

FINAL DRAINAGE REPORT
FOR
THE MEADOWS D1 TRAINING CENTER
LOT 2A-3A, BLOCK 3, THE MEADOWS FILING NO. 20,
PHASE 1 – AMENDMENT NO. 16

Prepared for:

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Prepared by:



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Kurt A. Lang, P.E.

January 25, 2024

RLEG NO. 230902
TOWN NO. CD24-XXXX

Engineer's Statement:

I affirm that this report and plan for the Phase III drainage design of the Meadows D1 Training Center, Meadows Town Center, Lot 2A-3A, Block 3, The Meadows Filing No. 20 Phase 1 – Amendment No. 16, Town of Castle Rock, Colorado was prepared by me (or under my direct supervision) in accordance with the provisions of the Town of Castle Rock Drainage Design and Technical Criteria for the owners thereof. I understand that the Town of Castle Rock does not and will not assume liability for drainage facilities designed by others.

Kurt A, Lang, P.E.

PE No. 32249

Owner/Developer's Statement:

Castle Rock Development hereby certifies that the drainage facilities for the Meadows D1 Training Center, Meadows Town Center, Lot 2A-3A, Block 3, The Meadows Filing No. 20 Phase 1 – Amendment No. 16, Town of Castle Rock, Colorado shall be constructed according to the design presented in this report. I understand that the Town of Castle Rock does not and will not assume liability for the drainage facilities designed and/or certified by my engineer and that the Town of Castle Rock reviews drainage plans pursuant to the Municipal Code; but cannot, on behalf of Meadows D1 Training Center, Meadows Town Center, Lot 2A-3A, Block 3, The Meadows Filing No. 20 Phase 1 – Amendment No. 16, Town of Castle Rock, Colorado, guarantee that final drainage design review will absolve Castle Rock Development and/or their successors and/or assigns of future liability for improper design.

Owner/Applicant

Date

Town of Castle Rock Approvals:

Engineering Division

Date

Development Services

Date

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I. GENERAL LOCATION AND DESCRIPTION

A. LOCATION

The Meadows D1 Training Center project, hereafter referred to as the Project, will be located on a parcel of land being a part of Lot 2A-3A, Block 3 of The Meadows Filing No. 20, Phase 1, Amendment No. 16 in the northeast quarter of Section 33, Township 7 South, Range 67 West of the 6th Principle Meridian, Town of Castle Rock, County of Douglas and State of Colorado. Meadows Parkway is adjacent to the southern boundary of the property, Bilberry Street exists to the west and Future Street to the east. Ubergrippen Indoor Climbing Crag exists to the north of the Project. A drive lane access to the site exists off Bilberry Street located off the northwest corner of the Project. This private drive lane is shared with the Ubergrippen to the north. Please refer to the vicinity map in Appendix E.

B. DESCRIPTION OF PROPERTY AND PROPOSED LAND USE

Currently, the boundaries of the parcel of land that the project site is located on (Lot 2A-3A, Block 3) is 1.618 acres (70,459 sq. ft.) and is undeveloped. The parcel of land that the project is situated on Lot 2A-3A, Block 3, has current existing topography slopes of approximately 3 percent falling from the southeast to the northwest. The Project proposes a 9,450 square-feet (0.22-acres) facility, a parking lot area and surrounding landscaped areas. Utility improvements will also take place throughout the site.

i. SCS Soil Group:

According to the U.S. Department of Agriculture Soil Conservation Service, the soil is made up of Bresser Sandy Loam (BrB), classified as hydrologic soil group “B”.

The National Cooperative Soil Survey Map outlines 100% of the site as Type B Bresser Sandy Loam soil. Type B soil type coefficients was used in hydrologic computations. Please refer to Appendix A for The National Cooperative Soil Survey Map for the Project.

ii. Irrigation facilities

There are no known irrigation facilities present on the site or near the project boundary.

II. DRAINAGE BASIN DESCRIPTION

Basin A1 (0.033-acres) consists of the west building rooftop runoff. Runoff for this basin is 0.12 cfs for the 5-year storm and 0.25 cfs for the 100-year storm. Runoff will be collected via roof downspouts and transmitted underground via 6-inch PVC pipes that connect with the proposed 12-inch landscape inlet located at Design Pont (DP) 1 in Basin A2.

Basin A2 (0.075-acres) consists of concrete sidewalk and landscaped area off the southwest side of the building. Runoff for this basin is 0.02 cfs for the 5-year storm and 0.23 cfs for the 100-year storm. Runoff will flow away from the building where it will be collected via a 12-inch landscape inlet. From here, this runoff will be conveyed via 10-inch PVC pipes to a 5-foot Type R inlet located at DP 2 in Basin A3.

Basin A3 (0.222-acres) consists of a paved asphalt parking lot, concrete sidewalks and accessible parking, and a landscape island. Runoff for this basin is 0.77 cfs for the 5-year storm and 1.61 cfs for the 100-year storm. Runoff will sheet flow to the north and west where it will be conveyed via curb and gutter where it will then be collected by a 5-foot Type R inlet at DP 2. From here, this runoff will be conveyed via 18-inch RCP pipes to an existing Type R inlet located at DP 6 in Basin A8.

Basin A4 (0.123-acres) consists of the southeast building rooftop runoff. Runoff for this basin is 0.46 cfs for the 5-year storm and 0.92 cfs for the 100-year storm. Runoff will be collected via roof downspouts and transmitted underground via 6-inch PVC pipes that connect with the proposed 8-inch landscape inlets located in Basin A5.

Basin A5 (0.182-acres) consists of proposed and existing concrete sidewalk and landscaped area off the southeast side of the building. Runoff for this basin is 0.18 cfs for the 5-year storm and 0.78 cfs for the 100-year storm. Runoff will flow away from the building where it will be collected via multiple 8-inch landscape inlets. From here, this runoff will be conveyed via 8-inch PVC pipes and 15-inch RCP pipes to a 15-inch FES located in Basin A6.

Basin A6 (0.523-acres) consists of existing concrete sidewalk and landscaped area northeast of the building and parking lot. Runoff for this basin is 0.17 cfs for the 5-year storm and 1.89 cfs for the 100-year storm. Runoff from Basin A5 will be discharged to this basin via a 15-inch FES. Runoff from Basin OS1 will flow out of the existing concrete underpass and sheet flow onto this basin. Runoff from Basins A5, OS1, and A6 will be collected by an 18-inch FES located at DP 5. From here, this runoff will be conveyed via proposed and existing 18-inch RCP pipes to an existing 6-foot diameter manhole located at DP 7 in Basin A8.

Basin A7 (0.061-acres) consists of the northeast building rooftop runoff. Runoff for this basin is 0.23 cfs for the 5-year storm and 0.45 cfs for the 100-year storm. Runoff will be collected via roof downspouts and transmitted underground via 6-inch PVC pipes where it will then connect to the 8-inch PVC pipes located in Basin A6.

Basin A8 (0.309-acres) consists of a paved asphalt parking lot, concrete sidewalks, and landscape areas, and existing asphalt private drive. Runoff for this basin is 0.79 cfs for the 5-year storm and 1.85 cfs for the 100-year storm. Runoff will sheet flow to the north and west where it will be conveyed via curb and gutter where it will then be collected by an existing Type R inlet at DP 6. From here, this runoff will be conveyed via 24-inch RCP pipes to an existing manhole located at DP 7.

Basin OS1 (0.473-acres) consists of an off-site area that consists of landscaped and existing sidewalk that leads to the entrance of an existing pedestrian underpass underneath Meadows Blvd. Runoff for this basin is 0.09 cfs for the 5-year storm and 1.18 cfs for the 100-year storm. Runoff flows to the base of the existing pedestrian underpass underneath Meadows Blvd, across the concrete base of the underpass, to the other side of Meadows Blvd. at DP 4. From here, the runoff sheet flows to the northwest where it is collected by an 18-inch FES located at DP 5 in Basin A6.

Basin OS2 (0.090-acres) consists of concrete sidewalk and landscape area. Runoff for this basin is 0.05 cfs for the 5-year storm and 0.39 cfs for the 100-year storm. Runoff will flow offsite and into the existing curb and gutter of Bilberry Street where it will then be collected by existing inlets. This is an existing basin and flow path that will not be changed by the Project.

The 100-yr and 5-yr HGL's of the proposed pipe network system are designed to match the HGL elevations within the existing RCP pipe system located on the northwest side of the Project.

Detention and water quality is accounted for in the previously approved drainage report *Addendum No. 1 to The Meadows, Filing 20, Phase III, Drainage Report, including Filing 20, Phase I, Amendment 2, Block 2, Lot 1A and Block 3, Lot1A, prepared by CVL Consultants of Colorado, May 15, 2008* (Appendix G). The report determined the volume of the Filing 20 regional detention pond for the Project as part of the original basin C15, which was originally designed to be a commercial development with a composite impervious value of 95%. The proposed composite imperviousness of the Project is less at 45.51%. Therefore, the pond has been oversized to account for any major storm occurring on the Project site. Runoff from the site is conveyed via an 84-inch RCP storm pipe that flows north to the Filing 20 regional detention pond. The pond has been designed to provide water quality treatment and detention for the major storm for the proposed Project. No additional improvements were proposed for water quality or detention for the Project on-site.

III. DRAINAGE DESIGN CRITERIA

A. REGULATIONS

This report was prepared using the "Town of Castle Rock Public Works Regulations" and the UDFCD Volumes 1 and 2 Hydrology criteria.

B. DRAINAGE STUDIES, MASTER PLANS, SITE CONSTRAINTS

This report was prepared using the "Town of Castle Rock Public Works Regulations" and the UDFCD Volumes 1 and 2 Hydrology criteria.

C. HYDROLOGICAL CRITERIA

Since the site is less than 160 acres, the Rational Method was used to calculate all storm water runoff as opposed to the Colorado Urban Hydrograph Procedure. The intensity-frequency curves used in the Rational Method calculations were taken from the Town of Castle Rock's Storm Drainage Design and Technical Criteria Manual. The Town of Castle Rock Storm Drainage Design & Technical Criteria Manual defines the Project's 1-hour point rainfall as 1.43 inches for the 5-year event and 2.60 inches for the 100-year event. All drainage facilities were analyzed and designed for both the minor (5-year) and major (100-year) storm events. Time of concentration calculations were used to determine the rainfall intensity. These calculations can be found in Appendix C.

D. HYDRAULIC CRITERIA

Hydraulic computations were performed to determine the capacity of the storm system. The design discharge is based on the peak flow rate calculated using the Rational Method. All inlets were sized using UDFCD UD-Inlet software and found in Appendix D. HGL calculations were determined using Storm Sewers for AutoCAD Civil 3D. These calculations can be found in Appendix D.

E. WATER QUALITY ENHANCEMENT

There is no water quality proposed for the project.

IV. DRAINAGE CONCEPT

The Meadows D1 Training Center project includes 1.62 acres of the previously approved original drainage basin C15, which contains the 1.62 acres of the Project site. (See *Addendum No. 1 to The Meadows, Filing 20, Phase III, Drainage Report, including Filing 20, Phase I, Amendment 2, Block 2, Lot 1A and Block 3, Lot1A, prepared by CVL Consultants of Colorado, May 15, 2008* (Appendix G)). It was designed conservatively to be a commercial site with 95% total imperviousness.

The Flood Insurance Rate Map (FIRM) Community Panel Number 08035C0169G shows that the site is in Zone “X” which is classified as an area determined to be outside the 500-year floodplain, is provided in Appendix A.

An existing 84-inch RCP storm pipe with an existing 8-foot diameter manhole has been previously installed within the Bilberry Street right-of-way near the site entrance as part of previous construction for the Meadows Filing No. 20 Phase 1 improvements.

To model the HGL’s for the storm network, we used the existing HGL elevations from the Record Drawings of the CDs by Roth Lang Engineering Group for ‘The Meadows Ubergripen Project’. An exhibit of the CD sheet of the existing 5-foot diameter manhole (located at DP 7 in the Drainage Map) is included in Appendix G. The 5-year and 100-year HGL values and calculations are provided in Appendix D of this report.

V. STORMWATER MANAGMENT FACILITY DESIGN

There are no stormwater management facilities proposed for the project.

This project and the stormwater management design complies with the Town of Castle Rock Storm Drainage Technical Criteria Manual.

Per the four step processes of water quality outlined in Section 14.1 of the Manual, the project follows these steps herein. Per the first step, runoff to the Regional Detention Pond Filing No. 20 is reduced by the addition of landscape islands within the parking lot and landscaped and grass lined zones along the perimeter of the property. Per the second step, full-spectrum detention has been provided and analyzed for the site per the previously approved report, ‘Addendum No. 1 to the Filing 20 Phase III Drainage Report for the Meadows Filing No. 20 prepared by CVL Consultants and included in this report. Sections of the report outline detention for the site. Per the third step, there are no open channels or streams proposed with the Project. Per the fourth step, the development is a potential source of illicit or irregular discharges of pollutants outlined in the Manual and is intended to be a commercial development. Potential pollutant sources for any landscape area include chemicals, fertilizers and herbicides. Potential pollutant sources for the parking lot area include windshield washer fluid, salt and other common vehicle pollutant discharges. Some of the structural and nonstructural control measures to contain said pollutants are identified below.

Structural Control Measures:

- Permanent covering of outdoor storage areas
- Spill containment and control

- Proper sanitary sewer connections
- Provision of designated storage and material handling areas
- Provision of proper waste receptacles

Non Structural Control Measures:

- General good housekeeping practices
- Preventative maintenance
- Recycling programs
- Spill prevention and response
- Employee “awareness” education and training.

VI. CONCLUSIONS

A. COMPLIANCE WITH STANDARDS

This report is in compliance with the standards set forth in the Town of Castle Rock Storm Drainage Design and Technical Criteria Manual and the Urban Drainage Flood Control criteria manuals

B. VARIANCES

There are no variances for the Project.

C. COMPLIANCE TO PREVIOUS REPORTS

The calculations presented in this report complies with the determinations as set forth in the drainage reports titled Addendum No. 1 to The Meadows, Filing 20, Phase III, Drainage Report, including Filing 20, Phase 1, Amendment 2, Block 2, Lot 1A and Block 3, Lot 1A.

This “Master Study” assumed a percent compositeness of 95% for the Project area. The percent imperviousness calculated herein is 45.5%. This is a substantial reduction from the “Master Study” assumption that results in a reduction of design flows to the existing storm system and the existing regional detention pond.

REFERENCES

Addendum No. 1 to The Meadows, Filing 20, Phase III, Drainage Report, including Filing 20, Phase I, Amendment 2, Block 2, Lot 1A and Block 3, Lot1A, prepared by CVL Consultants of Colorado, May 15, 2008.

Drainage Criteria Manual, Volume 1, 2 and 3, Urban Drainage and Flood Control District; Volumes 1 Revised August 2018; Volume 2 Revised September 2017; Volume 3 Revised November 2010 with Updates October 2021.

Phase III Drainage Report for The Meadows Filing No. 20, by RG Consulting Engineers, Inc., Revised: October 2004

Town of Castle Rock Public Works Regulations, Town of Castle Rock, February 1999.

