

### Summary of Culvert Flows at Crossing: CP-61 Sta 579+09

Headwater Elevation (ft)	Total Discharge (cfs)	CP-61 Sta 579+09 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2247.18	0.00	0.00	0.00	1
2247.96	7.30	7.30	0.00	1
2248.30	14.60	14.60	0.00	1
2248.57	21.90	21.90	0.00	1
2248.82	29.20	29.20	0.00	1
2249.06	36.50	36.50	0.00	1
2249.27	43.80	43.80	0.00	1
2249.47	51.10	51.10	0.00	1
2249.65	58.40	58.40	0.00	1
2249.83	65.70	65.70	0.00	1
2250.01	73.00	72.80	0.10	10
2250.00	72.37	72.37	0.00	Overtopping

### Culvert Summary Table: CP-61 Sta 579+09

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2247.18	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
7.30	7.30	2247.96	0.784	0.0*	1-S2n	0.337	0.595	0.345	0.222	10.148	1.988
14.60	14.60	2248.30	1.123	0.0*	1-S2n	0.469	0.843	0.487	0.318	9.532	2.424
21.90	21.90	2248.57	1.393	0.0*	1-S2n	0.600	1.039	0.601	0.389	10.864	2.712
29.20	29.20	2248.82	1.645	0.0*	1-S2n	0.681	1.216	0.690	0.448	11.782	2.933
36.50	36.50	2249.06	1.879	0.0*	1-S2n	0.762	1.361	0.771	0.499	12.602	3.114
43.80	43.80	2249.27	2.090	0.0*	1-S2n	0.843	1.504	0.844	0.544	13.359	3.268
51.10	51.10	2249.47	2.285	0.0*	1-S2n	0.918	1.625	0.924	0.585	13.843	3.405
58.40	58.40	2249.65	2.471	0.0*	1-S2n	0.980	1.746	0.985	0.623	14.417	3.527
65.70	65.70	2249.83	2.653	0.0*	1-S2n	1.042	1.856	1.046	0.658	14.927	3.638
73.00	72.80	2250.01	2.831	0.0*	1-S2n	1.103	1.955	1.110	0.691	15.277	3.739

\* theoretical depth is impractical. Depth reported is corrected.

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 Inlet Elevation (invert): 2247.18 ft, Outlet Elevation (invert): 2240.67 ft  
 Culvert Length: 186.11 ft, Culvert Slope: 0.0350  
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### Site Data - CP-61 Sta 579+09

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2247.18 ft  
 Outlet Station: 186.00 ft  
 Outlet Elevation: 2240.67 ft  
 Number of Barrels: 2

### Culvert Data Summary - CP-61 Sta 579+09

Barrel Shape: Circular  
 Barrel Diameter: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0130

Inlet Type: Conventional

Inlet Edge Condition: Grooved End in Headwall

Inlet Depression: NONE

**Downstream Channel Rating Curve (Crossing: CP-61 Sta 579+09)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2240.67	0.00	0.00	0.00	0.00
7.30	2240.89	0.22	1.99	0.33	0.86
14.60	2240.99	0.32	2.42	0.48	0.90
21.90	2241.06	0.39	2.71	0.58	0.93
29.20	2241.12	0.45	2.93	0.67	0.95
36.50	2241.17	0.50	3.11	0.75	0.96
43.80	2241.21	0.54	3.27	0.82	0.97
51.10	2241.26	0.59	3.41	0.88	0.98
58.40	2241.29	0.62	3.53	0.93	0.99
65.70	2241.33	0.66	3.64	0.99	1.00
73.00	2241.36	0.69	3.74	1.03	1.01

**Tailwater Channel Data - CP-61 Sta 579+09**

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 11.00 ft

Side Slope (H:V): 25.00 (1:1)

Channel Slope: 0.0240

Channel Manning's n: 0.0350

Channel Invert Elevation: 2240.67 ft

**Roadway Data for Crossing: CP-61 Sta 579+09**

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 2250.00 ft

Roadway Surface: Paved

Roadway Top Width: 150.00 ft

**Summary of Culvert Flows at Crossing: CP-62.2 Sta 570+97**

Headwater Elevation (ft)	Total Discharge (cfs)	CP-62.2 Sta 570+97 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2226.40	0.00	0.00	0.00	1
2227.18	7.10	7.10	0.00	1
2227.52	14.20	14.20	0.00	1
2227.79	21.30	21.30	0.00	1
2228.04	28.40	28.40	0.00	1
2228.28	35.50	35.50	0.00	1
2228.49	42.60	42.60	0.00	1
2228.68	49.70	49.70	0.00	1
2228.86	56.80	56.80	0.00	1
2229.04	63.90	63.90	0.00	1
2229.22	71.00	71.00	0.00	1
2232.00	149.99	149.99	0.00	Overtopping

**Culvert Summary Table: CP-62.2 Sta 570+97**

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2226.40	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
7.10	7.10	2227.18	0.781	0.0*	1-S2n	0.354	0.584	0.374	0.120	6.761	1.554
14.20	14.20	2227.52	1.120	0.0*	1-S2n	0.503	0.829	0.519	0.180	8.509	1.993
21.30	21.30	2227.79	1.391	0.0*	1-S2n	0.632	1.024	0.634	0.228	9.873	2.296
28.40	28.40	2228.04	1.642	0.0*	1-S2n	0.723	1.200	0.734	0.269	10.491	2.530
35.50	35.50	2228.28	1.876	0.0*	1-S2n	0.814	1.341	0.831	0.305	11.066	2.726
42.60	42.60	2228.49	2.087	0.0*	1-S2n	0.905	1.481	0.906	0.339	11.842	2.895
49.70	49.70	2228.68	2.281	0.0*	1-S2n	0.975	1.602	0.981	0.369	12.335	3.043
56.80	56.80	2228.86	2.465	0.0*	1-S2n	1.045	1.719	1.054	0.398	12.779	3.178
63.90	63.90	2229.04	2.644	0.0*	1-S2n	1.115	1.831	1.148	0.425	12.823	3.298
71.00	71.00	2229.22	2.822	0.0*	1-S2n	1.185	1.930	1.189	0.450	13.605	3.409

\* theoretical depth is impractical. Depth reported is corrected.

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 Inlet Elevation (invert): 2226.40 ft, Outlet Elevation (invert): 2222.80 ft  
 Culvert Length: 163.04 ft, Culvert Slope: 0.0221  
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**Site Data - CP-62.2 Sta 570+97**

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2226.40 ft  
 Outlet Station: 163.00 ft  
 Outlet Elevation: 2222.80 ft  
 Number of Barrels: 2

**Culvert Data Summary - CP-62.2 Sta 570+97**

Barrel Shape: Circular  
 Barrel Diameter: 3.00 ft

Barrel Material: Concrete  
 Embedment: 0.00 in  
 Barrel Manning's n: 0.0120  
 Inlet Type: Conventional  
 Inlet Edge Condition: Grooved End Projecting  
 Inlet Depression: NONE

**Downstream Channel Rating Curve (Crossing: CP-62.2 Sta 570+97)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2222.80	0.00	0.00	0.00	0.00
7.10	2222.92	0.12	1.55	0.19	0.82
14.20	2222.98	0.18	1.99	0.28	0.87
21.30	2223.03	0.23	2.30	0.36	0.91
28.40	2223.07	0.27	2.53	0.42	0.93
35.50	2223.11	0.31	2.73	0.48	0.94
42.60	2223.14	0.34	2.90	0.53	0.96
49.70	2223.17	0.37	3.04	0.58	0.97
56.80	2223.20	0.40	3.18	0.62	0.98
63.90	2223.22	0.42	3.30	0.66	0.99
71.00	2223.25	0.45	3.41	0.70	1.00

**Tailwater Channel Data - CP-62.2 Sta 570+97**

Tailwater Channel Option: Trapezoidal Channel  
 Bottom Width: 35.00 ft  
 Side Slope (H:V): 25.00 (1:1)  
 Channel Slope: 0.0250  
 Channel Manning's n: 0.0350  
 Channel Invert Elevation: 2222.80 ft

**Roadway Data for Crossing: CP-62.2 Sta 570+97**

Roadway Profile Shape: Constant Roadway Elevation  
 Crest Length: 30.00 ft  
 Crest Elevation: 2232.00 ft  
 Roadway Surface: Paved  
 Roadway Top Width: 100.00 ft



**Summary of Culvert Flows at Crossing: CP-62.3 569+78, 110' Lt**

Headwater Elevation (ft)	Total Discharge (cfs)	CP-62.3 569+78 66' Lt Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2220.80	0.00	0.00	0.00	1
2221.36	1.50	1.50	0.00	1
2221.60	3.00	3.00	0.00	1
2221.79	4.50	4.50	0.00	1
2221.99	6.00	6.00	0.00	1
2222.17	7.50	7.50	0.00	1
2222.32	9.00	9.00	0.00	1
2222.46	10.50	10.50	0.00	1
2222.60	12.00	12.00	0.00	1
2222.74	13.50	13.50	0.00	1
2222.88	15.00	15.00	0.00	1
2225.00	31.60	31.60	0.00	Overtopping

**Culvert Summary Table: CP-62.3 569+78 66' Lt**

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2220.80	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
1.50	1.50	2221.36	0.560	0.0*	1-S2n	0.279	0.420	0.280	0.161	5.427	1.413
3.00	3.00	2221.60	0.803	0.0*	1-S2n	0.413	0.604	0.416	0.234	6.386	1.746
4.50	4.50	2221.79	0.995	0.0*	1-S2n	0.500	0.741	0.501	0.290	7.248	1.965
6.00	6.00	2221.99	1.193	0.0*	1-S2n	0.587	0.862	0.591	0.336	7.726	2.133
7.50	7.50	2222.17	1.365	0.0*	1-S2n	0.657	0.971	0.661	0.377	8.254	2.271
9.00	9.00	2222.32	1.520	0.0*	1-S2n	0.724	1.067	0.729	0.413	8.663	2.388
10.50	10.50	2222.46	1.664	0.0*	1-S2n	0.791	1.158	0.792	0.446	9.062	2.492
12.00	12.00	2222.60	1.802	0.0*	1-S2n	0.850	1.241	0.856	0.476	9.341	2.583
13.50	13.50	2222.74	1.939	0.0*	1-S2n	0.908	1.318	0.951	0.504	9.159	2.667
15.00	15.00	2222.88	2.079	0.0*	5-S2n	0.966	1.395	1.013	0.530	9.389	2.744

\* theoretical depth is impractical. Depth reported is corrected.

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 Inlet Elevation (invert): 2220.80 ft, Outlet Elevation (invert): 2219.70 ft  
 Culvert Length: 56.01 ft, Culvert Slope: 0.0196  
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**Site Data - CP-62.3 569+78 66' Lt**

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2220.80 ft  
 Outlet Station: 56.00 ft  
 Outlet Elevation: 2219.70 ft  
 Number of Barrels: 1

**Culvert Data Summary - CP-62.3 569+78 66' Lt**

Barrel Shape: Circular  
 Barrel Diameter: 2.00 ft

Barrel Material: Concrete  
 Embedment: 0.00 in  
 Barrel Manning's n: 0.0130  
 Inlet Type: Conventional  
 Inlet Edge Condition: Beveled Edge (1.5:1)  
 Inlet Depression: NONE

**Downstream Channel Rating Curve (Crossing: CP-62.3 569+78, 110' Lt)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2219.70	0.00	0.00	0.00	0.00
1.50	2219.86	0.16	1.41	0.17	0.69
3.00	2219.93	0.23	1.75	0.25	0.73
4.50	2219.99	0.29	1.96	0.31	0.75
6.00	2220.04	0.34	2.13	0.36	0.77
7.50	2220.08	0.38	2.27	0.40	0.78
9.00	2220.11	0.41	2.39	0.44	0.79
10.50	2220.15	0.45	2.49	0.47	0.80
12.00	2220.18	0.48	2.58	0.50	0.80
13.50	2220.20	0.50	2.67	0.53	0.81
15.00	2220.23	0.53	2.74	0.56	0.82

**Tailwater Channel Data - CP-62.3 569+78, 110' Lt**

Tailwater Channel Option: Trapezoidal Channel  
 Bottom Width: 5.00 ft  
 Side Slope (H:V): 10.00 (1:1)  
 Channel Slope: 0.0170  
 Channel Manning's n: 0.0350  
 Channel Invert Elevation: 2219.70 ft

**Roadway Data for Crossing: CP-62.3 569+78, 110' Lt**

Roadway Profile Shape: Constant Roadway Elevation  
 Crest Length: 30.00 ft  
 Crest Elevation: 2225.00 ft  
 Roadway Surface: Paved  
 Roadway Top Width: 20.00 ft

**Summary of Culvert Flows at Crossing: CP-63 Sta 561+35**

Headwater Elevation (ft)	Total Discharge (cfs)	CP-63 Sta 561+35 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2204.26	0.00	0.00	0.00	1
2205.89	7.30	7.30	0.00	1
2205.99	14.60	14.60	0.00	1
2206.07	21.90	21.90	0.00	1
2206.14	29.20	29.20	0.00	1
2206.20	36.50	36.50	0.00	1
2206.37	43.80	43.80	0.00	1
2206.56	51.10	51.10	0.00	1
2206.75	58.40	58.40	0.00	1
2206.93	65.70	65.70	0.00	1
2207.11	73.00	73.00	0.00	1
2212.20	199.26	199.26	0.00	Overtopping

**Culvert Summary Table: CP-63 Sta 561+35**

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2204.26	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
7.30	7.30	2205.89	1.633	0.0*	1-S2n	0.361	0.595	0.385	0.168	6.657	1.656
14.60	14.60	2205.99	1.727	0.0*	1-S2n	0.517	0.843	0.533	0.249	8.458	2.079
21.90	21.90	2206.07	1.807	0.0*	1-S2n	0.644	1.039	0.651	0.311	9.613	2.362
29.20	29.20	2206.14	1.877	0.0*	1-S2n	0.740	1.216	0.746	0.364	10.547	2.579
36.50	36.50	2206.20	1.942	0.0*	1-S2n	0.836	1.361	0.851	0.410	11.024	2.757
43.80	43.80	2206.37	2.105	0.0*	1-S2n	0.924	1.504	0.927	0.452	11.810	2.909
51.10	51.10	2206.56	2.300	0.0*	1-S2n	0.998	1.625	1.004	0.490	12.280	3.043
58.40	58.40	2206.75	2.486	0.0*	1-S2n	1.071	1.746	1.079	0.525	12.723	3.163
65.70	65.70	2206.93	2.668	0.0*	1-S2n	1.144	1.856	1.146	0.558	13.212	3.271
73.00	73.00	2207.11	2.851	0.0*	1-S2n	1.215	1.958	1.217	0.589	13.573	3.371

\* theoretical depth is impractical. Depth reported is corrected.

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 Inlet Elevation (invert): 2204.26 ft, Outlet Elevation (invert): 2197.86 ft  
 Culvert Length: 256.08 ft, Culvert Slope: 0.0250  
 Inlet Throat Elevation: 2204.26 ft, Inlet Crest Elevation: 2205.73 ft  
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**Site Data - CP-63 Sta 561+35**

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2205.60 ft  
 Outlet Station: 256.00 ft  
 Outlet Elevation: 2197.86 ft  
 Number of Barrels: 2

**Culvert Data Summary - CP-63 Sta 561+35**

Barrel Shape: Circular

Barrel Diameter: 3.00 ft  
 Barrel Material: Concrete  
 Embedment: 0.00 in  
 Barrel Manning's n: 0.0130  
 Inlet Type: Conventional  
 Inlet Edge Condition: Grooved End in Headwall  
 Inlet Depression: Yes

**Downstream Channel Rating Curve (Crossing: CP-63 Sta 561+35)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2197.86	0.00	0.00	0.00	0.00
7.30	2198.03	0.17	1.66	0.21	0.77
14.60	2198.11	0.25	2.08	0.31	0.81
21.90	2198.17	0.31	2.36	0.39	0.84
29.20	2198.22	0.36	2.58	0.45	0.86
36.50	2198.27	0.41	2.76	0.51	0.87
43.80	2198.31	0.45	2.91	0.56	0.88
51.10	2198.35	0.49	3.04	0.61	0.89
58.40	2198.39	0.53	3.16	0.66	0.90
65.70	2198.42	0.56	3.27	0.70	0.91
73.00	2198.45	0.59	3.37	0.74	0.92

**Tailwater Channel Data - CP-63 Sta 561+35**

Tailwater Channel Option: Trapezoidal Channel  
 Bottom Width: 22.00 ft  
 Side Slope (H:V): 25.00 (1:1)  
 Channel Slope: 0.0200  
 Channel Manning's n: 0.0350  
 Channel Invert Elevation: 2197.86 ft

**Roadway Data for Crossing: CP-63 Sta 561+35**

Roadway Profile Shape: Constant Roadway Elevation  
 Crest Length: 30.00 ft  
 Crest Elevation: 2212.20 ft  
 Roadway Surface: Paved  
 Roadway Top Width: 150.00 ft

**Summary of Culvert Flows at Crossing: CP-64 Sta 555+06**

Headwater Elevation (ft)	Total Discharge (cfs)	CP-64 Sta 555+06 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2185.75	0.00	0.00	0.00	1
2186.84	16.10	16.10	0.00	1
2187.31	32.20	32.20	0.00	1
2187.68	48.30	48.30	0.00	1
2188.06	64.40	64.40	0.00	1
2188.39	80.50	80.50	0.00	1
2188.70	96.60	96.60	0.00	1
2188.98	112.70	112.70	0.00	1
2189.24	128.80	128.80	0.00	1
2189.50	144.90	144.90	0.00	1
2189.76	161.00	161.00	0.00	1
2195.00	385.89	385.89	0.00	Overtopping

**Culvert Summary Table: CP-64 Sta 555+06**

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2185.75	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
16.10	16.10	2186.84	1.088	0.0*	1-S2n	0.511	0.820	0.519	0.365	8.116	3.109
32.20	32.20	2187.31	1.558	0.0*	1-S2n	0.747	1.172	0.762	0.541	9.570	3.905
48.30	48.30	2187.68	1.932	0.0*	1-S2n	0.913	1.439	0.929	0.677	10.808	4.439
64.40	64.40	2188.06	2.307	0.0*	1-S2n	1.058	1.679	1.069	0.793	11.853	4.848
80.50	80.50	2188.39	2.645	0.0*	1-S2n	1.203	1.886	1.205	0.894	12.628	5.184
96.60	96.60	2188.70	2.947	0.0*	1-S2n	1.314	2.078	1.318	0.986	13.348	5.471
112.70	112.70	2188.98	3.226	0.0*	1-S2n	1.426	2.250	1.483	1.069	13.258	5.724
128.80	128.80	2189.24	3.491	0.0*	1-S2n	1.537	2.420	1.546	1.147	14.352	5.949
144.90	144.90	2189.50	3.751	0.0*	1-S2n	1.642	2.566	1.718	1.219	14.035	6.154
161.00	161.00	2189.76	4.012	0.0*	5-S2n	1.739	2.712	1.829	1.287	14.366	6.341

\* theoretical depth is impractical. Depth reported is corrected.

\*\*\*\*\*  
 Inlet Elevation (invert): 2185.75 ft, Outlet Elevation (invert): 2182.60 ft  
 Culvert Length: 156.03 ft, Culvert Slope: 0.0202  
 \*\*\*\*\*

**Site Data - CP-64 Sta 555+06**

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2185.75 ft  
 Outlet Station: 156.00 ft  
 Outlet Elevation: 2182.60 ft  
 Number of Barrels: 2

**Culvert Data Summary - CP-64 Sta 555+06**

Barrel Shape: Circular  
 Barrel Diameter: 4.00 ft

Barrel Material: Concrete  
 Embedment: 0.00 in  
 Barrel Manning's n: 0.0130  
 Inlet Type: Conventional  
 Inlet Edge Condition: Beveled Edge (1.5:1)  
 Inlet Depression: NONE

**Downstream Channel Rating Curve (Crossing: CP-64 Sta 555+06)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2182.60	0.00	0.00	0.00	0.00
16.10	2182.96	0.36	3.11	0.57	0.97
32.20	2183.14	0.54	3.91	0.84	1.03
48.30	2183.28	0.68	4.44	1.06	1.06
64.40	2183.39	0.79	4.85	1.24	1.09
80.50	2183.49	0.89	5.18	1.39	1.11
96.60	2183.59	0.99	5.47	1.54	1.12
112.70	2183.67	1.07	5.72	1.67	1.13
128.80	2183.75	1.15	5.95	1.79	1.14
144.90	2183.82	1.22	6.15	1.90	1.15
161.00	2183.89	1.29	6.34	2.01	1.16

**Tailwater Channel Data - CP-64 Sta 555+06**

Tailwater Channel Option: Trapezoidal Channel  
 Bottom Width: 12.00 ft  
 Side Slope (H:V): 6.00 (1:1)  
 Channel Slope: 0.0250  
 Channel Manning's n: 0.0350  
 Channel Invert Elevation: 2182.60 ft

**Roadway Data for Crossing: CP-64 Sta 555+06**

Roadway Profile Shape: Constant Roadway Elevation  
 Crest Length: 30.00 ft  
 Crest Elevation: 2195.00 ft  
 Roadway Surface: Paved  
 Roadway Top Width: 150.00 ft

**Summary of Culvert Flows at Crossing: CP-65 Sta 544+94**

Headwater Elevation (ft)	Total Discharge (cfs)	CP-65 Sta 544+94 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2164.50	0.00	0.00	0.00	1
2167.34	6.00	6.00	0.00	1
2167.42	12.00	12.00	0.00	1
2167.48	18.00	18.00	0.00	1
2167.54	24.00	24.00	0.00	1
2167.60	30.00	30.00	0.00	1
2167.65	36.00	36.00	0.00	1
2167.69	42.00	42.00	0.00	1
2167.74	48.00	48.00	0.00	1
2167.78	54.00	54.00	0.00	1
2167.82	60.00	60.00	0.00	1
2175.20	234.68	234.68	0.00	Overtopping

**Culvert Summary Table: CP-65 Sta 544+94**

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2164.50	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
6.00	6.00	2167.34	2.842	0.0*	1-S2n	0.345	0.524	0.353	0.153	6.242	1.882
12.00	12.00	2167.42	2.920	0.0*	1-S2n	0.485	0.755	0.495	0.226	7.662	2.348
18.00	18.00	2167.48	2.985	0.0*	1-S2n	0.615	0.942	0.621	0.281	8.561	2.661
24.00	24.00	2167.54	3.043	0.0*	5-S2n	0.701	1.091	0.701	0.328	9.466	2.899
30.00	30.00	2167.60	3.097	0.0*	5-S2n	0.787	1.232	0.792	0.369	9.980	3.096
36.00	36.00	2167.65	3.147	0.0*	5-S2n	0.872	1.351	0.880	0.406	10.400	3.262
42.00	42.00	2167.69	3.194	0.0*	5-S2n	0.945	1.470	0.949	0.440	10.999	3.410
48.00	48.00	2167.74	3.239	0.0*	5-S2n	1.011	1.574	1.018	0.471	11.321	3.541
54.00	54.00	2167.78	3.282	0.0*	5-S2n	1.076	1.673	1.082	0.500	11.723	3.660
60.00	60.00	2167.82	3.324	0.0*	5-S2n	1.142	1.772	1.151	0.527	11.996	3.768

\* theoretical depth is impractical. Depth reported is corrected.

\*\*\*\*\*  
 Inlet Elevation (invert): 2164.50 ft, Outlet Elevation (invert): 2159.00 ft  
 Culvert Length: 262.06 ft, Culvert Slope: 0.0210  
 Inlet Throat Elevation: 2164.50 ft, Inlet Crest Elevation: 2167.21 ft  
 \*\*\*\*\*

**Site Data - CP-65 Sta 544+94**

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2167.00 ft  
 Outlet Station: 262.00 ft  
 Outlet Elevation: 2159.00 ft  
 Number of Barrels: 2

**Culvert Data Summary - CP-65 Sta 544+94**

Barrel Shape: Circular

Barrel Diameter: 3.00 ft  
 Barrel Material: Concrete  
 Embedment: 0.00 in  
 Barrel Manning's n: 0.0130  
 Inlet Type: Conventional  
 Inlet Edge Condition: Grooved End in Headwall  
 Inlet Depression: Yes

**Downstream Channel Rating Curve (Crossing: CP-65 Sta 544+94)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2159.00	0.00	0.00	0.00	0.00
6.00	2159.15	0.15	1.88	0.29	0.92
12.00	2159.23	0.23	2.35	0.42	0.97
18.00	2159.28	0.28	2.66	0.53	1.00
24.00	2159.33	0.33	2.90	0.61	1.03
30.00	2159.37	0.37	3.10	0.69	1.04
36.00	2159.41	0.41	3.26	0.76	1.06
42.00	2159.44	0.44	3.41	0.82	1.07
48.00	2159.47	0.47	3.54	0.88	1.08
54.00	2159.50	0.50	3.66	0.94	1.09
60.00	2159.53	0.53	3.77	0.99	1.10

**Tailwater Channel Data - CP-65 Sta 544+94**

Tailwater Channel Option: Trapezoidal Channel  
 Bottom Width: 17.00 ft  
 Side Slope (H:V): 25.00 (1:1)  
 Channel Slope: 0.0300  
 Channel Manning's n: 0.0350  
 Channel Invert Elevation: 2159.00 ft

**Roadway Data for Crossing: CP-65 Sta 544+94**

Roadway Profile Shape: Constant Roadway Elevation  
 Crest Length: 30.00 ft  
 Crest Elevation: 2175.20 ft  
 Roadway Surface: Paved  
 Roadway Top Width: 150.00 ft



### Summary of Culvert Flows at Crossing: CP-66 Sta 526+65

Headwater Elevation (ft)	Total Discharge (cfs)	CP-66 Sta 526+65 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2119.03	0.00	0.00	0.00	1
2121.51	56.30	56.30	0.00	1
2121.64	112.60	112.60	0.00	1
2121.74	168.90	168.90	0.00	1
2121.84	225.20	225.20	0.00	1
2121.93	281.50	281.50	0.00	1
2122.01	337.80	337.80	0.00	1
2122.11	394.10	394.10	0.00	1
2122.42	450.40	450.40	0.00	1
2122.73	506.70	506.70	0.00	1
2123.04	563.00	563.00	0.00	1
2126.77	1141.63	1141.63	0.00	Overtopping

### Culvert Summary Table: CP-66 Sta 526+65

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2119.03	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
56.30	56.30	2121.51	2.477	0.0*	1-S2n	0.269	0.556	0.346	0.389	6.777	2.849
112.60	112.60	2121.64	2.606	0.0*	1-S2n	0.469	0.883	0.473	0.573	9.923	3.553
168.90	168.90	2121.74	2.713	0.0*	1-S2n	0.604	1.157	0.617	0.714	11.410	4.020
225.20	225.20	2121.84	2.809	0.0*	1-S2n	0.739	1.401	0.741	0.832	12.657	4.377
281.50	281.50	2121.93	2.898	0.0*	1-S2n	0.857	1.626	0.865	0.936	13.558	4.671
337.80	337.80	2122.01	2.980	0.0*	1-S2n	0.961	1.836	0.966	1.029	14.566	4.922
394.10	394.10	2122.11	3.079	0.0*	1-S2n	1.065	2.035	1.074	1.113	15.289	5.142
450.40	450.40	2122.42	3.395	0.0*	1-S2n	1.169	2.225	1.239	1.192	15.153	5.338
506.70	506.70	2122.73	3.705	0.0*	1-S2n	1.263	2.406	1.351	1.265	15.625	5.517
563.00	563.00	2123.04	4.014	0.0*	5-S2n	1.353	2.581	1.460	1.333	16.064	5.680

\* theoretical depth is impractical. Depth reported is corrected.

\*\*\*\*\*  
 Inlet Elevation (invert): 2119.03 ft, Outlet Elevation (invert): 2115.23 ft  
 Culvert Length: 200.04 ft, Culvert Slope: 0.0190  
 Inlet Throat Elevation: 2119.03 ft, Inlet Crest Elevation: 2121.29 ft  
 \*\*\*\*\*

### Site Data - CP-66 Sta 526+65

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2121.10 ft  
 Outlet Station: 200.00 ft  
 Outlet Elevation: 2115.23 ft  
 Number of Barrels: 3

### Culvert Data Summary - CP-66 Sta 526+65

Barrel Shape: Concrete Box

Barrel Span: 8.00 ft  
 Barrel Rise: 4.00 ft  
 Barrel Material: Concrete  
 Embedment: 0.00 in  
 Barrel Manning's n: 0.0120  
 Inlet Type: Conventional  
 Inlet Edge Condition: 1:1 Bevel (45° flare) Wingwall  
 Inlet Depression: Yes

**Downstream Channel Rating Curve (Crossing: CP-66 Sta 526+65)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2115.23	0.00	0.00	0.00	0.00
56.30	2115.62	0.39	2.85	0.49	0.88
112.60	2115.80	0.57	3.55	0.71	0.93
168.90	2115.94	0.71	4.02	0.89	0.96
225.20	2116.06	0.83	4.38	1.04	0.98
281.50	2116.17	0.94	4.67	1.17	0.99
337.80	2116.26	1.03	4.92	1.28	1.01
394.10	2116.34	1.11	5.14	1.39	1.02
450.40	2116.42	1.19	5.34	1.49	1.03
506.70	2116.49	1.26	5.52	1.58	1.04
563.00	2116.56	1.33	5.68	1.66	1.04

**Tailwater Channel Data - CP-66 Sta 526+65**

Tailwater Channel Option: Trapezoidal Channel  
 Bottom Width: 41.00 ft  
 Side Slope (H:V): 25.00 ( \_:1)  
 Channel Slope: 0.0200  
 Channel Manning's n: 0.0350  
 Channel Invert Elevation: 2115.23 ft

**Roadway Data for Crossing: CP-66 Sta 526+65**

Roadway Profile Shape: Constant Roadway Elevation  
 Crest Length: 30.00 ft  
 Crest Elevation: 2126.77 ft  
 Roadway Surface: Paved  
 Roadway Top Width: 150.00 ft

### Summary of Culvert Flows at Crossing: CP-67 Sta 515+35

Headwater Elevation (ft)	Total Discharge (cfs)	CP-67 Sta 515+35 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2094.92	0.00	0.00	0.00	1
2095.69	78.50	78.50	0.00	1
2096.14	157.00	157.00	0.00	1
2096.53	235.50	235.50	0.00	1
2096.86	314.00	314.00	0.00	1
2097.16	392.50	392.50	0.00	1
2097.43	471.00	471.00	0.00	1
2097.70	549.50	549.50	0.00	1
2097.96	628.00	628.00	0.00	1
2098.21	706.50	706.50	0.00	1
2098.45	785.00	785.00	0.00	1
2100.77	1476.04	1476.04	0.00	Overtopping

### Culvert Summary Table: CP-67 Sta 515+35

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2094.92	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
78.50	78.50	2095.69	0.773	0.0*	1-S2n	0.221	0.494	0.284	0.524	6.916	3.603
157.00	157.00	2096.14	1.224	0.0*	1-S2n	0.421	0.784	0.423	0.791	9.283	4.682
235.50	235.50	2096.53	1.605	0.0*	1-S2n	0.530	1.027	0.537	1.006	10.962	5.441
314.00	314.00	2096.86	1.943	0.0*	1-S2n	0.639	1.244	0.668	1.192	11.760	6.044
392.50	392.50	2097.16	2.237	0.0*	1-S2n	0.748	1.444	0.757	1.359	12.958	6.550
471.00	471.00	2097.43	2.513	0.0*	1-S2n	0.844	1.630	0.849	1.513	13.863	6.990
549.50	549.50	2097.70	2.778	0.0*	1-S2n	0.927	1.807	0.927	1.656	14.822	7.381
628.00	628.00	2097.96	3.035	0.0*	1-S2n	1.010	1.975	1.082	1.790	14.510	7.734
706.50	706.50	2098.21	3.286	0.0*	1-S2n	1.093	2.136	1.178	1.917	14.989	8.058
785.00	785.00	2098.45	3.534	0.0*	1-S2n	1.176	2.292	1.272	2.037	15.430	8.355

\* theoretical depth is impractical. Depth reported is corrected.

\*\*\*\*\*  
 Inlet Elevation (invert): 2094.92 ft, Outlet Elevation (invert): 2091.50 ft  
 Culvert Length: 178.03 ft, Culvert Slope: 0.0192  
 \*\*\*\*\*

### Site Data - CP-67 Sta 515+35

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2094.92 ft  
 Outlet Station: 178.00 ft  
 Outlet Elevation: 2091.50 ft  
 Number of Barrels: 4

### Culvert Data Summary - CP-67 Sta 515+35

Barrel Shape: Concrete Box  
 Barrel Span: 10.00 ft

Barrel Rise: 4.00 ft  
 Barrel Material: Concrete  
 Embedment: 0.00 in  
 Barrel Manning's n: 0.0120  
 Inlet Type: Conventional  
 Inlet Edge Condition: 1:1 Bevel Headwall  
 Inlet Depression: NONE

**Downstream Channel Rating Curve (Crossing: CP-67 Sta 515+35)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2091.49	0.00	0.00	0.00	0.00
78.50	2092.01	0.52	3.60	0.59	0.89
157.00	2092.28	0.79	4.68	0.89	0.95
235.50	2092.50	1.01	5.44	1.13	0.99
314.00	2092.68	1.19	6.04	1.34	1.01
392.50	2092.85	1.36	6.55	1.53	1.03
471.00	2093.00	1.51	6.99	1.70	1.05
549.50	2093.15	1.66	7.38	1.86	1.07
628.00	2093.28	1.79	7.73	2.01	1.08
706.50	2093.41	1.92	8.06	2.15	1.09
785.00	2093.53	2.04	8.36	2.29	1.10

**Tailwater Channel Data - CP-67 Sta 515+35**

Tailwater Channel Option: Trapezoidal Channel  
 Bottom Width: 40.00 ft  
 Side Slope (H:V): 3.00 (3:1)  
 Channel Slope: 0.0180  
 Channel Manning's n: 0.0350  
 Channel Invert Elevation: 2091.49 ft

**Roadway Data for Crossing: CP-67 Sta 515+35**

Roadway Profile Shape: Constant Roadway Elevation  
 Crest Length: 100.00 ft  
 Crest Elevation: 2100.77 ft  
 Roadway Surface: Paved  
 Roadway Top Width: 40.00 ft

**Summary of Culvert Flows at Crossing: CP-67.1 Sta 524+28 Driveway**

Headwater Elevation (ft)	Total Discharge (cfs)	CP-67.1 Sta 524+28 Driveway Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2112.50	0.00	0.00	0.00	1
2113.37	15.60	15.60	0.00	1
2113.77	31.20	31.20	0.00	1
2114.11	46.80	46.80	0.00	1
2114.39	62.40	62.40	0.00	1
2114.66	78.00	78.00	0.00	1
2114.91	93.60	93.60	0.00	1
2115.18	109.20	109.20	0.00	1
2115.47	124.80	124.80	0.00	1
2115.79	140.40	140.40	0.00	1
2116.06	156.00	152.09	3.80	10
2115.88	144.25	144.25	0.00	Overtopping

**Culvert Summary Table: CP-67.1 Sta 524+28 Driveway**

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2112.50	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
15.60	15.60	2113.37	0.872	0.0*	1-S2n	0.500	0.638	0.501	0.317	5.571	3.151
31.20	31.20	2113.77	1.266	0.0*	1-S2n	0.702	0.922	0.712	0.479	6.749	4.086
46.80	46.80	2114.11	1.608	0.109	1-S2n	0.869	1.141	0.877	0.609	7.596	4.742
62.40	62.40	2114.39	1.895	0.221	1-S2n	1.021	1.328	1.066	0.721	7.808	5.260
78.00	78.00	2114.66	2.155	0.323	1-S2n	1.155	1.498	1.214	0.823	8.248	5.696
93.60	93.60	2114.91	2.412	0.416	1-S2n	1.287	1.641	1.354	0.916	8.624	6.073
109.20	109.20	2115.18	2.680	0.502	5-S2n	1.415	1.778	1.487	1.002	8.970	6.408
124.80	124.80	2115.47	2.972	0.584	5-S2n	1.544	1.896	1.620	1.084	9.287	6.709
140.40	140.40	2115.79	3.295	0.661	5-S2n	1.676	2.009	1.745	1.161	9.593	6.985
156.00	152.09	2116.06	3.560	0.734	5-S2n	1.780	2.071	1.782	1.234	10.152	7.238

\* theoretical depth is impractical. Depth reported is corrected.

\*\*\*\*\*  
 Inlet Elevation (invert): 2112.50 ft, Outlet Elevation (invert): 2111.98 ft  
 Culvert Length: 52.00 ft, Culvert Slope: 0.0100  
 \*\*\*\*\*

**Site Data - CP-67.1 Sta 524+28 Driveway**

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2112.50 ft  
 Outlet Station: 52.00 ft  
 Outlet Elevation: 2111.98 ft  
 Number of Barrels: 4

**Culvert Data Summary - CP-67.1 Sta 524+28 Driveway**

Barrel Shape: Circular  
 Barrel Diameter: 2.50 ft

Barrel Material: Concrete  
 Embedment: 0.00 in  
 Barrel Manning's n: 0.0120  
 Inlet Type: Conventional  
 Inlet Edge Condition: Grooved End in Headwall  
 Inlet Depression: NONE

**Downstream Channel Rating Curve (Crossing: CP-67.1 Sta 524+28 Driveway )**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2112.00	0.00	0.00	0.00	0.00
15.60	2112.32	0.32	3.15	0.40	1.01
31.20	2112.48	0.48	4.09	0.60	1.07
46.80	2112.61	0.61	4.74	0.76	1.11
62.40	2112.72	0.72	5.26	0.90	1.14
78.00	2112.82	0.82	5.70	1.03	1.16
93.60	2112.92	0.92	6.07	1.14	1.18
109.20	2113.00	1.00	6.41	1.25	1.19
124.80	2113.08	1.08	6.71	1.35	1.21
140.40	2113.16	1.16	6.98	1.45	1.22
156.00	2113.23	1.23	7.24	1.54	1.23

**Tailwater Channel Data - CP-67.1 Sta 524+28 Driveway**

Tailwater Channel Option: Trapezoidal Channel  
 Bottom Width: 15.00 ft  
 Side Slope (H:V): 2.00 ( \_:1)  
 Channel Slope: 0.0200  
 Channel Manning's n: 0.0300  
 Channel Invert Elevation: 2112.00 ft

**Roadway Data for Crossing: CP-67.1 Sta 524+28 Driveway**

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	0.00	2116.04
1	33.00	2115.88
2	172.00	2118.50

Roadway Surface: Paved  
 Roadway Top Width: 20.00 ft

**Summary of Culvert Flows at Crossing: CP-70 Sta 442+87**

Headwater Elevation (ft)	Total Discharge (cfs)	CP-70 Sta 442+87 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2038.40	0.00	0.00	0.00	1
2041.15	140.40	84.30	55.60	10
2041.37	280.80	91.01	188.95	9
2041.52	421.20	95.15	324.58	6
2041.64	561.60	98.35	461.67	5
2041.74	702.00	101.00	600.42	5
2041.82	842.40	103.20	738.26	4
2041.90	982.80	105.16	877.26	4
2041.97	1123.20	106.90	1014.91	3
2042.03	1263.60	108.50	1154.45	3
2042.09	1404.00	109.98	1293.81	3
2040.90	76.00	76.00	0.00	Overtopping

**Culvert Summary Table: CP-70 Sta 442+87**

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2038.40	0.000	0.0*	0-NF	0.000	0.000	0.000	0.800	0.000	0.000
140.40	84.30	2041.15	2.752	0.0*	5-S2n	1.198	1.636	1.199	0.800	10.721	0.000
280.80	91.01	2041.37	2.974	0.0*	5-S2n	1.262	1.686	1.265	0.800	10.877	0.000
421.20	95.15	2041.52	3.120	0.0*	5-S2n	1.302	1.716	1.306	0.800	10.958	0.000
561.60	98.35	2041.64	3.236	0.0*	5-S2n	1.332	1.740	1.355	0.800	10.868	0.000
702.00	101.00	2041.74	3.336	0.0*	5-S2n	1.358	1.760	1.379	0.800	10.933	0.000
842.40	103.20	2041.82	3.421	0.0*	5-S2n	1.379	1.776	1.381	0.800	11.154	0.000
982.80	105.16	2041.90	3.497	0.0*	5-S2n	1.398	1.790	1.399	0.800	11.200	0.000
1123.20	106.90	2041.97	3.566	0.0*	5-S2n	1.417	1.803	1.417	0.800	11.221	0.000
1263.60	108.50	2042.03	3.631	0.0*	5-S2n	1.435	1.815	1.435	0.800	11.226	0.000
1404.00	109.98	2042.09	3.692	0.0*	5-S2n	1.452	1.826	1.455	0.800	11.253	0.000

\* theoretical depth is impractical. Depth reported is corrected.

\*\*\*\*\*  
 Inlet Elevation (invert): 2038.40 ft, Outlet Elevation (invert): 2036.20 ft  
 Culvert Length: 134.02 ft, Culvert Slope: 0.0164  
 \*\*\*\*\*

**Site Data - CP-70 Sta 442+87**

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2038.40 ft  
 Outlet Station: 134.00 ft  
 Outlet Elevation: 2036.20 ft  
 Number of Barrels: 4

**Culvert Data Summary - CP-70 Sta 442+87**

Barrel Shape: Circular  
 Barrel Diameter: 2.00 ft

Barrel Material: Concrete  
 Embedment: 0.00 in  
 Barrel Manning's n: 0.0120  
 Inlet Type: Conventional  
 Inlet Edge Condition: Grooved End in Headwall  
 Inlet Depression: NONE

**Downstream Channel Rating Curve (Crossing: CP-70 Sta 442+87)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	2037.00	0.80
140.40	2037.00	0.80
280.80	2037.00	0.80
421.20	2037.00	0.80
561.60	2037.00	0.80
702.00	2037.00	0.80
842.40	2037.00	0.80
982.80	2037.00	0.80
1123.20	2037.00	0.80
1263.60	2037.00	0.80
1404.00	2037.00	0.80

**Tailwater Channel Data - CP-70 Sta 442+87**

Tailwater Channel Option: Enter Constant Tailwater Elevation  
 Constant Tailwater Elevation: 2037.00 ft

**Roadway Data for Crossing: CP-70 Sta 442+87**

Roadway Profile Shape: Irregular Roadway Shape (coordinates)



Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	0.00	2043.50
1	100.00	2042.70
2	200.00	2042.10
3	300.00	2041.70
4	400.00	2041.40
5	500.00	2040.90
6	600.00	2040.90
7	700.00	2041.20
8	800.00	2041.80
9	900.00	2042.10
10	1000.00	2042.70
11	1100.00	2043.20
12	1200.00	2043.50

Roadway Surface: Paved

Roadway Top Width: 40.00 ft

## Summary of Culvert Flows at Crossing: FR-1 Sta 110+00

Headwater Elevation (ft)	Total Discharge (cfs)	FR-1 Sta 110+00 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2154.50	0.00	0.00	0.00	1
2155.35	8.20	8.20	0.00	1
2155.71	16.40	16.40	0.00	1
2156.00	24.60	24.60	0.00	1
2156.29	32.80	32.80	0.00	1
2156.53	41.00	41.00	0.00	1
2156.76	49.20	49.20	0.00	1
2156.97	57.40	57.40	0.00	1
2157.17	65.60	65.60	0.00	1
2157.38	73.80	73.80	0.00	1
2157.59	82.00	82.00	0.00	1
2160.00	150.83	150.83	0.00	Overtopping

## Culvert Summary Table: FR-1 Sta 110+00

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2154.50	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
8.20	8.20	2155.35	0.846	0.0*	1-S2n	0.384	0.627	0.417	0.334	6.644	2.235
16.40	16.40	2155.71	1.212	0.0*	1-S2n	0.563	0.902	0.571	0.500	8.672	2.852
24.60	24.60	2156.00	1.504	0.0*	1-S2n	0.687	1.106	0.696	0.632	9.805	3.272
32.80	32.80	2156.29	1.786	0.0*	1-S2n	0.797	1.287	0.797	0.745	10.809	3.600
41.00	41.00	2156.53	2.033	0.0*	1-S2n	0.905	1.450	0.906	0.845	11.399	3.869
49.20	49.20	2156.76	2.258	0.0*	1-S2n	0.989	1.594	1.043	0.937	11.229	4.101
57.40	57.40	2156.97	2.468	0.0*	1-S2n	1.074	1.729	1.140	1.021	11.622	4.305
65.60	65.60	2157.17	2.672	0.0*	1-S2n	1.158	1.855	1.166	1.099	12.891	4.487
73.80	73.80	2157.38	2.878	0.0*	1-S2n	1.236	1.969	1.322	1.173	12.281	4.653
82.00	82.00	2157.59	3.090	0.0*	5-S2n	1.309	2.084	1.410	1.243	12.555	4.805

\* theoretical depth is impractical. Depth reported is corrected.

\*\*\*\*\*  
 Inlet Elevation (invert): 2154.50 ft, Outlet Elevation (invert): 2152.50 ft  
 Culvert Length: 98.02 ft, Culvert Slope: 0.0204  
 \*\*\*\*\*

## Site Data - FR-1 Sta 110+00

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2154.50 ft  
 Outlet Station: 98.00 ft  
 Outlet Elevation: 2152.50 ft  
 Number of Barrels: 2

## Culvert Data Summary - FR-1 Sta 110+00

Barrel Shape: Circular  
 Barrel Diameter: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Grooved End in Headwall

Inlet Depression: NONE

**Downstream Channel Rating Curve (Crossing: FR-1 Sta 110+00)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2152.50	0.00	0.00	0.00	0.00
8.20	2152.83	0.33	2.23	0.21	0.71
16.40	2153.00	0.50	2.85	0.31	0.76
24.60	2153.13	0.63	3.27	0.39	0.78
32.80	2153.24	0.74	3.60	0.46	0.80
41.00	2153.35	0.85	3.87	0.53	0.81
49.20	2153.44	0.94	4.10	0.58	0.82
57.40	2153.52	1.02	4.31	0.64	0.83
65.60	2153.60	1.10	4.49	0.69	0.84
73.80	2153.67	1.17	4.65	0.73	0.85
82.00	2153.74	1.24	4.80	0.78	0.86

**Tailwater Channel Data - FR-1 Sta 110+00**

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 3.00 (1:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0300

Channel Invert Elevation: 2152.50 ft

**Roadway Data for Crossing: FR-1 Sta 110+00**

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 2160.00 ft

Roadway Surface: Paved

Roadway Top Width: 20.00 ft

### Summary of Culvert Flows at Crossing: FR-2 Sta 541+06

Headwater Elevation (ft)	Total Discharge (cfs)	FR-2 Sta 541+06 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2151.16	0.00	0.00	0.00	1
2151.54	0.70	0.70	0.00	1
2151.71	1.40	1.40	0.00	1
2151.84	2.10	2.10	0.00	1
2151.95	2.80	2.80	0.00	1
2152.05	3.50	3.50	0.00	1
2152.14	4.20	4.20	0.00	1
2152.23	4.90	4.90	0.00	1
2152.32	5.60	5.60	0.00	1
2152.40	6.30	6.30	0.00	1
2152.48	7.00	7.00	0.00	1
2155.00	28.35	28.35	0.00	Overtopping

### Culvert Summary Table: FR-2 Sta 541+06

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2151.16	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
0.70	0.70	2151.54	0.378	0.0*	1-S2n	0.223	0.272	0.250	0.155	4.566	1.303
1.40	1.40	2151.71	0.550	0.0*	1-S2n	0.308	0.407	0.320	0.231	4.191	1.643
2.10	2.10	2151.84	0.675	0.0*	1-S2n	0.394	0.494	0.395	0.290	4.773	1.871
2.80	2.80	2151.95	0.789	0.0*	1-S2n	0.449	0.580	0.454	0.340	5.172	2.047
3.50	3.50	2152.05	0.892	0.0*	1-S2n	0.502	0.649	0.508	0.385	5.516	2.190
4.20	4.20	2152.14	0.979	0.0*	1-S2n	0.554	0.713	0.562	0.425	5.774	2.314
4.90	4.90	2152.23	1.071	0.0*	1-S2n	0.605	0.777	0.606	0.462	6.103	2.422
5.60	5.60	2152.32	1.159	0.0*	1-S2n	0.646	0.833	0.652	0.496	6.286	2.518
6.30	6.30	2152.40	1.241	0.0*	1-S2n	0.686	0.884	0.693	0.528	6.503	2.606
7.00	7.00	2152.48	1.319	0.0*	1-S2n	0.726	0.935	0.734	0.558	6.687	2.686

\* theoretical depth is impractical. Depth reported is corrected.

\*\*\*\*\*  
 Inlet Elevation (invert): 2151.16 ft, Outlet Elevation (invert): 2150.47 ft  
 Culvert Length: 69.00 ft, Culvert Slope: 0.0100  
 \*\*\*\*\*

### Site Data - FR-2 Sta 541+06

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2151.16 ft  
 Outlet Station: 69.00 ft  
 Outlet Elevation: 2150.47 ft  
 Number of Barrels: 1

### Culvert Data Summary - FR-2 Sta 541+06

Barrel Shape: Circular  
 Barrel Diameter: 2.00 ft

Barrel Material: Concrete  
 Embedment: 0.00 in  
 Barrel Manning's n: 0.0120  
 Inlet Type: Conventional  
 Inlet Edge Condition: Grooved End in Headwall  
 Inlet Depression: NONE

**Downstream Channel Rating Curve (Crossing: FR-2 Sta 541+06)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2150.47	0.00	0.00	0.00	0.00
0.70	2150.62	0.15	1.30	0.10	0.62
1.40	2150.70	0.23	1.64	0.14	0.66
2.10	2150.76	0.29	1.87	0.18	0.68
2.80	2150.81	0.34	2.05	0.21	0.69
3.50	2150.85	0.38	2.19	0.24	0.70
4.20	2150.89	0.42	2.31	0.27	0.71
4.90	2150.93	0.46	2.42	0.29	0.72
5.60	2150.97	0.50	2.52	0.31	0.73
6.30	2151.00	0.53	2.61	0.33	0.73
7.00	2151.03	0.56	2.69	0.35	0.74

**Tailwater Channel Data - FR-2 Sta 541+06**

Tailwater Channel Option: Trapezoidal Channel  
 Bottom Width: 3.00 ft  
 Side Slope (H:V): 3.00 (1:1)  
 Channel Slope: 0.0100  
 Channel Manning's n: 0.0300  
 Channel Invert Elevation: 2150.47 ft

**Roadway Data for Crossing: FR-2 Sta 541+06**

Roadway Profile Shape: Constant Roadway Elevation  
 Crest Length: 100.00 ft  
 Crest Elevation: 2155.00 ft  
 Roadway Surface: Paved  
 Roadway Top Width: 20.00 ft

**Summary of Culvert Flows at Crossing: FR-3 Sta 104+06**

Headwater Elevation (ft)	Total Discharge (cfs)	FR-3 Sta 104+06 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2143.67	0.00	0.00	0.00	1
2144.10	1.80	1.80	0.00	1
2144.29	3.60	3.60	0.00	1
2144.44	5.40	5.40	0.00	1
2144.57	7.20	7.20	0.00	1
2144.69	9.00	9.00	0.00	1
2144.80	10.80	10.80	0.00	1
2144.91	12.60	12.60	0.00	1
2145.01	14.40	14.40	0.00	1
2145.10	16.20	16.20	0.00	1
2145.19	18.00	18.00	0.00	1
2147.50	56.57	56.57	0.00	Overtopping

**Culvert Summary Table: FR-3 Sta 104+06**

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2143.67	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
1.80	1.80	2144.10	0.431	0.0*	1-S2n	0.247	0.312	0.252	0.166	3.803	2.404
3.60	3.60	2144.29	0.623	0.0*	1-S2n	0.357	0.457	0.366	0.249	4.516	3.048
5.40	5.40	2144.44	0.773	0.0*	1-S2n	0.441	0.568	0.447	0.314	5.252	3.485
7.20	7.20	2144.57	0.901	0.0*	1-S2n	0.509	0.659	0.518	0.369	5.537	3.823
9.00	9.00	2144.69	1.018	0.0*	1-S2n	0.577	0.741	0.580	0.418	5.942	4.101
10.80	10.80	2144.80	1.134	0.0*	1-S2n	0.634	0.818	0.637	0.462	6.304	4.338
12.60	12.60	2144.91	1.241	0.0*	1-S2n	0.686	0.884	0.693	0.503	6.503	4.548
14.40	14.40	2145.01	1.341	0.0*	1-S2n	0.738	0.949	0.739	0.541	6.809	4.735
16.20	16.20	2145.10	1.434	0.0*	1-S2n	0.790	1.012	0.791	0.577	7.003	4.903
18.00	18.00	2145.19	1.523	0.0*	1-S2n	0.836	1.067	0.837	0.610	7.238	5.058

\* theoretical depth is impractical. Depth reported is corrected.

\*\*\*\*\*  
 Inlet Elevation (invert): 2143.67 ft, Outlet Elevation (invert): 2143.03 ft  
 Culvert Length: 64.00 ft, Culvert Slope: 0.0100  
 \*\*\*\*\*

**Site Data - FR-3 Sta 104+06**

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2143.67 ft  
 Outlet Station: 64.00 ft  
 Outlet Elevation: 2143.03 ft  
 Number of Barrels: 2

**Culvert Data Summary - FR-3 Sta 104+06**

Barrel Shape: Circular  
 Barrel Diameter: 2.00 ft

Barrel Material: Concrete  
 Embedment: 0.00 in  
 Barrel Manning's n: 0.0120  
 Inlet Type: Conventional  
 Inlet Edge Condition: Grooved End in Headwall  
 Inlet Depression: NONE

**Downstream Channel Rating Curve (Crossing: FR-3 Sta 104+06)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2143.03	0.00	0.00	0.00	0.00
1.80	2143.20	0.17	2.40	0.31	1.09
3.60	2143.28	0.25	3.05	0.47	1.16
5.40	2143.34	0.31	3.49	0.59	1.20
7.20	2143.40	0.37	3.82	0.69	1.22
9.00	2143.45	0.42	4.10	0.78	1.24
10.80	2143.49	0.46	4.34	0.87	1.26
12.60	2143.53	0.50	4.55	0.94	1.28
14.40	2143.57	0.54	4.73	1.01	1.29
16.20	2143.61	0.58	4.90	1.08	1.30
18.00	2143.64	0.61	5.06	1.14	1.31

**Tailwater Channel Data - FR-3 Sta 104+06**

Tailwater Channel Option: Trapezoidal Channel  
 Bottom Width: 4.00 ft  
 Side Slope (H:V): 3.00 (1:1)  
 Channel Slope: 0.0300  
 Channel Manning's n: 0.0300  
 Channel Invert Elevation: 2143.03 ft

**Roadway Data for Crossing: FR-3 Sta 104+06**

Roadway Profile Shape: Constant Roadway Elevation  
 Crest Length: 100.00 ft  
 Crest Elevation: 2147.50 ft  
 Roadway Surface: Paved  
 Roadway Top Width: 40.00 ft

### Summary of Culvert Flows at Crossing: Sta 487+44 Lt East Trico

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 487+44 Lt East Trico Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2054.96	0.00	0.00	0.00	1
2056.00	150.60	150.60	0.00	1
2056.61	301.20	301.20	0.00	1
2057.11	451.80	451.80	0.00	1
2057.53	602.40	602.40	0.00	1
2057.93	753.00	753.00	0.00	1
2058.32	903.60	903.60	0.00	1
2058.70	1054.20	1054.20	0.00	1
2059.08	1204.80	1204.80	0.00	1
2059.46	1355.40	1355.40	0.00	1
2059.86	1506.00	1506.00	0.00	1
2062.00	2204.33	2204.33	0.00	Overtopping

**Table 2 - Culvert Summary Table: Sta 487+44 Lt East Trico**

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2054.96	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
150.60	150.60	2056.00	1.041	0.0*	1-S2n	0.452	0.657	0.456	0.366	6.606	6.690
301.20	301.20	2056.61	1.649	0.024	1-S2n	0.701	1.043	0.759	0.554	7.940	8.742
451.80	451.80	2057.11	2.145	0.175	1-S2n	0.915	1.367	1.010	0.705	8.950	10.204
602.40	602.40	2057.53	2.572	0.306	1-S2n	1.105	1.655	1.241	0.836	9.705	11.374
753.00	753.00	2057.93	2.973	0.424	1-S2n	1.280	1.921	1.461	0.954	10.308	12.364
903.60	903.60	2058.32	3.359	0.533	1-S2n	1.442	2.169	1.667	1.063	10.839	13.231
1054.20	1054.20	2058.70	3.739	0.634	1-S2n	1.603	2.404	1.867	1.164	11.293	14.004
1204.80	1204.80	2059.08	4.118	0.730	5-S2n	1.749	2.628	2.058	1.260	11.709	14.706
1355.40	1355.40	2059.46	4.504	0.820	5-S2n	1.894	2.843	2.243	1.350	12.088	15.351
1506.00	1506.00	2059.86	4.903	0.906	5-S2n	2.036	3.049	2.423	1.436	12.429	15.949

\* theoretical depth is impractical. Depth reported is corrected.

\*\*\*\*\*  
 Inlet Elevation (invert): 2054.96 ft, Outlet Elevation (invert): 2054.44 ft  
 Culvert Length: 60.00 ft, Culvert Slope: 0.0087  
 \*\*\*\*\*

### Site Data - Sta 487+44 Lt East Trico

Site Data Option: Culvert Invert Data  
 Inlet Station: 0.00 ft  
 Inlet Elevation: 2054.96 ft  
 Outlet Station: 60.00 ft  
 Outlet Elevation: 2054.44 ft  
 Number of Barrels: 5

### Culvert Data Summary - Sta 487+44 Lt East Trico

Barrel Shape: Concrete Box



Barrel Span: 10.00 ft  
 Barrel Rise: 4.00 ft  
 Barrel Material: Concrete  
 Embedment: 0.00 in  
 Barrel Manning's n: 0.0120  
 Inlet Type: Conventional  
 Inlet Edge Condition: 1:1 Bevel Headwall  
 Inlet Depression: NONE

**Table 3 - Downstream Channel Rating Curve (Crossing: Sta 487+44 Lt East Trico )**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	2054.43	0.00	0.00	0.00	0.00
150.60	2054.80	0.37	6.69	1.14	1.97
301.20	2054.98	0.55	8.74	1.73	2.11
451.80	2055.13	0.70	10.20	2.20	2.19
602.40	2055.27	0.84	11.37	2.61	2.25
753.00	2055.38	0.95	12.36	2.98	2.30
903.60	2055.49	1.06	13.23	3.32	2.34
1054.20	2055.59	1.16	14.00	3.63	2.37
1204.80	2055.69	1.26	14.71	3.93	2.40
1355.40	2055.78	1.35	15.35	4.21	2.42
1506.00	2055.87	1.44	15.95	4.48	2.45

**Tailwater Channel Data - Sta 487+44 Lt East Trico**

Tailwater Channel Option: Trapezoidal Channel  
 Bottom Width: 60.00 ft  
 Side Slope (H:V): 4.00 (4:1)  
 Channel Slope: 0.0500  
 Channel Manning's n: 0.0250  
 Channel Invert Elevation: 2054.43 ft

**Roadway Data for Crossing: Sta 487+44 Lt East Trico**

Roadway Profile Shape: Constant Roadway Elevation  
 Crest Length: 20.00 ft  
 Crest Elevation: 2062.00 ft  
 Roadway Surface: Paved  
 Roadway Top Width: 35.00 ft



# CMG DRAINAGE ENGINEERING, INC.

3555 N. Mountain Ave. Tucson, Arizona 85719  
Phone (520) 882-4244 Fax (520) 888-1421

## City of Tucson: Grate Capacity in Sag project

Client: Psomas

Project #: CMG-10-027

Date Dec.12,2012

By: Jiankang

### Grate Formulas

Weir Flow (COT EQ. 10.10):  $Q_i = 3.0 * P_g * Y^{3/2} / C_f$

Orifice Flow (COT EQ. 10.11):  $Q_i = 5.35 * A * Y^{1/2} / C_f$

$Q_i$  = Rate of discharge into grate opening (cfs)

$P_g$  = Grate perimeter, disregarding bars and curbside (ft)

$A$  = Effective Length \* Effective Width

$Y$  = Depth of water at the grate, in feet

$C_f$  = Clogging factor; unitless

### Curb Inlet Formulas

Weir Flow (COT EQ. 10.14):  $Q_i = 2.3 * L * Y^{3/2} / C_f$

Orifice Flow (COT EQ. 10.16b):  $Q_i = 5.35 * A * Y^{1/2} / C_f$

$Q_i$  = Rate of discharge into grate opening (cfs)

$L$  = Length of curb inlet (ft)

$A$  = Inlet Height \* Length of Curb Inlet (ft<sup>2</sup>)

$Y$  = Depth of water at the inlet lip, in feet

$C_f$  = Clogging factor; unitless

### Grate Specification

Grate Type: COT DTL 311 (EF-1)

Length: 3.0104

Combination: Grate Only

Width: 1.427

Clogging Factor: 2.0

### Curb Specifications

Curb Type: COT DTL 305

Height of Inlet (ft): 0.5 Height of Batter (ft): 0.2

Clogging Factor: 1.25

CP	# Grates	Q in street (cfs)	Grate Orientation	Y Max (ft)	Inlet Length (ft)	Grate Capacity				Curb Inlet Capacity		Total Q Capacity (cfs)
						Area (ft <sup>2</sup> )	$P_g$ (ft)	Q (cfs)	Control	Q (cfs)	Control	
26.2	1	7.3	Longitudinal	0.7		4.30	8.87	7.80	Weir	0.00	N/A	7.80
47	7	50.0	Longitudinal	0.82		30.07	45.00	50.12	Weir	0.00	N/A	50.12

## X. STORM DRAINS

Capacity charts for grate and curb inlets are widely available. However, due to the variety of configurations on the market, it is considered more useful here to merely present the basic relationships under which they operate.

### 10.6.1 Capacity of a Grate Inlet in a Sag

At low-water depths, a grate inlet in a sag operates as a weir, with a crest length equal to the outside perimeter of the grate along which the flow enters. Weir operation continues to a depth of about 0.4 foot above the top of grate, and the discharge intercepted by the grate is:

$$Q_i = 3.0 P_g Y^{3/2} \quad (10.10)$$

Where:

- $Q_i$  = Rate of discharge into the grate opening, in cubic feet per second;
- $P_g$  = Perimeter of grate opening, in feet, disregarding bars and neglecting the side against the curb, if present; and,
- $Y$  = Depth of water at the grate, in feet.

When the depth at the grate exceeds about 1.4 feet, the grate begins to operate as an orifice, and the discharge intercepted by the grate is:

$$Q_i = 5.35 AY^{1/2} \quad (10.11)$$

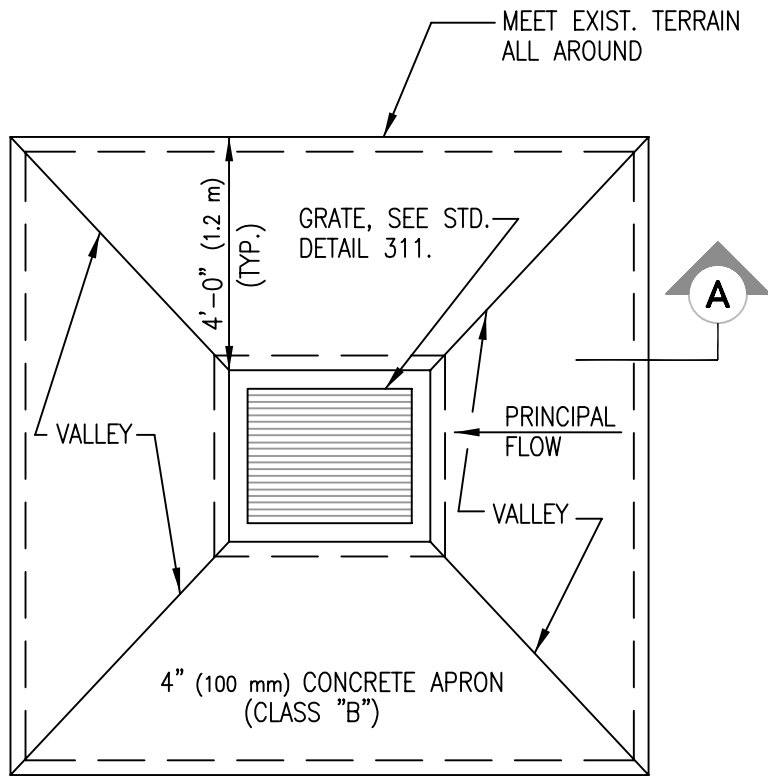
Where:

- $Q_i$  = Rate of discharge into the grate opening, in cubic feet per second;
- $A$  = Clear-opening area of the grate, in square feet; and,
- $Y$  = Depth of ponded water above the top of grate, in feet.

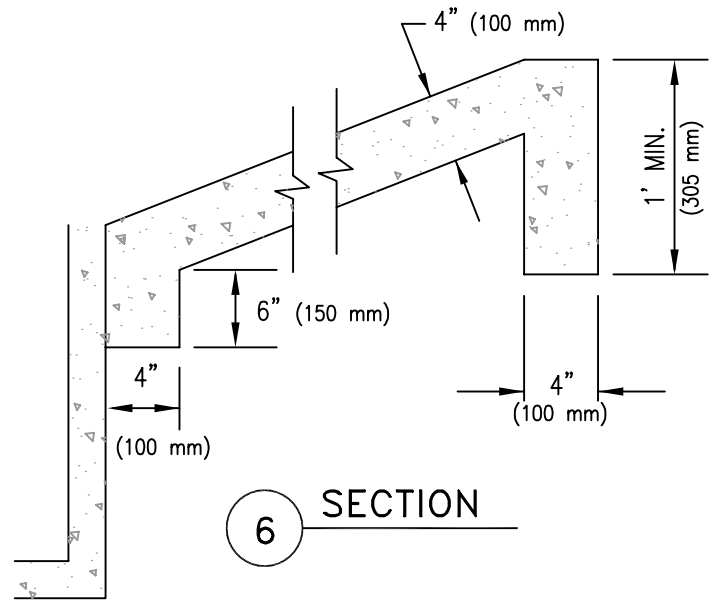
For depths over the grate between about 0.4 feet and about 1.4 feet, the operation of the grate inlet is indefinite. In this case, the depth of flow should be computed by both equations. The equation which yields the higher of the two values for depth should then be used for design purposes.

If the grate is sloped such that the side away from the curb is considerably higher than the curb side, the side inflow and end inflow should be computed separately. Inflow over the end of a grate, when it is operating as a weir, should be computed from:

$$Q_e = 2/5 \left[ \frac{CL}{Y_2 - Y_1} \right] \left[ Y_2^{5/2} - Y_1^{5/2} \right] \quad (10.12)$$



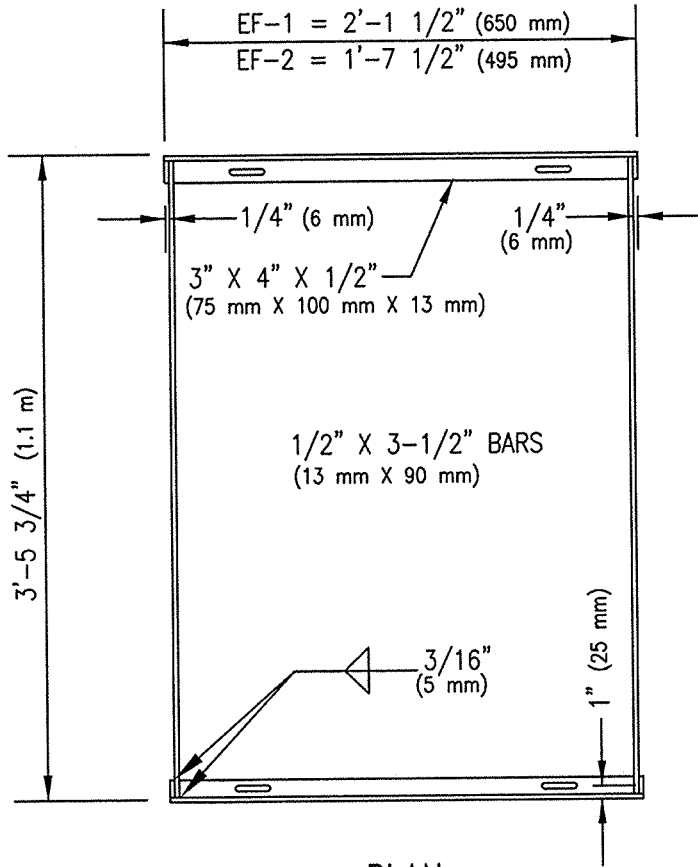
APRON SHALL BE SHAPED TO SUIT LOCAL CONDITIONS AND SHALL EXTEND A MINIMUM OF 4'-0" (1.2 m) FROM EDGE OF GRATE IN ALL DIRECTIONS. GRATE SHALL BE LEVEL AND DEPRESSED A MINIMUM OF 4" (100 mm) BELOW SURROUNDING TERRAIN. BEARING BARS SHALL PARALLEL TO THE DIRECTION OF PRINCIPAL FLOW.



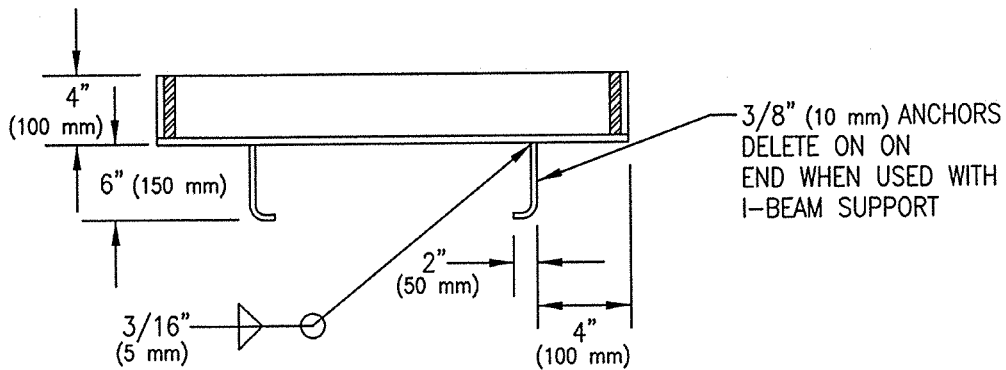
CATCH BASIN TYPE 4  
(OFF ROADWAY LOCATION ONLY)

30903B.DWG 04/03/00 12:12

ISSUED:		STANDARD DETAIL		DETAIL NO.
10/88		<b>CATCH BASIN TYPE 4</b>		<b>309</b>
REVISED:				
7/02				



PLAN



SECTION

GRATE TYPE	CLEAR BAR SPACING	NO. BARS	X	GRATE OPENING SQ. FT.
EF-1	1-5/8" (40 mm)	13	5/16" (8 mm)	4.66 (0.43 m <sup>2</sup> )
EF-2	1-5/8" (40 mm)	10	1/8" (3 mm)	3.48 (0.32 m <sup>2</sup> )

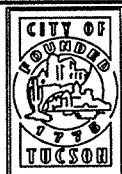
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ISSUED:

10/88

REVISED:

7/02



STANDARD DETAIL

CATCH BASIN GRATES  
LONGITUDINAL BARS

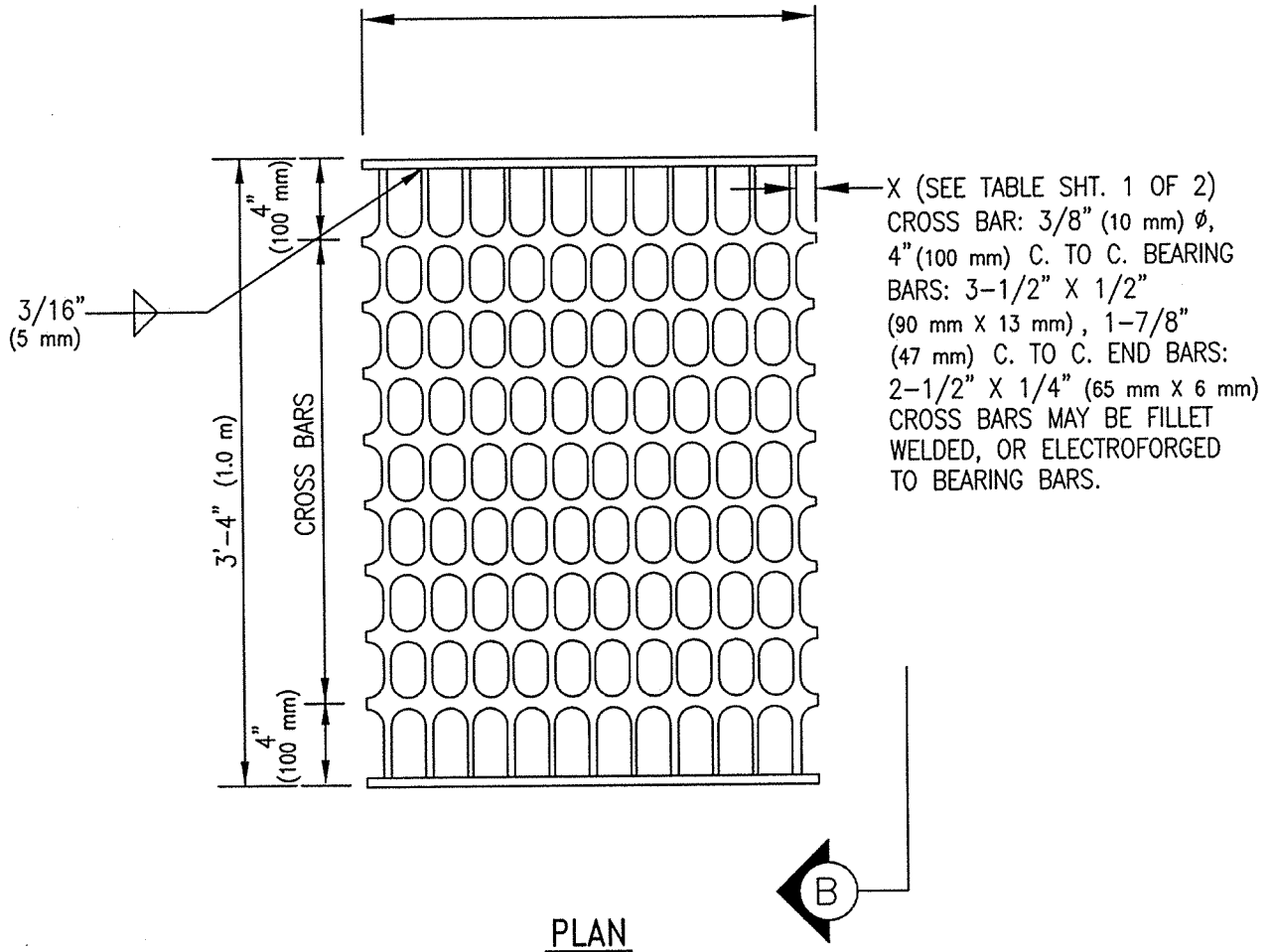


DETAIL NO.

311

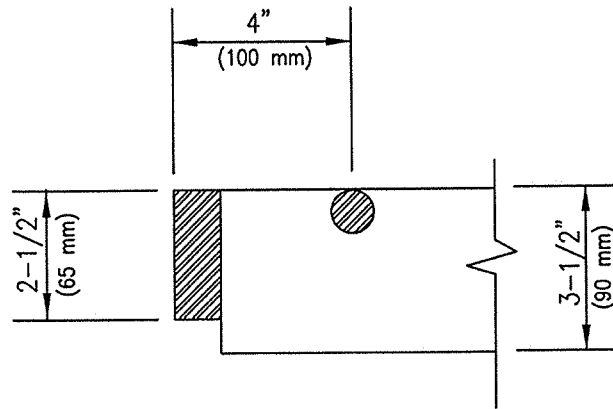
SHEET 1 OF 2

EF-1 = 1'-11 5/8" (600 mm) (13 BARS)  
 EF-2 = 1'-5 5/8" (450 mm) (10 BARS)



X (SEE TABLE SHT. 1 OF 2)  
 CROSS BAR: 3/8" (10 mm)  $\phi$ ,  
 4" (100 mm) C. TO C. BEARING  
 BARS: 3-1/2" X 1/2"  
 (90 mm X 13 mm), 1-7/8"  
 (47 mm) C. TO C. END BARS:  
 2-1/2" X 1/4" (65 mm X 6 mm)  
 CROSS BARS MAY BE FILLET  
 WELDED, OR ELECTROFORGED  
 TO BEARING BARS.

PLAN



SECTION

NOTE:  
 NOT TO BE USED AS  
 TRANSVERSE GRATE  
 ACCROSS ROADWAY.

