KW

Johnson Creek Pesticide Investigation - Continuous Turbidity Measurements Technical Memorandum

Technical Report
11.15.06

Prepared by:
Johnson Creek Watershed Council

In consultation with:
Johnson Creek Watershed Interjurisdictional Committee

Project Number: WO4558
DEQ Contract Number: 025-05

Johnson Creek Watershed Council
1900 SE Milport Rd.
Milwaukie, OR 97222
503.652.7477
www.jcwc.org

Interjurisditional Committee Members:
City of Portland
City of Gresham
City of Milwaukie
Clackamas County
Multnomah County
U.S. Geological Survey
Johnson Creek Watershed Council
East Multnomah Soil and Water Conservation District
Clackamas County Soil and Water Conservation District

Table of Contents:

1. **Purpose of Report**
   1.1. **Background – how this project builds upon previous work**

Johnson Creek flows 26 miles from its headwaters between Gresham and Sandy (east of Highway 26) to its confluence with the Willamette River in Milwaukie. Along the way the creek passes through four cities (Gresham, Happy Valley, Portland, and Milwaukie) in Clackamas and Multnomah Counties. The adjacent streamside lands are used for forestry, agriculture, industry and urban living.

Johnson Creek exceeds water quality standards set by DEQ and EPA for DDT and dieldrin, two pesticides in common use in the past. The pesticides have also been found in sediment, fish tissue and other aquatic life in the stream. Both pesticides have been banned since 1972, but remain in the soils where they were applied over three decades ago.

DEQ is requiring that all persons and organizations whose activities may cause the entry of DDT or dieldrin-laden soils into Johnson Creek develop plans to reduce their contribution of these pollutants. The plans are known as Total Maximum Daily Load (TMDL) Implementation Plans. The plans must include monitoring to both ensure that commitments are met, and document improvements in water quality.

   1.2. **Objectives**

Water quality sampling and associated laboratory analytical costs can be expensive. In particular, DDT and dieldrin are harmful to aquatic life at such low concentrations that no local laboratories are equipped to analyze them. Samples must be shipped to a laboratory in Texas, and the costs are high. To reduce costs, local governments decided to study whether pollutants that are comparatively inexpensive to analyze can serve as proxies for DDT and dieldrin. To fund the study, the governments sought, and were granted, matching funds from USGS and DEQ.

The purpose of this report is to present the methods, results, analyses, and conclusions of the study.

2. **Methodology**
   2.1. **Selection of Monitoring and Sampling Locations**

Since this project is based on two significant previous monitoring efforts, the monitoring locations needed to be chosen so that the results of this study fit seamlessly and can be interpreted with the results from the two previous studies. Considering the specific objectives and the limited funds available, the technical team decided to limit this study to two monitoring locations.

The two monitoring and sampling sites were selected based on the following criteria:

- Presence of USGS flow gauges and temperature monitors – this limited the selection to 3 locations on Johnson Creek main stem.
- Location with respect to land uses upstream – rural/agricultural or urban

The USGS operates five gauging stations in the Johnson Creek watershed. Three of them are located in the Johnson Creek main stem, while one each is located in the Crystal Springs and Kelley Creek tributaries. Due to the limited extent of the Kelley Creek and Crystal Springs watersheds only gauging station on the Johnson Creek main stem were considered. The most upstream gauging station at Regner Road (14211400) is approximately at the upstream end of the City of Gresham starts and the downstream end of the rural/agricultural area. Thus, this location will indicate the impacts of the rural/agricultural area on in-stream turbidity and pesticide load. The most downstream location at Milwaukie (14211550) is close to the mouth of Johnson Creek and captures the impacts from the urban areas of Gresham, Portland, and Milwaukie. Both gauging stations have been in place for over seven years and thus an extensive flow and temperature record is available.

2.2. Turbidity Meters

2.2.1. Instrument Type

The turbidity meter that was installed at two locations, Regner Rd. in Gresham and Milport Rd. in Milwaukie, is an Analite NEP395, manufactured by McVan Instruments, Victoria Australia. The light source and angle is indicated on the USGS real-time web page on the turbidity graph y-axis. The light source is monochrome, near infra-red, 780-900 nm, at 90 degrees, and the reporting units are in formazine nephelometric units (FNU) for the formazine standard that is the basis of calibration
http://waterdata.usgs.gov/or/nwis/uv?dd_cd=01%2C02%2C08%2c03&format=gif&period=7&site_no=14211400).
The USGS parameter code for this specific sensor is 63680. A description of the various turbidity sensors available, including this one, can be found at:
http://water.usgs.gov/owq/FieldManual/Chapter6/Section6.7_v2.1.pdf

2.2.2. Installation

The meter installation at the Gresham site is approximately mid-channel, mounted in a 20-foot PVC pipe extending mid-channel into the creek. The meter at the Milwaukie site is located about 1 foot from the edge of water, mounted near the vertical wall on the right bank.

2.2.3. Operation

At both sites, the sensor was checked with standards and with a separate calibrated unit (a hand-held YSI multi-probe). The hand-held unit was used to verify the readings at the sensor were consistent with the stream cross section.

The meters have been checked on a monthly basis through the year. Problems occurred at the Gresham site due to failure of the wiping mechanism. This failure was due to snails that lodged in the wiper, ultimately causing the wiper motor to fail completely. These problems resulted in missing turbidity data for much of the winter due to time required to troubleshoot and repair the meter. The meters were also subject to fouling from sediment and algal scum that built up on the sensor optics despite routine wiping by the internal wiper. At the Gresham site, the turbidity meter was operational during six of the eleven sampling times. The problem with snails has since been remedied by placing a guard over the end of the sensor, preventing much of the fouling problems that occurred in the past. The meter at the Milwaukie site was functional during all eleven sampling events, although intermittent failures occurred other times during the year due to fouling.

2.3. Surface Water Sampling and Handling

The Field Operation Section of the Investigation and Monitoring Services (IMS) of the City of Portland was responsible for the collection and handling of all samples. All samples collected were grab samples. Samples were collected according to standard operating procedures previously established by IMS. Only new or pre-cleaned sampling equipment devices and pre-cleaned sampling containers were used during sample collection.
Initially, samples were collected during monthly routine sampling events. Starting in December 2005, storm events were targeted to ensure that samples were collected during times with higher flow and turbidity (Table 1 and 2).

Sample containers were labeled with information including the sample number, date, and time. Information about each sample was entered on a chain of custody form that accompanied the samples to the laboratory.

Table 1. Summary of Sampling Events – Regner Road (JC15)

Event #	Sampling Date	Sampling Time	Antecedent 24-h rainfall	Sample Type
1	7/19/2005	13:38:00	0.00	monthly routine
2	8/10/2005	12:21:00	0.00	monthly routine
3	9/20/2005	12:47:00	0.00	monthly routine
4	10/19/2005	14:16:00	0.23	monthly routine
5	11/15/2005	13:03:00	0.00	monthly routine
6	12/20/2005	11:11:00	0.05	storm target
7	1/3/2006	15:45:00	0.24	storm target
8	1/11/2006	13:38:00	1.35	monthly routine
9	1/30/2006	12:08:00	0.76	storm target
10	2/1/2006	13:41:00	0.25	storm target
11	4/10/2006	15:16:00	0.69	storm target

Table 2. Summary of Sampling Events – Milport Road (M2)

Event #	Sampling Date	Sampling Time	Antecedent 24-h rainfall	Sample Type
1	7/19/2005	11:14:00	0.00	monthly routine
2	8/10/2005	9:14:00	0.00	monthly routine
3	9/20/2005	10:32:00	0.00	monthly routine
4	10/19/2005	10:45:00	0.14	monthly routine
5	11/15/2005	10:25:00	0.00	monthly routine
6	12/20/2005	10:22:00	0.19	monthly routine
7	1/3/2006	17:00:00	0.27	storm target
8	1/11/2006	10:56:00	1.03	monthly routine
9	1/30/2006	11:19:00	0.97	storm target
10	2/1/2006	12:52:00	0.33	storm target
11	4/10/2006	14:26:00	0.63	storm target

2.4. Laboratory Analysis Methods

Standard analytical methods and protocols were used to analyze all samples (Table 3). Pesticide analyses were performed by the Texas A&M GERG laboratory, while TSS and turbidity analyses were performed by the City of Portland Water Pollution Control Lab.

Table 3. Summary of Laboratory Analytical Methods

Parameter	Location	No. of Samples[i]	# QA Samples	Method	Detection Limit	Precision	Accuracy
DDT	Regner Rd. Milport Rd	22	4	EPA 8081M	Matrix dependent; ~ 0.1 ng/L	30%	75-125%
Dieldrin	Regner Rd. Milport Rd	22	4	EPA 8081M	Matrix dependent ~ 0.1 ng/L	30%	75-125%
Solids, Total Suspended	Regner Rd. Milport Rd	22	4	Standard Method SM2540D	1 mg/L	30%	75-125%
Turbidity	Regner Rd. Milport Rd	22	4	Standard Method SM2130B	1 NTU	30%	75-125%

[i] No. of samples includes all regular samples but does not include any QA samples such as field duplicates and equipment rinse blanks.

3. Results and Analyses

3.1. Sampling Event Hydrographs and Turbidigraphs

Figures 1 and 2 are examples of the graphical representation of the collected data. Continuous turbidity and flow data were collected at both monitoring locations and is plotted over a two to four day period to show the response of Johnson Creek with rainfall. It also indicates the sample collection times.

