



Phase II Drainage Report

Castleton Heights
3161 North Castleton Court
Castle Rock, Colorado 80109

Lot 3A, Castleton Center Filing No. 2, Amendment 2

Prepared for Owner/Developer:

TWG Development

1301 East Washington Street, Suite 100

Indianapolis, Indiana 46202

Prepared by:

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Basalt, Colorado 81621

KH Project No.: 196273005

Prepared: August 15th, 2025



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Castleton Heights Phase II Drainage Report

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January 16, 2025

Revised August 15, 2025

ENGINEER'S CERTIFICATION

I affirm that this report and plan for the Phase II drainage design of Castleton Heights 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 the drainage facilities designed by others.

SIGNATURE: _____

Bryce Christensen, P.E.
Registered Professional Engineer
State of Colorado No. 47935

DEVELOPER'S CERTIFICATION

TWG Development hereby certified that the drainage facilities for Castleton Heights 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 Castleton Heights, guarantee that final drainage design review will absolve TWG Development and/or their successors and/or assigns of future liability for improper design.

SIGNATURE: _____

Seth Atkins, TWG Development

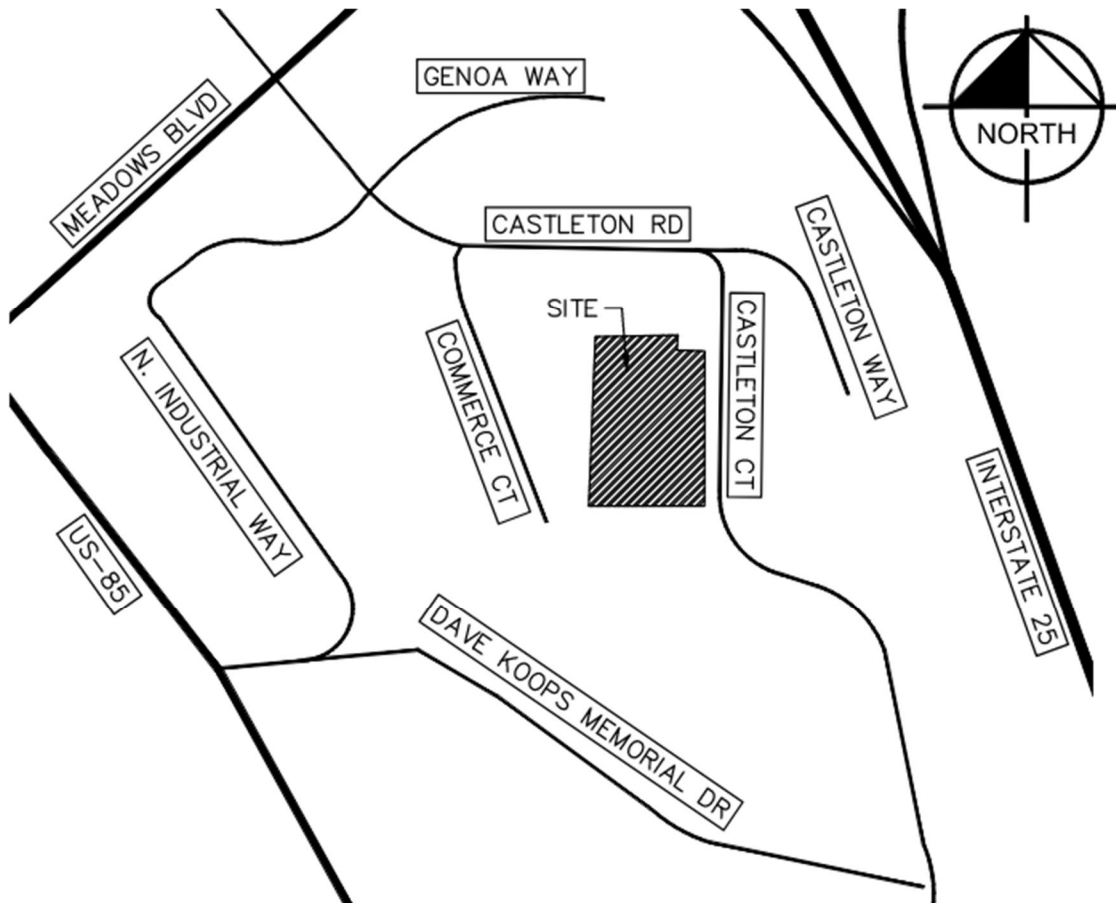
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GENERAL LOCATION AND DESCRIPTION

Site Location

A vicinity map is provided below for reference:



The project is located at 3161 North Castleton Court in Castle Rock, Colorado. It is described as Lot 3A, Castleton Center, Filing No. 2, 2nd Amendment. The Site is a portion of the Southeast quarter of Section 27, Township 7 South, Range 67 West of the 6th Principal Meridian, City of Castle Rock, County of Douglas, State of Colorado. The site is within the Castleton Center Subdivision, bounded to the north by an office building, to the east by North Castleton Court, to the south by a CWSD well site, and to the west by a brewery. The Site is located within the Town of Castle Rock while its northern, southern, and western neighbors are within unincorporated Douglas County. The Site is currently zoned B.

Description of Property

The Site is 3.10 acres and is currently undeveloped with a soil stockpile and bare earth showing evidence of construction activities on approximately one half-acre of the site. The rest of the site appears undisturbed and consists of sparse grasses with fewer than 10

small trees. The site generally slopes from east to west at slopes up to 2:1. An NRCS Web Soil Survey shows a singular hydrologic soil group classification type D. The Site has no drainageways within its bounds and is in flood hazard zone X. No significant geologic features are on the site.

The proposed development includes a 20,000 SF multifamily residential building and associated parking lot, sidewalks, and utilities. Stormwater will be captured via curb and gutter, routed through an onsite storm sewer, and be routed to the existing detention facility to the west. The connection to the existing storm sewer will be an existing inlet in the northwest corner of the project site.

DRAINAGE BASINS AND SUB-BASINS

Major Drainage Basins

The Site lies on and within the southern border of the Tributary C watershed, which flows from east to west and into East Plum Creek.

Minor Drainage Basins

The Site has been previously planned to drain to a subregional pond located on Lot 1, Castleton Center Filing No. 2. A drainage report for this development could not be found, so the runoff assumptions were recreated using plans for Castleton Center Filing 2. Applicable standards at the time of this development required detention for the 10 and 100 year storms but did not provide for water quality. Therefore, this development assumes that water quality treatment must be provided for all runoff generated onsite but that detention (up to the maximum runoff amount assumed by the prior report) will be provided in the subregional pond.

Plans showing the expected buildout of the project can be found in **Appendix D** and Calculations based on those plans can be found in **Appendix C**.

Sub-basin A1, located near the northern border of the site, is comprised of concrete, asphalt, and landscaping. Runoff will sheet flow north, be captured by curb and gutter, and enter the storm sewer via Inlet A1, which is in sump. In a clogged condition, runoff would spill over the curb northwest of the inlet and drain onto private property. This is not a compliant overflow path, so the inlet and downstream storm piping has been sized to convey twice the 100 year flows in addition to required clogging factors applied. Runoff from this basin enters the subregional pond after passing through a hydrodynamic separator.

Sub-basin A2, located west of the building, is comprised of concrete, asphalt, and landscaping. Runoff will sheet flow west and enter the storm sewer via inlet A2, which is in sump. In a clogged condition, runoff would overtop the asphalt grade break and flow north over to Basin A1. Runoff from this basin enters the subregional pond after passing through a hydrodynamic separator

Sub-basin A3, located west of the proposed building, is comprised of concrete, asphalt, and landscaping. Runoff will sheet flow west, be concentrated in the asphalt, and enter

the storm sewer via inlet A3, which is in sump. In a clogged condition, runoff would pond in the drive aisles until it spilled north into basin A2. Runoff from this basin enters the subregional pond after passing through a hydrodynamic separator.

Sub-basin A4, located west of the proposed building, is comprised of concrete, asphalt, and landscaping. Runoff will sheet flow west, be concentrated in the asphalt, and enter the storm sewer via inlet A4, which is in sump. In a clogged condition, runoff would pond in the drive aisles until it spilled north into basin A3. Runoff from this basin enters the subregional pond after passing through a hydrodynamic separator.

Sub-basin R1 represents the building roof. Runoff will be captured by a roof drain networked and be piped to the proposed underground FSD detention facility onsite. Downspouts will drain into the underground network via scuppers open to the air. Should any scuppers become clogged, runoff would overland flow west into one of the inlets in the parking lot.

Sub-basin OS1 is located along the site's northern border, is comprised of landscaping. Runoff will sheet flow north and drain to the neighboring property. The peak 100 year flow to the adjacent property, when combined with flows from OS7, is 1.74 CFS. This is an increase from the 1.24 CFS sent to the neighboring property in the existing condition. See **Appendix B** for supporting calculations showing the offsite inlet can handle the additional flow. This basin does not drain to a structural water quality control but achieves the water quality standard through runoff reduction as shown in **Appendix A**.

Sub-basin OS2, located in the northwest corner of the site, is comprised of landscaping. Runoff will sheet flow west and drain to the neighboring property. The peak 100-year flow to the adjacent property is 0.71 CFS, which is a decrease from the 3.35 CFS in the existing condition. Negligible impervious area is being added to this basin as a result of this development. This basin does not drain to a structural water quality control but achieves the water quality standard through runoff reduction as shown in **Appendix A**.

Sub-basin OS3, located along the western border of the site, is comprised of landscaping. Runoff will sheet flow west and drain onto the neighboring property. The peak 100-year flow to the adjacent property is 1.59 CFS, which is a decrease from 2.05 CFS in the existing condition. Negligible impervious area is being added to this basin as a result of this development. This basin does not drain to a structural water quality control but achieves the water quality standard through runoff reduction as shown in **Appendix A**.

Sub-basin OS4, located along the southern border of the site, is comprised of landscaping. Runoff will sheet flow south and drain onto the adjacent property. The peak 100-year flow to the adjacent property is 0.56 CFS, which is a decrease from the 1.25 CFS in the existing condition. Negligible impervious area is being added to this basin as a result of this development. This basin does not drain to a structural water quality control but achieves the water quality standard through runoff reduction as shown in **Appendix A**.

Sub-basin OS5, located along the southern border of the site, is comprised of landscaping. Runoff will sheet flow south and drain onto the adjacent property. The peak 100-year flow to the adjacent property is 0.53 CFS, which is a decrease from the 1.04 CFS in the existing condition. Negligible impervious area is being added to this basin as a result of this

development. This basin does not drain to a structural water quality control but achieves the water quality standard through runoff reduction as shown in **Appendix A**.

Sub-basin OS6, located along the eastern border of the site, is comprised of landscaping. Runoff will sheet flow east into Castleton Court Right-of-Way. In the existing condition, the site does not send any runoff into Castleton Court. See **Appendix B** for supporting calculations showing the offsite inlet can handle the additional flow. This basin does not drain to a structural water quality control but achieves the water quality standard through runoff reduction as shown in **Appendix A**.

Sub-basin OS7, located along the site's northern border, is comprised of landscaping, concrete, and asphalt. Runoff will sheet flow north to the adjacent development and be captured by an existing curb inlet. This flow pattern is the same as the existing condition, but at rates greater than existing as detailed previously. Water quality treatment is not provided for this basin as it would not be practical to capture this runoff from an existing driveway. This basin is the only onsite basin for which water quality is not provided. Sub-basin OS7 is 0.14 acres and represents 5% of the property.

Sub-basin OO1, located north of the site, is comprised of landscaping and asphalt. Runoff sheet flows west into an existing 5' Type R inlet, which is in sump. No improvements are proposed in this basin. This basin was analyzed to verify the additional flow from the site to its design point will not have any negative effects.

Sub-basin OO2, located east of the site, is comprised of concrete. This basin is the west half of Castleton Court. Runoff sheet flows to the curb and gutter, travels south, and is captured by the existing 5' Type R inlet. No improvements are proposed in this basin. This basin was analyzed to verify the additional flow from the site to its design point will not have any negative effects.

Existing and proposed drainage maps can be found in **Appendix E**.

DRAINAGE DESIGN CRITERIA

Regulations

The Town of Castle Rock Storm Drainage Design and Technical Criteria Manual (SDDTCM), updated June 2019, was used to develop the drainage design within this report. This Manual makes reference to MHFD; the Urban Storm Drainage Criteria Manual, Volumes 1-3, updated March 2024, was used in conjunction with the Town's Manual.

Town of Castle Rock Storm Drainage Design and Technical Criteria Manual was updated in February 2025 after the first submittal of this report. This updated version will be the enforceable document for the Phase III drainage report for Castleton Heights. Revisions to the SDP accompanying this report may be required if the design herein does not comply with the updated Manual.

Drainage Studies, Master Plans, and Site Constraints

The site has previously been planned to drain to a subregional pond located on Castleton Center Filing No. 2 Lot 1 to the west of the site. Available plans are titled *Construction Plans for Castleton Center Filing No. 2, Lots LI-15, C-1, C-2, and a Part of C-3*, dated February 20, 1997 and prepared by TST Inc. of Denver

No adjacent properties use the site for stormwater conveyance in the existing or proposed conditions.

Grade change is the largest site constrain in the drainage design of the site. The eastern property line varies from an elevation of 6154 to 6157, while the eastern property line varies from an elevation of 6125 to 6137. Castleton Court to the east is the Site's only access, sets the allowable elevation range of the building and therefore the necessity of retaining walls to support a parking lot.

Hydrology

The rational method was used to determine runoff generated onsite in accordance with SDDTCM Section 6.3. The major and minor storms analyzed were the 5 and 100 year storms, respectively. One-hour point rainfall values used were 1.43" for the minor storm and 2.6" for the major storm per section 6.1.3. Rational calculations can be found in **Appendix A**.

MHFD's UD-Detention spreadsheet and the site's watershed characteristics were used to determine the design volumes for the onsite detention facility and recreate the runoff planned for in the subregional detention facility.

Hydraulics

The project will construct a private storm sewer network onsite including curb inlets, a roof drain network, and storm sewer. All inlets have been sized using the MHFD's UD-Inlet workbook. Storm sewer hydraulics were modeled against Town Criteria using Bentley StormCAD. All hydraulic calculations were performed for the major and minor storms. Results can be found in **Appendix D**.

Storm Sewer calculations, performed in Bentley StormCAD, were performed in order to verify compliance with section 9.8 of the SDDTCM. Velocity within the storm sewer was kept between 2 FPS and 15 FPS for the major and minor design storms. The hydraulic grade line was contained within the pipe for the minor storm and within one foot of finished grade in the major storm. Losses in junctions were determined using the standard method and loss coefficients within the StormCAD users manual. Flows used in these calculations were twice the expected 100-year flow because the sump inlets onsite do not have emergency overflow paths compliant with SDDTCM.

The proposed detention facility was sized using MHFD's UD-Detention spreadsheet to provide full spectrum detention for a portion of the site. It accepts flows from the roof drain system and outflows to an existing inlet placed on the northwest corner of the site. This existing inlet was installed by the neighboring Lot 1, Castleton Center Filing No. 2. This inlet was installed for the future development of the Site. The 100-year peak outflow of the detention basin has been assumed to be lower than the flows for which this inlet was planned, and no analysis has been performed downstream of this inlet.

Storage and Water Quality Enhancement

Two detention facilities are used to manage runoff generated by the proposed development. The majority of the site will use the existing detention pond northwest of the property. This pond planned for a smaller buildout of the site, so a portion of the site will be detained onsite to make up the difference. The proposed vault will provide full spectrum detention for its tributary area. The existing detention facility does not provide for WQCV, so runoff will be treated in an inline WQ unit prior to leaving the property.

The four-step approach to water quality planning is discussed in the Water Quality Enhancement Control Measures section below.

STORMWATER MANAGEMENT FACILITY DESIGN

Stormwater Conveyance Facilities

Runoff generated onsite generally sheet flows across the parking lot and is captured within drive aisles at valley inlets in sump conditions. An underground storm network collects runoff, crosses under the retaining walls, and connects to the existing storm sewer in the northwest corner of the property. Basins with this drainage patterns are designated with an “A” in their name.

Some runoff will leave the site above ground and drain onto neighboring properties. This is either consistent with historic patterns and flow rates or the downstream inlet has been shown to have sufficient capacity for the additional flows. These basins are designated with an “OS” in the name.

The proposed storm sewer network has been analyzed in StormCAD and results can be found in **Appendix B**.

Stormwater Storage Facilities

Runoff generated from the majority of the site drains to an existing detention pond northwest of the site. This pond was assumed to provide flood control for the 10 and 100 year storm but no calculated drain time for the WQCV. Water quality for areas tributary to the detention pond is provided via a proposed hydrodynamic separator. The site will send 0.187 AC-FT to this detention pond without any onsite detention.

Some runoff will be captured in an onsite underground detention vault. This vault will capture runoff from the building roof, approximately 0.5 acres. This vault will provide full spectrum detention and drain WQCV, EURV, and the 100-year design volumes at rates consistent with MHFD guidelines.

Detention calculations can be found in **Appendix C**.

The proposed detention facility will be owned and maintained by the property owner. A drainage easement has been provided should inspection and/or maintenance by the Town of Castle Rock be necessary.

The applicant for the project site does not assume any maintenance requirements for the existing detention pond on Lot 1.

Flood Attenuation is summarized in Table 1 Below.

<i>Table 1: Site Runoff Summary</i>			
Basins	Storage Measure	Peak 100 Year Inflow (CFS)	Peak 100 Year Outflow (CFS)
A1-A4	Ex. Pond	9.67	3.73*
R1	UG Vault	3.8	0.8
OS1-OS7	None	6.27	6.27
Total	-	19.74	7.07
*Existing Pond is assumed to limit outflow to predevelopment levels			

Water Quality Enhancement Control Measures

The four steps in the water quality design process prescribed in section 14.1 of the SDDTCM are described below.

1. Reduce Runoff Volume to the Maximum Extent Possible

Opportunities to reduce runoff are limited with this development. Impervious area is generally at the minimum required to make the site function. Steep grade change along the site's borders means expanding the development to provide grass buffers. The use of semi-pervious materials such as porous pavers would be contrary to the safe design of the retaining walls supporting the development.

2. Provide Water Quality Capture Volume and Flood Control Detention via Full-Spectrum Detention.

The development was designed against the Pollutant Removal Standard outlined in Section 14.4.2 of the criteria reducing the amount of total suspended solids to under 30 mg/L. This is achieved through the use of a hydrodynamic separator placed just upstream of the site's connection to the existing storm sewer network.

Flood control is provided for the site in an existing detention pond on Lot 1. From a review of their construction plans, it has been calculated the future build out of the Site would contribute 0.27 AC-FT of runoff during a 100 year storm. The site will send no more than this amount of runoff directly to the existing detention pond.

The proposed development will generate more runoff than assumed during the design of the detention pond on Lot 1, so basin R1 will drain to an underground detention vault before being discharged to the existing pond. Drain times for the proposed vault will be

similar to those common in 1997 (the time of Lot 1's design) so the additional runoff leaving the detention vault is not expected to interfere with the existing pond's function.

Basins OS1 to OS6 do not drain to a structural water quality control but achieve the Runoff Reduction Standard in section 14.4.3 where the design must be a minimum of 60% of what the calculated WQCV would be if all impervious area for the applicable development site discharged without infiltration. Per the MHFD spreadsheet, these basins all equate to 100%. Please refer to **Appendix C** for the specific calculations. The only impervious area in these basins is associated with the retaining wall and of minimal impact. The basin as a whole is similar to a grass buffer and can be considered low impact development.

Basin OS7 does not drain to a structural water quality control. It is not practical to capture runoff from this basin due to the large grade changes on the site and the drainage patterns set by the existing driveway connection to North Castleton Court. This is a shared drive and must remain. Calculations for the existing inlet to which this basin drains can be found in Appendix D. This basin is 0.14 acres and makes up 4.5% of the entire site and falls under the exclusion allowed in 13.1.4 to have water quality control excluded for up to 20% of the site and not exceeding one acre.

3. Utilize Stream Channel Stabilization Techniques

This step is not applicable. Open channels are not used on this development and no drainageways are adjacent to or immediately downstream on the project.

4. Undertake Source Control

The proposed land use has low potential for illicit discharges. No outdoor storage, manufacturing, or fueling is expected or allowed. Illicit discharge prevention can be done through non-structural controls such as keeping the parking lot and dumpster clean and free of litter, not allowing the washing of cars on site, and the maintenance of onsite storm infrastructure outlined above.

Floodplain Modification

The site is not immediately adjacent to a floodplain and will not modify the floodplain. The nearest mapped floodplain is East Plum Creek, approximately 1,500' to the west.

Geotechnical Investigation and Sub-Surface Collection System Design

No evidence of geological hazards or significant groundwater have been observed. The hydraulics of the underground detention vault is not expected to be significantly affected by the presence of groundwater, should any be encountered.

Operation and Maintenance

All proposed stormwater infrastructure will be owned and maintained by the property owner. TWG Development is anticipated to be the property owner prior to construction. Maintenance responsibilities shall be transferred with the ownership of the property.

Grass buffers around the perimeter of the site should be subject to the following maintenance activities:

- Mow and keep free of weeds weekly during the growing season
- Inspect for evidence of erosion monthly and after large rain events
- Verify designed vegetation density monthly
- Ensure irrigation facilities are functioning adequately if vegetation growth issues are present

The proprietary water quality device known as the Hydrodynamic Separator (HDS) should be subject to the following maintenance activities:

- Routine inspections twice a year for any defect
- Remove trash and sediment twice annually or after large storm events
- Annual cleanout of entire structure through a vacuum truck or via manhole access

The underground detention vault should be subject to the following maintenance activities:

- Inspect for structural defects twice annually
- Remove any trash, debris, and sediment twice annually and after large rain events
- Clean outlet structure twice annually or upon evidence of long draw down times

Good housekeeping, such as keeping the parking lot free of pollutants, trash, and sediment should be ongoing.

The roof drains, inlets, and storm piping should not require regular maintenance but fall under the responsibility of the property owner to keep in functional condition.

Additional Permitting Requirements

No additional permits have been identified for this development.

CONCLUSIONS

Compliance with Standards

The drainage design presented in this report was designed in accordance with the Town of Castle Rock Storm Drainage Design and Technical Criteria Manual and the MHFD Urban Storm Drainage Criteria Manual. No master plans for this area were identified.

Variances

A variance has been requested and approved from SDDTCM Section 13.2.3 which states that underground detention is discouraged and allowed only by variance. The site has approximately 40' of fall in the existing condition, which requires the use of retaining walls for any significant development on the site. The existing grades are generally steepest in the lowest portions of the site. This grade change prevents the use of a standard detention pond due to the large amount of earthwork required to place a detention pond and its necessary proximity to retaining walls. Infiltration and porous options were not considered above the wall as saturated soils have the potential to compromise the wall's integrity. This project makes use of the existing detention pond on Lot 1 to the maximum extent for which it was designed but generates more runoff than originally assumed by the design of the detention pond. This variance request has been submitted separately from this report. Please refer to **Appendix H** to view the approved Variance.

Drainage Concept

The Project will capture runoff through the use of curb and gutter, storm inlets, and an underground storm network and route flows to an underground detention vault where full spectrum detention will be provided onsite. This detention facility will outfall to an existing storm sewer network for which this site has been planned. Offsite flow has been analyzed and found to have no negative effects to downstream infrastructure.

LIST OF REFERENCES

Custom Soil Resource Report, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. November 19, 2024.

Flood Insurance Rate Map, Map Number 08035C0186G, Federal Emergency Management Agency; March 16, 2016.

Storm Drainage Design and Technical Criteria Manual, Castle Rock Water Department, June 2019.

Urban Storm Drainage Criteria Manual, Volumes 1-3, Urban Drainage and Flood Control District, March 2024.

Tributary C and D Watersheds Master Plan, prepared by RESPEC, dated October 2014.

Construction Plans for Castleton Center Filing No. 2, Lots LI-15, C-1, C-2, and Part of C-3, Prepared by TST Inc. of Denver Consulting Engineers, dated February 20, 1997.

Construction Plans for Castleton Center Filing No. 2, Second Amendment, Lot 1, Prepared by Robinson/Dalton Consulting, Inc, dated March '98.

APPENDIX A – HYDROLOGIC COMPUTATIONS

STANDARD FORM SF-1
RUNOFF COEFFICIENTS - IMPERVIOUS CALCULATION

PROJECT NAME: Castleton Heights
PROJECT NUMBER: 196273005
CALCULATED BY: CAO
CHECKED BY: BEC

DATE: 8/13/2025

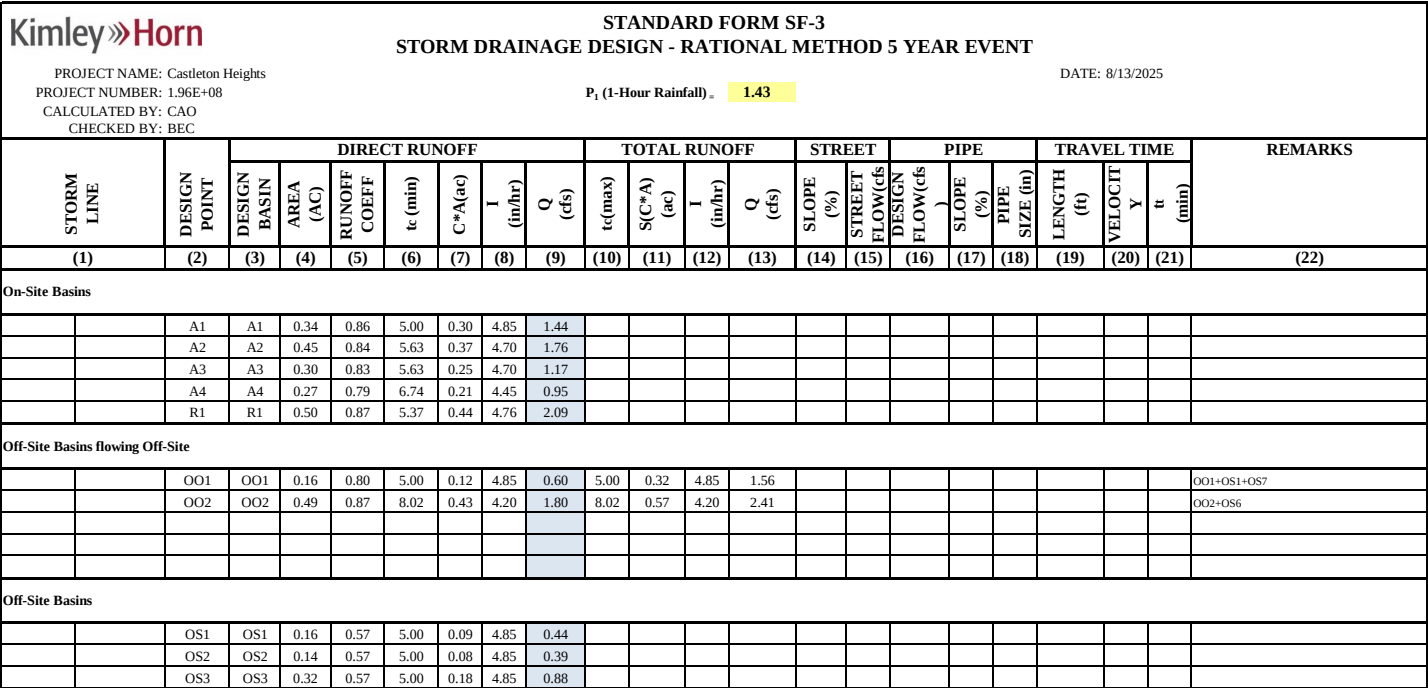
SOIL: Hydrologic Soil Group D

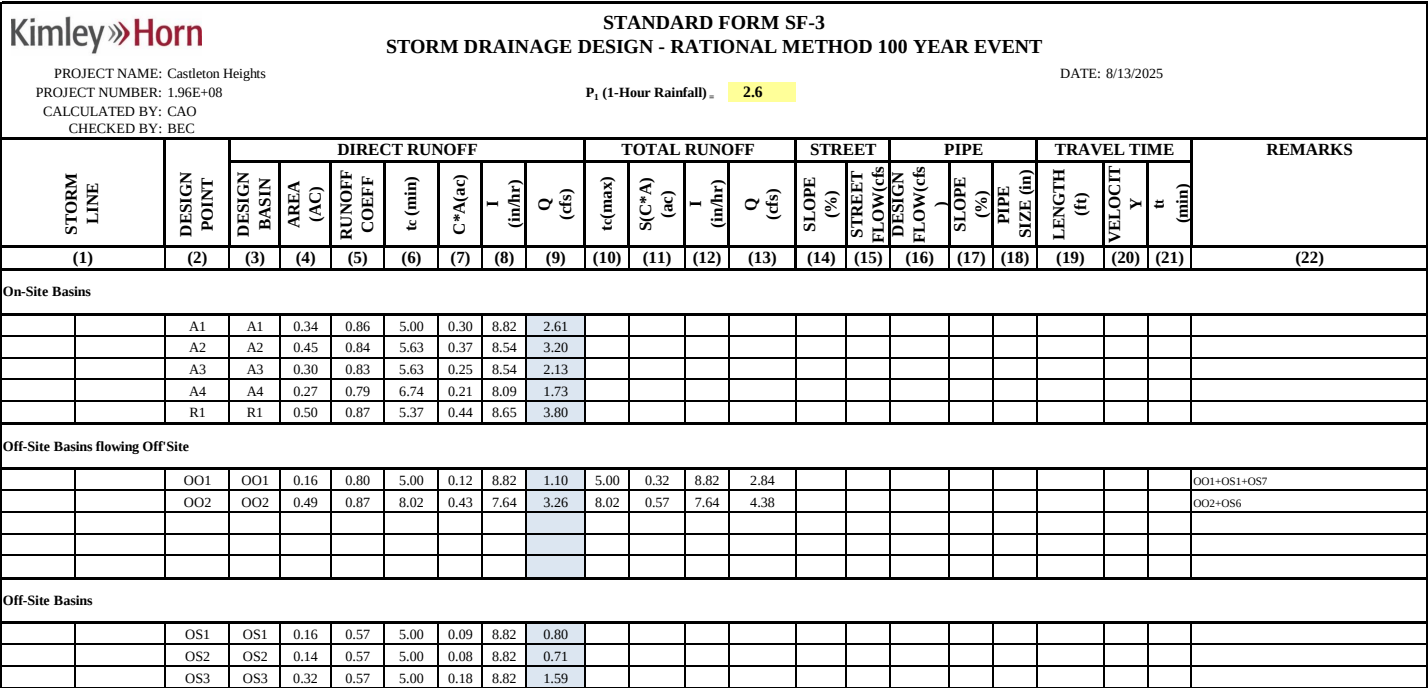
		LANDSCAPE AREA	CONCRETE AREA	GRAVEL AREA	ASHPALT AREA	ROOF AREA								
LAND USE:		AREA	AREA	AREA	AREA	AREA								
2-YEAR COEFF.		0.14	0.79	0.47	0.79	0.79								
5-YEAR COEFF.		0.20	0.81	0.52	0.81	0.81								
10-YEAR COEFF.		0.28	0.83	0.57	0.83	0.83								
25-YEAR COEFF.		0.43	0.85	0.66	0.85	0.85								
50-YEAR COEFF.		0.49	0.86	0.69	0.86	0.86								
100-YEAR COEFF.		0.57	0.87	0.73	0.87	0.87								
IMPERVIOUS %		20%	95%	60%	95%	95%								
DESIGN BASIN	DESIGN POINT	LANDSCAPE AREA (AC)	CONCRETE AREA (AC)	GRAVEL AREA (AC)	ASHPALT AREA (AC)	ROOF AREA (AC)	TOTAL AREA (AC)	C(2)	C(5)	C(10)	C(25)	C(50)	C(100)	Imp %
On-Site Basins Flowing On-Site														
A1	A1	0.01	0.01		0.32		0.34	0.76	0.79	0.81	0.84	0.85	0.86	92%
A2	A2	0.05	0.03		0.37		0.45	0.71	0.74	0.76	0.80	0.82	0.84	86%
A3	A3	0.04	0.01		0.25		0.30	0.70	0.73	0.76	0.80	0.81	0.83	85%
A4	A4	0.07	0.01		0.19		0.27	0.62	0.65	0.69	0.74	0.77	0.79	76%
R1	R1					0.50	0.50	0.79	0.81	0.83	0.85	0.86	0.87	95%
BASIN SUBTOTAL		0.18	0.06	0.00	1.13	0.50	1.87	0.73	0.75	0.78	0.81	0.83	0.84	88%
Off-Site Basins Flowing Off-Site														
OO1	OO1	0.04			0.12		0.16	0.63	0.66	0.69	0.75	0.77	0.80	76%
OO2	OO2		0.49				0.49	0.79	0.81	0.83	0.85	0.86	0.87	95%
BASIN SUBTOTAL		0.04	0.49	0.00	0.12	0.00	0.65	0.75	0.77	0.80	0.83	0.84	0.85	90%
On-Site Basins Flowing Off-Site														
OS1	OS1	0.16					0.16	0.14	0.20	0.28	0.43	0.49	0.57	20%
OS2	OS2	0.14					0.14	0.14	0.20	0.28	0.43	0.49	0.57	20%
OS3	OS3	0.32					0.32	0.14	0.20	0.28	0.43	0.49	0.57	20%
OS4	OS4	0.11	0.00				0.11	0.16	0.22	0.30	0.44	0.50	0.58	22%
OS5	OS5	0.09	0.01				0.10	0.20	0.25	0.33	0.47	0.53	0.59	27%
OS6	OS6	0.26					0.26	0.14	0.20	0.28	0.43	0.49	0.57	20%
OS7	OS7	0.05	0.01		0.08		0.14	0.56	0.59	0.63	0.70	0.73	0.76	68%
BASIN SUBTOTAL		1.13	0.02	0.00	0.08	0.00	1.23	0.19	0.25	0.33	0.47	0.52	0.59	26%
Basins tributary to ex-detention pond														
	A1, A2, A3	0.11	0.05	0.00	0.94	0.00	1.36	0.58	0.60	0.62	0.65	0.66	0.68	70%
Basins tributary to onsite detention														
	R1	0.00	0.00	0.00	0.00	0.50	0.50	0.79	0.81	0.83	0.85	0.86	0.87	95%
Basins within property line														
	All onsite basins	1.31	0.08	0.00	1.21	0.50	3.10	0.51	0.55	0.60	0.67	0.71	0.74	63%

STANDARD FORM SF-2

Time of Concentration

PROJECT NAME: Castleton Heights																	DATE: #####	
PROJECT NUMBER: 196273005																		
CALCULATED BY: CAO																		
CHECKED BY: BEC																		
SUB-BASIN			INITIAL TIME (T _i) USDCM 6-3			TRAVEL TIME (T _t) USDCM 6-4					T _c CHECK (URBANIZED BASINS) USDCM 6-4					FINAL T _c		
DESIGN	AREA	C5	LENGTH	SLOPE	T _i	LENGTH	SLOPE	C _v	VEL	T _t	COMP.	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	
BASIN	Ac		Ft	%	Min.	Ft	%		fps	Min.	t _c	LENGTH	SLOPE	IMP.	Min.	Min.	Min.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(11)	(12)	(13)	(14)	(15)	(16)	(17)			
On-Site Basins Flowing On-Site																		
A1	0.344	0.788	65	3.8%	3.0	153	1.8%	20.0	2.7	1.0	3.9	218	2.4%	92%	11.4	5.0		
A2	0.449	0.736	149	3.7%	5.3	51	1.4%	20.0	2.4	0.4	5.6	200	3.1%	86%	12.3	5.6		
A3	0.300	0.728	141	3.2%	5.5	20	1.7%	20.0	2.6	0.1	5.6	161	3.0%	85%	12.3	5.6		
A4	0.270	0.651	140	3.7%	6.3	33	0.4%	20.0	1.3	0.4	6.7	173	3.1%	76%	14.0	6.7		
R1	0.503	0.809	64	0.5%	5.4				0.0	0.0	5.4	64	0.5%	95%	10.5	5.4		
Off-Site Basins Flowing Off-Site																		
OO1	0.157	0.658	72	8.0%	3.4	125	7.0%	20.0	5.3	0.4	3.8	197	7.4%	76%	13.6	5.0		
OO2	0.490	0.809	25	2.5%	2.0	796	1.2%	20.0	2.2	6.1	8.0	821	1.2%	95%	15.4	8.0		
On-Site Basins Flowing Off-Site																		
OS1	0.16	0.20	96	35.0%	5.0				0.0	0.0	5.0	96	35.0%	20%	22.8	5.0		
OS2	0.14	0.20	10	19.8%	1.9				0.0	0.0	1.9	10	19.8%	20%	22.6	5.0		
OS3	0.32	0.20	26	25.0%	2.9				0.0	0.0	2.9	26	25.0%	20%	22.7	5.0		
OS4	0.11	0.22	83	25.0%	5.0				0.0	0.0	5.0	83	25.0%	22%	22.4	5.0		
OS5	0.10	0.25	76	25.0%	4.6				0.0	0.0	4.6	76	25.0%	27%	21.6	5.0		
OS6	0.26	0.20	35	2.0%	7.8				0.0	0.0	7.8	35	2.0%	20%	22.9	7.8		
OS7	0.14	0.59	92	6.5%	4.8				0.0	0.0	4.8	92	6.5%	68%	14.7	5.0		
$t_i = \frac{0.395(1.1 - C_s)\sqrt{L_i}}{S_o^{0.33}}$																		
$t_i = \frac{L_i}{60K\sqrt{S_o}} = \frac{L_i}{60V_i}$																		
$t_c = (26 - 17i) + \frac{L_i}{60(14i + 9)\sqrt{S_i}}$																		







PROJECT NAME: Castleton Heights
PROJECT NUMBER: 196273005
CALCULATED BY: CAO
CHECKED BY: BEC

DATE:

8/13/2025

RATIONAL CALCULATIONS SUMMARY

DESIGN POINT	TRIBUTARY AREA (AC)	IMPERVIOUSNESS	RUNOFF COEFFICIENT		PEAK FLOWS (CFS)		ROUTED FLOWS (CFS)	
			C5	C100	Q5	Q100	Q5	Q100

On-Site Basins Flowing On-Site

A1	0.34	92.36%	0.79	0.86	1.44	2.61		
A2	0.45	86.01%	0.74	0.84	1.76	3.20		
A3	0.30	85.00%	0.73	0.83	1.17	2.13		
A4	0.27	75.56%	0.65	0.79	0.95	1.73		
R1	0.50	95.00%	0.81	0.87	2.09	3.80		
TOTAL	1.87	87.93%	0.75	0.84	7.41	13.48		

Off-Site Basins Flowing Off-Site

OO1	0.16	76.40%	0.66	0.80	0.60	1.10	1.56	2.84
OO2	0.49	95.00%	0.81	0.87	1.80	3.26	2.41	4.38
TOTAL	0.65	90.50%	0.75	0.85	2.40	4.36	3.97	7.22

On-Site Basins Flowing Off-Site

OS1	0.16	20.00%	0.20	0.57	0.44	0.80		
OS2	0.14	20.00%	0.20	0.57	0.39	0.71		
OS3	0.32	20.00%	0.20	0.57	0.88	1.59		
OS4	0.11	22.49%	0.22	0.58	0.31	0.56		
OS5	0.10	26.82%	0.25	0.59	0.29	0.53		
OS6	0.26	20.00%	0.20	0.57	0.62	1.13		
OS7	0.14	68.21%	0.59	0.76	0.52	0.94		
TOTAL	1.23	26.26%	0.25	0.59	3.45	6.27		



STANDARD FORM SF-1

RUNOFF COEFFICIENTS - IMPERVIOUS CALCULATION

PROJECT NAME: Castleton Heights
PROJECT NUMBER: 196273005
CALCULATED BY: CAO
CHECKED BY: BEC

DATE: 8/12/2025

SOIL: Hydrologic Soil Group D

	UNDISTURBED	CONCRETE	GRAVEL	ASHPALT	ROOF
LAND USE:	AREA	AREA	AREA	AREA	AREA
2-YEAR COEFF.	0.03	0.79	0.47	0.79	0.79
5-YEAR COEFF.	0.08	0.81	0.52	0.81	0.81
10-YEAR COEFF.	0.17	0.83	0.57	0.83	0.83
25-YEAR COEFF.	0.35	0.85	0.66	0.85	0.85
50-YEAR COEFF.	0.42	0.86	0.69	0.86	0.86
100-YEAR COEFF.	0.50	0.87	0.73	0.87	0.87
IMPERVIOUS %	5%	95%	60%	95%	95%

DESIGN BASIN	DESIGN POINT	UNDISTURBED AREA (AC)	CONCRETE AREA (AC)	GRAVEL AREA (AC)	ASHPALT AREA (AC)	ROOF AREA (AC)	TOTAL AREA (AC)	C(2)	C(5)	C(10)	C(25)	C(50)	C(100)	Imp %
On-Site Basins Flowing On-Site														
BASIN SUBTOTAL		0.00	0.00	0.00	0.00	0.00	0.00							
Off-Site Basins Flowing On-Site														
BASIN SUBTOTAL		0.00	0.00	0.00	0.00	0.00	0.00							
On-Site Basins Flowing Off-Site														
EX1	EX1	0.42					0.42	0.03	0.08	0.17	0.35	0.42	0.50	5%
EX2	EX2	1.23					1.23	0.03	0.08	0.17	0.35	0.42	0.50	5%
EX3	EX3	0.71					0.71	0.03	0.08	0.17	0.35	0.42	0.50	5%
EX4	EX4	0.42					0.42	0.03	0.08	0.17	0.35	0.42	0.50	5%
EX5	EX5	0.32					0.32	0.03	0.08	0.17	0.35	0.42	0.50	5%
BASIN SUBTOTAL		3.10	0.00	0.00	0.00	0.00	3.10	0.03	0.08	0.17	0.35	0.42	0.50	5%
		100%	0%	0%	0%	0%	100%	0.03	0.08	0.17	0.35	0.42	0.50	5%

Kimley»Horn

STANDARD FORM SF-2
Time of Concentration

PROJECT NAME:		Castleton Heights										DATE:		#####		
PROJECT NUMBER:		196273005														
CALCULATED BY:		CAO														
CHECKED BY:		BEC														
SUB-BASIN		INITIAL TIME				TRAVEL TIME					Tc CHECK					FINAL
DATA		(T _i) USDCM 6-3				(T _i) USDCM 6-4					(URBANIZED BASINS) USDCM 6-4					Tc
DESIGN	AREA	C5	LENGTH	SLOPE	T _i	LENGTH	SLOPE	C _v	VEL	T _i	COMP.	TOTAL	TOTAL	TOTAL	Tc	
BASIN	Ac		Ft	%	Min.	Ft	%		fps	Min.	tc	LENGTH	SLOPE	IMP.	Min.	Min.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	
On-Site Basins Flowing On-Site																
Off-Site Basins Flowing On-Site																
On-Site Basins Flowing Off-Site																
EX1	0.42	0.08	270	8.5%	15.1				0.0	0.0	15.1	270	8.5%	5%	26.7	15.1
EX2	1.23	0.08	346	7.4%	17.9				0.0	0.0	17.9	346	7.4%	5%	27.3	17.9
EX3	0.71	0.08	302	8.5%	16.0				0.0	0.0	16.0	302	8.5%	5%	26.9	16.0
EX4	0.42	0.08	353	12.4%	15.2				0.0	0.0	15.2	353	12.4%	5%	26.9	15.2
EX5	0.32	0.08	213	10.9%	12.4				0.0	0.0	12.4	213	10.9%	5%	26.3	12.4
			$t_i = \frac{0.395(1.1 - C_s)\sqrt{L_i}}{S_o^{0.33}}$						$t_i = \frac{L_i}{60K\sqrt{S_o}} = \frac{L_i}{60V_i}$				$t_c = (26 - 17i) + \frac{L_i}{60(14i + 9)\sqrt{S_i}}$			



STANDARD FORM SF-3
STORM DRAINAGE DESIGN - RATIONAL METHOD 5 YEAR EVENT

PROJECT NAME: Castleton Heights
PROJECT NUMBER: 1.96E+08
CALCULATED BY: CAO
CHECKED BY: BEC

DATE: 8/12/2025

P₁ (1-Hour Rainfall) = 1.43

[illegible]



STANDARD FORM SF-3
STORM DRAINAGE DESIGN - RATIONAL METHOD 100 YEAR EVENT

PROJECT NAME: Castleton Heights
PROJECT NUMBER: 1.96E+08
CALCULATED BY: CAO
CHECKED BY: BEC

DATE: 8/12/2025

P₁ (1-Hour Rainfall) = 2.6

[illegible]



DESIGN POINT	TRIBUTARY AREA (AC)	IMPERVIOUSNESS	RUNOFF COEFFICIENT		PEAK FLOWS (CFS)		ROUTED FLOWS (CFS)	
			C5	C100	Q5	Q100	Q5	Q100
1	10	0.8	0.5	0.6	100	150	100	150
2	20	0.7	0.6	0.7	200	300	200	300
3	30	0.6	0.7	0.8	300	450	300	450
4	40	0.5	0.8	0.9	400	600	400	600
5	50	0.4	0.9	1.0	500	750	500	750

On-Site Basins Flowing On-Site								
TOTAL	0.00	0.00%	0.00	0.00	0.00	0.00		

TOTAL	0.00	0.00%	0.00	0.00	0.00	0.00		

EX1	0.42	5.00%	0.08	0.50	0.68	1.24		
EX2	1.23	5.00%	0.08	0.50	1.84	3.35		
EX3	0.71	5.00%	0.08	0.50	1.13	2.05		
EX4	0.42	5.00%	0.08	0.50	0.69	1.25		
EX5	0.32	5.00%	0.08	0.50	0.57	1.04		
TOTAL	3.10	5.00%	0.08	0.50	4.34	7.89		

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APPENDIX B – HYDRAULIC COMPUTATIONS

INLET MANAGEMENT

Worksheet Protected

INLET NAME	Inlet A1	Inlet A2	Inlet A3
Site Type (Urban or Rural)	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	STREET	STREET	STREET
Hydraulic Condition	In Sump	In Sump	In Sump
Inlet Type	Denver No. 16 Valley Grate	Denver No. 16 Combination	Denver No. 16 Combination

USER-DEFINED INPUT

User-Defined Design Flows			
Minor Q_{Known} (cfs)	1.4	1.8	1.2
Major Q_{Known} (cfs)	2.6	3.2	2.1
Bypass (Carry-Over) Flow from Upstream Inlets must be organized from upstream (left) to downstream (right) in order for bypass flows to be linked.			
Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0
Watershed Characteristics			
Subcatchment Area (acres)			
Percent Impervious			
NRCS Soil Type			
Watershed Profile			
Overland Slope (ft/ft)			
Overland Length (ft)			
Channel Slope (ft/ft)			
Channel Length (ft)			
Minor Storm Rainfall Input			
Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			
Major Storm Rainfall Input			
Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

CALCULATED OUTPUT

Minor Total Design Peak Flow, Q (cfs)	1.4	1.8	1.2
Major Total Design Peak Flow, Q (cfs)	2.6	3.2	2.1
Minor Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A	N/A
Major Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A	N/A

INLET MANAGEMENT

Worksheet Protected

INLET NAME	Inlet A4	EX 001	EX 002
Site Type (Urban or Rural)	URBAN	URBAN	URBAN
Inlet Application (Street or Area)	STREET	STREET	STREET
Hydraulic Condition	In Sump	In Sump	On Grade
Inlet Type	Denver No. 16 Valley Gate	CDOT Type R Curb Opening	CDOT Type R Curb Opening

