Tailwater Engineering
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July 24, 2023

Town of Richmond
Attention: Tyler Machia, Zoning Administrator
Planning and Zoning Office
P.O. Box 285
Richmond, VT 05477

RE: 2 Lot Subdivision – Application No. PRESUB2023-09 – Bradley & Karin LaRose – 156 Wortheim Road – Stormwater Letter Report

Dear Tyler,

Tailwater Engineering (T.E.) was contacted by Barnard & Gervais (B&G) to evaluate the stormwater management for the above-mentioned project. Per the Town subdivision regulations and specifically item no. 38 from the staff comments memo prepared by the Town of Richmond, the rules state: "*that all parking areas and associated roadways shall be designed and constructed with detention devices, such as, but not limited to overland grassed and/or stone lined swales, detention basins, and settling ponds, in order to assure that the post development peak flow stormwater volumes from such parking areas and roadways do not exceed the predevelopment quantities based on the run-off from a twenty-five year, twenty-four hour storm event.*" T.E. has performed a pre and post construction hydrologic model of the site for the 25-year rainstorm event using HYDROCAD® Stormwater Modeling Software. Additionally, T.E. has performed culvert capacity calculations for the proposed culverts. The results of the model and culvert sizing are summarized and presented below.

Stream Discussion & Proposed Culverts Sizing

There is an existing intermittent stream that crosses the site from south to north. This stream enters the property from an existing 18-inch diameter culvert that crosses Wortheim Road. Prior to and after the the July 2023 rainstorms which somewhere between 6-8 inches of rain in a 24-hour period fell (which is somewhere between a 200 year and 1000 year storm per the NOAA Atlas 14 Point Precipitation Frequency Estimates, see attached), the stream channel appears to have remained stable (no erosion) and the 30-inch culverts were not overtopped. The 18-inch culvert on Wortheim Road did washout during this storm and a significant amount of gravel was deposited on the Larose property which has since been cleaned out.

After attempting to perform a hydrologic analysis of the stream using GIS lidar and aerial photos, the exact watershed boundary was not able to be determined. Further inspection of the watershed could be made on the ground and a model could be developed but T.E. believes due to the drainage for this particular area, that a visual inspection and some culvert hydraulic calculations would be sufficient analysis for the stream and culverts sizing.

The current design prepared by B&G utilizes a 30-inch diameter culvert at the new driveway crossings which matches the existing 30-inch culvert further upstream. Since the stream is almost solely fed by the 18-inch culvert with some additional contributing area on the LaRose property, the 18-inch culverts discharge capacity is the key design factor in sizing the downstream culverts. Using the best available information and some assumptions including that the 18-inch culvert is inlet controlled, the estimated barrel capacity of the 18-inch culvert is approximately 14.86 cubic feet per second (cfs). The proposed 30-inch HDPE culverts approximate barrel capacities are 58 cfs each, which is almost 400% larger than the 18-inch culvert. Knowing the additional volume capacity provided by these larger culverts and the measured bank full width of the stream being 24-inch, the sizing of the two culverts likely exceeds the 25-year storm event.

On-site Stormwater Management

The site drainage is separated by the stream noted above which splits the site into two separate sub-catchments. The following are the inputs for both the pre and post models. The model uses TR-20 with the Lag/CN method which is the accepted modeling procedure of the State of Vermont's Stormwater Management Division.

Givens for both Pre & Post Sub-catchments

- Per the NRCS, the soils are hydrologic rated C/D and D which are poorly to extremely poorly drained.
- Per NOAA Atlas 14, the 25-year, 24-hour storm depth for Richmond is 4.23-inches.

Preconstruction Sub-Catchment No. 1

- Land Cover
    - 3,100 sq.ft. existing gravel drive
    - 37,630 sq.ft. woods / grass combination
    - Total Area = 40.730 sq. ft
- Average Slope = 10.4% +/-
- Total peak runoff from 25-year storm = 4.12 cfs

Preconstruction Sub-Catchment No. 2

- Land Cover
  - 3,161 sq.ft. existing gravel drive
  - 50.438 sq.ft. woods / grass combination
  - 3,307 sq.ft. rooftop / deck
  - Total Area = 56,906 sq. ft
- Average Slope = 8.6% +/-
- Total peak runoff from 25-year storm = 5.63 cfs

