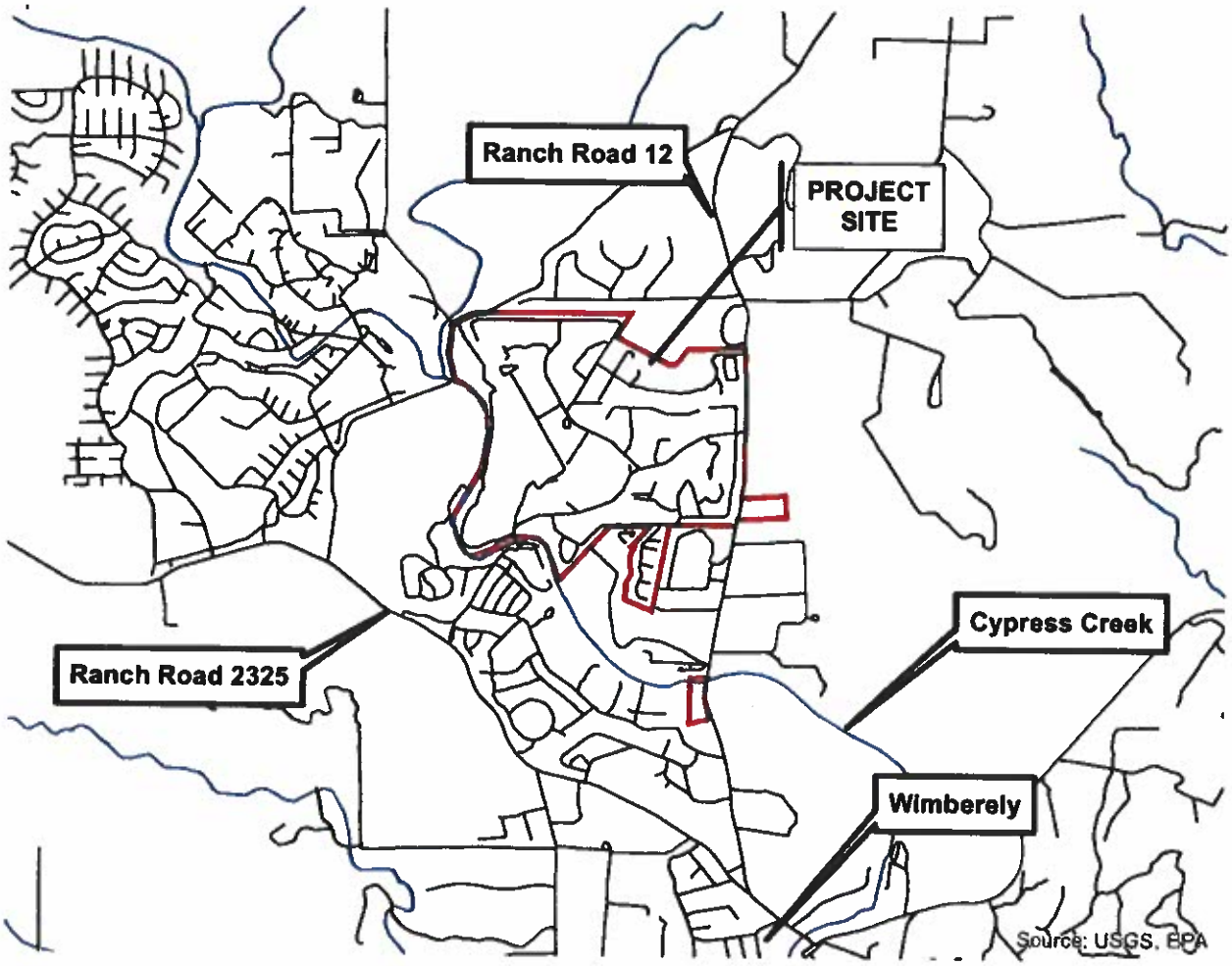
ROADWAY IMPROVEMENT DRAINAGE ASSESSMENT

For

CITY OF WOODCREEK

February, 2017
Project No. 14950-0001



Prepared by:

JONES|CARTER

Jones & Carter, Inc.
1701 Directors Blvd, Suite #400
Austin, TX 78744

512-441-9493
Firm Registration No. F-439

STATE OF TEXAS
JEFF C. HAEBER
103543
LICENSED
PROFESSIONAL ENGINEER
2/10/17

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1.0 Purpose

The City of Woodcreek is proposing a 10-Year Traffic Improvement Program. The first scope of work for the Roadway Improvement Drainage Assessment is to determine if there is an opportunity to increase the sizes of the culvert crossings along Hog Branch to reduce the frequency of overtopping. The second scope of work is a roadway drainage conveyance determination. The optimum cross-section for conveying the more frequent storms along the residential roadways have been determined in order to try and convey some amount of water within the road ROW during more frequent storm events that are less intense.

Project Location

The City of Woodcreek is in Hays County and located directly northwest of Wimberley. Hog Branch runs through the middle of Woodcreek, flowing from the north to Cypress Creek in the south. The three analyzed public culvert crossings are at Brookmeadow Street, Brookhollow Drive, and Brookside Drive.

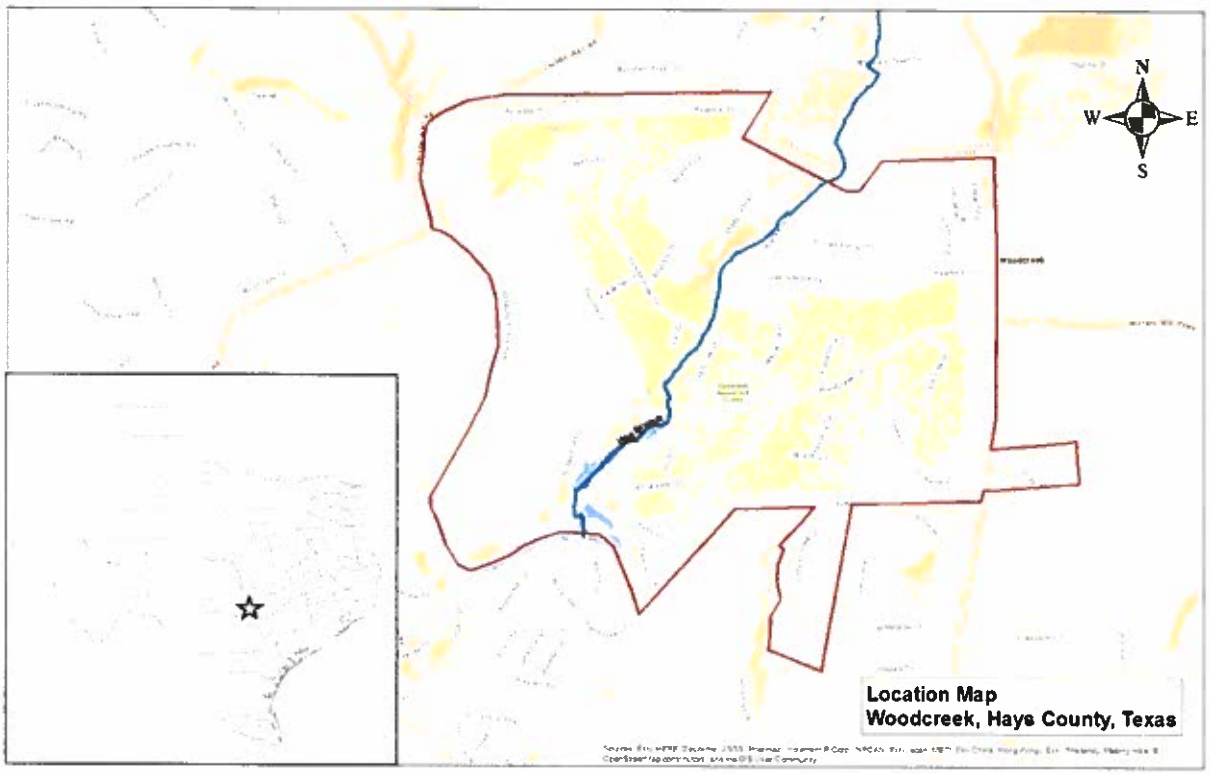

Figure 1 - Location Map

2.0 Existing Conditions

Hog Branch Creek runs through the middle of the city and is mapped as a FEMA flood zone A as shown in Exhibit 2. Zone A is defined as an approximate 100-year floodplain without a base flood elevation (BFE). Woodcreek is composed of residential homes in heavily wooded areas and an 18-hole golf course. The entire town has an area of approximately 1.1 square miles.

Culvert Crossings

The culvert crossings along Hog Branch in Woodcreek, Figure 2, overtop for all the storm events ranging from the 2-year to the 500-year. The creek is mostly natural with stones and moderate vegetation.

Figure 2- Culvert Crossing Location

Roadways

The majority of Woodcreek has no roadway drainage infrastructure. Runoff currently sheet flows throughout the neighborhoods due to the lack of curbs and underground storm sewer system. The roadways vary in width (16' to 24') throughout the city. Most of the roadways have a width approximately 22 feet in width. There are a few valley gutters. Heavy vegetation and tree cover is common throughout Woodcreek.

3.0 Drainage Structure Analyses

The crossings along Hog Branch, Figure 2, have been assessed. The existing Interim Feasibility Study Phase I HEC-RAS model prepared for the US Army Corps of Engineers (USACE) and Guadalupe-Blanco River Authority (GBRA) by Halff and Associates was used to obtain the information regarding hydraulic structure sizes. The HEC-RAS model was taken from Appendix D.3 of the Engineering Analysis and was prepared using version 4.1. There were some corrections made to the existing condition model. The main channel bank stations for the Hog Branch in the vicinity of Brookmeadow Street and Brookside Drive was widened slightly to give a more realistic hydraulic grade line. Originally, the profile was flat lined when spilling over Brookmeadow. HY-8 was used in order to document proposed changes to the existing culverts. HY-8 is an existing culvert analysis program used for analyzing and sizing culverts.

Determination

The creek for Brookhollow will need to be slightly regraded immediately upstream and downstream of the culvert to promote positive drainage. The creek immediately downstream and upstream of the Brookhollow Drive, Brookmeadow Street, and Brookside Drive crossing will also need to be regraded to improve conveyance and allow for a reduction of Water Surface Elevation (WSEL) and for a larger culvert opening. Approximately 35 feet of the creek cross section will be regraded and lowered between Brookmeadow and Brookside. The proposed creek bottom throughout this stretch will mostly be a trapezoidal channel with 0.2 foot per foot (ft/ft) slope and a 10 foot wide bottom. In addition, the existing vegetative cover creek bed will be replaced with a rock riprap to improve conveyance and lower the Manning's value thereby improving the conveyance. It is recommended to modify the driveway at 45 Brookmeadow to include culverts which would improve conveyance. Currently, the driveway exists as an inline structure that acts almost like a small damn and an obstruction.

The proposed crossings, Table 1 would improve the hydraulic grade line for Hog Branch. The proposed crossings for Brookhollow and Brookmeadow would contain and pass the 2-year storm which is the storm event most typically seen. The remaining storms will still overtop, but will be slightly improved. It is noted that modifications to existing structures would need to be analyzed in further detail during the design phase to determine potential impacts to the hydrologic conditions due to possible changes in timing. Also, the limits of re-grading will need to be examined further during the design phase to determine possible environmental requirements and permitting along with determinations for easements.

Table 1 - Hog Branch Crossings

Street	RAS Station	Existing Crossing	Option 1 Proposed Crossing	Option 2 Proposed Crossing
Brookhollow Drive	3039	4~4' CMP	5~4'x4' Conc Box	2~12'x4' Conc Box
Brookmeadow Street	4465	4~3' CMP	6~4'x4' Conc Box	2~12'x4' Conc Box
Driveway - 45 Brookmeadow Drive	4609	Inline Structure	4~3' CMP	4~3' CMP
Brookside Drive	4815	2~2' CMP	4~2' CMP	4~2' CMP

4.0 Roadway Drainage Conveyance Determination

A conveyance analysis has been performed to determine if the rehabilitated roadways in Woodcreek can convey additional runoff. Currently, the roadways lack any drainage control or infrastructure. It is proposed that the roadways will be dropped by approximately half a foot in order to capture sheet flow from adjacent drainage areas. The proposed subbasins for the roadway drainage analyses were subdivided from the overall existing drainage areas from the HALFF Interim Feasibility Study performed in September 2013. The ArcHydro extension in ArcGIS was utilized to determine flow patterns for the proposed condition modeling. The City of Austin Drainage Criteria Manual (May 27, 2016) was used as a reference for determination of storm runoff using the rational method. The method of analysis included the TR-55 and rational method. The runoff coefficient, manning's, rainfall intensity values for Travis County were applied based on the City of Austin's criteria.

