



## MEMORANDUM

TO: STEVE LANGE  
FROM: STACEY CLEAR, P.E.  
DATE: April 22, 2021  
SUBJECT: BASIN F4 STORMWATER MODELING  
ANALYSIS – REVISE TO EXISTING  
STORMS

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### INTRODUCTION

Per the City's current Stormwater Comprehensive Plan, the downstream system of Basin F4 was listed as being undersized. Numerous developments upstream would be allowed a flow control exemption if this surcharging condition did not exist. In light of the knowledge that City staff has never seen this area surcharge during recent sizable storms, the City of Anacortes requested Gray & Osborne rerun the model based on rainfall data representing recent large storms as recorded by the City's Wastewater Treatment Plant (WWTP).

The following memorandum provides the results of this analysis.

### MODELING SETUP

In March 2021, Gray & Osborne revised previous November 2020 modeling efforts to include asbuilt information along T Ave. In April 2021, City Staff provided Gray & Osborne rainfall data from the WWTP which represented the largest, most recent storms. The top three storms are described in Table 1 and are shown graphically in Figures 1 through 3.



**TABLE 1**

**Precipitation Data**

Date	Total Daily Rainfall (in.)
<b>December 21, 2020</b>	
12-21-21	1.86
<b>February 4-6, 2020</b>	
2-4-20	0.53
2-5-20	1.33
2-6-20	0.63
<b>January 31 – February 1, 2021</b>	
1-31-20 to 2-1-20	1.47

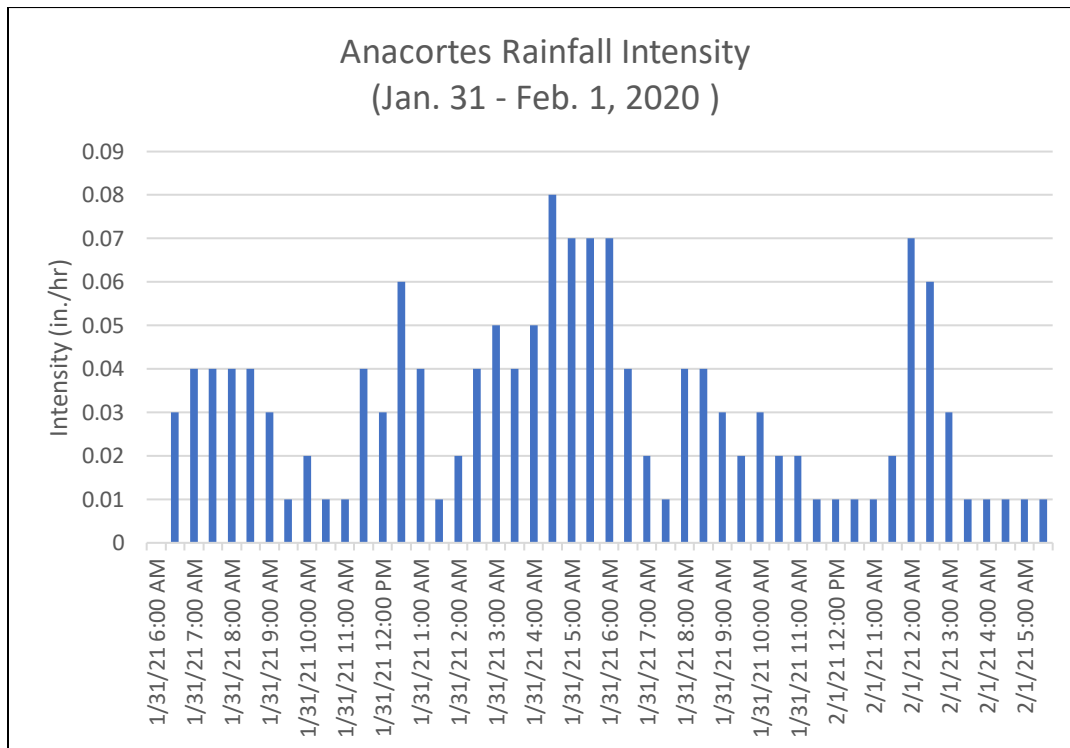


Figure 1. Rainfall Intensity at the Anacortes WWTP, January 31 – February 1, 2020