31102.DWG 08/03/00 13:31

ISSUED:	
10/88	
REVISED:	
7/02	



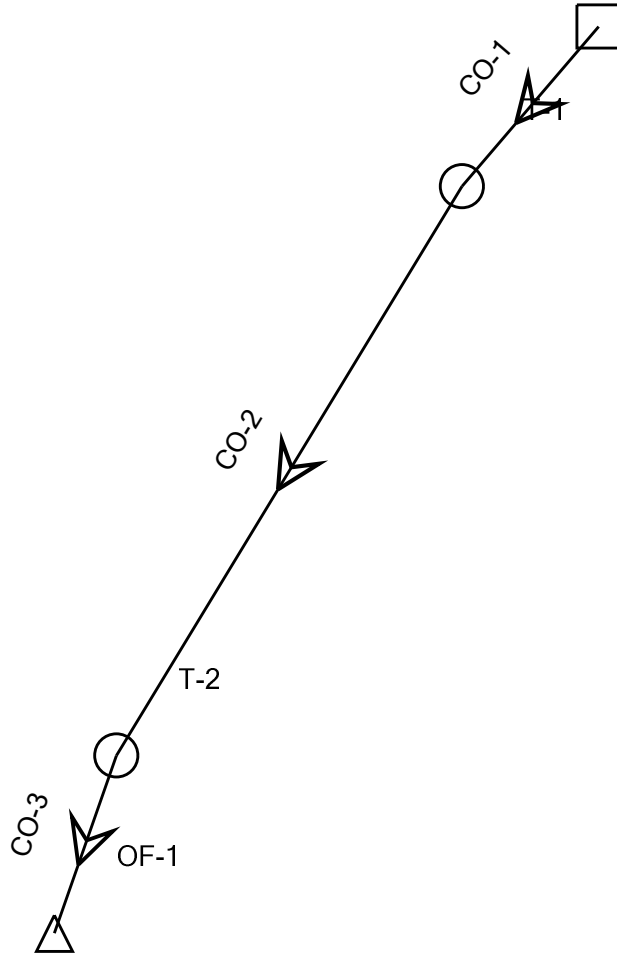
STANDARD DETAIL  
**CATCH BASIN GRATES  
 LONGITUDINAL BARS**



DETAIL NO.	
311	
SHEET 2 OF 2	

# Print Preview

CP-47



Label	Node Upstream Downstream	Upstream	Upstream	Upstream	Ground- Upstream Downstream (ft)	HGL Upstream Downstream (ft)	Section Discharge Capacity (ft <sup>3</sup> /s)	Length (ft)	Velocity (Average) (ft/s)
CO-1	CP-47	(N/A)	(N/A)	0	2,549.00	2,545.73	50	45	6.55
	T-1				2,549.00	2,545.55	144.77		
CO-2	T-1	(N/A)	(N/A)	0	2,549.00	2,545.50	50	203	11.31
	T-2				2,549.00	2,540.51	319.39		
CO-3	T-2	(N/A)	(N/A)	0	2,549.00	2,540.45	50	51	12.26
	OF-1				2,545.00	2,538.36	358.67		



## Scenario Summary Report

### Scenario: Base

Scenario Summary			
ID	1		
Label	Base		
Notes			
Active Topology	Base Active Topology		
Physical	Base Physical		
Headloss	Base Headloss		
Boundary Condition	Base Boundary Condition		
Rainfall Runoff	Base Rainfall Runoff		
Hydrologic	Base Hydrologic		
Design	Base Design		
System Flows	Base System Flows		
Gravity Varied Flow			
Numerical Engine	Base Calculation Options		
Calculation Options			
Hydraulic Summary			
Flow Profile Method	Backwater Analysis	Average Velocity Method	Actual Uniform Flow Velocity
Number of Flow Profile Steps	5	Minimum Structure Headloss	0.00 ft
Hydraulic Grade Convergence Test	0.001 ft	Minimum Time of Concentration	5.000 min
Inlets			
Neglect Side Flow?	False	Active Components for Combination Inlets In Sag	Grate and Curb
Neglect Gutter Cross Slope For Side Flow?	True	Active Components for Combination Inlets on Grade	Grate and Curb
HEC-22			
Elevations Considered Equal Within	0.50 ft	Depressed Unsubmerged	1.000
Consider Non-Piped Plunging Flow	False	Half Bench Submerged	0.950
Flat Submerged	1.000	Half Bench Unsubmerged	0.150
Flat Unsubmerged	1.000	Full Bench Submerged	0.750
Depressed Submerged	1.000	Full Bench Unsubmerged	0.070
AASHTO			
Expansion, Ke	0.350	Shaping Adjustment, Cs	0.500
Contraction, Kc	0.250	Non-Piped Flow Adjustment, Cn	1.300

# Scenario Summary Report

## Scenario: Base

### Bend Angle vs. Bend Loss Curve

Bend Angle (degrees)	Bend Loss Coefficient, Kb
0.00	0.000
15.00	0.190
30.00	0.350
45.00	0.470
60.00	0.560
75.00	0.640
90.00	0.700

---

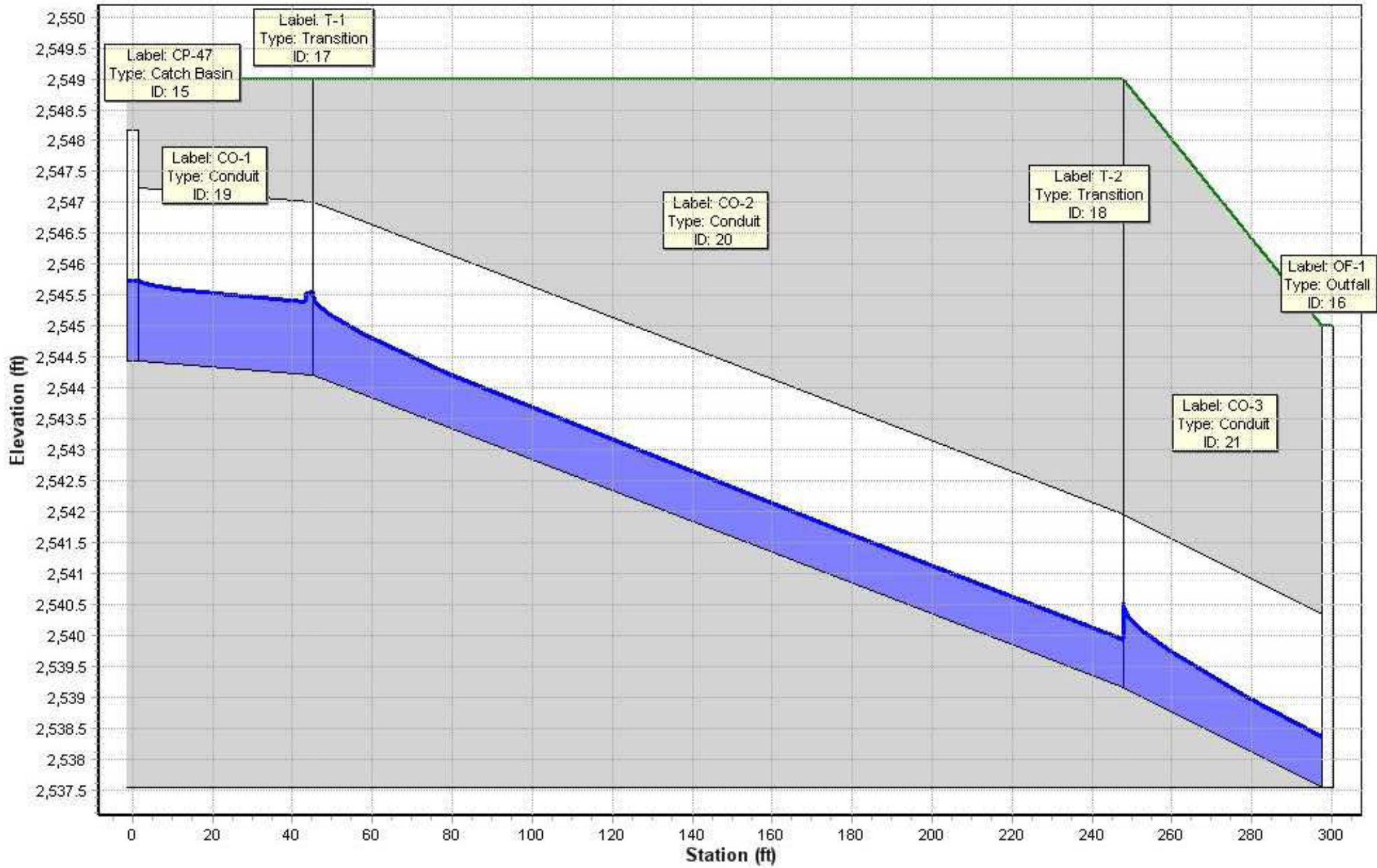
#### Generic Structure Loss

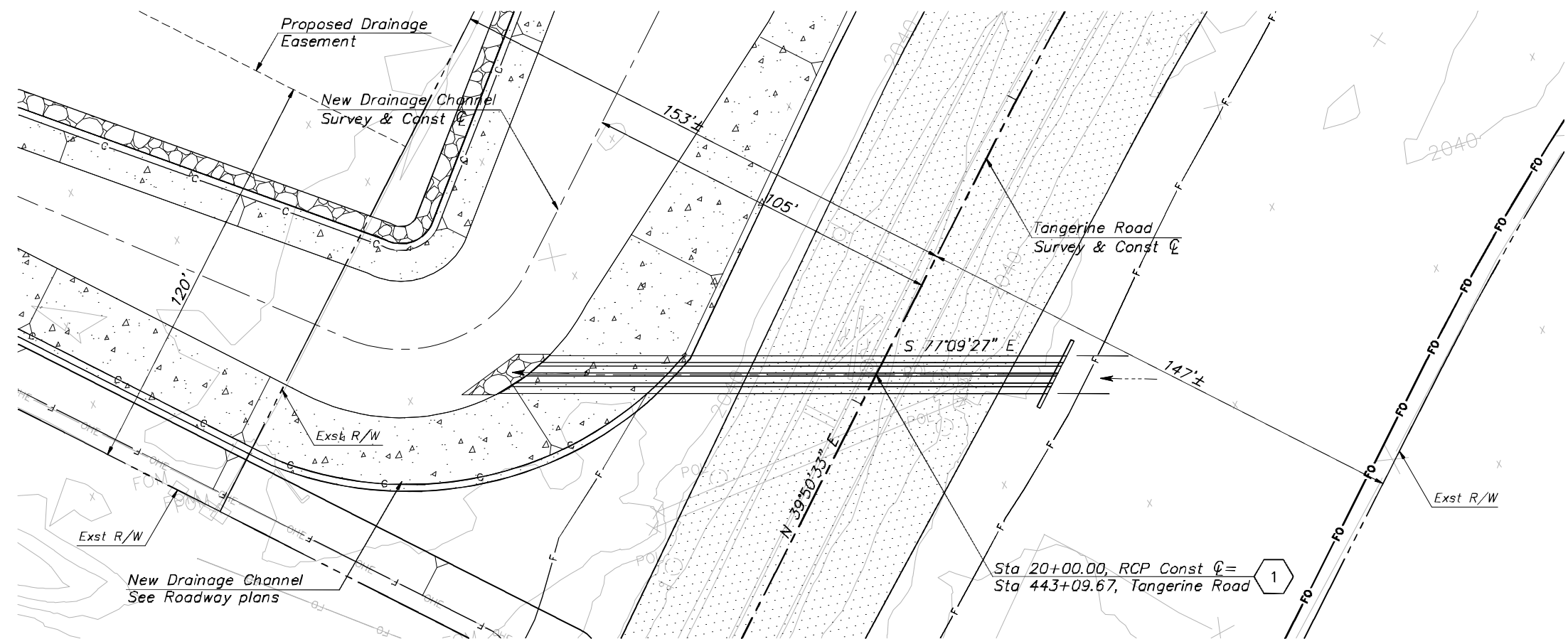
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Governing Upstream Pipe Selection Method      Pipe with Maximum QV

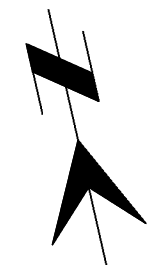
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### Profile - 1 - Base

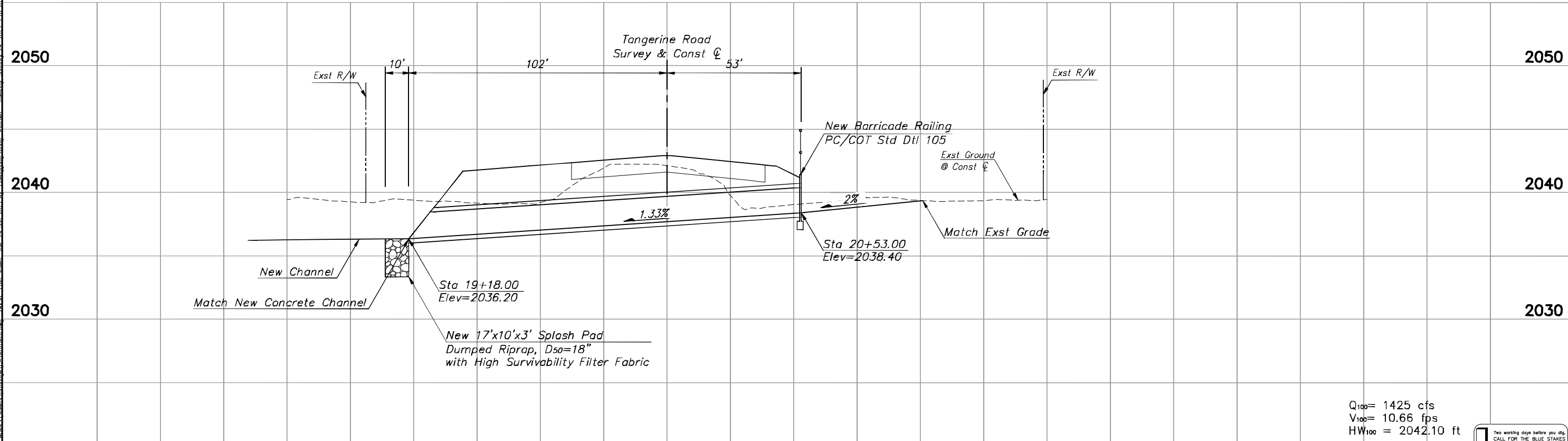




- NOTES:
1. Inlet headwall dimensions shall be based on ADOT Std Dwg B-11.11.
  2. Pipes shall be installed per ADOT Std Dwg C-13.10, C-13.15, and C-13.76.
  3. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 4:1 slopes.
  4. Barricade railing shall be placed on headwalls as shown on the profile.



18+00                      19+00                      20+00                      21+00                      22+00



Sta 443+09.67  
New 4-24"x155' RCP  
Skew 27' Rt

Q<sub>100</sub> = 1425 cfs  
V<sub>100</sub> = 10.66 fps  
HW<sub>100</sub> = 2042.10 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

DESIGNED:	CZ	DATE:	12/12
DRAWN:	CZ	DATE:	12/12
CHECKED:	AA	DATE:	12/12
PROJ. ENG.:	AA	DATE:	12/12

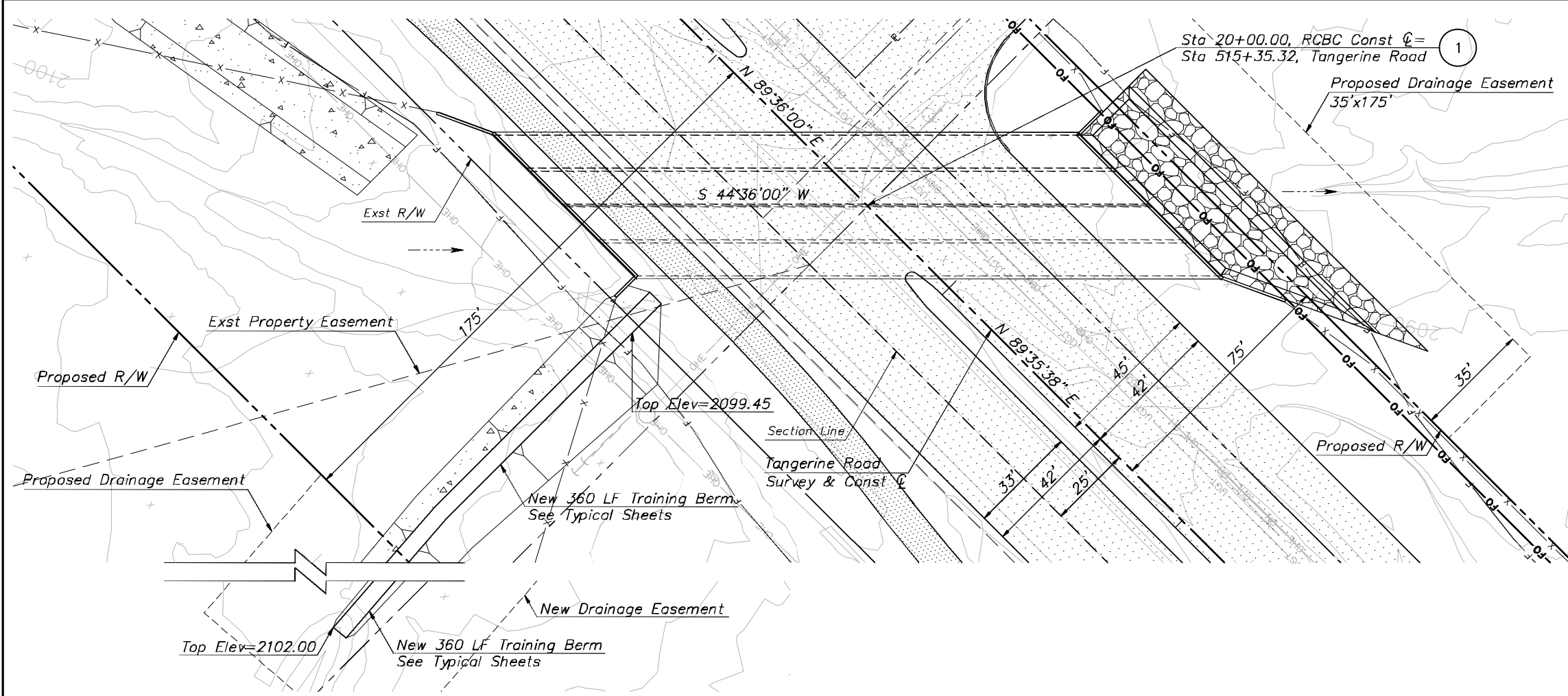
NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

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CONSTRUCTION

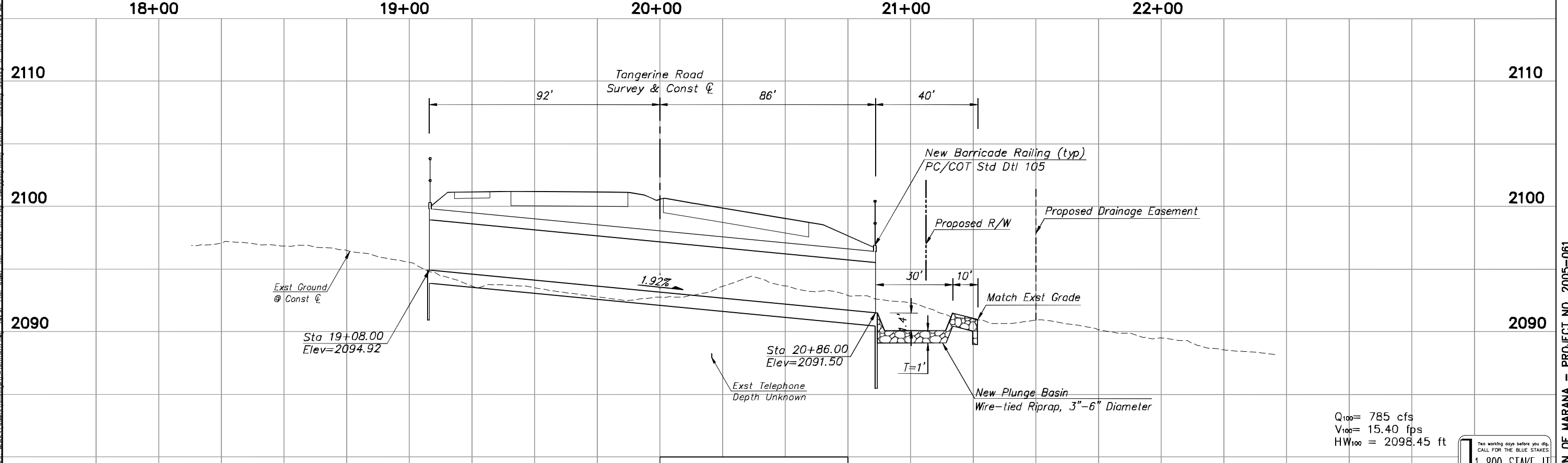
**P S O M A S**  
333 E. Weimers Road, Suite 450  
Tucson, AZ 85705  
(520) 292-2500 (520) 292-1290 fax  
www.psom.com

TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 443+09.67  
TANGERINE ROAD

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- NOTES:
1. Inlet headwall & wingwall dimensions shall be based on 45° skew, 4:1 slopes, and ADOT Std Dwg B-04.70.
  2. Outlet headwall & wingwall dimensions shall be based on 45° skew, 6:1 slopes, and ADOT Std Dwg B-04.50.
  3. Boxes shall be constructed per ADOT Std Dwg B-02.40.
  4. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.



Sta 515+35.32  
New 4-10'x4'x178' RCBC  
Skew 45° Rt

Q<sub>100</sub> = 785 cfs  
V<sub>100</sub> = 15.40 fps  
HW<sub>100</sub> = 2098.45 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

DESIGNED:	CZ	DATE:	12/12
DRAWN:	CZ	CHECKED:	AA
PROJECT ENG.:	AA	DATE:	12/12

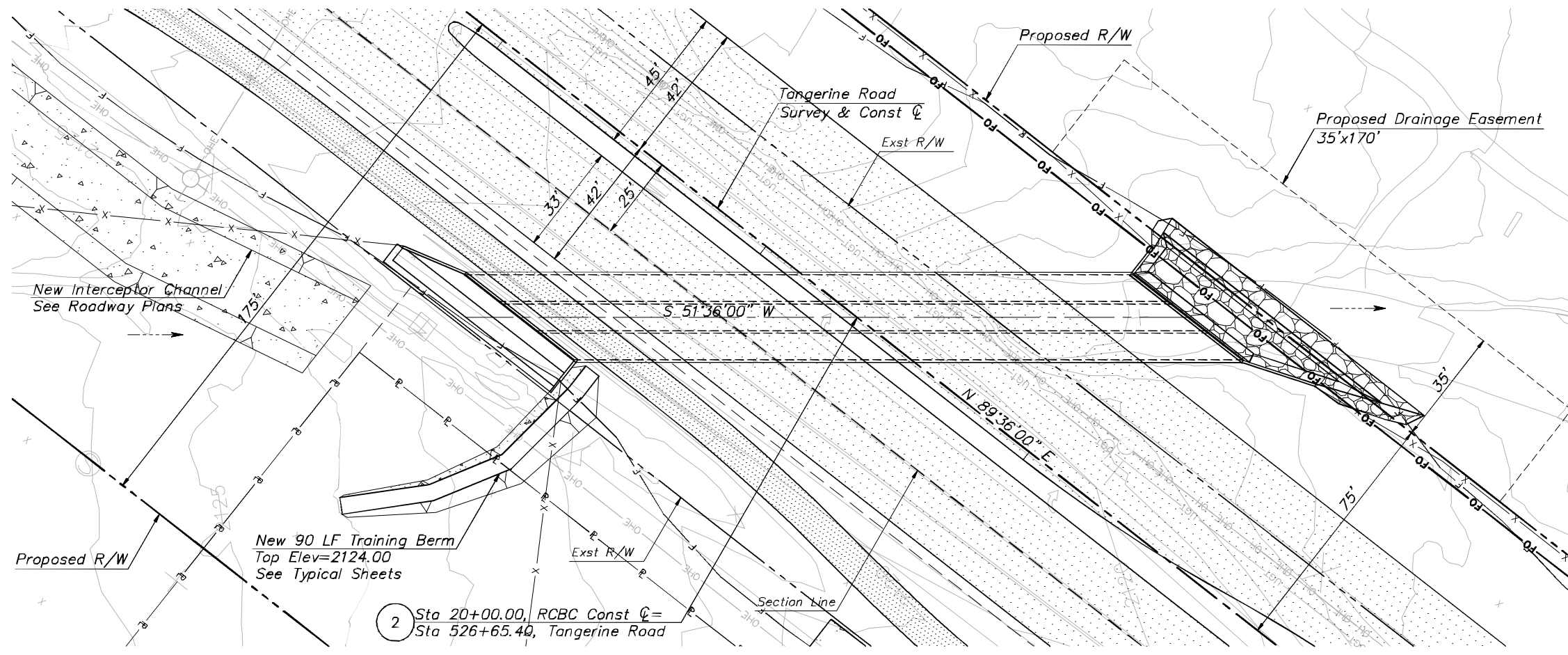
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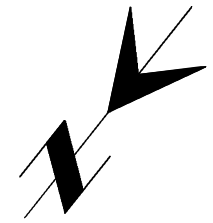
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Lucas, AL 35705  
(920) 292-2300 (920) 292-1290 fax  
www.psom.com

TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 515+35.32  
TANGERINE ROAD

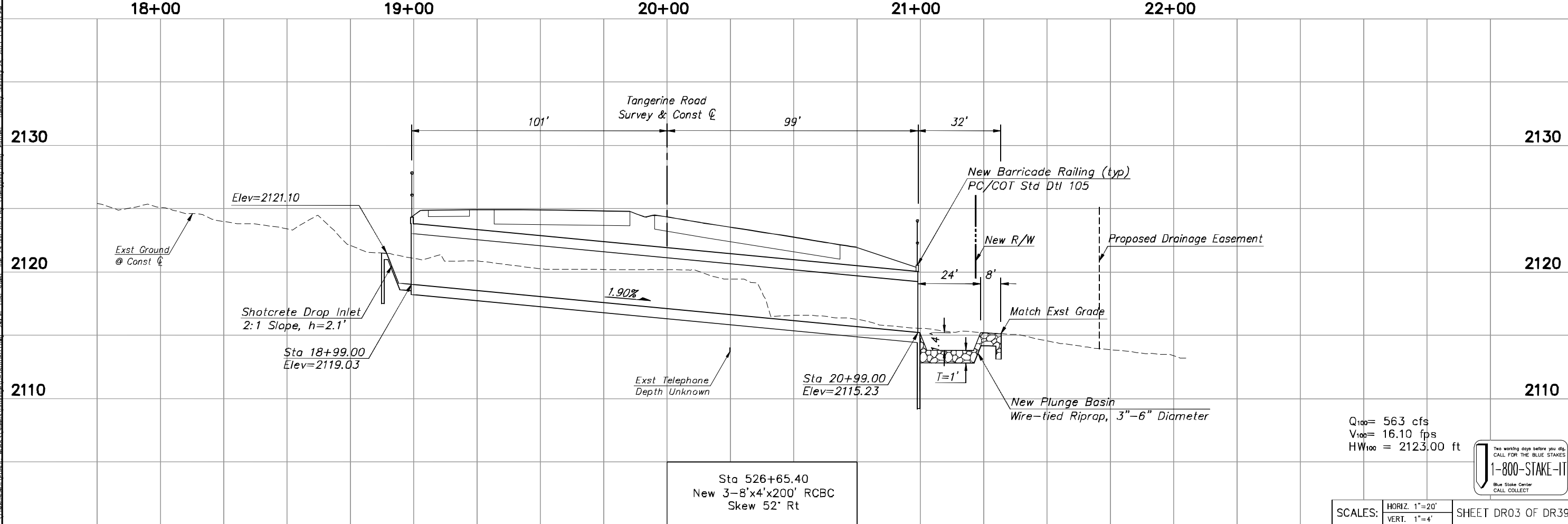
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- NOTES:
1. Inlet headwall & wingwall dimensions shall be based on 45° skew, 4:1 slopes, and ADOT Std Dwg B-04.70.
  2. Outlet headwall & wingwall dimensions shall be based on 45° skew, 6:1 slopes, and ADOT Std Dwg B-04.50.
  3. Boxes shall be constructed per ADOT Std Dwg B-02.30.
  4. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.



2 Sta 20+00.00, RCBC Const CL =  
Sta 526+65.40, Tangerine Road



Q<sub>100</sub> = 563 cfs  
V<sub>100</sub> = 16.10 fps  
HW<sub>100</sub> = 2123.00 ft

Two working days before you dig,  
CALL FOR THE BLUE STAKES!  
1-800-STAKE-IT  
Blue Stake Center  
CALL COLLECT

SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

Sta 526+65.40  
New 3'-8"x4'x200' RCBC  
Skew 52° Rt

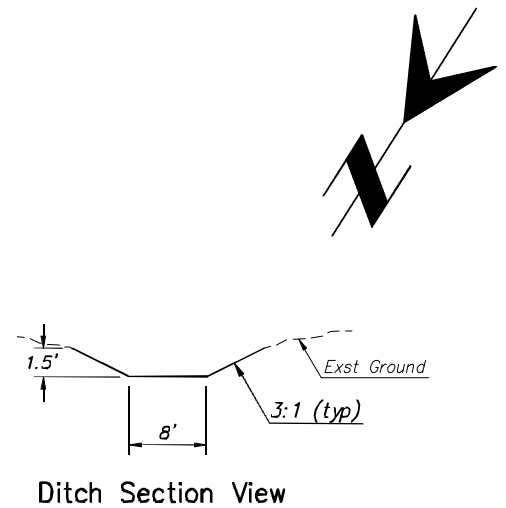
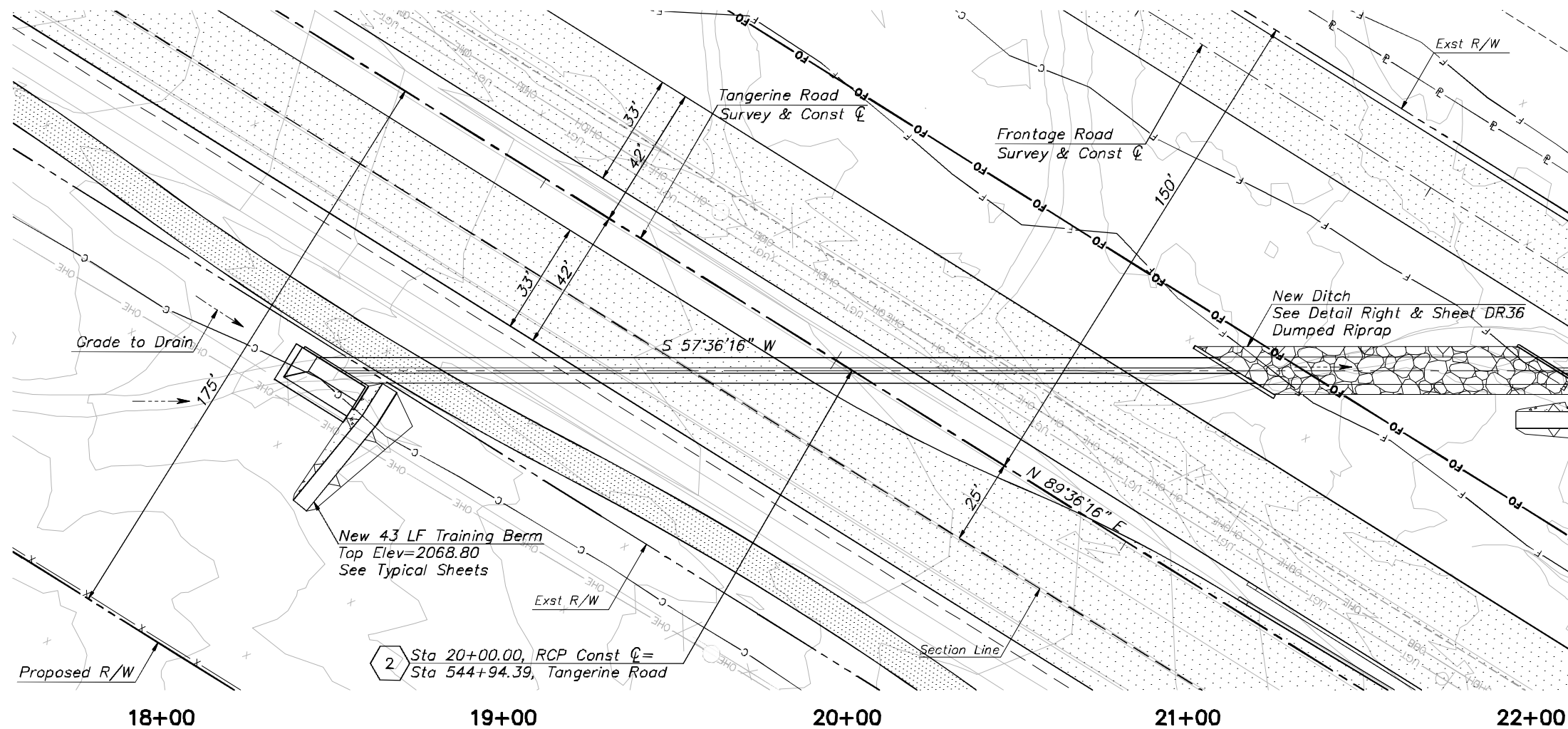
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PROJECT ENG.:	AA		

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

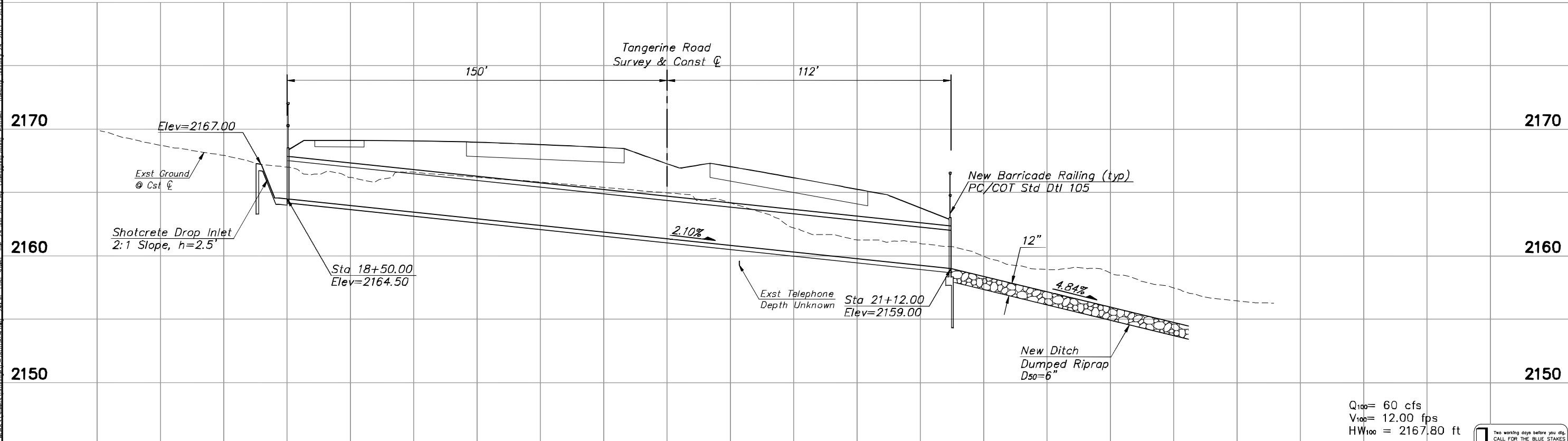
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NOT FOR  
CONSTRUCTION

**P S O M A S**  
333 E. Weirmere Road, Suite 450  
Tucson, AZ 85705  
(520) 292-2500 (520) 292-1290 fax  
www.psom.com

TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
TANGERINE ROAD  
STA 526+65.40  
TANGERINE ROAD



- NOTES:**
- Inlet & Outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11. Inlet shall be an "L" headwall.
  - Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
  - Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 3:1 slopes.
  - Barricade railing shall be placed on headwalls as shown on the profile.



Sta 544+94.39  
 New 2-36"x262' RCP  
 Skew 58' Rt

$Q_{100} = 60$  cfs  
 $V_{100} = 12.00$  fps  
 $HW_{100} = 2167.80$  ft



SCALES: HORIZ. 1"=20'  
 VERT. 1"=4'  
 SHEET DR04 OF DR39

DESIGNED:	CZ	DATE:	12/12
DRAWN:	CZ	DATE:	12/12
CHECKED:	AA	DATE:	12/12
PROJ. ENG.:	AA	DATE:	12/12

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

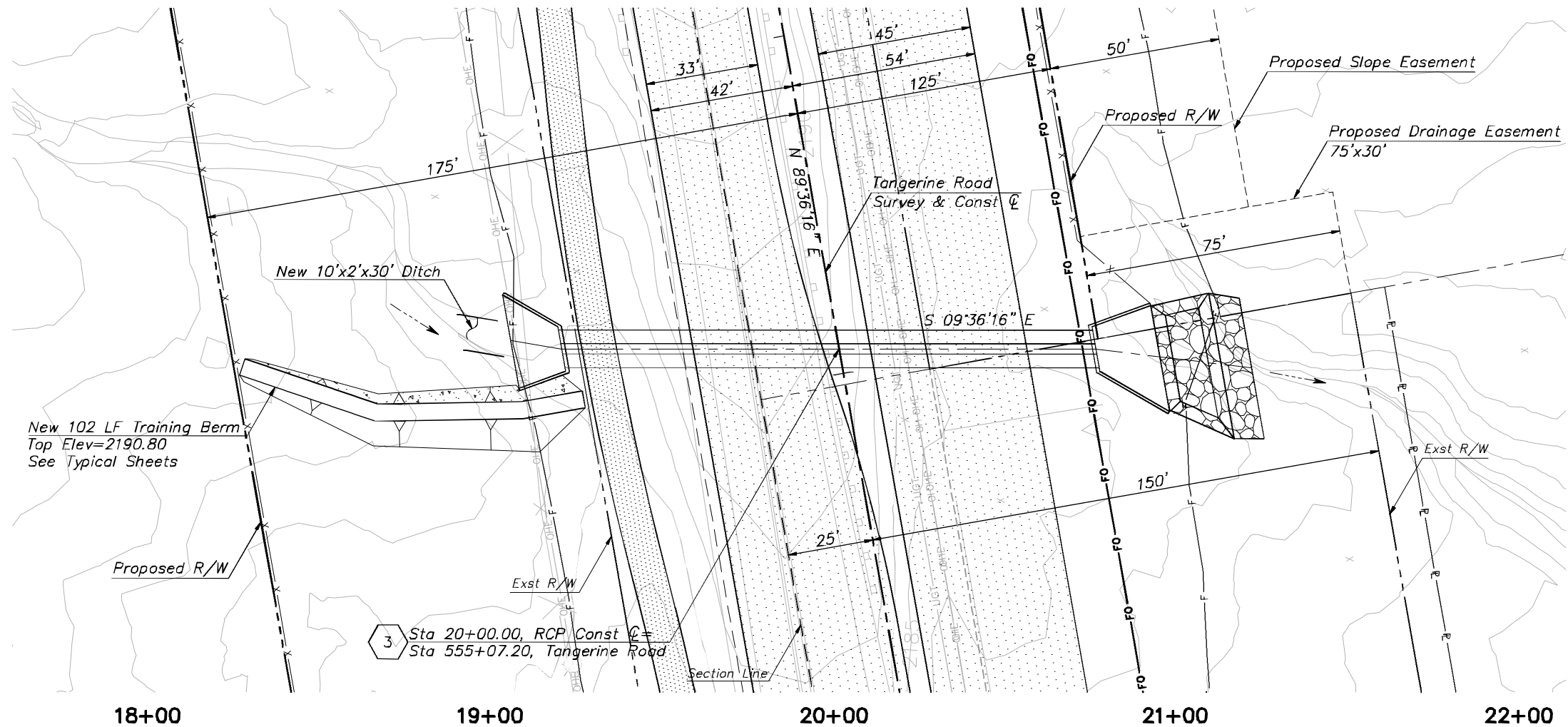
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 PRELIMINARY  
 NOT FOR  
 CONSTRUCTION

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 333 E. Weimers Road, Suite 450  
 Tucson, AZ 85705  
 (520) 292-2500 (520) 292-1290 fax  
 www.psomas.com

TOWN OF MARANA - PROJECT NO. 2005-061

DRAINAGE PLAN AND PROFILE  
 FOR  
**TANGERINE ROAD**  
 STA 544+94.39  
 TANGERINE ROAD

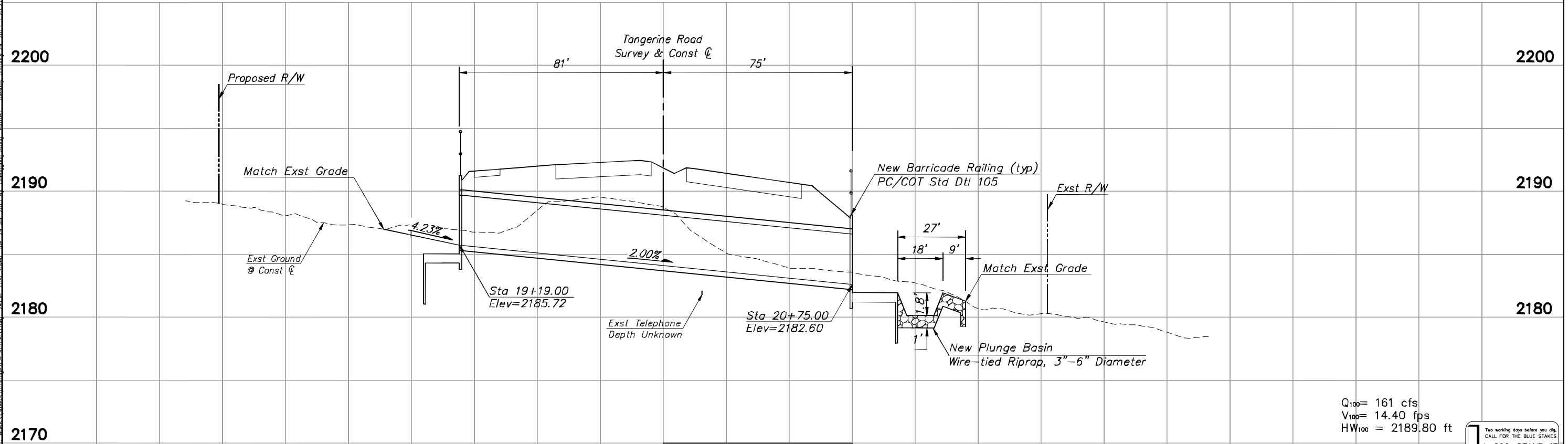




**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13 and 4:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13 and 6:1 slopes.
3. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
4. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 4:1 slopes.
5. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.

18+00                      19+00                      20+00                      21+00                      22+00



Sta 555+07.20  
New 2-48"x156' RCP  
Skew 10' Rt

Q<sub>100</sub> = 161 cfs  
V<sub>100</sub> = 14.40 fps  
HW<sub>100</sub> = 2189.80 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

DESIGNED:	CZ	DATE:	12/12
DRAWN:	CZ	DATE:	12/12
CHECKED:	AA	DATE:	12/12
PROJ. ENG.:	AA	DATE:	12/12

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

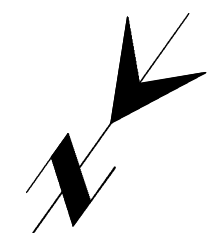
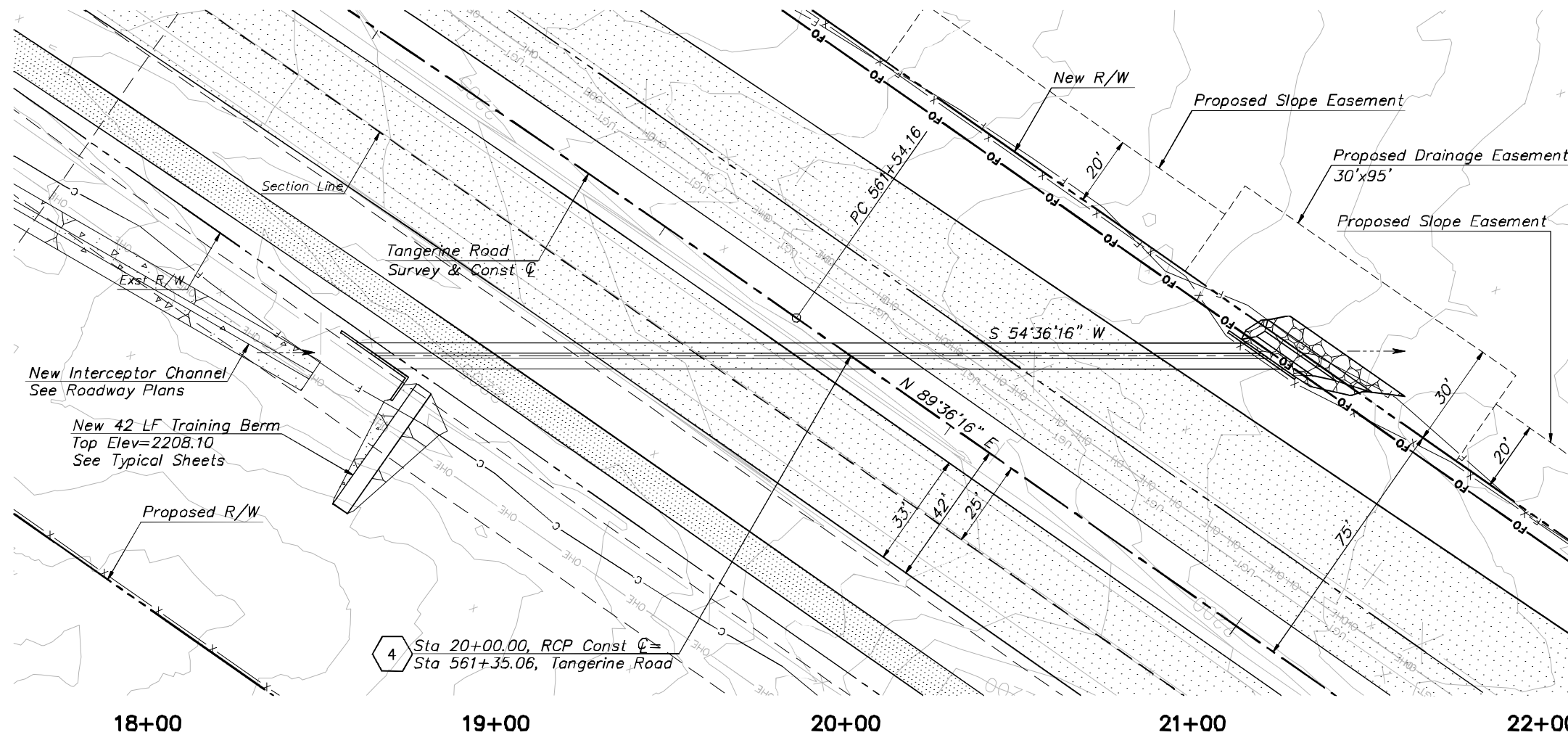
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TOWN OF MARANA - PROJECT NO. 2005-061

DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 555+07.20  
TANGERINE ROAD



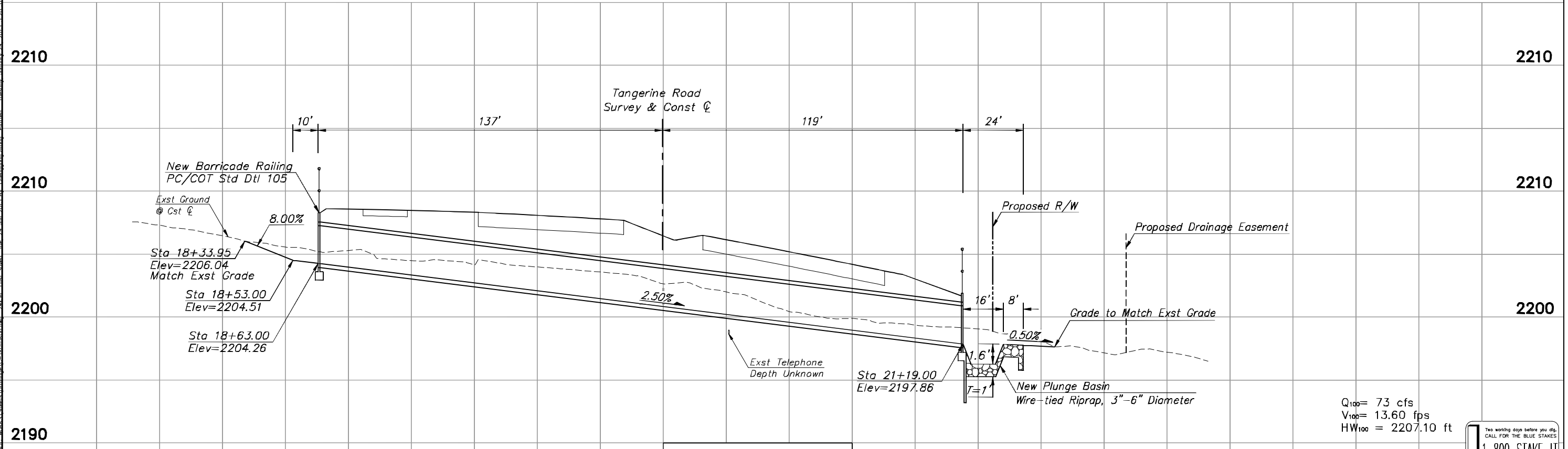


**NOTES:**

1. Inlet & outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11. Inlet shall be an "L" headwall.
2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
3. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.

4 Sta 20+00.00, RCP Const  $\phi$  =  
Sta 561+35.06, Tangerine Road

18+00                      19+00                      20+00                      21+00                      22+00



Q<sub>100</sub> = 73 cfs  
V<sub>100</sub> = 13.60 fps  
HW<sub>100</sub> = 2207.10 ft

Sta 561+35.06  
New 2-36"x256' RCP  
Skew 55° Rt

Two working days before you dig,  
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**1-800-STAKE-IT**  
Blue Stake Center  
CALL COLLECT

SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

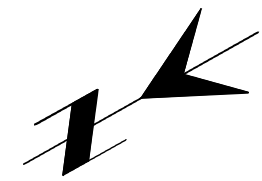
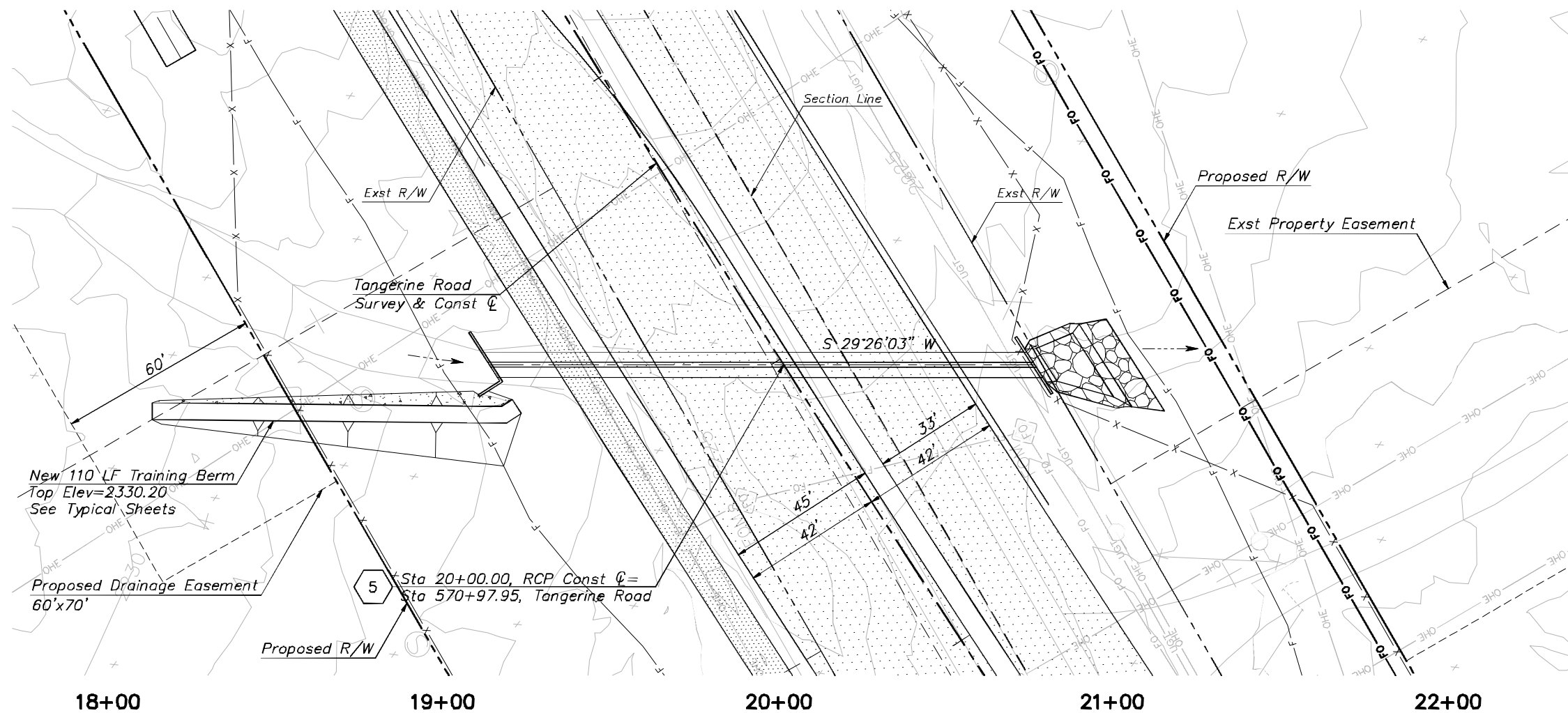
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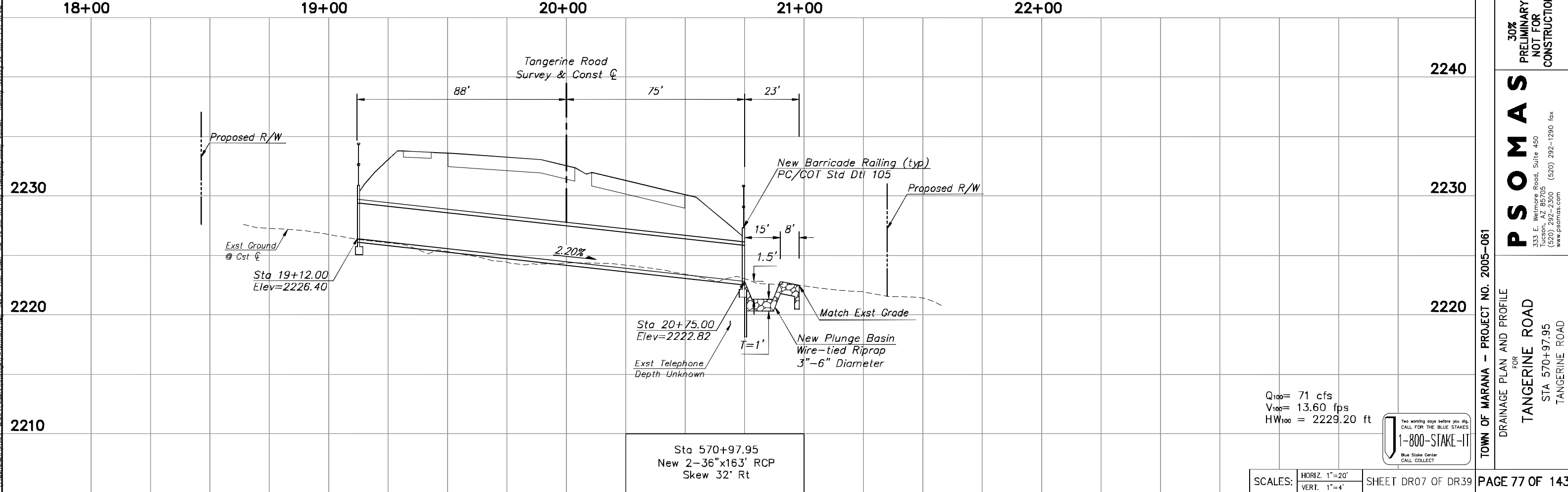
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TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 561+35.06  
TANGERINE ROAD



**NOTES:**

1. Inlet & outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11. Inlet shall be an "L" headwall.
2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
3. Barricade railing shall be placed on headwalls as shown on the profile.



$Q_{100} = 71$  cfs  
 $V_{100} = 13.60$  fps  
 $HW_{100} = 2229.20$  ft



Sta 570+97.95  
 New 2-36"x163' RCP  
 Skew 32' Rt

DESIGNED:	CZ	DATE:	12/12
DRAWN:	CZ	CHECKED:	AA
PROJ. ENG.:	AA	DATE:	12/12

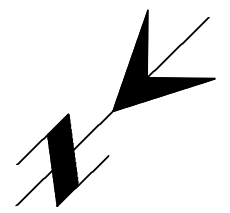
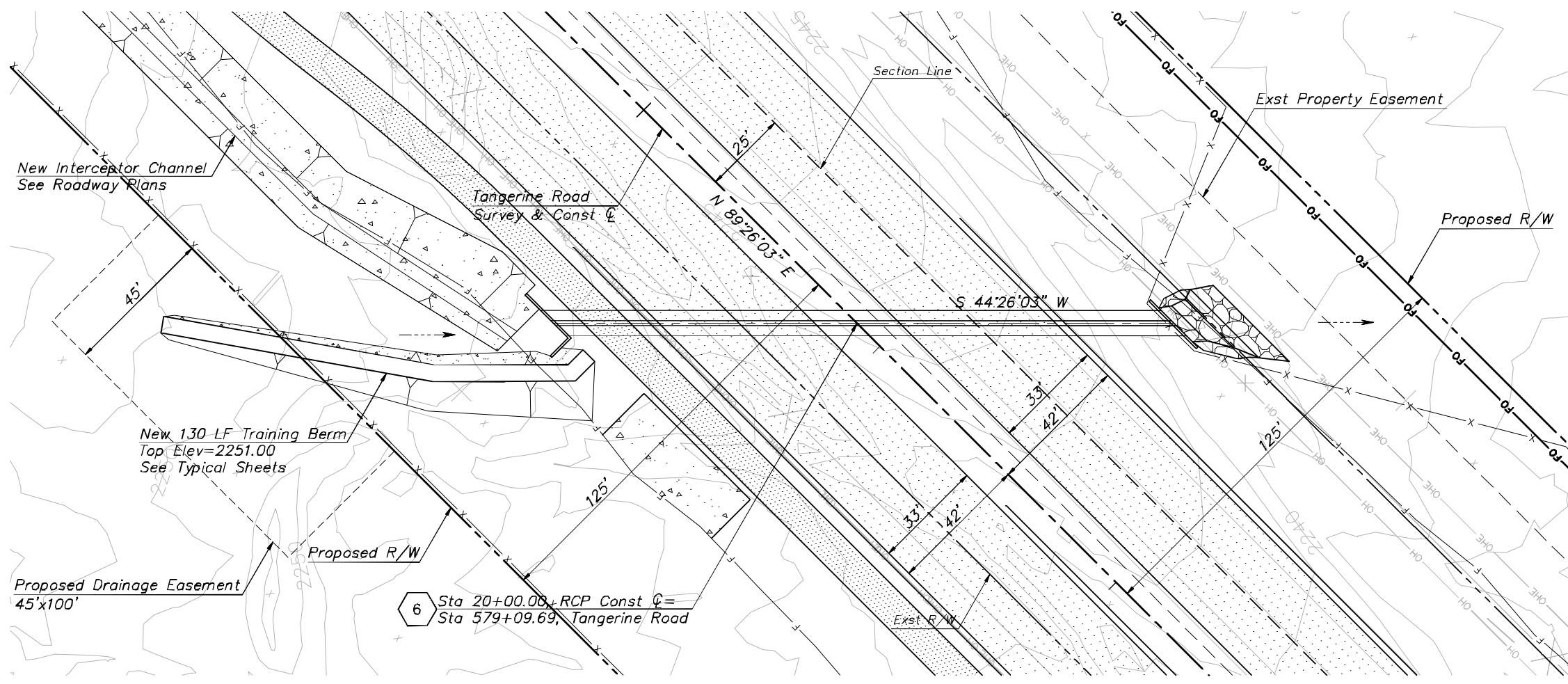
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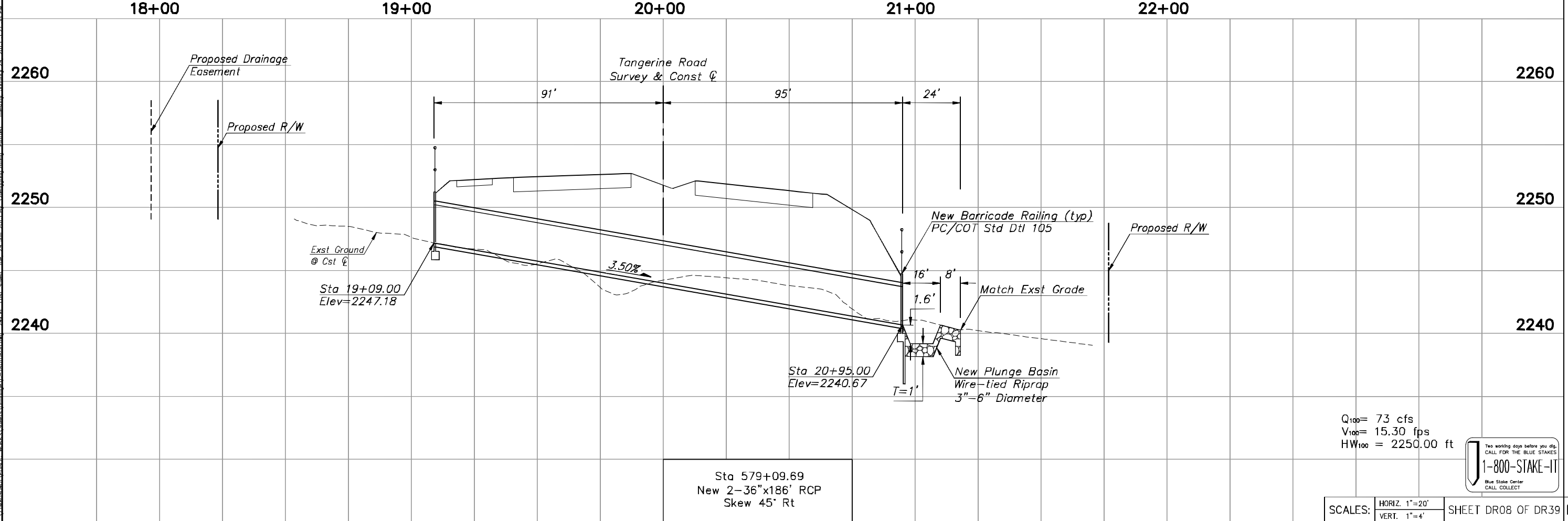
TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE FOR  
**TANGERINE ROAD**  
 STA 570+97.95  
 TANGERINE ROAD

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**NOTES:**

1. Inlet & outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11. Inlet shall be an "L" headwall.
2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
3. Barricade railing shall be placed on headwalls as shown on the profile.



Sta 579+09.69  
New 2-36"x186' RCP  
Skew 45' Rt

Q<sub>100</sub> = 73 cfs  
V<sub>100</sub> = 15.30 fps  
HW<sub>100</sub> = 2250.00 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

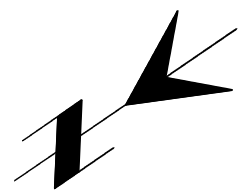
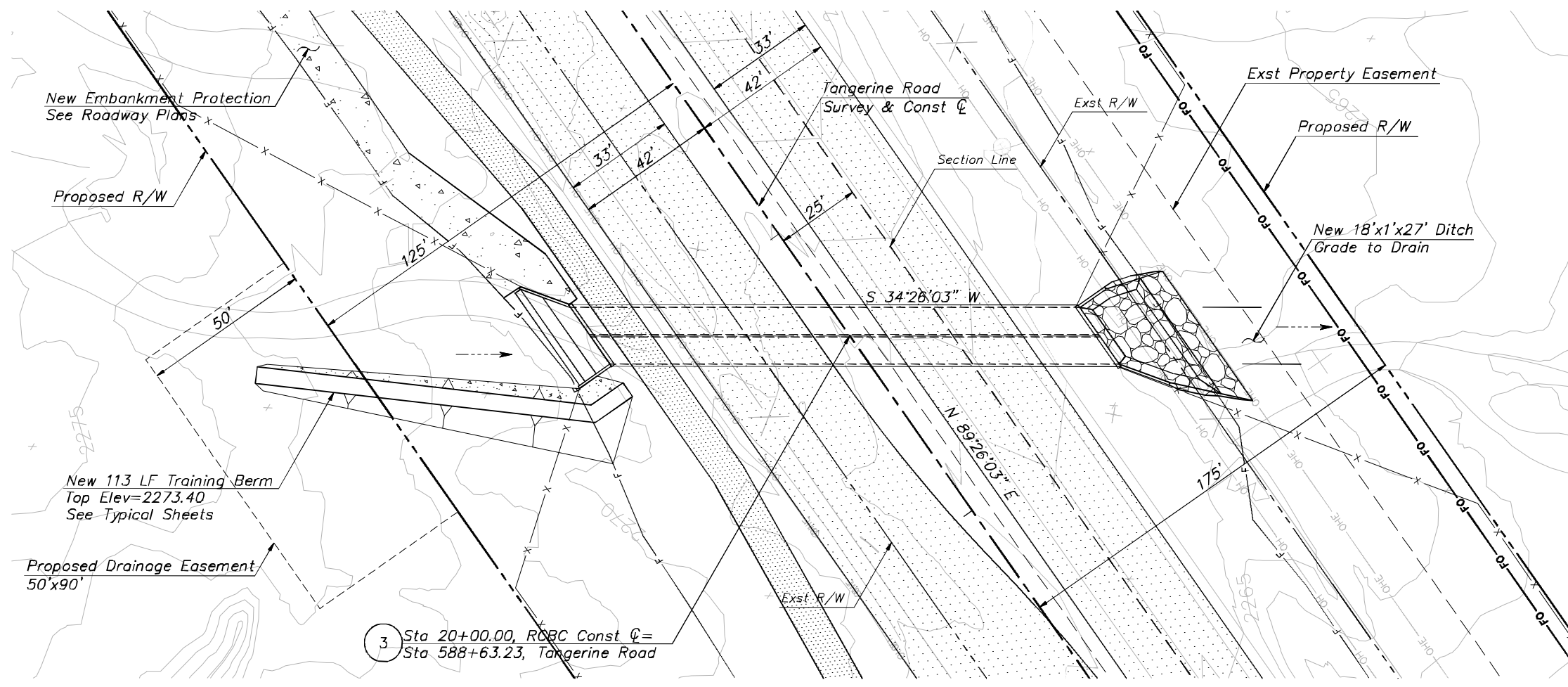
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PROJECT ENG.:	AA	DATE:	12/12

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DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 579+09.69  
TANGERINE ROAD

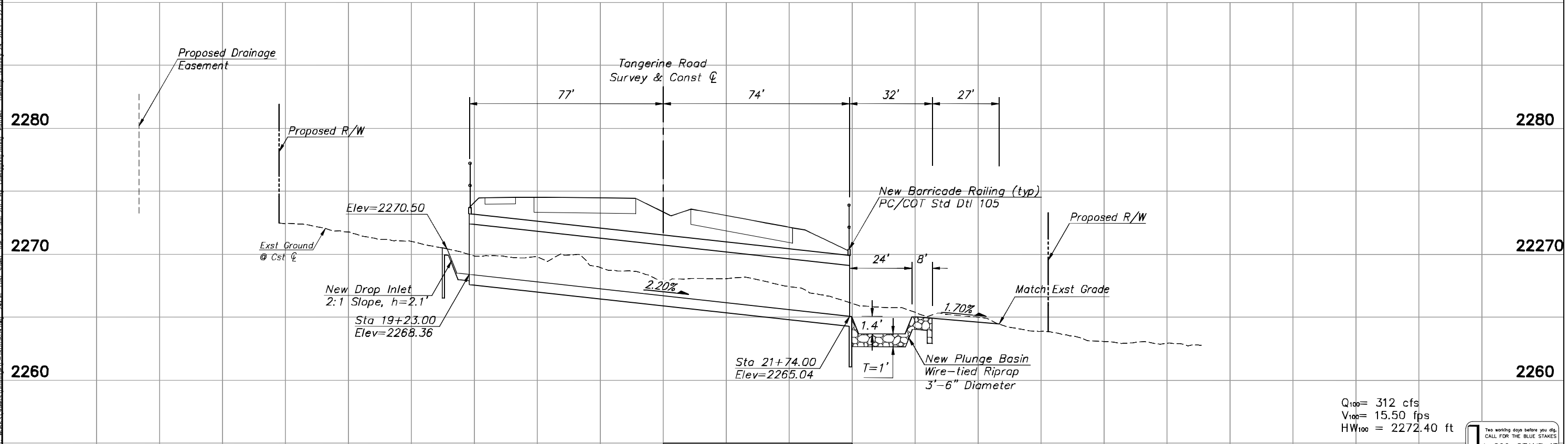


**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on 35° skew, 4:1 slopes, and ADOT Std Dwg B-04.70.
2. Outlet headwall & wingwall dimensions shall be based on 35° skew, 6:1 slopes, and ADOT Std Dwg B-04.50.
3. Boxes shall be constructed per ADOT Std Dwg B-02.30.
4. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 4:1 slopes.
5. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.

3 Sta 20+00.00, RCBC Const  $\phi$  = Sta 588+63.23, Tangerine Road

18+00                      19+00                      20+00                      21+00                      22+00



Sta 588+63.23  
New 2-8'x4'x151' RCBC  
Skew 35° Rt

Q<sub>100</sub> = 312 cfs  
V<sub>100</sub> = 15.50 fps  
HW<sub>100</sub> = 2272.40 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

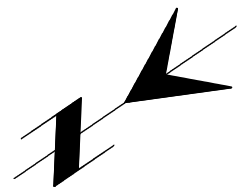
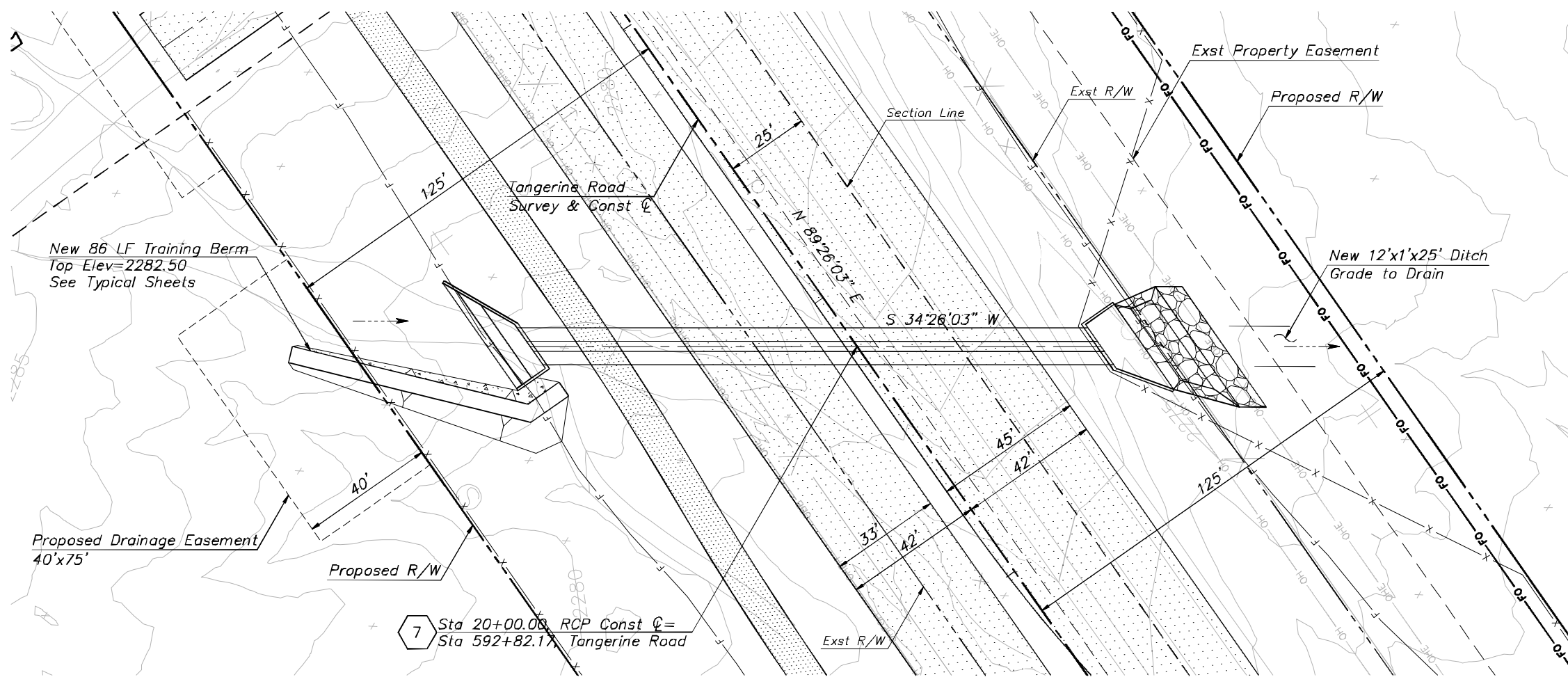
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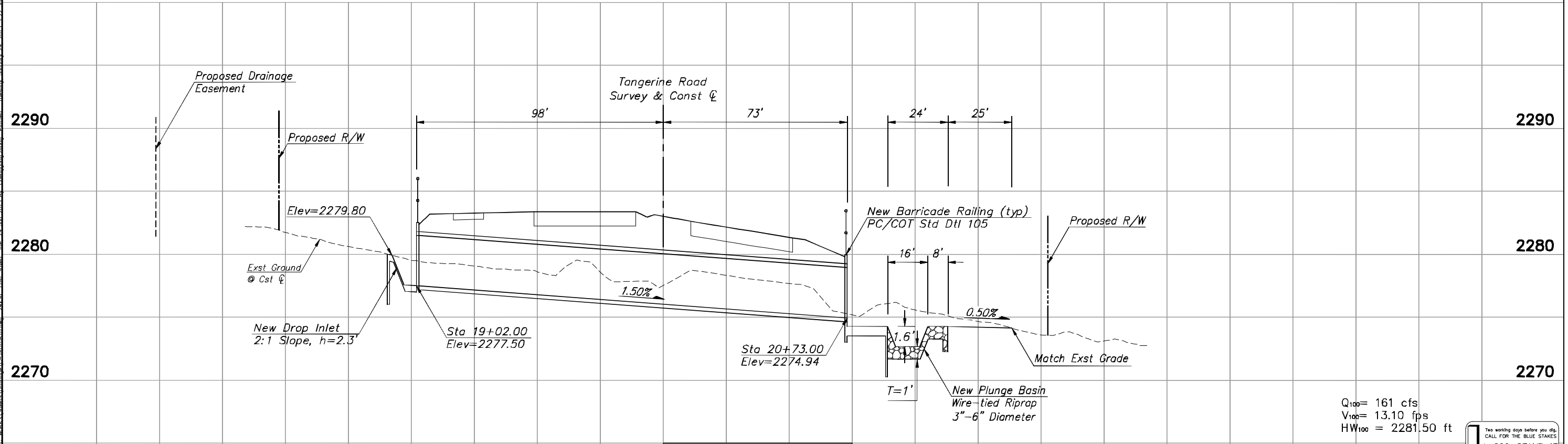
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DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 588+63.23  
TANGERINE ROAD



**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13 with 4:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13 with 6:1 slopes.
3. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
4. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 3:1 slopes.
5. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.

18+00                      19+00                      20+00                      21+00                      22+00



Q<sub>100</sub> = 161 cfs  
V<sub>100</sub> = 13.10 fps  
HW<sub>100</sub> = 2281.50 ft



Sta 592+82.17  
New 2-48"x171' RCP  
Skew 35° Rt

SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

DESIGNED:	CZ	DATE:	12/12
DRAWN:	CZ	DATE:	12/12
CHECKED:	AA	DATE:	12/12
PROJ. ENG.:	AA	DATE:	12/12

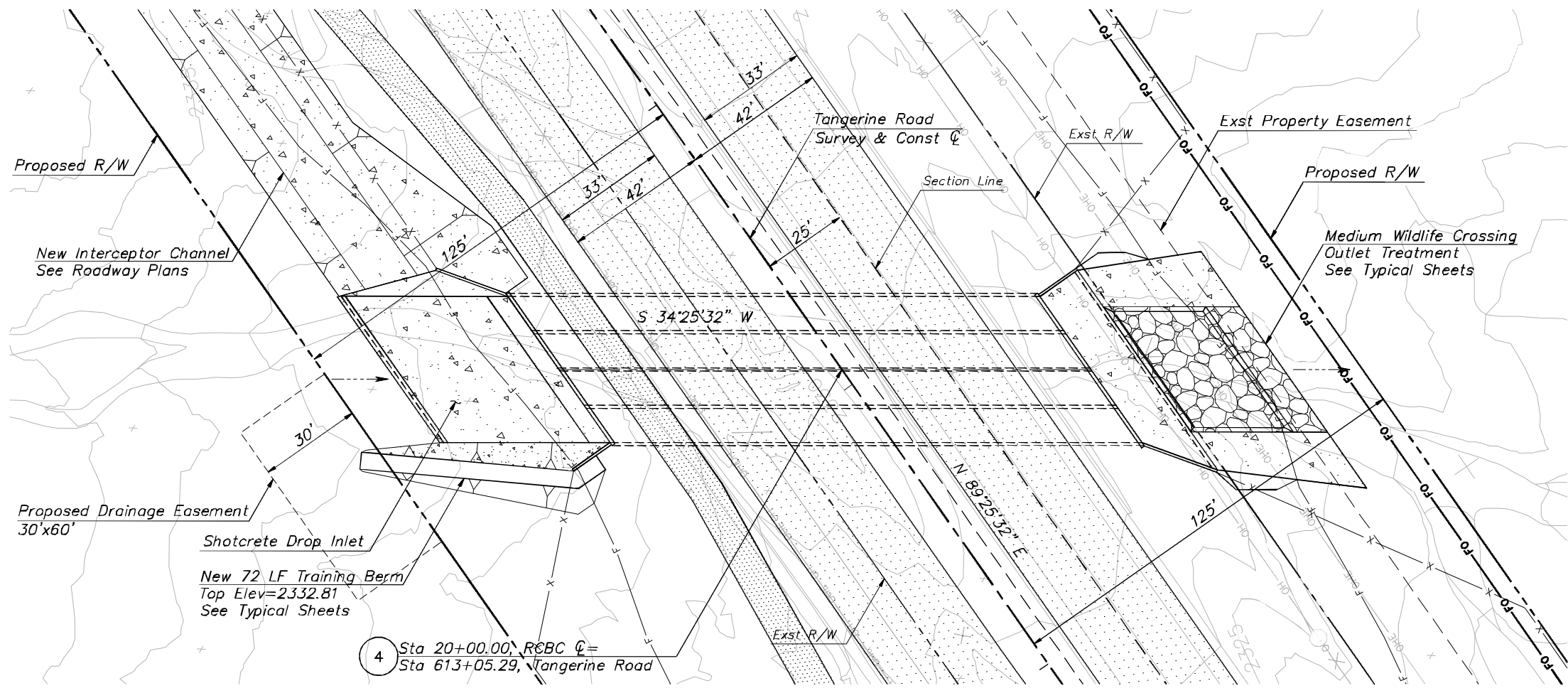
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**TANGERINE ROAD**  
STA 592+82.17  
TANGERINE ROAD

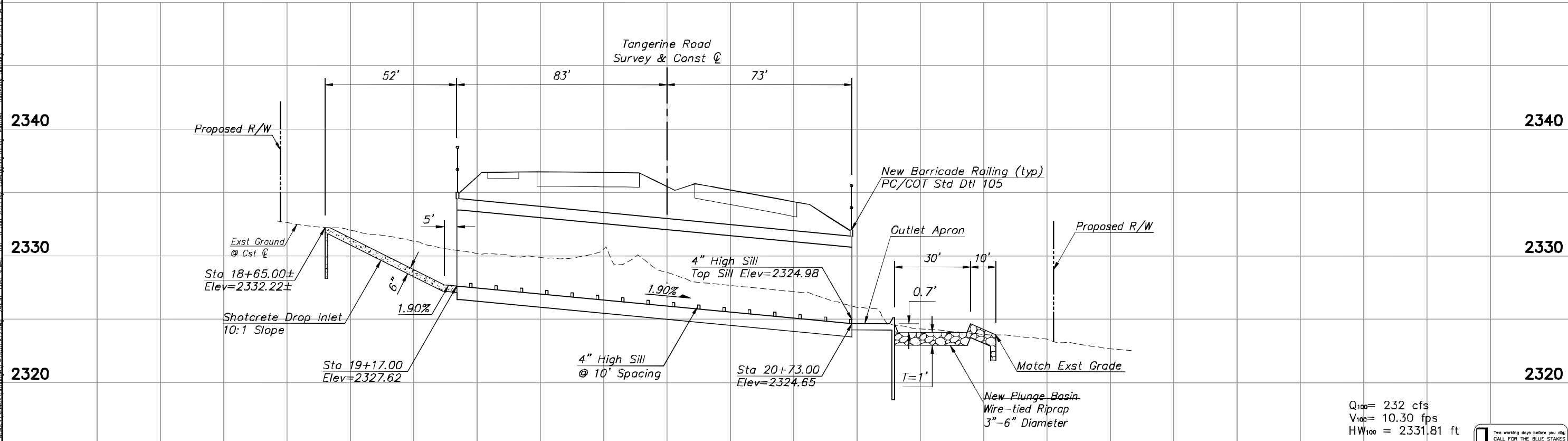




- NOTES:
1. Inlet headwall & wingwall dimensions shall be based on 30° skew, 4:1 slopes, and ADOT Std Dwg B-04.70.
  2. Outlet headwall & wingwall dimensions shall be based on 30° skew, 6:1 slopes, and ADOT Std Dwg B-04.50.
  3. Outlet apron dimensions shall be based on ADOT Std Dwg B-06.10, 30° skew and 6:1 slopes.
  4. Boxes shall be constructed per ADOT Std Dwg B-02.40.
  5. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.

