LEE'S SUMMIT FIRE STATION #3

MICRO STORM WATER DRAINAGE STUDY

Storm Water Drainage Study Submitted: January 16, 2018
Resubmitted: March 21, 2018

Proposed Fire Station located in:
SE ¼ of Section 2, Township 47N, Range 32W
Lee's Summit, Jackson County, Missouri

Little Blue River Watershed

Prepared For:
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1. General Information

Lee's Summit Fire Station #3 is a proposed fire station to be constructed on 2.23 acres of land. The property is just west of Pryor Road and a quarter mile north of SW 3rd Street. This locates the development within the southeast ¼ of Section 2, Township 47N, Range 32W in the Little Blue River watershed of Kansas City, Jackson County, Missouri. This 2.23 acre lot falls inside the overall 64 acre parcel number: 62-240-99-01-00-0-00-000.

Lee's Summit Fire Station #3 Vicinity Map

FEMA Floodplain Classification

FEMA Flood Boundary and Floodway Map Community Panel Number 29095C0416G classifies the Lee's Summit Fire Station #3 property as a "Zone X" Area. Zone X is the FEMA flood insurance rate zone that corresponds to "areas outside the 0.2-percent annual chance floodplain. Refer to Exhibit 1 for Floodplain Map depicting plat location with respect to designated floodplains.

Image taken from FEMA Floodway Map Community Panel Number 29095C0416G

2. Methodology

This Micro Stormwater Drainage Study has been prepared to analyze and fulfill all storm water requirements as specified by Section 5600 of the Kansas City Metropolitan Chapter – American Public Works Association (APWA) Standard Specifications & Design Criteria for comprehensive control.

The following methods were used in this study to model proposed conditions for storm water runoff:

- Haestad Methods, Inc. "PondPack" v8i
  TR-55 Unit Hydrograph Method
  - 2-year, 10-year, and 100-year Return Frequency storms
  - 24-Hour SCS Type II Rainfall Distribution
  - SCS Runoff Curve Numbers per SCS TR-55
  - SCS TR-55 Methods for determination of Time of Concentration and Travel Time

3. Existing Conditions:

Under existing conditions the site is an undeveloped pervious open field. A small portion of the site naturally drains west while the majority of the site drains south and east towards NW Pryor Road.

Refer to Exhibit 1 for existing conditions. Below is a summary of the areas analyzed under existing conditions.

Existing Conditions - Watershed Summary

Watershed	Pervious Area (acres)	Impervious Area (acres)	Total Area (acres)	Pervious CN:	Impervious CN:	Composite Subarea CN:	Tc (hrs)	Notes
A	0.69	0.00	0.69	69	98	69.00	0.100	Predeveloped Conditions
B	1.54	0.00	1.54	69	98	69.00	0.100	Predeveloped Conditions
	2.23	**0.00**	**2.23**					

4. Proposed Conditions:

The Proposed Conditions PondPack Model will show the Lot 1 site under proposed conditions. The proposed fire station will be located centrally on the lot. At the south end of the lot will be an extended dry detention pond labled Pond A. Through the use of sheet flow, concentrated curb flow and roof drains water will be conveyed to the pond from the majority of the proposed development. A small narrow portion on the west side of the proposed development will flow undetained offsite which maintains the original drainage pattern of the watershed.

Refer to Exhibit 2 for proposed conditions. Below is a summary of the areas analyzed under proposed conditions.

Proposed Conditions - Watershed Summary

Watershed	Pervious Area (acres)	Impervious Area (acres)	Total Area (acres)	Pervious CN:	Impervious CN:	Composite Subarea CN:	Tc (hrs)	Notes
A	0.22	0.15	0.37	74	98	83.73	0.100	Undetained
B	0.68	1.18	1.86	74	98	89.23	0.100	Detained by Pond A
	0.90	**1.33**	**2.23**					

5. Water Quality Volume Analysis with 40-hour Extended Detention

Section 5600 of the Kansas City Metropolitan Chapter – APWA Standard Specifications & Design Criteria states that for comprehensive control a 40-hour extended detention time must be achieved for the water quality volume. First, to calculate this water quality volume the proposed conditions outlined above and the methods outlined in chapter 6 of the 2012 BMP Manual were applied below. Which yields a required water quality treatment volume of 6,507 ft3.

