Nitrate and Coliform Study in the Des Moines and Raccoon Rivers and Tributaries: 2006-2008

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For

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TABLE OF CONTENTS

PAGE

Project Overview 1
- Study area watershed characteristics 1
- Raccoon River 2
- Des Moines River 3

Water Quality at the DMWW Intakes 3
- Des Moines River 4
- Raccoon River 6

Watershed Investigations 10
Beaver Creek 10
- Walnut Creek 11

Main stem tributaries 13
- Brushy Creek 15

Laboratory Studies 21
- Brushy Creek Sediment Re-suspension experiments 21
- *E. coli* counts in various sources common to the landscape 22
- Dispersion rate experiments 23

Project in review 29

Summary 34

Prologue to the Appendices (methods, definitions, units) 37
Appendix A: Water Quality at the Des Moines River Intake 38
Appendix B: Raccoon River Water Quality 49
Appendix C: Sample Site locations 60
Appendix D: Beaver Creek Watershed 63
Appendix E: Walnut Creek Water Quality 67
Appendix F: Raccoon River Main-stem Tributaries 71
Appendix G: Upper South Raccoon Watershed 77

PROJECT OVERVIEW

I. Objectives of the study

The primary purpose of this project as stated in the contract is to locate as precisely as possible sources of Nitrate, Nitrite, and *Escherichia coli* contamination and associated parameters within the Contractor's delineated watershed protection area, within the 72 hour time of transport. This includes the Des Moines River and tributaries downstream of the Saylorville Reservoir, the North Raccoon south of Jefferson, the Middle Raccoon downstream of Lake Panorama, and the South Raccoon, the area bordered in red (Fig 1).

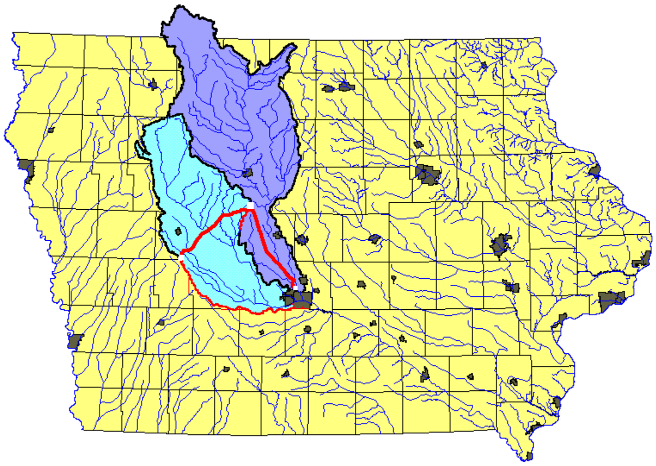


Fig. 1 Des Moines and Raccoon River Watersheds and study area

Study area watershed characteristics

Most of the landscape lies within the Des Moines lobe landform, a very young glaciated landscape formed by one of the last lobes of the Wisconsin ice age approximately 14000 years before present (fig 2). The current course of the Middle Raccoon roughly traces the furthest edge of glacial advance. The glaciated landscape has little natural drainage and is referred to as the prairie pothole region. Extensive marshes and wetlands interspersed within the prairie made

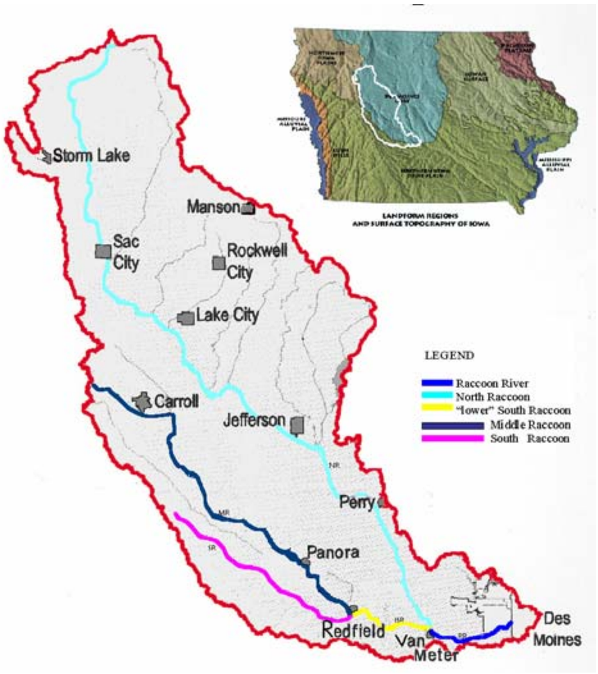


Fig. 2 Iowa landforms and Raccoon River watershed

this region essentially unsuited for agriculture until drainage ditches were developed and tile systems installed. Today, the terrain and prairie soils are ideal for highly productive agriculture with approximately 83% of the land in row crop agriculture. This region has some of the highest nitrate-N concentration in the nation and is a major contributor to nitrate loading in the Gulf of Mexico and the hypoxia zone.

The un-glaciated region south of the Middle Raccoon River, referred to as the Southern Iowa Drift Plain (SIDP), is a highly dissected landscape with a basin relief and slope that is nearly five times that of the Des Moines lobe. Land use varies considerably with as little as 37% row crop agriculture in the upper South Raccoon watershed. Livestock operations are primarily open feedlots and pasture compared to swine confinement operations in the Des Moines lobe. This area is particularly subject to surface runoff.

The Raccoon River watershed is primarily a rural landscape with the exception of Walnut Creek (78.4 sq. mi) which has approximately 50% of its watershed in the highly urbanized greater Des Moines area. The Des Moines River has several larger cities in its watershed upstream of Saylorville. Below the reservoir, several storm sewers from the City of Des Moines and northern suburbs discharge into Beaver Creek and the Des Moines River upstream of the Des Moines River intake. Sewage collection systems potentially discharge into Beaver Creek and the Des Moines River should they malfunction, especially during major rain events when the systems become surcharged with excess water.

A. Raccoon River

The Raccoon River is divided into two 8 digit hydrologic unit codes (HUCs): the South Raccoon (07100007) in yellow above Van Meter, and the North Raccoon (07100006) in blue (Fig. 3). The South Raccoon HUC has two

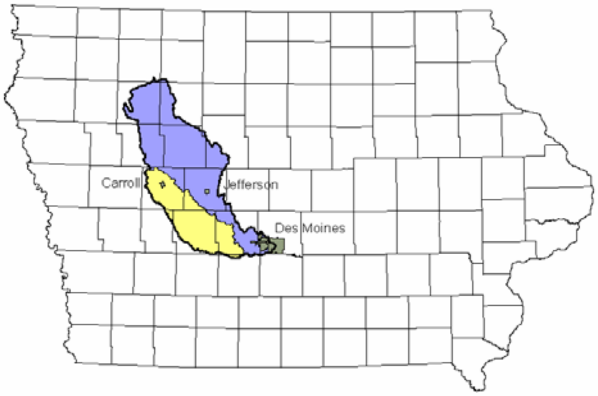


Fig. 3 North and South Raccoon HUC delineation

major tributaries, the South Raccoon and the Middle Raccoon. These two tributaries join near Redfield approximately 25 river miles upstream of Van Meter. The watershed of the South Raccoon tributary lies entirely within the SIDP landform while the most of the Middle Raccoon watershed lies within the Des Moines lobe landform. The entire North Raccoon watershed upstream of Van Meter is in the Des Moines Lobe. Most of the North Raccoon HUC downstream of Van Meter is in Des Moines lobe landform as well.

B. Des Moines River

The Des Moines River rises from Lake Shetek near the southwestern Minnesota city of Pipestone and flows 525 miles to its confluence with the Mississippi River in southeastern Iowa. The portion upstream from its confluence with the Raccoon River drains 26 Iowa counties and over 5800 square miles of land within the Des Moines lobe landform. There are 47 significant tributaries to the Des Moines, but only Beaver Creek with a 64.5 square mile watershed lies within the study area between Saylorville Lake and the Des Moines Water Works intake.

The 90000 ac-ft normal storage capacity of the Saylorville Reservoir attenuates flow and water quality in the Des Moines River downstream, especially bacterial counts. Upstream of the reservoir, the river behaves similarly to the North Raccoon. The proximity of Beaver Creek to the intake however creates a dynamic in flow and water quality disproportionate to its watershed size.

II. Water quality at the Des Moines and Raccoon River Intakes

Both rivers are sources of drinking water for the Des Moines Water Works and therefore must meet water quality standards appropriate for that use as mandated by the Clean Water Act. Extensive sampling of these source waters has been gathered by the utility and others which show impairment for nitrate and *E. coli* bacteria. This and other data sources have been used for Total Maximum Daily Load (TMDL) modeling in the Raccoon River. Nitrate-N loading based on the model prediction is reasonably close to the observed concentration while *E. coli* counts shows considerable variance to the model. Part of the problem with the bacteria model is that there is limited data at stream gauging stations to provide load calculations in the upstream tributaries (Schilling and Wolter 2007).

Extensive monitoring of water quality at the Raccoon and Des Moines River intake locations together with flow contributions from tributaries provides a frame of reference for determining which tributaries and sub-watersheds contribute a disproportionate share of contaminants relative to watershed area. Water quality must be examined in the context of weather, flow, and time of travel from the various tributaries.

A. Des Moines River

Bacteria, nutrient, and turbidity data for this study period is tabulated in Appendix A. Load data is not presented as much of the flow data is preliminary. Calculations can be made as flow data becomes finalized. Winter flows are most subject to revision. Graphs involving flow data, however, are used to illustrate water quality dynamics within a stream and time of travel dynamics on water quality in the receiving stream as observed in Beaver Creek and the Des Moines River.

