HYDROLOGY STUDY REPORT

PROJECT SITE:

V.I. FIRE & EMERGENCY MEDICAL SERVICES (VIFEMS)
1 COTTON VALLEY
CHRISTIANSTED, ST. CROIX, USVI 00820

PREPARED BY:

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INTRODUCTION

This site was previously developed and has a considerable amount of development that currently exist. The proposed improvements primarily encompass the replacement of the existing 3,600 square feet antiquated fire station building with a new expanded state-of-the-art facility measuring approximately 7,400 gross square footage. The new facility will be constructed immediately north of the existing facility which must remain operational throughout the duration of construction. Only after the new facility is placed into service will the existing facility be demolished.

This hydrology study will focus on a pre-development vs. a post-development analysis to ensure that the proposed improvements do not adversely impact stormwater quality and quantity beyond the pre-existing condition. Any additional impacts will be quantified and properly mitigated in accordance with the Department of Planning and Natural Resources (DPNR) requirements.

SOILS CLASSIFICATION

For Curve Number (CN) determination, there are four (4) main types of Hydrologic Soils Classification which are as follows:

Group A – Soils that have low runoff potential when thoroughly wet. These soils typically have less than 10% clays and more than 90% sand or gravel.

Group B – Soils that have moderately low runoff potential when thoroughly wet. These soils typically have between 10% - 20% clays and 50% - 90% sand.

Group C – Soils that have moderately high runoff potential when thoroughly wet. These soils typically have between 20% - 40% clays and less than 50% sand.

Group D – Soils that have high runoff potential when thoroughly wet. These soils typically have greater than 40% clays and less than 50% sand.

St. Croix Hydrologic Soils Classification (Source: *https://usvi.mapgeo.io*)

Based on the above, the Hydrologic Soils Classification for the Site is ***Group B***. This soil classification type is synonymous with Group D in Table 3.6 below.

CURVE NUMBER (CN) CLASSIFICATION

The curve number classification is determined based on land use type and hydrologic soil type. The table below indicates CN values for various land uses and hydrologic soil types.

Table 3-6. Typical Curve Number Values for Urban Areas (SCS 1986)

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area [2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Based on the above, the site falls into three (3) distinct classifications listed as follows:

Poor Condition (grass cover < 50%) – this accounts for the grass cover within the property.

Paved; open ditches (including right-of-way) – this accounts for the paved surfaces within the property.

Commercial and business – this accounts for the buildings within the property.

BASIN CHARACTERISTICS

The disturbed area of the site is approximately 1.22 acres broken down into three (3) major ground cover types. The table below shows the breakdown along with a Weighted Curve Number for each category and ultimately for the entire site.

- **PRE-DEVELOPMENT**

TABLE 1 - PRE-DEVELOPMENT BASIN CHARACTERISTICS

DESCRIPTION	AREA	UNITS	WEIGHTED CURVE NUMBER (CN)
BUILDINGS	0.09	AC	92
SIDEWALK	0.02	AC	98
GRASS COVER	0.87	AC	79
ASPHALT PAVEMENT	0.24	AC	98

TOTAL AREA	1.22	AC

WEIGHTED CN VALUE	**84**

- **POST-DEVELOPMENT**

TABLE 2 - POST-DEVELOPMENT BASIN CHARACTERISTICS

DESCRIPTION	AREA	UNITS	WEIGHTED CURVE NUMBER (CN)
BUILDINGS	0.17	AC	92
SIDEWALK	0.02	AC	98
CONCRETE PAVEMENT	0.36	AC	98
GRASS COVER	0.67	AC	79

