

MACRO STORM WATER DRAINAGE STUDY

291 & 150 Multi-Family Residential Development

SITE ACREAGE: 48.2 ACRES

Lee's Summit, MO

PREPARED BY:



Revision

Date	Comment	By
4-14-20	Revised per City Comments	AEP
5-18-20	Revised per City Comments	AEP

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3. GENERAL INFORMATION

The 291 & 150 Residential Development (Development) is a proposed multi-family residential development consisting of a combination of duplex units and 4-plex units to be constructed in multiple phases. The proposed development is located in the southern portion of the City approximately 1,000 feet south of 150 Highway and adjacent to the east outer road of 291 Highway. The site is bounded by farmland to the north and east, Saddlebrook single-family residential development to the south and 291 Highway to the west. The proposed development encompasses 48.2 acres. The property is located in Section 8, Township 48N, Range 31 W, Lee's Summit, Jackson County, Missouri. A portion of the property drains to an unnamed tributary on the east side of the property and the remainder of the property drains to Tributary G1 to Lake Winnebago along the southwest side of the property.

See Exhibit A for an aerial image of the proposed project site along with an aerial image of the watershed.

3.1 FEMA FLOODPLAIN DETERMINATION

The property is tributary to an Unnamed Branch of Tributary G1 and Tributary G1 to Lake Winnebago. The site contains Special Flood Hazard Areas, Zone A and Zone AE with Base Flood Elevations and Regulatory Floodway, according to FEMA Firm Map Numbers 29095C0551G, revised January 20, 2017.

See Exhibit B for a FIRMette which includes the proposed project site. In addition a FIRMette of Tributary G1 to Lake Winnebago downstream of the project site has been included in Exhibit B for reference.

3.2 NRCS SOIL CLASSIFICATION

Soil classifications published by the United States Department of Agriculture/National Resources Conservation Service (USDA/NRCS) website for Jackson County, Missouri, Version 20, September 16, 2019. The existing site contains five major soil types:

10000	Arisburg Silt Loam, 1 to 5 Percent Slopes Hydrologic Soil Group (HSG): Type C
10024	Greenton-Urban Land Complex, 5 to 9 Percent Slopes (HSG): Type D
10082	Arisburg-Urban Land Complex, 1 to 5 Percent Slopes (HSG): Type C
10180	Udarents-Urban Land-Sampsel Complex, 2 to 5 Percent Slopes (HSG): Type C
30080	Greenton Silty Clay Loam, 5 to 9 Percent Slopes, Eroded (HSG): Type C/D

See Exhibit K for a detailed soils report of the proposed project site.

4. METHODOLOGY

This Macro Storm Drainage Study has been prepared to evaluate potential hydrologic impacts from the proposed development and recommend improvements to eliminate potential negative impacts downstream if anticipated. City contours were utilized to create the 291 & 150 Existing Watershed Map, see Exhibit C. The subject watershed named Tributary G1 to Lake Winnebago has been studied by FEMA and data such as peak discharge rates from the FEMA Flood Insurance Study (FIS) are included in Exhibit D for reference. TR-55 was first introduced in 1975 by the SCS particularly for small urbanizing watersheds and has been utilized for this study per APWA 5602.2.B. The analysis contains results for the 2, 10 and 100-year design storms. This study conforms to KC Metro Area APWA Section 5600 requirements in addition to all other applicable codes and requirements of the City of Lee's Summit, Missouri.

Structural flooding is known to occur in lower reaches of the watershed. The property with reported structural flooding has a sub-basement finish floor elevation of 932.22. The reported 100-year FEMA Flood Elevation at this point is approximately 937.70. Based on current conditions flooding should be expected during the 50 year storm event and greater. The backwater is created by an undersized box culvert at Mandan Lane. A shed upstream has also been reported to structurally flood. The shed FFE is 938.15. The FEMA 100 year WSE at this point is approximately 939+ as determined from the FEMA FIS flood profile. As discussed the Mandan Lane RCB is undersized creating the elevated FEMA flood elevations. The City is currently working with an independent consultant to analyze the subject watershed and provide potential recommendations for mitigation of reported downstream issues. The remainder of this report will be focused on the proposed 291 and 150 multi-family development and its potential impacts.

Per APWA 5601.8.2 Buildings shall be protected from infrequent flooding by:

c. Non habitable accessory buildings are sometimes provided less protection by local City/County ordinances or policies. Consult the local authority for exceptions. The City is currently involved in a study to evaluate the situation.

