APPENDIX C – TMDL EXAMPLES AND CALCULATIONS

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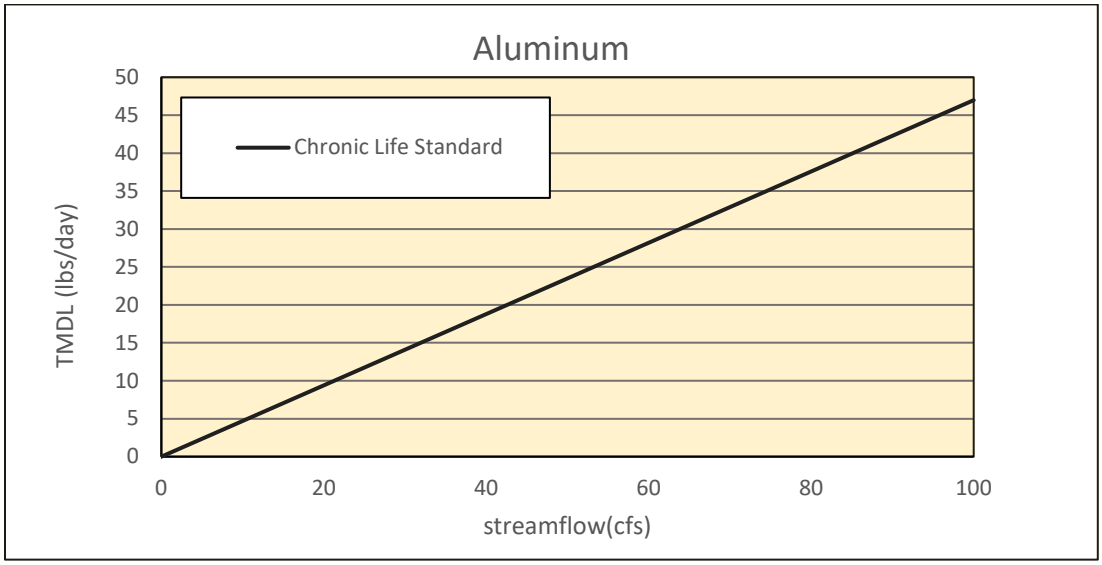