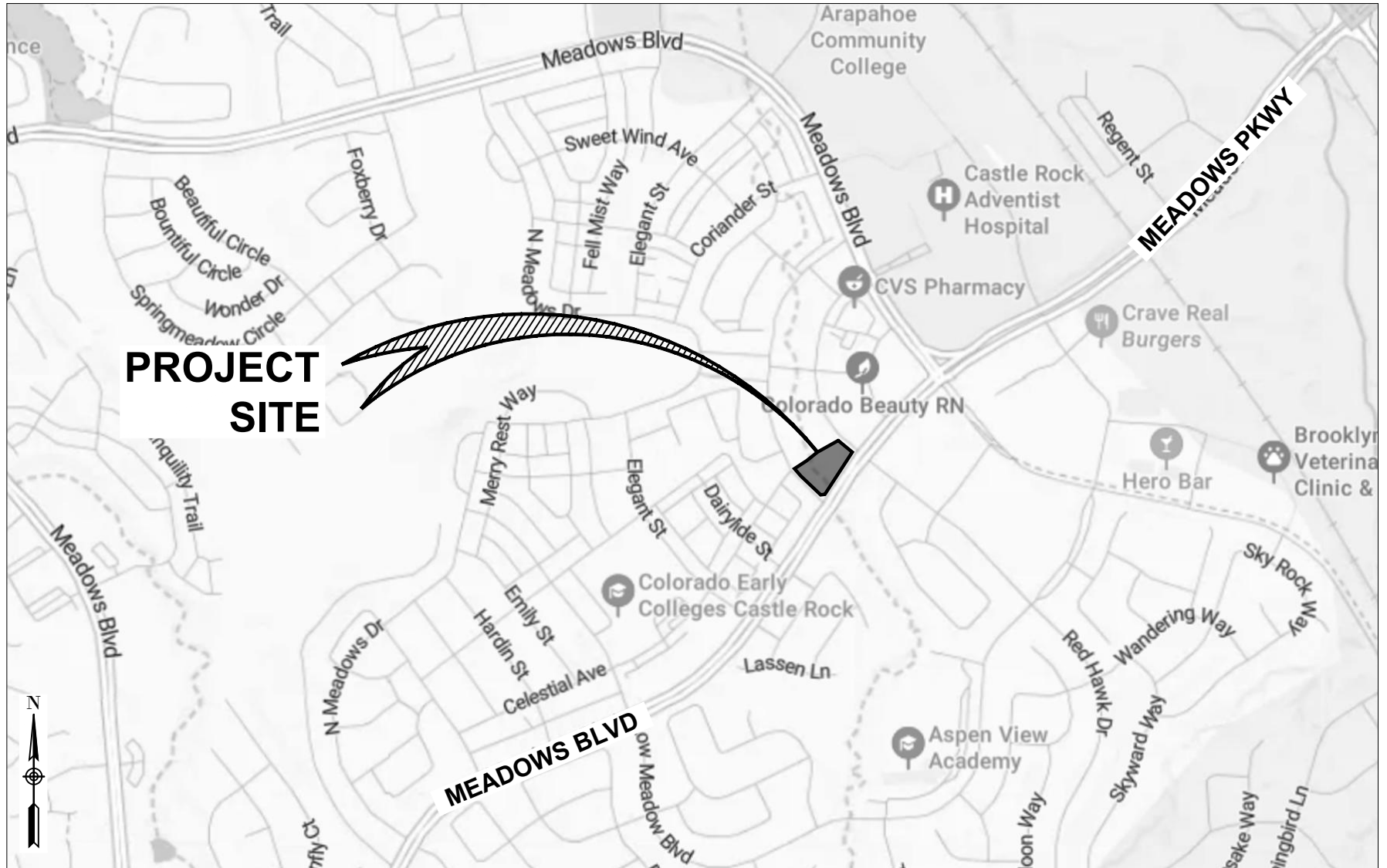
Town of Castle Rock Storm Drainage Design and Technical Criteria Manual, Town of Castle Rock, Revised June 2019.

Web Soil Survey of Castle Rock Area, Colorado, U.S. Department of Agriculture, Soil Conservation Service.

APPENDIX A – VICINITY MAP, FEMA MAP, WEB SOIL SURVEY

VICINITY MAP

SCALE: 1" = 1000'



NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations (BFEs)** and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables shown on this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Floodway Data table shown on this FIRM.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 13. The **horizontal datum** was NAD 83, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at <http://www.ngs.noaa.gov> or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242, or visit its website at <http://www.ngs.noaa.gov>.

Base map information shown on this FIRM was provided by the Douglas County GIS Department and the Town of Castle Rock GIS Department. Additional input was provided by the City of Lone Tree and Town of Parker. These data are current as of 2010.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **profile baselines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the **profile baseline**, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

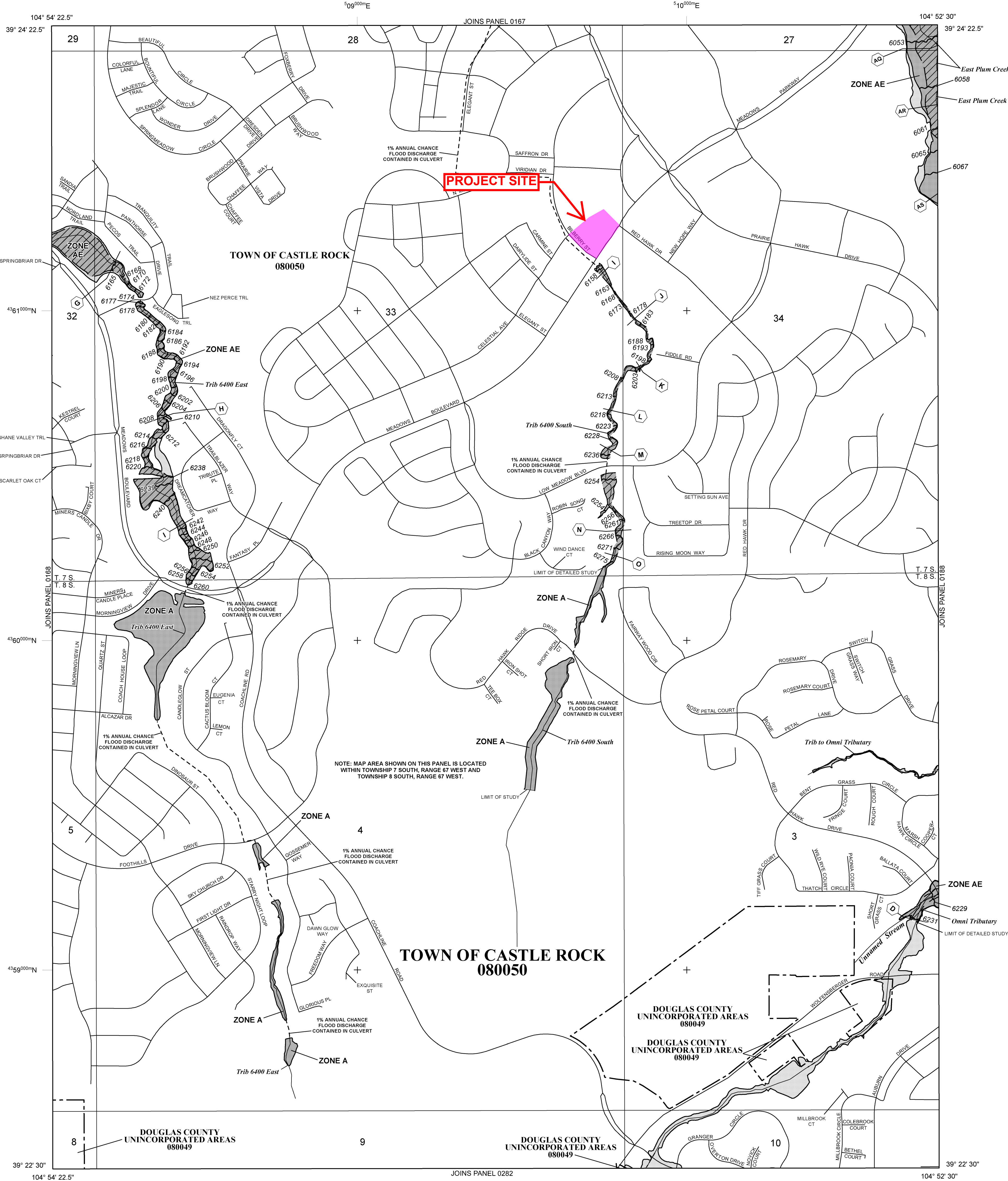
Based on updated topographic information, this map reflects more detailed and up-to-date **stream channel configurations** and **floodplain delineations** than those shown on the previous FIRM for this jurisdiction. As a result, the Flood Profiles and Floodway Data tables for multiple streams in the Flood Insurance Study Report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on the map. Also, the road to floodplain relationships for unrevised streams may differ from what is shown on previous maps.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at <http://msc.fema.gov>. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map**, how to order products, or the National Flood Insurance Program in general, please call the **FEMA Map Information eXchange (FMIX)** at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA website at <http://www.fema.gov/business/nfp>.



LEGEND

- SPECIAL FLOOD HAZARD AREAS (SFHAS) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD**
The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.
- ZONE A** No Base Flood Elevations determined.
ZONE AE Base Flood Elevations determined.
ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently deteriorated. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99 Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.
- FLOODWAY AREAS IN ZONE AE**
- OTHER FLOOD AREAS**
- ZONE X** Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.
OTHER AREAS
ZONE D Areas determined to be outside the 0.2% annual chance floodplain.
ZONE X Areas in which flood hazards are undetermined, but possible.
- COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS**
OTHERWISE PROTECTED AREAS (OPAs)
- CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.
- 1% Annual Chance Floodplain Boundary
0.2% Annual Chance Floodplain Boundary
Floodway boundary
Zone boundary
CBRS and OPA boundary
Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.
Base Flood Elevation line and value; elevation in feet*
(EL 987)
Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

Cross section line
Transsect line
45° 02' 08" 93° 02' 12"
Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere
1000-meter Universal Transverse Mercator grid values, zone 13
DX5510 X
Bench mark (see explanation in Notes to Users section of this FIRM panel)
M1.5
River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index
EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
SEPTEMBER 30, 2005
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
MARCH 16, 2016: to update corporate limits, to change base flood elevations, to add base flood elevations, to add special flood hazard areas, to update map format, to add roads and road names, to reflect updated topographic information, to incorporate previously issued letters of map revision.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'
250 0 500 1000
150 0 150 300
FEET
METERS

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0169G

FIRM
FLOOD INSURANCE RATE MAP
DOUGLAS COUNTY, COLORADO
AND INCORPORATED AREAS

PANEL 169 OF 495
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
CASTLE ROCK, TOWN OF	080050	0169	G
DOUGLAS COUNTY	080049	0169	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
08035C0169G
MAP REVISED
MARCH 16, 2016
Federal Emergency Management Agency



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 **Castle Rock Area, Colorado**



January 17, 2024

Preface

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

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

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

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

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

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

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

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How Soil Surveys Are Made

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

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

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

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

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

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

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

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

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

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

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

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

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identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

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

Custom Soil Resource Report Soil Map



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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 1:20,000.

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: Castle Rock Area, Colorado
Survey Area Data: Version 16, Aug 24, 2023

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

Date(s) aerial images were photographed: Jun 9, 2021—Jun 12, 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
BrB	Bresser sandy loam, cool, 1 to 3 percent slopes	1.9	100.0%
Totals for Area of Interest		1.9	100.0%

Map Unit Descriptions

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

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

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

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

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

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

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

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

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

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

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

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

Castle Rock Area, Colorado

BrB—Bresser sandy loam, cool, 1 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2tlpj

Elevation: 5,500 to 6,500 feet

Mean annual precipitation: 15 to 19 inches

Mean annual air temperature: 48 to 52 degrees F

Frost-free period: 100 to 130 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Bresser, cool, and similar soils: 90 percent

Minor components: 10 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bresser, Cool

Setting

Landform: Hillslopes, terraces

Landform position (two-dimensional): Footslope

Landform position (three-dimensional): Base slope, tread

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Tertiary aged alluvium derived from arkose

Typical profile

Ap - 0 to 5 inches: sandy loam

Bt1 - 5 to 8 inches: sandy loam

Bt2 - 8 to 27 inches: sandy clay loam

Bt3 - 27 to 36 inches: sandy loam

C - 36 to 80 inches: loamy coarse sand

Properties and qualities

Slope: 1 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 6.00 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum content: 5 percent

Maximum salinity: Nonsaline to very slightly saline (0.1 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: Low (about 5.4 inches)

Interpretive groups

Land capability classification (irrigated): 2e

Land capability classification (nonirrigated): 4s

Hydrologic Soil Group: B

Ecological site: R049XB210CO - Sandy Foothill

Hydric soil rating: No

Minor Components

Truckton

Percent of map unit: 5 percent
Landform: Hillslopes, terraces
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R049XB210CO - Sandy Foothill
Hydric soil rating: No

Sampson

Percent of map unit: 5 percent
Landform: Terraces, alluvial fans
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R049XC202CO - Loamy Foothill 14-19 PZ
Hydric soil rating: No

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APPENDIX B – TABLES AND FIGURES

Table 6-3. Recommended percentage imperviousness values

Land Use or Surface Characteristics	Percentage Imperviousness (%)
Business:	
Downtown Areas	95
Suburban Areas	75
Residential lots (lot area only):	
Single-family	
2.5 acres or larger	12
0.75 – 2.5 acres	20
0.25 – 0.75 acres	30
0.25 acres or less	45
Apartments	75
Industrial:	
Light areas	80
Heavy areas	90
Parks, cemeteries	10
Playgrounds	25
Schools	55
Railroad yard areas	50
Undeveloped Areas:	
Historic flow analysis	2
Greenbelts, agricultural	2
Off-site flow analysis (when land use not defined)	45
Streets:	
Paved	100
Gravel (packed)	40
Drive and walks	90
Roofs	90
Lawns, sandy soil	2
Lawns, clayey soil	2

Table 6-4. Runoff coefficient equations based on NRCS soil group and storm return period

NRCS Soil Group	Storm Return Period						
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
A	$C_A =$ $0.84i^{1.302}$	$C_A =$ $0.86i^{1.276}$	$C_A =$ $0.87i^{1.232}$	$C_A =$ $0.88i^{1.124}$	$C_A =$ $0.85i+0.025$	$C_A =$ $0.78i+0.110$	$C_A =$ $0.65i+0.254$
B	$C_B =$ $0.84i^{1.169}$	$C_B =$ $0.86i^{1.088}$	$C_B =$ $0.81i+0.057$	$C_B =$ $0.63i+0.249$	$C_B =$ $0.56i+0.328$	$C_B =$ $0.47i+0.426$	$C_B =$ $0.37i+0.536$
C/D	$C_{C/D} =$ $0.83i^{1.122}$	$C_{C/D} =$ $0.82i+0.035$	$C_{C/D} =$ $0.74i+0.132$	$C_{C/D} =$ $0.56i+0.319$	$C_{C/D} =$ $0.49i+0.393$	$C_{C/D} =$ $0.41i+0.484$	$C_{C/D} =$ $0.32i+0.588$

Where:

i = % imperviousness (expressed as a decimal)

C_A = Runoff coefficient for Natural Resources Conservation Service (NRCS) HSG A soils

C_B = Runoff coefficient for NRCS HSG B soils

$C_{C/D}$ = Runoff coefficient for NRCS HSG C and D soils.

The values for various catchment imperviousness and storm return periods are presented graphically in Figures 6-1 through 6-3, and are tabulated in Table 6-5. These coefficients were developed for the Denver region to work in conjunction with the time of concentration recommendations in Section 2.4. Use of these coefficients and this procedure outside of the semi-arid climate found in the Denver region may not be valid. The UD-Rational Excel workbook performs all the needed calculations to find the runoff coefficient given the soil type and imperviousness and the reader may want to take advantage of this macro-enabled Excel workbook that is available for download from the UDFCD's website www.udfcd.org.

See Examples 7.1 and 7.2 that illustrate the Rational Method.

2.3 Limitations

The Rational Method is the simplistic approach for estimating the peak flow rate and total runoff volume from a design rainstorm in a given catchment. Under the assumption of uniform hydrologic losses, the method is limited to catchments smaller than 90 acres. Under the condition of composite soils and land uses, use an area-weighted method to derive the catchment's hydrologic parameters.