Technical Memorandum – Basin F4 Stormwater Model  
April 22, 2021

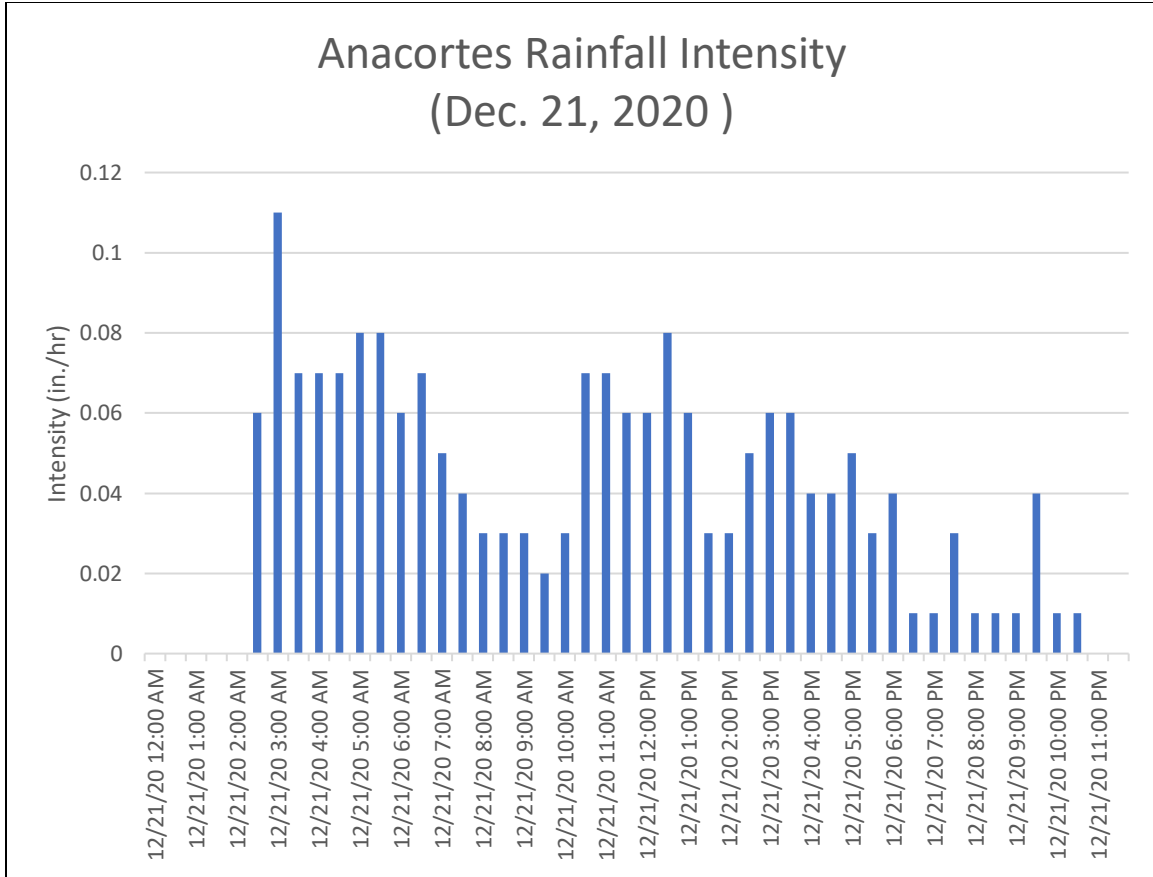


Figure 2. Rainfall Intensity at the Anacortes WWTP, December 21, 2020



Technical Memorandum – Basin F4 Stormwater Model  
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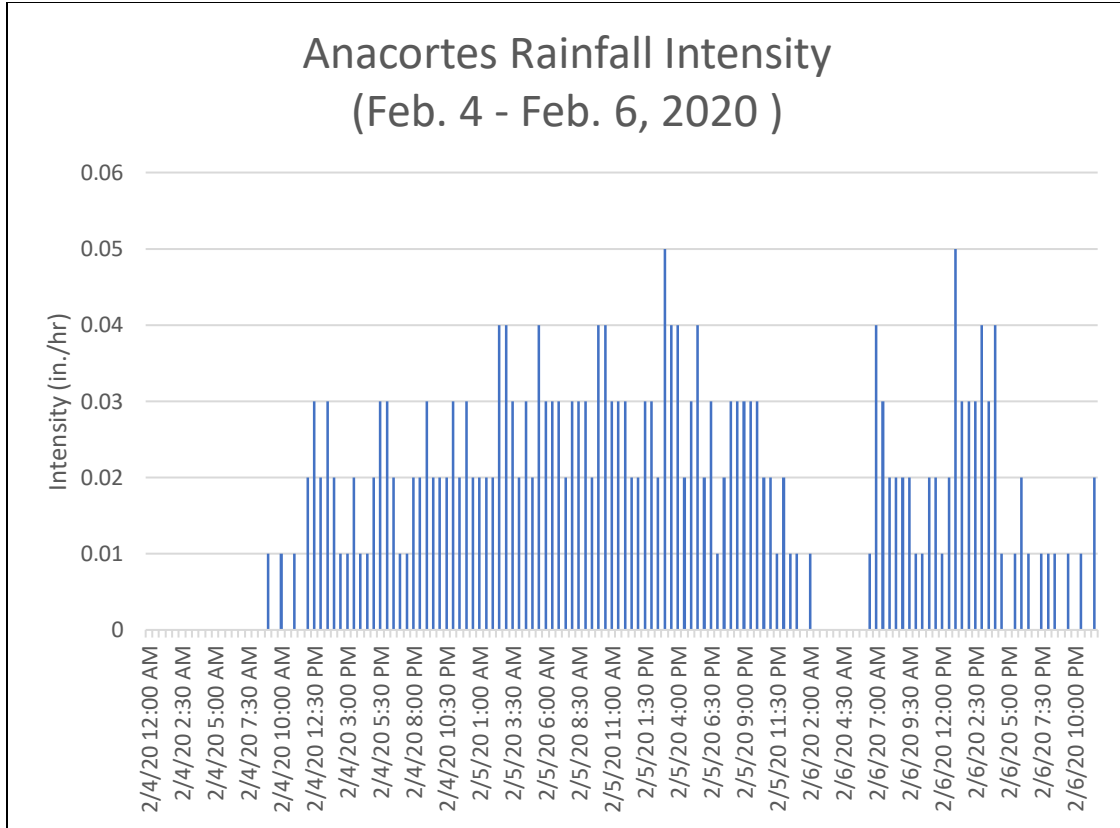


