# STORM DRAINAGE REPORT

***for***

# Hillcrest Property

**Olney, Maryland 20832**
**Montgomery County**

**Preliminary Plan No. 120230010**

July 14th, 2022
Revised: October 25, 2022


KIM ENGINEERING

1390 Piccard Drive, Suite 340
Rockville, Maryland 20850
240-614-7678


I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed Professional Engineer under the laws of the State of Maryland.

License No. 26286

10/25/2022

Expiration Date: 06/21/2023

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## OVERVIEW

The subject property is located on Hillcrest Avenue, 400ft east of Georgia Ave in Olney, Maryland and is identified as P846 and P829. The property is 0.64 acres in size with no 100-year floodplain or wetlands present. The site is zoned Commercial/Residential and is in the Patuxent watershed.

The owner proposes to demolish and remove an existing 1-story building and modular building and construct a 2-story office building with a parking lot. The disturbed area for the proposed site improvements encompasses 0.74 acres. The proposed development includes the office building and parking lot, grading, and the sidewalk along the frontage of the property.

## DRAINAGE ANALYSIS

For the purpose of this study, the site is broken into seven different drainage areas in its existing conditions, with drainage areas A and B being the main points of study. The drainage area to study point A drains to an existing curb inlet on Hillcrest Ave. The drainage area to study point B drains to an existing grate inlet in the rear of the adjacent property. These two drainage areas are impacted by the proposed conditions, whereas the remaining drainage areas remain unaffected.

Study points A and B, shown on the drainage area maps, have been analyzed to determine the peak flow to each point during different storm events at the pre-development and post-development stages.

When analyzing and comparing the existing and proposed conditions, two changes occur. A portion of the site that originally drained to study point B in the existing conditions, no longer drains to there in the proposed conditions due to the proposed on-site SWM devices. This results in a drainage area reduction for both study point B.

The second change that occurs is the change in pervious vs impervious area draining to study point A. A TR-55 analysis (**Appendix B**) was conducted to determine the impact of an increased impervious area draining to the existing curb inlet on the street capacity (or spread). The findings of this analysis can be found on page 4 of this report.

| Drainage Area & RCN Values | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Study Point A | Study Point B | Study Point C | Study Point D | Study Point E | Study Point F | Study Point G |
| Pre-Development | DA | 0.17 ac | 0.34 ac | 1.88 ac | 0.27 ac | 0.13 ac | 0.28 ac | 0.16 ac |
| | RCN | 91 | 85 | 86 | 89 | 92 | 93 | 96 |
| Post-Development | DA | 0.23 ac | 0.12 ac | 1.88 ac | 0.27 ac | 0.13 ac | 0.28 ac | 0.16 ac |
| | RCN | 92 | 93 | 87 | 92 | 92 | 93 | 96 |

## STUDY POINT A – EXISTING CURB INLET ANALYSIS

### STORM DRAIN DESIGN

The drainage area flowing to study point A enters an existing curb inlet that is in front of the adjacent property in the right-of-way. The inlet has an existing 33" RCP pipe that outfalls behind the adjacent property.

| **Existing Conditions** | | **Proposed Conditions** | |
|---|---|---|---|
| Drainage Area = | 0.17 Acres | Drainage Area = | 0.23 Acres |
| Hydrologic Soil Groups = | B- 100% | Hydrologic Soil Groups = | B - 100% |
| Tc = | 7 Minutes | Tc = | 7 Minutes |
| Weighted CN = | 91 | Weighted CN = | 92 |

Since the drainage area is less than 2.0 acres, the time of concentration (Tc) was determined using Table 3-3 in the MCDOT Drainage Design Manual. A Curve Number has been selected appropriately. This data has been used to determine the peak flows during the 2, 10, and 25-year storm event using the TR-55 program. The results are shown in **Appendix B**.

| | Peak Flow | |
|---|---|---|
| | Existing Conditions | Proposed Conditions |
| 2-Year Storm | 0.57 cfs | 0.79 cfs |
| 10-Year Storm | 0.97 cfs | 1.32 cfs |
| 25-Year Storm | 1.25 cfs | 1.69 cfs |

## STUDY POINT A (STRUCTURE 8/8A) - SPREAD ANALYSIS

**Spread Analysis: Pre-Development Structure 8/8A**

n = 0.013
$S_x$ = 0.033 ft/ft
S = 0.01 ft/ft
$Q_{10}$ = 0.97 cfs

$$\text{Spread, } T = \left( \frac{Q_{10} \times n}{(0.56)(S_x^{1.67})(S^{0.5})} \right)^{0.375}$$

$$\text{Spread, } T = \left( \frac{0.97 \times 0.013}{(0.56)(0.033^{1.67})(0.01^{0.5})} \right)^{0.375}$$

**T = 4.8 ft OK** ($T_{max}$ = 8 feet)

**Spread Analysis: Post-Development Structure 8/8A**

n = 0.013
$S_x$ = 0.033 ft/ft
S = 0.01 ft/ft
$Q_{10}$ = 1.32 cfs

$$\text{Spread, } T = \left( \frac{Q_{10} \times n}{(0.56)(S_x^{1.67})(S^{0.5})} \right)^{0.375}$$

$$\text{Spread, } T = \left( \frac{1.32 \times 0.013}{(0.56)(0.033^{1.67})(0.01^{0.5})} \right)^{0.375}$$

**T = 5.4 ft OK** ($T_{max}$ = 8 feet)

Although post-development conditions do cause an increase in flow to the Structure 8/8A, the post-development spread still remains below the accepted amount by county standards.

When accounting for the bypass from the upstream inlet at Structure #10, the following results are obtained for the post-development conditions:

**Spread Analysis: Structure 10**

n = 0.013
$S_x$ = 0.033 ft/ft
S = 0.01 ft/ft
$Q_{10}$ = 0.73 cfs

$$\text{Spread, } T = \left( \frac{Q_{10} \times n}{(0.56)(S_x^{1.67})(S^{0.5})} \right)^{0.375}$$

$$\text{Spread, } T = \left( \frac{0.73 \times 0.013}{(0.56)(0.033^{1.67})(0.01^{0.5})} \right)^{0.375}$$

**T = 4.33 ft OK** ($T_{max}$ = 8 feet)

**Inlet Efficiency: Structure 10**

L = 10 ft
$L_T$ = 13.8 ft ← Obtained via Equation 4-3 of MCDOT Drainage Manual

$E = 1 - (1 - L/L_T)^{1.8}$

$E = 1 - (1-10/13.8)^{1.8}$

E = 90%

Efficiency Lost, $E_L$ = 10%

Flow Uncaptured, $Q_U = E_L * Q$

$Q_U$ = 0.10 * 0.73 cfs = **0.073 cfs**

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The spread at Structure 10 is 4.33 ft which is acceptable by county standards. 90% of the flow at Structure 10 is captured, therefore 10% of the flow, 0.073 cfs, bypasses Structure 10 and travels to Structure 8/8A. This bypass or uncaptured flow, $Q_U$, has been added to the original flow rate, $Q_{10}$, to give an adjusted flow rate, $Q_A$.

**Spread Analysis + Bypass: Structure 8/8A**

$n = 0.013$
$S_x = 0.033$ ft/ft
$S = 0.01$ ft/ft
$Q_{10} = 1.320$ cfs
$Q_A = Q_{10} + Q_U = 1.320 + 0.073 = 1.393$ cfs

$$\text{Spread, } T = \left[\frac{Q_A \times n}{(0.56)(S_x^{1.67})(S^{0.5})}\right]^{0.375}$$

$$\text{Spread, } T = \left(\frac{1.393 \times 0.013}{(0.56)(0.033^{1.67})(0.01^{0.5})}\right)^{0.375}$$

**T = 5.52 ft**

When accounting for the bypass from Structure 10, the spread at Structure 8/8A increases to 5.52 ft which is still an acceptable amount by county standards.

**Sump Inlet Spread**

The curb inlet at Study Point A is a low point, therefore 100% of flow is captured at this point and a sump inlet spread analysis needs to be conducted to determine whether the depth of water ponding at the inlet is less than the 1-ft accepted amount.

$$Q = 3.0 * L * d^{1.5}$$

$$1.393 \text{ cfs} = 3.0 * 10' * d^{1.5}$$

**D = 0.129 ft** < 1ft, therefore acceptable

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## STUDY POINT B – EXISTING GRATE INLET ANALYSIS

**Hydrology**

| **Existing Conditions** | | **Proposed Conditions** | |
|---|---|---|---|
| Drainage Area = | 0.34 Acres | Drainage Area = | 0.12 Acres |
| Hydrologic Soil Groups = | B- 100% | Hydrologic Soil Groups = | B - 100% |
| Tc = | 7 Minutes | Tc = | 5 Minutes |
| Weighted CN = | 85 | Weighted CN = | 93 |

Since the drainage area is less than 2.0 acres, the time of concentration (Tc) was determined using Table 3-3 in the MCDOT Drainage Design Manual. A Curve Number has been selected appropriately.

This data has been used to determine the peak flows during the 2, 10, and 25-year storm event using the TR-55 program. The results are shown in **Appendix B**.

| | Peak Flow | |
|---|---|---|
| | Existing Conditions | Proposed Conditions |
| 2-Year Storm | 0.89 cfs | 0.44 cfs |
| 10-Year Storm | 1.66 cfs | 0.73 cfs |
| 25-Year Storm | 2.22 cfs | 0.93 cfs |

The results from the TR-55 program show a clear reduction in flow traveling to the existing grate inlet due to the decrease in drainage area. It can safely be assumed that the existing grate inlet is not negatively impacted by the post-development conditions.

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## STORM DRAIN COMPUTATIONS

Storm drain computations have been conducted to examine the flow, velocity, and normal depth of storm water in the existing storm drain system under the proposed conditions in a 10-year storm (**See Appendix C**). The normal depth of water throughout the storm drain system does not exceed any of the pipe sizing. We can conclude that the storm drain system is adequately sized for the proposed conditions of our site.

## CONCLUSION

Overall, the post-development conditions will have minimal impact on the existing storm drain system on Hillcrest Ave. The existing grate inlet (Structure 6) in the adjacent property that originally had a portion of our property draining towards it, no longer has any part of our property in its drainage area. This lessens the overall drainage area entering the existing storm drain system and outfalling at Outfall Structure 1.

Although the proposed conditions increase the imperviousness and flow rate within the drainage area going to Study Point A, the effects of this on the spread are relatively minor as the spread increases by 0.6 ft and remains well within the acceptable amount of spread by county standards. The storm drain computations show that the sizing of the current storm drain system is adequately sized to convey water from the 10-year storm.

The storm drain runoff from the site eventually discharges into a stream north of the property. Since there are no structures within 500 feet from the site discharge points, no downstream analysis was performed.

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# Appendix A

# Runoff Coefficient

# Computations

## STUDY POINT A

**Existing Conditions**

Open Space, Lawns, etc. = 1,481 sf = 0.034 ac

HSG – B; 2-7% → C = 0.16

Impervious Area = 5,967 sf = 0.137 ac

HSG – B; 2-7% → C = 0.90

$C_{WEIGHTED} = \Sigma C_X A_X / A_{TOTAL}$

$C_{WEIGHTED}$ = [0.16(0.034) + 0.90(0.137)] / (0.034+0.137) = 0.753

0.65 < 0.753 < 0.79 ← MCDOT Drainage Design Criteria Table 3-3

Therefore, **TC = 7 minutes**

**Proposed Conditions**

Open Space, Lawns, etc. = 1,555 sf = 0.036 ac

HSG – B; 2-7% → C = 0.16

Impervious Area = 8,286 sf = 0.190 ac

HSG – B; 2-7% → C = 0.90

$C_{WEIGHTED} = \Sigma C_X A_X / A_{TOTAL}$

$C_{WEIGHTED}$ = [0.16(0.036) + 0.90(0.190)] / (0.036+0.190) = 0.782

0.65 < 0.782 < 0.79 ← MCDOT Drainage Design Criteria Table 3-3

Therefore, **TC = 7 minutes**

**Table 3-3 – Small Drainage Area Time of Concentration**

| 'C' Factor | TC (minutes) |
|---|---|
| ≥ 0.8 | 5 |
| 0.65-0.79 | 7 |
| 0.40-0.64 | 10 |
| ≤ 0.39 | 15 |

## STUDY POINT B

**Existing Conditions**

Open Space, Lawns, etc. = 376 sf = 0.009 ac

HSG – B; 2-7% → C = 0.16

Open Space, Lawns, etc. = 4,853 sf = 0.111 ac

HSG – B; >7% → C = 0.21

Impervious Area = 9,540 sf = 0.219 ac

HSG – B; 2-7% → C = 0.90

$C_{WEIGHTED} = \Sigma C_X A_X / A_{TOTAL}$

$C_{WEIGHTED}$ = [0.16(0.009) + 0.21(0.111) + 0.90(0.219)] / (0.009 + 0.111 + 0.219) = 0.654

0.65 < 0.654 < 0.79 ← MCDOT Drainage Design Criteria Table 3-3

Therefore, **TC = 7 minutes**

**Proposed Conditions**

Open Space, Lawns, etc. = 238 sf = 0.005 ac

HSG – B; 2-7% → C = 0.16

Open Space, Lawns, etc. = 496 sf = 0.011 ac

HSG – B; >7% → C = 0.21

Impervious Area = 8376 sf = 0.100 ac

HSG – B; 2-7% → C = 0.90

$C_{WEIGHTED} = \Sigma C_X A_X / A_{TOTAL}$

$C_{WEIGHTED}$ = [0.16(0.005) + 0.21(0.011) + 0.90(0.100)] / (0.005 + 0.011 + 0.100) = 0.803

0.803 > 0.8 ← MCDOT Drainage Design Criteria Table 3-3

Therefore, **TC = 5 minutes**

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## STUDY POINT C

**Existing Conditions**

Open Space, Lawns, etc. = 24,870 sf = 0.571 ac

HSG – B; 2-7% → C = 0.16

Open Space, Lawns, etc. = 2,593 sf = 0.060 ac

HSG – D; 2-7% → C = 0.24

Impervious Area = 54,410 sf = 1.249 ac

HSG – B; 2-7% → C = 0.90

$C_{WEIGHTED} = \Sigma C_X A_X / A_{TOTAL}$

$C_{WEIGHTED}$ = [0.16(0.571) + 0.24(0.060) + 0.90(1.249)] / (0.571 + 0.060 + 1.249) = 0.654

0.65 < 0.654 < 0.79 ← MCDOT Drainage Design Criteria Table 3-3

Therefore, **TC = 7 minutes**

## STUDY POINT D

**Existing Conditions**

Open Space, Lawns, etc. = 2,820 sf = 0.065 ac

HSG – B; 2-7% → C = 0.16

Impervious Area = 9,043 sf = 0.208 ac

HSG – B; 2-7% → C = 0.90

$C_{WEIGHTED} = \Sigma C_X A_X / A_{TOTAL}$

$C_{WEIGHTED}$ = [0.16(0.065) + 0.90(0.208)] / (0.065+0.065) = 0.724

0.65 < 0.724 < 0.79 ← MCDOT Drainage Design Criteria Table 3-3

Therefore, **TC = 7 minutes**

## STUDY POINT E

**Existing Conditions**

Open Space, Lawns, etc. = 956 sf = 0.022 ac

HSG – B; 2-7% → C = 0.16

Open Space, Lawns, etc. = 86 sf = 0.002 ac

HSG – D; 2-7% → C = 0.24

Impervious Area = 4,767 sf = 0.109 ac

C = 0.90

$C_{WEIGHTED} = \Sigma C_X A_X / A_{TOTAL}$

$C_{WEIGHTED}$ = [0.16(0.022) + 0.24(0.002) + 0.90(0.109)] / (0.022 + 0.002 + 0.109) = 0.766

0.65 < 0.766 < 0.79 ← MCDOT Drainage Design Criteria Table 3-3

Therefore, **TC = 7 minutes**

## STUDY POINT F

**Existing Conditions**

Open Space, Lawns, etc. = 1,682 sf = 0.039 ac

HSG – B; <2% → C = 0.11

Impervious Area = 10,538 sf = 0.242 ac

HSG – B; <2% → C = 0.90

$C_{WEIGHTED} = \Sigma C_X A_X / A_{TOTAL}$

$C_{WEIGHTED}$ = [0.11(0.039) + 0.90(0.242)] / (0.039+0.242) = 0.790

0.65 < 0.790 = 0.79 ← MCDOT Drainage Design Criteria Table 3-3

Therefore, **TC = 7 minutes**

## STUDY POINT G

**Existing Conditions**

Open Space, Lawns, etc. = 336 sf = 0.008 ac

HSG – B; 2-7% → C = 0.16

Impervious Area = 6,531 sf = 0.150 ac

HSG – B; 2-7% → C = 0.90

$C_{WEIGHTED} = \Sigma C_X A_X / A_{TOTAL}$

$C_{WEIGHTED}$ = [0.16(0.008) +0.90(0.150)] / (0.008 + 0.150) = 0.863

0.860 > 0.80 ← MCDOT Drainage Design Criteria Table 3-3

Therefore, **TC = 5 minutes**

# Appendix B

# TR-55

# Analysis

# WinTR-55 Current Data Description

## --- Identification Data ---

```
User:     J Kim                                       Date:        7/14/2022
Project:  Hillcrest Ave                               Units:       English
SubTitle:                                             Areal Units: Acres
State:    Maryland
County:   Montgomery NOAA-C
Filename: Z:\Projects\1199 Hillcrest Avenue\Eng\Pavstorm\DOCS\22-0714 SD Analysis + Overall DA.w55
```

## --- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| SP A Exist | | Outlet | 0.17 | 91 | 0.117 |
| SP A Prop | | Outlet | 0.23 | 92 | 0.117 |
| SP B Exist | | Outlet | 0.34 | 85 | 0.117 |
| SP B Prop | | Outlet | 0.12 | 93 | 0.100 |
| SP C | | Outlet | 1.88 | 86 | 0.117 |
| SP D | | Outlet | 0.27 | 89 | 0.117 |
| SP E | | Outlet | 0.13 | 92 | 0.117 |
| SP F | | Outlet | 0.28 | 93 | 0.117 |
| SP G | | Outlet | 0.16 | 96 | 0.100 |

Total area: 3.58 (ac)

## --- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| 3.2 | 4.13 | 4.95 | 6.19 | 7.3 | 8.54 | 2.65 |

```
Storm Data Source:            User-provided custom storm data
Rainfall Distribution Type:   Type II
Dimensionless Unit Hydrograph: <standard>
```

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## Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| SP A Exist | Open space; grass cover > 75% | (good) | B | .034 | 61 |
| | Paved parking lots, roofs, driveways | | B | .137 | 98 |
| | Total Area / Weighted Curve Number | | | .17 | 91 |
| | | | | === | == |
| SP A Prop | Open space; grass cover > 75% | (good) | B | .036 | 61 |
| | Paved parking lots, roofs, driveways | | B | .19 | 98 |
| | Total Area / Weighted Curve Number | | | .23 | 92 |
| | | | | === | == |
| SP B Exist | Open space; grass cover > 75% | (good) | B | .12 | 61 |
| | Paved parking lots, roofs, driveways | | B | .219 | 98 |
| | Total Area / Weighted Curve Number | | | .34 | 85 |
| | | | | === | == |
| SP B Prop | Open space; grass cover > 75% | (good) | B | .017 | 61 |
| | Paved parking lots, roofs, driveways | | B | .1 | 98 |
| | Total Area / Weighted Curve Number | | | .12 | 93 |
| | | | | === | == |
| SP C | Open space; grass cover > 75% | (good) | B | .571 | 61 |
| | Open space; grass cover > 75% | (good) | D | .06 | 80 |
| | Paved parking lots, roofs, driveways | | B | 1.211 | 98 |
| | Paved parking lots, roofs, driveways | | D | .038 | 98 |
| | Total Area / Weighted Curve Number | | | 1.88 | 86 |
| | | | | ==== | == |
| SP D | Open space; grass cover > 75% | (good) | B | .065 | 61 |
| | Paved parking lots, roofs, driveways | | B | .208 | 98 |
| | Total Area / Weighted Curve Number | | | .27 | 89 |
| | | | | === | == |
| SP E | Open space; grass cover > 75% | (good) | B | .022 | 61 |
| | Open space; grass cover > 75% | (good) | D | .002 | 80 |
| | Paved parking lots, roofs, driveways | | B | .109 | 98 |
| | Total Area / Weighted Curve Number | | | .13 | 92 |
| | | | | === | == |
| SP F | Open space; grass cover > 75% | (good) | B | .039 | 61 |
| | Paved parking lots, roofs, driveways | | B | .242 | 98 |
| | Total Area / Weighted Curve Number | | | .28 | 93 |
| | | | | === | == |
| SP G | Open space; grass cover > 75% | (good) | B | .008 | 61 |
| | Paved parking lots, roofs, driveways | | B | .15 | 98 |
| | Total Area / Weighted Curve Number | | | .16 | 96 |
| | | | | === | == |

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## Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 10-Yr (cfs) | 25-Yr (cfs) |
|---|---|---|---|
| SUBAREAS | | | |
| SP A Exist | 0.57 | 0.97 | 1.25 |
| SP A Prop | 0.79 | 1.32 | 1.69 |
| SP B Exist | 0.89 | 1.66 | 2.22 |
| SP B Prop | 0.44 | 0.73 | 0.93 |
| SP C | 5.16 | 9.46 | 12.54 |
| SP D | 0.83 | 1.45 | 1.89 |
| SP E | 0.44 | 0.73 | 0.94 |
| SP F | 0.99 | 1.63 | 2.09 |
| SP G | 0.63 | 0.99 | 1.25 |
| REACHES | | | |
| OUTLET | 10.72 | 18.92 | 24.74 |

**Appendix C**

**Storm Drain**

**Computations**

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## Storm Drain Comps - Existing System under Proposed Conditions

HILLCREST PROPERTY - 1199
STORM DRAIN COMPUTATIONS
DATE: October 25, 2022
10-YEAR STORM

| FROM | TO | AREA (ac.) INCREM. | AREA (ac.) TOTAL | R=C | AR | ΣAR | Tc min | INLET Tc min | I in/hr | Q (cfs) INCREM. | Q (cfs) TOTAL | MANNING'S n | SLOPE MIN % | SLOPE ACT % | D inches | Q/A fps | LENGTH ft | TIME IN PIPE min | NORMAL DEPTH ft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 11 | 0.27 | 0.27 | 0.72 | 0.19 | 0.19 | 10.00 | 10.00 | 6.52 | 1.27 | 1.27 | 0.013 | 0.00% | **1.00%** | **30** | 0.26 | **17** | 1.10 | 0.30 |
| 11 | 9 | 1.88 | 2.15 | 0.65 | 1.22 | 1.42 | 11.10 | 10.00 | 5.64 | 6.89 | 7.99 | 0.013 | 0.04% | **1.00%** | **30** | 1.63 | **46** | 0.47 | 0.75 |
| 10 | 9 | 0.13 | 0.13 | 0.77 | 0.10 | 0.10 | 11.57 | 10.00 | 5.55 | 0.56 | 0.56 | 0.013 | 0.01% | **3.40%** | **15** | 0.45 | **50** | 1.84 | 0.19 |
| 9 | 7 | 0.00 | 2.28 | 0.00 | 0.00 | 1.52 | 13.41 | 10.00 | 5.24 | 0.00 | 7.95 | 0.013 | 0.02% | **0.77%** | **33** | 1.34 | **65** | 0.81 | 0.77 |
| 8 | 8A | 0.23 | 0.23 | 0.78 | 0.18 | 0.18 | 14.22 | 10.00 | 5.12 | 0.92 | 0.92 | 0.013 | 0.02% | **5.00%** | **15** | 0.75 | **1.58** | 0.04 | 0.21 |
| 8A | 7 | 0.00 | 0.23 | 0.00 | 0.00 | 1.70 | 14.25 | 10.00 | 5.11 | 0.00 | 8.67 | 0.013 | 0.03% | **0.77%** | **33** | 1.46 | **56** | 0.64 | 0.81 |
| 7 | 2 | 0.00 | 2.51 | 0.00 | 0.00 | 1.70 | 14.25 | 10.00 | 5.11 | 0.00 | 8.67 | 0.013 | 0.03% | **0.48%** | **33** | 1.46 | **99** | 1.13 | 0.91 |
| 6 | 4 | 0.12 | 0.12 | 0.80 | 0.10 | 0.10 | 15.38 | 10.00 | 4.94 | 0.47 | 0.47 | 0.013 | 0.01% | **0.50%** | **15** | 0.39 | **33** | 1.42 | 0.27 |
| 5 | 4 | 0.28 | 0.28 | 0.79 | 0.22 | 0.22 | 16.80 | 10.00 | 4.75 | 1.05 | 1.05 | 0.013 | 0.03% | **0.50%** | **15** | 0.86 | **114** | 2.22 | 0.41 |
| 4 | 3 | 0.16 | 0.56 | 0.86 | 0.14 | 0.45 | 19.02 | 10.00 | 4.48 | 0.62 | 2.04 | 0.013 | 0.10% | **2.00%** | **15** | 1.66 | **5** | 0.05 | 0.36 |
| 3 | 2 | 0.00 | 0.56 | 0.00 | 0.00 | 0.45 | 19.07 | 10.00 | 4.47 | 0.00 | 2.03 | 0.013 | 0.10% | **1.00%** | **15** | 1.66 | **52** | 0.52 | 0.43 |
| 2 | 1 | 0.00 | 3.07 | 0.00 | 0.00 | 2.15 | 19.60 | 10.00 | 4.41 | 0.00 | 9.49 | 0.013 | 0.03% | **0.50%** | **33** | 1.60 | **52** | 0.54 | 0.92 |

## Storm Drain Comps - Existing System under Proposed Conditions

Hillcrest SWM

STORM DRAIN COMPUTATIONS DATE: October 25, 2022
10-YEAR STORM

| FROM | TO | AREA acres INCREM. | AREA acres TOTAL | R=C | AR | ΣAR | Tc min | INLET Tc min | I in/hr | Q cfs INCREM. | Q cfs TOTAL | MANNING'S n | SLOPE MIN % | SLOPE ACT % | PIPE SIZE inches | Q/A fps | LENGTH ft | TIME IN PIPE min |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 2 | 0.05 | 0.05 | 0.90 | 0.04 | 0.04 | 5.00 | 5.00 | 7.08 | 0.31 | 0.31 | 0.013 | 0.06% | **1.00%** | **8** | 0.88 | **40** | 0.76 |
| 2 | MH | 0.07 | 0.12 | 0.90 | 0.06 | 0.10 | 5.76 | 5.00 | 6.85 | 0.41 | 0.71 | 0.013 | 0.34% | **1.00%** | **8** | 2.03 | **18** | 0.15 |
| MH | MH | 0.00 | 0.12 | 0.90 | 0.00 | 0.10 | 5.91 | 5.00 | 6.81 | 0.00 | 0.70 | 0.013 | 0.34% | **1.00%** | **8** | 2.02 | **19** | 0.16 |
| MH | 1 | 0.06 | 0.12 | 0.90 | 0.05 | 0.16 | 6.07 | 5.00 | 6.77 | 0.37 | 1.07 | 0.013 | 0.78% | **1.00%** | **8** | 3.05 | **83** | 0.45 |
| 1 | OUT | 0.19 | 0.36 | 0.90 | 0.17 | 0.32 | 6.52 | 5.00 | 6.65 | 1.11 | 2.15 | 0.013 | 0.37% | **1.00%** | **12** | 2.74 | **47** | 0.29 |

KIM ENGINEERING

# Appendix D

# Riprap

# Calculations

## Riprap Calculations

The following calculations were computed to determine whether the existing riprap at the existing outfall (Structure 1) are sufficient for the total flow being conveyed from both the existing storm drain system and the proposed storm drain outfall from the site.

The existing outfall is 47.5’ in length and is assumed to be Class I riprap. To be conservative, the smaller diameter of the two outfalling pipes is being used (1 ft instead of 2.75 ft).

$Q_{10}$ Existing = 9.49 cfs

$Q_{10}$ Proposed = 2.15 cfs

$Q_{10}$ Total = 11.64 cfs

### Riprap Outfall Calculations

**<u>Circular Pipes</u>**

$d50 = (0.020*D/TW*((Q/D^{5/2})^{4/3}))D$ **(4-9)**

TW< 0.5D

$L= (1.8(Q/D^{2.5})+7)*D$ **(4-11)**

TW>=0.5D

$L = (3(Q/D^{2.5}))*D$ **(4-12)**

$d_{50}$ = Diameter of Average Size Stone (ft)
D = Diameter of outlet for circular, Height for all other shapes (ft)
TW = Tailwater Depth above inverts of storm drain outlet (ft)
Q = Discharge (cfs)
q = Unit Discharge per foot of width for rectangular and other shaped outlets (cfs/ft)

**<u>Outfall (existing)</u>**

| | |
|---|---|
| D (ft) = 1 | $D_{50} = 0.020(D/TW)((Q/(D^{5/2}))^{4/3})(D)$ |
| $Q_{10}$ (cfs) = 11.64 | $D_{50}$ = 0.527595 ft |
| Inv Out = 511.1 | **$D_{50}$ = 6.33 in** |
| TW (ft) = 1 | |
| Conservative assumption | $L = (3(Q/(D^{/2})))D$ |
| | L = 34.92000 ft |
| | **L = 35 ft** |

Existing riprap exceeds minimum parameters.

The required riprap outfall length is 35 feet which is less than the existing riprap outfall length. The required average size stone diameter is 6.33 in which is less than the 9.5 in provided by the assumed existing Class I riprap. Therefore, the existing riprap outfall is sufficient for both the existing and proposed flow outfalling to it.