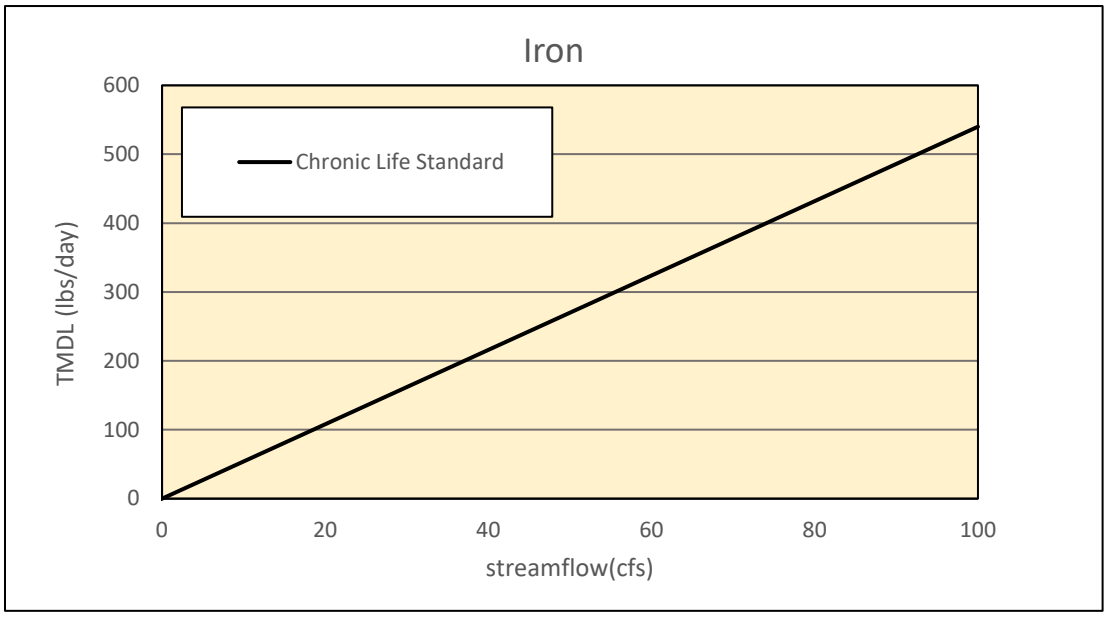
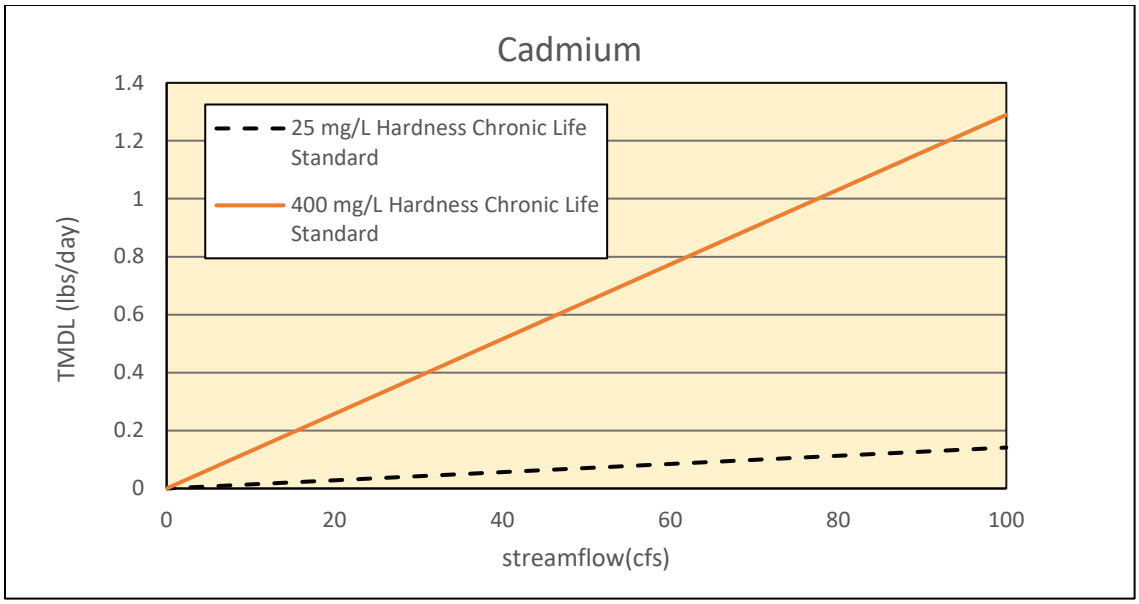
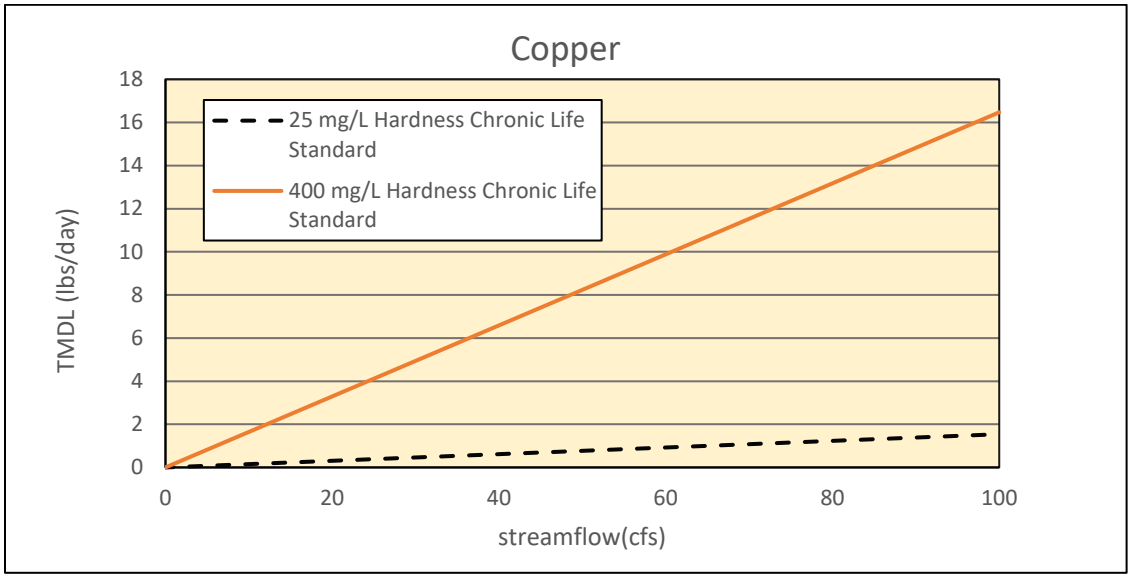
C.0 TMDL EXAMPLES AND CALCULATIONS