Figure 1. Hydrograph and Turbidigraph 1-29-2006 to 2-1-2006

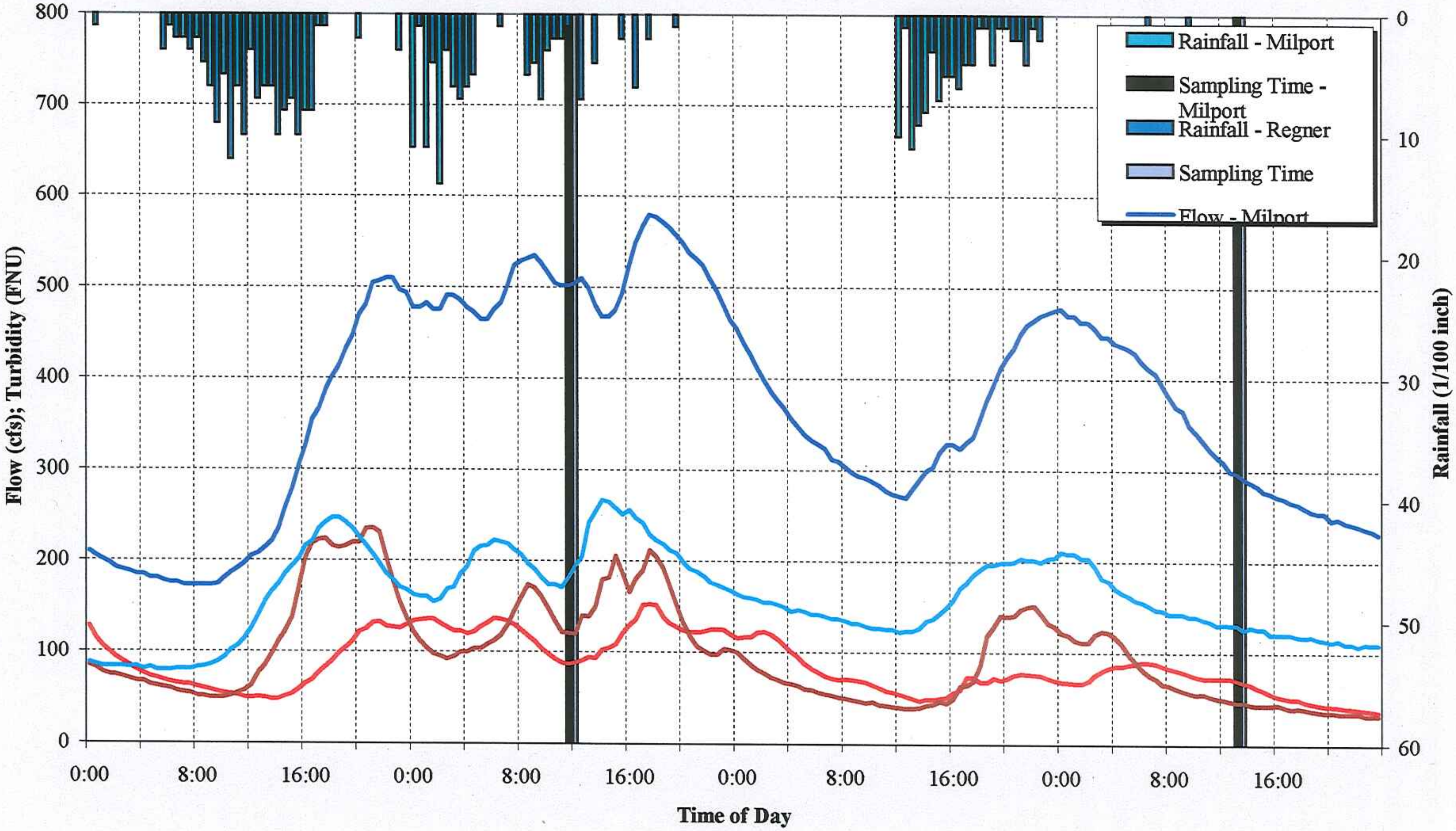
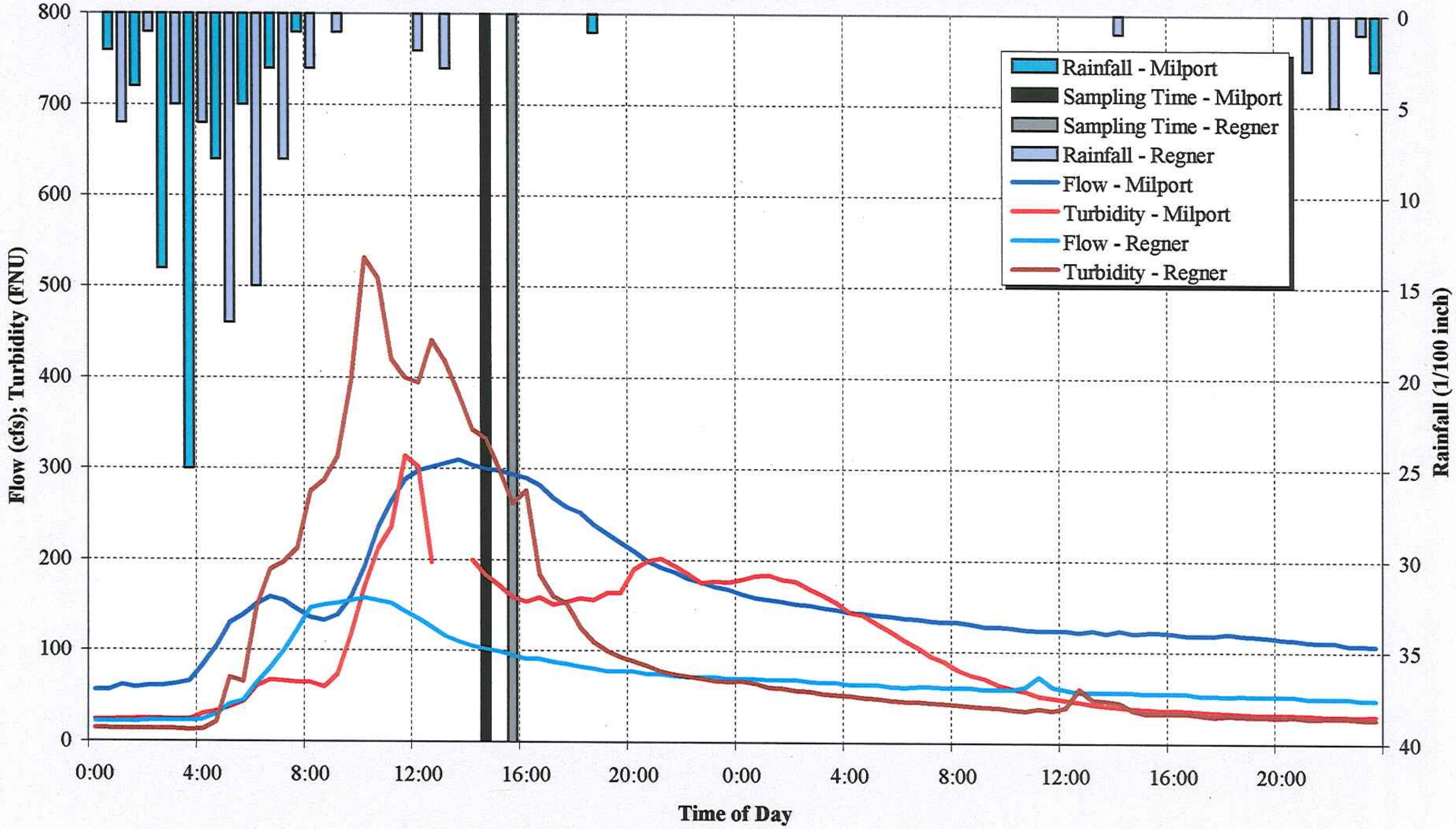
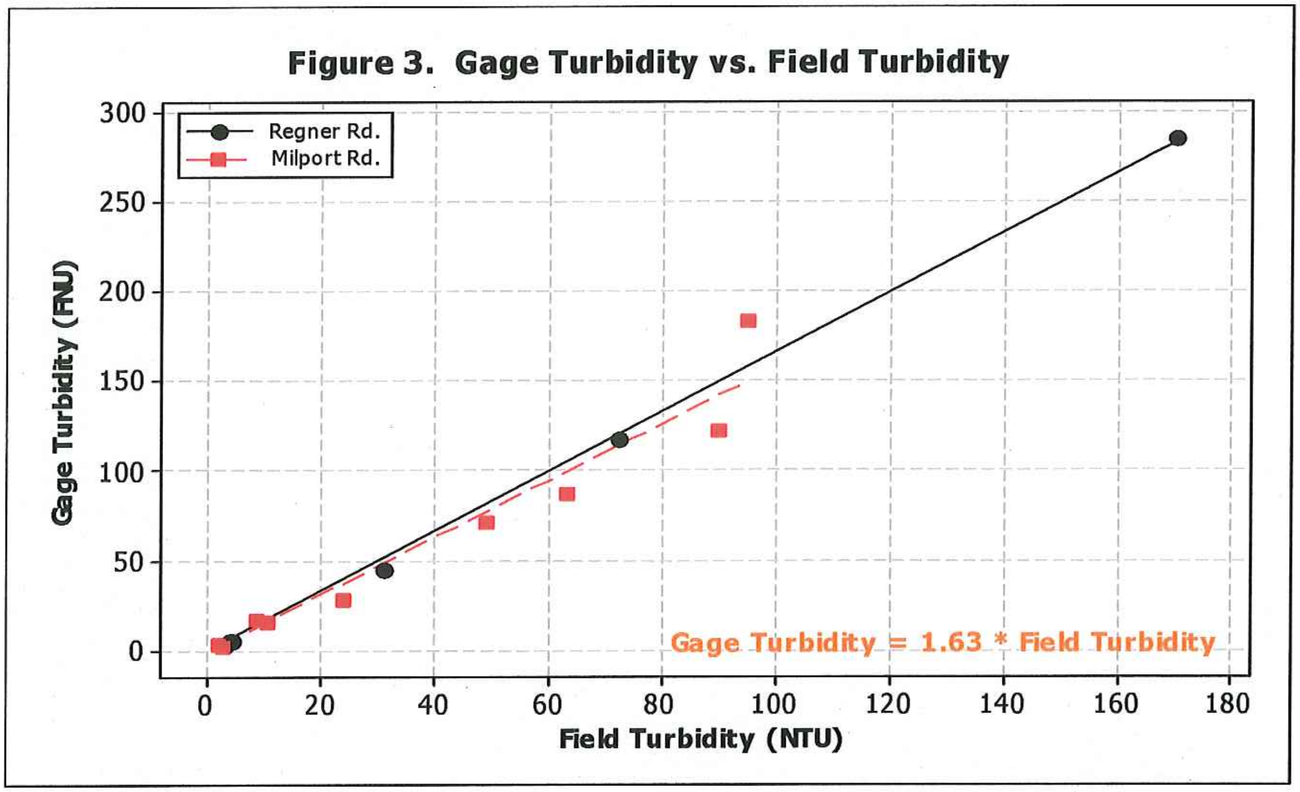
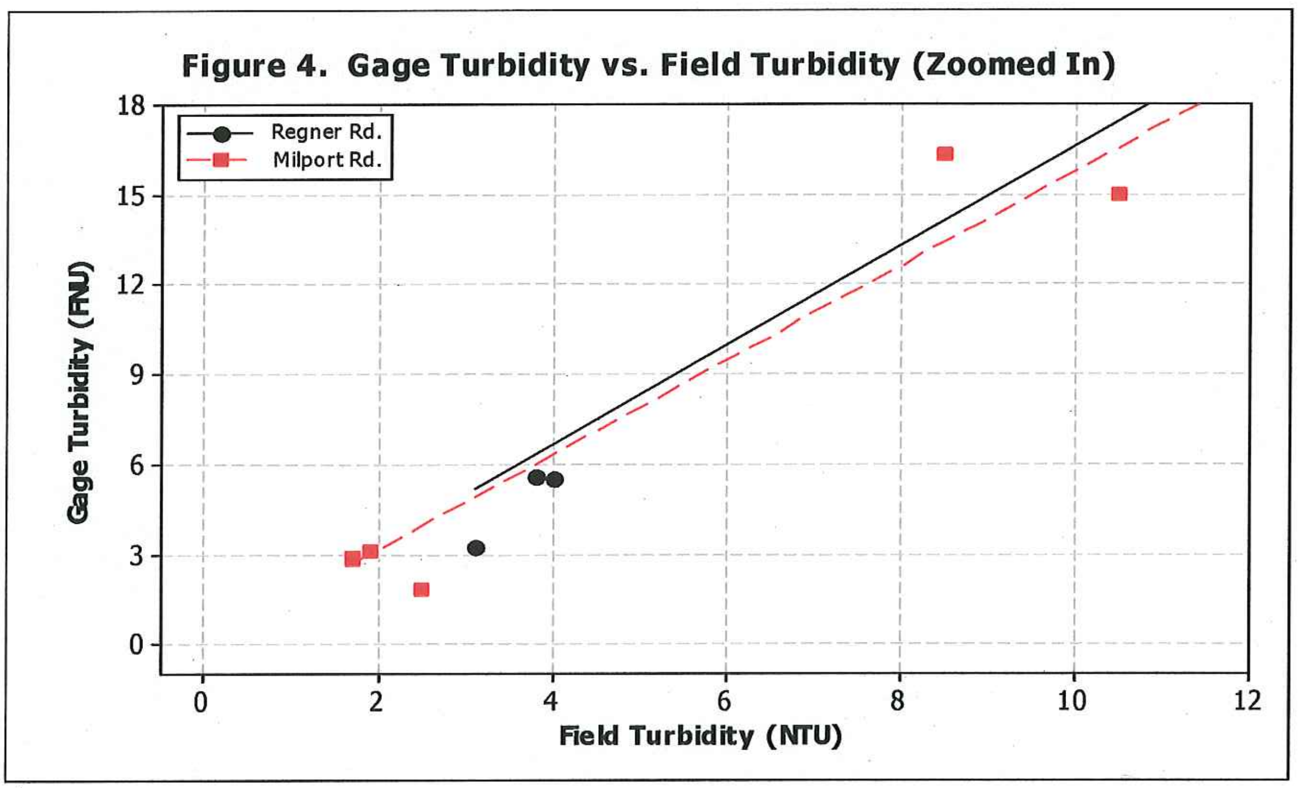