USER-DEFINED INPUT

User-Defined Design Flows

Minor Q_{known} (cfs)	1.0	1.6	2.4
Major Q_{known} (cfs)	1.7	2.9	4.4

Bypass (Carry-Over) Flow from Upstream

Receive Bypass Flow from:	No Bypass Flow Received	No Bypass Flow Received	No Bypass Flow Received
Minor Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0
Major Bypass Flow Received, Q_b (cfs)	0.0	0.0	0.0

Watershed Characteristics

Subcatchment Area (acres)			
Percent Impervious			
NRCS Soil Type			

Watershed Profile

Overland Slope (ft/ft)			
Overland Length (ft)			
Channel Slope (ft/ft)			
Channel Length (ft)			

Minor Storm Rainfall Input

Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

Major Storm Rainfall Input

Design Storm Return Period, T_r (years)			
One-Hour Precipitation, P_1 (inches)			

CALCULATED OUTPUT

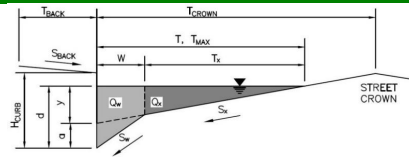
Minor Total Design Peak Flow, Q (cfs)	1.0	1.6	2.4
Major Total Design Peak Flow, Q (cfs)	1.7	2.9	4.4
Minor Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A	0.5
Major Flow Bypassed Downstream, Q_b (cfs)	N/A	N/A	1.9

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project:

Inlet ID: Inlet A1

**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)

$T_{BACK} =$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

$H_{CURB} =$ inches
 $T_{CROWN} =$ ft
 $W =$ ft
 $S_x =$ ft/ft
 $S_y =$ ft/ft
 $S_0 =$ ft/ft
 $n_{STREET} =$

Max. Allowable Spread for Minor & Major Storm

Warning 02

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

Check boxes are not applicable in SUMP conditions

	Minor Storm	Major Storm	
$T_{MAX} =$	<input type="text"/>	<input type="text"/>	ft
$d_{MAX} =$	<input type="text"/>	<input type="text"/>	inches
	☐	☐	

MINOR STORM Allowable Capacity is not applicable to Sump Condition

MAJOR STORM Allowable Capacity is not applicable to Sump Condition

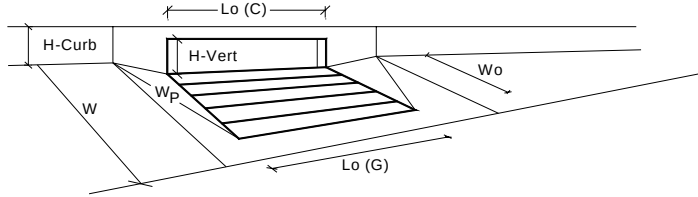
$Q_{allow} =$

Minor Storm	Major Storm
<input type="text"/>	<input type="text"/>

 cfs

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	Denver No. 16 Valley Grate	Type =	Denver No. 16 Valley Grate		
Local Depression (additional to continuous gutter depression 'a' from above)		a _{local} =	2.00	2.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	2	2	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	7.0	7.0	inches
Grate Information		MINOR		MAJOR	
Length of a Unit Grate		L _o (G) =	3.00	3.00	feet
Width of a Unit Grate		W _o =	1.73	1.73	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)		A _{ratio} =	0.31	0.31	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C _r (G) =	0.50	0.50	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C _w (G) =	3.60	3.60	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C _o (G) =	0.60	0.60	
Curb Opening Information		MINOR		MAJOR	
Length of a Unit Curb Opening		L _o (C) =	N/A	N/A	feet
Height of Vertical Curb Opening in Inches		H _{vert} =	N/A	N/A	inches
Height of Curb Orifice Throat in Inches		H _{throat} =	N/A	N/A	inches
Angle of Throat		Theta =	N/A	N/A	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W _p =	N/A	N/A	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C _r (C) =	N/A	N/A	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C _w (C) =	N/A	N/A	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C _o (C) =	N/A	N/A	
Low Head Performance Reduction (Calculated)		MINOR		MAJOR	
Depth for Grate Midwidth		d _{Grate} =	0.61	0.61	ft
Depth for Curb Opening Weir Equation		d _{Curb} =	N/A	N/A	ft
Grated Inlet Performance Reduction Factor for Long Inlets		RF _{Grate} =	0.82	0.82	
Curb Opening Performance Reduction Factor for Long Inlets		RF _{Curb} =	N/A	N/A	
Combination Inlet Performance Reduction Factor for Long Inlets		RF _{Combination} =	N/A	N/A	
Total Inlet Interception Capacity (assumes clogged condition)		MINOR		MAJOR	
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		Q _s =	6.0	6.0	cfs
		Q _{PEAK REQUIRED} =	1.4	2.6	cfs

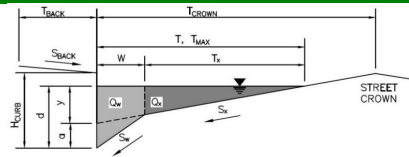
IN SUMP CONDITION
WITHOUT OVERLAND
OVERFLOW - 2X 100YEAR
CAPACITY REQUIRED

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project:

Inlet ID: Inlet A2

**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)

$T_{BACK} =$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

$H_{CURB} =$ inches
 $T_{CROWN} =$ ft
 $W =$ ft
 $S_x =$ ft/ft
 $S_y =$ ft/ft
 $S_0 =$ ft/ft
 $n_{STREET} =$

Max. Allowable Spread for Minor & Major Storm

Warning 02

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

Check boxes are not applicable in SUMP conditions

	Minor Storm	Major Storm	
$T_{MAX} =$	<input type="text"/>	<input type="text"/>	ft
$d_{MAX} =$	<input type="text"/>	<input type="text"/>	inches
	☐	☐	

MINOR STORM Allowable Capacity is not applicable to Sump Condition

MAJOR STORM Allowable Capacity is not applicable to Sump Condition

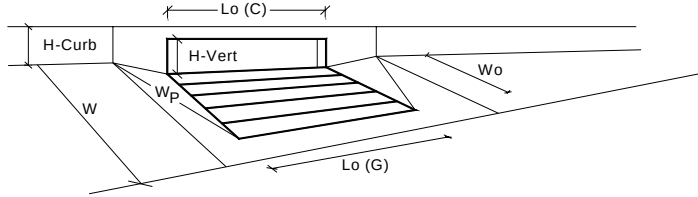
$Q_{allow} =$

Minor Storm	Major Storm
<input type="text"/>	<input type="text"/>

 cfs

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	Denver No. 16 Combination				
Local Depression (additional to continuous gutter depression 'a' from above)		a _{local} =	2.00	2.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	8.0	8.0	inches
Grate Information		MINOR		MAJOR	
Length of a Unit Grate		L _o (G) =	3.00	3.00	feet
Width of a Unit Grate		W _o =	1.73	1.73	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)		A _{ratio} =	0.31	0.31	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C _r (G) =	0.50	0.50	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C _w (G) =	3.60	3.60	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C _o (G) =	0.60	0.60	
Curb Opening Information		MINOR		MAJOR	
Length of a Unit Curb Opening		L _o (C) =	3.00	3.00	feet
Height of Vertical Curb Opening in Inches		H _{vert} =	6.50	6.50	inches
Height of Curb Orifice Throat in Inches		H _{throat} =	5.25	5.25	inches
Angle of Throat		Theta =	0.00	0.00	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W _p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C _r (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C _w (C) =	3.70	3.70	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C _o (C) =	0.66	0.66	
Low Head Performance Reduction (Calculated)		MINOR		MAJOR	
Depth for Grate Midwidth		d _{Grate} =	0.69	0.69	ft
Depth for Curb Opening Weir Equation		d _{Curb} =	0.50	0.50	ft
Grated Inlet Performance Reduction Factor for Long Inlets		RF _{Grate} =	1.00	1.00	
Curb Opening Performance Reduction Factor for Long Inlets		RF _{Curb} =	N/A	N/A	
Combination Inlet Performance Reduction Factor for Long Inlets		RF _{Combination} =	1.00	1.00	
Total Inlet Interception Capacity (assumes clogged condition)		MINOR		MAJOR	
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		Q _{is} =	7.6	7.6	cfs
		Q _{PEAK REQUIRED} =	1.8	3.2	cfs

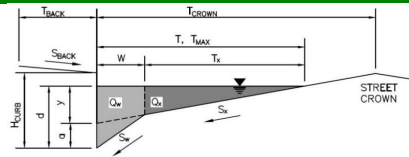
IN SUMP CONDITION
WITHOUT OVERLAND
OVERFLOW - 2X 100YEAR
CAPACITY REQUIRED

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project:

Inlet ID: Inlet A3

**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)

$T_{BACK} =$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

$H_{CURB} =$ inches
 $T_{CROWN} =$ ft
 $W =$ ft
 $S_x =$ ft/ft
 $S_w =$ ft/ft
 $S_0 =$ ft/ft
 $n_{STREET} =$

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	
$T_{MAX} =$	<input type="text"/>	<input type="text"/>	ft
$d_{MAX} =$	<input type="text"/>	<input type="text"/>	inches
	☐	☐	

MINOR STORM Allowable Capacity is not applicable to Sump Condition

MAJOR STORM Allowable Capacity is not applicable to Sump Condition

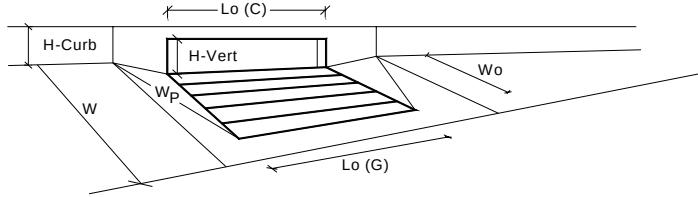
$Q_{allow} =$

Minor Storm	Major Storm
<input type="text"/>	<input type="text"/>

 cfs

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	Denver No. 16 Combination				
Local Depression (additional to continuous gutter depression 'a' from above)		a _{local} =	2.00	2.00	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) =	3.00	3.00	feet
Width of a Unit Grate		W _o =	1.73	1.73	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)		A _{ratio} =	0.31	0.31	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C _r (G) =	0.50	0.50	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C _w (G) =	3.60	3.60	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C _o (G) =	0.60	0.60	
Curb Opening Information		MINOR		MAJOR	
Length of a Unit Curb Opening		L _o (C) =	3.00	3.00	feet
Height of Vertical Curb Opening in Inches		H _{vert} =	6.50	6.50	inches
Height of Curb Orifice Throat in Inches		H _{throat} =	5.25	5.25	inches
Angle of Throat		Theta =	0.00	0.00	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W _p =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C _r (C) =	0.10	0.10	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C _w (C) =	3.70	3.70	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C _o (C) =	0.66	0.66	
Low Head Performance Reduction (Calculated)		MINOR		MAJOR	
Depth for Grate Midwidth		d _{grate} =	0.52	0.52	ft
Depth for Curb Opening Weir Equation		d _{curb} =	0.33	0.33	ft
Grated Inlet Performance Reduction Factor for Long Inlets		RF _{grate} =	0.94	0.94	
Curb Opening Performance Reduction Factor for Long Inlets		RF _{curb} =	N/A	N/A	
Combination Inlet Performance Reduction Factor for Long Inlets		RF _{combination} =	0.94	0.94	
Total Inlet Interception Capacity (assumes clogged condition)		MINOR		MAJOR	
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		Q _s =	5.6	5.6	cfs
		Q _{PEAK REQUIRED} =	1.2	2.1	cfs

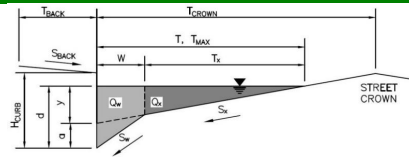
IN SUMP CONDITION
WITHOUT OVERLAND
OVERFLOW - 2X 100YEAR
CAPACITY REQUIRED

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project:

Inlet ID: Inlet A4

**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)

$T_{BACK} =$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

$H_{CURB} =$ inches
 $T_{CROWN} =$ ft
 $W =$ ft
 $S_x =$ ft/ft
 $S_w =$ ft/ft
 $S_0 =$ ft/ft
 $n_{STREET} =$

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	
$T_{MAX} =$	<input type="text"/>	<input type="text"/>	ft
$d_{MAX} =$	<input type="text"/>	<input type="text"/>	inches
	☐	☐	

MINOR STORM Allowable Capacity is not applicable to Sump Condition

MAJOR STORM Allowable Capacity is not applicable to Sump Condition

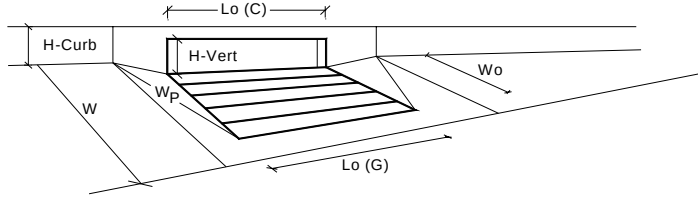
$Q_{allow} =$

Minor Storm	Major Storm
<input type="text"/>	<input type="text"/>

 cfs

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 5.03 (August 2023)



Design Information (Input)		MINOR		MAJOR	
Type of Inlet	Denver No. 16 Valley Grate	Type =	Denver No. 16 Valley Grate		
Local Depression (additional to continuous gutter depression 'a' from above)		a _{local} =	2.00	2.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	2	2	
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) =	3.00	3.00	feet
Width of a Unit Grate		W _o =	1.73	1.73	feet
Open Area Ratio for a Grate (typical values 0.15-0.90)		A _{ratio} =	0.31	0.31	
Clogging Factor for a Single Grate (typical value 0.50 - 0.70)		C _r (G) =	0.50	0.50	
Grate Weir Coefficient (typical value 2.15 - 3.60)		C _w (G) =	3.60	3.60	
Grate Orifice Coefficient (typical value 0.60 - 0.80)		C _o (G) =	0.60	0.60	
Curb Opening Information		MINOR		MAJOR	
Length of a Unit Curb Opening		L _o (C) =	N/A	N/A	feet
Height of Vertical Curb Opening in Inches		H _{vert} =	N/A	N/A	inches
Height of Curb Orifice Throat in Inches		H _{throat} =	N/A	N/A	inches
Angle of Throat		Theta =	N/A	N/A	degrees
Side Width for Depression Pan (typically the gutter width of 2 feet)		W _p =	N/A	N/A	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C _r (C) =	N/A	N/A	
Curb Opening Weir Coefficient (typical value 2.3-3.7)		C _w (C) =	N/A	N/A	
Curb Opening Orifice Coefficient (typical value 0.60 - 0.70)		C _o (C) =	N/A	N/A	
Low Head Performance Reduction (Calculated)		MINOR		MAJOR	
Depth for Grate Midwidth		d _{Grate} =	0.52	0.52	ft
Depth for Curb Opening Weir Equation		d _{Curb} =	N/A	N/A	ft
Grated Inlet Performance Reduction Factor for Long Inlets		RF _{Grate} =	0.71	0.71	
Curb Opening Performance Reduction Factor for Long Inlets		RF _{Curb} =	N/A	N/A	
Combination Inlet Performance Reduction Factor for Long Inlets		RF _{Combination} =	N/A	N/A	
Total Inlet Interception Capacity (assumes clogged condition)		MINOR		MAJOR	
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		Q _{is} =	4.1	4.1	cfs
		Q _{PEAK REQUIRED} =	1.0	1.7	cfs

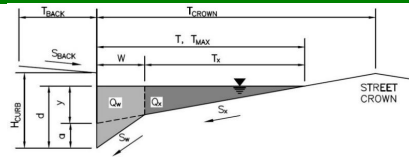
IN SUMP CONDITION
WITHOUT OVERLAND
OVERFLOW - 2X 100YEAR
CAPACITY REQUIRED

ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project:

Inlet ID: EX 001

**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)

$T_{BACK} =$ ft
 $S_{BACK} =$ ft/ft
 $n_{BACK} =$

$H_{CURB} =$ inches
 $T_{CROWN} =$ ft
 $W =$ ft
 $S_x =$ ft/ft
 $S_y =$ ft/ft
 $S_0 =$ ft/ft
 $n_{STREET} =$

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	
$T_{MAX} =$	<input type="text"/>	<input type="text"/>	ft
$d_{MAX} =$	<input type="text"/>	<input type="text"/>	inches

☐ ☐

MINOR STORM Allowable Capacity is not applicable to Sump Condition

MAJOR STORM Allowable Capacity is not applicable to Sump Condition

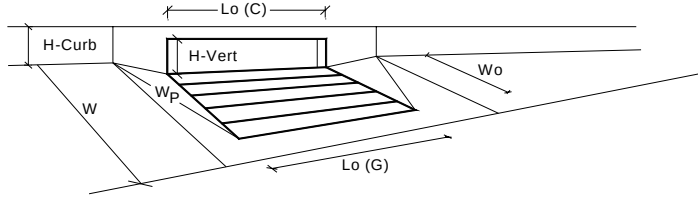
$Q_{allow} =$

Minor Storm	Major Storm
<input type="text"/>	<input type="text"/>

 cfs

INLET IN A SUMP OR SAG LOCATION

MHFD-Inlet, Version 5.03 (August 2023)



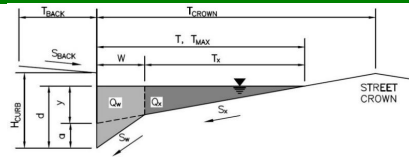
Design Information (Input)		MINOR		MAJOR	
Type of Inlet	CDOT Type R Curb Opening	Type =	CDOT Type R Curb Opening		
Local Depression (additional to continuous gutter depression 'a' from above)		a _{local} =	3.00	3.00	inches
Number of Unit Inlets (Grate or Curb Opening)		No =	1	1	
Water Depth at Flowline (outside of local depression)		Ponding Depth =	5.8	5.8	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 _r (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 =	2.00	2.00	feet
Clogging Factor for a Single Curb Opening (typical value 0.10)		C _r (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} =	0.32	0.32	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	
Inlet Capacity IS GOOD for Minor and Major Storms (>Q Peak)		Q _s =	5.0	5.0	cfs
		Q _{PEAK REQUIRED} =	1.6	2.9	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: EX 002

**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}	=	5.0	ft
S_{BACK}	=	0.010	ft/ft
n_{BACK}	=	0.013	

H_{CURB}	=	6.00	inches
T_{CROWN}	=	27.0	ft
W	=	2.00	ft
S_X	=	0.020	ft/ft
S_W	=	0.083	ft/ft
S_0	=	0.012	ft/ft
n_{STREET}	=	0.013	

Max. Allowable Spread for Minor & Major Storm

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

Allow Flow Depth at Street Crown (check box for yes, leave blank for no)

	Minor Storm	Major Storm	
T_{MAX}	18.0	18.0	ft
d_{MAX}	6.0	6.0	inches
	☐	☐	

MINOR STORM Allowable Capacity is based on Spread Criterion

MAJOR STORM Allowable Capacity is based on Spread Criterion

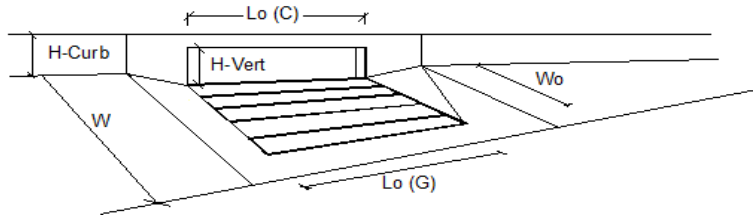
	Minor Storm	Major Storm	
Q_{allow}	16.9	16.9	cfs

Minor storm max. allowable capacity GOOD - greater than the design peak flow of 2.41 cfs on sheet 'Inlet Management'

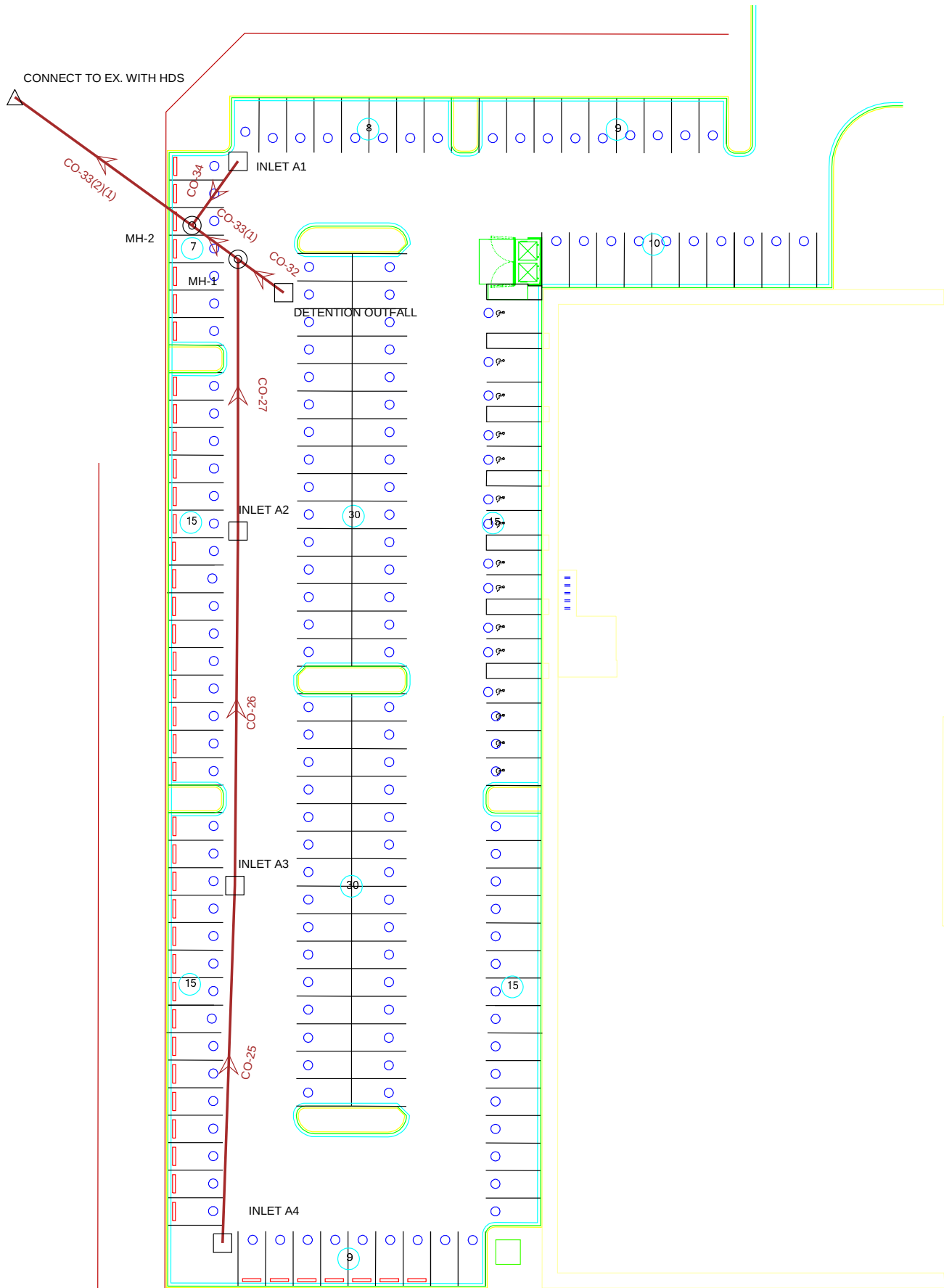
Major storm max. allowable capacity GOOD - greater than the design peak flow of 4.38 cfs on sheet 'Inlet Management'

INLET ON A CONTINUOUS GRADE

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')		a _{LOCAL} =	3.0	3.0	inches
Total Number of Units in the Inlet (Grate or Curb Opening)		No =	1	1	
Length of a Single Unit Inlet (Grate or Curb Opening)		L _o =	5.00	5.00	ft
Width of a Unit Grate (cannot be greater than W, Gutter Width)		W _o =	N/A	N/A	ft
Clogging Factor for a Single Unit Grate (typical min. value = 0.5)		C _l (G) =	N/A	N/A	
Clogging Factor for a Single Unit Curb Opening (typical min. value = 0.1)		C _l (C) =	0.10	0.10	
Street Hydraulics: OK - Q < Allowable Street Capacity					
Total Inlet Interception Capacity		Q =	1.9	2.5	cfs
Total Inlet Carry-Over Flow (flow bypassing inlet)		Q _b =	0.5	1.9	cfs
Capture Percentage = Q _i /Q _a		C% =	77	57	%



5 YEAR

FlexTable: Conduit Table

ID	Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Length (3D) (ft)
401	CO-25	INLET A4	6,147.56	INLET A3	6,146.14	18.0	0.013	0.95	3.95	117.1
403	CO-26	INLET A3	6,145.89	INLET A2	6,144.46	18.0	0.013	2.12	5.01	116.0
405	CO-27	INLET A2	6,144.21	MH-1	6,143.13	18.0	0.013	3.88	5.90	89.0
423	CO-32	DETENTION OUTFALL	6,145.00	MH-1	6,143.13	18.0	0.013	0.05	2.59	18.7
432	CO-34	INLET A1	6,143.30	MH-2	6,142.02	18.0	0.013	1.44	7.34	26.9
434	CO-33(1)	MH-1	6,142.88	MH-2	6,142.02	18.0	0.013	3.93	9.59	19.9
437	CO-33(2) (1)	MH-2	6,135.69	CONNECT TO EX. WITH HDS	6,133.48	24.0	0.013	5.37	8.83	71.6

5 YEAR

FlexTable: Catch Basin Table

ID	Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Inlet Type	Hydraulic Grade Line (In) (ft)	Flow (Additional Subsurface) (cfs)
412	INLET A1	6,151.51	6,151.51	6,143.30	Full Capture	6,143.83	1.44
414	INLET A2	6,152.58	6,152.58	6,144.21	Full Capture	6,145.11	1.76
415	INLET A4	6,152.70	6,152.70	6,147.56	Full Capture	6,147.99	0.95
420	DETENTION OUTFALL	6,153.45	6,153.45	6,145.00	Full Capture	6,144.11	0.05
443	INLET A3	6,152.71	6,152.71	6,145.89	Full Capture	6,146.56	1.17

5 YEAR

FlexTable: Manhole Table

ID	Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert in 1) (ft)	Flow (Total Out) (cfs)	Depth (Out) (ft)	Hydraulic Grade Line (Out) (ft)	Hydraulic Grade Line (In) (ft)
426	MH-1	6,152.57	6,152.57	6,143.13	3.93	0.76	6,143.64	6,143.82
433	MH-2	6,152.62	6,152.62	6,142.02	5.37	0.82	6,136.51	6,136.51

5 YEAR

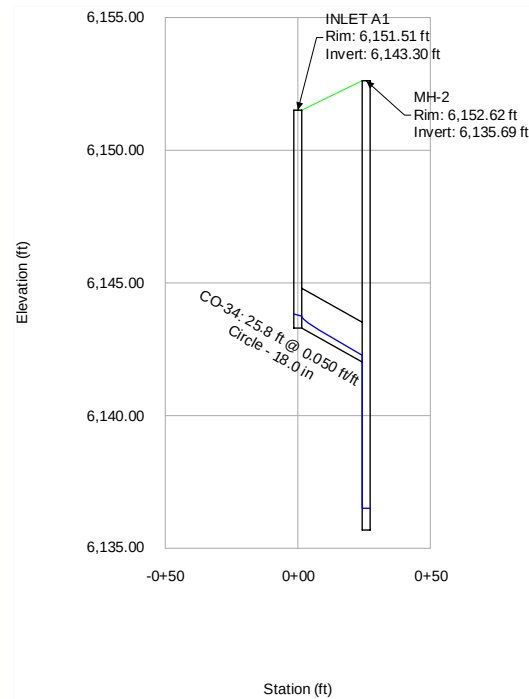
FlexTable: Outfall Table

ID	Label	Elevation (Ground) (ft)	Elevation (Invert) (ft)	Boundary Condition Type	Hydraulic Grade (ft)	Flow (Total Out) (cfs)
428	CONNECT TO EX. WITH HDS	6,137.54	6,133.48	Free Outfall	6,133.98	5.37

5 YEAR

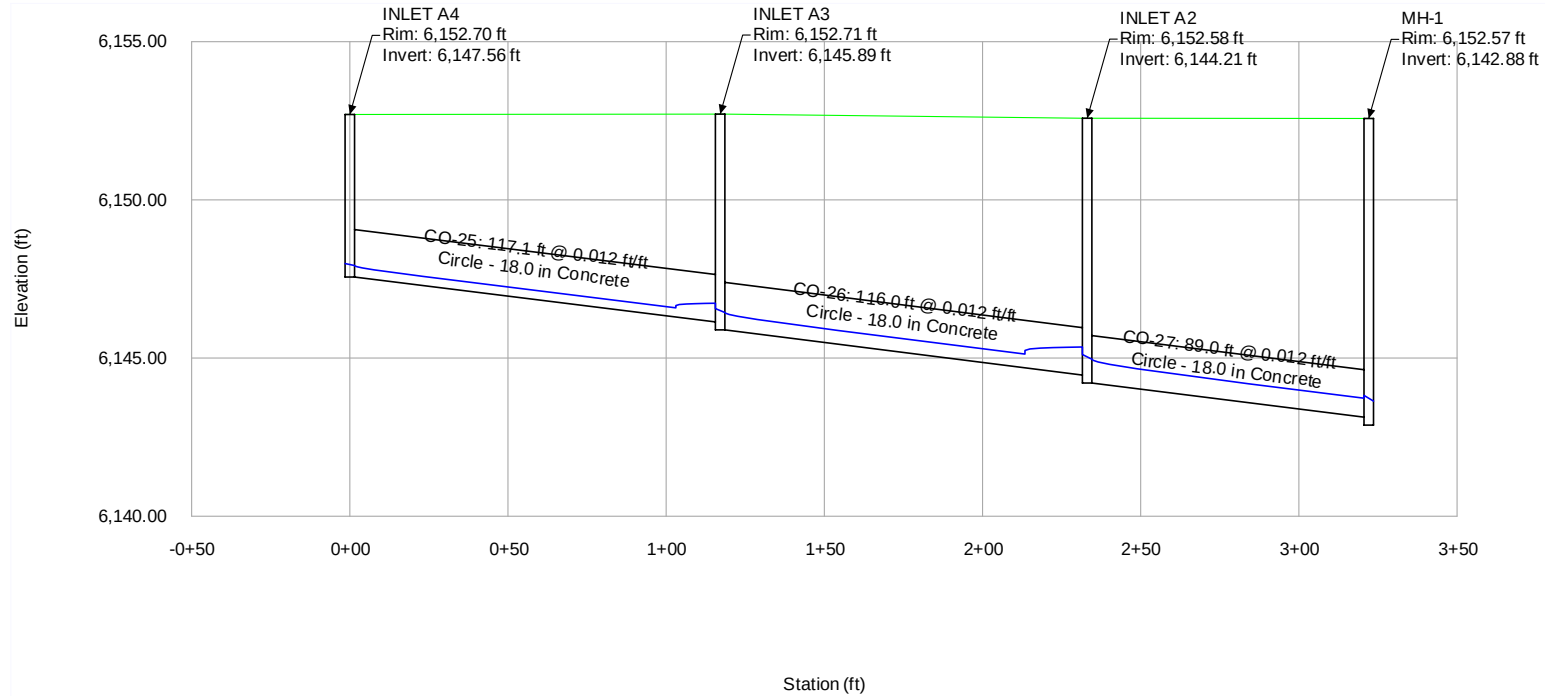
Profile Report

Engineering Profile - A1 (Castle Rock.stsw)



5 YEAR

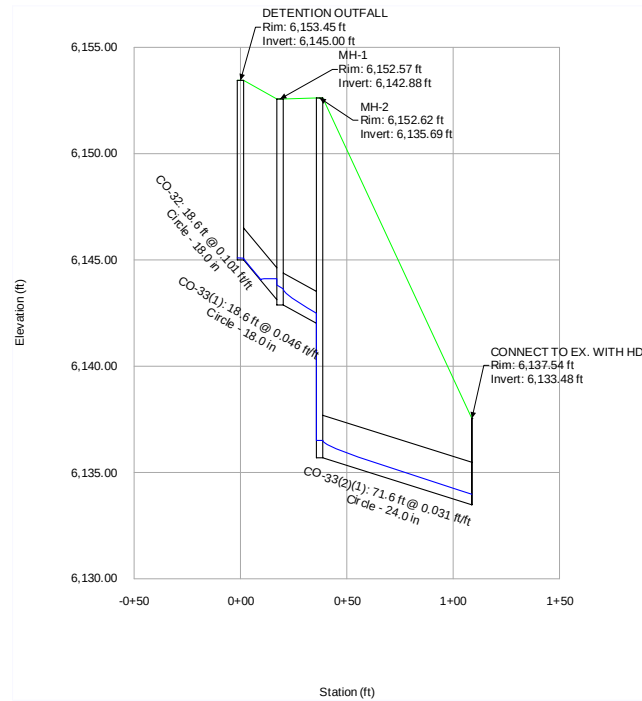
Profile Report Engineering Profile - A2 (Castle Rock.stsw)



5 YEAR

Profile Report

Engineering Profile - OUTFALL (Castle Rock.stsw)



100 YEAR

FlexTable: Conduit Table

ID	Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Length (3D) (ft)
401	CO-25	INLET A4	6,147.56	INLET A3	6,146.14	18.0	0.013	1.73	4.70	117.1
403	CO-26	INLET A3	6,145.89	INLET A2	6,144.46	18.0	0.013	3.86	5.92	116.0
405	CO-27	INLET A2	6,144.21	MH-1	6,143.13	18.0	0.013	7.06	6.87	89.0
423	CO-32	DETENTION OUTFALL	6,145.00	MH-1	6,143.13	18.0	0.013	0.80	6.04	18.7
432	CO-34	INLET A1	6,143.30	MH-2	6,142.02	18.0	0.013	2.61	8.74	26.9
434	CO-33(1)	MH-1	6,142.88	MH-2	6,142.02	18.0	0.013	7.86	11.63	19.9
437	CO-33(2) (1)	MH-2	6,135.69	CONNECT TO EX. WITH HDS	6,133.48	24.0	0.013	10.47	10.67	71.6

100 YEAR

FlexTable: Catch Basin Table

ID	Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Inlet Type	Hydraulic Grade Line (In) (ft)	Flow (Additional Subsurface) (cfs)
412	INLET A1	6,151.51	6,151.51	6,143.30	Full Capture	6,144.03	2.61
414	INLET A2	6,152.58	6,152.58	6,144.21	Full Capture	6,145.47	3.20
415	INLET A4	6,152.70	6,152.70	6,147.56	Full Capture	6,148.15	1.73
420	DETENTION OUTFALL	6,153.45	6,153.45	6,145.00	Full Capture	6,144.78	0.80
443	INLET A3	6,152.71	6,152.71	6,145.89	Full Capture	6,146.82	2.13

100 YEAR

FlexTable: Manhole Table

ID	Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert in 1) (ft)	Flow (Total Out) (cfs)	Depth (Out) (ft)	Hydraulic Grade Line (Out) (ft)	Hydraulic Grade Line (In) (ft)
426	MH-1	6,152.57	6,152.57	6,143.13	7.86	1.09	6,143.97	6,144.27
433	MH-2	6,152.62	6,152.62	6,142.02	10.47	1.16	6,136.85	6,136.85

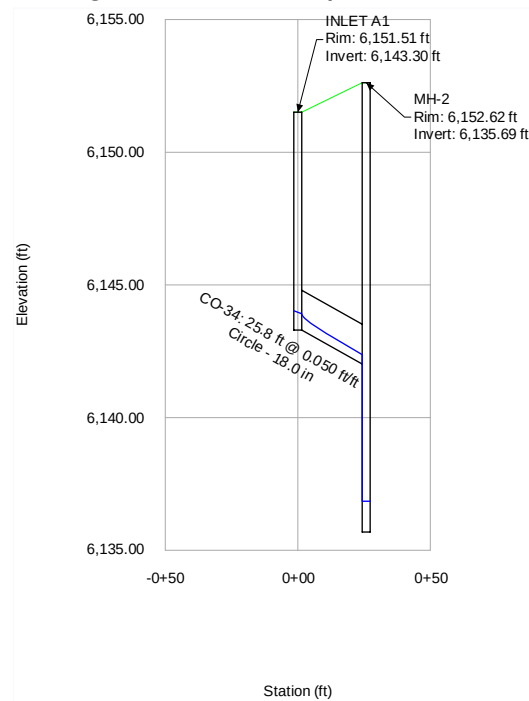
100 YEAR

FlexTable: Outfall Table

ID	Label	Elevation (Ground) (ft)	Elevation (Invert) (ft)	Boundary Condition Type	Hydraulic Grade (ft)	Flow (Total Out) (cfs)
428	CONNECT TO EX. WITH HDS	6,137.54	6,133.48	Crown	6,135.48	10.47

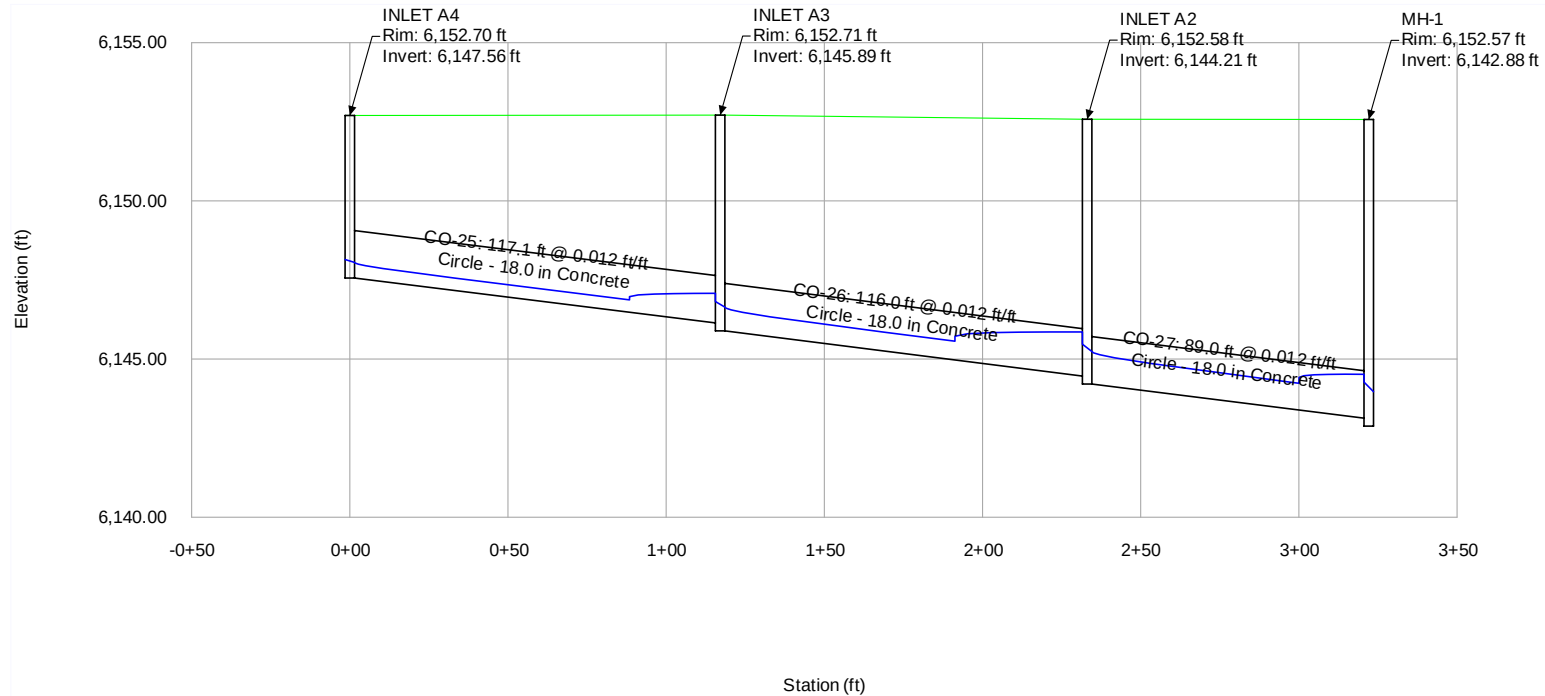
100 YEAR

Profile Report Engineering Profile - A1 (Castle Rock.stsw)



100 YEAR

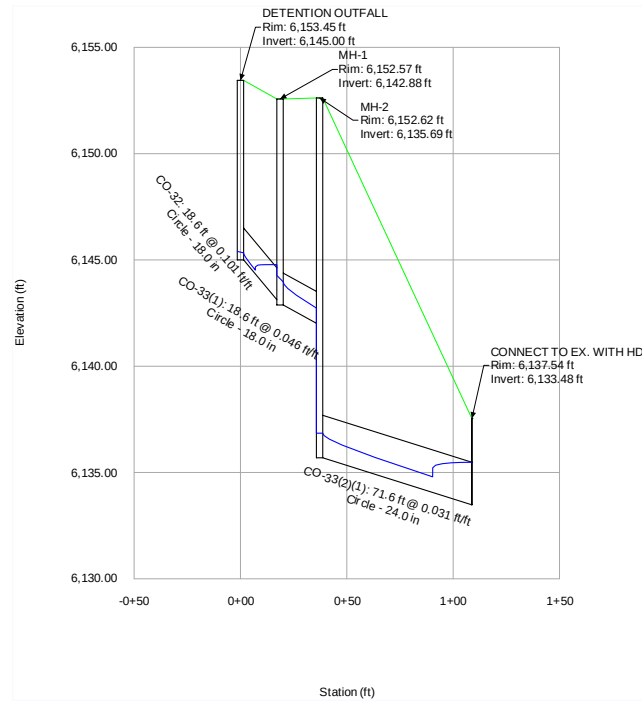
Profile Report Engineering Profile - A2 (Castle Rock.stsw)



100 YEAR

Profile Report

Engineering Profile - OUTFALL (Castle Rock.stsw)



2X100 YEAR

FlexTable: Conduit Table

ID	Label	Start Node	Invert (Start) (ft)	Stop Node	Invert (Stop) (ft)	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Length (3D) (ft)
401	CO-25	INLET A4	6,147.56	INLET A3	6,146.14	18.0	0.013	3.46	1.96	117.1
403	CO-26	INLET A3	6,145.89	INLET A2	6,144.46	18.0	0.013	7.72	4.37	116.0
405	CO-27	INLET A2	6,144.21	MH-1	6,143.13	18.0	0.013	14.12	7.99	89.0
423	CO-32	DETENTION OUTFALL	6,145.00	MH-1	6,143.13	18.0	0.013	0.80	7.88	18.7
432	CO-34	INLET A1	6,143.30	MH-2	6,142.02	18.0	0.013	5.22	10.66	26.9
434	CO-33(1)	MH-1	6,142.88	MH-2	6,142.02	18.0	0.013	14.92	13.65	19.9
437	CO-33(2) (1)	MH-2	6,135.69	CONNECT TO EX. WITH HDS	6,133.48	24.0	0.013	20.14	12.70	71.6

2X100 YEAR

FlexTable: Catch Basin Table

ID	Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert) (ft)	Inlet Type	Hydraulic Grade Line (In) (ft)	Flow (Additional Subsurface) (cfs)
412	INLET A1	6,151.51	6,151.51	6,143.30	Full Capture	6,144.36	5.22
414	INLET A2	6,152.58	6,152.58	6,144.21	Full Capture	6,147.27	6.40
415	INLET A4	6,152.70	6,152.70	6,147.56	Full Capture	6,149.16	3.46
420	DETENTION OUTFALL	6,153.45	6,153.45	6,145.00	Full Capture	6,146.15	0.80
443	INLET A3	6,152.71	6,152.71	6,145.89	Full Capture	6,148.77	4.26

2X100 YEAR

FlexTable: Manhole Table

ID	Label	Elevation (Ground) (ft)	Elevation (Rim) (ft)	Elevation (Invert in 1) (ft)	Flow (Total Out) (cfs)	Depth (Out) (ft)	Hydraulic Grade Line (Out) (ft)	Hydraulic Grade Line (In) (ft)
426	MH-1	6,152.57	6,152.57	6,143.13	14.92	1.40	6,144.28	6,144.99
433	MH-2	6,152.62	6,152.62	6,142.02	20.14	1.61	6,137.30	6,137.30

2X100 YEAR

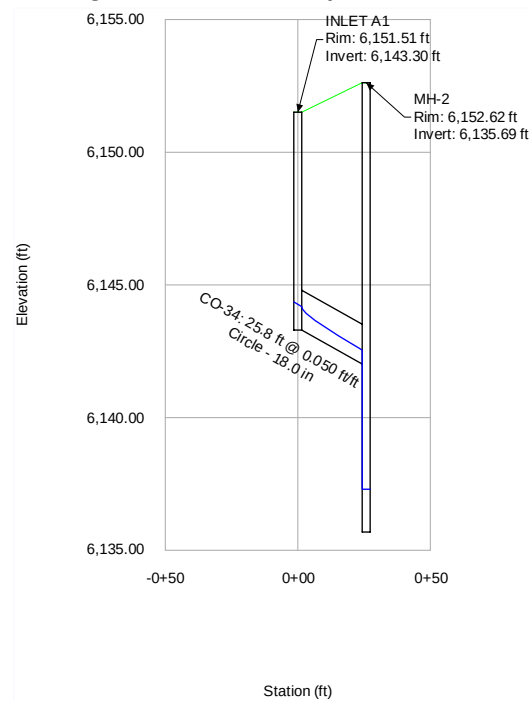
FlexTable: Outfall Table

ID	Label	Elevation (Ground) (ft)	Elevation (Invert) (ft)	Boundary Condition Type	Hydraulic Grade (ft)	Flow (Total Out) (cfs)
428	CONNECT TO EX. WITH HDS	6,137.54	6,133.48	Crown	6,135.48	20.14