4 Sta 20+00.00, RCBC  $\phi$  =  
Sta 613+05.29, Tangerine Road

18+00                      19+00                      20+00                      21+00                      22+00



Sta 613+05.29  
New 4-10'x6'x156' RCBC  
Skew 35° Rt

Q<sub>100</sub> = 232 cfs  
V<sub>100</sub> = 10.30 fps  
HW<sub>100</sub> = 2331.81 ft

Two working days before you dig,  
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SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

DESIGNED:	CZ	DATE:	12/12
DRAWN:	CZ	CHECKED:	AA
PROJECT:	AA	PROJ. ENG.:	AA

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

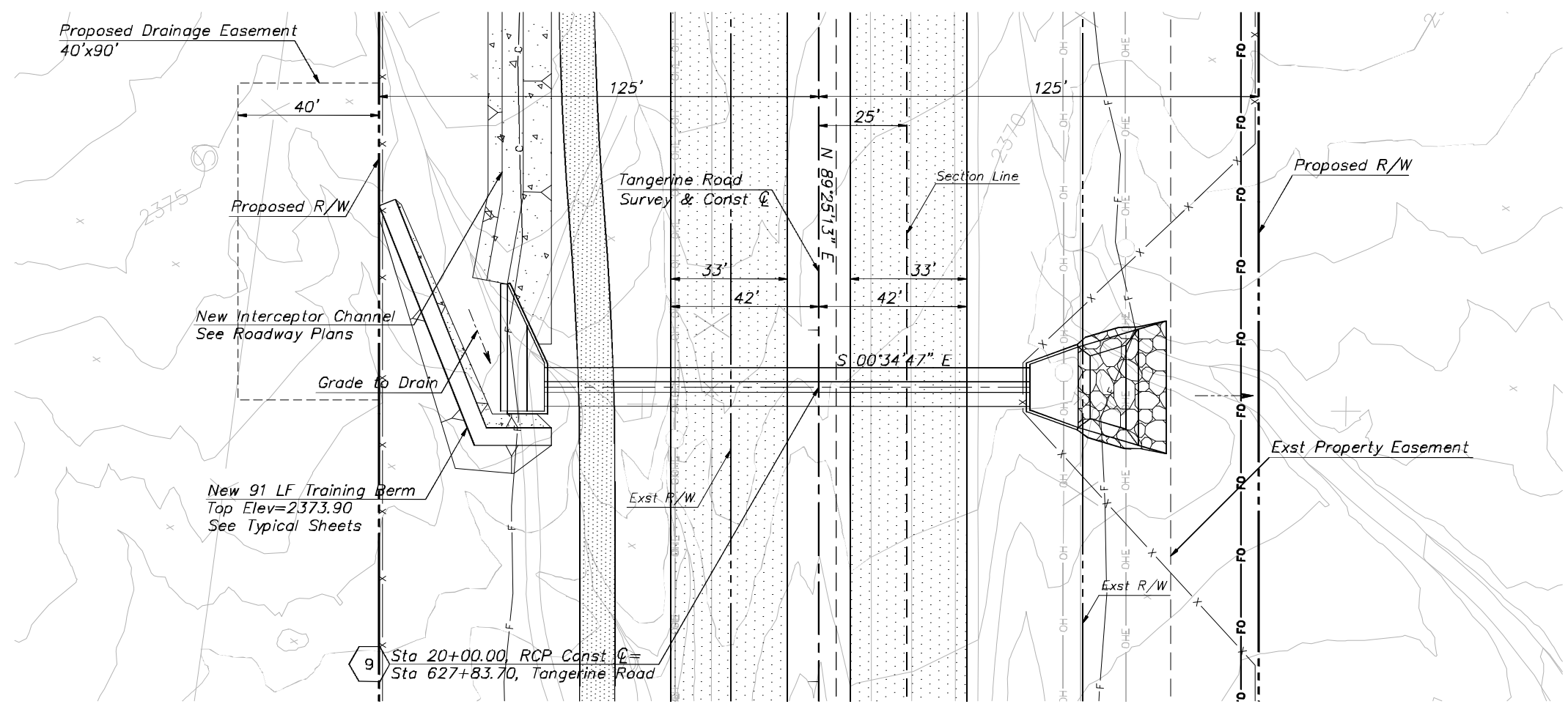
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DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 613+05.29  
TANGERINE ROAD



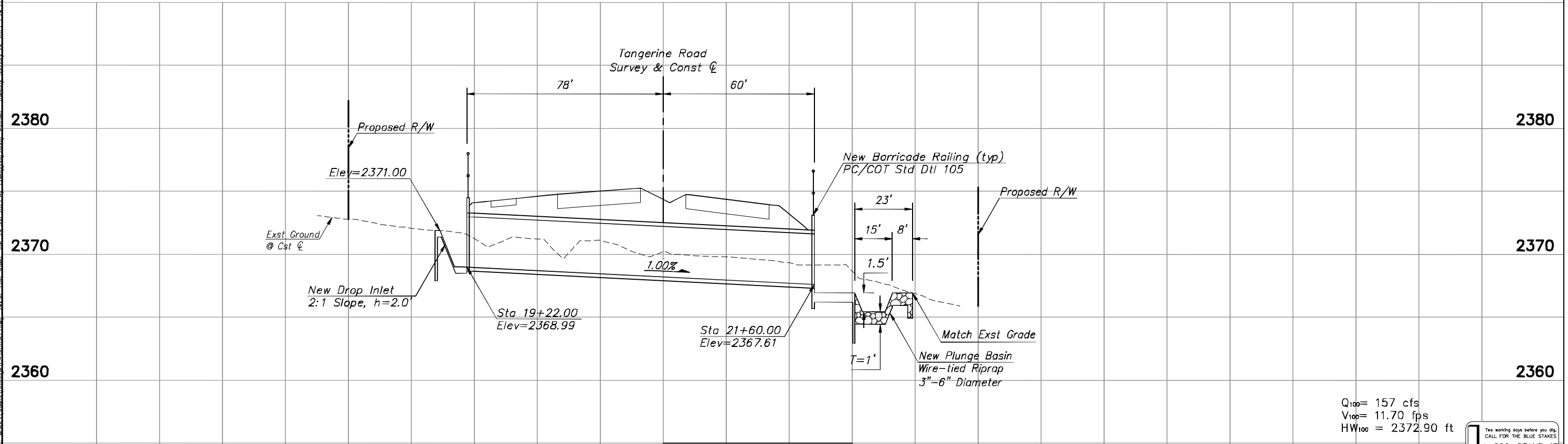
Proposed Drainage Easement  
40'x90'



NOTES:

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13, 45° skew.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.12, 0° skew
3. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
4. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.

18+00                      19+00                      20+00                      21+00                      22+00



Sta 627+83.70  
New 2-48"x138' RCP  
Skew 0°

Q<sub>100</sub> = 157 cfs  
V<sub>100</sub> = 11.70 fps  
HW<sub>100</sub> = 2372.90 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

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DRAWN:	CZ		12/12
CHECKED:	AA		12/12
PROJ. ENG.:	AA		12/12

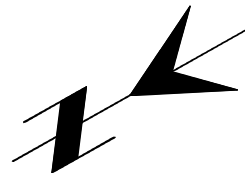
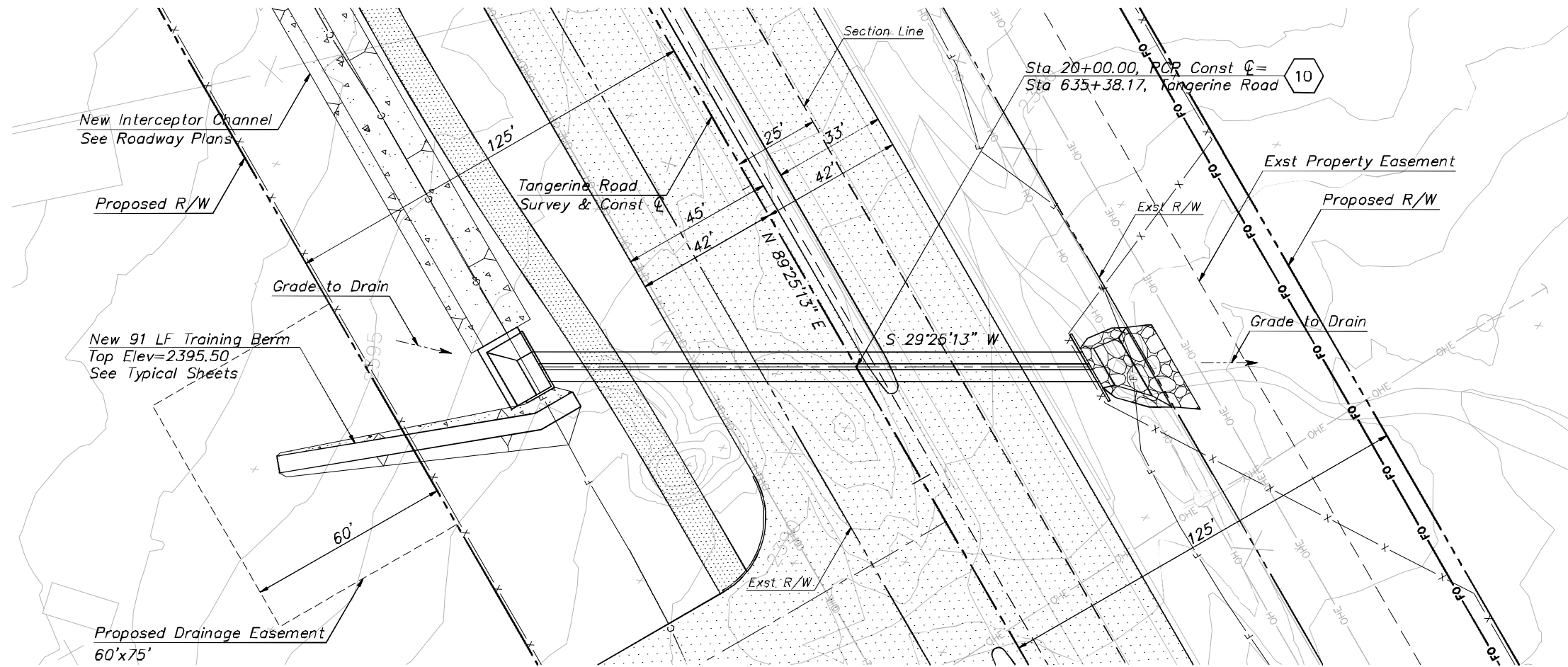
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DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 627+83.70  
TANGERINE ROAD





**NOTES:**

1. Inlet & outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11. Inlet shall be an "L" headwall.
2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
3. Barricade railing shall be placed on headwalls as shown on the profile.

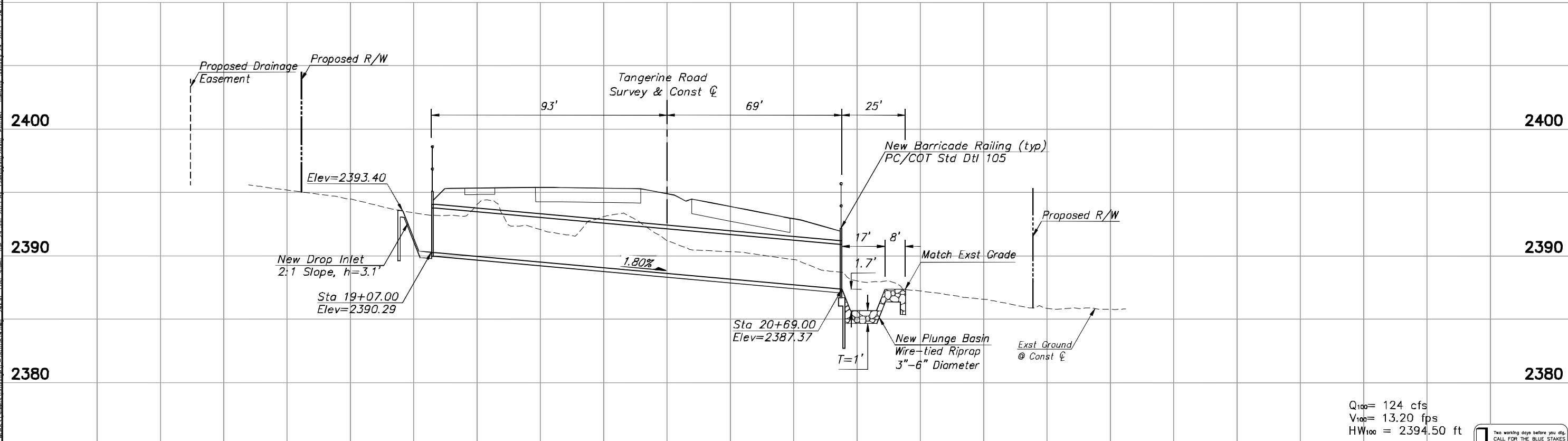
18+00

19+00

20+00

21+00

22+00



Sta 635+38.17  
New 2-42"x162' RCP  
Skew 30° Rt

Q<sub>100</sub> = 124 cfs  
V<sub>100</sub> = 13.20 fps  
HW<sub>100</sub> = 2394.50 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

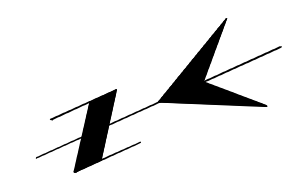
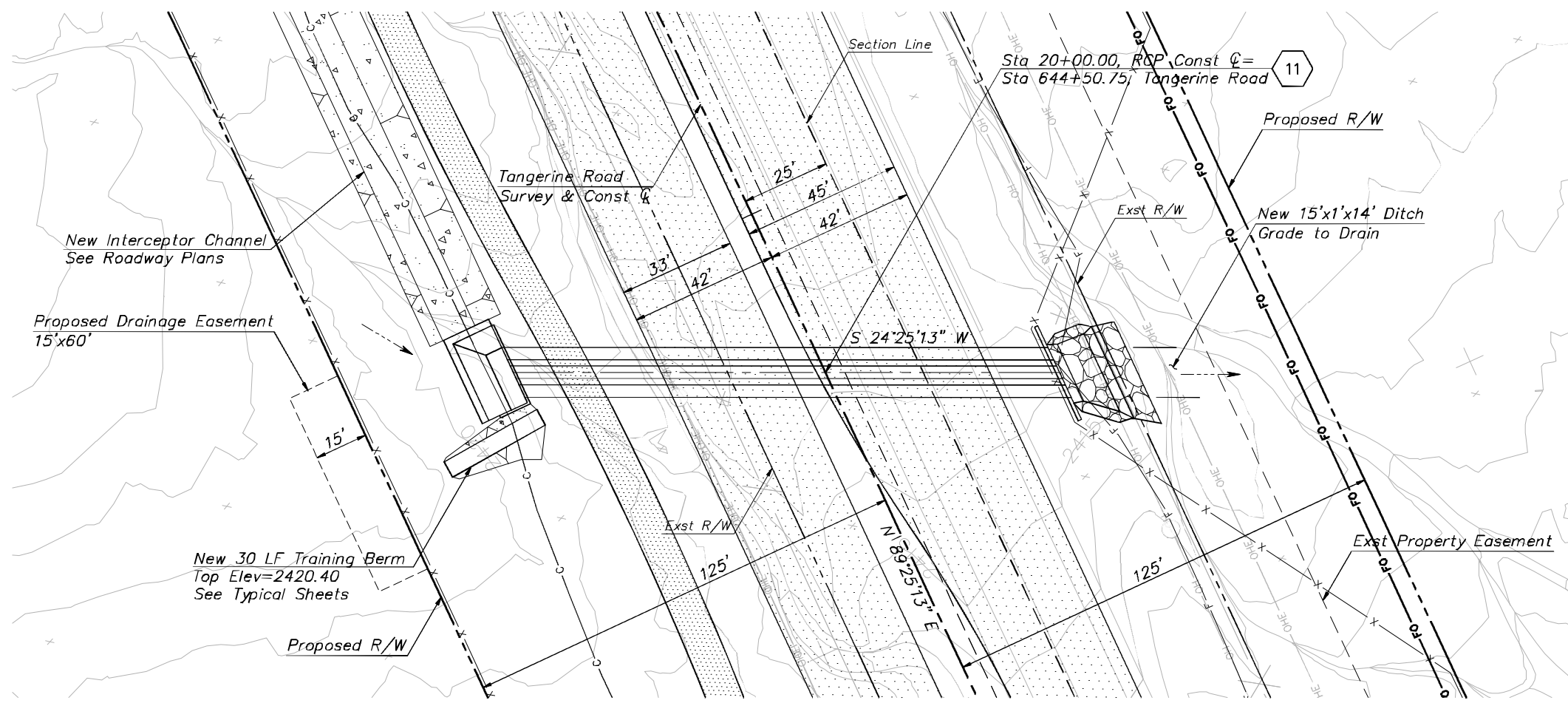
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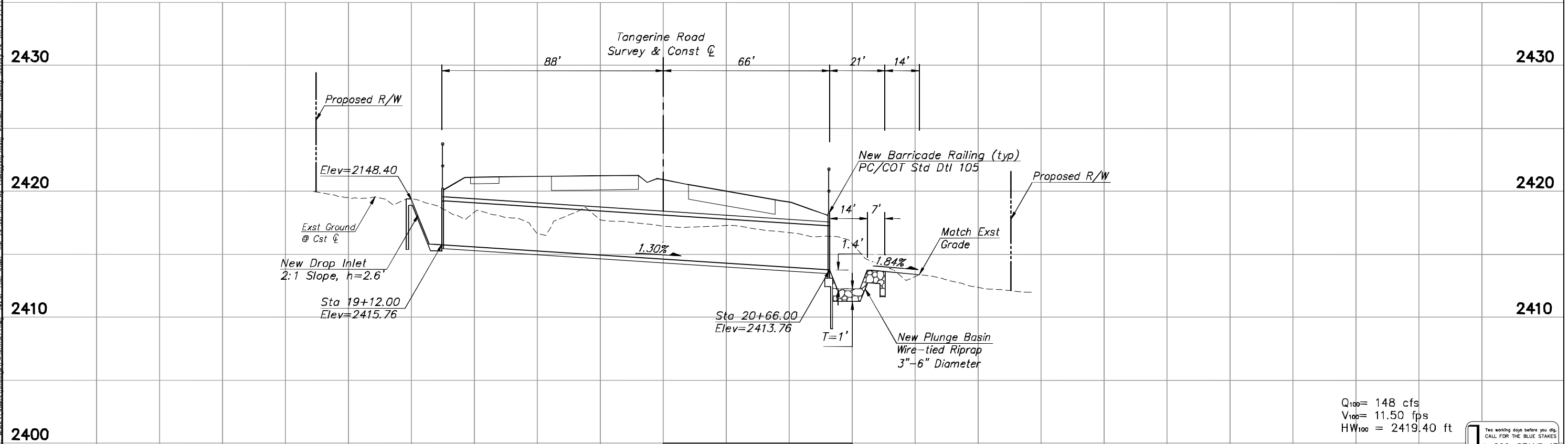
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FOR  
TANGERINE ROAD  
STA 635+38.17  
TANGERINE ROAD



- NOTES:
- Inlet & Out headwall dimensions shall be based on ADOT Std Dwg B-11.11. Inlet shall be an "L" headwall.
  - Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
  - Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 4:1 slopes.
  - Barricade railing shall be placed on headwalls as shown on the profile.

18+00                      19+00                      20+00                      21+00                      22+00



Sta 644+50.75  
New 3-42"x154' RCP  
Skew 25' Rt

Q<sub>100</sub> = 148 cfs  
V<sub>100</sub> = 11.50 fps  
HW<sub>100</sub> = 2419.40 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

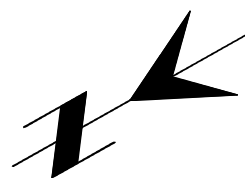
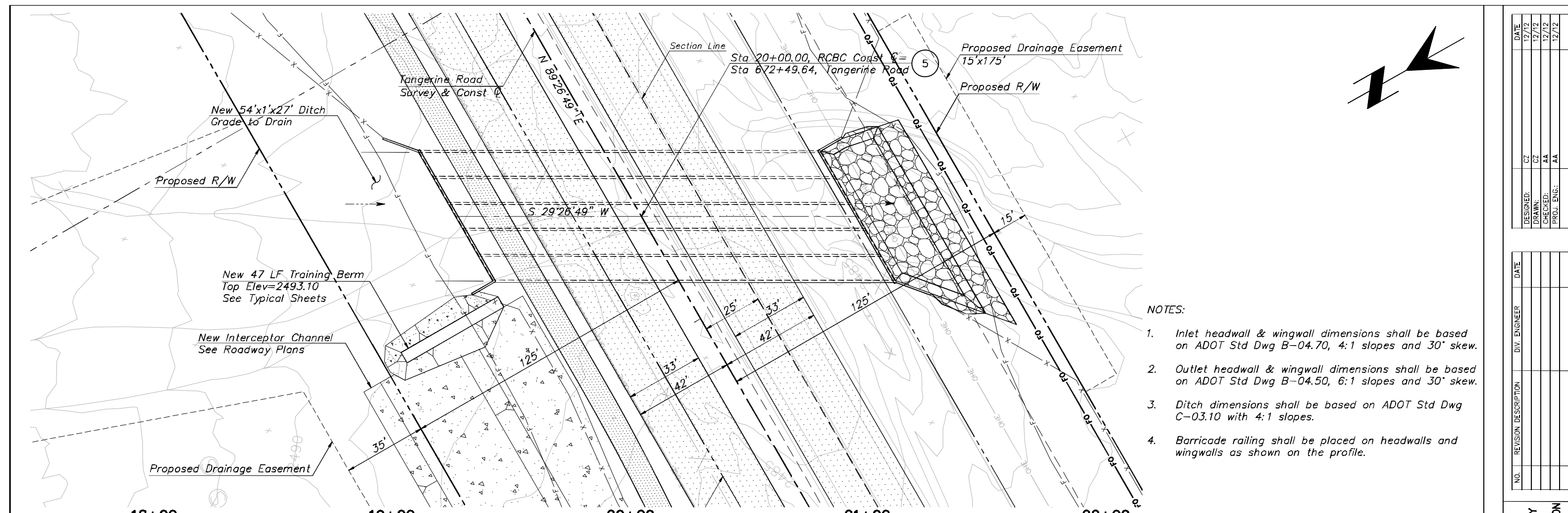
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TANGERINE ROAD  
STA 644+50.75  
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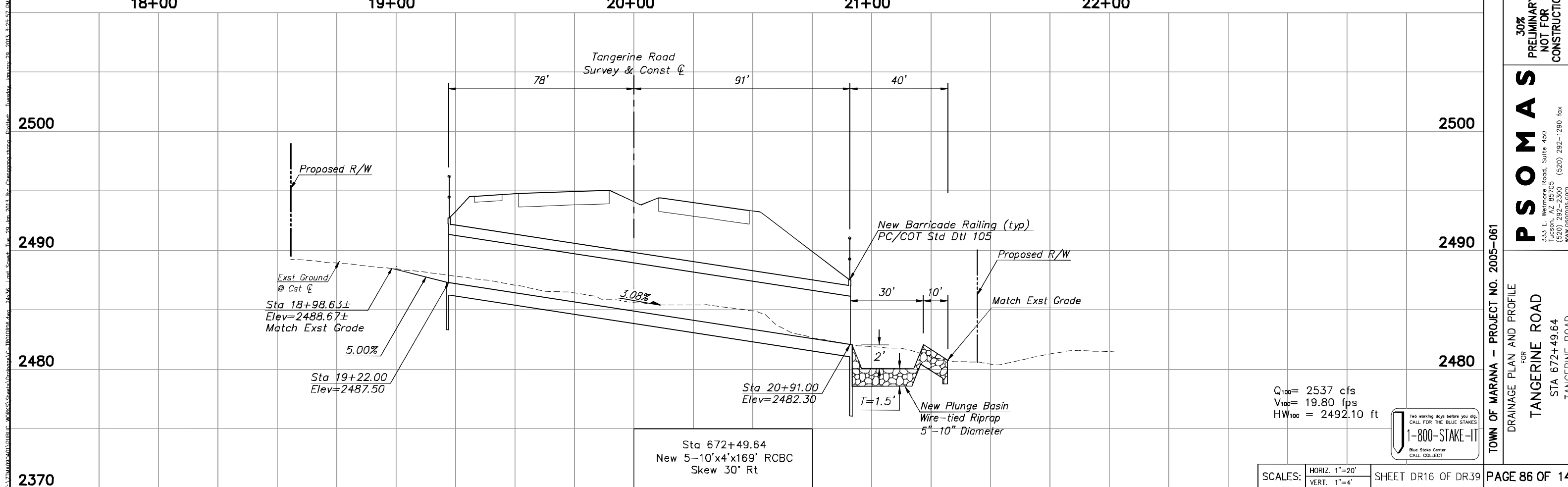
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**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.70, 4:1 slopes and 30° skew.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.50, 6:1 slopes and 30° skew.
3. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 4:1 slopes.
4. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.



Sta 672+49.64  
New 5-10'x4'x169' RCBC  
Skew 30° Rt

Q<sub>100</sub> = 2537 cfs  
V<sub>100</sub> = 19.80 fps  
HW<sub>100</sub> = 2492.10 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

DESIGNED:	CZ	DATE:	12/12
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CHECKED:	AA	DATE:	12/12
PROJ. ENG.:	AA	DATE:	12/12

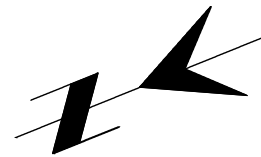
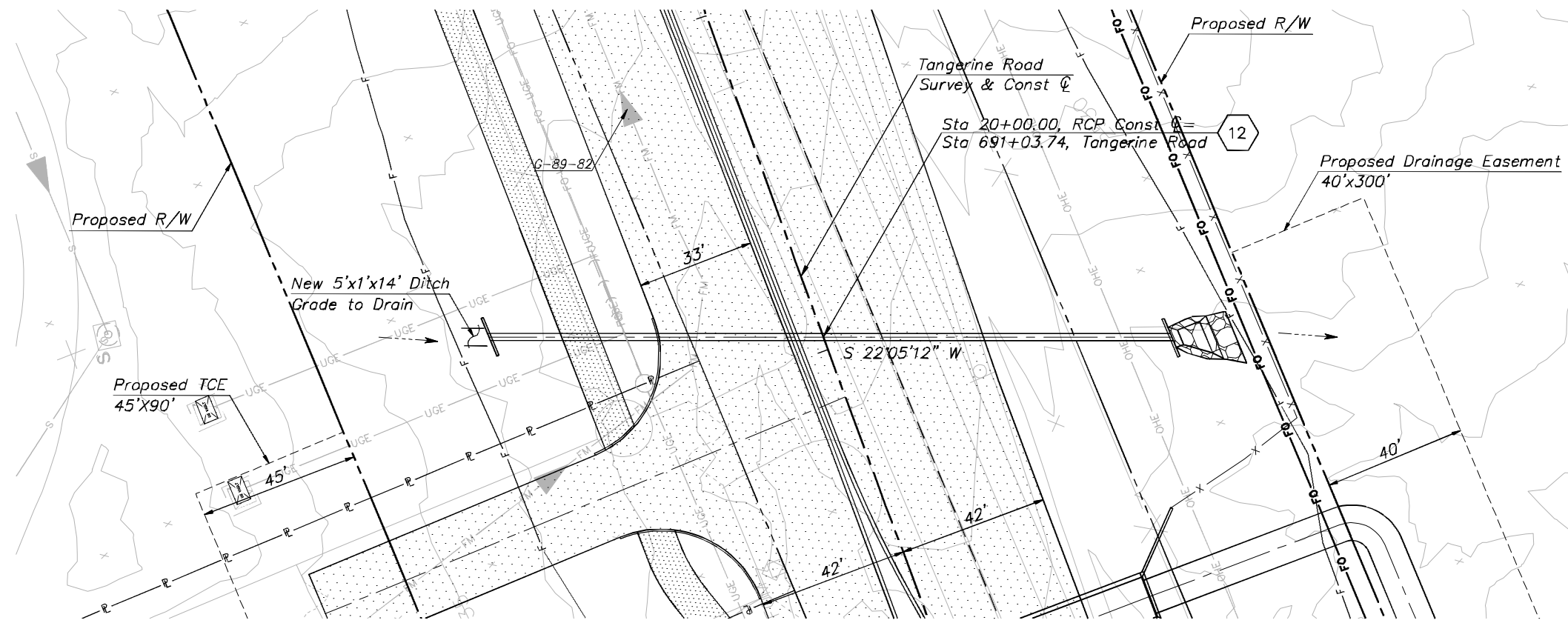
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FOR  
**TANGERINE ROAD**  
STA 672+49.64  
TANGERINE ROAD

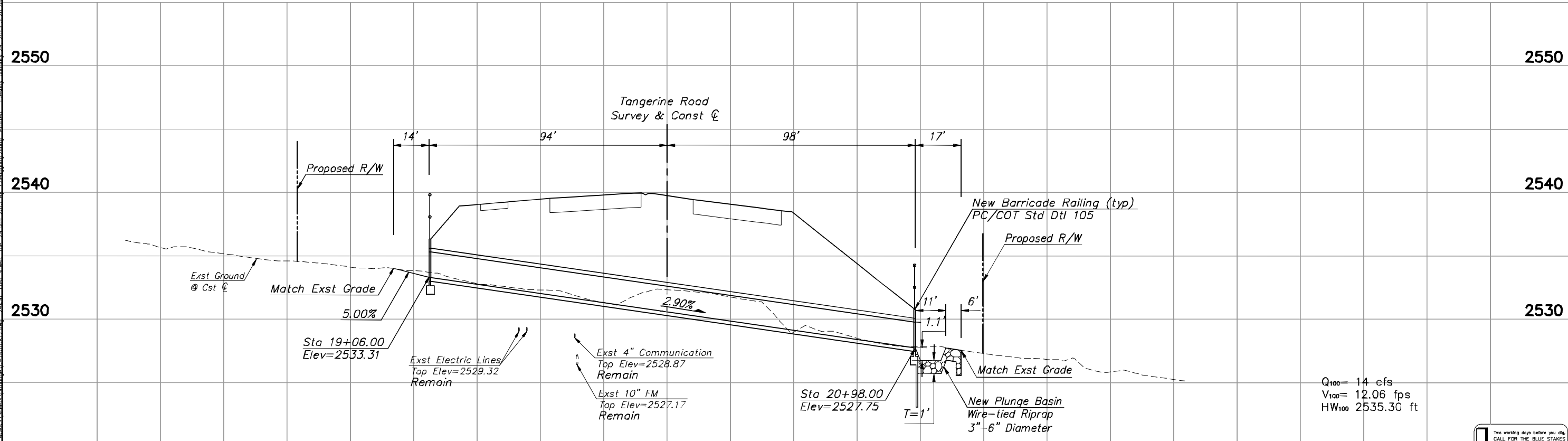
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**NOTES:**

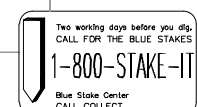
1. Inlet & Outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11.
2. Pipe shall be constructed per ADOT Std Dwg C-13.10 & C-13.15.
3. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 4:1 slopes.
4. Barricade railing shall be placed on headwalls as shown on the profile.

18+00                      19+00                      20+00                      21+00                      22+00



Sta 691+03.74  
New 1-24"x192' RCP  
Skew 20° Rt

Q<sub>100</sub> = 14 cfs  
V<sub>100</sub> = 12.06 fps  
HW<sub>100</sub> 2535.30 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

DESIGNED:	CZ	DATE:	12/12
DRAWN:	CZ	DATE:	12/12
CHECKED:	AA	DATE:	12/12
PROJ. ENG.:	AA	DATE:	12/12

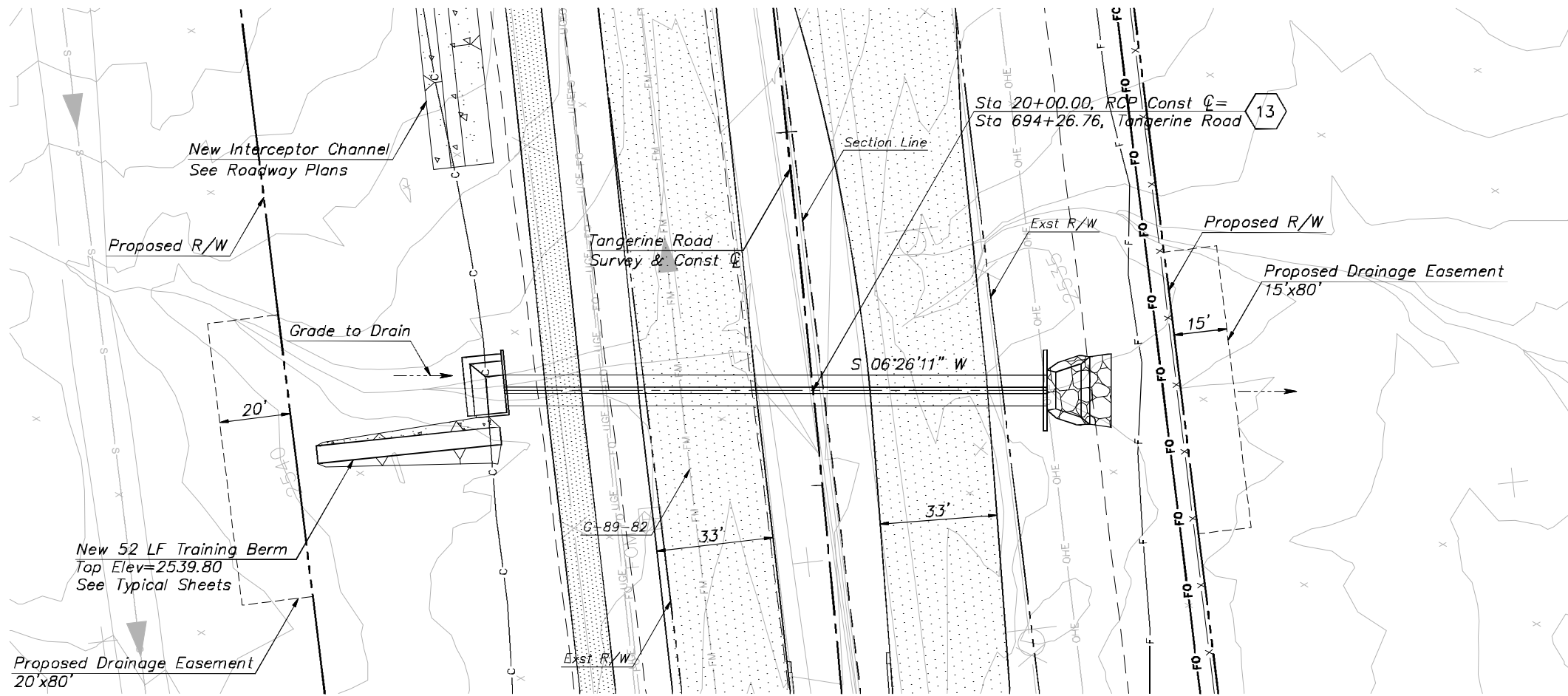
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Tucson, AZ 85705  
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TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
TANGERINE ROAD  
STA 691+03.74  
TANGERINE ROAD

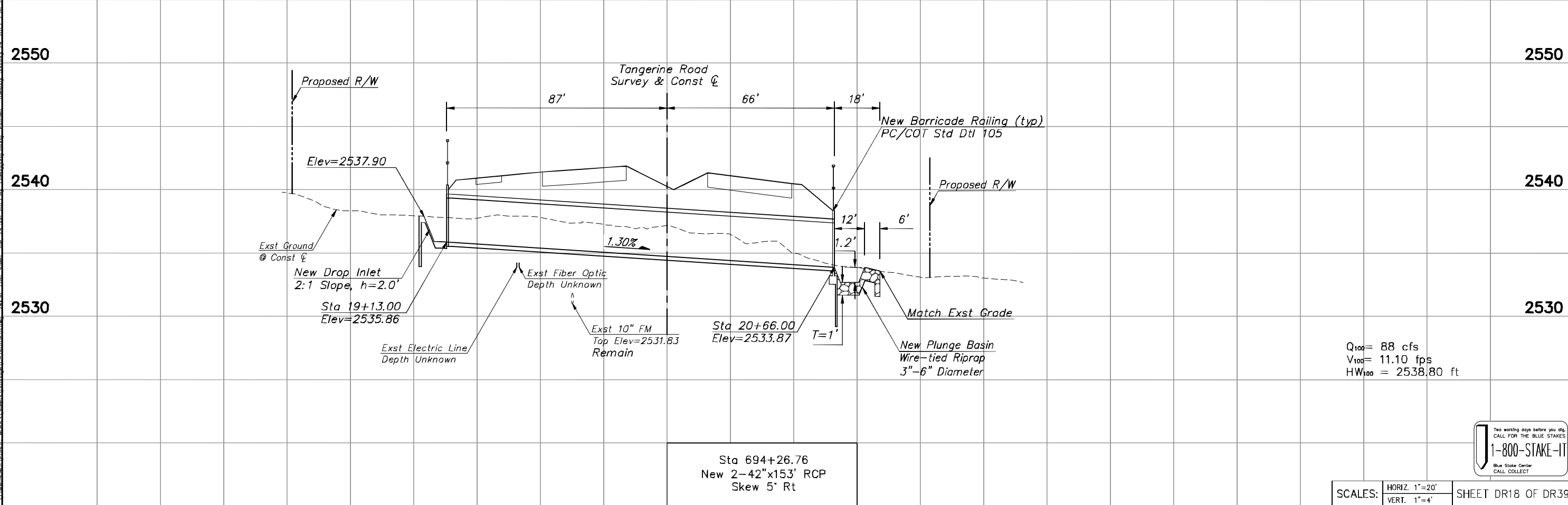
T:\217MAG0401\BIBLIC\_M08\CS\Sheets\Drainage\C-1801DR17.dwg - 24.56 - Tue, 29 Jan 2013 10:26:28 AM



**NOTES:**

1. Inlet & Outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11. Inlet shall be an "L" headwall.
2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
3. Barricade railing shall be placed on headwalls as shown on the profile.

18+00                      19+00                      20+00                      21+00                      22+00



Q<sub>100</sub> = 88 cfs  
V<sub>100</sub> = 11.10 fps  
HW<sub>100</sub> = 2538.80 ft

Sta 694+26.76  
New 2-42"x153' RCP  
Skew 5' Rt

Two working days before you dig,  
CALL FOR THE BLUE STAKES!  
1-800-STAKE-IT  
Blue Stake Center  
CALL COLLECT

SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

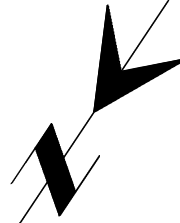
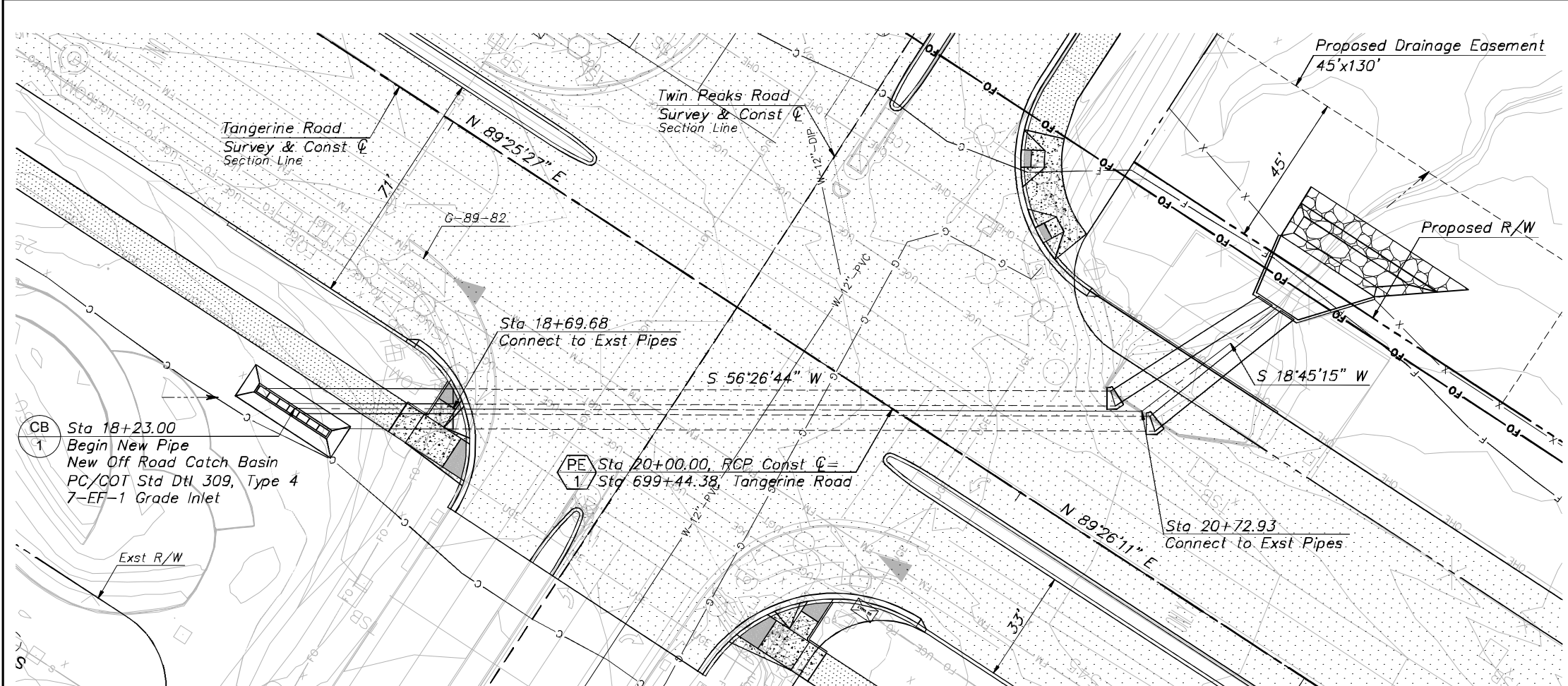
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CHECKED:	AA	DATE:	12/12
PROJ. ENG.:	AA	DATE:	12/12

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

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CONSTRUCTION

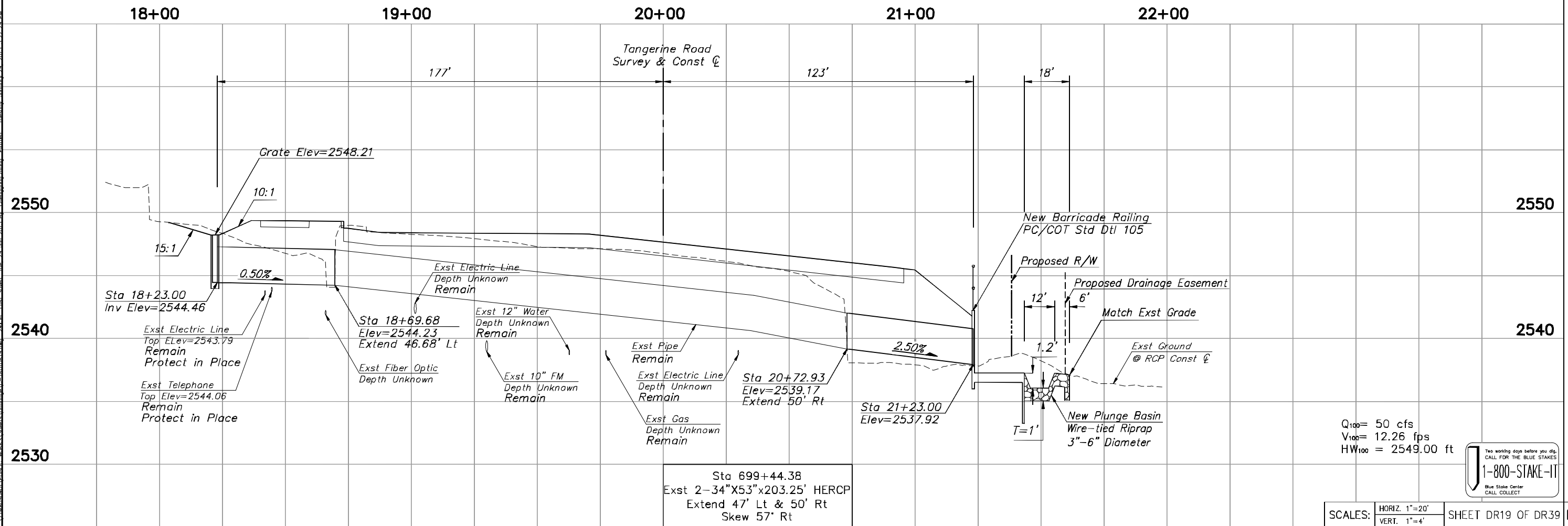
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Tucson, AZ 85705  
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TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 694+26.76  
TANGERINE ROAD



NOTES:

1. Inlet shall be based on PC/COT Std Dtl 309.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13, 6:1 slopes.
3. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
4. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.



Q<sub>100</sub> = 50 cfs  
 V<sub>100</sub> = 12.26 fps  
 HW<sub>100</sub> = 2549.00 ft

Two working days before you dig,  
 CALL FOR THE BLUE STAKES!  
 1-800-STAKE-IT  
 Blue Stake Center  
 CALL COLLECT

SCALES: HORIZ. 1"=20'  
 VERT. 1"=4'

DESIGNED:	CZ	DATE:	12/12
DRAWN:	CZ	DATE:	12/12
CHECKED:	AA	DATE:	12/12
PROJ. ENG.:	AA	DATE:	12/12

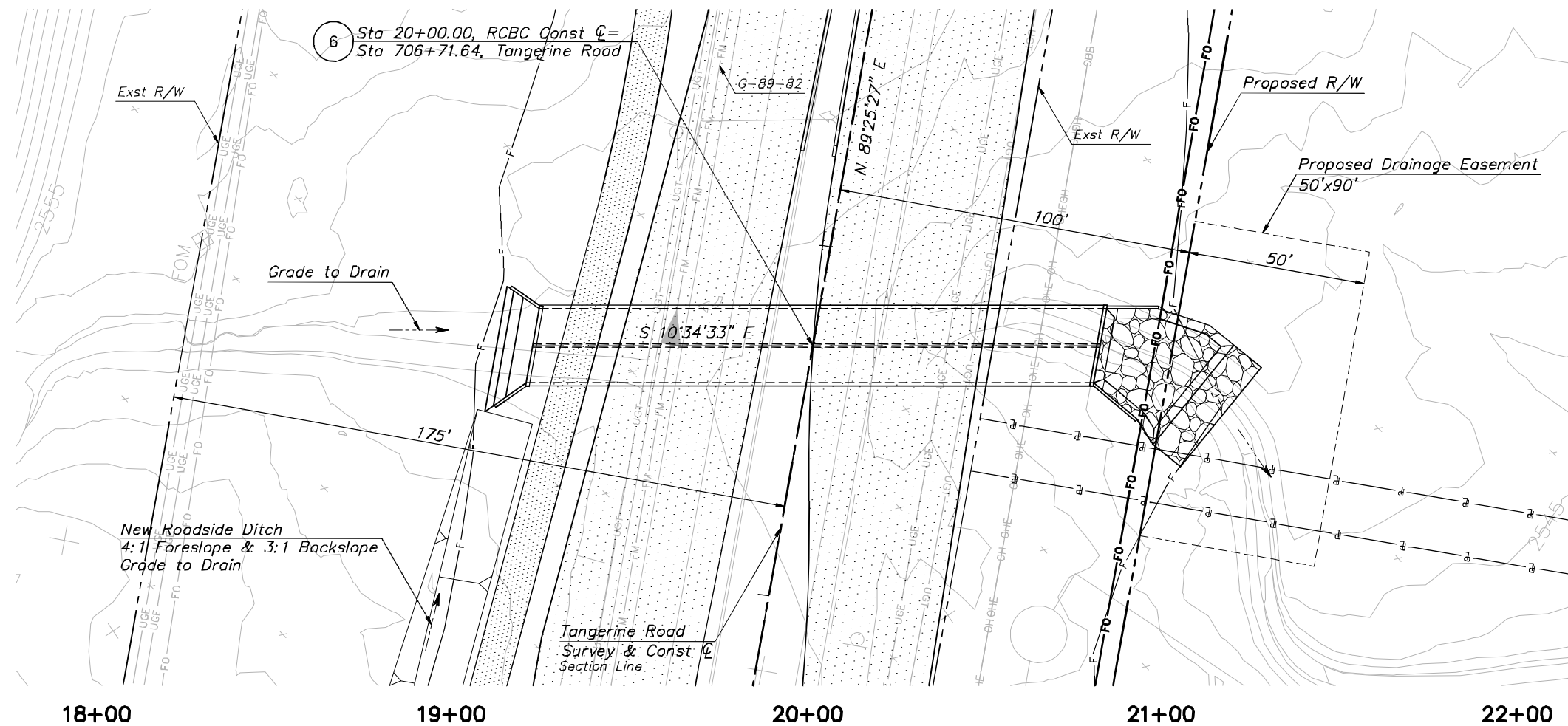
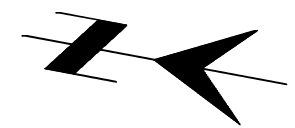
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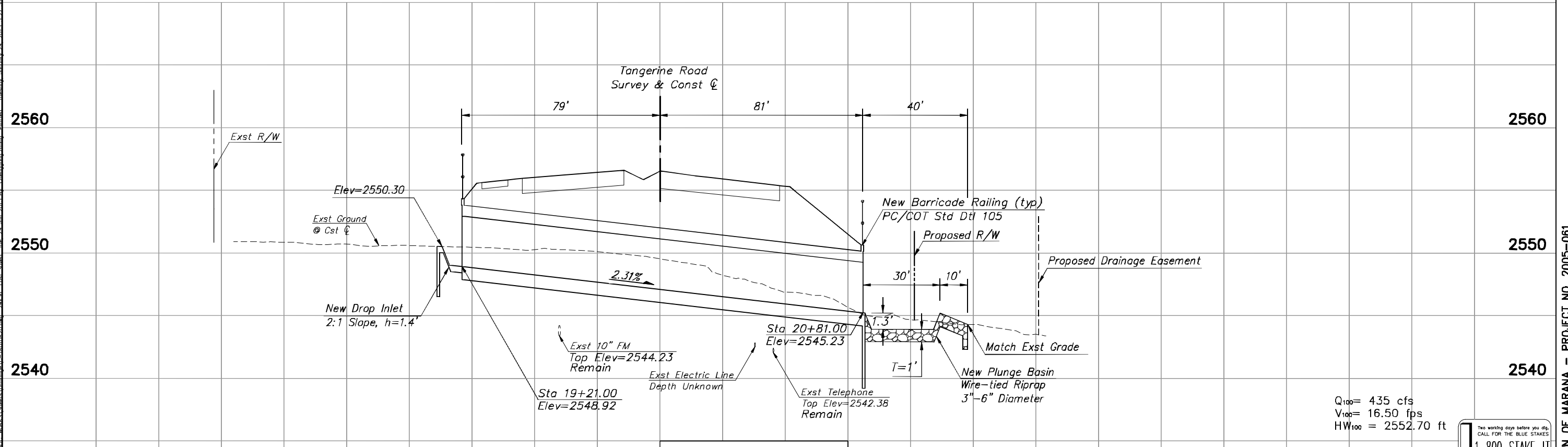
TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE  
 FOR  
**TANGERINE ROAD**  
 STA 699+44.38  
 TANGERINE ROAD

T:\21\10\0401\1\BIBLIC\_MORIS\Sheets\Drawings\1801DR19.dwg - 24.56 - Led. Sewer - Tue, 29 Jan 2013 10:20:13 AM - Tuesday, January 29, 2013 3:27:29 PM



**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on 10° skew, 4:1 slopes, and ADOT Std Dwg B-04.30.
2. Outlet headwall & wingwall dimensions shall be based on 10° skew, 6:1 slopes, and ADOT Std Dwg B-04.10.  $\theta_1=60^\circ$ ;  $\theta_2=80^\circ$ .
3. Boxes shall be constructed per ADOT Std Dwg B-02.20.
4. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.



Sta 706+71.64  
New 2-10'x4'x160' RCBC  
Skew 10° Lt

$Q_{100} = 435$  cfs  
 $V_{100} = 16.50$  fps  
 $HW_{100} = 2552.70$  ft



	DESIGNED: CZ	DATE: 12/12
	DRAWN: CZ	12/12
	CHECKED: AA	12/12
	PROJ. ENG.: AA	12/12

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

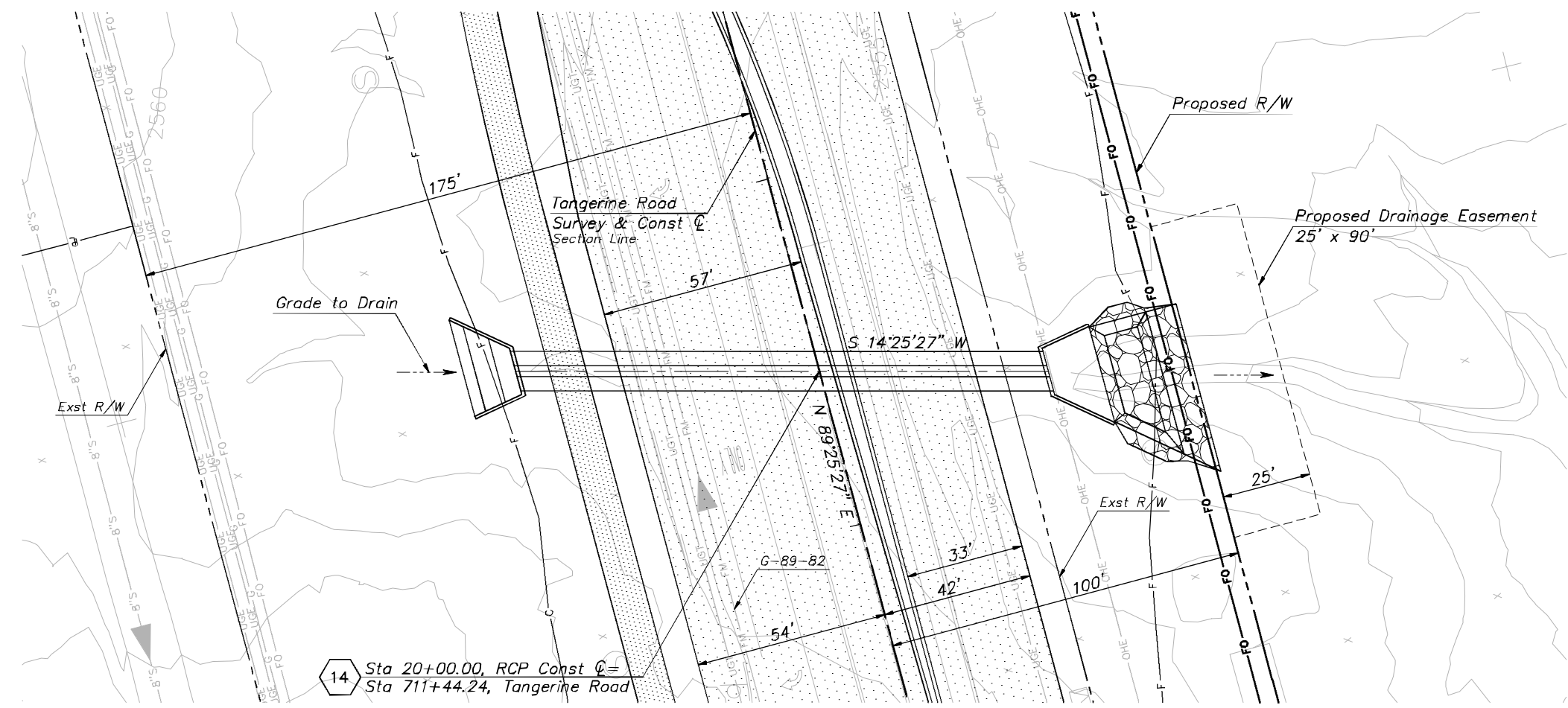
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Lucas, AL 35705  
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TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 706+71.64  
TANGERINE ROAD



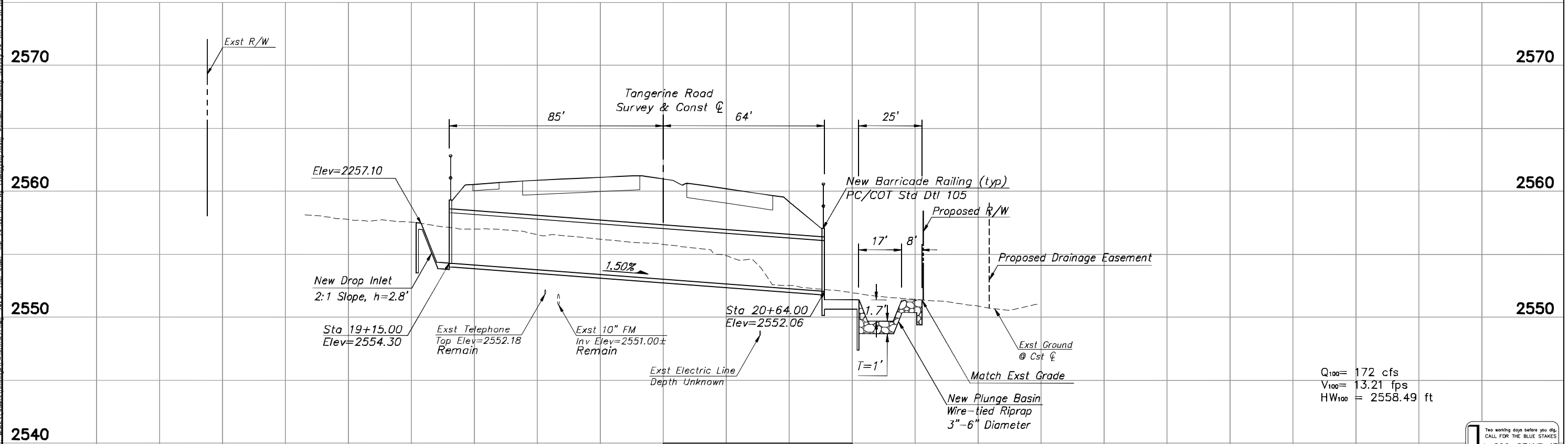


**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13 with 4:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13 with 6:1 slopes.
3. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
4. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.

14 Sta 20+00.00, RCP Const @ Sta 711+44.24, Tangerine Road

18+00                      19+00                      20+00                      21+00                      22+00



Q<sub>100</sub> = 172 cfs  
 V<sub>100</sub> = 13.21 fps  
 HW<sub>100</sub> = 2558.49 ft

Sta 711+44.24  
 New 2-48"x149' RCP  
 Skew 15' Rt

Two working days before you dig,  
 CALL FOR THE BLUE STAKES!  
**1-800-STAKE-IT**  
 Blue Stake Center  
 CALL COLLECT

SCALES: HORIZ. 1"=20'  
 VERT. 1"=4'

TOWN OF MARANA - PROJECT NO. 2005-061

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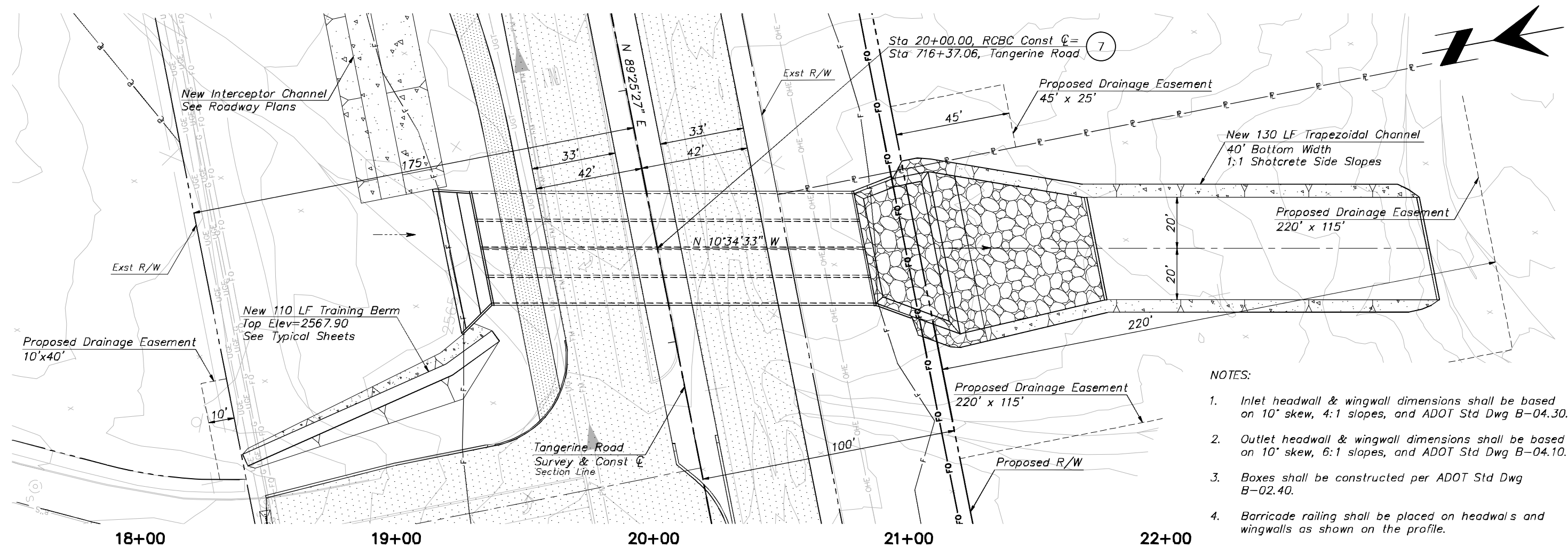
**PSOMAS**  
 333 E. Weimers Road, Suite 450  
 Tucson, AZ 85705  
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DRAINAGE PLAN AND PROFILE  
 FOR  
**TANGERINE ROAD**  
 STA 711+44.24  
 TANGERINE ROAD

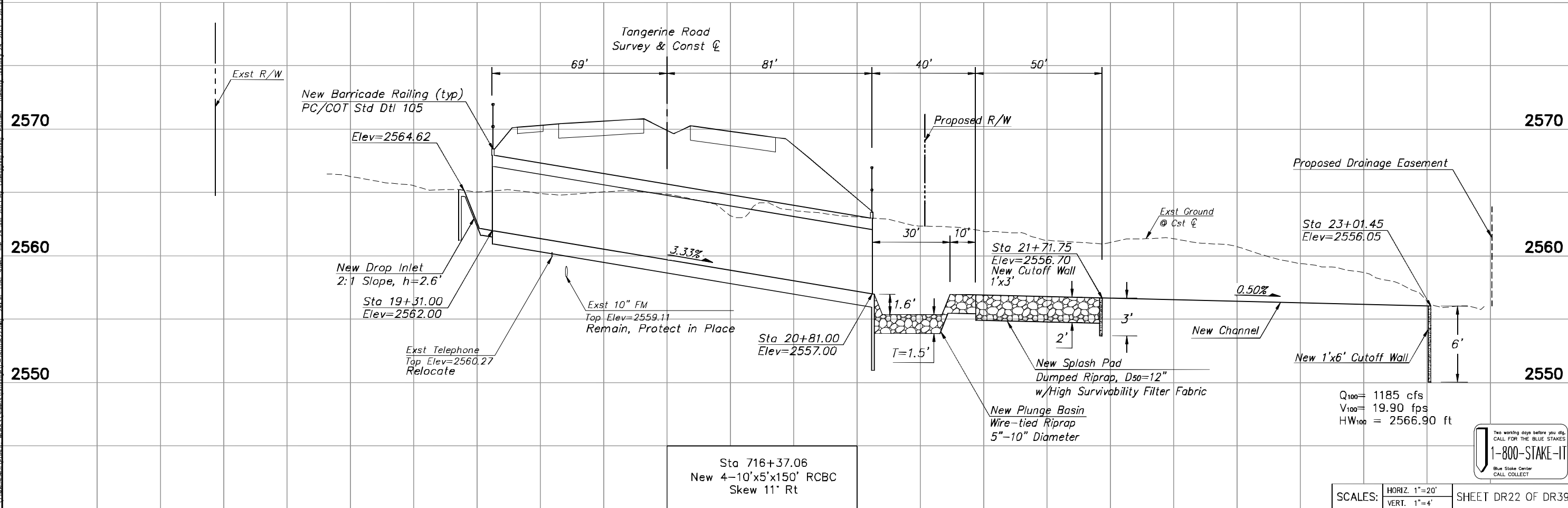
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PROJ. ENG.:	AA	DATE:	12/12

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE





- NOTES:
1. Inlet headwall & wingwall dimensions shall be based on 10° skew, 4:1 slopes, and ADOT Std Dwg B-04.30.
  2. Outlet headwall & wingwall dimensions shall be based on 10° skew, 6:1 slopes, and ADOT Std Dwg B-04.10.
  3. Boxes shall be constructed per ADOT Std Dwg B-02.40.
  4. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.



$Q_{100} = 1185$  cfs  
 $V_{100} = 19.90$  fps  
 $HW_{100} = 2566.90$  ft

Two working days before you dig,  
 CALL FOR THE BLUE STAKES!  
**1-800-STAKE-IT**  
 Blue Stake Center  
 CALL COLLECT

SCALES: HORIZ. 1"=20'  
 VERT. 1"=4'  
 SHEET DR22 OF DR39

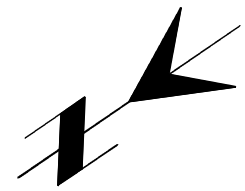
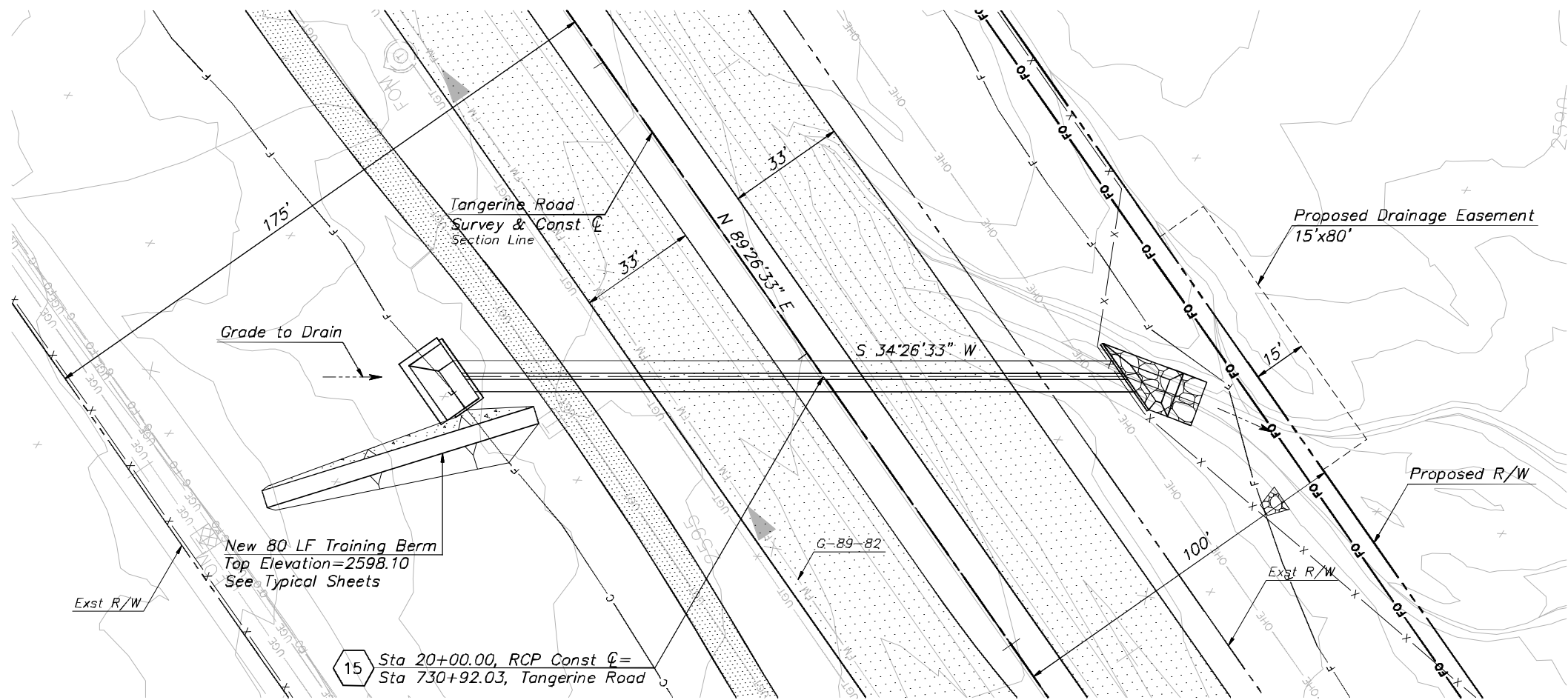
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PROJECT ENG.:	AA	DATE:	12/12

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TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE  
 FOR  
**TANGERINE ROAD**  
 STA 716+37.06  
 TANGERINE ROAD



**NOTES:**

1. Inlet & Outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11. Inlet shall be an "L" headwall.
2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
3. Barricade railing shall be placed on headwalls as shown on the profile.

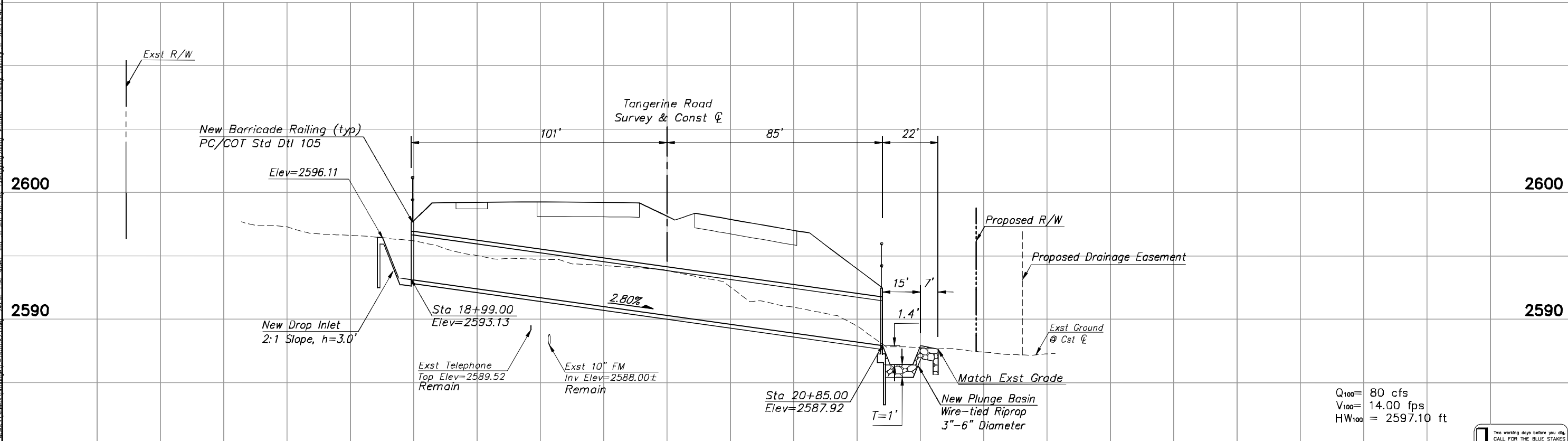
18+00

19+00

20+00

21+00

22+00



Sta 730+92.03  
New 2-42"x186' RCP  
Skew 35° Rt

Q<sub>100</sub> = 80 cfs  
V<sub>100</sub> = 14.00 fps  
HW<sub>100</sub> = 2597.10 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

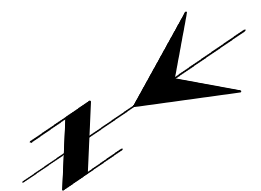
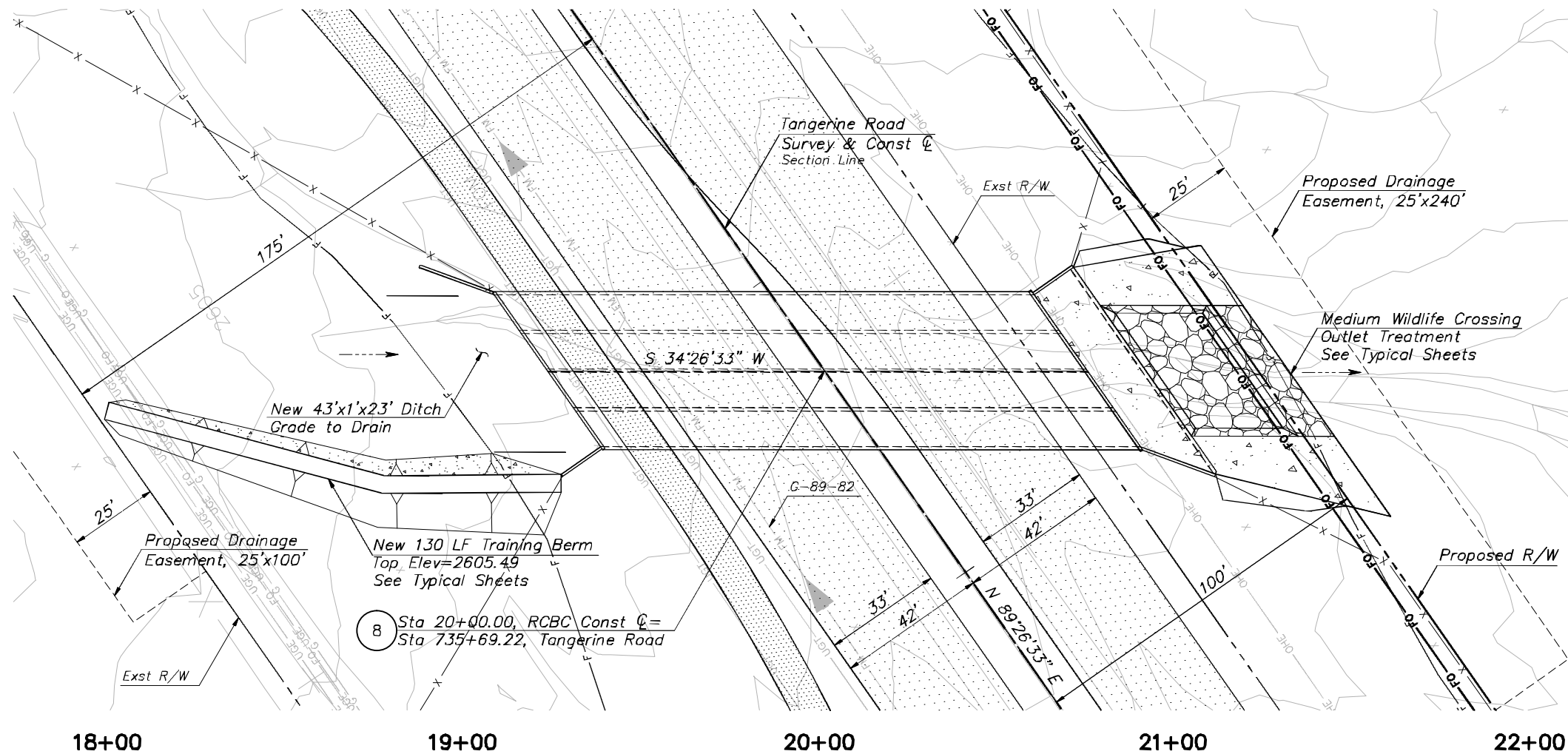
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DRAWN:	CZ	CHECKED:	AA
PROJECT ENG.:	AA		

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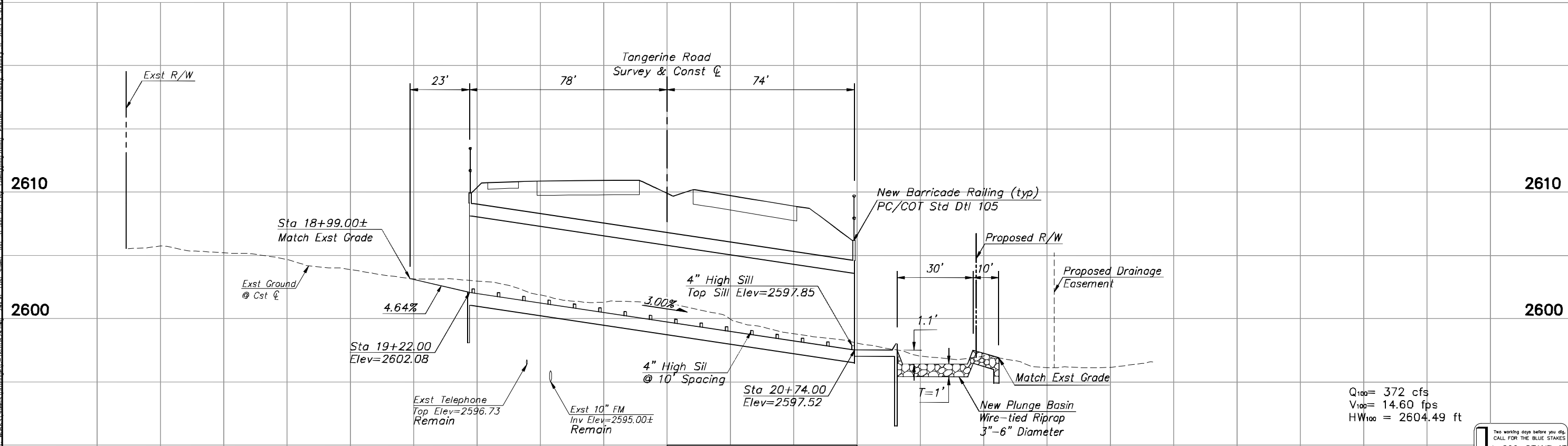
TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 730+92.03  
TANGERINE ROAD



**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on 30° skew, 4:1 slopes, and ADOT Std Dwg B-04.30.
2. Outlet headwall & wingwall dimensions shall be based on 30° skew, 6:1 slopes, and ADOT Std Dwg B-04.10.
3. Outlet apron dimensions shall be based on ADOT Std Dwg B-06.10, 30° skew and 6:1 slopes.
4. Boxes shall be constructed per ADOT Std Dwg B-02.40.
5. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 4:1 slopes.
6. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.

