Appendix K: Water Quality Calculations Spreadsheet

WATER QUALITY CALCULATION SUMMARY - EXISTING CONDITIONS

BASIN ID	TCEQ EDWARDS AQUIFER ZONE	PROPOSED BMP	ONSITE BASIN DRAINAGE AREA (AC)	OFFSITE BASIN DRAINAGE AREA (AC)	OFFSITE IMPERVIOUS COVER (AC)	EXISTING ONSITE IMPERVIOUS COVER (AC)	TCEQ CALCULATED CAPTURE VOLUME (CU FT)	TCEQ RAINFALL CAPTURE DEPTH (IN) [5]	PROVIDED POND VOLUME (CU FT)	COA CALCULATED CAPTURE DEPTH (IN) [5]	COA REQUIRED ONSITE CAPTURE DEPTH (IN)	COA REQUIRED OFFSITE CAPTURE DEPTH (IN)	COA REQUIRED CAPTURE VOLUME (CU FT)	CONTROLLING VOLUME REQUIREMENT	EXISTING ANNUAL TSS LOAD PRODUCED (LBS)	ANNUAL TSS LOAD REMOVED (LBS)	ANNUAL TSS LOAD DISCHARGED (LBS)
DEVIL'S PEN CREEK WATERSHED																	
UNTREATED AREA	Contributing	N/A	38.37	N/A	N/A	11.59	N/A	N/A	N/A	N/A	0.60	N/A	83,857	N/A	13,289	0	13,289
TOTAL FOR DEVIL'S PEN CREEK WATERSHED - CONTRIBUTING ZONE			**38.37**	**N/A**	**N/A**	**11.59**	**N/A**	**N/A**	**N/A**	**N/A**	**0.60**	**N/A**	**83,857**	**N/A**	**13,289**	**0**	**13,289**
WILLIAMSON CREEK WATERSHED																	
STORAGE AREA	Contributing	Storage Area	5.05	N/A	N/A	5.05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5,584	0	5,584
7 PFC	Contributing	Permeable Friction Course	18.49	N/A	N/A	18.49	N/A	4.00	N/A	N/A	1.30	N/A	87,269	N/A	20,463	18,428	2,035
UNTREATED AREA	Contributing	N/A	151.33	N/A	N/A	29.99	N/A	N/A	N/A	N/A	0.50	N/A	274,664	N/A	35,286	0	35,286
BEE CAVES DETENTION POND	Contributing	N/A	14.15	N/A	N/A	0.00	N/A	N/A	N/A	N/A	0.00	N/A	0	N/A	246	0	246
SUBTOTAL FOR WILLIAMSON CREEK WATERSHED - CONTRIBUTING ZONE			**189.02**	**N/A**	**N/A**	**53.53**	**N/A**	**N/A**	**N/A**	**N/A**	**0.58**	**N/A**	**400,145**	**N/A**	**61,579**	**18,428**	**43,151**
TOTAL FOR CONTRIBUTING ZONE			**227.39**	**N/A**	**N/A**	**65.12**	**N/A**	**N/A**	**N/A**	**N/A**	**0.59**	**N/A**	**484,002**	**N/A**	**74,868**	**18,428**	**56,440**
UNTREATED AREA	Recharge	N/A	28.94	N/A	N/A	13.93	N/A	N/A	N/A	N/A	0.78	N/A	82,082	N/A	15,674	0	15,674
3 **SUBTOTAL FOR WILLIAMSON CREEK WATERSHED - RECHARGE ZONE**			**28.94**	**N/A**	**N/A**	**13.93**	**N/A**	**N/A**	**N/A**	**N/A**	**0.78**	**N/A**	**82,082**	**N/A**	**15,674**	**0**	**15,674**
TOTAL FOR WILLIAMSON CREEK WATERSHED - ALL ZONES			**217.96**	**N/A**	**N/A**	**67.46**	**N/A**	**N/A**	**N/A**	**N/A**	**0.61**	**N/A**	**482,226**	**N/A**	**77,253**	**18,428**	**58,825**
BARTON CREEK WATERSHED																	
POND R	Recharge	Wet Basin	44.88	16.07	6.42	33.08	256,080	2.00	264,630.0	1.62	1.04	0.15	177,718	TCEQ	36,811	31,388	5,423
POND S	Recharge	Sand Filter Pond	36.18	54.44	22.97	25.93	170,306	1.08	174,894.0	1.33	1.02	0.15	163,185	COA	28,874	20,698	8,176
UNTREATED AREA	Recharge	N/A	0.915	N/A	N/A	0.515	N/A	N/A	N/A	N/A	0.86	N/A	2,866	N/A	577	0	577
SUBTOTAL FOR BARTON CREEK WATERSHED - RECHARGE ZONE			**81.98**	**70.50**	**29.39**	**59.53**	**N/A**	**N/A**	**439,524**	**1.48**	**1.03**	**0.15**	**343,769**	**N/A**	**66,262**	**52,086**	**14,176**
TOTAL FOR RECHARGE ZONE			**110.92**	**70.50**	**29.39**	**73.46**	**N/A**	**N/A**	**439,524**	**1.09**	**0.96**	**0.15**	**425,850**	**N/A**	**81,936**	**52,086**	**29,850**
TOTALS FOR PROJECT[10]			**338.31**	**70.50**	**29.39**	**138.58**	**N/A**	**N/A**	**439,524**	**0.36**	**0.71**	**0.15**	**909,852**	**N/A**	**156,804**	**70,514**	**86,290**

4 **ANNUAL PRECIP TRAVIS CO= 32 in**

NOTES:

1 COA minimum VFS width is 25-feet versus the TCEQ 15-feet for roadway runoff. A VFS width of 5.2' was used for SUP VFS. COA does not require treatment of SUP's located within public ROW or easement.
2 Pond I is located in the Recharge Zone, but discharges in the Contributing Zone.
3 Recharge zone boundary drawn with respect to TCEQ boundary and Pond I drainage area.
4 Annual Precipitation value based on guidance in RG-348.
5 Rainfall Capture Depth within the TCEQ spreadsheet is calculated differently than described in the COA ECM.
6 COA capture volumes are based on the efficiency of a Sedimentation Filtration (Sand Filter) BMP. Volumes for BMPS with lower efficiencies would need to be larger than shown.
7 Annual load produced, removed and discharged based on existing condition. This PFC will be removed and the loading added to the requirement.
8 Net increase in TSS load discharged for the project = (Proposed Annual TSS Load Discharged) - (Existing Annual TSS Load Produced)
9 For preliminary calculations, areas of proposed PFC and VFS were assumed to have no existing IC. Existing IC is accounted for within the Untreated Area.
10 Total basin drainage areas differ from existing conditions and post-project cnditions due to the inclusion of underpasses in the project totals.
11 Drainage areas and impervious cover are shown to the hundeths place (0.01), however inputs in the spreadsheet are to the ten thousandths place (0.0001).

WATER QUALITY CALCULATION SUMMARIES - PROPOSED CONDITIONS

BASIN ID	TCEQ EDWARDS AQUIFER ZONE	PROPOSED BMP	ONSITE BASIN DRAINAGE AREA (AC)	OFFSITE BASIN DRAINAGE AREA (AC)	OFFSITE IMPERVIOUS COVER (AC)	ONSITE EXISTING IMPERVIOUS COVER (AC)	ONSITE PROPOSED IMPERVIOUS COVER (AC)	TCEQ CALCULATED CAPTURE VOLUME (CU FT)	TCEQ RAINFALL CAPTURE DEPTH (IN)[5]	PROVIDED POND VOLUME (CU FT)	COA CALCULATED CAPTURE DEPTH (IN)[5]	COA REQUIRED CAPTURE DEPTH (IN)	COA REQUIRED OFFSITE CAPTURE DEPTH (IN)	COA REQUIRED CAPTURE VOLUME (CU FT)	CONTROLLING VOLUME REQUIREMENT	PROPOSED ANNUAL TSS LOAD PRODUCED (LBS)	ANNUAL TSS LOAD REMOVED (LBS)	ANNUAL TSS LOAD DISCHARGED (LBS)	% OF TOTAL TSS LOAD TREATED
DEVIL'S PEN CREEK WATERSHED																			
POND A	Contributing	Bioretention Pond	1.91	8.79	2.64	0.56	0.87	12,672	1.00	12,677	1.83	0.76	N/A	5,253	TCEQ	985	680	305	69%
6 POND B	Contributing	Batch Detention	8.06	N/A	N/A	3.58	4.17	47,600	2.40	47,705	1.63	0.82	N/A	23,911	TCEQ	4,679	4,014	666	86%
1/9 PFC to Pond B in Series	Contributing	PFC/Batch Detention Pond	1.91	N/A	N/A	0.00	1.91	N/A	1.00	N/A	N/A	1.30	N/A	9,022	N/A	2,116	2,030	85	96%
1/9 VFS	Contributing	Vegetated Filter Strip	3.65	N/A	N/A	0.00	3.65	N/A	4.00	N/A	N/A	1.30	N/A	17,215	N/A	4,036	3,433	603	85%
1/9 PFC	Contributing	Permeable Friction Course	5.55	N/A	N/A	0.00	5.55	N/A	4.00	N/A	N/A	1.30	N/A	26,208	N/A	6,145	5,534	611	90%
UNTREATED AREA	Contributing	N/A	15.04	N/A	N/A	6.69	5.41	0	0.00	N/A	N/A	0.66	N/A	36,015	N/A	6,153	0	6,153	0%
TOTAL FOR DEVIL'S PEN CREEK WATERSHED - CONTRIBUTING ZONE			**36.13**	**N/A**	**N/A**	**10.84**	**21.57**	**N/A**	**N/A**	**60,382**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**24,115**	**15,691**	**8,424**	**65%**
WILLIAMSON CREEK WATERSHED																			
POND C	Contributing	Sand Filter Pond	15.95	N/A	N/A	2.74	6.93	34,145	1.00	34,729	0.60	0.73	N/A	42,506	COA	7,820	5,465	2,355	70%
POND D	Contributing	Sand Filter Pond	11.24	N/A	N/A	3.40	3.00	42,570	2.00	44,006	1.08	0.57	N/A	23,130	TCEQ	3,463	2,850	613	82%
POND E	Contributing	Sand Filter Pond	14.27	N/A	N/A	3.13	6.30	33,602	1.32	33,714	0.65	0.74	N/A	38,400	COA	7,108	5,368	1,740	76%
POND F	Contributing	Sand Filter Pond	37.74	N/A	N/A	14.20	19.50	162,383	2.00	163,726	1.20	0.82	N/A	111,890	TCEQ	21,896	17,868	4,027	82%
POND G	Contributing	Sand Filter Pond	4.81	5.36	0.00	1.21	3.55	26,177	2.20	27,453	1.57	1.04	N/A	18,120	TCEQ	3,948	3,275	673	83%
POND H	Contributing	Sand Filter Pond	7.45	29.04	2.90	2.15	5.96	61,301	1.70	61,904	2.29	1.10	N/A	29,747	TCEQ	6,620	5,325	1,295	80%
POND K	Contributing	Bioretention Pond	5.57	N/A	N/A	1.94	2.79	26,039	3.00	26,685	1.32	0.80	N/A	16,185	TCEQ	3,132	2,715	417	87%
POND L	Contributing	Sand Filter Pond	2.96	N/A	N/A	1.28	2.64	16,904	1.80	17,243	1.60	1.19	N/A	12,808	TCEQ	2,927	2,379	548	81%
POND M	Contributing	Sand Filter Pond	0.97	N/A	N/A	0.48	0.86	10,167	3.33	10,674	3.03	1.18	N/A	4,174	TCEQ	952	830	122	87%
POND N	Contributing	Sand Filter Pond	1.43	N/A	N/A	0.76	1.28	7,303	1.60	7,758	1.50	1.20	N/A	6,214	TCEQ	1,422	1,133	289	80%
POND O	Contributing	Sand Filter Pond	5.87	22.45	8.53	3.58	2.82	37,883	0.80	38,806	1.82	0.78	N/A	16,636	TCEQ	3,174	2,003	1,171	63%
POND P	Contributing	Bioretention Pond	1.80	20.02	7.61	0.95	0.32	6,798	0.23	6,893	1.05	0.48	N/A	3,134	TCEQ	383	121	262	32%
POND Q	Contributing	Bioretention Pond	4.16	N/A	N/A	2.51	0.81	15,121	1.70	15,821	1.05	0.49	N/A	7,457	TCEQ	952	767	185	81%
1/9 VFS to Pond C in Series	Contributing	VFS/Sand Filter Pond	0.10	N/A	N/A	0.00	0.10	N/A	2.00	N/A	N/A	1.30	N/A	464	N/A	109	102	7	94%
1/9 VFS to Pond D in Series	Contributing	VFS/Sand Filter Pond	2.14	N/A	N/A	0.00	2.14	N/A	2.00	N/A	N/A	1.30	N/A	10,087	N/A	2,365	2,217	148	94%
1/9 VFS to Pond E in Series	Contributing	VFS/Sand Filter Pond	2.05	N/A	N/A	0.00	2.05	N/A	1.32	N/A	N/A	1.30	N/A	9,651	N/A	2,263	2,121	142	94%
1/9 VFS to Pond F in Series	Contributing	VFS/Sand Filter Pond	3.58	N/A	N/A	0.00	3.58	N/A	2.00	N/A	N/A	1.30	N/A	16,879	N/A	3,958	3,710	248	94%
1/9 PFC to Pond C in Series	Contributing	PFC/Sand Filter Pond	3.91	N/A	N/A	0.00	3.91	N/A	1.00	N/A	N/A	1.30	N/A	18,440	N/A	4,324	4,144	180	96%
9 PFC to Pond D in Series	Contributing	PFC/Sand Filter Pond	1.82	N/A	N/A	0.00	1.82	N/A	1.00	N/A	N/A	1.30	N/A	8,602	N/A	2,017	1,933	84	96%
9 PFC to Pond F in Series	Contributing	PFC/Sand Filter Pond	2.89	N/A	N/A	0.00	2.89	N/A	1.00	N/A	N/A	1.30	N/A	13,617	N/A	3,193	3,060	133	96%
9 PFC to Pond O in series	Contributing	PFC/Sand Filter Pond	2.25	N/A	N/A	0.00	2.25	N/A	1.00	N/A	N/A	1.30	N/A	10,620	N/A	2,490	2,387	103	96%
9 PFC to Pond P in series	Contributing	PFC/Sand Filter Pond	0.73	N/A	N/A	0.00	0.73	N/A	1.00	N/A	N/A	1.30	N/A	3,440	N/A	807	773	34	96%
9 PFC to Pond Q in Series	Contributing	PFC/Sand Filter Pond	2.04	N/A	N/A	0.00	2.04	N/A	1.00	N/A	N/A	1.30	N/A	9,628	N/A	2,258	2,164	94	96%
1/9 VFS SUP	Contributing	Vegetated Filter Strip	0.55	N/A	N/A	0.00	0.55	N/A	4.00	N/A	N/A	1.30	N/A	2,617	N/A	614	522	92	85%
9 PFC	Contributing	Permeable Friction Course	3.72	N/A	N/A	0.00	3.72	N/A	4.00	N/A	N/A	1.30	N/A	17,560	N/A	4,117	3,708	409	90%
UNTREATED AREA	Contributing	N/A	64.78	N/A	N/A	15.96	51.15	N/A	N/A	N/A	N/A	1.09	N/A	256,224	N/A	56,836	0	56,836	0%
BEE CAVES DETENTION POND	Contributing	N/A	14.15	N/A	N/A	0.00	0.00	N/A	N/A	N/A	N/A	0.00	N/A	0	N/A	246	0	246	0%
SUBTOTAL FOR WILLIAMSON CREEK WATERSHED - CONTRIBUTING ZONE			**197.41**	**N/A**	**N/A**	**54.28**	**112.18**	**N/A**	**N/A**	**489,411**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**125,610**	**76,940**	**48,670**	**61%**
TOTAL FOR CONTRIBUTING ZONE			**233.54**	**N/A**	**N/A**	**65.12**	**133.75**	**N/A**	**N/A**	**549,793**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**149,725**	**92,631**	**57,094**	**62%**
2 POND I	Recharge	Sand Filter Pond	14.04	6.12	1.09	8.35	11.57	76,874	1.70	77,272	1.52	1.12	N/A	57,285	TCEQ	12,843	10,350	2,493	81%
6 POND J	Recharge	Batch Detention	5.57	11.27	2.11	1.57	4.11	21,414	0.94	21,600	1.07	1.04	N/A	20,965	TCEQ	4,569	3,170	1,399	69%
UNTREATED AREA	Recharge	N/A	7.63	N/A	N/A	2.37	2.76	0	0.00	N/A	N/A	0.66	N/A	18,338	N/A	3,142	0	3,142	0%
3 **SUBTOTAL FOR WILLIAMSON CREEK WATERSHED - RECHARGE ZONE**			**27.24**	**N/A**	**N/A**	**12.29**	**18.44**	**N/A**	**N/A**	**98,872**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**20,553**	**13,520**	**7,033**	**66%**
TOTAL FOR WILLIAMSON CREEK WATERSHED - ALL ZONES			**224.65**	**N/A**	**N/A**	**66.57**	**130.62**	**N/A**	**N/A**	**588,284**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**146,163**	**90,460**	**55,704**	**62%**
BARTON CREEK WATERSHED																			
POND R	Recharge	Wet Basin	44.61	16.04	6.42	32.87	36.39	264,634	1.80	264,630	1.63	1.04	0.15	176,641	TCEQ	40,411	34,407	6,004	85%
POND S	Recharge	Sand Filter Pond	36.18	54.44	22.95	25.93	27.40	171,426	1.04	174,894	1.33	1.02	0.15	163,185	TCEQ	30,466	21,565	8,901	71%
6 POND T	Recharge	Batch Detention	3.84	N/A	N/A	1.65	3.29	13,578	1.16	13,720	0.98	0.73	N/A	10,180	TCEQ	3,650	2,740	910	75%
UNTREATED AREA	Recharge	N/A	1.409	N/A	N/A	0.714	1.474	0	0.00	N/A	N/A	0.81	N/A	4,126	N/A	1,629	0	1,629	0%
SUBTOTAL FOR BARTON CREEK WATERSHED - RECHARGE ZONE			**86.04**	**70.48**	**29.36**	**61.17**	**68.55**	**N/A**	**N/A**	**453,244**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**76,156**	**58,712**	**17,444**	**77%**
TOTAL FOR RECHARGE ZONE			**113.28**	**70.48**	**29.36**	**73.46**	**86.99**	**N/A**	**N/A**	**552,116**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**96,710**	**72,232**	**24,478**	**75%**
TOTALS FOR PROJECT[10]			**346.82**	**173.53**	**54.25**	**138.58**	**220.74**	**N/A**	**N/A**	**1,101,909**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**246,435**	**164,863**	**81,571**	**67%**

NET INCREASE IN TSS LOADING FOR PROJECT[8] = -4,718 lbs

4 **ANNUAL PRECIP TRAVIS CO= 32** in

WATER QUALITY CALCULATION SUMMARIES - PROPOSED CONDITIONS - TCEQ

BASIN ID	TCEQ EDWARDS AQUIFER ZONE	PROPOSED BMP	ONSITE BASIN DRAINAGE AREA (AC)	OFFSITE BASIN DRAINAGE AREA (AC)	OFFSITE IMPERVIOUS COVER (AC)	ONSITE EXISTING IMPERVIOUS COVER (AC)	ONSITE PROPOSED IMPERVIOUS COVER (AC)	TCEQ CALCULATED CAPTURE VOLUME (CU FT)	TCEQ RAINFALL CAPTURE DEPTH (IN)[5]	PROVIDED POND VOLUME (CU FT)	COA CALCULATED CAPTURE DEPTH (IN)[5]	COA REQUIRED CAPTURE DEPTH (IN)	COA REQUIRED OFFSITE CAPTURE DEPTH (IN)	COA REQUIRED CAPTURE VOLUME (CU FT)	CONTROLLING VOLUME REQUIREMENT	PROPOSED ANNUAL TSS LOAD PRODUCED (LBS)	ANNUAL TSS LOAD REMOVED (LBS)	ANNUAL TSS LOAD DISCHARGED (LBS)	% OF TOTAL TSS LOAD TREATED
DEVIL'S PEN CREEK WATERSHED																			
POND A	Contributing	Bioretention Pond	1.91	8.79	2.64	0.56	0.87	12,672	1.00	12,677	1.83	0.76	N/A	5,253	TCEQ	985	680	305	69%
6 POND B	Contributing	Batch Detention	8.06	N/A	N/A	3.58	4.17	47,600	2.40	47,705	1.63	0.82	N/A	23,911	TCEQ	4,679	4,014	665	86%
1/9 PFC to Pond B in Series	Contributing	PFC/Batch Detention Pond	1.91	N/A	N/A	0.00	1.91	N/A	1.00	N/A	N/A	1.30	N/A	9,022	N/A	2,116	2,030	85	96%
1/9 VFS	Contributing	Vegetated Filter Strip	3.65	N/A	N/A	0.00	3.65	N/A	4.00	N/A	N/A	1.30	N/A	17,215	N/A	4,036	3,433	603	85%
1/9 PFC	Contributing	Permeable Friction Course	4.68	N/A	N/A	0.00	4.68	N/A	4.00	N/A	N/A	1.30	N/A	22,107	N/A	5,183	4,668	515	90%
UNTREATED AREA	Contributing	N/A	15.91	N/A	N/A	6.69	6.28	0	0.00	N/A	N/A	0.69	N/A	40,116	N/A	7,115	0	7,115	0%
TOTAL FOR DEVIL'S PEN CREEK WATERSHED - CONTRIBUTING ZONE			**36.13**	**N/A**	**N/A**	**10.84**	**21.57**	**N/A**	**N/A**	**60,382**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**24,115**	**14,826**	**9,289**	**61%**
WILLIAMSON CREEK WATERSHED																			
POND C	Contributing	Sand Filter Pond	15.95	N/A	N/A	2.74	6.93	34,145	1.00	34,729	0.60	0.73	N/A	42,506	COA	7,820	5,465	2,355	70%
POND D	Contributing	Sand Filter Pond	11.24	N/A	N/A	3.40	3.00	42,570	2.00	44,006	1.08	0.57	N/A	23,130	TCEQ	3,463	2,850	613	82%
POND E	Contributing	Sand Filter Pond	14.27	N/A	N/A	3.13	6.30	33,602	1.32	33,714	0.65	0.74	N/A	38,400	COA	7,108	5,368	1,740	76%
~~POND F~~	~~Contributing~~	~~Sand Filter Pond~~	~~37.74~~	~~N/A~~	~~N/A~~	~~14.20~~	~~20.00~~	~~162,383~~	~~2.00~~	~~163,726~~	~~1.20~~	~~0.83~~	~~N/A~~	~~113,690~~	~~TCEQ~~	~~22,436~~	~~0~~	22,436	~~0%~~
POND G	Contributing	Sand Filter Pond	4.81	5.36	0.00	1.21	3.55	26,177	2.20	27,453	1.57	1.04	N/A	18,120	TCEQ	3,948	3,275	673	83%
POND H	Contributing	Sand Filter Pond	7.45	29.04	2.90	2.15	5.96	61,301	1.70	61,904	2.29	1.10	N/A	29,747	TCEQ	6,620	5,325	1,295	80%
POND K	Contributing	Bioretention Pond	5.57	N/A	N/A	1.94	2.79	26,039	3.00	26,685	1.32	0.80	N/A	16,185	TCEQ	3,132	2,715	417	87%
POND L	Contributing	Sand Filter Pond	2.96	N/A	N/A	1.28	2.64	16,904	1.80	17,243	1.60	1.19	N/A	12,808	TCEQ	2,927	2,379	548	81%
~~POND M~~	~~Contributing~~	~~Sand Filter Pond~~	~~0.97~~	~~N/A~~	~~N/A~~	~~0.48~~	~~0.86~~	~~10,167~~	~~3.33~~	~~10,674~~	~~3.03~~	~~1.18~~	~~N/A~~	~~4,174~~	~~TCEQ~~	~~952~~	~~0~~	952	~~0%~~
~~POND N~~	~~Contributing~~	~~Sand Filter Pond~~	~~1.43~~	~~N/A~~	~~N/A~~	~~0.76~~	~~1.28~~	~~7,303~~	~~1.60~~	~~7,758~~	~~1.50~~	~~1.20~~	~~N/A~~	~~6,214~~	~~TCEQ~~	~~1,422~~	~~0~~	1,422	~~0%~~
~~POND O~~	~~Contributing~~	~~Sand Filter Pond~~	~~5.87~~	~~22.45~~	~~8.53~~	~~3.58~~	~~3.59~~	~~37,883~~	~~0.80~~	~~38,806~~	~~1.82~~	~~0.91~~	~~N/A~~	~~19,433~~	~~TCEQ~~	~~4,013~~	~~0~~	4,013	~~0%~~
~~POND P~~	~~Contributing~~	~~Bioretention Pond~~	~~1.80~~	~~20.02~~	~~7.61~~	~~0.95~~	~~1.05~~	~~6,798~~	~~0.23~~	~~6,893~~	~~1.05~~	~~0.88~~	~~N/A~~	~~5,780~~	~~TCEQ~~	~~1,177~~	~~0~~	1,177	~~0%~~
POND Q	Contributing	Bioretention Pond	4.16	N/A	N/A	2.51	1.09	15,121	1.70	15,821	1.05	0.56	N/A	8,491	TCEQ	1,262	1,017	245	81%
1/9 VFS to Pond C in Series	Contributing	VFS/Sand Filter Pond	0.10	N/A	N/A	0.00	0.10	N/A	2.00	N/A	N/A	1.30	N/A	464	N/A	109	102	7	94%
1/9 VFS to Pond D in Series	Contributing	VFS/Sand Filter Pond	2.14	N/A	N/A	0.00	2.14	N/A	2.00	N/A	N/A	1.30	N/A	10,087	N/A	2,365	2,217	148	94%
1/9 VFS to Pond E in Series	Contributing	VFS/Sand Filter Pond	2.05	N/A	N/A	0.00	2.05	N/A	1.32	N/A	N/A	1.30	N/A	9,651	N/A	2,263	2,121	142	94%
1/9 VFS to Pond F in Series	Contributing	VFS/Sand Filter Pond	3.08	N/A	N/A	0.00	3.08	N/A	2.00	N/A	N/A	1.30	N/A	14,539	N/A	3,409	2,899	510	85%
1/9 PFC to Pond C in Series	Contributing	PFC/Sand Filter Pond	3.91	N/A	N/A	0.00	3.91	N/A	1.00	N/A	N/A	1.30	N/A	18,440	N/A	4,324	4,144	180	96%
9 PFC to Pond D in Series	Contributing	PFC/Sand Filter Pond	1.82	N/A	N/A	0.00	1.82	N/A	1.00	N/A	N/A	1.30	N/A	8,602	N/A	2,017	1,933	84	96%
9 PFC to Pond F in Series	Contributing	PFC/Sand Filter Pond	2.89	N/A	N/A	0.00	2.89	N/A	1.00	N/A	N/A	1.30	N/A	13,617	N/A	3,193	2,875	317	90%
9 PFC to Pond O in series	Contributing	PFC/Sand Filter Pond	1.48	N/A	N/A	0.00	1.48	N/A	1.00	N/A	N/A	1.30	N/A	6,983	N/A	1,637	1,475	163	90%
9 ~~PFC to Pond P in series~~	~~Contributing~~	~~PFC/Sand Filter Pond~~	~~0.00~~	~~N/A~~	~~N/A~~	~~0.00~~	~~0.00~~	~~N/A~~	~~1.00~~	~~N/A~~	~~N/A~~	~~0.00~~	~~N/A~~	~~0~~	~~N/A~~	~~0~~	~~0~~	0	~~0%~~
9 PFC to Pond Q in Series	Contributing	PFC/Sand Filter Pond	1.76	N/A	N/A	0.00	1.76	N/A	1.00	N/A	N/A	1.30	N/A	8,284	N/A	1,942	1,749	193	90%
1/9 ~~VFS SUP~~	~~Contributing~~	~~Vegetated Filter Strip~~	~~0.55~~	~~N/A~~	~~N/A~~	~~0.00~~	~~0.55~~	~~N/A~~	4.00	~~N/A~~	~~N/A~~	~~1.30~~	~~N/A~~	~~2,617~~	~~N/A~~	~~614~~	~~0~~	614	~~0%~~
9 PFC	Contributing	Permeable Friction Course	2.35	N/A	N/A	0.00	2.35	N/A	4.00	N/A	N/A	1.30	N/A	11,096	N/A	2,602	2,343	259	90%
UNTREATED AREA	Contributing	N/A	66.15	N/A	N/A	15.96	50.24	N/A	N/A	N/A	N/A	1.06	N/A	254,411	N/A	55,868	0	55,868	0%
BEE CAVES DETENTION POND	Contributing	N/A	14.15	N/A	N/A	0.00	0.00	N/A	N/A	N/A	N/A	0.00	N/A	0	N/A	246	0	246	0%
SUBTOTAL FOR WILLIAMSON CREEK WATERSHED - CONTRIBUTING ZONE			**197.41**	**N/A**	**N/A**	**54.28**	**112.18**	**N/A**	**N/A**	**489,411**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**125,610**	**50,253**	**75,357**	**40%**
TOTAL FOR CONTRIBUTING ZONE			**233.54**	**N/A**	**N/A**	**65.12**	**133.75**	**N/A**	**N/A**	**549,793**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**149,725**	**65,079**	**84,646**	**43%**
2 POND I	Recharge	Sand Filter Pond	14.04	6.12	1.09	8.35	11.57	76,874	1.70	77,272	1.52	1.12	N/A	57,285	TCEQ	12,843	10,350	2,493	81%
6 POND J	Recharge	Batch Detention	5.57	11.27	2.11	1.57	4.11	21,414	0.94	21,600	1.07	1.04	N/A	20,965	TCEQ	4,569	3,170	1,399	69%
UNTREATED AREA	Recharge	N/A	7.63	N/A	N/A	2.37	2.76	0	0.00	N/A	N/A	0.66	N/A	18,338	N/A	3,142	0	3,142	0%
3 **SUBTOTAL FOR WILLIAMSON CREEK WATERSHED - RECHARGE ZONE**			**27.24**	**N/A**	**N/A**	**12.29**	**18.44**	**N/A**	**N/A**	**98,872**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**20,553**	**13,520**	**7,033**	**66%**
TOTAL FOR WILLIAMSON CREEK WATERSHED - ALL ZONES			**224.65**	**N/A**	**N/A**	**66.57**	**130.62**	**N/A**	**N/A**	**588,284**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**146,163**	**63,773**	**82,390**	**44%**
BARTON CREEK WATERSHED																			
POND R	Recharge	Wet Basin	44.61	16.04	6.42	32.87	36.39	264,634	1.80	264,630	1.63	1.04	0.15	176,641	TCEQ	40,411	34,407	6,004	85%
POND S	Recharge	Sand Filter Pond	36.18	54.44	22.95	25.93	27.40	171,426	1.04	174,894	1.33	1.02	0.15	163,185	TCEQ	30,466	21,565	8,901	71%
6 ~~POND T~~	~~Recharge~~	~~Batch Detention~~	~~3.84~~	~~N/A~~	~~N/A~~	~~1.65~~	~~3.29~~	~~13,578~~	~~1.16~~	~~13,720~~	~~0.98~~	~~0.73~~	~~N/A~~	~~10,180~~	~~TCEQ~~	~~3,650~~	~~0~~	3,650	~~0%~~
UNTREATED AREA	Recharge	N/A	1.409	N/A	N/A	0.714	1.474	0	0.00	N/A	N/A	0.81	N/A	4,126	N/A	1,629	0	1,629	0%
SUBTOTAL FOR BARTON CREEK WATERSHED - RECHARGE ZONE			**86.04**	**70.48**	**29.36**	**61.17**	**68.55**	**N/A**	**N/A**	**453,244**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**76,156**	**55,972**	**20,184**	**73%**
TOTAL FOR RECHARGE ZONE			**113.28**	**70.48**	**29.36**	**73.46**	**86.99**	**N/A**	**N/A**	**552,116**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**96,710**	**69,492**	**27,218**	**72%**
TOTALS FOR PROJECT[10]			**346.82**	**173.53**	**54.25**	**138.58**	**220.74**	**N/A**	**N/A**	**1,101,909**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**246,435**	**134,571**	**111,864**	**55%**

NET INCREASE IN TSS LOADING FOR PROJECT[8] = **25,574 lbs**

TCEQ 80% TSS REMOVAL REQUIRED= 128,116

4 **ANNUAL PRECIP TRAVIS CO=** **32** in

SHADING KEY:

🟥	PONDS REMOVED
🟦	PONDS LOCATED WITHIN THE FLOODPLAIN TO BE PROTECTED
🟩	PONDS OR BMPS WHERE REMOVAL RATES CHANGE DUE TO FLOODPLAIN CONSIDERATIONS

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = EX Storage Area

Total drainage basin/outfall area = **5.05** acres
Predevelopment impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious area within drainage basin/outfall area = **5.05** acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **4393** lbs.
Annual TSS load produced = **5584** lbs.

Texas Commission on Environmental Quality

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where:

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A_N = Net increase in impervious area for the project

P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Travis**	
Total project area included in plan * =	**346.82**	acres
Predevelopment impervious area within the limits of the plan* =	**138.58**	acres
Total post-development impervious area within the limits of the plan* =	**220.74**	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**32**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**246435**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **71 EX PFC**

Total drainage basin/outfall area =	**8.58**	acres
Predevelopment impervious area within drainage basin/outfall area =	**0.00**	acres
Post-development impervious area within drainage basin/outfall area =	**8.58**	acres
Post-development impervious fraction within drainage basin/outfall area =	**1.00**	
$L_{M\ THIS\ BASIN}$ =	**7464**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Permeable Friction Course**

Removal efficiency = **90** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area

A_I = Impervious area proposed in the BMP catchment area

A_P = Pervious area remaining in the BMP catchment area

L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**8.58**	acres
A_I =	**8.58**	acres
A_P =	**0.00**	acres
L_R =	**8546**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **8546** lbs.

F = **1.00**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

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Date Prepared: 10/29/2019

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Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = Travis
Total project area included in plan * = 346.82 acres
Predevelopment impervious area within the limits of the plan* = 138.58 acres
Total post-development impervious area within the limits of the plan* = 220.74 acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 19

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = 290 EX PFC

Total drainage basin/outfall area = 9.92 acres
Predevelopment impervious area within drainage basin/outfall area = 0.00 acres
Post-development impervious area within drainage basin/outfall area = 9.92 acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **8632** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Permeable Friction Course
Removal efficiency = **90** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 9.92 acres
A_I = 9.92 acres
A_P = **0.00** acres
L_R = **9883** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 9883 lbs.

F = **1.00**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

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Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County = Travis
Total project area included in plan * = 346.82 acres
Predevelopment impervious area within the limits of the plan* = 138.58 acres
Total post-development impervious area within the limits of the plan* = 220.74 acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 19

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = EX Pond R

Total drainage basin/outfall area = 44.88 acres
Predevelopment impervious area within drainage basin/outfall area = 0.00 acres
Post-development impervious area within drainage basin/outfall area = 33.08 acres
Post-development impervious fraction within drainage basin/outfall area = **0.74**
$L_{M\ THIS\ BASIN}$ = **28796** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Wet Basin
Removal efficiency = **93** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 44.88 acres
A_I = 33.08 acres
A_P = **11.80** acres
L_R = **34255** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 31388 lbs.

F = **0.92**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Rainfall Depth = **2.00** inches
Post Development Runoff Coefficient = **0.55**
On-site Water Quality Volume = **177628** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = 16.07 acres
Off-site Impervious cover draining to BMP = 6.42 acres
Impervious fraction of off-site area = **0.40**
Off-site Runoff Coefficient = **0.31**
Off-site Water Quality Volume = **35772** cubic feet

Storage for Sediment = **42680**
Total Capture Volume (required water quality volume(s) x 1.20) = **256080** cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

11. Wet Basins

Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool = **256080** cubic feet **Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation = **433709** cubic feet **Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

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where:

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A_N = Net increase in impervious area for the project

P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Travis**	
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Predevelopment impervious area within the limits of the plan* =	**138.58**	acres
Total post-development impervious area within the limits of the plan* =	**220.74**	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**32**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**246435**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = EX Pond S

Total drainage basin/outfall area =	**36.18**	acres
Predevelopment impervious area within drainage basin/outfall area =	**0.00**	acres
Post-development impervious area within drainage basin/outfall area =	**25.93**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.72**	
$L_{M\ THIS\ BASIN}$ =	**22573**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**

Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:

A_C = Total On-Site drainage area in the BMP catchment area

A_I = Impervious area proposed in the BMP catchment area

A_P = Pervious area remaining in the BMP catchment area

L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**36.18**	acres
A_I =	**25.93**	acres
A_P =	**10.25**	acres
L_R =	**25713**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **20698** lbs.

F = **0.80**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Rainfall Depth =	**1.08**	inches
Post Development Runoff Coefficient =	**0.52**	
On-site Water Quality Volume =	**74170**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = **54.44** acres
Off-site Impervious cover draining to BMP = **22.97** acres
Impervious fraction of off-site area = **0.42**
Off-site Runoff Coefficient = **0.32**
Off-site Water Quality Volume = **67752** cubic feet

Storage for Sediment = **28384**
Total Capture Volume (required water quality volume(s) x 1.20) = 170306 cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

9. Filter area for Sand Filters

Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin = **170306** cubic feet

Minimum filter basin area = **4121** square feet

Maximum sedimentation basin area = **37085** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **9271** square feet **For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins = **170306** cubic feet

Minimum filter basin area = **7417** square feet

Maximum sedimentation basin area = **29668** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **1854** square feet **For maximum water depth of 8 feet**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Travis**	
Total project area included in plan * =	**346.82**	acres
Predevelopment impervious area within the limits of the plan* =	**138.58**	acres
Total post-development impervious area within the limits of the plan* =	**220.74**	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**32**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**246435**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Devil's Pen Contributing**

Total drainage basin/outfall area =	**36.13**	acres
Predevelopment impervious area within drainage basin/outfall area =	**10.84**	acres
Post-development impervious area within drainage basin/outfall area =	**21.57**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.60**	
$L_{M\ THIS\ BASIN}$ =	**9336**	lbs.

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Travis**	
Total project area included in plan * =	**346.82**	acres
Predevelopment impervious area within the limits of the plan* =	**138.58**	acres
Total post-development impervious area within the limits of the plan* =	**220.74**	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**32**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**246435**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond A**

Total drainage basin/outfall area =	**1.91**	acres
Predevelopment impervious area within drainage basin/outfall area =	**0.56**	acres
Post-development impervious area within drainage basin/outfall area =	**0.87**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.46**	
$L_{M\ THIS\ BASIN}$ =	**270**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**1.91**	acres
A_I =	**0.87**	acres
A_P =	**1.04**	acres
L_R =	**877**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 680 lbs.

F = 0.78

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Rainfall Depth = 1.00 inches
Post Development Runoff Coefficient = 0.34
On-site Water Quality Volume = 2324 cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = 8.79 acres
Off-site Impervious cover draining to BMP = 2.64 acres
Impervious fraction of off-site area = 0.30
Off-site Runoff Coefficient = 0.26
Off-site Water Quality Volume = 8237 cubic feet

Storage for Sediment = 2112
Total Capture Volume (required water quality volume(s) x 1.20) = 12672 cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

10. Bioretention System

Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin = 12672 cubic feet

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = Pond B

Total drainage basin/outfall area = **8.06** acres
Predevelopment impervious area within drainage basin/outfall area = **3.58** acres
Post-development impervious area within drainage basin/outfall area = **6.08** acres
Post-development impervious fraction within drainage basin/outfall area = **0.75**
$L_{M\ THIS\ BASIN}$ = **2172** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Batch Detention**
Removal efficiency = **91** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **8.06** acres
A_I = **6.08** acres
A_P = **1.99** acres
L_R = **6157** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **5800** lbs.

F = **0.94**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Rainfall Depth = **2.40** inches
Post Development Runoff Coefficient = **0.56**
On-site Water Quality Volume = **39666** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = **0.00** acres
Off-site Impervious cover draining to BMP = **0.00** acres
Impervious fraction of off-site area = **0**
Off-site Runoff Coefficient = **0.00**
Off-site Water Quality Volume = **0** cubic feet

Storage for Sediment = **7933**
Total Capture Volume (required water quality volume(s) x 1.20) = 47600 cubic feet

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project:

Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond B**

Total drainage basin/outfall area = **8.06** acres
Predevelopment impervious area within drainage basin/outfall area = **3.58** acres
Post-development impervious area within drainage basin/outfall area = **4.17** acres
Post-development impervious fraction within drainage basin/outfall area = **0.52**
$L_{M\ THIS\ BASIN}$ = **508** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Batch Detention**
Removal efficiency = **91** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **8.06** acres
A_I = **4.17** acres
A_P = **3.90** acres
L_R = **4260** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ =	4014	lbs.
F =	**0.94**	

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Rainfall Depth =	**2.40**	inches
Post Development Runoff Coefficient =	**0.37**	
On-site Water Quality Volume =	**25779**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	0.00	acres
Off-site Impervious cover draining to BMP =	0.00	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**5156**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**30935**	cubic feet

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **PFC Pond B** **PFC/Batch Detention**

Total drainage basin/outfall area = **1.91** acres
Predevelopment impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious area within drainage basin/outfall area = **1.91** acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **1664** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Permeable Friction Course**
Removal efficiency = **90** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **1.91** acres
A_I = **1.91** acres
A_P = **0.00** acres
L_R = **1905** lbs

16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and
the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or
across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 = 95.92 percent NET EFFICIENCY OF THE BMPs IN THE SERIES

EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 = 90.00 percent **PFC**

EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 = 91.00 percent **Batch Detention**

EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 = 0.00 percent

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

$L_R = E_{TOT}$ X P X (A_I X 34.6 X A_P X0.54) = 2030.38 lbs

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\text{ TOTAL PROJECT}}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **321.87** acres
Predevelopment impervious area within the limits of the plan* = **136.29** acres
Total post-development impervious area within the limits of the plan* = **209.94** acres
Total post-development impervious cover fraction * = **0.65**
P = **32** inches

$L_{M\text{ TOTAL PROJECT}}$ = **234241** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = VFS

Total drainage basin/outfall area = **3.65** acres
Predevelopment impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious area within drainage basin/outfall area = **3.65** acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\text{ THIS BASIN}}$ = **3175** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Vegetated Filter Strips**
Removal efficiency = **85** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **3.65** acres
A_I = **3.65** acres
A_P = **0.00** acres
L_R = **3433** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\text{ THIS BASIN}}$ = **3433** lbs.

F = **1.00**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Rainfall Depth = **4.00** inches
Post Development Runoff Coefficient = **0.82**
On-site Water Quality Volume = **43238** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = **0.00** acres

Off-site Impervious cover draining to BMP = 0.00 acres
Impervious fraction of off-site area = **0**
Off-site Runoff Coefficient = **0.00**
Off-site Water Quality Volume = **0** cubic feet

Storage for Sediment = **8648**
Total Capture Volume (required water quality volume(s) x 1.20) = 51886 cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

16. Vegetated Filter Strips

Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

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1. The Required Load Reduction for the total project:

Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: L_M = 27.2(A_N x P)

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **321.87** acres
Predevelopment impervious area within the limits of the plan* = **136.29** acres
Total post-development impervious area within the limits of the plan* = **209.94** acres
Total post-development impervious cover fraction * = **0.65**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **234241** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **PFC**

Total drainage basin/outfall area = **5.55** acres
Predevelopment impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious area within drainage basin/outfall area = **5.55** acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **4834** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Permeable Friction Course**
Removal efficiency = **90** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **5.55** acres
A_I = **5.55** acres
A_P = **0.00** acres
L_R = **5534** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **5534** lbs.

F = **1.00**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Rainfall Depth = **4.00** inches
Post Development Runoff Coefficient = **0.82**
On-site Water Quality Volume = **65826** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = **0.00** acres
Off-site Impervious cover draining to BMP = **0.00** acres
Impervious fraction of off-site area = **0**
Off-site Runoff Coefficient = **0.00**
Off-site Water Quality Volume = **0** cubic feet

Storage for Sediment = **13165**
Total Capture Volume (required water quality volume(s) x 1.20) = 78992 cubic feet

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project:

Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Travis**	
Total project area included in plan * =	**346.82**	acres
Predevelopment impervious area within the limits of the plan* =	**138.58**	acres
Total post-development impervious area within the limits of the plan* =	**220.74**	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**32**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**246435**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = Williamson Contributing

Total drainage basin/outfall area =	**197.41**	acres
Predevelopment impervious area within drainage basin/outfall area =	**54.28**	acres
Post-development impervious area within drainage basin/outfall area =	**112.18**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.57**	
$L_{M\ THIS\ BASIN}$ =	**50399**	lbs.