The greatest drawback to the Rational Method is that it normally provides only one point (the peak flow rate) on the runoff hydrograph. When the areas become complex and where subcatchments come together, the Rational Method will tend to overestimate the actual flow, which results in oversizing of drainage facilities. The Rational Method provides no means or methodology to generate and route hydrographs through drainage facilities. One reason the Rational Method is limited to small areas is that good design practice requires the routing of hydrographs for larger catchments to achieve an economically sound design.

Another disadvantage of the Rational Method is that with typical design procedures, one normally assumes that all of the design flow is collected at the design point and that there is no water running overland to the next design point. This is not an issue of the Rational Method but of the design procedure. Use additional analysis to account for this scenario.

2.4 Time of Concentration

One of the basic assumptions underlying the Rational Method is that runoff is linearly proportional to the average rainfall intensity during the time required for water to flow from the most remote part of the drainage area to the design point. In practice, the time of concentration is empirically estimated along the selected waterway through the catchment.

To calculate the time of concentration, first divide the waterway into overland flow length and channelized flow lengths, according to the channel characteristics. For urban areas (tributary areas of greater than 20 percent impervious), the time of concentration, t_c , consists of an initial time or overland flow time, t_i , plus the channelized flow travel time, t_t , through the storm drain, paved gutter, roadside ditch, or channel. For non-urban areas, the time of concentration consists of an overland flow time, t_i , plus the time of travel in a defined drainage path, such as a swale, channel, or stream. Estimate the channelized travel time portion, t_t , of the time of concentration from the hydraulic properties of the conveyance element. Initial or overland flow time, on the other hand, will vary with surface slope, depression storage, surface cover, antecedent rainfall, and infiltration capacity of the soil, as well as distance of surface flow. Compute the time of concentration for both urban and non-urban areas using Equation 6-2:

$$t_c = t_i + t_t \quad \text{Equation 6-2}$$

Where:

t_c = computed time of concentration (minutes)

t_i = overland (initial) flow time (minutes)

t_t = channelized flow time (minutes).

2.4.1 Initial or Overland Flow Time

The initial or overland flow time, t_i , may be calculated using Equation 6-3:

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_o^{0.33}} \quad \text{Equation 6-3}$$

Where:

- t_i = overland (initial) flow time (minutes)
- C_5 = runoff coefficient for 5-year frequency (from Table 6-4)
- L_i = length of overland flow (ft)
- S_o = average slope along the overland flow path (ft/ft).

Equation 6-3 is adequate for distances up to 300 feet in urban areas and 500 feet in rural areas. Note that in a highly urbanized catchment, the overland flow length is typically shorter than 300 feet due to effective man-made drainage systems that collect and convey runoff.

2.4.2 Channelized Flow Time

The channelized flow time (travel time) is calculated using the hydraulic properties of the conveyance element. The channelized flow time, t_t , is estimated by dividing the length of conveyance by the velocity. The following equation, Equation 6-4 (Guo 2013), can be used to determine the flow velocity in conjunction with Table 6-2 for the conveyance factor.

$$t_t = \frac{L_t}{60K\sqrt{S_o}} = \frac{L_t}{60V_t} \quad \text{Equation 6-4}$$

Where:

- t_t = channelized flow time (travel time, min)
- L_t = waterway length (ft)
- S_o = waterway slope (ft/ft)
- V_t = travel time velocity (ft/sec) = $K\sqrt{S_o}$
- K = NRCS conveyance factor (see Table 6-2).

Table 6-2. NRCS Conveyance factors, K

Type of Land Surface	Conveyance Factor, K
Heavy meadow	2.5
Tillage/field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

The time of concentration, t_c , is the sum of the initial (overland) flow time, t_i , and the channelized flow time, t_t , as per Equation 6-2.

2.4.3 First Design Point Time of Concentration in Urban Catchments

Equation 6-4 was solely determined by the waterway characteristics and using a set of empirical formulas. A calibration study between the Rational Method and the Colorado Urban Hydrograph Procedure (CUHP) suggests that the time of concentration shall be the lesser of the values calculated by Equation 6-2 and Equation 6-5 (Guo and Urbonas 2013).

$$t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}} \quad \text{Equation 6-5}$$

Where:

- t_c = minimum time of concentration for first design point when less than t_c from Equation 6-1.
- L_t = length of channelized flow path (ft)
- i = imperviousness (expressed as a decimal)
- S_t = slope of the channelized flow path (ft/ft).

Equation 6-5 is the regional time of concentration that warrants the best agreement on peak flow predictions between the Rational Method and CUHP when the imperviousness of the tributary area is greater than 20 percent. It was developed using the UDFCD database that includes 295 sample urban catchments under 2-, 5-, 10-, 50, and 100-yr storm events (MacKenzie 2010). It suggests that both initial flow time and channelized flow velocity are directly related to the catchment's imperviousness (Guo and MacKenzie 2013).

The first design point is defined as a node where surface runoff enters the storm drain system. For example, all inlets are “first design points” because inlets are designed to accept flow into the storm drain.

Typically, but not always, Equation 6-5 will result in a lesser time of concentration at the first design point and will govern in an urbanized watershed. For subsequent design points, add the travel time for each relevant segment downstream.

2.4.4 Minimum Time of Concentration

Use a minimum t_c value of 5 minutes for urbanized areas and a minimum t_c value of 10 minutes for areas that are not considered urban. Use minimum values even when calculations result in a lesser time of concentration.

2.4.5 Common Errors in Calculating Time of Concentration

A common mistake in urbanized areas is to assume travel velocities that are too slow. Another common error is to not check the runoff peak resulting from only part of the catchment. Sometimes a lower portion of the catchment or a highly impervious area produces a larger peak than that computed for the whole catchment. This error is most often encountered when the catchment is long or the upper portion contains grassy open land and the lower portion is more developed.

6.0 Introduction

This chapter summarizes methodology for determining rainfall and runoff information for the design of stormwater management facilities in the Town. The methodology is based on the procedures presented in the UDFCD Manual in the Rainfall and Runoff chapters. The design procedures outlined in the UDFCD Manual, supplemented by the information provided in this chapter, apply to all projects in the Town.

6.0.1 Stormwater Quality Considerations. One of the most significant impacts of urbanization is the increase in peak flow rates, runoff volumes, and frequency of runoff from impervious areas. This increase in runoff can lead to severe stream erosion, habitat disruption, and increased pollutant loading. At the same time, with proper planning, the increased runoff volumes can be managed to create or supplement existing wetland areas or riparian habitats, which may provide significant benefits to the watershed. The increase in runoff from development is especially pronounced when drainage systems are designed to quickly and “efficiently” convey runoff from paved areas and roofs directly into inlets and storm sewers, discharging eventually into drainageways that are typically designed to convey flows at maximum acceptable velocities. Whether for one site or for a whole watershed, this increase in runoff and acceleration of flood peaks is reflected accurately by the hydrologic methods discussed herein.

As discussed in Chapter 14, Stormwater Quality, effective stormwater management today seeks to disconnect impervious surfaces, slow down flows, and convey runoff over vegetated ground surfaces, leading to filtering, infiltration, and attenuation of flows. These principles can also be reflected in the hydrologic variables discussed in this chapter, yielding longer times of concentration and reduced peak runoff. Specifically, Section 6.6 provides design guidance to account for the hydrologic effects of Minimizing Directly Connected Impervious Areas.

6.1 Design Rainfall

Rainfall data to be used in the Town of Castle Rock is based on the *National Oceanic and Atmospheric Administration Precipitation-Frequency Atlas of the Western United States, Volume III-Colorado* (NOAA Atlas), published in 1973. Precipitation depth maps shown in the NOAA Atlas were used to determine representative one-hour and six-hour point rainfall values for the Town. Following the guidelines in the NOAA Atlas, these point values were used to develop two-hour and three-hour values as well as the intensity-duration curves for use in the Town. The Rainfall chapter of the UDFCD Manual provides additional discussion on the use of rainfall data obtained from the NOAA Atlas.

6.1.1 One-hour Rainfall. There is very little variation in the NOAA Atlas isopluvial (equal precipitation depth) map within the Town of Castle Rock; therefore, one

set of one hour design point rainfall values, indicated in Table 6-1, apply to the Town.

**TABLE 6-1
1-HOUR POINT RAINFALL VALUES FOR
THE TOWN OF CASTLE ROCK (INCHES)**

2- YR	5-YR	10-YR	50-YR	100-YR
1.06	1.43	1.66	2.26	2.60

The one-hour rainfall depths are the basis of the Town's intensity-duration rainfall curves and are used to formulate design storm distributions.

6.1.2 Intensity-Duration Curves. Rainfall intensity based on storm duration for a variety of storm return periods can be found on Figure 6-1 at the end of this chapter. These curves were developed using distribution factors provided in the NOAA Atlas and also provided in Table RA-4 of the UDFCD Manual. These Intensity-Duration curves are based on Equation RA-3 in the Rainfall Section of the UDFCD Manual.

6.1.3 Six-hour Rainfall. In order to use the Colorado Urban Hydrograph Procedure (CUHP), two, three or six-hour rainfall distributions are required, depending on watershed area. Table RA-1 in the UDFCD Manual summarizes storm durations, area adjustments, and incremental rainfall depths to be used in CUHP based on watershed area. The UD-Raincurve Spreadsheet included in the UDFCD Manual shall be used to generate the rainfall distribution curves necessary for a CUHP model. In order to generate these distribution curves, the one-hour and six-hour rainfall depths for the design return periods are necessary. Since the Town of Castle Rock is not located within UDFCD boundaries, the rainfall depth-duration-frequency curves provided in the UDFCD Manual do not provide rainfall values for the entire Town. Therefore these values are provided in these Criteria. The 1-hour point values can be found in Table 6-1 of this chapter. The six-hour point values are as follows:

**TABLE 6-2
6-HOUR POINT RAINFALL VALUES FOR
THE TOWN OF CASTLE ROCK (INCHES)**

2- YR	5-YR	10-YR	50-YR	100-YR
1.5	2.0	2.2	3.0	3.4

The UD-Raincurve spreadsheet shall be used for all portions of the Town. Once the rainfall distribution curves are generated using the UDFCD UD-Raincurve Spreadsheet, the CUHP model is to be set up following the procedures provided in the Runoff chapter in Volume 1 of the UDFCD Manual.

APPENDIX C – HYDROLOGY

COMPOSITE IMPERVIOUSNESS & RUNOFF COEFFICIENT CALCULATIONS - DEVELOPED CONDITIONS

SUB-BASIN	PROPOSED LAND USE ^a (sf)						TOTAL AREA (sf)	TOTAL AREA (acres)	COMPOSITE PERCENT IMPERVIOUS <i>i</i>	RUNOFF COEFFICIENTS ^b . HYDROLOGIC SOIL GROUP B ^c				NOTES
	PAVED	DRIVE AND WALKS	ROOF	LANDSCAPE	GRAVEL					C ₂	C ₅	C ₁₀	C ₁₀₀	
A1	-	-	1,437	-	-	-	1,437	0.033	90.0%	0.74	0.77	0.79	0.85	Bldg Rooftop
A2	-	403	-	2,857	-	-	3,260	0.075	12.9%	0.08	0.09	0.16	0.49	West Landscape Area
A3	-	9,068	-	593	-	-	9,661	0.222	84.6%	0.69	0.72	0.74	0.82	West Parking Lot
A4	-	-	5,367	-	-	-	5,367	0.123	90.0%	0.74	0.77	0.79	0.85	Bldg Rooftop
A5	-	2,522	-	5,396	-	-	7,918	0.182	30.0%	0.21	0.23	0.30	0.57	East Landscape Area
A6	-	2,369	-	20,406	-	-	22,775	0.523	11.2%	0.06	0.08	0.15	0.48	North Landscape Area
A7	-	-	2,646	-	-	-	2,646	0.061	90.0%	0.74	0.77	0.79	0.85	Bldg Rooftop
A8	-	10,453	-	3,028	-	-	13,481	0.309	70.2%	0.56	0.59	0.63	0.76	Parking Lot and Drive
OS1	-	1,779	-	18,838	-	-	20,617	0.473	9.6%	0.05	0.07	0.13	0.47	Offsite Area 1
OS2	-	570	-	3,344	-	-	3,914	0.090	14.8%	0.09	0.11	0.18	0.50	d.
Total	-	27,164	9,450	54,462	-	-	91,076	2.091	37.38%	0.27	0.29	0.36	0.60	Composite Site
Property Total*	-	25,385	9,450	35,624	-	-	70,459	1.618	45.51%	0.33	0.37	0.43	0.64	Composite Site

NOTES:

a. UDFCD, USDCM Volume 1, Table 6-3

b. UDFCD, USDCM Volume 1, Table 6-4 and Table 6-5

$$C_2 = 0.84i^{1.169} \quad C_5 = 0.86i^{1.088} \quad C_{10} = 0.81i + 0.057 \quad C_{100} = 0.47i + 0.426$$

c. WSS shows predominately Type B Soil for the proposed project development area

d. Bilberry Street Amenity Zone Collected by Filing 20 Regional Pond

*Total excludes Basin OS1 and only totals areas within the boundaries of Lot 2A-3A, Block 3, The Meadows Filing No. 20, Phase 1 - Amendment No. 16

TIME OF CONCENTRATIONS - DEVELOPED CONDITIONS

BASIN DATA			INITIAL/OVERLAND TIME (t_i) ^a			TRAVEL TIME (t_t) ^b					TIME OF CONC. (t_c) ^d	FIRST DESIGN POINT TIME OF CONC. IN URBAN CATCHMENT (t_c) ^e			FINAL (t_c) ^{f,g}	CONVEYANCE REMARKS
SUB-BASIN	AREA (acres)	C _s	LENGTH L_i (ft)	SLOPE S_o (ft/ft)	t_i (minutes)	LENGTH L_t (ft)	SLOPE S_t (ft/ft)	CONVEYANCE FACTOR K ^c	VELOCITY V_t (ft/s)	t_t (minutes)	t_c (minutes)	LENGTH L_i (ft)	IMPERVIOUS i (decimal)	t_c (minutes)	t_c (minutes)	
A1	0.03	0.77	40	0.020	3.0				-	-	3.0	-	0.900	10.70	5.0	
A2	0.07	0.09	55	0.020	10.7	140	0.005	20	1.4	1.65	12.4	140	0.129	25.34	12.4	
A3	0.22	0.72	70	0.030	4.0	100	0.015	20	2.4	0.68	4.7	100	0.846	12.08	5.0	
A4	0.12	0.77	60	0.020	3.7				-	-	3.7	-	0.900	10.70	5.0	
A5	0.18	0.23	45	0.035	7.0	115	0.005	20	1.4	1.36	8.3	115	0.300	21.67	8.3	
A6	0.52	0.08	105	0.150	7.7	75	0.030	15	2.6	0.48	8.2	75	0.112	24.41	8.2	
A7	0.06	0.77	50	0.020	3.4				-	-	3.4	-	0.900	10.70	5.0	
A8	0.31	0.59	90	0.030	6.1	180	0.020	20	2.8	1.06	7.2	180	0.702	14.98	7.2	
OS1	0.47	0.07	190	0.030	17.9	115	0.010	20	2.0	0.96	18.8	115	0.096	25.44	18.8	Underpass
OS2	0.09	0.11	-	0.030		-	0.010	20	2.0	-	-	-	0.148	23.48	5.0	Uncollected Flow

NOTES:

a. UDFCD, USDCM Volume 1, Equation 6-3: $t_i = 0.395(1.1 - C_s) \cdot \sqrt{L_i} / S_o^{0.333}$

b. UDFCD, USDCM Volume 1, Equation 6-4: $t_t = L_t / 60 \cdot K \cdot \sqrt{S_o} = L_t / 60 \cdot V_t$

c. UDFCD, USDCM Volume 1, Table 6-2: Heavy Meadow = 2.5, Tillage/field = 5, Short Pasture & Lawn = 7, Nearly Bare Ground = 10, Grassed Waterway = 15, Paved Areas & Shallow Paved Swales = 20

d. UDFCD, USDCM Volume 1, Equation 6-2: $t_c = t_i + t_t$

e. UDFCD, USDCM Volume 1, Equation 6-5: $t_t = (26 - 17i) + (L_t / 60(24i + 12)) \cdot \sqrt{S_t}$

f. UDFCD, USDCM Volume 1, Section 2.4.3, "The time of concentration shall be the lesser of the values calculated by Equation 6-2 and Equation 6-5."

g. UDFCD, USDCM Volume 1, Section 2.4.4, "Use a minimum t_c value of 5 minutes for urbanized areas."

STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE) - DEVELOPED CONDITIONS
DESIGN STORM: 5-YEAR

MASTER BASIN	DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			REMARKS
		AREA (Acres)	RUNOFF COEFF	T _c (min)	C * A (Acres)	P ₁ ^a	I ^b (in/hour)	Q (cfs) ^c	T _c (min)	(C A) (Acres)	I (in/hour)	Q (cfs)	SLOPE (%)	STREET FLOW (cfs)	DESIGN FLOW (cfs)	SLOPE (%)	PIPE SIZE (in)	LENGTH (ft)	VELOCITY (fps)	T _t (min)	
A1	1	0.03	0.77	5.0	0.03	1.43	4.85	0.12													
A2	1	0.07	0.09	12.4	0.01	1.43	3.54	0.02	5.4	0.03	4.75	0.12			0.12	0.5	8	40	1.69	0.39	Basin A1 routed to DP-1 Inlet
A3	2	0.22	0.72	5.0	0.16	1.43	4.85	0.77	13.0	0.01	3.46	0.02			0.14	0.5	10	75	1.96	0.64	Basin A1 and A2 routed to DP-2 Inlet
									13.7	0.19	3.39	0.65									ΣBasin A1, A2, A3 routed combined to DP-2 Inlet
A4	3	0.12	0.77	5.0	0.09	1.43	4.85	0.46							0.46	0.5	8	120	2.65	0.75	Basin A4 routed to DP-3 Inlet
A5	3	0.18	0.23	8.3	0.04	1.43	4.15	0.18	5.8	0.09	4.67	0.44			0.62	0.5	15	170	2.65	1.07	Basin A4 and A5 routed to DP-5 FES
									9.4	0.14	3.97	0.54									
OS1	4	0.47	0.07	18.8	0.03	1.43	2.90	0.09													Basin OS1 routed to DP-4
A6	5	0.52	0.08	8.2	0.04	1.43	4.16	0.17	18.8	0.03	2.90	0.09									Basin A6 routed to DP-5 FES
									8.2	0.07	4.16	0.30			0.85	1.00	18	195	3.34	0.97	ΣBasin A4, A5, OS1, A6 routed combined to DP-7 MH
A7	5	0.06	0.77	5.0	0.05	1.43	4.85	0.23													Basin A7 routed to DP-6 Inlet
A8	6	0.31	0.59	7.2	0.18	1.43	4.36	0.79	5.0	0.05	4.85	0.23									Basin A7 and A8 routed to DP-6 Inlet
	6								7.2	0.18	4.36	0.79									ΣBasin A1, A2, A3, A7, A8 routed combined to DP-6 Inlet
	7								13.7	0.37	3.39	1.26									ΣAll Basins (Exlcuding Basin OS2) routed combined to DP-7 MH
OS2	N/A	0.09	0.11	5.0	0.01	1.43	4.85	0.05	13.7	0.63	3.39	2.13									Basin OS2 in not collected in proposed storm sewer
									5.0	0.01	4.85	0.05									

NOTES:
a. Town of Castle Rock Storm Drainage Design and Technical Criteria Manual Table 6-1: P1 for Town of Castle Rock, 100-year (2.60), 10-year (1.66), 5-year (1.43), 2-year (1.06).
b. UDFCD, USDCM Volume 1, Equation 5-1: $I = (28.5 * P_1) / (10 + T_c)^{0.786}$
c. UDFCD, USDCM Volume 1, Equation 6-1: $Q = C/A$

STORM DRAINAGE SYSTEM DESIGN (RATIONAL METHOD PROCEDURE) - DEVELOPED CONDITIONS
DESIGN STORM: 100-YEAR

MASTER BASIN	DESIGN POINT	DIRECT RUNOFF							TOTAL RUNOFF				STREET		PIPE			TRAVEL TIME			REMARKS
		AREA (Acres)	RUNOFF COEFF	Tc (min)	C * A (Acres)	Pf ^a	I ^b (in/hour)	Q (cfs) ^c	Tc (min)	(C A) (Acres)	I (in/hour)	Q (cfs)	SLOPE (%)	STREET FLOW (cfs)	DESIGN FLOW (cfs)	SLOPE (%)	PIPE SIZE (in)	LENGTH (ft)	VELOCITY (fps)	Tt (min)	
A1	1	0.03	0.85	5.0	0.03	2.60	8.82	0.25													
A2	1	0.07	0.49	12.4	0.04	2.60	6.44	0.23	5.3	0.03	8.68	0.24			0.25	0.5	8	40	2.20	0.30	Basin A1 routed to DP-1 Inlet
A3	2	0.22	0.82	5.0	0.18	2.60	8.82	1.61	12.8	0.04	6.34	0.23			0.48	0.5	10	75	2.68	0.47	Basin A1 and A2 routed to DP-2 Inlet
									13.3	0.25	6.24	1.54									ΣBasin A1, A2, A3 routed combined to DP-2 Inlet
A4	3	0.12	0.85	5.0	0.10	2.60	8.82	0.92							0.92	0.5	8	120	3.02	0.66	Basin A4 routed to DP-3 Inlet
A5	3	0.18	0.57	8.3	0.10	2.60	7.54	0.78	5.7	0.10	8.52	0.89			1.67	0.5	15	170	3.51	0.81	Basin A4 and A5 routed to DP-5 FES
									9.1	0.21	7.29	1.51									
OS1	4	0.47	0.47	18.8	0.22	2.60	5.27	1.18													Basin OS1 routed to DP-4
A6	5	0.52	0.48	8.2	0.25	2.60	7.57	1.89	18.8	0.22	5.27	1.18									Basin A6 routed to DP-5 FES
									8.2	0.47	7.57	3.58			5.10	1.00	18	195	5.85	0.56	ΣBasin A4, A5, OS1, A6 routed combined to DP-7 MH
									9.7	0.73	7.13	5.22									
A7	5	0.06	0.85	5.0	0.05	2.60	8.82	0.45													Basin A7 routed to DP-6 Inlet
A8	6	0.31	0.76	7.2	0.23	2.60	7.92	1.85	5.0	0.05	8.82	0.45									Basin A7 and A8 routed to DP-6 Inlet
	6								7.2	0.23	7.92	1.85									ΣBasin A1, A2, A3, A7, A8 routed combined to DP-6 Inlet
	7								13.3	0.48	6.24	3.00									ΣAll Basins (Exlcuding Basin OS2) routed combined to DP-7 MH
									13.3	1.21	6.24	7.57									
OS2	N/A	0.09	0.50	5.0	0.04	2.60	8.82	0.39													Basin OS2 in not collected in proposed storm sewer
									5.0	0.04	8.82	0.39									

c. UDFCD, USDCM Volume 1, Equation 6-1: $Q = C/A$

BASIN SUMMARY:

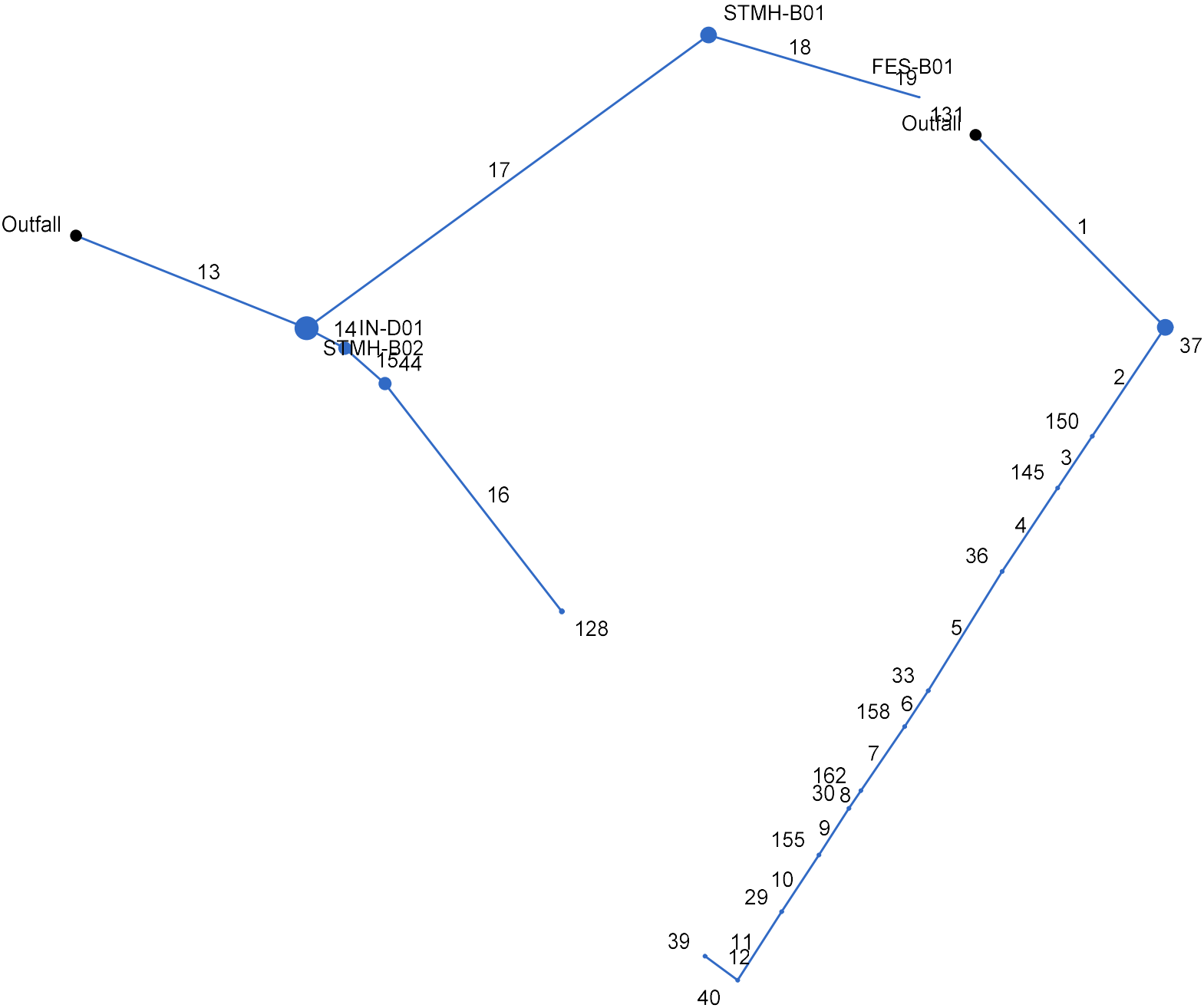
DRAINAGE BASIN	BASIN AREA (acres)	5-YEAR RUNOFF (cfs)	100-YEAR RUNOFF (cfs)
A1	0.03	0.12	0.25
A2	0.07	0.02	0.23
A3	0.22	0.77	1.61
A4	0.12	0.46	0.92
A5	0.18	0.18	0.78
A6	0.52	0.17	1.89
A7	0.06	0.23	0.45
A8	0.31	0.79	1.85
OS1	0.47	0.09	1.18
OS2	0.09	0.05	0.39

DESIGN POINT SUMMARY:

DESIGN POINT	TRIBUTARY DRAINAGE BASINS	5 YEAR RUNOFF		100 YEAR RUNOFF	
		DIRECT (cfs)	TOTAL (cfs)	DIRECT (cfs)	TOTAL (cfs)
1	A1, A2	0.02	0.14	0.23	0.48
2	A1, A2, A3	0.77	0.65	1.61	1.54
3	A4, A5	0.18	0.54	0.78	1.51
4	OS1	0.09	0.09	1.18	1.18
5	A4, A5, OS1, A6, A7	0.17	0.98	1.89	5.22
6	A1, A2, A3, A8	0.79	1.26	1.85	3.00
7	All Basins	2.13	2.13	7.57	7.57

APPENDIX D – HYDRAULICS

Hydraflow Storm Sewers Extension for Autodesk® Civil 3D® Plan



Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream								Len (ft)	Upstream								Check		JL coeff (K)	Minor loss (ft)
			Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)		Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)		
1	15	0.87	6146.40	6146.77	0.37	0.30	2.86	0.13	6146.90	0.498	74.186	6146.77	6147.14	0.37**	0.31	2.85	0.13	6147.27	0.493	0.496	0.368	0.98	0.12
2	8	0.87	6147.35	6147.86	0.51*	0.29	3.01	0.14	6148.01	0.499	36.020	6147.53	6148.04	0.51	0.29	3.01	0.14	6148.19	0.498	0.499	0.180	0.15	0.02
3	8	0.87	6147.54	6148.07	0.53*	0.30	2.92	0.13	6148.20	0.469	17.067	6147.62	6148.15	0.53	0.30	2.92	0.13	6148.28	0.469	0.469	0.080	0.15	0.02
4	8	0.64	6147.63	6148.17	0.54	0.30	2.11	0.07	6148.24	0.244	27.624	6147.77	6148.22	0.45	0.25	2.53	0.10	6148.32	0.368	0.306	0.085	0.50	0.05
5	8	0.64	6147.96	6148.37	0.41*	0.23	2.84	0.13	6148.50	0.491	38.669	6148.15	6148.56	0.41	0.23	2.84	0.12	6148.69	0.489	0.490	0.190	0.50	0.06
6	8	0.64	6148.35	6148.76	0.41*	0.22	2.88	0.13	6148.89	0.508	11.813	6148.41	6148.81	0.40	0.22	2.89	0.13	6148.94	0.513	0.510	0.060	0.15	0.02
7	8	0.18	6148.41	6148.83	0.42	0.23	0.77	0.01	6148.84	0.035	21.327	6148.52	6148.84	0.32	0.17	1.08	0.02	6148.86	0.085	0.060	0.013	0.15	0.00
8	8	0.18	6148.52	6148.84	0.32	0.17	1.08	0.02	6148.86	0.086	5.970	6148.55	6148.84	0.29	0.15	1.22	0.02	6148.87	0.120	0.103	0.006	0.50	0.01
9	8	0.18	6148.75	6148.95	0.20*	0.08	2.05	0.07	6149.02	0.501	15.190	6148.83	6149.03	0.20**	0.09	2.06	0.07	6149.09	0.502	0.502	0.076	0.15	0.01
10	8	0.18	6148.83	6149.04	0.21	0.08	1.97	0.06	6149.10	0.448	18.708	6148.92	6149.12	0.20**	0.09	2.06	0.07	6149.19	0.502	0.475	0.089	0.50	0.03
11	8	0.18	6149.12	6149.32	0.20*	0.08	2.05	0.07	6149.39	0.501	22.393	6149.23	6149.43	0.20**	0.09	2.06	0.07	6149.50	0.502	0.502	0.112	1.00	0.07
12	8	0.18	6149.24	6149.50	0.26	0.12	1.45	0.03	6149.53	0.191	11.204	6149.29	6149.51	0.22	0.10	1.80	0.05	6149.56	0.347	0.269	0.030	1.00	0.05
13	24	2.24	6142.50	6143.08	0.58	0.65	2.96	0.19	6143.27	0.000	68.224	6143.00	6143.52 j	0.52**	0.65	3.45	0.19	6143.71	0.000	0.000	n/a	0.87	0.16
14	24	1.26	6143.33	6143.72	0.39*	0.43	2.95	0.14	6143.85	0.462	11.900	6143.30	6143.83	0.53	0.67	1.87	0.05	6143.89	0.128	0.295	0.035	0.50	0.03
15	18	0.65	6143.80	6143.92	0.12*	0.06	10.10	0.10	6144.02	0.000	14.730	6146.89	6147.19	0.30**	0.25	2.60	0.10	6147.29	0.000	0.000	n/a	0.50	n/a
16	10	0.14	6147.09	6147.23	0.14*	0.06	2.36	0.06	6147.28	0.000	79.247	6147.87	6148.03	0.16**	0.07	1.90	0.06	6148.09	0.000	0.000	n/a	1.00	0.06
17	18	0.98	6143.50	6143.78	0.28*	0.22	4.40	0.13	6143.91	0.000	136.714	6145.70	6146.07	0.37**	0.34	2.91	0.13	6146.20	0.000	0.000	n/a	0.83	n/a
18	18	0.98	6145.94	6146.26	0.32*	0.27	3.61	0.13	6146.39	0.000	43.371	6146.34	6146.71	0.37**	0.34	2.91	0.13	6146.84	0.000	0.000	n/a	0.15	n/a
19	18	0.98	6146.34	6146.71	0.37*	0.34	2.91	0.13	6146.84	0.000	16.815	6146.46	6146.83	0.37**	0.34	2.91	0.13	6146.96	0.000	0.000	n/a	1.00	n/a