Figure 2. Hydrograph and Turbidigraph 4-10-2006 to 4-11-2006



3.2. Gage vs. Lab Turbidity





The turbidity measurements taken by the field sampling crew (field turbidity) and the turbidity reading collected at the flow-gage installed turbidity meter at the time of sample collection (gage turbidity) are highly correlated for both sampling locations and the slopes are not significantly different at p=0.1 (Figure 3).

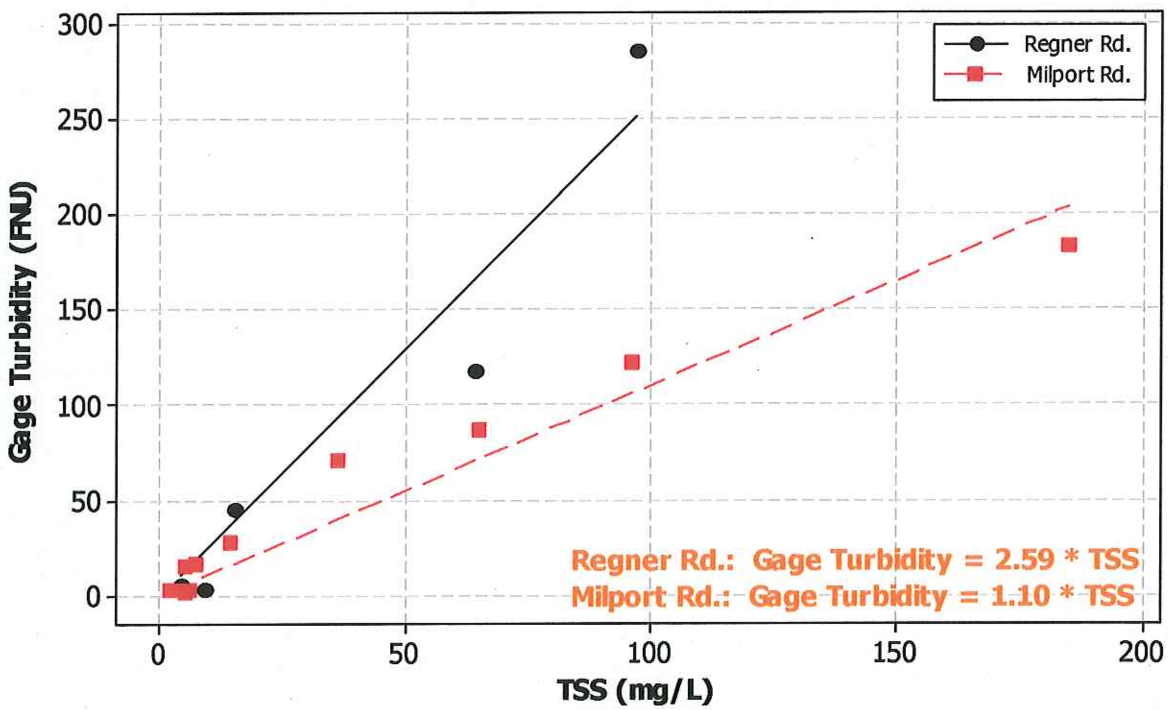
Combining the data set from the two sampling locations results in the following regression equation:

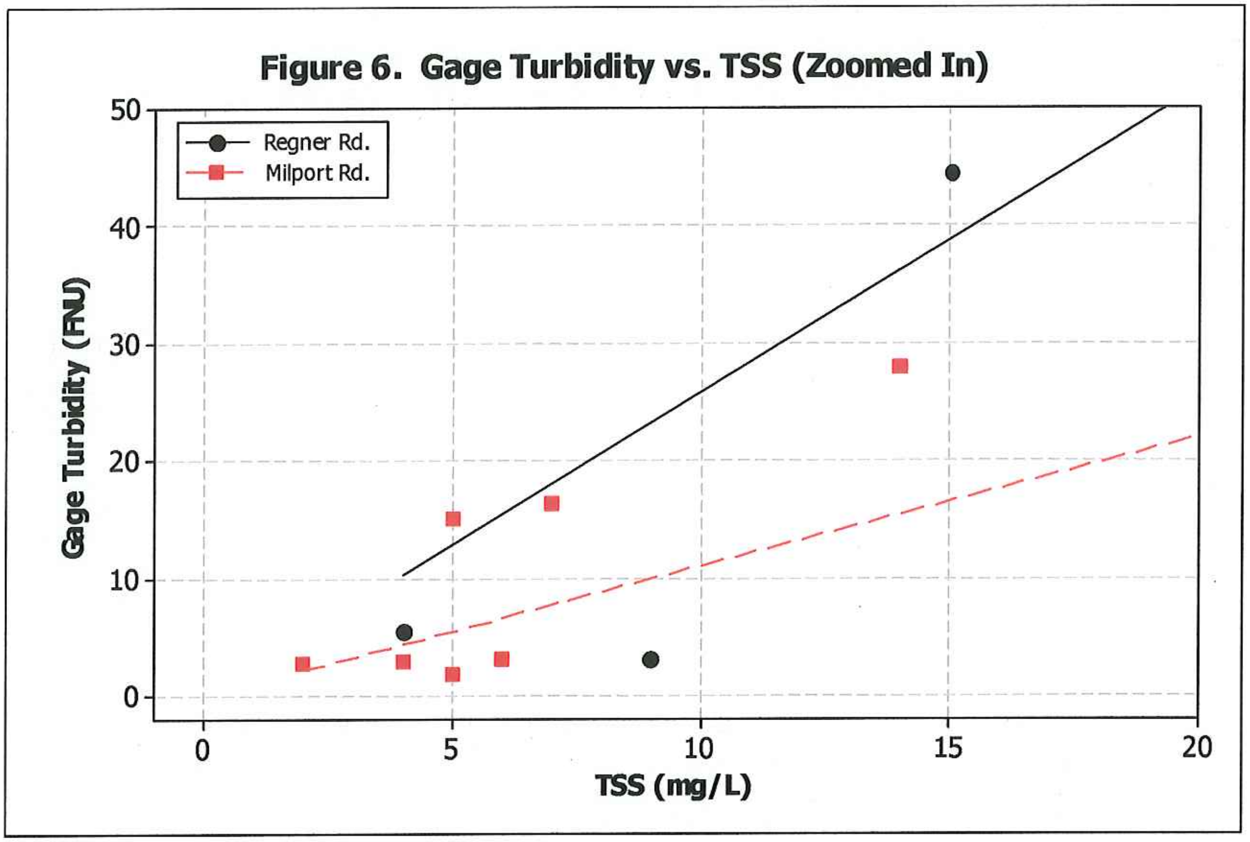
Gage Turbidity = 1.63 x Field Turbidity [Equation 1]

Due to this excellent correlation, field turbidity can be used as a surrogate for gage turbidity after applying the conversion factor. Even at the low end of the turbidity range the correlation is good (Figure 4) and the regression equation can be used for gage turbidity values as low as 3 FTU. This is of importance, because during five of the eleven sampling events at the Regner Rd. site, the turbidity meter was not operational, and, thus, insufficient data is available for a more rigorous statistical analysis.

3.3. TSS vs. Turbidity

Figure 5. Gage Turbidity vs. TSS





The relationship between TSS and Gage Turbidity is, as expected, substantially different between the two monitoring sites (Figure 5). While turbidity measures the light scattering due to suspended solids (TSS) but also colloidal particles and other substances in the water, TSS is only a measure of particles that are larger than a certain size. The relationship between the two measures is reasonably linear at both locations but the slopes of the linear regressions are significantly different at p=0.1.

Regner Rd.:

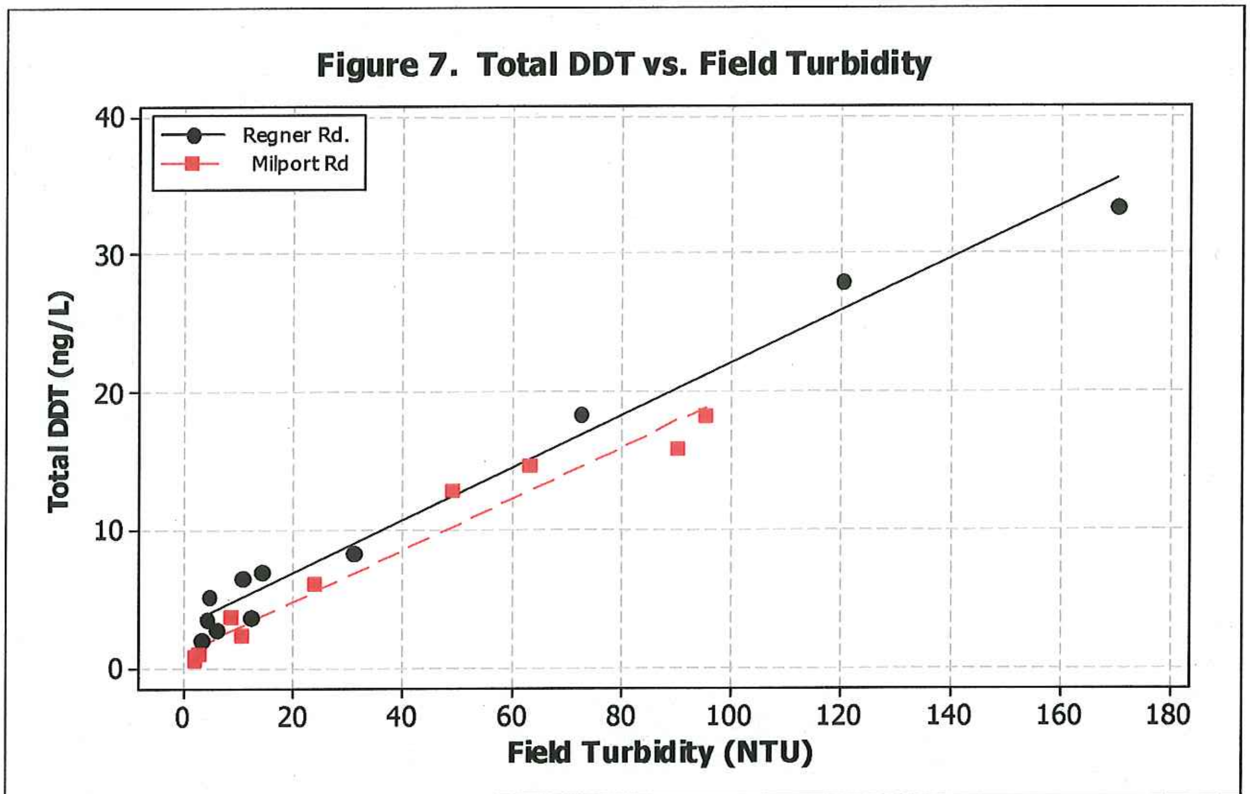
Gage Turbidity = 2.59 x TSS [Equation 2]

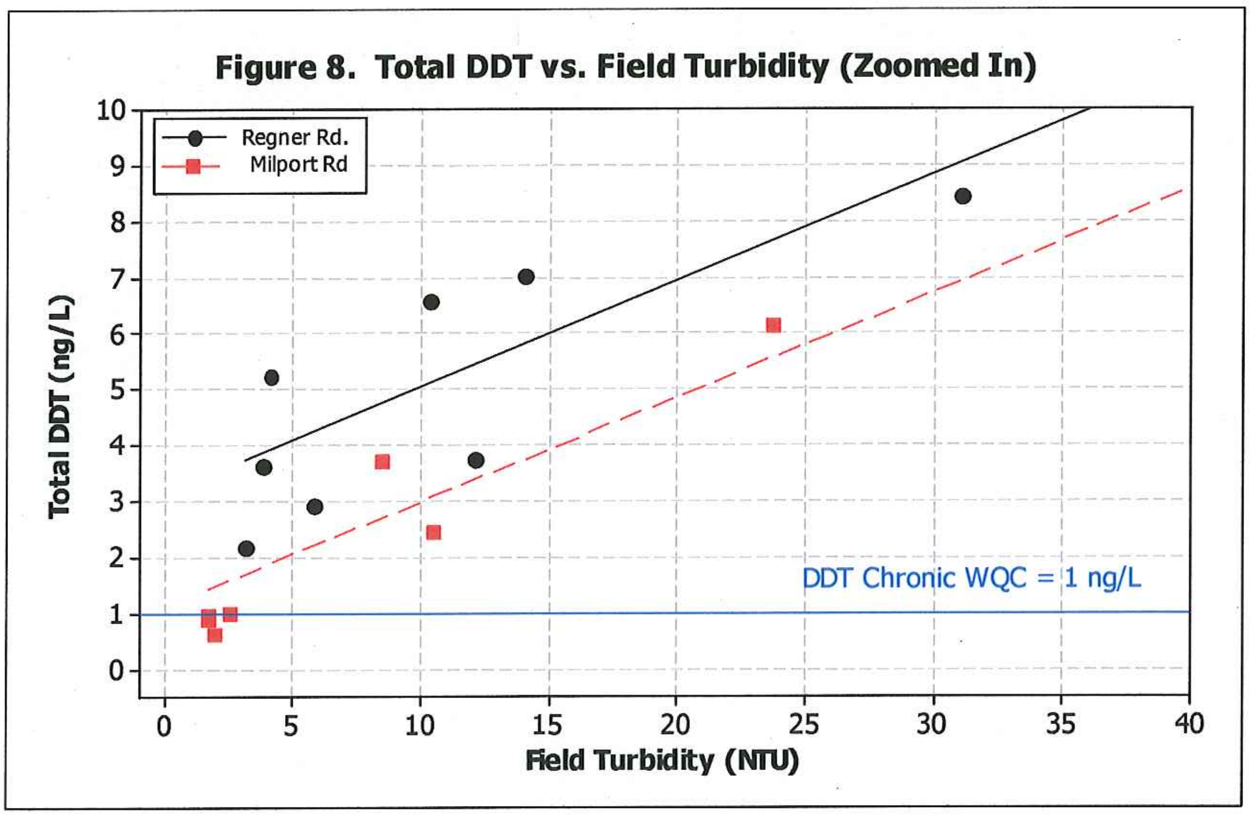
Milport Rd.:

Gage Turbidity = 1.10 x TSS [Equation 3]

At the lower end of the observed values (TSS < 20 mg/L) the correlation between TSS and gage turbidity is poor (Figure 6). Therefore, gage turbidity should not be used as a surrogate for TSS.