D. Lutz (2008) with the Des Moines River Quality Network reports high *E. coli* counts in the Des Moines River upstream of Saylorville Lake but low counts within the pool and river immediately downstream. However, further downstream, DMWW intake data shows counts exceeding the single sample water quality standard (WQS) of 235 counts/100 ml at a 20% frequency rate. Counts are quite variable and correlate remarkably well to flow from Beaver Creek (r^2=0.59) even though its watershed is only 6% that of the Des Moines River. In contrast, there was a slightly negative correlation (-0.005) between counts and Des Moines River flow. High counts typically occur when a rain event discharge from Beaver Creek enters the Des Moines River before there is an increase in discharge from Saylorville Lake. The highest counts (54750/100ml) during the study period occurred on 4/26/07 when Beaver Creek provided approximately 65% of the flow in the Des Moines River.

There is a cyclical pattern to these counts, however, with lower counts in the winter and elevated counts for the remainder of the year when the probability of recreational contact is greater (Fig. 4).

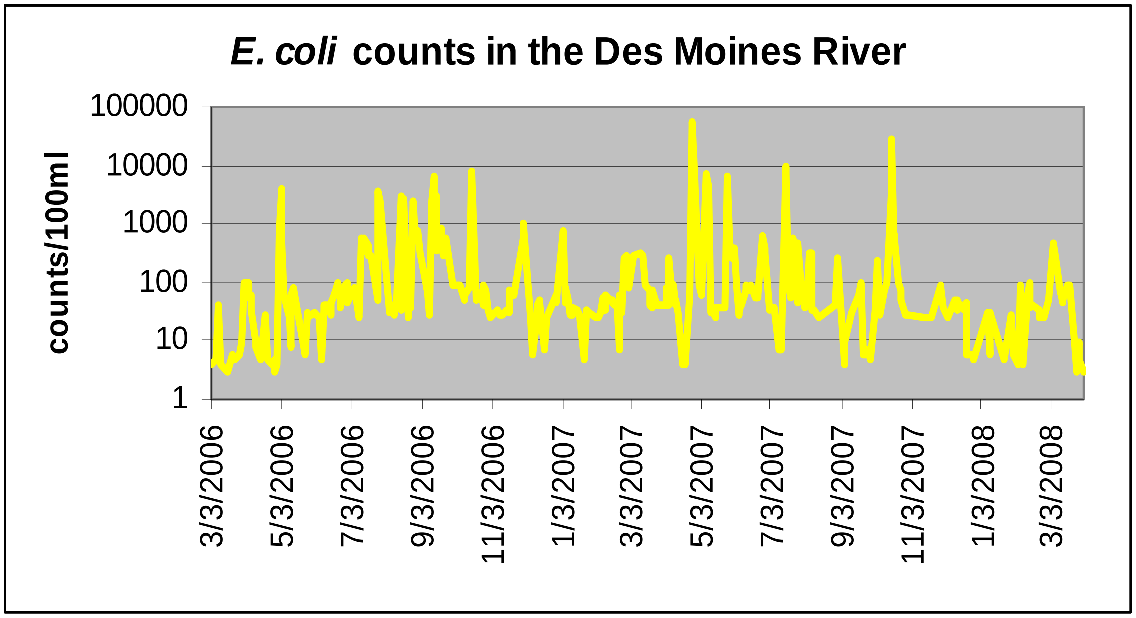


Fig. 4 seasonal distribution of *E. coli* counts in the Des Moines River

It should not be assumed however that this means less fecal matter is entering the rivers and streams during the winter months. The laboratory procedure provides counts of viable *E. coli* bacteria, not mass or quantity of fecal material. *E. coli* organisms that have died during storage will not grow or be included in the counts. This leads to low counts relative to the quantity of organic matter and nitrogen in the stored manure. Typically, manure is stored during the growing season and land applied after the crops have been harvested in the fall or spring before planting. Weather conditions last fall contributed to more surface application of manure onto frozen ground and perpetual snow cover trapped much of the ammonia that otherwise would have volatilized into the atmosphere. During the March 2008 snow melt runoff, strong manure odors in the rivers, record high concentrations of ammonia, organic matter, and heterotrophic plate count bacteria all indicated a high volume and concentration of fecal waste even though *E. Coli* counts remained below the WQS for most of this period (Brand, status report #8 and Appendix A). This raised serious utility concerns regarding the ability to provide adequate disinfection to protect water from pathogens while limiting the formation of disinfection by-products and taste and odor issues.

B. Raccoon River

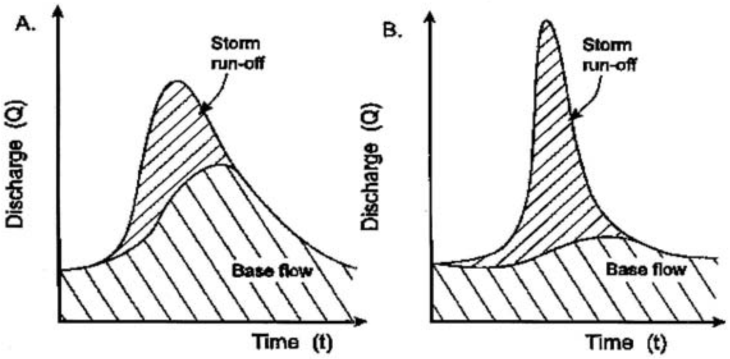


Fig. 5 Differences in infiltration rate on hydrographs

Water quality in the Raccoon River is much more complex and dynamic than in the Des Moines River. The watershed includes an urban stream component (Walnut Creek) where there is little infiltration (Fig 5B), and two distinct landforms with differing land use practices. Brushy Creek, a large tributary in the hilly SIDP landform produces a similar hydrograph to Fig 5B where the hydrograph is compressed into 16 hours and most of the flow is surface runoff (Fig 6). Water quality changes include very high *E. coli* counts from surface runoff or re-suspension from sediments on the ascending limb especially, (Fig 6a) and a big dip in nitrate concentration due to surface runoff dilution (Fig 6b).

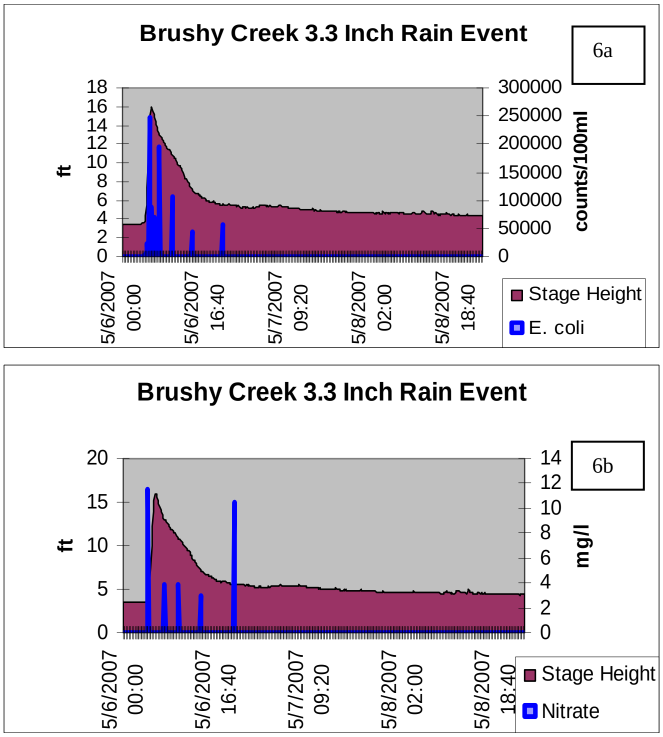


Fig. 6 SIDP hydrograph and water quality changes

The hydrograph of Cedar Creek during a similar rain event in the Des Moines Lobe landform is distributed over several days (Fig. 7) and is similar in shape to Fig 5A. *E. coli* counts are much lower than in Brushy for the same amount of rainfall (Fig 7a) and the dip in nitrate concentration is much less as well (Fig 7b). This is consistent with less surface runoff and greater retention and infiltration due to a flatter landscape.

Differences in hydrographs between streams in these landforms and time of travel during a rain event creates a dynamic in the relative contributions of tributaries to flow and water quality across the composite hydrograph in the Raccoon River.