2X100 YEAR

Profile Report

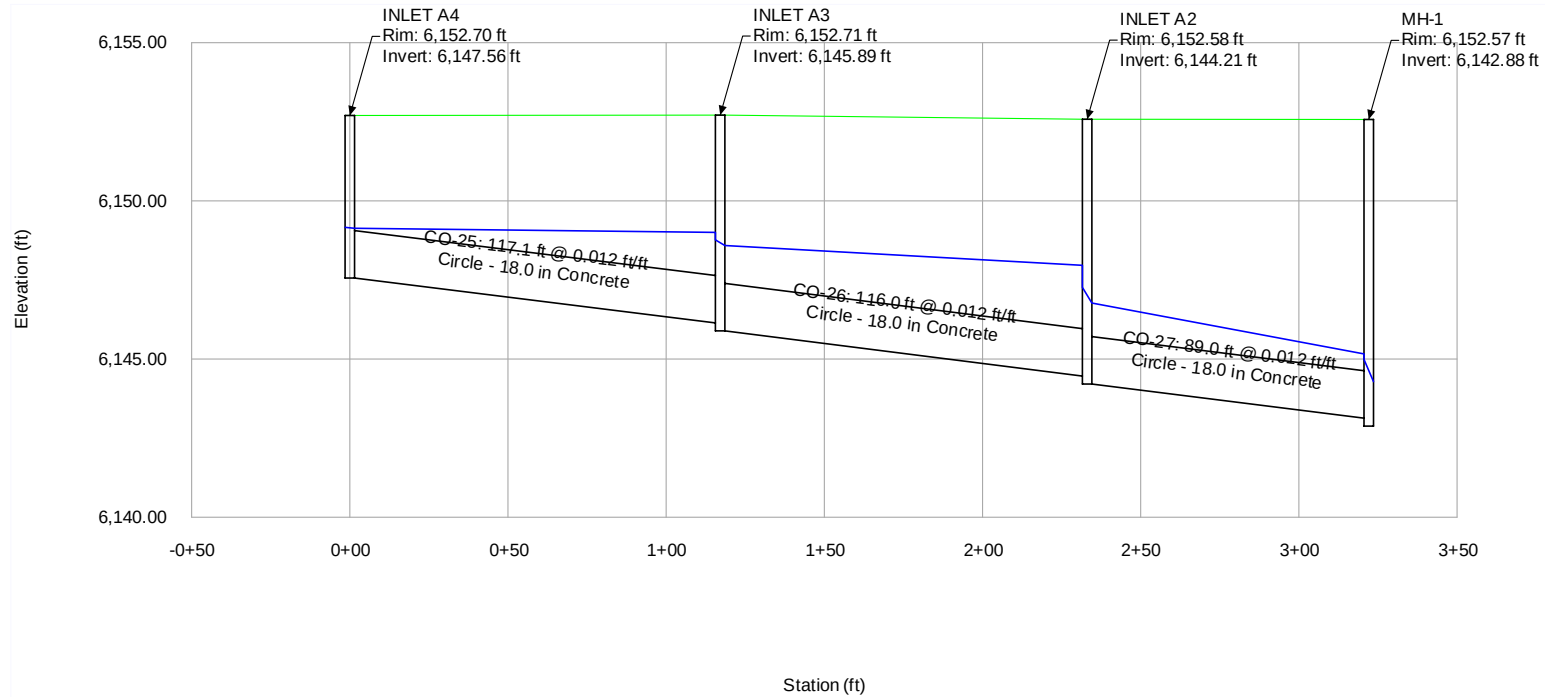
Engineering Profile - A1 (Castle Rock.stsw)



2X100 YEAR

Profile Report

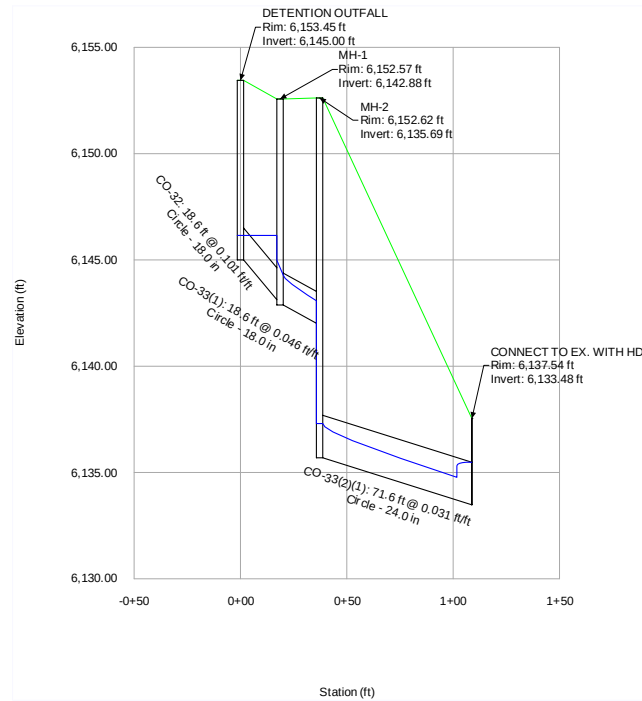
Engineering Profile - A2 (Castle Rock.stsw)



2X100 YEAR

Profile Report

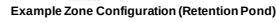
Engineering Profile - OUTFALL (Castle Rock.stsw)



APPENDIX C – WATER QUALITY ENHANCEMENT CONTROL MEASURES

MHFD-Detention, Version 4.06 (July 2022)

Basin ID: RECREATION OF THE LOT 3 ASSUMED BUILDOUT BASED ON 1997 PLANS



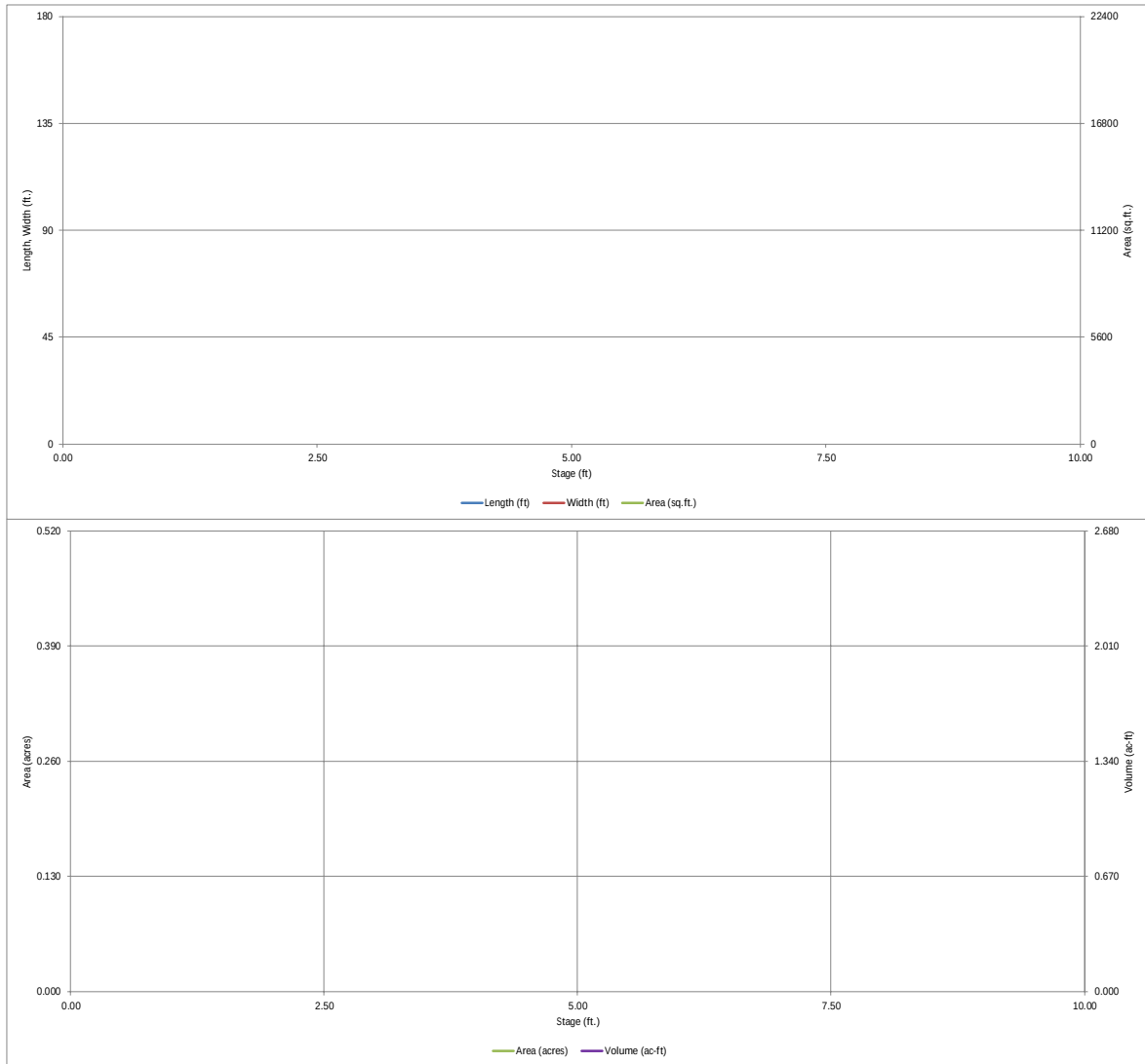
Initial Surcharge Area (A_{ISV})	=	ft ²
Surcharge Volume Length (L_{SV})	=	ft
Surcharge Volume Width (W_{SV})	=	ft
Depth of Basin Floor (H_{FLOOR})	=	ft
Length of Basin Floor (L_{FLOOR})	=	ft
Width of Basin Floor (W_{FLOOR})	=	ft
Area of Basin Floor (A_{FLOOR})	=	ft ²
Volume of Basin Floor (V_{FLOOR})	=	ft ³
Depth of Main Basin (H_{MAIN})	=	ft
Length of Main Basin (L_{MAIN})	=	ft
Width of Main Basin (W_{MAIN})	=	ft
Area of Main Basin (A_{MAIN})	=	ft ²
Volume of Main Basin (V_{MAIN})	=	ft ³
Calculated Total Basin Volume (V_{TOTAL})	=	acre-feet

	acre-feet
	acre-feet
1.06	inches
1.43	inches
1.66	inches
	inches
2.26	inches
2.60	inches
	inches

4/29/2025, 5:54 PM

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)

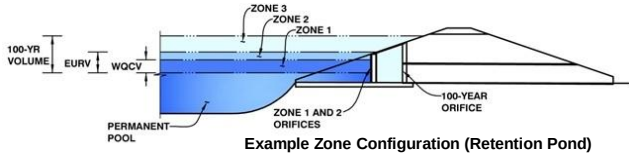


DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Project: CASTLETON HEIGHTS

Basin ID: RECREATION OF THE LOT 3 ASSUMED BUILDOUT BASED ON 1997 PLANS



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1			
Zone 2			
Zone 3			
Total (all zones)			

User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)

Underdrain Orifice Invert Depth = ft (distance below the filtration media surface)
Underdrain Orifice Diameter = inches

Calculated Parameters for Underdrain
Underdrain Orifice Area = ft²
Underdrain Orifice Centroid = feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)

Centroid of Lowest Orifice = ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate = ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing = inches
Orifice Plate: Orifice Area per Row = sq. inches

Calculated Parameters for Plate
WQ Orifice Area per Row = ft²
Elliptical Half-Width = feet
Elliptical Slot Centroid = feet
Elliptical Slot Area = ft²

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (optional)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Orifice Area (sq. inches)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Orifice Area (sq. inches)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

User Input: Vertical Orifice (Circular or Rectangular)

Invert of Vertical Orifice = ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice = ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter = inches

Calculated Parameters for Vertical Orifice
Vertical Orifice Area =
Vertical Orifice Centroid =

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir and No Outlet Pipe)

Overflow Weir Front Edge Height, H_o = ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length = feet
Overflow Weir Grate Slope = H:V
Horiz. Length of Weir Sides = feet
Overflow Grate Type =
Debris Clogging % = %

Calculated Parameters for Overflow Weir
Height of Grate Upper Edge, H_i =
Overflow Weir Slope Length =
Grate Open Area / 100-yr Orifice Area =
Overflow Grate Open Area w/o Debris =
Overflow Grate Open Area w/ Debris =

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

Depth to Invert of Outlet Pipe = ft (distance below basin bottom at Stage = 0 ft)
Circular Orifice Diameter = inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate
Outlet Orifice Area =
Outlet Orifice Centroid =
Half-Central Angle of Restrictor Plate on Pipe =

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage = ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length = feet
Spillway End Slopes = H:V
Freeboard above Max Water Surface = feet

Calculated Parameters for Spillway
Spillway Design Flow Depth = feet
Stage at Top of Freeboard = feet
Basin Area at Top of Freeboard = acres
Basin Volume at Top of Freeboard = acre-ft

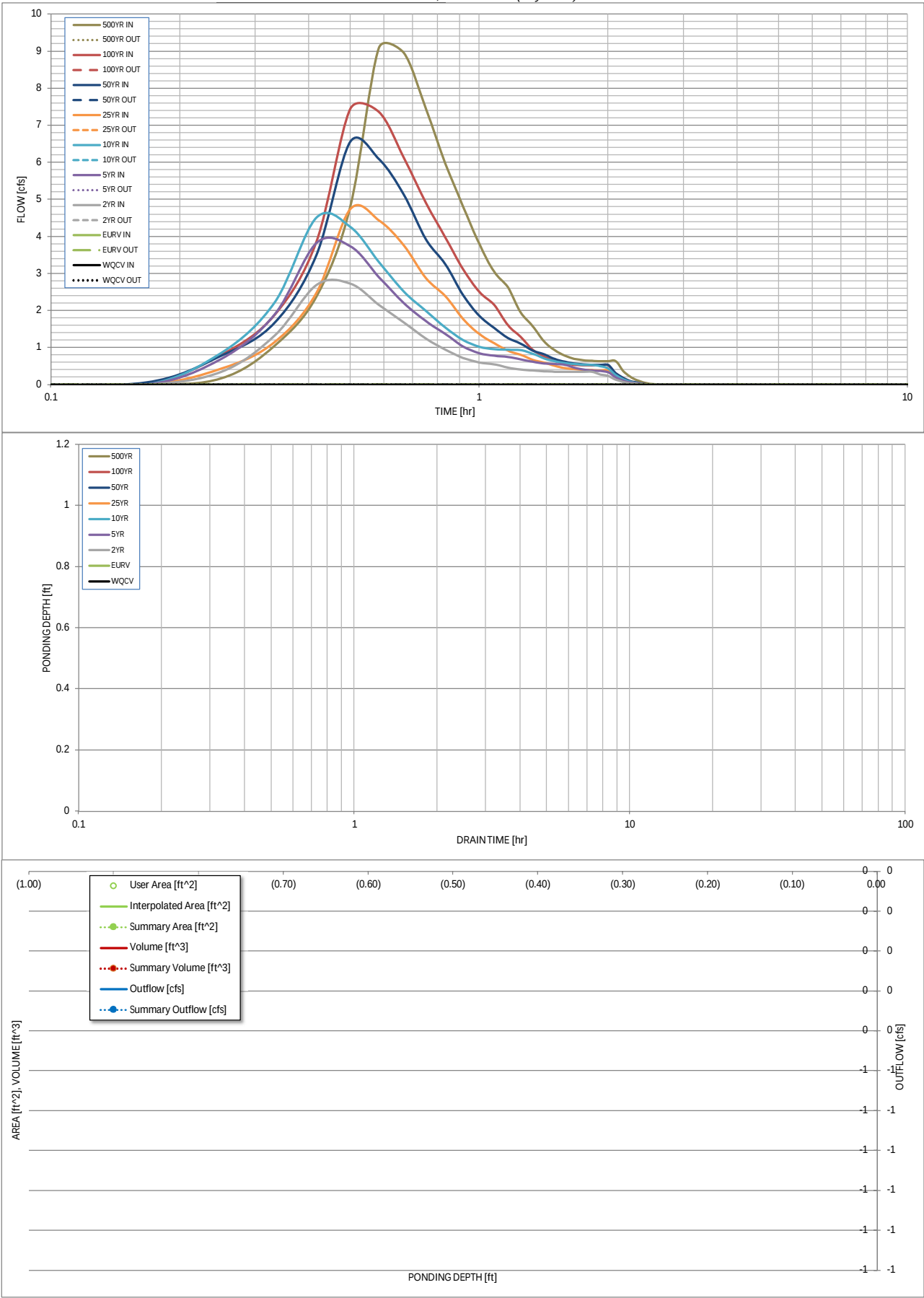
Routed Hydrograph Results

The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Design Storm Return Period =	N/A	N/A	1.06	1.43	1.66	1.69	2.26	2.60
One-Hour Rainfall Depth (in) =	0.059	0.161	0.132	0.187	0.222	0.227	0.314	0.367
CUHP Runoff Volume (acre-ft) =	N/A	N/A	0.132	0.187	0.222	0.227	0.314	0.367
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.2	0.8	1.1	1.4	2.5	3.2
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.12	0.44	0.61	0.77	1.33	1.71
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A	2.7	3.8	4.5	4.7	6.6	7.4
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A						
Peak Inflow Q (cfs) =								
Peak Outflow Q (cfs) =								
Ratio Peak Outflow to Predevelopment Q =								
Structure Controlling Flow =								
Max Velocity through Grate 1 (fps) =								
Max Velocity through Grate 2 (fps) =								
Time to Drain 97% of Inflow Volume (hours) =								
Time to Drain 99% of Inflow Volume (hours) =								
Maximum Ponding Depth (ft) =								
Area at Maximum Ponding Depth (acres) =								
Maximum Volume Stored (acre-ft) =								

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)



S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename: _____

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.03	0.17
	0:15:00	0.00	0.00	0.35	0.70	0.87	0.43	0.78	0.81	1.06
	0:20:00	0.00	0.00	1.33	1.91	2.24	1.16	1.68	1.90	2.38
	0:25:00	0.00	0.00	2.69	3.82	4.51	2.49	3.51	3.86	4.80
	0:30:00	0.00	0.00	2.73	3.74	4.26	4.74	6.55	7.44	9.08
	0:35:00	0.00	0.00	2.15	2.91	3.31	4.44	6.09	7.36	8.96
	0:40:00	0.00	0.00	1.68	2.21	2.52	3.76	5.13	6.13	7.45
	0:45:00	0.00	0.00	1.25	1.72	2.00	2.88	3.92	4.91	5.97
	0:50:00	0.00	0.00	0.95	1.37	1.54	2.39	3.25	3.98	4.83
	0:55:00	0.00	0.00	0.73	1.04	1.21	1.78	2.43	3.12	3.80
	1:00:00	0.00	0.00	0.60	0.85	1.03	1.37	1.86	2.51	3.05
	1:05:00	0.00	0.00	0.55	0.78	0.96	1.12	1.54	2.16	2.63
	1:10:00	0.00	0.00	0.46	0.75	0.94	0.92	1.26	1.60	1.96
	1:15:00	0.00	0.00	0.41	0.69	0.94	0.81	1.11	1.29	1.58
	1:20:00	0.00	0.00	0.38	0.62	0.84	0.67	0.92	0.95	1.17
	1:25:00	0.00	0.00	0.37	0.58	0.71	0.60	0.82	0.77	0.94
	1:30:00	0.00	0.00	0.35	0.56	0.63	0.51	0.69	0.64	0.79
	1:35:00	0.00	0.00	0.35	0.54	0.59	0.45	0.62	0.57	0.70
	1:40:00	0.00	0.00	0.35	0.46	0.56	0.42	0.57	0.54	0.66
	1:45:00	0.00	0.00	0.35	0.41	0.54	0.40	0.55	0.53	0.64
	1:50:00	0.00	0.00	0.35	0.38	0.53	0.39	0.54	0.52	0.64
	1:55:00	0.00	0.00	0.28	0.37	0.50	0.39	0.53	0.52	0.64
	2:00:00	0.00	0.00	0.23	0.34	0.44	0.39	0.53	0.52	0.64
	2:05:00	0.00	0.00	0.14	0.20	0.26	0.23	0.31	0.31	0.38
	2:10:00	0.00	0.00	0.08	0.11	0.15	0.14	0.19	0.18	0.22
	2:15:00	0.00	0.00	0.04	0.06	0.08	0.07	0.10	0.10	0.12
	2:20:00	0.00	0.00	0.02	0.03	0.04	0.04	0.06	0.06	0.07
	2:25:00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.03
	2:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
	2:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Summary Stage-Area-Volume-Discharge Relationships

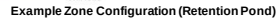
The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

[illegible]

MHFD-Detention, Version 4.06 (July 2022)

Basin ID: ONSITE BAISNS FLOWING TO EX. DETENTION POND

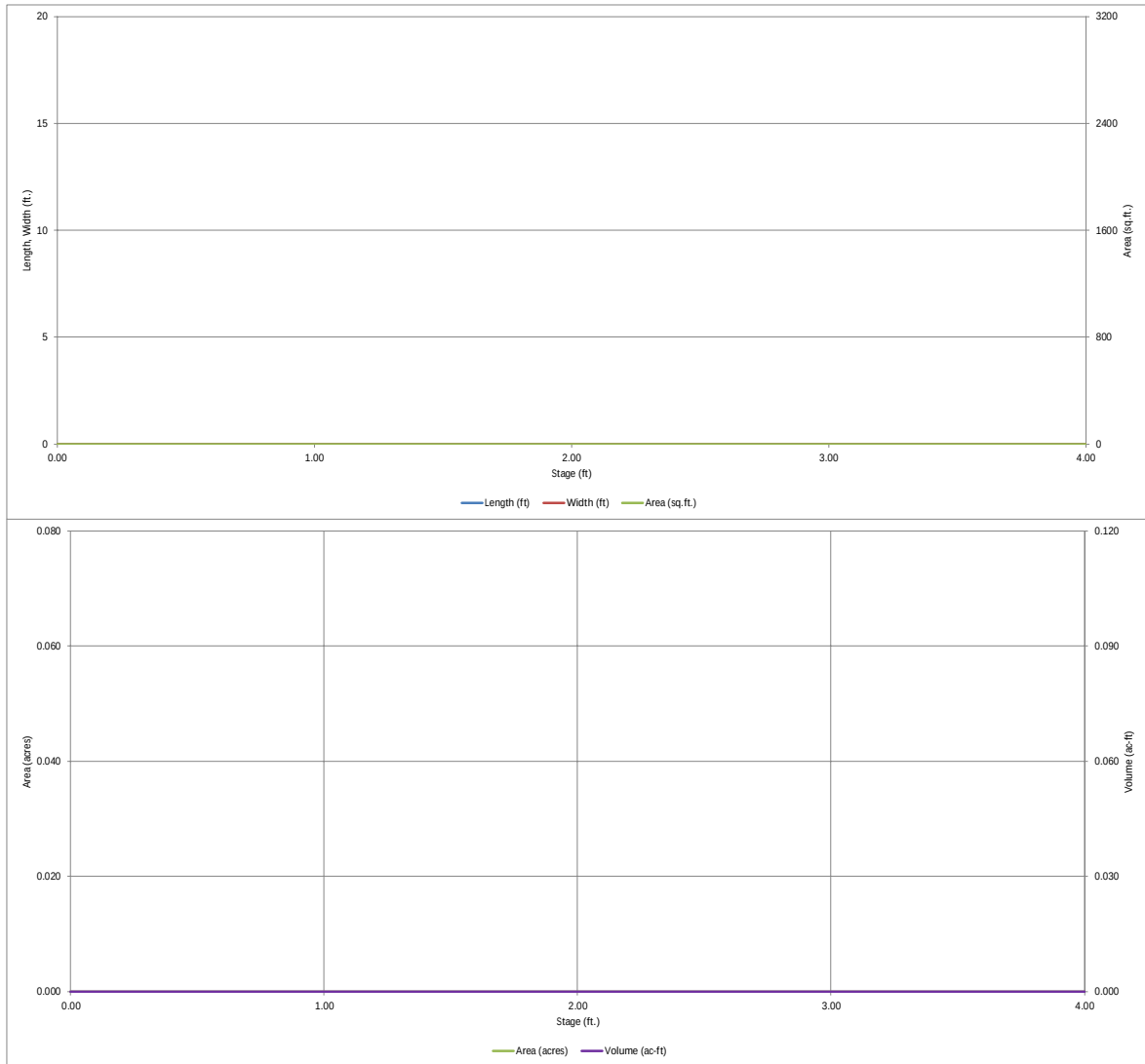


	acre-feet
	acre-feet
1.06	inches
1.43	inches
1.66	inches
	inches
2.26	inches
2.60	inches
	inches

4/30/2025, 9:26 AM

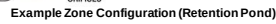
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)



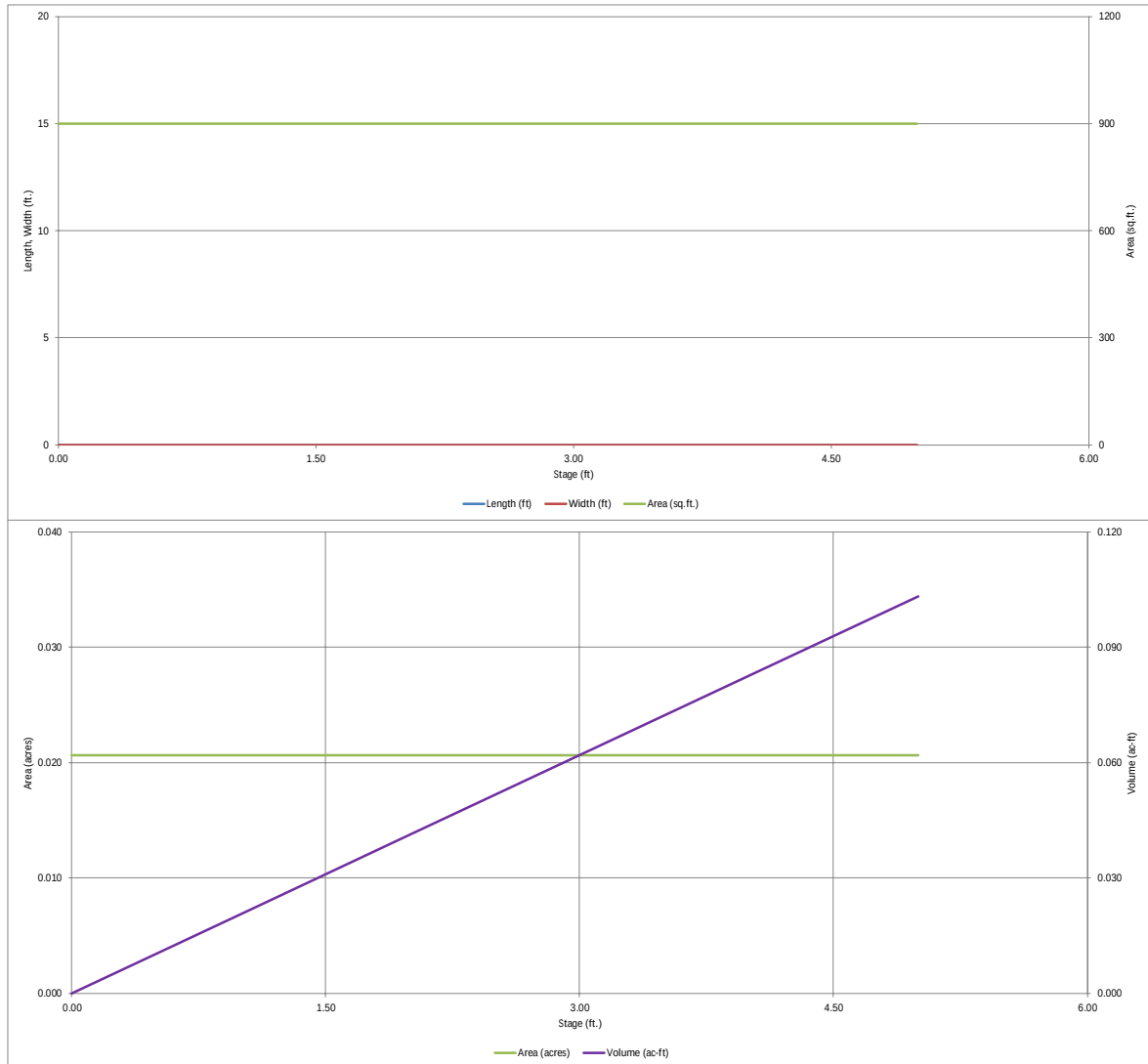
MHFD-Detention, Version 4.06 (July 2022)

Basin ID: ONSITE BAISNS FLOWING TO ONSITE UG DETENTION - DETAILS TO BE PROVIDED WITH CDS



DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.06 (July 2022)

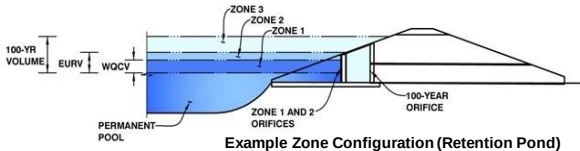


DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

Project: CASTLETON HEIGHTS

Basin ID: ONSITE BAISNS FLOWING TO ONSITE UG DETENTION - DETAILS TO BE PROVIDED WITH CDS



Example Zone Configuration (Retention Pond)

	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	0.91	0.019	Orifice Plate
Zone 2 (EURV)	2.29	0.029	Orifice Plate
Zone 3 (100-year)	3.68	0.029	Weir&Pipe (Rect.)
Total (all zones)		0.076	

User Input: Orifice at Underdrain Outlet (typically used to drain WOCV in a Filtration BMP)

Underdrain Orifice Invert Depth = ft (distance below the filtration media surface)
Underdrain Orifice Diameter = inches

Calculated Parameters for Underdrain

Underdrain Orifice Area = ft²
Underdrain Orifice Centroid = feet

User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WOCV and/or EURV in a sedimentation BMP)

Calculated Parameters for Plate

Centroid of Lowest Orifice = ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate = ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing = inches
Orifice Plate: Orifice Area per Row = sq. inches

WQ Orifice Area per Row = ft²
Elliptical Half-Width = feet
Elliptical Slot Centroid = feet
Elliptical Slot Area = ft²

User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00							
Orifice Area (sq. inches)	0.27							

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

User Input: Vertical Orifice (Circular or Rectangular)

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Invert of Vertical Orifice =	<input type="text" value="N/A"/>	<input type="text" value="N/A"/>	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	<input type="text" value="N/A"/>	<input type="text" value="N/A"/>	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =	<input type="text" value="N/A"/>	<input type="text" value="N/A"/>	inches

Vertical Orifice Area = ft²
Vertical Orifice Centroid = feet

User Input: Overflow Weir (Dropbox with Flat or Sloped Grate and Outlet Pipe OR Rectangular/Trapezoidal Weir and No Outlet Pipe)

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	3.00	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	4.00	N/A	feet
Overflow Weir Grate Slope =	0.00	N/A	H:V
Horiz. Length of Weir Sides =	4.00	N/A	feet
Overflow Grate Type =	Type C Grate	N/A	
Debris Clogging % =	50%	N/A	%

Height of Grate Upper Edge, H₁ = feet
Overflow Weir Slope Length = feet
Grate Open Area / 100-yr Orifice Area =
Overflow Grate Open Area w/o Debris = ft²
Overflow Grate Open Area w/ Debris = ft²

User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Rectangular	Not Selected	
Depth to Invert of Outlet Pipe =	1.00	N/A	ft (distance below basin bottom at Stage = 0 ft)
Rectangular Orifice Width =	6.00	N/A	inches
Rectangular Orifice Height =	6.00		inches

Outlet Orifice Area = ft²
Outlet Orifice Centroid = feet
Half-Central Angle of Restrictor Plate on Pipe = radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Calculated Parameters for Spillway

Spillway Invert Stage = ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length = feet
Spillway End Slopes = H:V
Freeboard above Max Water Surface = feet

Spillway Design Flow Depth = feet
Stage at Top of Freeboard = feet
Basin Area at Top of Freeboard = acres
Basin Volume at Top of Freeboard = acre-ft

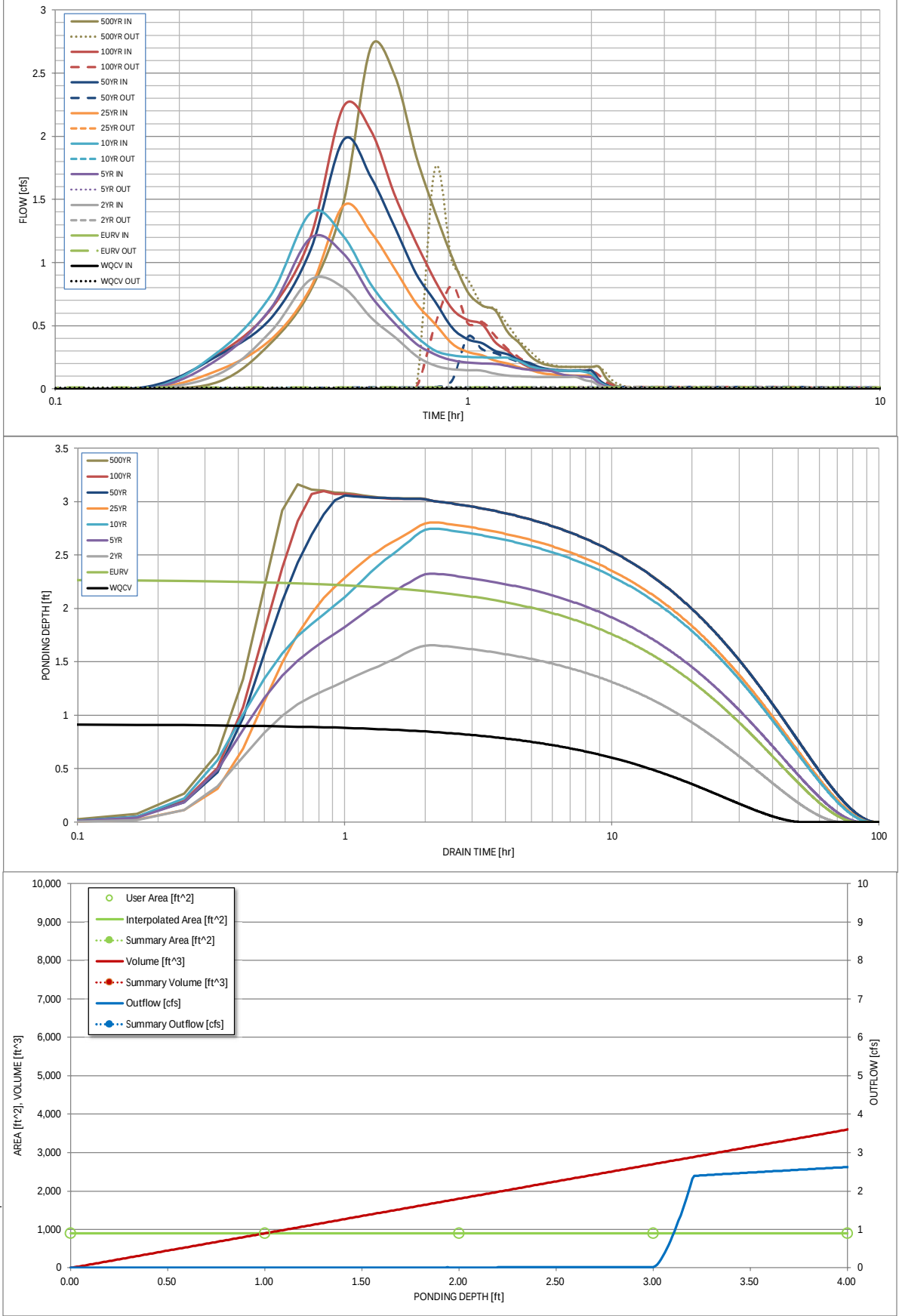
Routed Hydrograph Results

The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Design Storm Return Period =	N/A	N/A	1.06	1.43	1.66	1.69	2.26	2.60	3.14
One-Hour Rainfall Depth (in) =									
CUHP Runoff Volume (acre-ft) =	0.019	0.047	0.036	0.050	0.059	0.060	0.082	0.095	0.116
Inflow Hydrograph Volume (acre-ft) =	N/A	N/A	0.036	0.050	0.059	0.060	0.082	0.095	0.116
CUHP Predevelopment Peak Q (cfs) =	N/A	N/A	0.1	0.3	0.4	0.5	0.8	1.0	1.3
OPTIONAL Override Predevelopment Peak Q (cfs) =	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre) =	N/A	N/A	0.15	0.53	0.74	0.92	1.56	2.00	2.62
Peak Inflow Q (cfs) =	N/A	N/A	0.9	1.2	1.4	1.5	2.0	2.2	2.7
Peak Outflow Q (cfs) =	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.8	1.7
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.1	0.0	0.0	0.5	0.8	1.3
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Plate	Plate	Overflow Weir 1	Overflow Weir 1	Overflow Weir 1
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	0.0	0.1	0.2
Max Velocity through Grate 2 (fps) =	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours) =	44	69	61	72	78	79	79	78	76
Time to Drain 99% of Inflow Volume (hours) =	48	75	66	78	85	86	87	86	85
Maximum Ponding Depth (ft) =	0.92	2.28	1.66	2.33	2.75	2.81	3.06	3.10	3.17
Area at Maximum Ponding Depth (acres) =	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Maximum Volume Stored (acre-ft) =	0.019	0.047	0.034	0.048	0.057	0.058	0.063	0.064	0.065

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)



S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

DETENTION BASIN OUTLET STRUCTURE DESIGN

Outflow Hydrograph Workbook Filename:

Inflow Hydrographs

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

	SOURCE	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP	CUHP
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.00_min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.06
	0:15:00	0.00	0.00	0.12	0.25	0.30	0.15	0.27	0.28	0.37
	0:20:00	0.00	0.00	0.46	0.64	0.75	0.39	0.56	0.64	0.78
	0:25:00	0.00	0.00	0.87	1.20	1.40	0.80	1.11	1.21	1.48
	0:30:00	0.00	0.00	0.80	1.07	1.21	1.45	1.97	2.24	2.71
	0:35:00	0.00	0.00	0.56	0.74	0.83	1.24	1.67	2.04	2.47
	0:40:00	0.00	0.00	0.41	0.52	0.58	0.95	1.27	1.53	1.85
	0:45:00	0.00	0.00	0.26	0.36	0.42	0.68	0.91	1.16	1.40
	0:50:00	0.00	0.00	0.19	0.28	0.30	0.52	0.69	0.86	1.04
	0:55:00	0.00	0.00	0.16	0.23	0.27	0.36	0.48	0.63	0.77
	1:00:00	0.00	0.00	0.15	0.21	0.25	0.29	0.40	0.55	0.66
	1:05:00	0.00	0.00	0.15	0.20	0.25	0.27	0.36	0.51	0.62
	1:10:00	0.00	0.00	0.12	0.20	0.25	0.22	0.30	0.37	0.45
	1:15:00	0.00	0.00	0.11	0.18	0.25	0.20	0.27	0.30	0.36
	1:20:00	0.00	0.00	0.10	0.16	0.22	0.17	0.23	0.22	0.26
	1:25:00	0.00	0.00	0.10	0.15	0.18	0.15	0.21	0.17	0.21
	1:30:00	0.00	0.00	0.10	0.15	0.16	0.13	0.17	0.15	0.19
	1:35:00	0.00	0.00	0.10	0.15	0.15	0.12	0.16	0.15	0.18
	1:40:00	0.00	0.00	0.10	0.12	0.15	0.11	0.15	0.14	0.17
	1:45:00	0.00	0.00	0.10	0.11	0.15	0.11	0.15	0.14	0.17
	1:50:00	0.00	0.00	0.10	0.10	0.15	0.11	0.15	0.14	0.17
	1:55:00	0.00	0.00	0.07	0.10	0.14	0.11	0.15	0.14	0.17
	2:00:00	0.00	0.00	0.06	0.09	0.12	0.11	0.15	0.14	0.17
	2:05:00	0.00	0.00	0.03	0.04	0.06	0.05	0.07	0.07	0.09
	2:10:00	0.00	0.00	0.01	0.02	0.03	0.02	0.03	0.03	0.04
	2:15:00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02
	2:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:10:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:20:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:25:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:30:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:35:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:40:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:45:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:50:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5:55:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DETENTION BASIN OUTLET STRUCTURE DESIGN

MHFD-Detention, Version 4.06 (July 2022)

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points

The user should graphically compare the summary S-A-v-D table to the full S-A-v-D table in the chart to confirm it captures all key transition points.

[illegible]

Receiving Pervious Areas (Including Grass Buffers and Grass Swales)

SCM Design, Version 4.02 (June 2025)

Designer: _____
 Company: _____
 Date: August 12, 2025
 Project: _____
 Location: _____
 Outfall ID: SITE OUTFALL

UIA modeled as 20% impervious area of the buffers themselves. This calculation intended to show that basins OS1-OS6 satisfy water quality requirements for themselves. These basins do not receive flow from any upstream basins

DESIGN PROCEDURE AND CRITERIA FOR ALL RPAs (User Input in Blue Cells)

1. Apply Four-Cover Land Use Model to Site Layout

Design Point ID	SITE OUTFALL	OS1	OS1U	OS2	OS2U	OS3	OS3U	OS4	OS4U	OS5	OS5U	OS6	OS6U	
Area Type	RPA	RPA_Buffer	UIA	RPA_Buffer	UIA	RPA_Buffer	UIA	RPA_Buffer	UIA	RPA_Buffer	UIA	RPA_Buffer	UIA	
Downstream Design Point ID	--	SITE OUTFALL	OS1	SITE OUTFALL	OS2	SITE OUTFALL	OS3	SITE OUTFALL	OS4	SITE OUTFALL	OS5	SITE OUTFALL	OS6	
DCIA (ft ²)	--	--	--	--	--	--	--	--	--	--	--	--	--	
UIA (ft ²)	--	--	1,303	--	1,243	--	2,778	--	967	--	881	--	2,254	
RPA (ft ²)	--	6,518	--	6,217	--	13,890	--	4,844	--	4,407	--	11,270	--	
SPA (ft ²)	--	--	--	--	--	--	--	--	--	--	--	--	--	

2. Protect the RPA from Traffic

RPA Protection Type	--	Fencing	--	Fencing	--	Fencing	--	Fencing	--	Fencing	--	Fencing	--	
---------------------	----	---------	----	---------	----	---------	----	---------	----	---------	----	---------	----	--

3. Characterize On-site Topsoil and Determine Suitability for the RPA

HSG A (%)	--	0.0%	--	0.0%	--	0.0%	--	0.0%	--	0.0%	--	0.0%	--	
HSG B (%)	--	0.0%	--	0.0%	--	0.0%	--	0.0%	--	0.0%	--	0.0%	--	
HSG C/D (%)	--	100.0%	--	100.0%	--	100.0%	--	100.0%	--	100.0%	--	100.0%	--	

4. Select Appropriate Vegetation

RPA Vegetation Type	--	Seed	--	Seed	--	Seed	--	Seed	--	Seed	--	Seed	--	
Irrigation Type	--	Permanent	--	Permanent	--	Permanent	--	Permanent	--	Permanent	--	Permanent	--	

Notes:

GRASS BUFFER ADDITIONAL DESIGN PROCEDURE AND CRITERIA (User Input in Blue Cells)

1. Define the UIA:RPA pair, Ratio, and Interface Width

Sheet Flow Inflow Feature	--	Spreader	--	Spreader	--	Spreader	--	Spreader	--	Spreader	--	Spreader	--	
Is Concrete Edger used?	--	--	--	--	--	--	--	--	--	--	--	--	--	
Spacing between slots (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	
Slot Opening Length (in)	--	--	--	--	--	--	--	--	--	--	--	--	--	
Blind Swale Type	--	Vegetated	--	Vegetated	--	Vegetated	--	Vegetated	--	Vegetated	--	Vegetated	--	
Spreader Energy Dissipation	--	Space	--	Space	--	Space	--	Space	--	Space	--	Space	--	
Total Area of UIA:RPA (ft ²)	--	7,821	--	7,460	--	16,668	--	5,811	--	5,288	--	13,524	--	
UIA:RPA Ratio	--	0.2	--	0.2	--	0.2	--	0.2	--	0.2	--	0.2	--	
UIA:RPA Interface Width (ft)	--	180	--	106	--	284	--	124	--	131	--	316	--	
L / W Ratio of UIA:RPA	--	0.24	--	0.66	--	0.21	--	0.38	--	0.31	--	0.14	--	

2. Buffer Length

Average Buffer Length (ft)	--	36	--	59	--	49	--	39	--	34	--	36	--	
----------------------------	----	----	----	----	----	----	----	----	----	----	----	----	----	--

3. Buffer Slope

Average Buffer Slope (ft/ft)	--	0.250	--	0.250	--	0.250	--	0.250	--	0.250	--	0.050	--	
Effective Distance (ft)	--	17	--	17	--	17	--	17	--	17	--	50	--	

Number of Level Spreaders	--	3	--	4	--	3	--	3	--	2	--	1	--	
---------------------------	----	---	----	---	----	---	----	---	----	---	----	---	----	--

4. Provide a Vertical Drop

Vertical Drop (in)	--	0.00	--	0.00	--	0.00	--	0.00	--	0.00	--	0.00	--	
Mowing Strip Provided?	--	NO	--	NO	--	NO	--	NO	--	NO	--	NO	--	

5. Calculate Runoff for UIA and RPA Pair

Imperviousness (%)	--	16.7%	--	16.7%	--	16.7%	--	16.6%	--	16.7%	--	16.7%	--	
UIA:RPA Runoff (in)	--	0.00	--	0.00	--	0.00	--	0.00	--	0.00	--	0.00	--	
UIA:RPA Runoff (ft ³)	--	0	--	0	--	0	--	0	--	0	--	0	--	

6. Compare Runoff from UIA:RPA Pair to Runoff from UIA Only

UIA Runoff (ft ³)	--	54	--	52	--	116	--	40	--	37	--	94	--	
Runoff Reduction (ft ³)	--	54	--	52	--	116	--	40	--	37	--	94	--	
Runoff Reduction (%)	--	100.0%	--	100.0%	--	100.0%	--	100.0%	--	100.0%	--	100.0%	--	

Notes:

GRASS SWALE ADDITIONAL DESIGN PROCEDURE AND CRITERIA (User Input in Blue Cells)

1. Delineate Areas Tributary to Swale

Total Tributary Area (ft ²)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Imperviousness (%)	--	--	--	--	--	--	--	--	--	--	--	--	--	--

2. Swale Inflows

Concentrated Flow Type	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Blind Swale Type	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Spreader Energy Dissipation	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vertical Drop (in)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gutter Depression (in)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Curb Opening Length (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Concrete Sediment Pad	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Min. Forebay Volume (ft ³)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Design Forebay Volume (ft ³)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Max. Forebay Depth (in)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Design Forebay Depth (in)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Calculated Notch Width (in)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Design Notch Width (in)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Drain Time (minutes)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Energy Dissipation Type	--	--	--	--	--	--	--	--	--	--	--	--	--	--

3. Swale Cross Section

Length of Swale (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bottom Width (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bottom Area (ft ²)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Side Slopes (horiz/vert)	--	--	--	--	--	--	--	--	--	--	--	--	--	--

4. Longitudinal Slope

Available Slope (ft/ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Design Slope (ft/ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Drop Height (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Underdrains Provided?	--	--	--	--	--	--	--	--	--	--	--	--	--	--

5. Calculate Runoff from Tributary Area

Tributary Runoff (ft ³)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Reduced Trib. Runoff (ft ³)	--	--	--	--	--	--	--	--	--	--	--	--	--	--

6. Calculate Runoff Reduction through Swale Bottom

Volume Infiltrated (ft ³)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Swale Discharge (ft ³)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Runoff Reduction (%)	--	--	--	--	--	--	--	--	--	--	--	--	--	--

7. Design Discharge

2-year Discharge, Q2 (cfs)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
----------------------------	----	----	----	----	----	----	----	----	----	----	----	----	----	----

8. Design Velocity

Vegetal Retardance Curve	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Velocity, V2 (fps)	--	--	--	--	--	--	--	--	--	--	--	--	--	--

9. Design Flow Depth

Flow Depth, D2 (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Flow Area, A (ft ²)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Wetted Perimeter, P (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Top Width, T (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hydraulic Radius, Rh (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
VR Product (ft ² /sec)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Manning's n value	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hydraulic Depth, Dh (ft)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Froude Number	--	--	--	--	--	--	--	--	--	--	--	--	--	--

10. Swale Outflows

Outflows Considered?	--	--	--	--	--	--	--	--	--	--	--	--	--	--
----------------------	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Notes:

DESIGN POINT RESULT (Sums results for current column and all upstream design point columns.)