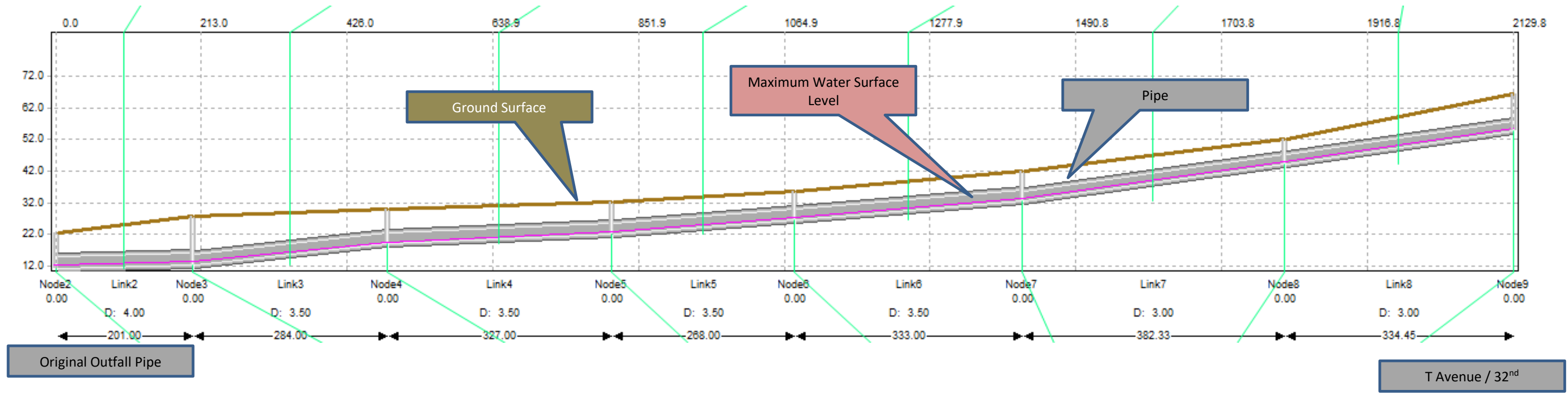
Figure 2. Rainfall Intensity at the Anacortes WWTP, February 4 – February 6, 2020

It should be noted that previous modeling efforts utilized a 25-year storm event of 2.5 in./day as determined by the NOAA Atlas 2, Volume IX – Washington. The November and March 2020 modeling efforts also included a 50% safety factor on top of this 25-year event.

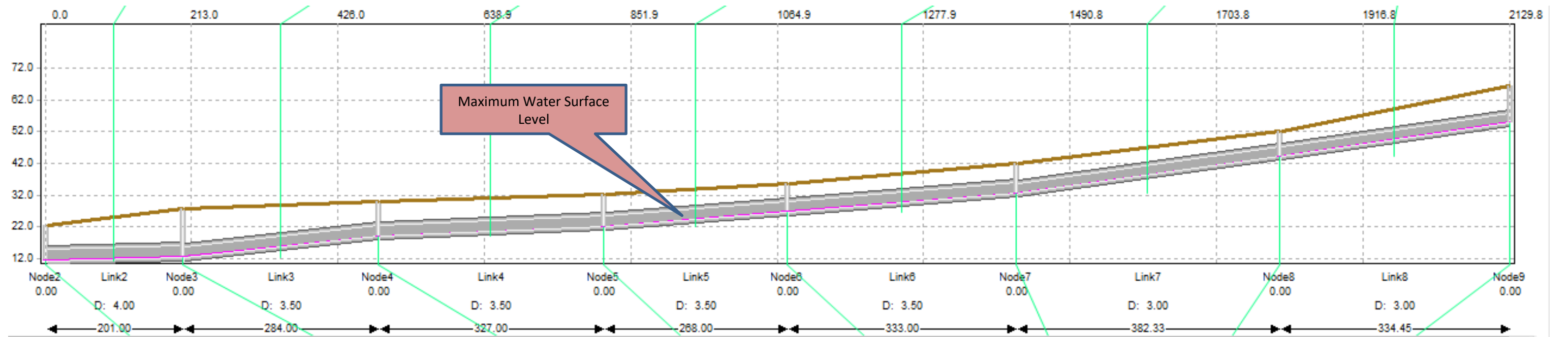
### MODELING RESULTS

Utilizing the same assumptions as previous efforts (i.e. same impervious surface estimates, soil curve numbers, and times of concentrations), based on the three storms provided, no surcharging was evident in the modeled pipes. The model output, including screenshots of the downstream storm pipes in T Ave., are provided at the end of this memorandum. Within the output, the “q/Q” column provides the capacity of the pipe in terms of how full it is during the peak moment. For instance, a q/Q ratio of 0.10 means the pipe was 10% full at its peak.

