Nebraska Water Quality Index (NWDI)

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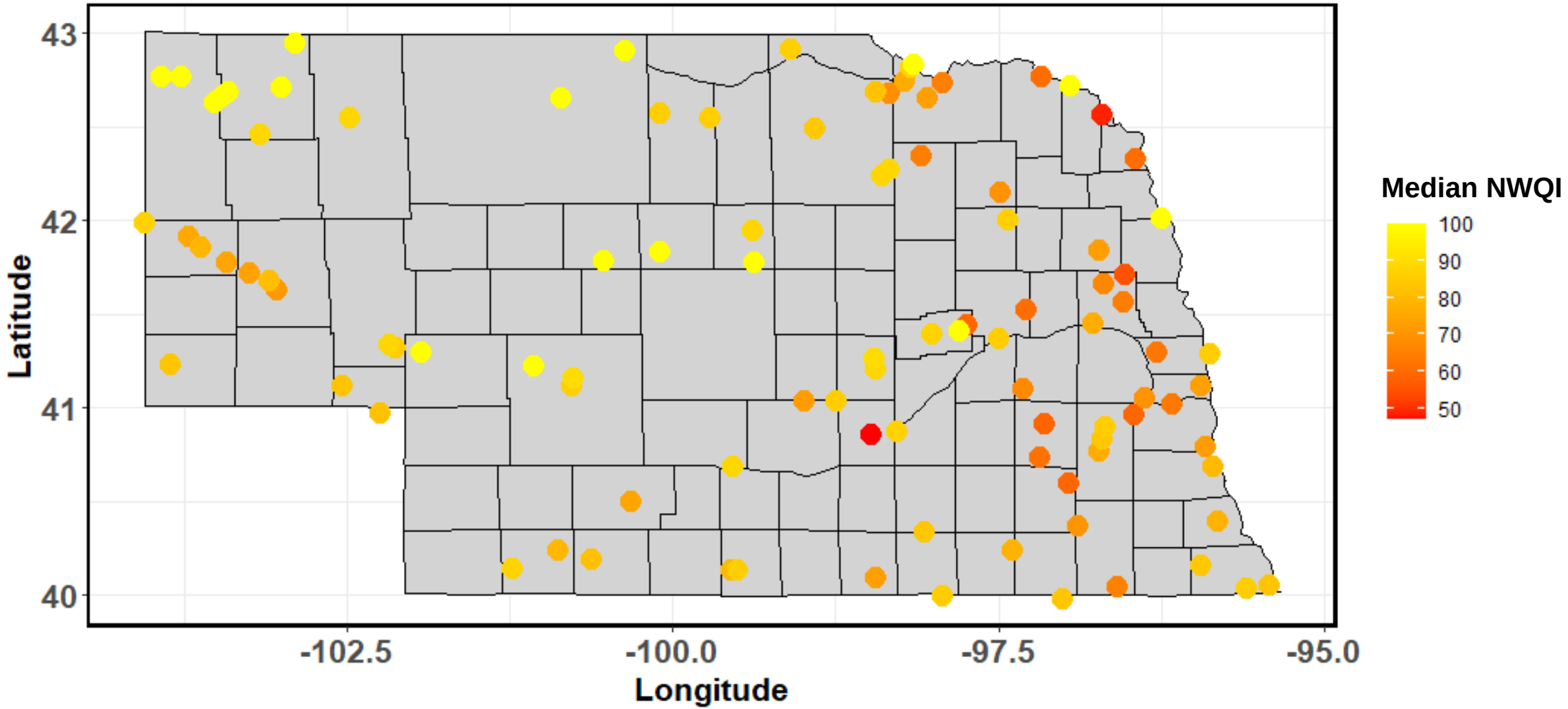
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ
1	Sub-Bas	Segment	Waterbo	Project D	Sub-Proj	Sample F	Program	Sample Y	Sample M	Activity Start Da	Alkalinity	Aluminum	Ammonia	Chloride	Chloropl	Nitrate a	Kjeldahl I	Orthopha	Phospha	Total Su	Acetochl	Atrazine	Metolacl	E coli	Microcys	Arsenic	Cadmium	Calcium	Chromiu	Copper	Lead	Magnesi	Mercury	Nickel	Selenium	Selenium
2	BB1	BB1-100	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	January	1/13/2009			<RL (0.0	45.558		4.1783	0.7069		0.7966	9.5						<RL (5)	<RL (1)	89.5	<RL (10)	<RL (10)	<RL (5)	21.13	<RL (1)	<RL (10)		<RL (5)
3	BB1	BB1-200	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	January	1/13/2009			0.1676	30.101		4.0293	0.7757		0.6067	14.5						5.0934		89.66				19.51				6.8067
4	BB2	BB2-100	Turkey C	Ambient	Trend Sit	Southeas	SBB2TF	2009	January	1/13/2009			<RL (0.0	57.094		2.6363	<RL (0.5)		0.3046	5.5						<RL (5)		80.45				17.09				5.0518
5	BB3	BB3-100	West Fo	Ambient	Trend Sit	Red Clo	SBB3WI	2009	January	1/13/2009			0.1235	38.633		4.3027	0.8227		0.6811	7.5						<RL (5)		81.5				16.59				5.6231
6	BB4	BB4-200	Lincoln C	Ambient	Trend Sit	Genoa	SBB4LN	2009	January	1/13/2009			<RL (0.0	13.987		4.1552	0.6434		0.3675	7.5						5.8625		80.51				16.09				8.7595
7	BB4	BB4-400	Big Blue	Ambient	Trend Sit	Genoa	SBB4BE	2009	January	1/13/2009			0.5007	106.57		2.8592	2.5157		0.3957	18						<RL (5)		69.72				17.66				<RL (5)
8	BB1	BB1-200	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	February	2/2/2009			<RL (0.0	24.555		4.0278	0.6877		0.5658	16.5																
9	BB2	BB2-100	Turkey C	Ambient	Trend Sit	Southeas	SBB2TF	2009	February	2/2/2009			<RL (0.0	56.172		2.0926	<RL (0.5)		0.2435	6																
10	BB3	BB3-100	West Fo	Ambient	Trend Sit	Red Clo	SBB3WI	2009	February	2/2/2009			<RL (0.0	32.894		4.1816	0.7921		0.6872	18																
11	BB4	BB4-200	Lincoln C	Ambient	Trend Sit	Genoa	SBB4LN	2009	February	2/2/2009			0.7524	12.178		2.3774	3.9439		1.1768	107																
12	BB4	BB4-400	Big Blue	Ambient	Trend Sit	Genoa	SBB4BE	2009	February	2/2/2009			2.0839	20.6		1.5527	5.0214		5.0737	33																
13	BB1	BB1-100	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	February	2/3/2009			<RL (0.0	43.237		3.9871	0.5969		0.6748	7																
14	BB1	BB1-200	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	March	3/3/2009			0.068	21.984		3.3345	0.8277		0.4579	31																
15	BB2	BB2-100	Turkey C	Ambient	Trend Sit	Southeas	SBB2TF	2009	March	3/3/2009			<RL (0.0	51.461		1.7957	<RL (0.5)		0.2203	14.5																
16	BB1	BB1-100	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	March	3/4/2009			<RL (0.0	39.39		3.4644	0.7062		0.5928	18.5																
17	BB4	BB4-200	Lincoln C	Ambient	Trend Sit	Genoa	SBB4LN	2009	March	3/4/2009			<RL (0.0	12.398		3.6018	<RL (0.5)		0.3418	12.5																
18	BB4	BB4-400	Big Blue	Ambient	Trend Sit	Genoa	SBB4BE	2009	March	3/4/2009			<RL (0.0	11.72		1.8575	1.177		0.3016	10.5																
19	BB3	BB3-100	West Fo	Ambient	Trend Sit	Red Clo	SBB3WI	2009	March	3/5/2009			<RL (0.0	27.957		3.7836	0.67		0.6148	22.5																
20	BB1	BB1-100	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	April	4/6/2009			<RL (0.0	46.379		<RL (0.0	2.4365		0.5357	73	0.47	0.64	0.09			<RL (5)	<RL (1)	36.05	<RL (10)	<RL (10)	<RL (5)	18.53	<RL (1)	<RL (10)		<RL (5)
21	BB1	BB1-200	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	April	4/6/2009			<RL (0.0	22.37		0.8756	1.7334		0.4139	48	0.16	0.13	<RL (0.07)			<RL (5)		75.95				19.17				<RL (5)
22	BB2	BB2-100	Turkey C	Ambient	Trend Sit	Southeas	SBB2TF	2009	April	4/6/2009			<RL (0.0	62.01		1.2374	<RL (0.5)		0.2062	7.5	0.17	0.12	0.2			<RL (5)		68.25				15.37				5.3186
23	BB1	BB1-100	Big Blue	Ambient	Trend Sit	Southeas	QCDUP1	2009	April	4/7/2009			<RL (0.0	45.28		<RL (0.0	2.6732		0.5301	75						<RL (5)		34.06				17.74				<RL (5)
24	BB1	BB1-100	Big Blue	Ambient	Trend Sit	Southeas	QCFBLK	2009	April	4/7/2009			<RL (0.0	<RL (1)		<RL (0.0	<RL (0.5)		<RL (0.0	<RL (5)						<RL (5)		<RL (0.15)				<RL (0.15)				<RL (5)
25	BB3	BB3-100	West Fo	Ambient	Trend Sit	Red Clo	SBB3WI	2009	April	4/9/2009			<RL (0.0	34.737		2.1461	1.1038		0.6048	51	0.13	0.1	<RL (0.07)			5.539		79.01				15.14				6.9141
26	BB4	BB4-200	Lincoln C	Ambient	Trend Sit	Genoa	SBB4LN	2009	April	4/9/2009			<RL (0.0	11.443		0.9823	2.9614		0.6685	184	0.14	0.06	<RL (0.07)			<RL (5)		59.25				15.52				9.1991
27	BB4	BB4-400	Big Blue	Ambient	Trend Sit	Genoa	SBB4BE	2009	April	4/9/2009			0.1774	17.113		0.8321	1.6066		0.4062	81.5	0.31	0.15	<RL (0.07)			<RL (5)		45.87				14.46				<RL (5)
28	BB1	BB1-100	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	May	5/4/2009			<RL (0.0	31.946		1.5022	1.5447		0.6312	144	2.22	7.5	0.96													
29	BB1	BB1-200	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	May	5/4/2009			<RL (0.0	28.18		1.0864	2.2692		0.6479	128	0.38	0.6	0.1													
30	BB2	BB2-100	Turkey C	Ambient	Trend Sit	Southeas	SBB2TF	2009	May	5/4/2009			0.2295	51.292		1.7783	1.1132		0.4233	52	0.68	1.13	0.41													
31	BB3	BB3-100	West Fo	Ambient	Trend Sit	Red Clo	SBB3WI	2009	May	5/4/2009			<RL (0.0	29.564		2.0846	1.0435		0.5492	41.5	0.25	0.2	<RL (0.07)													
32	BB4	BB4-200	Lincoln C	Ambient	Trend Sit	Genoa	SBB4LN	2009	May	5/5/2009			<RL (0.0	14.574		2.9364	1.9171		0.6368	212	0.23	0.23	0.1													
33	BB4	BB4-400	Big Blue	Ambient	Trend Sit	Genoa	SBB4BE	2009	May	5/5/2009			<RL (0.0	39.603		<RL (0.0	2.8341		0.482	76	0.81	0.43	0.21													
34	BB1	BB1-100	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	June	6/1/2009			0.1709	30.33		4.2124	1.6696		0.778	146	8.31	17.27	4.91													
35	BB1	BB1-200	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	June	6/1/2009			<RL (0.0	20.906		2.7726	1.874		0.7951	298	2.2	6.05	1.31													
36	BB2	BB2-100	Turkey C	Ambient	Trend Sit	Southeas	SBB2TF	2009	June	6/1/2009			0.1859	54.549		2.4045	1.8304		0.5949	166	3.96	10.67	3.1													
37	BB3	BB3-100	West Fo	Ambient	Trend Sit	Red Clo	SBB3WI	2009	June	6/1/2009			0.1438	30.958		2.1635	2.1454		0.8933	244	0.38	0.67	0.2													
38	BB4	BB4-200	Lincoln C	Ambient	Trend Sit	Genoa	SBB4LN	2009	June	6/3/2009			0.181	11.029		3.9368	1.8014		0.8925	299		3.96	0.79													
39	BB4	BB4-400	Big Blue	Ambient	Trend Sit	Genoa	SBB4BE	2009	June	6/3/2009			2.3039	20.583		3.1127	5.5685		0.5535	63	72.03	87.15	17.85													
40	BB1	BB1-100	Big Blue	Ambient	Trend Sit	Southeas	QCDUP1	2009	July	7/7/2009			<RL (0.0	12.848		1.2096	2.3251		0.5293	246																
41	BB4	BB4-200	Lincoln C	Ambient	Trend Sit	Genoa	SBB4LN	2009	July	7/21/2009			<RL (0.0	11.128		2.7883	1.6859		0.8159	226	0.5	0.52	0.2			3.9139		75.82				14.81				8.3852
42	BB4	BB4-400	Big Blue	Ambient	Trend Sit	Genoa	SBB4BE	2009	July	7/21/2009			0.1948	7.6082		0.9323	2.0047		0.492	80	1.4	1.33	0.4			5.6526		59.61				14.62				<RL (5)
43	BB1	BB1-100	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	July	7/22/2009			<RL (0.0	38.041		1.437	1.4847		0.8493	96	0.61	0.57	0.49			10.016	<RL (1)	86.32	10.837	<RL (10)	<RL (5)	19.79	<RL (1)	<RL (10)		<RL (5)
44	BB1	BB1-200	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	July	7/22/2009			<RL (0.0	23.6		3.2358	1.3715		1.0016	182	0.55	0.76	0.29			9.2105		81.76				17.23				5.7313
45	BB2	BB2-100	Turkey C	Ambient	Trend Sit	Southeas	SBB2TF	2009	July	7/22/2009			<RL (0.0	61.68		2.0701	0.342		0.522	48	0.46	0.21	0.24			7.8968		61.82				13.32				<RL (5)
46	BB3	BB3-100	West Fo	Ambient	Trend Sit	Red Clo	SBB3WI	2009	July	7/22/2009			<RL (0.0	22.732		4.3825	1.1805		1.0536	200	0.89	0.62	0.62			7.9353		75.37				14.53				6.6233
47	BB1	BB1-100	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	August	8/5/2009			<RL (0.0	58.827		2.1925	1.9719		0.9966	113	0.52	1.03	0.28													
48	BB1	BB1-200	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	August	8/5/2009			0.0522	18.944		2.7612	2.0948		1.0361	330	1.25	2.19	1.01													
49	BB2	BB2-100	Turkey C	Ambient	Trend Sit	Southeas	SBB2TF	2009	August	8/5/2009			0.5882	63.24		0.9557	2.2013		0.6693	75.5	0.19	0.35	0.16													
50	BB3	BB3-100	West Fo	Ambient	Trend Sit	Red Clo	SBB3WI	2009	August	8/5/2009			0.0631	10.862		2.3476	3.6143		1.6422	600	0.85	1.05	0.84													
51	BB4	BB4-200	Lincoln C	Ambient	Trend Sit	Genoa	SBB4LN	2009	August	8/5/2009			<RL (0.0	35.63		<RL (0.0	2.5596		0.443	127	0.38	1.28	0.23													
52	BB4	BB4-400	Big Blue	Ambient	Trend Sit	Genoa	SBB4BE	2009	August	8/5/2009			<RL (0.0	9.3256		<RL (0.0	2.0912		0.4656	76	1.05	1.82	0.55													
53	BB4	BB4-200	Lincoln C	Ambient	Trend Sit	Genoa	SBB4LN	2009	Septemb	9/14/2009			<RL (0.0	6.674		3.3367	0.3767		0.5745	138	0.18	0.07	0.18													
54	BB4	BB4-400	Big Blue	Ambient	Trend Sit	Genoa	SBB4BE	2009	Septemb	9/14/2009			0.2296	6.2758		0.7933	2.5416		0.7802	106	0.83	0.3	0.51													
55	BB1	BB1-100	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	Septemb	9/16/2009			<RL (0.0	34.464		2.1031	1.6331		1.0789	105	0.73	0.61	0.31													
56	BB1	BB1-200	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	Septemb	9/16/2009			<RL (0.0	20.83		1.8425	2.6733		1.237	420	0.41	0.31	0.41													
57	BB2	BB2-100	Turkey C	Ambient	Trend Sit	Southeas	SBB2TF	2009	Septemb	9/16/2009			0.0616	63.546		2.7932	0.9722		0.6166	70.5	0.47	0.24	0.37													
58	BB3	BB3-100	West Fo	Ambient	Trend Sit	Red Clo	SBB3WI	2009	Septemb	9/16/2009			0.1134	11.658		1.8375	2.1611		1.1587	200	1.09	0.35	0.95													
59	BB1	BB1-100	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	October	10/5/2009			<RL (0.0	59.396		1.4083	2.1733		1.0939	124						7.216	<RL (1)	76.44	<RL (10)	<RL (10)	<RL (5)	16.44	<RL (1)	<RL (10)		5.79
60	BB1	BB1-200	Big Blue	Ambient	Trend Sit	Southeas	SBB1BB	2009	October	10/6/2009			<RL (0.0	27.881		1.965	1.5043		0.6546	79						5.4122		76.72				15.14				<RL (5)
61	BB2	BB2-100	Turkey C	Ambient	Trend Sit	Southeas	QCDUP1	2009	October	10/6/2009			<RL (0.0	78.139		2.831	0.7131		0.36	23						5.2765		62.31				12.67				<RL (5)
62	BB2	BB2-100	Turkey C	Ambient	Trend Sit	Southeas	QCFBLK	2009	October	10/6/2009			<RL (0.0	<RL (1)		<RL (0.0	<RL (0.5)		<RL (0.0	<RL (5)						<RL (5)		<RL (0.15)				<RL (0.15)				<RL (5)
63	BB2	BB2-100	Turkey C	Ambient	Trend Sit	Southeas	SBB2TF	2009	October	10/6/2009			<RL (0.0	79.069		2.628	0.6712		0.3687	25						5.4934		62.1				12.75				5.1034
64	BB3	BB3-100	West Fo	Ambient	Trend Sit	Red Clo	SBB3WI	2009	October	10/6/2009			<RL (0.0	26.951		2.237	1.5187		0.5538	51						5.0765		77.48				14.15				<RL (5)
65	BB4	BB4-200	Lincoln C	Ambient	Trend Sit	Genoa	SBB4LN	2009	October	10/6/2009			<RL (0.0	6.7483		3.4278	0.6544		0.438	80.5						6.2599		78.6				15.04				7.9033