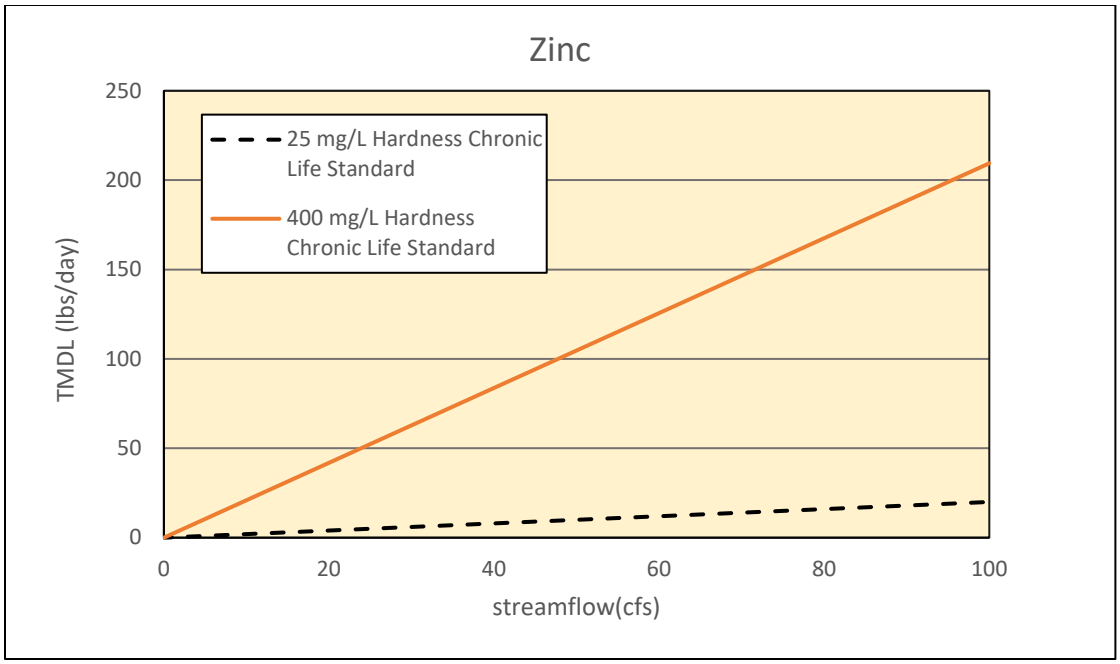
C.1. GRAPHS ILLUSTRATING TMDLS FOR EACH POLLUTANT AT DIFFERENT EXAMPLE FLOWS

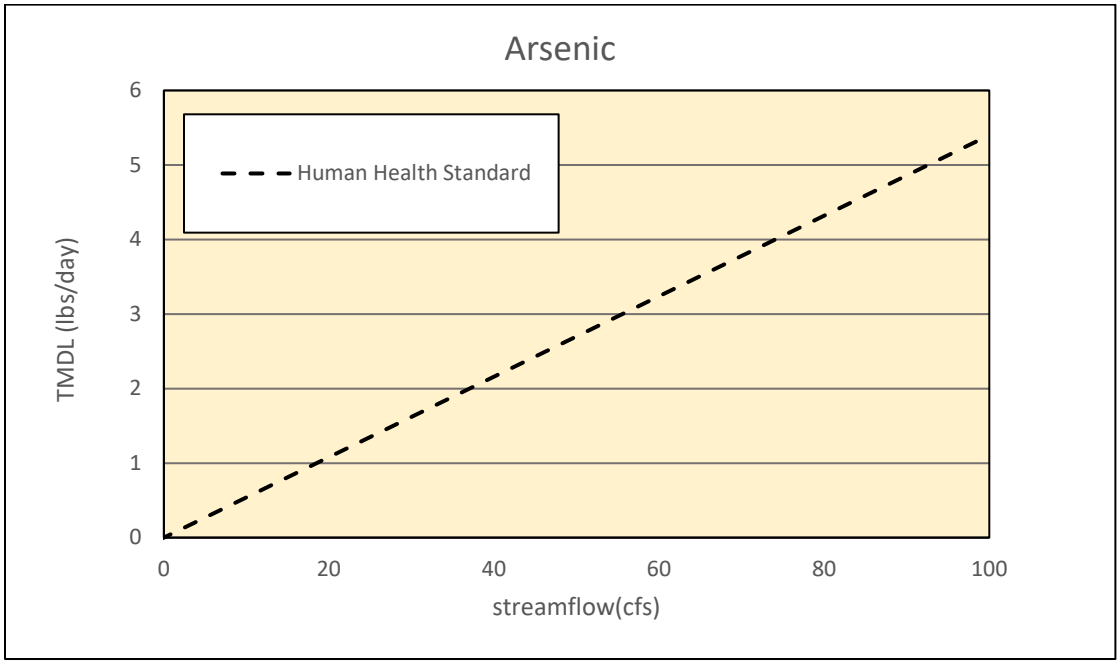


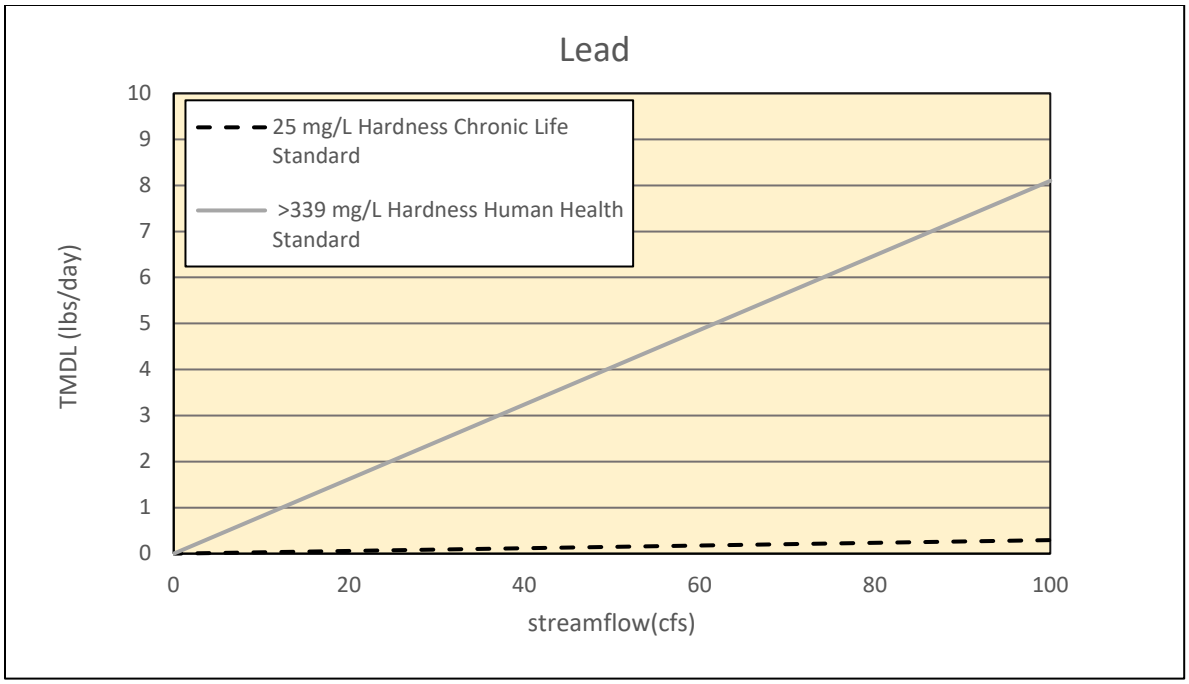



Cadmium
TMDL (lbs/day)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
streamflow(cfs)
25 mg/L Hardness Chronic Life Standard
400 mg/L Hardness Chronic Life Standard


Copper
TMDL (lbs/day)
18
16
14
12
10
8
6
4
2
0
0
20
40
60
80
100
streamflow(cfs)
25 mg/L Hardness Chronic Life Standard
400 mg/L Hardness Chronic Life Standard


Zinc
250
200
150
100
50
0
TMDL (lbs/day)
25 mg/L Hardness Chronic Life Standard
400 mg/L Hardness Chronic Life Standard
0
20
40
60
80
100
streamflow(cfs)


Arsenic
6
5
4
3
2
1
0
TMDL (lbs/day)
Human Health Standard
0
20
40