3.4. Total DDT vs. Turbidity

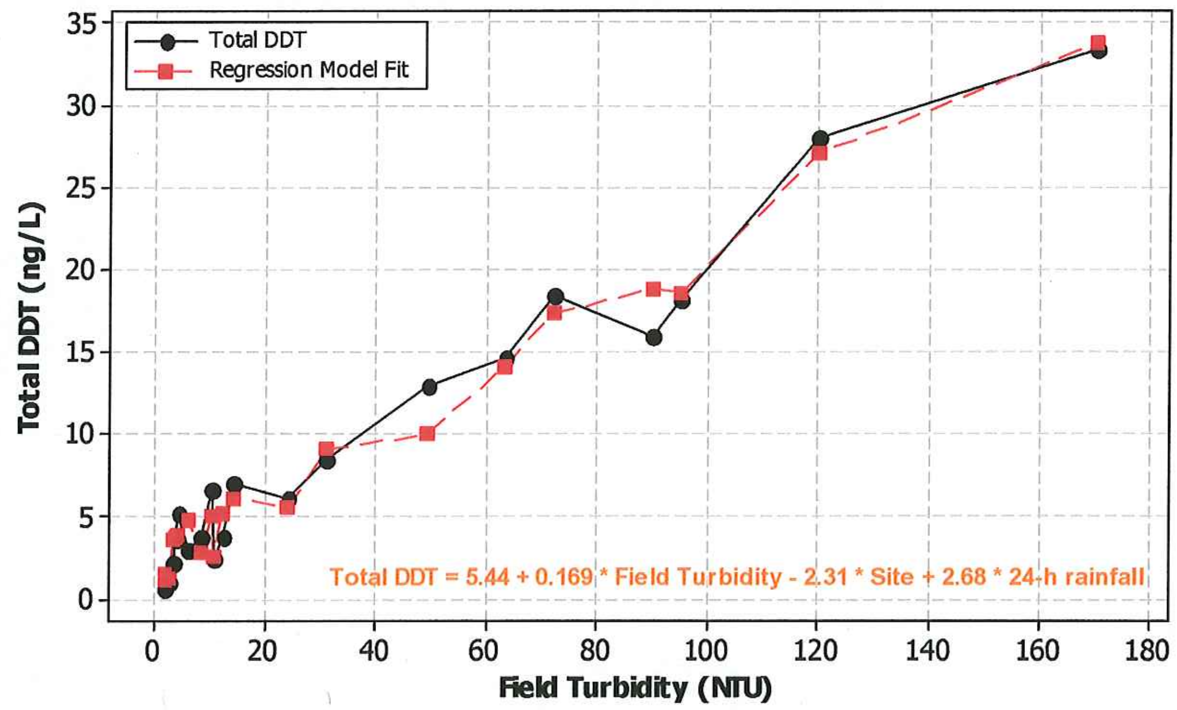


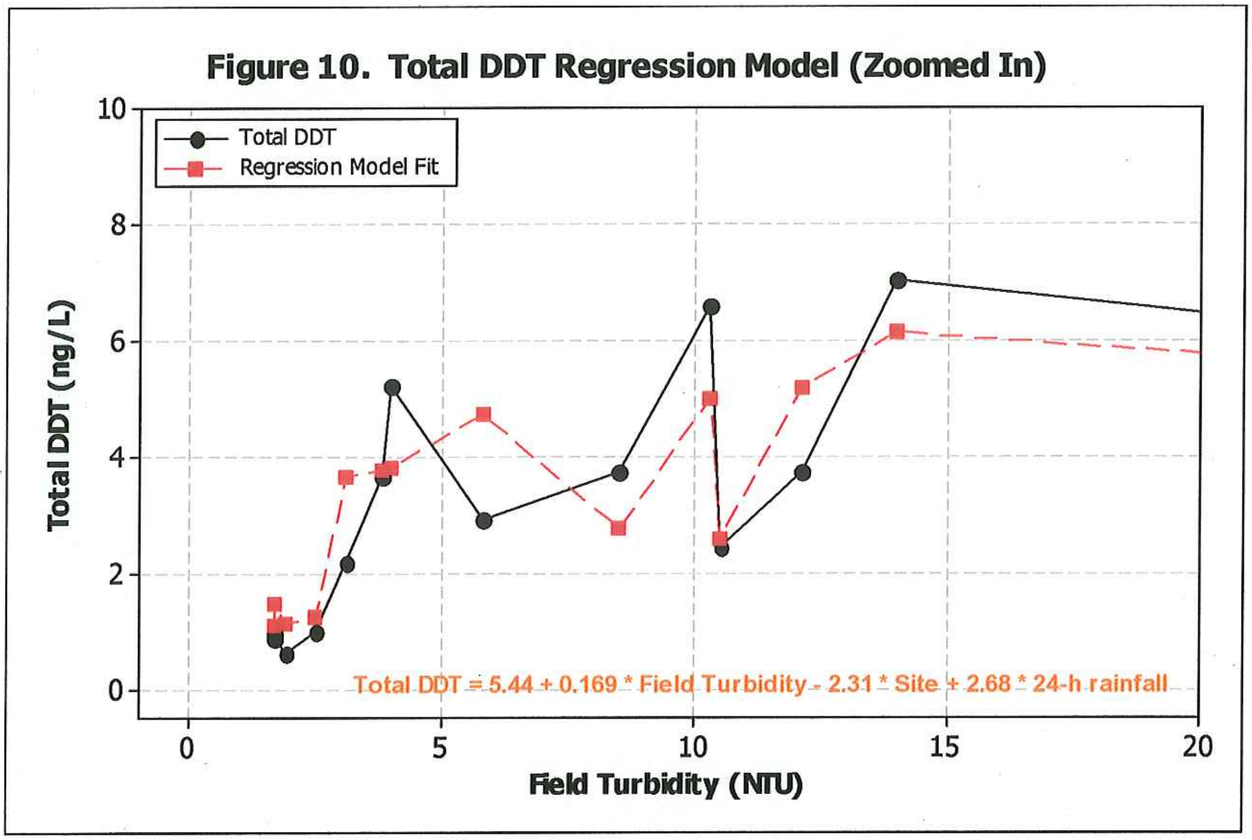


Total DDT and field turbidity are strongly correlated and a regression for both sites results in almost identical slopes at p = 0.1 (Figure 7). While a linear regression appears to approximate the data fairly well, there is some indication, especially at the Milport Rd. site, that the total DDT concentrations may be tapering off with increasing turbidity, i.e. a curvilinear regression may be more appropriate. However, due to the small number of data points fitting a higher order regression may not be appropriate.
The regression between total DDT and field turbidity is still reasonably good at turbidity values below 20 NTU (Figure 8). All samples at the Regner Rd. site and with few exceptions at the Milport Rd. site are clearly above the chronic water quality criterion (WQC) for DDT (1 ng/L). That means that even during summer when no turbidity causing runoff occurs and turbidity values are below 5 NTU, Johnson Creek exceeds the chronic DDT WQC.
It appears that while most likely no management measures are available that would allow meeting the chronic DDT WQC, reducing erosion will be able to reduce the amount of DDT in Johnson Creek.

A regression model was created to approximate total DDT using independently measured variables, such as turbidity and rainfall.

Figure 9. Total DDT Regression Model

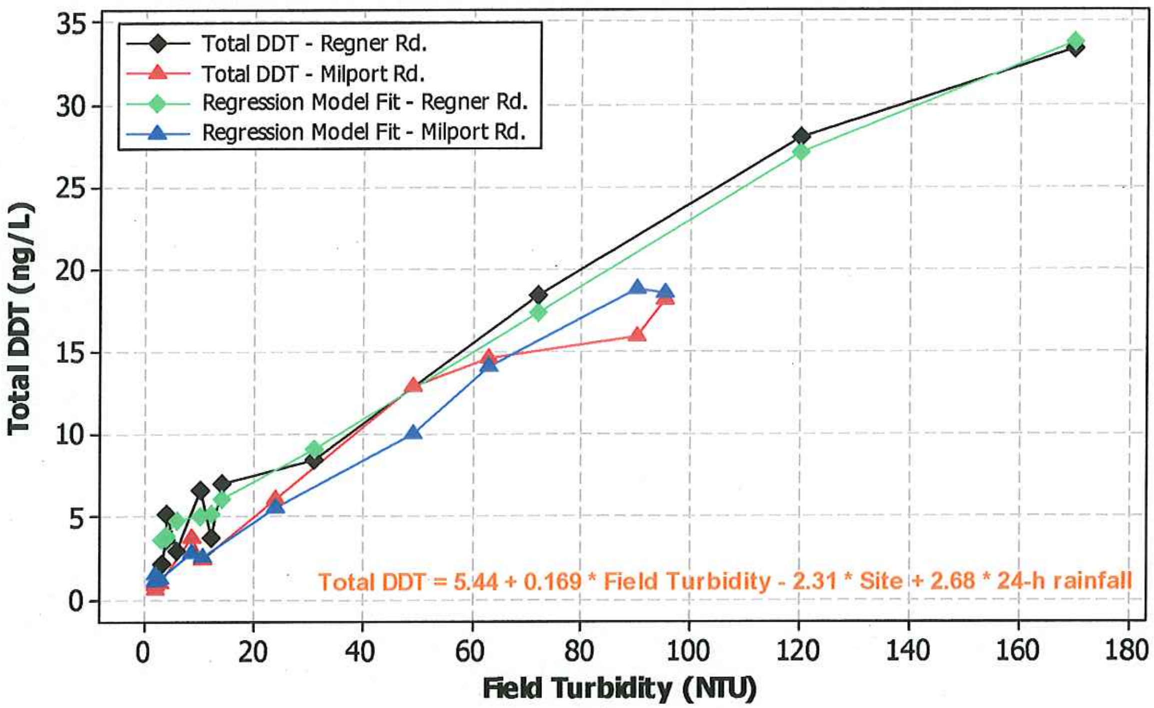




The above regression model shows the fitted data for both monitoring sites combined (Figure 9). The model includes field turbidity (instead of gage turbidity to increase the number of available data points), the 24-hour antecedent rainfall, and a dummy variable (1 = Regner Rd. and 2 = Milport Rd.) for the monitoring locations (a dummy variable allows to include none-numeric variables into a model). This regression model predicts over 97% of the variability of data (adjusted $R^2 = 97.6\%$) and provides and excellent fit of the data even at low DDT and turbidity values (Figure 10).

