Appendix F:
Technical Approach Used to Generate Maximum Daily Loads & TMDL Daily Loads and Statistics

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F.1 SUMMARY

This appendix documents the technical approach used to define maximum daily loads of iron, aluminum, ammonium, nitrate, and sulfate consistent with the average annual TMDL which, when met, will result in the protection of the water quality targets in the Western Maryland watersheds. The approach builds on the modeling analysis that was conducted to determine the loadings of iron, aluminum, and manganese and can be summarized as follows:

- The approach defines maximum daily loads for each metal.
- The approach builds on the TMDL modeling analysis that was conducted to ensure that compliance with average annual loading targets will result in compliance with water quality targets. These average annual loading targets were converted into allowable *daily* values by using the daily time-series loadings developed from the TMDL modeling analysis.
- The approach converts daily time-series loadings into TMDL values in a manner that is consistent with available EPA guidance on generating daily loads for TMDLs.
- The approach uses policy input related to the expected level of resolution and probability level provided by an advisory group led by EPA Region 3.

F.2 INTRODUCTION

This appendix documents the development and application of the approach used to define maximum daily loads on the basis of the average annual TMDLs for metals in the Western Maryland watersheds. It is divided into sections discussing

- Basis for approach
- Options considered
- Selected approach
- Application of approach
- Results of approach

F.3 BASIS FOR APPROACH

The overall approach for development of daily loads was based on the following factors:

- **Daily time-series loadings developed for this TMDL:** This TMDL employs continuous simulation modeling to determine compliance with the applicable water quality targets for metals, producing a time series of daily loads for the period that was simulated (March 1, 2007–February 28, 2008).
- **Draft EPA guidance on "Developing Daily Loads for Load-based TMDLs:"** This guidance provides options for defining maximum daily loads when using TMDL approaches that generate daily output.[1]

The rationale for developing TMDLs with *daily* load expressions was to accept the existing TMDL development methodology but to then develop a method for converting the resulting

[1] *Approaches for Developing a Daily Load Expression for TMDLs Computed for Longer Term Averages*. 2006 Draft guidance document. U.S. Environmental Protection Agency, Washington, DC.

daily time series of loadings into maximum *daily* values in a manner consistent with EPA guidance.

F.4 OPTIONS CONSIDERED

The available guidance for developing daily loads does not specify a single allowable approach; it contains a range of options. Selecting a specific method for translating a time-series of allowable loads into expression of a TMDL requires decisions regarding both the level of resolution (e.g., single daily load for all conditions vs. loads that vary with environmental conditions) and the level of probability (of exceedance) associated with the TMDL.

This section describes the range of candidate options that were considered for use in developing maximum daily loads for the Western Maryland watersheds. The section is first divided into discussions corresponding to the two primary decisions required in selecting an approach: (1) Level of Resolution, and (2) Probability Level. It concludes with a discussion of how various options were applied via the calculation of *sample* maximum daily loads.

F.4.1 Level of Resolution

The level of resolution pertains to the amount of detail used in specifying the maximum daily load. The draft EPA guidance on daily loads provides three categories of options for level of resolution, all of which are potentially applicable for the Western Maryland watersheds:

1. **Representative daily load:** In this option, a single daily load (or multiple representative daily loads) is specified that covers all time periods and environmental conditions.
2. **Flow-variable daily load:** This option allows the maximum daily load to vary according to the observed flow condition.
3. **Temporally-variable daily load:** This option allows the maximum daily load to vary according to seasons or times of varying source or waterbody behavior.

F.4.2 Probability Level

Essentially all TMDLs have some probability of being exceeded, with the specific probability being either explicitly stated or implicitly assumed. This level of probability reflects, directly or indirectly, two separate phenomena:

1. Water quality criteria consist of components describing acceptable magnitude, duration, and frequency. The frequency component addresses how often conditions can allowably surpass the combined magnitude and duration components.
2. Pollutant loads, especially from wet-weather sources, typically exhibit a large degree of variability over time. It is rarely practical to specify a *never to be exceeded value* for a daily load, because essentially any loading value has some finite probability of being exceeded.

The draft daily load guidance states that the probability component of the maximum daily load should be "based on a representative statistical measure" that is dependent on the specific TMDL and best professional judgment of the developers. This statistical measure represents how often the maximum daily load is expected/allowed to be exceeded. The primary options for selecting this level of protection would be

1. **The maximum daily load reflects some central tendency:** In this option, the maximum daily load is based on the mean or median value of the range of loads expected to occur. The variability in the actual loads is not addressed.
2. **The maximum daily load reflects a level of protection implicitly provided by the selection of some *critical* period**: In this option, the maximum daily load is based on the allowable load that is predicted to occur during some critical period examined during the analysis. The developer does not explicitly specify the probability of occurrence.
3. **The maximum daily load is a value that will be exceeded with a pre-defined probability:** In this option, a *reasonable* upper bound percentile is selected for the maximum daily load on the basis of a characterization of the variability of daily loads. For example, selection of the 95th percentile value would result in maximum daily load that would be exceeded 5 percent of the time.

F.5 SELECTED APPROACH

The approach selected for defining a maximum daily load for the Western Maryland watersheds was based on the level of information available.

Approach for Nonpoint Sources

The level of resolution selected for defining a maximum daily load for the Western Maryland watersheds is for a flow-variable daily load for each loading source. This approach was selected to provide the maximum detail possible, given the nature of the system.

The probability level will be based on the use of a critical condition. This approach was selected because it is directly analogous to the approach used in setting the original TMDL and will maintain the policy decisions made during development of that TMDL. The probability level for the annual TMDL determination was based on the use of a critical period approach. For the annual TMDL, the period of March 1, 2007 through February 28, 2008, was selected as representing a range of wet, average, and dry rainfall conditions. The most direct analogy for developing maximum daily loads will be to use the same critical period approach, with the critical period being defined as the highest single daily loading predicted during the same simulation period originally used in the TMDL. The maximum *daily* load for each contributing source is therefore defined as the highest observed (or predicted) daily load for each loading source over the course of the critical period. These maximum daily loads will be calculated for each of the flow strata considered.

F.6 APPLICATION OF APPROACH

This section documents the application of the selected approach to define maximum daily loads for the Western Maryland watersheds.

Calculation Approach for Nonpoint Sources

The specific approach used for application to the Western Maryland TMDLs was

1. Obtained the predicted daily loading time series over the simulation period (March 1, 2007–February 28, 2008) from each contributing source for the recommended TMDL scenario that demonstrates compliance with water quality targets.
2. Conducted a flow duration analysis for the Western Maryland watersheds' flow, dividing flows into 10 duration intervals by percentiles (i.e. 0–10%, 10–20%, 20–30%, 30–40%, 40–50%, 50–60%, 60–70%, 70–80%, 80–90%, and 90–100%).
3. Determined the maximum daily load over this period of simulation for each flow duration interval.
4. Used the maximum daily load obtained in Step 3 as the basis of the maximum daily load.

F.7 Results of Approach

Figures F-1 through F-18 and Tables F-1 through F-18 present the pollutant loadings by flow percentile for each of the impaired waterbody segments in the western Maryland watersheds.