The total combined existing peak runoff for the site = 9.75 cfs

Post Construction Sub-Catchment No. 1

- Land Cover
  - 3,100 sq.ft. existing gravel drive
  - 1,764 sq.ft. new gravel drive
  - 35,866 sq.ft. woods / grass combination
  - Total Area = 40.730 sq. ft
- Average Slope = 10.4% +/-
- Total peak runoff from 25-year storm = 4.23 cfs

Post Construction Sub-Catchment No. 2

- Land Cover
  - 3,161 sq.ft. existing gravel drive
  - 46,082 sq.ft. woods / grass combination
  - 3,307 sq.ft. existing rooftop / deck
  - 2,916 sq. ft new gravel drive
  - 1,440 sq.ft. new rooftops
  - Total Area = 56,906 sq. ft
- Average Slope = 8.6% +/-
- Total peak runoff from 25-year storm = 5.84 cfs

The total combined pre-routed peak runoff for the site = 10.07 cfs

Proposed Stormwater Management

The increase in runoff volume requires attenuation of the flows to reduce the post construction volumes to pre-construction volumes. Since the site's soil is so poorly drained, infiltrating of the water is not feasible. Therefore, the attenuation is proposed to be performed in a dry detention pond at the north end of the property. Sub catchment no.2 drains entirely to the proposed pond. The proposed pond has the following characteristics:

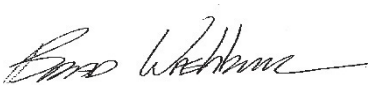
- 2-feet deep
- Water level controlled by a 12-inch vertical PVC riser with a grate set 6-inch from the pond bottom.
- The volume of the pond is 2,239 cubic feet.
- Total peak runoff from 25-year storm = 4.48 cfs

The total combined post construction peak runoff from the site = 8.71 cfs which is less than the preconstruction total combined peak runoff of 9.75 cfs.

The revised plans and hydrologic modeling reflect the information as outlined in this letter.

Please feel free to contact me with any questions.