The modeled total DDT concentrations are plotted for each monitoring site separately in Figure 11. As indicated in Figures 7 and 8, there are differences between the two sites, with the Milport Rd. site having lower total DDT concentration at a given turbidity value.

Figure 11. Total DDT Regression Model (Site Specific)



3.5. Dieldrin vs. Turbidity

Figure 12. Dieldrin vs Field Turbidity

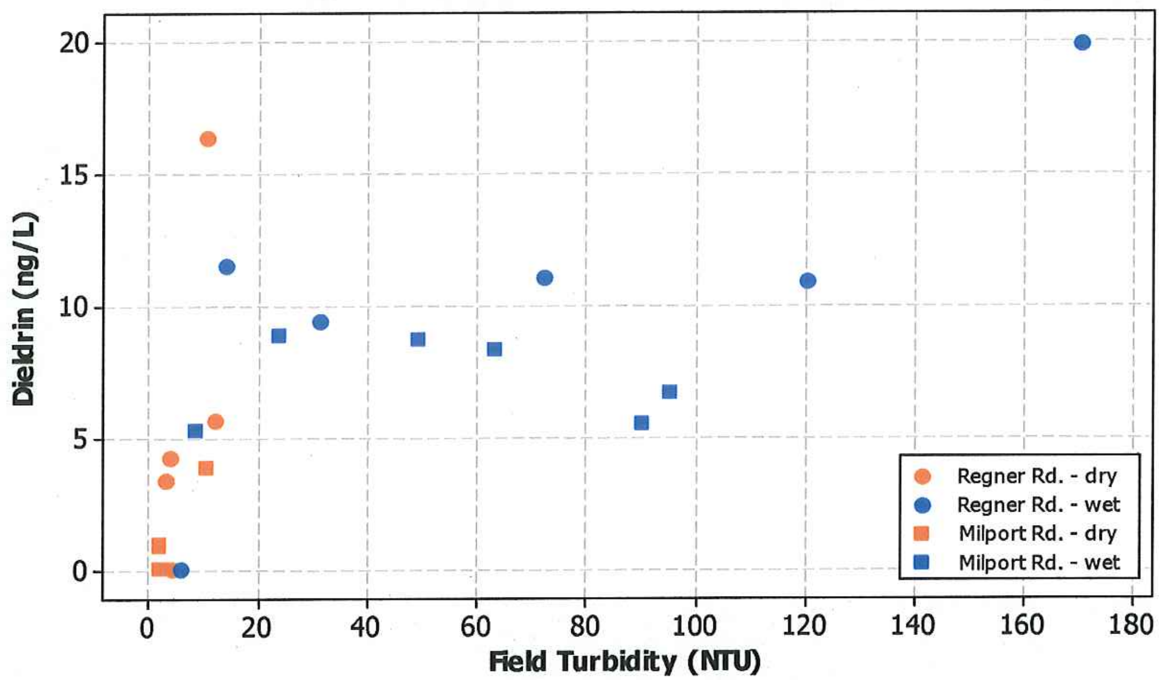
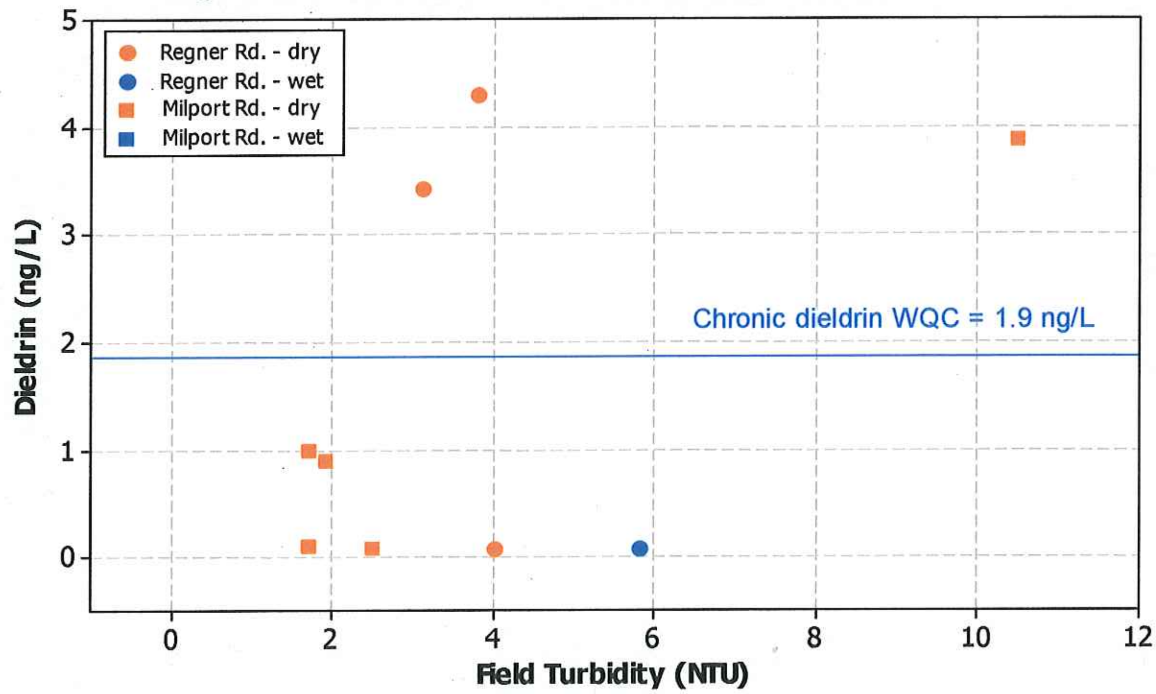


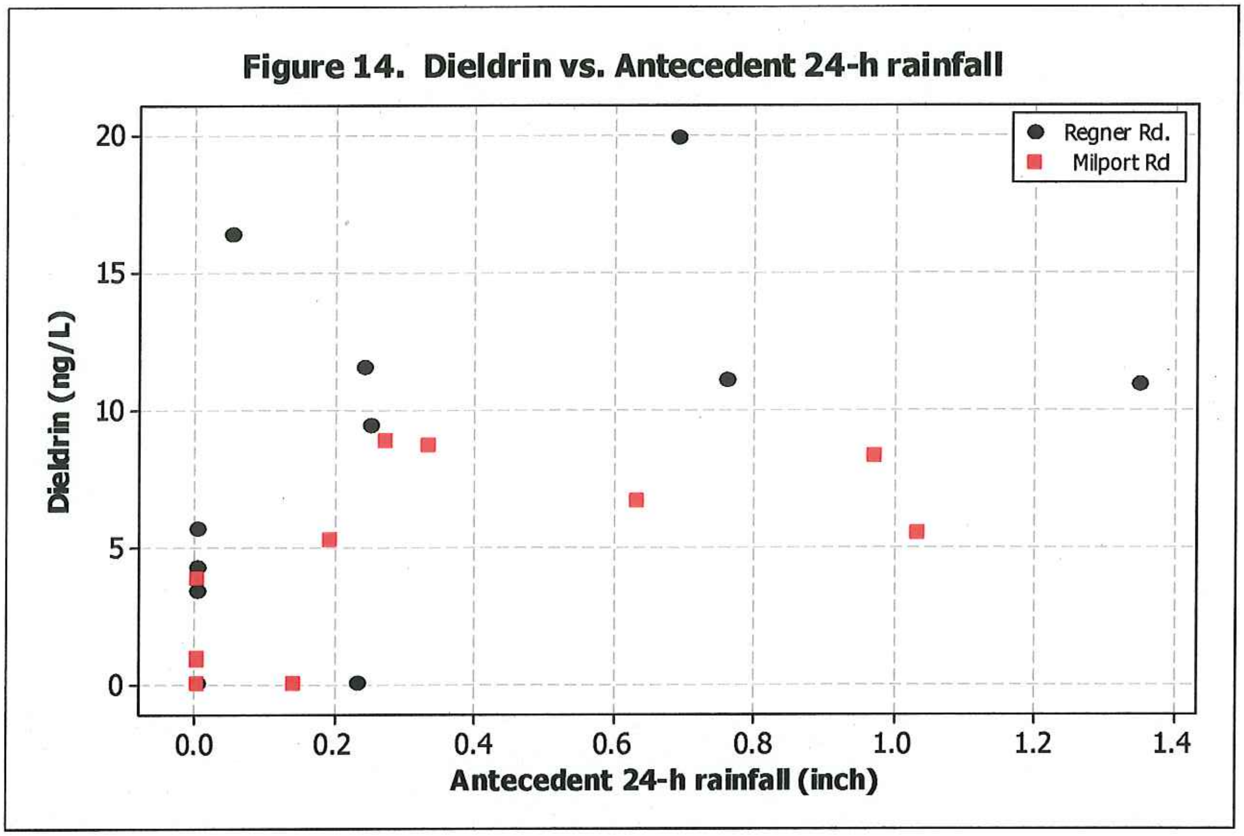
Figure 13. Dieldrin vs. Field Turbidity (Zoomed In)