43
42
41
40
Latitude
-102.5
-100.0
-97.5
-95.0
Longitude
Median NWQI
100
90
80
70
60
50

A water quality index is…

- A single value, from 0 – 100, that represents the chemical health of a river
- A composite value, composed of multiple chemical parameters
- A potential tool for public outreach and for estimating project effectiveness

Decisions, decisions...

1. A focus
2. Parameters
3. Criteria
4. A calculation

Focus: nonpoint pollution

Parameters: relevant and regular

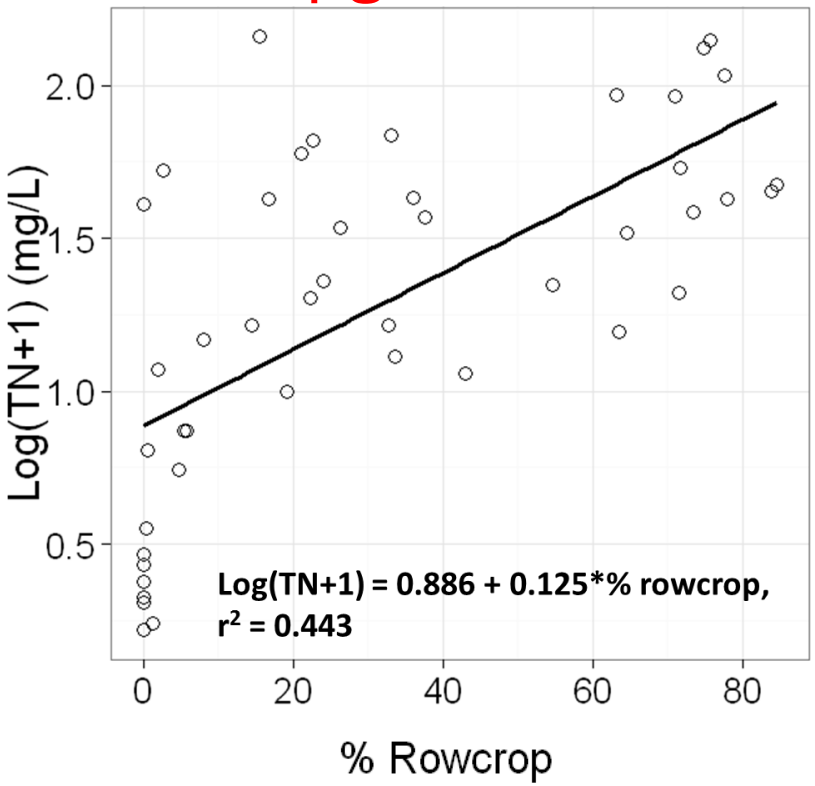
- Temperature
- Dissolved oxygen
- pH
- Total suspended solids
- Total nitrogen
- Total phosphorus
- Atrazine
- *E. coli* (fecal coliforms)

Parameters and criteria

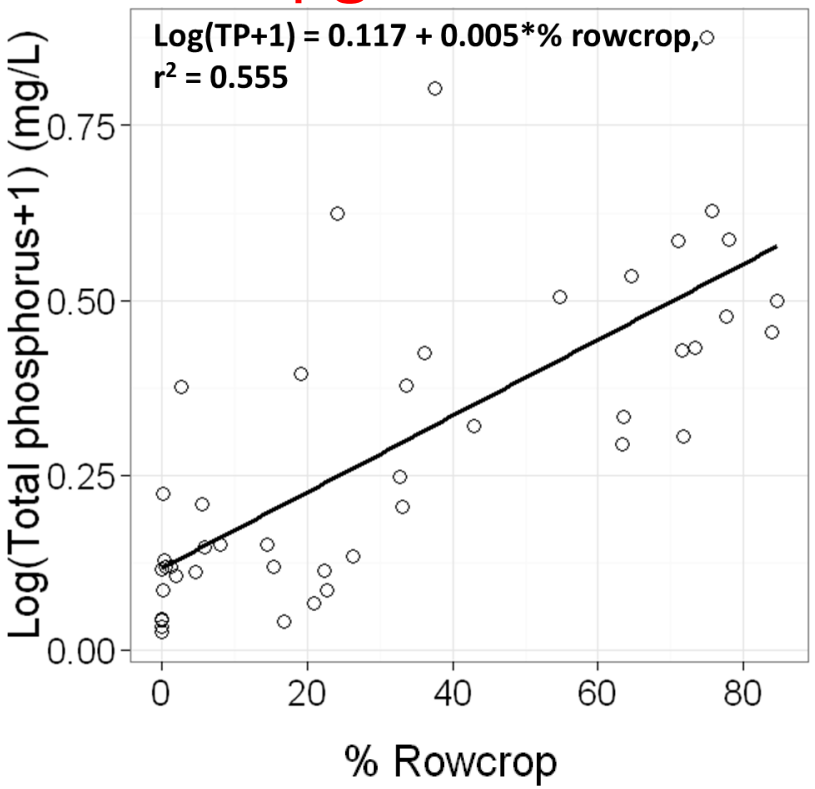
Parameter	Stream category	Source	Dates applicable	Criterion
Atrazine		NDEQ Title 117		12 µg/l
E. coli		NDEQ Title 117		126 cells/100 ml
pH		NDEQ Title 117		6.5 – 9.0
Temperature	Coldwater	NDEQ Title 117		22°C
	Warmwater	NDEQ Title 117		32°C
Dissolved oxygen	Coldwater A	NDEQ Title 117	October 1 – May 31	4 mg/l
	Coldwater A	NDEQ Title 117	June 1 – September 30	8 mg/l
	Coldwater B	NDEQ Title 117	July 1 – March 31	4 mg/l
	Coldwater B	NDEQ Title 117	April 1 – June 30	5 mg/l
	Warmwater A	NDEQ Title 117	October 1 – May 31	3 mg/l
	Warmwater A	NDEQ Title 117	June 1 – September 30	5 mg/l
	Warmwater B	NDEQ Title 117	October 1 – May 31	3 mg/l
	Warmwater B	NDEQ Title 117	June 1 – September 30	5 mg/l
Total suspended solids		Professional judgment		150 mg/l
Total nitrogen		Moderate land-use model		1518 µg/l
Total phosphorus		Moderate land-use model		379 µg/l