TOTAL AREA	1.22	AC

WEIGHTED CN VALUE	**87**

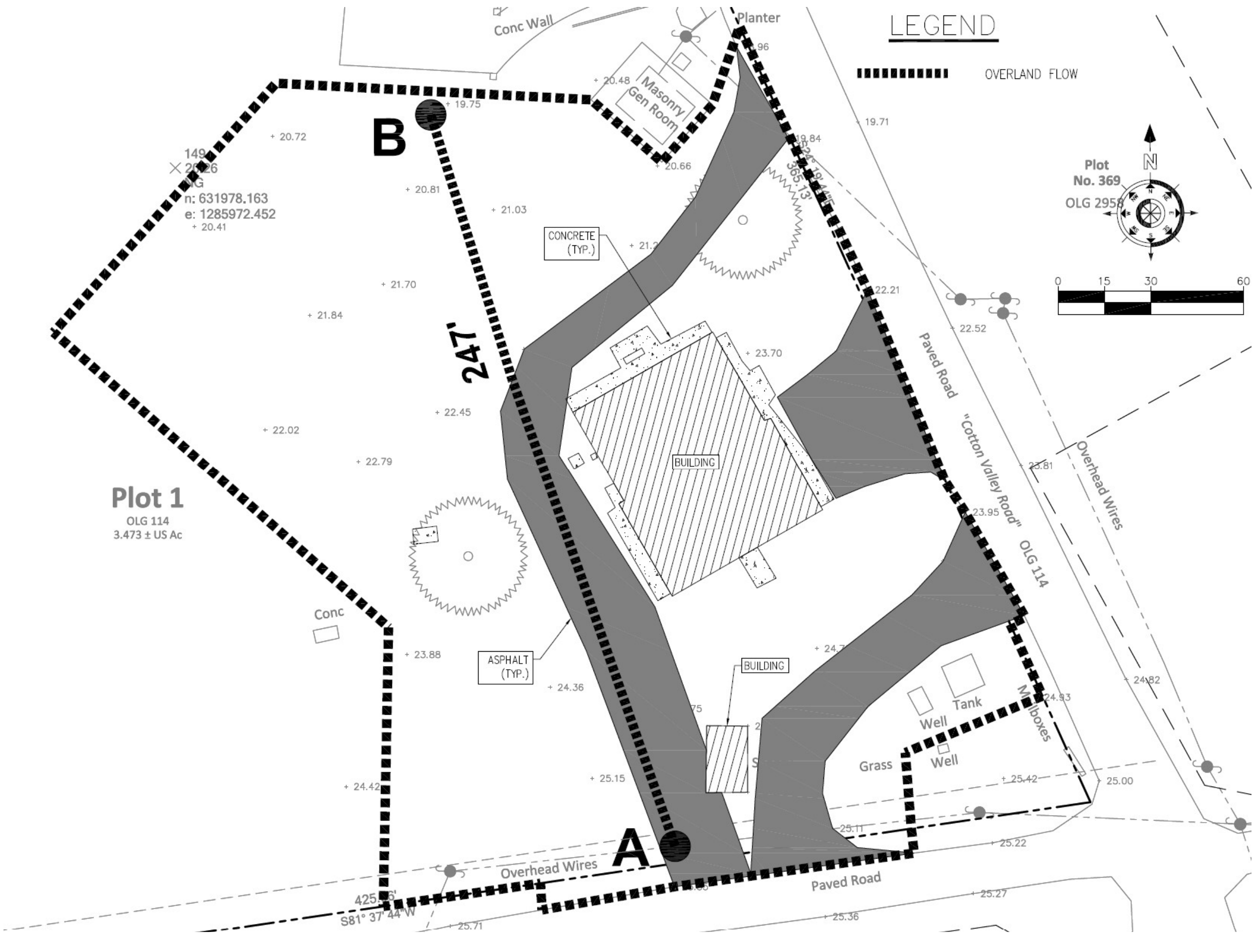
TIME OF CONCENTRATION (Tc)

The time of concentration is necessary to estimate peak discharge and is dependent upon the watershed characteristics. To accurately determine Tc, the hydraulics of each part of the flow path must be considered separately.

➢ PRE-DEVELOPMENT

In the pre-development, the site has one distinct flow path, which is **overland** flow as follows:

- A-B (Overland Flow) – 247 ft. travel distance @ average slope of 2.3%



The flow pattern will be evaluated to determine the Time of Concentration (Tc) which will be used to determine the stormwater water runoff volume.

