OSAGE THIRD PLAT MACRO & MICRO STORMWATER DRAINAGE STUDY

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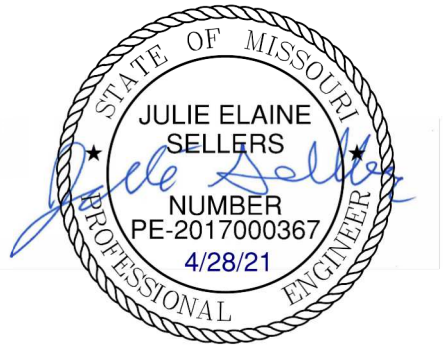

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1. INTRODUCTION

This Stormwater Drainage Study has been prepared to evaluate the stormwater hydrology of a proposed multi-family residential development named Osage Third Plat. Once fully developed, the area will be included in the overall Osage development, with this addition including 12 twin gallery homes, tracts reserved for open space, and a stormwater detention basin.

The site is located near the southwest corner of the intersection of MO-150 Highway and SW Pryor Road in Lee's Summit, Jackson County, Missouri. Figure 1 shows the Osage development and Third Plat boundaries.

Stormwater runoff from the project site is tributary to Mouse Creek, approximately 1.33 miles downstream of the study area.

This report is intended to serve as the project Macro and Micro Stormwater Drainage Study for the Osage Third Plat development and has been prepared to evaluate the Existing and Proposed Conditions stormwater hydrology. Refer to Appendix B and C for hydrologic model input data and simulation results for Existing and Proposed Conditions. Refer to Appendix A for maps and exhibits depicting the watersheds evaluated in the analyses.