Hydraflow Hydrographs Extension for AutoCAD Civil 3D was utilized to model the various SCS TR-55 stormwater rainfall runoff events. The following SCS TR-55 Unit Hydrograph variables were utilized;

- AMC II Soil Moisture Conditions
- 24-Hour SCS Type II Rainfall Distribution (Shape Factor 484)
- SCS Runoff Curve Numbers per SCS TR-55 (Tables 2-2a to 2-2c)

Time of Concentration has been calculated using the following formulas:

- Sheet Flow (Max. 100 LF): APWA Travel Time, $T_t = 1.8 \times (1.1 - C) \times (D^{0.5} / S^{0.33})$
Sheet Flow Time: Minimum: 5 Minutes, Maximum: 15 Minutes
- Shallow Concentrated Flow: SCS TR-55 Appendix F:
Unpaved $V = 16.1345(S)^{0.5}$
Paved $V = 20.3282(S)^{0.5}$

Shallow Concentrated Travel Time (min): SCS TR-55 Eq-3-1, $T_t = L / V \times 60$

- Channel Flow Improved: Manning's Equation (Full Flow)
Channel Flow Unimproved: APWA 5602.7.A. Travel Time, Table 5602-6

<u>Avg. Channel Slope (%)</u>	<u>Velocity (fps)</u>
< 2	7
2 to 5	10
>5	15

5. EXISTING CONDITIONS ANALYSIS

The upper five sub-basins of Tributary G1 to Lake Winnebago will be analyzed to develop existing peak discharge rates which will be used to determine baseline peak discharges for Sub-basins 4 and 5. The upper five sub-basins (1-5) constitute all the land upstream to and through the proposed development. The proposed development is part of Sub-basins 4 and 5. Sub-basins 4 and 5 terminate at the West and East POI, respectively. Points of Interest are the furthest downstream locations within a sub-basin used to determine net hydrologic and hydraulic impact to downstream sub-basins. Sub-basin 4 contains the west portion of the property and Sub-basin 5 contains the east portion of the property. The Upper Watershed Map and the Existing Drainage Map for the property may be found in Exhibit C.

An Existing Land Usage Map was created for the entire watershed. The land usage map consists of impervious area CN = 98, residential areas CN = 82 and undeveloped ground CN = 74. Existing composite curve numbers were generated for each sub-basin and shall be used in the analysis. The Existing Land Usage Map may be found in Exhibit E. Time of concentration calculations may be found in Exhibit F. The following table summarizes the results of the Existing Conditions Analysis for the upper watershed which contribute runoff to each Point of Interest, both POI's lie on the southern property boundary of the proposed development. A complete Hydraflow Report may be found in Exhibit G which contains both Existing and Proposed Hydrologic Data.

Table 5.1 Existing Conditions Sub-basin & Hydrologic Data at the POI

Sub-basin	POI	Area (ac.)	CN	Tc (min.)	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
1	West	77.44	85	54.3	93.60	164.63	270.80
2	East	74.64	76	56.2	57.26	117.70	214.33
3	West	60.08	84	42.1	84.81	151.22	250.87
4	West	36.49	78	27.3	47.97	94.06	166.18
5	East	96.37	76	42.3	92.42	189.16	343.71
Combined West	West	174.01			208.73	376.86	631.59
Combined East	East	171.01			143.81	295.49	538.51

The following table summarizes the results of the Existing Conditions Analysis for the proposed development property. The internal property sub-basins were configured in accordance with the proposed development and allow for ease of accounting and comparison.

Table 5.2 Existing Conditions Sub-basin & Hydrologic Data at the POI for the Proposed Development

Sub-basin	POI	Area (ac.)	CN	Tc (min.)	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
W	West	6.97	74	19.7	9.70	20.39	37.67
W1	West	2.32	74	21.6	3.09	6.51	12.04
E	East	8.93	74	27.4	9.95	21.07	39.14
E1	East	1.02	74	12.5	1.75	3.64	6.68
E2	East	3.28	74	30.2	3.52	7.47	13.89
S (4 Portion)	West	7.15	74	27.2	7.97	16.87	31.34
S (5 Portion)	East	18.55	74	33.0	18.51	39.32	73.19

The W and E Sub-basins encompass FEMA floodplain on the property and shall not be developed.

