Stormwater Design Standards Manual
Educational Workshop #2:

Peaking Factor
&
1% Annual Exceedance Probability (AEP)
Storm Event Analysis

04 June 2020

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Agenda

- General Manual Information
- Specific Workshop Information
- General Public Q&A
- Technical Information
  - Peaking Factor
  - 1% Annual Exceedance Probability (AEP) Storm Event Analysis
  - Example Projects
- Technical Q&A

General Manual Information

- Stormwater Design Standards Manual (SWDSM) is a federally mandated requirement of the National Pollution Discharge Elimination System (NPDES) Phase II Stormwater Program
- SWDSM is used by design community to develop designs and used by the City to review, approving, and permitting designs.
- SWDSM has 8 chapters:
    1. Introduction and Legal Authority
    2. Conceptual Overview
    3. Design Requirements
    4. Construction Activity Permitting
    5. Construction Phase
    6. Post-Construction
    7. City Inspection and Enforcement
    8. References
- Originally passed in 2007, first update was completed in 2013
- Newest update goes into effect ***July 1, 2020***

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Specific Workshop Information

- Peaking Factor
- 1% Annual Exceedance Probability (AEP) Storm Event Analysis
- Example Projects
  - Commercial Development in West Ashley
  - Residential Development on Johns Island
  - Mixed Use (multi-family residential/commercial) Development on the Peninsula

General Public Questions

Send questions and comments to:

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Stormwater Program Manager
City of Charleston
holtonk@charleston-sc.gov

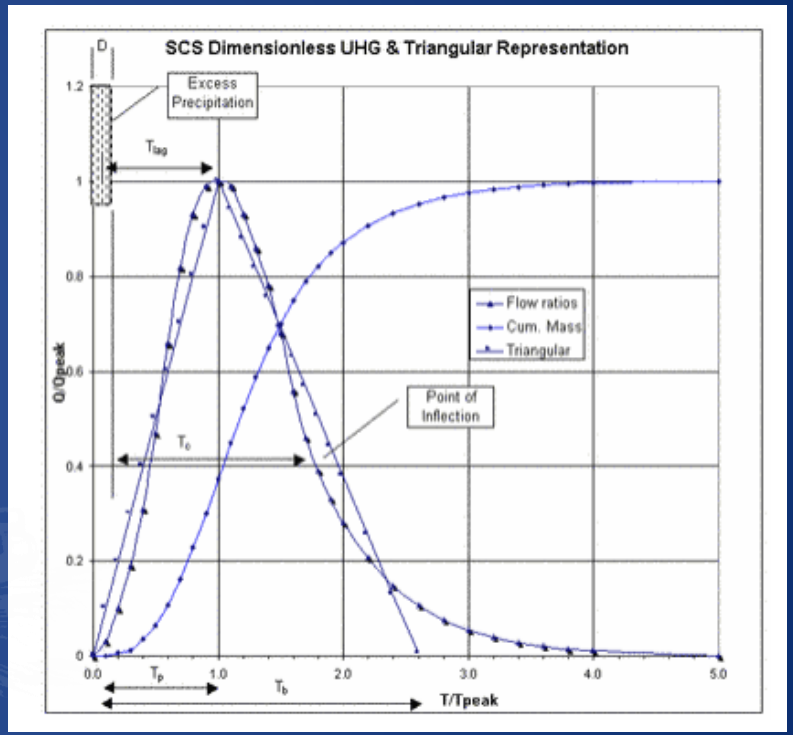
Peaking Factor

Technical Procedure Document #3

- What is a Peaking Factor?
- Range of Peaking Factors
- Design Requirements
  - Hydrologic Inputs/Requirements
- Peaking Factor of 323 vs 484
- Basin Specific Peaking Factor Determination

Peaking Factor – What is it?

- Conversion Constant (PF)
- Development of Unit Hydrographs
  - SCS/NRCS Dimensionless Unit Hydrograph
- Reflects the ability of the watershed to retain or delay flow
- Controls the rising and recession limbs of a hydrograph



$$q_p = \frac{PF\ A\ Q}{T_p}$$

q_p – Peak Rate (CFS)
PF – Peaking Factor
T_p – Time to Peak (hrs)
A – Drainage Area (Sq Mi)
Q – Runoff Volume (in)

Peaking Factor & Recession Limb Ratios

- 484 – Typical (Not applicable to all watersheds)
- Range 100-600
  - Based on watershed characteristics (Land use, Slopes, Storage)

Watershed General Description	Peaking Factors	Limb Ratio (Recession to Rising)
Urban Areas, Steep Slopes	575	1.25
Typical SCS	484	1.67
Mixed Urban/Rural	400	2.25
Rural, Rolling Hills	300	3.33
Rural, Slight Slopes	200	5.5
Rural, Very Flat	100	12.0