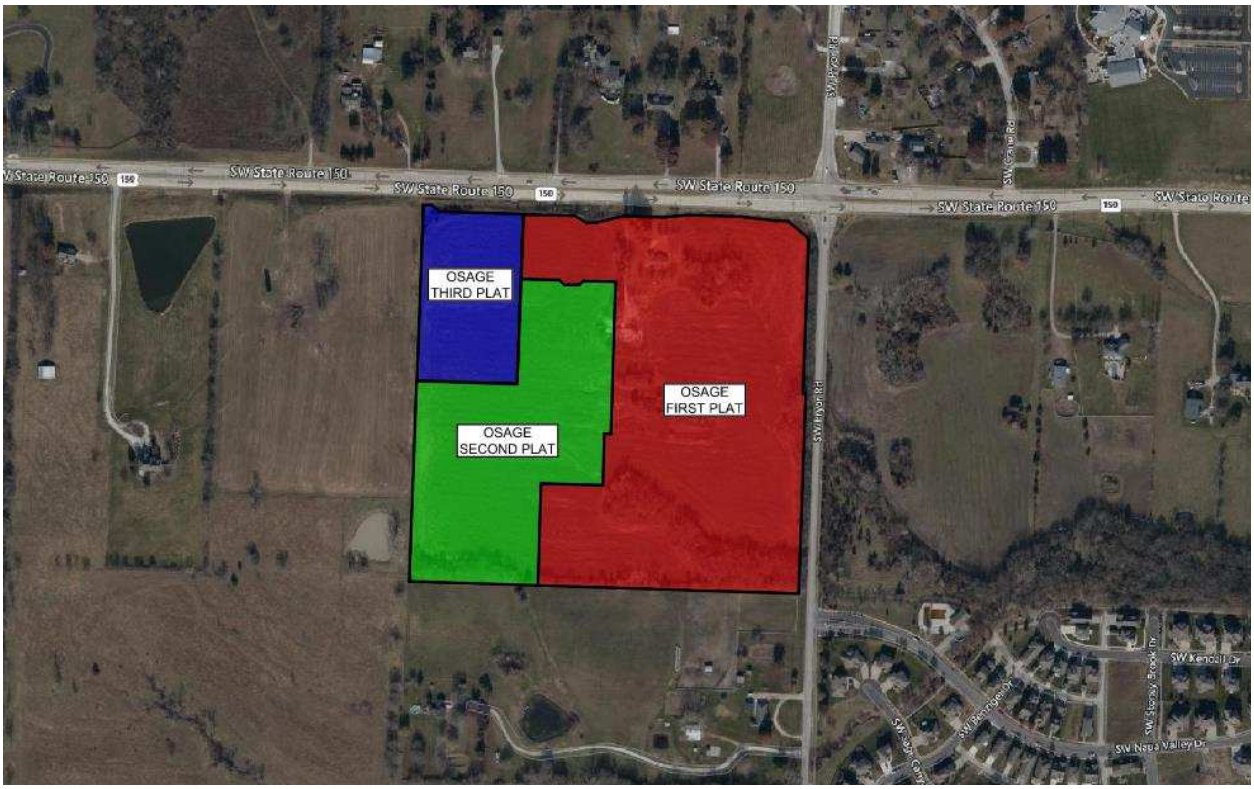

Figure 1. Vicinity Map

1.1. FEMA Floodplain Classification

The FEMA FIRM Panel 29095C0531G (eff. January 20, 2017) depicts the proposed development areas as "Zone X." This zone is described as "areas determined to be outside the 0.2% annual-chance floodplain." Refer to the attached FEMA Floodplain Map (Exhibit 8-1.1) for depiction of the established floodplains relative to the project site.

1.2. Soil Classification

Soil Maps published in the Soil Survey for Jackson County, Missouri categorizes soils in the study area as:

Table 1. Soil Classifications

Hydrologic Soil Group	Map Symbol	Type	Slopes
C	10082	Arisburg-Urban Land Complex	1% to 5%
C/D	10117	Sampsel Silty Clay Loam	5% to 9%
C	10120	Sharpsburg Silt Loam	2% to 5%
C	10122	Sharpsburg Silt Loam	5% to 9%

NRCS Runoff Curve Numbers (CN's) in this study have been assigned to tributary areas based upon these Hydrologic Soil Groups (HSG's) and associated existing and proposed land use. Land uses in the study area include open space, streets, and residential lots for twin gallery homes. The CN's are assigned accordingly. Refer to the Soils Map in Appendix A for distribution of soil types throughout the sub-watersheds.

2. METHODOLOGY

The base data for the models prepared for this report has been obtained from available online maps and aerial imagery. Stormwater management is based upon methods and objectives defined in the Kansas City Metropolitan Chapter of the American Public Works Association's (KC-APWA) 2011 design guidance document called "Section 5600 Storm Drainage Systems & Facilities" (2011).

The following methods were used in this study to model existing and proposed conditions for stormwater runoff:

Hydraflow Hydrographs Extension Version 12

- Soil Conservation Survey (SCS) Unit Hydrograph Method
  - 2-year, 10-year, and 100-year Return Frequency Storms
  - Antecedent Moisture Conditions (AMC) II Soil Moisture Conditions
  - 24-Hour SCS Type II Rainfall Distribution
  - SCS Runoff Curve Numbers per SCS TR-55 (Tables 2-2a – 2-2c)
  - SCS TR-55 methods for determination of time of concentration and travel time. Where specific data pertaining to channel geometry is not available, length and velocity estimates for channel flow travel time is used per Section 5600, KC-APWA Standard Specifications and Design Criteria.

Stormwater runoff models were created for the 2-, 10-, and 100-year design storm events. The precipitation depths used in the analysis have been interpolated from the "Technical Paper No. 40 Rainfall Frequency Atlas of the United States" (TP-40) isopluvial maps (May 1961). Table 2 below summarizes the rainfall depths used in this analysis:

Table 2. Precipitation Depths.

Return Period	24-Hour Precipitation Depth (inches)
Water Quality Storm* (WQ)	1.37
2-Year (50% Storm)	3.60
10-year (10% Storm)	5.34
100-Year (1% Storm)	7.90

*The "Water Quality Storm" is defined in the MARC & APWA "Manual of Best Management Practices for Stormwater Quality" as a 24-hour 1.37" rainfall depth. This particular storm event is utilized for proposed water quality analysis.

3. EXISTING CONDITIONS ANALYSIS

To quantify the effects of the proposed development, the following areas and points of interest have been chosen for existing and proposed conditions analysis. See Exhibit 3 – Existing Conditions Drainage Map in Appendix A for a visual depiction of the drainage areas and points of interest.

Drainage Area A represents the area in the northwestern corner of the site, which will be mostly captured by the proposed detention basin with some bypass to the north. In existing conditions, drainage area A has an area of 4.27 acres.

Drainage Area B represents the majority of the site in the existing conditions models and drains through parts of the first and second plats of the Osage development. In existing conditions, drainage area B has an area of 9.44 acres.

Drainage Area C (Surface) is located mostly north of the property and includes parts of MO-150 Highway and SW Pryor Road. In existing conditions, drainage area C (surface) has an area of 5.54 acres.

Drainage Area D is located southeast of the site and includes the majority of the first and second plats of the Osage development. In existing conditions, drainage area D has an area of 30.26 acres.

Four points of interest were chosen for comparison between existing and proposed conditions based on three points of discharge from the site and a point where three drainage areas converge. These points can be found in both exhibits 3 and 4 in Appendix A.