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond C** **Sand Filter**

Total drainage basin/outfall area = **15.95** acres
Predevelopment impervious area within drainage basin/outfall area = **2.74** acres
Post-development impervious area within drainage basin/outfall area = **10.93** acres
Post-development impervious fraction within drainage basin/outfall area = **0.69**
$L_{M\ THIS\ BASIN}$ = **7133** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **15.95** acres
A_I = **10.93** acres
A_P = **5.01** acres
L_R = **10850** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **8515** lbs. **L_M for pond sizing**

F = **0.78**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Rainfall Depth = **1.00** inches
Post Development Runoff Coefficient = **0.49**
On-site Water Quality Volume = **28454** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = 0.00 acres
Off-site Impervious cover draining to BMP = 0.00 acres
Impervious fraction of off-site area = 0
Off-site Runoff Coefficient = 0.00
Off-site Water Quality Volume = 0 cubic feet

Storage for Sediment = 5691
Total Capture Volume (required water quality volume(s) x 1.20) = 34145 cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

9. Filter area for Sand Filters

Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin = **34145** cubic feet

Minimum filter basin area = **1581** square feet

Maximum sedimentation basin area = **14227** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **3557** square feet **For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins = **34145** cubic feet

Minimum filter basin area = **2845** square feet

Maximum sedimentation basin area = **11382** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **711** square feet **For maximum water depth of 8 feet**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Travis**	
Total project area included in plan * =	**346.82**	acres
Predevelopment impervious area within the limits of the plan* =	**138.58**	acres
Total post-development impervious area within the limits of the plan* =	**220.74**	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**32**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**246435**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond C** **Sand Filter**

Total drainage basin/outfall area =	**15.95**	acres
Predevelopment impervious area within drainage basin/outfall area =	**2.74**	acres
Post-development impervious area within drainage basin/outfall area =	**6.93**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.43**	
$L_{M\ THIS\ BASIN}$ =	**3646**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**15.95**	acres
A_I =	**6.93**	acres
A_P =	**9.02**	acres
L_R =	**6964**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **5465** lbs. **L_M provided by Pond Only**

F = **0.78**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

See Sand Filter Pond C worksheet for pond sizing

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

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1. The Required Load Reduction for the total project:

Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = Travis
Total project area included in plan * = 346.82 acres
Predevelopment impervious area within the limits of the plan* = 138.58 acres
Total post-development impervious area within the limits of the plan* = 220.74 acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 19

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = VFS Pond C **VFS/Sand Filter**

Total drainage basin/outfall area = 0.10 acres
Predevelopment impervious area within drainage basin/outfall area = 0.00 acres
Post-development impervious area within drainage basin/outfall area = 0.10 acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **86** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Sand Filter
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 0.10 acres
A_I = 0.10 acres
A_P = **0.00** acres
L_R = **97** lbs

16. Vegetated Filter Strips

Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and
the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or
across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

19. BMPs Installed in a Series

Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

$E_{TOT} = [1 - ((1 - E_1) \times (1 - 0.65E_2) \times (1 - 0.25E_3))] \times 100 =$ 93.68 percent NET EFFICIENCY OF THE BMPs IN THE SERIES

EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 = 85.00 percent **VFS**

EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 = 89.00 percent **Sand Filter**

EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 = 0.00 percent

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

$L_R = E_{TOT}$ X P X (A_I X 34.6 X A_P X0.54) = 102.06 lbs

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **PFC Pond C** **PFC/Sand Filter**

Total drainage basin/outfall area = **3.91** acres
Predevelopment impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious area within drainage basin/outfall area = **3.91** acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **3401** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Permeable Friction Course**
Removal efficiency = **90** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **3.91** acres
A_I = **3.91** acres
A_P = **0.00** acres
L_R = **3894** lbs

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

$E_{TOT} = [1 - ((1 - E_1) \times (1 - 0.65E_2) \times (1 - 0.25E_3))] \times 100$ = 95.79 percent NET EFFICIENCY OF THE BMPs IN THE SERIES

EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 = 90.00 percent **PFC**

EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 = 89.00 percent **Sand Filter**

EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 = 0.00 percent

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

$L_R = E_{TOT} \times P \times (A_I \times 34.6 \times A_P \times 0.54)$ = 4144.13 lbs

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

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1. The Required Load Reduction for the total project:

Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County = Travis
Total project area included in plan * = 346.82 acres
Predevelopment impervious area within the limits of the plan* = 138.58 acres
Total post-development impervious area within the limits of the plan* = 220.74 acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 19

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = Pond D **Sand Filter**

Total drainage basin/outfall area = 11.24 acres
Predevelopment impervious area within drainage basin/outfall area = 3.40 acres
Post-development impervious area within drainage basin/outfall area = 6.96 acres
Post-development impervious fraction within drainage basin/outfall area = **0.62**
$L_{M\ THIS\ BASIN}$ = **3100** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Sand Filter
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 11.24 acres
A_I = 6.96 acres
A_P = **4.28** acres
L_R = **6925** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 6400 lbs. **L_M for pond sizing**

F = **0.92**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Rainfall Depth = **2.00** inches
Post Development Runoff Coefficient = **0.43**
On-site Water Quality Volume = **35475** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = **0.00** acres
Off-site Impervious cover draining to BMP = **0.00** acres
Impervious fraction of off-site area = **0**
Off-site Runoff Coefficient = **0.00**
Off-site Water Quality Volume = **0** cubic feet

Storage for Sediment = **7095**
Total Capture Volume (required water quality volume(s) x 1.20) = **42570** cubic feet
The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

9. Filter area for Sand Filters

Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin = **42570** cubic feet

Minimum filter basin area = **1971** square feet

Maximum sedimentation basin area = **17737** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **4434** square feet **For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins = **42570** cubic feet

Minimum filter basin area = **3547** square feet

Maximum sedimentation basin area = **14190** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **887** square feet **For maximum water depth of 8 feet**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load

A_N = Net increase in impervious area for the project

P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County = Travis

Total project area included in plan * = 346.82 acres

Predevelopment impervious area within the limits of the plan* = 138.58 acres

Total post-development impervious area within the limits of the plan* = 220.74 acres

Total post-development impervious cover fraction * = **0.64**

P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond D** **Sand Filter**

Total drainage basin/outfall area = 11.24 acres

Predevelopment impervious area within drainage basin/outfall area = 3.40 acres

Post-development impervious area within drainage basin/outfall area = 3.00 acres

Post-development impervious fraction within drainage basin/outfall area = **0.27**

$L_{M\ THIS\ BASIN}$ = **-347** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Sand Filter

Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area

A_I = Impervious area proposed in the BMP catchment area

A_P = Pervious area remaining in the BMP catchment area

L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 11.24 acres

A_I = 3.00 acres

A_P = **8.24** acres

L_R = **3083** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **2850** lbs. **L_M provided by Pond Only**

F = **0.92**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

See Sand Filter Pond D worksheet for pond sizing

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **VFS Pond D** **VFS/Sand Filter**

Total drainage basin/outfall area = **2.14** acres
Predevelopment impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious area within drainage basin/outfall area = **2.14** acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **1861** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **2.14** acres
A_I = **2.14** acres
A_P = **0.00** acres
L_R = **2106** lbs

16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

$E_{TOT} = [1 - ((1 - E_1)\ X\ (1 - 0.65E_2) \times (1 - 0.25E_3))]\ X\ 100 =$ 93.68 percent NET EFFICIENCY OF THE BMPs IN THE SERIES

EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 = 85.00 percent **VFS**

EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 = 89.00 percent **Sand Filter**

EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 = 0.00 percent

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

$L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =$ 2217.11 lbs

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = PFC Pond D **PFC/Sand Filter**

Total drainage basin/outfall area = **1.82** acres 2.0507
Predevelopment impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious area within drainage basin/outfall area = **1.82** acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **1587** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Permeable Friction Course**
Removal efficiency = **90** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **1.82** acres
A_I = **1.82** acres
A_P = **0.00** acres
L_R = **1816** lbs

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

$E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =$ 95.79 percent NET EFFICIENCY OF THE BMPs IN THE SERIES

EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 = 90.00 percent **PFC**

EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 = 89.00 percent **Sand Filter**

EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 = 0.00 percent

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

$L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =$ 1933.24 lbs

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond E** **Sand Filter**

Total drainage basin/outfall area = **14.27** acres
Predevelopment impervious area within drainage basin/outfall area = **3.13** acres
Post-development impervious area within drainage basin/outfall area = **8.34** acres
Post-development impervious fraction within drainage basin/outfall area = **0.58**
$L_{M\ THIS\ BASIN}$ = **4536** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **14.27** acres
A_I = **8.34** acres
A_P = **5.92** acres
L_R = **8313** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **7050** lbs. **L_M for pond sizing**

F = **0.85**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Rainfall Depth = **1.32** inches
Post Development Runoff Coefficient = **0.41**
On-site Water Quality Volume = **28001** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = 0.00 acres
Off-site Impervious cover draining to BMP = 0.00 acres
Impervious fraction of off-site area = 0
Off-site Runoff Coefficient = 0.00
Off-site Water Quality Volume = 0 cubic feet

Storage for Sediment = 5600
Total Capture Volume (required water quality volume(s) x 1.20) = 33602 cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

9. Filter area for Sand Filters

Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin = **33602** cubic feet

Minimum filter basin area = **1556** square feet

Maximum sedimentation basin area = **14001** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **3500** square feet **For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins = **33602** cubic feet

Minimum filter basin area = **2800** square feet

Maximum sedimentation basin area = **11201** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **700** square feet **For maximum water depth of 8 feet**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Travis**	
Total project area included in plan * =	**346.82**	acres
Predevelopment impervious area within the limits of the plan* =	**138.58**	acres
Total post-development impervious area within the limits of the plan* =	**220.74**	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**32**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**246435**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = Pond E **Sand Filter**

Total drainage basin/outfall area =	**14.27**	acres
Predevelopment impervious area within drainage basin/outfall area =	**3.13**	acres
Post-development impervious area within drainage basin/outfall area =	**6.30**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.44**	
$L_{M\ THIS\ BASIN}$ =	**2756**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**14.27**	acres
A_I =	**6.30**	acres
A_P =	**7.97**	acres
L_R =	**6329**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **5368** lbs. **L_M provided by Pond Only**

F = **0.85**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

See Sand Filter Pond E worksheet for pond sizing

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = VFS Pond E **VFS/Sand Filter**

Total drainage basin/outfall area = **2.05** acres
Predevelopment impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious area within drainage basin/outfall area = **2.05** acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **1780** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **2.05** acres
A_I = **2.05** acres
A_P = **0.00** acres
L_R = **2015** lbs

16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

$E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100$ = 93.68 percent NET EFFICIENCY OF THE BMPs IN THE SERIES

EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 = 85.00 percent **VFS**

EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 = 89.00 percent **Sand Filter**

EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 = 0.00 percent

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

$L_R = E_{TOT}$ X P X (A_I X 34.6 X A_P X0.54) = 2121.28 lbs

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **PFC Pond E** **PFC/Sand Filter**

Total drainage basin/outfall area = **0.00** acres 2.0507
Predevelopment impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious fraction within drainage basin/outfall area = **#DIV/0!**
$L_{M\ THIS\ BASIN}$ = **0** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Permeable Friction Course**
Removal efficiency = **90** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **0.00** acres
A_I = **0.00** acres
A_P = **0.00** acres
L_R = **0** lbs

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

$E_{TOT} = [1 - ((1 - E_1) \times (1 - 0.65E_2) \times (1 - 0.25E_3))] \times 100$ = 95.79 percent NET EFFICIENCY OF THE BMPs IN THE SERIES

EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 = 90.00 percent **PFC**

EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 = 89.00 percent **Sand Filter**

EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 = 0.00 percent

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

$L_R = E_{TOT} \times P \times (A_I \times 34.6 \times A_P \times 0.54)$ = 0.00 lbs

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond F** **Sand Filter**

Total drainage basin/outfall area = **37.74** acres
Predevelopment impervious area within drainage basin/outfall area = **14.20** acres
Post-development impervious area within drainage basin/outfall area = **25.96** acres
Post-development impervious fraction within drainage basin/outfall area = **0.69**
$L_{M\ THIS\ BASIN}$ = **10239** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **37.74** acres
A_I = **25.96** acres
A_P = **11.77** acres
L_R = **25767** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 23613 lbs. L_M **for pond sizing**

F = **0.92**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Rainfall Depth = **2.00** inches
Post Development Runoff Coefficient = **0.49**
On-site Water Quality Volume = **135319** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = **0.00** acres
Off-site Impervious cover draining to BMP = **0.00** acres
Impervious fraction of off-site area = **0**
Off-site Runoff Coefficient = **0.00**
Off-site Water Quality Volume = **0** cubic feet

Storage for Sediment = **27064**
Total Capture Volume (required water quality volume(s) x 1.20) = **162383** cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

9. Filter area for Sand Filters

Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin = **162383** cubic feet

Minimum filter basin area = **7518** square feet

Maximum sedimentation basin area = **67660** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **16915** square feet **For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins = **162383** cubic feet

Minimum filter basin area = **13532** square feet

Maximum sedimentation basin area = **54128** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **3383** square feet **For maximum water depth of 8 feet**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

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1. The Required Load Reduction for the total project:

Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ \text{TOTAL PROJECT}}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = Travis
Total project area included in plan * = 346.82 acres
Predevelopment impervious area within the limits of the plan* = 138.58 acres
Total post-development impervious area within the limits of the plan* = 220.74 acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ \text{TOTAL PROJECT}}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 19

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = Pond F **Sand Filter**

Total drainage basin/outfall area = 37.74 acres
Predevelopment impervious area within drainage basin/outfall area = 14.20 acres
Post-development impervious area within drainage basin/outfall area = 19.50 acres
Post-development impervious fraction within drainage basin/outfall area = **0.52**
$L_{M\ \text{THIS BASIN}}$ = **4615** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Sand Filter
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 37.74 acres
A_I = 19.50 acres
A_P = **18.24** acres
L_R = **19498** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ \text{THIS BASIN}}$ = 17868 lbs. **L_M provided by Pond Only**

F = **0.92**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

See Sand Filter Pond F worksheet for pond sizing

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = Travis
Total project area included in plan * = 346.82 acres
Predevelopment impervious area within the limits of the plan* = 138.58 acres
Total post-development impervious area within the limits of the plan* = 220.74 acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 19

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = VFS Pond F VFS/Sand Filter

Total drainage basin/outfall area = 3.58 acres
Predevelopment impervious area within drainage basin/outfall area = 0.00 acres
Post-development impervious area within drainage basin/outfall area = 3.58 acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **3113** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Sand Filter
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 3.58 acres
A_I = 3.58 acres
A_P = **0.00** acres
L_R = **3525** lbs

16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

$E_{TOT} = [1 - ((1 - E_1) \times (1 - 0.65E_2) \times (1 - 0.25E_3))] \times 100$ = 93.68 percent NET EFFICIENCY OF THE BMPs IN THE SERIES

EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 = 85.00 percent **VFS**

EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 = 89.00 percent **Sand Filter**

EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 = 0.00 percent

THERFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

$L_R = E_{TOT}$ X P X (A_I X 34.6 X A_P X0.54) = 3709.95 lbs

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = PFC Pond F **PFC/Sand Filter**

Total drainage basin/outfall area = **2.89** acres
Predevelopment impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious area within drainage basin/outfall area = **2.89** acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **2512** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Permeable Friction Course**
Removal efficiency = **90** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **2.89** acres
A_I = **2.89** acres
A_P = **0.00** acres
L_R = **2875** lbs

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

$E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100$ = 95.79 percent NET EFFICIENCY OF THE BMPs IN THE SERIES

EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 = 90.00 percent **PFC**

EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 = 89.00 percent **Sand Filter**

EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 = 0.00 percent

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

$L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54)$ = 3060.16 lbs

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\text{ TOTAL PROJECT}}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Travis**	
Total project area included in plan * =	**346.82**	acres
Predevelopment impervious area within the limits of the plan* =	**138.58**	acres
Total post-development impervious area within the limits of the plan* =	**220.74**	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**32**	inches
$L_{M\text{ TOTAL PROJECT}}$ =	**246435**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond G**

Total drainage basin/outfall area =	**4.81**	acres
Predevelopment impervious area within drainage basin/outfall area =	**1.21**	acres
Post-development impervious area within drainage basin/outfall area =	**3.55**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.74**	
$L_{M\text{ THIS BASIN}}$ =	**2038**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**4.81**	acres
A_I =	**3.55**	acres
A_P =	**1.26**	acres
L_R =	**3516**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\text{ THIS BASIN}}$ = **3275** lbs.

F = **0.93**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Rainfall Depth =	**2.20**	inches
Post Development Runoff Coefficient =	**0.55**	
On-site Water Quality Volume =	**20958**	cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = 5.36 acres
Off-site Impervious cover draining to BMP = 0.00 acres
Impervious fraction of off-site area = **0.00**
Off-site Runoff Coefficient = **0.02**
Off-site Water Quality Volume = **856** cubic feet

Storage for Sediment = **4363**
Total Capture Volume (required water quality volume(s) x 1.20) = **26177** cubic feet
The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

9. Filter area for Sand Filters

Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin = **26177** cubic feet

Minimum filter basin area = **1164** square feet

Maximum sedimentation basin area = **10479** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **2620** square feet **For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins = **26177** cubic feet

Minimum filter basin area = **2096** square feet

Maximum sedimentation basin area = **8383** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **524** square feet **For maximum water depth of 8 feet**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

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Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ \text{TOTAL PROJECT}}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ \text{TOTAL PROJECT}}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond H**

Total drainage basin/outfall area = **7.45** acres
Predevelopment impervious area within drainage basin/outfall area = **2.15** acres
Post-development impervious area within drainage basin/outfall area = **5.96** acres
Post-development impervious fraction within drainage basin/outfall area = **0.80**
$L_{M\ \text{THIS BASIN}}$ = **3313** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **7.45** acres
A_I = **5.96** acres
A_P = **1.49** acres
L_R = **5896** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **5325** lbs.

F = **0.90**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Rainfall Depth = **1.70** inches
Post Development Runoff Coefficient = **0.62**
On-site Water Quality Volume = **28680** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = **29.04** acres
Off-site Impervious cover draining to BMP = **2.90** acres
Impervious fraction of off-site area = **0.10**
Off-site Runoff Coefficient = **0.13**
Off-site Water Quality Volume = **22404** cubic feet

Storage for Sediment = **10217**
Total Capture Volume (required water quality volume(s) x 1.20) = **61301** cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

9. Filter area for Sand Filters

Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin = **61301** cubic feet

Minimum filter basin area = **1593** square feet

Maximum sedimentation basin area = **14340** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **3585** square feet **For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins = **61301** cubic feet

Minimum filter basin area = **2868** square feet

Maximum sedimentation basin area = **11472** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **717** square feet **For maximum water depth of 8 feet**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond K**

Total drainage basin/outfall area = **5.57** acres
Predevelopment impervious area within drainage basin/outfall area = **1.94** acres
Post-development impervious area within drainage basin/outfall area = **2.79** acres
Post-development impervious fraction within drainage basin/outfall area = **0.50**
$L_{M\ THIS\ BASIN}$ = **735** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **5.57** acres
A_I = **2.79** acres
A_P = **2.79** acres
L_R = **2789** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **2715** lbs.

F = **0.97**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Rainfall Depth = **3.00** inches
Post Development Runoff Coefficient = **0.36**
On-site Water Quality Volume = **21699** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = **0.00** acres
Off-site Impervious cover draining to BMP = **0.00** acres
Impervious fraction of off-site area = **0**
Off-site Runoff Coefficient = **0.00**
Off-site Water Quality Volume = **0** cubic feet

Storage for Sediment = **4340**

Total Capture Volume (required water quality volume(s) x 1.20) = 26039 cubic feet

10. Bioretention System Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin = **26039** cubic feet

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond L**

Total drainage basin/outfall area = **2.96** acres
Predevelopment impervious area within drainage basin/outfall area = **1.28** acres
Post-development impervious area within drainage basin/outfall area = **2.64** acres
Post-development impervious fraction within drainage basin/outfall area = **0.89**
$L_{M\ THIS\ BASIN}$ = **1185** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **2.96** acres
A_I = **2.64** acres
A_P = **0.32** acres
L_R = **2607** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **2379** lbs.

F = **0.91**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Rainfall Depth = **1.80** inches
Post Development Runoff Coefficient = **0.73**
On-site Water Quality Volume = **14087** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = 0.00 acres
Off-site Impervious cover draining to BMP = 0.00 acres
Impervious fraction of off-site area = 0
Off-site Runoff Coefficient = 0.00
Off-site Water Quality Volume = 0 cubic feet

Storage for Sediment = 2817
Total Capture Volume (required water quality volume(s) x 1.20) = 16904 cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

9. Filter area for Sand Filters

Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin = **16904** cubic feet

Minimum filter basin area = **783** square feet

Maximum sedimentation basin area = **7043** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **1761** square feet **For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins = **16904** cubic feet

Minimum filter basin area = **1409** square feet

Maximum sedimentation basin area = **5635** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **352** square feet **For maximum water depth of 8 feet**

Texas Commission on Environmental Quality

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = Travis
Total project area included in plan * = 346.82 acres
Predevelopment impervious area within the limits of the plan* = 138.58 acres
Total post-development impervious area within the limits of the plan* = 220.74 acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 19

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = Pond M

Total drainage basin/outfall area = 0.97 acres
Predevelopment impervious area within drainage basin/outfall area = 0.48 acres
Post-development impervious area within drainage basin/outfall area = 0.86 acres
Post-development impervious fraction within drainage basin/outfall area = **0.88**
$L_{M\ THIS\ BASIN}$ = **334** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Sand Filter
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 0.97 acres
A_I = 0.86 acres
A_P = **0.11** acres
L_R = **848** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 830 lbs.

F = **0.98**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Rainfall Depth = **3.33** inches
Post Development Runoff Coefficient = **0.72**
On-site Water Quality Volume = **8473** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = **0.00** acres
Off-site Impervious cover draining to BMP = **0.00** acres
Impervious fraction of off-site area = **0**
Off-site Runoff Coefficient = **0.00**
Off-site Water Quality Volume = **0** cubic feet

Storage for Sediment = **1695**
Total Capture Volume (required water quality volume(s) x 1.20) = **10167** cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

9. Filter area for Sand Filters

Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin = **10167** cubic feet

Minimum filter basin area = **471** square feet

Maximum sedimentation basin area = **4236** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **1059** square feet **For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins = **10167** cubic feet

Minimum filter basin area = **847** square feet

Maximum sedimentation basin area = **3389** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **212** square feet **For maximum water depth of 8 feet**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: L_M = 27.2(A_N x P)

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond N**

Total drainage basin/outfall area = **1.43** acres
Predevelopment impervious area within drainage basin/outfall area = **0.76** acres
Post-development impervious area within drainage basin/outfall area = **1.28** acres
Post-development impervious fraction within drainage basin/outfall area = **0.90**
$L_{M\ THIS\ BASIN}$ = **460** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **1.43** acres
A_I = **1.28** acres
A_P = **0.15** acres
L_R = **1267** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **1133** lbs.

F = **0.89**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Rainfall Depth = **1.60** inches
Post Development Runoff Coefficient = **0.73**
On-site Water Quality Volume = **6086** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = 0.00 acres
Off-site Impervious cover draining to BMP = 0.00 acres
Impervious fraction of off-site area = 0
Off-site Runoff Coefficient = 0.00
Off-site Water Quality Volume = 0 cubic feet

Storage for Sediment = 1217
Total Capture Volume (required water quality volume(s) x 1.20) = 7303 cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

9. Filter area for Sand Filters

Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin = 7303 cubic feet

Minimum filter basin area = 338 square feet

Maximum sedimentation basin area = 3043 square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = 761 square feet **For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins = 7303 cubic feet

Minimum filter basin area = 609 square feet

Maximum sedimentation basin area = 2434 square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = 152 square feet **For maximum water depth of 8 feet**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = Travis
Total project area included in plan * = 346.82 acres
Predevelopment impervious area within the limits of the plan* = 138.58 acres
Total post-development impervious area within the limits of the plan* = 220.74 acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 19

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = Pond O **Sand Filter**

Total drainage basin/outfall area = 5.87 acres
Predevelopment impervious area within drainage basin/outfall area = 3.58 acres
Post-development impervious area within drainage basin/outfall area = 5.07 acres
Post-development impervious fraction within drainage basin/outfall area = **0.86**
$L_{M\ THIS\ BASIN}$ = **1299** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Sand Filter
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 5.87 acres
A_I = 5.07 acres
A_P = **0.80** acres
L_R = **5009** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 3550 lbs. **L_M for pond sizing**

F = **0.71**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Rainfall Depth = **0.80** inches
Post Development Runoff Coefficient = **0.70**
On-site Water Quality Volume = **12086** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = **22.45** acres
Off-site Impervious cover draining to BMP = **8.53** acres
Impervious fraction of off-site area = **0.38**
Off-site Runoff Coefficient = **0.30**
Off-site Water Quality Volume = **19484** cubic feet

Storage for Sediment = **6314**
Total Capture Volume (required water quality volume(s) x 1.20) = 37883 cubic feet
The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

9. Filter area for Sand Filters

Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin = **37883** cubic feet

Minimum filter basin area = **671** square feet

Maximum sedimentation basin area = **6043** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **1511** square feet **For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins = **37883** cubic feet

Minimum filter basin area = **1209** square feet

Maximum sedimentation basin area = **4834** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **302** square feet **For maximum water depth of 8 feet**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond O** **Sand Filter**

Total drainage basin/outfall area = **5.87** acres
Predevelopment impervious area within drainage basin/outfall area = **3.58** acres
Post-development impervious area within drainage basin/outfall area = **2.82** acres
Post-development impervious fraction within drainage basin/outfall area = **0.48**
$L_{M\ THIS\ BASIN}$ = **-660** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **5.87** acres
A_I = **2.82** acres
A_P = **3.05** acres
L_R = **2826** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **2003** lbs. **L_M provided by Pond Only**

F = **0.71**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Travis**	
Total project area included in plan * =	**346.82**	acres
Predevelopment impervious area within the limits of the plan* =	**138.58**	acres
Total post-development impervious area within the limits of the plan* =	**220.74**	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**32**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**246435**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **PFC Pond O** **VFS/Sand Filter**

Total drainage basin/outfall area =	**2.25**	acres
Predevelopment impervious area within drainage basin/outfall area =	**0.00**	acres
Post-development impervious area within drainage basin/outfall area =	**2.25**	acres
Post-development impervious fraction within drainage basin/outfall area =	**1.00**	
$L_{M\ THIS\ BASIN}$ =	**1959**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Permeable Friction Course**
Removal efficiency = **90** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: L_R = (BMP efficiency) x P x (A_I x 34.6 + A_P x 0.54)

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**2.25**	acres
A_I =	**2.25**	acres
A_P =	**0.00**	acres
L_R =	**2242**	lbs

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

$E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =$	95.79	percent	NET EFFICIENCY OF THE BMPs IN THE SERIES
EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 =	90.00	percent	**PFC**
EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 =	89.00	percent	**Sand Filter**
EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 =	0.00	percent	

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

$L_R = E_{TOT}$ X P X (A_I X 34.6 X A_P X0.54) = 2386.62 lbs

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Travis**	
Total project area included in plan * =	**346.82**	acres
Predevelopment impervious area within the limits of the plan* =	**138.58**	acres
Total post-development impervious area within the limits of the plan* =	**220.74**	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**32**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**246435**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. =	**Pond P**		**Bioretention**
Total drainage basin/outfall area =	**1.80**	acres	
Predevelopment impervious area within drainage basin/outfall area =	**0.95**	acres	
Post-development impervious area within drainage basin/outfall area =	**1.05**	acres	
Post-development impervious fraction within drainage basin/outfall area =	**0.58**		
$L_{M\ THIS\ BASIN}$ =	**86**	lbs.	

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**1.80**	acres
A_I =	**1.05**	acres
A_P =	**0.75**	acres
L_R =	**1048**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **372** lbs. **L_M for pond sizing**

F = **0.35**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Rainfall Depth = **0.23** inches
Post Development Runoff Coefficient = **0.41**
On-site Water Quality Volume = **624** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = **20.02** acres
Off-site Impervious cover draining to BMP = **7.61** acres
Impervious fraction of off-site area = **0.38**
Off-site Runoff Coefficient = **0.30**
Off-site Water Quality Volume = **5041** cubic feet

Storage for Sediment = **1133**
Total Capture Volume (required water quality volume(s) x 1.20) = **6798** cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

10. Bioretention System

Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin = **6798** cubic feet

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Travis**	
Total project area included in plan * =	**346.82**	acres
Predevelopment impervious area within the limits of the plan* =	**138.58**	acres
Total post-development impervious area within the limits of the plan* =	**220.74**	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**32**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**246435**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond P** **Bioretention**

Total drainage basin/outfall area =	**1.80**	acres
Predevelopment impervious area within drainage basin/outfall area =	**0.95**	acres
Post-development impervious area within drainage basin/outfall area =	**0.32**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.18**	
$L_{M\ THIS\ BASIN}$ =	**-548**	lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Bioretention**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C =	**1.80**	acres
A_I =	**0.32**	acres
A_P =	**1.48**	acres
L_R =	**341**	lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **121** lbs. **L_M provided by Pond Only**

F = **0.35**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **PFC Pond P** **VFS/Bioretention**

Total drainage basin/outfall area = **0.73** acres
Predevelopment impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious area within drainage basin/outfall area = **0.73** acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **634** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Permeable Friction Course**
Removal efficiency = **90** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **0.73** acres
A_I = **0.73** acres
A_P = **0.00** acres
L_R = **726** lbs

19. BMPs Installed in a Series Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

$E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =$ 95.79 percent NET EFFICIENCY OF THE BMPs IN THE SERIES

EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 = 90.00 percent **PFC**

EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 = 89.00 percent **Bioretention**

EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 = 0.00 percent

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

$L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =$ 773.02 lbs

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = Travis
Total project area included in plan * = 346.82 acres
Predevelopment impervious area within the limits of the plan* = 138.58 acres
Total post-development impervious area within the limits of the plan* = 220.74 acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 19

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = Pond Q **Bioretention**

Total drainage basin/outfall area = 4.16 acres
Predevelopment impervious area within drainage basin/outfall area = 2.51 acres
Post-development impervious area within drainage basin/outfall area = 2.85 acres
Post-development impervious fraction within drainage basin/outfall area = **0.69**
$L_{M\ THIS\ BASIN}$ = **293** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Bioretention
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 4.16 acres
A_I = 2.85 acres
A_P = **1.31** acres
L_R = **2827** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 2558 lbs. L_M for pond sizing

F = 0.90

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Rainfall Depth = 1.70 inches
Post Development Runoff Coefficient = 0.49
On-site Water Quality Volume = 12601 cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = 0.00 acres
Off-site Impervious cover draining to BMP = 0.00 acres
Impervious fraction of off-site area = 0
Off-site Runoff Coefficient = 0.00
Off-site Water Quality Volume = 0 cubic feet

Storage for Sediment = 2520
Total Capture Volume (required water quality volume(s) x 1.20) = 15121 cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

10. Bioretention System

Designed as Required in RG-348 Pages 3-63 to 3-65

Required Water Quality Volume for Bioretention Basin = 15121 cubic feet

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = Travis
Total project area included in plan * = 346.82 acres
Predevelopment impervious area within the limits of the plan* = 138.58 acres
Total post-development impervious area within the limits of the plan* = 220.74 acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 19

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = Pond Q **Bioretention**

Total drainage basin/outfall area = 4.16 acres
Predevelopment impervious area within drainage basin/outfall area = 2.51 acres
Post-development impervious area within drainage basin/outfall area = 0.81 acres
Post-development impervious fraction within drainage basin/outfall area = **0.19**
$L_{M\ THIS\ BASIN}$ = **-1483** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Bioretention
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 4.16 acres
A_I = 0.81 acres
A_P = **3.35** acres
L_R = **847** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **767** lbs. **L_M provided by Pond Only**

F = **0.90**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project:

Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **PFC Pond Q** **VFS/Bioretention**

Total drainage basin/outfall area = **2.04** acres
Predevelopment impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious area within drainage basin/outfall area = **2.04** acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **1776** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Permeable Friction Course**
Removal efficiency = **90** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **2.04** acres
A_I = **2.04** acres
A_P = **0.00** acres
L_R = **2033** lbs

19. BMPs Installed in a Series

Designed as Required in RG-348 Pages 3-32

Michael E. Barrett, Ph.D.. P.E. recommended that the coefficient for E_2 be changed from 0.5 to 0.65 on May 3, 2006

$E_{TOT} = [1 - ((1 - E_1) X (1 - 0.65E_2) x (1 - 0.25E_3))] X 100 =$ 95.79 percent NET EFFICIENCY OF THE BMPs IN THE SERIES

EFFICIENCY OF FIRST BMP IN THE SERIES = E_1 = 90.00 percent **PFC**

EFFICIENCY OF THE SECOND BMP IN THE SERIES = E_2 = 89.00 percent **Bioretention**

EFFICIENCY OF THE THIRD BMP IN THE SERIES = E_3 = 0.00 percent

THEREFORE, THE NET LOAD REMOVAL WOULD BE:
(A_I AND A_P VALUES ARE FROM SECTION 3 ABOVE)

$L_R = E_{TOT} X P X (A_I X 34.6 X A_P X0.54) =$ 2163.80 lbs

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **SUP/SW**

Total drainage basin/outfall area = **0.55** acres
Predevelopment impervious area within drainage basin/outfall area = **0.00** acres
Post-development impervious area within drainage basin/outfall area = **0.55** acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **483** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Vegetated Filter Strips**
Removal efficiency = **85** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **0.55** acres
A_I = **0.55** acres
A_P = **0.00** acres
L_R = **522** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **522** lbs.

F = **1.00**

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

16. Vegetated Filter Strips Designed as Required in RG-348 Pages 3-55 to 3-57

There are no calculations required for determining the load or size of vegetative filter strips.
The 80% removal is provided when the contributing drainage area does not exceed 72 feet (direction of flow) and the sheet flow leaving the impervious cover is directed across 15 feet of engineered filter strips with maximum slope of 20% or across 50 feet of natural vegetation with a maximum slope of 10%. There can be a break in grade as long as no slope exceeds 20%.

If vegetative filter strips are proposed for an interim permanent BMP, they may be sized as described on Page 3-56 of RG-348.

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = Travis
Total project area included in plan * = 321.87 acres
Predevelopment impervious area within the limits of the plan* = 136.29 acres
Total post-development impervious area within the limits of the plan* = 209.94 acres
Total post-development impervious cover fraction * = **0.65**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **234241** lbs.

* The values entered in these fields should be for the total project area.

Number of drainage basins / outfalls areas leaving the plan area = 19

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = PFC

Total drainage basin/outfall area = 3.72 acres
Predevelopment impervious area within drainage basin/outfall area = 0.00 acres
Post-development impervious area within drainage basin/outfall area = 3.72 acres
Post-development impervious fraction within drainage basin/outfall area = **1.00**
$L_{M\ THIS\ BASIN}$ = **3239** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Permeable Friction Course
Removal efficiency = **90** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 3.72 acres
A_I = 3.72 acres
A_P = **0.00** acres
L_R = **3708** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 3708 lbs.

F = **1.00**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Rainfall Depth = **4.00** inches
Post Development Runoff Coefficient = **0.82**
On-site Water Quality Volume = **44104** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = 0.00 acres
Off-site Impervious cover draining to BMP = 0.00 acres
Impervious fraction of off-site area = **0**
Off-site Runoff Coefficient = **0.00**
Off-site Water Quality Volume = **0** cubic feet

Storage for Sediment = **8821**
Total Capture Volume (required water quality volume(s) x 1.20) = 52925 cubic feet

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Travis**	
Total project area included in plan * =	**346.82**	acres
Predevelopment impervious area within the limits of the plan* =	**138.58**	acres
Total post-development impervious area within the limits of the plan* =	**220.74**	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**32**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**246435**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **1**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = Williamson Recharge

Total drainage basin/outfall area =	**27.24**	acres
Predevelopment impervious area within drainage basin/outfall area =	**12.29**	acres
Post-development impervious area within drainage basin/outfall area =	**18.44**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.68**	
$L_{M\ THIS\ BASIN}$ =	**5350**	lbs.

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond I**

Total drainage basin/outfall area = **14.04** acres
Predevelopment impervious area within drainage basin/outfall area = **8.35** acres
Post-development impervious area within drainage basin/outfall area = **11.57** acres
Post-development impervious fraction within drainage basin/outfall area = **0.82**
$L_{M\ THIS\ BASIN}$ = **2800** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Sand Filter**
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **14.04** acres
A_I = **11.57** acres
A_P = **2.48** acres
L_R = **11437** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **10350** lbs.

F = **0.90**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Rainfall Depth = **1.70** inches
Post Development Runoff Coefficient = **0.66**
On-site Water Quality Volume = **57006** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = **6.12** acres
Off-site Impervious cover draining to BMP = **1.09** acres
Impervious fraction of off-site area = **0.18**
Off-site Runoff Coefficient = **0.19**
Off-site Water Quality Volume = **7055** cubic feet

Storage for Sediment = **12812**
Total Capture Volume (required water quality volume(s) x 1.20) = 76874 cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

9. Filter area for Sand Filters Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin = **76874** cubic feet

Minimum filter basin area = **3167** square feet

Maximum sedimentation basin area = **28503** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **7126** square feet **For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins = **76874** cubic feet

Minimum filter basin area = **5701** square feet

Maximum sedimentation basin area = **22802** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **1425** square feet **For maximum water depth of 8 feet**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = Travis
Total project area included in plan * = 346.82 acres
Predevelopment impervious area within the limits of the plan* = 138.58 acres
Total post-development impervious area within the limits of the plan* = 220.74 acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 19

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = Pond J

Total drainage basin/outfall area = 5.57 acres
Predevelopment impervious area within drainage basin/outfall area = 1.57 acres
Post-development impervious area within drainage basin/outfall area = 4.11 acres
Post-development impervious fraction within drainage basin/outfall area = **0.74**
$L_{M\ THIS\ BASIN}$ = **2204** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Batch Detention**
Removal efficiency = **91** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 5.57 acres
A_I = 4.11 acres
A_P = **1.46** acres
L_R = **4160** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **3170** lbs.

F = **0.76**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Rainfall Depth = **0.94** inches
Post Development Runoff Coefficient = **0.55**
On-site Water Quality Volume = **10411** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = **11.27** acres
Off-site Impervious cover draining to BMP = **2.11** acres
Impervious fraction of off-site area = **0.19**
Off-site Runoff Coefficient = **0.19**
Off-site Water Quality Volume = **7434** cubic feet

Storage for Sediment = **3569**
Total Capture Volume (required water quality volume(s) x 1.20) = 21414 cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project

County =	**Travis**	
Total project area included in plan * =	**346.82**	acres
Predevelopment impervious area within the limits of the plan* =	**138.58**	acres
Total post-development impervious area within the limits of the plan* =	**220.74**	acres
Total post-development impervious cover fraction * =	**0.64**	
P =	**32**	inches
$L_{M\ TOTAL\ PROJECT}$ =	**246435**	lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = Barton Recharge

Total drainage basin/outfall area =	**86.04**	acres
Predevelopment impervious area within drainage basin/outfall area =	**61.17**	acres
Post-development impervious area within drainage basin/outfall area =	**68.55**	acres
Post-development impervious fraction within drainage basin/outfall area =	**0.80**	
$L_{M\ THIS\ BASIN}$ =	**6424**	lbs.

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

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1. The Required Load Reduction for the total project:

Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **PR Pond R**

Total drainage basin/outfall area = **44.61** acres
Predevelopment impervious area within drainage basin/outfall area = **32.87** acres
Post-development impervious area within drainage basin/outfall area = **36.39** acres
Post-development impervious fraction within drainage basin/outfall area = **0.82**
$L_{M\ THIS\ BASIN}$ = **3064** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Wet Basin**
Removal efficiency = **93** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **44.61** acres
A_I = **36.39** acres
A_P = **8.22** acres
L_R = **37605** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **34407** lbs.

F = **0.91**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Rainfall Depth = **1.80** inches
Post Development Runoff Coefficient = **0.65**
On-site Water Quality Volume = **188354** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	16.04	acres
Off-site Impervious cover draining to BMP =	6.42	acres
Impervious fraction of off-site area =	**0.40**	
Off-site Runoff Coefficient =	**0.31**	
Off-site Water Quality Volume =	**32174**	cubic feet
Storage for Sediment =	**44106**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**264634**	cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

11. Wet Basins

Designed as Required in RG-348 Pages 3-66 to 3-71

Required capacity of Permanent Pool =	**264634**	cubic feet	**Permanent Pool Capacity is 1.20 times the WQV**
Required capacity at WQV Elevation =	**452987**	cubic feet	**Total Capacity should be the Permanent Pool Capacity plus a second WQV.**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: 290 West Oak Hill
Date Prepared: 10/29/2019

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project: Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:
$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = Travis
Total project area included in plan * = 346.82 acres
Predevelopment impervious area within the limits of the plan* = 138.58 acres
Total post-development impervious area within the limits of the plan* = 220.74 acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = 19

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = PR Pond S

Total drainage basin/outfall area = 36.18 acres
Predevelopment impervious area within drainage basin/outfall area = 25.93 acres
Post-development impervious area within drainage basin/outfall area = 27.40 acres
Post-development impervious fraction within drainage basin/outfall area = **0.76**
$L_{M\ THIS\ BASIN}$ = **1273** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = Sand Filter
Removal efficiency = **89** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:
A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = 36.18 acres
A_I = 27.40 acres
A_P = **8.79** acres
L_R = **27131** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = 21565 lbs.

F = **0.79**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area. Calculations from RG-348

Rainfall Depth = **1.04** inches
Post Development Runoff Coefficient = **0.57**
On-site Water Quality Volume = **77657** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP = 54.44 acres
Off-site Impervious cover draining to BMP = 22.95 acres
Impervious fraction of off-site area = **0.42**
Off-site Runoff Coefficient = **0.32**
Off-site Water Quality Volume = **65199** cubic feet

Storage for Sediment = **28571**
Total Capture Volume (required water quality volume(s) x 1.20) = 171426 cubic feet

The following sections are used to calculate the required water quality volume(s) for the selected BMP.
The values for BMP Types not selected in cell C45 will show NA.

9. Filter area for Sand Filters

Designed as Required in RG-348 Pages 3-58 to 3-63

9A. Full Sedimentation and Filtration System

Water Quality Volume for sedimentation basin = **171426** cubic feet

Minimum filter basin area = **4314** square feet

Maximum sedimentation basin area = **38828** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **9707** square feet **For maximum water depth of 8 feet**

9B. Partial Sedimentation and Filtration System

Water Quality Volume for combined basins = **171426** cubic feet

Minimum filter basin area = **7766** square feet

Maximum sedimentation basin area = **31063** square feet **For minimum water depth of 2 feet**
Minimum sedimentation basin area = **1941** square feet **For maximum water depth of 8 feet**

Texas Commission on Environmental Quality

TSS Removal Calculations 04-20-2009

Project Name: **290 West Oak Hill**
Date Prepared: **10/29/2019**

Additional information is provided for cells with a red triangle in the upper right corner. Place the cursor over the cell.
Text shown in blue indicate location of instructions in the Technical Guidance Manual - RG-348.
Characters shown in red are data entry fields.
Characters shown in black (Bold) are calculated fields. Changes to these fields will remove the equations used in the spreadsheet.

1. The Required Load Reduction for the total project:

Calculations from RG-348 Pages 3-27 to 3-30

Page 3-29 Equation 3.3: $L_M = 27.2(A_N \times P)$

where:

$L_{M\ TOTAL\ PROJECT}$ = Required TSS removal resulting from the proposed development = 80% of increased load
A_N = Net increase in impervious area for the project
P = Average annual precipitation, inches

Site Data: Determine Required Load Removal Based on the Entire Project
County = **Travis**
Total project area included in plan * = **346.82** acres
Predevelopment impervious area within the limits of the plan* = **138.58** acres
Total post-development impervious area within the limits of the plan* = **220.74** acres
Total post-development impervious cover fraction * = **0.64**
P = **32** inches

$L_{M\ TOTAL\ PROJECT}$ = **246435** lbs.

*** The values entered in these fields should be for the total project area.**

Number of drainage basins / outfalls areas leaving the plan area = **19**

2. Drainage Basin Parameters (This information should be provided for each basin):

Drainage Basin/Outfall Area No. = **Pond T**

Total drainage basin/outfall area = **3.84** acres
Predevelopment impervious area within drainage basin/outfall area = **1.65** acres
Post-development impervious area within drainage basin/outfall area = **3.29** acres
Post-development impervious fraction within drainage basin/outfall area = **0.86**
$L_{M\ THIS\ BASIN}$ = **1426** lbs.

3. Indicate the proposed BMP Code for this basin.

Proposed BMP = **Batch Detention**
Removal efficiency = **91** percent

4. Calculate Maximum TSS Load Removed (L_R) for this Drainage Basin by the selected BMP Type.

RG-348 Page 3-33 Equation 3.7: $L_R = (\text{BMP efficiency}) \times P \times (A_I \times 34.6 + A_P \times 0.54)$

where:

A_C = Total On-Site drainage area in the BMP catchment area
A_I = Impervious area proposed in the BMP catchment area
A_P = Pervious area remaining in the BMP catchment area
L_R = TSS Load removed from this catchment area by the proposed BMP

A_C = **3.84** acres
A_I = **3.29** acres
A_P = **0.55** acres
L_R = **3324** lbs

5. Calculate Fraction of Annual Runoff to Treat the drainage basin / outfall area

Desired $L_{M\ THIS\ BASIN}$ = **2740** lbs.

F = **0.82**

6. Calculate Capture Volume required by the BMP Type for this drainage basin / outfall area.

Calculations from RG-348

Rainfall Depth = **1.16** inches
Post Development Runoff Coefficient = **0.70**
On-site Water Quality Volume = **11315** cubic feet

Calculations from RG-348 Pages 3-36 to 3-37

Off-site area draining to BMP =	**0.00**	acres
Off-site Impervious cover draining to BMP =	**0.00**	acres
Impervious fraction of off-site area =	**0**	
Off-site Runoff Coefficient =	**0.00**	
Off-site Water Quality Volume =	**0**	cubic feet
Storage for Sediment =	**2263**	
Total Capture Volume (required water quality volume(s) x 1.20) =	**13578**	cubic feet

Appendix L: TCEQ WPAP Application Meeting Minutes

Oak Hill Parkway – TCEQ WPAP Application Meeting
Summary

Date and time: 31 July 2019 - 1:30 PM

Location: TCEQ Building A - Austin Regional Office

Attendees:

Kevin Smith	TCEQ
Robert Sadlier	TCEQ
Roberto Castro	TCEQ
Savannah Rains	TCEQ
Heather Ashley-Nguyen	TxDOT
Zach Lanfear	TxDOT
Jerel Rackley	Atkins

I. Oak Hill Parkway Description

a. The TxDOT project team described the Oak Hill Parkway project, covering the following:
   - i. Project Limits
   - ii. Proposed configuration
   - iii. Project schedule and delivery method
   - iv. Limits with Edward Aquifer Recharge and Contributing Zones

II. Description of Design-Build Projects

a. The key elements of a Design-Build (DB) project and what separates it from a typical Design-Bid-Build (DBB) project were discussed. These primarily consist of:
   - i. Structure – The DB Contractor performs the project final design
   - ii. Schedule - Construction begins before design is complete

III. Applicable TCEQ Edward Aquifer Rules and challenges to a Design-Build Project

a. Construction Activities cannot begin until a Water Pollution Abatement Plan (WPAP) is approved by the TCEQ Executive Director. Final Signed and Sealed plans are required with a WPAP application.
   - i. This requirement fits well within the project development of a DBB Project where WPAP application/approval can occur at the end of project design and before construction. This presents a significant challenge to a DB project where construction begins before design is complete.

b. The owner must have the right to possess and control all ROW before submitting a WPAP.

IV. **Project Segmentation and Phasing as potential approaches to WPAP Applications**

a. Segmentation

   i. The TxDOT project team proposed the following approach to segmenting the project.

      1. The DB Contractor could break the project into individual areas for WPAP application. If a break-out area is within the Edwards Aquifer Contributing Zone, it may be submitted and reviewed as a Contributing Zone Plan.
      2. These areas would be determined by the DB Contractor
      3. Potential Segmentation is shown in **Attachment 1**

   ii. The TCEQ staff agreed segmentation as presented would be appropriate and stressed that each segmented area needed to serve as a stand-alone WPAP application; A WPAP for one segment could not rely on the information or water quality controls from a separate WPAP

b. Phasing

   i. The TxDOT project team proposed phasing the WPAP applications based on project work activities. The Project phasing would be determined by the DB Contractor.

   ii. The following potential phasing structure was presented to TCEQ staff

	Work Type:	**WPAP to Include:**
Phase 1	- Clearing and Grubbing - Mass Grading - Drainage Structures - Drilled Shafts - Temporary Pavement	- Right to possess and control all ROW - Signed and sealed plans: * Clearing and Grubbing * Mass Grading * Drainage Structures * Drainage Areas * Temporary Pavement * Temporary BMPs (Full and Detailed)
Phase 2	- Final Pavement - Permanent BMPs	- Signed and sealed plans: * All plan sheets related to Impervious Cover, Drainage, and Permanent BMPs

   iii. The TCEQ staff agreed phasing of the WPAP applications would be acceptable.

   iv. The TCEQ staff stressed that final (signed and sealed) plans for the phased work must be submitted with the WPAP application.

   v. The TCEQ staff indicated interim permanent BMPs may be required to treat temporary impervious cover.

c. Combination of segmenting and phasing

   i. The TxDOT project team also asked if segmenting and phasing could be combined in a structure similar to the table below, again explaining that the organization of the WPAP application packages would be determined by the DB Contractor.

   ii. The TCEQ staff explained that both segmenting and phasing WPAP applications is reasonable and is consistent with previously approved segmented/phased projects. They also explained each WPAP application must be able to demonstrate how it complies with the Edwards Aquifer Rule requirements (independent of a previously approved WPAP) and each application must include the appropriate reference/background information (of prior WPAP's) indicating what phase/segment was previously approved and how it relates to the proposed application.

