Artisan Point
Drainage and Detention Report

Submitted: August 30, 2018
Revised:

Proposed Multi-Family Residential Development located in:
The NE/4, Section 11, T47N, R31E
Lee's Summit, Jackson County, Missouri

Little Blue River Watershed.
Tributary to Prairie Lee Lake

Prepared for:
Case Development
Artisan Point, LLC
4200 East 51st Street
Tulsa, OK 74135

Prepared by:

Tanner Consulting, LLC
5323 South Lewis Ave.
Tulsa, OK 74105
918-745-9929

Missouri COA 2007025524
Expires 12/31/2018

Table of Contents

Attachment: HEC-HMS Model electronic copy on CD

Tanner Consulting LLC
LAND PLANNING | LAND SURVEYING | CIVIL ENGINEERING
5323 SOUTH LEWIS AVENUE, TULSA OKLAHOMA 74105-6539

August 30, 2018

Artisan Point

The purpose of this report is to evaluate the hydrologic impact of the proposed multi-family development and to demonstrate reasonable compliance with ordinances and design requirements for drainage systems within the jurisdiction of Lee's Summit, Missouri.

General Information

The 30-acre proposed Artisan Point apartment development is located 1,300 feet east of Blackwell Road on the north side of the Blue Parkway service road (Highway 50), on the easterly boundary of the Lee's Summit City Limits. The property abuts unincorporated Jackson County on the east.

Subject Property

The abutting properties on the west, south and east are undeveloped. The subject property abuts the Highland Park Elementary School (Summit Mill 1st Plat) and the Summit Mill Pool Amenities (Summit Mill 2nd Plat) on the North.

The tract is located within the NE/4, Section 11, T47N, R31E, Jackson County:

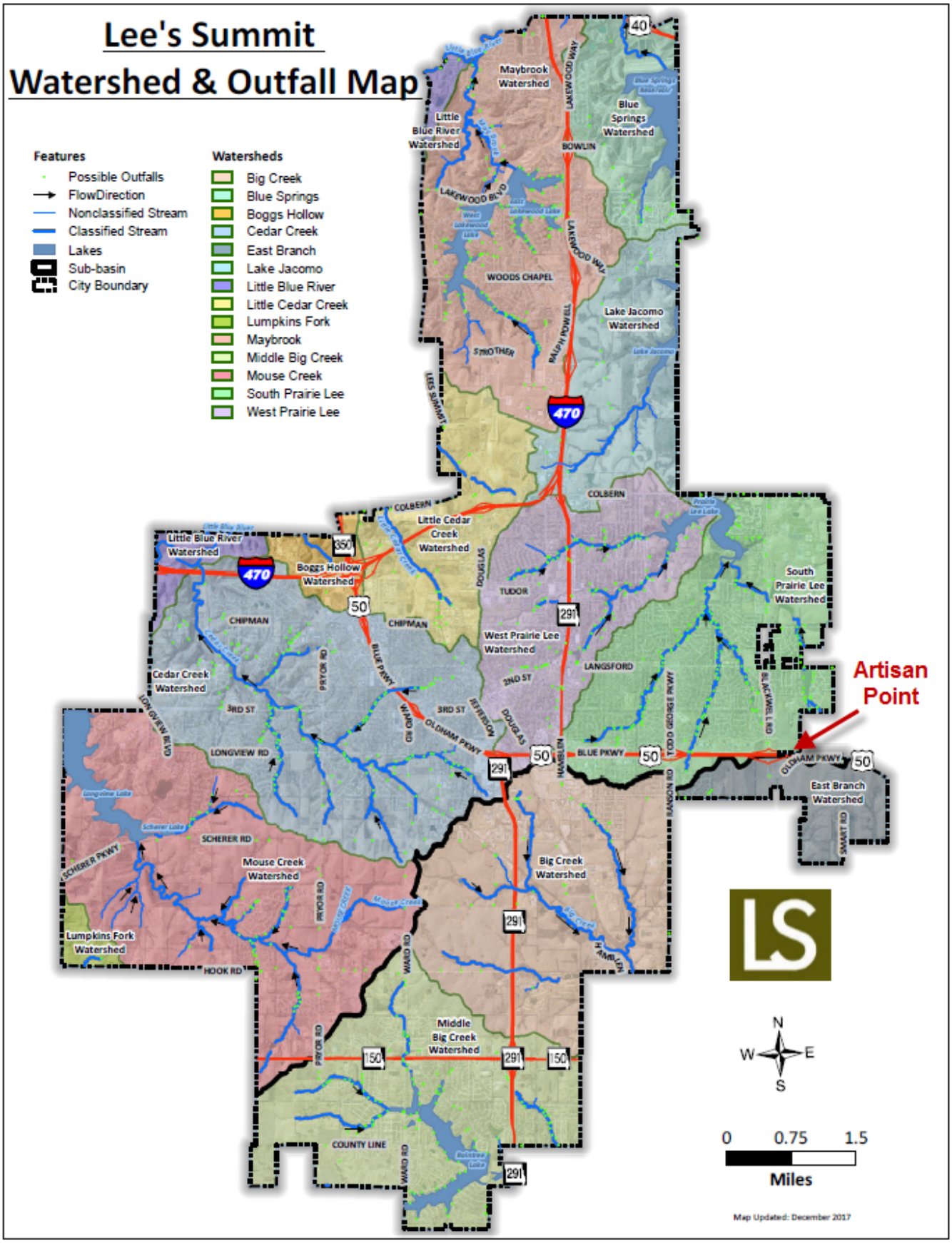
Latitude: 38°54'12.62"N
Longitude: 94°18'47.24"W

Missouri State Plane Coordinate System, West Zor
UTM Zone: 15
FIPSZONE: 2403
ADSZONE: 4451
USGS Quadrangle: Lake Jackamo
Primary Watershed: Little Blue River
Tributary: South Prairie Lee Lake

Watershed

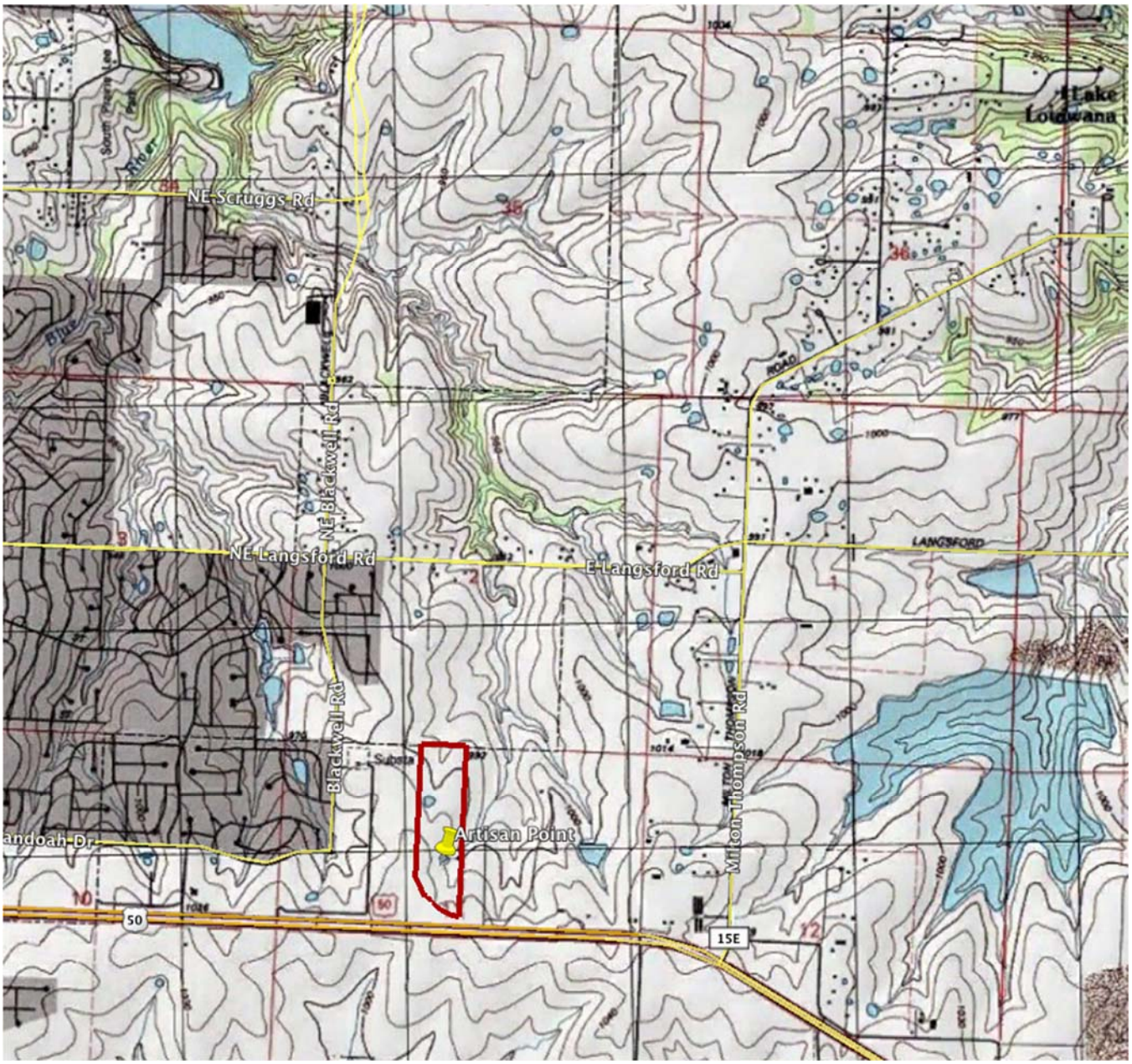
The subject property is located along the eastern boundary of the Little Blue River Watershed. The property drains 2 miles along a tributary to Prairie Lee Lake .

Little Blue River Watershed


Lee's Summit
Watershed & Outfall Map
Features
Possible Outfalls
FlowDirection
Nonclassified Stream
Classified Stream
Lakes
Sub-basin
City Boundary
Watersheds
Big Creek
Blue Springs
Boggs Hollow
Cedar Creek
East Branch
Lake Jacomo
Little Blue River
Little Cedar Creek
Lumpkins Fork
Maybrook
Middle Big Creek
Mouse Creek
South Prairie Lee
West Prairie Lee
Maybrook Watershed
Blue Springs Watershed
Little Blue River Watershed
Lake Jacomo Watershed
Little Cedar Creek Watershed
Boggs Hollow Watershed
South Prairie Lee Watershed
West Prairie Lee Watershed
Cedar Creek Watershed
Artisan Point
East Branch Watershed
Big Creek Watershed
Mouse Creek Watershed
Lumpkins Fork Watershed
Middle Big Creek Watershed
COUNTY LINE
N
W
E
S
0
0.75
1.5
Miles
Map Updated: December 2017

General Topography

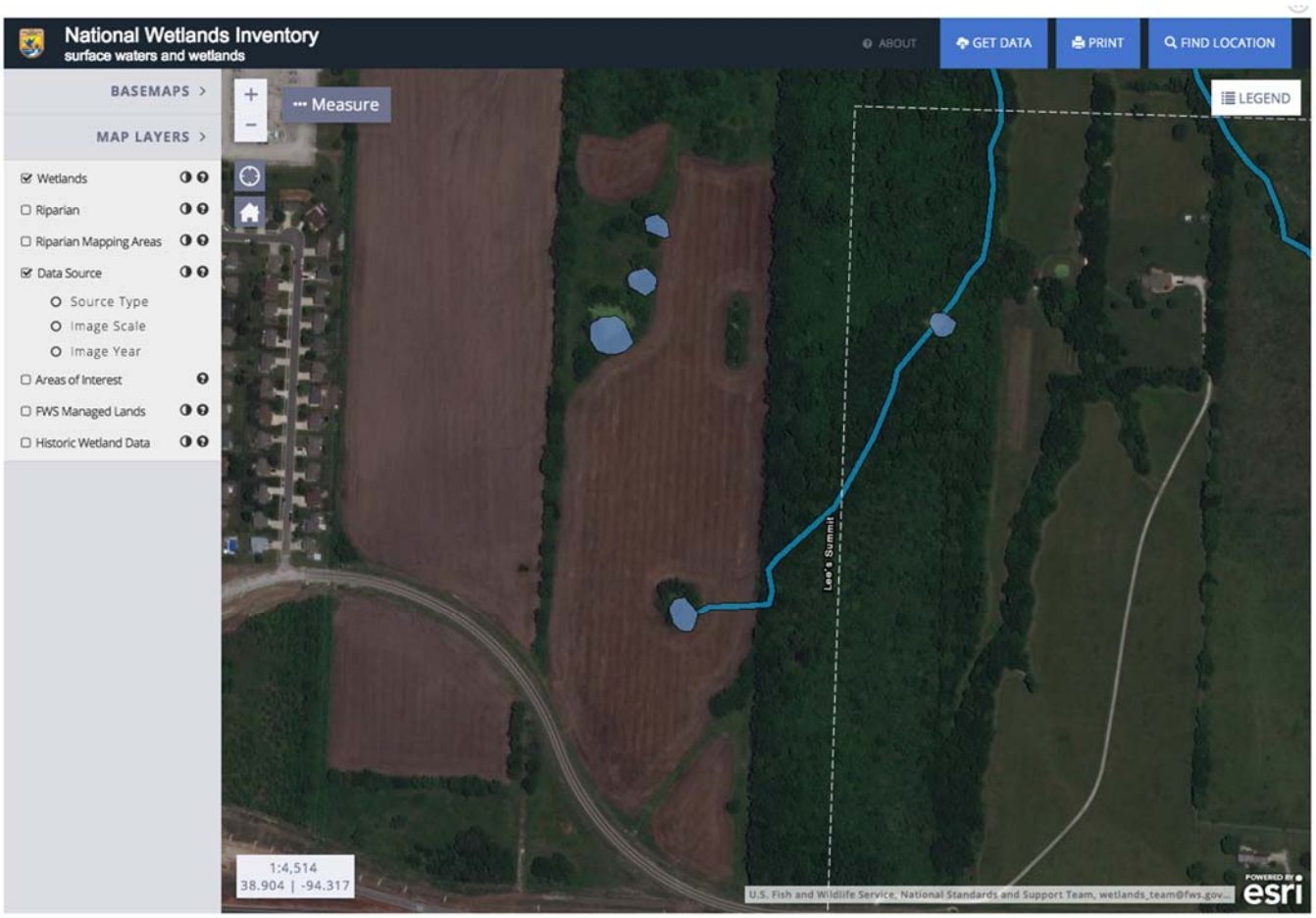
The property may be found on the Lake Jackamo USGS Quadrangle Map. The USGS map is useful to identify geographic relationships between the subject property and the adjacent region.



USGS Quadrangle Map

National Wetland Inventory

The Subject property contains water impoundments and stream connectivity indicators on the National Wetlands Inventory mapping. Field topographic design surveys undertaken by Tanner Consulting, LLC, in November 2017 and March 2018 have been analyzed and have determined that the first phase improvements may be permitted under a nationwide permit.