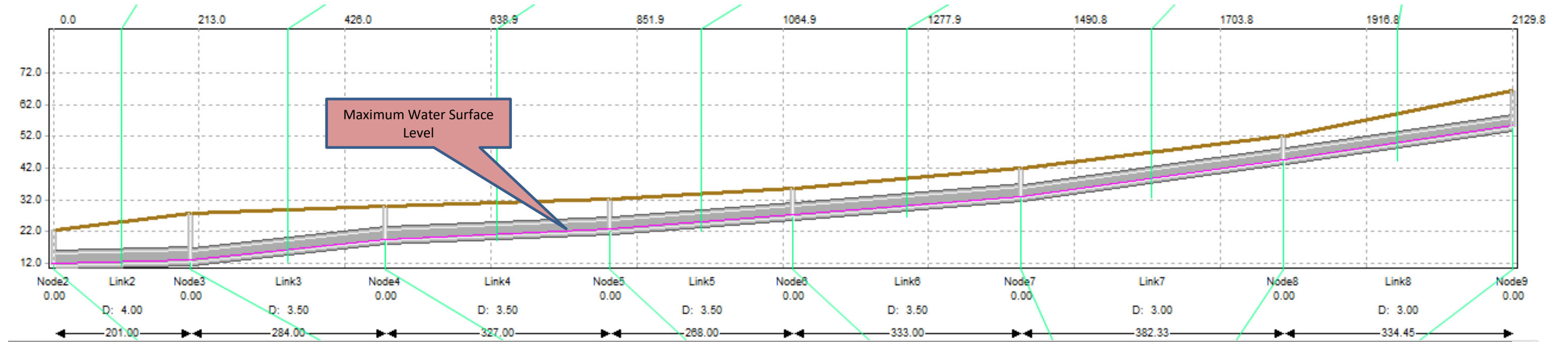
**T Ave. Pipes (December 21, 2020):**



**T Ave. Pipes (February 4-6, 2020):**



T Ave. Pipes (January 31 – February 1, 2020):

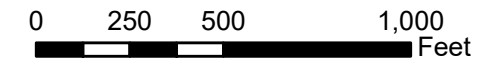




### Legend

- Modeled Catch Basin
- Link
- Modeled Pipe
- Storm Structure
- Non-modeled Storm Pipes
- Parcel

