATION
7	75	7292.0	7290.0	18	4.51	0.61	BASIN 1 OUTLET
8	55	7314.0	7312.0	24	3.96	1.04	TAILWATERS BLVD CROSSING
9	65	7334.0	7332.0	18	2.95	0.23	
10	65	7333.0	7332.0	18	2.95	0.23	
11	20	7333.0	7332.5	18	3.95	0.45	
12	60	7326.0	7325.0	24	3.30	0.45	CR16 ROADSIDE DITCH
13	80	7327.0	7325.0	24	5.18	0.69	CR16 ROAD CROSSSING - SIZED FOR 100-YR
14	75	7338.0	7336.0	18	1.85	0.18	CR18A ROADSIDE DITCH AT CREST CT ENTRANCE

NOTES:

ANAYSIS USING HY-8, FEDERAL HIGHWAY ADMINISTRATION
ALL CULVERTS WERE SIZED TO BE INLET CONTROLLED - MAX. OF 80% FULL
18" MIN. PIPE SIZE
ASSUMED CMP W/ FLARED END SECTIONS
ASSUMED FLOW RANGES APPROX. -25% TO +50% FOR 5-YR AT FULL DEVELOPMENT BUILD-OUT

UPDATED: 10/8/2024

APPENDIX C – Examples of Water Quality BMPs

APPENDIX C - WATER QUALITY BMP EXAMPLES

C.1 FACT SHEETS

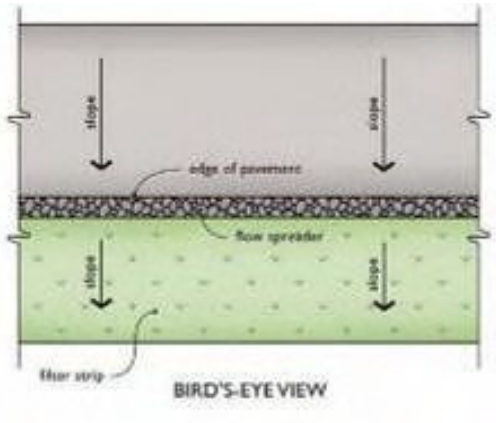
The following fact sheets provide information on potential water quality BMPs that may be used to reduce pollutant loading from the Bolts Lake Character Area into the Eagle River.

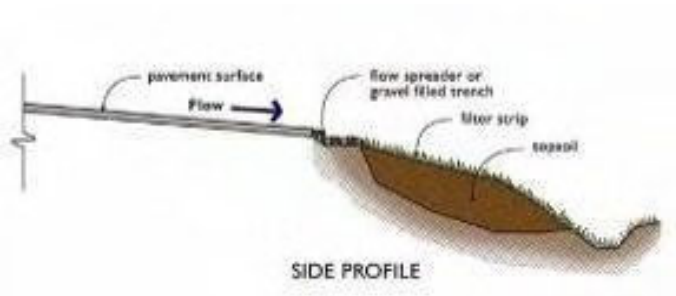
C.2 FILTER STRIP

C.2.1 Description

Uniformly graded and densely vegetated areas of turf grass, requiring sheet flow to promote filtration, infiltration and settling. GBs differ from grass swales as they are designed to accommodate overland sheet flow rather than concentrated flow.

Schematic Detail





C.2.2 Application

Can be used in residential and commercial areas and along highways and roads. Limit contributing area to provide evenly distributed sheet flow.

C.2.3 Design Criteria

- Minimum width (distance along sheet flow direction) = 10 feet.
- Preferred shape is rectangular and should be free of gullies or rills.
- Maximum design slope in direction of flow = 4%.
- Incorporate slotted curbing, modular block porous pavement (MBP), or other spreader devices to distribute flows into buffer.
- Outflow to grass swale (GS), storm sewer, street gutter, or underdrain.