National Wetland Inventory Mapper

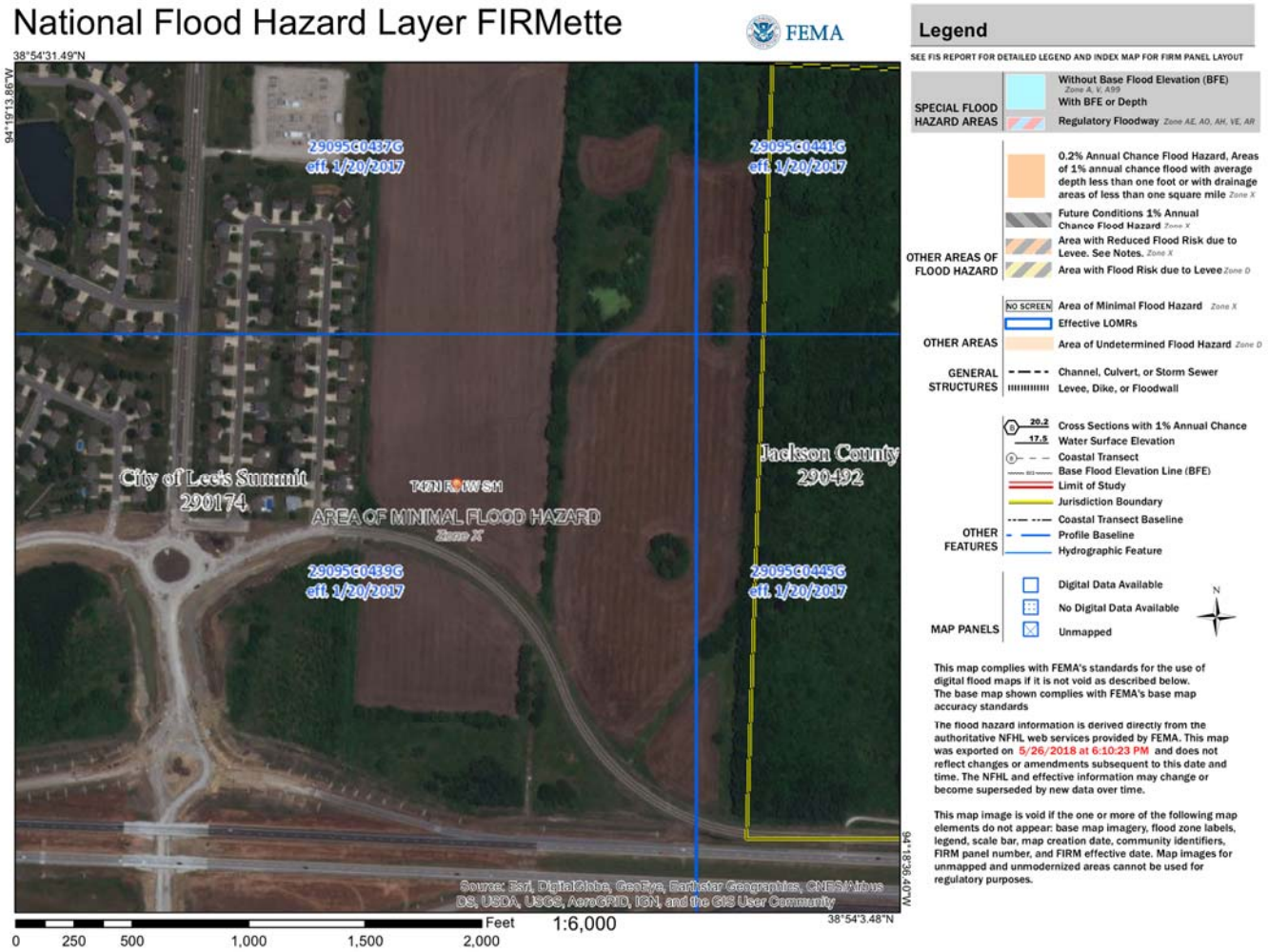
Terra Technologies has been retained to prepare Wetland related applications. A nation-wide permit has been filed for phase 1 and is currently in Corps of Engineers Review.

FEMA Flood Plain Mapping

The entire subject property has been designated as Zone X – Areas of 0.2% annual chance of flood; ~~areas of 1% annual chance flood with average depths of less than 1 foot~~ or with drainage areas less than 1 square mile; ~~and areas protected by levees from 1% annual chance flood.~~

The 1% annual chance flood plain has been mapped beginning on the north side of East Langford Road, approximately one half mile north of the site.

FEMA Community Number: 29095
Panels: 437G, 439G, 441G, 445G



Methodology

Section 5600 of the Lee's Summit 2015 Design and Construction Manual requires the analysis of the 50%, 10% and 1% storm frequencies.

5601.8.A.3 calls for Master Drainage Plan in support of construction documents.

5602.2.B Baseline Unit Hydrograph Method, SCS Technical Release No. 55., with U.S. Arby Corps of Engineers, Hydrological Engineering Center – "HEC-HMS Hydrologic Modeling System, version 4.2.1

6502.3.A Runoff Coefficients (SCS Curve Numbers)

- Hydrologic groups of soils have been identified on the USDA Soils Web.
- The architectural site plan has been measured to estimate planned impervious areas.
- Curve numbers have been calculated by weighted averages for values in SCS TR-55 Table 2.2.
- Curve numbers for the proposed condition correlate well with table 5602-3.

5602.7 Time of Concentration and Lag

- Calculated by methods presented TR-55 chapter 3 considering the 3 regimens of Sheet Flow, Shallow Concentrated Flow and lower reach velocities estimated by Manning Coefficient and Hydraulic Radius.
- The resulting times of concentration have been evaluated against equations presented in 5602.7 that limit inlet times as well as table 5602-6 that provides estimated travel time velocities for future development.

5602.8 HEC-HMS Hydrograph are routing modified Puls technique.

5601.5.A.4 Stormwater management

a. **Default Strategy: Comprehensive Protection – is utilized.**

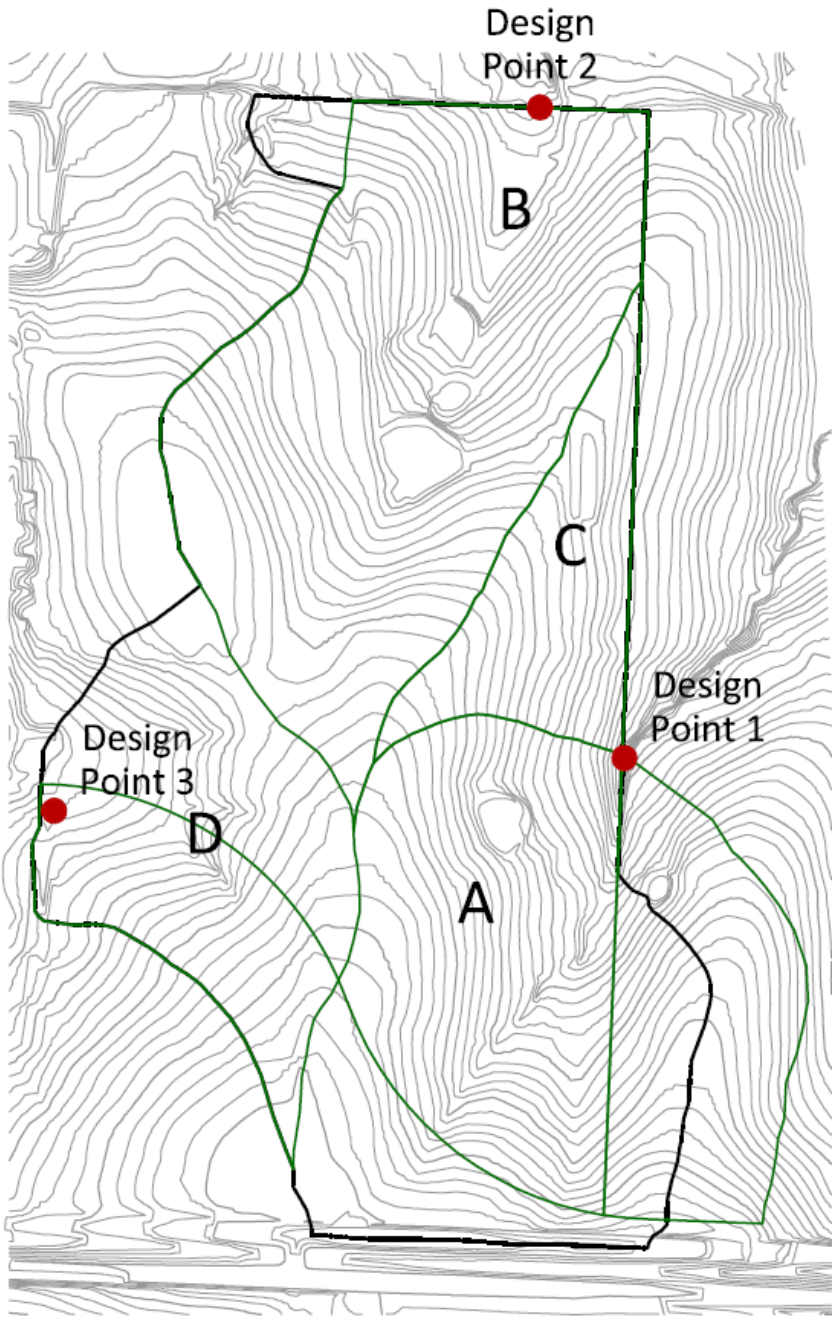
5608.2 Stormwater Detention and Retention

A. The water surface of the design storage pool shall be a minimum of 20 feet from property lines and buildings structures – **waiver is not required.**

5608.2 Easements are not required under private maintenance.

Existing Conditions Analysis
Drainage Basin and Design Points (Outfalls).

The proposed development will urbanize approximately xx acres of undeveloped land currently being partially cropped. The existing topographic conditions create a drainage pattern of 4 distinct drainage areas. Areas A, B and C drain to the north and northeast. Area D drains to the west.



Drainage Area A – receives approximately 4.8 acres from the south side of the Blue Parkway access road that will ultimately be developed for commercial uses. The Artisan Point project will receive and pass the existing condition flow rate. The flow rate may be further reduced under future conditions if the tract is developed under a "Comprehensive Control Strategy".

Drainage Area A discharges to an historical low point along the easterly boundary approximately 1,000 feet of the Blue Parkway access road. The point is labeled and referred to as Design Point 1 herein. Approximately 18 acres drains to Design Point 1, 13.5 acres of that will originate within the Artisan point development. Approximately 8.7 acres of the easterly adjacent tract currently sheet flows northwest and across the Artisan Point property boundary to reach the drainageway flowing to design point 1. Stormwater runoff reaching design point 1 flows approximately 1,600 feet through an undeveloped, wooded drainage course before reaching a culvert crossing SE Millstone Avenue.

Drainage Area B – discharges to the north property line abutting the Summit Mills Plats 1 and 2. Approximately 28.859 acres drains north to a point labeled and referred to herein as Design Point 2. Currently, a 15" storm drain extends from the surface inlet located 50 feet west of the Summit Mills pool house, to a point along the midpoint of the Artisan Point north boundary. Drainage exceeding the capacity of the 15" pipe will bypass to the surface inlet where a 48" storm drain flows north east through the Summit Mills development. Approximately 6.3 acres of the northwest corner of drainage area B appears to bypass the 15" pipe.

Drainage Area C – is an area of sheet flow leaving the Artisan Point property along the northerly half of the east boundary. Stormwater runoff originating on Area C meanders through the wooded area and reaches the drainageway flowing to SE Millstone Avenue.

Drainage Area D – consists of 13 acres flowing west along the Bluestone Parkway Service road. 6.4 Acres of Area D, lying north of the roadway, drains to a cross drain immediately east of Lot 32 of Asbury Park. The cross drain flows south to a Design Point 3 where the Bluestone Parkway Access road drainage system begins and continues west to recently constructed improvements related to the Blackwell Road roundabout.

Existing Condition On-site Soils:

The predominate soils are identified on the USDA Web Soil Survey as predominately hydrologic type C soils.

Existing Condition CN Calculation:

Existing Condition CN Value of 74 has been utilized pursuant to the code.

Times of Concentration and Lag:

Times of Concentration and Lag have been calculated in accordance with United States Department of Agriculture and the Natural Resources Conservation Service Technical Release No. 55 Urban Hydrology for Small Watersheds.

Stormwater runoff overland travel paths were derived from topographical mapping for the pre and post-development conditions.

TR-55 Worksheets were prepared for each travel path.

Figure 3-2 Worksheet 3 for example 3-1

Worksheet 3: Time of Concentration (T_c) or travel time (T_t)

Project: Heavenly Acres		By: DW	Date: 10/6/85
Location: Dyer County, Tennessee		Checked: NM	Date: 10/8/85

Check one: ☐ Present ☒ Developed

Check one: ☒ T_c ☐ T_t through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet. Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

	Segment ID	AB	
1.	Surface description (table 3-1)	Dense Grass	
2.	Manning's roughness coefficient, n (table 3-1)	0.24	
3.	Flow length, L (total L ≤ 300 ft) ft	100	
4.	Two-year 24-hour rainfall, P_2 in	3.6	
5.	Land slope, s ft/ft	0.01	
6.	$T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t hr	0.30 +	= 0.30

Shallow concentrated flow

	Segment ID	BC	
7.	Surface description (paved or unpaved)	Unpaved	
8.	Flow length, L ft	1400	
9.	Watercourse slope, s ft/ft	0.01	
10.	Average velocity, V (figure 3-1) ft/s	1.6	
11.	$T_t = \frac{L}{3600\ V}$ Compute T_t hr	0.24 +	= 0.24

Channel flow

	Segement ID	CD	
12.	Cross sectional flow area, a ft^2	27	
13.	Wetted perimeter, p_w ft	28.2	
14.	Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ft	0.957	
15	Channel slope, s ft/ft	0.005	
16.	Manning's roughness coefficient, n	0.05	
17.	$V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V ft/s	2.05	
18.	Flow length, L ft	7300	
19.	$T_t = \frac{L}{3600\ V}$ Compute T_t hr	0.99 +	= 0.99
20.	Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) Hr		1.53

The travel paths for pre-development are summarized below:

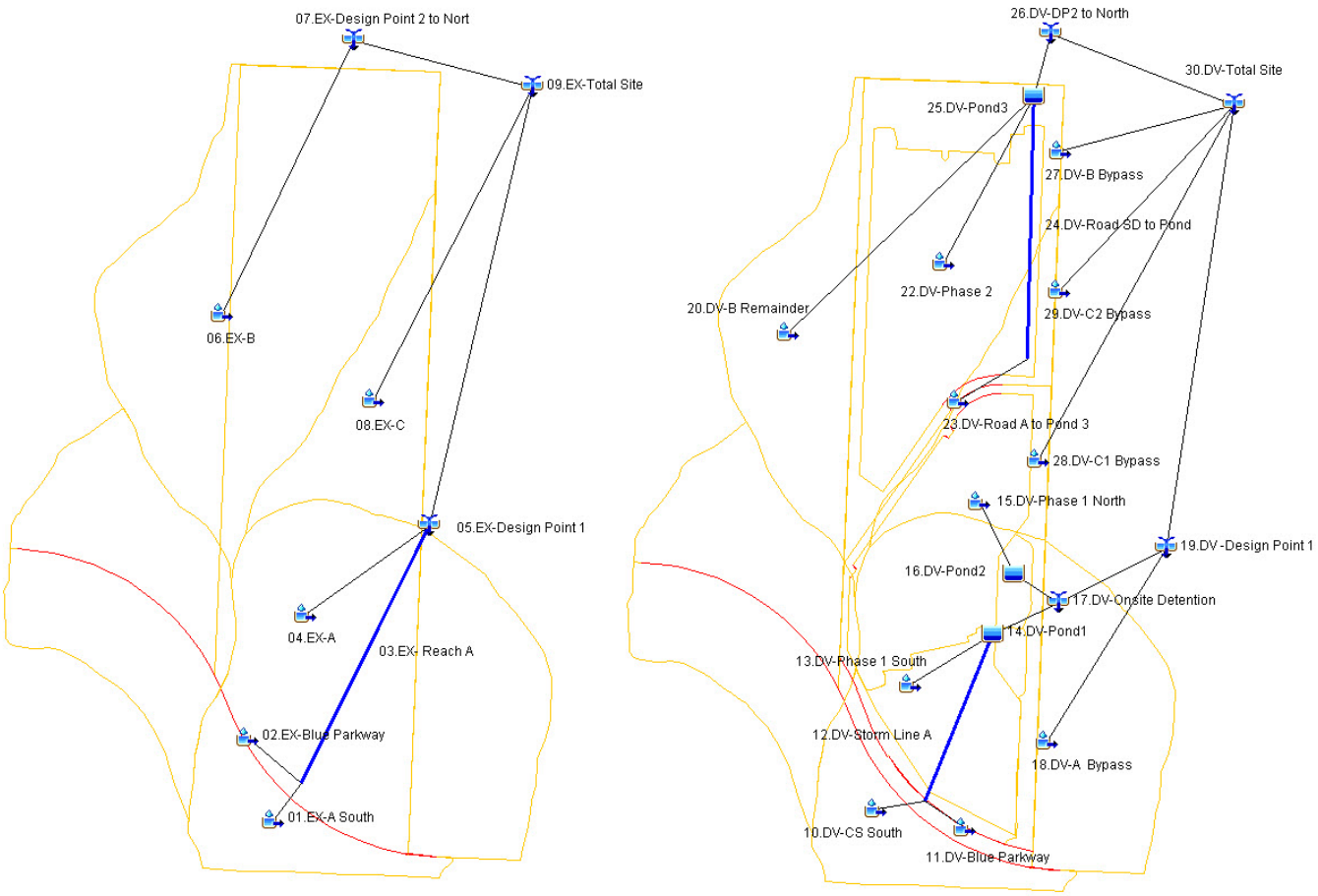
Existing Condition Time of Concentration and Lag:

Project: 17086 Lee's Summit			EXISTING				
2-Yr, 24-Hr Rainfall:	3.17		A1	A2	B	C	D
WQS =	1.37		EX-ASouth	EX-A	EX-B	EX-C	EX-D
Sheet Flow (Applicable to Tc only)		Segment ID	AB	AB	AB	AB	AB
1. Surface Description (Table 3-1)			residue)	residue)	residue)	residue)	residue)
2. Manning's roughness, n (Table 3-1)			0.24	0.05	0.05	0.05	0.05
High Elevation		ft	1,032.00	1,017.00	1,018.50	1,019.50	1,030.20
Low Elevation		ft	1,029.00	1,014.30	1,015.00	1,017.00	1,029.80
3. Flow Length, L (Total L≤ 300ft)		ft	100.00	100.00	200.00	100.00	100.00
4. Two-year, 24-hr rainfall, P		in	3.71	3.71	3.71	3.71	3.71
5. Land Slope, s		ft/ft	0.030	0.027	0.018	0.025	0.004
6. Compute Tt		hr	**0.188**	**0.056**	**0.116**	**0.058**	**0.120**
Shallow Concentrated Flow		Segment ID	BC	BC	BC	BC	BC
7. Surface Description			Unpaved	Unpaved	Unpaved	Unpaved	Unpaved
High Elevation		ft	1,029.00	1,014.30	1,015.00	1,017.00	1,029.80
Low Elevation		ft	1,022.00	1,007.00	992.00	1,002.00	1,018.00
8. Flow Length, L		ft	200.00	315.00	697.00	600.00	480.00
9. Watercourse slope, s		ft/ft	0.035	0.023	0.033	0.025	0.025
10. Average Velocity, V (Fig. 3-1)		ft/s	3.02	2.46	2.93	2.55	2.53
11. Compute Tt		hr	**0.018**	**0.036**	**0.066**	**0.065**	**0.053**
Channelized Flow		Segment ID	CD	CD	CD	CD	CD
12. Cross Sectional Flow Area, a		sq. ft	75.00	5.70	5.70	-	5.70
13. Wetted perimeter, pw		ft	75.00	12.52	12.52	-	12.52
14. Hydraulic radius, r=a/pw		ft	1.00	0.46	0.46	-	0.46
High Elevation		ft	-	1,007.00	992.00	-	1,018.00
Low Elevation		ft	-	1,004.00	987.00	-	1,007.00
18. Flow length, L		ft	-	260.00	468.00	-	480.00
15. Channel slope, s		ft/ft	-	0.012	0.011	-	0.023
Surface Description			N/A	N/A	N/A	N/A	N/A
16. Manning's roughness, n			0.030	0.045	0.045	-	0.045
17. Manning's Velocity		ft/s	-	2.10	2.03	-	2.97
19. Compute Tt		hr	**-**	**0.034**	**0.064**	**-**	**0.045**
20. Total Watershed Tc		hr	0.206	0.126	0.246	0.123	0.218
		min	12.37	7.55	14.75	7.38	13.05
Lag, (Lag=.6Tc)		**min**	7.42	4.53	8.85	4.43	7.83

Existing HMS Model

50% 10%, 1% Storm Runoff Rates

Army Corps of Engineers Hydrological Modeling System (HEC-HMS) version 4.2.1 was utilized to estimate pre and post-development conditions. The model is schematically shown below:



The existing condition is represented on the left. The proposed condition is shown on the right. Pre-Development drainage areas impacted by the apartment development have been labeled A, B and C. The drainage area affected by the round-about and improvements to Blue Parkway identified in previous preliminary studies has been labeled area D and is omitted for the purpose of the current land use applications.

The proposed condition, or post-construction model, identifies the 3 principal areas of onsite development that flow to detention facilities. The model further identifies areas that will be received and passed through the drainage system at pre-developed rates. Last, the proposed condition model identifies 'bypass' areas that are not captured by the detention ponds and those areas of bypass are added to detention release flow rates for the analysis at the east and north design points, or 'out falls'.

The HEC-HMS pre-existing model results are summarized below in Table 1.

Model-J 20180831

	HMS		50% Storm		10% Storm		1% Storm
			2-YR		10-YR		100-YR
Basin Element	**SM**	**Acres**	Q (cfs)		Q (cfs)		Q (cfs)
01.EX-A South	0.01	3.448	6.28		13.67		24.27
02.EX-Shendoah	0.00	1.901	3.04		8.06		15.76
03.EX- Reach A	0.01	5.349	8.52		19.69		35.96
04.EX-A	0.02	12.640	18.34		48.39		94.39
05.EX-Design Point 1	0.03	17.989	26.26		67.31		129.59
06.EX-B	0.04	24.618	27.39		72.59		142.68
07.EX-Design Point 2 to Nort	0.04	24.618	27.39		72.59		142.68
08.EX-C	0.01	6.229	9.11		23.99		46.76
09.EX-Total Site	0.08	48.836	59.11		153.75		298.34

Table 1 – Existing Condition Runoff Rates
50%, 10% and 1% Events

Proposed Conditions

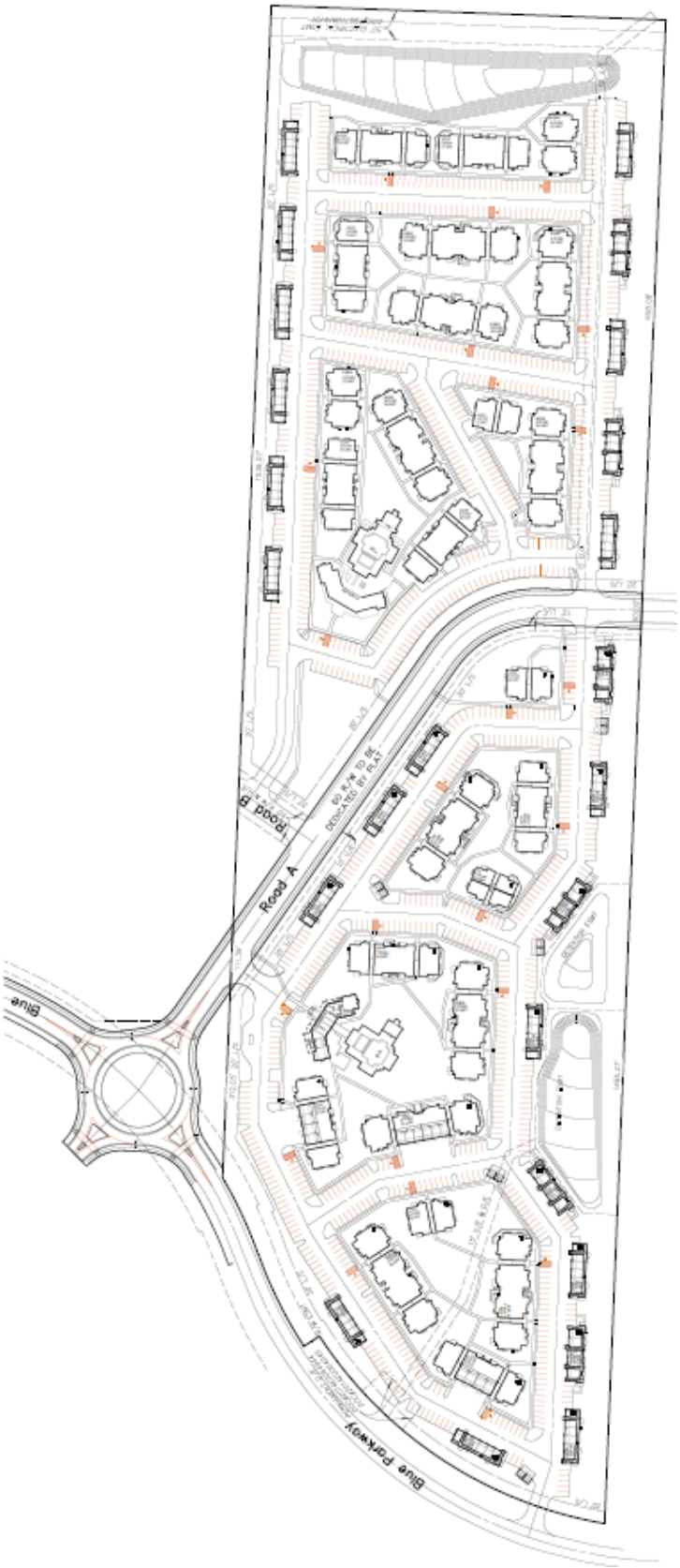
The Artisan Point development will improve sections of Blue Parkway to include curb and gutter and sidewalks from the east boundary of Asbury Park subdivision to a proposed round-about. A public street will be constructed north east from the round-about, to a point terminating the easterly boundary of the Artisan Point development. The street extension will create two distinct development areas.

Phase 1 will be located immediately north of Blue Parkway and will be bounded on the north by the new street extension. Phase 2 will be located north of the street extension.

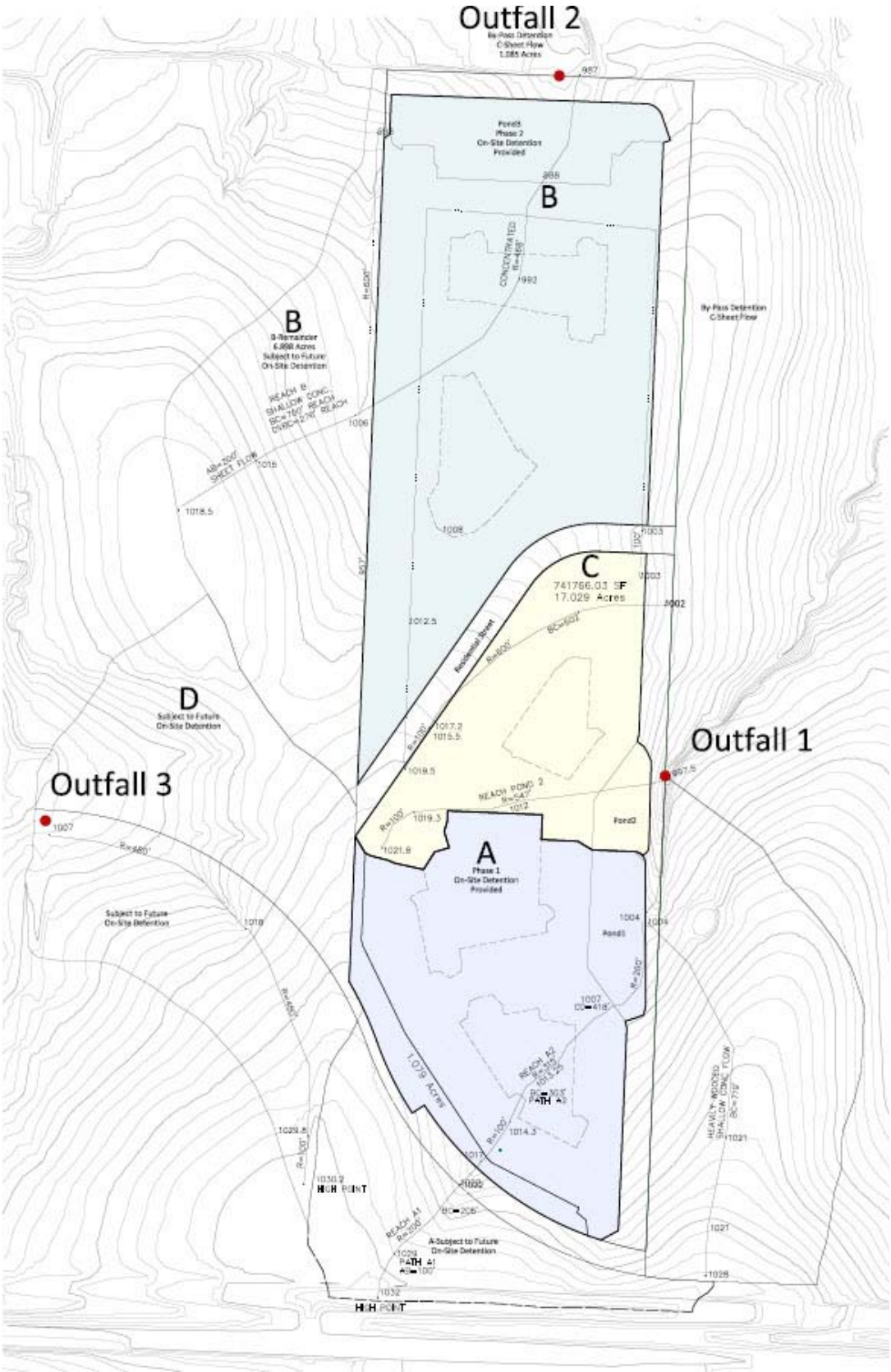
The proposed street extension will generally follow a minor topographic ridge line. Phase 1 will discharge to the historic drainageway flowing north east from the midpoint of the site, while Phase 2 will discharge to the north and be received by the existing storm sewer line extended from Summit Mill subdivision.

Each of the phases will create minor diversions of existing drainage patterns. Each phase will have minor areas bypassing the proposed detention facilities, largely consisting of one half of garage roofs and open spaces not captured by paving. The round-about construction will divert approximately ½ acre to developed drainage area A.