Required Water Quality Treatment Volume

Watershed	Treatment Notes	Pervious Area (acres)	Impervious Area (acres)	**DA =** Total Area (ft^2)	**DA =** Total Area (acres)	**I =** Percent Site Impervious %	**P =** KC Metro WQ Event **1.37** (in)	Volumetric Runoff Coefficient **Rv =** 0.05 + 0.009I	Required WQ Treatment Volume **WQv =** P(Rv) (in)	Required WQ Treatment Volume **WQv =** 1.37"(Rv)(DA) (ac-ft)	Required WQ Treatment Volume **WQv =** 1.37"(Rv)(DA) (ft^3)
A	Undetained	0.22	0.15	16,117	0.37	40.5%	1.37	0.415	0.568	0.018	**763**
B	Detained by Pond A	0.68	1.18	81,022	1.86	63.4%	1.37	0.621	0.851	0.132	**5,744**
Total		0.90	1.33	97,139	2.23						**6,507**

The extended dry detention pond will have 3:1 side slopes. The volume of the pond is approximately 0.810 acre-ft. The proposed elevation-area-volume table below for Pond A shows that the required water quality treatment volume is exceeded at elevation 971.60.

Pond A - Elevation-Area-Volume Table					
Elevation	Notes	Area ft^2	Area acres	Volume ft^3	Volume ac-ft
969.00	Bottom Orifice on Perf Riser	930	0.021	0	0.000
970.00		1,981	0.045	1,456	0.033
971.00		3,519	0.081	4,206	0.097
971.60	**WQv Treatment El.**	**4,637**	**0.106**	**6,652**	0.153
972.00		5,383	0.124	8,657	0.199
973.00		7,342	0.169	15,019	0.345
974.00		9,323	0.214	23,352	0.536
975.00	Top of Pond	14,554	0.334	35,290	0.810

Using this water quality treatment depth of 2.60 feet (971.60 – 969.00), the maximum allowable orifice diameter was calculated for a single orifice according to the 2012 BMP Manual.

Pond A - Single Orifice **40 Hour Extended Detention for Water Quality Volume****			
Z_{wq} = WQv Treatment Depth Above Orifice =	2.60	ft	
H_{wq} = Ave. Head of WQv Above Orifice = 0.5(Zwq) =	1.30	ft	
WQv = Water Quality Volume =	**6,652**	ft^3	
WQv = Water Quality Volume =	**0.153**	acre-ft	
Extended Detention Time =	40	hrs	
Q_{wq} = (WQv(43,560))/(40(3600)) =	0.046	cfs	
C_o = Orifice Discharge Coefficient =	0.66		
π =	3.14		
D_o = Maximum Allowable WQ Orifice Diameter			
$D_o = 12(2)(Q_{wq}/(Co(\pi)(2gH_{wq})^{.5}))^{.5}$ =	**1.18**	**inches**	**TOO SMALL**

However, at 1.18 inches this diameter is smaller than the required 2" single orifice diameter. Instead a perforated riser will be used to achieve the 40-hour detention time for the water quality event according to the 2012 BMP Manual on the following page.

Pond A - Perforated Riser **40 Hour Extended Detention for Water Quality Volume**		
Z_{wq} = WQv Treatment Depth Above Lowest Orifice	2.60	ft
WQv = Water Quality Volume =	**6,652**	ft^3
WQv = Water Quality Volume =	**0.153**	acre-ft
Recommened Max Outlet Area per Row = A_o		
$A_o = WQv/(0.013(Z_{WQ}^2 + 0.22(Z_{WQ}) - 0.10)$ =	0.27	in^2
Circular perforation diameter per row assuming a single column, D_1 (in) =	0.59	in
Number of columns (optimally 1), n_c =	1	column
Design circular perforation diameter (should be between 1 and 2 inches), D_{perf} (in) =	1.00	in
Number of rows (4" vertical spacing between perforations, center to center), n_r =	7.00	rows
Orifice 1 Flowline Elevation	969.00	
Orifice 2 Flowline Elevation	969.33	
Orifice 3 Flowline Elevation	969.67	
Orifice 4 Flowline Elevation	970.00	
Orifice 5 Flowline Elevation	970.33	
Orifice 6 Flowline Elevation	970.67	
Orifice 7 Flowline Elevation	971.00	

This calculation produced seven - one inch diameter orifices to achieve the 40-hour detention time for the water quality event. In addition to the orifice design the drainage structure has a 24" diameter horizontal orifice with a trash rack at elevation 973.60. The riser is then drained with a 39 foot 12" RCP pipe that ties into the existing City storm water system.