Per APWA Section 5608.4 and City of Lee's Summit criteria, the performance criteria for post development runoff is to limit peak flow rates at downstream points of interest to the following maximum release rates:

- 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

Allowable release rates are comprised of a combination of upstream offsite flows, undeveloped onsite flows and allowable onsite post development peak flows at each point of interest. The following Table details allowable release rates at each Point of Interest.

Example Calculation:

Allowable Release Rate: POI West (2-Yr) = 1 + 3 + PROP. 4 + W + W1 Area x 0.5 cfs + S (4 Portion) Area x 0.5

Allowable Release Rate POI West (2-Yr) = 93.60 + 84.81 + 25.64 + 9.70 + (2.32 x 0.5) + (7.15 * 0.5) = 220.06 cfs Note: Value shown is higher (less conservative) than required see actual determination below.

Allowable release rate calculations for Existing Sub-basins were performed in Hydraflow. Take the peak discharge rate for a given storm event and Point of Interest and add the Allowable Development flow to arrive at the Allowable Release Rate per Table 5.3 below.

Table 5.3 Existing Conditions APWA Allowable Release Rates

POI	Total Area (ac.)	Onsite Area (ac.)	*Developed Area (ac.)	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
West	174.01	16.44	9.47	200.23	370.37	615.31
East	171.01	31.78	22.85	132.57	295.06	523.61

- Developed Area Assumes Ultimate Buildout for the Development

6. PROPOSED CONDITIONS ANALYSIS

The 291 & 150 watershed shall remain constant except for the 48.2 acre parcel which represents the actual 291 & 150 multi-family Development. See Proposed Drainage Map, Exhibit H for a depiction of the watershed with full buildout of the 291 & 150 Development. The 291 & 150 parcel is assumed to be fully developed with multi-family residential usage as depicted on the Site Plan in Exhibit H. A CN of 88 was utilized per APWA for the proposed improvement areas on the property. The proposed Development was divided into six sub-basins W, W1, E, E1, E2 and S corresponding to their geographic location. The south (S) sub-basin will contain the majority of the hard infrastructure improvements in addition to a small piece of offsite area in the northwest. The south sub-basin will capture runoff and convey it via an enclosed storm sewer system to the south where it will be released just upstream of the East POI. Flood plain takes up a significant portion of buildable ground. The E and W Sub-basins contain the floodplains and constitute undevelopable ground. Runoff from the proposed Development will continue to contribute to the watershed via surface and shallow concentrated flow. The following table summarizes the results of the Proposed Conditions Analysis. Sub-basins 1, 2 and 3 remain unchanged refer to Table 5.1.

Table 6-1 Proposed Conditions Sub-basin & Hydrologic Data at the POI for the Proposed Development

Sub-basin	POI	Area (ac.)	CN	Tc (min.)	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
W	West	6.97	74	19.7	9.70	20.39	37.67
W1	West	2.32	88	17.2	6.33	10.54	16.73
E	East	8.93	74	27.4	9.95	21.07	39.14
E1	East	1.02	88	12.5	3.23	5.36	8.47
E2	East	3.28	88	25.7	7.29	12.22	19.43
S	East	27.22	87	15.3	76.17	128.65	205.65
PROP. 4	West	18.54	78	27.3	25.64	50.27	88.82

PROP. 5	East	64.59	76	42.3	61.94	126.78	230.36
Combined West	West	174.01			197.36	354.72	592.66
Combined East	East	171.01			159.38	309.72	548.06

As shown in Table 6.1 above the proposed peak discharge rates at the West POI will be below both Existing and Allowable therefore no further improvements will be required beyond the proposed enclosed storm sewer system. The S (South) Sub-basin will require retention to attenuate proposed peak discharge rates below both Existing Conditions and Allowable at the East POI.

6.1. RETENTION

A new single stage earthen retention basin is being proposed in Sub-basin S to attenuate proposed peak discharge rates. Following are a list of design parameters for the retention system.

Designation: Retention Basin S

Type: Earthen Basin

Side Slopes: 3:1 Max.