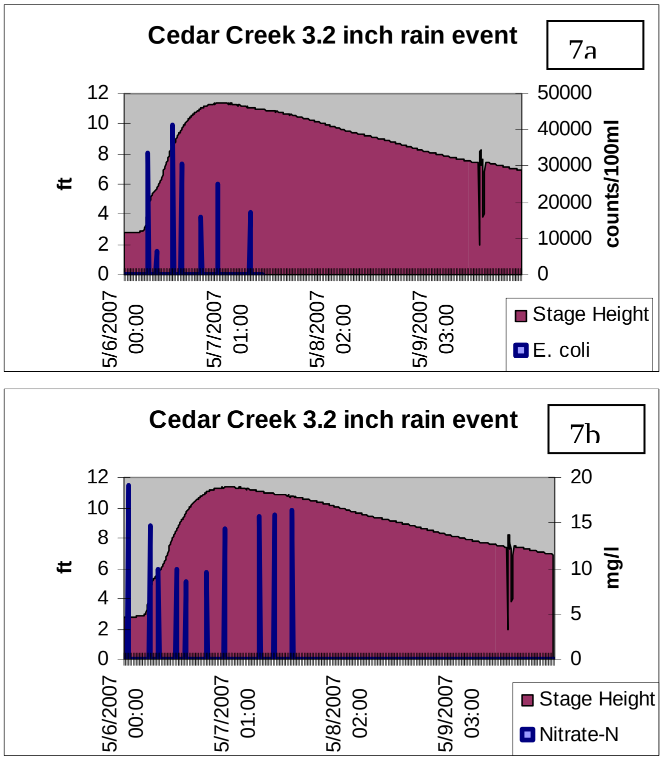


Fig. 7 DM Lobe hydrograph and water quality change

Time of travel differences can often be resolved by examining flow and water quality changes at the Fleur Drive intake and gauging station. This provides some indication as to source of contamination and load from the respective sources. For example, a rain event on June 2008 showed a spike in Raccoon flow due to discharge from Walnut Creek almost immediately following a rain (Fig. 8a). The flow receded before South Raccoon water discharge at Van Meter arrived (Fig. 8a). The next rise is flow can be traced to the South Raccoon which produced a spike in flow in the Raccoon River at Van

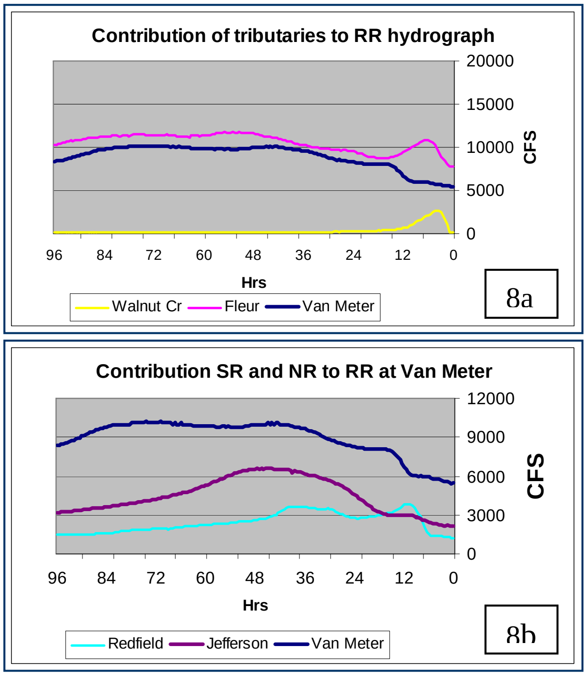


Fig. 8 Time of travel during storm event

Meter (Fig. 8b). There was a 5 hour travel time between Redfield and Van Meter (8b) and an addition 12 hour travel time to the Fleur Drive gauging station. Travel time between Jefferson and Van Meter (8b) is 30 hours and 42 hours to Fleur Drive during this storm event. The peaks become more flattening downstream so that the descending limb of the South Raccoon overlaps the ascending limb of the North Raccoon hydrograph to partially obscure the change in source contribution. The rapid change in nitrate concentration in the on-line nitrate analyzer at Van Meter is similar to the nitrate changes in SIDP hydrographs and is of the same duration as the South Raccoon hydrograph at Redfield (Fig. 9). The Redfield gauging station shows a high volume of flow from the South Raccoon arriving at Van Meter before flow arrives from the North Raccoon. The hydrograph in Fig. 9 compares a composite hydrograph of the South Raccoon at Redfield and the Jefferson hydrograph delayed by 24 hours to the actual hydrograph at Van Meter. The composite hydrograph is very similar to the actual hydrograph at Van Meter. The change in water quality related primarily to tributary landform source and time of travel propagates downstream to the DMWW intake creating a larger change in nitrate concentration in the Raccoon River than what occurs in any given tributary. Therefore time of sample collection will bias water quality toward the tributary providing most of the flow at time of collection. Careful attention to tributary flows and nitrate concentration through time frequently shows the primary contributor to flow and *E. coli*

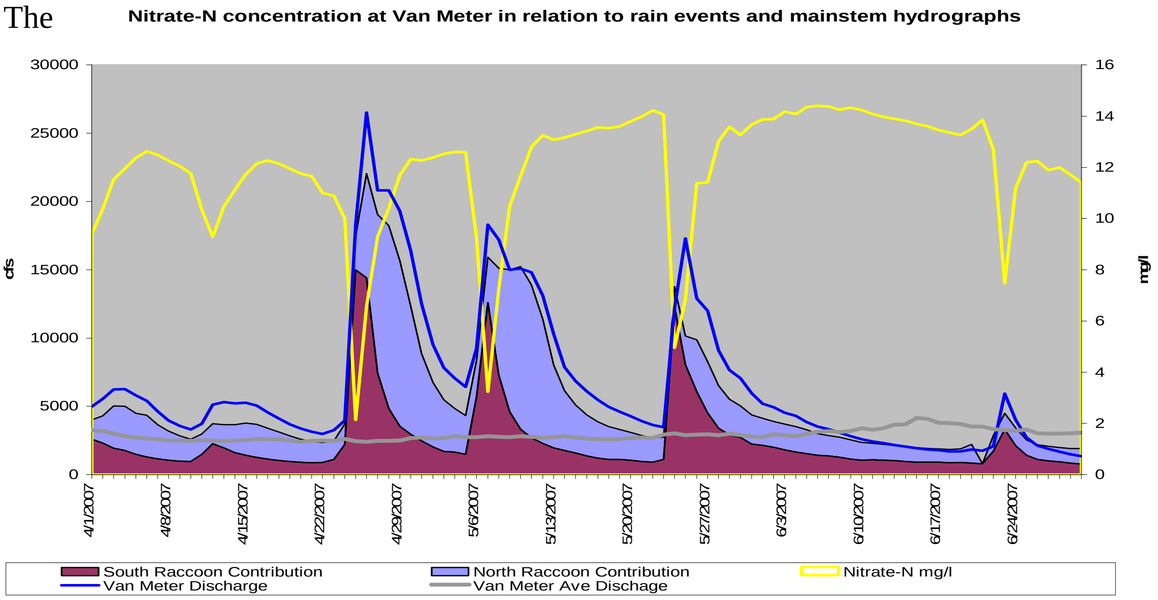


Fig. 9 Change in nitrate concentration across the Van Meter hydrograph

counts at the time of collection as noted in previous status reports. However, historical USGS stream flow data through a 24 hour period is not yet available in Iowa so approximate contribution of each tributary to flow and therefore influence on water quality in the Raccoon River at the time of collection is not included in this report. Without having source contribution to flow at the time of collection, there appears to be little relationship between flow, turbidity, and *E. coli* counts. This further challenges to ability to calibrate TMDL models for *E. coli* to observed data in the Raccoon River. Samples collected at the intake (Appendix B) are collected at 7:15 AM.

E. coli counts in the Raccoon River are highly variable with monthly median counts well above the WQS when rainfall exceeded the climatic mean. As with the Des Moines River, winter counts seldom exceeded the WQS (Fig. 10).

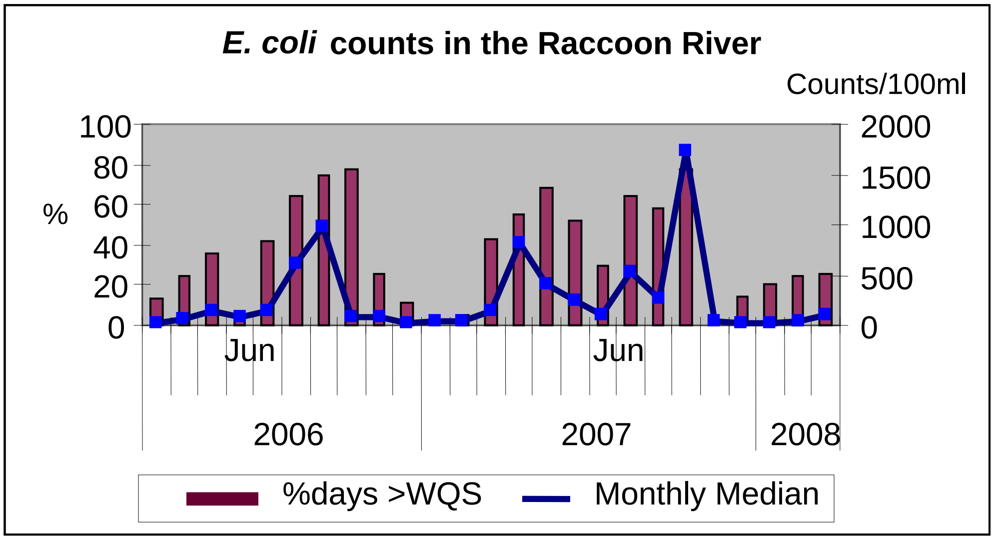


Fig. 10 Distribution of E. coli counts in the Raccoon River

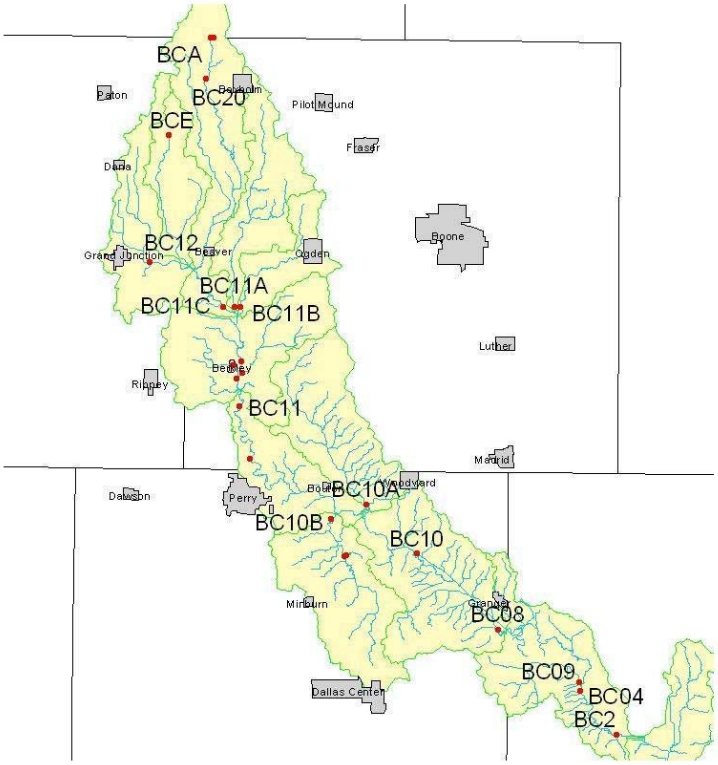
The low *E. coli* counts observed during the melt water runoff events in 2008 would suggest relatively high quality water. However, as in the Des Moines River, high manure threshold odor numbers (TON), HPC bacteria counts, TOC, ammonia, and phosphorus all implicate vast quantities of manure runoff during snow melt runoff. The low *E. coli* counts suggest old manure where these bacteria were no longer viable. Very high chlorine demand and concern regarding the ability to produce safe drinking water from this source resulted in a switch to the Des Moines River. High chlorine demand in the Des Moines River in March greatly compounded the magnitude of this problem.

