

Memo

To: David Anderson
Charles Kennedy

From: Phil Richerson

Date: 2/6/2020

Subject: Northern Malheur County Groundwater Management Area
Area-Wide Trend Analysis



State of Oregon
Department of
Environmental
Quality

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At your request, I have performed a trend analysis of the groundwater nitrate concentrations in the Northern Malheur County Groundwater Management (GWMA). The results are described below and summarized in the attached table and figures. It is worth noting that this email describes results of the fifth trend analysis conducted since 2003. Because the sampling frequency and well network changed over time, results are not necessarily directly comparable between analyses. The analysis described in this memo used annual data (April of each year).

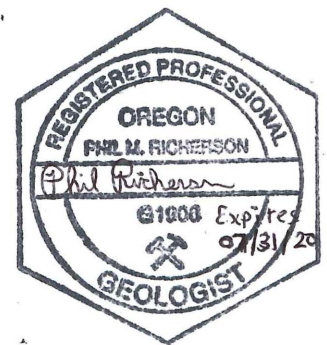
In summary, more wells are decreasing than increasing, and the area-wide trend of groundwater nitrate concentrations continues to decrease slightly. The decreasing area-wide trend meets the measure of Action Plan success that requires a statistically significant downward trend at the 80% confidence level.

Methods – As with previous analyses, the Seasonal Kendall procedure was used to evaluate trends at 35 individual wells. Data sets at most wells start in April 1993 and end in April 2019. Four data sets begin in April 1992, one begins in April 1994, and one in April 1995.

A variation of the Seasonal Kendall procedure known as the Regional Kendall test was used to evaluate the area-wide trend. The area-wide trend from April 1992 through April 2019 was calculated.

In order to evaluate changes in the area-wide trend over time, additional analyses were performed that consisted of deleting the most recent year of data then recalculating the area-wide trend. This process of deleting a year and recalculating trends was repeated until statistically significant trends were no longer observed.

Trends at Individual Wells – Table 1 summarizes the data set statistics (e.g., timeframe of data, average concentration) as well as the trend slope (in parts per million per year) and confidence level¹ (in percent). Figure 1 is a pie chart showing the breakdown of trends at individual wells. As shown in Table 1 and Figure 1, 10 wells (29%) showed increasing trends, 18 wells (51%) showed decreasing trends, and 7 wells (20%) showed statistically insignificant trends.



¹ The GWMA Action Plan calls for using a confidence level of 80% as the demarcation between statistically significant trends and statistically insignificant trends.



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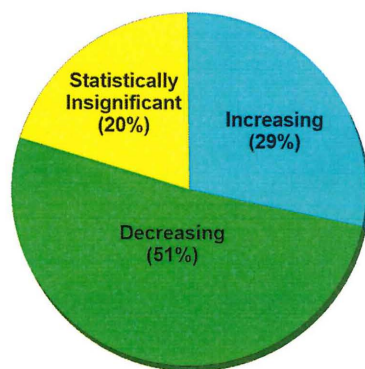


Figure 1 – Distribution of Trends at NMC GWMA Individual Wells

Table 1
Summary of Individual Well Nitrate Trends
Fifth Northern Malheur County GWMA Trend Analysis