$P_{24} =$ 4 IN (2yr_24 HOUR CUMMULATIVE RAINFALL AMOUNT)

$$T_t = \frac{(.007)(nL)^{.8}}{(P)^{.5}\ (S)^{.4}}$$ (OVERLAND FLOW)

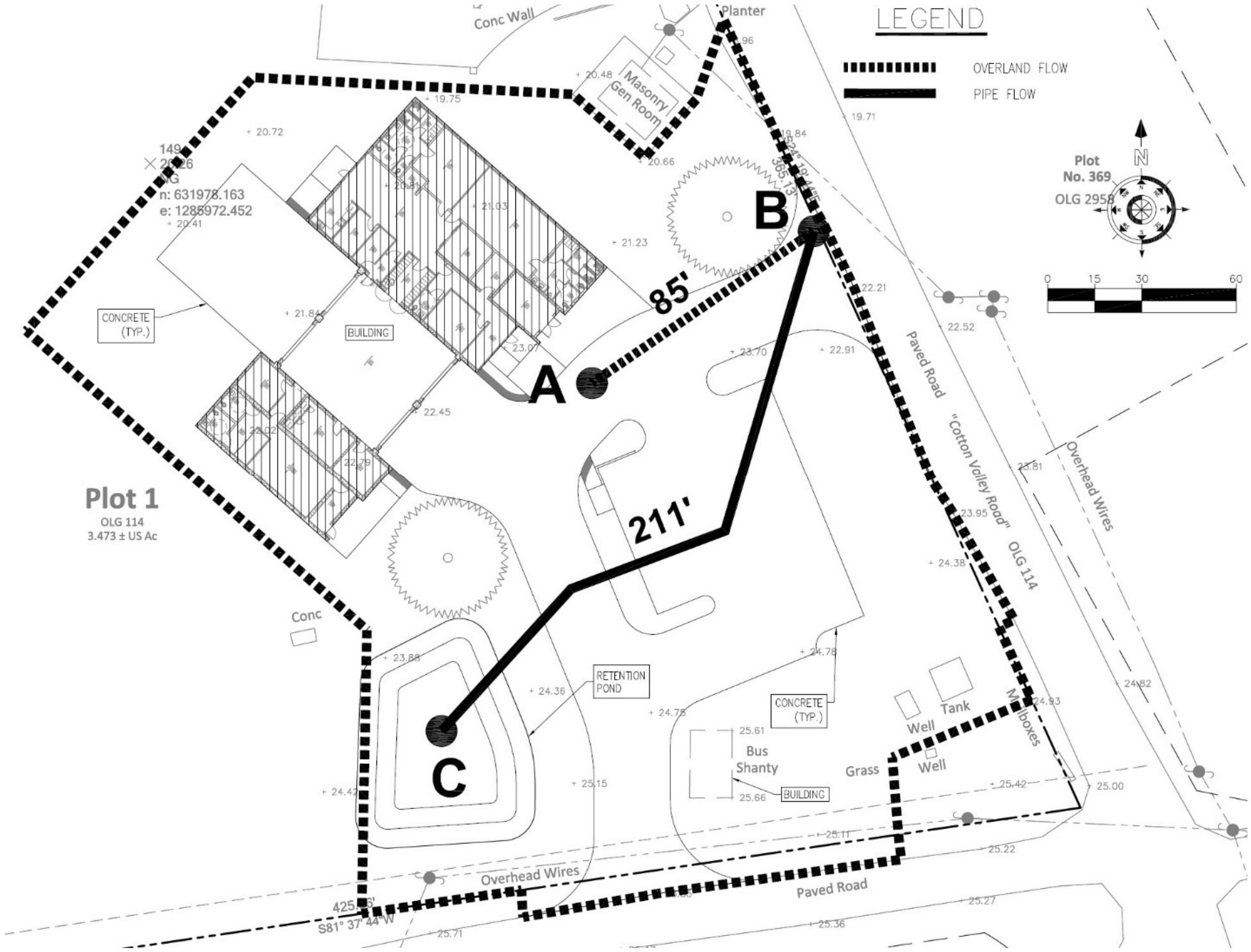
TABLE 3 - PRE-DEVELOPMENT TIME OF CONCENTRATION Tc (2yr - 24 HOUR STORM)				
SEGMENT DESCRIPTION	**SLOPE (S)**	**LENGTH (L)**	**MANNING'S COEF. (n)**	**Tt (hrs)**
A-B (OVERLAND FLOW)	0.023	247	0.03	**0.079**

$Tc = \sum Tt =$ **0.079 hrs** (2YR - 24HR STORM)

➢ POST-DEVELOPMENT

In the post-development, the site has one distinct flow path, which include a combination of **overland and pipe** flow as follows:

- A-B-C (Overland and Pipe Flow) – 296 ft. travel distance @ average slope of 2%



The flow pattern will be evaluated to determine the Time of Concentration (Tc) which will be used to determine the stormwater water runoff volume.