III. Watershed Investigations:

Sample site locations by GPS coordinates are listed in Appendix C. Maps with these sites are provided for visual reference.

A. Beaver Creek

Water quality in the Beaver Creek Watershed typified nutrient rich Des Moines Lobe drainage systems (Appendix D). Site BC10B recorded the highest nitrate-N concentration at 21.2 mg/l. Soluble phosphorus as P was usually below 0.05 mg/l except during runoff when elevated turbidity and *E. coli* counts are observed. Highest counts generally occurred in the upper region of the watershed following a rain event but counts are highly variable.

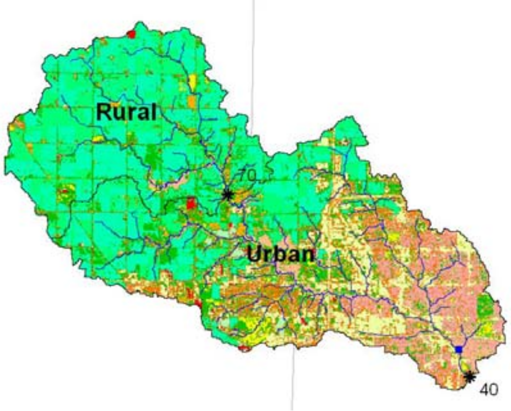


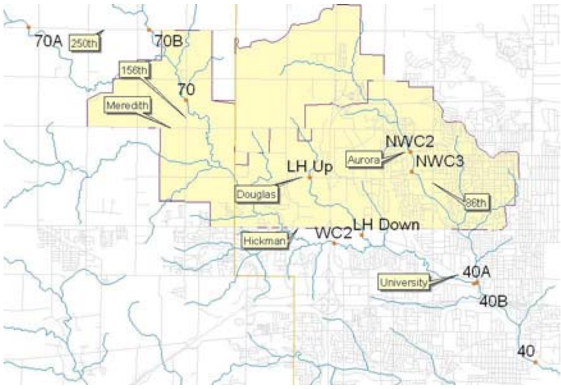
During low flow, sites BC11B and BC09 had slightly elevated chloride (64-71 mg/l) and phosphorus (0.2-0.6) indicating a point source contribution. However, downstream sites were no higher than upstream sites so these sources did not contribute materially to load. The highest chloride concentration (71 mg/l) in the more than 140 samples in the Beaver Creek Watershed occurred at site BC09.

The supposition from flow relationships that high *E. coli* counts in the Des Moines River come from Beaver Creek was supported by the watershed sampling. With one exception (prior to March 2008), flow which produced a turbidity >50 NTU also had elevated counts (>1000 counts/100 ml). High counts followed most rain events where the percentage contribution of Beaver Creek flow to Des Moines River flow was greater than 20%.

High concentrations of ammonium-N and o-phosphorus as P (>2.0 and 1.3 respectively) on March 6, 2008 caused a high chlorine demand at the water utility. Beaver Creek provided approximately 70% of the ammonia load on that date. High total coliform counts accompanied the high ammonia and phosphorus concentrations throughout this watershed, indicating a manure origin. The relatively low *E. coli* counts suggested surface application of stored manure where most of the *E. coli* has died.

B. Walnut Creek





The Walnut Creek Watershed is nearly equally divided into Urban and Rural components with site 70 receiving water from the rural watershed and site 40 near the outlet receiving water from both landscapes. Summary data from more than 40 sets of paired sampling at these two sites (Table 1) performed during widely differing flow and weather conditions shows the rural watershed as the primary contributor of nitrate at the outlet while *E. coli* data gave mixed results. Median and third quartile counts from the rural area are higher than the urban contribution but the highest counts occurred at the urban site 40 on November 13, 2006 when only ¼ inch of rain fell in Des Moines area. This suggests that storm sewers are both a source of *E. coli* as well as an efficient conduit for transporting fecal matter from urban landscapes directly into urban streams. This was supported by a hydrant flushing experiment (internal report) where very high counts were present in the initial flush of water from the storm sewers but which quickly declined with additional flushing.

Table 1. Walnut Creek Rural (site 70) and Urban (site 40) Contributions

Statistic	*E. coli* counts/100 ml		Nitrate-N mg/l	
	Site 40	Site 70	Site 40	Site 70
Minimum	101	100	0.22	0.25
First quartile	242	223	3.48	4.72
Median	462	970	8.61	14.09
Third quartile	952	1733	11.10	15.99
Maximum	10860	4352	14.11	19.56
Average	1413	1309	7.49	11.22

A comprehensive profile of Walnut Creek data collected by this project (Appendix E) show distinct differences between urban and rural streams. Urban streams have a very rapid rise and fall in flow following a rain and therefore rapidly changing water quality. Runoff from urban impervious surfaces occurs with little rain while in the rural watershed a similar rain causes little to no run off. Differences in data between urban sites may be more a function of collection time than differences in contaminant contribution.

Elevated chloride in urban streams was common throughout the year but especially during winter months following road salt application onto icy roads. Elevated chloride during warm weather base flow indicated that some of the salt had infiltrated soil and groundwater. Low fluoride concentrations and non-detectable phosphorus concentration counter-indicated contamination from leaking sewer systems. Data from the rural area was typical of Des Moines lobe sites and land use with high nitrate concentrations in the spring and late fall. The widespread elevated ammonium and phosphorus concentrations associated with manure runoff in early March 2008 also occurred in the rural section of Walnut Creek Watershed but not in the urban North Walnut Creek (site 40A) where soluble concentrations were 0.12 mg/l compared to 1.01 mg/l at the main stem site 40B.

C. Main-stem tributaries

Data from the Raccoon River at Van Meter (site 38), and the main-stem tributaries upstream are provided in Appendix F. The South Raccoon below the confluence with the Middle Raccoon is designated as lower South Raccoon (lSR) to distinguish it from the South Raccoon (SR) branch above the Middle Raccoon. Quartile statistics (yellow) and the median from over 40 sample sets show the South Raccoon as the predominant contributor to counts in the Raccoon River (Fig. 11).

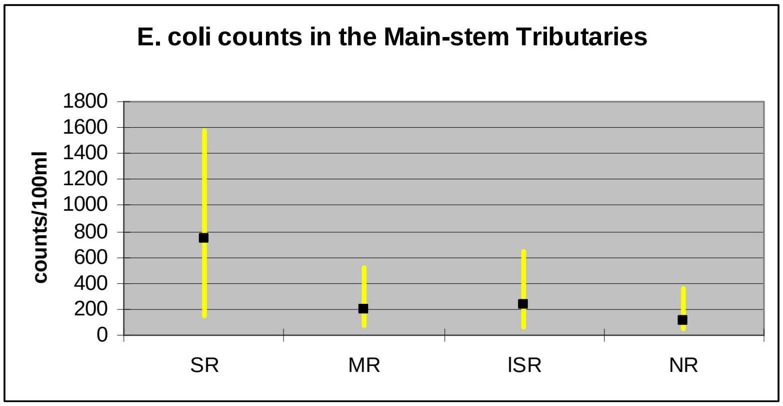


Fig. 11. Distribution of E. coli counts in the Main-stem tributaries

Counts in the Middle Raccoon near its confluence with the South Raccoon are much lower than the South Raccoon even though animal unit densities are similar. Samples collected by the Agriculture's Clean Water Alliance (ACWA) upstream of Lake Panorama, however, show counts similar to that observed in the South Raccoon. High counts may be expected in this portion of the watershed as there is a high concentration of open feedlot operations (Fig. 12) within a hilly mix of dissected landscape and hummocky terminal moraine.

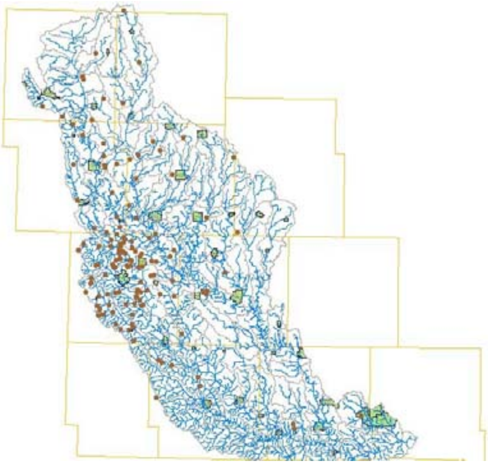


Fig. 12 Open feedlots in the Raccoon Watershed

Both landscape features are conducive to runoff of surface contaminants. Lake Panorama, however, stabilizes much of this contamination so that counts below the dam (site C) seldom exceeded the WQS during a two year sampling period and was therefore dropped as a sampling point. Tributaries downstream drain primarily Des Moines Lobe landscape though some contributions from the SIDP occur. Counts at the outlet increased but were only slightly higher than in the North Raccoon River during this study.