The preliminary site plan follows:



Artisan Point
Preliminary Development Plan



Schematic Drainage Area Map
Post-Development

Drainage Area Shifts:

The construction of the round-about, public street extension and the Artisan Point multi-family housing development will alter the existing drainage patterns as follows:

Outfall 1 will continue to receive drainage from 2 detention areas that discharge to the historical drainageway along the easterly boundary. The original drainage area of **17.99 Acres** is comprised of 4 sub-areas:

1.) EX-A - 12.64 Ac – Onsite area draining to pond 1.
2.) EX-Blue Parkway – 1.90 Ac – Offsite existing roadway.
3.) EX-A South - 3.45 Ac – Offsite future commercial area south of Blue Parkway received and passed.
4.) Ex-C – 6.23 Ac – Onsite area draining to pond 1.
24.22 Ac – to Outfall 1

As a result of the proposed apartment project, Outfall 1, will receive 6 sub-areas:
1.) DV-Phase 1 North - 5.97 Ac – North half of Phase 1.
2.) DV-Phase 1 South - 9.57 Ac – South half of Phase 1.
3.) DV-A Bypass - 1.06 Ac – Back side of garage units, east property line to bypass pond.
4.) DV-C1 Bypass - 0.62 Ac – Back side of garage units, east property line to bypass pond.
5.) DV-CS South – 3.45 Ac - Offsite commercial area south of Blue Parkway (received and passed).
6.) DV-Blue Parkway – 1.90 Ac – Offsite existing roadway.
22.57 Ac – to Outfall 1

2.31 Ac from Outfall 1 will be diverted to Outfall 2.
0.44 Ac from Outfall 1 will be diverted to Outfall 3.

Outfall 2 collects the majority of the phase 2 tract and an offsite area to the west of the property boundary. The original drainage area of **24.62 Acres** is comprised of 1 sub-areas:

1.) EX-B to Pond 3 – 24.62 Ac – Onsite and offsite area B draining to pond 3.
24.62 Ac – to Outfall 2

As a result of the proposed apartment project, Outfall 2 will receive 4 sub-areas:
1.) DV-B Remainder – 8.57 Ac – Offsite west of Phase 2 (received and passed).
2.) DV-Phase 2 – 14.93 Ac – Phase 2.
3.) DV-B Bypass – 1.37 Ac – Back side of garage units, east property line to bypass pond.
4.) DV-Road A to Pond 3 – 1.24 Ac – Offsite proposed roadway between Phases 1 and 2.
26.11 Ac – to Outfall 2

0.06 Ac from Outfall 2 will be diverted to Outfall 3.

Outfall 3 collects runoff from Blue Parkway and the proposed roundabout and discharges to the historical drainageway to west of the project boundary. The original drainage area of x is comprised of 2 sub-areas:

1.) EX-D1 – 5.72 Ac – From centerline of proposed Blue Parkway to local south ridge.
2.) EX-D2 – 6.41 Ac – From centerline of proposed Blue Parkway to local north ridge.
22.57 Ac – to Outfall 1

As a result of the proposed apartment project, Outfall 3 will receive 2 sub-areas:

1.) DV-D1 – 5.72 Ac – From centerline of proposed Blue Parkway to local south ridge.
2.) DV-D2 – 5.97 Ac – From centerline of proposed Blue Parkway to local north ridge.

No additional drainage areas will be diverted away from Outfall 3.

Developed Condition Times of Concentration and Lag:

Project: 17086 Lee's Summit							
2-Yr, 24-Hr Rainfall:	3.17						
WQS =	1.37						
Sheet Flow (Applicable to Tc only)		Segment ID					
1. Surface Description (Table 3-1)			AB residue)	AB residue)	AB residue)	AB residue)	AB residue)	AB residue)
2. Manning's roughness, n (Table 3-1)			0.050	0.050	0.050	0.015	-	0.015
High Elevation		ft	1,017.00	1,021.80	1,018.50	1,019.50	1,003.00	1,030.20
Low Elevation		ft	1,014.30	1,019.33	1,015.00	1,017.25	1,002.00	1,029.80
3. Flow Length, L (Total L≤ 300ft)		ft	100.00	100.00	200.00	100.00	100.00	100.00
4. Two-year, 24-hr rainfall, P		in	3.71	3.71	3.71	3.71	3.71	3.71
5. Land Slope, s		ft/ft	0.027	0.025	0.018	0.023	0.010	0.004
6. Compute Tt		hr	**0.056**	**0.058**	**0.116**	**0.023**	**-**	**0.046**
Shallow Concentrated Flow		Segment ID	BC Paved	BC Unpaved	BC Unpaved	BC Paved	BC Unpaved	BC Paved
7. Surface Description								
High Elevation		ft	1,014.30	1,019.33	1,015.00	1,017.25	-	1,029.80
Low Elevation		ft	1,007.00	997.50	1,006.00	1,012.50	-	1,018.00
8. Flow Length, L		ft	315.00	547.00	230.00	200.00	-	480.00
9. Watercourse slope, s		ft/ft	0.023	0.040	0.039	0.024	-	0.025
10. Average Velocity, V (Fig. 3-1)		ft/s	3.09	3.22	3.19	3.13	-	3.19
11. Compute Tt		hr	**0.028**	**0.047**	**0.020**	**0.018**	**-**	**0.042**
Channelized Flow		Segment ID	CD	CD	CD	CD	CD	CD
12. Cross Sectional Flow Area, a		sq. ft	2.00	-	4.40	4.40	4.40	7.07
13. Wetted perimeter, pw		ft	3.60	-	6.32	6.32	6.32	9.42
14. Hydraulic radius, r=a/pw		ft	0.56	-	0.70	0.70	0.70	0.75
High Elevation		ft	1,007.00	-	1,006.00	1,012.50	1,002.00	1,018.00
Low Elevation		ft	1,004.00	-	998.00	988.00	988.00	1,007.00
18. Flow length, L		ft	260.00	-	600.00	1,193.00	1,000.00	480.00
15. Channel slope, s		ft/ft	0.012	-	0.013	0.021	0.014	0.023
Surface Description			N/A	N/A	N/A	N/A	N/A	N/A
16. Manning's roughness, n			0.013	-	0.013	0.013	0.013	0.045
17. Manning's Velocity		ft/s	8.32	-	10.40	12.90	10.65	4.14
19. Compute Tt		hr	**0.009**	**-**	**0.016**	**0.026**	**0.026**	**0.032**
20. Total Watershed Tc		hr	0.093	0.105	0.152	0.066	0.026	0.120
		min	5.57	6.30	9.10	3.98	1.56	7.19
Lag, (Lag=.6Tc)		**min**	**3.34**	**3.78**	**5.46**	**2.39**	**0.94**	**4.31**

DEVELOPED

Ph 1 South Pond 1	Ph 1 North	DV-B Rem	DV-Pond3	DV-C	D
DV-A	**Pond 2**	**DV-B Rem**	**DV-Pond3**	**DV-C**	**DV-D**

Impervious Area Calculation:

The areas of impervious surfaces depicted on the proposed site plans were determined from AutoCad sources:

Phase 1

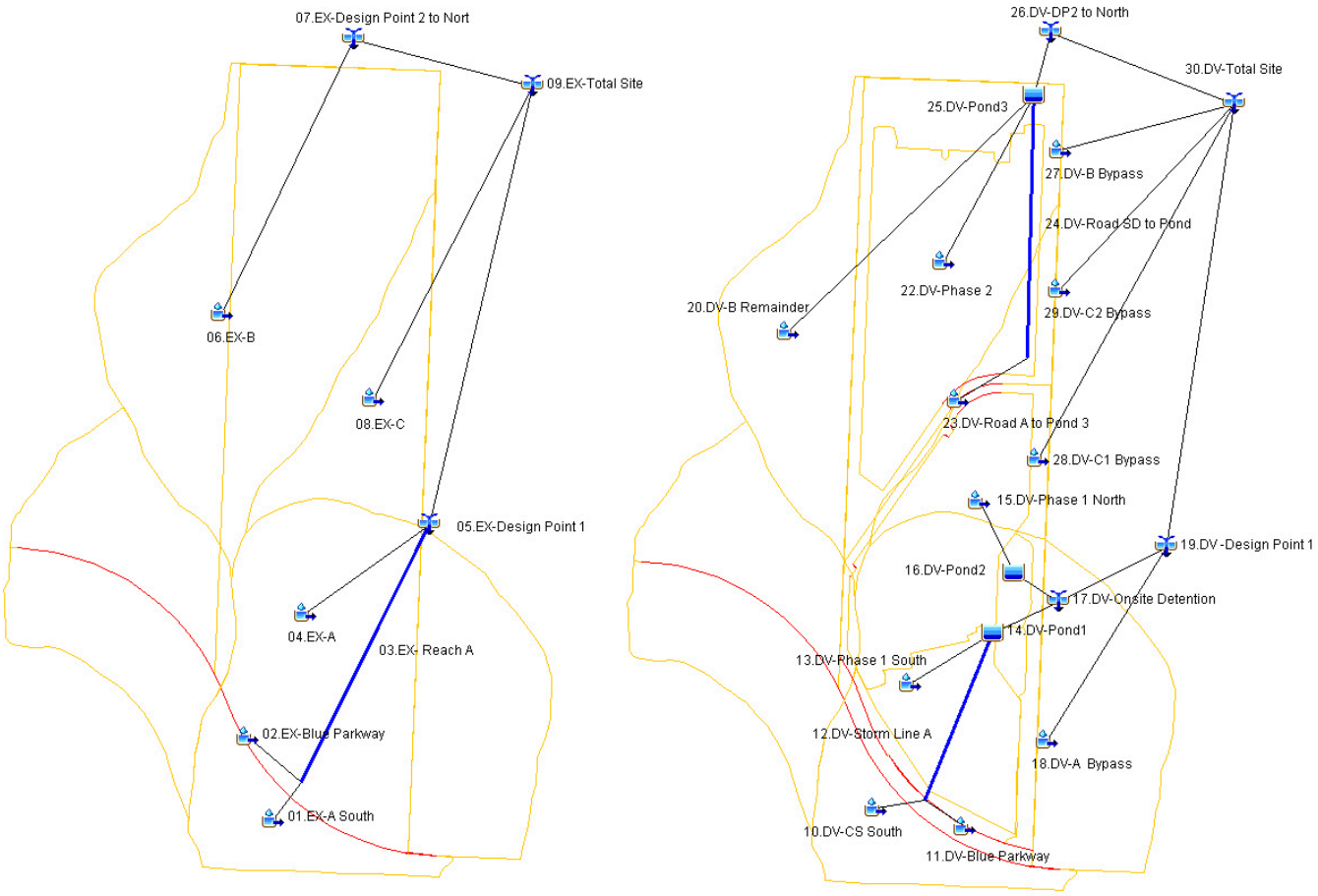
Paving	227,101	SF
Concrete	50,781	SF
Buildings	112,381	SF
Total	390,263	SF
Total Impervious	8.959	Acres
Phase Area	16.997	Acres
Pct. Impervious	52.7%	

Phase 2

Paving	217,811	SF
Concrete	57,268	SF
Buildings	116,077	SF
Total	391,156	SF
Total Impervious	8.980	Acres
Phase Area	17.029	Acres
Pct. Impervious	52.7%	

HEC-HMS Model
Developed Conditions

As previously discussed, the HEC-HMS post-development model is schematically shown below on the right:



Model-J 20180831

	HMS		50% Storm		10% Storm		1% Storm
			2-YR		10-YR		100-YR
Basin Element	**SM**	**Acres**	Q (cfs)		Q (cfs)		Q (cfs)
10.DV-CS South	0.01	3.448	4.16		10.89		21.39
11.DV-Shenandoah	0.00	1.901	3.04		8.06		15.76
12.DV-Storm Line A	0.01	5.349	6.41		16.96		33.15
13.DV-Phase 1 South	0.01	9.569	33.21		60.12		96.32
14.DV-Pond1	0.02	14.918	4.62		8.39		49.69
15.DV-Phase 1 North	0.01	5.786	19.12		34.70		55.67
16.DV-Pond2	0.01	5.786	0.16		3.66		37.63
17.DV-Onsite Detention	0.03	20.705	4.76		12.05		74.14
18.DV-A Bypass	0.00	1.048	1.84		4.66		8.93
19.DV -Design Point 1 to Eas	0.03	21.753	5.03		12.66		77.12
20.DV-B Remainder	0.01	8.574	17.38		38.05		67.45
22.DV-Phase 2	0.02	14.931	55.20		99.32		158.64
23.DV-Road A to Pond 3	0.00	1.340	4.63		8.52		13.76
24.DV-Road SD to Pond	0.00	1.340	4.43		8.11		13.07
25.DV-Pond3	0.04	24.845	1.06		5.46		59.23
26.DV-DP2 to North	0.04	24.845	1.06		5.46		59.23
27.DV-B Bypass	0.00	1.367	2.39		6.08		11.64
28.DV-C1 Bypass	0.00	0.615	1.08		2.74		5.24
29.DV-C2 Bypass	0.00	0.692	1.21		3.08		5.89
30.DV-Total Site	0.08	49.272	7.60		22.92		137.91

Table 2 – Developed Condition Runoff Rates

50%, 10% and 1% Events

Detention Volume Facilities – Phase 1:

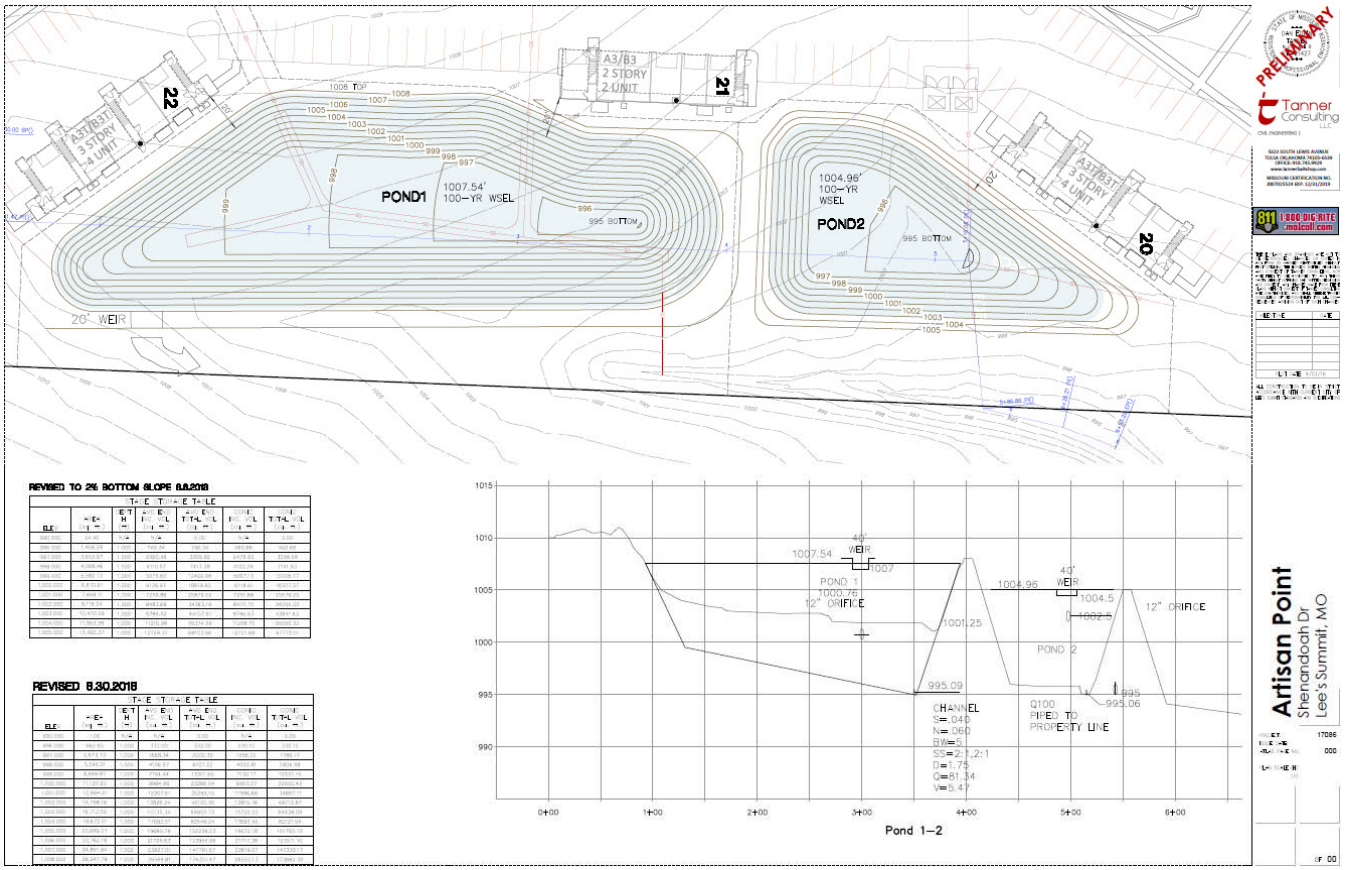
Separate detention facilities will be provided for each phase of the Artisan Point Development.