Sources: Wanielista, Martin, Robert Kersten, & Ron Eaglin, 1997. Hydrology : Water Quantity and Quality Control, 2nd Edition, Wiley and Sons, Inc., New York, NY.
Unit Hydrograph (UHG) Technical Manual NOAA , 2001 Available at: https://www.nohrsc.noaa.gov/technology/gis/uhg_manual.html

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Peaking Factor – Hydrologic Requirements

- Duration based on the 24-hour design storm with NRCS Type III distribution
- Typical inputs include, but are not limited to:
  - Rainfall depth or intensity
  - NRCS soil classification and hydrologic soil group
  - Land use
  - Time of concentration
  - Initial abstraction (surface storage and/or vegetative capture)

Peaking Factor – Value of 323 vs 484

2013 SWDSM (Expires on June 30, 2020)

- Default Peaking Factor – 323

2020 SWDSM (In Effect on July 1, 2020)

- Default Peaking Factor – 484
- Reasoning:
  - NRCS typical peaking factor is 484
  - Developed from land use classifications of mostly urban and moderate slopes

General City Characteristics that aided the Peaking Factor Revision

- Predominantly urbanized
- Have poorly drained or altered soils
- No significant surface storage
- High groundwater table

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Peaking Factor – Basin Specific and Process

Basin Specific Determination

- City understands there are a variety of landscapes within the jurisdictional boundaries
- Designers have the opportunity to justify a lower peaking factor than 484
  - Minimum allowed will be 323

Approval Process

- Application should identify one of the three Peaking Factors as applicable (484, 400 or 323)

Regional Scale/Site-Specific

- Use City's Model if available
  - Peaking Factor already established
- If Model is not available, designers need to modify peaking factor, following documents needs to be included at a minimum for justification:
  - Need detailed site-specific Modeling with appropriate input and output reports
  - Stormwater Technical Report, which must include:
    - Site Topography to establish the slope
    - Pre-development and Post-development impervious area determination
    - % Storage within the site along with stage-storage calculations
    - Ground water determination
    - Associated zoning classification

Communication is key! Justification for a lower peaking factor should be discussed with the City early in the design process!

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1% Annual Exceedance Probability (AEP) Storm Event Analysis

Technical Procedure Document #4

- Required Criteria
- Process
- Required Output

Example #3 - Mixed Use (multi-family residential/commercial) Development on the Peninsula

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1% Annual Exceedance Probability (AEP) Storm Event Analysis– Required Criteria

- **SWDSM Section 3.9.4**
- Use current zoning for all upstream and downstream land parcels
- Existing Land Use Curve Numbers for all developed areas outside the project
- The Weighted Curve Number for the proposed development site
- Flows shall be routed using a hydrologic and hydraulic method accepted by the Department of Stormwater Management
- Other criteria may be required based on the severity of potential impact and location of the project. Additional criteria will be discussed during the initial planning stages of the project with the Technical Review Committee

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1% Annual Exceedance Probability (AEP) Storm Event Analysis– Process

1. Determine which watershed the project is located in and if the City has a master plan for that watershed
2. If the City does have a master plan and model for the watershed, contact the City for boundary conditions of the site. If the City does not have a master plan for the watershed, then determine the watershed extents from all available terrain
3. Determine the point in the watershed where the proposed development represents 10% of the watershed analysis area
   a) Example 1: A 5-acre project at the top (highest point) of the watershed will have to examine downstream until the total drainage area for the outfall channel or structure is at least 50 acres. If the total area of the watershed does not total 50 acres before reaching the ultimate outfall, then the entire watershed will be used.
   b) Example 2: A 5-acre project in the middle of the watershed will need to first determine how much upstream area is contributing to the outfall channel or structure before reaching the site. If the upstream area is equal or greater than 45 acres, then only the next downstream structure from the site will need to be analyzed (if the upstream area is greater than 45 acres then the entire upstream area must be included in the analysis of the next downstream structure from the site). However, if the upstream basin is less than 45 acres, then continue downstream of the site until the 10% requirement is met.

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1% Annual Exceedance Probability (AEP) Storm Event Analysis– Process

4. Locate all off-site downstream structures and open-conveyance cross sections for the outfall channel or structure within the total watershed area and include them in the analysis
5. Determine the land-cover data and curve number information for the watershed by using zoning information. Undeveloped portions of the watershed shall be modeled as if in the built condition and according to the zoning classification.

Source: Low Impact Development in Coastal South Carolina: A Planning and Design Guide (Ellis et al, 2014)

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1% Annual Exceedance Probability (AEP) Storm Event Analysis– Process

6. Build a stormwater model to determine the impacts of the proposed development on all upstream and downstream conveyances until the 10% analysis point is reached as well as continue downstream for the project to identify any likely choke points The extent to which upstream drainage is routed through existing stormwater management systems will be up to the design engineer as the un-routed upstream system approach would yield more conservative 1 Percent AEP storm event water surface elevations. Additionally, the existing boundary conditions for this analysis must take into account either an elevation of 5.5 NAVD88 datum tailwater elevation as a minimum or elevations associated with any downstream constrictions (crown of pipe elevation), whichever is higher.