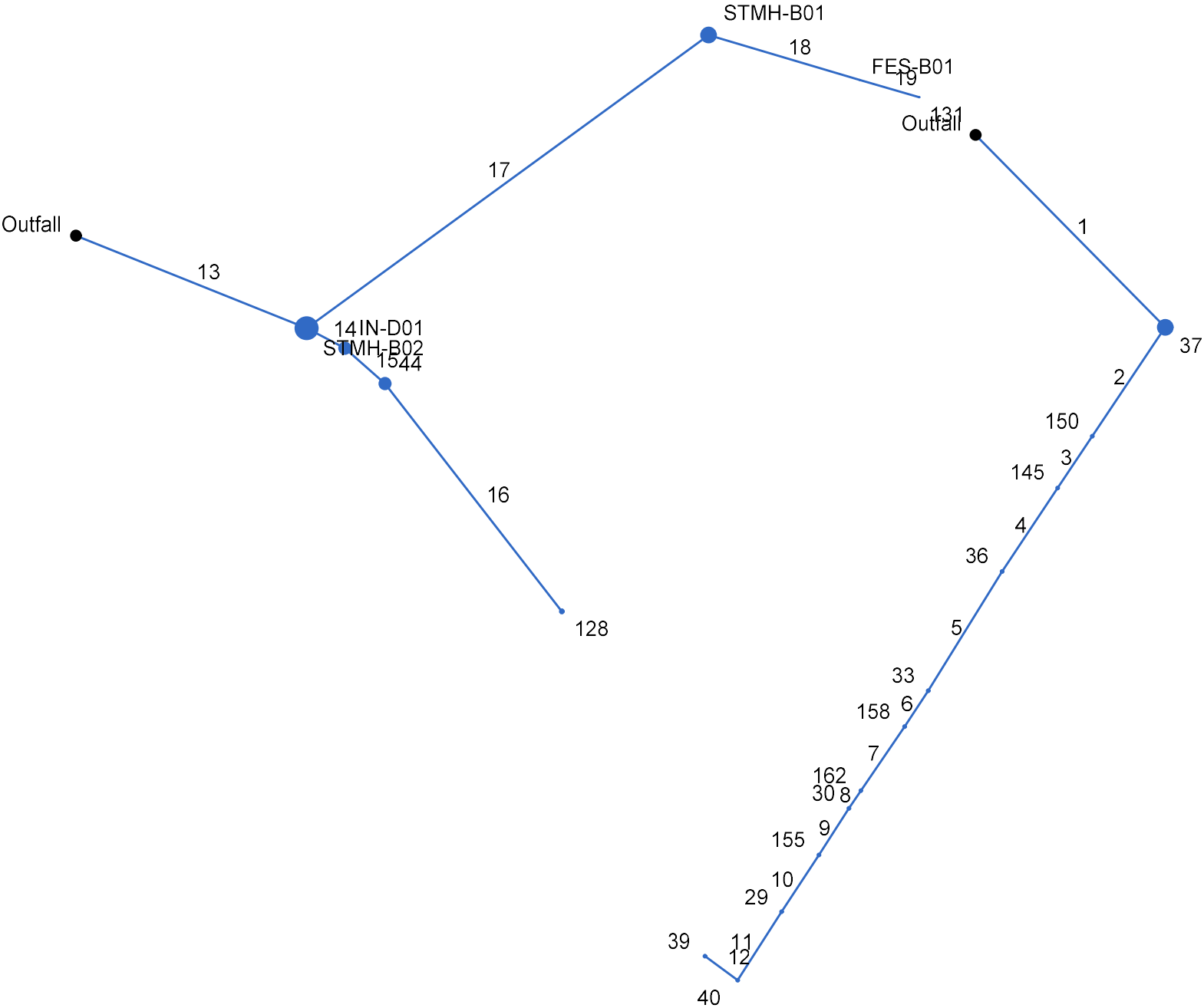
Project File: 5-YR.stm

Number of lines: 19

Run Date: 1/24/2024

Notes: * depth assumed; ** Critical depth.; j-Line contains hyd. jump ; c = cir e = ellip b = box

Hydraflow Storm Sewers Extension for Autodesk® Civil 3D® Plan



Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream								Len (ft)	Upstream								Check		JL coeff (K)	Minor loss (ft)
			Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)		Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)		
1	15	2.15	6146.40	6146.98	0.58	0.56	3.82	0.23	6147.21	0.559	74.186	6146.77	6147.39	0.62	0.61	3.53	0.19	6147.59	0.451	0.505	0.374	0.98	0.19
2	8	2.15	6147.35	6148.02	0.67*	0.35	6.16	0.59	6148.61	2.665	36.020	6147.53	6148.98	0.67	0.35	6.16	0.59	6149.57	2.700	2.683	0.966	0.15	0.09
3	8	2.15	6147.54	6149.07	0.67	0.35	6.16	0.59	6149.66	2.701	17.067	6147.62	6149.53	0.67	0.35	6.16	0.59	6150.12	2.700	2.701	0.461	0.15	0.09
4	8	1.70	6147.63	6149.62	0.67	0.35	4.87	0.37	6149.99	1.689	27.624	6147.77	6150.09	0.67	0.35	4.87	0.37	6150.46	1.688	1.689	0.466	0.50	0.18
5	8	1.70	6147.96	6150.27	0.67	0.35	4.87	0.37	6150.64	1.689	38.669	6148.15	6150.92	0.67	0.35	4.87	0.37	6151.29	1.688	1.689	0.653	0.50	0.18
6	8	1.70	6148.35	6151.11	0.67	0.35	4.87	0.37	6151.48	1.689	11.813	6148.41	6151.31	0.67	0.35	4.87	0.37	6151.68	1.688	1.689	0.199	0.15	0.06
7	8	0.78	6148.41	6151.36	0.67	0.35	2.23	0.08	6151.44	0.356	21.327	6148.52	6151.44	0.67	0.35	2.23	0.08	6151.52	0.355	0.355	0.076	0.15	0.01
8	8	0.78	6148.52	6151.45	0.67	0.35	2.23	0.08	6151.53	0.356	5.970	6148.55	6151.47	0.67	0.35	2.23	0.08	6151.55	0.355	0.355	0.021	0.50	0.04
9	8	0.78	6148.75	6151.51	0.67	0.35	2.23	0.08	6151.59	0.356	15.190	6148.83	6151.57	0.67	0.35	2.23	0.08	6151.64	0.355	0.355	0.054	0.15	0.01
10	8	0.78	6148.83	6151.58	0.67	0.35	2.23	0.08	6151.65	0.356	18.708	6148.92	6151.64	0.67	0.35	2.23	0.08	6151.72	0.355	0.355	0.067	0.50	0.04
11	8	0.78	6149.12	6151.68	0.67	0.35	2.23	0.08	6151.76	0.356	22.393	6149.23	6151.76	0.67	0.35	2.23	0.08	6151.84	0.355	0.355	0.080	1.00	0.08
12	8	0.78	6149.24	6151.84	0.67	0.35	2.23	0.08	6151.92	0.356	11.204	6149.29	6151.88	0.67	0.35	2.23	0.08	6151.96	0.355	0.355	0.040	1.00	0.08
13	24	8.22	6142.50	6144.38	1.88	1.61	2.68	0.40	6144.79	0.000	68.224	6143.00	6144.02	1.02**	1.61	5.10	0.40	6144.43	0.000	0.000	n/a	0.87	n/a
14	24	3.00	6143.33	6144.02	0.69	0.96	3.12	0.15	6144.17	0.269	11.900	6143.30	6144.09	0.79	1.16	2.58	0.10	6144.20	0.159	0.214	0.025	0.50	0.05
15	18	1.54	6143.80	6144.15	0.35	0.31	4.99	0.17	6144.32	0.000	14.730	6146.89	6147.36	0.47**	0.47	3.30	0.17	6147.52	0.000	0.000	n/a	0.50	n/a
16	10	0.48	6147.09	6147.36	0.27	0.15	3.21	0.11	6147.47	0.000	79.247	6147.87	6148.17	0.30**	0.18	2.68	0.11	6148.29	0.000	0.000	n/a	1.00	0.11
17	18	5.22	6143.50	6144.15	0.65*	0.74	7.08	0.37	6144.52	0.000	136.714	6145.70	6146.58	0.88**	1.08	4.85	0.37	6146.95	0.000	0.000	n/a	0.83	0.30
18	18	5.22	6145.94	6146.71	0.77*	0.91	5.75	0.37	6147.07	0.000	43.371	6146.34	6147.22	0.88**	1.08	4.85	0.37	6147.58	0.000	0.000	n/a	0.15	0.05
19	18	5.22	6146.34	6147.22	0.88*	1.08	4.85	0.37	6147.58	0.000	16.815	6146.46	6147.34	0.88**	1.08	4.85	0.37	6147.71	0.000	0.000	n/a	1.00	0.37

Project File: 100-YR.stm

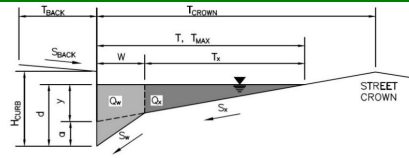
Number of lines: 19

Run Date: 1/24/2024

Notes: * depth assumed; ** Critical depth. ; c = cir e = ellip b = box

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)**(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)**

Project:

Inlet ID: **DP 2****Gutter Geometry:**

Maximum Allowable Width for Spread Behind Curb

Side Slope Behind Curb (leave blank for no conveyance credit behind curb)

Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line

Distance from Curb Face to Street Crown

Gutter Width

Street Transverse Slope

Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)

Street Longitudinal Slope - Enter 0 for sump condition

Manning's Roughness for Street Section (typically between 0.012 and 0.020)

T_{BACK}	=	10.0	ft
S_{BACK}	=	0.020	ft/ft
n_{BACK}	=	0.020	

H_{CURB}	=	6.00	inches
T_{CROWN}	=	60.0	ft
W	=	0.50	ft
S_x	=	0.030	ft/ft
S_w	=	0.083	ft/ft
S_0	=	0.000	ft/ft
n_{STREET}	=	0.020	

Max. Allowable Spread for Minor & Major Storm

Max. Allowable Depth at Gutter Flowline for Minor & Major Storm

Check boxes are not applicable in SUMP conditions

	Minor Storm	Major Storm	
T_{MAX}	60.0	60.0	ft
d_{MAX}	6.0	6.0	inches
	☐	☐	

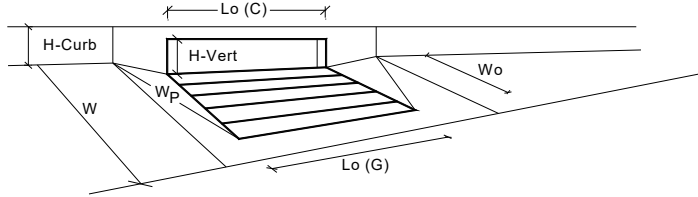
MINOR STORM Allowable Capacity is not applicable to Sump Condition

MAJOR STORM Allowable Capacity is not applicable to Sump Condition

	Minor Storm	Major Storm	
Q_{allow}	SUMP	SUMP	cfs

INLET IN A SUMP OR SAG LOCATION

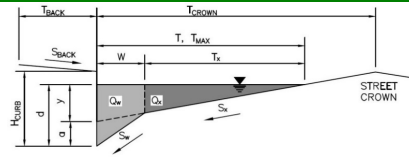
MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	CDOT Type R Curb Opening			
Local Depression (additional to continuous gutter depression 'a' from above)		$a_{local} =$	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	6.0	6.0	inches
Grate Information		MINOR		MAJOR	
Length of a Unit Grate		$L_o (G) =$	N/A	N/A	feet
Width of a Unit Grate		$W_o =$	N/A	N/A	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)		$A_{ratio} =$	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		$C_f (G) =$	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		$C_w (G) =$	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		$C_o (G) =$	N/A	N/A	
Curb Opening Information		MINOR		MAJOR	
Length of a Unit Curb Opening		$L_o (C) =$	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		$H_{vert} =$	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		$H_{throat} =$	6.00	6.00	inches
Angle of Throat		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		$W_p =$	0.50	0.50	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		$C_f (C) =$	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		$C_w (C) =$	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		$C_o (C) =$	0.67	0.67	
Low Head Performance Reduction (Calculated)		MINOR		MAJOR	
Depth for Grate Midwidth		$d_{Grate} =$	N/A	N/A	ft
Depth for Curb Opening Weir Equation		$d_{Curb} =$	0.46	0.46	ft
Grated Inlet Performance Reduction Factor for Long Inlets		$RF_{Grate} =$	N/A	N/A	
Curb Opening Performance Reduction Factor for Long Inlets		$RF_{Curb} =$	1.00	1.00	
Combination Inlet Performance Reduction Factor for Long Inlets		$RF_{Combination} =$	N/A	N/A	
Total Inlet Interception Capacity (assumes clogged condition)		MINOR		MAJOR	
		$Q_s =$	5.9	5.9	cfs
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		$Q_{PEAK REQUIRED} =$	0.8	1.6	cfs

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)**(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)**

Project:

Inlet ID: **DP 6****Gutter Geometry:**

Maximum Allowable Width for Spread Behind Curb

Side Slope Behind Curb (leave blank for no conveyance credit behind curb)

Manning's Roughness Behind Curb (typically between 0.012 and 0.020)

Height of Curb at Gutter Flow Line

Distance from Curb Face to Street Crown

Gutter Width

Street Transverse Slope

Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)

Street Longitudinal Slope - Enter 0 for sump condition

Manning's Roughness for Street Section (typically between 0.012 and 0.020)

T_{BACK}	=	10.0	ft
S_{BACK}	=	0.020	ft/ft
n_{BACK}	=	0.020	

H_{CURB}	=	6.00	inches
T_{CROWN}	=	15.0	ft
W	=	0.50	ft
S_X	=	0.020	ft/ft
S_W	=	0.083	ft/ft
S_O	=	0.000	ft/ft
n_{STREET}	=	0.020	

Max. Allowable Spread for Minor & Major Storm

Max. Allowable Depth at Gutter Flowline for Minor & Major Storm

Check boxes are not applicable in SUMP conditions

	Minor Storm	Major Storm	
T_{MAX}	15.0	15.0	ft
d_{MAX}	6.0	6.0	inches
	☐	☐	

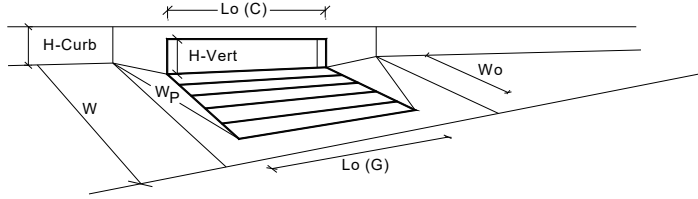
MINOR STORM Allowable Capacity is not applicable to Sump Condition