60
80
100
streamflow(cfs)


Lead
25 mg/L Hardness Chronic Life Standard
>339 mg/L Hardness Human Health Standard
TMDL (lbs/day)
streamflow(cfs)
0
1
2
3
4
5
6
7
8
9
10
0
20
40
60
80
100

C.2. CALCULATIONS USED IN DEVELOPMENT OF TMDLS

Table C-1 Calculations Used in Development of Example Lead TMDLs

	Grasshopper		Lower Rattlesnake		Upper Rattlesnake		Wellman	
	Low Flow	High Flow	Low Flow	High Flow	Low Flow	High Flow	Low Flow	High Flow
Flow (cfs)	0.370	332.72	3.62	26.32	33.06	134.17	0.30	0.80
Hardness	19.000	64	64.00	25.00	59.00	37.00	62.00	62.00
Target Concentration (ug/L) *(EXP(1.273*(LN(hardness))-4.705)*	0.380	1.8	1.80	0.55	1.62	0.89	1.66	1.66
Measured Concentration (µg/L)	0.900	4.2	7.60	12.20	19.80	19.80	3.30	3.30
Reference Concentration (µg/L)	0.500	0.5	0.50	0.50	0.50	0.50	0.50	0.50
Existing Load (µg/L) *(Measured µg/L* Flow * 0.0054)*	0.00180	7.55	0.149	1.734	3.535	14.345	0.005	0.014
TMDL Load (lbs/day) *(Target µg/L* Flow * 0.0054)*	0.00076	3.36	0.035	0.077	0.289	0.645	0.003	0.007
Natural Load (lbs day) *(Reference µg/L* Flow*0.0054)*	0.00100	0.898	0.010	0.071	0.089	0.362	0.001	0.002
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
*LAup (lbs/day) (Upstream Flow cfs*Target Concentration µg/L * 0.0054 – Upstream Natural Load)*	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000
WLAComp (lbs/day) (TMDL Load-Natural Load-LAup-WLA_{ACTIVE})	0.000	2.336	0.025	0.002	0.200	0.280	0.002	0.005
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	44.44	55.49	76.32	95.5	91.82	95.51	49.50	49.50