6. Storm Water Detention Analysis

For storm water detention and peak flow management The City of Lee's Summit requires comprehensive flood control under section 5608 of the February 16, 2011 issue of "APWA Section 5600". This section specifies that this development's maximum release rate for post-development peak discharges shall be as follows:

- 50% (2-year) storm peak rate less than or equal to 0.5 ft^3/s per site acre.
- 10% (10-year) storm peak rate less than or equal to 2.0 ft^3/s per site acre.
- 1% (100-year) storm peak rate less than or equal to 3.0 ft^3/s per site acre.

For the Kansas City area the 2-year, 10-year and 100-year 24-Hour SCS Type II rainfall depths are 3.5 inches, 5.3 inches and 7.7 inches respectively.

Modeling these three storms for Watersheds A and B yields the following table comparing allowable proposed peak discharges with proposed peak discharges.

Watershed 1 Proposed Peak Discharges

Watershed	Return Event (years)	Existing Drainage Area (acres)	Allowable Proposed Peak Discharge* (cfs/acre)	Allowable Proposed Peak Discharge (cfs)	Proposed Peak Discharge (cfs)
A	100	0.69	3.00	2.07	3.15
	10	0.69	2.00	1.38	1.98
	2	0.69	0.50	0.35	1.08
B	100	1.54	3.00	4.62	4.44
	10	1.54	2.00	3.08	0.33
	2	1.54	0.50	0.77	0.26

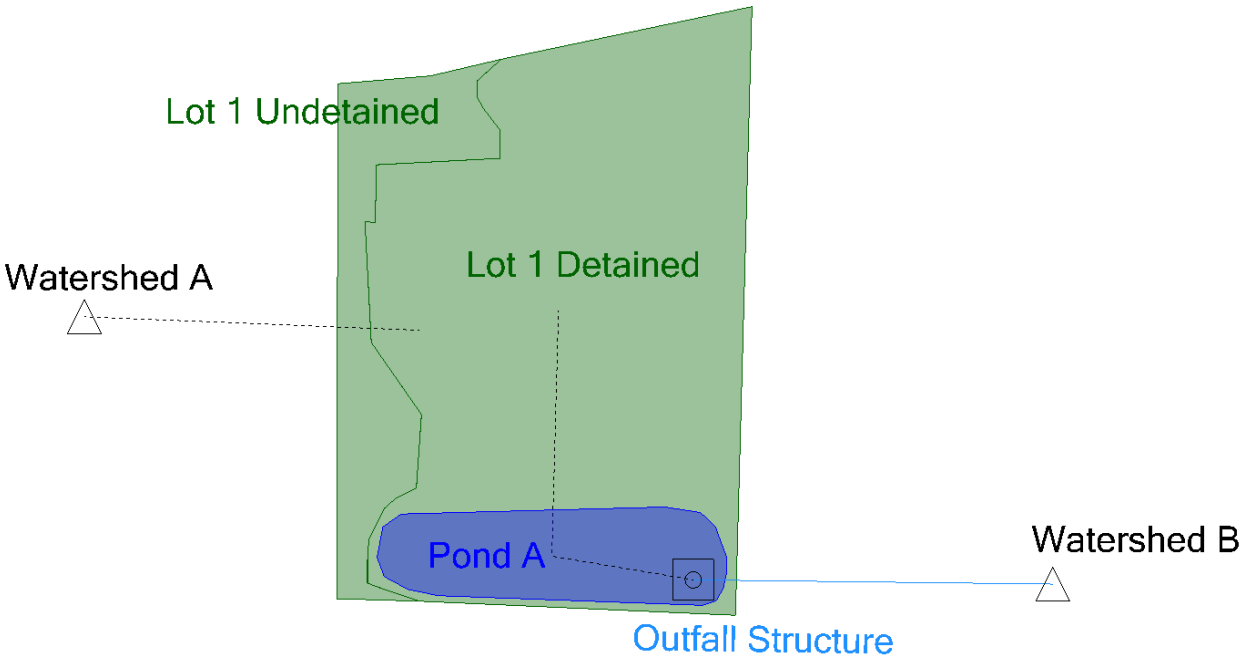
The allowable release rates through the detention pond (Watershed B) are not exceeded. However, the allowable release rates to the west for the undetained area (Watershed A) are slightly exceeded. These increases in flows for Watershed A will be attenuated with the future planed regional detention basin offsite.

