GREEN ROOF DESIGN CALCULATIONS

PROJECT: 336–340 MLK Drive Jersey City NJ

ARCHITECT:

HAMPTON HILL ARCHITECTURE
109 Liberty View Drive #1 GA Jersey City NJ
PH: ((201)-516-2133

PREPARED BY:

KSO
ENGINEERING, P.C
347 MERCER LOOP, JERSEY CITY, NJ 07302
TEL: (201)736-7546
Email : ksiengineering@gmail.com

NEW JERSEY P.E.:

MIRZA K. BAIG

LICENSE # 24GE84726688

SIGNATURE & SEAL:

GREEN ROOF SAMPLE DESIGN CALCULATIONS

366-340 MLK DRIVE, JERSEY CITY

NEW JERSEY

Project Site Existing/Proposed:

The project site is located at 366 -340 MLK Drive, Jersey City, NJ at the intersection of MLK Drive and Orient Way. The site existing condition comprises a vacant lot (broken concrete and gravel) abutting an existing building (refer to the site photographs). The lot size is approximately 4,049.2 sq. (0.093 acres).

The proposed development comprises a 6-story, 25 unit residential building with ground floor as commercial spaces. A green roof is part of the architectural design. The proposed building footprint occupies the entire lot and there is no room to put a subsurface detention system. As such, a green roof as per the architectural plans is a viable option for curtailing the surface runoff.

Design References:

- Design and performance criteria as per N.J.A.C 7:8-5
- NJ Stormwater Best Management Manual April -2021
- Part 630 Hydrology, National Engineering Handbook (NEH)
- NRCS TR 55 for Small Watersheds
- Jersey City MUA Stormwater Ordinance

Green Roof Design Parameters/Specifications:

Green Roof Composition:

The green roof comprise (top to bottom) actual vegetation, growing medium; filter fabric, drainage layer, root barrier, water proofing system, leak detection system and the roof structure.

Vegetation:

The criteria for selection of vegetation is to tolerate a broad range of conditions including, weather, water depth and inundation, high wind speed, temperature fluctuation, amount of direct sun light, presence or absence of surrounding structures, roof slope, architectural features etc. The selected plant species are native in nature to reflect healthy plant community for the available sunlight. The plant selection will be discussed with the reviewing agency.

Growing Medium:

The growing medium affects the ability of the installation to support vegetation, retain stormwater, and provide heat and noise insulation for the building; and is a crucial design parameter. The growing medium is selected to be (80 t0 90%) lightweight and to retain sufficient water to sustain vegetation. The growing medium is comprises lightweight aggregate, (10 to 20%) of stable organic matter, have sufficient permeability to prevent ponding or logging The selected medium should have low turbidity, suspended solids and carbon to decrease pollution in the discharge form the roof. The growing medium is selected to have sufficient water storage capacity. The recommended permeability of the growing medium is at

least 1-inch per hour as per ASTM E2399, the pH value range is between 6 and 8.5. The fine particles (10%) should be less than 0.002 inches or greater than 0.47 inches.

Filter Fabric:

A filter fabric is to be installed below the planting media with sufficient density to support the growing medium and permit root penetration.

Drainage Layer:

The drainage layer is a non-carbonate, coarser granular material resistant to freeze and thaw cycles and possess hydraulic conductivity greater than the growing medium.

Root Barrier:

A roof barrier is provided to ensure that the roots of the vegetation does not damage the roof structure and does not interfere with the root's access to water.

Water Proofing System:

A waterproofing system is included to ensure that water does not damage the roof or leak into the building. The impermeable root barrier may act as the waterproofing system.

Leak Detection:

Location of physical leak detection systems will depend on the manufacturer's specifications and shall be placed accordingly. A flood test is not recommended, as it is insufficient for detecting small leaks. Electronic leak detection and moisture monitoring systems are recommended.

Roof Slope:

The roof is relatively flat with pitch for positive drainage towards the drainage outlet.

Environmental Protection:

The green roof must be protected against the wind erosion. The vegetation must be established quickly especially around the perimeter and corners of the roof. Temporary erosion protection, such as mats or mesh, must be provided until mature plant cover is established.
If erosion becomes an issue, permanent stabilization must be installed. All stabilization measures must be included in the maintenance plan.

Safety:

All green roofs must be designed to safely convey overflows, up to and including the 100-year storm, to downstream drainage systems. The design of any overflow structure must be sufficient to provide safe and stable discharge of stormwater in the event of an overflow. Safe and stable discharge minimizes the possibility of adverse impacts, including erosion and flooding in down-gradient areas. All drains and scuppers must be protected to prevent clogging; one such method is a gravel apron, as shown in the image below.

Vegetated Areas:

- Bi-weekly inspections are required when establishing/restoring vegetation.
- A minimum of one inspection during the growing season and one inspection during the non-growing season is required to ensure the health, density and diversity of the vegetation. Additional inspections are required after major weather events, such as but not limited to, high wind events and lightning strikes.
- Trimming of the vegetation must be performed on a regular schedule based on specific site conditions.
- Vegetative cover must be maintained at 85%; damage in excess of 50% must be immediately addressed through replanting in accordance with the original specifications.
- Vegetated areas must be inspected at least once annually for erosion, scour and unwanted growth; any unwanted growth must be removed with minimum disruption to the remaining vegetation.
- All use of fertilizers, pesticides, mechanical treatments and other means to ensure optimum vegetation must not compromise the intended purpose of the green roof.

Drain Time:

- Water ponding on the surface and the drainage layer of green roofs must fully drain within 72 hours; ponding in excess of 72 hours may render the green roof ineffective and may result in anaerobic conditions, odor and both water quality and mosquito breeding issues.

Design of Green Roof:

Refer to attached site and building details.