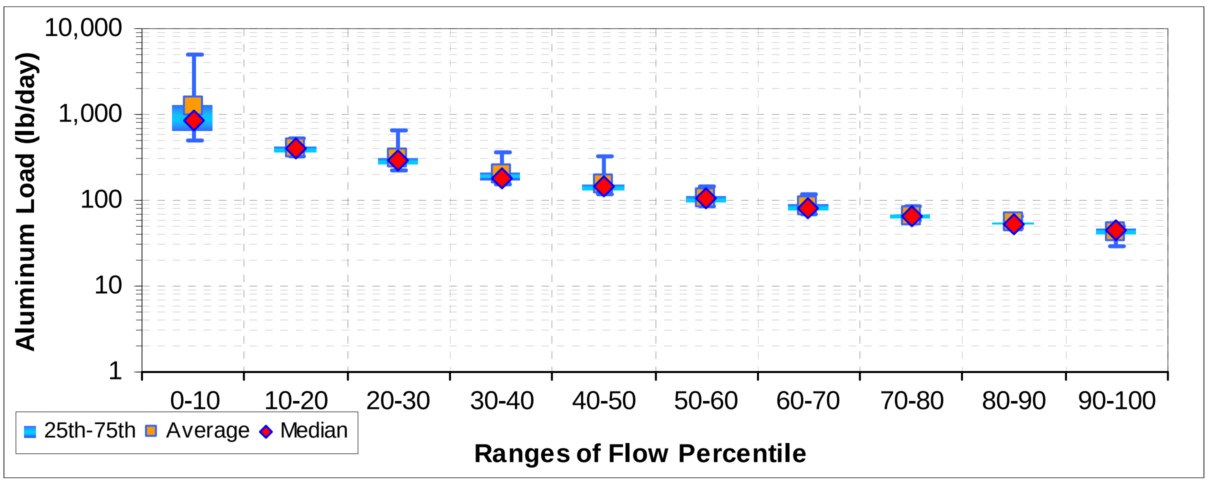

Figure F-1. Aluminum loads by flow percentile for Laurel Run (entire watershed)

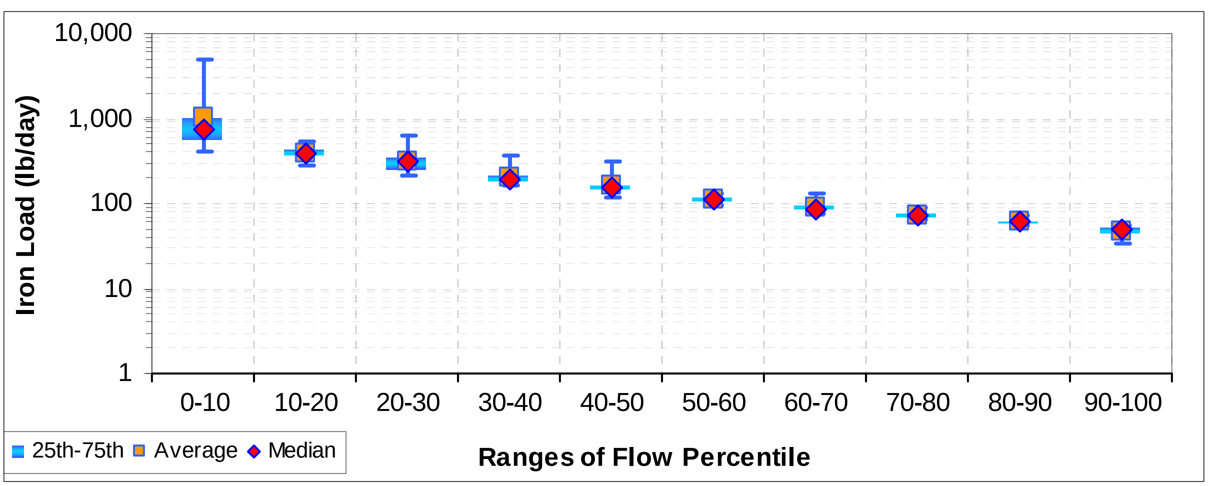

Figure F-2. Iron loads by flow percentile for Laurel Run (entire watershed)

Table F-1. Aluminum loads (lb/d) by flow percentile for Laurel Run (entire watershed)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	487.9	330.6	220.7	157.0	114.9	87.2	68.7	57.5	48.3	29.7
Average	1,224.3	409.0	314.1	197.9	154.8	104.1	83.8	66.8	54.1	42.2
Maximum	4,995.9	520.2	638.5	355.8	320.1	145.8	120.1	86.8	66.9	48.9
Median	858.8	404.2	296.0	184.7	146.9	103.5	80.9	66.3	53.3	43.8
25th	669.1	370.4	269.0	170.8	134.0	95.1	74.8	62.2	51.2	39.4
75th	1,303.8	431.8	313.1	209.6	156.9	109.7	89.0	69.4	56.9	46.5

Table F-2. Iron loads (lb/d) by flow percentile for Laurel Run (entire watershed)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	416.2	278.5	213.0	160.2	119.5	96.4	77.4	64.6	54.5	33.6
Average	1,043.4	393.8	315.5	205.1	161.7	112.3	90.0	73.3	60.2	47.5
Maximum	4,981.6	525.0	639.7	374.9	306.9	134.5	130.6	89.9	72.4	56.0
Median	756.4	382.3	316.2	191.0	153.2	111.4	87.3	72.5	60.0	48.6
25th	559.6	365.2	248.6	183.9	144.7	103.0	83.7	69.4	57.2	44.3
75th	1,012.2	426.1	340.8	219.3	166.2	119.3	94.5	76.5	62.5	52.4