   Additionally, the modeling must take into account the displacement of any existing storage provided on the site that will be displaced as part of any fill associated with the development. This is often modeled treating the site as a pond to realize how much volume is available for storage between the seasonal high water table (SHWT) and the resultant 1 Percent AEP storm event elevation. This displaced storage volume must be accounted for in the 1 Percent AEP modeling to reflect the loss of storage on the site prior to the development. This displaced storage can be offset through the on-site stormwater management practices (i.e. runoff reduction measure or additional storage volume) or simply by completing a fill balancing approach.
7. If any adverse impacts (i.e. increased water surface elevation) are noted, the design of the proposed site will need to be modified until all downstream impacts have been mitigated.

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1% Annual Exceedance Probability (AEP) Storm Event Analysis– Required Output

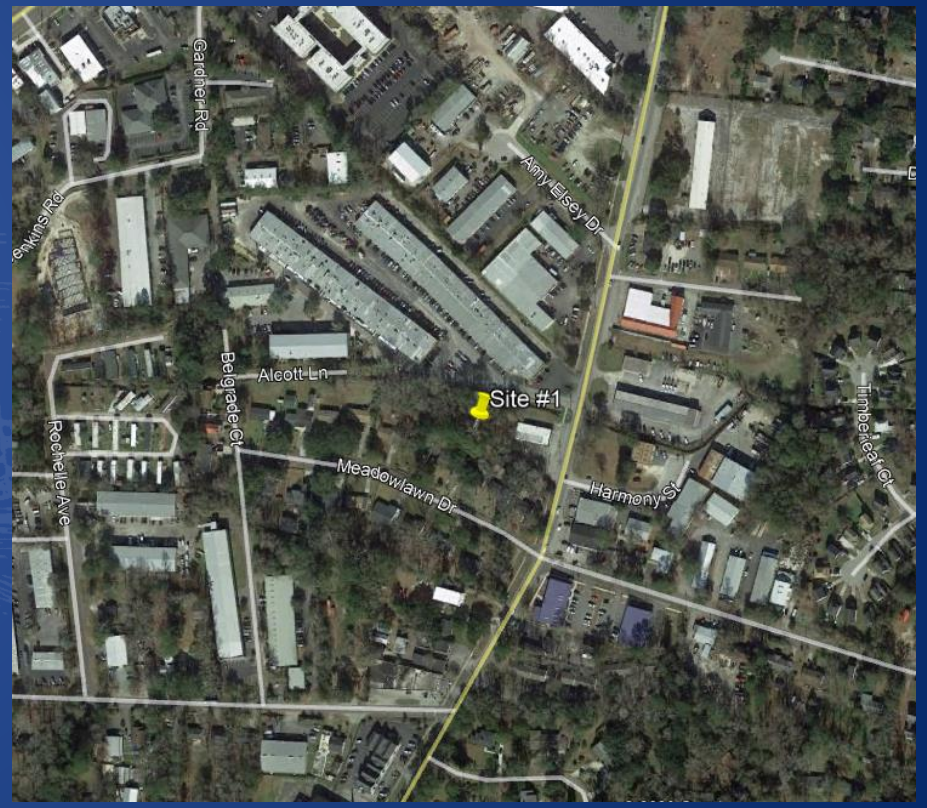
- Results are required in the Stormwater Technical Report that is prepared by a South Carolina Licensed Professional Engineer and submitted to the City as part of the application package
- Required Items are:
  - Pre-development and Post-development peak flowrate
  - Pre-development and Post-development runoff volume
  - Pre-development and Post-development model input
  - Pre-development and Post-development model output