The table below summaries the freeboard for Pond A. This table shows that the proposed Pond A has more than 0.5 feet of freeboard up to the 100-year event. This provides exceptional flood protection during extreme events. The weir is a 20 foot wide earthen embankment on the east side of the pond.

Extended Dry Detention Pond Freeboard

Pond	Return Event (years)	Max Water Surface Elevation (ft)	Top of Basin Weir Elevation (ft)	**Freeboard (ft)**
Pond A	100	973.96	974.50	**0.54**
	10	973.36	974.50	**1.14**
	2	972.17	974.50	**2.33**

Proposed Conditions Model



Proposed Conditions – 2-Year Event

Scenario Summary

Scenario:	TR-55 (KC Metro) - Synthetic Curve, 2 yrs	
Output Increment:	0.010	hours
Duration:	35.000	hours

Storm Summary

Return Event Tag:	2_YR	
Total Depth:	3.5	in
Rainfall Type:	Time-Depth Curve	
Storm Event:	TypeII 24hr (3.5 in)	

Executive Summary [Nodes] | Executive Summary [Links] | Messages

	Label	Scenario	Return Event (years)	Truncation	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
1	Lot 1 Detained	TR-55 (KC Metro) - Synt...	2	None	0.369	11.930	6.63	(N/A)	(N/A)
2	Lot 1 Undetai...	TR-55 (KC Metro) - Synt...	2	None	0.059	11.930	1.08	(N/A)	(N/A)
3	Pond A (IN)	TR-55 (KC Metro) - Synt...	2	None	0.369	11.930	6.63	(N/A)	(N/A)
4	Pond A (OUT)	TR-55 (KC Metro) - Synt...	2	None	0.344	13.680	0.26	972.17	0.224
5	Watershed A	TR-55 (KC Metro) - Synt...	2	None	0.059	11.930	1.08	(N/A)	(N/A)
6	Watershed B	TR-55 (KC Metro) - Synt...	2	None	0.344	13.680	0.26	(N/A)	(N/A)

Proposed Conditions – 10-Year Event

Scenario Summary

Scenario:	TR-55 (KC Metro) - Synthetic Curve, 10 yrs	
Output Increment:	0.010	hours
Duration:	35.000	hours

Storm Summary

Return Event Tag:	10_YR	
Total Depth:	5.3	in
Rainfall Type:	Time-Depth Curve	
Storm Event:	TypeII 24hr (5.3 in)	

Executive Summary [Nodes] | Executive Summary [Links] | Messages

	Label	Scenario	Return Event (years)	Truncation	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
1	Lot 1 Detained	TR-55 (KC Metro) - Synt...	10	None	0.639	11.930	11.20	(N/A)	(N/A)
2	Lot 1 Undetai...	TR-55 (KC Metro) - Synt...	10	None	0.110	11.930	1.98	(N/A)	(N/A)
3	Pond A (IN)	TR-55 (KC Metro) - Synt...	10	None	0.639	11.930	11.20	(N/A)	(N/A)
4	Pond A (OUT)	TR-55 (KC Metro) - Synt...	10	None	0.554	14.360	0.33	973.36	0.414
5	Watershed A	TR-55 (KC Metro) - Synt...	10	None	0.110	11.930	1.98	(N/A)	(N/A)
6	Watershed B	TR-55 (KC Metro) - Synt...	10	None	0.554	14.360	0.33	(N/A)	(N/A)

Proposed Conditions – 100-Year Event

Scenario Summary

Scenario:	TR-55 (KC Metro) - Synthetic Curve, 100 yr	
Output Increment:	0.010	hours
Duration:	35.000	hours

Storm Summary

Return Event Tag:	100_YR	
Total Depth:	7.7	in
Rainfall Type:	Time-Depth Curve	
Storm Event:	TypeII 24hr (7.7 in)	