	Segment 1	**Segment 2**	**Segment 3**
Phase 1	OHP Seg1 Phase1 WPAP	OHP Seg2 Phase1 WPAP	OHP Seg3 Phase1 WPAP
Phase 2	OHP Seg1 Phase2 WPAP	OHP Seg2 Phase2 WPAP	OHP Seg3 Phase2 WPAP

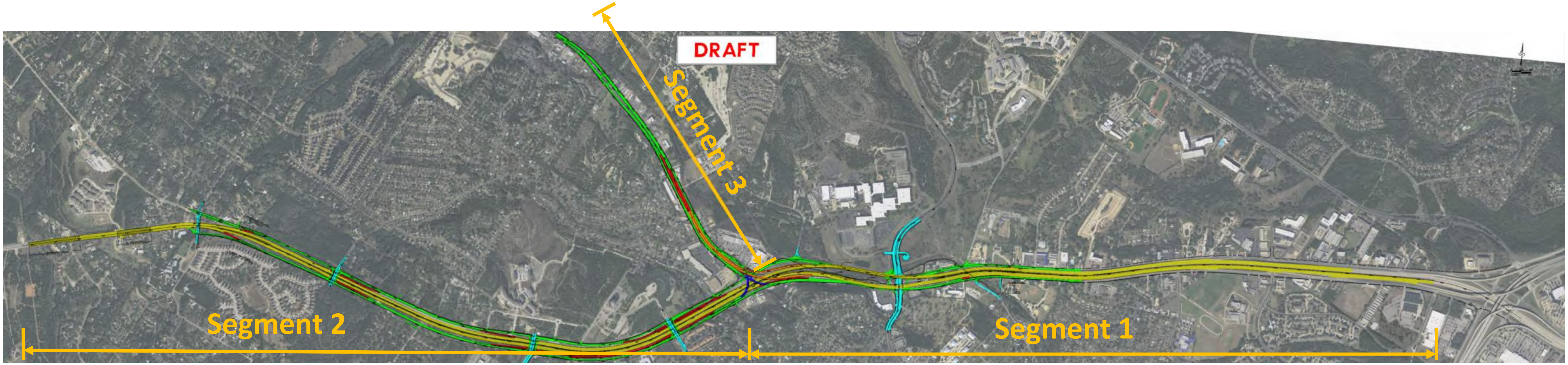
Attachments

Attachment 1 – Oak Hill Parkway Potential Segmentation

Attachment 1

Oak Hill Parkway Potential Segmentation

Oak Hill Parkway Potential Segmentation:



Attachment 4 – Technical Memorandum, Atlas 14 Rainfall Updates, Oak Hill Parkway, November 1, 2019

TECHNICAL MEMORANDUM

FOR INTERIM REVIEW ONLY
NOT INTENDED FOR
CONSTRUCTION BIDDING OR
PERMIT PURPOSES

DATE:	November 1, 2019
PREPARED FOR:	Rodriguez Transportation Group, Inc. and the Texas Department of Transportation
PREPARED BY:	Eric R. Friedrich, P.E. (TX PE# 64818) Teague Nall and Perkins, Inc. (Firm PE #230)
SUBJECT:	Atlas 14 Rainfall Updates
PROJECT:	Oak Hill Parkway (US 290 / SH 71 Interchange)

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1. Introduction

In November 2018, TNP (formerly H&H Resources) submitted a Hydrology and Hydraulics Study report for the Oak Hill Parkway (OHP) project, the planned reconstruction of the US290/SH71 interchange in southwest Austin. The modeling in that study was based on the Effective Federal Emergency Management Agency (FEMA) models for Williamson Creek. These models were released in 2008 and reflect older rain data for Travis County. In September 2018, the National Oceanic and Atmospheric Administration (NOAA) released a study showing significantly higher rainfall frequency values in parts of Texas. The study, published as “NOAA Atlas 14, Volume 11, Precipitation-Frequency Atlas of the United States, Texas” (Atlas 14), recommended increased values across the state, particularly in larger cities such as Austin and Houston. Implementation of Atlas 14 data has resulted in changes to rainfall rates and amounts that define the full spectrum of storm events, including the 100-year precipitation. This Technical Memorandum (TM) is intended to update the November 2018 report recommendations to accommodate Williamson Creek flows based on more recent Atlas 14 rainfall.

TNP was tasked with incorporating the Atlas 14 rainfall data for Travis County into the hydrologic and hydraulic models for the OHP. The previous OHP report outlined preliminary infrastructure recommendations for the US 290 / SH 71 interchange schematic design in order to mitigate water surface elevation (WSEL) increases in Williamson Creek due to increased impervious area and infrastructure additions.

This TM describes the modeling updates due to Atlas 14 and outlines additional recommendations to the OHP schematic design to mitigate Williamson Creek flow and WSEL increases emanating from the increased rainfall frequency values.

In addition, some modifications are recommended to the proposed HWY71 and Old Bee Cave (OBC) detention sites to address Atlas 14 and to fully comply with City of Austin (COA) and Texas Commission on Environmental Quality (TCEQ) standards for dam construction.

2. Rainfall Frequency Values – Atlas 14, September 2018

The new rainfall data is available on-line at:
https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=tx

The website requires a specific location for which rainfall data will then be extracted. For the Oak Hill project, the specific location was the centroid of the watershed upstream and including the Oak Hill project area. The centroid is located at latitude (30.244508) and longitude (-97.890536) (decimal degrees). Figure 1 below illustrates the centroid location from which September 2018 Atlas 14 rainfall was extracted.

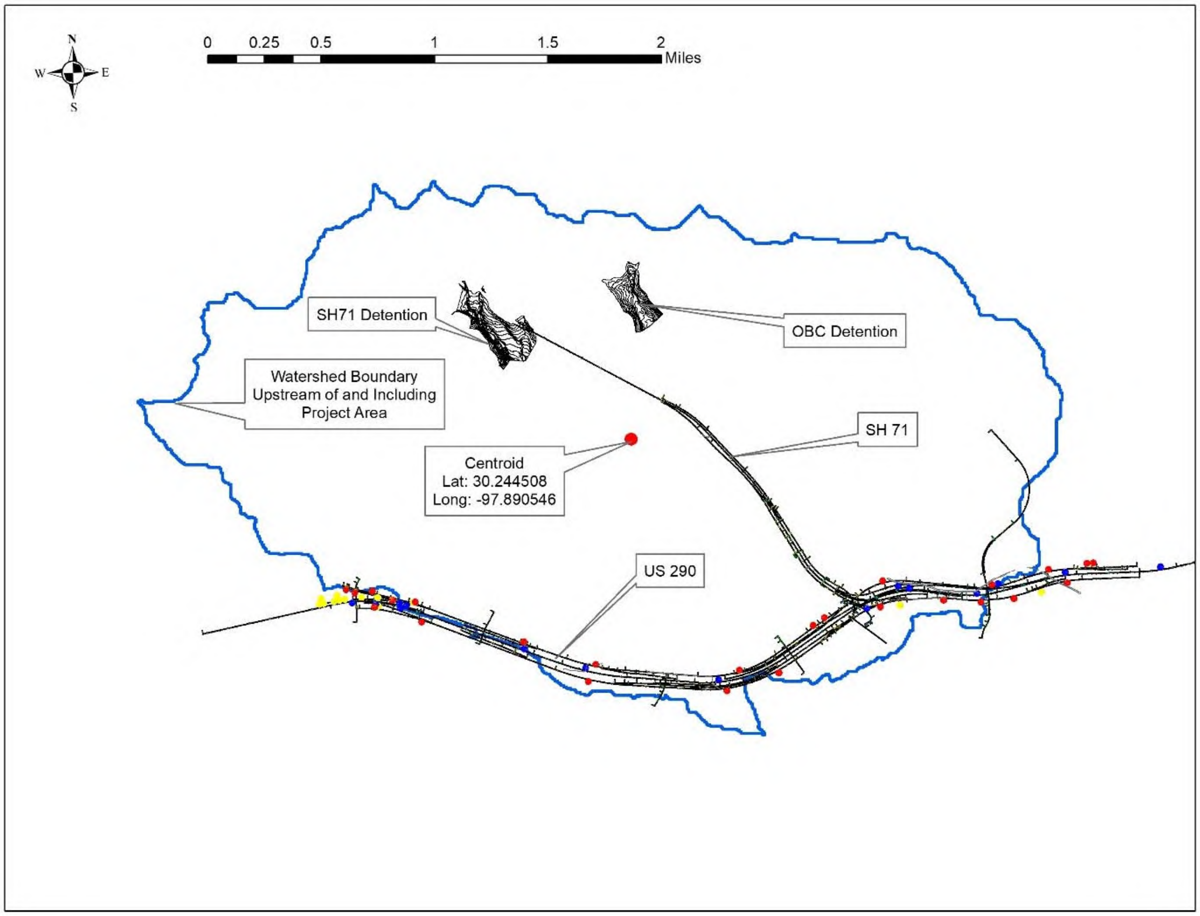


Figure 1 - Centroid Location

Table 1 compares the previous 10-year, 25-year, 50-year, and 100-year rainfall depth amounts with the Atlas 14 update.

Table 1 - Previous Rainfall and Atlas 14 Rainfall Depth Comparison

	Previous Rainfall	**Atlas 14**	**Previous Rainfall**	**Atlas 14**	**Previous Rainfall**	**Atlas 14**	**Previous Rainfall**	**Atlas 14**
Duration	**10-Year (inches)**		**25-Year (inches)**		**50-Year (inches)**		**100-Year (inches)**	
5 min.	0.67	0.808	0.81	0.995	0.93	1.14	1.05	1.30
15 min.	1.47	1.62	1.76	1.98	2.01	2.27	2.29	2.59
1 hour	2.68	3.01	3.28	3.71	3.79	4.25	4.37	4.85
2 hours	3.42	3.84	4.20	4.86	4.88	5.71	5.66	6.69
3 hours	3.71	4.35	4.55	5.61	5.28	6.70	6.11	7.97
6 hours	4.21	5.21	5.14	6.83	5.94	8.27	6.85	9.97
12 hours	4.81	6.01	5.90	7.88	6.86	9.55	7.96	11.50
1 day	6.10	6.80	7.64	8.88	8.87	10.70	10.20	12.90

3. Compliance with COA and TCEQ Standards

Two proposed detention facilities, HWY71 and OBC, were reconfigured to comply with several COA and TCEQ standards. The following modifications were made:

1) The emergency spillway inverts were set at the maximum WSEL of the 25-Year event. This is a TCEQ standard that serves to limit excessive operation of the emergency spillway. The TCEQ guidelines state, "Most emergency spillways are built to prevent passage of flows for less than about the 50- or 100-year flood." Most emergency spillways are earthen and therefore unable to successfully maintain structural integrity through continuous use. A moderate amount of damage is expected during extreme events, but the standard assumes these are infrequent, and can be repaired relatively quickly before another extreme event occurs. The 25-year event was used to define the emergency spillway invert.

2) Two feet of freeboard has been configured between the top of dam elevation and the maximum WSEL of the 100-year event. This is a COA standard. TCEQ has freeboard requirements, but for the two proposed detention facilities, TCEQ procedures will probably produce less required freeboard. However, the TCEQ guidelines caveat their standards with the following statement: "Design-flood criteria established by other public agencies, if shown to be more conservative, will generally be acceptable."

3) Additionally, COA requires that all dams safely pass 75 percent of the probable maximum flood (PMF). PMF events have not been routed through the two proposed detention facilities in the current modeling. However, design and construction logistics, and ROW space constraints, will certainly dictate that the downstream slope of each dam

be armored, in the same way the existing Oak Hill and Lantana regional detention facilities are armored.

This creates the possibility, however, for a variance from the first two standards discussed, limiting the use of the emergency spillway and a minimum two feet of freeboard between the top of dam elevation and the 100-year event maximum WSEL. If the downstream slope is armored, then overtopping of the dam is not as much of a concern. The armoring would protect the embankment from erosion, thereby making available discharge conveyance over the dam under a wide range of storm events.

This configuration of proposed regional detention facilities is summarized in the following Table 2 and Table 3. Additional detention scenarios and analysis are discussed in sections 6 and 7.

Table 2 - HWY71 Regional Detention Configuration

Primary Spillway	
Description	3-4’x4’ Concrete Box Culvert
Length	500 Feet
Inlet Invert Elevation	915.0 Feet
Outlet Invert Elevation	909.0 Feet
Emergency Spillway	
Description	Broad-Crested Weir
Length	705 Feet
Invert Elevation	933.3 Feet
Top of Dam	
Maximum Crest Elevation	936.0 Feet

Table 3 - OBC Regional Detention Facility

Primary Spillway	
Description	One 24” Reinforced Concrete Pipe
Length	160 Feet
Inlet Invert Elevation	908.0 Feet
Outlet Invert Elevation	906.0 Feet
Emergency Spillway	
Description	Broad-Crested Weir
Length	150 Feet
Invert Elevation	924.9 Feet
Top of Dam	
Maximum Crest Elevation	928.0 Feet

4. Hydrologic Impact – Atlas 14, September 2018

The Atlas 14 rainfall values in Table 1 were incorporated into the revised existing and proposed HEC-HMS models. Table 4 summarizes the discharge results and compares them to previous results. Figure 2-5 graphically illustrate the differences for each probability storm event.

The Atlas PROPOSED condition only includes the changes described previously for the COA and TCEQ dam compliance. All other infrastructure is unchanged from previous work. Infrastructure changes under proposed conditions to mitigate WSEL increases from the Atlas 14 update are described later in this TM.

Table 4 - Discharge Comparison, Previous vs. Atlas 14 Update

HEC RAS XS	HMS Node	Previous Revised Existing				Previous Proposed				Atlas 14 Update Revised Existing				Atlas 14 Update Proposed			
		10-yr	25-yr	50-yr	100-yr	10-yr	25-yr	50-yr	100-yr	10-yr	25-yr	50-yr	100-yr	10-yr	25-yr	50-yr	100-yr
90177	OAKHILL	950	1105	1196	1290	951	1106	1197	1290	1098	1508	1811	2091	1061	1477	1813	2091
89063	JWCR50***	1734	2356	2797	3157	1330	1916	2054	2980	2821	1089	1749	2821	950	1089	1744	2821
84632	JWCR60**	2625	3825	4717	5463	1864	2516	3313	3974	4564	2615	3084	4564	1707	1947	2920	4664
79948	**JWCR80**	**4015**	**5985**	**7519**	**8739**	**3405**	**5027**	**6491**	**7225**	**6229**	**4429**	**5406**	**6229**	**2374**	**3147**	**3686**	**5632**
75171.9	**JWCR1050***	**4835**	**7429**	**9424**	**11159**	**4414**	**6665**	**8791**	**10114**	**5457**	**8930**	**11164**	**13049**	**5457**	**8340**	**10392**	**12121**
75017	**JWCR1050**	**4835**	**7429**	**9424**	**11159**	**4414**	**6665**	**8791**	**10114**	**5457**	**8930**	**11164**	**13049**	**5457**	**8340**	**10392**	**12121**
67082	JWCR1040	4968	7582	9677	11587	4592	6912	9031	10448	13049	8930	11164	13049	5457	8340	10392	12121
59867	JWCR100	5145	7875	10055	11950	4808	7260	9447	10929	13679	9185	11635	13679	5659	8585	10765	12760
55940	JWCR160	10593	15374	19083	22356	10477	15053	18742	21678	14388	9619	12123	14388	5961	9047	11314	13449
50574	JWCR130	11262	16391	20732	24439	11201	16009	20448	23857	27311	18581	23036	27311	12586	18223	22463	26601
49429	JWCR120	11437	16636	21061	24849	11388	16263	20791	24299	30304	20383	25475	30304	13456	20087	25007	29671
46107	JWCR1170	11467	16547	20975	24781	11419	16210	20691	24191	30909	20743	25951	30909	13685	20467	25509	30294
43122	JWCR1000	11843	16984	21556	25521	11814	16674	21290	24964	30977	20736	26009	30977	13710	20427	25543	30351
37465	JWCR103	11901	16992	21460	25435	11863	16689	21171	24844	32429	21548	27181	32429	14235	21259	26742	31883
30000	JWCR360	12031	17072	21532	25542	11984	16772	21239	24922	32648	21555	27247	32648	14317	21245	26789	32117
23527	JWCR880	12141	17172	21704	25736	12083	16870	21404	25121	33283	21820	27706	33283	14532	21511	27246	32752
17814	JWCR370A	12181	17212	21743	25753	12117	16908	21434	25155	33882	22137	28168	33882	14724	21834	27713	33360
13810	JWCR370	12208	17245	21781	25796	12143	16942	21475	25203	34029	22232	28293	34029	14792	21930	27834	33499
7301	JWCR3900	12263	17329	21856	25926	12180	17029	21514	25344	34115	22291	28368	34115	14834	21986	27909	33587
4393	J400W	12284	17342	21819	25709	12194	17042	21468	25229	34480	22475	28634	34480	14938	22146	28169	33954
2454	JWCR400	12419	17511	22030	25956	12331	17216	21681	25480	34528	22464	28344	34528	14974	22126	27880	34000
618	outlet	12408	17494	21991	25831	12317	17198	21641	25388	34951	22736	28675	34951	15170	22403	28217	34436

***Downstream of HWY71 Regional Detention

**Downstream of both HWY71 and OBC Regional Detention

*Upstream of Main Lanes and Frontage Crossing

Bold Text indicates OHP project stream reach

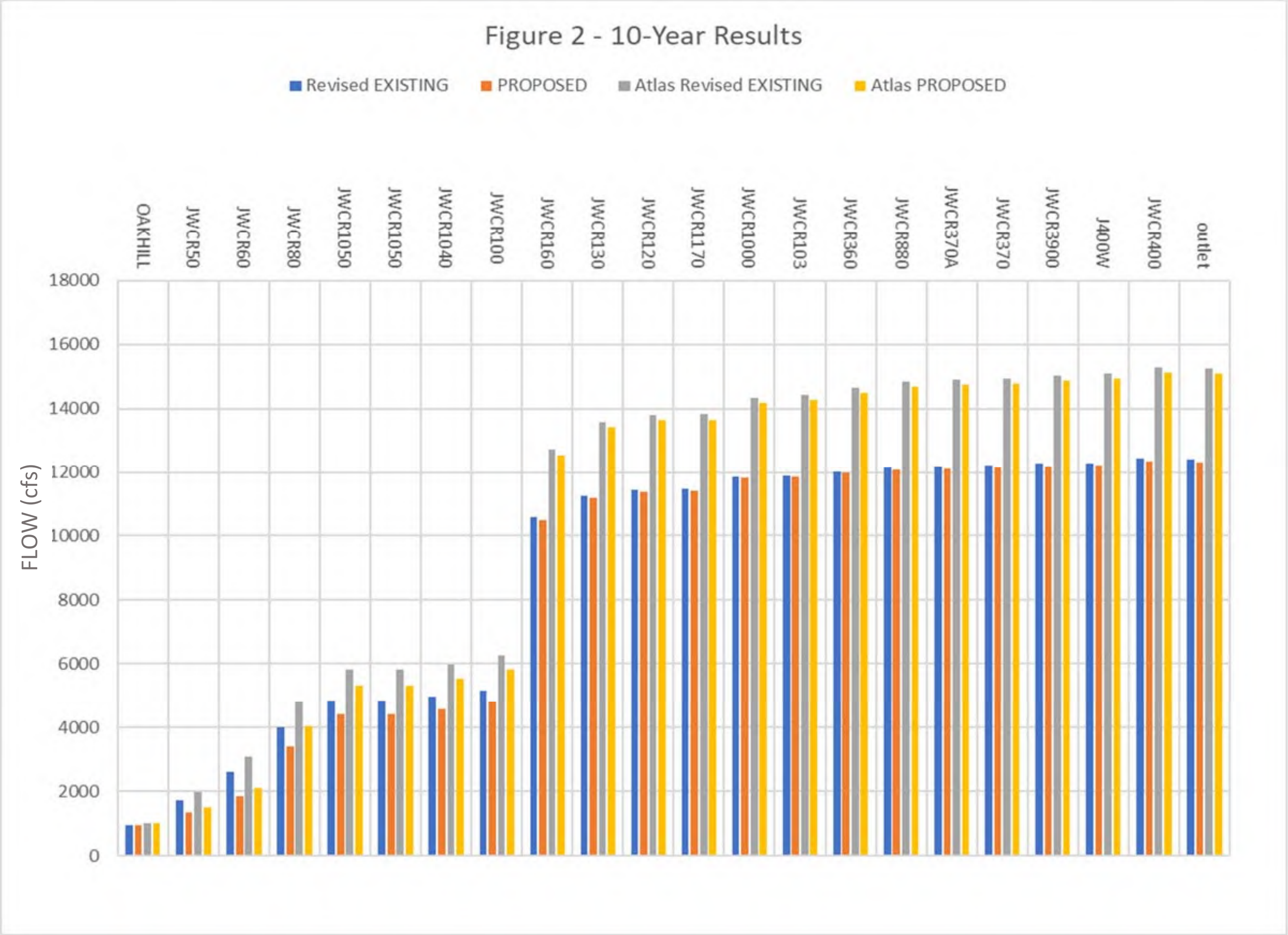


Figure 2 - 10-Year Results
Revised EXISTING
PROPOSED
Atlas Revised EXISTING
Atlas PROPOSED
FLOW (cfs)
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
OAKHILL
JWCR50
JWCR60
JWCR80
JWCR1050
JWCR1050
JWCR1040
JWCR100
JWCR160
JWCR130
JWCR120
JWCR1170
JWCR1000
JWCR103
JWCR360
JWCR880
JWCR370A
JWCR370
JWCR3900
J400W
JWCR400
outlet

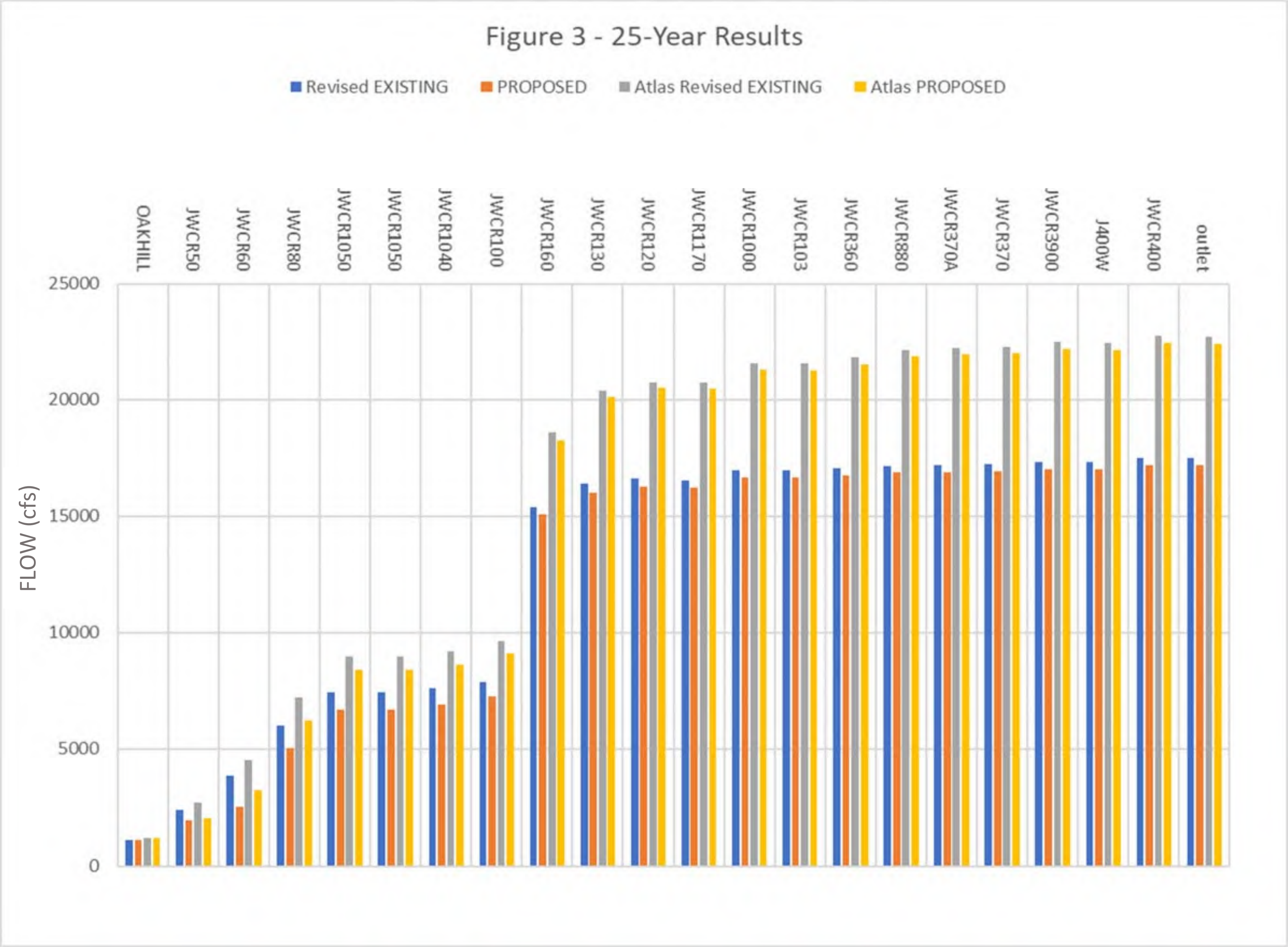


Figure 3 - 25-Year Results

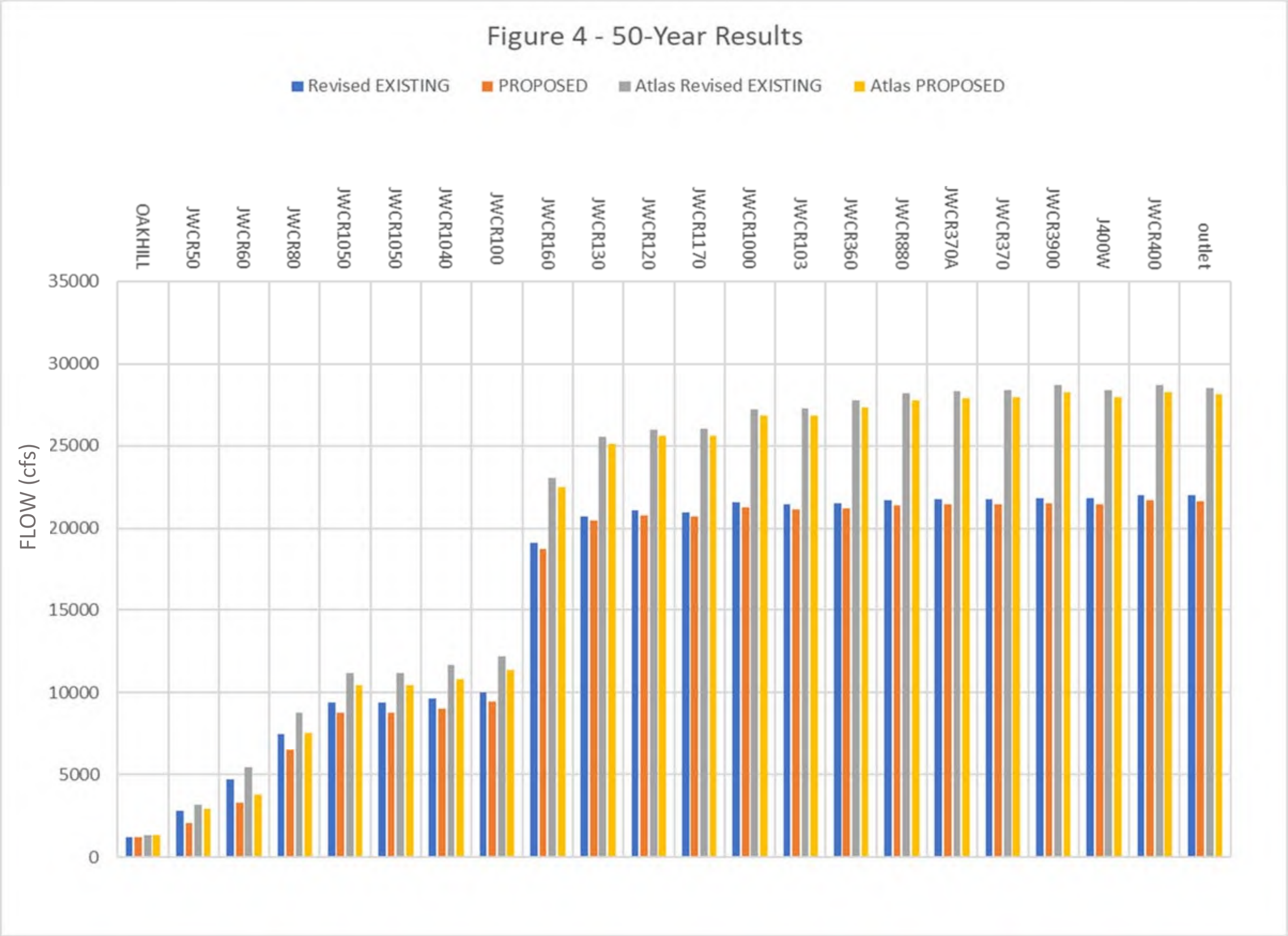


Figure 4 - 50-Year Results
Revised EXISTING
PROPOSED
Atlas Revised EXISTING
Atlas PROPOSED
FLOW (cfs)
35000
30000
25000
20000
15000
10000
5000
0
OAKHILL
JWCR50
JWCR60
JWCR80
JWCR1050
JWCR1050
JWCR1040
JWCR100
JWCR160
JWCR130
JWCR120
JWCR1170
JWCR1000
JWCR103
JWCR360
JWCR880
JWCR370A
JWCR370
JWCR3900
J400W
JWCR400
outlet

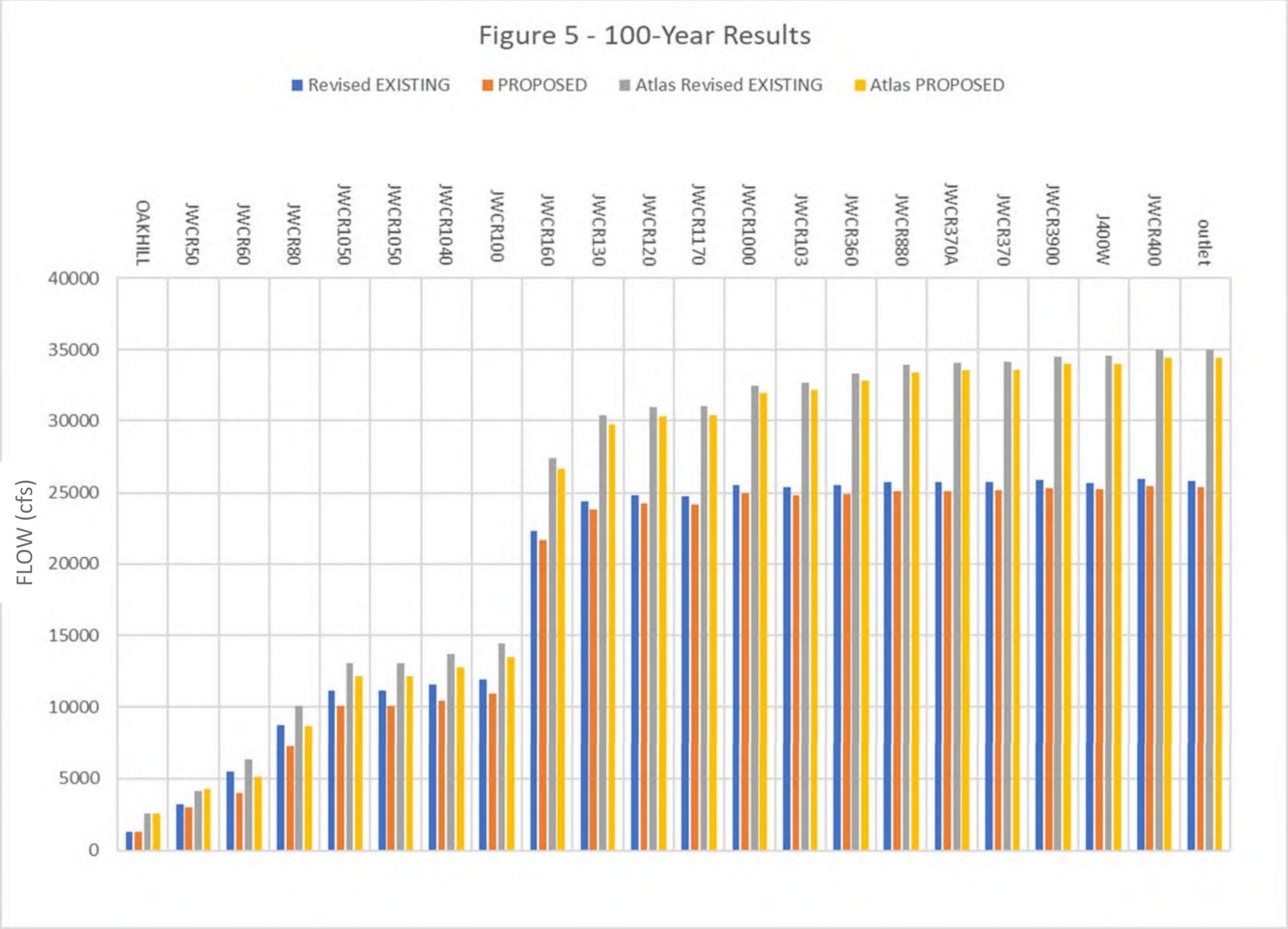


Figure 5 - 100-Year Results

5. Hydraulic Impact – Atlas 14 Update, September 2018

The 100-year discharges calculated in HEC-HMS from the updated Atlas 14 rainfall have been incorporated to the project HEC-RAS model. The results are illustrated in the following tables and graphs.

The Atlas 14 PROPOSED condition only includes the changes described previously for the COA and TCEQ dam compliance. All other infrastructure is unchanged from previous work. Infrastructure changes under proposed conditions to mitigate WSEL increases from the Atlas 14 update are described later in this technical memorandum.

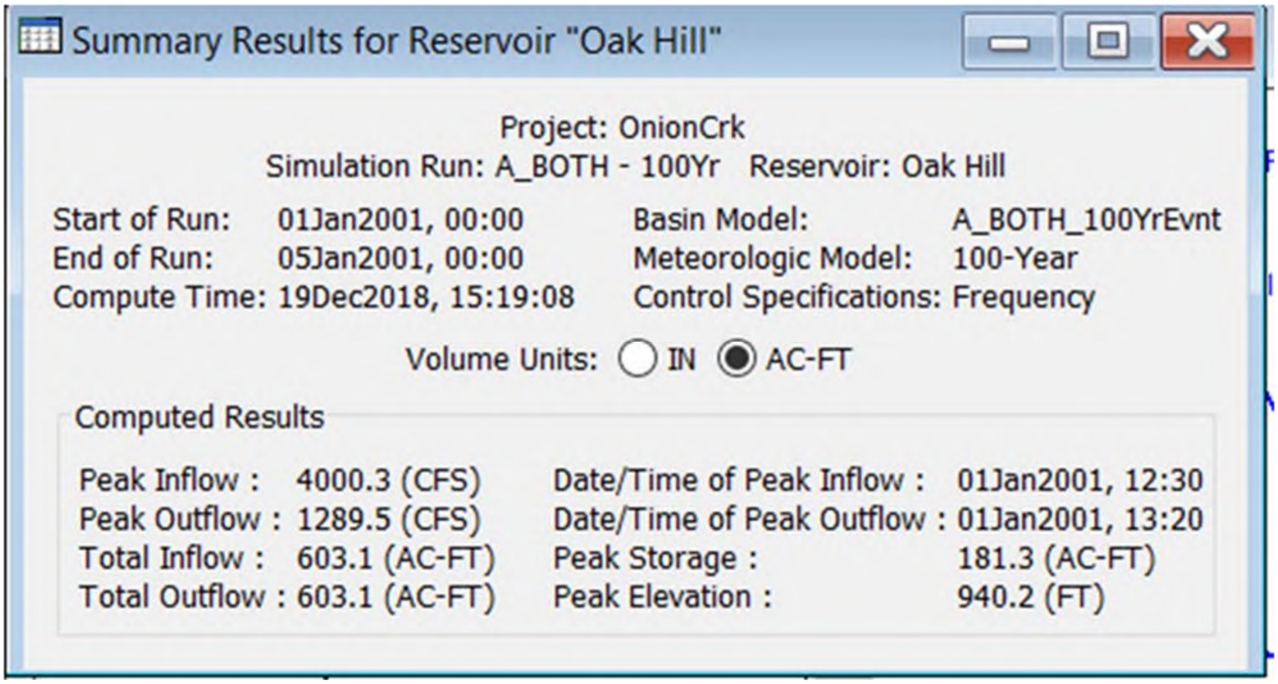
The following Table 5 summarizes the mitigated results prior to and after the Atlas 14 updates. Prior to the updates, only one river station location, 75491, still indicated a slight rise in 100-year elevations from existing to proposed. After the Atlas 14 updates are applied the locations along Williamson Creek showing WSEL impacts have significantly expanded.

In particular, there are sustained impacts downstream of the HWY71 proposed regional detention and upstream of the State Highway 71 bridge. These are due primarily to a 100-year discharge increase from the Oak Hill regional detention facility. The Oak Hill facility is located in Williamson Creek immediately upstream from its confluence with the HWY71 detention tributary. The Oak Hill increase is illustrated in Figure 6 and Figure 7, showing the HEC-HMS results output.

The Oak Hill facility is owned and operated by the COA and is a critical structure in the analysis. With the application of updated Atlas 14 flow data, there is a one-foot increase in the peak 100-year elevation in the pond. The previous peak discharge was 1,290 cfs, and after the Atlas 14 updates, the peak discharge increases to 2,558 cfs. Despite a near two-fold increase in outflow from the Oak Hill facility, there is only a moderate inflow increase from 4,000 cfs to 4,673 cfs. This indicates that most of the increase can be attributed to the performance capacity of the existing structure rather than the rainfall increases.

Table 5 - Previous Mitigated 100-year Results Prior to and After Atlas 14 Updates

HEC-RAS River Station	Location	100-Year Prior to Atlas 14			100-Year After Atlas 14		
		Existing W.S. Elev (ft)	Proposed W.S. Elev (ft)	Change	Existing W.S. Elev (ft)	Proposed W.S. Elev (ft)	Change
89063	Downstream of HWY71 Detention	912.48	912.29	-0.19	913.19	913.25	0.06
86254		887.43	887.19	-0.24	888.66	888.77	0.11
85611		883.63	883.36	-0.27	884.79	884.92	0.13
85045		879.44	879.43	-0.01	881.18	881.63	0.45
84982	Upstream of State Hwy 71 Bridge	879.4	879.39	-0.01	881.19	881.77	0.58
84745		878.54	877	-1.54	879.11	877.88	-1.23
84632	Downstream of Both Proposed Ponds	877.66	876.44	-1.22	878.29	877.42	-0.87
83997		874.68	873.42	-1.26	875.32	874.42	-0.9
79948		845.88	845.14	-0.74	846.46	845.83	-0.63
79547		842.98	842.83	-0.15	843.34	843.13	-0.21
79004	Main Lanes Berm	840.09	838.4	-1.69	840.57	840.04	-0.53
78807	Upstream of Old Bee Cave	837.08	836.99	-0.09	837.35	839.67	2.32
78502	Upstream of WestBound Flyover	834.6	834.21	-0.39	835.12	834.94	-0.18
77960		831.34	830.57	-0.77	831.84	831.33	-0.51
77525		827.84	827.1	-0.74	828.45	827.53	-0.92
76871		823.3	822.78	-0.52	823.64	824.59	0.95
76786	Upstream of William Cannon Bridge	822.8	822.49	-0.31	823.4	824.33	0.93
76285		818.34	817.17	-1.17	818.61	817.58	-1.03
75854		815.45	815.22	-0.23	815.87	816.2	0.33
75491		814.34	814.38	0.04	814.82	815.72	0.9
75171.9		813.21	813.06	-0.15	813.65	815.26	1.61
75017	Upstream of US 290 Crossings	813.16	812.17	-0.99	813.6	815.24	1.64
74437		808.41	807.64	-0.77	808.86	808.17	-0.69
74163		805.59	805.38	-0.21	805.9	805.75	-0.15
74022	Upstream of Joe Tanner	805.18	804.98	-0.2	805.47	805.32	-0.15
73960		804.9	804.71	-0.19	805.14	805.01	-0.13



Summary Results for Reservoir "Oak Hill"

Project: OnionCrk
Simulation Run: A_BOTH - 100Yr Reservoir: Oak Hill

Start of Run: 01Jan2001, 00:00
End of Run: 05Jan2001, 00:00
Compute Time: 19Dec2018, 15:19:08

Basin Model: A_BOTH_100YrEvnt
Meteorologic Model: 100-Year
Control Specifications: Frequency

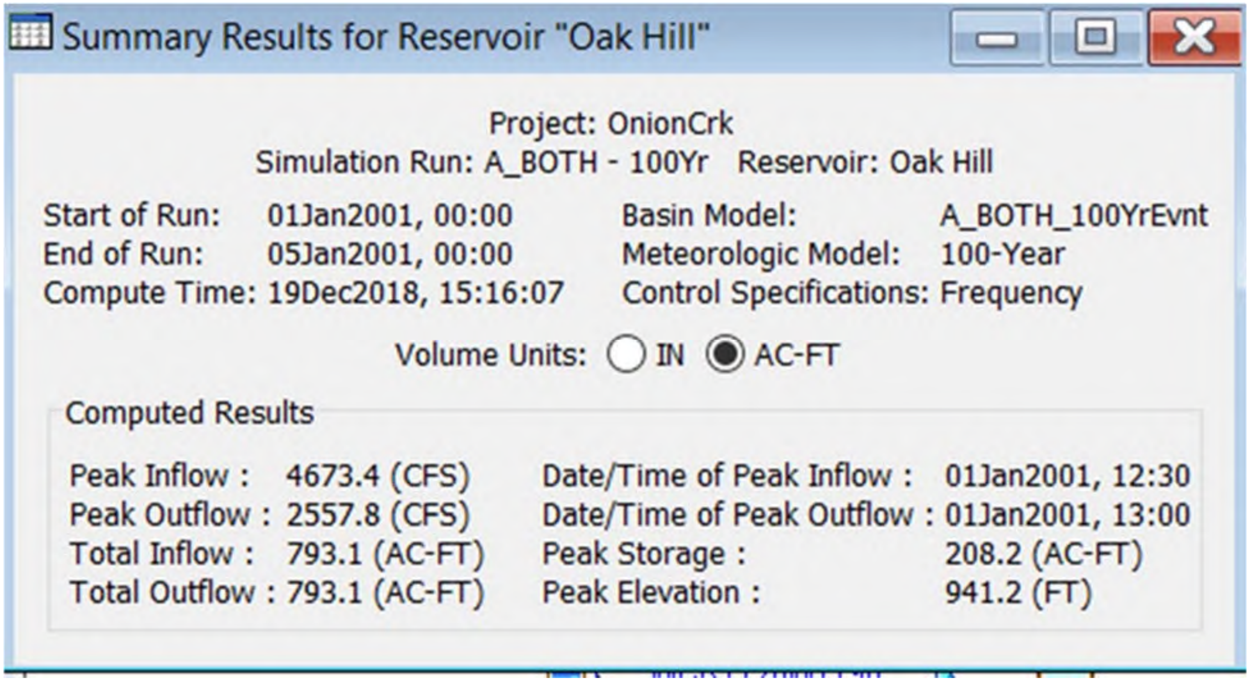
Volume Units: ○ IN ● AC-FT

Computed Results

Peak Inflow : 4000.3 (CFS)
Peak Outflow : 1289.5 (CFS)
Total Inflow : 603.1 (AC-FT)
Total Outflow : 603.1 (AC-FT)

Date/Time of Peak Inflow : 01Jan2001, 12:30
Date/Time of Peak Outflow : 01Jan2001, 13:20
Peak Storage : 181.3 (AC-FT)
Peak Elevation : 940.2 (FT)

Figure 6 - Oak Hill Detention Facility Prior to Atlas 14 Update



Summary Results for Reservoir "Oak Hill"

Project: OnionCrk
Simulation Run: A_BOTH - 100Yr Reservoir: Oak Hill

Start of Run: 01Jan2001, 00:00
End of Run: 05Jan2001, 00:00
Compute Time: 19Dec2018, 15:16:07

Basin Model: A_BOTH_100YrEvnt
Meteorologic Model: 100-Year
Control Specifications: Frequency

Volume Units: ○ IN ● AC-FT

Computed Results

Peak Inflow : 4673.4 (CFS)
Peak Outflow : 2557.8 (CFS)
Total Inflow : 793.1 (AC-FT)
Total Outflow : 793.1 (AC-FT)

Date/Time of Peak Inflow : 01Jan2001, 12:30
Date/Time of Peak Outflow : 01Jan2001, 13:00
Peak Storage : 208.2 (AC-FT)
Peak Elevation : 941.2 (FT)

Figure 7 - Oak Hill Detention Facility After Atlas 14 Update

6. Assessment of Additional Storage in Proposed Regional Detention

The HEC-HMS modeling, with updated Atlas 14 data, shows a reduction in the 100-year peak flows throughout the reach, except for downstream of the HWY 71 detention facility, as shown in Table 4 HMS Node “JWCR60”. This increase is due to a combination of the increased Atlas 14 rainfall and the reduced mitigative effect of the existing Oak Hill storage facility. Additional model runs were conducted to assess the impact of additional storage in the proposed regional detention facilities. The additional storage would consist of natural ground excavation to increase the available storage volume within the footprints of the two reservoirs. Where feasible, 20% additional volume was used to assess whether greater impact reduction could be realized.

In the following Table 6, there are four proposed conditions that are compared to the existing condition subsequent to the Atlas 14 update. Prop1 is the previous configuration of the proposed regional facilities examined with the Atlas 14 updates. Prop2 is the COA/TCEQ compliance configuration for the two proposed regional detention facilities. Prop3 is the COA/TCEQ compliance configuration along with an additional 20% storage volume within detention footprint. Prop4 is a review of the result if no regional detention facilities are constructed.