Proposed Green Roof Area = 844 sq.ft. + 360 sq.ft. = 1,204 sq. ft.

Selected Green Roof:

Extensive Green Roof is selected as these are economical and more suitable for retrofits. The growing medium depth for extensive green roof is 6-inches or less. The shallow depth has less unit weight. The selected depth is sufficient to the selected vegetation.

Selection of Vegetation:

Selection of growing medium: Refer to New Jersey Stormwater Best Management Practices Manual table attached)

The growing medium on a green roof will absorb and retain a portion of the rainfall that lands on it, thus reducing the volume of runoff that will reach downstream stormwater facilities. For the calculation of runoff retention, the available water capacity for runoff reduction is the difference in the water content

between the field capacity (the water content of the soil after free drainage has ceased) and the wilting point (the minimum soil moisture required by a plant to not wilt.

- 20% 1-7 mm pumice
- 60% 4-10 mm pumice
- 20% composted pine bark fines

Hydraulic Computations:

Calculation of runoff retention of the proposed Green Roof:

$$S_v = \frac{SA\ x\ [(d\ x\ \eta_1)+(DL\ x\ \eta_2)]}{12}, \text{ where:}$$

S_v = storage volume (cf)
SA = green roof area (sf)
d = media depth (in)
η_1 = available water capacity for runoff retention
DL = drainage layer depth (in)
η_2 = drainage layer field capacity

SA = Proposed Green Roof Area = 844 sq.ft. + 360 sq.ft. = 1,204 sq. ft.

d = 6-inches

η_1 = 0.231 [Refer to the Table attached from NJ Stormwater Best Management Manual April -2021

DL = 6-inches

η_2 = 0.349 [Refer to the Table attached from NJ Stormwater Best Management Manual April -2021

S_V = 1204 x [(6 x 0.231) + (6 x 0.349)]/12 = 349.16 ft^3

Calculation of discharged runoff volume from the roof area for 2, 10 and 100-year storms for Impervious Roof:

Reference Technical Release-55 (TR-55) NRCS Methodology

Discharged Runoff Volumes by NRCS TR-55 without Green Roof (NRCS Computer Software Hydrology Studio Version 2021 3.0.20)

CN=98, A=0.09 acres, Tc = 6 Minutes

Vol $_{2\text{-Year}}$ = 813 ft^3

Vol $_{10\text{-Year}}$ = 1368 ft^3

Vol $_{100\text{-Year}}$ = 2169 ft^3

Discharged runoff Volume = Runoff Volumes – Storage Volume

For 2-Year = 813 ft^3 – 349.16 ft^3 = 463.84 ft^3

For 10-Year = 1368 ft^3 – 349.16 ft^3 = 1018.84 ft^3

For 100-Year = 2169 ft^3 – 349.16 ft^3 = 1819.84 ft^3

Calculation of Direct Runoff Depth:

The direct runoff depth, Q, is calculated by dividing the discharged runoff volume by the roof area, yielding the following results:

$Q_{\text{2-Year Depth}}$ = 463.84 /4050 = 1.37 inch

$Q_{\text{10-Year Depth}}$ = 1018.84 /4050 = 3.02 inch

$Q_{\text{2-Year Depth}}$ = 1819.84 /4050 = 5.4 inch

Determination of Adjusted Curve Number:

From NRCS Methodology for two, 10 and 100-year design storm the rainfall precipitation depths are

P_2 = 3.33

P_{10} = 4.99

P_{100} = 8.15

Adjusted CN [Figure 10-2 NJ Best Management Practice Manual 2021]

$CN_{2\text{-Year}}$ = 81

$CN_{10\text{-Year}}$ = 82

$CN_{100\text{-Year}}$ = 83

Calculation of Peak Flow rates by Adjusted Curve Number:

The peak flow rates per adjusted Curve Number as per (NRCS Computer Software Hydrology Studio Version 2021 3.0.20)

Time of concentration: [N.J.A.C 7:8-2.4(g)4 for sheet flow and Equation 15-8 NEH 630

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}}$$

n = Manning's coefficient = 0.24 ref; Table 15-1 630 (NEH) and as per NJ Best Management Practices Manual 2021

L = Length of sheet flow 75 feet as per the location of discharge drain on the roof

P_2 = 2-Year, 24 hour rainfall (inches) = 3.33 in (Figure 5-8) NJ Stormwater BMP Manual April. 2021)

S = Slope of land surface, ft/ft = 0.010 as per architectural plans for a flat roof consider a pitch of 6- inch in 50 ft.

T_t = Travel time (hours)

Time of concentration (Green Roof) for 2 –Year = 14.71 minutes

Time of concentration (Green Roof) for 10 –Year = 12.04 minutes

Time of concentration for 100–Year = 9.42 Minutes

Consider Average Time of Concentration as 12.06 minutes

Consider Minimum Time of Concentration as 6 minutes for concrete roof.

Storm Event	Adjusted CN	Discharged Runoff Vol-Green Roof (ft^3)	Peak Flow (cfs)
2-Year	81	463.84	0.067
10-Year	82	1018.84	0.127
100-Year	83	1819.84	0.210

Compare these results with that from an impervious roof:

(NRCS Computer Software Hydrology Studio Version 2021 3.0.20)

CN = 98, A = 0.09 Acres, Tc = 6 Min

Storm Event	Adjusted CN	Discharged Runoff Vol-Imp. Roof (ft^3)	Peak Flow (cfs)
2-Year	98	895	0.530
10-Year	98	1505	0.682
100-Year	98	2386	0.931

Pre-Construction Surface Runoff for two, 10 and 100-Year Storms

Vacant lot approximately 4,049 sq.ft.