Bottom Slope: 2% Min., Turf Lined

Basin Bottom Elevation: 958.00

Basin Top Berm Elevation: 976.00

Basin Detention Volume: 573,236 cf from 964.00 to 976.00

Control Structure: 8' Diameter Manhole

Orifices: (1) 4" Diameter, FL=964.00

(1) 24" Diameter, FL=970.50

Effluent Pipe: 42" HDPE, FL (In) = 964.00, FL (Out) = 960.00, L=270', S=1.48%

Emergency Spillway: (2) 6' Diameter Manholes, Crest Elevation=973.25, Crest Length=37.70'

Consecutive 100-YR Q=205.65 cfs, Emergency Spillway HGL=974.64, Freeboard=1.36'

Sediment Storage Required: 5-Year Accumulated per APWA Figure 5608-1 = 100 x 27.22 x 5 = 13,610 cf

Sediment Storage Provided: 13,610 cf @ El= 958.59

The permanent pool shall be 6' deep with a 0.59' sedimentation allowance. The pond will not support fish which requires a minimum 10' of depth plus sedimentation allowance. The Retention Basin Plan may be found in Exhibit I. Basin S emergency overflow calculations may be found in Exhibit J. See Table 6.2 for a summary of retention basin data.

Table 6.2 Proposed Conditions Retention Basin S Data

	Peak Q In (cfs)	Tp In (min.)	Peak Q Out (cfs)	Tp Out (min)	Peak W.S.E.	Max. Storage Vol. (cf)
Basin S						
2-Year	76.17	723	0.88	1445	968.65	179,807
10-Year	128.65	723	2.75	1036	971.03	290,310
100-Year	205.65	723	17.96	765	972.74	379,131

As shown in the table above all proposed peak flowrates have been attenuated. See Table 6.3 below for a summary of proposed peak discharge rates at POI East. Hydrographs tributary to the POI have been combined to determine subsequent peak discharge rates.

Table 6.3 Proposed Conditions Post Retention Point of Interest Peak Discharge Rates

Point of Interest	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
East	126.85	258.96	485.44

As shown in the above Table all peak discharge rates attributable to the East POI have been attenuated below both Existing and Allowable Peak Discharge rates as outlined in Table 5.2 and Table 5.3 respectively.

Table 6.4 below provides a comparison of runoff data between Proposed, Existing and Allowable Conditions for the Proposed Development.

Table 6.4 Point of Interest Discharge Comparison

		Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
POI West	Proposed	197.36	354.72	592.66
	Existing	208.73	376.86	631.59
	Difference	-11.37	-22.14	-38.93
	Allowable	200.23	370.37	615.31
	Difference	-2.87	-15.65	-22.65
POI East	Proposed	126.85	258.96	485.44
	Existing	143.81	295.49	538.51
	Difference	-16.96	-36.53	-53.07
	Allowable	132.57	295.06	523.61
	Difference	-5.72	-36.10	-38.17

Peak discharge rates for the proposed Development will be reduced below both Existing and Allowable Peak Discharge Rates for all regulatory design storms.

7. 40 HOUR EXTENDED DETENTION

In addition to mitigation of peak flow rates, APWA Section 5608.4 also requires 40 hour extended detention of runoff from the local 90% mean annual event (1.37"/24-hour rainfall). The proposed retention facility will release the water quality event over a period of 40-72 hours. See Exhibit J for Retention Basin S extended detention calculations. The Water Quality Volume is released in approximately 40 hours from Basin S.

8. CONCLUSIONS & RECOMMENDATIONS

This macro storm water drainage study reveals that the Proposed 291 & 150 Multi-Family Development consisting of 48.2 acres shall not increase the peak discharge rate at either POI. The proposed peak discharge rates at both the West POI and East POI will be reduced below both Existing and Allowable peak discharge rates for all regulatory design storms. No additional negative impacts are anticipated downstream due to the proposed development. Reported structural flooding issues downstream will not be affected negatively nor resolved due to the low finish floor elevations of the sub-basement structure. Per the FEMA FIS the sub-basement will flood below the 50 year storm event. As discussed, the City has engaged an independent outside consultant to help them examine the downstream watershed and provide potential flood mitigation options.

In conclusion, no increase in peak discharge nor water surface elevation is anticipated downstream of the proposed development. A retention system will be employed in the S (South) Sub-basin to help attenuate Proposed Peak Discharge Rates below both Existing and Allowable. The retention basin will not only alleviate any potential hydrologic/hydraulic issues downstream but it will also provide the community with a tranquil site amenity. No negative impacts are anticipated downstream due to the proposed development. We recommend standard enclosed storm sewer conveyance systems for the development. The study is in conformance with all applicable City of Lee's Summit standards and criteria.

Waiver Requests:

- 1) N/A