Example Projects

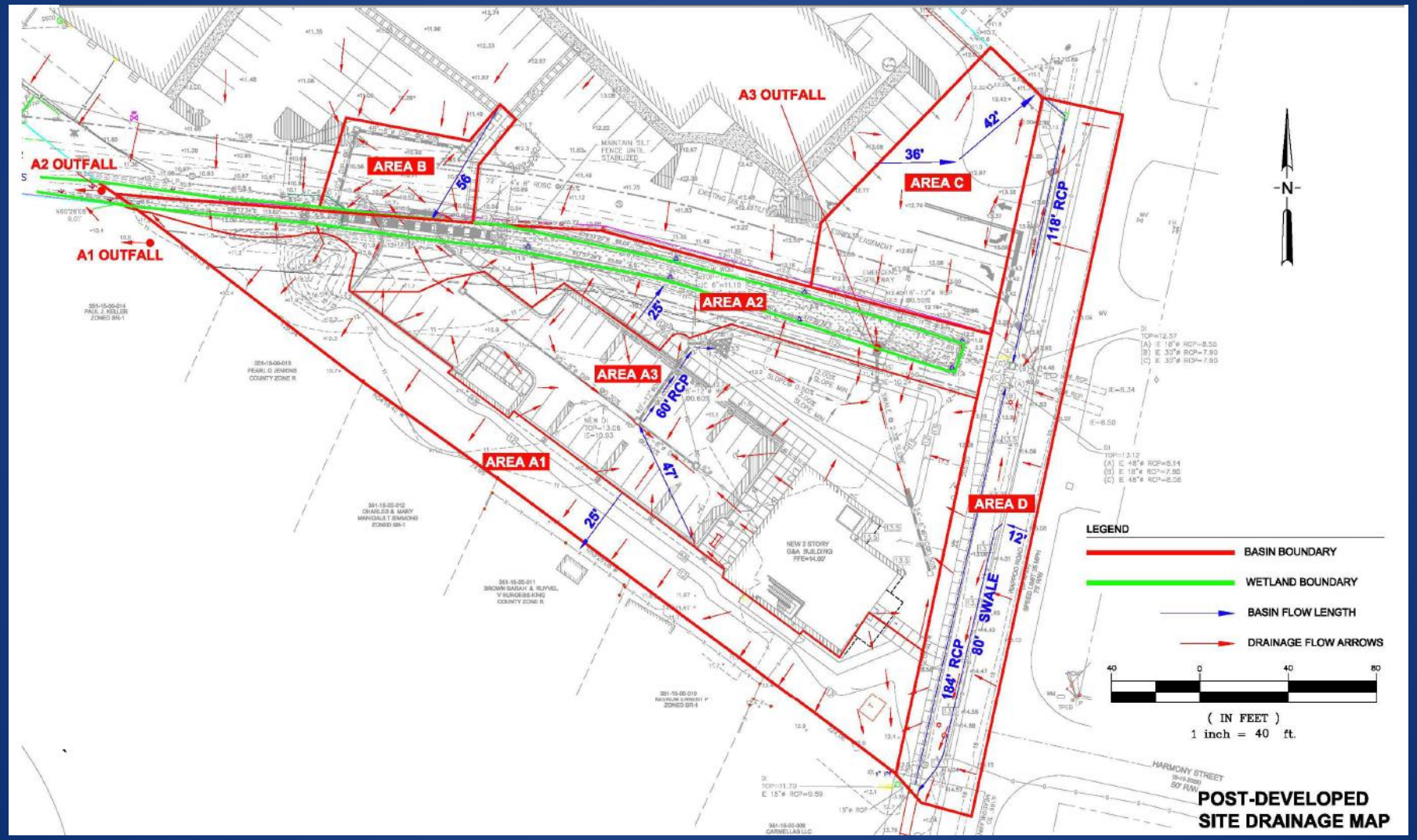
- Example Project #1
  - Commercial Development in a Special Protection Area of West Ashley
- Example Project #2
  - Residential Development on Johns Island
- Example Project #3
  - Mixed Use (multi-family residential/commercial) Development on the Peninsula

Example Project #1

- New 26,800 SF GA Building and associated parking
- Total Project Site Area = 1.5 ac
- Disturbed Area = 0.9 ac
- Pre-developed Conditions = Impervious build-out for retail
- Post-developed Conditions = Impervious build-out for lab building
- Outfall from detention pond to existing channel
- This site is within a watershed with an established Master Plan and located in a SPA.



Example Project #1



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Example Project #1 – Peaking Factor

- Approved 2013 SWDSM Peaking Factor = 323
- New 2020 SWDSM Required Peaking Factor = 484

Hyd. No. 3

Post A3 Pond

Hydrograph type	= SCS Runoff	Peak discharge	= 4.563 cfs
Storm frequency	= 100 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 17,383 cuft
Drainage area	= 0.513 ac	Curve number	= 92
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 6.00 min
Total precip.	= 10.30 in	Distribution	= Type III
Storm duration	= 24 hrs	Shape factor	= 323

Hyd. No. 3

Post A3 Pond

Hydrograph type	= SCS Runoff	Peak discharge	= 5.257 cfs
Storm frequency	= 100 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 17,908 cuft
Drainage area	= 0.513 ac	Curve number	= 92
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 6.00 min
Total precip.	= 10.30 in	Distribution	= Type III
Storm duration	= 24 hrs	Shape factor	= 484

- Conclusion :
  - Poorly drained soils on-site and surrounding areas (HSG “D”)
  - Urbanized area of the watershed
  - An exemption from the 484 Peaking Factor would not be appropriate for this site.