Phase 1 will construct 2 ponds along the east boundary that are stepped down approximately 6 feet from south to north. Each pond individually discharges to the historical drainageway flowing east from the site. This study identifies the point of discharge as Design Point 1 or Outfall 1.

Each pond will have three to one (3:1) minimum side slopes and 2% bottom slope with concrete trickle channel.

Each pond will be controlled by a low flow orifice meeting the requirement for 40-Hour Extended Detention.

The volume for each detention pond has been derived from preliminary grading designs and has been calculated by average end area methods.



Phase 1 Detention
Pond 1 and 2

The volume of Ponds 1 and 2 are tabulated in the following Table:

AECCSTAGESTORAGE TABLE

Pond 1 Elevation	Area (sq.ft.)	Depth (ft)	Avg Area (sq.ft.)	Tot Vol (cu.ft.)	Tot Vol (ac-ft)	HMS-Table Area (Ac)
995	1.06	0	-	-	-	-
996	662.95	1.00	332	332	0.0076	0.0152
997	2,673.73	1.00	1,668	2,000	0.0459	0.0614
998	5,540.01	1.00	4,107	6,107	0.1402	0.1272
999	8,848.87	1.00	7,194	13,302	0.3054	0.2031
1,000	11,120.90	1.00	9,985	23,287	0.5346	0.2553
1,001	12,894.31	1.00	12,008	35,294	0.8102	0.2960
1,001.63		6.63			1.01	
1,002	14,758.18	1.00	13,826	49,120	1.1276	0.3388
1,003	16,712.50	1.00	15,735	64,856	1.4889	0.3837
1,004	18,672.51	1.00	17,693	82,548	1.8950	0.4287
1,005	20,689.07	1.00	19,681	102,229	2.3469	0.4750
1,006	22,762.18	1.00	21,726	123,955	2.8456	0.5225
1,007	24,891.84	1.00	23,827	147,782	3.3926	0.5714
1,008	28,247.78	1.00	26,570	174,351	4.0026	0.6485

Pond 1
Average End Area Volume Calculation

AECCSTAGESTORAGE TABLE

Pond 1 Elevation	Area (sq.ft.)	Depth (ft)	Avg Area (sq.ft.)	Tot Vol (cu.ft.)	Tot Vol (ac-ft)	HMS-Table Acres
995.00	24.40	-	-	-	-	0.0006
996.00	1,468.28	1.00	746.34	746.34	0.0171	0.0337
997.00	3,652.67	1.00	2,560.48	3,306.82	0.0759	0.0839
998.00	4,568.46	1.00	4,110.57	7,417.39	0.1703	0.1049
999.00	5,582.73	1.00	5,075.60	12,492.98	0.2868	0.1282
999.44		4.44		17,990	0.4130	**0.1320**
1,000.00	6,670.61	1.00	6,126.67	18,619.65	0.4274	0.1531
1,001.00	7,849.11	1.00	7,259.86	25,879.52	0.5941	0.1802
1,002.00	9,118.24	1.00	8,483.68	34,363.19	0.7889	0.2093
1,003.00	10,470.59	1.00	9,794.42	44,157.61	1.0137	0.2404
1,004.00	11,963.38	1.00	11,216.98	55,374.59	1.2712	0.2746
1,005.00	13,495.37	1.00	12,729.37	68,103.96	1.5635	0.3098

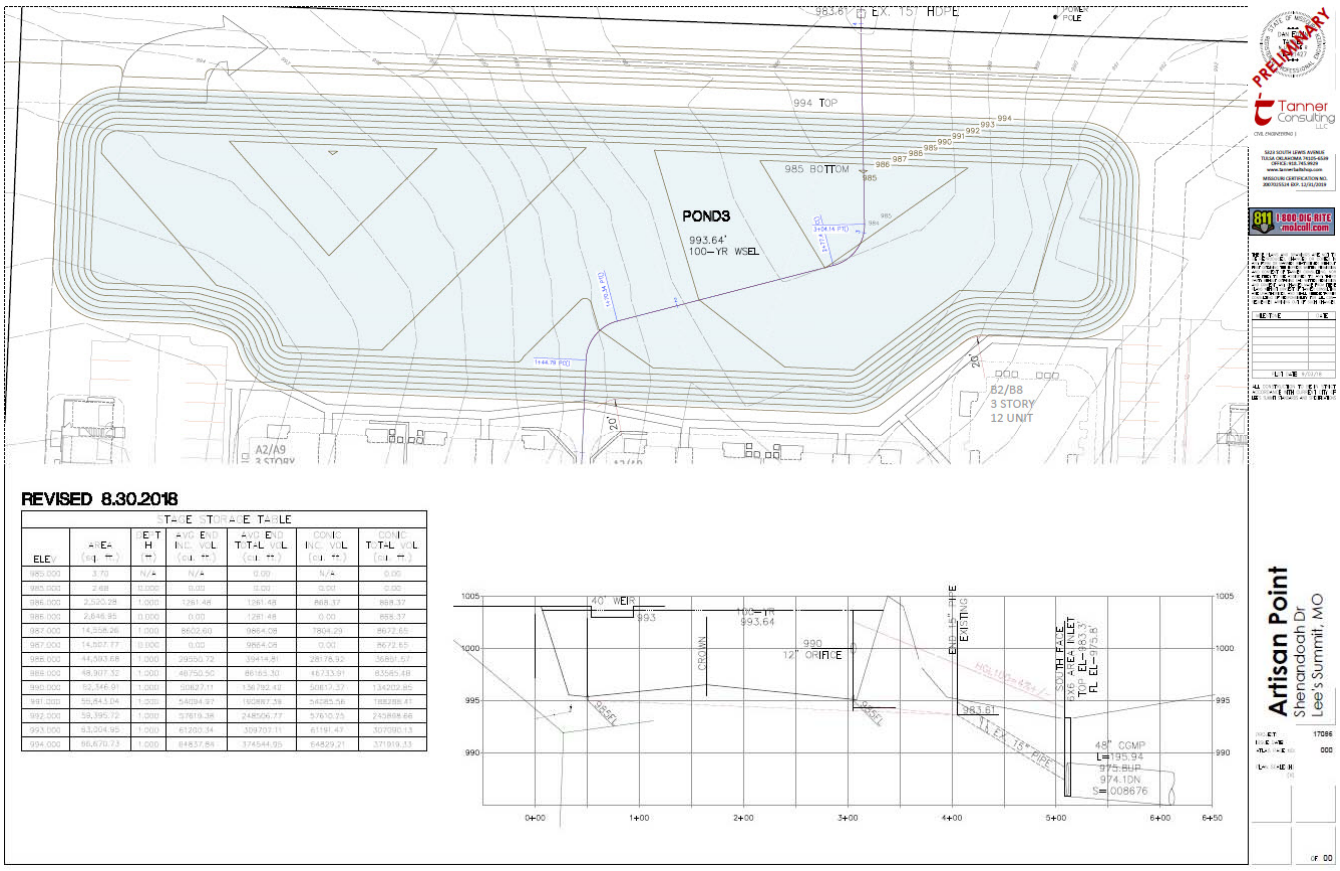
Pond 2
Average End Area Volume Calculation

Detention Volume Facilities – Phase 2:

Phase 2 of the Artisan Point development will construct a detention facility pond along the north boundary that discharges to an existing 15” pipe within the Summit Mill development.
This study identifies the point of discharge as Design Point 2 or Outfall 2.

The detention pond will have three to one (3:1) minimum side slopes and 2% bottom slope with concrete trickle channel.

The pond will be controlled by a low flow orifice meeting the requirement for 40-Hour Extended Detention.



Phase 2 Detention
Pond 3

The volume for the detention pond has been derived from preliminary grading designs and has been calculated by average end area methods.

The volume of Ponds 3 is tabulated in the following Table:

AECCSTAGESTORAGE TABLE

Pond3 Elevation	Area (sq.ft.)	Depth (ft)	Avg Area (sq.ft.)	Tot Vol (cu.ft.)	Tot Vol (ac-ft)	HMS-Table Acres
985.00	6.38	-	-	-	-	0.00
986.00	5,167.23	1.00	2,586.81	2,586.81	0.0594	0.12
987.00	29,066.03	1.00	17,116.63	19,703.44	0.4523	0.67
987.58	**38,077.27**	**2.58**			**0.9430**	0.87
988.00	44,593.68	1.00	36,829.86	56,533.29	1.2978	1.02
989.00	48,907.32	1.00	46,750.50	103,283.79	2.3711	1.12
989.00	48,907.32	1.00	48,907.32	152,191.11	3.4938	1.12
990.00	52,346.91	1.00	50,627.12	202,818.23	4.6561	1.20
991.00	55,843.04	1.00	54,094.98	256,913.20	5.8979	1.28
992.00	59,395.72	1.00	57,619.38	314,532.58	7.2207	1.36
993.00	63,004.95	1.00	61,200.34	375,732.92	8.6256	1.45
994.00	66,670.73	1.00	64,837.84	440,570.76	10.1141	1.53

Pond 3
Average End Area Volume Calculation

Control Structures

The storm water release rate for each detention facility will be controlled though a low flow orifice meeting the 40-hour extended detention requirement. An additional orifice and overflow weir will control the 50%, 10% and 1% stormwater events at levels above the Stormwater Quality Control Volume.

Pond Control Structure Configuration			
Control Structures	**Pond 1**	**Pond 2**	**Pond 3**
Bottom	995.00	995.000	985.00
Orifice 1 Diam (In)	2.50	1.500	2.50
Orifice 1 Center	995.09	995.063	985.10
Area (sf)	0.0341	0.012	0.0341
Orifice 2 Diam (In)	12.00	12.000	12.00
Orifice 2	1,000.76	1,002.500	990.00
Area (sf)	0.7850	0.785	0.7850
Weir	1,007.00	1,004.500	993.00
Length	40.00	40.000	40.00
WQV Elev	1,001.63	999.440	987.58
Top	1,008.00	1,005.000	994.00
1% Storm	1,007.54	1,004.960	993.64
Freeboard	0.46	0.040	0.360

Table 3
Detention Facility Control Structure Summary

Routing Results

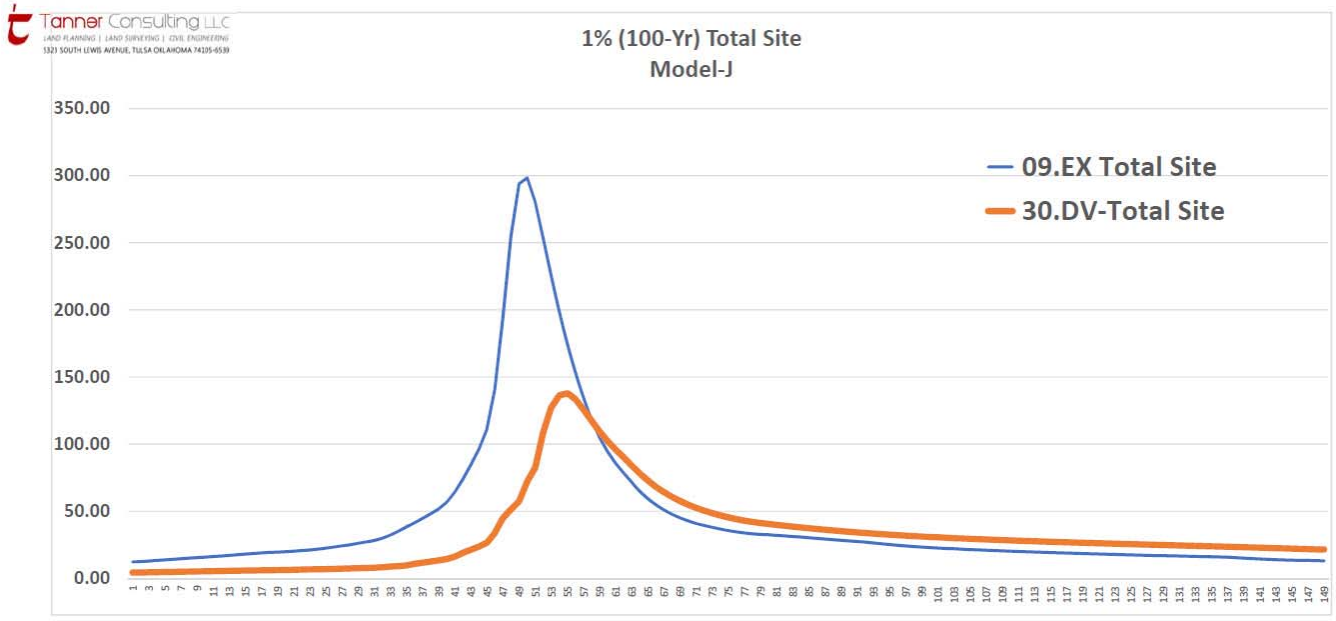
The HMS Model provides results at 9 discrete points under pre-development conditions together with 21 points and post-development conditions. The resulting hydrographs have been combined to represent flows to and from detention facilities then added to bypass flows to provide composite results at design points or outfalls.

The resultant post-development condition at design point 1 (Outfall 1) representing Phase 1 of Artisan Point is illustrated by the resultant hydrographs. Below are the 1%, 10% and 50% chance resultant hydrographs at Outfall 1 (East Boundary).

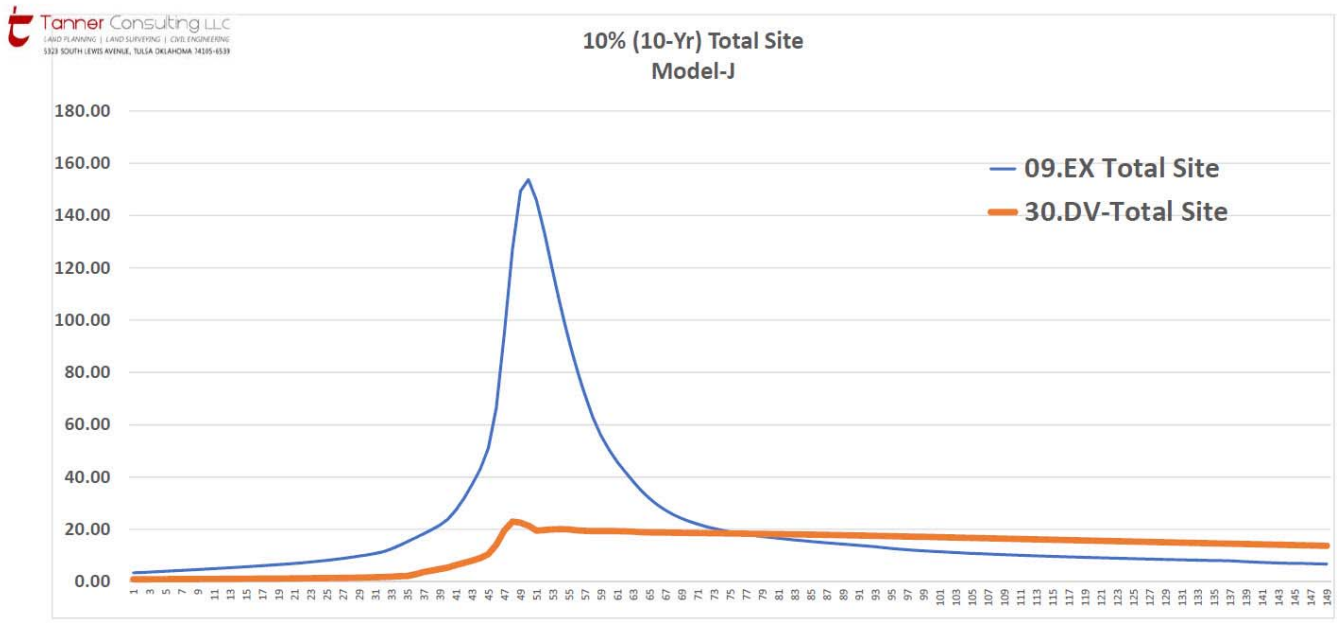
Hydrograph number 5 – EX Design Point 1 is the existing condition stormwater runoff peak. Hydrograph number 19 – DV Design Point 1 is the post-construction hydrograph representing the combined discharge of detention ponds 1 and 2 together with bypass areas reaching Outfall 1.