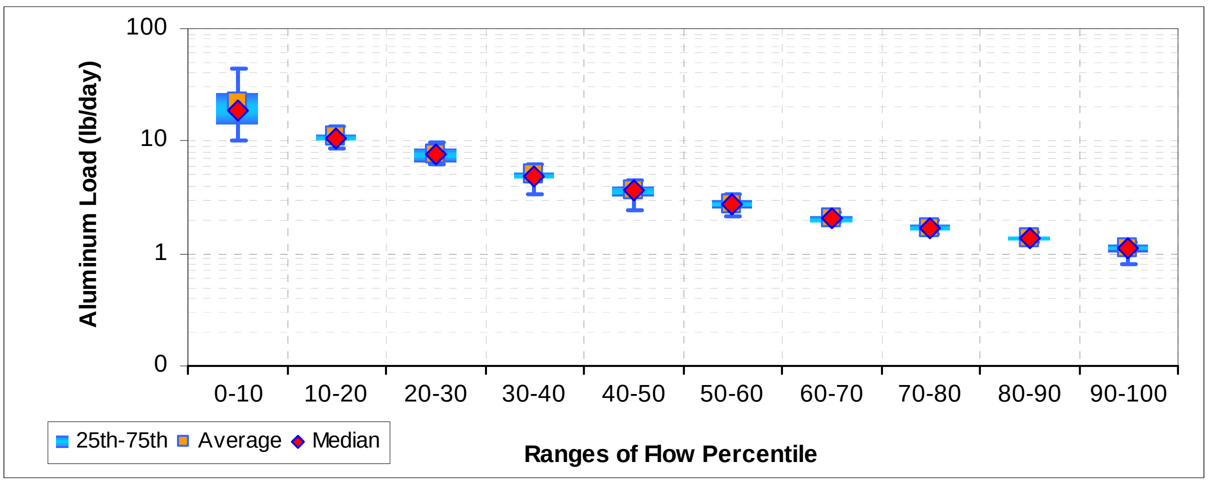

Figure F-3. Aluminum loads by flow percentile for UNT to Laurel Run

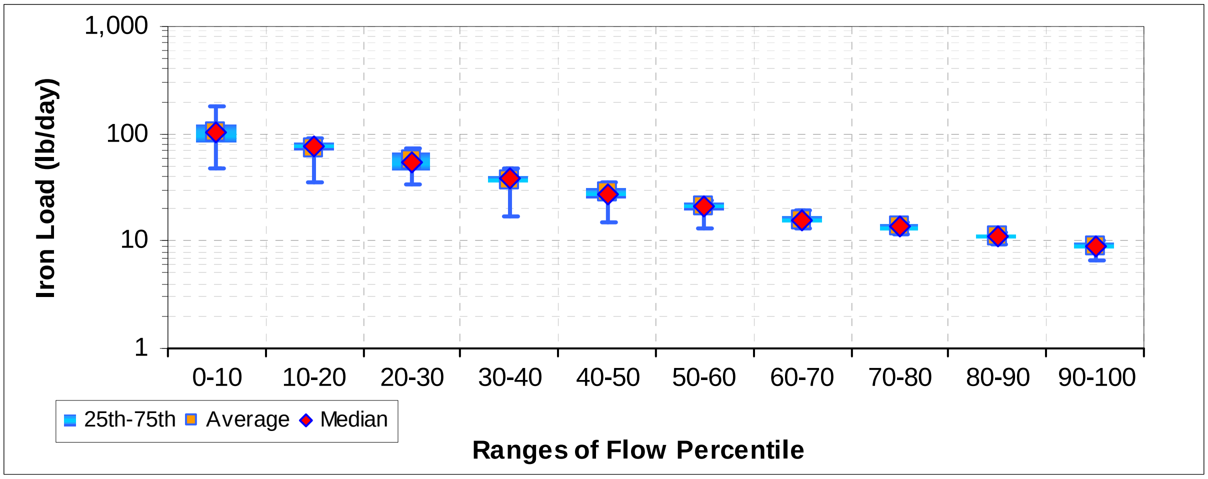

Figure F-4. Iron loads by flow percentile for UNT to Laurel Run

Table F-3. Aluminum loads (lb/d) by flow percentile for UNT to Laurel Run

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	10.083	8.762	6.189	3.414	2.399	2.142	1.864	1.493	1.263	0.812
Average	21.693	10.825	7.667	4.972	3.651	2.694	2.041	1.697	1.381	1.122
Maximum	44.689	13.275	9.556	6.188	4.441	3.391	2.372	1.942	1.537	1.264
Median	18.768	10.621	7.770	4.900	3.697	2.687	2.022	1.702	1.388	1.131
25th	14.297	10.046	6.571	4.672	3.245	2.486	1.921	1.603	1.323	1.040
75th	27.416	11.469	8.584	5.243	4.016	2.928	2.144	1.812	1.431	1.228

Table F-4. Iron loads (lb/d) by flow percentile for UNT to Laurel Run

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	47.65	35.77	33.60	16.99	14.93	13.11	13.19	11.63	9.43	6.55
Average	102.87	73.48	55.32	37.29	28.10	20.77	15.85	13.45	11.00	9.01
Maximum	180.77	89.91	72.64	48.40	34.70	24.35	18.94	14.99	11.97	10.20
Median	100.92	75.49	54.88	38.29	27.67	21.04	15.59	13.48	11.08	8.98
25th	81.77	68.57	45.22	35.66	25.21	19.44	14.92	12.63	10.43	8.39
75th	123.20	81.67	67.03	39.44	31.52	23.17	16.76	14.22	11.54	9.90

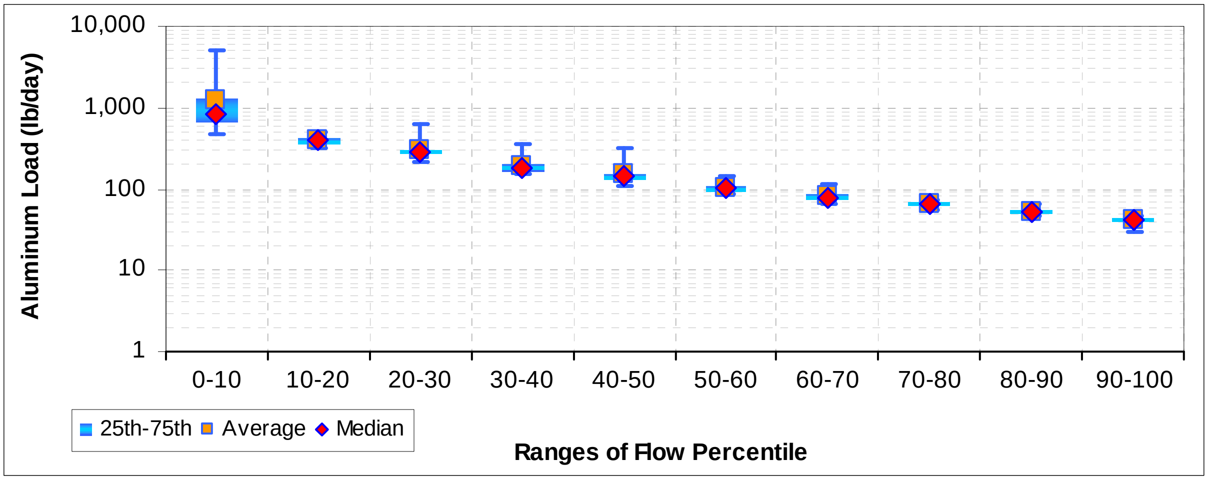

Figure F-5. Aluminum loads by flow percentile for Laurel Run (direct contributions)

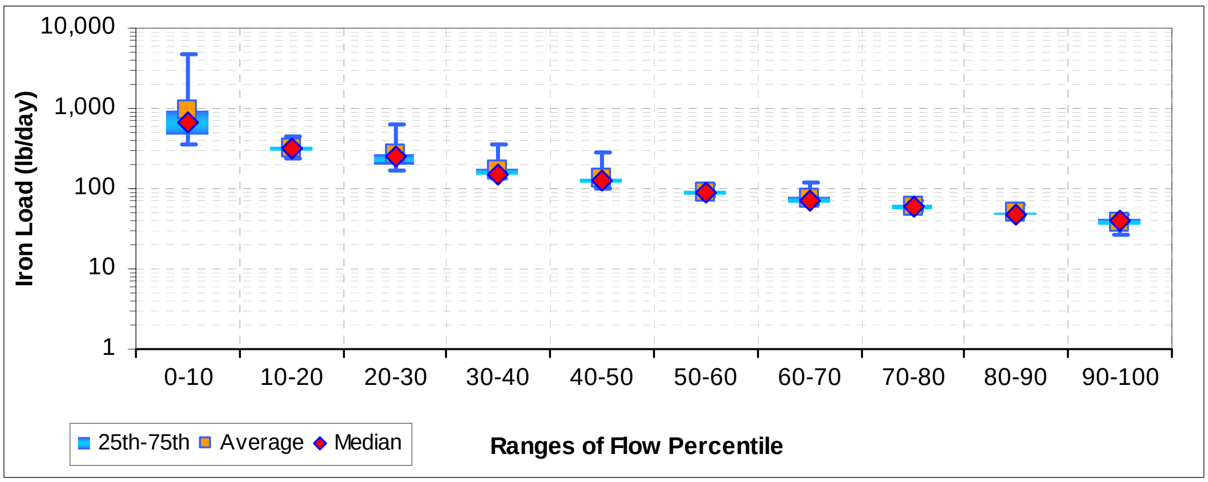

Figure F-6. Iron loads by flow percentile for Laurel Run (direct contributions)