Runoff Coefficient

The land use is from a National Land Cover Database (NLCD). The coefficient values, Appendix A.1, are calculated using a composite C value that incorporates the value for impervious cover and the value for pervious area. The runoff coefficient values for each drainage area is in Appendix A.2.

Time of Concentration

The TR-55 method was used for calculating the time of concentration. The minimum slope for a flow path was assumed as 0.005 (ft/ft). The subbasins were drawn to represent the flows for individual sections of roadway. The flow patterns for the proposed condition can be found in Exhibit 5. It was assumed that runoff would become channelized and follow the roadway while on the pavement. It should be noted that that the roadway will only capture the more frequent storm events. High enough storm events will spill over the proposed roadway curbs and sheet flow as existing conditions as it is not possible to convey all of the synthetic storm events. The calculations for the time of concentration is located in Appendix 4.1.

Rational Method

The flows were calculated using the rational method. The design storms for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year were used. The results for the runoff values can be found in Appendix A.5.

Determination

The flows for each subbasin for each design storm was applied to two different scenarios of road options. The first option had all roads improved to 24' wide 6" curb roadways (Figure 3) but Woodcreek Drive, Brookhollow Drive, Shady Grove Lane, Augusta Drive west of Brookhollow Drive, and Canyon Creek Drive which were improved to 20' or 22' wide 4" roll on curb roadways based on what exists currently at this. Detailed roadway options are described in be found in Appendix A.6.

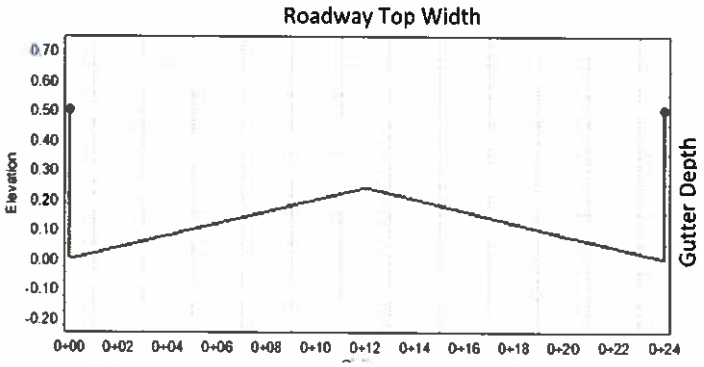

Figure 3 - Proposed Standard Curb Cross Section

Option 2 involved converting all roadways to 22' wide 4" roll on curbs except Woodcreek and Brookhollow Drive which would be 26' wide 4" roll on curbs (Figure 4).

The maximum storm event for each section in both options can be found in Appendix A.6.

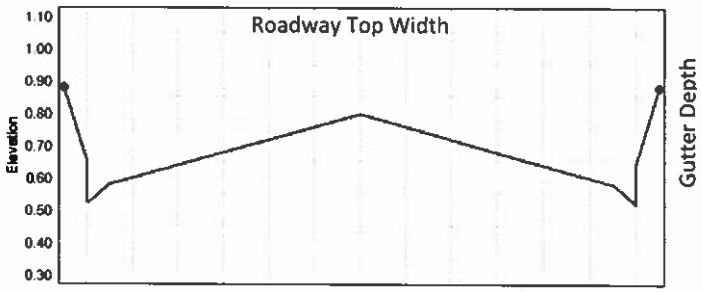

Figure 4: Proposed Roll on Curb Cross Section

Concerns

Location 1 at Brookmeadow:

Subbasin 1350 drains from the north to the south along Brookmeadow to the lowest point at mark noted. There is uncertainity on how the runoff should be routed from this point into subbasin 1340. One possible solultion is routing a portion of the subbasin down Elm Brook to connect with Deerfield. This area will be examined in greater detail during the design phase to develop potential solutions.

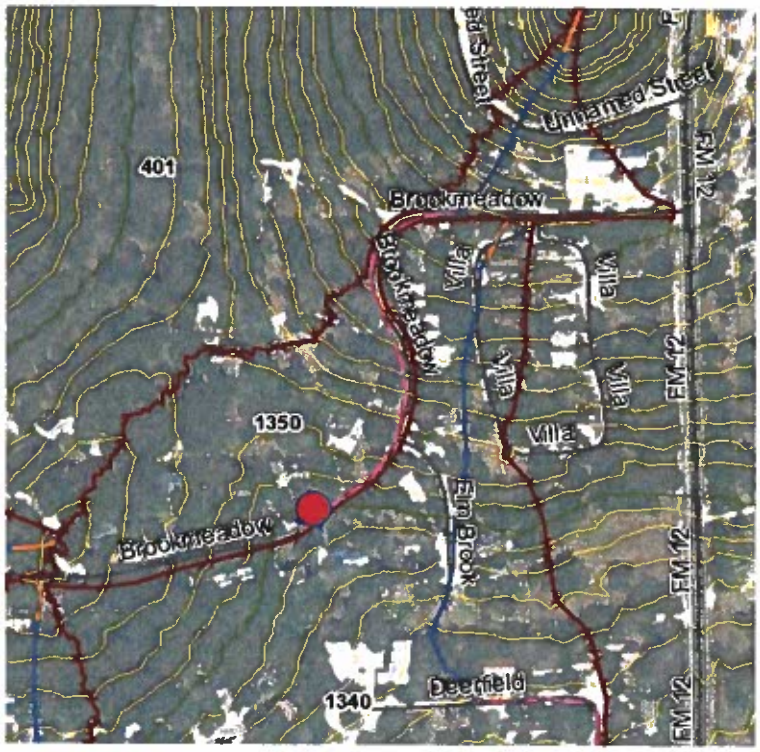

Figure 5 - Location 1 at Brookmeadow

Location 2 at Champion:

The proposed roadway improvement for subbasin 1210 ends at the mark. It is uncertain on where the channnelized flow should be routed to Cypress Creek. This area will be examined in greater detail during the design phase to develop potential solutions.

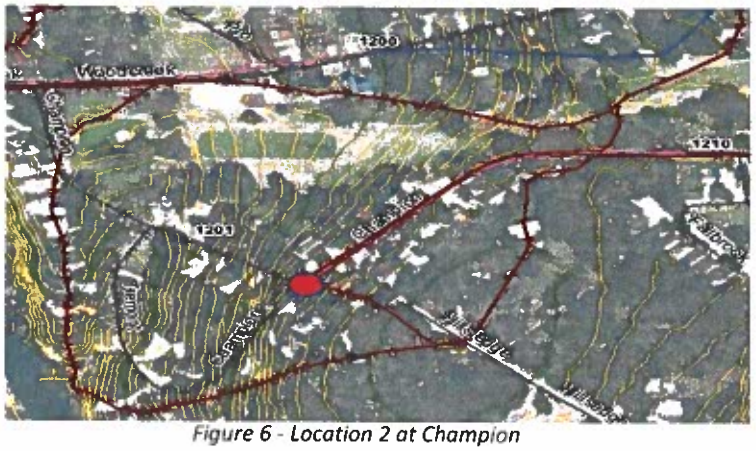

Figure 6 - Location 2 at Champion

5.0 Summary and Conclusions

The culverts along Hog Branch can be improved to contain approximately the 2-year storm at Brookmeadow and Brookhollow. There will need to be minor regrading within the creek to improve flow conditions. It is also recommended to improve the culverts to the driveway at 45 Brookmeadow. The remaining storms will still overtop the crossings. However, the WSELs have been slightly improved for the less frequent larger storm events for all the crossings as a result of the increased culvert capacity.

Improving the roadways in Woodcreek would capture the most frequent storm events and reduce the amount of sheet flow across residential property. Two concerns for routing the channelized flows need to be addressed. In addition, when final design of culvert improvements or roadway regrading is undertaken in the future, more detailed analyses may be required in order to determine potential specific project impacts. Any regrading within the creek areas will need to be examined to determine environmental concerns or permits that could be required in the future along for determining the need for additional easements or ROW. This could affect the proposed regrading within the creek areas.

After reviewing a draft of the report and meeting with the City to discuss, the direction was that most of the road rehabilitation would be designed at grade with ribbon curb to eliminate issues with trees and driveways. Some portions of the initial phase of Woodcreek may end up being designed with some type of curb and gutter. How this affects drainage on this initial phase of Woodcreek Drive will be determined during the detailed design phase. For the culvert improvements, a formal drainage analysis will be conducted during detailed design phases on future projects. The improvements to the culverts may require a submission to FEMA to document a Letter of Map Revision if improvements are completed after the new Flood Insurance Rate Maps are effective.

Appendices

A. **Hydrologic Calculations**
    1. **Land Use Values**
    2. **Runoff Coefficient**
    3. **Rainfall Intensity**
    4. **Time of Concentration**
    5. **Roadway Runoff**
    6. **Roadway Improvement Options**
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C. **Vicinity Map**
D. **FEMA Floodplain Map**
E. **Land Use Map**
F. **Topographic Map**
G. **Drainage Map**
H. **Drainage Map (Northeast)**
I. **Drainage Map (Northwest)**
J. **Drainage Map (Southeast)**
K. **Drainage Map (Southwest)**

	Impervious	Percent Impervious	Pervious	Runoff Coefficient						
				2 Years	5 Years	10 Years	25 Years	50 Years	100 Years	500 Years
Open Water										
Developed, Open Space	Concrete	5	Forest/WoodlandsFlat, 0-7%	0.247	0.278	0.308	0.339	0.379	0.419	0.506
Developed, Low Intensity	Concrete	30	Good Condition***Flat, 0-2%	0.372	0.401	0.424	0.467	0.500	0.543	0.643
Developed, Medium Intensity	Concrete	40	Good Condition***Flat, 0-2%	0.426	0.458	0.482	0.526	0.560	0.604	0.694
Deciduous Forest	Concrete	15	Forest/WoodlandsFlat, 0-7%	0.300	0.333	0.363	0.396	0.436	0.477	0.558
Evergreen Forest	Concrete	10	Forest/WoodlandsFlat, 0-7%	0.273	0.305	0.335	0.367	0.407	0.448	0.532
Shrub/Scrub	Concrete	30	Fair Condition**Flat, 0-2%	0.400	0.436	0.459	0.502	0.535	0.578	0.671
Herbaceous	Concrete	25	Fair Condition**Flat, 0-2%	0.375	0.410	0.433	0.475	0.508	0.550	0.648

C Value for Each Drainage Area

DA	Area (ac)	C2	C5	C10	C25	C50	C100
102	48.17	0.29	0.32	0.35	0.38	0.42	0.46
104	10.58	0.28	0.31	0.34	0.37	0.41	0.45
106	3.53	0.28	0.31	0.34	0.37	0.41	0.45
108	10.78	0.26	0.29	0.32	0.36	0.40	0.44
110	3.52	0.25	0.28	0.31	0.35	0.39	0.43
112	0.47	0.26	0.29	0.32	0.35	0.39	0.43
114	7.15	0.25	0.28	0.31	0.34	0.38	0.42
116	7.68	0.30	0.33	0.36	0.39	0.43	0.47
118	8.42	0.27	0.30	0.33	0.37	0.41	0.45
120	18.58	0.26	0.29	0.32	0.35	0.39	0.43
122	10.19	0.27	0.30	0.33	0.36	0.40	0.44
124	9.36	0.29	0.32	0.35	0.38	0.42	0.46
202	27.15	0.27	0.30	0.33	0.36	0.40	0.44
204	5.35	0.26	0.29	0.32	0.35	0.39	0.43
206	4.52	0.27	0.30	0.33	0.36	0.40	0.44
208	1.51	0.26	0.29	0.32	0.35	0.39	0.43
210	3.86	0.27	0.30	0.33	0.36	0.40	0.44
212	4.42	0.28	0.32	0.34	0.38	0.42	0.46
214	2.81	0.26	0.29	0.32	0.36	0.40	0.44
216	21.17	0.30	0.33	0.35	0.39	0.43	0.47
217	0.53	0.25	0.28	0.31	0.34	0.38	0.42
218	7.60	0.27	0.30	0.33	0.36	0.40	0.45
220	2.31	0.25	0.28	0.31	0.35	0.39	0.43
222	4.65	0.28	0.31	0.34	0.37	0.41	0.45
224	1.78	0.25	0.28	0.31	0.34	0.38	0.42
226	1.81	0.32	0.35	0.38	0.41	0.45	0.49
228	3.76	0.28	0.31	0.34	0.38	0.42	0.46
302	6.20	0.27	0.30	0.33	0.37	0.41	0.45
304	3.40	0.27	0.31	0.34	0.37	0.41	0.45
306	3.85	0.27	0.30	0.33	0.36	0.40	0.44
401	85.20	0.28	0.31	0.34	0.37	0.41	0.45
501	276.56	0.32	0.35	0.38	0.41	0.45	0.49
601	86.93	0.33	0.36	0.39	0.42	0.46	0.50
701	176.90	0.31	0.35	0.37	0.41	0.45	0.49
801	131.80	0.32	0.35	0.38	0.42	0.45	0.50
901	116.93	0.34	0.37	0.40	0.44	0.48	0.52
1000	72.95	0.28	0.31	0.34	0.38	0.41	0.46
1100	26.79	0.26	0.29	0.32	0.36	0.40	0.44
1110	5.11	0.25	0.28	0.31	0.35	0.39	0.43
1120	12.38	0.25	0.28	0.31	0.35	0.39	0.43
1130	18.64	0.26	0.29	0.32	0.35	0.39	0.43
1200	15.29	0.27	0.30	0.33	0.37	0.40	0.45
1210	38.23	0.27	0.30	0.33	0.36	0.40	0.44
1212	3.94	0.34	0.37	0.39	0.43	0.47	0.51
1214	18.17	0.29	0.32	0.35	0.38	0.42	0.46