18+00                      19+00                      20+00                      21+00                      22+00



Sta 735+69.22  
New 4-10'x6'x152' RCBC  
Skew 35° Rt

Q<sub>100</sub> = 372 cfs  
V<sub>100</sub> = 14.60 fps  
HW<sub>100</sub> = 2604.49 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

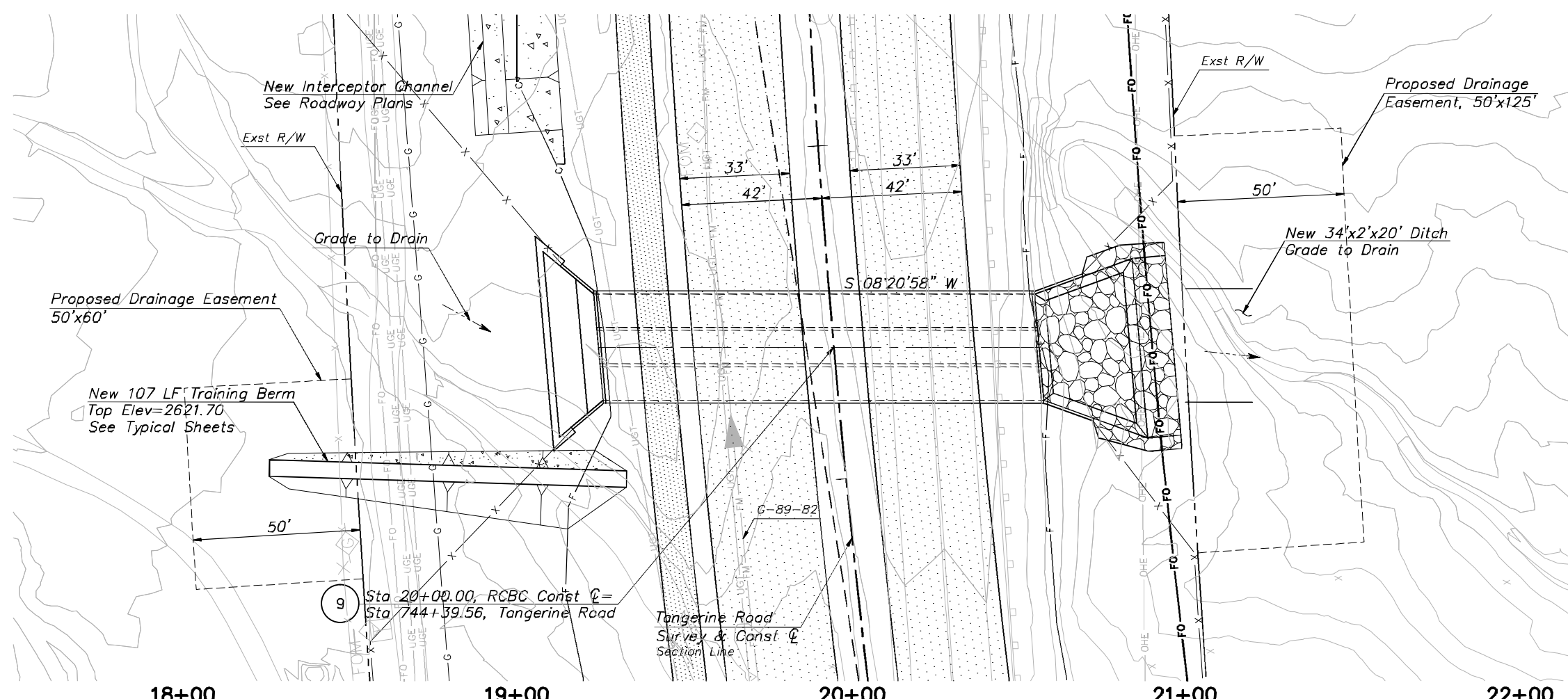
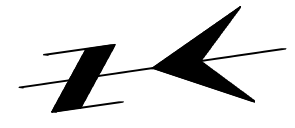
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PROJECT:	AA	PROJECT ENGINEER:	AA

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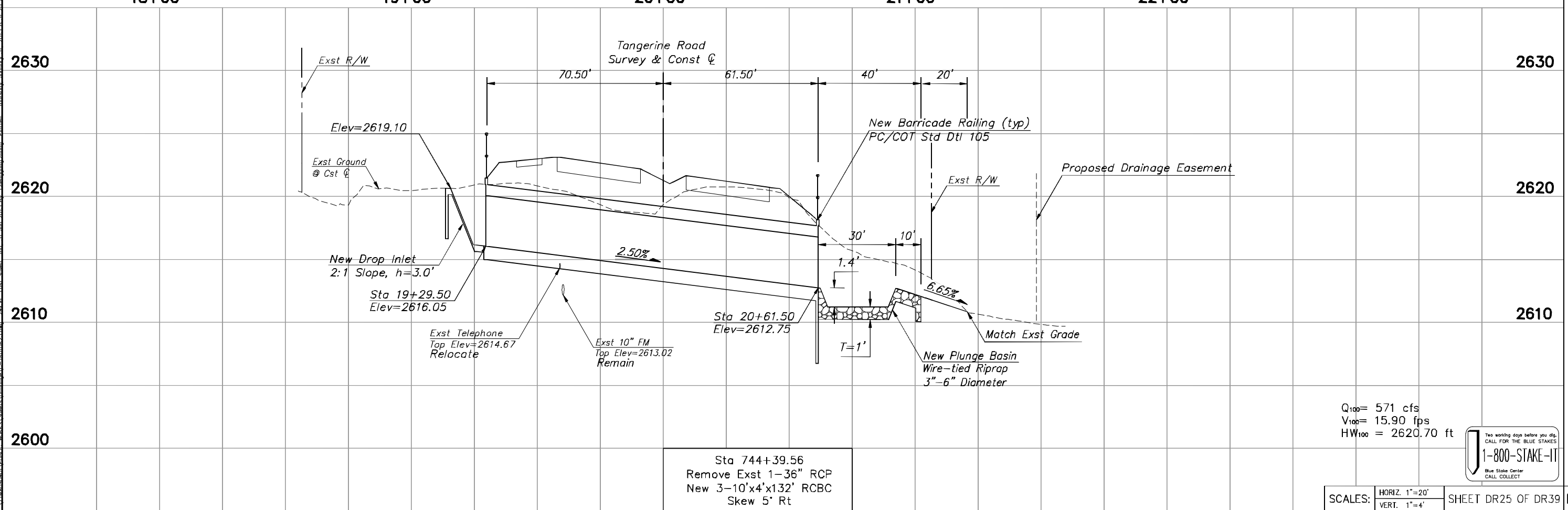
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TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 735+69.22  
TANGERINE ROAD



**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on 0° skew, 4:1 slopes, and ADOT Std Dwg B-04.30.
2. Outlet headwall & wingwall dimensions shall be based on 0° skew, 6:1 slopes, and ADOT Std Dwg B-04.10.
3. Boxes shall be constructed per ADOT Std Dwg B-02.30.
4. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 4:1 slopes.
5. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.



Sta 744+39.56  
 Remove Exst 1-36" RCP  
 New 3-10"x4"x132' RCBC  
 Skew 5° Rt

Q<sub>100</sub> = 571 cfs  
 V<sub>100</sub> = 15.90 fps  
 HW<sub>100</sub> = 2620.70 ft



SCALES: HORIZ. 1"=20'  
 VERT. 1"=4'

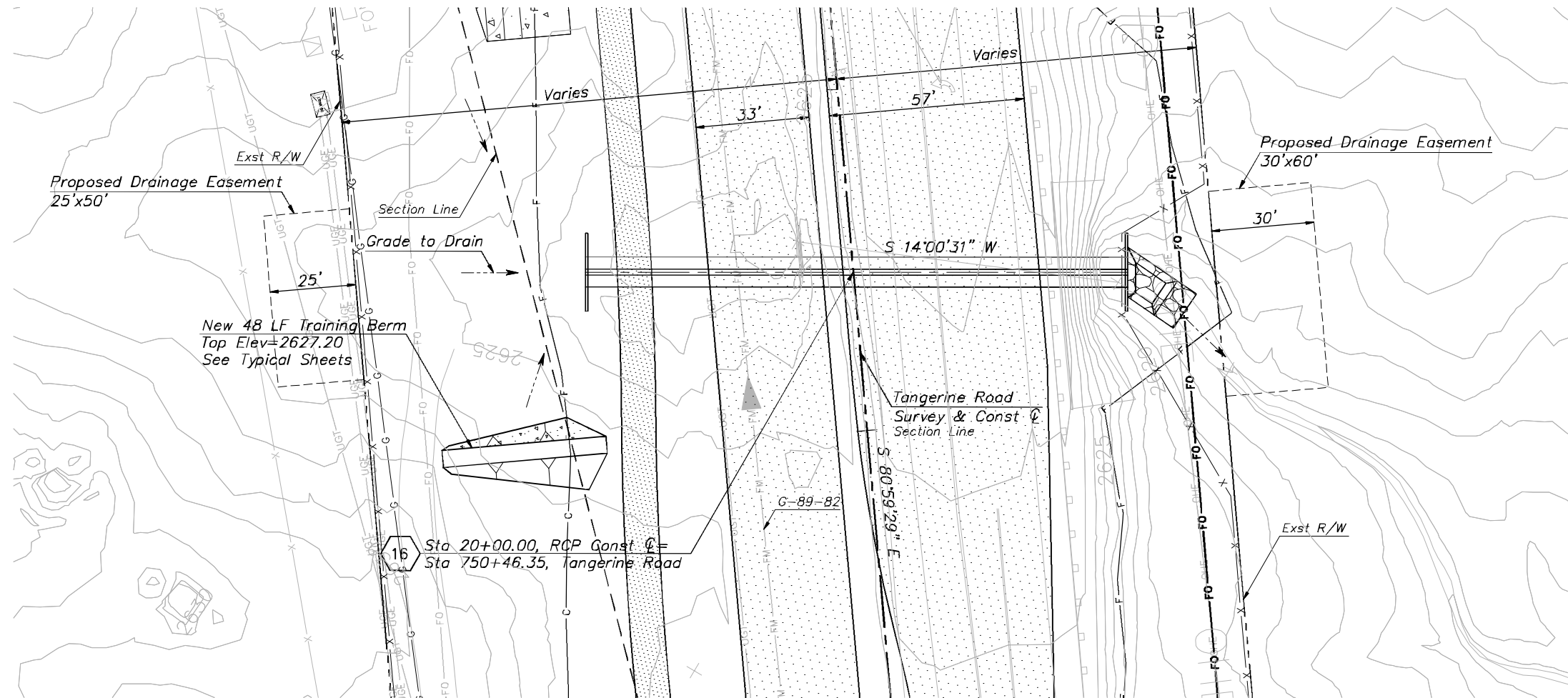
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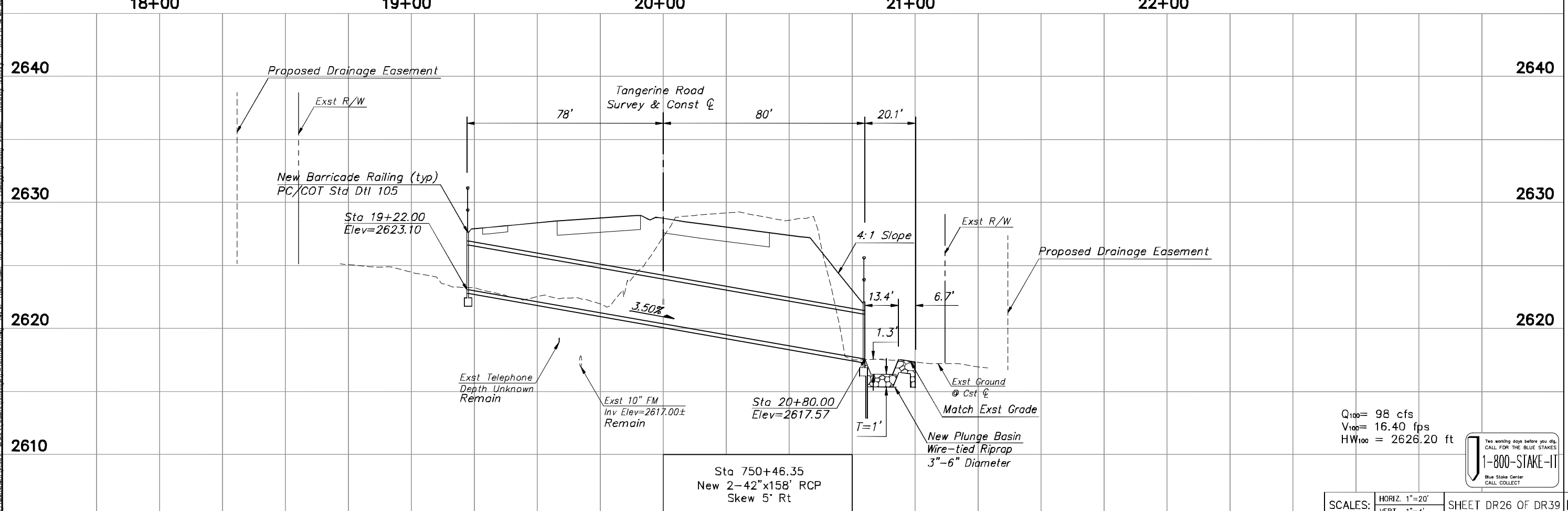
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TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE  
 FOR  
**TANGERINE ROAD**  
 STA 744+39.56  
 TANGERINE ROAD



- NOTES:
1. Inlet & outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11.
  2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
  3. Barricade railing shall be placed on headwalls as shown on the profile.



Sta 750+46.35  
New 2-42"x158' RCP  
Skew 5' Rt

Q<sub>100</sub> = 98 cfs  
V<sub>100</sub> = 16.40 fps  
HW<sub>100</sub> = 2626.20 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

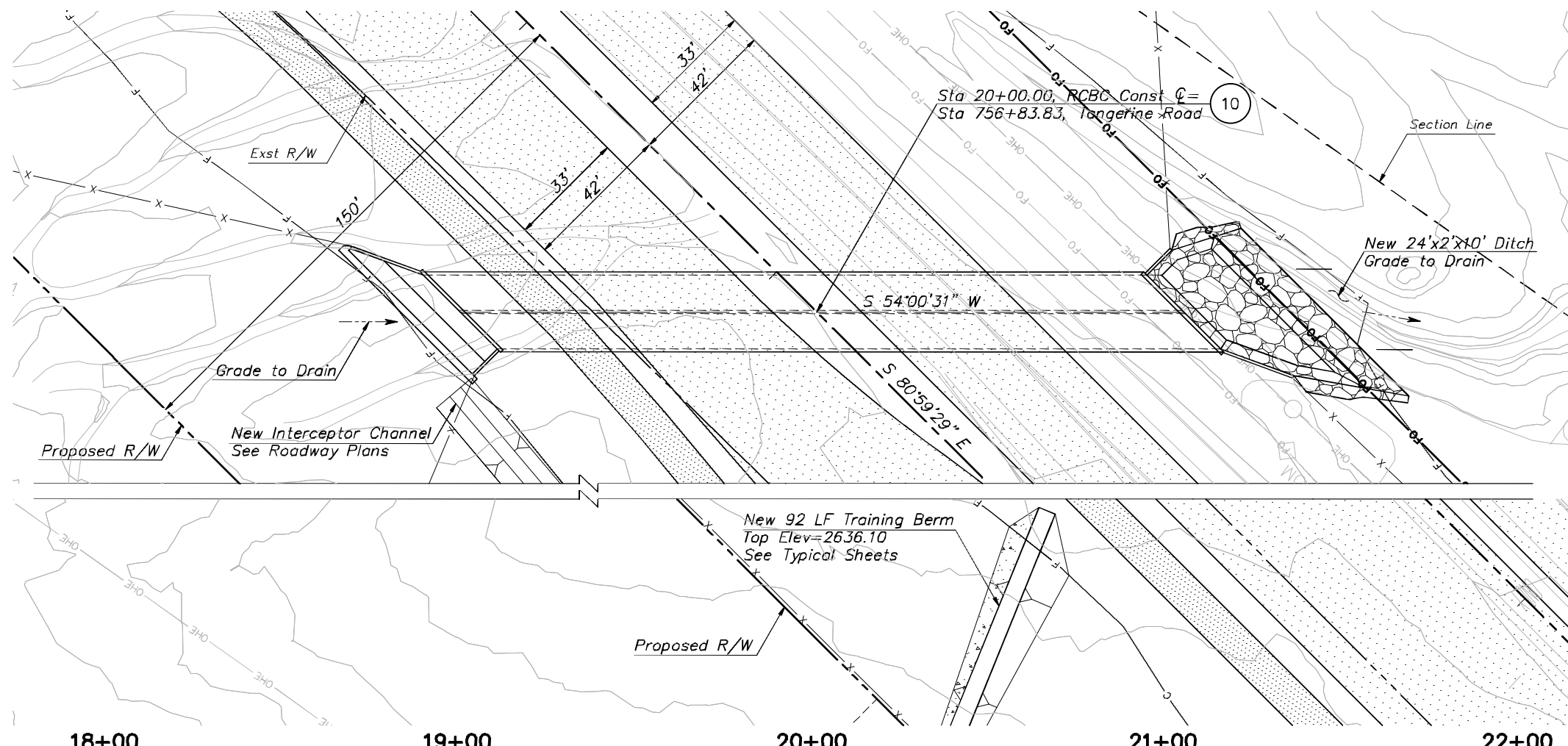
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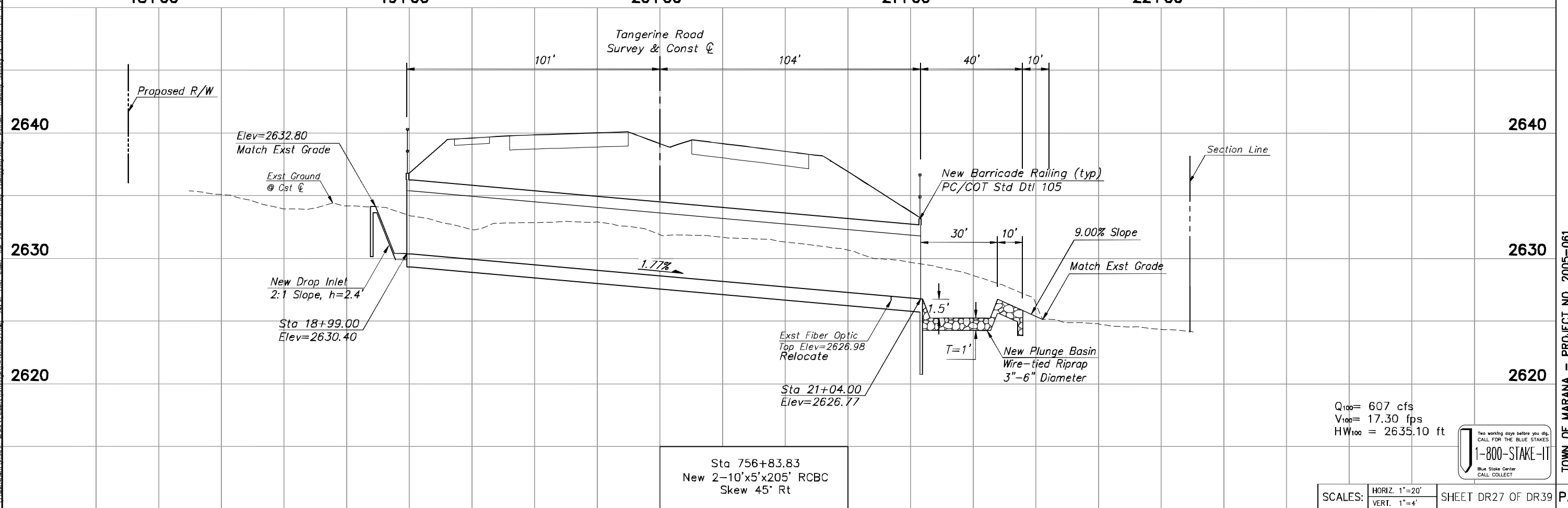
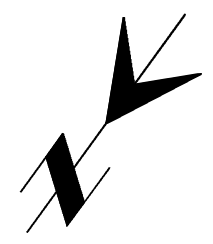
**P S O M A S**  
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(602) 292-2300 (602) 292-1290 fax  
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TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 750+46.35  
TANGERINE ROAD



**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on 45° skew, 4:1 slopes, and ADOT Std Dwg B-04.70.
2. Outlet headwall & wingwall dimensions shall be based on 45° skew, 6:1 slopes, and ADOT Std Dwg B-04.50.
3. Boxes shall be constructed per ADOT Std Dwg B-02.20.
4. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 4:1 slopes.
5. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.



Sta 756+83.83  
New 2-10'x5'x205' RCBC  
Skew 45° Rt

Q<sub>100</sub> = 607 cfs  
V<sub>100</sub> = 17.30 fps  
HW<sub>100</sub> = 2635.10 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

DESIGNED:	CZ	DATE:	12/12
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CHECKED:	AA	DRAWN:	12/12
PROJ. ENG.:	AA	CHECKED:	12/12
		PROJ. ENG.:	12/12

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

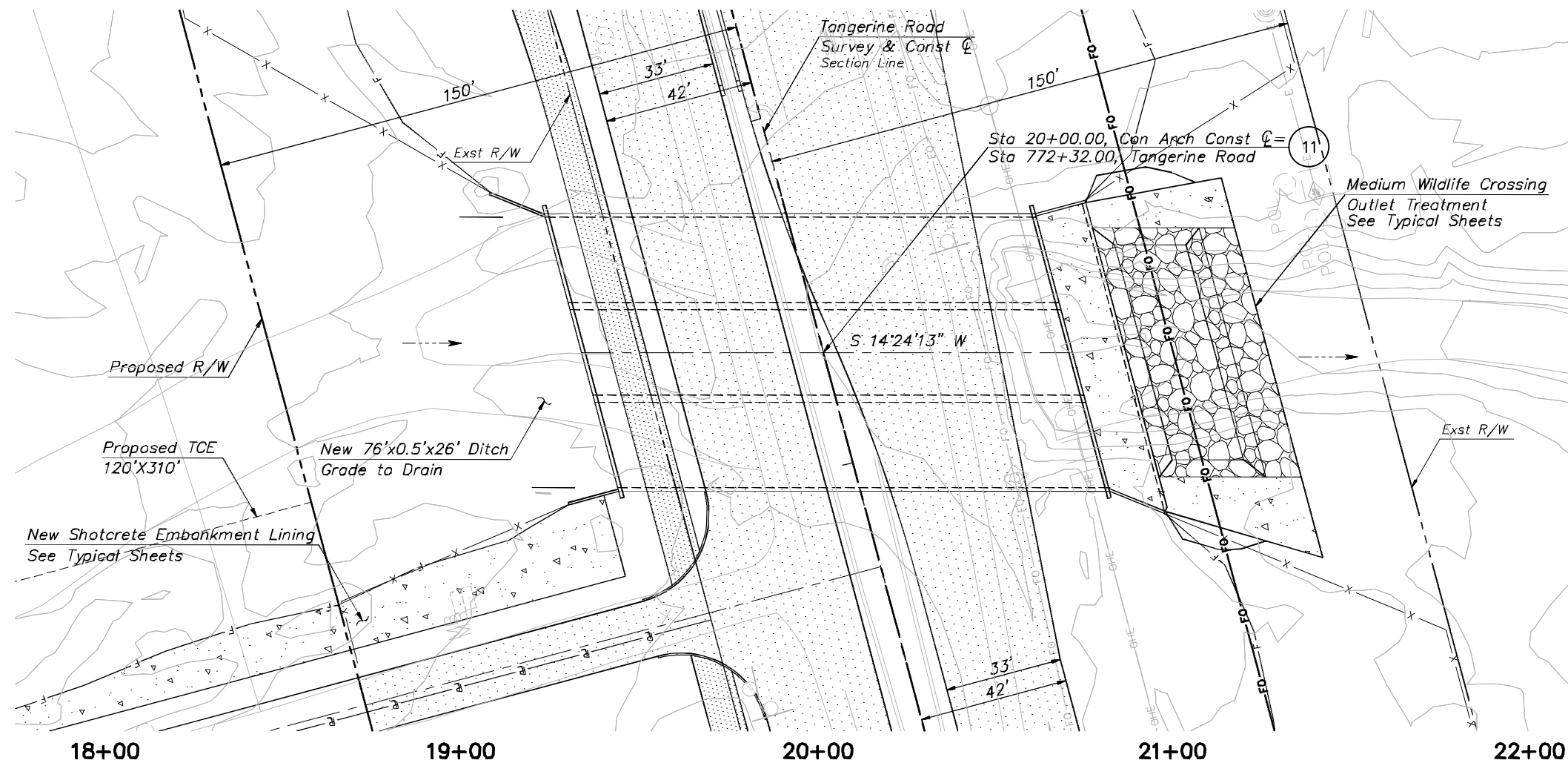
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TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 756+83.83  
TANGERINE ROAD

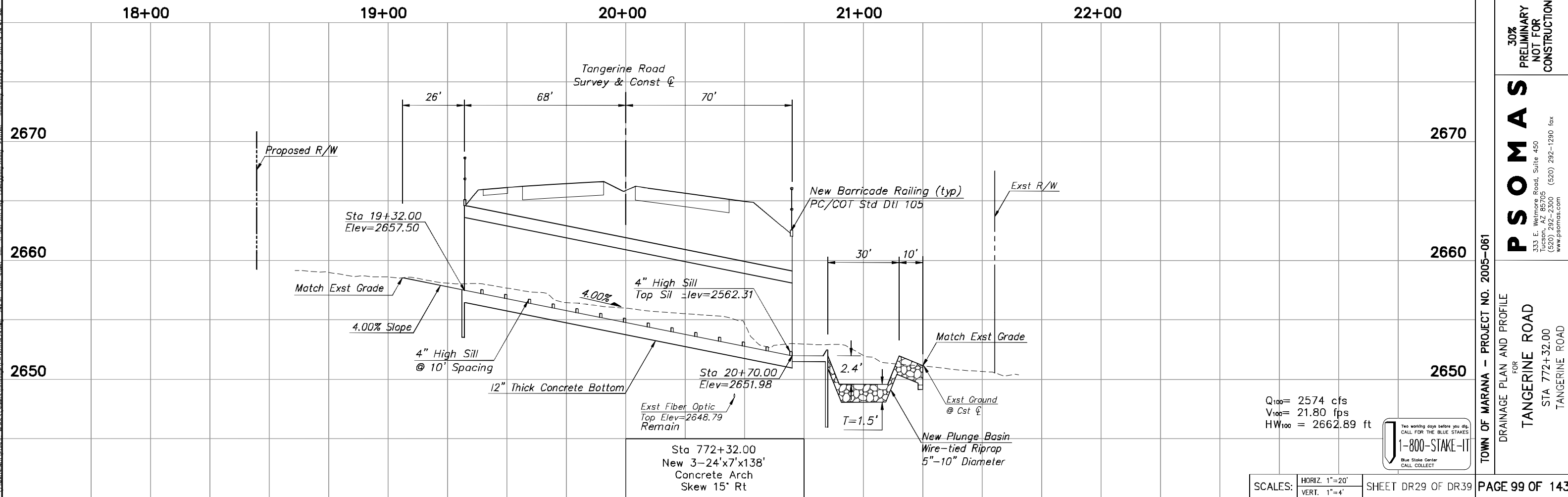






**NOTES:**

1. Concrete arch, headwalls, wingwalls, and outlet apron shall be based on manufacturer's design and specifications.
2. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 4:1 slopes.
3. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.



$Q_{100} = 2574$  cfs  
 $V_{100} = 21.80$  fps  
 $HW_{100} = 2662.89$  ft



DESIGNED:	DATE
CZ	12/12
DRAWN:	DATE
CZ	12/12
CHECKED:	DATE
AA	12/12
PROJ. ENG.:	DATE
AA	12/12

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

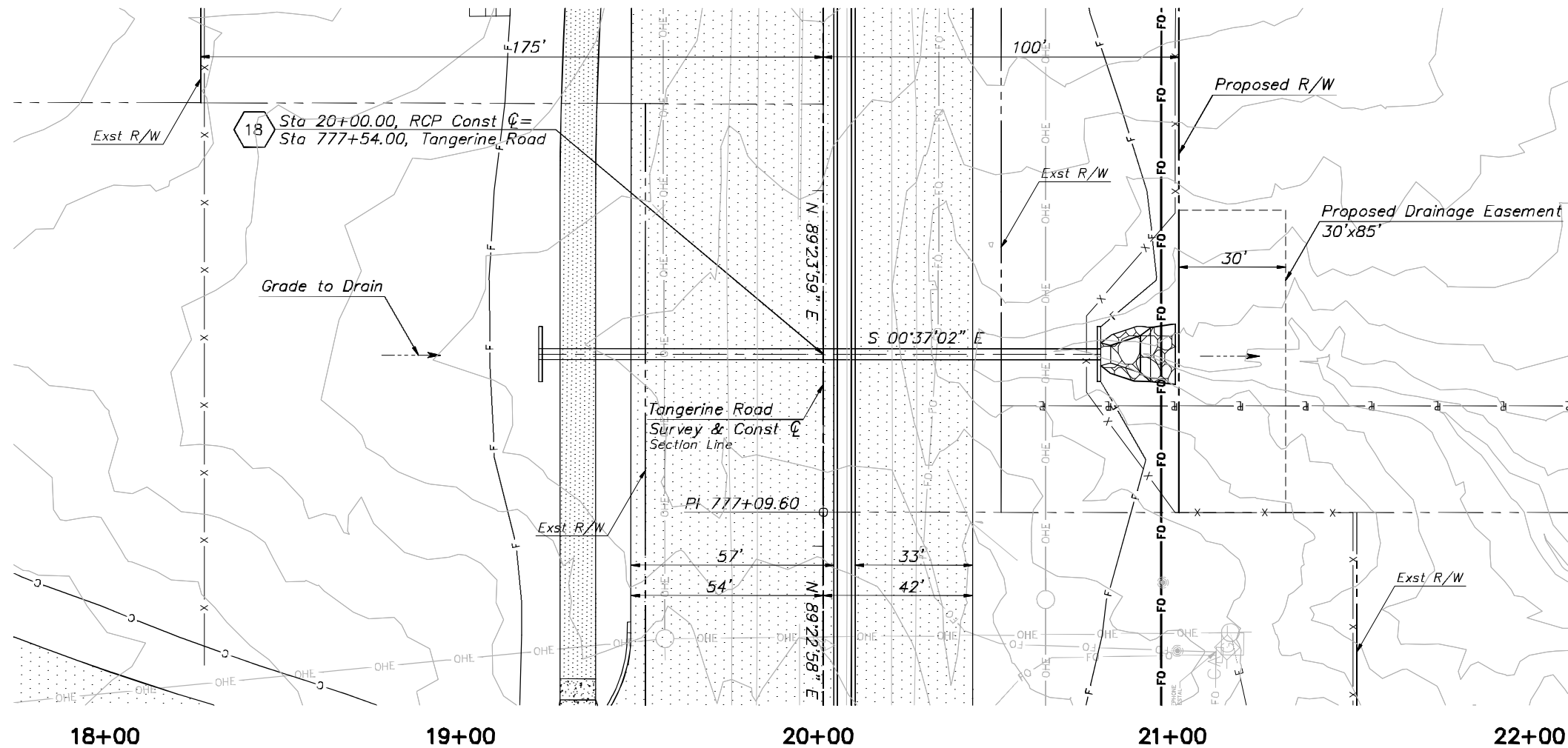
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 Tucson, AZ 85705  
 (520) 292-2500 (520) 292-1290 fax  
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TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD STA 772+32.00 TANGERINE ROAD

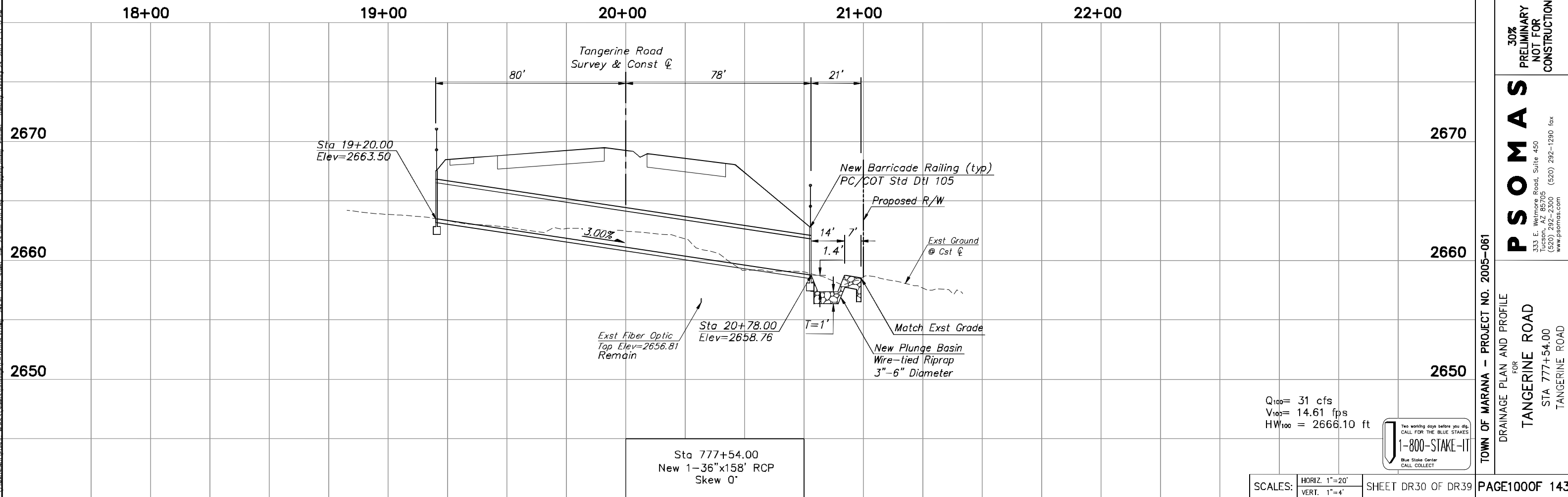
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**NOTES:**

1. Inlet & outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11.
2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
3. Barricade railing shall be placed on headwalls AS shown on the profile.



$Q_{100} = 31$  cfs  
 $V_{100} = 14.61$  fps  
 $HW_{100} = 2666.10$  ft

Two working days before you dig,  
 CALL FOR THE BLUE STAKES!  
**1-800-STAKE-IT**  
 Blue Stake Center  
 CALL COLLECT

Sta 777+54.00  
 New 1-36"x158' RCP  
 Skew 0°

DESIGNED:	CZ	DATE:	12/12
DRAWN:	CZ	DATE:	12/12
CHECKED:	AA	DATE:	12/12
PROJ. ENG.:	AA	DATE:	12/12

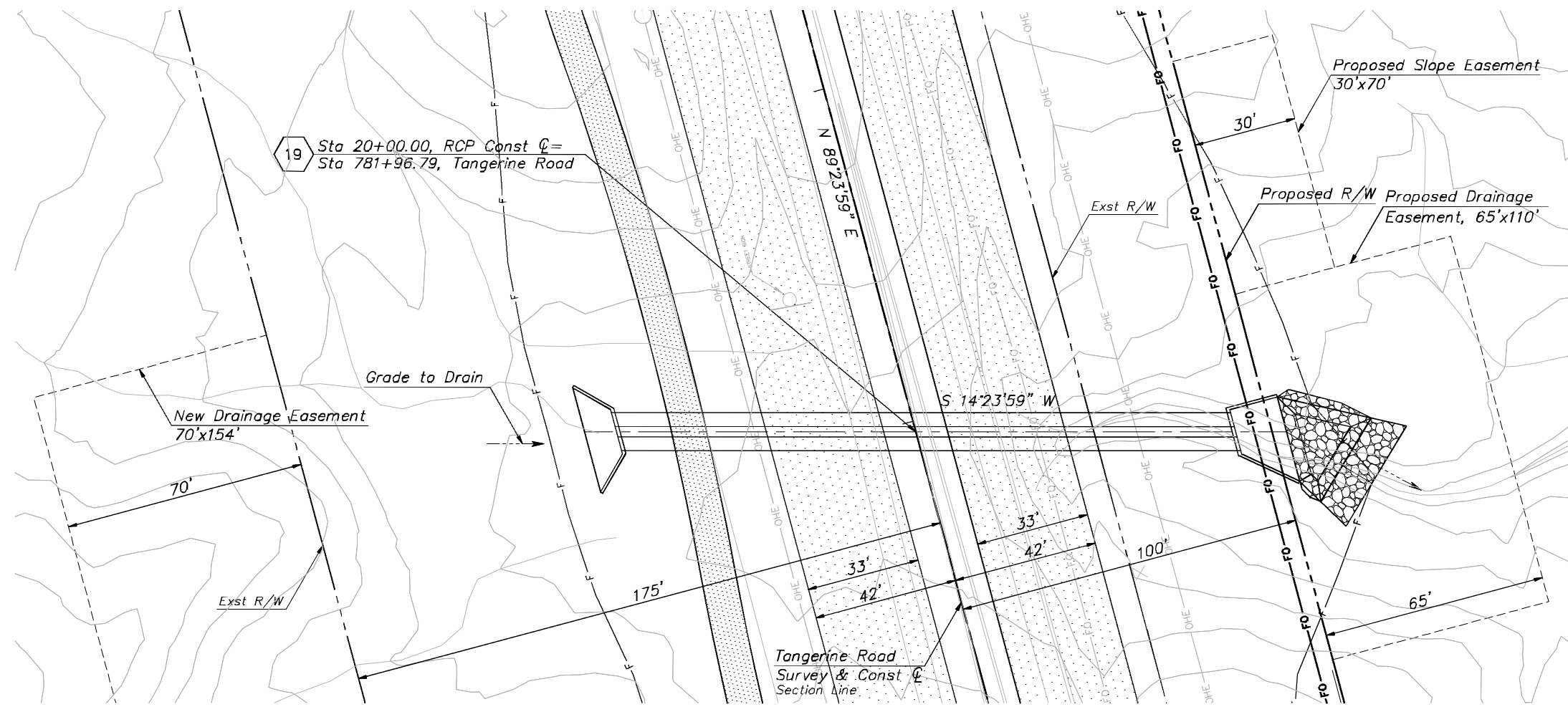
  

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TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE  
 FOR  
**TANGERINE ROAD**  
 STA 777+54.00  
 TANGERINE ROAD

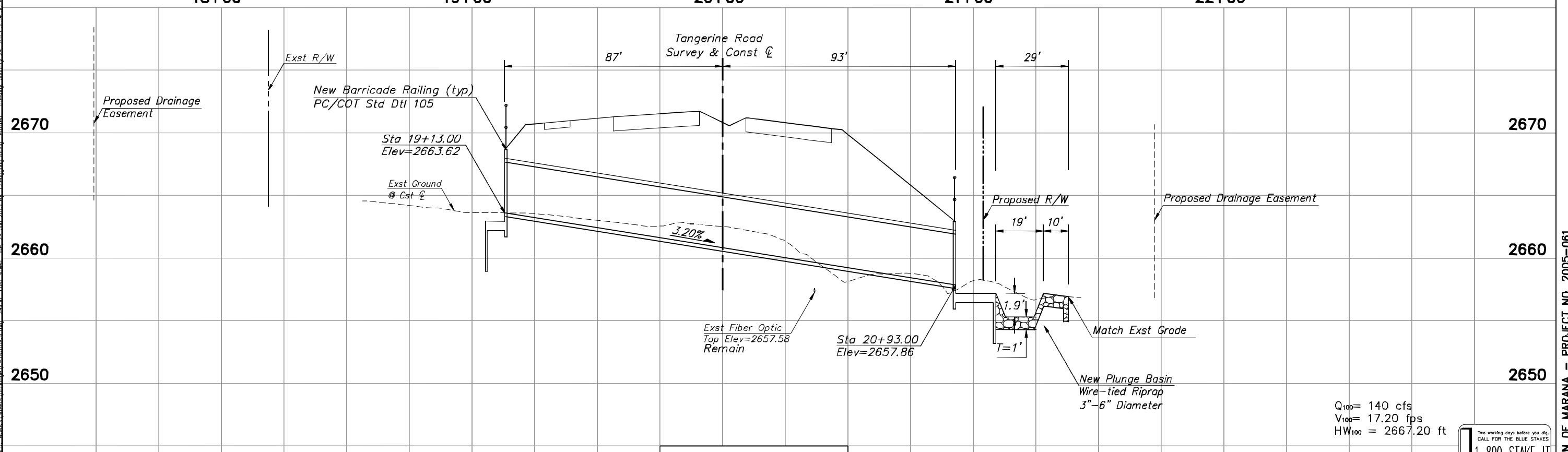
**PSOMAS**  
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 Tucson, AZ 85705  
 (520) 292-2300 (520) 292-1290 fax  
 www.psomas.com

30% PRELIMINARY NOT FOR CONSTRUCTION



**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13,  $\theta=45^\circ$ ;  $E=9'$ ,  $F=9'$ ,  $G=9'$ .
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13,  $\theta=50^\circ$ ;  $E=14'-3"$ ,  $F=12'$ ,  $G=0'$ .
3. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
4. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.



Sta 781+96.79  
New 2-48"x180' RCP  
Skew 15' Rt

$Q_{100} = 140$  cfs  
 $V_{100} = 17.20$  fps  
 $HW_{100} = 2667.20$  ft



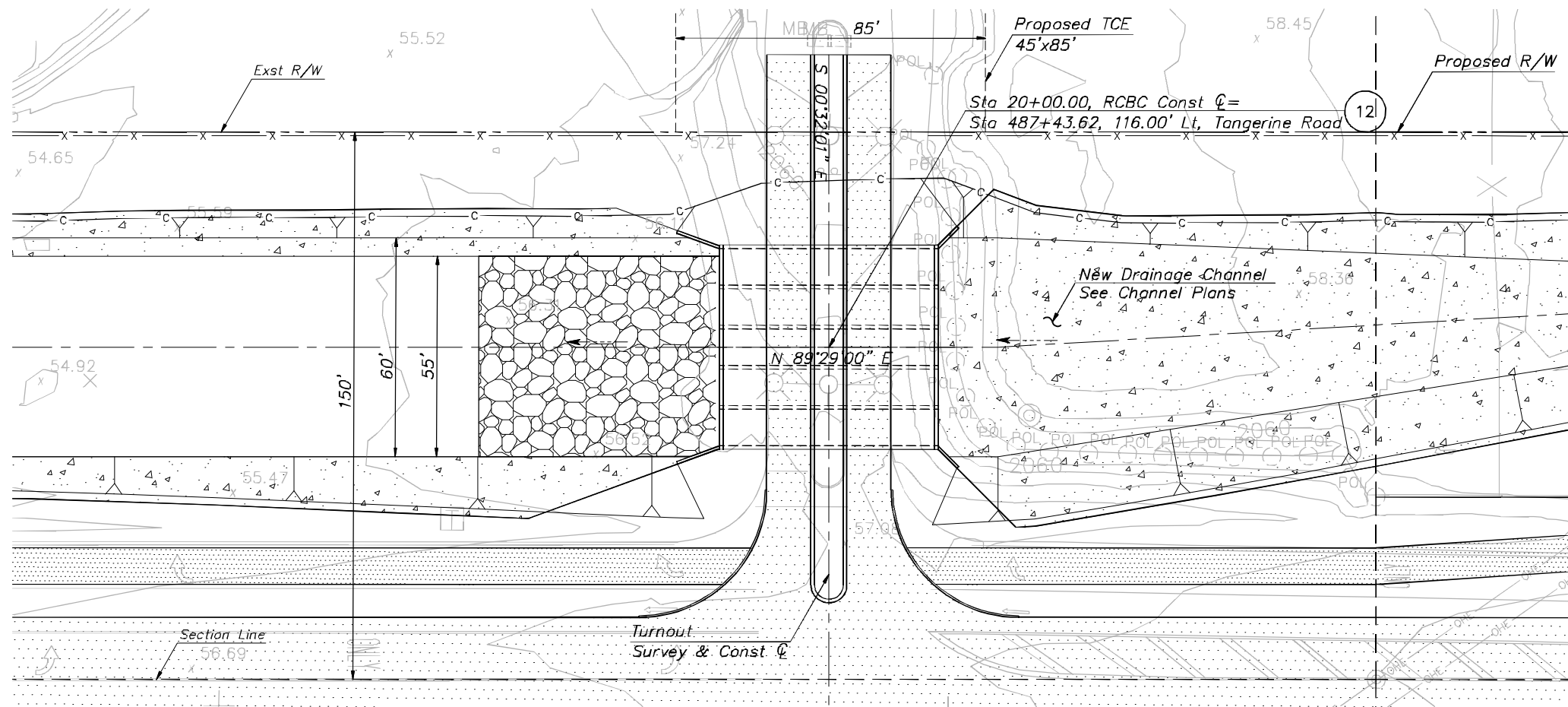
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DRAWN:	CZ	DATE:	12/12
CHECKED:	AA	DATE:	12/12
PROJ. ENG.:	AA	DATE:	12/12

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

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CONSTRUCTION

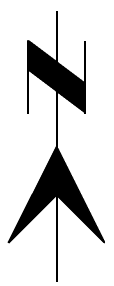
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333 E. Weirmere Road, Suite 450  
Tucson, AZ 85705  
(520) 292-2500 (520) 292-1290 fax  
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TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
TANGERINE ROAD  
STA 781+96.79  
TANGERINE ROAD

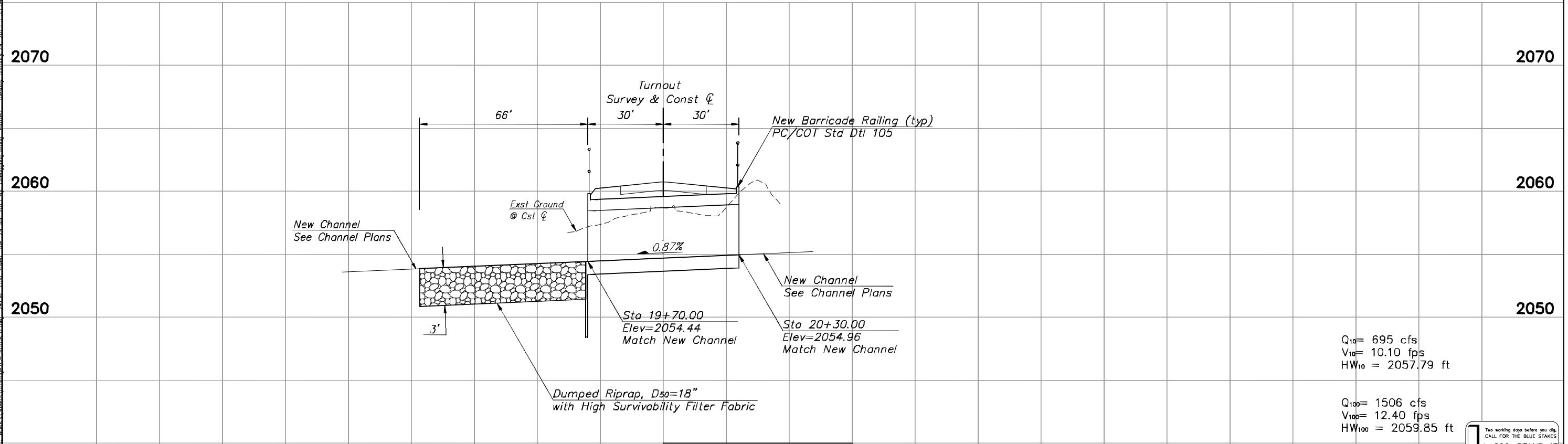


**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.70.
2. Outlet headwall dimensions shall be based on ADOT Std Dwg B-04.50.
3. Boxes shall be constructed per ADOT Std Dwg B-02.50.
4. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.



18+00                      19+00                      20+00                      21+00                      22+00



$Q_{10} = 695$  cfs  
 $V_{10} = 10.10$  fps  
 $HW_{10} = 2057.79$  ft  
  
 $Q_{100} = 1506$  cfs  
 $V_{100} = 12.40$  fps  
 $HW_{100} = 2059.85$  ft

Sta 487+43.62, 116.00' Lt  
New 5-10'x4'x60' RCBC  
Skew 0°

Two working days before you dig,  
CALL FOR THE BLUE STAKES!  
1-800-STAKE-IT  
Blue Stake Center  
CALL COLLECT

SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

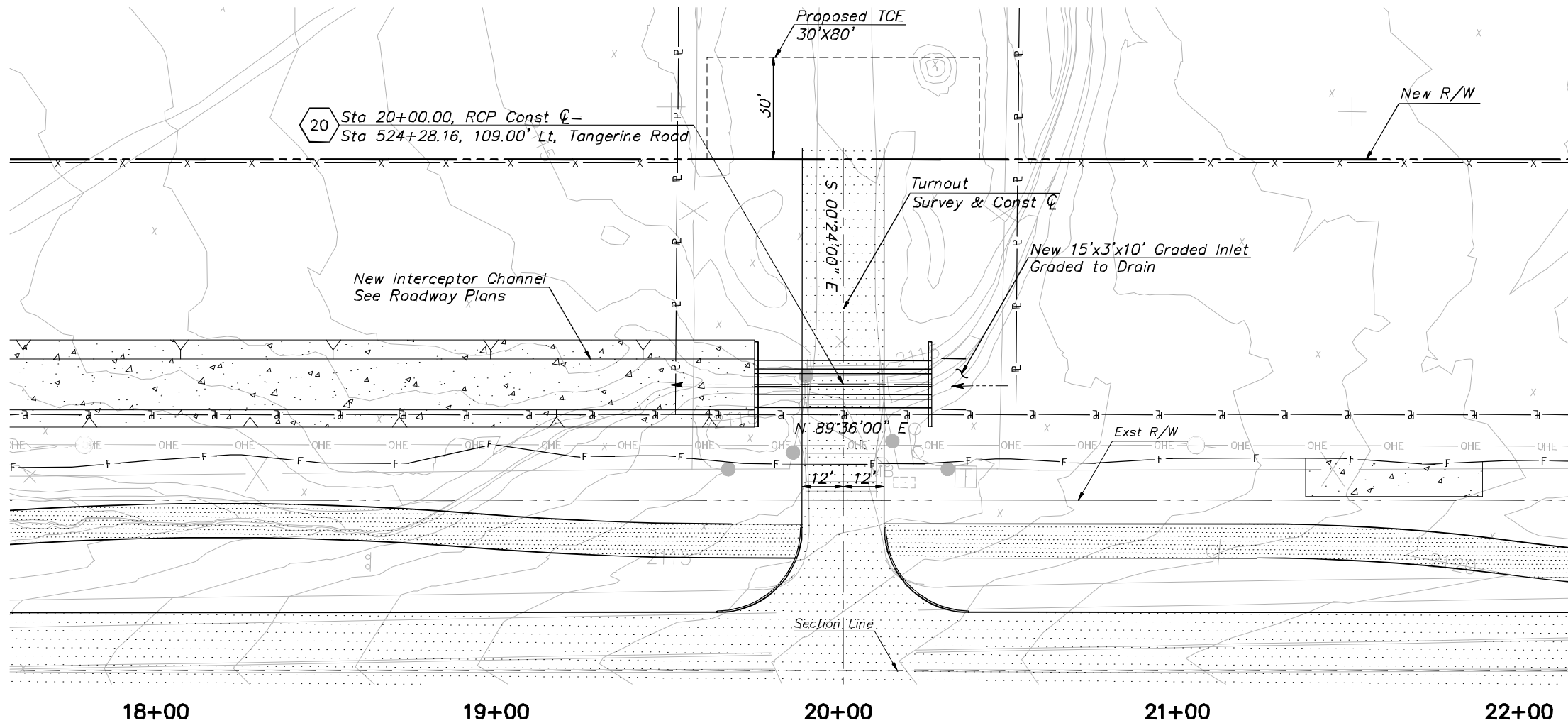
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DRAWN:	CZ	DATE:	12/12
CHECKED:	AA	DATE:	12/12
PROJ. ENG.:	AA	DATE:	12/12

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

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TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
TANGERINE ROAD  
STA 487+43.62  
TANGERINE ROAD



NOTES:

1. Inlet & Outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11.
2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
3. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 4:1 slopes.
4. Barricade railing shall be placed on headwalls as shown on the profile.

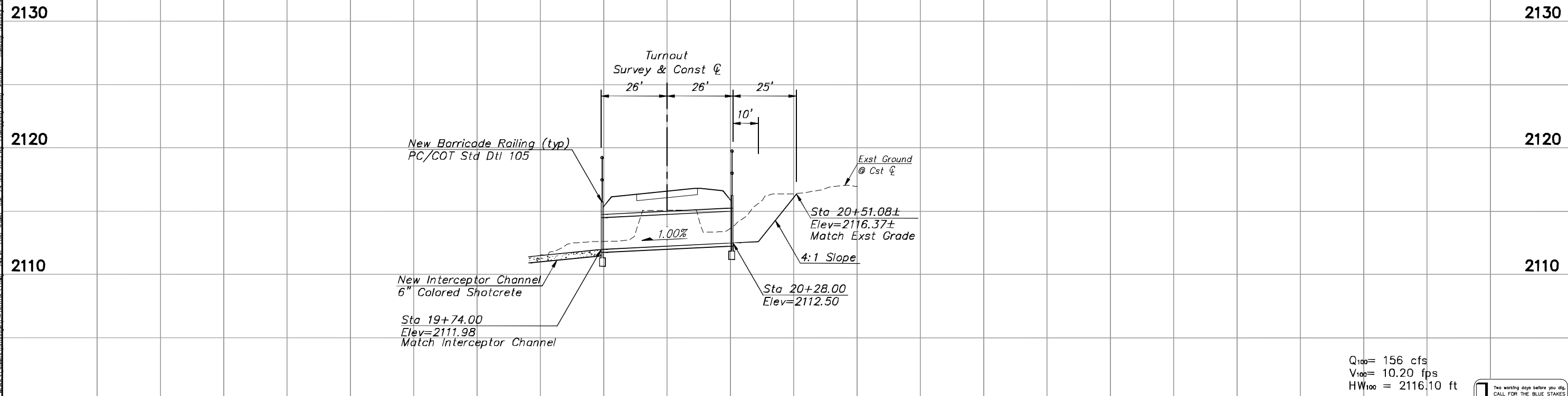
18+00

19+00

20+00

21+00

22+00



Q<sub>100</sub> = 156 cfs  
 V<sub>100</sub> = 10.20 fps  
 HW<sub>100</sub> = 2116.10 ft



Sta 524+28.16, 109.00' Lt  
 New 4-30"x52' RCP  
 Skew 0'

SCALES: HORIZ. 1"=20'  
 VERT. 1"=4'

TOWN OF MARANA - PROJECT NO. 2005-061

DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD

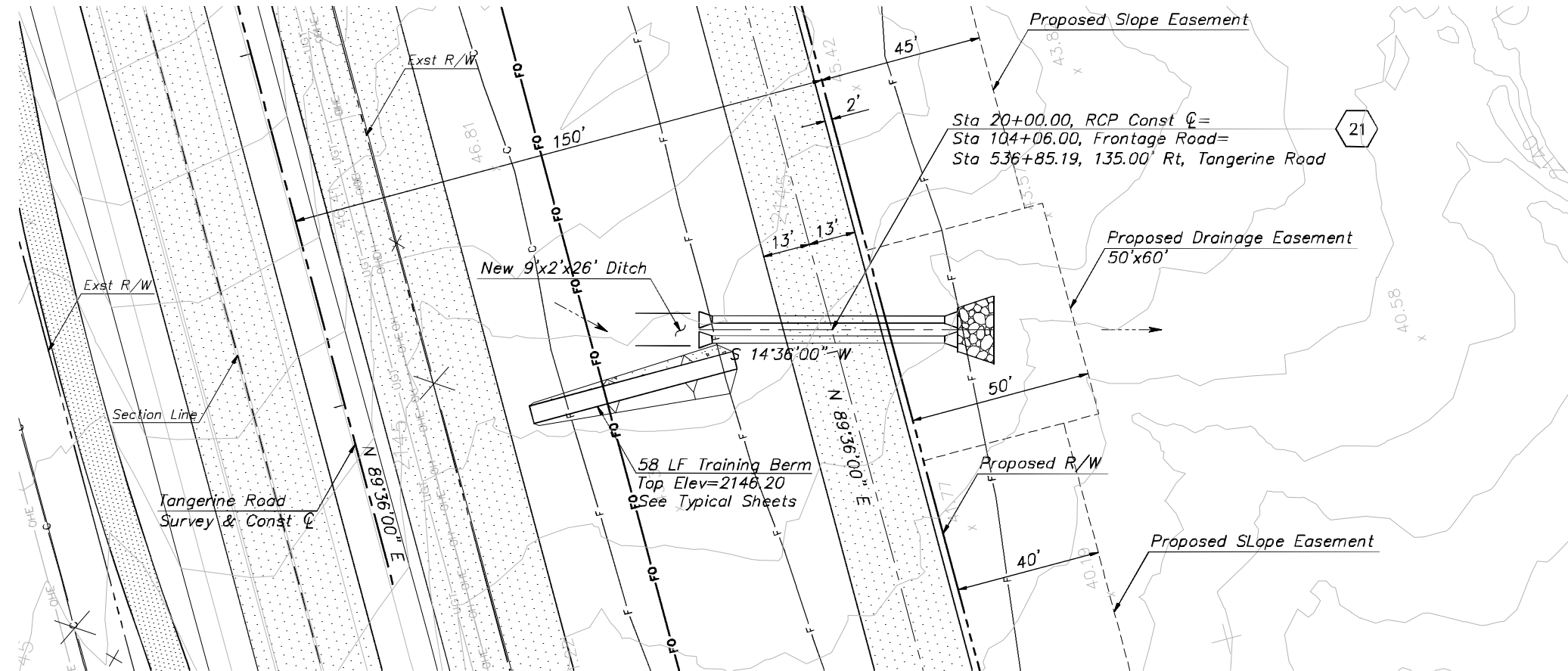
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NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

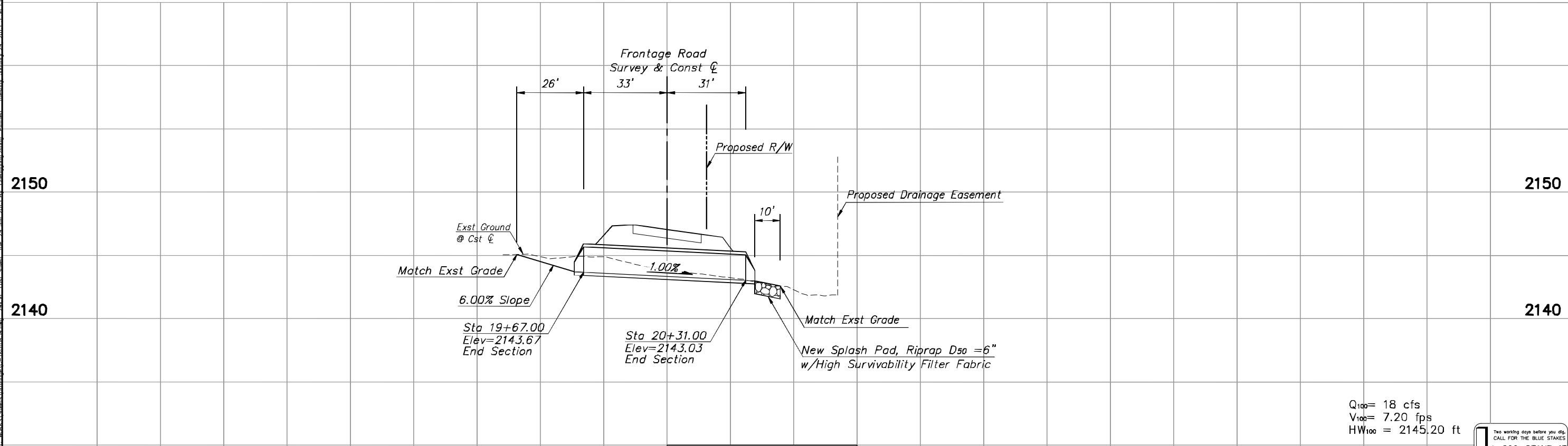
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CZ	12/12
DRAWN:	DATE
CZ	12/12
CHECKED:	DATE
AA	12/12
PROJ. ENG.:	DATE
AA	12/12



**NOTES:**

1. End sections shall be based on ADOT Std Dwg C-13.20.
2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
3. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 4:1 slopes.

18+00                      19+00                      20+00                      21+00                      22+00



Q<sub>100</sub> = 18 cfs  
 V<sub>100</sub> = 7.20 fps  
 HW<sub>100</sub> = 2145.20 ft



SCALES: HORIZ. 1"=20'  
 VERT. 1"=4'

DESIGNED:	CZ	DATE:	12/12
DRAWN:	CZ	CHECKED:	AA
PROJECT:	AA	PROJ. ENG.:	AA

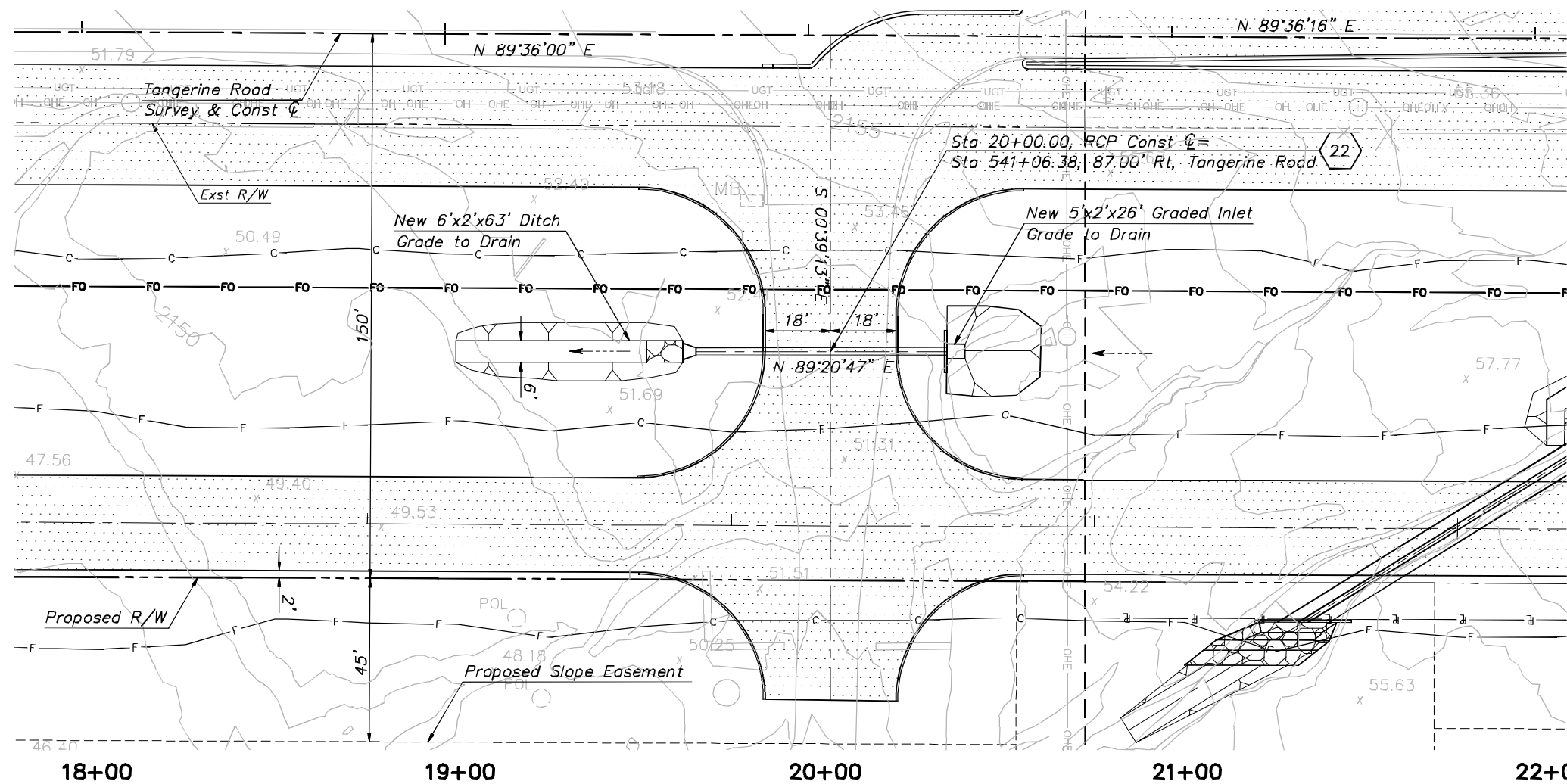
NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

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 333 E. Weirmere Road, Suite 450  
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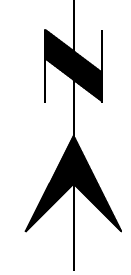
TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE FOR  
**TANGERINE ROAD**  
 STA 104+06.00  
 FRONTAGE ROAD

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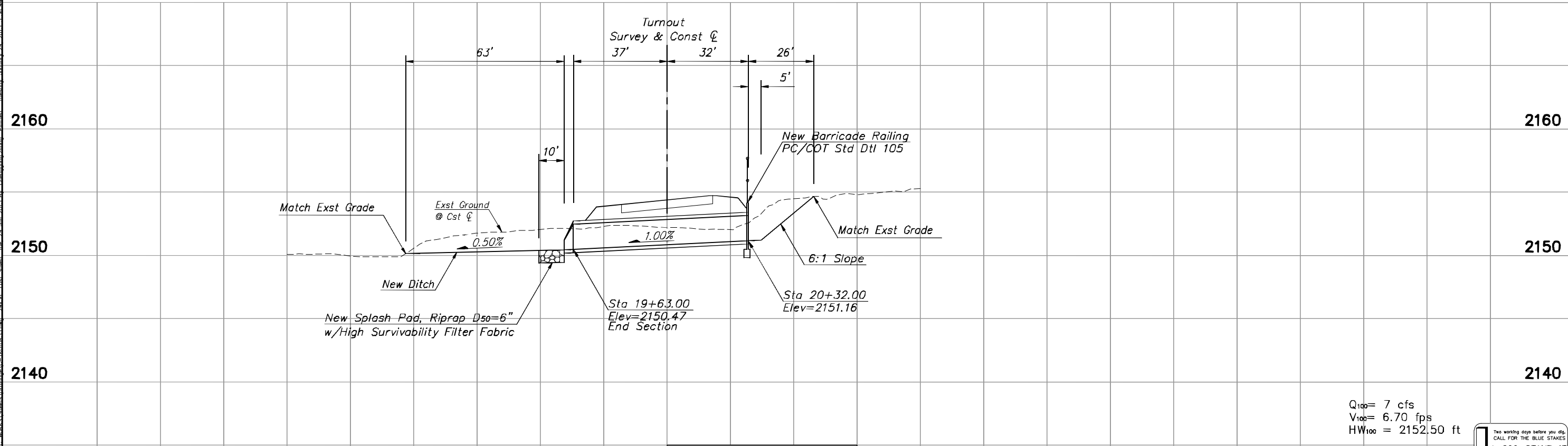


**NOTES:**

1. Headwall shall be based on ADOT Std Dwg B-11.11.
2. End section shall be based on ADOT Std Dwg C-13.20.
3. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
4. Ditch & Graded Inlet dimensions shall be based on ADOT Std Dwg C-03.10 with 3:1 slopes.



T:\21100\0401\1\BIBLIC\_M08\CS\Sheets\Drainage\AC-1801DR35.dwg - 2/6/16 - Last Saved: Tue, 20 Jan 2013 10:36:44 PM



Sta 541+06.38, 87.00' Rt  
New 1-24"x69' RCP  
Skew 0'

Q<sub>100</sub> = 7 cfs  
V<sub>100</sub> = 6.70 fps  
HW<sub>100</sub> = 2152.50 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

TOWN OF MARANA - PROJECT NO. 2005-061

DRAINAGE PLAN AND PROFILE

FOR  
TANGERINE ROAD

STA 541+06.38  
TANGERINE ROAD

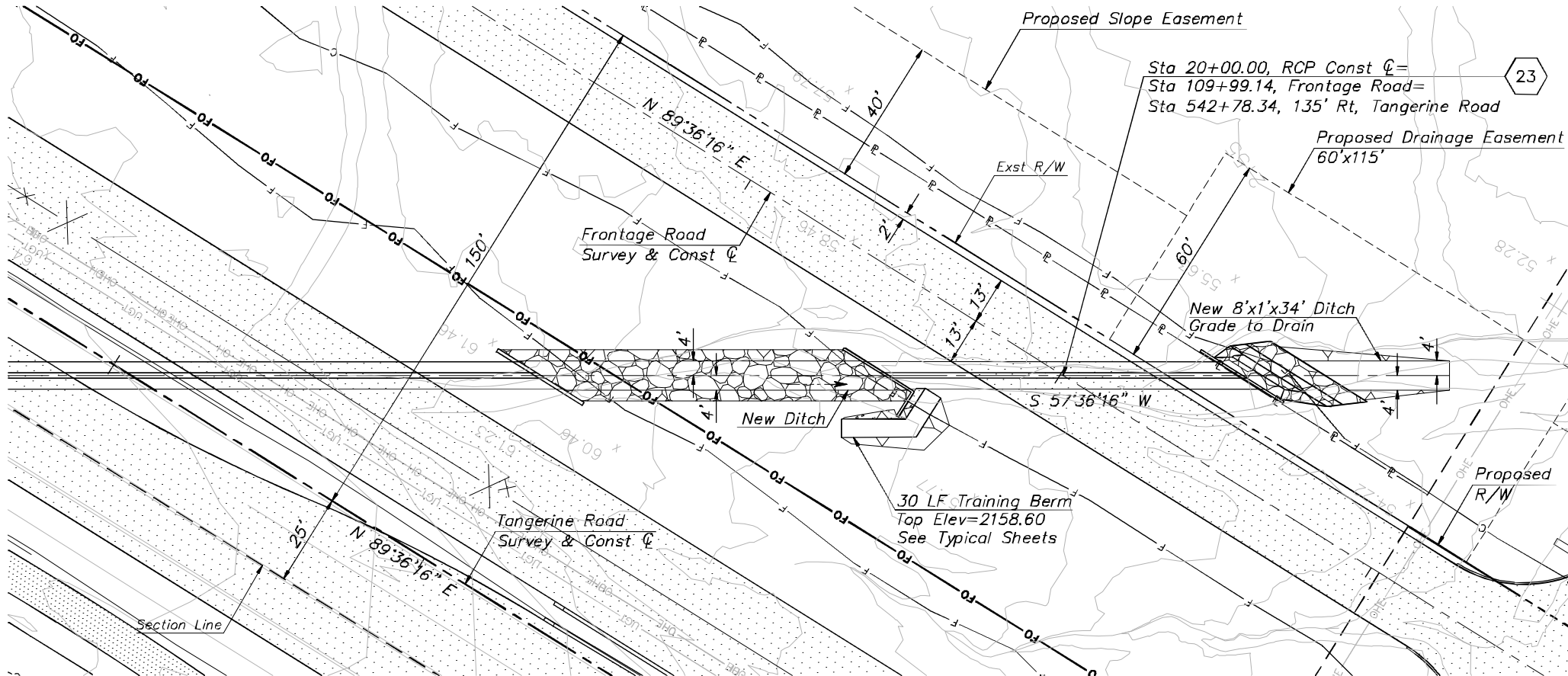
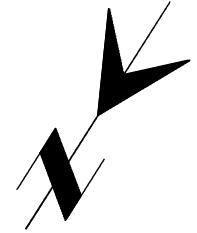
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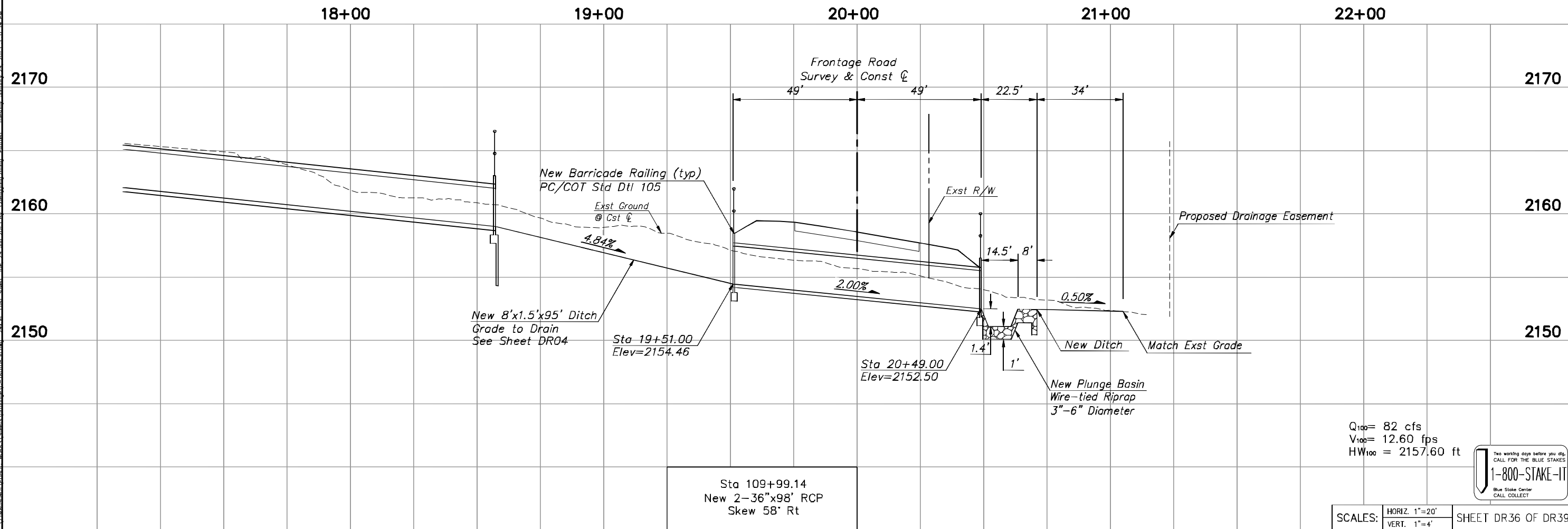
NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

DESIGNED:	DATE
CZ	12/12
DRAWN:	DATE
CZ	12/12
CHECKED:	DATE
AA	12/12
PROJ. ENG.:	DATE
AA	12/12



**NOTES:**

1. Inlet & outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11.
2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
3. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 3:1 slopes.
4. Barricade railing shall be placed on headwalls as shown on the profile.