Table F-5. Aluminum loads (lb/d) by flow percentile for Laurel Run (direct contributions)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	474.66	321.23	210.09	152.82	111.72	86.25	66.81	55.93	47.08	28.93
Average	1,202.59	398.19	306.47	193.11	151.13	101.95	81.51	64.70	52.67	41.05
Maximum	4,952.77	507.07	635.09	352.02	316.75	143.55	118.29	74.00	65.65	47.75
Median	847.67	392.92	287.73	179.41	142.64	100.82	78.84	64.47	51.90	42.61
25th	653.05	359.85	262.39	165.92	130.10	94.50	73.66	60.50	49.84	38.28
75th	1,282.57	420.04	304.15	203.37	152.38	107.71	85.48	67.88	55.51	45.19

Table F-6. Iron loads (lb/d) by flow percentile for Laurel Run (direct contributions)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	361.71	242.77	171.95	130.05	97.66	78.69	62.38	51.95	44.68	27.05
Average	940.51	320.35	261.00	168.61	133.71	90.88	73.93	59.36	49.13	38.38
Maximum	4,800.84	436.48	622.67	348.79	285.85	112.45	116.60	69.50	62.76	47.07
Median	673.51	308.67	249.99	152.34	125.02	89.31	71.24	59.51	48.10	39.43
25th	468.04	294.35	203.42	148.28	117.29	84.27	67.36	55.57	46.10	35.38
75th	926.27	343.14	270.73	180.71	131.80	96.86	77.49	61.76	50.48	42.49

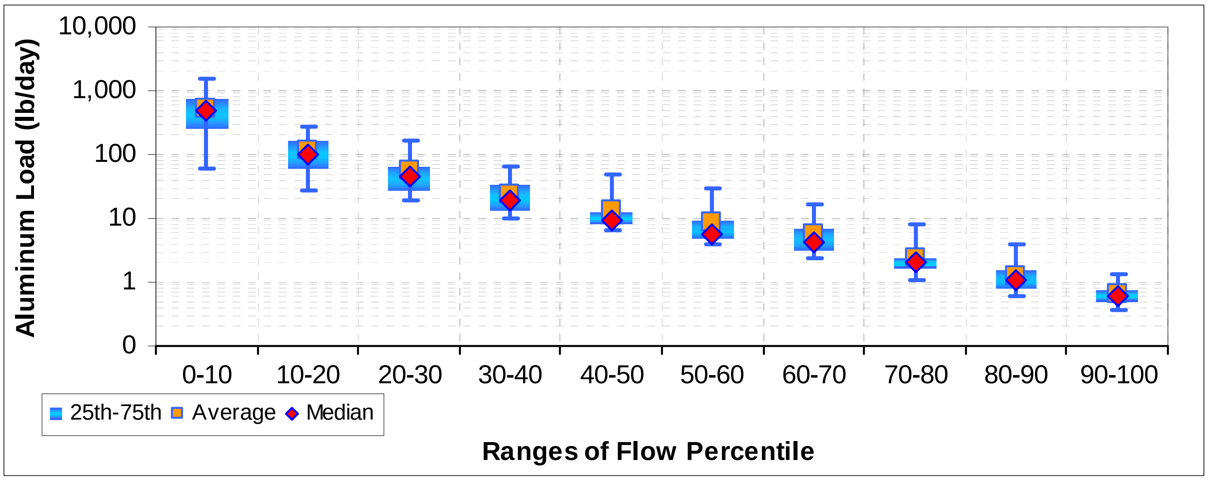

Figure F-7. Aluminum loads by flow percentile for Three Forks Run (entire watershed)

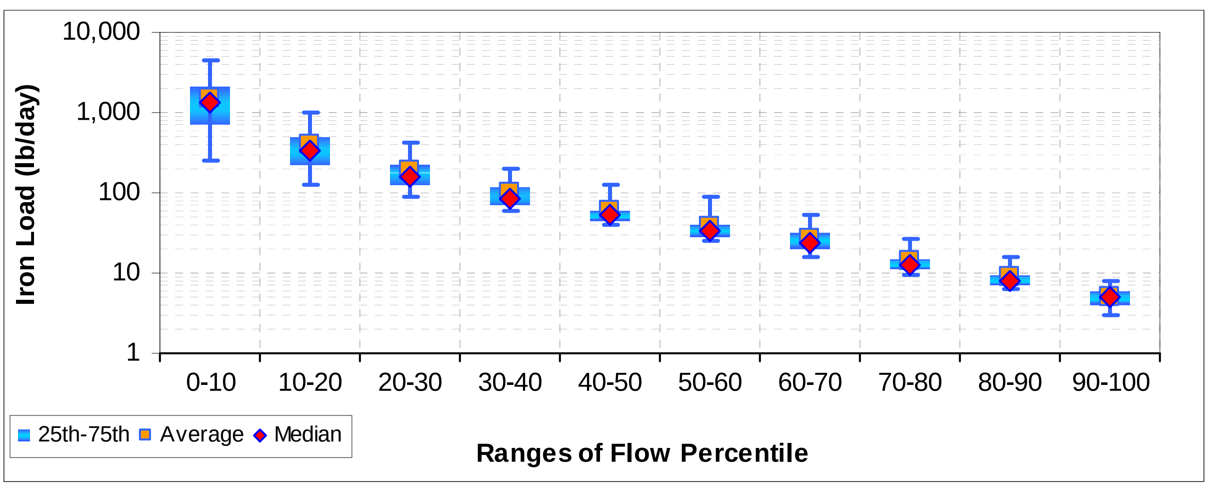

Figure F-8. Iron loads by flow percentile for Three Forks Run (entire watershed)

Table F-7. Aluminum loads (lb/d) by flow percentile for Three Forks Run (entire watershed)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	60.85	27.96	19.19	9.83	6.62	3.93	2.38	1.07	0.62	0.37
Average	530.03	118.00	54.90	24.53	12.89	8.44	5.72	2.33	1.28	0.66
Maximum	1,571.62	274.12	165.22	64.33	47.24	30.15	16.87	7.91	3.92	1.37
Median	494.20	102.86	44.31	19.40	9.07	5.72	4.10	2.00	1.10	0.60
25th	246.80	59.70	27.83	13.78	8.10	4.94	3.15	1.61	0.80	0.49
75th	731.28	163.90	67.08	32.91	12.35	9.24	6.96	2.36	1.51	0.77