Executive Summary [Nodes] | Executive Summary [Links] | Messages

	Label	Scenario	Return Event (years)	Truncation	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
1	Lot 1 Detained	TR-55 (KC Metro) - Synt...	100	None	0.997	11.920	17.03	(N/A)	(N/A)
2	Lot 1 Undetai...	TR-55 (KC Metro) - Synt...	100	None	0.178	11.930	3.15	(N/A)	(N/A)
3	Pond A (IN)	TR-55 (KC Metro) - Synt...	100	None	0.997	11.920	17.03	(N/A)	(N/A)
4	Pond A (OUT)	TR-55 (KC Metro) - Synt...	100	None	0.863	12.120	4.44	973.96	0.528
5	Watershed A	TR-55 (KC Metro) - Synt...	100	None	0.178	11.930	3.15	(N/A)	(N/A)
6	Watershed B	TR-55 (KC Metro) - Synt...	100	None	0.863	12.120	4.44	(N/A)	(N/A)

7. Summary

This Micro Stormwater Drainage Study has been prepared to analyze and fulfill all storm water requirements as specified by Section 5600 of the Kansas City Metropolitan Chapter – American Public Works Association (APWA) Standard Specifications & Design Criteria for comprehensive control. This project includes a proposed fire station to be constructed on 2.23 acres of land. The site is currently undeveloped vegetation. In order to meet the required discharges and water quality volume residence time an extended dry detention basin will be used to manage storm water.

8. Conclusions & Recommendations

Section 5600 of the Kansas City Metropolitan Chapter – APWA Standard Specifications & Design Criteria states that for comprehensive control a 40-hour extended detention time must be achieved for the water quality volume. Furthermore, calculations show that with the proposed increase in site imperviousness an overall water quality treatment volume of 6,507 ft^3 is required. Utilizing a perforated structure exceeds this requirement with 6,652 ft^3 treated. In addition to water quality volume extended detention time, APWA 5600 specifies maximum release rates for post-development peak discharges. These proposed peak discharges for the 100-year, 10-year and 2-year events through the detention pond (Watershed B) are not exceeded. However, the allowable release rates to the west for the undetained area (Watershed A) are slightly exceeded. These increases in flows for Watershed A will be attenuated with the future planed regional detention basin offsite. Furthermore it should be noted that the proposed Pond A has more than 0.50 feet of freeboard for all events which provides exceptional flood protection. Given that all storm water storm water requirements have been reasonably and safely fulfilled, the approval of this micro storm water drainage study is requested.

9. Exhibits

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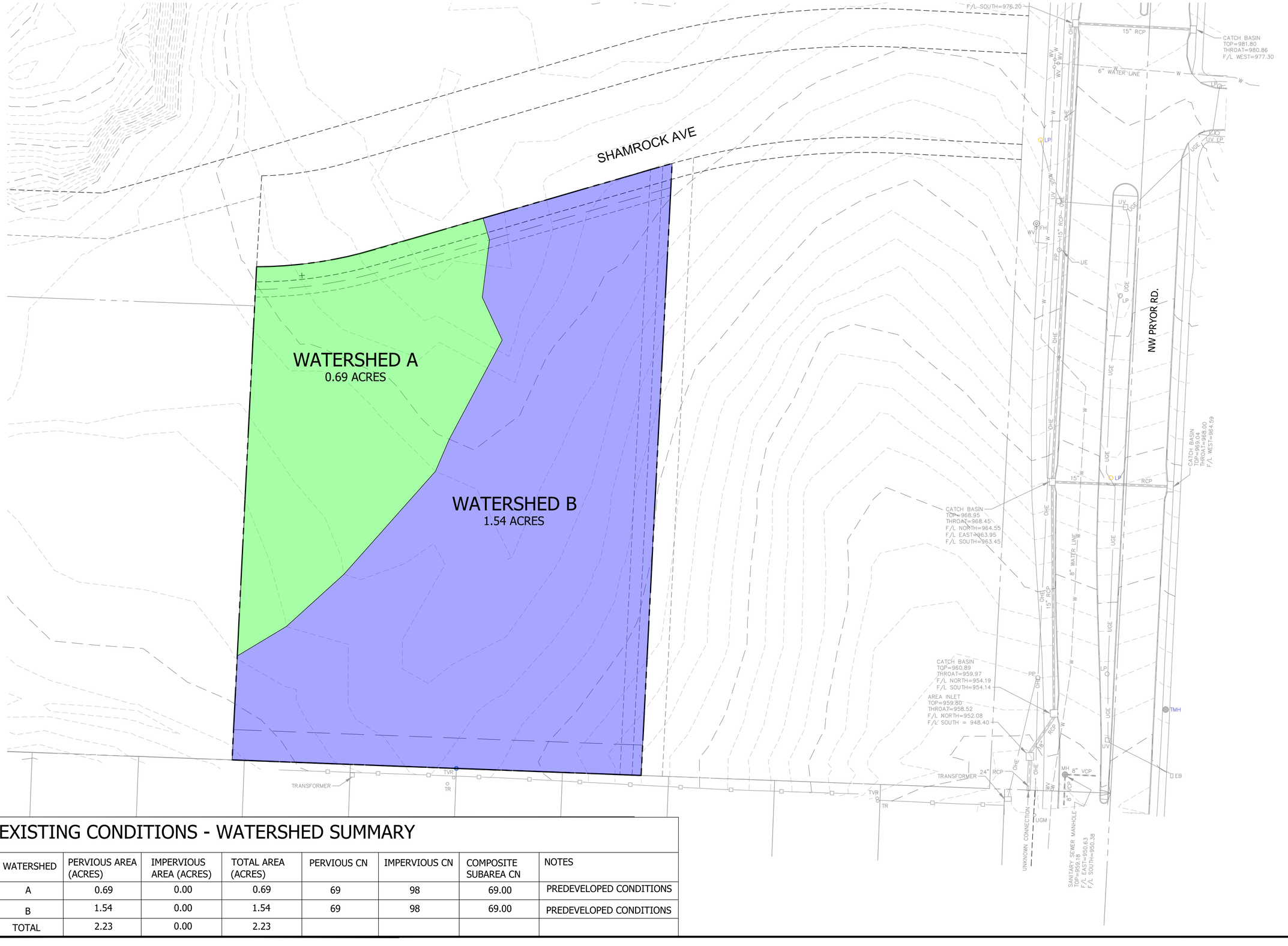