P_{24} = 4 IN (2yr_24 HOUR CUMMULATIVE RAINFALL AMOUNT)

$$T_t = \frac{(.007)(nL)^{.8}}{(P)^{.5}\ (S)^{.4}}$$ (OVERLAND FLOW)

$$T_t = \frac{L}{v}$$ (PIPE FLOW)

$$v = \frac{1.49}{n}(D/4)^{2/3}\ s^{1/2}$$ (PIPE VELOCITY)

TABLE 4 - POST-DEVELOPMENT TIME OF CONCENTRATION Tc (2yr - 24 HOUR STORM)								
SEGMENT DESCRIPTION		SLOPE (S)	LENGTH (L)	PIPE DIA (FT.)	PIPE VELOCITY (FT./S)	MANNING'S COEF. (n)	Individual Tt (hrs)	Cummulative Tt (hrs)
A-B-C (OVERLAND & PIPE FLOW)	A-B (OVERLAND)	0.05	85	N/A	N/A	0.03	0.025	0.042
	B-C (PIPE)	0.005	211	1.33	3.37	0.015	0.017	

Tc = ∑Tt = 0.042 hrs (2YR - 24HR STORM)

RUNOFF (Q) AND STORAGE VOLUME (V)

DPNR Runoff Onsite Storage Requirements as per the ***Territorial Pollutant Discharge Elimination System - General Permit Number VIGSA0000*** is as follows:

1) 3600 cubic feet per acre (1” over 1 acre) or,
2) 2yr – 24 hours storm; whichever is greater

PRE-DEVELOPMENT

PRE-DEVELOPMENT - RUNOFF (Q) AND TOTAL VOLUME (V)

Runoff equation

$$Q = \frac{\left[P - 0.2\left(\frac{1000}{CN} - 10\right)\right]^2}{P + 0.8\left(\frac{1000}{CN} - 10\right)}$$

where:
Q = runoff (in)
P = rainfall (in)
CN = runoff curve number

Volume Equation

$$V = QA$$

where:
Q = runoff (ft)
A = Area (ac)

DPNR Runoff Onsite Storage Requirements
(Territorial Pollutant Discharge Elimination System - General Permit Number VIGSA0000)

1) 3600 cubic feet per acre (1" over 1 acre), or

2) 2 yr - 24 hour storm; whichever is greater

1) 3600 CUBIC FEET PER ACRE

Disturbed Site Acreage = 1.22 ac

V= 0.10 ac-ft

2) 2 YR - 24 HOUR STORM

STORM EVENT	P (in)	CN	Q (in)	Area (ac)	V (ac-ft)
2 - YEAR	4	84	2.37	0.74	**0.15**

As can be noted from the above calculations, the 2yr – 24 hr. storm event generates the most runoff in the pre-development/ current site condition.

POST-DEVELOPMENT

POST-DEVELOPMENT - RUNOFF (Q) AND TOTAL VOLUME (V)

Runoff equation

$$Q = \frac{\left[P - 0.2\left(\frac{1000}{CN} - 10\right)\right]^2}{P + 0.8\left(\frac{1000}{CN} - 10\right)}$$

where:
Q = runoff (in)
P = rainfall (in)
CN = runoff curve number

Volume Equation

$$V = QA$$

where:

Q = runoff (ft)

A = Area (ac)

DPNR Runoff Onsite Storage Requirements
(Territorial Pollutant Discharge Elimination System - General Permit Number VIGSA0000)

1) 3600 cubic feet per acre (1" over 1 acre), or

2) 2 yr - 24 hour storm; whichever is greater

1) 3600 CUBIC FEET PER ACRE

Disturbed Site Acreage = 1.22 ac

V= 0.10 ac-ft

2) 2 YR - 24 HOUR STORM

STORM EVENT	P (in)	CN	Q (in)	Area (ac)	V (ac-ft)
2 - YEAR	4	87	2.64	0.74	**0.16**

As can be noted from the above calculations, the 2yr – 24 hr. storm event generates the most runoff in the post-development.