The cause of high counts in the South Raccoon is not simply a matter of livestock density as the estimated production of *E. coli* organisms/square mile watershed is only slightly higher than in the North Raccoon (1.35 E+13 vs. 1.04 E+13). Density differences, however, may contribute to count differences between sub-watersheds within the same landform.

The primary cause for differences between major watersheds must be delivery and transport of viable organisms. The total numbers of *E. coli* organisms generated within the watersheds are much greater than present in the streams. Therefore investigations as to the source(s) of high counts include land use practices and hydrology as they impact transport and mortality factors on both the landscape and within the stream.

The South Raccoon Watershed has a much higher density of open feedlots and pasture than the North Raccoon and the terrain has an average slope that is more than five times that in the North Raccoon Watershed. The terrain is highly dissected so that no operation is far from a stream. Highest counts were present in the upper reaches of the South Raccoon Watershed which includes Brushy Creek, the largest sub-watershed. Nutrient concentrations were considerably higher in Brushy Creek as well. Therefore most of the investigations were conducted in upper Brushy Creek. Water quality data from the South Raccoon and tributaries is presented in Appendix G.

D. Brushy Creek

This following site map (fig 13) shows sampling locations along Brushy Creek. The 28A series of sites (not shown on this map) are on the South Raccoon above the confluence with Brushy Creek.

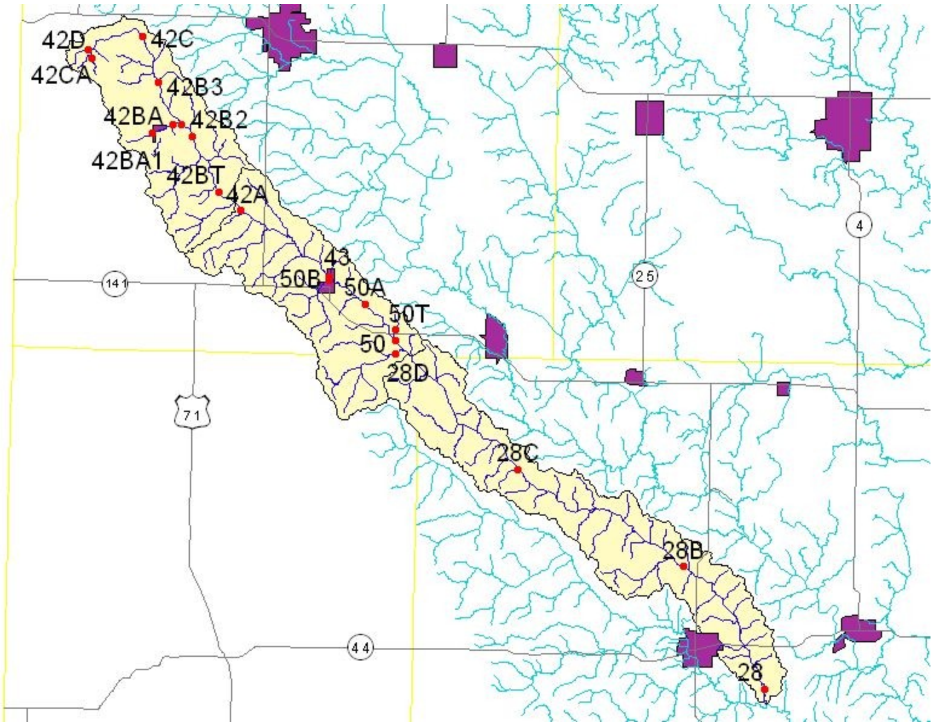


Fig. 13 Brushy Creek Watershed and sample sites

Watershed and Stream morphology:

The Brushy Creek watershed begins near the Mississippi-Missouri River Divide nine (9) miles southwest of Carroll and discharges into the South Raccoon three (3) miles SE of Guthrie Center. The headwaters area has long gentle slopes with predominantly row crop agriculture. The watershed soon changes to a prominent valley with long and often steep hillsides. There are numerous pastures and livestock feeding operations in the valley and surrounding hillsides. The stream is relatively straight but has many pools and areas of slow moving water due to beaver activity and artificial impoundments in the upper third of the watershed.

For much of the summer there was little flow giving these pools considerable detention time. The pools were shallow with a thick layer of black muck. Filamentous algae mats were common on the surface and attached to rock and concrete structures in faster flowing waters (Cladophora sp). An event triggered ISCO sampler was installed at site 50, approximately midway between the headwaters and the outlet. Downstream of this location, flow was relatively rapid with predominantly sandy sediments.

Sampling strategy:

Grab samples were collected for purposes of isolating tributaries and segments of stream with greatest contamination in the effort to identify specific causes, sources, and contributors. Additional sites were added based on previous rounds of sampling to improve resolution of potential fecal contribution sources. Results are tabulated in appendix G where it is organized by date in the approximate order of flow from the headwaters to outlet.

Sediment and benthic analyses were performed to better understand characteristics of the contamination such as:

a. episodic or chronic contamination
b. sediment contamination as a source of contamination during elevated flow (i.e. in-stream stores)
c. impact on aquatic life

Event triggered sampling at site 50 characterized contamination changes across a hydrograph. This provided additional information as to contaminant loading, potential location of contamination, and characteristics of the contamination such as *E. coli* counts and manure decomposition products. A time series collection was also performed during base flow where high counts were observed upstream. This provided information as to variability in grab sample results that may be expected as well as potential causes such as in stream disturbances and direct defecation from unrestricted grazing.

Results:

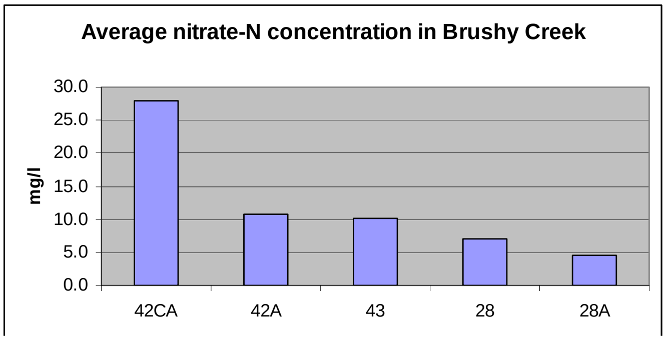


Fig. 14 Change in Brushy Creek Nitrate concentration

The headwaters of Brushy Creek begin as a small pool (42CA) that is maintained by the discharge from three tiles. Flow continued through dry weather when other drainage tiles stopped flowing. The tile discharge had higher nitrate concentrations than any other site in the study area with a high of 33.7 mg/l on 7/17/07 when dry weather and crop uptake typically lowers nitrate discharge from tile and groundwater into the streams. Soluble phosphorus was generally non-detectable but a concentration of 1.1 mg/l occurred in the pool following a heavy rain event on 3/12/07, likely from field runoff contribution into pool. Average nitrate concentrations from more that 40 rounds of sampling showed a consistent decrease in concentration as water flowed downstream to the outlet at site 28 (fig 14) but remained higher than the South Raccoon at its confluence (site 28A). Nitrate concentrations at the outlet were remained consistently higher than any other tributary to South Raccoon (site 32).

The first major runoff event on 7/26/06 showed considerable fecal contamination in the upper Brushy Creek area. At site 42B2, most units of measure were exceeded with *E. coli* counts exceeding 241920/100 ml and TKN exceeding 10mg/l. TOC was approximately 80 mg/l based on numerous dilutions (detailed in status report #2). Fecal indicators decreased downstream. One upstream site along Halbur Creek was implicated as a possible source of this contamination. However, subsequent sampling showed widespread contamination in upper Brushy Creek, including sites upstream of Halbur Creek. No particular site or source could account for the distribution of contamination observed. During a meeting with DNR staff, it was learned that a DNR investigation of the region occurred the previous winter in respond to a manure spill complaint. It was determined that manure runoff from multiple operations occurred due to inadequate manure holding structures. Whether the 7/26/06 contamination event came from the same surface runoff sources, new unidentified sources, or possibly from re-suspended fecal contaminated sediments as a legacy of the previous massive mid-winter runoff of manure was uncertain. That such high *E. coli* counts would remain in the sediments was thought improbable.

Corrective actions for manure containment structures were mandated and implemented to various degrees of completion during this study. Whether an improvement in water quality was achieved through these measures could not be established as there was essentially no monitoring of the stream prior to the installation of these structures. That a similar event of this magnitude was not repeated during this study gives some indication that these measures were effective in controlling massive runoff. However, as recorded in the status reports, high E. coli counts and other water quality issues in the upper Brushy Creek watershed remained. Further sampling showed dynamic relationships between source contribution, matrix and mortality, and transport both from the landscape and within the stream.

High counts were not limited to runoff events (appendix G). On 8/3/06 after the stream had returned to base flow, Site 42B2 below Halbur Creek had 2260 counts/100 ml with a turbidity of 5 NTU. Site 42BA, Halbur Creek, had 4500 counts on 9/21/06 with a turbidity of 8 NTU. Site 42B3 upstream of Halbur Creek had 3640 counts on the same date with a turbidity of 6 NTU. These and many other sites in the region had high counts during low flow and turbidity that can not be readily attributed to either runoff or re-suspension of contaminated sediments from elevated stream flow. This would suggest point source contamination into the stream except that contamination occurred upstream of any potential community source and no piped discharge could be found. Furthermore, the lowest counts occurred during the winter and early spring when treatment is least effective. This seasonality is consistent with unrestricted livestock access to the stream and direct defecation into the stream.