Point of Interest A is located at a field inlet in the first plat west of the entrance from MO-150 Highway and represents the northwestern corner of the site. This point will be considered internal to the site. This point compares drainage area A for both models.

Point of Interest B is located at a field inlet in the first plat east of the entrance from MO-150 Highway and represents drainage from the majority of the existing site. This point will be considered internal to the site. This point compares drainage area B for both models.

Point of Interest C is located at an end section on the north side of MO-150 Highway. This point represents a point of convergence for drainage areas A and B and compares the combined flow of the two drainage areas which make up the entire site in existing conditions and a majority of the site in proposed conditions. This point will be the main focus of this stormwater drainage study.

Point of Interest D is located at the outlet structure of the existing detention basin in Osage First Plat. This point has no flow to it from the site under existing conditions, however, will have additional flow to it once the Third Plat is developed.

Tables 3, 4, and 5 below summarize the results of the existing conditions analysis. The proposed conditions data is compared to these results in Section 4 of this report. Refer to Appendix B for output and a schematic for the existing conditions model and detailed calculations for the time of concentration.

Curve numbers were determined for existing and proposed conditions as shown in Table 3.

Table 3. Curve Numbers.

Land Use	Hydrologic Soil Group	Curve Number
Open Space	C	74
Residential (Town Houses)	C	90
Impervious Areas	C	98

Table 4. Existing Conditions Area Data.

Area Name	On-site Area (acres)	Off-site Area (acres)	Total Area (acres)	T_C (hours)	Weighted Curve Number
A	1.11	3.16	4.27	0.25	74.15
B	3.48	5.96	9.44	0.26	78.79
C (Surface)	0.00	5.54	5.54	0.21	88.48
D	0.00	30.26	30.26	0.27	87.24

Table 5. Existing Conditions Point of Interest Peak Flow Rates.

Point of Interest	Q_2 (cfs*)	Q_{10} (cfs)	Q_{100} (cfs)
A	6.93	14.30	26.10
B	19.31	36.65	63.36
C	44.81	81.33	137.02
D	86.93	145.56	231.49

*cfs = cubic feet per second

Per APWA Section 5608.4 and the City of Lee's Summit criteria, the performance criteria for comprehensive control is to provide detention to limit peak flow rates at downstream points of interest to maximum release rates:

- 50 percent storm peak rate less than or equal to 0.5 cubic feet per second (cfs) per site acre
- 10 percent storm peak rate less than or equal to 2.0 cfs per site acre
- 1 percent storm peak rate less than or equal to 3.0 cfs per site acre

Extended detention of the 90 percent mean annual event is also required for comprehensive control per APWA Section 5608.4.

Allowable release rates were calculated for the points of interest, allowing that off-site peak discharges would be permitted to bypass the detention. Off-site bypass peak flow rates were calculated as the third plat's percentage of the existing conditions, relating to the percentage of off-site area flowing to each point. The release rates for the proposed development on the site were calculated based on the detention criteria. The development release rates were added to the bypass peak flow rates to calculate an allowable peak flow rate for each point of interest as follows. These allowable release rates represent the third plat development only. Note that point D has no on-site area contributing to it from the third plat development; hence, the percent on-site is 0 percent, and no allowable release rate was calculated. Under proposed conditions, however, there will be additional flow to the existing basin from the third plat which will be analyzed in Section 4.4 of this report. Tables 6 and 7 below summarize the amount of area on-site and the allowable discharges for each storm event.

Table 6. Point of Interest On-site Area.

Point of Interest	Total Area (acres)	On-site Area (acres)	Percent (%) On-site
A	4.27	1.11	26.0
B	9.44	3.48	36.9
C	19.25	4.59	23.8
D	30.26	0.00	0.00

Table 7. Allowable Peak Flow Rates.

Point of Interest	Allowable 2-Year (cfs)	Allowable 10-Year Q (cfs)	Allowable 100-Year Q (cfs)
A	5.68	12.80	22.64
B	13.92	30.09	50.42
C	36.44	71.15	118.18

4. PROPOSED CONDITIONS ANALYSIS

The proposed conditions sections of this analysis assumes Osage Third Plat is fully constructed with no future development of the property to the west. This analysis includes the construction of the detention basin, swales, and storm sewer. The difference between the existing conditions model and the proposed conditions model will be evaluated in this section as well as the allowable release rates. Refer to Exhibit 4 – Proposed Conditions Drainage Map in Appendix A for a visual depiction of the drainage areas and points of interest.