Source: City GIS data



**CITY OF ANACORTES**  
**F4 BASIN MODELING**  
**MODELED STORM NODES**

**Gray & Osborne, Inc.**  
 CONSULTING ENGINEERS

**December 20, 2021**

Conduit Name	Capacity (cfs)	Capacity (fps)	Diameter (in.)	Modeled Flow (cfs)	Time of Occurrence (hr)	Time of Occurrence (min)	Max. Velocity (fps)	q/Q - Ratio of Max Flow to Capacity	Max Elev. Upstream (ft)	Max Elev. Downstream (ft)	d/D Upstream	d/D Downstream
Link1	113.1441	9.0037	48	15.0847	16	25	6.255	0.1333	12.2856	9.3307	0.247	0.246
Link2	113.2762	9.0142	48	15.0846	16	24	6.2611	0.1332	13.5347	12.2856	0.246	0.247
Link3	151.9174	15.79	42	12.9301	17	44	9.0515	0.0851	19.7143	13.5347	0.197	0.282
Link4	96.5015	10.0302	42	12.9302	17	44	6.5669	0.134	22.9583	19.7143	0.265	0.197
Link5	133.0942	13.8335	42	12.4663	17	44	8.3256	0.0937	27.446	22.9583	0.207	0.265
Link6	133.0942	13.8335	42	11.9039	17	48	8.5327	0.0894	33.2574	27.446	0.202	0.207
Link7	116.678	16.5066	36	11.7168	17	47	12.191	0.1004	44.8918	33.2574	0.214	0.236
Link8	119.0213	16.8381	36	11.4124	17	52	10.5942	0.0959	55.5273	44.8918	0.209	0.214
Link9	138.8036	19.6367	36	7.0874	17	51	9.7431	0.0511	65.6602	55.5273	0.153	0.209
Link10	131.9291	18.6641	36	6.9651	17	51	9.7952	0.0528	73.592	65.6602	0.157	0.153
Link11	113.6459	16.0776	36	6.9651	17	51	8.6124	0.0613	84.3188	73.592	0.173	0.157
Link14	94.4932	19.25	30	6.5416	17	53	10.8646	0.0692	110.9649	108.7327	0.178	0.197
Link16	98.0973	19.9842	30	6.4144	17	53	11.2311	0.0654	130.9038	123.5303	0.174	0.172
Link17	43.0219	13.6943	24	2.2779	18	2	6.8449	0.0529	132.8124	130.9038	0.156	0.217
Link18	52.8155	16.8117	24	2.2779	18	2	8.2363	0.0431	141.6124	132.8124	0.141	0.156
Link19	44.7579	14.2469	24	2.2779	18	2	7.1713	0.0509	149.6387	141.6124	0.159	0.141
Link20	38.7262	12.3269	24	2.2779	18	2	6.6278	0.0588	155.434	149.6387	0.167	0.159
Link21	45.9704	14.6328	24	2.1728	18	3	7.3432	0.0473	163.0453	155.434	0.148	0.167
Link22	42.0095	13.372	24	1.8573	18	5	6.6696	0.0442	172.2758	163.0453	0.143	0.148
Link23	18.5423	5.9022	24	1.8573	18	5	3.6171	0.1002	173.1159	172.2758	0.228	0.143
Link24	60.7355	19.3327	24	1.6882	18	8	7.2109	0.0278	181.5188	173.1159	0.114	0.228
Link25	57.7058	18.3683	24	1.6882	18	8	8.0344	0.0293	199.778	181.5188	0.119	0.114
Link26	41.0571	13.0689	24	0.8666	18	51	5.3404	0.0211	202.24	199.778	0.1	0.119
Link27	82.2825	26.1913	24	0.8666	18	51	9.3068	0.0105	219.1436	202.24	0.072	0.1
Link28	55.7079	17.7324	24	0.8666	18	51	5.9828	0.0156	224.6667	219.1436	0.093	0.072
Link29	48.0706	15.3014	24	0.8666	18	51	5.8393	0.018	233.6356	224.6667	0.093	0.093
Link30	29.2023	9.2954	24	0.8666	18	51	3.7755	0.0297	237.708	233.6356	0.129	0.093
Link31	30.0064	9.5513	24	0.8666	18	50	4.1507	0.0289	241.7332	237.708	0.117	0.129
Link32	28.2576	8.9947	24	0.8666	18	49	3.9907	0.0307	243.6935	241.7332	0.122	0.117
Link33	26.7033	8.4999	24	0.8666	18	49	3.8617	0.0325	245.8783	243.6935	0.124	0.122
Link34	38.6373	12.2986	24	0.8666	18	49	4.8698	0.0224	250.306	245.8783	0.103	0.124
Link35	58.5303	14.7206	27	4.393	17	59	8.0175	0.0751	65.9167	55.5273	0.185	0.279
Link36	32.4009	8.149	27	4.2824	17	0	5.2541	0.1322	69.3173	65.9167	0.27	0.185



**December 20, 2021**

Conduit Name	Capacity (cfs)	Capacity (fps)	Diameter (in.)	Modeled Flow (cfs)	Time of Occurrence (hr)	Time of Occurrence (min)	Max. Velocity (fps)	q/Q - Ratio of Max Flow to Capacity	Max Elev. Upstream (ft)	Max Elev. Downstream (ft)	d/D Upstream	d/D Downstream
Link37	13.8795	17.6719	12	0.2846	14	6	4.9614	0.0205	76.0886	69.3173	0.099	0.607
Link38	2.9614	8.4754	8.004	0.2846	14	6	4.744	0.0961	96.2776	76.0886	0.236	0.148
Link39	3.0726	8.7936	8.004	0.2847	14	6	5.3793	0.0926	97.9871	96.2776	0.206	0.236
Link40	2.2718	6.5018	8.004	0.2847	14	6	4.147	0.1253	109.4504	97.9871	0.255	0.206
Link41	78.7456	16.0419	30	6.9651	17	50	9.8513	0.0885	85.5925	84.3188	0.201	0.208
Link12	76.5251	15.5896	30	6.9651	17	50	9.6226	0.091	95.9033	85.5925	0.205	0.201
Link15	98.6527	20.0974	30	6.5416	17	53	11.3381	0.0663	119.3956	110.9649	0.174	0.178
Link44	101.1328	20.6026	30	6.5416	17	52	12.456	0.0647	123.5303	119.3956	0.172	0.174
Link13	74.8025	15.2386	30	6.5416	17	53	9.3335	0.0875	101.8098	95.9033	0.2	0.205
Link46	76.9462	15.6753	30	6.5416	17	53	9.5371	0.085	108.7327	101.8098	0.197	0.2
Link47	94.3258	13.3444	36	1.0588	16	56	5.1902	0.0112	69.2831	69.3173	0.094	0.172
Link48	94.3258	13.3444	36	0.6878	16	53	4.2892	0.0073	69.2657	69.3173	0.089	0.172
Link49	94.3258	13.3444	36	0.8573	17	9	2.5014	0.0091	69.3851	69.3173	0.128	0.172
Link50	149.1421	21.0993	36	0.8537	16	58	15.7	0.0057	131.16	130.9038	0.053	0.135
Link51	149.1421	21.0993	36	0.5566	16	54	16.503	0.0037	131.132	130.9038	0.044	0.135
Link52	149.1421	21.0993	36	0.7561	13	33	13.9317	0.0051	131.1513	130.9038	0.05	0.135
Link52.1	149.1421	21.0993	36	0	0	0	0	0	131	130.9038	0	0
FREE#	1	Undefnd	Undefnd	Undefnd	15.0847	16	25					

**February 4-6, 2020**

Conduit Name	Capacity (cfs)	Capacity (fps)	Diameter (in.)	Modeled Flow (cfs)	Time of Occurrence (hr)	Time of Occurrence (min)	Max. Velocity (fps)	q/Q - Ratio of Max Flow to Capacity	Max Elev. Upstream (ft)	Max Elev. Downstream (ft)	d/D Upstream	d/D Downstream
Link1	113.1441	9.0037	48	1.4662	22	25	3.1274	0.013	11.6183	8.665	0.08	0.08
Link2	113.2762	9.0142	48	1.4663	22	24	3.1303	0.0129	12.8681	11.6183	0.08	0.08
Link3	151.9174	15.79	42	1.4662	22	24	6.7596	0.0097	19.2646	12.8681	0.069	0.091
Link4	96.5015	10.0302	42	1.4665	22	24	3.3559	0.0152	22.3567	19.2646	0.093	0.069
Link5	133.0942	13.8335	42	1.4661	22	23	4.3748	0.011	26.9796	22.3567	0.073	0.093
Link6	133.0942	13.8335	42	1.4663	22	24	4.553	0.011	32.8071	26.9796	0.073	0.073
Link7	116.678	16.5066	36	1.4662	22	22	5.5959	0.0126	44.4857	32.8071	0.079	0.086
Link8	119.0213	16.8381	36	1.4662	22	21	5.7436	0.0123	55.1333	44.4857	0.078	0.079
Link9	138.8036	19.6367	36	0.3244	22	19	3.2864	0.0023	65.3031	55.1333	0.034	0.078
Link10	131.9291	18.6641	36	0.3246	22	16	6.8212	0.0025	73.2284	65.3031	0.036	0.034
Link11	113.6459	16.0776	36	0.3246	22	16	3.4111	0.0029	83.9211	73.2284	0.04	0.036
Link14	94.4932	19.25	30	0.3248	22	16	4.3763	0.0034	110.6262	108.3561	0.042	0.046
Link16	98.0973	19.9842	30	0.3249	22	16	8.9874	0.0033	130.5752	123.2032	0.042	0.041
Link17	43.0219	13.6943	24	0.3249	22	16	3.7484	0.0076	132.6298	130.5752	0.065	0.053
Link18	52.8155	16.8117	24	0.3246	22	14	10.6348	0.0061	141.4403	132.6298	0.055	0.065
Link19	44.7579	14.2469	24	0.3248	22	16	3.9391	0.0073	149.4442	141.4403	0.062	0.055
Link20	38.7262	12.3269	24	0.3247	22	14	3.6515	0.0084	155.2303	149.4442	0.065	0.062
Link21	45.9704	14.6328	24	0.3247	22	13	7.9902	0.0071	162.8679	155.2303	0.059	0.065
Link22	42.0095	13.372	24	0.3247	22	13	3.8346	0.0077	172.116	162.8679	0.063	0.059
Link23	18.5423	5.9022	24	0.3247	22	12	3.0786	0.0175	172.8607	172.116	0.1	0.063
Link24	60.7355	19.3327	24	0.3247	22	12	4.8419	0.0053	181.3934	172.8607	0.052	0.1
Link25	57.7058	18.3683	24	0.3249	22	12	23.9066	0.0056	199.6472	181.3934	0.054	0.052
Link26	41.0571	13.0689	24	0	0	0	0	0	202.04	199.6472	0	0
Link27	82.2825	26.1913	24	0	0	0	0	0	202.04	202.04	0	0
Link28	55.7079	17.7324	24	0	0	0	0	0	219	219	0	0
Link29	48.0706	15.3014	24	0	0	0	0	0	224.48	224.48	0	0
Link30	29.2023	9.2954	24	0	0	0	0	0	233.45	233.45	0	0
Link31	30.0064	9.5513	24	0	0	0	0	0	237.45	237.45	0	0
Link32	28.2576	8.9947	24	0	0	0	0	0	241.5	241.5	0	0
Link33	26.7033	8.4999	24	0	0	0	0	0	243.45	243.45	0	0
Link34	38.6373	12.2986	24	0	0	0	0	0	245.63	245.63	0	0