There are similar results for Prop1, Prop2, and Prop3. Prop1 resulted in marginally better results within the project footprint, but marginally worse downstream of the HWY71 detention. Prop3 with the additional storage is only slightly improved over the Prop2 results, and this is not enough benefit to justify the cost of storage excavation within the proposed detention footprints. The Prop4 results indicate a potential need for additional regional detention to assist with mitigating 100-year elevation increases.

Table 6 - Additional Proposed Scenarios for the 100-year Event

HEC-RAS River Station	Location	Existing W.S. Elev - ft	Prop1 W.S. Elev - ft	Change	Prop2 W.S. Elev - ft	Change	Prop3 W.S. Elev - ft	Change	Prop4 W.S. Elev - ft	Change
89063	DS of HWY71 Detention	913.19	913.32	0.13	913.25	0.06	913.29	0.10	913.19	0.00
86254		888.66	888.87	0.21	888.77	0.11	888.86	0.20	888.66	0.00
85611		884.79	885.01	0.22	884.92	0.13	885.01	0.22	884.83	0.04
85045		881.18	881.72	0.54	881.63	0.45	881.72	0.54	881.75	0.57
84982	US of State Hwy 71 Bridge	881.19	881.88	0.69	881.77	0.58	881.88	0.69	881.89	0.70
84745		879.11	878.00	-1.11	877.88	-1.23	877.91	-1.20	878.84	-0.27
84632	DS of Both Proposed Ponds	878.29	877.53	-0.76	877.42	-0.87	877.45	-0.84	878.29	0.00
83997		875.32	874.55	-0.77	874.42	-0.90	874.46	-0.86	875.32	0.00
79948		846.46	845.72	-0.74	845.83	-0.63	845.83	-0.63	846.50	0.04
79547		843.34	843.06	-0.28	843.13	-0.21	843.13	-0.21	843.22	-0.12
79004	Main Lanes Berm	840.57	839.79	-0.78	840.04	-0.53	840.03	-0.54	840.96	0.39
78807	US of Old Bee Cave	837.35	839.34	1.99	839.67	2.32	839.66	2.31	840.59	3.24
78502	US of WestBound Flyover	835.12	834.82	-0.30	834.94	-0.18	834.94	-0.18	835.56	0.44
77960		831.84	831.20	-0.64	831.33	-0.51	831.33	-0.51	831.98	0.14
77525		828.45	827.70	-0.75	827.53	-0.92	827.53	-0.92	828.00	-0.45
76871		823.64	823.51	-0.13	824.59	0.95	824.58	0.94	826.50	2.86
76786	US of W. Cannon Bridge	823.40	823.19	-0.21	824.33	0.93	824.31	0.91	826.56	3.16
76285		818.61	817.52	-1.09	817.58	-1.03	817.57	-1.04	817.99	-0.62
75854		815.87	815.81	-0.06	816.20	0.33	816.20	0.33	816.91	1.04
75491		814.82	815.16	0.34	815.72	0.90	815.71	0.89	816.51	1.69
75171.9		813.65	814.37	0.72	815.26	1.61	815.25	1.60	816.20	2.55
75017	US Main Lanes and Frontage	813.60	813.46	-0.14	815.24	1.64	815.24	1.64	816.18	2.58
74437		808.86	808.11	-0.75	808.17	-0.69	808.17	-0.69	808.42	-0.44
74163		805.90	805.73	-0.17	805.75	-0.15	805.75	-0.15	805.93	0.03
74022	US of Joe Tanner	805.47	805.32	-0.15	805.32	-0.15	805.32	-0.15	805.50	0.03
73960		805.14	805.03	-0.11	805.01	-0.13	805.00	-0.14	805.16	0.02

7. Further Analysis of Existing Oak Hill and Proposed HWY 71 Detention Facilities

The application of updated Atlas 14 flows resulted in several areas of increased impact in the HEC-RAS modeling. While the modifications to proposed infrastructure downstream are discussed in detail later in this memorandum, a particular range of impact, occurring just downstream of the proposed HWY 71 detention facility, appear to be the direct result of the combined performance of the existing Oak Hill detention facility and the proposed HWY 71 facility. The previous proposed design with updated flows results in a sustained increase in both flow and WSEL starting at the confluence of the tributaries downstream of the two facilities and extending a mile downstream to the HWY 71 bridge crossing. This extended area of impact, through a well-developed area of the Williamson Creek watershed, necessitates further analysis into how that combined performance might be optimized to mitigate these impacts.

The increased flows appear to be a result of both a significantly increased discharge from the existing Oak Hill facility and a shifted hydrograph peak from the HWY 71 facility. As discussed previously, the updated Atlas 14 flows have increased the volume of 100-year discharge over the top of the Oak Hill dam, resulting in a major increase in peak flow.

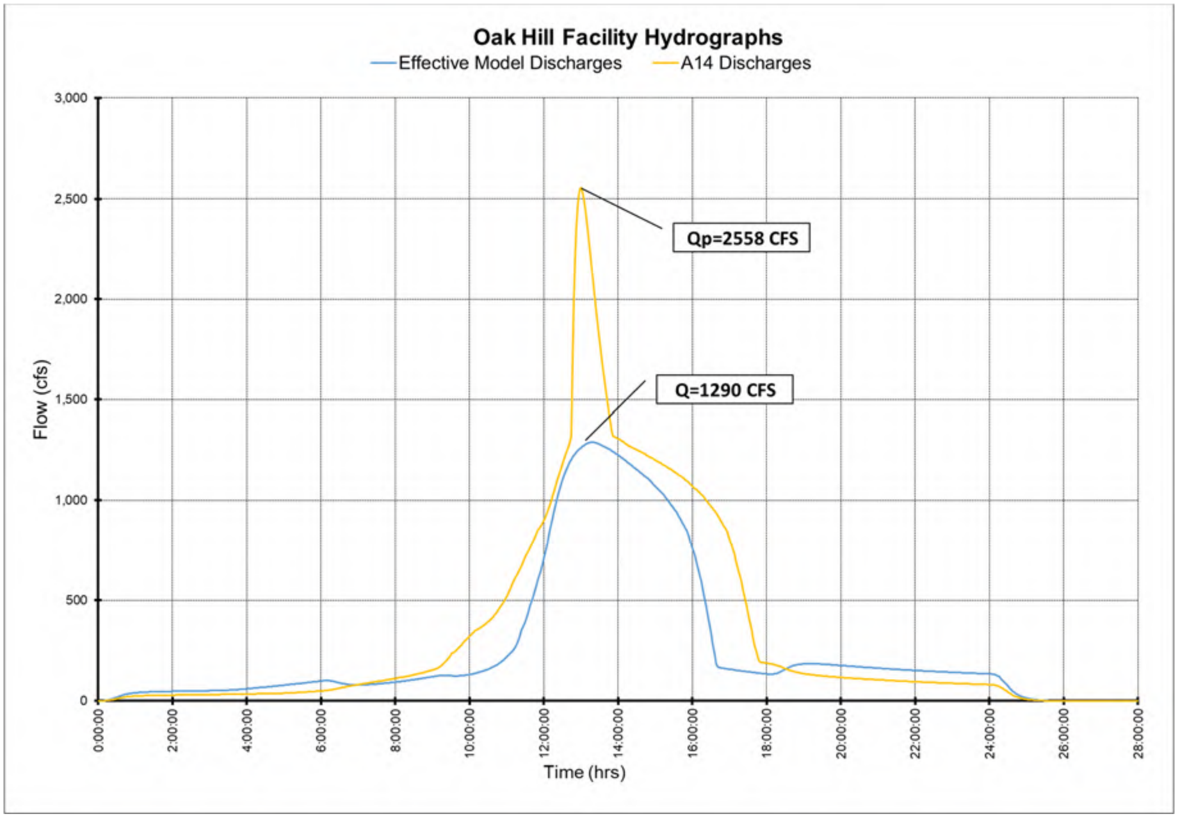


Figure 8 - Oak Hill Facility Hydrographs

The proposed HWY 71 facility peak discharge is decreased and the time to peak is delayed by approximately 6 minutes.

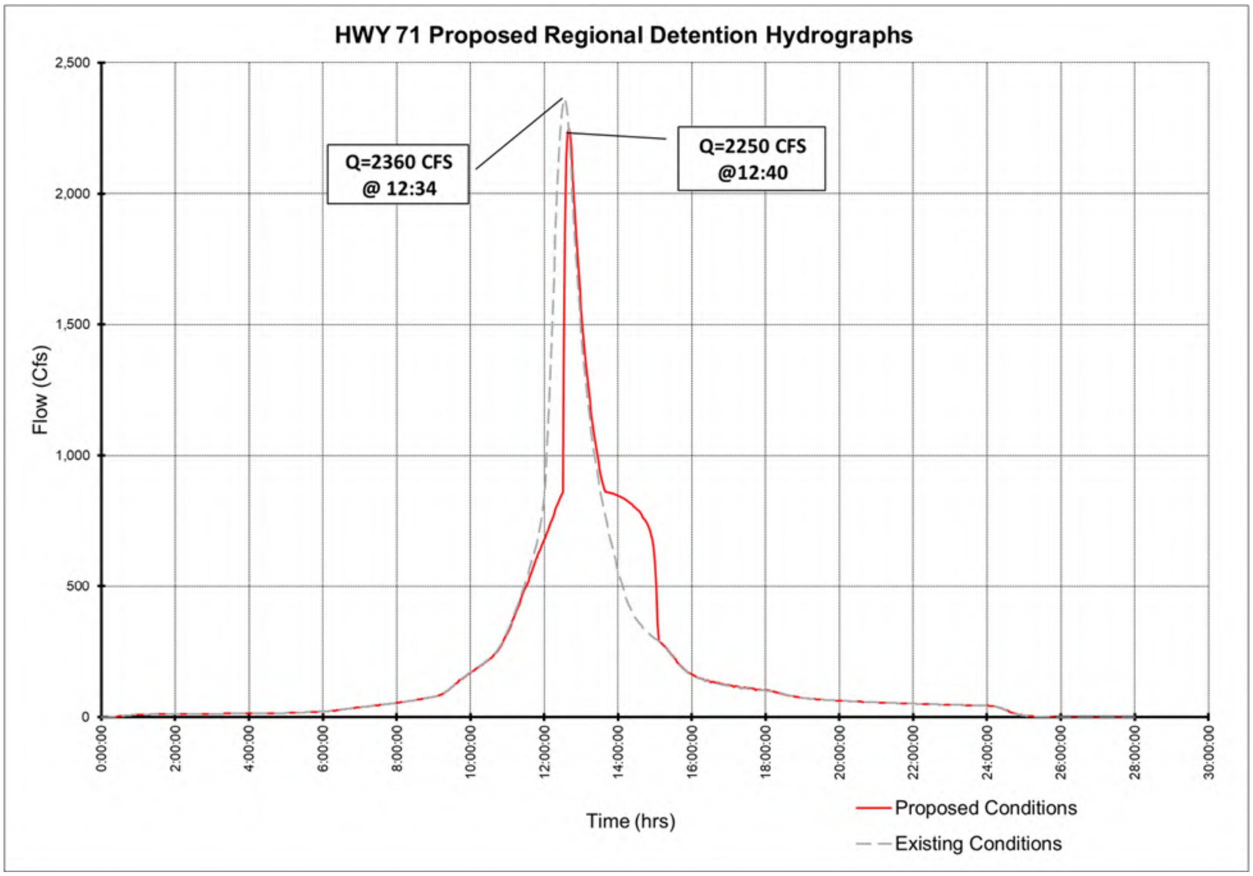


Figure 9 - HWY 71 Proposed Regional Detention Hydrographs

This subtle shift in timing moves the peak from the HWY 71 sub-basin closer to the peak at the confluence between the two detention facility tributaries, resulting in an increased peak discharge at that confluence. While this shift was also present in the previous design, an overall peak reduction was still achieved throughout the modeling. It was only with the addition of the substantial discharge increase from the existing Oak Hill facility that a downstream impact materialized.

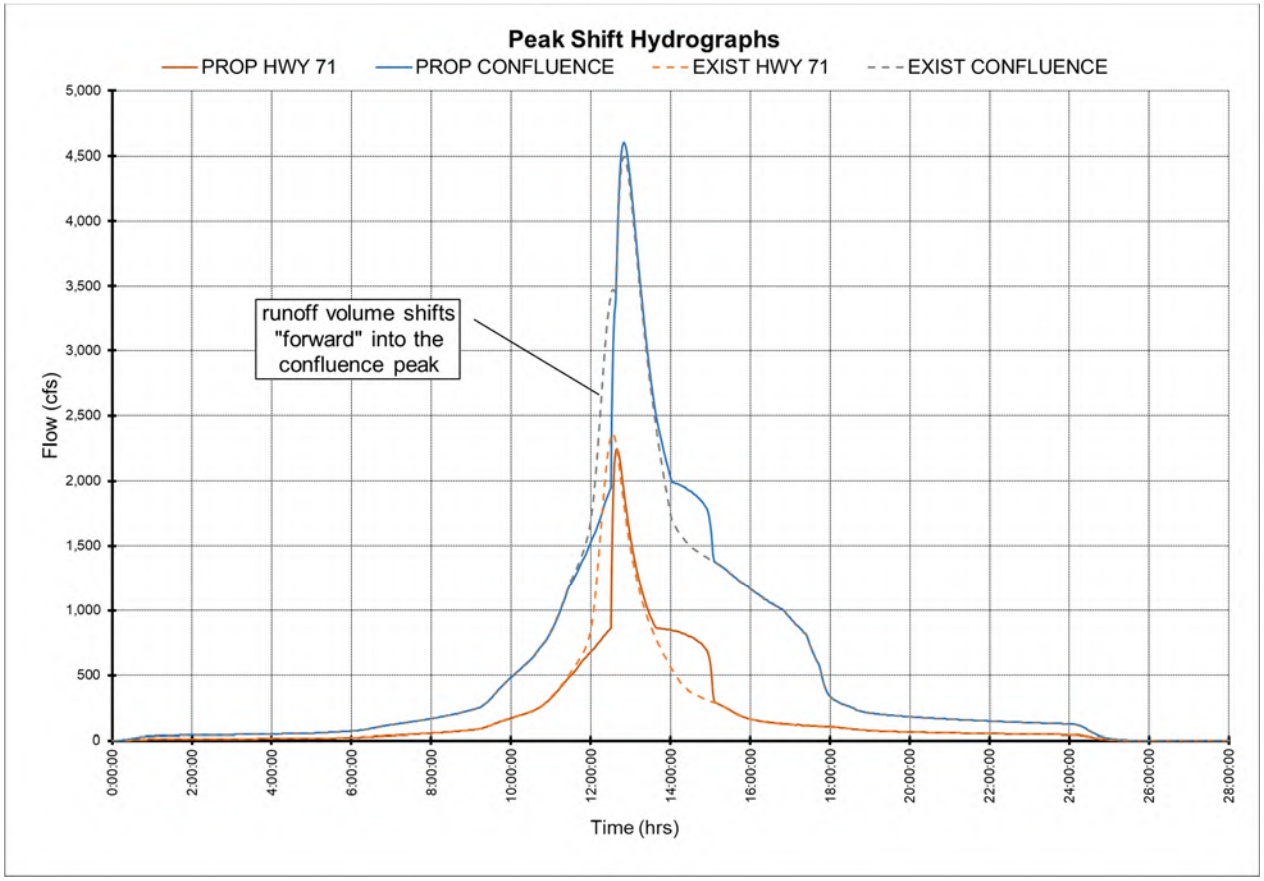


Figure 10 - Peak Shift Hydrograph

Due to the significant influence of the existing Oak Hill facility on the downstream flows, it was determined that an analysis of potential modifications to this facility should be pursued. The effective HMS model, provided by the COA, represents the Oak Hill storage facility via a series of rating curves. The model notes indicate that these curves were developed by Espey Consultants, Inc based on the COA 2003 LIDAR data. It is important to note that reservoir modeling in HEC-HMS (v 3.5) falls into one of two major categories, direct input from outside data, such as ratings curves or gage data, or geometric input which is the defining of individual components of a reservoir from which the software will then generate a rating curve. Therefore, in order to evaluate possible alternate dam configurations for this facility, such as invert changes, outlet redesign, or spillway modifications, it is necessary to switch from the direct input method used in the effective model to a geometric input. Subsequently, the COA provided TNP with data collected from a 2007 Freese & Nichols, Inc (FNI) Dam Safety Study. This data included a stage-discharge rating curve, as well as geometric data, such as a top of dam profile, and basic information on the outlet works including culvert size, length and invert elevations. Since the updated data did not include any storage information for the facility, TNP developed an updated stage-storage curve using the 2012 COA LIDAR. Using the FNI dam data, a new geometric reservoir was modeled in HMS with the dam modeled "as-is" creating a baseline for comparison.

Using this geometric baseline model, several modifications to the existing Oak Hill facility were analyzed, including adjusting the size of the outlet culvert, creating a secondary spillway, and adjusting the dam profile. The only analysis modification found that mitigates downstream impacts requires raising the elevation of the dam. This modification is not recommended due to the risk of affecting flood elevations on adjacent properties. Since no modifications to the existing Oak Hill facility were deemed viable and the rating curve provided by FNI produced higher discharges from the facility than the geometric alternative, all subsequent analyses proceeded using the FNI rating curve.

TNP also analyzed several alternative configurations of the proposed HWY71 facility to determine if the timing of the discharge hydrograph could be shortened or lengthened. TNP determined there is not enough storage in HWY71 facility to lengthen the discharge hydrograph timing. Alternately, releasing discharge more quickly from the HYW71 facility does lessen downstream impacts by shortening the hydrograph timing.

TNP then examined the results of removing the HWY71 facility, while retaining the OBC facility, and compared them to the previous proposed scenario that included both the HWY71 and OBC facilities. These results are found in Table 7. Removing the HWY71 facility produces a peak discharge reduction downstream of the Oak Hill facility as opposed to the increase that occurs if the HWY71 facility is retained. Further downstream in the project area, the peak discharge reductions are not as great after removal of HWY71 than when including HWY71, although there are still substantial peak discharge reductions in the project area. The discharges from this design scenario in which the HWY71 facility is removed, have also been applied and analyzed in the hydraulic modeling. These results are discussed in Section 8 of this Technical Memorandum.

Table 7 - Comparison of Peak Flows (cfs) With and Without HWY 71 Detention

HEC-RAS XS	HMS Node	Existing Atlas 14 Update	Proposed 100 Atlas 14 Update with both HWY71 and OBC Facilities	Difference	Proposed 100 Atlas 14 Update without HWY71 Facility and with OBC Facility	Difference
4031	JWCR90A	2091	2091	0	2091	0
90177	OAK HILL	2821	2821	0	2821	0
89063	JWCR50	4564	4664	100	4564	0
84632	JWCR60	6229	5632	-597	5550	-679
79948	JWCR80	10053	8635	-1419	9224	-829
75171.9	JWCR1050	13049	12121	-928	12516	-533
75017	JWCR1050	13049	12121	-928	12516	-533
67082	JWCR1040	13679	12760	-919	13174	-505
59867	JWCR100	14388	13449	-939	13892	-496
55940	JWCR160	27311	26601	-710	26912	-399
50574	JWCR130	30304	29671	-633	29950	-354
49429	JWCR120	30909	30294	-615	30559	-350
46107	JWCR1170	30977	30351	-626	30628	-349
43122	JWCR1000	32429	31883	-546	32113	-316
37465	JWCR103	32648	32117	-530	32344	-304
30000	JWCR360	33283	32752	-530	32983	-300
23527	JWCR880	33882	33360	-522	33588	-294
17814	JWCR370A	34029	33499	-530	33729	-300
13810	JWCR370	34115	33587	-528	33817	-297
7301	JWCR3900	34480	33954	-526	34181	-300
4393	J400W	34528	34000	-527	34229	-299
2454	JWCR400	34951	34436	-515	34658	-293
618	outlet	34949	34433	-516	34655	-294

8. Mitigation of Hydraulic Impact – Atlas 14 Update, September 2018

Due to the increased existing and proposed flows based on the updated Atlas 14 precipitation data and the removal of the HWY 71 storage facility, a review of the previous hydraulic analysis (Nov-2018 TNP -formerly HHR) determined that the previously proposed crossing designs were insufficient to mitigate the 100-year WSEL increases.

The updated discharges were first applied to the revised existing conditions model to establish the basis for comparison. The flows were then applied to the proposed conditions model, which reflects the project’s approved schematic design, or ‘Concept A’ as described in the November 2018 report. The incorporation of updated discharges resulted in the inundation of most proposed bridge crossings in the project area by the 100-yr event flows and of the roadway profile at the design flood in multiple locations. These inundations resulted in several areas showing a rise in WSELs compared to existing conditions. Further revisions to the bridge designs and overbank mitigations are necessary to reduce these impacts to proposed conditions.

8.1. Hydraulic Modeling

8.1.1. Revised Existing Conditions

Applying the updated Atlas 14 flows to the revised existing conditions model results in an overall increase in WSELs throughout the stream reach under consideration, ranging from 0.06’ to 2.18’ higher than in previous existing conditions modeling. In the previous modeling, the US 290 bridge crossing was inundated by the 100-year event; with the updated discharges, the inundation depth increases by 0.41’ for the 100-year event. In previous modeling the William Cannon existing bridge was also inundated by the 100-year event; the inundation depth increases by 0.53’ with the updated discharges. The existing low water crossing at Old Bee Cave Road had an inundation depth of 9.01’, and with increased flows, the inundation is now increased to 9.28’. The WSEL above the Highway 71 crossing has also increased by 1.76’. This results in inundation of the low chord for this crossing, whereas the previous modeling had 0.58’ of freeboard during the 100-year event.

8.1.2. Proposed Conditions Revisions

In the previous hydraulic analysis (Nov-2018 TNP – formerly HHR), preliminary bridge openings were designed to meet the service levels for proposed improvements by establishing low chords, span lengths and abutment designs necessary to meet the design criteria. The original design criteria established a 25-year event service level for all frontage roads and a 100-year event service level for all main lane roadways. In this latest reassessment the design requirements were further refined by the TxDOT Austin District. The previous design service level of 25 years for all frontage roads was retained while the main lanes now require a 50-yr service level with one-foot minimum freeboard below bridge low chords. An exception applies at Old Bee Cave bridge, where TxDOT requested one-foot minimum freeboard above the 100-yr WSEL, due to a commitment to the City of Austin. Mitigation of potential impacts due to increases in WSEL are still based upon the 100-yr discharge.

Applying, the increased Atlas 14 flows necessitated several design adjustments along Williamson Creek. Various bridge configurations and profile changes were applied to the frontage road and main lane alignments; proposed overbank grading and channel benching were altered, added, or expanded to increase conveyance. While most modifications to the bridge crossing profiles were required in order to meet minimum hydraulic design criteria, other considerations beyond hydraulic performance, such as intersection connections, clearances, and relocation of the shared use the path, resulted in roadway/bridge profile adjustments. TNP used schematic profile data and typical sections where available, but due to the preliminary nature of the design, some assumptions were necessary.

US 290 Main Lane and Frontage Road Grouped Crossings

The US 290 crossing at Williamson Creek, which consists of the eastbound frontage road bridge, the west bound main lane bridge, the eastbound main lane bridge, and the westbound frontage road bridge, required several design changes to produce a mitigated condition for 100-year flows based on Atlas 14 data. The increased flows result in a submerged low chord at both the eastbound and westbound frontage road bridges. These pressure flow transitions adversely affect the proposed water surface profile contributing to significant upstream rise.

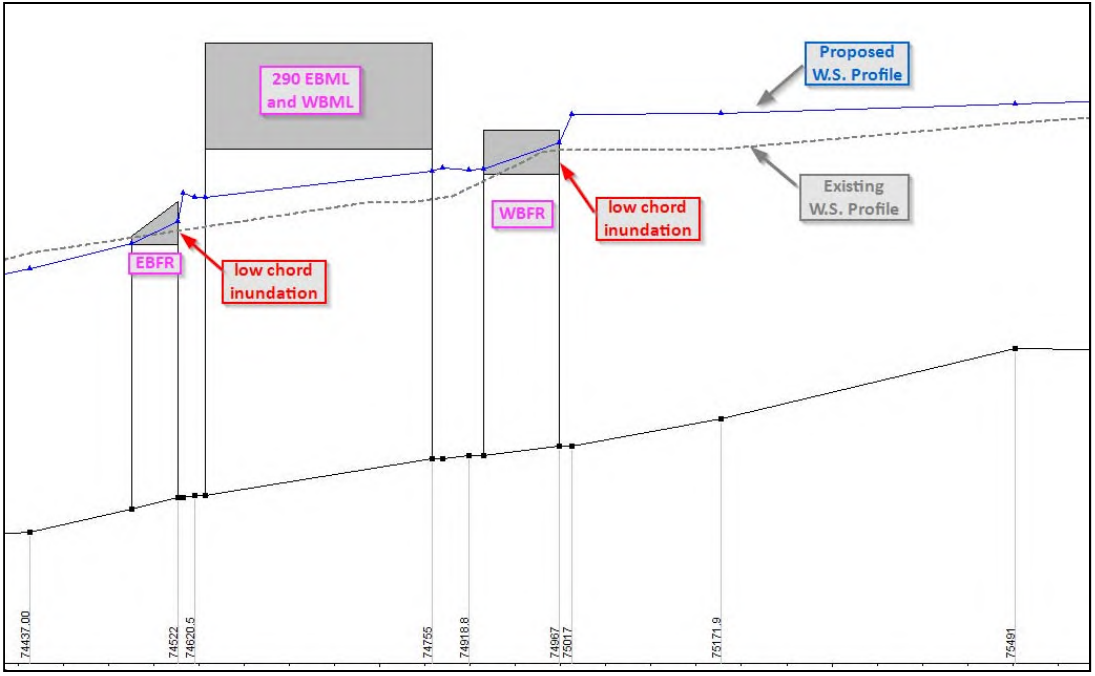


Figure 11 - Backwater Rise with Low Chord Inundation

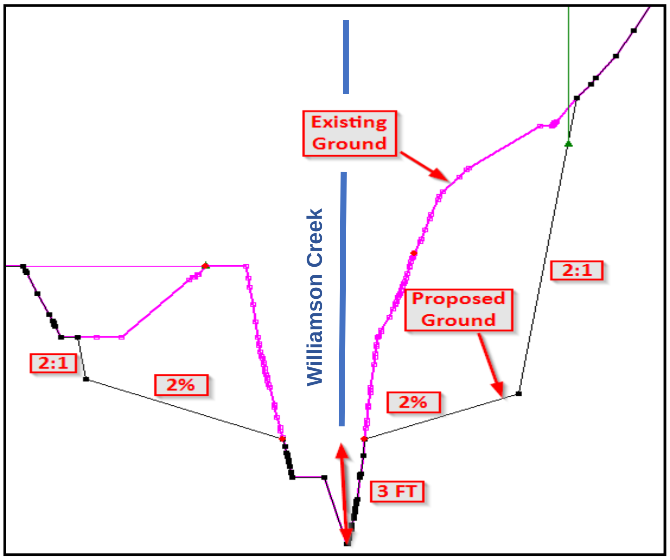


Figure 12 - Overbank Grading Details

Initial grading modifications were applied in the vicinity of the US 290 bridges. Originally, the overbank mitigation grading began at the bank point located approximately 5 feet above the channel bottom, and the overbank grading extended at a slope of 2% or greater to maintain proper drainage to the channel. In order to increase conveyance further this grading was dropped to 3 feet above the creek flowline. These graded areas used catch slopes ranging from 3:1 to 2:1 depending on location needs.

In addition to these changes, right-of-way and easement limits necessitated alterations to the overbank grading boundaries in areas up and downstream of the 290 crossings, resulting in several areas being reduced.

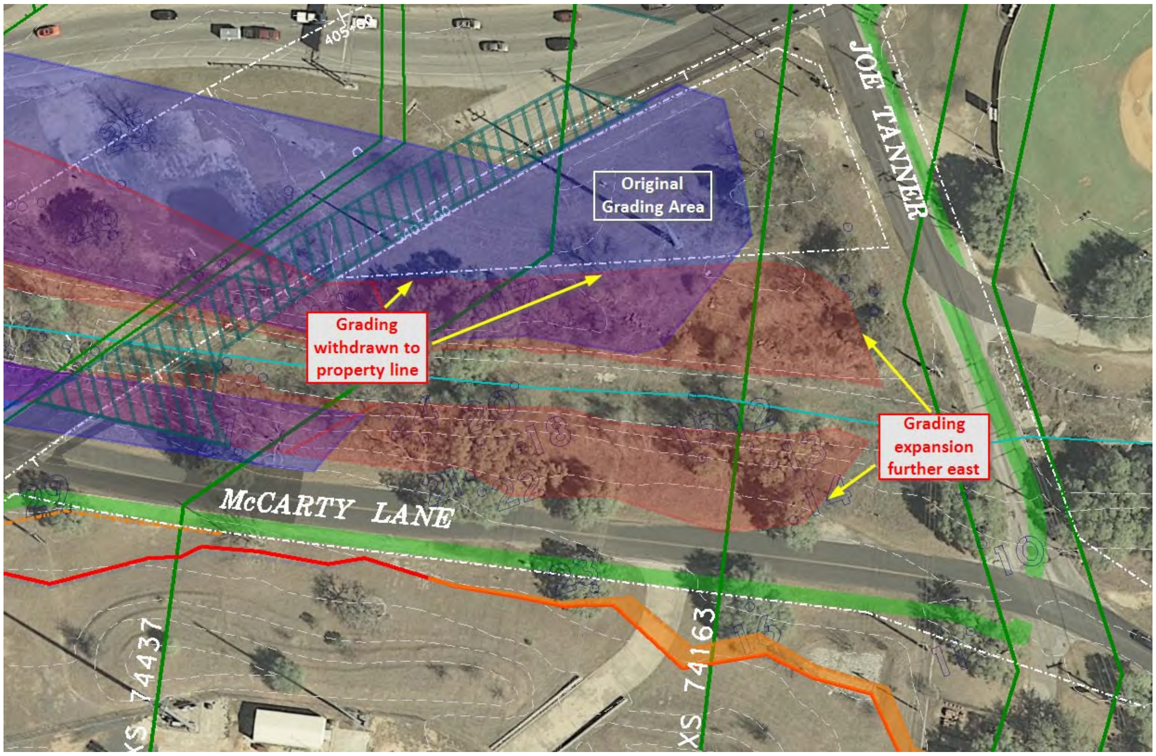


Figure 13 - Overbank Grading Changes Downstream of US 290

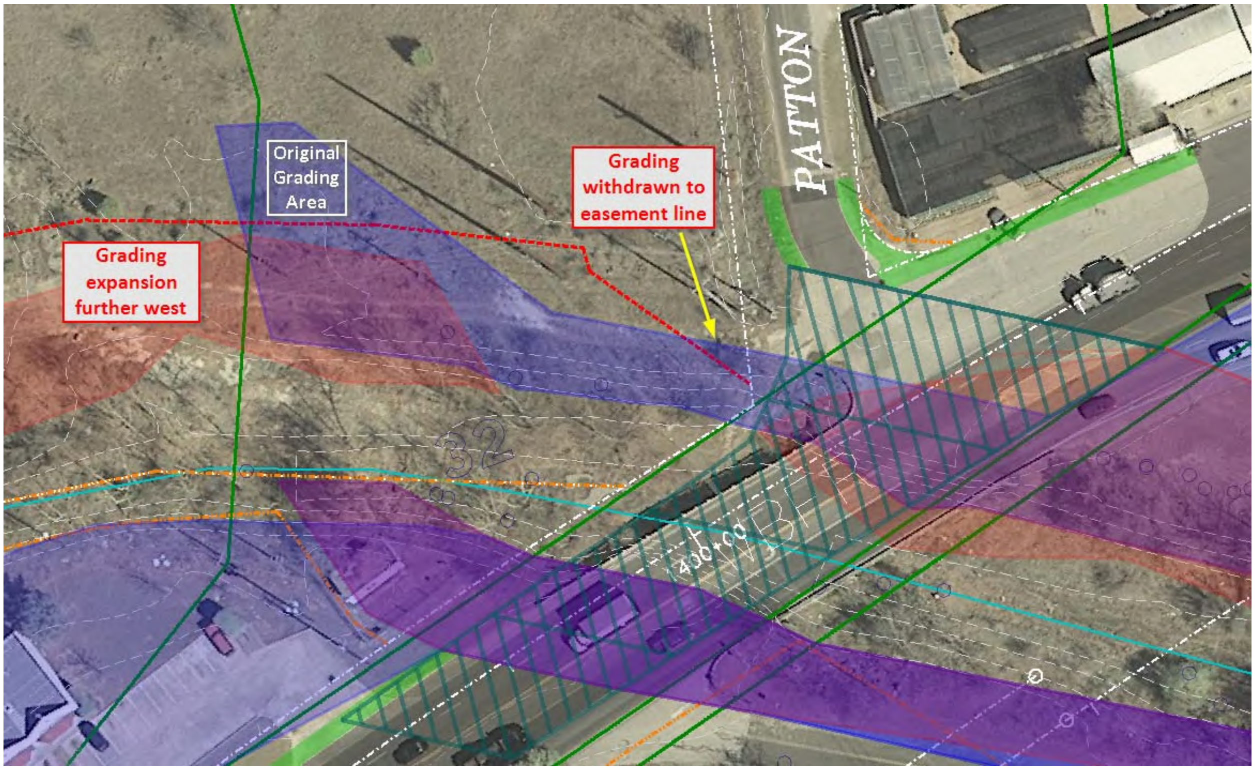


Figure 14 - Overbank Grading Changes Upstream of US 290

Even with these overbank modifications applied throughout the crossings, the increased conveyance from grading alone is not sufficient to mitigate all proposed impacts.

The following structural design changes were applied to further mitigate beyond grading. Both the eastbound and westbound frontage road bridge profiles were raised until the low chords were no longer inundated. Additionally, the main lane bridge design is significantly modified from the previous design iteration. In the previously modeled design, the main lane bridges began at approximately STA 400+00 and ended at approximately STA 404+00. In the revised schematic design, both the east and westbound main lanes crossings have been altered to serve as continuously raised lanes beginning at STA 394+00. This elevated main lane crossing allows more overbank conveyance than previously modeled under US 290. This is reflected in the HEC-RAS modeling as continuous bridge to the west with no abutment structure, an east bank abutment with a 2:1 catch slope transitioning back to roadway on infill, and 36-inch diameter columns for interior bents.

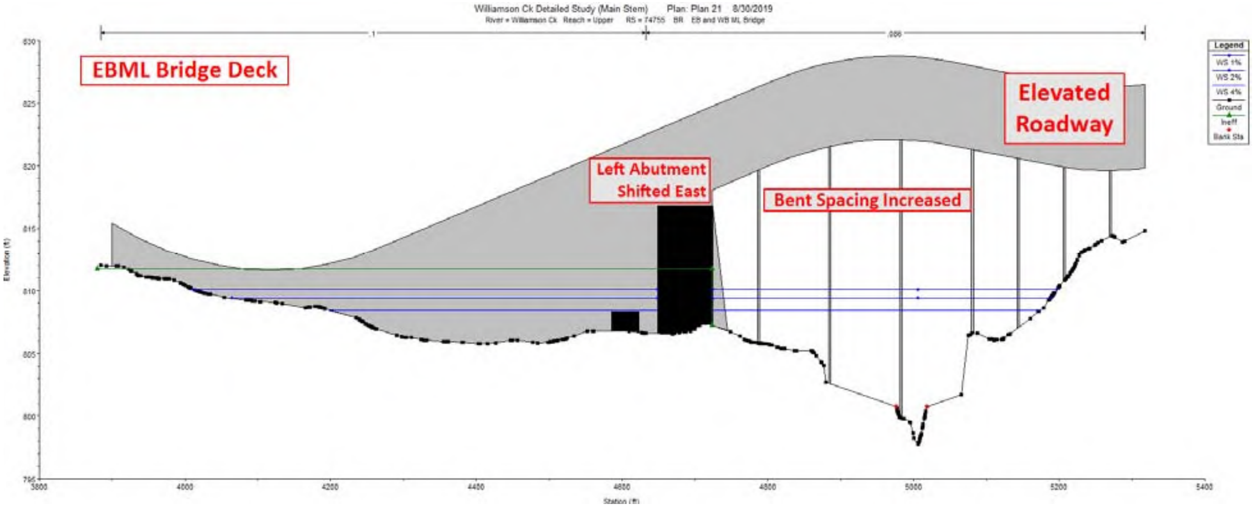


Figure 15 - Main Lane Structural Details

Despite higher roadway profiles and expanded overbank grading, persistent WSEL increases upstream of the proposed 290 crossings remain. It was ultimately determined that significant mitigation could be achieved if the westbound frontage road bridge could be extended 56 feet further to the west. The previous bridge began at WBFR station 1398+97 and ended at station 1401+81, for a total bridge length of approximately 284 feet. The extended WBFR bridge beginning station shifts to the west, starting at WBFR station 1398+41, with a new total bridge length of 340 feet.

In addition to expanding the westbound frontage road bridge, alternate span configurations were analyzed for each crossing. For the EBFR bridge the approximately 7 – 60’ spans were reconfigured in a 70’–90’–90’–90’–70’ arrangement; this reduction in number of bents and associated columns produced additional upstream impact reductions. The main lane pier spacing was also adjusted from its previous configuration using 75’ continuous spans to 90’ continuous spans from the west, with three expanded spans directly over Williamson Creek of 145’ and a final 100’ span adjacent to the eastern abutment. The expanded WBFR was altered from its original 5 – 55’ span configuration to 4 – 85’ spans as a final layout. All final recommended bridge configurations are found in Table 9-16.

These design modification in total result in the elimination of all WSEL impacts directly upstream of the grouped 290 crossings, while each structure also meets the level of service required. However, raised roadway profiles in the overbank area on the east bank downstream of the eastbound frontage road bridge have resulted in an increased water surface elevation in cross-sections 73862, 73960, 74022, and 74163. This area, just upstream and downstream of the existing Joe Tanner low water crossing, modeling indicates increased WSEL’s for the 100-year event, ranging from 0.08’ to 0.64’. With the areas immediately up and downstream of this isolated rise showing a lower proposed WSEL, it can be assumed that the resulting impact in this area would be minimal. Further evaluation of the surrounding property does not show any apparent roadway inundation or impact to any nearby structures. An approximate location of the 100-year inundation impact can be seen in Exhibit A-2. Despite expanding the overbank grading, TNP is unable to achieve the strict no rise result at these downstream cross-sections. With detailed survey of the banks and channel, this isolated rise in WSEL may be resolved in final project design.

William Cannon Drive Bridge

The previous proposed design for the William Cannon Drive bridge is no longer sufficient to mitigate impacts from the updated Atlas 14 discharge, which results in a submerged low chord at the upstream face of bridge. This condition results in a significant rise in WSELs immediately upstream of the crossing. Overbank modifications lowering the benching level from 5 feet above to 3 feet above the existing flowline were applied in the sections up and downstream of the crossing, mitigating some of the impacts. In addition, the bridge profile has been raised, the bridge length was extended by approximately 40 feet, and, due to limited right-of-way in the vicinity of this crossing, the bridge was shifted approximately 25 feet southeast. The previous abutment design slope of 2:1 on the left bank (north) remains unchanged, while a vertical abutment on the right bank (south) has been added. The previous span configuration of 5 – 40’ spans was also revised to 4 – 50’ spans.

Despite the elimination of the submerged low chord and the increased conveyance due to overbank grading and bridge expansions, impacts were still present in several upstream cross-sections. Additional overbank grading, using the lowered 3-foot benching design, was applied in the left overbank in an area spanning WBML station 372+00 to station 377+00, and in the right overbank area from EBML station 371+00 to station 377+00. This additional grading further mitigates the impacts due to proposed development, resulting in no increased water surface elevations directly upstream of the bridge between the William Cannon crossing and the westbound main lane flyover.

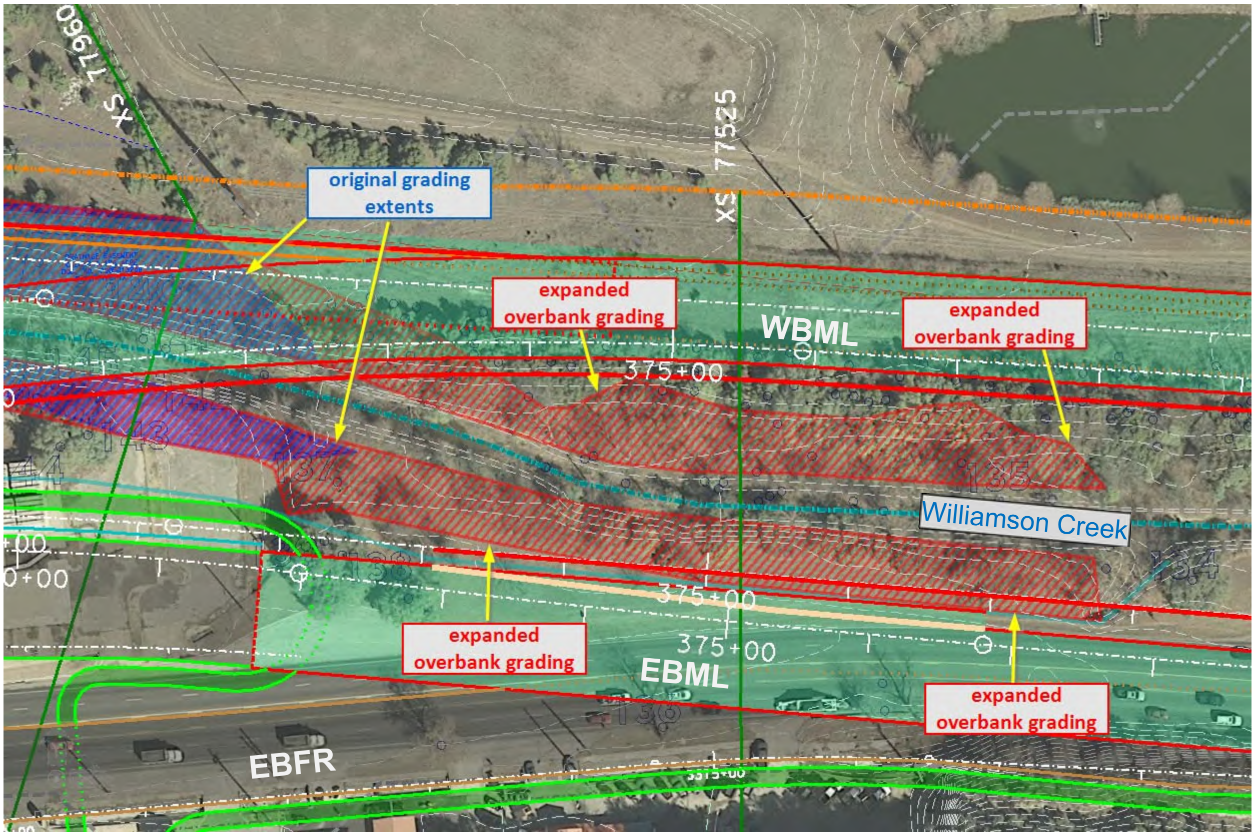


Figure 16 - Additional Overbank Grading Upstream of William Cannon Bridge

<u>Westbound Main Lane Flyover</u>

As discussed in detail in the previous analysis, the schematic ‘Concept A’ design calls for a shift of the westbound main lanes to the north bank of Williamson Creek. The resulting main lane flyover structure is proposed just east of the Old Bee Cave bridge crossing. Overbank grading modifications from the previous 5-foot design have been lowered to the 3-foot benching design and applied to cross-sections 77960 through 78502. In addition to the grading changes, a proposed extension of the flyover bridge by approximately 120’ to the southwest has also been incorporated. These improvements adequately mitigate the impacts due to proposed development resulting in no increased water surface elevations between the westbound main lane flyover and the Old Bee Cave Road crossing.

<u>Old Bee Cave Road Bridge</u>

In the previous analysis, initial design assumptions used to develop the Old Bee Cave crossing were outlined in detail. These same assumptions have been applied to the Atlas 14 update analysis. In addition to updating the discharges, the overbank grading boundaries upstream of the crossing were reduced significantly due to limited right-of-way. These changes result in a submerged upstream low chord and a rise in WSELs in several upstream cross-sections. Therefore, a lower benching level of 3 feet above the flowline was applied throughout this crossing, an extension of the bridge of approximately 60 feet further west, and the bridge was shifted approximately 6 feet north to optimize conveyance and remain within the right-of-way. Even with grading and bridge expansion an increase from previous design in the upstream low chord elevation was required in order to achieve the minimum freeboard over the 100-year WSEL. The previous span configuration of 3-105’ spans was altered for the newly expanded bridge to 4-95’ spans. As discussed in the previous analysis, the proposed improvements still require that a more natural stream thalweg be established to maintain a stable stream channel geometry and provide for a feasible bridge structure. Various other iterations, including altered abutment designs, alternative span lengths, and further expanded bridge lengths, have also been considered but are mostly ineffective. It was determined that the most effective mitigation occurs when overbank grading is widened to the south (right) overbank just downstream of the proposed bridge.

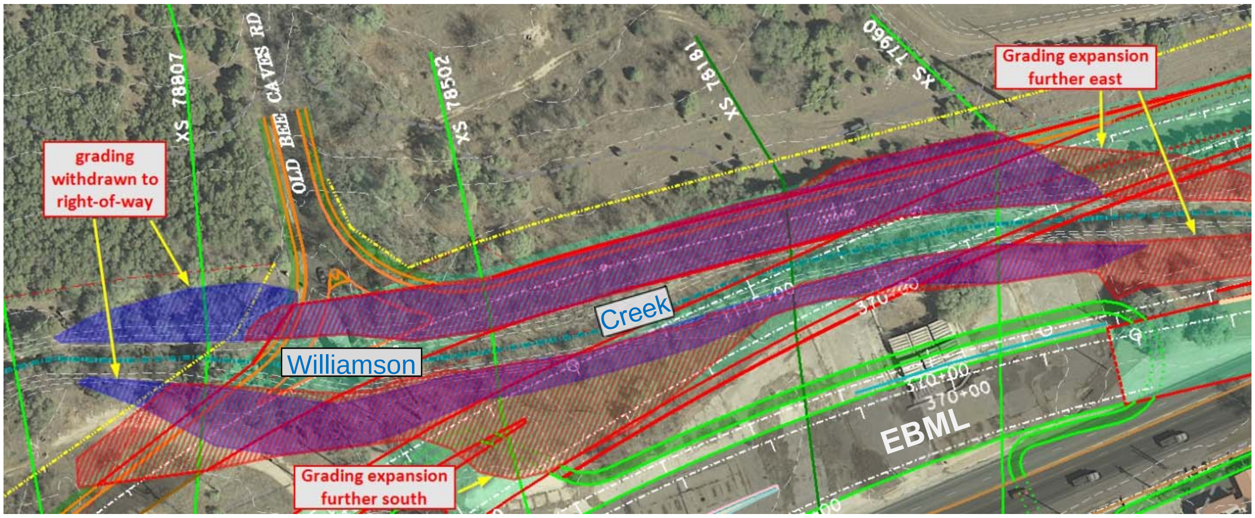


Figure 17 - Grading Modifications near Old Bee Caves Bridge and WBML Flyover

While alterations to the bridge configuration and expanded overbank grading resulted in a reduction of impacts, they did not eliminate all WSEL impacts upstream of the proposed crossing. Despite these mitigation efforts, a rise of 2.75’ remains at the upstream face of the proposed Old Bee Cave Bridge, at cross-section 78807, and a 0.12’ at cross-section 78807. However, a 0.34’ drop in WSEL at cross-section 79948 and a 0.97’ drop at cross-section 78502 downstream of the bridge indicate this rise is isolated to the area immediately upstream of the proposed bridge.