4.1. Effects of Development

The proposed conditions analysis assumes completion of the Osage Third Plat development. The modeled points of interest are the same as the existing conditions model, however, throughout the site, some shifting of ridgelines will occur, accommodating the proposed detention basin and anticipated grading activities, which will change the relative areas draining to each point of interest. The following is a summary of the proposed conditions drainage areas. See Exhibit 4 – Proposed Conditions Drainage Map in Appendix A. Table 8 summarizes the proposed conditions area data.

Drainage Area A represents the area in the northwestern corner of the site which will drain onto the site but not be captured by the proposed detention basin. In proposed conditions, drainage area A has an area of 2.66 acres.

Drainage Area B (Basin) represents the area captured by the proposed detention basin. This drainage area includes the majority of the site as well as some undeveloped area to the west. In proposed conditions, drainage area B (basin) has an area of 7.35 acres.

Drainage Area B (Bypass) represents the eastern portion of the site not captured by the detention basin and draining through parts of the second and first plats. In proposed conditions, drainage area B (bypass) has an area of 3.38 acres.

Drainage Area C (Surface) is unaffected from existing conditions under the proposed conditions. It is located mostly north of the property and includes parts of MO-150 Highway and SW Pryor Road. Drainage area C has an area of 5.54 acres.

Drainage Area D is in the southeastern corner of the site and includes the majority of the first and second plats of the Osage development. In proposed conditions, drainage area D has an area of 30.58 acres.

The analysis provided in Section 3 established existing conditions of the development's drainage areas. The analysis in this section will provide guidance for configuring the detention basin to meet the objectives established in Section 3.

The following tables summarize the results of the proposed conditions analysis. Tables 9 and 10 assume no detention is provided, to demonstrate the effects of development for each drainage area. Refer to Appendix C for output and a schematic of the proposed conditions Hydraflow Hydrographs model.

Table 8. Proposed Conditions Area Data.

Area Name	On-site Area (acres)	Off-site Area (acres)	Total Area (acres)	T_C* (hours)	Weighted Curve Number
A	0.53	2.13	2.66	0.23	75.18
B (Basin)	2.98	4.37	7.35	0.25	80.16
B (Bypass)	0.80	2.58	3.38	0.08	88.89
C (Surface)	0.00	5.54	5.54	0.26	88.48
D	0.29	30.29	30.58	0.27	87.27

*Tc = Time of Concentration

Table 9. Proposed (No Detention) Conditions Point of Interest Peak Flow Rates.

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A	4.56	9.22	16.61
B	26.62	46.88	77.40
C	48.78	85.09	139.62
D	88.15	147.42	234.23

Table 10. Proposed (No Detention) vs. Existing Conditions.

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A	-2.37	-5.08	-9.49
B	7.31	10.23	14.04
C	3.97	3.76	2.60
D	1.22	1.86	2.74

Table 9 shows post-development peak discharge values at the points of interest assuming no detention is provided. Table 10 compares these to the existing conditions from Section 3 at the points of interest. Negative values indicate a reduction in peak flow rate, while positive values indicate an increase. Without detention, flow rates will increase at points B and C, but decrease

for point A. The decrease in flow rate at Point A is due to the proposed changes in grading, which shifts parts of existing drainage area A to proposed drainage area B. The increase in discharge to point D will be further analyzed in Section 4.4 due to an increase in drainage to an existing development and detention basin.

4.2. Proposed Detention Facilities

To mitigate the increases in peak flows (shown in the previous table) and, where possible, to decrease further to the allowable release rates established in Section 3, detention will be provided for drainage area B. This detention facility will be constructed as part of the third plat development.

The detention facility is designed to capture most of the site runoff and mitigate increases in peak discharge from the site. The detention facility will be located near the northeastern corner of the site and will meet all of the requirements outlined in KC-APWA Section 5600. It will contain a multistage outlet structure and an independent 60-foot-long broad-crested weir graded into the northern side of the berm. The following points summarize the multistage outlet structure and the emergency spillway:

- The structure will be a 5-foot-by-5-foot (inside) open-top concrete box with a top weir elevation of 1,033.50 feet, which generally controls the 10-year and 100-year discharge.
- A 15-inch opening on the face of the box at an elevation of 1,031.25 feet, which generally controls the 10-year and 100-year discharge.
- A 1.5-inch water quality orifice on the face of the box at the bottom elevation of the pond at 1029.00 feet. The 2-year discharge is controlled by a combination of the 1.5-inch orifice and the 15-inch opening.
- The entire structure outlets to an 18-inch HDPE pipe sloped at roughly 1.25%, which carries the water to an existing curb inlet located in Osage First Plat.
- The emergency spillway will consist of a 60-foot-long broad-crested weir set at an elevation of 1,037.50 feet on the northern side of the basin.