C Value for Each Drainage Area

DA	Area (ac)	C2	C5	C10	C25	C50	C100
1220	8.40	0.29	0.33	0.35	0.39	0.43	0.47
1222	5.22	0.33	0.36	0.38	0.42	0.46	0.50
1224	5.99	0.33	0.36	0.39	0.43	0.46	0.50
1226	2.25	0.37	0.40	0.42	0.46	0.50	0.54
1230	5.82	0.30	0.33	0.36	0.40	0.43	0.48
1300	2.22	0.29	0.32	0.35	0.39	0.42	0.47
1301	1.18	0.30	0.33	0.36	0.39	0.43	0.47
1310	19.69	0.28	0.31	0.34	0.37	0.41	0.45
1320	9.89	0.28	0.31	0.34	0.37	0.41	0.45
1330	4.14	0.29	0.32	0.35	0.38	0.42	0.46
1340	23.18	0.30	0.33	0.36	0.39	0.43	0.47
1350	3.82	0.30	0.33	0.36	0.39	0.43	0.47
1352	7.32	0.28	0.31	0.34	0.37	0.41	0.45
1354	3.43	0.34	0.37	0.39	0.43	0.47	0.51
1400	8.81	0.28	0.31	0.34	0.38	0.42	0.46
1410	3.00	0.36	0.39	0.41	0.45	0.49	0.53
1420	50.75	0.33	0.36	0.39	0.43	0.46	0.51

*Rational method C values for each individual drainage area by itself were calculated for the 6 storm events above.

IDF Curve for Travis County:

Taken From Austin Drainage Criteria Manual.

Year	a	b	c
2	54.767	11.051	0.8116
5	62.981	10.477	0.782
10	70.82	10.396	0.7725
25	82.936	10.746	0.7634
50	100.6	12.172	0.7712
100	118.3	13.185	0.7736

DA	tc (min)	i2	i5	i10	i25	i50	i100
102	-	-	-	-	-	-	-
104	31.768	2.596	3.372	3.934	4.737	5.440	6.229
106	28.954	2.743	3.558	4.150	4.991	5.725	6.548
108	25.914	2.925	3.789	4.416	5.304	6.075	6.939
110	65.670	1.617	2.127	2.494	3.028	3.500	4.033
112	30.497	2.660	3.453	4.029	4.848	5.565	6.369
114	61.599	1.690	2.220	2.602	3.157	3.648	4.202
116	39.062	2.285	2.977	3.478	4.198	4.833	5.545
118	45.068	2.084	2.722	3.184	3.848	4.437	5.097
120	38.396	2.310	3.009	3.515	4.241	4.882	5.600
122	39.520	2.268	2.956	3.454	4.169	4.800	5.508
124	40.307	2.240	2.920	3.412	4.119	4.744	5.445
202	50.357	1.937	2.535	2.967	3.591	4.144	4.766
204	41.913	2.184	2.849	3.331	4.023	4.635	5.322
206	29.798	2.697	3.500	4.083	4.912	5.636	6.449
208	31.441	2.612	3.392	3.958	4.765	5.472	6.264
210	47.126	2.024	2.646	3.095	3.743	4.317	4.962
212	33.264	2.525	3.281	3.830	4.614	5.302	6.073
214	45.548	2.070	2.704	3.162	3.823	4.408	5.065
216	44.137	2.113	2.758	3.225	3.898	4.493	5.161
217	48.745	1.980	2.589	3.030	3.665	4.229	4.861
218	36.337	2.391	3.112	3.634	4.382	5.041	5.779
220	50.344	1.938	2.536	2.968	3.592	4.145	4.767
222	29.684	2.703	3.508	4.092	4.922	5.648	6.462
224	24.613	3.011	3.898	4.542	5.453	6.240	7.123
226	27.800	2.809	3.642	4.247	5.105	5.852	6.690
228	33.050	2.534	3.294	3.844	4.631	5.321	6.095
302	39.968	2.252	2.935	3.430	4.140	4.768	5.472
304	34.742	2.458	3.197	3.733	4.499	5.172	5.928
306	37.275	2.353	3.064	3.579	4.317	4.967	5.696
401	66.002	1.611	2.120	2.486	3.018	3.489	4.020
501	-	-	-	-	-	-	-
601	-	-	-	-	-	-	-
701	-	-	-	-	-	-	-
801	-	-	-	-	-	-	-
901	-	-	-	-	-	-	-
1000	52.209	1.891	2.476	2.899	3.510	4.052	4.661
1100	64.216	1.642	2.159	2.532	3.072	3.551	4.091
1110	31.629	2.603	3.380	3.945	4.749	5.454	6.244
1120	41.883	2.185	2.851	3.332	4.025	4.637	5.324
1130	27.522	2.825	3.663	4.271	5.133	5.884	6.726
1200	45.360	2.075	2.711	3.171	3.833	4.419	5.078
1210	51.690	1.904	2.493	2.918	3.533	4.078	4.690
1212	-	-	-	-	-	-	-
1214	-	-	-	-	-	-	-

DA	tc (min)	I2	I5	I10	I25	I50	I100
1220	36.333	2.391	3.112	3.634	4.382	5.041	5.780
1222	28.906	2.746	3.562	4.154	4.996	5.730	6.554
1224	31.783	2.595	3.371	3.933	4.736	5.439	6.227
1226	35.011	2.447	3.182	3.716	4.479	5.150	5.902
1230	29.077	2.736	3.550	4.140	4.980	5.712	6.533
1300	47.148	2.024	2.645	3.094	3.742	4.316	4.961
1301	48.549	1.985	2.596	3.037	3.675	4.239	4.873
1310	48.886	1.976	2.584	3.024	3.659	4.221	4.853
1320	40.633	2.228	2.905	3.395	4.099	4.721	5.419
1330	42.449	2.167	2.827	3.305	3.992	4.600	5.282
1340	48.369	1.990	2.602	3.044	3.683	4.249	4.884
1350	25.261	2.967	3.843	4.478	5.378	6.156	7.030
1352	38.732	2.297	2.992	3.496	4.219	4.857	5.572
1354	26.174	2.908	3.768	4.392	5.276	6.043	6.903
1400	32.551	2.558	3.324	3.879	4.672	5.367	6.146
1410	37.349	2.350	3.060	3.574	4.311	4.961	5.690
1420	64.535	1.637	2.152	2.523	3.063	3.540	4.078

Time of Concentration Equations:

$$t_{sh} = \frac{0.007(n_{ol}L_{sh})^{0.8}}{P_2^{0.5}S_{sh}^{0.4}} \qquad t_{sc} = \frac{L_{sc}}{3600\,K\,S_{sc}^{0.5}} \qquad t_{ch} = \frac{L_{ch}}{\left(3600\frac{1.49}{n}R^{2/3}S_{ch}^{1/2}\right)}$$

catchment name	L_{sh} sheet flow length	S_{sh} sheet flow slope (ft/ft)	P_2 2-yr, 24-hr rainfall depth (in.)	n_{ol} overland flow roughness coeff.	t_{sh} sheet flow travel time (hr)	L_{sc} shallow conc. flow length (ft)	S_{sc} shallow conc. flow slope (ft/ft)	K Paved (20.32) / Unpaved (16.13)	t_{sc} shallow conc. flow time (hr)	L_{ch} channel flow length (ft)	S_{ch} channel flow slope (ft/ft)	n_{ch} channel Manning's roughness coeff.	R hydraulic radius (ft)	t_{ch} shallow conc. flow time (hr)	t_c time of conc. (hr)	tc time of conc. (min)	Upstream DA	tc Conc Time TOTAL (min)
102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
104	-	-	3.44	0.40	**0.00**	-	-	16.13	**0.00**	1457.1	0.0050	0.016	0.36	**0.12**	**0.12**	7.3	108	33.9
106	100	0.014	3.44	0.40	**0.40**	544.7	0.01	16.13	**0.08**	100.8	0.0067	0.016	0.36	**0.01**	**0.48**	29.0	-	29.0
108	100	0.027	3.44	0.40	**0.31**	622.6	0.02	16.13	**0.08**	726.7	0.0050	0.016	0.36	**0.06**	**0.44**	26.6	-	26.6
110	-	-	3.44	0.40	**0.00**	-	-	16.13	**0.00**	822.0	0.0112	0.016	0.36	**0.05**	**0.05**	2.8	114	33.2
112	-	-	3.44	0.40	**0.00**	-	-	16.13	**0.00**	266.6	0.0117	0.016	0.36	**0.01**	**0.01**	0.9	206	30.8
114	100	0.017	3.44	0.40	**0.37**	716.4	0.01	16.13	**0.11**	433.9	0.0129	0.016	0.36	**0.02**	**0.51**	30.5	-	30.5
116	100	0.009	3.44	0.40	**0.48**	975.2	0.01	16.13	**0.15**	390.5	0.0050	0.016	0.36	**0.03**	**0.66**	39.4	-	39.4
118	-	-	3.44	0.40	**0.00**	-	-	16.13	**0.00**	1123.3	0.0112	0.016	0.36	**0.06**	**0.06**	3.7	122	41.4
120	100	0.013	3.44	0.40	**0.41**	1,276.7	0.01	16.13	**0.22**	161.1	0.0096	0.016	0.36	**0.01**	**0.64**	38.5	-	38.5
122	100	0.027	3.44	0.40	**0.31**	1,282.2	0.01	16.13	**0.26**	774.7	0.0050	0.016	0.36	**0.06**	**0.63**	37.7	-	37.7
124	100	0.008	3.44	0.40	**0.51**	583.9	0.01	16.13	**0.12**	686.9	0.0050	0.016	0.36	**0.06**	**0.68**	41.0	-	41.0