For low turbidity values, dieldrin seems to increase linearly with turbidity, even though the correlation is poor (Figure 12). However, above a turbidity of about 20 NTU, dieldrin concentrations are essentially constant. Above a turbidity of 20 NTU, the dieldrin concentration ranges from 5 to 10 ng/L at the Milport Rd. site and from 10 to 20 ng/L at the Regner Rd. site. During two sampling events, dieldrin was not detected at either monitoring site at a detection limit of 0.09 ng/L (Figure 13). Two additional samples at Milport Rd. site were below the chronic WQC of 1.9 ng/L.

It is still unclear how dieldrin behaves in Johnson Creek. Based on its hydrophobicity, it is expected to be mostly attached to particles but it clearly shows different characteristics and transport mechanism which are still unknown. However, all indications are that reducing the turbidity in the Johnson Creek to values of less than 10 NTU will reduce the amount of dieldrin. Based on Figure 13, it appears that a turbidity reading of less than 10 NTU may be required to meet the chronic dieldin WQC. However, due to the high data variability a much larger data set is required to provide a more specific ambient turbidity guidance level.

3.6. Dieldrin vs. Antecedent Rainfall



Dieldrin appears completely independent of the amount of rainfall if the rainfall is greater than about 0.2 inches in the 24 hours preceding the sampling event. Dieldrin concentrations are between 5 and 10 ng/L at the Milport Rd gage and between 10 and 20 ng/L at the Regner Rd. gage during these rain events. During dry periods, the dieldrin concentration is around 4 ng/L at the Regner Rd. site and about 1 ng/L at the Milport Rd. site. The current ambient chronic standard is 1.9 ng/L.

4. Discussions and Conclusions

- Under high flow conditions (associated with stormwater runoff), DDT and dieldrin exceed water quality standards more frequently and by a greater margin at the upstream site (Regner Road), than at the downstream site (Milport Road). Flows from the urban areas appear to dilute the level of pesticides in the Creek under these conditions.

- During the dry season, when turbidity is at its lowest (<10 NTU), the presence of DDT and Dieldrin still exceed the WQC. However, all indications documented in this study suggest that reducing the turbidity in Johnson Creek to levels <10 NTU will reduce the amount of DDT and Dieldrin present in Johnson Creek.

- A statistically significant correlation exists between turbidity and TSS levels at both sites. The relationship may be characterized by equations 2 and 3 above.

- A statistically significant correlation exists between both TSS and turbidity, and DDT (see Figures 7 and 8).

- No statistically significant relationship exists between dieldrin and TSS or turbidity. However, splitting the dataset indicates a potentially linear relationship for turbidity values below about 20 NTU but no relationship above about 20 NTU.

- The inconclusive dieldrin results suggest a need for further study.

5. Information and Outreach Sharing

Now that the data analysis is complete, we will share this data with local agencies and stakeholders in order to increase their understanding of the water quality issues in Johnson Creek. Specifically, we will share this data with the Natural Resources Division of the Oregon Department of Agriculture and the Lower Willamette Agricultural Water Quality Local Advisory Committee. The Johnson Creek Watershed Council (JCWC), East Multnomah Soil and Water Conservation District (EMSWCD), and the Clackamas County Soil and Water Conservation District (CCSWCD) will incorporate this data into their outreach materials including newsletters and web pages. The EMSWCD and CCSWCD will include the data in presentations at workshops that target commercial and 'hobby' farmers. The data will be used to demonstrate that non-point source pollution is a significant problem in the Johnson Creek watershed. Presentations will include a description of the Agricultural Water Quality Rules, the TMDL, the necessary source reductions for toxics from all non-point sources, and best management practices.

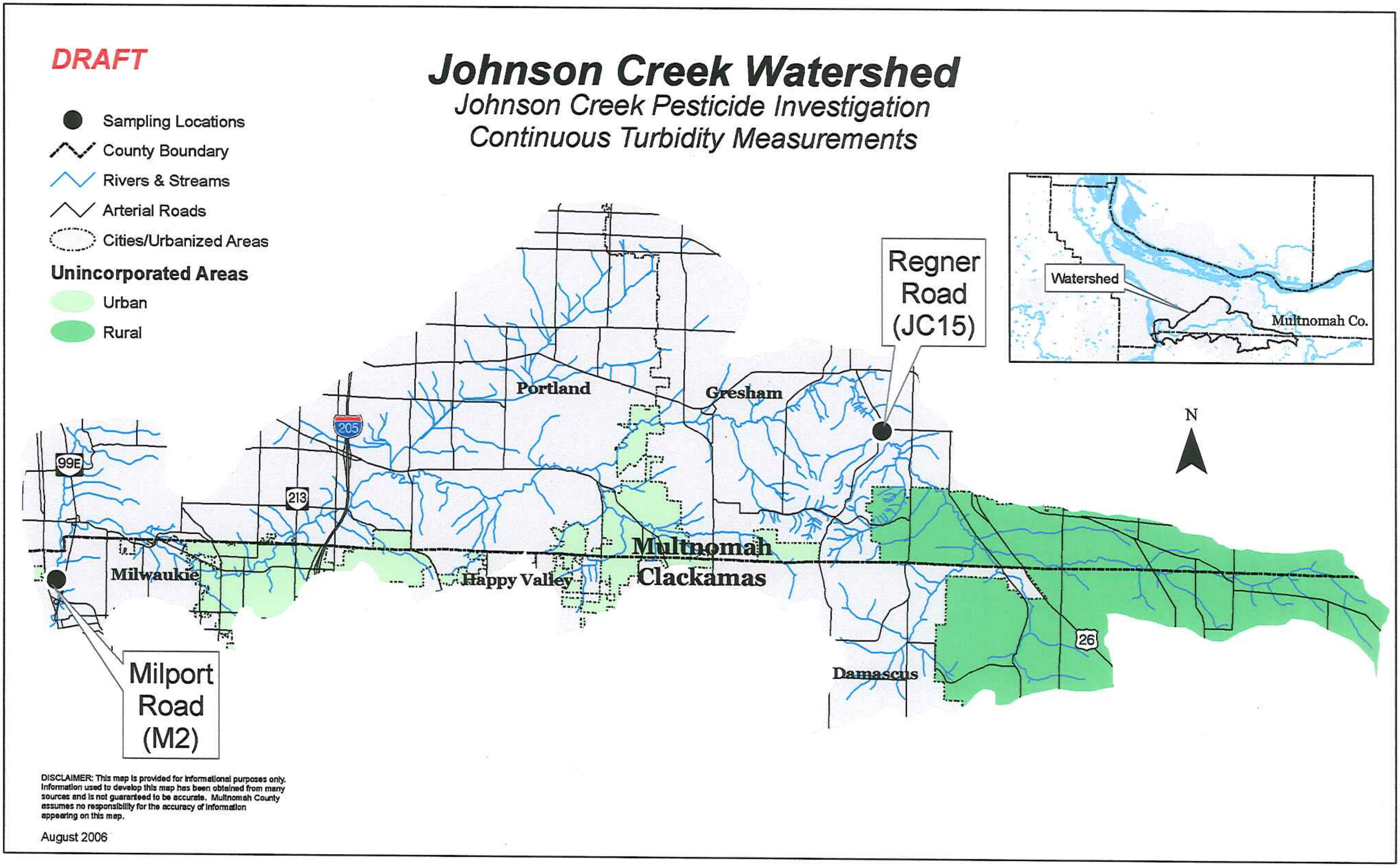
6. Appendices

Regner Road (JC15)