C.2.4 Effectiveness

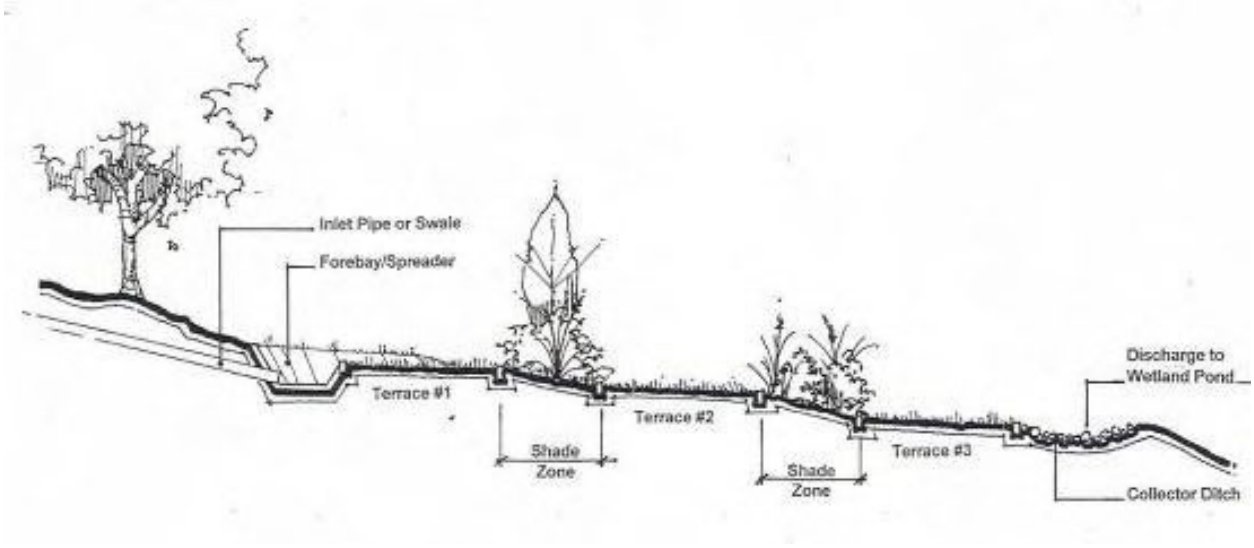
- TSS: 50% - 80%
- N and P: 50% - 80%
- Pathogens: < 30%
- Metals: 30% - 65%

C.3 TERRACED FILTER STRIP

C.3.1 Description

Densely vegetated areas requiring sheet flow to promote filtration, infiltration and settling. Terraced to slow runoff on steeper slopes.

Schematic Detail



C.3.2 Application

Can be used in residential and commercial areas and along highways and roads where steep slopes exist adjacent to impervious surfaces (e.g. parking lots or roadways). Runoff can be direct to the facility via an inlet pipe or sheet flow into the forebay.

C.3.3 Design Criteria

- Forebay volume to be approximately 25% of the total water quality storm volume
- Maximum design slope along Terrace Zone is 4%.
- Terrace sections to conform with Filter Strip design criteria.
- Shade Zones to be delineated with hard edged surface to control grade transition between Terrace Zones.
- Maximize sun exposure in Terrace Zones to promote evapotranspiration.

C.3.4 Effectiveness

Assumed to be similar to the Filter Strip:

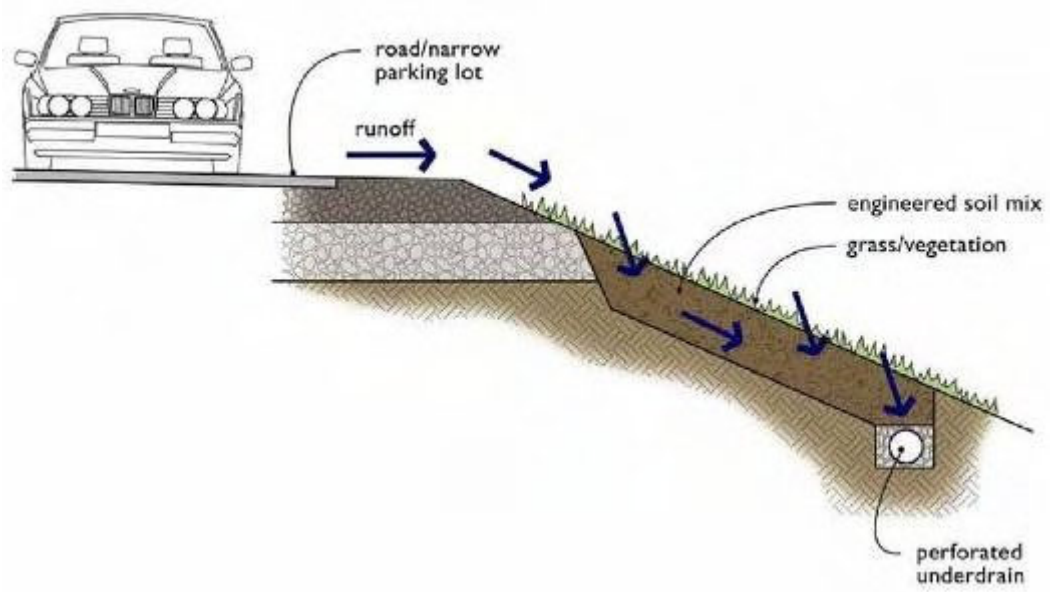
- TSS: 50% - 80%
- N and P: 50% - 80%
- Pathogens: < 30%
- Metals: 30% - 65%