Table F-8. Iron loads (lb/d) by flow percentile for Three Forks Run (entire watershed)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	254.78	126.87	90.23	58.90	39.44	25.29	15.96	9.68	6.24	2.92
Average	1,522.21	397.05	186.21	99.17	59.04	38.40	26.53	13.80	8.72	5.00
Maximum	4,345.55	1,028.83	421.97	203.61	129.02	90.49	52.81	27.12	15.86	8.09
Median	1,322.45	332.22	155.24	83.97	51.75	33.99	23.65	12.82	8.14	5.08
25th	706.04	219.05	122.86	70.42	45.25	28.96	19.56	11.02	6.94	4.02
75th	2,081.83	502.69	224.38	117.58	58.79	40.54	30.99	15.35	9.39	5.99

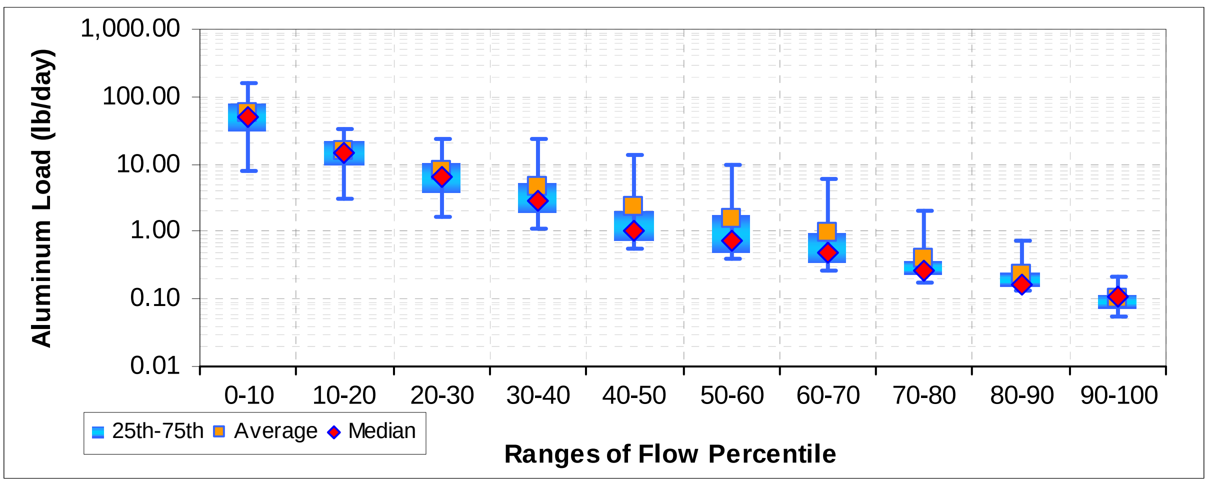

Figure F-9. Aluminum loads by flow percentile for Right Prong Three Forks Run

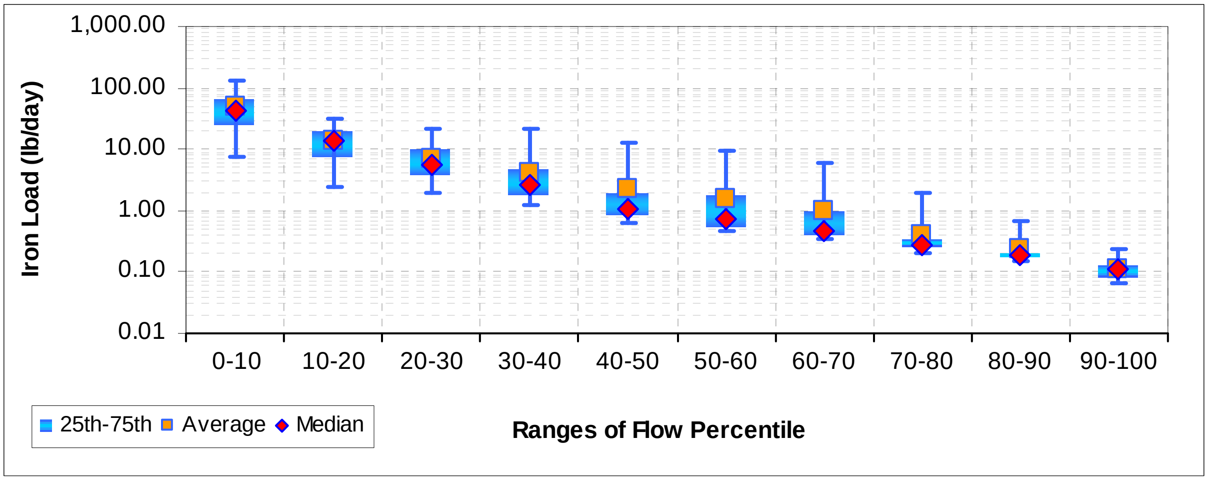

Figure F-10. Iron loads by flow percentile for Right Prong Three Forks Run

Table F-9. Aluminum loads (lb/d) by flow percentile for Right Prong Three Forks Run

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	7.948	3.006	1.670	1.092	0.559	0.387	0.272	0.173	0.131	0.056
Average	55.305	15.731	8.026	4.475	2.380	1.580	0.985	0.397	0.231	0.102
Maximum	158.701	34.161	23.001	23.697	13.326	9.564	5.991	2.054	0.728	0.219
Median	50.567	15.117	6.365	2.901	1.041	0.739	0.475	0.260	0.168	0.106
25th	30.434	9.424	3.790	1.900	0.738	0.497	0.349	0.222	0.152	0.072
75th	79.733	21.962	10.556	5.105	1.972	1.766	0.971	0.375	0.242	0.118

Table F-10. Iron loads (lb/d) by flow percentile for Right Prong Three Forks Run

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	7.343	2.451	1.884	1.237	0.647	0.464	0.331	0.196	0.146	0.064
Average	48.277	14.195	7.201	4.087	2.314	1.519	0.958	0.399	0.230	0.112
Maximum	130.329	31.417	21.167	21.165	12.320	9.169	5.795	1.997	0.656	0.229
Median	43.439	14.184	5.546	2.582	1.057	0.704	0.461	0.276	0.186	0.114
25th	25.680	7.643	3.757	1.738	0.862	0.552	0.404	0.246	0.174	0.083
75th	68.961	20.479	9.888	4.922	1.928	1.757	0.982	0.344	0.206	0.131