Pre-construction Drainage Computation:

Rational formula $Q=C \times i \times A$

Where:

Q = the surface runoff in cubic feet per second (ft^3/sec)

C = the coefficient of surface runoff

A = the area in acres

i = the rainfall intensity in in/hour

Consider 'C' as 0.3 for the pre-developed condition as the undeveloped land with vegetative cover.

Consider 2-year, 10-year and 100-year design storms for stormwater quantity estimation.

Time of concentration [N.J.A.C 7:8-2.4(g)4 for sheet flow and Equation 15-8 NEH 630

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}}$$

n = Manning's coefficient = 0.40 ref; Table 15-1 630 (NEH)

L = Length of sheet flow 10 feet (630 (NEH)

P_2 = 2-Year, 24 hour rainfall (inches) = 3.33 in (Figure 5-8) NJ Stormwater BMP Manual April. 2021)

S = Slope of land surface, ft/ft = 0.033 as per site plan with topographic survey.

T_t = Travel time (hours)

$T_{t\text{-}2\text{-}year\ Pre}$ = 0.287 hours = 17.2 minutes.

Rational Method Hydrology

The peak flow rates as per (Rational Method) Computer Software Hydrology Studio Version 2021 3.0.20)

Storm Event	Peak Runoff Vol-Vacant Lot (ft^3)	Peak Flow (ft^3/sec)
2-Year	106	0.111
10-Year	140	0.146
100-Year	195	0.203

Pre-Construction Peak Flow by NRCS:

CN = 61 for good condition grass cover >75%

Storm Event	Peak Runoff Vol-Vacant Lot (ft^3)	Peak Flow (ft^3/sec)
2-Year	104	0.035
10-Year	384	0.142
100-Year	944	0.337

Sizing/capacity check for the drainage outlet:

A 4-inch Schedule 40 PVC pipe carries the roof drainage to the equipment room cellar and carries the drainage to combined sewer on Orient Way. As per the manning's equation the flow carrying capacity of the drainage pipe is calculated below:

$$Q = VA = \left(\frac{1.49}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [U.S.]$$

$$Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}} \sqrt{S} \quad [SI]$$

Where:

Q = Flow Rate, (ft^3/s)
v = Velocity, (ft/s)
A = Flow Area, (ft^2) = 0.049 ft^2
n = Manning's Roughness Coefficient = 0.013 for smooth PVC pipe
R = Hydraulic Radius, (ft) – Consider full pipe (full)
S = Channel Slope, (ft/ft) = 0.002

Hydraulic Radius = Area of the pipe/wetted parameter = 0.049/0.393 = 0.785

Q = 0.216 ft^3/sec
Q 10-Year for the post construction discharge with green roof = 0.127 ft^3/sec

The Q provided > Q required OK

Conclusion:

The proposed residential/commercial building occupies the entire lot. A preconstruction and post construction hydraulic and hydrologic (H&H) analysis is done to meet the requirements of N.J.A.C 7:8, New Jersey Best Management Practices Manual April 202, and Jersey City MUA Stormwater Ordinance and other documents and standards as mentioned in the design references; and utilizing NRCS Computer Software Hydrology Studio Version 2021 3.0.20.

The recent NJDEP amendments for N.J.A.C 7:8 to maximize green infrastructure compared to Low Impact Development (LID) Strategies and use of non-structural best management practices. The proposed green roof justifies the NJDEP amendments for the stormwater management.

Drainage computations are done for the preconstruction site condition for the vacant lot and compared with the post construction development. The post construction drainage computations are done for the roof drainage with and without green roof to establish the volume of water and surface runoff reduction achieved by the proposed green roof.

As depicted in the drainage calculations, the post construction peak flows are less than the preconstruction peak flows.

The drainage outlet is located in the roof plan. 10-Year flow storm peak flow is used to check the capacity.