Sta 109+99.14  
New 2-36"x98' RCP  
Skew 58' Rt

Q<sub>100</sub> = 82 cfs  
V<sub>100</sub> = 12.60 fps  
HW<sub>100</sub> = 2157.60 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

DESIGNED:	CZ	DATE:	12/12
DRAWN:	CZ	CHECKED:	AA
PROJ. ENG.:	AA		

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

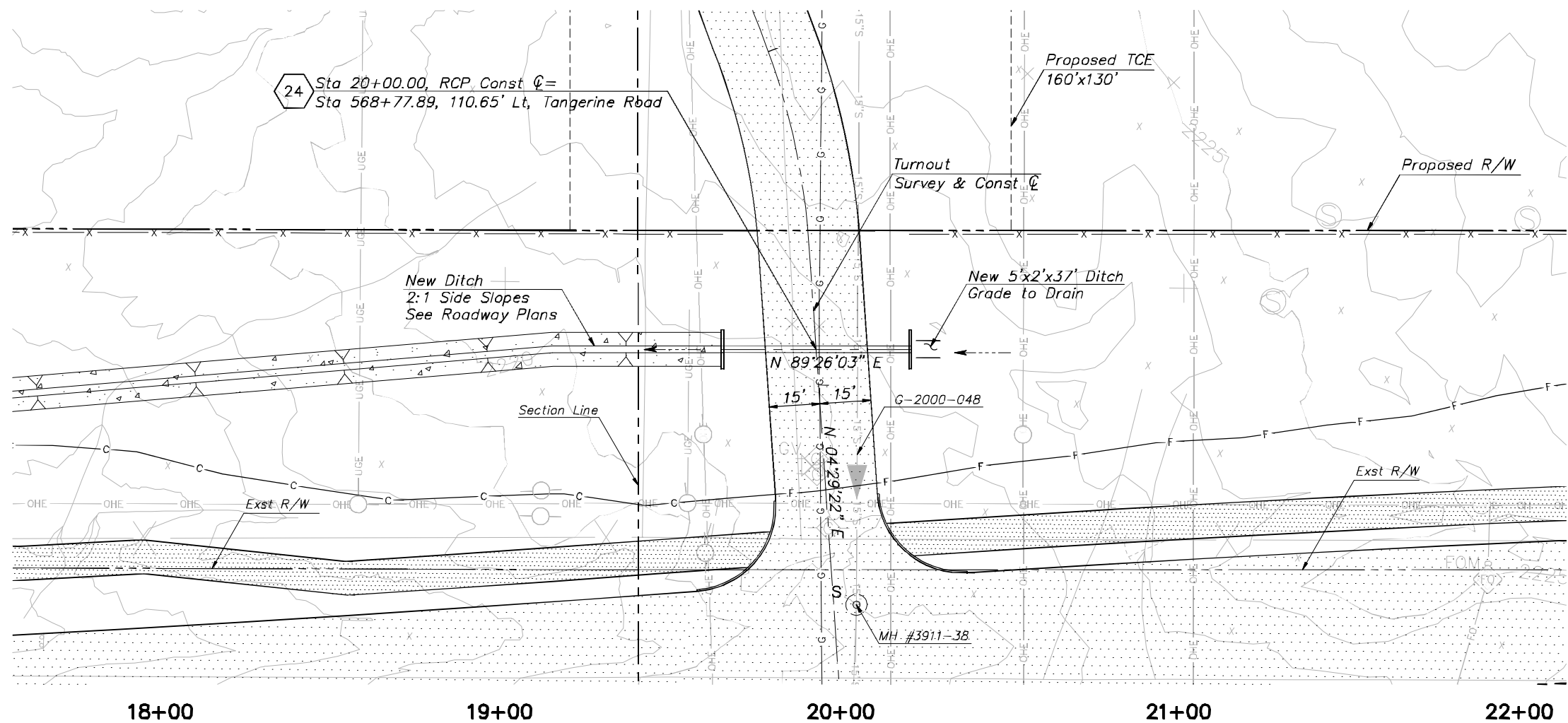
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CONSTRUCTION

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TOWN OF MARANA - PROJECT NO. 2005-061

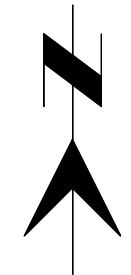
DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 109+99.14  
FRONTAGE ROAD

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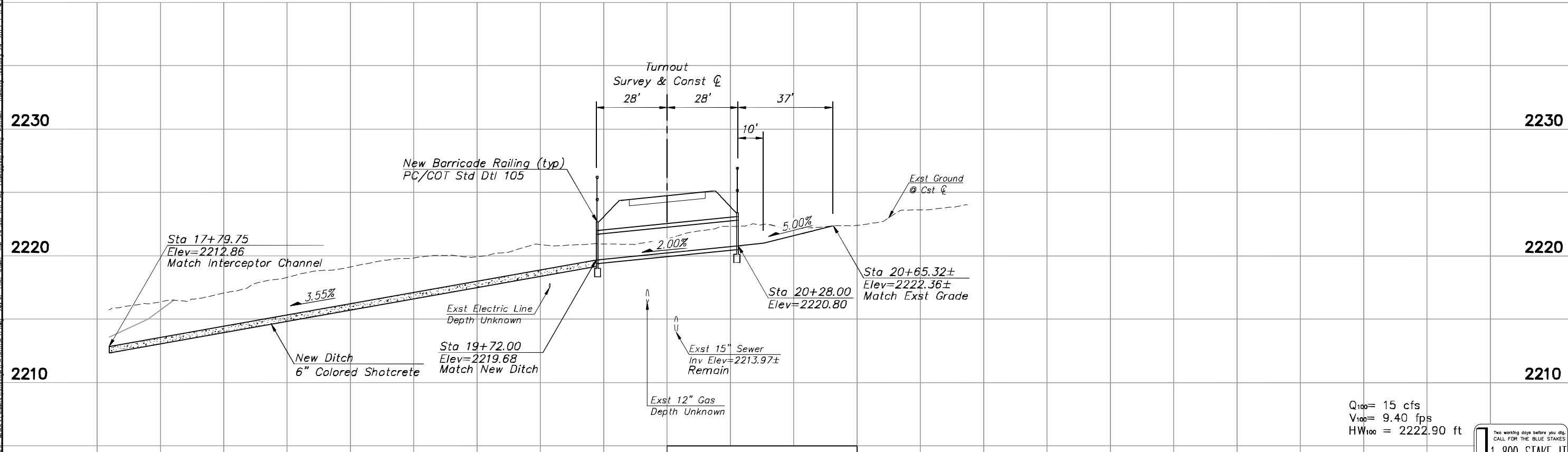


**NOTES:**

1. Inlet & Outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11.
2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
3. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 3:1 slopes unless otherwise noted.
4. Barricade railing shall be placed on headwalls as shown on the profile.



18+00                      19+00                      20+00                      21+00                      22+00



Sta 568+77.89, 110.65' Lt  
New 1-24"x56' RCP  
Skew 4' Rt

Q<sub>100</sub> = 15 cfs  
V<sub>100</sub> = 9.40 fps  
HW<sub>100</sub> = 2222.90 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

DESIGNED:	CZ	DATE:	12/12
DRAWN:	CZ	CHECKED:	AA
PROJECT ENG.:	AA	DATE:	12/12

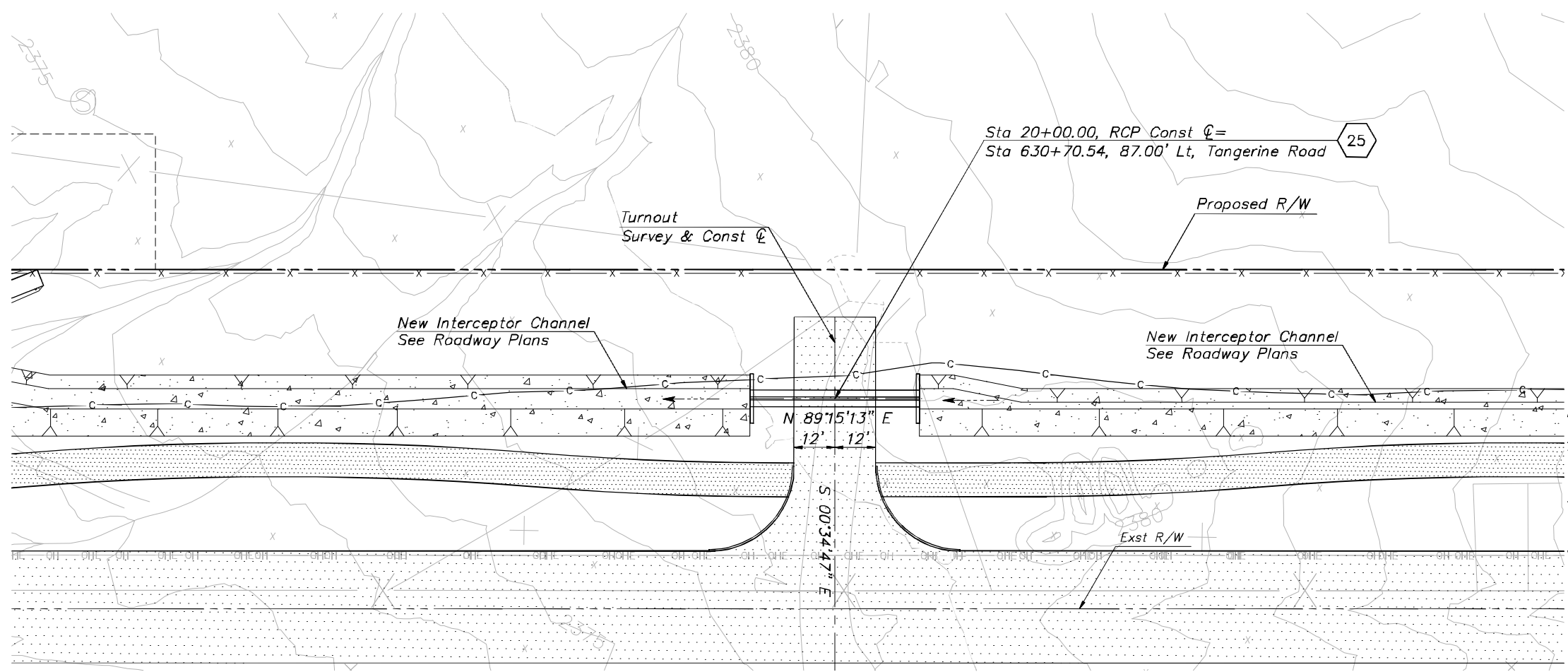
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CONSTRUCTION

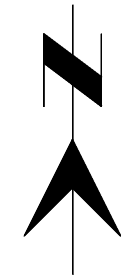
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TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
TANGERINE ROAD  
STA 568+77.89  
TANGERINE ROAD





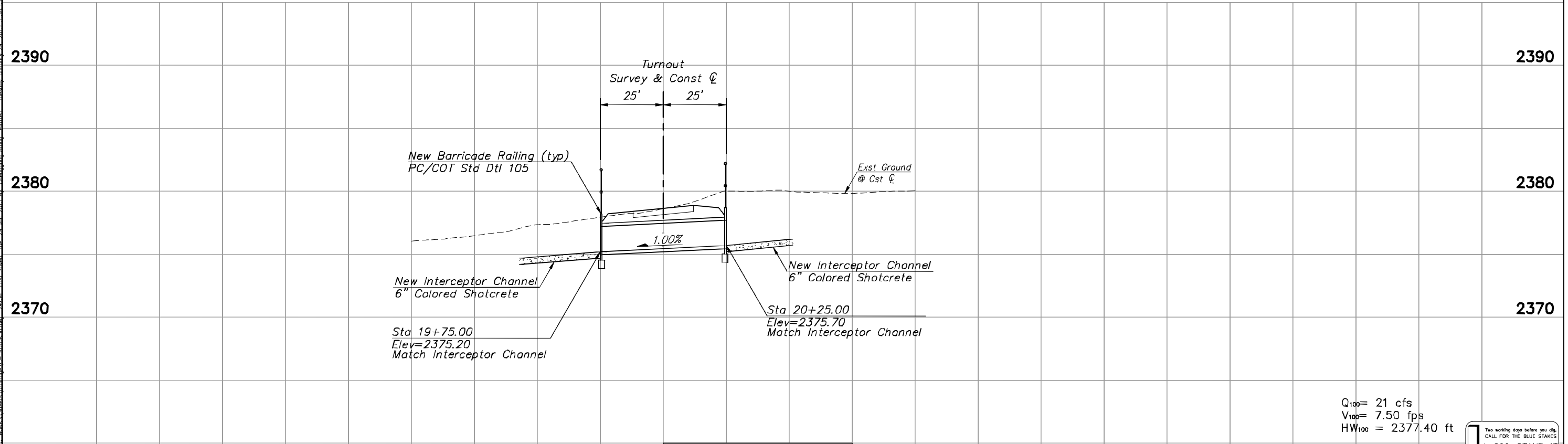
Sta 20+00.00, RCP Const  $\phi$ =  
 Sta 630+70.54, 87.00' Lt, Tangerine Road



NOTES:

1. Inlet & Outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11.
2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
3. Barricade railing shall be placed on headwalls as shown on the profile.

18+00                      19+00                      20+00                      21+00                      22+00



Sta 630+70.54, 87.00' Lt  
 New 2-24"x50' RCP  
 Skew 0'

Q<sub>100</sub> = 21 cfs  
 V<sub>100</sub> = 7.50 fps  
 HW<sub>100</sub> = 2377.40 ft



SCALES: HORIZ. 1"=20'  
 VERT. 1"=4'

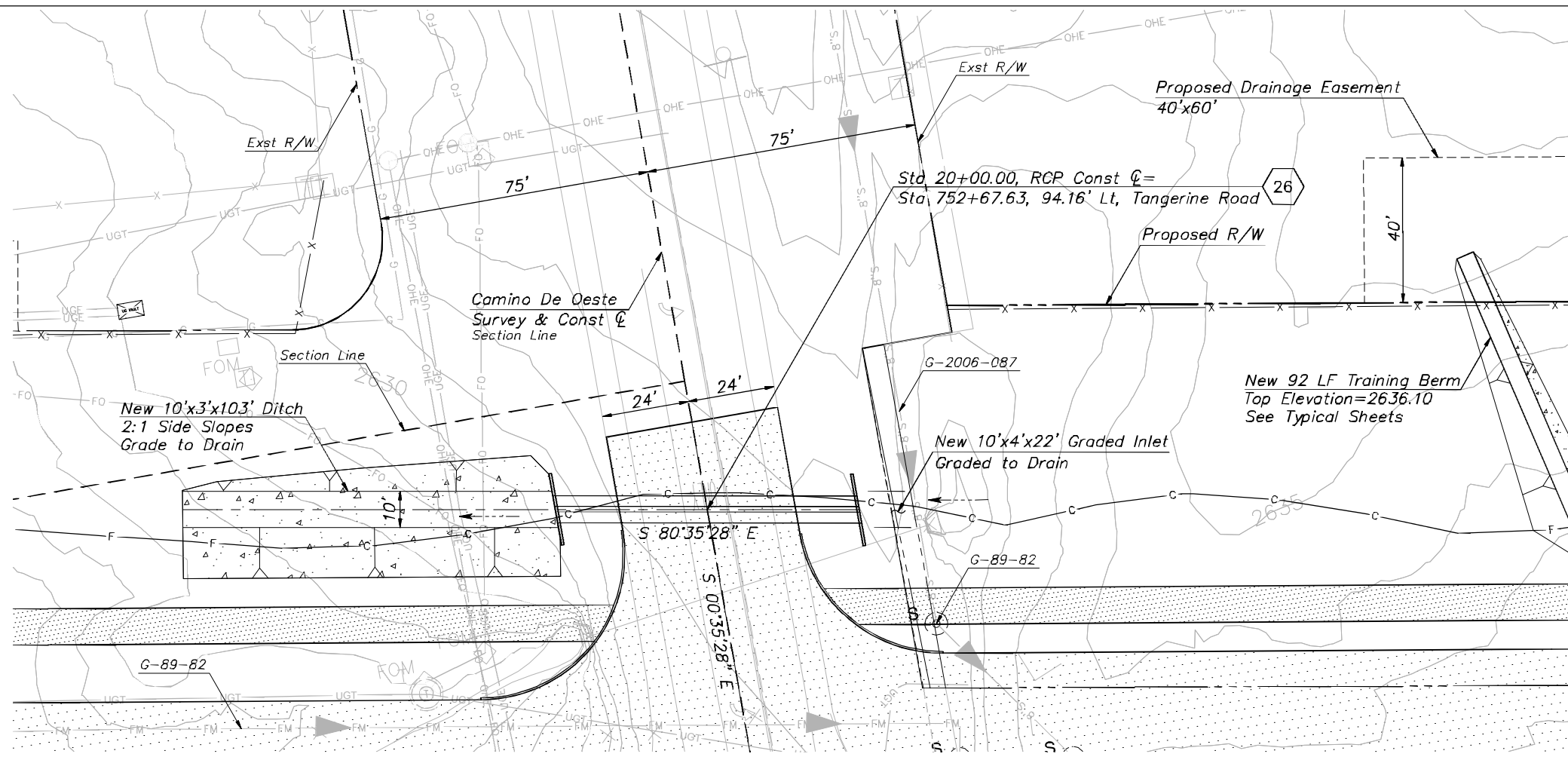
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PROJ. ENG.:	AA	DATE:	12/12

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

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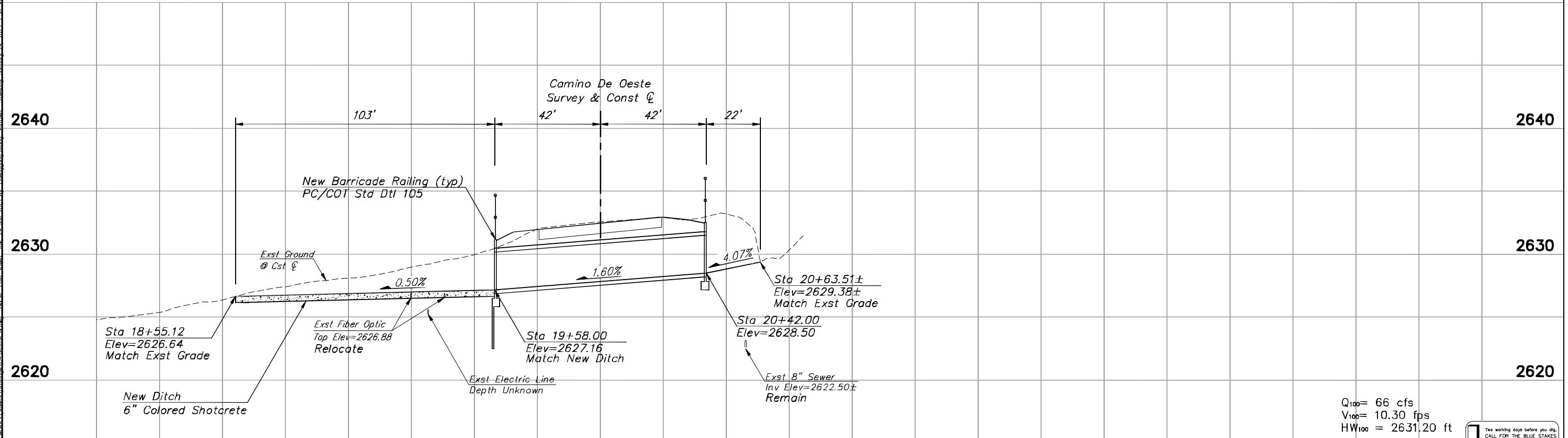
TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE  
 FOR  
**TANGERINE ROAD**  
 STA 630+70.54  
 TANGERINE ROAD



NOTES:

1. Inlet & outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11.
2. Pipes shall be installed per ADOT Std Dwg C-13.10 and C-13.15.
3. Ditch dimensions shall be based on ADOT Std Dwg C-03.10 with 4:1 slopes unless otherwise noted.
4. Barricade railing shall be placed on headwalls and wingwalls as shown on the profile.

18+00                      19+00                      20+00                      21+00                      22+00



Sta 752+67.63, 94.16' Lt  
Remove Exst 1-36" RCP  
New 2-36"x84" RCP  
Skew 10' Rt

Q<sub>100</sub> = 66 cfs  
V<sub>100</sub> = 10.30 fps  
HW<sub>100</sub> = 2631.20 ft



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

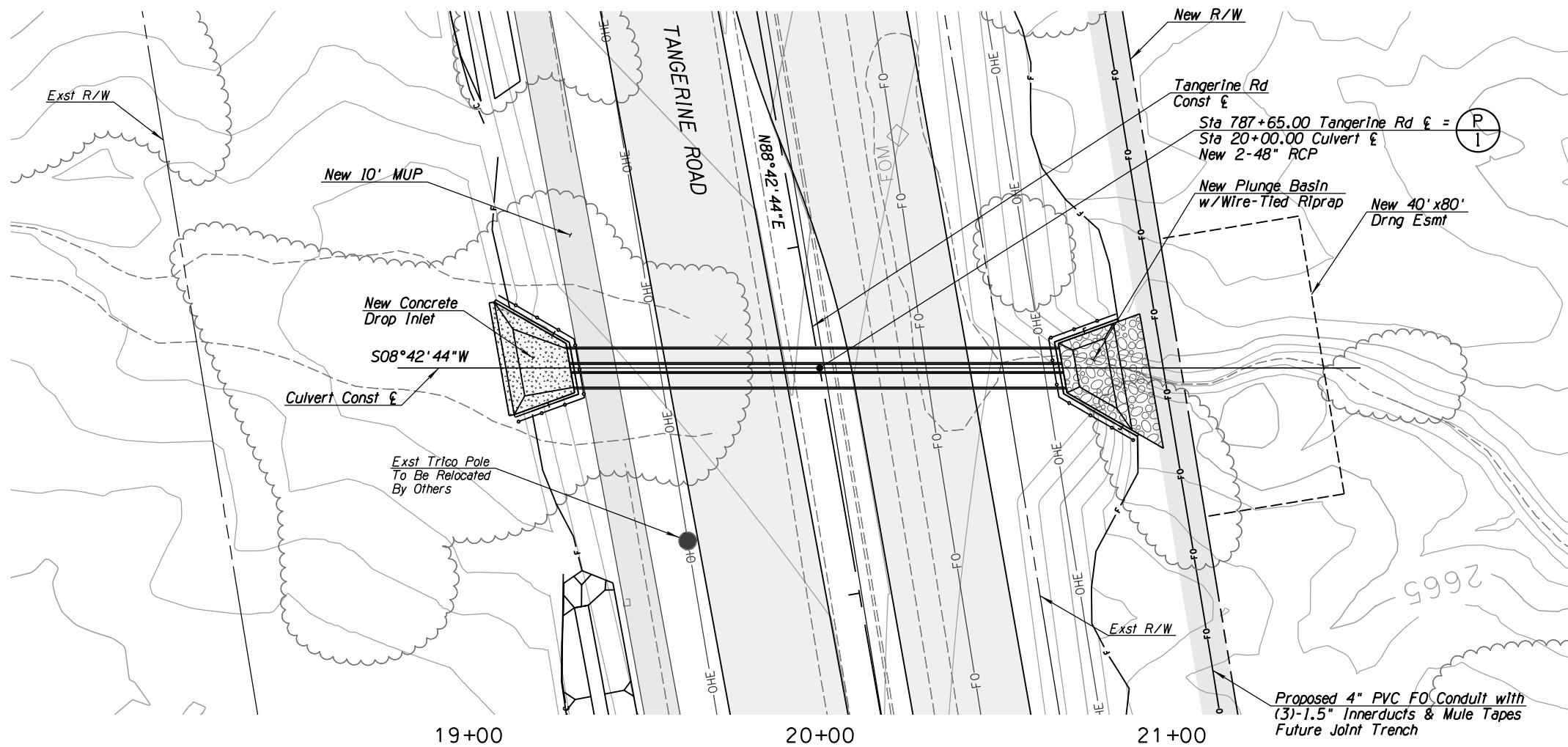
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PROJ. ENG.:	AA	DATE:	12/12

NO.	REVISION DESCRIPTION	DIV. ENGINEER	DATE

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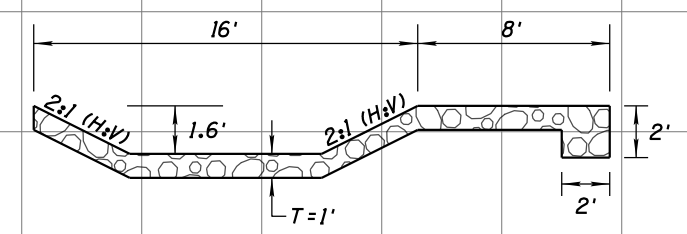
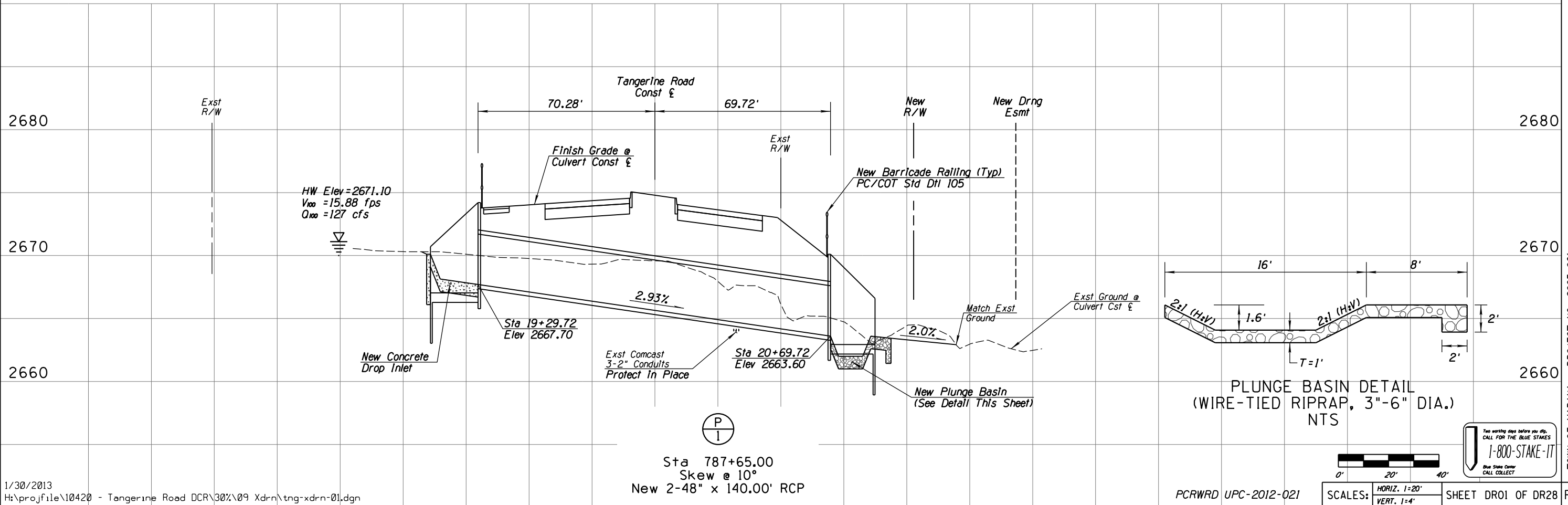
**PSOMAS**  
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(520) 292-2500 (520) 292-1290 fax  
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
TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
TANGERINE ROAD  
STA 752+67.63  
TANGERINE ROAD



**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 (Modified) with 15° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 (Modified) with 15° skew and 6:1 slopes.



  
 Sta 787+65.00  
 Skew @ 10°  
 New 2-48" x 140.00' RCP



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

Two working days before you dig,  
CALL FOR THE BLUE STAKES  
1-800-STAKE-IT  
Blue State Center  
CALL COLLECT

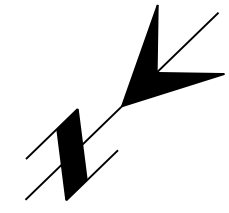
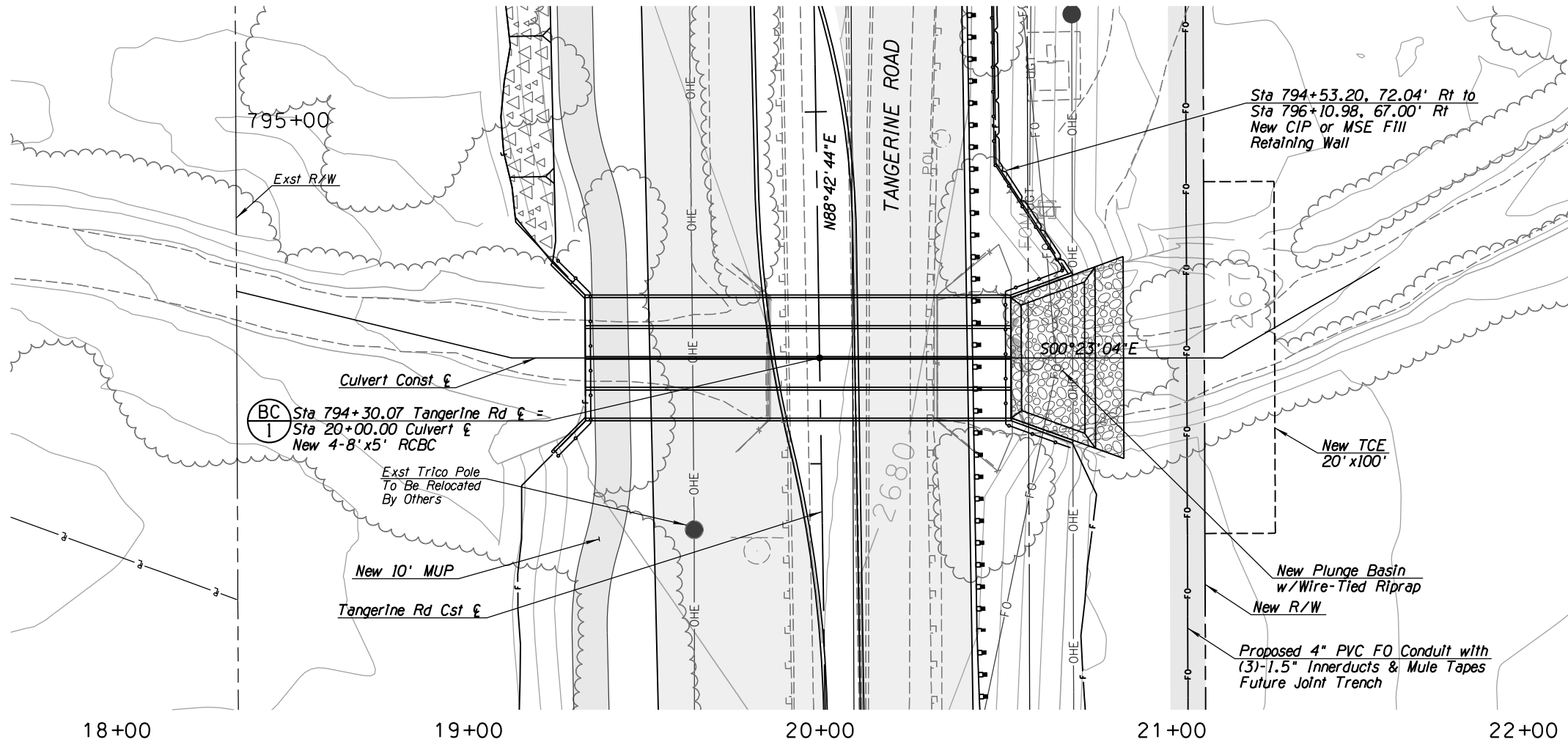
TOWN OF MARANA - PROJECT NO. 2005-061

DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD STA 787+65.00 TANGERINE ROAD

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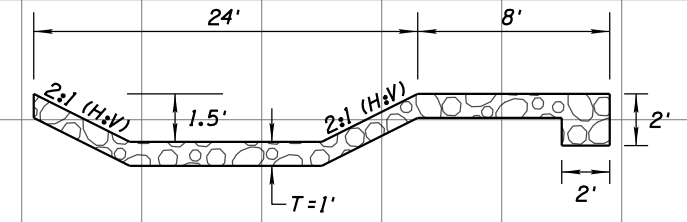
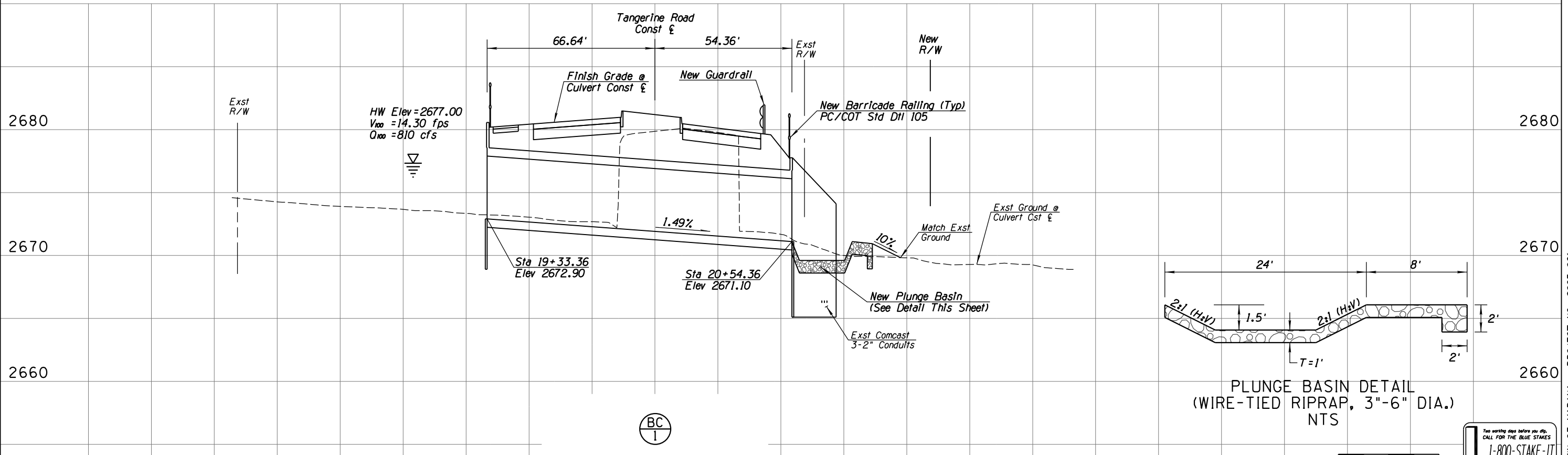
NO.	REVISION DESCRIPTION	DATE	DESIGNED	DRAWN	CHECKED	PROJ. ENG.
			AW	TWS	MDA	MDA
			01/13	01/13	01/13	01/13

Kittelson & Associates, Inc.  
33 North Stone Ave., Suite 800  
Tucson, AZ 85701  
(520) 544-4067

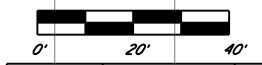


**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.30 (Modified) with 0° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.10 (Modified) with 0° skew and 4:1 slopes.



PLUNGE BASIN DETAIL  
(WIRE-TIED RIPRAP, 3"-6" DIA.)  
NTS



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'



BC  
Sta 794+30.07  
Skew @ 0°  
New 4-8'x5' x 121.00' RCBC

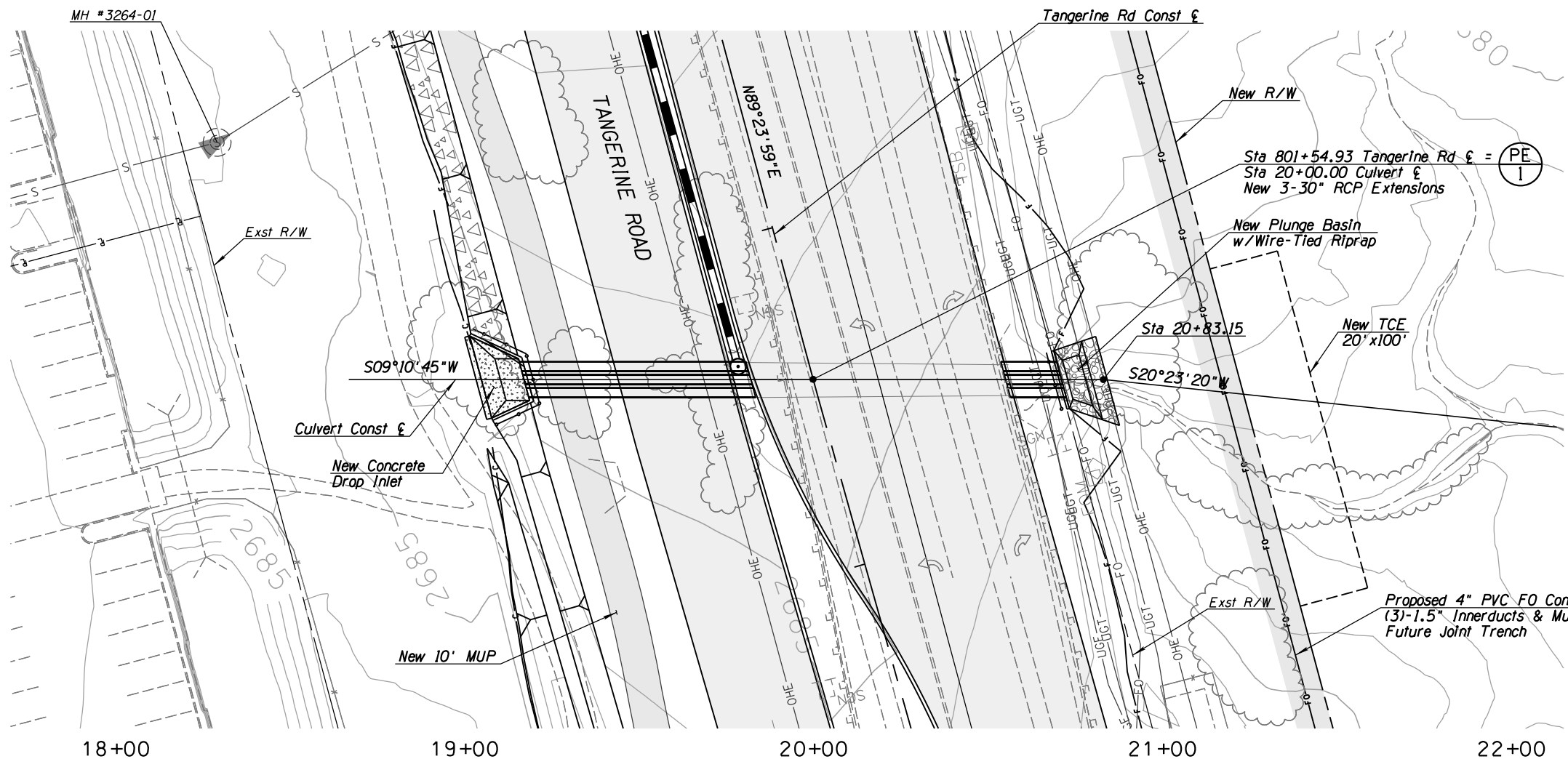
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NO.	REVISION DESCRIPTION	DATE

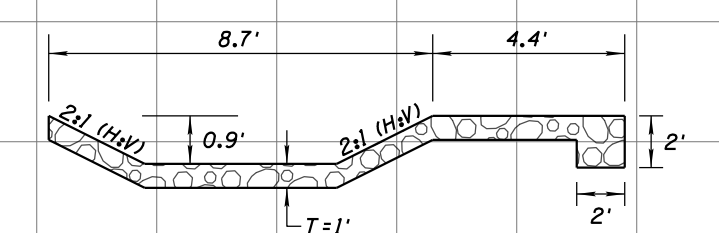
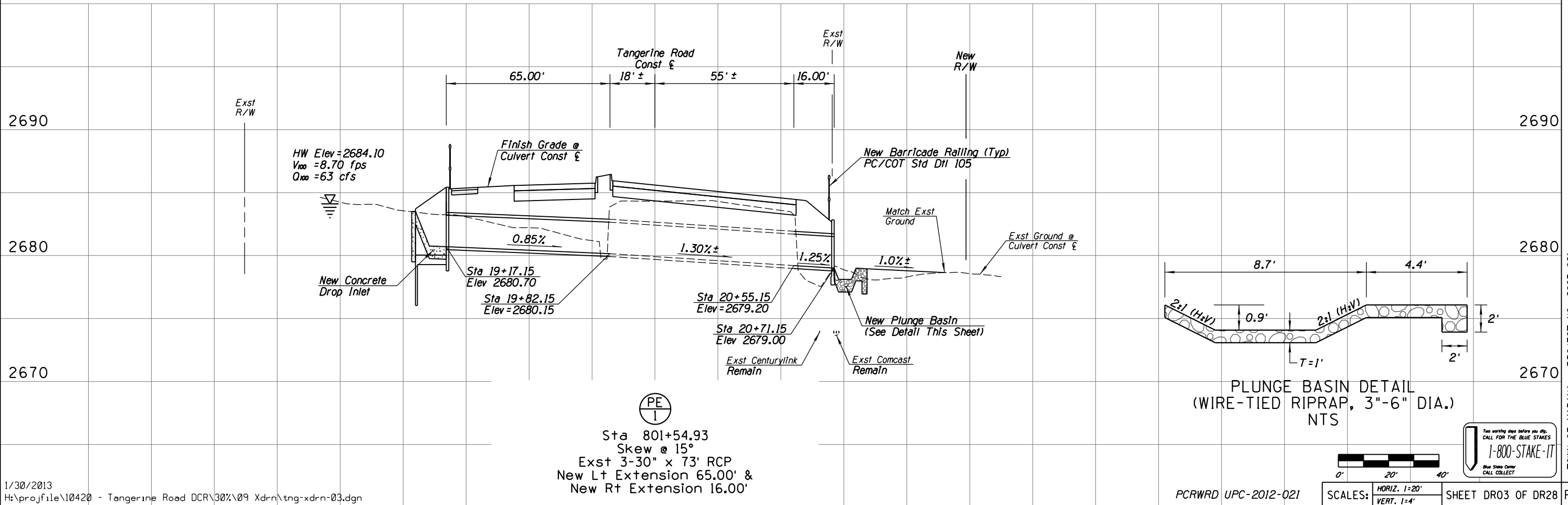
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PRELIMINARY  
NOT FOR  
CONSTRUCTION


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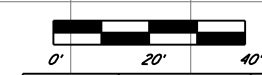
TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
TANGERINE ROAD  
STA 794+30.07  
TANGERINE ROAD



- NOTES:**
- Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 (Modified) with 15° skew and 6:1 slopes.
  - Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.11 (Modified) with 15° skew and 6:1 slopes.



  
 Sta 801+54.93  
 Skew @ 15°  
 Exst 3-30" x 73' RCP  
 New Lt Extension 65.00' &  
 New Rt Extension 16.00'



Two working days before you dig,  
 CALL FOR THE BLUE STAKES  
**1-800-STAKE-IT**  
 Blue State Center  
 CALL COLLECT

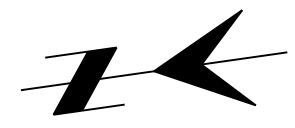
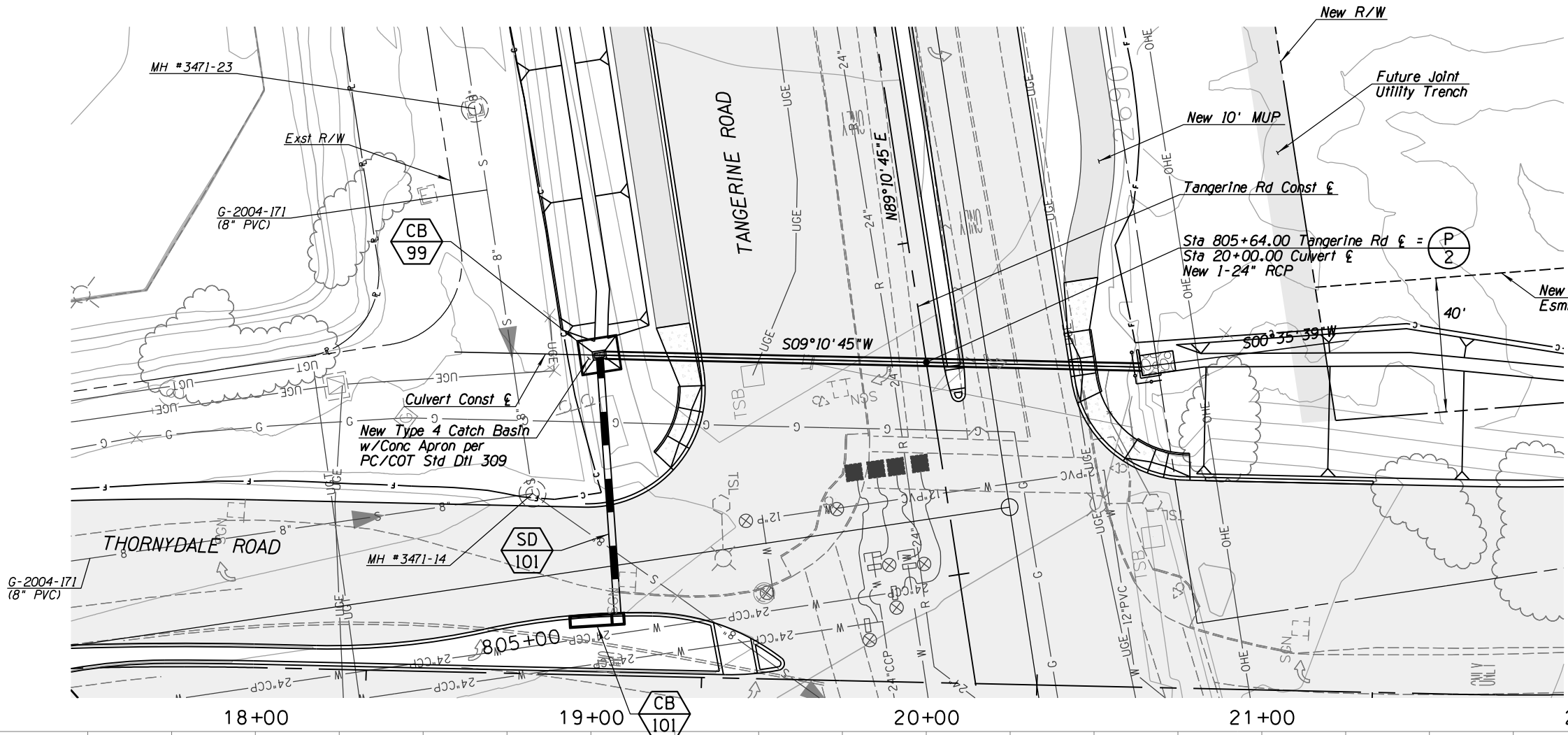
TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD STA 801+54.93 TANGERINE ROAD

NO.	REVISION DESCRIPTION	DATE	DESIGNED BY	DRAWN BY	CHECKED BY	PROJ. ENG. BY

30% PRELIMINARY NOT FOR CONSTRUCTION

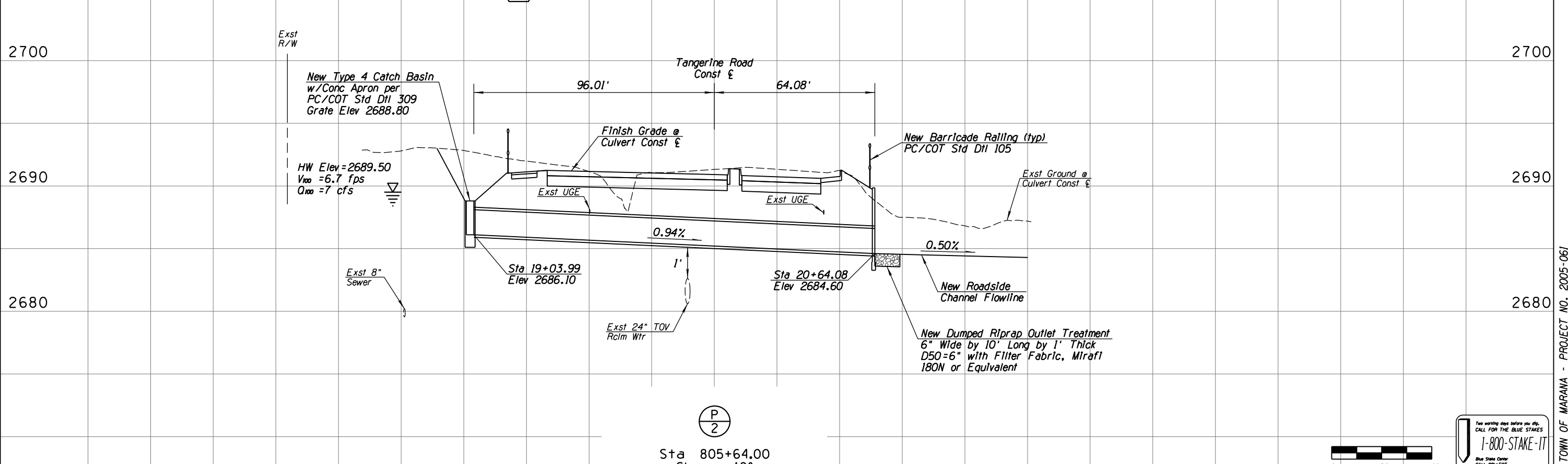
Kittelson & Associates, Inc.  
 33 North Stone Ave., Suite 800  
 Tucson, AZ 85701  
 (520) 544-4067

PAGE 89 OF 128



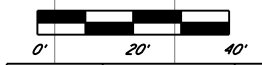
**NOTES:**

- Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.11 (Modified) with 15° skew and 6:1 slopes.



P  
2

Sta 805+64.00  
Skew @ 10°  
New 1-24" x 160.09' RCP



Two working days before you dig,  
CALL FOR THE BLUE STAKES  
**1-800-STAKE-IT**  
Blue State Center  
CALL COLLECT

TOWN OF MARANA - PROJECT NO. 2005-061

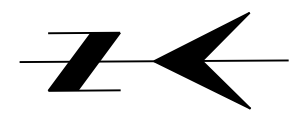
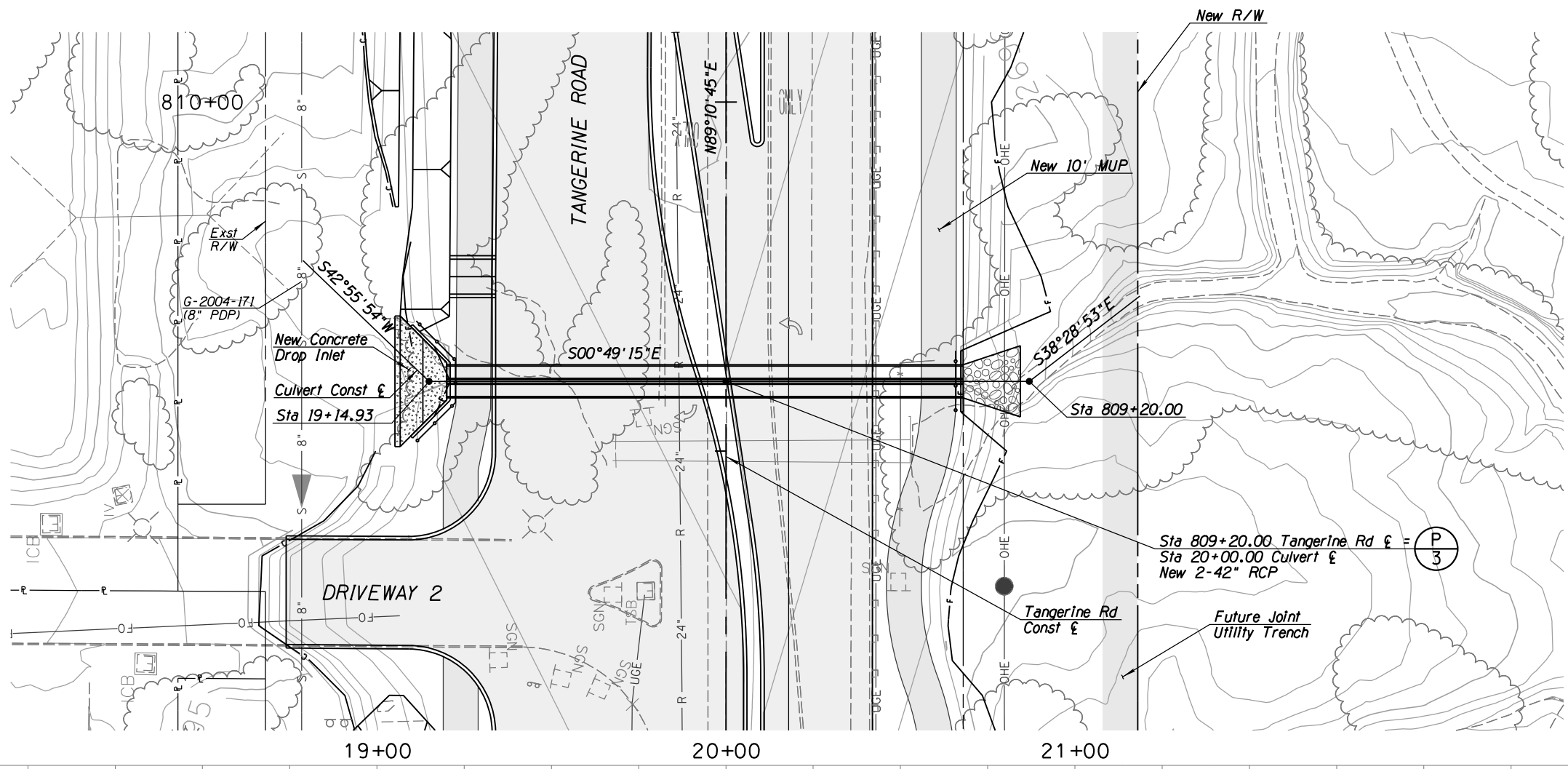
DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD STA 805+64.00 TANGERINE ROAD

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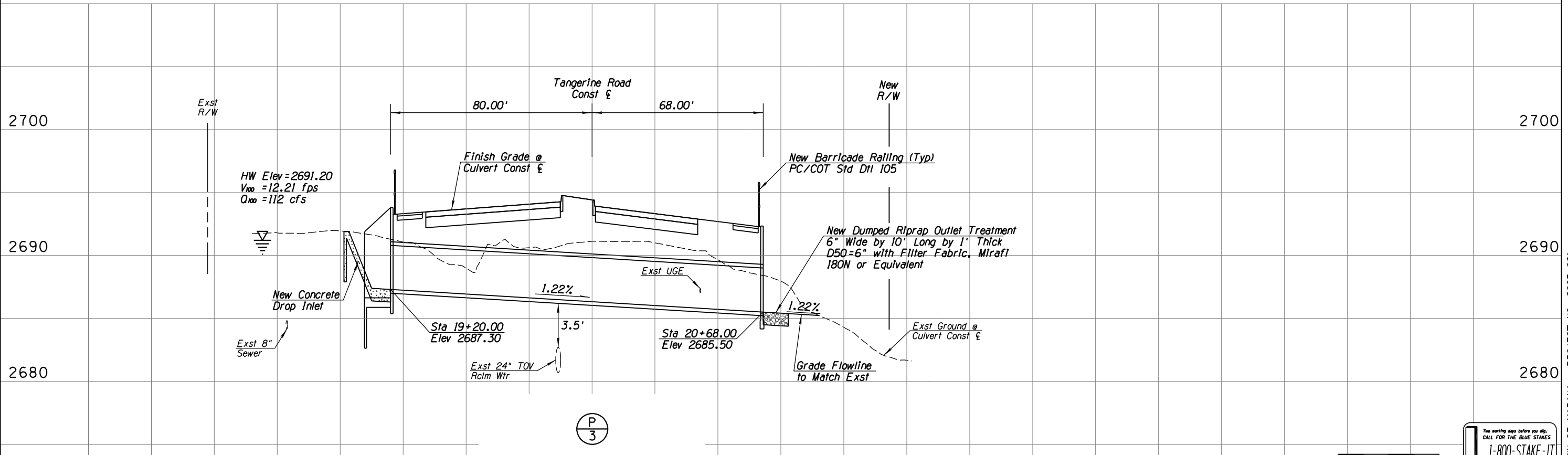
NO.	REVISION DESCRIPTION	DATE	DESIGNED	DRAWN	CHECKED	PROJ. ENG.

DATE	DESIGNED	DRAWN	CHECKED	PROJ. ENG.
07/13				
07/13				
07/13				

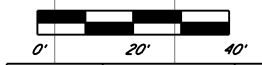


**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 (Modified) with 15° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.11 (Modified) with 15° skew and 6:1 slopes.



Sta 809+20.00  
Skew @ 0°  
New 2-42" x 148.00' RCP



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'



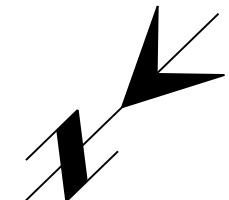
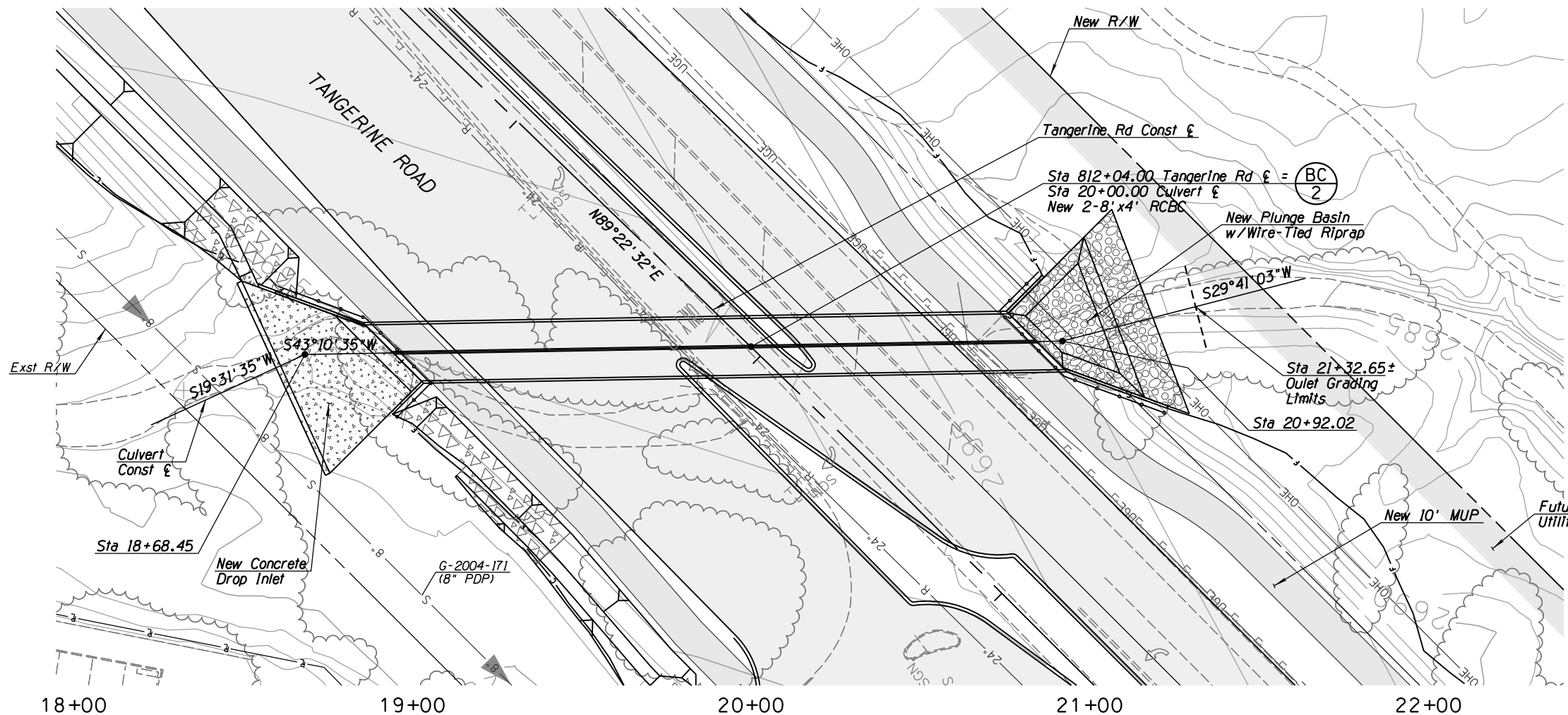
NO.	REVISION DESCRIPTION	DATE	DESIGNED:	DATE
			AW	07/13
			DRW	07/13
			CHECKED:	07/13
			PROJ. ENG.:	07/13

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TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD STA 809+20.00 TANGERINE ROAD

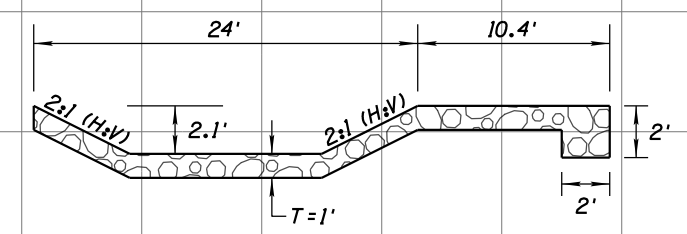
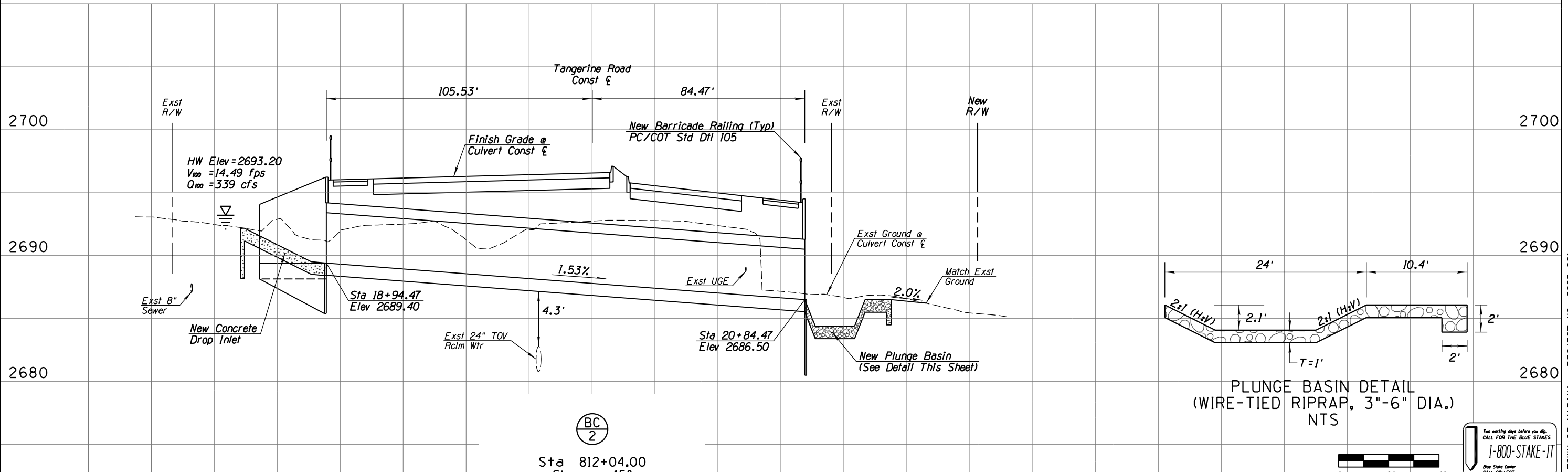




**NOTES:**

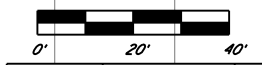
1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.70 (Modified) with 45° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.50 (Modified) with 45° skew and 6:1 slopes.

18+00                      19+00                      20+00                      21+00                      22+00



**PLUNGE BASIN DETAIL**  
(WIRE-TIED RIPRAP, 3"-6" DIA.)  
NTS

BC  
2  
 Sta 812+04.00  
 Skew @ 45°  
 New 2-8'x4' x 190.00' RCBC



Two working days before you dig,  
CALL FOR THE BLUE STAKES  
**1-800-STAKE-IT**  
Blue Stakes Center  
CALL COLLECT

	DATE	01/13	01/13	01/13	01/13
DESIGNED:	DATE				
DRAWN:	DATE				
CHECKED:	DATE				
PROJ. ENG.:	DATE				

NO.	REVISION DESCRIPTION	DATE	DIV.	ENGINEER

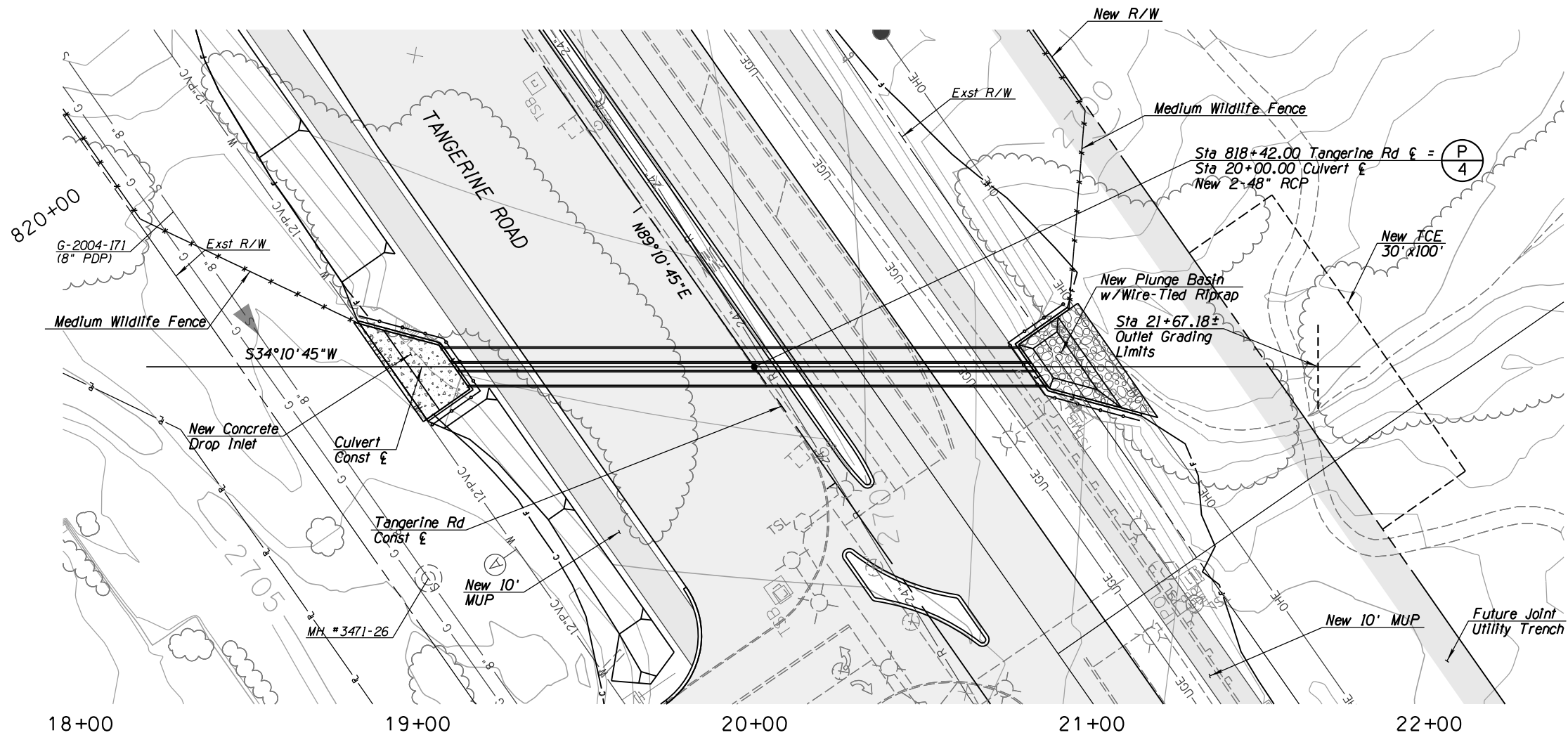
  

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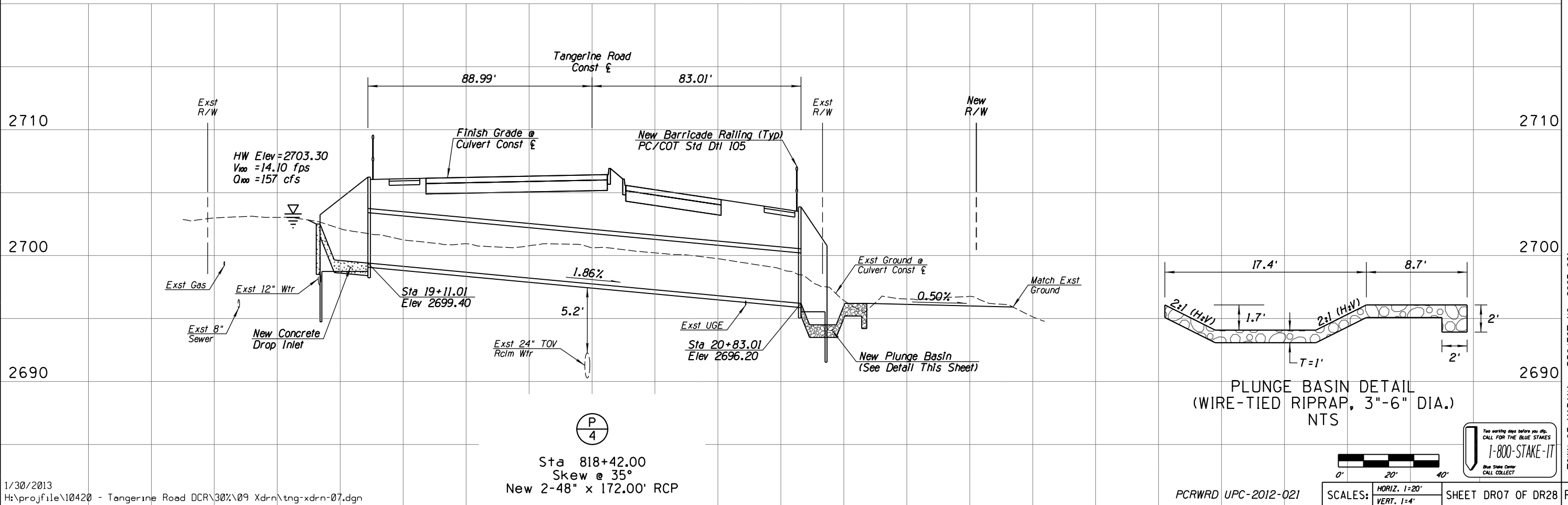
TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE  
 FOR  
**TANGERINE ROAD**  
 STA 812+04.00  
 TANGERINE ROAD





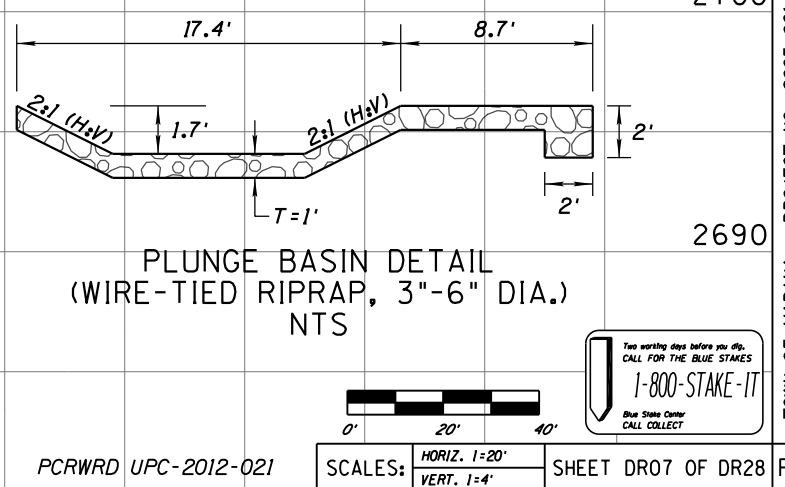
**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 (Modified) with 30° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 (Modified) with 30° skew and 6:1 slopes.



(P/4)

Sta 818+42.00  
Skew @ 35°  
New 2-48" x 172.00' RCP

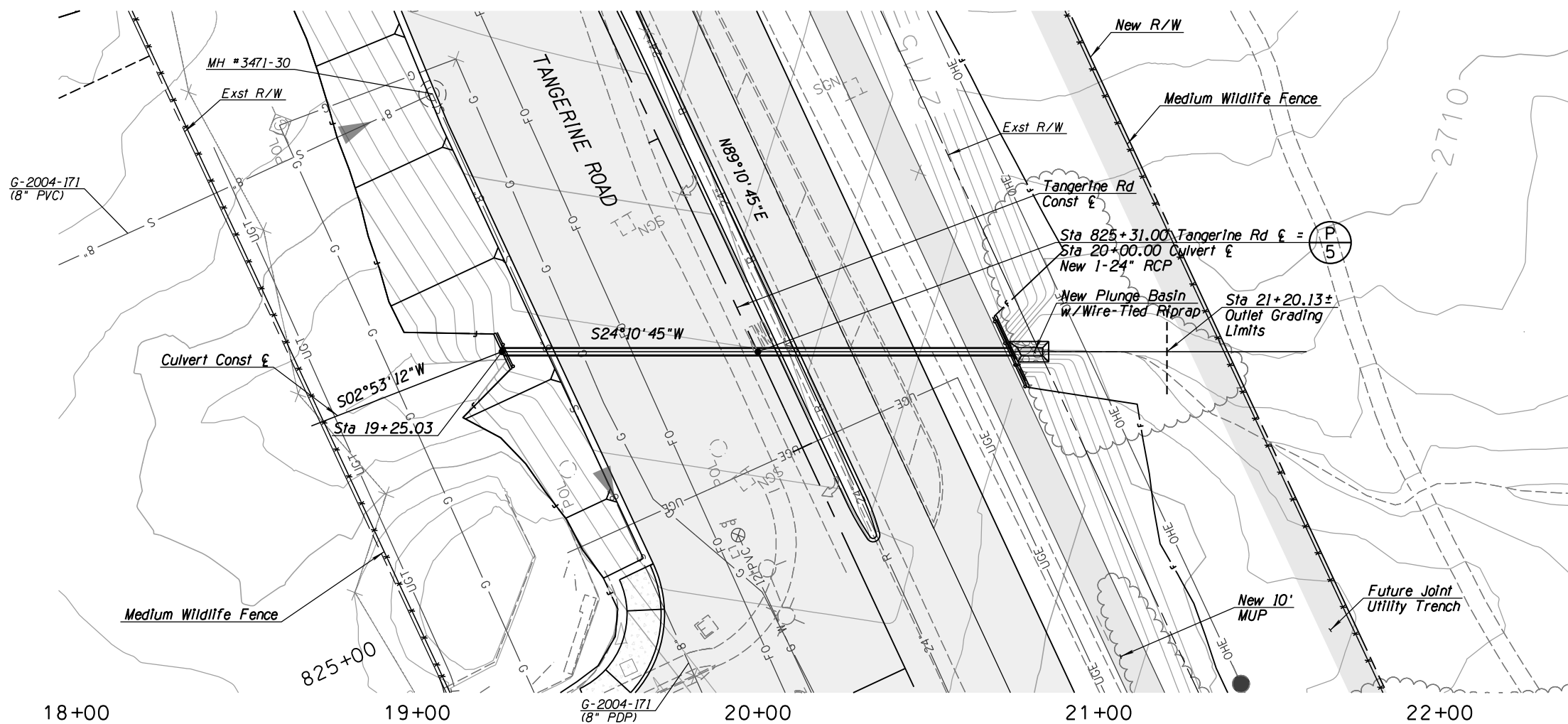


TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD STA 818+42.00 TANGERINE ROAD

NO.	REVISION DESCRIPTION	DATE	DESIGNED BY	DRAWN BY	CHECKED BY	PROJ. ENG. BY
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		07/13				
		07/13				
		07/13				

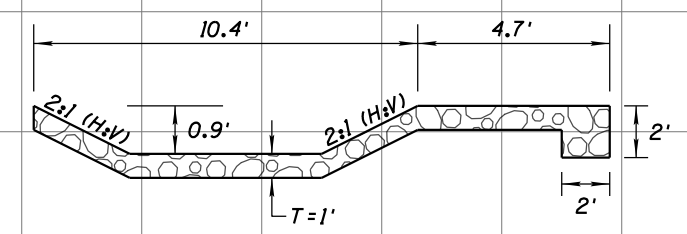
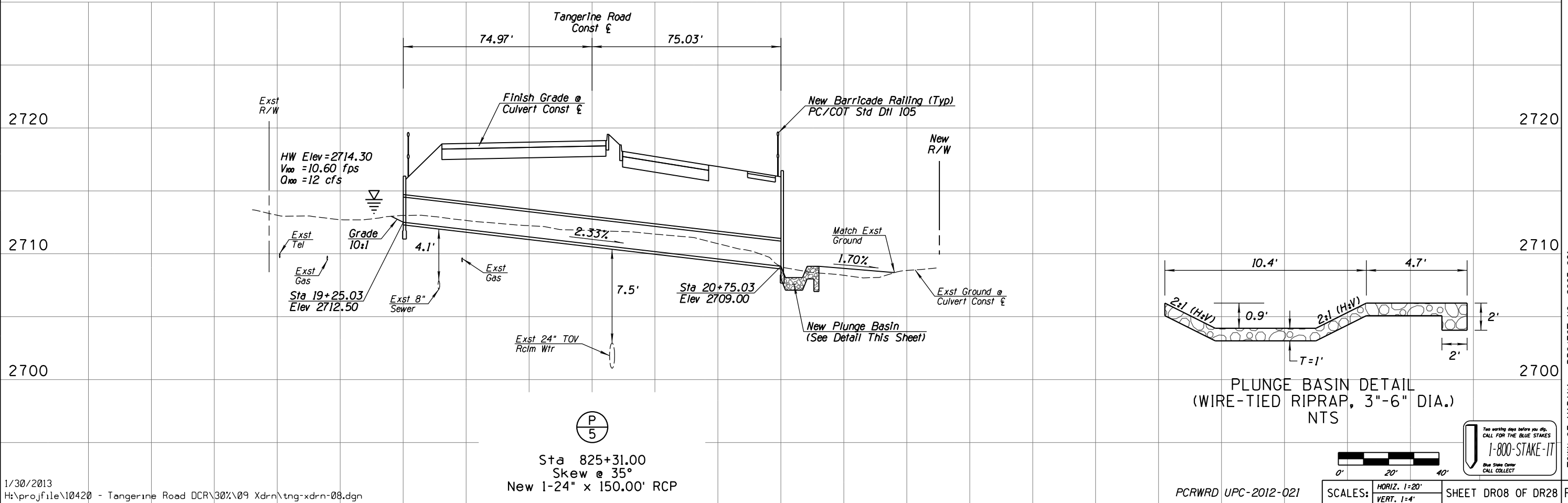
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Tucson, AZ 85701  
(520) 544-4067

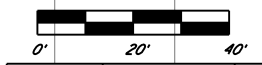


**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.11 with 25° skew and 4:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.11 (Modified) with 25° skew and 6:1 slopes.



**PLUNGE BASIN DETAIL**  
(WIRE-TIED RIPRAP, 3"-6" DIA.)  
NTS



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

DATE	01/13	01/13	07/13
DESIGNED BY	AW	TWS	MDA
DRAWN			
CHECKED			
PROJ. ENG.			