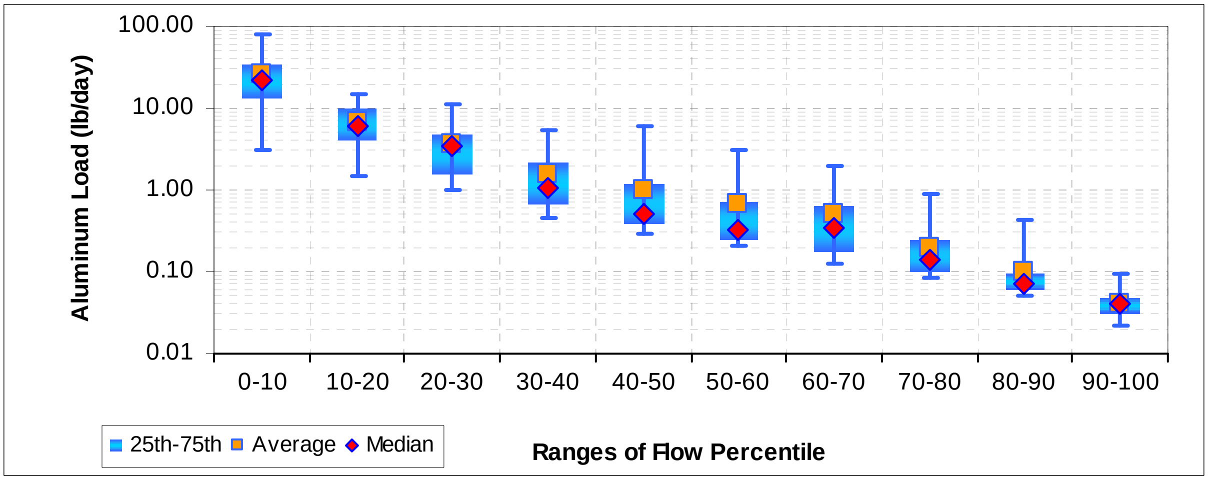

Figure F-11. Aluminum loads by flow percentile for Left Prong Three Forks Run

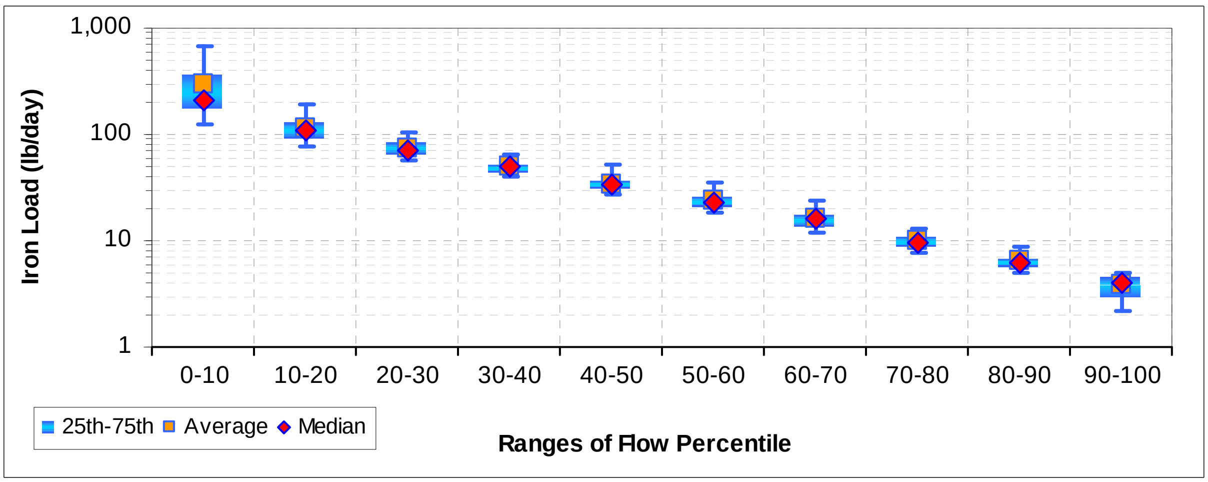

Figure F-12. Iron loads by flow percentile for Left Prong Three Forks Run

Table F-11. Aluminum loads (lb/d) by flow percentile for Left Prong Three Forks Run

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	3.157	1.500	0.985	0.453	0.288	0.204	0.127	0.084	0.052	0.023
Average	25.635	6.733	3.598	1.547	1.023	0.676	0.505	0.200	0.100	0.041
Maximum	80.063	14.770	11.368	5.301	5.925	3.110	1.966	0.905	0.438	0.097
Median	21.775	6.020	3.480	1.041	0.503	0.326	0.344	0.139	0.072	0.042
25th	13.495	4.160	1.576	0.690	0.392	0.245	0.175	0.103	0.062	0.030
75th	33.498	9.733	4.758	2.142	1.217	0.723	0.627	0.242	0.096	0.048

Table F-12. Iron loads (lb/d) by flow percentile for Left Prong Three Forks Run

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	126.077	78.286	56.817	39.391	26.988	18.747	11.665	7.559	5.075	2.211
Average	290.778	112.440	73.322	49.237	34.261	23.795	16.108	9.817	6.349	3.810
Maximum	664.685	188.410	105.695	64.508	51.213	35.504	24.258	12.719	8.763	5.067
Median	213.444	110.282	71.214	49.665	34.125	23.219	16.293	9.376	6.172	4.065
25th	173.209	92.293	65.650	44.119	30.316	21.325	13.794	8.835	5.760	2.960
75th	376.179	127.012	82.549	52.684	36.774	25.932	17.959	10.869	6.724	4.565

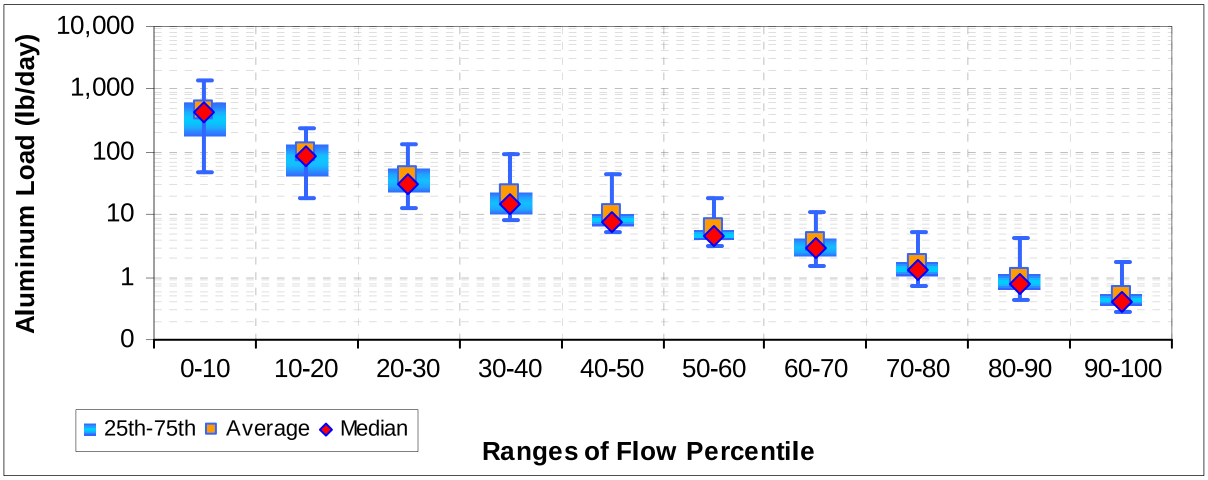

Figure F-13. Aluminum loads by flow percentile for Three Forks Run (direct contributions)

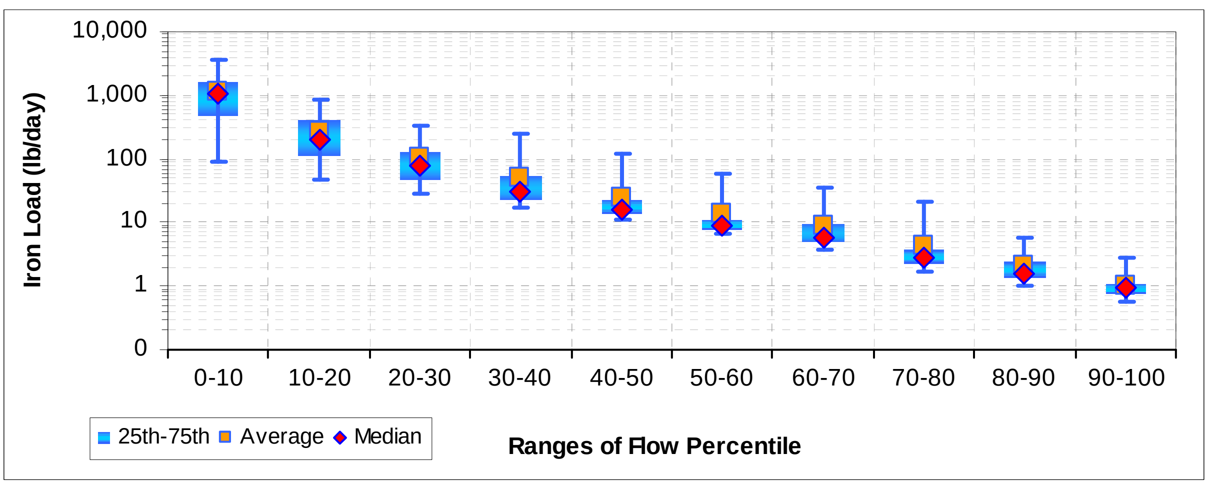

Figure F-14. Iron loads by flow percentile for Three Forks Run (direct contributions)

Table F-13. Aluminum loads (lb/d) by flow percentile for Three Forks Run (direct contributions)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	48.01	18.65	12.86	8.02	5.34	3.25	1.46	0.75	0.44	0.28
Average	444.85	98.97	41.80	20.68	10.27	5.94	3.57	1.67	0.99	0.49
Maximum	1,332.86	236.82	136.87	89.47	43.28	17.61	10.97	5.34	4.31	1.74
Median	412.53	82.65	31.15	15.09	7.50	4.60	2.82	1.28	0.77	0.42
25th	177.90	41.01	22.19	10.42	6.57	3.88	2.23	1.02	0.64	0.36
75th	630.92	134.60	54.32	23.25	10.26	5.83	4.12	1.79	1.13	0.53

Table F-14. Iron loads (lb/d) by flow percentile f for Three Forks Run (direct contributions)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	90.66	46.13	29.14	16.83	11.15	6.72	3.69	1.68	0.98	0.57
Average	1,170.68	276.28	105.01	50.39	23.94	13.52	9.08	4.33	2.02	0.99
Maximum	3,584.05	877.58	333.59	257.10	122.27	56.64	34.72	21.47	5.87	2.74
Median	1,047.19	205.30	77.67	29.96	15.84	9.21	5.90	2.88	1.60	0.92
25th	470.43	110.01	48.29	22.49	13.41	7.77	4.90	2.27	1.40	0.76
75th	1,585.76	409.09	125.83	53.74	22.23	11.30	9.50	3.66	2.39	1.08

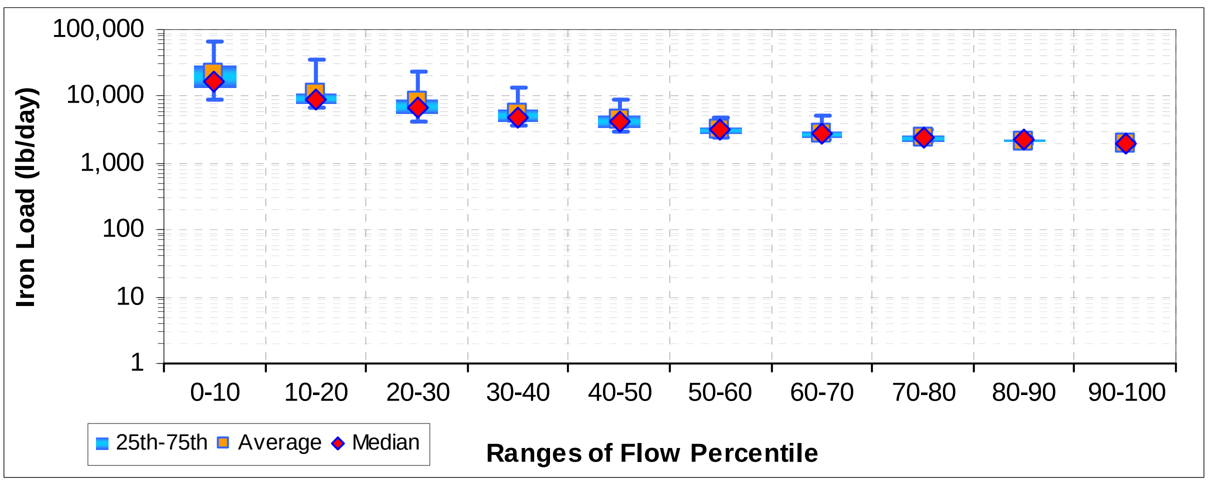

Figure F-15. Iron loads by flow percentile for UNBPR (entire watershed)

Table F-15. Iron loads (lb/d) by flow percentile for UNBPR (entire watershed)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	9,238	6,716	4,147	3,716	2,896	2,357	2,206	2,080	1,958	1,889
Average	21,548	10,936	8,320	5,534	4,633	3,199	2,780	2,414	2,177	1,982
Maximum	66,040	35,632	22,993	13,524	9,226	4,735	5,135	3,101	2,488	2,151
Median	16,325	8,748	6,708	4,901	4,254	3,248	2,695	2,409	2,183	1,968
25th	13,123	7,819	5,685	4,263	3,513	2,692	2,344	2,138	2,056	1,927
75th	28,085	10,960	8,760	6,269	5,161	3,425	2,879	2,621	2,279	2,024

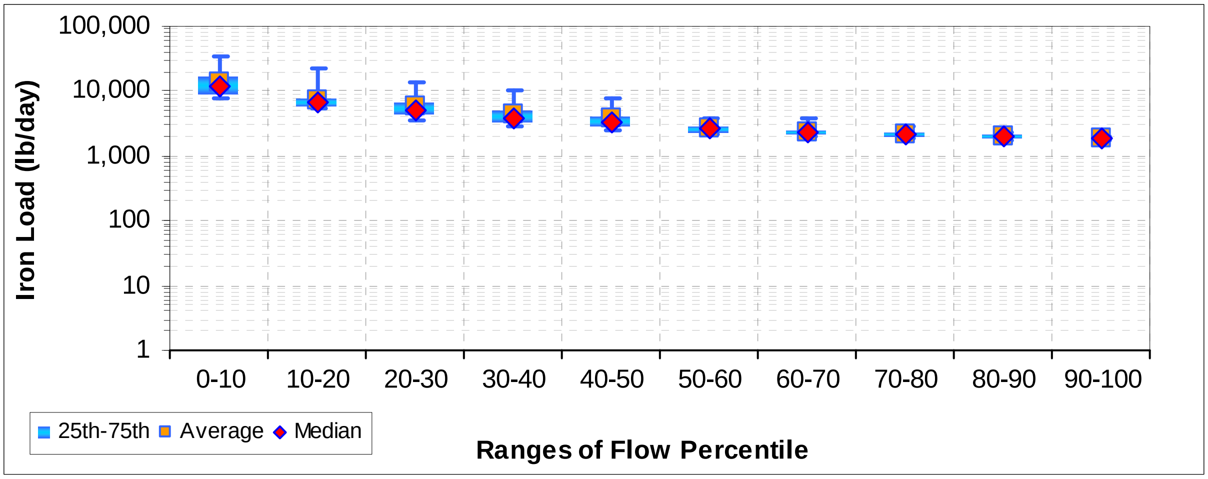

Figure F-16. Iron loads by flow percentile for UNBPR (WV contributions)

Table F-16. Iron loads (lb/d) by flow percentile for UNBPR (WV contributions)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	7,602	5,437	3,549	2,938	2,438	2,088	2,015	1,909	1,797	1,762
Average	13,430	7,407	5,991	4,429	3,685	2,616	2,334	2,150	2,005	1,865
Maximum	35,367	21,945	14,012	10,405	7,516	3,824	3,845	2,781	2,266	1,998
Median	11,899	6,543	5,164	3,787	3,411	2,586	2,235	2,144	2,006	1,855
25th	8,645	5,896	4,393	3,362	2,849	2,300	2,116	1,979	1,929	1,824
75th	16,907	7,567	6,661	5,157	4,151	2,861	2,435	2,274	2,087	1,902

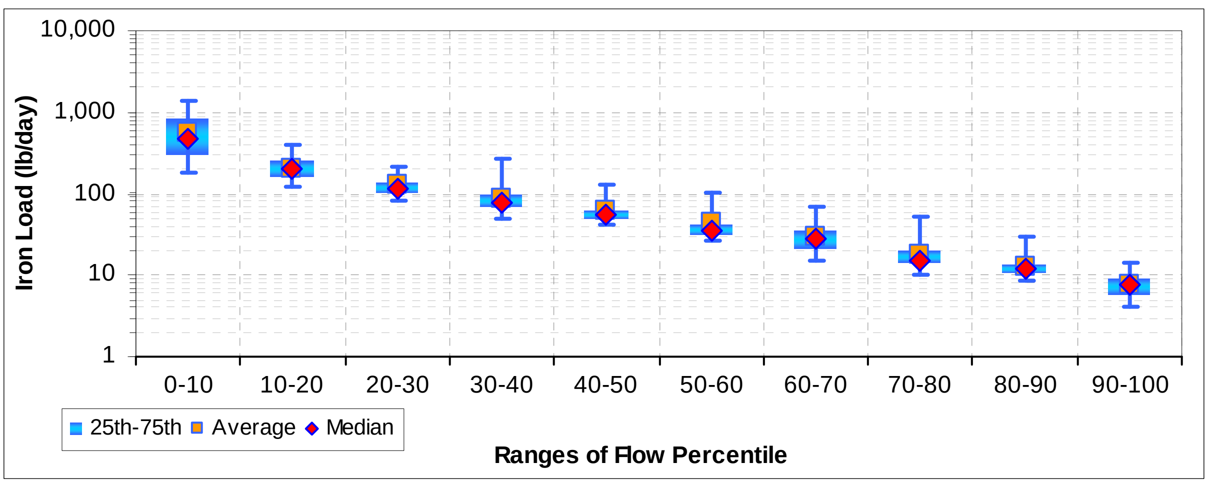

Figure F-17. Iron loads by flow percentile for UNBPR (direct contributions)

Table F-17. Iron loads (lb/d) by flow percentile for UNBPR (direct contributions)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	181.4	124.5	80.6	49.1	41.5	26.2	14.9	10.4	8.4	4.1
Average	572.8	207.3	126.1	87.2	62.3	43.6	30.3	18.2	12.9	7.7
Maximum	1,409.7	389.8	218.1	269.8	127.2	103.4	70.2	51.7	29.7	14.0
Median	464.2	198.2	114.7	77.4	55.2	36.1	28.4	15.3	11.8	7.6
25th	303.4	161.2	101.6	69.5	48.7	31.7	21.2	14.3	10.7	5.7
75th	812.6	250.5	137.4	94.9	62.4	42.1	35.3	19.9	13.7	8.8

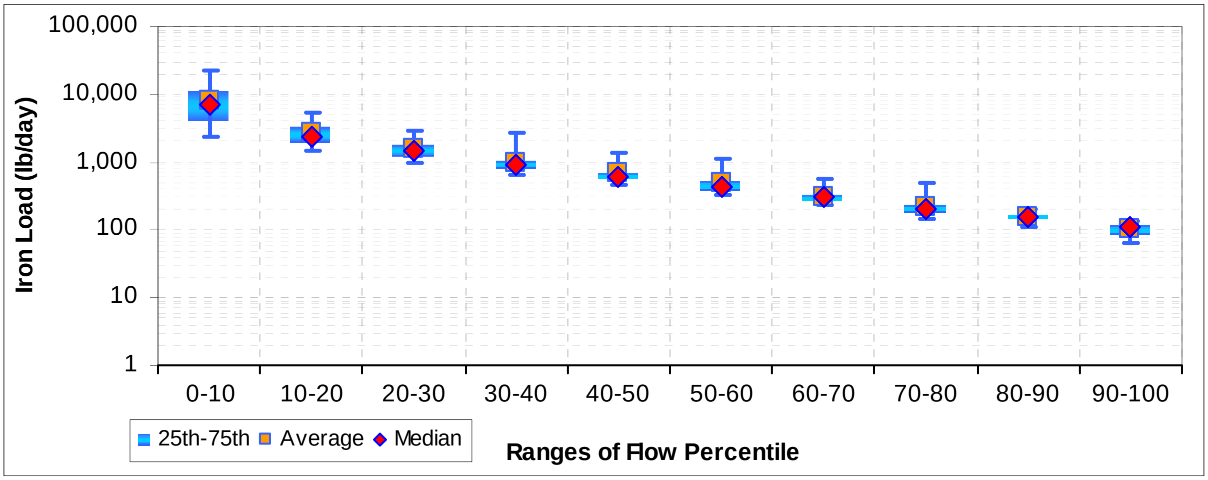

Figure F-18. Iron loads by flow percentile for UNBPR (tributary contributions)

Table F-18. Iron loads (lb/d) by flow percentile for UNBPR (tributary contributions)

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Minimum	2,281	1,447	994	667	463	318	229	140	108	66
Average	8,139	2,706	1,545	969	683	499	311	219	152	102
Maximum	22,265	5,462	2,914	2,700	1,366	1,153	557	507	205	136
Median	6,956	2,420	1,429	891	621	428	298	202	153	106
25th	4,037	1,960	1,194	786	557	366	267	180	140	83
75th	11,620	3,247	1,746	1,027	694	525	330	233	164	117