Nutrients and land use

1518 µg/L



379 µg/L



Criteria are model-predicted estimates at 33% rowcrop in the basin;
From Heatherly (2014), *Ecological Indicators*

Calculation

- From the Canadian Council of Ministers of the Environment (CCME 2001)

- Also adopted by the UN as a Global Drinking Water Quality Index

- Incorporates scope, frequency, and magnitude of criteria exceedance

$$\mathrm{WQI} = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}\right)$$

$$F_1 = \left(\frac{\#\ failed\ parameters}{total\ \#\ parameters}\right) \times 100$$

Scope, how many parameters failed

$$F_2 = \left(\frac{\#\ failed\ tests}{total\ \#\ tests}\right) \times 100$$

Frequency, how often parameters failed

$$F_3 = \left(\frac{nse}{0.01nse + 0.01}\right)$$

Magnitude, how bad parameters failed

$$Excursion = \left(\frac{failed\ test\ value}{guideline\ value}\right) - 1$$

$$nse = \left(\frac{\sum excursion}{total\ \#\ tests}\right)$$

Long Pine Creek at Long Pine SRA

Date	Temp	Atrazine	DO	pH	TN	TP	TSS	*E.coli*
05/06/2003	14.50	0.03	9.00	8.27	**1.71**	0.25	13.5	**248**
05/13/2003	14.54	0.03	10.46	8.09	1.44	0.22	18	36
05/20/2003	12.95	0.11	11.13	7.99	**1.68**	0.17	9.5	**166**
05/28/2003	16.70	0.03	9.24	8.27	**1.56**	0.16	6	**291**
06/03/2003	13.30	0.03	9.39	8.35	**1.54**	0.20	7.5	**194**
06/10/2003	13.70	0.03	8.80	8.17	1.47	0.20	5	**488.4**
06/17/2003	16.80	0.21	9.70	8.14	**1.55**	0.17	5	**157**
06/24/2003	16.64	0.03	7.86	8.07	**1.48**	0.18	5	**345**

$$F_1 = \left(\frac{2}{8}\right) \times 100 = 25.0$$

$$F_2 = \left(\frac{13}{56}\right) \times 100 = 23.21$$

$$F_3 = \left(\frac{0.023}{0.01(0.023)+0.01}\right) = 2.24$$

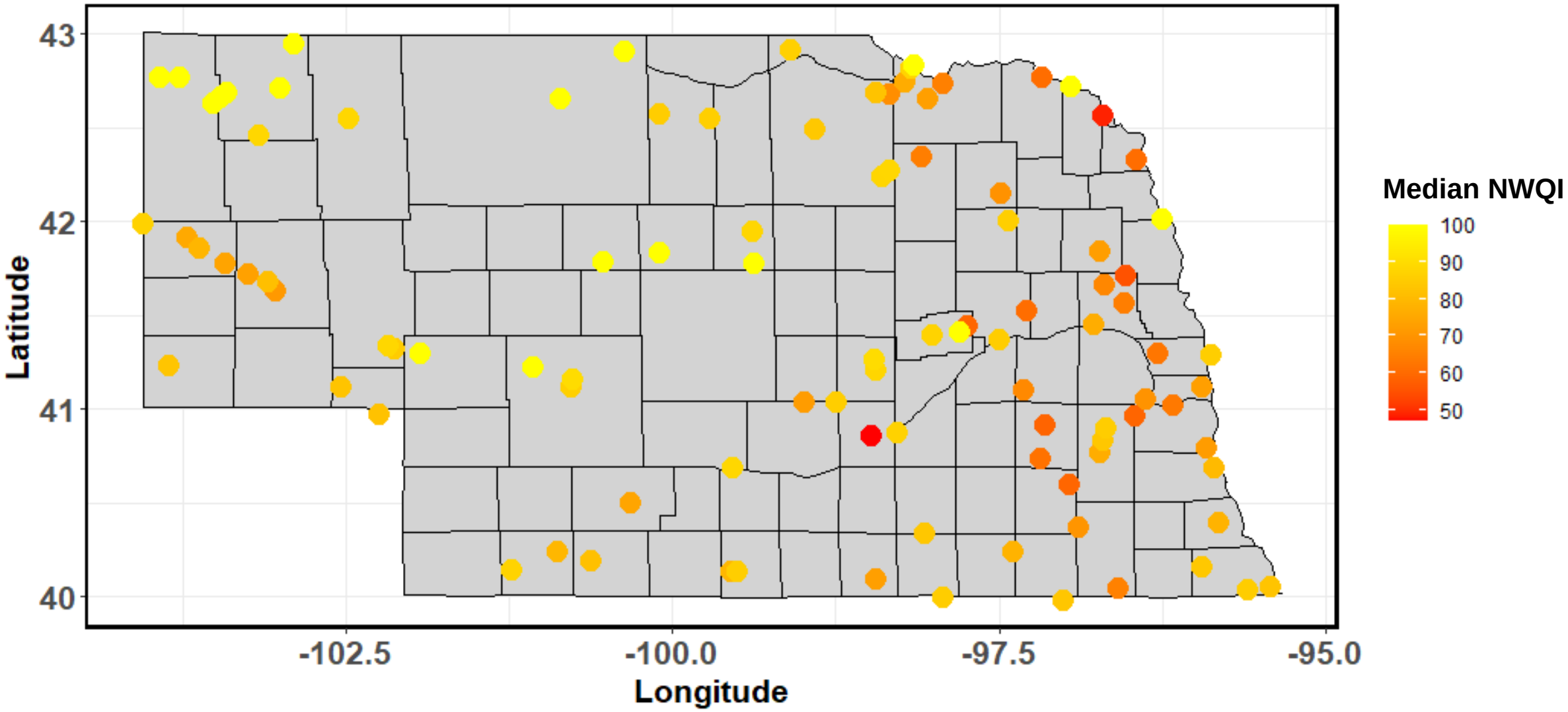
$$Excursion = \left(\frac{1.71}{1.518}\right) - 1 = 0.125, \text{ etc.} \qquad nse = \left(\frac{1.292}{56}\right) = 0.023$$

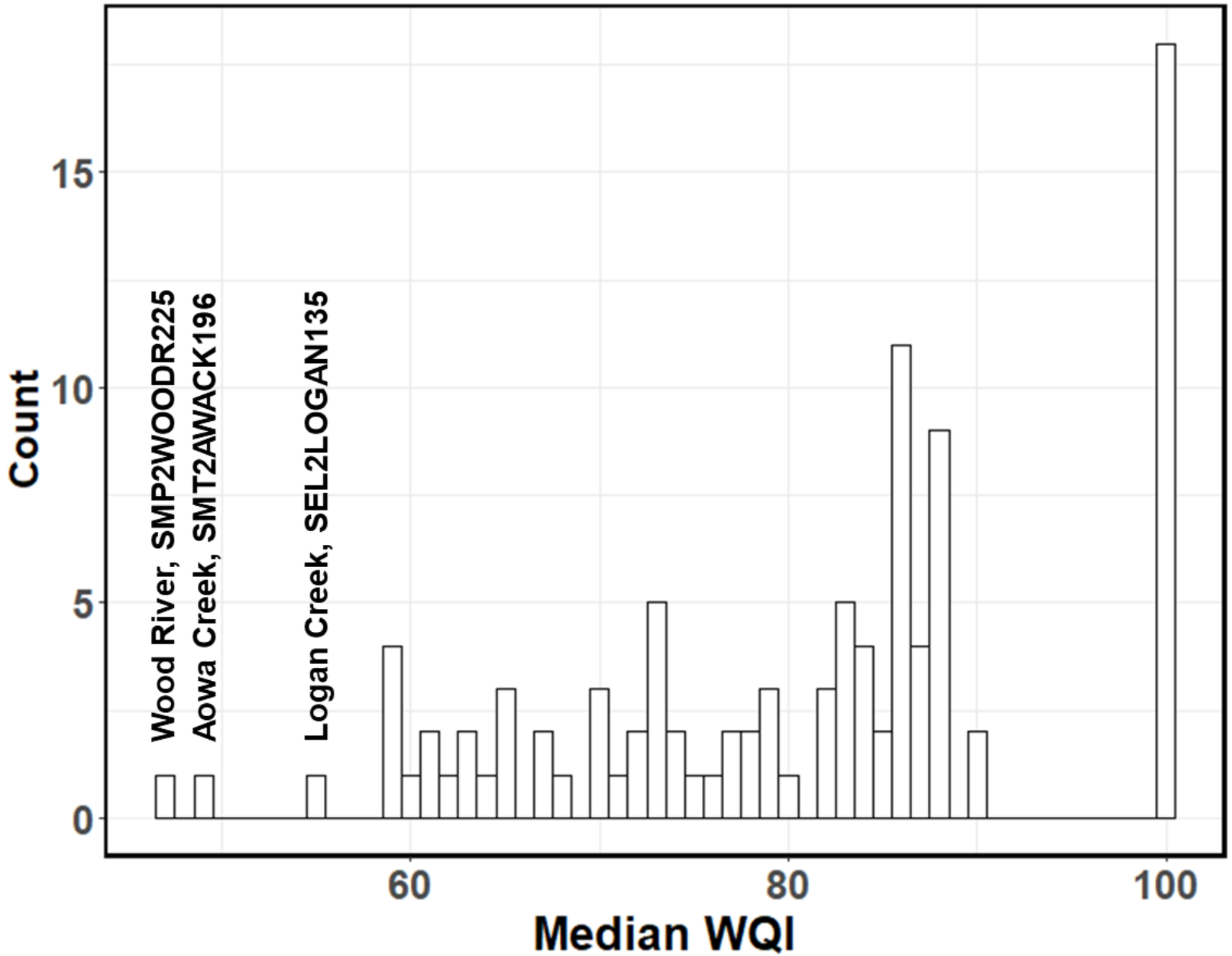
$$\text{WQI} = 100 - \left(\frac{\sqrt{28.57^2 + 23.21^2 + 2.24^2}}{1.732}\right) = 78.71 = \textbf{GOOD}$$

Assigning quality

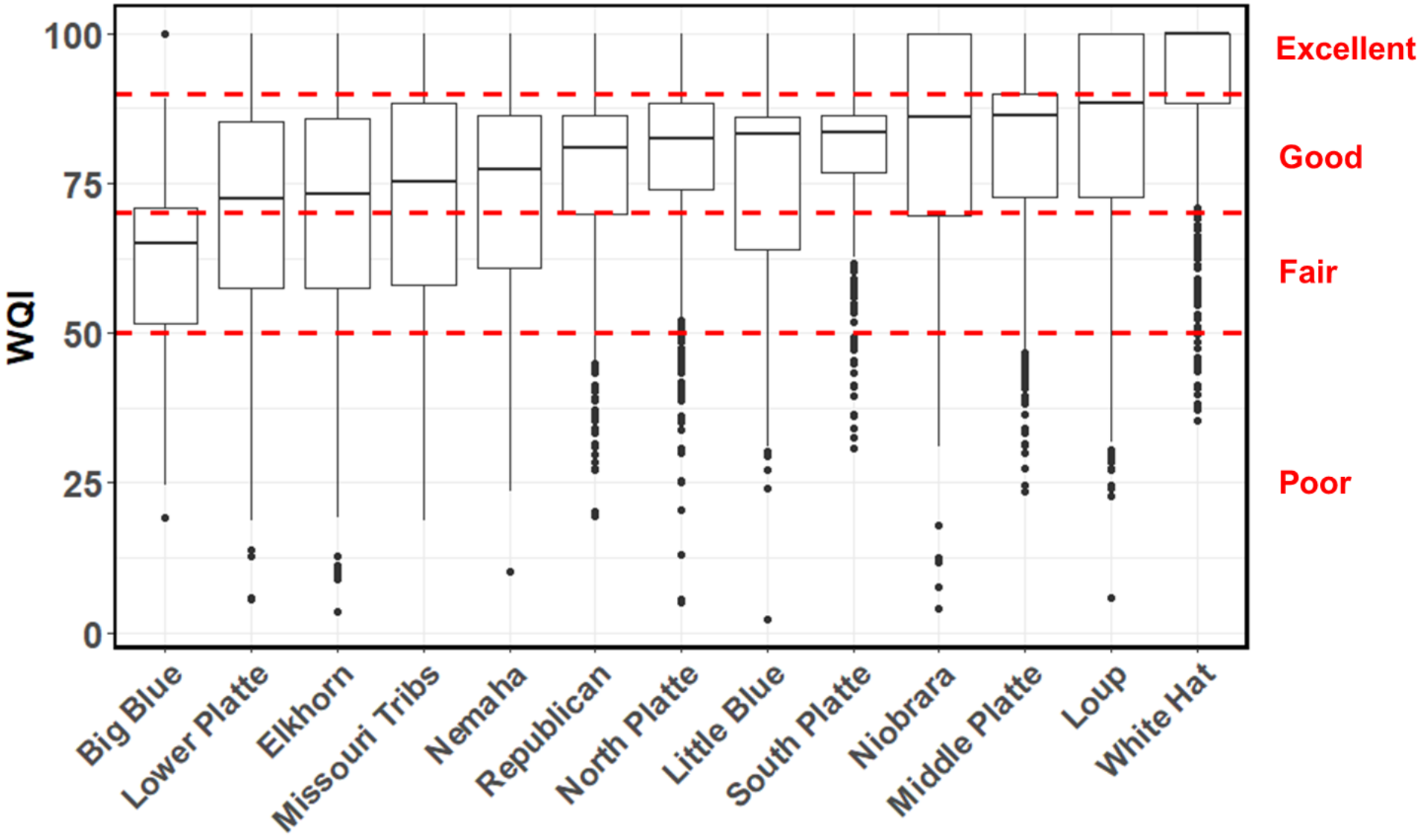
Class	WQI scores
Excellent	90-100
Good	70-89.99
Fair	50-69.99
Poor	1-49.99