CONCLUSION

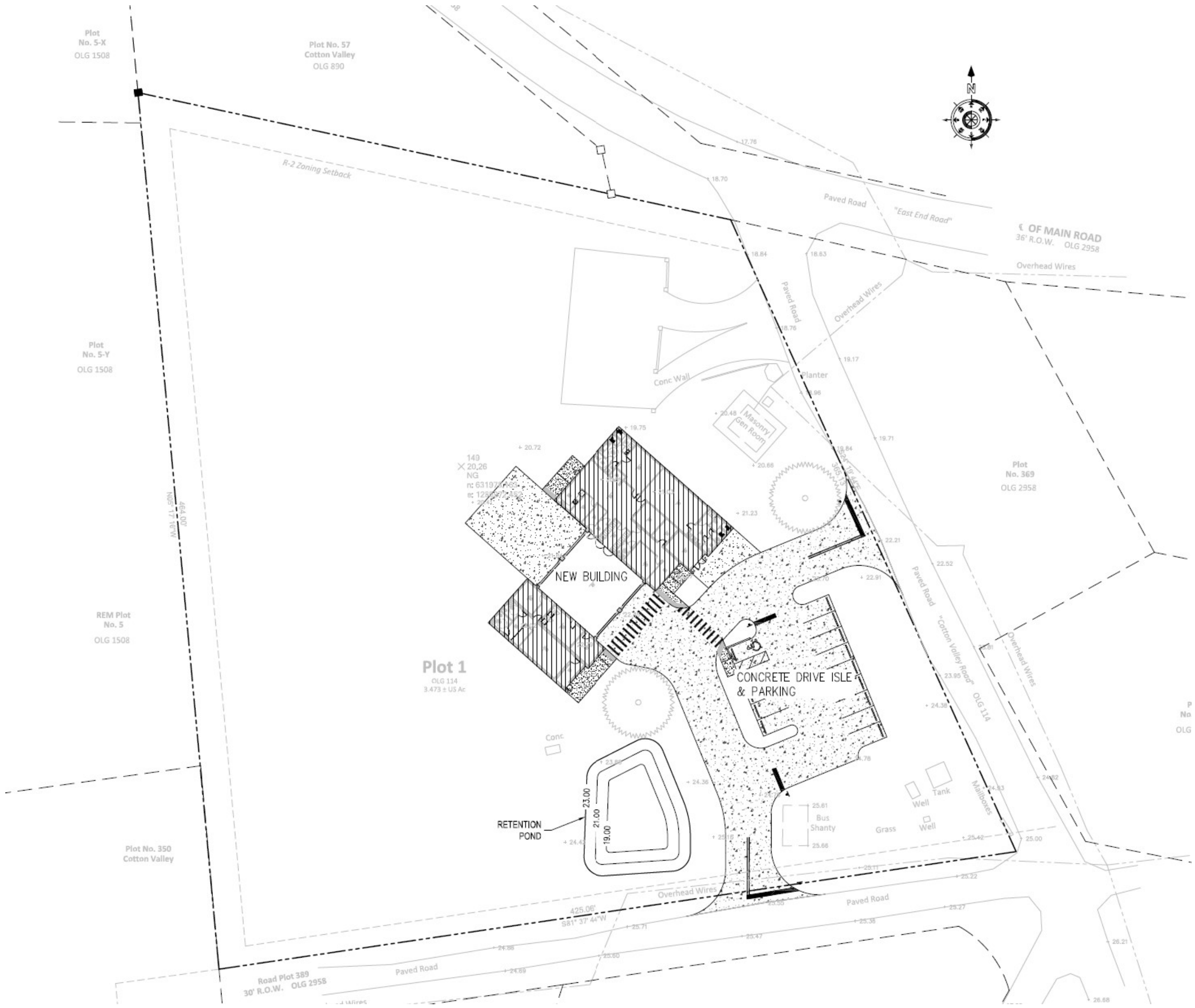
The proposed improvements result in a slight net increase in building and impervious areas over the existing condition which is evident in the pre vs. post runoff coefficient increasing from 84 to 87. The additional storage required to offset this adverse impact is only **0.01 ac-ft** (0.16 ac-ft – 0.15 ac-ft). However, rather than provide just **0.01 ac-ft,** enough storage will be provided to cover at least 1-inch of runoff over the entire disturbed site which equates to **0.10 ac-ft**. Site layout allowed for a larger storage volume resulting in a retention pond totaling **0.20 ac-ft.**