Variability in counts along differing segments of the same stream during base flow raises the question of how much of the variability is due to location and proximity to fecal source verses variability at a site through time. Direct defecation into a stream or disturbance such as trampling would create high numbers locally that would be transported downstream. Variability in water quality due to cattle activity within the stream was tested by collecting samples from a stream surrounded by pasture, with an ISCO automated sampler triggered to sample very ½ hour over a 24 hour period during base flow. Spikes in counts and turbidity would be considered evidence of sediment disturbance while large spikes in counts with little increase in turbidity would be interpreted as a defecation event. Several sites were tested but only the Purgatory Creek sampler provided a consistent sampling through time. The results were indeed quite variable (Table 2), more variable than counts at the DMWW intake during base flow.

Table 2. Time Study of Variability in Water Quality During Base Flow

Sample Date	Creek Name	Client Id	Chloride	*E. coli*	Turbidity
10/31/2007	Purgatory Creek	19-1		677	50.7
		19-2		143	31.3
		19-3		404	28.9
		19-4		305	27.4
		19-5		278	31.6
		19-6		663	26.3
		19-7		350	29.1
		19-8		295	26.4
		19 Up	23.5	359	24.2
11/1/2007	Purgatory Creek	19-9		262	26.2
		19-10		529	28.1
		19-11		1153	32.7
		19-12		813	32.9
		19-13		697	31.8
		19-14		594	32.3
		19-15		651	29.6
		19-16		20	26.8
		19 Up	23.57	259	17.7

The highest counts (1153 counts/100ml) occurred at 2 AM when there was only a small increase in turbidity. It is doubtful whether livestock would be active in the stream at this time but disturbance by wildlife is possible. Beaver were observed in the area and are active at night. Eighty nine percent (89%) of the samples exceeded the *E. coli* water quality standard. It is probable that fecal pats had been deposited into the stream at and upstream of this location and would become dispersed on a non-uniform manner. Artificial disturbances of the sediments at or near this site may help data interpretation but was not performed. The data is consistent with the grab sample observation where the highest counts during base flow occur in first and second order streams but where results are variable and seemingly inconsistent. This time study raises doubts whether single snapshot grab samples adequately represent water quality in the smaller streams and comparative evaluation of water quality between streams. In this example, a single grab sample from this stream could vary between less than 20 counts/100 ml (indicating a high quality stream) and greater than 1153 counts/100ml (indicating a low quality stream with point source contamination).

The occurrence of high fecal indicators in upper Brushy suggested at least the potential of deposition and storage of fecal matter onto pool sediments and potentially a re-suspension of the contaminated sediments during elevated flow. Benthic and sediment analyses performed in several pool sites showed grossly contaminated sediments with *E. coli* counts as high as 24 million/100ml (Status report #3). The sediments were anaerobic with high organic content (>9% volatile solids). There were very few macro-invertebrates, mostly pollution tolerant leaches and a few oligochaetes. These sediments provided at large in-stream store of fecal contamination which could be re-suspended during elevated flow. The source and cause of such high counts in the sediments is problematic. If transported by landscape runoff, the elevated flow from such an event would likely keep *E. coli* suspended and therefore transported downstream. Also counts of this magnitude were never observed during runoff. To achieve this high count density, *E. coli* organisms would need to settle and accumulate during low flow in the pool and remain viable. Transport and deposition rates of fecal sources on the sediments, time between rain events and mortality rates within the stream and sediments creates a dynamic in the potential contribution of these sources to stream contamination during elevated flow.

IV Laboratory studies:

A series of laboratory experiments were conducted to determine the potential of differing fecal sources to counts of viable *E. coli* in the stream and sediments and the interaction of fecal contaminated sediments to surface water contamination.

A. Brushy Creek sediment re-suspension experiments:

A series of laboratory experiments was conducted to test the potential contribution of pool sediments to *E. coli* counts in Brushy Creek during elevated flow. The results are summarized in this report. Details of the experiments are available in Status Report #3. It was important to determine whether high *E. coli* counts are necessarily from the event runoff or whether the elevated flow re-suspended *E. coli* from upstream sediments.

One hundred (100) ml aliquots of sediment from upper Brushy site 42B2 and mid-point site 50 were placed into 1000 ml beakers and filled to volume with de-chlorinated tap water spiked with $NaNO_3$ to a 30 mg/l nitrate-N concentration. Three different flow regimes (stagnant, low flow, and rapid flow) were simulated on water above the two substrates using 2, six-paddle mixers operating at 10 rpm (4 cm/sec) and 30 rpm (12 cm/sec) respectively. Samples were analyzed for *E. coli* after a 24-hour equilibration period. Another set was analyzed after eight (8) days of treatment to indicate effect of time on *E. coli* counts in a stream and substrate environment (Table 3).

Table 3 *E. coli* Re-suspension from Stream Sediments

Test period	42B2 Stagnant	42B2 Slow	42B2 Fast	50 Stagnant	50 Slow	50 Fast
1 day	6770	3880	77010	<100	<100	310
8 day	310	<100	11780	<100	<100	300

The rapid mix flow (12 cm/sec) over site 42B2 sediments during the 24 hour test resulted in suspended *E. coli* counts very similar to that collected from the pool at 42A. The longer test period of 8 days indicated substantial die-off and stabilization with time when the sediments were kept in suspension. High stream *E. coli* counts, evidently, can be due to re-suspension. Once suspended, *E. coli* has a high mortality rate.

B. *E. coli* counts in various fecal sources common to the landscape

Fresh bovine and porcine feces and samples from various stages of manure storage were analyzed for viable *E. coli* concentrations (Table 4). Counts in the fresh feces compared favorably to the literature values used for the TMDL calculations. Two bovine samples were analyzed, the first from a feedlot and the second from a pasture. The second bovine sample yielded lower counts (0.6 billion vs. 2.4 billion/100ml) but it was uncertain whether it was fresh or related to diet or other causes. Therefore feces from the feedlot was used as the initial count concentration as it was known to be fresh.

Table 4. *E. coli* Counts/100 ml in Fresh and Stored Manure

Source	Fresh	1 week [a]	3 months [b]	Lagoon [c]	1 year [d]
Bovine	2.4 billion	65 million	41 thousand	110 thousand	
Porcine	2.5 billion				66 thousand

[a] Estimated age of manure bladed off a dirt feedlot and stored on concrete slab.

[b] Estimated age of manure pile.

[c] Lagoon that captured runoff below the concrete slab

[d] Pit below swine confinement. Collected at time of land application

Assuming a pat volume of 500 ml and 12 pats per day, each cow produces 144 billion *E. coli* per day. This compares favorably to 104 billion/day used for TMDL calculations. The common supposition that high *E. coli* counts necessarily comes from large quantities of fecal matter is fundamentally flawed. *E. coli* counts are number units of viable *E. coli,* not mass or weight of fecal material. Count concentration in fresh fecal matter is remarkably high where a single pat can provide higher counts than tons of aged fecal matter as illustrated in the following examples:

1. Counts in a single fresh bovine pat weighing one pound (12 billion *E. coli*) are equivalent to counts in 146 tons of the three month old stored manure.

2. Each cow potentially contributes 6 counts/100ml at a 1000 CFS flow (the average daily flow in the Raccoon River 2006).
3. Counts generated from 10 cows at a base flow of 250 CFS would exceed the water quality standard.

Several field observations indicate fresh fecal material as a major contributor to high count concentrations in rivers, streams, and sediments:

1. In 2007, the Raccoon River had an *E. coli* count of 123000/100ml. This is a higher count concentration than samples from either the swine confinement lagoon or the feedlot runoff containment lagoon. Fresh fecal sources with high count concentrations would have to supplement the *E. coli* counts in the manure and lagoon storage sources to achieve the same high count concentration in the river.
2. A small tributary of Lake Creek had a count concentration of 2 million/100 ml below a small active feedlot during dry weather. At an estimated flow of 0.1 CFS, this stream discharged 4899 trillion *E. coli* into Lake Creek per day, enough to cause water quality impairment in the Raccoon River at a 760 CFS flow as observed on that date.
3. *E. coli* counts in Brushy Creek sediments (11 million at site 42B2) were equivalent to freshly bladed feedlot manure even though a considerable amount of silt was mixed with the sample to dilute the counts.

That the counts observed at Des Moines were not higher (above the WQS) is somewhat problematic. The following experiments were conducted to determine what happens to a fecal pat that enters a stream and its influence on water quality through time.

C. Dispersion rate experiments:

The first experiment examined dispersion rate of *E. coli* out of a fecal pat matrix under various environmental conditions (Table 5). The fecal pat was collected from a pasture and had a count concentration of 0.6 billion/100 ml. Approximately 10 grams of fecal material was dropped into each 1 liter beaker containing treated water prior to chlorine addition. Simulated flow was provided with a Phipps and Bird 6 paddle mixer set at 10 rpm. Slow movement was simulated by attaching a paper clipped rod to the paddle where only the rod had contact with the sample. Three hourly samples were collected from the top one centimeter for enumeration followed by a 24 hour sample. All samples, including "pool simulation" water exceeded the water quality standard within one hour of deposit. The observation of a turbidity plume as the sample fell through the water suggests that the resulting turbulence caused much of the initial dispersion. Dispersion in the field would be much greater however due to the greater height of drop. The results were not consistent but showed an overall increase in counts with time. The fecal material remained visually intact with relatively little of the *E. coli* dispersing into the water within three hours. The samples with greater agitation and surface area developed higher counts with time as expected. Counts 24 hours later exceeded 2.4 million except for the pool water. Visually, the fecal pats remained intact.