MAJOR STORM Allowable Capacity is not applicable to Sump Condition

	Minor Storm	Major Storm	
Q_{allow}	SUMP	SUMP	cfs

INLET IN A SUMP OR SAG LOCATION

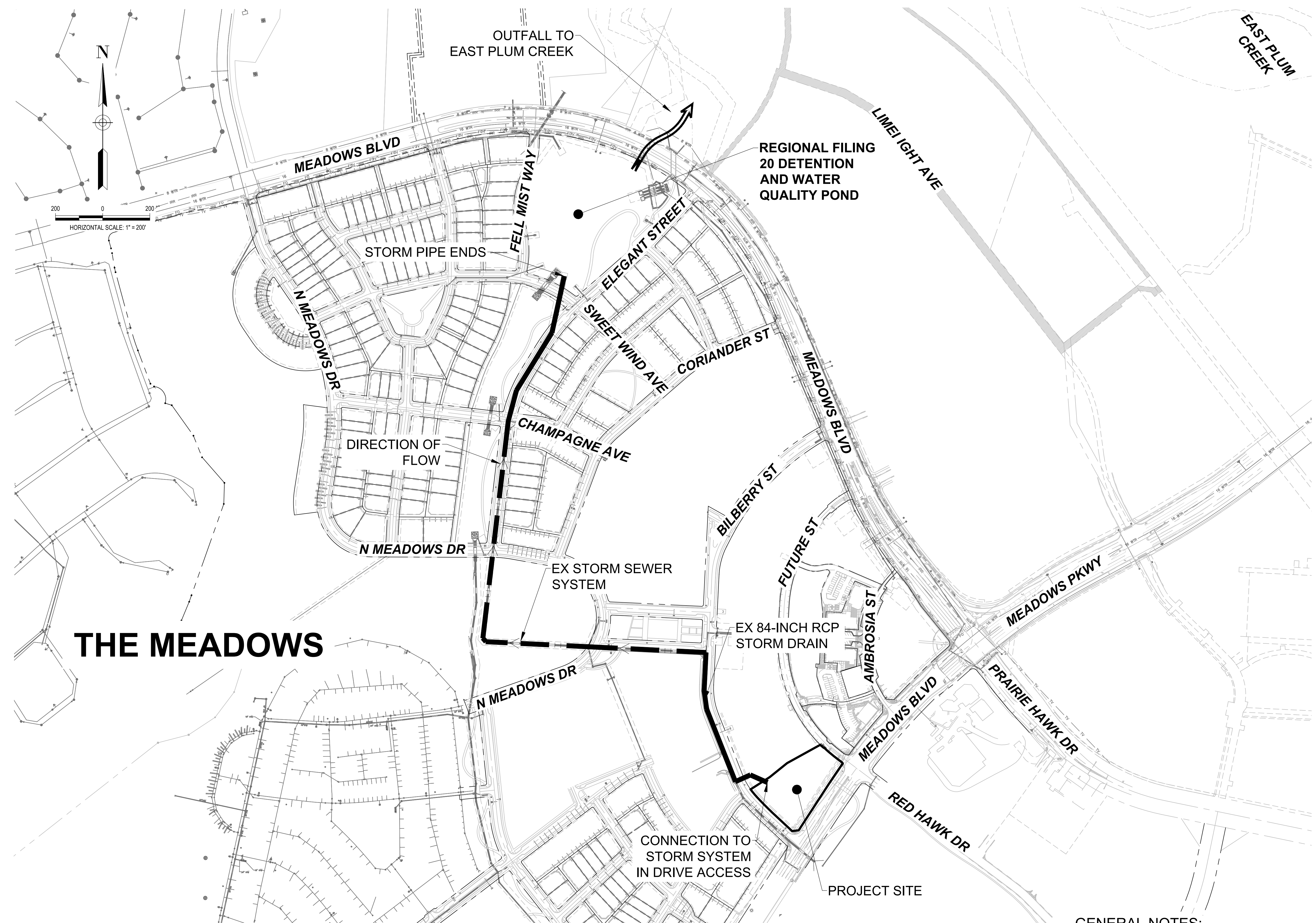
MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type = CDOT Type R Curb Opening			
Local Depression (additional to continuous gutter depression 'a' from above)		a _{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	4.0	4.0	inches
Grate Information		MINOR		MAJOR	
Length of a Unit Grate		L _o (G) =	N/A	N/A	feet
Width of a Unit Grate		W _o =	N/A	N/A	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)		A _{ratio} =	N/A	N/A	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C _f (G) =	N/A	N/A	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C _w (G) =	N/A	N/A	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C _o (G) =	N/A	N/A	
Curb Opening Information		MINOR		MAJOR	
Length of a Unit Curb Opening		L _o (C) =	5.00	5.00	feet
Height of Vertical Curb Opening in Inches		H _{vert} =	6.00	6.00	inches
Height of Curb Orifice Throat in Inches		H _{throat} =	6.00	6.00	inches
Angle of Throat		Theta =	63.40	63.40	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W _p =	0.50	0.50	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C _f (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C _w (C) =	3.60	3.60	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C _o (C) =	0.67	0.67	
Low Head Performance Reduction (Calculated)		MINOR		MAJOR	
Depth for Grate Midwidth		d _{Grate} =	N/A	N/A	ft
Depth for Curb Opening Weir Equation		d _{Curb} =	0.29	0.29	ft
Grated Inlet Performance Reduction Factor for Long Inlets		RF _{Grate} =	N/A	N/A	
Curb Opening Performance Reduction Factor for Long Inlets		RF _{Curb} =	1.00	1.00	
Combination Inlet Performance Reduction Factor for Long Inlets		RF _{Combination} =	N/A	N/A	
Total Inlet Interception Capacity (assumes clogged condition)		MINOR		MAJOR	
		Q _s =	3.0	3.0	cfs
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		Q _{PEAK REQUIRED} =	0.8	1.9	cfs

APPENDIX E – DETENTION WATER QUALITY

DETENTION WATER QUALITY EXHIBIT



THE MEADOWS

APPENDIX F – DRAINAGE MAP

APPENDIX G – EXISTING STUDIES, MAPS, REFERENCES

**Approved Phase III Final Drainage Report for The Meadows
Filing No. 20 (Project Ref. No. CRDC-0304A).**

PHASE III FINAL DRAINAGE REPORT

FOR

THE MEADOWS FILING NO. 20

Volume 1 of 2

Prepared For:

Castle Rock Development Company
3033 East First Avenue, Suite 410
Denver, Colorado 80206

Prepared by:

RG Consulting Engineers, Inc.
1331 17th Street, Suite 710
Denver, CO 80202

June 2004

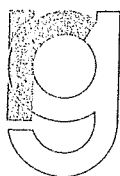
Revised August 2004

Revised September 2004

Revised October 2004

Project Reference No. CRDC-0304A

RGCE Job No. 820.0001



rg consulting engineers, inc.

RUNOFF COEFFICIENTS

Subdivision: The Meadows Filing No. 20

Calculated by: VJV

Job No.: 820.0001

Checked by: FJB

Date: September 16, 2004

Building/Surface Type	Percent Imperv.	Runoff Coefficients (Type B Soil)			Runoff Coefficients (Type C/D Soil)		
		5yr	10yr	100yr	5yr	10yr	100yr
Carriage Condos	48%	0.34	0.40	0.52	0.39	0.44	0.59
Mansion Condos	61%	0.41	0.46	0.56	0.46	0.51	0.63
Stacked Rowhouses	63%	0.44	0.48	0.58	0.48	0.53	0.65
Uphill Townhouses	64%	0.44	0.48	0.58	0.48	0.53	0.65
Back Yard Rowhouses	63%	0.44	0.48	0.58	0.48	0.53	0.65
Small Cottages	43%	0.32	0.38	0.51	0.37	0.44	0.59
Mid Cottages	43%	0.32	0.38	0.51	0.37	0.44	0.59
Village Houses	47%	0.34	0.40	0.52	0.39	0.44	0.59
Estates	50%	0.35	0.40	0.52	0.40	0.46	0.60
Commercial	95%	0.81	0.83	0.88	0.82	0.84	0.89
Roads/Flatwork	100%	0.90	0.92	0.96	0.90	0.92	0.96
Roof	90%	0.73	0.75	0.81	0.75	0.77	0.83
Grass	0%	0.08	0.15	0.35	0.15	0.25	0.50
School	50%	0.35	0.40	0.52	0.40	0.46	0.60

Note : Runoff Coefficients for soil type A were not shown. All soil for The Meadows Filing No. 20 is either type B or type C/D.

Carriage Condos, Mansion Condos, Stacked Rowhouses, Back Yard Rowhouses, Small Cottages, Mid Cottages, Village Houses, and Estates are all products used throughout Meadows Filing No. 20. The overall percent imperviousness was calculated for each product using the imperviousness for Roads/Flatwork, Roof, and Grass per average lot area. See product type exhibits on following pages.

An overall percent impervious value of 95% is anticipated for the Project site.

Approved Phase III Final Drainage Report for The Meadows Filing No. 20 (Project Ref. No. CRDC-0304A).

BASIN OSC4 HAS BEEN CALCULATED IN THIS REPORT AS AN UNDEVELOPED BASIN WITH AN IMPERVIOUS PERCENTAGE OF 5%. THIS HAS BEEN DONE TO PUSH INLET IMPROVEMENTS LIKELY REQUIRED AT INTERSECTION OF BILBERRY AND MERCANTILE STREET TO BE DESIGNED BY EITHER FUTURE DEVELOPMENT OF BLOCK 3 LOT 2 OR EXTENSION OF MERCANTILE STREET FROM FUTURE STREET TO BILBERRY STREET. NOTE THAT CONSTRUCTION OF BILBERRY STREET WILL NOT WARRANT IMPROVEMENTS AS BASIN C15 WILL BE OVERLOT GRADED IN THE INTERIM WHERE THIS REPORT HAS MODELED THIS AREA AS FULLY DEVELOPED. PLEASE NOTE THAT ANTICIPATED RUNOFF FOR BASIN OSC4 WITH AN IMPERVIOUS OF 100% HAS BEEN PROVIDED IN THE REPORT SF2 AND SF3 FORMS, AS WELL AS NOTED IN THE BASIN SUMMARY TABLE ON THIS MAP.

GREEN HATCH REPRESENTS MEADOWS UBERGRIPPEN SITE.

ANTICIPATED AND DESIGNED VALUES FOR MEADOWS D1 TRAINING CENTER PROJECT SITE (TAKEN FROM ORIGINAL 2004 REPORT) DICTATE AN OVERALL COMPOSITE PERCENT IMPERVIOUSNESS OF 95%, WHICH IS LESS THAN THE CURRENT PROPOSED PERCENT COMPOSITE IMPERVIOUSNESS OF THE PROJECT OF 45.5%.

BLUE HATCH REPRESENTS PROPOSED MEADOWS D1 TRAINING CENTER PROJECT SITE.

Approved Phase III Final Drainage Report for The Meadows Filing No. 20 (Project Ref. No. CRDC-0304A).

LEGEND

- A = BASIN DESIGNATION
B = BASIN AREA (A₂)
C = MINOR RUNOFF COEFFICIENT
D = MAJOR RUNOFF COEFFICIENT
- △ DESIGN POINT DESIGNATION
- EXISTING MAJOR CONTOUR
--- EXISTING MINOR CONTOUR
--- PROPOSED MAJOR CONTOUR
--- PROPOSED MINOR CONTOUR
- FLOW ARROW
- MAJOR BASIN
MAJOR SUBBASIN
- PROPOSED STORM PIPE
- PROPOSED TYPE-R INLET
- FILING 20 BOUNDARY

FILING 20, BLOCKS 1, 2, AND 3

	VOLUME REQUIRED		VOLUME PROVIDED		ELEVATION (FEET)	RELEASE RATE (CFS)
	CUBIC FT	ACRE-FT	CUBIC FT	ACRE-FT		
WATER QUALITY	42,431	1.0	373,745	8.58	6076.48	
10 YEAR	83,821	1.9	1,311,156	30.10		N.A.
10 YEAR + WQ	126,252	2.9	1,684,901	38.68	6081.89	
100 YEAR	155,477	3.6	2,112,660	48.50		N.A.
100 YEAR + WQ	155,477	3.6	2,112,660	48.50	6083.80	

*FOR REGIONAL POND, LOCATED IN FILING 20 AT INTERSECTION OF MEADOWS BOULEVARD AND ELEGANT STREET. WQ IS INCLUDED IN 100 YEAR VOLUME

BLOCK 2, LOT 1A AND TRACT A

	VOLUME REQUIRED		VOLUME PROVIDED		ELEVATION (FEET)	RELEASE RATE (CFS)
	CUBIC FT	ACRE-FT	CUBIC FT	ACRE-FT		
WATER QUALITY	2,435	0.06	373,745	8.58	N.A.	
10 YEAR	4,811	0.11	1,311,156	30.10		N.A.
10 YEAR + WQ	7,246	0.17	1,684,901	38.68	N.A.	
100 YEAR	8,923	0.20	2,112,660	48.50		N.A.
100 YEAR + WQ	8,923	0.20	2,112,660	48.50	N.A.	

*FOR REGIONAL POND, LOCATED IN FILING 20 AT INTERSECTION OF MEADOWS BOULEVARD AND ELEGANT STREET. WQ IS INCLUDED IN 100 YEAR VOLUME

BLOCK 3, LOT 1A AND TRACT A

	VOLUME REQUIRED		VOLUME PROVIDED		ELEVATION (FEET)	RELEASE RATE (CFS)
	CUBIC FT	ACRE-FT	CUBIC FT	ACRE-FT		
WATER QUALITY	1,714	0.04	373,745	8.58	N.A.	
10 YEAR	3,387	0.08	1,311,156	30.10		N.A.
10 YEAR + WQ	5,101	0.12	1,684,901	38.68	N.A.	
100 YEAR	6,282	0.14	2,112,660	48.50		N.A.
100 YEAR + WQ	6,282	0.14	2,112,660	48.50	N.A.	