C.4 ECOLOGY EMBANKMENT

C.4.1 Description

A filter strip designed for impervious areas with flow paths of 30 feet or less that can drain along their widest dimension to grassy areas. Uses filtration through a pervious, alkalinity-generating treatment medium called the ecology mix.

Schematic Detail



C.4.2 Application

Typical applications are side slopes and medians for highways and roads with limited right-of-way widths and narrow parking strips.

C.4.3 Design Criteria

- Lateral gradients generally less than 25% (4H:1V).
- Longitudinal gradients less than 5%.
- Water should sheet flow across the dual ecology embankment.
- Group C or D soils require a perforated underdrain.
- Engineered soil mix to promote infiltration.

C.4.4 Effectiveness

Assumed to be similar to the Filter Strip:

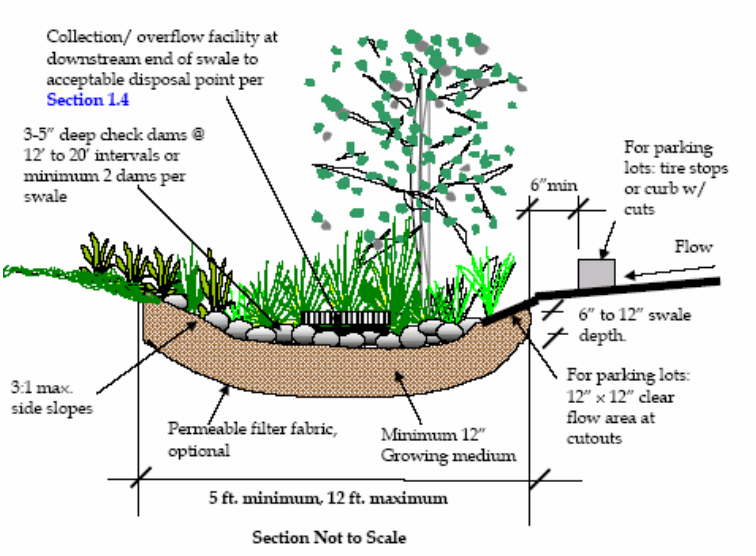
- TSS: 50% - 80%
- N and P: 50% - 80%
- Pathogens: < 30%
- Metals: 30% - 65%

C.5 ENHANCED GRASS SWALE

C.5.1 Description

Earthen conveyance systems in which pollutants are removed from urban stormwater by filtration through grass and infiltration through soil utilizing check dams and wide depressions to increase runoff storage and promote greater settling of pollutants.

Schematic Detail



C.5.2 Application

- Maximum drainage area approximately 5 acres.
- Adjacent to paved areas, including streets and parking lots, contributing runoff via sheet flow or point discharge.

C.5.3 Design Criteria

- Swales should be designed with relatively wide bottoms.
- Maximum velocity = 1.5 fps.
- Maximum slope is 6%.
- Minimum slope is 1%.
- Minimum swale length is 20 feet.
- Silty or clayey soils shall be amended in the top 12 inches of the swale.
- Check dams shall be 12 inches in length and 3 inches in height.
- Liners may be required for protection of groundwater or building foundation.

C.5.4 Effectiveness

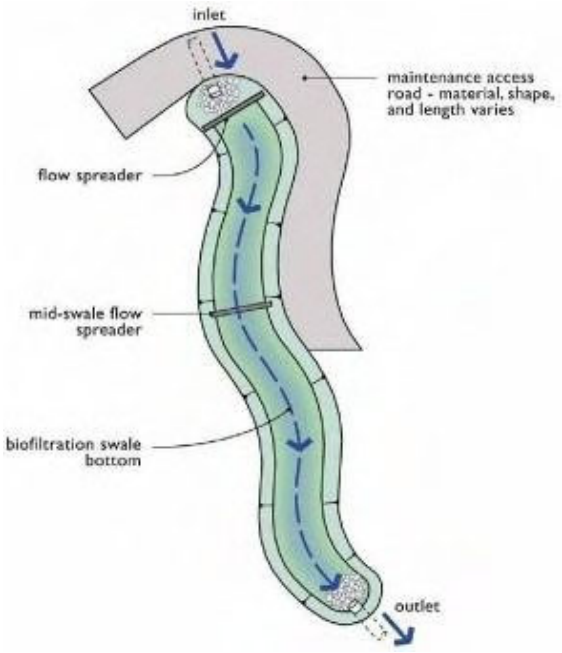
- TSS: 50% - 80%
- N and P: 50% - 80%
- Pathogens: < 30%
- Metals: 30% - 65%

C.6 WET BIOFILTRATION SWALE

C.6.1 Description

A swale is a densely vegetated drainageway with low-pitched side slopes that collect and slowly convey runoff. A wet biofiltration swale is a variation with vegetation specifically adapted to wet soil conditions.

Schematic Detail



C.6.2 Application

- Collects overland flows from parking lots, buildings, residential yards, roadways, and grass buffer strips.
- Use where the centerline slope is slight, groundwater tables are high, or a continuous base flow is likely to result in wet soil conditions.
- Can be part of plans to minimize a directly connected impervious area.

C.6.3 Design Criteria

- Maximum flow velocity = 1 fps.
- Maximum flow depth = 1 foot for 2-year peak flow.
- Prevent flooding from larger storms (5-year to 100-year).
- Developed with dense vegetation established with temporary irrigation, if necessary.
- Trapezoidal or triangular cross section with side slopes flatter than 4:1.
- Longitudinal slope between 0.2 and 1.0%.

C.6.4 Effectiveness

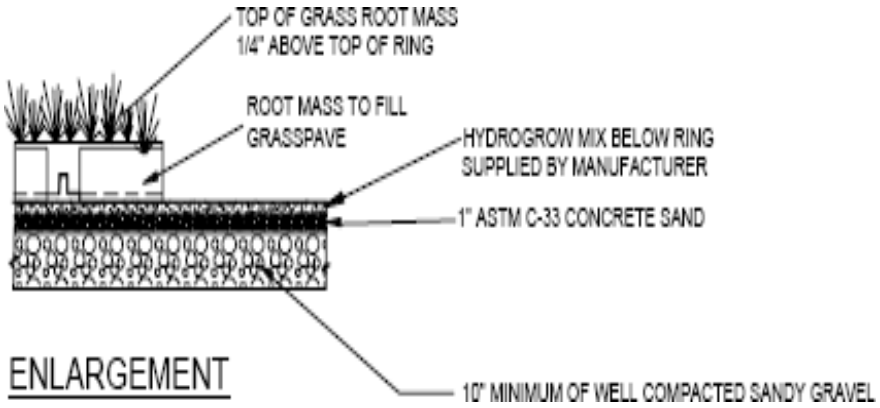
- TSS: 50% - 80%
- N and P: 50% - 80%
- Pathogens: < 30%
- Metals: 30% - 65%

C.7 REINFORCED GRASS PAVEMENT (RGP)

C.7.1 Description

Porous pavement is designed to infiltrate stormwater runoff instead of shedding it off the surface. RGP is a stabilized grass surface.

Schematic Detail



C.7.2 Application

- Intended for use in parking lots that experience intermittent use, roadway shoulders, residential street parking lanes, and emergency vehicle access lanes.
- Also used with light aircraft not exceeding a gross load of 12,500 pounds.

C.7.3 Design Criteria

- Closely follow manufacturer's instructions.
- Under grass, install compacted gravel layer and non-woven geotextile fabric.
- Adequate compaction of sub-grade is critical.
- Vehicle lanes that lead up to RGP surfaces must be asphalt, concrete or porous concrete pavement.

C.7.4 Effectiveness

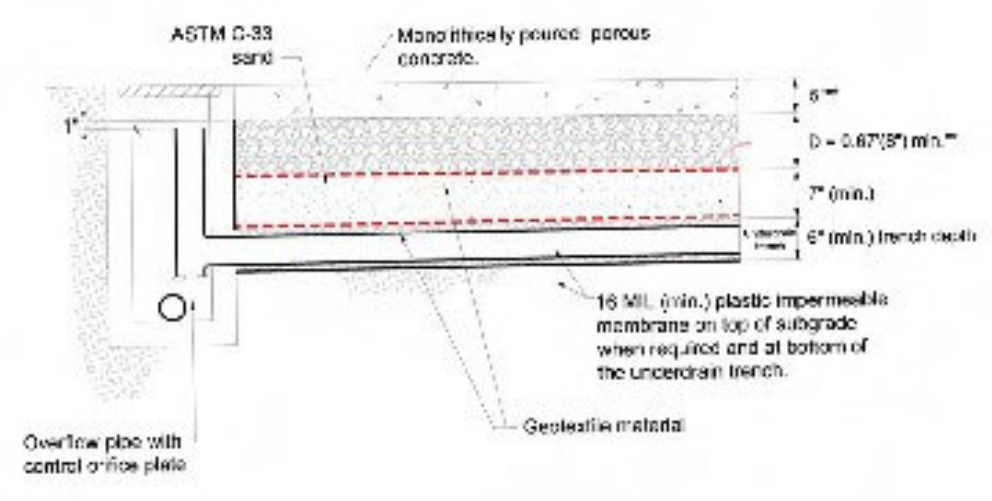
- TSS: 65% - 100%
- N: 65% - 100%
- P: 30% - 65%
- Pathogens: 65% - 100%
- Metals: 65% - 100%

C.8 POROUS CONCRETE PAVEMENT (PCP)

C.8.1 Description

Porous pavement is designed to infiltrate stormwater runoff instead of shedding it off the surface. PCP is a monolithically poured porous concrete pavement that has 15% to 21% of its volume as void ratio. Voids are achieved by eliminating fine sand from the mix.

Schematic Detail



C.8.2 Application

- Low vehicle movement zones, including roadway shoulders, driveways, parking strips/lanes, parking lots, maintenance roads, airport aprons, crossover lanes on divided highways, emergency vehicle access lanes, and equipment storage areas.
- PCP is not recommended for use in Porous Pavement Detention installations.

C.8.3 Design Criteria

- Strictly enforce the concrete mix and placement specifications.
- A sufficient aggregate base course layer under the porous concrete slab is critical to store the runoff and allow it to infiltrate slowly into the ground.
- Use an underdrain pipe system.

C.8.4 Effectiveness

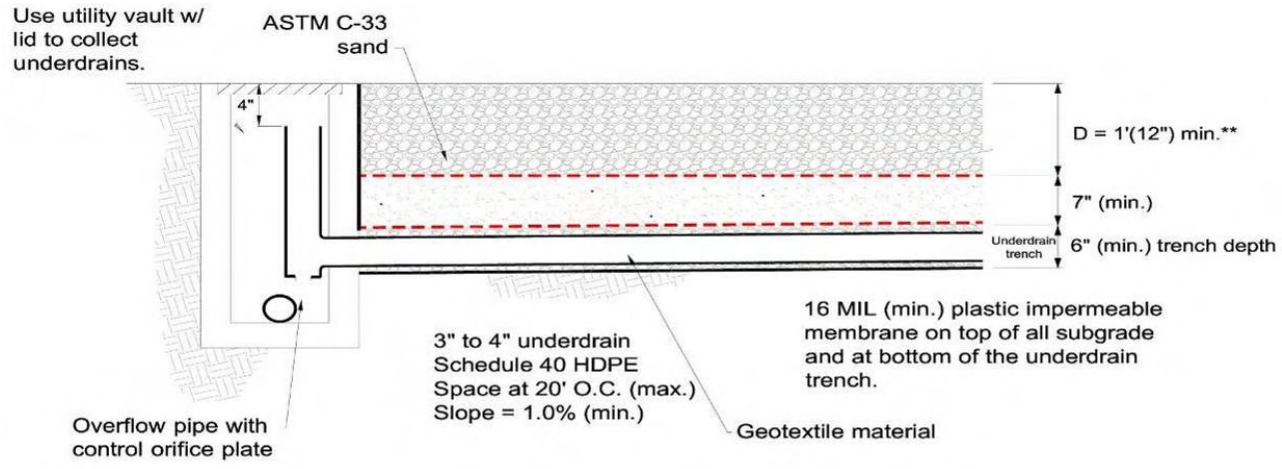
- TSS: 65% - 100%
- N: 65% - 100%
- P: 30% - 65%
- Pathogens and metals: 65% - 100%

C.9 POROUS GRAVEL PAVEMENT (PGP)

C.9.1 Description

Porous pavement is designed to infiltrate stormwater runoff instead of shedding it off the surface. PGP is a loose gravel-surface paving.

Schematic Detail



C.9.2 Application

- Used for industrial or commercial storage yards or for parking of vehicles in such yards.
- Also used for maintenance roads, crossover lanes on divided highways, street parking lanes in low density areas, maintenance roads, emergencyaccess lanes.
- Can be used in Porous Pavement Detention installations.

C.9.3 Design Criteria

A sufficient aggregate base course layer under the porous concrete slab is critical to store the runoff and allow it to infiltrate slowly into the ground.

C.9.4 Effectiveness

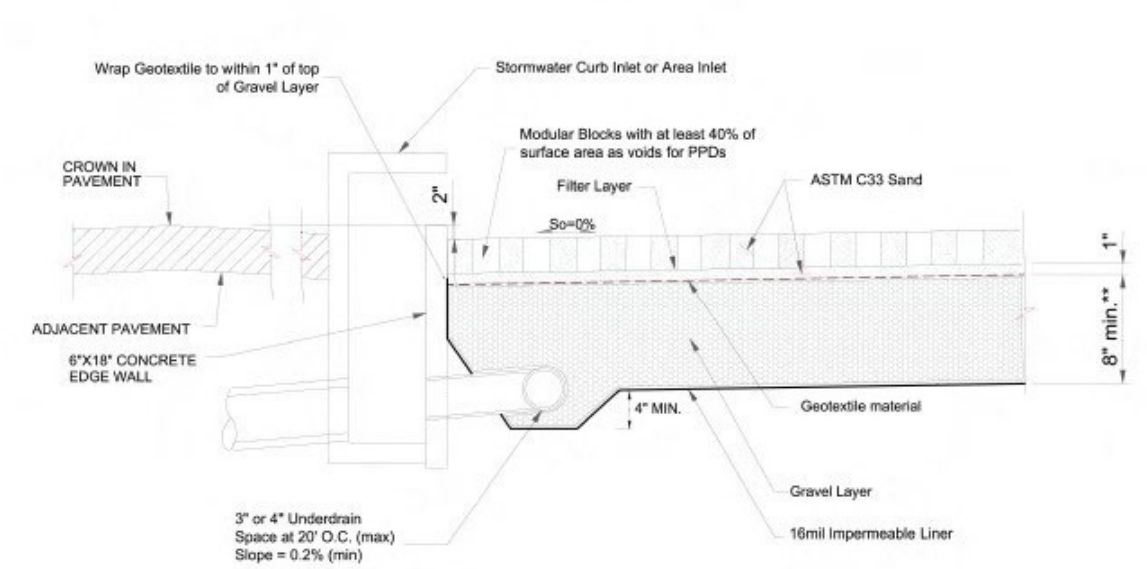
- TSS: 65% - 100%
- N: 65% - 100%
- P: 30% - 65%
- Pathogens and metals: 65% - 100%

C.10 POROUS PAVEMENT DETENTION (PPD)

C.10.1 Description

Porous pavement detention (PPD) consists of an installation of flat porous pavement, provided with 2” deep surcharge zone to temporarily store the WQCV. The ponded and filtered water slowly exits through an underdrain.

Schematic Detail



C.10.2 Application

Used in the same types of low vehicle movement zones identified for Modular Block Pavement, with the driveways leading up to them being solid pavement.

C.10.3 Design Criteria

- So=0.00% in all directions.
- Modular blocks with no less than 40% of the surface area open.
- The MBP openings filled with graded sand, and a 1-inch layer of sandleveling-course below the blocks.
- Use a geotextile material to encourage infiltration or install animpermeable membrane below the base coarse.