catchment name	L_{sh} sheet flow length	S_{sh} sheet flow slope (ft/ft)	P_2 2-yr, 24-hr rainfall depth (in.)	n_{ol} overland flow roughness coeff.	t_{sh} sheet flow travel time (hr)	L_{sc} shallow conc. flow length (ft)	S_{sc} shallow conc. flow slope (ft/ft)	K Paved (20.32) / Unpaved (16.13)	t_{sc} shallow conc. flow time (hr)	L_{ch} channel flow length (ft)	S_{ch} channel flow slope (ft/ft)	n_{ch} channel Manning's roughness coeff.	R hydraulic radius (ft)	t_{ch} shallow conc. flow time (hr)	t_c time of conc. (hr)	tc time of conc. (min)	Upstream DA	tc Conc Time TOTAL (min)
202	100	0.008	3.44	0.40	**0.49**	873.3	0.02	16.13	**0.11**	1441.7	0.0050	0.040	0.36	**0.30**	**0.90**	53.9	-	53.9
204	100	0.005	3.44	0.40	**0.60**	369.5	0.02	16.13	**0.05**	448.1	0.0056	0.016	0.36	**0.04**	**0.68**	41.0	-	41.0
206	100	0.012	3.44	0.40	**0.42**	457.4	0.01	16.13	**0.07**	170.2	0.0097	0.016	0.36	**0.01**	**0.50**	29.9	-	29.9
208	100	0.009	3.44	0.40	**0.47**	364.0	0.01	16.13	**0.05**	25.3	0.0050	0.016	0.36	**0.00**	**0.52**	31.5	-	31.5
210	-	-	3.44	0.40	**0.00**	-	-	16.13	**0.00**	439.1	0.0062	0.016	0.36	**0.03**	**0.03**	2.0	214	48.1
212	100	0.010	3.44	0.40	**0.46**	462.6	0.01	16.13	**0.09**	51.9	0.0050	0.016	0.36	**0.00**	**0.56**	33.3	-	33.3
214	-	-	3.44	0.40	**0.00**	-	-	16.13	**0.00**	586.8	0.0140	0.016	0.36	**0.03**	**0.03**	1.8	216	46.1
216	100	0.011	3.44	0.40	**0.44**	2,019.7	0.02	16.13	**0.28**	275.5	0.0060	0.016	0.36	**0.02**	**0.74**	44.4	-	44.4
217	-	-	3.44	0.40	**0.00**	-	-	16.13	**0.00**	431.7	0.0182	0.016	0.36	**0.02**	**0.02**	1.1	210	49.2
218	-	-	3.44	0.40	**0.00**	-	-	16.13	**0.00**	337.5	0.0115	0.016	0.36	**0.02**	**0.02**	1.1	304	35.7
220	-	-	3.44	0.40	**0.00**	-	-	16.13	**0.00**	358.2	0.0129	0.016	0.36	**0.02**	**0.02**	1.1	217	50.4
222	-	-	3.44	0.40	**0.00**	-	-	16.13	**0.00**	648.7	0.0096	0.016	0.36	**0.04**	**0.04**	2.3	226	30.4
224	100	0.022	3.44	0.40	**0.33**	466.1	0.01	16.13	**0.07**	133.3	0.0050	0.016	0.36	**0.01**	**0.41**	24.7	-	24.7
226	100	0.018	3.44	0.40	**0.36**	530.7	0.01	16.13	**0.08**	439.6	0.0148	0.016	0.36	**0.02**	**0.47**	28.1	-	28.1
228	100	0.010	3.44	0.40	**0.46**	364.6	0.01	16.13	**0.06**	427.1	0.0050	0.016	0.36	**0.04**	**0.56**	33.5	-	33.5

catchment name	L_{sh} sheet flow length	S_{sh} sheet flow slope (ft/ft)	P_2 2-yr, 24-hr rainfall depth (in.)	n_{oi} overland flow roughness coeff.	t_{sh} sheet flow travel time (hr)	L_{sc} shallow conc. flow length (ft)	S_{sc} shallow conc. flow slope (ft/ft)	K Paved (20.32) / Unpaved (16.13)	t_{sc} shallow conc. flow time (hr)	L_{ch} channel flow length (ft)	S_{ch} channel flow slope (ft/ft)	n_{ch} channel Manning's roughness coeff.	R hydraulic radius (ft)	t_{ch} shallow conc. flow time (hr)	t_c time of conc. (hr)	tc time of conc. (min)	Upstream DA	tc Conc Time TOTAL (min)
302	100	0.012	3.44	0.40	**0.43**	1,412.0	0.02	16.13	**0.19**	375.1	0.0069	0.040	0.36	**0.07**	**0.68**	40.8	-	40.8
304	100	0.011	3.44	0.40	**0.44**	956.7	0.02	16.13	**0.13**	156.0	0.0135	0.016	0.36	**0.01**	**0.58**	34.5	-	34.5
306	100	0.006	3.44	0.40	**0.56**	241.6	0.01	16.13	**0.04**	747.2	0.0211	0.016	0.36	**0.03**	**0.63**	37.6	-	37.6
1000	100	0.017	3.44	0.40	**0.37**	3,458.6	0.01	16.13	**0.49**	80.7	0.0050	0.016	0.36	**0.01**	**0.87**	52.0	-	52.0
1100	-	-	3.44	0.40	**0.00**	-	-	16.13	**0.00**	1860.2	0.0061	0.016	0.36	**0.14**	**0.14**	8.4	1000	60.4
1110	100	0.013	3.44	0.40	**0.42**	426.1	0.01	16.13	**0.07**	906.8	0.0097	0.016	0.36	**0.05**	**0.54**	32.3	-	32.3
1120	100	0.008	3.44	0.40	**0.50**	1,006.5	0.01	16.13	**0.20**	-	-	-	0.36	**0.00**	**0.70**	41.9	-	41.9
1130	100	0.024	3.44	0.40	**0.32**	514.4	0.01	16.13	**0.09**	1280.6	0.0150	0.016	0.36	**0.06**	**0.47**	28.2	-	28.2
1200	100	0.024	3.44	0.40	**0.32**	882.7	0.01	16.13	**0.17**	670.5	0.0139	0.016	0.36	**0.03**	**0.52**	31.1	-	31.1
1201	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1210	100	0.010	3.44	0.40	**0.45**	1,870.9	0.01	16.13	**0.32**	1434.6	0.0050	0.016	0.36	**0.12**	**0.89**	53.1	-	53.1
1220	100	0.010	3.44	0.40	**0.45**	1,246.5	0.02	16.13	**0.15**	44.3	0.0142	0.016	0.50	**0.00**	**0.60**	36.3	-	36.3
1222	100	0.025	3.44	0.40	**0.31**	1,263.3	0.02	16.13	**0.16**	99.6	0.0050	0.016	0.50	**0.01**	**0.48**	28.6	-	28.6

catchment name	L_{sh} sheet flow length	S_{sh} sheet flow slope (ft/ft)	P_2 2-yr, 24-hr rainfall depth (in.)	n_{ol} overland flow roughness coeff.	t_{sh} sheet flow travel time (hr)	L_{sc} shallow conc. flow length (ft)	S_{sc} shallow conc. flow slope (ft/ft)	K Paved (20.32) / Unpaved (16.13)	t_{sc} shallow conc. flow time (hr)	L_{ch} channel flow length (ft)	S_{ch} channel flow slope (ft/ft)	n_{ch} channel Manning's roughness coeff.	R hydraulic radius (ft)	t_{ch} shallow conc. flow time (hr)	t_c time of conc. (hr)	tc time of conc. (min)	Upstream DA	tc Conc Time TOTAL (min)
1224	100	0.025	3.44	0.40	**0.32**	1,353.5	0.02	16.13	**0.17**	425.2	0.0063	0.016	0.50	**0.03**	**0.51**	30.6	-	30.6
1226	100	0.010	3.44	0.40	**0.46**	562.8	0.01	16.13	**0.10**	256.3	0.0050	0.016	0.50	**0.02**	**0.57**	34.2		83.6
1230	100	0.013	3.44	0.40	**0.41**	502.4	0.02	16.13	**0.06**	318.4	0.0143	0.016	0.36	**0.02**	**0.49**	29.3	-	29.3
1300	-	-	3.44	0.40	**0.00**	-	-	16.13	**0.00**	634.9	0.0050	0.016	0.36	**0.05**	**0.05**	3.2	1330	45.3
1301	-	-	3.44	0.40	**0.00**	-	-	20.32	**0.00**	189.3	0.0050	0.016	0.36	**0.02**	**0.02**	0.9	1310	50.3
1310	100	0.005	3.44	0.40	**0.60**	1,046.7	0.01	16.13	**0.18**	730.1	0.0115	0.016	0.36	**0.04**	**0.82**	49.4	-	49.4
1320	100	0.013	3.44	0.40	**0.41**	1,314.8	0.01	16.13	**0.26**	108.2	0.0050	0.016	0.36	**0.01**	**0.68**	40.7	-	40.7
1330	100	0.006	3.44	0.40	**0.57**	600.4	0.01	16.13	**0.12**	132.5	0.0060	0.016	0.36	**0.01**	**0.70**	42.2	-	42.2
1340	100	0.011	3.44	0.40	**0.44**	1,088.9	0.01	20.32	**0.13**	821.3	0.0055	0.016	0.36	**0.07**	**0.64**	38.3	-	38.3
1350	100	0.020	3.44	0.40	**0.34**	459.3	0.03	16.13	**0.05**	993.4	0.0109	0.016	0.36	**0.06**	**0.45**	26.8	-	26.8
1400	100	0.025	3.44	0.40	**0.32**	865.5	0.02	16.13	**0.12**	235.7	0.0063	0.016	0.36	**0.02**	**0.46**	27.3	-	27.3
1410	100	0.005	3.44	0.40	**0.60**	-	-	16.13	**0.00**	805.2	0.0182	0.016	0.36	**0.04**	**0.64**	38.2	-	38.2

Table 1: Option 1

DA	Q2	Q5	Q10	Q25	Q50	Q100	
102	No Rehabilitated Roadway						
104	18.97385	27.49864	35.04144	46.38374	58.81028	74.08869	
106	2.667554	3.862555	4.935731	6.509892	8.263458	10.39873	
108	8.267936	11.99632	15.37619	20.30401	25.82844	32.54884	
110	6.482905	9.55932	12.36397	16.51854	21.26387	27.06908	
112	3.578976	5.174151	6.611701	8.757503	11.12422	14.0288	
114	2.980941	4.408133	5.725151	7.645070	9.878309	12.59343	
116	5.158769	7.464783	9.473209	12.53634	15.84585	19.93266	
118	26.187436	38.1772685	49.0119801	65.0636793	83.1554175	105.252449	
120	11.11266	16.2118	20.87058	27.69242	35.46169	44.91467	
122	6.262851	9.107542	11.67912	15.47702	19.749973	24.9627076	
124	6.605131	9.539986	12.11947	16.0623	20.32566	25.59654	
202	No Rehabilitated Roadway						
204	3.025120	4.425977	5.708753	7.572962	9.71716	12.317020	
206	3.313121	4.784577	6.109348	8.089784	10.26677	12.9406	
208	1.025921	1.492297	1.918736	2.538822	3.243208	4.098348	
210	18.53547	26.84559	34.20618	45.46295	57.71935	72.87883	
212	3.176071	4.578568	5.827751	7.712012	9.765448	12.29335	
214	14.35025	20.7364	26.37102	35.03756	44.40049	56.00809	
216	13.16209	18.97766	24.08905	31.99652	40.47252	51.00585	
217	19.41852	28.14948	35.89601	47.71746	60.62756	76.58220	
218	7.157165	10.40912	13.35611	17.64723	22.51832	28.42486	
220	25.942358	37.719610	48.229464	64.097814	81.641661	103.22783	
222	9.570318	13.81491	17.62374	23.29791	29.54229	37.19541	
224	1.319169	1.922488	2.481956	3.279748	4.196214	5.302677	
226	5.227736	7.507565	9.53144	12.58883	15.88212	19.94339	
228	2.683583	3.872458	4.933616	6.526329	8.271141	10.41447	
302	No Rehabilitated Roadway						
304	2.296906	3.335891	4.275560	5.643735	7.192096	9.069466	
306	2.424713	3.521365	4.512779	5.985538	7.632585	9.647756	
401	No Rehabilitated Roadway						
501	No Rehabilitated Roadway						
601	No Rehabilitated Roadway						
701	No Rehabilitated Roadway						
801	No Rehabilitated Roadway						
901	No Rehabilitated Roadway						
1000	38.965217	56.66956	72.41752	96.307952	122.61338	155.04491	*Overtops For All Events
1100	18.863602	27.77886	35.88822	47.89414	61.58798	78.32965	
1110	3.33384	4.863185	6.270866	8.305448	10.63951	13.46694	
1120	7.208165	10.53697	13.57282	18.04105	23.12518	29.32453	
1130	14.41041	20.9222	26.83822	35.44046	45.13731	56.9132	
1200	8.627458	12.57126	16.11377	21.40391	27.31918	34.56779	
1201	No Rehabilitated Roadway						
1210	25.08881	36.58462	46.86311	62.29797	79.48539	100.5871	
1220	5.917115	8.513775	10.804304	14.304166	18.072147	22.732074	
1222	4.665185	6.61777	8.288926	10.955752	13.652966	17.055511	
1224	5.161047	7.310753	9.135927	12.097708	15.055584	18.811516	
1226	2.022779	2.843072	3.516143	4.664947	5.752306	7.163194	
1230	4.785941	6.847573	8.654905	11.43043	14.36609	18.00883	
1300	9.33172	13.54159	17.26658	22.95535	29.16387	36.84025	
1301	41.10524	59.717353	76.147585	101.19906	128.57855	162.40115	*Overtops For All Events
1310	10.67441	15.52535	19.86795	26.43622	33.70025	42.64884	
1320	7.329182	10.57773	13.41941	17.82656	22.53426	28.39375	
1330	2.603570	3.773787	4.799040	6.362772	8.060793	10.158167	
1340	26.13861	37.68226	47.75741	63.21339	79.79041	100.3148	
1350	8.341108	12.0285	15.30948	20.19665	25.52877	32.06793	
1400	7.236522	10.446	13.28064	17.5193	22.1266	27.78441	
1410	2.467184	3.495738	4.341803	5.756174	7.129884	8.894139	