Design Point ID	SITE OUTFALL	OS1	OS1U	OS2	OS2U	OS3	OS3U	OS4	OS4U	OS5	OS5U	OS6	OS6U	
Area Type	RPA	RPA Buffer	UIA	RPA Buffer	UIA	RPA Buffer	UIA	RPA Buffer	UIA	RPA Buffer	UIA	RPA Buffer	UIA	
Total Area (ft ²)	56,572	7,821	1,303	7,460	1,243	16,668	2,778	5,811	967	5,288	881	13,524	2,254	
Imperviousness (%)		16.7%	100.0%	16.7%	100.0%	16.7%	100.0%	16.6%	100.0%	16.7%	100.0%	16.7%	100.0%	
Tributary Runoff (ft ³)		54	54	52	52	116	116	40	40	37	37	94	94	
Runoff Reduction (ft ³)	393	54	0	52	0	116	0	40	0	37	0	94	0	
Runoff Remaining (ft ³)	0	0	54	0	52	0	116	0	40	0	37	0	94	

Total Tributary Area entered on Site Layout Worksheet is: 37,026 square feet

NJCAT TECHNOLOGY VERIFICATION

**HIGH EFFICIENCY CONTINUOUS
DEFLECTIVE SEPARATOR (CDS[®])**

CONTECH CONSTRUCTION PRODUCTS Inc.

January 2010

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1. Introduction

1.1 New Jersey Corporation for Advance Technology (NJCAT) Program

NJCAT is a not-for-profit corporation to promote in New Jersey the retention and growth of technology-based businesses in emerging fields such as environmental and energy technologies. NJCAT provides innovators with the regulatory, commercial, technological and financial assistance required to bring their ideas to market successfully. Specifically, NJCAT functions to:

- Advance policy strategies and regulatory mechanisms to promote technology commercialization;
- Identify, evaluate, and recommend specific technologies for which the regulatory and commercialization process should be facilitated;
- Facilitate funding and commercial relationships/alliances to bring new technologies to market and new business to the state; and
- Assist in the identification of markets and applications for commercialized technologies.

The technology verification program specifically encourages collaboration between vendors and users of technology. Through this program, teams of academic and business professionals are formed to implement a comprehensive evaluation of vendor specific performance claims. Thus, suppliers have the competitive edge of an independent third party confirmation of claims.

Pursuant to N.J.S.A. 13:1D-134 et seq. (Energy and Environmental Technology Verification Program) the New Jersey Department of Environmental Protection (NJDEP) and NJCAT have established a Performance Partnership Agreement (PPA) whereby NJCAT performs the technology verification review and NJDEP certifies that the technology meets the regulatory intent and that there is a net beneficial environmental effect of the technology. In addition, NJDEP/NJCAT work in conjunction to develop expedited or more efficient timeframes for review and decision-making of permits or approvals associated with the verified/certified technology.

The PPA also requires that:

- The NJDEP shall enter into reciprocal environmental technology agreements concerning the evaluation and verification protocols with the United States Environmental Protection Agency, other local required or national environmental agencies, entities or groups in other states and New Jersey for the purpose of encouraging and permitting the reciprocal acceptance of technology data and information concerning the evaluation and verification of energy and environmental technologies; and
- The NJDEP shall work closely with the State Treasurer to include in State bid specifications, as deemed appropriate by the State Treasurer, any technology verified under the Energy and Environment Technology Verification Program.

1.2 Interim Certification

CONTECH Construction Products Inc. (CONTECH) is a leading provider of innovative, long-term, stormwater treatment solutions, offering a variety of products, maintenance, laboratory, and engineering support to meet stormwater treatment needs. CONTECH's patented product, the High Efficiency Continuous Deflective Separator (CDS[®]) unit is a Best Management Practice (BMP) designed to meet federal, state, and local requirements for treating stormwater runoff in compliance with the Clean Water Act. The High Efficiency CDS unit improves the quality of stormwater runoff before it enters receiving waterways through continuous deflective separation and settling to provide enhanced solids removal. (See Section 2 for an additional description of the technology.)

CDS Technologies, Inc., now CONTECH, received New Jersey Corporation for Advanced Technology (NJCAT) verification of claims for the CDS in June 2003. This verification was revised in December of 2004 and a Conditional Interim Certification was issued by NJDEP in January of 2005 for the High Efficiency CDS when used as a pre-treatment device. A major condition of this Conditional Interim Certification was the execution of a field evaluation in accordance with the TARP Tier II Protocol (TARP, 2003) and New Jersey Tier II Stormwater Test Requirements—Amendments to TARP Tier II Protocol (NJDEP, 2006). Conditional Interim Certification was extended in August of 2007. A Project Plan for the Field Evaluation was completed in November of 2007, resulting in the commencement of monitoring activities.

1.3 Applicant Profile

CONTECH offers a range of stormwater treatment products including filtration, hydrodynamic separation, volumetric separation, detention/retention, screening, oil/water separation, and flow control technologies. A knowledgeable team of 200 professionals across the U.S. provide the engineering and customer service support to determine a project's most appropriate stormwater treatment system that meets the requirements of the relevant permitting jurisdiction.

At CONTECH's state-of-the-art laboratories, engineers and scientists conduct ongoing research to further the understanding of non-point source pollution and develop practical product solutions. CONTECH helps its customers achieve their water quality goals by providing treatment technologies that remove a variety of pollutants from stormwater runoff. These stormwater treatment products are specifically designed to meet federal, state, and local regulations.

Former CONTECH subsidiaries Vortechtechnics (2004) and Stormwater Management, Inc. (2005) combined to form Stormwater360 (2006), and later became CONTECH Stormwater Solutions, Inc. a division of CONTECH Construction Products Inc. In December 2006, CDS Technologies, Inc. was added into CONTECH's product offerings.

CONTECH has four primary regional offices that service their customers.

Ohio (Headquarters)

9025 Centre Pointe Drive, Suite 400
West Chester, OH 45069
800-395-0608

Maryland

521 Progress Drive, Suite H
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Maine

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Scarborough, ME 04074
207-885-9830

Oregon

11835 NE Glenn Widing Dr
Portland, OR 97220
866-400-3180

California

3777 Long Beach Blvd., Suite 400
Long Beach, CA 90807
562-264-0701

Key managers of CONTECH are Rick Stepien – President CONTECH Marketing, James Lenhart – Chief Technical Officer, and Frank Birney – Vice President of Stormwater.

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2. The High Efficiency CDS

The High Efficiency CDS unit is typically comprised of a manhole that houses flow and screening controls designed around patented, continuous deflective separation technology. Stormwater runoff enters the High Efficiency CDS unit's diversion chamber where the diversion weir guides the flow into the unit's separation chamber and pollutants are removed. The separation and containment chamber consist of a containment sump in the lower section and an upper separation section. Gross pollutants are separated within the chamber using a perforated plate allowing the filtered water to pass through to a volute return system and thence to the outlet pipe. The water and associated pollutants contained within the separation chamber are kept in continuous motion by the energy generated by the incoming flow. This has the effect of

preventing the separation plate from being blocked by the gross solids separated from the inflow. The heavier solids ultimately settle into the containment sump. Figure 1 is a schematic representation of the solid separation mechanism of the CDS technology.

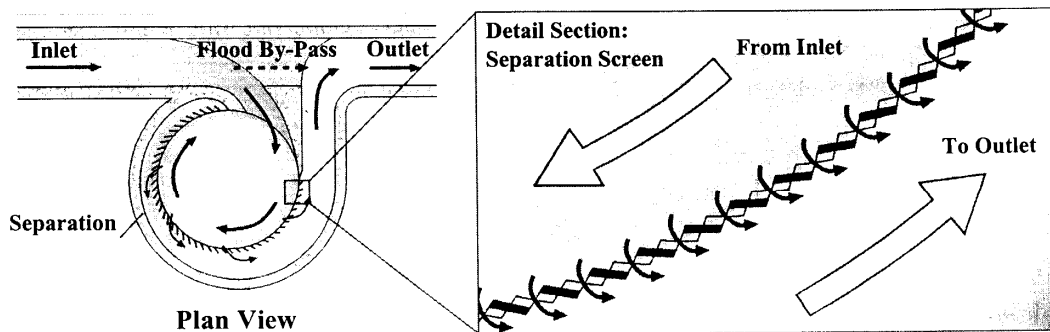


Figure 1 Schematic Representation of the CDS System

The diversion of the stormwater and associated pollutants into a separation chamber overcomes problems associated with the direct filtration systems of conventional gross pollutant traps. The present design of the CDS system utilizes a simple solid diversion unit to divert flows into the separation chamber. The diversion unit is designed to divert all flows into the separation chamber as long as water levels are below the crest level of the diversion unit. As water levels exceed the crest of the diversion unit, some flows would by-pass the CDS system. The crest level of the diversion unit may be adjusted to suit individual installations.

The solid separation system consists of a large expanded stainless steel plate which acts as a filter screen with an outer volute outlet passage. The perforations in the separation screen are typically elongated in shape and are aligned with the longer axis in the vertical direction. The size of the elliptical holes can be specified according to performance requirements and typical width of the short axis ranges from 2.4 mm to 4.7 mm. The separation screen is installed in the unit such that the leading edge of each perforation extends into the flow within the containment chamber.

Operating Mechanism

The essential operational function of the CDS unit is to ensure that the separation screen remains free from blocking by trapped material as the volume of pollutants trapped increases. All flows up to the unit's treatment design capacity enter the separation chamber. Swirl concentration and screen deflection forces direct floatables and solids to the center of the separation chamber, where floatables and neutrally buoyant debris larger than the screen apertures are trapped. Stormwater then moves through the separation screen, over the sediment weir, and exits the unit. The separation screen remains clog free due to continuous deflection. During flow events exceeding the design treatment capacity, the diversion weir bypasses excessive flows around the separation chamber, so captured pollutants will not wash out. Once treated, stormwater is

directed to a collection pipe or discharged to an open channel drainage way. For more detailed information about the High Efficiency CDS unit visit www.contechstormwater.com.

The screen surface area is of the order of 40-45 times the pipe inlet area. Measurement of screen perforations indicates that the orifice area in the direction perpendicular to the plate is approximately 20% of the total plate area. The radial flow velocity through the screen is thus an order of magnitude less than the pipe inlet velocity. Gross solids are prevented from blocking the separation screen using the significantly higher tangential flow velocity compared to the radial velocity throughout the surface of the separation screen. The flow direction in the outer volute outlet system is opposite to that of the circular motion in the separation chamber.

Tangential velocity decreases along the separation screen as well as with depth and decreases from the screen to the center of the separation chamber. The radial velocity distribution is a direct reflection of the distribution of flow through the separation screen. Different inlet conditions can influence distribution of flow through the separation screen and optimization of the CDS unit configuration has been conducted to promote a radial velocity distribution which is consistent with the distribution of tangential velocities along the separation screen. Thus the ratio of tangential to radial velocities is maintained at a high level throughout the surface of the separation screen with both velocities decreasing with increasing distance from the inlet.

Gross Solids Separation

Solids entering the separation chamber can either be floating or settleable materials with those solids which are larger than the aperture size of the separation screen being prevented from passing through the screen. The trapped material is kept in motion within the separation chamber by the design of the unit which maintains the ratio of tangential to radial velocities necessary to promote the non-blocking mechanism throughout the surface of the separation screen. The settleable material ultimately settles into the containment sump. The floating material that enters the CDS unit (including organic matter which over time absorbs water and eventually sinks, e.g. leaf litter) remains within the separation chamber and circulates at the water surface until the water level drops and inflow ceases. The action of the inflow jet, the shaping of the screen and centrifugal effects tend to concentrate this floating material towards the center of the chamber away from the screen.

Fine Solids Separation

For solids which are smaller than the aperture size of the separation screen, trapping efficiency will be affected by the ability of the unit in keeping these solids away from the separation screen as they progressively settle into the containment chamber. The trajectory of these fine particles within the separation chamber is defined by the combined effect of fluid velocity within the chamber and the settling velocity of the particles. The likelihood for very fine particles to flow through the separation screen is higher than coarser particles owing to the trajectory of the former being more exposed to the separation screen. Both particle size and its settling velocity have a direct influence on the trapping efficiency of these particles by the CDS unit.

Oil and Grease Removal

Oil and grease and other total petroleum hydrocarbons (TPHs) are primary water quality constituents of concern from many catchment areas, such as parking areas and highways. CDS units are equipped with a conventional oil baffle to capture and retain oil and grease and TPH pollutants as they are transported through the storm drain system during dry weather (gross spills) and wet weather flows.

There are three (3) types of configurations that CDS units are available in to meet the hydraulic and water quality needs of large and small projects. These treatment configurations can have either an internal or external bypass. Figure 2 provides an illustration of a typical off-line CDS unit.

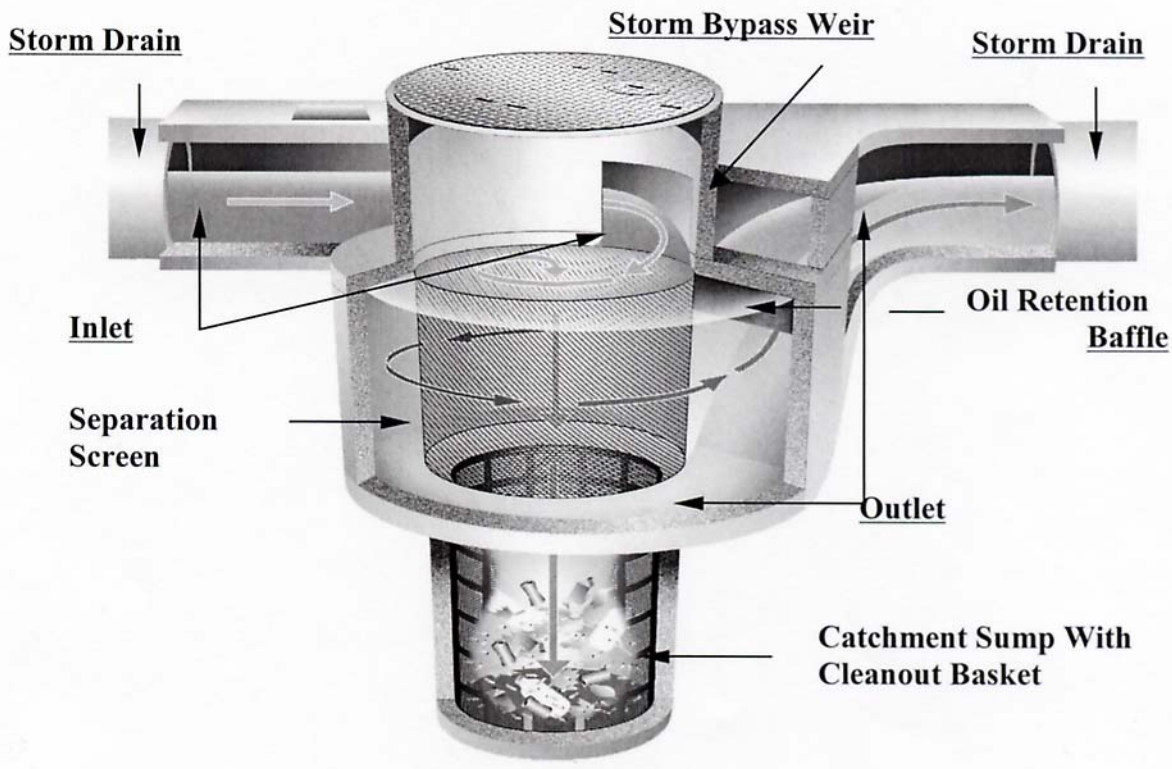


Figure 2 Schematic of an Off-Line CDS Unit

3. Technology System Evaluation: Project Plan

3.1 Introduction

CDS Technologies, Inc., now CONTECH, received New Jersey Corporation for Advanced Technology (NJCAT) verification of claims for the CDS in June 2003. This verification was

revised in December of 2004 and a Conditional Interim Certification (CIC) was issued by NJDEP on January of 2005 for the High Efficiency CDS for 50% TSS removal. A major condition of this Conditional Interim Certification was the execution of a field evaluation in accordance with the TARP Tier II Protocol (TARP, 2003) and New Jersey Tier II Stormwater Test Requirements—Amendments to TARP Tier II Protocol (NJDEP, 2006). Conditional Interim Certification was extended in August of 2007. A Project Plan for the Field Evaluation was completed in November of 2007, resulting in the commencement of monitoring activities.

3.2 Site and System Description

The Manasquan Savings Bank study site is located in the Borough of Point Pleasant, New Jersey (Lat: N 40.0834, Lon: W 74.07208) approximately 18 feet above sea level and is situated at the northeastern end of Ocean County, New Jersey. The site is located at the intersection of Route 88 and Herbertsville Road. A convenience store and bank currently occupy the site. Based on information provided by the specifying engineer the total drainage area of the site is 1.972 acres, 79% impervious. The contributing drainage area to the High Efficiency CDS installed on site is 0.90 acres. An aerial photo of the Manasquan Savings Bank study site is shown in Figure 3 and photographs of the study site are provided in Figures 4 and 5.

Stormwater runoff from the site is directed to a High Efficiency CDS unit model PMSU20_25 (CDS2025) seen in Figure 6, before eventually discharging into the Manasquan River. The unit was installed during redevelopment of the site. The installation was allowed by NJDEP under the Conditional Interim Certification of the High Efficiency CDS. The High Efficiency CDS unit is designed in an on-line configuration with respect to the stormwater conveyance pipe system.

The water quality flow rate provided by the specifying engineer for the Manasquan Savings Bank study site is 1.4 cfs, based on the New Jersey Water Quality Design Storm of 1.25 inches over 2 hours. The Model 20_25 High Efficiency CDS unit is rated to treat a maximum water quality flow rate of 1.6 cfs and a peak flow rate of 5.43 cfs. The next smallest CDS Model is only rated for a water quality flow of 1.1 cfs so the Model 20_25 is appropriately sized for this site. Sizing is based on laboratory testing that serves as the basis of the CIC; the testing demonstrated a suspended solids removal rate of 73.7% or greater based on silica sand particles <100 μ m with a d_{50} of 63 μ m.

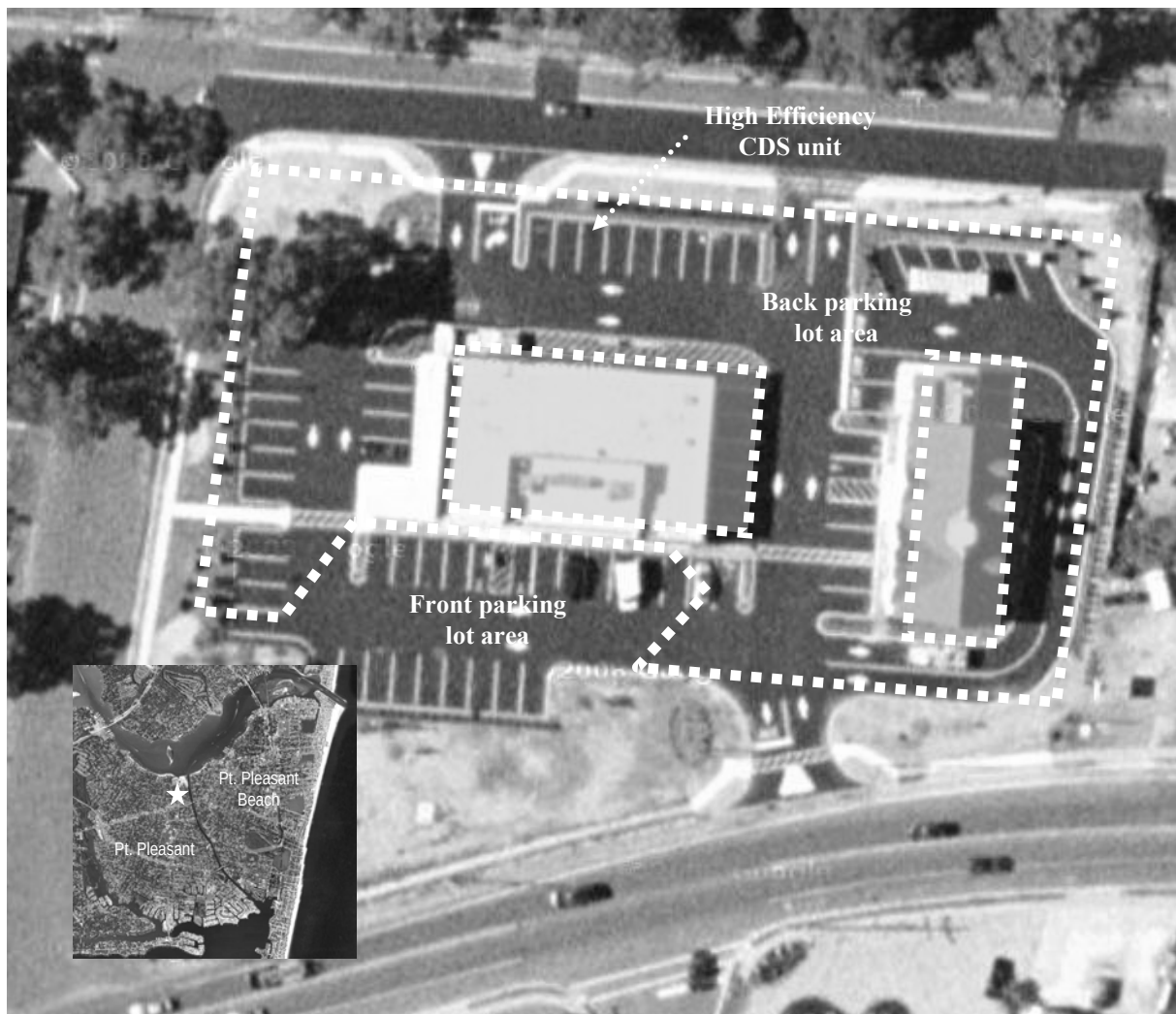


Figure 3 Aerial view of Manasquan Savings Bank study site with drainage area outlined.



Figure 4 View of front parking lot area of Manasquan Savings Bank study site



Figure 5 View of back parking lot area of Manasquan Savings Bank study site

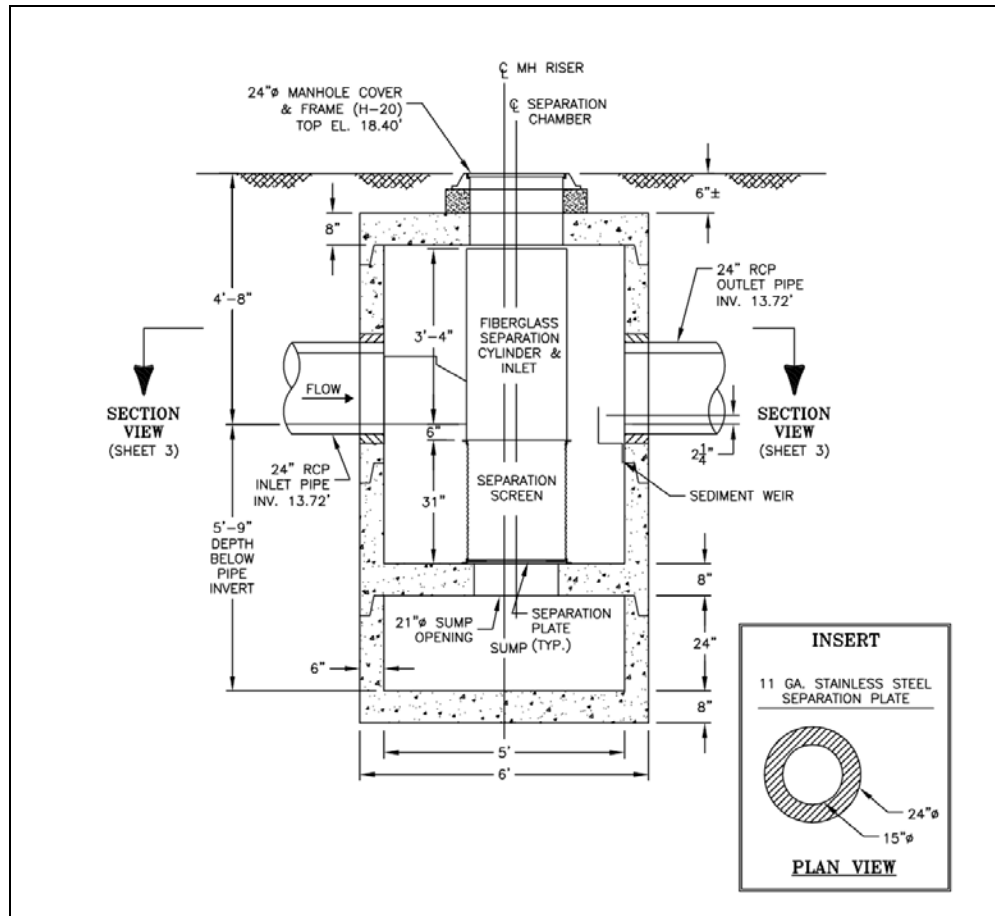


Figure 6 Elevation view of High Efficiency CDS unit installed at Manasquan Savings Bank study site

3.3 Sampling Design

The equipment and sampling techniques used for this study are in accordance with the Project Plan (CONTECH, 2007) developed by CONTECH in consultation with NJDEP and NJCAT under the TARP Tier II Stormwater Protocol (TARP, 2003) and New Jersey Tier II Stormwater Test Requirements—Amendments to TARP Tier II Protocol (NJDEP, 2006). CONTECH personnel were responsible for the installation, operation, and maintenance of the sampling equipment. Sovereign Consulting was utilized for sample retrieval, system reset, and sample submittal activities. Water sample processing and analysis was performed by NJAL and Test America. A general overview of the methodology is provided.

A mobile monitoring unit (MMU) was provided, installed, maintained, and operated by CONTECH for sampling purposes. The MMU is a towable, fully enclosed, self-contained stormwater monitoring system specially designed and built by CONTECH for remote, extended-deployment stormwater monitoring. The design allows for remote control of sampling equipment, eliminates confined space entry requirements, and streamlines the sample pickup and data collection process. The MMU is shown in Figure 7.



Figure 7 View of Mobile Monitoring Unit (MMU) installed at the Manasquan Savings Bank study site

Influent and effluent samples were collected using individual ISCO 6712 Portable Automated Samplers configured for standard, individual, round, wide-mouth sample bottles with HDPE bottles in the 1 through 12 positions for discrete sample collection. The samplers were connected to individual 12VDC deep cycle power supplies recharged by a solar panel. The effluent sampler was equipped with an ISCO 750 Area Velocity Flow Module with a Low Profile Area Velocity Flow Sensor for flow analysis and effluent sample pacing. Sample pacing was based upon effluent flow readings by using a paired sampler configuration though the use of an ISCO SPA 1026 cable. Each sampler was also connected to an ISCO SPA 1489 Digital Cell Phone Modem to allow for remote communication and data access. Rainfall was analyzed with 0.01-in resolution with a Texas Electronics TR-4 tipping bucket-type rain gauge. The sample intake from each automated sampler pump was connected to a stainless steel sample strainer (9/16" diameter, 6" length, with multiple 1/4" openings) via a length of 3/8" ID Acutech Duality FEP/LDPE tubing. Sample strainers and the effluent flow sensor were mounted to the invert of the influent/effluent pipes using stainless steel spring rings.

The sample collection program input into each automated sampler was a two-part program developed to maximize the number of water quality samples collected as well as the coverage of the storm event. Influent and effluent sample collection programs were configured to collect two 500-mL aliquots per bottle spread between up to 12 1-L HDPE bottles. Samplers were

programmed to enable and start the sample collection program when flow conditions exceeded 5 gpm. Once enabled, the sampling equipment collected samples on a volume-paced basis allowing the specified pacing volume to pass before taking a sample. Pacing volumes were calculated for each storm event based on the predicted depth of precipitation in order to satisfy storm event coverage requirements.

Upon the collection of samples following a precipitation event, CONTECH personnel remotely communicated with the automated sampling equipment to confirm sample collection and dispatch personnel from Sovereign to retrieve the samples and reset the automated sampling equipment. Samples were delivered to NJAL by Sovereign using cold transport and accompanied by chain-of-custody documentation. At the direction of CONTECH personnel, sample bottles were combined by NJAL to create composite samples through identification of those bottles best representing the storm event based upon the storm event hydrograph. Selected sample bottles were thoroughly shaken and emptied into a cone splitter with a 2000 micron sieve on top to remove particles greater than 2000µm to ensure proper operation of the cone splitter (USGS, 1980).

Table 1 Analytical methods used for analytical parameters of interest

Parameter	Analytical Method
Suspended Sediment Conc. (SSC)	ASTM D3977
Total Suspended Solids (TSS-SM)	SM2540 D
Total Suspended Solids (TSS-EPA)	EPA 160.2
Total Volatile Suspended Solids (TVSS)	SM 2540G
Particle Size Distribution	ASTM D4464

As per the Project Plan, the following quality control samples were used to assess the quality of both field sampling and analytical activities: equipment rinsate blanks, equipment field blanks, method blank, and duplicate analysis. Sample processing blank samples were not taken. Except for solids analyses that employ the use of the whole sample volume (SSC), all method blanks and duplicate analyses were handled by NJAL. Since solids analyses that employ the use of whole sample volume (SSC) consume the entire sample volume, replicate samples were prepared in place of duplicate samples and analyzed to allow the assessment of analytical accuracy. The results of equipment rinsate blanks, equipment blanks, and sample processing blanks are shown in Table 2 accompanied by associated decisions and action items for instances of detection.

Table 2 Instances of contaminant detection in equipment rinsate blank and equipment field blank samples

Date	Blank Type	Detections	Level (mg/L)	Action	% of Sample Pairs Affected
04/15/08	Rinsate			None	0
09/18/08	Field			None	0
01/29/08	Field	TVSS	0.9	Disqualify TVSS results ≤ 4.5 mg/L for events since last QC Blank.	TVSS(<50 μ m) 21% TVSS(<500 μ m) 16% TVSS(<2000 μ m) 5% TVSS(>2000 μ m) 21%

3.4 Particle Size Distribution and Residual Solids Assessment Methods

Two methods of evaluating influent particle size were used for this project. The first method, laser diffraction, was used in accordance with the TARP Tier II Protocol. The second method was a serial filtration process that was utilized for every storm event sampled. The serial filtration method is a direct measurement of particle size by mass whereas indirect methods such as Laser Diffraction and the electrical sensing zone method (Coulter Principle) convert counted data points into mass by way of assumptions regarding particle shape and density (CONTECH, 2004). For each storm event sampled, samples were poured through a 2000 μ m sieve prior to being split with a cone splitter as seen in Figure 6. Subsamples intended for SSC (<50 μ m) and SSC (<500 μ m) analysis were passed through 50 μ m and 500 μ m sieves respectively prior to analysis, as seen in Figure 8 and 9.

Results were obtained for SSC, SSC (>2000 μ m), SSC (<2000 μ m), SSC (<500 μ m), and SSC (<50 μ m). Results for SSC (>2000 μ m) and SSC were calculated. SSC (>2000 μ m) was calculated using the estimated volume of the sample used for the composite and the mass of material retained by the 2000 μ m sieve. SSC was equal to the sum of SSC (>2000 μ m) and SSC (<2000 μ m). The use of 2000 μ m and 50 μ m sieves to bracket the sand fraction is based upon the USDA particle size distribution system.

Residual solids captured by the system were assessed at the end of the monitoring phase of the project. The assessment involved the estimation of captured material found inside the system and the collection of a 20 liter composite sample of the residual solids. The composite sample of residual solids was homogenized by hand and representatively sampled for analysis. Subsamples were analyzed to determine moisture content, bulk density, and particle size distribution using hydrometer and sieve techniques. Results were used to characterize and determine the dry mass of captured residual solids.

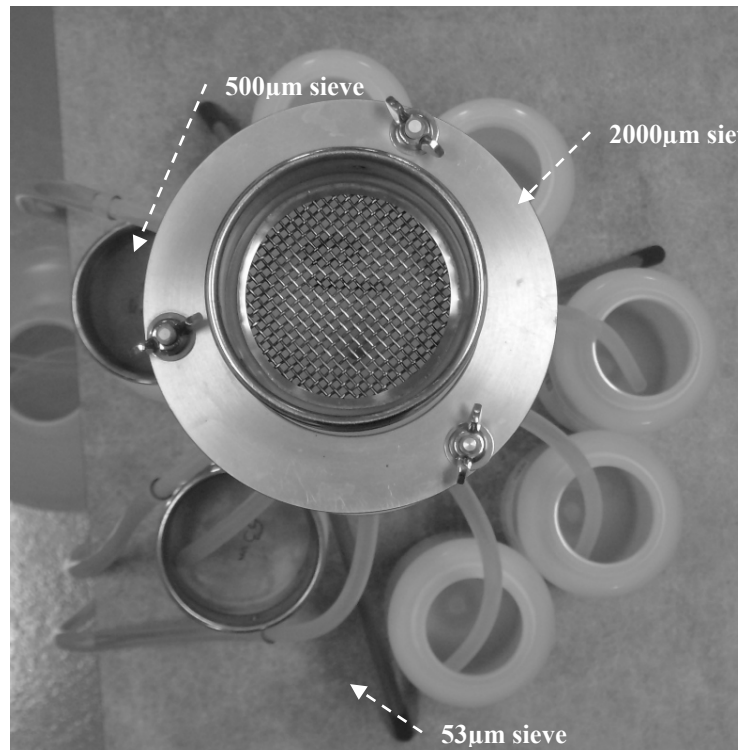


Figure 8 Top view of cone splitter apparatus prior sample splitting using sieves

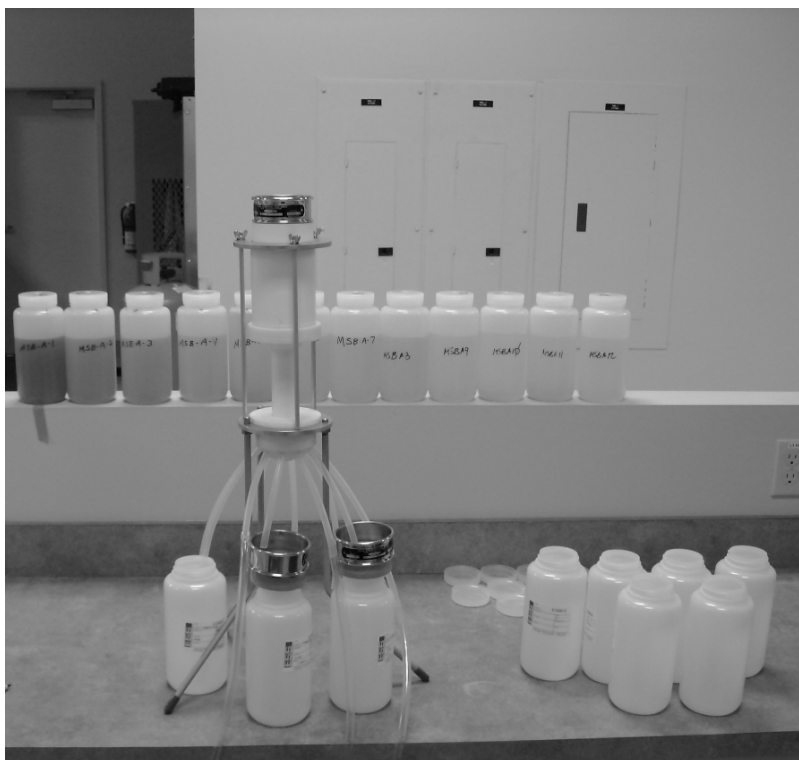


Figure 9 Side view of cone splitter apparatus prior to sample splitting using sieves

3.5 Precipitation Measurement

Rainfall was measured with a Texas Electronics TR-4 tipping bucket-type rain gauge. The rain gauge was connected to the ISCO 6712 programmed to record the total number of tips (0.01 inch per tip) every 5 minutes. A comparison of data collected during the monitoring period to data from a National Weather Service (NWS) cooperative station in Toms River, NJ (about 12 miles south of Point Pleasant) on a monthly basis indicated that the rain gauge was working properly during the monitoring period (Table 3). A comparison of the Toms River rain gauge monthly totals to monthly normal totals shows that rainfall in the area was below normal in October (2007), November (2007), January (2008), April (2008), June (2008), July (2008), August (2008), and October (2008). Rainfall was noticeably above normal in December (2007), February (2008) and September (2008).

Table 3 Comparison of monthly rainfall data between National Weather Service (NWS) cooperative station in Toms River, NJ and Manasquan Savings Bank study site rain gage

Month	MSB rain gage (in.)	NCDC Toms River rain gage (in.)	Percent of normal (%)	Monthly normal totals (1977-2000)
October (2007)	--	2.6	73	3.6
November (2007)	2.0	1.9	46	4.1
December (2007)	6.1	6.8	167	4.1
January (2008)	2.2	2.6	61	4.2
February (2008)	5.3	5.6	168	3.4
March (2008)	4.5	4.8	110	4.3
April (2008)	2.2	1.5	37	4.0
May (2008)	4.6	4.9	118	4.2
June (2008)	3.8	2.6	73	3.5
July (2008)	3.0	3.2	70	4.6
August (2008)	1.3	2.9	58	5.0
September (2008)	3.9	8.5	214	4.0
October (2008)	2.1	1.6	46	3.6
November (2008)	5.0	4.6	114	4.1

A total of 19 qualifying storm events were successfully sampled during the monitoring period between January of 2008 and November of 2008. Collection of storm events commenced after the review and conditional approval of the Project Plan by project stake holders. Storm event durations ranged from 2.58 hours to 27.08 hours, rainfall depth for sampled events ranged from 0.31 to 3.20 inches, and 15 and 30 minute maximum intensities were 2.44 and 1.74 inches/hour respectively. Based on the drainage area provided by the specifying engineer of 0.90 acres the calculated total rainfall volume ranged from 7575 to 78,199 gallons (Table 4).

Table 4 Rainfall and runoff statistics for sampled events at the Manasquan Savings Bank study site.

Event ID	Duration of storm event (hours)	Total rainfall (in.)	P15 (in/hr)	P30 (in/hr)	Total rainfall volume (gal)
MSB011008	11.25	0.50	0.16	0.52	12219
MSB011308	10.08	0.63	0.32	0.46	15395
MSB011708	15.08	0.70	0.24	0.30	17106
MSB020108	9.08	1.22	0.40	0.62	29813
MSB040408	27.00	0.57	0.24	0.24	13929
MSB050908	23.58	1.21	0.36	0.40	29569
MSB051208	18.08	0.97	0.28	0.38	23704
MSB052708	2.58	0.39	0.52	0.66	9530
MSB053108	21.58	0.31	0.52	0.26	7576
MSB060408	10.83	0.85	0.64	0.90	20772
MSB061408	10.58	0.57	1.12	0.56	13929
MSB061508	21.08	0.92	2.44	1.74	22482
MSB070508	21.08	0.88	0.80	0.88	21505
MSB072408	8.08	1.14	1.44	0.80	27858
MSB081408	27.08	0.85	0.76	0.46	20772
MSB092508	15.08	3.20	1.40	1.38	78199
MSB111508	25.33	0.97	0.28	0.26	23704
MSB112508	14.83	0.97	0.16	0.30	23704
MSB113008	32.08	1.46	0.36	0.50	35678

3.6 Flow Measurement

An ISCO 750 Area Velocity Flow Module with a Low Profile Area Velocity Flow Sensor was used to measure flow and pace sample collection. Level measurements were adjusted by applying corrections that reflected differences between recorded and measured water surface elevations in the effluent pipe where the ISCO flow sensor was installed. On average 78 percent of the calculated total rainfall volume was measured as runoff for the events monitored (Table 5).

Table 5 Percentage of calculated rainfall runoff volumes measured at Manasquan Savings Bank study site

Event ID	Event depth (in)	Influent volume (gal)	Total rainfall volume (gal)	Percent runoff (%)
MSB011008	0.50	8275	12219	68
MSB011308	0.63	10530	15395	68
MSB011708	0.70	9487	17106	55
MSB020108	1.22	30508	29813	102
MSB040408	0.57	4740	13929	34
MSB050908	1.21	13134	29569	44
MSB051208	0.97	10050	23704	42
MSB052708	0.39	7915	9530	83
MSB053108	0.31	10153	7576	134
MSB060408	0.85	24003	20772	116
MSB061408	0.57	13560	13929	97
MSB061508	0.92	15465	22482	69
MSB070508	0.92	24748	22482	110
MSB072408	1.14	28963	27858	104
MSB081408	0.85	19781	20772	95
MSB092508	3.20	65868	78199	84
MSB111508	0.97	15806	23704	67
MSB112508	0.97	11707	23704	49
MSB113008	1.46	24187	35678	68

3.7 Stormwater Data Collection Requirements

Of the 19 qualifying storm events sampled between January of 2008 and November of 2008: 1) the total rainfall was greater than 0.1 inch for all storm events sampled, 2) the minimum inter-event period was greater than 12 hours for all storm events sampled, 3) flow-weighted composite samples covered a minimum of 70% of total storm flow for all storm events sampled, 4) the average number of samples collected per storm event was 11, 5) the total sampled rainfall was 18.35 inches, 6) three events exceeded 75% of the design treatment capacity, and 6) TSS-SM, TSS-EPA, and SSC data were collected for all storm events sampled. All but two of the events qualified to strict interpretation of the stormwater data collection requirements as per New Jersey Tier II Stormwater Test Requirements—Amendments to TARP Tier II Protocol (NJDEP, 2006) and the NJDEP interpretation of TARP (2003), Table 6. For the storm events in question, MSB040408 and MSB072408, less than 6 samples were collected but storm event coverage was greater than 90%. Considering the very small margin separating these events from qualification, they were deemed qualified based upon best professional judgment.

Table 6 Stormwater data collection requirements results

Event ID	Coverage (nearest 10%)	Number of samples	Event depth (in.)	Antecedent dry period (hr)	Influent volume (gal)	Peak flow (gpm)	Percent of hyd. design (%)
MSB011008	70	6	0.50	734	8275	241	34
MSB011308	70	8	0.63	53	10530	162	23
MSB011708	90	9	0.70	64	9487	113	16
MSB020108	80	24	1.22	49	30508	209	29
MSB040408	>90	5	0.57	45	4740	66	9
MSB050908	70	9	1.21	235	13134	132	18
MSB051208	80	8	0.97	51	10050	103	14
MSB052708	90	9	0.39	12	7915	353	49
MSB053108	90	9	0.31	81	10153	238	33
MSB060408	>90	22	0.85	69	24003	339	47
MSB061408	>90	14	0.57	228	13560	436	61
MSB061508	>90	9	0.92	12	15465	743	103
MSB070508	>90	8	0.92	89.6	24748	363	51
MSB072408	>90	5	1.14	84.8	28963	620	86
MSB081408	90	6	0.85	14.8	19781	349	49
MSB092508	>90	21	3.20	304	65868	619	86
MSB111508	>90	10	0.97	33	15806	145	20
MSB112508	>90	8	0.97	212	11707	57	8
MSB113008	>90	14	1.46	114	24187	158	22

4. Technology System Performance

4.1 Data Analysis

Of the 19 storm events captured between January of 2008 and November of 2008, data verification and validation did not lead to the outright disqualification of any events due to obvious monitoring, handling, or analytical errors, or the substantial exceedance of the design operating parameters. However, some instances were encountered that suggested the disqualification or separation of select analytical results from the data set. Some monitoring error was encountered in the form of equipment contamination as discussed in the Sampling Design section. This suggests the disqualification of a portion of the Total Volatile Suspended Solids (TVSS) data as well as calculated parameters that utilize TVSS data according to Table 2. Disqualification of either an influent or effluent result resulted in the elimination of the paired data from the final data set. Event mean concentrations (EMCs) from influent and effluent samples are summarized in Table 7, 8, and 9.

Table 7 Suspended Solids Event Mean Concentrations (EMCs) for the 19 events sampled at the Manasquan Savings Bank study site

Event ID	TSS-SM (<2000µm) (mg/l)		TSS-EPA (<2000µm) (mg/l)		SSC (mg/l)		SSC (>2000µm) (mg/l)		SSC (<2000µm) (mg/l)		SSC (<500µm) (mg/l)		SSC (<50µm) (mg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
MSB011008	180.0	40.0	130.0	30.0	1360.0	40.3	367.0	2.5	993.0	40.3	397.0	40.3	55.7	26.9
MSB011308	60.0	10.0	50.0	10.0	760.0	13.2	381.0	4.1	379.0	13.2	101.0	13.0	26.2	12.8
MSB011708	60.0	30.0	60.0	40.0	178.0	36.5	25.5	4.4	152.0	36.5	81.1	35.7	44.2	35.5
MSB020108	60.0	50.0	60.0	50.0	152.0	65.3	42.7	11.1	109.0	54.2	70.0	43.4	56.6	51.6
MSB040408	310.0	2.9	40.0	10.0	341.0	2.4	NT	NT	341.0	2.4	99.7	2.9	26.5	2.9
MSB050908	56	21	48	21	78.7	23.3	24.7	0.2	54	23.3	27.7	23.8	4.8	7.6
MSB051208	41	6	32	8.7	50.6	9.3	15.7	0.2	34.9	9.3	10.2	6.3	4.6	3.7
MSB052708	68	32	60	34.7	74.5	40.7	7	2.4	67.5	38.3	40.5	29.6	14.3	7.5
MSB053108	154	43.2	141	41	188.5	41.1	27.7	0.27	160.8	40.8	60	30.3	20.8	12.8
MSB060408	24.3	9	23.3	7.7	27.7	10.5	0.8	0.6	26.9	9.9	17.4	5.3	6	7.3
MSB061408	718	84	658	51	710.7	74.7	25.2	4.4	685.5	70.3	508.6	41.6	125.1	32.8
MSB061508	304	40	298	37	299.5	55.9	11	0.1	288.5	55.9	241	29.5	72.6	11.8
MSB070508	271	26	232	25.5	241.9	30.3	3.9	0.38	238	29.9	158	13.6	52.4	6.8
MSB072408	458.7	46	427	43.3	500	49.7	8.6	6.71	491.1	43	256.2	24.2	74.4	9.4
MSB081408	657	48	468.5	41	598	42.5	55.2	0.2	542.8	42.3	271.2	31.9	50	14.2
MSB092508	2259	13.8	2075	12.7	6995	22.5	845	0.1	6150	22.5	2558	9.1	16.2	4.7
MSB111508	75.5	25.1	46.6	17	113	21.8	41.1	0.1	71.9	21.7	21.4	9.3	11.6	7.2
MSB112508	29.4	2.5	20.5	2.5	38.9	3.8	14.2	0.1	24.7	3.7	9.2	1.4	ND	ND
MSB113008	519	16.8	348	16.7	381.8	15.7	25.5	0.1	356.3	15.6	178.6	7.6	56.1	5.1
Min	24.3	2.5	20.5	2.5	27.7	2.4	0.8	0.1	24.7	2.4	9.2	1.4	4.6	2.9
Max	2259.0	84.0	2075.0	51.0	6995.0	74.7	845.0	11.1	6150.0	70.3	2558.0	43.4	125.1	51.6
Median	154.0	26.0	60.0	25.5	241.9	30.3	25.4	0.3	238.0	29.9	99.7	23.8	35.4	8.5
Mean	331.8	28.8	274.6	26.3	688.9	31.6	106.8	2.1	587.7	30.2	268.8	21.0	39.9	14.5

ND = Non-detect

NT = Not Tested

Table 8 Total Volatile Suspended Solids Event Mean Concentrations (EMCs) for the 19 events sampled at the Manasquan Savings Bank study site

Event ID	TVSS (>2000µm) (mg/l)		TVSS (<2000µm) (mg/l)		TVSS (<500µm) (mg/l)		TVSS (<50µm) (mg/l)		TVSS (mg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
MSB011008	NT	NT	90.7	17.3	46.5	19.2	20.9	11.5	NT	NT
MSB011308	NT	NT	41.1	7.3	21.2	7.2	12.2	7.1	NT	NT
MSB011708	NT	NT	29.0	15.1	23.8	14.8	17.4	14.7	NT	NT
MSB020108	NT	NT	25.9	20.7	24.3	16.8	21.1	19.8	NT	NT
MSB040408	NT	NT	24.9	2.4	19.9	2.9	11.8	2.9	NT	NT
MSB050908	23.4	0.2	35.4	14.8	16.4	12.7	5.1	3.6	58.8	14.8
MSB051208	14.4	0.2	28	9.3	8.8	8.5	6.4	5.2	42.4	9.3
MSB052708	6.6	2.3	40.3	19.9	23	15.6	6.6	2.6	46.9	22.2
MSB053108	9.6	0.3	100.8	22	30.1	14.5	6.6	6	110.4	22.3
MSB060408	0.8	0.6	13.9	6.8	8.9	3.4	3.2	1.4	14.7	7.4
MSB061408	22.9	4	284.5	32.8	207.6	18	38.6	12.4	307.4	36.8
MSB061508	8.7	0.1	119	23.9	91.8	10.7	20.2	4.1	127.7	23.9
MSB070508	3.5	0.3	106	11.9	58.3	6.3	15.4	2.7	109	12.2
MSB072408	8.6	5.7	220.2	43	106.4	24.2	23.6	9.4	229	49
MSB081408	39.6	0.2	235.2	13.2	94.4	11.6	3.2	6.1	274.8	13.4
MSB092508	QC DQ	QC DQ	67.2	9.1	QC DQ	QC DQ	QC DQ	QC DQ	97.4	9.2
MSB111508	QC DQ	QC DQ	44.8	10.9	10.3	4.8	QC DQ	QC DQ	69	11
MSB112508	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	21	2.9
MSB113008	QC DQ	QC DQ	145.6	6.2	QC DQ	QC DQ	QC DQ	QC DQ	171.1	6.3
Min	0.8	0.1	13.9	2.4	8.8	2.9	3.2	1.4	14.7	2.9
Max	39.6	5.7	284.5	43.0	207.6	24.2	38.6	19.8	307.4	49.0
Median	9.2	0.3	56.0	14.0	24.1	12.2	12.2	6.0	103.2	12.8
Mean	13.8	1.4	91.8	15.9	49.5	11.9	14.2	7.3	120.0	17.2

NT = Not Tested

QC DQ = Quality Control Disqualification

Table 9 Calculated Parameters (mineral) Event Mean Concentrations (EMCs) for the 19 events sampled at the Manasquan Savings Bank study site

Event ID	Coarse Solids (mineral) (material >2000um) (mg/l)		Sand (mineral) (material 2000um to 50um) (mg/l)		Silt (mineral) (material <50um) (mg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
MSB011008	NT	NT	868.0	2.4	35.0	15.0
MSB011308	NT	NT	324.0	1.8	14.0	6.0
MSB011708	NT	NT	96.0	1.6	27.0	21.0
MSB020108	NT	NT	48.0	1.4	36.0	32.0
MSB040408	NT	NT	301.0	2.9	14.7	2.9
MSB050908	1.3	0.2	19	4.5	1.7	4
MSB051208	1.3	0.2	8.7	2.3	ND	ND
MSB052708	0.4	0.1	19.5	13.5	7.7	4.9
MSB053108	18.1	0.1	45.8	12	14.2	6.8
MSB060408	ND	ND	10.2	0.6	2.8	5.9
MSB061408	2.3	0.4	314.5	17.1	86.5	20.4
MSB061508	2.3	0.1	117.1	24.3	52.4	7.7
MSB070508	ND	ND	95	13.9	37	4.1
MSB072408	0	1.01	220.1	0	50.8	0
MSB081408	15.6	0.2	260.8	21	46.8	8.1
MSB092508	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ
MSB111508	QC DQ	QC DQ	20.9	5.1	QC DQ	QC DQ
MSB112508	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ
MSB113008	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ
Min	0.0	0.1	8.7	0.0	1.7	0.0
Max	18.1	1.0	868.0	24.3	86.5	32.0
Median	1.8	0.2	95.5	3.7	31.0	6.4
Mean	5.2	0.3	173.0	7.8	30.5	9.9

ND = Non-detect

NT = Not Tested

QC DQ = Quality Control Disqualification

Using SSC (<500 µm) and SSC (<50 µm) EMC results the percent of corresponding SSC (<2000 µm) EMC results was calculated. The calculated percentages of corresponding SSC (<2000µm) EMC results indicates the portion of material that are less than 500 µm and 50 µm in size and are summarized in Table 13.