In each of the 50%,10% and 1% events, the proposed condition runoff is less than existing. The 1% (100-YR) Total Site pre and post-development hydrographs are depicted below. The Artisan Point development is expected to reduce existing peak stormwater runoff flows from a pre-developed rate of 298 cubic feet per second to approximately 138 cfs.

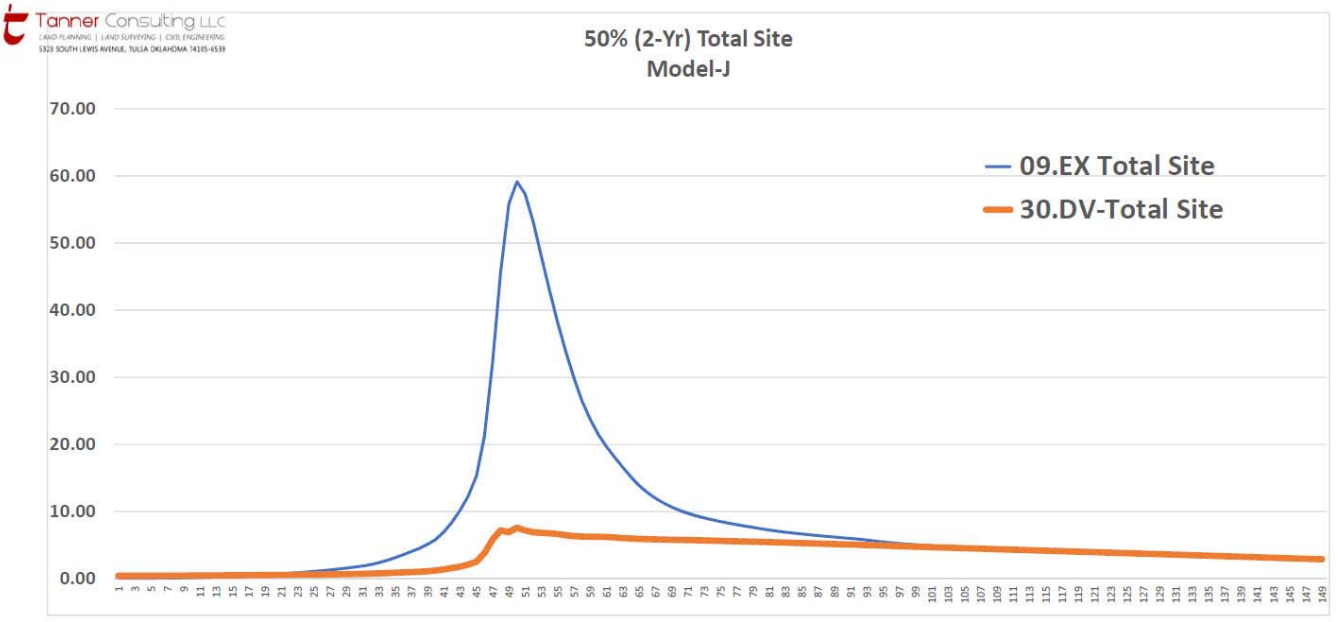
Total Site:



1% Event – Total Site
Discharge in CFS



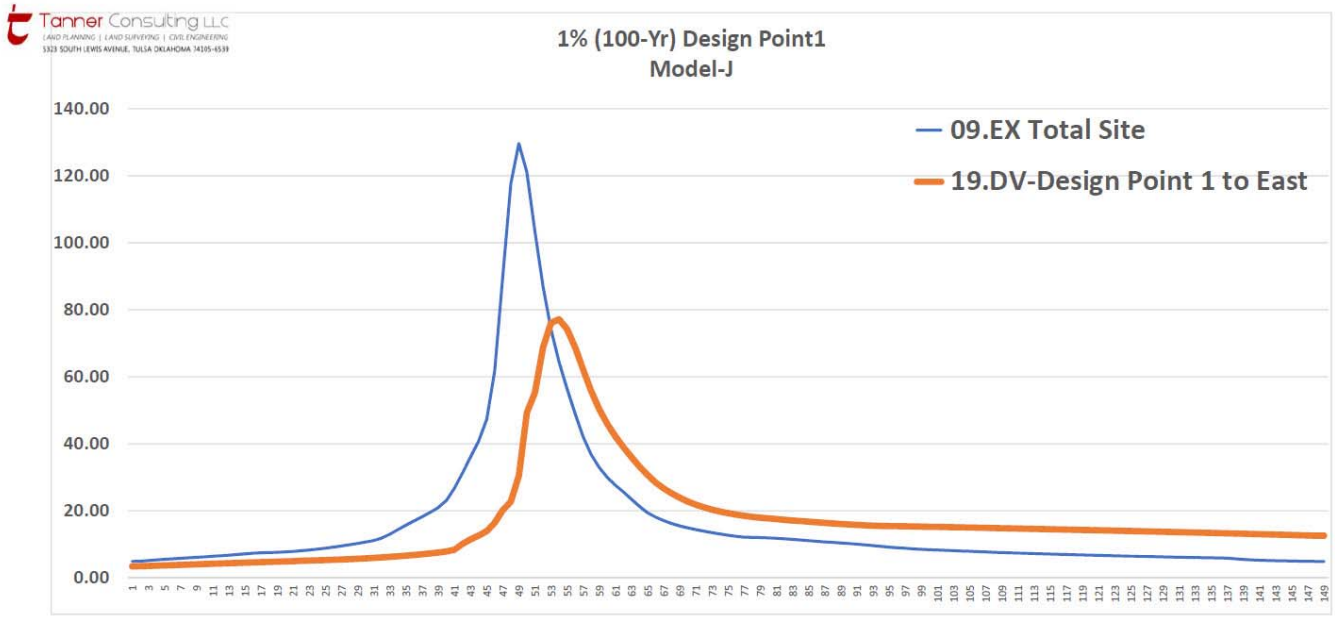
10% Event – Total Site
Discharge in CFS



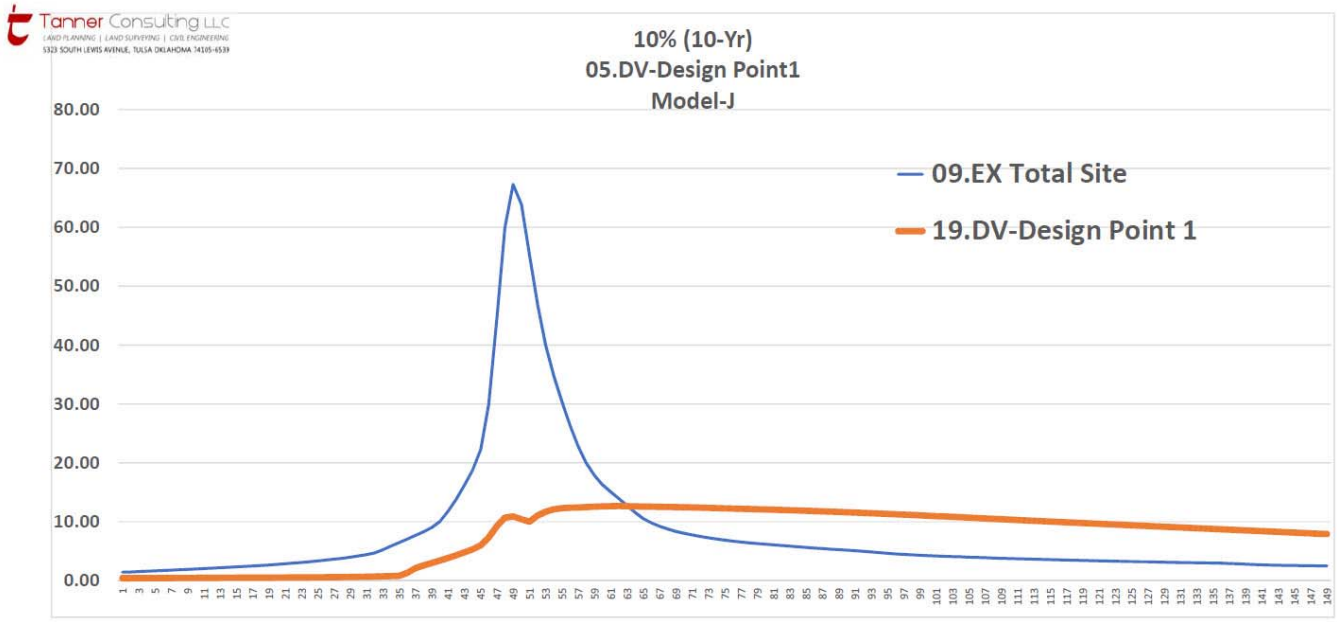
50% Event – Total Site
Discharge in CFS

Design Point 1

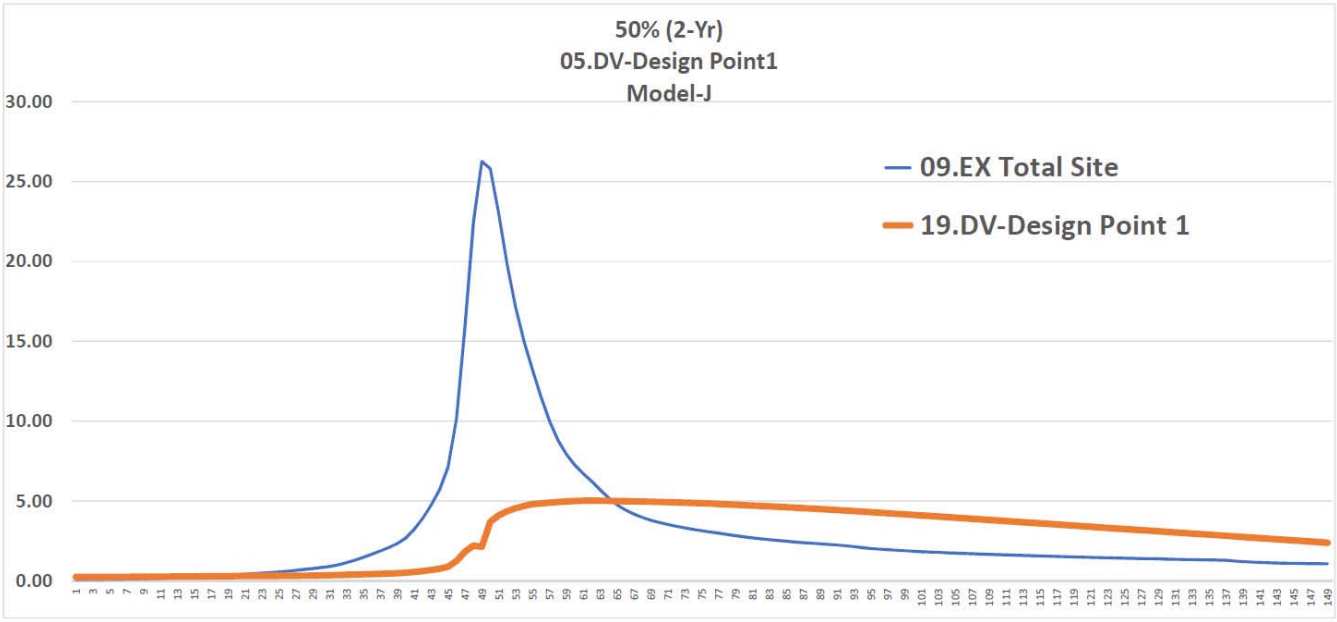
Discharges to the East Boundary. Includes Phase 1.



1% Event – Design Point 1
Discharge in CFS



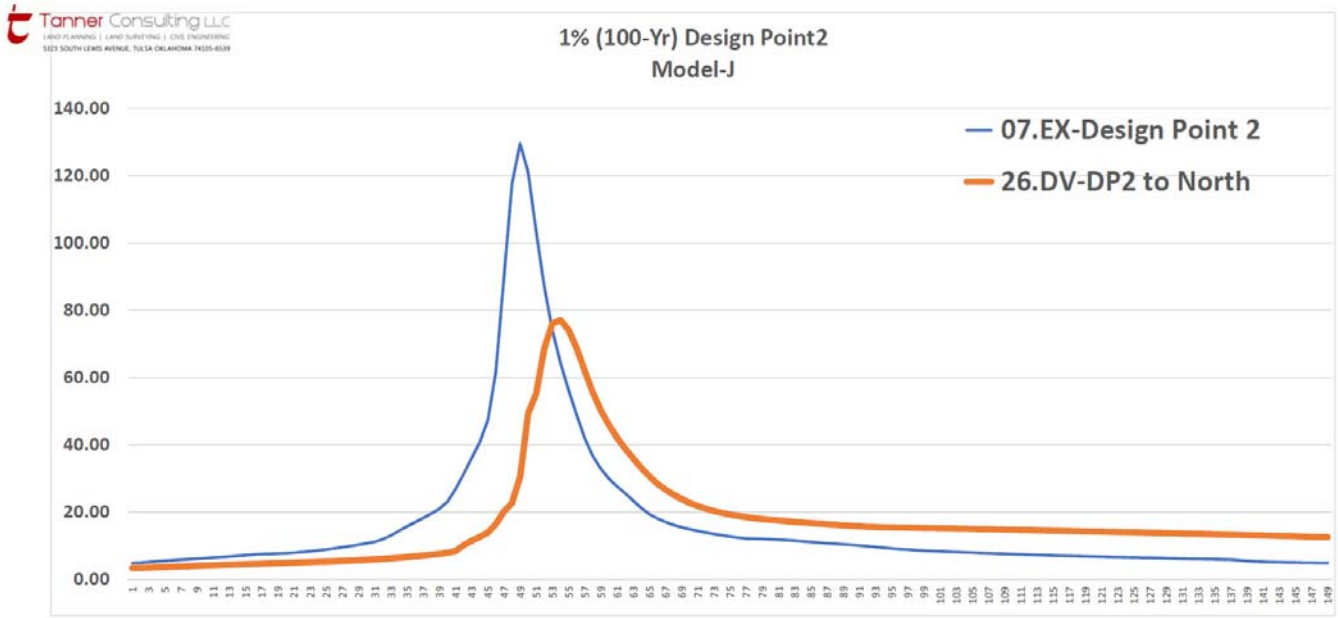
10% Event – Design Point 1
Discharge in CFS