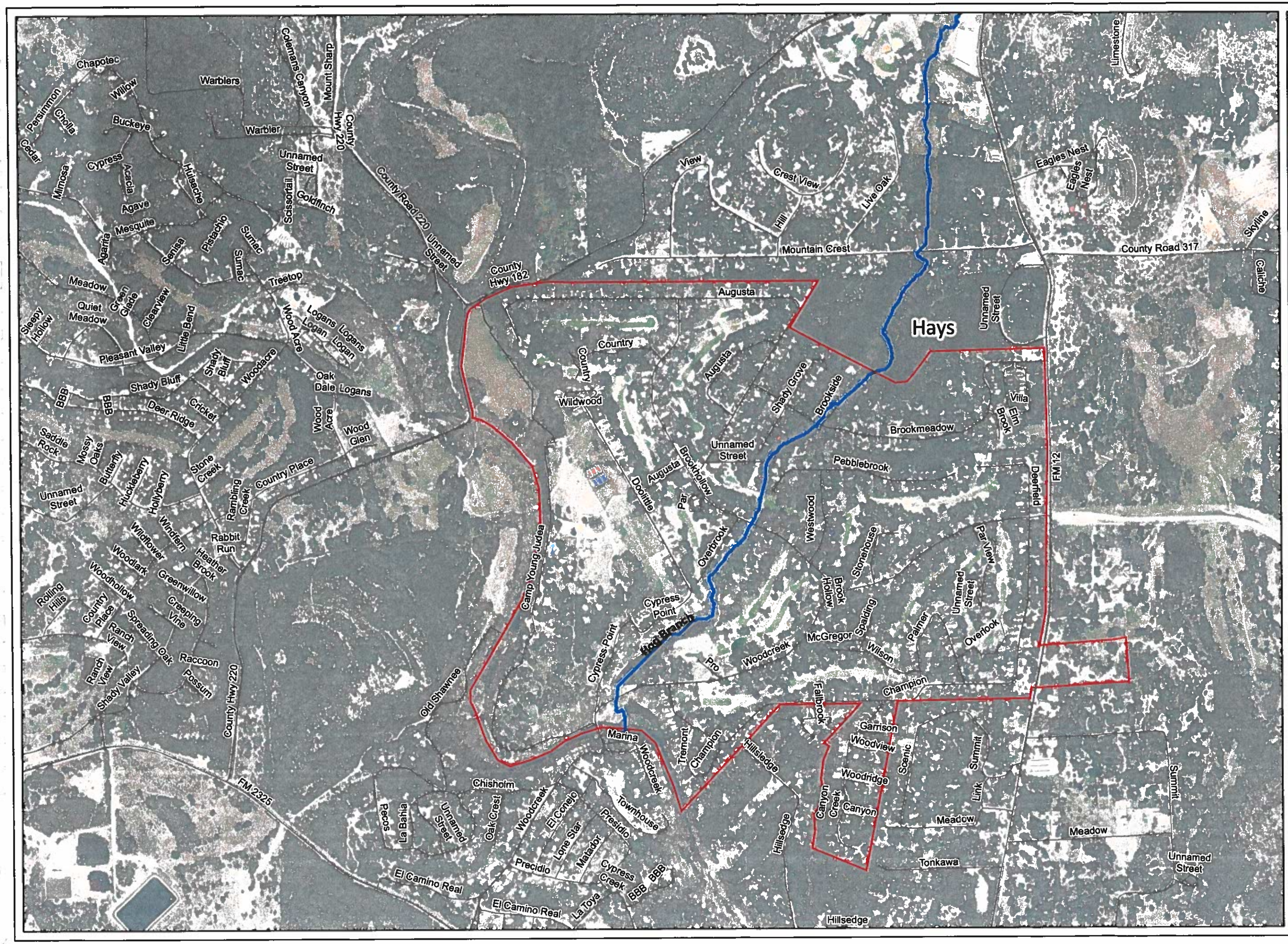
**Highlighted cell represents maximum design storm for proposed cross section

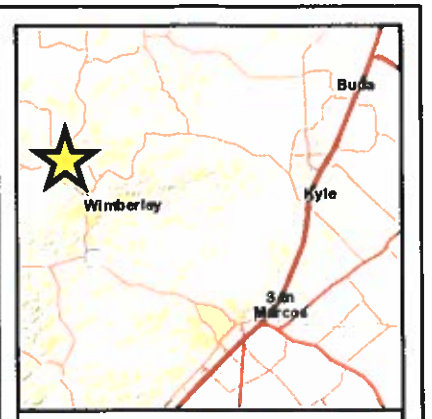
Table 2: Option 2

DA	Q2	Q5	Q10	Q25	Q50	Q100	
102	No Rehabilitated Roadway						
104	18.97385	27.49864	35.04144	46.38374	58.81028	74.08869	*Overtops For All Events
106	2.667554	3.862555	4.935731	6.509892	8.263458	10.39873	
108	8.267936	11.99632	15.37619	20.30401	25.82844	32.54884	
110	6.482905	9.55932	12.36397	16.51854	21.26387	27.06908	
112	3.578976	5.174151	6.611701	8.757503	11.12422	14.0288	
114	2.980941	4.408133	5.725151	7.645070	9.878309	12.59343	
116	5.158769	7.464783	9.473209	12.53634	15.84585	19.93266	
118	26.187436	38.1772685	49.0119801	65.0636793	83.1554175	105.252449	*Overtops For All Events
120	11.11266	16.2118	20.87058	27.69242	35.46169	44.91467	
122	6.262851	9.107542	11.67912	15.47702	19.749973	24.9627076	
124	6.605131	9.539986	12.11947	16.0623	20.32566	25.59654	
202	No Rehabilitated Roadway						
204	3.025120	4.425977	5.708753	7.572962	9.71716	12.317020	
206	3.313121	4.784577	6.109348	8.089784	10.26677	12.9406	
208	1.025921	1.492297	1.918736	2.538822	3.243208	4.098348	
210	18.53547	26.84559	34.20618	45.46295	57.71935	72.87883	*Overtops For All Events
212	3.176071	4.578568	5.827751	7.712012	9.765448	12.29335	
214	14.35025	20.7364	26.37102	35.03756	44.40049	56.00809	
216	13.16209	18.97766	24.08905	31.99652	40.47252	51.00585	*Overtops For All Events
217	19.41852	28.14948	35.89601	47.71746	60.62756	76.58220	
218	7.157165	10.40912	13.35611	17.64723	22.51832	28.42486	
220	25.942358	37.719610	48.229464	64.097814	81.641661	103.22783	*Overtops For All Events
222	9.570318	13.81491	17.62374	23.29791	29.54229	37.19541	
224	1.319169	1.922488	2.481956	3.279748	4.196214	5.302677	
226	5.227736	7.507565	9.53144	12.58883	15.88212	19.94339	
228	2.683583	3.872458	4.933616	6.526329	8.271141	10.41447	
302	No Rehabilitated Roadway						
304	2.296906	3.335891	4.275560	5.643735	7.192096	9.069466	
306	2.424713	3.521365	4.512779	5.985538	7.632585	9.647756	
401	No Rehabilitated Roadway						
501	No Rehabilitated Roadway						
601	No Rehabilitated Roadway						
701	No Rehabilitated Roadway						
801	No Rehabilitated Roadway						
901	No Rehabilitated Roadway						
1000	38.965217	56.66956	72.41752	96.307952	122.61338	155.04491	*Overtops For All Events
1100	18.863602	27.77886	35.88822	47.89414	61.58798	78.32965	*Overtops For All Events
1110	3.33384	4.863185	6.270866	8.305448	10.63951	13.46694	
1120	7.208165	10.53697	13.57282	18.04105	23.12518	29.32453	
1130	14.41041	20.9222	26.83822	35.44046	45.13731	56.9132	
1200	8.627458	12.57126	16.11377	21.40391	27.31918	34.56779	
1201	No Rehabilitated Roadway						
1210	25.08881	36.58462	46.86311	62.29797	79.48539	100.5871	*Overtops For All Events
1220	5.917115	8.513775	10.804304	14.304166	18.072147	22.732074	
1222	4.665185	6.61777	8.288926	10.955752	13.652966	17.055511	
1224	5.161047	7.310753	9.135927	12.097708	15.055584	18.811516	
1226	2.022779	2.843072	3.516143	4.664947	5.752306	7.163194	
1230	4.785941	6.847573	8.654905	11.43043	14.36609	18.00883	
1300	9.33172	13.54159	17.26658	22.95535	29.16387	36.84025	
1301	41.10524	59.717353	76.147585	101.19906	128.57855	162.40115	*Overtops For All Events
1310	10.67441	15.52535	19.86795	26.43622	33.70025	42.64884	
1320	7.329182	10.57773	13.41941	17.82656	22.53426	28.39375	
1330	2.603570	3.773787	4.799040	6.362772	8.060793	10.158167	
1340	26.13861	37.68226	47.75741	63.21339	79.79041	100.3148	*Overtops For All Events
1350	8.341108	12.0285	15.30948	20.19665	25.52877	32.06793	
1400	7.236522	10.446	13.28064	17.5193	22.1266	27.78441	
1410	2.467184	3.495738	4.341803	5.756174	7.129884	8.894139	

**Highlighted cell represents maximum design storm for proposed cross section

	Option 1		Option 2	
Road	Design	Max Storm Event Carried	Design	Max Storm Event Carried
Cypress Point Drive	24' wide 6" standard curb	100-Year	22' wide 4" roll-on-curb	100-Year
Augusta Drive East of Brookhollow Drive (West/East Section)	24' wide 6" standard curb	OVERTOPS	22' wide 4" roll-on-curb	Overtops
Augusta Drive East of Brookhollow Drive (Southwest/Northeast Section)		10-Year		Overtops
Augusta Drive West of Brookhollow Drive	24' wide 6" standard curb	100-Year	22' wide 4" roll-on-curb	100-Year
Dolittle Drive	24' wide 6" standard curb	5-Year	22' wide 4" roll-on-curb	Overtops
Brookhollow Drive (West of Hog Branch)	24' wide 6" standard curb	100-Year	26' wide 4" roll-on-curb	25-Year
Brookhollow Drive (East of Hog Branch)	24' wide 6" standard curb	5-Year	26' wide 4" roll-on-curb	Overtops
Woodcreek Drive (West highpoint between Stonehouse and Par View to Brookhollow)	24' wide 6" standard curb	100-Year	26' wide 4" roll-on-curb	2-Year
Woodcreek Drive (East between Stonehouse and Par View to FM12)	24' wide 6" standard curb	OVERTOPS	26' wide 4" roll-on-curb	Overtops
Westwood Drive	24' wide 6" standard curb	50-Year	22' wide 4" roll-on-curb	2-Year
Stonehouse Circle	24' wide 6" standard curb	100-Year	22' wide 4" roll-on-curb	5-Year
Shady Grove Lane	24' wide 6" standard curb	100-Year	22' wide 4" roll-on-curb	50-Year
Brookmeadow Drive (West of Hog Branch Creek)	24' wide 6" standard curb	10-Year	22' wide 4" roll-on-curb	Overtops
Brookmeadow Drive (East of Hog Branch Creek for 1,000')	24' wide 6" standard curb	100-Year	22' wide 4" roll-on-curb	100-Year
Brookmeadow Drive (West of FM 12)	24' wide 6" standard curb	100-Year	22' wide 4" roll-on-curb	10-Year
Pebblebrook Lane	24' wide 6" standard curb	100-Year	22' wide 4" roll-on-curb	5-Year
Country Lane	24' wide 6" standard curb	50-Year	22' wide 4" roll-on-curb	2-Year
Canyon Creek Drive	24' wide 6" standard curb	100-Year	22' wide 4" roll-on-curb	25-Year
Champions Circle	24' wide 6" standard curb	2-Year	22' wide 4" roll-on-curb	Overtops
Par View Drive	24' wide 6" standard curb	100-Year	22' wide 4" roll-on-curb	5-Year
Deerfield Drive	24' wide 6" standard curb	2-Year	22' wide 4" roll-on-curb	Overtops