*FOR REGIONAL POND, LOCATED IN FILING 20 AT INTERSECTION OF MEADOWS BOULEVARD AND ELEGANT STREET. WQ IS INCLUDED IN 100 YEAR VOLUME

DESIGN POINT SUMMARY

D.P.	Q _s (cfs)	Q ₁₀₀ (cfs)
1	5.5	10.8
2	2.9	5.7
3	8.1	15.9
4	2.1	4.2
5	10.0	19.7
6	8.0	15.9
7	18.0	35.6
8	4.3	8.4
9	2.0	3.9
10	23.2	45.8
10a	7.9	15.7
11	14.1	27.9
12	3.3	14.2
13	16.8	40.8
14	1.5	2.9
15	17.9	43.1
16	38.5	83.7
17	11.5	22.7
18	2.0	3.9
19	12.8	25.2
20	1.4	2.7
21	3.2	6.4
22	4.4	8.7
23	16.6	32.8
24	18.3	36.2
25	34.3	67.6
26	2.0	5.4
27	0.9	3.6
28	30.3	61.2

BASIN SUMMARY

BASIN	Q _s (cfs)	Q ₁₀₀ (cfs)
A05	5.5	10.8
A10	2.9	5.7
A11	2.1	4.2
A15	8.0	15.9
A16	4.3	8.4
A20	2.0	3.9
A21	2.2	4.3
A25	14.1	27.9
OSA1	3.3	14.2
OSA2	1.5	2.9
OSA3	5.9	11.6
B05	0.3	0.5
C04	9.7	19.1
C05	2.0	3.9
C10	1.5	2.9
C15	16.9	33.4
C20	2.1	4.2
C21	1.4	2.7
C25	0.9	1.9
OSC1	1.9	3.8
OSC2	2.3	4.5
OSC3	1.7	3.4
OSC4	0.4	2.2
OSC4 *	2.0	4.0

SEE NOTE PROVIDED ON PLAN VIEW CONCERNING FLOW FOR BASIN OSC4*

Approved Addendum No. 1 to the Filing 20 Phase III Drainage Report (2004 Report) for The Meadows Filing No. 20 which includes: Filing No. 20 Phase 1, Amendment 2 (PWP 08-013) Block 2, Lot 1A (PWP 08-011) and Block 3, Lot 1A (PWP 08-012)

**ADDENDUM NO. 1 TO THE FILING 20
PHASE III DRAINAGE REPORT**

For

JUN 13 2008

THE MEADOWS FILING 20 TO INCLUDE:

**Filing No. 20 Phase 1,
Amendment 2 (PWP 08-013)
Block 2, Lot 1A (PWP 08-011)
Block 3, Lot 1A (PWP 08-012)**

*Located north of Meadows Boulevard and west of Meadows Boulevard
Sections 33 and 34, Township 7 South, Range 67 West,
Town of Castle Rock*

Prepared for:

Castle Rock Development Company
3033 E. First Avenue Ste. 410
Denver, CO 80206

Prepared by:

CVL Consultants of Colorado, Inc.
7901 E. Belleview Ave, Suite 150
Englewood, CO 80111
Phone (720) 482-9526

February 22, 2008
April 22, 2008
May 15, 2008

Approved Addendum No. 1 to the Filing 20 Phase III Drainage Report (2004 Report) for The Meadows Filing No. 20 which includes: Filing No. 20 Phase 1, Amendment 2 (PWP 08-013) Block 2, Lot 1A (PWP 08-011) and Block 3, Lot 1A (PWP 08-012)

55 acres and is this basin will flow onto Meadows Boulevard and be captured by an existing Type-R curb inlet located in Meadows Boulevard between Future Street and Bilberry Street and released undetained into the Tributary to Plum Creek.

Sub-basin A25, a portion of Block 2, Lot 2, is 4.63 acres and is planned for future commercial development. In the future, runoff from this basin will collect in a private storm system and be conveyed to the Filing 20 regional detention pond via an existing and proposed public storm drain system. In the interim, before the lot develops, the runoff will be collected in Temporary Sediment Pond D and then be routed into the existing public storm system to the existing Filing 20 regional detention pond.

Sub-basin OSA1 is a 0.87-acre offsite basin that is planned for future Bilberry Street. Runoff from this basin will be captured by an existing Type-R curb inlet located at the intersection of Bilberry Street and Meadows Boulevard. This flow will then be routed to the existing Filing 20 regional detention pond by an existing public storm drain system.

**DESCRIPTION OF ORIGINAL
OFFSITE BASIN HEREIN LABELED
AS 'SUB-BASIN OSA2' IS
MEADOWS D1 TRAINING CENTER
PROJECT SITE.**

Sub-basin OSA2 is a 0.37-acre offsite basin that is planned for future Bilberry Street. Runoff from this basin will be captured by an existing Type-R curb inlet located at the intersection of Bilberry Street and Meadows Boulevard. This flow will then be routed to the existing Filing 20 regional detention pond by an existing public storm drain system.

Sub-basin OSA3 is a 1.55-acre offsite basin that is part of Meadows Boulevard. Runoff from this basin will be captured by an existing Type-R curb inlet located between Bilberry Street and Future Street in Meadows Boulevard. This flow will then be routed undetained to the Tributary to Plum Creek.

Sub-basin B05 is 0.07 acres and is planned for future commercial development. Runoff from this basin will be captured by an existing Type-R curb inlet located at the intersection of Meadows Boulevard and Meadows Boulevard. This flow will then be routed through an existing storm system along the northeastern side of Meadows Boulevard and released undetained into the Tributary to East Plum Creek.

Sub-basin C04 is 2.56 acres and is planned for part of Block 3, Lot 1A, Tract A, Lot 1 Remainder, and Lot 1B. A proposed Type-13 combination inlet located at the northwestern corner of the proposed parking lot at DP17 will collect runoff from this basin. This flow will be routed to the Filing 20 regional detention pond via a proposed and existing public storm system.

FINAL WEIGHTED COMPOSITE BASIN COEFFICIENTS

Subdivision The Meadows Filing 20
Location Castle Rock

Project No. 30101307
Calculated By: ACS
Checked By: BRH
Date: 5/16/2008

Storm Drain Line B

Sub-Basin ID	Surface Description	Area (ac)	Percent Impervious (%)	Weighted Percent Impervious (%)	Weighted Runoff Coefficient (5yr)	Weighted Runoff Coefficient (100yr)
B05	Commercial	0.07	95%	95.0%	0.82	0.89
		0.07		95.0%	0.82	0.89

Summary of Basin B: 0.07 Ac. 95.0% Impervious

Summary Onsite Basin B
0.07 95.0%

Storm Drain Line C

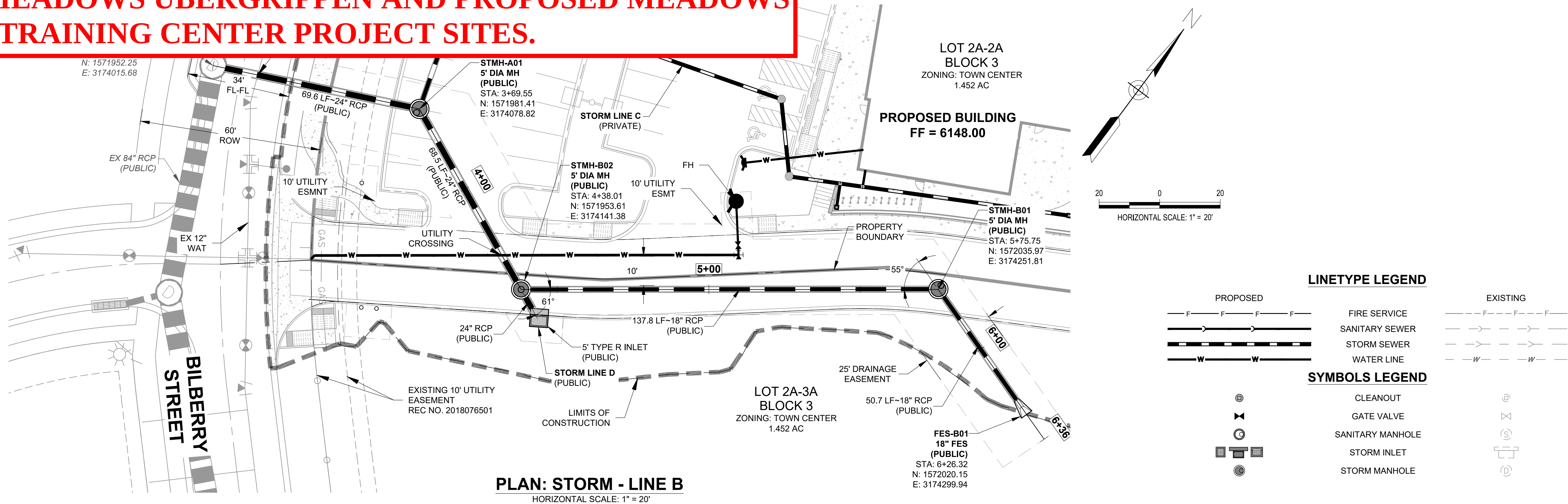
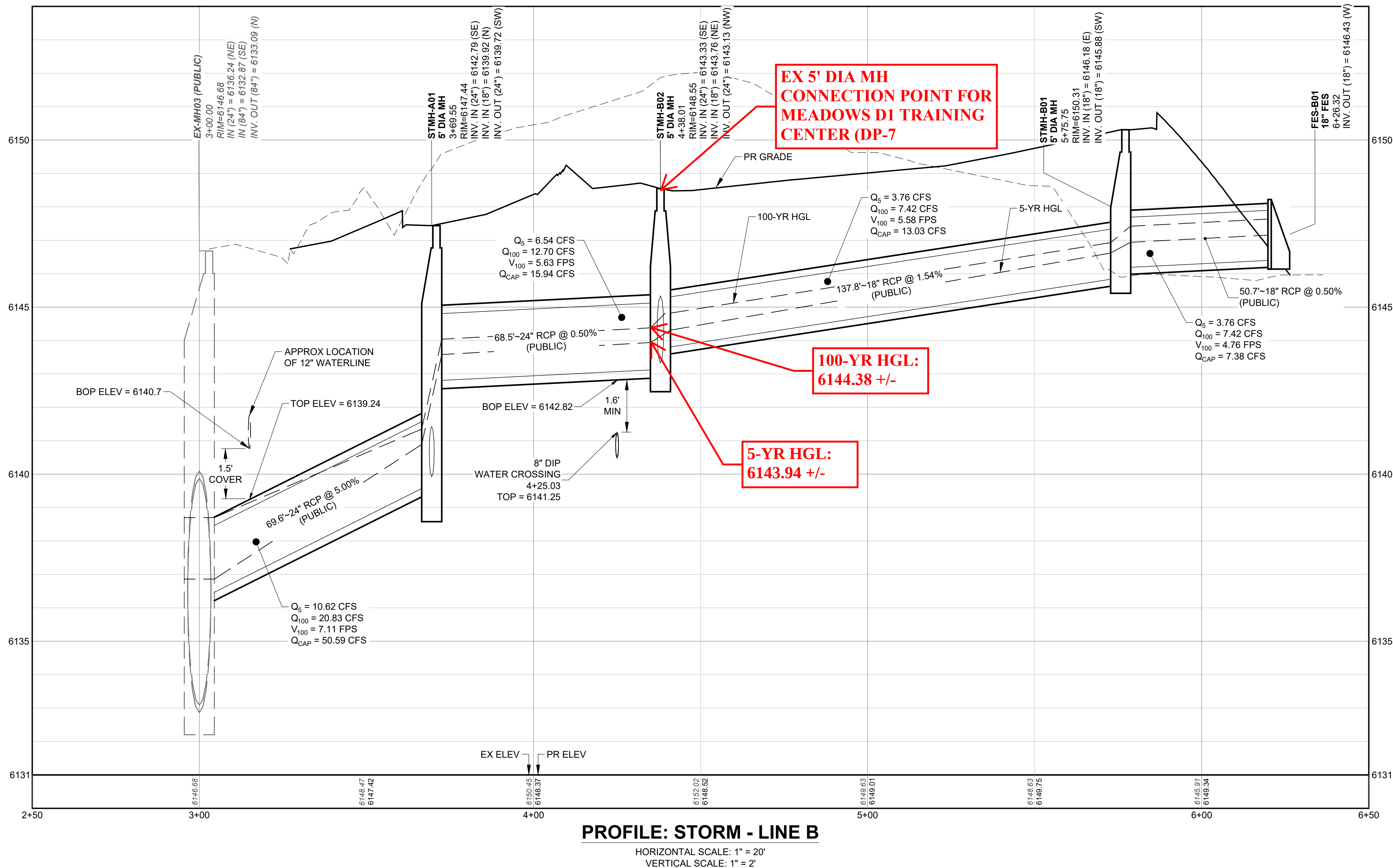
Sub-Basin ID	Surface Description	Area (ac)	Percent Impervious (%)	Weighted Percent Impervious (%)	Weighted Runoff Coefficient (5yr)	Weighted Runoff Coefficient (100yr)
C04	Commercial	2.56	95%	95.0%	0.82	0.89
		2.56		95.0%	0.82	0.89
C05	Commercial	0.50	95%	95.0%	0.82	0.89
		0.50		95.0%	0.82	0.89
C10	Commercial	0.37	95%	95.0%	0.82	0.89
		0.37		95.0%	0.82	0.89
C15	Commercial	5.12	95%	95.0%	0.82	0.89
		5.12		95.0%	0.82	0.89
C20	Commercial	0.62	95%	95.0%	0.82	0.89
		0.62		95.0%	0.82	0.89
C21	Commercial	0.34	95%	95.0%	0.82	0.89
		0.34		95.0%	0.82	0.89
C25	Commercial	0.25	95%	95.0%	0.82	0.89
		0.25		95.0%	0.82	0.89

Summary Onsite Basin C
9.76 Ac. 95.0%

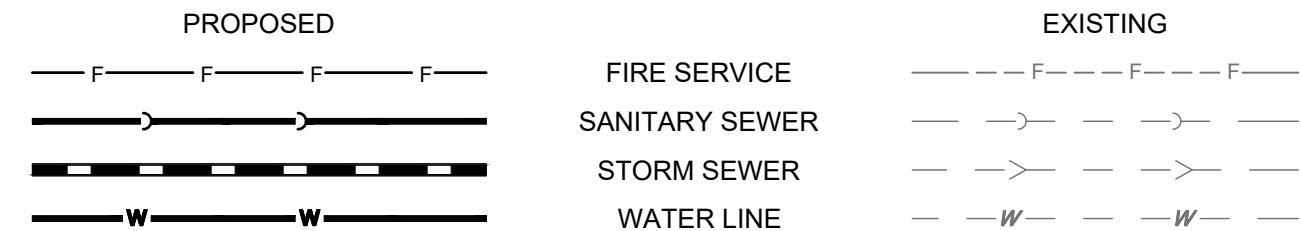
PREVIOUS REPORT USED A TOTAL PERCENT COMPOSITE IMPERVIOUSNESS OF 95% (COMMERCIAL DEVELOPMENT). THIS VALUE IS GREATER THAN WHAT IS TO BE DEVELOPED FOR THE MEADOWS D1 TRAINING CENTER PROJECT, WHERE I=45.5%.

Approved Addendum No. 1 to the Filing 20 Phase III Drainage Report (2004 Report) for The Meadows Filing No. 20 which includes: Filing No. 20 Phase 1, Amendment 2 (PWP 08-013) Block 2, Lot 1A (PWP 08-011) and Block 3, Lot 1A (PWP 08-012)

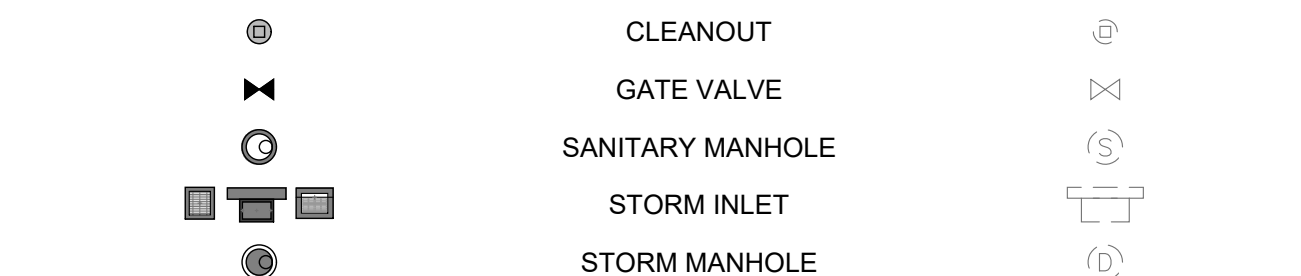
EXISTING HGL FROM RECORD DRAWING OF EXISTING STORM MAIN IN DRIVE ACCESS TO MEADOWS UBERGRIPPEN AND PROPOSED MEADOWS D1 TRAINING CENTER PROJECT SITES.



LINETYPE LEGEND



SYMBOLS LEGEND



BASIS OF BEARINGS

THE EAST LINE OF SECTION 33, TOWNSHIP 7 SOUTH, RANGE 67 WEST OF THE 6TH PRINCIPAL MERIDIAN, BEING MONUMENTED AT THE NORTHEAST CORNER BY A NO. 6 REBAR WITH 3-1/4" ALUMINUM CAP MARKED "AZTEC PLS 38064" AND AT THE SOUTHEAST CORNER BY A NO. 6 REBAR WITH 3-1/4" ALUMINUM CAP MARKED "AZTEC PLS 33204", ASSUMED TO BEAR SOUTH 01°03'47" EAST.