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction
	Starting Date	Ending Date	Minimum	Maximum	Mean	Median	n	% BDL	Slope (ppm/yr)	Confidence Level	
MAL005	Apr-93	Apr-19	4.8	8.6	6.8	7.0	28	0%	0.048	96%	Increasing
MAL012	Apr-92	Apr-19	9.39	36	21.7	21.0	28	0%	-0.539	99%	Decreasing
MAL016	Apr-93	Apr-19	8.55	27.9	19.3	21.6	26	0%	0.514	99%	Increasing
MAL030	Apr-93	Apr-19	17.3	30	22.5	20.4	27	0%	-0.443	99%	Decreasing
MAL035	Apr-93	Apr-19	9.4	35.7	23.6	22.2	25	0%	-0.670	99%	Decreasing
MAL041	Apr-93	Apr-19	16.8	24.9	19.1	18.5	27	0%	0.029	49%	nst
MAL044	Apr-93	Apr-19	8.59	21	15.0	15.1	27	0%	-0.328	99%	Decreasing
MAL047	Apr-93	Apr-19	19.3	41	24.2	22.4	27	0%	-0.322	99%	Decreasing
MAL062	Apr-93	Apr-16	10.6	48	32.7	34.4	11	0%	-1.398	98%	Decreasing
MAL064	Apr-92	Apr-19	<0.005	14.7	6.1	5.9	28	4%	0.049	33%	nst
MAL078	Apr-93	Apr-19	2.3	65.4	11.6	8.3	28	0%	0.012	0%	nst
MAL079	Apr-93	Apr-19	5.57	17.5	11.1	10.9	27	0%	0.135	97%	Increasing
MAL083	Apr-93	Apr-19	12.2	47	20.1	17.6	27	0%	-0.363	99%	Decreasing
MAL101	Apr-93	Apr-19	2.1	16.4	7.2	6.4	27	0%	0.110	66%	nst
MAL105	Apr-93	Apr-19	12.1	32.6	21.1	22.6	29	0%	-0.691	99%	Decreasing
MAL106	Apr-93	Apr-13	0.0088	30	9.7	3.6	20	0%	-0.975	94%	Decreasing
MAL108	Apr-92	Apr-19	0.07	3.67	1.3	0.9	29	0%	0.073	99%	Increasing
MAL116	Apr-93	Apr-19	2.5	15	5.8	4.8	24	0%	0.005	2%	nst
MAL121	Apr-93	Apr-19	7.24	14	10.9	11.3	27	0%	-0.210	99%	Decreasing
MAL125	Apr-93	Apr-19	2.35	17	5.1	4.3	28	0%	-0.113	89%	Decreasing
MAL126	Apr-93	Apr-19	5.2	45	12.3	9.5	27	0%	-0.054	84%	Decreasing
MAL129	Apr-93	Apr-19	0.708	6.02	2.9	3.3	26	0%	-0.537	83%	Decreasing
MAL136	Apr-93	Apr-19	7.93	14	10.0	9.7	29	0%	0.095	97%	Increasing
MAL147	Apr-93	Apr-19	<0.005	0.08	0.02	0.02	27	33%	0.000	68%	nst
MAL152	Apr-94	Apr-16	2.88	13.4	7.5	8.1	16	0%	-0.353	99%	Decreasing
MAL164	Apr-93	Apr-19	2.92	21.4	6.9	4.9	18	0%	0.185	61%	nst
MAL172	Apr-92	Apr-10	2.18	13	7.1	6.6	28	0%	-0.253	99%	Decreasing
MAL175	Apr-93	Apr-19	5.26	17	11.4	11.1	28	0%	-0.215	99%	Decreasing
MAL180	Apr-93	Apr-19	2.3	13.1	5.6	5.5	27	0%	0.240	99%	Increasing
MAL189	Apr-93	Apr-19	7.9	11.4	9.4	9.0	24	0%	0.096	99%	Increasing
MAL216	Apr-93	Apr-19	<0.005	0.04	<0.01	<0.005	23	57%	-0.001	99%	Decreasing
MAL217	Apr-93	Apr-19	12	20.1	17.3	17.9	27	0%	0.090	91%	Increasing
MAL218	Apr-95	Apr-16	0.708	30	8.3	7.1	22	0%	-0.627	99%	Decreasing
OWY002	Apr-93	Apr-19	0.229	6.42	4.6	5.1	27	0%	0.026	82%	Increasing
OWY101	Apr-93	Apr-14	8.3	12	9.9	9.74	23	0%	0.006	92%	Increasing

Notes:

n = number of samples; BDL = below detection limit

nst = no significant trend at an 80% confidence level

\\deqpd1\prcher\Malheur\2020 Trend Analysis\all trends.xls\Nitrate Trends thru 2018

# of Increasing Trends at wells ==>	10	28%
# of Decreasing Trends at wells ==>	18	51%
# of Flat Trends at wells ==>	0	0%
# of Insignificant Trends at wells==>	7	20%
Average slope of significant trends at the 35 wells ==>	-0.242	
Average slope of all trends at the 35 wells ==>	-0.182	

Area-wide trend calculated using these 35 wells is -0.019 ppm/yr

Area-Wide Trend – Figure 2 shows the 896 individual nitrate results from as many as 35 wells sampled during each event, the Regional Kendall trend line, and the LOWESS² line through the data. As indicated in Figure 2, the area-wide trend is slightly declining at a rate of -0.019 ppm/yr at a 99% confidence level (p-value of 0.0000005). The LOWESS line also shows the data slightly declines over time.