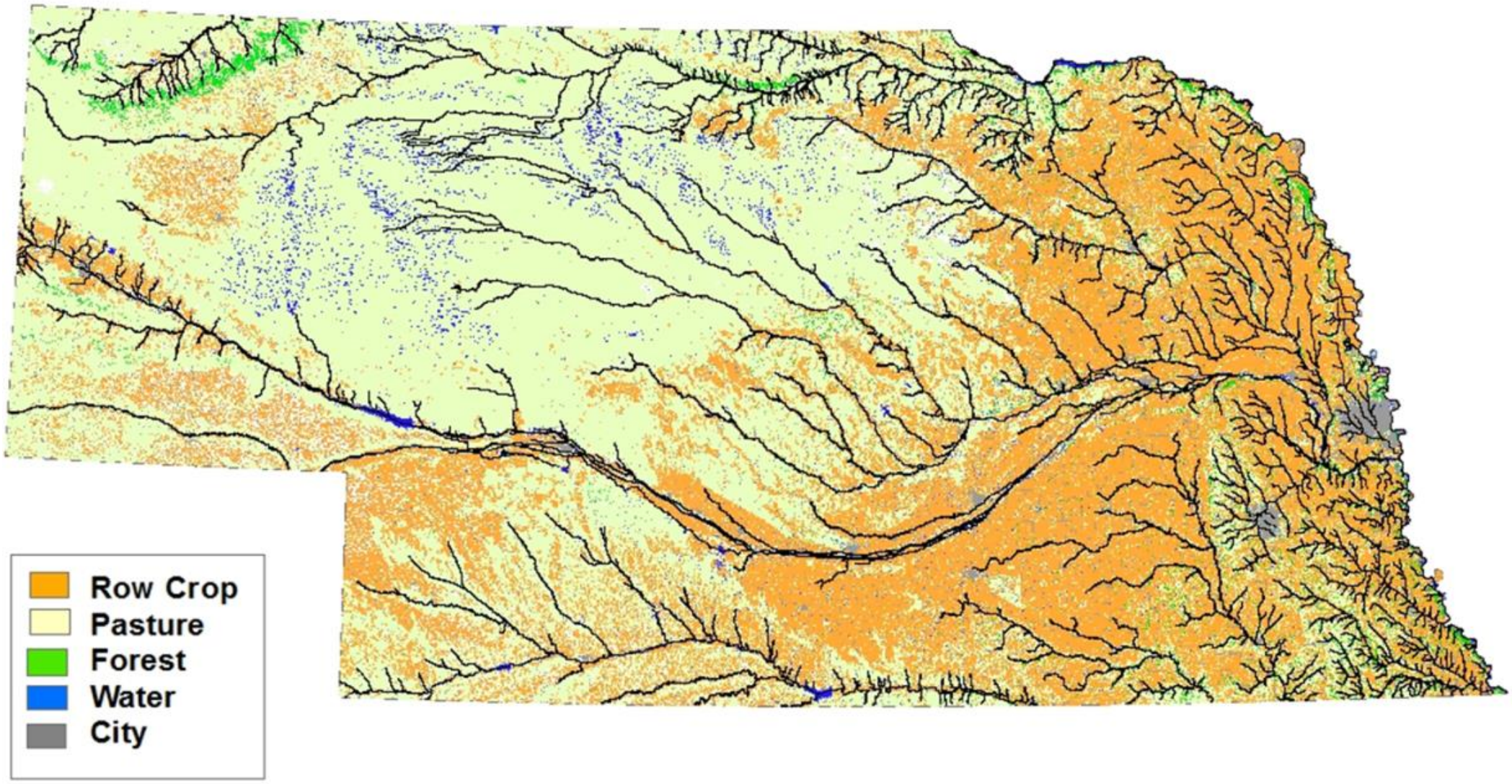
The NDEE Ambient Stream Monitoring Network

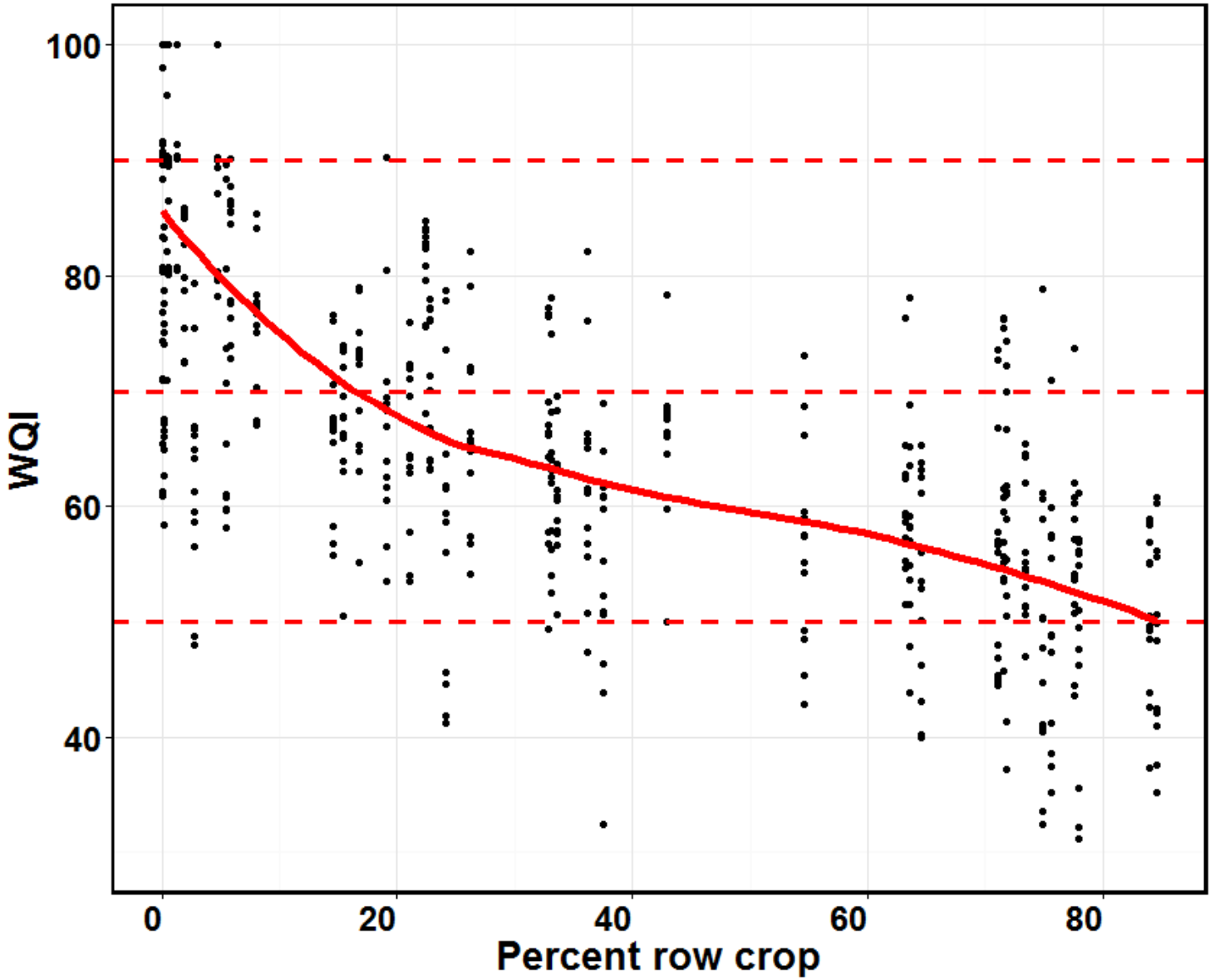



Count
15
10
5
0
Wood River, SMP2WOODR225
Aowa Creek, SMT2AWACK196
Logan Creek, SEL2LOGAN135
60
80
100
Median WQI