Using TVSS EMC results the percent of corresponding SSC results was calculated. The calculated percentages of corresponding SSC (<2000µm) results indicate the portion of material that is less than 500 µm and 50 µm in size and are summarized in Table 14.

Appendix A details system performance on an individual storm basis (discrete removal efficiency) using the Washington State Department of Ecology “individual storm reduction in pollutant concentration” method (WADOE, 2002 method #1)—the performance of the system over the course of a single storm event based upon EMC. Hydrograph and rainfall data from the events are also shown in Appendix A.

In order to determine if data was normally or log-normally distributed the Kolmogorov-Smirnov test was used. EMCs for all parameters analyzed were tested. Influent EMCs for SSC (<50µm), TVSS, TVSS (>2000µm), TVSS (<50µm), and Silt (mineral) were normally distributed. Effluent EMCs for SSC, TVSS, SSC (<2000µm), SSC (<500µm), TVSS (<2000µm), TVSS (<500µm), TVSS (<50µm), TSS-SM (<2000µm), and TSS-EPA (<2000µm) were normally distributed. Influent EMCs for Sand (mineral), SSC, SSC (>2000µm), SSC (<2000µm), SSC (<500µm), TVSS (<2000µm), TVSS (<500µm), and TSS-SM (<2000µm) were log normally distributed. Effluent EMCs for Coarse Solids (mineral) and SSC (>2000µm) were log-normally distributed.

Non-parametric statistical methods were used to evaluate correlations and differences between influent and effluent EMCs since influent and effluent EMCs were generally not from the same statistical distribution. To test for positive correlations between influent and effluent EMCs, the Spearman Rank Order Correlation test was used (USGS, 1991). To evaluate the significance of differences between influent and effluent EMCs, the Mann-Whitney Rank Sum Test was used (USGS, 1991). For the Mann-Whitney Rank Sum Test the null hypothesis was that the two samples were not drawn from populations with different medians. A significant difference between influent and effluent EMCs was concluded when $P < 0.05$.

Performance was calculated using the summation of loads (SOL) method. The SOL method defines the efficiency as a percentage based on the ratio of the summation of all incoming loads to the summation of all outlet loads. The SOL method assumes: 1) monitoring data accurately represents the actual entire total loads in and out of the BMP for a period long enough to overshadow any temporary storage or export of pollutants and 2) any significant storm events that were not monitored had a ratio of inlet to outlet loads similar to the storm events that were monitored (URS/ EPA 1999). Sum of Loads (SOL) Efficiency Calculations for the 19 events sampled at the Manasquan Savings Bank study are summarized in Tables 10, 11, and 12.

Detectable concentrations were observed for all parameters analyzed except for SSC (<50µm) for the MSB092508 event, Coarse Solids (mineral) for the MSB060408 and MSB070508 events, and Silt (mineral) for the MSB051208 event. For values that were reported as non-detect no substitutions were made for statistical testing or calculation of event loads.

Table 10 Suspended Solids Event Sum of Loads (SOL) Efficiency Calculations for the 19 events sampled at the Manasquan Savings Bank study site

Event ID	TSS-SM (<2000µm) (kg)		TSS-EPA (<2000µm) (kg)		SSC (kg)		SSC (>2000µm) (kg)		SSC (<2000µm) (kg)		SSC (<500µm) (kg)		SSC (<50µm) (kg)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
MSB011008	5.6	1.3	4.1	0.9	42.6	1.3	11.5	0.1	31.1	1.3	12.4	1.3	1.7	0.8
MSB011308	2.4	0.4	2.0	0.4	30.3	0.5	15.2	0.2	15.1	0.5	4.0	0.5	1.0	0.5
MSB011708	2.2	1.1	2.2	1.4	6.4	1.3	0.9	0.2	5.5	1.3	2.9	1.3	1.6	1.3
MSB020108	6.9	5.8	6.9	5.8	17.6	7.5	4.9	1.3	12.6	6.3	8.1	5.0	6.5	6.0
MSB040408	5.6	0.1	0.7	0.2	6.1	0.0	NT	NT	6.1	0.0	1.8	0.1	0.5	0.1
MSB050908	2.8	1.0	2.4	1.0	3.9	1.2	1.2	0.0	2.7	1.2	1.4	1.2	0.2	0.4
MSB051208	1.6	0.2	1.2	0.3	1.9	0.4	0.6	0.0	1.3	0.4	0.4	0.2	0.2	0.1
MSB052708	2.0	1.0	1.8	1.0	2.2	1.2	0.2	0.1	2.0	1.1	1.2	0.9	0.4	0.2
MSB053108	5.9	1.7	5.4	1.6	7.2	1.6	1.1	0.0	6.2	1.6	2.3	1.2	0.8	0.5
MSB060408	2.2	0.8	2.1	0.7	2.5	1.0	0.1	0.1	2.4	0.9	1.6	0.5	0.5	0.7
MSB061408	36.9	4.3	33.8	2.6	36.5	3.8	1.3	0.2	35.2	3.6	26.1	2.1	6.4	1.7
MSB061508	17.8	2.3	17.4	2.2	17.5	3.3	0.6	0.0	16.9	3.3	14.1	1.7	4.2	0.7
MSB070508	25.4	2.4	21.7	2.4	22.7	2.8	0.4	0.0	22.3	2.8	14.8	1.3	4.9	0.6
MSB072408	50.3	5.0	46.8	4.7	54.8	5.4	0.9	0.7	53.8	4.7	28.1	2.7	8.2	1.0
MSB081408	49.2	3.6	35.1	3.1	44.8	3.2	4.1	0.0	40.6	3.2	20.3	2.4	3.7	1.1
MSB092508	563.2	3.4	517.3	3.2	1743.9	5.6	210.7	0.0	1533.3	5.6	637.7	2.3	4.0	1.2
MSB111508	4.5	1.5	2.8	1.0	6.8	1.3	2.5	0.0	4.3	1.3	1.3	0.6	0.7	0.4
MSB112508	1.3	0.1	0.9	0.1	1.7	0.2	0.6	0.0	1.1	0.2	0.4	0.1	ND	ND
MSB113008	47.5	1.5	31.9	1.5	35.0	1.4	2.3	0.0	32.6	1.4	16.4	0.7	5.1	0.5
Total	833.2	37.6	736.5	34.2	2084.4	43.0	259.2	2.9	1825.1	40.6	795.3	25.8	50.9	17.7
SOL Efficiency	95		95		98		99		98		97		65	

ND = Non-detect

NT = Not Tested

Table 11 Total Volatile Suspended Solids Event Sum of Loads (SOL) Efficiency Calculations for the 19 events sampled at the Manasquan Savings Bank study site

Event ID	TVSS (>2000µm) (kg)		TVSS (<2000µm) (kg)		TVSS (<500µm) (kg)		TVSS (<50µm) (kg)		TVSS (kg)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
MSB011008	NT	NT	2.8	0.5	1.5	0.6	0.7	0.4	NT	NT
MSB011308	NT	NT	1.6	0.3	0.8	0.3	0.5	0.3	NT	NT
MSB011708	NT	NT	1.0	0.5	0.9	0.5	0.6	0.5	NT	NT
MSB020108	NT	NT	3.0	2.4	2.8	1.9	2.4	2.3	NT	NT
MSB040408	NT	NT	0.4	0.0	0.4	0.1	0.2	0.1	NT	NT
MSB050908	1.2	0.0	1.8	0.7	0.8	0.6	0.3	0.2	2.9	0.7
MSB051208	0.5	0.0	1.1	0.4	0.3	0.3	0.2	0.2	1.6	0.4
MSB052708	0.2	0.1	1.2	0.6	0.7	0.5	0.2	0.1	1.4	0.7
MSB053108	0.4	0.0	3.9	0.8	1.2	0.6	0.3	0.2	4.2	0.9
MSB060408	0.1	0.1	1.3	0.6	0.8	0.3	0.3	0.1	1.3	0.7
MSB061408	1.2	0.2	14.6	1.7	10.7	0.9	2.0	0.6	15.8	1.9
MSB061508	0.5	0.0	7.0	1.4	5.4	0.6	1.2	0.2	7.5	1.4
MSB070508	0.3	0.0	9.9	1.1	5.5	0.6	1.4	0.3	10.2	1.1
MSB072408	0.9	0.6	24.1	4.7	11.7	2.7	2.6	1.0	25.1	5.4
MSB081408	3.0	0.0	17.6	1.0	7.1	0.9	0.2	0.5	20.6	1.0
MSB092508	QC DQ	QC DQ	16.8	2.3	QC DQ	QC DQ	QC DQ	QC DQ	24.3	2.3
MSB111508	QC DQ	QC DQ	2.7	0.7	0.6	0.3	QC DQ	QC DQ	4.1	0.7
MSB112508	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	0.9	0.1
MSB113008	QC DQ	QC DQ	13.3	0.6	QC DQ	QC DQ	QC DQ	QC DQ	15.7	0.6
Total	8.3	1.0	124.1	20.3	51.0	11.6	13.1	6.9	135.7	17.7
SOL Efficiency	88		84		77		47		87	

NT = Not Tested

QC DQ = Quality Control Disqualification

Table 12 Calculated Parameters (mineral) Event Sum of Loads (SOL) Efficiency Calculations for the 19 events sampled at the Manasquan Savings Bank study site

Event ID	Coarse Solids (mineral) (kg)		Sand (mineral) (kg)		Silt (mineral) (kg)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
MSB011008	NT	NT	27.2	0.1	1.1	0.5
MSB011308	NT	NT	12.9	0.1	0.6	0.2
MSB011708	NT	NT	3.4	0.1	1.0	0.8
MSB020108	NT	NT	5.5	0.2	4.2	3.7
MSB040408	NT	NT	5.4	0.1	0.3	0.1
MSB050908	0.1	0.0	0.9	0.2	0.1	0.2
MSB051208	0.0	0.0	0.3	0.1	ND	ND
MSB052708	0.0	0.0	0.6	0.4	0.2	0.1
MSB053108	0.7	0.0	1.8	0.5	0.5	0.3
MSB060408	ND	ND	0.9	0.1	0.3	0.5
MSB061408	0.1	0.0	16.1	0.9	4.4	1.0
MSB061508	0.1	0.0	6.9	1.4	3.1	0.5
MSB070508	ND	ND	8.9	1.3	3.5	0.4
MSB072408	0.0	0.1	24.1	0.0	5.6	0.0
MSB081408	1.2	0.0	19.5	1.6	3.5	0.6
MSB092508	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ
MSB111508	QC DQ	QC DQ	1.3	0.3	QC DQ	QC DQ
MSB112508	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ
MSB113008	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ
Total	2.2	0.2	135.8	7.1	28.2	8.8
SOL Efficiency	92		95		69	

ND = Non-detect

NT = Not Tested

QC DQ = Quality Control Disqualification

Table 13 Calculated percentages of material less than 500 µm and 50 µm for the 19 events sampled at the Manasquan Savings Bank study site

Event ID	SSC (<500-um) (mg/l)/ SSC (<2000-um) (mg/l)		SSC (<50-um) (mg/l)/ SSC (<2000-um) (mg/l)	
	Influent	Effluent	Influent	Effluent
MSB011008	40%	100%	6%	67%
MSB011308	27%	98%	7%	97%
MSB011708	53%	98%	29%	97%
MSB020108	64%	80%	52%	95%
MSB040408	29%	121%	8%	125%
MSB050908	51%	102%	9%	33%
MSB051208	29%	68%	13%	40%
MSB052708	60%	77%	21%	20%
MSB053108	37%	74%	13%	31%
MSB060408	65%	54%	22%	74%
MSB061408	74%	59%	18%	47%
MSB061508	84%	53%	25%	21%
MSB070508	66%	45%	22%	23%
MSB072408	52%	56%	15%	22%
MSB081408	50%	75%	9%	34%
MSB092508	42%	40%	0%	21%
MSB111508	30%	43%	16%	33%
MSB112508	37%	38%	ND	ND
MSB113008	50%	49%	16%	33%
Min	27%	38%	0%	20%
Max	84%	121%	52%	125%
Median	50%	68%	15%	33%
Mean	50%	70%	17%	51%

ND = Non-detect

Table 14 Calculated percentages of combustible materials that are assumed to be organic in nature for the 19 events sampled at the Manasquan Savings Bank study site

Event ID	TVSS (<2000-um) (mg/l) / SSC (<2000-um) (mg/l)		TVSS (<500-um) (mg/l) / SSC (<500-um) (mg/l)		TVSS (<50-um) (mg/l) / SSC (<50-um) (mg/l)		TVSS (>2000-um) (mg/l) / SSC (>2000-um) (mg/l)		TVSS (mg/l) / SSC(mg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
MSB011008	9%	43%	12%	48%	38%	43%	NT	NT	NT	NT
MSB011308	11%	56%	21%	56%	47%	56%	NT	NT	NT	NT
MSB011708	19%	41%	29%	41%	39%	41%	NT	NT	NT	NT
MSB020108	24%	38%	35%	39%	37%	38%	NT	NT	NT	NT
MSB040408	7%	100%	20%	100%	45%	100%	NT	NT	NT	NT
MSB050908	66%	64%	59%	53%	106%	47%	95%	100%	75%	64%
MSB051208	80%	100%	86%	135%	139%	141%	92%	100%	84%	100%
MSB052708	60%	52%	57%	53%	46%	35%	94%	96%	63%	55%
MSB053108	63%	54%	50%	48%	32%	47%	35%	111%	59%	54%
MSB060408	52%	69%	51%	64%	53%	19%	100%	100%	53%	70%
MSB061408	42%	47%	41%	43%	31%	38%	91%	91%	43%	49%
MSB061508	41%	43%	38%	36%	28%	35%	79%	100%	43%	43%
MSB070508	45%	40%	37%	46%	29%	40%	90%	79%	45%	40%
MSB072408	45%	100%	42%	100%	32%	100%	100%	85%	46%	99%
MSB081408	43%	31%	35%	36%	6%	43%	72%	100%	46%	32%
MSB092508	1%	40%	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	1%	41%
MSB111508	62%	50%	48%	52%	QC DQ	QC DQ	QC DQ	QC DQ	61%	50%
MSB112508	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	54%	76%
MSB113008	41%	40%	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	QC DQ	45%	40%
Min	1%	31%	12%	36%	6%	19%	35%	79%	1%	32%
Max	80%	100%	86%	135%	139%	141%	100%	111%	84%	100%
Median	42%	48%	39%	50%	38%	43%	91%	100%	50%	52%
Mean	39%	56%	41%	59%	47%	55%	85%	96%	51%	58%

NT = Not Tested

QC DQ = Quality Control Disqualification

4.2 Test Results

Based on the use of the Spearman Rank Order correlation, test positive correlations ($P < 0.05$) were determined between influent and effluent EMCs for TVSS, SSC ($< 50\mu\text{m}$), TVSS ($< 500\mu\text{m}$), TVSS ($< 50\mu\text{m}$), and TSS-EPA ($< 2000\mu\text{m}$). The concentration of influent and effluent sample pairs tended to increase together.

Based on the use of the Mann-Whitney Rank Sum test the difference in the median values between the influent and effluent EMCs is greater than would be expected by chance; there is a statistically significant difference ($P < 0.05$) for all parameters analyzed.

Suspended Solids Parameters

Influent EMCs for TSS-SM ($< 2000\mu\text{m}$) ranged from 24.3 mg/l to 2259.0 mg/l with a median of 154.0 mg/l and a mean of 331.8 mg/l. Corresponding effluent EMCs ranged from 2.5 mg/l to 84.0 mg/l with a median of 26.0 mg/l and a mean of 28.8 mg/l. Total event loadings for the study were 833.2 kg at the influent and 37.6 kg at the effluent sampling location, resulting in an overall removal efficiency of 95%.

Influent EMCs for SSC ($< 2000\mu\text{m}$) ranged from 24.7 mg/l to 6150.0 mg/l with a median of 238.0 mg/l and a mean of 587.7 mg/l. Corresponding effluent EMCs ranged from 2.4 mg/l to 70.3 mg/l with a median of 29.9 mg/l and a mean of 30.2 mg/l. Total event loadings for the study were 1825.1 kg at the influent and 40.6 kg at the effluent sampling location, resulting in an overall removal efficiency of 98 %.

In general, the relationship between TSS-SM ($< 2000\mu\text{m}$) and SSC ($< 2000\mu\text{m}$) was determined to be positive based on the linear regression results for both influent ($R^2 = 0.9$) and effluent ($R^2 = 0.91$) EMCs. The ratio of TSS-SM ($< 2000\mu\text{m}$) to SSC ($< 2000\mu\text{m}$) EMCs ranged from 0.2 to 1.5 with a median of 1.0 for the influent compared to a range from 0.6 to 1.2 with a median of 0.9 for the effluent.

Influent EMCs for TSS-EPA ($< 2000\mu\text{m}$) ranged from 20.5 mg/l to 2075.0 mg/l with a median of 60.0 mg/l and a mean of 274.6 mg/l. Corresponding effluent EMCs ranged from 2.5 mg/l to 51.0 mg/l with a median of 25.5 mg/l and a mean of 26.3 mg/l. Total event loadings for the study were 736.5 kg at the influent and 34.2 kg at the effluent sampling location, resulting in an overall removal efficiency of 95%.

Influent EMCs for SSC ranged from 27.7 mg/l to 6995.0 mg/l with a median of 241.9 mg/l and a mean of 688.9 mg/l. Corresponding effluent EMCs ranged from 2.4 mg/l to 74.7 mg/l with a median of 30.3 mg/l and a mean of 31.6 mg/l. Total event loadings for the study were 2084.4 kg at the influent and 43.0 kg at the effluent sampling location, resulting in an overall removal efficiency of 98%.

Influent EMCs for SSC ($> 2000\mu\text{m}$) ranged from 0.8 mg/l to 845.0 mg/l with a median of 25.4 mg/l and a mean of 106.8 mg/l. Corresponding effluent EMCs ranged from 0.1 mg/l to 11.1 mg/l with a median of 0.3 mg/l and a mean of 2.1 mg/l. Total event loadings for the study were 259.2

kg at the influent and 2.9 kg at the effluent sampling location, resulting in an overall removal efficiency of 99%.

Influent EMCs for SSC (<500µm) ranged from 9.2 mg/l to 2558.0 mg/l with a median of 99.7 mg/l and a mean of 268.8 mg/l. Corresponding effluent EMCs ranged from 1.4 mg/l to 43.4 mg/l with a median of 23.8 mg/l and a mean of 21.0 mg/l. Total event loadings for the study were 795.3 kg at the influent and 25.8 kg at the effluent sampling location, resulting in an overall removal efficiency of 97%. For each storm event the percent of SSC (<2000 µm) represented by SSC (<500 µm) was calculated. Influent and effluent median percentages of SSC (<2000µm) were 50% and 68% respectively. The percentage of corresponding SSC (<2000µm) results indicates the portion of material that are less than 500µm in size.

Influent EMCs for SSC (<50µm) ranged from 4.6 mg/l to 125.1 mg/l with a median of 35.4 mg/l and a mean of 39.9 mg/l. Corresponding effluent EMCs ranged from 2.9 mg/l to 51.6 mg/l with a median of 8.5 mg/l and a mean of 14.5 mg/l. Total event loadings for the study were 50.9 kg at the influent and 17.7 kg at the effluent sampling location, resulting in an overall removal efficiency of 65 %. For each storm event the percent of SSC (<2000 µm) represented by SSC (<50 µm) was calculated. Influent and effluent median percentages of SSC (<2000µm) were 15% and 33% respectively. The percentage of corresponding SSC (<2000µm) results indicates the portion of materials that are less than 50µm in size.

Volatile Suspended Solids Parameters

Influent EMCs for TVSS (>2000µm) ranged from 0.8 mg/l and 39.6 mg/l with a median of 9.2 mg/l and a mean of 13.8 mg/l. Corresponding effluent EMCs ranged from 0.1 mg/l to 5.7 mg/l with a median of 0.3 mg/l and a mean of 1.4 mg/l. Total event loadings for the study were 8.3 kg at the influent and 1.0 kg at the effluent sampling location, resulting in an overall removal efficiency of 88%. For each storm event the percent of SSC (>2000 µm) represented by TVSS (>2000µm) was calculated. Influent and effluent median percentages of SSC (>2000µm) were 91% and 100% respectively. Percentage of corresponding SSC (>2000µm) results indicates the percent of combustible materials that are assumed to be organic in nature.

Influent EMCs for TVSS ranged from 14.7 mg/l and 307.4 mg/l with a median of 103.2 mg/l and a mean of 120.0 mg/l. Corresponding effluent EMCs ranged from 2.9 mg/l to 49.0 mg/l with a median of 12.8 mg/l and a mean of 17.2 mg/l. Total event loadings for the study were 135.7 kg at the influent and 17.7 kg at the effluent sampling location, resulting in an overall removal efficiency of 87%. For each storm event the percent of SSC represented by TVSS was calculated. Influent and effluent median percentages of SSC were 50% and 52% respectively. Percentage of corresponding SSC results indicates the percent of combustible materials that are assumed to be organic in nature.

Influent EMCs for TVSS (<2000µm) ranged from 284.5 mg/l and 13.9 mg/l with a median of 56.0 mg/l and a mean of 91.8 mg/l. Corresponding effluent EMCs ranged from 2.4 mg/l to 43.0 mg/l with a median of 14.0 mg/l and a mean of 15.9 mg/l. Total event loadings for the study were 124.1 kg at the influent and 20.3 kg at the effluent sampling location, resulting in an overall removal efficiency of 84%. For each storm event the percent of SSC (<2000 µm) represented by

TVSS (<2000µm) was calculated. Influent and effluent median percentages of SSC (<2000µm) were 42% and 48% respectively. Percentage of corresponding SSC (<2000µm) results indicates the percent of combustible materials that are assumed to be organic in nature.

Influent EMCs for TVSS (<500µm) ranged from 207.6 mg/l and 8.8 mg/l with a median of 24.1 mg/l and a mean of 49.5 mg/l. Corresponding effluent EMCs ranged from 24.2 mg/l to 2.9 mg/l with a median of 12.2 mg/l and a mean of 11.9 mg/l. Total event loadings for the study were 51.0 kg at the influent and 11.6 kg at the effluent sampling location, resulting in an overall removal efficiency of 77%. For each storm event the percent of SSC (<500 µm) represented by TVSS (<500 µm) was calculated. Influent and effluent median percentages of SSC (<500µm) were 39% and 50% respectively. Percentage of corresponding SSC (<500µm) results indicates the percent of combustible materials that are assumed to be organic in nature.

Influent EMCs for TVSS (<50µm) ranged from 3.2 mg/l and 38.6 mg/l with a median of 12.2 mg/l and a mean of 14.2 mg/l. Corresponding effluent EMCs ranged from 1.4 mg/l to 19.8 mg/l with a median of 6.0 mg/l and a mean of 7.3 mg/l. Total event loadings for the study were 13.1 kg at the influent and 6.9 kg at the effluent sampling location, resulting in an overall removal efficiency of 47%. For each storm event the percent of SSC (<50 µm) represented by TVSS (<50 µm) was calculated. Influent and effluent median percentages of SSC (<50µm) were 38% and 43% respectively. Percentage of corresponding SSC (<50µm) results indicates the percent of combustible materials that are assumed to be organic in nature.

Additional Parameters

Influent EMCs for Coarse Solids (mineral) ranged from 0.00 mg/l and 18.1 mg/l with a median of 1.8 mg/l and a mean of 5.2 mg/l. Corresponding effluent EMCs ranged from 0.1 mg/l to 1.0 mg/l with a median 0.2 mg/l and a mean of 0.3 mg/l. Total event loadings for the study were 2.2 kg at the influent and 0.2 kg at the effluent sampling location, resulting in an overall removal efficiency of 92%.

Influent EMCs for Sand (mineral) ranged from 8.7 mg/l and 868.0 mg/l with a median of 95.5 mg/l and a mean of 173.0 mg/l. Corresponding effluent EMCs ranged from 0.0 mg/l to 24.3 mg/l with a median of 3.7 mg/l and a mean of 7.8 mg/l. Total event loadings for the study were 135.8 kg at the influent and 7.1 kg at the effluent sampling location, resulting in an overall removal efficiency of 95%.

Influent EMCs for Silt (mineral) ranged from 1.7 mg/l and 86.5 mg/l with a median of 31.0 mg/l and a mean of 30.5 mg/l. Corresponding effluent EMCs ranged from 0.0 mg/l to 32.0 mg/l with a median of 6.4 mg/l and a mean of 9.9 mg/l. Total event loadings for the study were 28.2 kg at the influent and 8.8 kg at the effluent sampling location, resulting in an overall removal efficiency of 69%.

4.3 System Maintenance and Residual Solids Assessment Results

Inspection of the CDS system in April 2008 revealed that a substantial volume of leaf litter had accumulated in the separation chamber. A vactor truck was contracted to remove this material

from the separation chamber on April, 15, 2008. Upon removal of the leaf litter it was determined that the remainder of the system did not require maintenance. At the conclusion of the monitoring period in January 2009 a vactor truck was contracted to remove all contents from the CDS system. Prior to this maintenance event on January 13, 2009 samples were collected from the separation chamber, sediment sump and annulus area for evaluation. In order to safely enter the system a vactor truck was used to dewater the system. Following the dewatering of the system, multiple sediment samples were collected of materials contained in the system and depth measurements taken. Sediment samples were combined into a composite sample. Subsamples were then collected from this composite and analyzed for bulk density and particle size distribution. Prior to particle size distribution analysis the subsample was passed through a 2000 μ m sieve in an effort to isolate soil separates. Particle size analysis of materials <2000 μ m revealed that the total solids portion of materials contained in the system had a sand texture (USDA classification).

The mass of materials contained in the system was estimated using depth measurements and bulk density results. The mass of materials contained in the system included material removed during both the maintenance inspection performed on April 15, 2008 and final maintenance performed on January 13, 2009. The estimated total dry mass of materials contained in the system, after dewatering, was approximately 1300 kg (2860 lbs). Approximately 8% of the of the mass was located in the annulus area outside of the separation chamber, approximately 51% of the mass was located in the treatment chamber, and approximately 41% of the mass was located in the sump of the unit. The accuracy of the estimated mass of materials contained in the system should be considered limited, due to the non uniform distribution of materials contained in the system as well as the unaccounted for material removed by the vactor truck during the dewatering process.

Particle Size Distribution Analysis Results

The particle size distribution (PSD) results obtained using the Laser Diffraction method are summarized in Table 15. Results suggest the average d_{50} is greater than 100 μ m for both influent and effluent sampling locations for all three events submitted for analysis. These results are supported by the observed (TSS-EPA, TSS-SM, and SSC<2000 μ m) removal efficiency of greater than 90%, which suggests the presence of a substantial mass of coarse solids and a d_{50} greater than 100 μ m.

Table 15 Particle size distribution analysis results using ASTM D4464 for events sampled at the Manasquan Savings Bank study site

Event ID	SAND		SILT		CLAY		d_{50}	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
MSB051208A	99.17	97.82	0.83	2.18	0.00	0.00	1315.63	1163.59
MSB061408A	50.49	66.54	47.11	31.67	2.40	1.80	76.38	392.77
MSB111508A	76.93	67.47	22.11	31.15	0.96	1.38	582.00	412.15
Median	76.93	67.47	22.11	31.15	0.96	1.38	582.00	412.15
Mean	75.53	77.28	23.35	21.67	1.12	1.06	658.00	656.17

Influent particle size distribution (PSD) obtained using the serial filtration method covering the 6350 μm to 1.5 μm particle size range suggests that the average d_{50} is greater than 100 μm for all of the events captured to date, as shown in Figure 10. The upper size limit of 6350 μm is approximately equal to the sample strainer opening. It is assumed that particles larger than the opening will not be sampled. The lower size limit of 1.5 μm is equal to the pore size of filters used by the analytical laboratory for solids analysis. Serial filtration particle size distribution results are also supported by observed solids (TSS-EPA, TSS-SM, and SSC <2000 μm removal efficiency rates of greater than 90%, which suggests the presence of a substantial mass of coarse solids and a d_{50} greater than 100 μm .

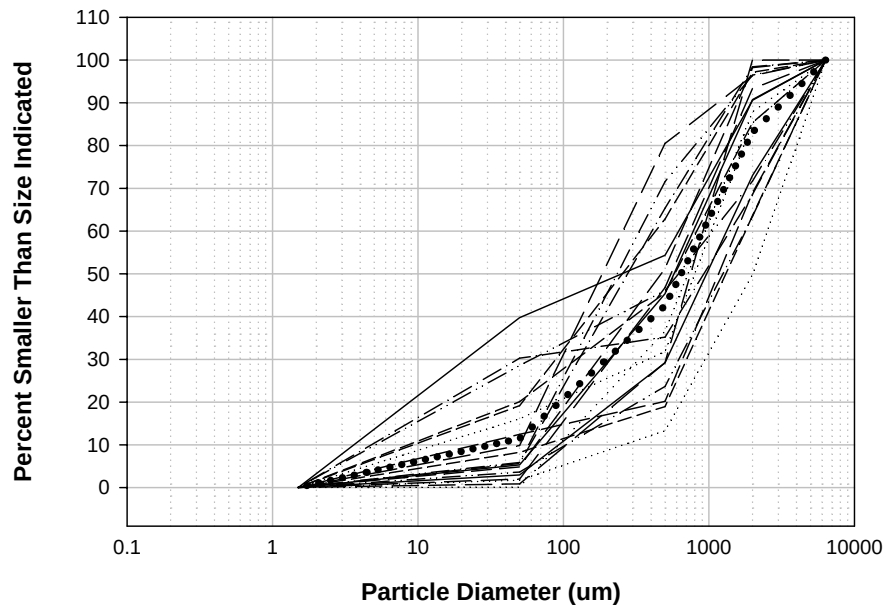


Figure 10 Influent particle size distribution generated using serial filtration covering 6350 μm to 1.5 μm particle size range; dashed line represents mean particle size distribution

Influent particle size distribution (PSD) obtained using the serial filtration method covering the 500 μm to 1.5 μm particle size range reflect an average d_{50} that is less than 100 μm for all the events captured to date, as seen in Figure 11.

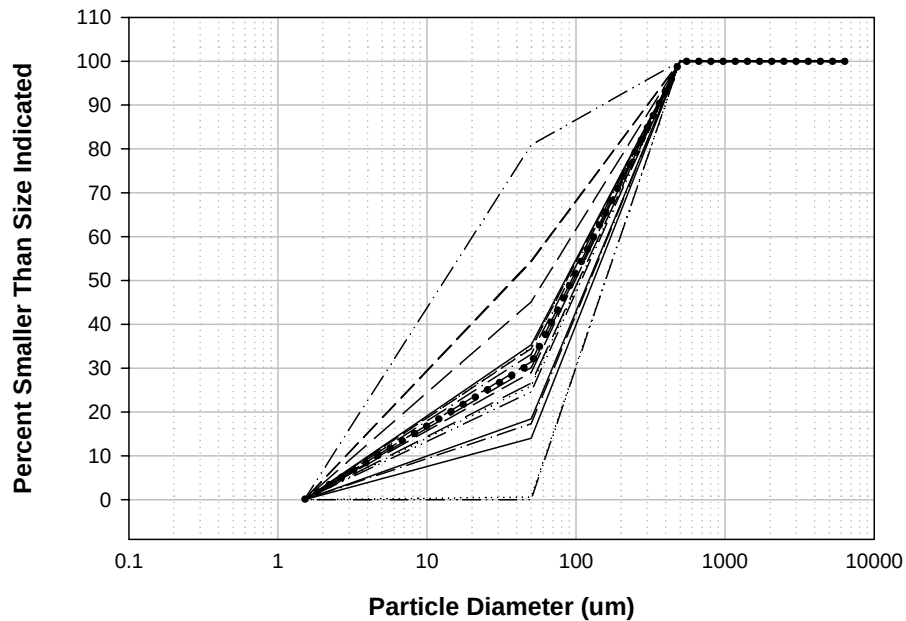


Figure 11 Influent PSD generated using serial filtration covering 500µm to 1.5µm particle size range; dashed line represents mean particle size distribution

Influent and effluent mean particle size distributions were compared using data obtained using serial filtration covering the 6350µm to 1.5µm particle size range, as seen in Figure 12. Plotted results indicate that the d_{50} values were greater than 100µm for the influent sampling location and less than 100µm at the effluent sampling location.

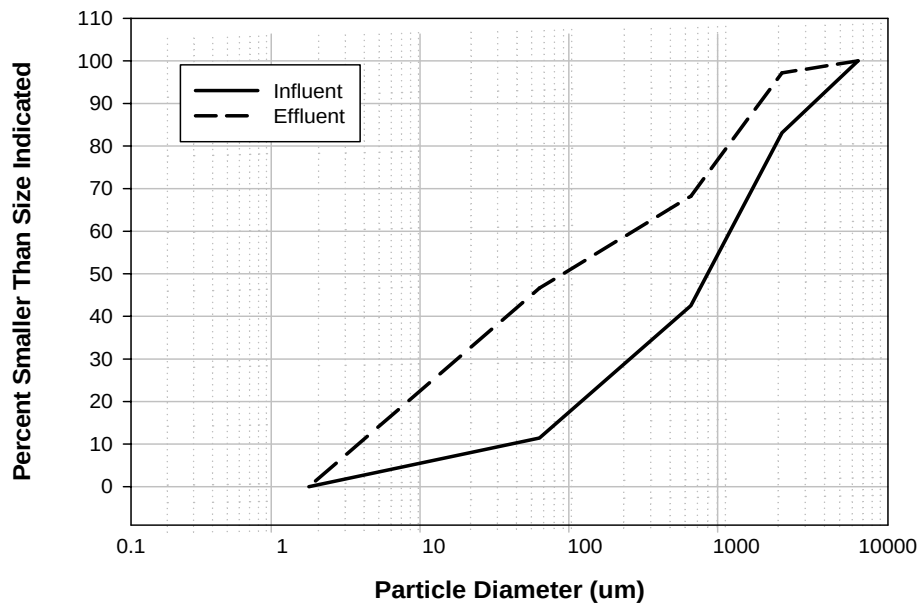


Figure 12 Comparison of mean influent and effluent particle size distributions generated using serial filtration covering 6350µm to 1.5µm particle size range

Influent and effluent mean particle size distributions were compared using data obtained using serial filtration covering the 500 μ m to 1.5 μ m particle size range, as seen in Figure 13. Plotted results indicate that the d_{50} values were less than 100 μ m for both the influent sampling location and the effluent sampling location.

4.4 Summary

Between January of 2008 and November of 2008, 19 storm events were monitored and were determined to meet the storm data collection requirements as per New Jersey Tier II Stormwater Test Requirements—Amendments to TARP Tier II Protocol (NJDEP, 2006) and the NJDEP interpretation of TARP (2003). Total rainfall depth for qualified events was 18.35 inches and three events exceeded 75% of the design treatment capacity, thus satisfying TARP Tier II and NJDEP completeness criteria.

Significant reductions for suspended solids loads were observed between influent and effluent sampling locations: SSC (<2000 μ m) 98%, TSS-SM (<2000 μ m) 95%, TSS-EPA (<2000 μ m) 95%, SSC (<500 μ m) 97%, and SSC (<50 μ m) 65%. The positive capture of solids by the system was verified as part of the residual solids assessment during both the maintenance inspection as well as the final maintenance. Comparison of the estimated mass of material contained in the system to calculated loads using water quality results was determined to be within the realm of expectations for the study.

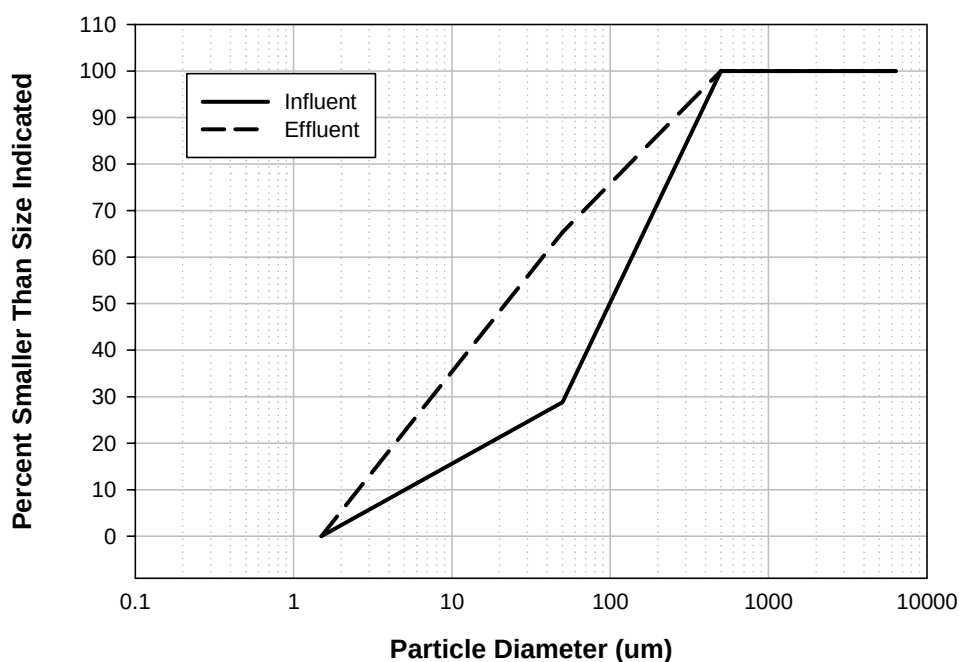


Figure 13 Comparison of mean influent and effluent particle size distributions generated using serial filtration covering 500 μ m to 1.5 μ m particle size range

5. Performance Claim Verification

Given that the performance standard is based on TSS-SM, and TSS-SM removal efficiency results for this study are associated with suspended solids with a d_{50} greater than $100\mu\text{m}$, the review of additional data was required to further understand removal efficiency results. In general, removal efficiency results in excess of 90% are not typical for a flow through gravity separation technology but are within the realm of expected performance associated with observed influent TSS-SM EMCs with a d_{50} greater than $100\mu\text{m}$. In an effort to isolate suspended sediment removal efficiency based on specific particle size ranges, SSC samples were sieved prior to analysis. The particle size ranges that were isolated for this study include $6350\mu\text{m}$ to $1.5\mu\text{m}$, $2000\mu\text{m}$ to $1.5\mu\text{m}$, $500\mu\text{m}$ to $1.5\mu\text{m}$, and $50\mu\text{m}$ to $1.5\mu\text{m}$.

The isolation of suspended solids removal efficiency based on particles $500\mu\text{m}$ to $1.5\mu\text{m}$ with d_{50} less than $100\mu\text{m}$ and particles between $50\mu\text{m}$ and $1.5\mu\text{m}$ with a d_{50} less than $50\mu\text{m}$ resulted in an overall removal efficiency of 97% and 65% respectively. The use of these results is proposed to confirm favorable removal of solids and in order to satisfy the site qualification requirements ($d_{50} < 100\mu\text{m}$) as per New Jersey Tier II Stormwater Test Requirements—Amendments to TARP Tier II Protocol (NJDEP, 2006) and the NJDEP interpretation of TARP (2003). Additionally, these results demonstrate performance greater than 60% removal (65% SSC $< 50\mu\text{m}$) of suspended solids with a d_{50} less than $50\mu\text{m}$. Past research has concluded that when coarse particles are not present results obtained with the SSC method differ very little from results obtained using the TSS method (Gray et al 2000, Guo 2006), so results of the SSC $< 50\mu\text{m}$ analysis are expected to be representative of TSS results.

Focusing on finer solids fractions also reduces the potential for bias towards the sampling of coarse mineral solids using accepted sampling techniques. Finer mineral particles smaller than $50\mu\text{m}$ (Silt (mineral)) are generally expected to be more or less uniformly distributed throughout the water column. In addition to SSC, removal efficiency based on mineral particles smaller than $50\mu\text{m}$ was isolated. Silt (mineral) results were calculated by subtracting the volatile suspended solids results (TVSS ($< 50\mu\text{m}$)) composed of combustible materials assumed to be organic in nature from the suspended solids results (SSC ($< 50\mu\text{m}$)). Removal efficiency based on Silt (Mineral) results resulted in an overall removal efficiency of 69%.

Recognizing the potential of a limited number of storm events to dominate sum of loads performance efficiency calculations, storm events with TSS-SM ($< 2000\mu\text{m}$) EMCs less than 500mg/l were segregated from the data set and evaluated. Significant reductions for suspended solids loads were observed between influent and effluent sampling locations: SSC ($< 2000\mu\text{m}$) 85%, TSS-SM ($< 2000\mu\text{m}$) 82%, TSS-EPA ($< 2000\mu\text{m}$) 80%, SSC ($< 500\mu\text{m}$) 81%, SSC ($< 50\mu\text{m}$) 58%, and Silt (mineral) 65%.

The primary purpose of this project was to document High Efficiency CDS system performance with respect to suspended solids removal and quantify performance in accordance with the TARP Protocol for Stormwater Best Management Practice Demonstrations and NJDEP Tier II monitoring requirements.

The High Efficiency CDS unit model PMSU20_25 (CDS2025) installed online at the Manasquan Savings Bank study site sized based on the New Jersey Water Quality Design Storm to treat a maximum water quality flow rate of 1.6 cfs and a peak flow of 5.43 cfs demonstrated significant suspended solids removal including greater than 60% removal of suspended solids with a d_{50} less than 50 μ m. The CDS2025 also demonstrated the ability to remove greater than 80% of stormwater solids when the influent particle size distribution is predominantly sand sized particles (50-2000 microns).

6. Net Environmental Benefit

The High Efficiency CDS unit requires no input of raw material, has no moving parts and therefore uses no water or energy other than that provided by stormwater runoff. During the 11-month monitoring period the mass of materials captured and retained by the High Efficiency CDS unit was approximately 1300 kg (2860 lbs). This material would otherwise have been released to the environment during runoff producing rain events.

7. References

CONTECH Stormwater Solutions Inc.(CONTECH) (2007). Quality Assurance Project Plan for Manasquan Savings Bank High Efficiency CDS[®] Model PMSU20_25 Field Evaluation Portland, Oregon.

Gray, J.R., Glysson, D.G., Turcios, M. L., and Schwarz, E.G. (2000). *Comparability of Suspended-Sediment Concentration and Total Suspended Solids Data*. U.S. Geological Survey Investigations Report 00-4191. Available Online:
<http://water.usgs.gov/osw/pubs/WRIR00-4191.pdf>

New Jersey Department of Environmental Protection (NJDEP). (2006). New Jersey Tier II Stormwater Test Requirements—Amendments to TARP Tier II Protocol. Trenton, New Jersey. Available online: http://www.state.nj.us/dep/dsr/bscit/NJStormwater_TierII.pdf

Technology Acceptance and Reciprocity Partnership (TARP). (2003). The Technology Acceptance Reciprocity Partnership Protocol for Stormwater Best Management Practice Demonstrations. Harrisburg, Pennsylvania. Available online:
<http://www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp/pdf/Tier2protocol.pdf>

United States Environmental Protection Agency (USEPA). (2002). Urban Stormwater BMP Performance Monitoring: A Guidance Manual for Meeting the National Stormwater BMP Database Requirements (EPA-821-B-02-001). Washington, D.C. Available Online:
<http://epa.gov/waterscience/stormwater/montcomplete.pdf>

U.S. Geological Survey (USGS). (1980). Water Resources Division by Office of Water Quality (OWQ) Technical Memorandum No. 80.17

U.S. Geological Survey (USGS). (1991) U.S. Geological Survey, Techniques of Water-Resources Investigations Reston, Virginia: D.R. Helsel and R.M. Hirsch

CONTECH Stormwater Solutions Inc. (CONTECH) (2004) A Comparison of Methods to Determine the Particle Size Distribution of Solids in Stormwater Samples. Portland, Oregon.

URS Greiner Woodward Clyde, Urban Drainage and Flood Control District, Urban Water Resources Research Council (UWRRC) of ASCE, Office of Water US Environmental Protection Agency (URS/EPA) (1999). Development of Performance Measures Task 3.1 – Technical Memorandum Determining Urban Stormwater Best Management Practice (BMP) Removal Efficiencies. Washington, D.C.

Rutgers, The State University of New Jersey Department of Civil and Environmental Engineering, New Jersey Department of Environmental Protection Division of Science, Research and Technology. (Rutgers/NJDEP) (2006). Correlation of Total Suspended Solids (TSS) and Suspended Sediment Concentration (SSC) Test Methods: Trenton, New Jersey: Qizhong (George) Guo.

APPENDIX A

INDIVIDUAL STORM REPORTS

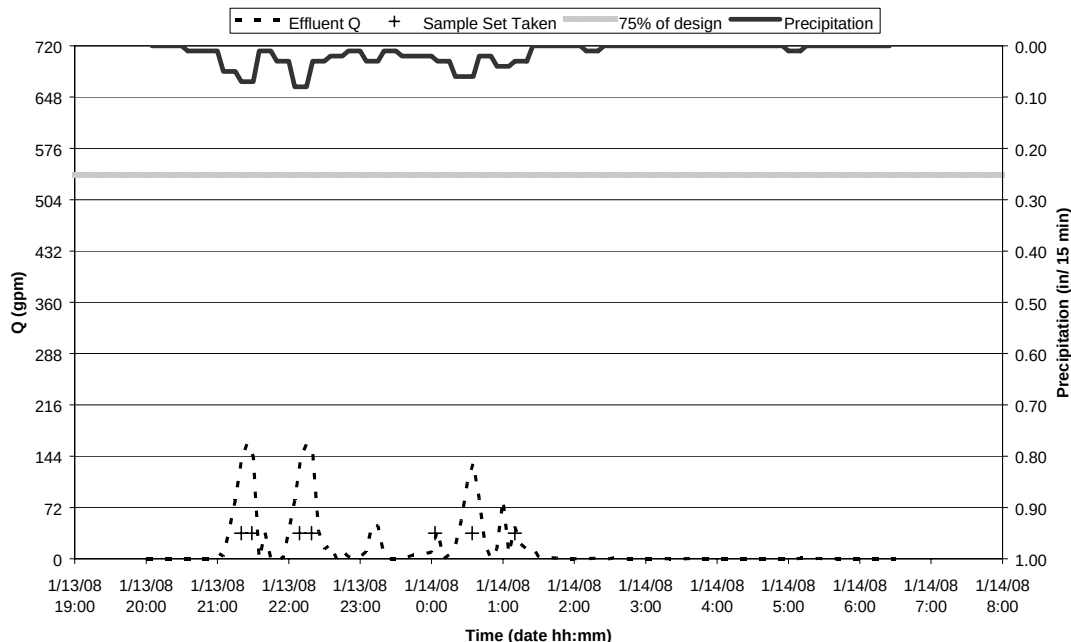
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 01/13/08
 Date of Last Maintenance: 10/29/07
 Antecedent Conditions: 53 hours since last rain event, 0.11"

Hydrology

Total Precipitation (in): 0.63
 Peak Flow (gpm): 162 (23% of design)
 Total Runoff Volume (gal): 10530
 Vol. Coverage (nearest 10%): 70

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Discrete Removal	
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
IN: 8 (3.2-L) EFF: 8	<u>Sand (mineral)</u>	324	ND	1.79	20%	99%
	<u>Silt (mineral)</u>	14	6	1.75	20%	60%
	<u>SSC (>2000-um)</u>	381	ND	4.08	20%	99%
	<u>SSC</u>	760	13.2	4.08	20%	98%
	SSC (<2000-um)	379	13.2	1.79	24.3%	97%
	SSC (<500-um)	101	13.0	1.77	24.3%	87%
	SSC (<50-um)	26.2	12.8	1.75	24.3%	51%
	TVSS (<2000-um)	41.1	7.33	1.79	20%	82%
	TVSS (<500-um)	21.2	7.22	1.77	20%	66%
	TVSS (<50-um)	12.2	7.13	1.75	20%	42%
	TSS (SM)	60.0	10.0	10.0	20%	83%
	TSS (EPA)	50.0	10.0	10.0	20%	80%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results. A single influent and effluent aliquot from 01/10/2008 (not displayed) was included in the composite due to overlap between events and their corresponding sample bottles on account of the "stacked" sampling approach.

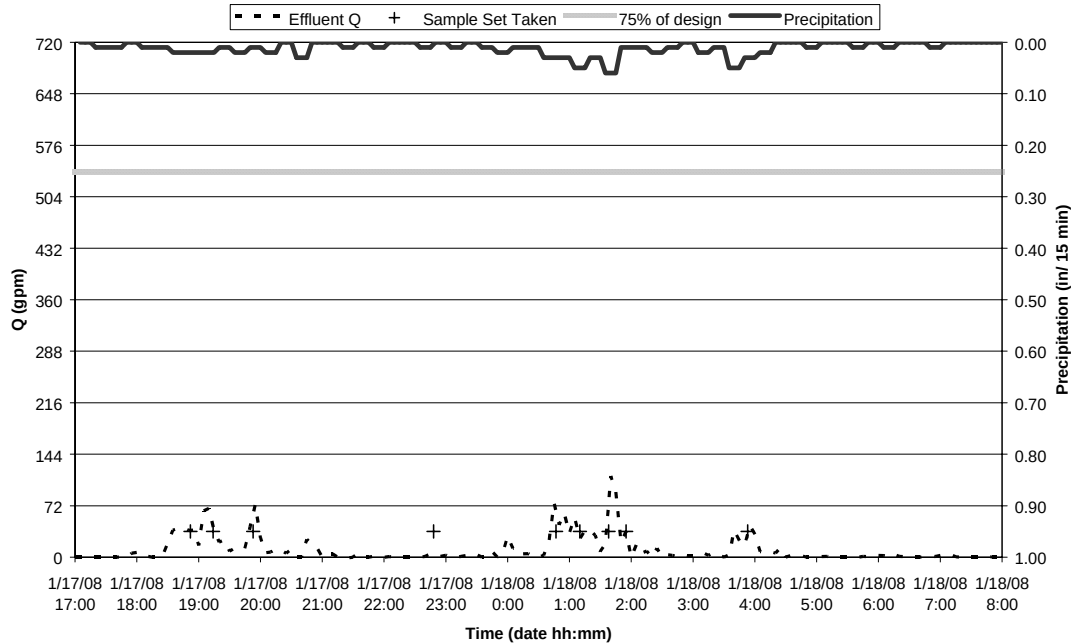
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 01/17/08
 Date of Last Maintenance: 10/29/07
 Antecedent Conditions: 64 hours since last rain event, 0.09"

Hydrology

Total Precipitation (in): 0.70
 Peak Flow (gpm): 113 (16% of design)
 Total Runoff Volume (gal): 9487
 Vol. Coverage (nearest 10%): 90

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Discrete Removal	
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
IN: 9 (3.6-L) EFF: 9	<u>Sand (mineral)</u>	96	ND	1.61	20%	98%
	<u>Silt (mineral)</u>	27	21	1.58	20%	22%
	<u>SSC (>2000-um)</u>	25.5	ND	4.37	20%	83%
	<u>SSC</u>	178	36.5	4.37	20%	79%
	SSC (<2000-um)	152	36.5	1.61	15.8%	76%
	SSC (<500-um)	81.1	35.7	1.59	15.8%	56%
	SSC (<50-um)	44.2	35.5	1.58	15.8%	20%
	TVSS (<2000-um)	29.0	15.1	1.61	20%	48%
	TVSS (<500-um)	23.8	14.8	1.59	20%	38%
	TVSS (<50-um)	17.4	14.7	1.58	20%	undeterminable
	TSS (SM)	60.0	30.0	10.0	20%	50%
	TSS (EPA)	60.0	40.0	10.0	20%	33%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

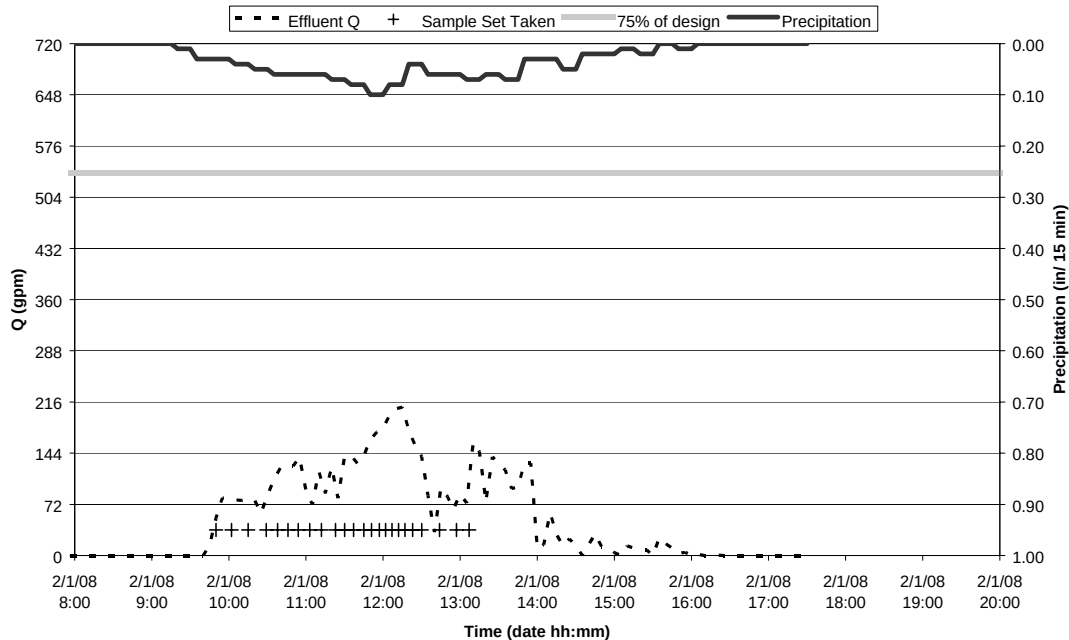
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 02/01/2008
 Date of Last Maintenance: 10/29/07
 Antecedent Conditions: 49 hours since last rain event, 0.05"

Hydrology

Total Precipitation (in): 1.22
 Peak Flow (gpm): 209 (29% of design)
 Total Runoff Volume (gal): 30508
 Vol. Coverage (nearest 10%): 80

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Discrete Removal	
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
IN: 24 (9.1-L)	<u>Sand (mineral)</u>	48	ND	1.43	20%	97%
EFF: 24	<u>Silt (mineral)</u>	36	32	1.32	20%	undeterminable
	<u>SSC (>2000-um)</u>	42.7	ND	11.1	20%	74%
	<u>SSC</u>	152	65.3	11.1	20%	57%
	SSC (<2000-um)	109	54.2	1.18	5.7%	50%
	SSC (<500-um)	70.0	43.4	1.43	5.7%	38%
	SSC (<50-um)	56.6	51.6	1.32	5.7%	9%
	TVSS (<2000-um)	25.9	20.7	1.18	20%	20%
	TVSS (<500-um)	24.3	16.8	1.43	20%	31%
	TVSS (<50-um)	21.1	19.8	1.32	20%	undeterminable
	TSS (SM)	60.0	50.0	10.0	20%	undeterminable
	TSS (EPA)	60.0	50.0	10.0	20%	undeterminable

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

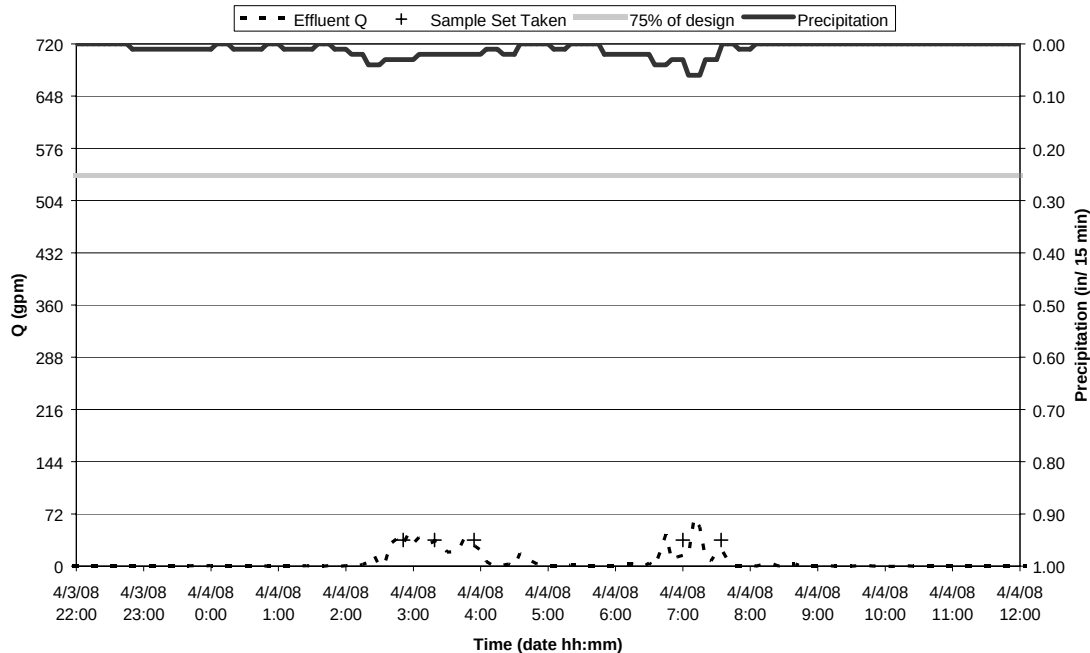
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 04/04/08
 Date of Last Maintenance: 10/29/07
 Antecedent Conditions: 45 hours since last rain event, 0.06"

Hydrology

Total Precipitation (in): 0.57
 Peak Flow (gpm): 66(9% of design)
 Total Runoff Volume (gal): 4740
 Vol. Coverage (nearest 10%): >90%

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Discrete Removal	
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
IN: 5 (2.5-L)	<u>Sand (mineral)</u>	301	ND	2.85	20%	99%
EFF: 5	<u>Silt (mineral)</u>	14.7	ND	2.94	20%	80%
	<u>SSC (>2000-um)</u>	NT	NT	---	---	---
	SSC	341	2.36	2.8	20%	99%
	SSC (<2000-um)	341	2.36	2.77	20%	99%
	SSC (<500-um)	99.7	ND	2.85	20%	97%
	SSC (<50-um)	26.5	ND	2.94	20%	89%
	TVSS (<2000-um)	24.9	2.36	2.77	20%	91%
	TVSS (<500-um)	19.9	ND	2.85	20%	86%
	TVSS (<50-um)	11.8	ND	2.94	20%	75%
	TSS (SM)	310	ND	2.87	0.00%	99%
	TSS (EPA)	40.0	10.0	10.0	0.00%	75%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot)

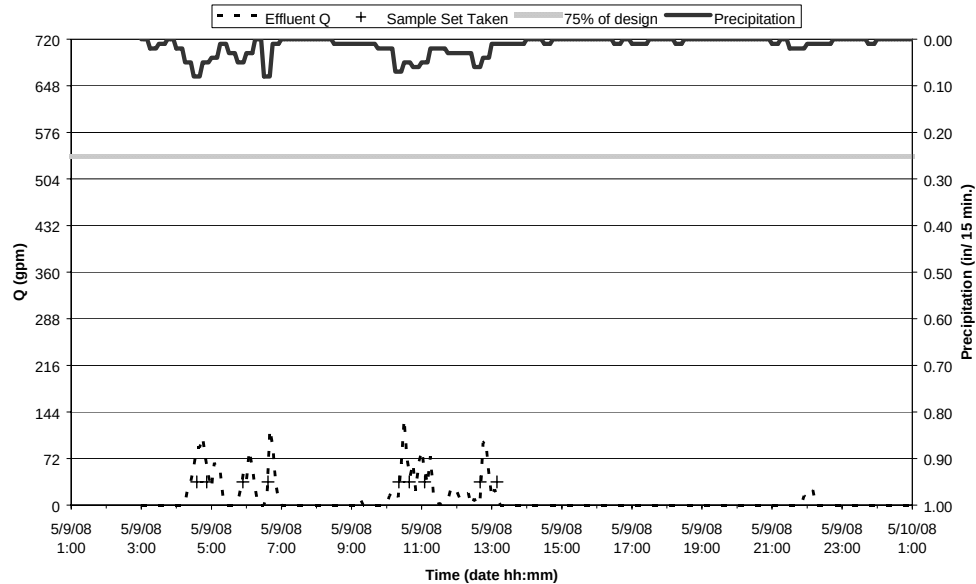
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 05/09/08
 Date of Last Maintenance: 4/15/08
 Antecedent Conditions: 235 hours since last rain event, 0.62"

Hydrology

Total Precipitation (in): 1.21
 Peak Flow (gpm): 132 (18% of design)
 Total Runoff Volume (gal): 13134
 Vol. Coverage (nearest 10%): 70

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Discrete Removal	
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
IN: 9 (4.5-L)	Coarse Solids (mineral)	1.3	ND	0.2	20%	85%
EFF: 9	Sand (mineral)	19	4.5	1.7	20%	76%
	Silt (mineral)	ND	4.0	1.7	20%	release
	SSC	78.7	23.3	1.7	10%	70%
	TVSS	58.8	14.8	1.7	20%	75%
	SSC (>2000-um)	24.7	ND	0.2	10%	99%
	SSC (<2000-um)	54.0	23.3	1.7	10%	57%
	SSC (<500-um)	27.7	23.8	1.7	10%	14%
	SSC (<50-um)	4.8	7.6	1.7	10%	release
	TVSS(>2000-um)	23.4	ND	0.2	20%	99%
	TVSS (<2000-um)	35.4	14.8	1.7	20%	58%
	TVSS (<500-um)	16.4	12.7	1.7	20%	23%
	TVSS (<50-um)	5.1	3.6	1.7	20%	29%
	TSS (SM)	56.0	21.0	5.0	20%	63%
	TSS (EPA)	48.0	21.0	5.0	20%	56%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

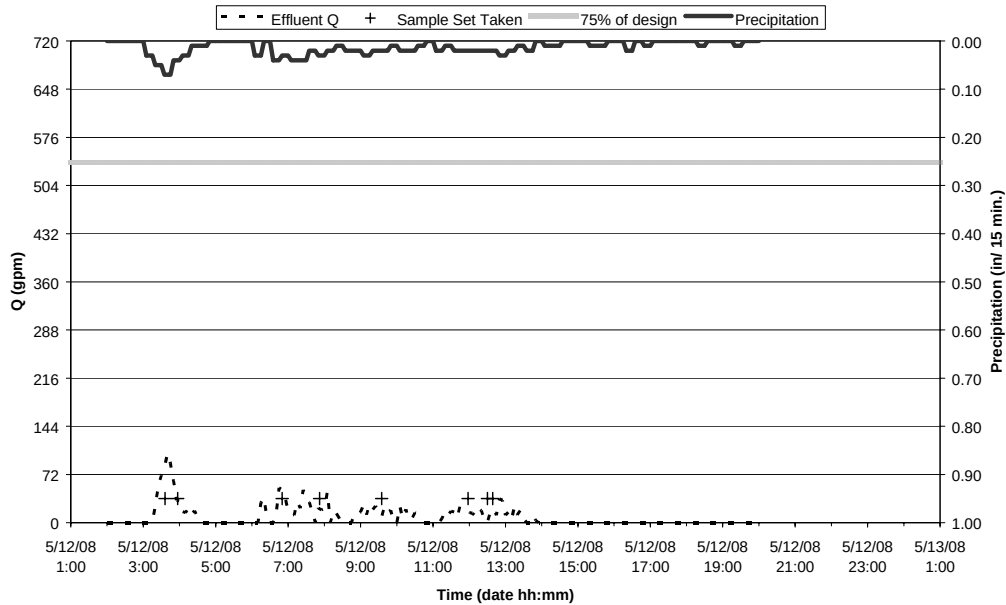
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 05/12/08
 Date of Last Maintenance: 4/15/08
 Antecedent Conditions: 51 hours since last rain event, 1.21"

Hydrology

Total Precipitation (in): 0.97
 Peak Flow (gpm): 103 (14% of design)
 Total Runoff Volume (gal): 10050
 SF Vol. Coverage (nearest 10%): 80

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Dup. RPD	Discrete Removal Efficiency
		Influent EMC	Effluent EMC	MRL		
IN: 8 (8-L)	<u>Coarse Material (mineral)</u>	1.3	ND	0.2	20%	85%
EFF: 8	<u>Sand (mineral)</u>	8.7	ND	2.3	20%	74%
	<u>Silt (mineral)</u>	ND	ND	2.3	20%	undeterminable
	<u>SSC</u>	50.6	9.3	2.3	8%	82%
	<u>TVSS</u>	42.4	9.3	2.3	20%	78%
	SSC (>2000-um)	15.7	ND	0.2	8%	99%
	SSC (<2000-um)	34.9	9.3	2.3	8%	73%
	SSC (<500-um)	10.2	6.3	2.3	8%	38%
	SSC (<50-um)	4.6	3.7	2.3	8%	20%
	TVSS(>2000-um)	14.4	ND	0.2	20%	99%
	TVSS (<2000-um)	28	9.3	2.3	20%	67%
	TVSS (<500-um)	8.8	8.5	2.3	20%	undeterminable
	TVSS (<50-um)	6.4	5.2	2.3	20%	19%
	TSS (SM)	41.0	6.0	5.0	20%	85%
	TSS (EPA)	32.0	8.7	5.0	20%	73%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

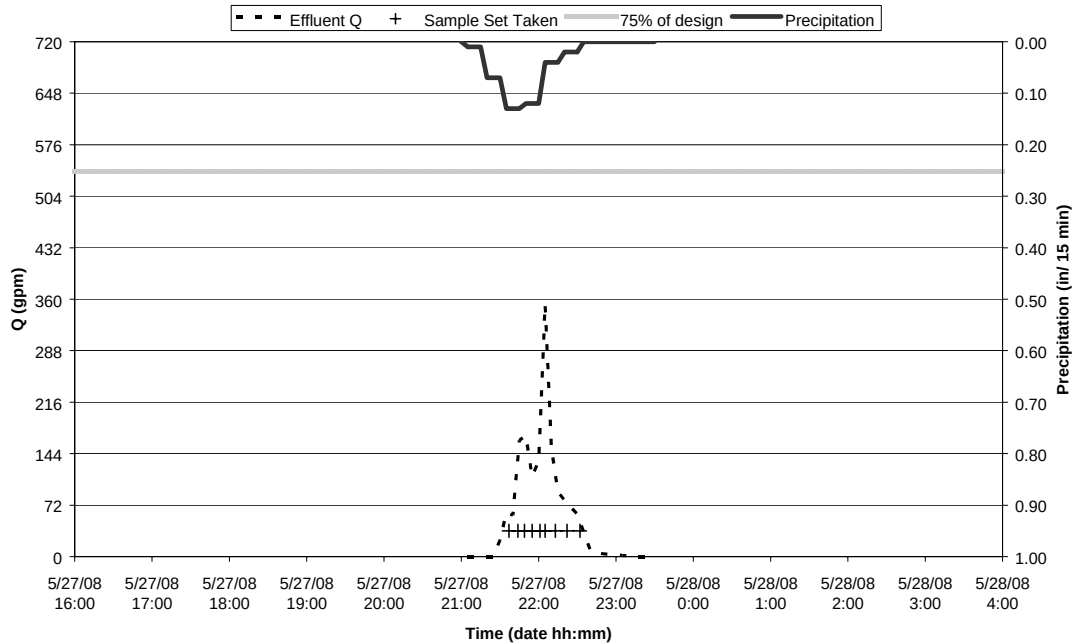
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 05/27/08
 Date of Last Maintenance: 4/15/08
 Antecedent Conditions: 12 hours since last rain event, 0.04"

Hydrology

Total Precipitation (in): 0.39
 Peak Flow (gpm): 353 (49% of design)
 Total Runoff Volume (gal): 7915
 Vol. Coverage (nearest 10%): >90

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Dup. RPD	Discrete Removal Efficiency
		Influent EMC	Effluent EMC	MRL		
IN: 9 (8.5-L)	<u>Coarse Material (mineral)</u>	0.4	0.1	0.1	20%	75%
	<u>Sand (mineral)</u>	19.5	13.5	1.4	20%	31%
EFF: 9	<u>Silt (mineral)</u>	7.7	4.9	1.4	20%	36%
	<u>SSC</u>	74.5	40.7	1.4	20%	45%
	<u>TVSS</u>	46.9	22.2	1.4	20%	53%
	SSC (>2000-um)	7.0	2.4	0.1	14%	66%
	SSC (<2000-um)	67.5	38.3	1.4	14%	43%
	SSC (<500-um)	40.5	29.6	1.4	14%	27%
	SSC (<50-um)	14.3	7.5	1.4	14%	48%
	TVSS(>2000-um)	6.6	2.3	0.1	20%	65%
	TVSS (<2000-um)	40.3	19.9	1.4	20%	51%
	TVSS (<500-um)	23.0	15.6	1.4	20%	32%
	TVSS (<50-um)	6.6	2.6	1.4	20%	61%
	TSS (SM)	68.0	32.0	5.0	4.3%	53%
	TSS (EPA)	60.0	34.7	6.3	12.5%	42%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

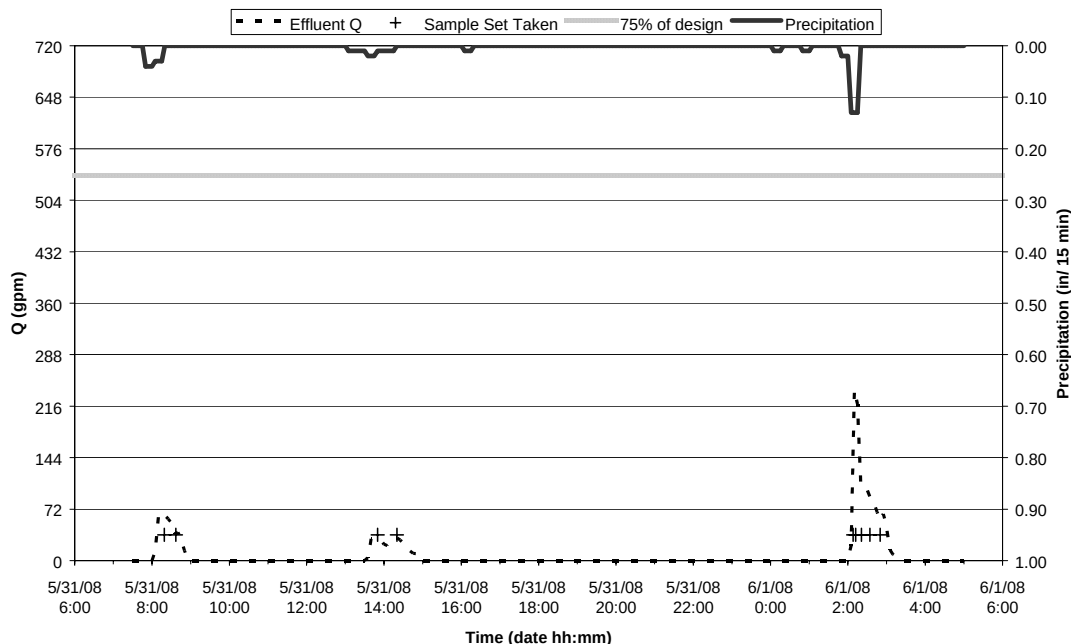
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 05/31/08
 Date of Last Maintenance: 4/15/08
 Antecedent Conditions: 81.4 hours since last rain event, 0.39"

Hydrology

Total Precipitation (in): 0.31
 Peak Flow (gpm): 238 (33% of design)
 Total Runoff Volume (gal): 10153
 Vol. Coverage (nearest 10%): 90

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Discrete Removal Efficiency
		Influent EMC	Effluent EMC	MRL	
IN: 9 (8.5-L)	<u>Coarse Material (mineral)</u>	18.1	ND	0.1	20%
	<u>Sand (mineral)</u>	45.8	12.0	1.4	20%
EFF: 9	<u>Silt (mineral)</u>	14.2	6.8	1.4	20%
	<u>SSC</u>	188.5	41.1	1.4	14%
	<u>TVSS</u>	110.4	22.3	1.4	20%
	SSC (>2000-um)	27.7	0.27	0.1	14%
	SSC (<2000-um)	160.8	40.8	1.4	14%
	SSC (<500-um)	60.0	30.3	1.4	14%
	SSC (<50-um)	20.8	12.8	1.4	14%
	TVSS(>2000-um)	9.6	0.3	0.1	20%
	TVSS (<2000-um)	100.8	22.0	1.4	20%
	TVSS (<500-um)	30.1	14.5	1.4	20%
	TVSS (<50-um)	6.6	6.0	1.4	20%
	TSS (SM)	154.0	43.2	5.0	0.7%
	TSS (EPA)	141.0	41.0	5.0	24.1%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

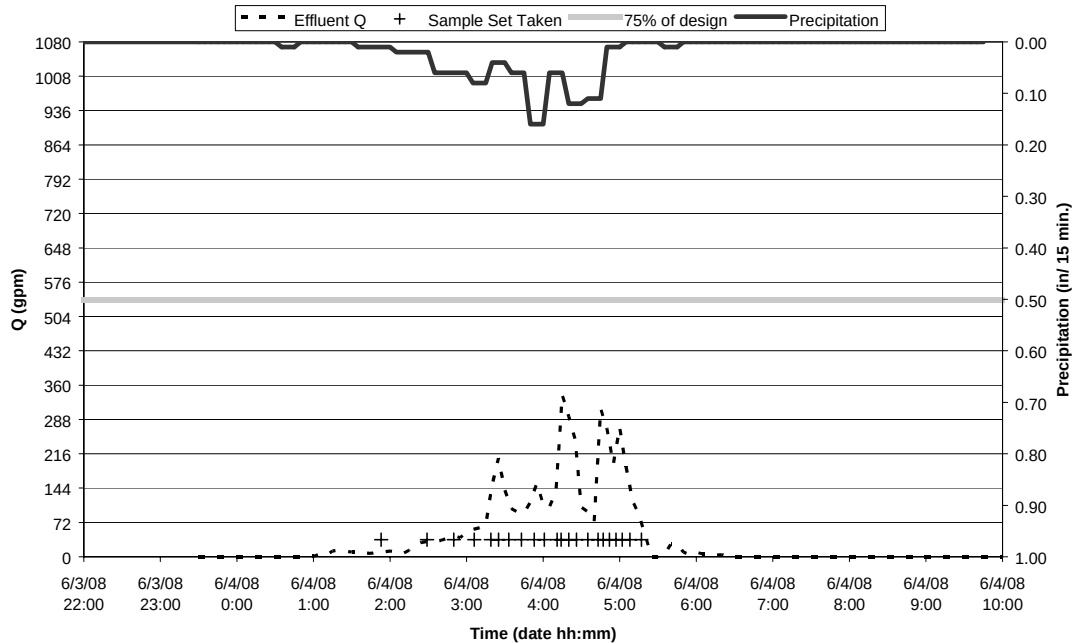
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 06/04/08
 Date of Last Maintenance: 04/15/08
 Antecedent Conditions: 69 hours since last rain event, 0.17 "

Hydrology

Total Precipitation (in): 0.85
 Peak Flow (gpm): 339 (47% of design)
 Total Runoff Volume (gal): 24003
 Vol. Coverage (nearest 10%): >90%

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Dup. RPD	Discrete Removal Efficiency
		Influent EMC	Effluent EMC	MRL		
IN: 22 (11-L)	<u>Coarse Material (mineral)</u>	ND	ND	0.1	20%	undeterminable
EFF: 22 (11-L)	<u>Sand (mineral)</u>	10.2	ND	0.6	20%	94%
	<u>Silt (mineral)</u>	2.8	5.9	0.6	20%	release
	<u>SSC</u>	27.7	10.5	0.6	5.7%	62%
	<u>TVSS</u>	14.7	7.4	0.6	20%	50%
	SSC (>2000-um)	0.8	0.6	0.1	5.7%	25%
	SSC (<2000-um)	26.9	9.9	0.6	5.7%	63%
	SSC (<500-um)	17.4	5.3	0.6	5.7%	70%
	SSC (<50-um)	6.0	7.3	0.6	5.7%	release
	TVSS(>2000-um)	0.8	0.6	0.1	20%	25%
	TVSS (<2000-um)	13.9	6.8	0.6	20%	51%
	TVSS (<500-um)	8.9	3.4	0.6	20%	62%
	TVSS (<50-um)	3.2	1.4	0.6	20%	56%
	TSS (SM)	24.3	9.0	2.5	22.6%	63%
	TSS (EPA)	23.3	7.7	2.5	6.4%	67%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

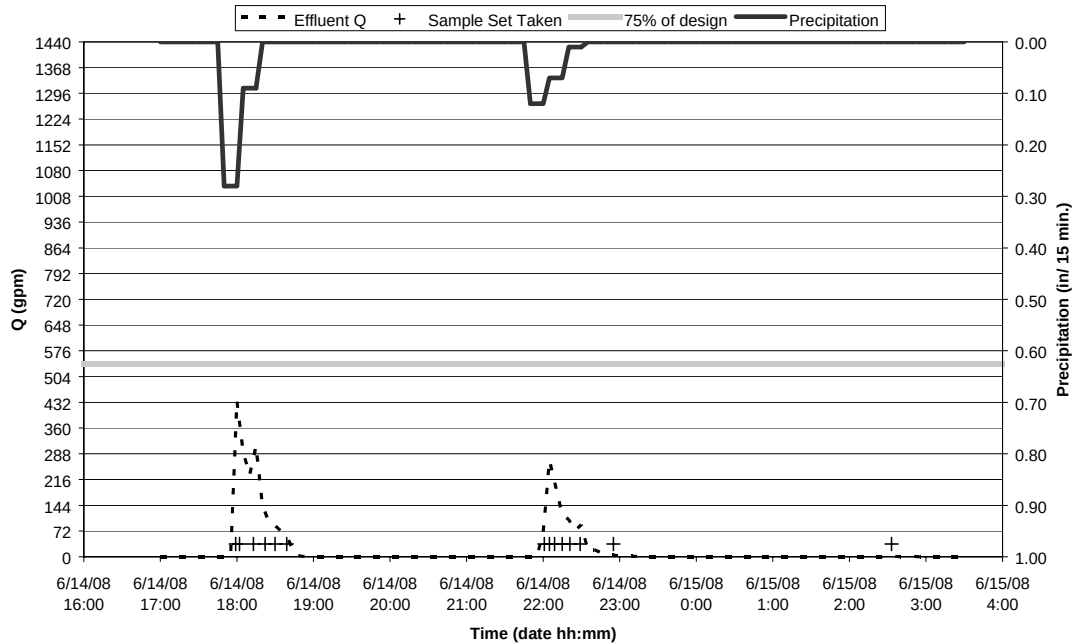
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 06/14/08
 Date of Last Maintenance: 04/15/08
 Antecedent Conditions: 228 hours since last rain event, 1.55"

Hydrology

Total Precipitation (in): 0.57
 Peak Flow (gpm): 436(61% of design)
 Total Runoff Volume (gal): 13560
 Vol. Coverage (nearest 10%): >90%

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Dup. RPD	Discrete Removal Efficiency
		Influent EMC	Effluent EMC	MRL		
IN: 14 (7000-mL)	<u>Coarse Solids (mineral)</u>	2.30	0.40	0.1	20%	83%
EFF: 14 (7000-mL)	<u>Sand (mineral)</u>	314.5	17.1	1.1	20%	95%
	<u>Silt (mineral)</u>	86.5	20.4	1.1	20%	76%
	<u>SSC</u>	710.7	74.7	1.1	6.9%	89%
	<u>TVSS</u>	307.4	36.8	1.1	20%	88%
	SSC (>2000-um)	25.2	4.4	0.1	6.9%	83%
	SSC (<2000-um)	685.5	70.3	1.1	6.9%	90%
	SSC (<500-um)	508.6	41.6	1.1	6.9%	92%
	SSC (<50-um)	125.1	32.8	1.1	6.9%	74%
	TVSS(>2000-um)	22.9	4.0	0.1	20%	83%
	TVSS (<2000-um)	284.5	32.8	1.1	20%	88%
	TVSS (<500-um)	207.6	18.0	1.1	20%	91%
	TVSS (<50-um)	38.6	12.4	1.1	20%	68%
	TSS (SM)	718.0	84.0	20.0	1.1%	88%
	TSS (EPA)	658.0	51.0	20.0	3.0%	92%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

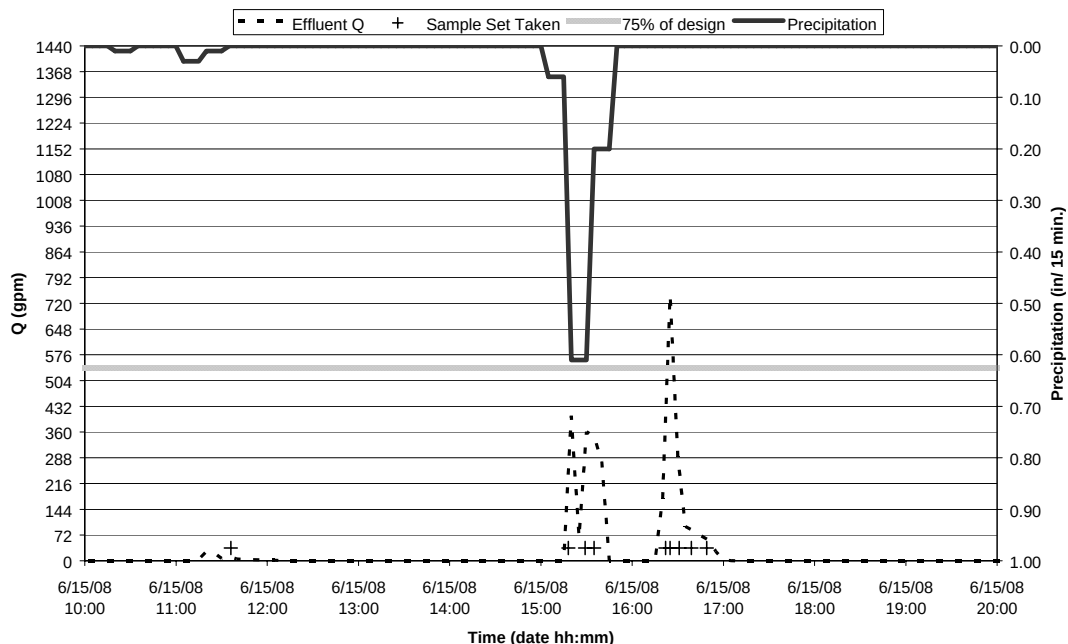
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 06/15/08
 Date of Last Maintenance: 04/15/08
 Antecedent Conditions: 12 hours since last rain event, 0.57"

Hydrology

Total Precipitation (in): 0.92
 Peak Flow (gpm): 743 (103% of design)
 Total Runoff Volume (gal): 15465
 Vol. Coverage (nearest 10%): >90%

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Dup. RPD	Discrete Removal Efficiency
		Influent EMC	Effluent EMC	MRL		
IN: 9 (4500-mL)	<u>Coarse Solids (mineral)</u>	2.3	ND	0.1	20%	96%
EFF: 9 (4500-mL)	<u>Sand (mineral)</u>	117.1	24.3	1.1	20%	79%
	<u>Silt (mineral)</u>	52.4	7.7	1.1	20%	85%
	<u>SSC</u>	299.5	55.9	1.1	10.0%	81%
	<u>TVSS</u>	127.7	23.9	1.1	20%	81%
	SSC (>2000-um)	11.0	ND	0.1	10.0%	99%
	SSC (<2000-um)	288.5	55.9	1.1	10.0%	81%
	SSC (<500-um)	241.0	29.5	1.1	10.0%	88%
	SSC (<50-um)	72.6	11.8	1.1	10.0%	84%
	TVSS(>2000-um)	8.7	ND	0.1	20%	99%
	TVSS (<2000-um)	119	23.9	1.1	20%	80%
	TVSS (<500-um)	91.8	10.7	1.1	20%	88%
	TVSS (<50-um)	20.2	4.1	1.1	20%	80%
	TSS (SM)	304.0	40.0	10.0	1.1%	87%
	TSS (EPA)	298.0	37.0	10.0	3.0%	88%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

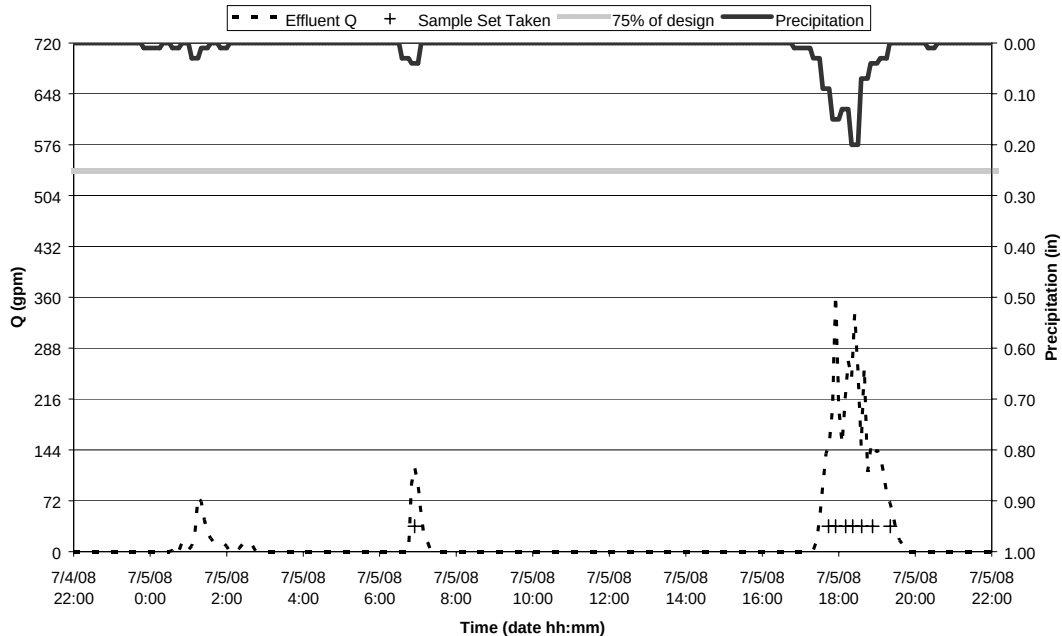
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 07/05/08
 Date of Last Maintenance: 04/15/08
 Antecedent Conditions: 89.6 hours since last rain event, 0.06"

Hydrology

Total Precipitation (in): 0.92
 Peak Flow (gpm): 363 (51% of design)
 Total Runoff Volume (gal): 24748
 Vol. Coverage (nearest 10%): >90%

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Dup. RPD	Discrete Removal Efficiency
		Influent EMC	Effluent EMC	MRL		
IN: 8 (4000-mL)	<u>Coarse Solids (mineral)</u>	ND	ND	0.1	20%	undeterminable
EFF: 8 (4000-mL)	<u>Sand (mineral)</u>	95	13.9	1.4	20%	85%
	<u>Silt (mineral)</u>	37.0	4.1	1.4	20%	89%
	<u>SSC</u>	241.9	30.3	1.4	4.1%	87%
	<u>TVSS</u>	109	12.2	1.4	20%	89%
	SSC (>2000-um)	3.9	0.38	0.1	4.1%	90%
	SSC (<2000-um)	238	29.9	1.4	4.1%	87%
	SSC (<500-um)	158	13.6	1.4	4.1%	91%
	SSC (<50-um)	52.4	6.8	1.4	4.1%	87%
	TVSS(>2000-um)	3.5	0.3	0.1	20%	91%
	TVSS (<2000-um)	106	11.9	1.4	20%	89%
	TVSS (<500-um)	58.3	6.3	1.4	20%	89%
	TVSS (<50-um)	15.4	2.7	1.4	20%	82%
	TSS (SM)	271	26.0	5.0	4.9%	90%
	TSS (EPA)	232	25.5	5.0	3.0%	89%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

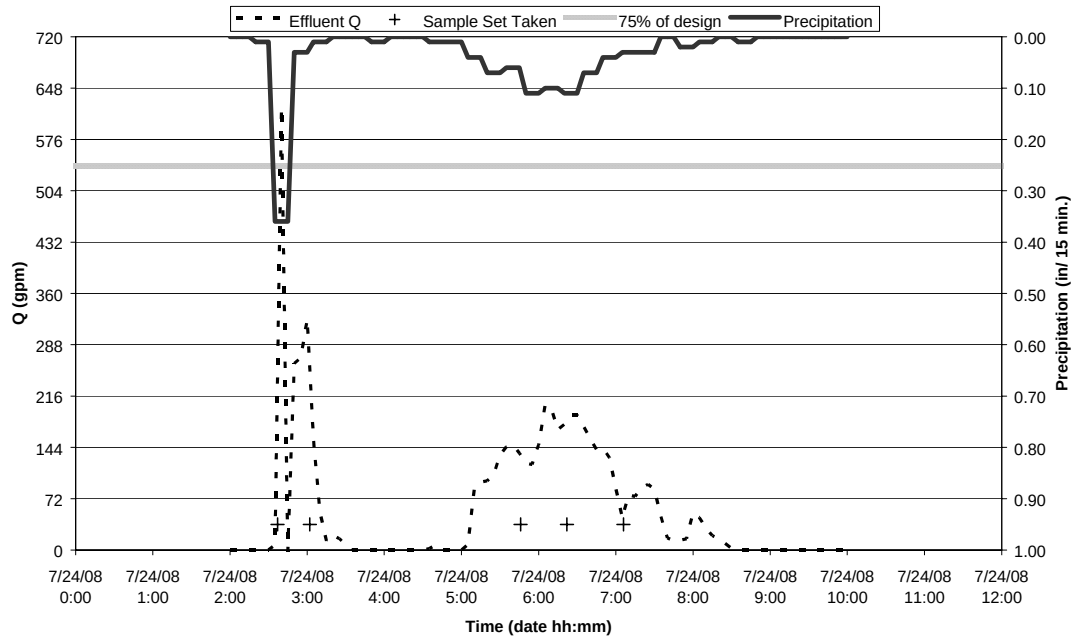
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 07/24/08
 Date of Last Maintenance: 04/15/08
 Antecedent Conditions: 84.8 hours since last rain event, 0.24"

Hydrology

Total Precipitation (in): 1.14
 Peak Flow (gpm): 620 (86% of design)
 Total Runoff Volume (gal): 28963
 Vol. Coverage (nearest 10%): >90%

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Dup. RPD	Discrete Removal Efficiency
		Influent EMC	Effluent EMC	MRL		
IN: 5(2500-mL)	<u>Coarse Solids (mineral)</u>	0.0	1.01	0.2	20%	release
EFF: 5 (2500-mL)	<u>Sand (mineral)</u>	220.1	0.0	2.5	20%	100%
	<u>Silt (mineral)</u>	50.8	0.0	2.5	20%	100%
	<u>SSC</u>	500	49.7	2.5	1.3%	90%
	<u>TVSS</u>	229	49	1.4	20%	79%
	SSC (>2000-um)	8.6	6.71	0.2	1.3%	22%
	SSC (<2000-um)	491.1	43.0	2.5	1.3%	91%
	SSC (<500-um)	256.2	24.2	2.5	1.3%	91%
	SSC (<50-um)	74.4	9.4	2.5	1.3%	87%
	TVSS(>2000-um)	8.6	5.7	0.2	20%	34%
	TVSS (<2000-um)	220.2	43.0	2.5	20%	80%
	TVSS (<500-um)	106.4	24.2	2.5	20%	77%
	TVSS (<50-um)	23.6	9.4	2.5	20%	60%
	TSS (SM)	458.7	46.0	5.0	2.3%	90%
	TSS (EPA)	427.0	43.3	6.7	6.6%	90%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

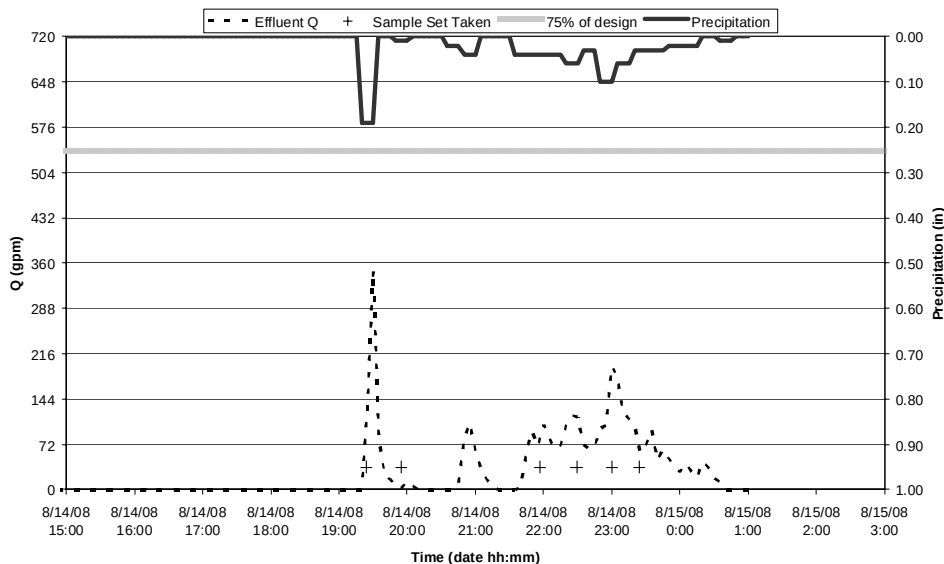
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 08/14/08
 Date of Last Maintenance: 04/15/08
 Antecedent Conditions: 14.8 hours since last rain event, 0.08"

Hydrology

Total Precipitation (in): 0.85
 Peak Flow (gpm): 349 (49% of design)
 Total Runoff Volume (gal): 19781
 Vol. Coverage (nearest 10%): 90

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Discrete Removal	
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
IN: 6 (3000-mL)	<u>Coarse Solids (mineral)</u>	15.6	ND	0.2	20%	99%
EFF: 6 (3000-mL)	<u>Sand (mineral)</u>	260.8	21.0	1.6	20%	92%
	<u>Silt (mineral)</u>	46.8	8.1	1.6	20%	83%
	SSC	598.0	42.5	1.6	10.0%	93%
	TVSS	274.8	13.4	1.6	20%	95%
	SSC (>2000-um)	55.2	ND	0.2	10.0%	100%
	SSC (<2000-um)	542.8	42.3	1.6	10.0%	92%
	SSC (<500-um)	271.2	31.9	1.6	10.0%	88%
	SSC (<50-um)	50.0	14.2	1.6	10.0%	72%
	TVSS(>2000-um)	39.6	ND	0.2	20%	99%
	TVSS (<2000-um)	235.2	13.2	1.6	20%	94%
	TVSS (<500-um)	94.4	11.6	1.6	20%	88%
	TVSS (<50-um)	3.2	6.1	1.6	20%	release
	TSS (SM)	657.0	48.0	4.0	4.1%	93%
	TSS (EPA)	468.5	41.0	4.0	16.9%	91%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

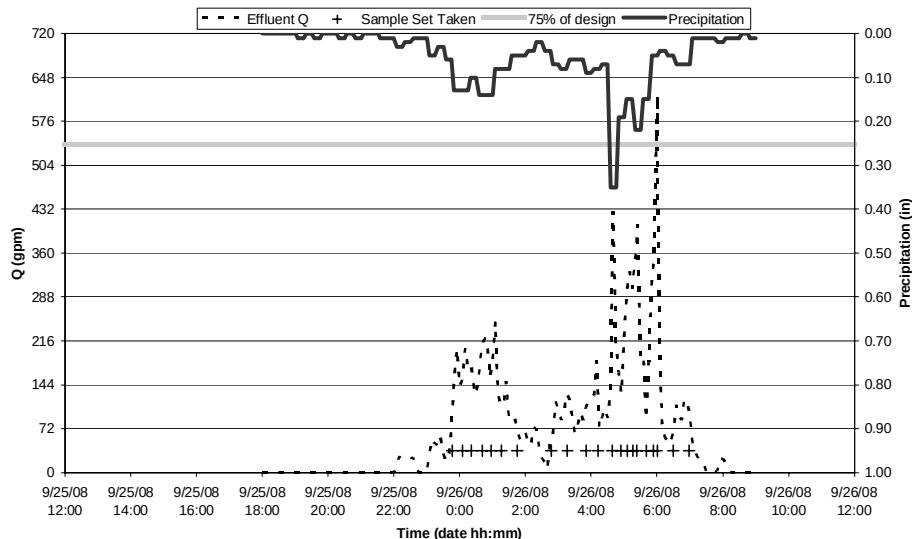
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 09/25/08
 Date of Last Maintenance: 04/15/08
 Antecedent Conditions: 304 hours since last rain event, 0.68"

Hydrology

Total Precipitation (in): 3.20
 Peak Flow (gpm): 619 (86% of design)
 Total Runoff Volume (gal): 65868
 Vol. Coverage (nearest 10%): >90

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Discrete Removal	
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
IN: 21 (10500-mL)	<u>Coarse Solids (mineral)</u>	815	ND	0.1	20%	100%
EFF: 21 (10500-mL)	<u>Sand (mineral)</u>	6071	10.5	1.0	20%	100%
	<u>Silt (mineral)</u>	11.8	2.9	1.0	20%	75%
	<u>SSC</u>	6995	22.5	1.0	20%	100%
	<u>TVSS</u>	97.4	9.2	1.0	20%	91%
	SSC (>2000-um)	845	ND	0.1	20%	100%
	SSC (<2000-um)	6150	22.5	1.0	20%	100%
	SSC (<500-um)	2558	9.1	1.0	20%	100%
	SSC (<50-um)	16.2	4.7	1.0	20%	71%
	TVSS(>2000-um)	30.2	ND	0.1	20%	100%
	TVSS (<2000-um)	67.2	9.1	1.0	20%	86%
	TVSS (<500-um)	25.0	3.6	1.0	20%	86%
	TVSS (<50-um)	4.4	1.8	1.0	20%	59%
	TSS (SM)	2259	13.8	5.0	14.5%	99%
	TSS (EPA)	2075	12.7	5.0	2.4%	99%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

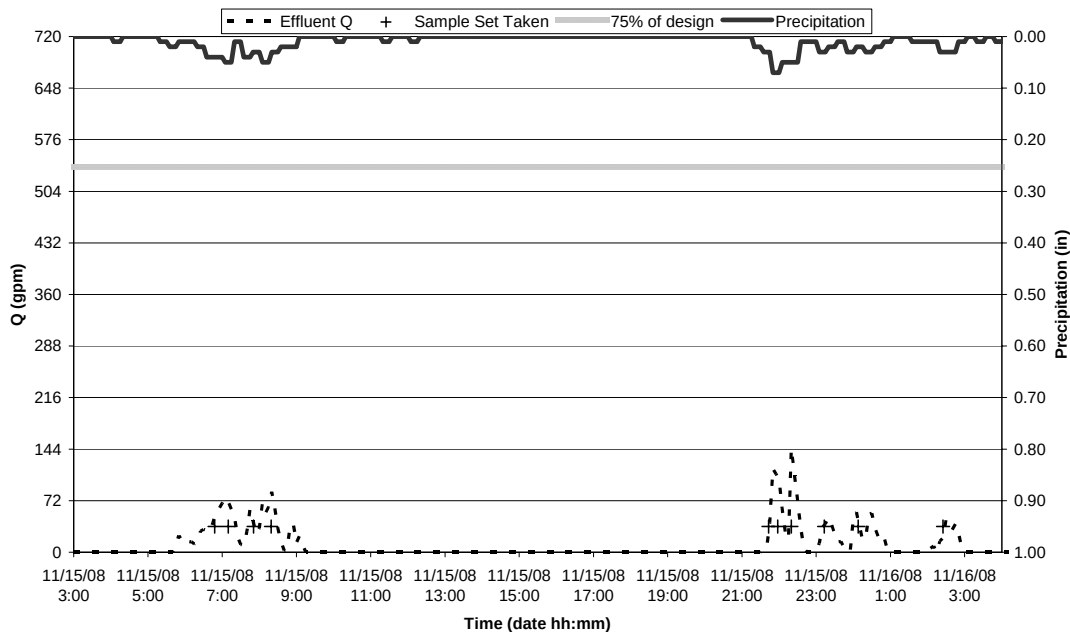
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 11/15/08
 Date of Last Maintenance: 04/15/08
 Antecedent Conditions: 33 hours since last rain event, 0.57"

Hydrology

Total Precipitation (in): 0.97
 Peak Flow (gpm): 145 (20% of design)
 Total Runoff Volume (gal): 15806
 Vol. Coverage (nearest 10%): >90%

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Discrete Removal	
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
IN: 10 (5000-mL)	<u>Coarse Solids (mineral)</u>	16.9	ND	0.1	20%	99%
EFF: 10 (5000-mL)	Sand (mineral)	20.9	5.1	1.0	20%	76%
	Silt (mineral)	6.2	5.7	1.0	20%	undeterminable
	SSC	113	21.8	1.0	27.7%	81%
	TVSS	69.0	11.0	1.0	20%	84%
	SSC (>2000-um)	41.1	ND	0.1	27.7%	100%
	SSC (<2000-um)	71.9	21.7	1.0	27.7%	70%
	SSC (<500-um)	21.4	9.3	1.0	27.7%	57%
	SSC (<50-um)	11.6	7.2	1.0	27.7%	38%
	TVSS(>2000-um)	24.2	0.1	0.1	20%	100%
	TVSS (<2000-um)	44.8	10.9	2.2	20%	76%
	TVSS (<500-um)	10.3	4.8	2.1	20%	53%
	TVSS (<50-um)	5.4	1.5	1.0	20%	72%
	TSS (SM)	75.5	25.1	5.0	5.7%	67%
	TSS (EPA)	46.6	17.0	5.0	9.0%	64%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

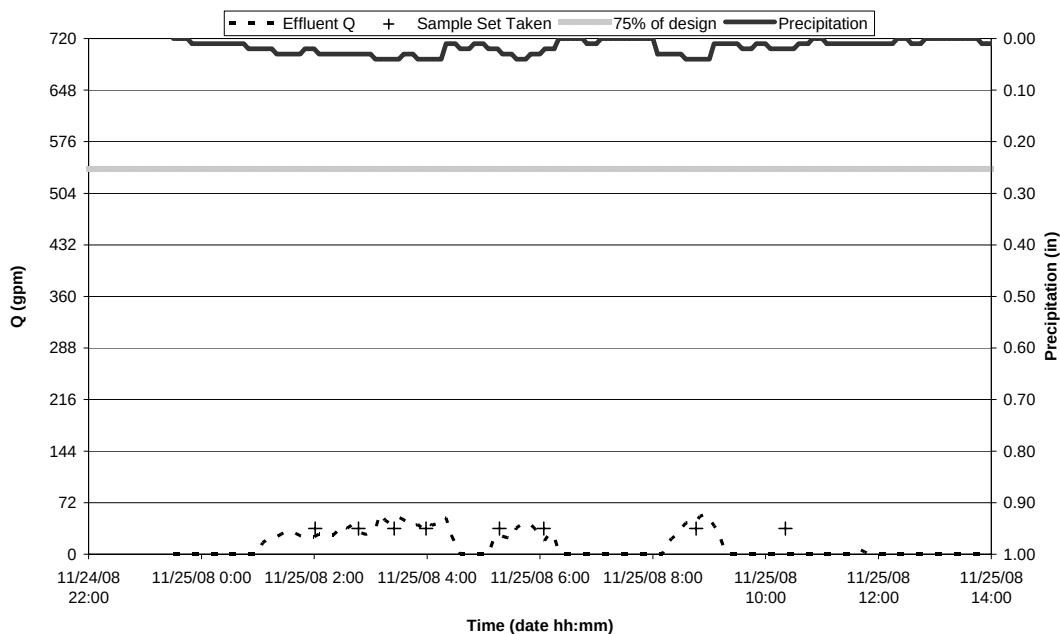
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 11/25/08
 Date of Last Maintenance: 04/15/08
 Antecedent Conditions: 212 hours since last rain event, 0.53"

Hydrology

Total Precipitation (in): 0.97
 Peak Flow (gpm): 57 (8% of design)
 Total Runoff Volume (gal): 11707
 Vol. Coverage (nearest 10%): >90%

Event Hydrograph



Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Discrete Removal	
		Influent EMC	Effluent EMC	MRL	Dup. RPD	Efficiency
IN: 8 (4000-mL)	<u>Coarse Solids (mineral)</u>	2.6	ND	0.1	20%	96%
EFF: 8 (4000-mL)	Sand (mineral)	15.3	ND	1.4	20%	91%
	Silt (mineral)	ND	ND	1.4	20%	undeterminable
	SSC	38.9	3.8	1.4	8.5%	90%
	TVSS	21.0	2.9	1.4	20%	86%
	SSC (>2000-um)	14.2	ND	0.1	8.5%	99%
	SSC (<2000-um)	24.7	3.7	1.4	8.5%	85%
	SSC (<500-um)	9.2	ND	1.4	8.5%	85%
	SSC (<50-um)	ND	ND	1.4	8.5%	undeterminable
	TVSS(>2000-um)	11.6	ND	0.1	20%	99%
	TVSS (<2000-um)	9.4	2.8	1.4	20%	70%
	TVSS (<500-um)	5.0	ND	1.4	20%	72%
	TVSS (<50-um)	1.4	ND	1.4	20%	undeterminable
	TSS (SM)	29.4	2.5	2.5	20%	91%
	TSS (EPA)	20.5	ND	2.5	20%	88%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

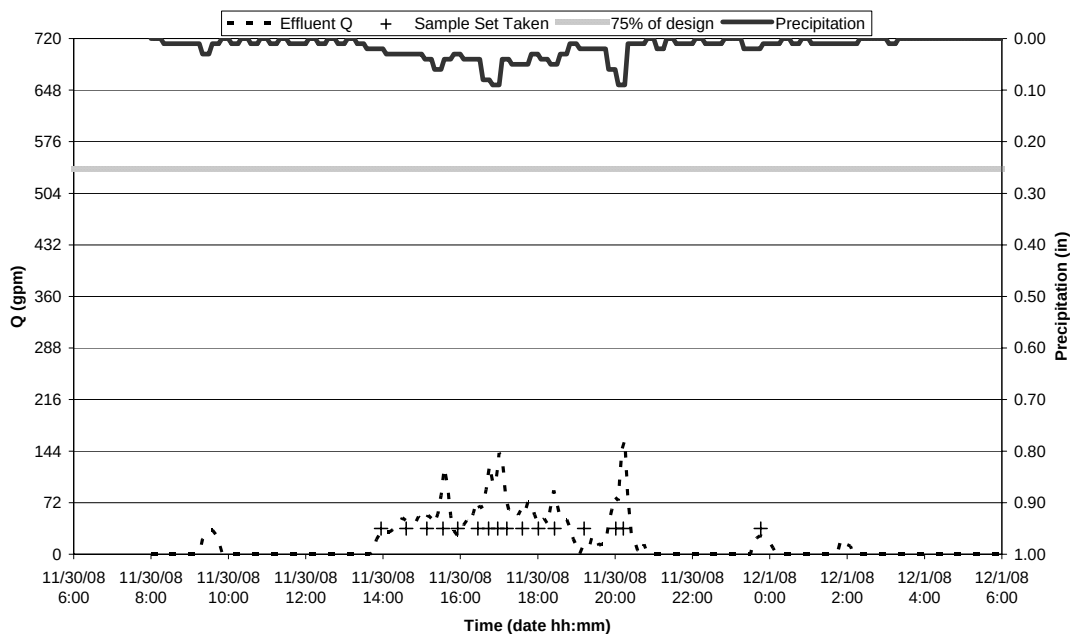
General Information

Site: Manasquan Savings Bank, (31378), Point Pleasant, NJ
 System Description: CDS PMSU20_25HE (40.5 ft² sediment storage capacity, design 1.6 cfs)
 Event Date: 11/30/08
 Date of Last Maintenance: 04/15/08
 Antecedent Conditions: 14 days since last rain event, 0.97"

Hydrology

Total Precipitation (in): 1.46
 Peak Flow (gpm): 158(22% of design)
 Total Runoff Volume (gal): 24187
 Vol. Coverage (nearest 10%): >90%

Event Hydrograph



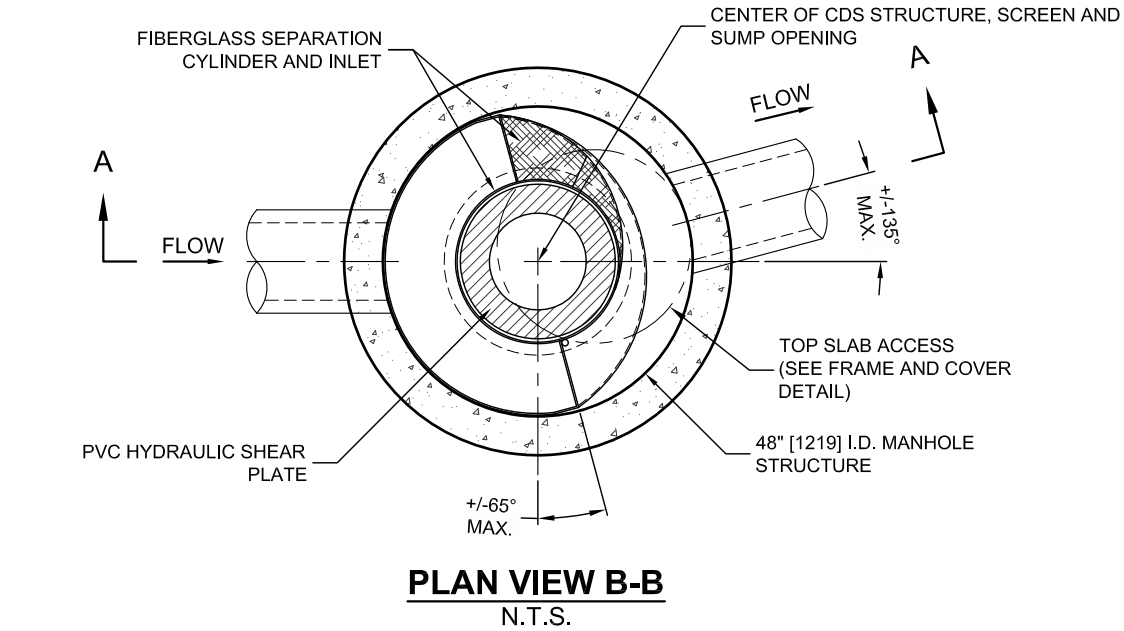
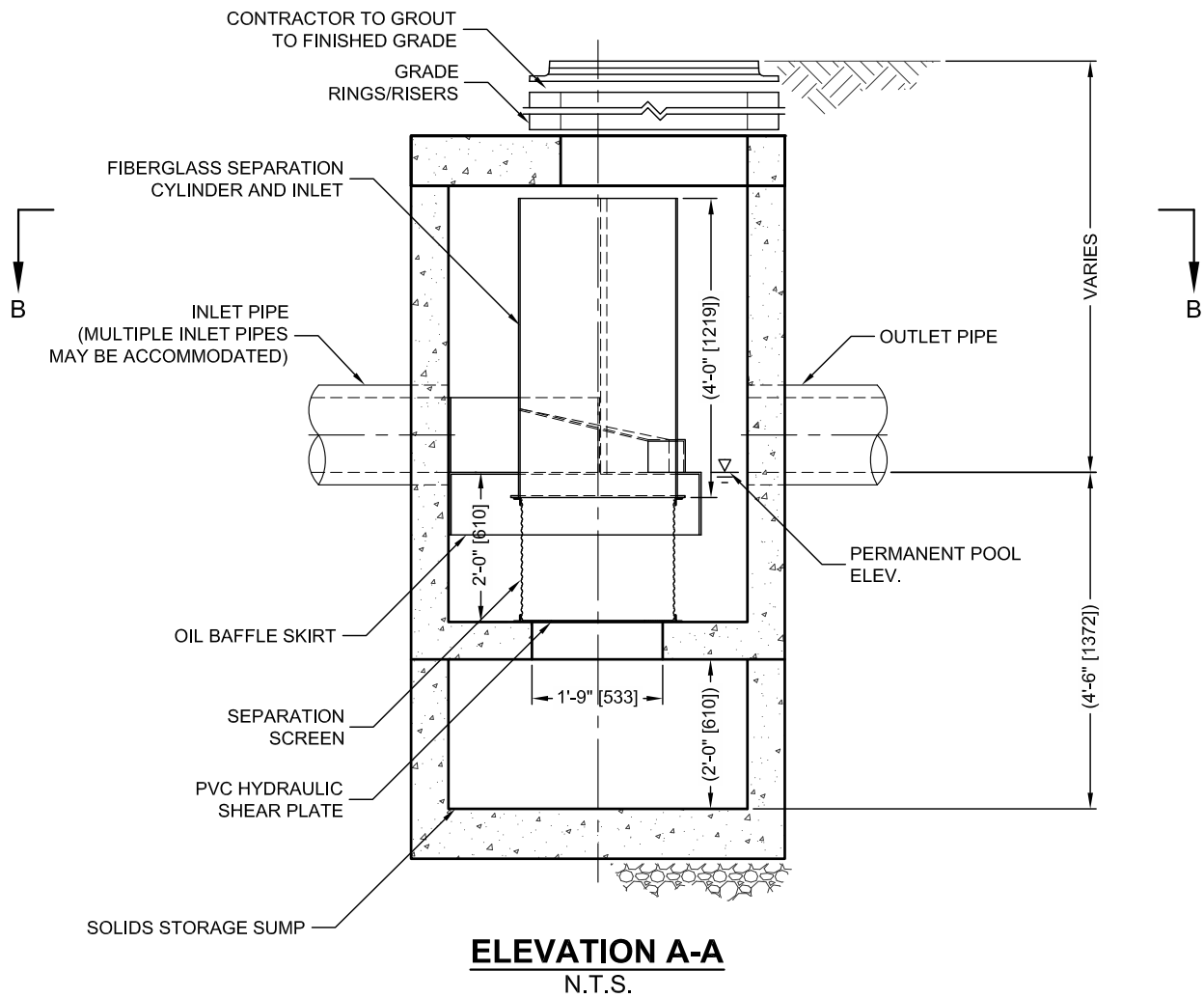
Analytical

Number of Aliquots:	Parameter	Concentrations (mg/L)			Dup. RPD	Discrete Removal Efficiency
		Influent EMC	Effluent EMC	MRL		
IN: 14(7000-mL)	<u>Coarse Solids (mineral)</u>	ND	ND	0.1	20%	undeterminable
EFF: 14(7000-mL)	<u>Sand (mineral)</u>	170.1	7.0	1.4	20%	96%
	<u>Silt (mineral)</u>	40.6	2.4	1.4	20%	94%
	<u>SSC</u>	381.8	15.7	1.4	11.1%	96%
	<u>TVSS</u>	171.1	6.3	1.4	20%	96%
	SSC (>2000-um)	25.5	ND	0.1	11.1%	100%
	SSC (<2000-um)	356.3	15.6	1.4	11.1%	96%
	SSC (<500-um)	178.6	7.6	1.4	11.1%	96%
	SSC (<50-um)	56.1	5.1	1.4	11.1%	91%
	TVSS(>2000-um)	25.5	ND	0.1	20%	100%
	TVSS (<2000-um)	145.6	6.2	1.4	20%	96%
	TVSS (<500-um)	66.5	4.4	1.4	20%	93%
	TVSS (<50-um)	15.5	2.7	1.4	20%	83%
	TSS (SM)	519.0	16.8	10.0	20%	97%
	TSS (EPA)	348.0	16.7	10.0	0%	95%

Notes

Peak flow and total runoff volume based on effluent flow measurements. Shaded RPD values defaulted to 20% standard due to QC complications. All samples passed through a 2000-um sieve prior to splitting. Underlined parameters are calculated: SSC defined as sum of SSC (>2000-um) and SSC (<2000-um); Coarse Solids defined as >2000-um; Sand defined as between 2000-um and 50-um; Silt defined as <50-um; SSC (>2000-um) calculated using estimated volume of sample used for composite (visual estimate of actual aliquot volume) and mass of material retained by the 2000-um sieve; mineral fraction determined through subtraction of volatile from total results.

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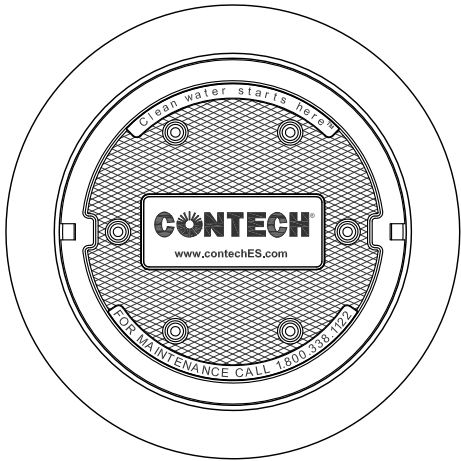


CDS2015-4-C DESIGN NOTES

THE STANDARD CDS2015-4-C CONFIGURATION IS SHOWN. ALTERNATE CONFIGURATIONS ARE AVAILABLE AND ARE LISTED BELOW. SOME CONFIGURATIONS MAY BE COMBINED TO SUIT SITE REQUIREMENTS.

CONFIGURATION DESCRIPTION

- GRATED INLET ONLY (NO INLET PIPE)
- GRATED INLET WITH INLET PIPE OR PIPES
- CURB INLET ONLY (NO INLET PIPE)
- CURB INLET WITH INLET PIPE OR PIPES
- SEPARATE OIL BAFFLE (SINGLE INLET PIPE REQUIRED FOR THIS CONFIGURATION)
- SEDIMENT WEIR FOR NJDEP / NJCAT CONFORMING UNITS



FRAME AND COVER
(DIAMETER VARIES)
N.T.S.

SITE SPECIFIC
DATA REQUIREMENTS

STRUCTURE ID			
WATER QUALITY FLOW RATE (CFS OR L/s)			*
PEAK FLOW RATE (CFS OR L/s)			*
RETURN PERIOD OF PEAK FLOW (YRS)			*
SCREEN APERTURE (2400 OR 4700)			*
PIPE DATA:	I.E.	MATERIAL	DIAMETER
INLET PIPE 1	*	*	*
INLET PIPE 2	*	*	*
OUTLET PIPE	*	*	*
RIM ELEVATION			*
ANTI-FLOTATION BALLAST		WIDTH	HEIGHT
		*	*
NOTES/SPECIAL REQUIREMENTS:			
* PER ENGINEER OF RECORD			

GENERAL NOTES

- CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
- DIMENSIONS MARKED WITH () ARE REFERENCE DIMENSIONS. ACTUAL DIMENSIONS MAY VARY.
- FOR FABRICATION DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHTS, PLEASE CONTACT YOUR CONTECH ENGINEERED SOLUTIONS LLC REPRESENTATIVE. www.contechES.com
- CDS WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING.
- STRUCTURE SHALL MEET AASHTO HS20 AND CASTINGS SHALL MEET HS20 (AASHTO M 306) LOAD RATING, ASSUMING GROUNDWATER ELEVATION AT, OR BELOW, THE OUTLET PIPE INVERT ELEVATION. ENGINEER OF RECORD TO CONFIRM ACTUAL GROUNDWATER ELEVATION.
- PVC HYDRAULIC SHEAR PLATE IS PLACED ON SHELF AT BOTTOM OF SCREEN CYLINDER. REMOVE AND REPLACE AS NECESSARY DURING MAINTENANCE CLEANING.

INSTALLATION NOTES

- ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
- CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE CDS MANHOLE STRUCTURE (LIFTING CLUTCHES PROVIDED).
- CONTRACTOR TO ADD JOINT SEALANT BETWEEN ALL STRUCTURE SECTIONS, AND ASSEMBLE STRUCTURE.
- CONTRACTOR TO PROVIDE, INSTALL, AND GROUT PIPES. MATCH PIPE INVERTS WITH ELEVATIONS SHOWN.
- CONTRACTOR TO TAKE APPROPRIATE MEASURES TO ASSURE UNIT IS WATER TIGHT, HOLDING WATER TO FLOWLINE INVERT MINIMUM. IT IS SUGGESTED THAT ALL JOINTS BELOW PIPE INVERTS ARE GROUTED.



www.contechES.com
9025 Centre Pointe Dr., Suite 400, West Chester, OH 45069
800-338-1122 513-645-7000 513-645-7993 FAX

CDS2015-4-C
INLINE CDS
STANDARD DETAIL

APPENDIX D – REFERENCED STUDIES

National Flood Hazard Layer FIRMMette



104°52'26"W 39°24'44"N



Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) Zone A, V, A99
		With BFE or Depth Zone AE, AO, AH, VE, AR
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
		Future Conditions 1% Annual Chance Flood Hazard Zone X
		Area with Reduced Flood Risk due to Levee. See Notes. Zone X
		Area with Flood Risk due to Levee Zone D
OTHER AREAS		NO SCREEN Area of Minimal Flood Hazard Zone X
		Effective LOMRs
		Area of Undetermined Flood Hazard Zone D
GENERAL STRUCTURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES		20.2 Cross Sections with 1% Annual Chance Water Surface Elevation
		17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
		Coastal Transect
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
		Coastal Transect Baseline
		Profile Baseline
MAP PANELS		Digital Data Available
		No Digital Data Available
		Unmapped



The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 11/19/2024 at 9:22 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.



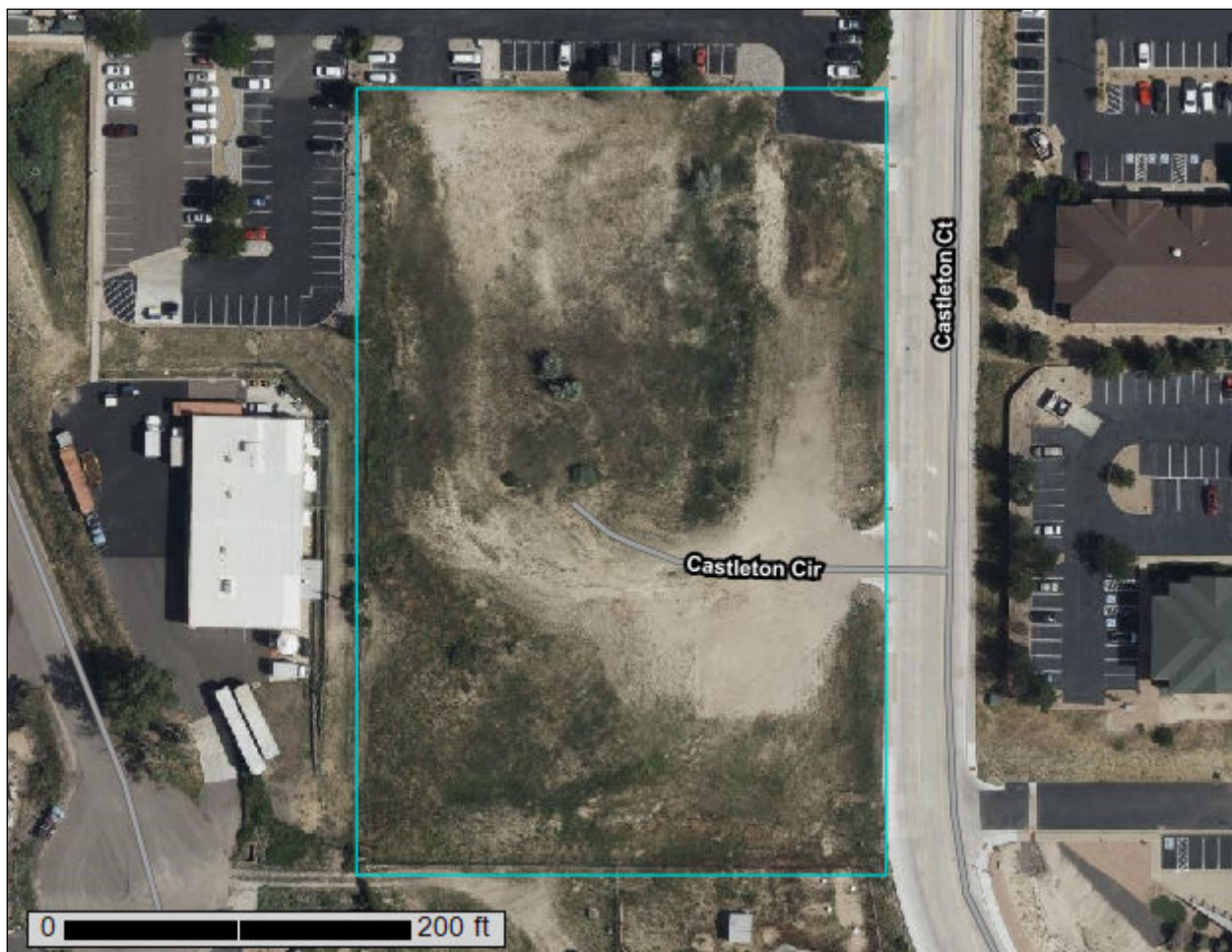
United States
Department of
Agriculture

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**



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.

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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

Custom Soil Resource Report

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



Custom Soil Resource Report

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 17, Aug 29, 2024

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

Date(s) aerial images were photographed: Mar 1, 2023—Sep 1, 2023

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
KtE	Kutch sandy loam, 5 to 20 percent slopes	3.2	100.0%
Totals for Area of Interest		3.2	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.

Custom Soil Resource Report

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

KtE—Kutch sandy loam, 5 to 20 percent slopes

Map Unit Setting

National map unit symbol: jqz5
Elevation: 5,500 to 6,800 feet
Mean annual precipitation: 15 to 19 inches
Mean annual air temperature: 47 to 50 degrees F
Frost-free period: 120 to 135 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Kutch

Setting

Landform: Drainageways, alluvial fans, valley sides
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Calcareous fine-loamy clayey shale

Typical profile

H1 - 0 to 6 inches: sandy loam
H2 - 6 to 32 inches: clay
H3 - 32 to 36 inches: weathered bedrock

Properties and qualities

Slope: 5 to 20 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: R049XB210CO - Sandy Foothill
Hydric soil rating: No

Minor Components

Bresser

Percent of map unit: 7 percent

Custom Soil Resource Report

Hydric soil rating: No

Newlin

Percent of map unit: 7 percent

Hydric soil rating: No

Aquic haplustolls

Percent of map unit: 1 percent

Landform: Swales

Hydric soil rating: Yes

References

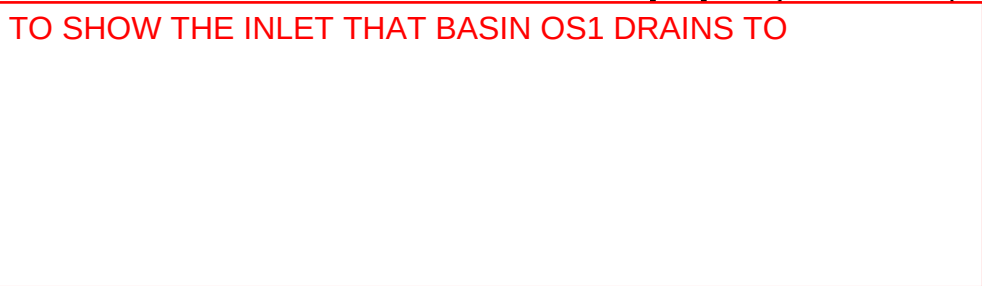
- American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.
- American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.
- Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.
- Federal Register. July 13, 1994. Changes in hydric soils of the United States.
- Federal Register. September 18, 2002. Hydric soils of the United States.
- Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.
- National Research Council. 1995. Wetlands: Characteristics and boundaries.
- Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262
- Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577
- Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580
- Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.
- United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.
- United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374
- United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. <http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084>

Custom Soil Resource Report

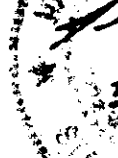
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf



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CHECKED	JPC
DESIGNED	JDC
FILE	GRADALL

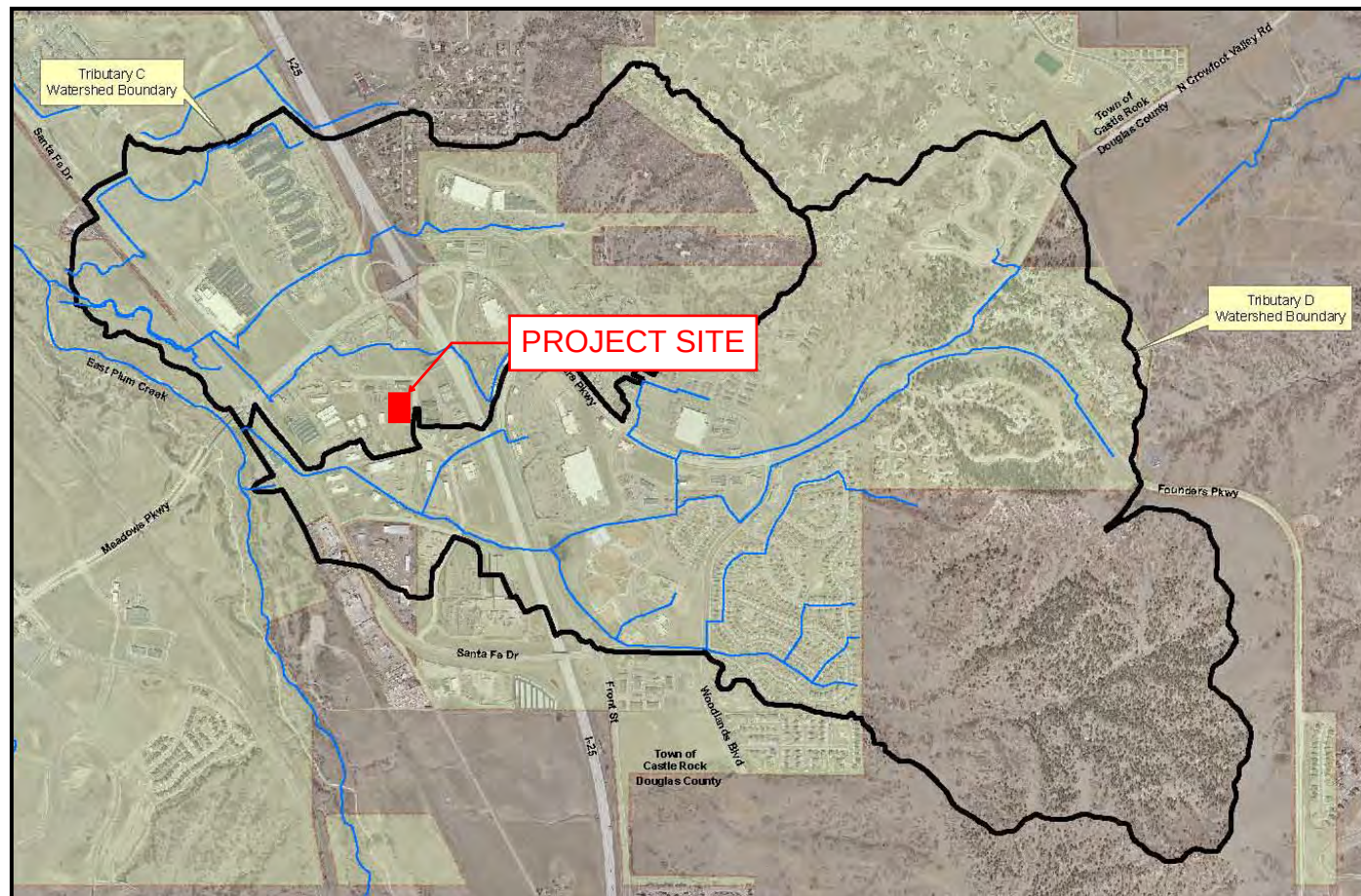


A circular official stamp from the State of Colorado, Department of Public Safety. The outer ring contains the text "STATE OF COLORADO" at the bottom and "DEPARTMENT OF PUBLIC SAFETY" at the top. Inside the ring, there is a signature that appears to read "WILL PATRICK COLEMAN". Below the signature, the date "3-10-97" is stamped. At the very bottom of the inner circle, it says "COLORADO, COLORADO". There are two stars on either side of the date.

	
TST INC. OF DENVER Consulting Engineers	
JOB NO. <u>40-055-001</u>	
SCALE <u>1"=30'</u>	
DATE <u>20 FEBRUARY 1997</u>	
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TO SHOW LOCATION WITHIN WATERSHED

TRIBUTARY C AND D WATERSHEDS MASTER PLAN



Project Sponsor:



TOWN OF CASTLE ROCK

Prepared by:

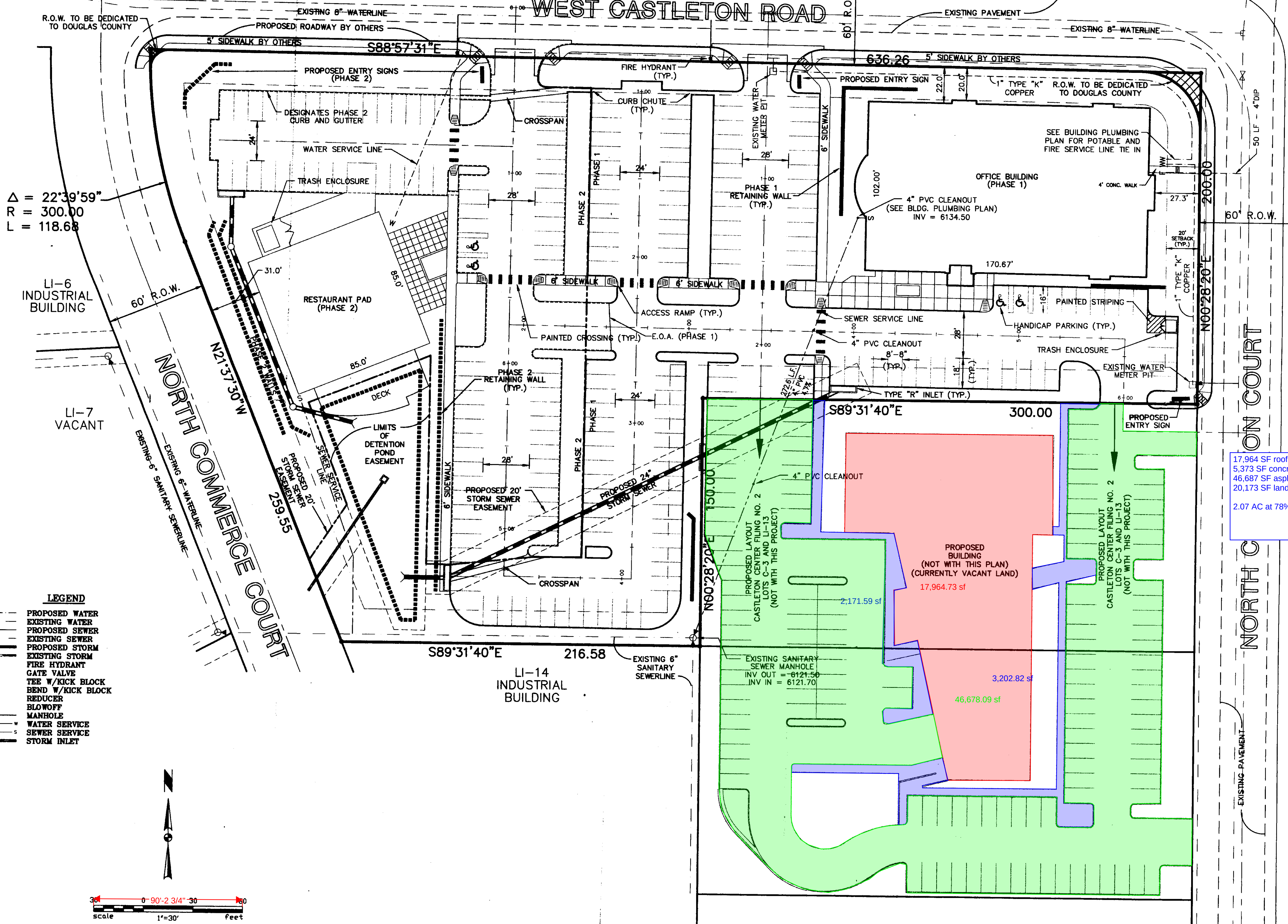


720 South Colorado Boulevard
Suite 410 S
Denver, Colorado 80246
phone (303) 757-3655
fax (303) 300-1635

October 2014

CASTLE PINES COMMERCIAL PD
FILING 3
VACANT

WEST CASTLETON ROAD



$\Delta = 22^{\circ}39'59''$
 $R = 300.00$
 $L = 118.68$

LI-6
INDUSTRIAL
BUILDING

LI-7
VACANT

NORTH COMMERCE COURT

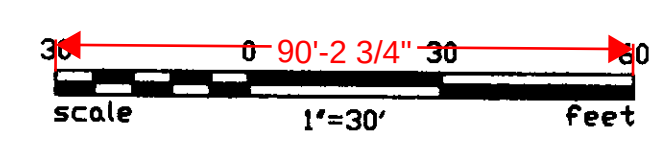
LI-14
INDUSTRIAL
BUILDING

NORTH COURT

VACANT

LEGEND

- PROPOSED WATER
- EXISTING WATER
- PROPOSED SEWER
- EXISTING SEWER
- PROPOSED STORM
- EXISTING STORM
- EXISTING FIRE HYDRANT
- GATE VALVE
- TEE W/ KICK BLOCK
- BEND W/ KICK BLOCK
- REDUCER
- BLOWOFF
- MANHOLE
- WATER SERVICE
- SEWER SERVICE
- STORM INLET



17,964 SF roof at 95% imp
5,373 SF concrete at 95% imp
46,687 SF asphalt at 95% imp
20,173 SF landscape at 20% imp
2.07 AC at 78% imp

D'GRUPPE LLC
MEADOWS CROSSING

OVERALL IMPROVEMENT PLAN



TST INC. OF DENVER
Consulting Engineers

JOB NO. 40-055-002
SCALE 1"=30'
DATE 20 FEBRUARY 1997
SHEETS 8 2

These construction plans have been reviewed by Douglas County for street and drainage improvements only.