Sincerely,
Tailwater Engineering



Brad Washburn, P.E.
Owner

NOAA Atlas 14, Volume 10, Version 3
Location name: Richmond, Vermont, USA*
Latitude: 44.3859°, Longitude: -73.0263°
Elevation: 780 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.307 (0.241-0.390)	0.361 (0.283-0.459)	0.450 (0.351-0.571)	0.523 (0.405-0.669)	0.624 (0.466-0.826)	0.702 (0.512-0.945)	0.779 (0.549-1.08)	0.857 (0.580-1.23)	0.961 (0.624-1.42)	1.04 (0.658-1.56)
10-min	0.436 (0.341-0.552)	0.512 (0.401-0.650)	0.637 (0.497-0.811)	0.740 (0.573-0.947)	0.883 (0.660-1.17)	0.993 (0.726-1.34)	1.10 (0.778-1.53)	1.21 (0.821-1.74)	1.36 (0.884-2.01)	1.47 (0.932-2.22)
15-min	0.512 (0.402-0.650)	0.602 (0.471-0.765)	0.749 (0.584-0.954)	0.871 (0.676-1.12)	1.04 (0.777-1.38)	1.17 (0.854-1.57)	1.30 (0.916-1.80)	1.43 (0.967-2.04)	1.60 (1.04-2.36)	1.73 (1.10-2.61)
30-min	0.696 (0.545-0.882)	0.818 (0.640-1.04)	1.02 (0.793-1.29)	1.18 (0.916-1.51)	1.41 (1.05-1.87)	1.58 (1.16-2.13)	1.76 (1.24-2.44)	1.94 (1.31-2.77)	2.17 (1.41-3.20)	2.34 (1.49-3.53)
60-min	0.879 (0.689-1.11)	1.03 (0.808-1.31)	1.28 (1.00-1.63)	1.49 (1.16-1.91)	1.78 (1.33-2.36)	2.00 (1.46-2.69)	2.22 (1.57-3.08)	2.44 (1.65-3.50)	2.74 (1.78-4.04)	2.96 (1.88-4.46)
2-hr	1.09 (0.862-1.38)	1.28 (1.01-1.61)	1.58 (1.24-2.00)	1.83 (1.43-2.33)	2.18 (1.64-2.88)	2.44 (1.80-3.28)	2.71 (1.94-3.76)	3.01 (2.04-4.27)	3.41 (2.22-5.01)	3.73 (2.37-5.59)
3-hr	1.23 (0.972-1.54)	1.44 (1.13-1.80)	1.77 (1.40-2.24)	2.06 (1.61-2.60)	2.44 (1.85-3.22)	2.74 (2.03-3.67)	3.04 (2.18-4.22)	3.38 (2.30-4.79)	3.87 (2.53-5.66)	4.26 (2.72-6.36)
6-hr	1.47 (1.17-1.83)	1.72 (1.37-2.15)	2.14 (1.70-2.68)	2.49 (1.96-3.13)	2.96 (2.26-3.88)	3.32 (2.48-4.44)	3.70 (2.68-5.13)	4.14 (2.82-5.83)	4.78 (3.14-6.96)	5.33 (3.41-7.90)
12-hr	1.73 (1.39-2.14)	2.05 (1.64-2.54)	2.56 (2.05-3.19)	2.99 (2.37-3.74)	3.58 (2.75-4.67)	4.02 (3.02-5.36)	4.49 (3.28-6.21)	5.05 (3.46-7.07)	5.88 (3.87-8.50)	6.58 (4.22-9.69)
24-hr	2.03 (1.64-2.50)	2.40 (1.94-2.96)	3.02 (2.42-3.73)	3.53 (2.82-4.38)	4.23 (3.26-5.48)	4.75 (3.59-6.28)	5.31 (3.90-7.29)	5.97 (4.11-8.31)	6.95 (4.59-9.98)	7.77 (5.00-11.4)
2-day	2.39 (1.94-2.92)	2.81 (2.28-3.44)	3.50 (2.83-4.29)	4.07 (3.27-5.02)	4.86 (3.77-6.24)	5.44 (4.13-7.13)	6.06 (4.46-8.24)	6.78 (4.69-9.37)	7.83 (5.19-11.2)	8.70 (5.62-12.7)
3-day	2.66 (2.17-3.24)	3.10 (2.53-3.78)	3.83 (3.11-4.68)	4.43 (3.57-5.44)	5.26 (4.09-6.72)	5.88 (4.47-7.66)	6.53 (4.81-8.82)	7.28 (5.05-10.0)	8.35 (5.55-11.9)	9.23 (5.98-13.4)
4-day	2.89 (2.36-3.51)	3.35 (2.74-4.07)	4.11 (3.34-5.00)	4.73 (3.83-5.80)	5.60 (4.36-7.13)	6.25 (4.76-8.11)	6.93 (5.10-9.31)	7.69 (5.35-10.6)	8.78 (5.85-12.5)	9.68 (6.28-14.0)
7-day	3.49 (2.87-4.21)	4.00 (3.29-4.84)	4.85 (3.96-5.87)	5.55 (4.51-6.75)	6.51 (5.10-8.23)	7.23 (5.53-9.33)	7.99 (5.90-10.6)	8.82 (6.16-12.0)	9.99 (6.68-14.1)	10.9 (7.11-15.7)
10-day	4.06 (3.35-4.88)	4.63 (3.81-5.57)	5.55 (4.56-6.70)	6.32 (5.15-7.67)	7.38 (5.79-9.29)	8.18 (6.27-10.5)	9.00 (6.66-11.9)	9.90 (6.93-13.5)	11.1 (7.47-15.7)	12.1 (7.91-17.4)
20-day	5.82 (4.84-6.95)	6.54 (5.42-7.81)	7.70 (6.36-9.23)	8.66 (7.11-10.4)	9.98 (7.89-12.5)	11.0 (8.47-14.0)	12.0 (8.91-15.8)	13.1 (9.22-17.7)	14.5 (9.80-20.3)	15.7 (10.2-22.3)
30-day	7.32 (6.10-8.70)	8.14 (6.78-9.68)	9.48 (7.86-11.3)	10.6 (8.72-12.7)	12.1 (9.60-15.0)	13.3 (10.3-16.8)	14.5 (10.7-18.8)	15.7 (11.1-21.1)	17.3 (11.7-24.0)	18.5 (12.1-26.2)
45-day	9.19 (7.69-10.9)	10.1 (8.47-12.0)	11.7 (9.72-13.9)	13.0 (10.7-15.5)	14.7 (11.7-18.2)	16.1 (12.4-20.2)	17.4 (12.9-22.5)	18.8 (13.3-25.1)	20.5 (13.9-28.3)	21.8 (14.3-30.7)
60-day	10.8 (9.04-12.7)	11.8 (9.90-14.0)	13.5 (11.3-16.0)	14.9 (12.4-17.8)	16.9 (13.4-20.7)	18.4 (14.2-23.0)	19.9 (14.8-25.5)	21.3 (15.1-28.4)	23.1 (15.7-31.9)	24.4 (16.1-34.4)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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PF graphical