Stormwater Retention Pond Calculations

POND No. 1

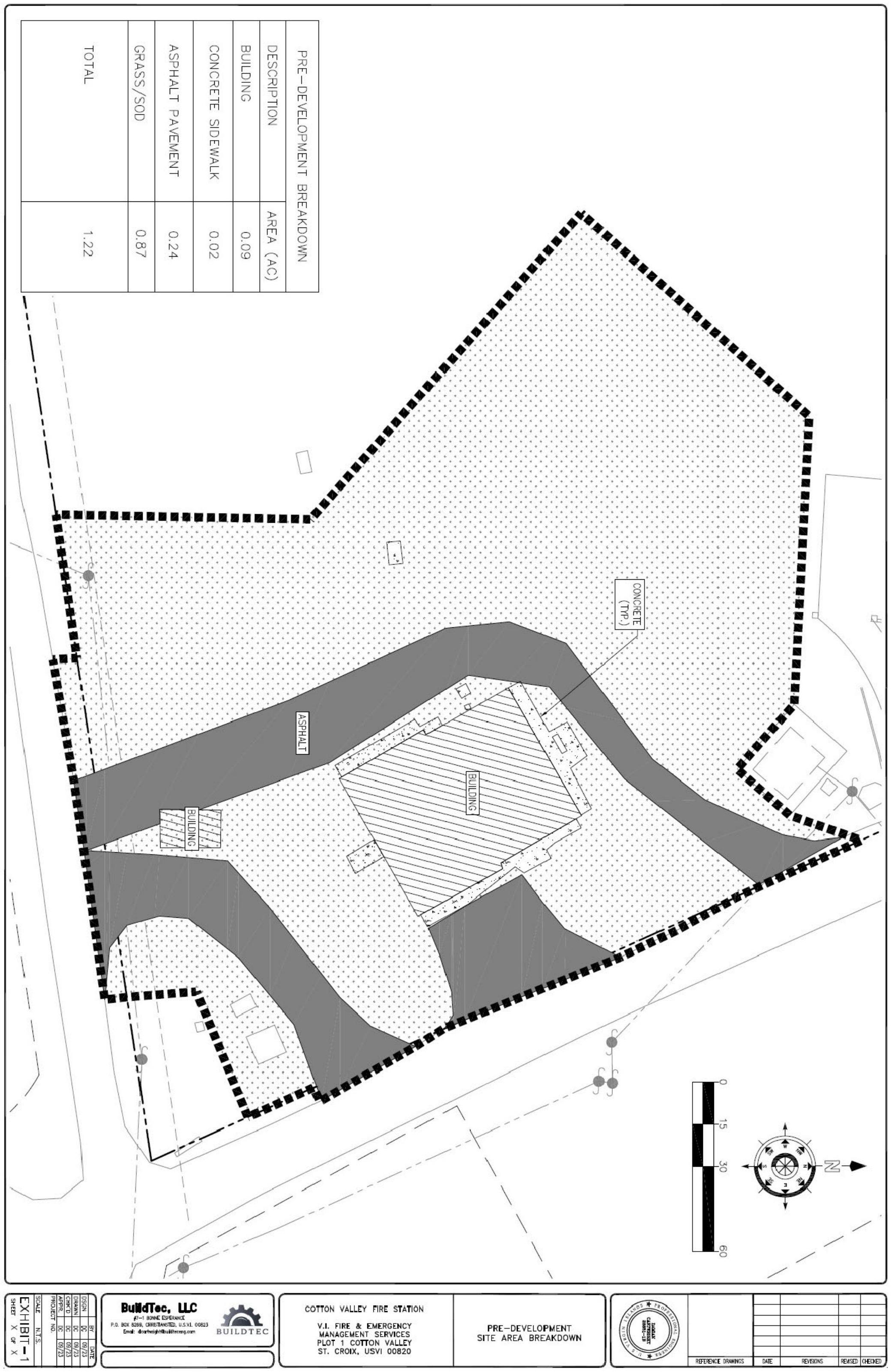
Stage	Area	Area	Average Area	Incremental Volume	Cumulative Pond Volume
(ft)	*(Sq. Ft)*	*(Acres)*	*(Acres)*	*(Ac-ft)*	*(Ac-ft)*
19.0	*1,168*	*0.027*			
21.0	*2,130*	*0.049*	*0.04*	*0.08*	*0.08*
23.0	*3,319*	*0.076*	*0.06*	*0.13*	*0.20*