VICINITY MAP

Scale: 1 inch equals 10 miles

LEGEND

Woodcreek City Limits

CL

*Imagery by ESRI Basemap

PROJECT NAME

____ County, TEXAS

JONES|CARTER

Texas Board of Professional Engineers Registration No. F-439

Exhibit 1: Vicinity Map

N

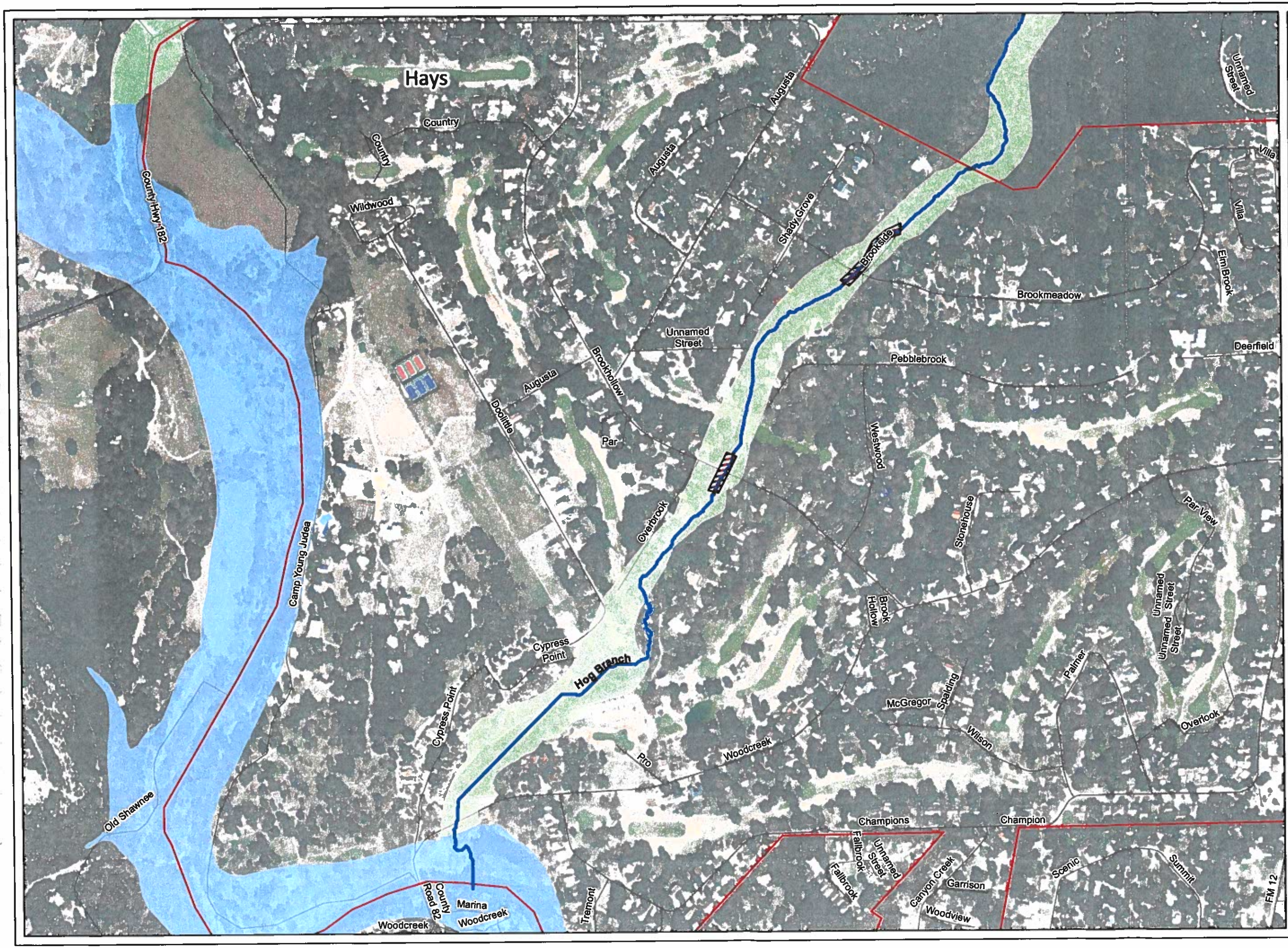
W E

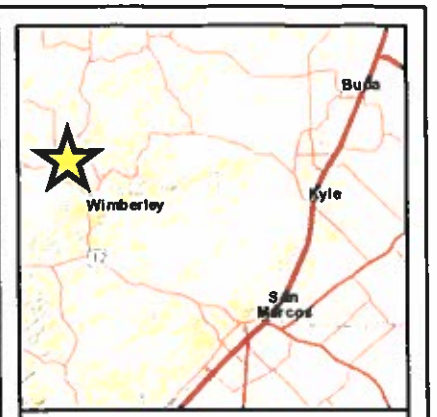
S

1 inch equals 1,000 feet

Coordinate System: NAD 83 TX CENTRAL 4203 FEET
Vertical Datum: NAVD 1988

Path: K:\14950\14950-0001-00 Roadway Improvement Drainage Assessment\2 Design Phase\Reports\Attachments\1- Vicinity Map.mxd Project Number: D106-0010 Date: 10/19/2016 User Name: JPA





VICINITY MAP

Scale: 1 inch equals 10 miles

LEGEND

- Woodcreek City Limits
- Crossing Improvements
- CL

FEMA Floodzone

- A
- AE

*Imagery by ESRI Basemap

PROJECT NAME

____ County, TEXAS

JONES|CARTER

Texas Board of Professional Engineers Registration No. F-439

Exhibit 2: Floodplain Map

N W E S

1 inch equals 500 feet

Coordinate System: NAD 83 TX CENTRAL 4203 FEET
Vertical Datum: NAVD 1988

Path: K:\14950\14950-0001-00 Roadway Improvement Drainage Assessment\2 Design Phase\Reports\Attachments\2-FEMA Floodplain Rep.mxd Project Number: D106-0010 Date: 10/19/2016 User Name: JPA

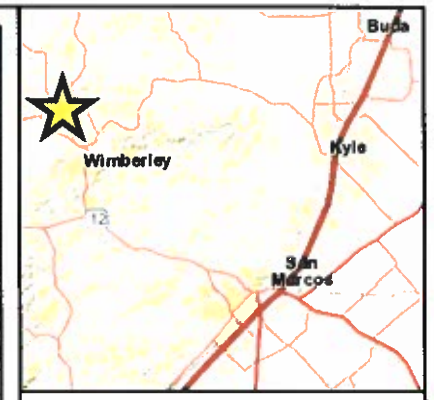
Land Use

- Deciduous Forest
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, Open Space
- Evergreen Forest
- Herbaceous
- Open Water
- Shrub/Scrub

Hays

Hog Branch

Land use classifications were derived from the NLCD 2011 land use datasets.



VICINITY MAP

Scale: 1 inch equals 10 miles

LEGEND

- Hog Branch
- Drainage Subbasins

Exhibit 3:
Land Use Map

City of Woodcreek
HAYS COUNTY, TEXAS

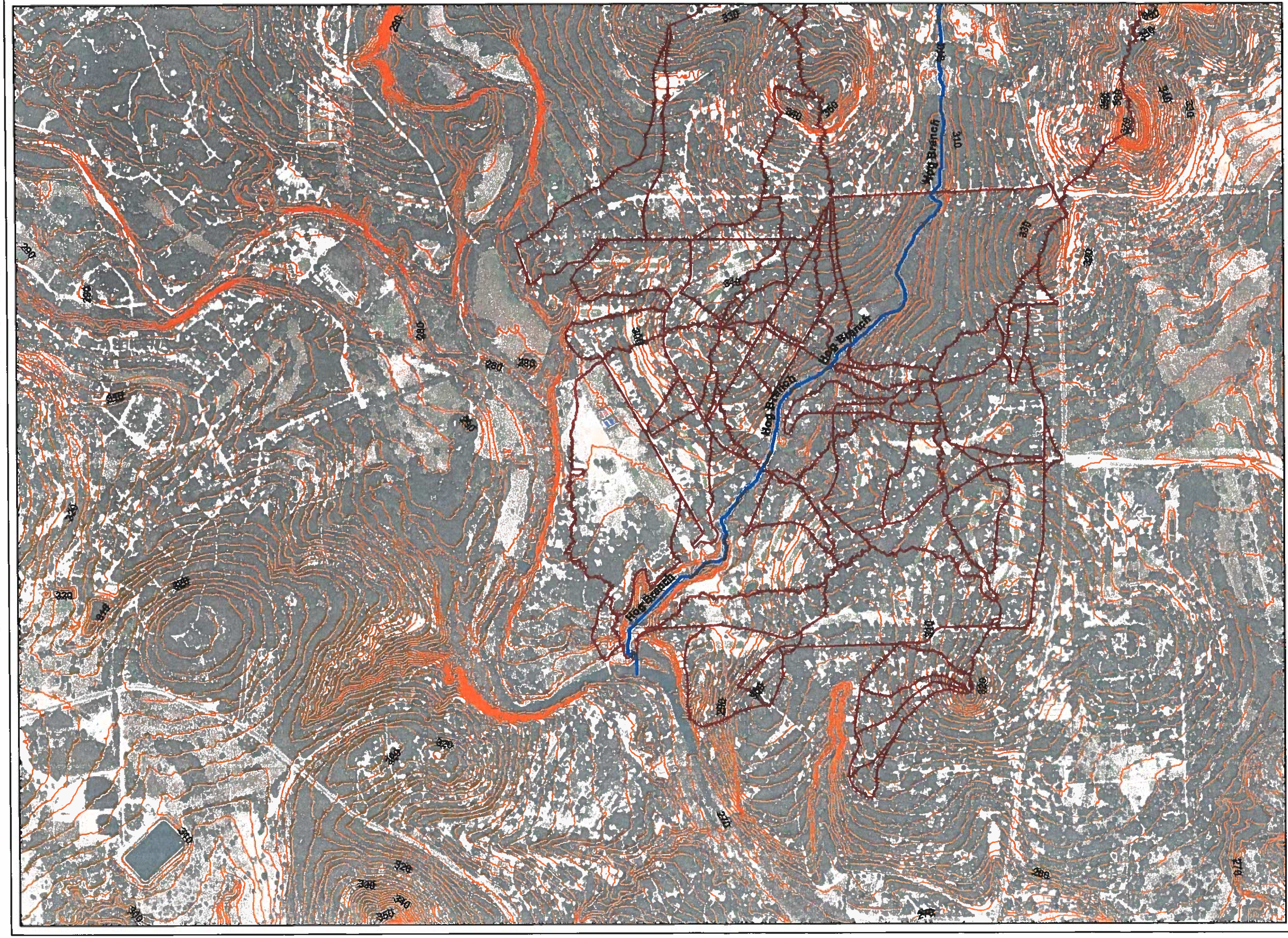
N
W E
S

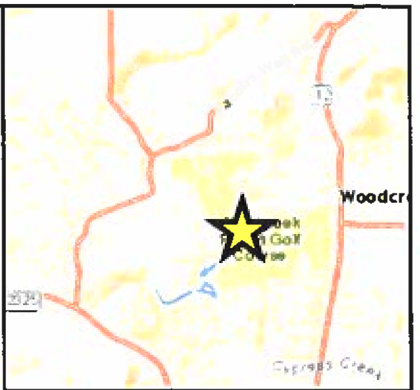
1 inch equals 1,000 feet

JONES | CARTER

Texas Board of Professional Engineers Registration No. F-439

Path: K:\14950\16950-0001-00 Roadway Improvement Drainage Assessment\2 Design Phase\Reports\Attachments\Exhibits\3-Land Use Map.mxd Project Number: 14950-0001-00 Date: 1/24/2017 User Name: JMB3





VICINITY MAP

Scale: 1 inch equals 10 miles

LEGEND

- Hog Branch
- Drainage Subbasins
- Countour 2ft

Exhibit 4: Topographic Map

City of Woodcreek
HAYS COUNTY, TEXAS

N W E S

1 inch equals 1,000 feet

Disclaimer: This product is offered for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. It does not represent an on-the-ground survey and represents only the approximate relative location of property, governmental and/or political boundaries or related facilities to said boundary. No express warranties are made by Jones & Carter, Inc concerning the accuracy, completeness, reliability, or usability of the information included within this exhibit.