Figure 3 shows changes in the area-wide nitrate trend over time. As indicated in Figure 3, the area-wide trend was a statistically insignificant (i.e., low confidence level) flat trend (i.e., a slope of zero) from April 1992 through April 2000. The area-wide trend was then a statistically insignificant slightly decreasing (i.e., a negative slope) trend from April 1992 through April 2001. Then, the area-wide trend became a statistically significant (i.e., high confidence level) slightly decreasing trend from April 1992 through April 2002. The area-wide trend remained a statistically significant slightly decreasing trend from 2002 through 2019. The area-wide trend through 2010 was decreasing most steeply.



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² LOWESS stands for Locally Weighted Scatterplot Smoothing, is similar to a moving average, and is a way to gauge the general nature of change within a dataset.

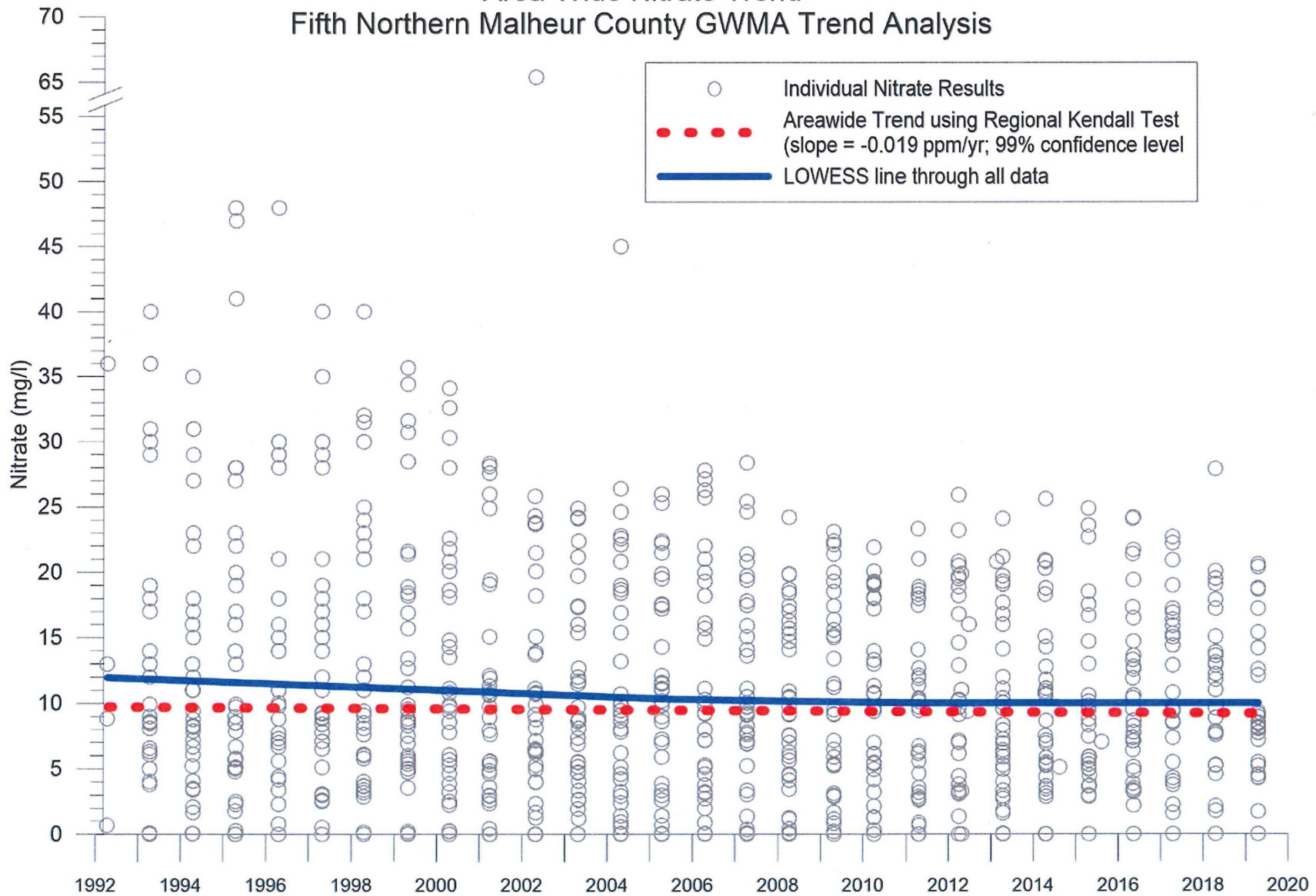


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Figure 2
Area-Wide Nitrate Trend
Fifth Northern Malheur County GWMA Trend Analysis





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Figure 3
Changes in Area-Wide Nitrate Trend
Fifth Northern Malheur County GWMA Trend Analysis