BENCHMARK

SITE BENCHMARK IS DOUGLAS COUNTY CONTROL MONUMENT 2.015030, RECOVERED 3.25" ALUMINUM CAP LOCATED 410' MORE OR LESS EAST OF THE RAILROAD TRACKS AND 3200' MORE OR LESS NORTH OF MEADOWS PARKWAY. ELEVATION = 6082.17 (NAVD 88).

PROFESSIONAL ENGINEER CERTIFICATION

I HEREBY AFFIRM THAT THESE FINAL CONSTRUCTION PLANS WERE PREPARED UNDER MY DIRECT SUPERVISION, IN ACCORDANCE WITH ALL APPLICABLE TOWN OF CASTLE ROCK AND STATE OF COLORADO STANDARDS AND STATUTES, RESPECTIVELY; AND THAT I AM FULLY RESPONSIBLE FOR ALL DESIGN AND REVISIONS RELATIVE TO SAID PLANS.



TOWN OF CASTLE ROCK APPROVAL

PHASE 1 DEVELOPMENT SERVICES APPROVAL
DATE OF DEVELOPMENT SERVICES APPROVAL
by Dena Paulin
on 04/21/2020

5-CD19-0044 Plans for Approval.pdf
Record Document on File
DEVELOPMENT SERVICES DATE 4/17/20

ISSUE DATE: 4/17/20		
DATE	REVISIONS	BY

DESIGNED BY:	DRT
DRAWN BY:	DRT
JOB NUMBER:	190501

**REFERENCE MATERIAL FOR REGIONAL POND
PROVIDING WATER QUALITY FOR PROJECT SITE**

PHASE III FINAL DRAINAGE REPORT

FOR

THE MEADOWS FILING NO. 20

Volume 1 of 2

Prepared For:

Castle Rock Development Company
3033 East First Avenue, Suite 410
Denver, Colorado 80206

Prepared by:

RG Consulting Engineers, Inc.
1331 17th Street, Suite 710
Denver, CO 80202

June 2004

Revised August 2004

Revised September 2004

Revised October 2004

Project Reference No. CRDC-0304A

RGCE Job No. 820.0001



rg consulting engineers, inc.

Rock standards. Summary tables and schematic drawings from the StormCAD program are included in Appendix C for the 5 year and 100 year storm illustrating that the design criteria are met.

Major Drainage Channels

The two major drainage channels upstream of culvert 1 and culvert 2 were designed using the Manning's Formula Method in Flow Master for irregular channels (see Appendix C). The major drainage channels have a bottom width of 20 feet, a slope of 1.15 to 1.2 percent, and Froude numbers less than 0.80. These major drainage channels will have boulder edged low-flow channels (see Low Flow Channel section in Appendix C) which has been included in the Flow Master sections. All major drainage channels will be maintained by the Town of Castle Rock. All channels were designed to include 1 foot of free board. In addition, to determine the effect of backwater through the culverts, a HEC-RAS calculation was performed to show the hydraulic grade line through the channel.

Culverts

The two concrete box culverts sizes and headwater elevations were determined using the CulvertMaster computer program. The necessary culvert sizes were determined to ensure that design criteria outlined in the Public Works Regulations (Ref. 4) were met. These were also checked using the HEC-RAS computer program.

Detention Ponds & Water Quality

The design as outlined in the Phase I Master Drainage Report for The Meadows (Ref. 1) called for two regional detention ponds within The Meadows Filing No. 20, (see Master Drainage Report Supplemental Material in Appendix D). Due to layout constraints, The Meadows Filing No. 20 will install one larger Regional Detention Pond which is designed to detain the required detention and water quality capture volume (WQCV) for The Meadows Filing No. 18 and Filing No. 20 and release flow at historical rates (see Appendix C). UDSWM routing was used to determine release rates below historic release rates. This routing method was found to be the appropriate method because of the flows from historic Basins 201, 202 and 203 that are routed through the pond. These offsite basins are part of 6400 South Tributary routing and will also be released at historic rates when development occurs in this area.

The Regional Detention Pond was designed using UDSWM for the required detention and current Town of Castle Rock Standards for the WQCV (see Appendix C). The required 10-year and 100-year detention from UDSWM are 30.10 acre-feet and 48.50 acre-feet, respectively. The required WQCV was determined to be 8.58 acre-feet. Since the onsite detention pond is considered regional, the WQCV is included in the 100 year detention volume and will be added to the 10 year detention volume. The total required 10 year and 100 year detention volumes, including WQCV, for the Regional Detention Pond are 38.68 acre-feet and 48.50 acre-feet, respectively (see Appendix C). The method used to calculate the incremental volume provided in the Regional Detention Pond was modeled after the Urban Drainage Estimating Detention Volume Workbook Stage-Storage for Irregular Geometry spreadsheet.

The pond releases flow into the existing 20'x12' concrete box culvert which conveys the flow north underneath Meadows Boulevard. The release out of the pond and through the existing concrete box culvert needs to be at or below historical rates. The historical flow rate for the 10 year and 100 year storm north of the existing 20'x12' concrete box culvert are 307 cfs and 1012 cfs, respectively (see UDSWMM output for conveyance element 108 in Appendix G). The developed release rates out of the Regional Detention Pond for the 10-year and 100-year storm are 203 cfs and 991 cfs, respectively (see Appendix C). The developed 10 year and 100 year flows are below the historical 10 year and 100 year flows. Therefore, no downstream properties north of Meadows Boulevard will be negatively impacted by The Meadows Filing No. 18 or Filing No. 20 development.

Detention facilities, emergency spillways and water quality features of the outlet structure have been designed in conformance with the most recent Urban Drainage and Flood Control District criteria (Ref. 5), draft issue of March 2001, published issue of July 2001. Calculations are included in Appendix C.

Storm Sewer and Inlets

The layout of the proposed storm sewer system is shown on the Proposed Drainage Plan included with this report (see Pocket in Volume I). Design points have been placed at the proposed inlet locations to determine the approximate amount of runoff intercepted by each inlet. Runoff calculations for all inlet design points are shown on Standard Forms SF-2 and SF-3, and are included in Appendix B. Included in Appendix C are the calculations for inlet sizes and street capacities.

CONCLUSION

This Phase III Drainage Report was prepared in compliance with the Town of Castle Rock Public Works Regulations drainage improvement design criteria. Proposed drainage improvements for the site have been discussed. Regional detention for The Meadows Filing No. 18 and Filing No. 20 will be provided onsite in Regional Detention Pond. The major storm (100-year) system was designed to ensure the protection of property from significant damage during the major storm event. It has been shown that no downstream properties will be adversely affected from the development of The Meadows Filing No. 18 or Filing No. 20.

Regional Detention Pond - Required Detention and Water Quality Capture Volume

Subdivision: The Meadows Filing No. 20

Calculated by: VJV

Checked by: FJB

Job No.: 820.0001

Date: September 16, 2004

$$WQCV = IA/2400$$

100 Yr Storm

Basin(s)	Area, A (ac)	Impervious, I (%)	WQCV (ac-ft)	WQCV (cu-ft)
A-N	324.38	45.93	6.21	270,428
OS1	61.31	20.00	0.51	22,256
OS2	13.80	45.00	0.26	11,271
OS3	96.00	40.00	1.60	69,696
Total			8.58	373651

Required Detention for the 100 Yr Storm	48.50	ac-ft
Release Rate	991	cfs
(from UDSWMM Output**)		

Required Detention for the 10 Yr Storm	30.10	ac-ft
Release Rate	203	cfs
(from UDSWMM Output**)		

***Total Required Detention for the 100 Yr Storm 48.50 ac-ft**

* - Water quality does not need to be added to the 100 year detention volume for regional detention ponds.

Total Required Detention for the 10 Yr Storm	38.68	ac-ft
---	--------------	--------------

100 Yr Historic Flows 1012 cfs

10 Yr Historic Flows 307 cfs

**Includes flows from Red Hawk Subdivision routed through pond but not detained.

The Meadows Filing 20

REGIONAL DETENTION POND VOLUME CALCULATIONS

SUBDIVISION The Meadows - Filing 20

CALCULATED BY VJV

DATE 10/14/04

POND DESIG	ELEV	AREA (ft ²)	VOLUME (ft ³)	VOLUME _{sum} (ft ³)	METHOD
PROPOSED REGIONAL DETENTION POND	6071.3	0	0	0	prismoidal
	6072	61452	14,338.80	14,338.80	
	6074	147114	202,431.52	216,770.32	
	6076	179373	325,954.46	542,724.78	
	6078	190356	369,674.61	912,399.40	
	6080	206164	396,414.92	1,308,814.32	
	6082	217326	423,440.96	1,732,255.28	
	6084	257236	474,001.61	2,206,256.89	
	6086	265447	522,661.50	2,728,918.39	
	6087	283905	274,624.30	3,003,542.69	

8.58 acre-feet = 373,744.80 ft³
 38.68 acre-feet = 1,684,900.80 ft³
 48.50 acre-feet = 2,112,660.00 ft³

By Interpolation
 Elev_{wq}(ft)= 6076.48
 Elev₁₀(ft)= 6081.89
 Elev₁₀₀(ft)= 6083.80

The Meadows Filing 20

DETENTION POND WEIR AND ORIFICE SIZING CALCULATIONS

SUBDIVISION The Meadows - Filing 20

CALCULATED BY VJV

DATE 10/14/04

REGIONAL DETENTION POND

WATER SURFACE	INVERT ELEV	PONDING ELEV	Qr (cfs)	HEAD at Qr (ft)	WEIR LENGTH (ft)	AREA (ft2)	ORIFICE DIAMETER (in)	
							Calculated	***Actual
*10yr	6076.48	6081.89	203.00	5.41	5.97			
**100yr	6081.89	6083.80	330.33	1.91	37.79			
***100yr	6071.30	6083.80	330.33	10.00		20.02	60.60	60 1/2

Detention pond outlet structure consists of three outlet boxes, each with a 72" outlet pipe. Center box contains water quality release, 10-year release rate and one-third of the total 100-year release rate. Side outlet boxes release one-third of the total 100-year release rate per box.

*10-year weir opening in center outlet box is contracted weir; $L = (Q_r / (3.3h^{1.5})) + 0.2h$

**2-100-year side boxes-flow is controlled by standard weir, length of walls; $L = Q_r / (3.3h^{1.5})$

***Center outlet box 100-year flow is controlled by orifice plate over outlet pipe; $Area = Q_r / (.65(2gh)^{1/2})$

The Meadows Filing 20

WEIR DESIGN

Pond: WATER QUALITY/DETENTION POND

DESIGNED BY: VJV

JOB NAME

The Meadows - Filing 20

DATE:

14-Oct-04

EMERGENCY OVERFLOW WEIR DESIGN

Determine min. weir length to assure control of the pipe inlet:

Release Rate (Q_{weir})= 1982.00 cfs = 2 x 100 yr. release

$$L = Q_{\text{weir}} / (C(H)^{3/2})$$

Where:

Q_{weir}= 1982.00 cfs

C= 3.4

from Table 1301

H= 3.20 ft

Weir Height

L= 101.8 ft

Length of Weir

WATER QUALITY OUTLET SIZING (DRY POND)

SUBDIVISION The Meadows - Filing 20

CALCULATED BY VJV DATE 10/14/04

WATER QUALITY CONTROL DESIGN	
<p><u>Water Quality Volume:</u> 373,745 ft³ 8.58 acre-ft</p>	<p><u>*Required Area Per Row:</u> 6.31 in² a=WQCV/K₄₀ K₄₀=0.013D_{WQ}²+0.22D_{WQ}-0.10 <u>Number/Size of Holes per Row:</u> 8 Columns of 1" Diameter Holes</p>
<p><u>Depth at Outlet:</u> 5.1 ft</p>	

# Columns	Area per diameter of hole and number of columns												
	1/4	3/8	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1	1 1/8	1 1/4
1	0.049	0.110	0.196	0.249	0.307	0.371	0.442	0.518	0.601	0.690	0.785	0.994	1.227
2	0.098	0.221	0.393	0.497	0.614	0.742	0.884	1.037	1.203	1.381	1.571	1.988	2.454
3	0.147	0.331	0.589	0.746	0.920	1.114	1.325	1.555	1.804	2.071	2.356	2.982	3.682
4	0.196	0.442	0.785	0.994	1.227	1.485	1.767	2.074	2.405	2.761	3.142	3.976	4.909
5	0.245	0.552	0.982	1.243	1.534	1.856	2.209	2.592	3.007	3.451	3.927	4.970	6.136
6	0.295	0.663	1.178	1.491	1.841	2.227	2.651	3.111	3.608	4.142	4.712	5.964	7.363
7	0.344	0.773	1.374	1.740	2.148	2.599	3.093	3.629	4.209	4.832	5.498	6.958	8.590
8	0.393	0.884	1.571	1.988	2.454	2.970	3.534	4.148	4.811	5.522	6.283	7.952	9.817



Phase III Drainage Report Checklist

The Phase III Drainage Report must be in conformance with the latest Town of Castle Rock Storm Drainage Design and Technical Criteria Manual available on the Town's website.

The Phase III Drainage Report must be signed and sealed by a Professional Engineer licensed in the State of Colorado. The purpose of the Phase III Drainage Report is to update the concepts, and to present the design details on construction plans for the drainage facilities discussed in the Phase II Drainage Report.

The preparer should contact and work with the Town Stormwater Engineering Staff regarding any design, master planning and existing system questions (720-733-6000). The following outline sets forth the **required minimum** content to be provided in the Phase III Drainage Report that shall be submitted with the Planned Development Plan or Straight Zoning documents. A copy of this checklist must be submitted with the Phase III Drainage Report.

Please see Chapter 4 of the Town of Castle Rock Storm Drainage Design and Technical Criteria Manual for additional details and information. Please check off the following items to assure your report is complete. Appropriate notations shall be provided with the checklist. For example, if a specific item is not addressed or not applicable, an explanation needs to be provided.

Included	N/A	
Y		I. COVER SHEET
Y		A. Name of Project, including legal name of development
Y		B. Address
Y		C. Owner
Y		D. Developer
Y		E. Engineer
Y		F. Submittal date and revision dates as applicable
Y		II. GENERAL LOCATION AND DESCRIPTION
Y		A. Site Location
Y		B. Description of Property and Land Use
Y		III. DRAINAGE BASIN AND SUB-BASINS
Y		A. Major Drainage Basins
Y		B. Minor Drainage Basins
Y		IV. DRAINAGE DESIGN CRITERIA
Y		A. Regulations
Y		B. Drainage Studies, Master Plans, Site Constraints
Y		C. Hydrology
Y		D. Hydraulics
	N/A	E. Water Quality Enhancement

Phase III Drainage Report Checklist

Included	N/A	
	N/A	V. STORMWATER MANAGEMENT FACILITY DESIGN
	N/A	A. Stormwater Conveyance Facilities
	N/A	B. Stormwater Storage Facilities
	N/A	C. Water Quality Enhancement Best Management Practices
	N/A	D. Floodplain Modification
	N/A	E. Additional Permitting Requirements
	N/A	F. General
Y		VI. CONCLUSIONS
Y		A. Compliance with Standards
Y		B. Variances
Y		C. Drainage Concept
Y		VII. REFERENCES
Y		VIII. APPENDICES
Y		A. Hydrologic Computations
Y		B. Hydraulic Computations
	N/A	C. Water Quality Enhancement Best Management Practices
Y		D. Referenced Information
Y		OVERALL DRAINAGE PLAN (IN POCKET)
	N	DETAILED DRAINAGE PLANS (IN POCKET)

Notes/Comments: