Final Assessment

A review of the existing conditions associated with Reach 14W-11A and Reach 14W-12A with respect to aquatic habitat, Redside Dace and benthic macroinvertebrate community including benthic drift was undertaken. Once the function of each reach related to those criteria, the changes expected during all phases of development related to a reduction in flow, specifically related to the "Sensitive Period" for Redside Dace (April to May) was undertaken. The assessment has confirmed that although the magnitude of flow at all three Nodes reviewed will be slightly reduced; noticeable changes to the existing conditions in terms of flow continuity and wetted habitat during the "Sensitive Period" are not anticipated for Reach 14W-11A.

Based on the enclosed monthly hydrographs and the flow depths under different flows (0.005 cms, 0.015 cms, 2-year flow, and 5-year flow), the anticipated flows will provide partial maintenance of existing functions (i.e. flow conveyance and nutrients to Reach 14W-12) on a monthly basis, and during the "Sensitive period" of April and May.

Furthermore, with respect to flows in the downstream Reach 14W-12 Occupied Redside Dace habitat, there will be no reduction of flow as the reduced flow from 14W-12A will be compensated with the flows from Reach 14W-22 and the stormwater management facilities outflows. Monthly flows are presented at the end of this memorandum, and they show marginal changes in peak flows, and no changes in frequency and duration. In addition, Erosion Control Analysis has been completed as part of the assessment of impact of development at Node 3.

Although the main purpose of this document is to assess the impacts of flow modification on these particular nodes as it relates to ecological function, there is a factor that must be considered as well; the benefits of the proposed channel realignments (Reach 14W-22 and Reach 14W-23). The use of natural channel design principles (i.e., riffle/pool sequences with a connecting low flow channel) will result in greater habitat diversity, specifically the introduction of morphological variation and coarse substrate (i.e., gravel and cobble) not present or present in limited amount in Reach 14W-11A, Reach 14W-13 and Reach 14W-14, as well as, substantial expansion of the riparian stream corridor widths. These features will potentially improve the function of these reaches for the aquatic community including:

- Expansion of fish ranges (refuge pools);
- Spawning habitat (morphology and substrate);
- Redside Dace spawning (riffles and substrate);
- Redside Dace range expansion into Reach 14W-22 and Reach 14W-23 when the rehabilitation of Reach 14W-11 occurs (pools, riffles);
- Improved benthic macroinvertebrate production and diversity (riffle);
- Improved drift as active agricultural operations has a lower number of drifting macroinvertebrates than urban settings (Hennigar, 2012); and
- Improved fish productivity as the density of macroinvertebrate and their drift can influence fish growth and population size (Wills et. al., 2006).

As a result, this final assessment takes into account the ecological function of these reaches, the potential effects of the flow changes during the period when the reaches Has the greater ecological function (i.e., April and May) and the anticipated benefits of the realigned channels.

Node 9 (Reach 14W-11A)

- Function of this reach in general is limited in the existing condition due to its modified nature, intermittent flows and lack of habitat diversity for aquatic species providing limited direct use.
- Realigned channel (Reach 14W-23) will introduce habitat diversity including riffles, pools and coarse substrates.
- Reach 14W-23 potential to provide spawning and refuge habitat for fish, potential increase to benthic macroinvertebrate community diversity and productivity.
- The associated wider riparian stream corridor width will provide additional allochthonous inputs during runoff events.

Node 2 (Reach 14W-12A)

- Function of this reach in general is limited in the existing condition due to its modified nature, intermittent flows and lack of habitat diversity for aquatic species providing limited direct use.
- Exhibit the greatest reduction in flow due to the removal of the headwaters.
- Reduced flows will be lessen by directing rooftop drainage into this reach.
- Peak flows during the “Sensitive Period” to Redside Dace (April to May) have shown to be able to provide sufficient flow to maintain partial ecological function.
- Contributions of flow and benthic macroinvertebrates will be addressed since mean annual flow and flushing flow (2 x mean annual flow according to Tessman) will provide flow continuity and fine sand entrainment.

Node 2B (Reach 14W-22)

- No existing condition as located in the realigned Reach 14W-22.
- Realigned channel (Reach 14W-22) will introduce habitat diversity including riffles, pools, coarse substrates beyond what is provided by Reaches 14W-13 and 14W-14.
- Reach 14W-22 potential to provide spawning and refuge habitat for fish, potential increase to benthic macroinvertebrate community diversity and productivity.
- The associated wider riparian stream corridor width will provide additional allochthonous inputs during runoff events.

Responses to Comments

The comments received on July 15th, 2016 are as follows:

- b) Discussion of Tessman Method Results
- c) Appendix A, Flow Duration Curves
- d) Discussion of the Flow Duration Method Results
- e) Table 6.3, Summary of Impacts on Ecology and Sediment Transport, All Nodes
- f) Table 6.3, Summary of Impacts on Ecology and Sediment Transport, Node 2

The table below provides brief responses. Responses to comments received in January 2017 are presented in another table.

Table 8. Comment and Responses

Comment	Response
b) Discussion of Tessman Method Results	
i) The hybrid tool	The hybrid tool was removed. For clarity purposes, the Tennant and Tessman methods results are now included separately.
ii) Tessman Method recommendations	Tessman method results are now compatible with the table
iii) Applicability of Tennant Method	The application of the Tennant was based on 30 years of hydrologic record, with average values estimated for two seasons. Instantaneous flows were evaluated under the detailed analysis portion of this report.
iv) use of MMF under Tennant	We used two seasons. MMF and MAF were only used under the Tessman method.
v) The hybrid tool	The hybrid tool was removed. For clarity purposes, the Tennant and Tessman methods results are now included separately.
vi) Using standard Tennant and Tessman methods for nodes 2, 2B, and 9	The two methods are now used separately.
vii) Redside Dace sensitive months	The detailed analysis discusses the timing and other natural flow regime considerations.
c) Appendix A, Flow Duration Curves	Noted. 2 is compared to 2A, 2C to 2B, and 9 to 9.
d) Discussion of the Flow Duration Method Results	Noted. Discussion revised.
e) Table 6.3, Summary of Impacts on Ecology and Sediment Transport, All Nodes	Flushing flows for Nodes 2, 2B, and 9 are discussed in this report.
f) Table 6.3, Summary of Impacts on Ecology and Sediment Transport, Node 2	Flushing flows "in a fashion similar to existing or baseline conditions" have been identified for sensitive months for nodes 2, 2B, and 9.

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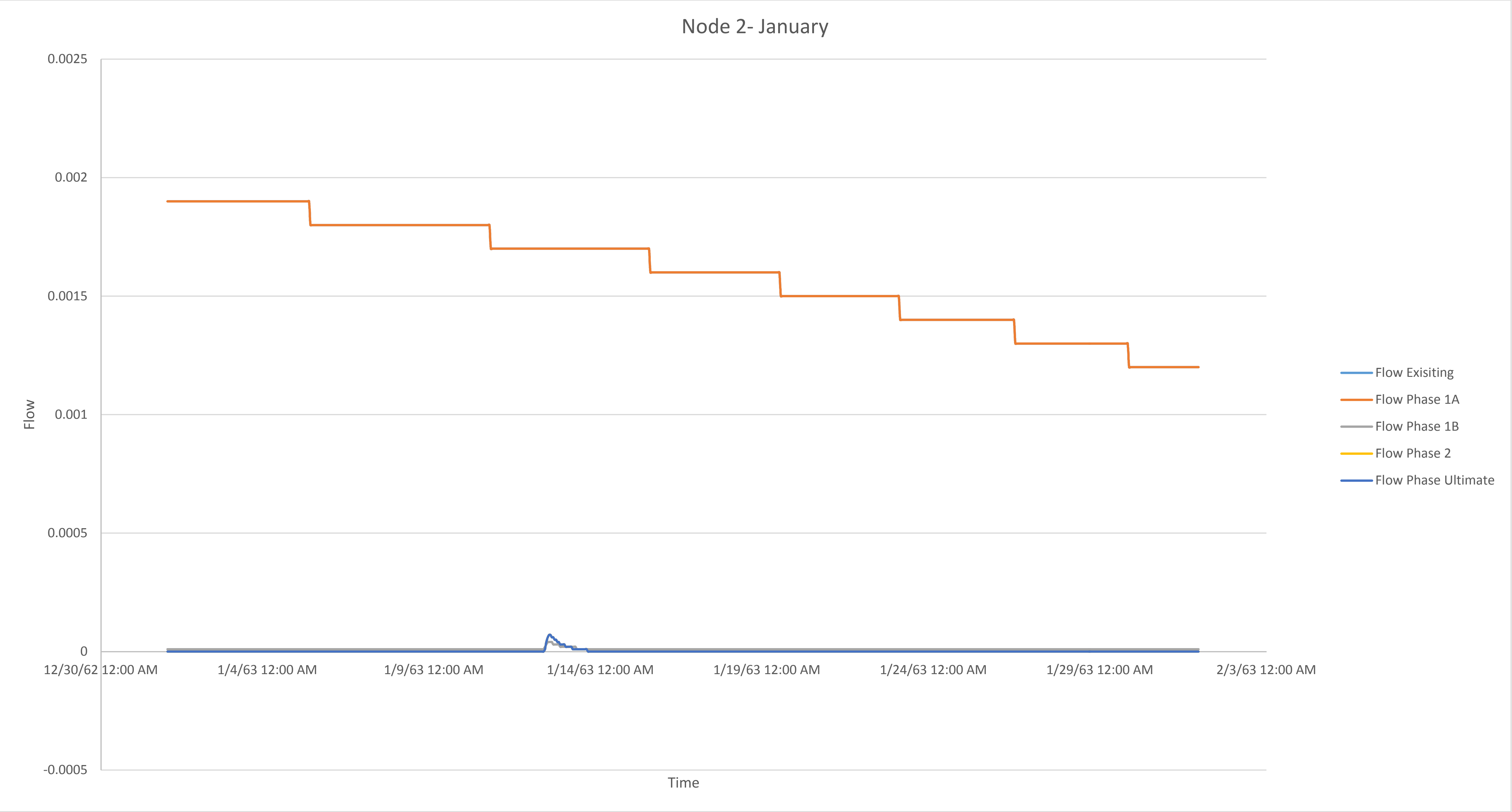
Monthly Comparative (phase-based) Hydro-Graphs for 3 years (wet, average, and dry) at 3 nodes (2, 2B/2C, and 9).

Table of Contents

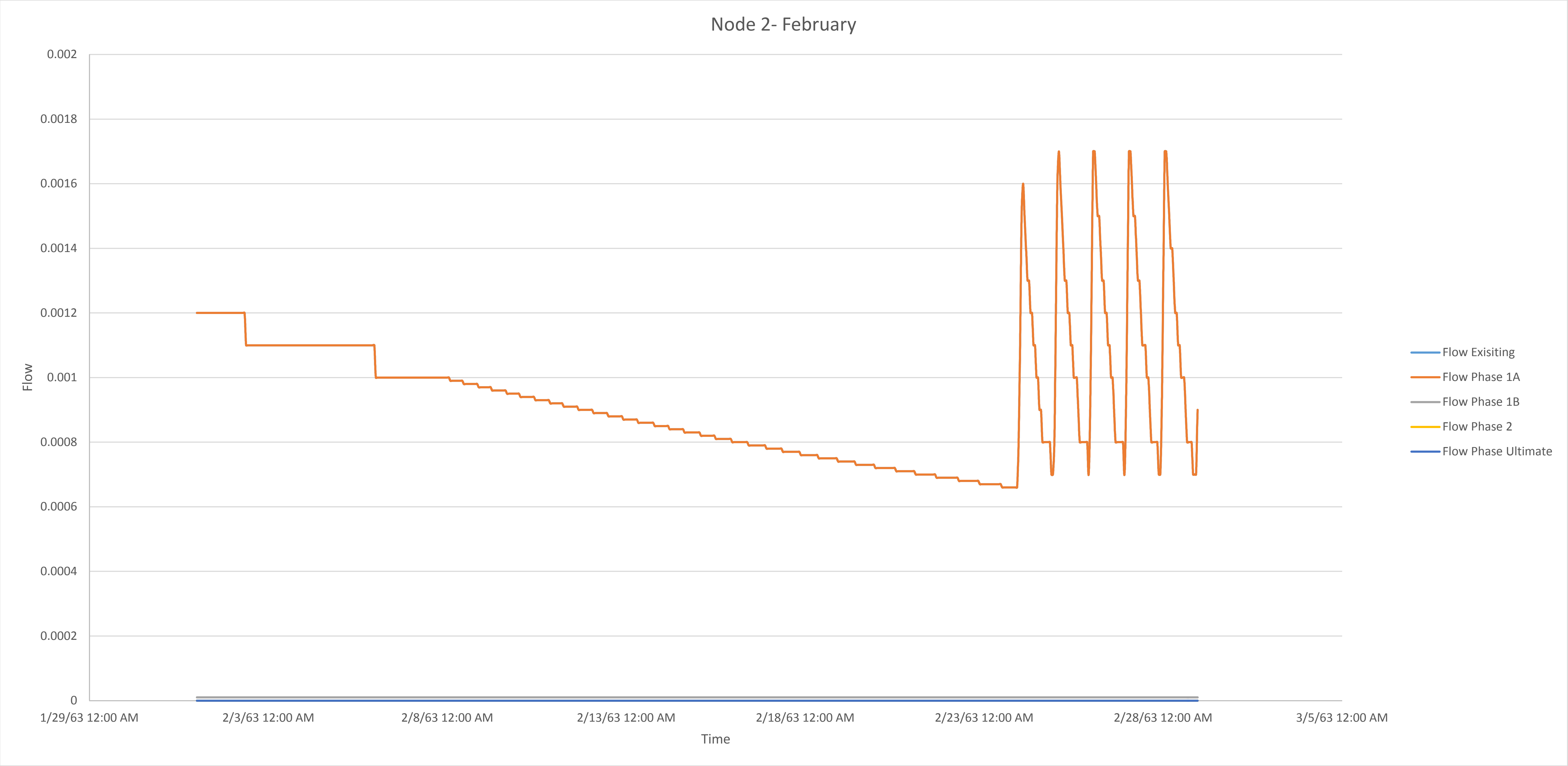
Note:

1) All graphs have cms as unit of flow.
2) The wet year-1992, has data only till October.
3) Page attributes-size is 11x17 (tabloid) and orientation is landscape.

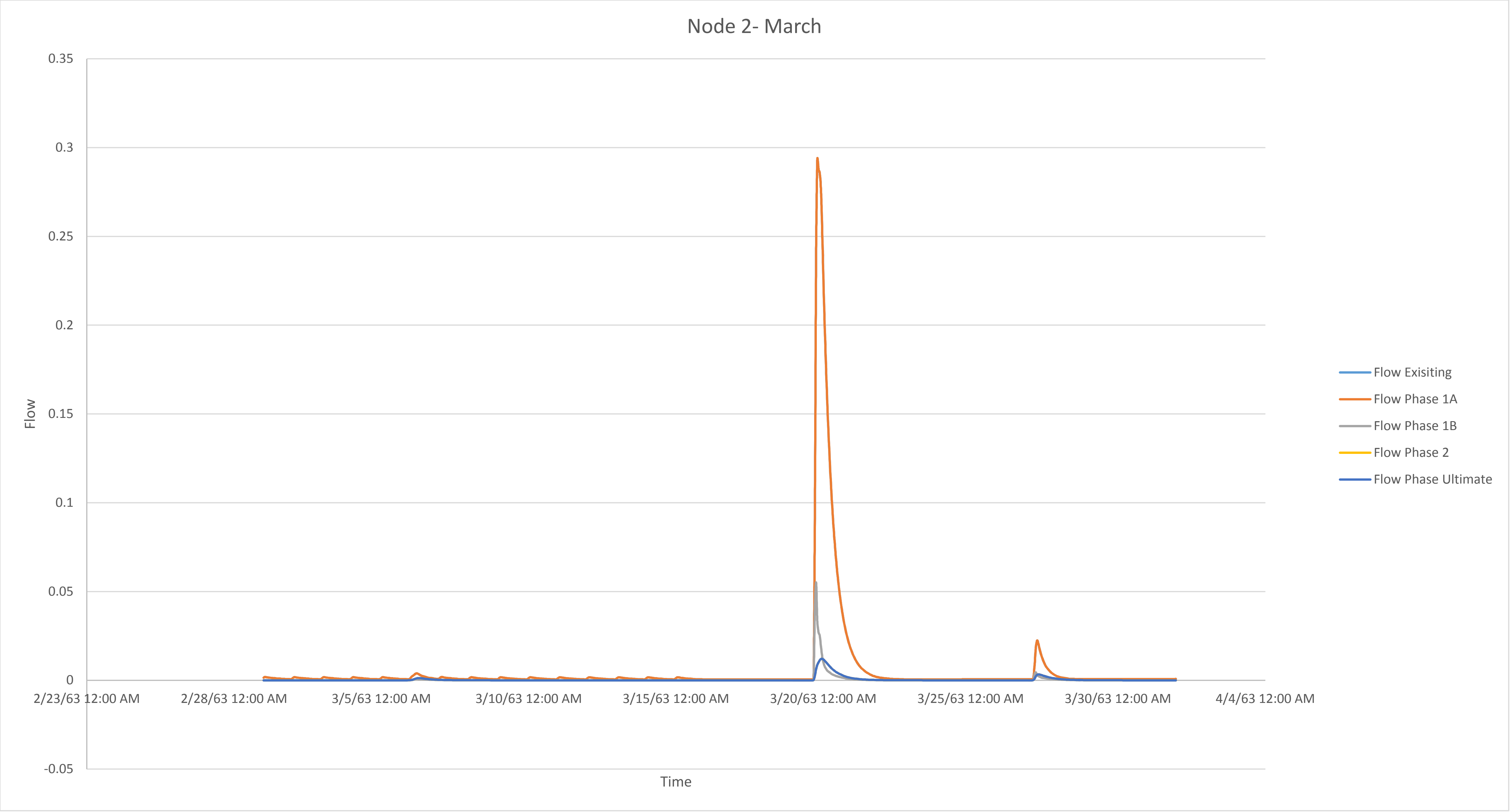
Dry Year-1963



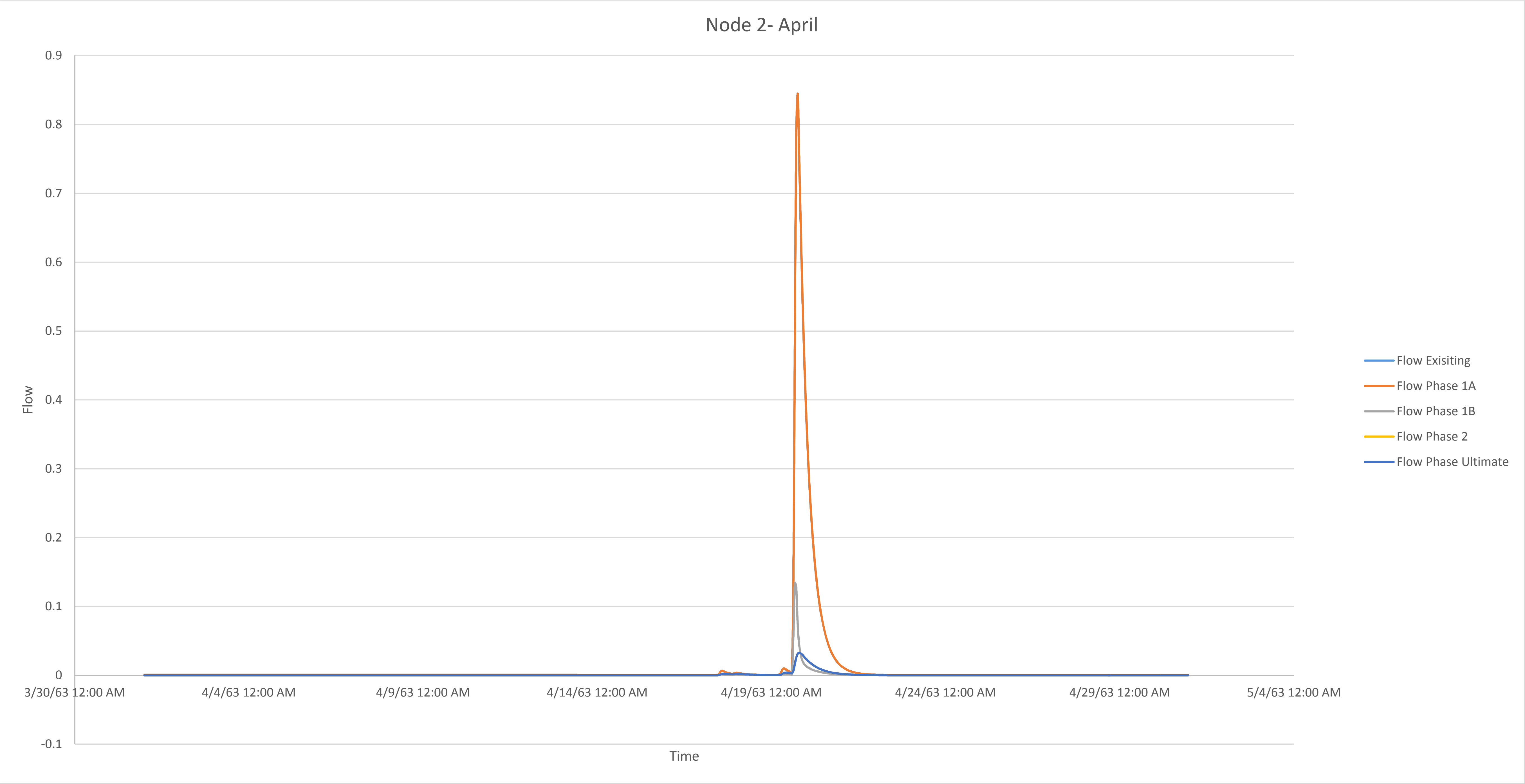
January						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		0	0	1	1	1
Magnitudes (cm/s)	Max.			0.00004	0.00007	0.00007
	Min.					
Duration (h)	Max.			23	20	20
	Min.					



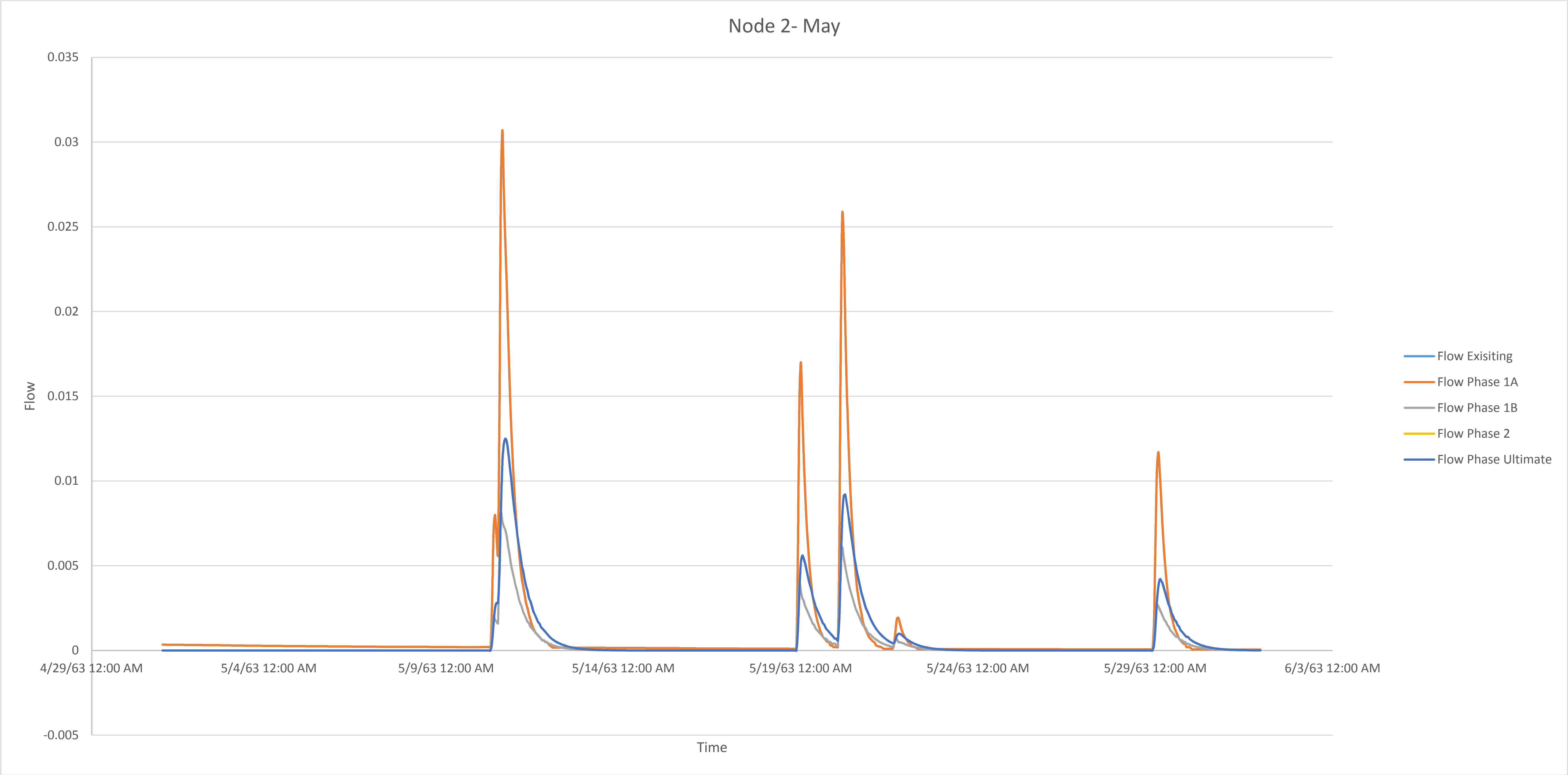
February						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	0	0	0
Magnitudes (cm/s)	Max.	0.0017	0.0017			
	Min.	0.0016	0.0016			
Duration (h)	Max.	24	24			
	Min.	22	22			



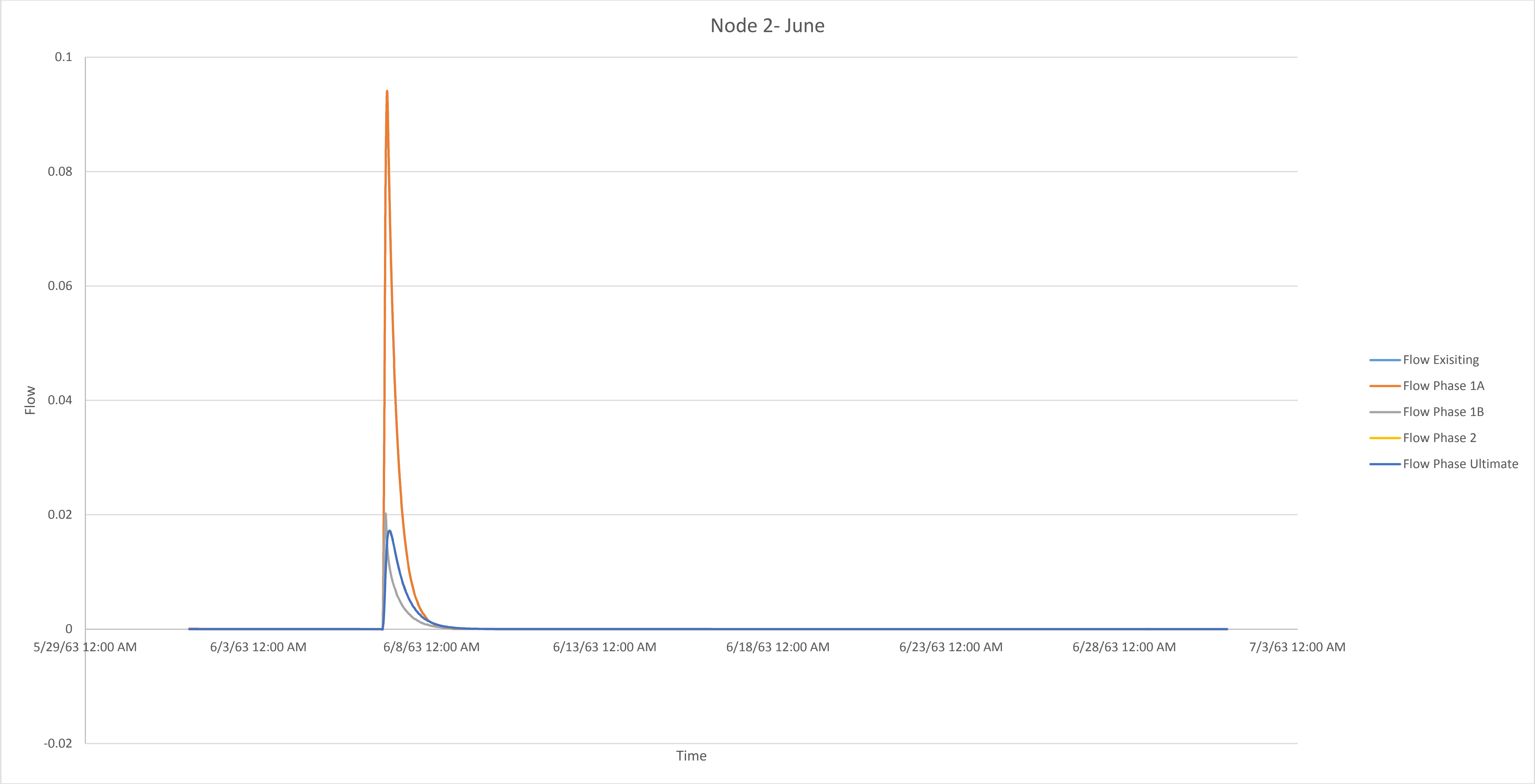
March						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		17	17	3	3	3
Magnitudes (cm/s)	Max.	0.2935	0.2935	0.0551	0.012	0.012
	Min.	0.00168	0.00168	0.00076	0.00125	0.00073
Duration (h)	Max.	75	75	80	77	77
	Min.	24	24	57	56	56



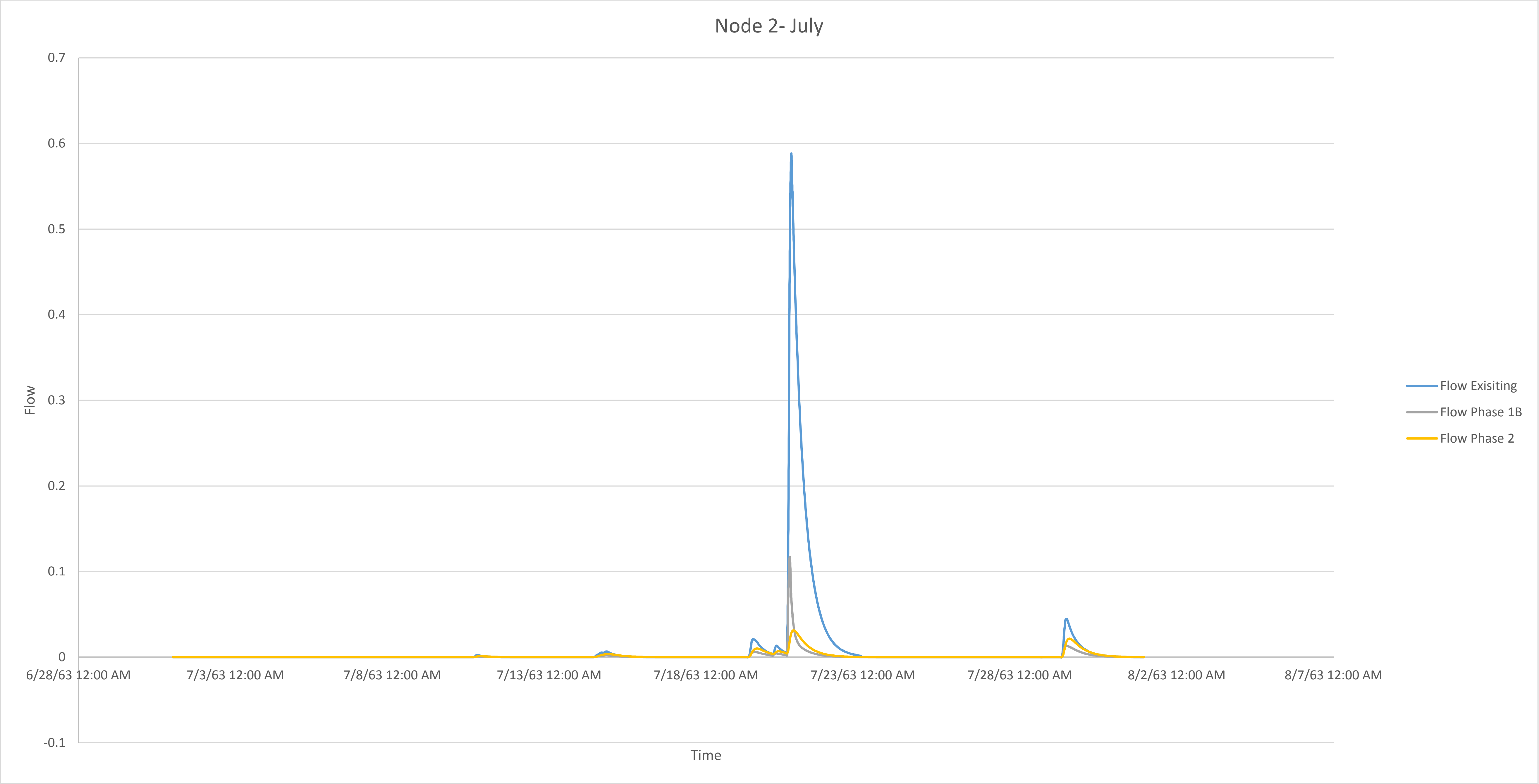
April						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		4	4	4	4	4
Magnitudes (cm/s)	Max.	0.8448	0.8448	0.1337	0.0327	0.0327
	Min.	0.0066	0.0066	0.0014	0.00218	0.00218
Duration (h)	Max.	79	79	77	88	88
	Min.	32	32	35	36	36



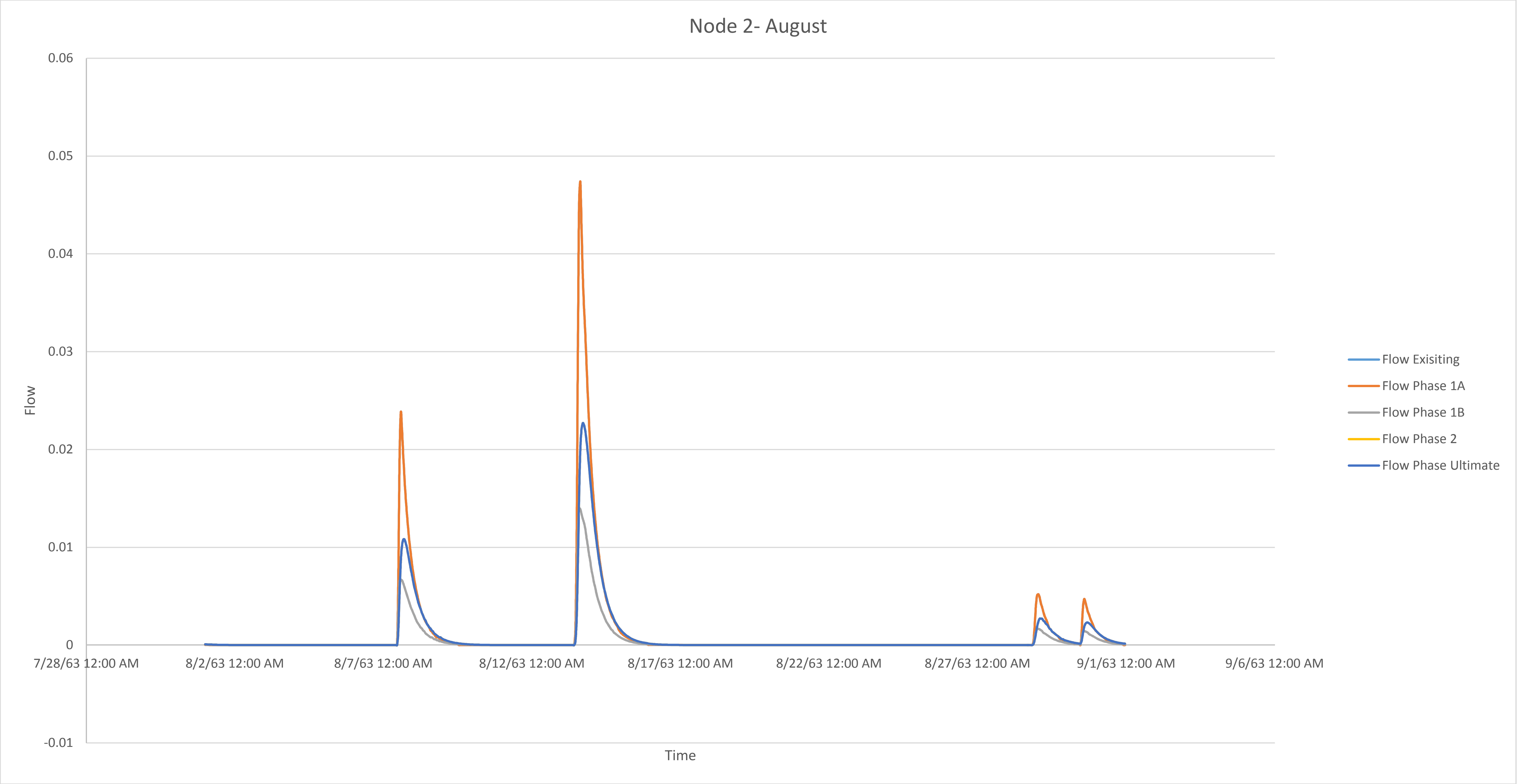
May						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		4	4	4	4	4
Magnitudes (cm/s)	Max.	0.9027	0.9027	0.1589	0.038	0.038
	Min.	0.0051	0.0051	0.00027	0.00021	0.00021
Duration (h)	Max.	60	60	77	66	66
	Min.	7	7	22	21	21



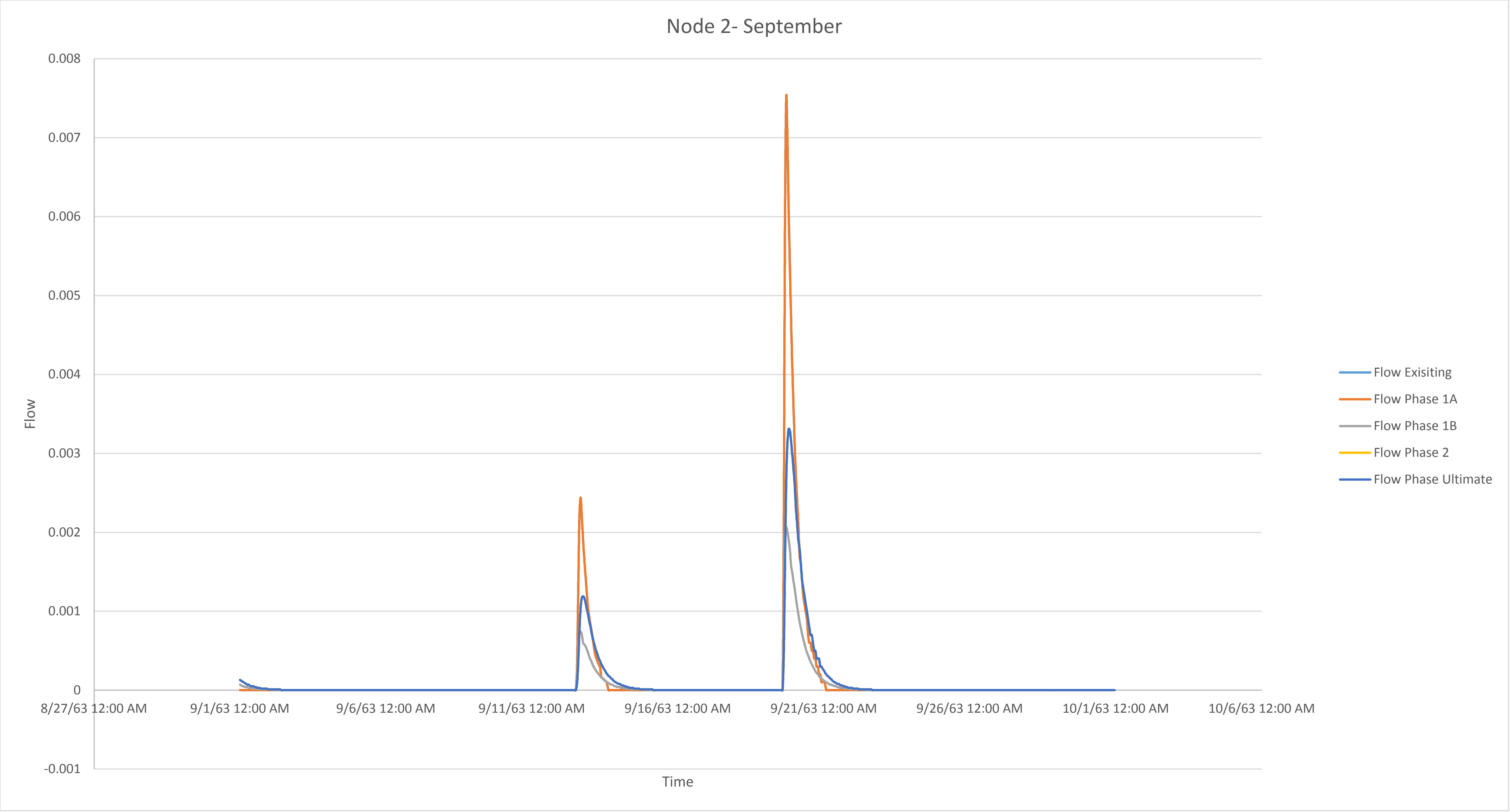
June						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		1	1	1	1	1
Magnitudes (cm/s)	Max.	0.094	0.094	0.0151	0.0172	0.0172
	Min.					
Duration (h)	Max.	63	63	65	72	72
	Min.					



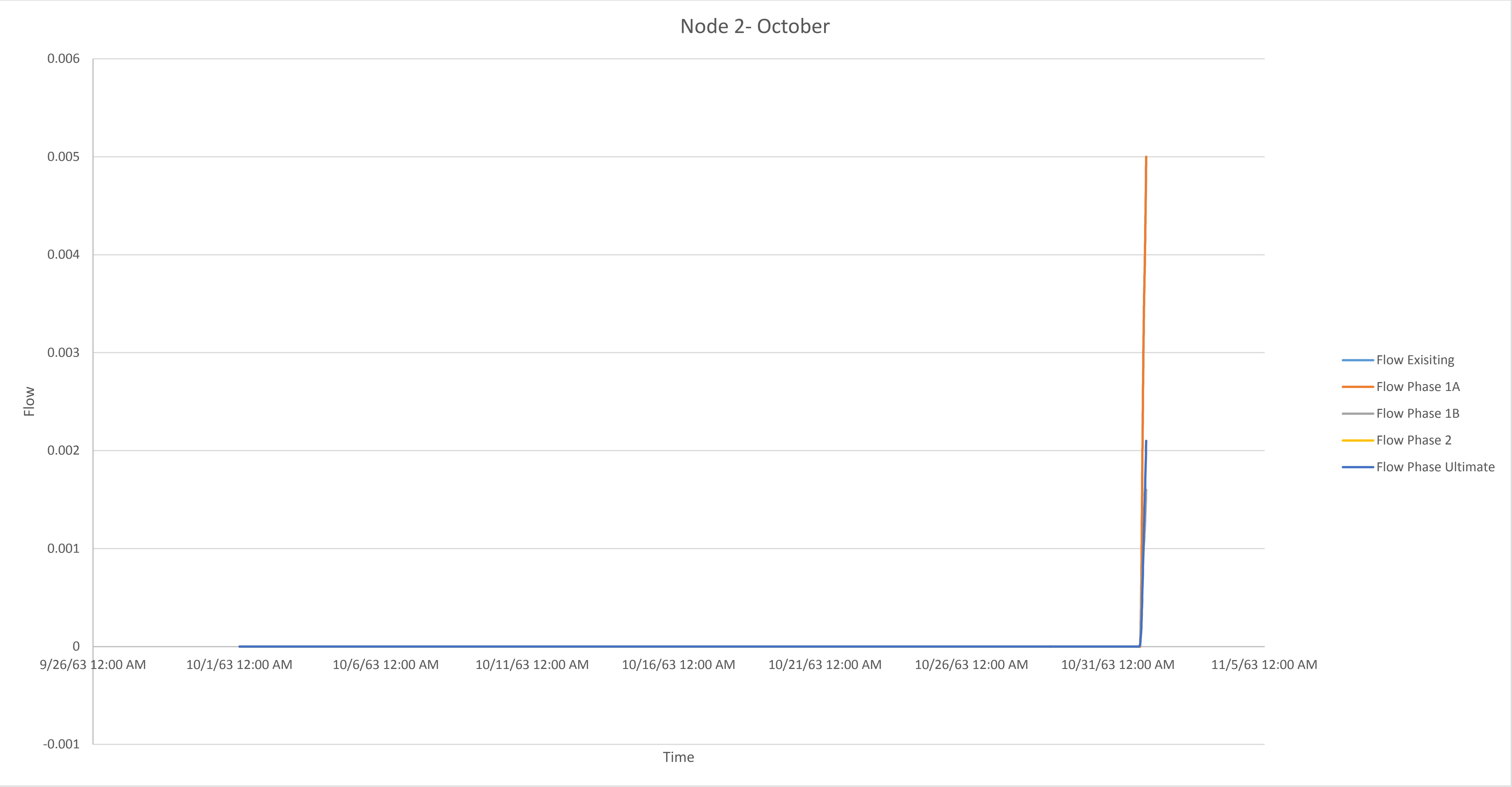
July						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitudes (cm/s)	Max.	0.5865	0.5865	0.1173	0.0313	0.0313
	Min.	0.00246	0.00246	0.0007	0.00112	0.00112
Duration (h)	Max.	100	100	101	109	109
	Min.	24	24	54	61	61



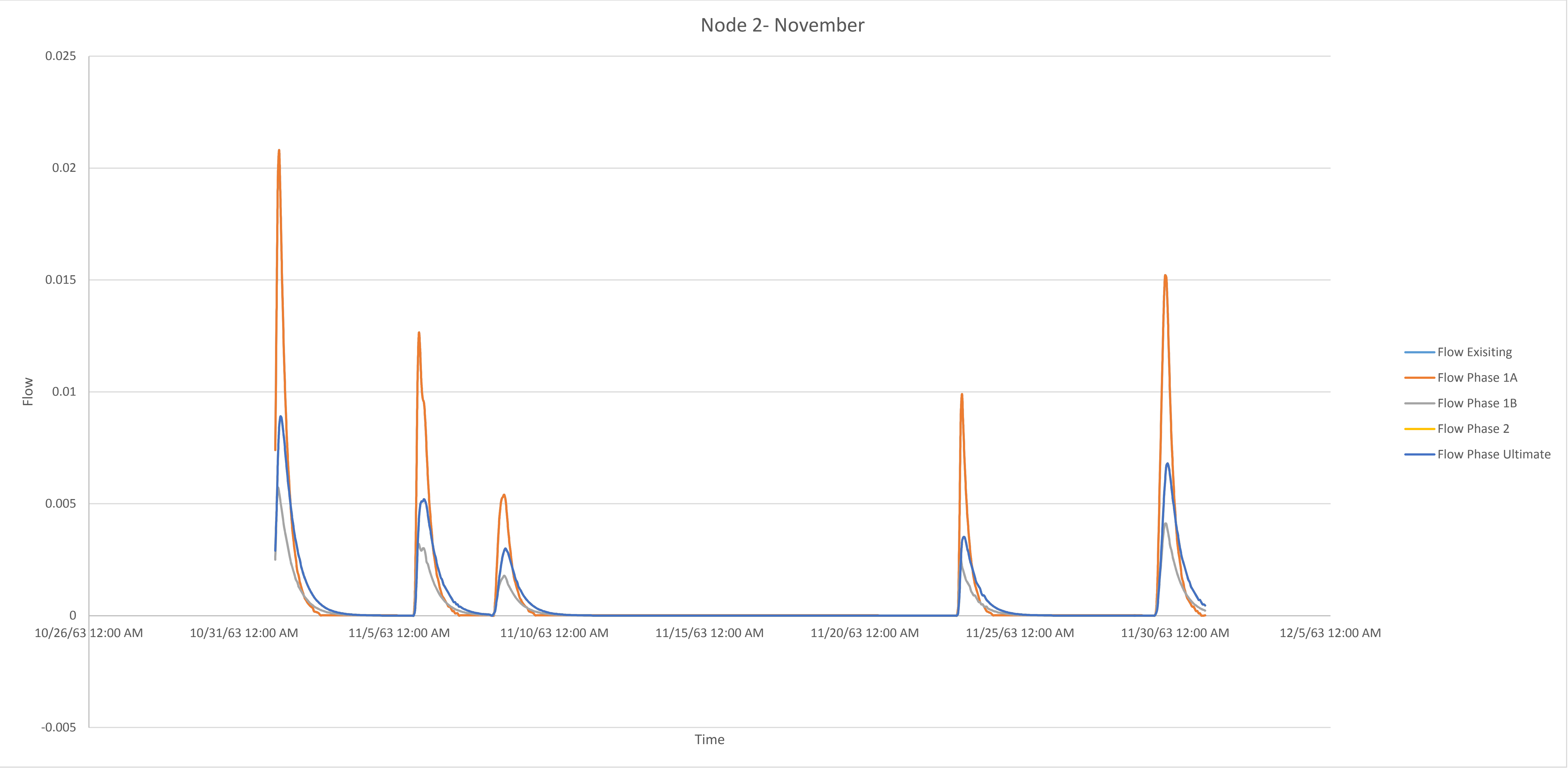
August						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		4	4	4	4	4
Magnitudes (cm/s)	Max.	0.0474	0.0474	0.0139	0.0227	0.0227
	Min.	0.0052	0.0052	0.00166	0.0027	0.0027
Duration (h)	Max.	83	89	83	91	91
	Min.	38	38	38	38	38



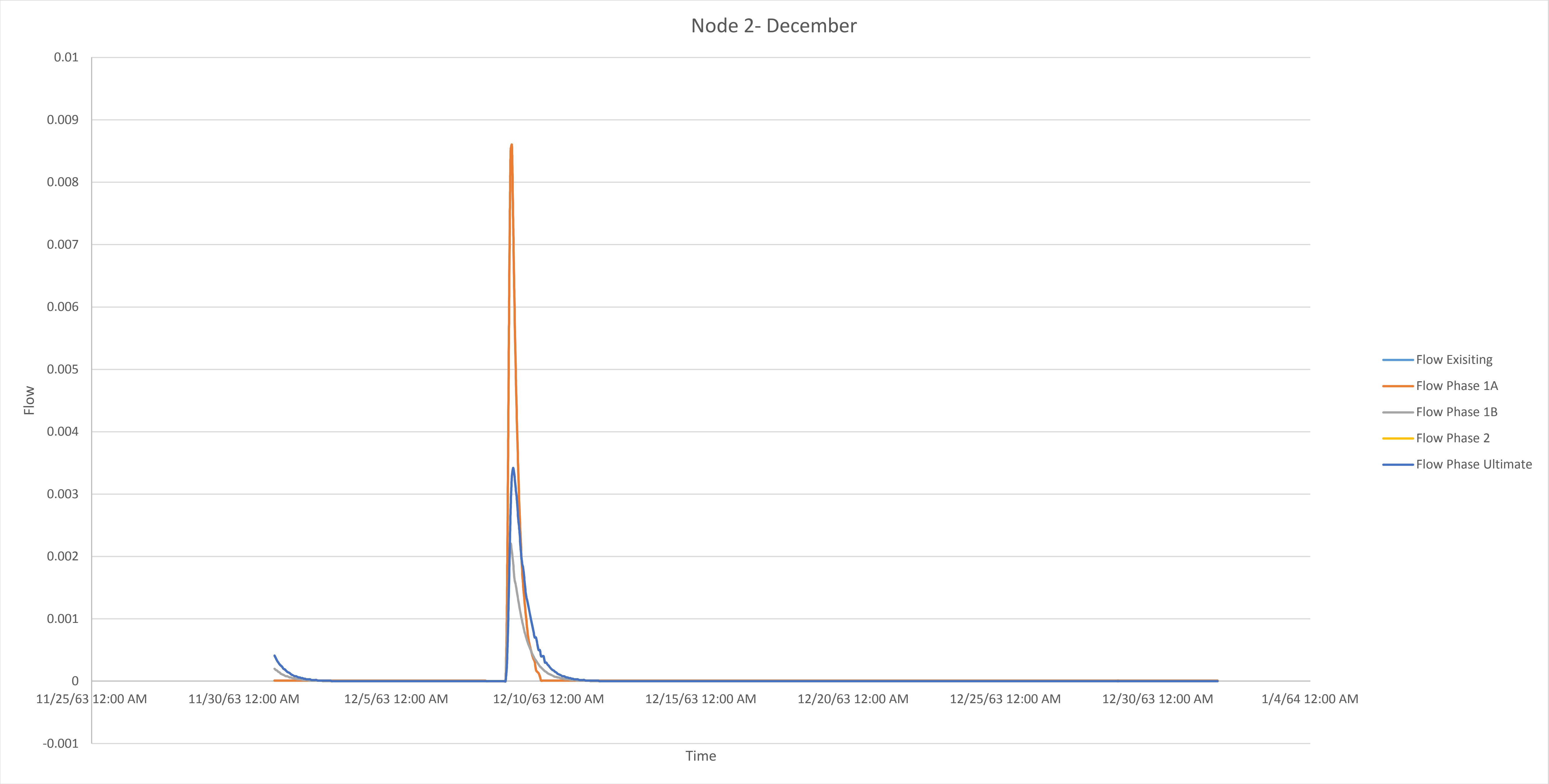
September						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		2	2	2	2	2
Magnitudes (cm/s)	Max.	0.0075	0.0075	0.00207	0.00331	0.00331
	Min.	0.00244	0.00244	0.00075	0.00119	0.00119
Duration (h)	Max.	35	35	66	73	73
	Min.	26	26	55	63	63



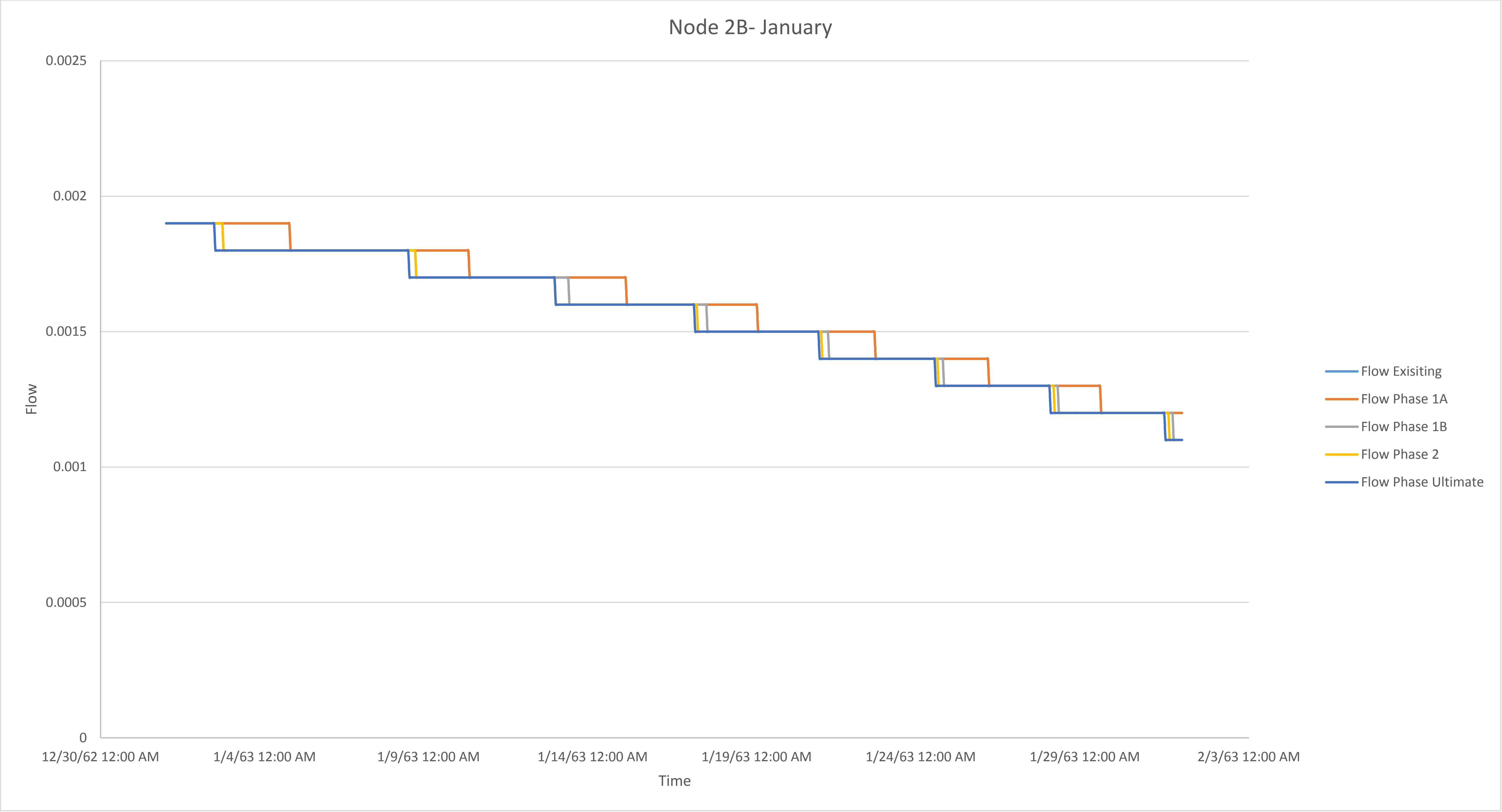
October						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency						
Magnitudes (cm/s)	Max.					
	Min.					
Duration (h)	Max.					
	Min.					



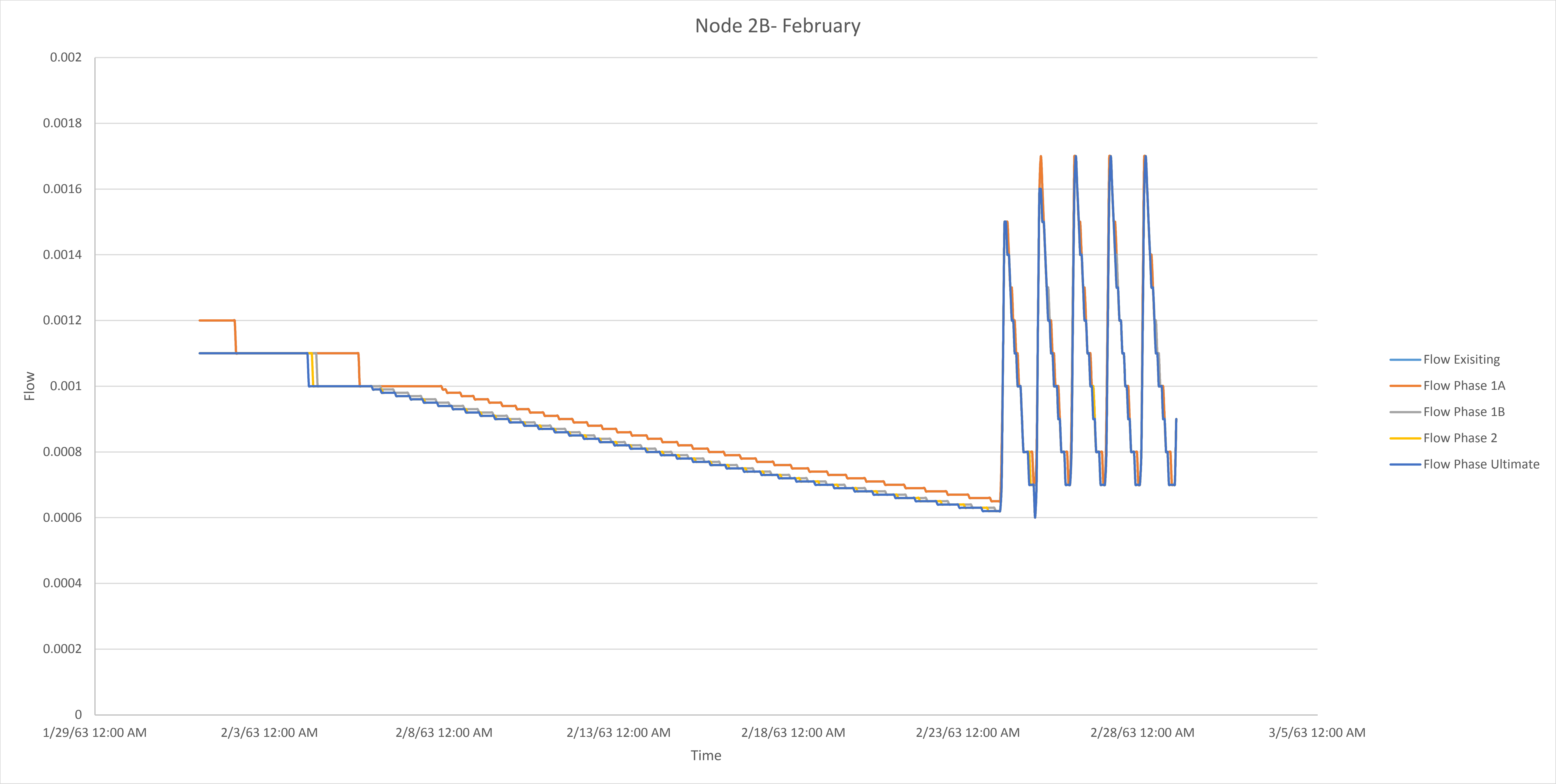
November						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitudes (cm/s)	Max.	0.0126	0.0126	0.0032	0.0052	0.0052
	Min.	0.0052	0.0052	0.00178	0.0029	0.0029
Duration (h)	Max.	41	41	80	87	87
	Min.	22	22	44	47	47



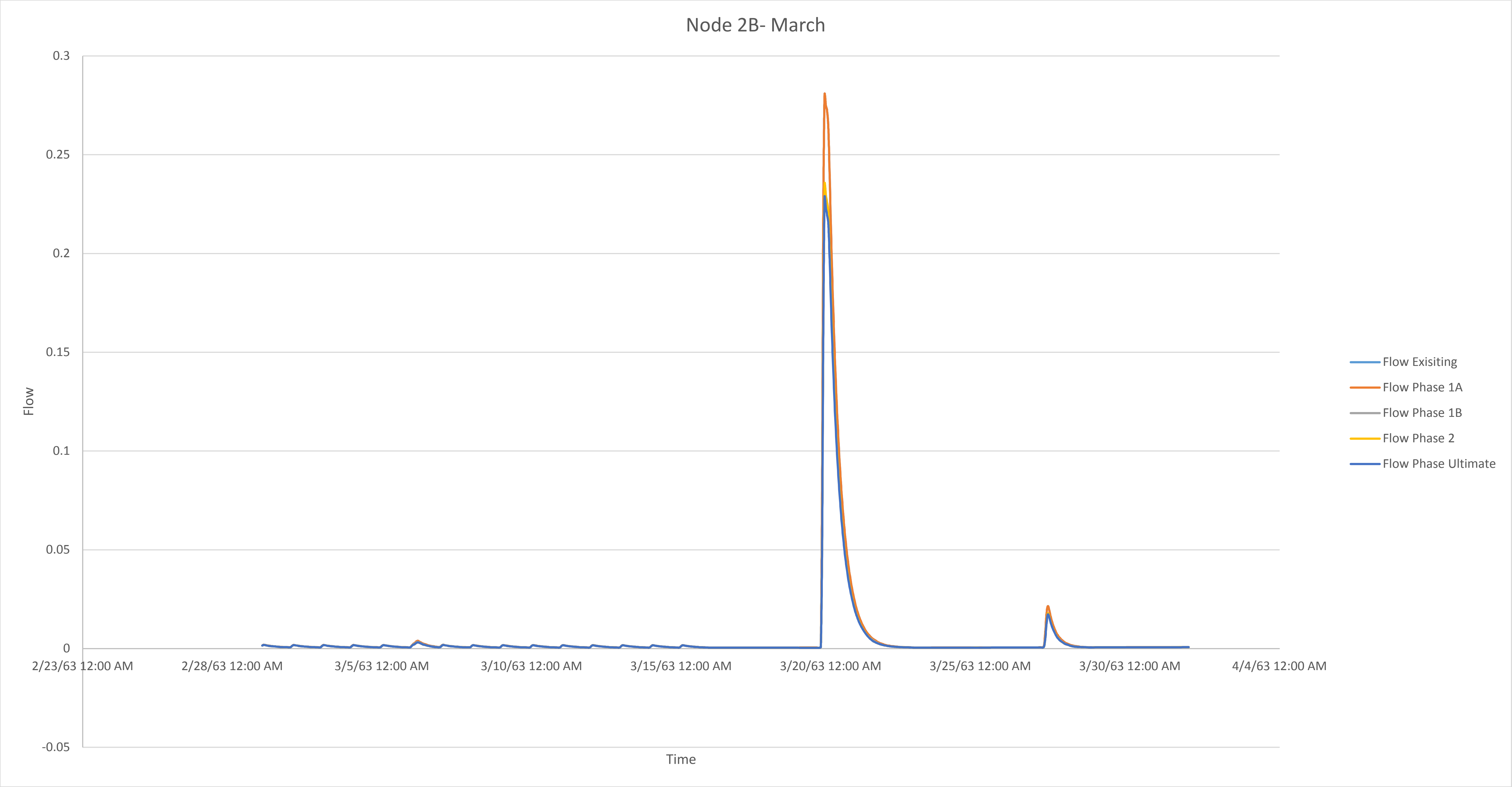
December						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		1	1	1	1	1
Magnitudes (cm/s)	Max.	0.0086	0.0086	0.0022	0.00342	0.00342
	Min.					
Duration (h)	Max.	27	27	66	72	72
	Min.					



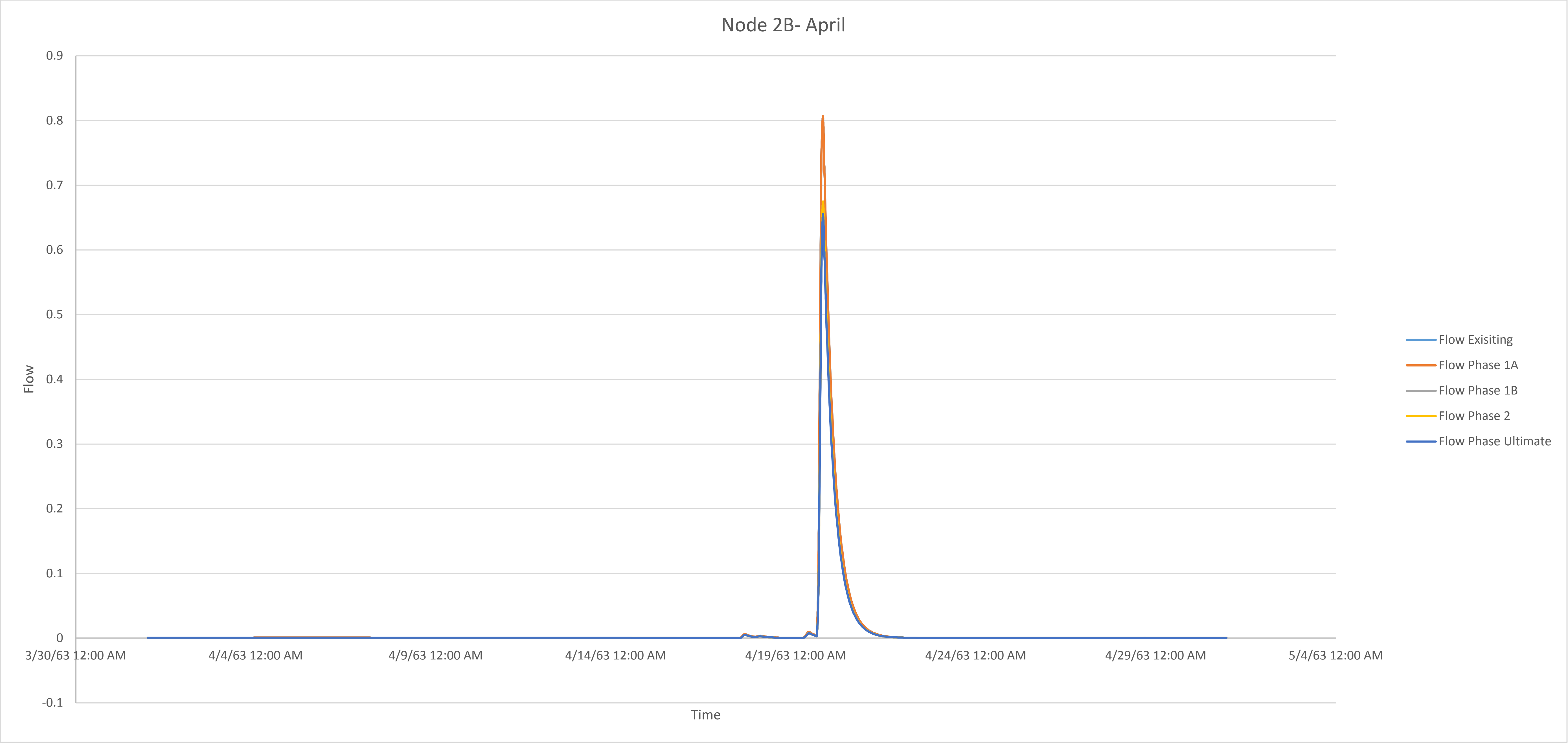
January						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		0	0	0	0	0
Magnitude (cm/s)	Max.					
	Min.					
Duration (h)	Max.					
	Min.					



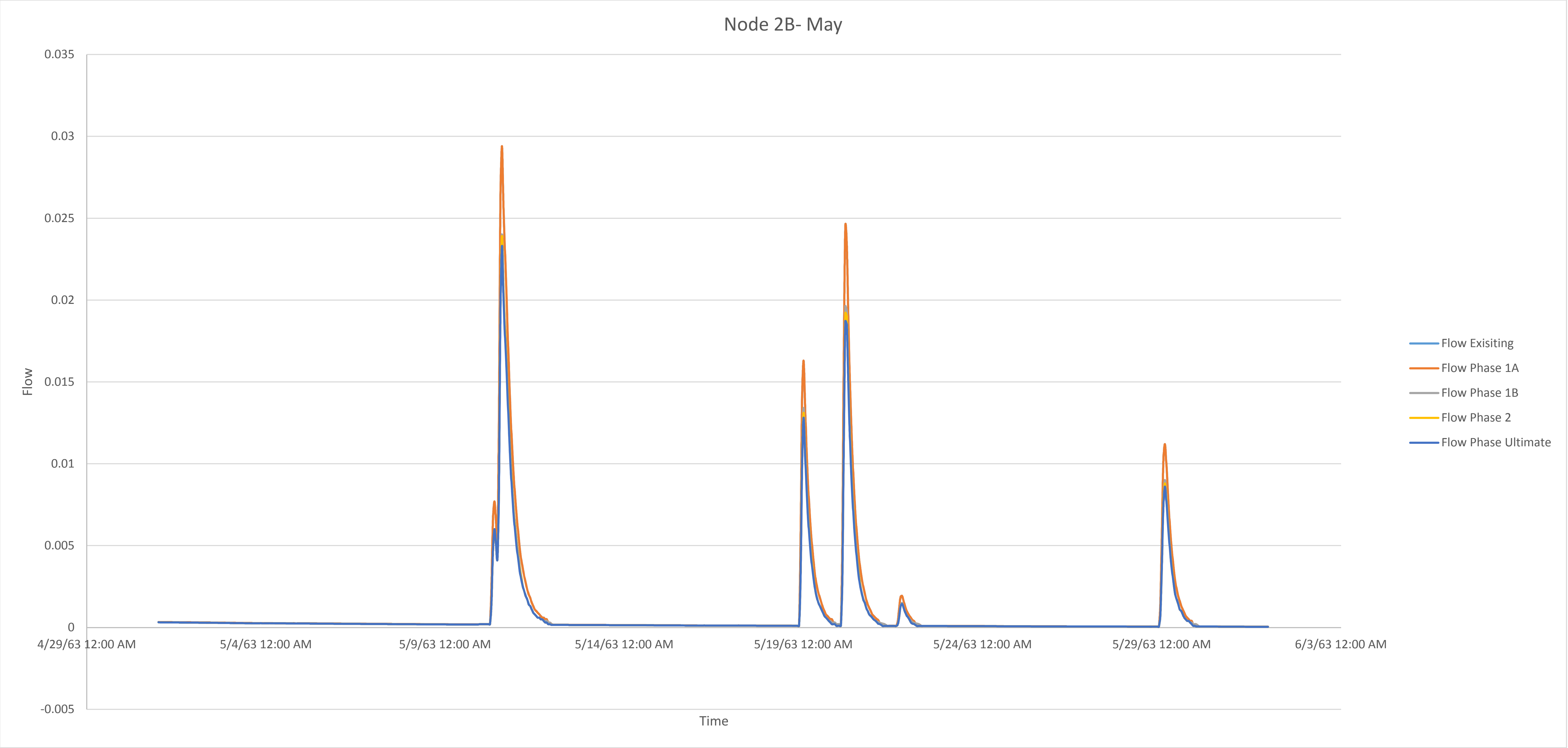
February						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitude (cm/s)	Max.	0.0017	0.0017	0.0017	0.0017	0.0017
	Min.	0.0015	0.0015	0.0015	0.0015	0.0015
Duration (h)	Max.	21	21	19	19	19
	Min.	22	22	20	20	19



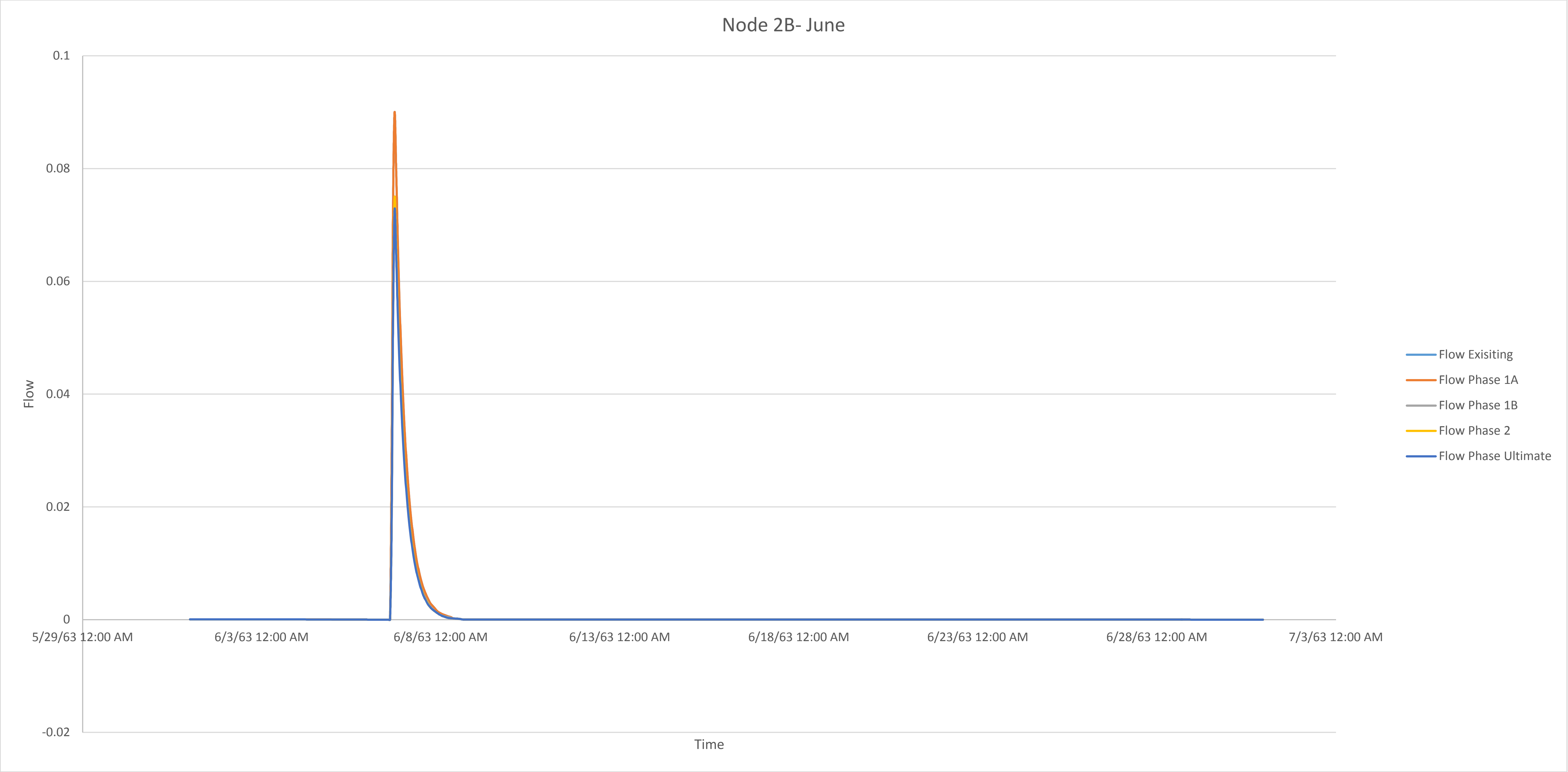
March						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		16	16	16	16	16
Magnitude (cm/s)	Max.	0.2804	0.2804	0.2349	0.2352	0.2285
	Min.	0.00168	0.00168	0.00166	0.00165	0.00165
Duration (h)	Max.	75	75	75	75	75
	Min.	23	23	23	23	23



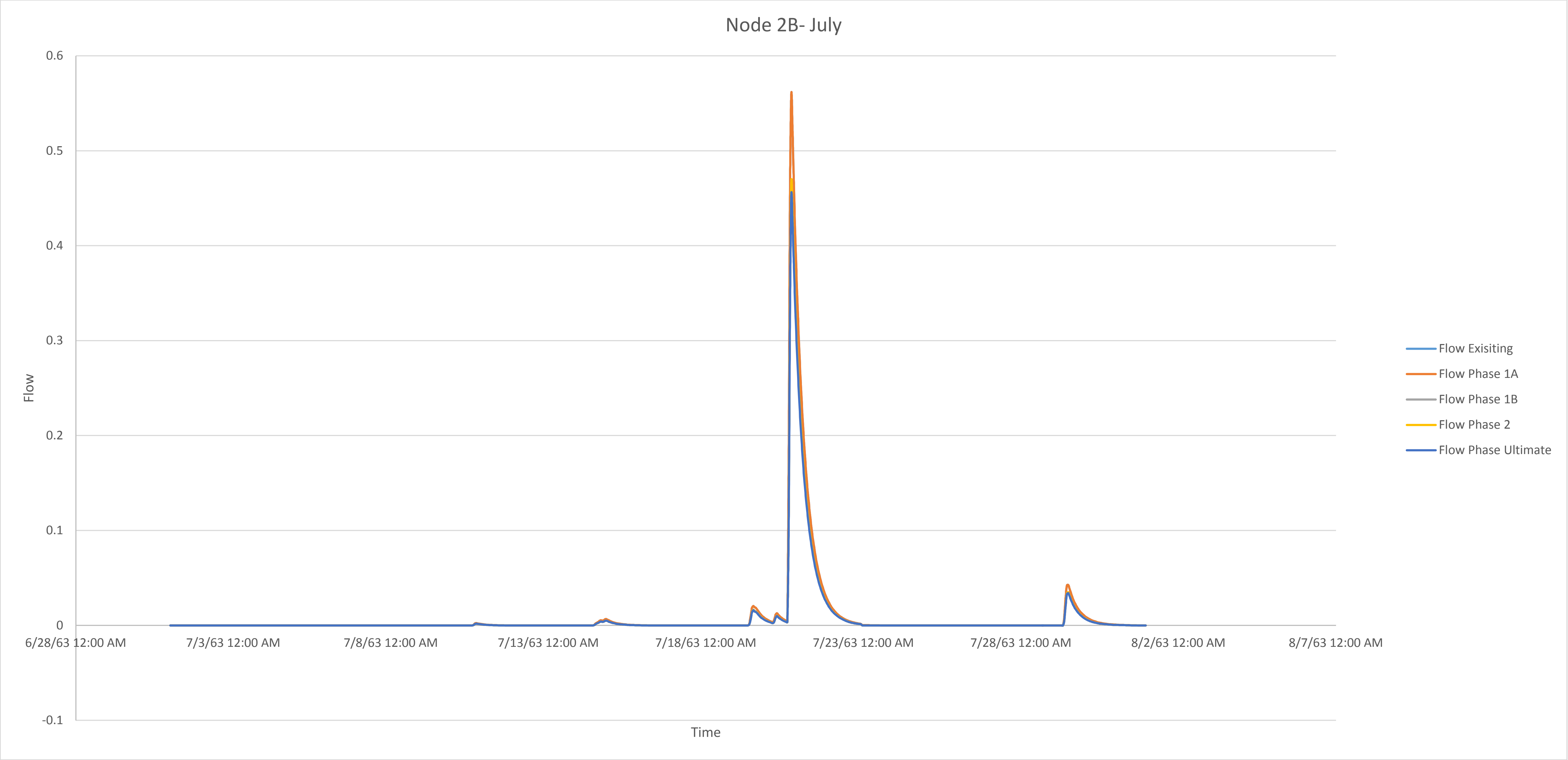
April						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		4	4	4	4	4
Magnitude (cm/s)	Max.	0.8066	0.8066	0.6739	0.6746	0.6553
	Min.	0.0037	0.0037	0.0028	0.0028	0.0028
Duration (h)	Max.	79	79	79	78	78
	Min.	23	23	23	19	19



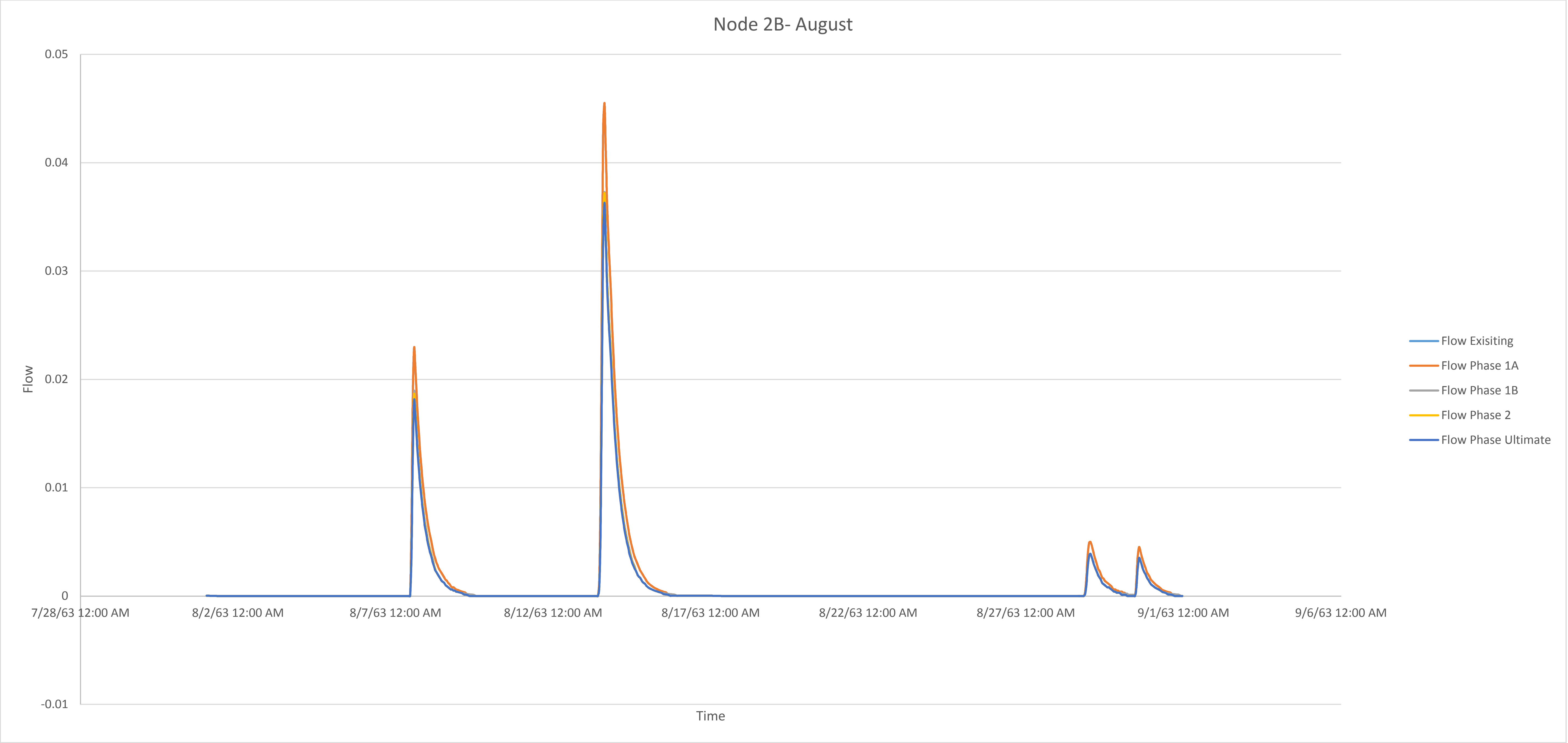
May						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitude (cm/s)	Max.	0.0294	0.0294	0.024	0.0239	0.0233
	Min.	0.00193	0.00193	0.0015	0.00144	0.00144
Duration (h)	Max.	41	41	41	40	40
	Min.	16	16	16	13	13



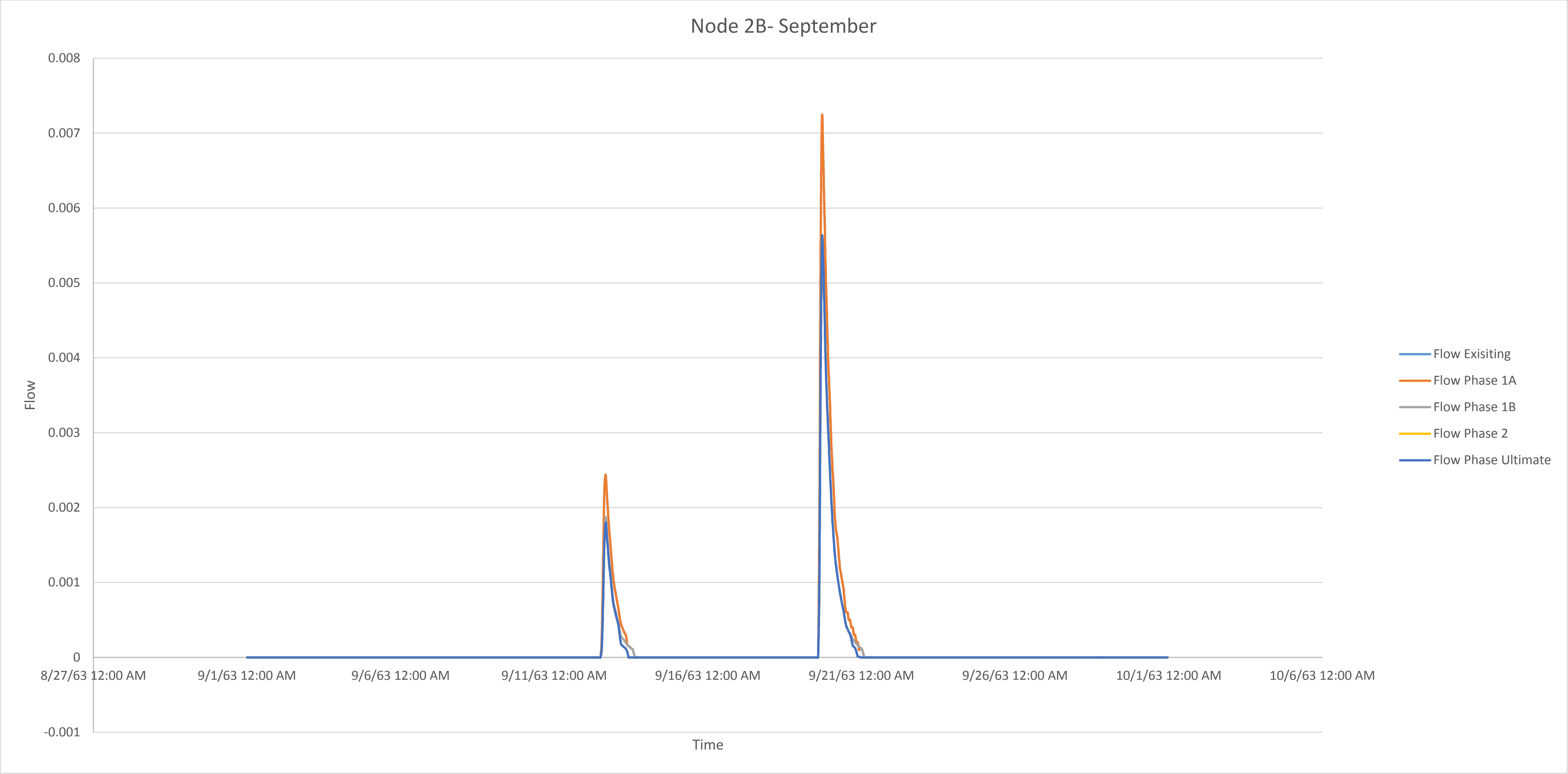
June						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		1	1	1	1	1
Magnitude (cm/s)	Max.	0.0899	0.0899	0.0745	0.0746	0.0725
	Min.					
Duration (h)	Max.	47	47	47	47	47
	Min.					



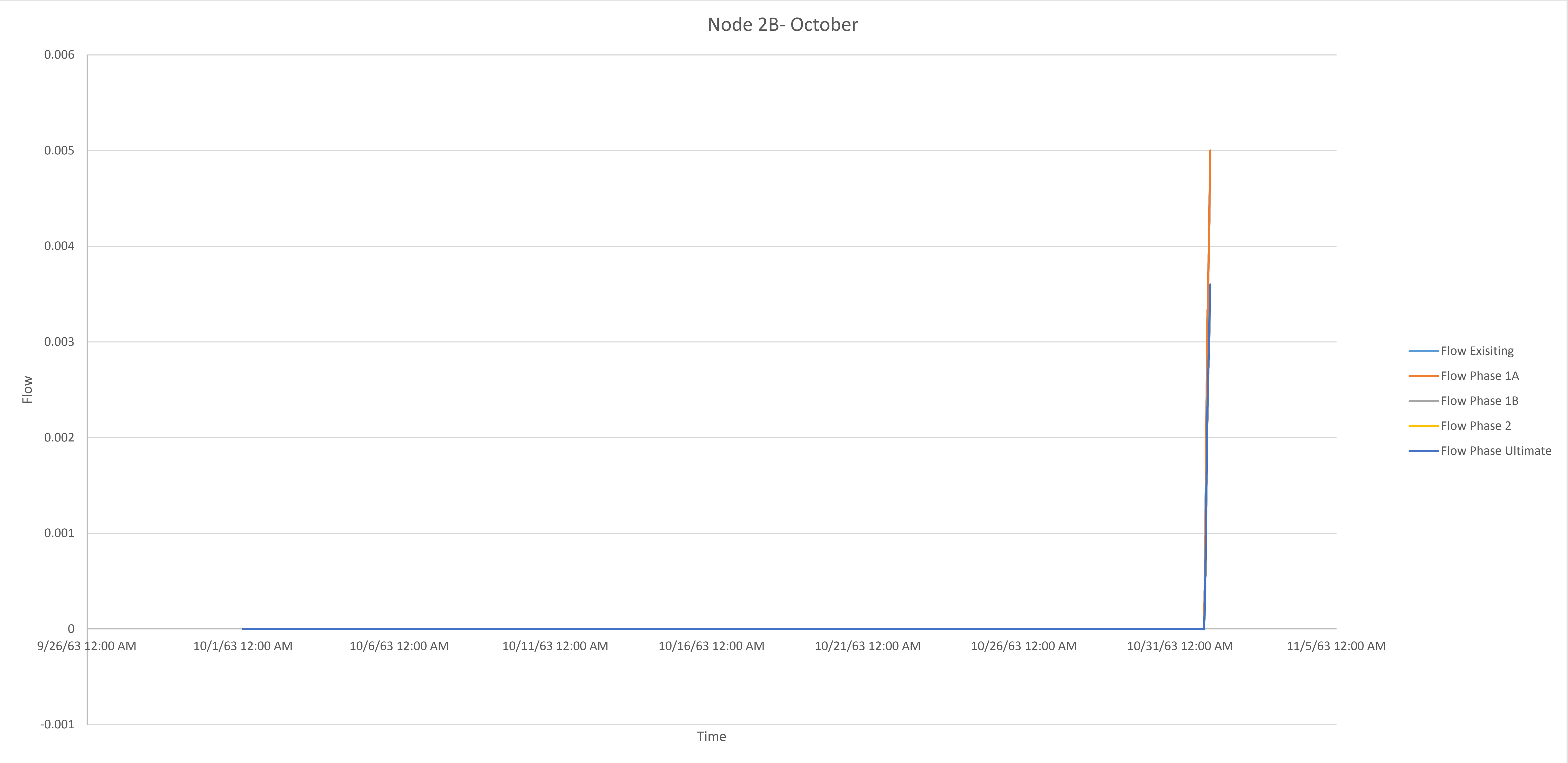
July						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitude (cm/s)	Max.	0.5596	0.5596	0.4657	0.4662	0.4527
	Min.	0.00246	0.00246	0.0019	0.0019	0.0019
Duration (h)	Max.	70	70	56	56	56
	Min.	24	24	24	19	19



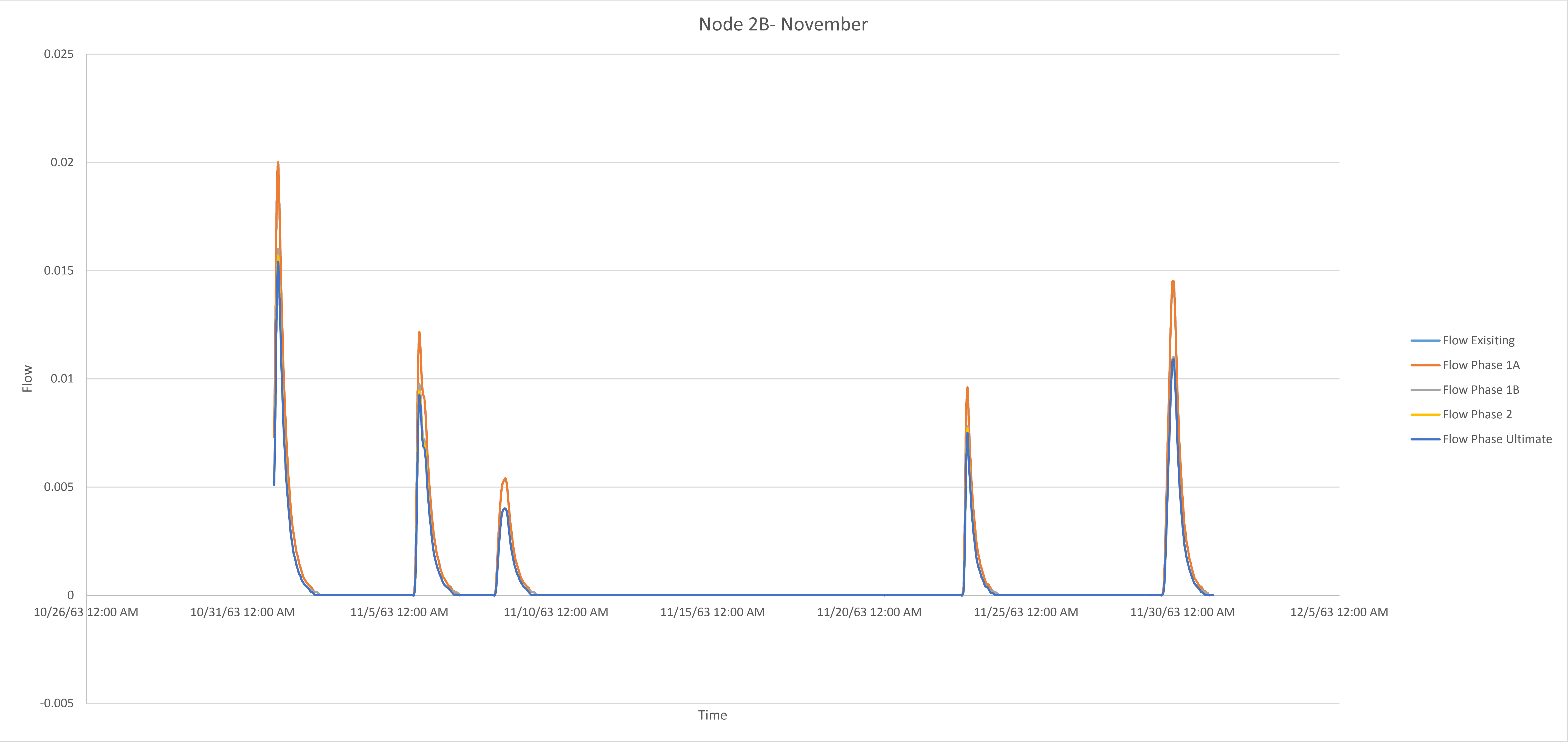
August						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		4	4	4	4	4
Magnitude (cm/s)	Max.	0.0455	0.0455	0.0373	0.0372	0.0363
	Min.	0.0045	0.0045	0.0035	0.0035	0.0035
Duration (h)	Max.	59	59	59	54	54
	Min.	34	34	34	29	29



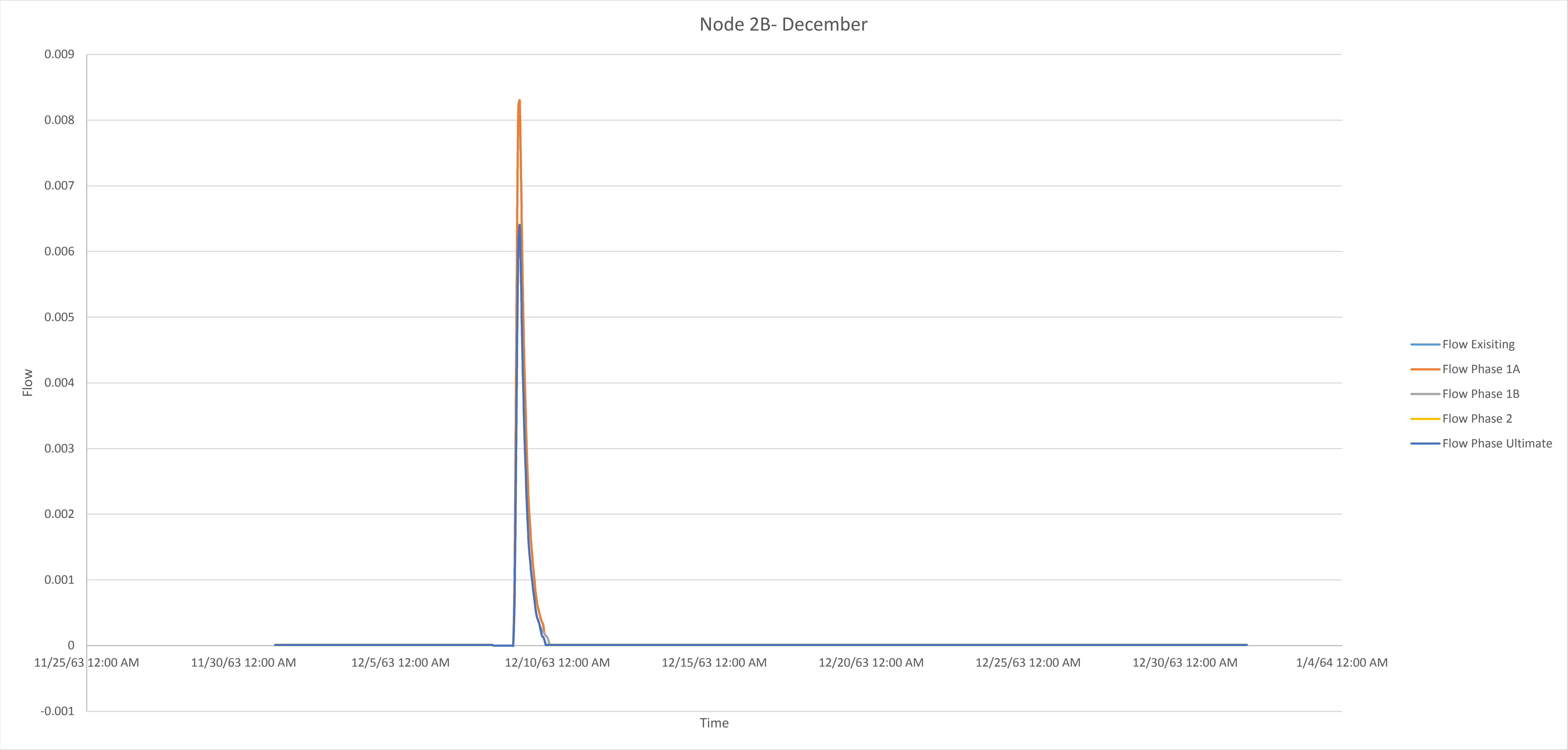
September						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		2	2	2	2	2
Magnitude (cm/s)	Max.	0.0072	0.0072	0.0056	0.0056	0.0056
	Min.	0.00244	0.00244	0.00187	0.0018	0.0018
Duration (h)	Max.	35	35	35	32	32
	Min.	26	26	26	21	21



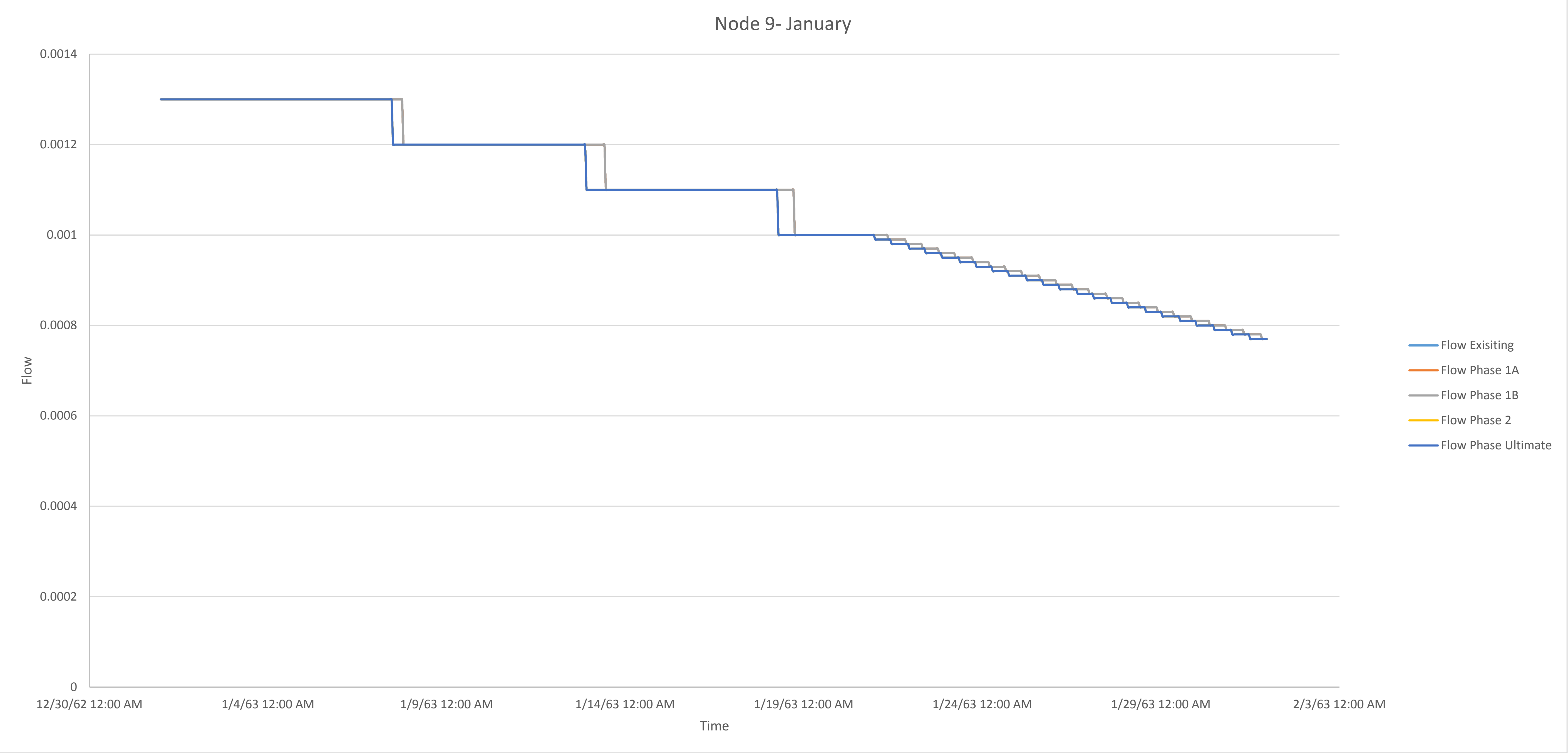
October						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		0	0	0	0	0
Magnitude (cm/s)	Max.					
	Min.					
Duration (h)	Max.					
	Min.					



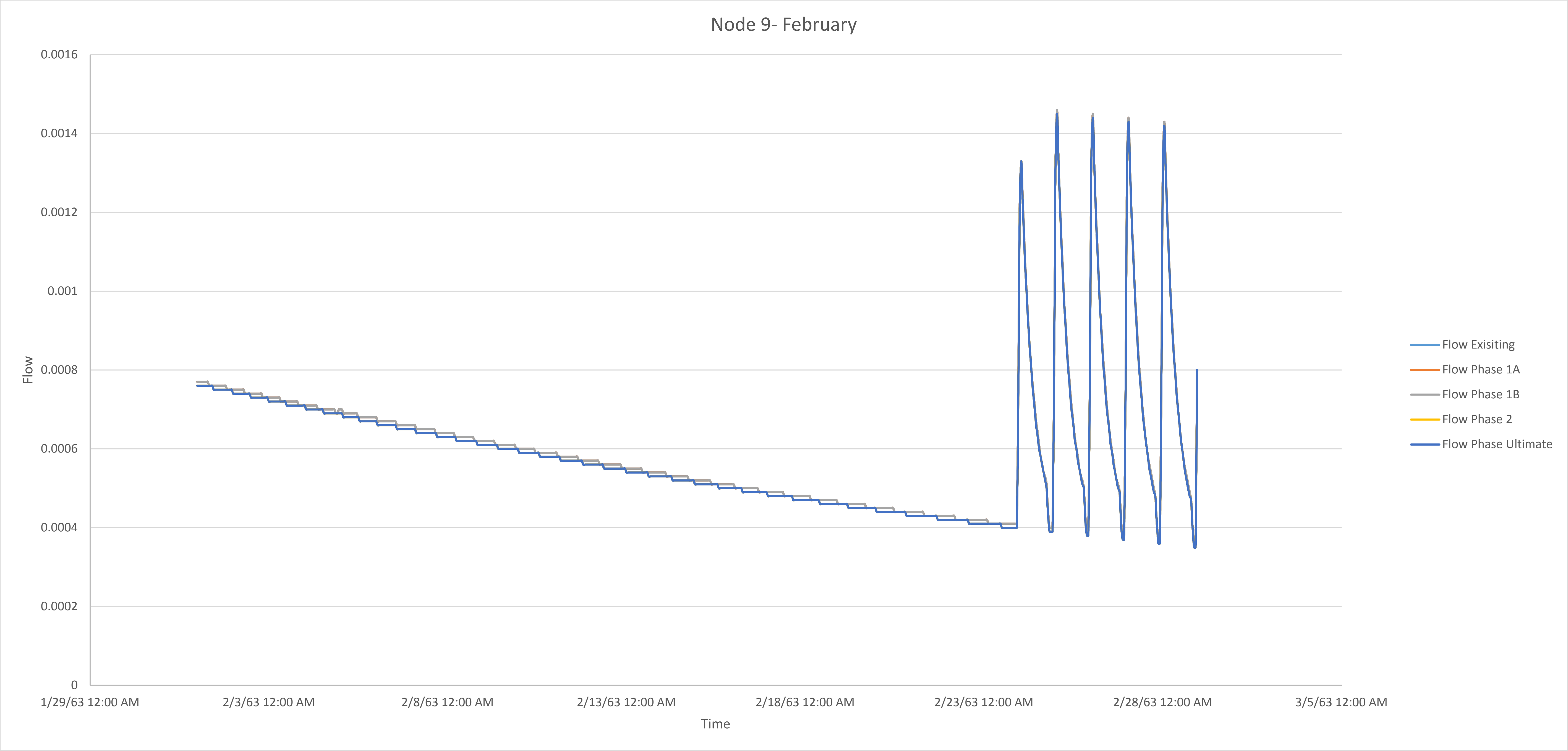
November						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitude (cm/s)	Max.	0.0145	0.0145	0.011	0.0109	0.0109
	Min.	0.0054	0.0054	0.004	0.004	0.004
Duration (h)	Max.	35	35	35	32	32
	Min.	31	31	31	27	27



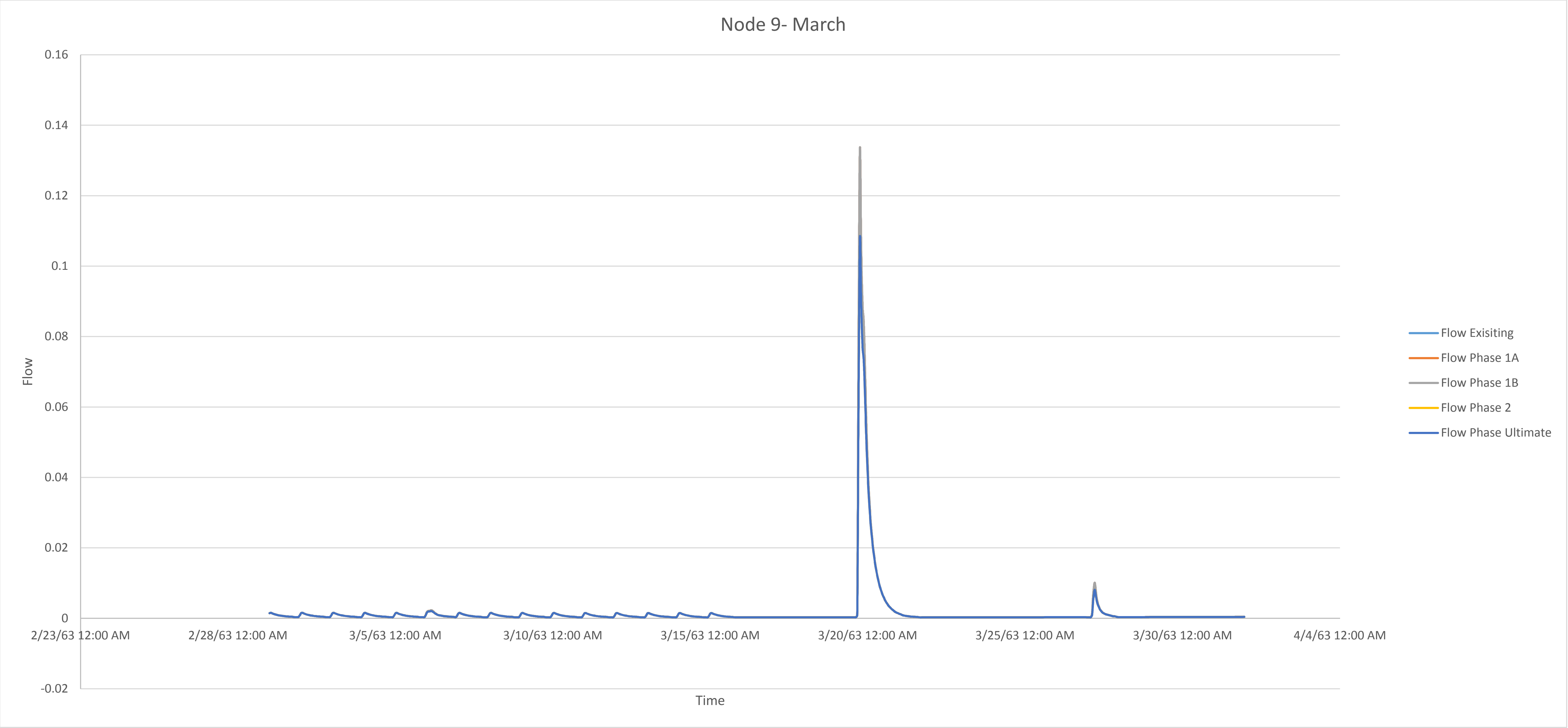
December						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		1	1	1	1	1
Magnitude (cm/s)	Max.	0.0083	0.0083	0.0064	0.0064	0.0064
	Min.					
Duration (h)	Max.	27	27	27	24	24
	Min.					



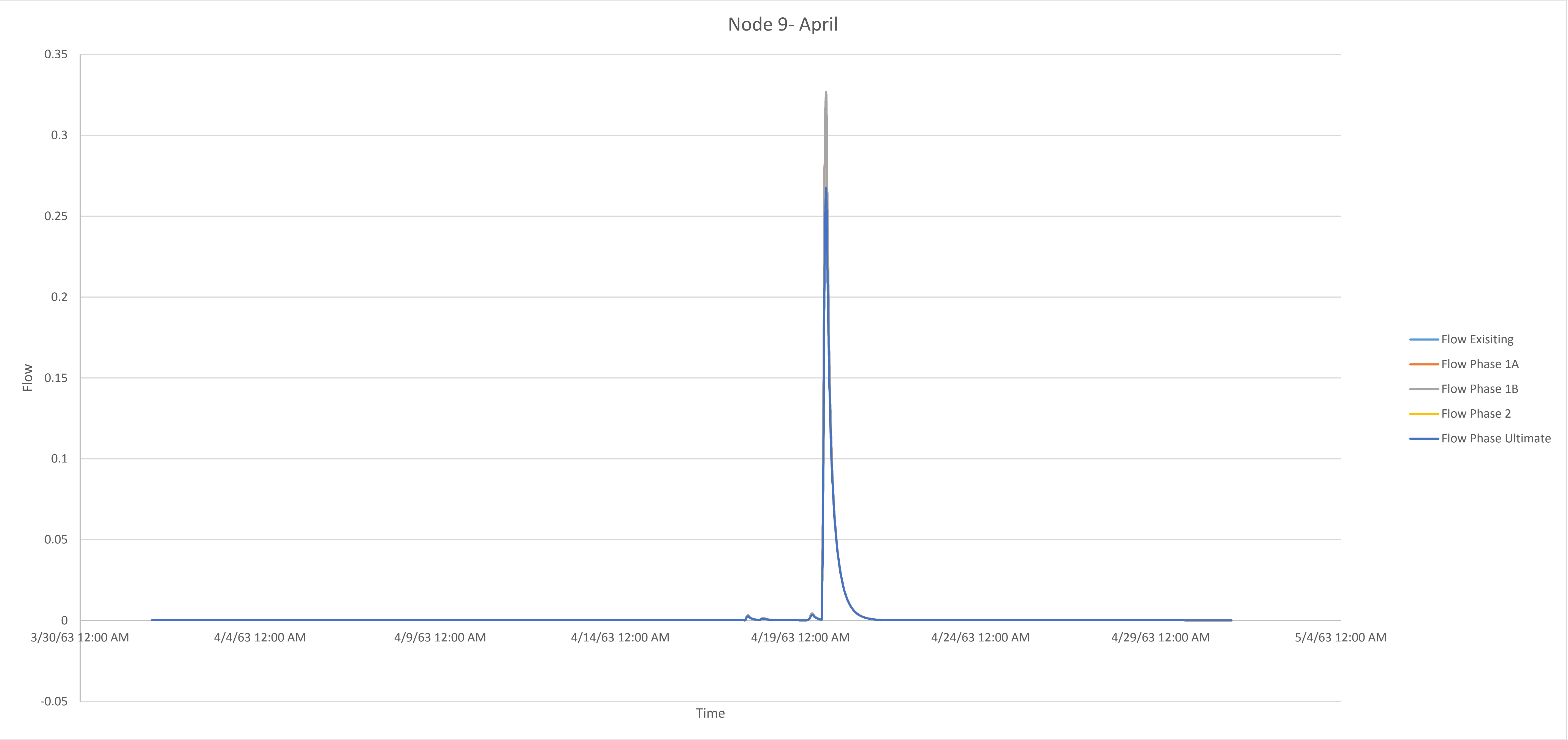
January						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		0	0	0	0	0
Magnitude (cm/s)	Max.					
	Min.					
Duration (h)	Max.					
	Min.					



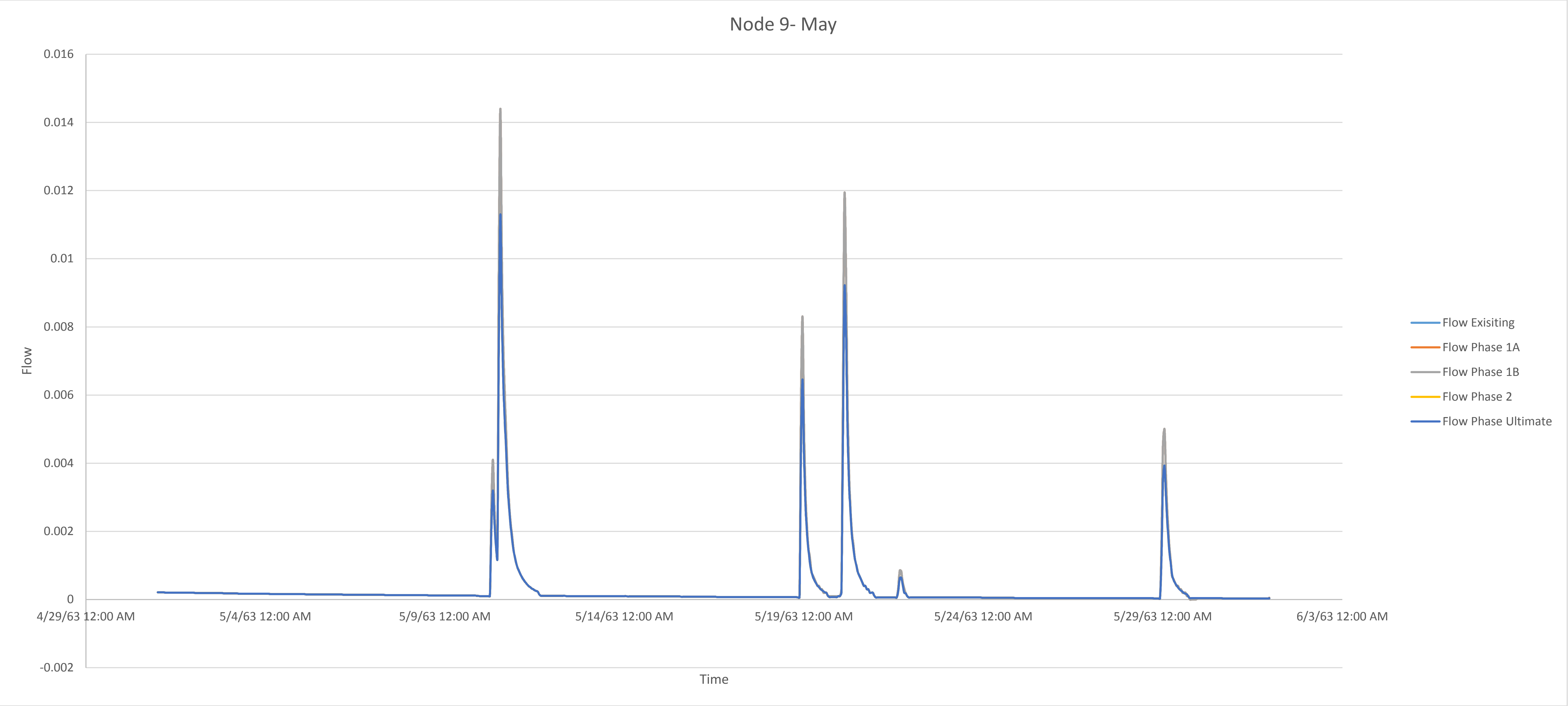
February						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitude (cm/s)	Max.	0.00146	0.00146	0.00146	0.00145	0.00145
	Min.	0.00133	0.00133	0.00133	0.00133	0.00133
Duration (h)	Max.	22	553629	553629	553629	553629
	Min.	21	21	21	21	21



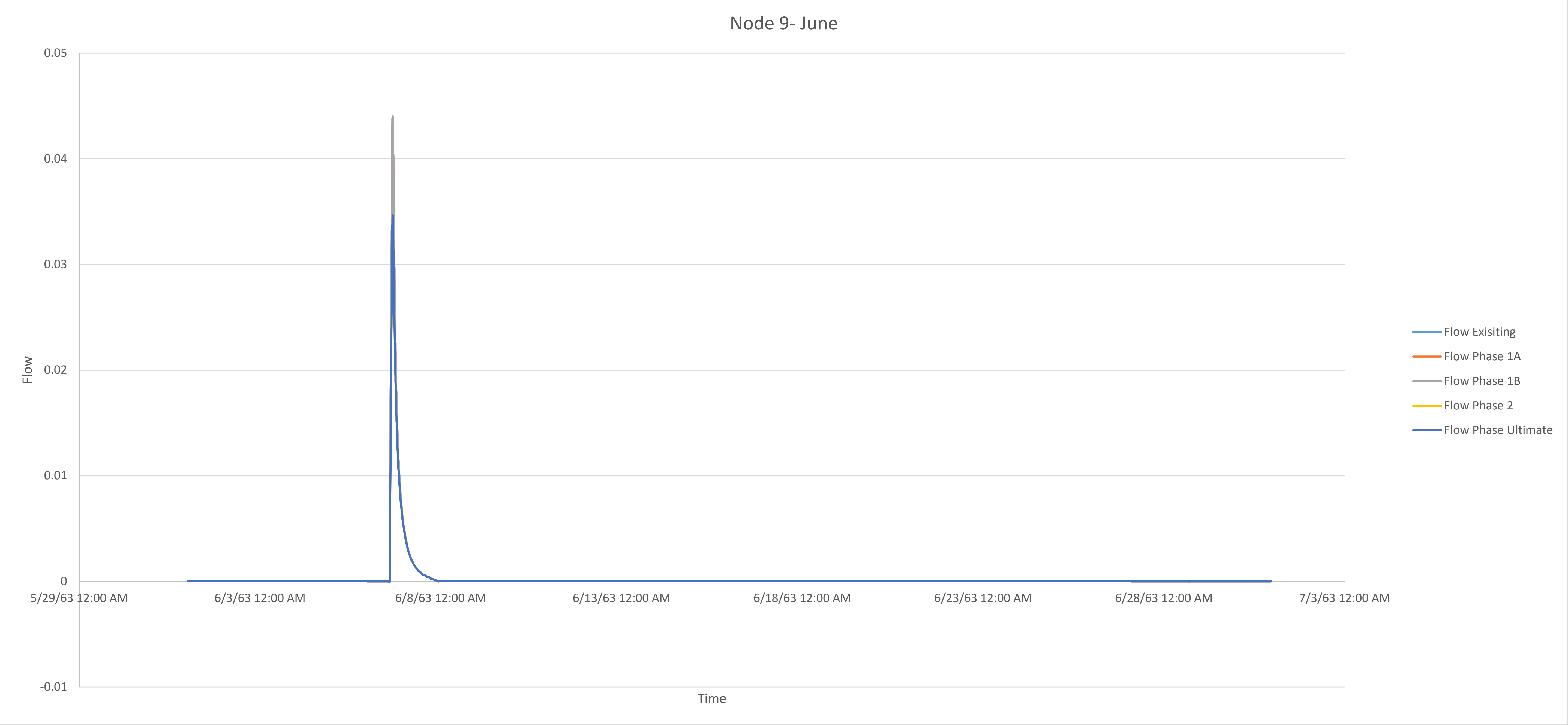
March						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		16	16	16	16	16
Magnitude (cm/s)	Max.	0.1333	0.1333	0.1333	0.1078	0.1078
	Min.	0.0015	0.0015	0.0015	0.0015	0.0015
Duration (h)	Max.	48	48	48	48	48
	Min.	20	20	20	20	20



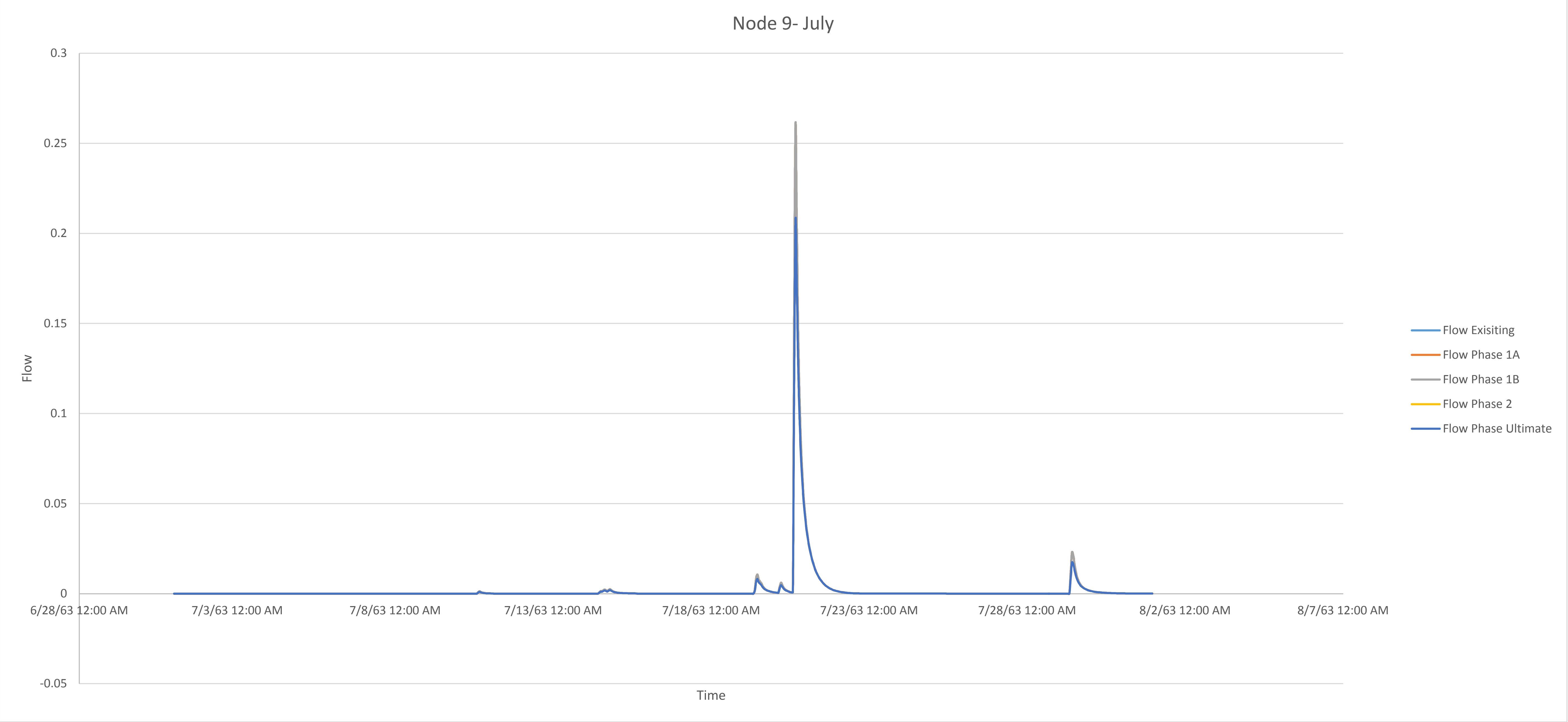
April						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		4	4	4	4	4
Magnitude (cm/s)	Max.	0.3262	0.3262	0.3262	0.2674	0.2674
	Min.	0.00138	0.00138	0.00138	0.0011	0.0011
Duration (h)	Max.	44	44	44	44	44
	Min.	13	13	13	13	13



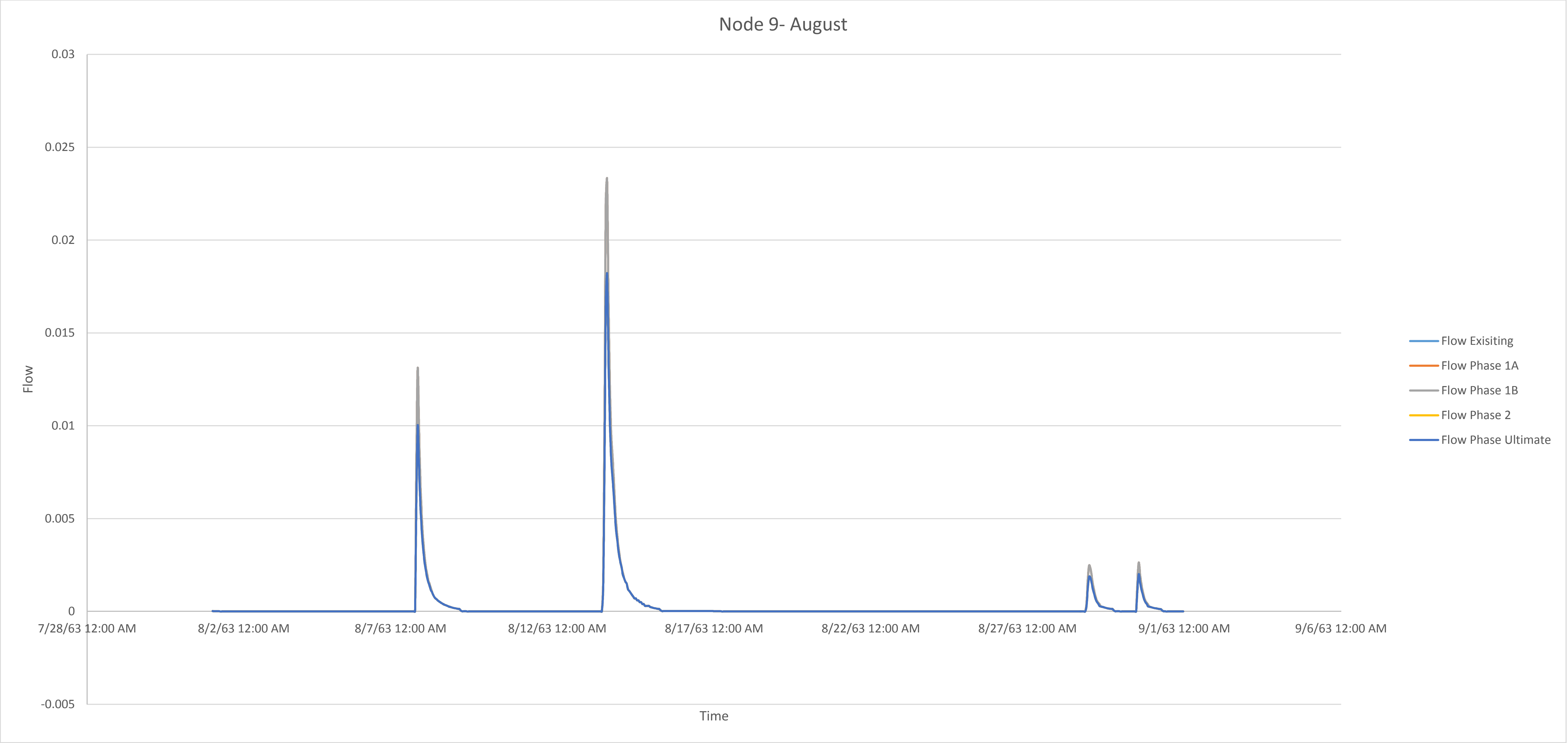
May						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitude (cm/s)	Max.	0.0144	0.0144	0.0144	0.0113	0.0113
	Min.	0.00085	0.00085	0.00085	0.00064	0.00064
Duration (h)	Max.	33	33	33	33	33
	Min.	7	7	7	7	7



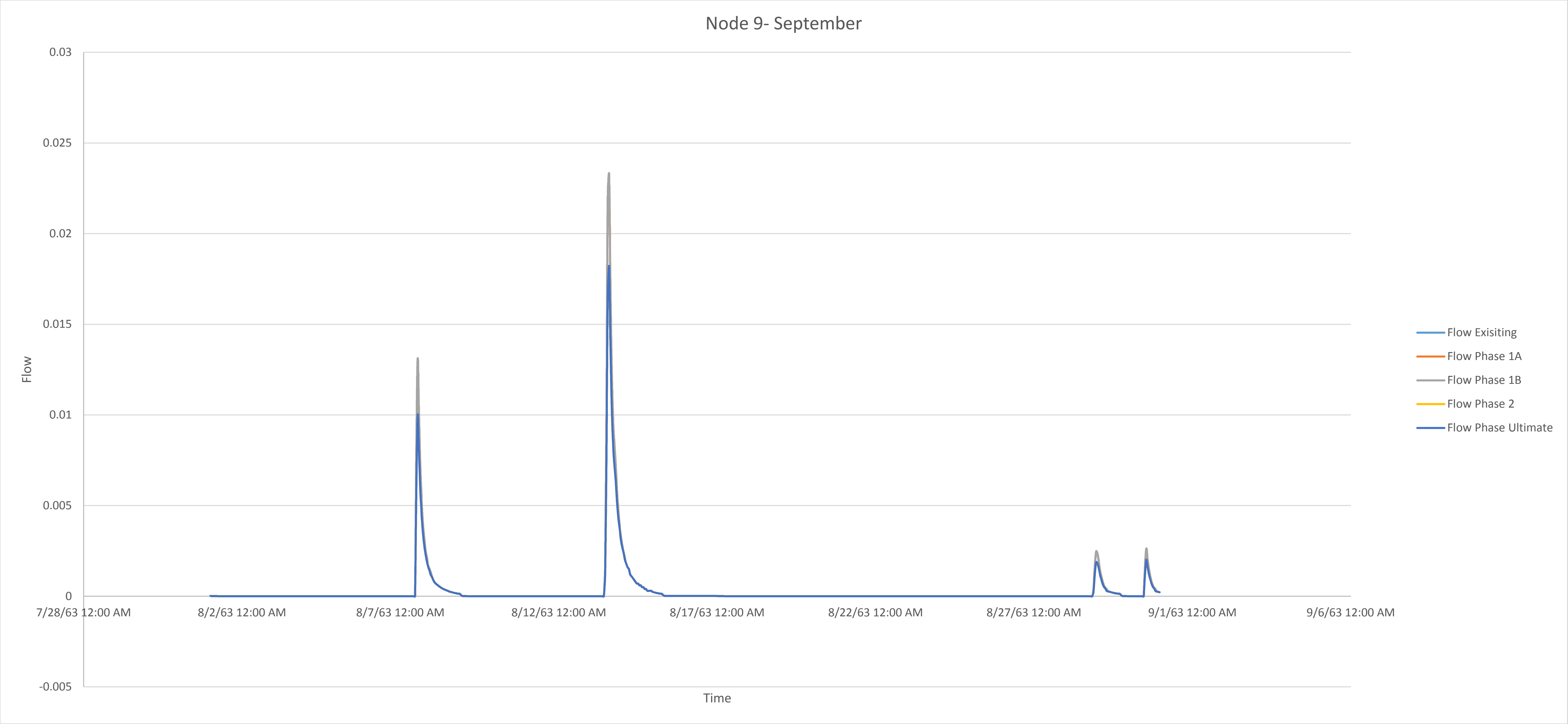
June						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		1	1	1	1	1
Magnitude (cm/s)	Max.	0.044	0.044	0.044	0.0346	0.0346
	Min.					
Duration (h)	Max.	31	31	31	31	31
	Min.					



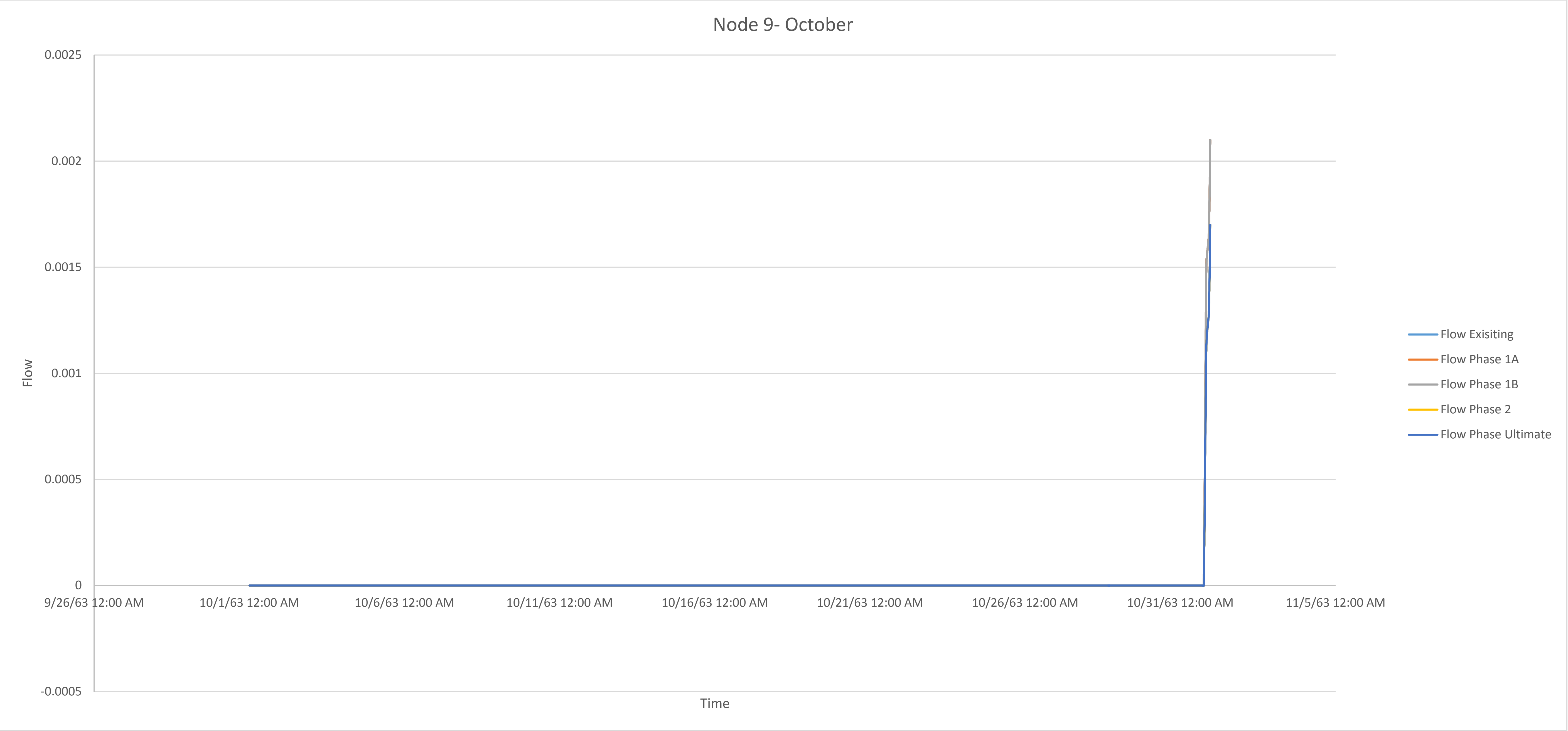
July						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitude (cm/s)	Max.	0.2609	0.2609	0.2609	0.2074	0.2074
	Min.	0.00133	0.00133	0.00133	0.00099	0.00099
Duration (h)	Max.	39	39	39	39	39
	Min.	12	12	12	12	12



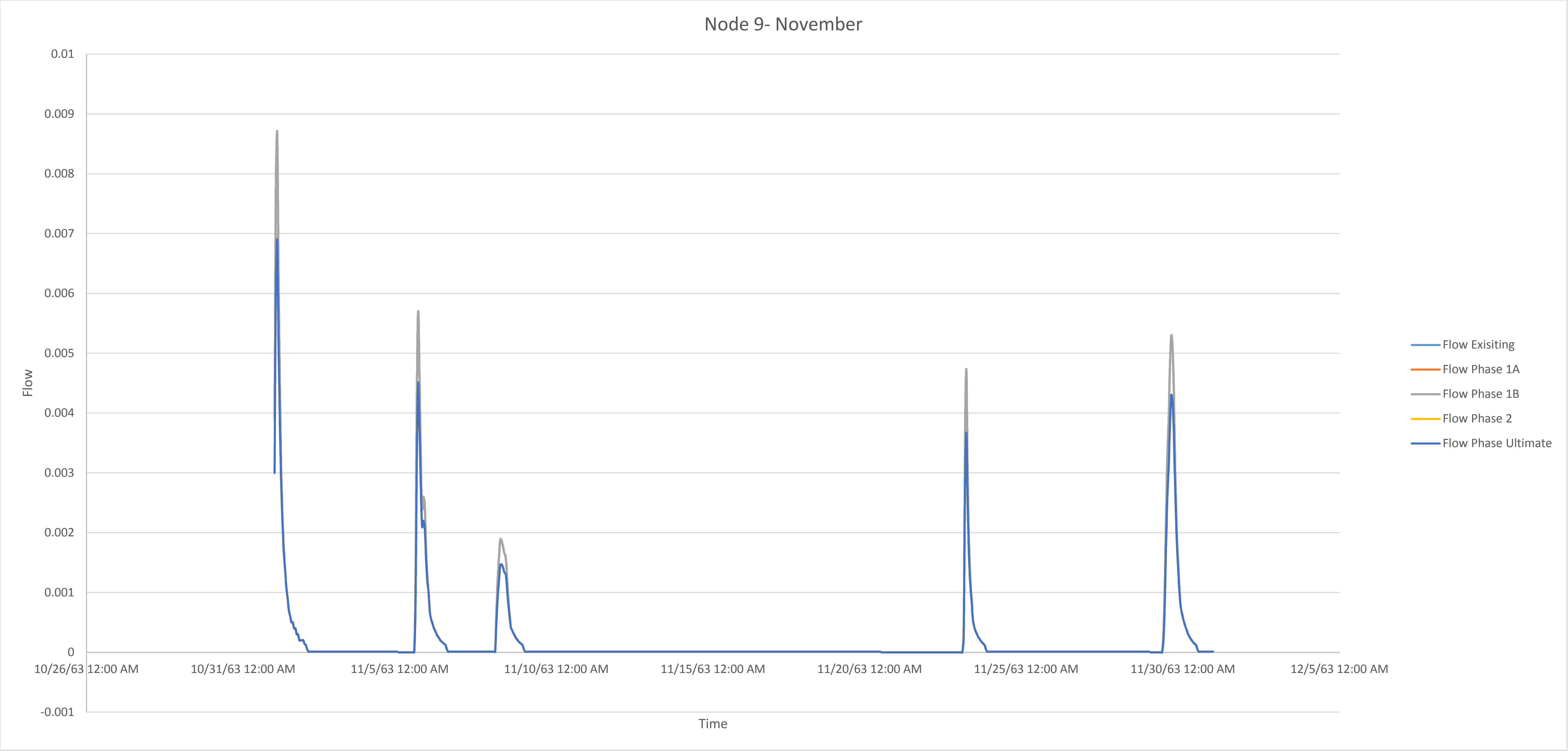
August						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		4	4	4	4	4
Magnitude (cm/s)	Max.	0.0233	0.0233	0.0233	0.0182	0.0182
	Min.	0.00247	0.00247	0.00247	0.00188	0.00188
Duration (h)	Max.	45	45	45	45	45
	Min.	26	26	26	26	26



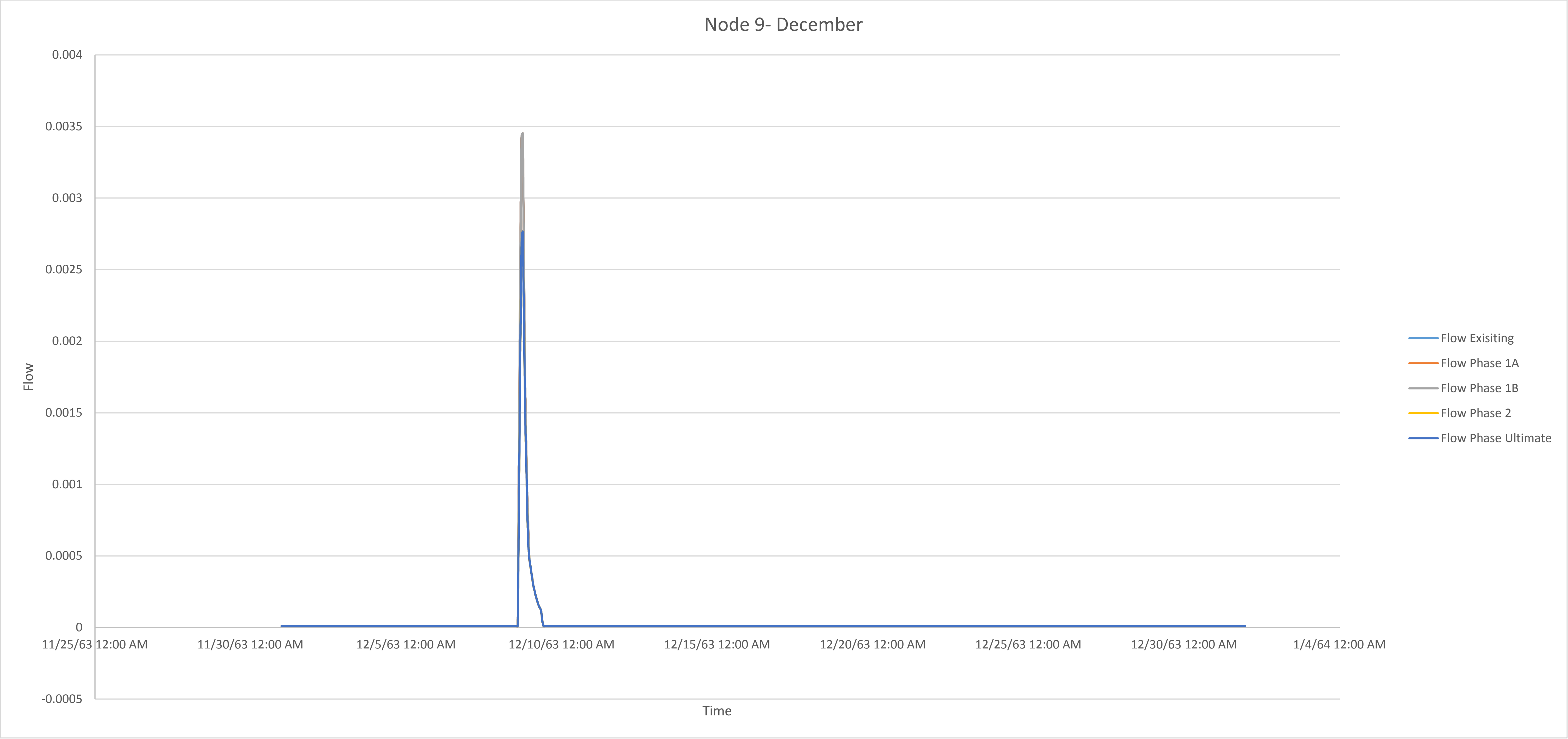
September						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		2	2	4	2	2
Magnitude (cm/s)	Max.	0.00402	0.00402	0.00402	0.00307	0.00307
	Min.	0.00119	0.00119	0.00119	0.00089	0.00089
Duration (h)	Max.	30	30	30	30	30
	Min.	12	12	12	12	12



October						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		0	0	0	0	0
Magnitude (cm/s)	Max.					
	Min.					
Duration (h)	Max.					
	Min.					

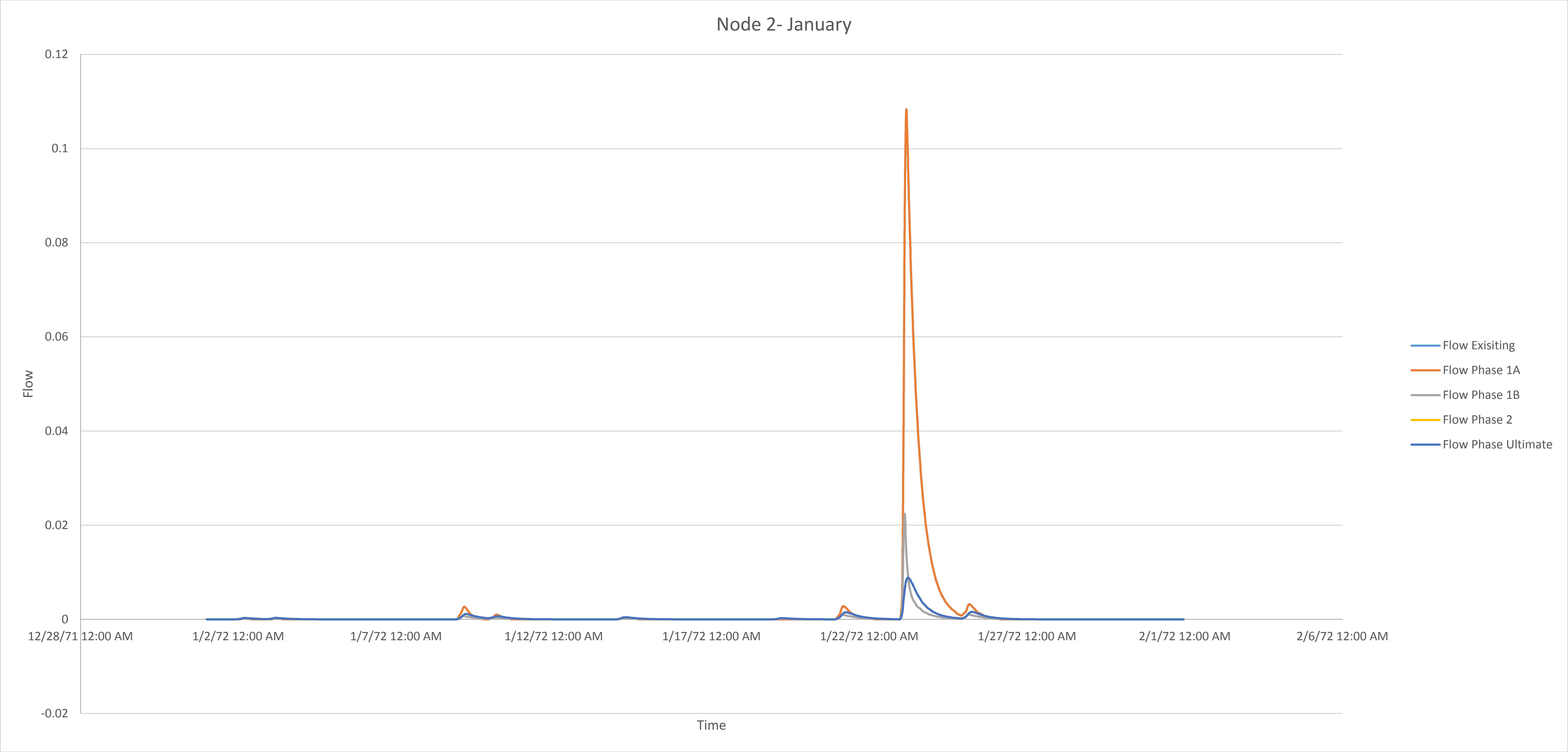


November						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitude (cm/s)	Max.	0.00570	0.00570	0.00570	0.00450	0.00450
	Min.	0.00189	0.00189	0.00189	0.00147	0.00147
Duration (h)	Max.	25	25	25	25	25
	Min.	22	22	22	22	22

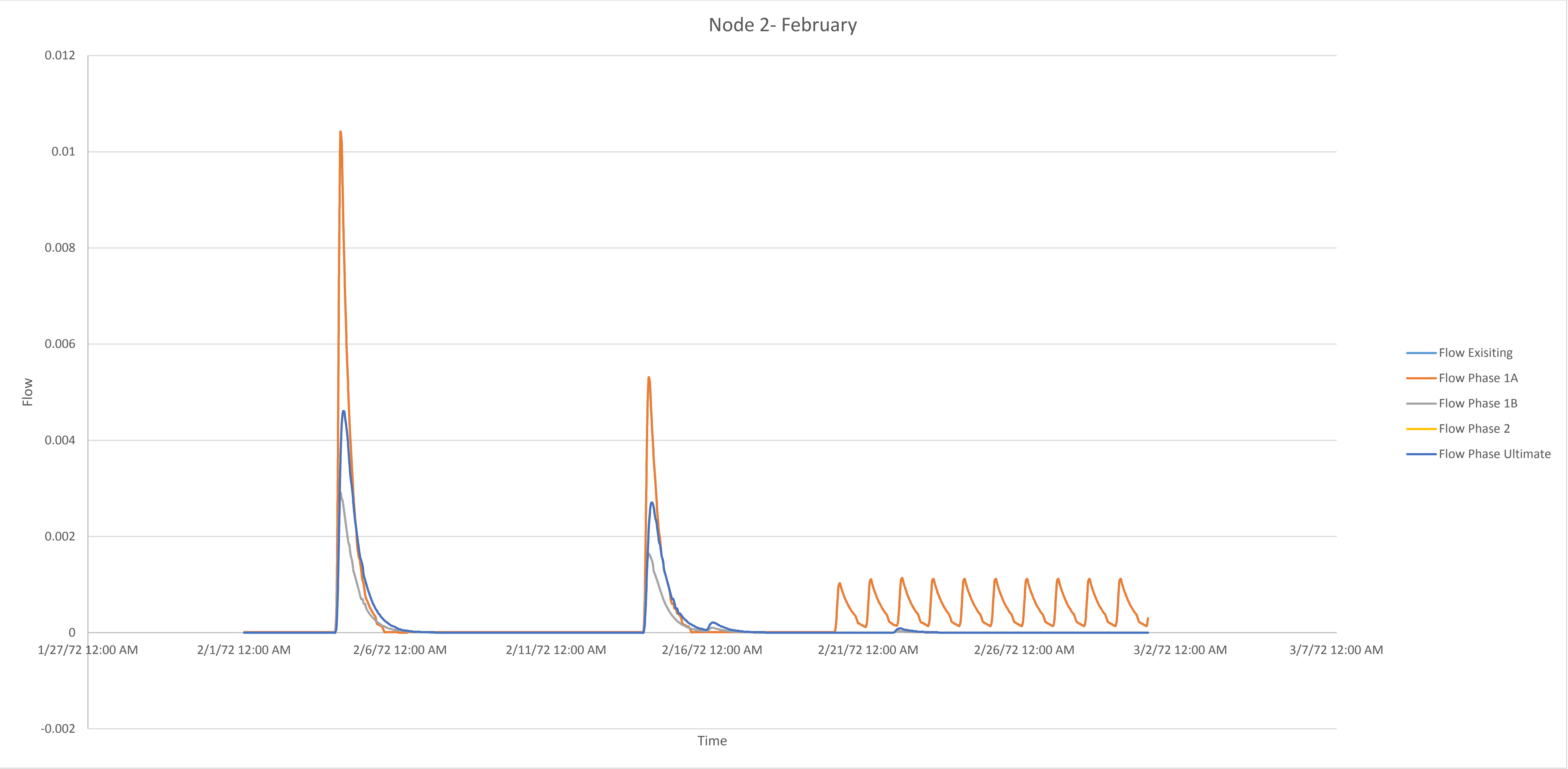


December						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		1	1	1	1	1
Magnitude (cm/s)	Max.	0.00345	0.00345	0.00345	0.00276	0.00276
	Min.					
Duration (h)	Max.	19	19	19	19	19
	Min.					

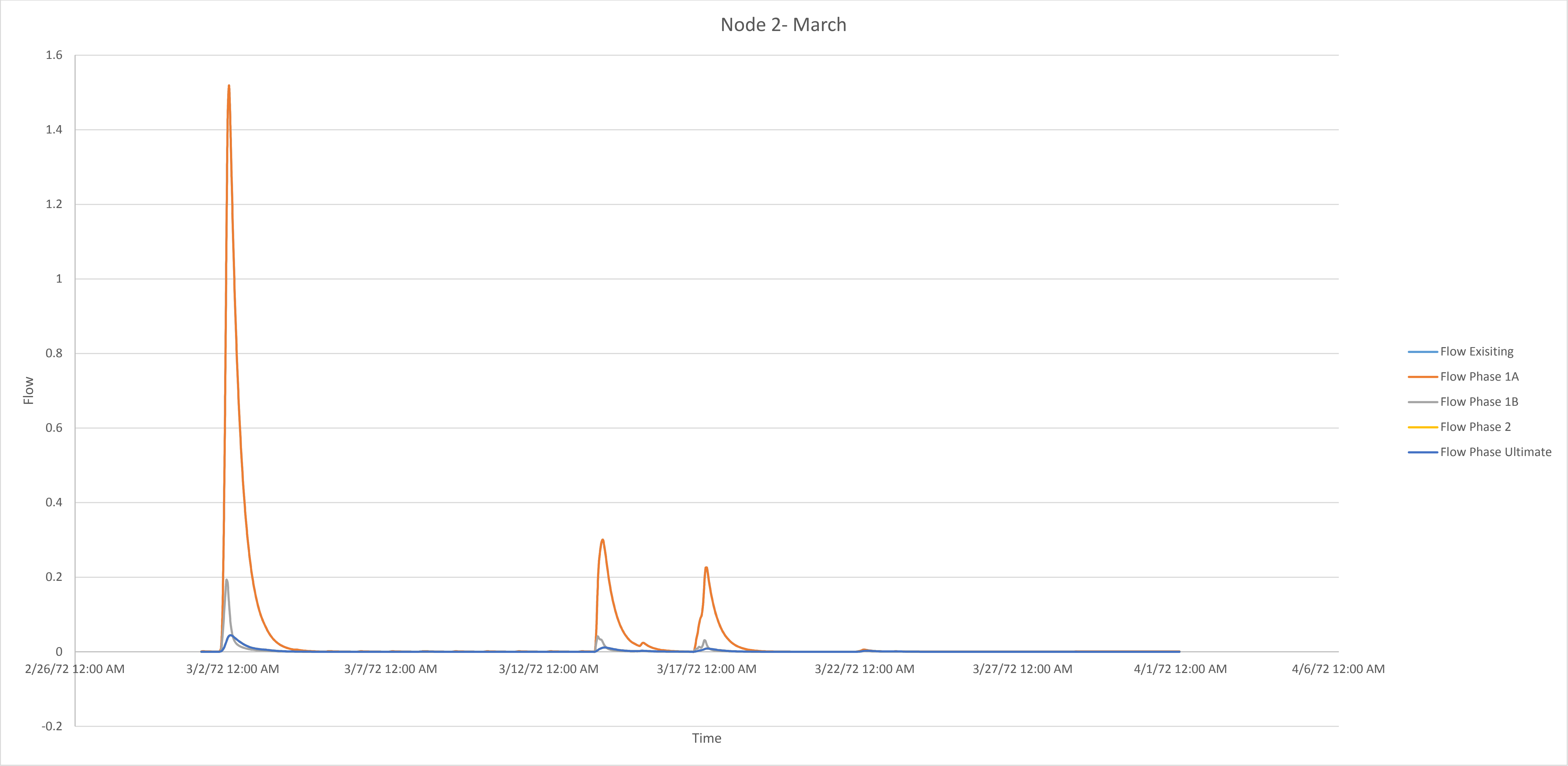
Average Year-1972



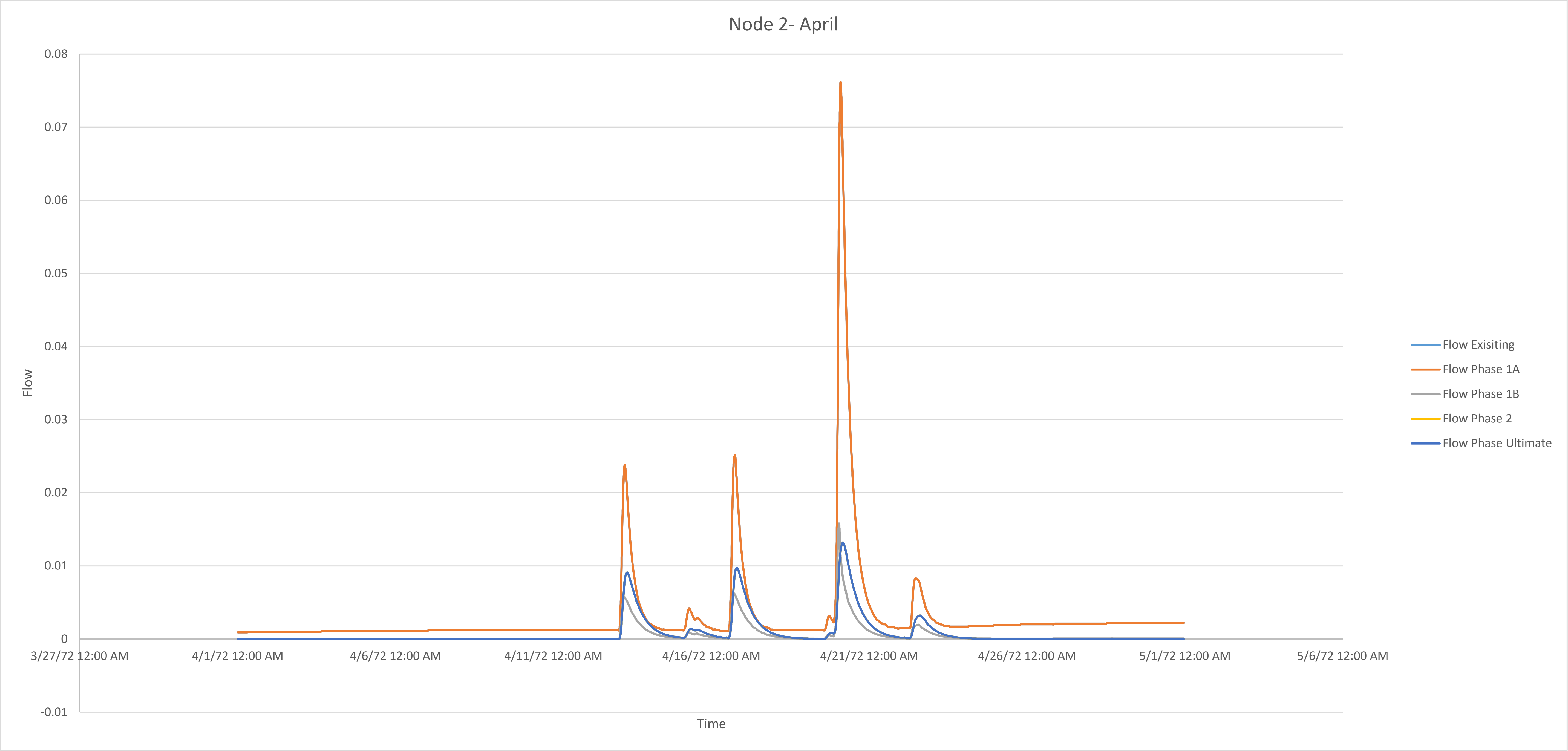
January						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		8	8	9	9	9
Magnitudes (cm/s)	Max.	0.1079	0.1079	0.0224	0.0088	0.0088
	Min.	0.00027	0.00027	0.00013	0.00027	0.00027
Duration (h)	Max.	76	76	97	104	104
	Min.	8	8	30	38	38



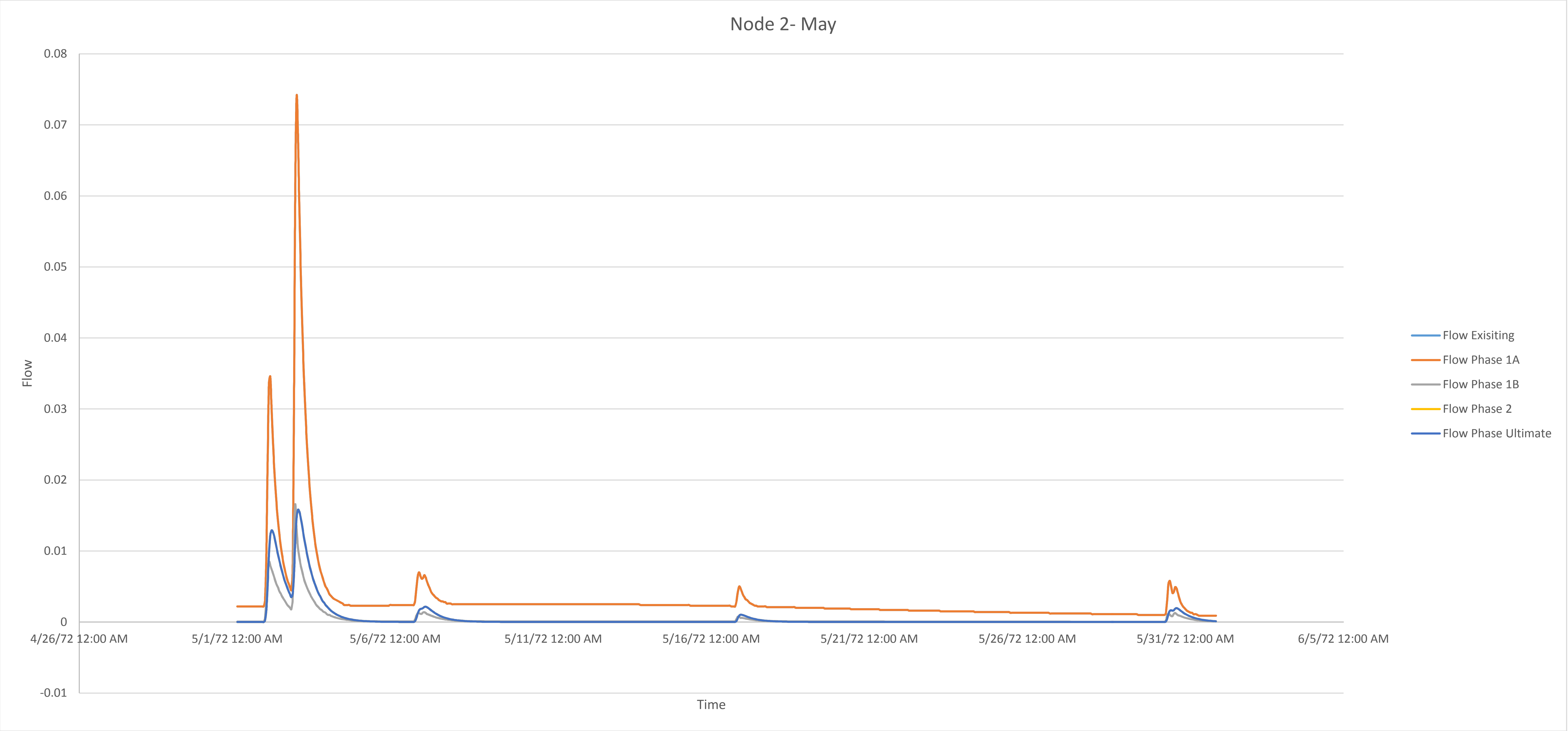
February						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		12	12	4	4	4
Magnitudes (cm/s)	Max.	0.0104	0.0104	0.0029	0.0046	0.0046
	Min.	0.00103	0.00103	0.00004	0.00009	0.00009
Duration (h)	Max.	48	48	71	76	76
	Min.	23	23	24	34	34



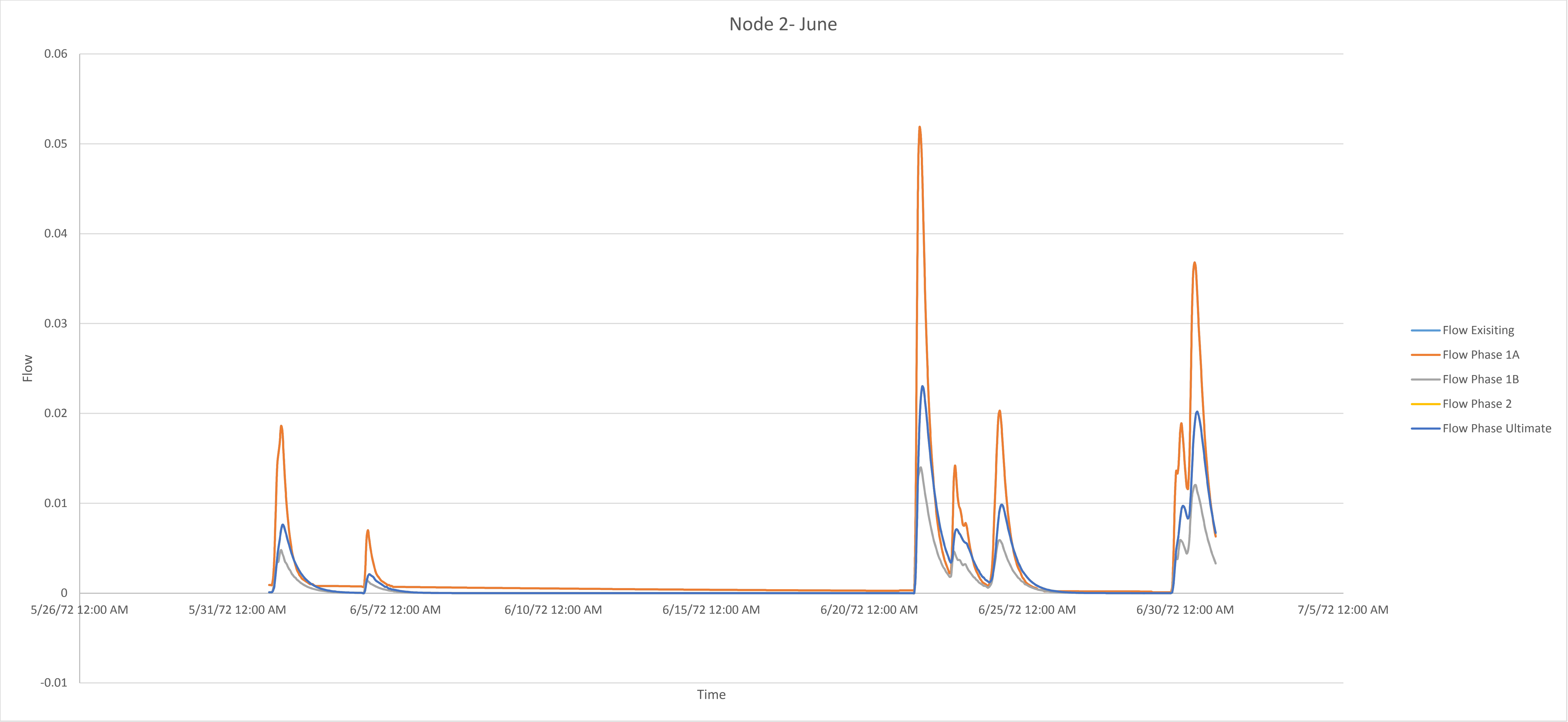
March						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitudes (cm/s)	Max.	1.5191	1.5191	0.1927	0.0443	0.0443
	Min.	0.00158	0.00158	0.00016	0.00033	0.00033
Duration (h)	Max.	79	79	100	107	107
	Min.	25	25	46	54	54



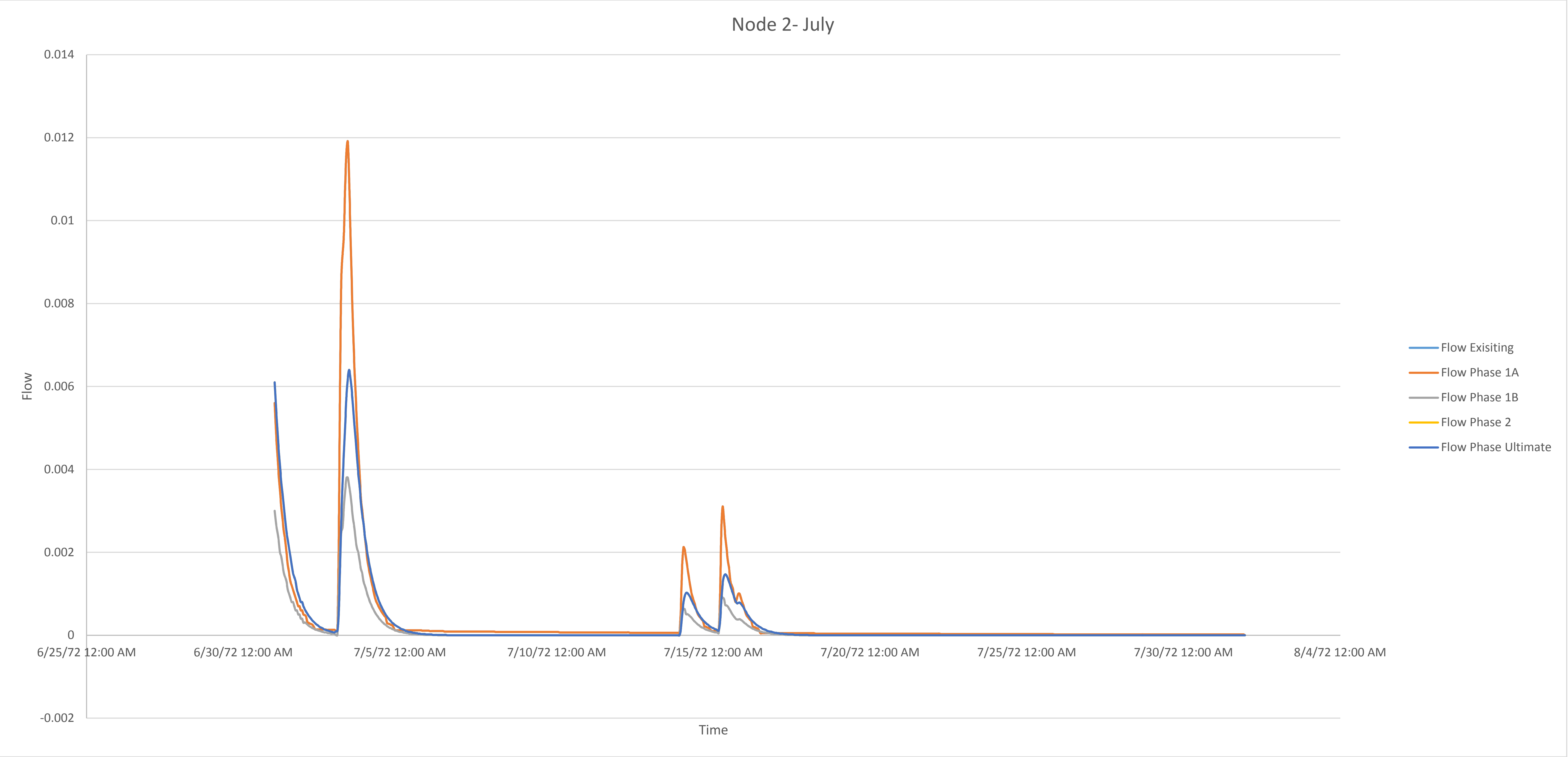
April						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitudes (cm/s)	Max.	0.0759	0.0759	0.0158	0.0132	0.0132
	Min.	0.0042	0.0042	0.00089	0.00135	0.00135
Duration (h)	Max.	55	55	65	64	64
	Min.	27	27	28	33	33



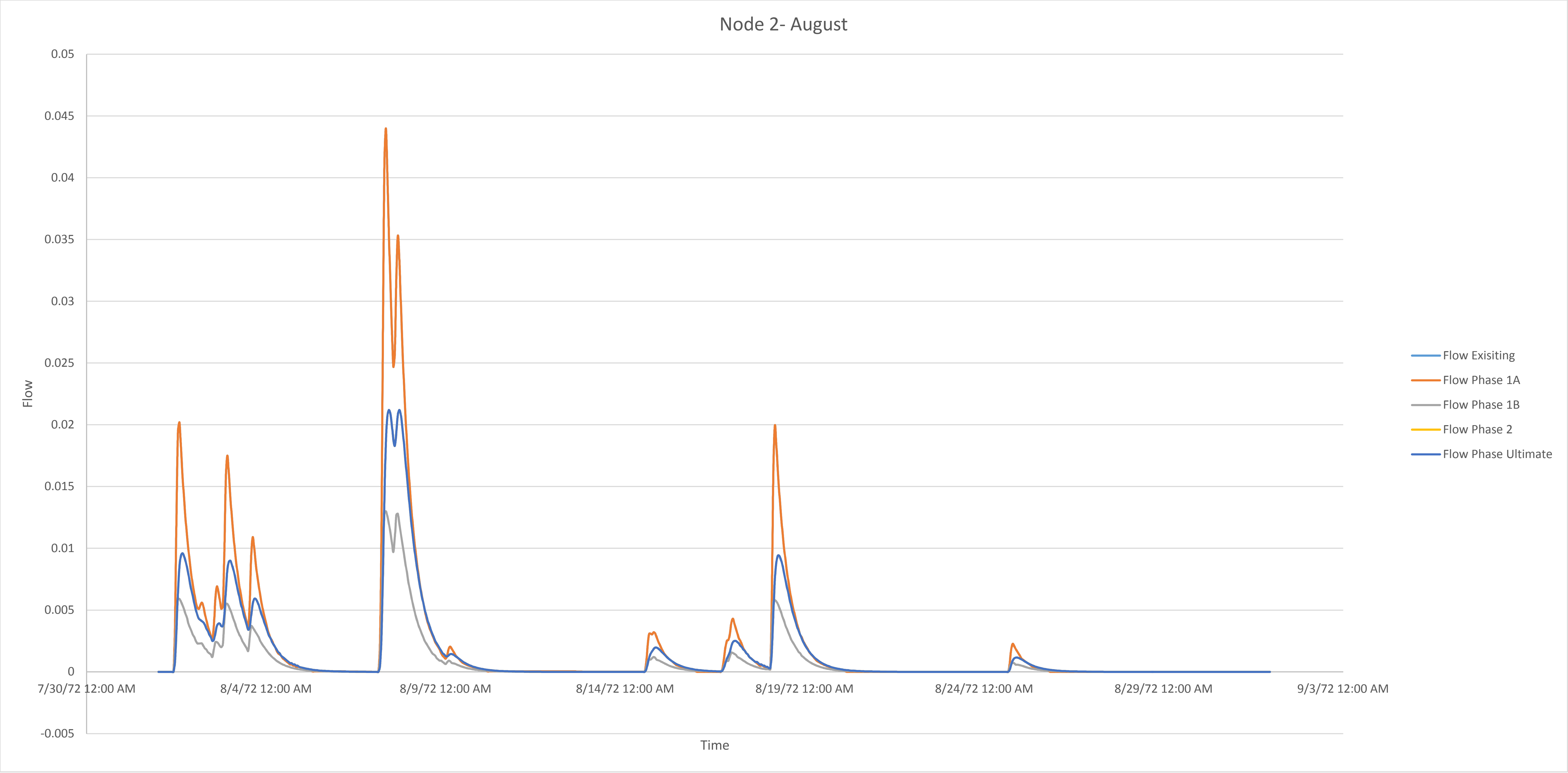
May						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitudes (cm/s)	Max.	0.074	0.074	0.0166	0.0158	0.0158
	Min.	0.005	0.005	0.00076	0.00102	0.00102
Duration (h)	Max.	45	45	71	93	93
	Min.	23	23	47	55	55



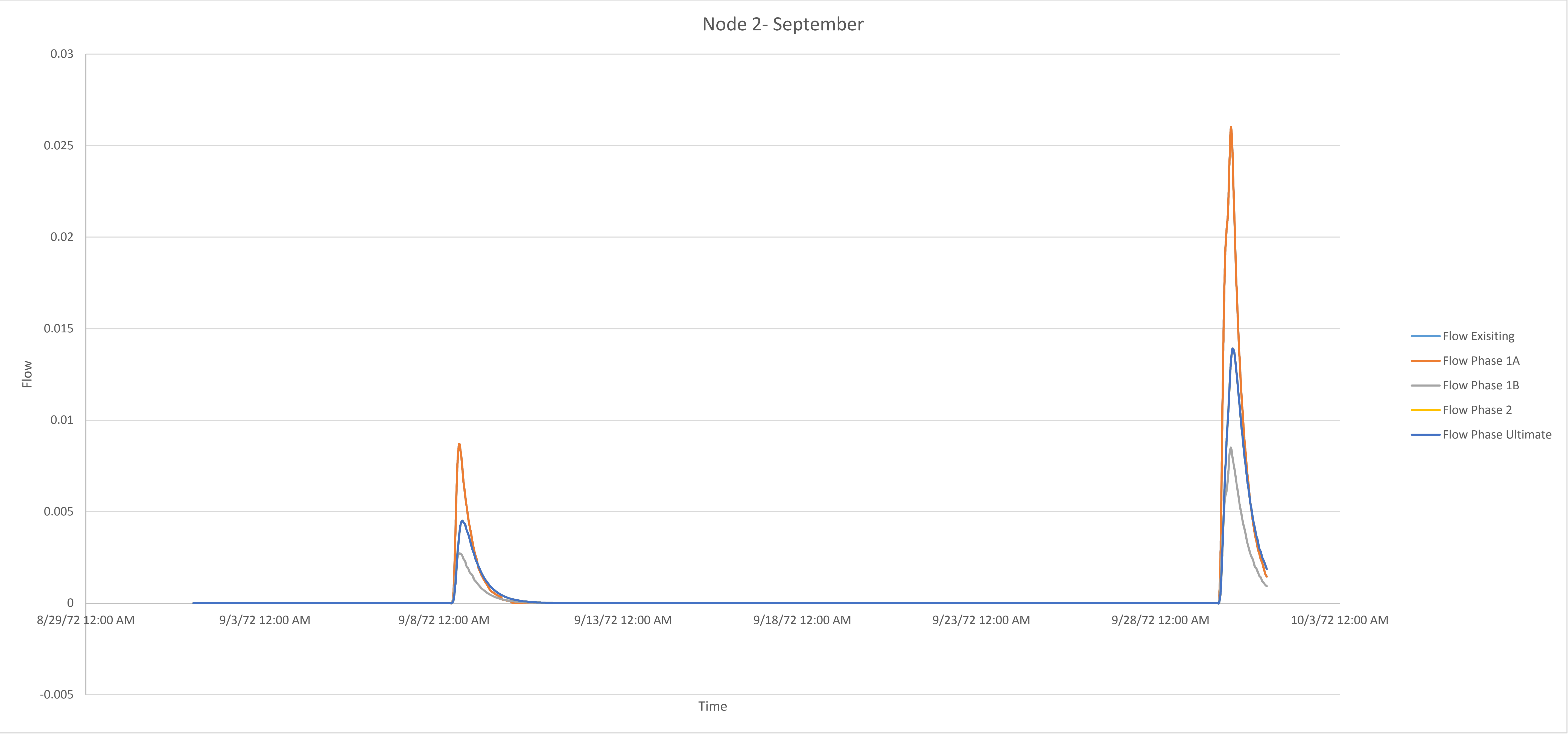
June						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		7	7	7	7	7
Magnitudes (cm/s)	Max.	0.0518	0.0518	0.014	0.023	0.023
	Min.	0.0062	0.0062	0.00153	0.0021	0.0021
Duration (h)	Max.	26	26	26	27	27
	Min.	36	36	56	66	66



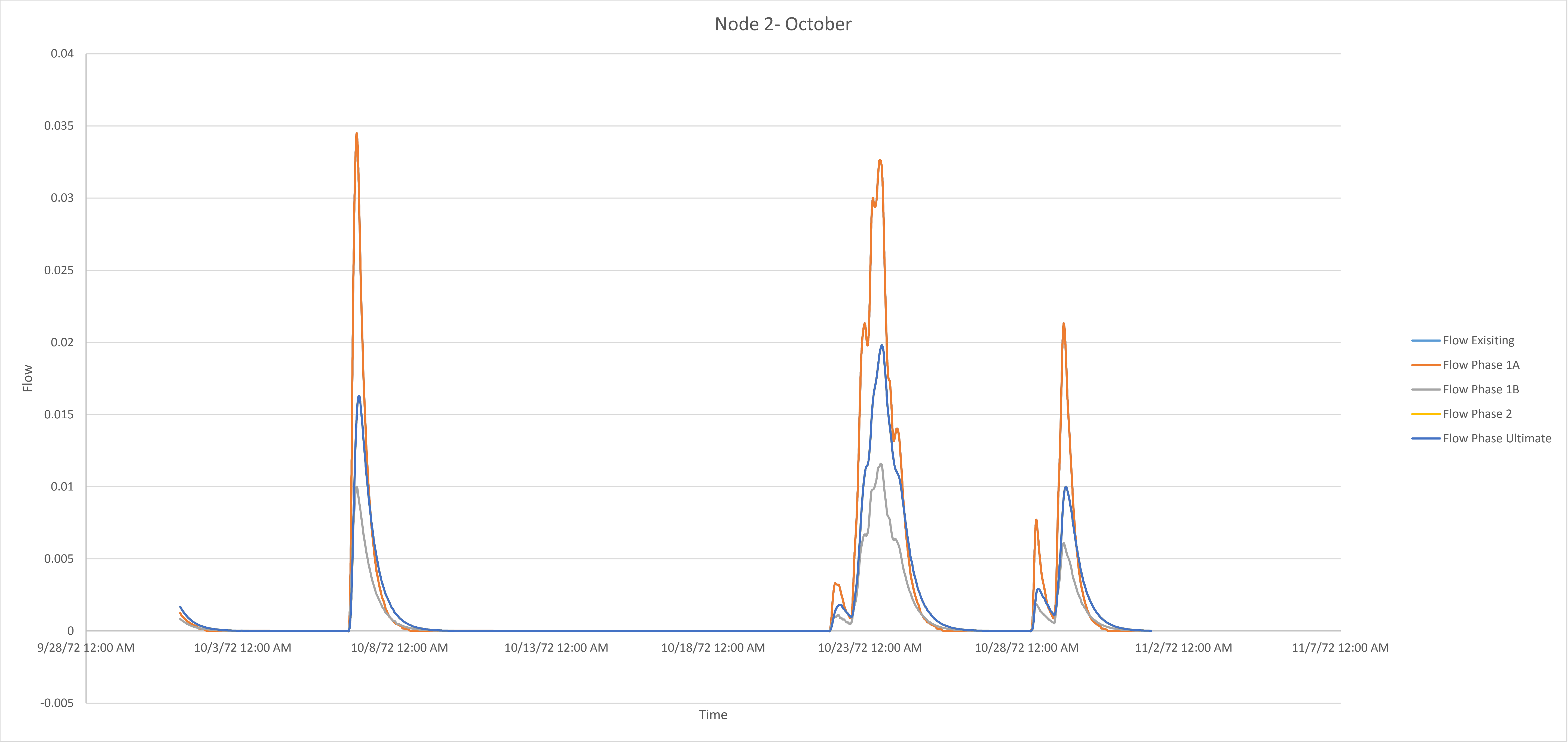
July						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		3	3	3	3	3
Magnitudes (cm/s)	Max.	0.0119	0.0119	0.0038	0.0064	0.0064
	Min.	0.00212	0.00212	0.00063	0.00102	0.00102
Duration (h)	Max.	70	70	76	83	83
	Min.	25	25	29	29	29



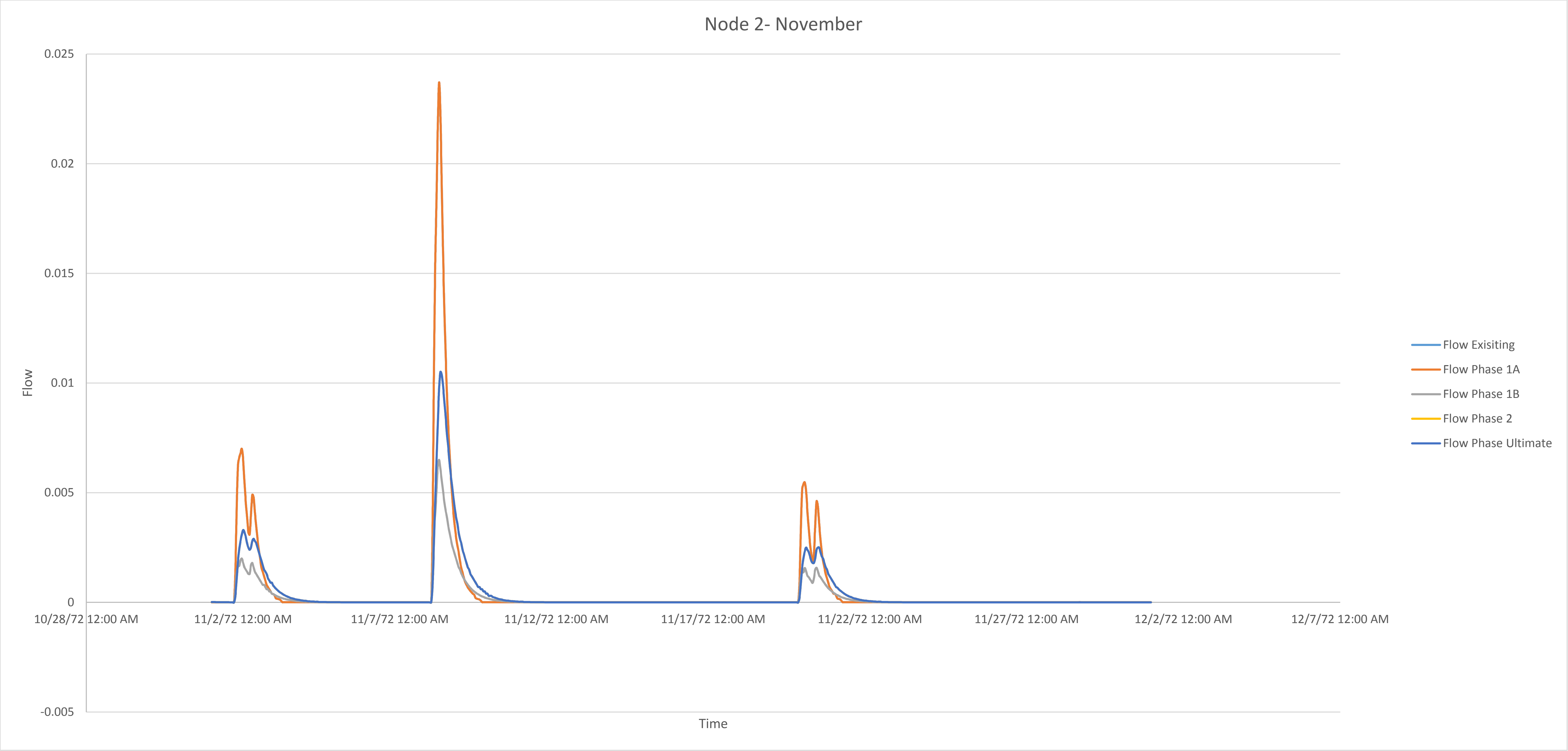
August						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		11	11	11	11	11
Magnitudes (cm/s)	Max.	0.044	0.044	0.013	0.0212	0.0212
	Min.	0.00226	0.00226	0.00071	0.00116	0.00116
Duration (h)	Max.	72	72	100	108	108
	Min.	27	27	55	63	63



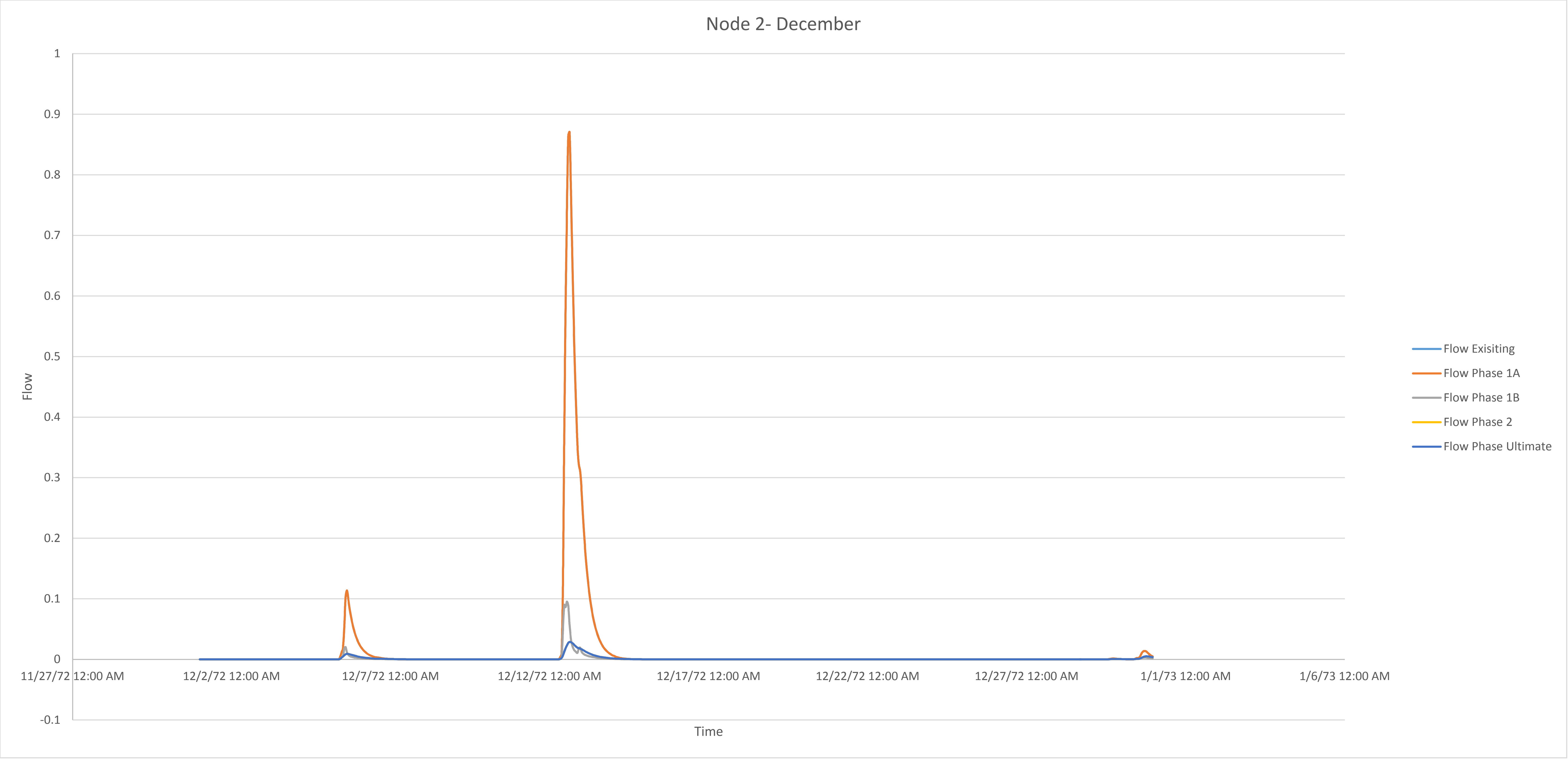
September						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		2	2	2	2	2
Magnitudes (cm/s)	Max.	Not Finish within August				
	Min.	0.0087	0.0087	0.0027	0.0045	0.0045
Duration (h)	Max.					
	Min.	40	40	71	71	78



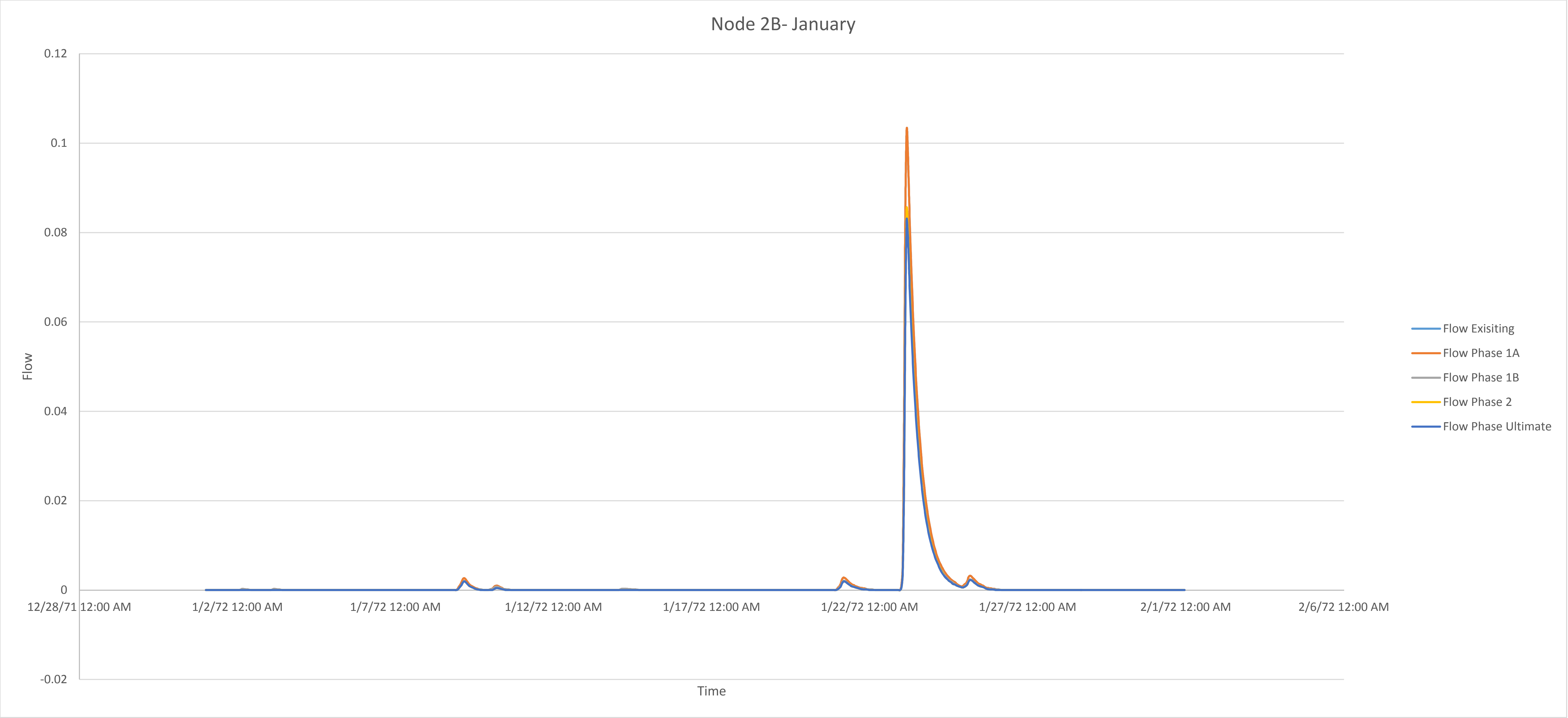
October						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitudes (cm/s)	Max.	0.0345	0.0345	0.0116	0.0198	0.0198
	Min.	0.00326	0.00326	0.0011	0.0018	0.0018
Duration (h)	Max.	46	46	52	61	61
	Min.	15	15	14	15	15



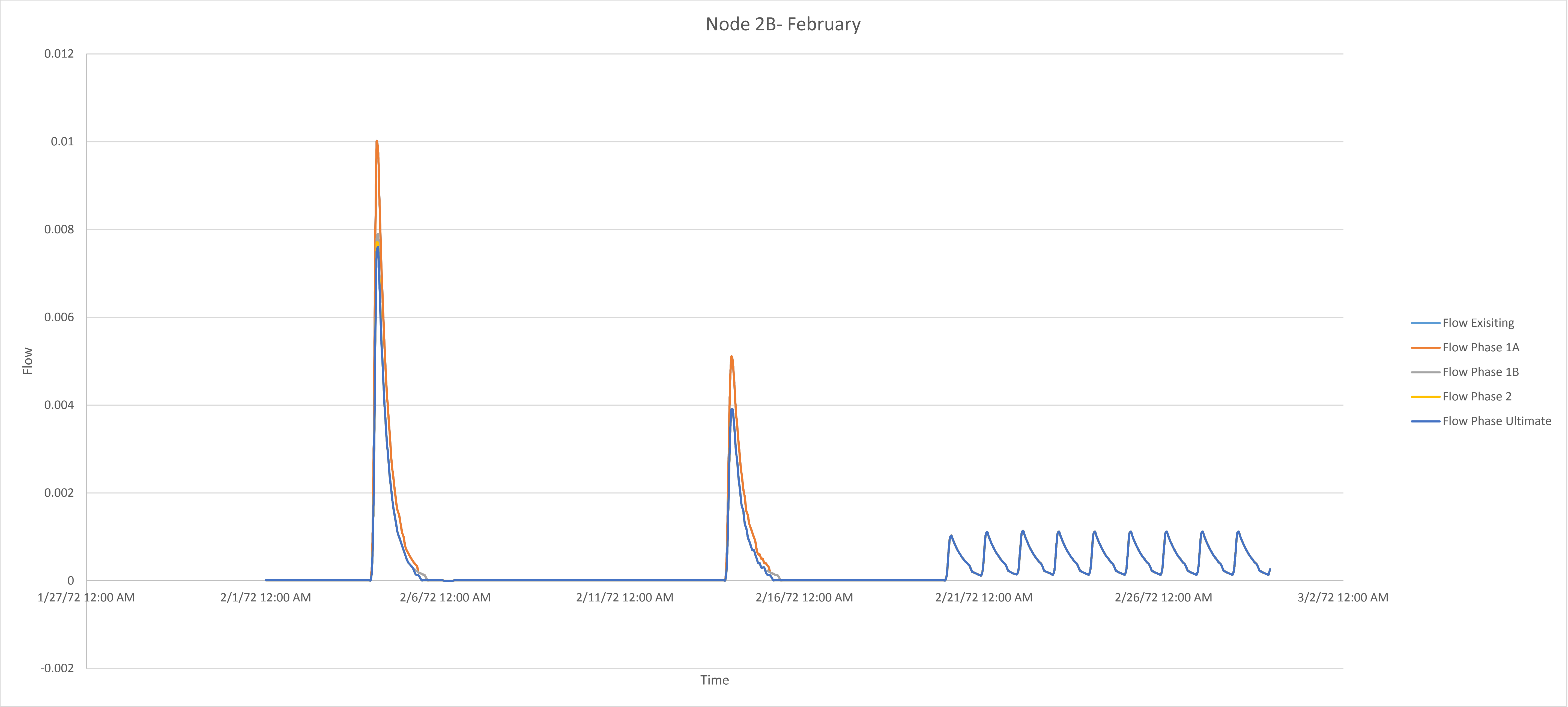
November						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitudes (cm/s)	Max.	0.0237	0.0237	0.0065	0.0105	0.0105
	Min.	0.00547	0.00547	0.00157	0.0025	0.0025
Duration (h)	Max.	38	38	68	87	87
	Min.					



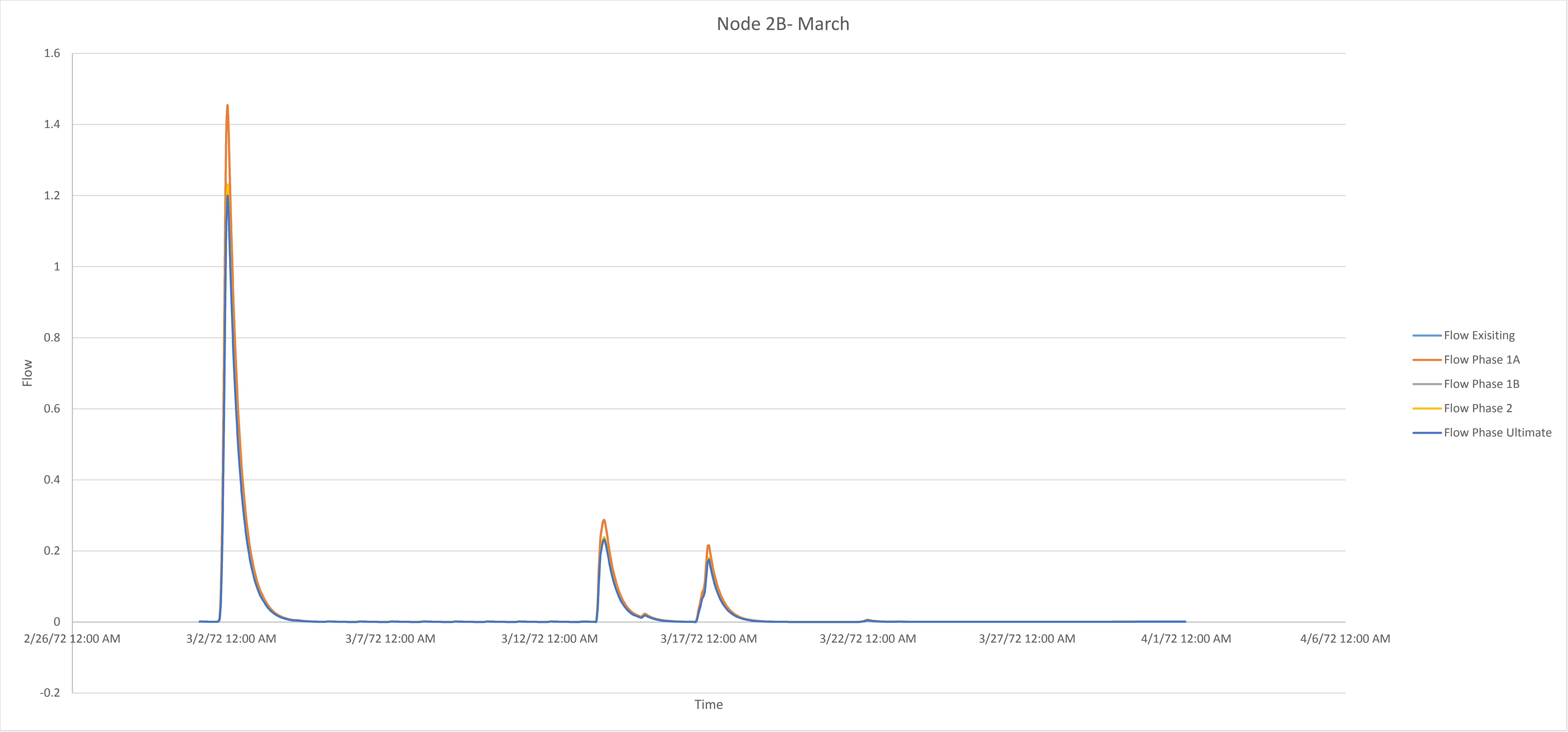
December						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		4	4	5	4	4
Magnitudes (cm/s)	Max.	0.8704	0.8704	0.0954	0.0288	0.0288
	Min.	0.00143	0.00143	0.00041	0.00066	0.00066
Duration (h)	Max.	65	65	82	89	89
	Min.	14	14	15	17	17



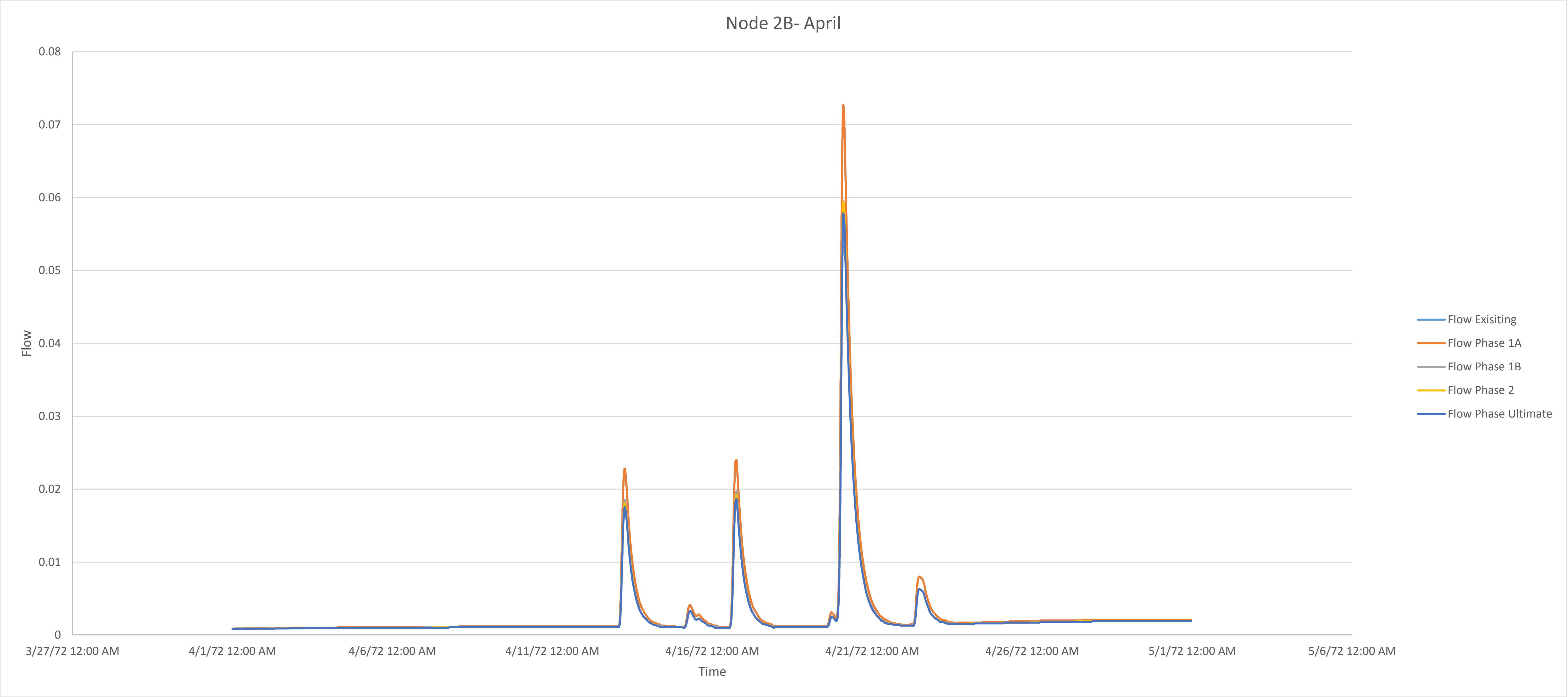
January						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		8	8	8	8	8
Magnitude (cm/s)	Max.	0.1029	0.1029	0.0851	0.0852	0.0827
	Min.	0.00027	0.00027	0.00027	0.00045	0.00045
Duration (h)	Max.	46	46	46	46	46
	Min.	8	8	8	10	10



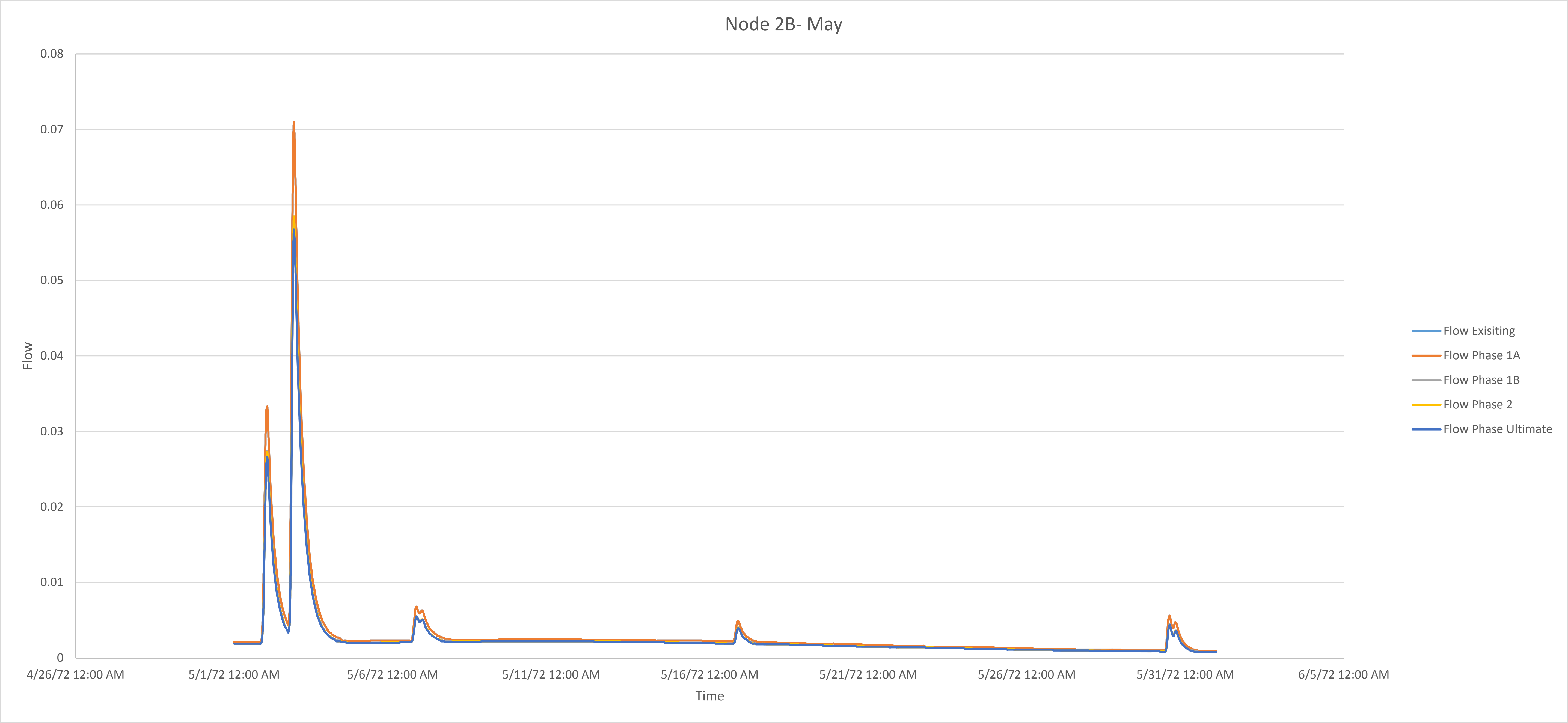
February						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		11	11	11	11	11
Magnitude (cm/s)	Max.	0.01	0.01	0.0079	0.0077	0.0076
	Min.	0.00103	0.00103	0.00103	0.00103	0.00103
Duration (h)	Max.	37	37	37	33	33
	Min.	46	46	46	46	46



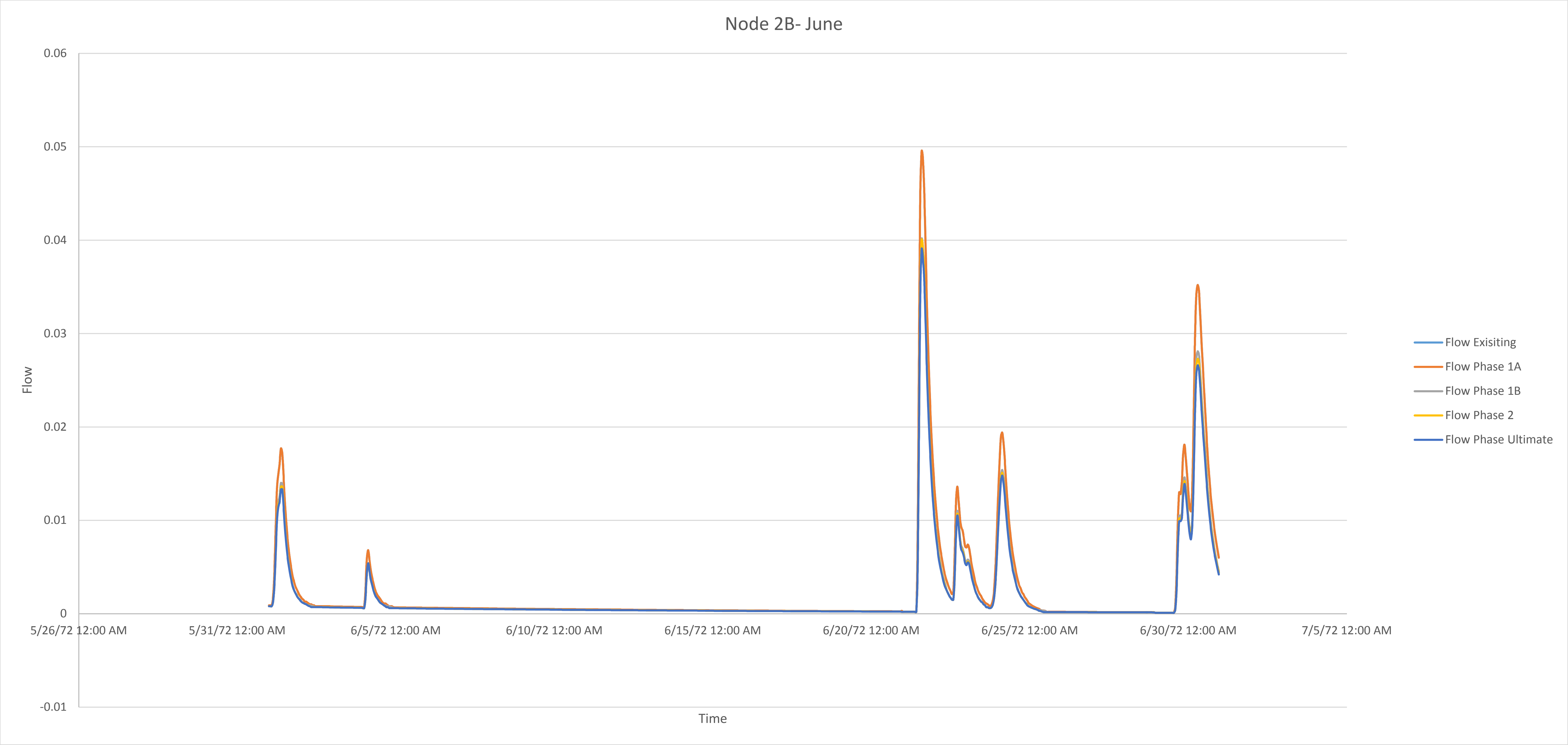
March						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitude (cm/s)	Max.	1.4546	1.4546	1.2305	1.2305	1.1991
	Min.	0.00121	0.00121	0.00084	0.00084	0.00084
Duration (h)	Max.	79	79	79	79	79
	Min.	21	21	22	30	30



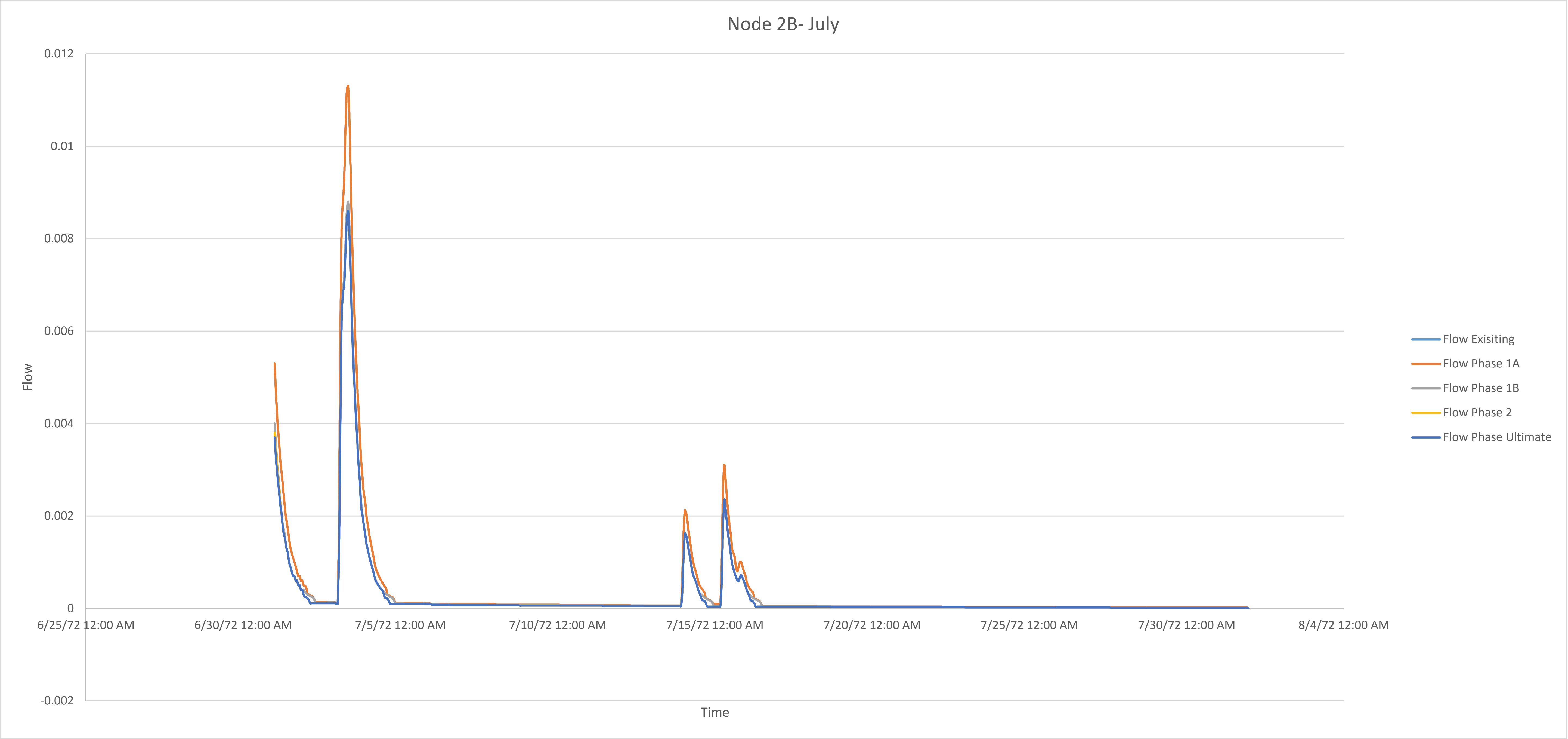
April						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitude (cm/s)	Max.	0.0724	0.0724	0.0594	0.0593	0.0577
	Min.	0.0041	0.0041	0.0033	0.0033	0.0033
Duration (h)	Max.	55	55	55	55	55
	Min.	25	25	25	22	22



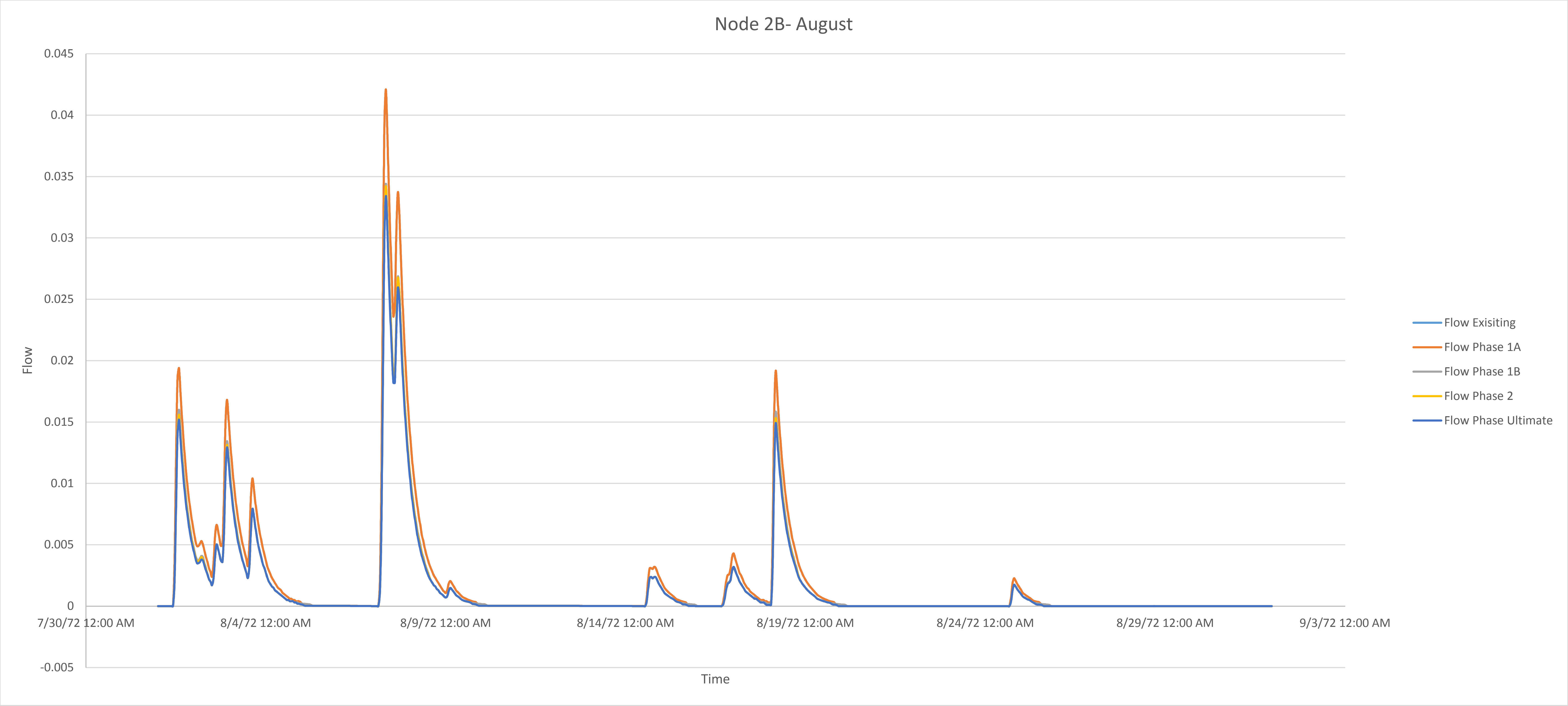
May						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitude (cm/s)	Max.	0.0707	0.0707	0.0581	0.0581	0.0564
	Min.	0.0049	0.0049	0.004	0.004	0.0039
Duration (h)	Max.	27	27	27	27	27
	Min.	15	15	16	14	13



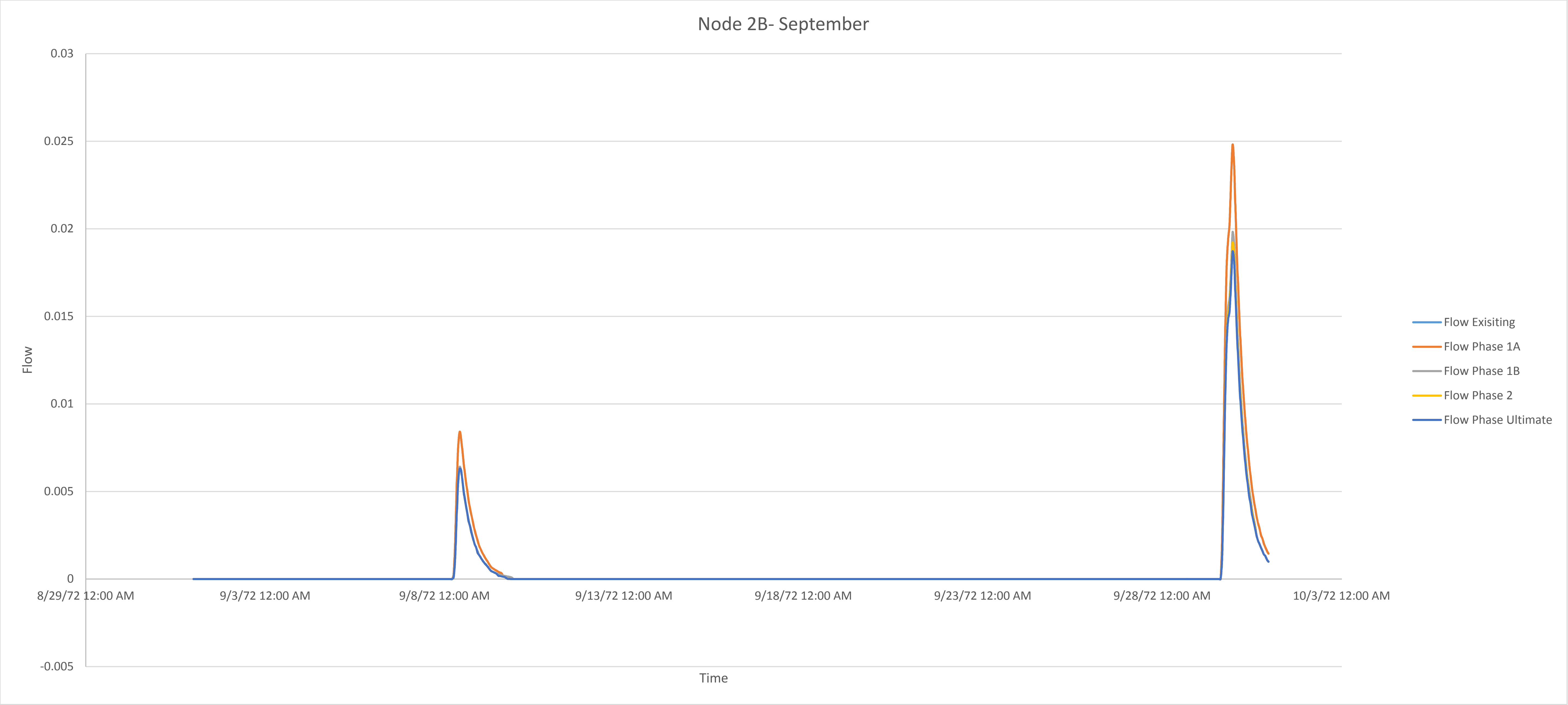
June						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		7	7	7	7	7
Magnitude (cm/s)	Max.	0.0495	0.0495	0.0401	0.04	0.039
	Min.	0.0068	0.0068	0.0054	0.0054	0.0054
Duration (h)	Max.	55	55	54	54	54
	Min.	21	21	21	18	18



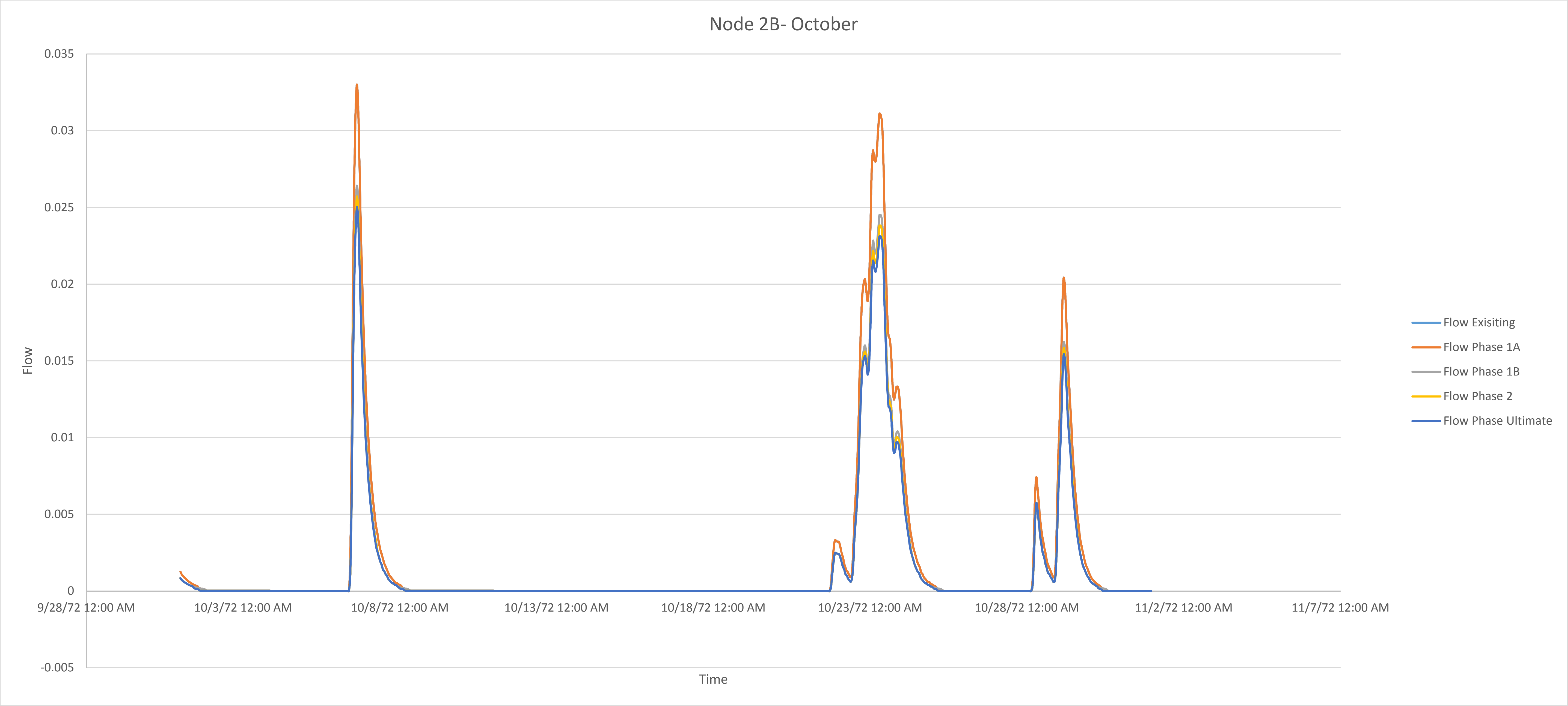
July						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		3	3	3	3	3
Magnitude (cm/s)	Max.	0.0113	0.0113	0.0088	0.0086	0.0086
	Min.	0.00212	0.00212	0.00162	0.00162	0.00162
Duration (h)	Max.	43	43	43	39	39
	Min.	24	24	24	19	19



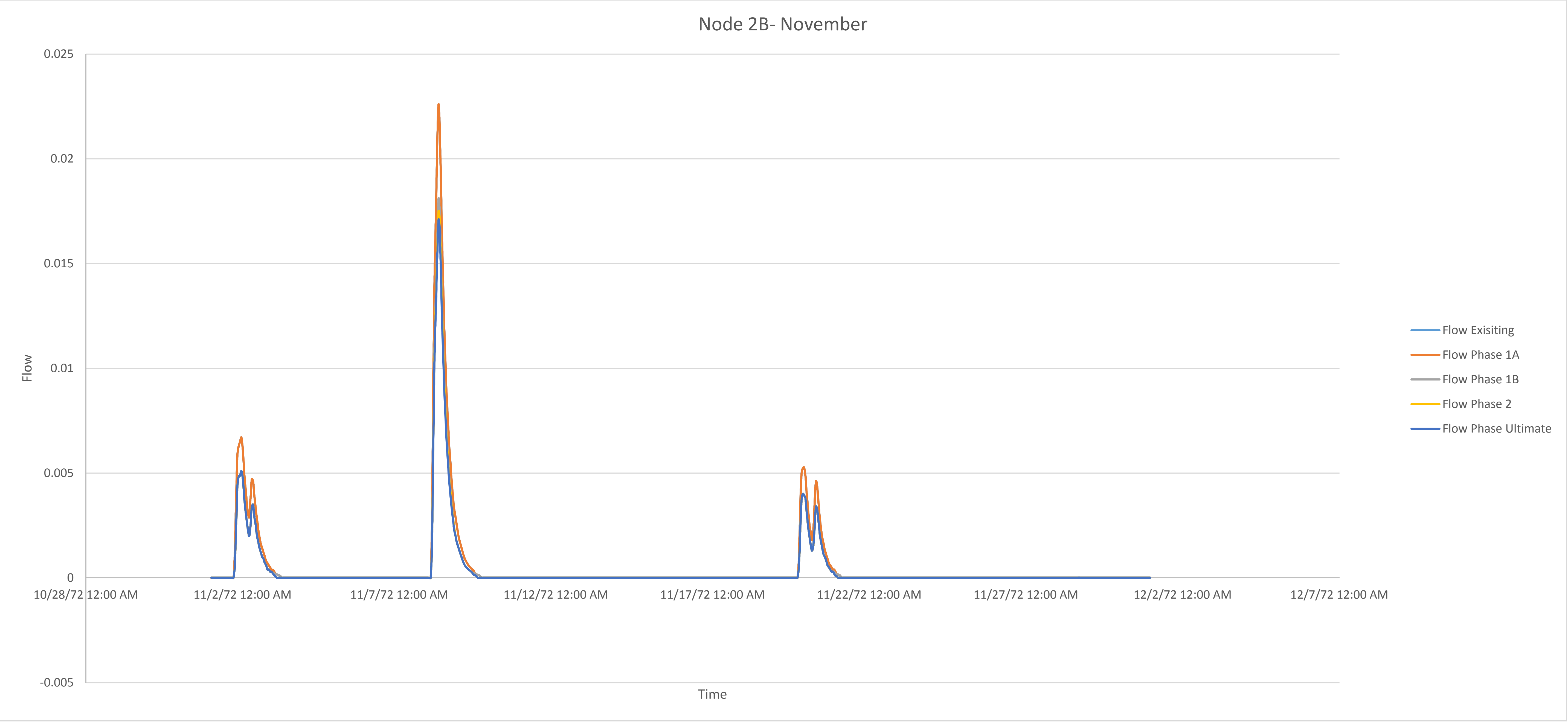
August						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		11	11	11	11	11
Magnitude (cm/s)	Max.	0.0421	0.0421	0.0344	0.0342	0.0334
	Min.	0.00226	0.00226	0.00173	0.00173	0.00173
Duration (h)	Max.	72	72	72	66	66
	Min.	27	27	27	22	22



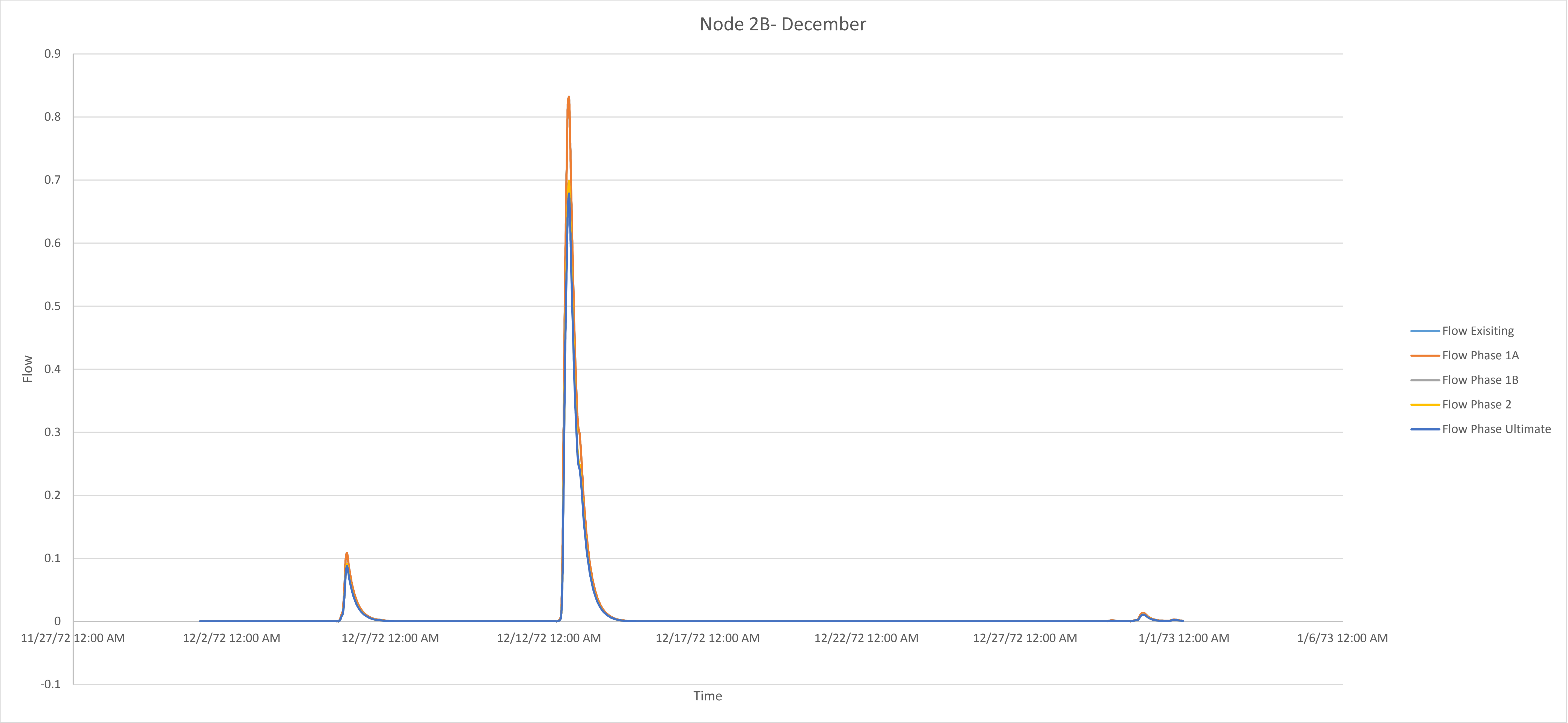
September						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		2	2	2	2	2
Magnitude (cm/s)	Max.	Not finished within this month				
	Min.	0.0084	0.0084	0.0064	0.0063	0.0063
Duration (h)	Max.					
	Min.	40	40	40	38	38



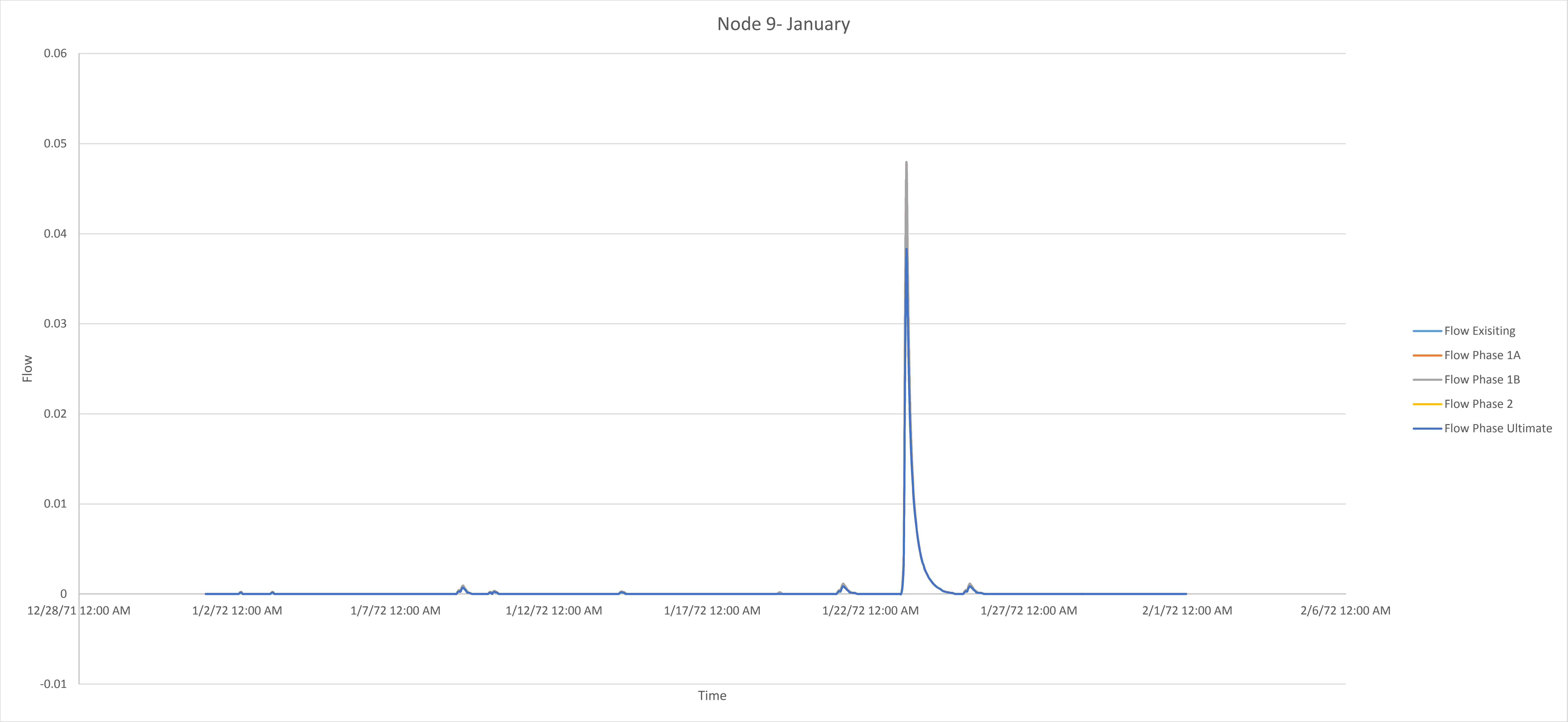
October						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitude (cm/s)	Max.	0.033	0.033	0.0264	0.0257	0.025
	Min.	0.0033	0.0033	0.00248	0.00248	0.00248
Duration (h)	Max.	46	46	46	42	42
	Min.	15	15	15	15	15



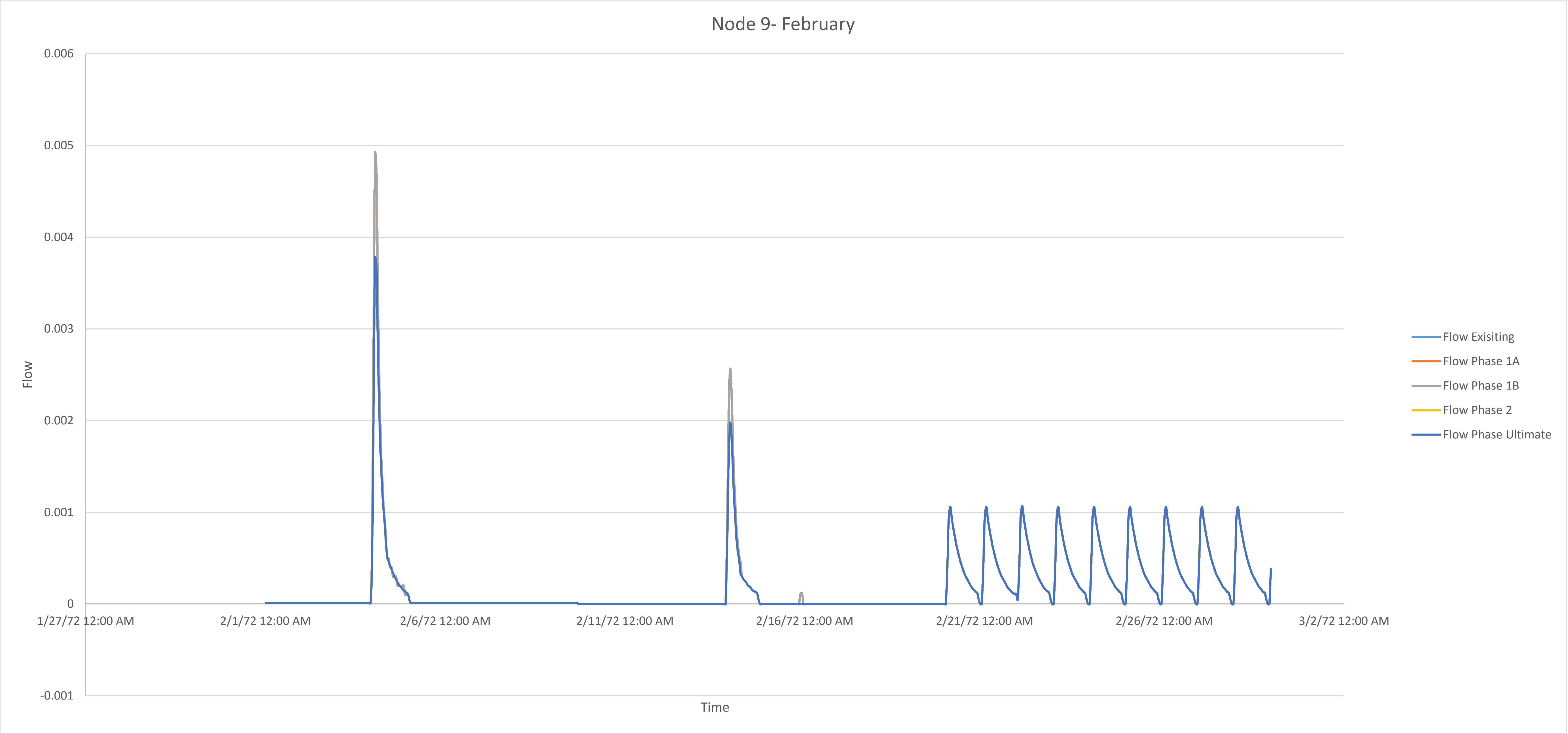
November						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitude (cm/s)	Max.	0.0226	0.0226	0.0181	0.0175	0.0171
	Min.	0.0046	0.0046	0.0034	0.0034	0.0034
Duration (h)	Max.	38	38	38	35	35
	Min.	22	22	22	19	19



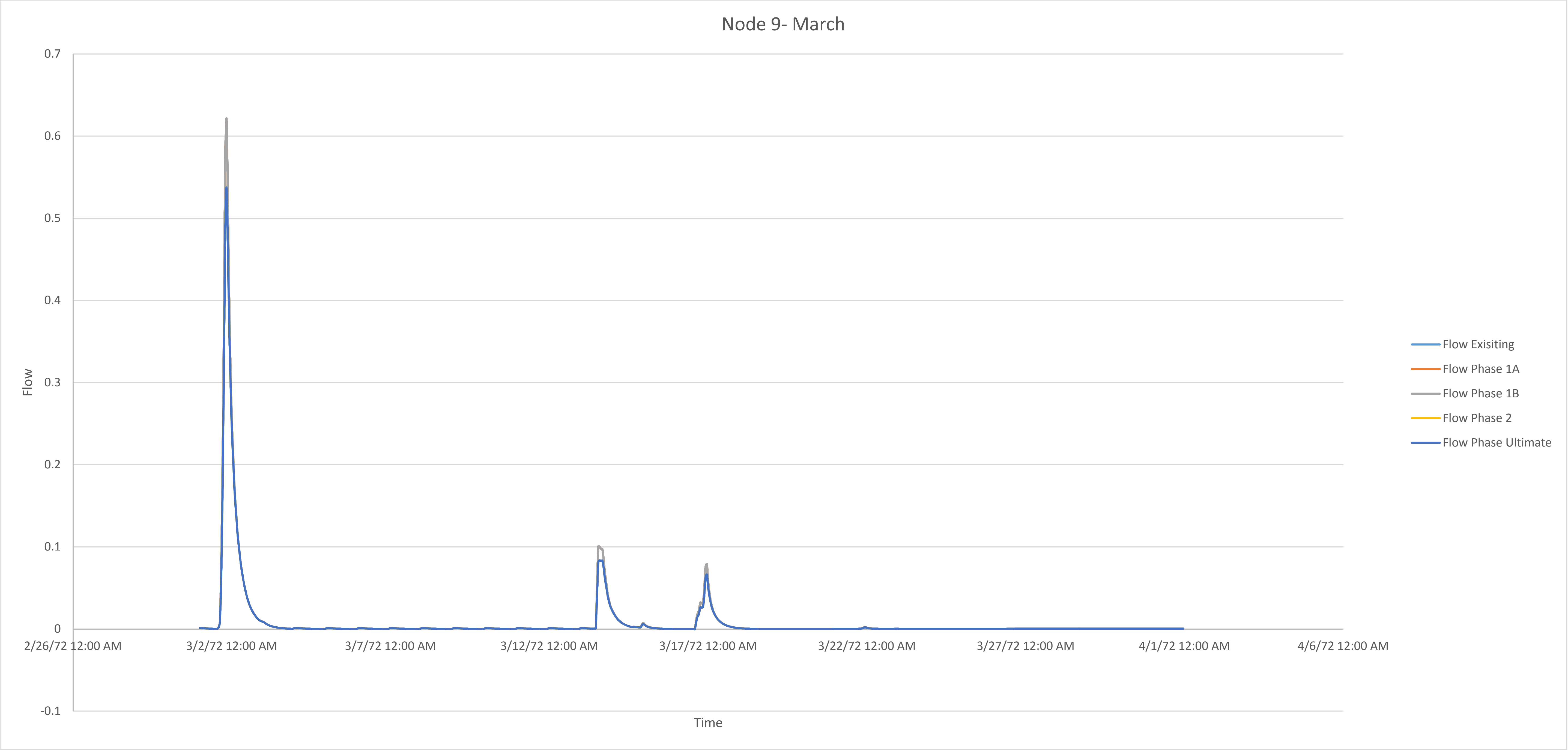
December						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		3	3	3	3	3
Magnitude (cm/s)	Max.	0.8316	0.8316	0.6973	0.6977	0.6783
	Min.	0.0134	0.0134	0.011	0.0107	0.0105
Duration (h)	Max.	65	65	65	65	65
	Min.	27	27	27	27	27



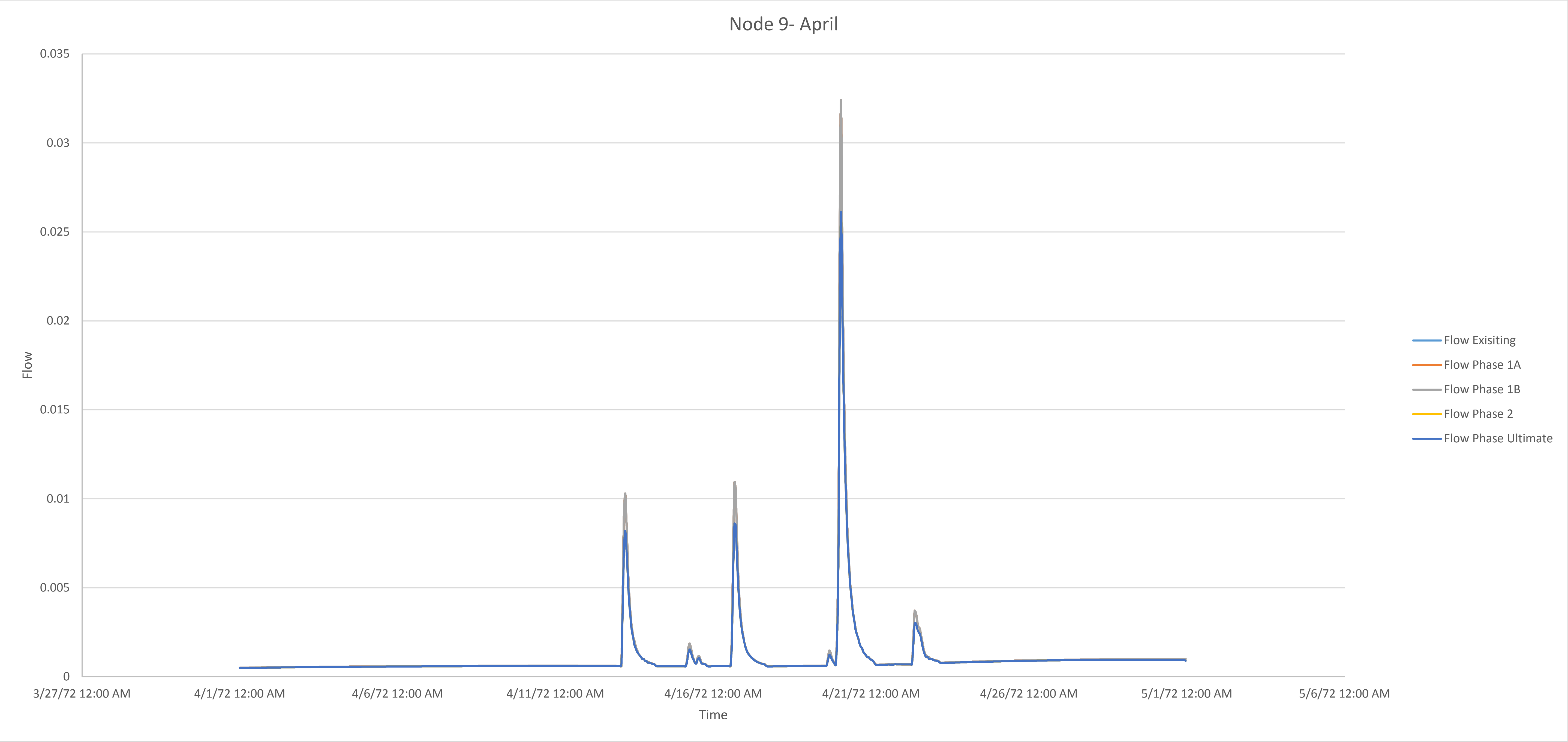
January						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		9	9	9	8	8
Magnitude (cm/s)	Max.	0.0479	0.0479	0.0479	0.0382	0.0382
	Min.	0.00019	0.00019	0.00019	0.00016	0.00016
Duration (h)	Max.	40	40	40	40	40
	Min.	3	3	3	2	2



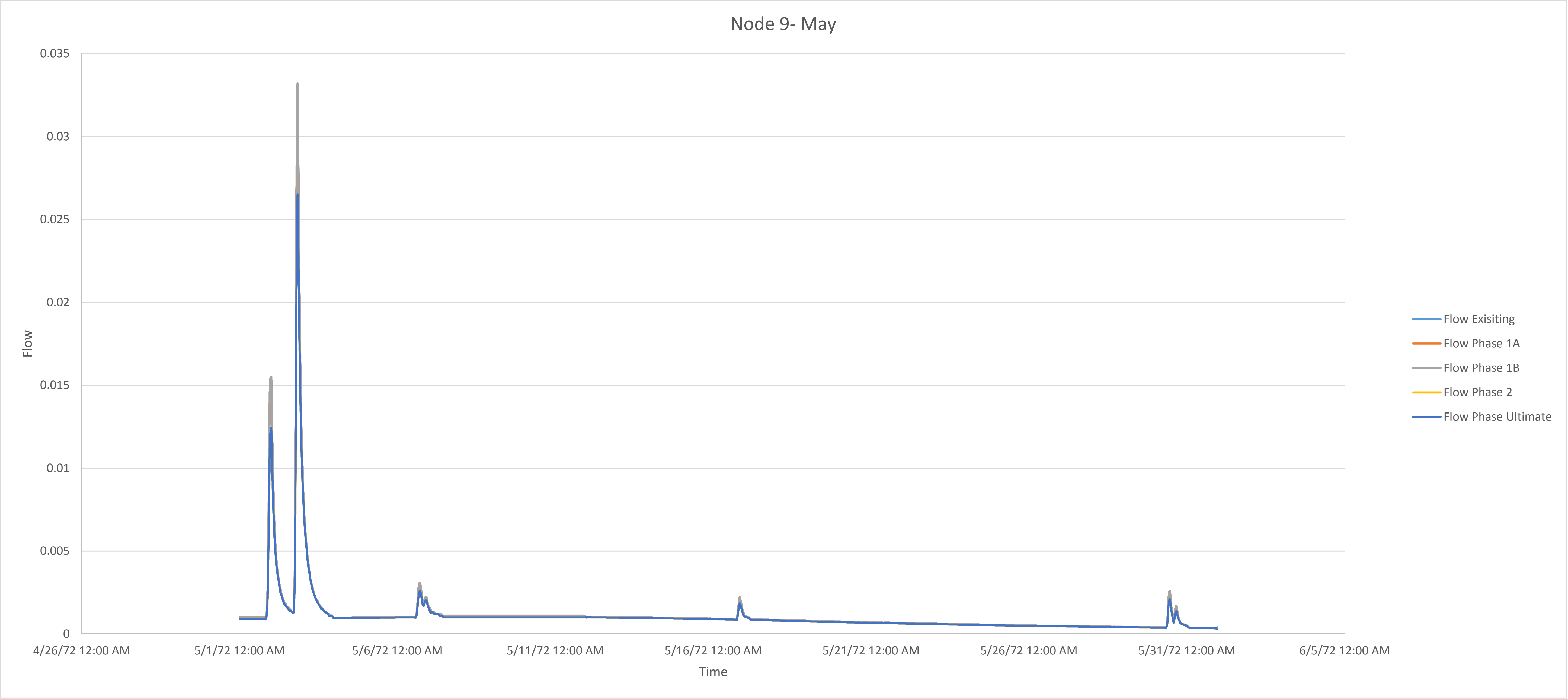
February						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		13	13	13	12	12
Magnitude (cm/s)	Max.	0.0049	0.0049	0.0049	0.00377	0.00377
	Min.	0.00012	0.00012	0.00012	0.00106	0.00106
Duration (h)	Max.	26	26	26	26	26
	Min.	2	2	2	22	22



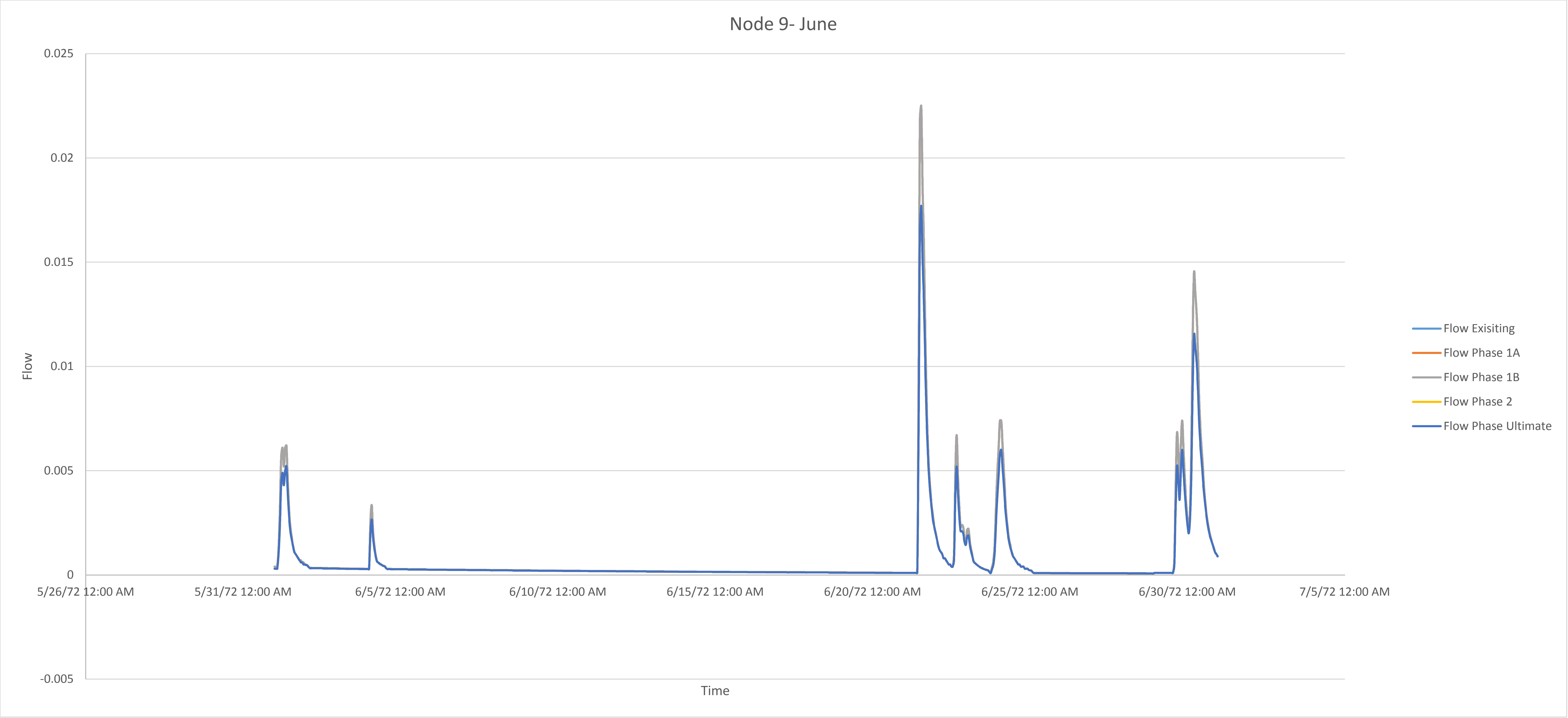
March						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		15	15	15	15	15
Magnitude (cm/s)	Max.	0.6211	0.6211	0.6211	0.5374	0.5374
	Min.	0.00125	0.00125	0.00125	0.00125	0.00125
Duration (h)	Max.	42	42	42	42	42
	Min.	20	20	20	20	20



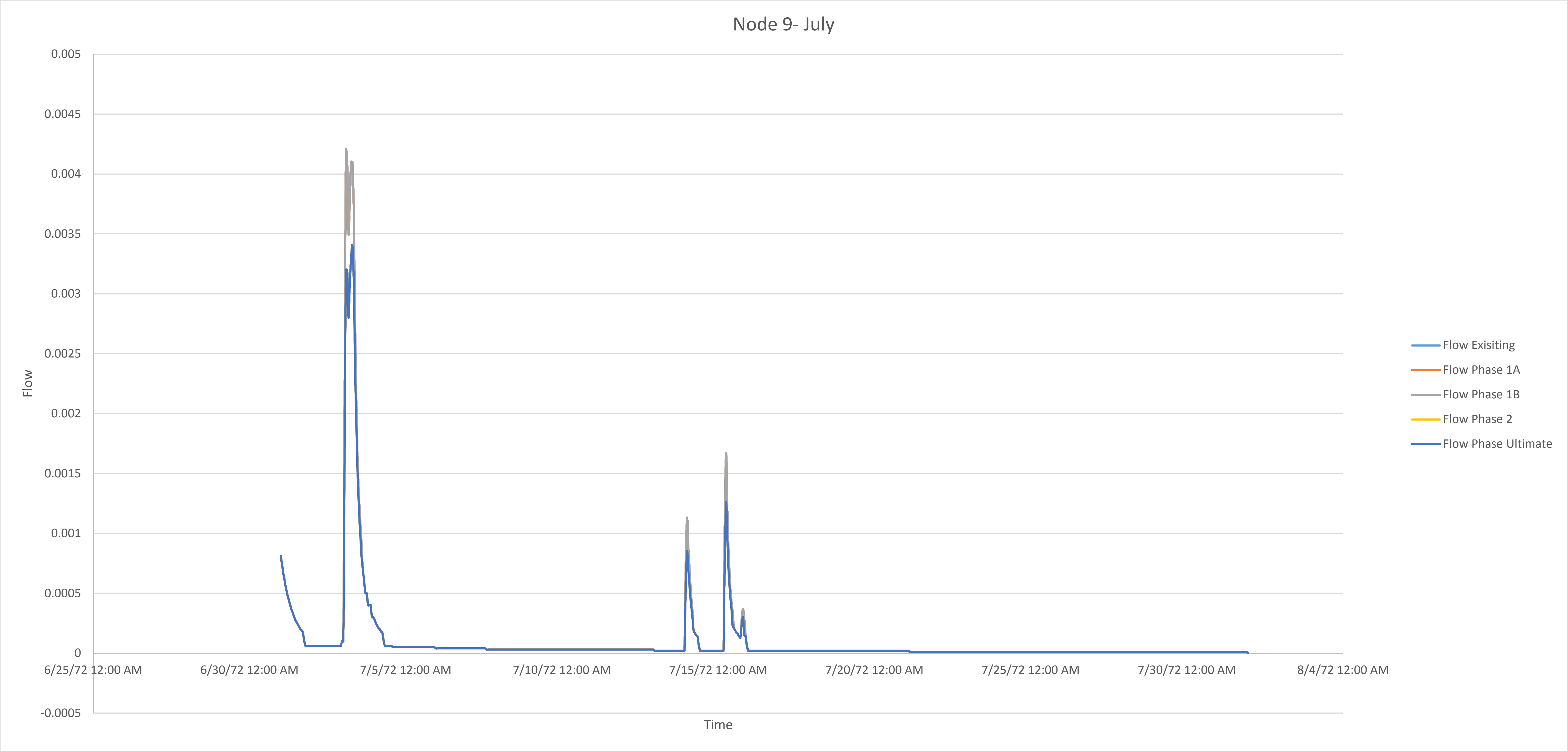
April						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		7	7	7	7	7
Magnitude (cm/s)	Max.	0.0324	0.0324	0.0324	0.0261	0.0261
	Min.	0.00118	0.00118	0.00118	0.00105	0.00105
Duration (h)	Max.	30	30	30	30	30
	Min.	8	8	8	8	8



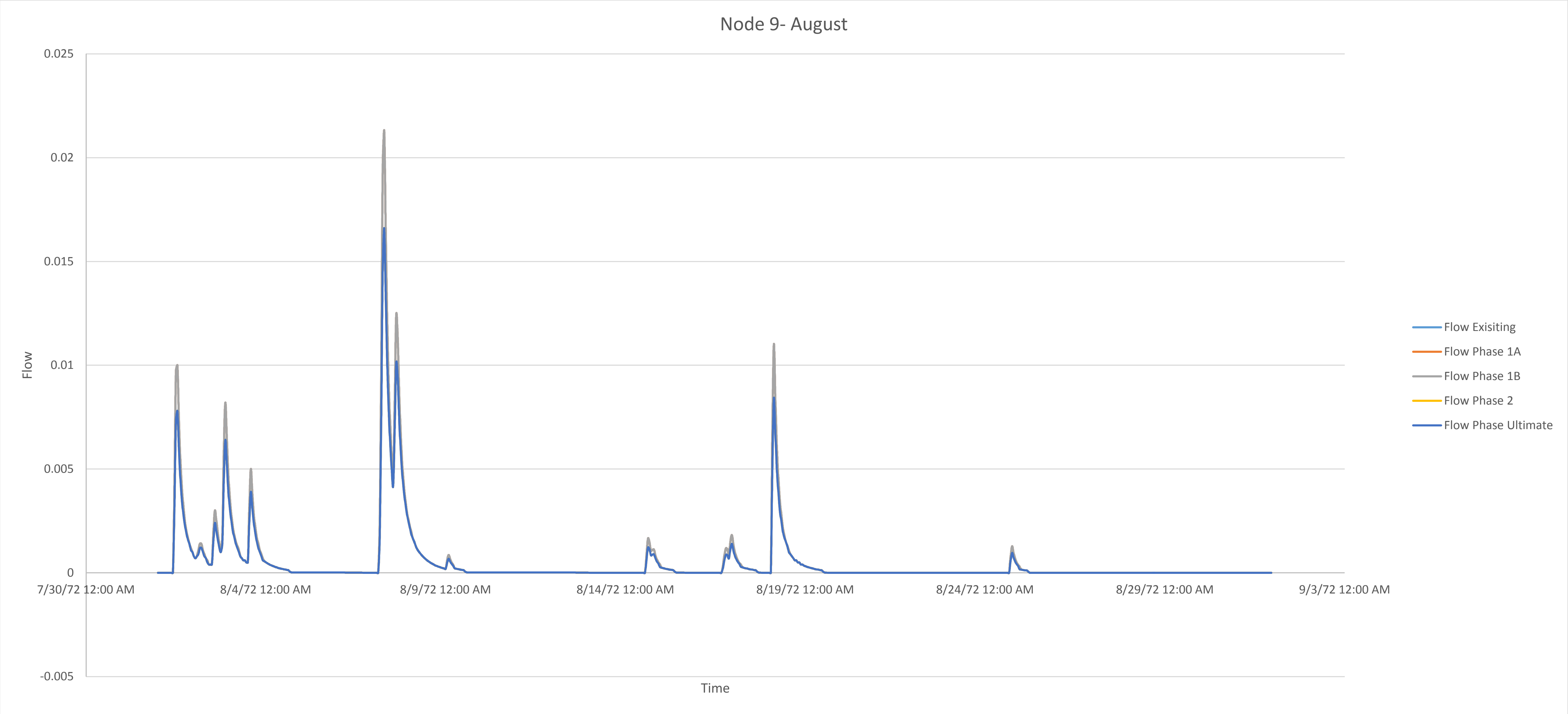
May						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		7	7	7	7	7
Magnitude (cm/s)	Max.	0.0332	0.0332	0.0332	0.0265	0.0265
	Min.	0.0022	0.0022	0.0022	0.00184	0.00184
Duration (h)	Max.	23	23	23	23	23
	Min.	10	10	10	9	9



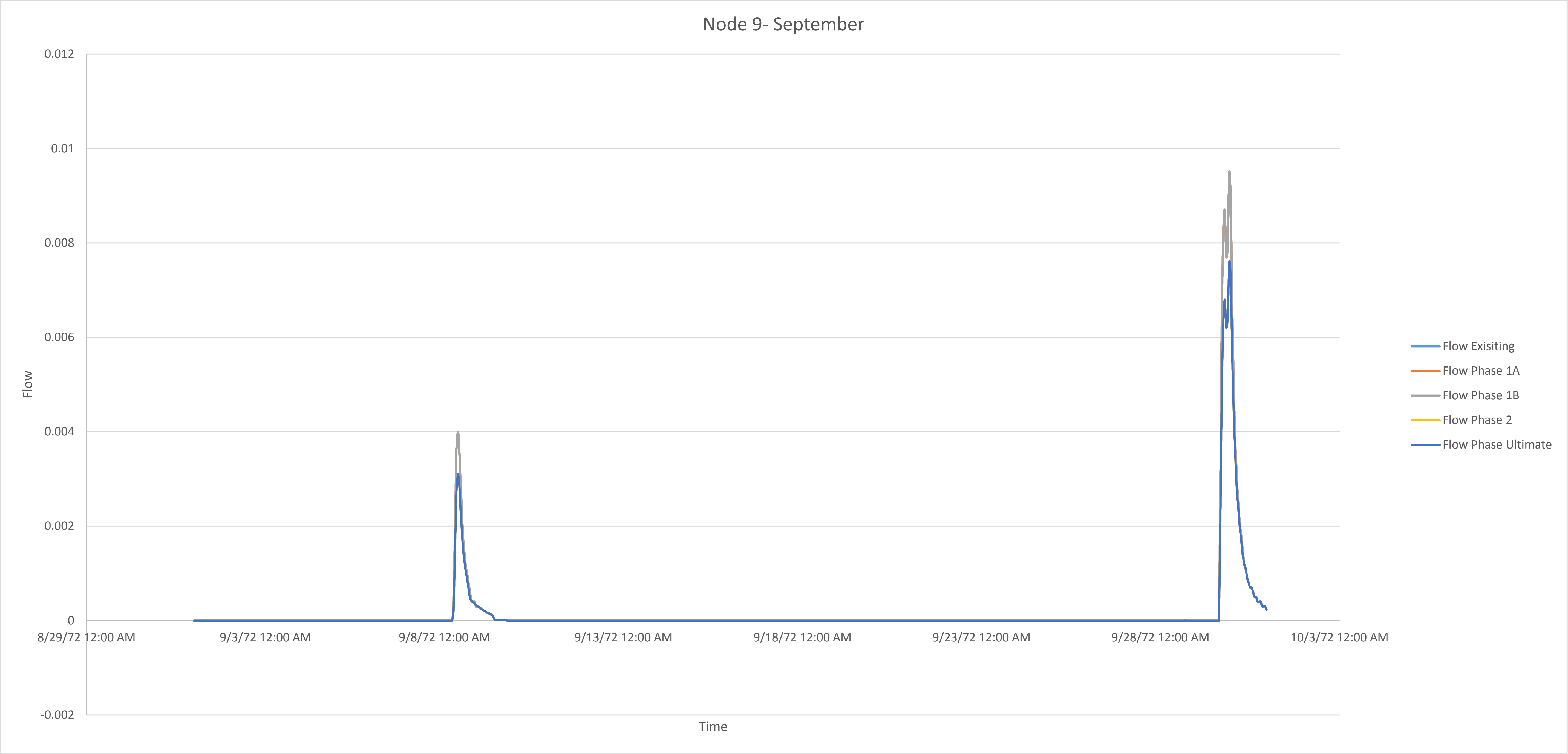
June						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		8	8	8	8	8
Magnitude (cm/s)	Max.	0.0225	0.0225	0.0225	0.0177	0.0177
	Min.	0.00335	0.00335	0.00335	0.00266	0.00266
Duration (h)	Max.	25	25	25	25	25
	Min.	13	13	13	13	13



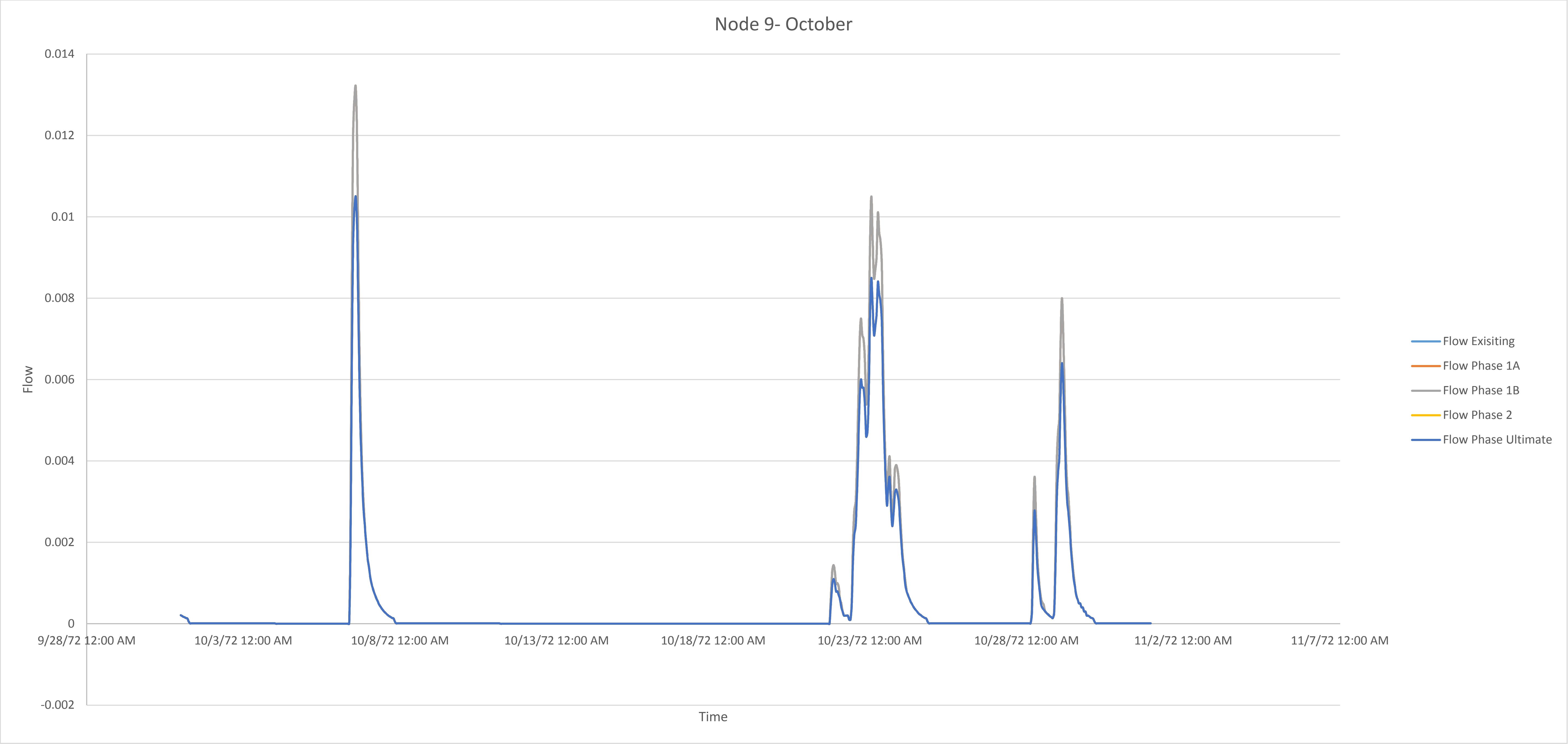
July						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		4	4	4	4	4
Magnitude (cm/s)	Max.	0.0042	0.0042	0.0042	0.0034	0.0034
	Min.	0.00037	0.00037	0.00037	0.0003	0.0003
Duration (h)	Max.	33	33	33	33	33
	Min.	5	5	5	5	5



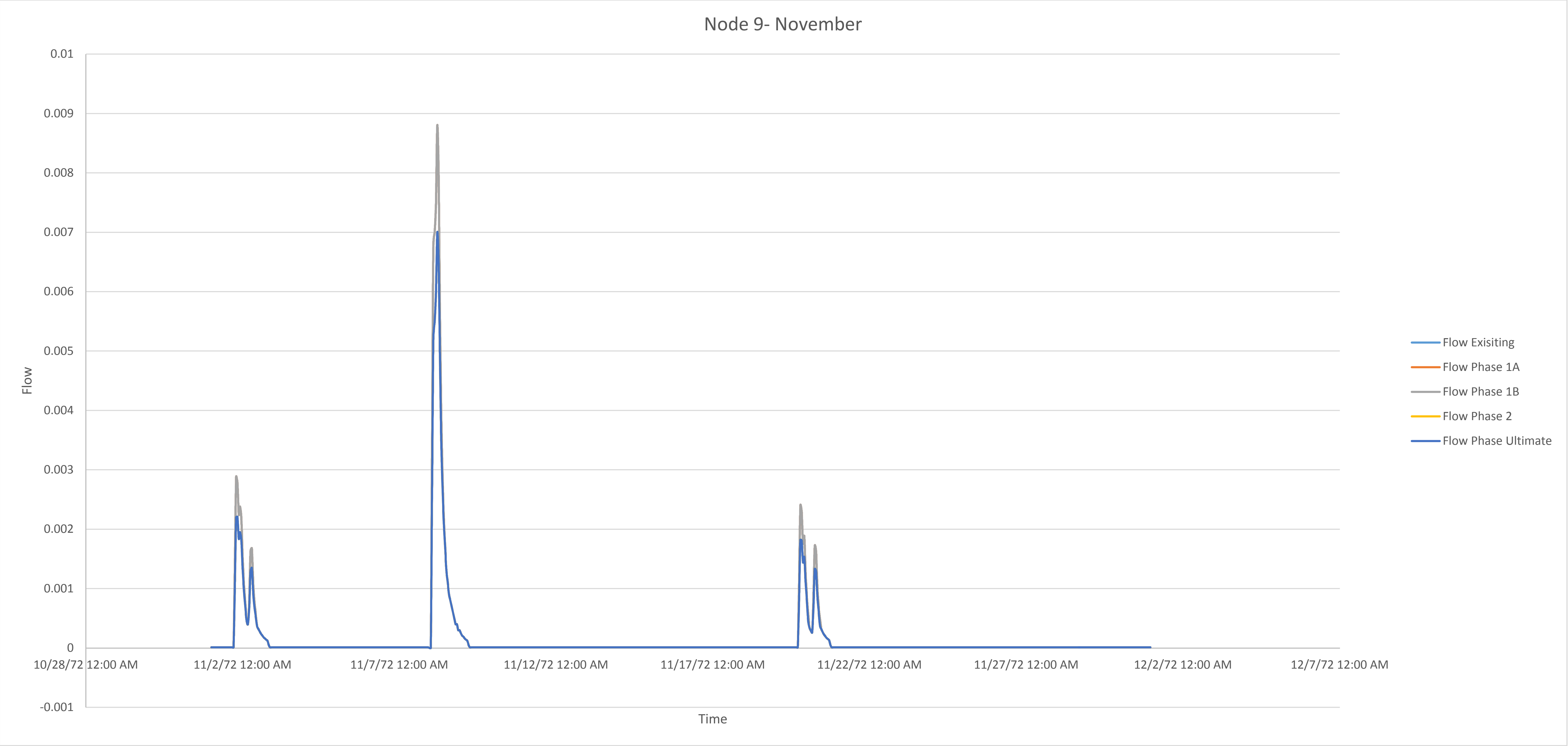
August						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		12	12	12	12	12
Magnitude (cm/s)	Max.	0.0213	0.0213	0.0213	0.0166	0.0166
	Min.	0.00086	0.00086	0.00086	0.00068	0.00068
Duration (h)	Max.	44	44	44	44	44
	Min.	13	13	13	13	13



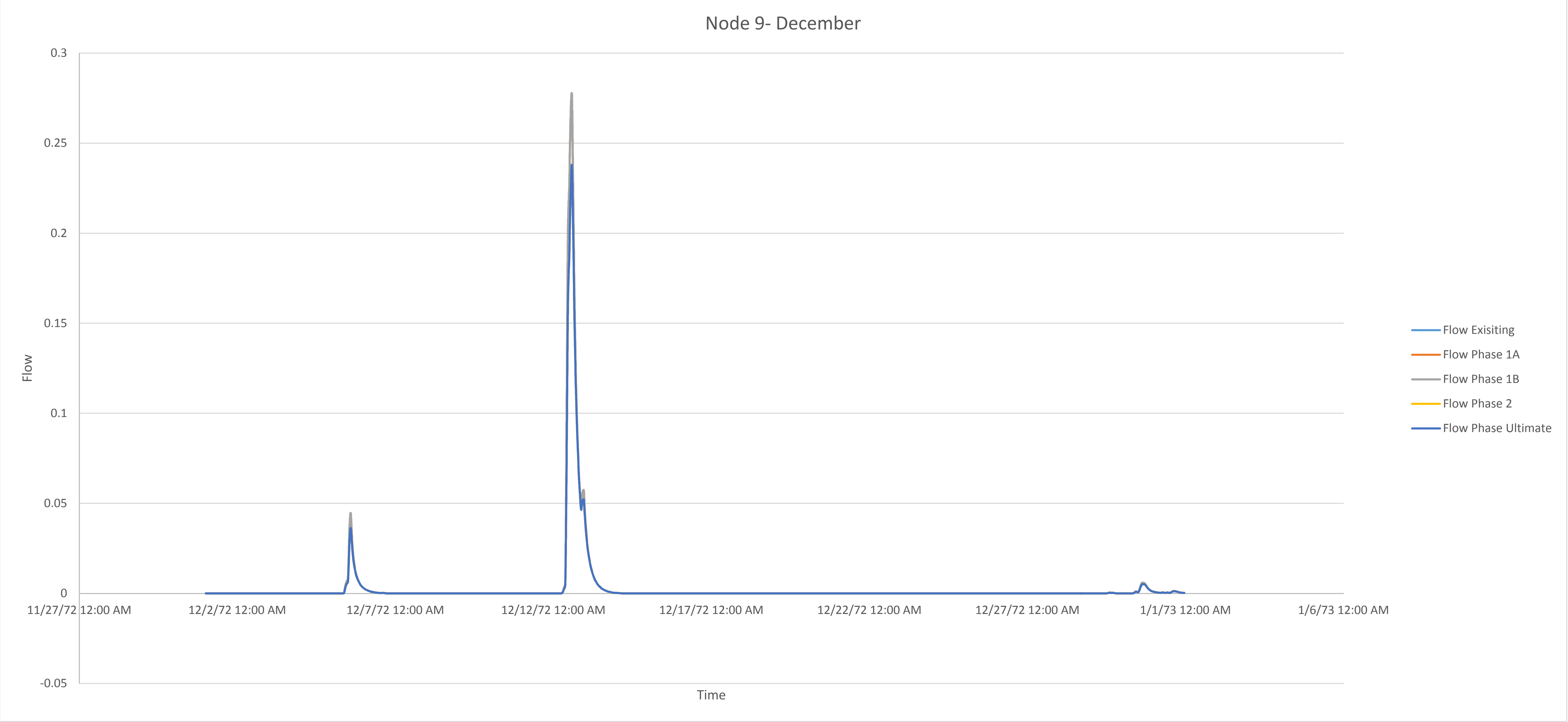
September						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		2	2	2	2	2
Magnitude (cm/s)	Max.	Not finished within this month				
	Min.	0.004	0.004	0.004	0.0031	0.0031
Duration (h)	Max.					
	Min.	36	36	36	36	36



October						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		9	9	9	9	9
Magnitude (cm/s)	Max.	0.0132	0.0132	0.0132	0.0105	0.0105
	Min.	0.00144	0.00144	0.00144	0.0011	0.0011
Duration (h)	Max.	35	35	35	35	35
	Min.	10	10	10	10	10

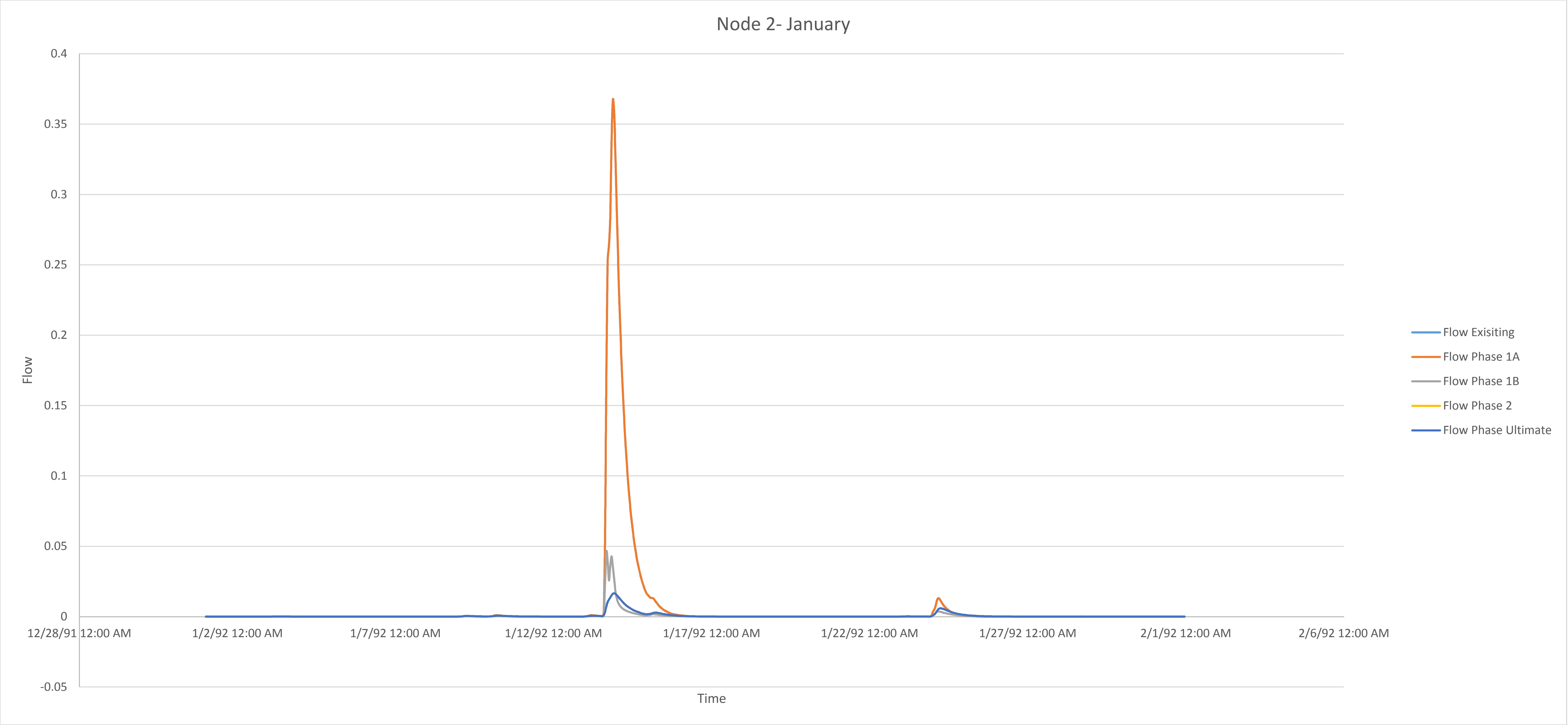


November						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitude (cm/s)	Max.	0.0088	0.0088	0.0088	0.007	0.007
	Min.	0.00172	0.00172	0.00172	0.00133	0.00133
Duration (h)	Max.	29	29	29	29	29
	Min.	14	14	14	14	14

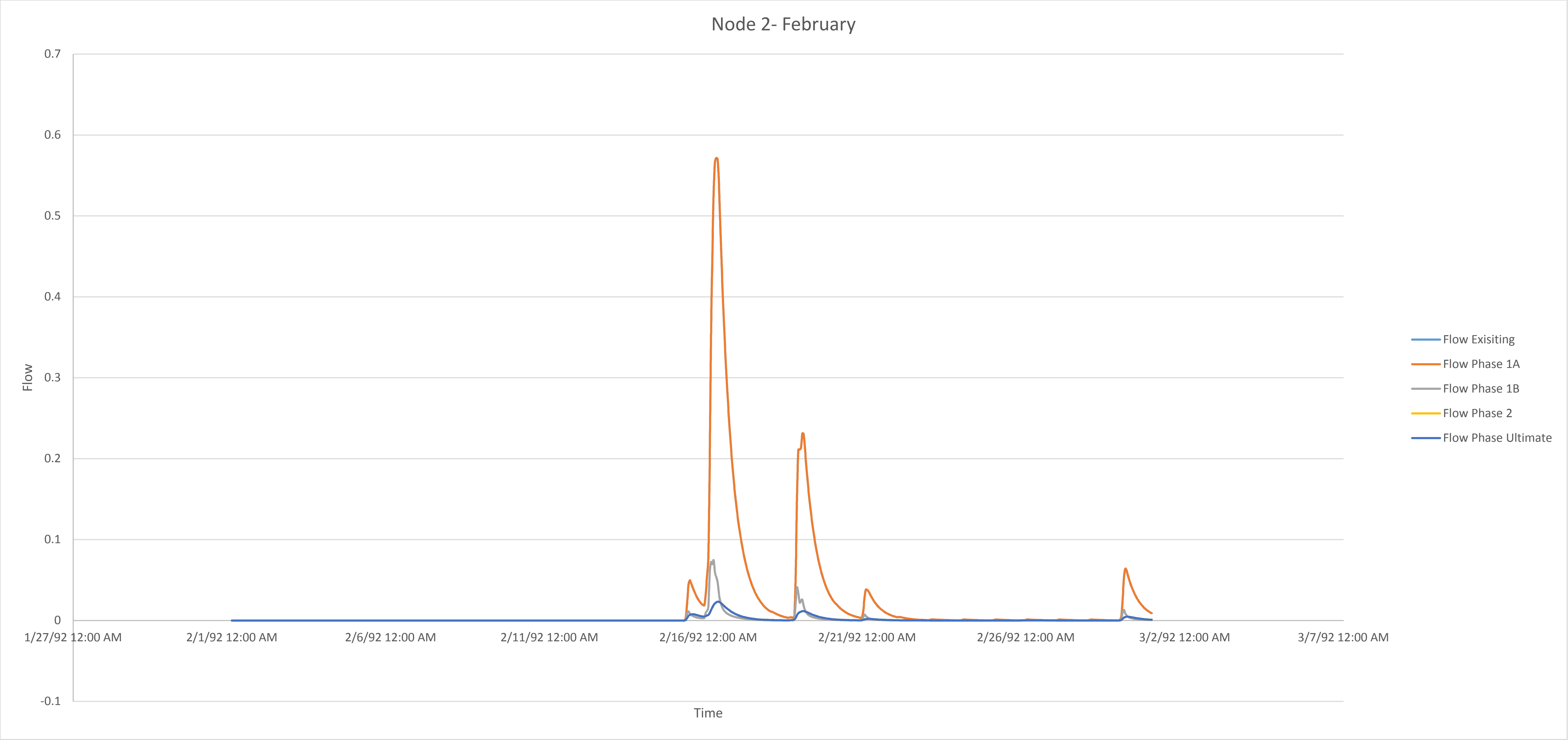


December						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		3	3	3	3	3
Magnitude (cm/s)	Max.	0.2764	0.2764	0.2764	0.2373	0.2373
	Min.	0.00105	0.00105	0.00105	0.00105	0.00105
Duration (h)	Max.	45	45	45	45	45
	Min.	7	7	7	7	7

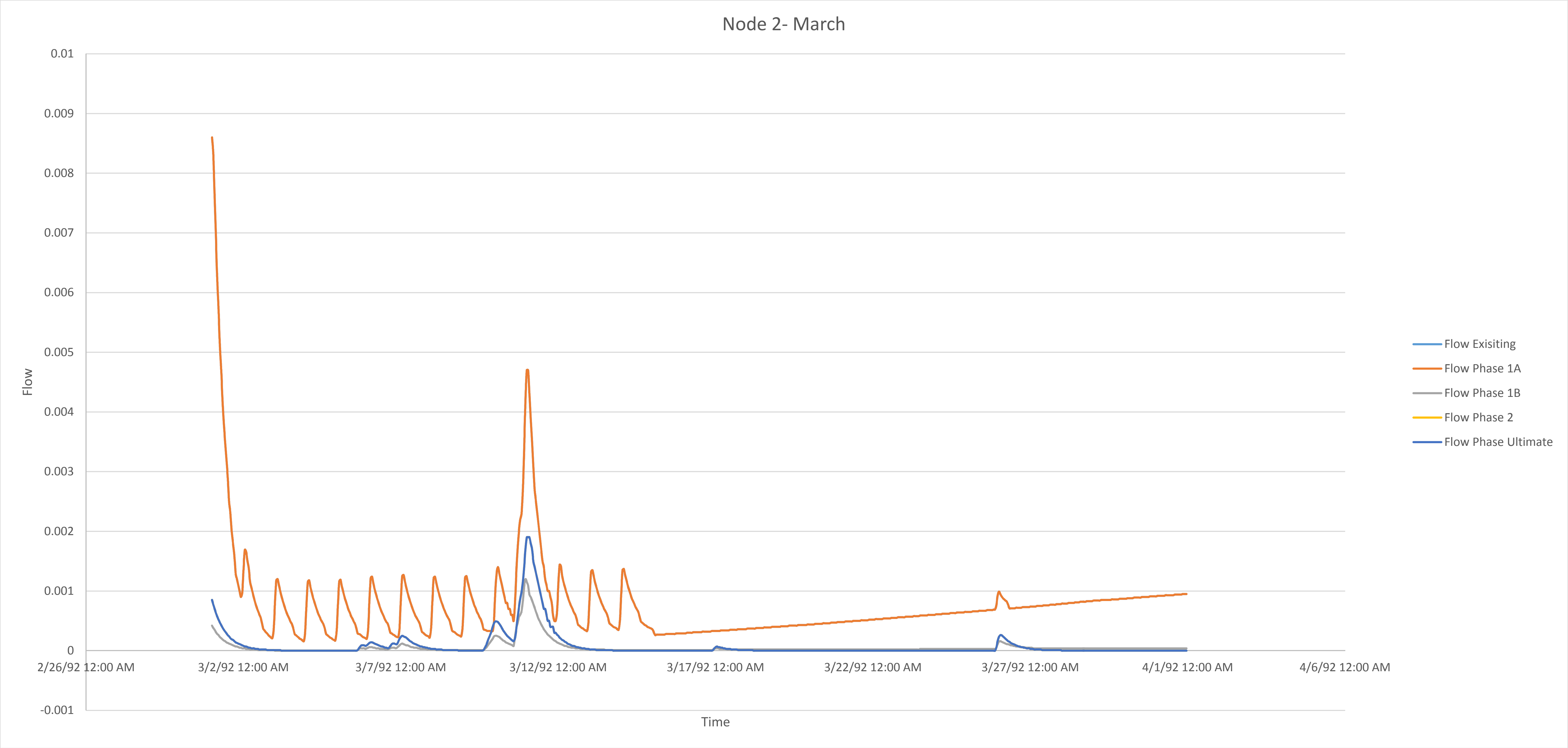
Wet Year-1992



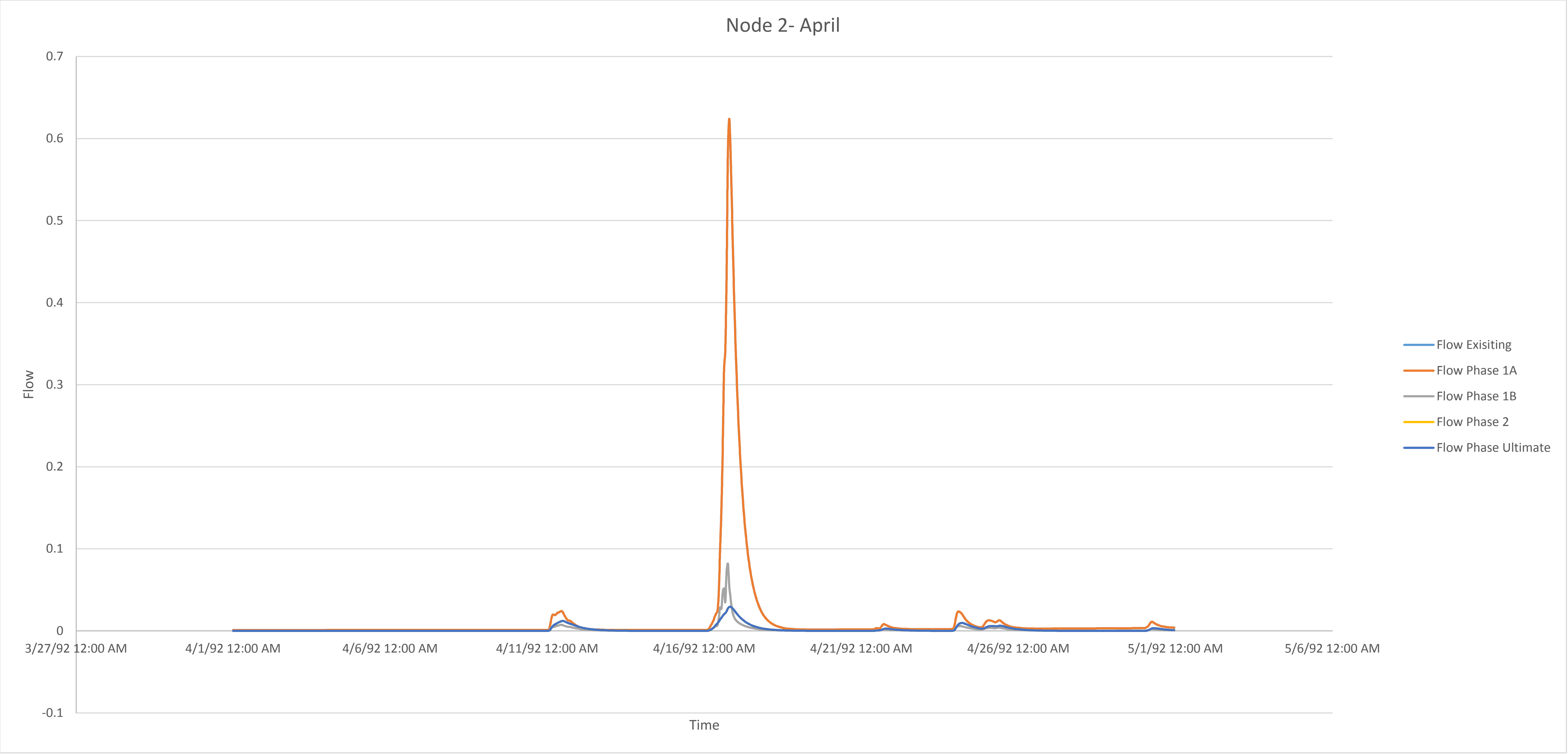
January						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		4	4	8	8	8
Magnitudes (cm/s)	Max.	0.3675	0.3675	0.0461	0.0166	0.0166
	Min.	0.00034	0.00034	0.00005	0.0001	0.0001
Duration (h)	Max.	87	87	101	109	109
	Min.	14	14	21	38	38



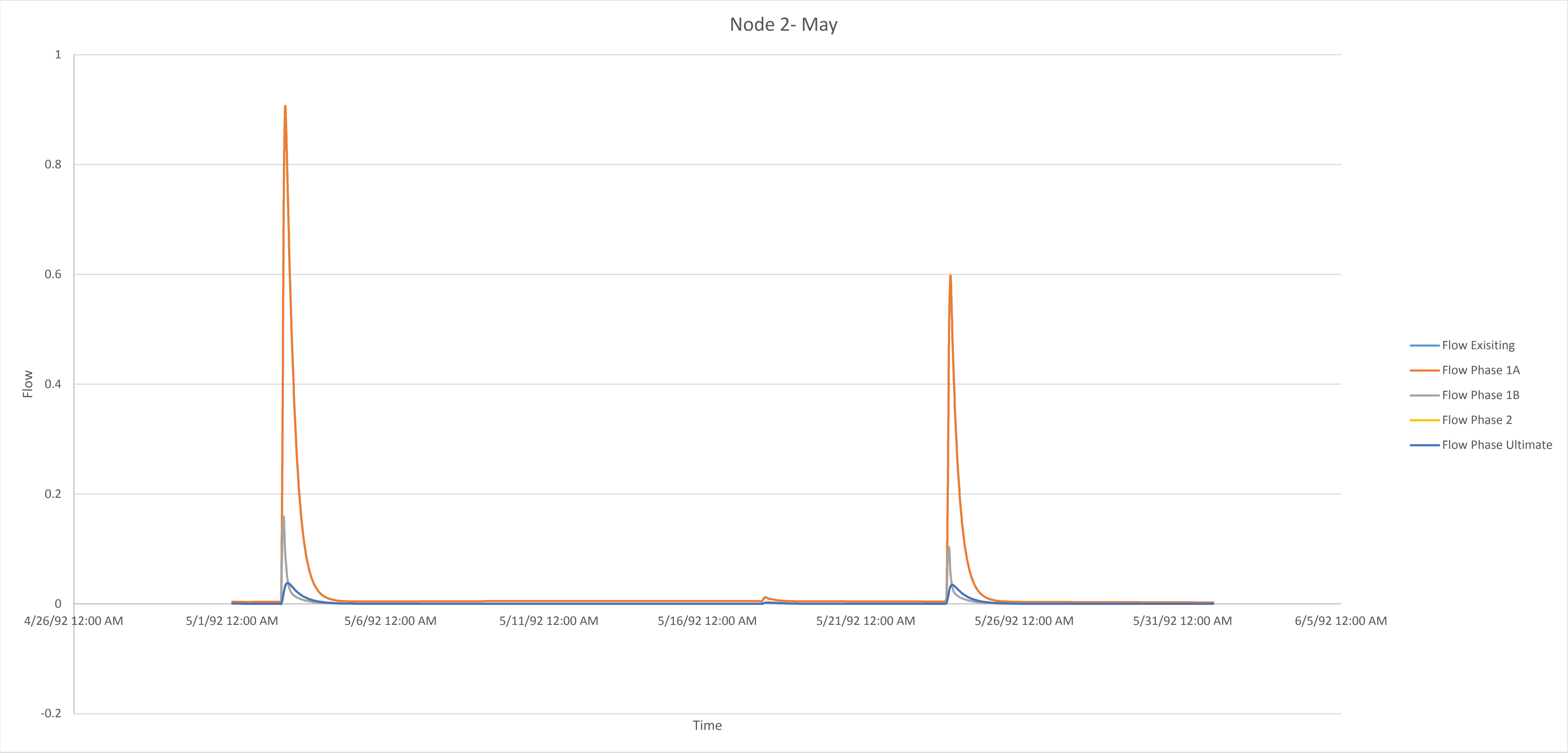
February						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitudes (cm/s)	Max.	0.5716	0.5716	0.0744	0.0232	0.0232
	Min.	0.00118	0.00118	0.00009	0.00018	0.00018
Duration (h)	Max.	65	65	71	74	74
	Min.	23	23	34	43	43



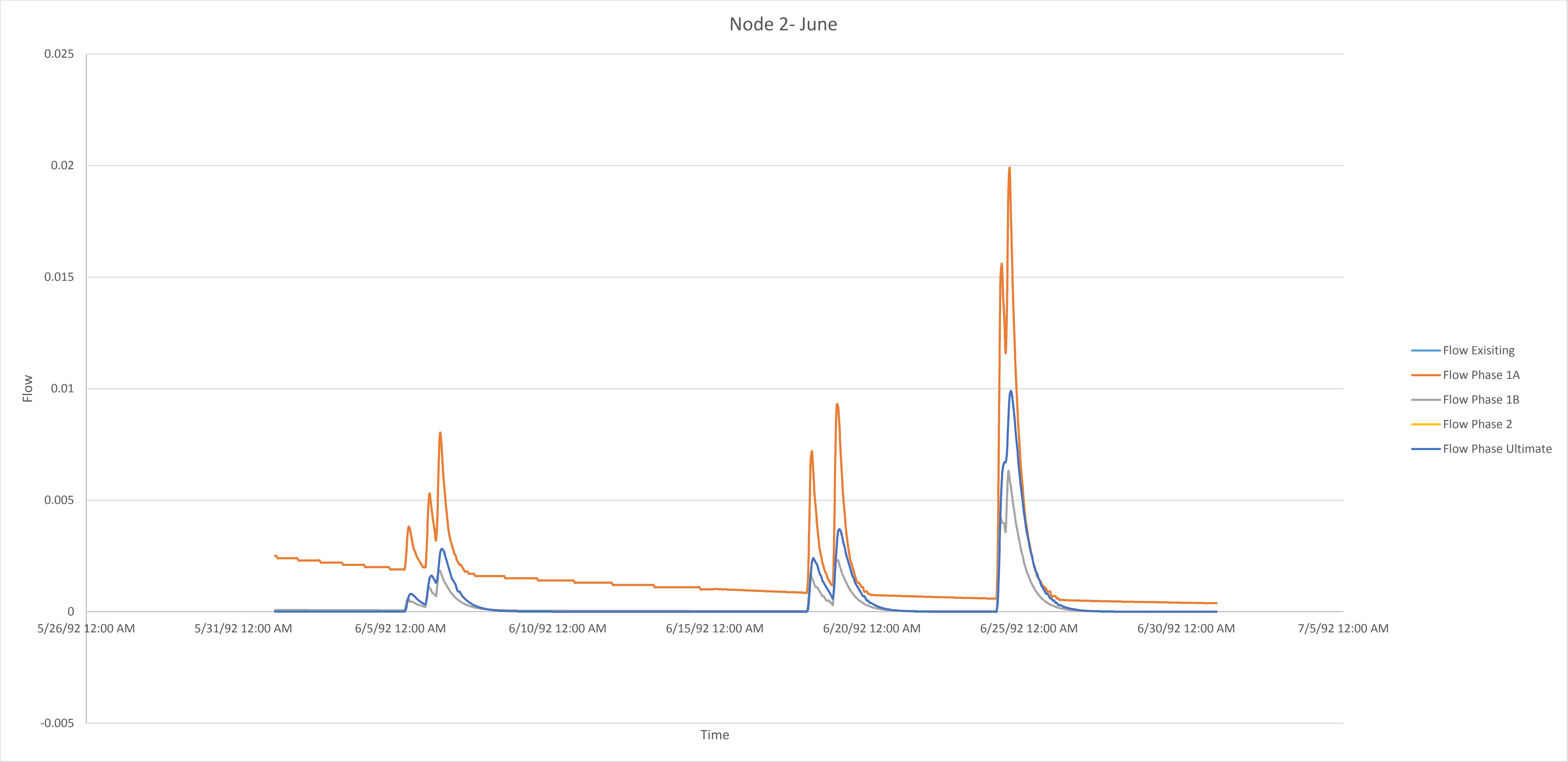
March						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		14	14	6	6	6
Magnitudes (cm/s)	Max.	0.0047	0.0047	0.0012	0.0019	0.0019
	Min.	0.00099	0.00099	0.00004	0.00007	0.00007
Duration (h)	Max.	30	30	38	38	38
	Min.	14	14	11	31	31



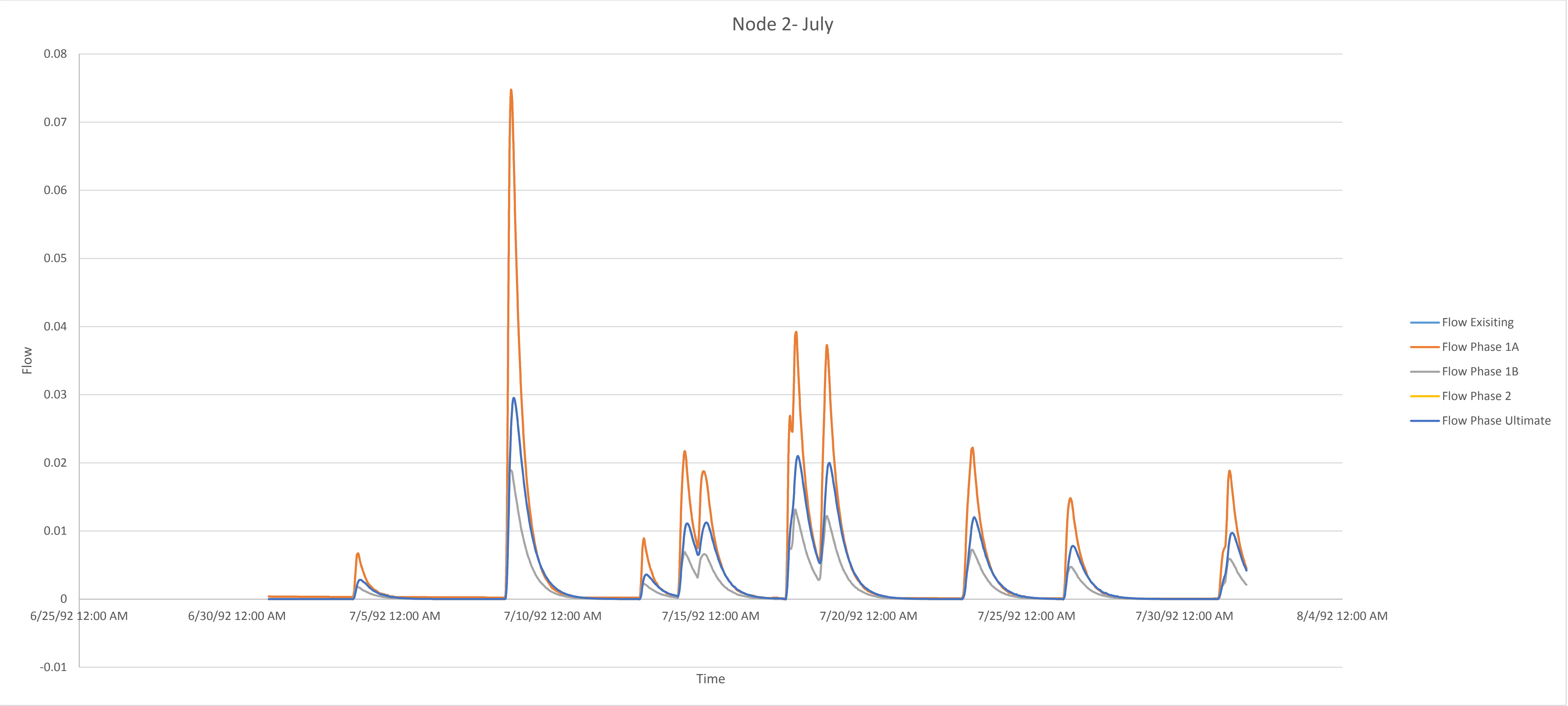
April						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitudes (cm/s)	Max.	0.624	0.624	0.0817	0.0293	0.0293
	Min.	0.0082	0.0082	0.00179	0.00267	0.00267
Duration (h)	Max.	79	79	94	98	98
	Min.	33	33	44	57	57



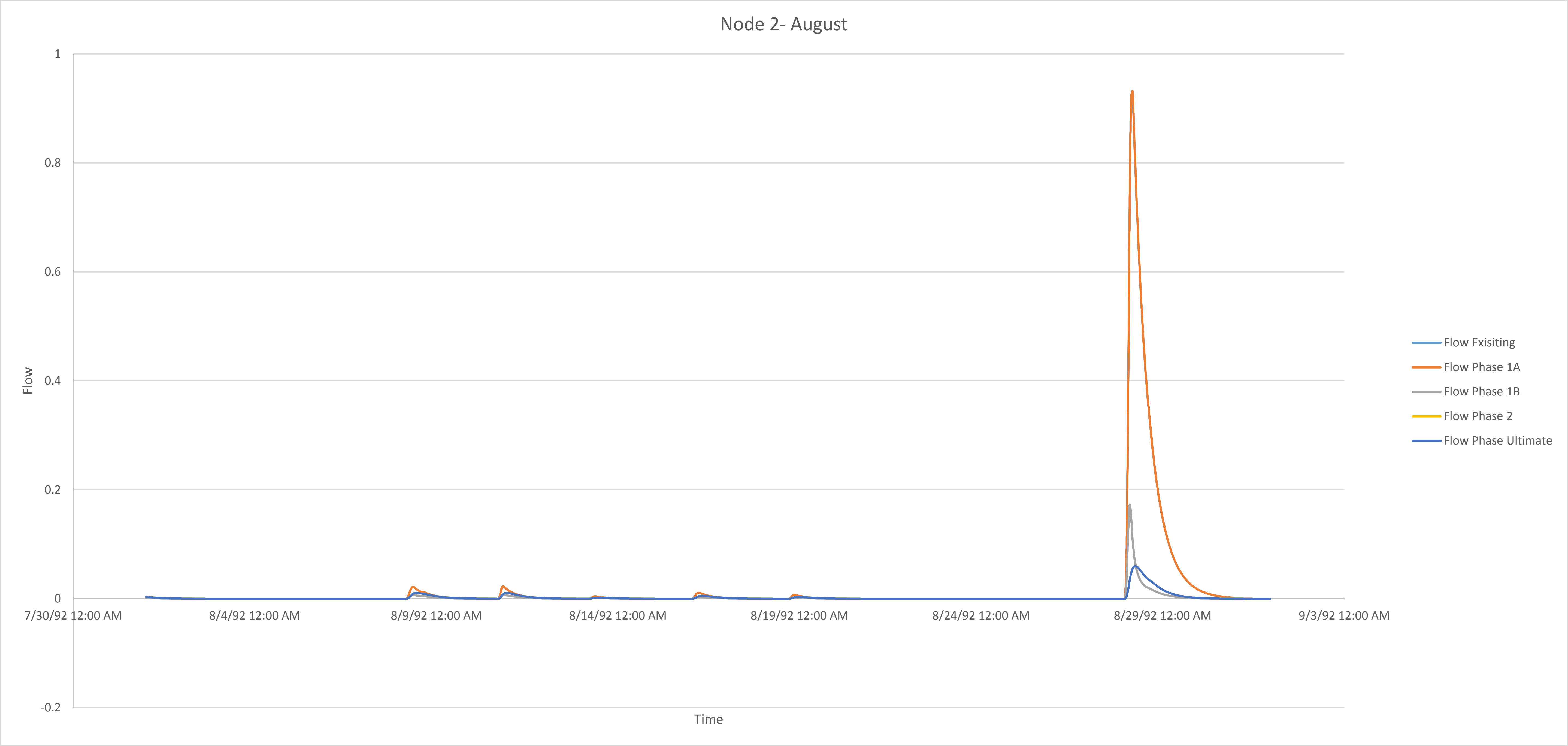
May						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		4	4	4	4	4
Magnitudes (cm/s)	Max.	0.9027	0.9027	0.1589	0.038	0.038
	Min.	0.0051	0.0051	0.00027	0.00021	0.00021
Duration (h)	Max.	60	60	77	66	66
	Min.	7	7	22	21	21



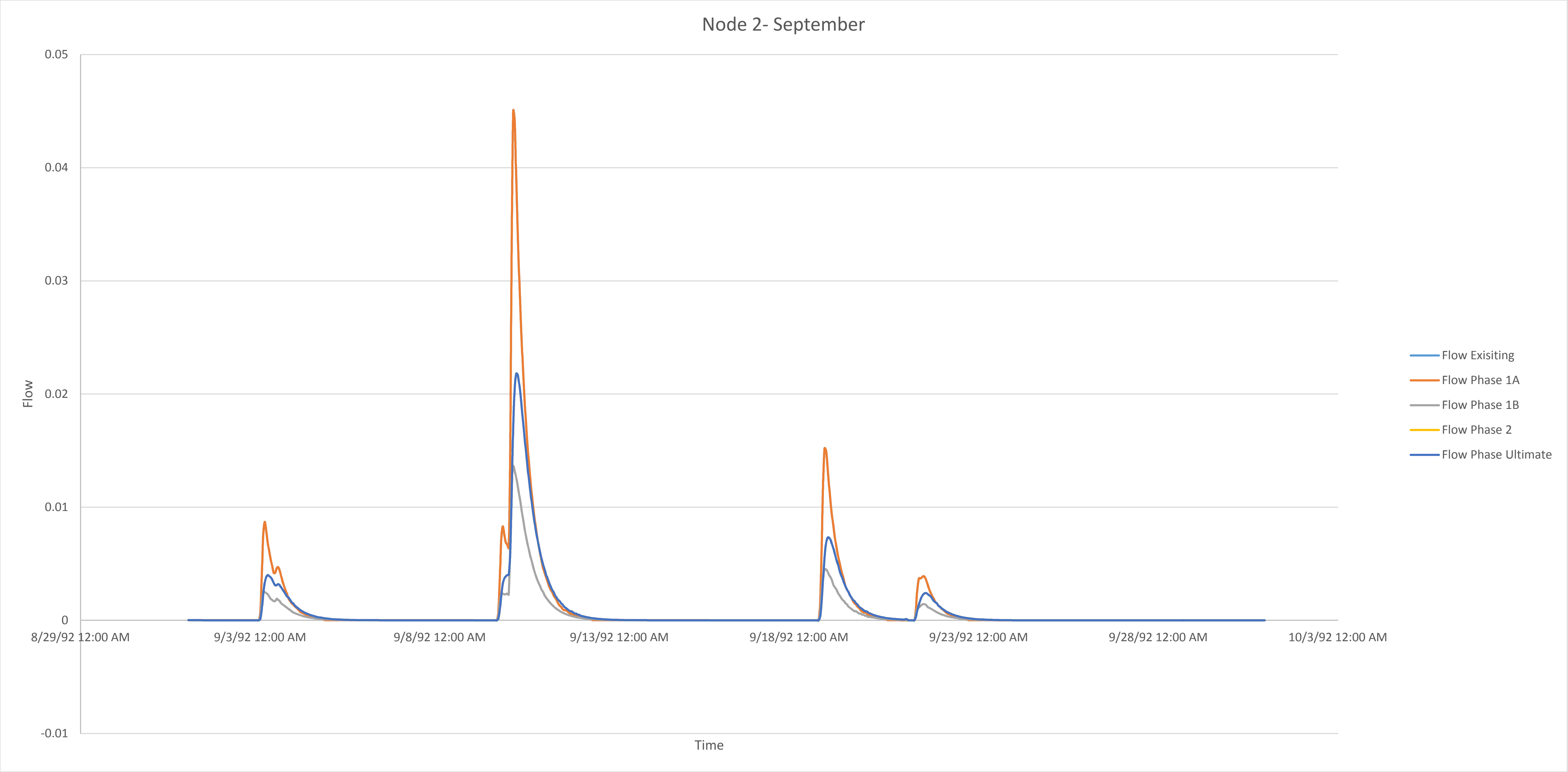
June						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		7	7	7	6	6
Magnitudes (cm/s)	Max.	0.0199	0.0199	0.0063	0.0099	0.0099
	Min.	0.0038	0.0038	0.00058	0.0008	0.0008
Duration (h)	Max.	46	46	89	89	89
	Min.	13	13	14	14	14



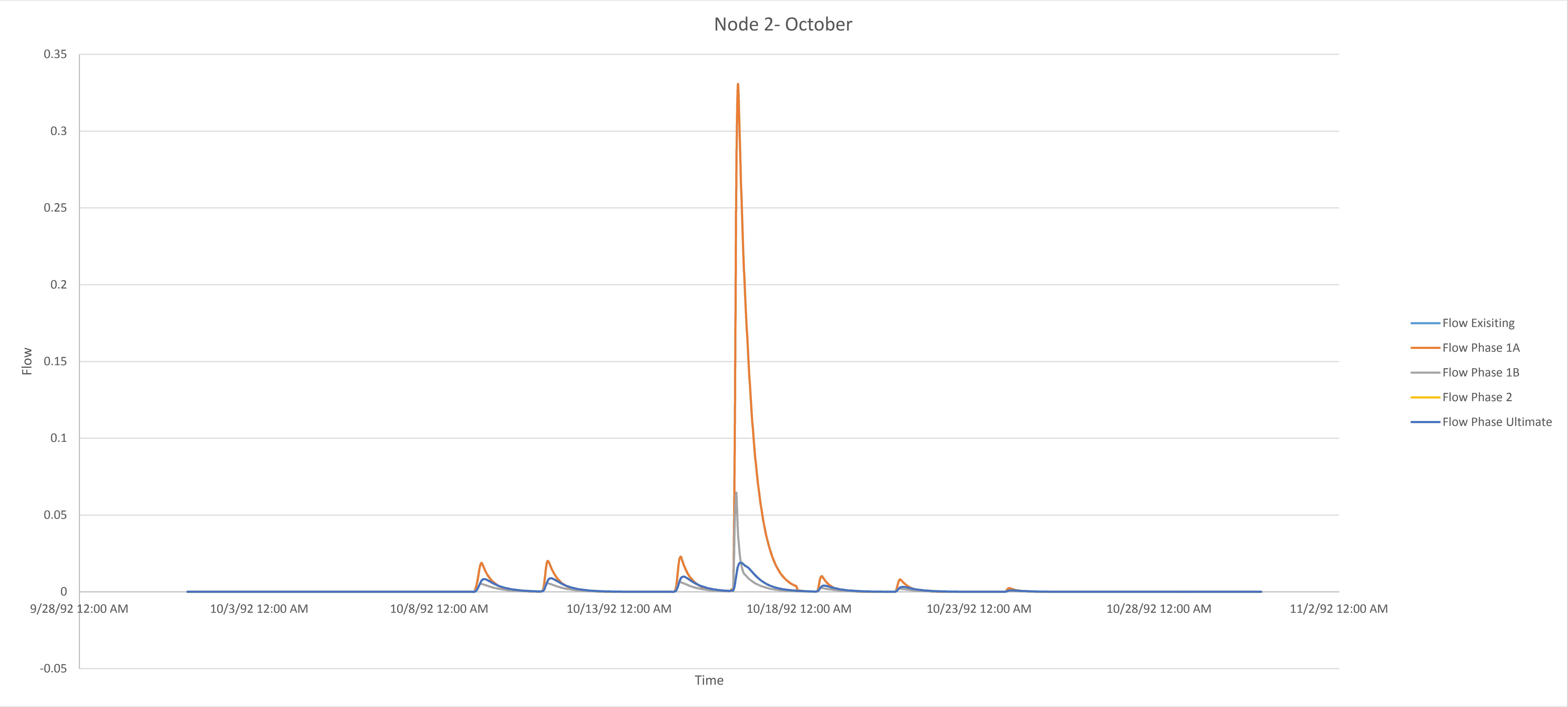
July						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		10	10	10	10	10
Magnitudes (cm/s)	Max.	0.0746	0.0746	0.0189	0.0295	0.0295
	Min.	0.0067	0.0067	0.00182	0.00281	0.00281
Duration (h)	Max.	95	95	98	98	98
	Min.	31	31	34	40	40



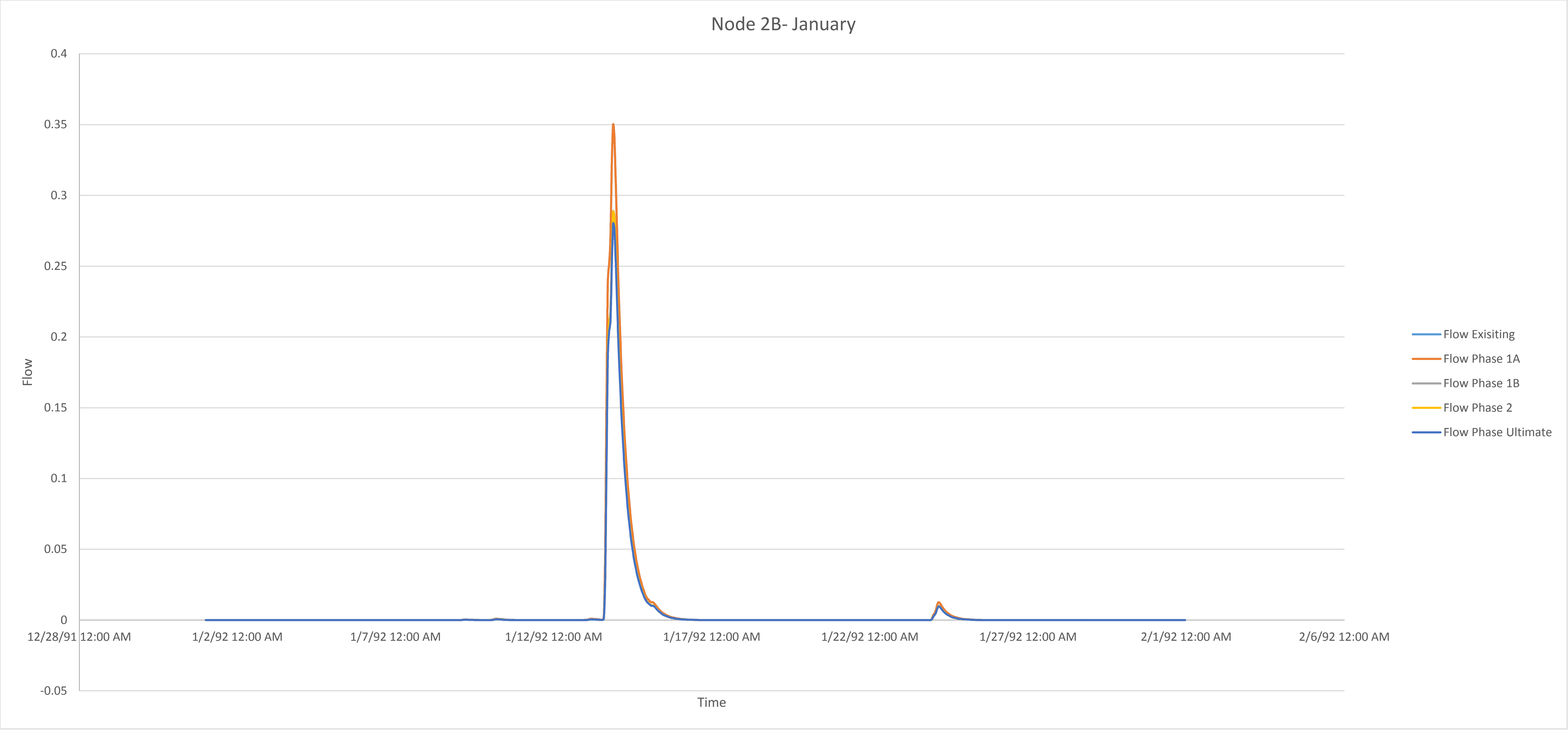
August						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitudes (cm/s)	Max.	0.9313	0.9313	0.1716	0.0598	0.0598
	Min.	0.0045	0.0045	0.00143	0.0023	0.0023
Duration (h)	Max.	84	84	82	89	89
	Min.	35	35	52	59	59



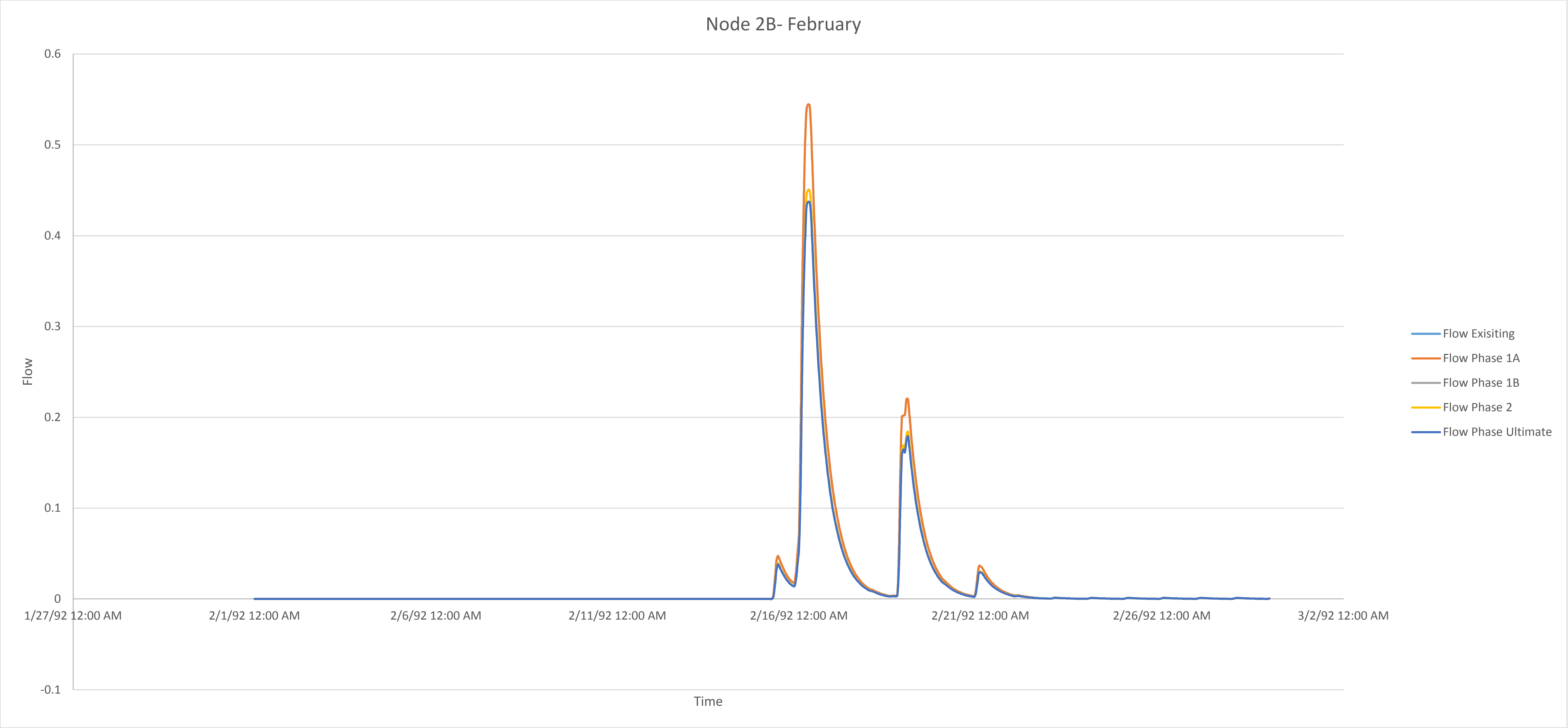
September						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		4	4	4	4	4
Magnitudes (cm/s)	Max.	0.045	0.045	0.0136	0.0218	0.0218
	Min.	0.0039	0.0039	0.00144	0.0024	0.0024
Duration (h)	Max.	63	63	77	84	84
	Min.	35	35	49	56	56



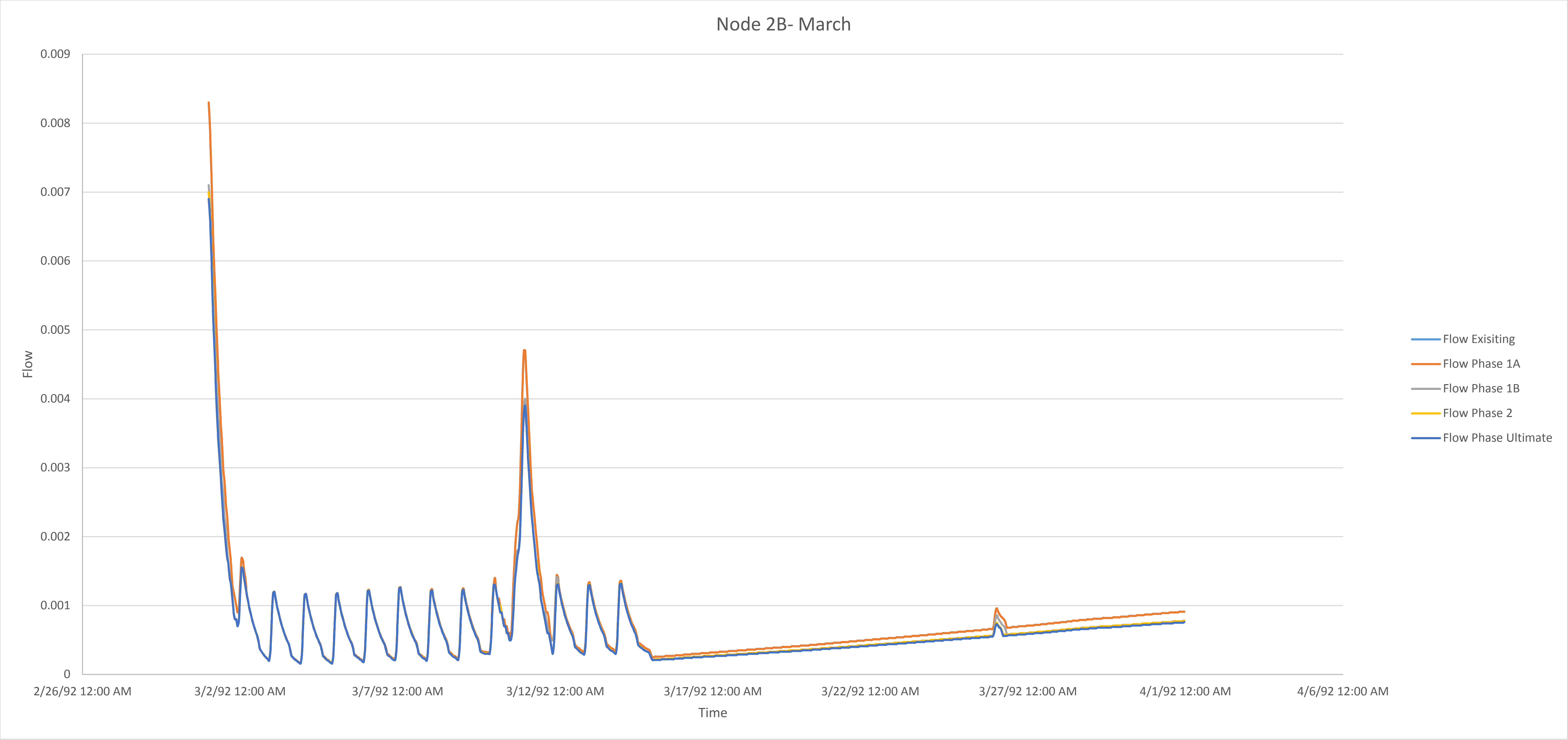
October						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		7	7	7	7	7
Magnitudes (cm/s)	Max.	0.3294	0.3294	0.0646	0.019	0.019
	Min.	0.00242	0.00242	0.00067	0.00097	0.00097
Duration (h)	Max.	87	87	97	104	104
	Min.	20	20	41	48	48



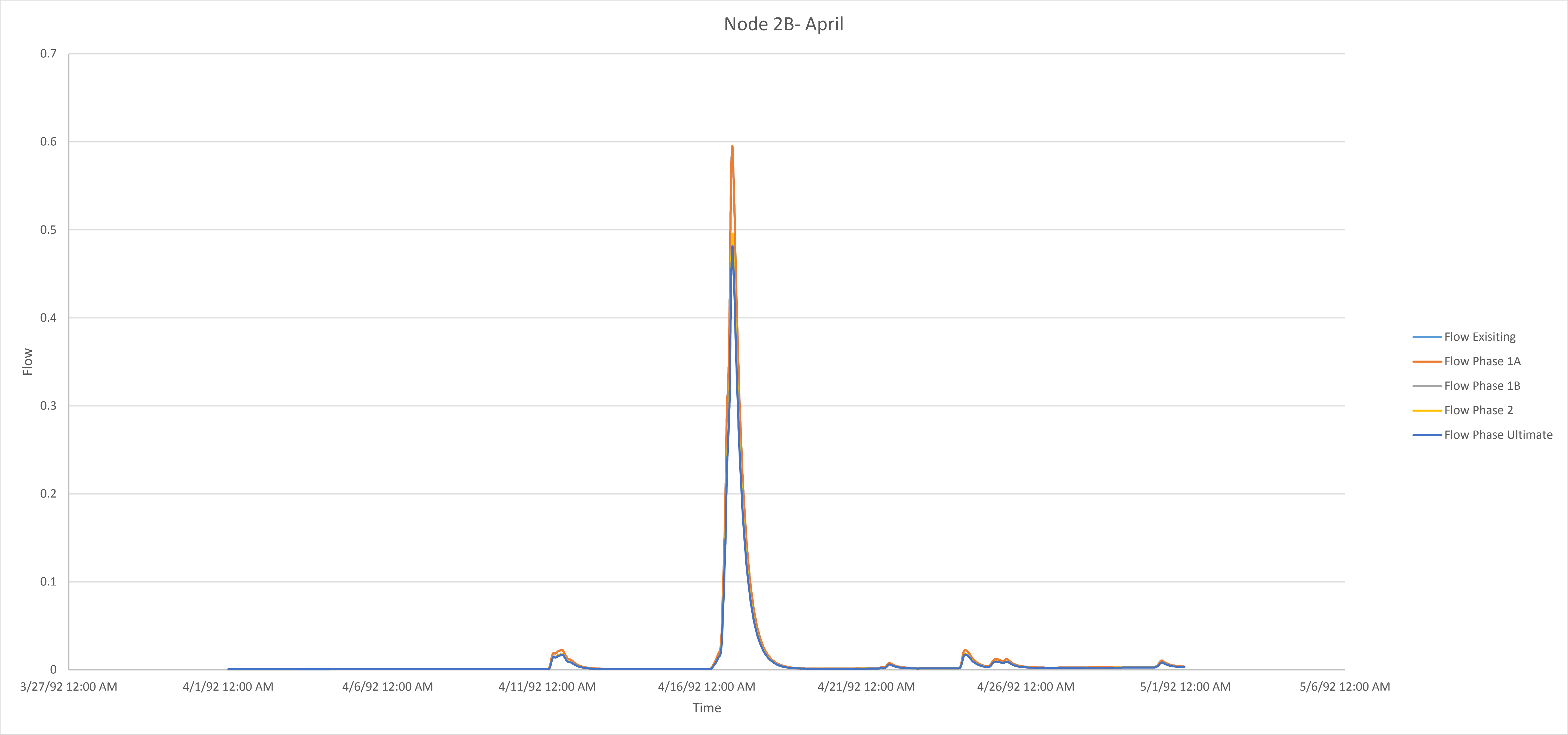
January						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		5	5	5	5	5
Magnitude (cm/s)	Max.	0.3499	0.3499	0.2885	0.2882	0.2799
	Min.	0.00034	0.00034	0.00034	0.00021	0.00021
Duration (h)	Max.	73	73	73	73	73
	Min.	14	14	14	10	10



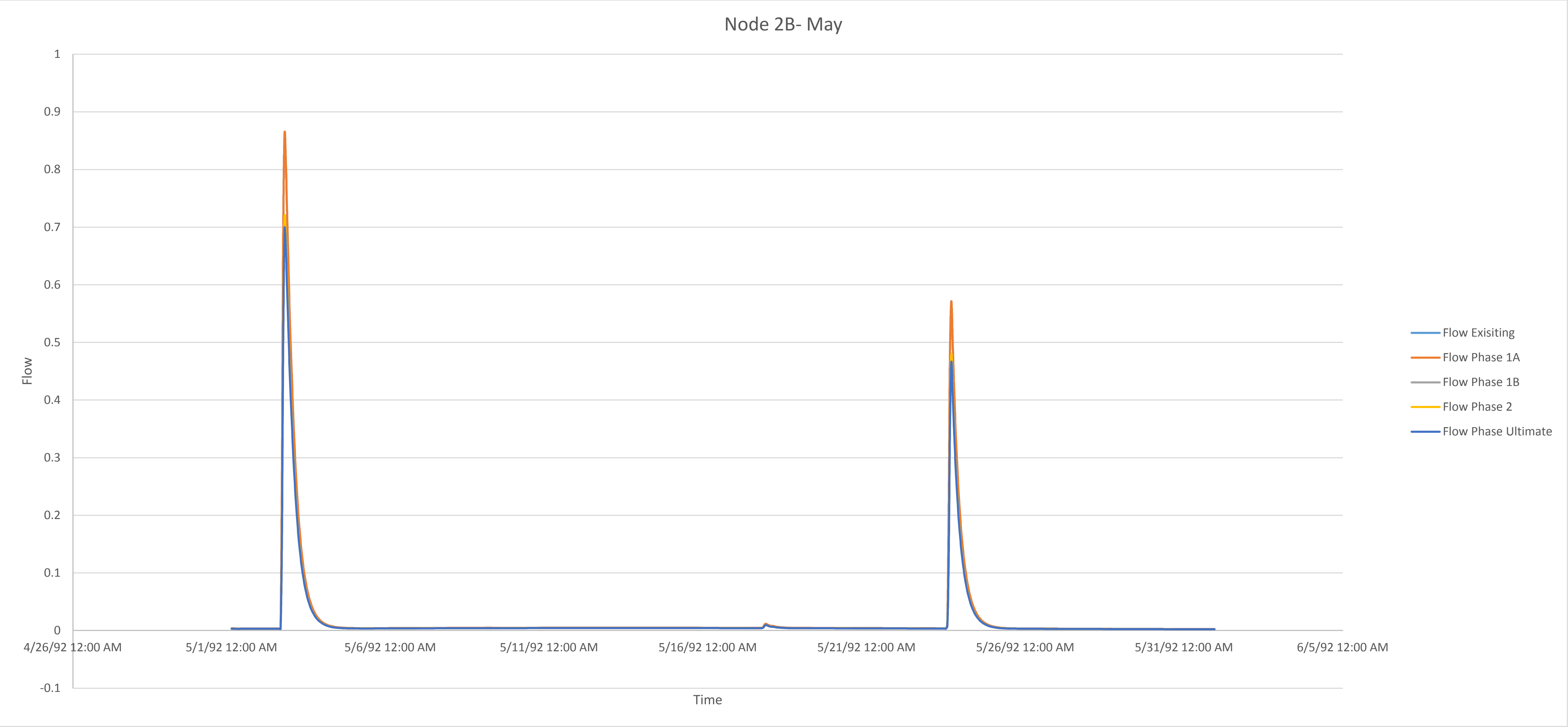
February						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		11	11	11	11	11
Magnitude (cm/s)	Max.	0.5446	0.5446	0.4504	0.4499	0.4372
	Min.	0.00114	0.00114	0.00114	0.00114	0.00114
Duration (h)	Max.	44	44	44	44	44
	Min.	20	20	20	20	20



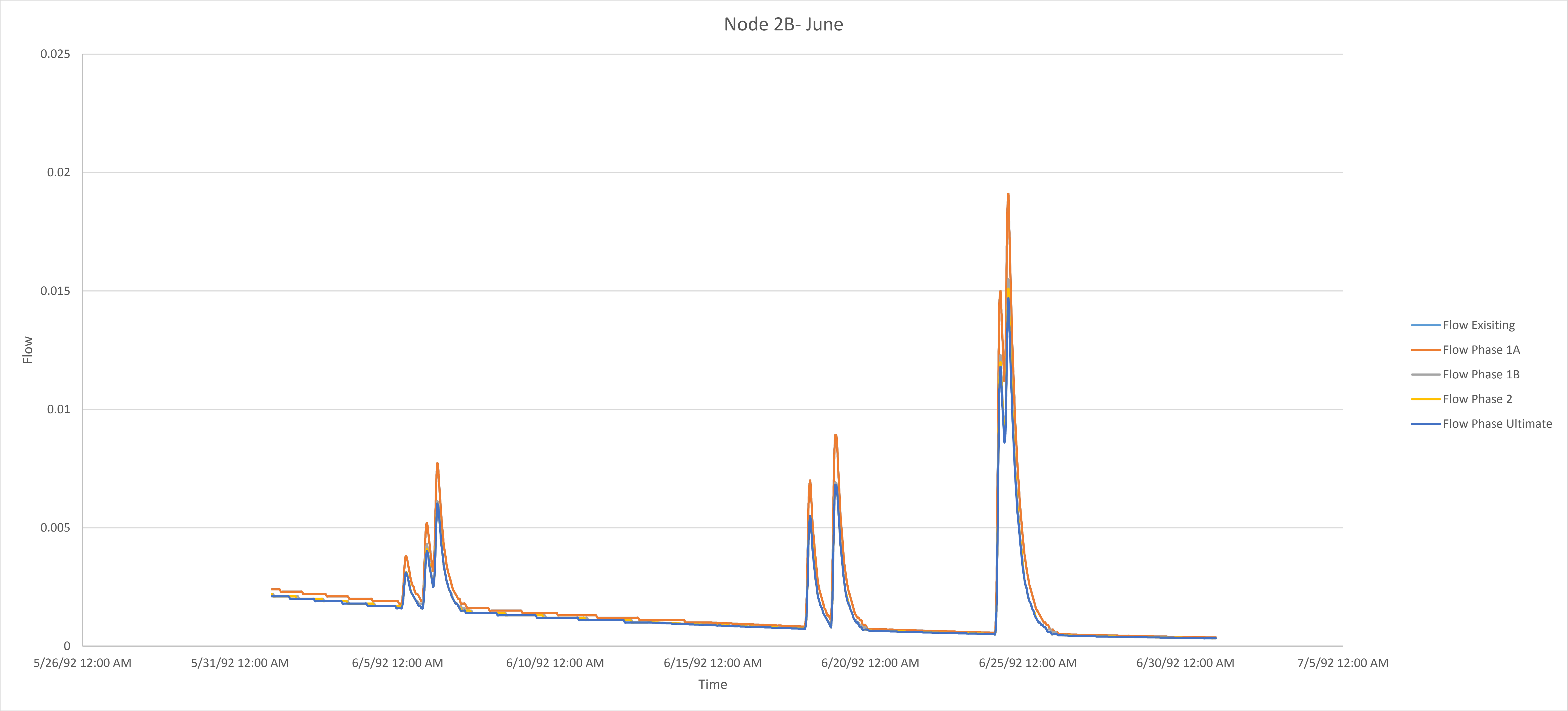
March						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		14	14	14	14	14
Magnitude (cm/s)	Max.	0.0047	0.0047	0.004	0.0039	0.0039
	Min.	0.00096	0.00096	0.00086	0.00075	0.00073
Duration (h)	Max.	30	30	29	29	29
	Min.	10	10	10	10	7



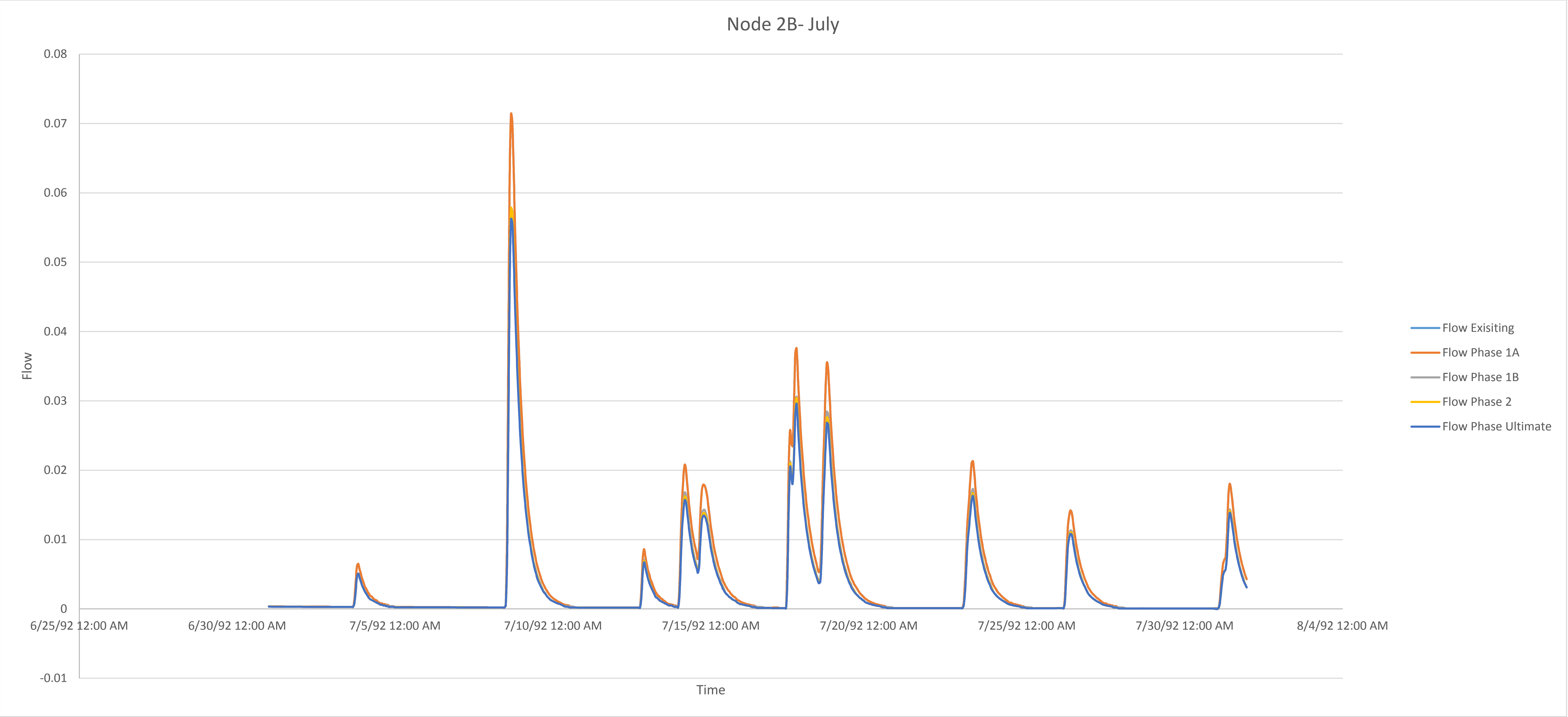
April						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitude (cm/s)	Max.	0.5952	0.5952	0.495	0.4952	0.4809
	Min.	0.0079	0.0079	0.0062	0.0062	0.0062
Duration (h)	Max.	69	69	65	65	65
	Min.	24	24	16	16	16



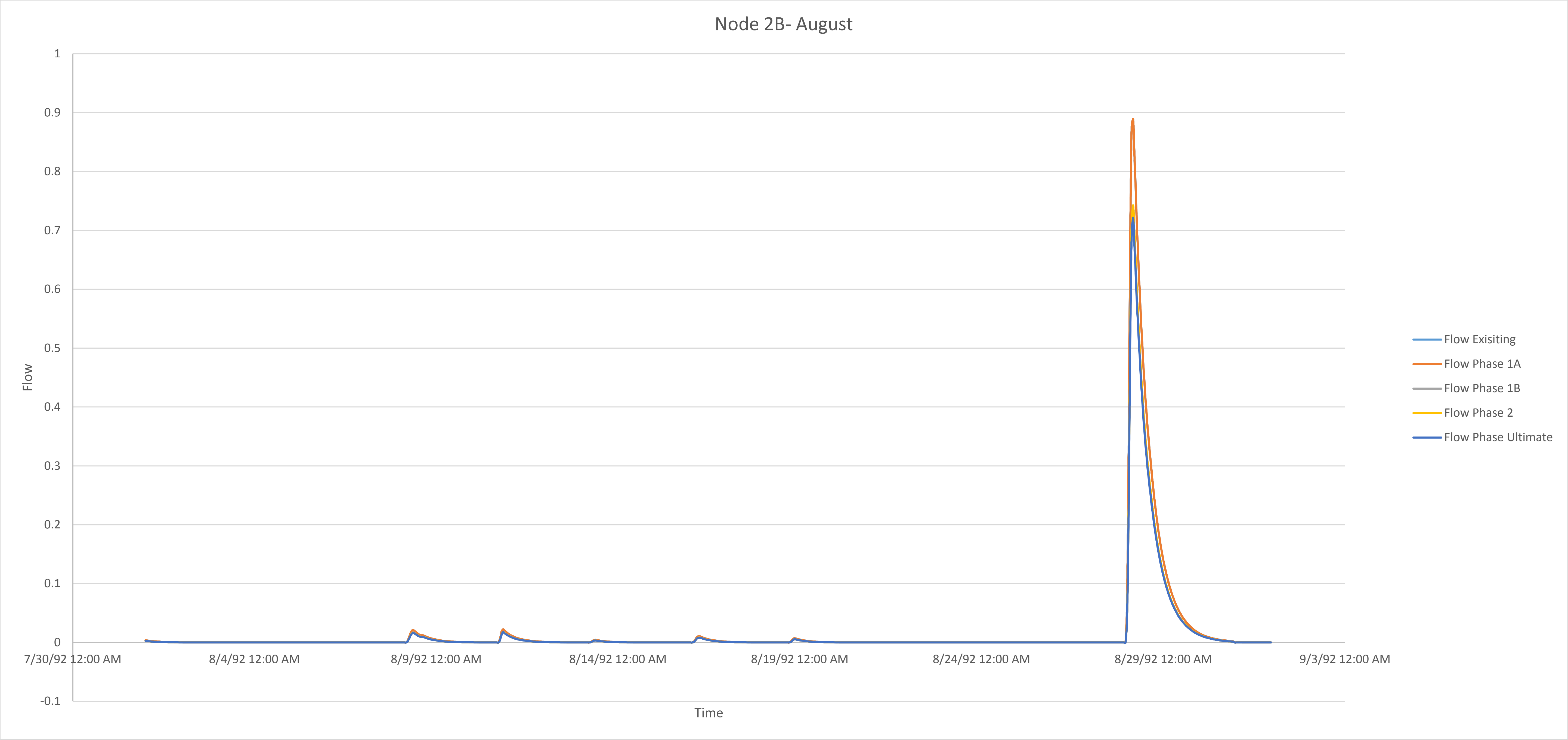
May						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		3	3	3	3	3
Magnitude (cm/s)	Max.	0.861	0.861	0.7158	0.7164	0.6955
	Min.	0.0116	0.0116	0.0096	0.0096	0.0096
Duration (h)	Max.	41	41	39	39	38
	Min.	23	23	15	15	14



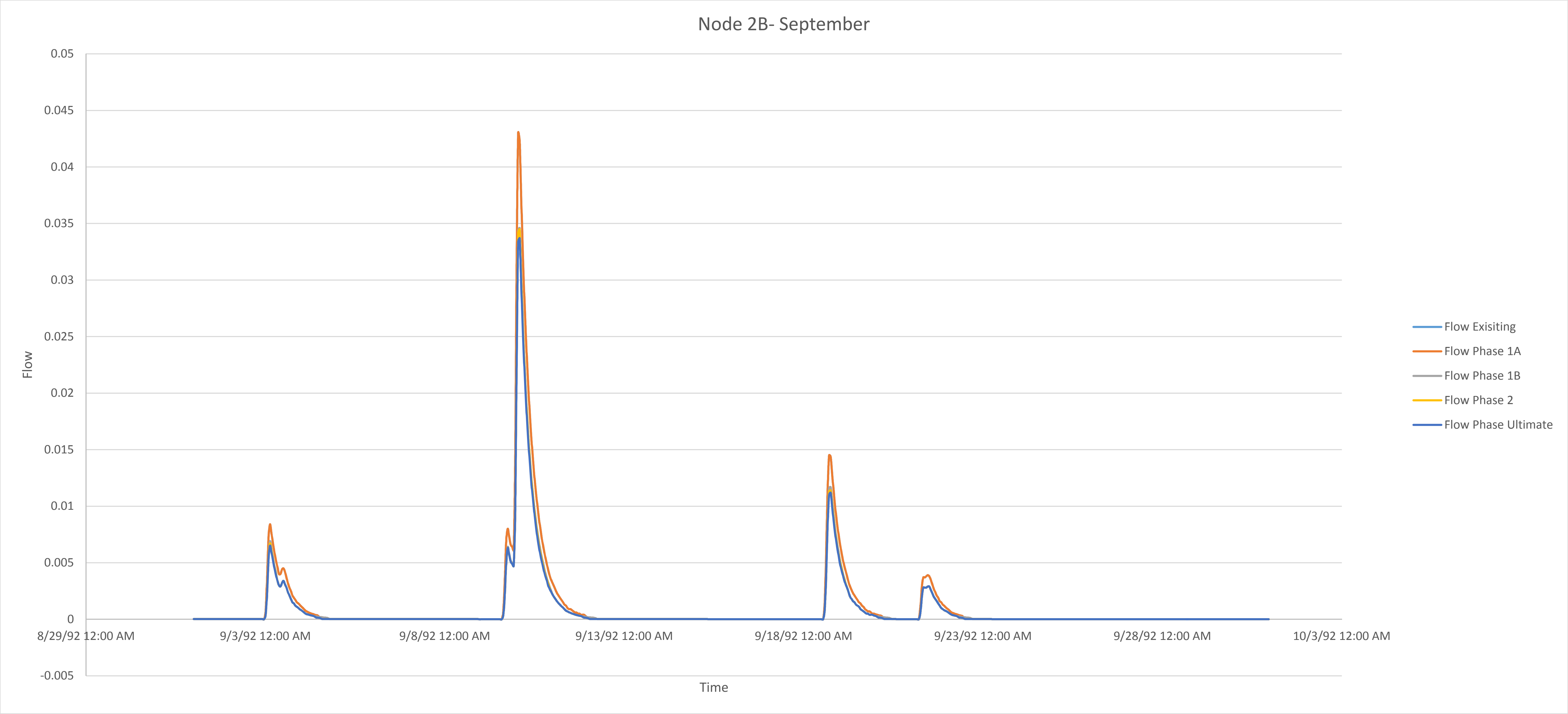
June						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		7	7	7	7	7
Magnitude (cm/s)	Max.	0.0191	0.0191	0.0155	0.0151	0.0147
	Min.	0.0038	0.0038	0.0031	0.0031	0.0031
Duration (h)	Max.	48	48	48	48	48
	Min.	14	14	12	14	14



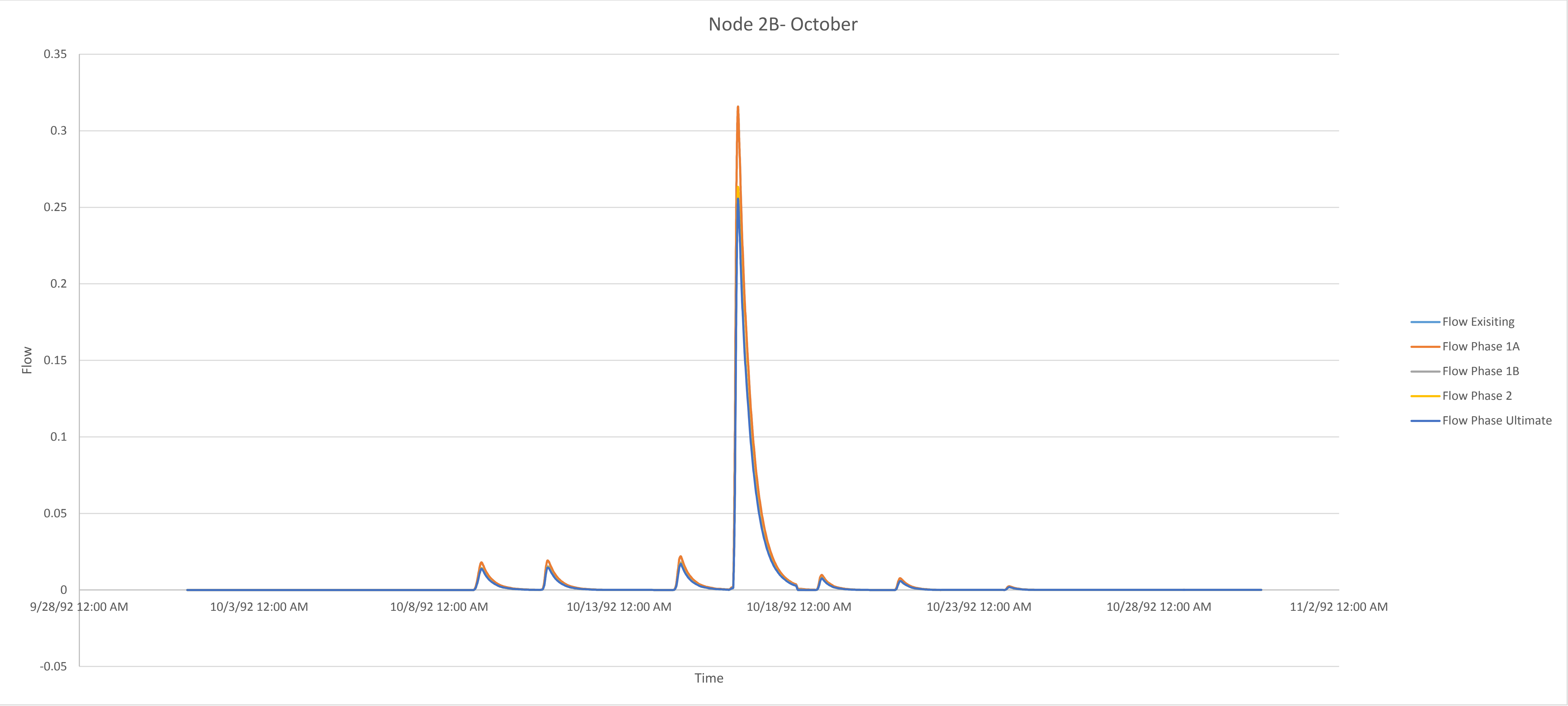
July						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		10	10	10	10	10
Magnitude (cm/s)	Max.	0.0713	0.0713	0.0578	0.0578	0.0562
	Min.	0.0065	0.0065	0.0051	0.0051	0.0051
Duration (h)	Max.	53	53	53	49	49
	Min.	27	27	26	24	24



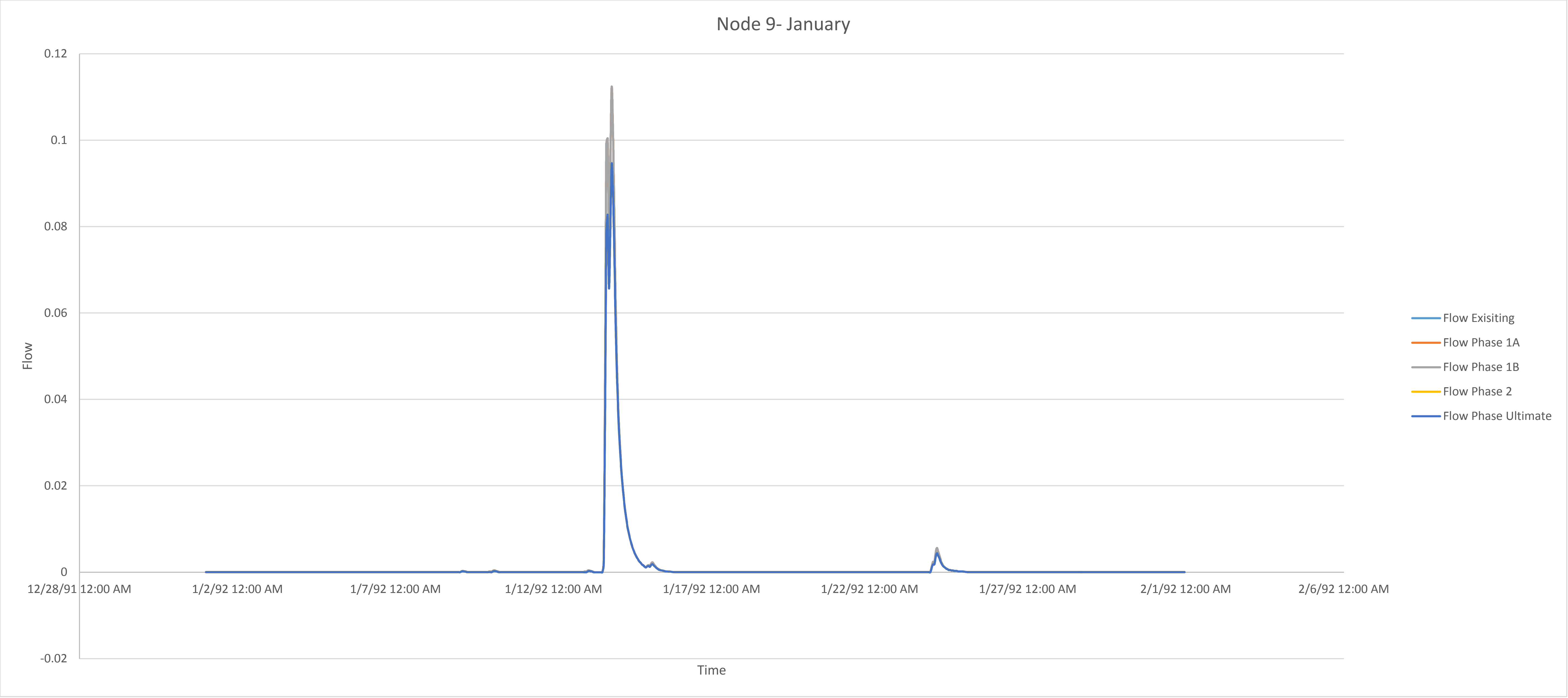
August						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitude (cm/s)	Max.	0.8893	0.8893	0.742	0.7425	0.7215
	Min.	0.0044	0.0044	0.0034	0.0034	0.0034
Duration (h)	Max.	84	84	72	71	71
	Min.	19	19	16	16	16



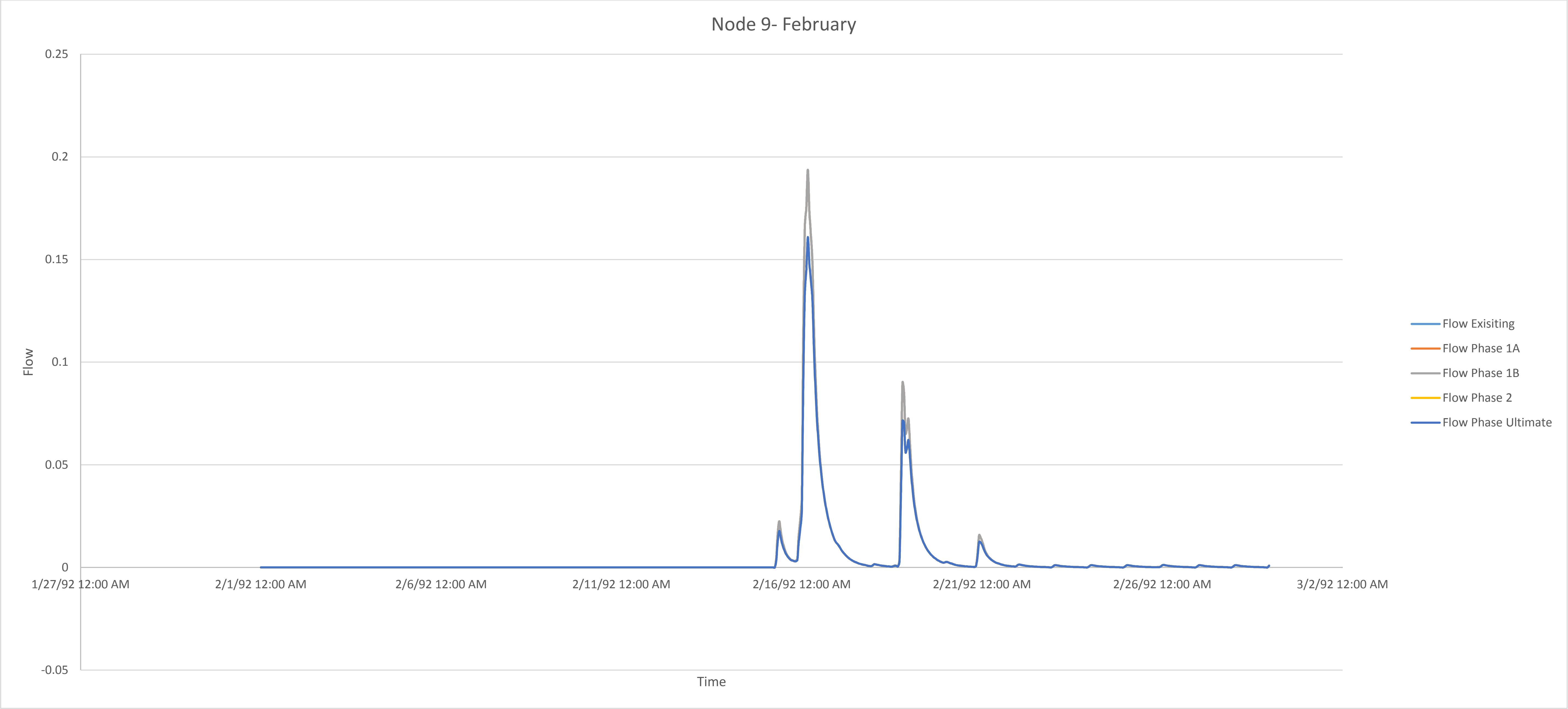
September						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		4	4	4	4	4
Magnitude (cm/s)	Max.	0.043	0.043	0.0346	0.0345	0.0337
	Min.	0.0039	0.0039	0.0029	0.0029	0.0029
Duration (h)	Max.	63	63	63	58	58
	Min.	35	35	35	30	30



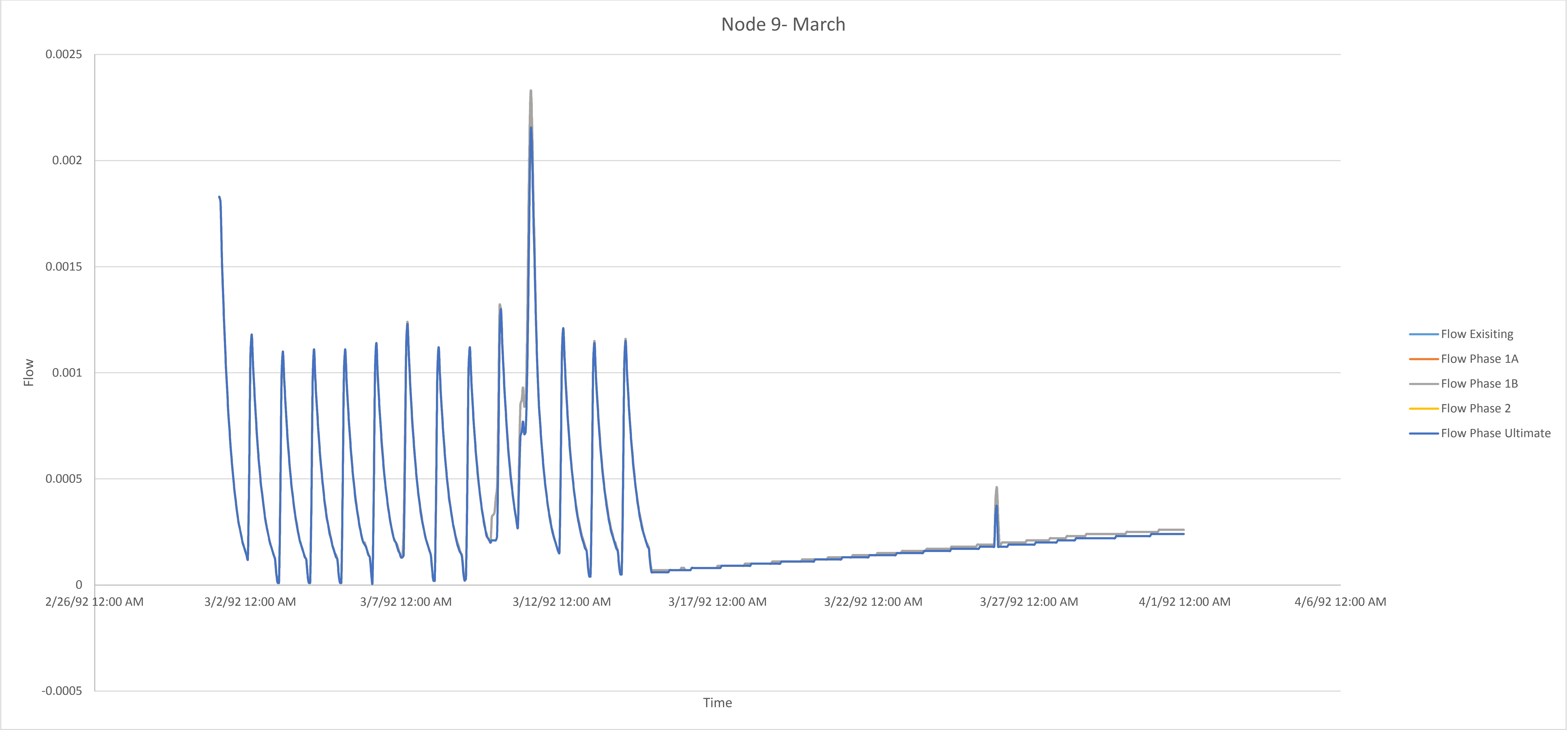
October						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		7	7	7	7	7
Magnitude (cm/s)	Max.	0.3143	0.3143	0.2613	0.2615	0.2539
	Min.	0.00242	0.00242	0.00187	0.00187	0.00187
Duration (h)	Max.	45	45	45	45	45
	Min.	20	20	20	16	16



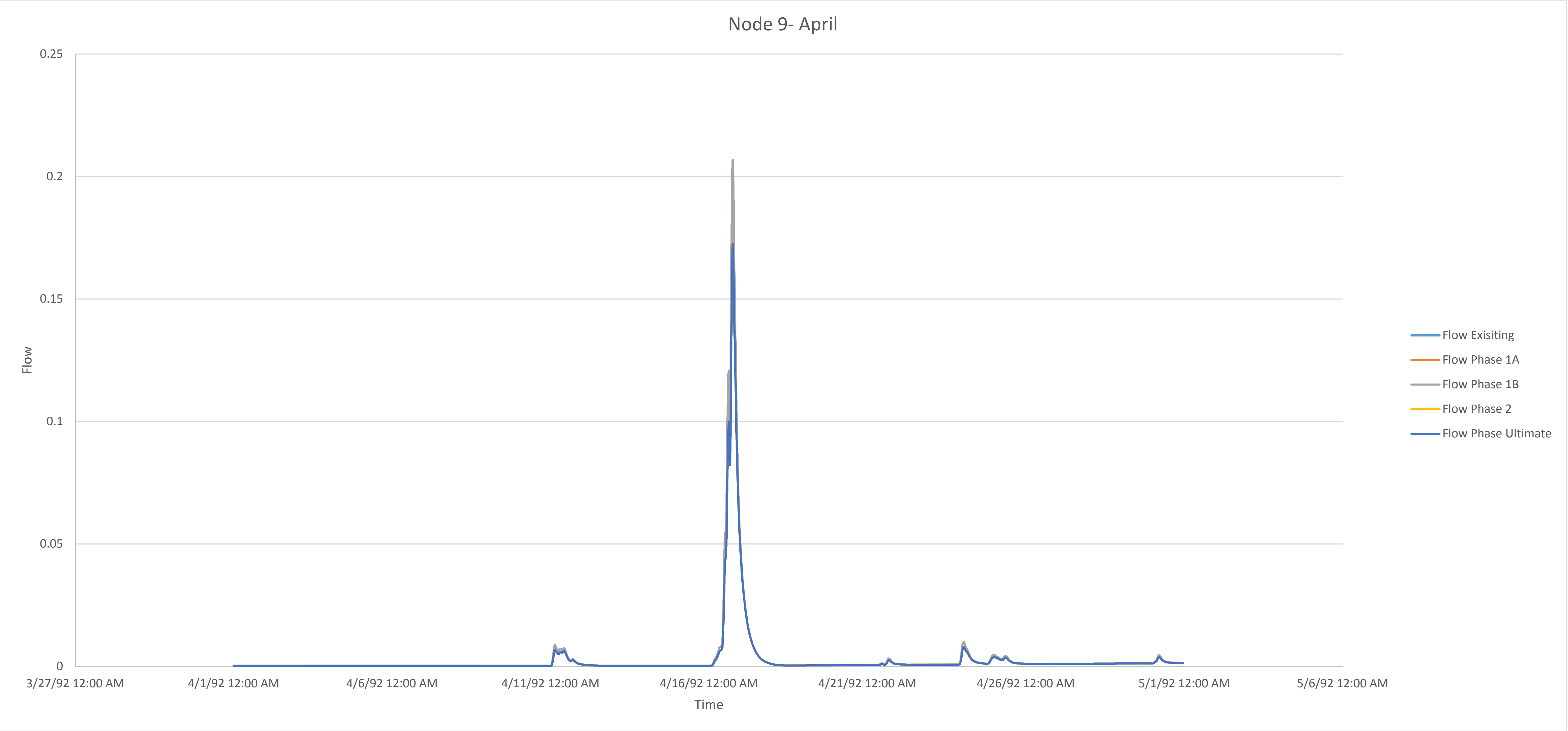
January						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitude (cm/s)	Max.	0.11220	0.11220	0.11220	0.09440	0.09440
	Min.	0.0003	0.0003	0.0003	0.00021	0.00021
Duration (h)	Max.	53	53	53	53	53
	Min.	4	4	4	4	4



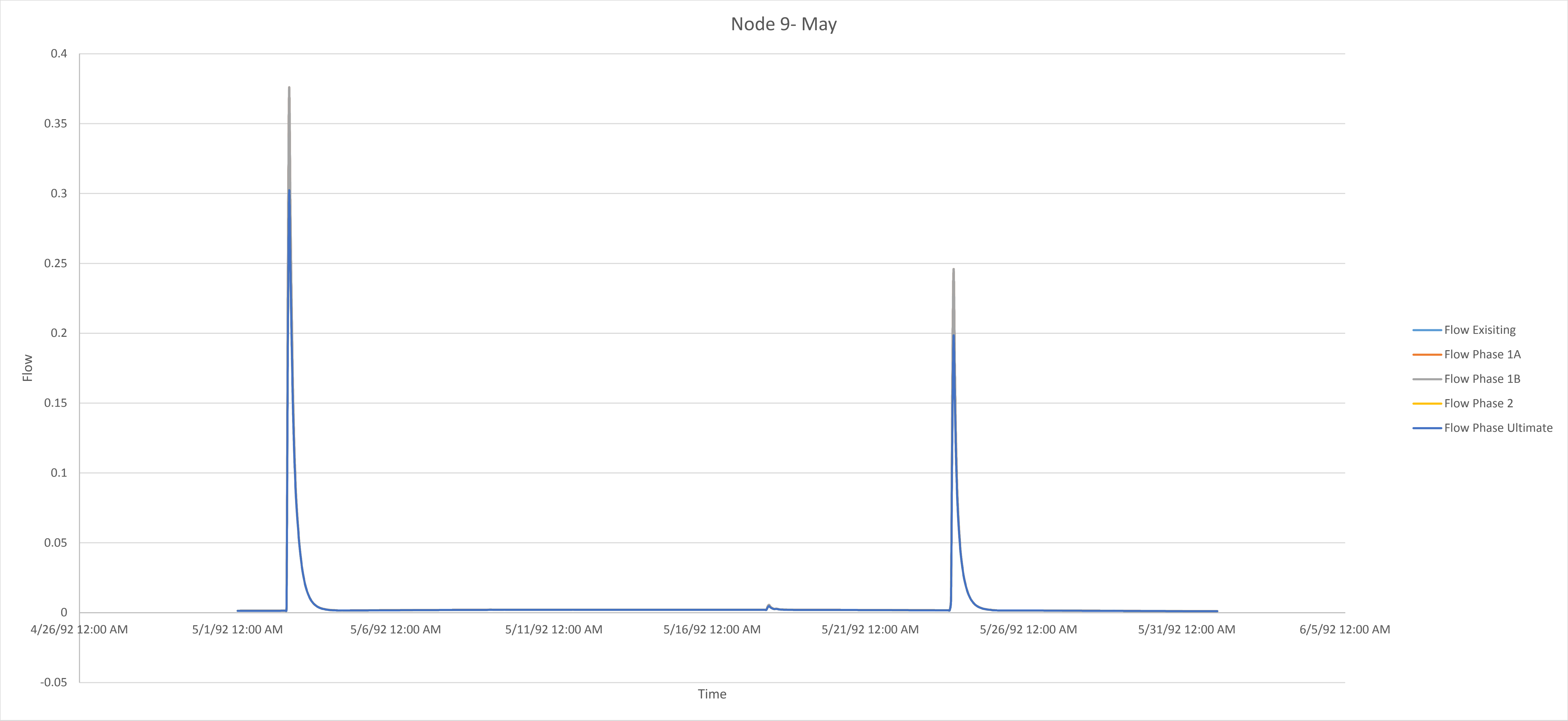
February						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		12	12	12	12	12
Magnitude (cm/s)	Max.	0.19370	0.19370	0.19370	0.16090	0.16090
	Min.	0.0011	0.0011	0.0011	0.0011	0.0011
Duration (h)	Max.	76	76	76	76	76
	Min.	22	22	22	22	22



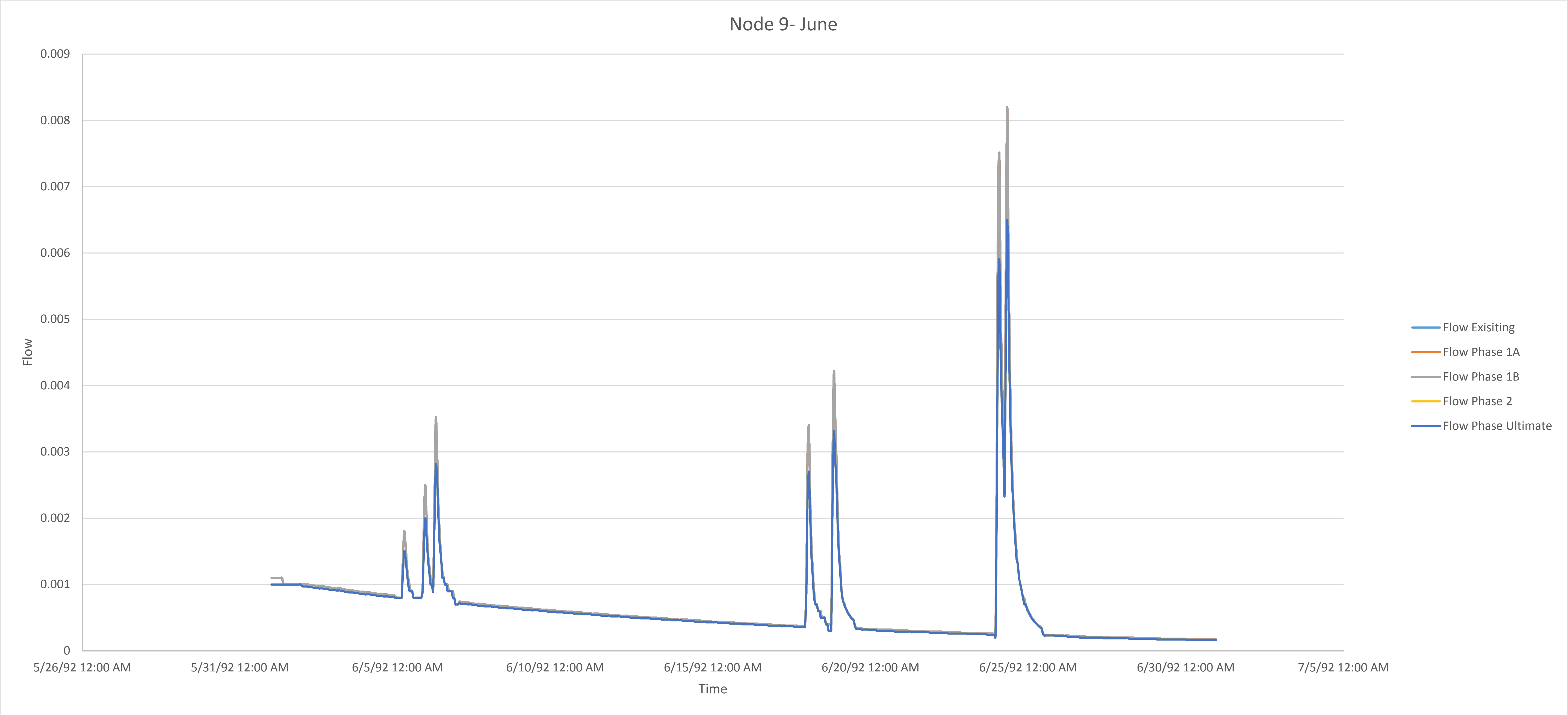
March						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		14	14	14	14	14
Magnitude (cm/s)	Max.	0.00233	0.00233	0.00233	0.00215	0.00215
	Min.	0.00046	0.00046	0.00046	0.00037	0.00037
Duration (h)	Max.	25	25	25	25	25
	Min.	3	3	3	2	2



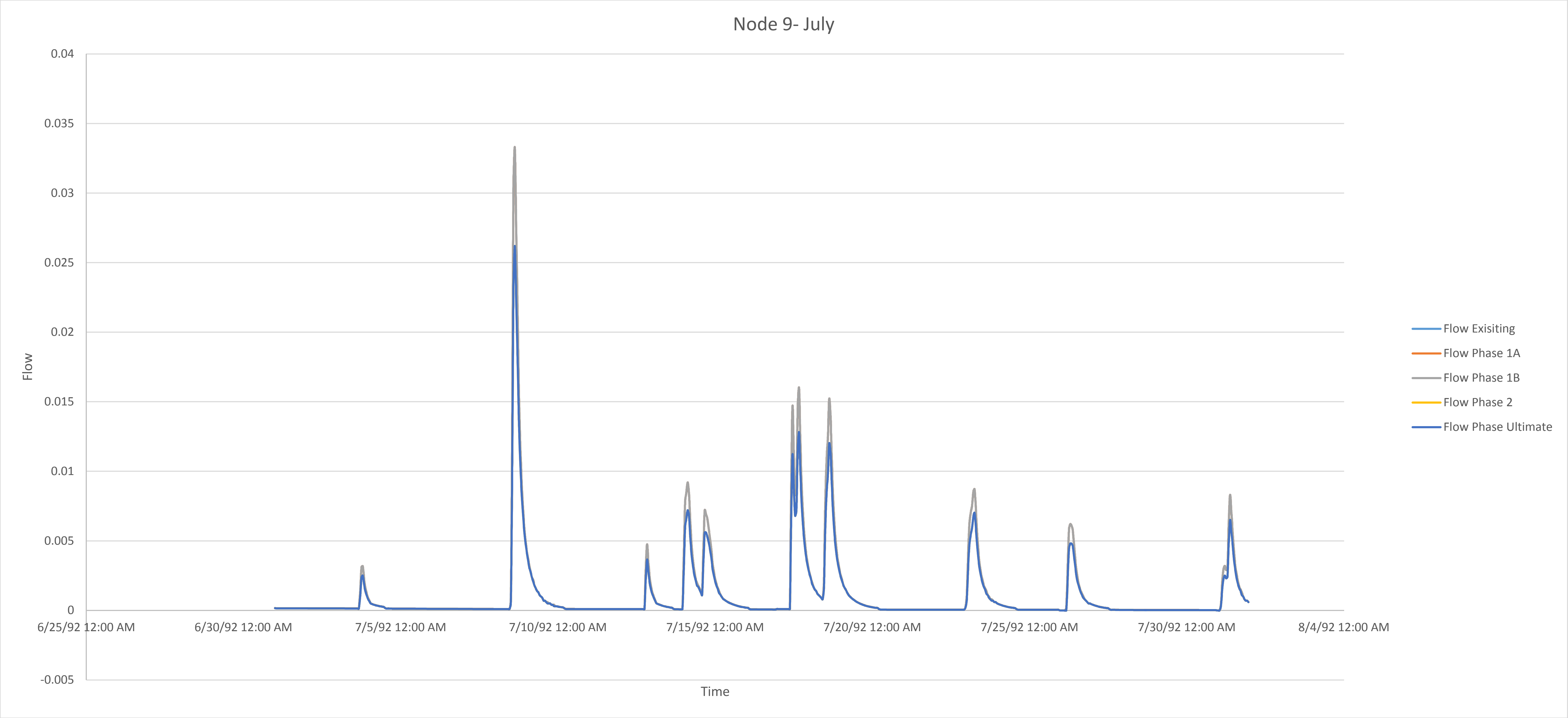
April						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		7	7	7	7	7
Magnitude (cm/s)	Max.	0.20670	0.20670	0.20670	0.17230	0.17230
	Min.	0.0032	0.0032	0.0032	0.00256	0.00256
Duration (h)	Max.	55	55	55	55	55
	Min.	14	14	14	16	16



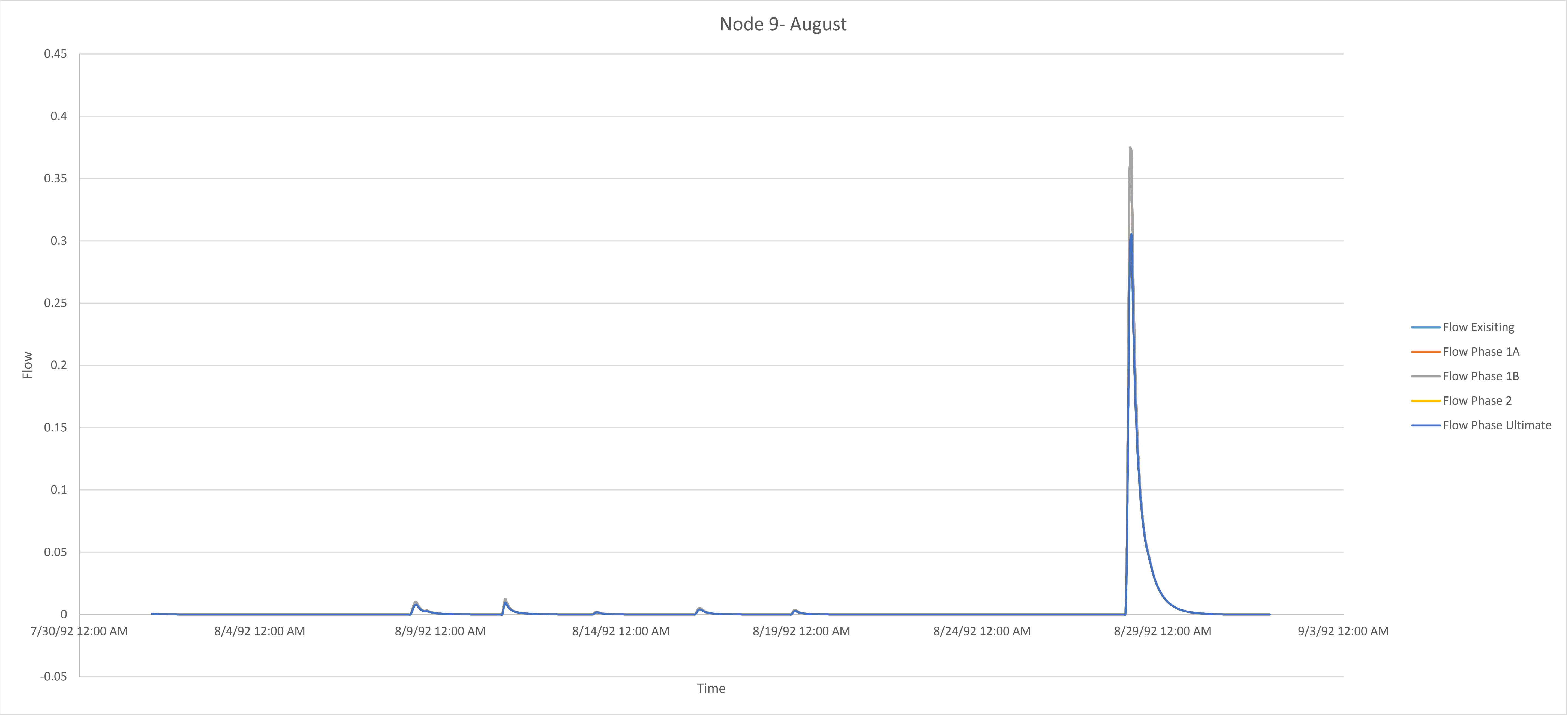
May						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		3	3	3	3	3
Magnitude (cm/s)	Max.	0.37530	0.37530	0.37530	0.30080	0.30080
	Min.	0.0056	0.0056	0.0056	0.0047	0.0047
Duration (h)	Max.	38	38	38	39	39
	Min.	15	15	15	12	12



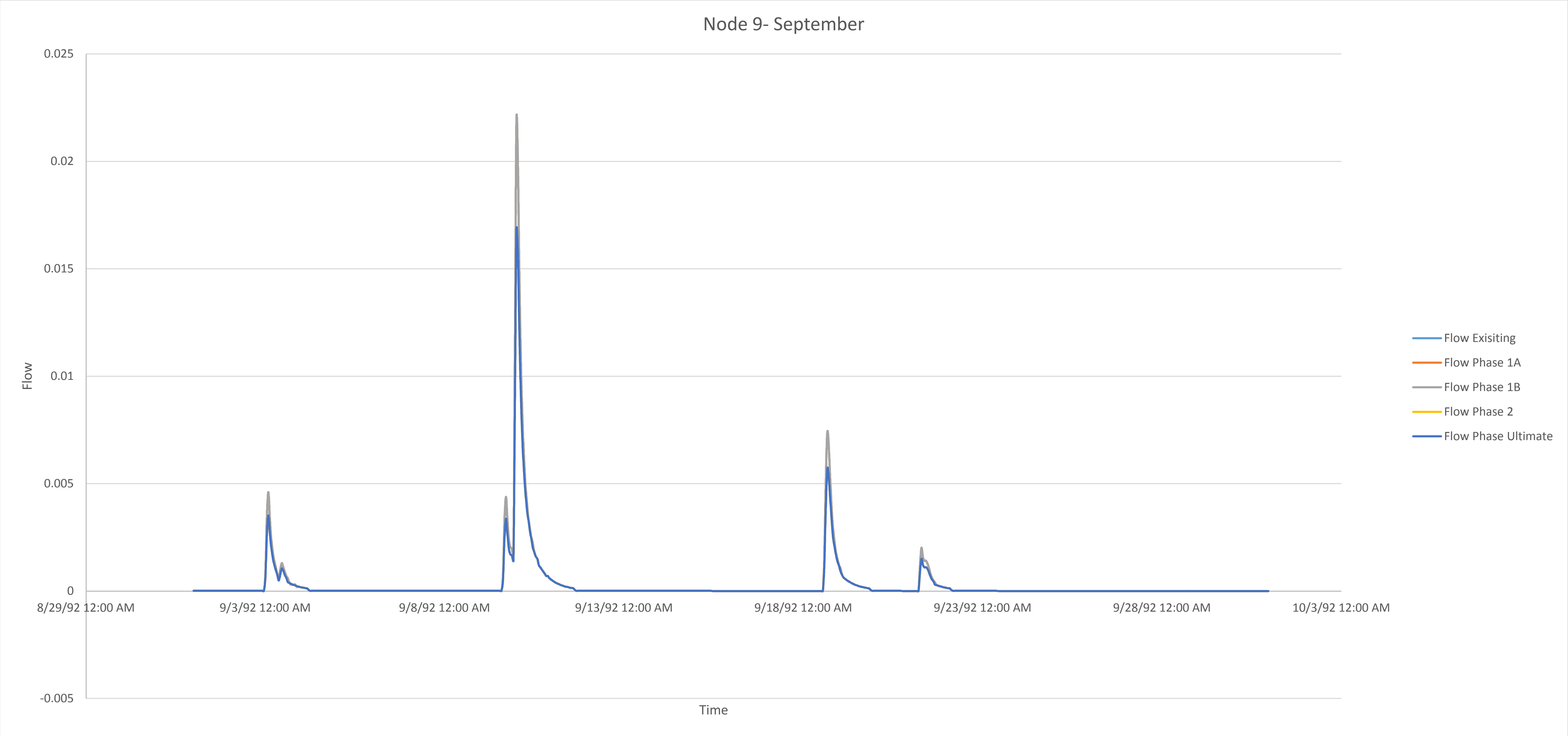
June						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		7	7	7	7	7
Magnitude (cm/s)	Max.	0.00820	0.00820	0.00820	0.00650	0.00650
	Min.	0.0018	0.0018	0.0018	0.0015	0.0015
Duration (h)	Max.	37	37	37	37	37
	Min.	8	8	8	8	8



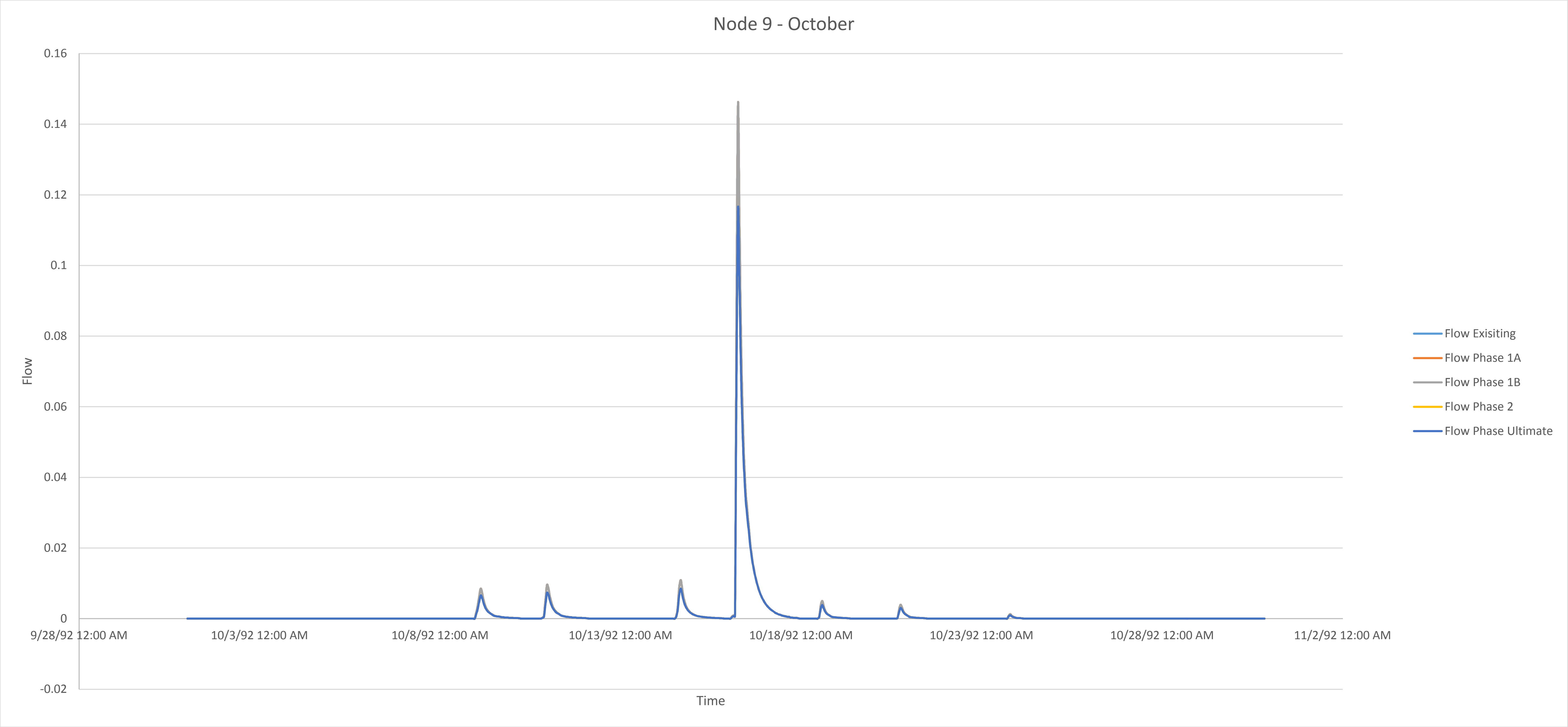
July						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		11	11	11	11	11
Magnitude (cm/s)	Max.	0.03330	0.03330	0.03330	0.02620	0.02620
	Min.	0.00318	0.00318	0.00318	0.00251	0.00251
Duration (h)	Max.	25	25	25	25	25
	Min.	20	20	20	20	20



August						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitude (cm/s)	Max.	0.37450	0.37450	0.37450	0.30490	0.30490
	Min.	0.00223	0.00223	0.00223	0.00172	0.00172
Duration (h)	Max.	64	64	64	64	64
	Min.	21	21	21	21	21



September						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		6	6	6	6	6
Magnitude (cm/s)	Max.	0.02190	0.02190	0.02190	0.01680	0.01680
	Min.	0.00201	0.00201	0.00201	0.0015	0.0015
Duration (h)	Max.	49	49	49	49	49
	Min.	22	22	22	22	22



October						
Conditions		Existing	Phase 1A	Phase 1B	Phase 2	Ultimate
Frequency		7	7	7	7	7
Magnitude (cm/s)	Max.	0.14590	0.14590	0.14590	0.11600	0.11600
	Min.	0.00127	0.00127	0.00127	0.00096	0.00096
Duration (h)	Max.	37	37	37	37	37
	Min.	10	10	10	10	10

Appendix 7.5 – Dandas Street Expansion Supporting Documents

ESR - Catchment #	GAWSER - Catchment #	ESR - Culvert #	NOCSS - Culvert #	Area (ha)	Existing Imp (%)	Proposed (%)	GAWSER - Existing 100-Year Flow (cms)	GAWSER - Proposed Uncontrolled 100-Year Flow (cms)	GAWSER - Proposed Controlled 100-Year Flow (cms)	Storage Available for 100-Year Event (m3)	Storage Provided by	Control Level
D21A	1501	C21A	FM-D2	1.23	40	85	0.073	0.100	0.067	**370**	On-site Control	100-Year
D21B	1502	C21B	FM-D3	2.24	31	82	0.125	0.182	-	**670**	SWM Pond 2	Regional
D22	1503	C22	FM-D4	1.82	38	80	0.107	0.147	0.096	**550**	On-site Control	100-Year
D22A	1504	C22A	FM-D4A	1.33	51	89	0.085	0.109	0.076	**400**	On-site Control	100-Year
D22B	1505	C22B	FM-D5	0.56	39	80	0.033	0.045	0.029	**170**	On-site Control	100-Year
D23	1506	C23	FM-D6	1.17	42	77	0.070	0.094	0.062	**350**	On-site Control	100-Year

Sources:
Environmental Study Report (ESR) - Dundas Street Class EA Study Brant Street to Bronte Road, MMM Group, May 2015
Section 6.1.6.6
Exhibits 6-17 through 6-20
Table 6-2

Dundas Expansion SWM Pond Flows
ULTIMATE CONDITIONS
MAR 11 2016, MMM, AZZ

Onsite Control	4501	
ULTIMATE Drainage Area	1.23	ha
Imperviousness	85	%

Rating Curve

OUTFLOW	STORAGE
(cms)	**(ha*m)**
0.0000	0.0000
0.0010	0.0261
0.0730	0.0370

Return Period	Inflow (cms)	Utilized Storage (ha*m)	Outflow (cms)
Gawser ID	**1501**	**4501**	**4501**
25 mm 24 hr	0.017	0.0203	0.001
2-Yr	0.041	0.0284	0.016
5-Yr	0.058	0.0304	0.030
10-Yr	0.068	0.0317	0.038
25-Yr	0.081	0.0336	0.050
50-Yr	0.090	0.0348	0.059
100-Yr	0.100	0.0361	0.067
Regional	0.118	0.0432	0.114

Beyond Available Storage - Regional Control Not Provided

Onsite Control	4503	
ULTIMATE Drainage Area	1.82	ha
Imperviousness	80	%

Rating Curve

OUTFLOW	STORAGE
(cms)	**(ha*m)**
0.0000	0.0000
0.0010	0.0364
0.1068	0.0550

Return Period	Inflow (cms)	Utilized Storage (ha*m)	Outflow (cms)
Gawser ID	**1503**	**4503**	**4503**
25 mm 24 hr	0.025	0.0296	0.001
2-Yr	0.060	0.0404	0.024
5-Yr	0.084	0.0438	0.043
10-Yr	0.099	0.0458	0.055
25-Yr	0.119	0.0490	0.073
50-Yr	0.133	0.0510	0.084
100-Yr	0.147	0.0532	0.096
Regional	0.175	0.0656	0.167

Beyond Available Storage - Regional Control Not Provided

Onsite Control	4504	
ULTIMATE Drainage Area	1.33	ha
Imperviousness	89	%

Rating Curve

OUTFLOW	STORAGE
(cms)	**(ha*m)**
0.0000	0.0000
0.0010	0.0296
0.0848	0.0400

Return Period	Inflow (cms)	Utilized Storage (ha*m)	Outflow (cms)
Gawser ID	**1504**	**4504**	**4504**
25 mm 24 hr	0.019	0.0230	0.001
2-Yr	0.045	0.0317	0.018
5-Yr	0.063	0.0336	0.033
10-Yr	0.074	0.0347	0.042
25-Yr	0.088	0.0365	0.057
50-Yr	0.098	0.0376	0.066
100-Yr	0.109	0.0389	0.076
Regional	0.128	0.0449	0.125

Beyond Available Storage - Regional Control Not Provided

Onsite Control 4505

ULTIMATE Drainage Area 0.56 ha

Imperviousness 80 %

Rating Curve

OUTFLOW	STORAGE
(cms)	(ha*m)
0.0000	0.0000
0.0010	0.0112
0.0327	0.0170

Return Period	Inflow (cms)	Utilized Storage (ha*m)	Outflow (cms)	
Gawser ID	1505	4505	4505	
25 mm 24 hr	0.008	0.0078	0.001	
2-Yr	0.018	0.0122	0.007	
5-Yr	0.026	0.0133	0.013	
10-Yr	0.030	0.0140	0.016	
25-Yr	0.036	0.0149	0.021	
50-Yr	0.041	0.0156	0.025	
100-Yr	0.045	0.0163	0.029	
Regional	0.054	0.0204	0.051	Beyond Available Storage - Regional Control Not Provided

Onsite Control 4506

ULTIMATE Drainage Area 1.17 ha

Imperviousness 77 %

Rating Curve

OUTFLOW	STORAGE
(cms)	(ha*m)
0.0000	0.0000
0.0010	0.0225
0.0704	0.0350

Return Period	Inflow (cms)	Utilized Storage (ha*m)	Outflow (cms)	
Gawser ID	1506	4506	4506	
25 mm 24 hr	0.015	0.0175	0.001	
2-Yr	0.038	0.0250	0.015	
5-Yr	0.054	0.0273	0.028	
10-Yr	0.063	0.0286	0.035	
25-Yr	0.076	0.0307	0.047	
50-Yr	0.085	0.0320	0.054	
100-Yr	0.094	0.0334	0.062	
Regional	0.112	0.0416	0.107	Beyond Available Storage - Regional Control Not Provided

The design of quality and quantity control measures, and storm sewer outlet details, if required, will be finalized during detailed design.

6.1.6.6 Fourteen Mile Creek Tributary Catchment

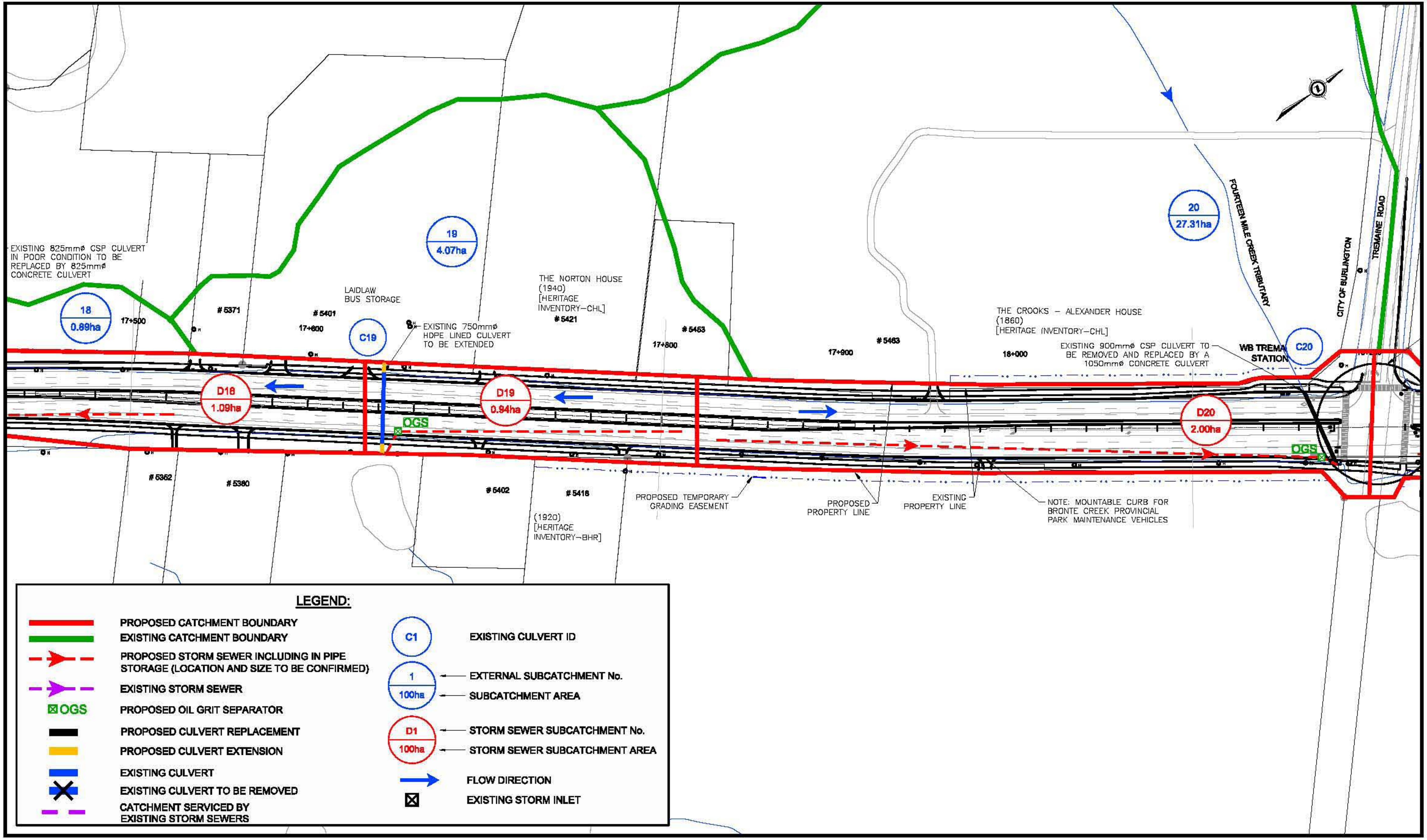
Fourteen Mile Creek and its tributaries cross Dundas Street through eight culverts as shown in **Exhibits 6-17**, **6-18**, **6-19** and **6-20**. This portion of Dundas Street is located between approximately 710 m east of Sutton Drive and approximately 90 m west of Valleyridge Drive. This Dundas Street catchment is divided in eight different sub-catchments as follows:

1. Approximately 710 m east of Sutton Drive to approximately 380 m West of Tremaine Road, draining to Culvert C19.
2. Approximately 380 m West of Tremaine Road to Tremaine Road, draining to Culvert C20.
3. Tremaine Road to approximately 220 m East of Tremaine Road, draining to Culvert C21A.
4. Approximately 220 m East of Tremaine Road to approximately 650 m East of Tremaine Road, draining to Culvert C21B.
5. Approximately 650 m East of Tremaine Road to approximately 140 m west of Colonel William Parkway, draining to Culvert C22
6. Approximately 140 m west of Colonel William Parkway to approximately 100 m east of Colonel William Parkway, draining to Culvert C22A.
7. Approximately 100 m east of Colonel William Parkway to approximately 210 m east of Colonel William Parkway, draining to Culvert C22B.
8. Approximately 210 m East of Colonel William Parkway to approximately 330 m west of Bronte Road, draining to Culvert C23.

Stormwater management (SWM) requirements for the Fourteen Mile Creek and its tributaries are as per the NOCSS for the quality treatment and quantity control, which includes:

- Quality control of runoff to Enhanced level of treatment in accordance with the Ministry of the Environment and Climate Change's Stormwater Management Planning and Design Manual, 2003.
- Quantity control of runoff such that the post-development flows do not exceed the pre-development flows.

Due to space constraints within the road right-of-way, no erosion control is proposed for runoff from widened portion of Dundas Street. However, it is anticipated that when the upstream areas are developed, stormwater management and erosion control strategies will be reviewed and explored; there may be opportunities to accommodate runoff from Dundas Street.



LEGEND:

🟥	PROPOSED CATCHMENT BOUNDARY
🟩	EXISTING CATCHMENT BOUNDARY
- -➤- -	PROPOSED STORM SEWER INCLUDING IN PIPE STORAGE (LOCATION AND SIZE TO BE CONFIRMED)
- -➤- -	EXISTING STORM SEWER
☒OGS	PROPOSED OIL GRIT SEPARATOR
▬	PROPOSED CULVERT REPLACEMENT
▬	PROPOSED CULVERT EXTENSION
▬	EXISTING CULVERT
✕	EXISTING CULVERT TO BE REMOVED
- - -	CATCHMENT SERVICED BY EXISTING STORM SEWERS
C1	EXISTING CULVERT ID
1	EXTERNAL SUBCATCHMENT No.
100ha	SUBCATCHMENT AREA
D1	STORM SEWER SUBCATCHMENT No.
100ha	STORM SEWER SUBCATCHMENT AREA
➔	FLOW DIRECTION
☒	EXISTING STORM INLET

Halton REGION MMM GROUP

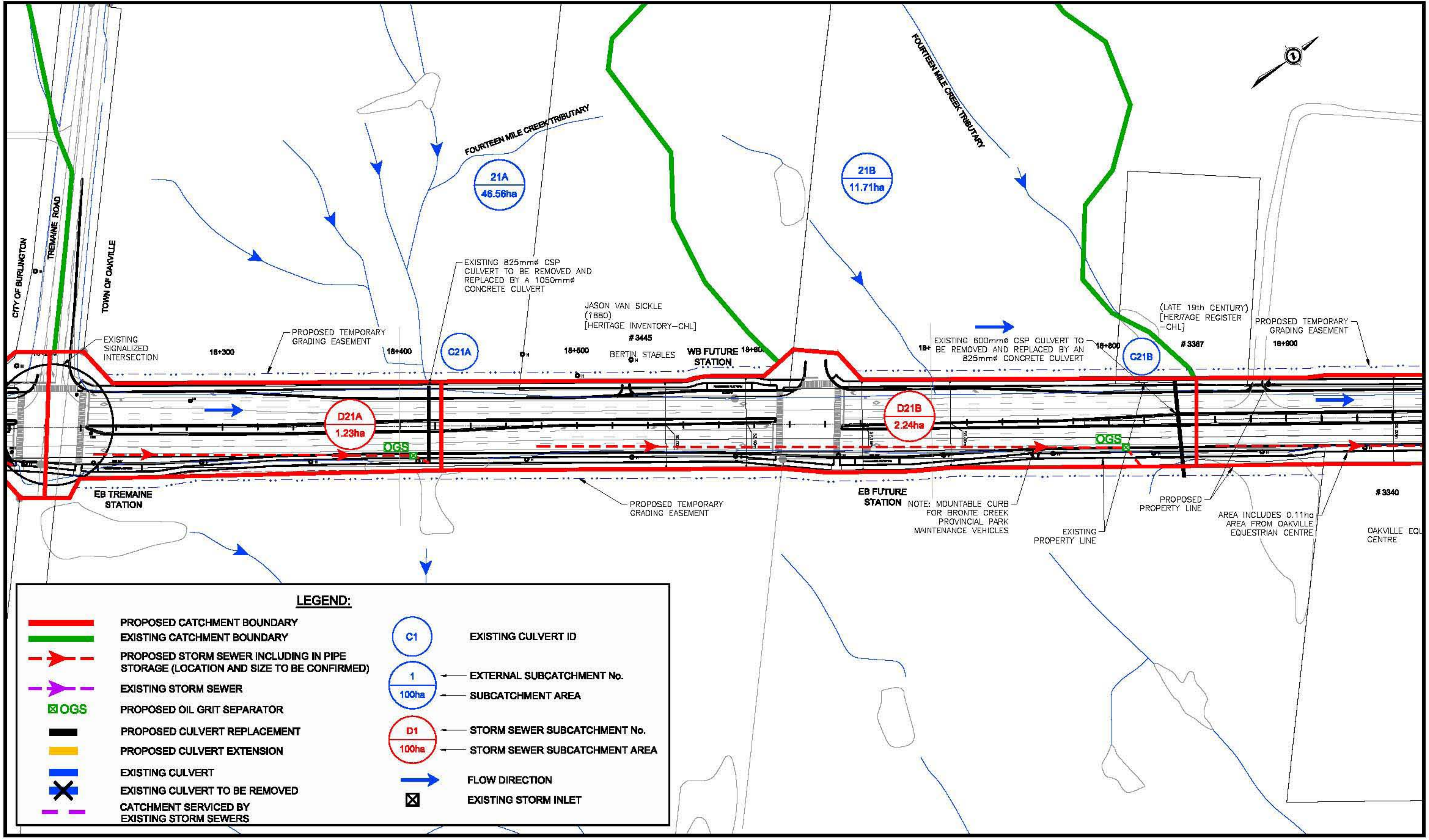
DUNDAS STREET CLASS EA STUDY
Brant Street to Bronte Road

NOTE:
THE LOCATION AND LENGTHS OF CULVERTS SHOWN SCHEMATICALLY ONLY (NOT TO SCALE)

Metric Scale
25m 0 50m
Horizontal

Future Drainage Mosaic
Fourteen Mile Creek Tributary Catchment

Exhibit
6-17



DUNDAS STREET CLASS EA STUDY

Brant Street to Bronte Road

NOTE:

THE LOCATION AND LENGTHS OF CULVERTS SHOWN SCHEMATICALLY ONLY (NOT TO SCALE)

Metric Scale

25m 0 50m

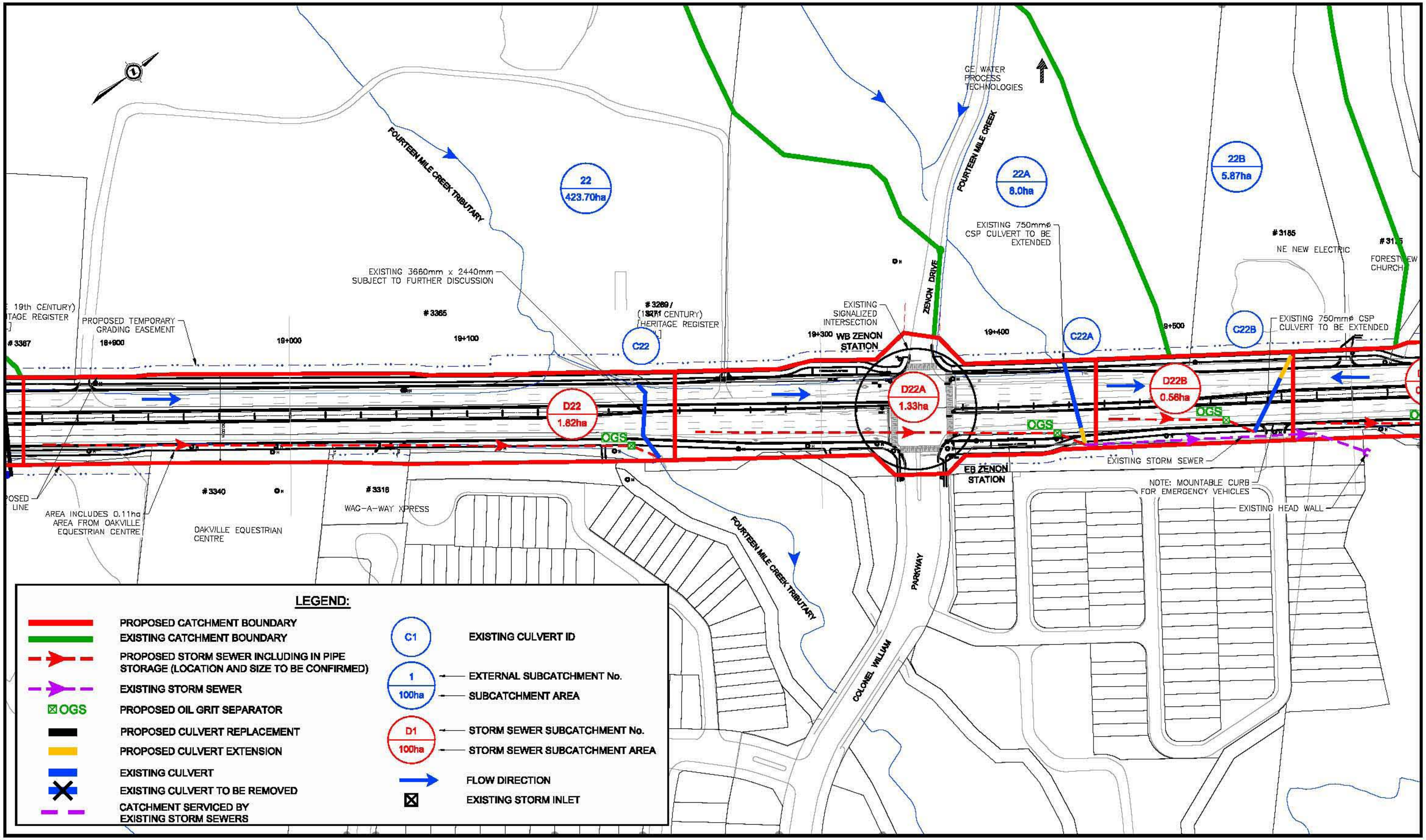
Horizontal

Future Drainage Mosaic

Fourteen Mile Creek Tributary Catchment

Exhibit

6-18



LEGEND:

🟥	PROPOSED CATCHMENT BOUNDARY
🟩	EXISTING CATCHMENT BOUNDARY
⇢	PROPOSED STORM SEWER INCLUDING IN PIPE STORAGE (LOCATION AND SIZE TO BE CONFIRMED)
⇢	EXISTING STORM SEWER
☒OGS	PROPOSED OIL GRIT SEPARATOR
⬛	PROPOSED CULVERT REPLACEMENT
🟨	PROPOSED CULVERT EXTENSION
🟦	EXISTING CULVERT
✕	EXISTING CULVERT TO BE REMOVED
- -	CATCHMENT SERVICED BY EXISTING STORM SEWERS
C1	EXISTING CULVERT ID
1	EXTERNAL SUBCATCHMENT No.
100ha	SUBCATCHMENT AREA
D1	STORM SEWER SUBCATCHMENT No.
100ha	STORM SEWER SUBCATCHMENT AREA
→	FLOW DIRECTION
☒	EXISTING STORM INLET

Halton REGION

MMM GROUP

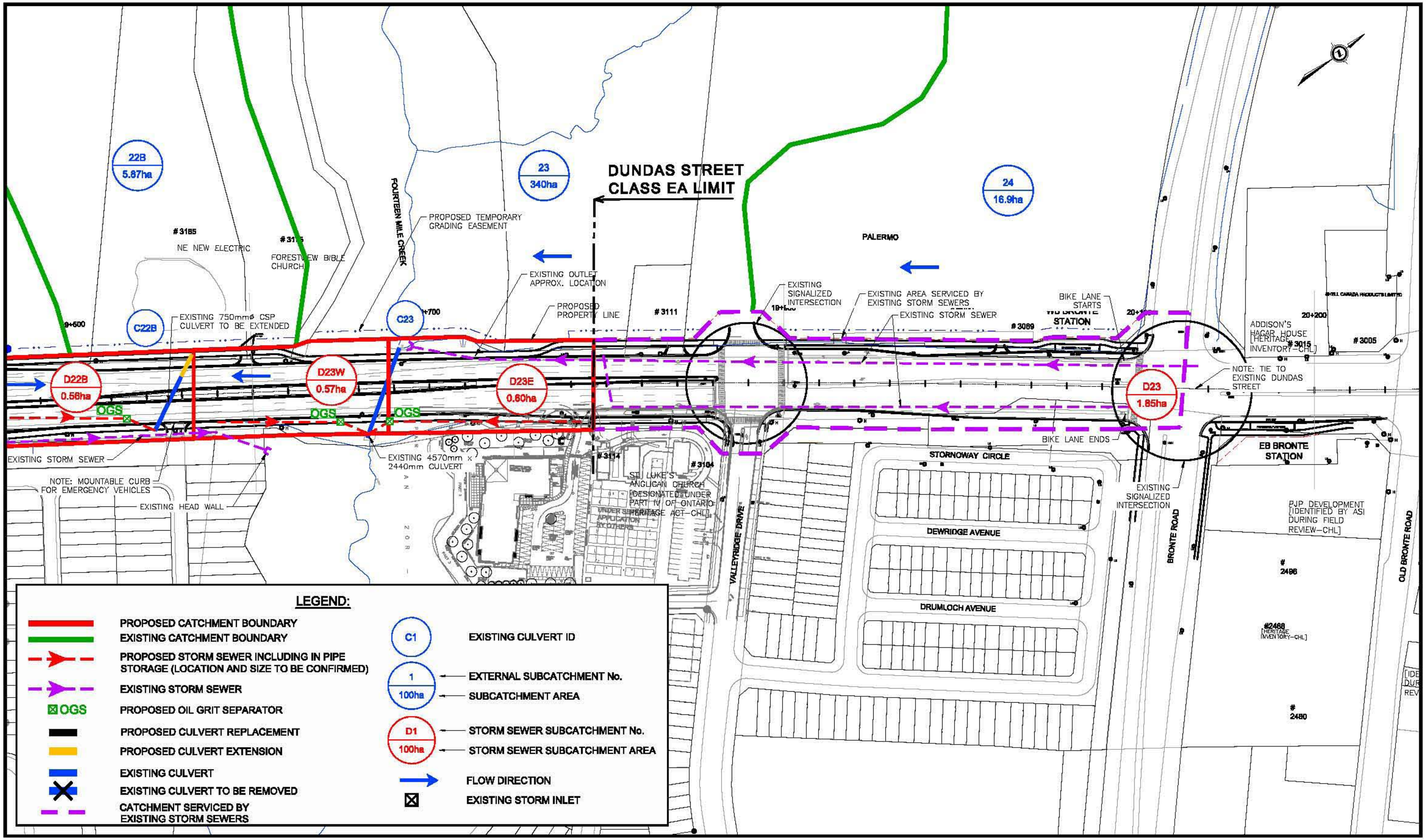
DUNDAS STREET CLASS EA STUDY
Brant Street to Bronte Road

NOTE:
THE LOCATION AND LENGTHS OF CULVERTS SHOWN SCHEMATICALLY ONLY (NOT TO SCALE)

Metric Scale
25m 0 50m
Horizontal

Future Drainage Mosaic
Fourteen Mile Creek Tributary Catchment

Exhibit
6-19



LEGEND:

🟥	PROPOSED CATCHMENT BOUNDARY
🟩	EXISTING CATCHMENT BOUNDARY
➤	PROPOSED STORM SEWER INCLUDING IN PIPE STORAGE (LOCATION AND SIZE TO BE CONFIRMED)
➤	EXISTING STORM SEWER
☒ OGS	PROPOSED OIL GRIT SEPARATOR
■	PROPOSED CULVERT REPLACEMENT
🟨	PROPOSED CULVERT EXTENSION
🟦	EXISTING CULVERT
✕	EXISTING CULVERT TO BE REMOVED
▬ ▬	CATCHMENT SERVICED BY EXISTING STORM SEWERS
C1	EXISTING CULVERT ID
1	EXTERNAL SUBCATCHMENT No.
100ha	SUBCATCHMENT AREA
D1	STORM SEWER SUBCATCHMENT No.
100ha	STORM SEWER SUBCATCHMENT AREA
→	FLOW DIRECTION
☒	EXISTING STORM INLET

Halton REGION MMM GROUP

DUNDAS STREET CLASS EA STUDY
Brant Street to Bronte Road

NOTE:
THE LOCATION AND LENGTHS OF CULVERTS SHOWN SCHEMATICALLY ONLY (NOT TO SCALE)

Metric Scale
25m 0 50m
Horizontal

Future Drainage Mosaic
Fourteen Mile Creek Catchment

Exhibit

6-20

order to achieve no overtopping of Dundas Street during a Regional Storm event, the existing 825 mm diameter CSP culvert will be replaced by a 1050 mm diameter concrete culvert. The proposed sizing is tabulated in **Table 6-3**.

For quantity control, underground storage in oversized storm sewers will be provided to control the post-development flows to pre-development flows for all storms from 2 year to 100 year storm events. About 310 m^3 to 370 m^3 of storage volume will be required to provide peak flow control.

In terms of quality control of storm runoff from Dundas Street, the most feasible method to obtain Enhanced level water quality treatment will be through an OGS at the outlet of the storm sewer system. Given the proposed urban cross-section of future Dundas Street, other methodologies are not easily implemented. The proposed location of the OGS is indicated in **Exhibit 6-18**.

The design of quality and quantity control measures will be finalized during detailed design.

Culvert 21B: Approximately 220 m East of Tremaine Road to approximately 650 m East of Tremaine Road

The existing ditch system drains a portion (2.24 ha) of Dundas Street and will be replaced by a storm sewer system which is generally shown in **Exhibit 6-18**. As indicated in **Section 3.5.4.6**, Culvert C21B can convey the 50 year and 100 year flows without overtopping Dundas Street, but the Regional Storm flow will overtop Dundas Street. In order to achieve no overtopping of Dundas Street during a Regional Storm event, the existing 600 mm diameter CSP culvert will be replaced by an 825 mm diameter concrete culvert. The proposed sizing is tabulated in **Table 6-3**.

For quantity control, underground storage in oversized storm sewers will be provided to control the post-development flows to pre-development flows for all storms from 2 year to 100 year storm events. About 560 m^3 to 670 m^3 of storage volume will be required to provide peak flow control.

In terms of quality control of storm runoff from Dundas Street, the most feasible method to obtain Enhanced level water quality treatment will be through an oil-grit separator (OGS) at the outlet of the storm sewer system. Given the proposed urban cross-section of future Dundas Street, other methodologies are not easily implemented. The proposed location of the OGS is indicated in **Exhibit 6-18**.

The design of quality and quantity control measures will be finalized during detailed design.

It is noted that the Environmental Implementation Report / Functional Servicing Study (EIR/FSS) for the Lazy Pat Farm Development, under review by various approval agencies, indicates that the flows from this portion of Dundas Street can be treated in the proposed SWM Pond 2 (as noted in the EIR/FSS) for the proposed development. Depending on the schedule of the Lazy Pat Farm Development and Dundas Street Widening projects, the runoff from this portion of Dundas Street can be managed within the proposed SWM Pond 2. If the Dundas Street widening proceeds in advance of the Lazy Pat Farm development, the runoff from Dundas Street will be managed within underground pipe storage and treated by OGS.

Table 6-2: Summary of Existing and Post Development Flows and the Required Storage Volumes

Road Catchment ID*	Catchment	Drainage Area (ha)*	Existing Road Area (ha)	% Imp.	Proposed Road Area (ha)	% Imp.	Existing Flows (m^3/s)*							Post Development Uncontrolled Flows (m^3/s)*							Max Storage Volume Required to Attenuate 100 Year Flow (m^3)
							2 Yr	5 Yr	10 Yr	25 Yr	50 Yr	100 Yr	Reg.	2 Yr	5 Yr	10 Yr	25 Yr	50 Yr	100 Yr	Reg.	
D1	Tuck Creek Tributary	1.33	0.45	34	0.94	71	0.097	0.141	0.187	0.236	0.271	0.31	0.181	0.191	0.267	0.325	0.395	0.441	0.495	0.19	400
D2	Tuck Creek Tributary	0.92	0.35	38	0.66	72	0.076	0.116	0.142	0.177	0.202	0.230	0.126	0.138	0.196	0.232	0.280	0.312	0.350	0.131	280
D3	Tuck Creek Tributary	2.27	0.87	38	1.71	75	0.161	0.240	0.292	0.398	0.457	0.522	0.308	0.307	0.435	0.519	0.631	0.706	0.816	0.325	680
D4	Tuck Creek Tributary	0.79	0.31	39	0.59	75	0.064	0.092	0.120	0.150	0.172	0.196	0.108	0.118	0.164	0.199	0.240	0.268	0.301	0.113	240
D5	Tuck Creek Tributary	1.19	0.44	37	0.94	79	0.090	0.130	0.171	0.215	0.246	0.281	0.162	0.179	0.251	0.297	0.366	0.408	0.457	0.171	360
D6	Tuck Creek Tributary	1.07	0.36	34	0.70	65	0.080	0.125	0.153	0.193	0.221	0.253	0.146	0.146	0.211	0.252	0.307	0.343	0.386	0.152	320
D7	Tuck Creek Tributary	2.06	0.97	47	1.73	84	0.173	0.254	0.306	0.404	0.461	0.524	0.283	0.298	0.424	0.504	0.610	0.681	0.764	0.298	620
D8	Tuck Creek Tributary	3.03	1.55	52	2.70	89	0.237	0.397	0.480	0.592	0.671	0.795	0.418	0.342	0.556	0.666	0.812	0.911	1.026	0.432	910
D9	Shoreacres Creek	1.18	0.77	65	1.00	85	0.142	0.201	0.239	0.301	0.337	0.380	0.166	0.185	0.258	0.306	0.368	0.415	0.465	0.171	360
D10	Shoreacres Creek	0.66	0.32	48	0.46	70	0.067	0.098	0.118	0.146	0.165	0.187	0.092	0.096	0.137	0.163	0.197	0.220	0.247	0.094	200
D11	Shoreacres Creek	5.18	2.56	49	4.39	85	0.383	0.618	0.749	0.926	1.050	1.279	0.708	0.626	1.004	1.200	1.459	1.632	1.835	0.748	1550
D12	Appleby Creek	3.05	1.49	48	2.63	86	0.275	0.397	0.488	0.602	0.711	0.807	0.420	0.467	0.656	0.777	0.943	1.050	1.176	0.442	920
D13	Sheldon Creek	4.18	1.93	46	3.5	83	0.284	0.414	0.527	0.727	0.827	0.940	0.567	0.493	0.701	0.849	1.165	1.304	1.468	0.602	1250
D17	Sheldon Creek	1.69	0.75	44	1.41	83	0.134	0.197	0.239	0.318	0.364	0.414	0.231	0.242	0.344	0.410	0.496	0.554	0.622	0.244	Se Note **
DB1	Bronte Creek	1.59	0.96	60	1.98	88	0.172	0.246	0.295	0.375	0.422	0.477	0.222	0.310	0.434	0.514	0.62	0.689	0.781	0.288	480
D18	Bronte Creek	1.09	0.39	36	1.15	77	0.077	0.115	0.152	0.192	0.221	0.252	0.148	0.167	0.235	0.279	0.345	0.385	0.432	0.165	330
D19	Fourteen Mile Creek Tributary	0.94	0.36	38	0.71	76	0.074	0.107	0.139	0.175	0.2	0.228	0.129	0.140	0.195	0.232	0.286	0.319	0.358	0.135	280
D20	Fourteen Mile Creek Tributary	2.00	0.78	39	1.58	79	0.150	0.222	0.269	0.365	0.418	0.477	0.272	0.293	0.412	0.489	0.591	0.673	0.755	0.288	600
D21A***	Fourteen Mile Creek Tributary	1.23	0.49	40	1.05	85	0.101	0.145	0.174	0.213	0.241	0.267	0.112	0.209	0.301	0.362	0.451	0.512	0.571	0.178	370
D21B***	Fourteen Mile Creek Tributary	2.24	0.70	31	1.83	82	0.135	0.200	0.242	0.297	0.337	0.378	0.203	0.321	0.474	0.576	0.714	0.816	0.914	0.323	670
D22***	Fourteen Mile Creek Tributary	1.82	0.69	38	1.45	80	0.129	0.188	0.227	0.279	0.318	0.355	0.156	0.263	0.388	0.470	0.583	0.665	0.745	0.262	550
D22A***	Fourteen Mile Creek Tributary	1.33	0.68	51	1.18	89	0.136	0.196	0.234	0.286	0.325	0.36	0.132	0.234	0.337	0.405	0.501	0.568	0.633	0.193	400
D22B***	Fourteen Mile Creek Tributary	0.56	0.22	39	0.45	80	0.049	0.069	0.082	0.099	0.112	0.124	0.049	0.100	0.143	0.171	0.209	0.237	0.264	0.081	170
D23***	Fourteen Mile Creek Tributary	1.17	0.49	42	0.90	77	0.107	0.153	0.182	0.221	0.248	0.275	0.109	0.198	0.287	0.344	0.422	0.479	0.534	0.168	350

* *Roadway runoff from Dundas Street only - does not include external area flows to culvert*

** *The existing storm sewers on Sutton Drive are designed to convey flows from 1.05 ha area of Dundas Street. The storm sewers drain to a downstream SWM pond located beyond the cul-de-sac of Dutchess Court. During detailed design, the capacity of the storm sewers will be assessed to accommodate the flows from the widened Dundas Street and if required, quality and quantity controls for the storm runoff from Dundas Street (1.69 ha) will be finalised at that time.*

*** *Including NOCSS Flows for the Adjacent Pervious Areas*

Appendix 7.6 – Stormwater Management Pond Calculations

MMM GROUP

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Subject **POND 1 - SWM Pond Design (1)**

Updated 2018.01.22

SWM Pond Stage-Storage Relationship:

Elevation (m)	Cumulative Storage (m^3)				
	Forebay	Main Cell	Total PP	Active Storage	
149.00			0	-	*Bottom of pond*
150.00			3,716	-	
151.00			8,529	-	
152.00			14,564	0	*Permanent pool*
153.00	-	-	-	7,552	*Extended Detention*
154.00	-	-	-	16,915	
155.00	-	-	-	28,257	
156.00	-	-	-	41,743	*Top of pond (Regional)*
156.75	-	-	-	53,117	*Buffer (including Freeboard)*

Permanent Pool Area (m^2) : 6,730

Extended Detention Pond Area (m^2) : 8,725 est.

All stage-storage volumes based on measurements from proposed grading model in Civil 3D.

SWM Pond Storage Requirements:

Drainage Area		23.55	ha
Imperviousness		88.0	%
Storage Criteria for Enhanced Level Quality Control (Wet Pond)		255.0	m^3/ha
Storage for Enhanced Level Quality Control (Wet Pond)		6,005	m^3
Required Permanent Pool Storage		5,063	m^3
Extended Detention Storage for Water Quality Control (40m ^{3}/ha)		942	m^3
25 mm Runoff Depth		19.70	mm
Required Extended Detention Storage for Erosion Control		4,639	m^3
Provided Storage for Proposed Stormwater Management Wet Pond	Permanent Pool Storage	14,564	m^3
	Active Storage for Water Quantity Control (Regional Storm)	41,743	m^3
	Total Max. Storage including Freeboard	53,117	m^3

Forebay Length Sizing Calculation

Settling Calculation

$$Dist = \sqrt{\frac{rQ_p}{V_s}}$$

Dist - Forebay Length	22.54	m	
Q - Peak Design Flowrate (25mm - Pond Outflow)	0.051	m3/s	
r - Length to width ratio	3		
V_s - Settling Velocity	0.0003	m/s	for 0.15mm diameter particle size

Dispersion Length Calculation

$$Dist = \frac{8Q}{dV_f};\ Width = \frac{Dist}{8}$$

Dist - Forebay Length		5.92	m	
Q - Inlet Flowrate	5-Year STM inflow to Forebay	1.11	m3/s	
d - Depth of Permanent Pool		3.00	m	
V_f - Desired Velocity in Forebay		0.5	m/s	max. permissible velocity in the forebay

Required Minimum Forebay Length **22.54 m**

Requred Minimum Bottom Width **2.82 m**

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Subject **POND 1 - SWM Pond Design (2)**

Pond Outlet Design - Erosion Control Orifice:

Provided Extended Detention Storage (m^3) :	7,552
Extended Detention Elevation (m) :	153.00
Permanent Pool Elevation (m)	152.00
Max. Extended Detention Depth (m) :	1.00
Permanent Pool Area (m^2) :	6,730
Extended Detention Pond Area (m^2) :	8,725
Orifice Flow Coefficient :	0.6
Diameter of Orifice Used (mm):	215
Area of Orifice Used (m^2) :	0.0363
Peak Flow (m^3/s) :	0.0957

Detention Time:

The falling head orifice equation is used to calculate the detention time:

$$t = \frac{2A_p}{CA_0(2g)^{0.5}}\left(h_1^{0.5} - h_2^{0.5}\right)$$

Where,
t = Drawdown Time in Seconds; *(target 72 hours)*
A_p = Surface Area of the Pond (m^2);
C = Orifice Flow Coefficient;
A_0 = Cross-sectional Area of the Orifice (m^2);
g = Gravitational Acceleration Constant (9.81 m/s^2);
h_1 = Starting Water Elevation above the orifice (m);
h_2 = Ending Water Elevation above the orifice (m).

Description	Elevation (m)	Surface Area (m^2)		Volume (m^3)	h_1 (m)	h_2 (m)	Maximum Flow (m^3/s)	Drawdown Time (hours)
Extended Detention	153.00	8,725	7,727	7,727	1.00	0.00	0.096	42.4
Permanent Pool	152.00	6,730						
							Total Drawdown Time (hours):	42.4

Updated 2018.01.19

Outlet Configuration:

	Orifice at Reversed Pipe to Control MH	Control MH		Emergency Spill
		Weir	Orifice at Outlet Pipe of Control MH (D/S)	
Ori. dia (mm) / Weir Length (m):	215	2.00	350	15.00
Invert Elevation:	152.00	153.00	152.00	156.10
Orifice/Weir Flow Coefficient:	0.61	1.84	0.61	1.84

Emergency Spillway design target:
To pass full Regional incoming flow within freeboard allowance (0.30 m maximum head)

Description	Elevation (m)	Depth to PP (m)	Active Storage (m3)	Controlled Flow (m3/s)					
				Reversed Pipe to Control MH^1	Control MH			Emergency Spill ^{3}	Total
					Weir^2	Outlet Pipe from Control MH (D/S) ^{1}	Restricted Flow from Control MH		
Permanent Pool	**152.00**	0.000	**0**	0.000	0.000	0.000	0.000	0.000	0.000
	152.50	0.500	3,776	0.061	0.000	0.000	0.061	0.000	0.061
Extended Detention	**153.00**	1.000	**7,552**	0.093	0.000	0.000	0.093	0.000	0.093
	153.50	1.500	12,234	0.116	1.301	0.299	0.299	0.000	0.299
	154.00	2.000	**16,915**	0.135	3.680	0.351	0.351	0.000	0.351
	154.50	2.500	22,586	0.152	6.761	0.396	0.396	0.000	0.396
	155.00	3.000	**28,257**	0.167	10.409	0.437	0.437	0.000	0.437
	155.50	3.500	35,000	0.181	14.546	0.474	0.474	0.000	0.474
Top of Pond (Flood Control Up to Regional)	**156.00**	**4.000**	**41,743**	**0.194**	**19.122**	**0.508**	**0.508**	**0.000**	**0.508**
0.3 m Freeboard	**156.30**	**4.300**	**46,293**	**0.201**	**22.061**	**0.528**	**0.528**	**2.469**	**2.997**
	156.45	4.450	48,568	0.204	23.582	0.537	0.537	5.715	6.252
Freeboard	**156.75**	**4.750**	**53,117**	**0.211**	**26.724**	**0.556**	**0.556**	**14.464**	**15.020**

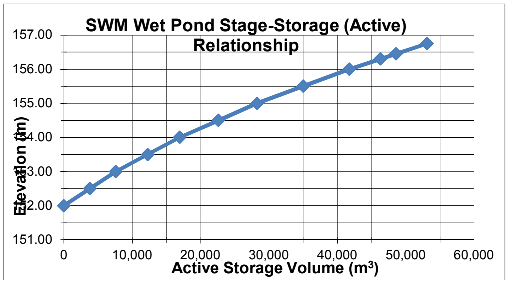
1) Orifice Equation: $Q = C A (2gh)^{1/2}$
2) Broad-Crested Weir Equation: $Q = C L H^{3/2}$
3) Emergency Spill to pass uncontrolled Regional Flows

Storage - Discharge Relationship

Elevation (m)	Discharge (m^3/s)	Storage (ha-m)
152.000	0.0000	0.0000
152.500	0.0615	0.3776
153.000	0.0927	0.7552
153.500	0.2992	1.2234
154.000	0.3512	1.6915
154.500	0.3964	2.2586
155.000	0.4369	2.8257
155.500	0.4740	3.5000
156.000	0.5084	4.1743
156.300	2.9966	4.6293
156.450	6.2524	4.8568
156.750	15.0197	5.3117

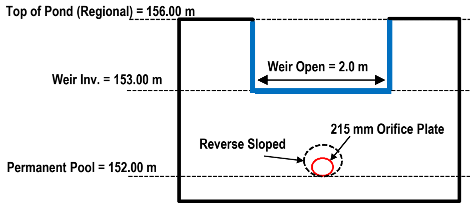
Water Elevation vs Return Periods

Elevation (m)	Discharge (m^3/s)	Storage (ha-m)	Return Period
152.41	0.05	0.3120	25 mm 24 hr
152.90	0.09	0.6808	2-Yr
153.14	0.15	0.8843	5-Yr
153.25	0.20	0.9930	10-Yr
153.43	0.27	1.1543	25-Yr
153.53	0.30	1.2553	50-Yr
153.68	0.32	1.3884	100-Yr
155.84	0.50	3.9624	Regional

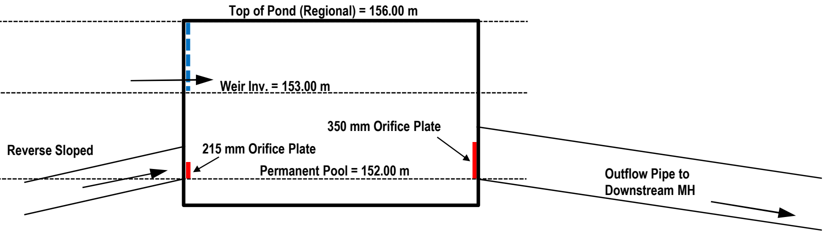


GAWSER RATING CURVE

152.00	0.0000	0.0000	Permanent Pool
152.50	0.0615	0.3776	
153.00	0.0927	0.7552	Extended Detention
153.50	0.2992	1.2234	
154.00	0.3512	1.6915	
155.00	0.4369	2.8257	
156.00	0.5084	4.1743	Top of Pond (Flood Control Up to Regional)
156.30	2.9966	4.6293	0.3 m Freeboard
156.45	6.2524	4.8568	
156.75	15.020	5.3117	Top of Pond (All)



Outlet Control MH
Conceptual Design - Side View 1



Outlet Control MH
Conceptual Design - Side View 2

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Subject POND 2 - SWM Pond Design (1)

Updated 2019.04.08

SWM Pond Stage-Storage Relationship:

Elevation (m)	Cumulative Storage (m^3)				
	Forebay	Main Cell	Total PP	Active Storage	
143.69	-	-	0	-	*Bottom of pond*
144.44	-	-	1,373	-	
145.44	-	-	4,381	-	
146.19	-	-	7,641	-	
146.69	-	-	10,431	0	*Permanent pool*
147.12	-	-	-	2,929	
147.64	-	-	-	7,132	*Extended Detention*
147.69	-	-	-	7,561	
148.44	-	-	-	14,550	
149.44	-	-	-	25,326	
150.74	-	-	-	41,935	*Top of pond (Regional)*
151.44	-	-	-	53,048	*Buffer (including Freeboard)*

Permanent Pool Area (m^2) :	6,264	
Extended Detention Pond Area (m^2) :	8,551	est.

All stage-storage volumes based on measurements from proposed grading model in Civil 3D.

SWM Pond Storage Requirements:

Drainage Area		20.75	ha
Imperviousness		89.1	%
Storage Criteria for Enhanced Level Quality Control (Wet Pond)		256.9	m^3/ha
Storage for Enhanced Level Quality Control (Wet Pond)		5,331	m^3
Required Permanent Pool Storage		4,501	m^3
Extended Detention Storage for Water Quality Control (40m ^{3}/ha)		830	m^3
25 mm Runoff Depth		20.06	mm
Required Extended Detention Storage for Erosion Control		4,162	m^3
Provided Storage for Proposed Stormwater Management Wet Pond	Permanent Pool Storage	10,431	m^3
	Active Storage for Water Quantity Control (Regional Storm)	41,935	m^3
	Total Max. Storage including Freeboard	53,048	m^3

Forebay Length Sizing Calculation

Settling Calculation

$$Dist = \sqrt{\frac{rQ_p}{V_s}}$$

Dist - Forebay Length	21.56	m	
Q - Peak Design Flowrate (25mm - Pond Outflow)	0.047	m3/s	
r - Length to width ratio	3		
V_s - Settling Velocity	0.0003	m/s	for 0.15mm diameter particle size

Dispersion Length Calculation

$$Dist = \frac{8Q}{dV_f};\ Width = \frac{Dist}{8}$$

Dist - Forebay Length		5.19	m	
Q - Inlet Flowrate	5-Year STM inflow to Forebay	0.97	m3/s	
d - Depth of Permanent Pool		3.00	m	
V_f - Desired Velocity in Forebay		0.5	m/s	max. permissible velocity in the forebay

Required Minimum Forebay Length 21.56 m
Requred Minimum Bottom Width 2.70 m

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Subject **POND 2 - SWM Pond Design (2)**

Pond Outlet Design - Erosion Control Orifice:

Provided Extended Detention Storage (m^3) :	7,155
Extended Detention Elevation (m) :	147.64
Permanent Pool Elevation (m)	146.69
Max. Extended Detention Depth (m) :	0.95
Permanent Pool Area (m^2) :	6,264
Extended Detention Pond Area (m^2) :	8,551
Orifice Flow Coefficient :	0.6
Diameter of Orifice Used (mm):	**200**
Area of Orifice Used (m^2) :	0.0314
Peak Flow (m^3/s) :	0.0783

Detention Time:

The falling head orifice equation is used to calculate the detention time:

$$t = \frac{2A_p}{CA_0(2g)^{0.5}}\left(h_1^{0.5} - h_2^{0.5}\right)$$

Where,

t = Drawdown Time in Seconds; *(target 72 hours)*

A_p = Surface Area of the Pond (m^2);

C = Orifice Flow Coefficient;

A_0 = Cross-sectional Area of the Orifice (m^2);

g = Gravitational Acceleration Constant (9.81 m/s^2);

h_1 = Starting Water Elevation above the orifice (m);

h_2 = Ending Water Elevation above the orifice (m).

Description	Elevation (m)	Surface Area (m^2)		Volume (m^3)	h_1 (m)	h_2 (m)	Maximum Flow (m^3/s)	Drawdown Time (hours)
Extended Detention	147.64	8,551	7,408	7,038	0.95	0.00	0.078	**47.3**
Permanent Pool	146.69	6,264						
							Total Drawdown Time (hours):	47.3

Outlet Configuration:

	Orifice at Reversed Pipe to Control MH	Control MH		Emergency Spill
		Weir	Orifice at Outlet Pipe of Control MH (D/S)	
Ori. dia (mm) / Weir Length (m):	200	2.00	270	15.00
Invert Elevation:	146.69	147.64	146.69	150.84
Orifice/Weir Flow Coefficient:	0.61	1.84	0.61	1.84

Emergency Spillway design target:

To pass full Regional incoming flow within freeboard allowance (0.30 m maximum head)

Description	Elevation (m)	Depth to PP (m)	Active Storage (m3)	Controlled Flow (m3/s)					
					Control MH				
				Reversed Pipe to Control MH[1]	Weir[2]	Outlet Pipe from Control MH (D/S) [1]	Restricted Flow from Control MH	Emergency Spill [3]	Total
Permanent Pool	**146.69**	0.000	**0**	0.000	0.000	0.000	0.000	0.000	0.000
	146.91	0.215	1,464	0.029	0.000	0.000	0.029	0.000	0.029
	147.12	0.430	**2,929**	0.049	0.000	0.000	0.049	0.000	0.049
Extended Detention	147.64	0.950	7,155	0.078	0.000	0.000	0.078	0.000	0.078
	147.69	1.000	**7,561**	0.081	0.041	0.144	0.041	0.000	0.041
	148.07	1.375	11,056	0.096	1.020	0.172	0.172	0.000	0.172
	148.44	1.750	**14,550**	0.109	2.633	0.197	0.197	0.000	0.197
	148.94	2.250	19,938	0.124	5.455	0.225	0.225	0.000	0.225
	149.44	2.750	**25,326**	0.138	8.887	0.250	0.250	0.000	0.250
	150.09	3.400	33,631	0.154	14.112	0.280	0.280	0.000	0.280
Top of Pond (Flood Control Up to Regional)	**150.74**	**4.050**	**41,935**	**0.169**	**20.086**	**0.306**	**0.306**	**0.000**	**0.306**
0.3 m Freeboard	**151.04**	**4.350**	**46,698**	**0.175**	**23.071**	**0.318**	**0.318**	**2.469**	**2.786**
	151.14	4.450	48,285	0.177	24.096	0.321	0.321	4.535	4.856
Top of Pond (All)	**151.44**	**4.750**	**53,048**	**0.183**	**27.260**	**0.332**	**0.332**	**12.827**	**13.160**

1) Orifice Equation: $Q = C A (2gh)^{1/2}$

2) Broad-Crested Weir Equation: $Q = C L H^{3/2}$

3) Emergency Spill to pass uncontrolled Regional Flows

Storage - Discharge Relationship

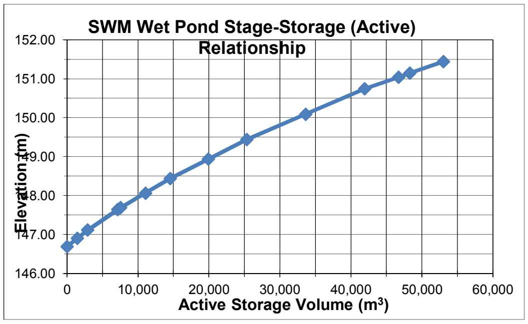
Elevation (m)	Discharge (m^3/s)	Storage (ha-m)
146.690	0.0000	0.0000
146.905	0.0288	0.1464
147.120	0.0488	0.2929
147.640	0.0783	0.7155
147.690	0.0411	0.7561
148.065	0.1723	1.1056
148.440	0.1966	1.4550
148.940	0.2250	1.9938
149.440	0.2502	2.5326
150.090	0.2795	3.3631
150.740	0.3061	4.1935
151.040	2.7862	4.6698
151.140	4.8565	4.8285
151.440	13.1597	5.3048

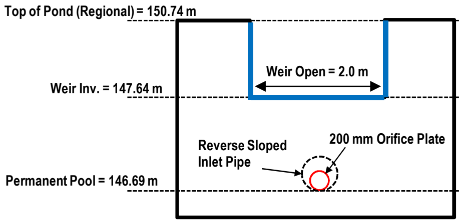
Water Elevation vs Return Periods (Simulated)

Elevation (m)	Discharge (m^3/s)	Storage (ha-m)	Return Period
147.72	0.05	0.2759	25 mm 24 hr
147.84	0.07	0.6166	2-Yr
147.87	0.08	0.8721	5-Yr
147.95	0.09	0.9939	10-Yr
148.13	0.13	1.1700	25-Yr
148.25	0.16	1.2759	50-Yr
148.38	0.18	1.3981	100-Yr
150.63	0.30	4.0505	Regional

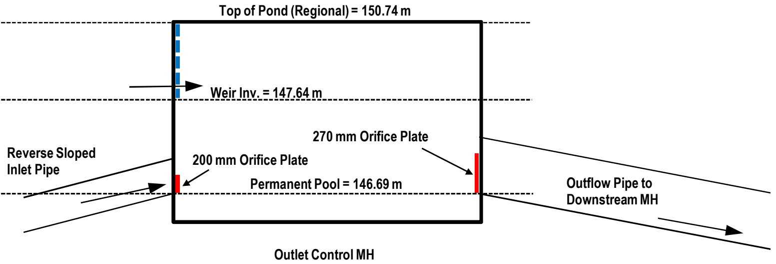
GAWSER RATING CURVE

146.69	0.0000	0.0000	Permanent Pool
146.91	0.0288	0.1464	
147.12	0.0488	0.2929	
147.64	0.0783	0.7155	Extended Detention
147.69	0.0411	0.7561	
148.44	0.1966	1.4550	
149.44	0.2502	2.5326	
150.74	0.3061	4.1935	Top of Pond (Flood Control Up to Regional)
151.14	4.8565	4.8285	
151.44	13.160	5.3048	Top of Pond (All)



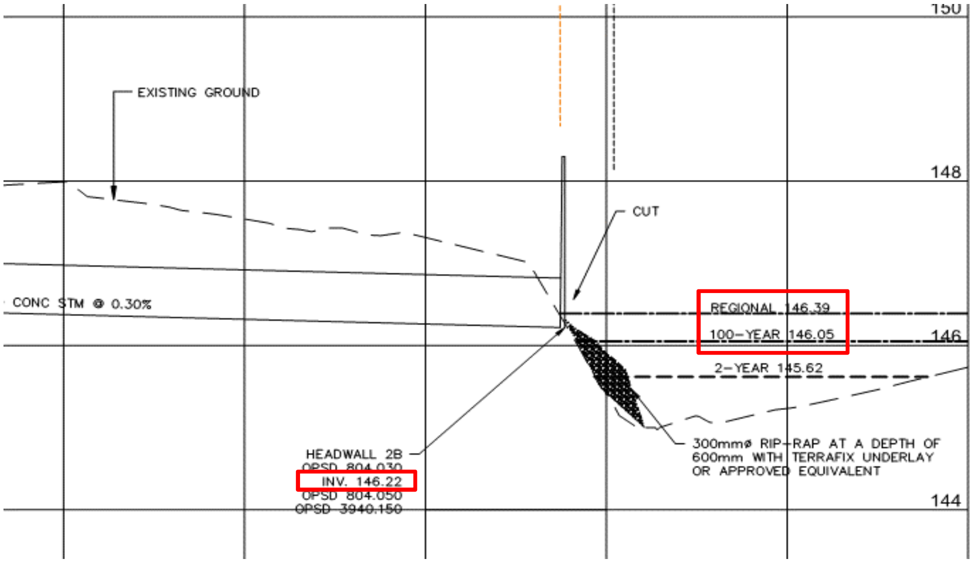


Outlet Control MH
Conceptual Design - Side View 1



Outlet Control MH
Conceptual Design - Side View 2

Tailwater Analysis



Permanent Pool	146.69 m
Invert of Outlet	146.22 m
100-Year Flood Elevation at Receiving Water Course	146.05 m
Regional Flood Elevation at Receiving Water Course	146.39 m

Permanent Pool Elevation is higher than the Regional flood elevation at the Receiving Water Course

Although the outlet pipe would be submerged during the Regional event, the rating curve developed is still hydraulically functional and valid.

Consequently, tailwater analysis is not required.

MMM GROUP

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Subject: **POND 3 - SWM Pond Design (1)**

Phase 1B / 2

Updated 2019.04.09

SWM Pond Stage-Storage Relationship:

Elevation (m)	Cumulative Storage (m^3)				
	Forebay	Main Cell	Total PP	Active Storage	
143.20	-	-	0	-	*Bottom of pond*
145.00	-	-	14,621	-	
145.77	-	-	23,126	-	
146.20	-	-	28,690	0	*Permanent pool*
146.63	-	-	-	6,360	
146.95	-	-	-	11,546	
147.00	-	-	-	12,381	*Extended Detention*
147.50	-	-	-	21,146	
148.20	-	-	-	34,698	
149.25	-	-	-	57,641	
150.30	-	-	-	84,112	*Top of pond (Regional)*
151.00	-	-	-	105,151	*Buffer (including Freeboard)*

Permanent Pool Area (m^2) :	13,825	
Extended Detention Pond Area (m^2) :	16,787	est.

All stage-storage volumes based on measurements from proposed grading model in Civil 3D.

SWM Pond Storage Requirements:

Drainage Area		36.99	ha
Imperviousness		90.0	%
Storage Criteria for Enhanced Level Quality Control (Wet Pond)		258.3	m^3/ha
Storage for Enhanced Level Quality Control (Wet Pond)		9,556	m^3
Required Permanent Pool Storage		8,076	m^3
Extended Detention Storage for Water Quality Control (40m^3/ha)		1,480	m^3
25 mm Runoff Depth		20.06	mm
Required Extended Detention Storage for Erosion Control		7,420	m^3
Provided Storage for Proposed Stormwater Management Wet Pond	Permanent Pool Storage	28,690	m^3
	Active Storage for Water Quantity Control (Regional Storm)	74,486	m^3
	Total Max. Storage including Freeboard	105,151	m^3

Forebay Length Sizing Calculation

Settling Calculation

$$Dist = \sqrt{\frac{rQ_p}{V_s}}$$

Dist - Forebay Length	20.59	m	
Q - Peak Design Flowrate (25mm - Pond Outflow)	0.042	m3/s	
r - Length to width ratio	3		
V_s - Settling Velocity	0.0003	m/s	for 0.15mm diameter particle size

Dispersion Length Calculation

$$Dist = \frac{8Q}{dV_f}; \; Width = \frac{Dist}{8}$$

Dist - Forebay Length		6.83	m	
Q - Inlet Flowrate	5-Year STM inflow to Forebay	1.28	m3/s	
d - Depth of Permanent Pool		3.00	m	
V_f - Desired Velocity in Forebay		0.5	m/s	max. permissible velocity in the forebay

Required Minimum Forebay Length	**20.59 m**
Requred Minimum Bottom Width	**2.57 m**

For PhaseS 1B/2 Only. 22.58 m and 2.82 m for Ultimate Conditions.

MMM GROUP	Project	Bentall 407 West	No.	14-09222-001-SW1		
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Subject	**POND 3 - SWM Pond Design (2)**					

Pond Outlet Design - Erosion Control Orifice:

Provided Extended Detention Storage (m^3) :	12,381
Extended Detention Elevation (m) :	147.00
Permanent Pool Elevation (m)	146.20
Max. Extended Detention Depth (m) :	0.80
Permanent Pool Area (m^2) :	13,825
Extended Detention Pond Area (m^2) :	16,787
Orifice Flow Coefficient :	0.6
Diameter of Orifice Used (mm):	**255**
Area of Orifice Used (m^2) :	0.0511
Peak Flow (m^3/s) :	0.1169

For Phase 1B/2 Only. 290 mm Dia for Ultimate Conditions.

Detention Time:

The falling head orifice equation is used to calculate the detention time:

$$t = \frac{2A_p}{CA_0(2g)^{0.5}}\left(h_1^{0.5} - h_2^{0.5}\right)$$

Where,
t = Drawdown Time in Seconds; *(target 72 hours)*
A_p = Surface Area of the Pond (m^2);
C = Orifice Flow Coefficient;
A_0 = Cross-sectional Area of the Orifice (m^2);
g = Gravitational Acceleration Constant (9.81 m/s^2);
h_1 = Starting Water Elevation above the orifice (m);
h_2 = Ending Water Elevation above the orifice (m).

Description	Elevation (m)	Surface Area (m^2)		Volume (m^3)	h_1 (m)	h_2 (m)	Maximum Flow (m^3/s)	Drawdown Time (hours)
Extended Detention	147.00	16,787	15,306	12,245	0.80	0.00	0.117	53.4
Permanent Pool	146.20	13,825						
							Total Drawdown Time (hours):	53.4

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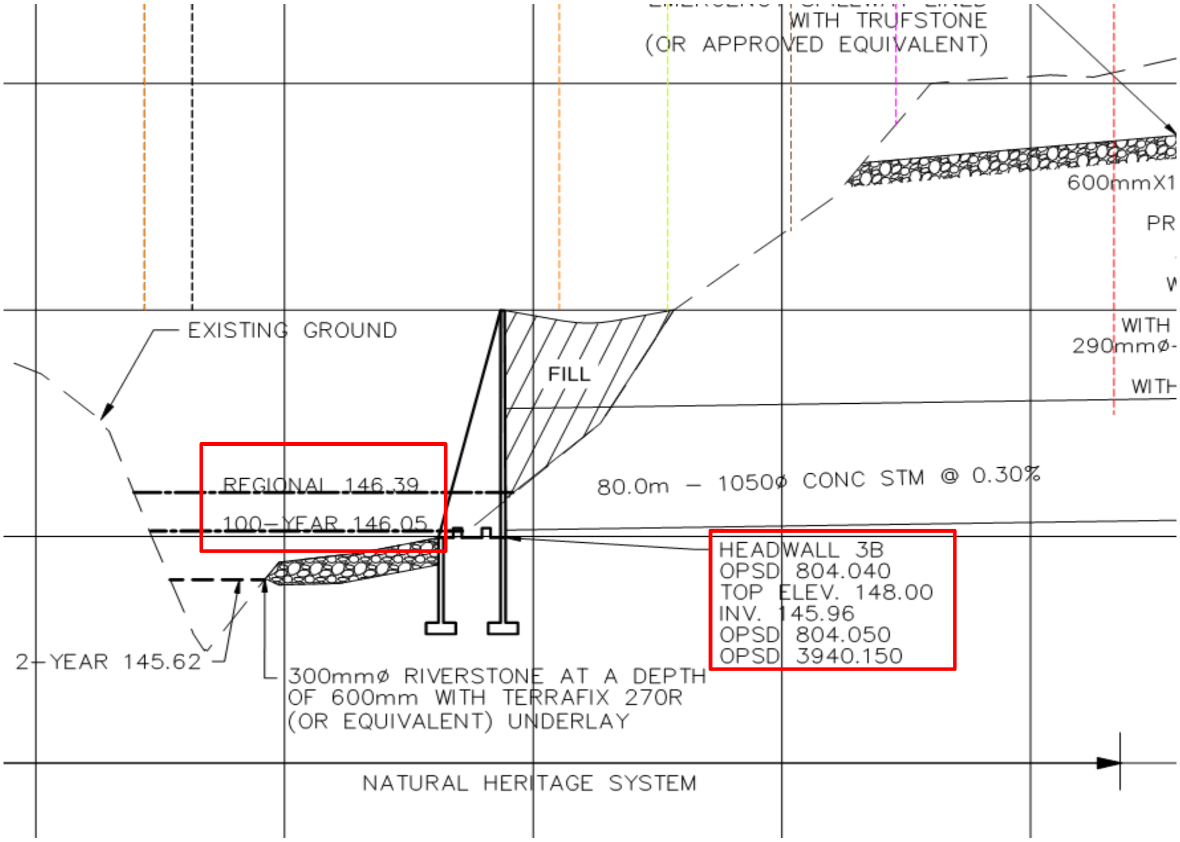
Subject **POND 3 - SWM Pond Design (3)**

Phase 1B / 2

Updated 2019.04.09

Tailwater Analysis



Permanent Pool	146.20	m
Invert of Outlet	145.96	m
100-Year Flood Elevation at Receiving Water Course	146.05	m
Regional Flood Elevation at Receiving Water Course	146.39	m

Permanent Pool Elevation is higher than the 100-year, but lower than the Regional flood elevations at the Receiving Water Course

Although the outlet pipe would be submerged during the 100-year events, the rating curve developed is still hydraulically functional and valid for storm events of 2- to 100-years.

The permanent pool elevation is lower than the Regional flood elevation at the receiving water course, the rating curve needs to be revised to accommondate the reduced headwater depth due to the high water elevation at the receiving water course during the Regional storm event.

MMM GROUP

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Subject	POND 3 - SWM Pond Design (4)				

Tailwater Analysis

Outlet Configuration:

For Phase 1B/2 Only. 290 mm Dia for Ultimate Conditions.

	Orifice at Reversed Pipe to Control MH	Control MH		Emergency Spill
		Weir	Orifice at Outlet Pipe of Control MH (D/S)	
Ori. dia (mm) / Weir Length (m):	255	2.00	400	20.00
Invert Elevation:	146.39	147.00	146.39	149.88
Orifice/Weir Flow Coefficient:	0.61	1.84	0.61	1.84

Regional Water Level at Receiving Water Course (Tailwater)

Emergency Spillway design target:
To pass full Regional incoming flow within freeboard allowance (0.30 m maximum head)

Description	Elevation (m)	Depth to PP (m)	Active Storage (m3)	Controlled Flow (m3/s)					
				Reversed Pipe to Control MH[1]	Control MH			Emergency Spill [3]	Total
					Weir[2]	Outlet Pipe from Control MH (D/S) [1]	Restricted Flow from Control MH		
Permanent Pool	**146.20**	0.000	**0**	0.000	0.000	0.000	0.000	0.000	0.000
	146.42	0.215	3,180	0.000	0.000	0.000	0.000	0.000	0.000
	146.63	0.430	**6,360**	0.046	0.000	0.000	0.046	0.000	0.046
	146.95	0.750	**11,546**	0.091	0.000	0.000	0.091	0.000	0.091
Extended Detention	147.00	0.800	12,648	0.096	0.000	0.000	0.096	0.000	0.096
	147.50	1.300	**21,146**	0.137	1.301	0.324	0.324	0.000	0.324
	147.85	1.650	27,922	0.159	2.884	0.381	0.381	0.000	0.381
	148.20	2.000	**34,698**	0.179	4.837	0.431	0.431	0.000	0.431
	148.73	2.525	46,169	0.205	8.337	0.496	0.496	0.000	0.496
	149.25	3.050	**57,641**	0.228	12.420	0.554	0.554	0.000	0.554
Top of Pond (Flood Control Up to Regional)	**149.78**	**3.575**	**74,486**	**0.249**	**17.011**	**0.606**	**0.606**	**0.000**	**0.606**
0.3 m Freeboard	**150.08**	**3.875**	**84,112**	**0.260**	**19.843**	**0.634**	**0.634**	**3.291**	**3.925**
	150.30	4.100	89,230	0.268	22.061	0.654	0.654	10.196	10.850
	150.70	4.500	98,328	0.282	26.191	0.688	0.688	27.576	28.264
Top of Pond (All)	**151.00**	**4.800**	**105,151**	**0.292**	**29.440**	**0.713**	**0.713**	**43.911**	**44.624**

1) Orifice Equation: $Q = C A (2gh)^{1/2}$
2) Broad-Crested Weir Equation: $Q = C L H^{3/2}$
3) Emergency Spill to pass uncontrolled Regional Flows

Storage - Discharge Relationship

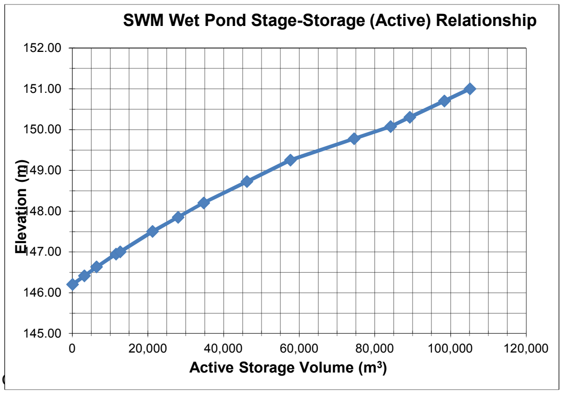
Elevation (m)	Discharge (m^3/s)	Storage (ha-m)
146.200	0.0000	0.0000
146.415	0.0000	0.3180
146.630	0.0463	0.6360
146.950	0.0907	1.1546
147.000	0.0959	1.2648
147.500	0.3239	2.1146
147.850	0.3811	2.7922
148.200	0.4308	3.4698
148.725	0.4961	4.6169
149.250	0.5538	5.7641
149.775	0.6060	7.4486
150.075	3.9253	8.4112
150.300	10.8500	8.9230
150.700	28.2642	9.8328
151.000	44.6244	10.5151

Water Elevation vs Return Periods

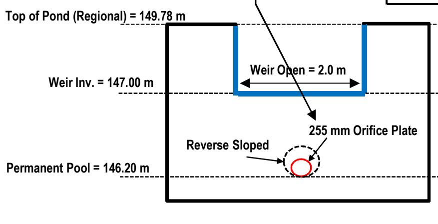
Elevation (m)	Discharge (m^3/s)	Storage (ha-m)	Return Period
146.59	0.04	0.5818	25 mm 24 hr
146.97	0.09	1.1953	2-Yr
147.15	0.16	1.5220	5-Yr
147.26	0.22	1.7138	10-Yr
147.43	0.29	2.0003	25-Yr
147.53	0.33	2.1782	50-Yr
147.64	0.34	2.4120	100-Yr
149.48	1.48	6.4894	Regional

GAWSER RATING CURVE

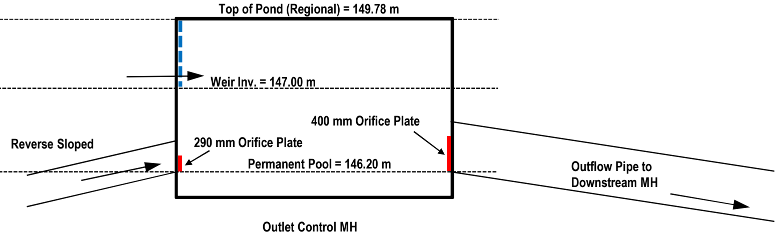
146.20	0.0000	0.0000	Permanent Pool
146.63	0.0463	0.6360	
146.95	0.0907	1.1546	
147.00	0.0959	1.2648	Extended Detention
147.50	0.3239	2.1146	
149.25	0.5538	5.7641	
150.08	3.9253	8.4112	Top of Pond (Flood (
150.30	10.850	8.9230	
150.70	28.264	9.8328	
151.00	44.624	10.5151	Top of Pond (All)



For Phase 2 Only. 290 mm Dia for Ultimate Conditions.



Outlet Control MH
Conceptual Design - Side View 1



Outlet Control MH
Conceptual Design - Side View 2

MMM GROUP

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Subject **POND 3 - SWM Pond Design (1)**

Ultimate Condition

Updated 2019.04.09

SWM Pond Stage-Storage Relationship:

Elevation (m)	Cumulative Storage (m^3)				
	Forebay	Main Cell	Total PP	Active Storage	
143.20	-	-	0	-	*Bottom of pond*
145.00	-	-	14,621	-	
145.77	-	-	23,126	-	
146.20	-	-	28,690	0	*Permanent pool*
146.63	-	-	-	6,360	
146.95	-	-	-	11,546	
147.00	-	-	-	12,381	*Extended Detention*
147.50	-	-	-	21,146	
148.20	-	-	-	34,698	
149.25	-	-	-	57,641	
150.30	-	-	-	84,112	*Top of pond (Regional)*
151.00	-	-	-	105,151	*Buffer (including Freeboard)*

Permanent Pool Area (m^2) :	13,825	
Extended Detention Pond Area (m^2) :	16,787	est.

All stage-storage volumes based on measurements from proposed grading model in Civil 3D.

SWM Pond Storage Requirements:

Drainage Area		39.85	ha
Imperviousness		90.0	%
Storage Criteria for Enhanced Level Quality Control (Wet Pond)		258.3	m^3/ha
Storage for Enhanced Level Quality Control (Wet Pond)		10,295	m^3
Required Permanent Pool Storage		8,701	m^3
Extended Detention Storage for Water Quality Control (40m^3/ha)		1,594	m^3
25 mm Runoff Depth		20.06	mm
Required Extended Detention Storage for Erosion Control		7,994	m^3
Provided Storage for Proposed Stormwater Management Wet Pond	Permanent Pool Storage	28,690	m^3
	Active Storage for Water Quantity Control (Regional Storm)	74,486	m^3
	Total Max. Storage including Freeboard	105,151	m^3

Forebay Length Sizing Calculation

Settling Calculation

$$Dist = \sqrt{\frac{rQ_p}{V_s}}$$

Dist - Forebay Length	22.58	m	
Q - Peak Design Flowrate (25mm - Pond Outflow)	0.051	m3/s	
r - Length to width ratio	3		
V_s - Settling Velocity	0.0003	m/s	for 0.15mm diameter particle size

Dispersion Length Calculation

$$Dist = \frac{8Q}{dV_f}; \; Width = \frac{Dist}{8}$$

Dist - Forebay Length	6.83	m	
Q - Inlet Flowrate 5-Year STM inflow to Forebay	1.28	m3/s	
d - Depth of Permanent Pool	3.00	m	
V_f - Desired Velocity in Forebay	0.5	m/s	max. permissible velocity in the forebay

Required Minimum Forebay Length	**22.58**	**m**
Requred Minimum Bottom Width	**2.82**	**m**

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	By	**AZZ**	**Date**	**2019 04 09**		**Page** **2**
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Subject	**POND 3 - SWM Pond Design (2)**

Pond Outlet Design - Erosion Control Orifice:

Provided Extended Detention Storage (m^3) :	12,381
Extended Detention Elevation (m) :	147.00
Permanent Pool Elevation (m)	146.20
Max. Extended Detention Depth (m) :	0.80
Permanent Pool Area (m^2) :	13,825
Extended Detention Pond Area (m^2) :	16,787
Orifice Flow Coefficient :	0.6
Diameter of Orifice Used (mm):	**290**
Area of Orifice Used (m^2) :	0.0661
Peak Flow (m^3/s) :	0.1492

Detention Time:

The falling head orifice equation is used to calculate the detention time:

$$t = \frac{2A_p}{CA_0(2g)^{0.5}}\left(h_1^{0.5} - h_2^{0.5}\right)$$

Where,
t = Drawdown Time in Seconds; *(target 72 hours)*
A_p = Surface Area of the Pond (m^2);
C = Orifice Flow Coefficient;
A_0 = Cross-sectional Area of the Orifice (m^2);
g = Gravitational Acceleration Constant (9.81 m/s^2);
h_1 = Starting Water Elevation above the orifice (m);
h_2 = Ending Water Elevation above the orifice (m).

Description	Elevation (m)	Surface Area (m^2)		Volume (m^3)	h_1 (m)	h_2 (m)	Maximum Flow (m^3/s)	Drawdown Time (hours)
Extended Detention	147.00	16,787	15,306	12,245	0.80	0.00	0.149	41.3
Permanent Pool	146.20	13,825						
							Total Drawdown Time (hours):	41.3

Project	Bentall 407 West	No.	14-09222-001-SW1		
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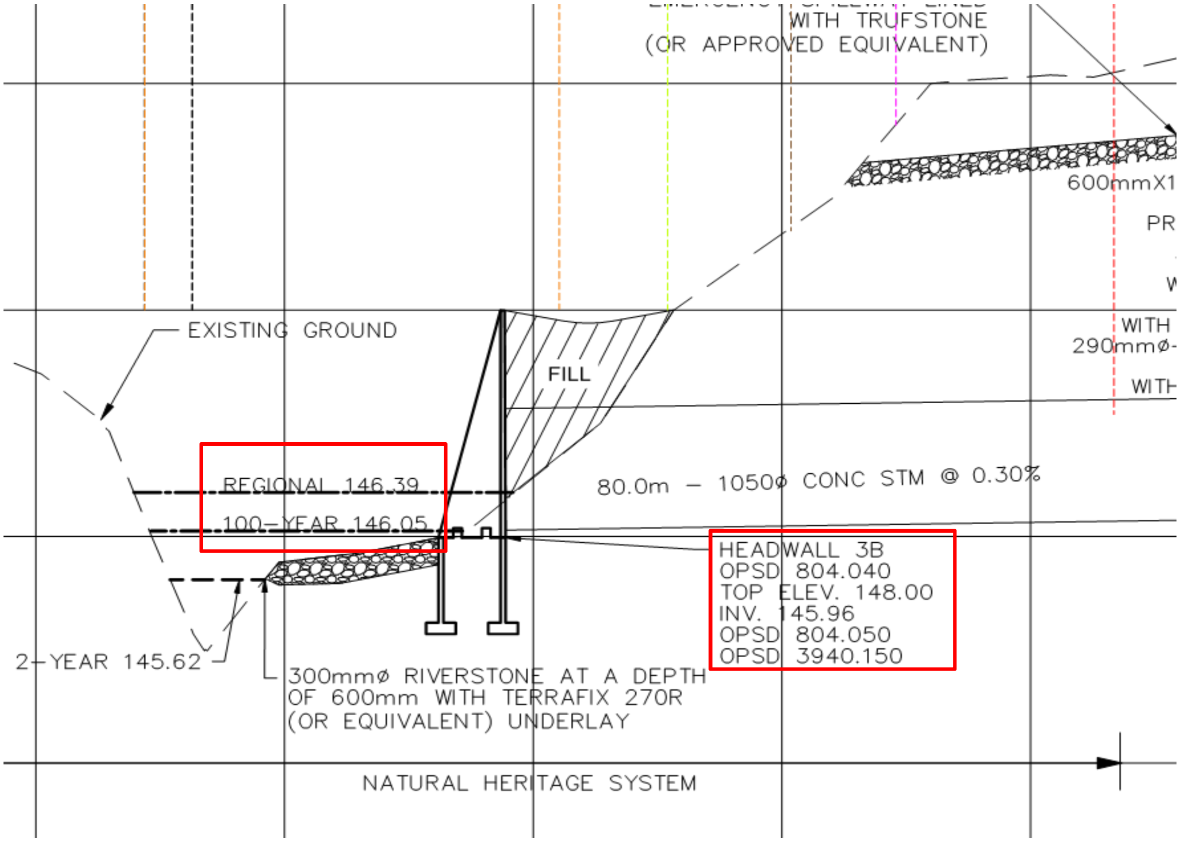
Subject **POND 3 - SWM Pond Design (3)**

Ultimate Condition

Updated 2019.04.09

Tailwater Analysis



Permanent Pool	146.20	m
Invert of Outlet	145.96	m
100-Year Flood Elevation at Receiving Water Course	146.05	m
Regional Flood Elevation at Receiving Water Course	146.39	m

Permanent Pool Elevation is higher than the 100-year, but lower than the Regional flood elevations at the Receiving Water Course

Although the outlet pipe would be submerged during the 100-year events, the rating curve developed is still hydraulically functional and valid for storm events of 2- to 100-years.

The permanent pool elevation is lower than the Regional flood elevation at the receiving water course, the rating curve needs to be revised to accommondate the reduced headwater depth due to the high water elevation at the receiving water course during the Regional storm event.

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Subject	POND 3 - SWM Pond Design (4)				

Tailwater Analysis

Outlet Configuration:

	Orifice at Reversed Pipe to Control MH	Control MH		Emergency Spill
		Weir	Orifice at Outlet Pipe of Control MH (D/S)	
Ori. dia (mm) / Weir Length (m):	290	2.00	400	20.00
Invert Elevation:	146.39	147.00	146.39	149.88
Orifice/Weir Flow Coefficient:	0.61	1.84	0.61	1.84

Regional Water Level at Receiving Water Course (Tailwater)

Emergency Spillway design target:
To pass full Regional incoming flow within freeboard allowance (0.30 m maximum head)

Description	Elevation (m)	Depth to PP (m)	Active Storage (m3)	Controlled Flow (m3/s)					
				Reversed Pipe to Control MH[1]	Control MH			Emergency Spill [3]	Total
					Weir[2]	Outlet Pipe from Control MH (D/S) [1]	Restricted Flow from Control MH		
Permanent Pool	**146.20**	0.000	**0**	0.000	0.000	0.000	0.000	0.000	0.000
	146.42	0.215	3,180	0.000	0.000	0.000	0.000	0.000	0.000
	146.63	0.430	**6,360**	0.055	0.000	0.000	0.055	0.000	0.055
	146.95	0.750	**11,546**	0.115	0.000	0.000	0.115	0.000	0.115
Extended Detention	147.00	0.800	12,648	0.122	0.000	0.000	0.122	0.000	0.122
	147.50	1.300	**21,146**	0.175	1.301	0.324	0.324	0.000	0.324
	147.85	1.650	27,922	0.205	2.884	0.381	0.381	0.000	0.381
	148.20	2.000	**34,698**	0.230	4.837	0.431	0.431	0.000	0.431
	148.73	2.525	46,169	0.264	8.337	0.496	0.496	0.000	0.496
	149.25	3.050	**57,641**	0.294	12.420	0.554	0.554	0.000	0.554
Top of Pond (Flood Control Up to Regional)	**149.78**	**3.575**	**74,486**	**0.321**	**17.011**	**0.606**	**0.606**	**0.000**	**0.606**
0.3 m Freeboard	**150.08**	**3.875**	**84,112**	**0.336**	**19.843**	**0.634**	**0.634**	**3.291**	**3.925**
	150.30	4.100	89,230	0.346	22.061	0.654	0.654	10.196	10.850
	150.70	4.500	98,328	0.364	26.191	0.688	0.688	27.576	28.264
Top of Pond (All)	**151.00**	**4.800**	**105,151**	**0.377**	**29.440**	**0.713**	**0.713**	**43.911**	**44.624**

1) Orifice Equation: $Q = C A (2gh)^{1/2}$
2) Broad-Crested Weir Equation: $Q = C L H^{3/2}$
3) Emergency Spill to pass uncontrolled Regional Flows

Storage - Discharge Relationship

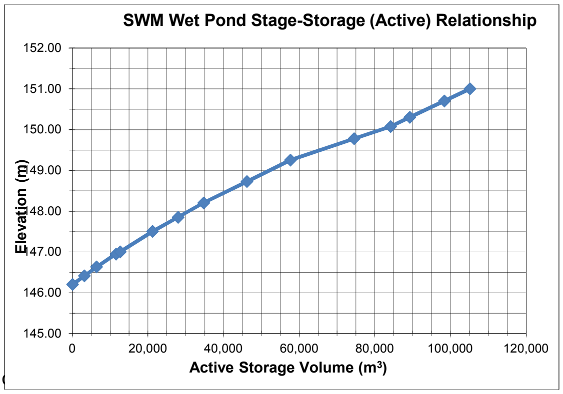
Elevation (m)	Discharge (m^3/s)	Storage (ha-m)
146.200	0.0000	0.0000
146.415	0.0000	0.3180
146.630	0.0550	0.6360
146.950	0.1150	1.1546
147.000	0.1217	1.2648
147.500	0.3239	2.1146
147.850	0.3811	2.7922
148.200	0.4308	3.4698
148.725	0.4961	4.6169
149.250	0.5538	5.7641
149.775	0.6060	7.4486
150.075	3.9253	8.4112
150.300	10.8500	8.9230
150.700	28.2642	9.8328
151.000	44.6244	10.5151

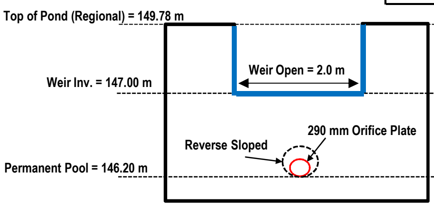
Water Elevation vs Return Periods

Elevation (m)	Discharge (m^3/s)	Storage (ha-m)	Return Period
146.60	0.05	0.5895	25 mm 24 hr
146.97	0.12	1.1951	2-Yr
147.15	0.18	1.5270	5-Yr
147.27	0.23	1.7237	10-Yr
147.44	0.30	2.0154	25-Yr
147.54	0.33	2.1959	50-Yr
147.66	0.34	2.4381	100-Yr
149.47	1.44	6.4583	Regional

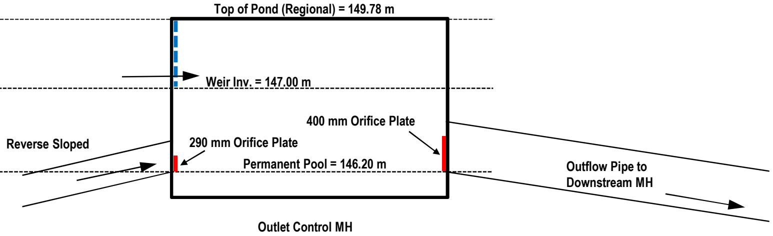
GAWSER RATING CURVE

146.20	0.0000	0.0000	Permanent Pool
146.63	0.0550	0.6360	
146.95	0.1150	1.1546	
147.00	0.1217	1.2648	Extended Detention
147.50	0.3239	2.1146	
149.25	0.5538	5.7641	
150.08	3.9253	8.4112	Top of Pond (Flood
150.30	10.850	8.9230	
150.70	28.264	9.8328	
151.00	44.624	10.5151	Top of Pond (All)





Outlet Control MH
Conceptual Design - Side View 1



Outlet Control MH
Conceptual Design - Side View 2

Rooftop Control

Updated 2019.04.09

FOR PH1B

Catchment GAWSER ID	2309
Area (ha)	2.56
Imperviousness	100
Rooftop Control GAWSER ID	1020

Rating Curve

ELEVATION (m)	OUTFLOW (cms)	STORAGE (ha*m)
160	0	0
160.15	0.1050	0.3840
	↑	↑
Assume:	41 L/s/ha	0.15 m Depth

REVISED FOR PH2 AND ULT

Catchment GAWSER ID	2309
Area (ha)	5.12
Imperviousness	100
Rooftop Control GAWSER ID	1020

Rating Curve

ELEVATION (m)	OUTFLOW (cms)	STORAGE (ha*m)
160	0	0
160.15	0.2099	0.7680
	↑	↑
Assume:	41 L/s/ha	0.15 m Depth

Typical Roof Drain Design
Zurn Control-Flow Roof Drains

Area per Drain (sq. m.)	Drain Rise (mm)	Max. Discharge per Drain (L/min)	Unit Controlled Flow Rate (L/s/ha)
518	150	127.5	41

Results

Phase 1B

Return Period	ROOFTOP			
	Inflow (cms)	Water Depth (m)	Utilized Storage (ha*m)	Outflow (cms)
Gawser ID	**2309**			**1020**
25 mm 24 hr	0.040	0.013	0.0327	0.009
2-Yr	0.090	0.026	0.0659	0.018
5-Yr	0.124	0.034	0.0871	0.024
10-Yr	0.145	0.039	0.1002	0.027
25-Yr	0.172	0.047	0.1199	0.033
50-Yr	0.192	0.052	0.1322	0.036
100-Yr	0.212	0.057	0.1460	0.040
Regional	0.247	0.136	0.3490	0.095

Phase 2 and Ultimate

Return Period	ROOFTOP			
	Inflow (cms)	Water Depth (m)	Utilized Storage (ha*m)	Outflow (cms)
Gawser ID	**2309**			**1020**
25 mm 24 hr	0.080	0.013	0.0654	0.018
2-Yr	0.180	0.026	0.1318	0.036
5-Yr	0.249	0.034	0.1743	0.048
10-Yr	0.291	0.039	0.2004	0.055
25-Yr	0.345	0.047	0.2399	0.066
50-Yr	0.385	0.052	0.2643	0.072
100-Yr	0.425	0.057	0.2921	0.080
Regional	0.493	0.136	0.6982	0.191

SWM Pond Flows

PH1A CONDITIONS

QUANTITY CONTROL UP TO REGIONAL STORM EVENT

FINAL, APRIL 2017, MMM, AZZ

POND 2

PH1A Drainage Area	15.58 ha	Plus Dundas Street	2.24	ha
Imperviousness	90 %		82	%
Total Drainage Area	17.82 ha			
Imperviousness	89 %			
Detention Time	47 Hr			

Rating Curve

ELEVATION (m)	OUTFLOW (cms)	STORAGE (ha*m)	
146.69	0.0000	0.0000	Permanent Pool
146.91	0.0288	0.1464	
147.12	0.0488	0.2929	
147.64	0.0783	0.7155	Extended Detention
147.69	0.0411	0.7561	
148.44	0.1966	1.4550	
149.44	0.2502	2.5326	
150.74	0.3061	4.1935	Top of Pond (Flood Control Up to Regional)
151.14	4.8565	4.8285	
151.44	13.1597	5.3048	Top of Pond (All)

Return Period	**POST POND 2**			
	Inflow (cms)	**Water Elevation (m)**	**Utilized Storage (ha*m)**	**Outflow (cms)**
Gawser ID	**3090**		**4500**	**4500**
25 mm 24 hr	0.244	147.70	0.253	0.043
2-Yr	0.587	147.84	0.626	0.072
5-Yr	0.819	147.87	0.917	0.078
10-Yr	0.964	148.00	1.047	0.106
25-Yr	1.146	148.20	1.234	0.148
50-Yr	1.282	148.32	1.346	0.172
100-Yr	1.417	148.46	1.479	0.198
Regional	1.550	150.80	4.289	0.987

SWM Pond Flows

PH1B CONDITIONS

QUANTITY CONTROL UP TO REGIONAL STORM EVENT

FINAL, APRIL 2017, MMM, AZZ

POND 2

PH1B Drainage Area	15.57	ha	Plus Dundas Street	2.24	ha
Imperviousness	90	%		82	%
Total Drainage Area	17.81	ha			
Imperviousness	89	%			
Detention Time	47	Hr			

Rating Curve

ELEVATION	OUTFLOW	STORAGE	
(m)	(cms)	(ha*m)	
146.69	0.0000	0.0000	Permanent Pool
146.91	0.0288	0.1464	
147.12	0.0488	0.2929	
147.64	0.0783	0.7155	Extended Detention
147.69	0.0411	0.7561	
148.44	0.1966	1.4550	
149.44	0.2502	2.5326	
150.74	0.3061	4.1935	Top of Pond (Flood Control Up to Regional)
151.14	4.8565	4.8285	
151.44	13.1597	5.3048	Top of Pond (All)

Return Period	POST POND 2			
	Inflow (cms)	Water Elevation (m)	Utilized Storage (ha*m)	Outflow (cms)
Gawser ID	3090		4500	4500
25 mm 24 hr	0.244	147.70	0.253	0.043
2-Yr	0.587	147.84	0.626	0.072
5-Yr	0.819	147.87	0.917	0.078
10-Yr	0.964	148.00	1.047	0.106
25-Yr	1.146	148.20	1.234	0.148
50-Yr	1.282	148.32	1.346	0.172
100-Yr	1.417	148.46	1.479	0.198
Regional	1.550	150.80	4.289	0.987

POND 3

PH1B Drainage Area	24.57	ha
Imperviousness	50	%
Detention Time	41	Hr

Rating Curve

ELEVATION	OUTFLOW	STORAGE	
(m)	(cms)	(ha*m)	
146.20	0.0000	0.0000	Permanent Pool
146.63	0.0463	0.6360	
146.95	0.0907	1.1546	
147.00	0.0959	1.2648	Extended Detention
147.50	0.3239	2.1146	
149.25	0.5538	5.7641	
150.08	3.9253	8.4112	Top of Pond (Flood Control Up to Regional) + 0.3 m Freeboard
150.30	10.8500	8.9230	
150.70	28.2642	9.8328	
151.00	44.6244	10.5151	Top of Pond (All)

Return Period	POST POND 3			
	Inflow (cms)	Water Elevation (m)	Utilized Storage (ha*m)	Outflow (cms)
Gawser ID	2140		1000	1000
25 mm 24 hr	0.241	146.37	0.250	0.018
2-Yr	0.678	146.63	0.637	0.046
5-Yr	0.984	146.78	0.887	0.068
10-Yr	1.175	146.88	1.045	0.081
25-Yr	1.419	147.01	1.287	0.102
50-Yr	1.599	147.09	1.410	0.135
100-Yr	1.779	147.17	1.548	0.172
Regional	2.246	148.64	4.496	0.474

SWM Pond Flows

PH2 CONDITIONS

QUANTITY CONTROL UP TO REGIONAL STORM EVENT

FINAL, APRIL 2017, MMM, AZZ

POND 2

PH2 Drainage Area	15.57	ha	Plus Dundas Street	2.24	ha
Imperviousness	90	%		82	%
Total Drainage Area	17.81	ha			
Imperviousness	89	%			
Detention Time	47	Hr			

Rating Curve

ELEVATION (m)	OUTFLOW (cms)	STORAGE (ha*m)	
146.69	0.0000	0.0000	Permanent Pool
146.91	0.0288	0.1464	
147.12	0.0488	0.2929	
147.64	0.0783	0.7155	Extended Detention
147.69	0.0411	0.7561	
148.44	0.1966	1.4550	
149.44	0.2502	2.5326	
150.74	0.3061	4.1935	Top of Pond (Flood Control Up to Regional)
151.14	4.8565	4.8285	
151.44	13.1597	5.3048	Top of Pond (All)

Return Period	POST POND 2			
	Inflow (cms)	Water Elevation (m)	Utilized Storage (ha*m)	Outflow (cms)
Gawser ID	**3090**		**4500**	**4500**
25 mm 24 hr	0.244	147.70	0.253	0.043
2-Yr	0.587	147.84	0.626	0.072
5-Yr	0.819	147.87	0.917	0.078
10-Yr	0.964	148.00	1.047	0.106
25-Yr	1.146	148.20	1.234	0.148
50-Yr	1.282	148.32	1.346	0.172
100-Yr	1.417	148.46	1.479	0.198
Regional	1.550	150.80	4.289	0.987

POND 3

PH2 Drainage Area	36.99	ha
Imperviousness	90	%
Detention Time	53	Hr

Rating Curve

ELEVATION (m)	OUTFLOW (cms)	STORAGE (ha*m)	
146.20	0.0000	0.0000	Permanent Pool
146.63	0.0463	0.6360	
146.95	0.0907	1.1546	
147.00	0.0959	1.2648	Extended Detention
147.50	0.3239	2.1146	
149.25	0.5538	5.7641	
150.08	3.9253	8.4112	Top of Pond (Flood Control Up to Regional) + 0.3 m Freeboard
150.30	10.8500	8.9230	
150.70	28.2642	9.8328	
151.00	44.6244	10.5151	Top of Pond (All)

Return Period	POST POND 3			
	Inflow (cms)	Water Elevation (m)	Utilized Storage (ha*m)	Outflow (cms)
Gawser ID	**2140**		**1000**	**1000**
25 mm 24 hr	0.517	146.59	0.582	0.042
2-Yr	1.197	146.97	1.195	0.093
5-Yr	1.666	147.15	1.522	0.165
10-Yr	1.959	147.26	1.714	0.216
25-Yr	2.329	147.43	2.000	0.293
50-Yr	2.604	147.53	2.178	0.328
100-Yr	2.879	147.64	2.412	0.343
Regional	3.494	149.48	6.489	1.478

SWM Pond Flows

ULTIMATE CONDITIONS

QUANTITY CONTROL UP TO REGIONAL STORM EVENT

FINAL, APRIL 2019, WSP/MMM, AZZ

POND 2

ULTIMATE Drainage Area	18.51	ha	Plus Dundas Street	2.24	ha
Imperviousness	90	%		82	%
Total Drainage Area	20.75	ha			
Imperviousness	89	%			
Detention Time	47	Hr			

Rating Curve

ELEVATION	OUTFLOW	STORAGE	
(m)	(cms)	(ha*m)	
146.69	0.0000	0.0000	Permanent Pool
146.91	0.0288	0.1464	
147.12	0.0488	0.2929	
147.64	0.0783	0.7155	Extended Detention
147.69	0.0411	0.7561	
148.44	0.1966	1.4550	
149.44	0.2502	2.5326	
150.74	0.3061	4.1935	Top of Pond (Flood Control Up to Regional)
151.14	4.8565	4.8285	
151.44	13.1597	5.3048	Top of Pond (All)

Return Period	POST POND 2				TARGET FLOW - EXISTING FLOW AT COMPARIABLE LOCATION
	Inflow (cms)	Water Elevation (m)	Utilized Storage (ha*m)	Outflow (cms)	
Gawser ID	**3090**		**4500**	**4500**	**1203**
25 mm 24 hr	0.290	147.72	0.2759	0.047	0.025
2-Yr	0.698	147.84	0.6166	0.071	0.107
5-Yr	0.974	147.87	0.8721	0.078	0.165
10-Yr	1.146	147.95	0.9939	0.094	0.198
25-Yr	1.361	148.13	1.1700	0.133	0.250
50-Yr	1.523	148.25	1.2759	0.157	0.284
100-Yr	1.683	148.38	1.3981	0.184	0.319
Regional	1.842	150.63	4.0505	0.301	0.787

POND 3

ULTIMATE Drainage Area	39.85	ha
Imperviousness	90	%
Detention Time	41	Hr

Rating Curve

ELEVATION	OUTFLOW	STORAGE	
(m)	(cms)	(ha*m)	
146.20	0.0000	0.0000	Permanent Pool
146.63	0.0550	0.6360	
146.95	0.1150	1.1546	
147.00	0.1217	1.2648	Extended Detention
147.50	0.3239	2.1146	
149.25	0.5538	5.7641	
150.08	3.9253	8.4112	Top of Pond (Flood Control Up to Regional) + 0.3 m Freeboard
150.30	10.8500	8.9230	
150.70	28.2642	9.8328	
151.00	44.6244	10.5151	Top of Pond (All)

Return Period	POST POND 3				EXISTING FLOW AT COMPARIABLE LOCATION
	Inflow (cms)	Water Elevation (m)	Utilized Storage (ha*m)	Outflow (cms)	
Gawser ID	**2140**		**1000**	**1000**	**1105**
25 mm 24 hr	0.431	146.60	0.5895	0.051	0.057
2-Yr	0.925	146.97	1.1951	0.118	0.253
5-Yr	1.281	147.15	1.5270	0.184	0.390
10-Yr	1.492	147.27	1.7237	0.231	0.467
25-Yr	1.788	147.44	2.0154	0.300	0.590
50-Yr	1.996	147.54	2.1959	0.329	0.670
100-Yr	2.207	147.66	2.4381	0.344	0.754
Regional	3.233	149.47	6.4583	1.438	1.857

POND 5

ULTIMATE Drainage Area	14.40	ha
Imperviousness	88	%
Detention Time	47	Hr

Rating Curve

ELEVATION	OUTFLOW	STORAGE	
(m)	(cms)	(ha*m)	
153.00	0.0000	0.0000	Permanent Pool
154.20	0.0540	0.4708	Extended Detention
154.25	0.0411	0.4926	
155.00	0.1676	0.8980	
156.00	0.2074	1.5524	
156.55	0.2264	1.9857	
157.10	0.2439	2.4190	
157.26	0.3429	2.6129	Top of Pond (Flood Control Up to Regional) + 0.3 m Freeboard
157.30	0.3816	2.6185	
157.56	2.3626	2.8780	0.3 m Freeboard

Return Period	POST POND 5				TARGET FLOW - Based on Existing Flows from Existing Catchment 1202 (ID 2501) in Proportion to Drainage Area
	Inflow (cms)	Water Elevation (m)	Utilized Storage (ha*m)	Outflow (cms)	
Gawser ID	**3060**		**4510**	**4510**	**N/A**
25 mm 24 hr	0.206	153.52	0.2054	0.024	0.024
2-Yr	0.487	154.10	0.4302	0.049	0.100
5-Yr	0.679	154.40	0.5756	0.067	0.153
10-Yr	0.799	154.54	0.6501	0.090	0.182
25-Yr	0.951	154.74	0.7598	0.125	0.229
50-Yr	1.063	154.87	0.8262	0.145	0.260
100-Yr	1.176	155.01	0.9028	0.168	0.292
Regional	1.385	157.26	2.5943	0.342	0.715

POND 1

ULTIMATE Drainage Area	23.55	ha
Imperviousness	88	%
Detention Time	42	Hr

Rating Curve

ELEVATION	OUTFLOW	STORAGE	
(m)	(cms)	(ha*m)	
152.00	0.0000	0.0000	Permanent Pool
152.50	0.0615	0.3776	
153.00	0.0927	0.7552	Extended Detention
153.50	0.2992	1.2234	
154.00	0.3512	1.6915	
155.00	0.4369	2.8257	
156.00	0.5084	4.1743	Top of Pond (Flood Control Up to Regional)
156.30	2.9966	4.6293	0.3 m Freeboard
156.45	6.2524	4.8568	
156.75	15.0197	5.3117	Top of Pond (All)

Return Period	POST POND 1				TARGET FLOW - Based on Existing Flows to Culvert FM-D2 in Proportion to Drainage Area
	Inflow (cms)	Water Elevation (m)	Utilized Storage (ha*m)	Outflow (cms)	
Gawser ID	**3000**		**4000**	**4000**	
25 mm 24 hr	0.337	152.41	0.3120	0.051	0.042
2-Yr	0.796	152.90	0.6808	0.087	0.165
5-Yr	1.111	153.14	0.8843	0.150	0.269
10-Yr	1.306	153.25	0.9930	0.198	0.332
25-Yr	1.555	153.43	1.1543	0.269	0.426
50-Yr	1.739	153.53	1.2553	0.303	0.490
100-Yr	1.923	153.68	1.3884	0.318	0.557
Regional	2.266	155.84	3.9624	0.497	1.299

POND WEST OF TREMAINE

- ORIGINAL STAGE STORAGE -REGIONAL CONTROL NOT PROVIDED

- UPDATED STAGE STORAGE -REGIONAL CONTROL PROVIDED (Preliminary)

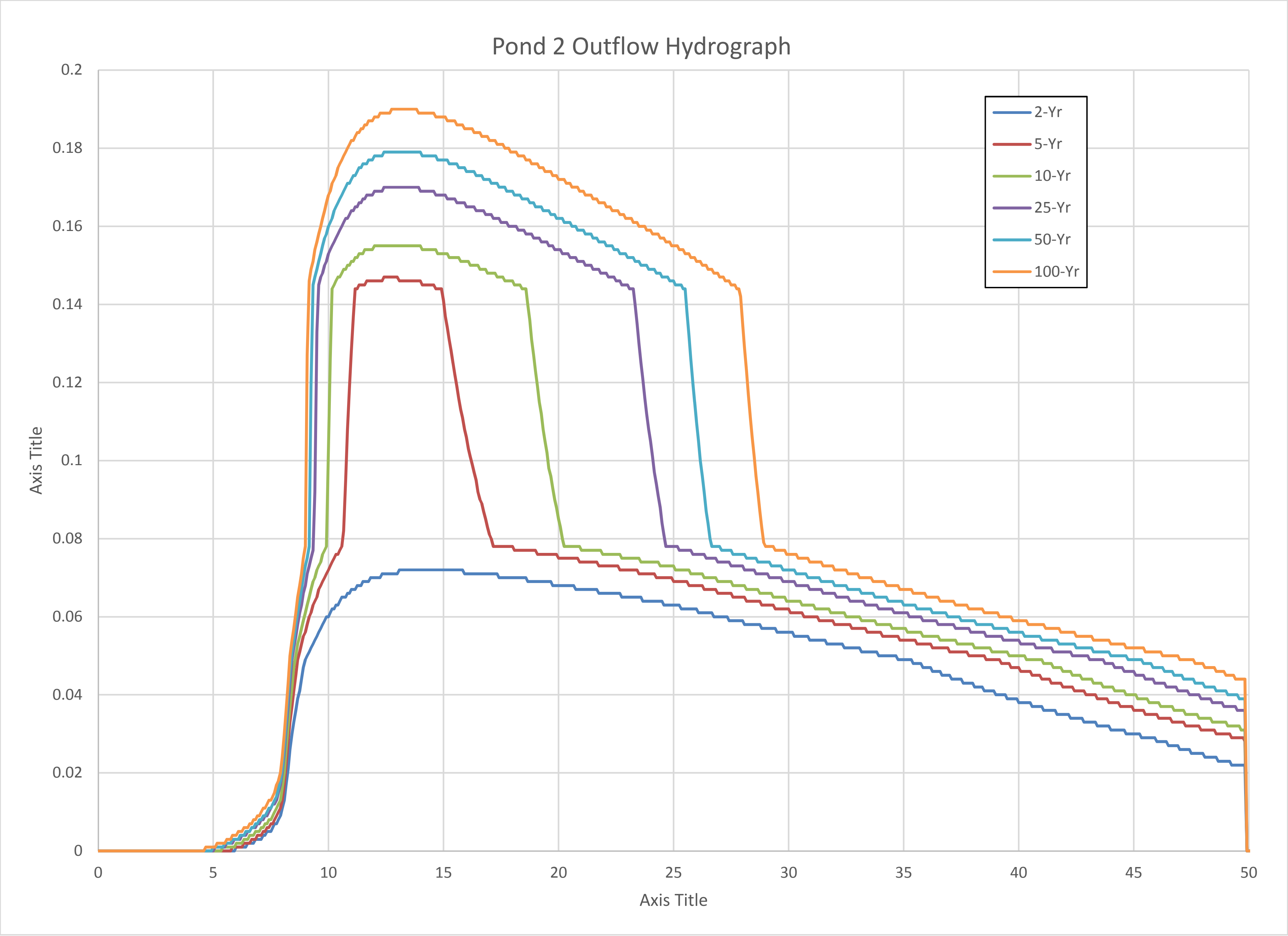
ULTIMATE Drainage Area 21.05 ha

Imperviousness 20 %

Rating Curve

ELEVATION (m)	OUTFLOW (cms)	STORAGE (ha*m)
156.10	0.0000	0.0000
156.50	0.1661	0.3000
156.80	0.2706	0.4000
157.10	0.3229	0.5000
157.40	0.4106	0.6000
157.70	0.4890	0.7000
158.00	0.5413	0.7500
158.10	1.1000	1.9000

Return Period	POST POND 5				TARGET FLOW - Based on Existing Flows from Existing Catchment 1202 (ID 2501) in Proportion to Drainage Area
	Inflow (cms)	Water Elevation (m)	Utilized Storage (ha*m)	Outflow (cms)	
Gawser ID	3050		500	500	N/A
25 mm 24 hr	0.145	156.21	0.080	0.044	0.035
2-Yr	0.545	156.48	0.286	0.158	0.146
5-Yr	0.828	156.82	0.406	0.274	0.223
10-Yr	1.006	157.05	0.484	0.314	0.266
25-Yr	1.232	157.39	0.598	0.408	0.335
50-Yr	1.399	157.61	0.669	0.465	0.380
100-Yr	1.568	157.97	0.744	0.535	0.428
Regional	2.007	158.10	1.869	1.085	1.045


Pond 2 Outflow Hydrograph
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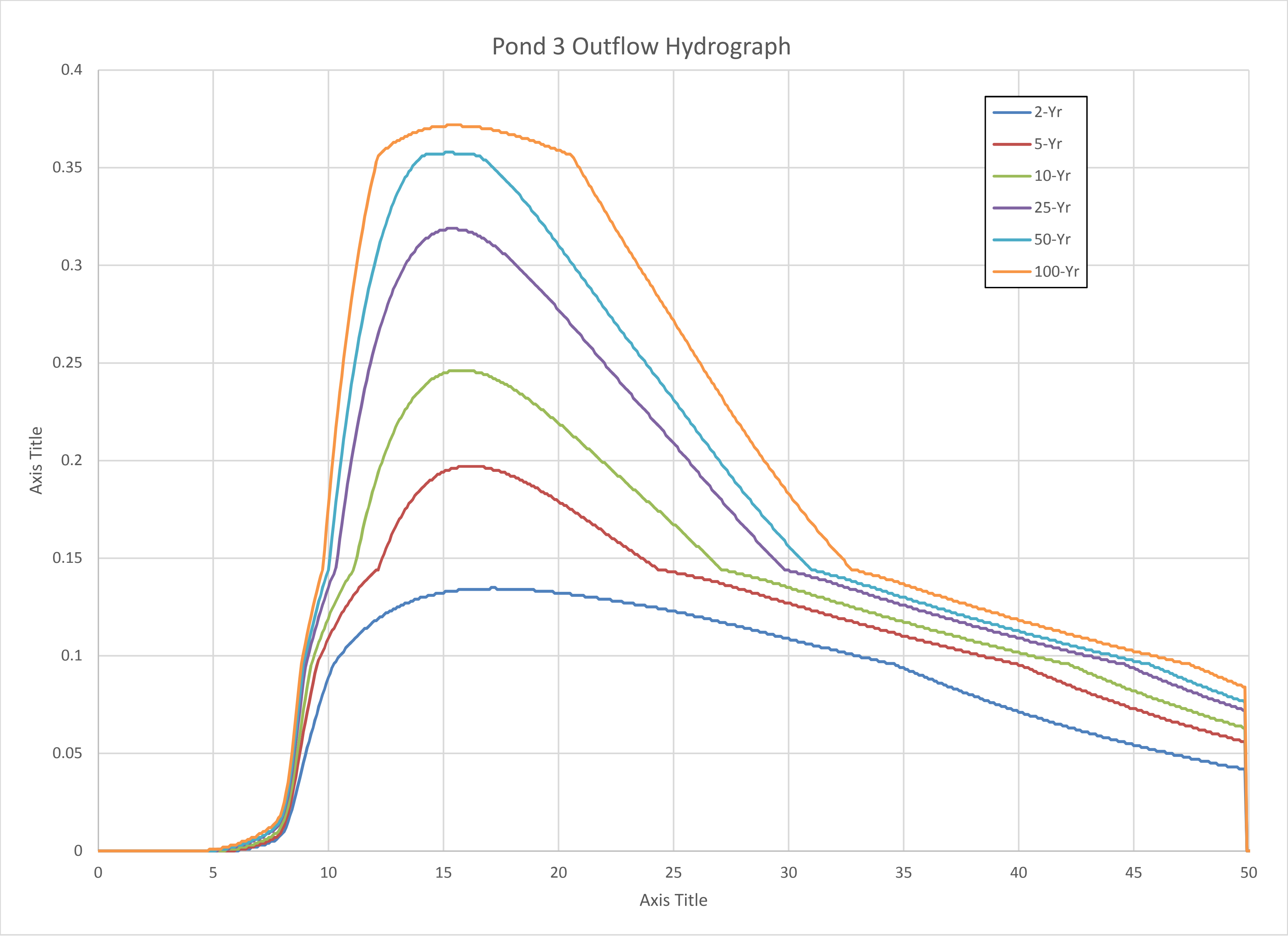
2-Yr
5-Yr
10-Yr
25-Yr
50-Yr
100-Yr

POND 2 **OUTFLOW**

Weir Empty - Flow Limit **0.078**

Return Period	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
DT (HR)	0.08	0.08	0.08	0.08	0.08	0.08
DT (MIN)	5.00	5.00	5.00	5.00	5.00	5.00
PEAK (CMS)	0.072	0.147	0.155	0.170	0.179	0.190
PEAK - TIME (HR)	13.08	12.42	12.00	12.42	12.42	12.75
WEIR EMPTY - TIME (HR)	0.00	17.17	20.25	24.67	26.67	29.00
TIME TO DRAIN FLOW FROM WEIR AND SPILLWAY (HR)	0.00	4.75	8.25	12.25	14.25	16.25
Calculated 25 mm Detention Time (hr) for Erosion Control - Ultimate Development	47.36	47.36	47.36	47.36	47.36	47.36
Pond Drawdown Time (hr)	**47.36**	**52.11**	**55.61**	**59.61**	**61.61**	**63.61**


Pond 3 Outflow Hydrograph
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Axis Title
0
5
10
15
20
25
30
35
40
45
50
Axis Title
2-Yr
5-Yr
10-Yr
25-Yr
50-Yr
100-Yr

POND 3	**OUTFLOW**
Weir Empty - Flow Limit	**0.144**

Return Period	**2-Yr**	**5-Yr**	**10-Yr**	**25-Yr**	**50-Yr**	**100-Yr**
DT (HR)	0.08	0.08	0.08	0.08	0.08	0.08
DT (MIN)	5.00	5.00	5.00	5.00	5.00	5.00
PEAK (CMS)	0.135	0.197	0.246	0.319	0.358	0.372
PEAK - TIME (HR)	17.08	15.67	15.25	15.17	15.08	15.17
WEIR EMPTY - TIME (HR)	0.00	24.33	27.08	29.83	31.00	32.75
TIME TO DRAIN FLOW FROM WEIR AND SPILLWAY (HR)	0.00	8.67	11.83	14.67	15.92	17.58
Calculated 25 mm Detention Time (hr) for Erosion Control - Ultimate Development	41.31	41.31	41.31	41.31	41.31	41.31
Pond Drawdown Time (hr)	**41.31**	**49.98**	**53.14**	**55.98**	**57.23**	**58.89**

Updated 2019.04.10

Proposed SWM Pond Summary

Pond #	Phase 1A		Phase 1B		Phase 2		Ultimate	
	Drainage Area (ha)	Imperviousness (%)	Drainage Area (ha)	Imperviousness (%)	Drainage Area (ha)	Imperviousness (%)	Drainage Area (ha)	Imperviousness (%)
Pond 2	17.8	89	17.8	89	17.8	89	20.8	89
Pond 3	-	-	24.6	50	37.0	90	39.9	90
Pond 1	-	-	-	-	-	-	23.6	88
Pond 5	-	-	-	-	-	-	14.4	88

Summary of SWM Pond Permanent Pool Requirements under Ultimate Development Conditions

Element	Pond 2	Pond 3	Pond 1	Pond 5
Drainage Area (ha)	20.8	39.9	23.6	14.4
Imperviousness (%)	89	90	88	88
Storage Criteria for Enhanced Level Treatment (m^3/ha)	257	258	255	255
Storage Required for Enhanced Level Treatment (m^3)	5,331	10,295	6,005	3,672
Permanent Pool Storage Required (m^3)	4,501	8,701	5,063	3,096
Water Quality Extended Detention (m^3)	830	1,594	942	576
Permanent Pool Volume Provided (m^3)	10,431	28,690	14,564	3,679

Summary of SWM Pond Erosion Control (Drawdown Time)

Element	Pond 2	Pond 3		Pond 1	Pond 5
Required Extended Detention Storage for Erosion Control (m^3)	4,162	7,994		4,639	2,837
Provided Extended Detention Storage for Erosion Control (m^3)	7,155	12,381		7,552	4,926
Permanent Pool Elevation (m)	146.69	146.20		152.00	153.00
Extended Detention Elevation (m)	147.64	147.00		153.00	154.20
Max. Extended Detention Depth (m)	0.95	0.80		1.00	1.20
Development Phases	Ultimate Conditions	Phase 1A, Phase 1B and Phase 2	Ultimate Conditions	Ultimate Conditions	Ultimate Conditions
Orifice Diameter (mm)	200	255	290	215	155
Peak Outflow Rate (m3/s)	0.078	0.117	0.149	0.096	0.054
Drawdown Time (hours)	47.3	53.4	41.3	42.4	46.9

Summary of SWM Pond Forebay Design

Element		Pond 2	Pond 3	Pond 1	Pond 5
Forebay Design	Required Minimum Forebay Length (m)	21.56	22.58	22.54	15.36
	Required Minimum Bottom Width (m)	2.70	2.82	2.82	1.92

Summary of SWM Pond Flood Control MH

Element		Pond 2	Pond 3	Pond 1	Pond 5
Low Flow Control	Reversed Pipe Orifice Invert - Permanent Pool Elevation (masl)	146.69	146.20 (at Permanent Pool); 146.39 (for Tailwater Analysis)	152.00	153.00
	Reversed Pipe Orifice Diameter (mm)	200	290 (Ultimate) 255 (All Interim)	215	155
Flow Control MH (Flood Control up to Regional Event)	Weir Invert - Erosion Control Extended Detention - (masl)	147.64	147.00	153.00	154.20
	Weir Width/Opening (m)	2.00	2.00	2.00	2.00
	Invert of a Pipe Connecting the Control MH to D/S	146.69	146.20 (at Permanent Pool); 146.39 (for Tailwater Analysis)	152.00	153.00
	D/S Pipe Orifice Diameter (mm)	270	400	350	240
	High Flow Weir (2nd Weir) - Wdith/Opening (m)	Not required	Not required	Not required	0.80
	High Flow Weir (2nd Weir) - Invert (masl)	Not required	Not required	Not required	157.10
Emergency Spill (to pass uncontrolled Regional Flows)	Spillway Invert - (masl)	150.84	149.88	156.10	157.32
	Spillway Width (m)	15.00	20.00	15.00	10.00
Freeboard	Top of Regional Storm Storage Elevation (masl) - Simulated/Modelled	150.63	149.47	155.84	157.26
	Top of Pond Elevation including Freeboard (masl)	151.44	151.00	156.75	157.80
	Freeboard Depth (m)	0.81	1.53	0.91	0.54

Summary of Simulated SWM Pond Design Events Elevation (Ultimate Conditions)

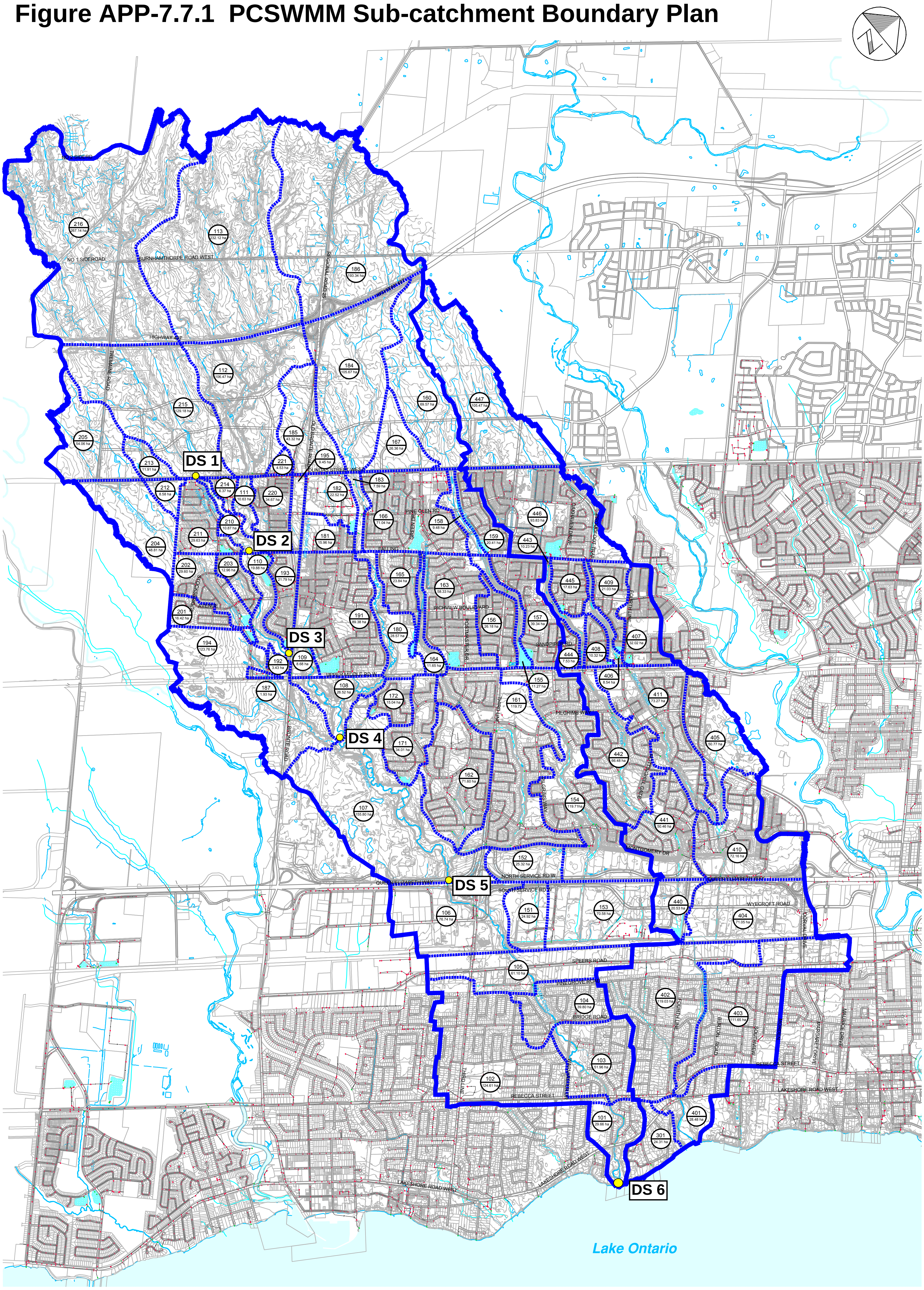
Return Period	Pond 2	Pond 3	Pond 1	Pond 5
25 mm 24 hr	147.72	146.60	152.41	153.52
2-Yr	147.84	146.97	152.90	154.10
5-Yr	147.87	147.15	153.14	154.40
10-Yr	147.95	147.27	153.25	154.54
25-Yr	148.13	147.44	153.43	154.74
50-Yr	148.25	147.54	153.53	154.87
100-Yr	148.38	147.66	153.68	155.01
Regional	150.63	149.47	155.84	157.26

Water Surface Level at Pond Outlet (Ultimate Conditions / Uncontrolled) - 2019.04.10

Return Period	Pond 2	Pond 3	Pond 5
HEC-RAS Cross Section	River-2, Reach-1, XS 204.25	River-2, Reach-1, XS 204.25	River-2, Reach-1A, XS 207
25 mm 24 hr	n/a	n/a	n/a
2-Yr	145.62	145.62	150.69
5-Yr	145.74	145.74	150.81
10-Yr	145.80	145.80	150.83
25-Yr	145.93	145.93	150.85
50-Yr	146.00	146.00	150.87
100-Yr	146.05	146.05	150.88
Regional	146.39	146.39	151.11

Appendix 7.7 – Regional Flow Downstream Impact

Figure APP-7.7.1 PCSWMM Sub-catchment Boundary Plan



LEGEND

▬	WATERSHED BOUNDARY
┅	SUBCATCHMENT BOUNDARY
101	SUBCATCHMENT NUMBER
29.66 ha	SUBCATCHMENT AREA

SCALE VALID ONLY FOR
24"x36" VERSION

FOURTEEN MILE CREEK
McCRANEY CREEK SYSTEM FLOOD
MITIGATION OPPORTUNITIES STUDY

TOWN OF OAKVILLE

SUBCATCHMENT
BOUNDARY PLAN

amec

Scale 1:17500
0 200 400 800

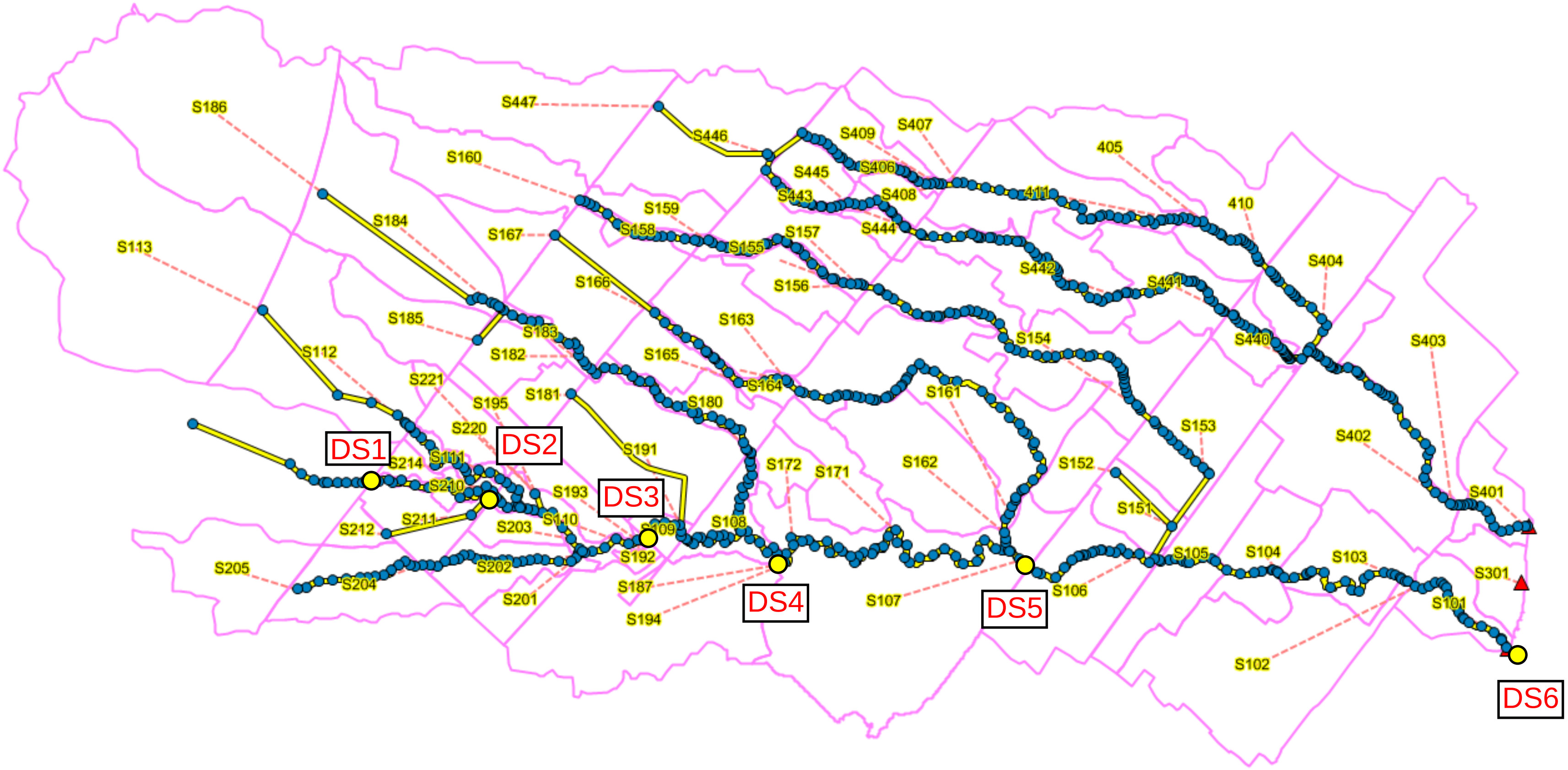
Consultant File No.
TP111031

Drawing No.
1

P:\Work\111031\water\dwg\July2013\Dwg-1 Sub-Catch.dwg

Jul 17/13 – richard.bartolo

Figure APP-7.7.2 PCSWMM Schematic



PCSWMM Conduit	Schematic Node Name	PCSWMM Catchment	Location	Area (ha)	Original Reg. Flows	Existing	Interim 1a Uncontrolled		Interim 1a Controlled		Interim 1b Uncontrolled		Interim 1b Controlled		Interim 2 Uncontrolled		Interim 2 Controlled		Ultimate Uncontrolled		Ultimate Controlled	
					AMEC Model	Flow (m3/s)	Flow (m3/s)	% difference	Flow (m3/s)	% difference	Flow (m3/s)	% difference	Flow (m3/s)	% difference	Flow (m3/s)	% difference	Flow (m3/s)	% difference	Flow (m3/s)	% difference	Flow (m3/s)	% difference
3660.527	DS1	215	Dundas Rd	408.23	48.226	20.344	20.599	1%	19.135	-6%	20.46	1%	18.495	-9%	22.14	9%	18.153	-11%	23.19	14%	17.402	-14%
2528.637	DS2	210	Richview Blvd	457.31	53.573	23.191	23.826	3%	21.854	-6%	23.89	3%	21.488	-7%	26.18	13%	20.876	-10%	27.48	18%	20.131	-13%
1130.117	DS3	110	Bronte Rd	1062.95	122.589	89.9	90.524	1%	88.732	-1%	90.64	1%	88.491	-2%	92.89	3%	87.869	-2%	94.25	5%	87.181	-3%
7322.142	DS4	108	Fourteen Mile Creek Lands	1604.5	170.839	139.782	140.419	0%	138.579	-1%	140.50	1%	138.343	-1%	142.76	2%	137.743	-1%	144.15	3%	137.032	-2%
4232.339	DS5	107	HW 403	2317.58	222.989	192.612	193.2	0%	191.483	-1%	193.34	0%	191.324	-1%	195.35	1%	190.763	-1%	196.57	2%	190.241	-1%
OF100	DS6	101	Lake Ontario	3118.23	270.239	243.229	243.72	0%	242.173	0%	243.80	0%	241.986	-1%	245.76	1%	241.536	-1%	246.78	1%	241.083	-1%

Appendix 7.8 – Monitoring Program

Appendix 7.8 – Monitoring Program

1.1 OPA 289 Monitoring Requirements

Policy 8.9.5.2 of OPA 289 (North Oakville West Secondary Plan) specifies that monitoring be completed as dictated below, on an annual basis:

> "*A program shall be established by the Town in consultation with the Region of Halton and Conservation Halton to monitor the development in the Planning Area on an annual basis. The monitoring program shall be in accordance with directions established in the North Oakville Creeks Subwatershed Study and shall also consider such factors as:*
>
> *a) relationship and level of population and employment growth in North Oakville;*
> *b) supply of existing lots and number of building permits granted;*
> *c) the general achievement of housing mix targets in North Oakville;*
> *d) the functioning of stormwater management facilities to ensure they are constructed and operate as designed,*
> *e) stream alterations/relocations to ensure that natural channel designs were implemented and operate as designed;*
> *f) erosion and operation of sediment controls during construction;*
> *g) utilization of wastewater treatment and water supply system capacity; and,*
> h) *development application status.*"

1.2 NOCSS Monitoring Requirements

Monitoring Requirements were specified in the NOCSS and include the following requirements as agreed to in the Ontario Municipal Board (OMB) Mediation Item: Stormwater Management – Temperature and Dissolved Oxygen Targets dated July 12, 2007 and incorporated into Appendix KK of the NOCSS:

1) Erosion and sediment control plans;
2) Stormwater management facility monitoring;
3) Modified streams monitoring; and,
4) Monitoring in relation to stormwater management works, municipal services and trails installed by an owner within the Natural Heritage System.

1.3 Monitoring Approach

The proposed monitoring plan will be based on the Adaptive Environmental Monitoring (AEM) approach for the management of the NHS in accordance with the recommendations of NOCSS. The AEM approach will allow for a flexible monitoring plan that will use real-time monitoring results to revise and update, as required, the monitoring plan to ensure the anticipated results are achieved. By applying AEM, undesirable environmental effects/results can potentially be identified early in the monitoring program and corrected through management interventions to avoid major problems before they occur, as well as, maximize the fulfillment of the monitoring objectives. Details of the AEM approach, including the determination of the monitoring parameters will developed at the detail design stage in discussion with Conservation Halton (CH).

Erosion and Sediment Control (ESC)

1) An ESC plan will be submitted to the Town of Oakville (Town). The plan must be reviewed and approved by the Town prior to the start of any clearing and grading;
2) The ESC requirements will follow the applicable approved guidelines and by-laws in effect at the time of development. Deliverables will include a site alteration design report, an existing site conditions survey plan, an ESC plan, and a schedule of monitoring and reporting;
3) The ESC plan will include inspection, sampling for total suspended solids at all outlets from the site, and reporting of results; and,
4) Remedial action to correct deficiencies of erosion and sediment control practices and facilities may be required based on either inspection or sampling results.

Stormwater Management Facility Monitoring

1) Stormwater management (SWM) facilities constructed in the conveyance system and at the end-of-pipe will be included in the monitoring program, which applies to the period prior to the assumption of the facilities by the Town. The monitoring plan will include monitoring of the receiving system for the effectiveness of the stormwater management facilities at the location of the outfall for the purpose of water quality monitoring, and at a location or locations to be determined through the EIR for the purpose of erosion control. Monitoring will follow applicable approved guidelines in effect at the time of development (e.g., Town of Oakville's "*Stormwater Monitoring Guideline North of Dundas Street. Operation, Maintenance and Monitoring of Stormwater Management Ponds*", January 2012). These guidelines will replace Appendix KK - Stormwater Pond Monitoring Protocol from the Subwatershed Study. The Town of Oakville and Conservation Authority will consult with the North Oakville landowners in the preparation of such guidelines. Monitoring requirements will be reflected in subdivision agreements;
2) Privately owned SWM facilities are not included in this mediation document and will be subject to site specific requirements at the time of application;
3) All SWM facilities to be assumed by the Town will be monitored by the owner for design conformance, maintenance of function and hydraulic performance. Monitoring and reporting plans are to be reviewed and approved by the Town;
4) Facilities with water quality function(s) will be monitored by the owner for performance in meeting the specific pond design target for total suspended solids (80% removal). Total phosphorus and temperature sampling will also be required. Temperature monitoring should be according to the OMB mediation dated July 12, 2007, as well as any other commitments/criteria required through permits and/or approvals obtained during detail design (e.g., *Guidance for Development Activities in Redside Dace Protected Habitat,* 2016); and,
5) Facilities subject to *Ontario Water Resources Act* approval may be required to do additional monitoring as a condition of the Certificate of Approval.

Monitoring of Modified Streams

1) A multidisciplinary monitoring program approved by the Town and CH will be implemented for all stream modifications. The monitoring program will be implemented by the proponent of the stream modification; and,

2) Notwithstanding Principle 1 immediately above, additional monitoring associated with Fisheries and Oceans Canada (DFO) approvals under the federal *Fisheries Act* may be required and shall be the responsibility of the proponent.

Monitoring in Relation to Stormwater Management Works, Municipal Services and Trails Installed by an Owner within the Natural Heritage System

In addition to items identified in the three sub-sections above:

1) A monitoring program will be implemented for all municipal services such as roads, watermains, sanitary sewers, SWM works or trails within the Natural Heritage System;
2) A monitoring program approved by the Town and CH is to be developed based on the natural features and functions potentially affected by the specific works noted above;
3) The details of the monitoring program are to be included in the EIR; and,
4) The monitoring program will be implemented by the landowners installing the stormwater management works, municipal services and trails.

1.4 Proposed Monitoring

Monitoring programs that meet the requirements above will be carried out by the landowner. The monitoring plan will be developed as the plan is advanced in the detailed design stage. The parameters and locations for monitoring shall be developed during the detailed design of the proposed watercourse realignments and SWM facilities. Given the outstanding review of the project under other legislation (e.g., Endangered Species Act (2007), Fisheries Act (1985)) and the potential for specific monitoring requirements that may arise, the finalization of the monitoring plan will be specified as a condition of Draft Plan Approval. This will provide an opportunity to develop a comprehensive monitoring program that will include the various legislative requirements, minimize duplication of effort and avoid proposing monitoring events/parameters that may not be permitted (i.e., fish community sampling in Redside Dace habitat). Furthermore, it will allow for greater certainty as it relates to necessary monitoring as the detail design works progress.

Figures A7.8.1 and A7.8.2 present the proposed monitoring locations under the baseline (pre-construction) and ultimate development conditions.

Erosion and Sediment Control

The Erosion and Sediment Control Plan (ESC Plan) will be developed in advance of any site alteration work and will follow the requirements set out in the "*Site Alteration: Erosion and Sediment Controls. Permit Procedures and Guidelines*" (Town of Oakville, February 2013) and the "*Erosion & Sediment Control Guidelines for Urban Construction*" (Greater Golden Horseshoe Conservation Authorities, December 2006). The ESC Plan will include the following elements:

- ESC measures to be implanted at the site including types of measures with construction details, their locations, timing of installation of these measures;
- Spill Control and Response Plan;
- Inspections and Performance Monitoring Plan, including identifying responsibilities for inspections, maintenance and repair of the ESC measures, and for taking remedial actions if ESC measures are found to be not working as planned; and,

- Reporting requirements.

Stormwater Management Facilities

Two SWM facilities (SWM facilities 2 & 3) are proposed between Dundas Street and the Burnhamthorpe Road Extension to control post-development peak flows to prescribed rates, as well as, provide water quality treatment and erosion control in the receiving watercourses. The Town has issued monitoring guidelines for stormwater management facilities north of Dundas Street (January 2012) including details on operation, maintenance and monitoring. SWM facilities 2 & 3 have been designed to allow for monitoring, inspection and maintenance according to the Town guidelines, including design conformance, inspection, functionality and sediment accumulation. Full access is available from public rights of way to the applicable sampling locations.

A detailed sampling and monitoring program will be developed at the time of detailed design and will include an estimate of costs, as well as, defining the frequency and duration of the monitoring.

Note that as indicated in the OMB mediation dated July 12, 2007, discharge temperatures for stormwater management facilities connected to coldwater streams should be below 20°C and have dissolved oxygen concentrations of at least six milligrams per litre. These thresholds represent temperature and oxygen conditions suitable to support for Redside Dace. Therefore, temperature monitoring will also be incorporated in the detailed monitoring program.

Modified Stream Monitoring, Reach 14W-22, Reach 14W-23 and Reach 14W-12A

Reach 14W-22 and Reach 14W-23 are proposed to be realigned using natural channel design principles. These realigned reaches will be monitored from a hydraulic, as well as, an ecological perspective following the completion of construction. Given that Reach 14W-12A will be maintained, it will only be monitored from an ecological perspective. The following provides a conceptual approach to the monitoring program that will apply to the realigned reaches and Reach 14W-12A. The final details of the plan will be developed as the design progresses and as other agencies (i.e., Ministry of Natural Resources and Forestry (MNRF), DFO) provide input in order that the program is comprehensive and adheres to potential restriction associated with other legislation (i.e., *Endangered Species Act* (2007)) while avoiding duplicated efforts.

Monitoring will be initiated within a Baseline Monitoring period with a minimum of one monitoring event within two years of the realignment works. The baseline data will be combined with all previous data collected during previous site investigations. Post-construction Monitoring of the realigned reaches will commence once the channel diversions are completed for a period of three years. Annual reports will be filed in tabular and graphical form with remedial measures or additional enhancements recommended to address deficiencies (if any) provided.

Specifically related to Reach 14W-22, a commitment will be made to ensure the desired ecological function has been obtained and that if this reach is not functioning as intended, the reach will be revisited to undertake the necessary remedial measures required to ensure the desired function.

Hydraulic Monitoring

For the hydraulic component, the Baseline Monitoring period consists of the period immediately prior to/after connection of the realigned channel to the active upstream and downstream reaches; however, prior to the first spring freshet. Post-construction Monitoring will continue once per year for three years following Baseline Monitoring. The intent of the Post-construction Monitoring is to provide annual comparisons and inspections of the affected reaches. This will provide a determination of stream widening, aggradation or erosion processes have been accelerated by development.

The proposed monitoring of the hydraulic function of these systems will examine the channel cross-section in the area beneath a standard elevation (to be determined at detailed design). Cross-sections will be established at 2 set locations within Reach 14W-22 (upstream and downstream of Avenue One) and 1 set location within Reach 14W-23. Baseline monitoring is also proposed within Reaches 14W-12 and 14W-16 to establish a pre-development rate of stream widening, if any. Any evidence of erosive stress including downcutting, slumping or other soil failures, exposed vegetation root mass, and channel bar formation will also be documented during monitoring.

Ecology Monitoring

The timing of monitoring events will be set by acceptable protocols (e.g., Marsh Monitoring Protocol). Set Baseline Monitoring stations will be located at/in close proximity to stations established in support of the EIR (where possible). This will provide the opportunity to build upon existing data thereby providing greater context to the post-construction monitoring results.

In general, the proposed monitoring program will examine the function of the realigned reaches as fish habitat, benthic macroinvertebrate habitat, examination of the vegetation community within the riparian habitat (specimen survival and ground cover establishment), as well as, the function of the floodplain as habitat for anurans. There will also be specific temperature monitoring related to the discharging of flows from SMW facilities to Reach 14W-12 with the outflow temperature target being 20^{o}C.

The extent of the owners' participation in the monitoring of the aquatic habitat and community is currently unclear given the classification of Reach 14W-11A, Reach 14W-12A and Reach 14W-14 as Redside Dace Contributing habitat. Typically the MNRF will restrict in-water sampling within Redside Dace habitat and will often not issue the required licence(s). The outcome of post-construction monitoring requires further discussion with the MNRF given the habitat classification and the additional approvals that are anticipated as part of the *Endangered Species Act* (2007) review process.

Based on previous discussions with the DFO related to the proposed watercourse realignment, a *Fisheries Act* (1985) Authorization is not anticipated, and as such, additional monitoring as a requirement of the Act is unlikely. As the design progresses, the DFO will be consulted and in the event that additional monitoring is required, it will be undertaken by the owners.

Subject to the agency approvals and requirements as indicated above, the proposed ecological monitoring is anticipated to generally consist of the following components as identified in Table A7.8.1 below, with potential monitoring locations shown on Figures A7.8.1 and A7.8.2.

Table A7.8.1 - Anticipated Ecological Monitoring Components

Monitoring Event	Protocol	Spring	Summer	Fall	Reach
Vegetation	Ecological Land Classification (ELC)	*	*		14W-22 14W-23
Birds	Breeding Bird Survey (BBS)	*			14W-22 14W-23
Anurans	Marsh Monitoring Protocol (MMP)	*			14W-22 14W-23
Fish Habitat and Community	Ontario Stream Assessment Protocol (select module(s))	*			14W-12A 14W-22 14W-23
Benthic Macroinvertebrates	Ontario Benthos Biomonitoring Network (OBBN)	*			14W-12A 14W-22 14W-23

The ecological component of the Monitoring Report will generally consist of the following based on agency approval:

- Description of the existing conditions documented in accordance with the aforementioned protocols.
- Photographic record, with photos taken from the same location and vantage point year after year.
- Assessment of the current year's results with previous years/baseline.
- Recommendations for adjustments to mitigation measures and/or remedial works to address efficiencies (if any). Recommendations to the monitoring measure and/or remedial works will be forwarded to the landowner following the monitoring events in the event that these works must be undertaken during specific timing windows (e.g., fisheries in-water timing windows).

Additional monitoring parameters and/or reporting schedule may be required following the review of the proposed works by the regulatory agencies and if required will be undertaken by the owners. For instance, CH has indicated that benthic macroinvertebrate sampling be undertaken in the spring, a minimum of two weeks before the fish community surveys are undertaken. This monitoring parameter will be included into the final monitoring plan.

Groundwater Monitoring

A groundwater monitoring program will be undertaken using a well network constructed within the Natural Heritage System Lands as shown on Figures A7.8.1 and A7.8.2. Existing monitoring wells and mini-piezometers constructed for use with the EIR/FSS studies and located within the NHS will be retained (eight monitoring well locations, four mini-piezometer locations). It is also proposed to construct monitoring wells at four additional locations as shown on the figure, with two monitoring well nests to be constructed within the proposed diversion Reach 14W-22, and two monitoring well nests at Reach 14W-12A. Stream channel mini-piezometers are also proposed nearby the proposed monitoring well locations along the proposed diversion Reach 14W-22 and at Reach 14W-12A. The monitoring wells and mini-piezometers proposed along the diversion reaches would be constructed in coordination with the channel re-alignment construction.

Three channel monitoring points are proposed in the area of Reach 14W-12A that will monitor watercourse levels and temperatures. They will be located next to existing or proposed monitoring stations, with one to be located next to mini-piezometer MP-24 in the small channel leading to the existing Farm Pond, one to be located along Reach 14W-12A at the proposed monitoring station, upstream of the proposed confluence with Reach 14W-22, and one along Reach 14W-14 next to monitoring well nest MMM-09-10S/D (Figure A7.8.1). This latter channel monitor would be moved into Reach 14W-22 after completion of the channel realignments in the future (see Figure A7.8.2).

Monitoring of the infiltration trenches is also proposed at two locations (see Figure A7.8.2). The locations for the trench monitors have been selected to coincide with groundwater monitoring stations downslope (i.e., downgradient) of the infiltration trenches to monitor the effectiveness of these mitigative measures in maintaining shallow overburden groundwater contributions to the watercourses.

Monitoring is proposed at quarterly intervals (spring, summer, fall, winter) with manual measurements recorded at each monitoring location. Data loggers will be installed at selected wells and at the infiltration trenches set to record at hourly intervals and these units will be uploaded at the time of the quarterly events. The groundwater monitoring data will be used to support the other monitoring data collected at the Subject Property and the groundwater monitoring program would continue for up to 3 years following the construction of the realigned channels.

In addition, monitoring of the effectiveness of the infiltration trenches will be performed after major rain events, after a rainfall event of 30 mm or greater. A data logger will be installed at the inlet pipe to each of the monitored infiltration trenches, and at the outlet to the trench, and will be set to monitor temperature and water level fluctuations on an hourly interval and uploaded at the time of quarterly monitoring visits and after significant rainfall events. Water quality samples will also be obtained from the infiltration trenches after significant rainfall events. Total Suspended Solids, Nitrogen, and Phosphorous will be sampled at both the inlet and outlet pipes of the infiltration trenches. As it is not proposed to direct pavement runoff to the infiltration trenches, sampling for salts, and oil and grease is not planned. The configuration of the infiltration trench monitoring and sampling ports would be defined at the time of the detailed design.

Monitoring in Relation to Stormwater Management Works, Municipal Services and Trails Installed within the Natural Heritage System

Reach 14W-16 and Reach 14W-22 will be subject to crossings by roads and municipal servicing (i.e., water mains and sewers). In an effort to minimize encroachments, the municipal servicing has been located within the road right-of-ways.

The proposed road/municipal services crossing of Reach 14W-22 will occur in a realigned reach and is anticipated to be constructed at the same time as the channel works (prior to “tie-in” to the existing watercourse). As a result, the final monitoring program associated with the watercourse realignment (previous section) will include monitoring of this road crossing. Monitoring information prepared for the MNRF (if required) will also be forwarded to the Town and CH for their files.

The proposed road/municipal services crossing of Reach 14W-16 will occur within Redside Dace Occupied habitat and, as a result, it is anticipated that there will be specific monitoring requirements for this crossing issued by the MNRF as part of their review and approval process under the ESA (2007). This will likely include monitoring vegetation survival, as well as, aquatic community and habitat monitoring. Furthermore, permission to undertake in-water monitoring works (e.g., fish community, aquatic habitat, etc.) in Redside Dace Occupied habitat is typically restricted. It is anticipated that the monitoring required by MNRF for the aforementioned parameters will be sufficient to address the Town and CH requirements. Monitoring information prepared for the MNRF will also be forwarded to the Town and CH for their files. As the interests of MNRF required monitoring will likely focus on Redside Dace habitat, additional monitoring for this road crossing will be consistent (where applicable) to the monitoring associated with the reach realignments.

As identified on Figure 5.8, the proposed trail corridors have limited interaction with naturalized areas within the NHS. Monitoring is only necessary in those areas where there are encroachments into these naturalized areas of the NHS. Proposed reach/riparian habitat crossings have been consolidated onto the proposed road/municipal services crossings of Reach 14W-16 and Reach 14W-22 thereby limiting interactions with the NHS. In those limited instance where the trail does encroach into the NHS (principally cultural meadow habitat), the trail alignments have not been finalized. Finalization of the trail alignment will occur once the limits of the NHS have been agreed to by the Town, CH and proponent. The monitoring requirements associated with the trail will be developed as the trail design is complete and is proposed to be undertaken as a condition of Draft Plan approval.

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J:\1442 Projects by Job Number\2009\14-09222-001-HG1 Bentall Lands\050 Mapping\MXD\Report\Appendix 7.8.1 Proposed Monitoring Stations Baseline Condition.mxd

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Proposed Monitoring Stations Baseline Condition

Legend

- — Existing Watercourse
- ▭ Subject Property
- ⊕ Existing Groundwater Monitoring Wells
- ⊕ Mini-Piezometer
- ◆ Staff Gauge
- ✦ Pond Logger
- ■ Existing Surface Water / Water Quality Monitoring Station

Proposed Monitoring Stations

- ⊕ Proposed Mini Piezometer
- ⊕ Proposed Monitoring Well
- ◎ Stream Flow/Temperature Monitoring Point
- ▲ Baseline Amphibian Survey Station
- ● Post Channel Realignment Amphibian Survey Station
- ★ Baseline Bird Sampling Station
- ✱ Post Channel Realignment Bird Sampling Station
- ○ Baseline Stream Temperature & Dissolved Oxygen Station
- ⊗ Baseline Benthic Macroinvertebrate Station
- ⊙ Post Channel Realignment Benthic Macroinvertebrate Station
- ⦸ Baseline Fish Habitat and Community Station
- ◓ Post Channel Realignment Fish Habitat and Community Station
- ●—● Watercourse Cross Section Annual Measurement

Note: Locations shown are proposed and subject to revision pending final design.

Scale 0 100 200 400
Metres

Client
QuadReal

Prepared By
wsp

Date May 2019

Project No. 09M-00013-01

Scale as Shown

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Appendix: 7.8.1

J:\1442 Projects by Job Number\2009\14-09222-001-HG1 Bentall Lands\050 Mapping\MXD\Report\Appendix 7.8.2 Proposed Monitoring Stations Post Construction.mxd

Environmental Implementation Report / Functional Servicing Study for 14 Mile Creek West and the Lazy Pat Farm Property

Proposed Monitoring Stations
Post Construction Condition

Legend

- ― Existing Watercourse
- ▬ ▬ 1.1m Infiltration Swale
- ▬ ▬ 1.5m Infiltration Swale
- 🟥 Subject Property
- ◆ Existing Groundwater Monitoring Wells
- ◆ Existing Mini-Piezometer
- ◆ Existing Staff Gauge
- ■ Existing Surface Water / Water Quality Monitoring Station

Proposed Monitoring Stations

- ■ Proposed Infiltration Trench Monitor
- ⊕ Proposed Mini Piezometer
- ◆ Proposed Monitoring Well
- ◎ Stream Flow/Temperature Monitoring Point
- ▲ Baseline Amphibian Survey Station
- ● Post Channel Realignment Amphibian Survey Station
- ☆ Baseline Bird Sampling Station
- ✳ Post Channel Realignment Bird Sampling Station
- ○ Baseline Stream Temperature & Dissolved Oxygen Station
- ― Development Plan
- ― Proposed Channel Diversions
- ⊗ Baseline Benthic Macroinvertebrate Station
- ⊙ Post Channel Realignment Benthic Macroinvertebrate Station
- ⊘ Baseline Fish Habitat and Community Station
- ◒ Post Channel Realignment Fish Habitat and Community Station
- ▲ SWM Facility Quality Sampling Station
- ●―● Watercourse Cross Section Annual Measurement

Note: Locations shown are proposed and subject to revision pending final design.

Scale 0 100 200 400
Metres

Client
QuadReal

Prepared By
wsp

Date May 2019

Project No. 09M-00013-01

Scale as Shown

Appendix: 7.8.2