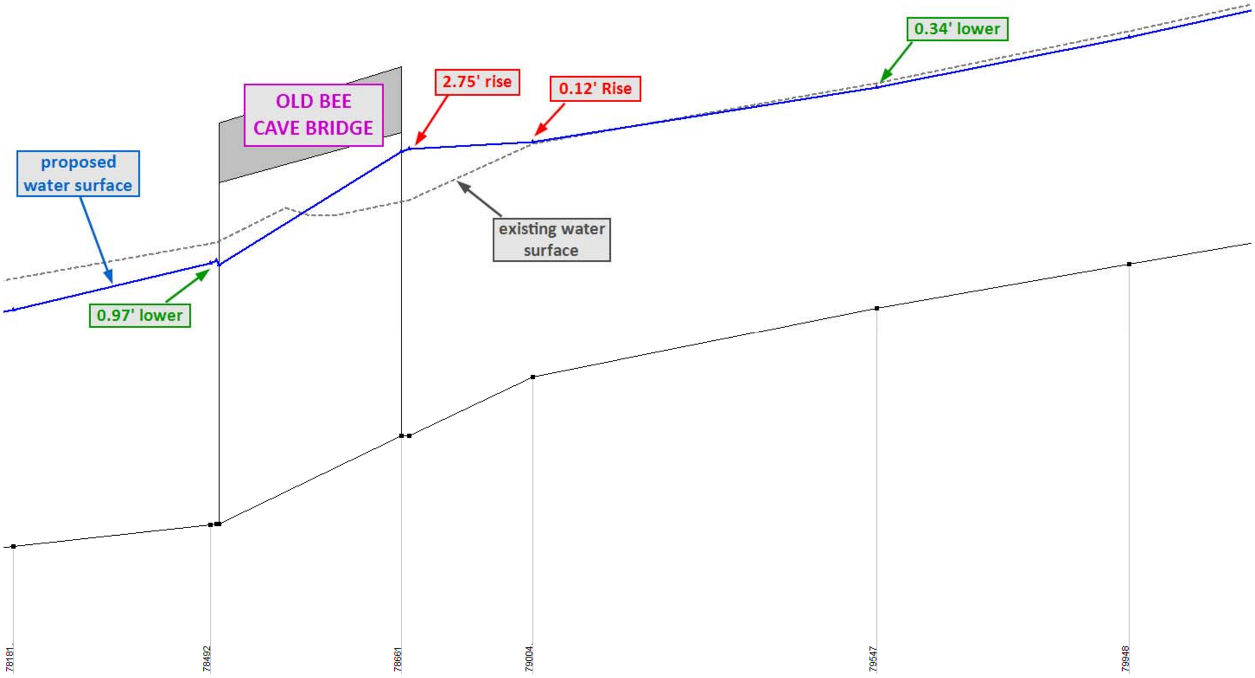


Figure 18 - Old Bee Cave Bridge Backwater Rise

The adjacent properties do not appear to have any insurable structures that would be adversely impacted by this isolated area of rise. Preliminary inundation mapping in Figure 19 show an approximate area of minor impacts due to these isolated sections of rise. As stated previously, with detailed survey of the banks and channel, these increases may be resolved in the final project design.

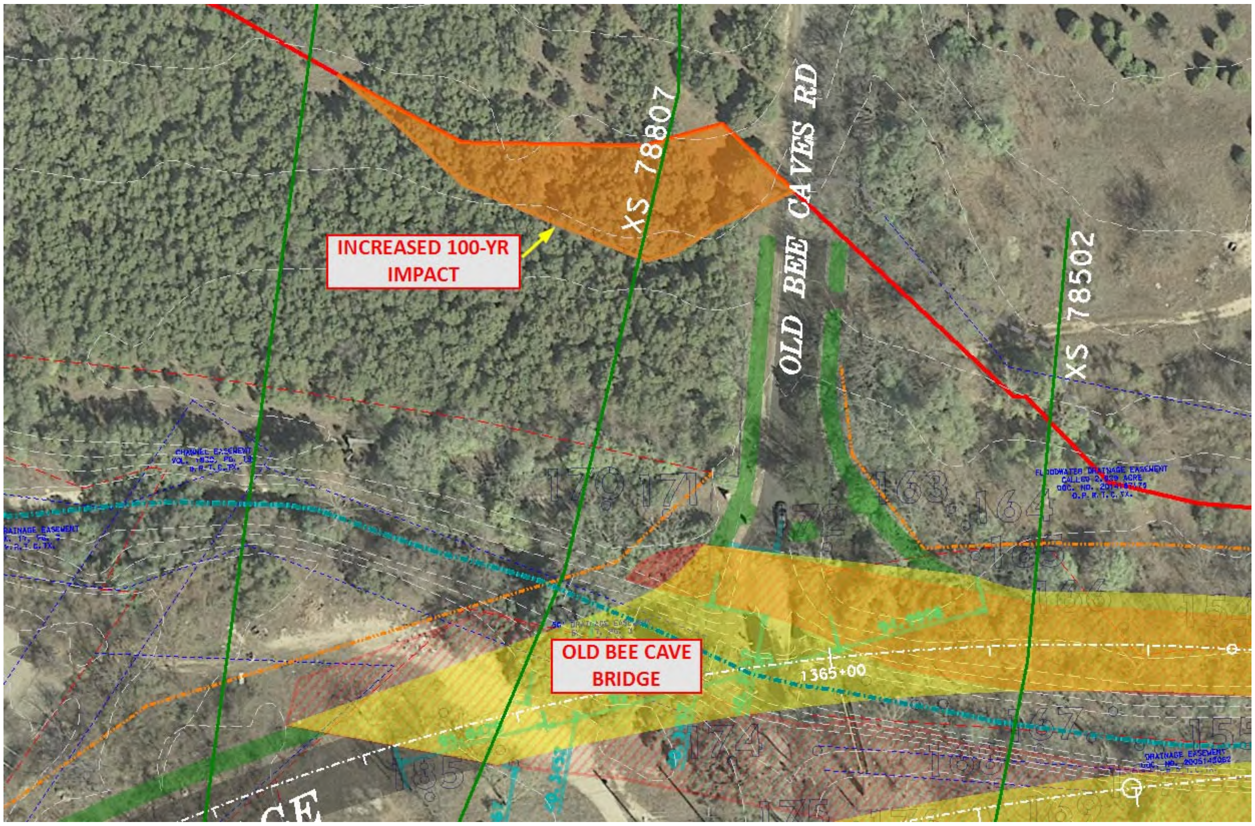


Figure 19 - Impact Areas due to Old Bee Cave Bridge Backwater Rise

State Highway 71 Bridge

Applying updated Atlas 14 flows to the proposed SH 71 crossing design results in a submerged upstream low chord. This chord inundation increases WSEL's upstream of the crossing. Due to this impact as well as tree preservation efforts along the banks of the creek, this bridge crossing modeling was revised. Originally, the bridge was modeled as one structure, expanded in width to accommodate the proposed roadway section. Modeling two parallel bridges allows for a more individualized design of abutments, piers, and overbank mitigation efforts for each bridge. Additional cross-sections and section modifications were made to both the existing and proposed models. The original proposed HWY 71 bridges were both defined as 100 feet long with four 25-foot spans. As outlined previously for other crossings, overbank benching has been lowered to 3 feet above the flowline and applied to both the EBFR and WBFR bridges. Despite this additional conveyance, the low chord of both the EBFR and WBFR remained inundated. Ultimately further profiles adjustments and lengthening of both bridges were applied to eliminate the impacts to the WSEL profile. The final WBFR bridge configuration has a total length of 120 feet with four 30-foot spans. The final EBFR bridge is modeled with a total length of 180-feet and four 45-foot spans. Because the EBFR bridge is skewed approximately 43 degrees, the effective lengths and span openings of both bridges are the same. In order to preserve the trees between the two proposed structures, overbank grading has been limited as much as possible in the right overbank area of each bridge.

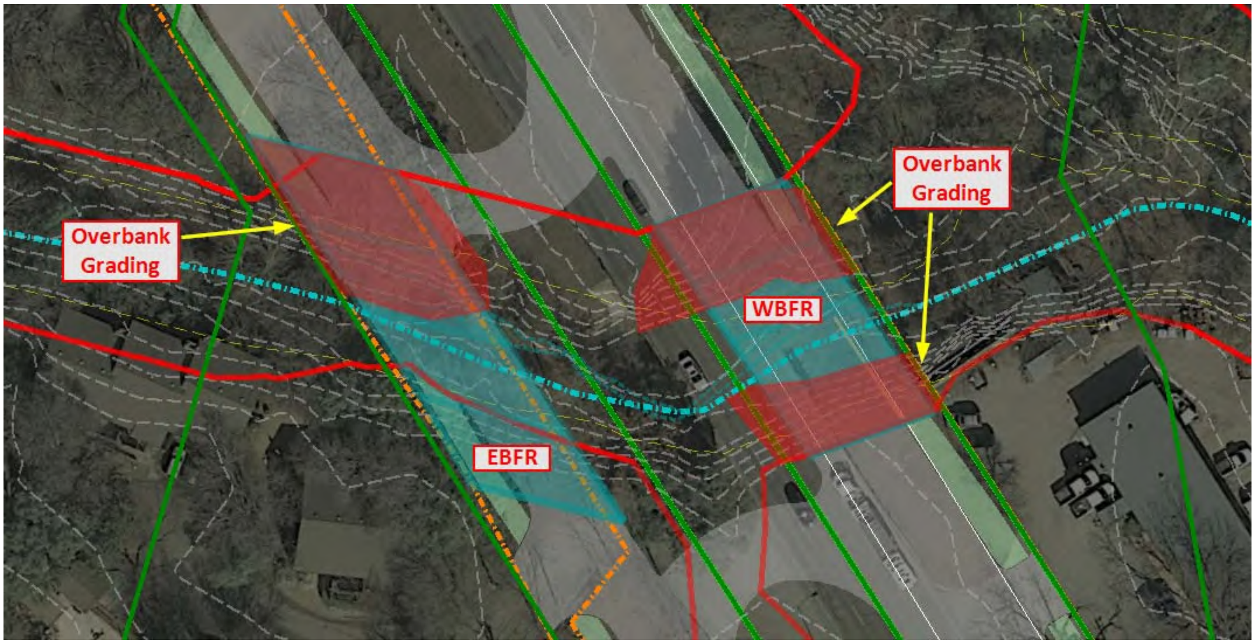


Figure 20 - Overbank Grading near HWY 71 Eastbound and Westbound Bridges

Overbank Obstructions

Minor modifications have been made to some overbank obstructions in this updated analysis to reflect the latest schematic profiles, the expansion of the west bound main lane flyover approximately 120 feet to the west, and the conversion of infill to elevated roadway on the west bank of Williamson Creek at the US 290 grouped crossings. These obstructions appear in the right and left overbanks of cross-sections in the area of the proposed roadway profile changes. Typically, the obstructions represent either the roadway fill associated with the new structure, or the roadway support structures that will be used to elevate main lanes in various locations along the corridor. In areas where roadway profiles were modified there were typically only minor adjustments to elevation or obstruction extent. However, there is one area where significant change from our previous design occurs in the cross-sections downstream of the grouped US290 crossings. The elevations of obstructions in the left overbank were raised significantly, to reflect roadway and bridge profile changes that were needed to maintain the required levels of service. As discussed previously in this memo, these expanded obstructions result in some minor WSEL impacts in the cross-sections immediately adjacent to the existing Joe Tanner low water crossing. These minor impacts were not ultimately mitigated but appear to have no adverse effect on existing roadways or structures. In addition to roadway structures several new obstructions were added representing the water quality ponds associated with the preliminary water quality design developed by K Friese & Associates. These pond structures were set at or above the 100-year event WSEL in order to prevent inundation during that event as required.

Main Lanes Berm

As outlined in the previous report, the proposed hydraulic design includes a berm intended to prevent inundation of a depressed section of roadway. The previous configuration extended along the WBML of US 290 for approximately 350 linear feet with a maximum height of 2.5 ft and was modeled in HEC-RAS as a levee. Due to changes in the water surface elevations in this section of the design the levee elevations were increased slightly to maintain the 100-year level of service. Table 8 shows the approximate modified levee profile.

Figure 21 - Berm Plan View

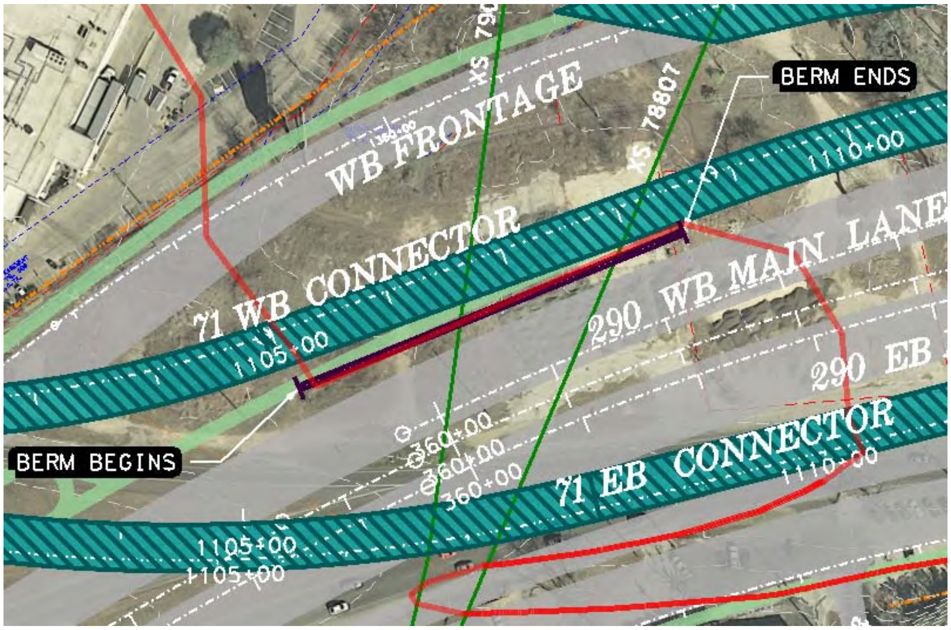


Table 8 - Levee Profile (US 290 WBML Alignment)

Levee Profile	
STA	ELEV
359+00	841
361+00	841
361+75	840
362+25	839

Williamson to Barton Watershed Overflows

It was determined that overflow from the Williamson Creek watershed into the Barton Creek watershed occurs above an elevation of 809, which corresponds to a low point in Patton Ranch Road. Updated Atlas 14 flows show that this overflow is currently occurring in as low as the 10-year flooding event, which has a peak WSELEV of 810.21. The recommended US 290 Crossing design has resulted in a WSELEV of 809.00 during the 10-year event. It is estimated that the proposed design will result in reduced overflow into Barton Creek watershed, which will occur during all events greater than a 10-year event.

8.2. HEC-RAS Modeling Results and Recommendations

The recommended design configuration necessary to meet conveyance criteria and to limit WSEL increases during the 100-year frequency event are outlined in the following tables.

Table 9 - US 290 EBFR Bridge Details

US 290 EB Frontage Road Bridge		
Specifications		
Beginning Station	3401+70	
End Station	3405+80	
Total Length	410'	
Pier Width	2'	
Span Configuration	70' - 90' - 90' - 90' - 70'	
Hydraulic Performance		
	DS	US
Low Chord Elev	812.63	813.19
25-yr WSEL	807.14	807.90
50-yr WSEL	807.87	808.71
100-yr WSEL	808.41	809.33

Table 10 - US 290 WBFR Bridge Details

US 290 WB Frontage Road Bridge		
Specifications		
Beginning Station	1398+41	
End Station	1401+81	
Total Length	340'	
Pier Width	2'	
Span Configuration	85' - 85' - 85' - 85'	
Hydraulic Performance		
	DS	US
Low Chord Elev	813.6	813.46
25-yr WSEL	809.60	810.47
50-yr WSEL	810.44	811.37
100-yr WSEL	811.10	812.06

Table 11 - EBML US 290 Bridge Details

US 290 EB Main Lane Bridge	
Specifications	
Beginning Station	--
End Station	405+00
Total Length	--
Pier Width	3'
Span Configuration	145' - 145' - 145' - 100'
Hydraulic Performance	
Low Chord Elev	818.08
25-yr WSEL	808.46
50-yr WSEL	809.38
100-yr WSEL	810.11

Table 12 - WBML US 290 Bridge Details

US 290 WB Main Lane Bridge	
Specifications	
Beginning Station	--
End Station	405+00
Total Length	--
Pier Width	3'
Span Configuration	145' - 145' - 145' - 100'
Hydraulic Performance	
Low Chord Elev	817.9
25-yr WSEL	809.59
50-yr WSEL	810.47
100-yr WSEL	811.18

Table 13 - William Cannon Bridge

William Cannon Bridge		
Specifications		
Beginning Station	22+23	
End Station	24+33	
Total Length	~210'	
Pier Width	2'	
Span Configuration	50' - 50' - 50' - 50'	
Hydraulic Performance		
	DS	US
Low Chord Elev	821.32	821.32
25-yr WSEL	817.15	818.73
50-yr WSEL	817.90	819.62
100-yr WSEL	818.32	820.23

Table 14 - Old Bee Cave Bride Details

Old Bee Cave Road Bridge		
Specifications		
Beginning Station	1362+21	
End Station	1366+51	
Total Length	~380'	
Pier Width	2'	
Span Configuration	95' - 95' - 95' - 95'	
Hydraulic Performance		
	DS	US
Low Chord Elev	835.29	840.83
25-yr WSEL	832.01	837.89
50-yr WSEL	833.11	839.06
100-yr WSEL	833.91	839.94

Table 15 - HWY 71 Westbound Frontage Road Bridge Details

HWY 71 WB Frontage Road Bridge		
Specifications		
Beginning Station	2076+11	
End Station	2077+31	
Total Length	120'	
Pier Width	2'	
Span Configuration	30' - 30' - 30' - 30'	
Hydraulic Performance		
	DS	US
Low Chord Elev	880.00	880.38
25-yr WSEL	877.06	877.26
50-yr WSEL	877.78	877.97
100-yr WSEL	878.45	878.78

Table 16 - HWY 71 Eastbound Frontage Road Bridge Details

HWY 71 EB Frontage Road Bridge		
Specifications		
Beginning Station	4074+51	
End Station	4076+31	
Total Length	~180	
Pier Width	2'	
Span Configuration	45' - 45' - 45' - 45'	
Hydraulic Performance		
	DS	US
Low Chord Elev	880.56	881.63
25-yr WSEL	877.59	877.89
50-yr WSEL	878.30	878.61
100-yr WSEL	879.29	879.74

The following Table 17 summarizes the HEC-RAS model results after incorporating the Atlas 14 discharge updates, and the mitigation measures described in the previous section.

Table 17 - HEC-RAS 100-year Results

HEC-RAS	EXISTING		PROPOSED		Change
RIVER	Q	WSELEV	Q	WSELEV	
STATION	(cfs)	(ft)	(cfs)	(ft)	
90177	2821	921.14	2821	921.14	0
89560	2821	915.15	2821	915.15	0
89063	4564	913.44	4564	913.44	0
88954	4564	913.4	4564	913.4	0
88894 COVERED BRIDGE D					
88832	4564	910.04	4564	910.04	0
88697	4564	909.42	4564	909.42	0
88042	4564	904.3	4564	904.3	0
87893	4564	902.95	4564	902.95	0
87863 PRIVATE DAM					
87831	4564	902.33	4564	902.33	0
87631	4564	900.62	4564	900.62	0
87444	4564	899.9	4564	899.9	0
87419 PRIVATE DAM					
87387	4564	899.74	4564	899.74	0
87324	4564	898.17	4564	898.17	0
87300 PRIVATE DRIVE					
87257	4564	898.83	4564	898.83	0
86718	4564	893.52	4564	893.52	0
86554	4564	893.63	4564	893.63	0
86512 SILVERMINE DAM					
86490	4564	893.28	4564	893.28	0
86455	4564	892.71	4564	892.67	-0.04
86417 SILVERMINE DR					
86383	4564	889.74	4564	889.73	-0.01
86254	4564	889.15	4564	889.14	-0.01
85611	4564	885.3	4564	885.01	-0.29
85045	4564	881.18	4564	880.07	-1.11
84982	4564	880.2	4564	879.92	-0.28
84851.4 STATE HWY 71					
84745	4564	878.85	4564	878.46	-0.39
84632	6229	878.23	5550	877.73	-0.5
83997	6229	875.26	5550	874.75	-0.51
83450	6229	872.55	5550	872.13	-0.42
83310	6229	872.44	5550	872.02	-0.42
83264 PRIVATE DRIVE					
83216	6229	868.45	5550	868.14	-0.31
83088	6229	867.47	5550	867.23	-0.24
82500	6229	864.41	5550	864.17	-0.24
82259	6229	861.52	5550	861.28	-0.24
82227 PRIVATE DAM					
82202	6229	861.51	5550	861.27	-0.24
81951	6229	859.59	5550	859.37	-0.22
81923 PRIVATE DAM					
81903	6229	859.58	5550	859.36	-0.22
81746	6229	858.49	5550	858.06	-0.43
81703 PRIVATE DR					
81655	6229	858.72	5550	858.42	-0.3
81534	6229	857.02	5550	856.8	-0.22
80983	6229	853.3	5550	852.94	-0.36
80345	6229	849.32	5550	848.98	-0.34
79948	10053	846.38	9224	846.04	-0.34
79547	10053	843.58	9224	843.37	-0.21
79004	10053	840.35	9224	840.47	0.12
78807	10053	837.34	9224	840.09	2.75
78661 OLD BEE CAVE RD					
78502	10053	835.09	9224	834.12	-0.97
78181	10053	831.81	9224	831.48	-0.33
77960	10053	831.81	9224	830.25	-1.56
77525	10053	828.51	9224	827.49	-1.02
76871	10053	823.67	9224	821.65	-2.02
76786	10053	823.21	9224	820.8	-2.6
76587. WILLIAM CANNON D					
76285	10053	818.6	9224	818.21	-0.39
75854	10053	815.85	9224	815.65	-0.2
75491	10053	814.8	9224	814.77	-0.03
75171.9	13049	813.63	12516	813.47	-0.16
75017	13049	813.58	12516	812.97	-0.61
MAIN 290 CROSSINGS					
74437	13049	808.84	12516	808.07	-0.77
74163	13049	805.89	12516	806.53	0.64
74022	13049	805.46	12516	805.71	0.25
73988 JOE TANNER RD					
73960	13049	805.13	12516	805.24	0.11
73862	13049	804.36	12516	804.44	0.08
73413	13049	799.71	12516	799.63	-0.08

Despite testing various design iterations, two remaining modeled areas are showing impact due to the proposed Oak Hill Parkway improvements: the rise around the existing Joe Tanner low water crossing, and the backwater rise just upstream of the proposed Old Bee Cave Bridge. Due to their isolated occurrence, these areas of impact are relatively small. Approximate extents of some of these impact areas have been highlighted in Exhibits A-1 and A-2. While a strict no-rise condition could not be achieved in these locations, as stated previously, with detailed survey of the proposed detention sites, stream banks, and channels, these impacts may be resolved in final design. Additional study should be considered by the final design team, such as further analysis of the watershed spill-over occurring near Patton Ranch Road just north the US 290 grouped crossings, as the current study has conservatively assumed no loss of flow from this watershed overflow condition.

Attachment 5 – Geologic Assessment U.S. Highway 290 (US 290) / State Highway (SH) 71 West from State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and SH 71 to Silvermine Drive, Travis County, Texas, CSJ: 0113-08-060 and 0700-03-077 revised November 2019

Geologic Assessment

U.S. Highway 290 (US 290) / State Highway (SH) 71 West from State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and SH 71 to Silvermine Drive

Travis County, Texas

CSJ: 0113-08-060 and 0700-03-077

December 2016; Revised November 2017, August 2018, April 2019,

November 2019

The environmental review, consultation, and other actions required by applicable Federal environmental laws for this project are being, or have been, carried-out by TxDOT pursuant to 23 U.S.C. 327 and a Memorandum of Understanding dated December 16, 2014, and executed by FHWA and TxDOT.

Geologic Assessment

Texas Commission on Environmental Quality

For Regulated Activities on The Edwards Aquifer Recharge/transition Zones and Relating to 30 TAC §213.5(b)(3), Effective June 1, 1999

To ensure that the application is administratively complete, confirm that all fields in the form are complete, verify that all requested information is provided, consistently reference the same site and contact person in all forms in the application, and ensure forms are signed by the appropriate party.

Note: Including all the information requested in the form and attachments contributes to more streamlined technical reviews.

Signature

To the best of my knowledge, the responses to this form accurately reflect all information requested concerning the proposed regulated activities and methods to protect the Edwards Aquifer. My signature certifies that I am qualified as a geologist as defined by 30 TAC Chapter 213.

Print Name of Geologist: Paula Jo Lemonds   Telephone: 512-912-5127

Date: November 26, 2019   Fax: 512-912-5158

Representing: HDR Engineering, Inc. (TBPG Firm No. 50226; TBPE Firm No. F-754) (Name of Company and TBPG or TBPE registration number)

Signature of Geologist:

Paula Jo Lemonds

PAULA JO MUDD LEMONDS
99449

Paula Jo Lemonds
11/27/19

Regulated Entity Name: U.S. Highway 290 (US 290) / State Highway (SH) 71 West from State Loop 1 (Mopac) to Ranch-to-Market (RM) 1826 and SH 71 to Silvermine Drive- Travis County, Texas

Project Information

1. Date(s) Geologic Assessment was performed: March 18, 2016; June 22, 2018; March 14 and 19, 2019; March 29, 2019; April 4 and 9, 2019; November 19 and 20, 2019
2. Type of Project:

   ☒ WPAP
   ☐ SCS
   ☐ AST
   ☐ UST
3. Location of Project:

   ☒ Recharge Zone

☐ Transition Zone
☒ Contributing Zone within the Transition Zone

4. ☒ **Attachment A - Geologic Assessment Table**. Completed Geologic Assessment Table (Form TCEQ-0585-Table) is attached.

5. ☒ Soil cover on the project site is summarized in the table below and uses the SCS Hydrologic Soil Groups* (Urban Hydrology for Small Watersheds, Technical Release No. 55, Appendix A, Soil Conservation Service, 1986). If there is more than one soil type on the project site, show each soil type on the site Geologic Map or a separate soils map.

Table 1 - Soil Units, Infiltration Characteristics and Thickness

Soil Name	Group*	Thickness(feet)
See Attached Table 1		

** Soil Group Definitions (Abbreviated)*

A. Soils having a high infiltration rate when thoroughly wetted.

B. Soils having a moderate infiltration rate when thoroughly wetted.

C. Soils having a slow infiltration rate when thoroughly wetted.

D. Soils having a very slow infiltration rate when thoroughly wetted.

6. ☒ **Attachment B – Stratigraphic Column**. A stratigraphic column showing formations, members, and thicknesses is attached. The outcropping unit, if present, should be at the top of the stratigraphic column. Otherwise, the uppermost unit should be at the top of the stratigraphic column.

7. ☒ **Attachment C – Site Geology**. A narrative description of the site specific geology including any features identified in the Geologic Assessment Table, a discussion of the potential for fluid movement to the Edwards Aquifer, stratigraphy, structure(s), and karst characteristics is attached.

8. ☒ **Attachment D – Site Geologic Map(s)**. The Site Geologic Map must be the same scale as the applicant's Site Plan. The minimum scale is 1”: 400'

   Applicant's Site Plan Scale: 1" = 400'
   Site Geologic Map Scale: 1" = 400'
   Site Soils Map Scale (if more than 1 soil type): 1" = 400'

9. Method of collecting positional data:

   ☒ Global Positioning System (GPS) technology.
   ☐ Other method(s). Please describe method of data collection: _____

10. ☒ The project site and boundaries are clearly shown and labeled on the Site Geologic Map.

11. ☒ Surface geologic units are shown and labeled on the Site Geologic Map.

12. ☒ Geologic or manmade features were discovered on the project site during the field investigation. They are shown and labeled on the Site Geologic Map and are described in the attached Geologic Assessment Table.

    ☐ Geologic or manmade features were not discovered on the project site during the field investigation.

13. ☒ The Recharge Zone boundary is shown and labeled, if appropriate.

14. All known wells (test holes, water, oil, unplugged, capped and/or abandoned, etc.): If applicable, the information must agree with Item No. 20 of the WPAP Application Section.

    ☐ There are _____ (#) wells present on the project site and the locations are shown and labeled. (Check all of the following that apply.)
        ☐ The wells are not in use and have been properly abandoned.
        ☐ The wells are not in use and will be properly abandoned.
        ☐ The wells are in use and comply with 16 TAC Chapter 76.
    ☒ There are no wells or test holes of any kind known to exist on the project site.

Administrative Information

15. ☒ Submit one (1) original and one (1) copy of the application, plus additional copies as needed for each affected incorporated city, groundwater conservation district, and county in which the project will be located. The TCEQ will distribute the additional copies to these jurisdictions. The copies must be submitted to the appropriate regional office.

Table 1 - Soil Units, Infiltration Characteristics and Thickness

Soil Name	Group*	Thickness(feet)
Brackett-Rock outcrop complex, 1 to 12 percent slopes (BlD)	D	Veneer to 1.5 ft
Brackett-Rock outcrop-Real complex, 8 to 30 percent slopes (BoF)	D	Veneer to 1.5 ft
Crawford clay, 0 to 1 percent slopes (CrA)	D	Greater than 6.7 ft
Crawford clay, 1 to 3 percent slopes (CrB)	D	2.7 ft
Denton silty clay, 1 to 3 percent slopes (DeB)	D	3 ft
Pits, gravel, 1 to 90 percent slopes (GP)	-	-
Mixed alluvial land, 0 to 1 percent slopes, frequently flooded (Md)	A	4 ft
Purves silty clay, 1 to 5 percent slopes (PuC)	D	Veneer to 1.5 ft
San Saba clay, 1 to 2 percent slopes (SaB)	D	3.2 ft
Speck stony clay loam, 1 to 5 percent slopes (SsC)	D	1.5 ft
Tarrant and Speck soils, 0 to 2 percent slopes (TcA)	D	Veneer to 1.5 ft
Volente silty clay loam, 1 to 8 percent slopes (VoD)	D	Greater than 6.7 ft

** Soil Group Definitions (Abbreviated)*

- *A. Soils having a high infiltration rate when thoroughly wetted.*
- *B. Soils having a moderate infiltration rate when thoroughly wetted.*
- *C. Soils having a slow infiltration rate when thoroughly wetted.*
- *D. Soils having a very slow infiltration rate when thoroughly wetted.*

Attachment A

Geologic Assessment Table

(TCEQ-0585 Table)

Comments to Geologic Assessment Table

Project and Feature Photographs

GEOLOGIC ASSESSMENT TABLE	**PROJECT NAME:**	U.S. Highway 290 (US 290) / State Highway (SH) 71 West from State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and SH 71 to Silvermine Drive, Travis County, Texas

LOCATION			**FEATURE CHARACTERISTICS**												**EVALUATION**			**PHYSICAL SETTING**		
1A	1B *	1C*	2A	2B	3	4			5	5A	6	7	8A	8B	9	10		11		12
FEATURE ID	LATITUDE	LONGITUDE	FEATURE TYPE	POINTS	FORMATION	DIMENSIONS (FEET)			TREND (DEGREES)	DOM	DENSITY (NO/FT)	APERTURE (FEET)	INFILL	RELATIVE INFILTRATION RATE	TOTAL	SENSITIVITY		CATCHMENT AREA (ACRES)		TOPOGRAPHY
						X	Y	Z		10						<40	≥40	<1.6	≥1.6	
F-1	30° 14' 7.44" N	97° 51' 37.44" W	Z-SF	30	Ked	12	1	0.05	N34E	10	0.1	0.005	N	5	45		X		X	Floodplain
F-2	30° 14' 5.03" N	97° 51' 37.91" W	SC	20	Ked	4	2	0.5	-	0	-	-	O	10	30	X		X		Hillside
F-3	30° 14' 4.38" N	97° 51' 43.45" W	O	5	Ked	15	10	0.1	-	0	4	0.1	N	15	20	X		X		Drainage
F-4	30° 14' 4.09" N	97° 51' 37.26" W	Z-SF	30	Ked	100	30	0.05	N20E	10	0.5	0.1	O	15	55		X	X		Hillside
F-5	30° 14' 8.63" N	97° 51' 41.11" W	F	20	Ked	17	4	1.1	N12E	10	1	0.01	C	20	50		X		X	Streambed
F-6	30° 14' 2.04" N	97° 51' 44.82" W	SC	20	Ked	2	2	4	-	0	-	-	F	36	56		X		X	Hillside
F-7	30° 14' 5.75" N	97° 51' 52.96" W	SC	20	Ked	1.25	0.83	1.75	-	0	-	-	O	5	25	X		X		Hillside
F-8	30° 15' 18.4" N	97° 53' 25.15" W	Z-SF	30	Kgr(u)	3	1	0.05	N5E	0	1	0.05	N	15	45		X		X	Streambed
F-9	30° 15' 2.99" N	97° 54' 1.01" W	Z-SF	30	Kgr(u)	10	1	0.05	N10W	0	2	0.02	N	15	45		X	X		Hillside/Drainage
F-10	30° 13' 43.68" N	97° 53' 11.54" W	SC	20	Kgr(u)	0.75	0.5	3	-	0	-	-	O	5	25	X		X		Hillside
F-11	30° 13' 43.46" N	97° 53' 10.32" W	SF	20	Kgr(u)	2	0.5	0.5	N20W	0	-	-	O	5	25	X		X		Hillside
F-12	30° 13' 42.42" N	97° 53' 4.88" W	SF	20	Kgr(u)	20	1	0.17	N25W	0	-	-	N	25	45		X		X	Streambed
F-13	30° 14' 1.79" N	97° 52' 0.14" W	O	5	Kgr(u)	650	20-70	0	-	0	-	-	N	5	10	X			X	Cliff

* DATUM: WGS84

2A TYPE	TYPE	2B POINTS
C	Cave	30
SC	Solution cavity	20
SF	Solution-enlarged fracture(s)	20
F	Fault	20
O	Other natural bedrock features	5
MB	Manmade feature in bedrock	30
SW	Swallow hole	30
SH	Sinkhole	20
CD	Non-karst closed depression	5
Z	Zone, clustered or aligned features	30

8A INFILLING	
N	None, exposed bedrock
C	Coarse - cobbles, breakdown, sand, gravel
O	Loose or soft mud or soil, organics, leaves, sticks, dark colors
F	Fines, compacted clay-rich sediment, soil profile, gray or red colors
V	Vegetation. Give details in narrative description
FS	Flowstone, cements, cave deposits
X	Other materials

12 TOPOGRAPHY

Cliff, Hilltop, Hillside, Drainage, Floodplain, Streambed

I have read, I understood, and I have followed the Texas Commission on Environmental Quality's Instructions to Geologists. The information presented here complies with that document and is a true representation of the conditions observed in the field. My signature certifies that I am qualified as a geologist as defined by 30 TAC Chapter 213.

PAULA JO MUDD LEMONDS
GEOLOGY
10173

Paula Jo Lemonds

Date 11/27/19

Sheet 1 of 1

TCEQ-0585-Table (Rev. 10-01-04)

Comments to Geologic Assessment Table
U.S. Highway 290 (US 290) / State Highway (SH) 71 West from State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and SH 71 to Silvermine Drive
Travis County, Texas
CSJ: 0113-08-060 and 0700-03-077

Feature F-1
GPS Coordinates: 30° 14' 7.44" N 97° 51' 37.44" W

Feature F-1 is a group of widely spaced fractures within the Williamson Creek streambed located just upstream of US 290. The orientation of the fractures, N34ºE, suggests they may be related to displacement along the Mount Bonnell Fault, which is located a few hundred feet to the northwest. However, these fractures do not appear to be able to convey a significant amount of recharge into the subsurface because fracture apertures are less than one-tenth of one inch and the opposing sides are similar in shape. This suggests that enlargement through dissolution has occurred. The feature is evaluated as a sensitive feature.

Recommendations:

Because of the correspondence of the orientation of these fractures with the orientation of Mount Bonnell Fault, the feature could have a connection to a deeper karst feature in the subsurface. Appropriate precautions should be considered in planning for construction and during construction.

Feature F-2
GPS Coordinates: 30° 14' 5.03" N 97° 51' 37.91" W

Features F-2 is a solution cavity situated along the base of a bedding outcrop. The extent of the feature is limited due to infilling by soil and organic debris and animal burrowing is evident. The potential for rapid infiltration is low and the feature was evaluated as non-sensitive.

Recommendations:

This feature likely does not have a strong connection to a deeper karst feature in the subsurface. Appropriate precautions should be considered in planning for construction and during construction.

Feature F-3
GPS Coordinates: 30° 14' 4.38" N 97° 51' 43.45" W

Feature F-3 is a small outcrop of limestone on the south side of US 290 exhibiting small interconnected solution enlarged cavities. This type of feature, commonly referred to as a “honeycomb” texture, suggests the outcrop may at one time have been exposed to significant groundwater flow. It is positioned along a small drainage paralleling US 290, however no water was present in the drainage, and it appears that surface flow is only present during significant precipitation events. Natural vegetation, plant debris, and high runoff potential soils appear to cover most of the area. These factors limit infiltration while supporting rapid runoff. The feature was evaluated as non-sensitive with a low relative potential for infiltration.

Recommendations:

This feature likely does not exhibit high infiltration and recharge to the subsurface. Appropriate precautions should be considered in planning for construction and during construction.

Feature F-4

GPS Coordinates: 30° 14' 4.09" N 97° 51' 37.26" W

Feature F-4 is zone of fractures located south of US 290 along the southern margin of the TxDOT right-of-way. The feature encompasses an approximately 100-ft by 30-ft area on a gently sloping hillside covered with live oak trees and Ashe juniper (locally referred to as cedar). Multiple fractures are present, and apertures appear to show some evidence of solution enlargement although most are infilled with vegetation and soil. While there are slight variations, the average trend of the fractures is about N20ºE, which is consistent with the regional structural trend. This suggests the fractures may be related to displacement along the Mount Bonnell Fault to the northwest. The outcrop in which the fractures are present also shows some honeycomb texture that supports the possibility of recharge enhancement through solution enlargement. However, the large amount of vegetative debris filling the fractures, coupled with the Speck soils that are characterized by high runoff potential and occur across this portion of the study area, suggest a rapid runoff potential in lieu of infiltration. Overall, the feature is expected to have a low potential for recharge to the aquifer. However, due to the zone classification of the feature and similarity with the regional structural trend, the feature was evaluated as sensitive.

Recommendations:

This feature contains a zone of fractures coincident with the regional structural trend and could have a connection to a deeper karst feature in the subsurface that contributes greater than average recharge to the Edwards Aquifer. Appropriate precautions should be considered in planning for construction and during construction.

Feature F-5

GPS Coordinates: 30° 14' 8.63" N 97° 51' 41.11" W

Feature F-5 is identified as the surface expression of the Mount Bonnell Fault within Williamson Creek. According to the available publications (USGS, 1996; BEG, 1981) this fault is referred to as the Mount Bonnell Fault. It is a major fault that marks the boundary between the Edwards Aquifer Contributing and Recharge Zones. The only surface expression of this fault was identified along the streambed of Williamson Creek north of US 290. Normal displacement along the fault denotes displacement to the southeast, typical of the majority of other nearby faults. The amount of vertical throw along the Mount Bonnell Fault has been estimated to be up to 670-ft (USGS, 1996). This and other faults within the surrounding region generally trend from southwest to northeast at about N35ºE.

Where exposed within Williamson Creek, the Mount Bonnell Fault shows little evidence of solution enlargement. The location of the feature is based upon nearby fractures and changes in lithology on opposing sides of the fault. The fault juxtaposes the Glen Rose Limestone to the northwest against Edwards Limestone. Most fractures within the streambed appear to be sealed with fine grained sediment and vegetative debris. This feature is not exposed in any other location within the project area. It was evaluated as sensitive with a moderate potential for infiltration.

Recommendations:

Feature F-5, the surface expression of the Mount Bonnell Fault within Williamson Creek, does not occur within the existing right-of-way area and would not be affected by project activities.

Feature F-6

GPS Coordinates: 30° 14' 2.04" N 97° 51' 44.82" W

Feature F-6 is a solution cavity located along the southern limits of the TxDOT right-of-way south of US 290. The area where the feature is exposed in the bedrock is about two square feet. The adjacent area is partly covered with native vegetation. However, an abandoned small business surrounded by a security fence is located about 20 ft to the east. The feature itself appears Y-shaped in plan view and extends vertically about 4 ft. Native soils infill the cavity on the sides and the feature does not appear to open or expand laterally with depth. The feature was evaluated as sensitive with a moderate potential for infiltration.

Recommendations:

This feature includes characteristics that could contribute greater than average recharge to the Edwards Aquifer. The feature is currently surrounded with silt fencing, and similarly, appropriate precautions should be considered in planning for construction and during construction.

Feature F-7

GPS Coordinates: 30° 14' 5.75" N 97° 51' 52.96" W

Feature F-7 is a cavity in the transmission line right-of-way. The feature is located between a fire hydrant near northbound William Cannon Drive and electrical pole in the right-of-way. This area is located just north of the existing US 290 right-of-way, east of William Cannon Drive. This cavity is in the soil, no exposed rocks were present, and the cavity was filled with sticks and mulch from recent clearing activities, indicating a likely origin of the cavity as settling within cleared material. The feature is oval shaped, with an opening approximately 15 inches by 10 inches and depth of less than two feet. The feature drains less than 1.6 acres, and is evaluated as non-sensitive with a low relative potential for infiltration.

Recommendations:

This feature likely does not exhibit high infiltration and recharge to the subsurface. Appropriate precautions should be considered in planning for construction and during construction.

Feature F-8

GPS Coordinates: 30° 15' 18.4" N 97° 53' 25.15" W

Feature F-8 includes a zone of fractures area of horizontal bedding in a streambed drainage. The feature is located south of the intersection of Old Bee Caves Road and the Bell Hill Country Apartments exit road on the proposed right-of-way. The fractures have apertures of approximately 0.6 inch with no infilling evident at the time of the survey. The feature is evaluated as sensitive. It has a drainage area of greater than 1.6 acres.

Recommendations:

This feature likely does not exhibit high infiltration and recharge to the subsurface. Appropriate precautions should be considered in planning for and during construction.

Feature F-9

GPS Coordinates: 30° 15' 2.99" N 97° 54' 1.01" W

Feature F-9, an area of horizontal fractures, is located on a hillside drainage within proposed right-of-way for the detention pond on the southwest side of SH 71. This zone of surface enlarged fractures in limestone had apertures between 1-2 centimeters. The zone of fractures extends approximately 10 ft laterally parallel with the hillside and 1 ft vertically. The feature is evaluated as sensitive. It drains less than 1.6 acres, with a relatively moderate potential for infiltration.

Recommendations:

This feature includes characteristics that could contribute greater than average recharge to the Edwards Aquifer. Appropriate precautions should be considered in planning for and during construction.

Feature F-10

GPS Coordinates: 30° 13' 43.68" N 97° 53' 11.54" W

Feature F-10 is a solution cavity, over 3 feet deep, at the base of an Ashe juniper root in a hillside drainage. The tree is flagged with a tag #1591. The cavity is in soil and most likely originated from animal activity. The feature is 9 inches wide and 6 inches in length. The feature has been marked with white flagging tape and is located south of US 290 and east of RM 1826 within the existing right-of-way. The feature is evaluated as non-sensitive. It drains less than 1.6 acres with a low relative potential for infiltration.

Recommendations:

This feature likely does not exhibit high infiltration and recharge to the subsurface. Appropriate precautions should be considered in planning for and during construction.

Feature F-11

GPS Coordinates: 30° 13' 43.46" N 97° 53' 10.32" W

Feature F-11 is an enlarged solution fracture on a small hillside slope. The feature is located south of US 290 and east of RM 1826 within existing right-of-way. Feature F-11 is within a wooded area and consists of a bench formation with weaker rock underneath the bench. The feature is between tagged trees with marker numbers: 2380, 2828, 2378 and 1579. The feature was evaluated as non-sensitive. It drains less than 1.6 acres, with a low relative potential for infiltration.

Recommendations:

This feature likely does not exhibit high infiltration and recharge to the subsurface. Appropriate precautions should be considered in planning for and during construction.

Feature F-12

GPS Coordinates: 30° 13' 42.42" N 97° 53' 4.88" W

Feature F-12 is a solution enlarged fracture in a streambed. The feature is located south of US 290 and east of RM 1826, downstream of a large culvert. The feature is located within existing right-of-way and within the drainage area ordinary high water mark. The feature had a drainage area greater than 6 acres and is evaluated as sensitive with a moderate potential for infiltration.

Recommendations:

This feature includes characteristics that could contribute greater than average recharge to the Edwards Aquifer. Appropriate precautions should be considered in planning for and during construction.

Feature F-13

GPS Coordinates: 30° 14' 1.79" N 97° 52' 0.14" W

Feature F-13 is the cliff located southwest of the intersection of US 290 and William Cannon Drive. The cliff varies in height from about 20 feet to over 70 feet at its maximum height and extends over 600 ft along US 290. Part of the feature is located within the existing right-of-way. The cliff is classified in the geologic assessment table as an “other natural bedrock feature,” and it has a drainage area greater than 1.6 acres. The feature exposes cliff-forming, massively bedded limestone. It is evaluated as non-sensitive with a low potential for infiltration.

Recommendations:

This feature likely does not exhibit high infiltration and recharge to the subsurface. Appropriate precautions should be considered in planning for and during construction.

Site and Feature Photographs
Comments to Geologic Assessment Table
U.S. Highway 290 (US 290) / State Highway (SH) 71 West from State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and SH 71 to Silvermine Drive
Travis County, Texas
CSJ: 0113-08-060 and 0700-03-077

General Site Photographs

Feature F-1. Widely spaced fractures within the Williamson Creek streambed located just upstream of US 290

Feature F-2 solution cavity situated along the base of a bedding outcrop

Feature F-2 zoom-in of solution cavity situated along the base of a bedding outcrop

Feature F-3 small outcrop of limestone on the south side of US 290 exhibiting small interconnected solution enlarged cavities (Depression, veg cover)

Feature F-4. Zone of fractures located south of US 290 along the southern margin of the TxDOT right-of-way

Feature F-4. Zone of fractures looking to the east.

Feature F-5. Surface expression of the Mount Bonnell Fault within Williamson Creek.

Feature F-6 – solution cavity located along the southern limits of the TxDOT right-of-way south of US 290.

Feature F-6 – solution cavity located along the southern limits of the TxDOT right-of-way south of US 290.

Feature F-7 – Cavity located north of the existing US 290 right-of-way along the transmission line corridor.