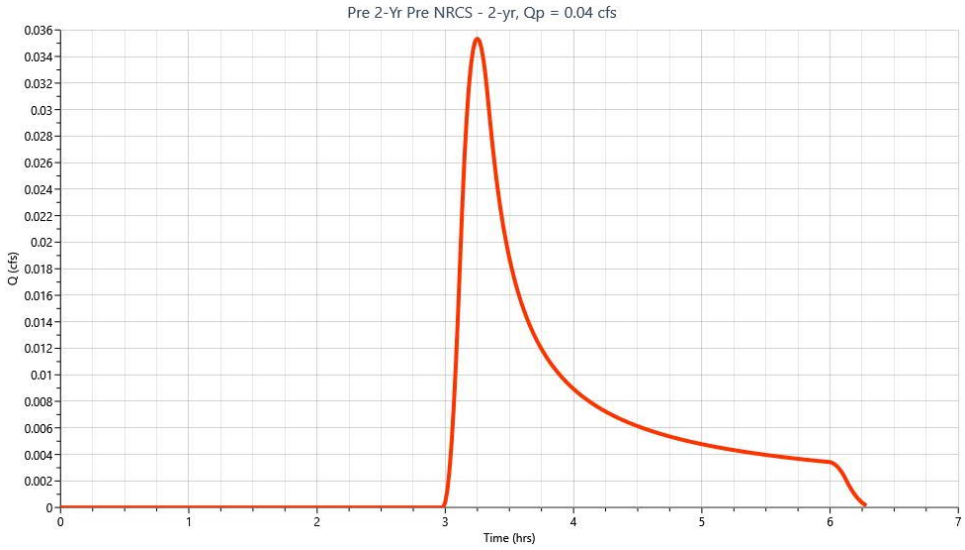
APPENDIX 1

HYDROGRAPHS

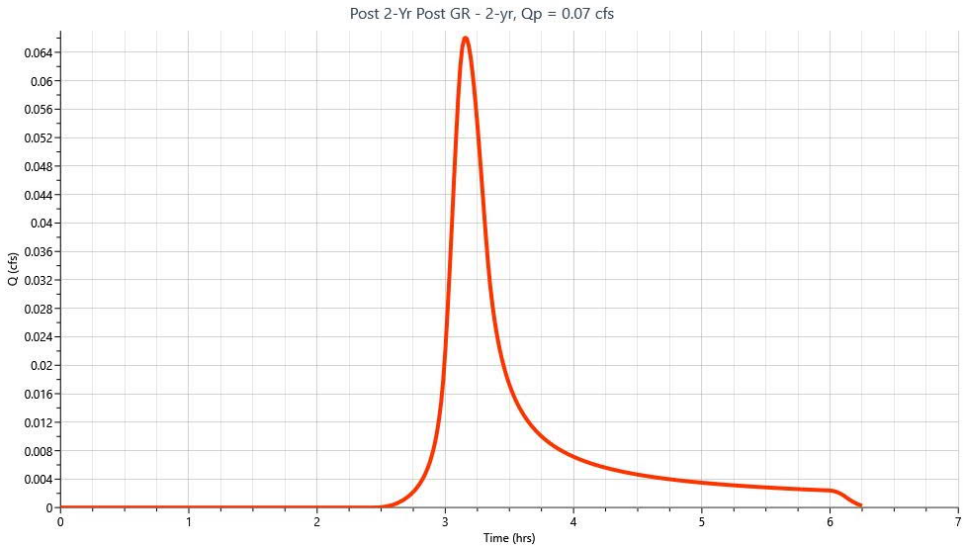
2 Year

10 year

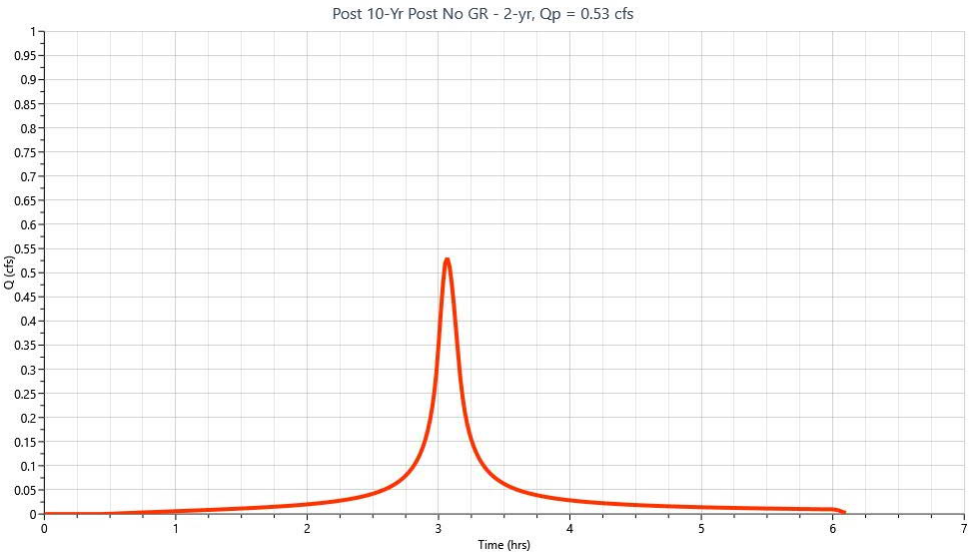
100 Year



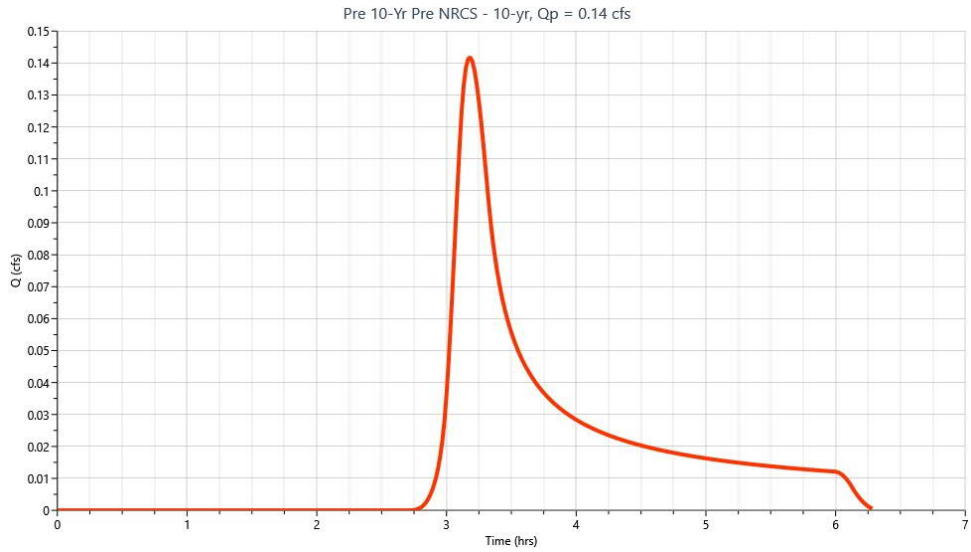