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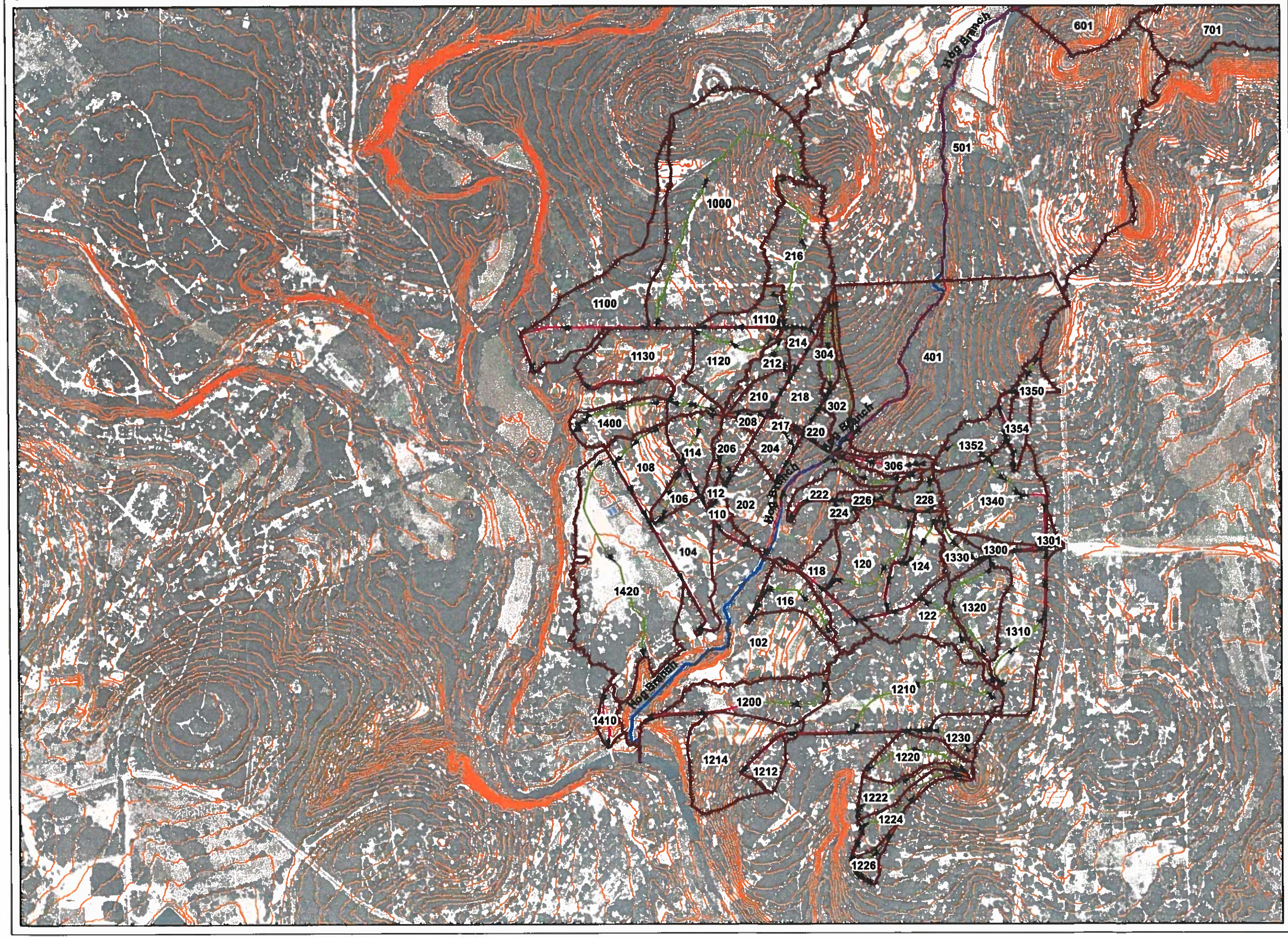
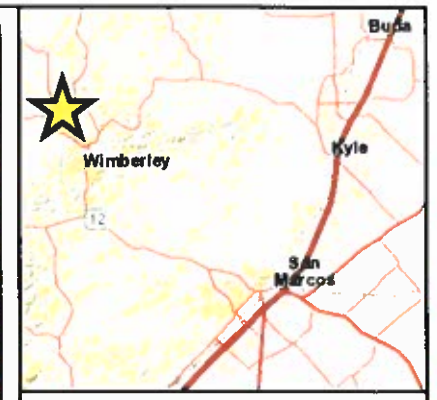




VICINITY MAP

Scale: 1 inch equals 10 miles

LEGEND

- Channel
- Shallow
- Sheet
- Drainage Subbasins
- Hog Branch
- Countour 2ft

Exhibit 5: Drainage Map

City of Woodcreek
HAYS COUNTY, TEXAS

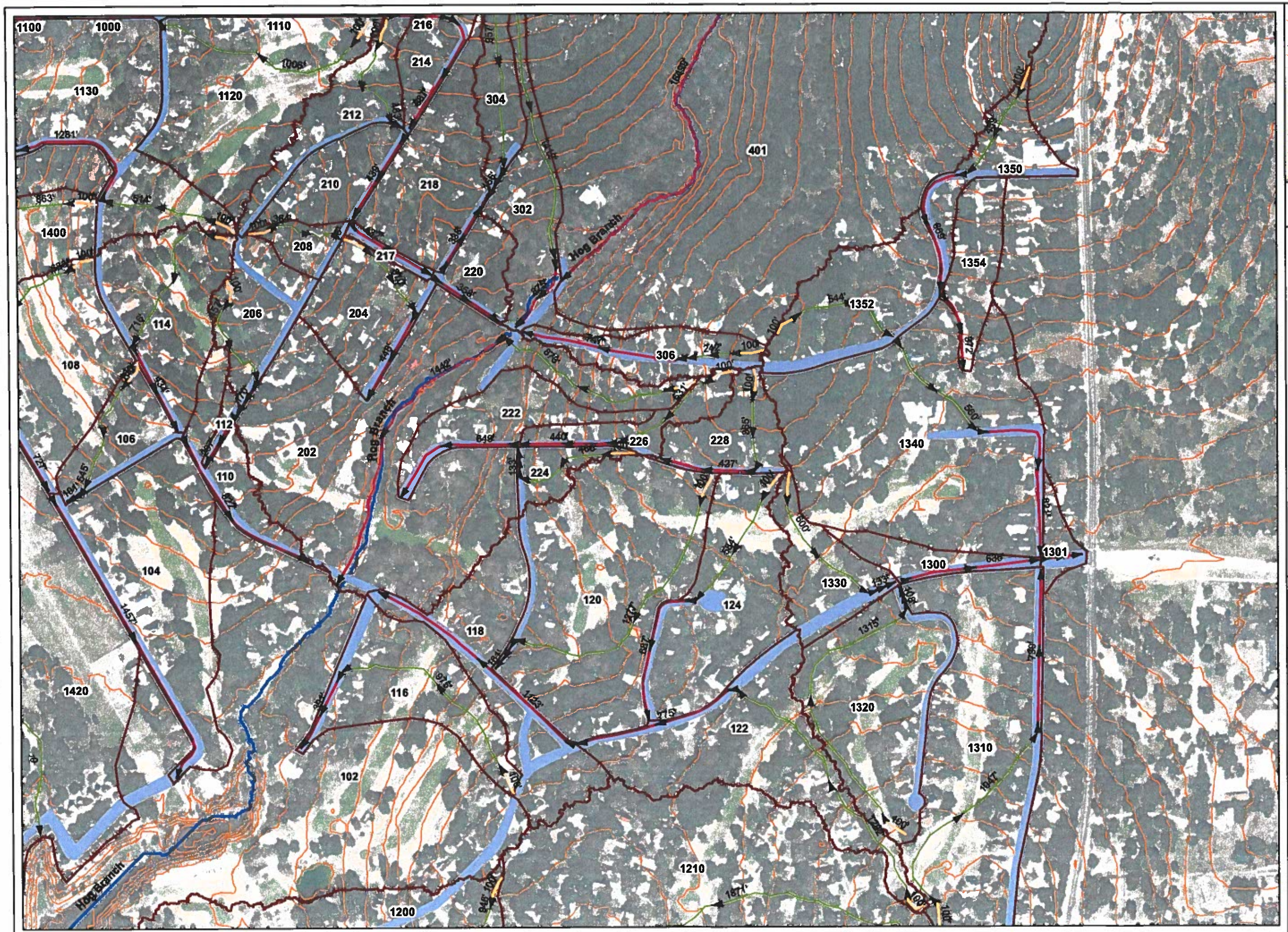
N
W E
S

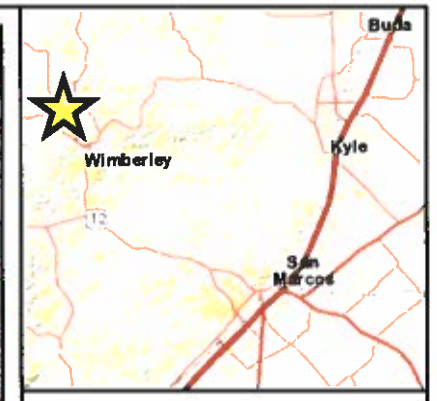
1 inch equals 1,000 feet

JONES | CARTER

Texas Board of Professional Engineers Registration No. F-439

Path: K:\14950\14950-0001-00 Roadway Improvement Drainage Assessment\1 Design Phase\Reports\Attachments\Exhibits\5 - Drainage Map.mxd Project Number: 14950-0001-00 Date: 1/30/2017 User Name: JMB3





VICINITY MAP

Scale: 1 inch equals 10 miles

LEGEND

- Channel
- Shallow
- Sheet
- Drainage Subbasins
- Rehabilitated Road
- Hog Branch
- Countour 2ft

Exhibit 6: Drainage Map

(Northeast)

City of Woodcreek
HAYS COUNTY, TEXAS

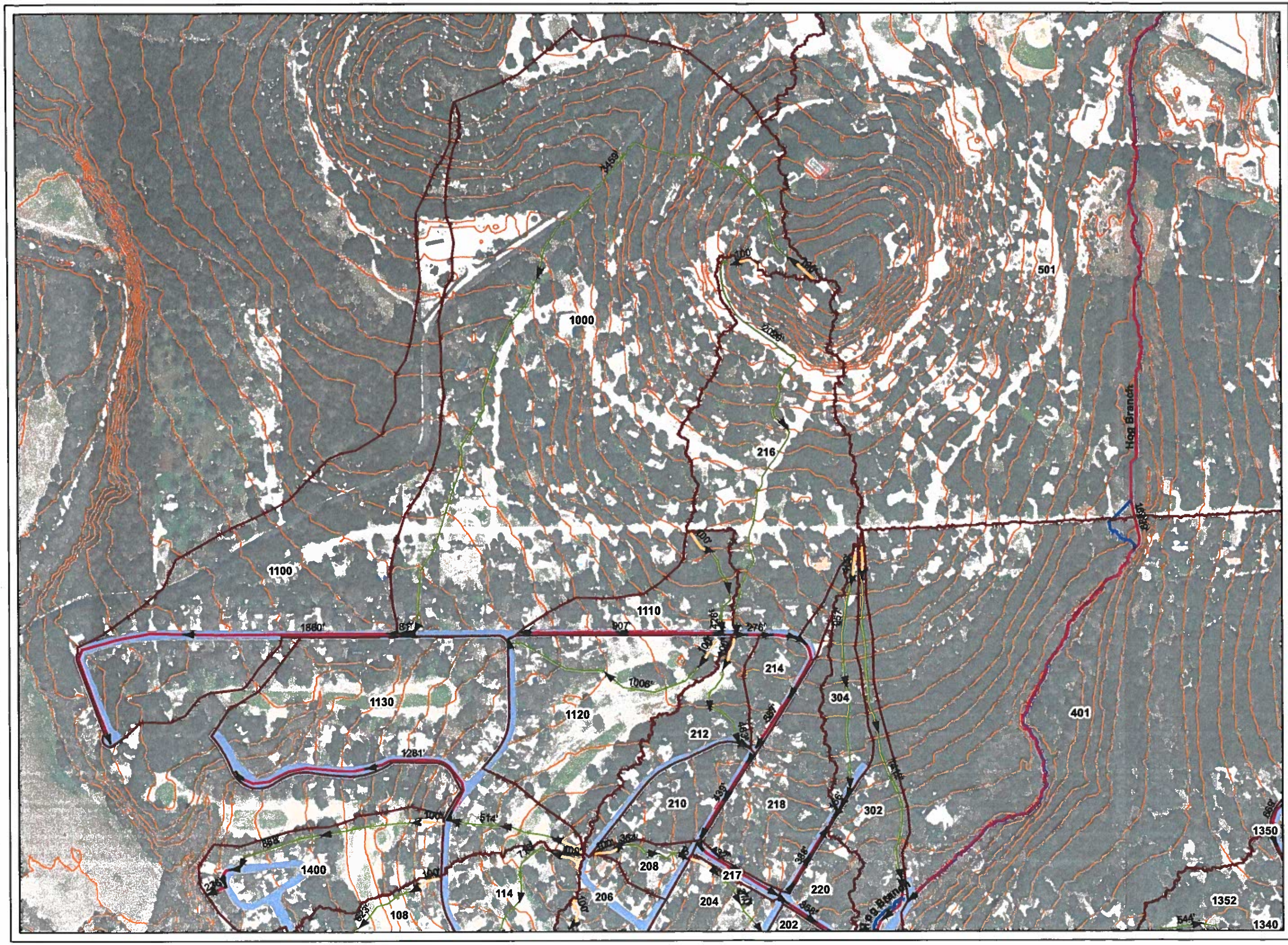
N
W E
S

1 inch equals 400 feet

JONES | CARTER

Texas Board of Professional Engineers Registration No. F-439

Path: K:\14950\14950-0001-00 Roadway Improvement Drainage Assessment\3 Design Phase\Reports\Attachments\Exhibits\6 - Drainage Map (Northeast).mxd Project Number: 14950-0001-00 Date: 1/30/2017 User Name: JMB3



