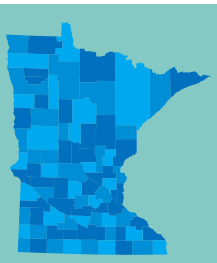
Construction and demolition

October 2019

Groundwater Impacts of Unlined Construction and Demolition Debris Landfilling: Appendices

MINNESOTA POLLUTION CONTROL AGENCY



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Contents

Appendix A: Results

The tables below represent the results of the statistical analysis and determination of exceedance by facility and contaminant of concern (COCs). The detailed results for each facility can be found in the profile sheets in Appendix B.

Table 1. Summary of results by facility for individual COCs. If the concentration of a COCs was not statistically higher downgradient then exceedance could not be determined and that is indicated in the table with "N/A" for "Not Applicable"

Permit	Arsenic concentration is statistically higher downgradient	Boron concentration is statistically higher downgradient	Manganese concentration is statistically higher downgradient	Level of exceedance for Arsenic	Level of exceedance for Boron	Level of exceedance for Manganese
SW-143	No	No	No	N/A	N/A	N/A
SW-168	No	No	No	N/A	N/A	N/A
SW-17	Yes	No	Yes	No Exceedance	N/A	No Exceedance
SW-188	Yes	Yes	Yes	IL	HT	HT
SW-254	No	No	No	N/A	N/A	N/A
SW-291	No	Yes	No	N/A	HT	N/A
SW-303	No	No	No	N/A	N/A	N/A
SW-306	Yes	Yes	Yes	IL	HT	HT
SW-311	No	Yes	No	N/A	IL	N/A
SW-315	No	No	No	N/A	N/A	N/A
SW-318	No	Yes	Yes	N/A	HT	HT
SW-332	No	Yes	Yes	N/A	HT	HT
SW-333	No	Yes	No	N/A	HT	N/A
SW-335	No	Yes	Yes	N/A	HT	HT
SW-337	No	Yes	Yes	N/A	HT	HT
SW-355	Yes	No	Yes	IL	N/A	HT
SW-399	No	No	No	N/A	N/A	N/A
SW-403	No	Yes	No	N/A	IL	N/A
SW-406	Yes	Yes	Yes	IL	HT	HT
SW-429	No	No	No	N/A	N/A	N/A
SW-432	Yes	Yes	Yes	HT	HT	HT
SW-440	No	No	Yes	N/A	N/A	HT
SW-448	Yes	Yes	No	HT	HT	N/A
SW-464	Yes	Yes	Yes	HT	HT	HT
SW-473	Yes	Yes	Yes	IL	HT	HT
SW-475	No	Yes	No	N/A	HT	N/A
SW-486	No	Yes	No	N/A	HT	N/A
SW-499	No	Yes	Yes	N/A	IL	HT
SW-508	No	No	No	N/A	N/A	N/A
SW-518	No	Yes	Yes	N/A	HT	HT

Permit	Arsenic concentration is statistically higher downgradient	Boron concentration is statistically higher downgradient	Manganese concentration is statistically higher downgradient	Level of exceedance for Arsenic	Level of exceedance for Boron	Level of exceedance for Manganese
SW-527	No	Yes	No	N/A	HT	N/A
SW-541	No	Yes	Yes	N/A	HT	HT
SW-542	No	No	No	N/A	N/A	N/A
SW-543	No	Yes	Yes	N/A	HT	HT
SW-544	Yes	Yes	No	HT	HT	N/A
SW-548	No	Yes	No	N/A	HT	N/A
SW-590	Yes	Yes	Yes	No Exceedance	HT	HT
SW-600	No	Yes	No	N/A	HT	N/A
SW-603	No	No	No	N/A	N/A	N/A
SW-620	Yes	No	No	IL	N/A	N/A
SW-658	Yes	No	Yes	IL	N/A	HT
SW-79	No	Yes	No	N/A	IL	N/A
SW-90	No	Yes	Yes	N/A	HT	HT

Table 2. Summary statistics from the Peto-Prentice generalized Wilcoxon tests conducted for each facility and contaminant. The reported p-value is the two-sided p-value divided by 2 but is only considered statistically significant if $Observed_u < Expected_u$ and the p-value < 0.05. This ensures that the test reflects the correct side of the Chi-squared distribution. The subscripts represent whether the summary statistic is for the downgradient samples (d) or the upgradient samples (u).

Permit	Contaminant	n_d	n_u	$Observed_d$	$Observed_u$	$Expected_d$	$Expected_u$	χ^2	df	p-value	Statistically Significant
SW-143	Arsenic	15	5	0.70	2.41	1.92	1.19	2.60	1	0.107	No
SW-143	Boron	18	3	8.75	0.38	7.46	1.67	1.66	1	0.197	No
SW-143	Manganese	25	8	10.45	6.52	15.24	1.73	18.90	1	0.000	No
SW-168	Arsenic	10	10	0.00	0.00	0.00	0.00	0.00	-1	N/A	No
SW-168	Boron	10	10	4.08	1.60	2.80	2.88	1.42	1	0.233	No
SW-168	Manganese	10	10	5.15	2.65	3.15	4.65	2.70	1	0.101	No
SW-17	Arsenic	9	12	2.74	0.73	0.88	2.59	6.00	1	0.014	Yes
SW-17	Boron	9	10	0.00	0.00	0.00	0.00	0.00	-1	N/A	No
SW-17	Manganese	9	12	3.57	0.95	1.81	2.71	3.15	1	0.076	Yes
SW-188	Arsenic	40	11	12.64	0.59	9.87	3.37	3.74	1	0.053	Yes
SW-188	Boron	82	22	39.43	3.81	31.61	11.63	10.76	1	0.001	Yes
SW-188	Manganese	40	11	24.75	0.85	16.12	9.48	21.48	1	0.000	Yes
SW-254	Arsenic	26	13	9.25	9.38	14.61	4.03	12.45	1	0.000	No
SW-254	Manganese	26	13	10.92	9.54	15.99	4.47	10.72	1	0.001	No
SW-291	Arsenic	44	16	6.19	8.64	11.56	3.27	13.47	1	0.000	No
SW-291	Boron	41	14	25.61	0.00	15.79	9.83	24.30	1	0.000	Yes
SW-291	Manganese	41	14	10.35	10.85	17.73	3.47	23.70	1	0.000	No
SW-303	Arsenic	33	7	1.98	0.00	1.63	0.35	0.43	1	0.512	No
SW-303	Boron	75	15	31.12	4.00	29.00	6.12	1.17	1	0.279	No
SW-303	Manganese	33	7	9.21	4.73	11.75	2.19	4.41	1	0.036	No
SW-306	Arsenic	104	11	21.25	0.00	18.85	2.39	3.05	1	0.081	Yes
SW-306	Boron	105	11	31.10	0.00	27.71	3.39	4.50	1	0.034	Yes
SW-306	Manganese	107	11	54.98	2.32	49.41	7.89	7.20	1	0.007	Yes
SW-311	Arsenic	28	14	5.20	2.31	4.79	2.72	0.12	1	0.724	No
SW-311	Boron	36	18	20.76	2.31	12.68	10.38	16.57	1	0.000	Yes

Permit	Contaminant	n_d	n_u	$Observed_d$	$Observed_u$	$Expected_d$	$Expected_u$	χ^2	df	p-value	Statistically Significant
SW-311	Manganese	30	15	1.62	7.14	6.59	2.16	17.93	1	0.000	No
SW-315	Arsenic	16	7	1.00	0.96	1.33	0.62	0.27	1	0.605	No
SW-315	Boron	18	7	8.42	2.34	8.42	2.34	0.00	1	1.000	No
SW-315	Manganese	18	7	6.47	6.04	11.27	1.24	26.04	1	0.000	No
SW-318	Arsenic	12	6	0.00	0.00	0.00	0.00	0.00	-1	N/A	No
SW-318	Boron	14	7	9.69	0.71	5.12	5.29	12.44	1	0.000	Yes
SW-318	Manganese	15	8	9.04	2.30	6.00	5.35	4.88	1	0.027	Yes
SW-332	Arsenic	18	10	0.00	2.76	1.57	1.19	3.94	1	0.047	No
SW-332	Boron	22	9	13.06	0.75	7.84	5.98	12.00	1	0.001	Yes
SW-332	Manganese	21	9	14.03	1.47	7.73	7.77	17.16	1	0.000	Yes
SW-333	Arsenic	54	9	5.52	0.87	5.93	0.46	0.43	1	0.511	No
SW-333	Boron	67	13	37.00	0.00	28.12	8.88	17.78	1	0.000	Yes
SW-333	Manganese	54	9	23.81	3.57	22.99	4.39	0.25	1	0.618	No
SW-335	Arsenic	27	6	0.00	0.00	0.00	0.00	0.00	-1	N/A	No
SW-335	Boron	83	18	49.15	0.19	34.53	14.80	34.74	1	0.000	Yes
SW-335	Manganese	72	16	41.53	0.38	29.85	12.06	25.27	1	0.000	Yes
SW-337	Arsenic	24	12	2.87	0.93	2.53	1.27	0.50	1	0.480	No
SW-337	Boron	24	12	16.56	0.33	8.56	8.33	23.03	1	0.000	Yes
SW-337	Manganese	24	12	16.56	0.92	8.56	8.92	23.10	1	0.000	Yes
SW-355	Arsenic	24	8	12.75	0.00	8.50	4.25	8.50	1	0.004	Yes
SW-355	Boron	24	8	1.97	0.00	1.47	0.50	0.68	1	0.409	No
SW-355	Manganese	24	8	11.72	0.53	8.25	4.00	5.83	1	0.016	Yes
SW-399	Arsenic	49	9	0.00	4.71	4.26	0.44	48.33	1	0.000	No
SW-399	Boron	49	9	16.89	1.69	15.18	3.40	1.44	1	0.230	No
SW-399	Manganese	43	8	18.55	3.10	18.59	3.06	0.00	1	0.978	No
SW-403	Arsenic	7	3	0.00	1.00	0.67	0.33	2.00	1	0.157	No
SW-403	Boron	7	3	4.90	0.00	2.80	2.10	5.25	1	0.022	Yes
SW-403	Manganese	7	3	1.90	0.00	1.60	0.30	0.43	1	0.513	No

Permit	Contaminant	n_d	n_u	$Observed_d$	$Observed_u$	$Expected_d$	$Expected_u$	χ^2	df	p-value	Statistically Significant
SW-406	Arsenic	21	8	10.00	0.45	7.37	3.09	4.77	1	0.029	Yes
SW-406	Boron	44	19	28.48	3.13	16.16	15.44	31.42	1	0.000	Yes
SW-406	Manganese	21	8	13.31	1.59	8.48	6.41	10.34	1	0.001	Yes
SW-429	Arsenic	23	8	2.13	7.10	8.06	1.16	40.89	1	0.000	No
SW-429	Boron	23	8	1.97	0.00	1.45	0.52	0.71	1	0.399	No
SW-429	Manganese	23	8	5.58	7.10	11.52	1.16	40.89	1	0.000	No
SW-432	Arsenic	40	14	25.26	0.00	15.17	10.09	26.46	1	0.000	Yes
SW-432	Boron	68	26	44.28	0.00	25.47	18.81	51.41	1	0.000	Yes
SW-432	Manganese	68	26	44.20	1.31	25.41	20.10	51.23	1	0.000	Yes
SW-440	Arsenic	13	7	0.00	0.00	0.00	0.00	0.00	-1	N/A	No
SW-440	Boron	13	7	0.00	0.00	0.00	0.00	0.00	-1	N/A	No
SW-440	Manganese	12	7	5.21	0.00	3.00	2.21	4.42	1	0.035	Yes
SW-448	Arsenic	45	30	11.38	1.00	6.74	5.64	8.31	1	0.004	Yes
SW-448	Boron	45	30	11.70	2.60	7.94	6.36	4.53	1	0.033	Yes
SW-448	Manganese	45	30	19.09	16.96	23.24	12.81	2.96	1	0.086	No
SW-464	Arsenic	47	6	25.89	1.08	21.91	5.06	6.57	1	0.010	Yes
SW-464	Boron	43	6	25.08	0.00	20.55	4.53	9.39	1	0.002	Yes
SW-464	Manganese	48	6	27.13	0.22	21.80	5.56	11.76	1	0.001	Yes
SW-473	Arsenic	45	23	25.39	6.27	16.44	15.22	15.64	1	0.000	Yes
SW-473	Boron	48	24	31.19	5.78	17.88	19.10	31.19	1	0.000	Yes
SW-473	Manganese	16	7	10.09	1.96	6.65	5.39	6.27	1	0.012	Yes
SW-475	Arsenic	15	7	7.09	2.98	6.48	3.58	0.23	1	0.634	No
SW-475	Boron	11	5	7.88	0.00	4.75	3.13	7.77	1	0.005	Yes
SW-475	Manganese	29	18	12.43	11.77	17.36	6.83	7.21	1	0.007	No
SW-486	Arsenic	13	10	4.00	8.09	9.65	2.43	23.42	1	0.000	No
SW-486	Boron	11	4	6.67	0.00	4.27	2.40	5.18	1	0.023	Yes
SW-486	Manganese	15	14	8.72	6.31	6.76	8.28	1.55	1	0.213	No
SW-499	Arsenic	23	15	10.58	8.66	12.21	7.03	0.87	1	0.350	No

Permit	Contaminant	n_d	n_u	$Observed_d$	$Observed_u$	$Expected_d$	$Expected_u$	χ^2	df	p-value	Statistically Significant
SW-499	Boron	19	10	13.34	0.34	6.79	6.90	18.97	1	0.000	Yes
SW-499	Manganese	28	16	19.43	0.70	9.25	10.89	30.92	1	0.000	Yes
SW-508	Arsenic	36	6	18.45	3.21	18.74	2.93	0.05	1	0.831	No
SW-508	Boron	27	4	14.97	1.32	13.68	2.61	1.23	1	0.268	No
SW-508	Manganese	36	16	15.48	7.06	15.71	6.83	0.01	1	0.903	No
SW-518	Arsenic	4	3	0.00	0.00	0.00	0.00	0.00	-1	N/A	No
SW-518	Boron	12	6	8.33	0.80	4.33	4.80	11.08	1	0.001	Yes
SW-518	Manganese	12	8	8.55	1.65	4.05	6.15	12.60	1	0.000	Yes
SW-527	Arsenic	59	17	19.33	6.16	19.16	6.33	0.01	1	0.931	No
SW-527	Boron	48	15	17.73	0.00	12.73	5.00	8.31	1	0.004	Yes
SW-527	Manganese	48	15	21.10	8.84	23.48	6.46	1.56	1	0.212	No
SW-541	Arsenic	25	9	0.00	0.00	0.00	0.00	0.00	-1	N/A	No
SW-541	Boron	23	8	14.23	0.24	9.06	5.40	11.63	1	0.001	Yes
SW-541	Manganese	25	9	14.62	3.00	11.29	6.32	4.25	1	0.039	Yes
SW-542	Arsenic	27	8	6.24	0.00	4.55	1.69	2.68	1	0.101	No
SW-542	Boron	30	8	8.95	2.53	9.58	1.89	0.30	1	0.582	No
SW-542	Manganese	27	8	11.63	1.98	9.94	3.68	1.38	1	0.240	No
SW-543	Arsenic	28	7	1.95	0.00	1.53	0.42	0.55	1	0.458	No
SW-543	Boron	30	7	18.18	0.00	12.66	5.52	12.83	1	0.000	Yes
SW-543	Manganese	31	7	15.97	1.53	13.21	4.29	3.37	1	0.067	Yes
SW-544	Arsenic	24	63	7.83	7.36	4.05	11.14	5.36	1	0.021	Yes
SW-544	Boron	63	76	30.30	12.01	12.86	29.45	43.72	1	0.000	Yes
SW-544	Manganese	27	63	11.12	24.03	9.93	25.22	0.26	1	0.610	No
SW-548	Arsenic	11	21	1.91	1.00	1.00	1.91	1.29	1	0.256	No
SW-548	Boron	11	22	7.27	9.73	4.06	12.94	4.70	1	0.030	Yes
SW-548	Manganese	11	21	3.22	12.41	6.63	9.00	4.64	1	0.031	No
SW-590	Arsenic	15	12	9.58	2.95	5.19	7.34	9.32	1	0.002	Yes
SW-590	Boron	21	15	14.53	3.11	7.31	10.33	18.17	1	0.000	Yes

Permit	Contaminant	n_d	n_u	$Observed_d$	$Observed_u$	$Expected_d$	$Expected_u$	χ^2	df	p-value	Statistically Significant
SW-590	Manganese	21	15	14.75	3.81	6.81	11.75	22.96	1	0.000	Yes
SW-600	Arsenic	16	10	8.27	3.65	6.38	5.54	1.69	1	0.194	No
SW-600	Boron	33	22	23.45	0.00	10.25	13.20	42.68	1	0.000	Yes
SW-600	Manganese	18	10	10.11	4.68	8.89	5.89	0.64	1	0.425	No
SW-603	Arsenic	16	10	1.94	0.00	1.12	0.82	1.47	1	0.225	No
SW-603	Boron	16	10	2.23	8.27	8.38	2.12	29.09	1	0.000	No
SW-603	Manganese	16	10	5.33	4.82	6.38	3.77	0.60	1	0.438	No
SW-620	Arsenic	12	8	5.90	0.00	3.00	2.90	7.00	1	0.008	Yes
SW-620	Boron	11	8	0.00	3.45	2.12	1.33	6.31	1	0.012	No
SW-620	Manganese	11	8	6.53	3.47	5.05	4.95	1.30	1	0.254	No
SW-658	Arsenic	25	13	14.91	0.46	8.00	7.37	17.08	1	0.000	Yes
SW-658	Boron	25	13	0.00	3.84	2.63	1.21	8.70	1	0.003	No
SW-658	Manganese	25	13	17.13	1.21	8.58	9.76	24.99	1	0.000	Yes
SW-79	Arsenic	14	15	6.46	6.50	6.68	6.29	0.02	1	0.889	No
SW-79	Boron	17	15	7.13	0.00	3.38	3.75	8.89	1	0.003	Yes
SW-79	Manganese	14	15	0.00	7.03	3.86	3.17	9.74	1	0.002	No
SW-90	Arsenic	24	19	13.86	8.26	10.79	11.33	2.56	1	0.110	No
SW-90	Boron	24	18	17.43	2.55	7.19	12.79	34.15	1	0.000	Yes
SW-90	Manganese	24	17	17.32	1.54	7.39	11.46	32.35	1	0.000	Yes

Table 3. Results by facility and COCs for trends assessed at individual downgradient wells from 2010 through 2017. Trend direction is determined by the sign of the slope coefficient if the slope was statistically significant (p-value <0.05). If the slope is not statistically significant then no trend could be determined.

Permit	Contaminant	Number of wells showing decreasing trend in concentration of contaminant	Number of wells showing increasing trend in concentration of contaminant	Number of wells where no trend was determined	Total well trends evaluated
SW-17	Arsenic	0	0	1	1
SW-17	Manganese	0	0	2	2
SW-188	Arsenic	0	0	4	4
SW-188	Boron	0	0	7	7
SW-188	Manganese	1	1	5	7
SW-291	Boron	0	1	2	3
SW-306	Arsenic	1	0	5	6
SW-306	Boron	0	0	6	6
SW-306	Manganese	1	0	7	8
SW-311	Boron	1	0	1	2
SW-318	Boron	0	0	2	2
SW-318	Manganese	0	0	2	2
SW-332	Boron	1	0	1	2
SW-332	Manganese	0	0	2	2
SW-333	Boron	0	2	0	2
SW-335	Boron	1	0	4	5
SW-335	Manganese	0	0	4	4
SW-337	Boron	1	0	1	2
SW-337	Manganese	0	2	0	2
SW-355	Arsenic	0	0	3	3
SW-355	Manganese	0	1	1	2
SW-403	Boron	0	0	1	1
SW-406	Arsenic	0	0	2	2
SW-406	Boron	0	1	1	2
SW-406	Manganese	0	1	1	2
SW-432	Arsenic	0	0	3	3
SW-432	Boron	0	0	3	3
SW-432	Manganese	0	0	3	3
SW-440	Manganese	0	0	1	1
SW-448	Arsenic	1	0	1	2
SW-448	Boron	0	1	0	1
SW-464	Arsenic	0	1	7	8
SW-464	Boron	1	0	6	7
SW-464	Manganese	0	0	8	8
SW-473	Arsenic	0	0	2	2
SW-473	Boron	1	1	0	2

Permit	Contaminant	Number of wells showing decreasing trend in concentration of contaminant	Number of wells showing increasing trend in concentration of contaminant	Number of wells where no trend was determined	Total well trends evaluated
SW-473	Manganese	0	0	2	2
SW-475	Boron	0	0	2	2
SW-486	Boron	0	0	4	4
SW-499	Boron	0	0	2	2
SW-499	Manganese	0	0	2	2
SW-518	Boron	0	0	2	2
SW-518	Manganese	0	0	2	2
SW-527	Boron	0	1	2	3
SW-541	Boron	0	1	2	3
SW-541	Manganese	0	0	3	3
SW-543	Boron	0	0	6	6
SW-543	Manganese	0	0	6	6
SW-544	Arsenic	0	0	3	3
SW-544	Boron	0	1	2	3
SW-548	Boron	0	0	2	2
SW-590	Arsenic	0	0	2	2
SW-590	Boron	0	1	1	2
SW-590	Manganese	0	0	2	2
SW-600	Boron	0	1	2	3
SW-620	Arsenic	0	0	1	1
SW-658	Arsenic	1	0	1	2
SW-658	Manganese	2	0	0	2
SW-79	Boron	0	0	2	2
SW-90	Boron	1	0	2	3
SW-90	Manganese	0	0	3	3

Appendix B: CDLF Profile Sheets

Of the 49 facilities assessed in this report, each had an individual profile sheet created that displays a map of the facility and general overview of solid waste activities. The map indicates the location of their solid waste activities, groundwater monitoring well location and position to the facility (i.e. upgradient, downgradient, or sidegradient), and direction of groundwater flow. There is also a small-scale map of Minnesota that displays the facility's relative location within the state.

For the 43 facilities that had upgradient sampling during the period of 2010 through 2017, detailed statistical analysis for determining facility impact to groundwater is provided for each of the three contaminants of concern. If a contaminant could not be assessed by the statistical test due to heavily censored results, the p-value is listed as NA in Table 1.

There are 33 facilities that demonstrated strong evidence of impact (p-value < 0.05) to the groundwater (i.e. downgradient values were statistically greater than upgradient values) and for these facilities detailed contaminant trends were generated for each possible downgradient well.

For all facilities, the raw data is available in the published Tableau report
https://www.pca.state.mn.us/waste/construction-and-demolition-landfills-groundwater

Facility specific datalinks are provided in the profile sheets under section A.

SW-17 East Central Solid Waste Commission

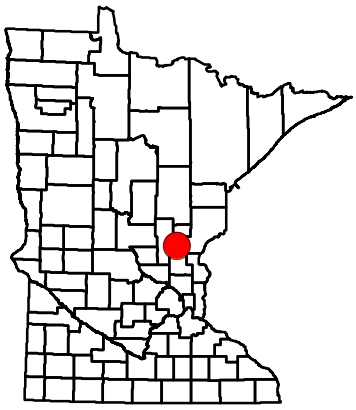
0 335 670 1,340 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-17 East Central Solid Waste Commission

A. Facility overview

1. **C&D disposal activity to date:** Construction and Demolition Landfill
2. **Other solid waste:** Yard waste composting, Solid Waste transfer station, Owner/Operator operates Municipal Solid Waste landfill, but is lined, not upgradient well close to Municipal Solid Waste Landfill leachate spray field
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 2
2. **Downgradient well(s):** 2
3. **Groundwater flow:** is mostly northeast, with some fanwise motion

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for arsenic and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

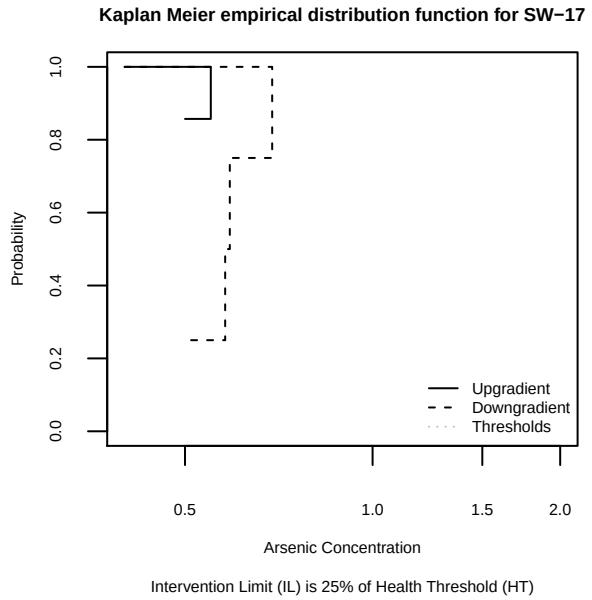
This facility does not show any significant trends for Arsenic or Manganese and no points are above their respective IL.

Kaplan Meier empirical distribution function (EDF)

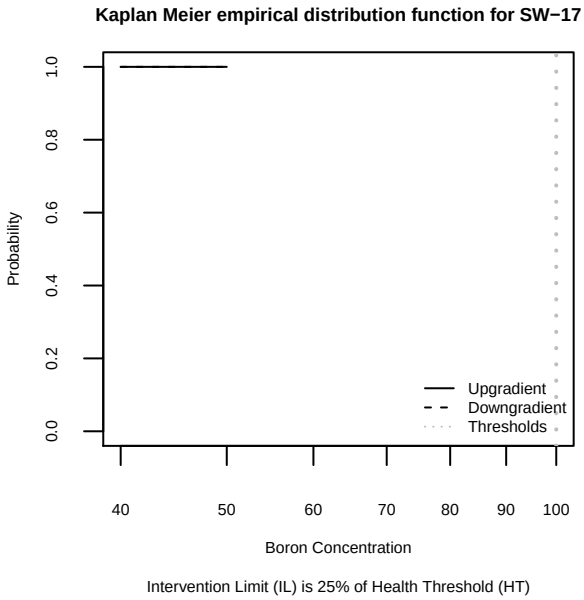
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

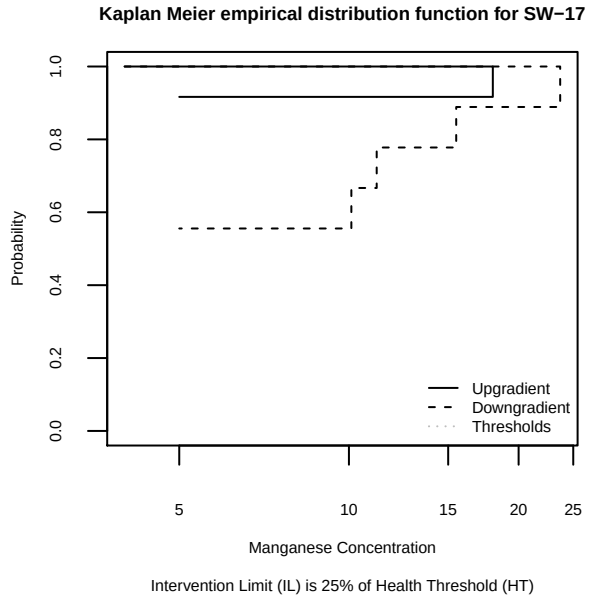
The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)

Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-17	Arsenic	9	12	6.004	1	0.007***	Yes
	Boron	9	10	0.000	-1	NA	No
	Manganese	9	12	3.147	1	0.038**	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for arsenic and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-17	Arsenic	MW-20A	0	0	5
		MW-22	0	0	4
	Manganese	MW-20A	0	0	5
		MW-22	0	0	4
	All	All	0	0	18

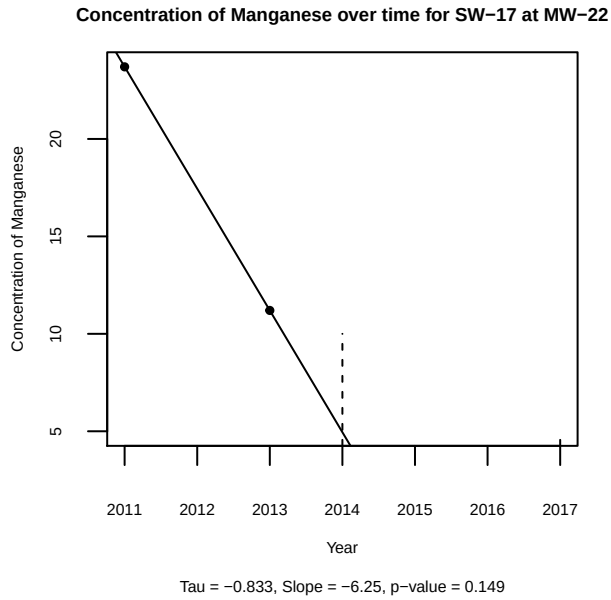
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

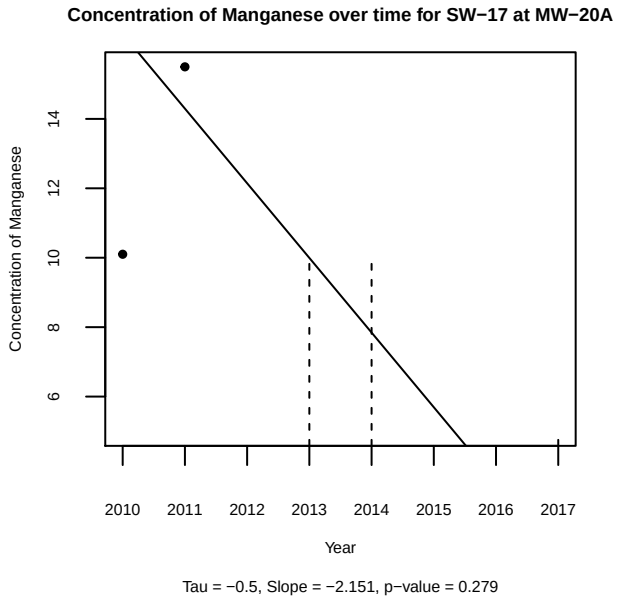
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

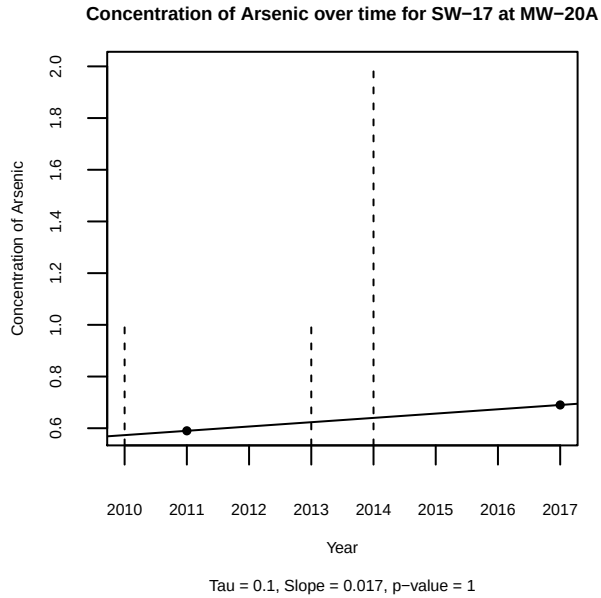
Table 3: Well/contaminant combinations where trends cannot be evaluated

Well ID	Contaminant	Number of measured values	Number of censored values	Total
MW-22	Arsenic	1	3	4

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.

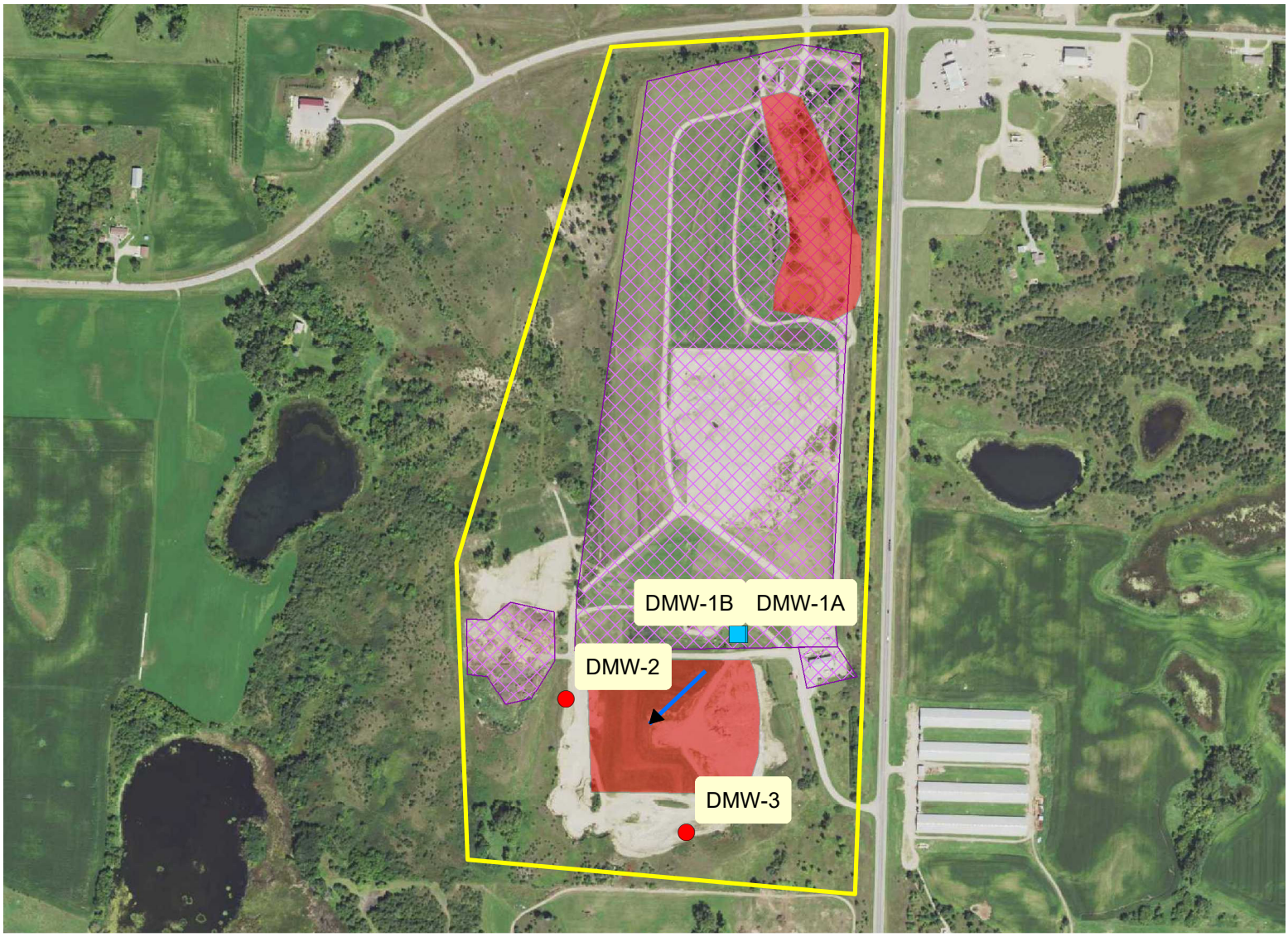






This facility does not show any significant trends for Arsenic or Manganese and no points are above their respective IL.

SW-79 Kandiyohi County Sanitary Landfill



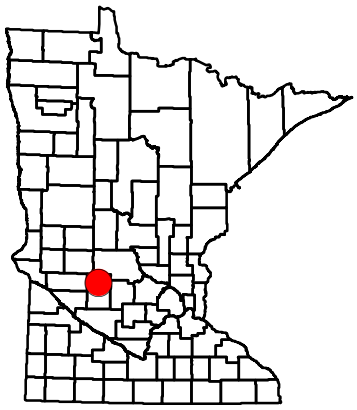
0 485 970 1,940 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-79 Kandiyohi County Sanitary Landfill

A. Facility overview

1. **C&D disposal activity to date:** Original demo Landfill ceased operation in 1997 and was capped. Later Owner/Operator opened another demo Landfill and this continues in use.
2. **Other solid waste:** Yard waste compost area, recycling, tire storage, and Municipal Solid Waste landfill on site. Municipal Solid Waste landfill is north of current demo Landfill.
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 2
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to southwest

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

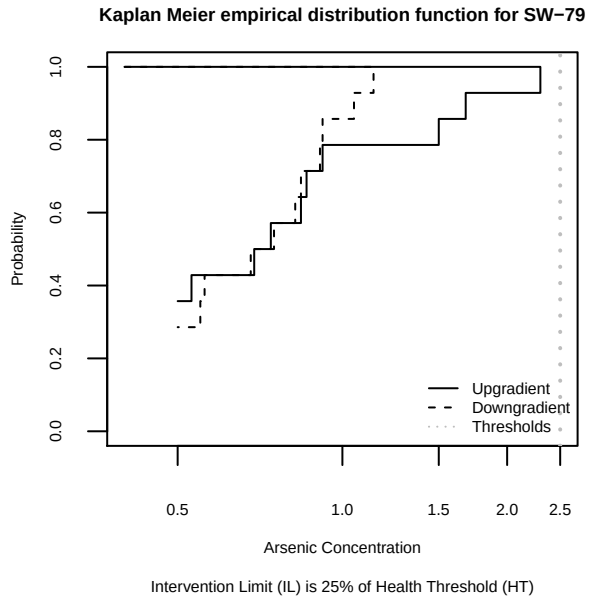
This facility does not show any significant trends for Boron, however all points are above the respective IL.

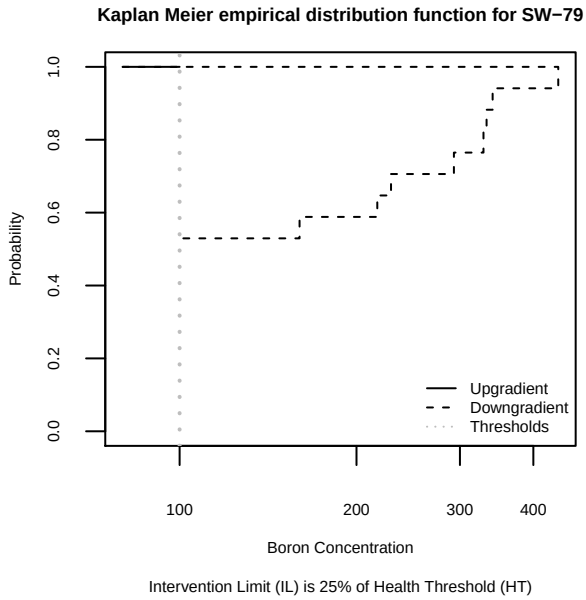
Kaplan Meier empirical distribution function (EDF)

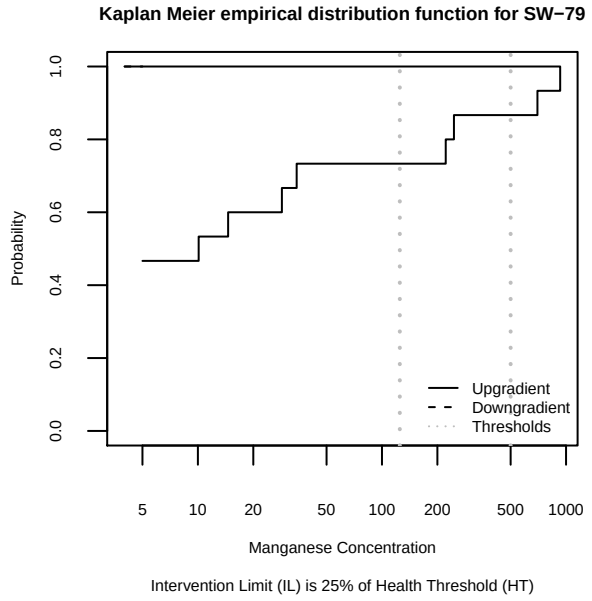
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-79	Arsenic	14	15	0.019	1	0.444	No
	Boron	17	15	8.889	1	0.001***	Yes
	Manganese	14	15	9.739	1	0.001***	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

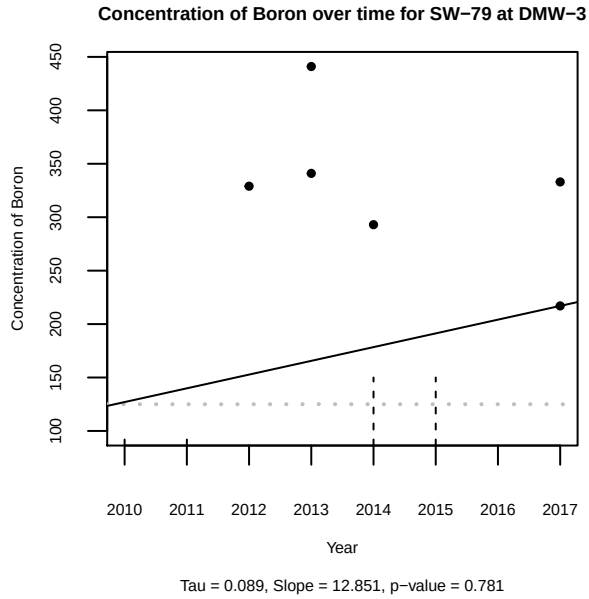
Table 2: Exceedance of thresholds by contaminant and Well ID

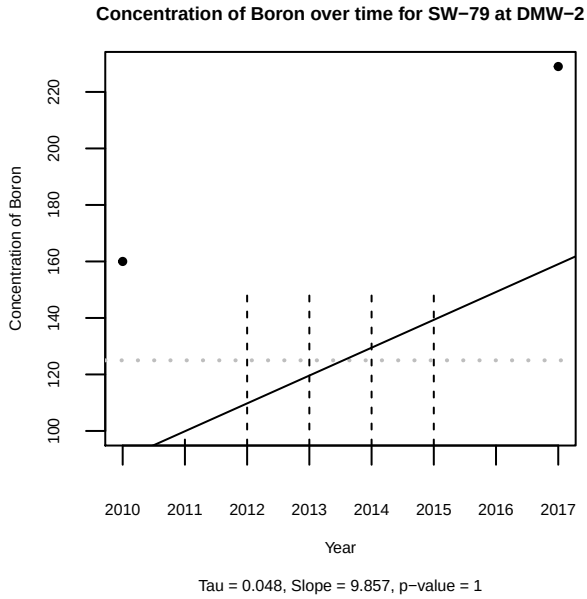
Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-79	Boron	DMW-2	0	2	5
		DMW-3	0	6	4
	All	All	0	8	9

Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.





This facility does not show any significant trends for Boron, however all points are above the respective IL.

SW-90 Renville County Sanitary Landfill

0 335 670 1,340 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-90 Renville County Sanitary Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill, some portions are no longer active
2. **Other solid waste:** Lined and unlined Municipal Solid Waste Landfill cell; Source-separated organic materials compost facility; bean-dust composting.
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 2
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to southwest

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

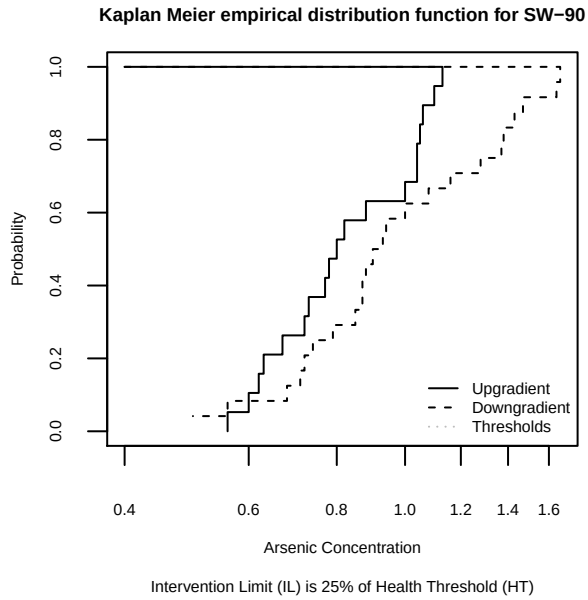
The concentration of Boron as measured in well OW-116A is decreasing over time (slope is negative and p-value is less than 0.05), however all points are above the HT. Monitoring wells 34-OWA and 33-OWA do not show any significant trends for Boron, however several points are above the HT. Manganese concentrations measured in wells OW-116A, 33-OWA, and 34-OWA do not show any significant trends. All points in 33-OWA and 34-OWA for Manganese were above the HT, all but one point in well OW-116A was above the HT.

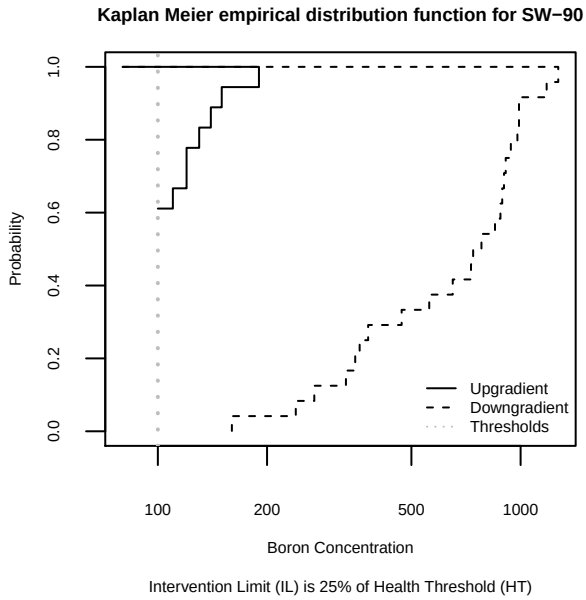
Kaplan Meier empirical distribution function (EDF)

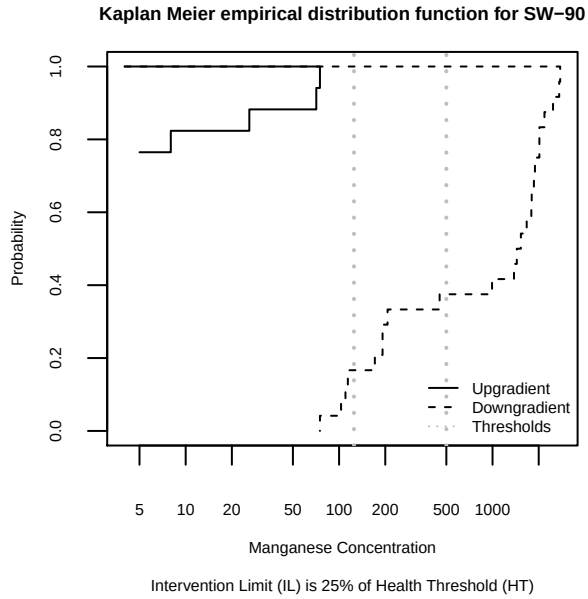
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-90	Arsenic	24	19	2.559	1	0.055*	No
	Boron	24	18	34.148	1	0***	Yes
	Manganese	24	17	32.355	1	0***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

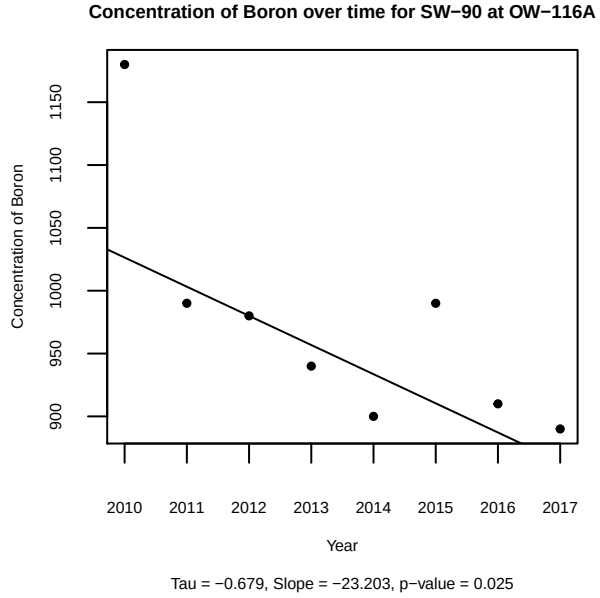
Table 2: Exceedance of thresholds by contaminant and Well ID

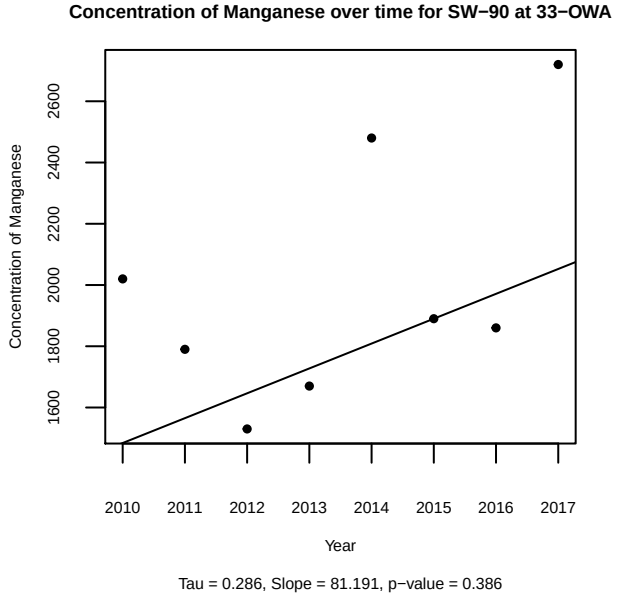
Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-90	Boron	33-OWA	3	5	0
		34-OWA	5	3	0
		OW-116A	8	0	0
	Manganese	33-OWA	8	0	0
		34-OWA	8	0	0
		OW-116A	7	1	0
	All	All	39	9	0

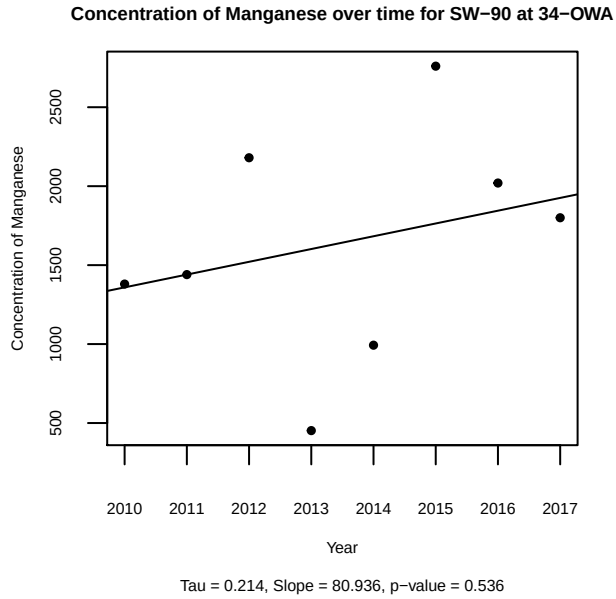
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

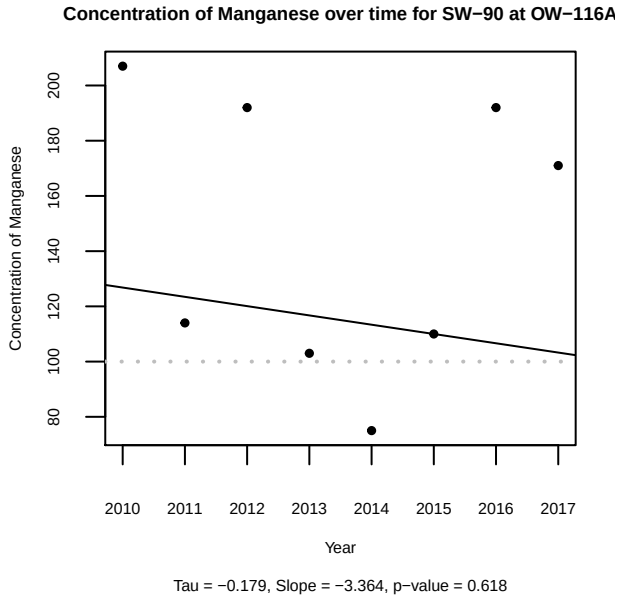
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

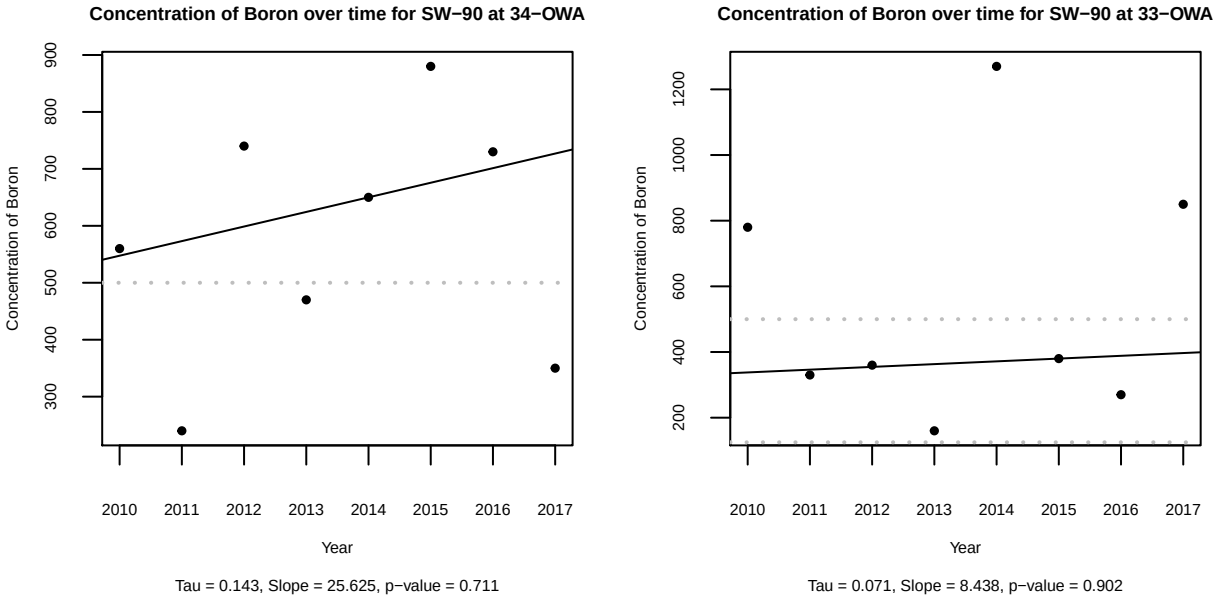
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.





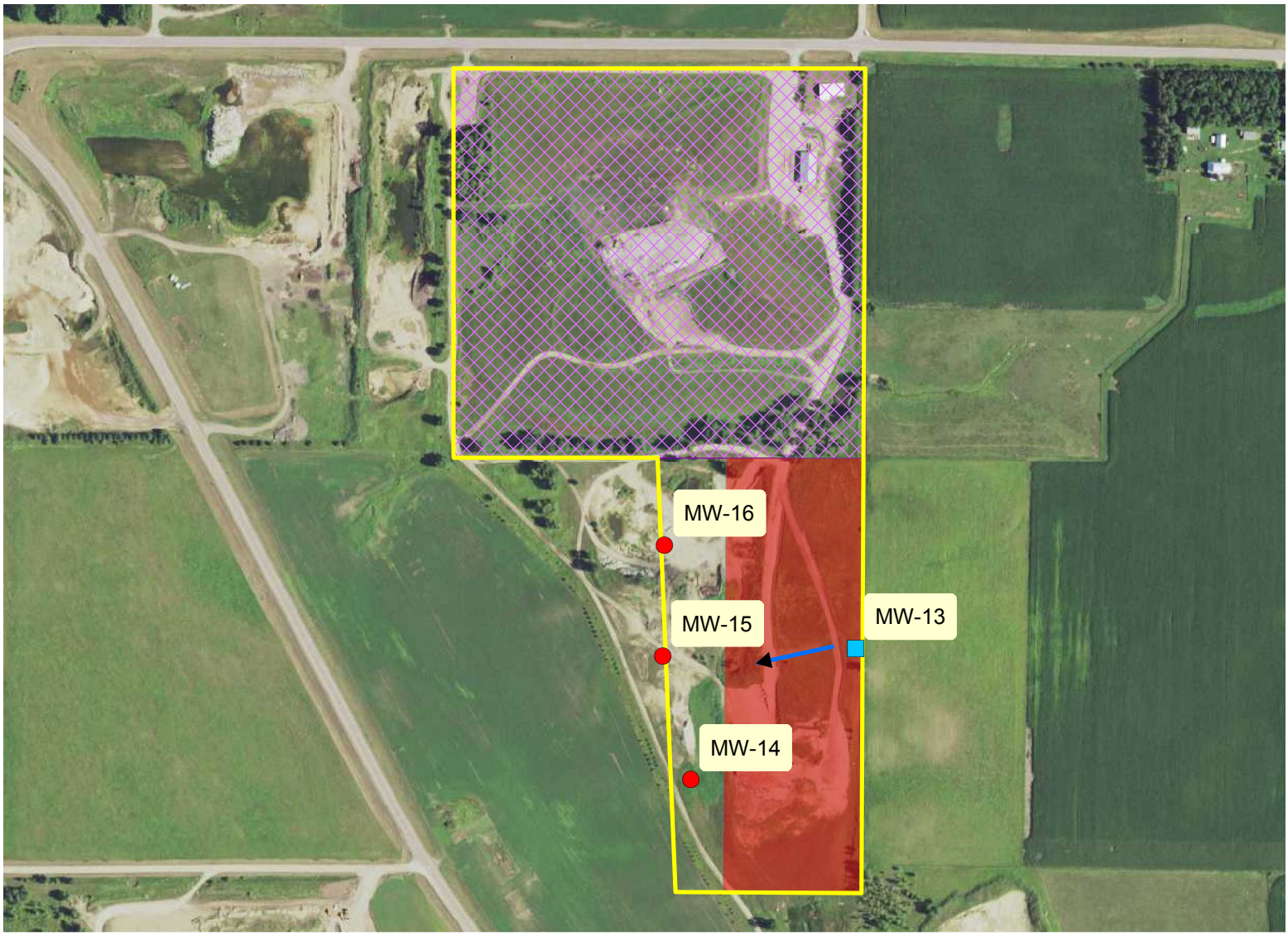






The concentration of Boron as measured in well OW-116A is decreasing over time (slope is negative and p-value is less than 0.05), however all points are above the HT. Monitoring wells 34-OWA and 33-OWA do not show any significant trends for Boron, however several points are above the HT. Manganese concentrations measured in wells OW-116A, 33-OWA, and 34-OWA do not show any significant trends. All points in 33-OWA and 34-OWA for Manganese were above the HT, all but one point in well OW-116A was above the HT.

SW- 143 Cottonwood County Sanitary Landfill



0 335 670 1,340 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-143 Cottonwood County Sanitary Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** Yard waste compost; Municipal Solid Waste cell is north of demo area. Previous PBR demo cells.
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to west-southwest

C. Facility impact on groundwater

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

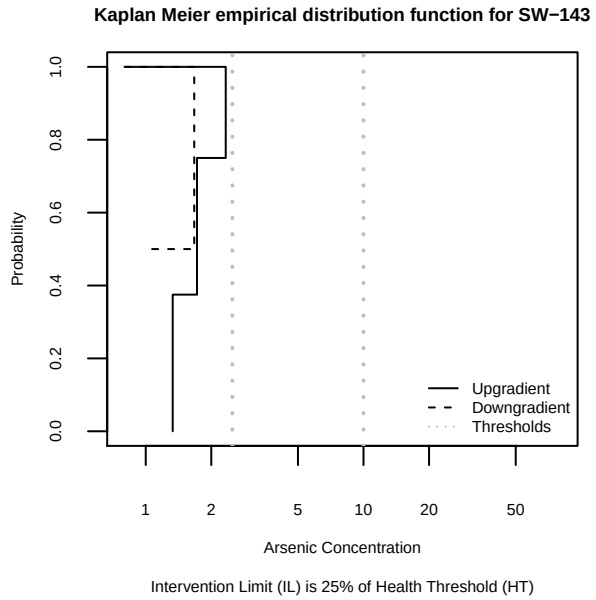
No trends were evaluated for this facility.

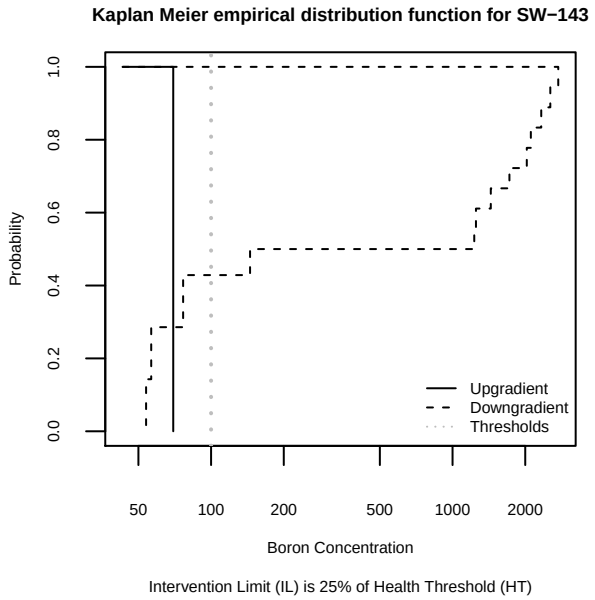
Kaplan Meier empirical distribution function (EDF)

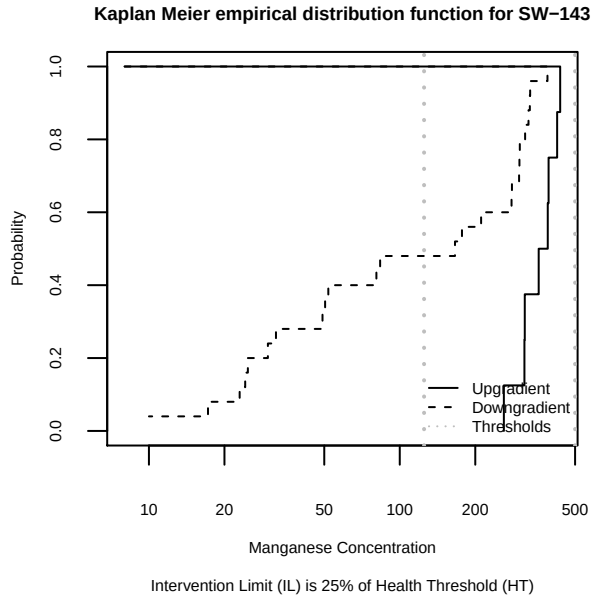
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

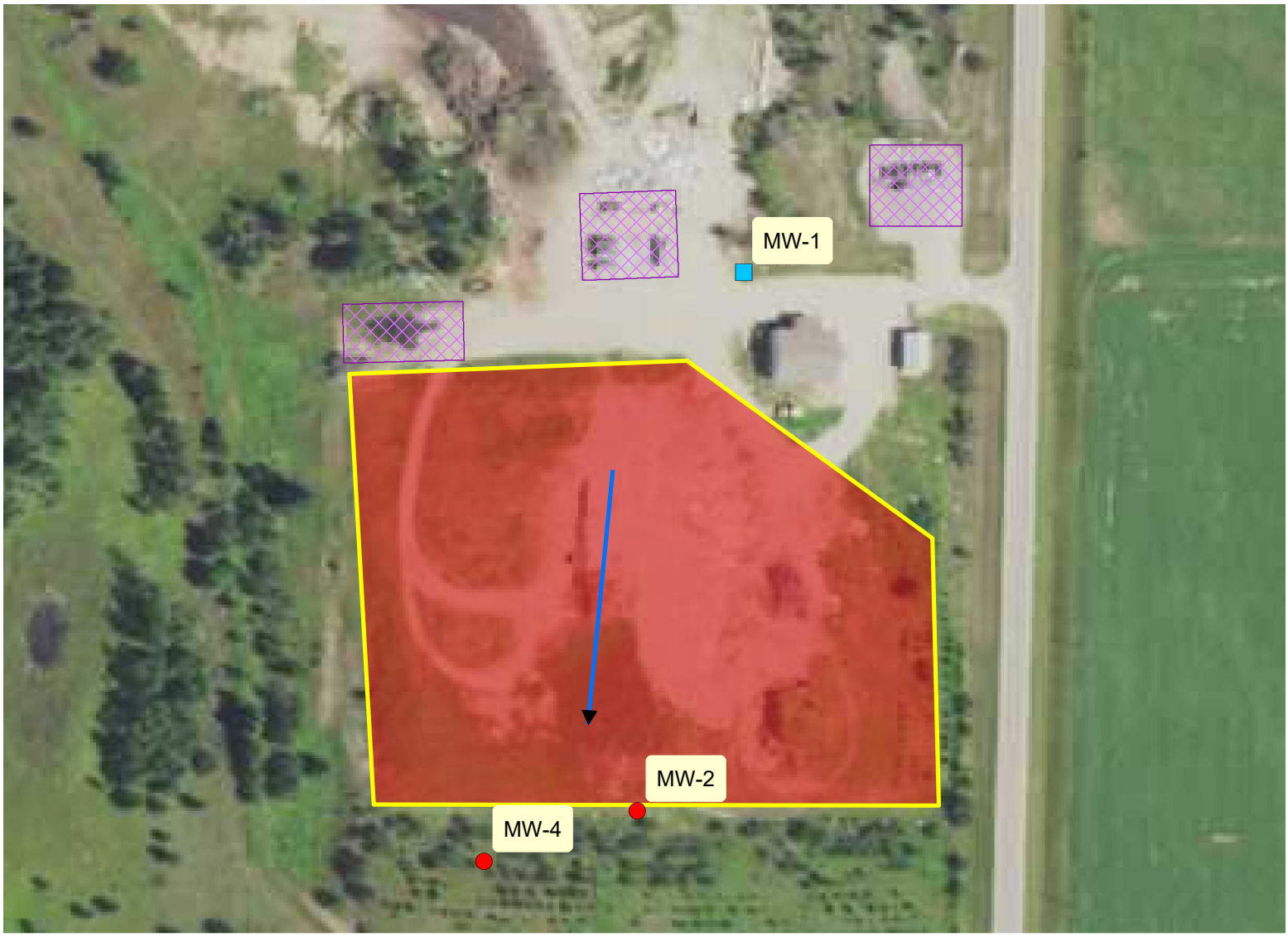
Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-143	Arsenic	15	5	2.597	1	0.054*	No
	Boron	18	3	1.663	1	0.099*	No
	Manganese	25	8	18.898	1	0***	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

SW-168 Clearwater County Demolition Debris Land Disposal



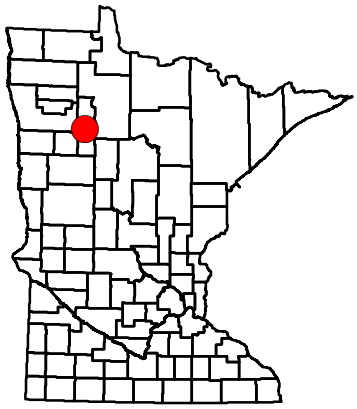
0 112.5 225 450 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-168 Clearwater County Demolition Debris Land Disposal

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to south

C. Facility impact on groundwater

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

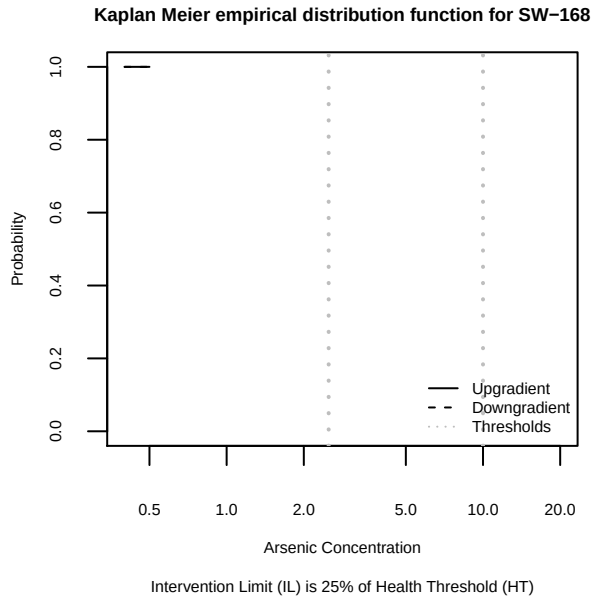
No trends were evaluated for this facility.

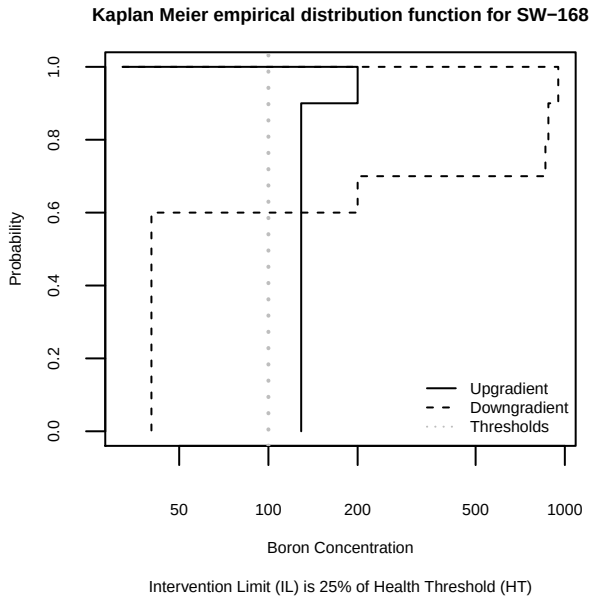
Kaplan Meier empirical distribution function (EDF)

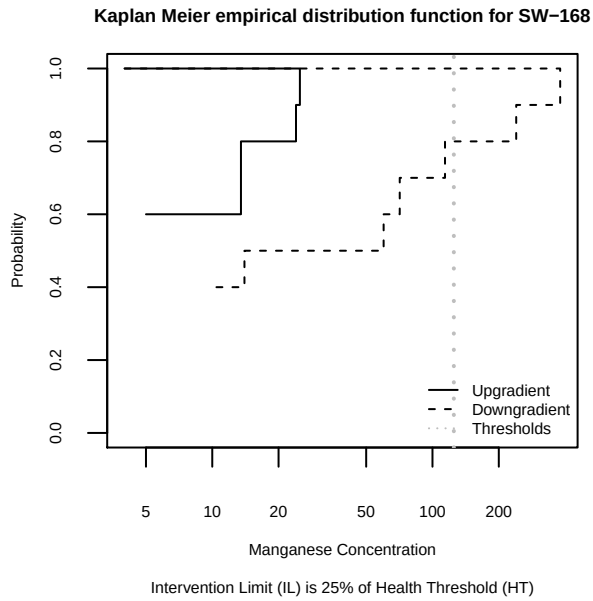
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-168	Arsenic	10	10	0.000	-1	NA	No
	Boron	10	10	1.421	1	0.117	No
	Manganese	10	10	2.697	1	0.05*	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

SW-188 Henkemeyer Demolition Landfill

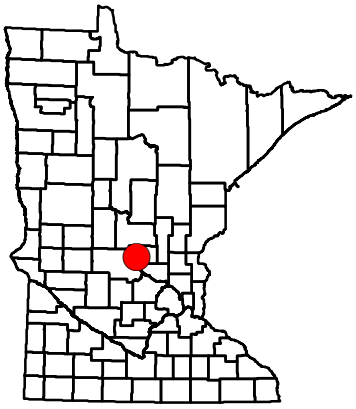
0 165 330 660 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-188 Henkemeyer Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** Recycling area
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 2
2. **Downgradient well(s):** 7
3. **Groundwater flow:** to northwest

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

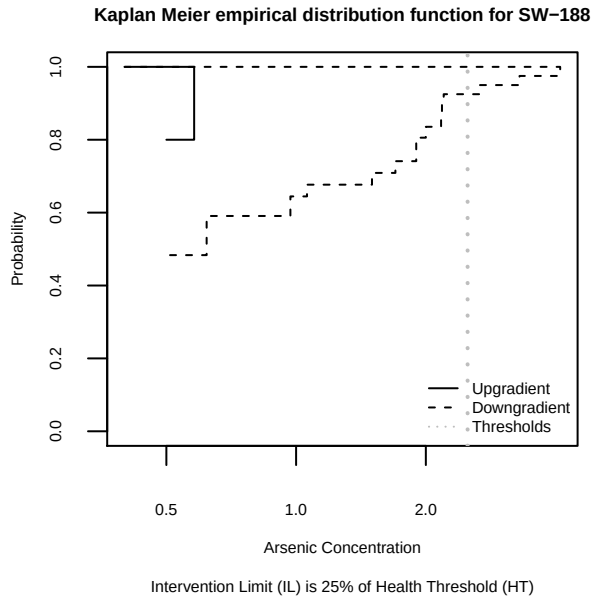
The concentration of Manganese as measured in well MW-2 is decreasing over time (slope is negative and p-value is less than 0.05), however all points are above the HT. The concentration of Manganese as measured in well MW-5 is increasing over time (slope is positive and p-value is less than 0.05), however all points are above the HT. The remaining well trends are not statistically significant.

Kaplan Meier empirical distribution function (EDF)

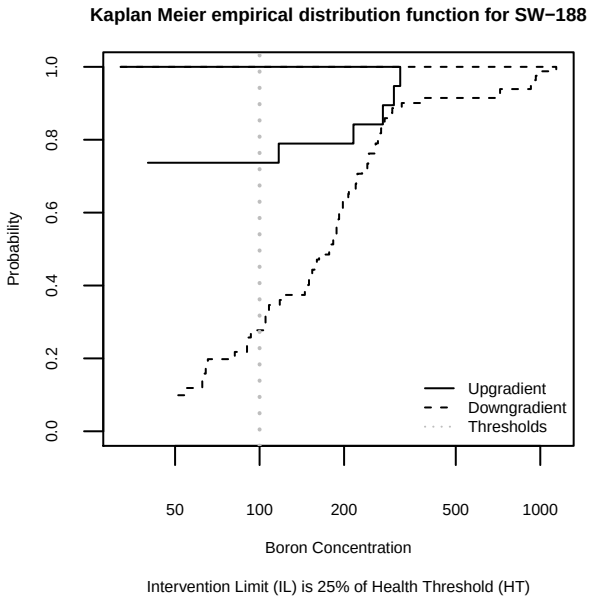
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

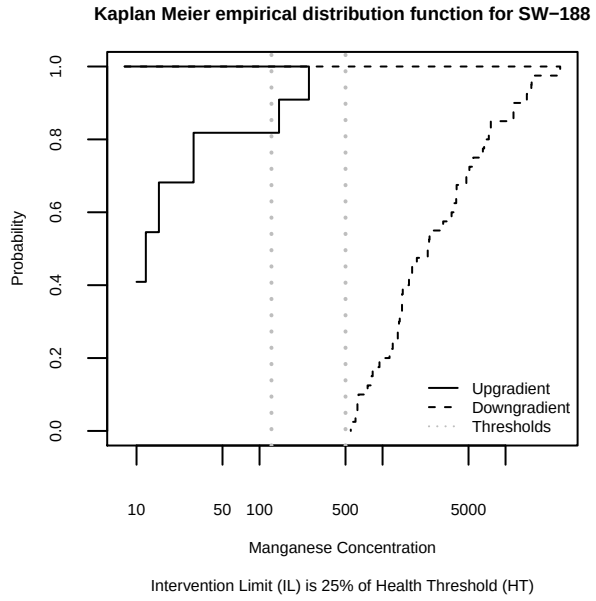
The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)

Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-188	Arsenic	40	11	3.742	1	0.027**	Yes
	Boron	82	22	10.761	1	0.001***	Yes
	Manganese	40	11	21.483	1	0***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-188	Arsenic	MW-10	0	0	5
		MW-10R	0	0	6
		MW-11	0	0	3
		MW-12	0	0	3
		MW-2	0	1	8
		MW-5	0	0	8
		MW-9	0	2	4
	Boron	MW-10	0	10	3
		MW-10R	0	5	3
		MW-11	0	6	1
		MW-12	6	1	0
		MW-2	0	0	18
		MW-5	0	12	5
		MW-9	1	5	6
	Manganese	MW-10	5	0	0
		MW-10R	6	0	0
		MW-11	3	0	0
		MW-12	3	0	0
		MW-2	9	0	0
		MW-5	8	0	0
		MW-9	6	0	0
	All	All	47	42	73

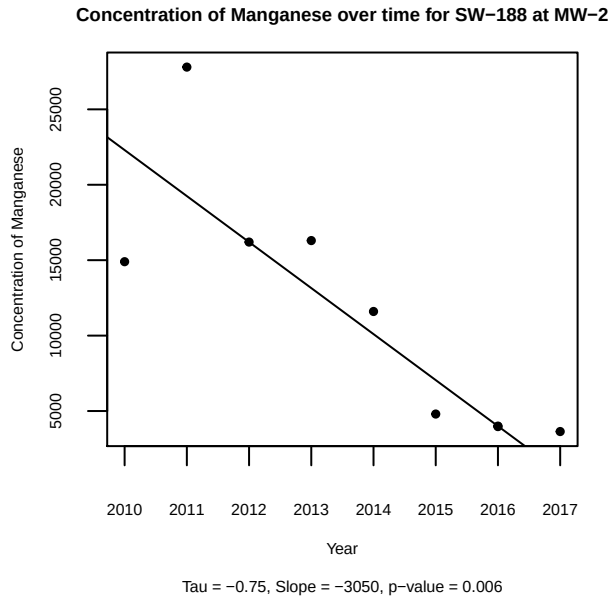
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

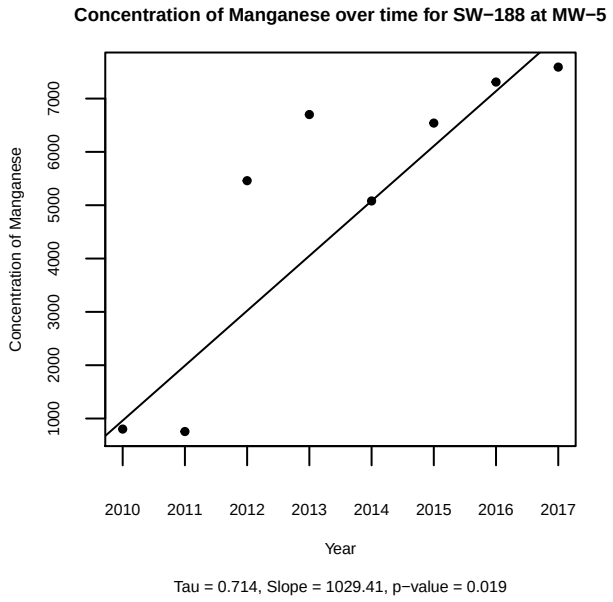
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

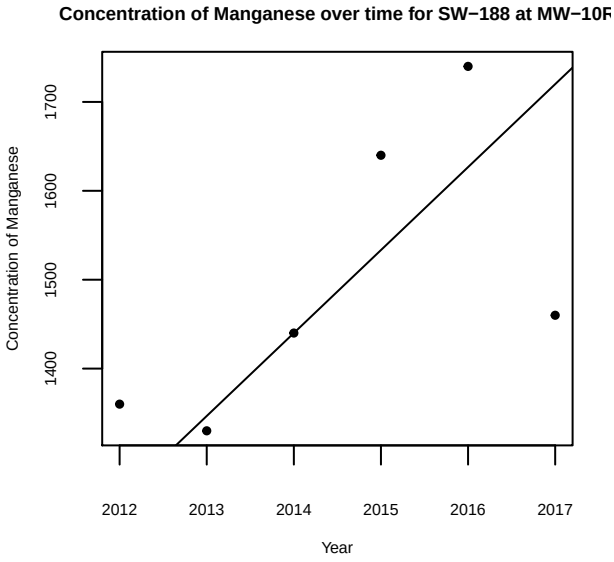
Table 3: Well/contaminant combinations where trends cannot be evaluated

Well ID	Contaminant	Number of measured values	Number of censored values	Total
MW-10R	Arsenic	0	6	6
MW-11	Arsenic	1	2	3
MW-12	Arsenic	0	3	3

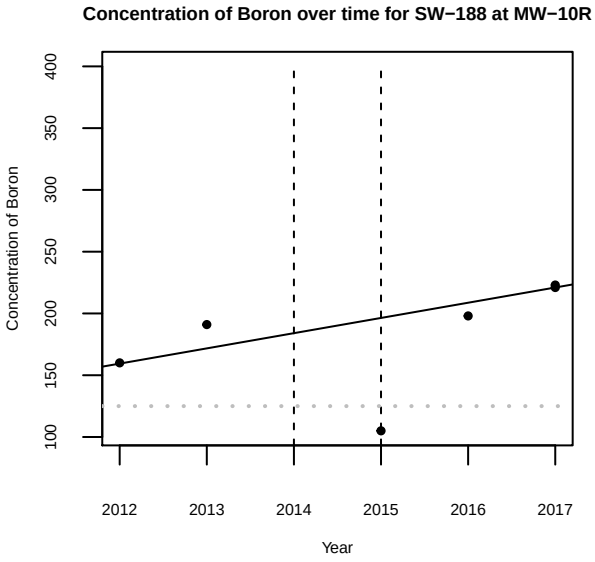
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



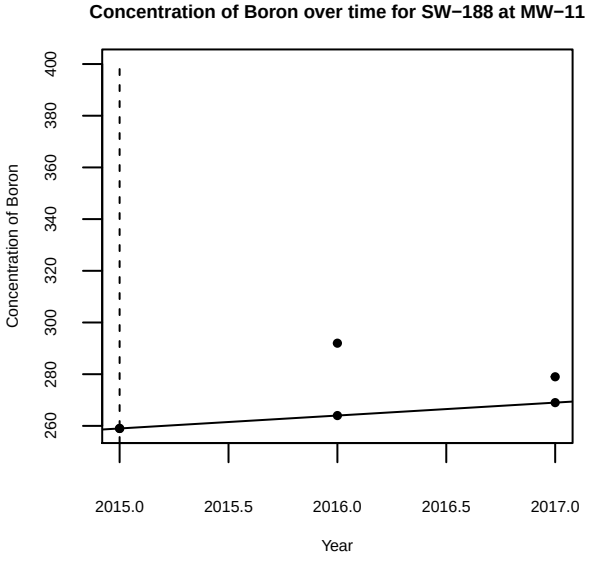




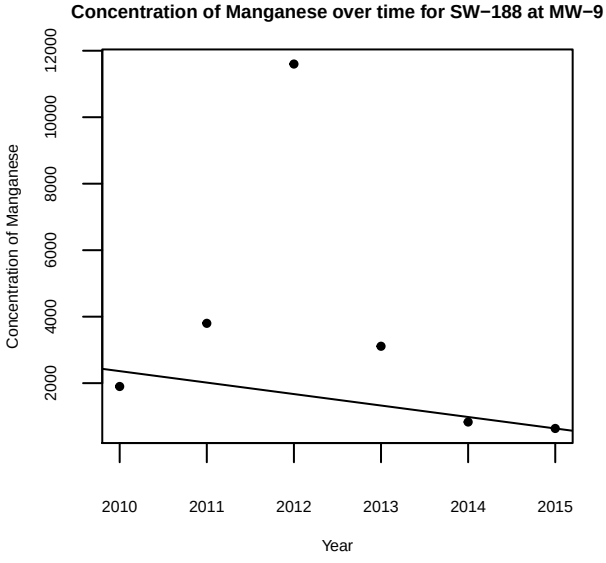
Tau = 0.6, Slope = 93.333, p−value = 0.133



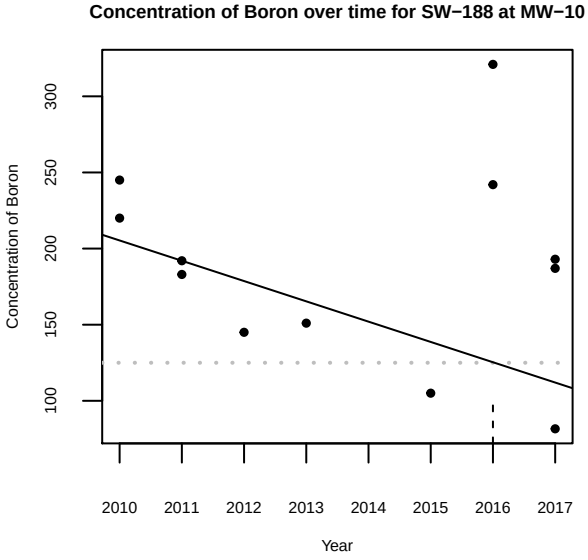
Tau = 0.357, Slope = 12.32, p−value = 0.205



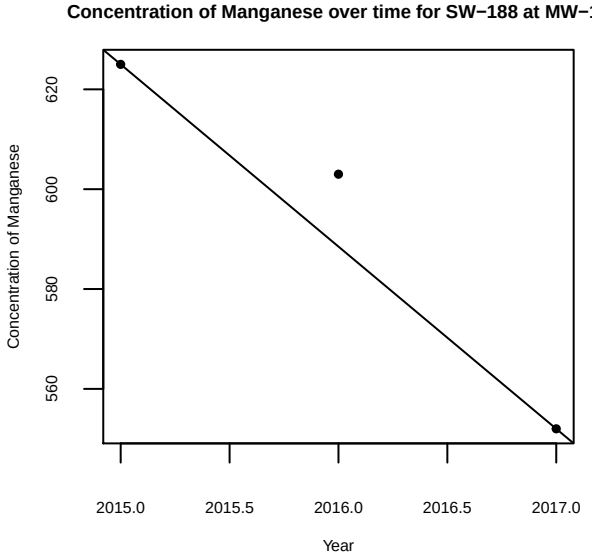
Tau = 0.381, Slope = 5, p−value = 0.215



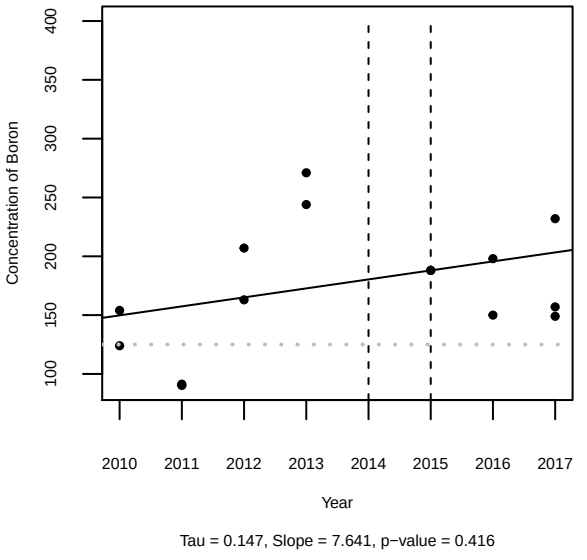
Tau = −0.467, Slope = −345, p−value = 0.26



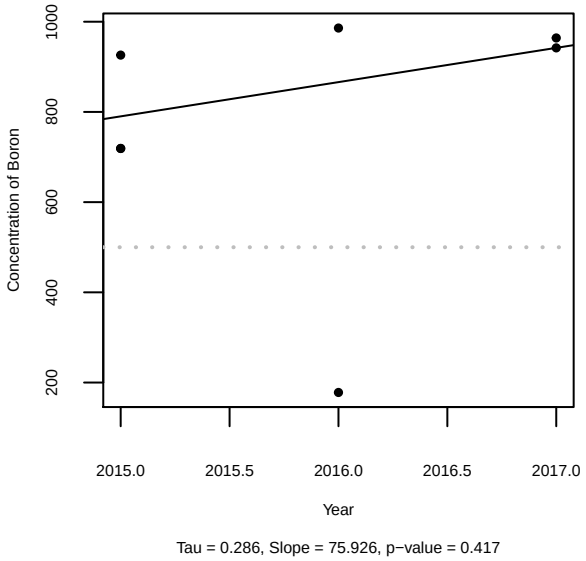
Tau = −0.244, Slope = −13.333, p−value = 0.263



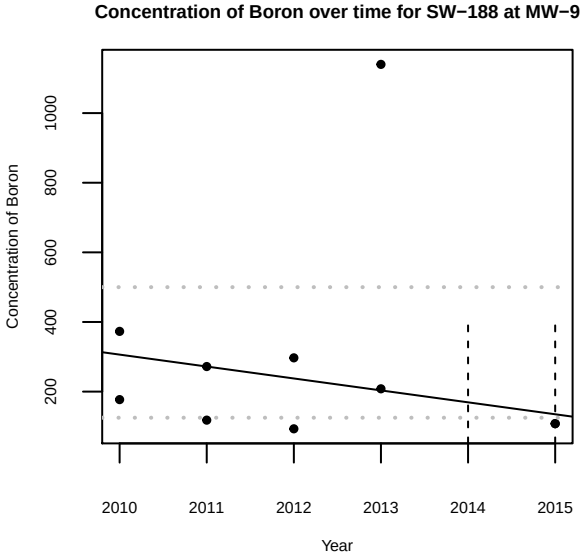
Tau = −1, Slope = −36.5, p−value = 0.296



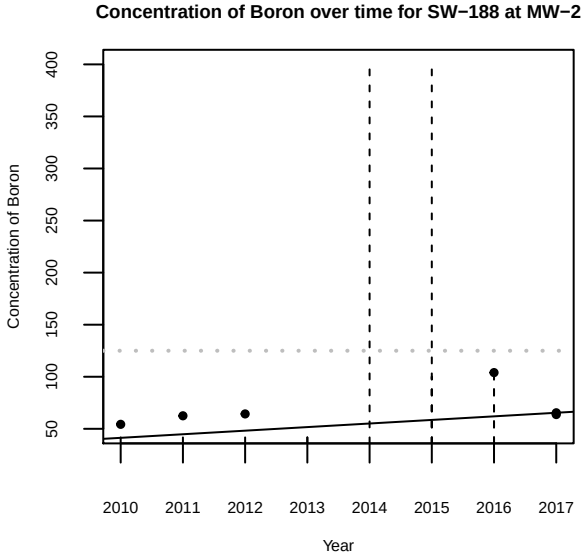
Tau = 0.147, Slope = 7.641, p−value = 0.416



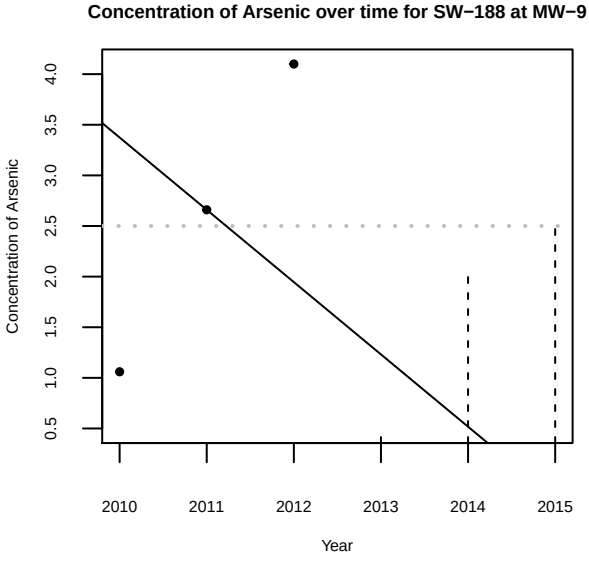
Tau = 0.286, Slope = 75.926, p−value = 0.417



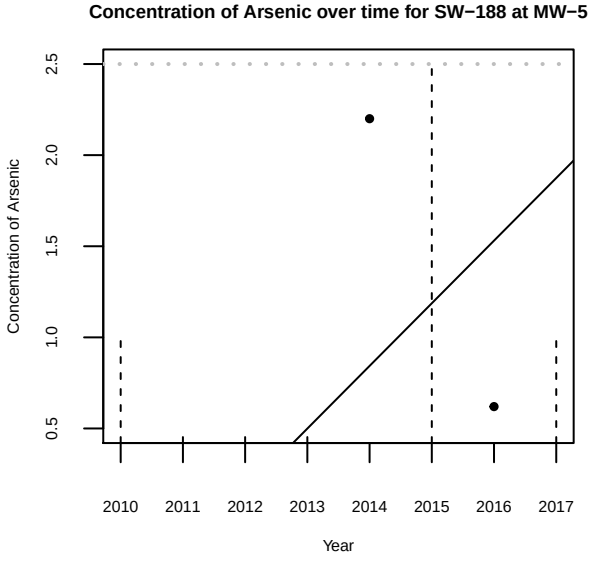
Tau = −0.182, Slope = −34.27, p−value = 0.419



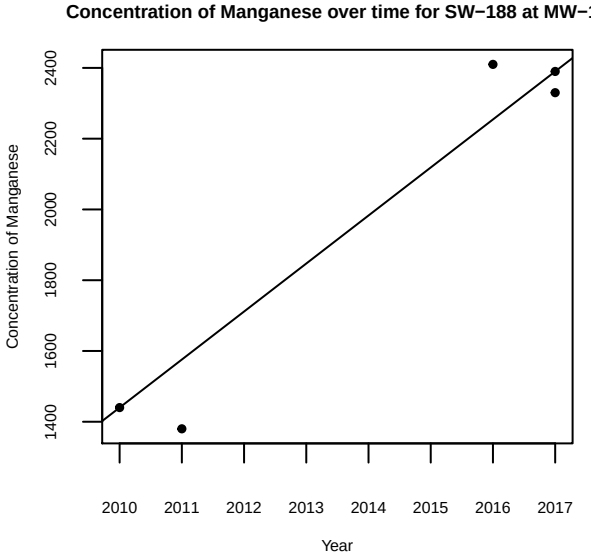
Tau = 0.124, Slope = 3.438, p−value = 0.443



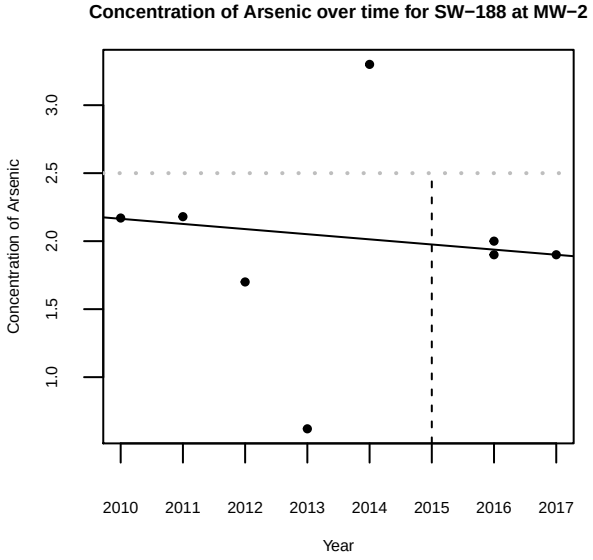
Tau = −0.267, Slope = −0.714, p−value = 0.535



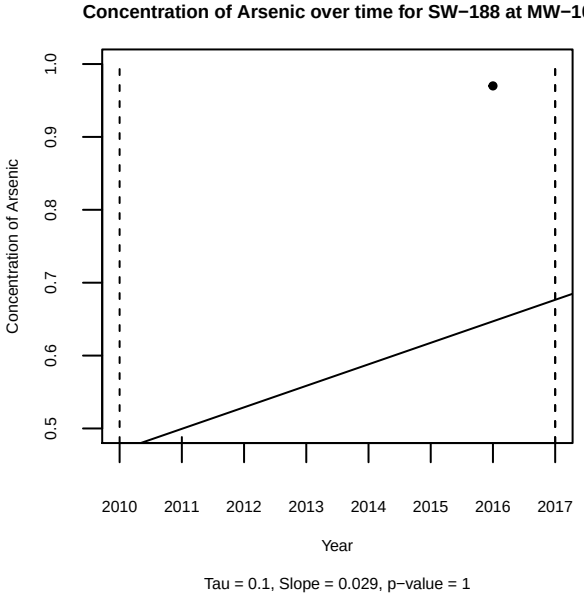
Tau = 0.179, Slope = 0.344, p−value = 0.55



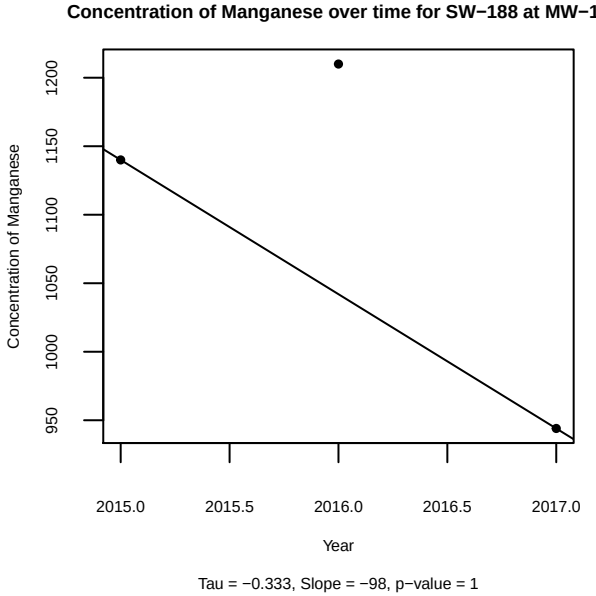
Tau = 0.3, Slope = 135.714, p−value = 0.613



Tau = −0.139, Slope = −0.038, p−value = 0.661



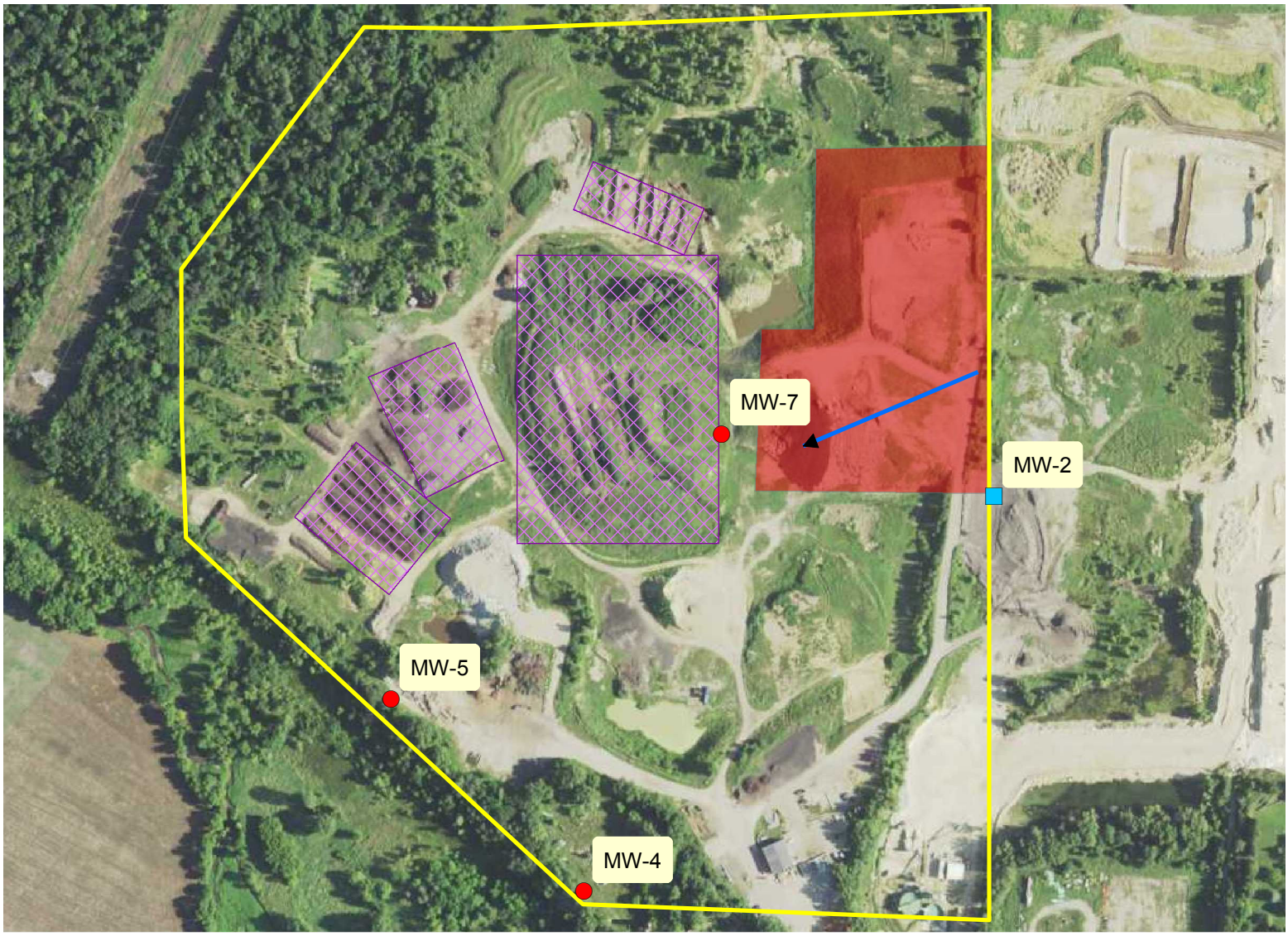
Tau = 0.1, Slope = 0.029, p−value = 1



Tau = −0.333, Slope = −98, p−value = 1

The concentration of Manganese as measured in well MW-2 is decreasing over time (slope is negative and p-value is less than 0.05), however all points are above the HT. The concentration of Manganese as measured in well MW-5 is increasing over time (slope is positive and p-value is less than 0.05), however all points are above the HT. The remaining well trends are not statistically significant.

SW- 254 Pilgrim Demolition Landfill



0 280 560 1,120 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-254 Pilgrim Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill, partialy covered
2. **Other solid waste:** Site has been used for yard waste composting, shingle grinding, and concrete recycling. This facility does not sample for Boron.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to southwest

C. Facility impact on groundwater

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

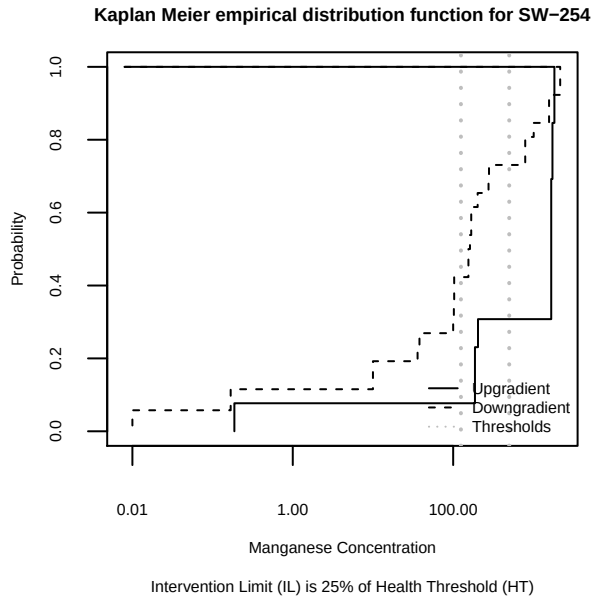
No trends were evaluated for this facility.

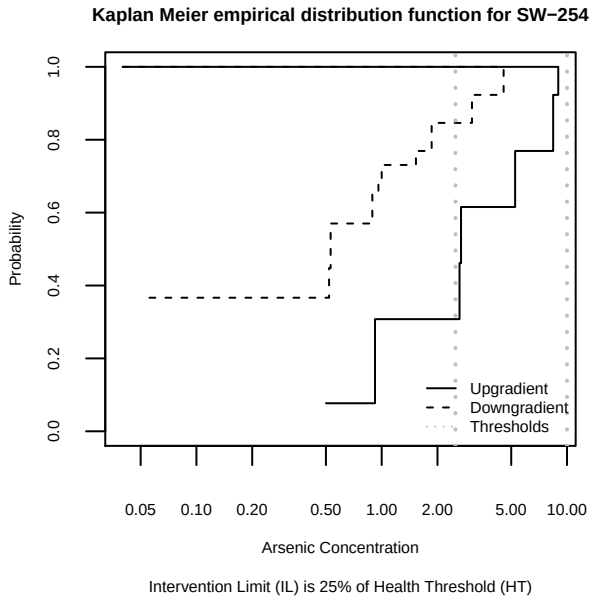
Kaplan Meier empirical distribution function (EDF)

Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.





Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

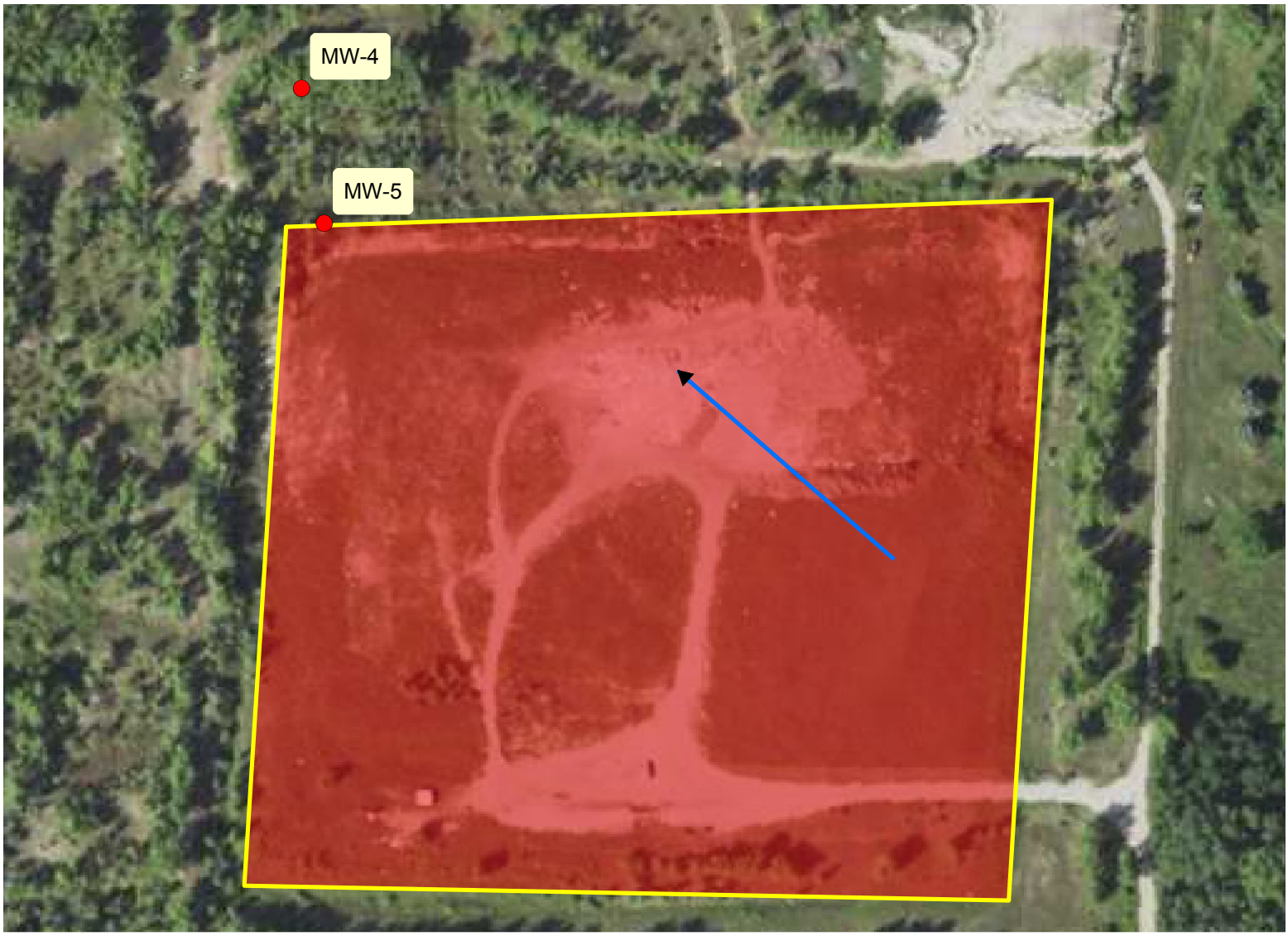
Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-254	Arsenic	26	13	12.445	1	0***	No
	Manganese	26	13	10.724	1	0.001***	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

SW- 277 Clay Demolition Landfill



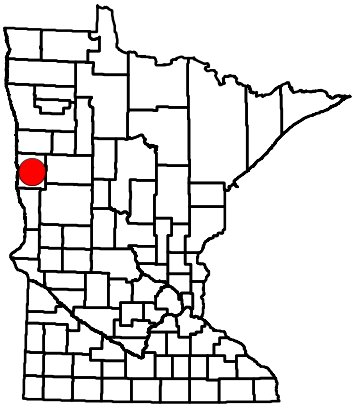
0 140 280 560 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-277 Clay Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1, first permitted in 2002
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 0
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to the northwest

C. Facility impact on groundwater

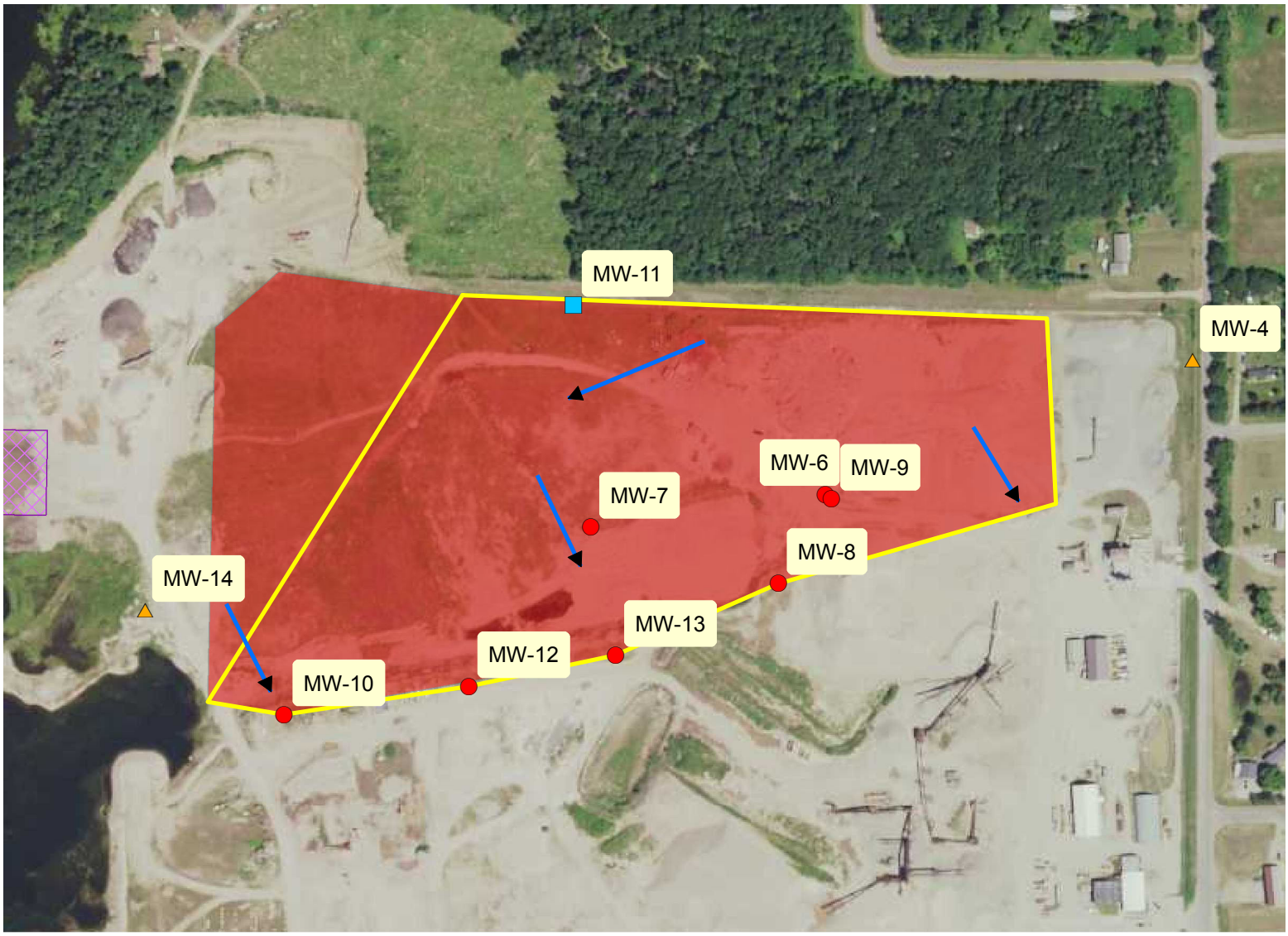
Facility lacks sample results from upgradient wells and thus cannot be evaluated for impacts to groundwater.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

No trends were evaluated for this facility.

SW- 291 Hengel Ready Mix & Construction Inc



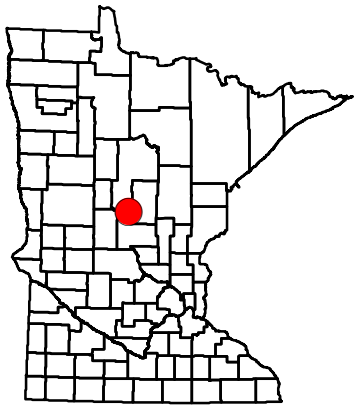
0 225 450 900 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-291 Hengel Ready Mix & Construction Inc

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** Yard waste composting and concrete production plant.
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 7
3. **Groundwater flow:** to southwest and southeast

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

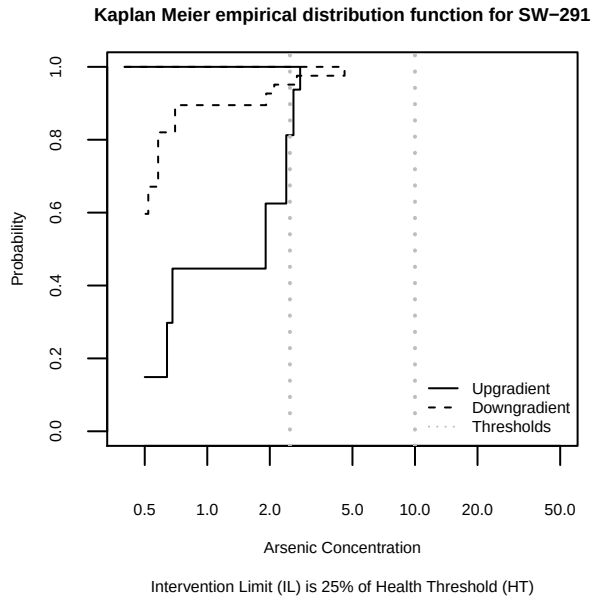
The concentration of Boron as measured in well MW-12 is increasing over time (slope is positive and p-value is less than 0.05). All points are greater than the IL, from 2012 to 2017 the points are above the HT. The remaining well trends are not statistically significant.

Kaplan Meier empirical distribution function (EDF)

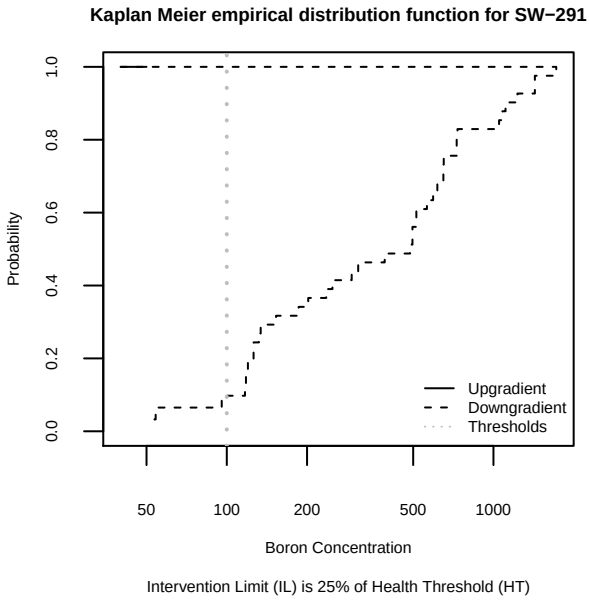
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

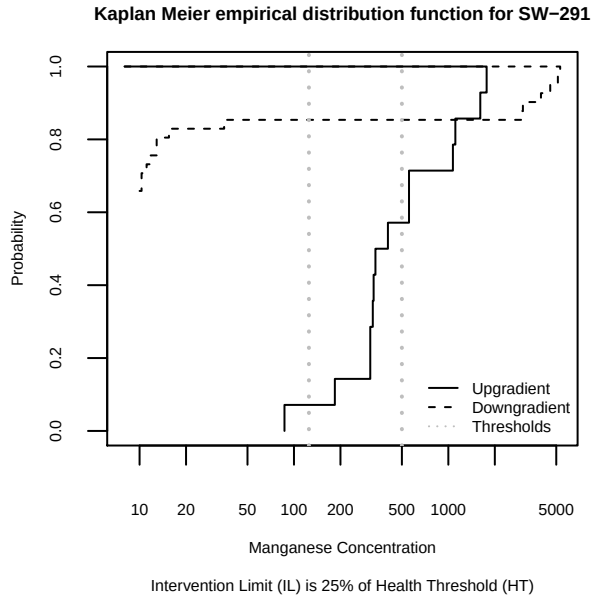
The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)

Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-291	Arsenic	44	16	13.467	1	0***	No
	Boron	41	14	24.297	1	0***	Yes
	Manganese	41	14	23.698	1	0***	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-291	Boron	MW-10	7	4	0
		MW-12	7	4	0
		MW-13	0	6	5
		MW-6	0	1	1
		MW-7	2	0	0
		MW-8	0	0	2
		MW-9	2	0	0
	All	All	18	15	8

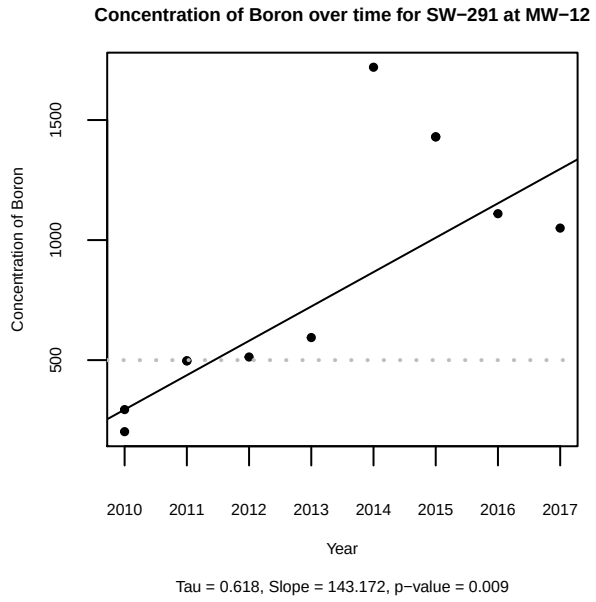
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

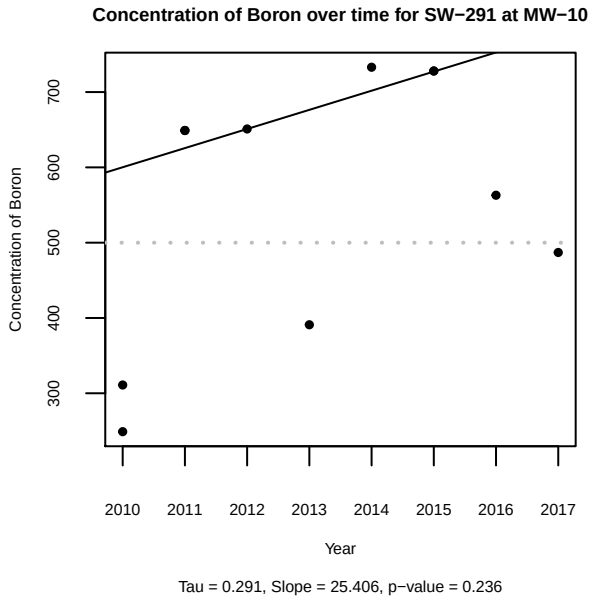
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

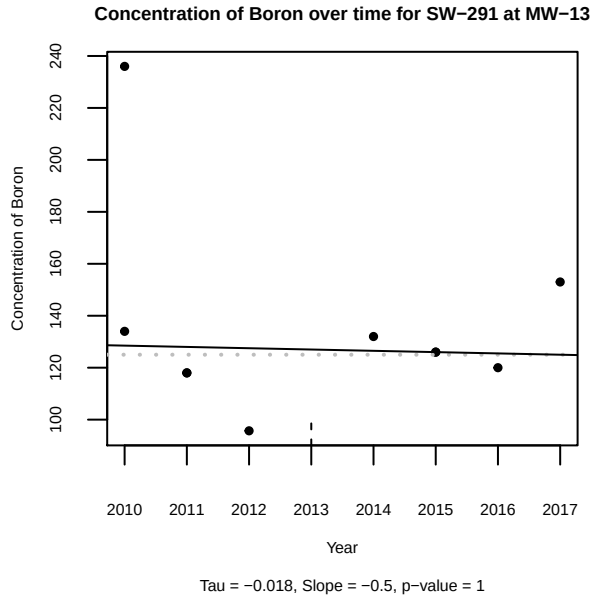
Table 3: Well/contaminant combinations where trends cannot be evaluated

Well ID	Contaminant	Number of measured values	Number of censored values	Total
MW-6	Boron	2	0	2
MW-7	Boron	2	0	2
MW-8	Boron	1	1	2
MW-9	Boron	2	0	2

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.







The concentration of Boron as measured in well MW-12 is increasing over time (slope is positive and p-value is less than 0.05). All points are greater than the IL, from 2012 to 2017 the points are above the HT. The remaining well trends are not statistically significant.

SW- 303 Dawnway Demolition Landfill

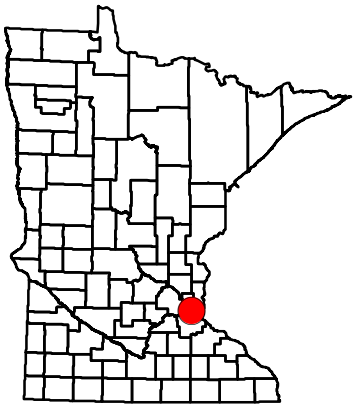
0 225 450 900 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-303 Dawnway Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 5
3. **Groundwater flow:** southwest and west

C. Facility impact on groundwater

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

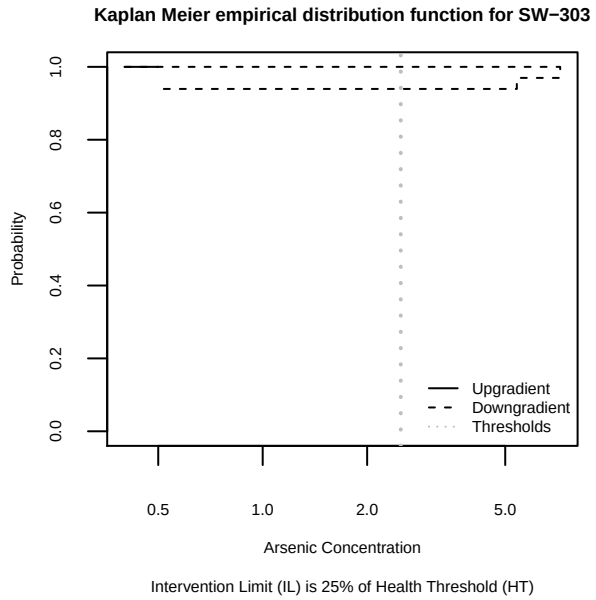
No trends were evaluated for this facility.

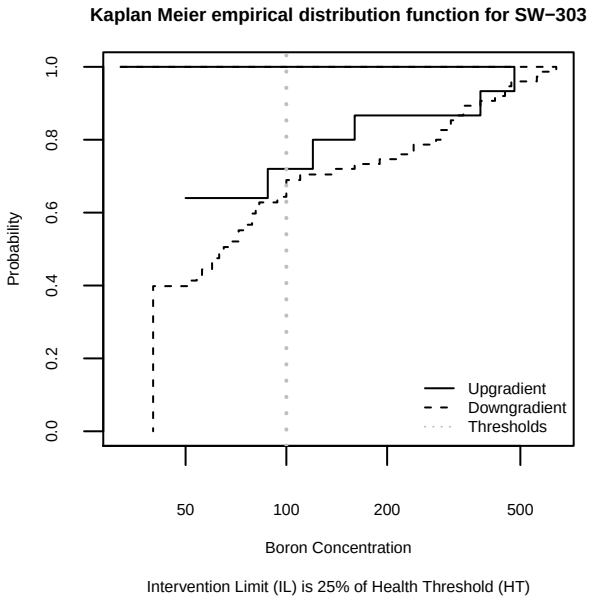
Kaplan Meier empirical distribution function (EDF)

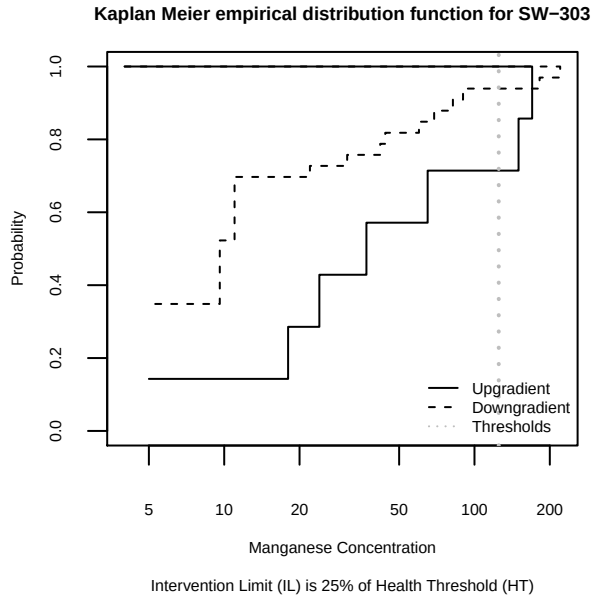
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

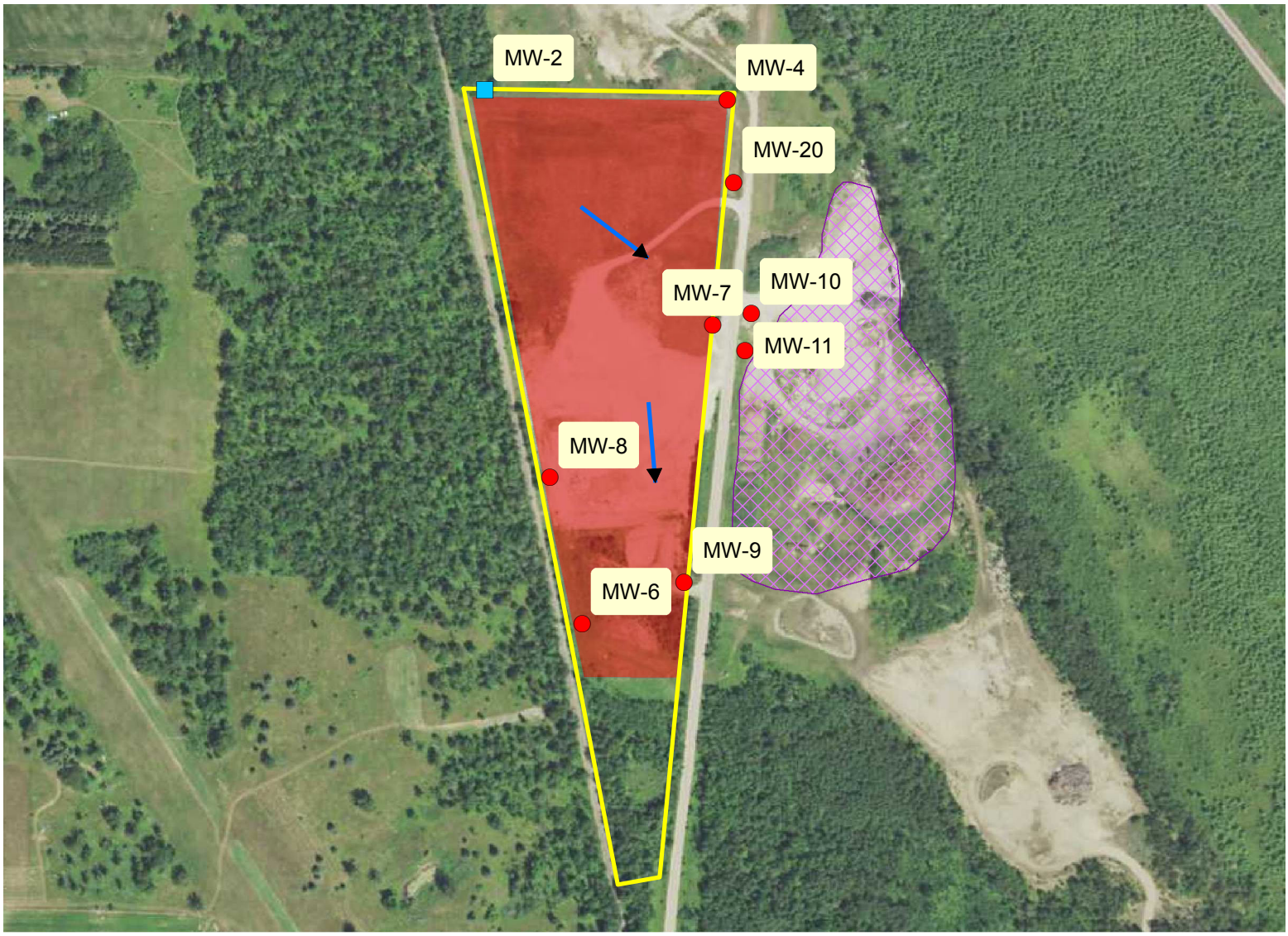
Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-303	Arsenic	33	7	0.431	1	0.256	No
	Boron	75	15	1.174	1	0.139	No
	Manganese	33	7	4.412	1	0.018**	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

SW- 306 Beltrami County Demolition Landfill



0 280 560 1,120 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-306 Beltrami County Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill opened in 1987
2. **Other solid waste:** Recycling area to east
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 8
3. **Groundwater flow:** Slow, complex flow to south and southwest. Flat gardient.

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

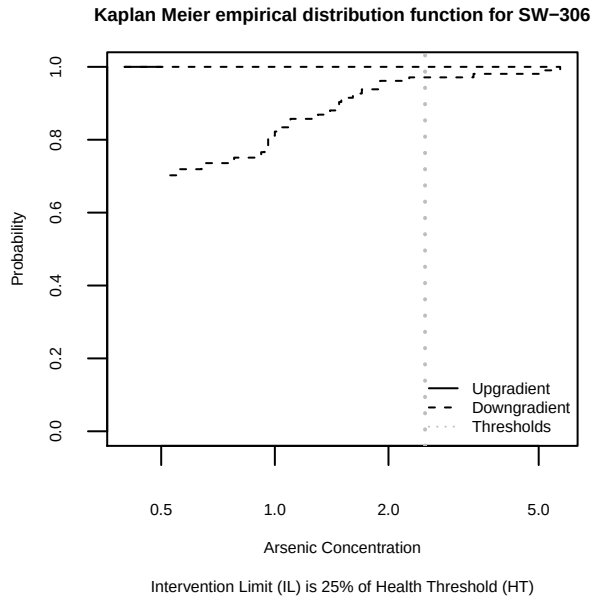
The concentration of Arsenic as measured in well MW-7 is decreasing over time (slope is negative and p-value is less than 0.05), from 2012 to 2017 the points are below the IL. The concentration of Manganese as measured in well MW-8 is decreasing over time (slope is positive and p-value is less than 0.05), from 2015 to 2017 the points are below the HT. The remaining well trends are not statistically significant.

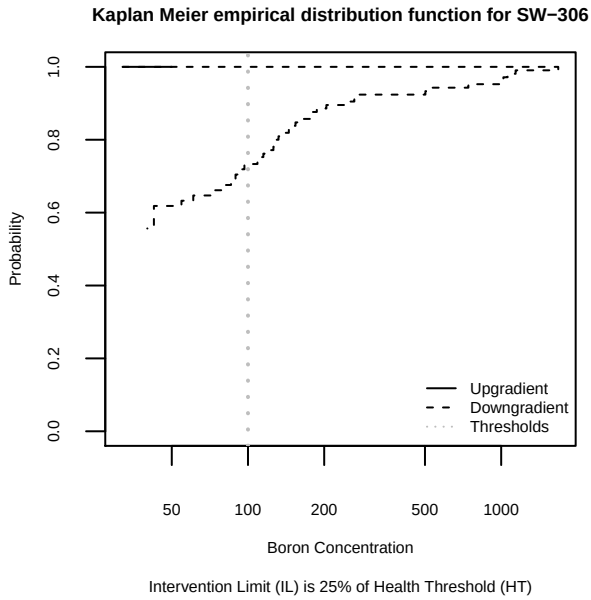
Kaplan Meier empirical distribution function (EDF)

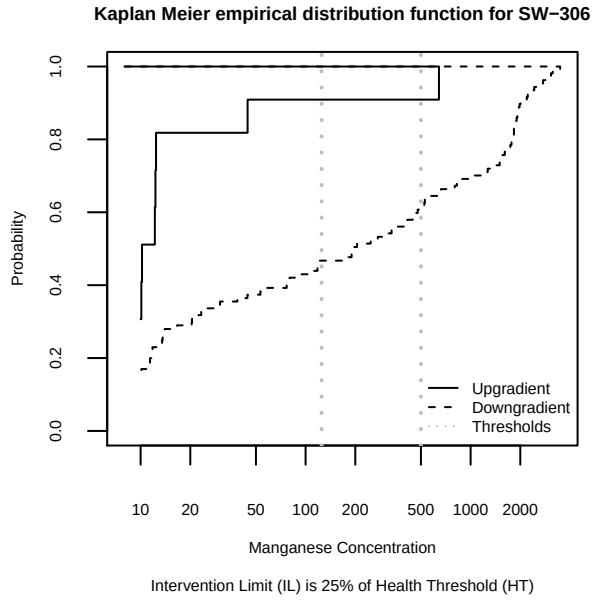
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-306	Arsenic	104	11	3.049	1	0.04**	Yes
	Boron	105	11	4.501	1	0.017**	Yes
	Manganese	107	11	7.199	1	0.004***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-306	Arsenic	MW-10	0	0	15
		MW-11	0	0	14
		MW-20	0	0	2
		MW-4	0	0	16
		MW-6	0	0	14
		MW-7	0	3	11
		MW-8	0	0	14
		MW-9	0	0	15
	Boron	MW-10	0	8	7
		MW-11	0	0	14
		MW-20	3	0	0
		MW-4	0	0	16
		MW-6	0	0	13
		MW-7	4	8	2
		MW-8	0	0	14
		MW-9	1	0	15
	Manganese	MW-10	0	3	11
		MW-11	15	0	0
		MW-20	3	0	0
		MW-4	17	0	0
		MW-6	1	0	12
		MW-7	15	0	0
		MW-8	8	6	0
		MW-9	2	1	13
	All	All	69	29	218

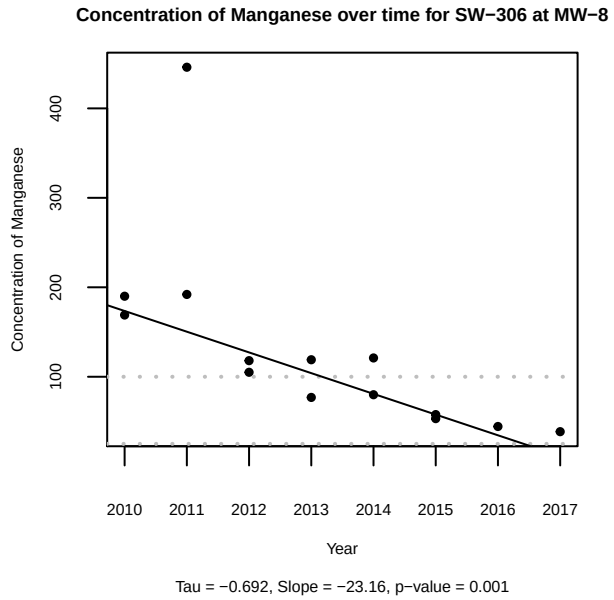
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

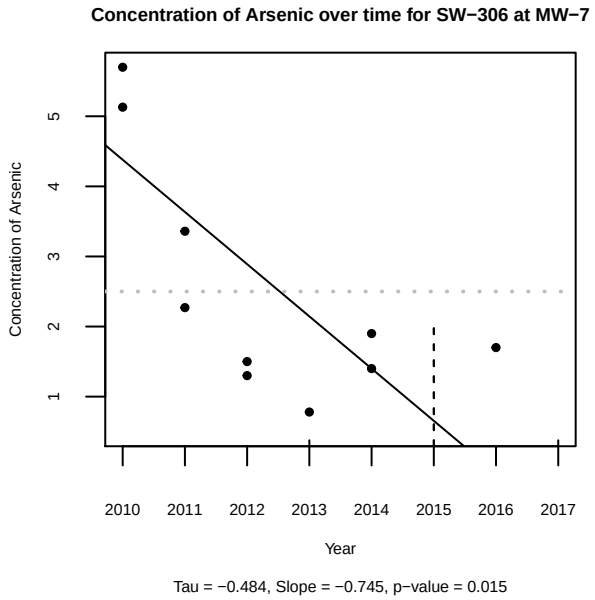
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

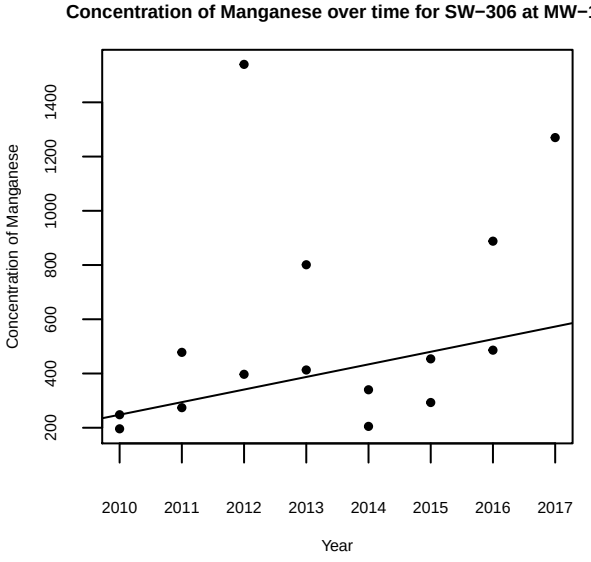
Table 3: Well/contaminant combinations where trends cannot be evaluated

Well ID	Contaminant	Number of measured values	Number of censored values	Total
MW-10	Arsenic	0	15	15
MW-6	Arsenic	0	14	14
MW-6	Boron	0	13	13
MW-8	Boron	0	14	14

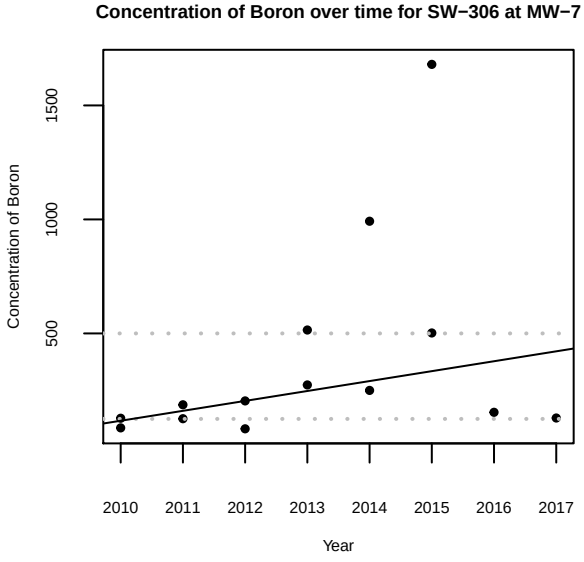
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



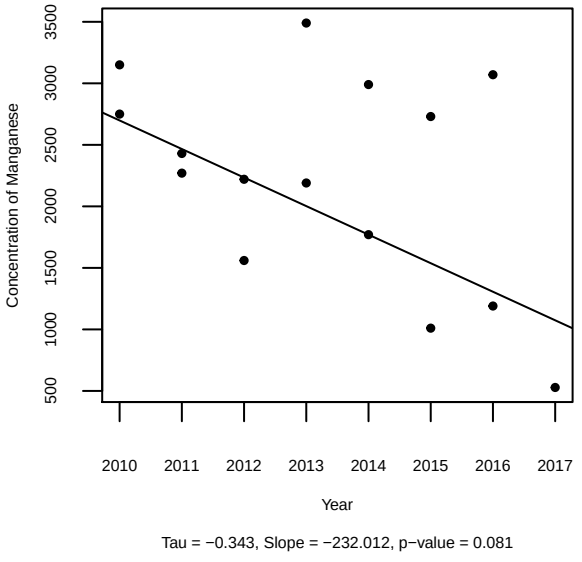




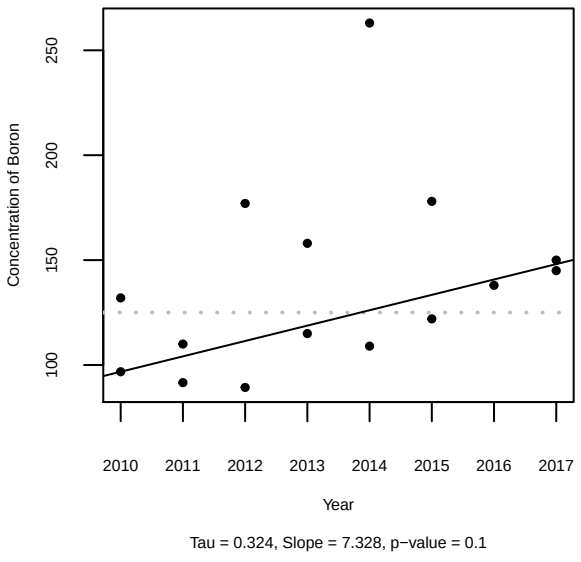
Tau = 0.381, Slope = 46.423, p−value = 0.052



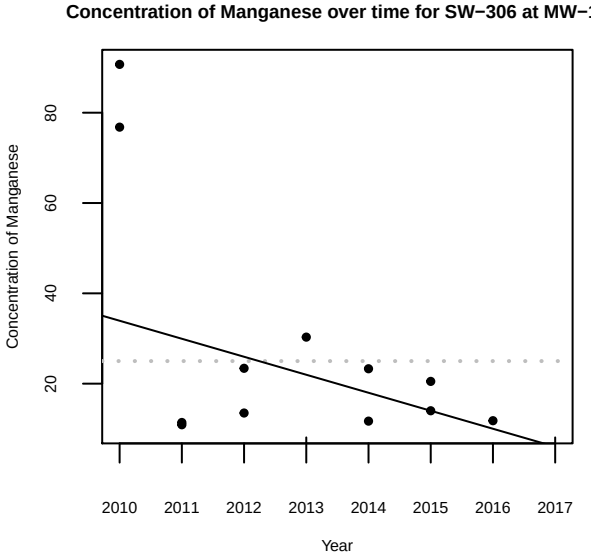
Tau = 0.363, Slope = 43.5, p−value = 0.077



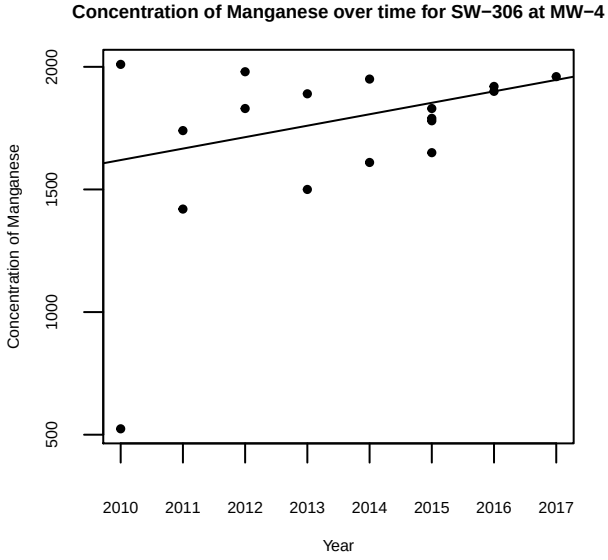
Tau = −0.343, Slope = −232.012, p−value = 0.081



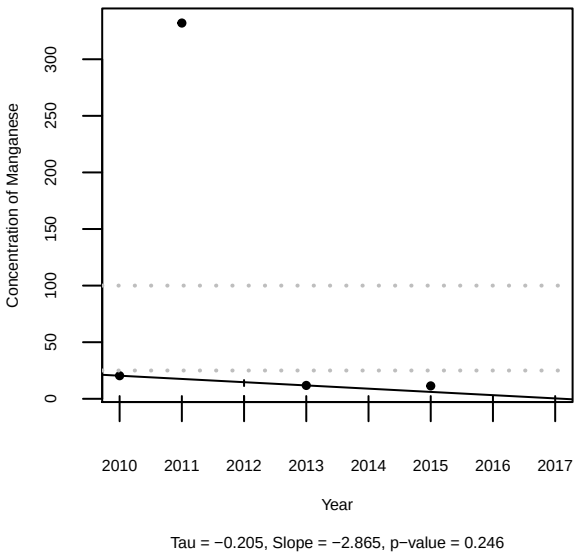
Tau = 0.324, Slope = 7.328, p−value = 0.1



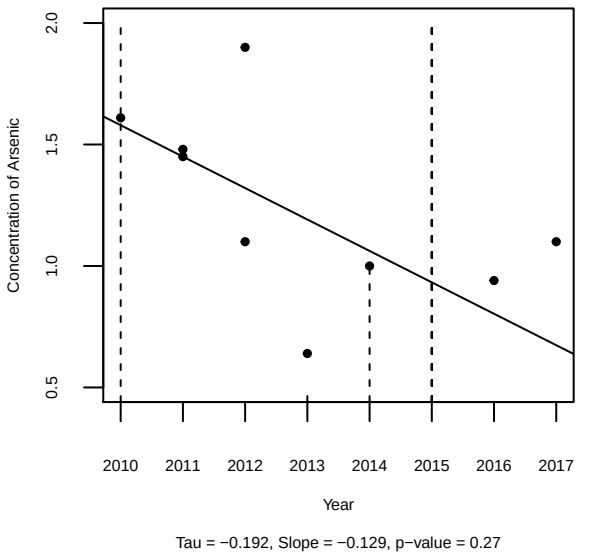
Tau = −0.286, Slope = −3.985, p−value = 0.167



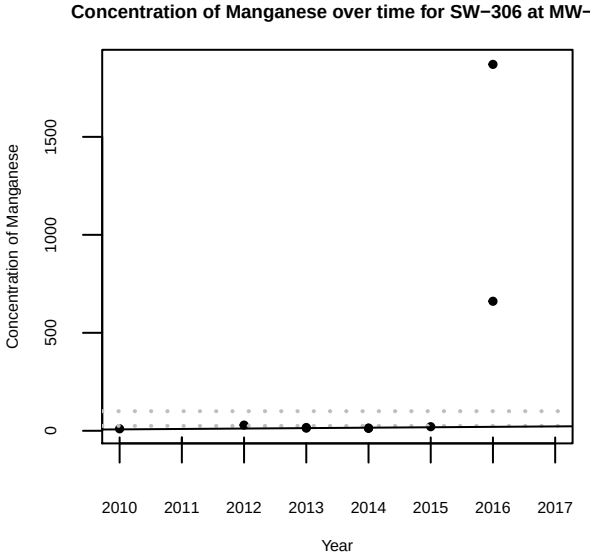
Tau = 0.243, Slope = 46.686, p−value = 0.182



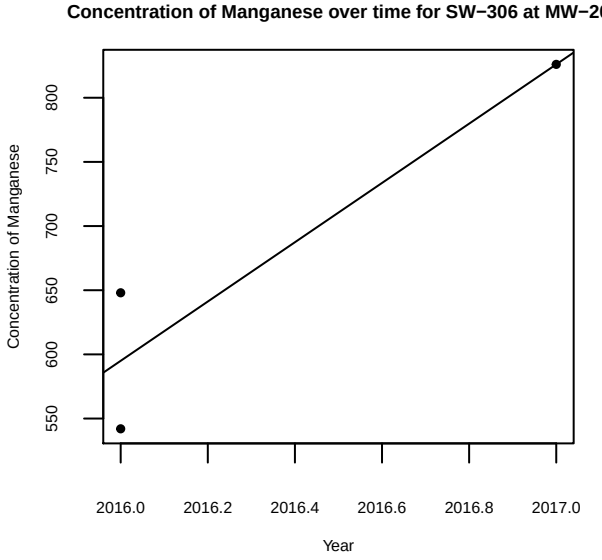
Tau = −0.205, Slope = −2.865, p−value = 0.246



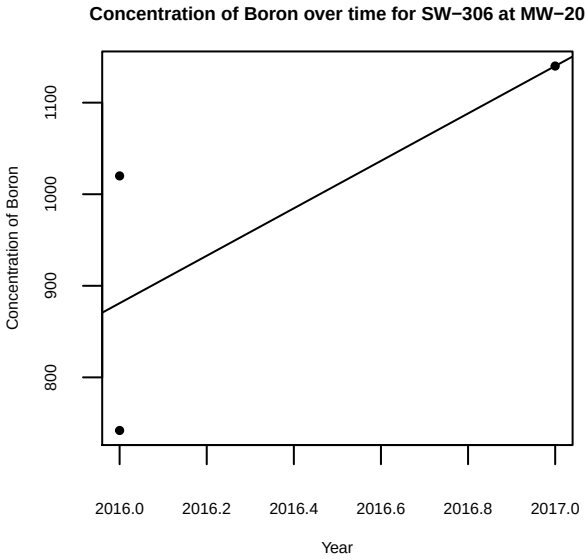
Tau = −0.192, Slope = −0.129, p−value = 0.27



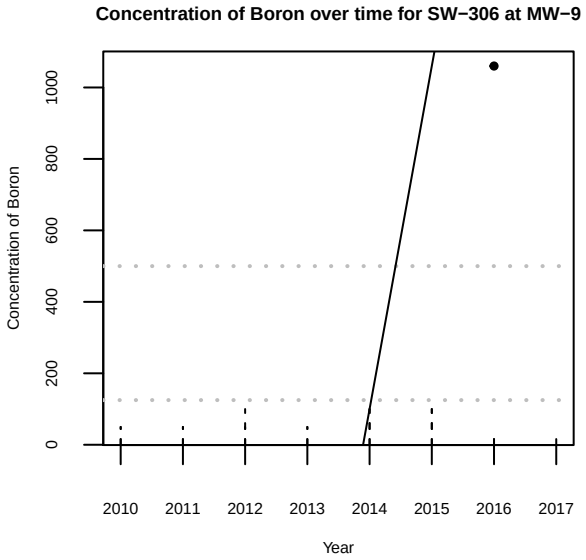
Tau = 0.175, Slope = 2.147, p−value = 0.337



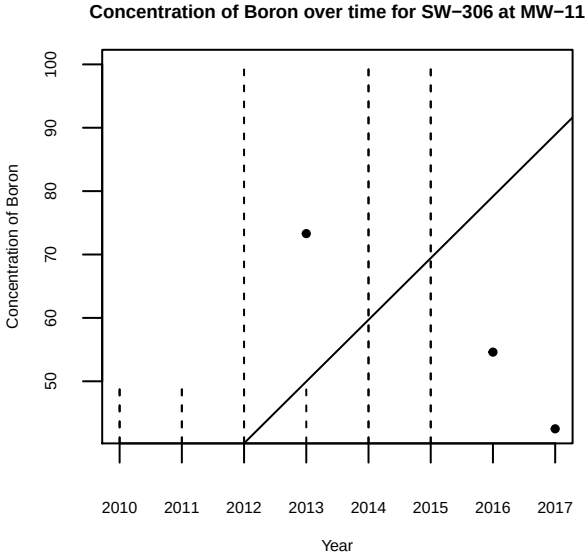
Tau = 0.667, Slope = 231, p−value = 0.54



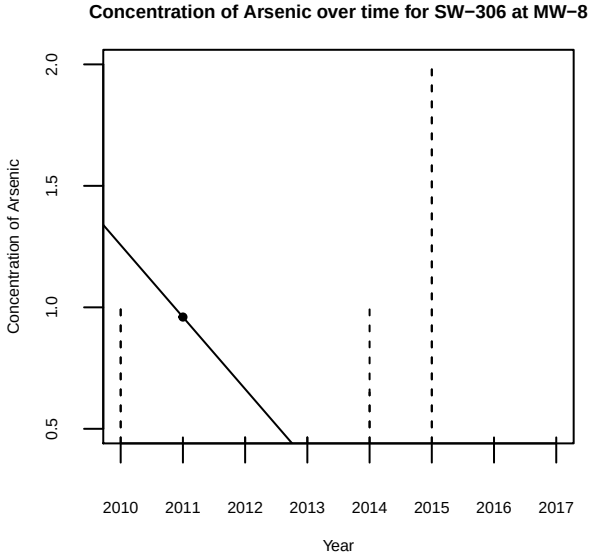
Tau = 0.667, Slope = 259, p−value = 0.54



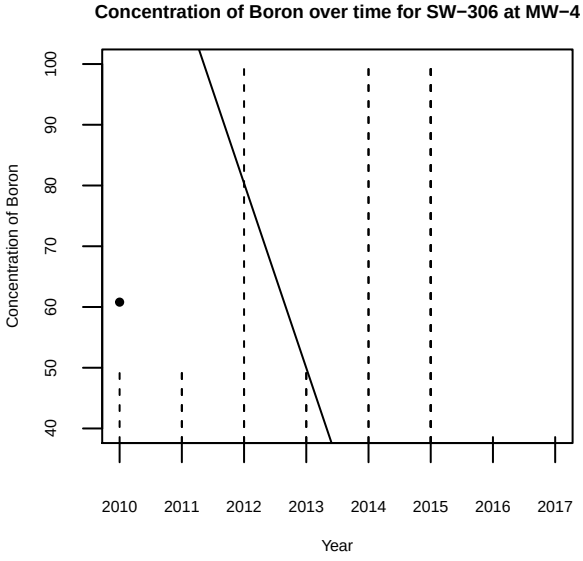
Tau = 0.092, Slope = 960.04, p−value = 0.58



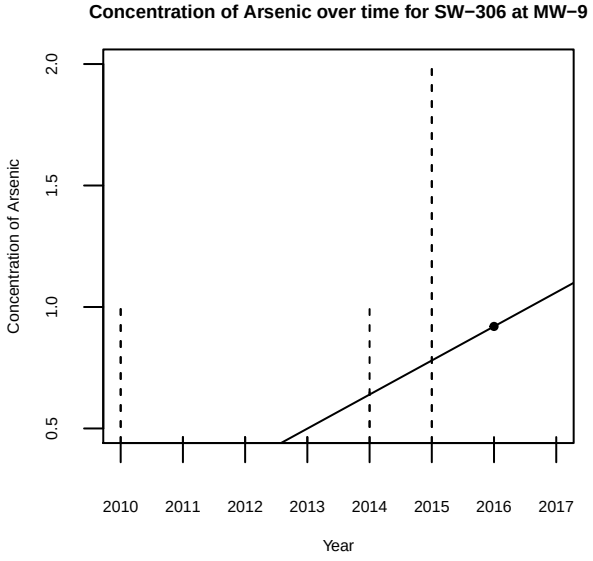
Tau = 0.088, Slope = 9.735, p−value = 0.634



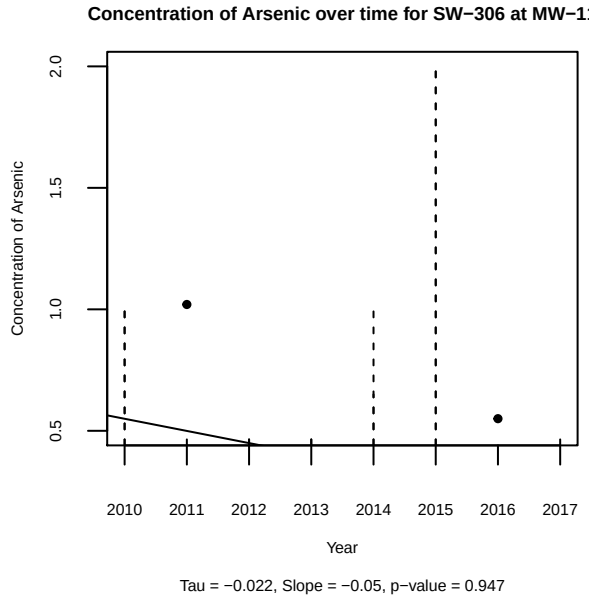
Tau = −0.077, Slope = −0.296, p−value = 0.675

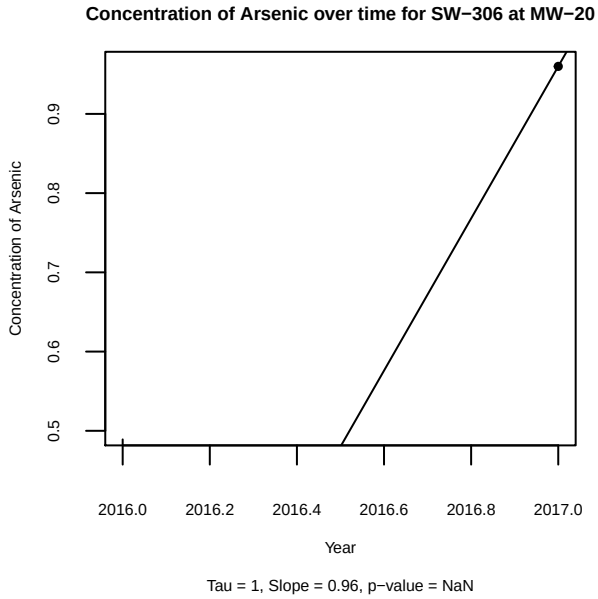


Tau = −0.058, Slope = −30.4, p−value = 0.732



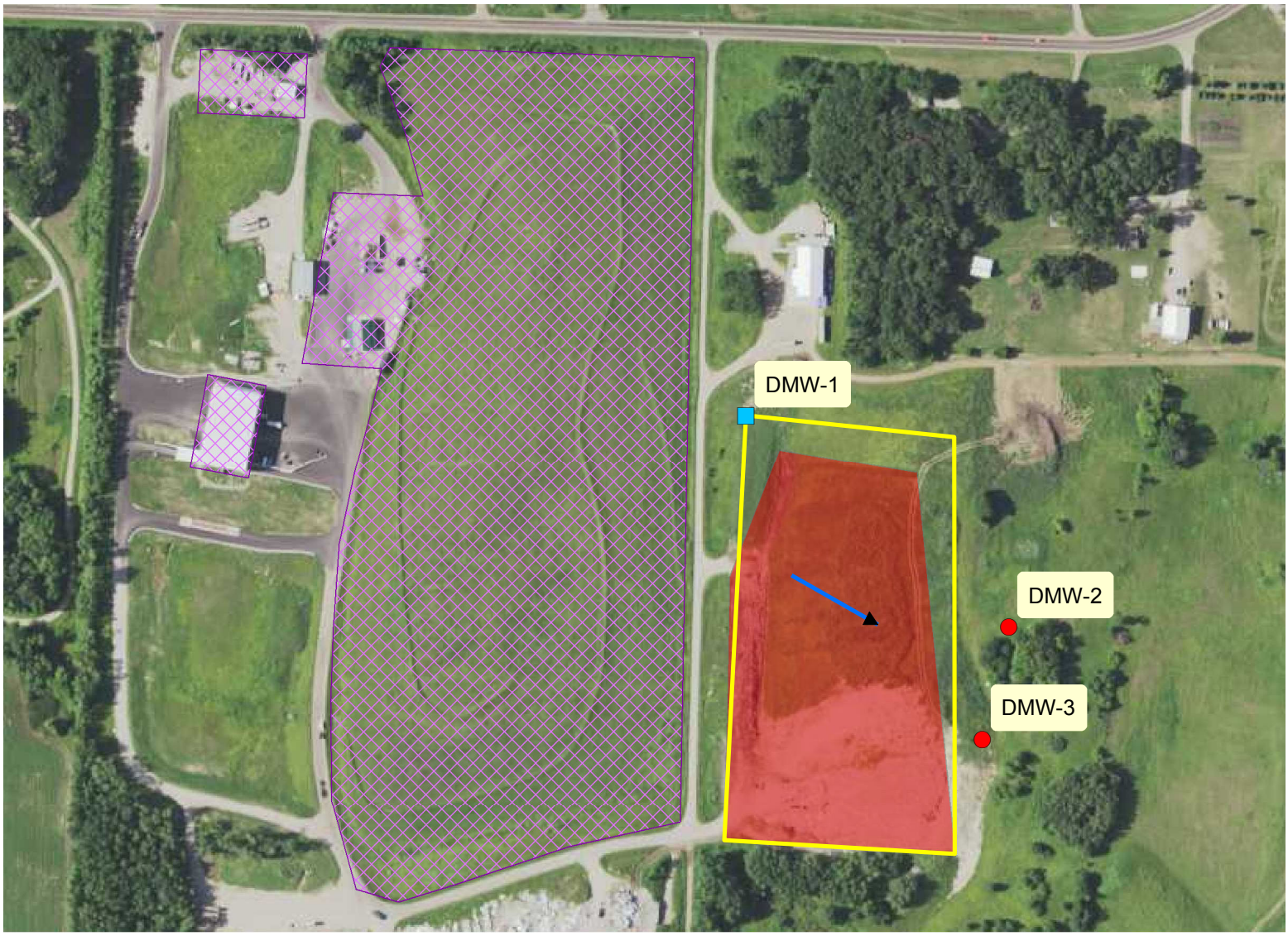
Tau = 0.057, Slope = 0.14, p−value = 0.75





The concentration of Arsenic as measured in well MW-7 is decreasing over time (slope is negative and p-value is less than 0.05), from 2012 to 2017 the points are below the IL. The concentration of Manganese as measured in well MW-8 is decreasing over time (slope is positive and p-value is less than 0.05), from 2015 to 2017 the points are below the HT. The remaining well trends are not statistically significant.

SW- 311 Becker County Demolition Landfill



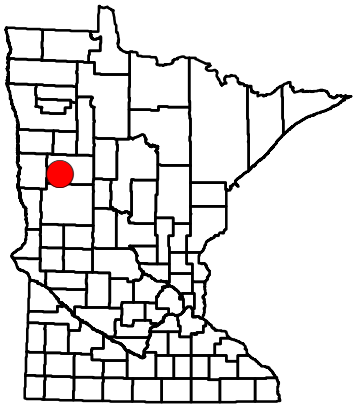
0 225 450 900 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-311 Becker County Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Construction and Demolition Landfill
2. **Other solid waste:** Closed Landfill Program site SW-99 is upgradient, having pump and treatment system to deal with plume with VOCs. Recycling area nearby.
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to southeast

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

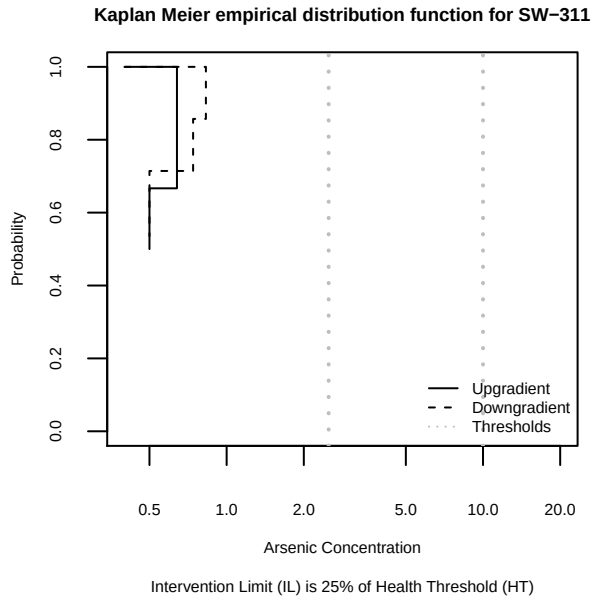
The concentration of Boron as measured in well DMW-2 is decreasing over time (slope is negative and p-value is less than 0.05), however all but two points are above the IL. The remaining well trends are not statistically significant.

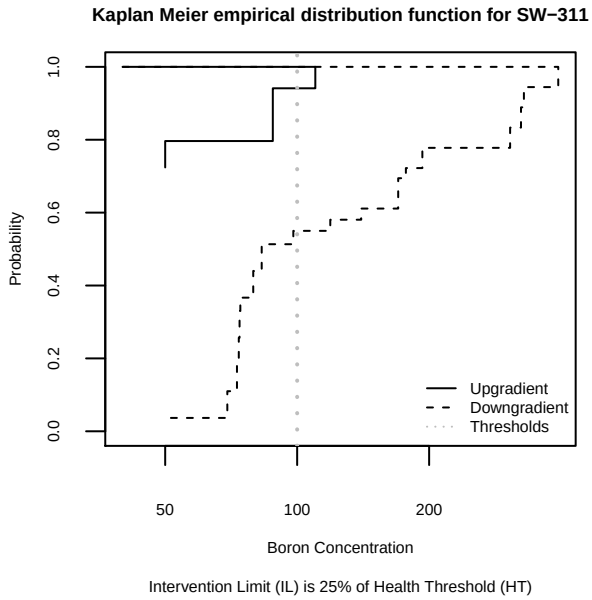
Kaplan Meier empirical distribution function (EDF)

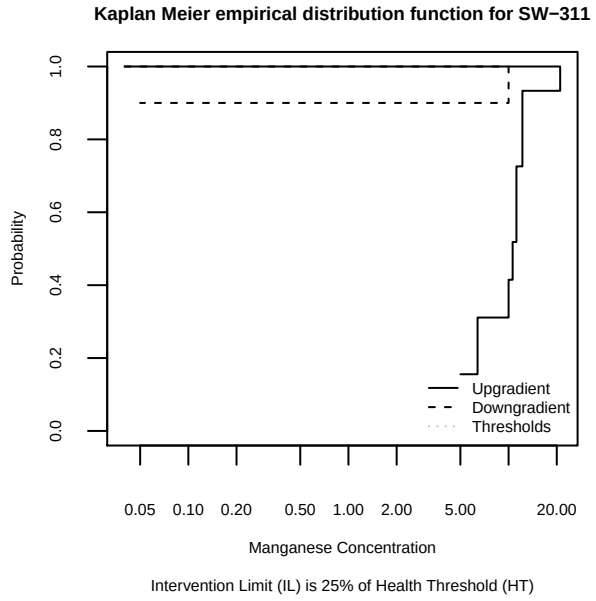
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-311	Arsenic	28	14	0.124	1	0.362	No
	Boron	36	18	16.568	1	0***	Yes
	Manganese	30	15	17.931	1	0***	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

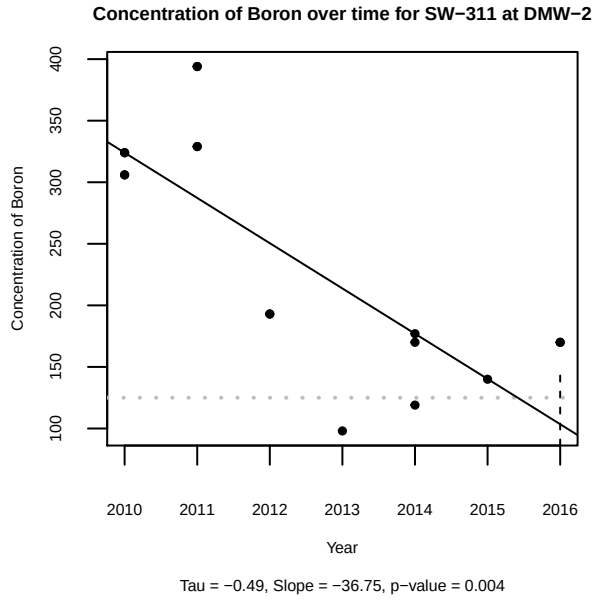
Table 2: Exceedance of thresholds by contaminant and Well ID

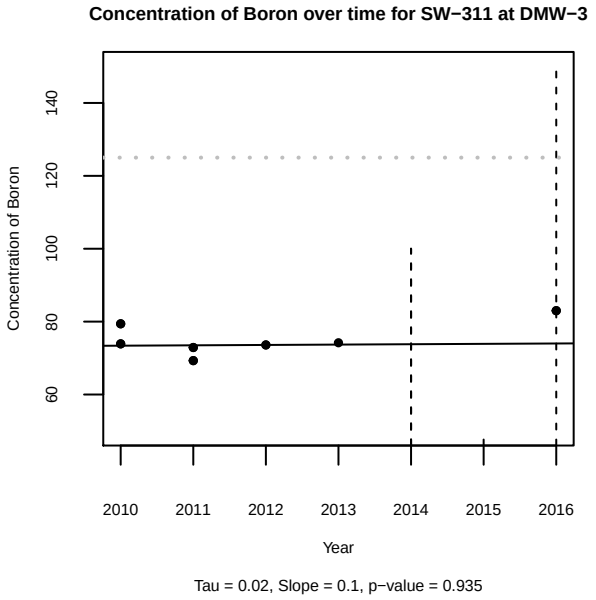
Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-311	Boron	DMW-2	0	15	3
		DMW-3	0	0	18
	All	All	0	15	21

Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.





The concentration of Boron as measured in well DMW-2 is decreasing over time (slope is negative and p-value is less than 0.05), however all but two points are above the IL. The remaining well trends are not statistically significant.

SW-315 Hubbard County Northern Transfer/Demolition Landfill

0 165 330 660 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-315 Hubbard Co Northern Transfer/Demo

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 2
2. **Downgradient well(s):** 4
3. **Groundwater flow:** to east-southeast

C. Facility impact on groundwater

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

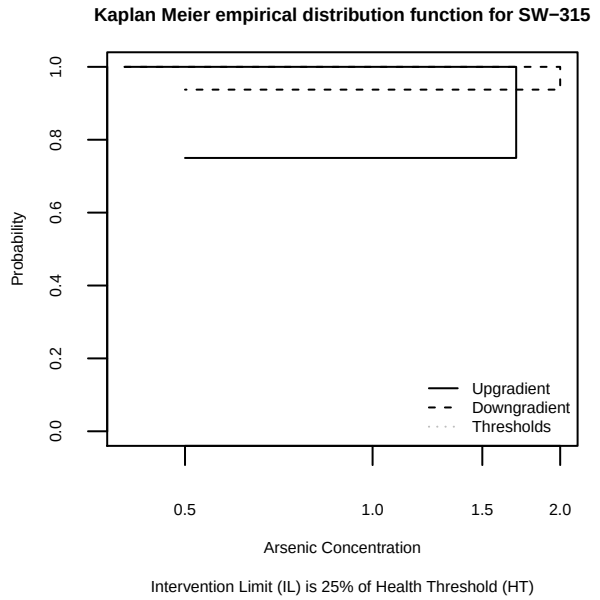
No trends were evaluated for this facility.

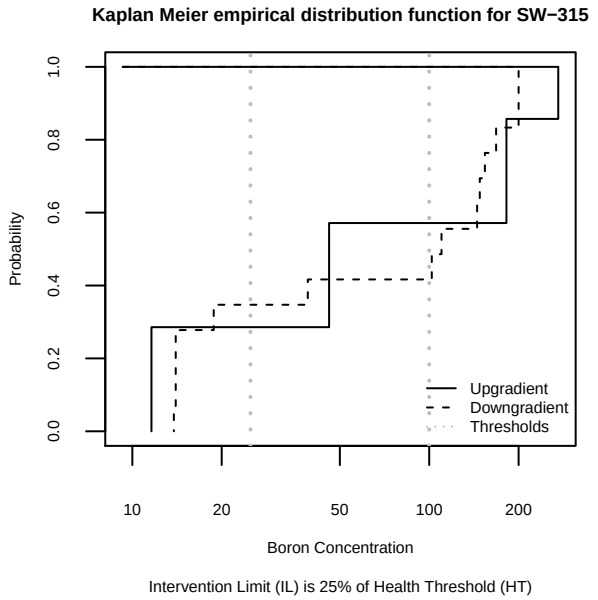
Kaplan Meier empirical distribution function (EDF)

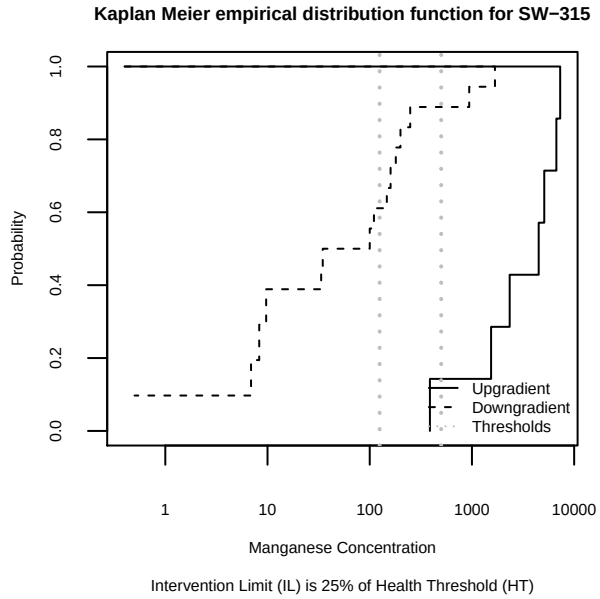
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

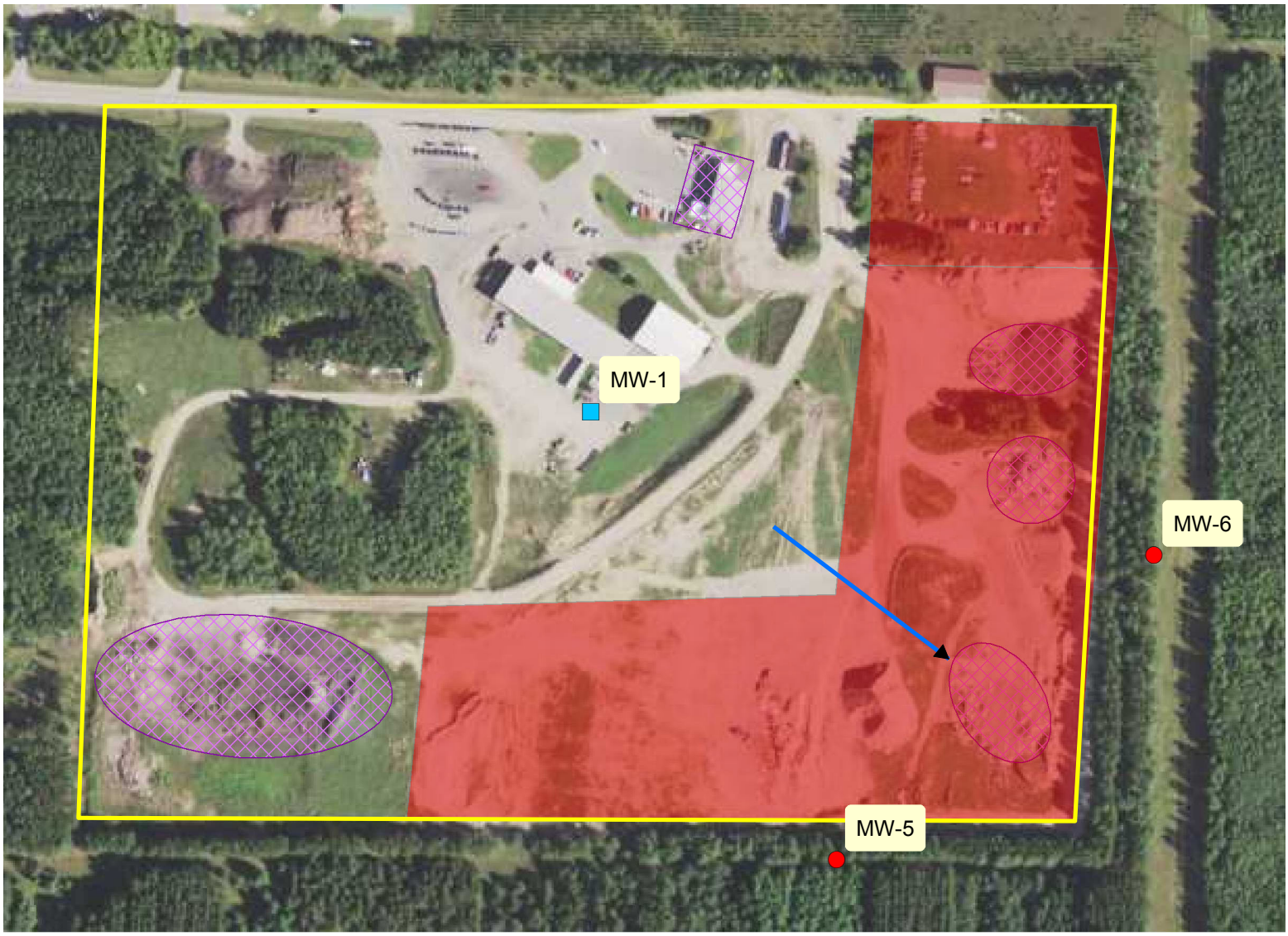
Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-315	Arsenic	16	7	0.268	1	0.302	No
	Boron	18	7	0.000	1	0.5	No
	Manganese	18	7	26.040	1	0***	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

SW- 318 Hubbard County Southern Transfer Facility



0 165 330 660 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-318 Hubbard Co So Transfer & Demo Landfill

A. Facility overview

1. **C&D disposal activity to date:** Construction and Demolition Landfill
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to southeast

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

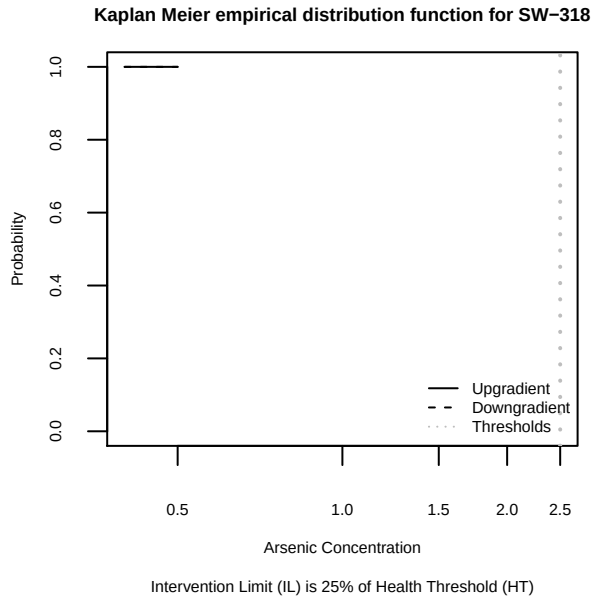
While trends were evaluated for MW-5 and MW-6, they were all found to not be statically significant.

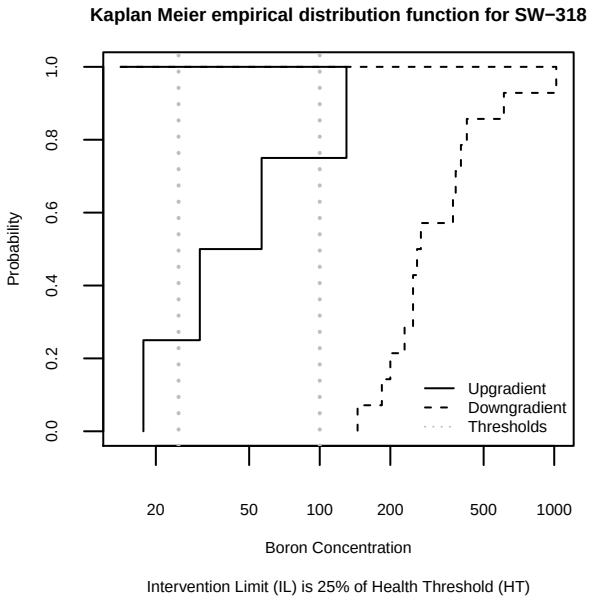
Kaplan Meier empirical distribution function (EDF)

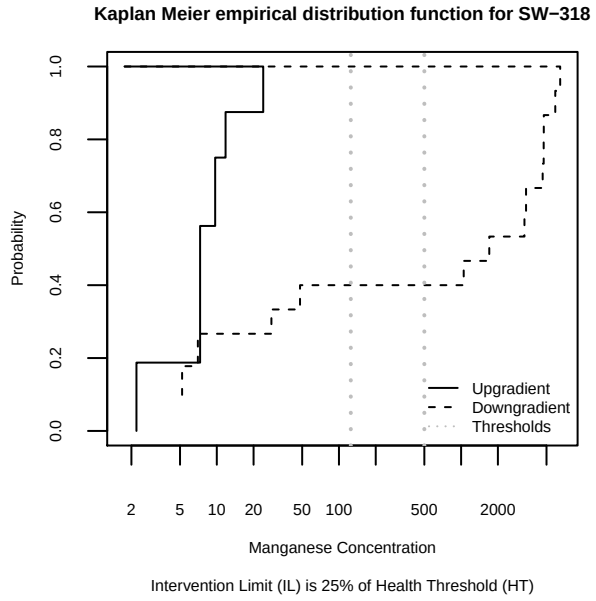
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-318	Arsenic	12	6	0.000	-1	NA	No
	Boron	14	7	12.437	1	0***	Yes
	Manganese	15	8	4.880	1	0.014**	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

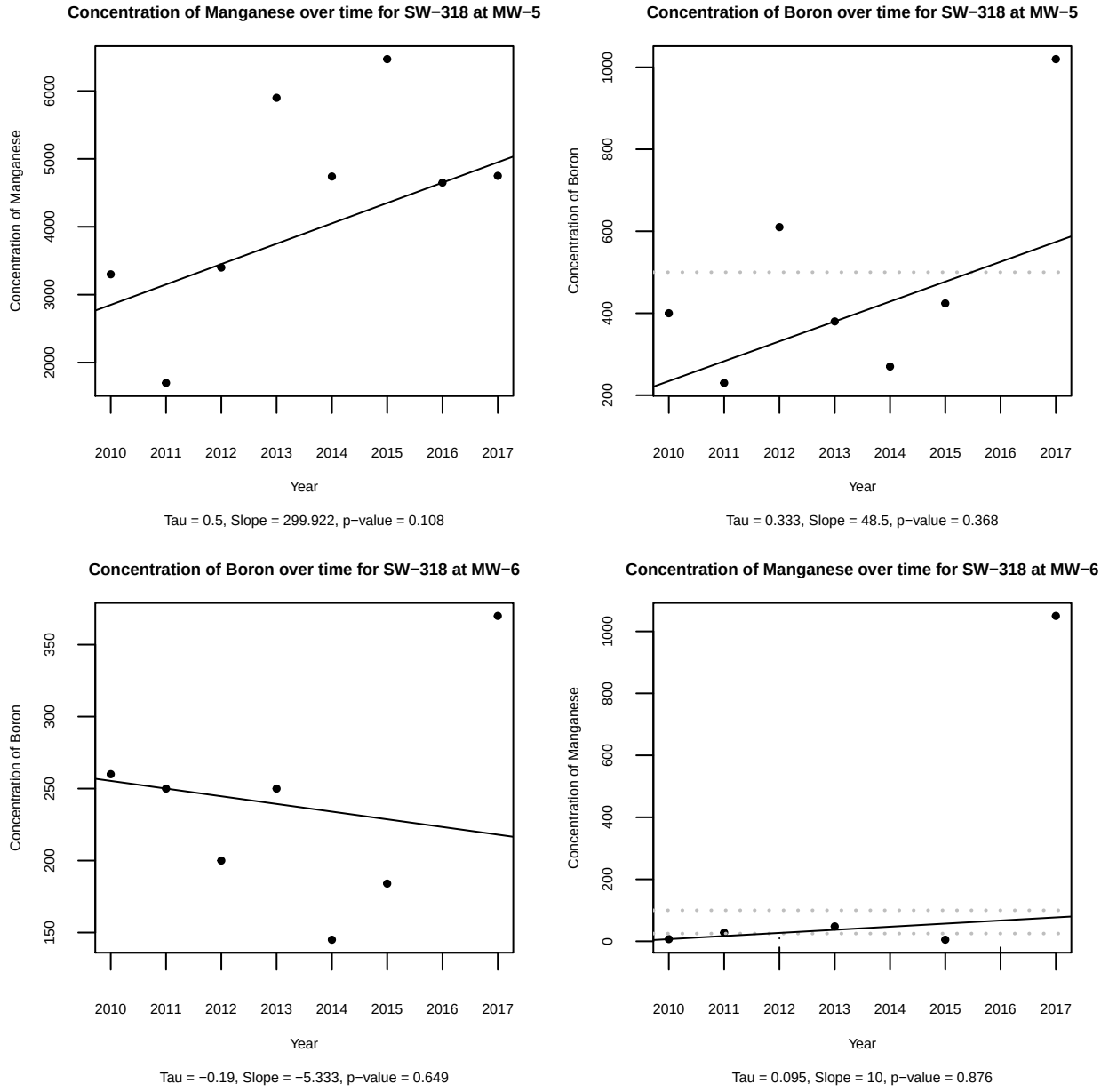
Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-318	Boron	MW-5	2	5	0
		MW-6	0	7	0
	Manganese	MW-5	8	0	0
		MW-6	1	2	4
	All	All	11	14	4

Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



While trends were evaluated for MW-5 and MW-6, they were all found to not be statically significant.

SW-332 Norman County Demolition Landfill

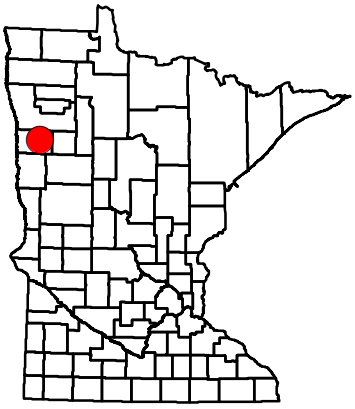
0 140 280 560 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-332 Norman County Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Construction and Demolition Landfill
2. **Other solid waste:** Storage area for appliance and metal recyclables.
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to west

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

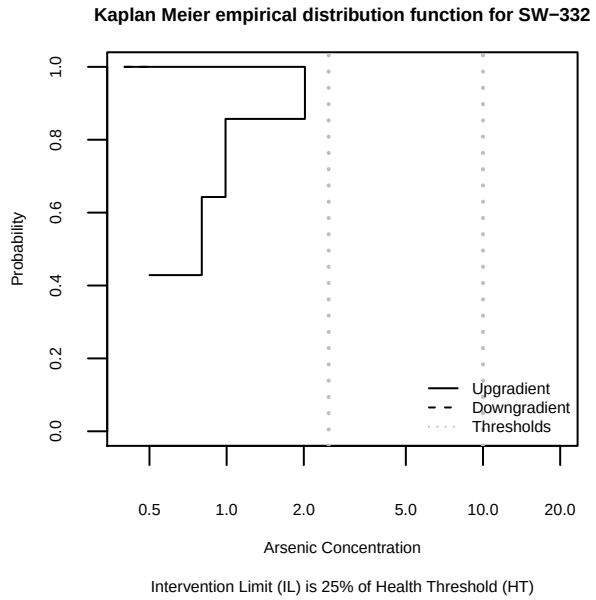
The concentration of Boron as measured in well MW-2 is decreasing over time (slope is negative and p-value is less than 0.05), however all points are above the IL, with two points above the HT. The remaining well trends are not statistically significant.

Kaplan Meier empirical distribution function (EDF)

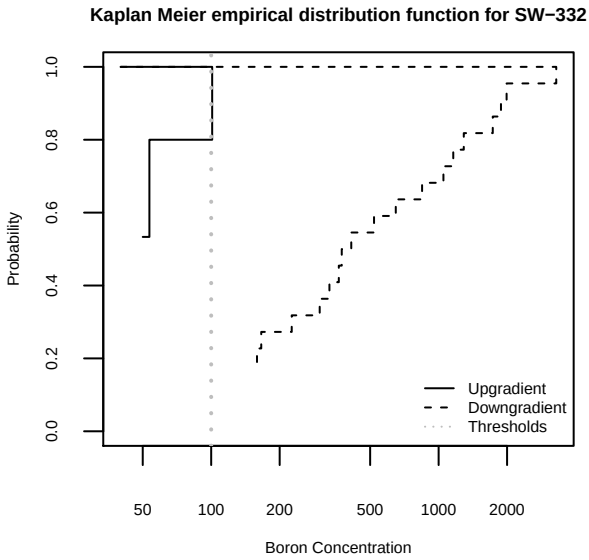
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

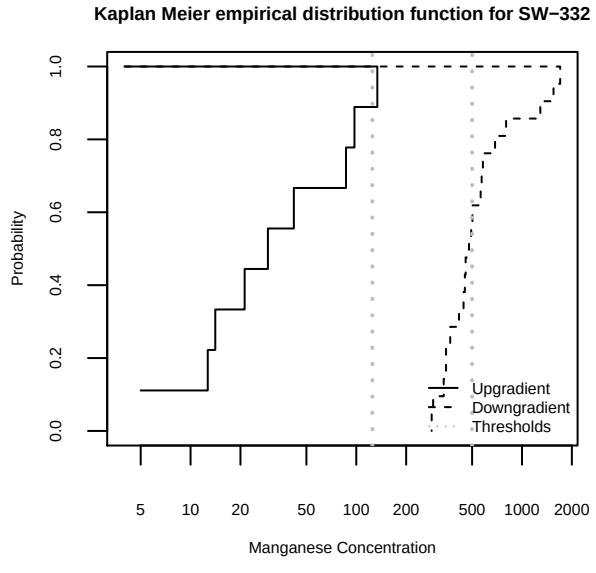
The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)

Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-332	Arsenic	18	10	3.944	1	0.024**	No
	Boron	22	9	12.000	1	0***	Yes
	Manganese	21	9	17.165	1	0***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-332	Boron	MW-2	2	6	4
		MW-3	6	2	0
		MW-4	2	0	0
	Manganese	MW-2	9	0	0
		MW-3	10	0	0
		MW-4	2	0	0
	All	All	31	8	4

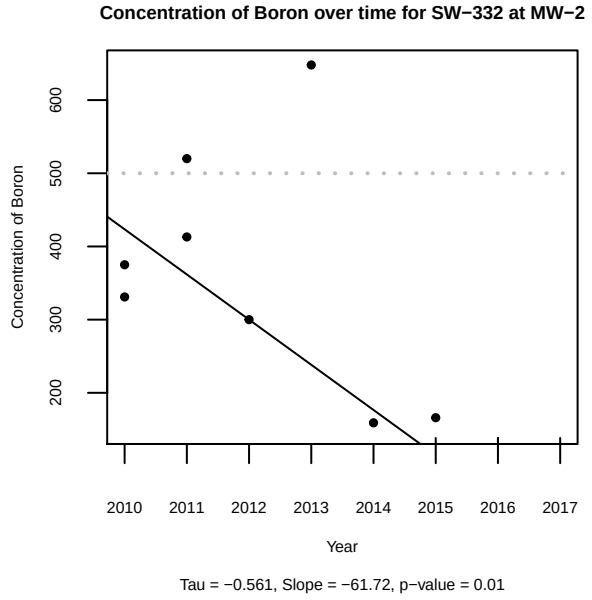
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

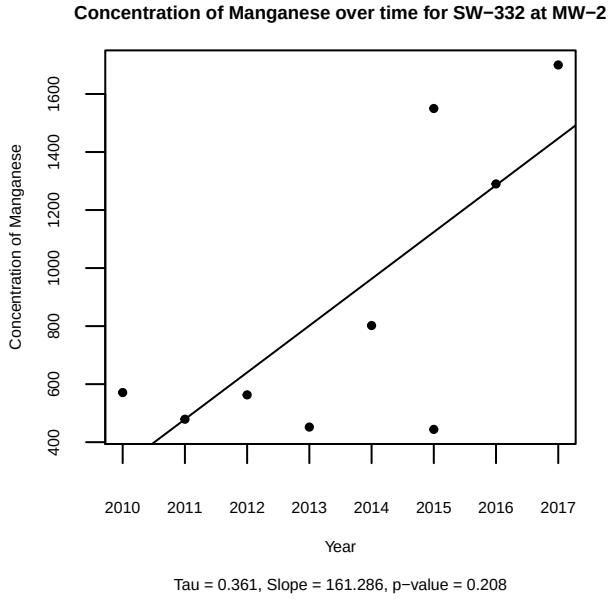
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

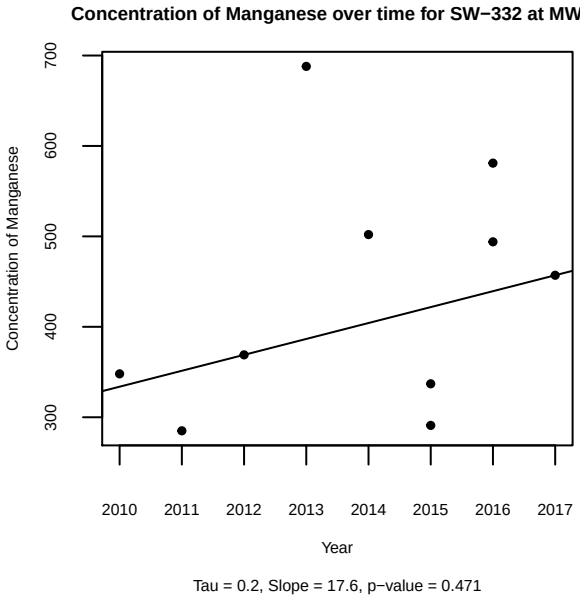
Table 3: Well/contaminant combinations where trends cannot be evaluated

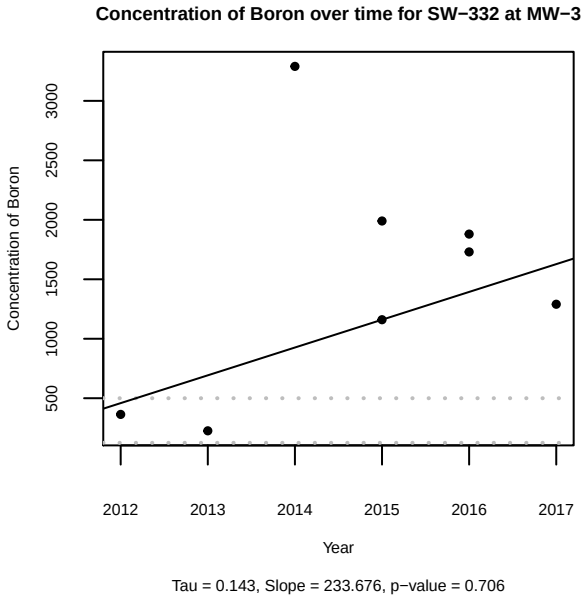
Well ID	Contaminant	Number of measured values	Number of censored values	Total
MW-4	Boron	2	0	2
MW-4	Manganese	2	0	2

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



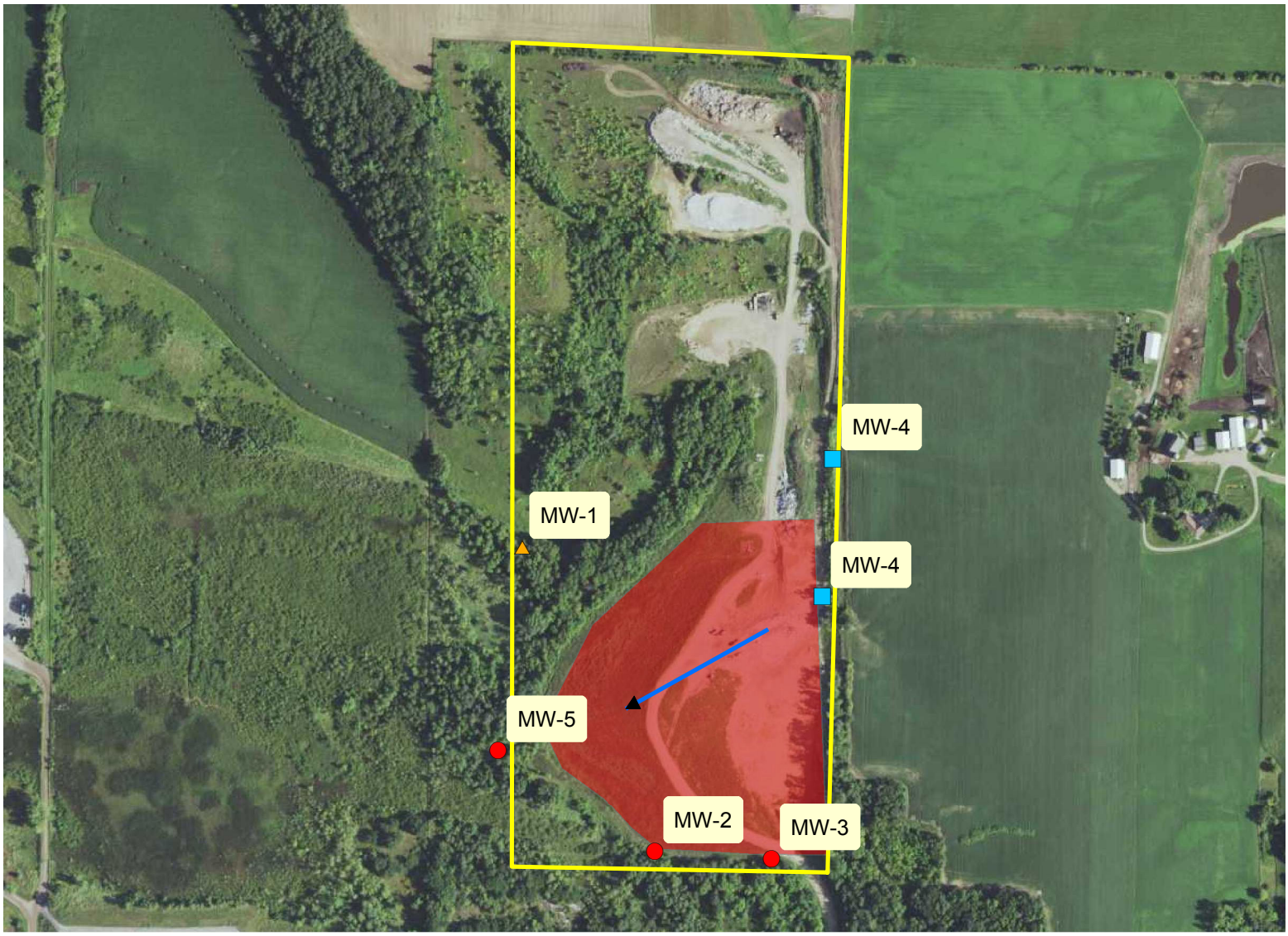






The concentration of Boron as measured in well MW-2 is decreasing over time (slope is negative and p-value is less than 0.05), however all points are above the IL, with two points above the HT. The remaining well trends are not statistically significant.

SW-333 TK Demolition Disposal LLC



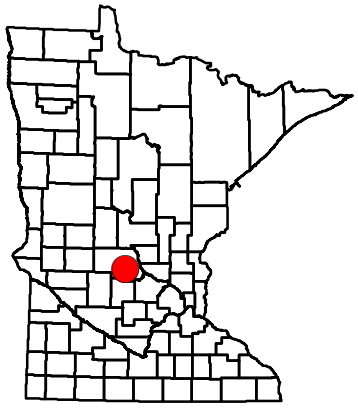
0 335 670 1,340 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-333 TK Demolition Disposal LLC

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill, some portions are closed
2. **Other solid waste:** Recycling area
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to southwest

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

The concentration of Boron as measured in wells MW-2 and MW-3 are increasing over time (slope is positive and p-value is less than 0.05). For MW-2 all points from 2015 to 2017 are above the HT, however all points from the 2010

SW-335 South Side Demolition

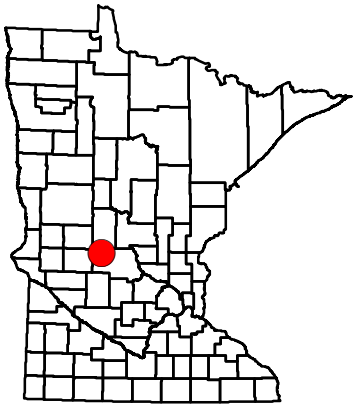
0 225 450 900
Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-335 Bueckers City Sanitation Services

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** Transfer station, yard waste, recycling, storage. Some demo disposal areas are no longer active.
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 5
3. **Groundwater flow:** to northeast

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

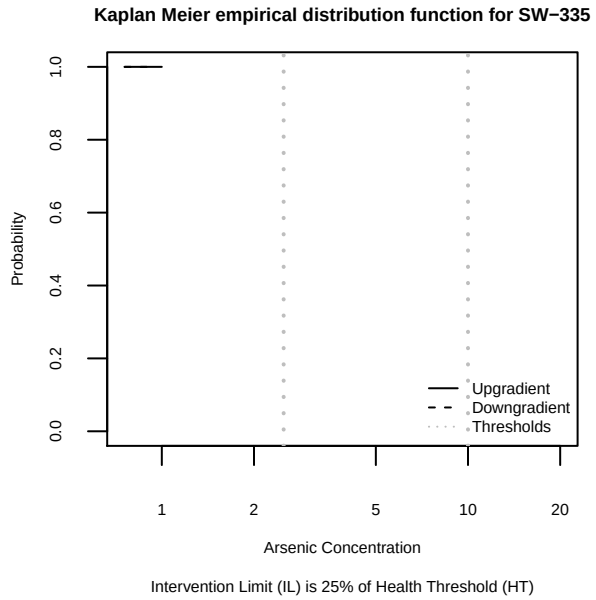
The concentration of Boron as measured in well MW-11 is decreasing over time (slope is negative and p-value is less than 0.05). All points are greater than the HT. The remaining well trends are not statistically significant.

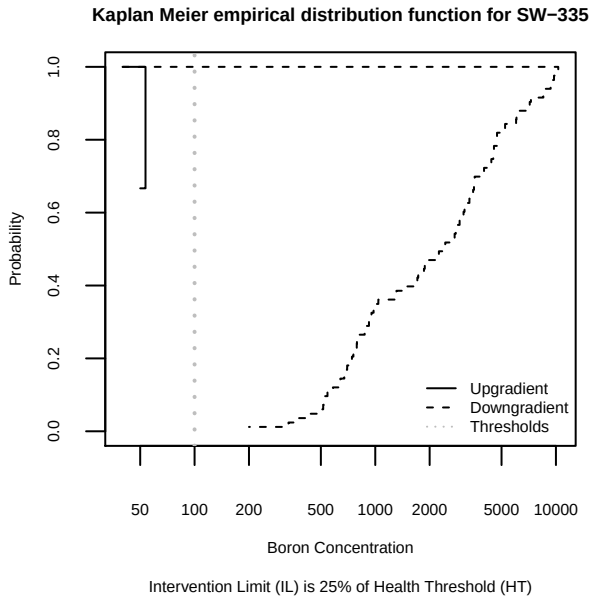
Kaplan Meier empirical distribution function (EDF)

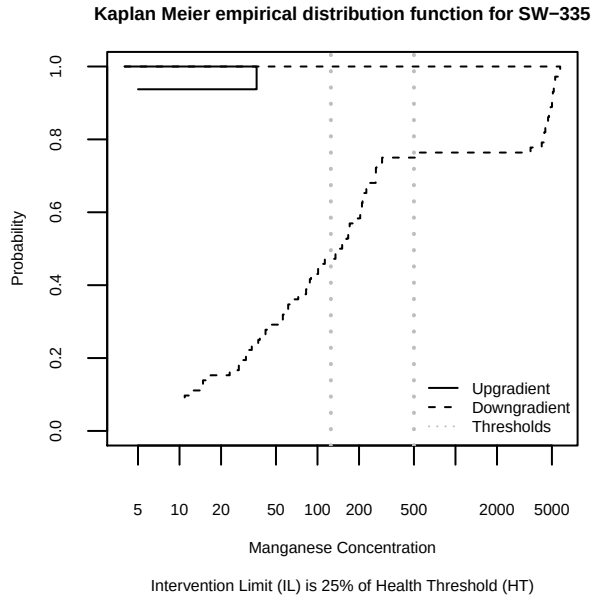
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-335	Arsenic	27	6	0.000	-1	NA	No
	Boron	83	18	34.745	1	0***	Yes
	Manganese	72	16	25.266	1	0***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-335	Boron	MW-10	18	0	0
		MW-11	18	0	0
		MW-12	5	1	1
		MW-8	22	0	0
		MW-9	15	3	0
	Manganese	MW-10	0	10	6
		MW-11	7	9	0
		MW-12	0	0	6
		MW-8	18	0	0
		MW-9	16	0	0
	All	All	119	23	13

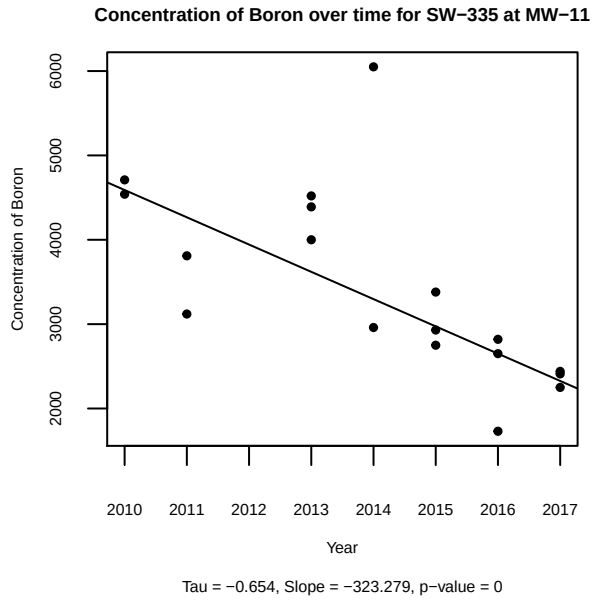
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

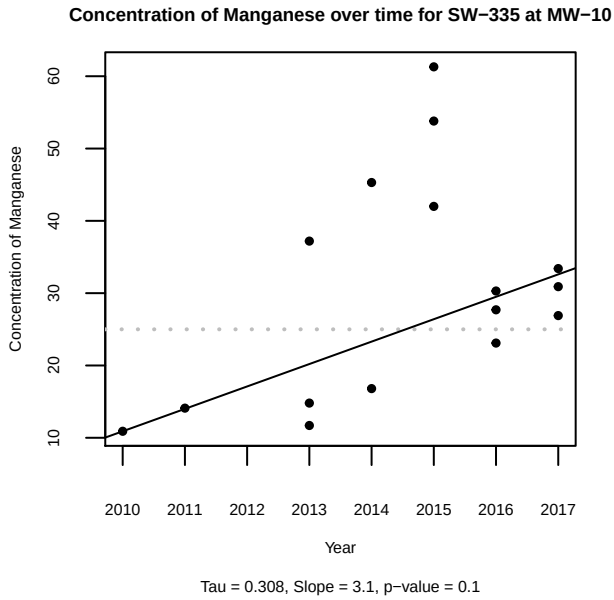
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

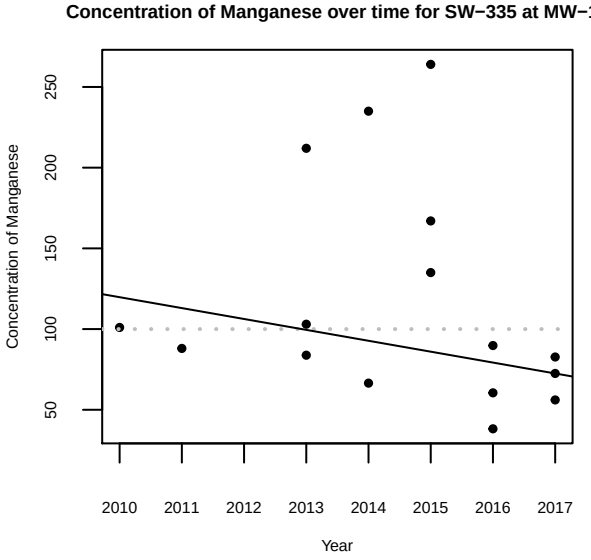
Table 3: Well/contaminant combinations where trends cannot be evaluated

Well ID	Contaminant	Number of measured values	Number of censored values	Total
MW-12	Manganese	0	6	6

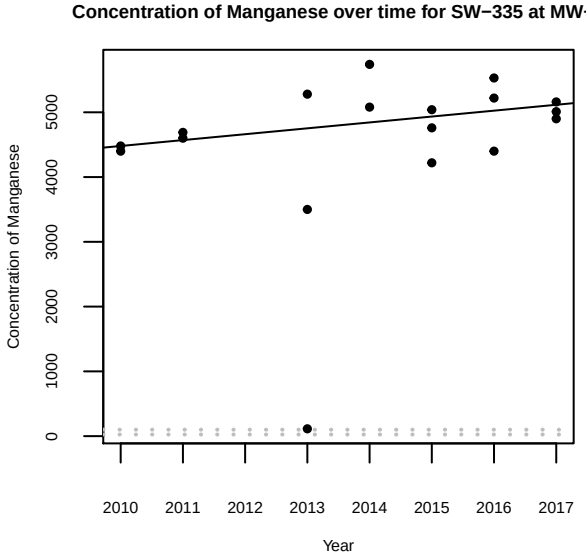
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



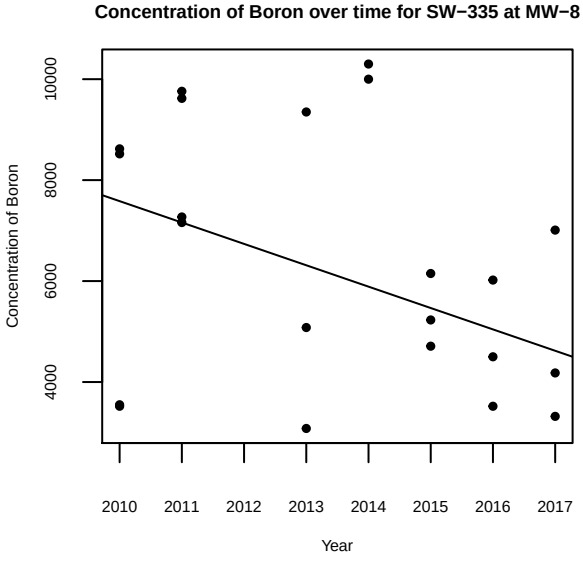




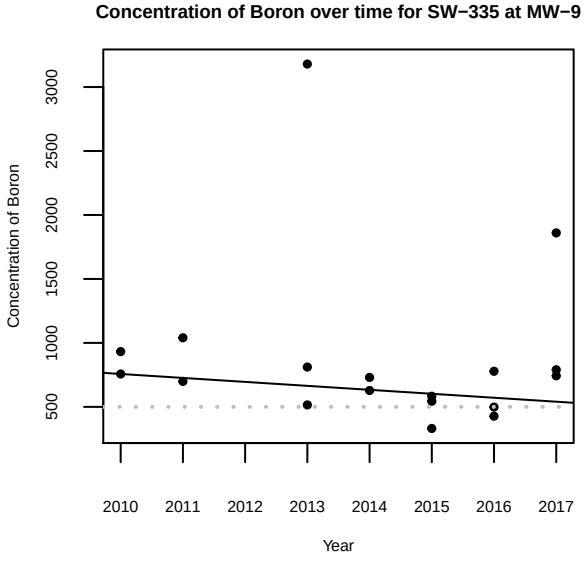
Tau = −0.292, Slope = −6.75, p−value = 0.12



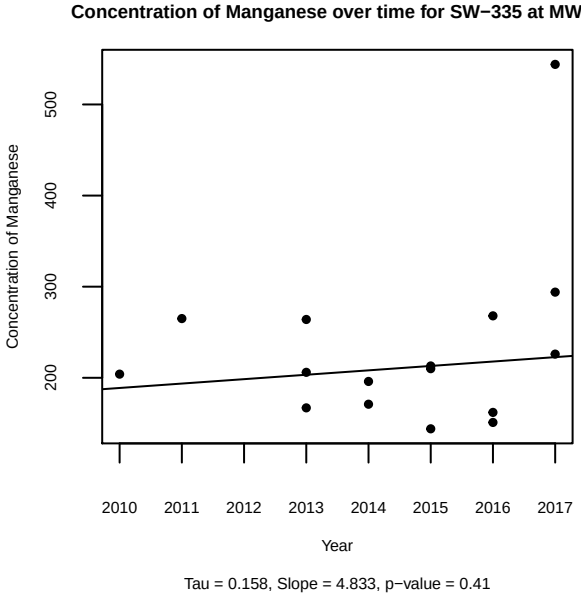
Tau = 0.255, Slope = 90.885, p−value = 0.145

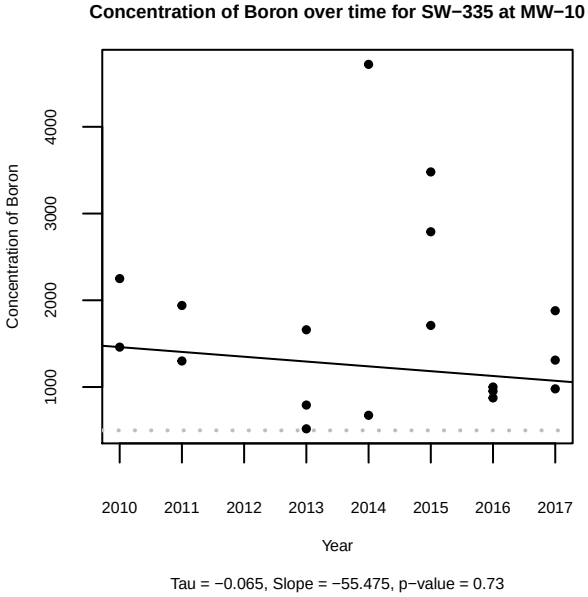


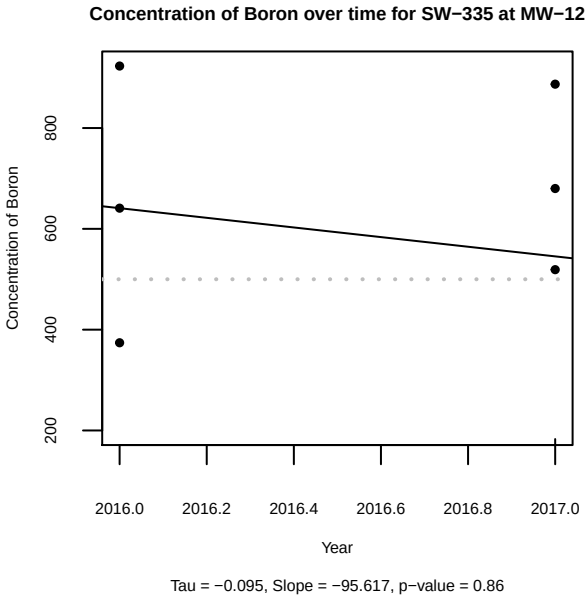
Tau = −0.212, Slope = −423.467, p−value = 0.17



Tau = −0.157, Slope = −30.972, p−value = 0.378







The concentration of Boron as measured in well MW-11 is decreasing over time (slope is negative and p-value is less than 0.05). All points are greater than the HT. The remaining well trends are not statistically significant.

SW-337 Mahnomen County Demolition Landfill

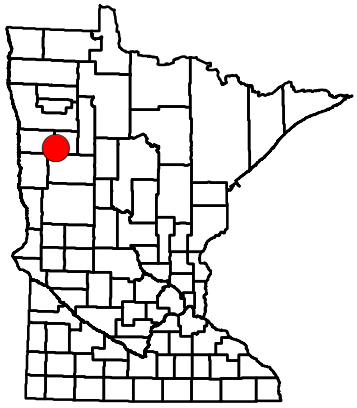
0 112.5 225 450 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-337 Mahnomen County Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to north

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

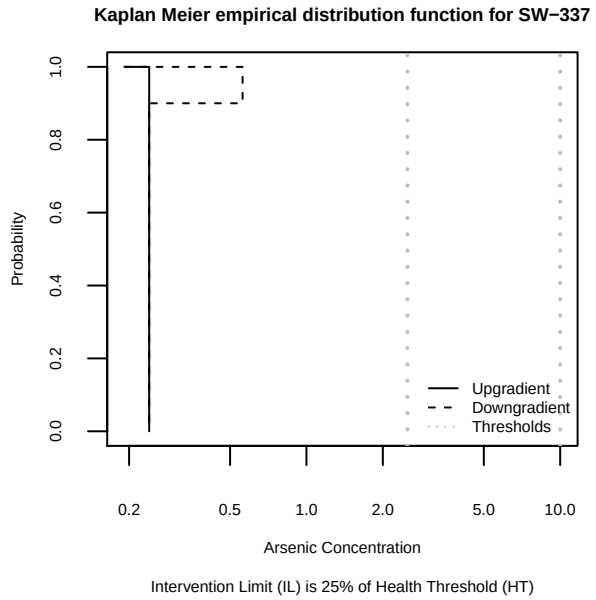
The concentration of Boron as measured in well MW-2 is decreasing over time (slope is negative and p-value is less than 0.05), the points are at least greater than the IL with some greater than the HT. The concentration of Manganese as measured in wells MW-2 and MW-3 are increasing over time (slope is positive and p-value is less than 0.05). All points for MW-2 are above the HT, while for MW-3 the points from 2013 to 2017 were above the HT. The remaining well trends are not statistically significant.

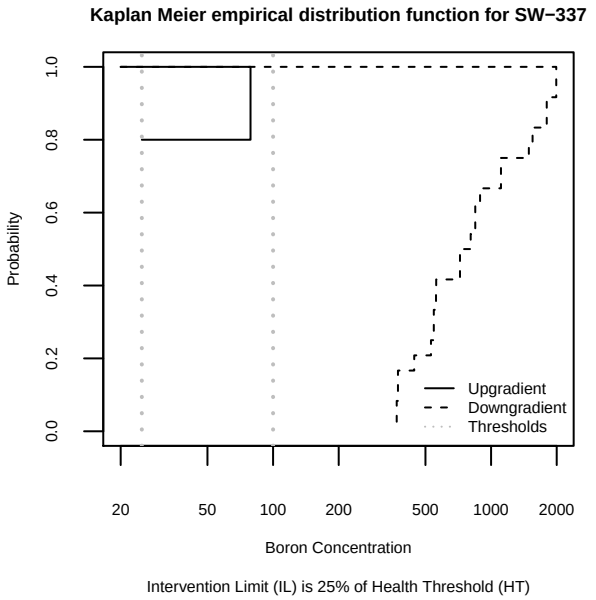
Kaplan Meier empirical distribution function (EDF)

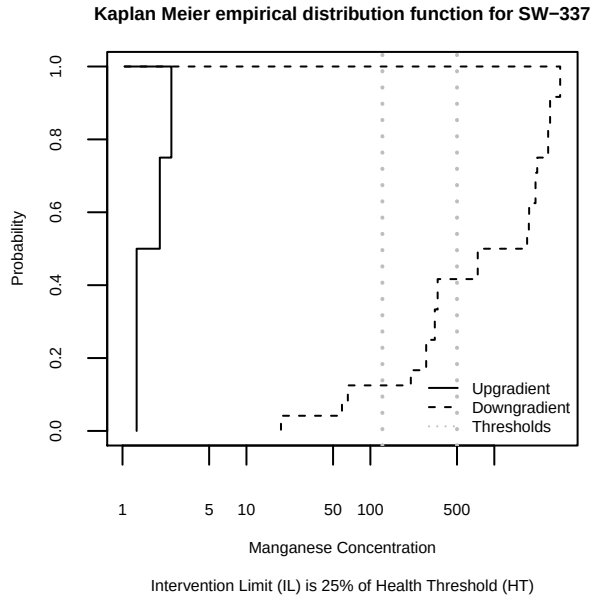
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-337	Arsenic	24	12	0.500	1	0.24	No
	Boron	24	12	23.027	1	0***	Yes
	Manganese	24	12	23.098	1	0***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

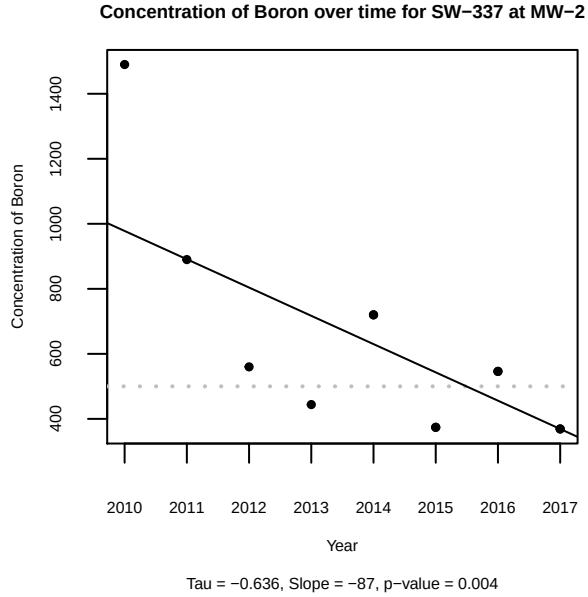
Table 2: Exceedance of thresholds by contaminant and Well ID

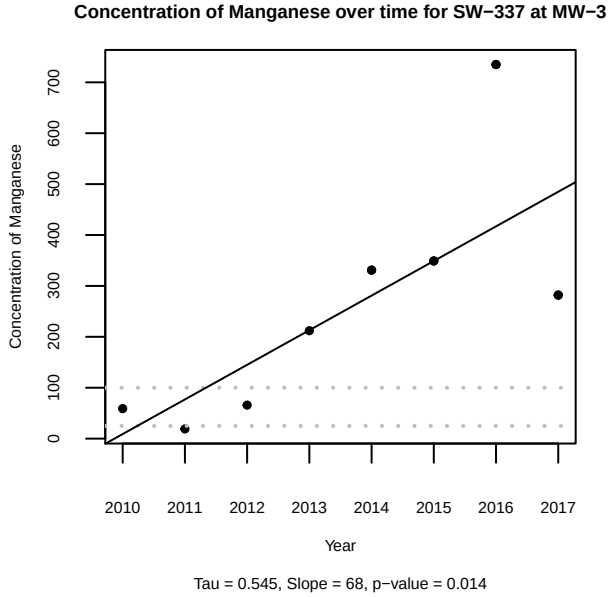
Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-337	Boron	MW-2	7	5	0
		MW-3	12	0	0
	Manganese	MW-2	12	0	0
		MW-3	9	2	1
	All	All	40	7	1

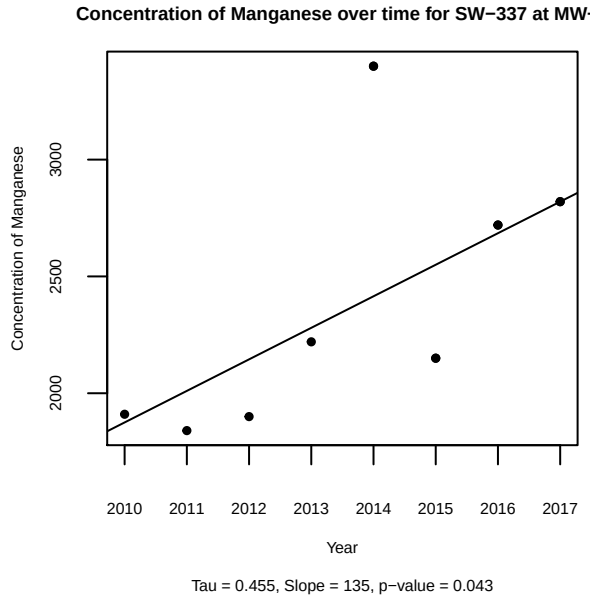
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

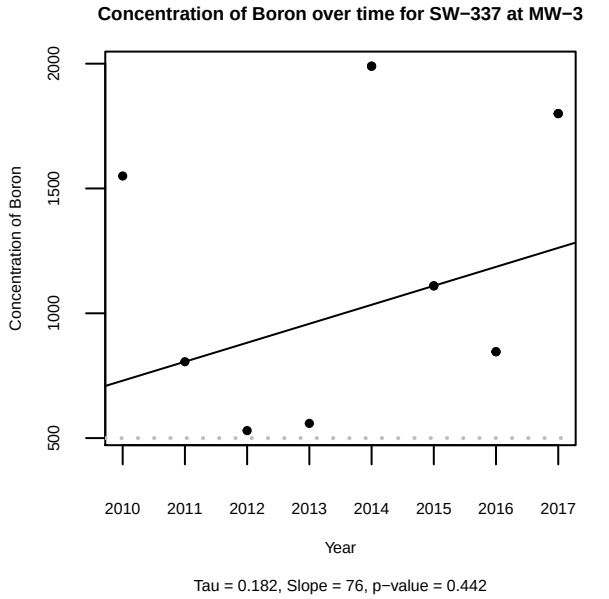
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.









The concentration of Boron as measured in well MW-2 is decreasing over time (slope is negative and p-value is less than 0.05), the points are at least greater than the IL with some greater than the HT. The concentration of Manganese as measured in wells MW-2 and MW-3 are increasing over time (slope is positive and p-value is less

than 0.05). All points for MW-2 are above the HT, while for MW-3 the points from 2013 to 2017 were above the HT. The remaining well trends are not statistically significant.

SW-355 Olmsted County - Kalmar Landfill

0 335 670 1,340 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-355 Olmsted County - Kalmar Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill, on north side of the waste complex
2. **Other solid waste:** Lined, operating Municipal Solid Waste Landfill, lined operating Municipal Solid Waste combuster ash Landfill
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to north-northeast

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for arsenic and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

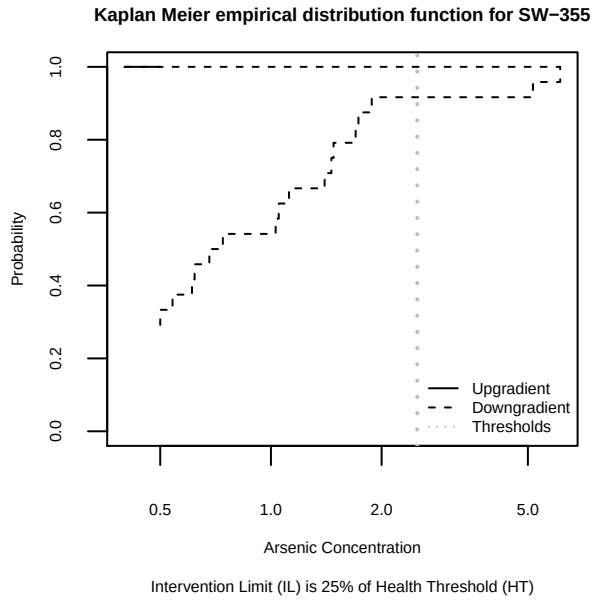
The concentration of Manganese as measured in well EMS-21 is increasing over time (slope is positive and p-value is less than 0.05). From 2012 to 2017 the points were above the HT. The remaining well trends are not statistically significant.

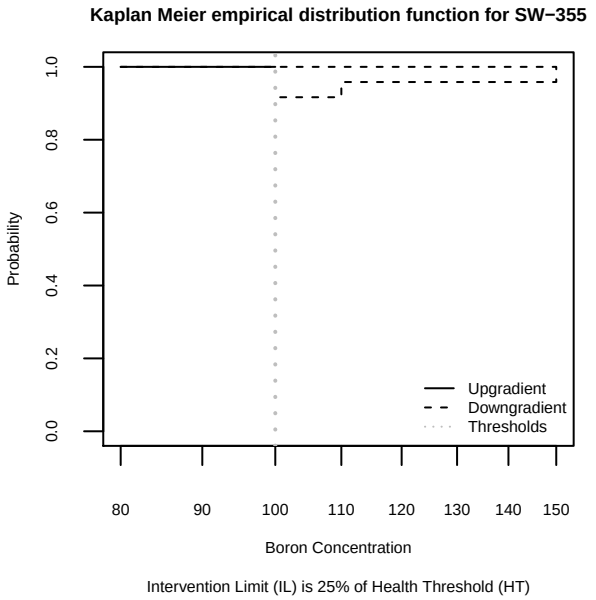
Kaplan Meier empirical distribution function (EDF)

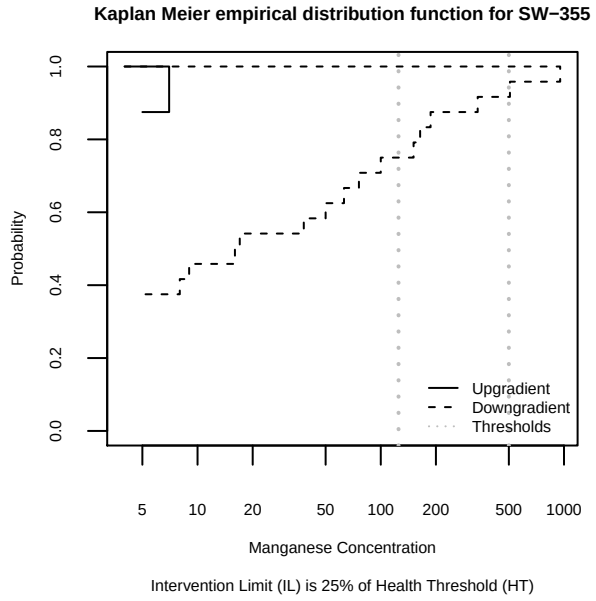
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-355	Arsenic	24	8	8.500	1	0.002***	Yes
	Boron	24	8	0.681	1	0.205	No
	Manganese	24	8	5.834	1	0.008***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for arsenic and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-355	Arsenic	EMS-21	0	1	7
		EMS-22	0	1	7
		EMS-27	0	0	8
	Manganese	EMS-21	6	2	0
		EMS-22	0	3	5
		EMS-27	0	0	8
	All	All	6	7	35

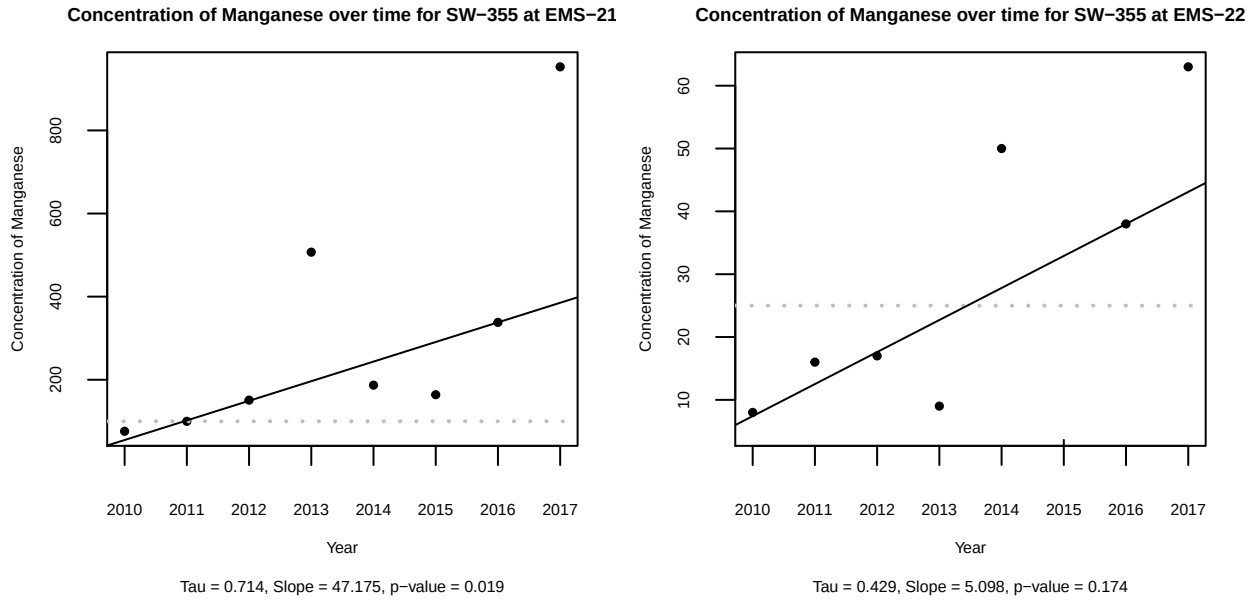
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

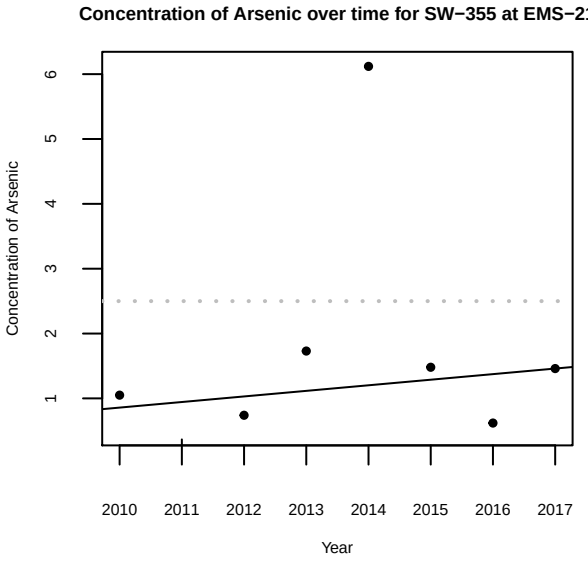
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

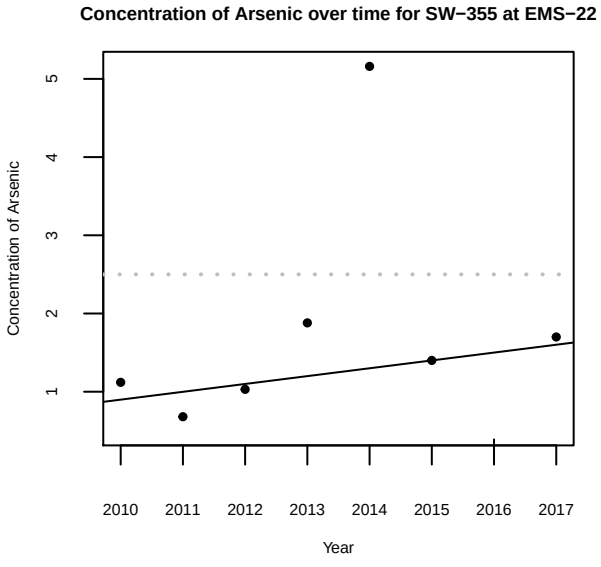
Table 3: Well/contaminant combinations where trends cannot be evaluated

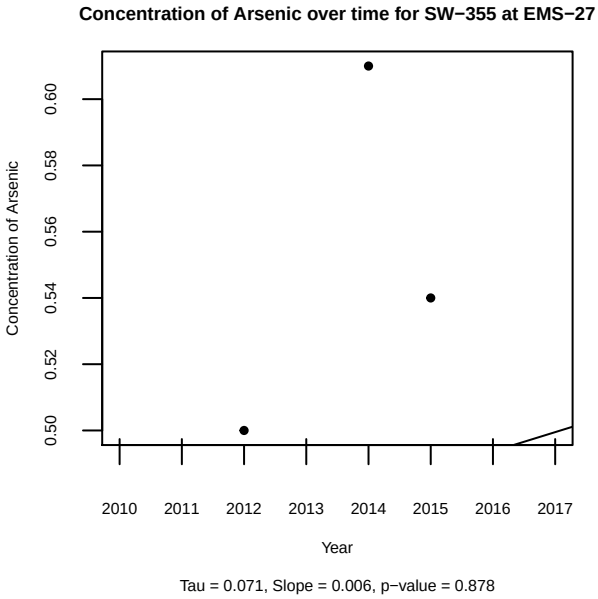
Well ID	Contaminant	Number of measured values	Number of censored values	Total
EMS-27	Manganese	0	8	8

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.









The concentration of Manganese as measured in well EMS-21 is increasing over time (slope is positive and p-value is less than 0.05). From 2012 to 2017 the points were above the HT. The remaining well trends are not statistically significant.

SW-399 Shamrock Environmental Landfill

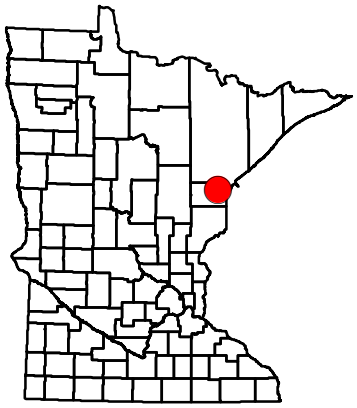
0 225 450 900 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-399 SKB Environmental Cloquet Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill. Disposal started 2011
2. **Other solid waste:** Lined ISW Landfill to west
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 7
3. **Groundwater flow:** to east

C. Facility impact on groundwater

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

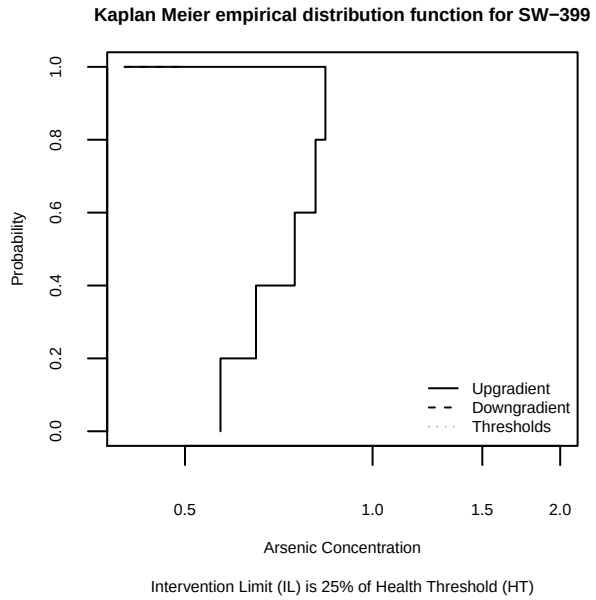
No trends were evaluated for this facility.

Kaplan Meier empirical distribution function (EDF)

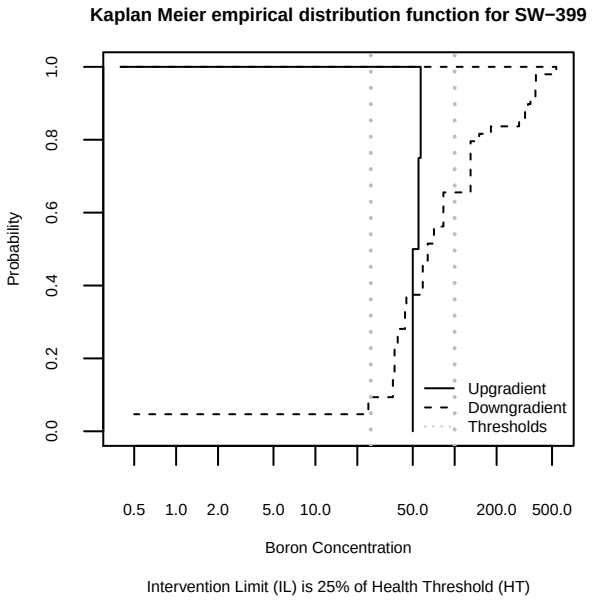
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

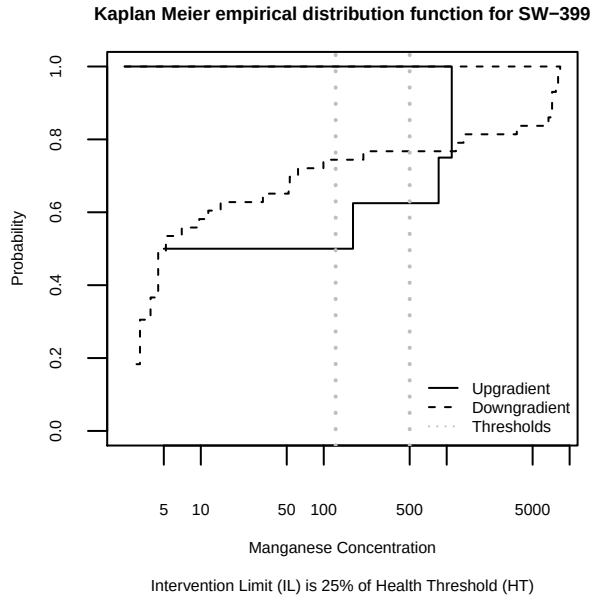
The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)

Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

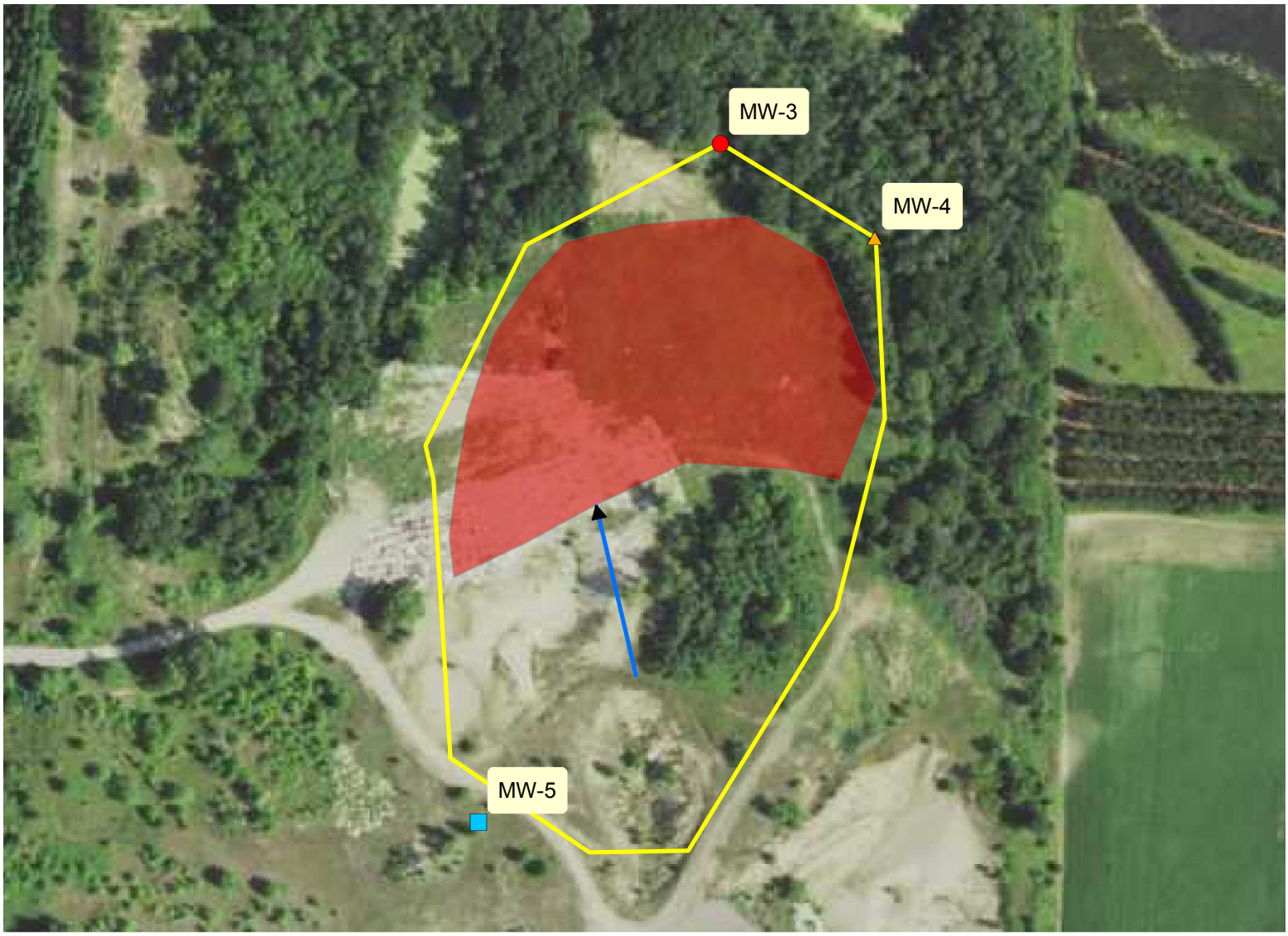
Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-399	Arsenic	49	9	48.333	1	0***	No
	Boron	49	9	1.442	1	0.115	No
	Manganese	43	8	0.001	1	0.489	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

SW-403 Todd County Demolition Landfill



0 145 290 580 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-403 Todd County Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill, some portions are no longer active
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 1
3. **Groundwater flow:** to north-northwest

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

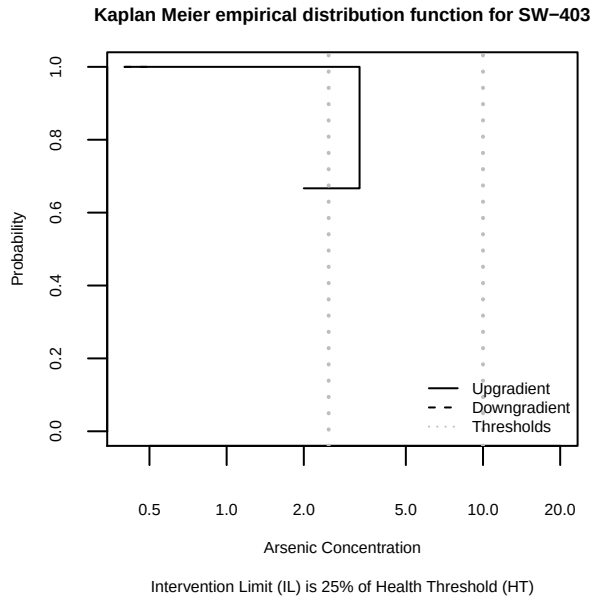
While a single trend was evaluated for Boron at MW-3, it was found to not be statically significant. However all points were above the IL.

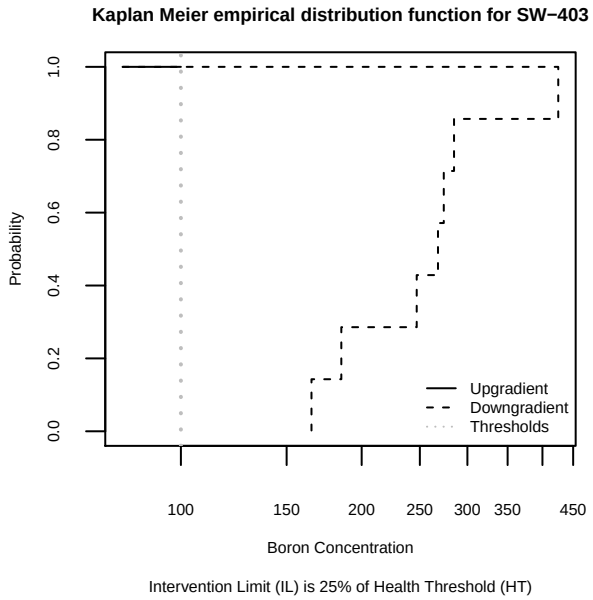
Kaplan Meier empirical distribution function (EDF)

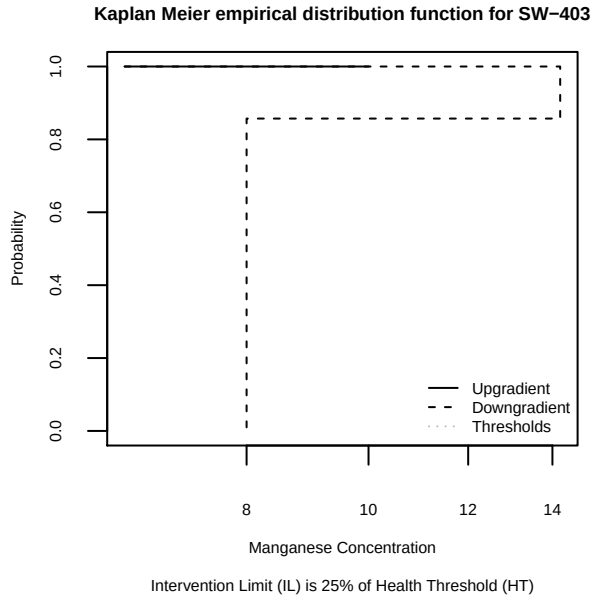
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-403	Arsenic	7	3	2.000	1	0.079*	No
	Boron	7	3	5.250	1	0.011**	Yes
	Manganese	7	3	0.429	1	0.256	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

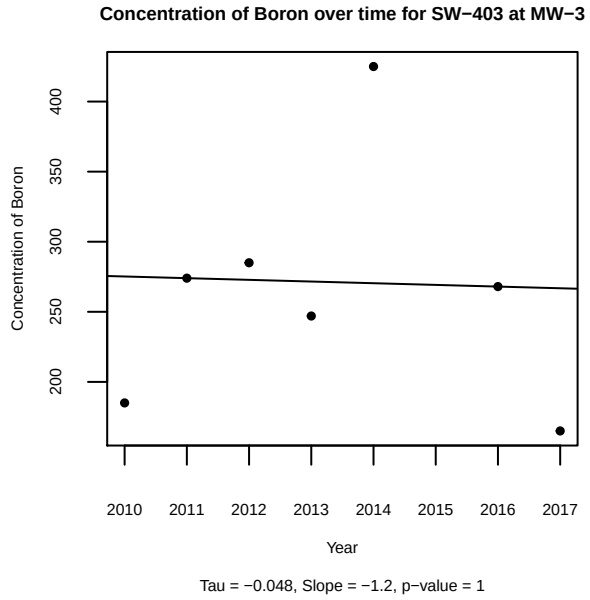
Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-403	Boron	MW-3	0	7	0
	All	All	0	7	0

Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

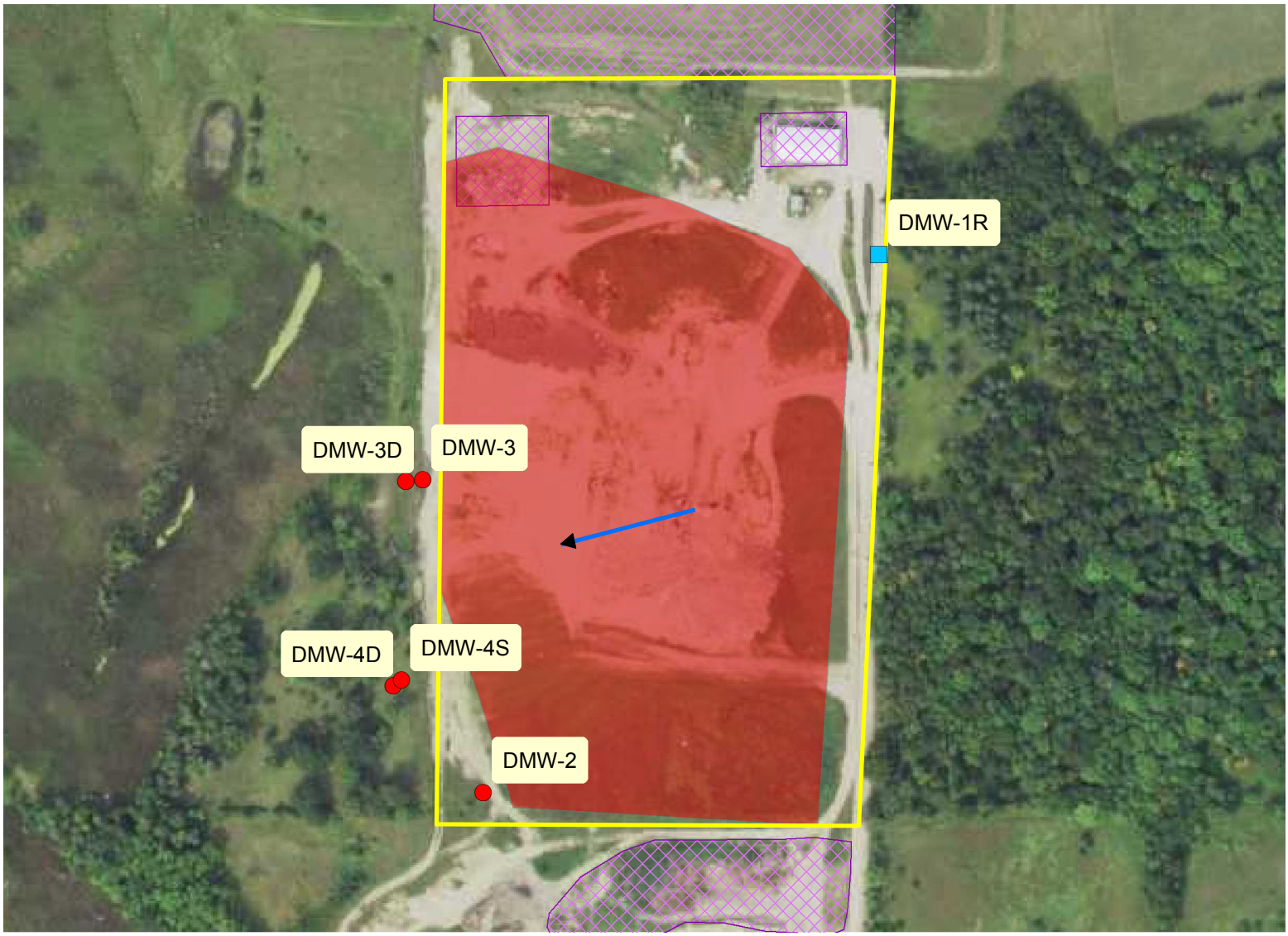
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



While a single trend was evaluated for Boron at MW-3, it was found to not be statically significant. However all points were above the IL.

SW-406 Douglas County Demo & Landfill LLC



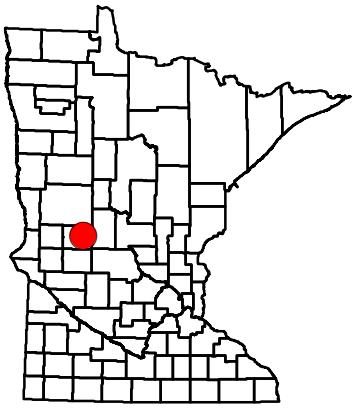
0 165 330 660 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-406 Alex Rubbish & Recycling Inc

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** Closed Landfill Program site to north
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 5
3. **Groundwater flow:** to west-southwest

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

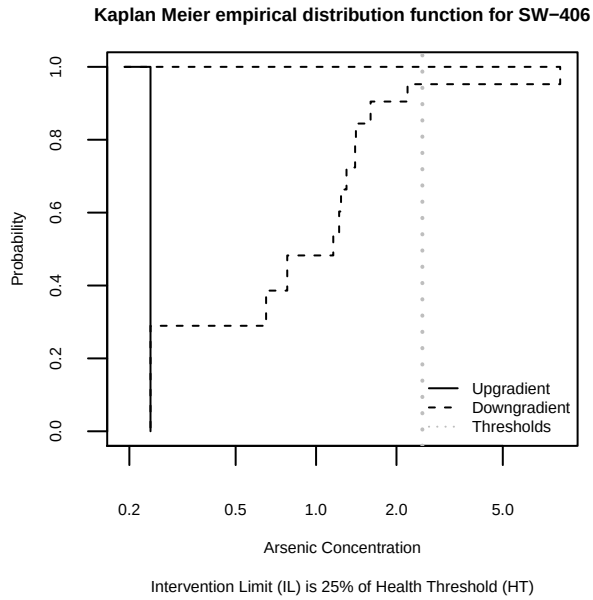
The concentration of Boron as measured in well DMW-3 is increasing over time (slope is positive and p-value is less than 0.05), all points are above the HT. The concentration of Manganese as measured in well DMW-3 is increasing over time (slope is positive and p-value is less than 0.05), from 2015 to 2017 the points were above the HT. The remaining well trends are not statistically significant.

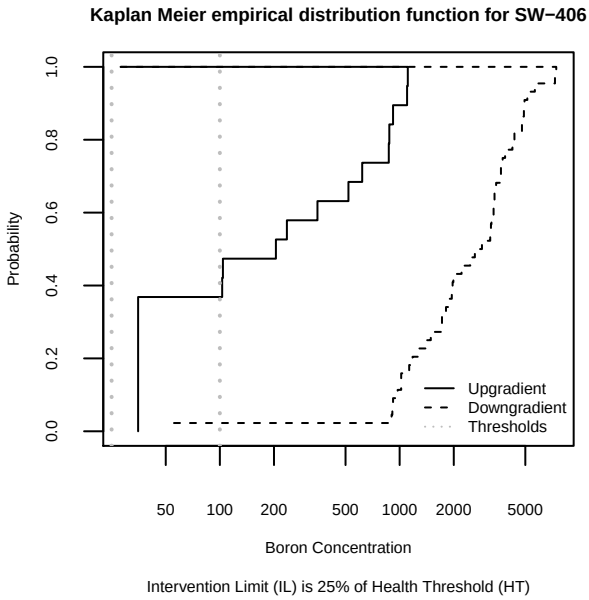
Kaplan Meier empirical distribution function (EDF)

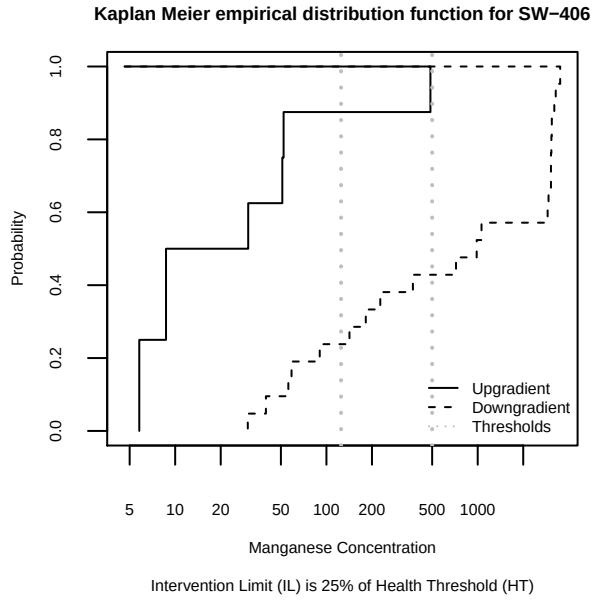
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-406	Arsenic	21	8	4.773	1	0.014**	Yes
	Boron	44	19	31.425	1	0***	Yes
	Manganese	21	8	10.338	1	0.001***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-406	Arsenic	DMW-2	0	0	8
		DMW-3	0	0	10
		DMW-3D	0	0	1
		DMW-4D	0	1	0
		DMW-4S	0	0	1
	Boron	DMW-2	18	0	1
		DMW-3	22	0	0
		DMW-3D	1	0	0
		DMW-4D	1	0	0
		DMW-4S	1	0	0
	Manganese	DMW-2	8	0	0
		DMW-3	5	5	0
		DMW-3D	1	0	0
		DMW-4D	1	0	0
		DMW-4S	1	0	0
	All	All	59	6	21

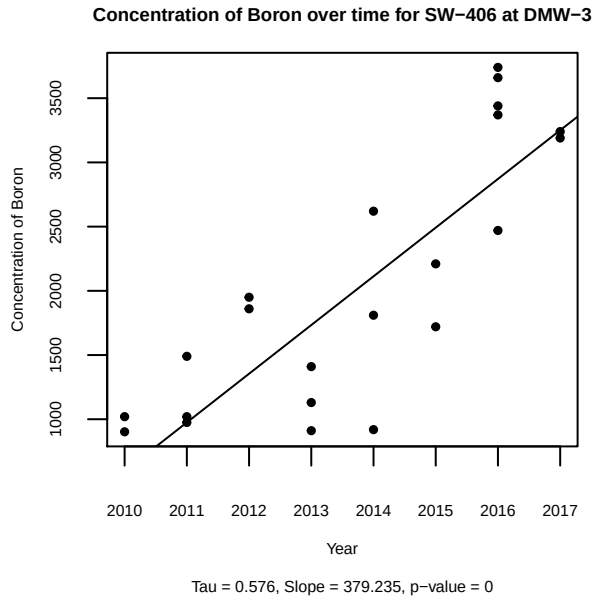
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

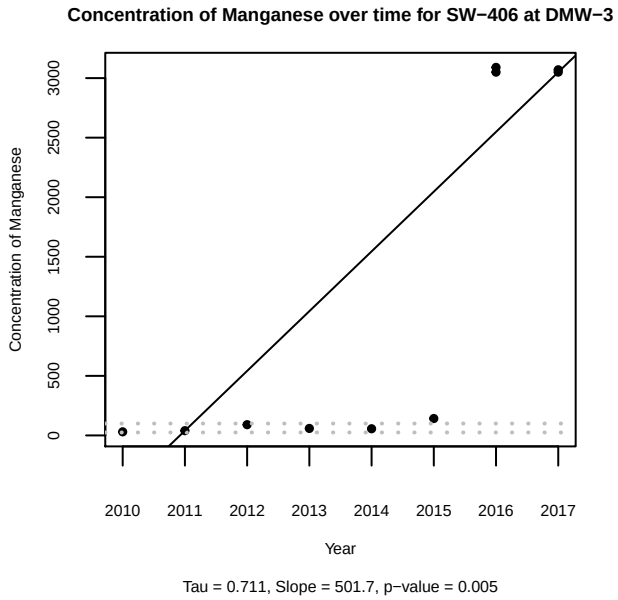
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

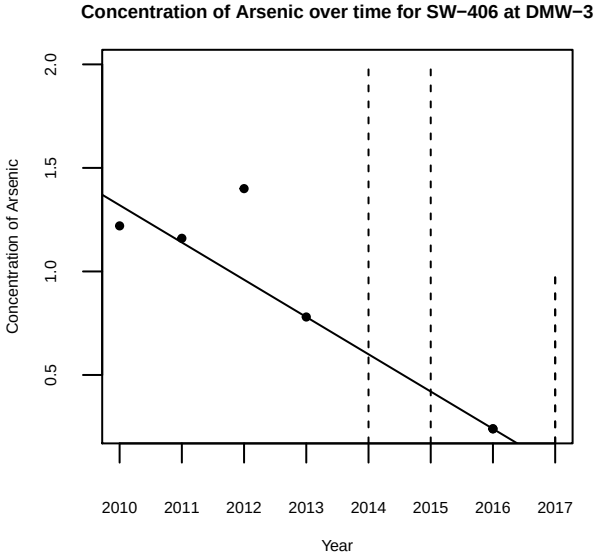
Table 3: Well/contaminant combinations where trends cannot be evaluated

Well ID	Contaminant	Number of measured values	Number of censored values	Total
DMW-3D	Arsenic	1	0	1
DMW-3D	Boron	1	0	1
DMW-3D	Manganese	1	0	1
DMW-4D	Arsenic	1	0	1
DMW-4D	Boron	1	0	1
DMW-4D	Manganese	1	0	1
DMW-4S	Arsenic	1	0	1
DMW-4S	Boron	1	0	1
DMW-4S	Manganese	1	0	1

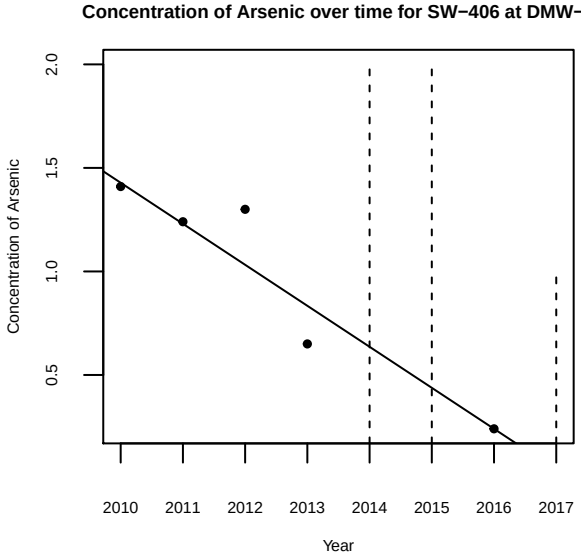
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



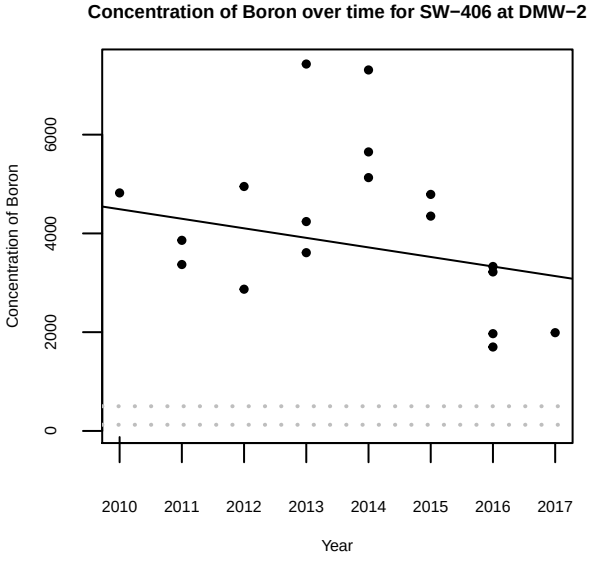




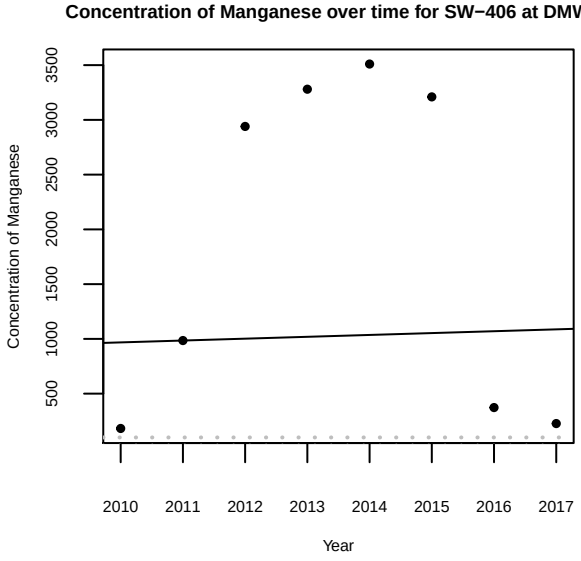
Tau = −0.356, Slope = −0.18, p−value = 0.13



Tau = −0.393, Slope = −0.198, p−value = 0.159



Tau = −0.146, Slope = −193.333, p−value = 0.395



Tau = 0.071, Slope = 17.024, p−value = 0.902

The concentration of Boron as measured in well DMW-3 is increasing over time (slope is positive and p-value is less than 0.05), all points are above the HT. The concentration of Manganese as measured in well DMW-3 is increasing over time (slope is positive and p-value is less than 0.05), from 2015 to 2017 the points were above the HT. The remaining well trends are not statistically significant.

SW-407 Lakes Area Demolition Landfill

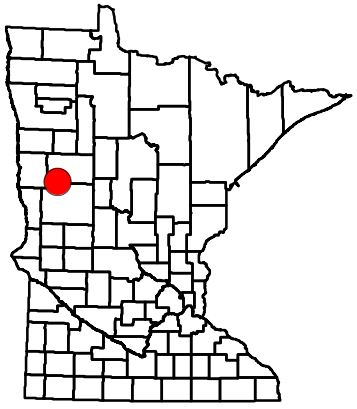
0 165 330 660 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-407 Lakes Area Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 0
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to southwest

C. Facility impact on groundwater

Facility lacks sample results from upgradient wells and thus cannot be evaluated for impacts to groundwater.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

No trends were evaluated for this facility.

SW-412 Crosslake Construction Demolition Debris

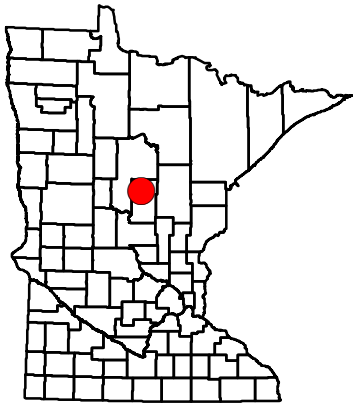
0 165 330 660 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-412 Crosslake Construction Demolition Debris

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** Recycling, storage, concrete production plant
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 0
2. **Downgradient well(s):** 5
3. **Groundwater flow:** to southeast

C. Facility impact on groundwater

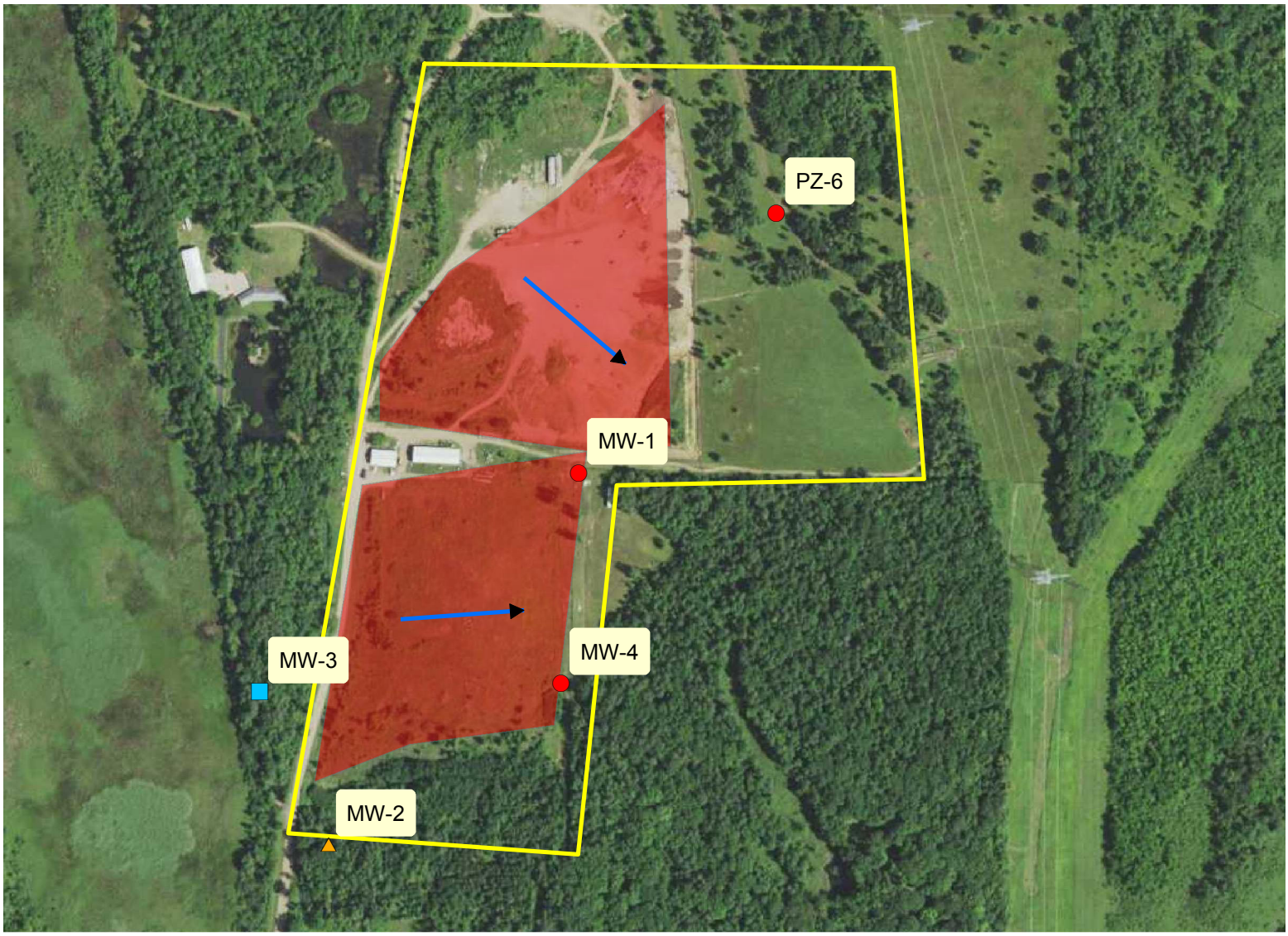
Facility lacks sample results from upgradient wells and thus cannot be evaluated for impacts to groundwater.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

No trends were evaluated for this facility.

SW-429 DKV Demolition Landfill



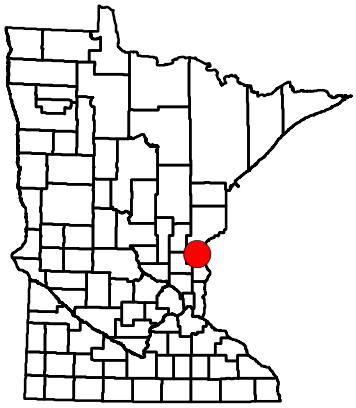
0 280 560 1,120
Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-429 DKV Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill opened in 1993, some portions no longer receiving waste
2. **Other solid waste:** Previously area had been used for hot mix plant, and town dump. Demo Landfill began as PBR demo in 1990-91.
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to east-southeast

C. Facility impact on groundwater

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

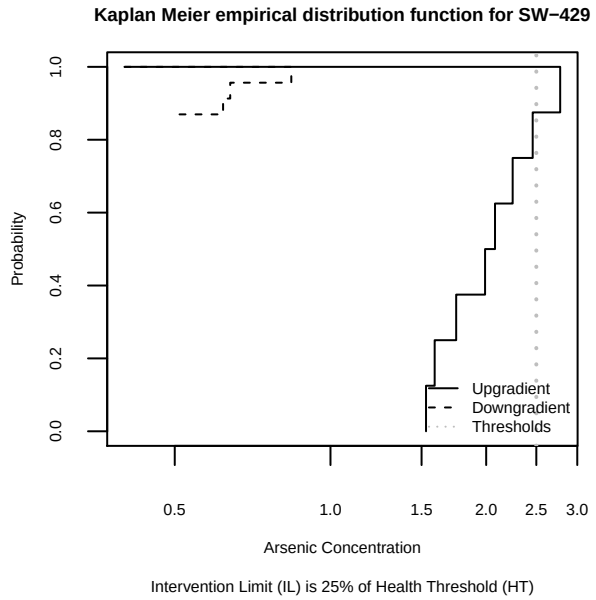
No trends were evaluated for this facility.

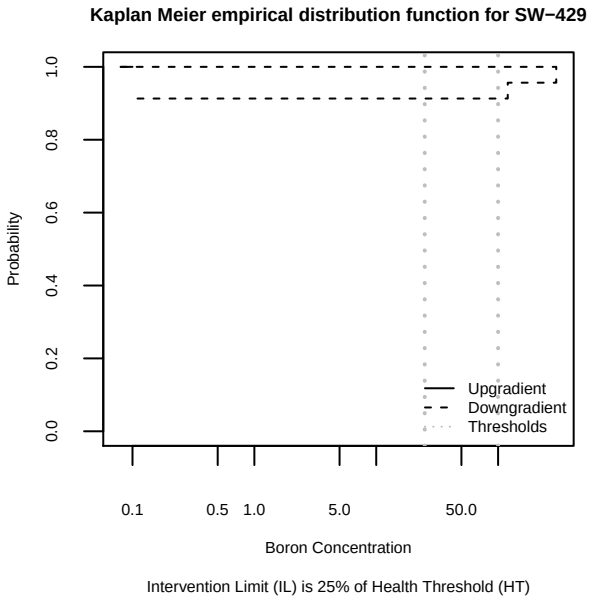
Kaplan Meier empirical distribution function (EDF)

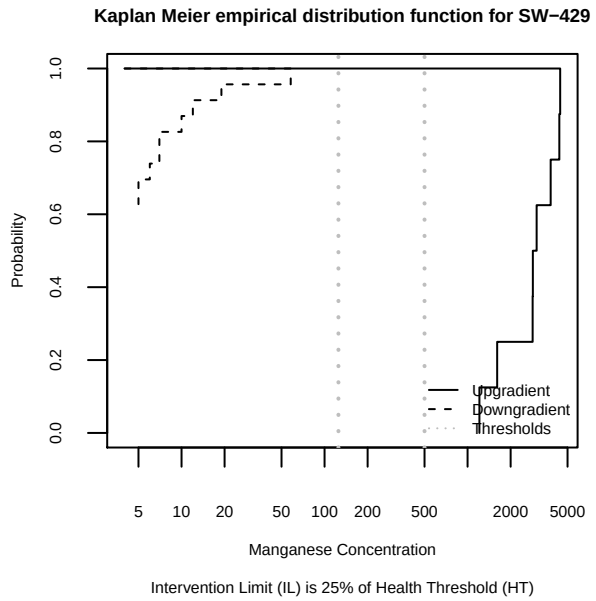
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-429	Arsenic	23	8	40.889	1	0***	No
	Boron	23	8	0.711	1	0.2	No
	Manganese	23	8	40.889	1	0***	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

SW-432 Hansen Demolition Landfill

0 140 280 560 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-432 Hansen Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to southwest

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

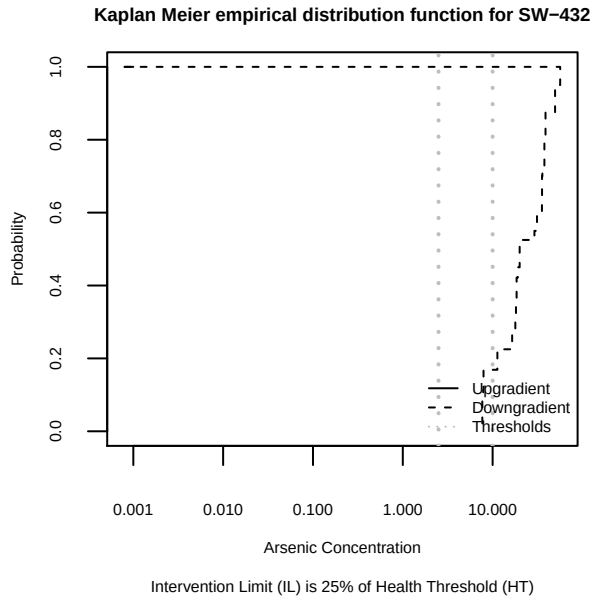
This facility does not show any significant trends for Arsenic, Boron, or Manganese however 95% of the points were above the respective HT.

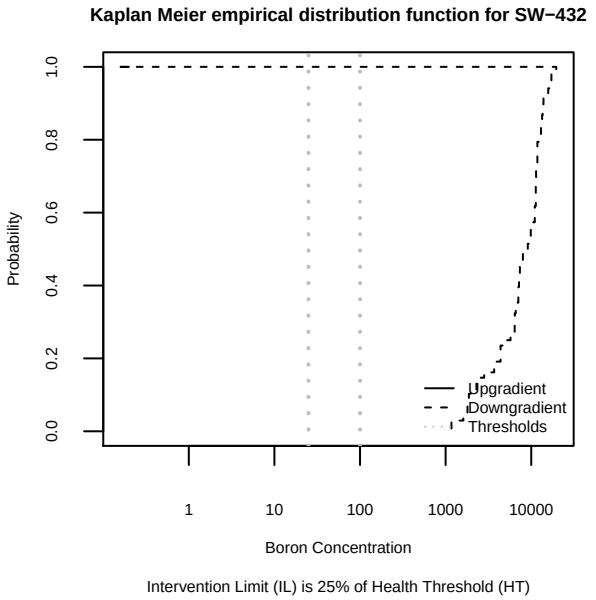
Kaplan Meier empirical distribution function (EDF)

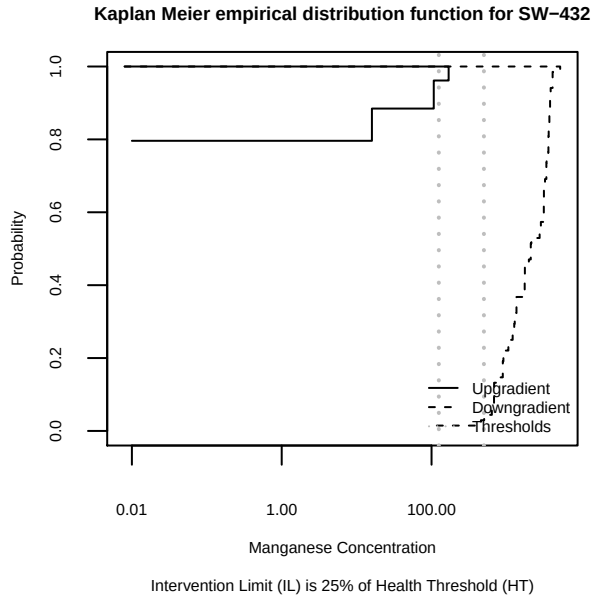
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-432	Arsenic	40	14	26.463	1	0***	Yes
	Boron	68	26	51.407	1	0***	Yes
	Manganese	68	26	51.231	1	0***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

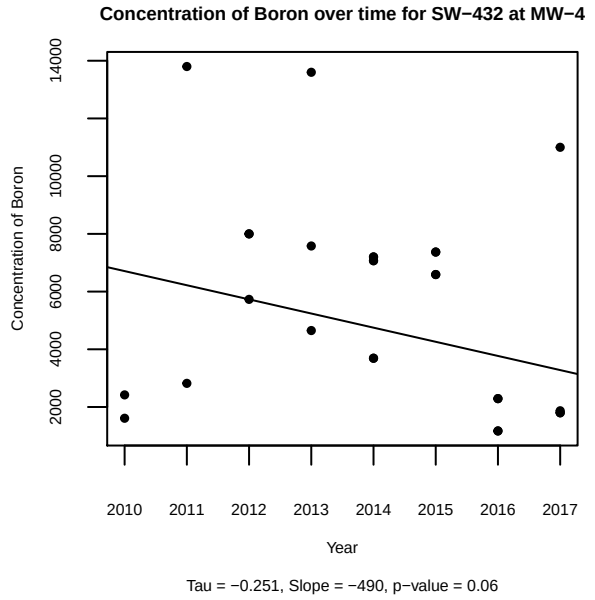
Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-432	Arsenic	MW-3	7	1	0
		MW-3R	13	3	0
		MW-4	12	2	2
	Boron	MW-3	19	0	0
		MW-3R	21	0	0
		MW-4	28	0	0
	Manganese	MW-3	19	0	0
		MW-3R	21	0	0
		MW-4	28	0	0
	All	All	168	6	2

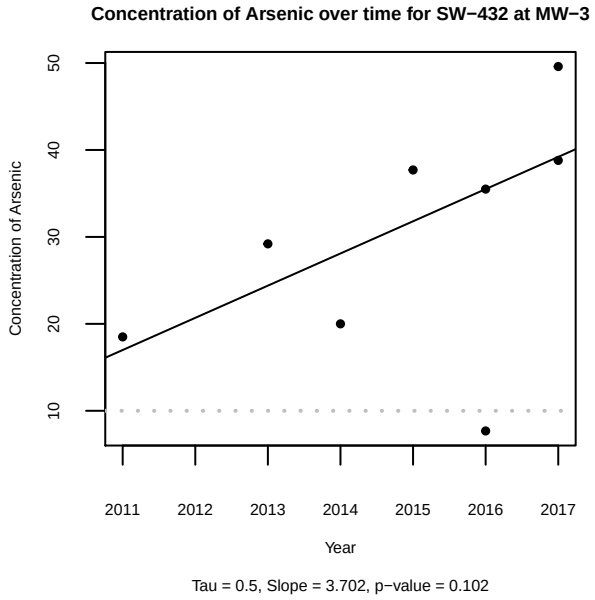
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

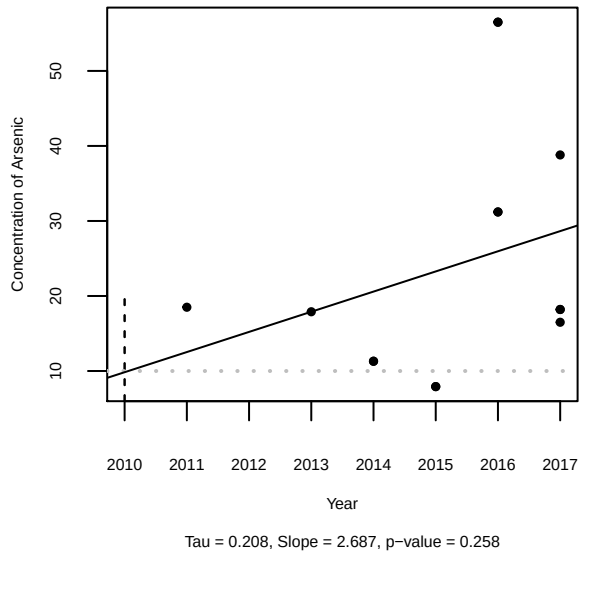
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



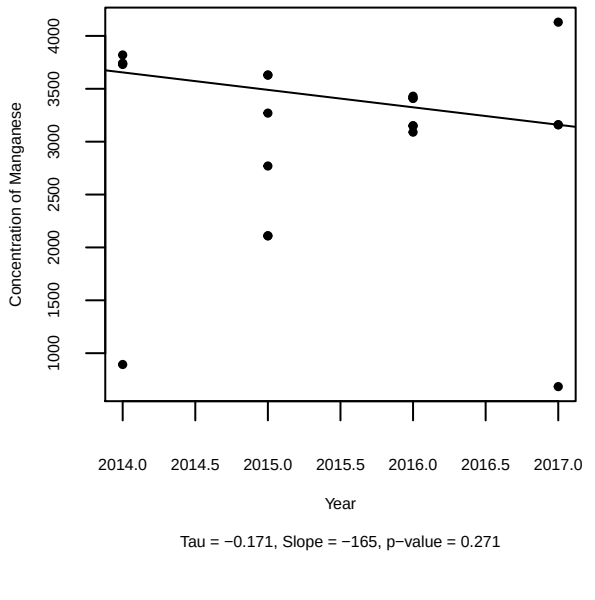
Tau = −0.251, Slope = −490, p−value = 0.06



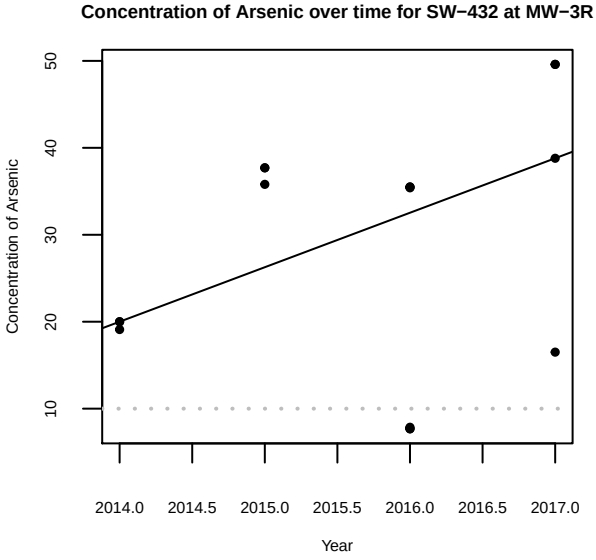
Tau = 0.5, Slope = 3.702, p−value = 0.102



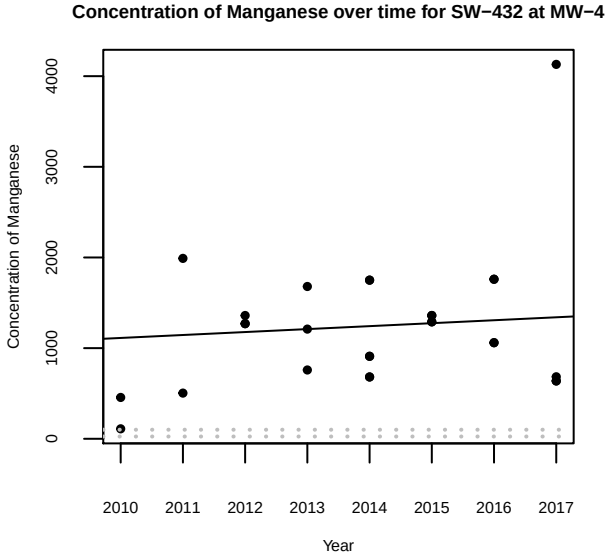
Tau = 0.208, Slope = 2.687, p−value = 0.258



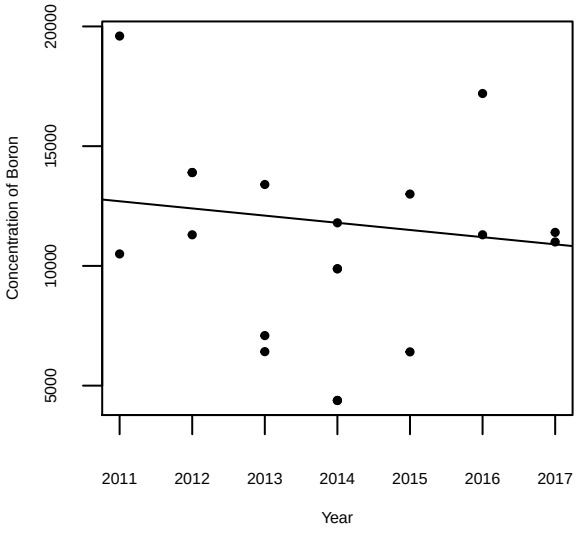
Tau = −0.171, Slope = −165, p−value = 0.271



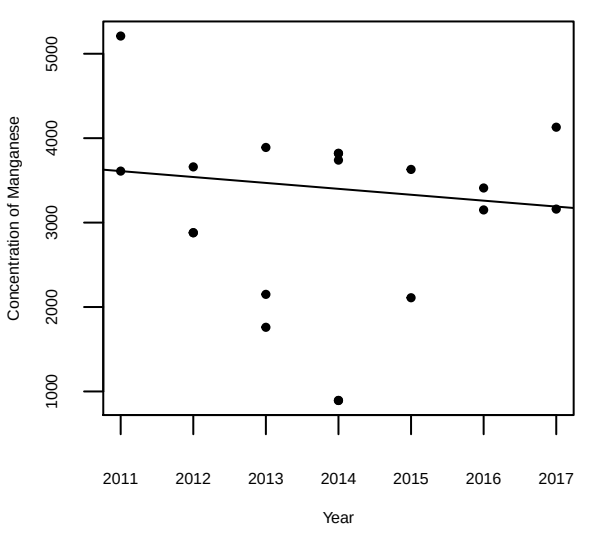
Tau = 0.175, Slope = 6.267, p−value = 0.343



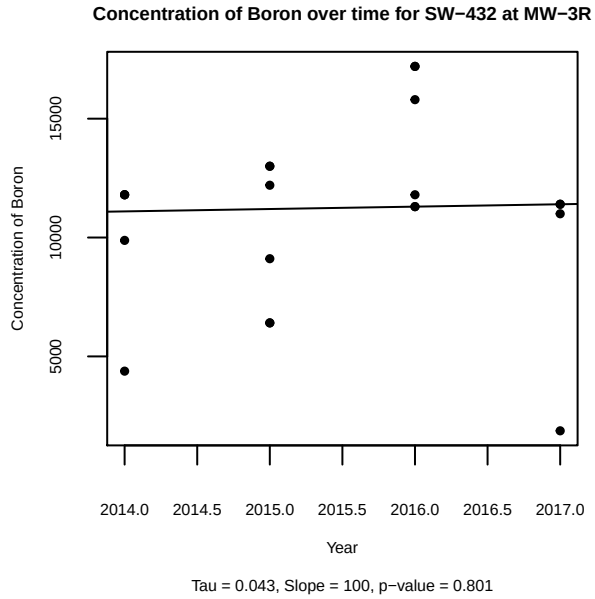
Tau = 0.119, Slope = 32.571, p−value = 0.378



Tau = −0.129, Slope = −300, p−value = 0.454



Tau = −0.053, Slope = −70, p−value = 0.775



This facility does not show any significant trends for Arsenic, Boron, or Manganese however 95% of the points were above the respective HT.

SW-440 Crow Wing County Demo Debris Landfill

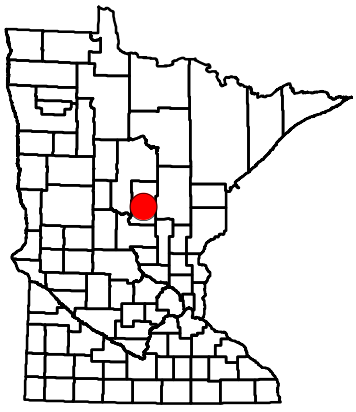
0 450 900 1,800 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-440 Crow Wing County Demo Debris Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** Municipal Solid Waste landfill with leachate application, recycling, yard waste compost, storage, leachate ponds, closed Closed Landfill Program landfill, closed industrial Landfill
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to northwest

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

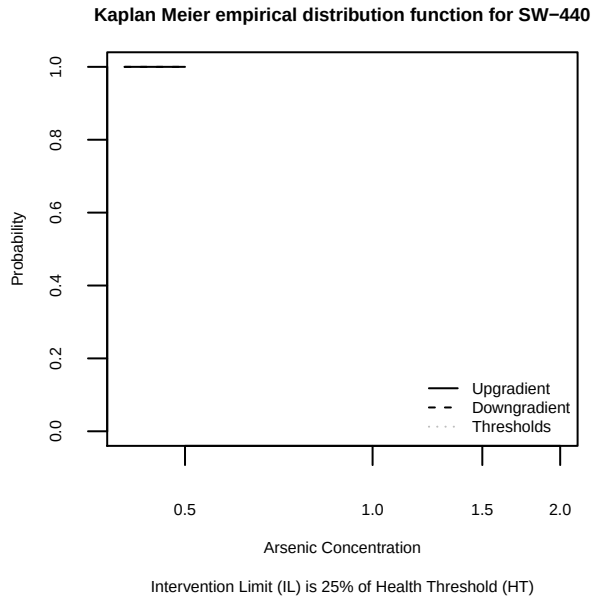
While a single trend was evaluated for Manganese at MW-37, it was found to not be statically significant. However all points were above the HT.

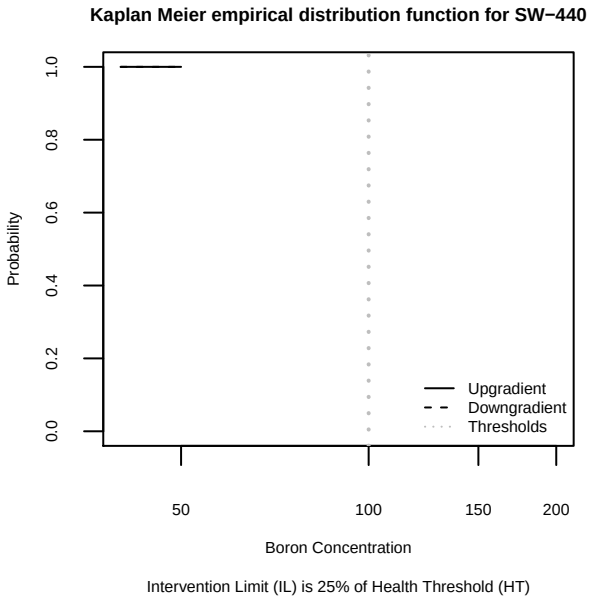
Kaplan Meier empirical distribution function (EDF)

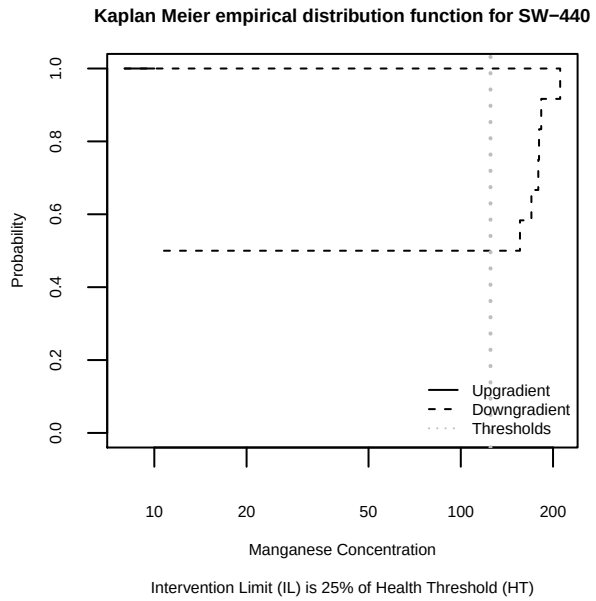
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-440	Arsenic	13	7	0.000	-1	NA	No
	Boron	13	7	0.000	-1	NA	No
	Manganese	12	7	4.421	1	0.018**	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-440	Manganese	MW-33	0	0	6
		MW-37	6	0	0
	All	All	6	0	6

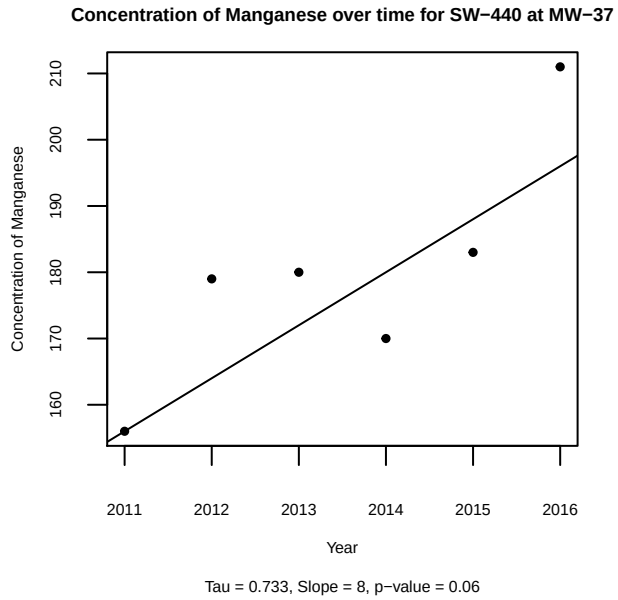
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

Table 3: Well/contaminant combinations where trends cannot be evaluated

Well ID	Contaminant	Number of measured values	Number of censored values	Total
MW-33	Manganese	0	6	6

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



While a single trend was evaluated for Manganese at MW-37, it was found to not be statically significant. However all points were above the HT.

SW-448 Itasca County Demo Landfill/MSW Transfer Station

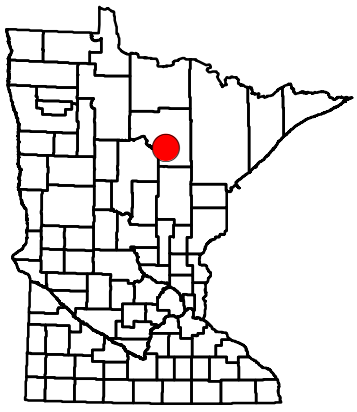
0 170 340 680 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-448 Itasca Co Demo Landfill/MSW Transfer Sta

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill. Old Construction and Demolition Landfill cell to SE
2. **Other solid waste:** Closed Municipal Solid Waste Landfill to east-southeast beyond closed Demo Landfill cell, and Municipal Solid Waste Transfer Station.
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 2
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to east-northeast

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for arsenic and boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

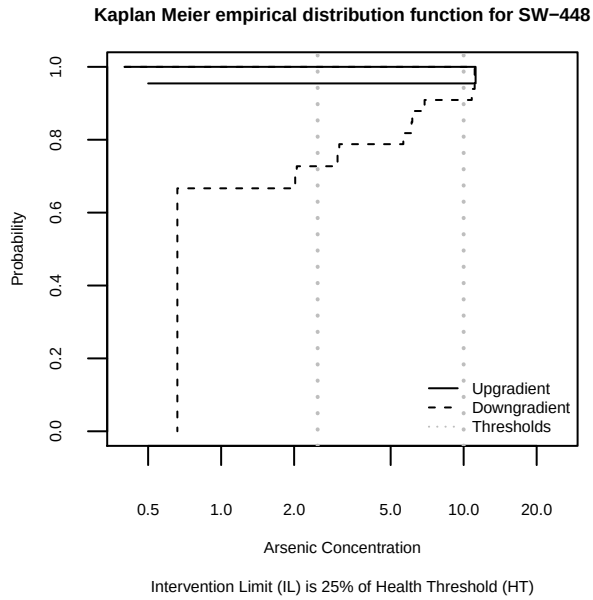
The concentration of Boron as measured in well MW-4 is increasing over time (slope is positive and p-value is less than 0.05). Arsenic is decreasing in the same well, but most points are still above the IL for Arsenic. There is no significant trend for Arsenic in MW-5 (p-value =0.912).

Kaplan Meier empirical distribution function (EDF)

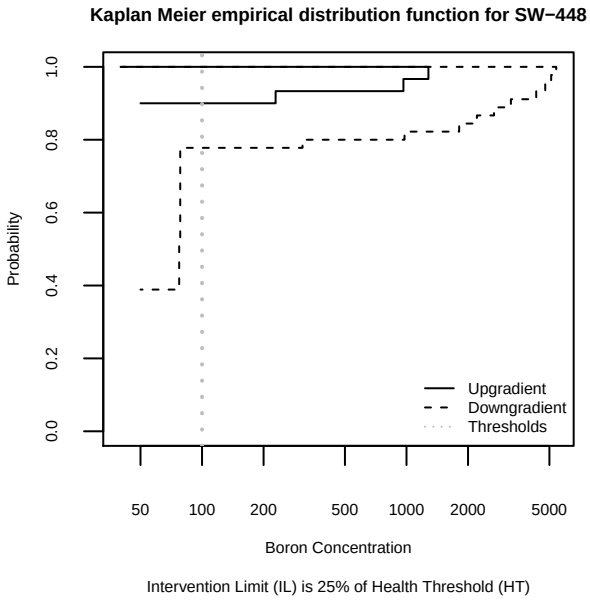
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

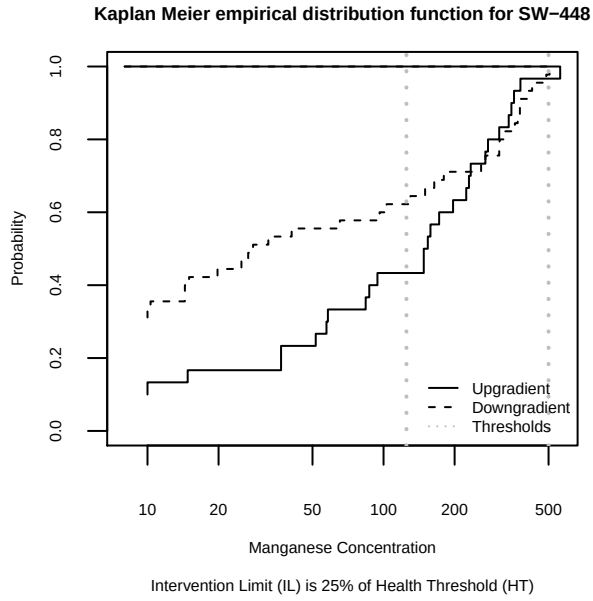
The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)

Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-448	Arsenic	45	30	8.309	1	0.002***	Yes
	Boron	45	30	4.528	1	0.017**	Yes
	Manganese	45	30	2.957	1	0.043**	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for arsenic and boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-448	Arsenic	MW-1	0	0	14
		MW-4	3	6	6
		MW-5	0	0	16
	Boron	MW-1	0	0	14
		MW-4	9	1	5
		MW-5	0	0	16
	All	All	12	7	71

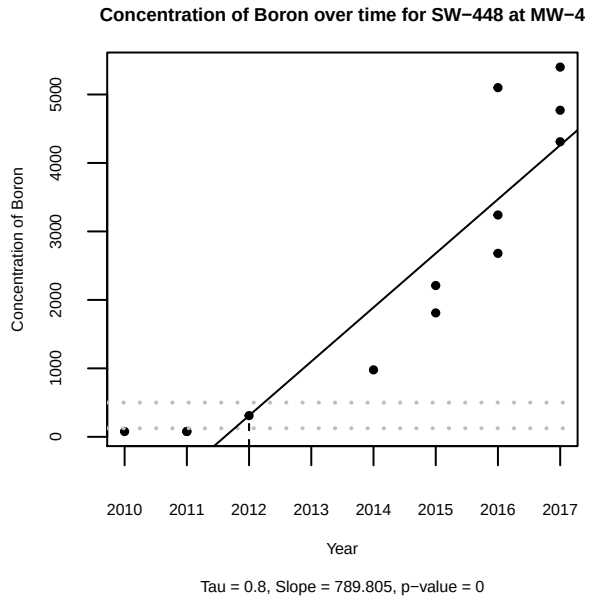
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

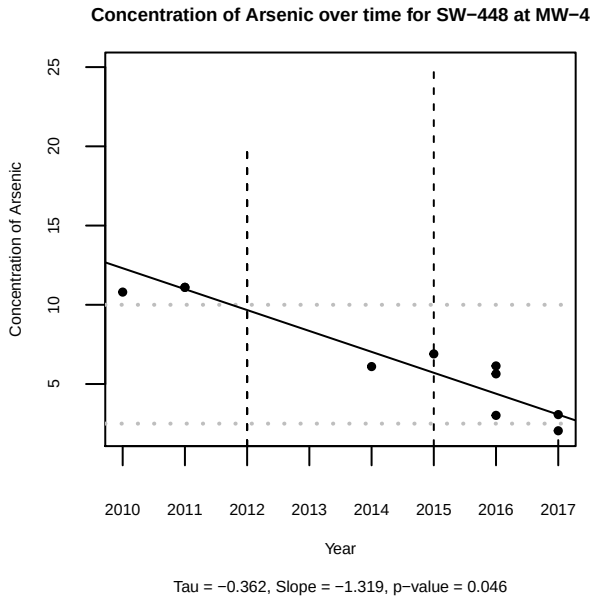
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

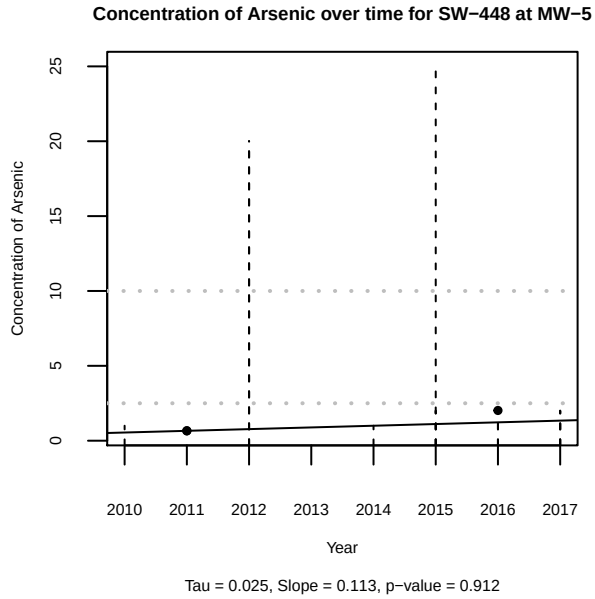
Table 3: Well/contaminant combinations where trends cannot be evaluated

Well ID	Contaminant	Number of measured values	Number of censored values	Total
MW-1	Arsenic	0	14	14
MW-1	Boron	0	14	14
MW-5	Boron	0	16	16

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.







The concentration of Boron as measured in well MW-4 is increasing over time (slope is positive and p-value is less than 0.05). Arsenic is decreasing in the same well, but most points are still above the IL for Arsenic. There is no significant trend for Arsenic in MW-5 (p-value =0.912).

SW-464 Hoffman Demolition Landfill

0 225 450 900 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-464 Hoffman Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill. Disposal began in 1994
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 8
3. **Groundwater flow:** to northwest

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

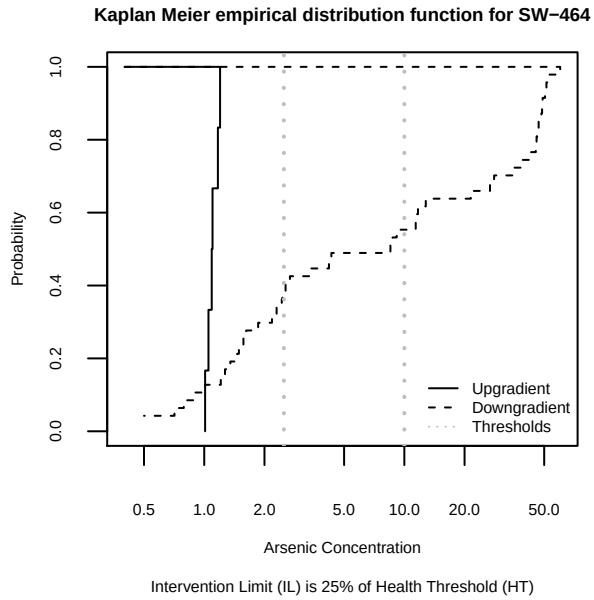
The concentration of Boron as measured in well MW-3B is decreasing over time (slope is negative and p-value is less than 0.05), however points are above the IL from 2012 to 2013 and below the IL from 2013 to 2017. The concentration of Arsenic as measured in well MW-3B is increasing over time (slope is positive and p-value is less than 0.05). From 2014 to 2016 all points are above the IL, in 2017 the points were above the HT. The remaining well trends are not statistically significant.

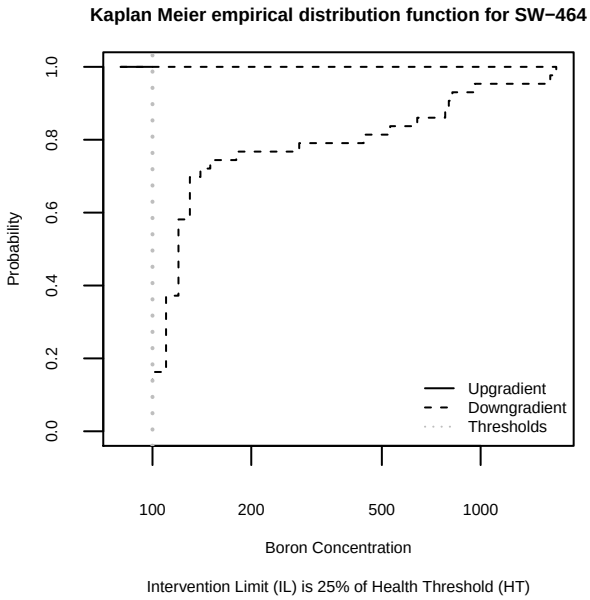
Kaplan Meier empirical distribution function (EDF)

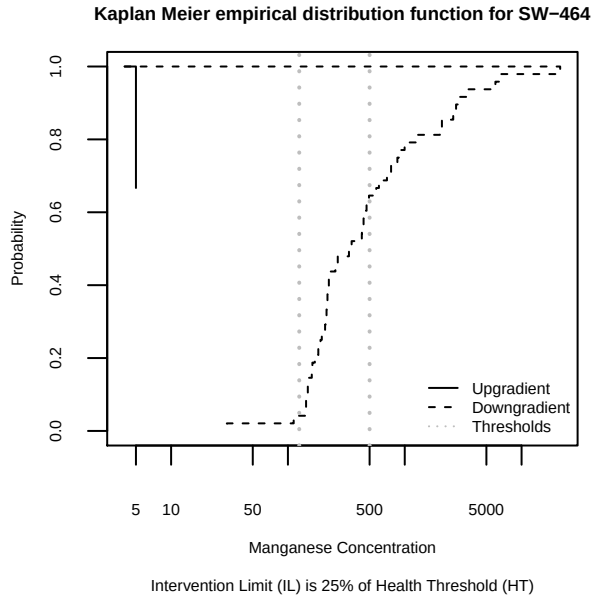
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-464	Arsenic	47	6	6.574	1	0.005***	Yes
	Boron	43	6	9.387	1	0.001***	Yes
	Manganese	48	6	11.756	1	0***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-464	Arsenic	MW-2A	3	3	1
		MW-2B	0	0	6
		MW-3A	7	0	0
		MW-3B	1	3	2
		MW-4A	7	0	0
		MW-5A	0	2	5
		MW-6A	0	0	4
		MW-6B	3	0	0
	Boron	MW-2A	0	3	3
		MW-2B	0	3	3
		MW-3A	0	0	6
		MW-3B	0	2	4
		MW-4A	0	0	6
		MW-5A	5	1	0
		MW-6A	3	1	0
		MW-6B	0	0	3
	Manganese	MW-2A	7	0	0
		MW-2B	7	0	0
		MW-3A	7	0	0
		MW-3B	5	1	0
		MW-4A	7	0	0
		MW-5A	7	0	0
		MW-6A	4	0	0
		MW-6B	3	0	0
	All	All	76	19	43

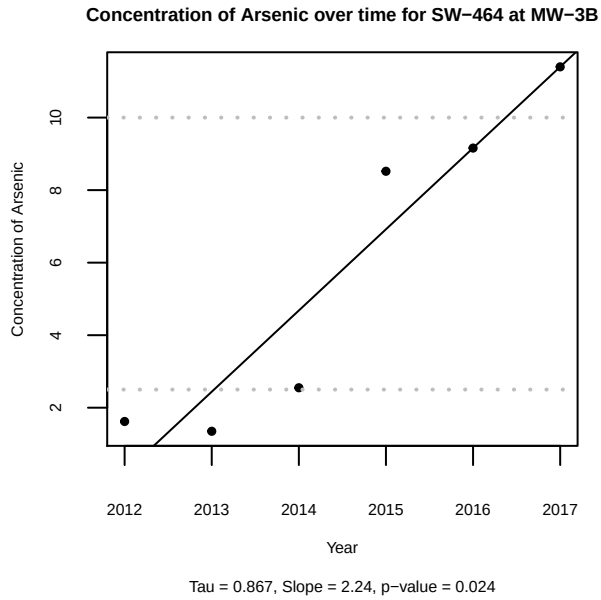
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

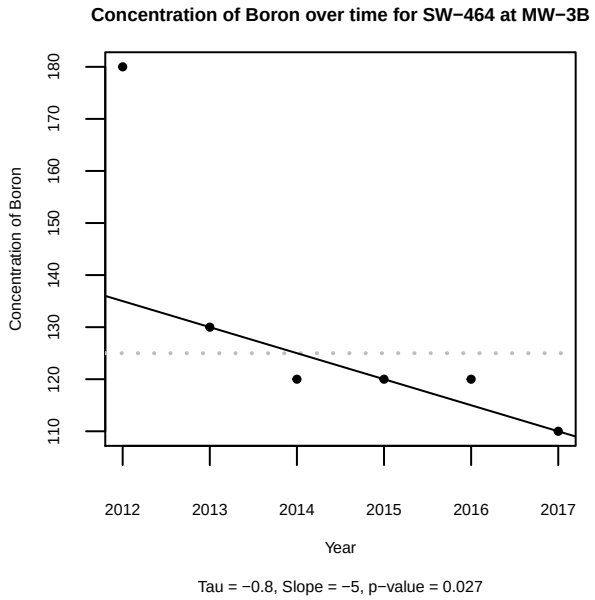
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

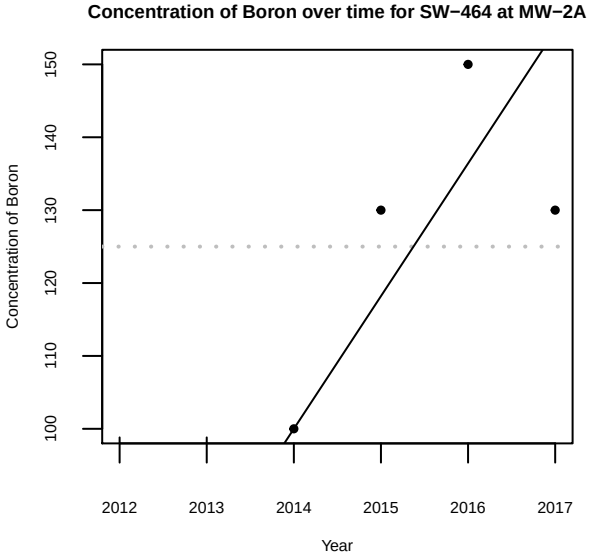
Table 3: Well/contaminant combinations where trends cannot be evaluated

Well ID	Contaminant	Number of measured values	Number of censored values	Total
MW-6B	Boron	0	3	3

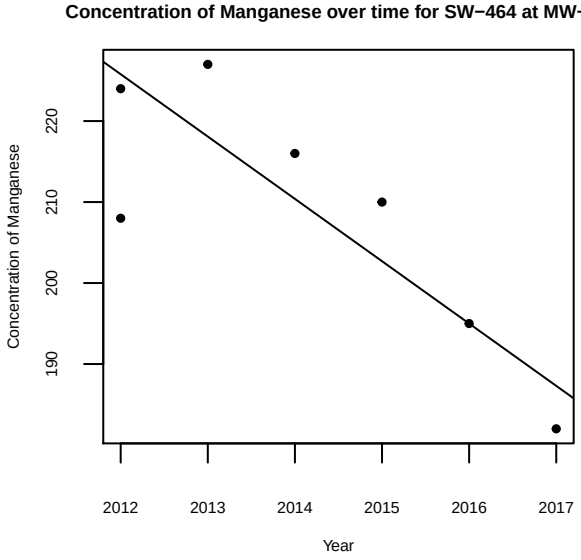
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



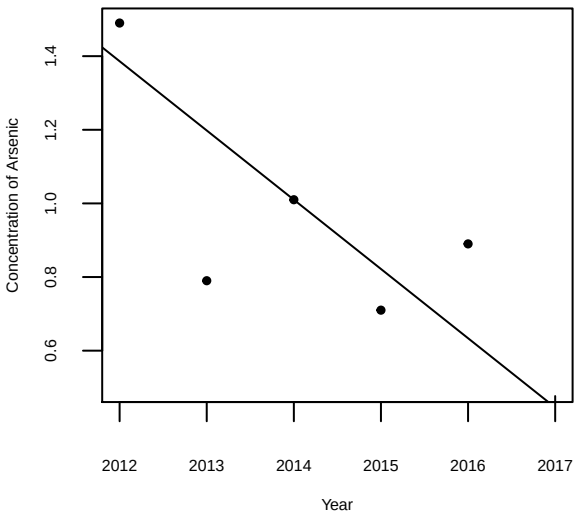




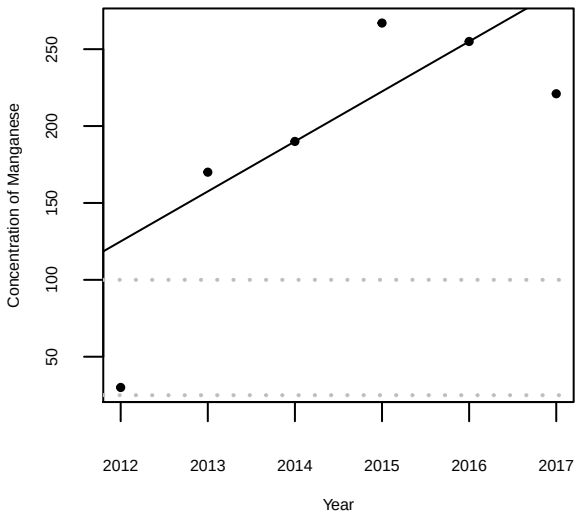
Tau = 0.733, Slope = 18.203, p−value = 0.051



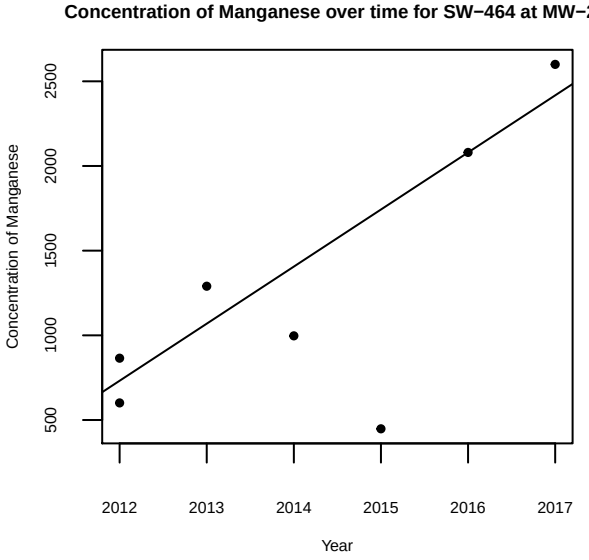
Tau = −0.571, Slope = −7.695, p−value = 0.095



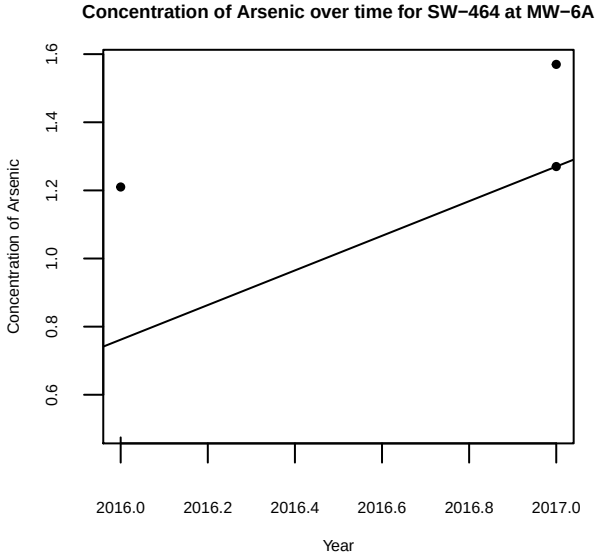
Tau = −0.6, Slope = −0.188, p−value = 0.133



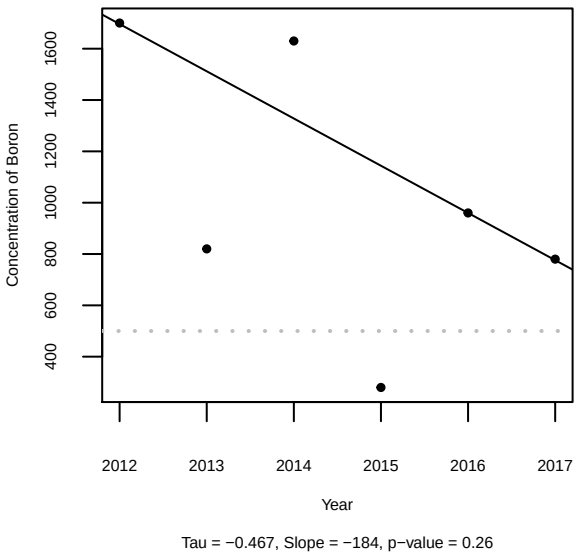
Tau = 0.6, Slope = 32.5, p−value = 0.133



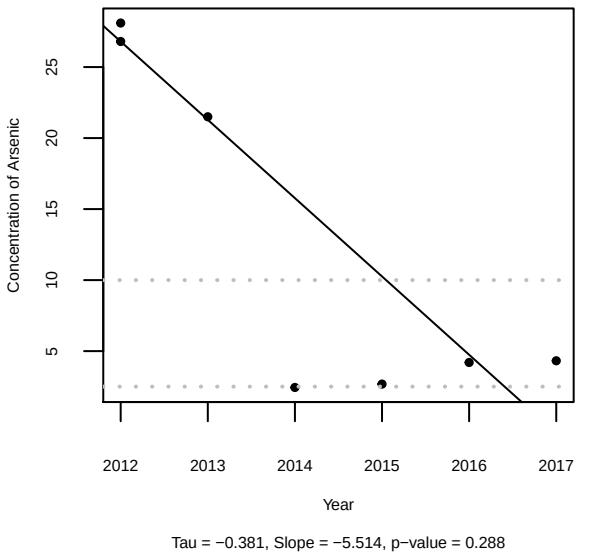
Tau = 0.476, Slope = 337.031, p−value = 0.172



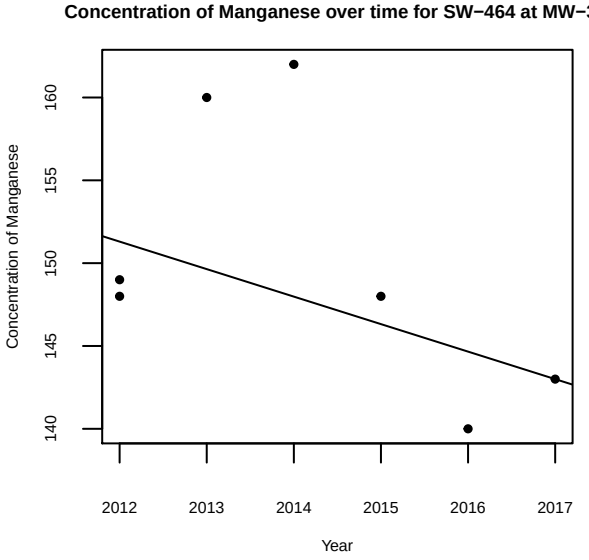
Tau = 0.667, Slope = 0.508, p−value = 0.245



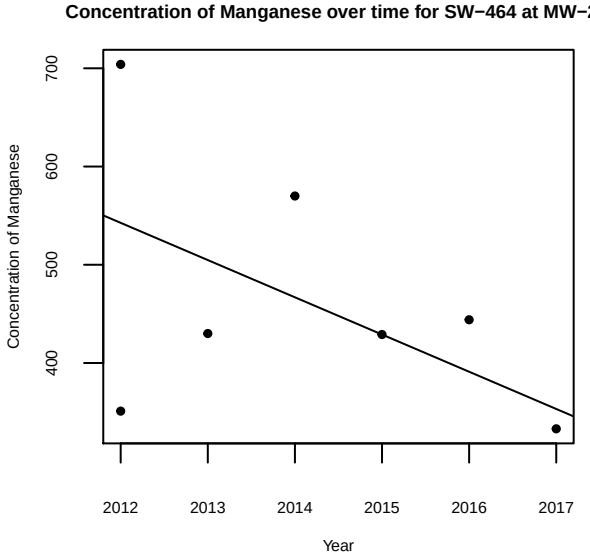
Tau = −0.467, Slope = −184, p−value = 0.26



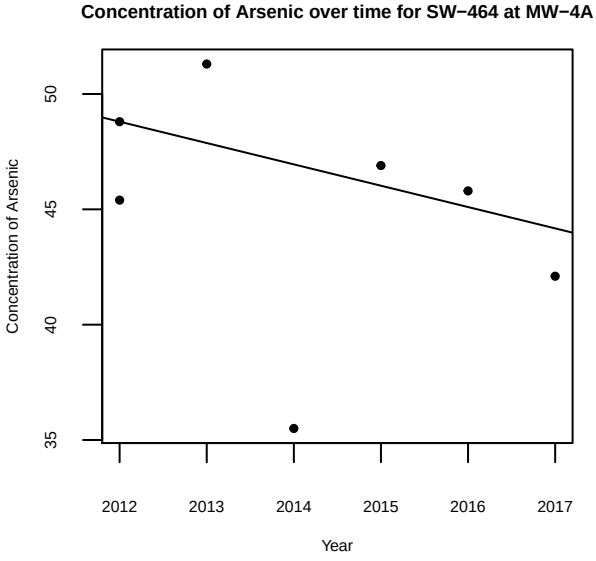
Tau = −0.381, Slope = −5.514, p−value = 0.288



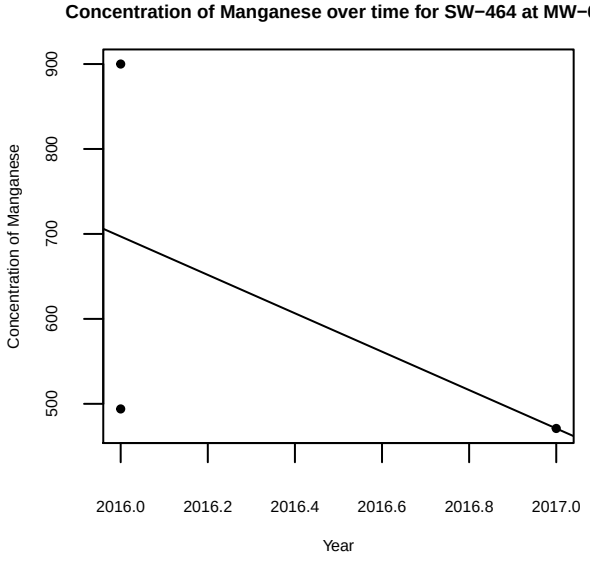
Tau = −0.333, Slope = −1.66, p−value = 0.357



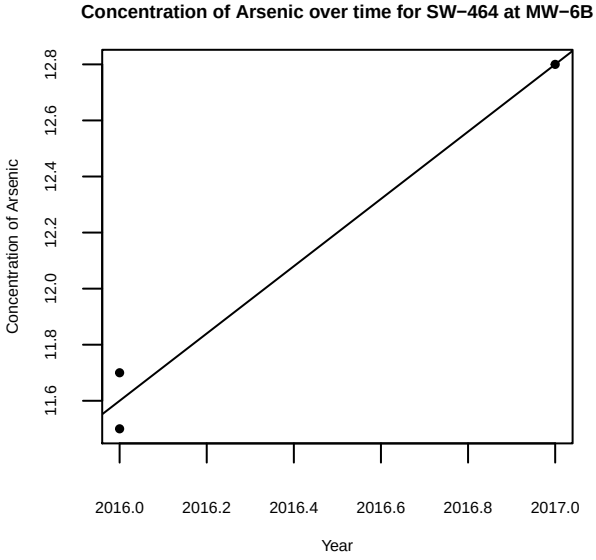
Tau = −0.286, Slope = −37.891, p−value = 0.448

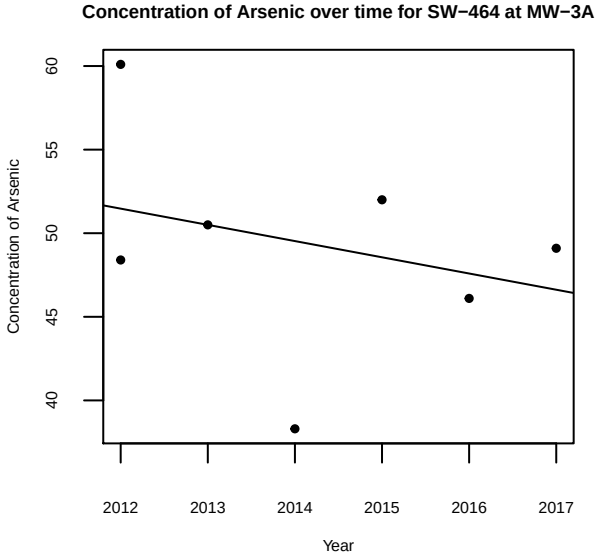


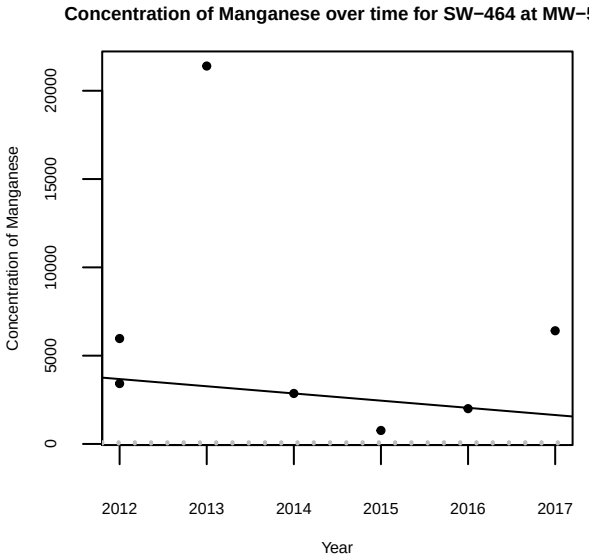
Tau = −0.286, Slope = −0.925, p−value = 0.448

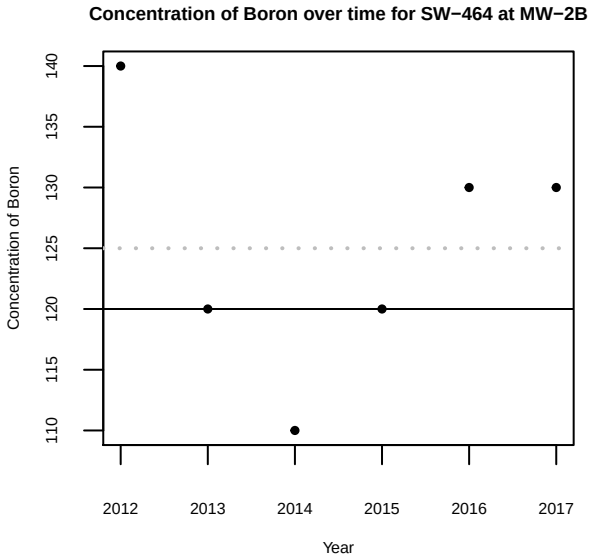


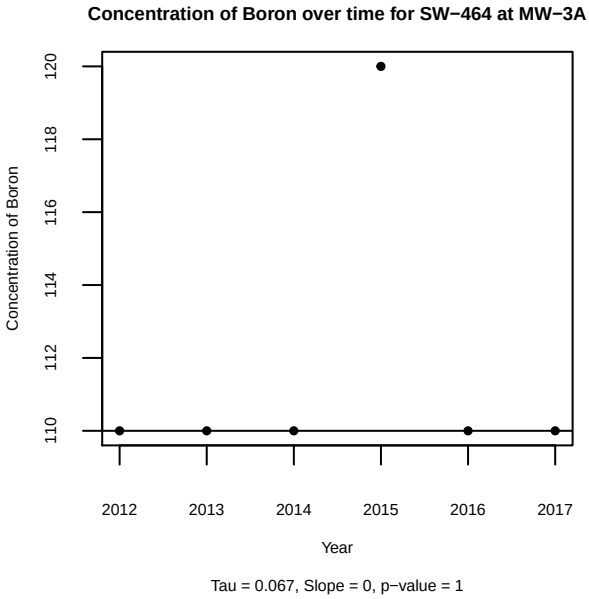
Tau = −0.667, Slope = −226, p−value = 0.54

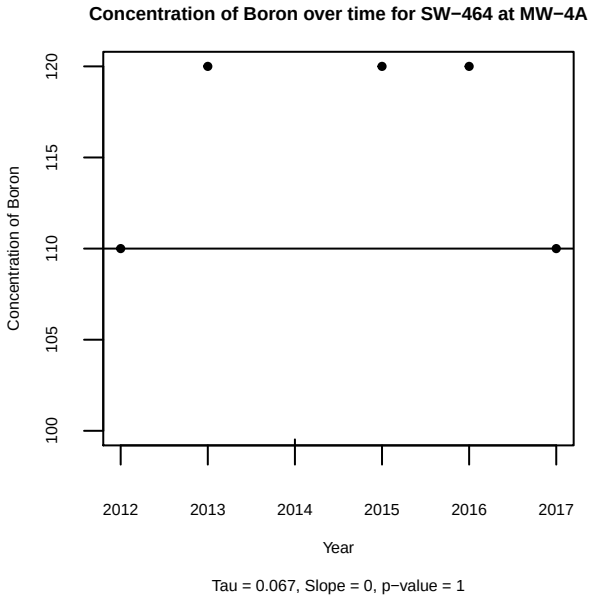

Concentration of Arsenic over time for SW−464 at MW−6B
Concentration of Arsenic
11.6
11.8
12.0
12.2
12.4
12.6
12.8
2016.0
2016.2
2016.4
2016.6
2016.8
2017.0
Year
Tau = 0.667, Slope = 1.2, p−value = 0.54

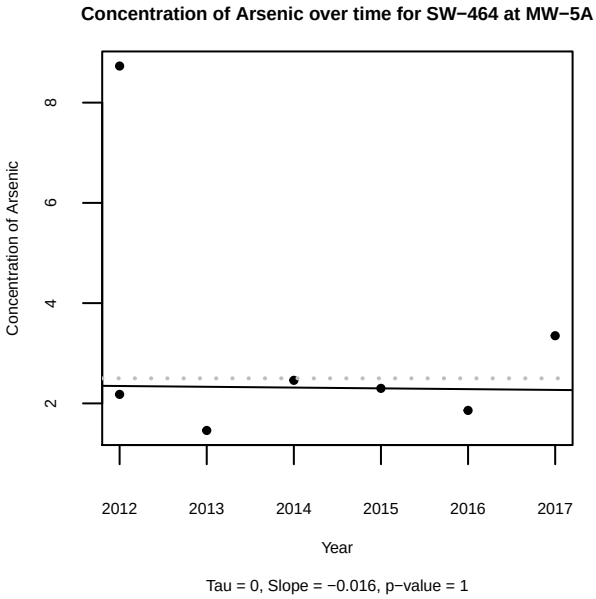

Concentration of Arsenic over time for SW−464 at MW−3A
Concentration of Arsenic
40
45
50
55
60
2012
2013
2014
2015
2016
2017
Year
Tau = −0.19, Slope = −0.97, p−value = 0.649

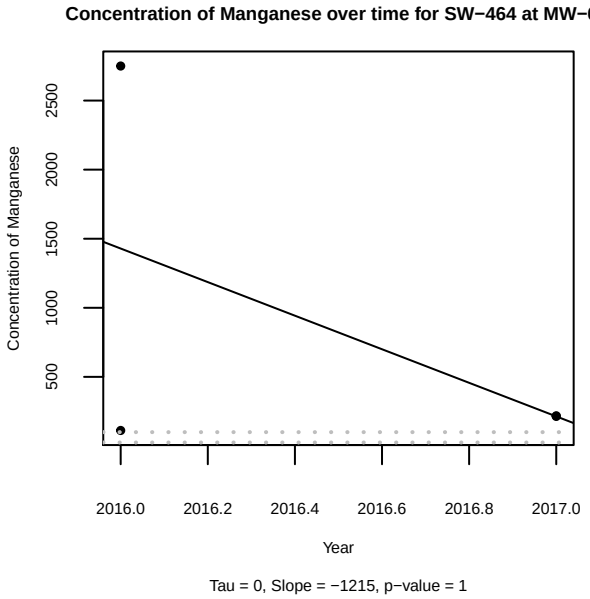

Concentration of Manganese over time for SW−464 at MW−5A
Concentration of Manganese
0
5000
10000
15000
20000
2012
2013
2014
2015
2016
2017
Year
Tau = −0.19, Slope = −407.053, p−value = 0.649

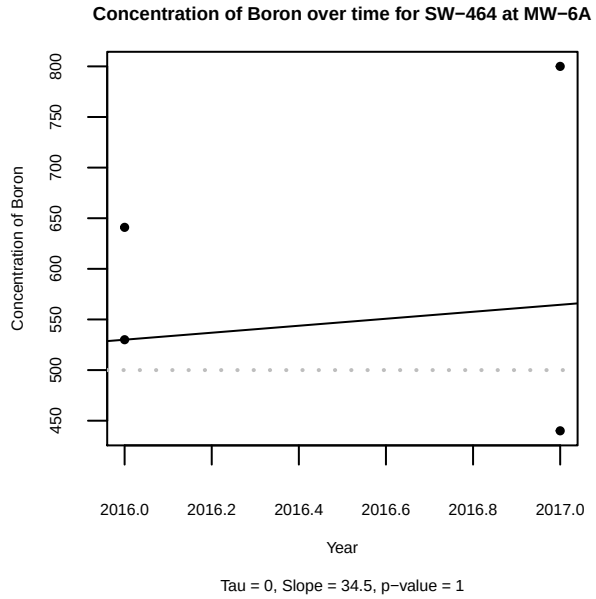

Concentration of Boron over time for SW−464 at MW−2B
Concentration of Boron
110
115
120
125
130
135
140
2012
2013
2014
2015
2016
2017
Year
Tau = 0.067, Slope = 0, p−value = 1


Concentration of Boron over time for SW−464 at MW−3A
Concentration of Boron
110
112
114
116
118
120
2012
2013
2014
2015
2016
2017
Year
Tau = 0.067, Slope = 0, p−value = 1


Concentration of Boron over time for SW−464 at MW−4A
Concentration of Boron
100
105
110
115
120
2012
2013
2014
2015
2016
2017
Year
Tau = 0.067, Slope = 0, p−value = 1


Concentration of Arsenic over time for SW−464 at MW−5A
Concentration of Arsenic
2
4
6
8
2012
2013
2014
2015
2016
2017
Year
Tau = 0, Slope = −0.016, p−value = 1


Concentration of Manganese over time for SW−464 at MW−6A
Concentration of Manganese
500
1000
1500
2000
2500
2016.0
2016.2
2016.4
2016.6
2016.8
2017.0
Year
Tau = 0, Slope = −1215, p−value = 1



The concentration of Boron as measured in well MW-3B is decreasing over time (slope is negative and p-value is less than 0.05), however points are above the IL from 2012 to 2013 and below the IL from 2013 to 2017. The concentration of Arsenic as measured in well MW-3B is increasing over time (slope is positive and p-value is less than 0.05). From 2014 to 2016 all points are above the IL, in 2017 the points were above the HT. The remaining well trends are not statistically significant.

SW-473 Lac Qui Parle County Demolition Landfill

0 140 280 560 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-473 Lac Qui Parle County Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to north

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

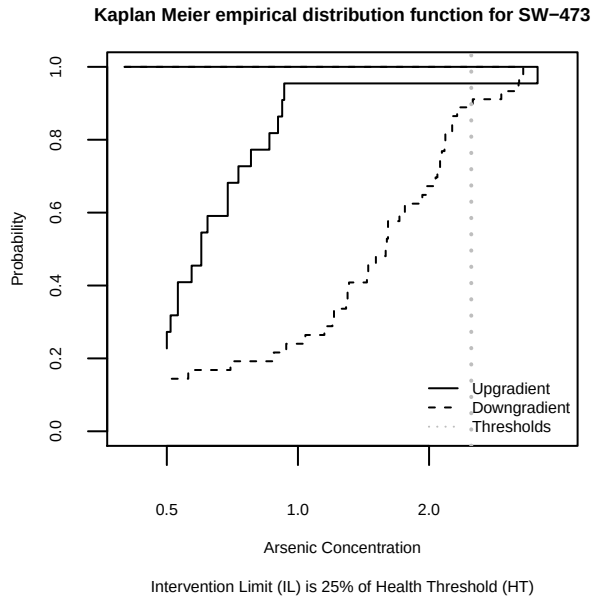
The concentration of Boron as measured in well MW-3 is decreasing over time (slope is negative and p-value is less than 0.05), however all points are above the HT except for 2016 and 2017 points. The concentration of Boron as measured in well MW-2 is increasing over time (slope is positive and p-value is less than 0.05), however all points are above the HT. The remaining well trends are not statistically significant.

Kaplan Meier empirical distribution function (EDF)

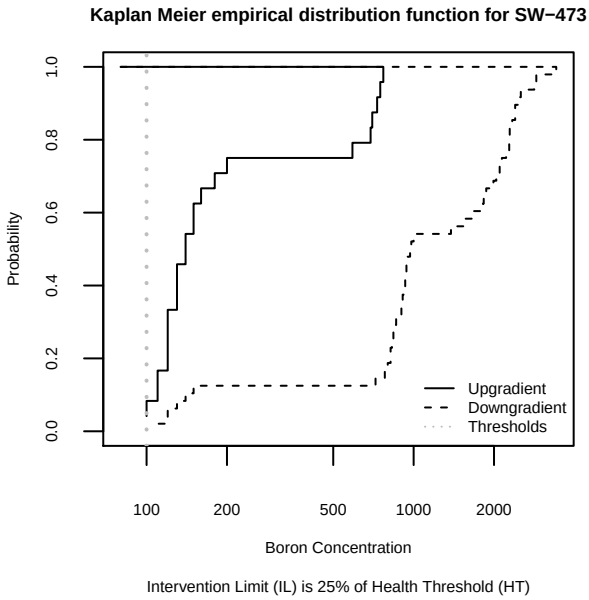
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

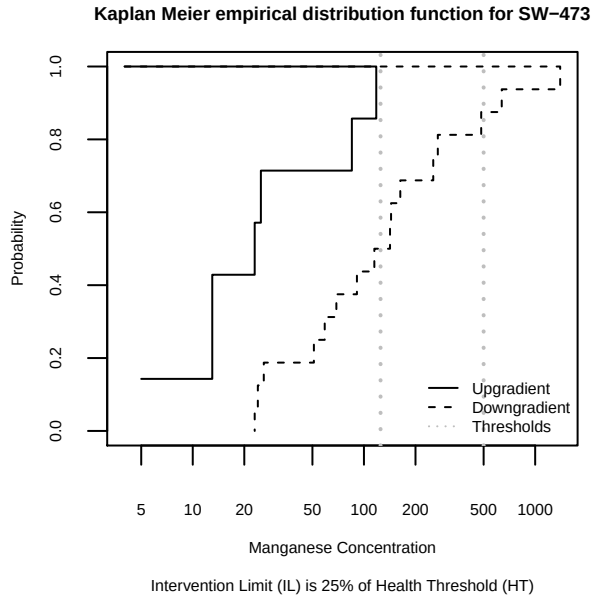
The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)

Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-473	Arsenic	45	23	15.635	1	0***	Yes
	Boron	48	24	31.186	1	0***	Yes
	Manganese	16	7	6.266	1	0.006***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

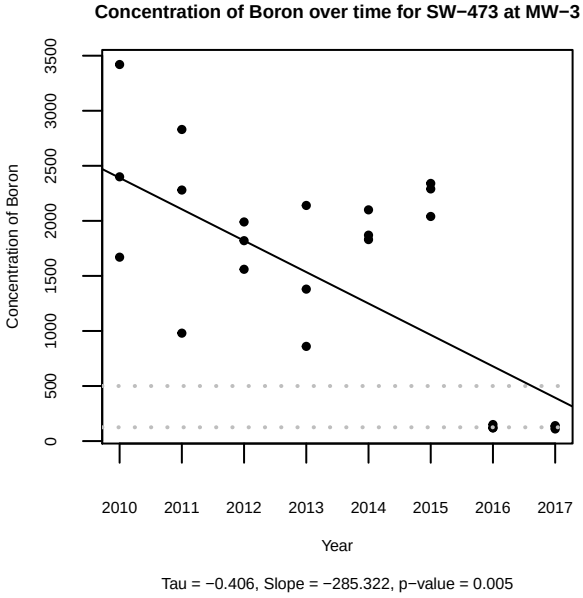
Table 2: Exceedance of thresholds by contaminant and Well ID

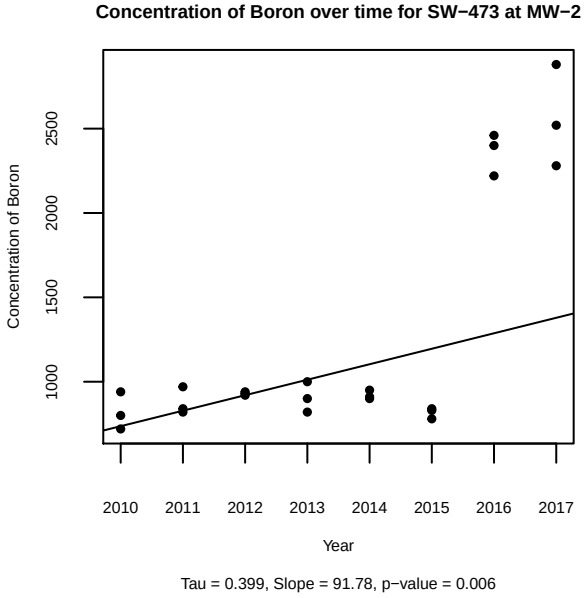
Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-473	Arsenic	MW-2	0	1	21
		MW-3	0	4	19
	Boron	MW-2	24	0	0
		MW-3	18	3	3
	Manganese	MW-2	4	4	0
		MW-3	5	1	2
	All	All	51	13	45

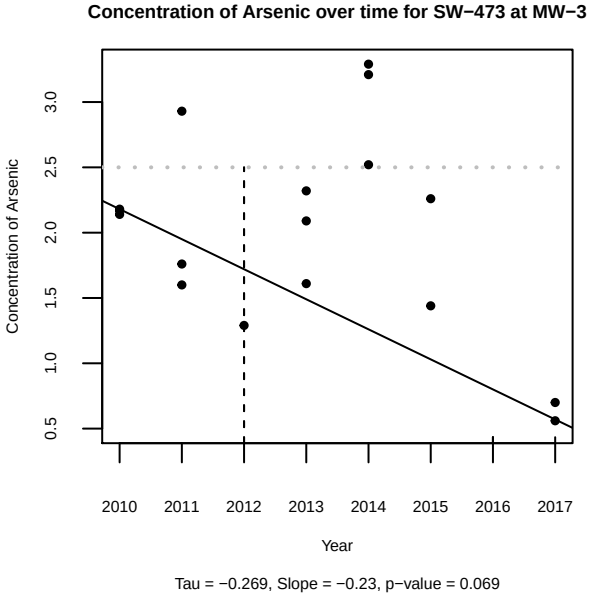
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

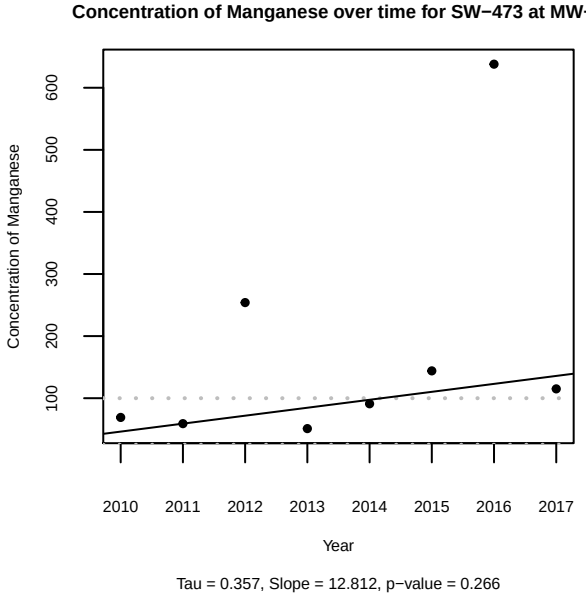
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

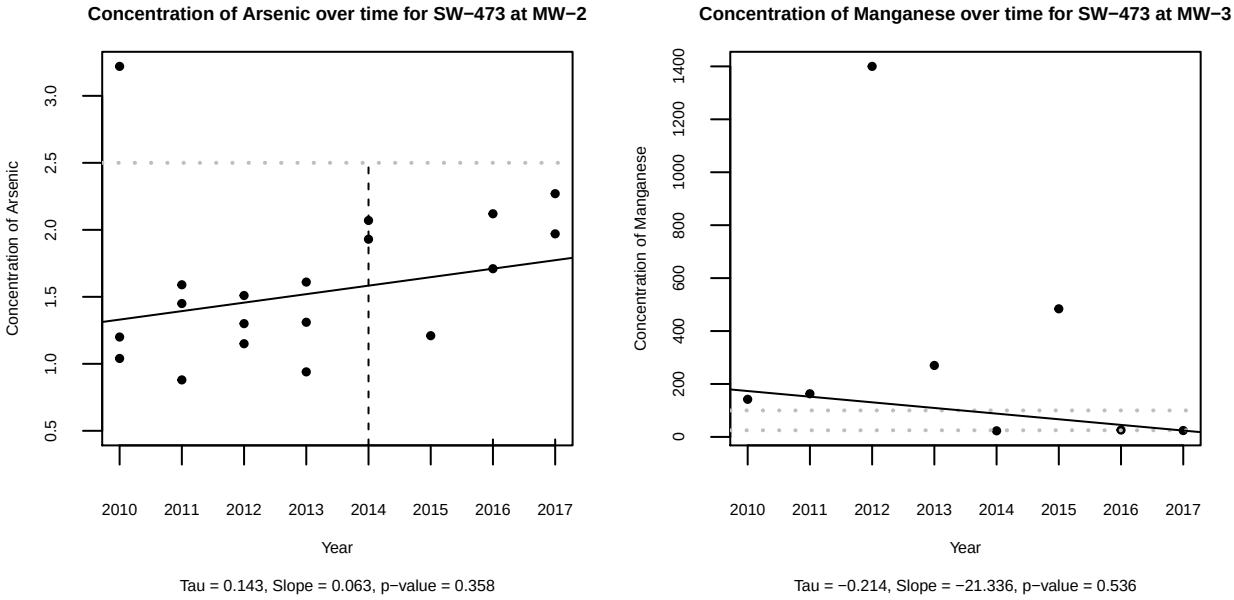
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.











The concentration of Boron as measured in well MW-3 is decreasing over time (slope is negative and p-value is less than 0.05), however all points are above the HT except for 2016 and 2017 points. The concentration of Boron as measured in well MW-2 is increasing over time (slope is positive and p-value is less than 0.05), however all points are above the HT. The remaining well trends are not statistically significant.

SW-475 Chippewa County Demolition Landfill

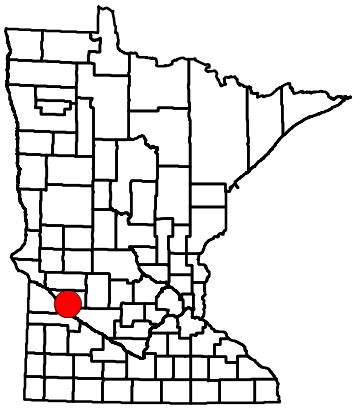
0 225 450 900 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-475 Chippewa County Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill, some portions are no longer active
2. **Other solid waste:** 46-acre closed sanitary landfill. DLandfill occupies area split from original 120-acre Chippewa SLandfill permit.
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to southwest

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

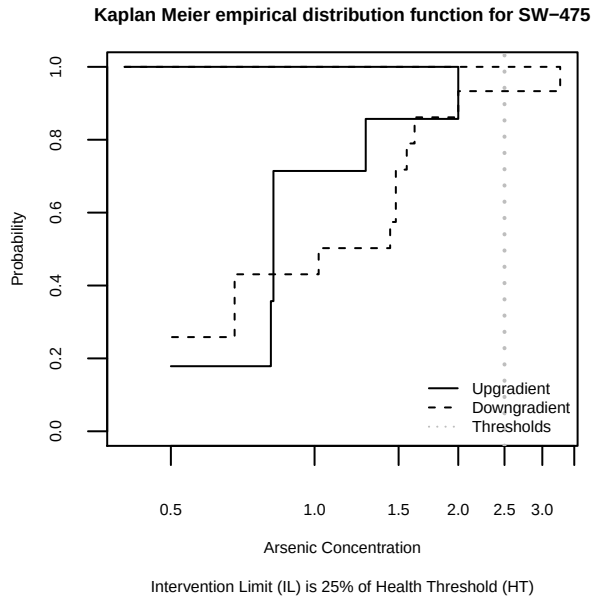
This facility does not show any significant trends for Boron.

Kaplan Meier empirical distribution function (EDF)

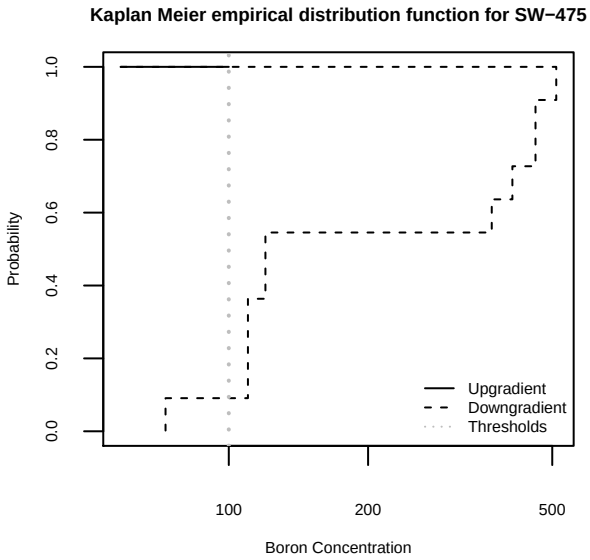
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

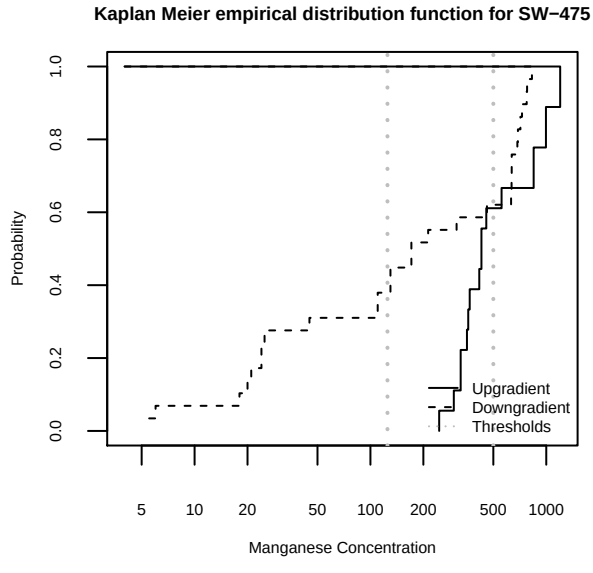
The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)

Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-475	Arsenic	15	7	0.226	1	0.317	No
	Boron	11	5	7.767	1	0.003***	Yes
	Manganese	29	18	7.209	1	0.004***	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

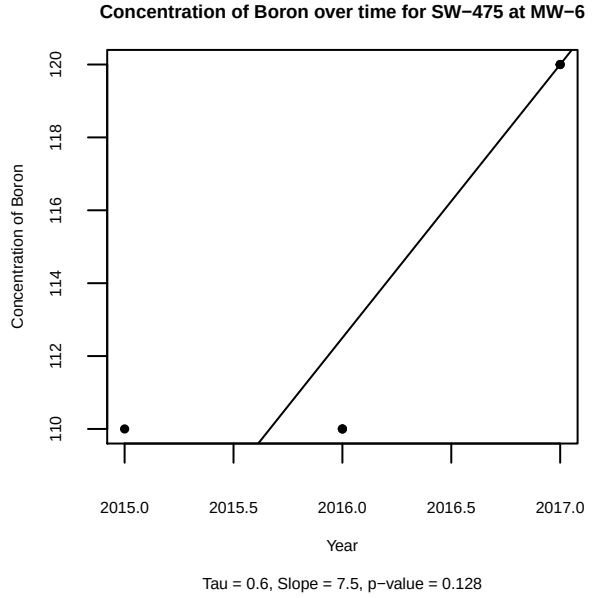
Table 2: Exceedance of thresholds by contaminant and Well ID

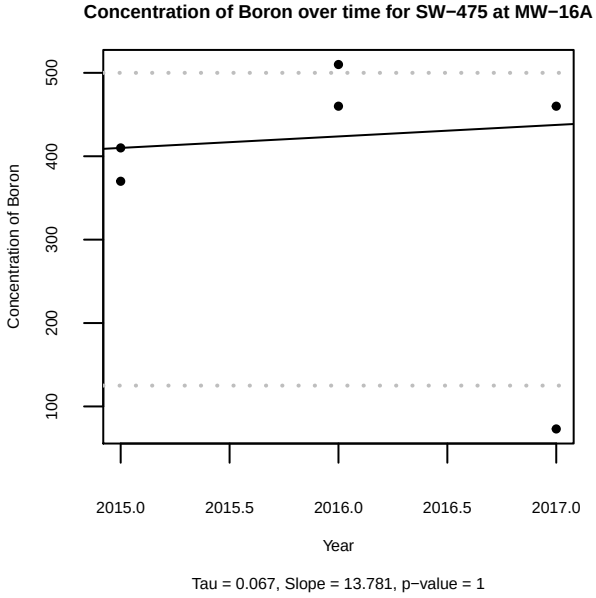
Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-475	Boron	MW-16A	1	4	1
		MW-6	0	0	5
	All	All	1	4	6

Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.





This facility does not show any significant trends for Boron.

SW-486 Meeker County Demolition Landfill

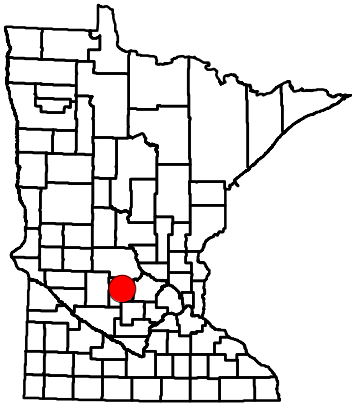
0 225 450 900 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-486 Meeker County Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill, some portions no longer active. Began operation in 2008.
2. **Other solid waste:** Transfer station; Closed Landfill Program site (former Meeker County Municipal Solid Waste) to west; some excavation of mucky waste went onto that site.
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 4
3. **Groundwater flow:** to south, showing some slight change over time

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

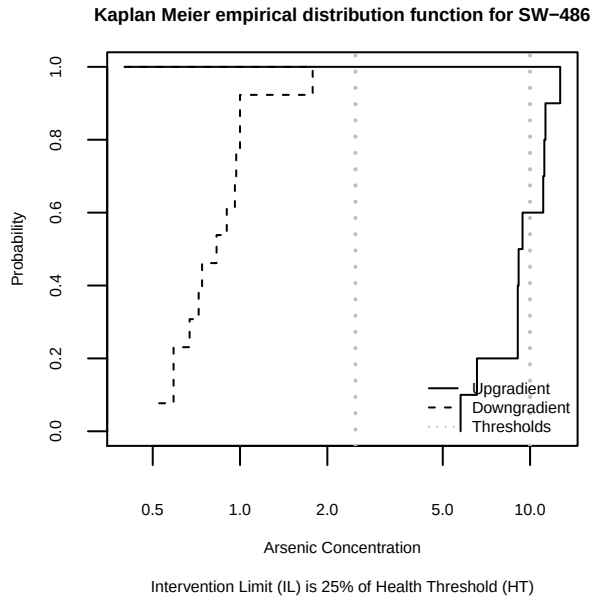
This facility does not show any significant trends for Boron.

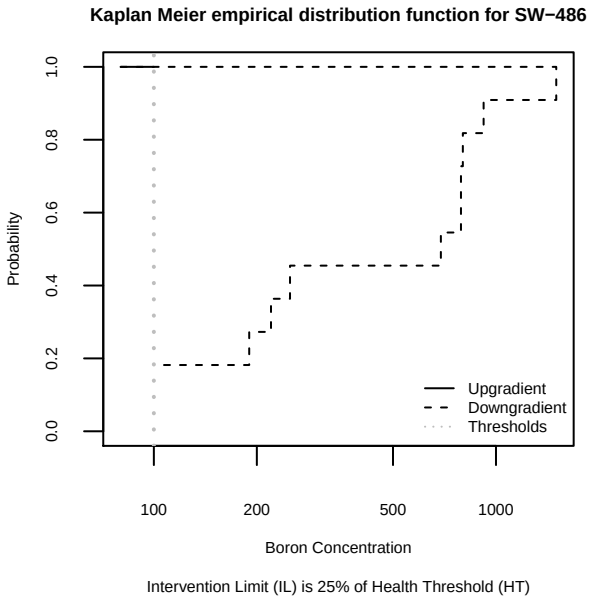
Kaplan Meier empirical distribution function (EDF)

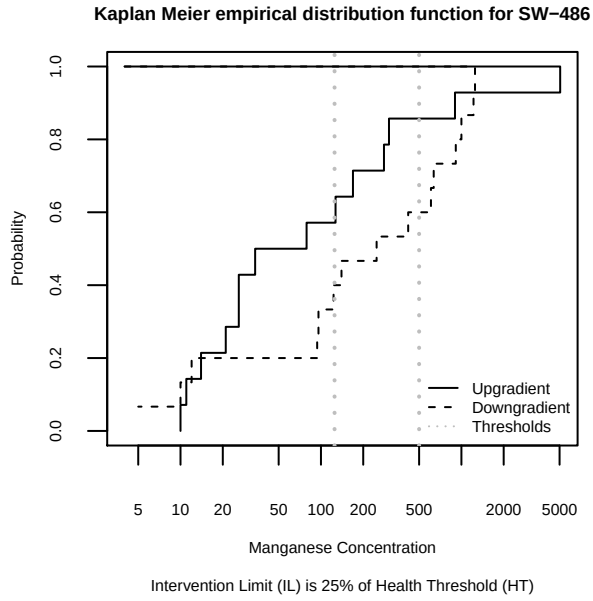
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-486	Arsenic	13	10	23.423	1	0***	No
	Boron	11	4	5.180	1	0.011**	Yes
	Manganese	15	14	1.550	1	0.107	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

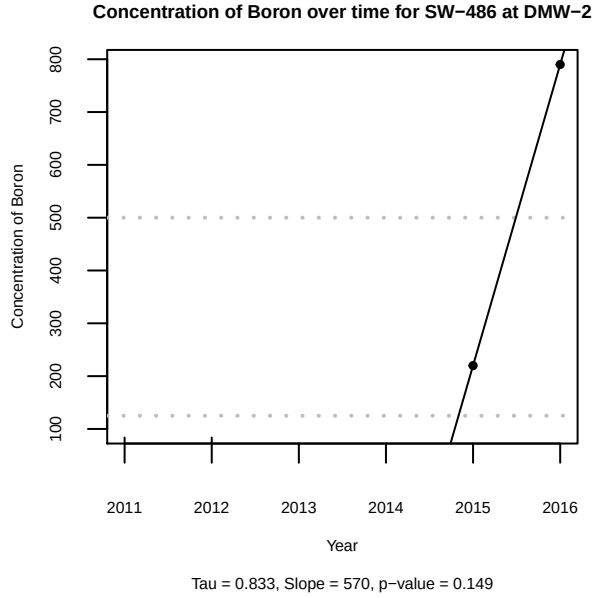
Table 2: Exceedance of thresholds by contaminant and Well ID

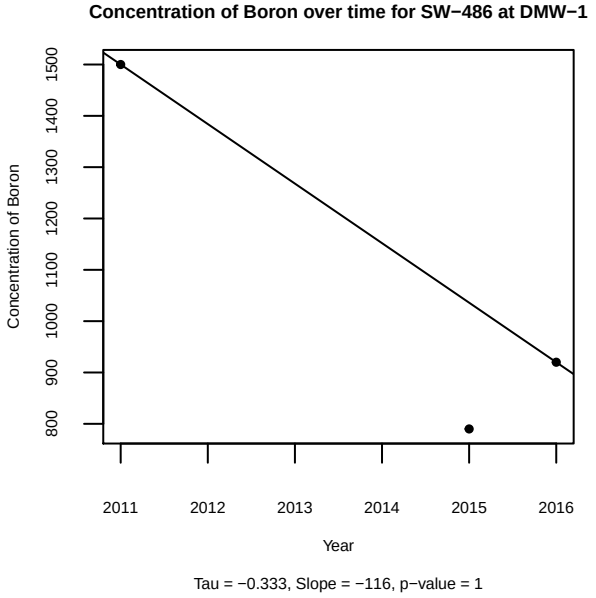
Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-486	Boron	DMW-1	3	0	0
		DMW-1A	2	0	0
		DMW-2	1	1	2
		DMW-2A	0	2	0
	All	All	6	3	2

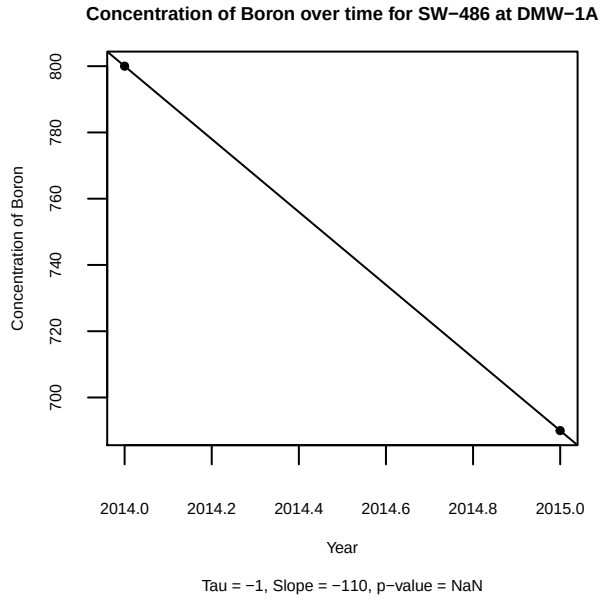
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

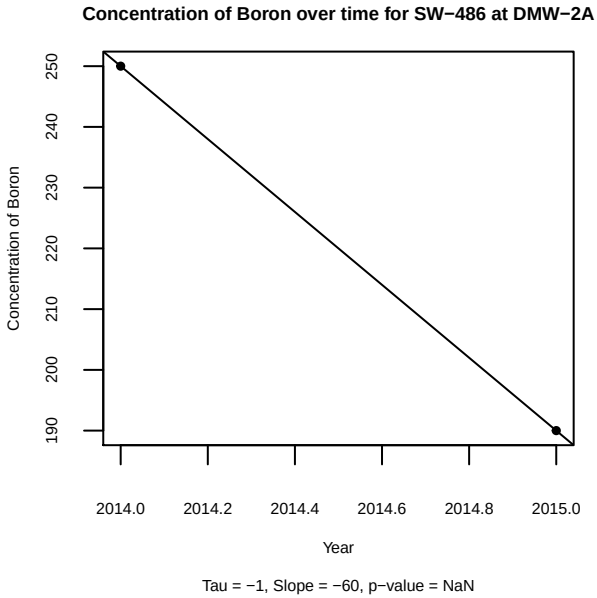
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.









This facility does not show any significant trends for Boron.

SW-499 Rock County Transfer Station

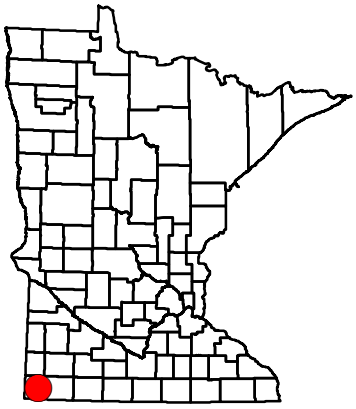
0 140 280 560 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-499 Rock County Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill, some portions are no longer active. Began operations in 1995
2. **Other solid waste:** Transfer station, Closed Landfill Program site SW-77 to north
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to northeast

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

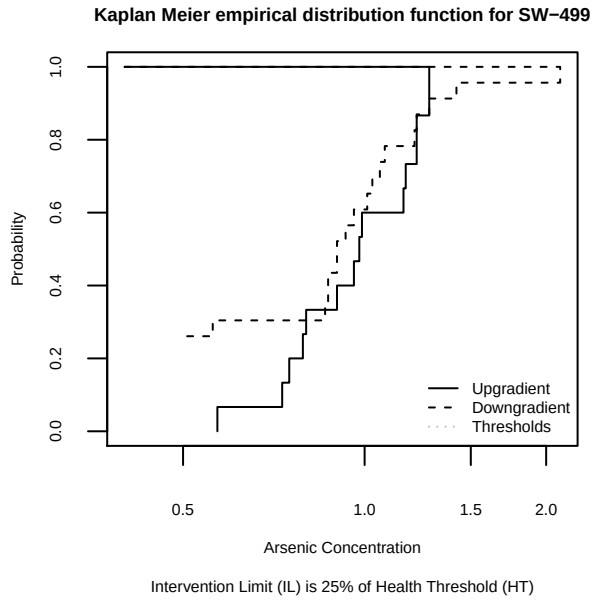
This facility does not show any significant trends for Boron or Manganese.

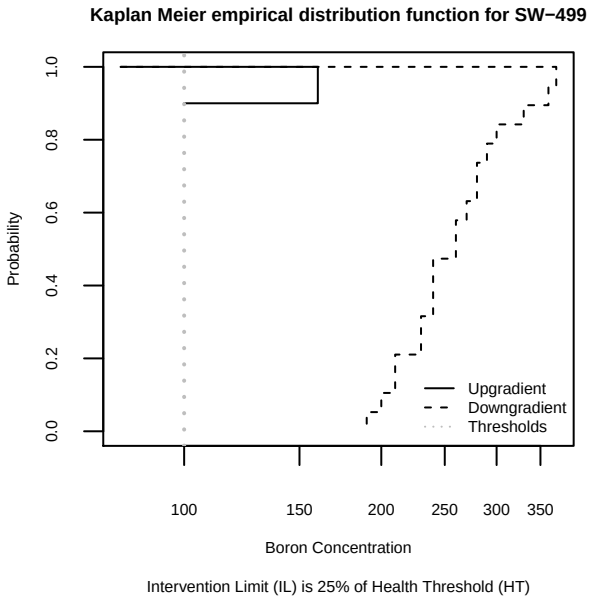
Kaplan Meier empirical distribution function (EDF)

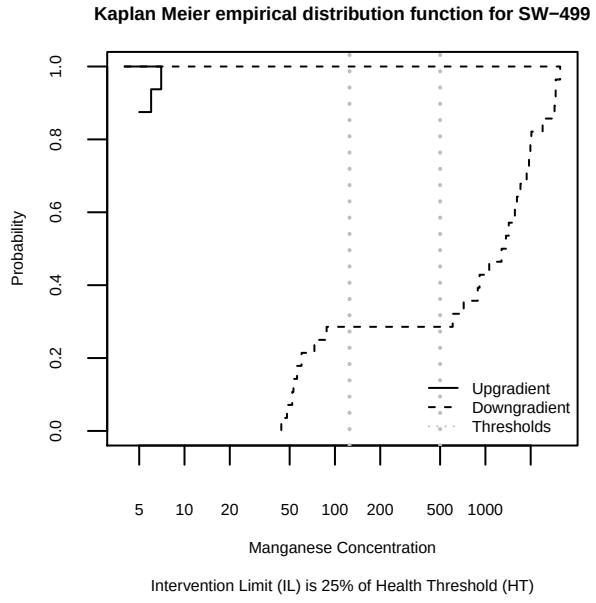
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-499	Arsenic	23	15	0.872	1	0.175	No
	Boron	19	10	18.973	1	0***	Yes
	Manganese	28	16	30.918	1	0***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

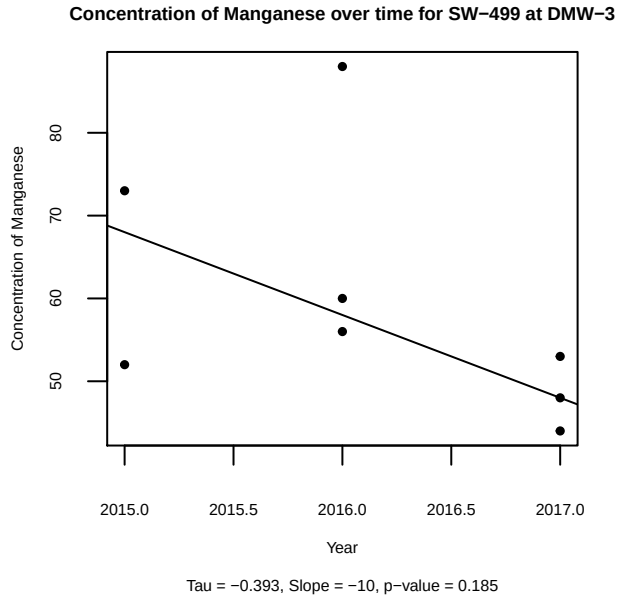
Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-499	Boron	DMW-2	0	11	0
		DMW-3	0	8	0
	Manganese	DMW-2	20	0	0
		DMW-3	0	8	0
	All	All	20	27	0

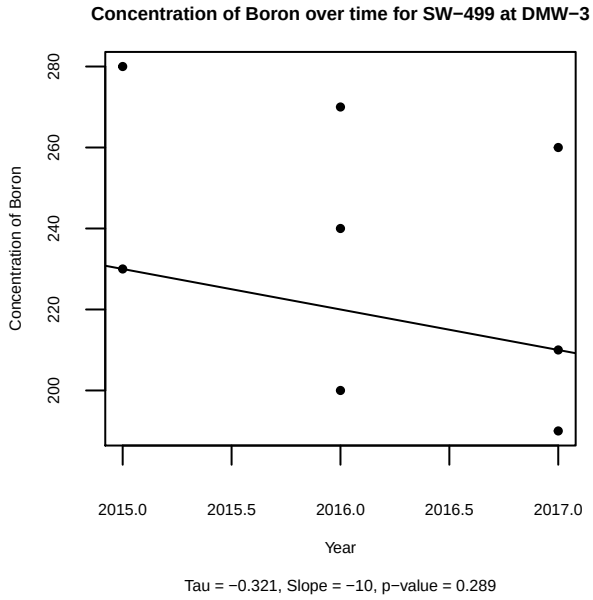
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

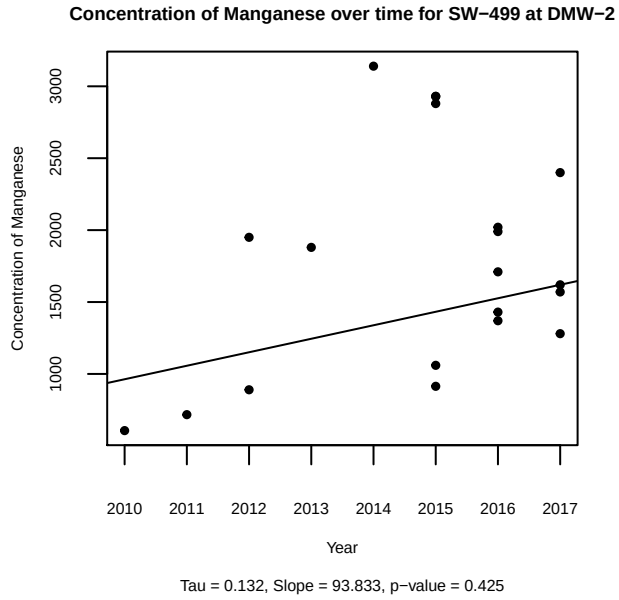
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



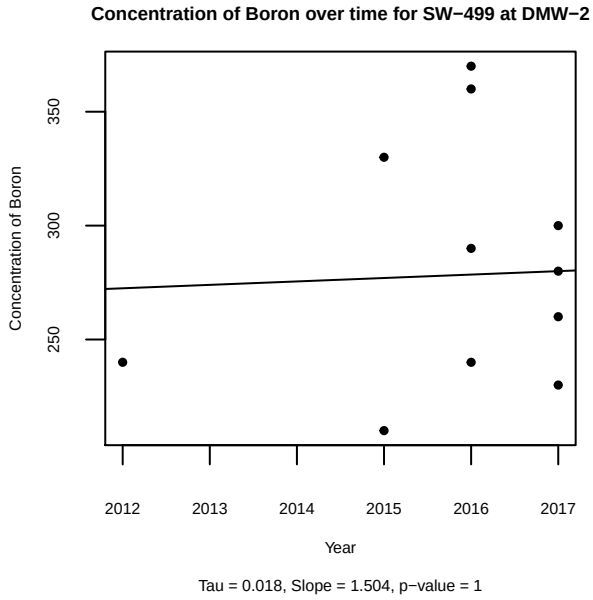
Tau = −0.393, Slope = −10, p−value = 0.185



Tau = −0.321, Slope = −10, p−value = 0.289



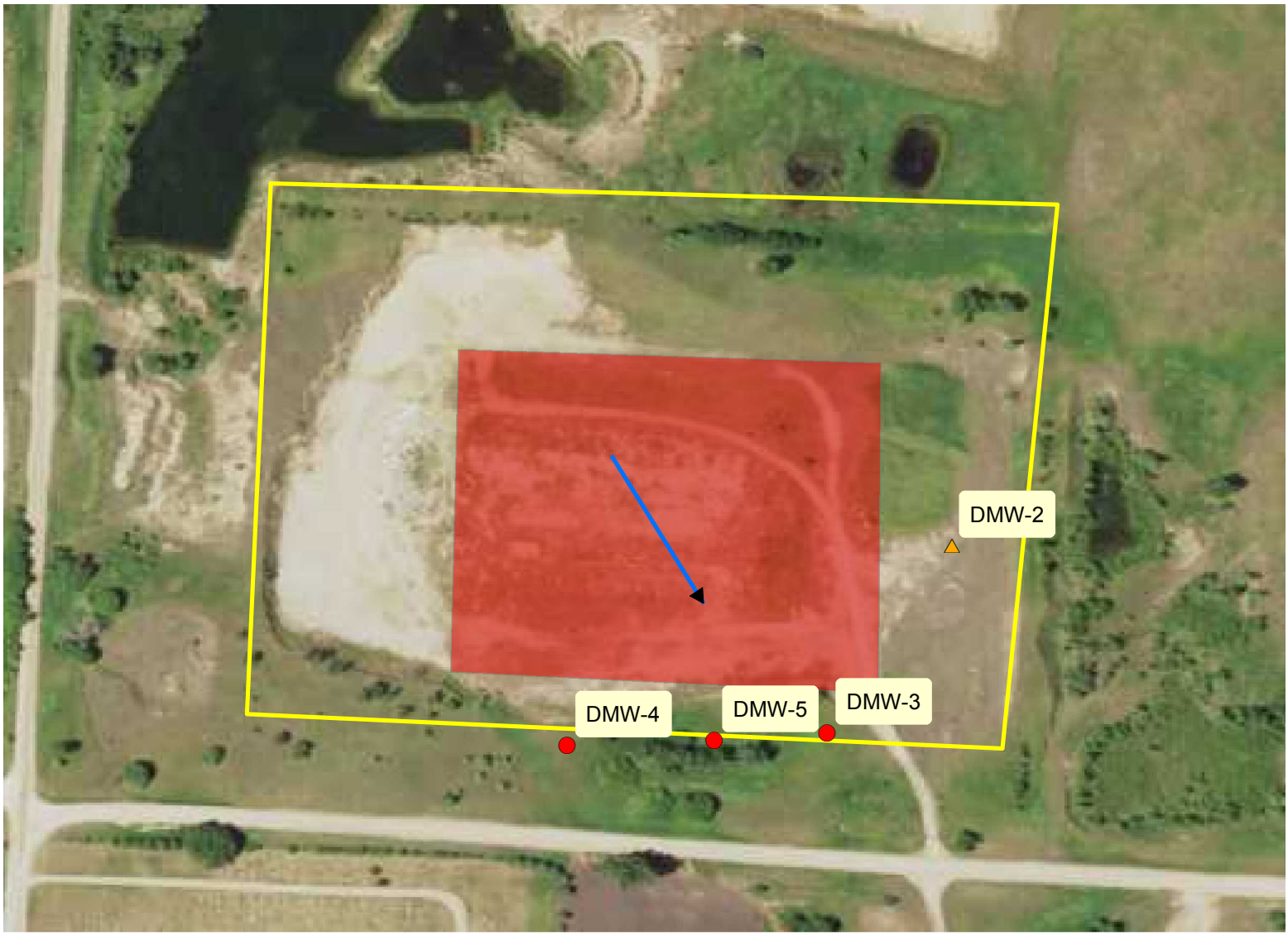
Tau = 0.132, Slope = 93.833, p−value = 0.425



Tau = 0.018, Slope = 1.504, p−value = 1

This facility does not show any significant trends for Boron or Manganese.

SW-501 Lyon County Demolition Landfill



0 140 280 560 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-501 Lyon County Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill, some portions are no longer active
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 0
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to southeast

C. Facility impact on groundwater

Facility lacks sample results from upgradient wells and thus cannot be evaluated for impacts to groundwater.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

No trends were evaluated for this facility.

SW-508 Stevens County Facility

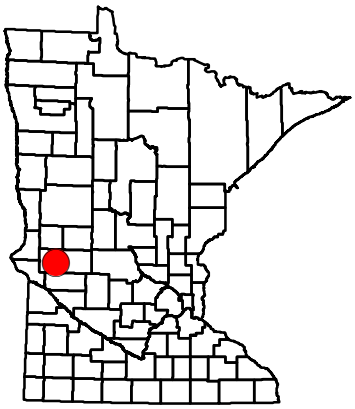
0 280 560 1,120 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-508 Stevens County Facility

A. Facility overview

1. **C&D disposal activity to date:** Construction and Demolition Landfill, began demo disposal in 1972. Portion is covered
2. **Other solid waste:** Transfer station
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 2
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to southeast

C. Facility impact on groundwater

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

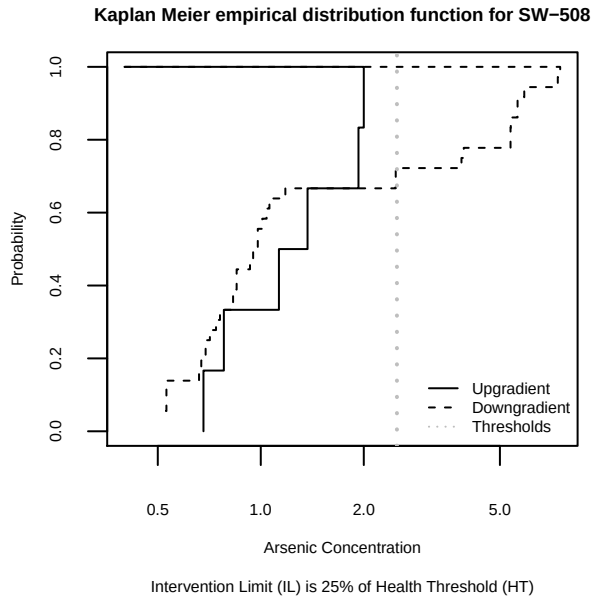
No trends were evaluated for this facility.

Kaplan Meier empirical distribution function (EDF)

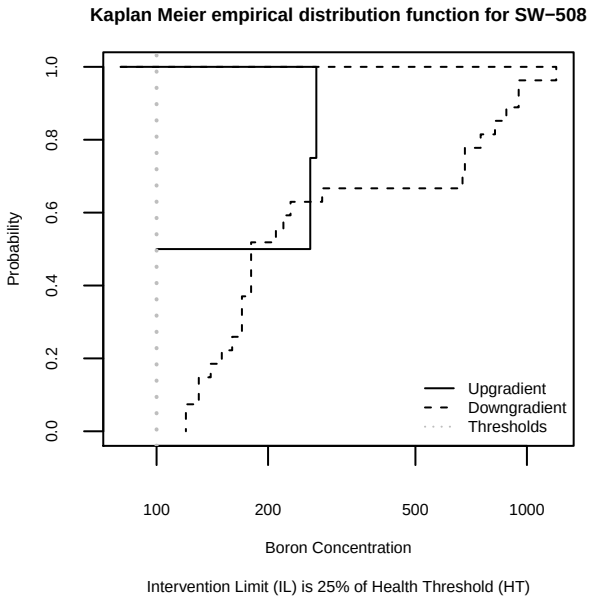
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

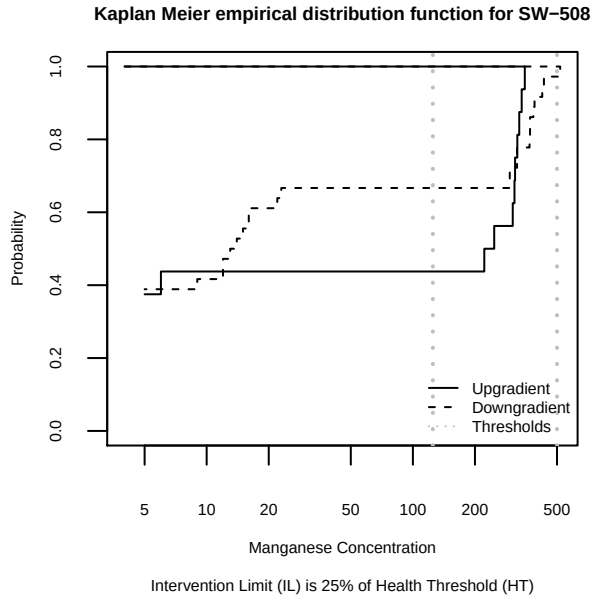
The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)

Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

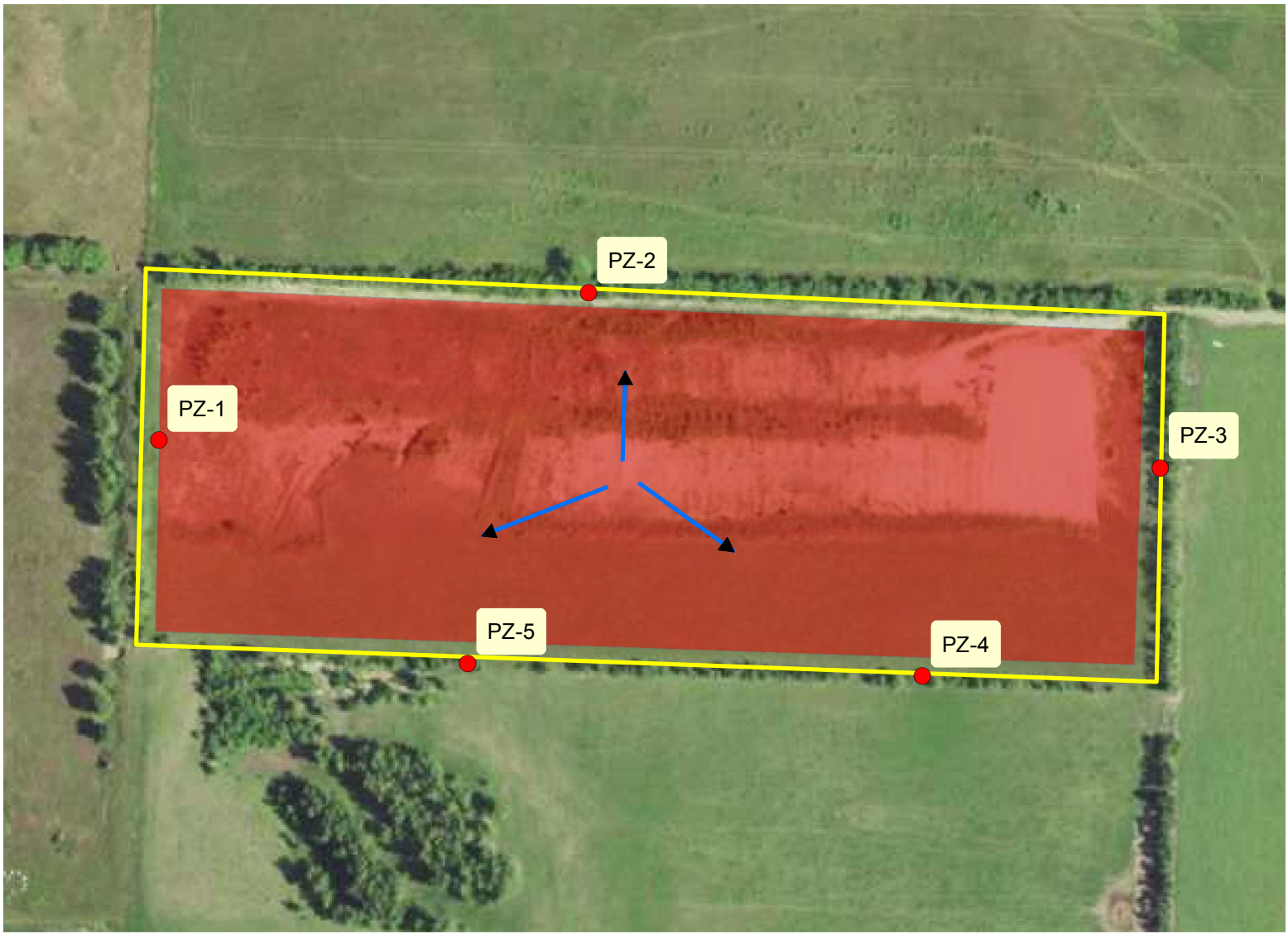
Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-508	Arsenic	36	6	0.046	1	0.415	No
	Boron	27	4	1.226	1	0.134	No
	Manganese	36	16	0.015	1	0.451	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

SW-511 Canby Demolition Debris Landfill



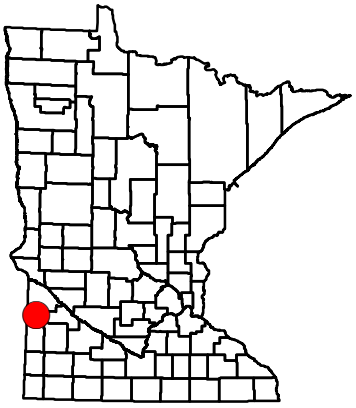
0 165 330 660 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-511 Canby Demolition Debris Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill, some portions are no longer active
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 0
2. **Downgradient well(s):** 5
3. **Groundwater flow:** radial groundwater flow

C. Facility impact on groundwater

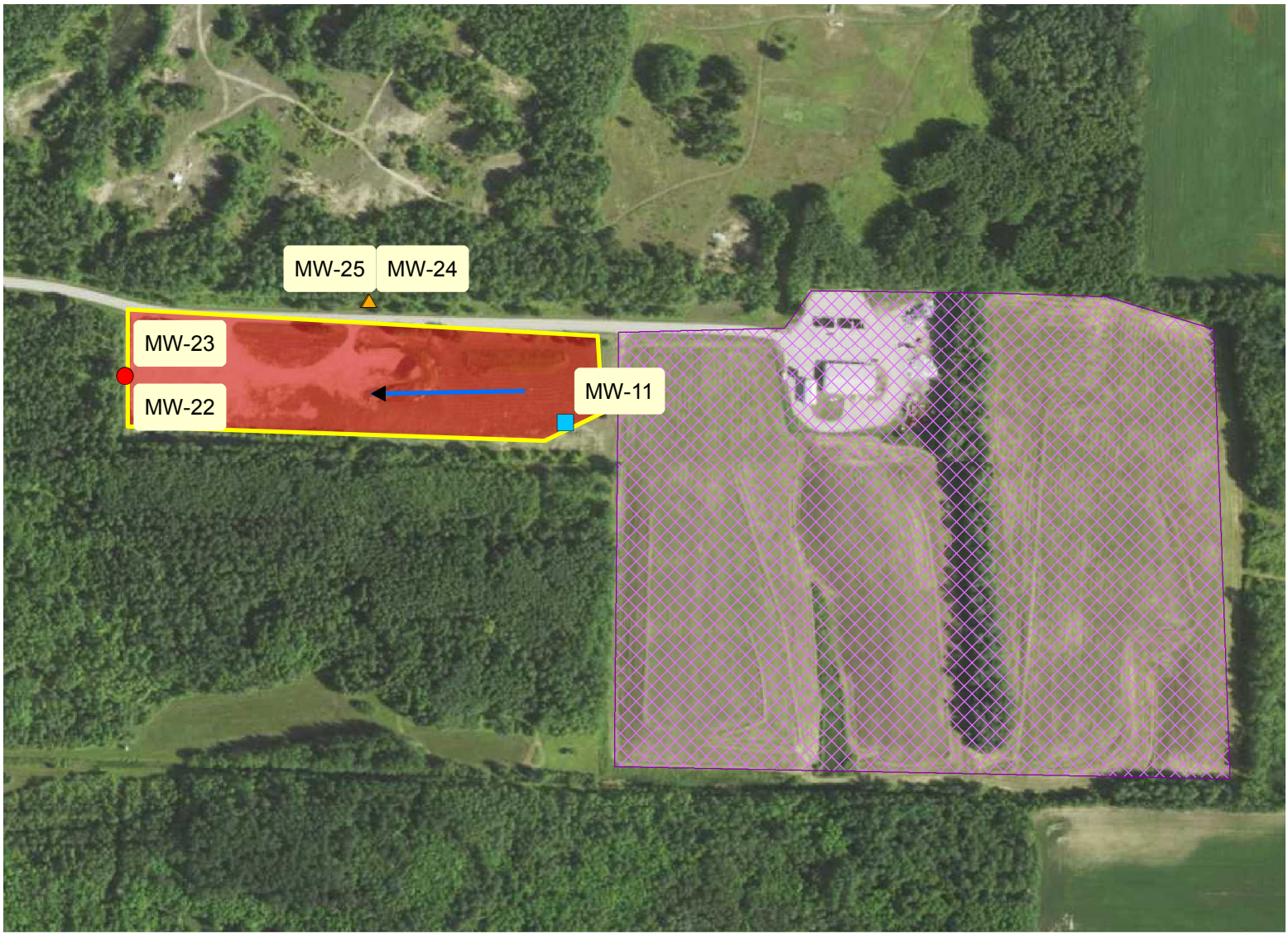
Facility lacks sample results from upgradient wells and thus cannot be evaluated for impacts to groundwater.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

No trends were evaluated for this facility.

SW-518 Roseau County SW Transfer Facility/Demolition Landfill



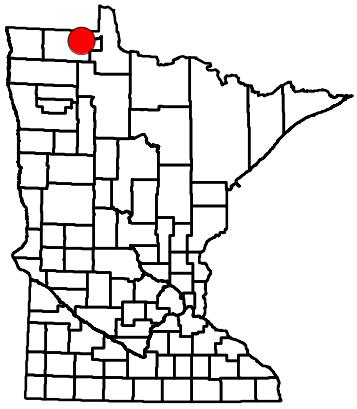
0 280 560 1,120 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-518 Roseau Co SW Transfer Facility/Demolition Landfil

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** Closed landfill nearby
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to west

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

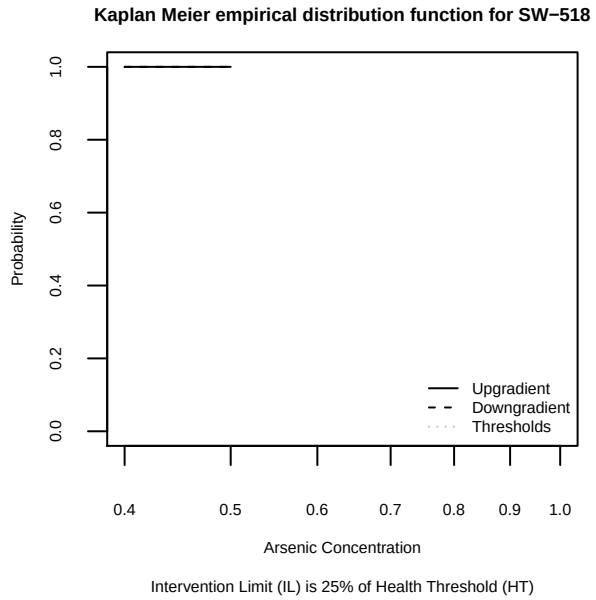
This facility does not show any significant trends for Boron, or Manganese.

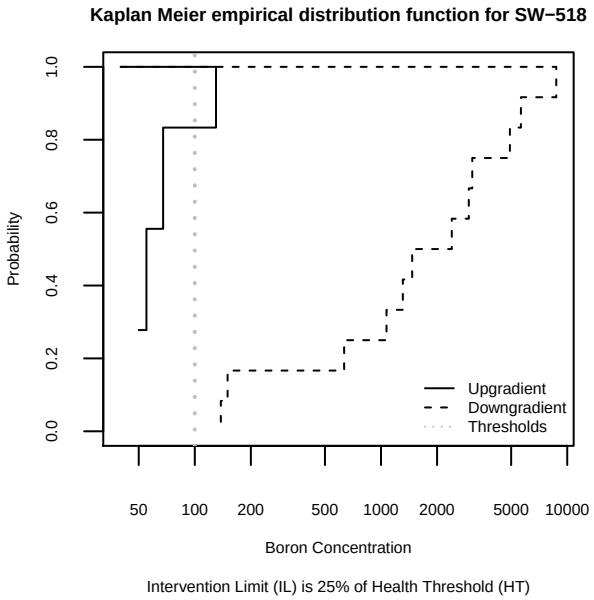
Kaplan Meier empirical distribution function (EDF)

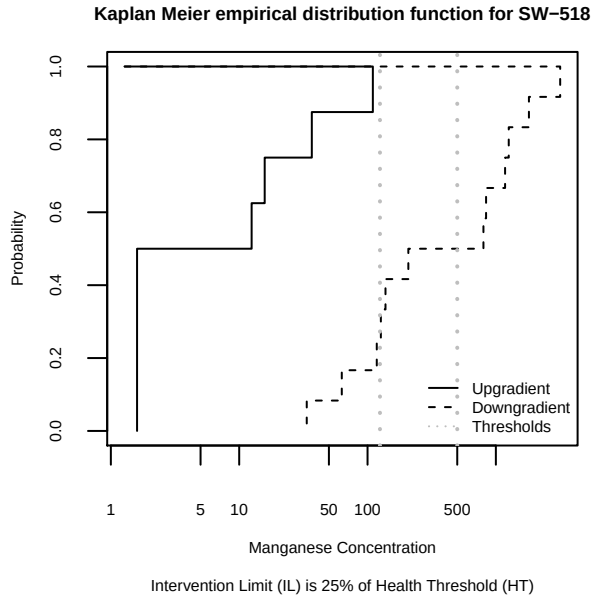
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-518	Arsenic	4	3	0.000	-1	NA	No
	Boron	12	6	11.077	1	0***	Yes
	Manganese	12	8	12.597	1	0***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

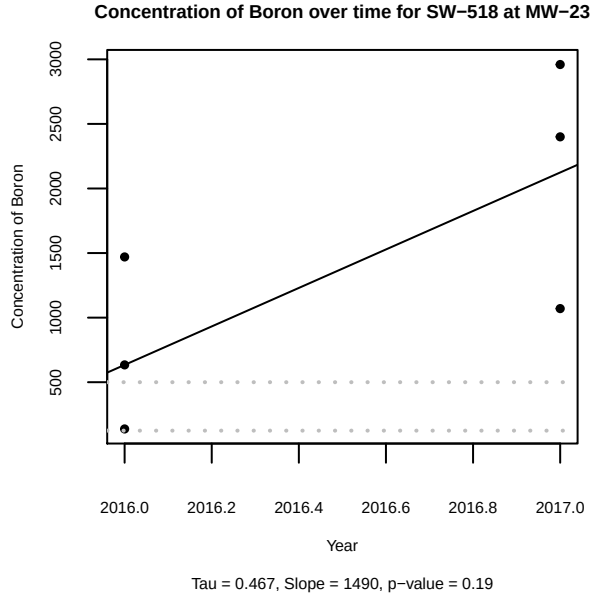
Table 2: Exceedance of thresholds by contaminant and Well ID

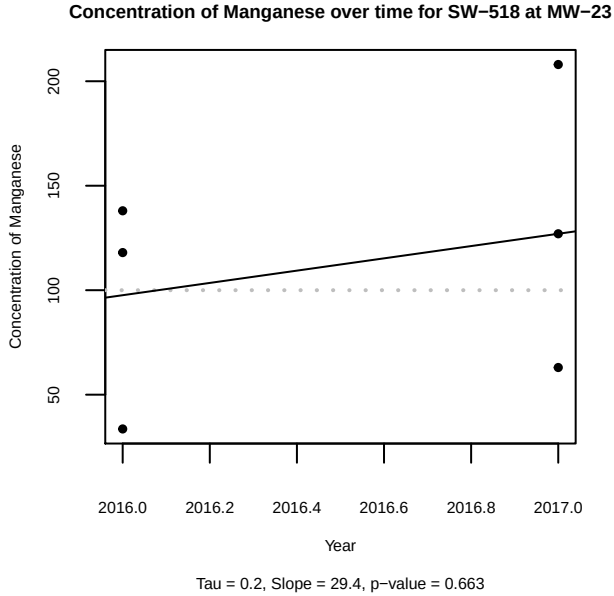
Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-518	Boron	MW-22	5	1	0
		MW-23	5	1	0
	Manganese	MW-22	6	0	0
		MW-23	4	2	0
	All	All	20	4	0

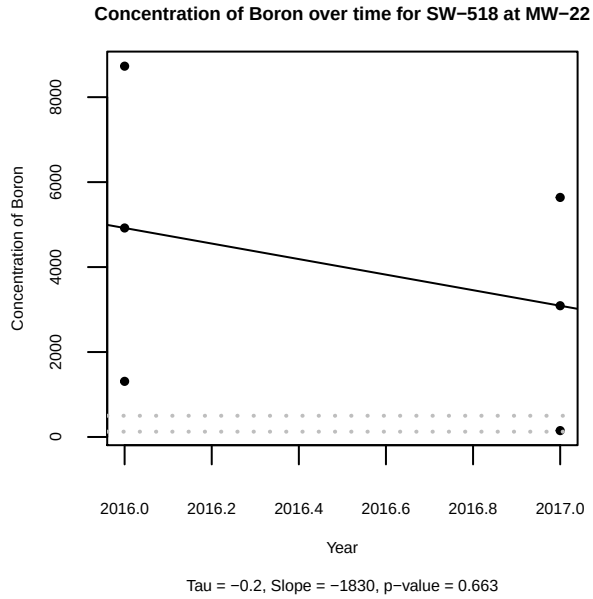
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

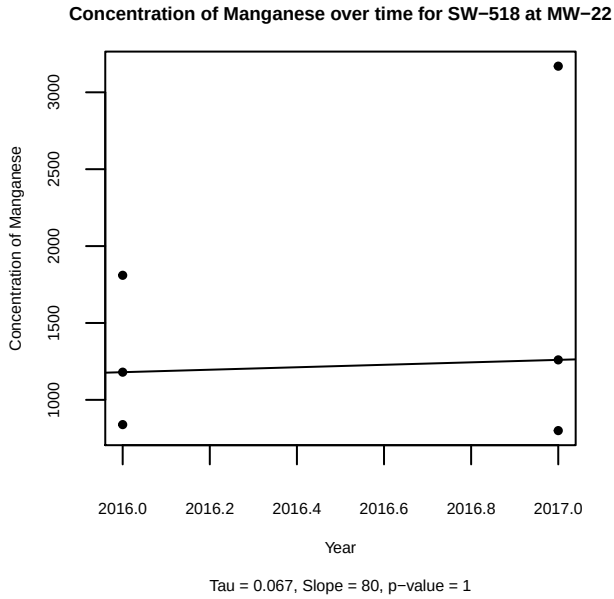
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



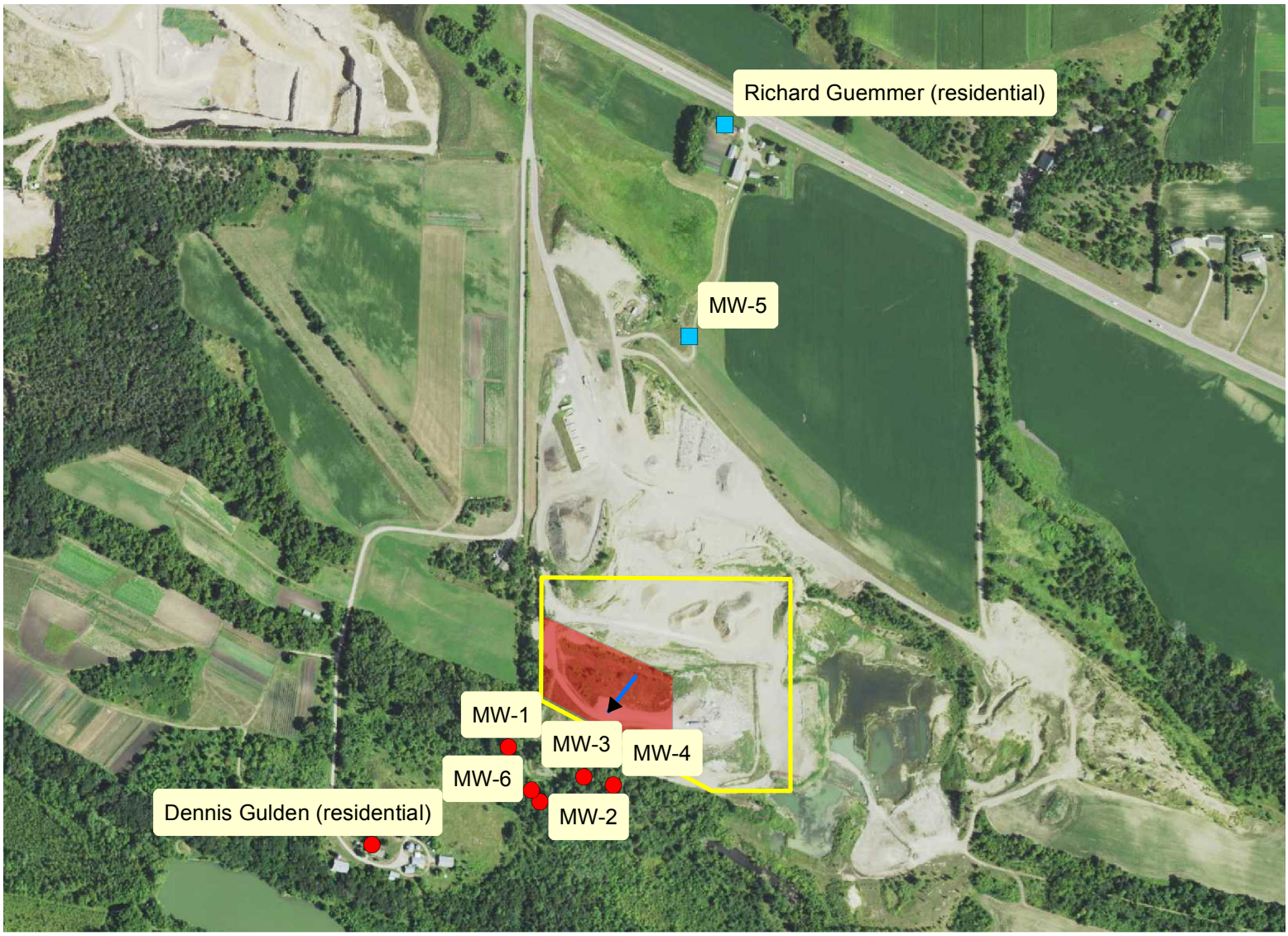






This facility does not show any significant trends for Boron, or Manganese.

SW-527 Valley Demo & Recycling LLC



0 450 900 1,800 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-527 Valley Demo & Recycling LLC

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill. Began operations in 1997
2. **Other solid waste:** Demo Landfill preceded by PBR demo
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 2
2. **Downgradient well(s):** 6
3. **Groundwater flow:** to southwest

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

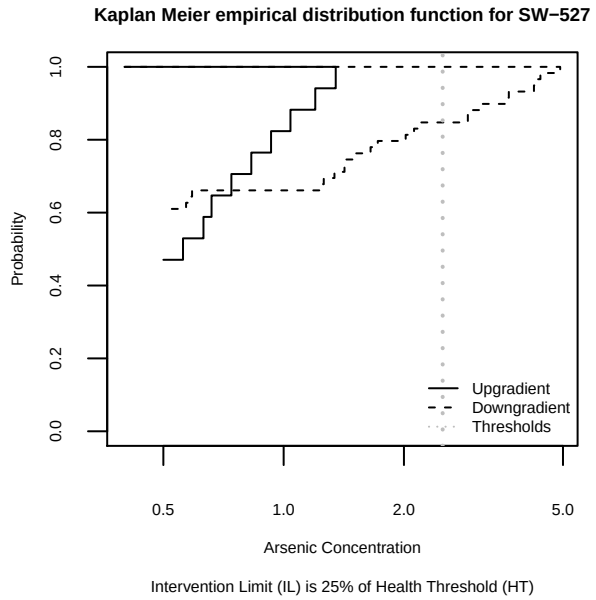
The concentration of Boron as measured in well MW-2 is increasing over time (slope is positive and p-value is less than 0.05), all points are above the IL. The remaining well trends are not statistically significant.

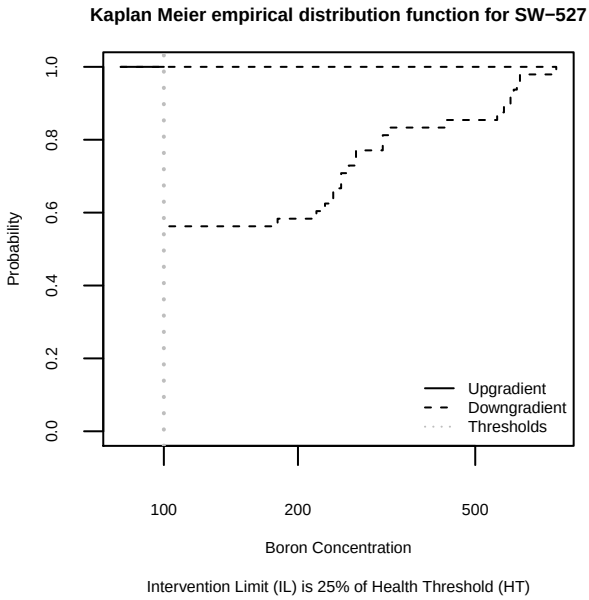
Kaplan Meier empirical distribution function (EDF)

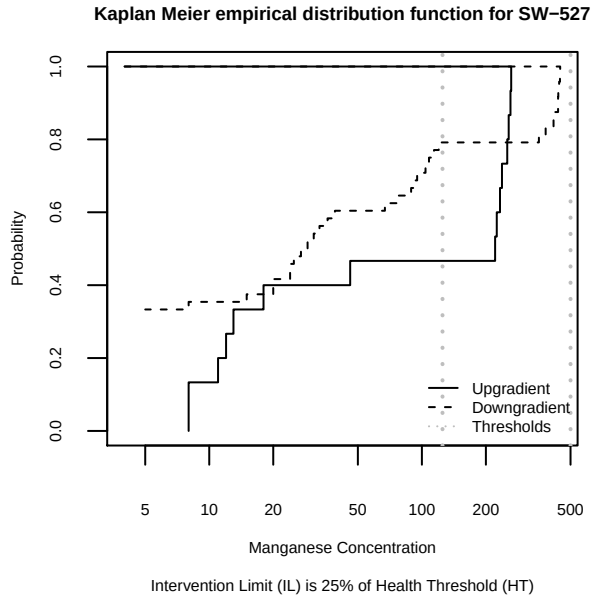
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-527	Arsenic	59	17	0.008	1	0.465	No
	Boron	48	15	8.307	1	0.002***	Yes
	Manganese	48	15	1.560	1	0.106	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-527	Boron	Dennis Gulden (residential)	0	0	7
		MW-1	7	0	0
		MW-2	0	7	0
		MW-3	0	7	0
		MW-4	0	0	10
		MW-6	0	0	10
	All	All	7	14	27

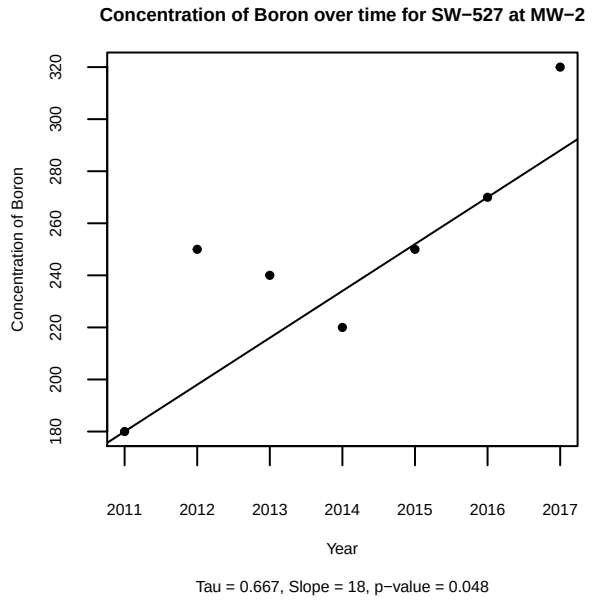
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

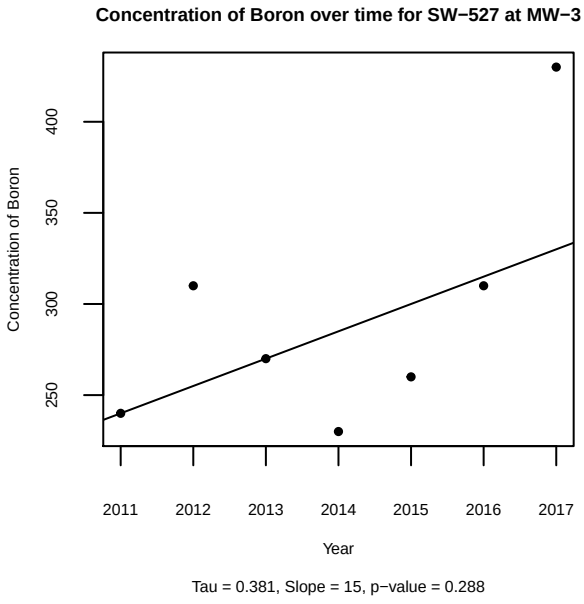
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

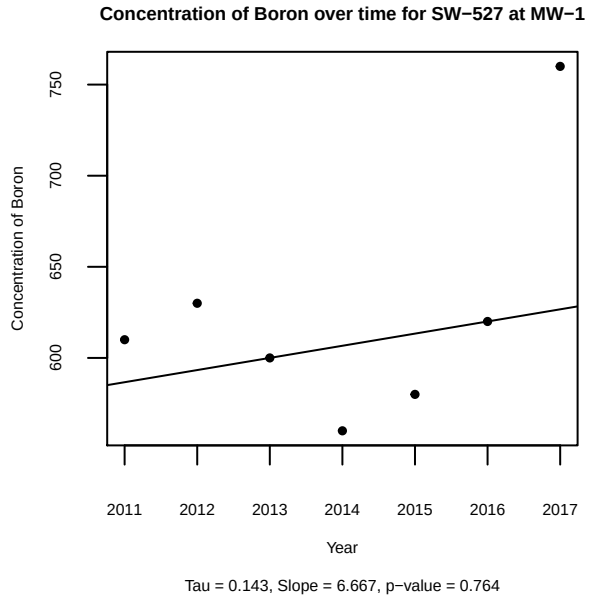
Table 3: Well/contaminant combinations where trends cannot be evaluated

Well ID	Contaminant	Number of measured values	Number of censored values	Total
Dennis Gulden (residential)	Boron	0	7	7
MW-4	Boron	0	10	10
MW-6	Boron	0	10	10

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.







The concentration of Boron as measured in well MW-2 is increasing over time (slope is positive and p-value is less than 0.05), all points are above the IL. The remaining well trends are not statistically significant.

SW-541 Oak Ridge Demolition Landfill

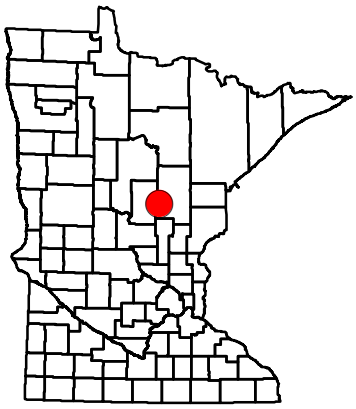
0 175 350 700 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-541 Oak Ridge Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** Adjacent to Closed Landfill Program site lying to northwest: Aitkin County Sanitary Landfill
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 4
3. **Groundwater flow:** to north

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

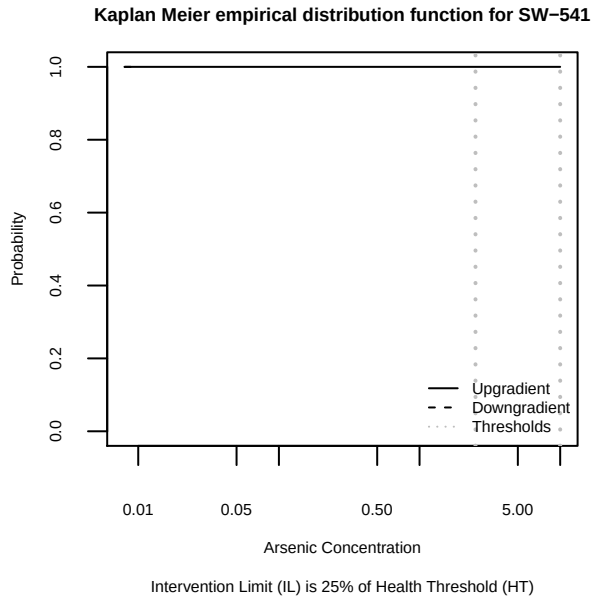
The concentration of Boron as measured in well MW-3(03) is increasing over time (slope is positive and p-value is less than 0.05), all points are below the IL. The remaining well trends are not statistically significant.

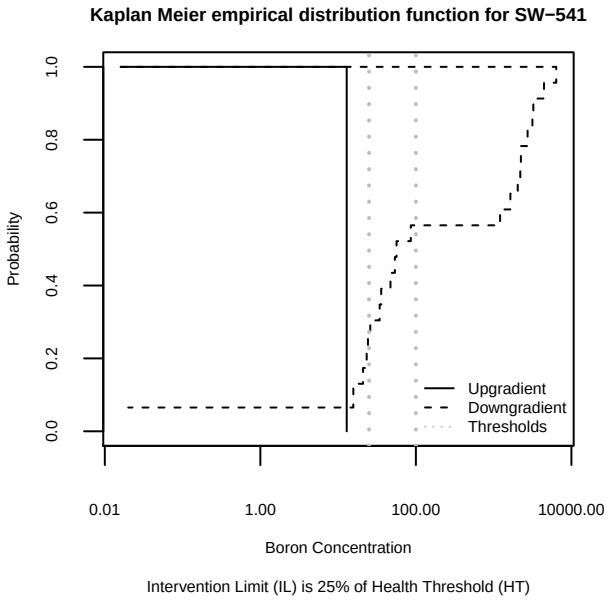
Kaplan Meier empirical distribution function (EDF)

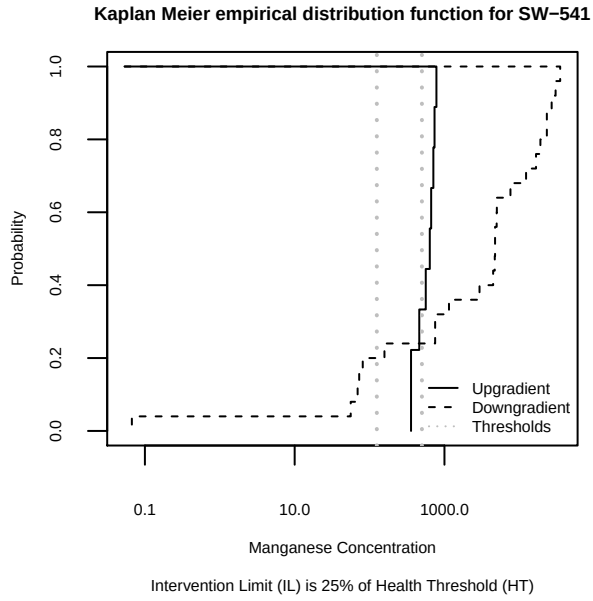
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-541	Arsenic	25	9	0.000	-1	NA	No
	Boron	23	8	11.635	1	0***	Yes
	Manganese	25	9	4.250	1	0.02**	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-541	Boron	MW-2(03)	8	0	0
		MW-3(03)	0	0	8
		MW-4(03)	0	0	5
		MW-5	2	0	0
	Manganese	MW-2(03)	9	0	0
		MW-3(03)	9	0	0
		MW-4(03)	0	4	1
		MW-5	2	0	0
	All	All	30	4	14

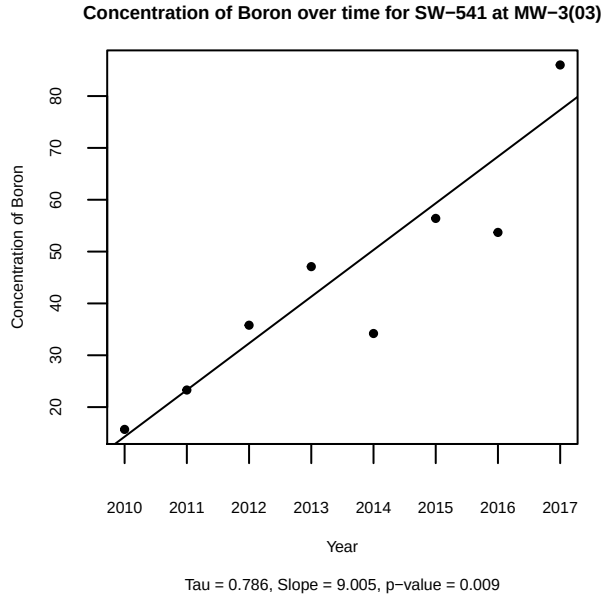
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

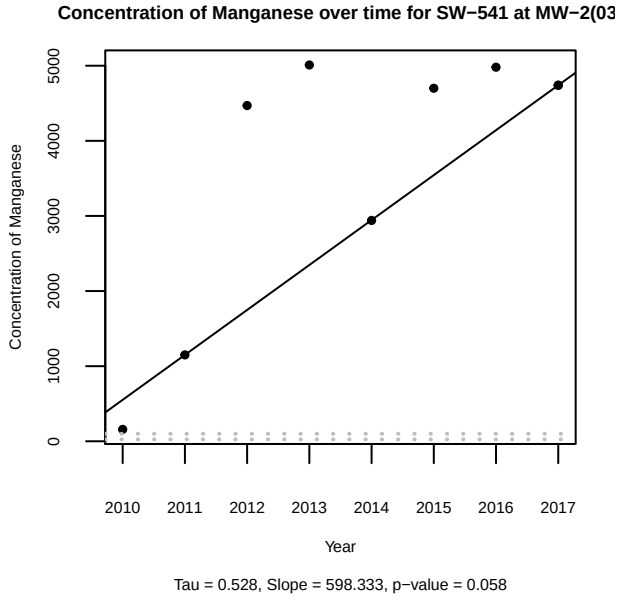
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

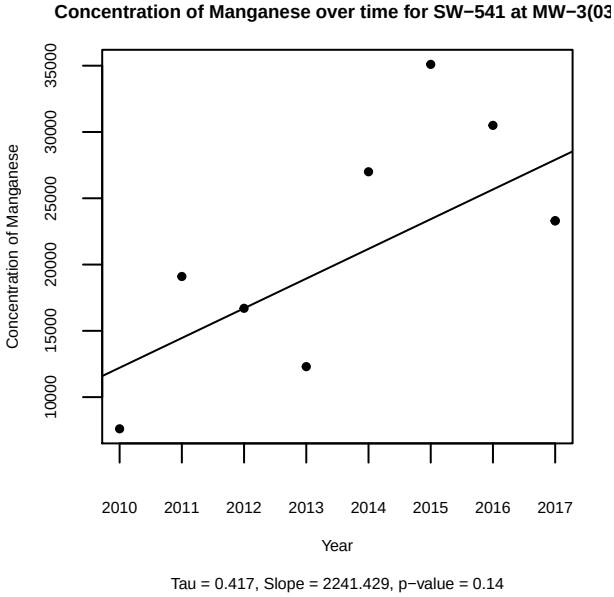
Table 3: Well/contaminant combinations where trends cannot be evaluated

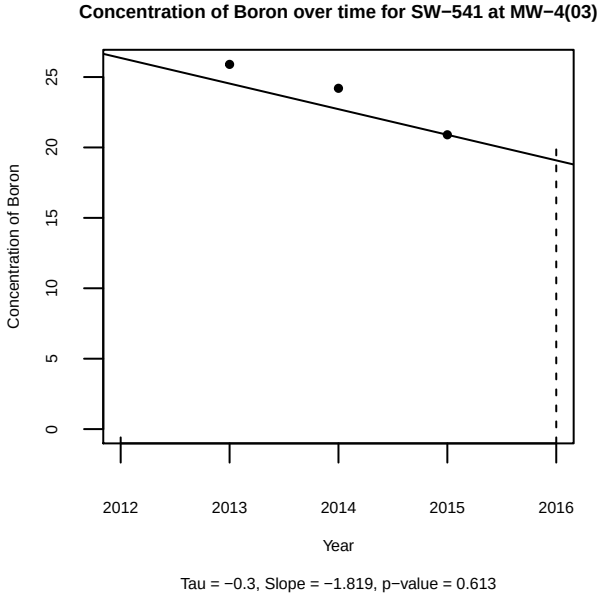
Well ID	Contaminant	Number of measured values	Number of censored values	Total
MW-5	Boron	2	0	2
MW-5	Manganese	2	0	2

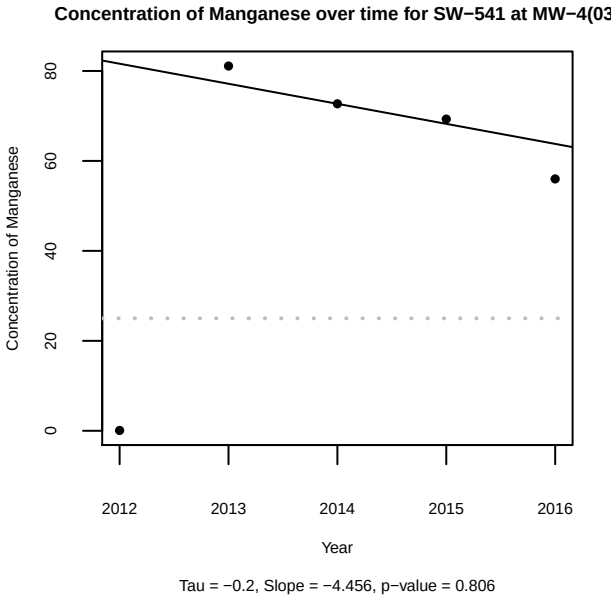
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.

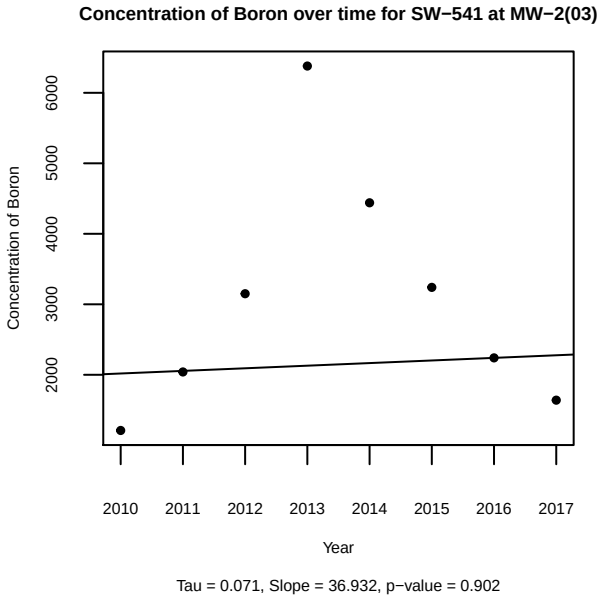












The concentration of Boron as measured in well MW-3(03) is increasing over time (slope is positive and p-value is less than 0.05), all points are below the IL. The remaining well trends are not statistically significant.

SW-514/SW-542 WCI Austin Landfill LLC

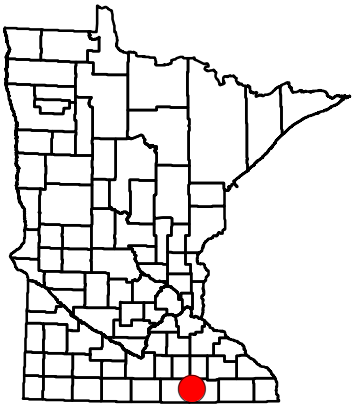
0 350 700 1,400 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-542 SKB Austin Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Construction and Demolition Landfill. Will be repermitted into SW-514
2. **Other solid waste:** Adjacent to Lined Class 3 Demo Landfill: SW-514 SKB Lansing
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to west

C. Facility impact on groundwater

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

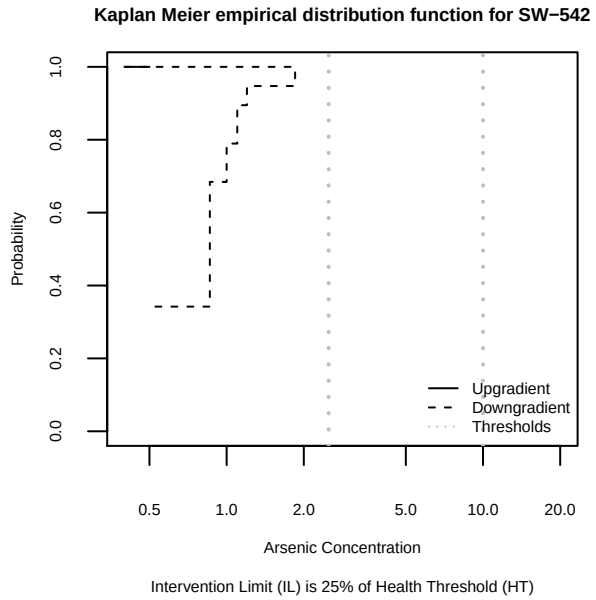
No trends were evaluated for this facility.

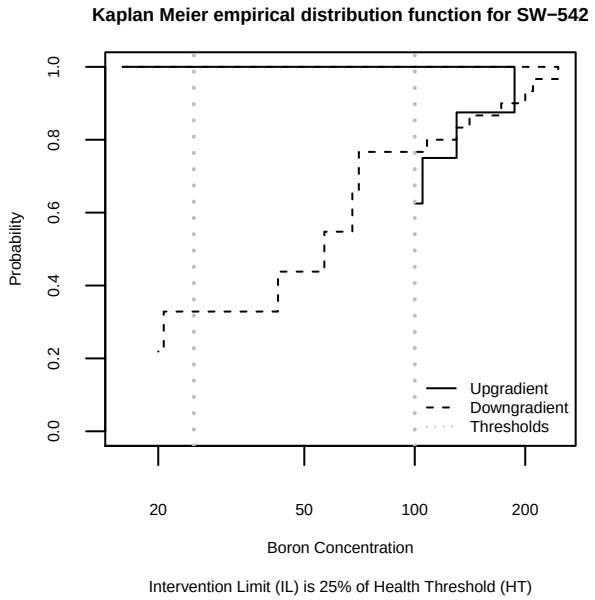
Kaplan Meier empirical distribution function (EDF)

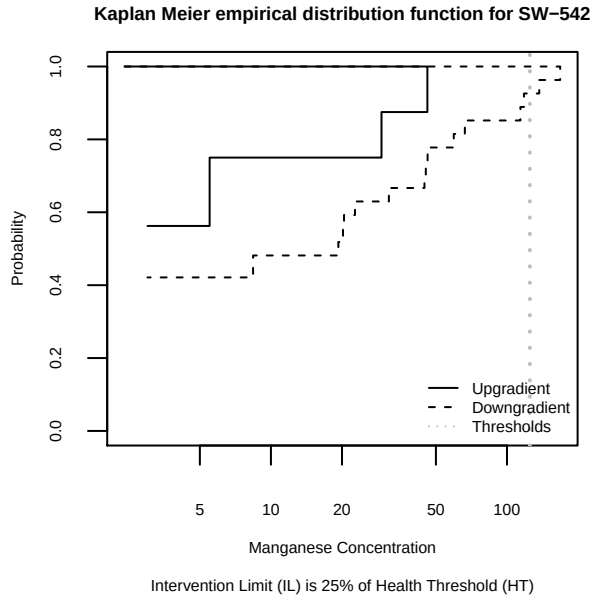
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-542	Arsenic	27	8	2.683	1	0.051*	No
	Boron	30	8	0.303	1	0.291	No
	Manganese	27	8	1.380	1	0.12	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

SW-543 Hoss Demolition Landfill

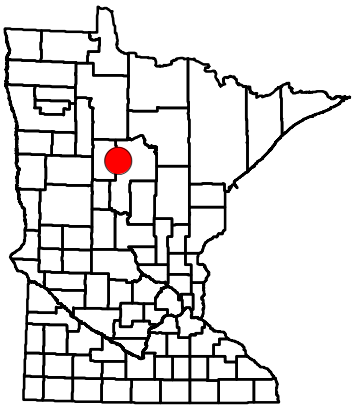
0 165 330 660 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-543 Hoss Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 6
3. **Groundwater flow:** to north

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

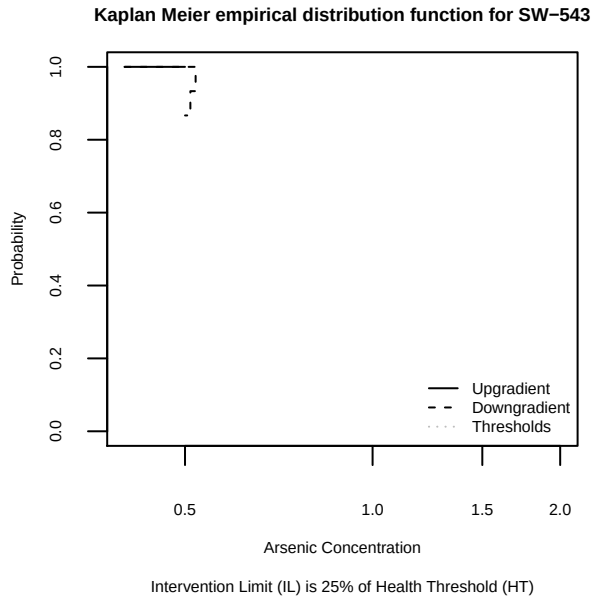
This facility does not show any significant trends for Boron or Manganese.

Kaplan Meier empirical distribution function (EDF)

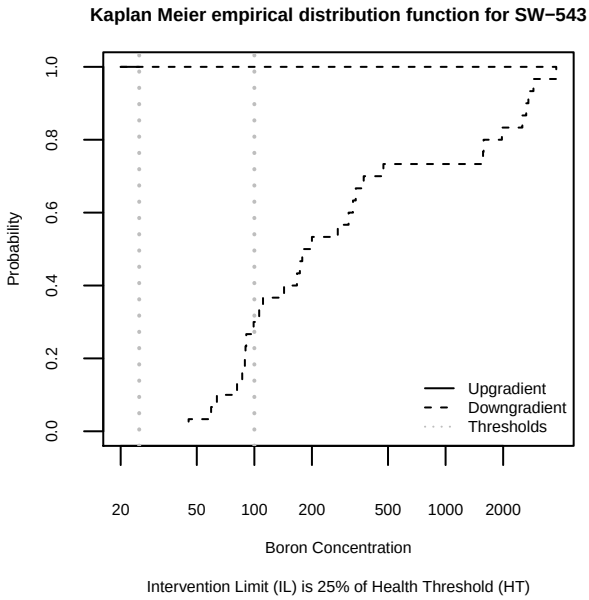
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

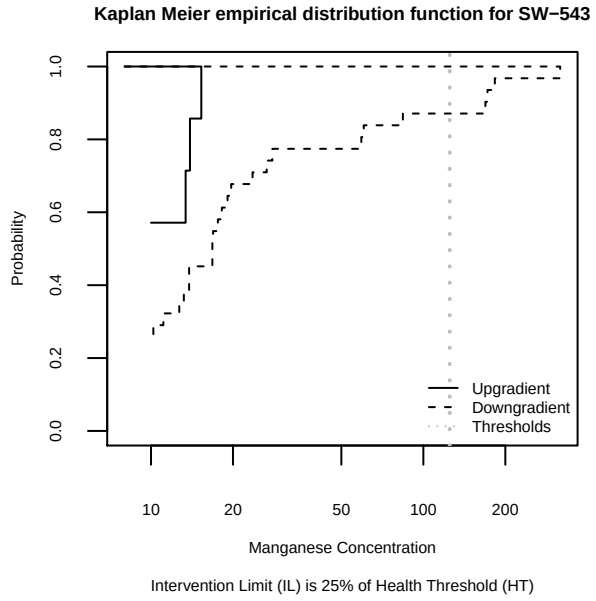
The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)

Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-543	Arsenic	28	7	0.552	1	0.229	No
	Boron	30	7	12.829	1	0***	Yes
	Manganese	31	7	3.365	1	0.033**	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

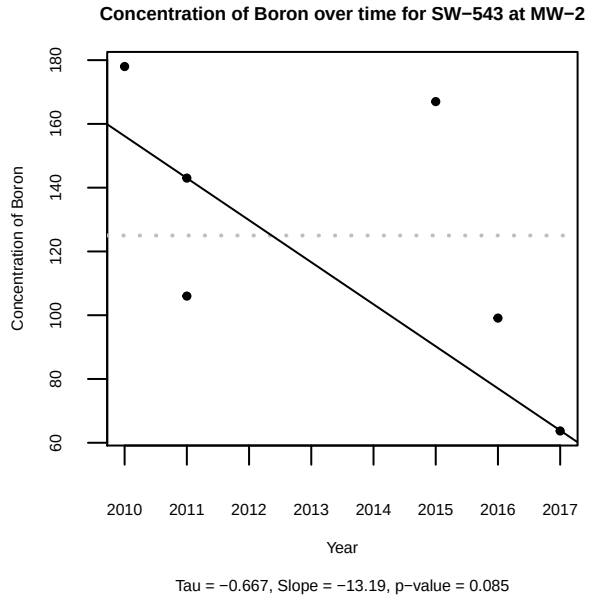
Table 2: Exceedance of thresholds by contaminant and Well ID

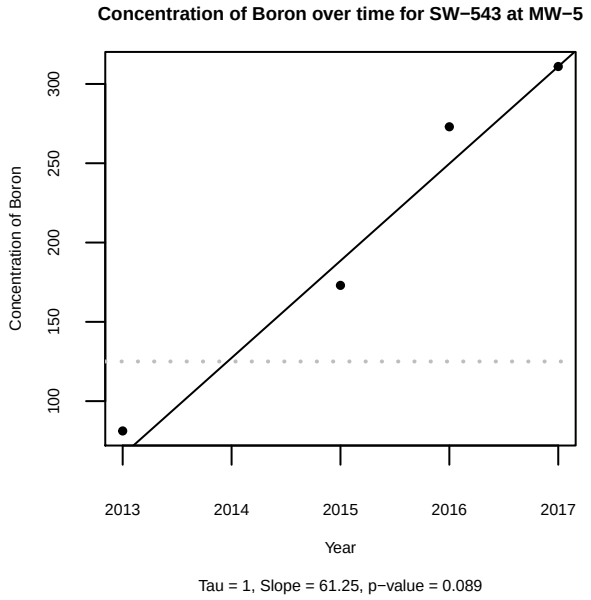
Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-543	Boron	MW-1	5	2	0
		MW-2	0	3	3
		MW-4	3	2	0
		MW-5	0	3	1
		MW-5D	0	1	4
		MW-6	0	0	3
	Manganese	MW-1	0	1	6
		MW-2	0	1	5
		MW-4	1	1	3
		MW-5	2	0	2
		MW-5D	1	1	3
		MW-6	0	1	3
	All	All	12	16	33

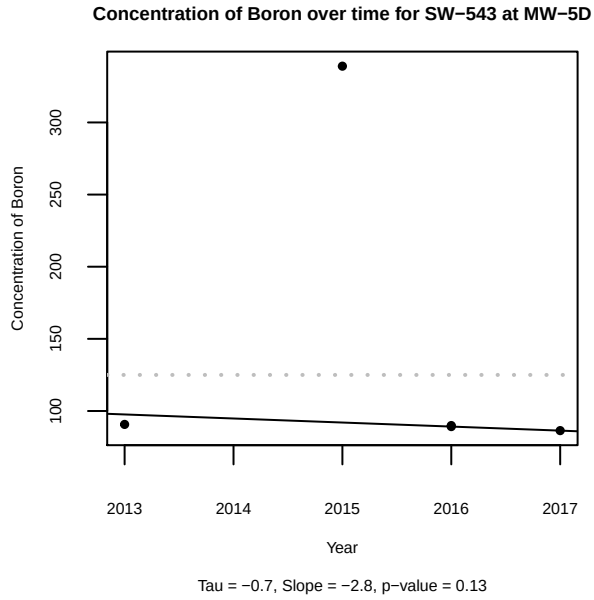
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

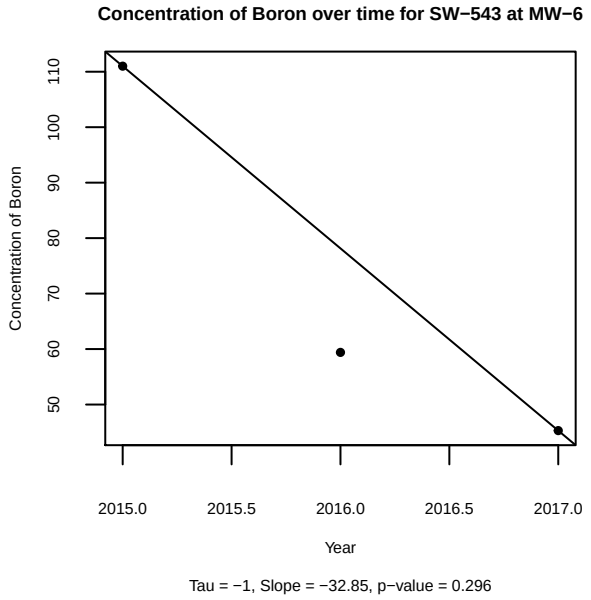
Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

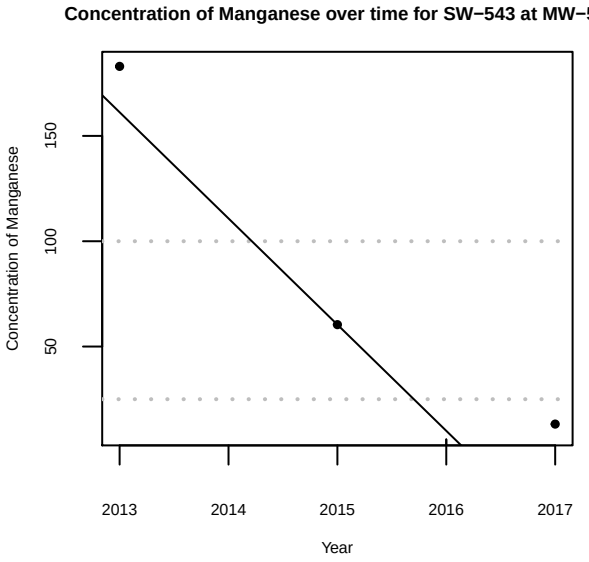
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.

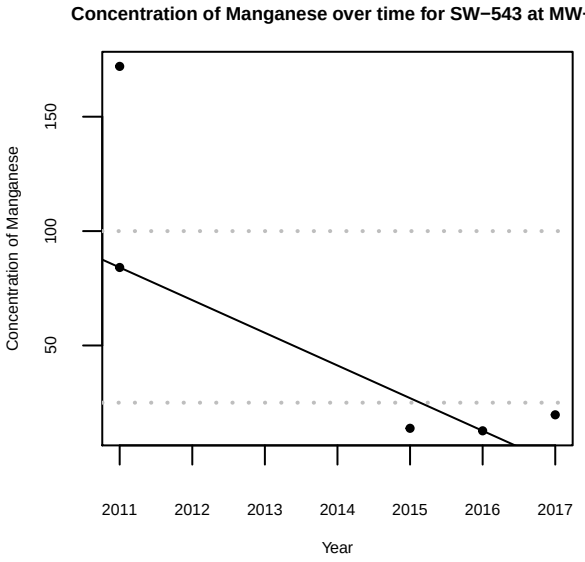


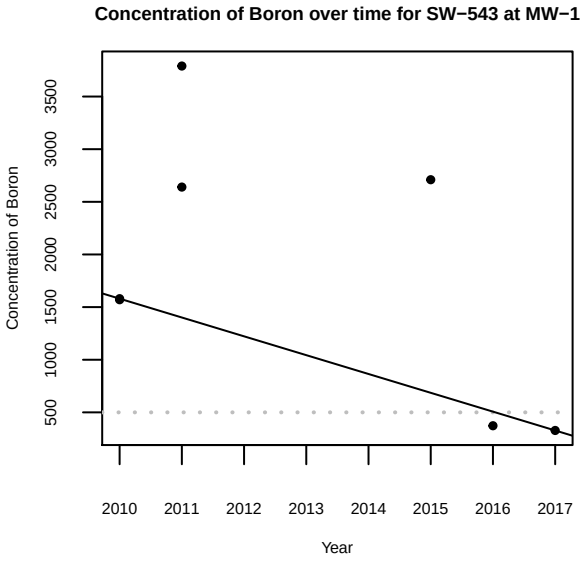


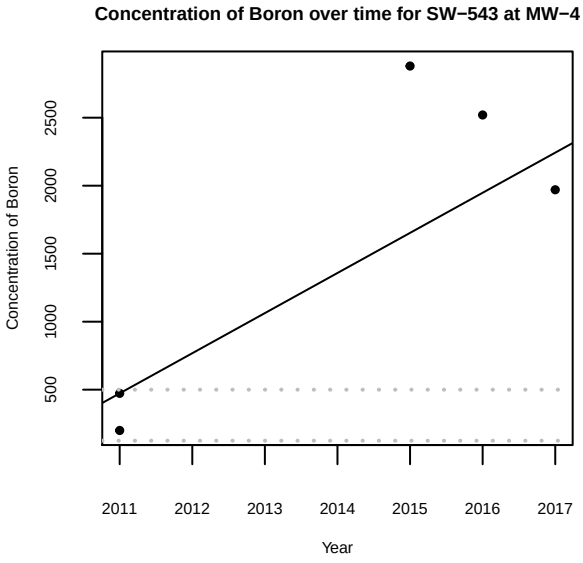


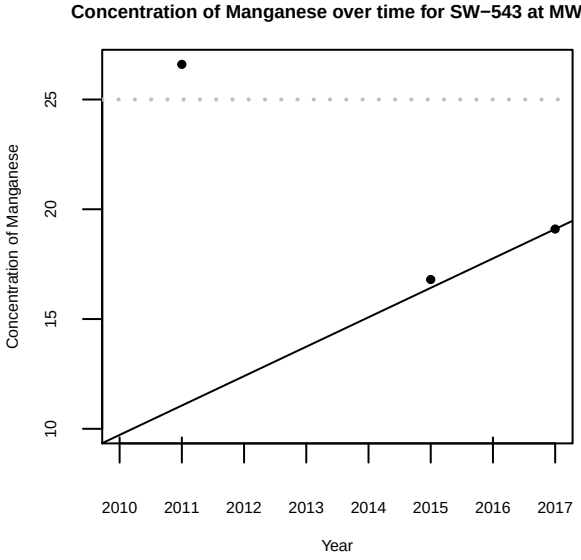


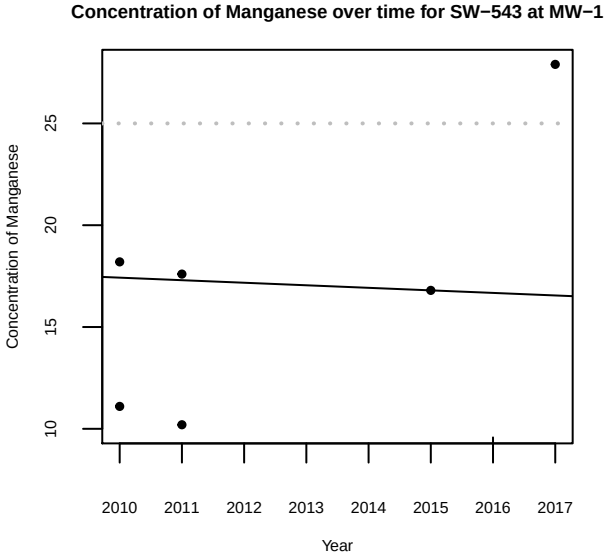

Concentration of Manganese over time for SW−543 at MW−5D
Concentration of Manganese
50
100
150
2013
2014
2015
2016
2017
Year
Tau = −0.5, Slope = −50.41, p−value = 0.296

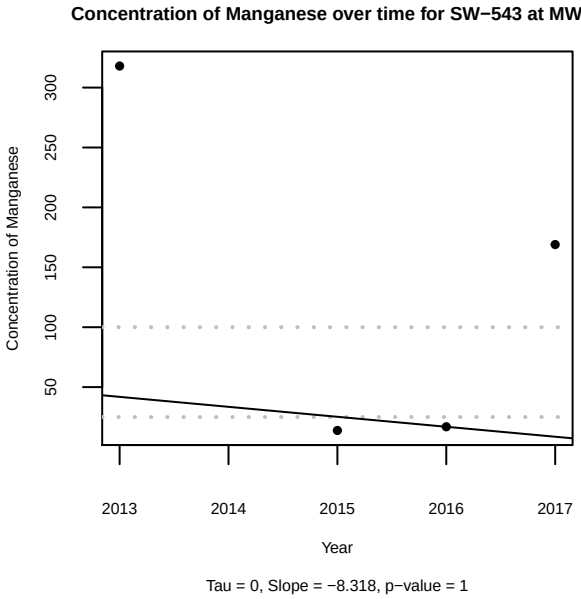

Concentration of Manganese over time for SW−543 at MW−4
Concentration of Manganese
50
100
150
2011
2012
2013
2014
2015
2016
2017
Year
Tau = −0.5, Slope = −14.28, p−value = 0.312

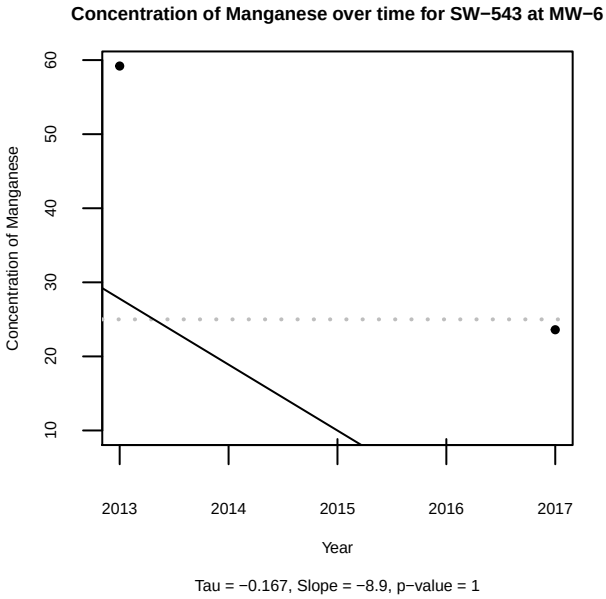

Concentration of Boron over time for SW−543 at MW−1
Concentration of Boron
500
1000
1500
2000
2500
3000
3500
2010
2011
2012
2013
2014
2015
2016
2017
Year
Tau = −0.238, Slope = −178.857, p−value = 0.539


Concentration of Boron over time for SW−543 at MW−4
Concentration of Boron
500
1000
1500
2000
2500
2011
2012
2013
2014
2015
2016
2017
Year
Tau = 0.3, Slope = 295, p−value = 0.613



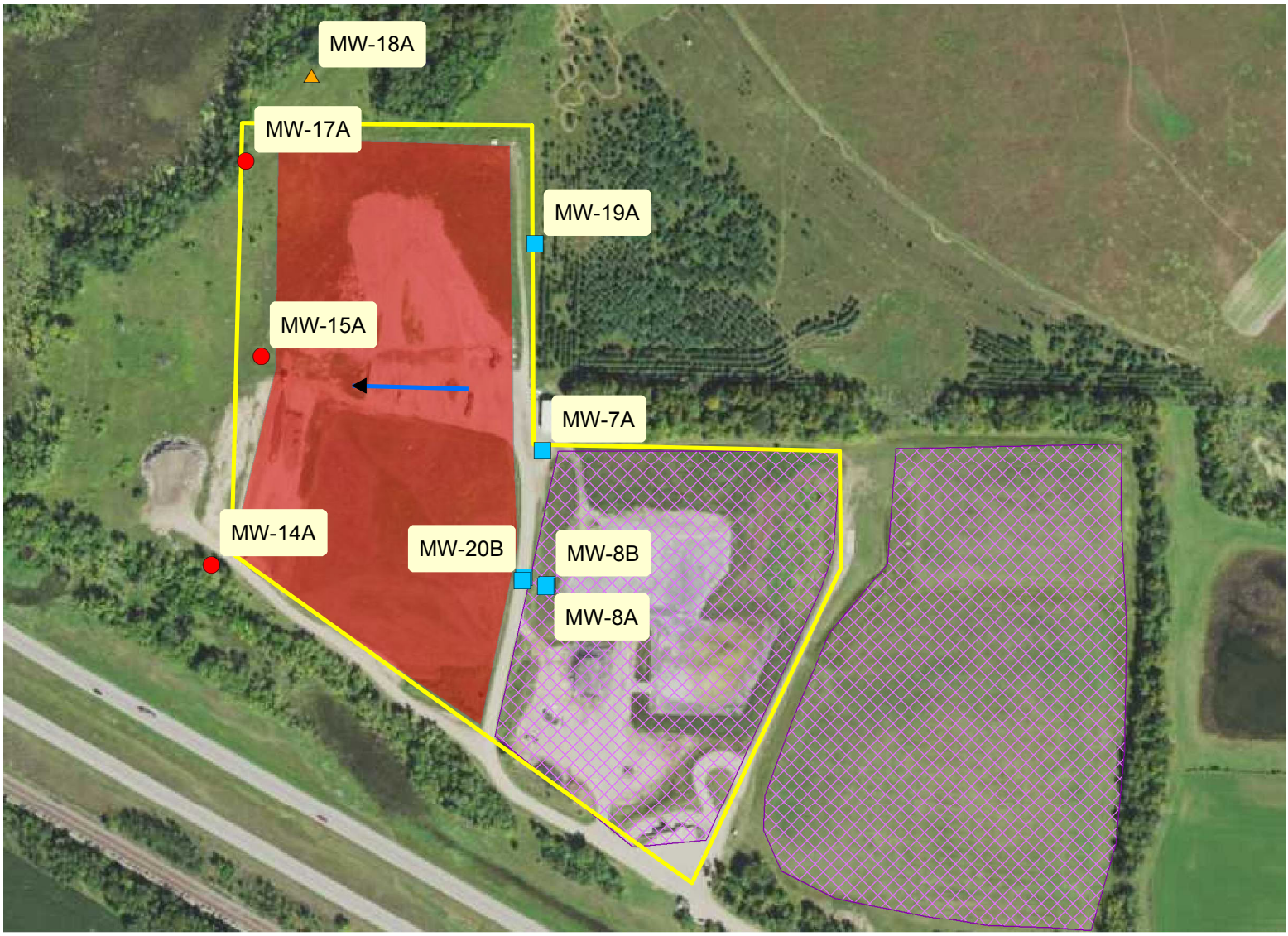






This facility does not show any significant trends for Boron or Manganese.

SW-544 NE Otter Tail Phase II Ash & Demolition Landfill



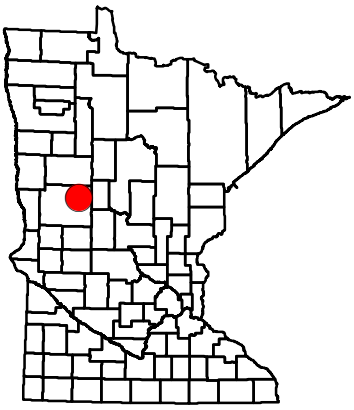
0 225 450 900 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-544 NE Otter Tail Phase II Ash & Demo

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** Closed Landfill Program site southwest to southeast, has combustor ash Landfill
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 6
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to west

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for arsenic and boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

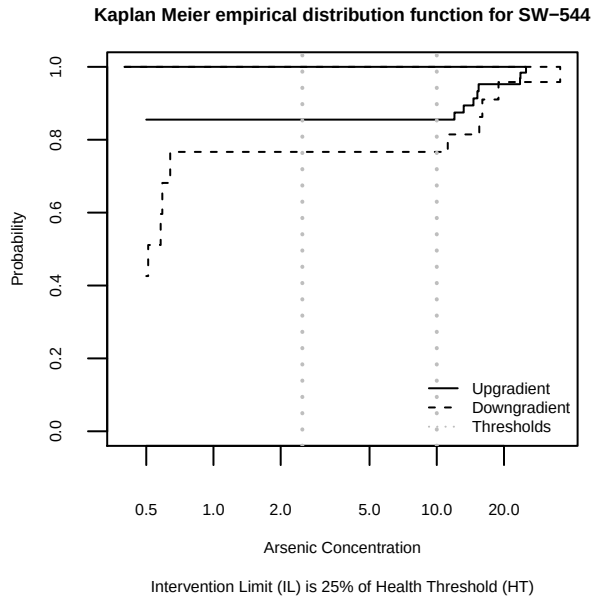
The concentration of Boron as measured in well MW-17A is increasing over time (slope is positive and p-value is less than 0.05), in 2017 all points are above the HT. The remaining well trends are not statistically significant.

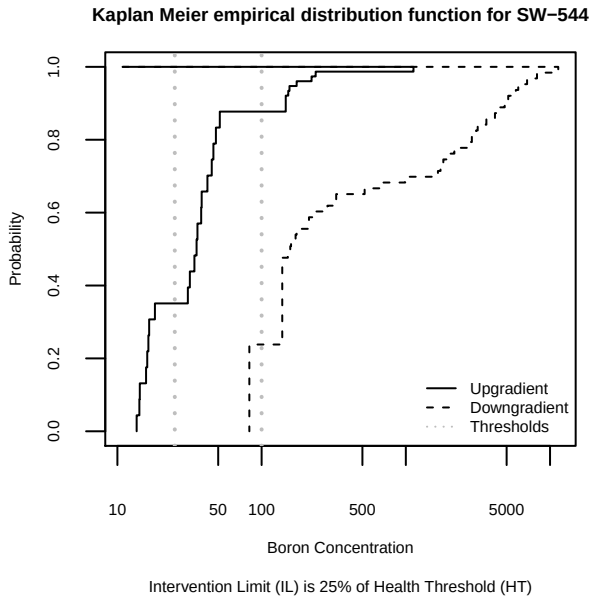
Kaplan Meier empirical distribution function (EDF)

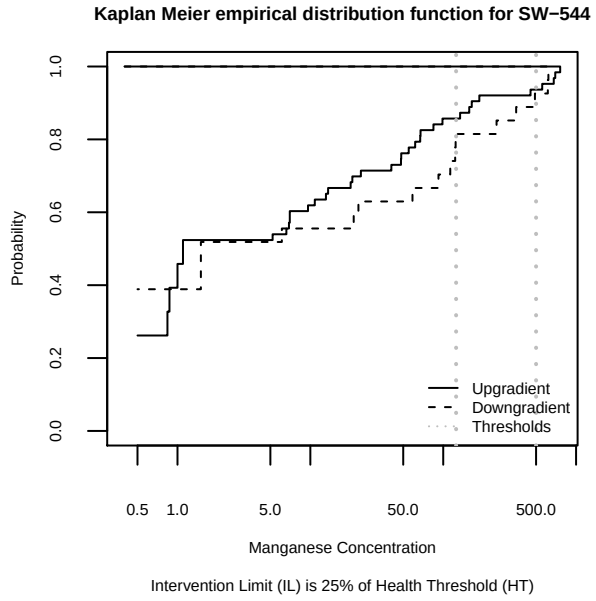
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-544	Arsenic	24	63	5.358	1	0.01**	Yes
	Boron	63	76	43.724	1	0***	Yes
	Manganese	27	63	0.260	1	0.305	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for arsenic and boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

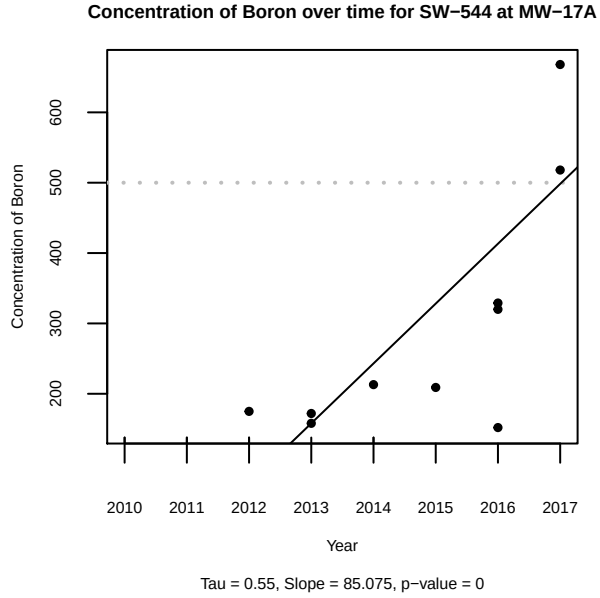
Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-544	Arsenic	MW-14A	3	0	5
		MW-15A	1	0	7
		MW-17A	1	0	7
	Boron	MW-14A	20	0	0
		MW-15A	0	4	20
		MW-17A	2	8	9
	All	All	27	12	48

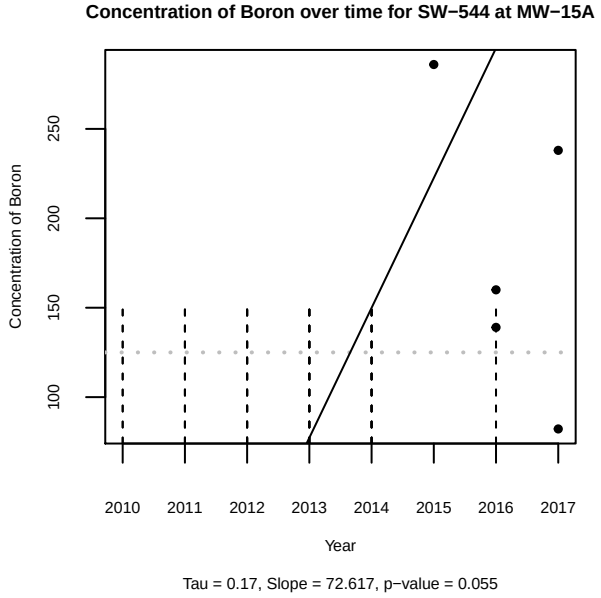
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

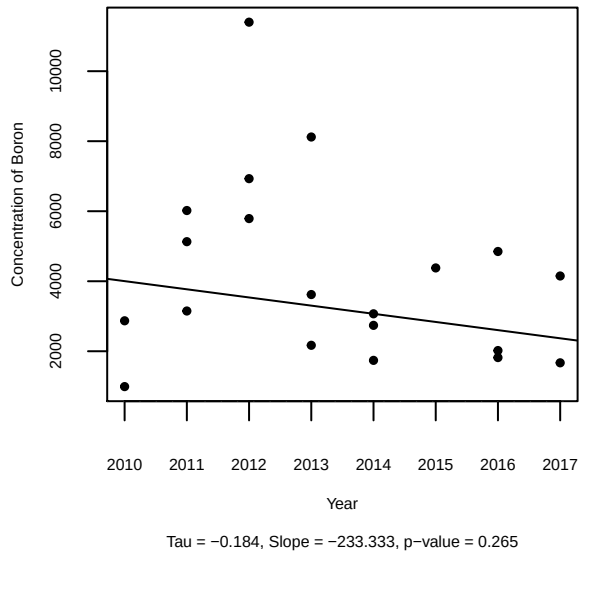
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



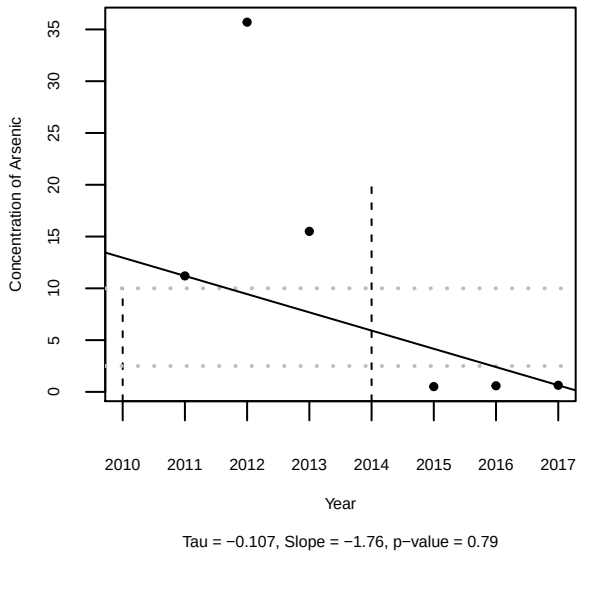
Tau = 0.55, Slope = 85.075, p−value = 0



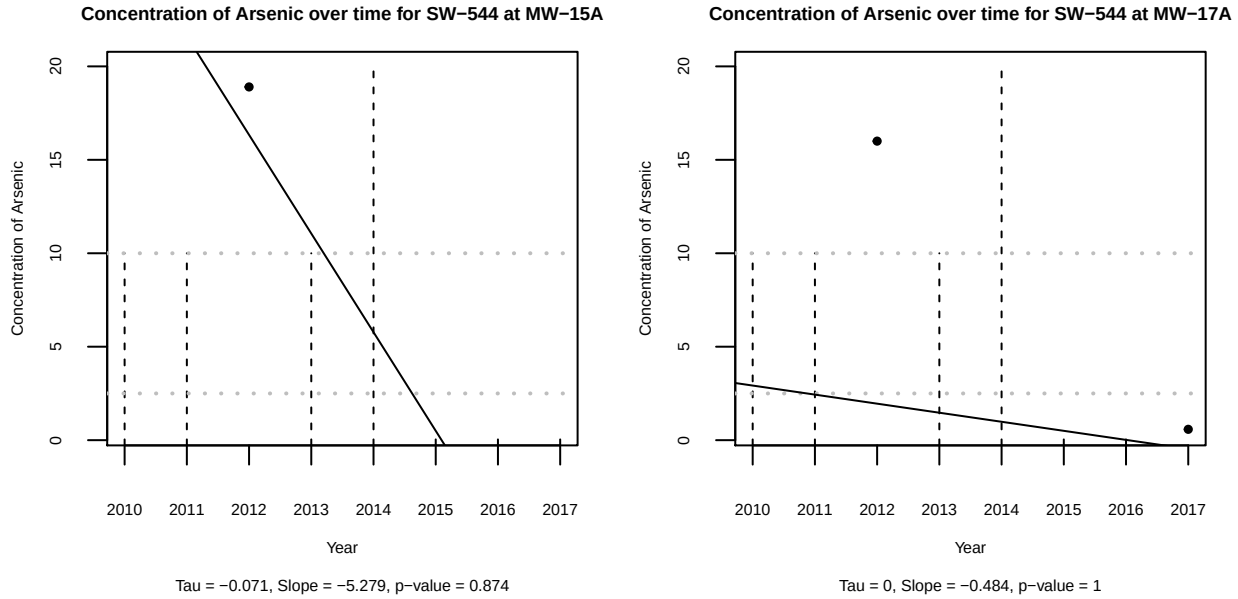
Tau = 0.17, Slope = 72.617, p−value = 0.055



Tau = −0.184, Slope = −233.333, p−value = 0.265



Tau = −0.107, Slope = −1.76, p−value = 0.79



The concentration of Boron as measured in well MW-17A is increasing over time (slope is positive and p-value is less than 0.05), in 2017 all points are above the HT. The remaining well trends are not statistically significant.

SW-548 Waste Management Demolition Landfill

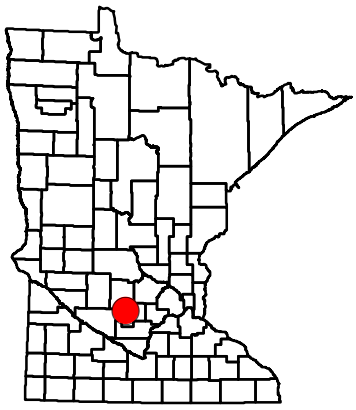
0 225 450 900 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-548 Waste Management Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill. Began operations in 1998, some portions are no longer active.
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 2
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to east

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

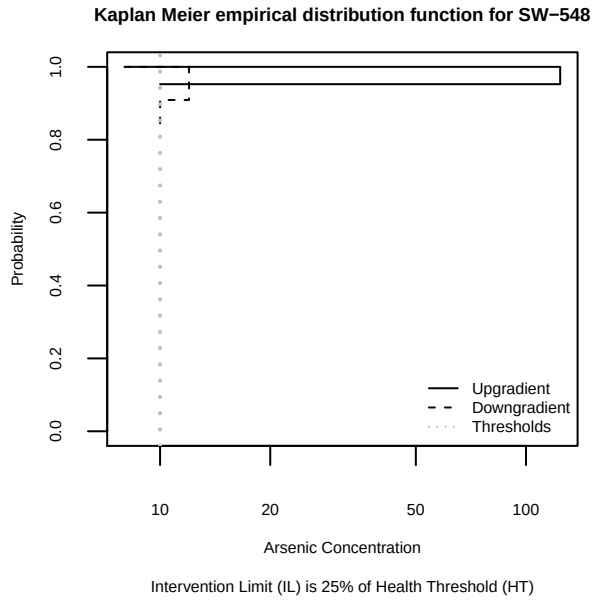
This facility does not show any significant trends for Boron.

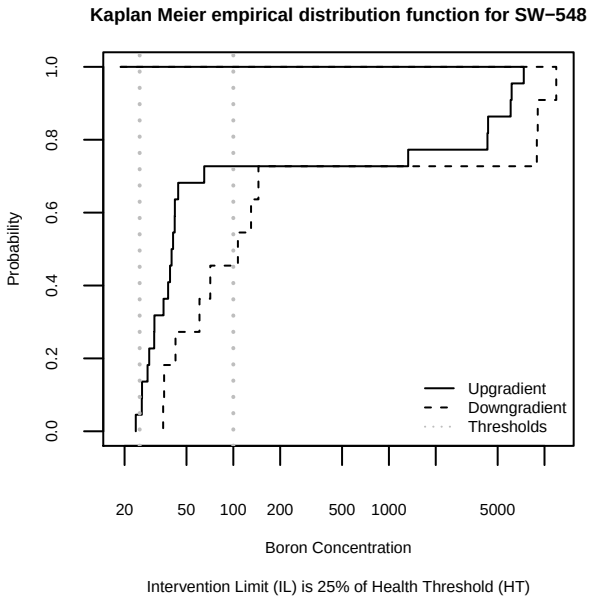
Kaplan Meier empirical distribution function (EDF)

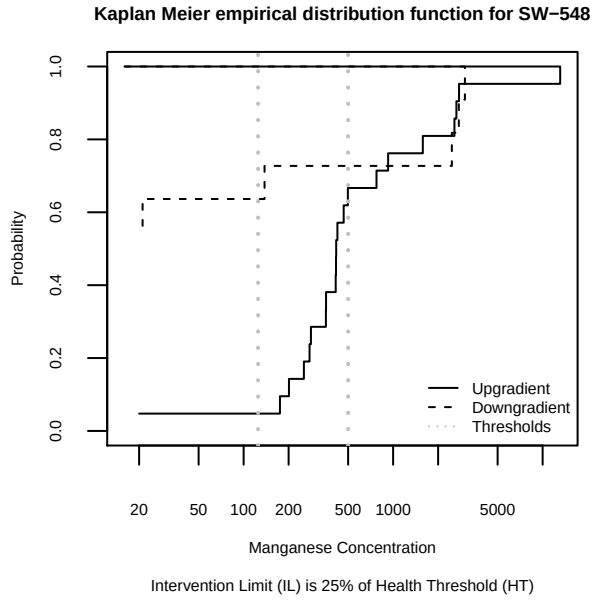
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-548	Arsenic	11	21	1.292	1	0.128	No
	Boron	11	22	4.697	1	0.015**	Yes
	Manganese	11	21	4.645	1	0.016**	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

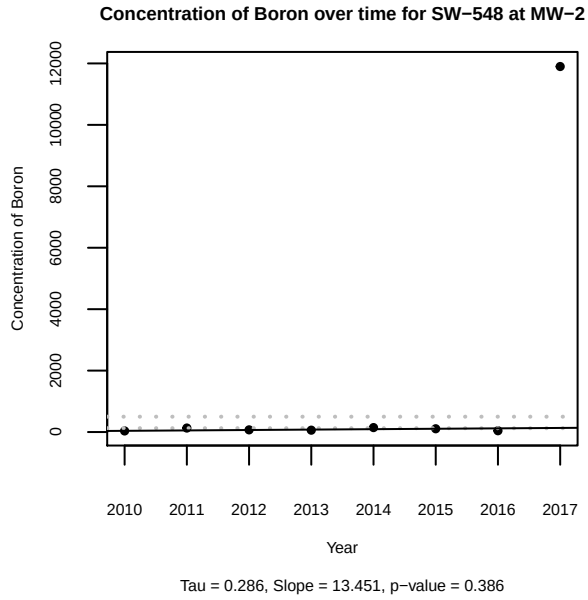
Table 2: Exceedance of thresholds by contaminant and Well ID

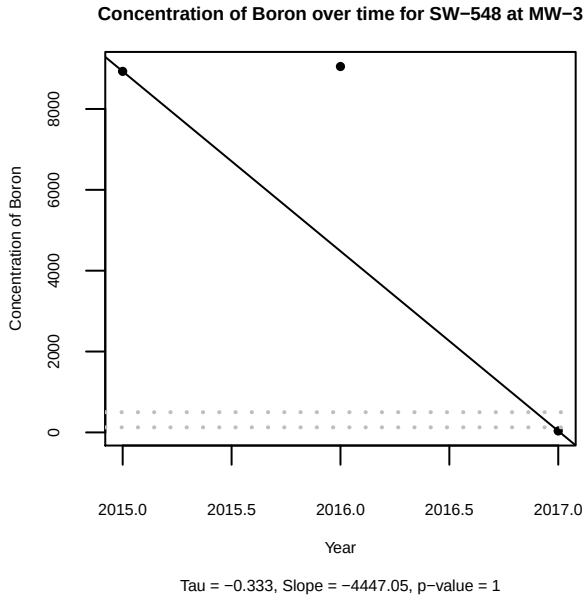
Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-548	Boron	MW-2	1	2	5
		MW-3	2	0	1
	All	All	3	2	6

Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

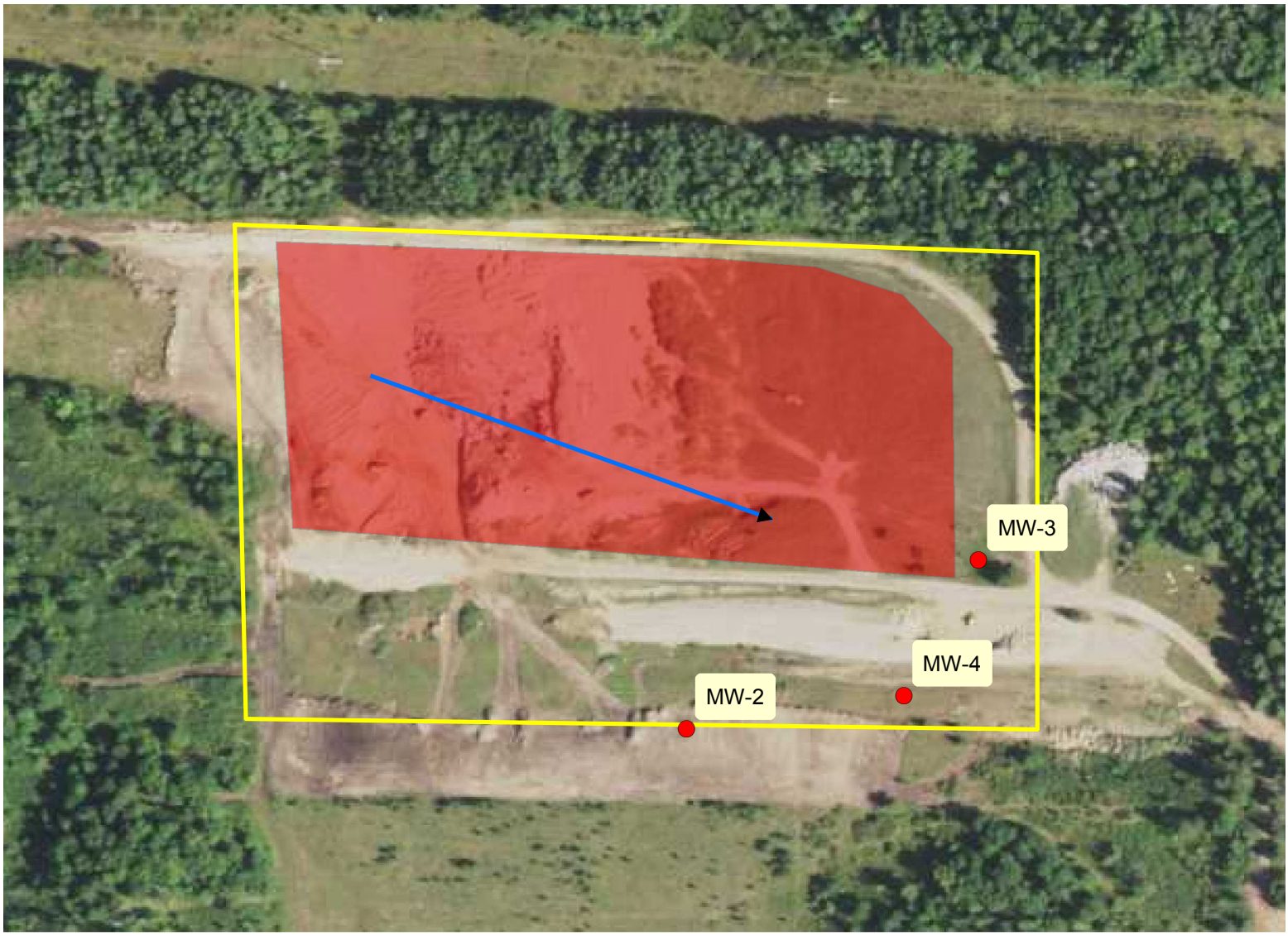
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.





This facility does not show any significant trends for Boron.

SW-556 Grinning Bear Demolition Landfill



0 165 330 660 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-556 Grinning Bear Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill, some portions are no longer active
2. **Other solid waste:** Storage area, concrete pile
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 0
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to east-southeast

C. Facility impact on groundwater

Facility lacks sample results from upgradient wells and thus cannot be evaluated for impacts to groundwater.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

No trends were evaluated for this facility.

SW-590 Double D Demolition Landfill

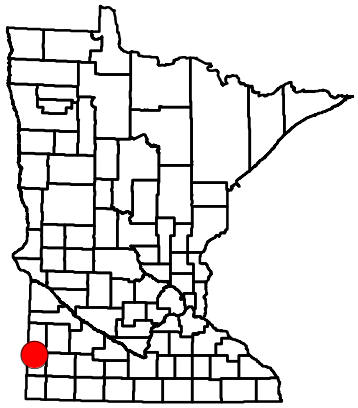
0 140 280 560 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-590 Double D Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill, some portions are no longer active
2. **Other solid waste:** Originally part of Double D gravel operations. Was PBR Demo Landfill prior to permit of SW-590.
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to north-northeast

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

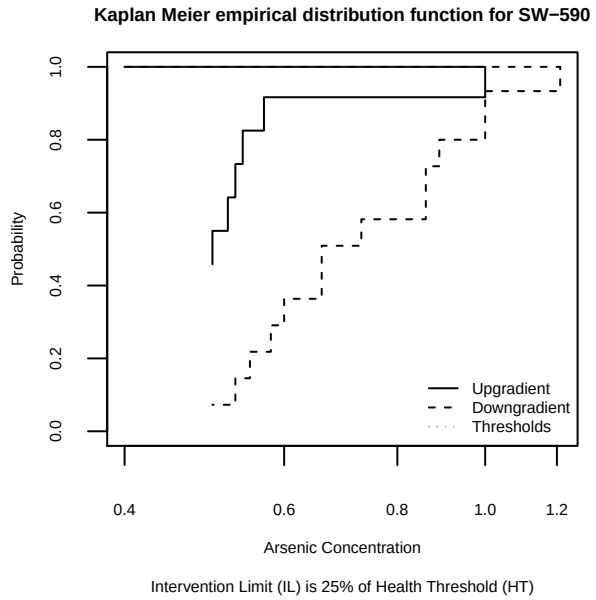
The concentration of Boron as measured in well MW-2 is increasing over time (slope is positive and p-value is less than 0.05), all points are above the IL. The remaining well trends are not statistically significant.

Kaplan Meier empirical distribution function (EDF)

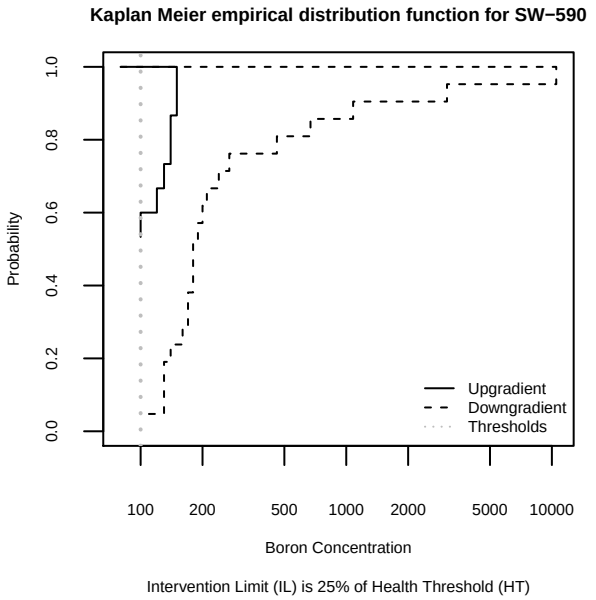
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

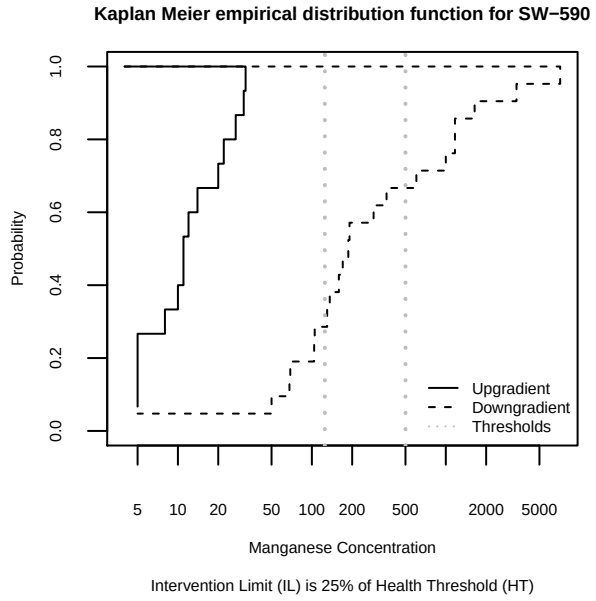
The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)

Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-590	Arsenic	15	12	9.318	1	0.001***	Yes
	Boron	21	15	18.167	1	0***	Yes
	Manganese	21	15	22.956	1	0***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for arsenic, boron, and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

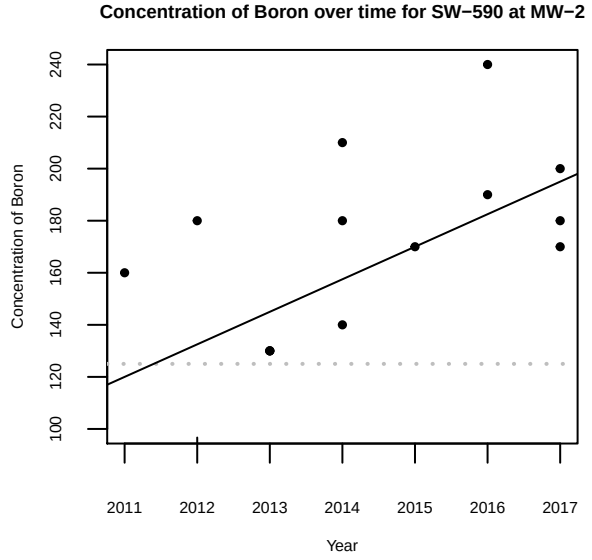
Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-590	Arsenic	MW-2	0	0	12
		MW-3	0	0	3
	Boron	MW-2	0	14	1
		MW-3	4	2	0
	Manganese	MW-2	12	3	0
		MW-3	5	0	1
	All	All	21	19	17

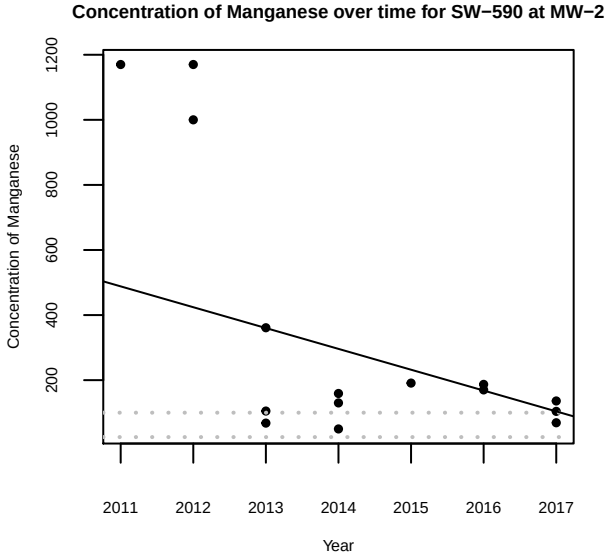
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

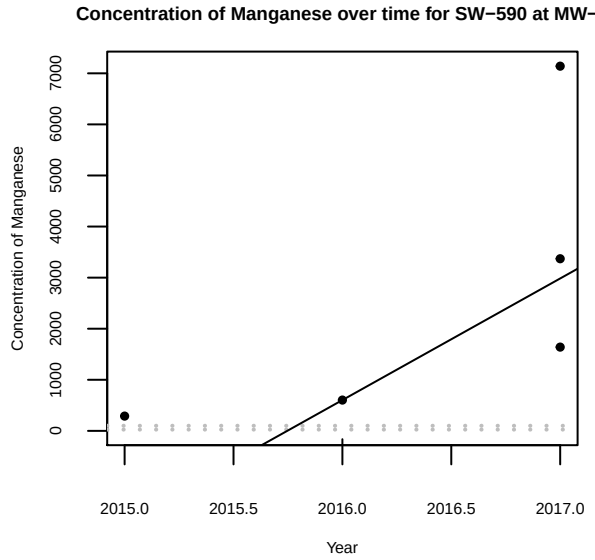
The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



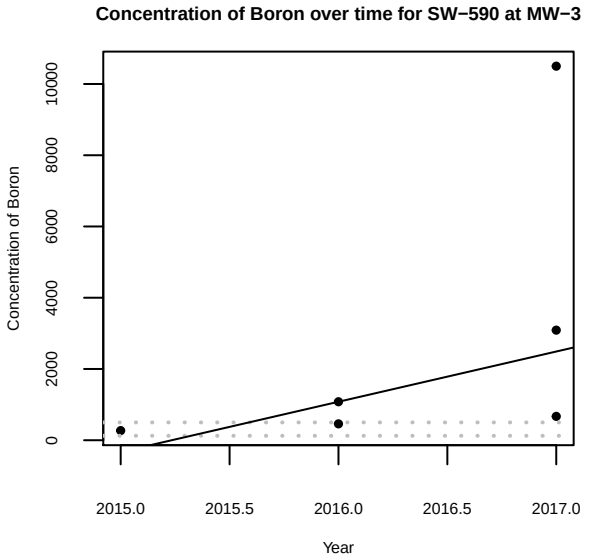
Tau = 0.419, Slope = 12.5, p−value = 0.029



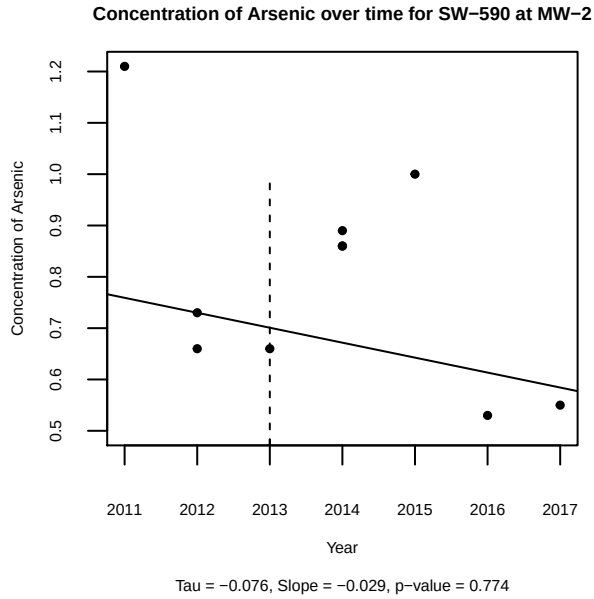
Tau = −0.371, Slope = −64.03, p−value = 0.056

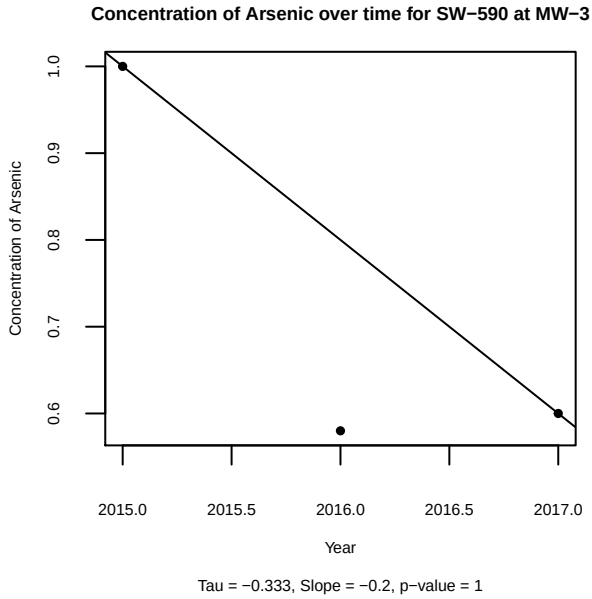


Tau = 0.6, Slope = 2380.797, p−value = 0.1



Tau = 0.6, Slope = 1410, p−value = 0.1





The concentration of Boron as measured in well MW-2 is increasing over time (slope is positive and p-value is less than 0.05), all points are above the IL. The remaining well trends are not statistically significant.

SW-600 D & G Excavating Inc

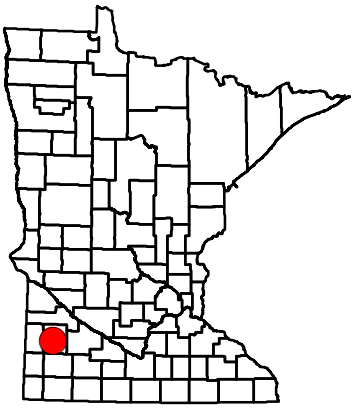
0 165 330 660 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-600 D & G Excavating Inc

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill, some portions no longer active. Began operating in 2002.
2. **Other solid waste:** Demo Landfill preceded by PBR demo
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 3
3. **Groundwater flow:** to east-southeast

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

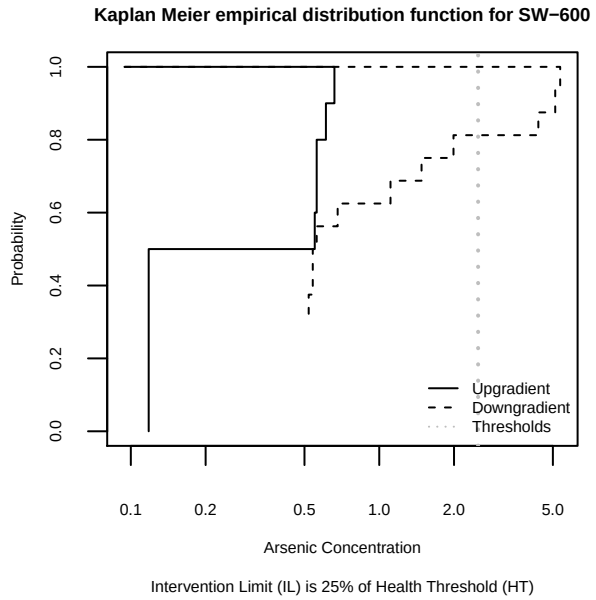
The concentration of Boron as measured in well MW-2 is increasing over time (slope is positive and p-value is less than 0.05), all points except for one are above the HT. The remaining well trends are not statistically significant.

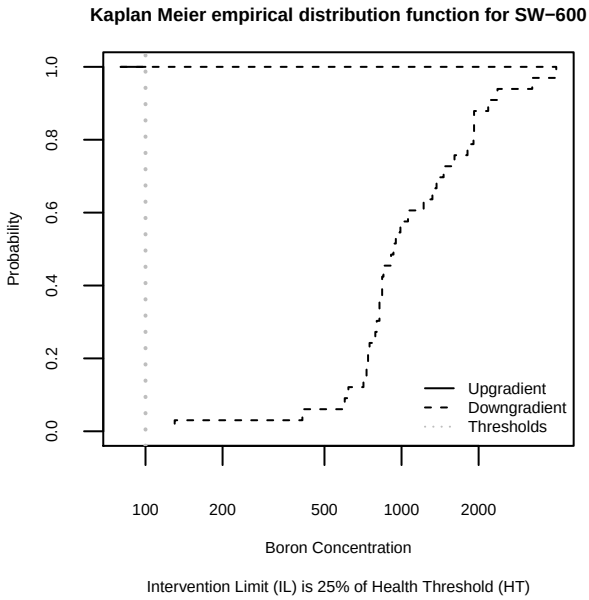
Kaplan Meier empirical distribution function (EDF)

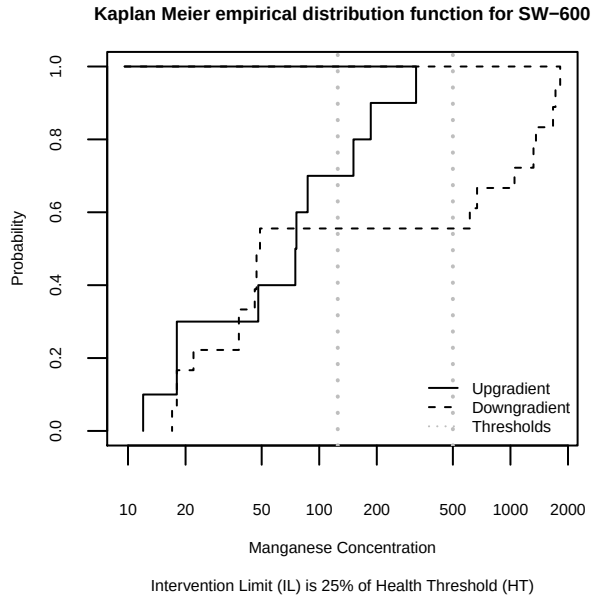
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-600	Arsenic	16	10	1.689	1	0.097*	No
	Boron	33	22	42.682	1	0***	Yes
	Manganese	18	10	0.637	1	0.212	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for boron show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

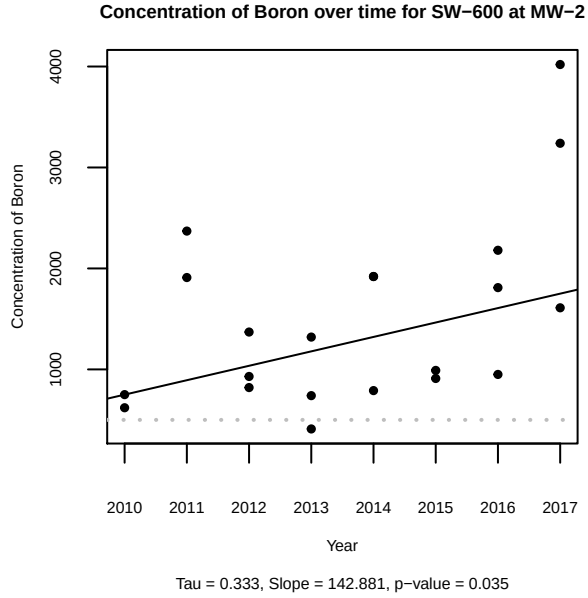
Table 2: Exceedance of thresholds by contaminant and Well ID

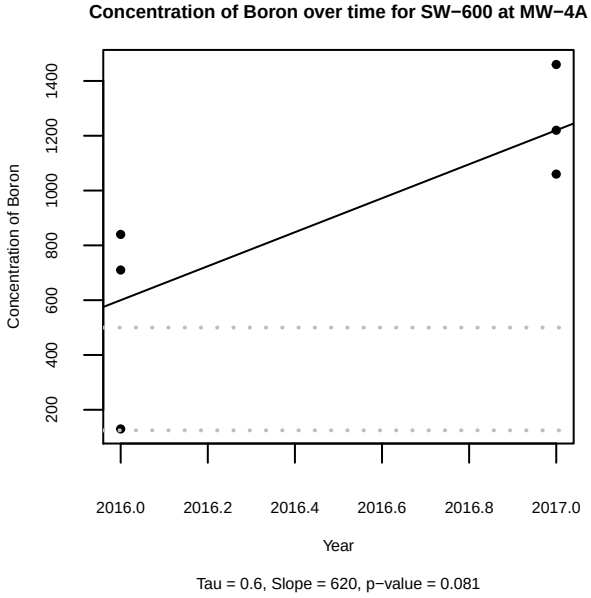
Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-600	Boron	MW-2	20	1	0
		MW-4A	5	1	0
		MW-4B	6	0	0
	All	All	31	2	0

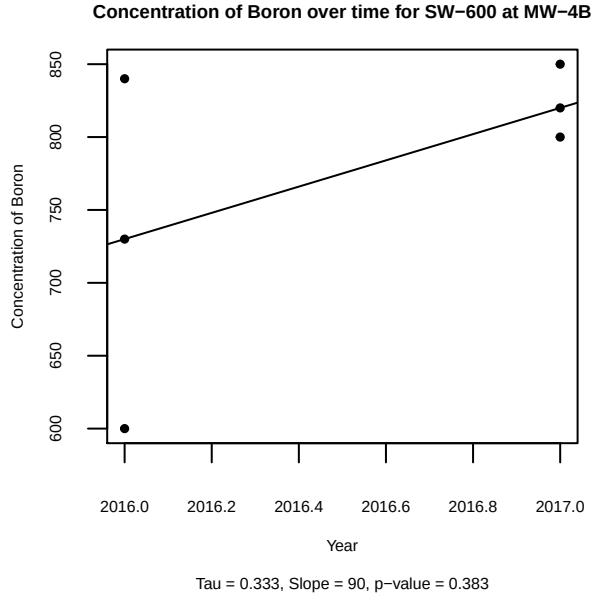
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.







The concentration of Boron as measured in well MW-2 is increasing over time (slope is positive and p-value is less than 0.05), all points except for one are above the HT. The remaining well trends are not statistically significant.

SW-603 Trout Demolition Debris Land Disposal

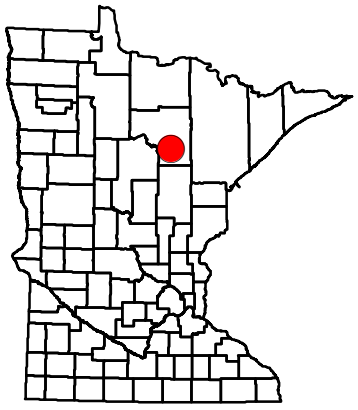
0 140 280 560
Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-603 Trout Demolition Debris Land Disposal

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill
2. **Other solid waste:** Concrete recycling operation
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to east

C. Facility impact on groundwater

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

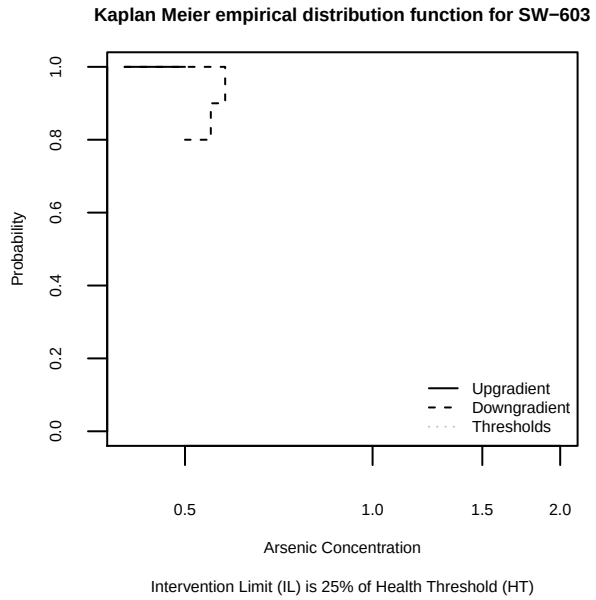
No trends were evaluated for this facility.

Kaplan Meier empirical distribution function (EDF)

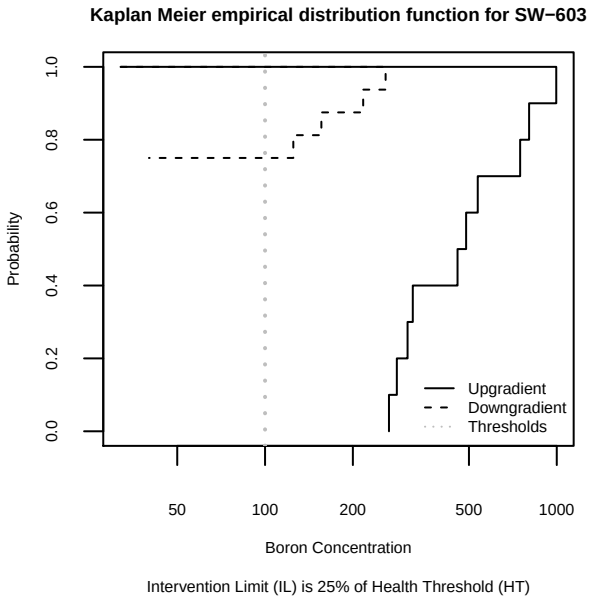
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

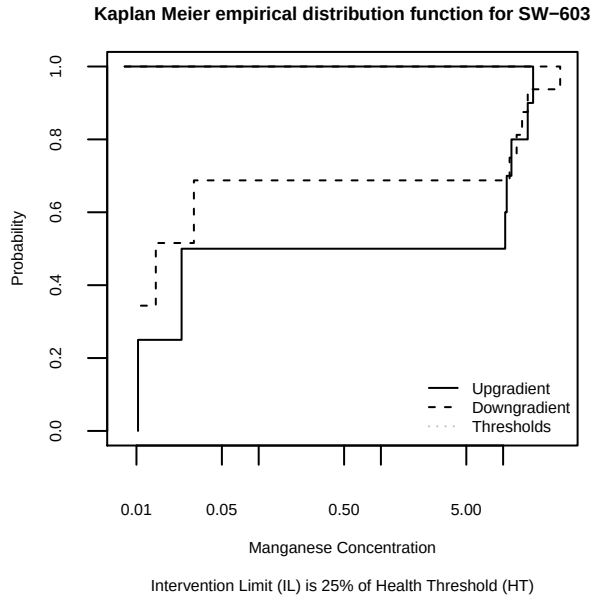
The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)

Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

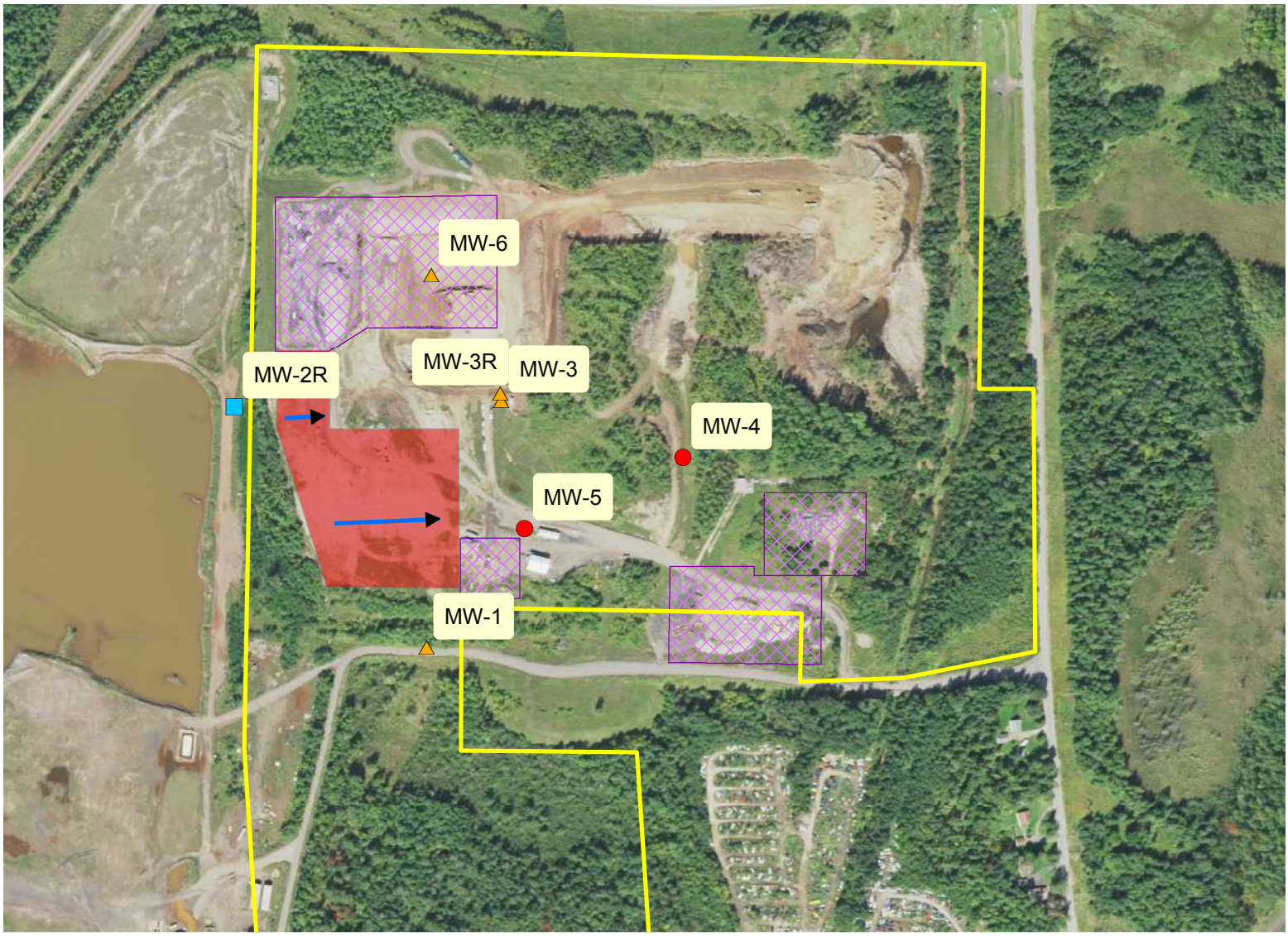
Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-603	Arsenic	16	10	1.474	1	0.112	No
	Boron	16	10	29.091	1	0***	No
	Manganese	16	10	0.601	1	0.219	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test do not show a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient for any of the contaminants of concern.

SW-620 General Waste & Recycling LLC



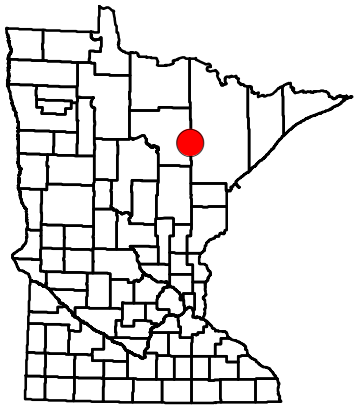
0 335 670 1,340 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste



SW-620 General Waste & Recycling LLC

A. Facility overview

1. **C&D disposal activity to date:** Class 2 Construction and Demolition Landfill
2. **Other solid waste:** Lined Industrial Solid Waste landfill nearby. Mine tailings unit. Waste storage and recycling area
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to southeast

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for arsenic show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

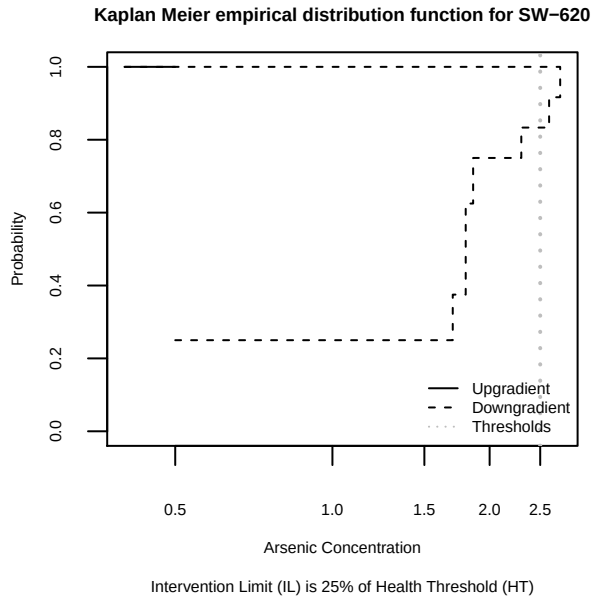
While a single trend was evaluated for Arsenic at MW-5, it was found to not be statically significant. However two points were above the IL in 2011 and 2015.

Kaplan Meier empirical distribution function (EDF)

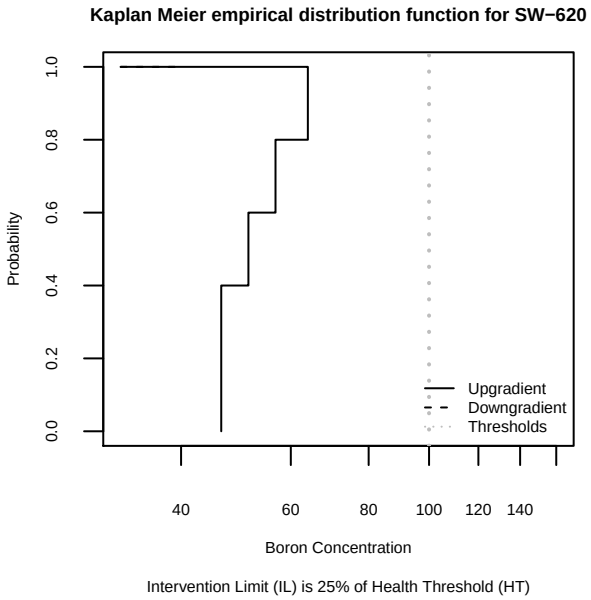
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

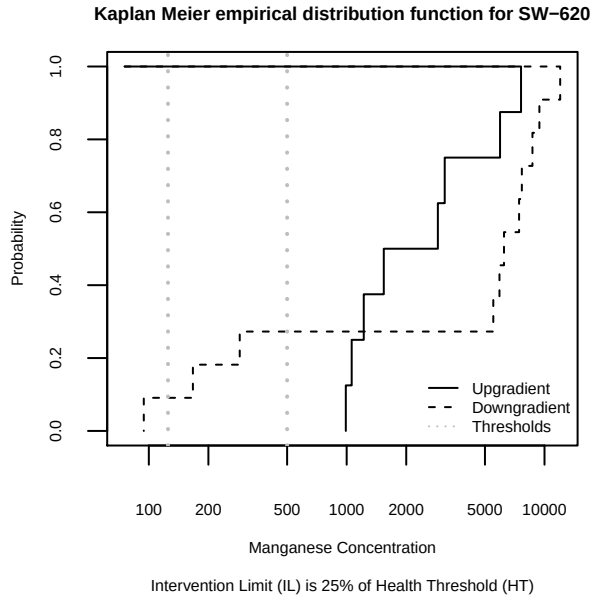
The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)



Intervention Limit (IL) is 25% of Health Threshold (HT)

Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-620	Arsenic	12	8	6.997	1	0.004***	Yes
	Boron	11	8	6.314	1	0.006***	No
	Manganese	11	8	1.300	1	0.127	No

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for arsenic show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-620	Arsenic	MW-4	0	0	3
		MW-5	0	2	7
	All	All	0	2	10

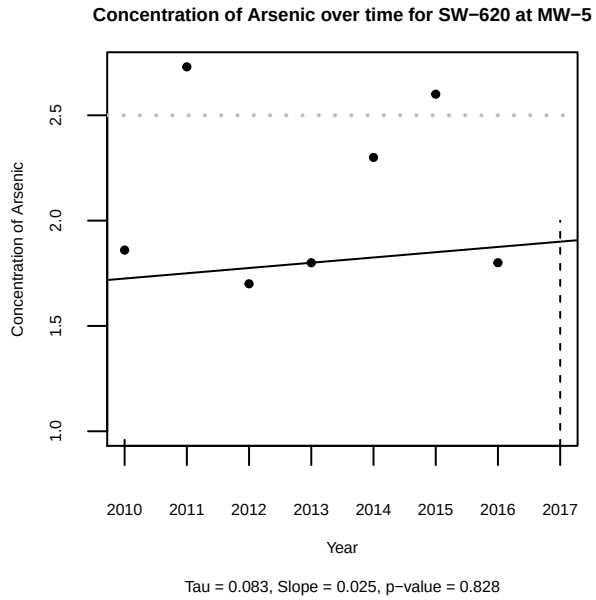
Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

Table 3: Well/contaminant combinations where trends cannot be evaluated

Well ID	Contaminant	Number of measured values	Number of censored values	Total
MW-4	Arsenic	0	3	3

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



While a single trend was evaluated for Arsenic at MW-5, it was found to not be statically significant. However two points were above the IL in 2011 and 2015.

SW-658 Timms Demolition Landfill

0 112.5 225 450 Feet

2017 Aerial Photo MN Geospacial Information Office

N

Legend

- Upgradient Well
- Downgradient Well
- Sidegradient Well
- Approximate Groundwater Flow Direction
- Approximate Permitted Boundary
- Approximate Area of Unlined Demolition Debris
- Approximate Area of Other Solid Waste

SW-658 Timms Demolition Landfill

A. Facility overview

1. **C&D disposal activity to date:** Class 1 Construction and Demolition Landfill. Began operations in 2012
2. **Other solid waste:** N/A
3. **Link to Tableau Report:** Click here to launch

Note: Tableau link is a visual representation of the raw, self-reported data compared to the IL and HT for the concentrations of concern.

B. Groundwater monitoring network overview:

1. **Upgradient well(s):** 1
2. **Downgradient well(s):** 2
3. **Groundwater flow:** to east

C. Facility impact on groundwater

The results of the generalized Wilcoxon test for arsenic and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

D. Contaminant trends by well

For the contaminants that showed a statistically higher concentration downgradient of the facility, the samples collected at each downgradient well were evaluated for trends.

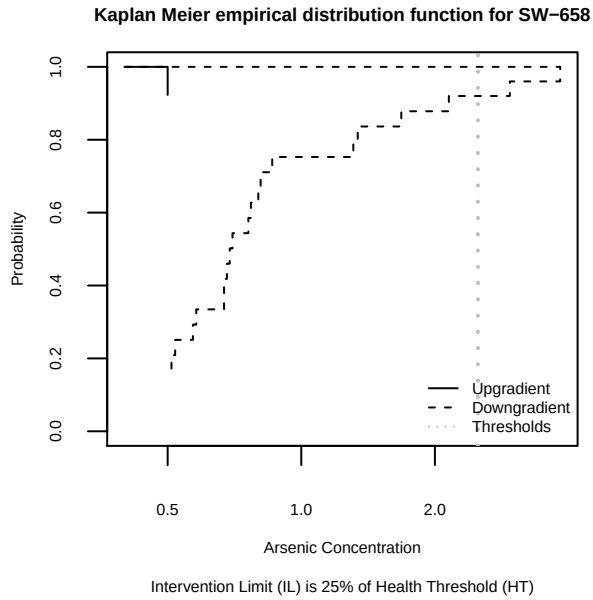
The concentration of Arsenic as measured in well MW-4 is decreasing over time (slope is negative and p-value is less than 0.05), all points are below the IL from 2013 to 2017. The concentration of Manganese as measured in well MW-4 is decreasing over time (slope is negative and p-value is less than 0.05), from 2012 to 2016 points were above the HT. The remaining well trends are not statistically significant.

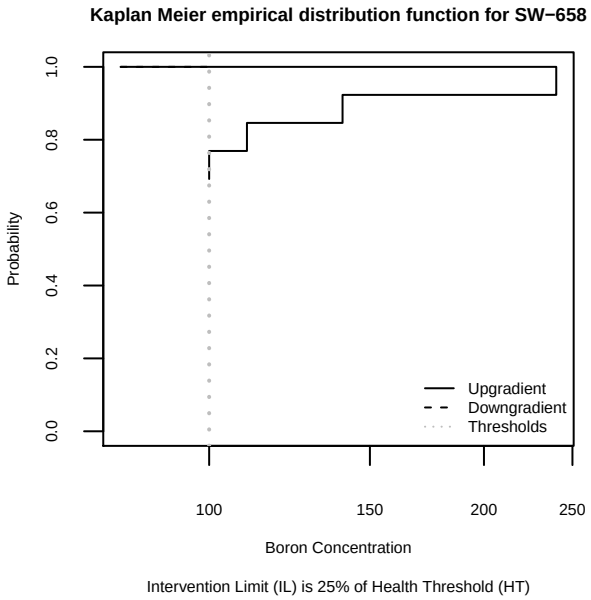
Kaplan Meier empirical distribution function (EDF)

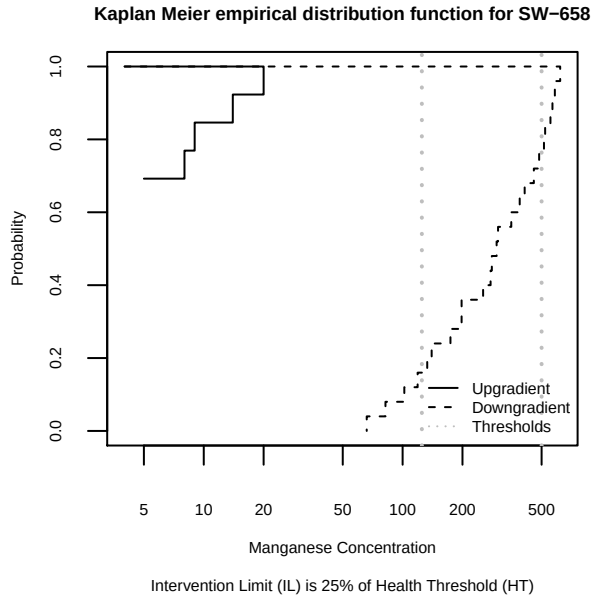
Empirical distribution functions (EDF) plot the sample percentiles for each observation in the data set by ranking them from lowest to highest and are estimations of the true cumulative distribution function (CDF) of the population.

The Kaplan Meier method places each non-detect at its reporting limit prior to ranking and assigns the smallest rank possible in the case of ties. This allows us to account for censored observations in the creation of the EDF. However, if all data are censored or the same value then no EDF can be determined as the Kaplan Meier relies on the number of observations lower than each detected value. (Helsel)

The below graphs show the Kaplan Meier EDF for each contaminant of concern by well position (upgradient vs downgradient). The Intervention Limit (IL) and Health Threshold (HT) are also displayed.







Generalized Wilcoxon results for upgradient vs downgradient wells

In order to determine whether or not there is a statistically significant increase in the concentration of the contaminants of concern downgradient vs upgradient, we used the Peto-Prentice generalized Wilcoxon test which is a special case of the general class of weighted log-rank tests. (Helsel)

These tests are non-parametric score tests which determine whether the distribution functions differ between groups and works well for censored data with multiple reporting limits. The Peto-Prentice test is more appropriate if there are deviations from assumption of proportional hazards. The Peto-Prentice test statistic has a chi-squared distribution with one degree of freedom when the null hypothesis is true. (Collett)

Table 1: Results of the Peto-Prentice generalized Wilcoxon test for downgradient vs upgradient concentrations of the given contaminant of concern

Permit	Contaminant	Downgradient samples (n_d)	Upgradient samples (n_u)	χ^2	Degrees of Freedom	p-value	Downgradient greater than upgradient?
SW-658	Arsenic	25	13	17.085	1	0***	Yes
	Boron	25	13	8.696	1	0.002***	No
	Manganese	25	13	24.989	1	0***	Yes

Note: *p-value < 0.1, **p-value < 0.05, ***p-value < 0.01

The results of the generalized Wilcoxon test for arsenic and manganese show that there is a statistically significant increase in concentrations of samples taken downgradient compared to those taken upgradient of the demo area.

For contaminants that display an increased concentration downgradient we then evaluated the downgradient samples vs the IL and HT thresholds. Below is a summary of the results of the downgradient sampling events assessed for this facility during the period 2010 to 2017.

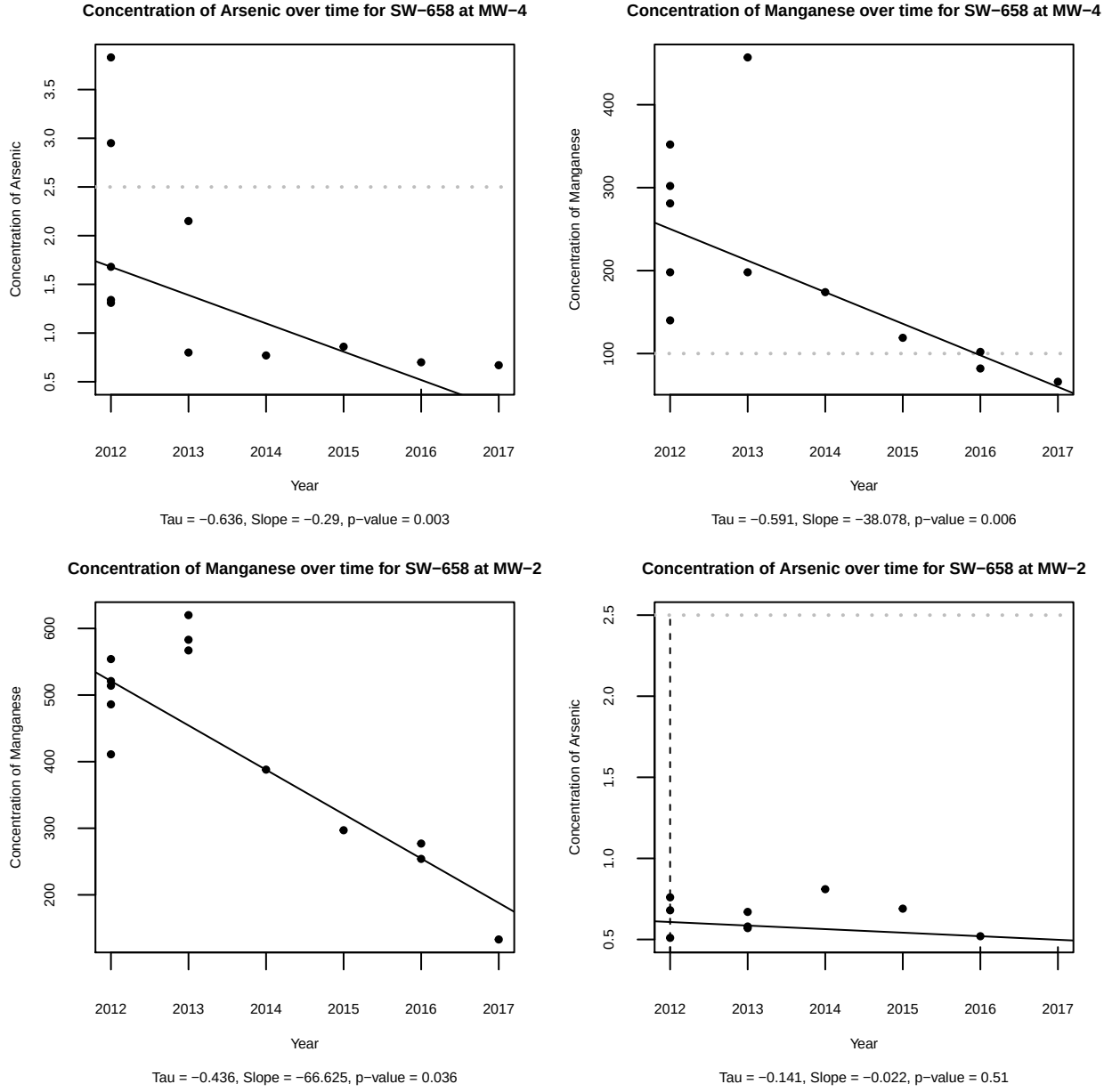
Table 2: Exceedance of thresholds by contaminant and Well ID

Permit	Contaminant	Well ID	Count of samples exceeding HT	Count of samples exceeding IL only	Count of samples below IL
SW-658	Arsenic	MW-2	0	0	13
		MW-4	0	2	10
	Manganese	MW-2	13	0	0
		MW-4	10	2	0
	All	All	23	4	23

Kendall tau correlation coefficient and Akritas-Theil-Sen slope estimator

Trends can be assessed at individual downgradient wells for facilities that showed a statistically significant increase in downgradient wells from upgradient wells, as evaluated by the Peto-Prentice generalized Wilcoxon test. We could not assess trends at wells for a given contaminant if all of the data for a well was censored or had a combination of lack of distinct values, small sample sizes, or too high of a percentage of censored result compared to measured results in the data. Scatter diagrams are not displayed for wells whose trends cannot be assessed.

The figures below are sorted by the p-value, ascending. Thus all significant trends will be displayed first.



The concentration of Arsenic as measured in well MW-4 is decreasing over time (slope is negative and p-value is less than 0.05), all points are below the IL from 2013 to 2017. The concentration of Manganese as measured in well MW-4 is decreasing over time (slope is negative and p-value is less than 0.05), from 2012 to 2016 points were

above the HT. The remaining well trends are not statistically significant.