February 4-6, 2020

Conduit Name	Capacity (cfs)	Capacity (fps)	Diameter (in.)	Modeled Flow (cfs)	Time of Occurrence (hr)	Time of Occurrence (min)	Max. Velocity (fps)	q/Q - Ratio of Max Flow to Capacity	Max Elev. Upstream (ft)	Max Elev. Downstream (ft)	d/D Upstream	d/D Downstream
Link35	58.5303	14.7206	27	1.142	22	21	5.6925	0.0195	65.7167	55.1333	0.096	0.104
Link36	32.4009	8.149	27	1.1421	22	21	5.5111	0.0352	69.0275	65.7167	0.141	0.096
Link37	13.8795	17.6719	12	0	0	0	0	0	75.99	69.0275	0	0
Link38	2.9614	8.4754	8.004	0	0	0	0	0	75.99	75.99	0	0
Link39	3.0726	8.7936	8.004	0	0	0	0	0	96.12	96.12	0	0
Link40	2.2718	6.5018	8.004	0	0	0	0	0	97.85	97.85	0	0
Link41	78.7456	16.0419	30	0.3252	22	18	3.8659	0.0041	85.205	83.9211	0.046	0.048
Link12	76.5251	15.5896	30	0.3247	22	18	3.7897	0.0042	95.5071	85.205	0.047	0.046
Link15	98.6527	20.0974	30	0.3248	22	16	4.5733	0.0033	119.0643	110.6262	0.042	0.042
Link44	101.1328	20.6026	30	0.3249	22	16	4.664	0.0032	123.2032	119.0643	0.041	0.042
Link13	74.8025	15.2386	30	0.3247	22	16	5.3181	0.0043	101.4277	95.5071	0.047	0.047
Link46	76.9462	15.6753	30	0.3247	22	17	3.8244	0.0042	108.3561	101.4277	0.046	0.047
Link47	94.3258	13.3444	36	-0.0041	23	4	0.0991	0	69.0275	69.0275	0.0092	0.076
Link48	94.3258	13.3444	36	-0.0041	23	4	0.0991	0	69.0275	69.0275	0.0092	0.076
Link49	94.3258	13.3444	36	-0.0041	23	4	0.0991	0	69.0275	69.0275	0.0092	0.076
Link50	149.1421	21.0993	36	0	0	0	0	0	131	130.5752	0	0
Link51	149.1421	21.0993	36	0	0	0	0	0	131	130.5752	0	0
Link52	149.1421	21.0993	36	0	0	0	0	0	131	130.5752	0	0
Link52.1	149.1421	21.0993	36	0	0	0	0	0	131	130.5752	0	0
FREE#	1	Undefnd	Undefnd	Undefnd	1.4677	22	27					

**January 31-February 1, 2021**

Conduit Name	Capacity (cfs)	Capacity (fps)	Diameter (in.)	Modeled Flow (cfs)	Time of Occurrence (hr)	Time of Occurrence (min)	Max. Velocity (fps)	q/Q - Ratio of Max Flow to Capacity	Max Elev. Upstream (ft)	Max Elev. Downstream (ft)	d/D Upstream	d/D Downstream
Link1	113.1441	9.0037	48	9.7667	21	31	5.5134	0.0863	12.0935	9.1396	0.199	0.198
Link2	113.2762	9.0142	48	9.7667	21	30	5.5181	0.0862	13.3429	12.0935	0.198	0.199
Link3	151.9174	15.79	42	7.8949	21	43	7.7678	0.052	19.5657	13.3429	0.155	0.227
Link4	96.5015	10.0302	42	7.8949	21	43	5.6503	0.0818	22.7594	19.5657	0.208	0.155
Link5	133.0942	13.8335	42	7.5739	21	47	11.4766	0.0569	27.2889	22.7594	0.162	0.208
Link6	133.0942	13.8335	42	7.2297	21	52	7.3654	0.0543	33.1037	27.2889	0.158	0.162
Link7	116.678	16.5066	36	7.0771	21	51	10.4342	0.0607	44.7506	33.1037	0.167	0.185
Link8	119.0213	16.8381	36	6.9277	21	55	9.1499	0.0582	55.3908	44.7506	0.164	0.167
Link9	138.8036	19.6367	36	4.187	21	51	8.3089	0.0302	65.5575	55.3908	0.119	0.164
Link10	131.9291	18.6641	36	4.0858	21	52	8.3643	0.031	73.4844	65.5575	0.121	0.119
Link11	113.6459	16.0776	36	4.0859	21	52	7.3302	0.036	84.2005	73.4844	0.134	0.121
Link14	94.4932	19.25	30	3.78	22	59	11.5711	0.04	110.8604	108.6162	0.136	0.15
Link16	98.0973	19.9842	30	3.69	22	1	9.5256	0.0376	130.8011	123.4295	0.132	0.132
Link17	43.0219	13.6943	24	1.3321	21	58	5.8405	0.031	132.7414	130.8011	0.121	0.166
Link18	52.8155	16.8117	24	1.3321	21	58	7.0069	0.0252	141.5481	132.7414	0.109	0.121
Link19	44.7579	14.2469	24	1.3321	21	58	6.0989	0.0298	149.566	141.5481	0.123	0.109
Link20	38.7262	12.3269	24	1.3321	21	58	5.64	0.0344	155.3574	149.566	0.129	0.123
Link21	45.9704	14.6328	24	1.2482	22	1	6.2083	0.0272	162.9762	155.3574	0.113	0.129
Link22	42.0095	13.372	24	0.9996	22	5	5.5044	0.0238	172.2019	162.9762	0.106	0.113
Link23	18.5423	5.9022	24	0.9996	22	4	2.952	0.0539	173.0007	172.2019	0.17	0.106
Link24	60.7355	19.3327	24	0.8704	22	11	5.8639	0.0143	181.457	173.0007	0.084	0.17
Link25	57.7058	18.3683	24	0.8704	22	11	6.5698	0.0151	199.7131	181.457	0.087	0.084
Link26	41.0571	13.0689	24	0.4191	23	6	11.3102	0.0102	202.1814	199.7131	0.071	0.087
Link27	82.2825	26.1913	24	0.4191	23	6	8.8378	0.0051	219.1011	202.1814	0.051	0.071
Link28	55.7079	17.7324	24	0.4191	23	5	10.1754	0.0075	224.6116	219.1011	0.066	0.051
Link29	48.0706	15.3014	24	0.4191	23	6	4.6608	0.0087	233.5806	224.6116	0.065	0.066
Link30	29.2023	9.2954	24	0.4191	23	5	3.0196	0.0144	237.6323	233.5806	0.091	0.065
Link31	30.0064	9.5513	24	0.4191	23	4	3.3338	0.014	241.6651	237.6323	0.083	0.091
Link32	28.2576	8.9947	24	0.4191	23	3	3.1993	0.0148	243.6219	241.6651	0.086	0.083
Link33	26.7033	8.4999	24	0.4191	23	3	3.0965	0.0157	245.8052	243.6219	0.088	0.086
Link34	38.6373	12.2986	24	0.4191	23	3	3.9078	0.0108	250.2458	245.8052	0.073	0.088
Link35	58.5303	14.7206	27	2.7565	22	59	6.9976	0.0471	65.8317	55.3908	0.147	0.218