Table C-2 Calculations Used in Development of Example Iron TMDLs

	Spring Creek		Upper Stone Creek		Lower Stone Creek	
	Low Flow	High Flow	Low Flow	High Flow	Low Flow	High Flow
Flow (cfs)	1.12	3.56	0.95	2.04	0.10	0.96
Hardness	NA	NA	NA	NA	NA	NA
Target Concentration (ug/L) *(1000 µg/L)*	1000	1000	1000.00	1000.00	1000.00	1000.00
Measured Concentration (µg/L)	690	1460	1280.00	4080.00	110.00	9960.00
Reference Concentration (µg/L)	240	240	240.00	240.00	240.00	240.00
Existing Load (µg/L) *(Measured µg/L* Flow * 0.0054)*	4.173	28.067	6.566	44.945	0.059	51.633
TMDL Load (lbs/day) *(Target µg/L* Flow * 0.0054)*	6.048	19.224	5.130	11.016	0.540	5.184
Natural Load (lbs day) *(Reference µg/L* Flow*0.0054)*	1.452	4.614	0.285	0.635	0.130	1.244
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000	3.940	8.370	0.000	0.000
*LAup(lbs/day) (Upstream Flow cfs*Concentration µg/L * 0.0054)*	0.000	0.000	0.000	0.000	0.000	0.000
WLAComp (lbs/day) (TMDL Load-Natural Load-LAup-WLAACTIVE)	4.596	14.61	0.905	2.010	0.410	3.940
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	0.00	31.51	21.88	75.49	0.00	52.46

Table C-3. Calculations Used in Development of Example Copper TMDLs

	Lower Rattlesnake Creek		Lower Stone Creek		Wellman Creek	
	Low Flow	High Flow	Low Flow	High Flow	Low Flow	High Flow
Flow (cfs)	3.62	26.32	0.1	0.96	0.30	0.80
Hardness	64.00	13.00	199	199	62	62
Target Concentration (ug/L) *EXP(0.8545*(LN(hardness))-1.702)*	6.37	2.85	16.79	16.79	6.20	6.20
Measured Concentration (µg/L)	2.00	52.00	2	20	48.00	48.00
Reference Concentration (µg/L)	1.00	1.00	1	1	1.00	1.00
Existing Load (µg/L) *(Measured µg/L* Flow * 0.0054)*	0.039	7.391	0.0011	0.1037	0.078	0.207
TMDL Load (lbs/day) *(Target µg/L* Flow * 0.0054)*	0.125	0.403	0.0091	0.0870	0.010	0.027
Natural Load (lbs day) *(Reference µg/L* Flow *0.0054)*	0.020	0.140	0.0005	0.0052	0.002	0.004
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000	0.000	0.000	0.000	0.000
*LAup (lbs/day) (Upstream Flow cfs*Target Concentration µg/L * 0.0054 – Upstream Natural Load)*	0.000	0.155	0.0000	0.0000	0.000	0.000
WLAComp (lbs/day) (TMDL Load-Natural Load-LAup-WLA_{ACTIVE})	0.105	0.108	0.0085	0.0820	0.008	0.022
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	0.00	94.52	0.00	16.05	87.08	87.08

Table C-4. Calculations Used in Development of Zinc TMDL's

	Wellman Creek	
	Low Flow	High Flow
Flow (cfs)	0.30	0.80
Hardness	62.00	62.00
Target Concentration (ug/L) *EXP(0.8473*(LN(hardness))-0.884)*	79.90	79.90
Measured Concentration (µg/L)	219.00	219.00
Reference Concentration (µg/L)	2.75	2.75
Existing Load (µg/L) *(Measured µg/L* Flow * 0.0054)*	0.35	0.95
TMDL Load (lbs/day) *(Target µg/L* Flow * 0.0054)*	0.13	0.35
Natural Load (lbs day) *(Reference µg/L* Flow *0.0054)*	0.004	0.012
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000