C.10.4 Effectiveness

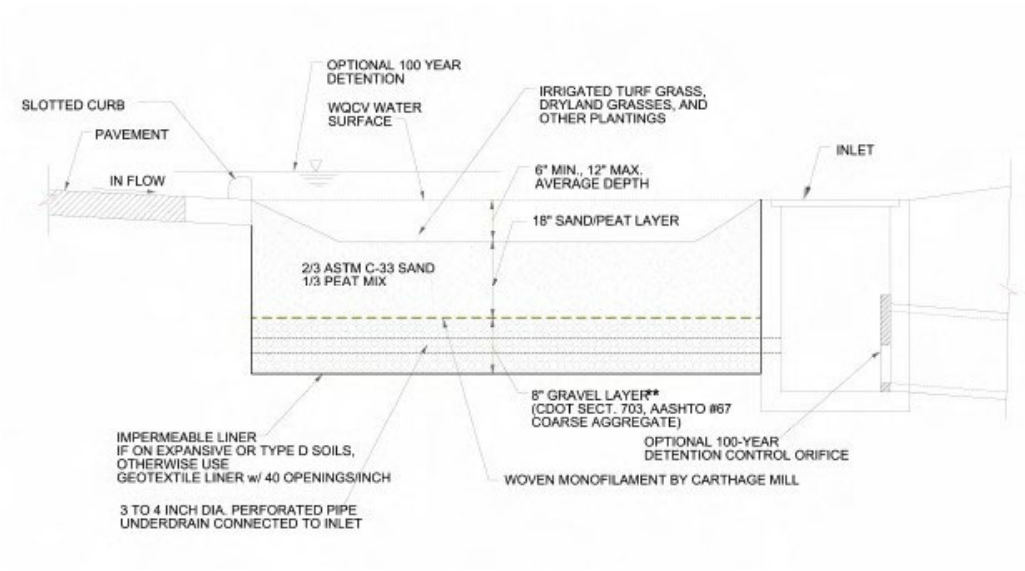
- TSS: 70% - 90%
- TP: 40% - 55%
- TN: 10% - 20%
- Metals: 40% - 80%

C.11 POROUS LANDSCAPE DETENTION (PLD)

C.11.1 Description

Consists of a low-lying vegetated area underlain by a sand bed with an underdrain pipe. A shallow surcharge zone exists above the PLD, and an underdrain gradually dewaters the sand bed and discharges the runoff to a nearby channel, swale, or storm sewer.

Schematic Detail



C.11.2 Application

- A PLD can be located in just about any of the open areas of a site. It is ideally suited for small installations such as parking lot islands, street medians, roadside swale features, and site entrance or buffer features.
- May also be implemented at a larger scale, serving as an infiltration basin for an entire site.

C.11.3 Design Criteria

- Vegetation: irrigated bluegrass or natural grasses; shrub and tree plantings if desired.
- Avoid side slopes steeper than 4h:1v.
- Underdrain not needed for Type A, B or C soils.
- Use impermeable liner for basin if expansive or Type D soils are present.
- If soils are not expansive (i.e., Type A, B or C), use a geotextile material.

C.11.4 Effectiveness

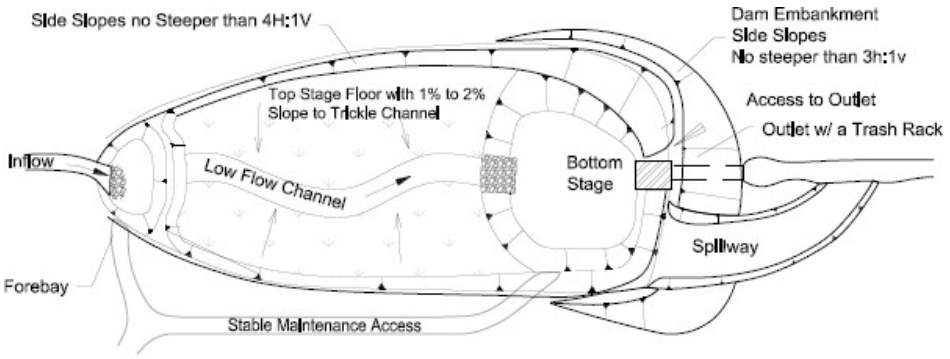
- TSS: 70% - 90%
- TP: 40% - 55%
- TN: 20% - 55%
- Metals: 50% - 80%

C.12 EXTENDED DETENTION BASIN (EDB)

C.12.1 Description

An adaptation of a flood control basin, with smaller outlet that extends the emptying time of the more frequently occurring runoff events to facilitate pollutant removal.