Table 5. Simulated Dispersion Rate of *E. coli* from Bovine Fecal Pat

Simulated stream conditions	Grams of fecal pat	1 hr	2 hr	3 hrs	24 hrs
Pool area	10.7			85000	689300
Slow moving	11.2	29090	63000	31000	>2419200
Moderate flow	10.2	44100	717000	488000	>2419200
Moderate flow HS *	10.3	2000	670000	1043000	>2419200

* HS (high surface) Fecal pat was separated into many small pieces to simulate splash separation such as from impact on a hard surface.

The second experiment was a continuation of the first to observe the *E. coli* population dynamics through time (Table 6). Count concentration in the samples collected at the surface increased to nearly that of the original pat. This is nearly a 2 log increase in total numbers over the starting counts. Since the original pat concentration was 0.6 billion/100 ml, a 10 ml pat volume contains 60 million *E. coli*. When placed in 1 liter of water, the calculated count concentration is 60 million/liter or 6 million/100ml compared to a high of 580 counts/100 ml observed. Furthermore, these counts varied little with change through time after the first 24 hours. Fifty seven (57) days after the start of the experiment, the entire contents were uniformly dispersed through rapid mixing. With one exception, counts exceeded 242 million counts/100 ml, the maximum measurable value. This shows a net growth from 60 million to >2.4 billion *E. coli* counts. This observation suggests an initial increase in counts the first day or two followed by a dynamic equilibrium between growth of *E. coli* in the fecal matrix with dispersion and mortality of *E. coli* in the overlying water column.

Table 6. Log value of *E. coli* Counts/100ml in Water Overlying a Fecal Matrix

Days	1	4	5	6	7	11	18	28	57*
Quiet	5.8	8.3	8.2	8.4	8.3	8.1	7.8	8.1	>8.4
Gentle	>6.4	8.5	8.3	8.2	8.1	7.0	8.2	7.7	>8.4
Moderate	>6.4	8.8		6.5	6.1	7.2	7.9	6.8	>8.4
Mod HS	>6.4	8.3	7.1	6.6	6.7	5.7	7.5	7.2	7.2

* Samples rapidly mixed to a uniform suspension

A third experiment studied long term changes in counts downstream of a fecal pat in a simulated stream environment. A ten (10) ml bovine pat was placed in a four (4) liter beaker into which treated, chlorine-free water continuously overflowed at a 1.2 liter/minute rate. Samples of the overflow water were analyzed for *E. coli* counts daily then longer increments of time until counts fell below 235 counts/100, the water quality standard for *E. coli* in streams. The experiment differed substantially from the previous experiment in that the continuously flowing water over the fecal material continuously transported nutrients and *E. coli* away from the fecal pat and overlying water. Different results would be expected with differing flow rates.

Counts in the overflow water varied considerably with a minimum value of 2924 in the first week to a maximum of >24192 counts (Table 7). The average of known counts was 3200. At this concentration and overflow rate, 0.4 billion *E. coli* were transported out of the beaker (downstream) in the one week period from a fecal pat containing initially 60 million *E. coli*. At a minimum, there was a 6.6 fold increase in *E. coli* counts in first week period with little indication of declining growth rate. This suggests a dynamic equilibrium between the reproductive rates of *E. coli* in the fecal matrix to transport downstream. After the initial week, the fecal pat lost its form and dispersed throughout the bottom of the beaker. Thereafter, counts declined.

Table 7. Overflow Experiment

Days	*E. coli* counts/100ml
1	2924
3	>2419
4	3255
5	>24192
7	3448
18	192
28	59

These results show that fecal pats deposited into a stream are capable of creating sustained elevated counts in the stream for at least a week during base flow. Count values and variability are similar to that observed in streams where cattle were present. After a sustained period of time, the fecal pat disintegrated and counts declined. This decline in count concentration is also observed in Brushy Creek and the upper South Raccoon after a sustained period of low flow and after cattle are removed from pasture.

The final experiment tested the influence of suspended particles in the stream to *E. coli* survival and sedimentation in pool areas. The high counts in the sediment relative to the overlying water at the pool sites in Brushy Creek suggested either settling of *E. coli* with stream sediments or possibly greater survival or even growth of *E. coli* on organic rich sediments.

Organic rich sediments from a pool area in Brushy Creek (site 42B2) were autoclaved to eliminate competition and predation by other organisms as well assuring uniform known *E. coli* concentrations from an inoculum. Varying amounts of the sediment (0, 1, 10, 100 ml) were placed into 1 liter beakers containing chlorine-free treated water to constitute an experiment. High flow and base flow stream conditions were simulated using two paddle mixers, one set at 60 rpm to simulate high flow, the other at 5 rpm to simulate base flow.

Changes in counts through time in the rapid flow experiment (Table 8) show a clear relationship between *E. coli* counts to amount of sediment suspended in the water. Without sediment, counts rapidly declined. With increasing sediment volume, counts remain high for a longer period of time or even increased.

Table 8. *E. coli* in Rapid Flow Environment

	Sediment volume			
Day	0	1	10	100
0	2400000	2400000	2400000	2400000
1	2419200	1732900	>2419200	1986300
2	1732900	>2419200	>2419200	>2419200
3	307600	980400	>2419200	>2419200
4	85700	1413600	>2419200	>2419200
12	36400	48000	344800	>2419200
End	36400	48000	344800	>2419200

The change in counts under base flow simulation (Table 9) was similar to the rapid flow experiment with one distinct difference, counts in all re-suspended matrices at the end of the experiment were higher than counts in the water matrix above the sediments (Table 8). It is unlikely that this is due to co-sedimentation since samples with the greater quantity of sediment would sweep more of the suspended *E. coli* to the bottom of the beaker than samples with lesser sediment volume. This was not observed. Also counts in the base flow simulation were similar to rapid flow suggesting processes independent of sedimentation. The sediments used in this experiment contained a high percent of organic matter and high counts before autoclaving. It is possible if not probable that much of the organic matter was of fecal origin and provided a favorable environment for growth.

The settled sediments in this experiment should have similar characteristics so that *E. coli* present in these sediments would likely be in a more favorable matrix for growth and survival as well. Therefore suspension of *E. coli* in the sediments at the end of the experiment would result in higher counts.

These experiments were designed as a test of concept regarding source and fate of *E. coli* in the environment. They demonstrated a dynamic in growth and survival of *E. coli* that may have a greater influence on counts over time than mass of fecal material. Environmental matrix is a key determinant on *E. coli* growth and survival in stream sediments and may be the key to understanding *E. coli* dynamics in streams. This was especially true for understanding the water quality dynamics observed throughout the Des Moines and Raccoon Watershed during the last quarter of testing (status report #8)

Table 9. *E. coli* and Turbidity in Base Flow Simulation Environment

	Sediment Volume (ml/liter)			
Day	0	1	10	100
0	2400000	2400000	2400000	2400000
1	>2419200	>2419200	>2419200	>2419200
2	1773100	1553100	>2419200	>2419200
3	344800	146700		1732900
4	307600	119800	307600	>2419200
12	30500	195600	547500	>2419200
End	77600	686700	1732900	>2419200
	Turbidity (NTU)			
Day	0	1	10	100
0	5.3	116	2480	24900
1	2.3	10.6	39.3	388
2	2.2	8.1	28.5	197
3	4.5	10.7	12	114
4	0.87	2.44	3.76	29
12	0.55	1.18	1.58	122
End	3	120	1800	23000

Exceptionally high chlorine demand at the water utility beginning in late February (Fig. 15) was linked to high ammonia concentrations in both rivers and watersheds. Manure odors, high HPC bacteria counts, and total coliform counts that accompanied remarkably high TOC, phosphorus, and organic nitrogen concentrations all strongly implicated a large quantity of manure that contributed little to *E. coli* counts. The distribution of the contamination was widespread in both the Des Moines and Raccoon River watersheds. The highest concentration occurred in Brushy Creek where there is a high concentration of open feedlots where manure is typically surface applied with spreaders. This is also the location of chronically high *E. coli* counts during the growing season.

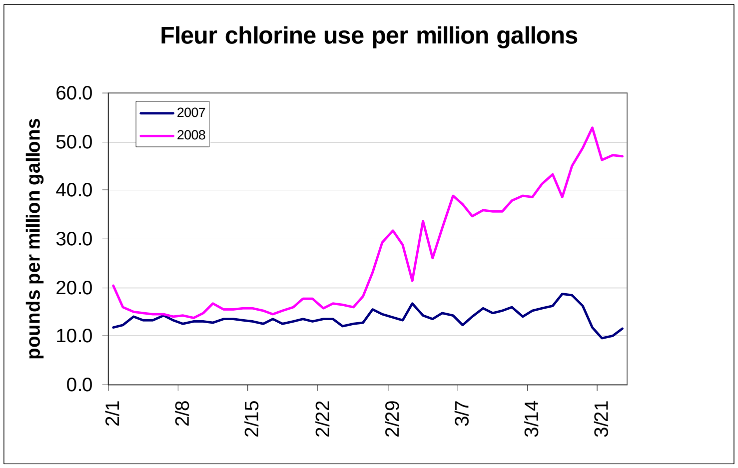


Fig. 15 Chlorine demand in source water 2008

The North Raccoon Watershed has a similar animal unit concentration as in the South Raccoon but with a higher percentage population of livestock in swine confinement operations. Strong odors and ammonia smell from these operations contributes to the speculation by the public that confinement operations are the primary source of ammonia and nutrient contamination in Iowa rivers and streams. Ammonia and other indicators of a manure origin were elevated though not to the extent as in the South Raccoon Watershed, even though the North Raccoon had greater snow cover. The reason for this difference is uncertain. Assuming the primary source of the ammonia in the snow melt to be from surface applied manure, the lower concentration in the North Raccoon would suggest less surface application of manure and higher percentage of soil injection.