The 1.5-inch orifice at the bottom of the structure is sized to comply with the KC-AWPA requirement for 40-hour release of the 90 percent mean annual event. Table 11 includes a hydrologic summary of the proposed detention facility.

Table 11. Proposed Conditions Detention Flow and Volume Data.

Return Period	Peak Q In (cfs)	Time to Peak In (hr)	Peak Q Out (cfs)	Time to Peak Out (hr)	Peak W.S.E.* (ft)	Stored Volume (ac-ft)
WQ	1.65	12.07	0.07	19.13	1030.36	0.08
2-Year	16.02	12.03	6.79	12.23	1033.16	0.37
10-Year	29.72	12.03	16.66	12.20	1034.63	0.59
100-Year	50.60	12.03	19.11	12.30	1037.00	1.07

*W.S.E. = water surface elevation

4.3. Effects of Proposed Detention

The following tables compare the results of the proposed conditions analysis with the detention described above to the existing conditions from Section 3 at the points of interest. Table 12 shows peak discharge values at points of interest for the completion of the third plat and detention facility. Tables 13 and 14 compare these discharge values to existing and allowable discharge values. In Tables 13 and 14, negative values indicate a reduction in peak flows, while positive values indicate an increase.

Table 12. Proposed (with Detention) Point of Interest Peak Flow Rates.

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A	4.55	9.22	16.61
B	13.94	28.34	50.38
C	35.93	67.59	110.87

Table 13. Proposed (with Detention) vs. Allowable Release Rates.

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A	-1.13	-3.58	-6.03
B	0.02	-1.75	-0.04
C	-0.51	-3.62	-7.31

Table 14. Proposed (with Detention) vs. Existing Conditions.

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A	-2.38	-5.08	-9.49
B	-5.37	-8.31	-12.98
C	-8.88	-13.80	-26.15

As shown in Table 13, with the addition of the detention facility, peak discharge at points A, B and C will be at or below the allowable release rates for every storm event except for point B during the 2-year storm event. When compared to the existing conditions however, the flow at point B during the 2-year storm event is decreased by over 5 cfs so this will not negatively impact areas downstream of the site.

4.4. Effect on Existing Detention

Due to proposed drainage to point of interest D being unable to be captured in the proposed detention basin, the water will drain through Osage First and Second Plat to the existing detention basin located near the southeastern corner of Osage First Plat. The existing detention basin has been modeled accounting for this extra flow and Table 15 shows the basin properties under existing conditions, proposed conditions and the maximum allowable values based on KC-APWA 5600.

Table 15. Proposed Development Effects on Existing Detention Basin.

Return Period	2-Year			10-Year			100-Year		
	W.S.E. (ft)	**Q In (cfs)**	**Q Out (cfs)**	**W.S.E. (ft)**	**Q In (cfs)**	**Q Out (cfs)**	**W.S.E. (ft)**	**Q In (cfs)**	**Q Out (cfs)**
Existing	1013.56	86.93	4.32	1015.05	145.56	28.62	1017.29	231.49	61.15
Proposed	1013.60	88.15	4.39	1015.10	147.42	29.66	1017.35	234.23	63.60
Allowable*	-	-	30.40	-	-	74.70	1017.90	245.00	117.30

*Allowable values were taken from the Osage Development Final/First Plat Micro Stormwater Drainage Study

As shown in Table 15, although the total flow is increased to the existing detention basin, the basin is still able to operate within the design requirements set forth in KC-APWA 5600.

5. SUMMARY

This stormwater drainage study was prepared to evaluate the hydrologic impact generated by the development of Osage Third Plat and to provide a comprehensive stormwater management plan for the proposed development. Once fully developed, the area will include 12 twin gallery homes, tracts reserved for open space, and a stormwater detention basin.

Increases in peak flow rates caused by the third plat development will be mitigated for downstream points of discharge through a combination of dry detention and drainage area changes.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the analysis demonstrate that the proposed third plat macro and micro stormwater management plan for the project achieves compliance with design criteria, including extended detention of the 90 percent mean annual event in effect for the city of Lee's Summit, Missouri. Once fully developed, all flows at the determined points of interest are at or below the existing conditions flows or allowable release rates and will not negatively impact the areas downstream of the site. We therefore request approval of this Osage Third Plat Macro and Micro Stormwater Drainage Study.

7. REFERENCES

KC-APWA (Kansas City Metropolitan Chapter of the American Public Works Association). (2011). "Section 5600 Storm Drainage & Facilities."

United States Weather Bureau. "Technical Paper No. 40 Rainfall Frequency Atlas of the United States" (1961). Department of Commerce, Washington, D.C