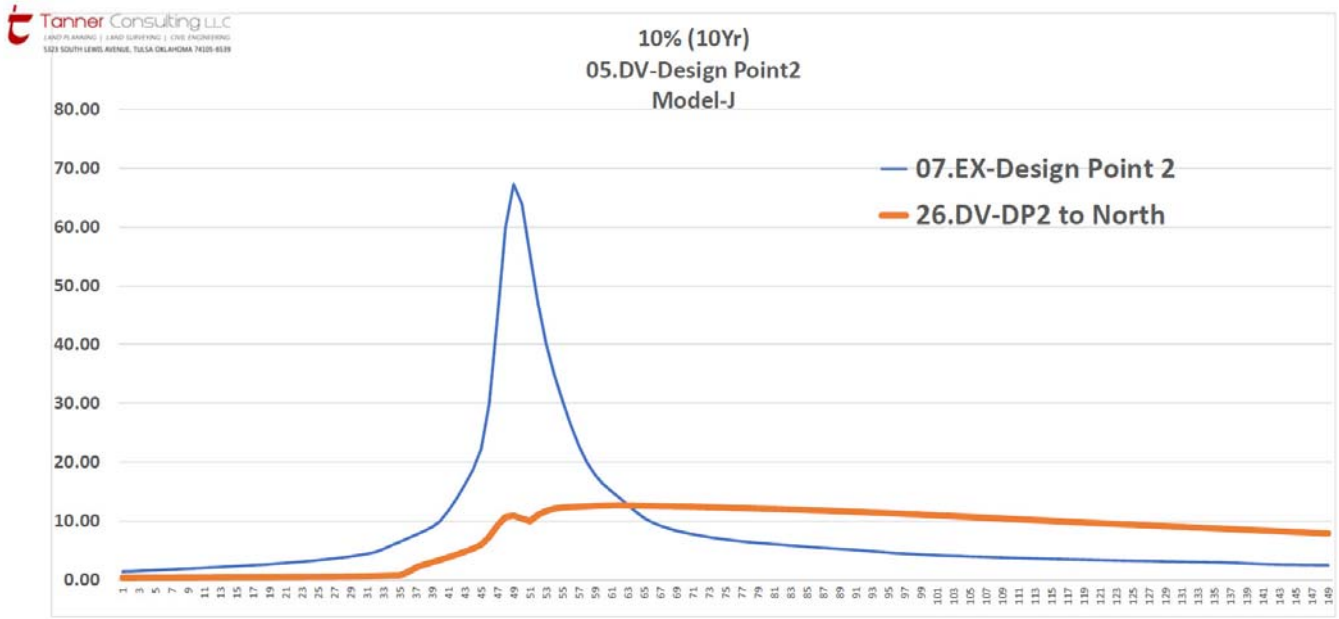
50% Event – Design Point 1
Discharge in CFS

Design Point 2

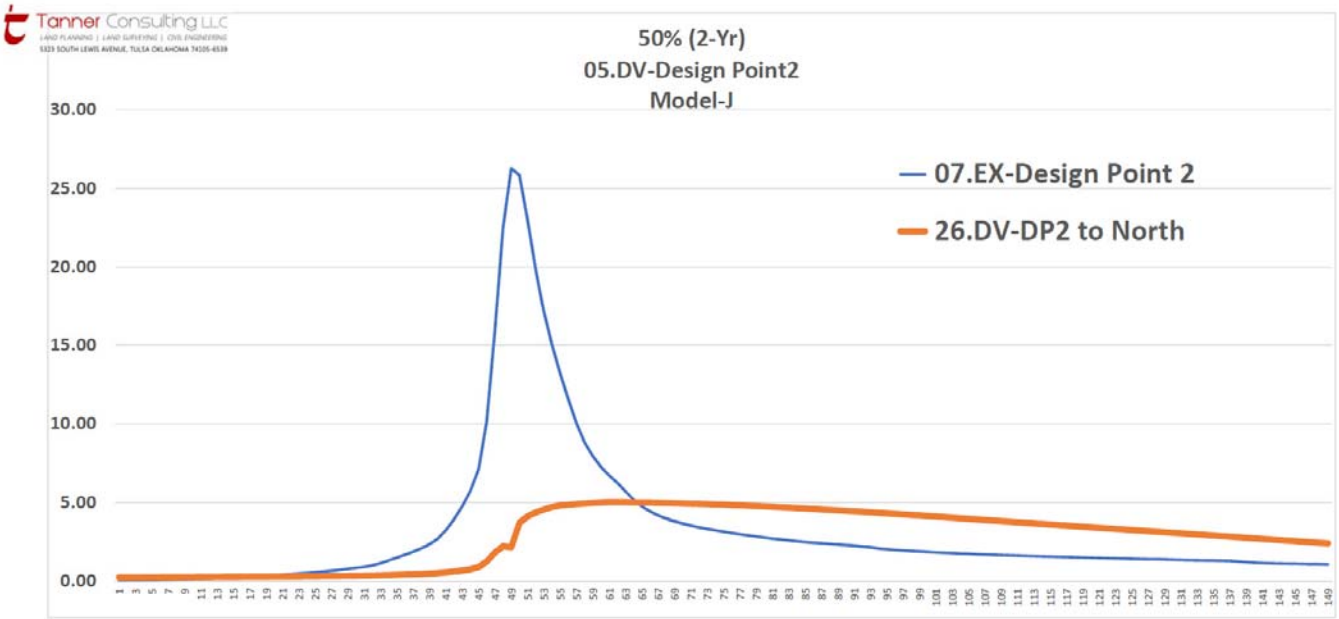
Discharges to the North Boundary. Includes Phase 2.



1% Event – Design Point 2
Discharge in CFS



10% Event – Design Point 2
Discharge in CFS



50% Event – Design Point 1
Discharge in CFS

Summary
Default Strategy: Comprehensive Protection

The Artisan Point development complies with the 'Default Strategy' of 'Comprehensive Protection' that limits the discharge of developed properties pursuant to Section 5608 of APWA.

1. Comprehensive Control
   a. Post-development peak discharge rates from the site shall not exceed those indicated below:
      - 50% storm peak rate less than or equal to 0.5 cfs per site acre
      - 10% storm peak rate less than or equal to 2.0 cfs per site acre
      - 1% storm peak rate less than or equal to 3.0 cfs per site acre
   b. 40-hour extended detention of runoff from the local 90% mean annual event (1.37"/24-hour rainfall). See Chapter 6 of the MARC/APWA BMP Manual for calculating this volume.

The HEC-HMS Hydrograph Analysis summary table for the 50%, 10% and 100% events is presented below. The SCS-TR 55 discharge value for each event is tabulated in cubic per second. The 'allowable' discharge rate is shown in red and the over or under allowable is indicated to the right.

Model-J 20180831			Allowable				Allowable				Allowable	
		50% Storm	0.50			10% Storm	2.00			1% Storm	3.00	
		2-YR				10-YR				100-YR		
Basin Element	Acres	Q (cfs)	CFS/AC	(+/-)		Q (cfs)	CFS/AC	(+/-)		Q (cfs)	CFS/AC	(+/-)
01.EX-A South	3.448	6.28				13.67				24.27		
02.EX-Shendoah	1.901	3.04				8.06				15.76		
03.EX- Reach A	5.349	8.52				19.69				35.96		
04.EX-A	12.640	18.34				48.39				94.39		
05.EX-Design Point 1	17.989	26.26				67.31				129.59		
06.EX-B	24.618	27.39				72.59				142.68		
07.EX-Design Point 2 to Nort	24.618	27.39				72.59				142.68		
08.EX-C	6.229	9.11				23.99				46.76		
09.EX-Total Site	48.836	59.11				153.75				298.34		
10.DV-CS South	3.448	4.16				10.89				21.39		
11.DV-Shenandoah	1.901	3.04				8.06				15.76		
12.DV-Storm Line A	5.349	6.41				16.96				33.15		
13.DV-Phase 1 South	9.569	33.21				60.12				96.32		
14.DV-Pond1	14.918	4.62	7.46	(2.84)		8.39	29.84	(21.45)		49.69	44.76	4.93
15.DV-Phase 1 North	5.786	19.12				34.70				55.67		
16.DV-Pond2	5.786	0.16	2.89	(2.73)		3.66	11.57	(7.91)		37.63	17.36	20.27
17.DV-Onsite Detention	20.705	4.76				12.05				74.14		
18.DV-A Bypass	1.048	1.84				4.66				8.93		
19.DV -Design Point 1 to Eas	21.753	5.03				12.66				77.12		
20.DV-B Remainder	8.574	17.38				38.05				67.45		
22.DV-Phase 2	14.931	55.20				99.32				158.64		
23.DV-Road A to Pond 3	1.340	4.63				8.52				13.76		
24.DV-Road SD to Pond	1.340	4.43				8.11				13.07		
25.DV-Pond3	24.845	1.06				5.46				59.23		
26.DV-DP2 to North	24.845	1.06	12.42	(11.36)		5.46	49.69	(44.23)		59.23	74.54	(15.31)
27.DV-B Bypass	1.367	2.39				6.08				11.64		
28.DV-C1 Bypass	0.615	1.08				2.74				5.24		
29.DV-C2 Bypass	0.692	1.21				3.08				5.89		
30.DV-Total Site	49.272	7.60				22.92				137.91		
* Calc'd total to Detention Ponds	45.550			(16.94)				(73.59)				9.90

HMS Summary Chart

Detention Analysis

The detention ponds receive and pass contributing drainage areas in addition to the on-site proposed apartment development. A total of 45.55 acres is routed through the detention ponds in contrast to a total project area of 34.33 acres.

Model-J 20180831

		Allowable				Allowable				Allowable		
		50% Storm	0.50			10% Storm	2.00			1% Storm	3.00	
		2-YR				10-YR				100-YR		
Basin Element	**Acres**	Q (cfs)	CFS/AC	(+/-)		Q (cfs)	CFS/AC	(+/-)		Q (cfs)	CFS/AC	(+/-)
14.DV-Pond1	14.918	4.62	7.46	(2.84)		8.39	29.84	(21.45)		49.69	44.76	4.93
16.DV-Pond2	5.786	0.16	2.89	(2.73)		3.66	11.57	(7.91)		37.63	17.36	20.27
25.DV-Pond3	24.845	1.06	12.42	(11.36)		5.46	49.69	(44.23)		59.23	74.54	(15.31)
* Calc'd total to Detention Ponds	45.550			(16.94)				(73.59)				9.90

Water Quality Volume

The Water Quality Volume requirements have been calculated for the Artisan Point Detention facilities based on the Development Plan application. The overall site impervious area percentage has been taken from detailed quantity take offs. Impervious area calculations include all buildings, paving and sidewalks.

Water Quality Volume has been calculated by phase and for each area contributing to detention ponds. The 40-Hour Extended calculations are based on the total contributing drainage areas and would therefore include some offsite pass-through property.

6.1 GENERAL

Sizing BMPs properly is critical to their success. Design detention and retention BMPs to capture and treat the WQv. Design conveyance BMPs to handle peak discharge of the WQv. WQv is defined as the storage needed to capture and treat 90 percent of the average annual stormwater runoff volume. WQv is based on the Water Quality Storm and volumetric runoff coefficient and site area. The Water Quality Storm is defined as the storm event that produces less than or equal to 90 percent volume of all 24-hour storms on an annual basis.

The Water Quality Storm for the Kansas City Metropolitan Area is 1.37 inches (Young and McEnroe 2002).

Two methods can be used to estimate the WQv for a proposed development—the Short-Cut Method and the Small-Storm Hydrology Method.

6.2 SHORT-CUT METHOD

Use the Short-Cut Method (Claytor and Schueler 1996) only for sites with one predominant type of cover and a drainage area less than 10 acres:

WQv = P * Rv

Where:

WQv = Water Quality Volume (inches)

P = Rainfall event in inches (the Water Quality Storm of 1.37 inches or other appropriate amount, with the approval of the city engineer)

Rv = Volumetric runoff coefficient
= 0.05 + 0.009(I)

I = Percent site imperviousness (%)

Site Impervious Area	0.5270	
RV=	52.43%	
P=	1.37	Inches
WQv=	0.72	inches

Phase Net Area from Plat	SM	Acres	WQ Volume
DV-Phase 1		16.866	43,976 Cu.Ft.
DV-Phase 2		17.465	45,538 Cu.Ft.
Total Net of RW		34.331	89,515 Cu.Ft.

Areas from HMS	SM	Acres	WQ Volume
DV-Phase 1 South	0.01867	11.949	31,155 Cu.Ft.
DV-Phase 1 North	0.01079	6.906	18,006 Cu.Ft.
DV-Phase 2	0.02462	15.757	41,084 Cu.Ft.
Total		34.611	90,245 Cu.Ft.

Water Quality Times of Retention

EDDB Calculations were derived from published EXCEL worksheets issued by the APWA and MARC manual of Best Management Practices, 2012. 40-hour detention is provided at each pond

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Single Orifice Outlet Worksheet[8]

Designer: _____
Checked By: _____
Company: Tanner Consulting, LLC
Date: 8.14.2018
Project: Artisan Point
Location: Pond 1

This worksheet is for calculating EDDB water quality drain-down time for a single orifice outlet as specified in Section 2b of the Main Worksheet. Enter cumulative volumes in first column to represent the specific stage-volume relationship of the EDDB. Extend the number of rows as needed.

Enter orifice diameter (in): 2.080

Cumulative Volume (ft^3)	Depth Interval From (ft)	To (ft)	Avg H (ft)	Q (cfs)	Incremental Volume (ft^3)	Incremental Time (hrs)	Cumulative Time (hrs)
23,777	3.2	3.36	3.19	0.22	1,662	2.05	2.05
22,125	3.1	3.2	3.11	0.22	5,506	6.94	9.00
16,619	3.0	3.1	2.99	0.22	2,753	3.54	12.54
13,866	2.9	3.0	2.88	0.21	1,751	2.29	14.83
12,115	2.8	2.9	2.77	0.21	842	1.12	15.96
11,273	2.7	2.8	2.66	0.20	842	1.15	17.10
10,431	2.6	2.7	2.55	0.20	842	1.17	18.27
9,589	2.5	2.6	2.43	0.19	842	1.20	19.47
8,747	2.4	2.5	2.32	0.19	842	1.23	20.70
7,905	2.2	2.4	2.21	0.19	842	1.26	21.96
7,063	2.1	2.2	2.10	0.18	842	1.29	23.25
6,221	2.0	2.1	1.99	0.18	842	1.33	24.58
5,379	1.9	2.0	1.87	0.17	867	1.41	25.99
4,512	1.8	1.9	1.76	0.17	417	0.70	26.69
4,095	1.7	1.8	1.65	0.16	417	0.72	27.41
3,679	1.6	1.7	1.54	0.15	417	0.75	28.16
3,262	1.5	1.6	1.43	0.15	417	0.78	28.93
2,845	1.3	1.5	1.31	0.14	417	0.81	29.74
2,428	1.2	1.3	1.20	0.14	417	0.85	30.58
2,012	1.1	1.2	1.09	0.13	417	0.89	31.47
1,595	1.0	1.1	0.98	0.12	417	0.94	32.41
1,178	0.9	1.0	0.87	0.12	138	0.33	32.74
1,040	0.8	0.9	0.75	0.11	129	0.33	33.07
911	0.7	0.8	0.64	0.10	129	0.36	33.43
782	0.6	0.7	0.53	0.09	129	0.39	33.82
654	0.4	0.6	0.42	0.08	129	0.44	34.26
525	0.3	0.4	0.31	0.07	129	0.52	34.78
396	0.2	0.3	0.19	0.05	129	0.65	35.43
267	0.1	0.2	0.08	0.04	257	2.01	37.44
139	0.1	0.2	0.08	0.04	129	1.00	36.43
10	0.0	0.1	-0.03	--	--	--	--

Phase 1 – Pond 1

Design Procedure Form: Extended Dry Detention Basin (EDDB)
Single Orifice Outlet Worksheet[6]

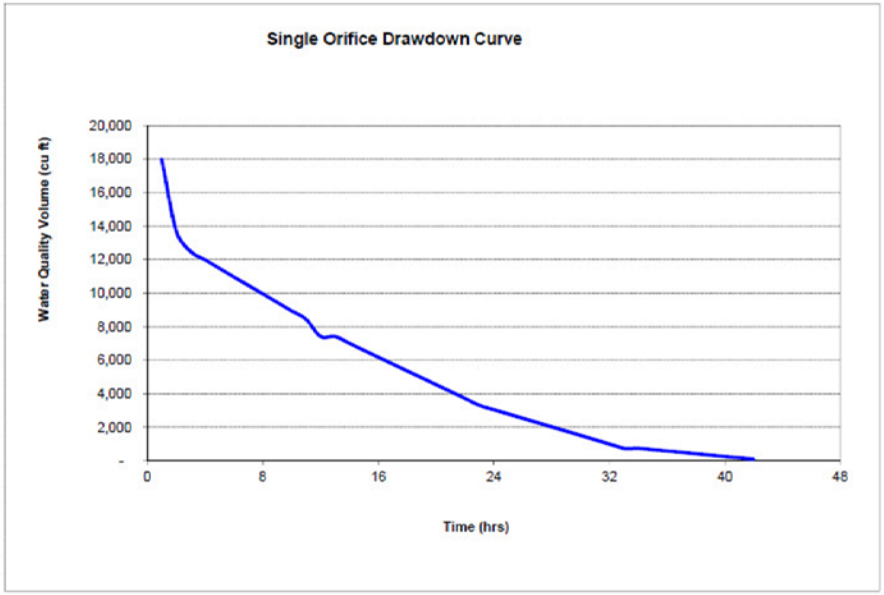
Designer: _____
Checked By: _____
Company: Tanner Consulting, LLC
Date: 8.13.2018
Project: Artisan Point
Location: Pond2

This worksheet is for calculating EDDB water quality drain-down time for a single orifice outlet as specified in Section 2b of the Main Worksheet. Enter cumulative volumes in first column to represent the specific stage-volume relationship of the EDDB. Extend the number of rows as needed.