Table C-4. Calculations Used in Development of Zinc TMDL's

	Wellman Creek	
	Low Flow	High Flow
*LAup(lbs/day) (Upstream Flow cfs*Concentration µg/L * 0.0054)*	0.000	0.000
Natural Load (lbs day) *(Reference µg/L* Flow *0.0054)*	0.12	0.33
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	63.52	63.52

Table C-5. Calculations Used in Development of Example Cadmium TMDLs

	Wellman Creek	
	Low Flow	High Flow
Flow (cfs)	0.3	0.8
Hardness	62	62
Target Concentration (ug/L) *EXP(0.7977*(LN(hardness))-3.909)*	0.185	0.185
Measured Concentration (µg/L)	0.58	0.58
Reference Concentration (µg/L)	0.03	0.03
Existing Load (µg/L) *(Measured µg/L* Flow * 0.0054)*	0.001	0.003
TMDL Load (lbs/day) *(Target µg/L* Flow * 0.0054)*	0.0003	0.0008
Natural Load (lbs day) *(Reference µg/L* Flow *0.0054)*	0.0000	0.0001
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000
*LAup(lbs/day) (Upstream Flow cfs*Concentration µg/L * 0.0054)*	0.000	0.000
Natural Load (lbs day) *(Reference µg/L* Flow*0.0054)*	0.000	0.001
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	68.10	68.10

Table C-7. Calculations Used in Development of Example Aluminum TMDLs

	Lower Stone Creek		Wellman Creek	
	Low Flow	High Flow	Low Flow	High Flow
Flow (cfs)	0.1	0.96	0.30	0.80
Hardness	NA	NA	NA	NA
Target Concentration (ug/L)	87	87	87.00	87.00
Measured Concentration (ug/L)	16	183	166.00	166.00
Reference Concentration (ug/L)	50	50	50.00	50.00
Existing Load (µg/L) *(Measured µg/L* Flow * 0.0054)*	0.009	0.949	0.269	0.717
TMDL Load (lbs/day) *(Target µg/L* Flow * 0.0054)*	0.047	0.451	0.141	0.376
Natural Load (lbs day) *(Reference µg/L* Flow*0.0054)*	0.027	0.259	0.081	0.216
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000	0.000	0.000
*LAup(lbs/day) (Upstream Flow cfs*Concentration µg/L * 0.0054)*	0.000	0.000	0.000	0.000
WLAComp (lbs/day) (TMDL Load-Natural Load-LAup-WLA_{ACTIVE})	0.020	0.192	0.060	0.160
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	0.00	52.46	47.59	47.59

Table C-8. Calculations Used in Example Arsenic TMDL

	Steel Creek	West Fork Blacktail Deer Creek	
	Low/High Flow	Low Flow	High Flow
Flow (cfs)	0.05	8.59	41.5
Hardness	NA	383	280
Target Concentration (10 ug/L)	10	10	10
Measured Concentration (ug/L)	22	16	16
Reference Concentration (ug/L)	3.5	3.5	3.5
Existing Load (µg/L) (Measured µg/L* Flow * 0.0054)	0.0059	0.742	3.586
TMDL Load (lbs/day) (Target µg/L* Flow * 0.0054)	0.0027	0.464	2.241
Natural Load (lbs day) *(Reference µg/L* Flow *0.0054)*	0.0009	0.162	0.784
WLA_{ACTIVE}(lbs/day) *(Outfall Flow cfs *Concentration µg/L * 0.0054)*	0.000	0.000	0.000
*LAup(lbs/day) (Upstream Flow cfs*Concentration µg/L * 0.0054)*	0.000	0.000	0.000
WLAComp (lbs/day) (TMDL Load-Natural Load-LAup-WLA_{ACTIVE})	0.0018	0.302	1.457
% Reduction *((Existing Load-TMDL Load/Existing Load)*100*	54.55	37.5	37.5