**January 31-February 1, 2021**

Conduit Name	Capacity (cfs)	Capacity (fps)	Diameter (in.)	Modeled Flow (cfs)	Time of Occurrence (hr)	Time of Occurrence (min)	Max. Velocity (fps)	q/Q - Ratio of Max Flow to Capacity	Max Elev. Upstream (ft)	Max Elev. Downstream (ft)	d/D Upstream	d/D Downstream
Link36	32.4009	8.149	27	2.6478	22	1	4.4967	0.0817	69.1856	65.8317	0.211	0.147
Link37	13.8795	17.6719	12	0.1953	22	4	6.6721	0.0141	76.0728	69.1856	0.083	0.476
Link38	2.9614	8.4754	8.004	0.1953	22	4	4.2521	0.066	96.2505	76.0728	0.196	0.124
Link39	3.0726	8.7936	8.004	0.1953	22	3	4.8124	0.0636	97.9639	96.2505	0.171	0.196
Link40	2.2718	6.5018	8.004	0.1953	22	3	3.7146	0.086	109.4212	97.9639	0.212	0.171
Link41	78.7456	16.0419	30	4.0858	21	52	8.4027	0.0519	85.4766	84.2005	0.155	0.16
Link12	76.5251	15.5896	30	4.0858	21	51	16.6603	0.0534	95.7851	85.4766	0.158	0.155
Link15	98.6527	20.0974	30	3.78	22	59	9.619	0.0383	119.2935	110.8604	0.133	0.136
Link44	101.1328	20.6026	30	3.7801	22	59	12.4723	0.0374	123.4295	119.2935	0.132	0.133
Link13	74.8025	15.2386	30	3.78	22	59	7.9225	0.0505	101.6915	95.7851	0.153	0.158
Link46	76.9462	15.6753	30	3.78	22	59	8.0972	0.0491	108.6162	101.6915	0.15	0.153
Link47	94.3258	13.3444	36	0.6793	21	55	7.761	0.0072	69.2171	69.1856	0.072	0.129
Link48	94.3258	13.3444	36	0.4102	21	43	2.9237	0.0043	69.1656	69.1856	0.055	0.129
Link49	94.3258	13.3444	36	0.32	21	43	4.7751	0.0034	69.1468	69.1856	0.049	0.129
Link50	149.1421	21.0993	36	0.5582	21	57	16.8629	0.0037	131.1321	130.8011	0.044	0.1
Link51	149.1421	21.0993	36	0.364	21	53	16.9116	0.0024	131.106	130.8011	0.035	0.1
Link52	149.1421	21.0993	36	0.5501	21	19	12.9981	0.0037	131.1313	130.8011	0.044	0.1
Link52.1	149.1421	21.0993	36	0	0	0	0	0	131	130.8011	0	0
FREE#	1	Undefnd	Undefnd	Undefnd	9.7667	21	31					