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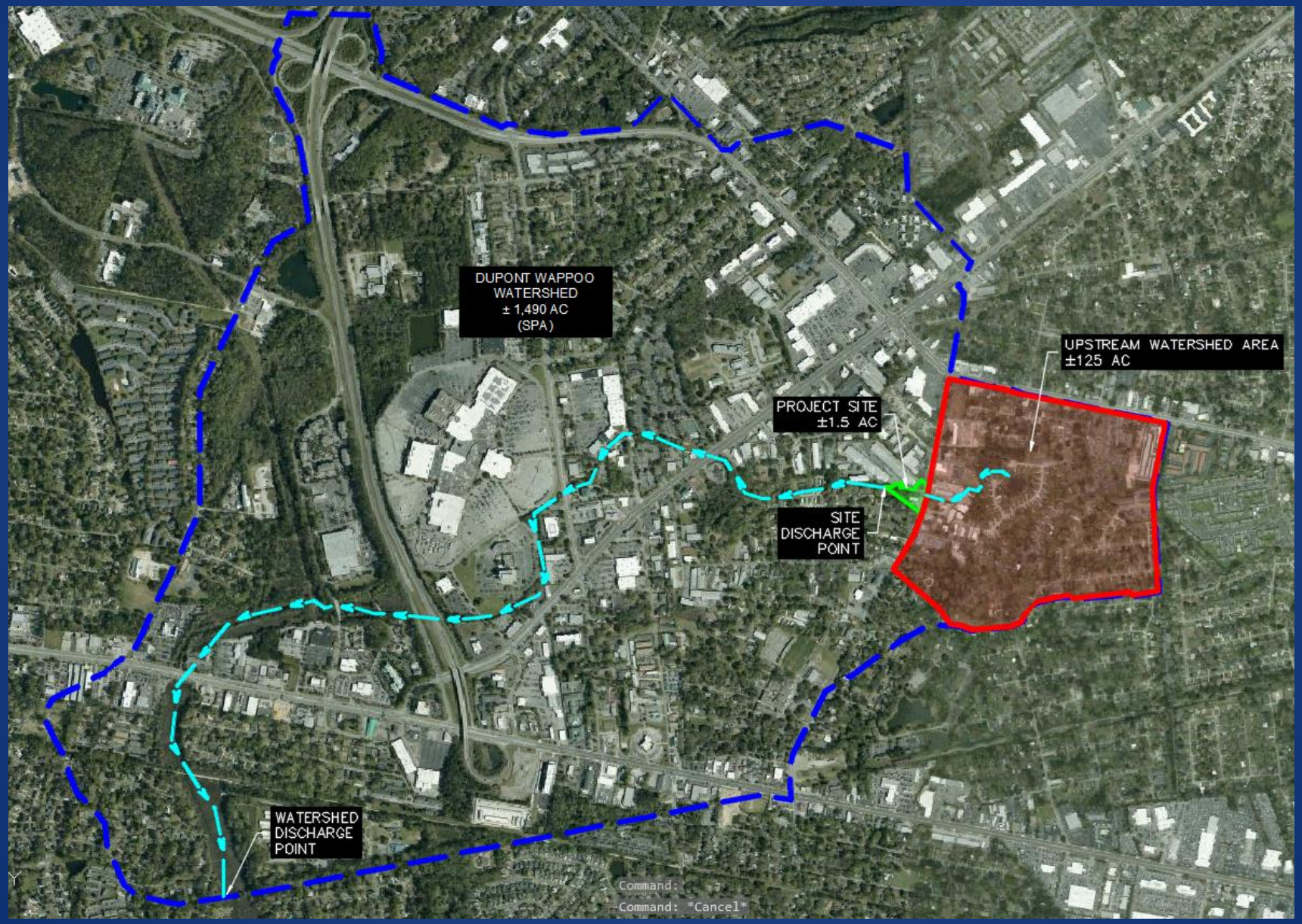
Example Project #1 – 1% Annual Exceedance Probability (AEP) Storm Event Analysis



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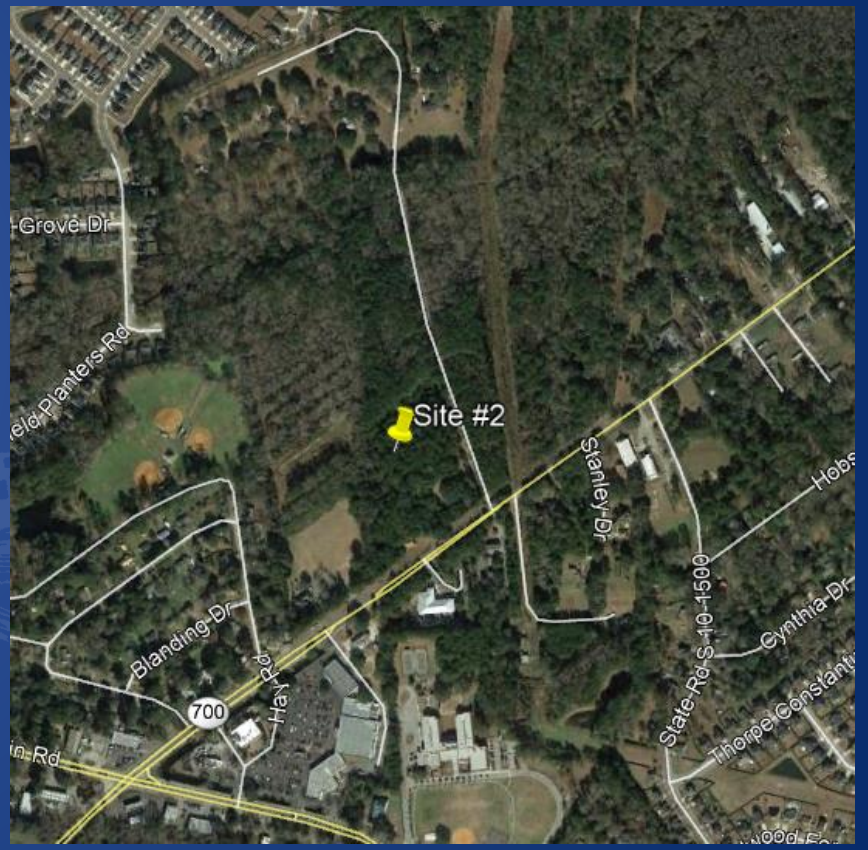
Example Project #2