NO.	REVISION DESCRIPTION	DATE	BY

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TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD STA 825+31.00 TANGERINE ROAD

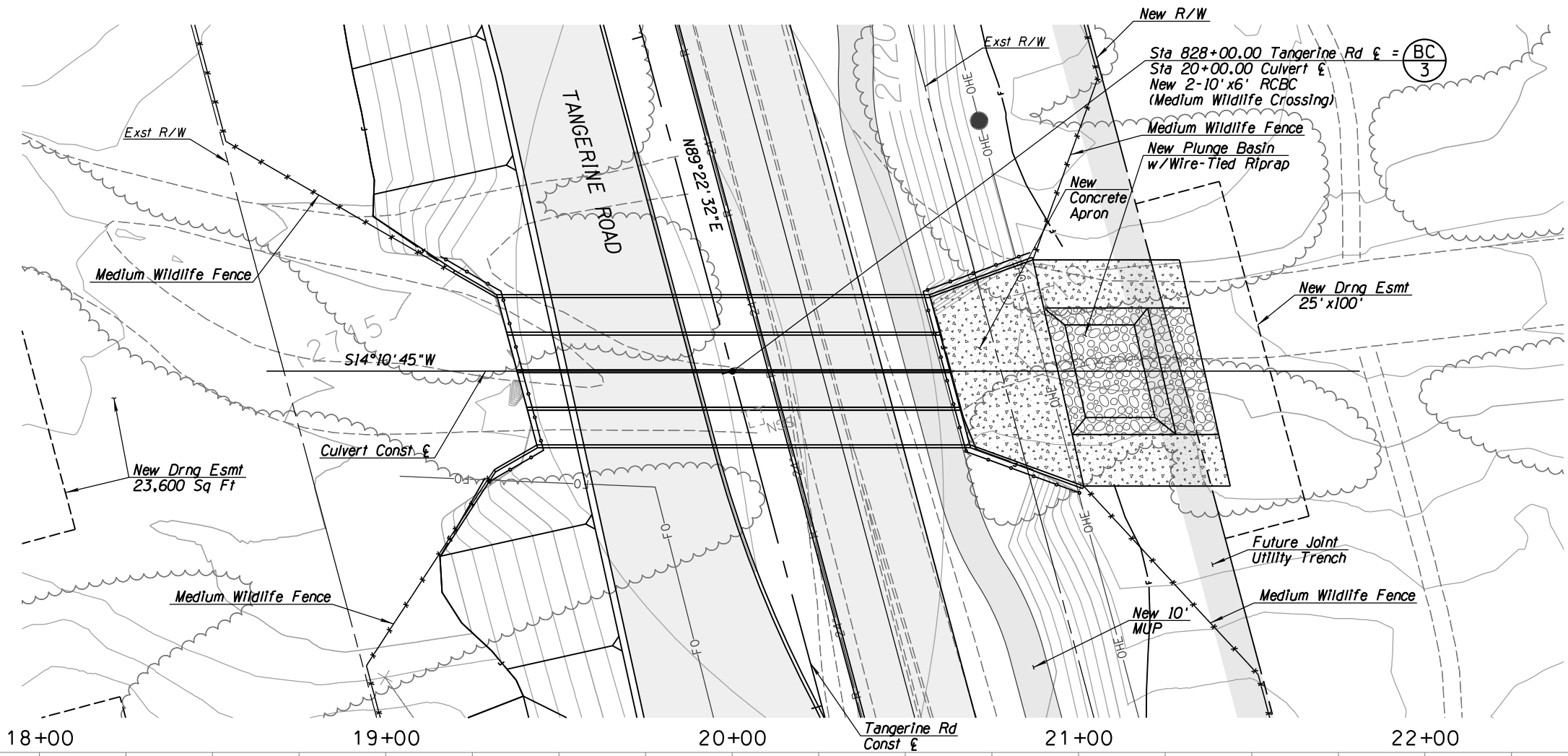
1-800-STAKE-IT  
Two working days before you dig, CALL FOR THE BLUE STAKES  
Blue State Center CALL COLLECT

1/30/2013  
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PCRWRD UPC-2012-021

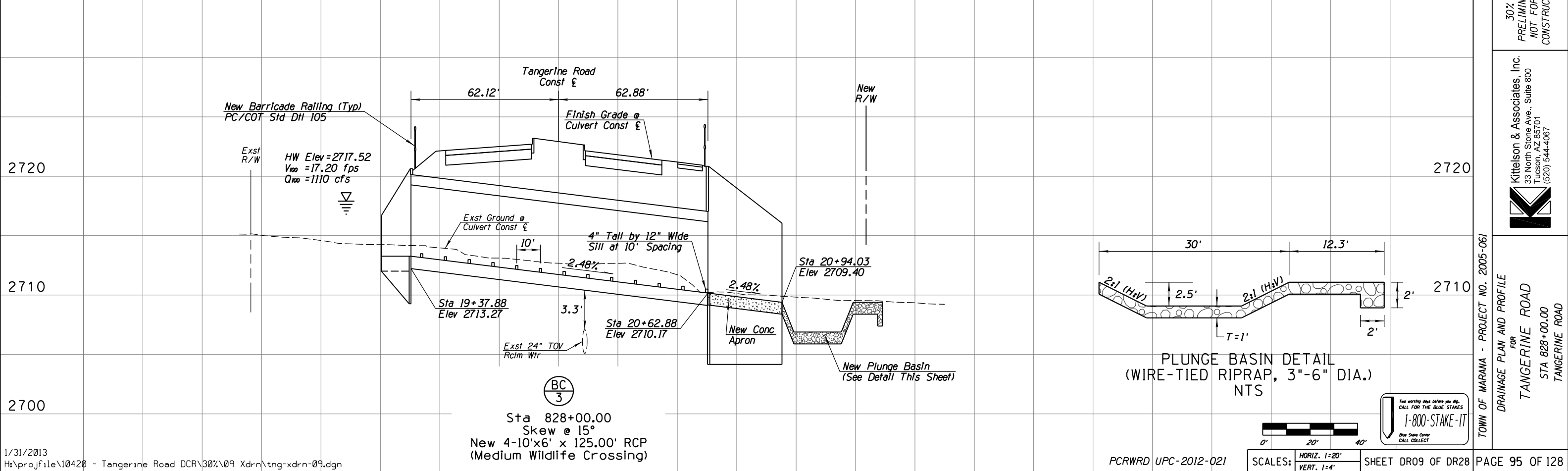
SHEET DR08 OF DR28

PAGE 94 OF 128



**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.30 with 15° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.10 (Modified) with 15° skew and 6:1 slopes.



Sta 828+00.00  
Skew @ 15°  
New 4-10'x6' x 125.00' RCP  
(Medium Wildlife Crossing)

NO.	REVISION DESCRIPTION	DATE	DESIGNED:	DRAWN:	CHECKED:	PROJ. ENG.:
		01/13				
		01/13				
		07/13				

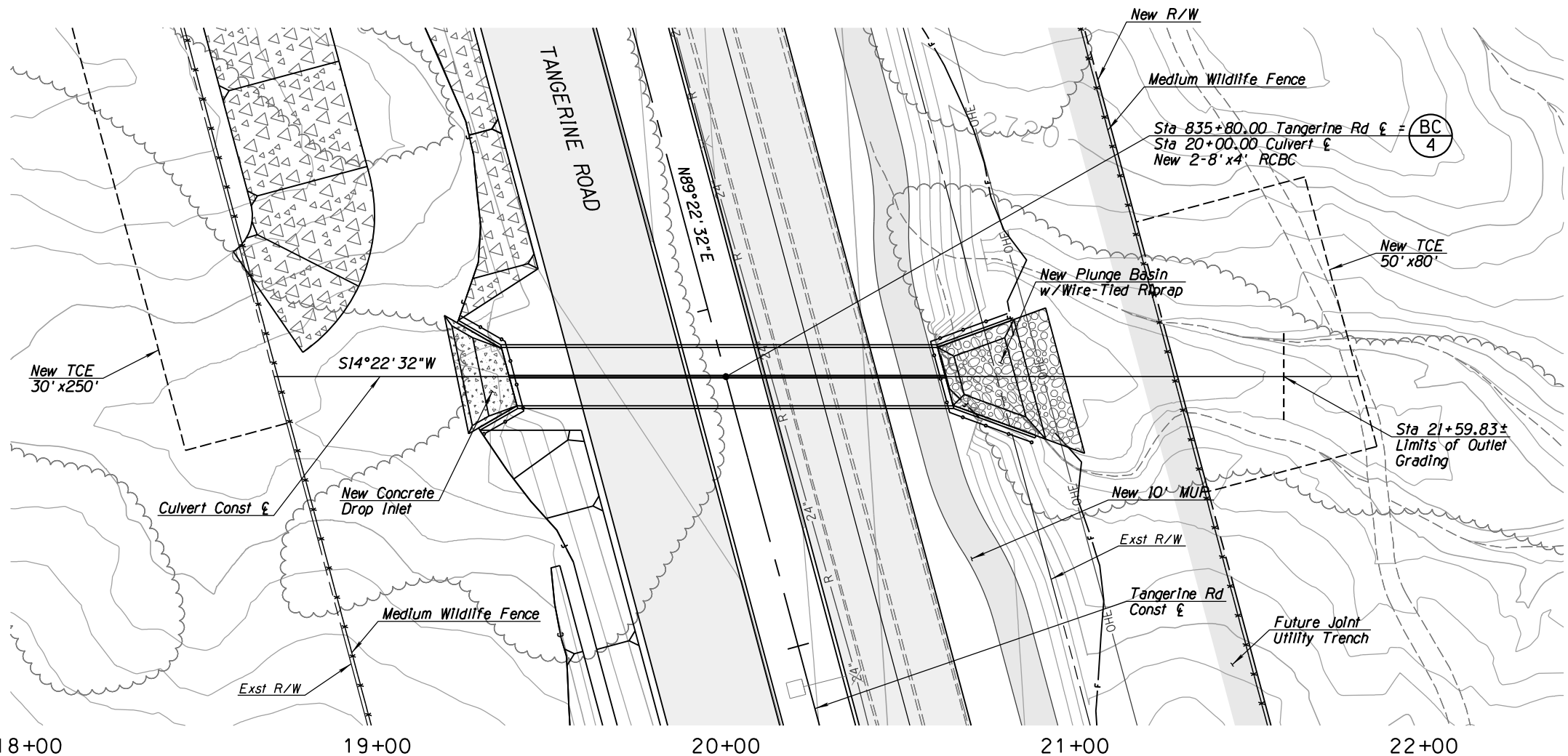
NO.	REVISION DESCRIPTION	DATE	DESIGNED:	DRAWN:	CHECKED:	PROJ. ENG.:

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CONSTRUCTION

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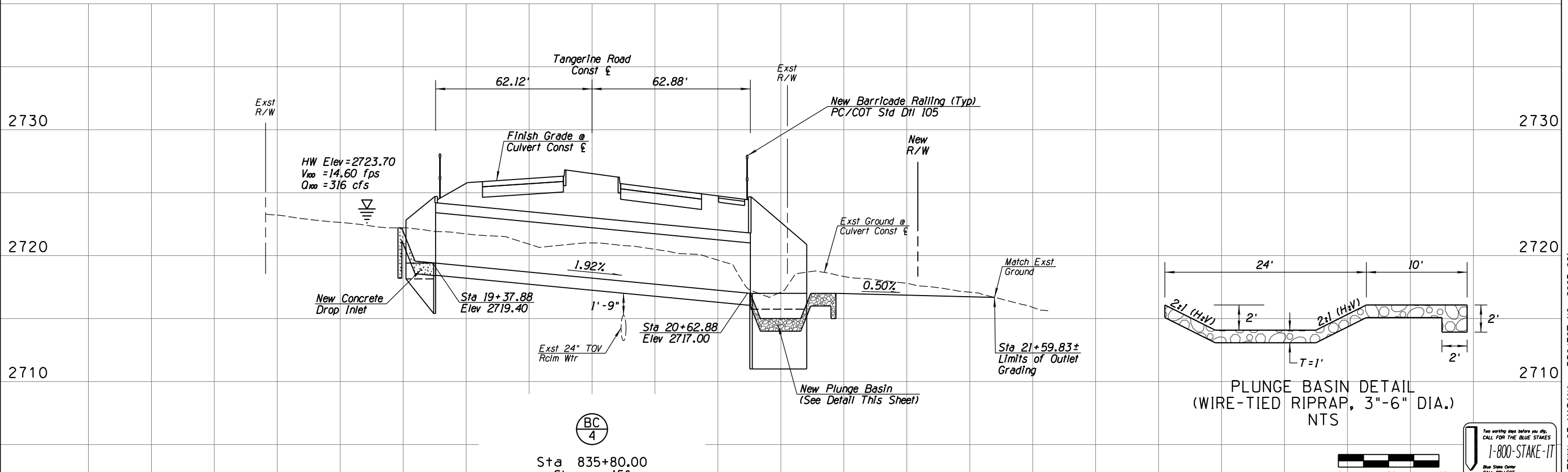
TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
TANGERINE ROAD  
STA 828+00.00  
TANGERINE ROAD



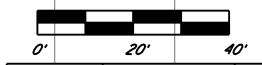


**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.30 with 15° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.10 (Modified) with 15° skew and 6:1 slopes.



Sta 835+80.00  
Skew @ 15°  
New 2-8'x4' x 125.00' RCP



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

Two working days before you dig,  
CALL FOR THE BLUE STAKES  
1-800-STAKE-IT  
Blue Stakes Center  
CALL COLLECT

DATE	01/13	01/13	07/13
DESIGNED BY	AW	TMB	MDA
DRAWN			
CHECKED BY			
PROJ. ENG. I.			

NO.	REVISION DESCRIPTION	DATE	ENG.

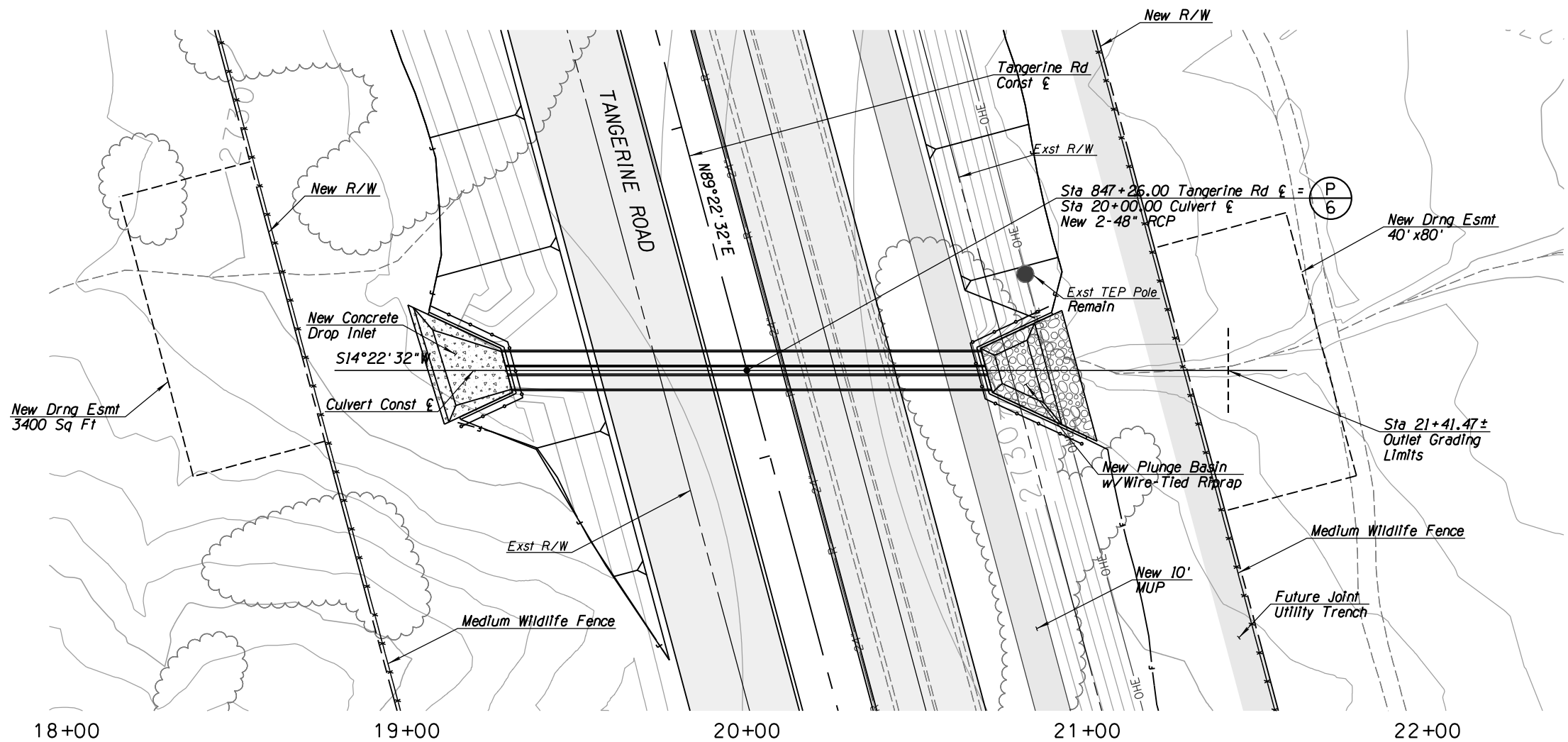
  

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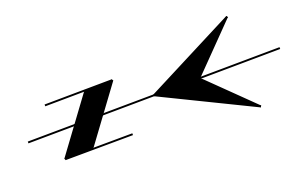
TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD STA 835+80 TANGERINE ROAD

PCRWRD UPC-2012-021 SHEET DR10 OF DR28 PAGE 96 OF 128



**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 with 15° skew and 6:1 slopes
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 (Modified) with 15° skew and 6:1 slopes.



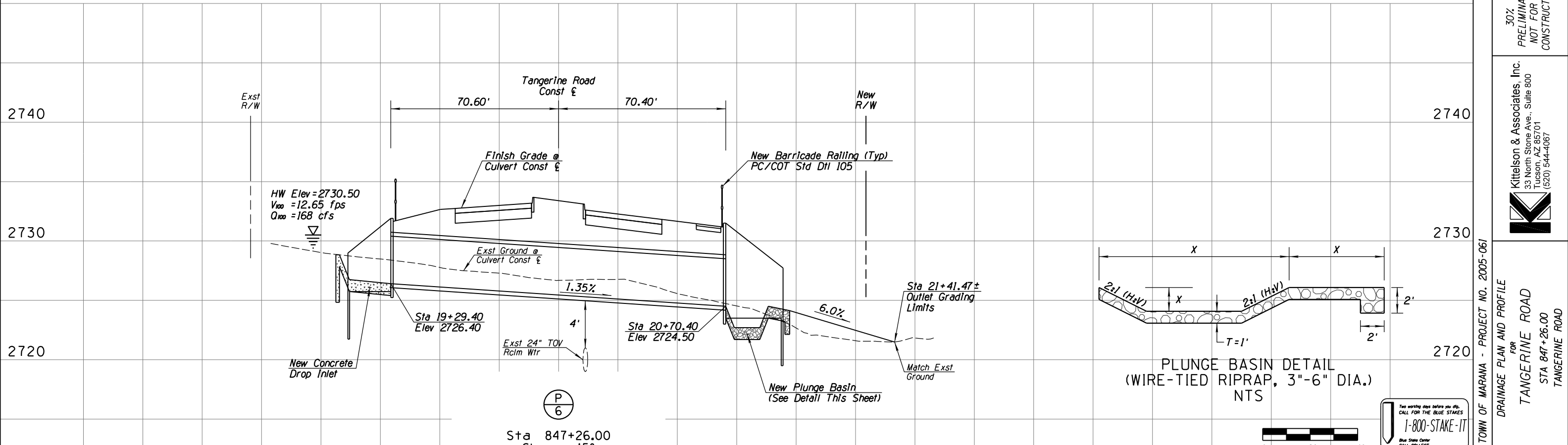
DATE	DESIGNED BY	DRAWN	CHECKED	PROJ. ENG.
01/13	AW	TWS	MDA	MDA
07/13				
07/13				

NO.	REVISION DESCRIPTION	DATE	BY	CHKD

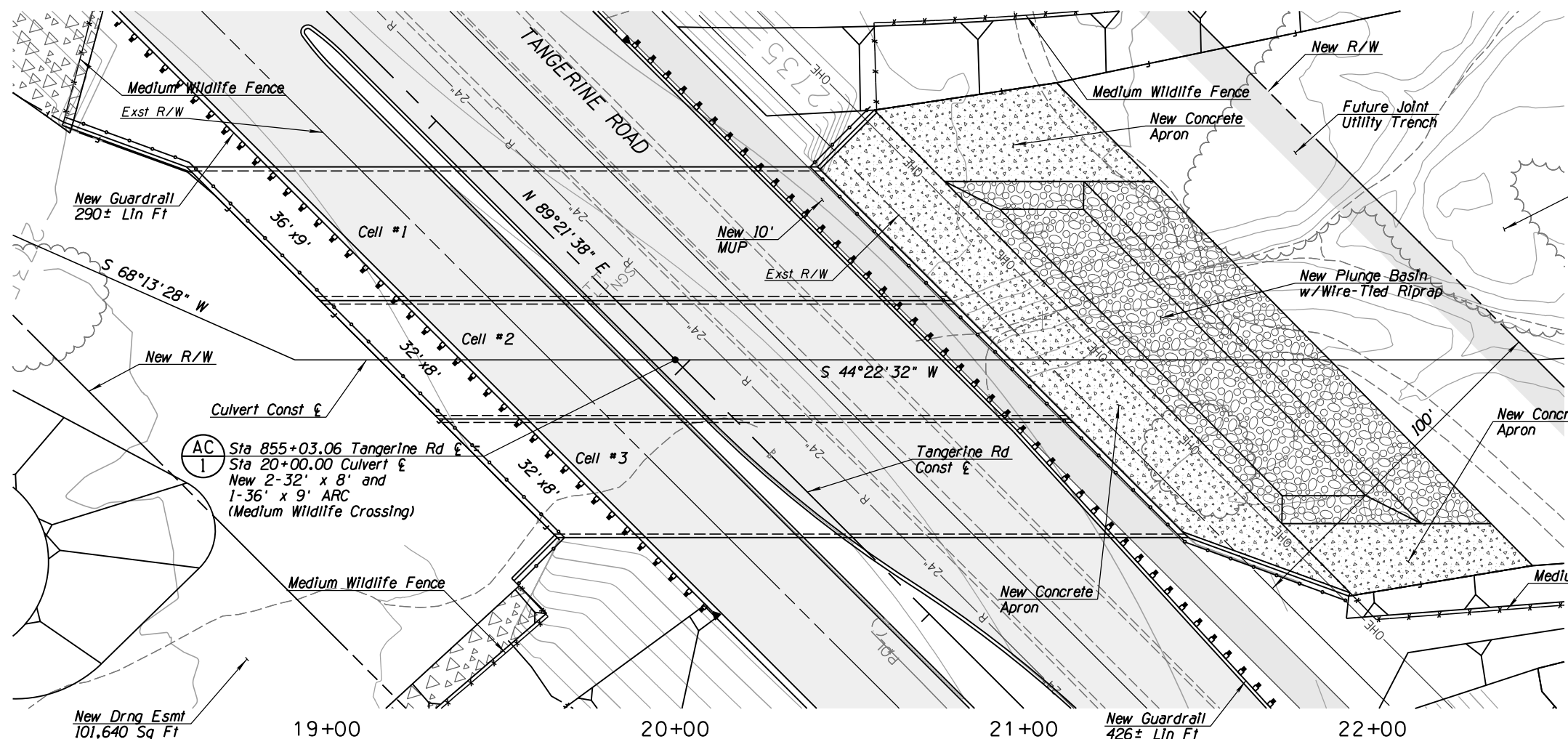
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PRELIMINARY  
NOT FOR  
CONSTRUCTION

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Tucson, AZ 85701  
(520) 544-4067

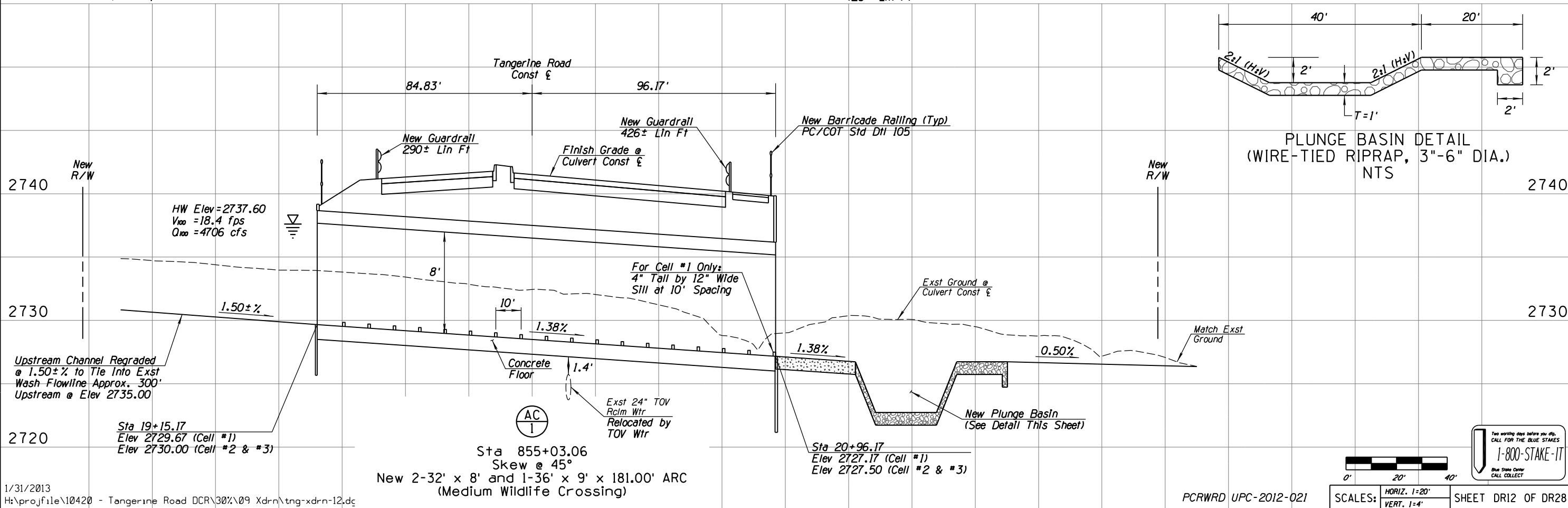
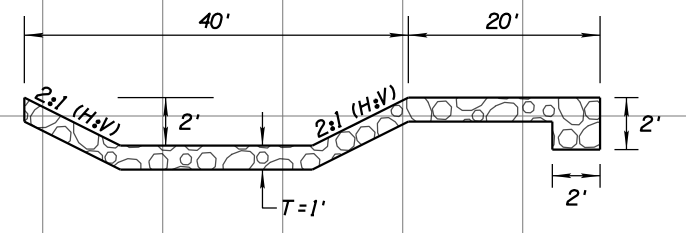
TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
**TANGERINE ROAD**  
STA 847+26.00  
TANGERINE ROAD



Sta 847+26.00  
Skew @ 15°  
New 2-48" x 141.00' RCP



- NOTES:**
1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.80 with 45° skew and 6:1 slopes.
  2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.60 (Modified) with 45° skew and 6:1 slopes.



TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD STA 855+03.06 TANGERINE ROAD

NO.	REVISION DESCRIPTION	DATE	BY	CHECKED	DATE

DESIGNED: R/W  
DRAWN: TWS  
CHECKED: MDA  
PROJ. ENG.: MDA

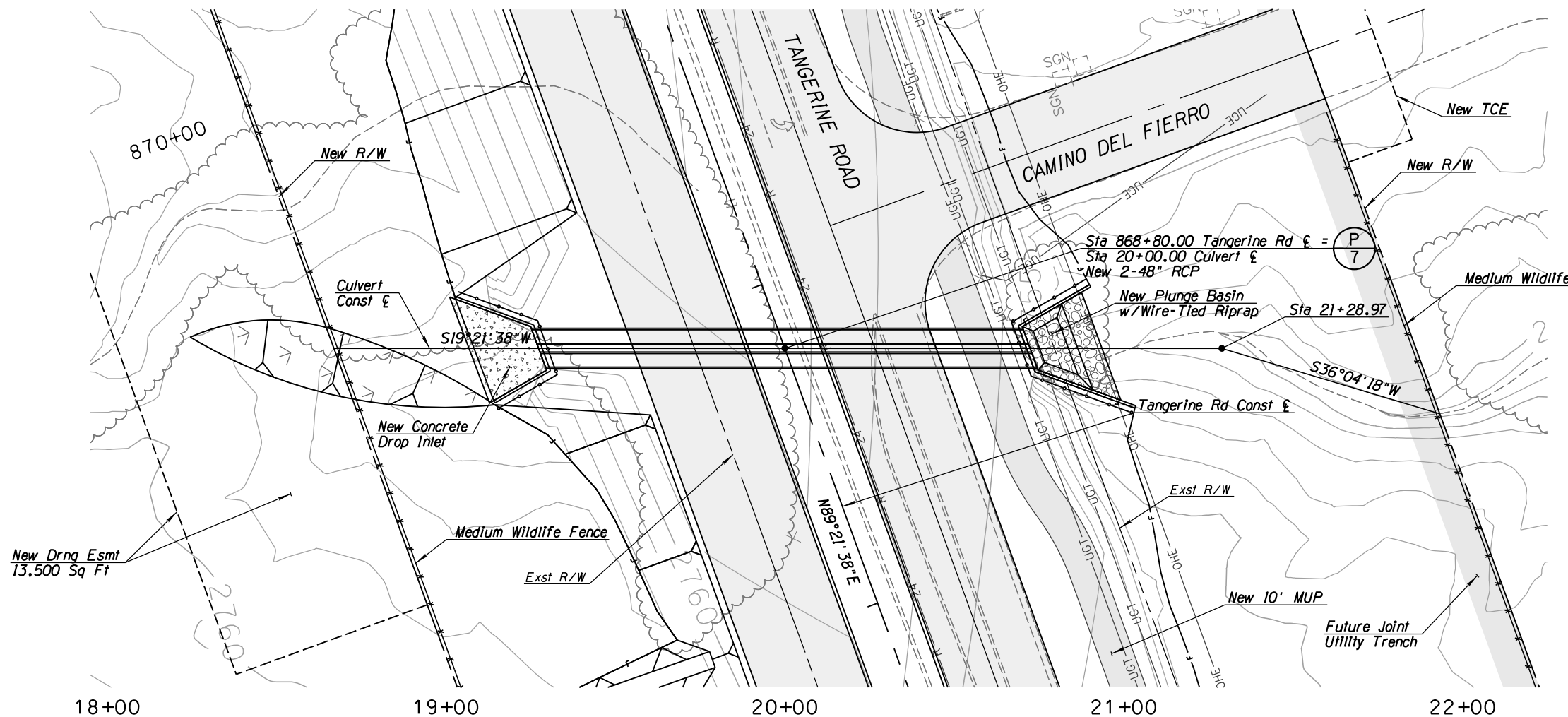
DATE: 01/13, 07/13, 07/13

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Tucson, AZ 85701  
(520) 544-4067

Two working days before you dig, CALL FOR THE BLUE STAKES  
1-800-STAKE-IT  
Blue State Center CALL COLLECT





**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 with 15° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.11 (Modified) with 15° skew and 6:1 slopes.

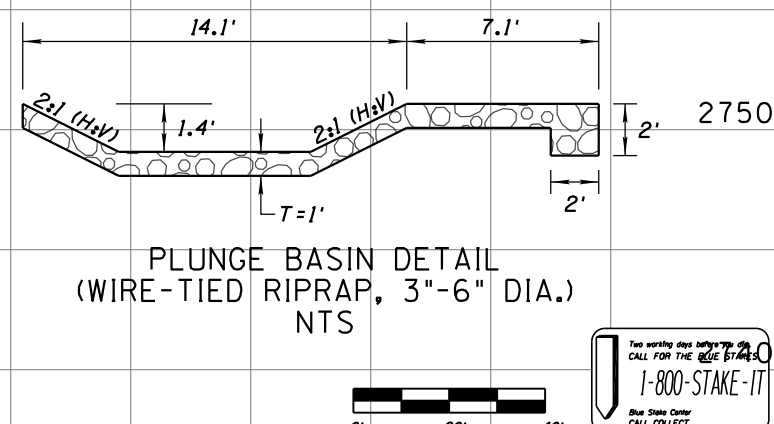
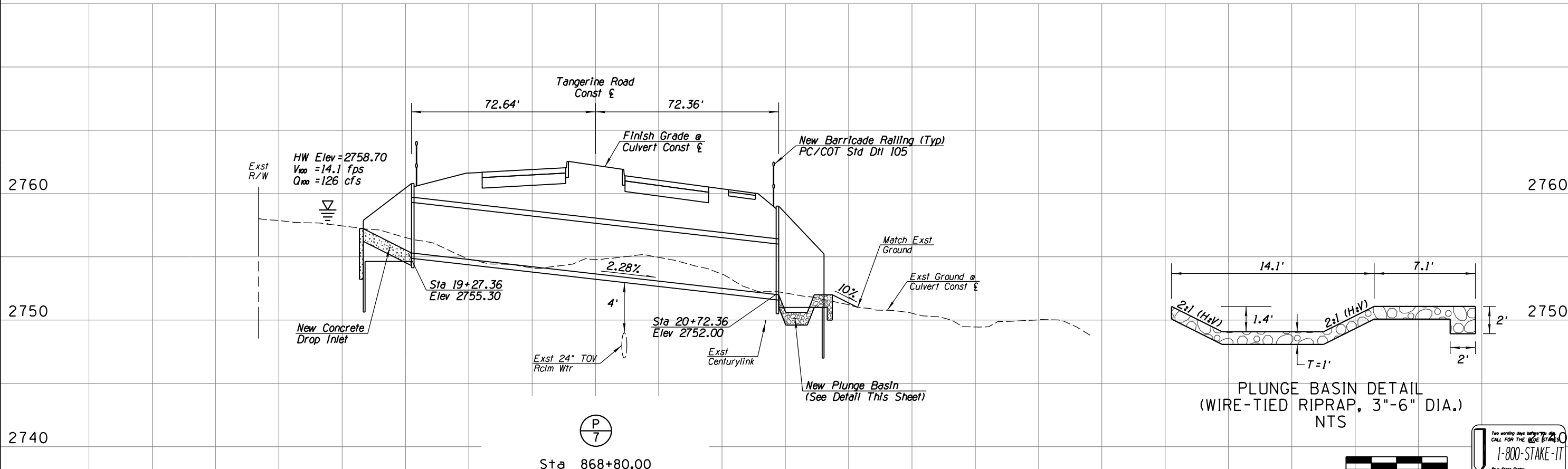
DATE	01/13	01/13	07/13
DESIGNED BY	AW	TWS	MDA
DRAWN			
CHECKED			
PROJ. ENG.			

NO.	REVISION DESCRIPTION	DATE

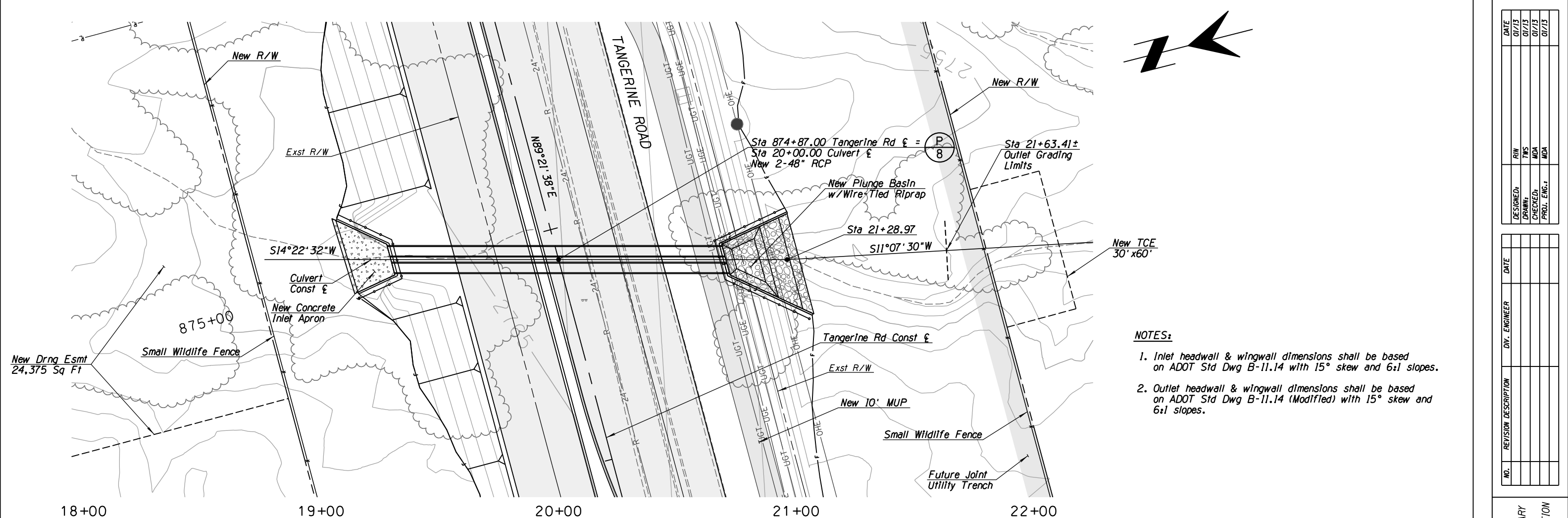
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PRELIMINARY  
NOT FOR  
CONSTRUCTION

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Tucson, AZ 85701  
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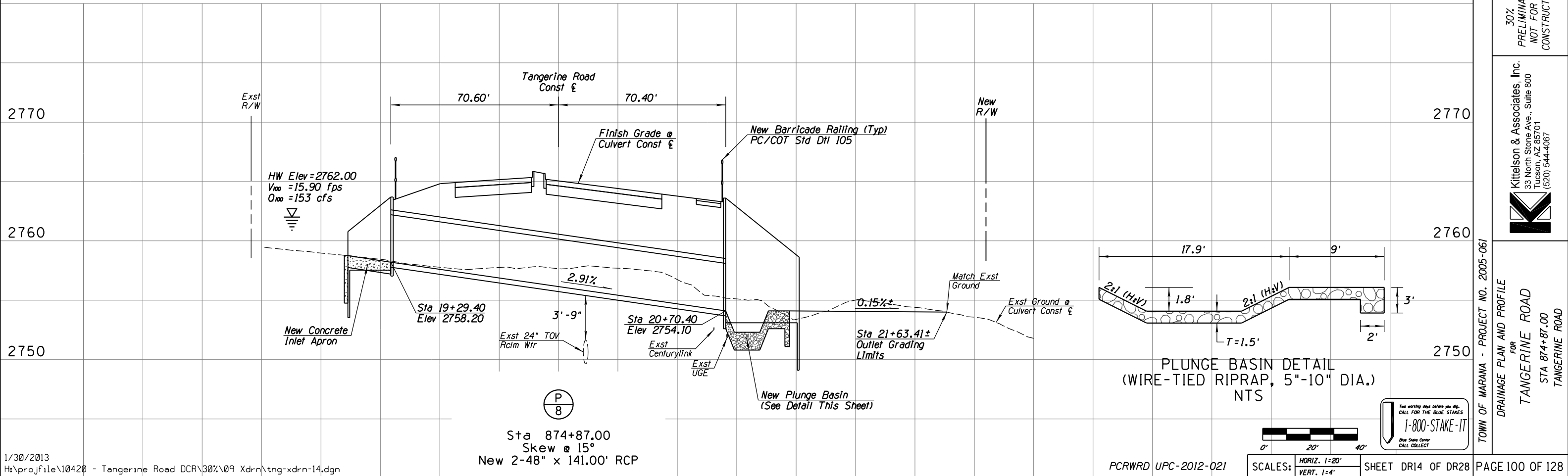
TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
TANGERINE ROAD  
STA 868+80.00  
TANGERINE ROAD



Sta 868+80.00  
Skew @ 20°  
New 2-48" x 145.00' RCP



- NOTES:**
- Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 with 15° skew and 6:1 slopes.
  - Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 (Modified) with 15° skew and 6:1 slopes.



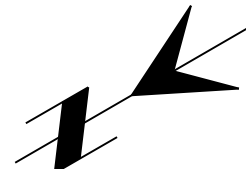
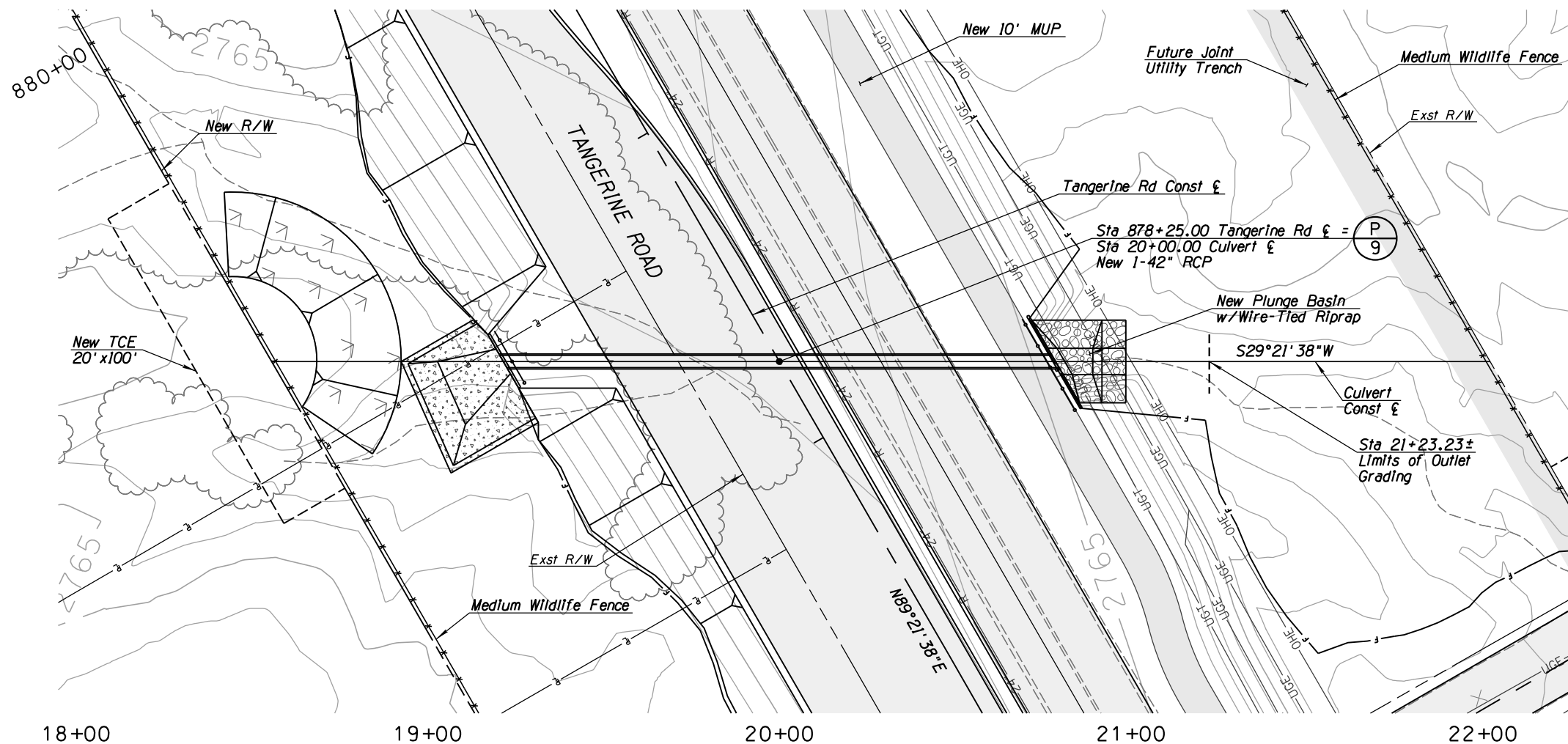
NO.	REVISION DESCRIPTION	DATE	DESIGNED BY	CHECKED BY	DATE

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TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD STA 874+87.00 TANGERINE ROAD

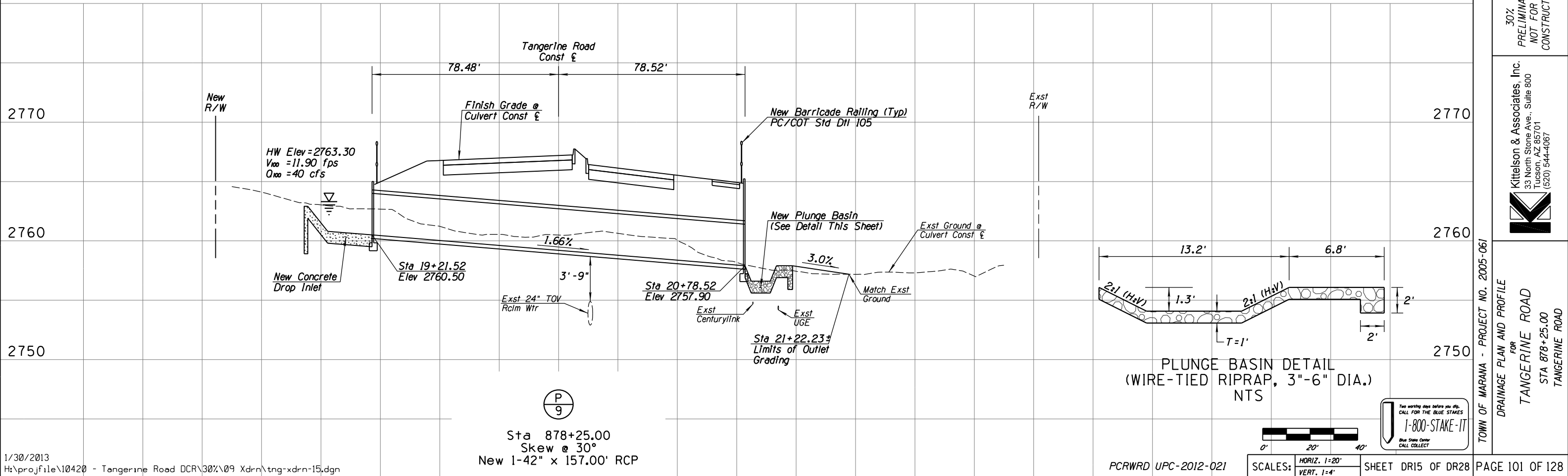




**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.1 with 30° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.11 (Modified) with 30° skew and 6:1 slopes.

NO.	REVISION DESCRIPTION	DATE	BY	CHKD	APP'D



Sta 878+25.00  
Skew @ 30°  
New 1-42" x 157.00' RCP

**PLUNGE BASIN DETAIL**  
(WIRE-TIED RIPRAP, 3"-6" DIA.)  
NTS



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

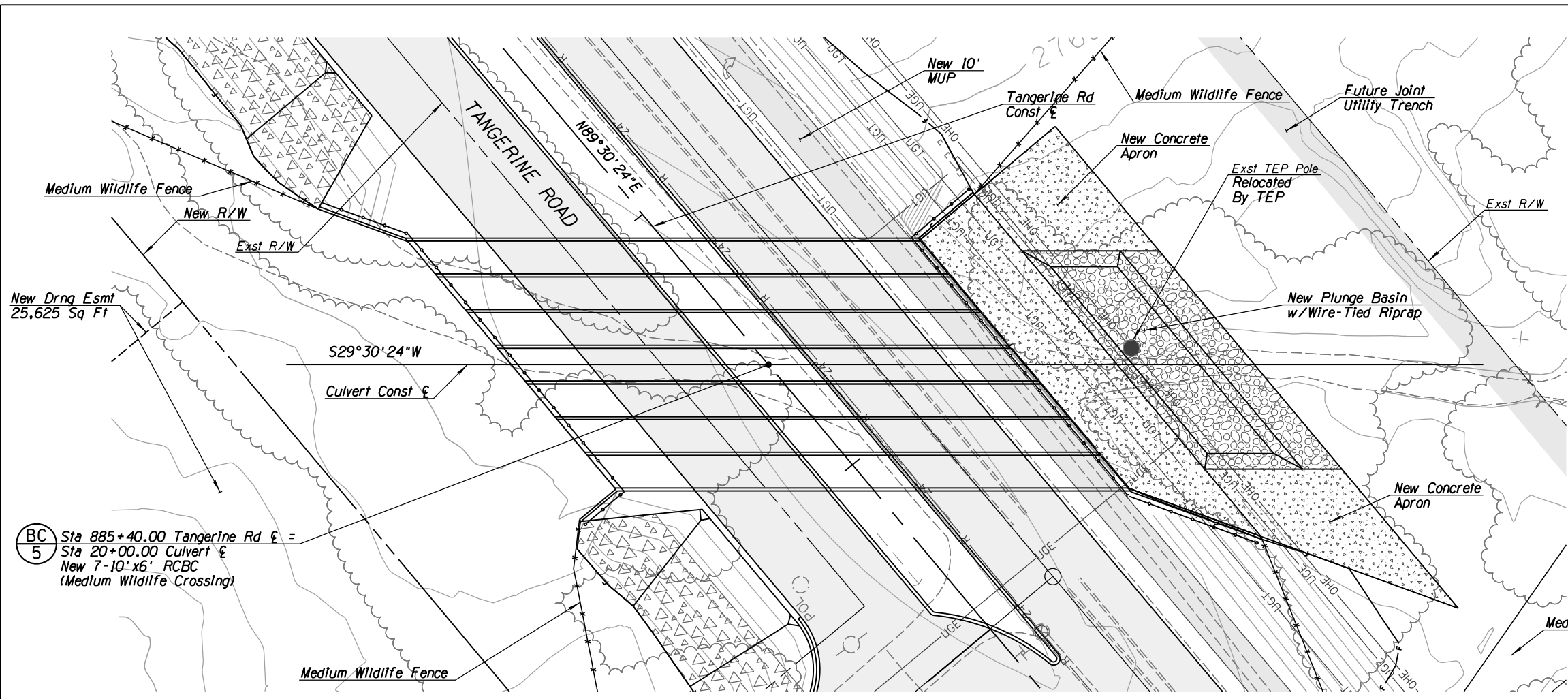


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CONSTRUCTION

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TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
TANGERINE ROAD  
STA 878+25.00  
TANGERINE ROAD

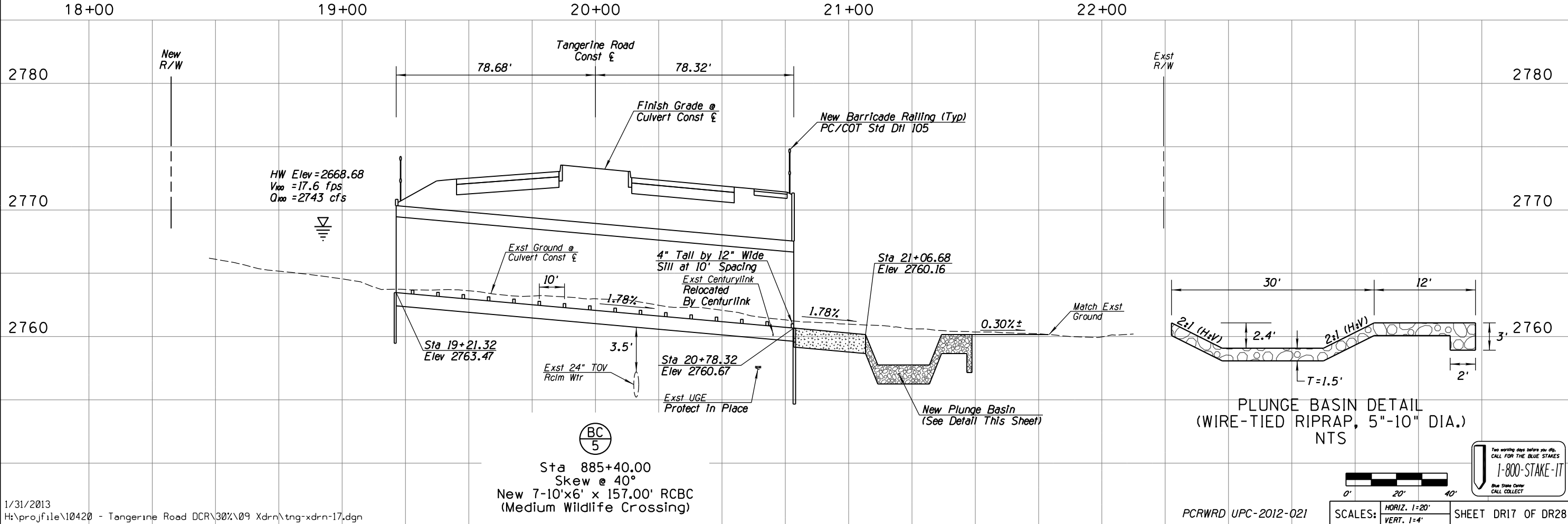




**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.70 with 40° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.50 (Modified) with 40° skew and 4:1 slopes.

BC 5  
 Sta 885+40.00 Tangerine Rd  $\epsilon$  =  
 Sta 20+00.00 Culvert  $\epsilon$   
 New 7-10'x6' RCBC  
 (Medium Wildlife Crossing)



BC 5  
 Sta 885+40.00  
 Skew @ 40°  
 New 7-10'x6' x 157.00' RCBC  
 (Medium Wildlife Crossing)

TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE  
 FOR  
**TANGERINE ROAD**  
 STA 885+40.00  
 TANGERINE ROAD

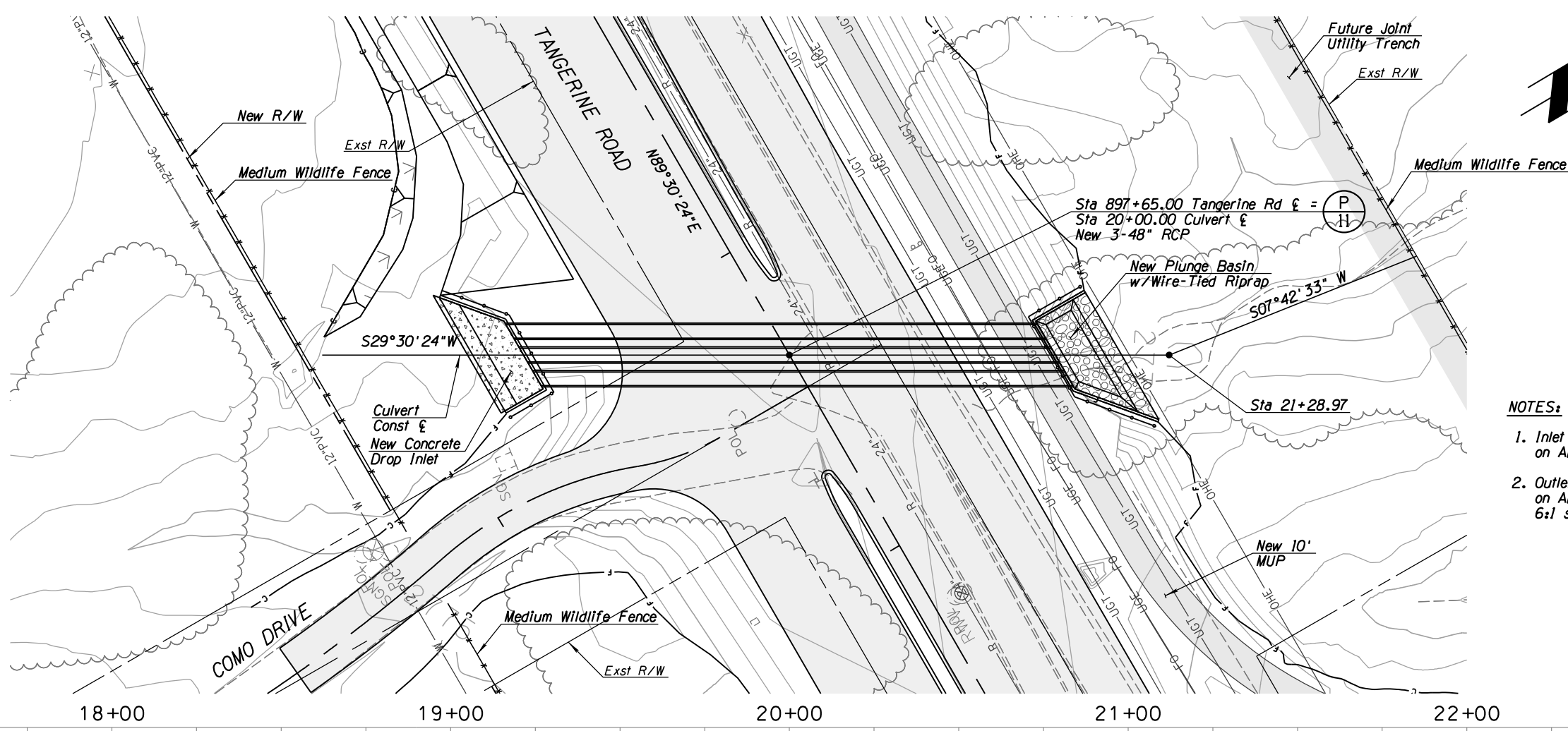
NO.	REVISION DESCRIPTION	DATE	BY	CHKD.	APP.

DESIGNED: DATE 01/13  
 DRAWN: DATE 01/13  
 CHECKED: DATE 01/13  
 PROJ. ENG.: DATE 01/13  
 MDA  
 MDA

30% PRELIMINARY NOT FOR CONSTRUCTION

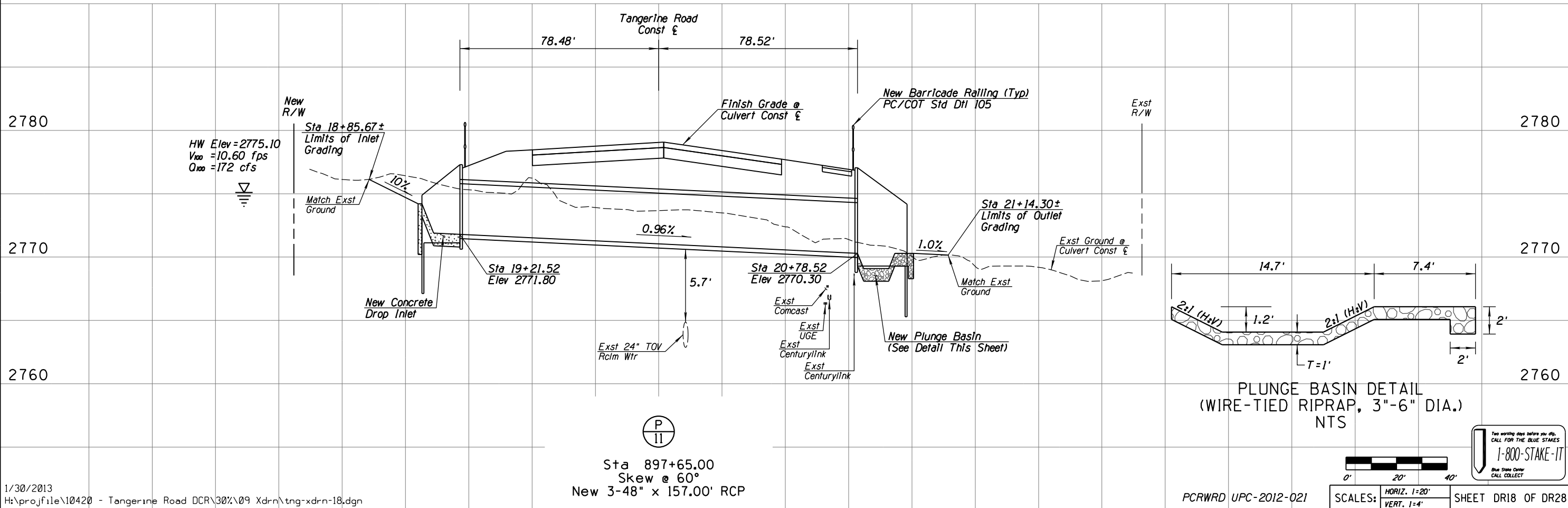
Kittelson & Associates, Inc.  
 33 North Stone Ave., Suite 800  
 Tucson, AZ 85701  
 (520) 544-4067

Two working days before you dig,  
 CALL FOR THE BLUE STAKES  
 1-800-STAKE-IT  
 Blue Stakes Center  
 CALL COLLECT

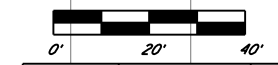


**NOTES:**

- Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 with 30° skew and 6:1 slopes.
- Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 (Modified) with 30° skew and 6:1 slopes.



Sta 897+65.00  
 Skew @ 60°  
 New 3'-48" x 157.00' RCP



SCALES: HORIZ. 1"=20'  
 VERT. 1"=4'



DATE	01/13	01/13	01/13
DESIGNED			
DRAWN			
CHECKED			
PROJ. ENG.			

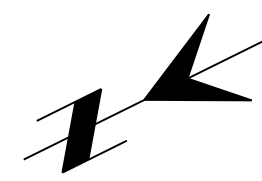
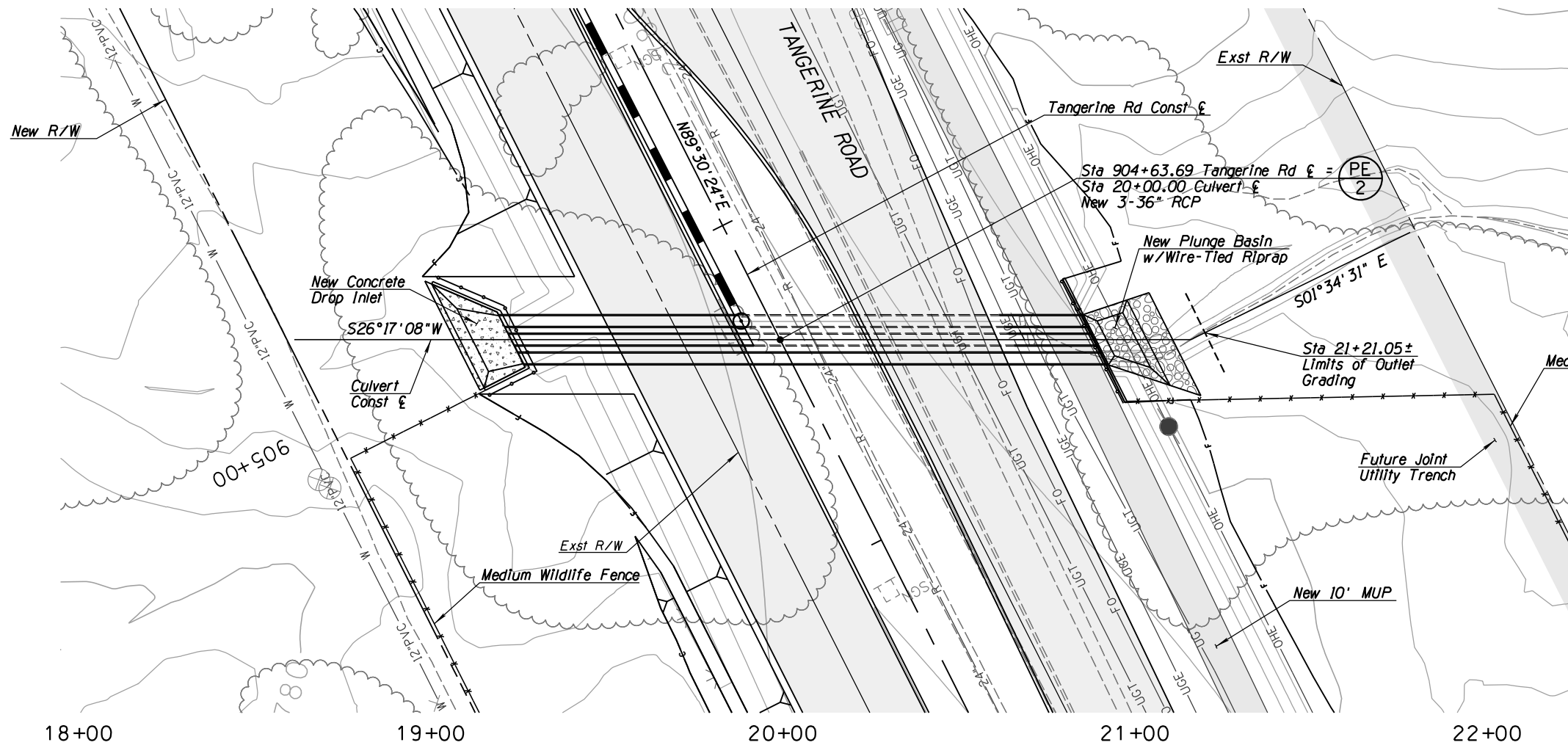
NO.	REVISION DESCRIPTION	DATE

30% PRELIMINARY NOT FOR CONSTRUCTION

Kittelson & Associates, Inc.  
 33 North Stone Ave., Suite 800  
 Tucson, AZ 85701  
 (520) 544-4067

TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD STA 897+65.00 TANGERINE ROAD

PCRWDR UPC-2012-021 SHEET DR18 OF DR28 PAGE 104 OF 128



**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 (Modified) with 30° skew and 6:1 slopes
2. Outlet headwall dimensions shall be based on ADOT Std Dwg B-11.11 (Modified) with 30° skew and 6:1 slopes.

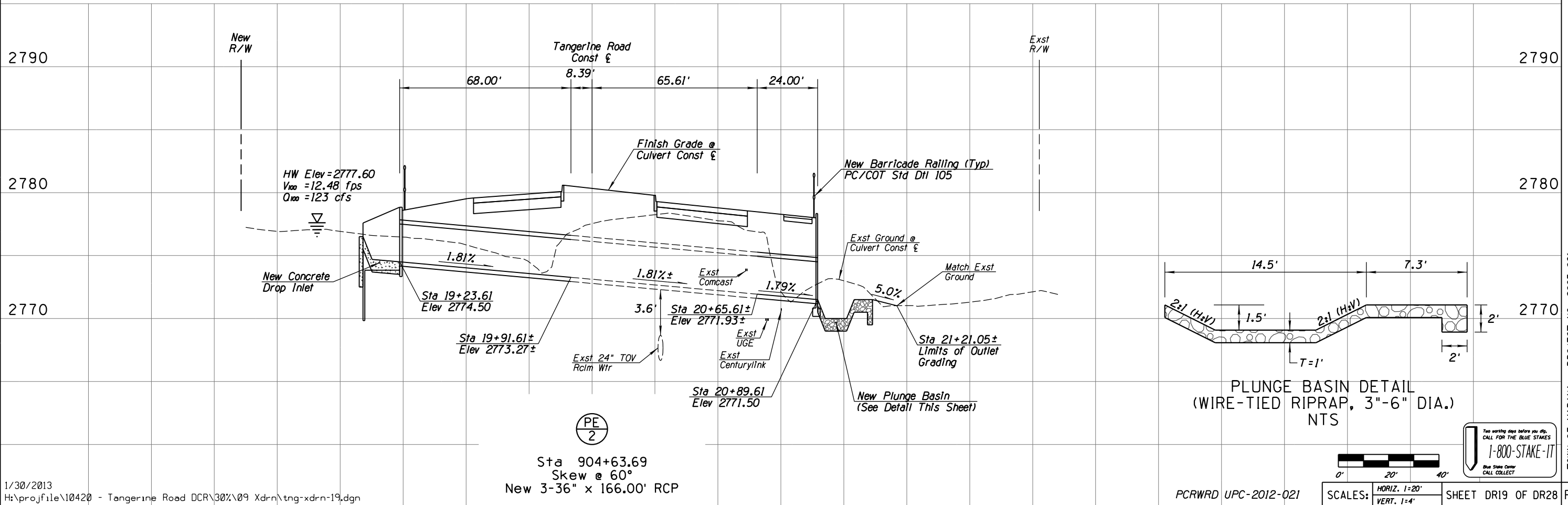
DATE	DESIGNED BY	DRAWN	CHECKED	PROJ. ENG.
01/13				
01/13				
07/13				

NO.	REVISION DESCRIPTION	DATE	BY

30%  
PRELIMINARY  
NOT FOR  
CONSTRUCTION

Kittelson & Associates, Inc.  
33 North Stone Ave., Suite 800  
Tucson, AZ 85701  
(520) 544-4067

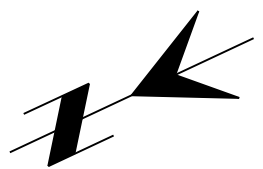
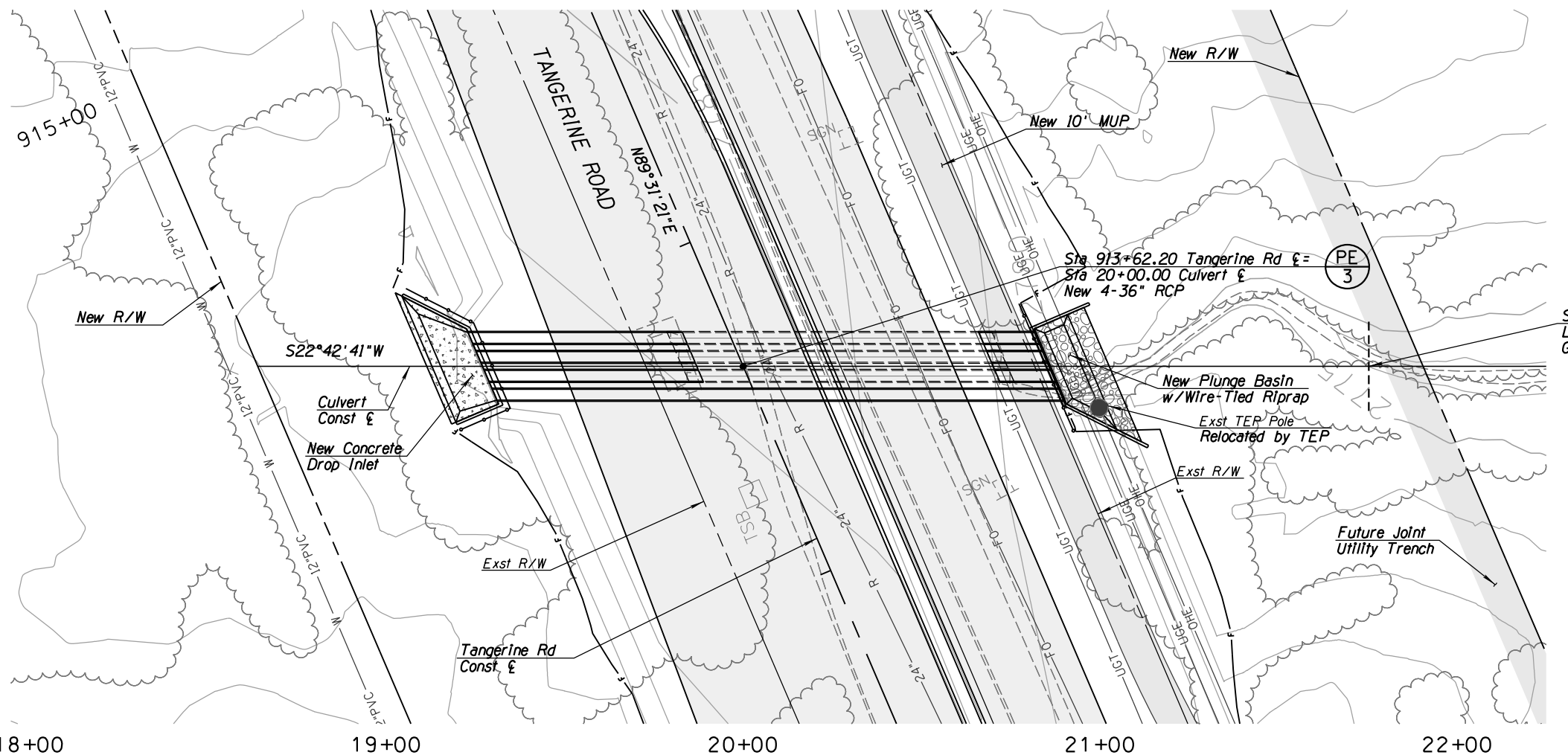
TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
TANGERINE ROAD  
STA 904+63.69  
TANGERINE ROAD



Sta 904+63.69  
Skew @ 60°  
New 3-36" x 166.00' RCP

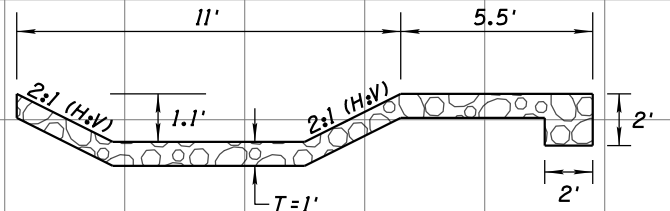
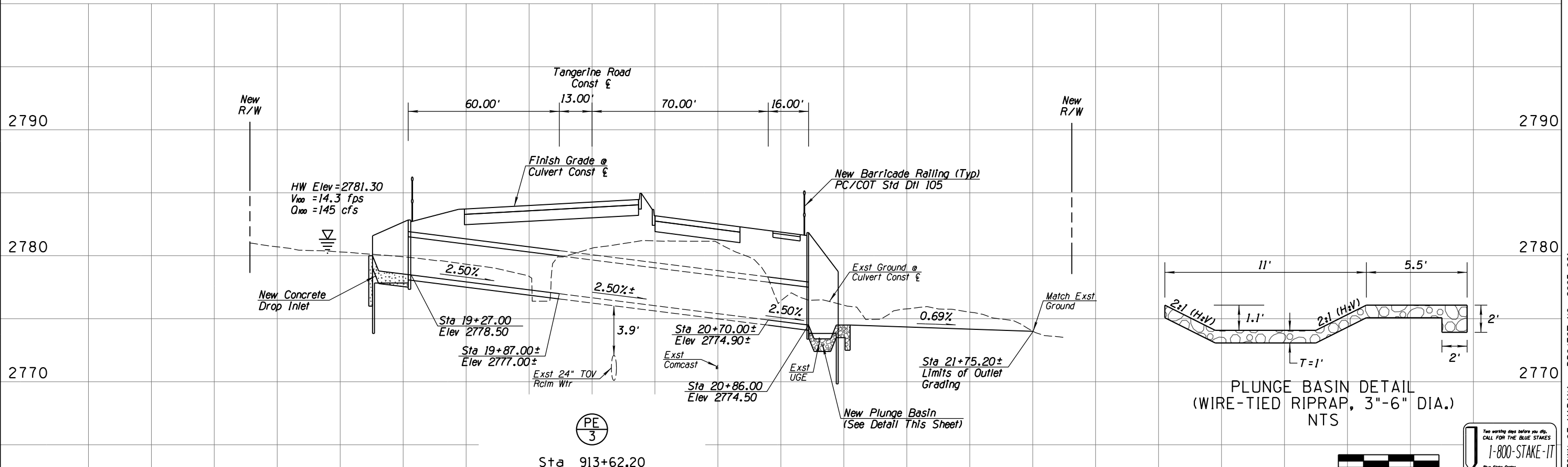




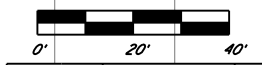


**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 (Modified) with 30° skew and 6:1 slopes
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.14 (Modified) with 30° skew and 6:1 slopes



Sta 913+62.20  
Skew @ 23°  
New 4-36" x 159.00' RCP



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'



DESIGNED:	AW	DATE	01/13
DRAWN:	TWS	DATE	01/13
CHECKED:	MDA	DATE	07/13
PROJ. ENG.:	MDA	DATE	07/13

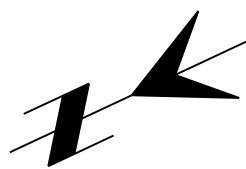
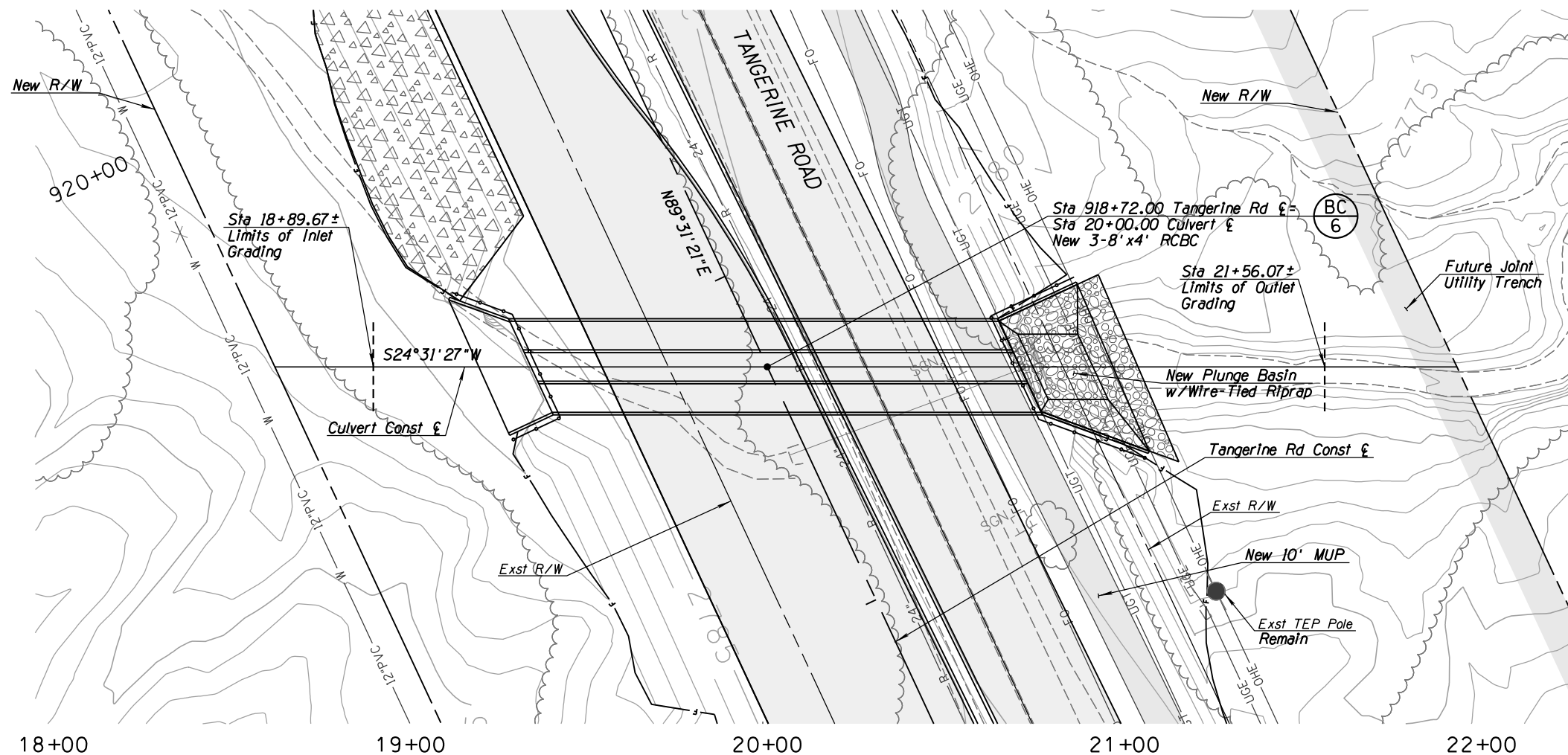
  

NO.	REVISION DESCRIPTION	DATE	ENGINEER

30% PRELIMINARY NOT FOR CONSTRUCTION

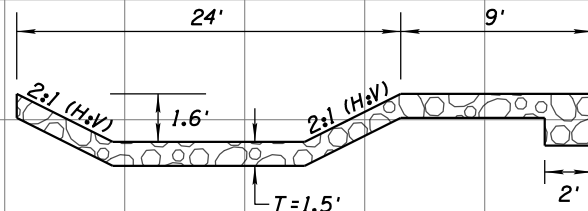
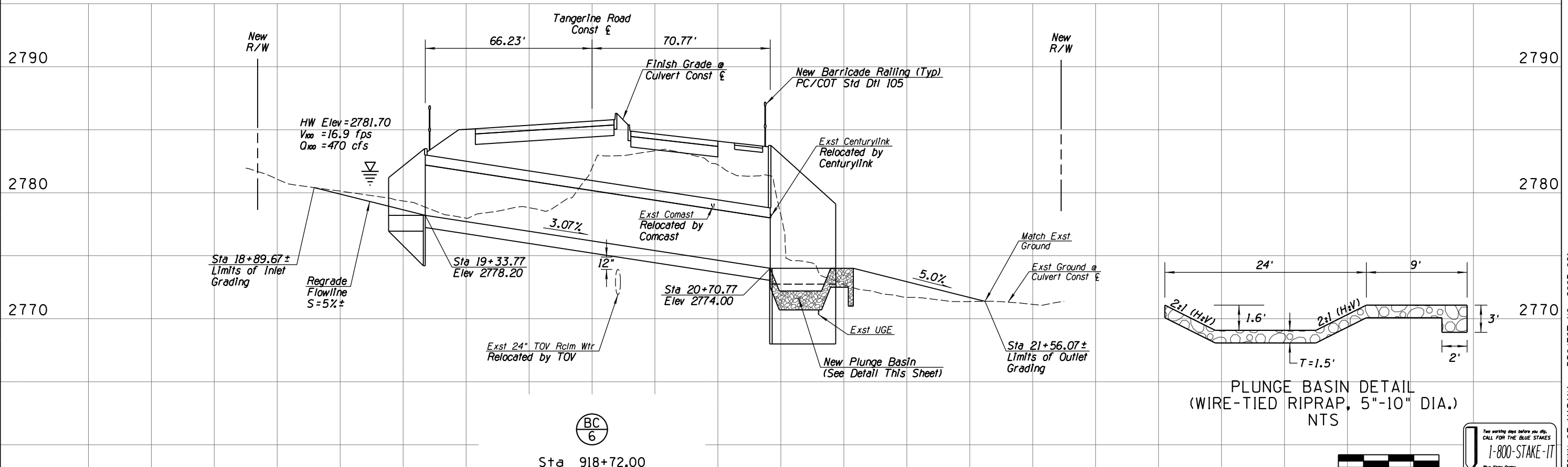
Kittelson & Associates, Inc.  
33 North Stone Ave., Suite 800  
Tucson, AZ 85701  
(520) 544-4067

TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD STA 913+62.20 TANGERINE ROAD

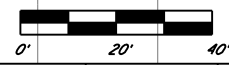


**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.70 with 25° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.50 (Modified) with 25° skew and 6:1 slopes.