VICINITY MAP

Scale: 1 inch equals 10 miles

LEGEND

- Channel
- Shallow
- Sheet
- Drainage Subbasins
- Rehabilitated Road
- Hog Branch
- Countour 2ft

Exhibit 7: Drainage Map

(Northwest)

City of Woodcreek
HAYS COUNTY, TEXAS

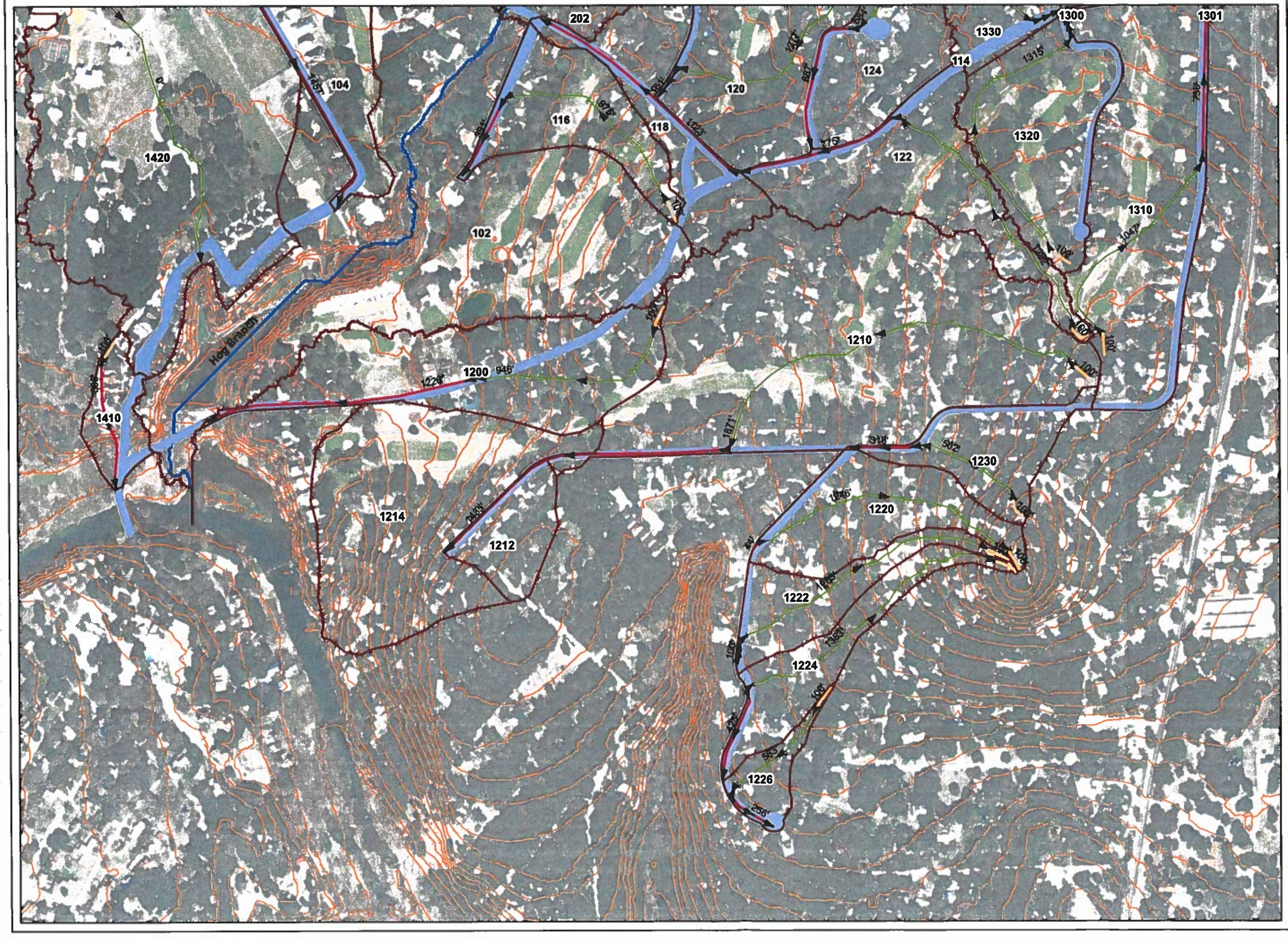
N
W E
S

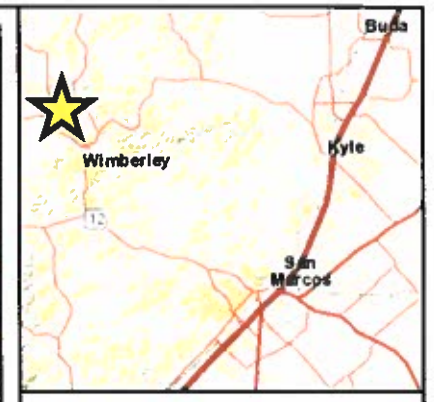
1 inch equals 400 feet

JONES | CARTER

Texas Board of Professional Engineers Registration No. F-439

Path: K:\14950\14950-0001-00 Roadway Improvement Drainage Assessment\2 Design Phase\Reports\Attachments\Exhibits\7 - Drainage Map (Northwest).mxd Project Number: 14950-0001-00 Date: 1/30/2017 User Name: JMB3





VICINITY MAP

Scale: 1 inch equals 10 miles

LEGEND

- Channel
- Shallow
- Sheet
- Drainage Subbasins
- Rehabilitated Road
- Hog Branch
- Countour 2ft

Exhibit 8: Drainage Map

(Southeast)

City of Woodcreek

HAYS COUNTY, TEXAS

N W E S

1 inch equals 400 feet

JONES | CARTER

Texas Board of Professional Engineers Registration No. F-439

Path: K:\14950\14950-0001-00 Roadway Improvement Drainage Assessment\2 Design Phase\Reports\Attachments\Exhibits\8 - Drainage Map (Southeast).mxd
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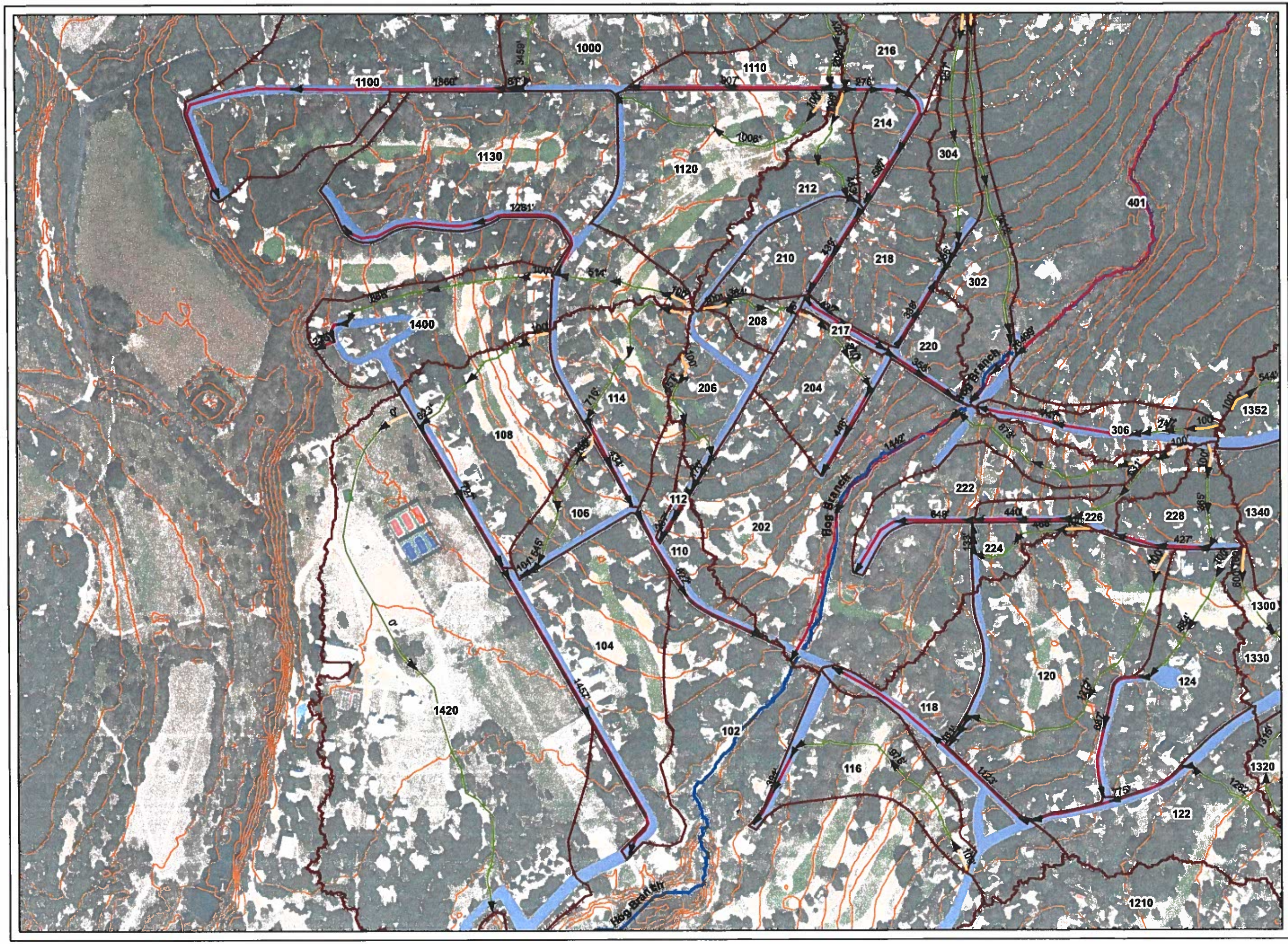

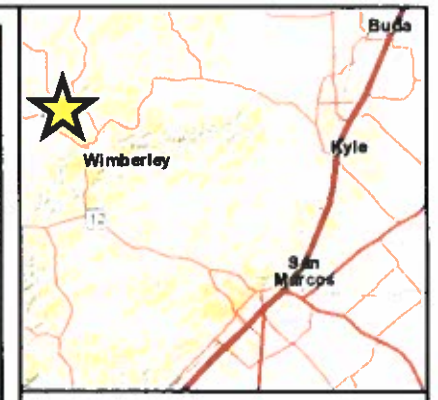

VICINITY MAP

Scale: 1 inch equals 10 miles

LEGEND

- Channel
- Shallow
- Sheet
- Drainage Subbasins
- Rehabilitated Road
- Hog Branch
- Countour 2ft

Exhibit 9:
Drainage Map
(Southwest)

City of Woodcreek
HAYS COUNTY, TEXAS

N
W E
S

1 inch equals 400 feet

JONES | CARTER

Texas Board of Professional Engineers Registration No. F-439

Path: P:\14950\14950-0001-00 Roadway Improvement Drainage Assessment\2 Design Phase\Reports\Attachments\Exhibits\9 - Drainage Map (Southwest).mxd Project Number: 14950-0001-00 Date: 1/30/2017 User Name: JMB3