- 56 New residential lots, 3 commercial tracks, and HOA green space.
- Total Project Site Area = 17.6 ac
- Disturbed Area = 14.9 ac
- Pre-developed Conditions = Sparsely wooded area, predominantly pine
- Post-developed Conditions = Impervious residential area
- Outfall from detention pond to existing wetlands
- This site is located on Johns Island



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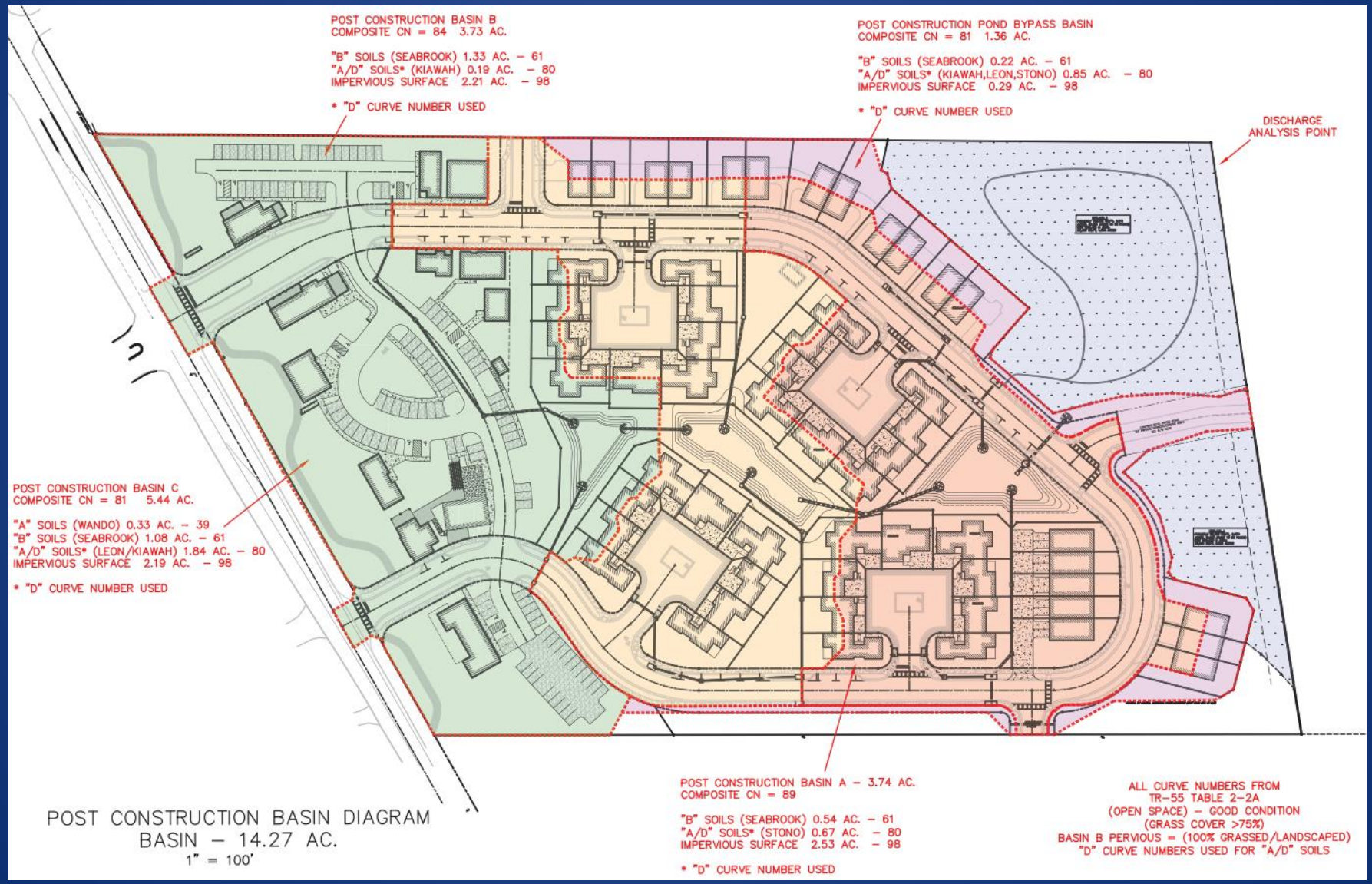
Example Project #2