**PLUNGE BASIN DETAIL**  
(WIRE-TIED RIPRAP, 5"-10" DIA.)  
NTS



Two working days before you dig,  
CALL FOR THE BLUE STAKES  
**1-800-STAKE-IT**  
Blue Stakes Center  
CALL COLLECT

Sta 918+72.00  
Skew @ 25°  
New 3-8'x4' x 137.00' RCBC

TOWN OF MARANA - PROJECT NO. 2005-061  
FOR  
DRAINAGE PLAN AND PROFILE  
TANGERINE ROAD  
STA 918+72.00  
TANGERINE ROAD

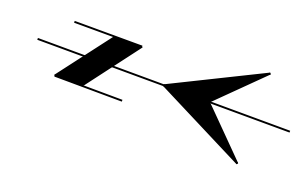
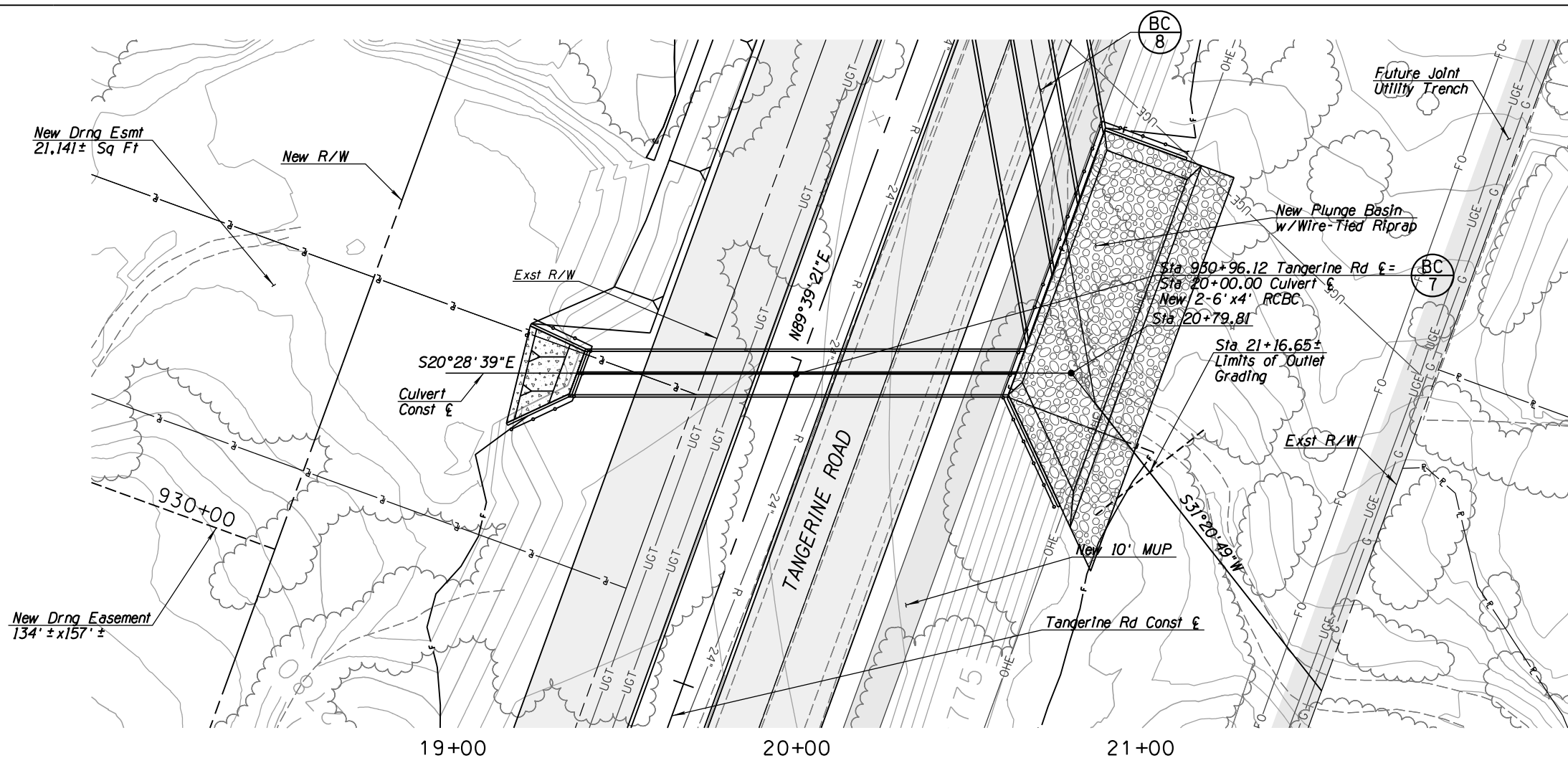
NO.	REVISION DESCRIPTION	DATE	DESIGNED BY	CHECKED BY	DATE

DATE	DESIGNED BY	CHECKED BY
01/13	AW	TWS
01/13	AW	MDA
07/13	AW	MDA

30% PRELIMINARY NOT FOR CONSTRUCTION

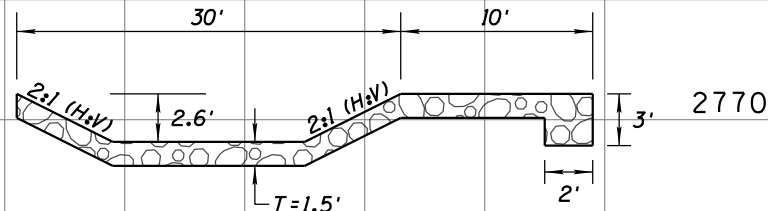
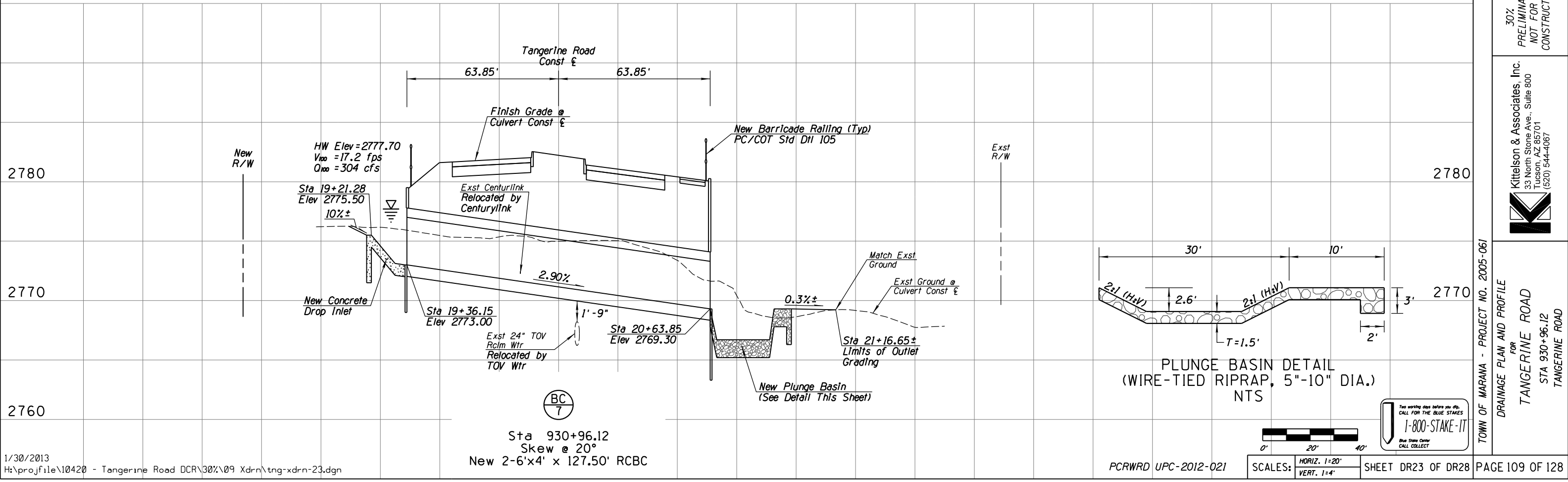
Kittelson & Associates, Inc.  
33 North Stone Ave., Suite 800  
Tucson, AZ 85701  
(520) 544-4067



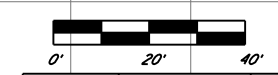


**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.30 (Modified) with 20° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.50 (Modified).



**PLUNGE BASIN DETAIL**  
(WIRE-TIED RIPRAP, 5"-10" DIA.)  
NTS



Two working days before you dig,  
CALL FOR THE BLUE STAKES  
**1-800-STAKE-IT**  
Blue State Center  
CALL COLLECT

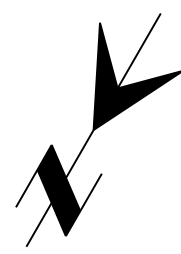
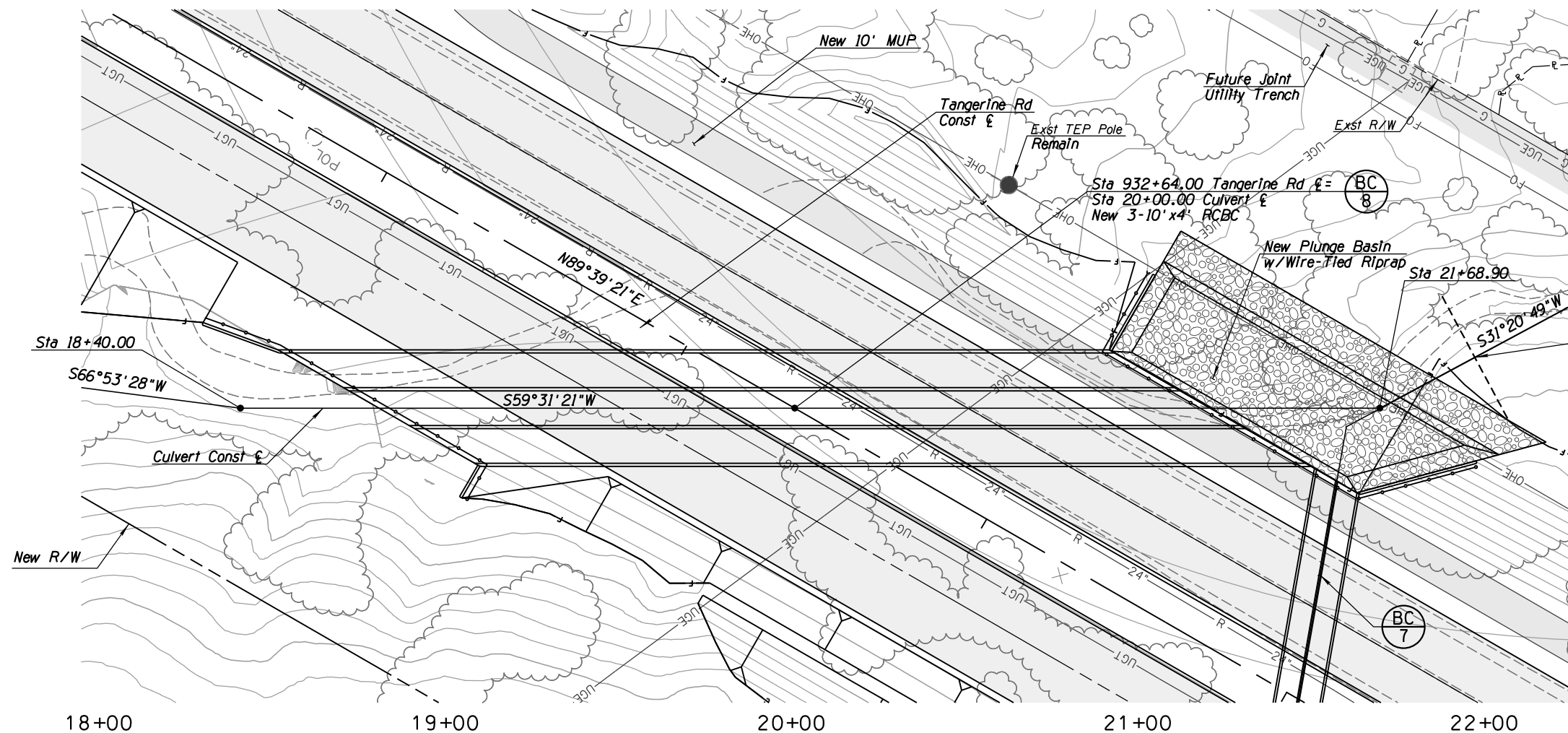
Sta 930+96.12  
Skew @ 20°  
New 2-6'x4' x 127.50' RCBC

NO.	REVISION DESCRIPTION	DATE	DESIGNED BY	DATE

30%  
PRELIMINARY  
NOT FOR  
CONSTRUCTION

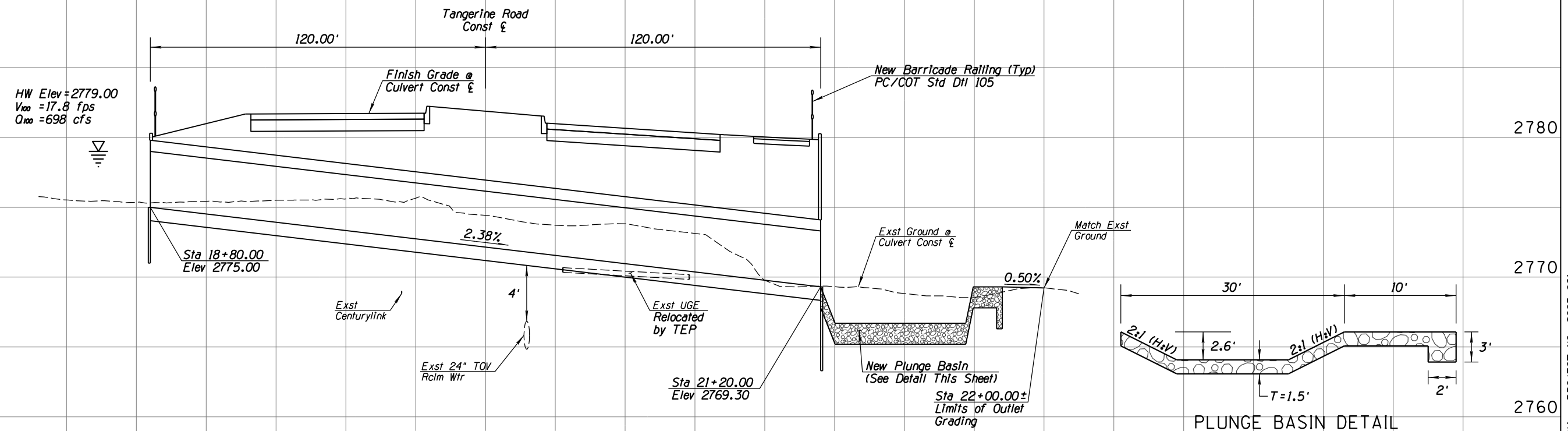
**Kittelson & Associates, Inc.**  
33 North Stone Ave., Suite 800  
Tucson, AZ 85701  
(520) 544-4067

TOWN OF MARANA - PROJECT NO. 2005-061  
FOR  
DRAINAGE PLAN AND PROFILE  
**TANGERINE ROAD**  
STA 930+96.12  
TANGERINE ROAD

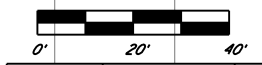


**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.70 (Modified) with 60° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.50 (Modified).



**PLUNGE BASIN DETAIL**  
(WIRE-TIED RIPRAP, 5"-10" DIA.)  
NTS



Two working days before you dig,  
CALL FOR THE BLUE STAKES  
**1-800-STAKE-IT**  
Blue State Center  
CALL COLLECT

SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

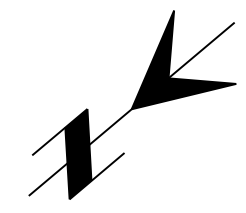
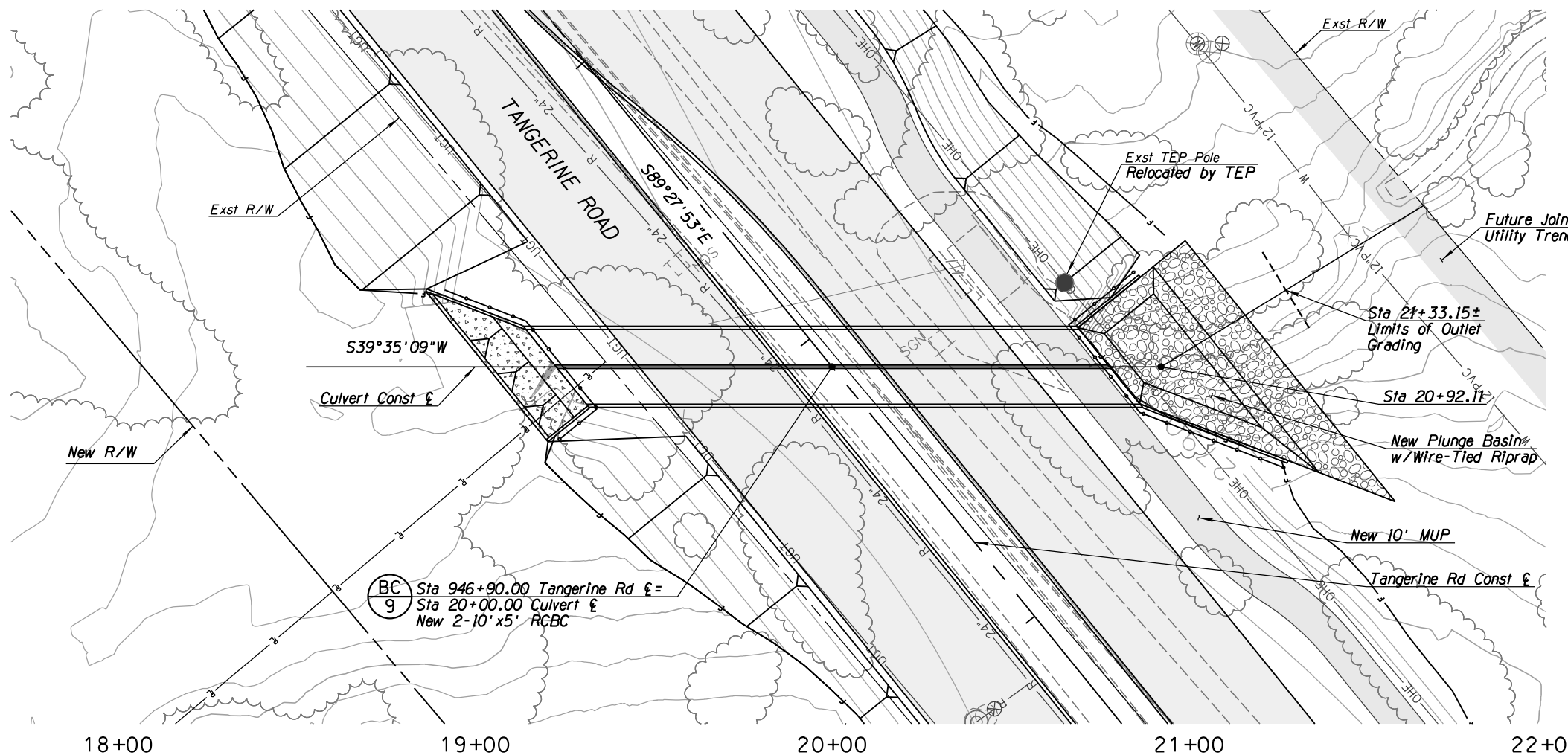
**BC 8**  
Sta 932+64.00  
Skew @ 60°  
New 3-10'x4' x 240.00' RCBC

TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE  
FOR  
TANGERINE ROAD  
STA 932+64.00  
TANGERINE ROAD

30%  
PRELIMINARY  
NOT FOR  
CONSTRUCTION

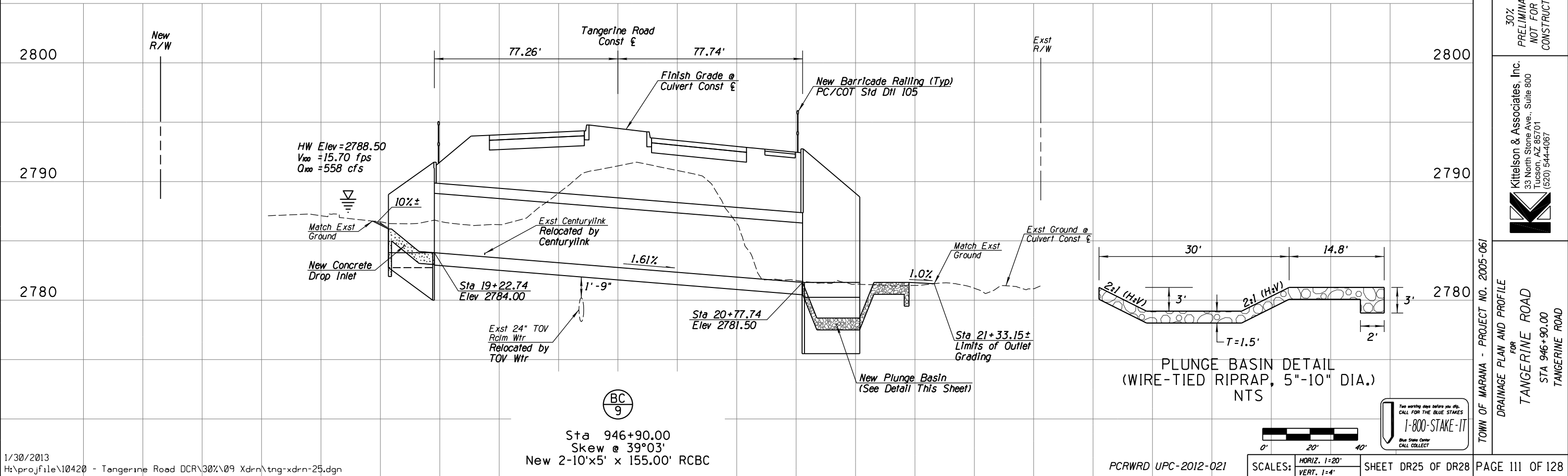
Kittelson & Associates, Inc.  
33 North Stone Ave., Suite 800  
Tucson, AZ 85701  
(520) 544-4067

NO.	REVISION DESCRIPTION	DATE	DESIGNED	DRAWN	CHECKED	PROJ. ENG.
			AW	TWB	MDA	MDA

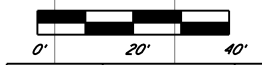


**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.70 (Modified) with 40° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.50 (Modified) with 40° skew and 6:1 slopes.



BC 9  
Sta 946+90.00  
Skew @ 39°03'  
New 2-10'x5' x 155.00' RCBC



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'



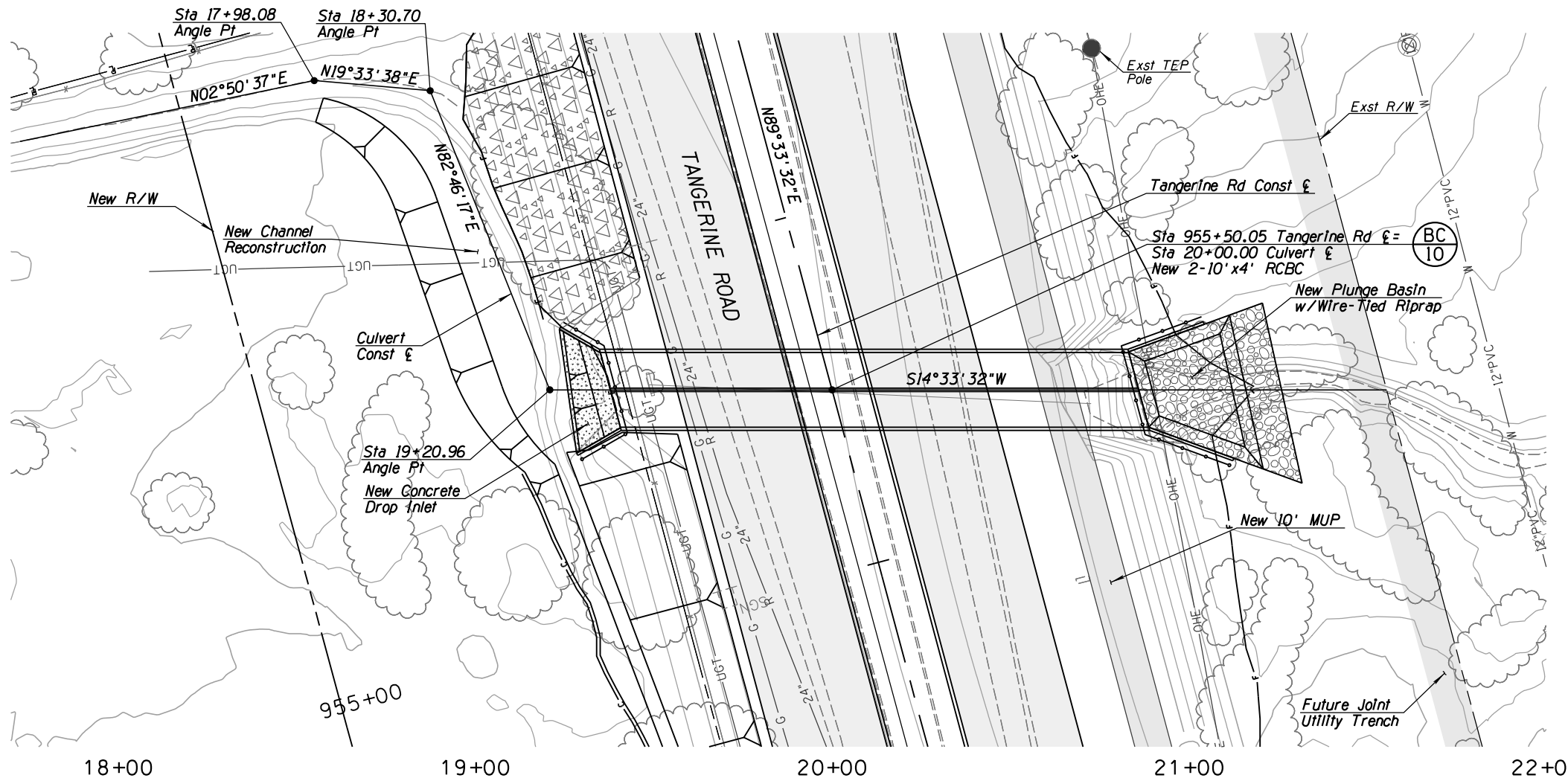
TOWN OF MARANA - PROJECT NO. 2005-061

30% PRELIMINARY NOT FOR CONSTRUCTION

Kittelson & Associates, Inc.  
33 North Stone Ave., Suite 800  
Tucson, AZ 85701  
(520) 544-4067

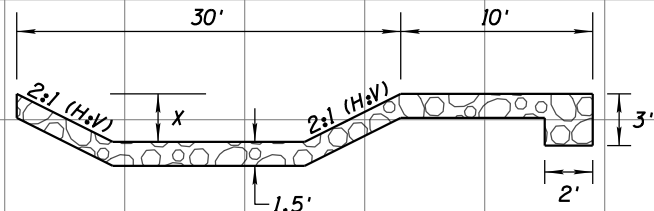
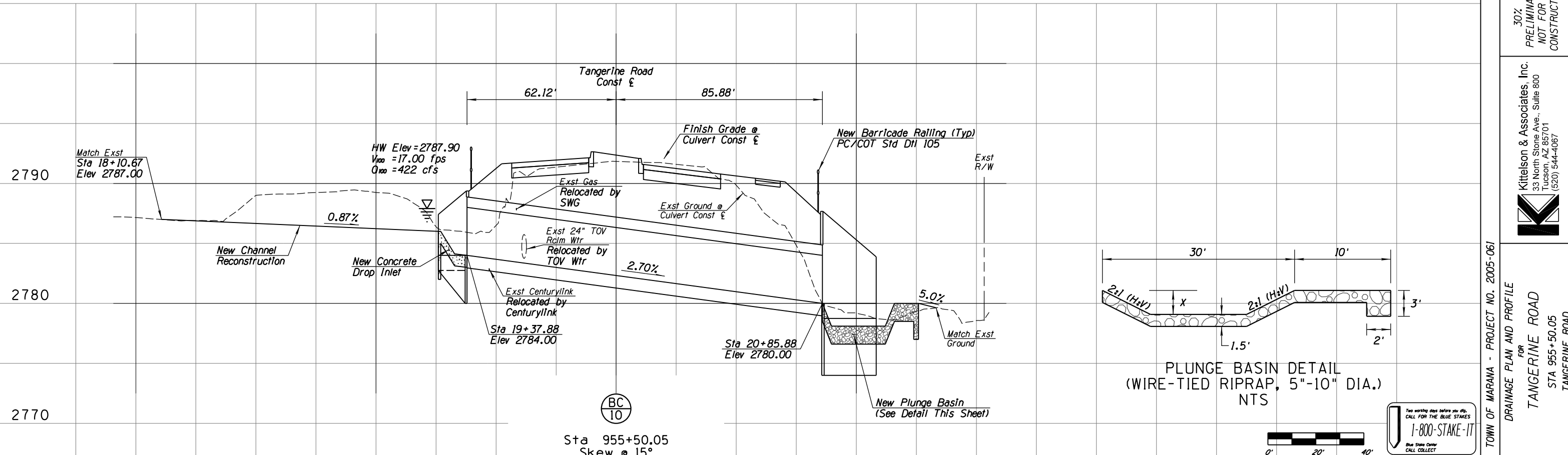
FOR  
DRAINAGE PLAN AND PROFILE  
TANGERINE ROAD  
STA 946+90.00  
TANGERINE ROAD

NO.	REVISION DESCRIPTION	DATE	DESIGNED	DRAWN	CHECKED	PROJ. ENG.
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		01/13				
		07/13				
		07/13				



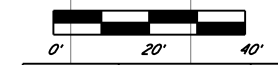
**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.30 with 15° skew and 6:1 slopes.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-04.10 (Modified) with 15° skew and 6:1 slopes.



PLUNGE BASIN DETAIL  
(WIRE-TIED RIPRAP, 5"-10" DIA.)  
NTS

Two working days before you dig,  
CALL FOR THE BLUE STAKES!  
1-800-STAKE-IT  
Blue State Center  
CALL COLLECT



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

DATE	01/13	01/13	07/13
DESIGNED BY	RIN	TWS	MDA
DRAWN			
CHECKED			
PROJ. ENG.			

NO.	REVISION DESCRIPTION	DATE

30%  
PRELIMINARY  
NOT FOR  
CONSTRUCTION

TOWN OF MARANA - PROJECT NO. 2005-061  
FOR  
DRAINAGE PLAN AND PROFILE  
TANGERINE ROAD  
STA 955+50.05  
TANGERINE ROAD

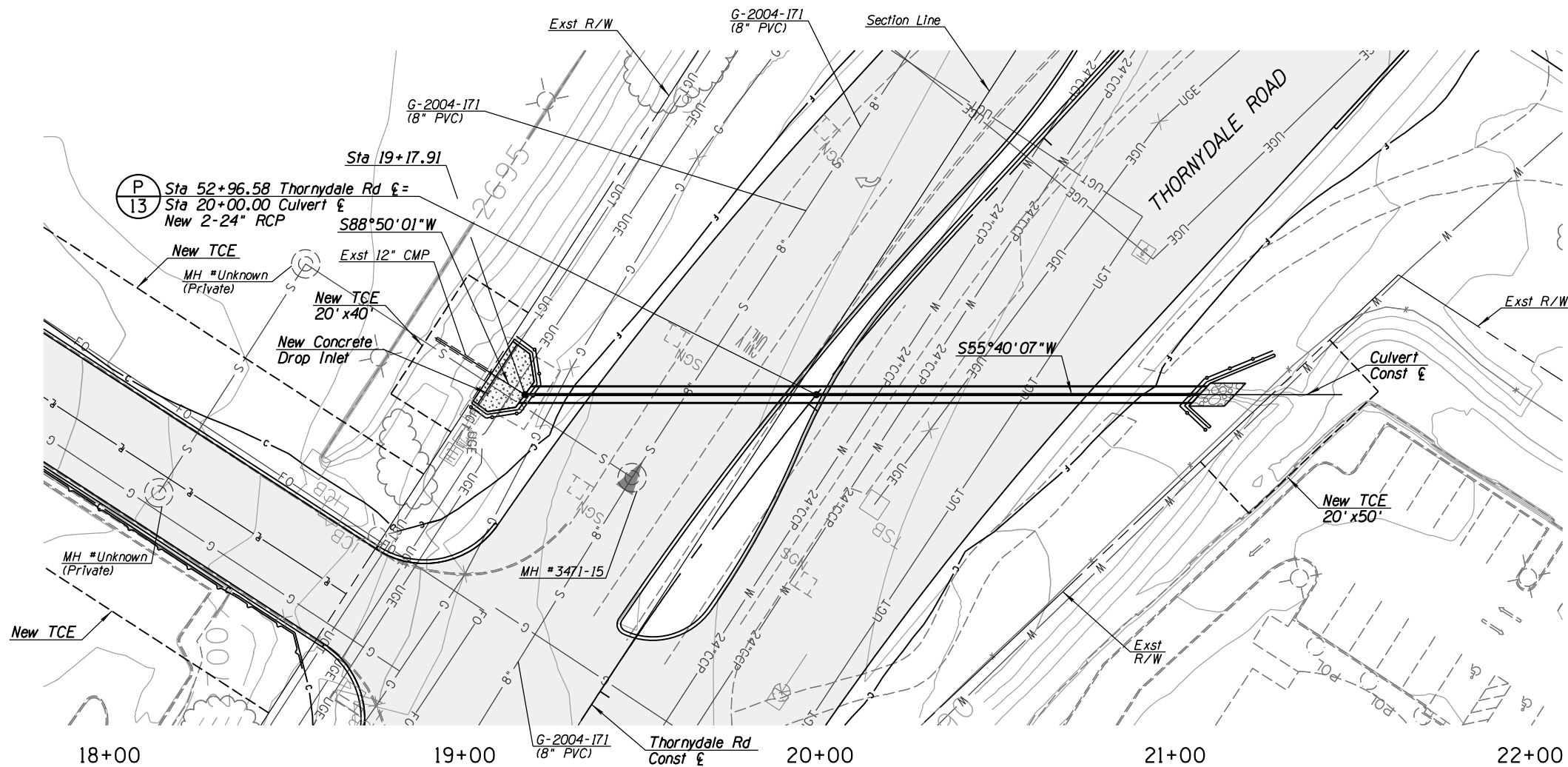
Kittelson & Associates, Inc.  
33 North Stone Ave., Suite 800  
Tucson, AZ 85701  
(520) 544-4067

1/30/2013  
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PCRWRD UPC-2012-021

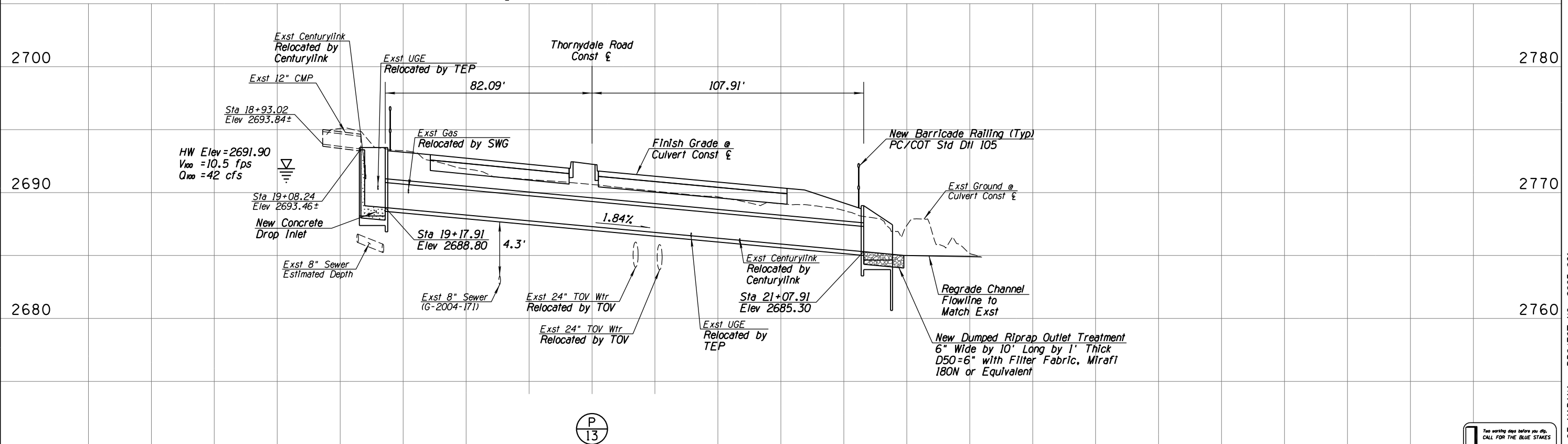
SHEET DR26 OF DR28


PAGE 112 OF 128

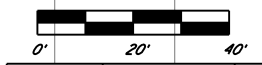


**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13 (Modified) with 45° skew, 6:1 slopes and dimensions for a 48" RCP.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13 (Modified) with 45° skew, 6:1 slopes and dimensions for a 48" RCP.



  
 Sta 52+96.58  
 Skew @ 40°  
 New 2-24" x 190.00' RCP



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'

Two working days before you dig,  
 CALL FOR THE BLUE STAKES  
**1-800-STAKE-IT**  
Blue Stake Center  
CALL COLLECT

TOWN OF MARANA - PROJECT NO. 2005-061  
 DRAINAGE PLAN AND PROFILE  
 FOR  
**TANGERINE ROAD**  
 THORNYDALE ROAD

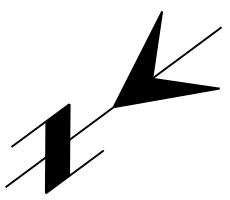
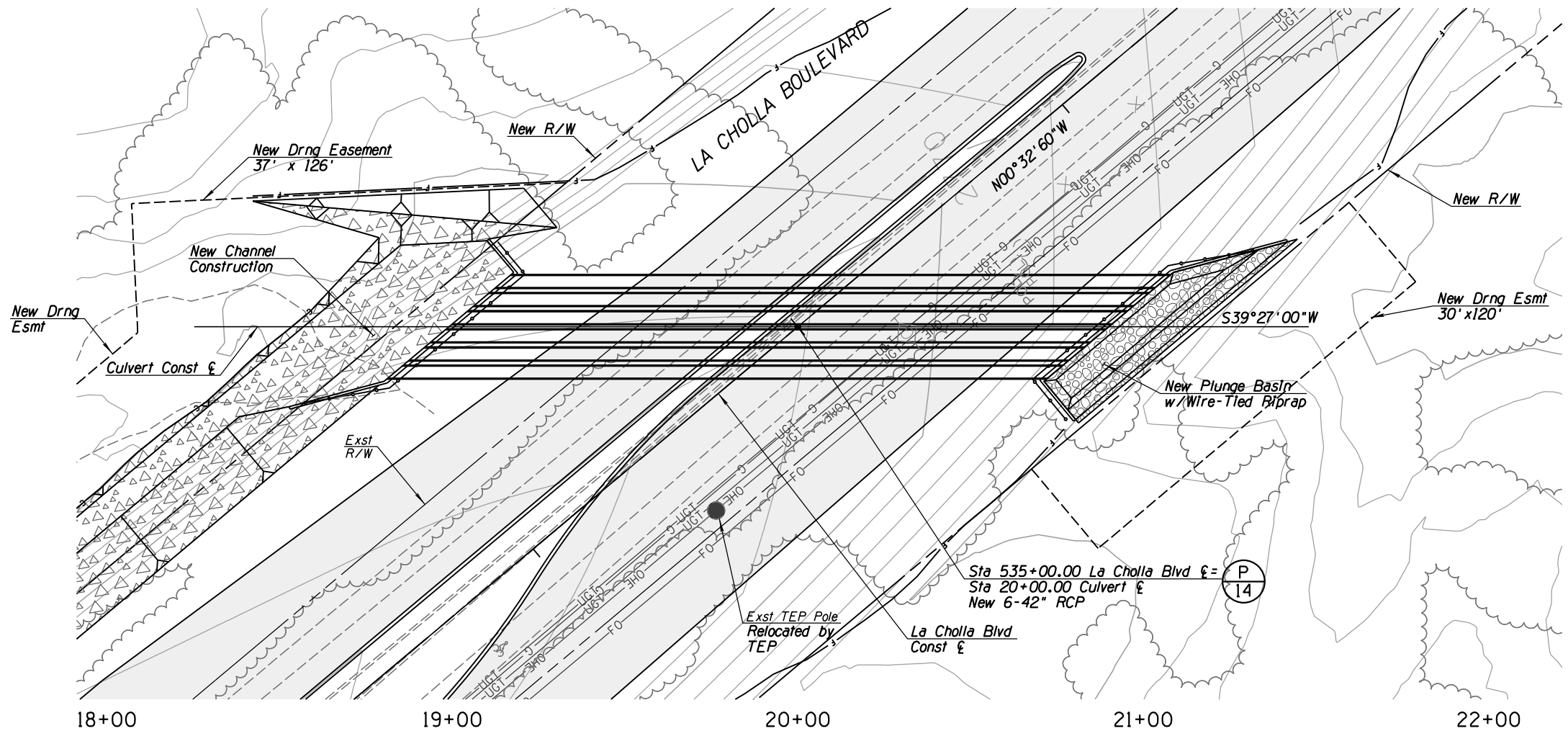
30%  
 PRELIMINARY  
 NOT FOR  
 CONSTRUCTION

Kittelson & Associates, Inc.  
 33 North Stone Ave., Suite 800  
 Tucson, AZ 85701  
 (520) 544-4067

NO.	REVISION DESCRIPTION	DATE

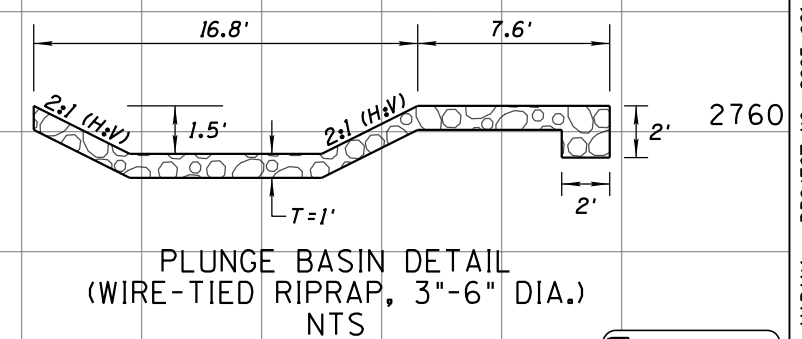
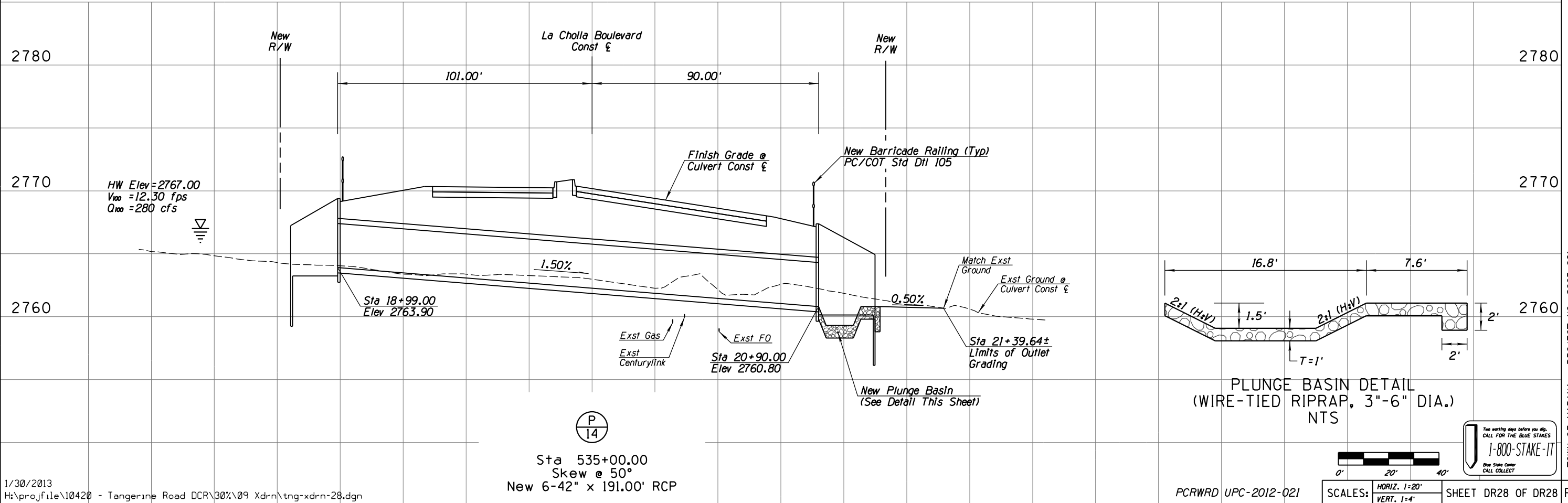
DATE	DESIGNED BY	DRAWN BY	CHECKED BY	PROJ. ENG. BY
01/13				
07/13				
07/13				





**NOTES:**

1. Inlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13 with 45° skew, 6:1 slopes and dimensions for a 48" RCP.
2. Outlet headwall & wingwall dimensions shall be based on ADOT Std Dwg B-11.13 with 45° skew, 6:1 slopes and dimensions for a 48" RCP.



**PLUNGE BASIN DETAIL**  
(WIRE-TIED RIPRAP, 3"-6" DIA.)  
NTS



SCALES: HORIZ. 1"=20'  
VERT. 1"=4'



DATE	01/13	01/13	07/13
DESIGNED BY	AW	TWS	MDA
DRAWN			
CHECKED BY			
PROJ. ENG.:	MDA	MDA	

NO.	REVISION DESCRIPTION	DATE

30% PRELIMINARY NOT FOR CONSTRUCTION

**Kittelson & Associates, Inc.**  
33 North Stone Ave., Suite 800  
Tucson, AZ 85701  
(520) 544-4067

TOWN OF MARANA - PROJECT NO. 2005-061  
DRAINAGE PLAN AND PROFILE FOR TANGERINE ROAD STA 535+00.00 LA CHOLLA BOULEVARD

1-800-STAKE-IT  
Blue State Center CALL COLLECT

PCRWDR UPC-2012-021 SHEET DR28 OF DR28 PAGE 114 OF 128

**P 14**  
Sta 535+00.00  
Skew @ 50°  
New 6-42" x 191.00' RCP

## **APPENDIX G**

### **CROSS CULVERT SEDIMENT TRANSPORT COMPUTATIONS**

- Sediment Transport Computations



**C.O.T Sedimentation at Culvert Crossings  
Eq. 11.9**

**Tangerine Road**

Date 2011.11.10

By: wjg

$$R_s = \frac{Q_{ac}}{Q_p} \left( \frac{S_{ac}}{S_p} \right)^{1.66} \left( \frac{n_{ac}}{n_p} \right)^{-1.55} \left( \frac{R_{ac}}{R_p} \right)^{0.91} \quad (11.9)$$

Where:

- $R_s$  = Sediment-transport ratio (channel to culvert);
- $Q_{ac}$  = Discharge in approach channel, in cubic feet per second;
- $Q_p$  = Total culvert discharge, in cubic feet per second;
- $S_{ac}$  = Longitudinal slope of approach channel, in feet/foot;
- $S_p$  = Longitudinal slope of culvert, in feet/foot;
- $n_{ac}$  = Manning's roughness coefficient for the approach channel;

CP	$Q_{ac}$	$Q_p$	$S_{ac}$	$S_p$	$n_{ac}$	$n_p$	$R_{ac}$	$R_p$	$R_s$
1	422	422	0.009	0.027	0.04	0.012	0.6	0.97	0.016
2	558	558	0.012	0.016	0.035	0.012	1	1.32	0.091
4	698	698	0.026	0.0237	0.035	0.012	1.24	0.99	0.273
5	278	278	0.017	0.029	0.035	0.012	0.93	1.00	0.073
7	496	496	0.013	0.0294	0.035	0.012	2.33	0.83	0.126
8	145	145	0.022	0.025	0.035	0.012	0.35	0.63	0.091
9	135	135	0.032	0.0235	0.035	0.012	0.29	0.49	0.195
La Cholla 534+93	280	280	0.017	0.016	0.035	0.012	1.03	0.77	0.273
10	123	123	0.012	0.0185	0.035	0.012	0.94	0.72	0.118
11	172	172	0.009	0.01	0.035	0.012	0.64	0.92	0.115
13	2743	2743	0.0128	0.0192	0.035	0.012	1.83	1.36	0.128
14	77	77	0.014	0.0113	0.035	0.012	0.51	0.66	0.214
15	40	40	0.021	0.0166	0.035	0.012	0.3	0.72	0.127
16	153	153	0.021	0.0293	0.035	0.012	0.54	0.83	0.074
17	126	126	0.033	0.023	0.035	0.012	0.71	0.80	0.311
19	4706	4706	0.015	0.0139	0.035	0.015	1.22	1.90	0.204
20	168	168	0.022	0.0136	0.035	0.012	0.55	1.00	0.245
21	318	318	0.019	0.192	0.035	0.012	0.34	0.92	0.002
22	1110	1110	0.0135	0.0254	0.035	0.012	1.2	1.06	0.075





# CMG DRAINAGE ENGINEERING, INC.

3555 N. Mountain Ave. Tucson, Arizona 85719  
Phone (520) 882-4244 Fax (520) 888-1421

CP	Q <sub>ac</sub>	Q <sub>p</sub>	S <sub>ac</sub>	S <sub>p</sub>	n <sub>ac</sub>	n <sub>p</sub>	R <sub>ac</sub>	R <sub>p</sub>	R <sub>s</sub>
23	12	12	0.027	0.0233	0.035	0.012	0.2	0.43	0.122
24	157	157	0.019	0.0188	0.035	0.012	0.54	0.91	0.120
25	339	339	0.021	0.015	0.035	0.012	0.92	1.02	0.303
26.1	112	112	0.03	0.0122	0.035	0.012	0.84	0.85	0.839
26.2	7.3	7.3	0.018	0.01	0.035	0.012	0.20	0.41	0.264
27 E	42	42	0.01	0.02	0.035	0.012	1.10	0.47	0.132
27	63	63	0.03	0.011	0.035	0.012	0.29	0.62	0.503
28	810	810	0.015	0.015	0.035	0.012	1.06	1.12	0.181
29	127	127	0.0133	0.0299	0.035	0.012	0.71	0.73	0.048
30	140	140	0.0185	0.0319	0.035	0.012	0.59	0.76	0.061
31	31	31	0.033	0.03	0.035	0.012	0.2	0.56	0.087
32	2574	2574	0.022	0.0399	0.035	0.012	1.38	1.16	0.083
33.1	26	26	0.029	0.025	0.035	0.012	0.2	0.56	0.096
35	607	607	0.03	0.0189	0.035	0.012	0.77	1.19	0.275
36	63	63	0.021	0.0147	0.035	0.012	0.38	0.69	0.199
37	98	98	0.023	0.0337	0.035	0.012	0.46	0.67	0.072
39	571	571	0.02	0.025	0.035	0.012	0.83	0.87	0.126
40	372	372	0.021	0.029	0.035	0.012	0.83	0.56	0.159
41	80	80	0.024	0.028	0.035	0.012	0.45	0.64	0.106
44	1185	1185	0.02	0.037	0.035	0.012	0.76	0.99	0.054
45	172	172	0.019	0.015	0.035	0.012	0.53	0.99	0.160
46	435	435	0.015	0.023	0.035	0.012	1.10	0.96	0.106
47	50	50	0.025	0.025	0.035	0.012	0.65	0.57	0.215
48	88	88	0.025	0.013	0.035	0.012	0.65	0.79	0.473
49.1	14	14	0.025	0.0297	0.035	0.012	0.20	0.42	0.072
52	2537	2537	0.03	0.035	0.035	0.012	0.30	1.13	0.044
53	148	148	0.033	0.013	0.035	0.012	0.53	0.82	0.597
54	124	124	0.029	0.0181	0.035	0.012	0.33	0.85	0.177
55	157	157	0.027	0.01	0.035	0.012	0.48	1.03	0.492
56	232	232	0.027	0.0189	0.035	0.012	0.45	0.46	0.335
58	91	91	0.029	0.016	0.035	0.012	0.37	0.77	0.264
59	161	161	0.028	0.015	0.035	0.012	0.46	0.96	0.274
60	312	312	0.034	0.022	0.035	0.012	0.26	0.89	0.126
61	73	73	0.034	0.035	0.035	0.012	0.26	0.60	0.084
62.2	71	71	0.028	0.0221	0.035	0.012	0.25	0.63	0.121
62.3	15	15	0.022	0.0196	0.035	0.012	0.26	0.49	0.129
63	73	73	0.029	0.025	0.035	0.012	0.35	0.65	0.138
64	161	161	0.025	0.0202	0.035	0.012	0.72	0.91	0.219



# **CMG DRAINAGE ENGINEERING, INC.**

3555 N. Mountain Ave. Tucson, Arizona 85719  
Phone (520) 882-4244 Fax (520) 888-1421

<b>CP</b>	<b>Q<sub>ac</sub></b>	<b>Q<sub>p</sub></b>	<b>S<sub>ac</sub></b>	<b>S<sub>p</sub></b>	<b>n<sub>ac</sub></b>	<b>n<sub>p</sub></b>	<b>R<sub>ac</sub></b>	<b>R<sub>p</sub></b>	<b>R<sub>s</sub></b>
<b>65</b>	<b>60</b>	<b>60</b>	<b>0.03</b>	<b>0.021</b>	<b>0.035</b>	<b>0.012</b>	<b>0.53</b>	<b>0.62</b>	<b>0.298</b>
<b>66</b>	<b>563</b>	<b>563</b>	<b>0.036</b>	<b>0.019</b>	<b>0.035</b>	<b>0.012</b>	<b>1.04</b>	<b>1.01</b>	<b>0.564</b>
<b>67</b>	<b>785</b>	<b>785</b>	<b>0.02</b>	<b>0.0192</b>	<b>0.035</b>	<b>0.012</b>	<b>1.04</b>	<b>0.95</b>	<b>0.220</b>
<b>70</b>	<b>1404</b>	<b>1404</b>	<b>0.03</b>	<b>0.0164</b>	<b>0.035</b>	<b>0.012</b>	<b>0.53</b>	<b>0.73</b>	<b>0.384</b>
<b>FR1</b>	<b>82</b>	<b>82</b>	<b>0.015</b>	<b>0.02</b>	<b>0.035</b>	<b>0.012</b>	<b>1.10</b>	<b>0.68</b>	<b>0.182</b>
<b>FR2</b>	<b>7</b>	<b>7</b>	<b>0.015</b>	<b>0.01</b>	<b>0.035</b>	<b>0.012</b>	<b>1.10</b>	<b>0.39</b>	<b>0.965</b>
<b>FR3</b>	<b>18</b>	<b>18</b>	<b>0.015</b>	<b>0.01</b>	<b>0.035</b>	<b>0.012</b>	<b>1.10</b>	<b>0.47</b>	<b>0.815</b>
<b>Trico</b>	<b>1506</b>	<b>1506</b>	<b>0.016</b>	<b>0.009</b>	<b>0.035</b>	<b>0.012</b>	<b>1.10</b>	<b>1.49</b>	<b>0.376</b>

## **APPENDIX H**

### **CHANNEL AND BANK PROTECTION DESIGN COMPUTATIONS**

Includes

- Channel and Bank Protection Summary Table
- Channel and Bank Protection Computations

Roadside Channel/Bank Protection Analyses Summary Table - From Sta. 442+00 to Sta. 785+00

Cross Section Station	Watershed	Est. Q100 (cfs)	Allowable Velocity for Earthen Channel and Roadway embankment (fps)	Roadway Embank Protection								North Side Channel											
				Water Ponding Depth Increase at ROW	Flow Velocity (fps)	Water Depth (ft)	YES/NO	Type	Station		Toedown Depth (ft)	Channel Types	YES/NO	Station		Bottom Width (ft)	Depth (ft)	Min. Longitudal Slopes (ft/ft)	Side Slope (ft/ft)		Flow Depth (ft)	Channel Flow Velocity (fps)	Freeboard (ft)
									YES/NO	From				To	From				To	North			
520+00	67	232	4.9	NO	9.9	1.4	YES	Colored Shotcrete	516+47	524+14	N/A	Colored Shotcrete	Yes	516+47	524+14	15	2.5	0.02	2	2	1.4	9.9	0.5
526+00	67	Concentrated flow from north					YES	Colored Shotcrete	525+64	526+16	3	-	No	-	-	-	-	-	-	-	-	-	-
530+00	66	395	4.9	NO	9.8	1.7	YES	Colored Shotcrete	527+86	534+00	N/A	Colored Shotcrete	Yes	527+86	534+00	20	3	0.015	2	2	1.7	9.8	0.5
565+00	63	44	4.9	NO	6.8	1.4	YES	Colored Shotcrete	562+61	568+41	N/A	Colored Shotcrete	Yes	562+61	568+41	2	2	0.015	2	2	1.4	6.8	0.4
577+15	62.1	637	4.9	NO	9.6	1.8	YES	Colored Shotcrete	576+12	577+59	5.7	-	No	-	-	-	-	-	-	-	-	-	-
578+36	62.1	40	4.9	NO	3.9	0.5	YES	Colored Shotcrete	578+95	579+40	3	-	No	-	-	-	-	-	-	-	-	-	-
583+00	61	73	4.9	NO	8.4	1.3	YES	Colored Shotcrete	579+74	585+32	N/A	Colored Shotcrete	Yes	579+74	585+32	4	2	0.02	2	2	1.3	8.4	0.4
590+59	60	312	4.9	NO	6.9	1.3	YES	Colored Shotcrete	589+18	591+20	3	-	No	-	-	-	-	-	-	-	-	-	-
602+00	58	91	4.9	NO	8.6	1.3	YES	Colored Shotcrete	597+10	606+50	N/A	Colored Shotcrete	Yes	597+10	606+50	6	2	0.02	2	2	1.3	8.6	0.4
608+00	57	28	4.9	NO	4.9	1.2	NO	-	-	-	-	Earthen	Yes	606+50	609+90	0	2	0.02	4	4	1.2	4.9	0.3
615+55	56	232	4.9	NO	9.7	1.4	YES	Colored Shotcrete	613+80	617+52	N/A	Colored Shotcrete	Yes	613+80	617+52	15	2.5	0.02	2	2	1.4	9.7	0.5
620+00	56	30	4.9	NO	4.9	1.2	NO	-	-	-	-	Earthen	Yes	617+42	625+65	0	2	0.02	4	4	1.2	4.9	0.3
629+00	55	120	4.9	NO	9.3	1.5	YES	Colored Shotcrete	627+96	630+55	N/A	Colored Shotcrete	Yes	627+96	630+55	6	2	0.02	2	2	1.5	9.3	0.5
633+00	55	25	4.9	NO	7.6	0.9	YES	Colored Shotcrete	630+85	634+58	N/A	Colored Shotcrete	Yes	630+85	634+58	2	2	0.03	2	2	0.9	7.6	0.3
640+00	54	124	4.9	NO	9	1.3	YES	Colored Shotcrete	635+95	642+50	N/A	Colored Shotcrete	Yes	635+95	642+50	8	2	0.02	2	2	1.3	9	0.4
649+85	53	118	4.9	NO	9.8	1.2	YES	Colored Shotcrete	645+00	654+00	N/A	Colored Shotcrete	Yes	645+00	654+00	10	2	0.025	2	2	1.2	9.8	0.4
665+79	52	1200	4.9	NO	12.5	2.4	YES	Colored Shotcrete	662+72	672+50	N/A	Colored Shotcrete	Yes	662+72	672+44	35	3.5	0.015	2	2	2.4	12.5	0.8
676+00	51	183	4.9	NO	9.7	1.3	YES	Colored Shotcrete	675+60	681+00	N/A	Colored Shotcrete	Yes	675+60	681+00	12	2	0.022	2	2	1.3	9.7	0.5
684+00	51	183	4.9	NO	8.6	1.5	YES	Colored Shotcrete	681+00	684+54	3	-	No	-	-	-	-	-	-	-	-	-	-
686+00	50	106	4.9	NO	7.8	1.3	YES	Colored Shotcrete	684+54	689+10	N/A	Colored Shotcrete	Yes	684+54	689+10	8	2	0.015	2	2	1.3	7.8	0.4
696+00	48	30	4.9	NO	5.1	1	YES	Colored Shotcrete	695+00	697+42	N/A	Colored Shotcrete	Yes	695+00	697+42	4	1.5	0.01	2	2	1	5.1	0.2
705+00	46	5	4.9	NO	1.9	0.8	NO	-	-	-	-	Earthen	Yes	703+90	705+70	0	1	0.005	4	4	0.8	1.9	0.1
716+24	44	1185	4.9	NO	9.9	2.8	YES	-	-	-	-	Colored Shotcrete	Yes	See Plan		40	4	0.0075	1	1	2.8	9.9	0.7
722+37	43	496	4.9	NO	12.3	2.6	YES	Colored Shotcrete	716+50	723+58	N/A	Colored Shotcrete	Yes	716+50	723+58	10	4	0.016	2	2	2.6	12.3	0.8
725+00	43	496	4.9	NO	14.6	2.3	YES	Colored Shotcrete	723+58	726+13	N/A	Colored Shotcrete	Yes	723+58	726+13	10	4	0.026	2	2	2.3	14.6	0.9
727+00	43	399	4.9	NO	10.3	1.2	YES	Colored Shotcrete	726+13	727+46	N/A	Colored Shotcrete	Yes	726+13	727+46	30	2	0.025	2	2	1.2	10.3	0.5
743+00	40	3	4.9	NO	1.7	0.7	NO	-	-	-	-	Earthen	Yes	742+31	743+82	0	1	0.005	4	4	0.7	1.7	0.1
747+00	38	35	4.9	NO	4	1.1	YES	Colored Shotcrete	745+00	748+00	N/A	Colored Shotcrete	Yes	745+10	747+93	6	2	0.005	2	2	1.1	4	0.2
751+55	37	66	4.9	NO	4.7	1.2	YES	Colored Shotcrete	751+24	752+27	N/A	Colored Shotcrete	Yes	751+24	752+27	10	2	0.006	2	2	1.2	4.7	0.3
754+00	36	5.0	4.9	NO	1.9	0.8	NO	-	-	-	-	Earthen	Yes	753+49	755+00	0	1	0.005	4	4	0.8	1.9	0.1
756+79	35	15	4.9	NO	3	0.7	NO	-	-	-	-	Earthen	Yes	755+74	757+16	4	1	0.008	4	4	0.7	3	0.1
762+58	35	58	4.9	NO	7.5	1	YES	Colored Shotcrete	759+85	767+35		Colored Shotcrete	Yes	759+85	767+35	6	1.5	0.02	2	2	1	7.5	0.3
778+45	31	5.8	4.9	NO	2	0.6	NO	-	-	-	-	Earthen	Yes	778+49	778+84	3	1	0.005	4	4	0.6	2	0.1

Tangerine Road: Prelim. Roadside Channel/Bank Protection Analyses Summary Table - Sta. 785+00 to Sta.960+00 - 12-2-2012																						
ID Station	Watershed	Est. Q100 (cfs)	Allowable Velocity for Earthen Channel (fps)	Roadway Embankment Protection									Roadside Channel									
				Water Ponding Depth Increase at ROW	Flow Velocity (fps)	Water Depth (ft)	YES/NO	Type	Station		Toedown Depth (ft)	YES/NO	Station		Long-slope (%)	Bottom Width (ft)	Side Slope (_ H:1V)	Flow Depth (ft)	Flow Velocity (fps)	Freeboard (ft)	Min Required Channel Depth	Bank Protection type
									From	To			From	To								
Tangerine Rd																						
956+00, Lt	1	422	4.9	no	7.8	2.0	yes	grouted riprap or shotcrete	955+75	957+00	6ft (N & S slopes)	Yes	See inlet approach channel regrading sketch submitted previously with Sta. 955+49 culvert									
951+60, Lt	1W & 2E	6	4.9	no	1.8	0.5	no	-	-	-	-	KAI Chnl OK	-	-	-	-	-	-	-	-	-	veg
945+45, Lt	2W & 3E	< 5	4.9	no	< 2	< 0.5	no	-	-	-	-	KAI Chnl OK	-	-	-	-	-	-	-	-	-	veg
941+00, Lt	3	66	4.9	no	-	-	N/A, see chnl	-	-	-	-	Yes	937+20	944+80	0.5 - 2.1	4	3 N, 6 S	1.5	6.7	0.3	2.0	fully lined grouted riprap or shotcrete
937+00, Rt	Pvmt + local south wtshd	3	4.9	no	< 2	< 0.5	no	-	-	-	-	KAI Chnl OK	934+00	940+00	-	-	-	-	-	-	-	veg
926+75, Lt	5W & 6E	30	4.9	no	-	-	N/A, see chnl	-	-	-	-	yes	924+00	929+50	1.75 max	4	3 N, 6 S	0.8	5.1	0.2	-	fully lined grouted riprap or shotcrete
922+13, Lt	6W & 7E	8	4.9	no	1.8	0.5	no	-	-	-	-	KAI Chnl OK	-	-	-	-	-	-	-	-	-	veg
906+95, Lt	10E	3	4.9	no	1.5	0.4	no	-	-	-	-	KAI Chnl OK	-	-	-	-	-	-	-	-	-	veg
903+35, Lt	10W	3	4.9	no	1.5	0.4	no	-	-	-	-	KAI Chnl OK	-	-	-	-	-	-	-	-	-	veg
900+45, Lt	11E	69	4.9	no	-	-	no	-	-	-	-	yes	898+40	902+50	0.5	4	6 N, 6 S	1.6	4.0	0.3	2.0	with 6:1 N slope, veg earthen channel ok
894+95, Lt	12E (70%)	42	4.9	no	-	-	N/A, see chnl	-	-	-	-	Yes	894+00	895+90	1.0	4	3 N, 6 S	1.1	4.6	0.2	1.5	fully lined grouted riprap or shotcrete
890+70, Lt	12 + 13E	62	4.9	no	-	-	N/A, see chnl	-	-	-	-	Yes	887+80	893+60	0.5	4	3 N, 6 S	1.5	3.9	0.3	2.0	fully-lined grouted riprap or shotcrete 887+80 - 889+50, veg 889+50 - 892+00, loose riprap N slope & bot 892+00 - 893+60
862+55, Lt	17W, 18 & 19E	43	4.9	no	-	-	N/A, see chnl	-	-	-	-	Yes	857+90	867+20	2.5	4	3 N, 6 S	0.9	6.4	0.3	2.0	fully lined grouted riprap or shotcrete
857+00, Lt	19	4706	4.9	no	12.2	4.2	yes	grouted riprap or shotcrete	856+65, 45 ft Lt	859+70, 155 ft Lt	8ft (N & S slopes)	Yes	See inlet approach channel regrading sketch submitted previously with Sta. 854+72 Shannon Rd culvert									
852+50, Lt	20 east 1/3	56	4.9	no	3.3	0.9	no	-	851+00	854+00	-	No	-	-	-	-	-	-	-	-	-	-
849+00, Lt	20 east 2/3	112	4.9	no	3.6	1.2	no	-	847+50	851+00	-	No	-	-	-	-	-	-	-	-	-	-
845+75, Lt	20 W	5	4.9	no	-	-	no	-	-	-	-	KAI Chnl OK	844+00	847+30	0.5	4	3 N, 6 S	0.5	1.7	0.1	1.0	veg earthen chnl graded to drain east to 847+26 culvert
841+65, Lt	21 E	20	4.9	no	-	-	N/A, see chnl	-	-	-	-	yes	839+30	844+00	1.4	4	3 N, 6 S	0.7	4.2	0.2	1.5	fully lined grouted riprap or shotcrete. Grade chnl around dwy apron @ 840+40
837+73	21 E 95%	300	4.9	no	-	-	N/A, see chnl	-	-	-	-	yes	836+15	839+30	1.0	20	3 N, 6 S	1.8	6.1	0.4	3.0	fully lined grouted riprap or shotcrete
833+35, Lt	22E	4	4.9	no	-	-	N/A, see chnl	-	-	-	-	KAI Chnl OK	831+30	835+40	1.0	4	3 N, 6 S	0.3	2.1	0.1	1.0	veg
829+90, Lt	22 east	25	4.9	no	3.3	0.3	no	-	-	-	-	no	-	-	-	-	-	-	-	-	-	veg
821+53, Lt	24 E	8	4.9	no	-	-	N/A, see chnl	-	-	-	-	yes	819+25	823+80	2.25	4	3 N, 6 S	0.4	3.4	0.1	1.0	loose riprap N slope & bot

815+18, Lt	25 E	6	4.9	no	-	-	N/A, see chnl	-	-	-	-	yes	813+10	817+25	2.0	4	3 N, 6 S	0.4	3	0.1	1.0	fully lined grouted riprap or shotcrete 812+00 - 812+65 & 813+10 - 813+50, veg remainder
810+15, Lt	26.1	<5	4.9	no	-	-	N/A, see chnl	-	-	-	-	KAI Chnl OK	809+50	810+80	0.75	4	3 N, 6 S	0.4	2	0.1	1.0	veg
807+05, Lt	26.2	7	4.9	nlo	-	-	N/A, see chnl	-	-	-	-	KAI Chnl OK	805+85	808+25	0.5	4	3 N, 6 S	0.6	1.9	0.1	1.0	veg, modify chnl invert to: 807+00=2689.6, 806+00=2689.1 to grate inlet EI 2688.8
802+45, Lt	27	63	4.9	no	-	-	Yes	loose riprap	801+95	802+95	3 ft	no	-	-	-	-	-	-	-	-	-	N/A, see rdwy embankmnt
799+55, Lt	28 E	20	4.9	no	-	-	N/A, see chnl	-	-	-	-	yes	798+30	800+80	0.8	35	3 N, 6 S	0.9	3	0.2	1.5	veg, modify chnl grading as shown on sketch
796+18, Lt	28	810	4.9	no	-	-	Yes, KAI plan OK	grouted riprap or shotcrete	794+50	797+85	3ft	no	-	-	-	-	-	-	-	-	-	N/A, see rdwy embankmnt
789+95, Lt	29 E	7	4.9	no	-	-	N/A, see chnl	-	-	-	-	KAI Chnl OK	788+40	791+50	1.0	4	3 N, 6 S	0.5	2.4	0.1	1.0	veg, modify chnl grading as shown on sketch
786+48, Lt	29 W	5	4.9	no	-	-	N/A, see chnl	-	-	-	-	KAI Chnl OK	785+80	787+15	0.6	4	3 N, 6 S	0.5	1.8	0.1	1.0	veg, modify chnl grading as shown on sketch
La Cholla Blvd																						
539+00, Rt	9	280	4.9	no	N/A	N/A	N/A, see chnl	-	-	-	-	yes	536+20	541+80	1.9	10	3	2	8.6	0.5	3.0	fully lined grouted riprap or shotcrete
Thornsdale Rd																						
48+68, Rt	26.2 + Thrnlyde Pvmt	10	4.9	no	N/A	N/A	N/A, see chnl	-	-	-	-	yes	47+70	49+65	0.5 to 1.0	4	6 W, 3 E	0.6	2.7	0.1	1.0	veg
Notes:																						
1. For roadside channels not noted in this table, Kittelson 11-15-2012 roadway design channels (vegetated earthen) ok.																						
2. All loose riprap is D50 = 6", Thickness = 1 ft, underlain by Mirafi 180 filter fabric (or equivalent) unless noted otherwise.																						
3. Grouted riprap is per typical section included with CMG 1-23-2012 channel design submittal.																						



































































# Channel Hydraulic Analysis Report

## Project Data

Project Title: Tangerine Rd Sta. 785+00 to 960+00

Designer: jlc

Project Date: December 6, 2012

Project Units: U.S. Customary Units

Notes:

## Channel Analysis: 951+60, Lt-KAI

Notes:

## Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0050 (ft/ft)

Manning's n: 0.0300

Flow: 6.0000 (cfs)

## Result Parameters

Depth: 0.5201 (ft)

Area of Flow: 3.2976 (ft<sup>2</sup>)

Wetted Perimeter: 8.8083 (ft)

Hydraulic Radius: 0.3744 (ft)

Average Velocity: 1.8195 (ft/s)

Top Width: 8.6809 (ft)

Froude Number: 0.5202

Critical Depth: 0.3575 (ft)

Critical Velocity: 2.9925 (ft/s)

Critical Slope: 0.0205 (ft/ft)

Critical Top Width: 7.2173 (ft)

Calculated Max Shear Stress: 0.1623 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.1168 (lb/ft<sup>2</sup>)

## Channel Analysis: 941+00, Lt @ 0.5%

Notes:

### Input Parameters

Channel Type: Trapezoidal grouted rip rap

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0050 (ft/ft)

Manning's n: 0.0250

Flow: 66.0000 (cfs)

### Result Parameters

Depth: 1.5288 (ft)

Area of Flow: 16.6329 (ft<sup>2</sup>)

Wetted Perimeter: 18.1339 (ft)

Hydraulic Radius: 0.9172 (ft)

Average Velocity: 3.9680 (ft/s)

Top Width: 17.7593 (ft)

Froude Number: 0.7226

Critical Depth: 1.3038 (ft)

Critical Velocity: 5.1305 (ft/s)

Critical Slope: 0.0100 (ft/ft)

Critical Top Width: 15.7339 (ft)

Calculated Max Shear Stress: 0.4770 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.2862 (lb/ft<sup>2</sup>)

## Channel Analysis: 941+00, Lt @ 1.5%

Notes:

### Input Parameters

Channel Type: Trapezoidal grouted rip rap

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0150 (ft/ft)

Manning's n: 0.0250

Flow: 66.0000 (cfs)

### Result Parameters

Depth: 1.1862 (ft)

Area of Flow: 11.0764 (ft<sup>2</sup>)

Wetted Perimeter: 14.9663 (ft)

Hydraulic Radius: 0.7401 (ft)

Average Velocity: 5.9586 (ft/s)

Top Width: 14.6757 (ft)

Froude Number: 1.2087

Critical Depth: 1.3037 (ft)

Critical Velocity: 5.1310 (ft/s)

Critical Slope: 0.0100 (ft/ft)

Critical Top Width: 15.7332 (ft)

Calculated Max Shear Stress: 1.1103 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.6927 (lb/ft<sup>2</sup>)

## Channel Analysis: 941+00, Lt @ 2.1%

Notes:

### Input Parameters

Channel Type: Trapezoidal grouted rip rap

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0210 (ft/ft)

Manning's n: 0.0250

Flow: 66.0000 (cfs)

### Result Parameters

Depth: 1.0957 (ft)

Area of Flow: 9.7855 (ft<sup>2</sup>)

Wetted Perimeter: 14.1299 (ft)

Hydraulic Radius: 0.6925 (ft)

Average Velocity: 6.7447 (ft/s)

Top Width: 13.8614 (ft)

Froude Number: 1.4146

Critical Depth: 1.3043 (ft)

Critical Velocity: 5.1270 (ft/s)

Critical Slope: 0.0100 (ft/ft)

Critical Top Width: 15.7390 (ft)

Calculated Max Shear Stress: 1.4358 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.9075 (lb/ft<sup>2</sup>)

## Channel Analysis: 937+00, Rt @ 2.0%

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 6.0000 (ft/ft)

Side Slope 2 (Z2): 3.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0200 (ft/ft)

Manning's n: 0.0300

Flow: 3.0000 (cfs)

### Result Parameters

Depth: 0.2457 (ft)

Area of Flow: 1.2545 (ft<sup>2</sup>)

Wetted Perimeter: 6.2715 (ft)

Hydraulic Radius: 0.2000 (ft)

Average Velocity: 2.3914 (ft/s)

Top Width: 6.2113 (ft)

Froude Number: 0.9378

Critical Depth: 0.2364 (ft)

Critical Velocity: 2.5067 (ft/s)

Critical Slope: 0.0229 (ft/ft)

Critical Top Width: 6.1272 (ft)

Calculated Max Shear Stress: 0.3066 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.2496 (lb/ft<sup>2</sup>)



## Channel Analysis: 926+75, Lt

Notes:

### Input Parameters

Channel Type: Trapezoidal grouted rip rap

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0175 (ft/ft)

Manning's n: 0.0250

Flow: 30.0000 (cfs)

### Result Parameters

Depth: 0.7818 (ft)

Area of Flow: 5.8774 (ft<sup>2</sup>)

Wetted Perimeter: 11.2276 (ft)

Hydraulic Radius: 0.5235 (ft)

Average Velocity: 5.1043 (ft/s)

Top Width: 11.0360 (ft)

Froude Number: 1.2326

Critical Depth: 0.8726 (ft)

Critical Velocity: 4.3373 (ft/s)

Critical Slope: 0.0112 (ft/ft)

Critical Top Width: 11.8534 (ft)

Calculated Max Shear Stress: 0.8537 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.5716 (lb/ft<sup>2</sup>)

## Channel Analysis: 922+13, Lt-KAI

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0050 (ft/ft)

Manning's n: 0.0300

Flow: 6.0000 (cfs)

### Result Parameters

Depth: 0.5201 (ft)

Area of Flow: 3.2976 (ft<sup>2</sup>)

Wetted Perimeter: 8.8083 (ft)

Hydraulic Radius: 0.3744 (ft)

Average Velocity: 1.8195 (ft/s)

Top Width: 8.6809 (ft)

Froude Number: 0.5202

Critical Depth: 0.3575 (ft)

Critical Velocity: 2.9925 (ft/s)

Critical Slope: 0.0205 (ft/ft)

Critical Top Width: 7.2173 (ft)

Calculated Max Shear Stress: 0.1623 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.1168 (lb/ft<sup>2</sup>)

## Channel Analysis: 906+95, Lt-KAI

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0050 (ft/ft)

Manning's n: 0.0300

Flow: 3.0000 (cfs)

### Result Parameters

Depth: 0.3599 (ft)

Area of Flow: 2.0223 (ft<sup>2</sup>)