Schematic Detail



C.12.2 Application

- Runoff from roads, parking lots, residential neighborhoods, commercial areas, and industrial sites.
- Generally for regional or follow-up treatment, but can be used as an onsite BMP.
- Most applicable for catchments with impervious area of 10 acres or more.
- Can be used during construction to trap sediment.
- Can sometimes be retrofitted into existing flood control detention basins.
- Preferable to accommodate other urban uses within the basin (e.g., recreation).

C.12.3 Design Criteria

- Drain time = 40 hours.
- Enhance pollutant removal with small wetland pond in the basin's bottom.
- A perforated outlet is standard, but other types may be used.
- Basin length to width ratio between 2:1 to 3:1.
- Provide a maintainable trickle-flow channel.
- Provide a forebay near the inlet that allows for larger particles to settle out.

C.12.4 Effectiveness

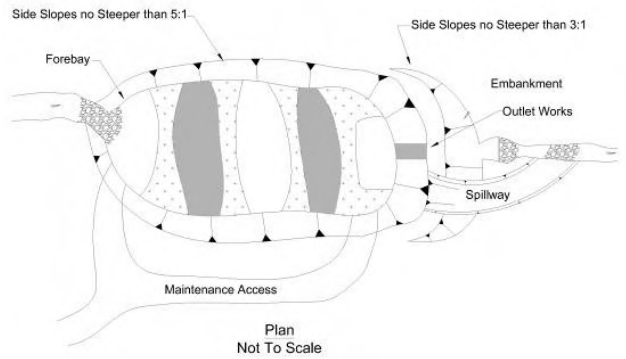
- TSS: 30% - 65%
- N and P: 15% - 45%
- Pathogens: < 30%
- Metals: 15% - 45%

C.13 CONSTRUCTED WETLANDS BASIN (CWB)

C.13.1 Description

A shallow retention pond that requires a perennial base flow to permit the growth of rushes, willows, cattails, and reeds to slow runoff and allow time for sedimentation, filtering, and biological uptake.

Schematic Detail



C.13.2 Application

- Used as a follow-up BMP in a watershed, or as stand-alone facility if runoffis sufficient.
- Not generally allowed on receiving waters.
- Cannot be used to mitigate the loss of natural wetlands.

C.13.3 Design Criteria

- Maximum surcharge depth = 2.0 feet.
- Shape the pond to limit short circuiting.
- Basin length to width ratio between 2:1 and 4:1.
- Basin side slopes should be no steeper than 4:1, preferably 5:1 or flatter.
- Provide a means to dissipate flow energy entering the basin.
- Cattails, sedges, reeds, and wetland grasses should be planted in thewetland bottom. Berms and side-slopes planted with native or irrigated turf-forming grasses.

C.13.4 Effectiveness

- TSS and metals: 50% - 80%
- N: < 30%
- P: 15% - 45%
- Pathogens: < 30%

C.14 CONSTRUCTED WETLANDS CHANNEL (CWC)

C.14.1 Description

Use dense natural vegetation (rushes, willows, cattails, and reeds) to slow down runoff and allow time for settling out sediment and biological uptake.

Schematic Detail

C.14.2 Application

- Used along wide and gently sloping channels.
- Located downstream of a stormwater detention facility. Receives stormwater and base flows from the detention facility, provides water quality enhancement, and conveys flow.
- A CWC requires a net influx of water to maintain vegetation and microorganisms.

C.14.3 Design Criteria

- Pass the design 2-year flow rate at 2.0 fps with depth of 2.0 to 4.0 feet.
- Trapezoidal cross-section with side slopes of 4:1 or flatter.
- Longitudinal slope of 0.001 ft/ft or steeper.
- Contain 100-year flood while maintaining 1’ free-board.
- Minimum bottom width = 8 feet.
- Cover channel bottom with loamy soils and establish cattails, sedges, and reeds.
- Side slopes planted with native or irrigated turf grasses.

C.14.4 Effectiveness

- TSS: 30% - 50%
- TP and metals: 20% - 40%
- TN: 10% - 30%