Feature F-7 – Cavity located north of the existing US 290 right-of-way along the transmission line corridor.

Feature F-8 – Area of fractures located south of the intersection of Old Bee Caves Road and the Bell Hill Country Apartments entrance road. On proposed right-of-way.

Feature F-9 – Area of fractures located within proposed right-of-way for the detention pond on the southwest side of SH 71.

Feature F-9 – Area of fractures located within proposed right-of-way for the detention pond on the southwest side of SH 71.

Feature F-10 – Hole (possibly and animal hole) at the base of a tree. Located within the existing right-of-way south of US 290 and east of RM 1826.

Feature F-11 – Enlarged fracture, which consisted of a rock bench with a weaker area underneath. This feature was located south of US 290 and east of RM 1826.

Feature F-12 – A solution enlarged fracture in a streambed. Feature F-12 is located within existing right-of-way south of US 290 and east of RM 1826.

Feature F-12 – A solution enlarged fracture in a streambed. Feature F-12 is located within existing right-of-way south of US 290 and east of RM 1826.

Feature F-13 – Cliff located southwest of the intersection of US 290 and William Cannon Drive. Portion of Feature F-13 is located within existing right-of-way south of US 290.

Attachment B

Stratigraphic Column

Stratigraphic Column
Comments to Geologic Assessment Table
U.S. Highway 290 (US 290) / State Highway (SH) 71 West from State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and SH 71 to Silvermine Drive
Travis County, Texas
CSJ: 0113-08-060 and 0700-03-077

Bureau of Economic Geology (BEG) (1972) describes the Edwards Group, as present in the project area. Further modification and description of groups, formations, members and thicknesses were modified from the USGS Publication WRIR 96-4306 (USGS, 1996), and the BEG Geologic Atlas of Texas, Austin Sheet (BEG, 1981).The stratigraphic column below shows the lithology and hydrogeologic properties of the hydrogeologic subdivisions of the Edwards Group and associated units.

Table 1. Stratigraphic Column and Hydrogeologic Summary of the Edwards Aquifer Outcrop (Barton Springs Segment)

System	Hydrogeologic Unit		Group, Formation, or Member				Map Symbol	Thickness	Description
Quaternary	----		Alluvium				Q_{al}	Variable	Floodplain and terrace deposits; clay, silt, sand, and gravel.
Upper Cretaceous	Upper Confining Units		Taylor Group				K_{nt}	600	Clay; chalky limestone
			Austin Group				K_{au}	130 – 150	White to light-tan to gray limestone
			Eagle Ford Group				K_{ef}	30 – 50	Brown, flaggy sandy shale and argillaceous limestone
			Buda Limestone				K_{bu}	40 – 50	Buff, light-gray, dense mudstone
			Del Rio Clay				K_{dr}	50 - 60	Blue-green to yellow-brown clay
Lower Cretaceous	I	Edwards Aquifer	Georgetown Formation				K_{gt}	40 - 60	Gray to light-tan, marly limestone
	II		Devils River Formation	Edwards Group	Person Formation	Cyclic and Marine Members	K_p	50 - 180	Mudstone to packstone;*miliolid* grainstone; chert.
	III					Leached and Collapsed Member			Crystalline limestone; mudstone to wackestone to *miliolid* grainstone; chert; collapsed breccia
	IV					Regional Dense Member			Light-tan, dense, argillaceous mudstone
	V				Kainer Formation	Grainstone Member	K_k	265 - 345	*Light-gray, Miliolid* grainstone; mudstone to wackestone; chert.
	VI					Kirschberg Evaporite Member			Light-gray, crystalline limestone; chalky mudstone; chert.
	VII					Dolomitic Member			Mudstone to grainstone; crystalline limestone; chert.
	VIII					Basal Nodular Member			Shaly, fossiliferous, nodular limestone; mudstone; *miliolid* grainstone.
	Upper Trinity Aquifer		Upper member of the Glen Rose Limestone				K_{gru}	350 – 500	Yellowish-tan, thinly bedded limestone and marl

Notes: Groups, formations, and members and thicknesses were modified from the USGS Publication WRIR 96-4306 (USGS, 1996), and the Bureau of Economic Geology Geologic Atlas of Texas, Austin Sheet (BEG, 1981).

Attachment C

Site Geology
Narrative of Project Specific Geology

Narrative of Project Specific Geology
Comments to Geologic Assessment Table
U.S. Highway 290 (US 290) / State Highway (SH) 71 West from
State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and
SH 71 to Silvermine Drive
Travis County, Texas
CSJ: 0113-08-060 and 0700-03-077

1.0 Introduction and Purpose

In December 2018 the Texas Department of Transportation (TxDOT) approved a Final Environmental Impact Statement (EIS) and Record of Decision (ROD) for mobility improvements to U.S. Highway (US) 290/State Highway (SH) 71 West from State Loop 1 (MoPac) to west of Ranch-to-Market Road (RM) 1826 and from US 290 to Silvermine Drive. The proposed project, known as the Oak Hill Parkway Project is located in the City of Austin, Travis County, Texas. As a result of minor project design changes following the 2018 ROD, TxDOT is conducting a documented reevaluation to determine whether or not the previous environmental decision remains valid under circumstances listed in 43 TAC 2.85 and 23 CFR 771.129.

The following discussion is a site-specific assessment of existing geological conditions and potential aquifer recharge features within the project boundaries, as amended during the documented reevaluation. This Geologic Assessment documents conditions observed by HDR within the project boundaries during site visits.

The purpose of this document is to complete a Geologic Assessment compliant with the requirements of Title 30, Texas Administrative Code (TAC) Chapter 213, related to the protection of the Edwards Aquifer Recharge Zone. The Geologic Assessment was prepared in accordance with the revised *Instructions to Geologists for Geologic Assessments on the Edwards Aquifer Recharge/Transition Zones* (TCEQ-0585) (TCEQ, 2004). The Geologic Assessment is a component of a Water Pollution Abatement Plan (WPAP), which will be completed based on the final design of the project. The WPAP identifies measures that will be implemented to protect the water quality of the aquifer.

This Geologic Assessment report focuses on the project area (**Figure 1**) defined as the area within the existing right-of-way (ROW) boundary where the mapped extent of the surface expression of the Edwards Aquifer Recharge Zone intersects U.S. Highway 290 (US 290) / State Highway (SH) 71 West through Oak Hill (the Oak Hill Parkway). The survey area is defined as existing TxDOT ROW and proposed ROW of the project limits described in this section.

2.0 Geologic Setting

The following sections address the geology and soils within the study area, which is defined as an area within one-half mile of the existing right-of-way.

The study area is situated at the eastern edge of the Edwards Plateau ecoregion, just west of the Blackland Prairies ecoregion (Griffith et al., 2004). The topography in the study area is hilly and highly dissected by the tributaries and main channels of larger creeks. Devils Pen Creek and other tributaries of Slaughter Creek flow cut through the western portion of the study area. Tributaries of Williamson Creek, including Kincheon Branch, Wheeler Branch, and Motorola Branch, as well as several unnamed tributaries and Williamson Creek proper, dissect the central portion of the study area, and unnamed tributaries of Barton Creek divide the far northeastern portion. Bluffs run parallel to US 290 near its intersection with SH 71. Elevations in the study area range from approximately 1,050 feet above mean sea level (amsl) in the west to approximately 700 feet amsl in the east. Total topographic relief is approximately 350 feet, and most slopes are in the 5 percent to 10 percent range with steeper slopes up to 15 percent in isolated locales (USGS, 1986a; USGS, 1986b; USGS, 1988a; USGS, 1988b).

Rocks within the study area are of sedimentary origin. Geologic formations within the project area are Lower Cretaceous marine deposits and more recent Quaternary sediments. These rocks, comprised chiefly of limestone, were deposited on a vast submerged plain known as the Comanche Shelf (BEG, 1972). The Comanche Shelf depositional environment is located between the San Marcos Platform to the south and the Maverick Basin to the west (Abbott et al., 1986).

Edwards Aquifer Recharge and Contributing Zones

Based on available published geologic maps and field observations, the geologic units mapped within the Edwards Aquifer Recharge Zone (EARZ) portion of the project area include the following from youngest to oldest: Quaternary Alluvium (Qal), Quaternary Fluviatile terrace deposits (Qhg), the Kainer Formation (Kk) of the Edwards Group and the Upper member of the Glen Rose Limestone (Kgru). The Kk and the younger Person Formation (Kp) of the Edwards Group have been further divided into seven geologic members (BEG, 1972; Table 1). These subdivisions were later modified into eight hydrogeologic subdivisions that include the overlying Georgetown Formation (USGS, 1996), Table 1). Members of the Kk, from youngest to oldest, include the Basal Nodular, Dolomitic, Kirschberg Evaporite, and Grainstone Members. The overlying Kp is divided into four members: Regional Dense, Leached and Collapsed, and Cyclic and Marine Members. Geologic units found within the EARZ portion of the project area predominantly include Kk and a smaller area of Qhg along the southeastern border. The remaining portion of the project area lies within the Edwards Aquifer Contributing Zone and contains mainly Kgru areas and moderate portions of Qal located within the north-central portion of the project study area.

Geologic publications including reports and published maps were used in preparation of this report. The Texas Speleological Survey (TSS) database was queried for possible known or existing recharge features within the boundaries of the investigation area. The TSS did not find any records for existing recharge features within the project area (TSS, 2008).

Some of the development within the project area predates the era of comprehensive record- keeping of karst features. Thus, it is possible that construction in the vicinity of developed lots might encounter undocumented karst features covered during prior development. According to communications from the TSS, the distribution of caves on a countywide basis suggests a concentration of caves exists along the east side of the Mount Bonnell Fault. The Mount Bonnell Fault forms the boundary between the Edwards Aquifer Contributing and Recharge Zones and occurs within the central portion of the project area (**Figure 2**). Fracturing coincident with the fault may provide a pathway for groundwater to enter the limestone and enhance the formation of caves. This suggests that the likelihood of karst features occurring within the project area may be greatest east of the Mount Bonnell Fault within the EARZ.

As previously discussed, a portion of the project study area lies within an environmentally sensitive area known as the Edwards Aquifer. Numerous enhanced karst features occur within this area, and as a result the Edwards Aquifer is a very productive groundwater aquifer. Karst features are formed from the dissolution of soluble rocks, including limestone, and are characterized by sinkholes, caves, and underground drainage systems. The majority of the recharge into the Edwards Aquifer occurs where surface water flows over faults, fractures, and karst features that have been solutionally enhanced.

The Edwards Aquifer contains several zones, which are based on how water drains in these areas; these include the Recharge Zone, Transition Zone, and Contributing Zone. The Recharge Zone includes an area where highly faulted and fractured Edwards Limestone outcrops occur at the surface, providing a means for large quantities of water to flow into the aquifer with little filtration. The Transition Zone contains areas where limestone that overlies the aquifer are faulted and fractured and include caves and sinkholes. Within this area, it is possible for surface water to flow into the Edwards Aquifer below. The Contributing Zone consists of areas of non-Edwards Aquifer limestones, which outcrop at a higher elevation, causing water to drain to stream courses that overlie the Recharge Zone.

The portion of the project area east of the Mount Bonnell Fault is located in the Recharge Zone of the Barton Springs Segment of the Edwards Aquifer (BSEACD, 2010). Groundwater in this area generally flows from the southwest to northeast toward a few focused discharge points and recharge is typically focused at faults and karst features, such as caves and sinkholes. Within the project area, the groundwater hydrology is largely influenced by the karst units of the Edwards Group, which form an outcrop east of the Mount Bonnell Fault.

3.0 Investigation Methods

The following investigation methods and activities were used to develop this technical memorandum.

- Review of data and literature to determine the regional geology and known caves associated with the right of way;

- Review of existing geological field reports, cave studies, and correspondence regarding geologic features on the right of way, including those previously referenced, and
- Analysis of collected field data.

Reconnaissance of the site included the methodology described in Texas Commission on Environmental Quality's (TCEQ's) (2004) *Instructions to Geologists for Geologic Assessments*. The geologic assessment was conducted with a team of two people (Professional Geologist [PG] #10173 and a karst technician) walking about 25 ft apart in the same direction toward a specific point. When that point was reached, the team walked back to the starting point in the opposite direction, searching the area adjacent to the original pass.

Specific publications and data sources reviewed and utilized in this investigation include the following list and those included in the Section 6.0 References:

- Bureau of Economic Geology (BEG) (1972), which describes the Edwards Group, as present in the project area;
- USGS Publication WRIR 96-4306 (USGS, 1996), which further modifies and describes the geologic groups, formations, members and thicknesses;
- BEG Geologic Atlas of Texas, Austin Sheet (BEG, 1981); and
- Geologic assessment of a similar areal extent completed in 2009 by Bret Rahe.
- Environmental geologic assessment of a similar areal extent completed by Charles Woodruff, Jr. (1986).
- Soil descriptions were compiled from the Web Soil Survey of the U.S. Department of Agriculture (USDA) (2015a).
- Texas Water Development Board (TWDB) and TCEQ water well data were used to locate water wells in proximity of the right of way.

4.0 Findings

This section includes information found in both field visits and through review of existing data and literature.

4.1 Water Wells

A search of the TWDB Groundwater Database (GWDB) Record of Wells Report for Travis County was completed (TWDB, 2016). Several wells are located near the project area but none are located within the survey area defined as the existing TxDOT ROW and proposed ROW. One well in the TWDB database was identified within 50 ft of the survey area, TWDB Well #5849310. The TWDB GWDB information on this well indicates that it was completed in 1962 in the Upper Member of Glen Rose Limestone and is currently unused. The well was not located during the survey. The well's location according to the TWDB GWDB is shown on page one of eight of Site Geologic Map included as **Attachment D**.

4.2 Gaines Sink

Gaines Sink, also known as Gaines Ranch Sink, is located to the east of the eastern boundary of the project area that includes existing TxDOT ROW and proposed ROW. **Figure 2b** shows the location of the sinkhole and its surface expression. Gaines Sink was not assessed during the field geologic survey, as it was outside the bounds of the survey area. However, a description of its location and its characteristics are described in this document for reference. In a geologic assessment provided by TxDOT staff, it is stated that before the construction of MoPac, the sinkhole drained approximately 4 acres of land (ZARA Environmental, 2016).

ZARA Environmental (2016) describe the area where the sinkhole is located as being "protected from surface runoff from adjacent at-grade roadways by curbs and gutters that are conveyed by a surface and subsurface stormwater system, treated by existing water quality facilities, and released to the north into the Barton Creek drainage." No dye tracing has been done at this site. ZARA Environmental (2016) describe the site as being close to the groundwater divide between Cold Springs and Sunset Valley (Barton Springs) and that recharge into Gaines Sink could flow to either Cold Springs, Barton Springs, or both (Hauwert et al. 2004).

4.3 Flea Market Sink

Flea Market Sink is a closed depression outside of the northern limits of the TxDOT right-of-way east of William Cannon Drive between Industrial Oaks Boulevard and Oak Boulevard, along the frontage road of westbound US 290, as shown in **Figure 2c**. The area was identified as "Flea Market Sink" by City of Austin staff member Ed Peacock in email communication to TxDOT dated May 23, 2018. The sink area is approximately 35 ft in diameter, sloping to approximately 2 to 2.5 ft in depth. A corrugated metal pipe standing above the ground surface is located in the center of the sink area. The pipe extends to a depth of approximately 6 ft below grade, where it intersects an approximately 12-inch diameter pipe that runs to the south toward the US 290 stormwater drain system. Various pieces of anthropogenic litter were present both inside the pipe and in the sink area. Several limestone boulders 1 foot in diameter are present. The sink area is fenced but was not locked when visited on June 22, 2018.

It appears that the stand pipe and storm sewer connection were constructed to alleviate ponding of stormwater in the feature and impacting the car lot east and adjacent to the site. In research of the site and communication with staff, it was not determined what entity (i.e., City of Austin and/or TxDOT) constructed the stand pipe and adjoining infrastructure to connect the pipe to the storm sewer system.

Based on organic and anthropogenic material present, it appears that during flood events, the feature can hold water for long periods of time. Therefore, it is estimated that the feature does not contribute a significant amount of recharge to the Edwards Aquifer. With the current stormwater drain installed, it does not appear that the feature will receive project drainage. The current stormwater system drains the parcels surrounding the area into the project stormwater system.

4.4 Non-Karst Features

Two features that appear to be non-karstic in nature were identified on November 20, 2019, at two driveways leading to the Oak Hill Plaza shopping center along the south bound lane of SH 71 immediately beyond the split with US 290. The features appeared to be the result of differential settling adjacent to the driveway culverts and not related to karst, although because they appear to be sinkholes, they are described here. Soil slumping over the existing concrete culverts is evident. The features occur at the head of the slumps and could be scarps that have been smoothed by stormwater flowing from the adjacent parking lot into the ditch containing the culverts. The two circular features are both about 2 ft deep and have a diameter of 2 ft. One feature contained a small bag filled with sand, and the other feature contained various pieces of garbage. Photos of the features are included below.

Non-karstic soil slump features identified at two driveways leading to the Oak Hill Plaza shopping center along the south bound lane of SH 71 immediately beyond the split with US 290.

4.5 Known Sensitive Karst Feature Area

In August 2019, TxDOT staff member Christiana Astarita requested that a Known Sensitive Karst Feature Area exhibit be provided as a RID showing the areas of known sensitive features that would be required by TCEQ to either be 1) protected with a permanent protective buffer or 2) sealed/mitigated based on impacts by the project during construction. This exhibit is included as Figure 3.

5.0 Site Visits

HDR personnel completed the first site reconnaissance visit on March 18, 2016. Visibility during the day was high with high humidity and temperatures of approximately 65°F and a cloudy sky.

HDR personnel, including Paula Jo Lemonds (PG #10173) and Shane Valentine (PG #10062), completed a second site visit on June 22, 2018, to assess Flea Market Sink discussed in Section 4.3.

Following the approval of the ROD, slight design changes and securing of right-of-entry onto select parcels prompted a reevaluation of portions of the project area. Additional field visits were conducted on March 14 and 29, April 4 and 9, and November 19 and 20, 2019. The 2019 site visits were completed by Paula Jo Lemonds (PG #10173) and Jenna Kromann Rao (PG #12014).

6.0 References

Abbott, Patrick L. and Woodruff, C.M., Jr., ed., 1986. The Balcones Escarpment, Central Texas: Geological Society of America, p. 163-183.

Barton Springs/Edwards Aquifer Conservation District (BSEACD), 2010. About the Aquifers. http://www.bseacd.org/aquifer-science/about -the-aquifers/. Accessed on July 24, 2015.

Bureau of Economic Geology (BEG), 1981. Geologic Atlas of Texas, Austin Sheet.

______BEG, 1972. Edwards Group Surface and Subsurface, Central Texas. Report of Investigations No. 74.

Griffith, G.E., S.A. Bryce, J.M. Ornernik, J.A. Comstock, A.C. Rogers, B. Harrison, *et. al*., 2004. Ecoregions of Texas (color poster with map, descriptive text, and photographs). U.S. Geological Survey, Reston, Virginia (map scale 1:2,500,000).

Hauwert, N.M., Johns, D., Hunt, B., Beery, J., Smith, B., and J.M. Sharp. 2004. Flow systems of the Edwards Aquifer Barton Springs Segment interpreted from tracing and associated field studies, Edwards Water Resources in Central Texas, Retrospective and Prospective Symposium Proceedings, 21 May 2004 San Antonio, South Texas Geological Society and Austin Geological Society, 18 p. In: ZARA Environmental, 2016. Draft Geologic Assessment for MoPac South Environmental Study, Austin, Travis County, Texas. Prepared for Jacobs Engineering, Inc., February 3, 2016.

Soil Survey Staff, Natural Resources Conservation Service (NRCS), United States Department of Agriculture. 2015a. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed July 21, 2015.

______NRCS. 2015b. Hydric Soils. Available online at http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/use/hydric, (accessed July 22, 2015).

Texas Commission on Environmental Quality (TCEQ). 2004. Instructions to Geologists for Geologic Assessments on the Edwards Aquifer Recharge/Transition Zone. TCEQ RG0508, Revised 1 October 2004. 34 p.

Texas Department of Transportation (TxDOT), 2009. Geologic Assessment. Performed by Bret Rahe, P.G., CH2M Hill, Inc.

Texas Speleological Survey (TSS), 2008. Written communication regarding karst features near the project site. http://www.utexas.edu/tmm/sponsored_sites/tss/. In: Texas Department of Transportation (TxDOT), 2009. Geologic Assessment. Performed by Bret Rahe, P.G., CH2M Hill, Inc.

Texas Water Development Board (TWDB), 2016. Groundwater Database (GWDB) Record of Wells Report for Travis County. http://www.twdb.texas.gov/groundwater/data/gwdbrpt.asp, accessed October 31, 2016.

U. S. Department of Agriculture (USDA), 1974. Soil Survey of Travis County, Texas.

U.S. Geological Survey (USGS), 1986a. 7.5-Minute Topographic Quadrangle (1:24,000), Bee Cave, Texas.

______USGS, 1986b. 7.5-Minutes Topographic Quadrangle (1:24,000), Signal Hill, Texas.

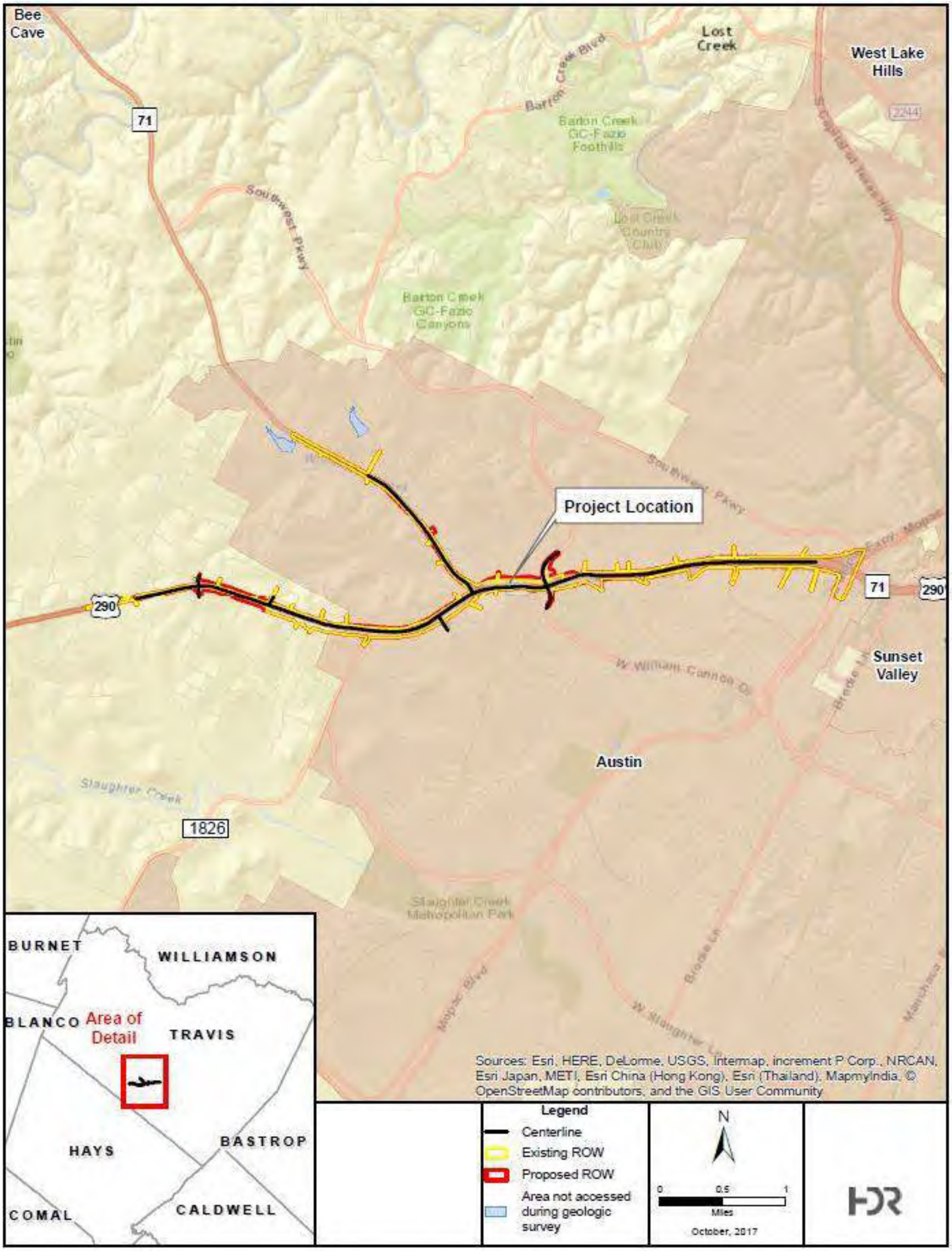
______USGS, 1988a. 7.5-Minutes Topographic Quadrangle (1:24,000), Austin West, Texas.

______USGS, 1988b. 7.5-Minutes Topographic Quadrangle (1:24,000), Oak Hill, Texas.

______USGS, 1996. Geologic Framework and Hydrogeologic Characteristics of the Edwards Aquifer Outcrop (Barton Springs Segment), Northeastern Hays and Southwestern Travis Counties, Texas. Water Resources Investigations Report 96-4306.

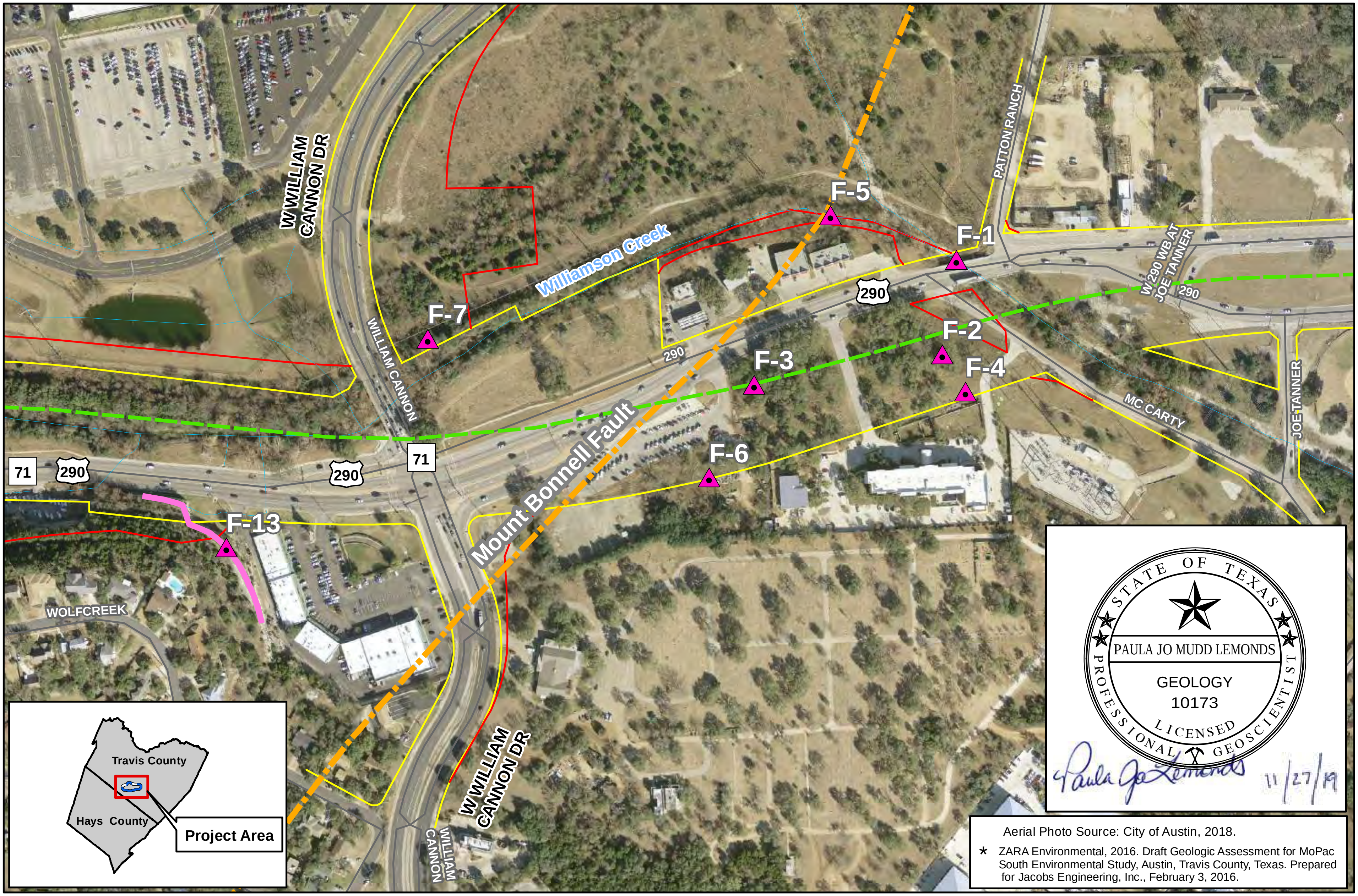
Woodruff, Charles, Jr., 1986. Environmental Geologic Assessment of the U.S. Highway 290 / Texas State Highway 71 Upgrade, Travis County, Texas. Final Report prepared for Lockwood, Andrews, and Newnam, Inc..

ZARA Environmental, 2016. Draft Geologic Assessment for MoPac South Environmental Study, Austin, Travis County, Texas. Prepared for Jacobs Engineering, Inc., February 3, 2016.



Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 1. Project location



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Aerial Photo Source: City of Austin, 2018.

* ZARA Environmental, 2016. Draft Geologic Assessment for MoPac South Environmental Study, Austin, Travis County, Texas. Prepared for Jacobs Engineering, Inc., February 3, 2016.

Figure 2a. Geologic Features Map

Oak Hill Parkway: US 290W from Mopac/Loop1 to west of Circle Drive and SH 71 from US 290W to Silvermine Drive

Legend

▲ Geologic Feature
- - Centerline
-·- Mount Bonnell Fault
— Existing ROW
— Proposed ROW

N

0 175 350
Feet

Prepared for: TxDOT

CSJ: 0013-08-060 and 0700-03-077

November 2019

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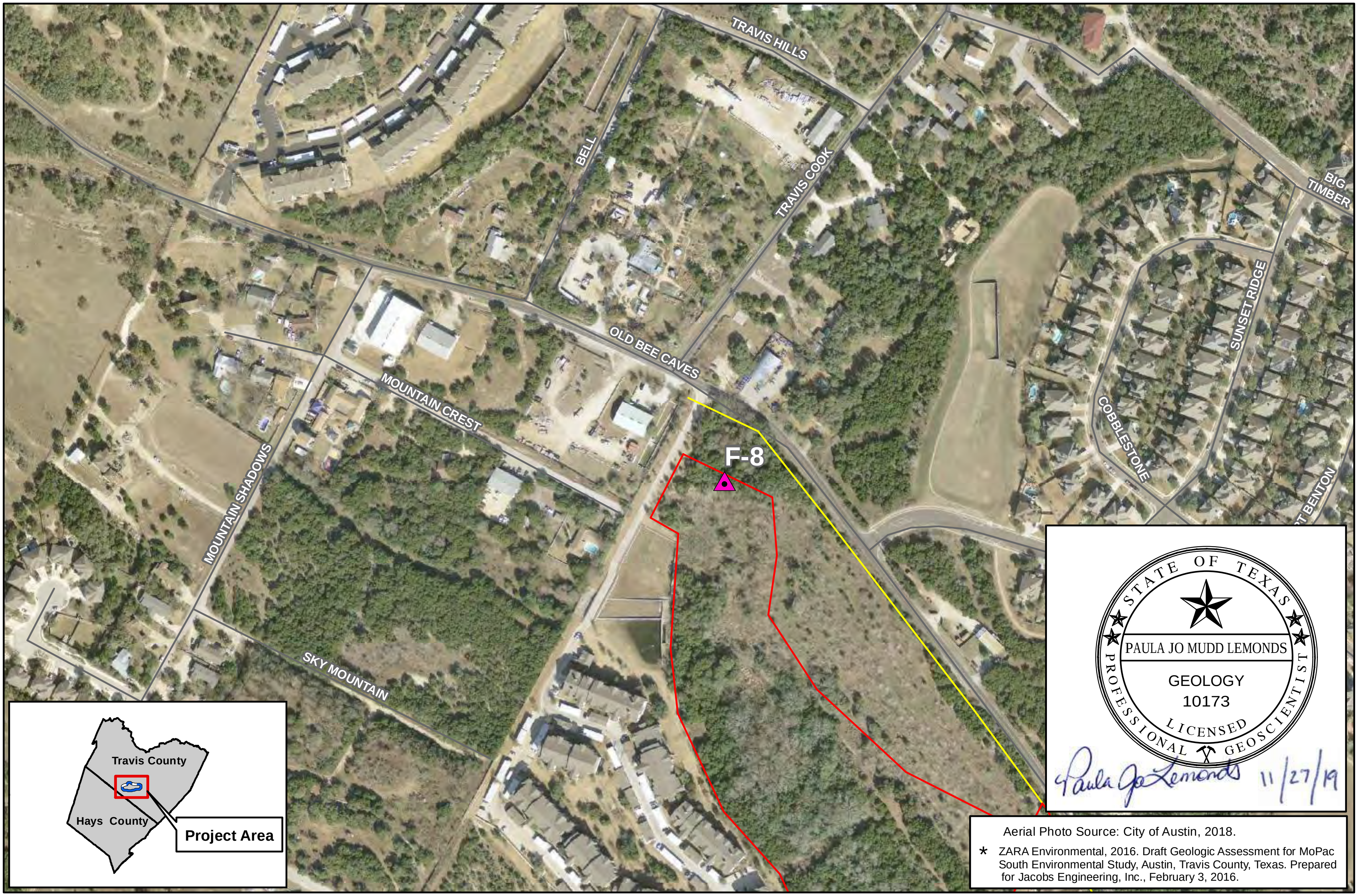

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Legend

- ▲ Geologic Feature
- Mount Bonnell Fault
- Proposed ROW
- Centerline
- Existing ROW

N

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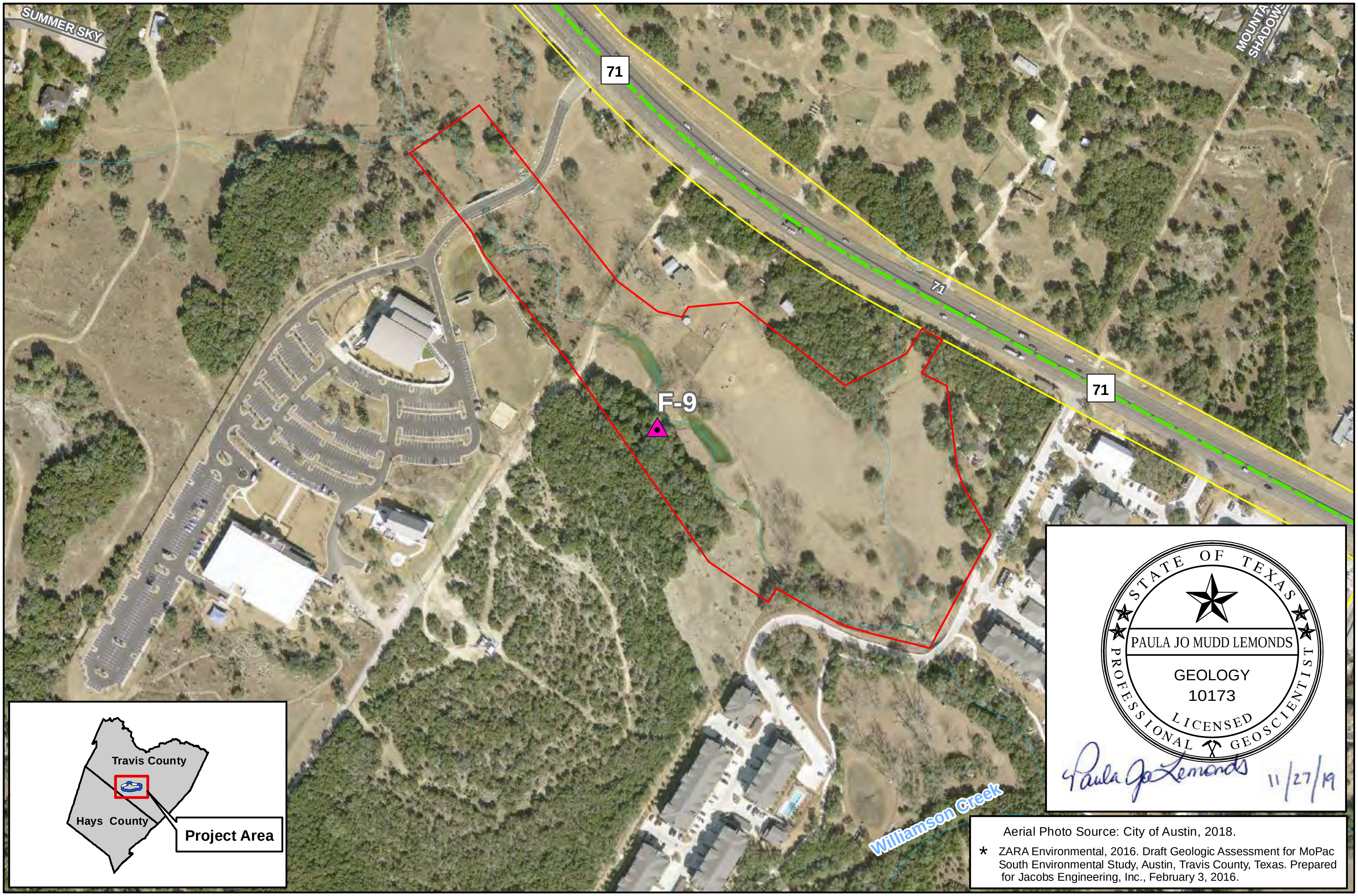

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Legend

- ▲ Geologic Feature
- Mount Bonnell Fault
- Proposed ROW
- Centerline
- Existing ROW

N

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Feet

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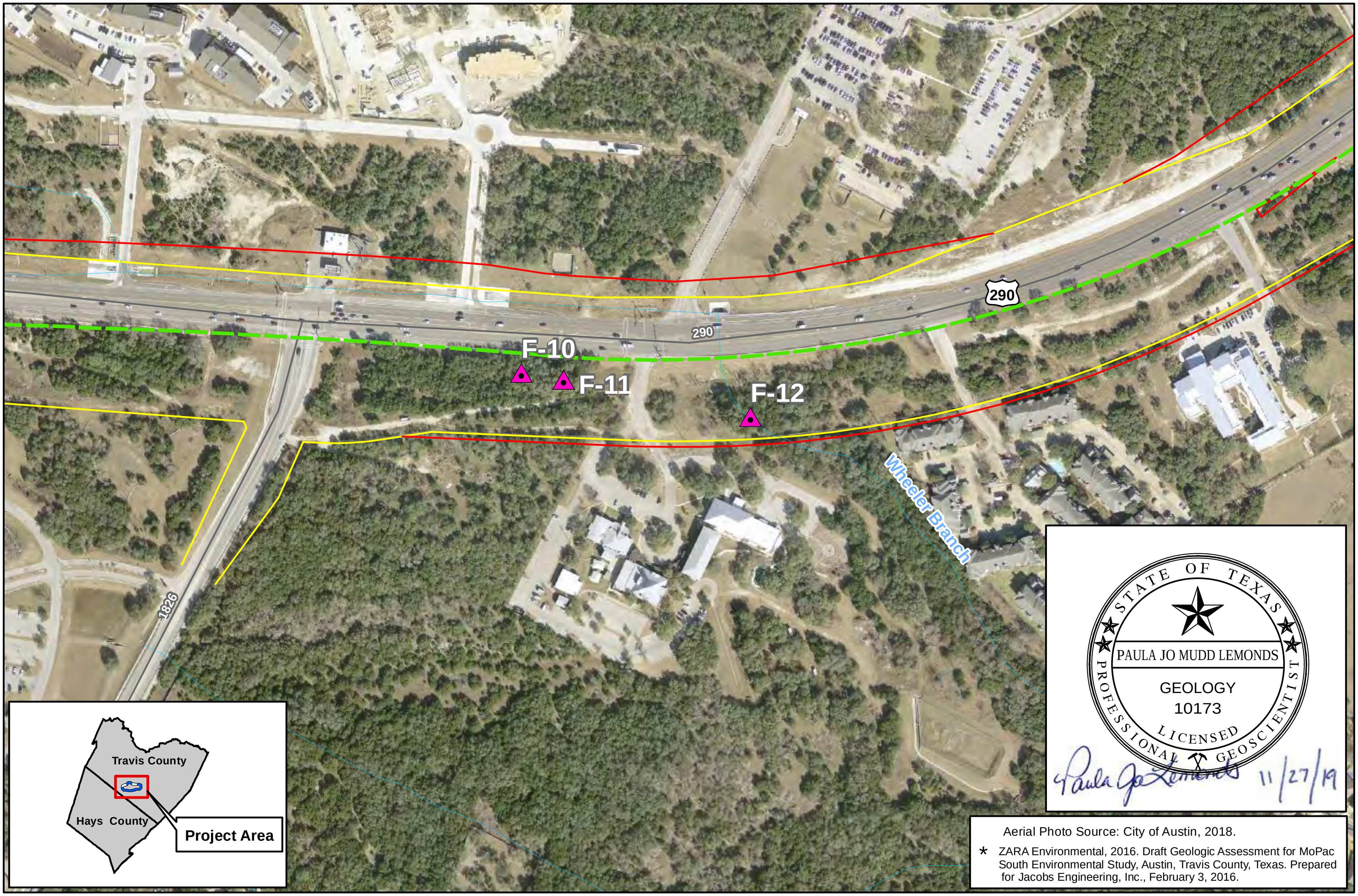

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Legend

- ▲ Geologic Feature
- ▬ ▬ Centerline
- ▬ · ▬ Mount Bonnell Fault
- ─ Existing ROW
- ─ Proposed ROW

N

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Feet

Prepared for: TxDOT

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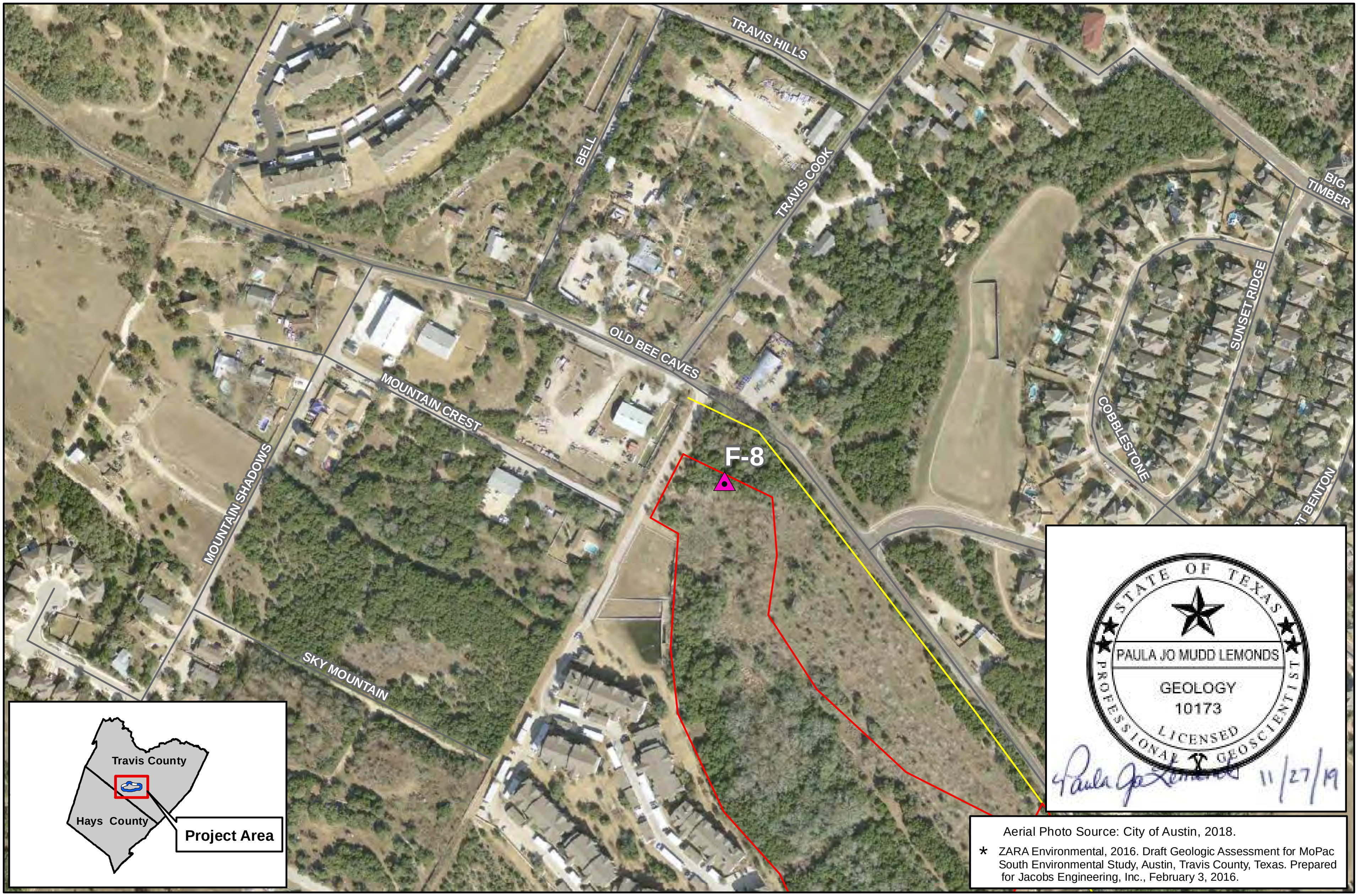

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Legend

- ▲ Geologic Feature
- Mount Bonnell Fault
- Proposed ROW
- Centerline
- Existing ROW

N

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Feet

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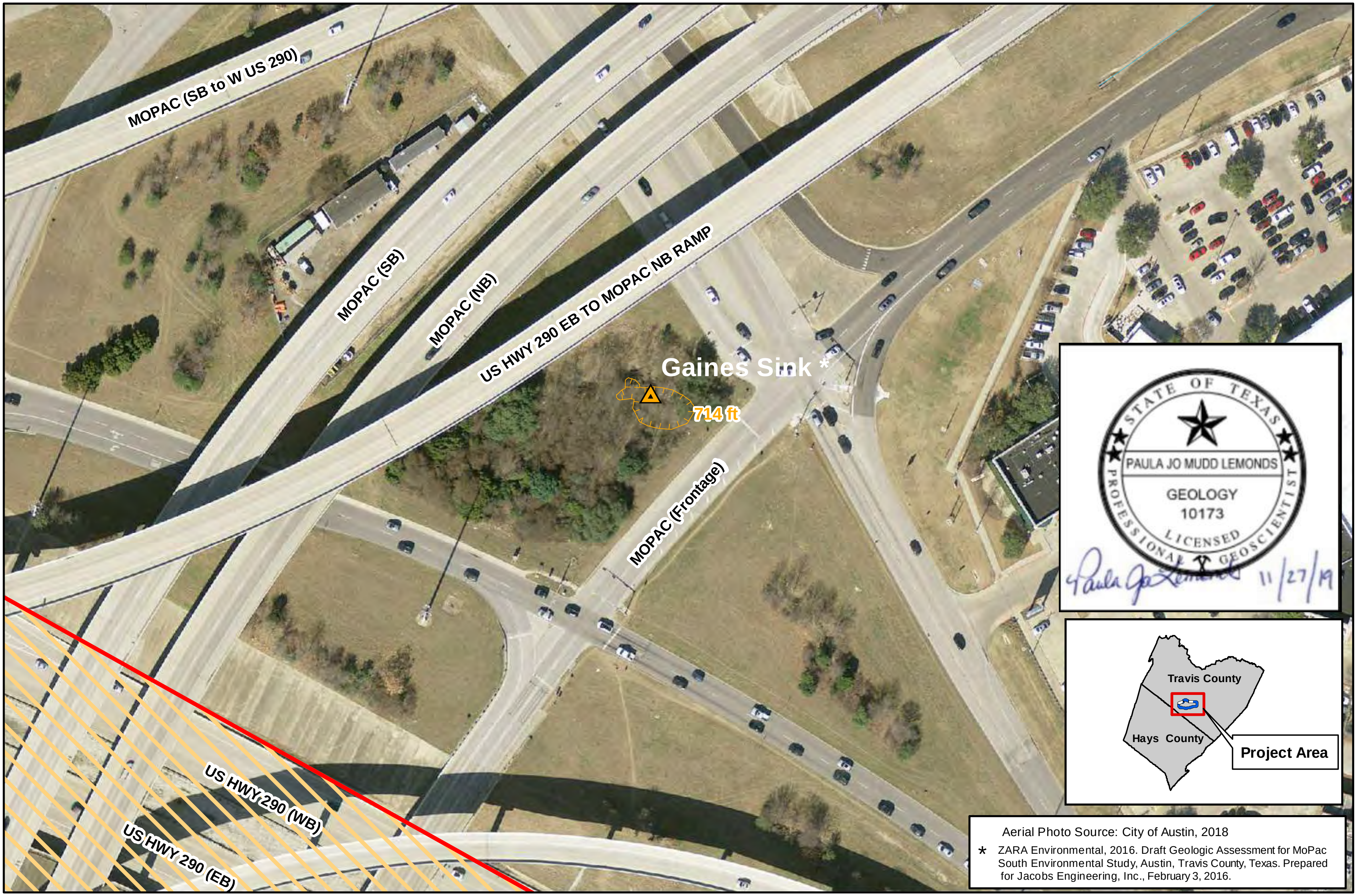

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* ZARA Environmental, 2016. Draft Geologic Assessment for MoPac South Environmental Study, Austin, Travis County, Texas. Prepared for Jacobs Engineering, Inc., February 3, 2016.