Example Project #2 – Peaking Factor

- Approved 2013 SWDSM Peaking Factor = 323
- New 2020 SWDSM Required Peaking Factor = 484

Hyd. No. 1

Post- Basin A

Hydrograph type	= SCS Runoff	Peak discharge	= 23.19 cfs
Storm frequency	= 100 yrs	Time to peak	= 733 min
Time interval	= 1 min	Hyd. volume	= 121,662 cuft
Drainage area	= 3.740 ac	Curve number	= 89
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 15.40 min
Total precip.	= 10.30 in	Distribution	= Type III
Storm duration	= 24 hrs	Shape factor	= 323

Hyd. No. 1

Post- Basin A

Hydrograph type	= SCS Runoff	Peak discharge	= 27.73 cfs
Storm frequency	= 100 yrs	Time to peak	= 731 min
Time interval	= 1 min	Hyd. volume	= 123,056 cuft
Drainage area	= 3.740 ac	Curve number	= 89
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 15.40 min
Total precip.	= 10.30 in	Distribution	= Type III
Storm duration	= 24 hrs	Shape factor	= 484

- Conclusion :
  - Mixed soil types soils on-site and surrounding areas
  - Watershed is mostly Rural
  - 3 ac of wetlands on-site with additional wetlands surrounding
  - An exemption from the 484 Peaking Factor may be appropriate for this site.

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Example Project #2 – 1% Annual Exceedance Probability (AEP) Storm Event Analysis

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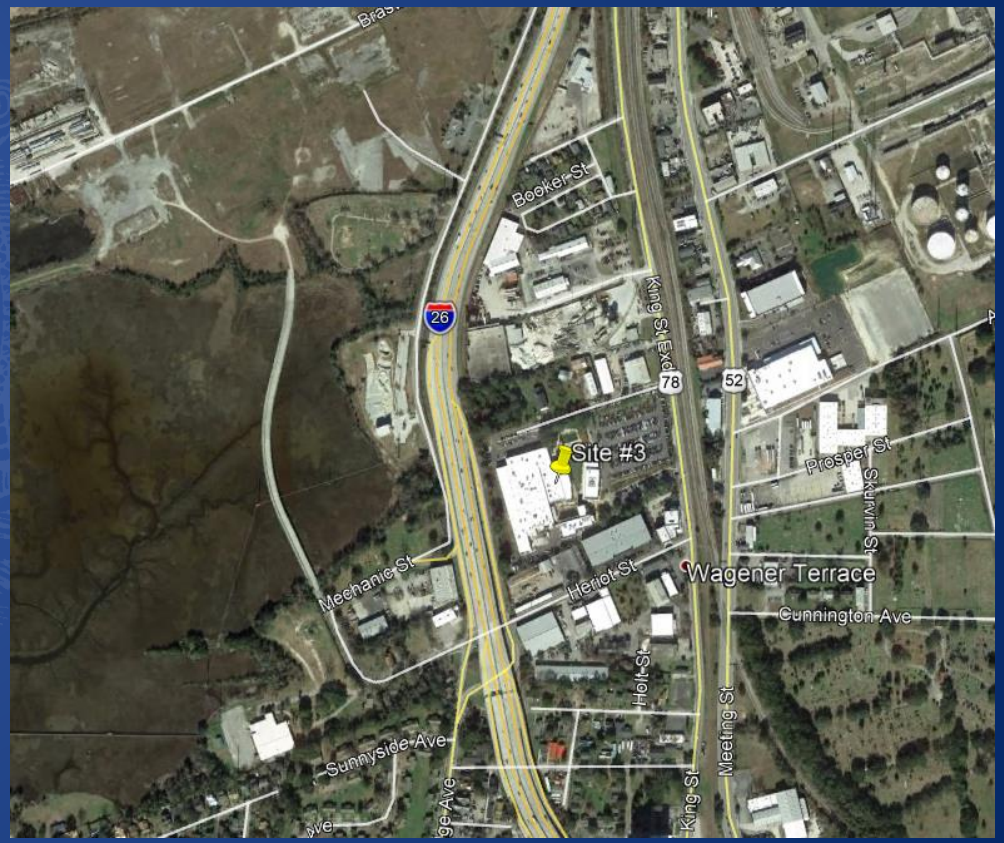
Example Project #3

- New restaurant, brewery, and parking lot
- Total Project Site Area = 9.2 ac
- Disturbed Area = 7.8 ac
- Pre-developed Conditions = Impervious commercial development
- Post-developed Conditions = Impervious commercial development
- Outfall from underground stormwater systems to existing box structures of adjacent streets.
- Located between Charleston and North Charleston in a highly urbanized area.



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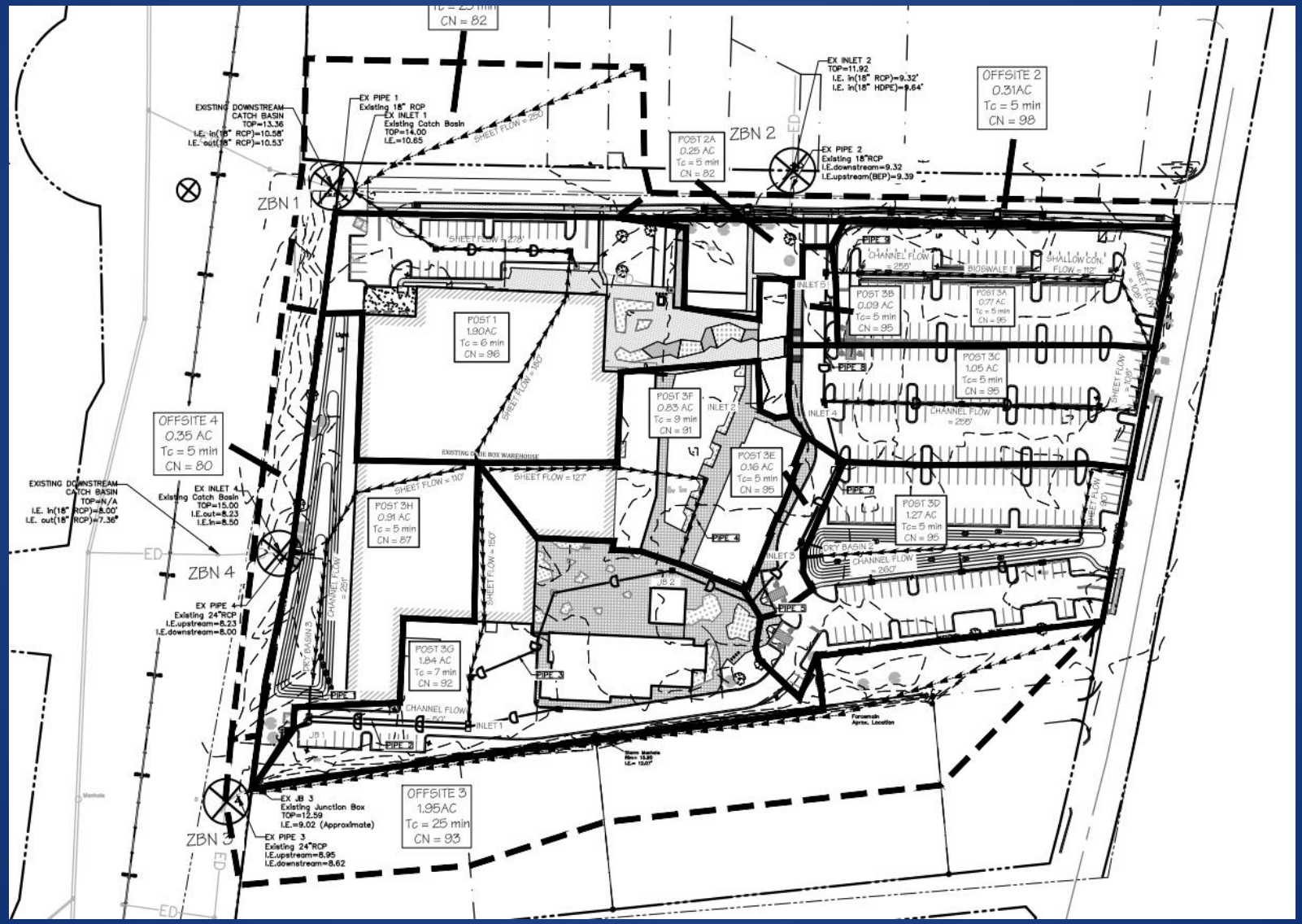
Example Project #3



Example Project #3 – Peaking Factor

- Approved 2013 SWDSM Peaking Factor = 323
- New 2020 SWDSM Required Peaking Factor = 484

Hyd. No. 17

Post 3G

Hydrograph type	= SCS Runoff	Peak discharge	= 15.34 cfs
Storm frequency	= 100 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 63,014 cuft
Drainage area	= 1.840 ac	Curve number	= 92
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 7.00 min
Total precip.	= 10.40 in	Distribution	= Type III
Storm duration	= 24 hrs	Shape factor	= 323

Hyd. No. 17

Post 3G

Hydrograph type	= SCS Runoff	Peak discharge	= 17.29 cfs
Storm frequency	= 100 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 61,376 cuft
Drainage area	= 1.840 ac	Curve number	= 92
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 7.00 min
Total precip.	= 10.40 in	Distribution	= Type III
Storm duration	= 24 hrs	Shape factor	= 484

- Conclusion :
  - Poorly drained soils on-site and surrounding areas (HSG “D”)
  - Highly Urbanized area of the watershed
  - An exemption from the 484 Peaking Factor would not be appropriate for this site.

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Example Project #3 – 1% Annual Exceedance Probability (AEP) Storm Event Analysis

Technical Q&A

Send questions and comments to:

Kinsey Holton
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