2 yr Pre-construction NRCS



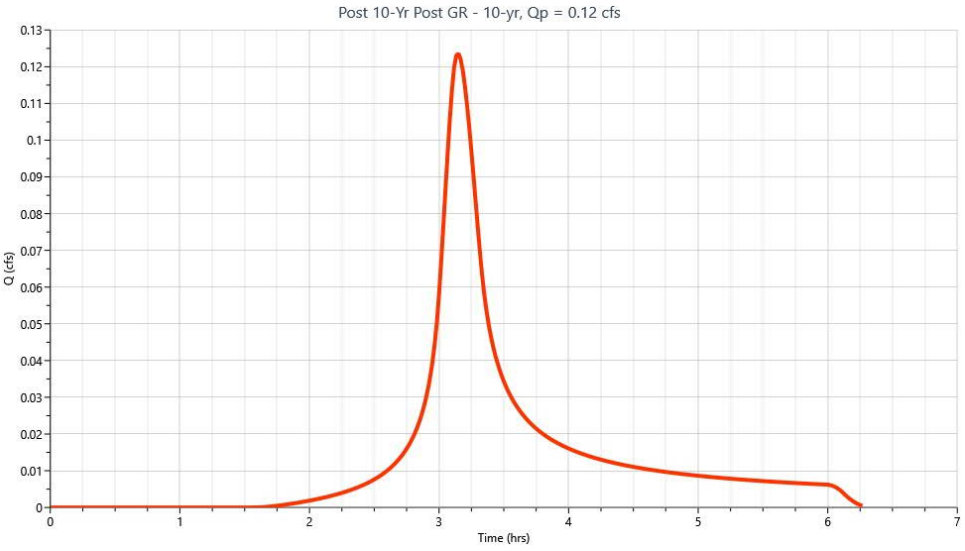
2 Yr Post Construction with GR



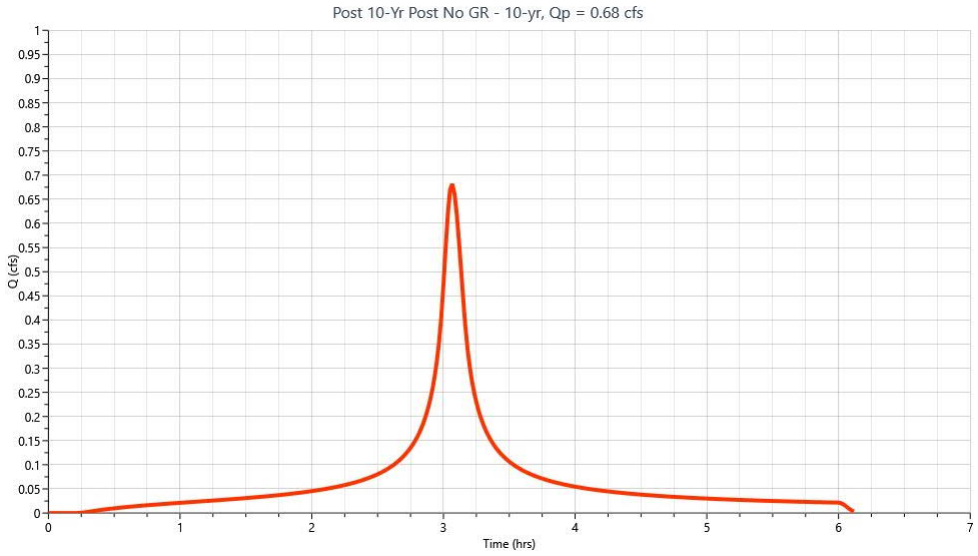
2 Yr Post Construction without GR



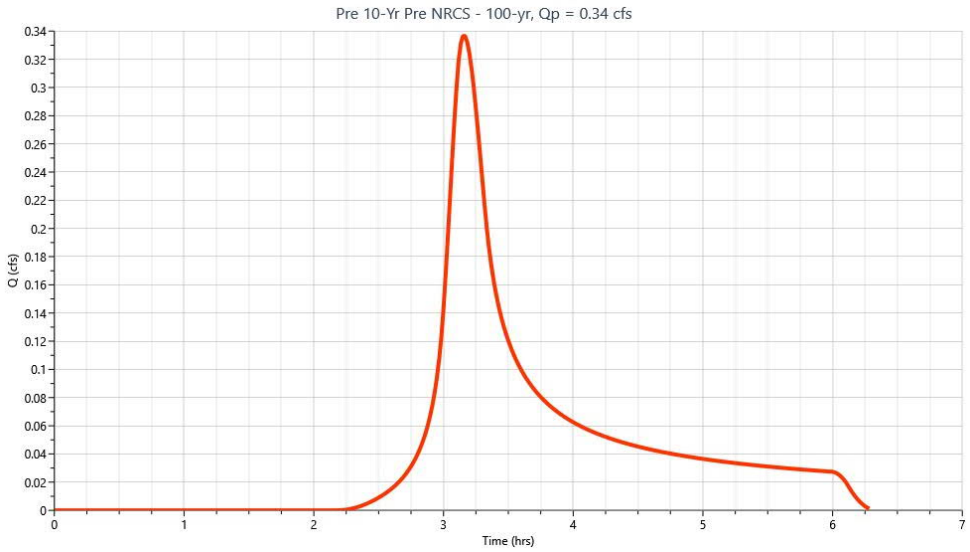
10 yr Pre-construction NRCS



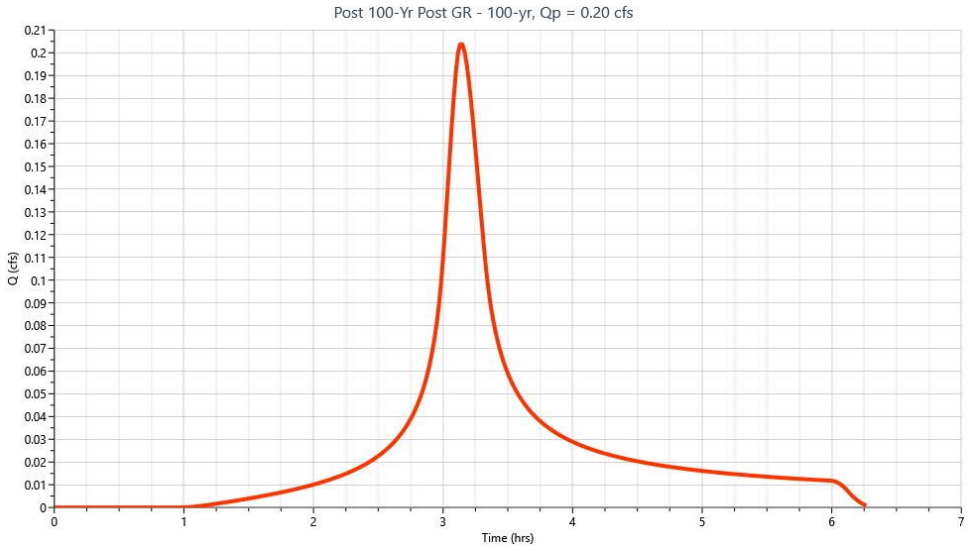
10 Yr Post Construction with GR



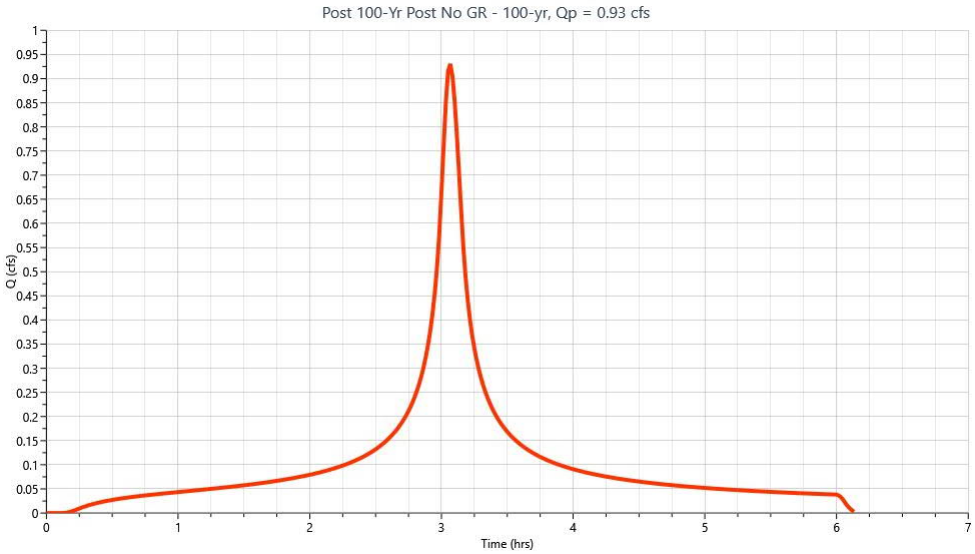
10 Yr Post Construction without GR



100 yr Pre-construction NRCS



100 Yr Post Construction with GR

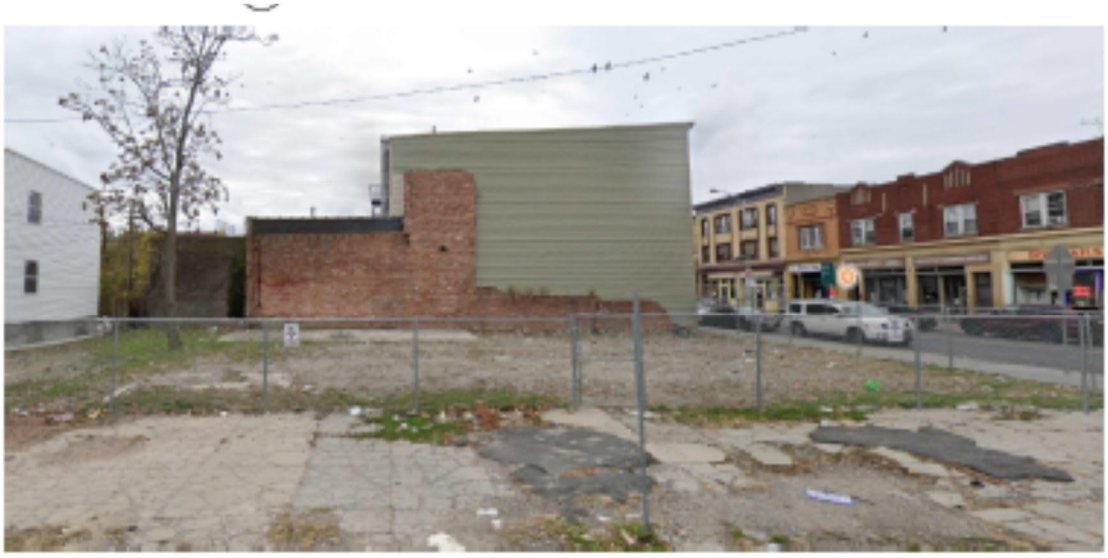


100 Yr Post Construction without GR

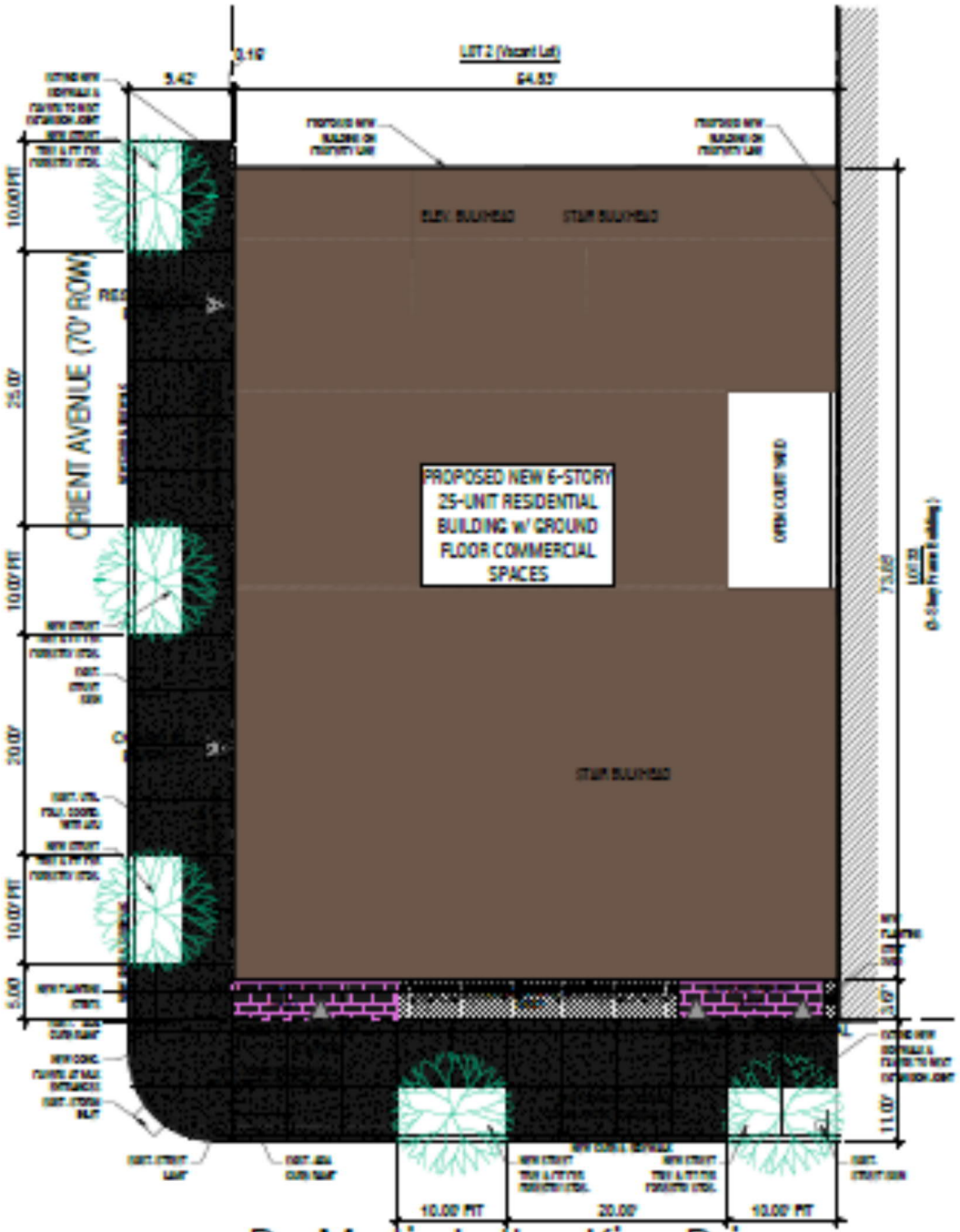
APPENDIX 2

Site Plans:

5 CURRENT STREET VIEW ALONG MLK DRIVE



6 CURRENT STREET VIEW ALONG ORIENT AVE

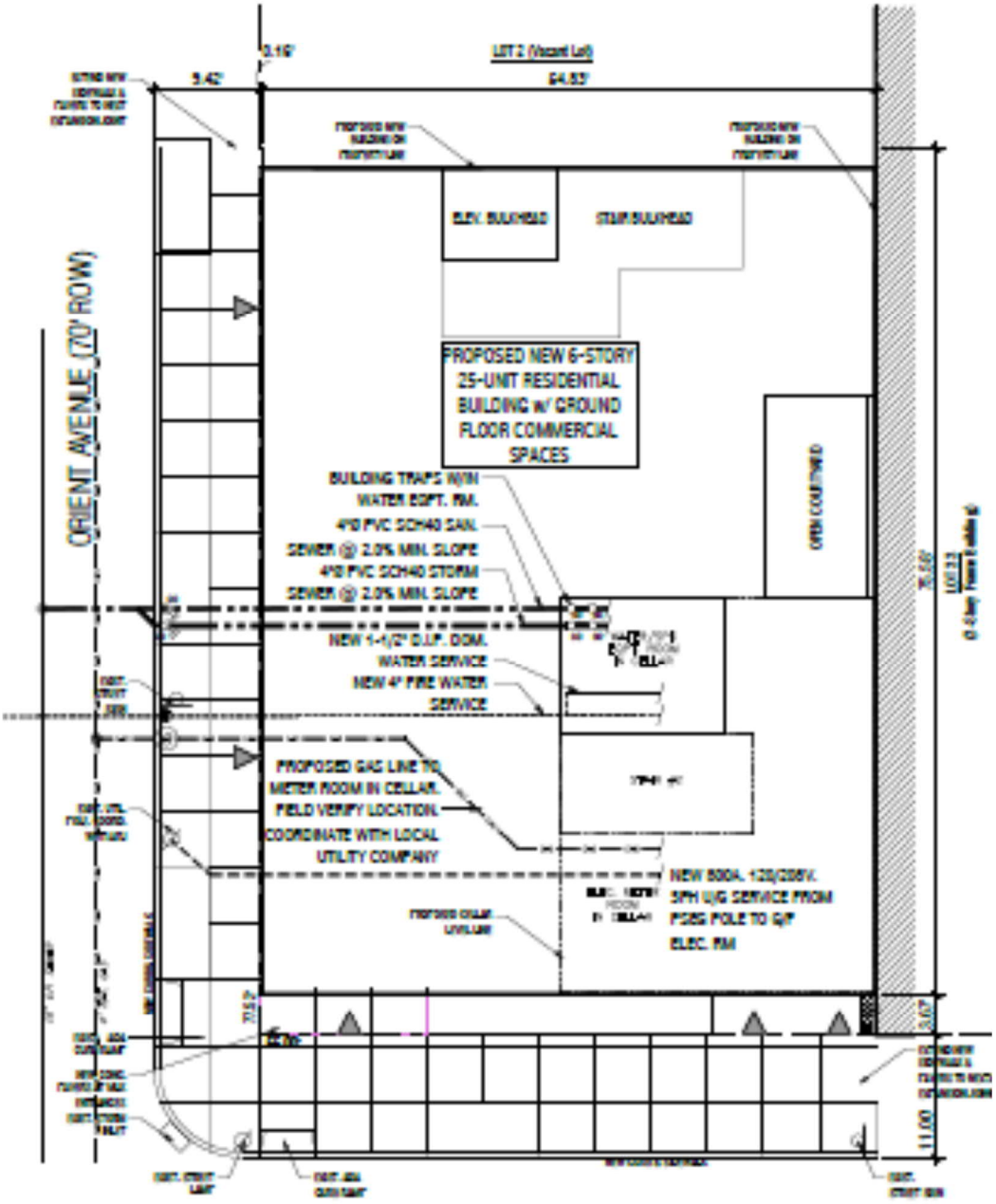


2 PROPOSED SITE PLAN

SCALE: 1"=10'-0"

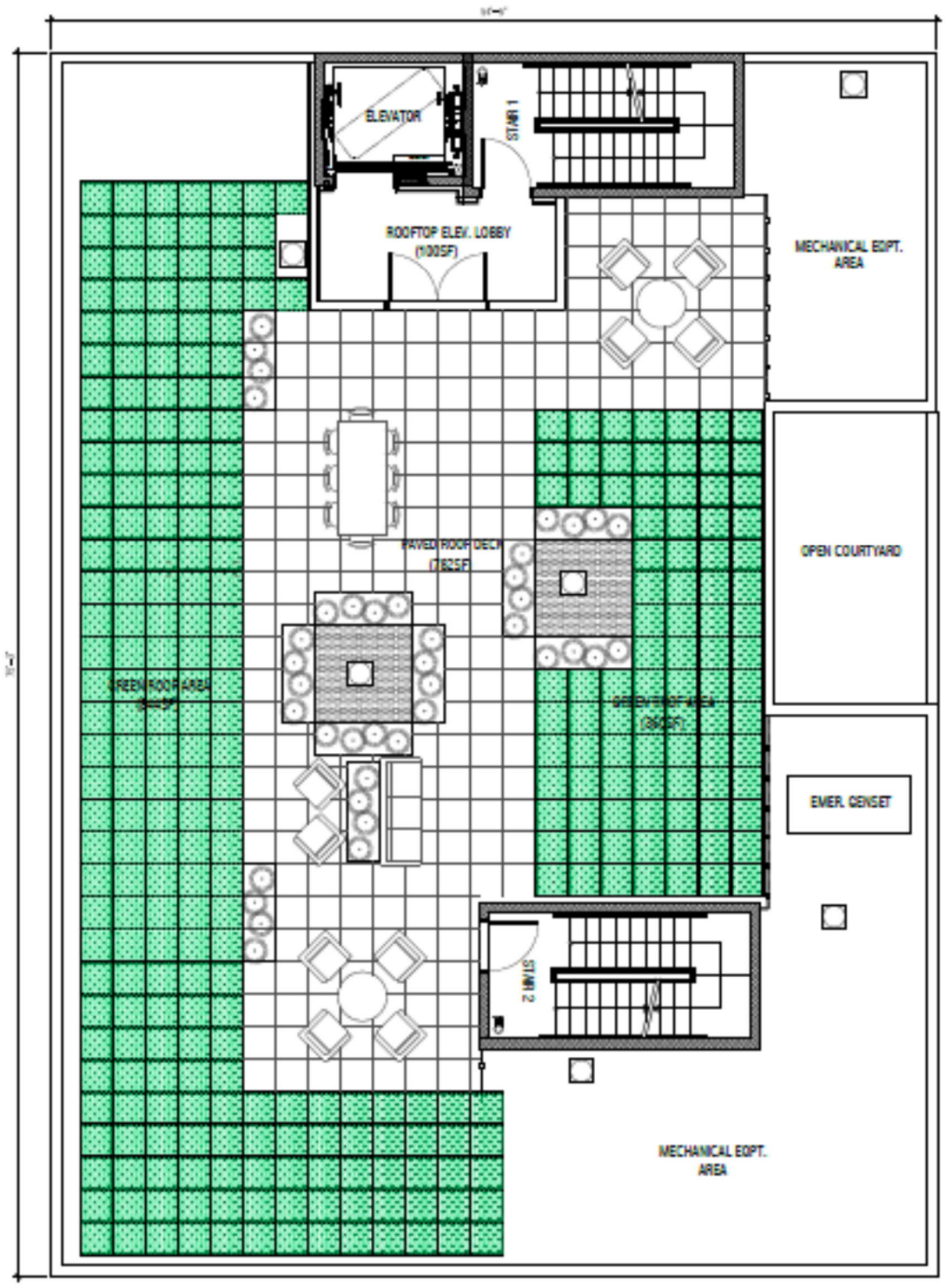
0 5 10 15 30

GRAPHIC SCALE



Dr. Martin Luther King Drive

(60' Wide Right-of-Way)



1 ROOFDECK PLAN

1 PROPOSED ELEVATION ALONG MLK DRIVE

1 PROPOSED ELEVATION ALONG ORIENT AVENUE