Figure 2b. Gaines Sink

Oak Hill Parkway: US 290W from Mopac/Loop1 to west of Circle Drive and SH 71 from US 290W to Silvermine Drive

Legend

▲	Geologic Feature Outside of Project Area	┴┴┴┴	Gaines Sink Feature Outline
▨	Existing ROW	🟥	Proposed ROW

N

0 62.5 125
Feet

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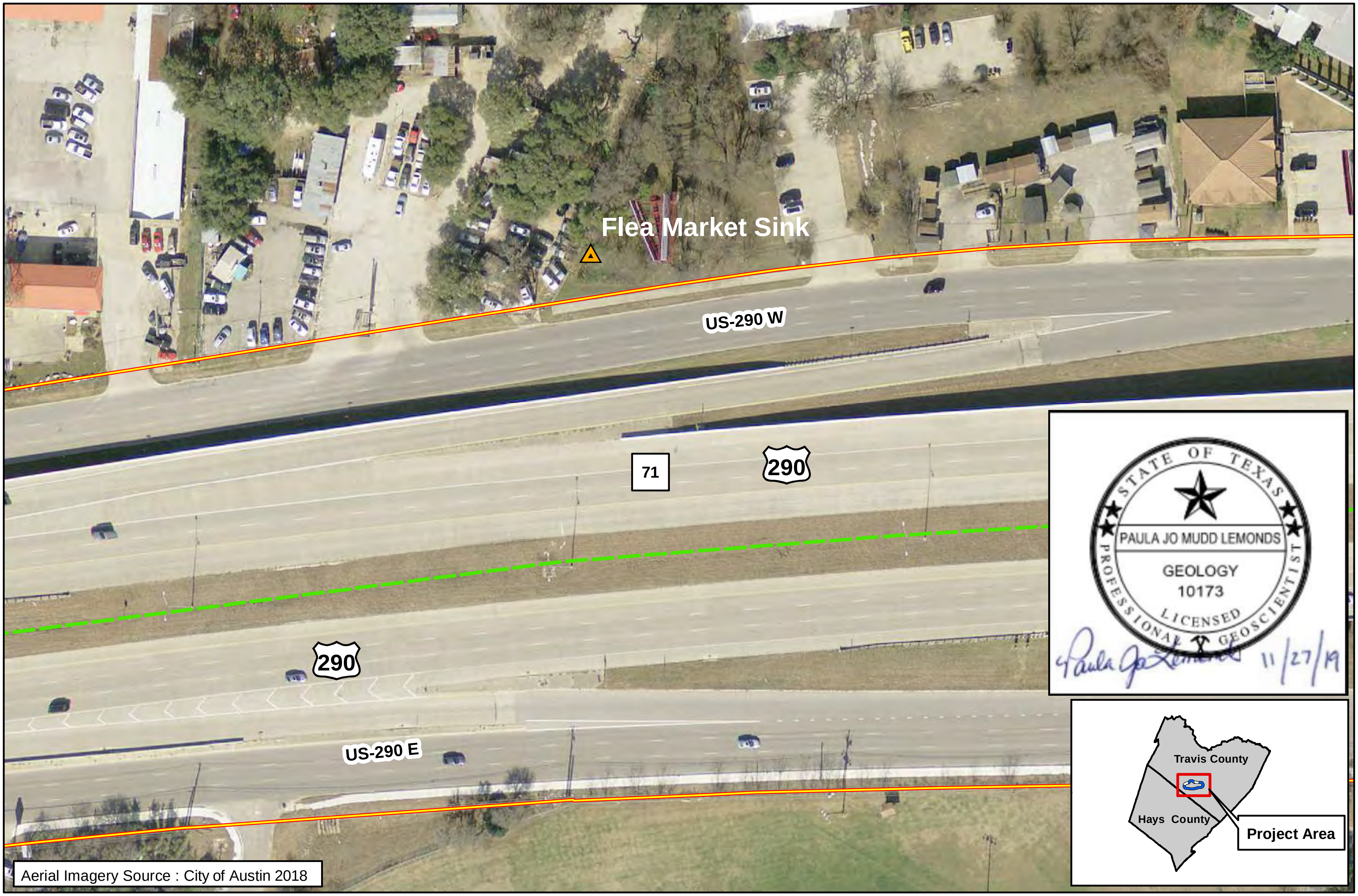

Aerial Imagery Source : City of Austin 2018

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Figure 2c. Flea Market Sink

Oak Hill Parkway: US 290W from Mopac/Loop1 to west of Circle Drive and SH 71 from US 290W to Silvermine Drive

Legend

▲	Geologic Feature Outside of Project Area
– –	Centerline
🟨	Existing ROW
🟥	Proposed ROW

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Feet

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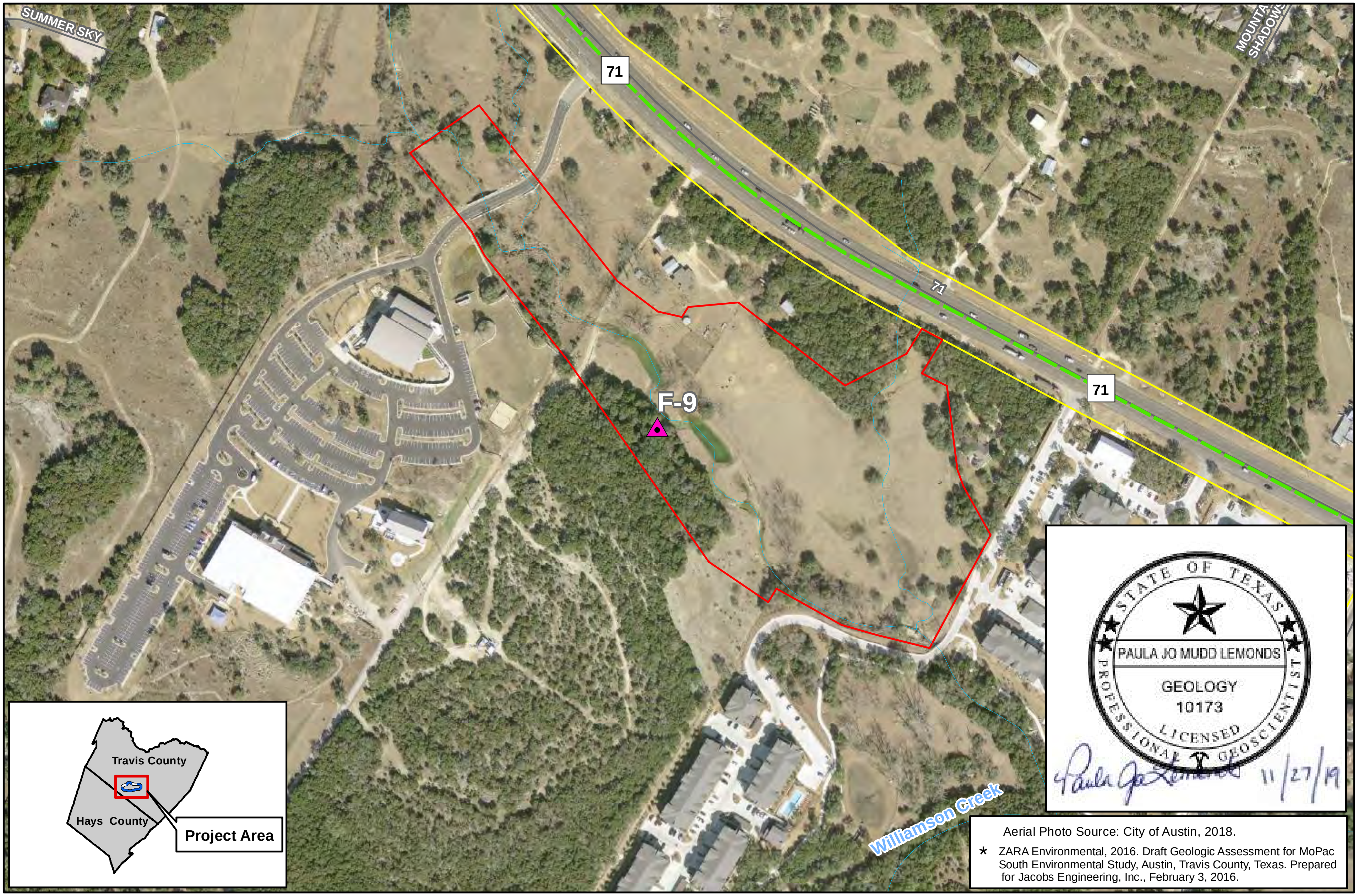

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Figure 3. Known Sensitive Karst Features

Oak Hill Parkway: US 290W from Mopac/Loop1 to west of Circle Drive and SH 71 from US 290W to Silvermine Drive

Legend

▲	Geologic Feature	▬ ▬	Mount Bonnell Fault	▬	Proposed ROW
▬ ▬	Centerline	▬	Existing ROW		

N

0 175 350

Feet

Prepared for: TxDOT

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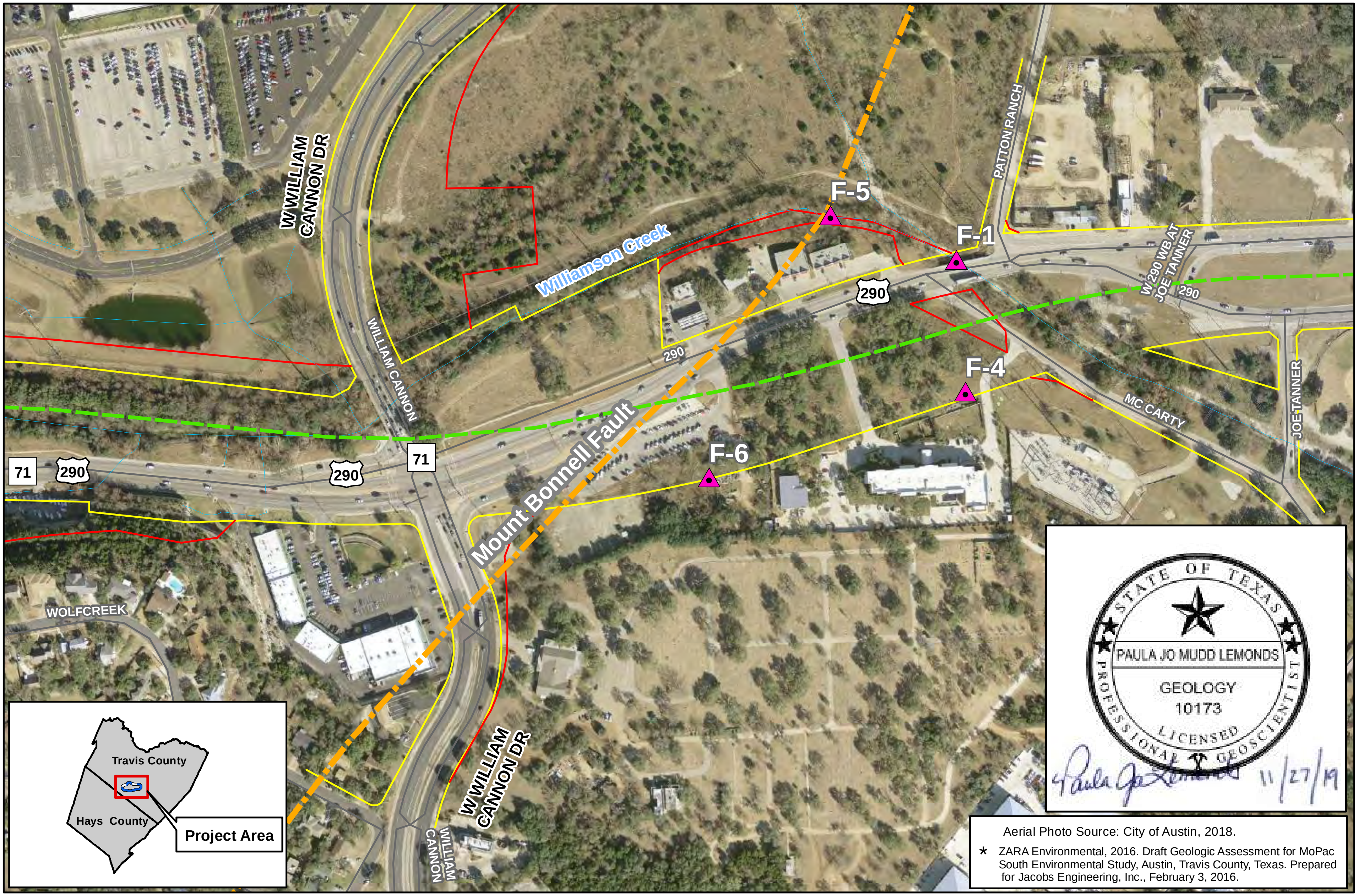

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Legend

- ▲ Geologic Feature
- Mount Bonnell Fault
- Proposed ROW
- Centerline
- Existing ROW

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Feet

Prepared for: TxDOT

CSJ: 0013-08-060 and 0700-03-077

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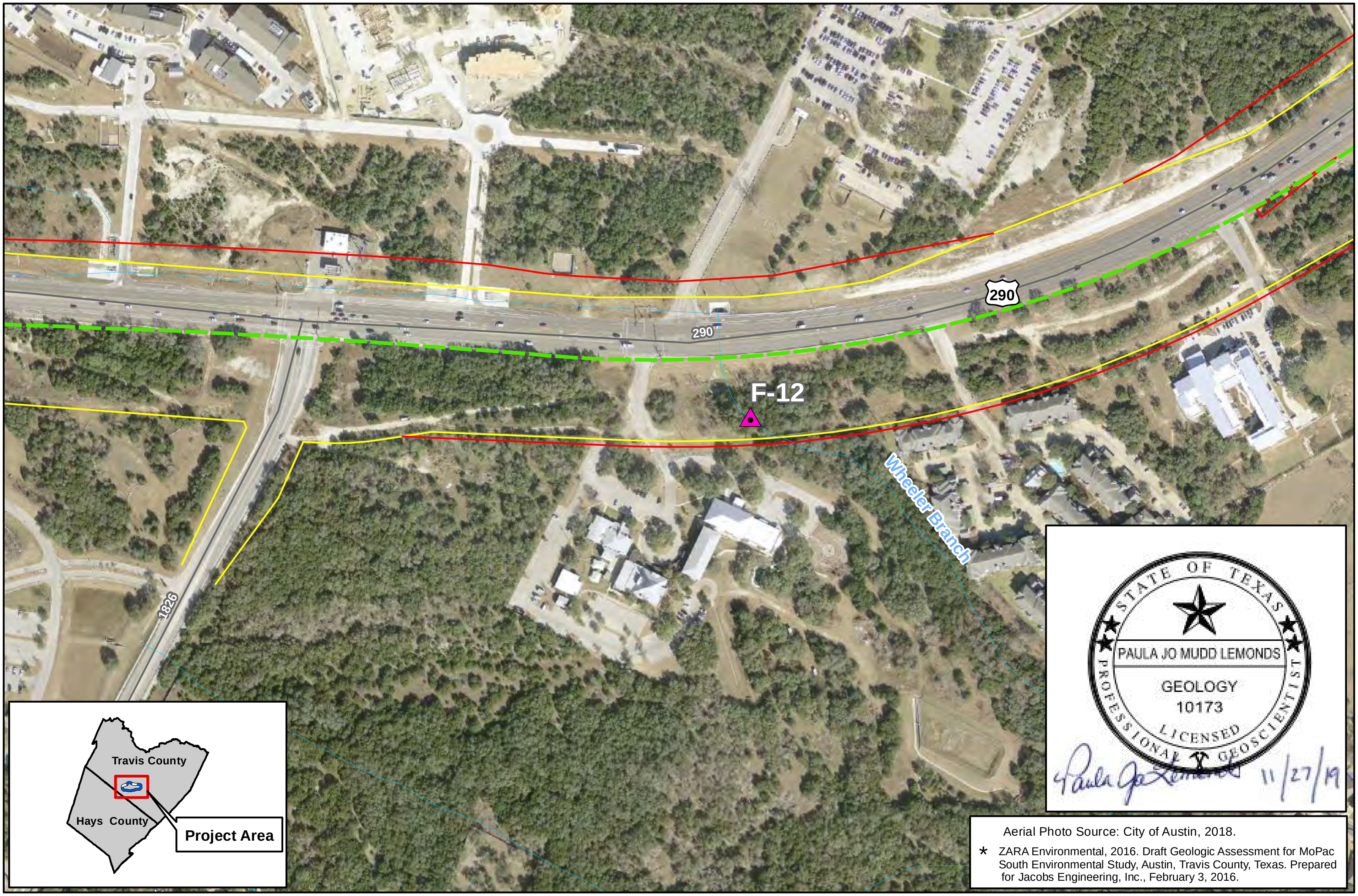

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- ▲ Geologic Feature
- Mount Bonnell Fault
- Proposed ROW
- Centerline
- Existing ROW

N

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Feet

Prepared for: TxDOT

CSJ: 0013-08-060 and 0700-03-077

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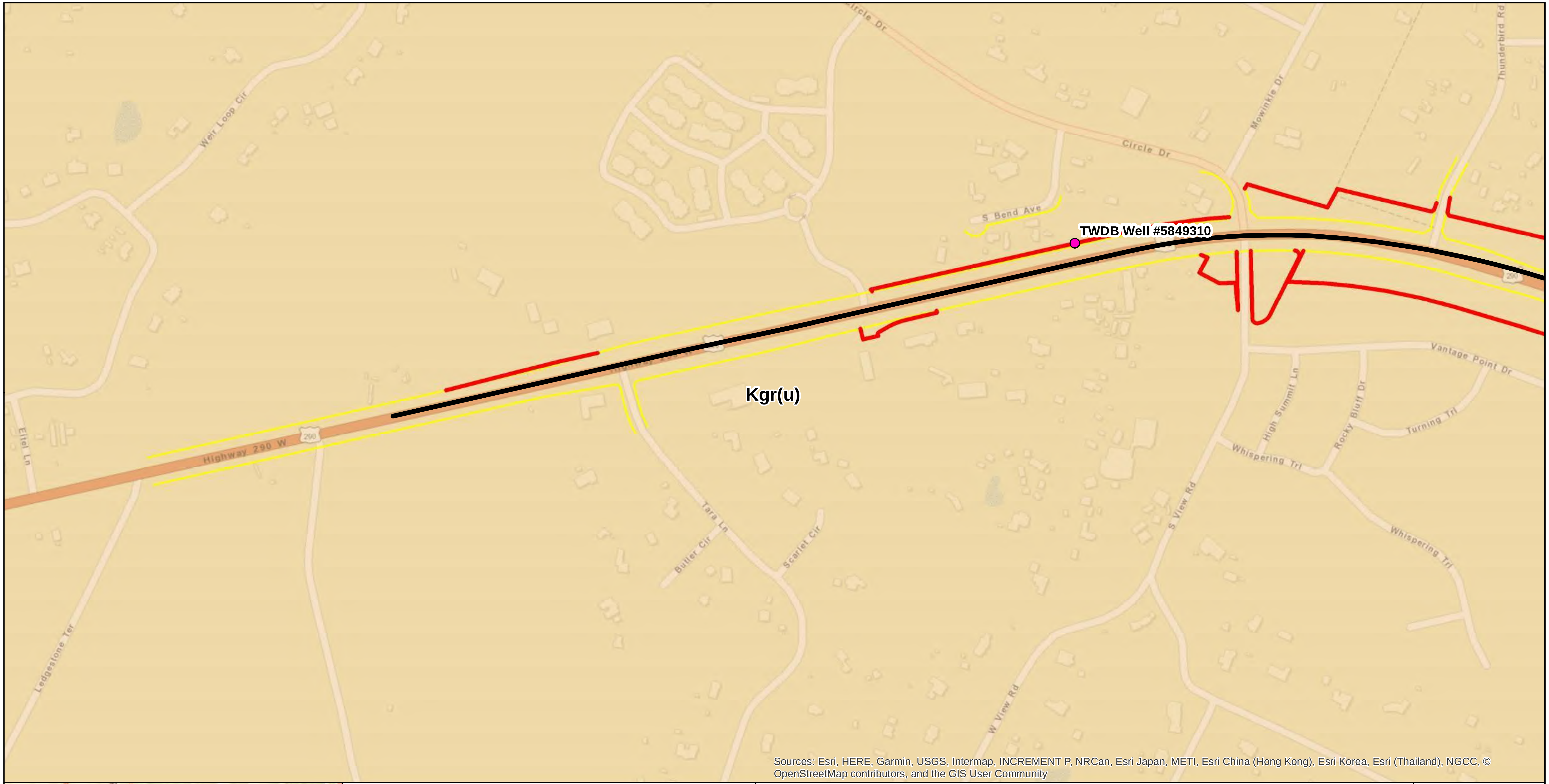
Attachment D

Site Geologic Map

Soil Profile and Narrative of Soil Units

Site Soils Map

Site Geologic Map
U.S. Highway 290 (US 290) / State Highway (SH) 71 West from
State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and
SH 71 to Silvermine Drive
Travis County, Texas
CSJ: 0113-08-060 and 0700-03-077



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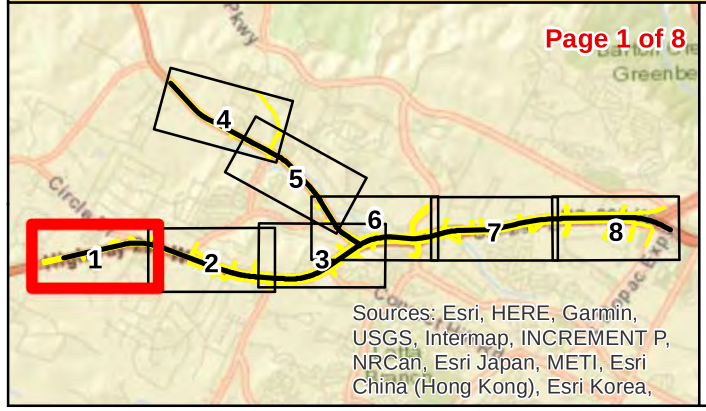

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Legend

- ● TWDB Wells
- ━ Centerline
- ━ Existing ROW
- ━ Proposed ROW
- ▨ Area not accessed during geologic survey

Geologic Formations

- ▨ Kdg - Del RIo Clay and Georgetown Formation
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- ▨ Qal - Alluvium
- ▨ Qhg - High gravel deposits

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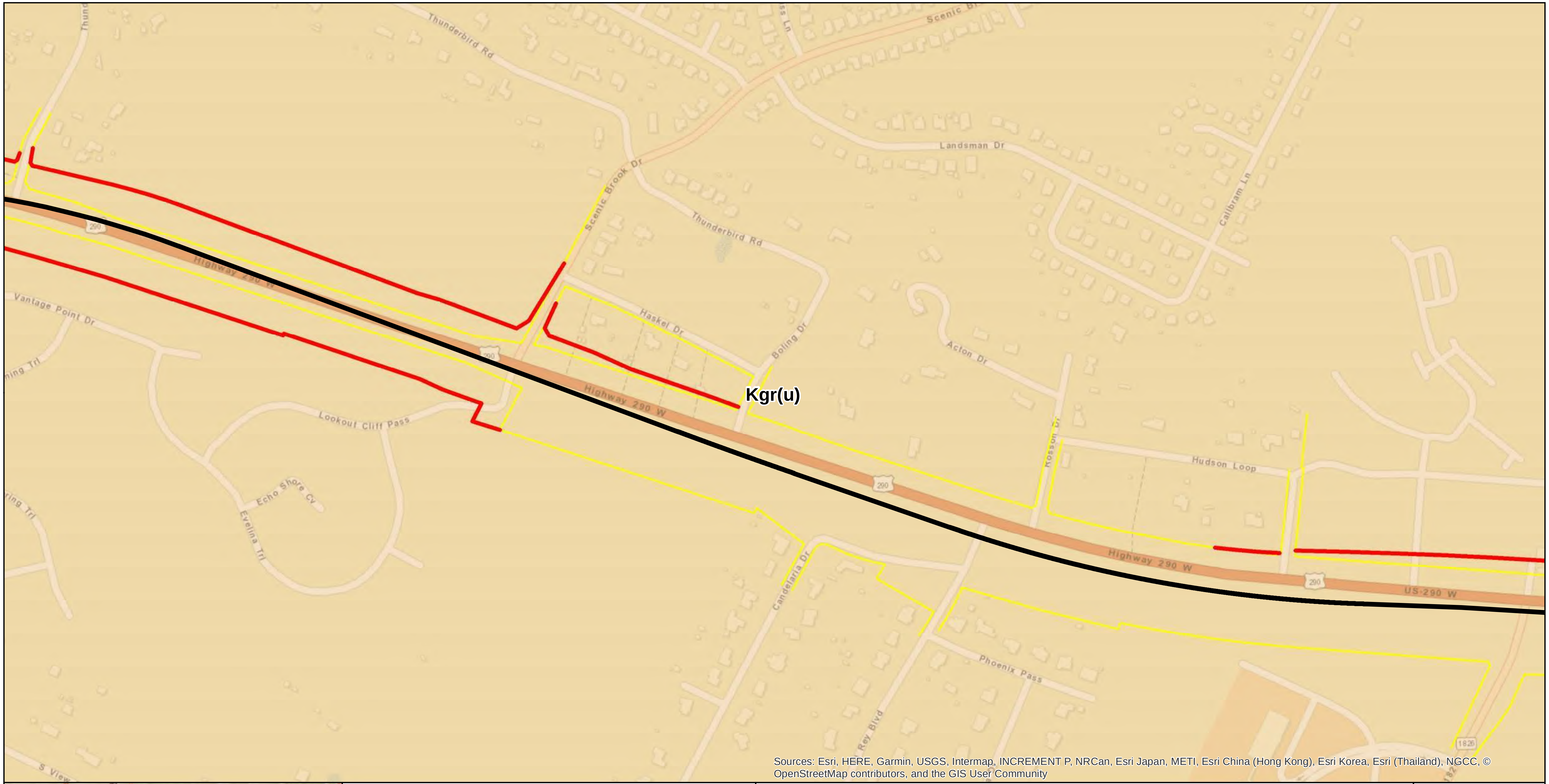
Feet

April 2019



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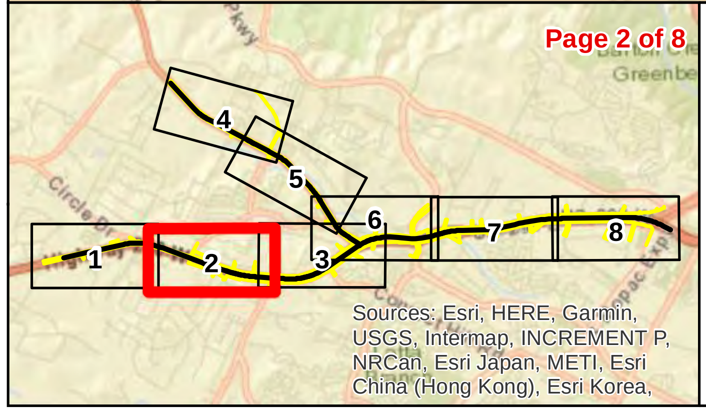

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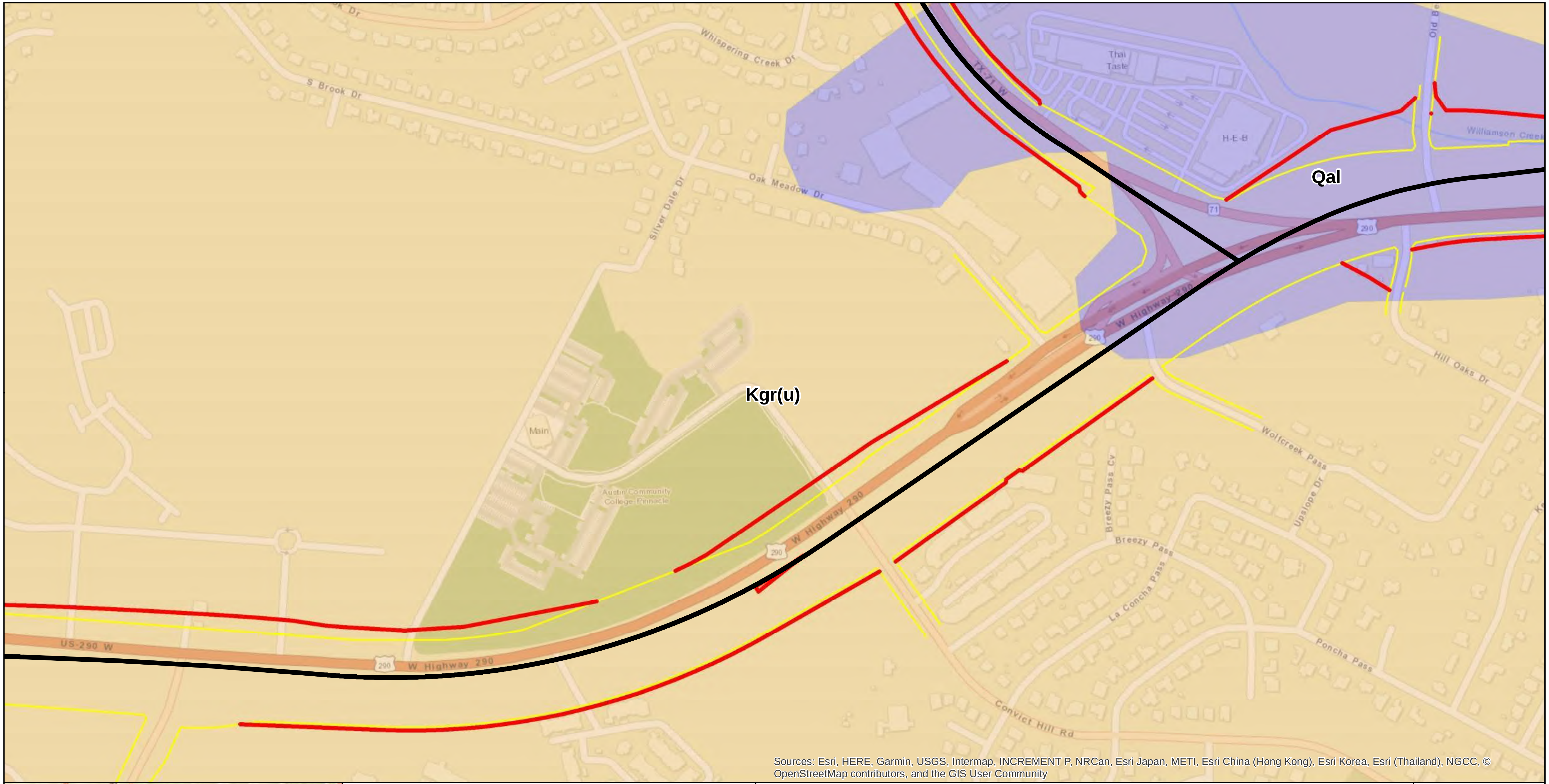

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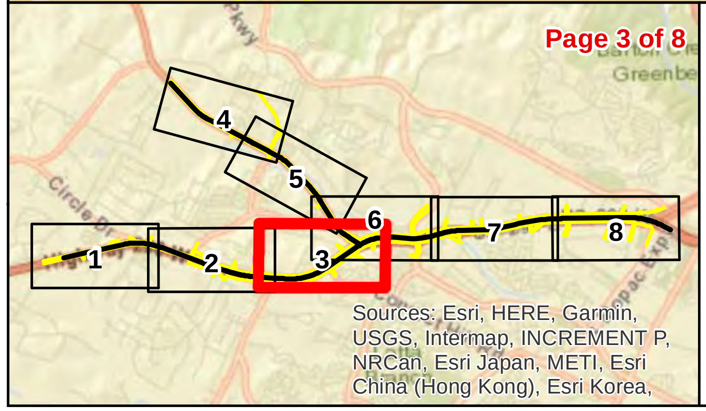

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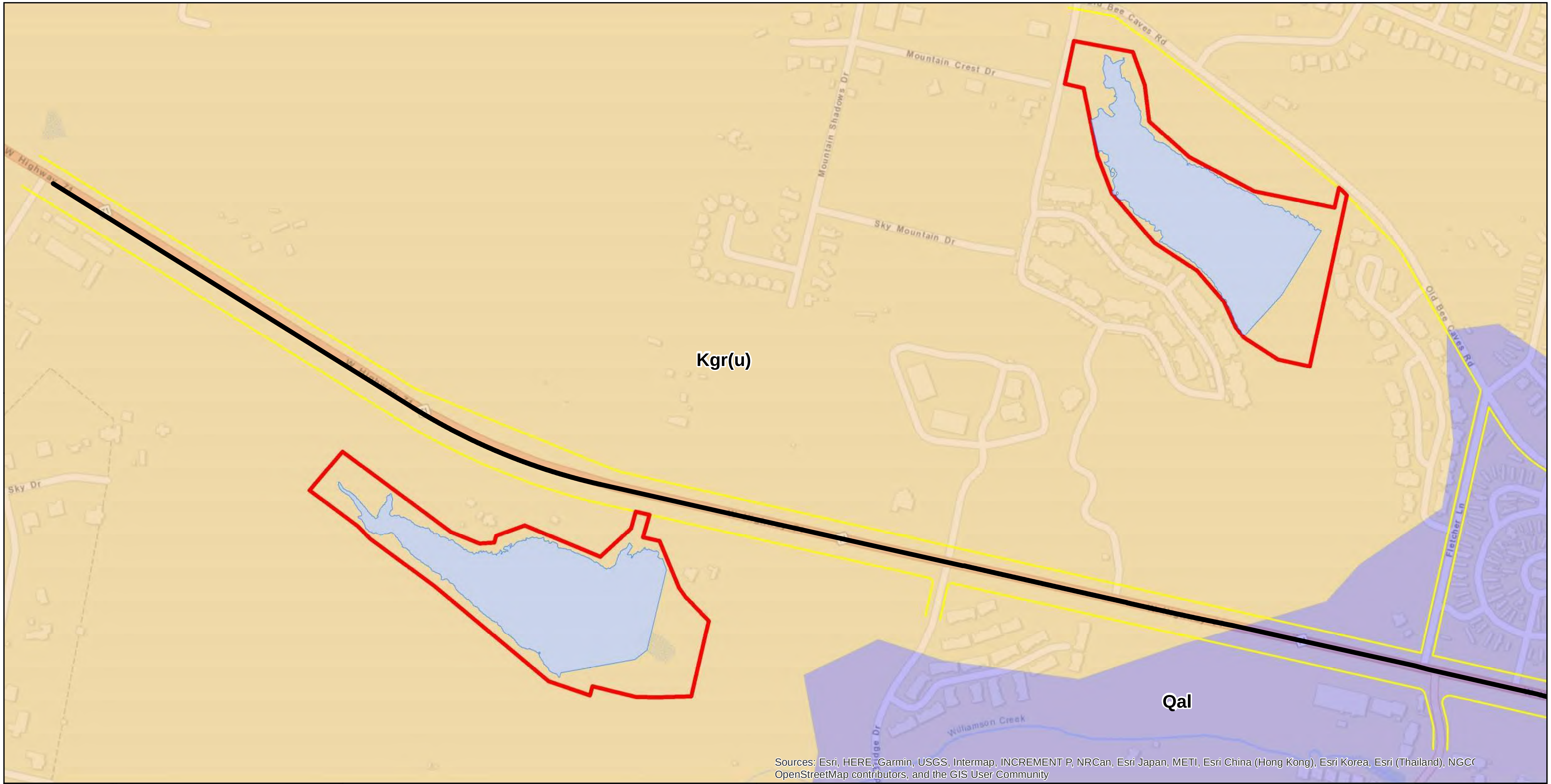

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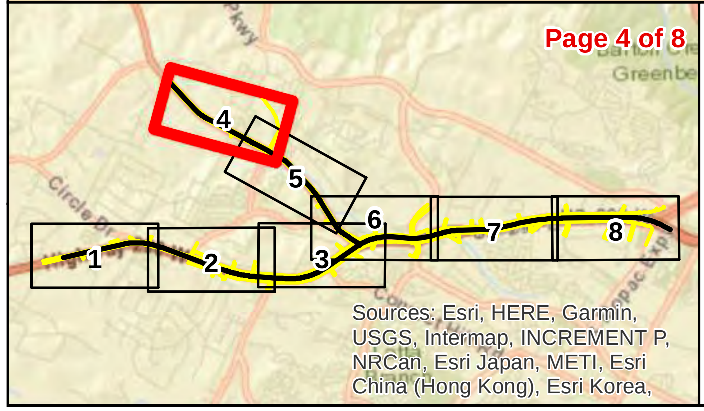

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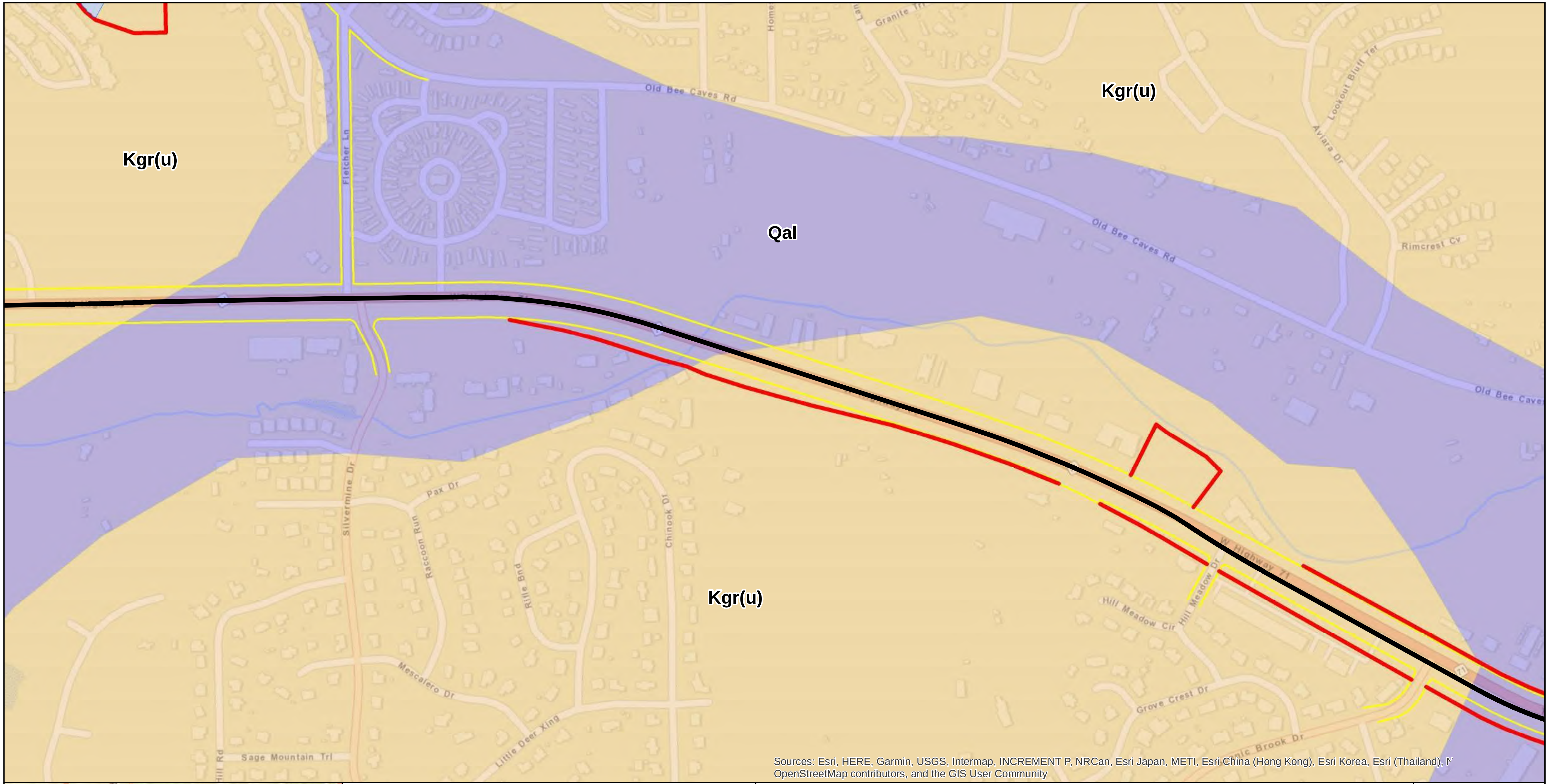

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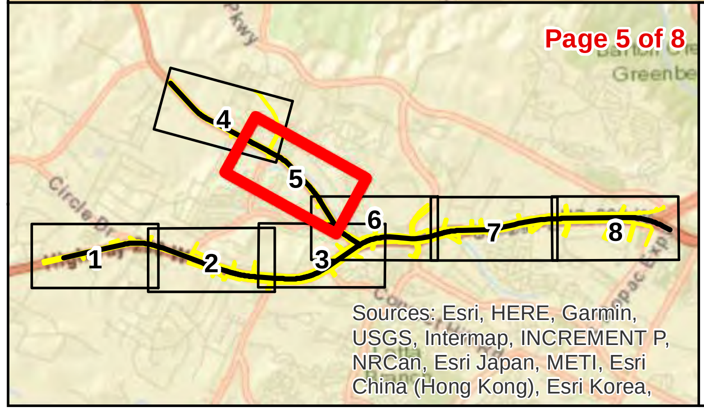

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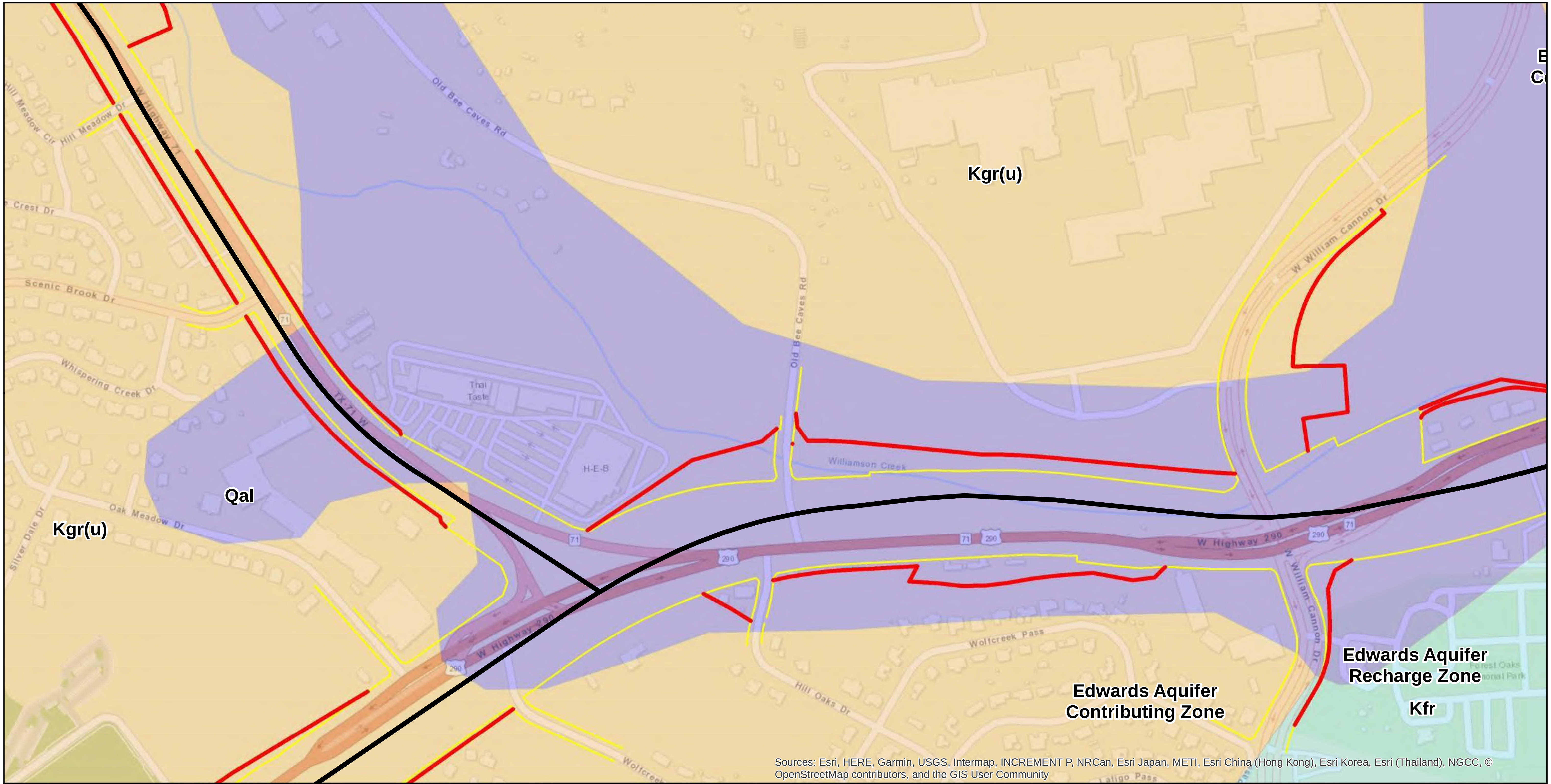