Proposed Cumulative Pond Storage of 0.20 Ac-ft > Required Storage of 0.01 Ac-ft

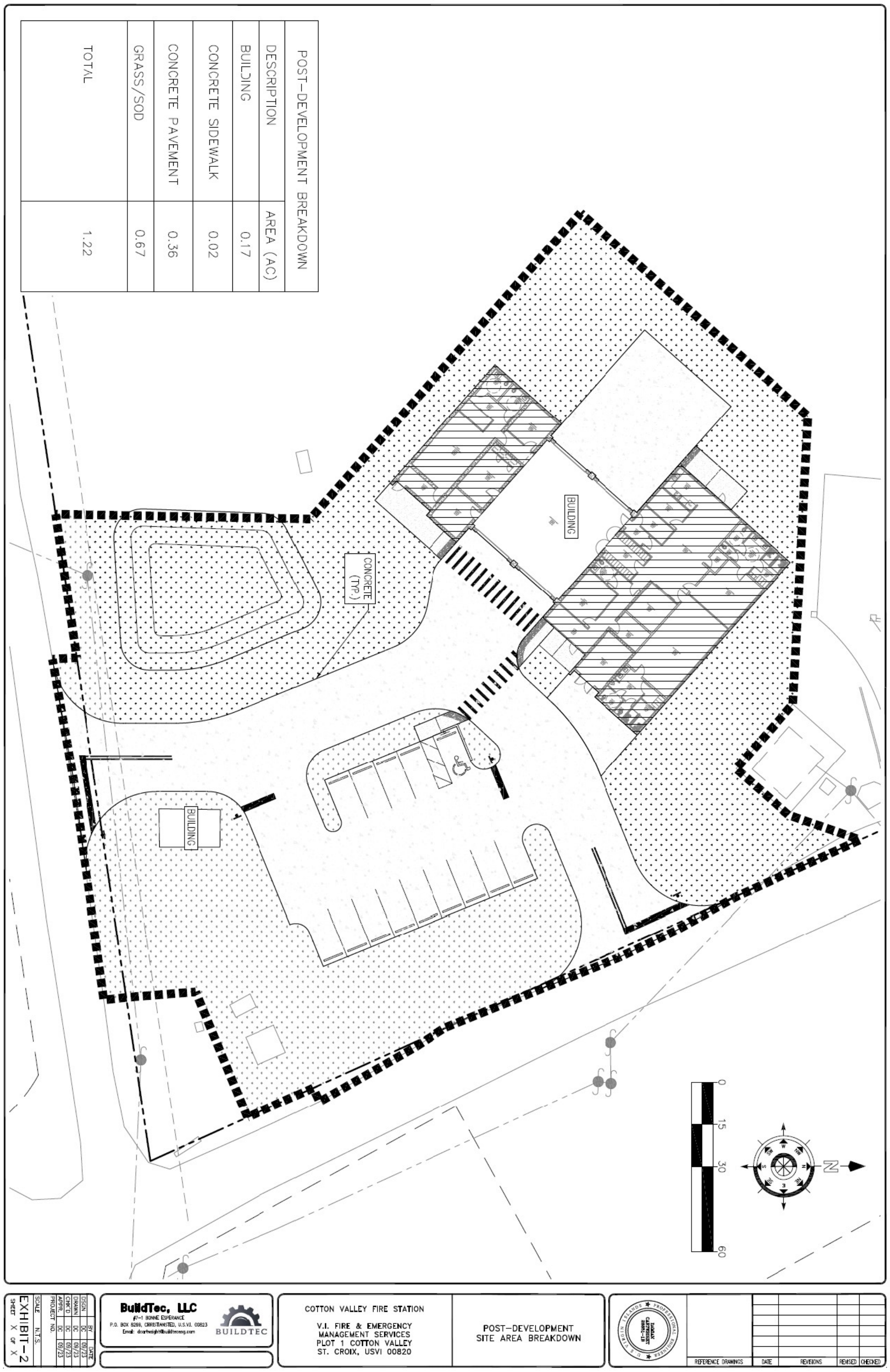


STORAGE POND LAYOUT FOR A TOTAL VOLUME OF 0.20 AC-FT

APPENDICES



PRE-DEVELOPMENT SITE AREA BREAKDOWN



POST-DEVELOPMENT SITE AREA BREAKDOWN