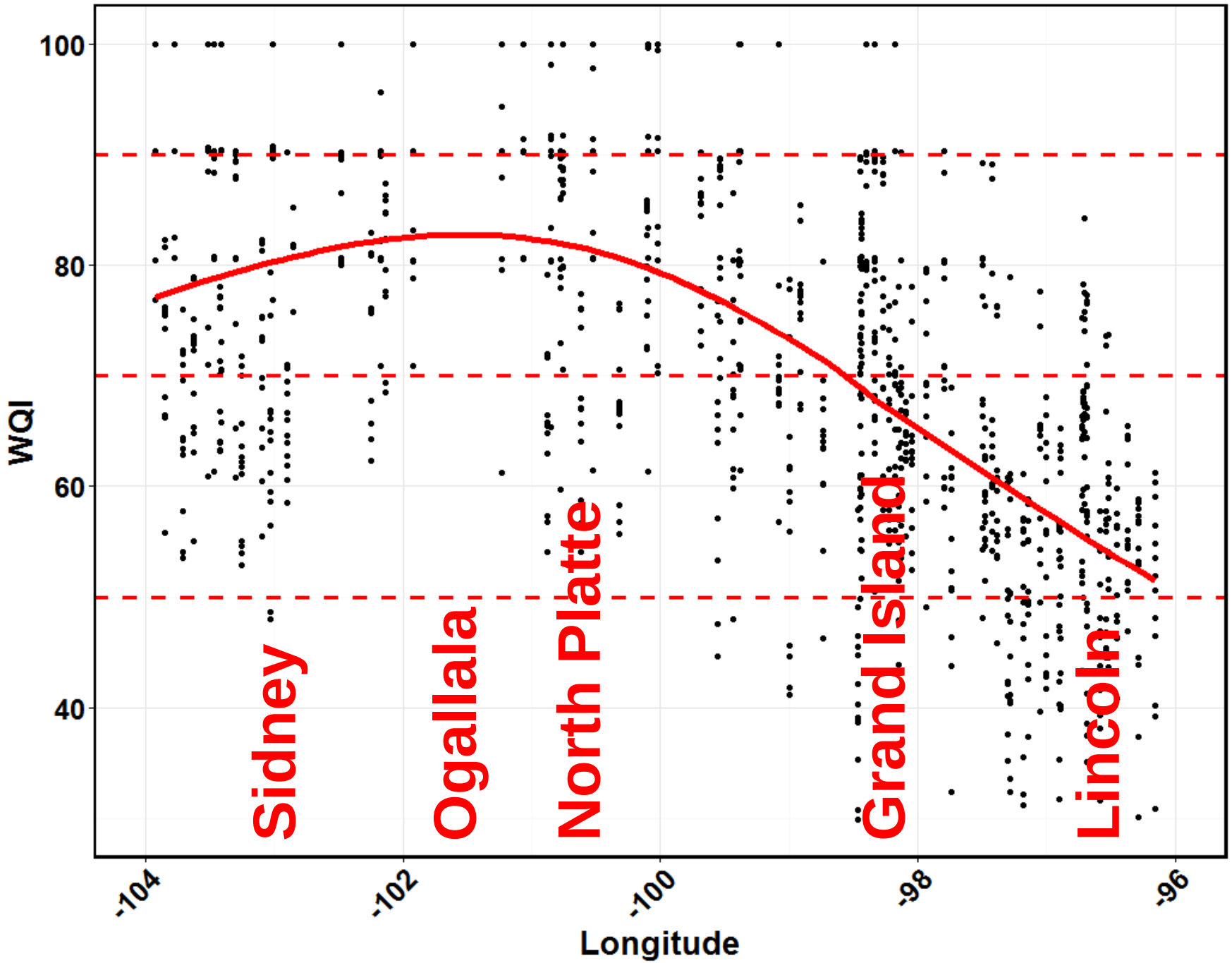
Some spatial patterns



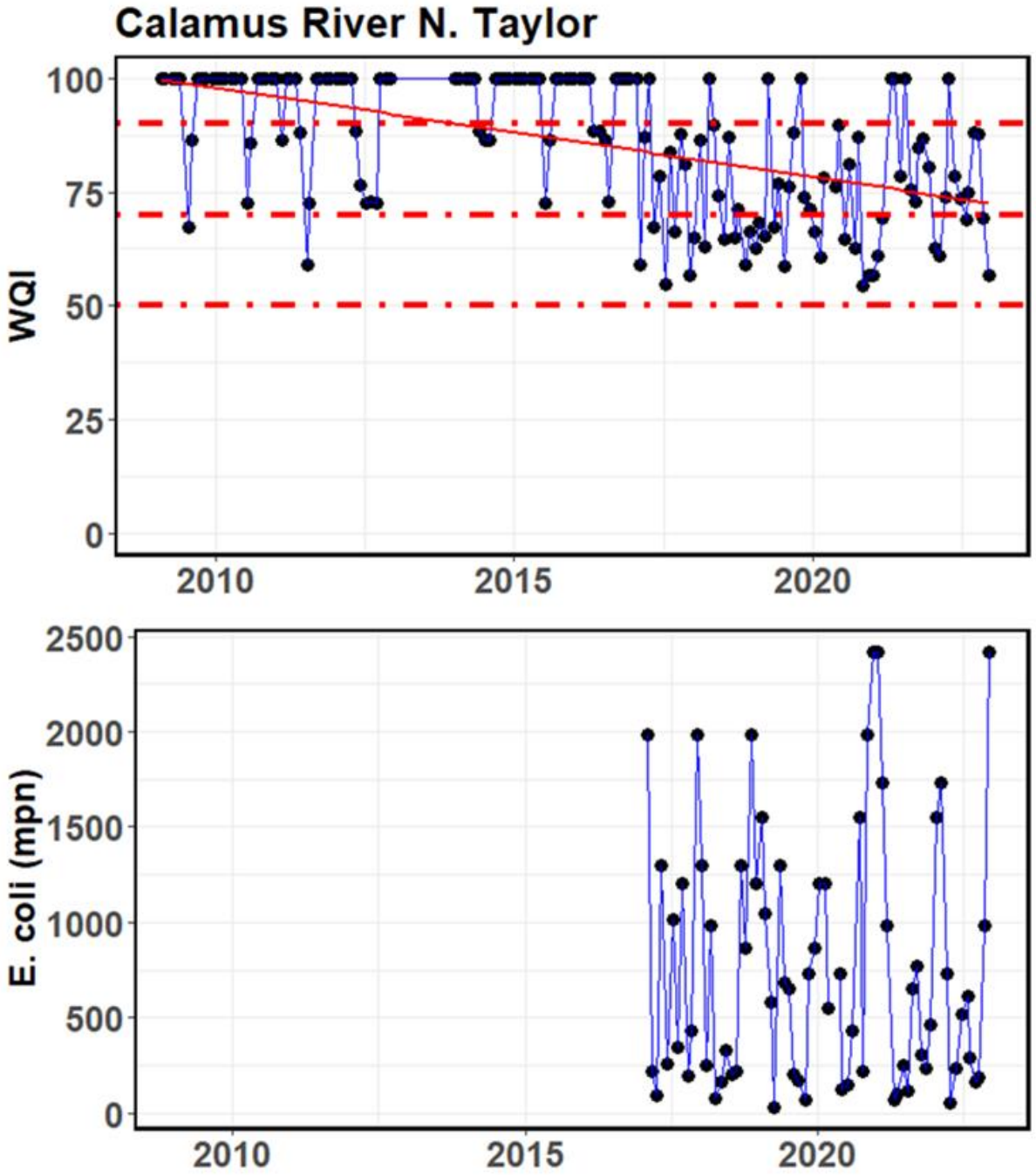

Row Crop
Pasture
Forest
Water
City



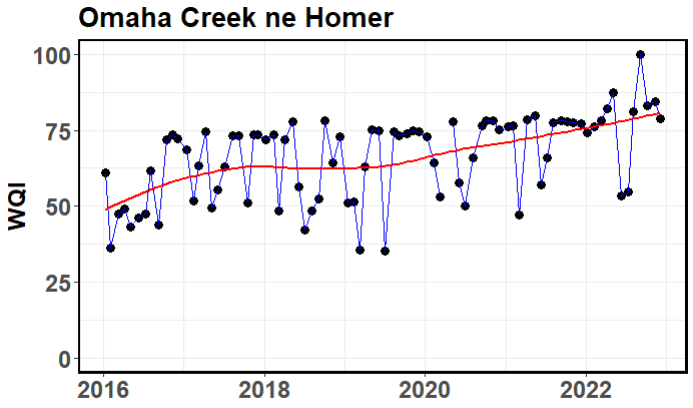
If you put in pivots and start growing corn, the water draining your land will become worse

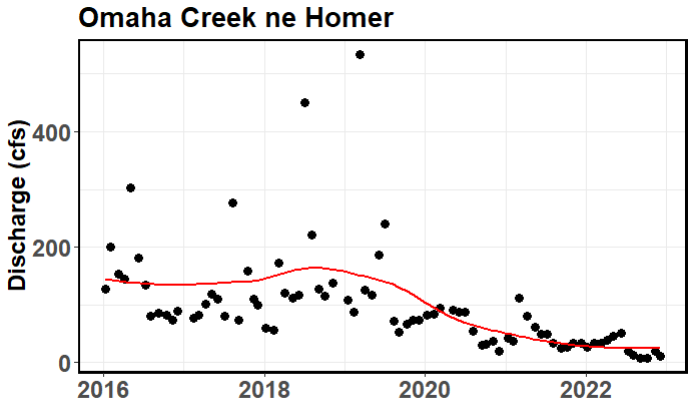

100
80
60
40
WQI
Sidney
Ogallala
North Platte
Grand Island
Lincoln
-104
-102
-100
-98
-96
Longitude

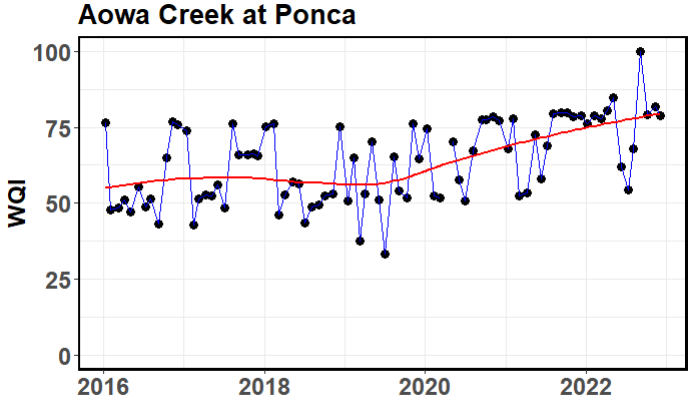
Some temporal patterns

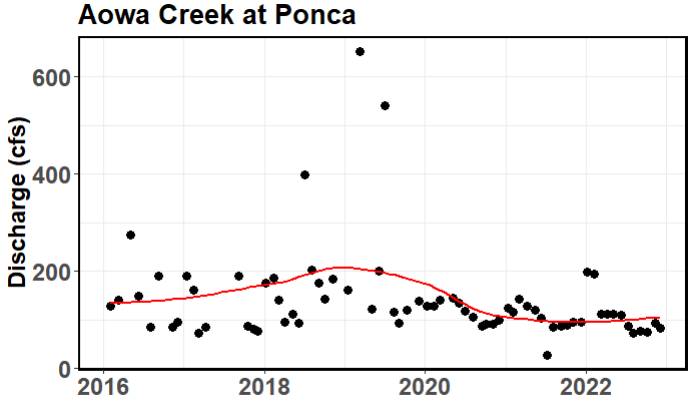


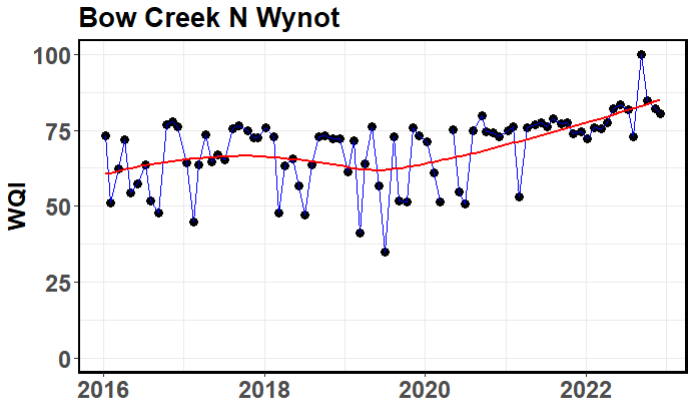
The addition of year-round monthly sampling of E. coli gave the impression of worsening water quality