Analyte	Units	7/19/2005	8/10/2005	9/20/2005	10/19/2005	11/15/2005	12/20/2005	1/3/2006	1/11/2006	1/30/2006	2/1/2006	4/10/2006
2,4'-ddd	ng/L	0.57	0.13	0.38	0.27	0.25	0.49	0.45	0.41	0.33	0.2	0.29
2,4'-dde	ng/L	<0.27	0.01	<0.29	<0.3	<0.28	<0.29	<0.29	1.05	<0.29	<0.29	0.71
2,4'-ddt	ng/L	0.08	0.16	0.18	<0.14	<0.13	0.81	0.69	2.1	1.7	0.8	2.77
4,4'-ddd (p,p'-tde)	ng/L	0.18	0.51	0.58	0.77	0.6	0.92	1.39	1.94	1.85	1.14	0.9
4,4'-dde (p,p'-ddx)	ng/L	0.86	0.68	0.78	1.12	1.27	1.96	2.21	9.07	5.98	2.82	9.91
4,4'-ddt	ng/L	1.68	0.68	3.02	0.31	1.21	2.1	1.99	13.4	8.23	3.17	18.8
aldrin	ng/L	1.53	0.16	0.99	<0.11	<0.1	1.35	0.28	0.39	0.11	<0.11	0.13
bhc, alpha	ng/L	0.57	0.53	1.13	0.48	0.18	0.55	0.85	0.47	0.72	0.58	2.61
bhc, beta	ng/L	0.36	0.8	2.15	<0.09	<0.08	0.14	0.14	0.16	<0.09	<0.09	<0.09
bhc, delta	ng/L	<0.06	<0.06	0.45	<0.06	0.08	0.84	0.09	0.34	0.15	0.08	0.3
bhc, gamma (lindane)	ng/L	<0.09	<0.1	1.52	<0.1	<0.09	0.18	0.2	2.14	<0.1	<0.1	0.15
chlordane, alpha	ng/L	<0.1	0.12	0.2	0.15	0.23	0.42	0.23	0.92	0.25	0.15	0.63
chlordane, gamma	ng/L	0.06	0.63	0.35	0.11	0.16	0.09	0.21	0.56	0.29	0.15	0.76
dieldrin	ng/L	4.31	3.44	<0.09	<0.09	5.71	16.4	11.53	10.9	11.1	9.45	19.9
endosulfan I	ng/L	<0.23	<0.25	<0.25	<0.25	<0.23	0.41	0.5	<0.21	<0.25	0.39	<0.25
endosulfan II	ng/L	<0.23	<0.25	<0.25	<0.25	0.3	1.37	0.83	1.79	0.67	0.36	33.5
endrin	ng/L	N	N	N	N	N	N	N	N	N	N	N
endrin aldehyde	ng/L	<0.11	<0.12	<0.12	<0.12	<0.11	<0.12	<0.12	<0.1	<0.12	<0.12	<0.12
endrin ketone	ng/L	<0.11	<0.12	<0.12	<0.12	0.18	0.38	0.51	0.55	0.19	0.16	0.55
heptachlor	ng/L	0.84	0.56	0.5	<0.12	<0.11	0.46	<0.12	<0.1	<0.12	<0.12	<0.12
heptachlor epoxide	ng/L	0.39	0.26	0.55	0.12	<0.1	1.66	0.59	0.72	0.51	0.44	0.61
methoxychlor	ng/L	<0.27	1.8	0.72	<0.3	0.65	2.29	1.64	0.93	<0.29	0.3	1.93
toxaphene	ng/L	<9.3	<10	<10	<10.2	<9.4	<10	<10	<8.33	<10	<10	<10.1
turbidity	NTU	3.8	3.1	4	5.8	12.1	10.3	14	120	72	31	170
conductivity - specific	µmhos/cm	134	124	136	115	99	95	84	65		77	63
solids - total suspended	mg/L	4	9	4	2	5	4	13	126	64	15	97
temperature	° C	19.9	17.4	12.6	14	8.2	2.6	7.5	8		9.5	12.3
pH	S.U.	7.6	7.6	7.5	7.2	7	7	6.9	6.5		6.5	6.2
dissolved oxygen	mg/L	8	6.6	10	9.3	11.4	14.4	11.7	11.8		11.6	9.1
24-h antecedent rainfall	inch	0.00	0.00	0.00	0.23	0.00	0.05	0.24	1.35	0.76	0.25	0.69
Flow - daily average	ft^3/s	1.7	1.3	1.2	4.5	40	41	126	328	203	141	85
Flow - Sampling Time	ft^3/s	1.5	1.3	1.0	4.3	40	21	116	446	173	129	97
Turbidity - Sampling Time	FNU	5.6	3.2	5.5						117	44.5	285
Rain		1	1	1	2	1	1	2	2	2	2	2
Total DDT	ng/L	3.64	2.17	5.23	2.91	3.74	6.57	7.02	27.97	18.38	8.42	33.38
		1	2	3	4	5	6	7	8	9	10	11

Milport Road (M2)

Analyte	Units	7/19/2005	8/10/2005	9/20/2005	10/19/2005	11/15/2005	12/20/2005	1/3/2006	1/11/2006	1/30/2006	2/1/2006	4/10/2006
2,4'-ddd	ng/L	0.16	0.01	<0.11	<0.12	<0.12	0.53	0.48	0.17	0.19	0.22	0.28
2,4'-dde	ng/L	<0.27	0.03	0.29	<0.3	<0.29	<0.29	<0.29	0.5	<0.29	<0.29	0.81
2,4'-ddt	ng/L	0.07	0.01	<0.13	<0.14	<0.13	<0.13	0.35	0.88	1.08	1.17	1.89
4,4'-ddd (p,p'-tde)	ng/L	0.14	0.17	0.16	0.12	0.36	0.2	0.83	1.58	1.72	1.29	0.71
4,4'-dde (p,p'-ddx)	ng/L	0.18	0.2	0.13	0.15	0.84	1.24	1.9	3.71	4.91	4.38	6.83
4,4'-ddt	ng/L	0.04	0.18	0.17	<0.11	0.7	1.33	2.28	9.02	6.45	5.57	7.67
aldrin	ng/L	<0.1	0.04	0.81	<0.11	<0.11	3.07	0.77	0.21	0.17	0.27	0.12
bhc, alpha	ng/L	0.92	0.39	0.68	0.44	0.2	0.63	0.54	0.34	0.64	0.49	2.47
bhc, beta	ng/L	0.82	<0.09	0.92	<0.09	<0.09	0.23	0.16	0.21	<0.09	<0.09	<0.09
bhc, delta	ng/L	<0.06	0.32	<0.06	<0.06	0.1	0.67	1.58	0.52	0.23	0.12	0.59
bhc, gamma (lindane)	ng/L	<0.09	<0.1	0.89	<0.1	<0.1	1.36	<0.1	2.53	<0.1	<0.1	<0.1
chlordane, alpha	ng/L	0.33	0.09	0.11	<0.12	0.16	0.57	0.16	0.76	0.2	0.18	0.52
chlordane, gamma	ng/L	<0.08	0.2	<0.08	0.09	0.14	<0.09	0.14	0.35	0.2	0.19	0.61
dieldrin	ng/L	1	0.9	<0.09	<0.1	3.87	5.33	8.89	5.57	8.32	8.72	6.72
endosulfan I	ng/L	<0.23	<0.24	<0.24	<0.26	<0.25	0.27	1.25	<0.22	<0.25	<0.25	<0.25
endosulfan II	ng/L	0.06	0.03	<0.24	<0.26	<0.25	0.42	0.42	0.72	0.26	0.43	5.16
endrin	ng/L	N	N	N	N	N	N	N	N	N	N	N
endrin aldehyde	ng/L	<0.11	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.11	<0.12	<0.12	<0.12
endrin ketone	ng/L	<0.11	<0.12	<0.12	<0.12	<0.12	0.87	1.13	0.48	0.18	0.17	0.28
heptachlor	ng/L	<0.11	0.18	<0.12	<0.13	<0.12	0.13	<0.12	0.14	<0.12	<0.12	<0.12
heptachlor epoxide	ng/L	0.07	0.48	0.16	<0.11	<0.11	1.78	0.76	0.4	0.44	0.43	0.41
methoxychlor	ng/L	<0.27	0.83	0.73	<0.3	0.54	0.81	10.1	0.95	<0.29	0.37	1.03
toxaphene	ng/L	<9.4	<9.9	<9.6	<10.4	<10	<10	<10	<9.1	<10	<10	<10
turbidity	NTU	1.7	1.9	2.5	1.7	10.5	8.5	23.7	90	63	49	95
conductivity - specific	µmhos/cm	196	201	201	168	128	131	99	80		92	57
solids - total suspended	mg/L	4	6	5	2	5	7	14	96	65	36	185
temperature	° C	19.5	17.7	14.5	14.2	8.2	2.6	7.5	8.4		8.9	12.2
pH	S.U.	7.7	7.4	7.3	7.4	7.1	7.1	7.2	7.1		6.7	6.4
dissolved oxygen	mg/L	8.9	8.9	10.2	9.2	11.5	14.2	12.2	10.6		11.9	9.8
24-h antecedent rainfall	inch	0.00	0.00	0.00	0.14	0.00	0.19	0.27	1.03	0.97	0.33	0.63
Flow - daily average	ft^3/s	13	11	10	21	67	72	227	907	507	335	189
Flow - Sampling Time	ft^3/s	13	11	11	19	66	50	225	712	502	298	300
Turbidity - Daily Median	FNU	3.4	3.7	4.2	3.9	15.6	24.9	32.9	127	124	68.5	154
Turbidity - Sampling Time	FNU	2.9	3.1	1.8	2.8	15	16.3	28	122	87	70.7	183
Rain		1	1	1	1	1	2	2	2	2	2	2
Total DDT	ng/L	0.86	0.60	0.99	0.94	2.44	3.72	6.13	15.86	14.64	12.92	18.19


DRAFT
Johnson Creek Watershed
Johnson Creek Pesticide Investigation
Continuous Turbidity Measurements
Sampling Locations
County Boundary
Rivers & Streams
Arterial Roads
Cities/Urbanized Areas
Unincorporated Areas
Urban
Rural
Regner Road (JC15)
Milport Road (M2)
Watershed
Multnomah Co.
N
Portland
Gresham
Milwaukie
Happy Valley
Multnomah
Clackamas
Damascus
99E
213
205
26
DISCLAIMER: This map is provided for informational purposes only. Information used to develop this map has been obtained from many sources and is not guaranteed to be accurate. Multnomah County assumes no responsibility for the accuracy of information appearing on this map.
August 2006