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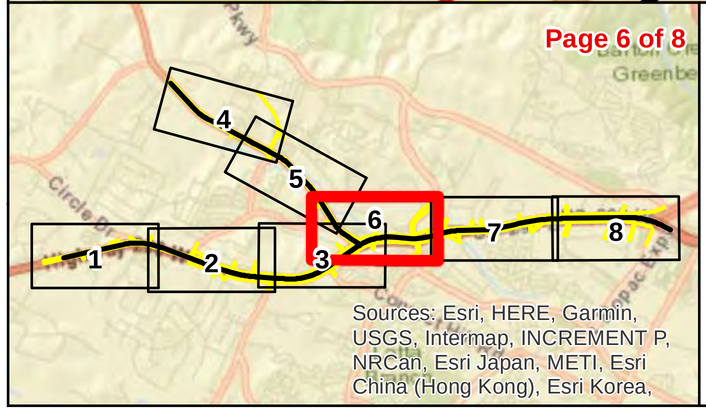

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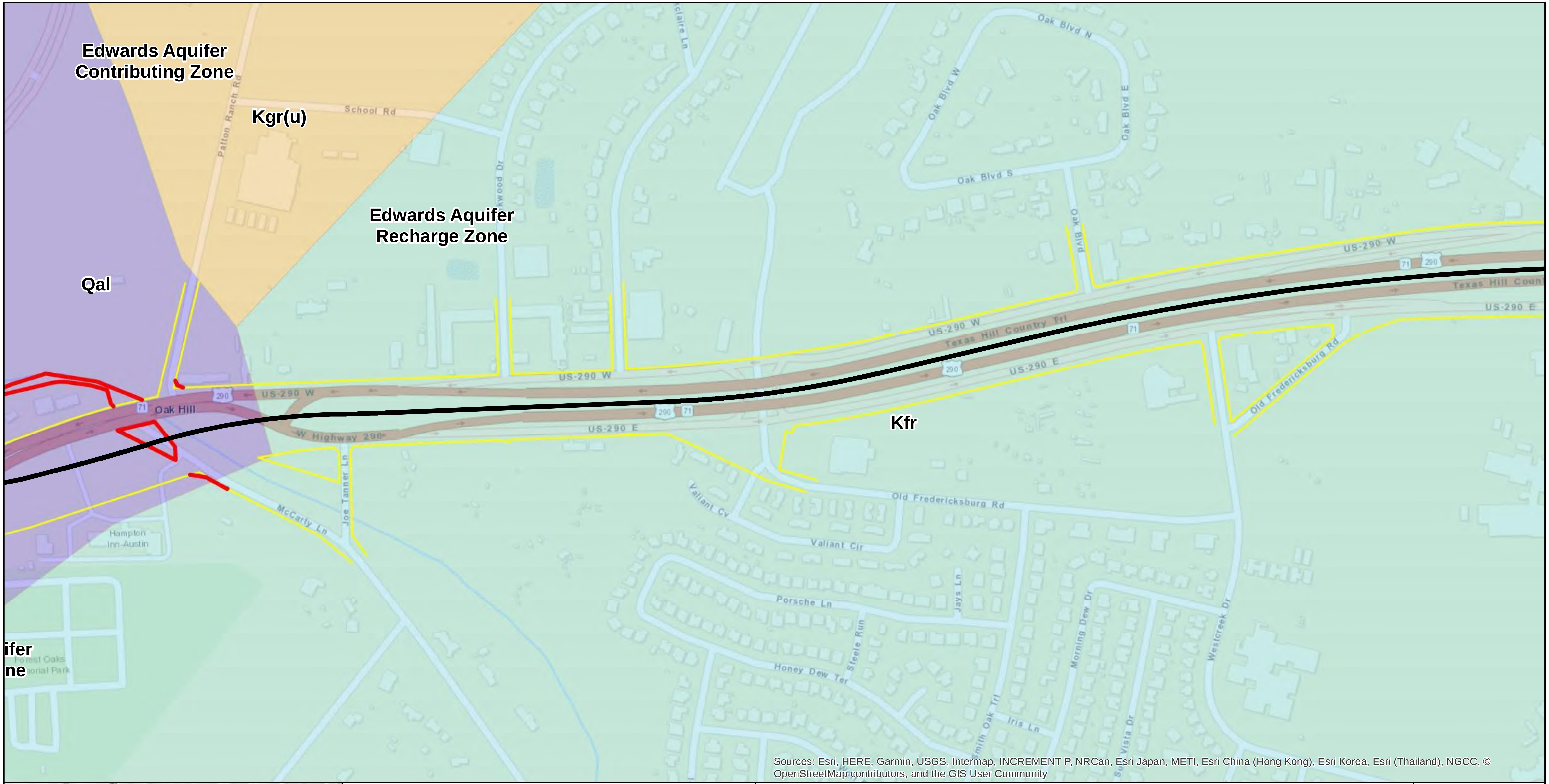

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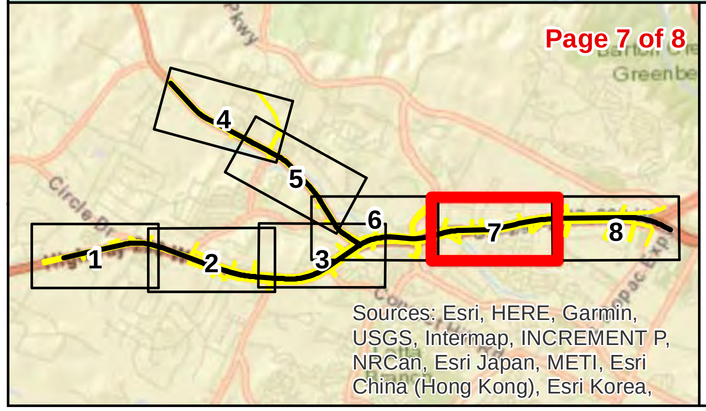

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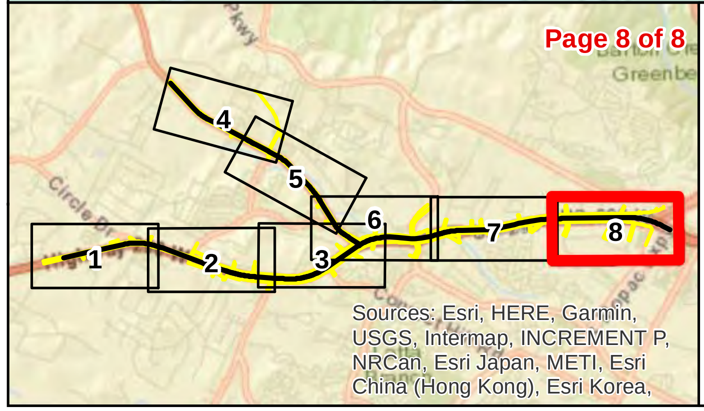

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Soil Profile, Narrative of Soil Units, Site Soils Map
U.S. Highway 290 (US 290) / State Highway (SH) 71 West from
State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and
SH 71 to Silvermine Drive
Travis County, Texas
CSJ: 0113-08-060 and 0700-03-077

Site Soils Description and Map

The following table of site soil descriptions was prepared based on the United States Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) (2015) in addition to field visit observations.

The project study area includes two general soil map units, the Brackett Association and the Speck-Tarrant Association. These soil associations are described as mainly shallow, rolling and steep soils of the Edwards Plateau (USDA, 1974). The Brackett Association occurs in the western portion of the project area, beginning near the intersection of US 290 and William Cannon Drive. This general soil map unit includes gently undulating to steep soils capped in some locations on narrow ridges (USDA, 1974). The Brackett Association primarily includes Brackett and Tarrant soils, with lesser percentages of Volente, Denton, San Saba, Pedernales, and Altoga soils. Although this association is generally considered to be too shallow, stony, gravelly or steep for farming, it is well suited for use as rangeland.

The Speck-Tarrant Association includes shallow, stony, loamy soils and very shallow, stony, clayey soils overlying limestone (USDA, 1974). This soil association occurs east of the Brackett Association soils and is described as nearly level to gently sloping and gently undulating. The Speck-Tarrant Association contains two major soil types, Speck soils and Tarrant soils, along with minimal amounts of San Saba soils, Crawford soils and mixed alluvial land. Areas of this soil association are commonly used for range and are well suited as wildlife habitat.

According to the Soil Survey of Travis County, Texas (USDA, 1974), and the USDA Web Soil Service (http://websoilsurvey.nrcs.usda.gov/app/) (NRCS, 2015a), twelve soil units occur within an area defined as 500 ft. wide on either side of the project centerline and within the detention pond areas (Figure 3). These soils are described in detail within Table 2 below.

Table 2. Soil Series and Descriptions

Soil Series and Description	Map Unit Name and (ID)	Description of Map Unit	Thickness (feet)	Prime Farmland Soil	Hydric Soil	Hydrologic Group*	Acres within Area	% of Area
The Brackett soil series consists of shallow, well-drained soils that developed under prairie vegetation of mid and tall grasses and trees. Brackett soils mostly have a gravelly surface layer and are underlain by interbedded limestone and marl; some are underlain by fractured chalk. Permeability is moderately slow, and the available water capacity is low.	Brackett-Rock outcrop complex, 1 to 12 percent slopes (BID)	This complex occupies rolling topography with areas of soil separated by outcrops of limestone and marl. Slopes are typically 5 to 12 percent.	Veneer to 1.5 ft	N	N	D	338.9	35.4
	Brackett-Rock outcrop complex, 12 to 60 percent slopes (BoF)	This unit occurs on steep breaks along creeks and rivers with areas of soil separated by outcrops of limestone and marl.	Veneer to 1.5 ft	N	N	D	21.1	2.2
Crawford series consists of well-drained, moderately deep, noncalcareous, clay soils that developed over hard limestone. These soils are in valleys and on side slopes and ridges, and developed under bunch and short grasses and scattered clumps of trees. These soils crack when dry and are very slowly permeable when wet	Crawford clay, 0 to 1 percent slopes (CrA)	This soil occupies valleys and ridges, mostly in association with more sloping Crawford soils.	Greater than 6.7 ft	Y	N	D	6.4	0.7
	Crawford clay, 1 to 2 percent slopes (CrB)	Slopes on this soil are smooth and this soil seldom gullies. Well suited to range, crops,	2.7 ft	Y	N	D	129.7	13.5

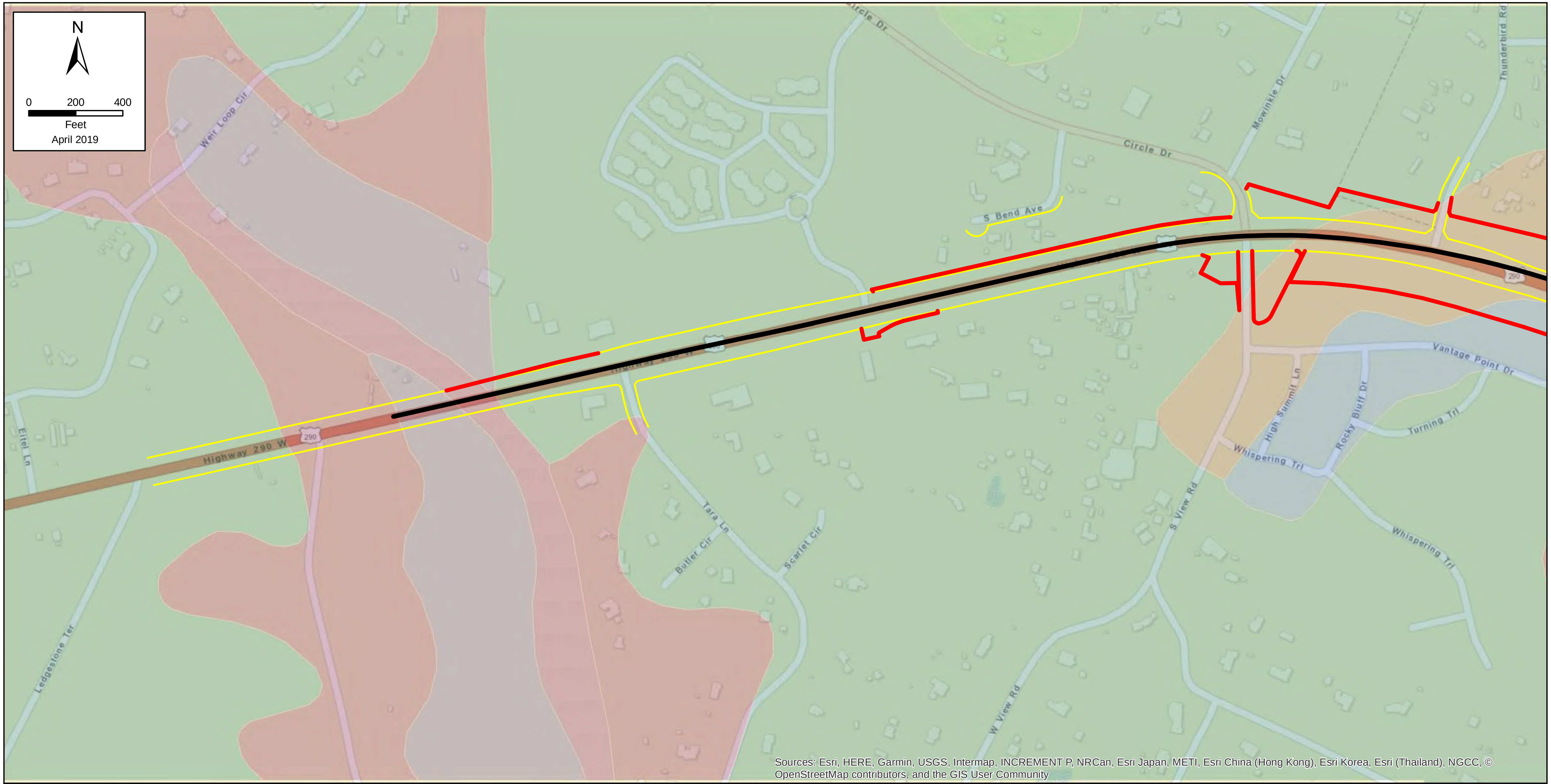
with a high available water capacity.		improved pasture, or hay.							
The Denton series consists of moderately deep, well-drained, calcareous, clayey soils that developed over interbedded limestone and marly clays. Typically gently sloping and mildly undulating, these soils developed under mid and tall grasses. Denton soils are slowly permeable with high available water capacity.	Denton silty clay, 1 to 3 percent slopes (DeB)	This soil occurs on smooth ridges and has a moderate erosion hazard, but is mostly cultivated.	3 ft	Y	N	D	8.3	0.9
Gravel Pits	Gravel pits, 1 to 90 percent slopes (GP)	Gravel pits.	-	N	N	--	1.4	0.2
Mixed alluvial land is a miscellaneous land type that occurs on floodplains of creeks and rivers. It consists of gravelly alluvium, beds of gravel, and exposed limestone beds and boulders randomly interspersed with moderately deep to deep calcareous alluvial materials.	Mixed alluvial land, 0 to 1 percent slopes, frequently flooded (Md)	Mixed alluvial land is found on floodplains. It typically includes very gravelly coarse sand. Well drained, this map unit has very low available water storage.	4 ft	N	N	A	41.5	4.3

Purves series soils consist of shallow, well-drained soils that developed in interbedded limestone and marl under a cover of mid and tall grasses. Purves soils are moderately, slowly permeable and have a low available water capacity.	Purves silty clay, 1 to 5 percent slopes (PuC)	These soils are typically on small knolls where the weathered limestone has been exposed.	Veneer to 1.5 ft	N	N	D	37.3	3.9
San Saba series soils include moderately well drained, moderately deep, clay soils which overly limestone. These soils are found in irregular areas on high broad ridges in addition to long, narrow valleys.	San Saba clay, 1 to 2 percent slopes (SaB)	This soil typically occupies smooth, single and complex slopes on broad uplands and in narrow valleys.	3.2 ft	Y	N	D	99.8	10.4
Speck series soils consist of shallow, well-drained soils overlying limestone. Slopes are smooth and complex and are dissected by widely spaced shallow drainageways. These soils developed under a cover of mid and tall grasses. Speck soils are slowly permeable and the water capacity is low.	Speck stony clay loam, 1 to 5 percent slopes (SsC)	This soil occupies smooth, gently undulating topography. Reddish-brown chert pebbles and cobblestones cover up to 50 percent of the surface in most areas.	1.5 ft	N	N	D	108.0	11.3

Tarrant series soils consist of shallow to very shallow, well-drained, stony, clayey soils overlying limestone. Large limestone rocks cover 25 to 85 percent of the surface in these soils. They occupy nearly level to gently sloping ridges, rolling side slopes, and steep, hilly breaks. These soils developed under tall grass and an open canopy of trees and are moderately slowly permeable and low water capacity.	Tarrant and Speck soils, 0 to 2 percent slopes (TcA)	This group occupies long areas on ridges with about 60 percent Tarrant soils, 30 percent Speck soils and small amounts of Crawford soils and rock outcrop. This soil unit is well suited to range use.	Veneer to 1.5 ft	N	N	D	21.6	2.3
The Volente series consists of deep, well-drained soils that developed in slope alluvium under a cover of mid and tall grasses and a scattered overstory of trees. Volente soils are moderately slowly permeable, and their water capacity is high.	Volente silty clay loam, 1 to 8 percent slopes (VoD)	This soil series is found on stream terraces. It is well drained with high water storage capabilities.	Greater than 6.7 ft	N	N	C	144.4	15.1
						Total	958.6	100.0

** Soil Group Definitions (Abbreviated)*

A. Soils having a high infiltration rate when thoroughly wetted.
B. Soils having a moderate infiltration rate when thoroughly wetted.
C. Soils having a slow infiltration rate when thoroughly wetted.
D. Soils having a very slow infiltration rate when thoroughly wetted.



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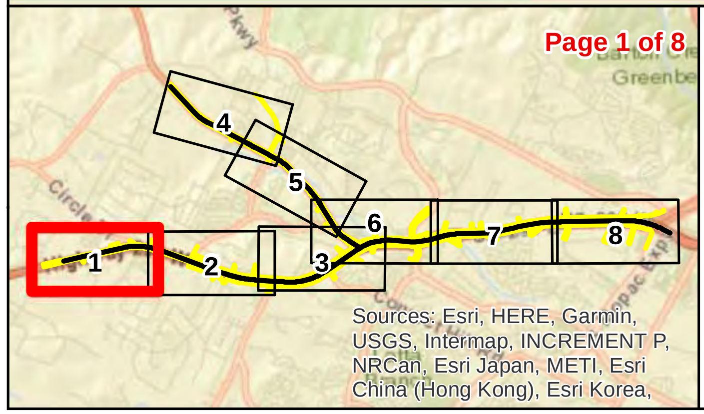

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SSURGO Soil Data

- ▨ BID - Brackett-Rock outcrop complex, 1 to 12 percent slopes
- ▨ BoF - Brackett-Rock outcrop-Real complex, 8 to 30 percent slopes
- ▨ CrB - Crawford clay, 1 to 3 percent slopes
- ▨ DeB - Denton silty clay, 1 to 3 percent slopes
- ▨ GP - Pits, gravel, 1 to 90 percent slopes
- ▨ Md - Mixed alluvial land, 0 to 1 percent slopes, frequently flooded
- ▨ PuC - Purves silty clay, 1 to 5 percent slopes
- ▨ QU - Quarry, 1 to 40 percent slopes
- ▨ SaB - San Saba clay, 1 to 2 percent slopes
- ▨ SsC - Speck stony clay loam, 1 to 5 percent slopes
- ▨ TaD - Tarrant soils, 5 to 18 percent slopes
- ▨ TcA - Tarrant and Speck soils, 0 to 2 percent slopes
- ▨ TdF - Tarrant-Rock outcrop complex, 18 to 50 percent slopes
- ▨ CrA - Crawford clay, 0 to 1 percent slopes

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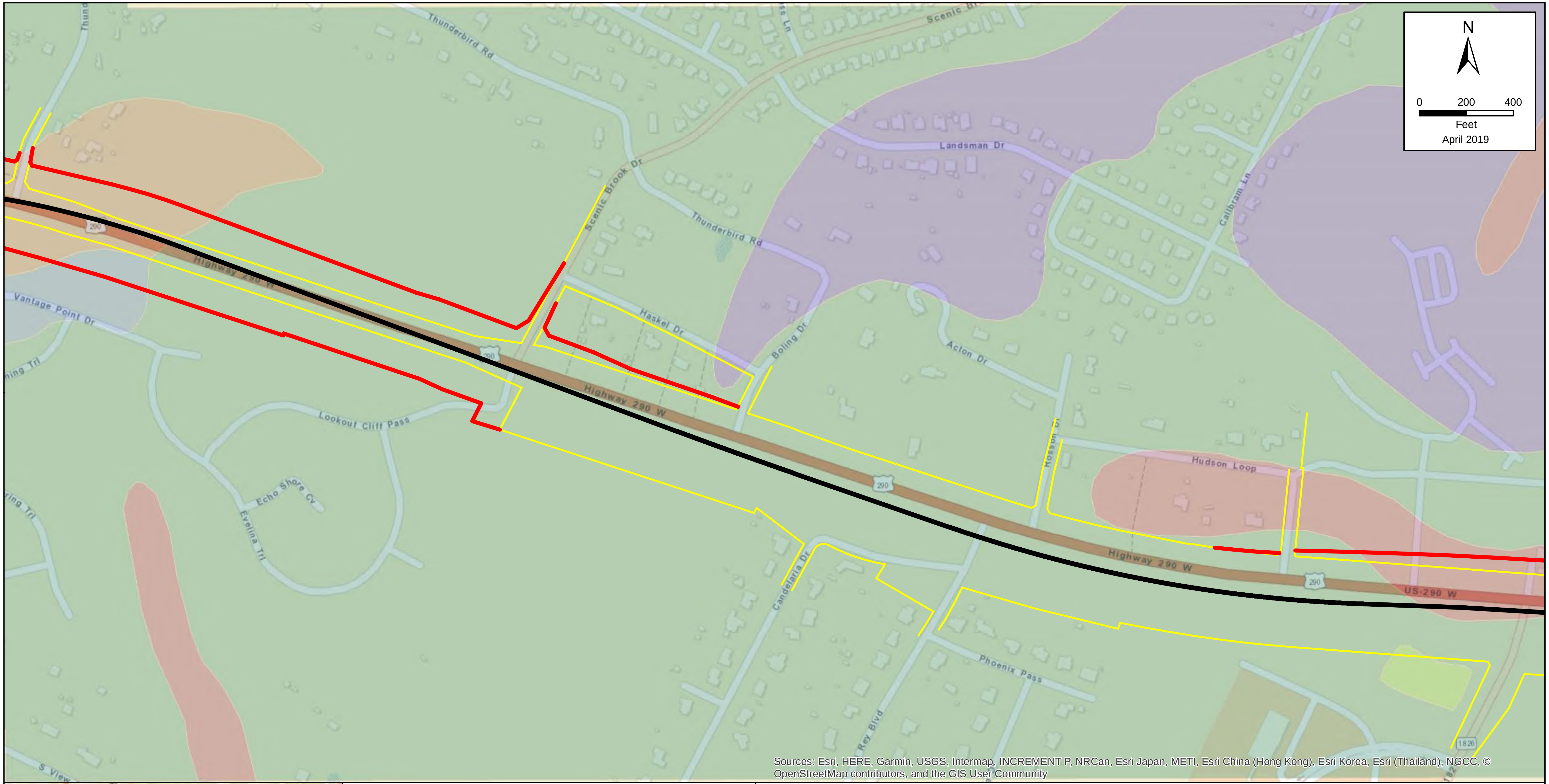

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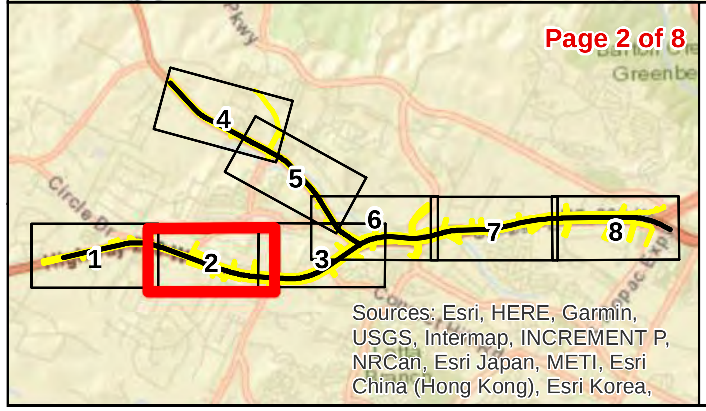

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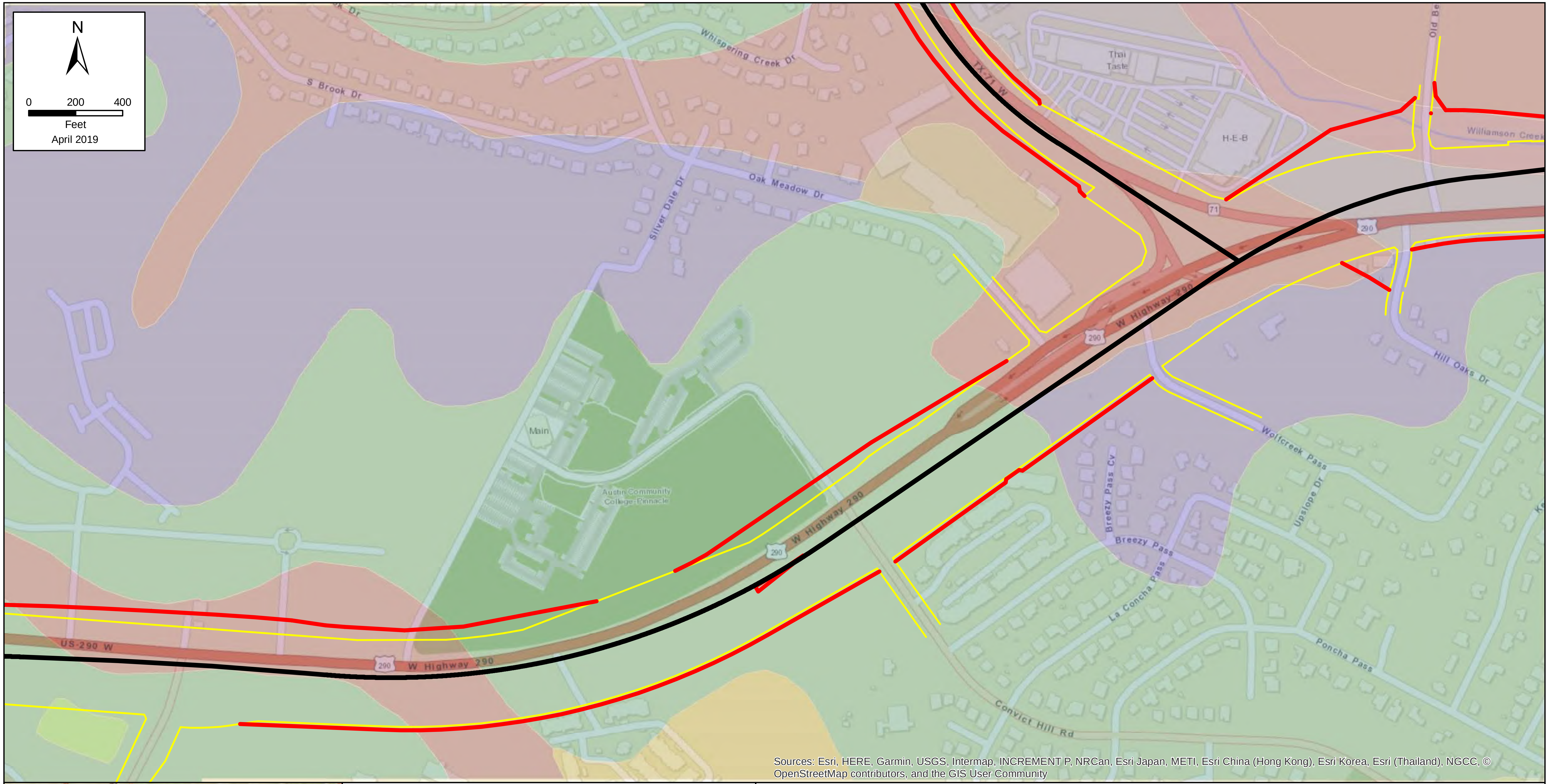

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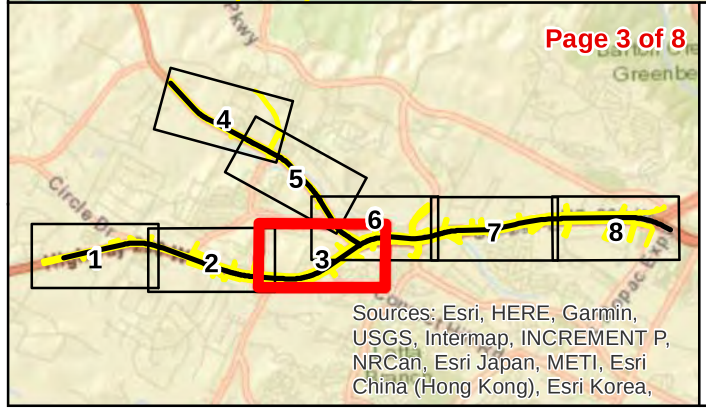

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Legend

━	Centerline
━	Existing ROW
━	Proposed ROW
▨	Area not accessed during geologic survey

SSURGO Soil Data

▨	BID - Brackett-Rock outcrop complex, 1 to 12 percent slopes
▨	BoF - Brackett-Rock outcrop-Real complex, 8 to 30 percent slopes
▨	CrB - Crawford clay, 1 to 3 percent slopes
▨	DeB - Denton silty clay, 1 to 3 percent slopes
▨	GP - Pits, gravel, 1 to 90 percent slopes
▨	Md - Mixed alluvial land, 0 to 1 percent slopes, frequently flooded
▨	PuC - Purves silty clay, 1 to 5 percent slopes
▨	QU - Quarry, 1 to 40 percent slopes
▨	SaB - San Saba clay, 1 to 2 percent slopes
▨	SsC - Speck stony clay loam, 1 to 5 percent slopes
▨	TaD - Tarrant soils, 5 to 18 percent slopes
▨	TcA - Tarrant and Speck soils, 0 to 2 percent slopes
▨	TdF - Tarrant-Rock outcrop complex, 18 to 50 percent slopes
▨	CrA - Crawford clay, 0 to 1 percent slopes

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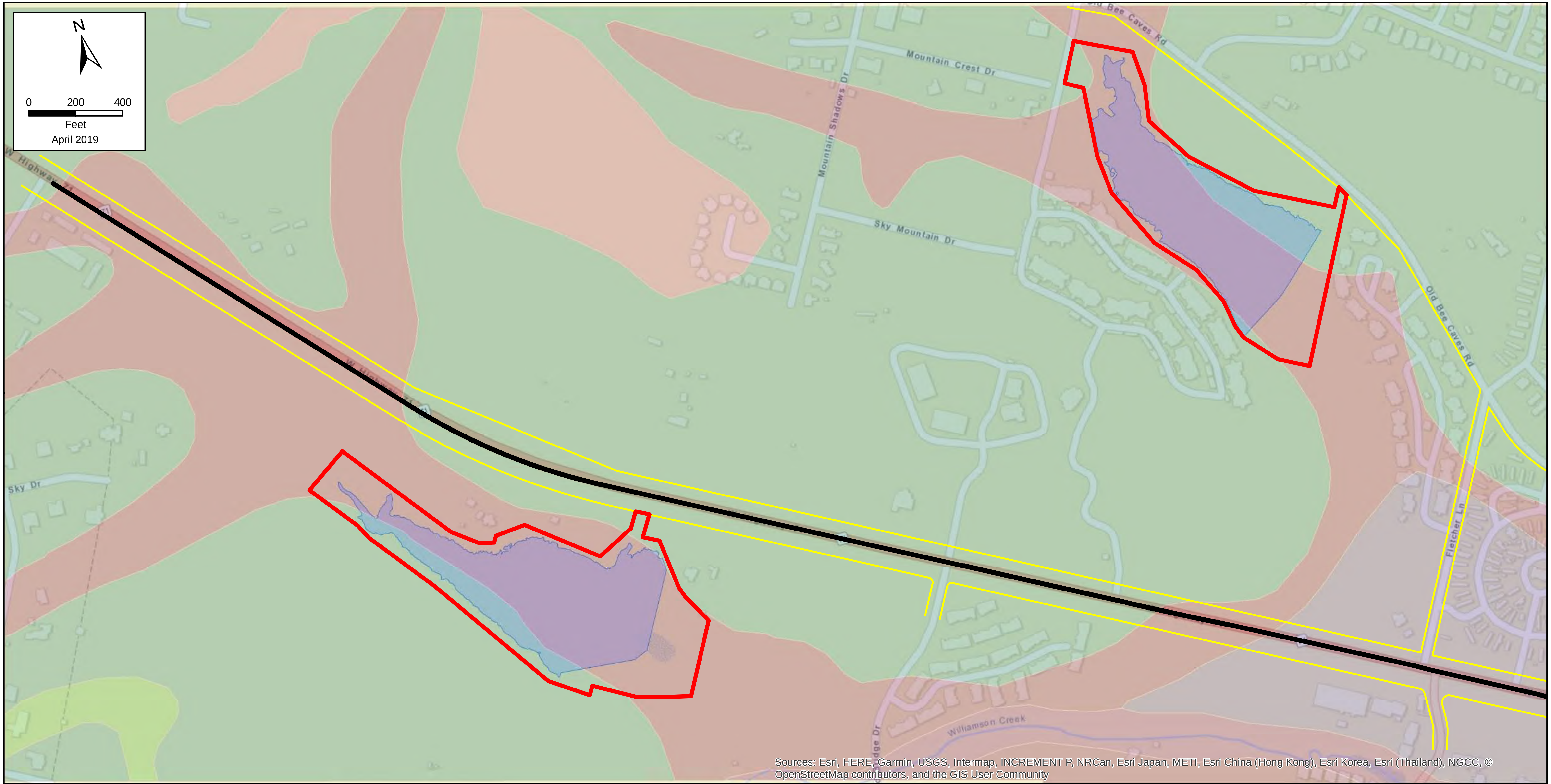

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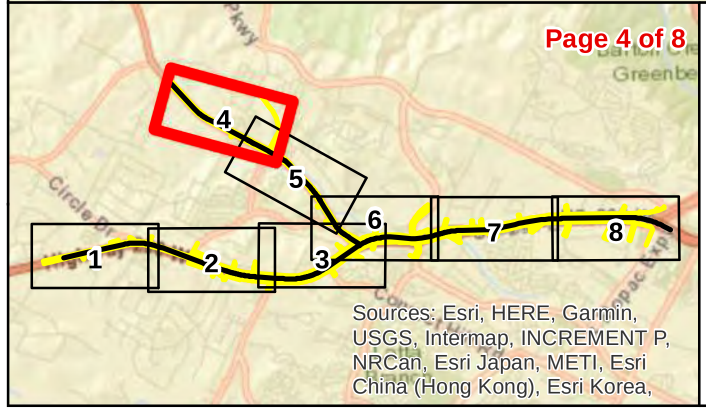

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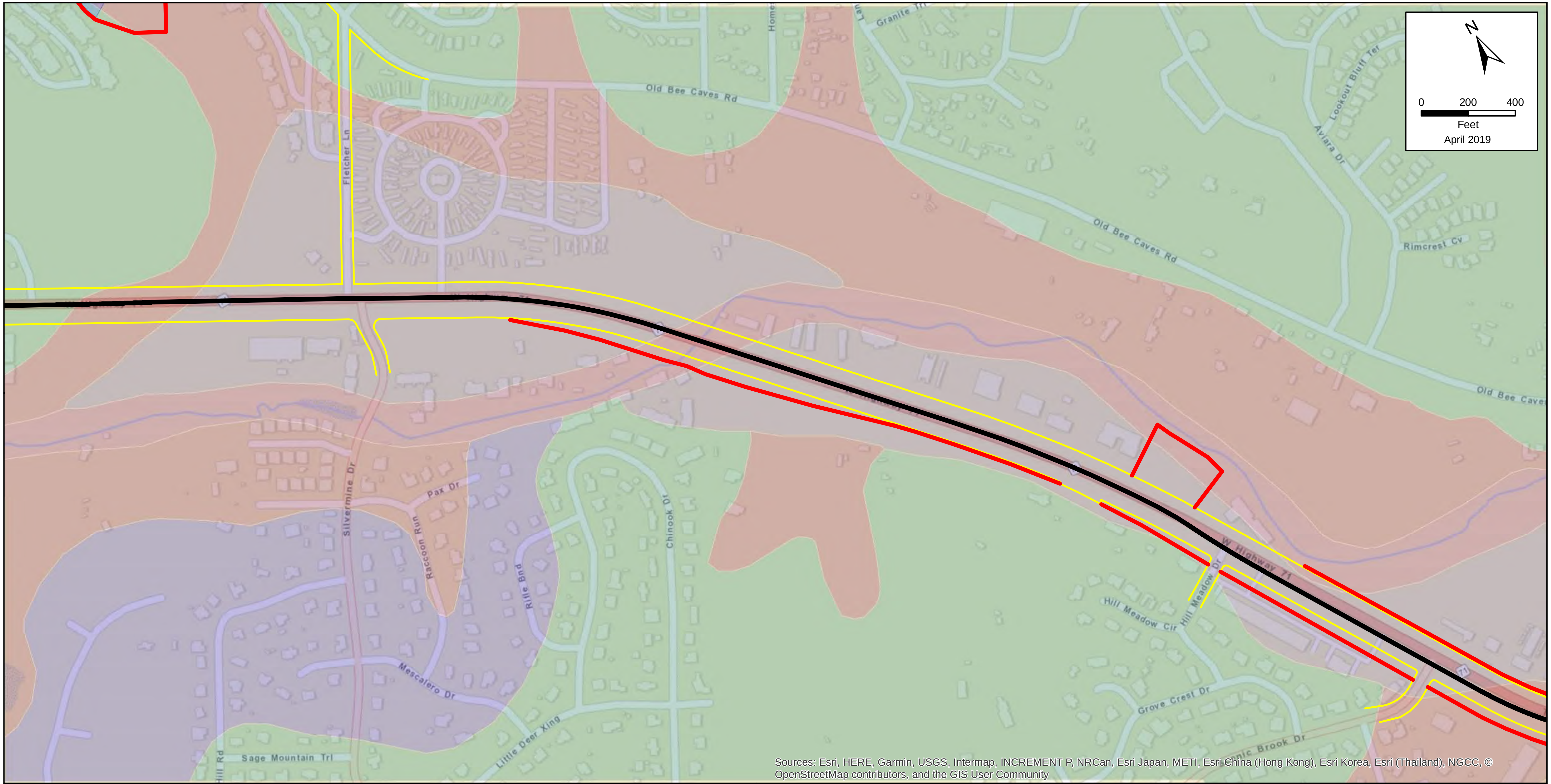

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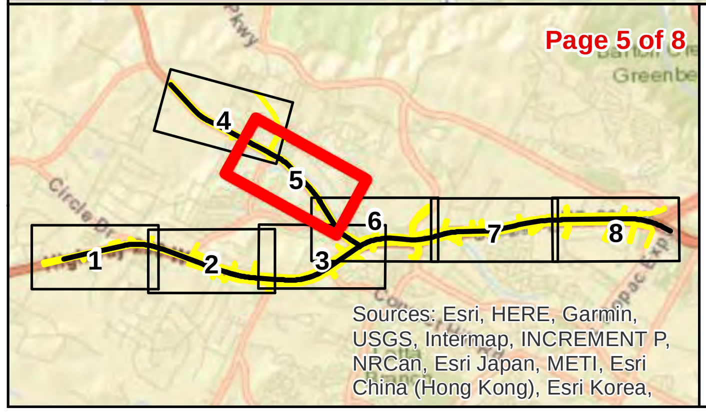

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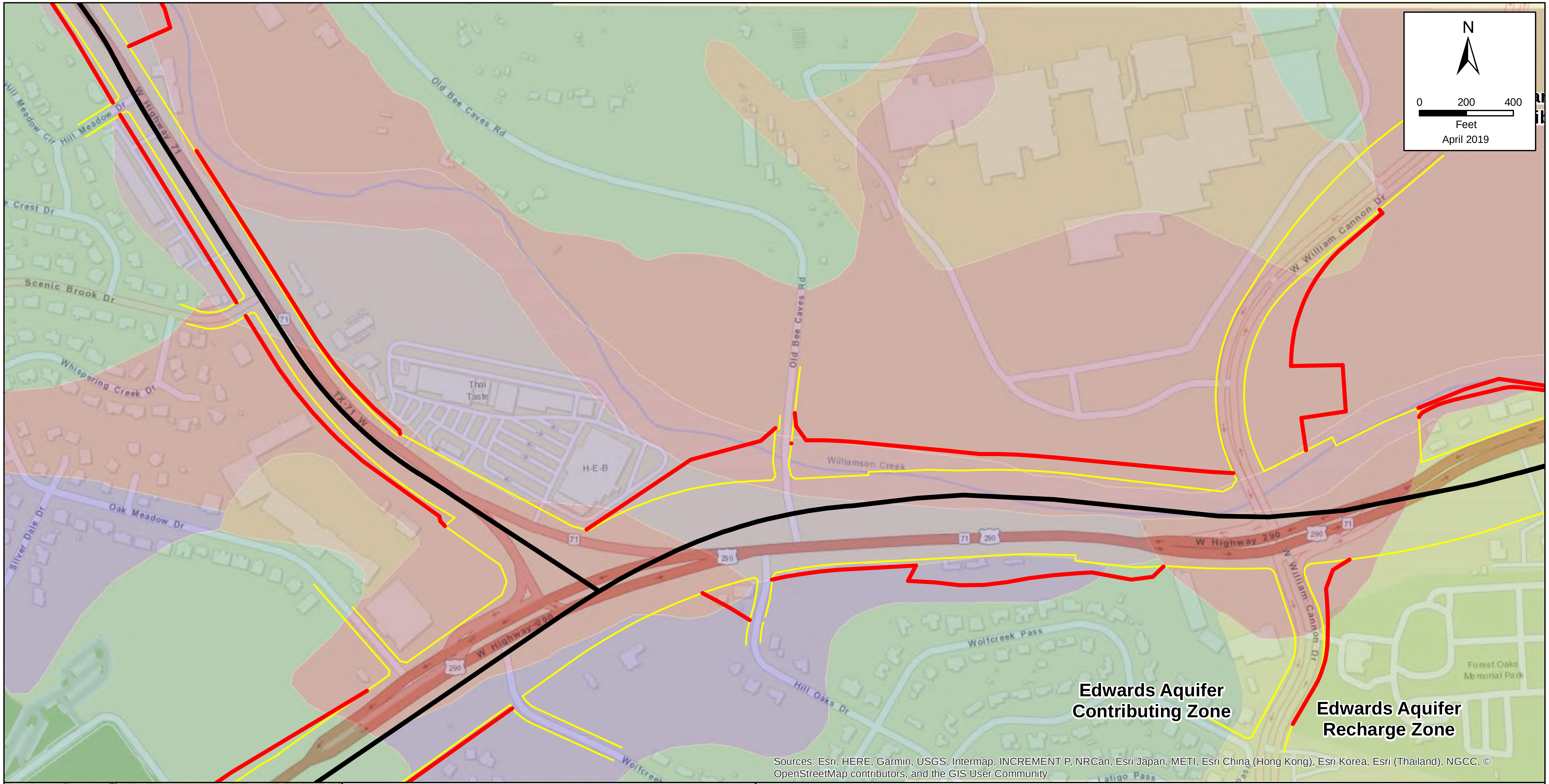

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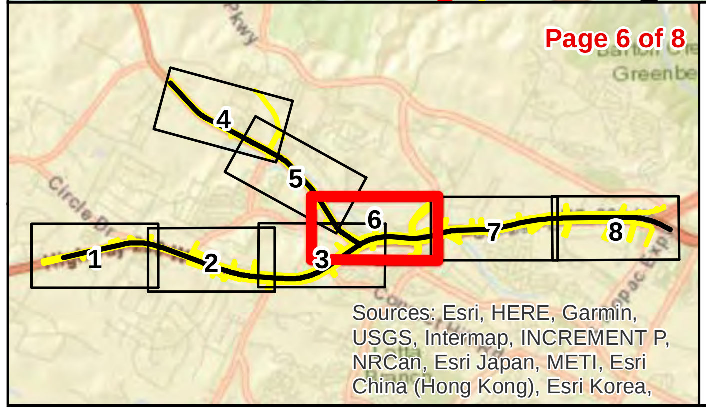

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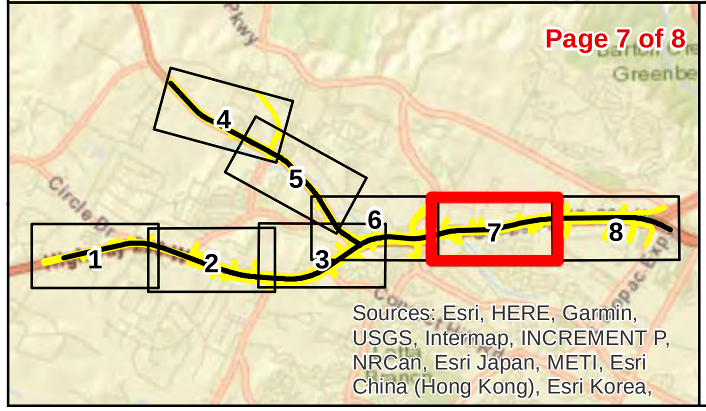

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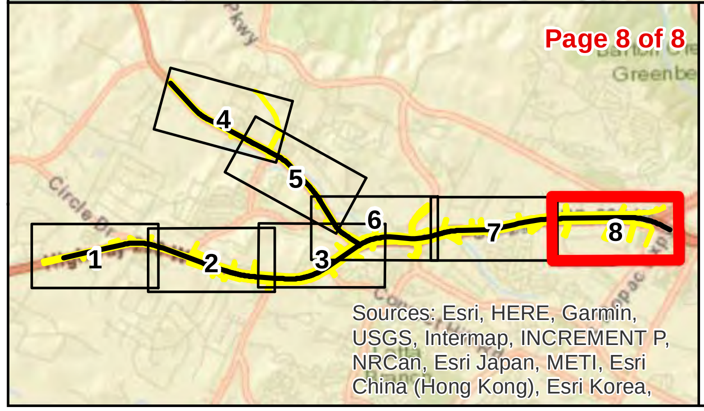

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This report was written on behalf of the Texas Department of Transportation by

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