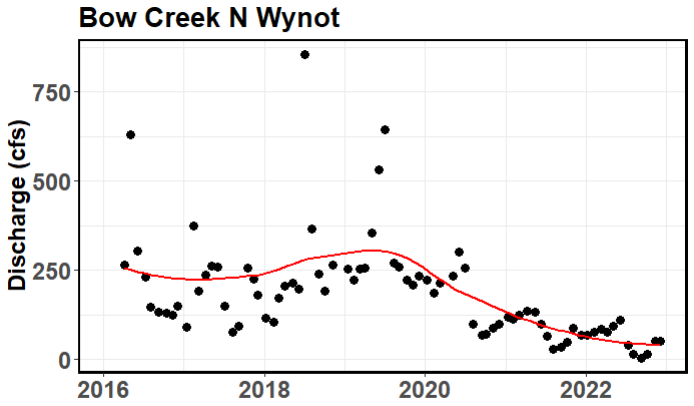




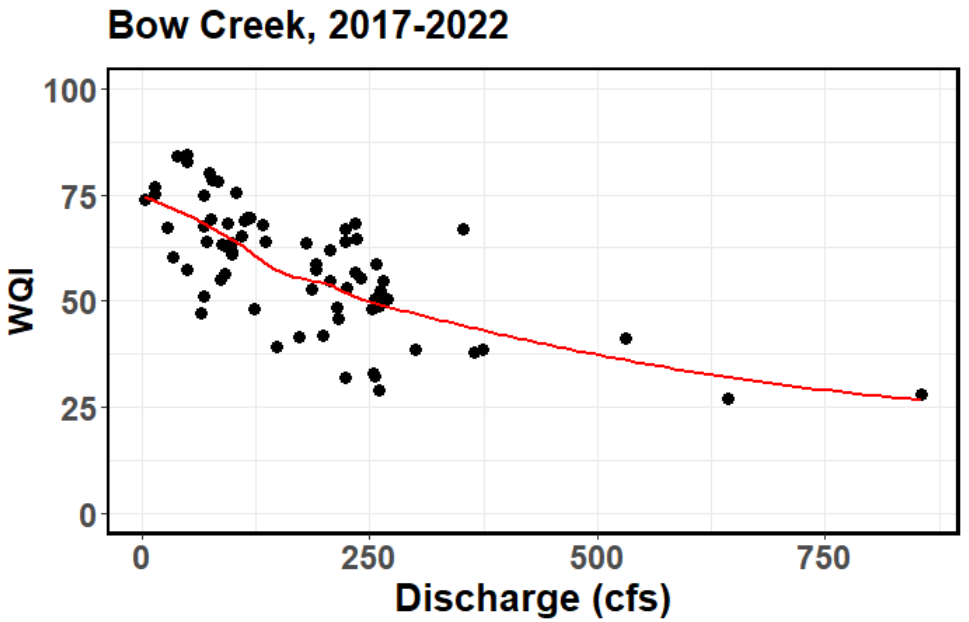




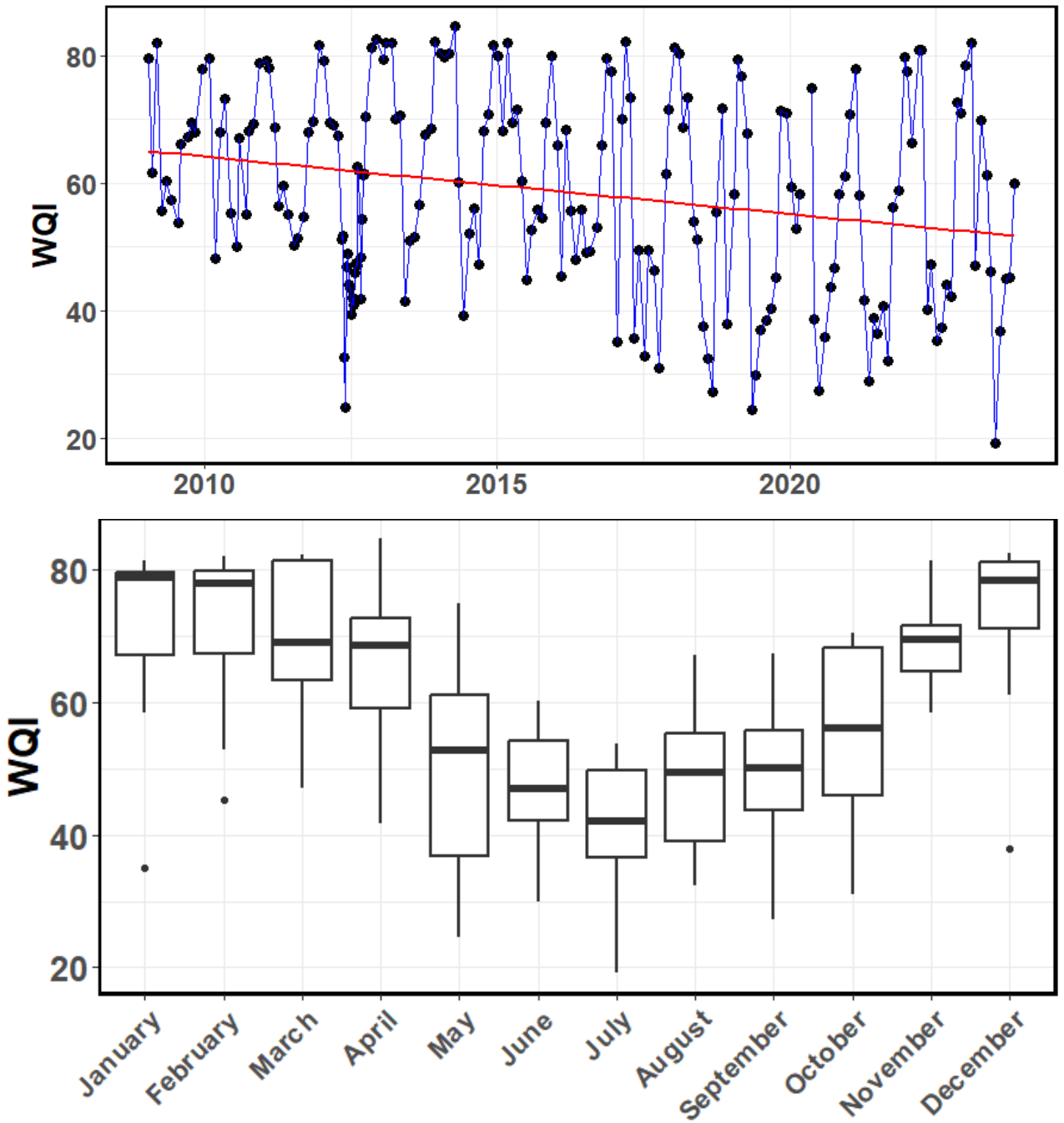


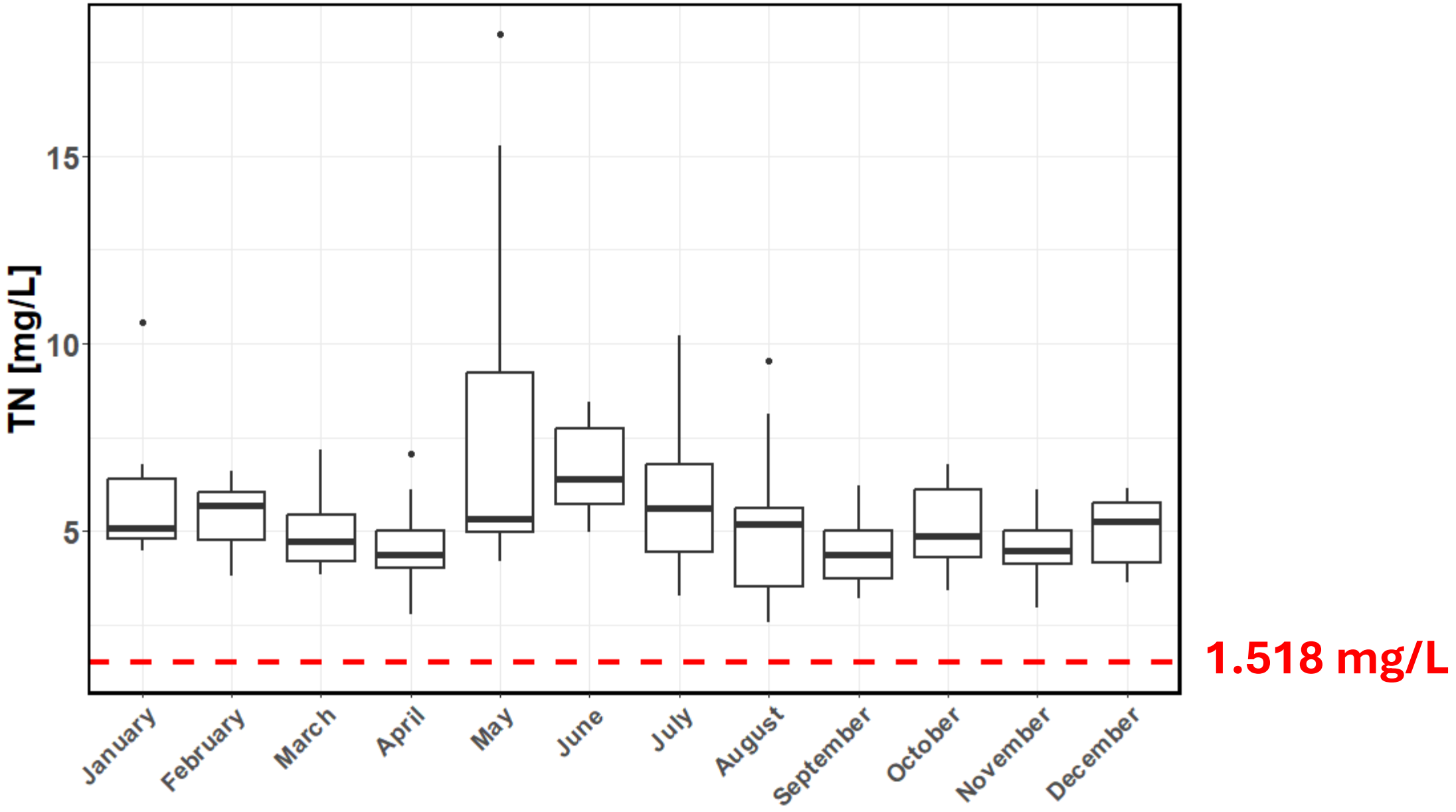


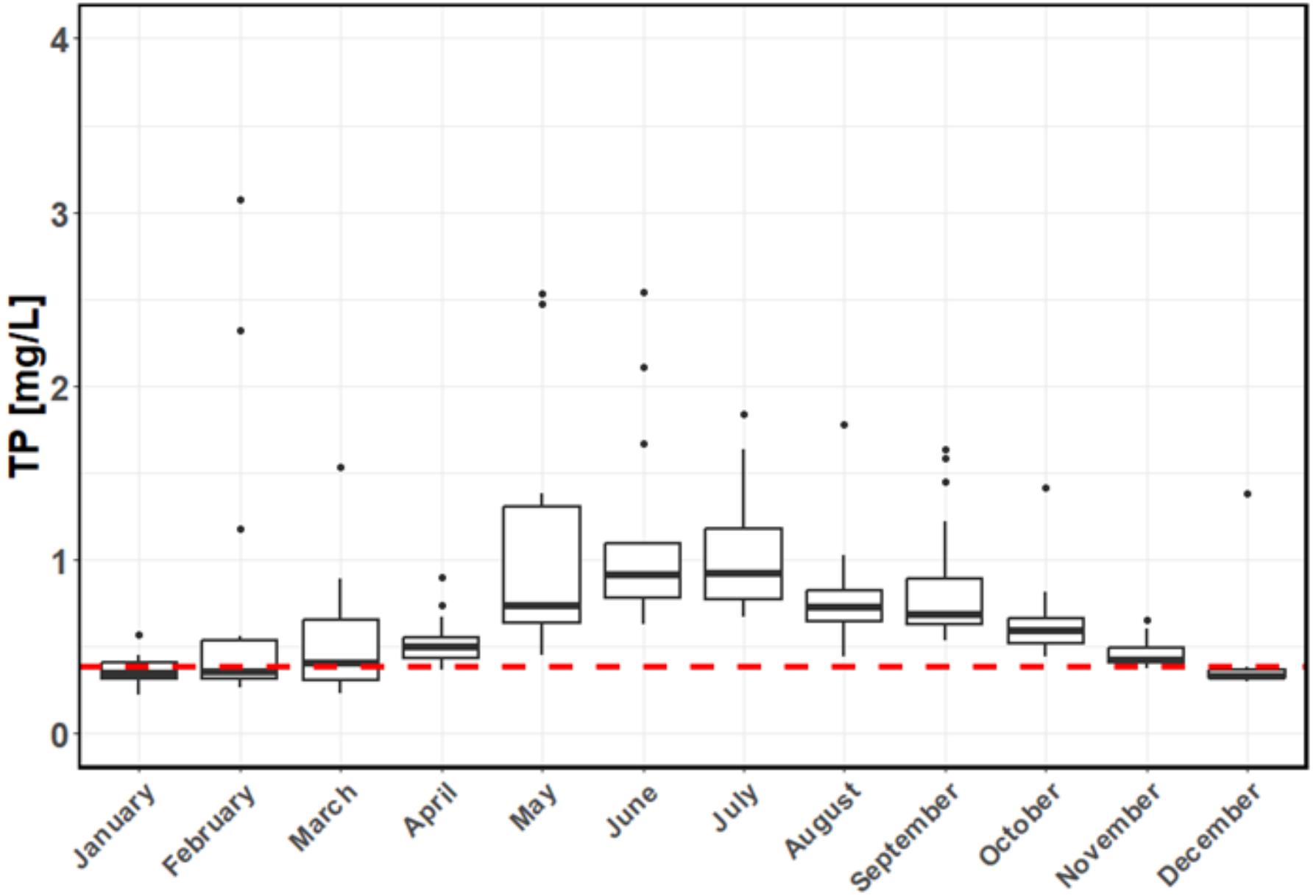
The drought appeared responsible for our greatest increases in water quality even without E. coli. These stations were also added to the ASMP in 2016.



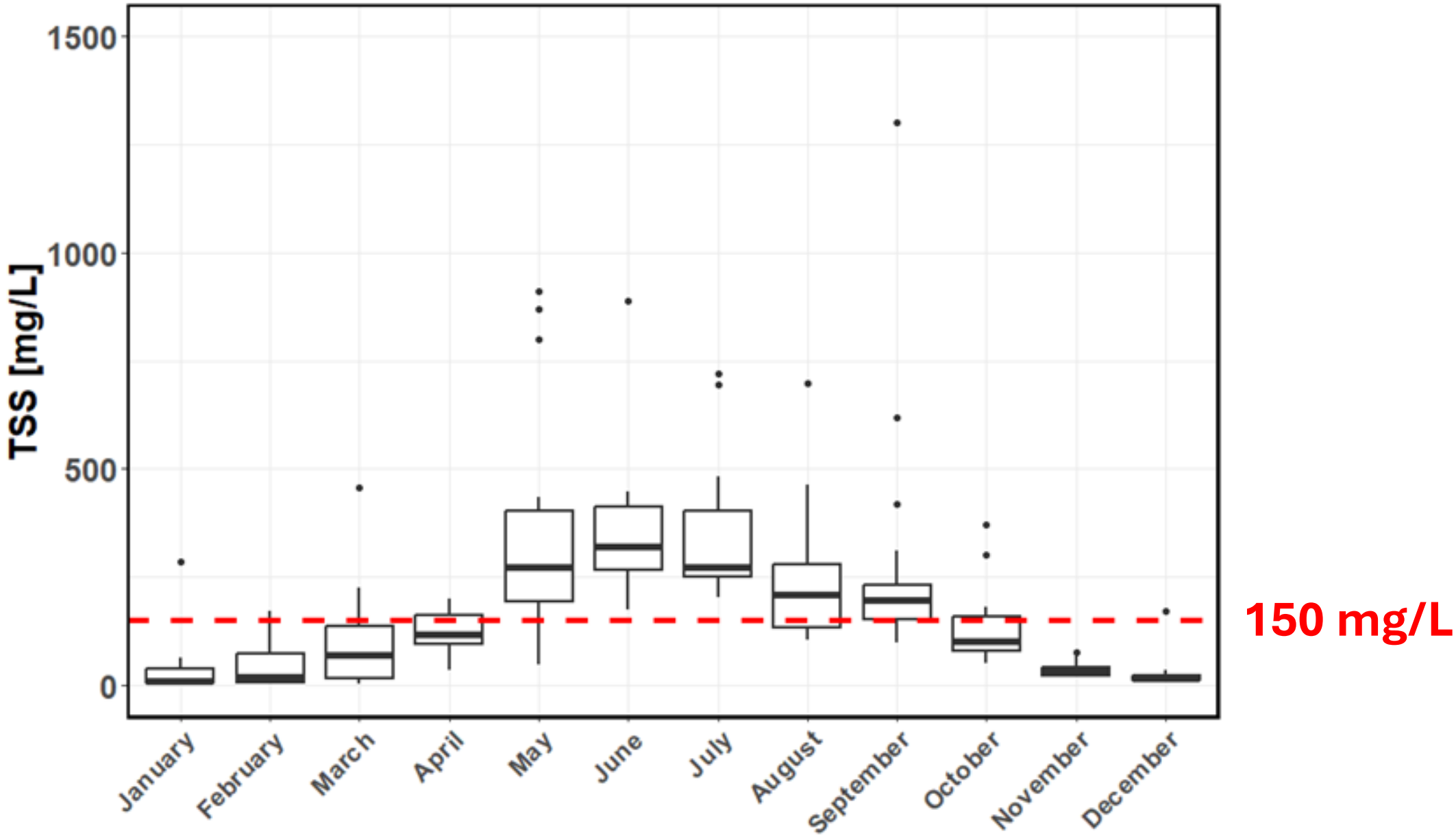
Lincoln Creek at Seward

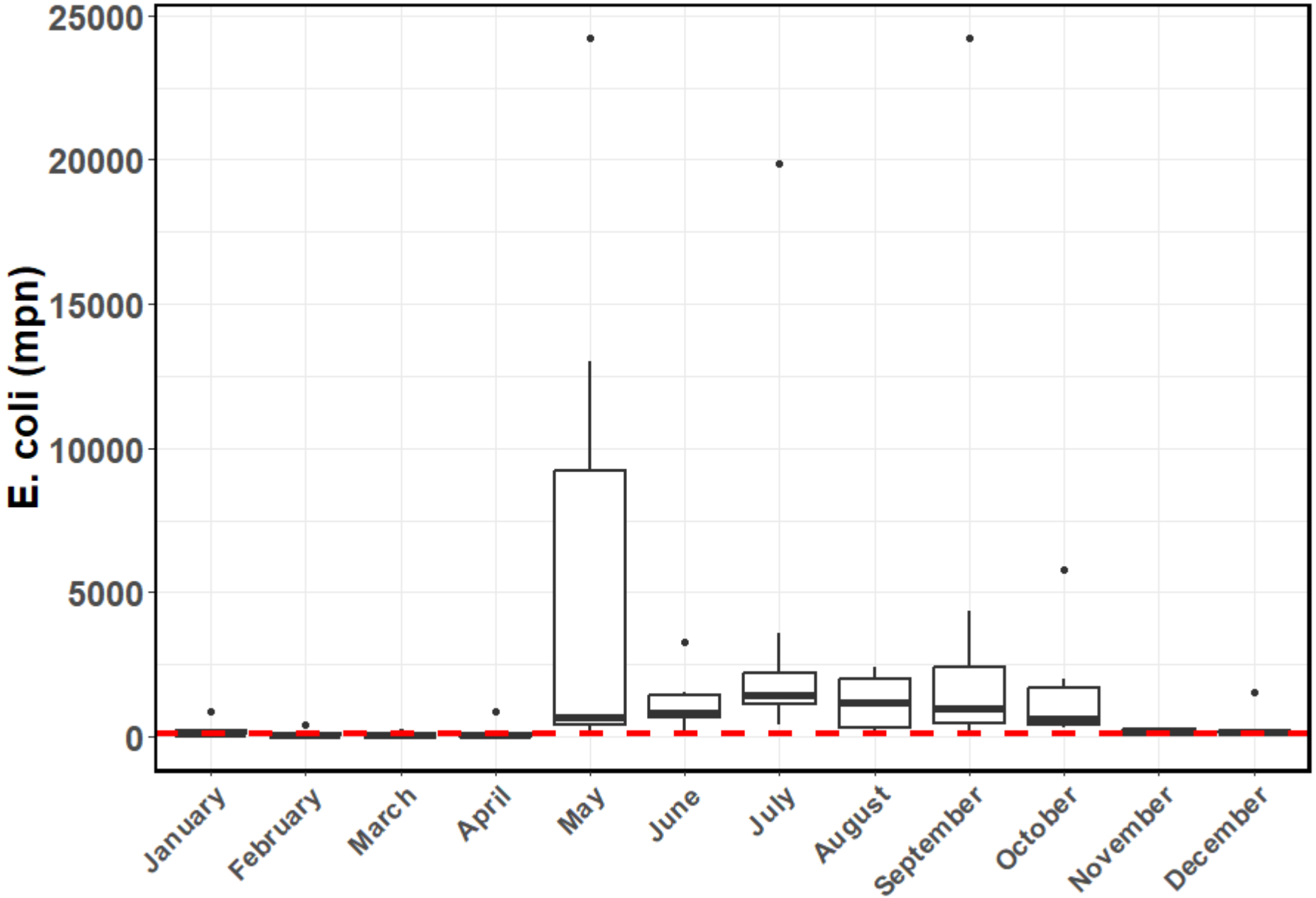



TN [mg/L]
15
10
5
January
February
March
April
May
June
July
August
September
October
November
December
1.518 mg/L

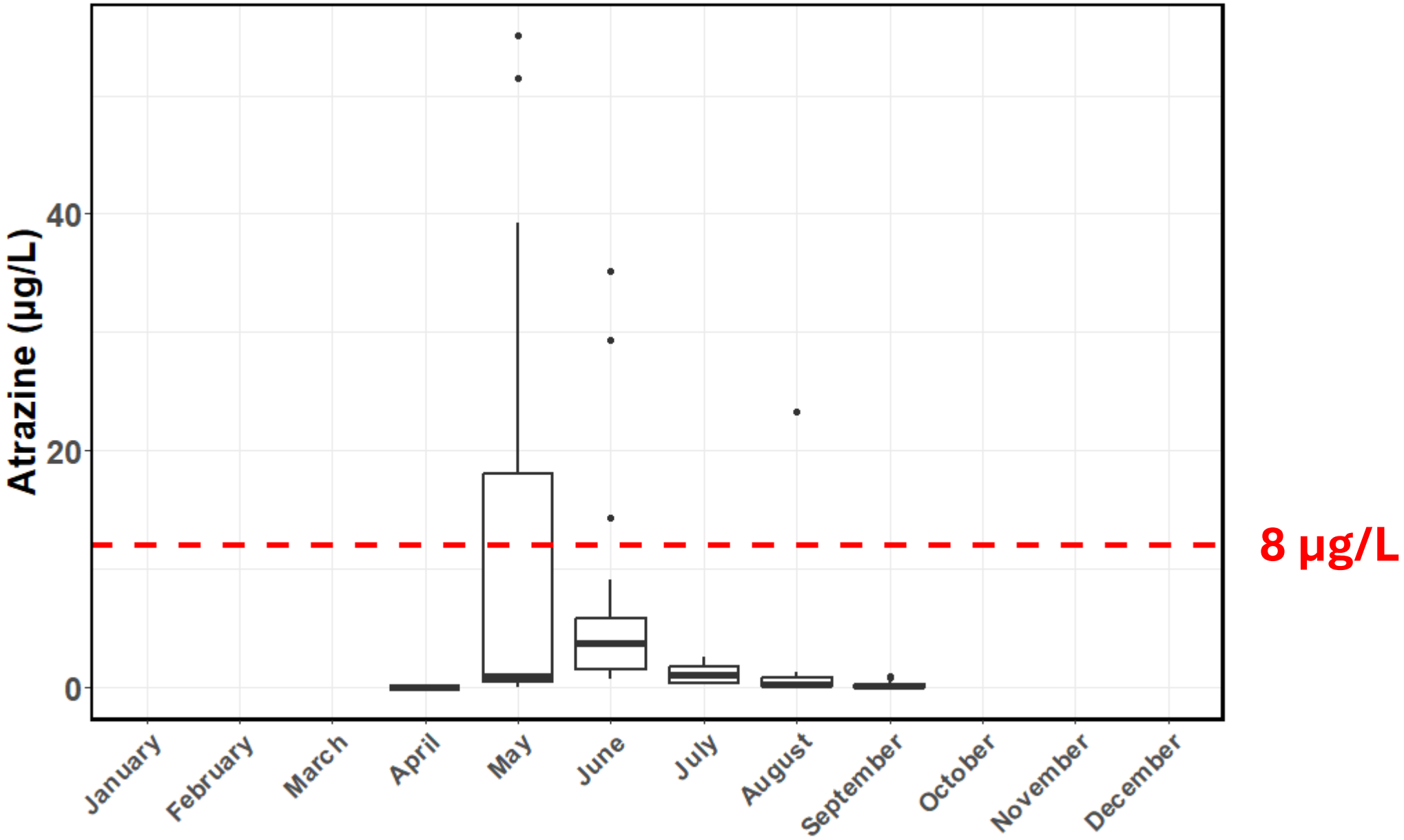

TP [mg/L]
4
3
2
1
0
January
February
March
April
May
June
July
August
September
October
November
December

0.379 mg/L


TSS [mg/L]
1500
1000
500
0
January
February
March
April
May
June
July
August
September
October
November
December
150 mg/L


E. coli (mpn)
25000
20000
15000
10000
5000
0
January
February
March
April
May
June
July
August
September
October
November
December

126 mpn/cfu

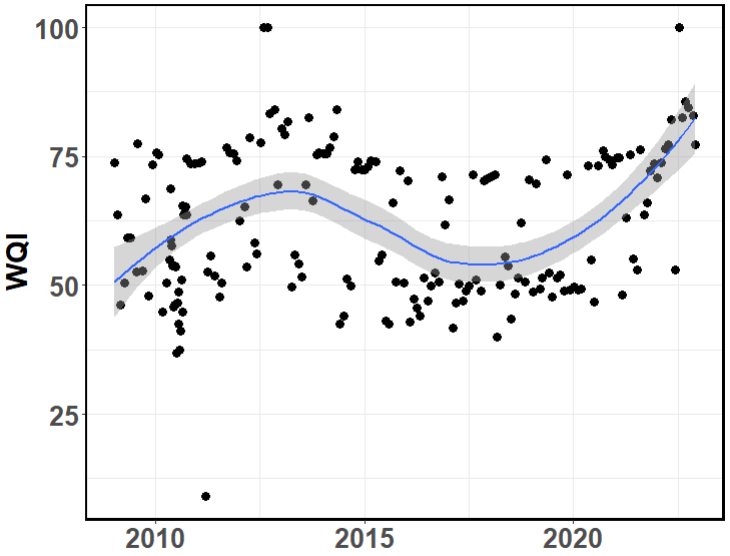

Atrazine (µg/L)
40
20
0
January
February
March
April
May
June
July
August
September
October
November
December
8 µg/L

$$WQI_{(no\ E.\ coli)} \sim Discharge + Month + Date$$

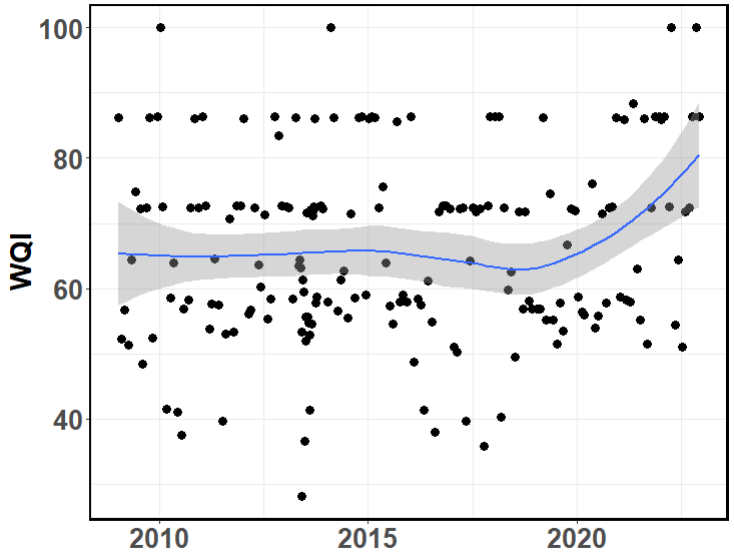
Parameter	No. significant	No. positive	No. negative
Discharge	73	8	65
Month	81		
Date	25	11	14

Always correlated with worsening TN, TP, & TSS

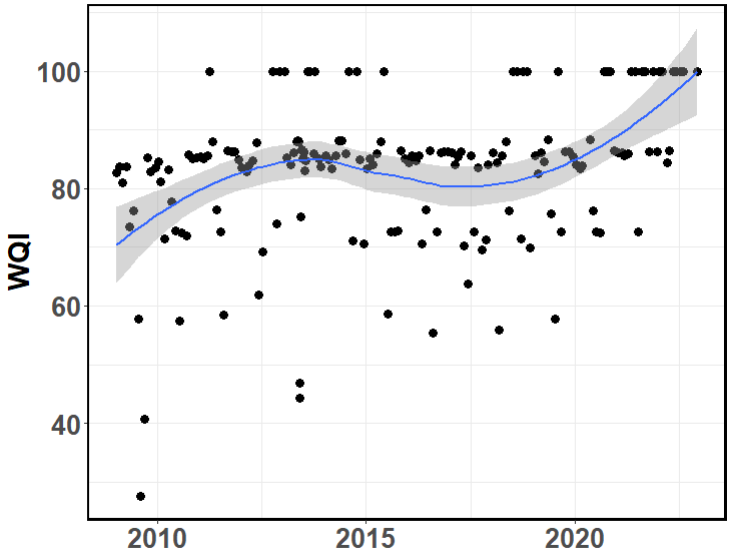
Logan Creek, SEL2LOGAN135



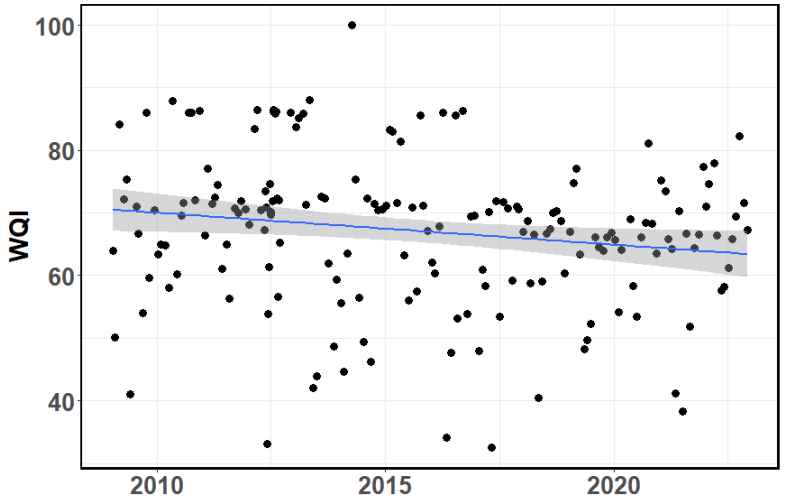
Beaver Creek, SLO1BEAVR114



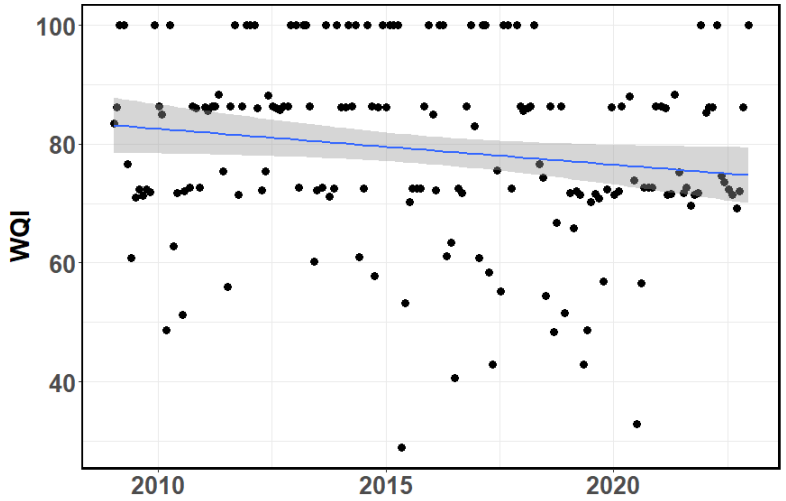
Platte River at Duncan, SMP1PLATT225



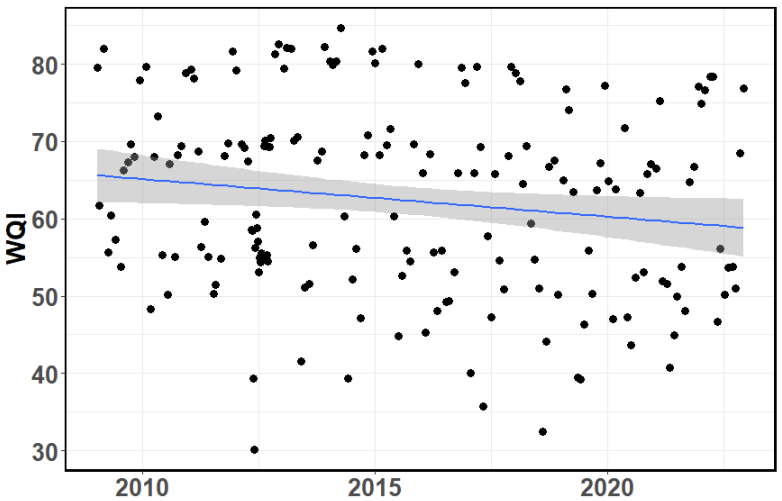
Big Blue River, SBB4BBLUE411



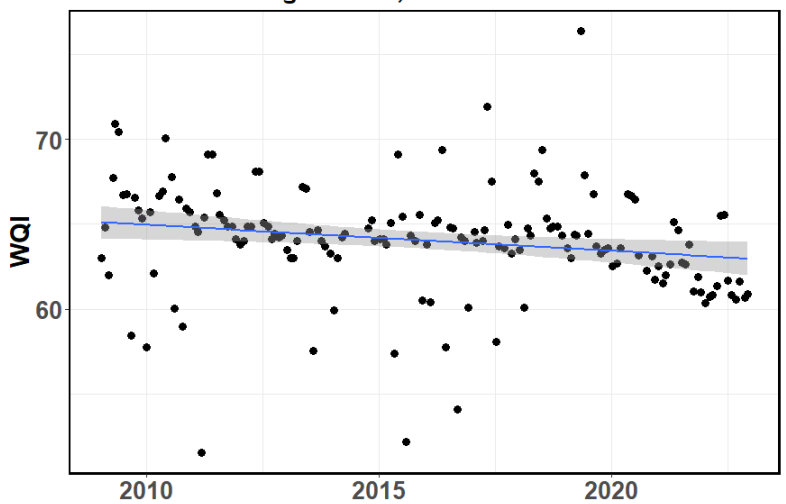
Salt Creek, SLP2SALTC301

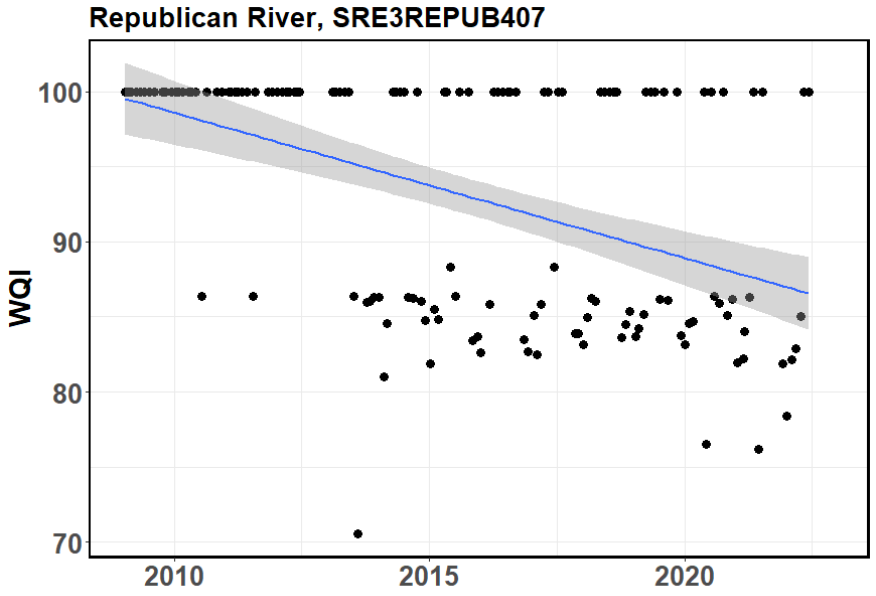


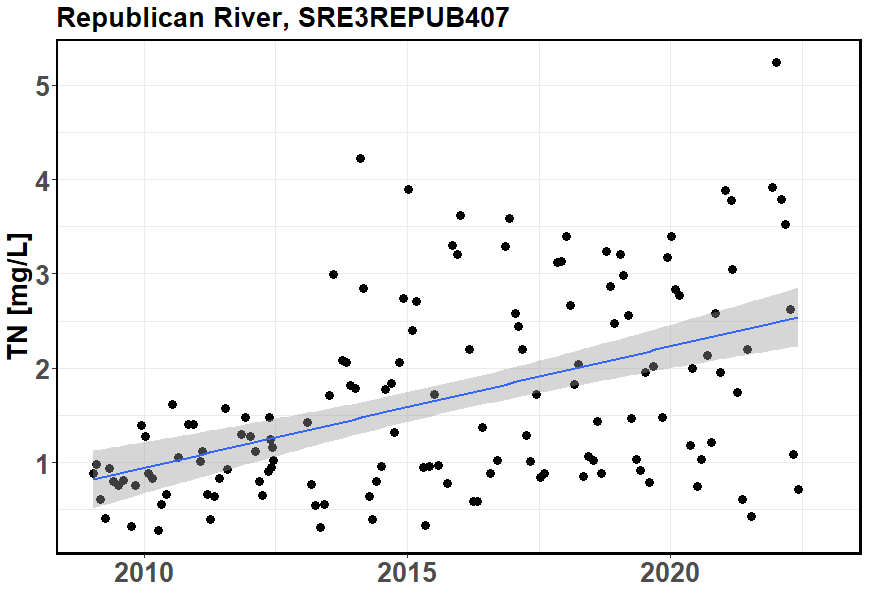
Lincoln Creek, SBB4LNCLN107



East Branch Verdigre Creek, SNI2EBVER285




Republican River, SRE3REPUB407
WQI
100
90
80
70
2010
2015
2020


Republican River, SRE3REPUB407
TN [mg/L]
5
4
3
2
1
2010
2015
2020