EXISTING CONDITIONS - WATERSHED SUMMARY

WATERSHED	PERVIOUS AREA (ACRES)	IMPERVIOUS AREA (ACRES)	TOTAL AREA (ACRES)	PERVIOUS CN	IMPERVIOUS CN	COMPOSITE SUBAREA CN	NOTES
A	0.69	0.00	0.69	69	98	69.00	PREDEVELOPED CONDITIONS
B	1.54	0.00	1.54	69	98	69.00	PREDEVELOPED CONDITIONS
TOTAL	2.23	0.00	2.23				

0 30'
SCALE: 1" = 30'

EXHIBIT 1
EXISTING CONDITIONS

LEE'S SUMMIT FIRE STATION #3

LEE'S SUMMIT, MISSOURI

#	DATE	DESCRIPTION	BY

BARTLETT & WEST
117 W 5TH STE 210, BARTLESVILLE, OK 74003
P (918) 876.0348 F (888) 220.6464
WWW.BARTWEST.COM

DESIGNED BY:	
DRAWN BY:	
APPROVED BY:	
DESIGN PROJ:	19622.000
CONST PROJ:	
SCALE:	
DATE:	JAN. 2018
DRAWING NO:	1
SHEET NO:	1 of 2

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PROPOSED CONDITIONS - WATERSHED SUMMARY

WATERSHED	PERVIOUS AREA (ACRES)	IMPERVIOUS AREA (ACRES)	TOTAL AREA (ACRES)	PERVIOUS CN	IMPERVIOUS CN	COMPOSITE SUBAREA CN	NOTES
A	0.22	0.15	0.37	74	98	83.73	UNDETAINED
B	0.68	1.18	1.86	74	98	89.23	DRAINS TO POND A
TOTAL	0.90	1.33	2.23				

0 30'
SCALE: 1" = 30'

EXHIBIT 2
PROPOSED CONDITIONS

LEE'S SUMMIT FIRE STATION #3

LEE'S SUMMIT, MISSOURI

#	DATE	DESCRIPTION	BY

BARTLETT & WEST
117 W 5TH STE 210, BARTLESVILLE, OK 74003
P (918) 876.0348 F (888) 220.6464
WWW.BARTWEST.COM

DESIGNED BY:	
DRAWN BY:	
APPROVED BY:	
DESIGN PROJ:	19622.000
CONST PROJ:	
SCALE:	
DATE:	JAN. 2018
DRAWING NO:	2
SHEET NO:	2 of 2

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