Enter orifice diameter (in): 1.500

Phase 1 – Pond 2

Cumulative Volume (ft^3)	Depth Interval From (ft)	Depth Interval To (ft)	Avg H (ft)	Q (cfs)	Incremental Volume (ft^3)	Incremental Time (hrs)	Cumulative Time (hrs)
17,990	4.44	4.10	4.21	0.13	4,268	8.89	8.89
13,722	4.00	4.10	3.99	0.13	1,230	2.63	11.52
12,492	3.90	4.00	3.89	0.13	508	1.10	12.62
11,985	3.80	3.90	3.79	0.13	508	1.11	13.74
11,477	3.70	3.80	3.69	0.12	508	1.13	14.87
10,970	3.60	3.70	3.59	0.12	508	1.15	16.01
10,462	3.50	3.60	3.49	0.12	508	1.16	17.18
9,955	3.40	3.50	3.39	0.12	508	1.18	18.35
9,447	3.30	3.40	3.29	0.12	508	1.20	19.55
8,940	3.20	3.30	3.19	0.12	508	1.21	20.76
8,432	3.10	3.20	3.09	0.11	508	1.24	22.00
7,417	3.00	3.10	2.99	0.11	508	1.26	23.26
7,417	2.90	3.00	2.89	0.11	411	1.03	24.29
7,006	2.80	2.90	2.79	0.11	411	1.05	25.34
6,595	2.70	2.80	2.69	0.11	411	1.07	26.41
6,184	2.60	2.70	2.59	0.10	411	1.09	27.51
5,773	2.50	2.60	2.49	0.10	411	1.11	28.62
5,362	2.40	2.50	2.39	0.10	411	1.14	29.76
4,950	2.30	2.40	2.29	0.10	411	1.16	30.92
4,539	2.20	2.30	2.19	0.10	411	1.19	32.11
4,128	2.10	2.20	2.09	0.09	411	1.22	33.32
3,717	2.00	2.10	1.99	0.09	411	1.25	34.57
3,306	1.90	2.00	1.89	0.09	256	0.80	35.37
3,050	1.80	1.90	1.79	0.09	256	0.82	36.18
2,794	1.70	1.80	1.69	0.08	256	0.84	37.03
2,538	1.60	1.70	1.59	0.08	256	0.87	37.89



Phase 2 – Pond 3

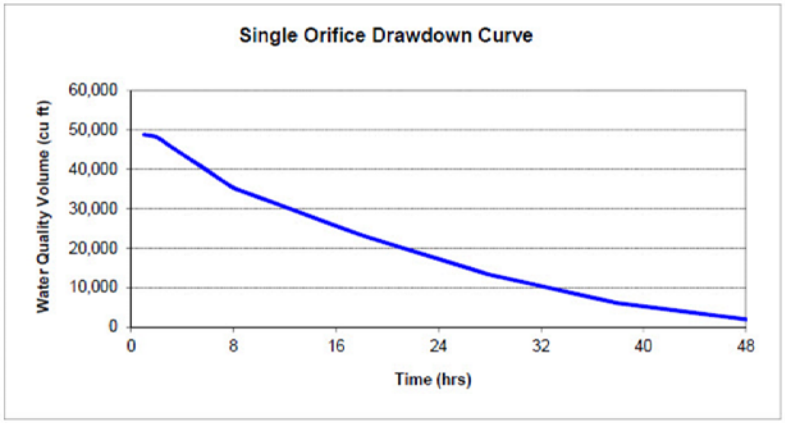
Design Procedure Form: Extended Dry Detention Basin (EDDB)
Single Orifice Outlet Worksheet[6]

Designer:
Checked By:
Company: Tanner Consulting, LLC
Date: 8.30.2018
Project: Artisan Point
Location: Pond 3

This worksheet is for calculating EDDB water quality drain-down time for a single orifice outlet as specified in Section 2b of the Main Worksheet. Enter cumulative volumes in first column to represent the specific stage-volume relationship of the EDDB. Extend the number of rows as needed.

Enter orifice diameter (in): 2.500

Cumulative Volume (ft^3)	Depth Interval From (ft)	Depth Interval To (ft)	Orifice Avg H (ft)	Q (cfs)	Incremental Volume (ft3)	Incremental Time (hrs)	Cumulative Time (hrs)
48,776	6.60	6.63	6.51	0.46	642.00	0.39	0.39
48,134	6.50	6.60	6.45	0.46	2,140.00	1.30	1.68
45,994	6.40	6.50	6.35	0.45	2,140.00	1.31	2.99
43,854	6.30	6.40	6.25	0.45	2,140.00	1.32	4.31
41,714	6.20	6.30	6.15	0.45	2,140.00	1.33	5.64
39,574	6.10	6.20	6.05	0.44	2,140.00	1.34	6.98
37,434	6.00	6.10	5.95	0.44	2,140.00	1.35	8.33
35,294	5.90	6.00	5.85	0.44	1,200.70	0.76	9.09
34,093	5.80	5.90	5.75	0.43	1,200.70	0.77	9.86
32,893	5.70	5.80	5.65	0.43	1,200.70	0.78	10.64
31,692	5.60	5.70	5.55	0.43	1,200.70	0.78	11.42
30,491	5.50	5.60	5.45	0.42	1,200.70	0.79	12.21
29,291	5.40	5.50	5.35	0.42	1,200.70	0.80	13.01
28,090	5.30	5.40	5.25	0.41	1,200.70	0.81	13.82
26,889	5.20	5.30	5.15	0.41	1,200.70	0.81	14.63
25,688	5.10	5.20	5.05	0.41	1,200.70	0.82	15.46
24,488	5.00	5.10	4.95	0.40	1,200.70	0.83	16.29
23,287	4.90	5.00	4.85	0.40	998.50	0.70	16.98

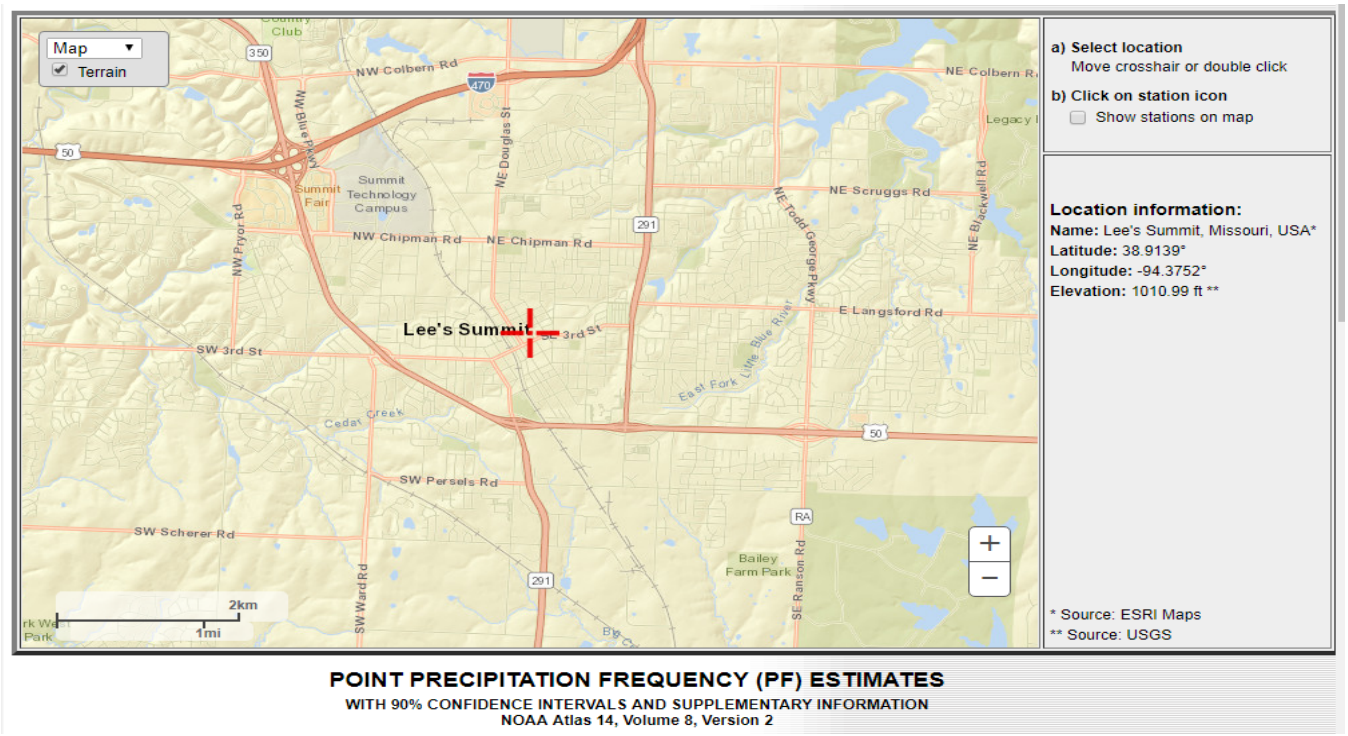


It is my opinion that the drainage features proposed for the Artisan Point development meet the intent of the Lee's Summit criteria and subsequent final design and permitting may affect the assumptions relied upon herein.

The complete digital HEC-HMS model entitled 17086-J is attached to this report.

Issued for Approval,

Site Specific Rainfall From NOAA 14



POINT PRECIPITATION FREQUENCY (PF) ESTIMATES
WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 8, Version 2

NOAA 14 Precipitation (Inches)

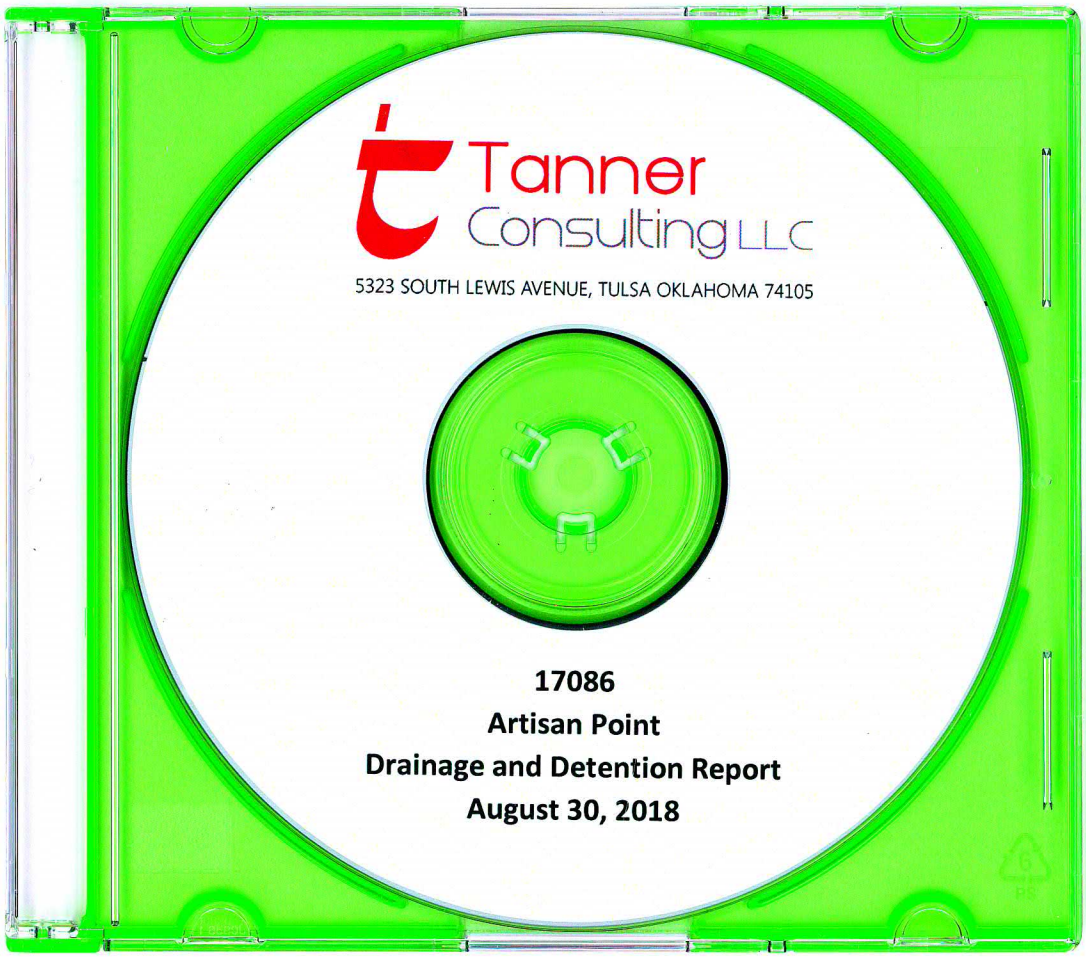
Recurrence Interval (Pct Storm)

Duration	**1.37"**	**2% Storm**	**50% Storm**	**1% Storm**
5-min	0.23	0.48	0.70	1.05
15-min	0.40	0.86	1.24	1.87
60-min	0.76	1.57	2.29	3.52
2-hr	0.95	1.94	2.84	4.40
3-hr	1.10	2.19	3.23	5.07
6-hr	1.38	2.66	3.98	6.38
12-hr	1.70	3.17	4.83	7.85
24-hr	2.00	3.71	5.67	9.25

Note: *1.37" Rainfall was pro-rated from 1% Storm distribution*

Distribution Notice:

This report has been issued in original PDF file format containing color graphics. Further distribution and/or printing requires an original PDF file copy. Significant degradation of the graphic quality of this report will result from scanning a printed color printed copy of this report and/or printing on black and white copiers. Original copies may be obtained by contacting Tanner Consulting, LLC.


Tanner
Consulting LLC
5323 SOUTH LEWIS AVENUE, TULSA OKLAHOMA 74105
17086
Artisan Point
Drainage and Detention Report
August 30, 2018