Wetted Perimeter: 7.3270 (ft)

Hydraulic Radius: 0.2760 (ft)

Average Velocity: 1.4835 (ft/s)

Top Width: 7.2388 (ft)

Froude Number: 0.4946

Critical Depth: 0.2363 (ft)

Critical Velocity: 2.5079 (ft/s)

Critical Slope: 0.0229 (ft/ft)

Critical Top Width: 6.1263 (ft)

Calculated Max Shear Stress: 0.1123 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.0861 (lb/ft<sup>2</sup>)

## Channel Analysis: 903+35, Lt-KAI

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0050 (ft/ft)

Manning's n: 0.0300

Flow: 3.0000 (cfs)

### Result Parameters

Depth: 0.3599 (ft)

Area of Flow: 2.0223 (ft<sup>2</sup>)

Wetted Perimeter: 7.3270 (ft)

Hydraulic Radius: 0.2760 (ft)

Average Velocity: 1.4835 (ft/s)

Top Width: 7.2388 (ft)

Froude Number: 0.4946

Critical Depth: 0.2363 (ft)

Critical Velocity: 2.5079 (ft/s)

Critical Slope: 0.0229 (ft/ft)

Critical Top Width: 6.1263 (ft)

Calculated Max Shear Stress: 0.1123 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.0861 (lb/ft<sup>2</sup>)

## Channel Analysis: 900+45, Lt

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0050 (ft/ft)

Manning's n: 0.0300

Flow: 69.0000 (cfs)

### Result Parameters

Depth: 1.5604 (ft)

Area of Flow: 17.1987 (ft<sup>2</sup>)

Wetted Perimeter: 18.4261 (ft)

Hydraulic Radius: 0.9334 (ft)

Average Velocity: 4.0119 (ft/s)

Top Width: 18.0437 (ft)

Froude Number: 0.7242

Critical Depth: 1.3327 (ft)

Critical Velocity: 5.1790 (ft/s)

Critical Slope: 0.0100 (ft/ft)

Critical Top Width: 15.9942 (ft)

Calculated Max Shear Stress: 0.4868 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.2912 (lb/ft<sup>2</sup>)

## Channel Analysis: 894+95, Lt

Notes:

### Input Parameters

Channel Type: Trapezoidal grouted rip rap

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0100 (ft/ft)

Manning's n: 0.0250

Flow: 42.0000 (cfs)

### Result Parameters

Depth: 1.0543 (ft)

Area of Flow: 9.2190 (ft<sup>2</sup>)

Wetted Perimeter: 13.7470 (ft)

Hydraulic Radius: 0.6706 (ft)

Average Velocity: 4.5558 (ft/s)

Top Width: 13.4886 (ft)

Froude Number: 0.9711

Critical Depth: 1.0387 (ft)

Critical Velocity: 4.6616 (ft/s)

Critical Slope: 0.0107 (ft/ft)

Critical Top Width: 13.3483 (ft)

Calculated Max Shear Stress: 0.6579 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.4185 (lb/ft<sup>2</sup>)

## Channel Analysis: 890+70, Lt

Notes:

### Input Parameters

Channel Type: Trapezoidal  
Side Slope 1 (Z1): 3.0000 (ft/ft) grouted rip rap  
Side Slope 2 (Z2): 6.0000 (ft/ft)  
Channel Width: 4.0000 (ft)  
Longitudinal Slope: 0.0050 (ft/ft)  
Manning's n: 0.0250  
Flow: 62.0000 (cfs)

### Result Parameters

Depth: 1.4864 (ft)  
Area of Flow: 15.8873 (ft<sup>2</sup>)  
Wetted Perimeter: 17.7415 (ft)  
Hydraulic Radius: 0.8955 (ft)  
Average Velocity: 3.9025 (ft/s)  
Top Width: 17.3773 (ft)  
Froude Number: 0.7193  
Critical Depth: 1.2640 (ft)  
Critical Velocity: 5.0630 (ft/s)  
Critical Slope: 0.0101 (ft/ft)  
Critical Top Width: 15.3760 (ft)  
Calculated Max Shear Stress: 0.4637 (lb/ft<sup>2</sup>)  
Calculated Avg Shear Stress: 0.2794 (lb/ft<sup>2</sup>)

## Channel Analysis: 862+55, Lt @ 2.5%

Notes:

### Input Parameters

Channel Type: Trapezoidal grouted rip rap

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0250 (ft/ft)

Manning's n: 0.0250

Flow: 43.0000 (cfs)

### Result Parameters

Depth: 0.8548 (ft)

Area of Flow: 6.7074 (ft<sup>2</sup>)

Wetted Perimeter: 11.9028 (ft)

Hydraulic Radius: 0.5635 (ft)

Average Velocity: 6.4108 (ft/s)

Top Width: 11.6933 (ft)

Froude Number: 1.4917

Critical Depth: 1.0513 (ft)

Critical Velocity: 4.6851 (ft/s)

Critical Slope: 0.0106 (ft/ft)

Critical Top Width: 13.4613 (ft)

Calculated Max Shear Stress: 1.3335 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.8791 (lb/ft<sup>2</sup>)



## Channel Analysis: 862+55, Lt @ 0.5%

Notes:

### Input Parameters

Channel Type: Trapezoidal grouted rip rap

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0050 (ft/ft)

Manning's n: 0.0250

Flow: 43.0000 (cfs)

### Result Parameters

Depth: 1.2552 (ft)

Area of Flow: 12.1106 (ft<sup>2</sup>)

Wetted Perimeter: 15.6044 (ft)

Hydraulic Radius: 0.7761 (ft)

Average Velocity: 3.5506 (ft/s)

Top Width: 15.2968 (ft)

Froude Number: 0.7032

Critical Depth: 1.0515 (ft)

Critical Velocity: 4.6837 (ft/s)

Critical Slope: 0.0106 (ft/ft)

Critical Top Width: 13.4631 (ft)

Calculated Max Shear Stress: 0.3916 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.2421 (lb/ft<sup>2</sup>)

## Channel Analysis: 845+75 Lt-KAI

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0050 (ft/ft)

Manning's n: 0.0300

Flow: 5.0000 (cfs)

### Result Parameters

Depth: 0.4730 (ft)

Area of Flow: 2.8985 (ft<sup>2</sup>)

Wetted Perimeter: 8.3726 (ft)

Hydraulic Radius: 0.3462 (ft)

Average Velocity: 1.7250 (ft/s)

Top Width: 8.2567 (ft)

Froude Number: 0.5131

Critical Depth: 0.3210 (ft)

Critical Velocity: 2.8605 (ft/s)

Critical Slope: 0.0211 (ft/ft)

Critical Top Width: 6.8894 (ft)

Calculated Max Shear Stress: 0.1476 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.1080 (lb/ft<sup>2</sup>)

## Channel Analysis: 841+65, Lt

Notes:

### Input Parameters

Channel Type: Trapezoidal grouted rip rap

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0140 (ft/ft)

Manning's n: 0.0250

Flow: 20.0000 (cfs)

### Result Parameters

Depth: 0.6744 (ft)

Area of Flow: 4.7444 (ft<sup>2</sup>)

Wetted Perimeter: 10.2349 (ft)

Hydraulic Radius: 0.4635 (ft)

Average Velocity: 4.2155 (ft/s)

Top Width: 10.0697 (ft)

Froude Number: 1.0823

Critical Depth: 0.7037 (ft)

Critical Velocity: 3.9659 (ft/s)

Critical Slope: 0.0118 (ft/ft)

Critical Top Width: 10.3332 (ft)

Calculated Max Shear Stress: 0.5892 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.4050 (lb/ft<sup>2</sup>)

## Channel Analysis: 837+73, Lt

Notes:

### Input Parameters

Channel Type: Trapezoidal grouted rip rap

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 20.0000 (ft)

Longitudinal Slope: 0.0100 (ft/ft)

Manning's n: 0.0250

Flow: 300.0000 (cfs)

### Result Parameters

Depth: 1.7664 (ft)

Area of Flow: 49.3703 (ft<sup>2</sup>)

Wetted Perimeter: 36.3308 (ft)

Hydraulic Radius: 1.3589 (ft)

Average Velocity: 6.0765 (ft/s)

Top Width: 35.8980 (ft)

Froude Number: 0.9131

Critical Depth: 1.6747 (ft)

Critical Velocity: 6.5055 (ft/s)

Critical Slope: 0.0122 (ft/ft)

Critical Top Width: 35.0722 (ft)

Calculated Max Shear Stress: 1.1023 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.8480 (lb/ft<sup>2</sup>)

## Channel Analysis: 833+35, Lt-KAI

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0100 (ft/ft)

Manning's n: 0.0300

Flow: 4.0000 (cfs)

### Result Parameters

Depth: 0.3486 (ft)

Area of Flow: 1.9410 (ft<sup>2</sup>)

Wetted Perimeter: 7.2225 (ft)

Hydraulic Radius: 0.2687 (ft)

Average Velocity: 2.0608 (ft/s)

Top Width: 7.1370 (ft)

Froude Number: 0.6964

Critical Depth: 0.2811 (ft)

Critical Velocity: 2.7024 (ft/s)

Critical Slope: 0.0218 (ft/ft)

Critical Top Width: 6.5302 (ft)

Calculated Max Shear Stress: 0.2175 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.1677 (lb/ft<sup>2</sup>)

## Channel Analysis: 829+90, Lt

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 15.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 20.0000 (ft)

Longitudinal Slope: 0.0240 (ft/ft)

Manning's n: 0.0300

Flow: 25.0000 (cfs)

### Result Parameters

Depth: 0.3232 (ft)

Area of Flow: 7.5608 (ft<sup>2</sup>)

Wetted Perimeter: 26.8247 (ft)

Hydraulic Radius: 0.2819 (ft)

Average Velocity: 3.3065 (ft/s)

Top Width: 26.7872 (ft)

Froude Number: 1.0968

Critical Depth: 0.3424 (ft)

Critical Velocity: 3.0941 (ft/s)

Critical Slope: 0.0197 (ft/ft)

Critical Top Width: 27.1911 (ft)

Calculated Max Shear Stress: 0.4840 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.4221 (lb/ft<sup>2</sup>)

## Channel Analysis: 821+53, Lt

Notes:

### Input Parameters

Channel Type: Trapezoidal loose rip rap / earthen

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0225 (ft/ft)

Manning's n: 0.0350

Flow: 8.0000 (cfs)

### Result Parameters

Depth: 0.4070 (ft)

Area of Flow: 2.3734 (ft<sup>2</sup>)

Wetted Perimeter: 7.7627 (ft)

Hydraulic Radius: 0.3057 (ft)

Average Velocity: 3.3707 (ft/s)

Top Width: 7.6630 (ft)

Froude Number: 1.0674

Critical Depth: 0.4226 (ft)

Critical Velocity: 3.2072 (ft/s)

Critical Slope: 0.0195 (ft/ft)

Critical Top Width: 7.8038 (ft)

Calculated Max Shear Stress: 0.5714 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.4293 (lb/ft<sup>2</sup>)

## Channel Analysis: 815+18, Lt

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0200 (ft/ft)

Manning's n: 0.0300

Flow: 6.0000 (cfs)

### Result Parameters

Depth: 0.3599 (ft)

Area of Flow: 2.0223 (ft<sup>2</sup>)

Wetted Perimeter: 7.3270 (ft)

Hydraulic Radius: 0.2760 (ft)

Average Velocity: 2.9670 (ft/s)

Top Width: 7.2388 (ft)

Froude Number: 0.9892

Critical Depth: 0.3577 (ft)

Critical Velocity: 2.9901 (ft/s)

Critical Slope: 0.0204 (ft/ft)

Critical Top Width: 7.2194 (ft)

Calculated Max Shear Stress: 0.4491 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.3444 (lb/ft<sup>2</sup>)



## Channel Analysis: 810+15, Lt-KAI

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0075 (ft/ft)

Manning's n: 0.0300

Flow: 5.0000 (cfs)

### Result Parameters

Depth: 0.4246 (ft)

Area of Flow: 2.5096 (ft<sup>2</sup>)

Wetted Perimeter: 7.9253 (ft)

Hydraulic Radius: 0.3167 (ft)

Average Velocity: 1.9924 (ft/s)

Top Width: 7.8213 (ft)

Froude Number: 0.6198

Critical Depth: 0.3211 (ft)

Critical Velocity: 2.8603 (ft/s)

Critical Slope: 0.0211 (ft/ft)

Critical Top Width: 6.8895 (ft)

Calculated Max Shear Stress: 0.1987 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.1482 (lb/ft<sup>2</sup>)

## Channel Analysis: 807+05, Lt-KAI

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0050 (ft/ft)

Manning's n: 0.0300

Flow: 7.0000 (cfs)

### Result Parameters

Depth: 0.5635 (ft)

Area of Flow: 3.6824 (ft<sup>2</sup>)

Wetted Perimeter: 9.2091 (ft)

Hydraulic Radius: 0.3999 (ft)

Average Velocity: 1.9009 (ft/s)

Top Width: 9.0711 (ft)

Froude Number: 0.5258

Critical Depth: 0.3911 (ft)

Critical Velocity: 3.1070 (ft/s)

Critical Slope: 0.0200 (ft/ft)

Critical Top Width: 7.5202 (ft)

Calculated Max Shear Stress: 0.1758 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.1248 (lb/ft<sup>2</sup>)

## Channel Analysis: 799+55, Lt

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0080 (ft/ft)

Manning's n: 0.0300

Flow: 20.0000 (cfs)

### Result Parameters

Depth: 0.8494 (ft)

Area of Flow: 6.6438 (ft<sup>2</sup>)

Wetted Perimeter: 11.8524 (ft)

Hydraulic Radius: 0.5605 (ft)

Average Velocity: 3.0103 (ft/s)

Top Width: 11.6443 (ft)

Froude Number: 0.7023

Critical Depth: 0.7040 (ft)

Critical Velocity: 3.9634 (ft/s)

Critical Slope: 0.0170 (ft/ft)

Critical Top Width: 10.3359 (ft)

Calculated Max Shear Stress: 0.4240 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.2798 (lb/ft<sup>2</sup>)

## Channel Analysis: 789+95, Lt

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0100 (ft/ft)

Manning's n: 0.0300

Flow: 7.0000 (cfs)

### Result Parameters

Depth: 0.4705 (ft)

Area of Flow: 2.8778 (ft<sup>2</sup>)

Wetted Perimeter: 8.3494 (ft)

Hydraulic Radius: 0.3447 (ft)

Average Velocity: 2.4324 (ft/s)

Top Width: 8.2341 (ft)

Froude Number: 0.7251

Critical Depth: 0.3911 (ft)

Critical Velocity: 3.1071 (ft/s)

Critical Slope: 0.0200 (ft/ft)

Critical Top Width: 7.5201 (ft)

Calculated Max Shear Stress: 0.2936 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.2151 (lb/ft<sup>2</sup>)

## Channel Analysis: 786+48, Lt

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0060 (ft/ft)

Manning's n: 0.0300

Flow: 5.0000 (cfs)

### Result Parameters

Depth: 0.4504 (ft)

Area of Flow: 2.7141 (ft<sup>2</sup>)

Wetted Perimeter: 8.1635 (ft)

Hydraulic Radius: 0.3325 (ft)

Average Velocity: 1.8423 (ft/s)

Top Width: 8.0532 (ft)

Froude Number: 0.5592

Critical Depth: 0.3210 (ft)

Critical Velocity: 2.8605 (ft/s)

Critical Slope: 0.0211 (ft/ft)

Critical Top Width: 6.8894 (ft)

Calculated Max Shear Stress: 0.1686 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.1245 (lb/ft<sup>2</sup>)

## Channel Analysis: 854+72 Culv Inlet Channel

Notes:

### Input Parameters

Channel Type: Trapezoidal loose rip rap / grouted rip rap

Side Slope 1 (Z1): 3.0000 (ft/ft)

Side Slope 2 (Z2): 3.0000 (ft/ft)

Channel Width: 80.0000 (ft)

Longitudinal Slope: 0.0150 (ft/ft)

Manning's n: 0.0350

Flow: 4706.0000 (cfs)

### Result Parameters

Depth: 4.1550 (ft)

Area of Flow: 384.1937 (ft<sup>2</sup>)

Wetted Perimeter: 106.2786 (ft)

Hydraulic Radius: 3.6150 (ft)

Average Velocity: 12.2490 (ft/s)

Top Width: 104.9301 (ft)

Froude Number: 1.1281

Critical Depth: 4.4838 (ft)

Critical Velocity: 11.2310 (ft/s)

Critical Slope: 0.0115 (ft/ft)

Critical Top Width: 106.9029 (ft)

Calculated Max Shear Stress: 3.8891 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 3.3836 (lb/ft<sup>2</sup>)

## Channel Analysis: 955+49 Culv Inlet Channel

Notes:

### Input Parameters

Channel Type: Trapezoidal grouted rip rap

Side Slope 1 (Z1): 2.0000 (ft/ft)

Side Slope 2 (Z2): 6.0000 (ft/ft)

Channel Width: 20.0000 (ft)

Longitudinal Slope: 0.0100 (ft/ft)

Manning's n: 0.0250

Flow: 422.0000 (cfs)

### Result Parameters

Depth: 1.9508 (ft)

Area of Flow: 54.2379 (ft<sup>2</sup>)

Wetted Perimeter: 36.2282 (ft)

Hydraulic Radius: 1.4971 (ft)

Average Velocity: 7.7805 (ft/s)

Top Width: 35.6063 (ft)

Froude Number: 1.1109

Critical Depth: 2.0758 (ft)

Critical Velocity: 7.1827 (ft/s)

Critical Slope: 0.0080 (ft/ft)

Critical Top Width: 36.6065 (ft)

Calculated Max Shear Stress: 1.2173 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.9342 (lb/ft<sup>2</sup>)

## Channel Analysis: Channel @ SouthEast Corner of Tangerine/La Cholla

Notes:

### Parameters

Channel Type: Trapezoidal  
Flow: 280.0000 (cfs)  
Depth: 2.0468 (ft)  
Mannings 0.0300  
Side Slope 1 (Z1): 3.0000 (ft/ft)  
Side Slope 2 (Z2): 3.0000 (ft/ft)  
Channel Width: 10.0000 (ft)  
Longitudinal Slope: 0.0180 (ft/ft)  
Area of Flow: 33.0352 (ft<sup>2</sup>)  
Wetted Perimeter: 22.9448 (ft)  
Average Velocity: 8.4758 (ft/s)  
Top Width: 22.2805 (ft)  
Froude Number: 1.2267  
Critical Depth: 2.2918 (ft)  
Critical Velocity: 7.2400 (ft/s)  
Critical Slope: 0.0116 (ft/ft)  
Critical Top Width: 23.7505 (ft)  
Calculated Max Shear Stress: 2.2989 (lb/ft<sup>2</sup>)  
Calculated Avg Shear Stress: 1.6171 (lb/ft<sup>2</sup>)



## Channel Analysis: Th Rd 48+68, Rt

Notes:

### Input Parameters

Channel Type: Trapezoidal earthen, vegetated

Side Slope 1 (Z1): 6.0000 (ft/ft)

Side Slope 2 (Z2): 3.0000 (ft/ft)

Channel Width: 4.0000 (ft)

Longitudinal Slope: 0.0100 (ft/ft)

Manning's n: 0.0300

Flow: 10.0000 (cfs)

### Result Parameters

Depth: 0.5666 (ft)

Area of Flow: 3.7110 (ft<sup>2</sup>)

Wetted Perimeter: 9.2382 (ft)

Hydraulic Radius: 0.4017 (ft)

Average Velocity: 2.6947 (ft/s)

Top Width: 9.0993 (ft)

Froude Number: 0.7436

Critical Depth: 0.4799 (ft)

Critical Velocity: 3.3832 (ft/s)

Critical Slope: 0.0189 (ft/ft)

Critical Top Width: 8.3189 (ft)

Calculated Max Shear Stress: 0.3536 (lb/ft<sup>2</sup>)

Calculated Avg Shear Stress: 0.2507 (lb/ft<sup>2</sup>)

## **APPENDIX I**

### **CROSS CULVERT OUTLET TREATMENT COMPUTATIONS**

Includes

- HEC-14 Outlet Basin Computations
- Conceptual Outlet Treatment for Wildlife Crossings Exhibit



# CMG DRAINAGE ENGINEERING, INC.

3555 N. Mountain Ave. Tucson, Arizona 85719  
Phone (520) 882-4244 Fax (520) 888-1421

## HEC 14 RipRap Basin

### Tangerine

Client: Psomas  
Project #: 10-027-Tangerine

Date 2013.01.30  
By: J.W.

HEC-14 Equation 10.1

$$\frac{h_s}{y_e} = 0.86 \left( \frac{D_{50}}{y_e} \right)^{-0.55} \left( \frac{V_0}{\sqrt{g y_e}} \right) - C_0$$

$h_s$  = dissipator pool depth (ft)

$y_e$  = equivalent brink (outlet) depth (ft) = for circular culverts  $(A/2)^{0.5}$

$D_{50}$  = median rock size (ft)

$W_0$  = Culvert/Channel outlet width (ft)

$C_0$  = tailwater parameter

$TW/y_e < 0.75$

$C_0 = 1.4$

$0.75 < TW/y_e < 1.0$

$C_0 = 4.01(TW/y_e) - 1.6$

$1.0 < TW/y_e$

$C_0 = 2.4$

$L_s$  (Pool length) =  $10 * h_s$  ;  $L_s$  minimum =  $3 * W_0$

$L_A$  (Apron Length) =  $5 * h_s$  ;  $L_A$  minimum =  $W_0$

CP	$W_0$	$V_0$	A	$T_w$	$y_e$	$C_0$	$h_s$	$L_s$	$L_A$	$L_B$	Error Note (1):	Error Note (2):
1	10.0	17.0	n/a	3.5	1.24	2.4	1.3	30.0	10.0	40.0	n/a	n/a
2	10.0	15.7	n/a	1.9	1.78	2.4	1.5	30.0	10.0	40.0	n/a	n/a
4	10.0	17.8	n/a	1.8	1.3	2.4	1.6	30.0	10.0	40.0	n/a	n/a
5	6.0	17.2	n/a	1.1	1.48	1.5	2.0	19.8	9.9	29.7	n/a	n/a



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CP	W <sub>0</sub>	V <sub>0</sub>	A	T <sub>w</sub>	y <sub>e</sub>	C <sub>0</sub>	h <sub>s</sub>	L <sub>s</sub>	L <sub>A</sub>	L <sub>B</sub>	Error Note (1):	Error Note (2):
7	8.0	16.9	n/a	1.9	1.16	2.4	1.6	24.0	8.0	32.0	n/a	n/a
8	3.0	14.3	2.5	1.1	1.12	2.2	1.1	11.0	5.5	16.5	n/a	n/a
La Cholla 534+93	3.5	12.3	3.8	1.0	1.38	1.4	1.5	15.1	7.6	22.7	n/a	n/a
10	3.0	12.5	3.3	0.8	1.28	1.4	1.5	14.6	7.3	21.9	n/a	n/a
11	4.0	10.6	5.4	1.4	1.64	1.8	1.5	15.0	7.5	22.5	n/a	n/a
13	10.0	17.6	n/a	3.4	2.22	2.4	1.6	30.0	10.0	40.0	n/a	n/a
14	3.0	9.2	2.8	1.3	1.18	2.4	1.2	11.9	5.9	17.8	n/a	n/a
15	3.5	11.9	3.4	0.3	1.30	1.4	1.3	13.2	6.6	19.8	n/a	n/a
16	4.0	15.9	4.8	1.3	1.55	1.6	1.8	17.7	8.9	26.6	n/a	n/a
17	4.0	14.1	4.5	1.3	1.49	1.8	1.7	16.6	8.3	24.9	n/a	n/a
19	12.0	18.4	n/a	3.8	3.03	2.4	2.2	36.0	12.0	48.0	n/a	n/a
20	4.0	12.7	6.6	1.3	1.82	1.4	1.8	18.5	9.2	27.7	n/a	n/a
21	8.0	14.6	n/a	1.9	1.36	2.4	1.2	24.0	8.0	32.0	n/a	n/a
22	10.0	17.2	n/a	2.2	1.61	2.4	1.8	30.0	10.0	40.0	n/a	n/a
24	4.0	14.1	5.6	1.2	1.67	1.4	1.8	17.9	9.0	26.9	n/a	n/a
25	8.0	14.5	n/a	1.8	1.46	2.4	1.3	24.0	8.0	32.0	n/a	n/a
26.1	3.5	12.2	4.5	1.9	1.51	2.4	1.1	10.9	5.5	16.4	n/a	n/a
27	2.5	8.7	2.4	0.8	1.10	1.4	0.9	8.7	4.4	13.1	n/a	n/a
28	8.0	14.3	n/a	2.5	1.77	2.4	1.5	24.0	8.0	32.0	n/a	n/a
29	4.0	15.9	4.0	1.8	1.41	2.4	1.7	16.8	8.4	25.1	n/a	n/a
30	4.0	17.2	4.1	1.1	1.43	1.5	1.9	19.0	9.5	28.4	n/a	n/a
31	3.0	14.6	2.1	0.9	1.03	1.9	1.4	13.9	6.9	20.8	n/a	n/a
32	10.0	21.8	n/a	3.7	1.95	2.4	2.4	30.0	11.9	41.9	n/a	n/a
33.1	3.0	12.4	2.1	0.7	1.02	1.4	1.4	13.8	6.9	20.8	n/a	n/a
35	10.0	17.3	n/a	3.0	1.76	2.4	1.5	30.0	10.0	40.0	n/a	n/a
37	3.5	16.4	3.0	1.2	1.22	2.2	1.3	13.4	6.7	20.0	n/a	n/a
39	10.0	15.9	n/a	2.7	1.20	2.4	1.4	30.0	10.0	40.0	n/a	n/a
40	10.0	14.5	n/a	1.1	0.64	2.4	1.1	30.0	10.0	40.0	n/a	n/a
41	3.5	14.0	2.9	0.6	1.19	1.4	1.4	14.4	7.2	21.5	n/a	n/a
44	10.0	19.9	n/a	2.6	1.49	2.4	1.6	30.0	10.0	40.0	n/a	n/a
45	4.0	13.2	6.5	1.1	1.81	1.4	1.7	16.8	8.4	25.2	n/a	n/a
46	10.0	16.5	n/a	2.6	1.32	2.4	1.3	30.0	10.0	40.0	n/a	n/a
47	3.0	12.3	0.0	0.7	0.80	2.1	1.2	11.8	5.9	17.7	n/a	n/a
48	3.5	11.1	3.9	0.9	1.40	1.4	1.2	12.2	6.1	18.4	n/a	n/a



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CP	W <sub>0</sub>	V <sub>0</sub>	A	T <sub>w</sub>	y <sub>e</sub>	C <sub>0</sub>	h <sub>s</sub>	L <sub>s</sub>	L <sub>A</sub>	L <sub>B</sub>	Error Note (1):	Error Note (2):
49.1	2.0	12.1	1.2	0.6	0.76	1.6	1.1	10.8	5.4	16.2	n/a	n/a
52.1	10.0	19.8	n/a	3.5	1.50	2.4	2.0	30.0	10.0	40.0	n/a	n/a
53	3.5	11.5	4.3	0.8	1.46	1.4	1.4	13.9	7.0	20.9	n/a	n/a
54	3.5	13.2	4.7	0.7	1.53	1.4	1.7	16.6	8.3	24.9	n/a	n/a
55	4.0	11.7	6.7	1.1	1.83	1.4	1.5	14.9	7.5	22.4	n/a	n/a
56	10.0	10.5	n/a	1.0	0.55	2.4	0.7	30.0	10.0	40.0	n/a	n/a
58	3.5	12.1	3.8	0.6	1.37	1.4	1.5	14.7	7.4	22.1	n/a	n/a
59	4.0	13.1	6.1	1.1	1.75	1.4	1.6	16.0	8.0	24.0	n/a	n/a
60	8.0	15.5	n/a	1.1	1.26	2.0	1.4	24.0	8.0	32.0	n/a	n/a
61	3.0	15.3	2.4	0.7	1.09	1.4	1.6	15.6	7.8	23.4	n/a	n/a
62.2	3.0	13.6	2.6	0.5	1.14	1.4	1.5	15.4	7.7	23.1	n/a	n/a
63	3.0	13.6	2.7	0.6	1.16	1.4	1.6	15.7	7.8	23.5	n/a	n/a
64	4.0	14.4	5.6	1.3	1.67	1.5	1.8	17.6	8.8	26.3	n/a	n/a
66	8.0	16.1	n/a	1.3	1.46	2.0	1.4	24.0	8.0	32.0	n/a	n/a
67	10.0	15.4	n/a	2.0	1.27	2.4	1.4	30.0	10.0	40.0	n/a	n/a
FR1	3.0	12.6	3.4	1.2	1.30	2.1	1.4	14.3	7.2	21.5	n/a	n/a



**Table 2. Stone Sizes and Allowable Velocities for Gabions (courtesy of and adapted from Maccaferri Gabions)**

Type	Thickness (ft)	Filling Stone Range	D50	Critical* Velocity	Limit** Velocity
Mattress	0.5	3 - 4"	3.4"	11.5	13.8
	0.5	3 - 6"	4.3"	13.8	14.8
	0.75	3 - 4"	3.4"	14.8	16
	0.75	3 - 6"	4.7"	14.8	20
	1	3 - 5"	4"	13.6	18
	1	4 - 6"	5"	16.4	21
Basket	1.5	4 - 8"	6"	19	24.9
	1.5	5 - 10"	7.5"	21	26.2

When the data in Table 2 are compared to Equation 1, if  $V = 11.5$ ,  $C_s = 0.1$ ,  $C_v = 1.0$ ,  $K_1 = 0.71$ ,  $\gamma_w = 150$  and  $S_f = 1.1$ , the local flow depth must be on the order of 25 ft in order to arrive at the stone diameter of 3.4 in. shown in Table 2. Designers should use Equation 1 to take the depth of flow into account. Table 2 does, however, give some general guidelines for fill sizes and is a quick reference for maximum allowable velocities.

Maccaferri also gives guidance on the stability of gabions in terms of shear stress limits. The following equation gives the shear for the bed of the channel:

$$t_b = g_w S d \quad (2)$$

with the bank shear  $t_m$  taken as 75 percent of the bed shear, i.e.  $t_m = 0.75 t_b$ . ( $S$  is the bed or water surface slope through the reach.) These values are then compared to the critical stress for the bed calculated by the following equation:

$$t_c = 0.10(g_s - g_w) d_m \quad (3)$$

with critical shear stress for the banks given as:

$$t_s = t_c \sqrt{1 - \frac{\sin^2 \mathbf{q}}{0.4304}} \quad (4)$$

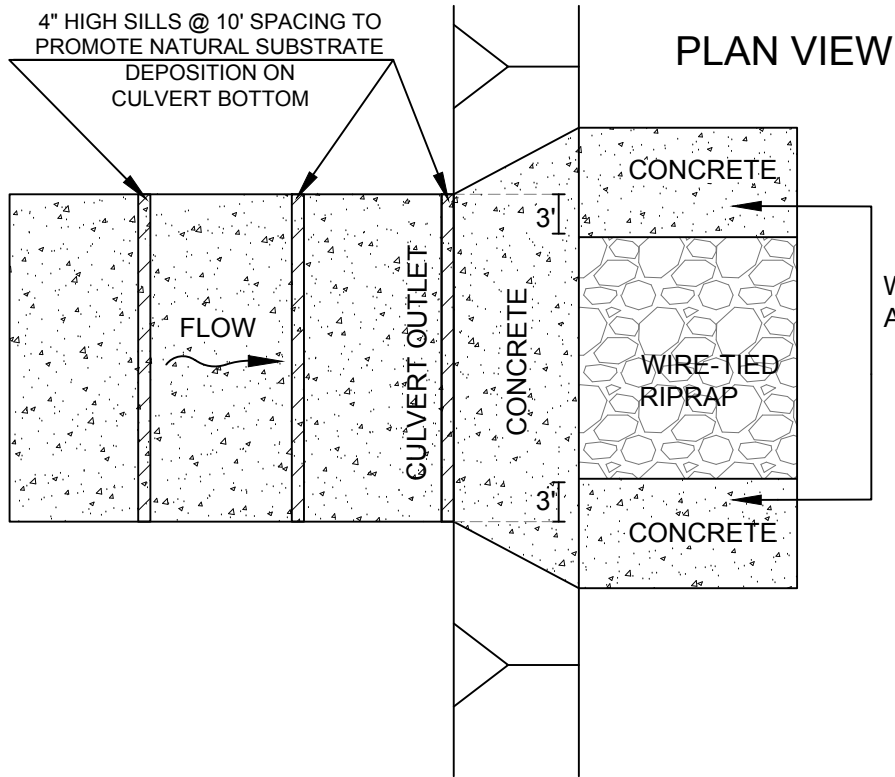
where  $\mathbf{q}$  = the angle of the bank rotated up from horizontal.

A design is acceptable if  $t_b < t_c$  and  $t_m < t_s$ . If either  $t_b > t_c$  or  $t_m > t_s$ , then a check must be made to see if they are less than 120 percent of  $t_b$  and  $t_s$ . If the values are less than 120 percent of  $t_b$  and  $t_s$ , the gabions will not be subject to more than what Maccaferri defines as "acceptable" deformation. However, it is recommended that stone size be increased to limit deformation if possible.

Research has indicated that stone in the gabion mattress should be sized such that the largest stone diameter is not more than about two times the diameter of the smallest stone diameter and the mattress should be at least twice the depth of the largest stone size. The size range should, however, vary by about a factor of two to ensure proper packing of the stone material into the gabions. Since the mattresses normally come in discrete sizes, i.e. 0.5, 1.0, and 1.5 ft in depth, normal practice is to size the stone and then select the basket depth that is deep enough to be at least two times the largest stone diameter. The smallest stone should also be sized such that it cannot pass through the wire mesh.

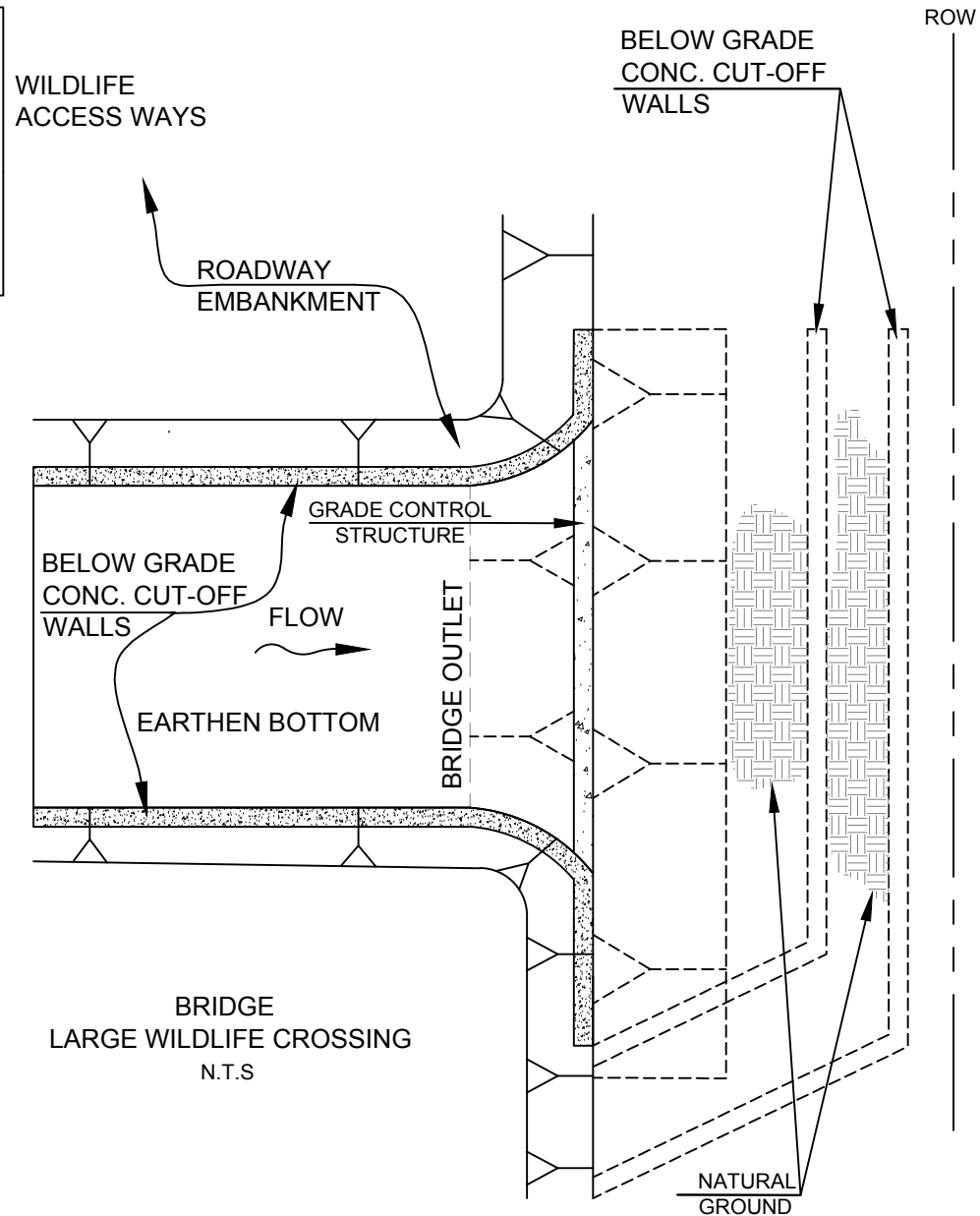
**Stability of Underlying Bed and Bank Materials.** Another critical consideration is the stability of the gabion foundation. This includes both geotechnical stability and the resistance of the soil under the gabions to the erosive forces

Z:\PROJECTS\2010\10-027\_Psomas-Tangerine Rd I-10 to La Canada(Dwg)\Wildlife Cross Sec D115.dwg, Layout1, 1/31/2013 2:04:42 PM



CULVERT OR ARCH  
MEDIUM WILDLIFE CROSSING  
N.T.S

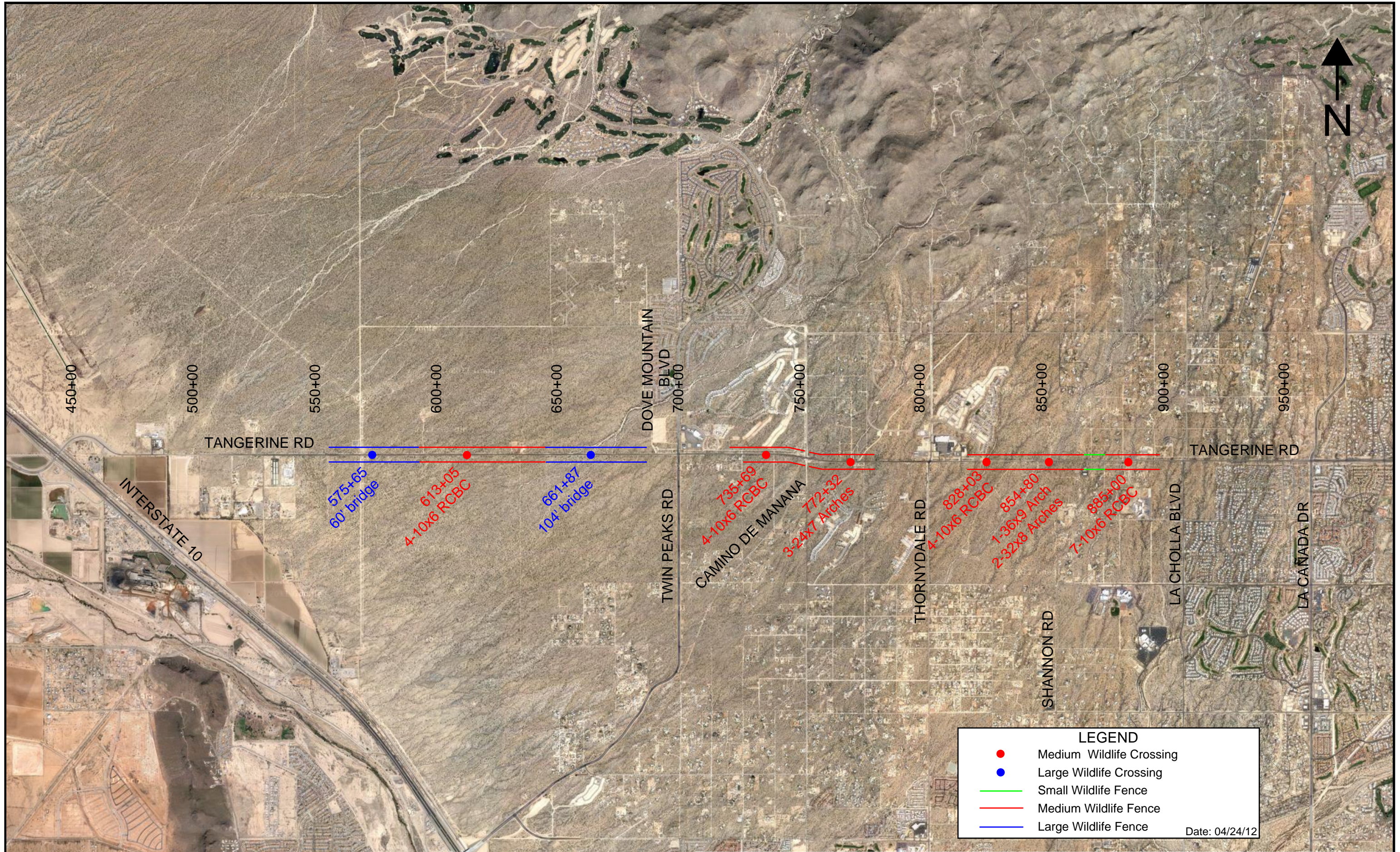
# CONCEPTUAL OUTLET TREATMENT FOR WILDLIFE CROSSING



BRIDGE  
LARGE WILDLIFE CROSSING  
N.T.S



# TANGERINE ROAD WILDLIFE CROSSING & FENCING



**LEGEND**

- Medium Wildlife Crossing
- Large Wildlife Crossing
- Small Wildlife Fence
- Medium Wildlife Fence
- Large Wildlife Fence

Date: 04/24/12



## **APPENDIX J**

### **BRIDGE ANALYSES**

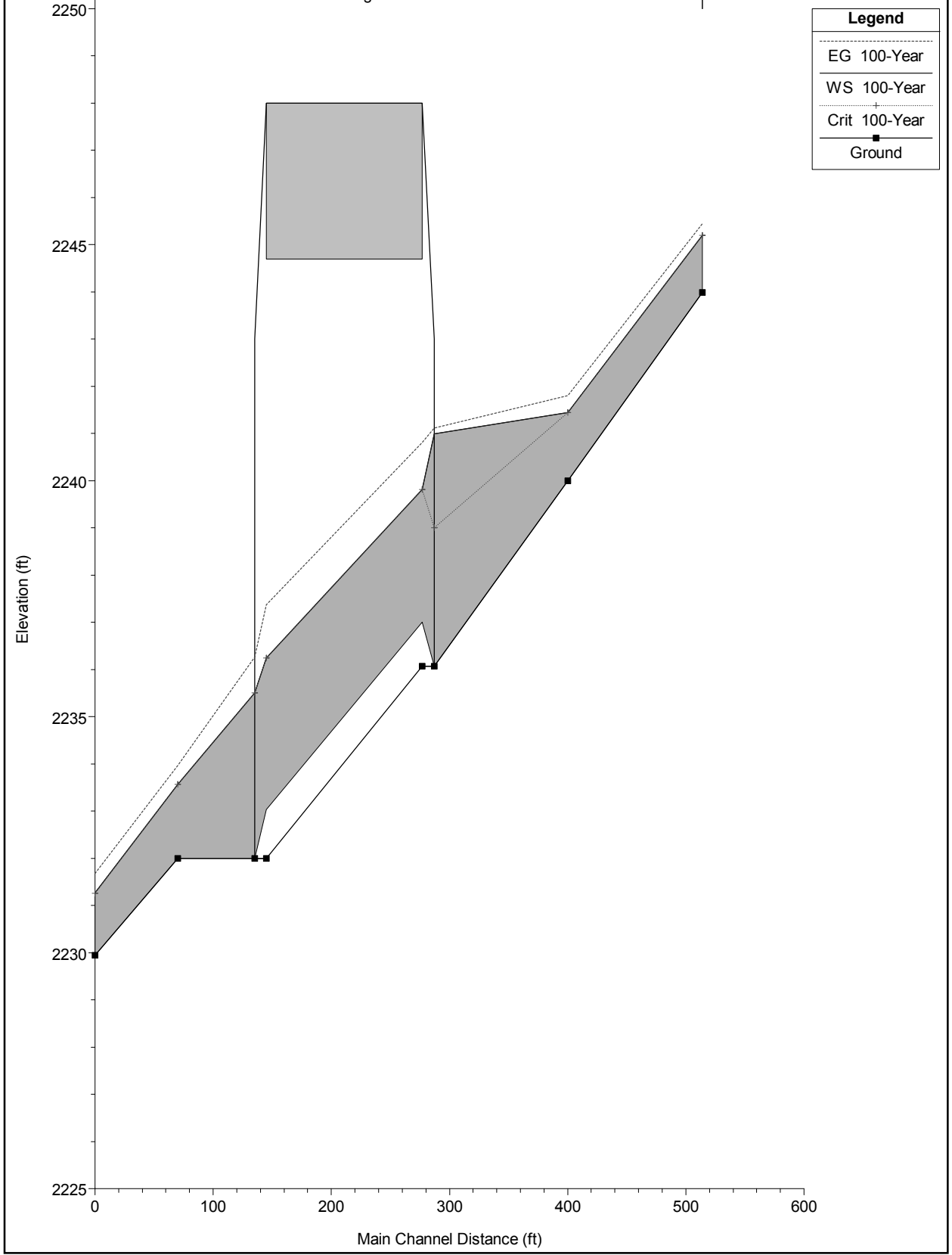
Includes

- HEC-RAS Output
- Scour Analyses
- Grade Control Structure at Bridges

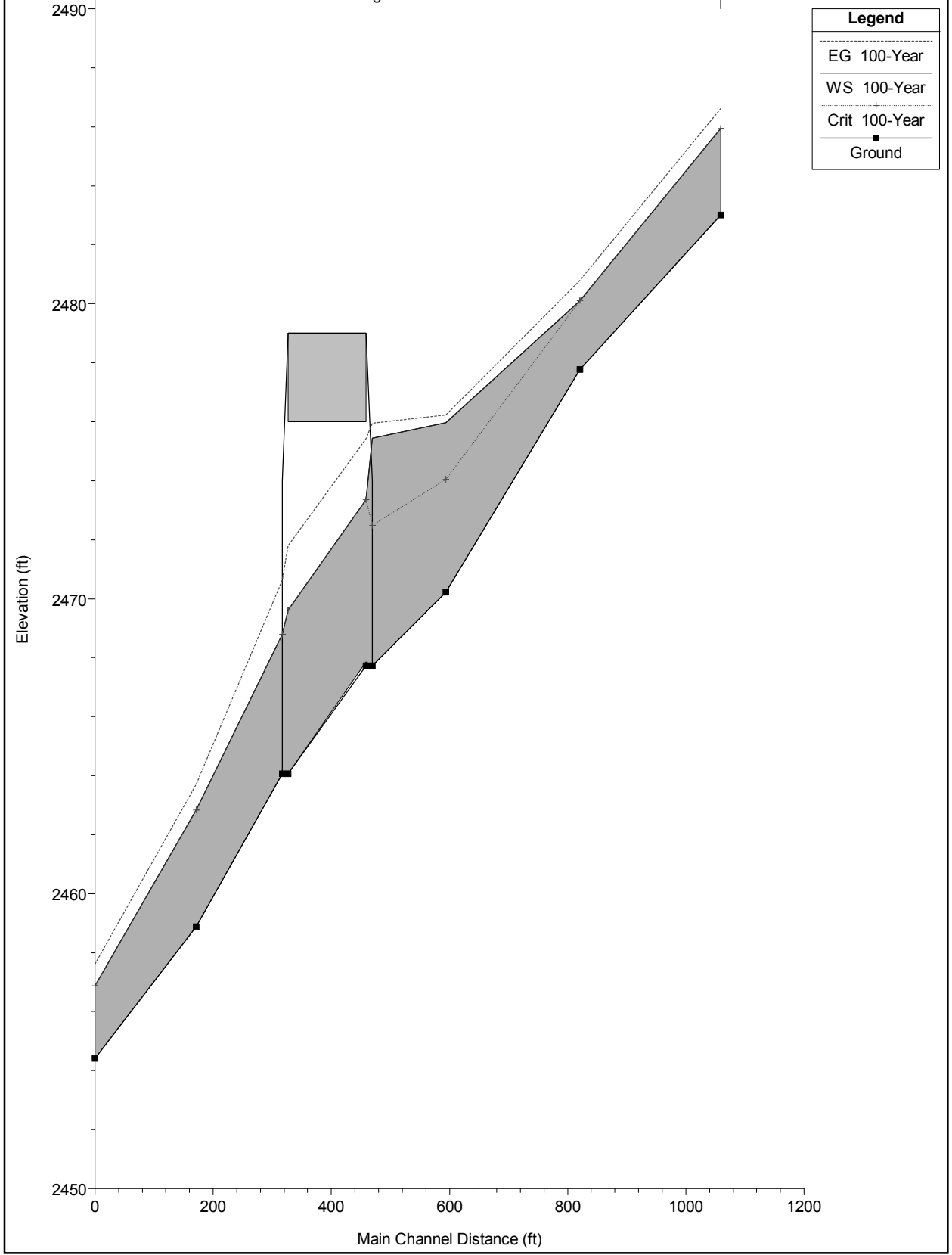
HEC-RAS Plan: Single\_Span Profile: 100-Year

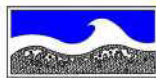
Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Sta575+67	60	100-Year	637.00	2243.99	2245.20	2245.20	2245.45	0.027892	4.08	164.86	322.09	0.90
Sta575+67	50	100-Year	637.00	2240.00	2241.44	2241.44	2241.80	0.027439	4.07	140.38	194.87	0.89
Sta575+67	40	100-Year	637.00	2236.07	2241.00	2239.00	2241.11	0.001294	2.79	235.82	127.69	0.26
Sta575+67	35	Bridge										
Sta575+67	30	100-Year	637.00	2232.00	2235.50	2235.50	2236.26	0.017204	7.61	97.53	110.45	0.88
Sta575+67	20	100-Year	637.00	2232.00	2233.57	2233.57	2233.96	0.027378	4.64	128.76	155.80	0.92
Sta575+67	10	100-Year	637.00	2229.94	2231.26	2231.26	2231.67	0.030011	5.17	125.13	160.41	0.98
Sta661+84	70	100-Year	4059.00	2483.00	2485.95	2485.95	2486.62	0.014231	4.94	694.99	456.93	0.73
Sta661+84	60	100-Year	4059.00	2477.78	2480.10	2480.10	2480.79	0.016689	6.73	657.73	447.50	0.84
Sta661+84	50	100-Year	4059.00	2470.22	2475.96	2474.04	2476.23	0.002255	4.60	1002.48	241.60	0.35
Sta661+84	40	100-Year	4059.00	2467.73	2475.44	2472.49	2475.94	0.002324	5.96	722.04	177.04	0.39
Sta661+84	35	Bridge										
Sta661+84	30	100-Year	4059.00	2464.07	2468.80	2468.80	2470.63	0.017124	11.64	380.21	180.22	0.97
Sta661+84	20	100-Year	4059.00	2458.88	2462.84	2462.84	2463.71	0.015141	8.35	592.96	318.89	0.86
Sta661+84	10	100-Year	4059.00	2454.41	2456.88	2456.88	2457.61	0.022687	7.33	605.29	406.25	0.97
Sta672 +50	60	100-Year	2537.00	2494.87	2496.86	2496.86	2497.51	0.010758	6.55	406.84	317.81	0.96
Sta672 +50	55	Lat Struct										
Sta672 +50	50	100-Year	2094.05	2490.36	2492.68	2492.33	2493.13	0.005743	5.48	392.67	253.41	0.73
Sta672 +50	40	100-Year	1463.44	2487.90	2492.14	2491.03	2492.72	0.003121	7.08	271.06	74.00	0.62
Sta672 +50	35	Culvert										
Sta672 +50	30	100-Year	1463.44	2481.52	2485.07	2485.07	2486.36	0.008888	9.28	166.30	115.29	0.98
Sta672 +50	20	100-Year	1463.44	2480.00	2483.33	2483.33	2484.10	0.006711	8.23	266.61	184.62	0.85
Sta672 +50	10	100-Year	1463.44	2476.96	2479.94	2479.94	2480.47	0.005528	7.23	358.77	320.31	0.77

Bridge Sta575+67



Bridge Sta661+84





# CMG DRAINAGE ENGINEERING, INC.

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Phone (520) 882-4244 Fax (520) 888-1421

## Design Scour Depth C.O.T. EQTN 6.3

### Station 576+00 Bridge Abutments

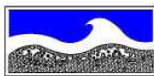
Client: PSOMAS  
Project #: 10-027

Date 2/6/2012  
By: cmg

INPUTS	
<i>General Scour</i>	
Factor of Safety:	1.3
Discharge, Q (cfs):	892.0
Channel Bottom Width, b (ft):	42
Average Velocity, $V_m$ (fps):	8.83
Max Depth of Flow, $Y_{max}$ (ft):	3.74
Hydraulic Depth of Flow, $Y_h$ (ft):	3.73
Energy Slope, $S_e$ (ft/ft):	0.0013
Top Width, $T_w$ (ft):	50
Long Term Factor of Safety (not reqd):	0.0
<i>Low-Flow Thalweg</i>	
Thalweg Depth Required?:	no
Thalweg Depth, $Z_{lft}$ (ft):	0.00
<i>Bend Scour</i>	
Bend Angle, $\alpha$ (deg):	15.00
<i>Local Scour due to Pier</i>	
Pier Width (normal to flow), $b_p$ (ft):	0.00
Upstream Froude, $F_u$ :	0.00
Pier Shape	Cylinder
Pier Shape Reduction Factor	0.9
<i>Local Scour below Channel Drops</i>	
Drop Height, h (ft):	0.00
Downstream Depth of Flow, TW (ft):	0.00
Total drop in head, $H_T$ (ft):	0.00

Results	
<i>General Scour</i>	
General Scour, $Z_{gs}$ (ft) [Eq. 6.4] :	2.61
Anti-dune Trough Depth, $Z_a$ (ft) [6.5] :	1.07
Low Flow Thalweg Depth, $Z_{lft}$ (ft):	0.00
Bend Scour, $Z_{bs}$ (ft) [Eq. 6.6] :	0.00
<i>local scour:</i>	
Pier Scour Depth, $Z_{lsp}$ (ft) [Eq 6.9] :	0.00
Contraction Scour Depth, $Z_{lse}$ (ft)	0.00
Vertical Drop Scour Depth, $Z_{lss}$ (ft) [Eq. 6.14] :	0.00
Calculated Scour Depth, $Z_t$ (ft) [Eq 6.3] :	4.78
Long Term Agg/Deg (ft) [Eq 6.26] :	2.36

<b>Design Scour Depth (ft):</b>	<b>7.14</b>
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## Design Scour Depth C.O.T. EQTN 6.3

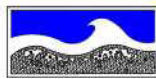
### Station 576+00 Bridge Abutments

Client: PSOMAS  
Project #: 10-027

Date 2/6/2012  
By: cmg

INPUTS	
Length to Hinge Point, (ft):	200
10-Year Natural Discharge, $Q_n$ (cfs):	320
10-Year Urbanized Discharge, $Q_u$ (cfs):	320
Natural Channel Bottom Width, $b_n$ (ft):	127
Urbanized Channel Bottom Width, $b_n$ (ft):	42
Manning's "n" Natural Channel:	0.035
Manning's "n" Urbanized Channel:	0.035
Natural Channel Slope, $S_n$ (ft/ft):	0.031
Reduction Factor for Sediment Supply, $R_s$ :	0.05

Results	
Equilibrium Slope after urbanization, $S_{eq}$ (EQ 6.25):	0.0016
Equilibrium Slope after urbanization, $S_{eq}$ (EQ 6.26):	0.0192
Design Equilibrium Slope (Steepest of 6.26 & 6.25)	0.0192
Natural Channel Slope * $L_h$ (ft):	6.20
Design Equilibrium Slope * $L_h$ (ft):	3.84
Long Term Aggradation/Degradation (ft):	2.36



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## Design Scour Depth C.O.T. EQTN 6.3

Station 576+00 Bridge West Berm

Client: PSOMAS

Station 662+00

Date 2/6/2012

Project #: 10-027

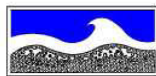
By: cmg

<b>INPUTS</b>	
<i>General Scour</i>	
Factor of Safety:	1.3
Discharge, Q (cfs):	637.0
Channel Bottom Width, b (ft):	322
Average Velocity, $V_m$ (fps):	4.18
Max Depth of Flow, $Y_{max}$ (ft):	1.20
Hydraulic Depth of Flow, $Y_h$ (ft):	1.20
Energy Slope, $S_e$ (ft/ft):	0.0130
Top Width, $T_w$ (ft):	322
Long Term Factor of Safety (not reqd):	0.0
<i>Low-Flow Thalweg</i>	
Thalweg Depth Required?:	Yes
Thalweg Depth, $Z_{ift}$ (ft):	1.00
<i>Bend Scour</i>	
Bend Angle, $\alpha$ (deg):	15.00
<i>Local Scour due to Pier</i>	
Pier Width (normal to flow), $b_p$ (ft):	0.00
Upstream Froude, $F_u$ :	0.00
Pier Shape	Cylinder
Pier Shape Reduction Factor	0.9
<i>Local Scour below Channel Drops</i>	
Drop Height, h (ft):	
Downstream Depth of Flow, TW (ft):	
Total drop in head, $H_T$ (ft):	

<b>Results</b>	
<i>General Scour</i>	
General Scour, $Z_{gs}$ (ft) [Eq. 6.4] :	0.00
Anti-dune Trough Depth, $Z_a$ (ft) [6.5] :	0.24
Low Flow Thalweg Depth, $Z_{ift}$ (ft):	1.00
Bend Scour, $Z_{bs}$ (ft) [Eq. 6.6] :	0.00
<i>local scour:</i>	
Pier Scour Depth, $Z_{lsp}$ (ft) [Eq 6.9] :	0.00
Contraction Scour Depth, $Z_{lse}$ (ft):	0.80
Vertical Drop Scour Depth, $Z_{lss}$ (ft) [Eq. 6.14] :	0.00
Calculated Scour Depth, $Z_t$ (ft) [Eq 6.3] :	2.65
Long Term Agg/Deg (ft) [Eq 6.26] :	4.73

<b>Design Scour Depth (ft):</b>	<b>7.38</b>
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## Design Scour Depth C.O.T. EQTN 6.3

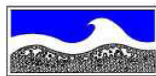
### Station 576+00 Bridge/Berm

Client: PSOMAS  
Project #: 10-027

Date 2/6/2012  
By: cmg

INPUTS	
Length to Hinge Point, (ft):	500
10-Year Natural Discharge, $Q_n$ (cfs):	320
10-Year Urbanized Discharge, $Q_u$ (cfs):	320
Natural Channel Bottom Width, $b_n$ (ft):	322
Urbanized Channel Bottom Width, $b_n$ (ft):	127
Manning's "n" Natural Channel:	0.035
Manning's "n" Urbanized Channel:	0.035
Natural Channel Slope, $S_n$ (ft/ft):	0.030
Reduction Factor for Sediment Supply, $R_s$ :	0.01

Results	
Equilibrium Slope after urbanization, $S_{eq}$ (EQ 6.25):	0.0021
Equilibrium Slope after urbanization, $S_{eq}$ (EQ 6.26):	0.0205
Design Equilibrium Slope (Steepest of 6.26 & 6.25)	0.0205
Natural Channel Slope * $L_h$ (ft):	15.00
Design Equilibrium Slope * $L_h$ (ft):	10.27
Long Term Aggradation/Degradation (ft):	4.73



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**Design Scour Depth C.O.T. EQTN 6.3  
Station 576+00 East Road embankment**

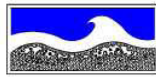
Client: PSOMAS  
Project #: 10-027

Date 2/6/2012  
By: cmg

<b>INPUTS</b>	
<i>General Scour</i>	
Factor of Safety:	1.3
Discharge, Q (cfs):	18.0
Channel Bottom Width, b (ft):	20
Average Velocity, $V_m$ (fps):	4.18
Max Depth of Flow, $Y_{max}$ (ft):	1.00
Hydraulic Depth of Flow, $Y_h$ (ft):	1.00
Energy Slope, $S_e$ (ft/ft):	0.0013
Top Width, $T_w$ (ft):	20
Long Term Factor of Safety (not reqd):	0.0
<i>Low-Flow Thalweg</i>	
Thalweg Depth Required?:	Yes
Thalweg Depth, $Z_{ift}$ (ft):	1.00
<i>Bend Scour</i>	
Bend Angle, $\alpha$ (deg):	45.00
<i>Local Scour due to Pier</i>	
Pier Width (normal to flow), $b_p$ (ft):	0.00
Upstream Froude, $F_u$ :	0.00
Pier Shape	Cylinder
Pier Shape Reduction Factor	0.9
<i>Local Scour below Channel Drops</i>	
Drop Height, h (ft):	
Downstream Depth of Flow, TW (ft):	
Total drop in head, $H_T$ (ft):	

<b>Results</b>	
<i>General Scour</i>	
General Scour, $Z_{gs}$ (ft) [Eq. 6.4] :	0.58
Anti-dune Trough Depth, $Z_a$ (ft) [6.5] :	0.24
Low Flow Thalweg Depth, $Z_{ift}$ (ft):	1.00
Bend Scour, $Z_{bs}$ (ft) [Eq. 6.6] :	0.84
<i>local scour:</i>	
Pier Scour Depth, $Z_{isp}$ (ft) [Eq 6.9] :	0.00
Contraction Scour Depth :	0.00
Vertical Drop Scour Depth, $Z_{lss}$ (ft) [Eq. 6.14] :	0.00
Calculated Scour Depth, $Z_t$ (ft) [Eq 6.3] :	3.46
Long Term Agg/Deg (ft) [Eq 6.26] :	2.23

<b>Design Scour Depth (ft):</b>	<b>5.69</b>
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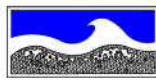
## Design Scour Depth C.O.T. EQTN 6.3 Station 576+00 East Road Embankment

Client: PSOMAS  
Project #: 10-027

Date 2/6/2012  
By: cmg

INPUTS	
Length to Hinge Point, (ft):	300
10-Year Natural Discharge, $Q_n$ (cfs):	18
10-Year Urbanized Discharge, $Q_u$ (cfs):	18
Natural Channel Bottom Width, $b_n$ (ft):	160
Urbanized Channel Bottom Width, $b_n$ (ft):	80
Manning's "n" Natural Channel:	0.035
Manning's "n" Urbanized Channel:	0.035
Natural Channel Slope, $S_n$ (ft/ft):	0.030
Reduction Factor for Sediment Supply, $R_s$ :	0.01

Results	
Equilibrium Slope after urbanization, $S_{eq}$ (EQ 6.25):	0.0036
Equilibrium Slope after urbanization, $S_{eq}$ (EQ 6.26):	0.0226
Design Equilibrium Slope (Steepest of 6.26 & 6.25)	0.0226
Natural Channel Slope * $L_h$ (ft):	9.00
Design Equilibrium Slope * $L_h$ (ft):	6.77
Long Term Aggradation/Degradation (ft):	2.23



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## ADWR - EQUILIBRIUM SLOPE ANALYSIS

project

Client: PSOMAS

Project #: 10-027

Date 2/6/2012

By: cmg

### Equilibrium Slope Analysis

$$S = S_{ex} \left( \frac{Q_{sup}}{Q_{cap}} \right)^{\left( \frac{2}{c-x} \right)} \quad \text{Eq. 5.12}$$

Where :

- $S$  = equilibrium channel slope (ft/ft)
- $S_{ex}$  = existing channel slope (ft/ft)
- $Q_{sup}$  = upstream sediment supply (ft<sup>3</sup>/sec)
- $Q_{cap}$  = sediment transport capacity of study reach (ft<sup>3</sup>/sec)
- $x$  =  $0.6 (0.33 * c + b)$
- $c, b$  = Table 5.6b Regression Parameters

$$Q_{sup} = a Y_h^b V^c Tw \quad \text{Eq. 5.8a}$$

Where :

- $Y_h$  = hydraulic depth for supply reach (ft)
- $V$  = velocity for supply reach (fps)
- $Tw$  = flow top width for supply reach (ft)
- $a, b, c$  = Table 5.6b Regression Parameters

$$Q_{cap} = a Y_h^b V^c Tw \quad \text{Eq. 5.8a}$$

Where :

- $Y_h$  = hydraulic depth for study reach (ft)
- $V$  = velocity for study reach (fps)
- $Tw$  = flow top width for study reach (ft)
- $a, b, c$  = Table 5.6b Regression Parameters

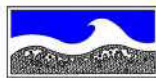
Reference: *Design Manual for Engineering Analysis of Fluvial Systems*, Simons, Li & Associates. March 1985

$$LTD = (S_{DS} - S_{eq}) \times L_R$$

LTD = Long term degradation downstream of bridge

$S_{DS}$  = downstream channel slope

$L_R$  = downstream reach length



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## ADWR - EQUILIBRIUM SLOPE ANALYSIS

project

Client: PSOMAS  
Project #: 10-027

Date 2/6/2012  
By: cmg

### Input Parameters

Calculate G:

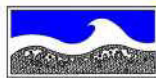
D84 (mm)	D50 (mm)	D16 (mm)	G
3.6	1	0.4	3.05

*Reach coefficients a,b & c should not be zero(0)*

$L_R$ : 1000		Supply Reach			Study Reach		
$S_{DS}$ : 0.02		G: 1			G: 1		
		$D_{50}$ : 1.0mm			$D_{50}$ : 1.0mm		
		a	b	c	a	b	c
$S_{exist}$ : 0.022		0.0000058	-0.198	4.42	0.0000058	-0.198	4.42
Location	Discharge (cfs)	TW (ft)	Hyd. Depth (ft)	Velocity (fps)	TW (ft)	Hyd. Depth (ft)	Velocity (fps)
Station 576+00	320	170	0.48	3.96	128	0.5	5.03

### Computational Results

Location	$Q_{sup}$ (cfs)	$Q_{cap}$ (cfs)	EQ. Slope (S) (ft)	LTD (ft)
Station 576+00	0.500	1.074	0.014	-5.5



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## Design Scour Depth C.O.T. EQTN 6.3 Prospect Wash West Bridge Abutments

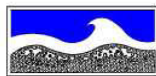
Client: PSOMAS Station 662+00  
Project #: 10-027

Date 2/6/2012  
By: cmg

<b>INPUTS</b>	
<i>General Scour</i>	
Factor of Safety:	1.3
Discharge, Q (cfs):	5683.0
Channel Bottom Width, b (ft):	72
Average Velocity, $V_m$ (fps):	13.73
Max Depth of Flow, $Y_{max}$ (ft):	6.67
Hydraulic Depth of Flow, $Y_h$ (ft):	6.67
Energy Slope, $S_e$ (ft/ft):	0.0023
Top Width, $T_w$ (ft):	87
Long Term Factor of Safety (not reqd):	0.0
<i>Low-Flow Thalweg</i>	
Thalweg Depth Required?:	no
Thalweg Depth, $Z_{ift}$ (ft):	0.00
<i>Bend Scour</i>	
Bend Angle, $\alpha$ (deg):	15.00
<i>Local Scour due to Pier</i>	
Pier Width (normal to flow), $b_p$ (ft):	0.00
Upstream Froude, $F_u$ :	0.00
Pier Shape	Cylinder
Pier Shape Reduction Factor	0.9
<i>Local Scour below Channel Drops</i>	
Drop Height, h (ft):	0.00
Downstream Depth of Flow, TW (ft):	0.00
Total drop in head, $H_T$ (ft):	0.00

<b>Results</b>	
<i>General Scour</i>	
General Scour, $Z_{gs}$ (ft) [Eq. 6.4] :	4.09
Anti-dune Trough Depth, $Z_a$ (ft) [6.5] :	2.58
Low Flow Thalweg Depth, $Z_{ift}$ (ft):	0.00
Bend Scour, $Z_{bs}$ (ft) [Eq. 6.6] :	0.00
<i>local scour:</i>	
Pier Scour Depth, $Z_{lsp}$ (ft) [Eq 6.9] :	0.00
Contraction Scour Depth, $Z_{lse}$ (ft)	0.80
Vertical Drop Scour Depth, $Z_{lss}$ (ft) [Eq. 6.14] :	0.00
Calculated Scour Depth, $Z_t$ (ft) [Eq 6.3] :	9.71
Long Term Agg/Deg (ft) [Eq 6.26] :	2.53

<b>Design Scour Depth (ft):</b>	<b>12.24</b>
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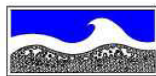
## Design Scour Depth C.O.T. EQTN 6.3 Prospect Wash West Bridge Abutments

Client: PSOMAS  
Project #: 10-027

Date 2/6/2012  
By: cmg

INPUTS	
Length to Hinge Point, (ft):	200
10-Year Natural Discharge, $Q_n$ (cfs):	1300
10-Year Urbanized Discharge, $Q_u$ (cfs):	1300
Natural Channel Bottom Width, $b_n$ (ft):	350
Urbanized Channel Bottom Width, $b_n$ (ft):	72
Manning's "n" Natural Channel:	0.035
Manning's "n" Urbanized Channel:	0.035
Natural Channel Slope, $S_n$ (ft/ft):	0.026
Reduction Factor for Sediment Supply, $R_s$ :	0.05

Results	
Equilibrium Slope after urbanization, $S_{eq}$ (EQ 6.25):	0.0014
Equilibrium Slope after urbanization, $S_{eq}$ (EQ 6.26):	0.0133
Design Equilibrium Slope (Steepest of 6.26 & 6.25)	0.0133
Natural Channel Slope * $L_h$ (ft):	5.20
Design Equilibrium Slope * $L_h$ (ft):	2.67
Long Term Aggradation/Degradation (ft):	2.53



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**Design Scour Depth C.O.T. EQTN 6.3  
Prospect Wash West Bridge West Berm**

Client: PSOMAS Station 662+00  
Project #: 10-027

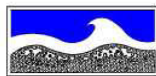
Date 2/6/2012  
By: cmg

<b>INPUTS</b>	
<i>General Scour</i>	
Factor of Safety:	1.3
Discharge, Q (cfs):	4059.0
Channel Bottom Width, b (ft):	278
Average Velocity, $V_m$ (fps):	8.61
Max Depth of Flow, $Y_{max}$ (ft):	2.11
Hydraulic Depth of Flow, $Y_h$ (ft):	1.34
Energy Slope, $S_e$ (ft/ft):	0.0250
Top Width, $T_w$ (ft):	424
Long Term Factor of Safety (not reqd):	0.0
<i>Low-Flow Thalweg</i>	
Thalweg Depth Required?:	Yes
Thalweg Depth, $Z_{ift}$ (ft):	1.00
<i>Bend Scour</i>	
Bend Angle, $\alpha$ (deg):	15.00
<i>Local Scour due to Pier</i>	
Pier Width (normal to flow), $b_p$ (ft):	0.00
Upstream Froude, $F_u$ :	0.00
Pier Shape	Cylinder
Pier Shape Reduction Factor	0.9
<i>Local Scour below Channel Drops</i>	
Drop Height, h (ft):	
Downstream Depth of Flow, TW (ft):	
Total drop in head, $H_T$ (ft):	

<b>Results</b>	
<i>General Scour</i>	
General Scour, $Z_{gs}$ (ft) [Eq. 6.4] :	0.07
Anti-dune Trough Depth, $Z_a$ (ft) [6.5] :	1.02
Low Flow Thalweg Depth, $Z_{ift}$ (ft):	1.00
Bend Scour, $Z_{bs}$ (ft) [Eq. 6.6] :	0.00
<i>local scour:</i>	
Pier Scour Depth, $Z_{isp}$ (ft) [Eq 6.9] :	0.00
Contraction Scour Depth, $Z_{lse}$ (ft):	0.80
Vertical Drop Scour Depth, $Z_{lss}$ (ft) [Eq. 6.14] :	0.00
Calculated Scour Depth, $Z_t$ (ft) [Eq 6.3] :	3.75
Long Term Agg/Deg (ft) [Eq 6.26] :	4.56

<b>Design Scour Depth (ft):</b>	<b>8.31</b>
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## Design Scour Depth C.O.T. EQTN 6.3

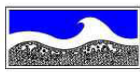
### Prospect Wash West Bridge/Berm

Client: PSOMAS  
Project #: 10-027

Date 2/6/2012  
By: cmg

INPUTS	
Length to Hinge Point, (ft):	900
10-Year Natural Discharge, $Q_n$ (cfs):	1600
10-Year Urbanized Discharge, $Q_u$ (cfs):	1600
Natural Channel Bottom Width, $b_n$ (ft):	278
Urbanized Channel Bottom Width, $b_n$ (ft):	177
Manning's "n" Natural Channel:	0.035
Manning's "n" Urbanized Channel:	0.035
Natural Channel Slope, $S_n$ (ft/ft):	0.026
Reduction Factor for Sediment Supply, $R_s$ :	0.05

Results	
Equilibrium Slope after urbanization, $S_{eq}$ (EQ 6.25):	0.0016
Equilibrium Slope after urbanization, $S_{eq}$ (EQ 6.26):	0.0209
Design Equilibrium Slope (Steepest of 6.26 & 6.25)	0.0209
Natural Channel Slope * $L_h$ (ft):	23.40
Design Equilibrium Slope * $L_h$ (ft):	18.84
Long Term Aggradation/Degradation (ft):	4.56



## Live Bed Contraction Scour

### Prospect Wash West Bridge

Client: PSOMAS  
Project #: 10-027

Date 2/16/2012  
By: cmg

$$V_c = K_u y^{1/6} D^{1/3}$$

$V_c$  = Critical velocity above which bed material of size  $D$  and smaller will be transported (ft/s)

$y$  = Average depth of flow upstream of the bridge (ft)

$D$  = Particle size for  $V_c$  (ft)

$D_{50}$  = Particle size in mixture of which 50 percent are smaller (ft)

$K_u$  = 11.17

$\omega$  = fall velocity of bed material based on  $D$  (figure 5.8)

$$\frac{y_2}{y_1} = \left( \frac{Q_2}{Q_1} \right)^{6/7} \left( \frac{W_1}{W_2} \right)^{k_1}$$

$y_1$  = Average depth in the upstream main channel (ft)

$y_2$  = Average depth in the contracted section (ft)

$Q_1$  = Flow in the upstream channel transporting sediment (ft<sup>3</sup>/s)

$Q_2$  = Flow in the contracted channel (ft<sup>3</sup>/s)

$W_1$  = Bottom width of upstream channel transporting bed material (ft)

$W_2$  = Bottom width of main channel in contracted section less piers (ft)

$k_1$  = velocity dependent exponent

$y_s = y_2 - y_0$  = Average contraction scour depth (ft)

$y_0$  = Existing depth in the contracted section before scour - approx  $y_1$  (ft)

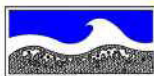
$V_* = (g y_1 S_1)^{1/2}$  = shear velocity in the upstream section (ft/s)

$g = 32.2 \text{ ft/s}^2$

$S_1$  = Slope of energy grade line of main channel (ft/ft)

			Average Depth (ft)	Energy Slope (ft/ft)	Q (cfs)	Width (ft)
X-sec upstream of contraction:	50		4.54	0.00138	5,683	352
X-sec of contraction:	30		1.83	0.05972	5,683	180
Bounding X-sections of main channel upstream of contraction:	Upstream	Downstream	$y_1$			
	60.00	20	1.20		5,683	448

$y_0$ (ft)	$D$ (ft)	$V_*$ (ft/s)	$\omega$ (ft/s)	$V_c$ (ft/s)	$k_1$	$y_2$ (ft)	$y_s$ (ft)
1.20	0.00262	0.450	0.360333	1.98	0.64	1.84	0.64



# CMG DRAINAGE ENGINEERING, INC.

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Phone (520) 882-4244 Fax (520) 888-1421

## Design Scour Depth C.O.T. EQTN 6.3 Prospect Wash West Bridge East Road embankment

Client: PSOMAS  
Project #: 10-027

Date 2/6/2012  
By: cmg

INPUTS	
<i>General Scour</i>	
Factor of Safety:	1.3
Discharge, Q (cfs):	581.0
Channel Bottom Width, b (ft):	20
Average Velocity, $V_m$ (fps):	4.30
Max Depth of Flow, $Y_{max}$ (ft):	2.00
Hydraulic Depth of Flow, $Y_h$ (ft):	2.00
Energy Slope, $S_e$ (ft/ft):	0.0023
Top Width, $T_w$ (ft):	20
Long Term Factor of Safety (not reqd):	0.0
<i>Low-Flow Thalweg</i>	
Thalweg Depth Required?:	Yes
Thalweg Depth, $Z_{ift}$ (ft):	1.00
<i>Bend Scour</i>	
Bend Angle, $\alpha$ (deg):	45.00
<i>Local Scour due to Pier</i>	
Pier Width (normal to flow), $b_p$ (ft):	0.00
Upstream Froude, $F_u$ :	0.00
Pier Shape	Cylinder
Pier Shape Reduction Factor	0.9
<i>Local Scour due to Embankments</i>	
Slope Angle of Abutment Face, $\theta_a$ (deg):	33.00
Upstream Froude, $F_u$ :	0.97
Upstream Flow Depth, $Y_u$ (ft):	0.79
Encroachment Length, $a_e$ (ft):	0.00
<i>Local Scour below Channel Drops</i>	
Drop Height, h (ft):	
Downstream Depth of Flow, TW (ft):	
Total drop in head, $H_T$ (ft):	

Results	
<i>General Scour</i>	
General Scour, $Z_{gs}$ (ft) [Eq. 6.4] :	0.06
Anti-dune Trough Depth, $Z_a$ (ft) [6.5] :	0.25
Low Flow Thalweg Depth, $Z_{ift}$ (ft):	1.00
Bend Scour, $Z_{bs}$ (ft) [Eq. 6.6] :	1.10
<i>local scour:</i>	
Pier Scour Depth, $Z_{isp}$ (ft) [Eq 6.9] :	0.00
Encroachment Scour Depth, $Z_{ise}$ (ft) [Eq 6.12] :	0.00
Vertical Drop Scour Depth, $Z_{iss}$ (ft) [Eq. 6.14] :	0.00
Calculated Scour Depth, $Z_t$ (ft) [Eq 6.3] :	3.14
Long Term Agg/Deg (ft) [Eq 6.26] :	1.88

Design Scour Depth (ft):	5.02
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