[Signature]
County Engineer

[Signature]
Date

ENGINEERING DIVISION ACCEPTANCE BLOCK

REVISIONS	DATE	BY	DESCRIPTION
1	12/19/96	JDC	FIRST SUBMITTAL TO DOUGLAS COUNTY
2	12/23/96	JDC	DESIGN SUBMITTAL TO DOUGLAS COUNTY
3	2/13/97	JDC	SECOND SUBMITTAL TO DOUGLAS COUNTY
4	2/26/97	JDC	CONSTRUCTION DOCUMENTS
5	2/28/97	JDC	REVISIONS
6	3/7/97	JDC	REVISED AS PER OWNER COMMENTS

DRAWN JDC
CHECKED JPC
DESIGNED JDC
FILE OVERALL

[Stamp: 100% 3-10-97]

C:\acad-dwg\10-D'GRUPPE\OVERALL.FP1 Mar 07 18:31:31 1997 JDC

APPENDIX E – DRAINAGE MAPS

THIS DOCUMENT, TOGETHER WITH THE CONCEPTS & DESIGN PRESENTED HEREIN, AS AN INSTRUMENT OF SERVICE, IS INTENDED ONLY FOR THE SPECIFIC PURPOSE AND CLIENT FOR WHICH IT WAS PREPARED. REUSE OF & IMPROPER RELIANCE ON THIS DOCUMENT WITHOUT WRITTEN AUTHORIZATION & ADAPTATION BY NCU & KIMLEY-HORN & ASSOCIATES, INC. SHALL BE WITHOUT LIABILITY TO NCU & KIMLEY-HORN & ASSOCIATES, INC.

3161 N Castleton CT, Castle Rock CO 80104
CASTLETON HEIGHTS 8/11/2025

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OWNER | **TWG Development, LLC**
1301 E. Washington Street, Suite 100
Indianapolis, IN 46202



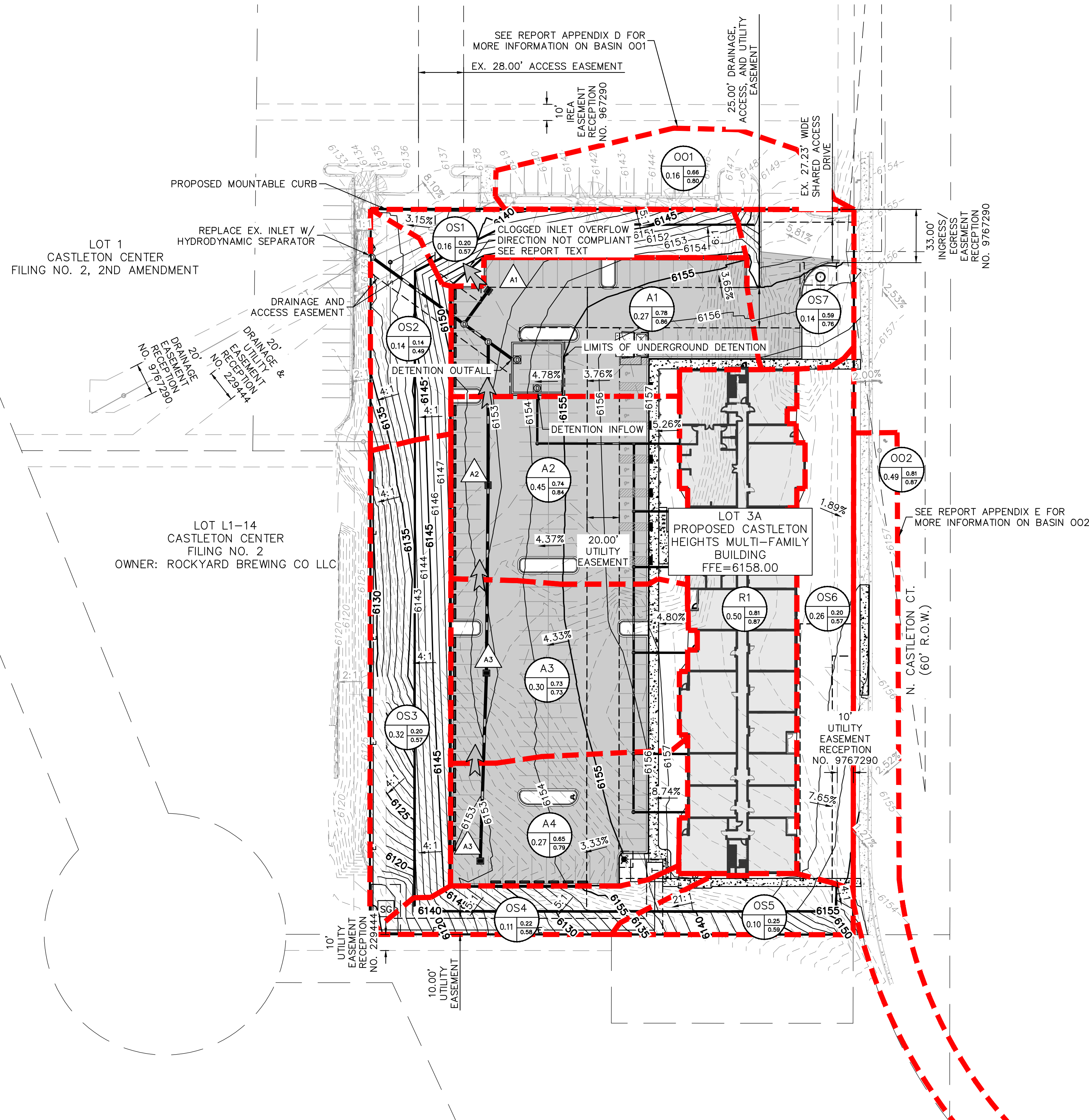
CONSULTANT | **STUDIO** | Architect Designer
3575 Ringsby Court 300A - Denver, CO - 80216

Kimley»Horn

CONSULTANT | **KIMLEY-HORN** | Civil Engineer
6200 South Syracuse Way, Suite 300 - Greenwood
Village, CO - 80111

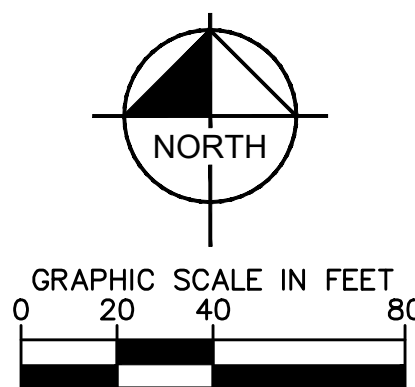
PROPOSED DRAINAGE MAP

SDP25-0002



LEGEND

- PROPERTY LINE
- EXISTING EASEMENT
- PROPOSED EASEMENT
- R.O.W.
- PROPOSED SLOPE
- EXISTING SLOPE
- EXISTING CONTOUR
- PROPOSED CONTOUR
- PROPOSED STORM
- DRAINAGE BASIN BOUNDARY
- STORM INLET
- STORM MANHOLE
- SEWER MANHOLE
- FLARED END SECTION
- A = BASIN ID
B = BASIN AREA (AC)
C = 5-YR C-COEFFICIENT
D = 100-YR C-COEFFICIENT
- DESIGN POINT
- EMERGENCY OVERFLOW DIRECTION

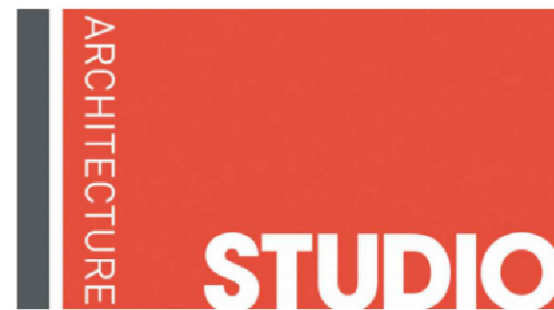


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CASTLETON HEIGHTS 5/1/2025

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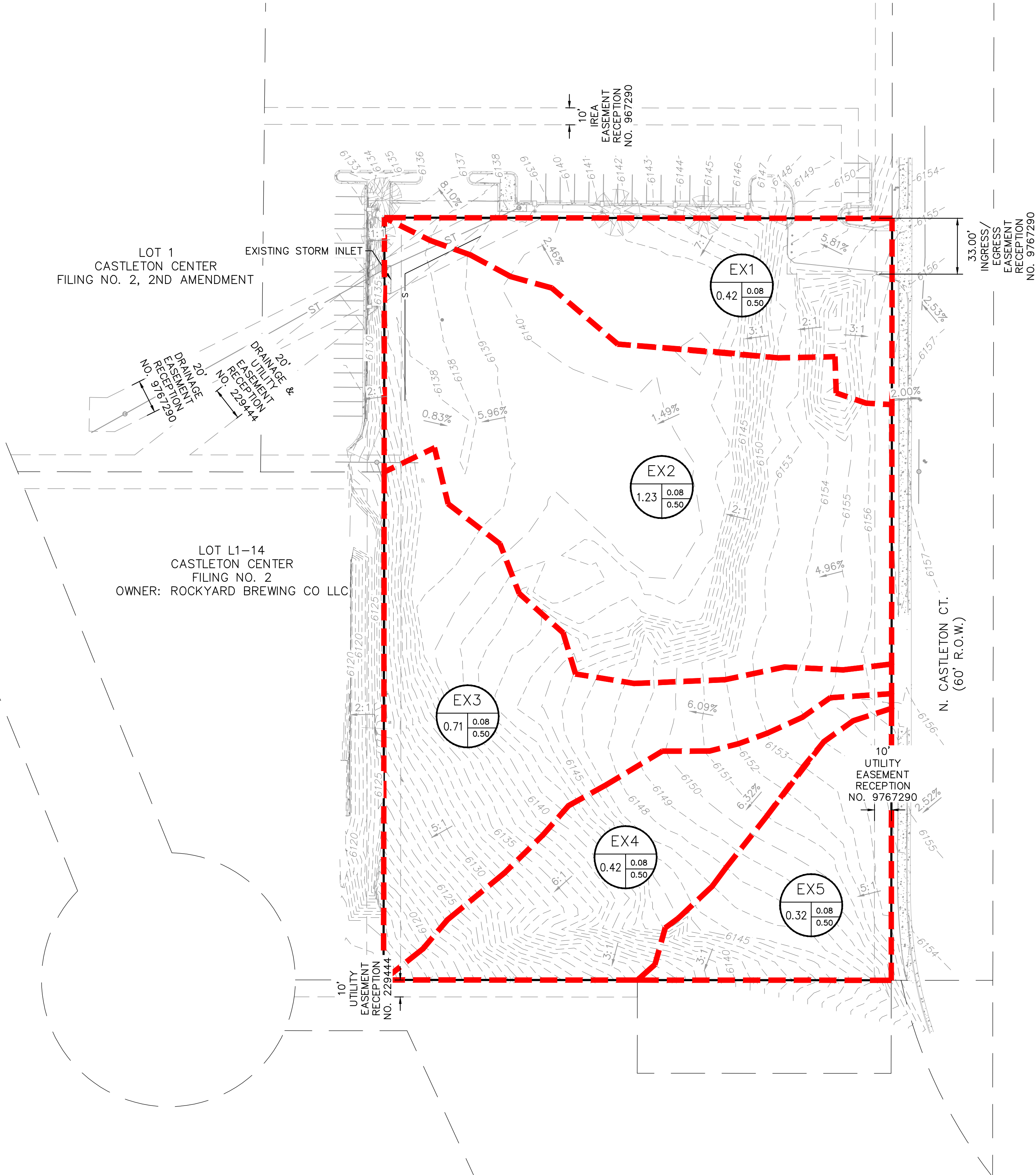
CONSULTANT | STUDIO | Architect Designer
3575 Ringsby Court 300A - Denver, CO - 80216

Kimley»Horn

CONSULTANT | KIMLEY-HORN | Civil Engineer
6200 South Syracuse Way, Suite 300 - Greenwood
Village, CO - 80111

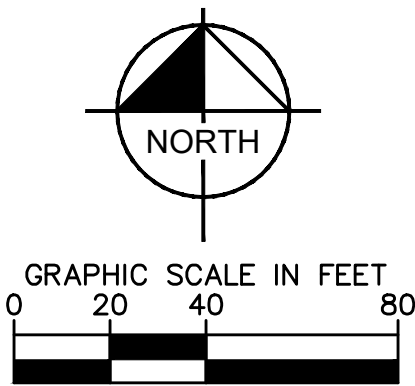
EXISTING DRAINAGE MAP

SDP25-0002



LEGEND

	PROPERTY LINE
	EXISTING EASEMENT
	R.O.W.
	EXISTING SLOPE
	EXISTING CONTOUR
	DRAINAGE BASIN BOUNDARY
	STORM INLET
	STORM MANHOLE
	SEWER MANHOLE
	FLARED END SECTION
	A = BASIN ID B = BASIN AREA (AC) C = 100-YR C-COEFFICIENT
	DESIGN POINT







~~WEST CASTLETON ROAD~~

LI-7
VACANT

	PROPOSED WATER
	EXISTING WATER
	PROPOSED SEWER
	EXISTING SEWER
	PROPOSED STORM
	EXISTING STORM
	FIRE HYDRANT
	GATE VALVE
	TEE W/KICK BLOCK
	BEND W/KICK BLOCK
	REDUCER
	BLOWOFF
	MANHOLE
	WATER SERVICE
	SEWER SERVICE
	STORM INLET

- 17,964 SF roof at 95% imp
- 5,373 SF concrete at 95% imp
- 46,687 SF asphalt at 95% imp
- 20,173 SF landscape at 20%imp
- 2.07 AC at 78% imp

These construction plans have been reviewed by Douglas County for street and drainage improvements only.

County Engineer Date 4/8/97

TST INC. OF DENVER

JOB NO. 10-055-003

SCALE
 $1"=30'$

DATE 20 FEBRUARY 1997

SHEETS	SHEET
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8 | 2

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10

APPENDIX F – PERMANENT WATER QUALITY WORKSHEET

Permanent Water Quality Determination Worksheet (Taken from 2019 SDDTCM Sections 13.1.4 and 13.1.5)

Project:		Project#		Applicant:
Section	Questions	Response	Check those that apply	Instructions
1	Non-applicable Sites			
1.1	Will the project result in a temporary disturbance of greater than one acre?	No Yes	☐ ☒	Proceed to section 1.2. Proceed to section 2.
1.2	Is the project part of a larger common plan of development or sale where multiple separate and distinct construction activities may be taking place at different times on different schedules, but remain related and are within 1/4 mile of each other? (A common plan of development will generally be documented on a site development plan, master plan, or equivalent, for the property/project)	No Yes	☐ ☐	Proceed to section 1.3. Proceed to section 2.
1.3	Is the project within the Cherry Creek Watershed?	Yes No	☐ ☐	Permanent water quality control measures may be required. Refer to Water Quality Control Regulation 72.7 for details and allowable exclusions. Permanent water quality control measures are not required.
2	Applicable Site Types and Exclusions by Variance			
2.1	Does the project have more than 35% impervious area on the existing site?	No Yes	☒ ☐	Project is an applicable Development Site. Proceed to section 3. Proceed to 2.2.
2.2	Does the project have greater than 75% impervious area on the existing site?	No Yes	☐ ☐	Project is an applicable Redevelopment Site. Proceed to section 3. Project is an applicable Constrained Redevelopment Site. Proceed to 2.3.
2.3	Will 100% of the runoff from the existing and proposed site be captured and treated using one or more of the allowable design standards for permanent water quality?	Yes No	☐ ☐	No further action required. Proceed to 2.4.
2.4	Do any other water quality exclusions apply to the site?	No Yes	☐ ☐	Portions of the project are excluded. Proceed with design in accordance with Constrained Redevelopment standards and apply for variance for <u>Constrained Redevelopment Sites</u> . Proceed to section 3. Following approval of other exclusions, design remaining site in accordance with Constrained Redevelopment standards and apply for variance for <u>Constrained Redevelopment Sites</u> .
3	Applicable Sites with Other Exclusions by Variance			
3.1	Category 1: Roadways, bridges and trails only			
3.1.1	Is the project a bike or pedestrian trail?	Yes No	☐ ☒	Proceed to next line. Proceed to 3.1.2.
	Is the trail for a roadway?	Yes No	☐ ☐	Proceed to 3.1.2. Project is excluded. Submit variance for <u>Trails Excluded from Permanent Water Quality Requirements</u> .
3.1.2	Is the project primarily used for parking or access to parking?	Yes No	☐ ☒	This exclusion does not apply. Permanent water quality is required. Proceed to 3.1.3.
3.1.3	Does the project add impervious area?	No Yes	☐ ☒	Project is excluded. Submit variance for <u>Pavement Management Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.1.4.

Section	Questions	Response	Check those that apply	Instructions
3.1.4	Does the project add more than 8.25 feet of paved width at any location to the existing roadway?	No Yes	☐ ☒	Project is excluded. Submit variance for <u>Roadway Redevelopment Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
	Does the project add more than one acre of paved area per mile to an existing roadway?	No Yes	☐ ☒	Project is excluded. Submit variance for <u>Roadway Redevelopment Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
	Does the project increase the width by two times or more, on average, of the original roadway area?	No Yes	☐ ☒	Existing areas of site are excluded only. Submit variance for <u>Existing Roadway Surfaces Only Excluded from Permanent Water Quality Requirements</u> . This exclusion does not apply. Permanent water quality is required.
3.2	Category 2: Non-residential and non-commercial projects only			
3.2.1	Is the project associated with oil and gas exploration, production, processing, or treatment operations or transmission facilities, including activities necessary to prepare a site for drilling and the movement and placement of drilling equipment?	Yes No	☐ ☒	Project is excluded. Submit variance for <u>Oil and Gas Exploration Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.2.2.
3.2.2	Is the project for stream stabilization?	Yes No	☐ ☒	Project is excluded. Submit variance for <u>Stream Stabilization Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.2.3.
3.2.3	Is the project for installation or maintenance of aboveground or underground utilities or infrastructure that does not permanently alter the terrain, ground cover, or drainage patterns from those present prior to the construction activity including activities to install, replace or maintain utilities under roadways or other paved areas that return the surface to the same condition?	Yes No	☐ ☒	Project is excluded. Submit variance for <u>Aboveground and Underground Utilities Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.2.4.
3.2.4	Is the project on undeveloped land (land with no human-made structures such as buildings or pavement) that will remain undeveloped after the project?	Yes No	☐ ☒	Project is excluded. Submit variance for <u>Sites with Land Disturbances to Undeveloped Land that will Remain Undeveloped Excluded from Permanent Water Quality Requirements</u> . Proceed to 3.2.5.
3.2.5	Will the post-project condition result in surface water discharge during the 80th percentile storm runoff event?	No Yes	☐ ☒	Project is excluded. Submit study along with variance for <u>Non-residential and Non-commercial Infiltration Conditions Excluded from Permanent Water Quality Requirements</u> . This exclusion does not apply. Permanent water quality is required.
3.3	Category 3: Residential, Agricultural and Commercial projects			
3.3.1	Is the project a single-family residential lot, or agricultural zoned lands, greater than or equal to 2.5 acres in size per dwelling unit?	Yes No	☐ ☒	Proceed to next line. Proceed to 3.3.2.
	Is the project site greater than 10% impervious?	No Yes	☐ ☒	Project is excluded. Submit variance for <u>Large Lot Single Family Sites Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
	Is the project site greater than 20% impervious?	Yes No	☒ ☐	This exclusion does not apply. Permanent water quality is required. Proceed to next line.
	Will the post-project condition result in surface water discharge during the 80th percentile storm runoff event?	No Yes	☐ ☒	Project is excluded. Submit study along with variance for <u>Large Lot Single Family Sites Excluded from Permanent Water Quality Requirements</u> . This exclusion does not apply. Permanent water quality is required.

Section	Questions	Response	Check those that apply	Instructions
3.3.2	Will 100% of the runoff from the residential or commercial site be captured?	Yes	☐	This exclusion does not apply. Permanent water quality is required.
		No	☒	Proceed to next line.
	Is all or a portion of the site undeveloped or will it remain undeveloped after construction?	Yes	☐	This portion of the project is excluded. Submit variance for <u>Sites with Land Disturbance to Undeveloped Land that will Remain Undeveloped Excluded from Permanent Water Quality Requirements</u> . Proceed to next line.
		No	☒	Proceed to next line.
	Is the remaining untreated impervious area greater than 20% of the site?	Yes	☐	This exclusion does not apply. Permanent water quality is required.
		No	☒	Proceed to next line.
	Is the remaining untreated impervious area greater than one acre?	Yes	☐	This exclusion does not apply. Permanent water quality is required.
		No	☒	Proceed to next line.
	Is it practicable to capture runoff from portions of the site that will not drain to a control measure?	No	☒	Document justification demonstrating that it is not practicable to capture runoff from this portion of the site in the drainage report . No further action is needed.
		Yes	☐	This exclusion does not apply. Permanent water quality is required.

APPENDIX G – MS4 COMPLIANCE SUMMARY



Summary of Water Quality Conformance to MS4 Permit

The purpose of this worksheet is to document conformance with the Town of Castle Rock's MS4 permit with regard to permanent water quality on land disturbance projects.

Project Name Castleton Heights

Project Owner TWG Development

Project Location Lot 31, Castleton Center Filing No. 2

ToCR Project Number SDP25-0002

Total Site Area 3.10 acres

Total Size of Common Plan of Development 3.10 acres

Check all that apply:

☐ **Project within Plum Creek Basin**

☐ **Project within Cherry Creek Basin**

Estimated construction completion date 3/6/26

1. The water quality control measure(s) for applicable development sites shall meet one of the following base design standards as per the SDDTCM Section 14.4. Please select all design standards that were applied to meet conformance with the MS4 on this site.

☒ WQCV standard **R1**

☒ Pollutant removal standard **A1-A4**

☒ Runoff reduction standard **OS1-OS6**

☐ Applicable site draining to regional WQVC control measure (accepts drainage prior to discharging to WOTS)

☐ Applicable site draining to regional WQVC control facility (with receiving pervious area control measure upstream of WOTS)

☐ Constrained redevelopment sites standard

• Imperviousness of existing site _____/_____ (Imp. Ac/Site Ac) = ____%

• Variance required TCV No. _____

☐ Existing control measure with WQCV per previous criteria standards

• Reference Construction Permit No. _____

☐ Cherry Creek Basin only, choose one: ☐ Tier 1 ☐ Tier 2 ☐ Tier 3

☐ No control measures provided (See Permanent WQ Worksheet for applicability)

Summary of Water Quality Conformance to MS4 Permit

2. Was an exclusion to water quality applied as per SDDTCM Section 13.1.5? ☐ Yes ☒ No

i. If yes, please select all that apply, provide total excluded impervious area(s) and submit variance, as applicable: TCV No. _____

- ☐ Pavement management site
Excluded impervious area: _____ acres
- ☐ Excluded roadway redevelopment
Excluded impervious area: _____ acres
- ☐ Excluded existing roadway areas
Excluded impervious area: _____ acres
- ☐ Above ground and below ground utilities
- ☐ Large lot single family home
- ☐ Non-residential and non-commercial infiltration
Excluded impervious area: _____ acres
- ☐ Land disturbance for land to remain undeveloped
Excluded impervious area: _____ acres
- ☐ Stream Stabilization Sites
Excluded impervious area: _____ acres
- ☐ Trails
Excluded impervious area: _____ acres
- ☐ Oil and Gas Exploration

3. For Development and Redevelopment sites, following any exclusions claimed above, was any portion of the site excluded up to 20% of the site and not to exceed one acre? ☒ Yes ☐ No

If yes, complete the following:

Excluded area: 0.14 acres

Total Site area: 3.10 acres, 4.5% % site excluded

4. For Constrained sites, was any portion of the site excluded up to 50% of the site and not to exceed 50% of the impervious area? ☐ Yes ☐ No

If yes, complete the following:

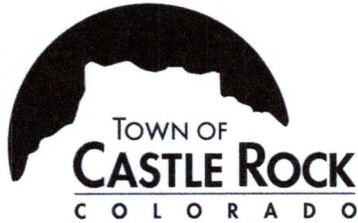
Excluded area: _____ acres

Excluded impervious area: _____ acres

Total Site area: _____ acres, _____ % site excluded

Total Impervious area: _____ acres, _____ % impervious excluded

APPENDIX G – MS4 COMPLIANCE SUMMARY



Development Services
100 N. Wilcox Street
Castle Rock, CO 80104
720-733-2200 FAX 720-733-2231

NO. TCV25-0002

DATE 07.22.2025

TECHNICAL CRITERIA VARIANCE APPLICATION

DEVELOPMENT Castleton Heights SDP 25-0002

LEGAL DESCRIPTION OF SUBJECT PROPERTY

Lot 3A, Castleton Center Filing No. 2, 2nd Amendment, as described in lot line vacation approval certificate recorded November 26, 2001 in Book 2189 at Page 2159, county of Douglas, state of Colorado.

VARIANCE REQUESTED:

Code Section(s) 13.2.3 ...Underground detention is discouraged and only allowed by Variance based on merit and limited circumstances.

Describe the Variance Requested

A variance is requested to detain ~4,000 CF in an underground vault. This number represents the change in runoff generated by the site in the current proposed design from that generated by the assumed future site based on the plans. All other detention will be provided in an existing subregional detention pond installed on Lot 1 to the west.

1. Describe the exceptional situation or condition that exists

Existing conditions are bulleted below and described in more detail in the supporting documents.

- The site sits above the adjacent properties on 3 sides and no suitable emergency overflow path exists
- steep grades along the property lines limit the ability to provide detention storage volume and vehicular maintenance
- The available space for detention lies within a differential use buffer in which planning requires trees to be used for screening
- Retaining walls are necessary to connect the site to N Castleton Way which further limits the available area for storage

2. Describe the difficulty or hardship that would be created by a strict enforcement of the code

Alternative options have been exhausted and no viable alternatives to underground detention were found. Any detention provided onsite would create the following undesirable conditions:

- Emergency overflow paths crossing developed private property
- Retaining walls immediately adjacent to pond water surfaces

3. Describe why there would not be any adverse impact on public health, safety and welfare

It is the engineer's opinion that underground detention is a beneficial alternative to above ground detention because it may be placed far enough away from retaining walls to avoid potential saturated soil failures and that a piped emergency overflow is preferable to an overland one since the site sits higher than its neighbors

Additional Information: Please see P3 and beyond

1. Attach an improvement survey.
2. Attach a drawing showing the intended uses.
3. Provide any other information helpful to discussion.

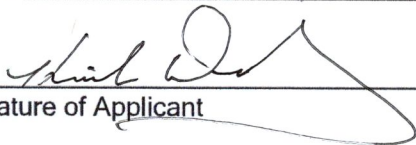
PROPERTY OWNER

Name: Kirk Drabing

Address: 3027 Vallejo Street
Denver, CO 80211

Phone #: 303 378 6068

Fax #: _____


Signature of Applicant

For Staff Use Only

Staff Recommendation: Approved ☒ Yes ☐ No

Signed by:

Mark Marlowe

Signature

- ☐ Public Works Director
- ☒ Director of Castle Rock Water
- ☐ Parks & Recreation Director
- ☐ Development Services Director

7/22/2025 | 1:35 PM MDT

Date

Comments

None

Conditions of Acceptance

None



June 11, 2025

Castle Rock Public Works
4075 Castleton Court
Castle Rock, CO 80109

RE: *Technical Criteria Variance Request for Underground Detention*

This letter is intended to demonstrate that all practical solutions have been explored to comply with SDDTCM section 13.2.3 and site constraints are such that a variance will be required for the project. The applicant requests to use an underground detention vault to provide approximately 4,000 CF of storage. This volume represents the difference between runoff generated by the proposed development and the runoff that was anticipated for the property per previous studies providing neighborhood detention.

DEFINITIONS

“Master Plan” Construction Plans for Castleton Center Filing No. 2 Lots LI-14, C-1, C-2, and a Part of C-3 prepared by TST Inc. of Denver and dated February 20, 1997. No associated drainage report for this development was found.

“Neighborhood Detention Pond” The pond within Lot 1 as proposed by the Master Plan. Lot 1 is currently occupied by Rockyard Brewing at 880 Castleton Road.

SITE DESCRIPTION

The project Site is located at 3161 North Castleton Court in Castle Rock, Colorado. It is described as Lot 3A Castleton Center Filing No. 2, 2nd Amendment. The property is 3.10 acres and is bounded to the north by an office building, to the east by North Castleton Court, to the south by Castleton Water and Sanitation District's well site, and to the west by Rockyard Brewing. The Site is located within the Town of Castle Rock, CO while its northern, southern and western neighbors are within unincorporated Douglas County. The Site is zoned B.

In the existing condition, the site is undeveloped with sparse grasses and fewer than 10 trees. The property generally slopes from east to west with an elevation ranging from 6157' to 6115'. An NRCS Web Soil Survey shows all soil onsite falls within hydrologic soil group classification type D. The Site has no drainageways within its bounds and is in flood hazard zone X. The Site lies on and within the southern border of the Tributary C watershed, which flows from east to west into East Plum Creek.

An Existing Conditions map is shown in **Appendix A**.

PROPOSED DEVELOPMENT

The proposed development consists of a 20,000 SF multifamily building with associated parking lots, sidewalks, and utilities. Retaining walls are proposed on the northern, western, and southern sides of the development.

Runoff generated onsite generally flows from east to west towards inlets in sump conditions where it will travel through underground private storm sewer to the northwest corner of the site and connect to the existing public storm sewer leading to the neighborhood detention pond. This connection will be made at an existing inlet that was installed to serve the Site.

The proposed development has a higher impervious area than the site plan assumed by the Master Plan. To stay within the constraints of the Master Plan and use the existing pond without modifications, some detention will need to be provided onsite. The detention vault proposed will provide full spectrum detention for approximately 0.50 acres of the site in order to reduce developed runoff conveyed to the neighborhood pond. Detention for the rest of the site will be provided in the existing, offsite pond.

Water quality treatment for the area tributary to the underground detention vault will be provided by detaining the WQCV and draining it in 40 hours per Section 14.4.1. Water quality treatment for this area not tributary to the onsite vault will be provided through the use of a hydrodynamic separator satisfying the pollutant removal standard noted in Section 14.4.2.

SITE CONSTRAINTS

The Site's existing topographical fall from east to west varies from 17' to 39' and at the property is vertically situated above developed private property to the north, west, and east. This does not allow for a safe emergency overflow path for any above ground detention facility installed on the Site. North Castleton Court could provide a suitable emergency overflow path but is the high point of the Site.

Onsite detention was not anticipated for the Site during the creation of the Master Plan, so storm sewer and sanitary sewer infrastructure was placed in the northwest corner of the site adjacent to the inlet which serves as the storm outfall. This infrastructure and associated easements eliminate approximately 2,200 SF from the area available for detention.

Slopes along the property lines in the northwest corner of the Site (where the existing curb inlet serves as the Site's planned outfall) vary from three to eight percent. An above ground detention facility is further limited in its size due to the additional area required by the grade change.

The topography of the Site necessitates the use of retaining walls in order to provide an accessible route and drive aisles that meet Town standards for slopes. Infiltration or reduced-pervious ground covers were not designed to be placed above the walls as a safety consideration to eliminate the chance of negative interaction with the retaining walls. Above-ground detention was considered below the retaining walls, but the space required for grade adjustments to keep water levels below the wall foundations exceeds the available space.

The proposed multifamily building is required to provide an enhanced landscaping buffer as well as screening from the neighboring commercial uses. While detention is allowed in this buffer, no trees may be planted in the detention pond limiting the Site's screening ability.

DESIGN ALTERNATIVES

An above ground extended detention basin was considered the primary alternative but the required storage volumes were not achievable in the space available onsite. The maximum achievable storage volume and site constraints are shown in the **Appendix C**.

Runoff reduction was explored to reduce the runoff generated by the site, but opportunities for decreased and/or disconnected impervious area were not available. The provided off-street parking is at code minimum and drive aisles are sized only to fit the turning movements of the required fire trucks. Because the west half of the Site is very steep, extending the Site west to provide a grass buffer in the parking lot would increase the height of the retaining walls dramatically.

Sand filters, rain gardens, and porous landscape detention were not considered below the retaining walls as they provide less storage volume than an EDB due to the required media reducing the available depth. The landscape islands were considered as potential PLD locations, but do not have sufficient volume to reduce the need for underground detention. At a 4:1 slope these landscape islands would provide negligible storage volume; with 30" vertical walls these islands would provide 256 CF of storage each (768 CF/0.02 AC-FT total) which is far less than the required storage volume. A variance to use retaining walls beyond 30" was not pursued as it was deemed to be an unsafe design. The three interior landscape islands were considered for PLD and the exterior landscape islands do not provide an opportunity for stormwater treatment as the geogrid from the retaining wall would conflict with underground piping. Open space directly adjacent to the building does not have conflicts but could not achieve the depths required to pick up the roof drain laterals.

IMPACTS OF THE REQUESTED VARIANCE

It is the opinion of the applicant that an underground detention vault is a safer alternative to other means of detention. The proposed variance would eliminate an above ground emergency overflow path that would drain onto neighboring properties and structures. A concrete vault is also seen as the option with the lowest risk of negative interaction with the proposed retaining walls. The vault will be accessed from an asphalt parking lot with typical slopes, whereas an above ground basin would need an access road at the steepest allowable slope to maximize storage.

All storm infrastructure onsite will be owned and maintained by the property owner, and their assigns. An Operations and Maintenance Plan is submitted with the SDP package and the applicant is open to additional considerations required for the use of an underground vault.

To comply with the Master Plan, the proposed detention vault is required to have a tributary area of approximately half an acre of impervious area. The subject property is 3.1 acres and the detention vault will make up a small portion of the stormwater management for the Site.



We Appreciate your attention and support of this request. Please contact me at (303) 228-2339 or bryce.christensen@kimley-horn.com should you have any questions.

Sincerely,

A handwritten signature in blue ink, appearing to read 'B. Christensen'.

Bryce Christensen, P.E.
Project Manager

ENCLOSURES:

APPENDIX A: Existing Site Map

APPENDIX B: Proposed Drainage Map

APPENDIX C: Available Above Ground Detention

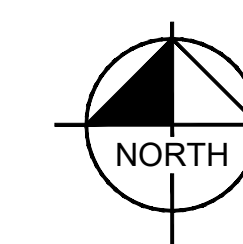
APPENDIX D: Owner Authorization

APPENDIX E: Master Plan Excerpts



APPENDIX A: Existing Site Map

	PROPERTY LINE
	EXISTING EASEMENT
	PROPOSED EASEMENT
	R.O.W.
	PROPOSED SLOPE
	EXISTING SLOPE
	EXISTING CONTOUR
	PROPOSED CONTOUR



Kimley»»Horn

6200 SOUTH SYRACUSE WAY
SUITE 300
GREENWOOD VILLAGE, COLORADO, 80111
303.228.2300

NOTE: THIS PLAN IS CONCEPTUAL IN NATURE



APPENDIX B: Proposed Drainage Map

K:\DEN_Civil\196273005_TWG - Castle Rock_CO\CADD\PlanSheets\Drainage Maps\DRN_P_1962733004.dwg Officiss, Cody 7/11/2025 3:50 PM
THIS DOCUMENT, TOGETHER WITH THE CONCEPTS & DESIGN PRESENTED HEREIN, AS AN INSTRUMENT OF SERVICE, IS INTENDED ONLY FOR THE SPECIFIC PURPOSE AND CLIENT FOR WHICH IT WAS PREPARED. REUSE OF & IMPROPER RELIANCE ON THIS DOCUMENT WITHOUT WRITTEN AUTHORIZATION & ADAPTATION BY NCU & KIMLEY-HORN & ASSOCIATES, INC. SHALL BE WITHOUT LIABILITY TO NCU & KIMLEY-HORN & ASSOCIATES, INC.

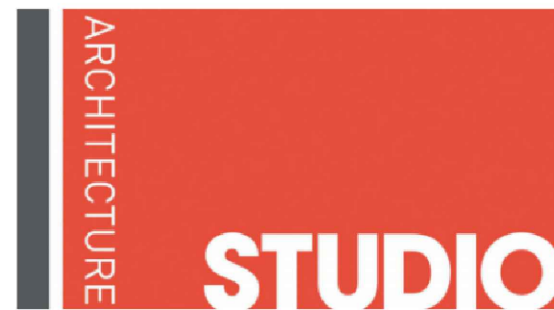
3161 N Castleton CT, Castle Rock CO 80104
CASTLETON HEIGHTS 6/3/2025

COPYRIGHT © 2022 STUDIO ARCHITECTURE

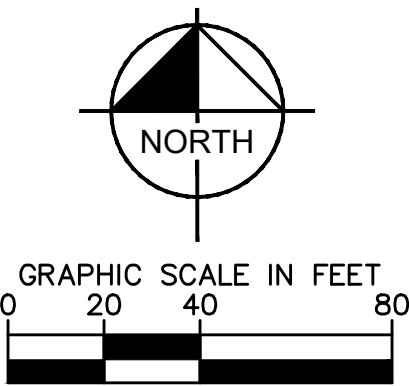
OWNER | TWG Development, LLC
1301 E. Washington Street, Suite 100
Indianapolis, IN 46202



TWG
DEVELOPMENT, LLC



CONSULTANT | STUDIO | Architect Designer
3575 Ringsby Court 300A - Denver, CO - 80216

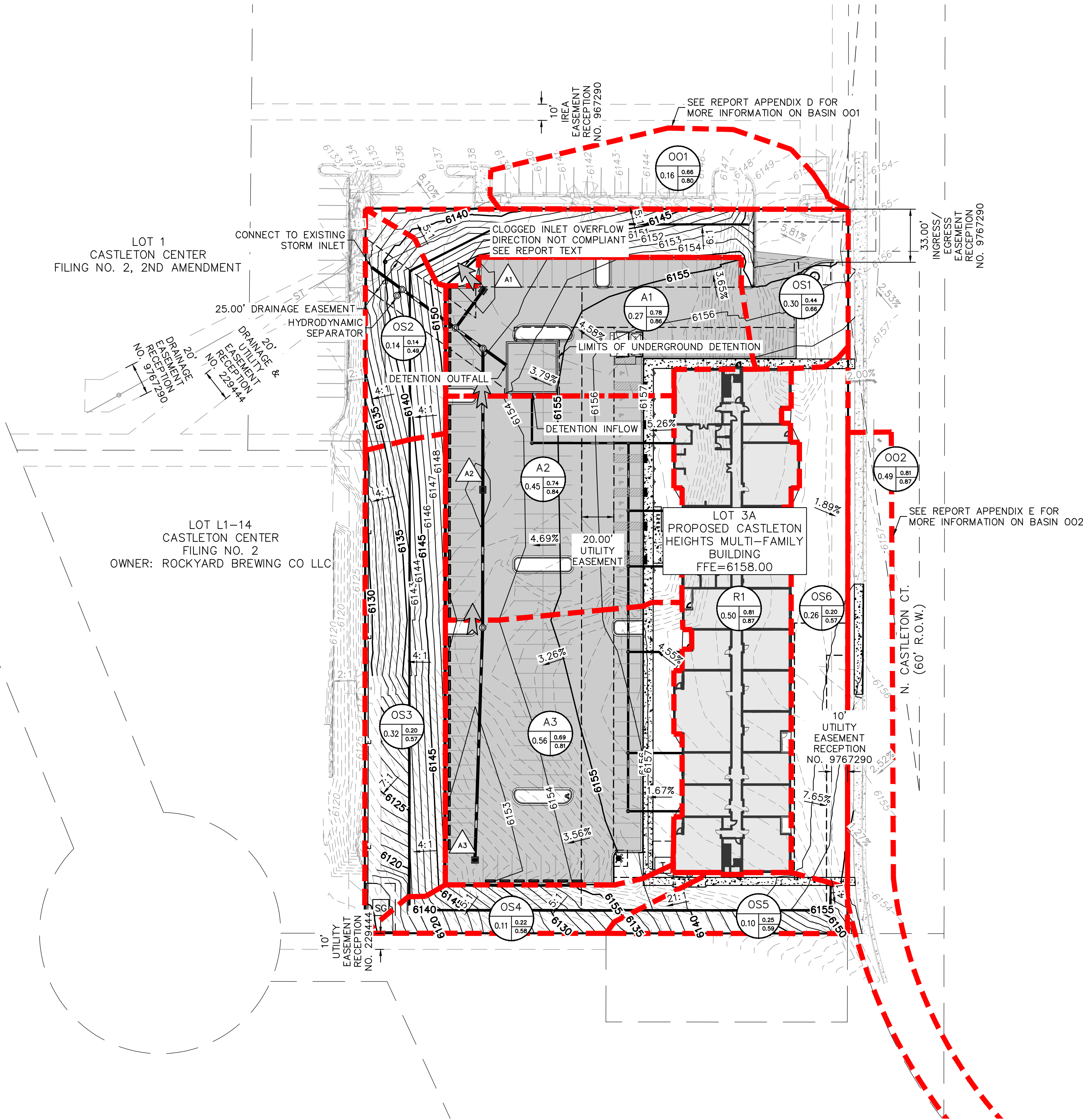


Kimley»Horn

CONSULTANT | KIMLEY-HORN | Civil Engineer
6200 South Syracuse Way, Suite 300 - Greenwood
Village, CO - 80111

PROPOSED DRAINAGE MAP

SDP25-0002

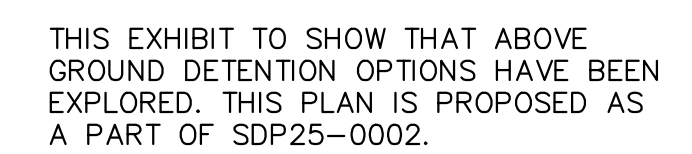


LEGEND

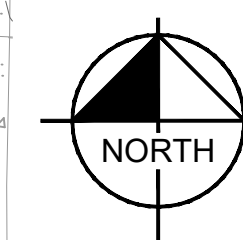
- PROPERTY LINE
- EXISTING EASEMENT
- PROPOSED EASEMENT
- R.O.W.
- PROPOSED SLOPE
- EXISTING SLOPE
- EXISTING CONTOUR
- PROPOSED CONTOUR
- PROPOSED STORM
- DRAINAGE BASIN BOUNDARY
- STORM INLET
- STORM MANHOLE
- SEWER MANHOLE
- FLARED END SECTION
- A = BASIN ID
B = BASIN AREA (AC)
C = 5-YR C-COEFFICIENT
D = 100-YR C-COEFFICIENT
- DESIGN POINT
- EMERGENCY OVERFLOW DIRECTION



APPENDIX C: Available Above Ground Detention



CASTLETON HEIGHTS
AVAILABLE DETENTION EXHIBIT
6/11/25



Kimley»»Horn

6200 SOUTH SYRACUSE WAY
SUITE 300
GREENWOOD VILLAGE, COLORADO, 80111
303.228.2300



APPENDIX D: Owner Authorization

January 16, 2025

RE: Property Owner Approval Letter for 3161 North Castleton Court, Castle Rock, CO 80109

To whom it may concern:

I am the owner/seller of the property mentioned above and I approve of TWG's forthcoming development submittal and land use application.

Sincerely,

A handwritten signature in black ink, appearing to read "Kirk Drabing", with a stylized flourish at the end.

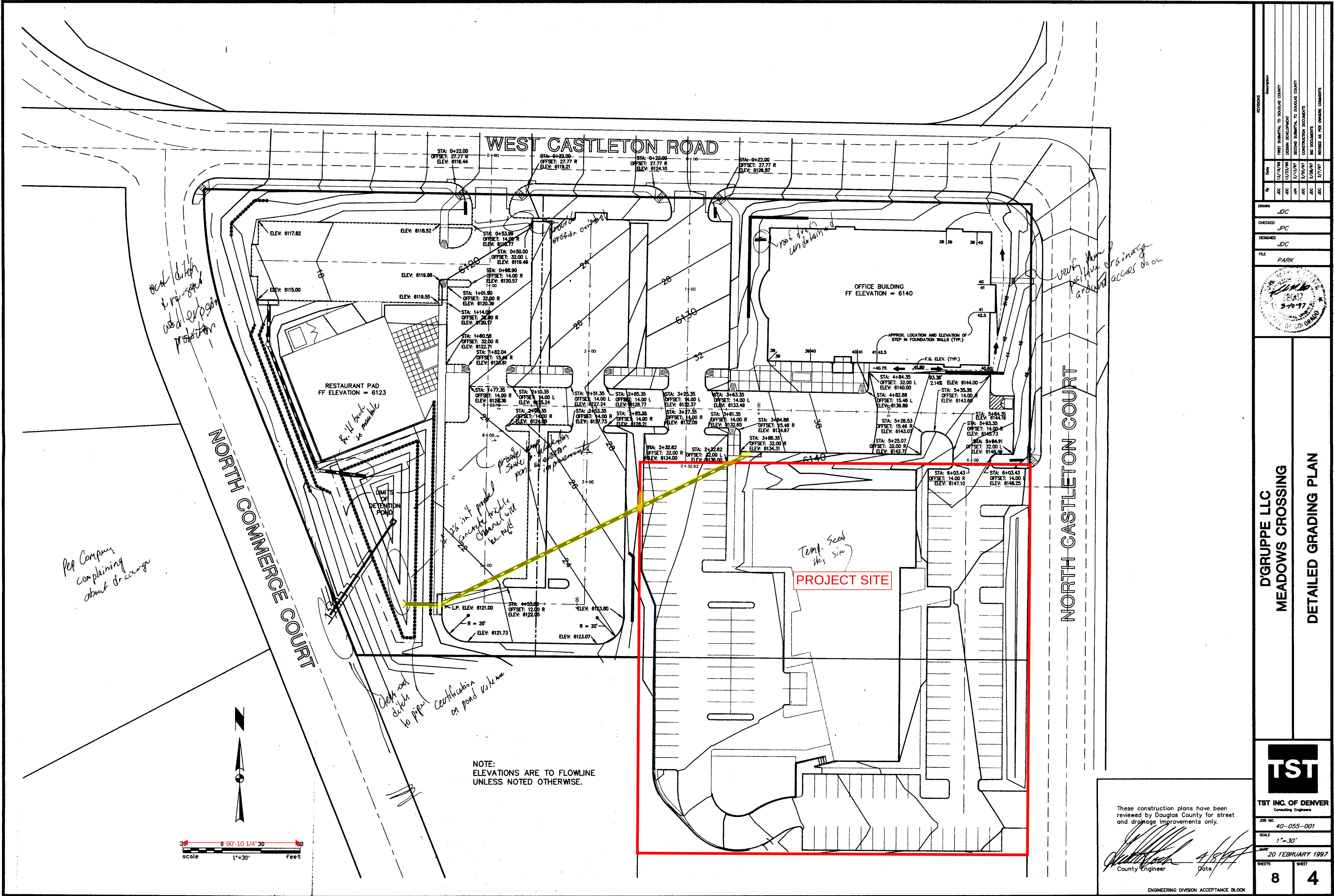
Kirk Drabing, Enterprise LTD

303-378-6068

kirkdrabing@gmail.com



APPENDIX E: Master Plan Excerpts



REVISIONS	
NO.	DESCRIPTION
1	12/15/96 FIRST SUBMITTAL TO DOUGLAS COUNTY
2	12/23/96 DESIGN DEVELOPMENT
3	2/13/97 SECOND SUBMITTAL TO DOUGLAS COUNTY
4	2/20/97 CONSTRUCTION DOCUMENTS
5	NO COMMENTS
6	REVISED AS PER OWNER COMMENTS

DRAWN	
JDC	
CHECKED JPC	
DESIGNED JDC	
FILE PARK	

D'GRUPPE LLC
MEADOWS CROSSING
DETAILED GRADING PLAN

These construction plans have been reviewed by Douglas County for street and drainage improvements only.

[Signature] 4/18/97
County Engineer Date

JOB NO.	SCALE	DATE	SHEETS	SHEET
40-055-001	1"=30'	20 FEBRUARY 1997	8	4

ENGINEERING DIVISION ACCEPTANCE BLOCK