The unique weather conditions may have contributed to a higher than usual concentration of fecal indicators in two ways. The late fall wet weather reportedly forced a change in manure management toward surface application while the prolonged heavy snow cover trapped ammonia that would otherwise have volatilized to the atmosphere. The frozen ground during snow melt prevented infiltration of ammonia rich water and accentuated manure runoff. During previous years without prolonged snow cover, a similar winter application of manure may have gone largely unnoticed because of low *E. coli* counts and ammonia concentrations. Periodic episodes of spring time odors, color, and fine organic particulates that are difficult to remove by coagulation commonly occurred in late winter and early spring at DMWW and the Panora surface water treatment plant on the Middle Raccoon. This suggests contribution from aged manure low in ammonia during spring runoff events. The practice of manure application onto frozen ground when there is limited potential to retain the material on the landscape raises treatment concerns regarding turbidity removal and the potential presence of chlorine resistant parasite cysts such as *Cryptosporidium parvum*.

Project in review:

The goal of this study was to determine as precisely as possible sources of fecal contamination (especially *E. coli* and nitrogen) upstream of the DMWW drinking water intakes within a 72-hour time of transport. Few point sources of contamination were found but access was limited to public land and roadways. The most contaminated streams within the study area during both base and elevated flow occurred in the upper region of the South Raccoon River, especially in upper Brushy Creek and South Raccoon region upstream of Brushy Creek. This region has numerous open feedlot operations and several pastures with unrestricted access to the streams. The headwaters area of the Middle Raccoon near Carroll also has a high concentration of open feedlot operators and high indicators of fecal contamination in the river. However, counts in the river downstream of Lake Panorama within the study area usually met the water quality standard except during very high flows where there is little detention time.

The presence of elevated *E. coli* counts relative to other rivers and streams intuitively suggests a large population of humans or livestock capable of generating large quantities of fecal matter. More fecal matter is generally equated to more *E. coli* therefore greater potential to enter a stream by various diverse routes. However, this study shows the relationship between source of *E. coli* and counts observed in the rivers to be complex. Large population centers or concentrations of livestock do not necessarily lead to elevated *E. coli* counts in the receiving stream. Part of the apparent discrepancy is that *E. coli* concentration is based on counts of viable *E. coli*, not mass. Counts of viable *E. coli* in fresh fecal matter are extremely high (1.2 billion/100ml) so that a very small quantity as of fresh fecal material dispersed into a stream is capable a producing counts well above the water quality standard as long as the *E. coli* remains viable and in suspension. For example, 5 gallons of fresh bovine fecal matter dispersed into the Raccoon River near the intake over a 24 hour period at normal flow (750 CFS) would cause a violation of the water quality standard. This is a miniscule quantity compared to fecal mass generated within the watershed. Therefore viability (a function of growth and mortality over time in differing environmental conditions) and transport to a stream and within a stream play a much greater role in determining counts within a stream than mass of fecal mass entering a stream.

Highest counts invariably occur during elevated flow. The source and cause of high counts is remarkably complex. Time on the landscape and environmental matrix in which *E. coli* is present are primary factors determining viability of *E. coli* entering the stream (Brand, status report # 7). Attenuation rates within the stream, time of transport, deposition onto sediments, and population dynamics within differing sediment matrices also greatly affect *E. coli* counts in the stream and sediments (Brand, status report #7). *E. coli* counts as high as 24 million/100ml were present in the organic rich pool sediments (9.5% V.S.) in upper Brushy Creek when counts within the pool were 4500 counts/100ml (Brand status report #3). Howell (1996) and others have shown that particle size and other factors greatly influence mortality rates of *E. coli* in the stream environment. In-stream simulation experiments with fecal pats showed that total *E. coli* counts through time in the downstream water exceeded counts from the original pat, demonstrating continued reproduction. Counts remained at an elevated level (approximately 2500/100ml) until the fecal pat dispersed 11 days later (Brand, status report #7). Jamieson et al (2005) noted that fine grained organic rich sediments especially provide an environment suitable for extended survival and possible growth (Burton et al 1987). Muirhead (2004) demonstrated high yield of fecal bacteria from in-stream stores during artificial flood events. The high counts observed in the pool sediments in upper Brushy Creek had the potential of producing high counts during elevated flow without any additional terrestrial influx. The cause of elevated counts in Brushy Creek in 2006 may also have been influenced by an extensive manure runoff from several producers the previous winter (IDNR investigation verbal report). The full legacy of this event on the stream is unknown but it is probable that the fecal contaminated sediment matrix promoted survival if not growth of *E. coli* which could be suspended during elevated flow.

Highly variable counts with high median values during base flow best fits the model of direct deposition of fecal material into the stream by cattle when no other point source is observed. First and second order streams especially often flow through pastures as they provide convenient and safe access. The potential of direct defecation into a stream to elevated counts during low flow was observed in a small tributary stream of Lake Creek (outside the study area). Counts downstream of a small pasture lot containing approximately 50 cattle were in excess of 2 million/100ml. At the estimated flow of 1 CFS, this would cause the Raccoon River to exceed the water quality standard should all the *E. coli* remain viable and in suspension. Samples collected by the Agriculture Clean

Water Alliance (ACWA) however have demonstrated a general increase in counts as sampling processed from the outlet of a stream toward its headwaters (Appendix A). The only exceptions occurred following a runoff event where the outlet had high turbidity and flow while the tributaries that produced that flow had low turbidity, indicating a return to nearly base flow when lower counts would be expected. Time study experiments on *E. coli* viability in Raccoon River water at the DMWW laboratory showed a daily mortality rate in excess of 50% per day at ambient temperatures. The longer travel times in the North Raccoon relative to the South Raccoon, especially during base flow, would contribute to greater mortality and lower counts.

Plotting *E. coli* turbidity ratios against turbidity from ACWA samples in the North Raccoon show that most samples follow a mainstream relationship with highest ratios occurring during low flow but which become nearly constant during higher flow and turbidity. Plotting these points makes variances from this relationship more apparent. Several anomalous data points occurred were the *E. coli* turbidity ratio was much higher than would be expected from general landscape runoff (Fig. 16)

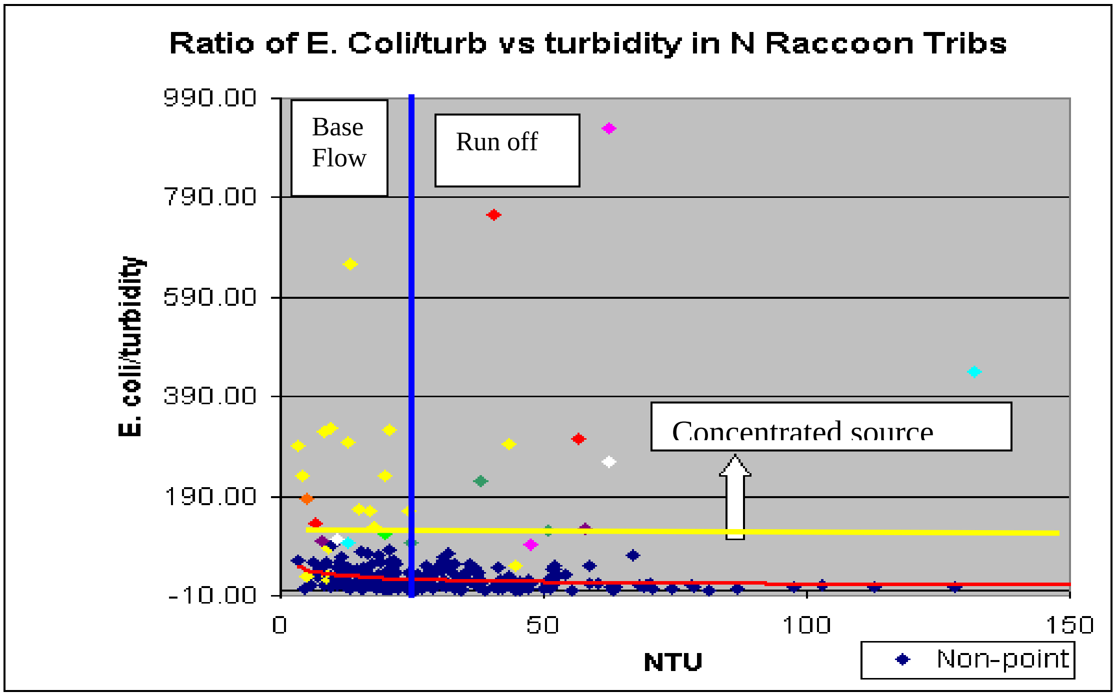
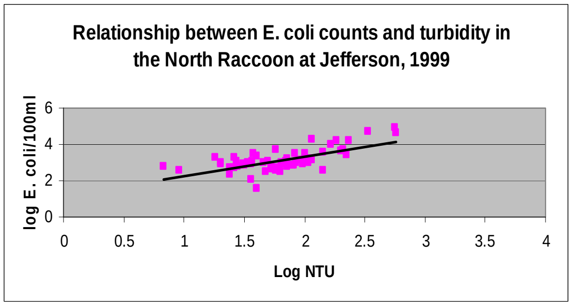
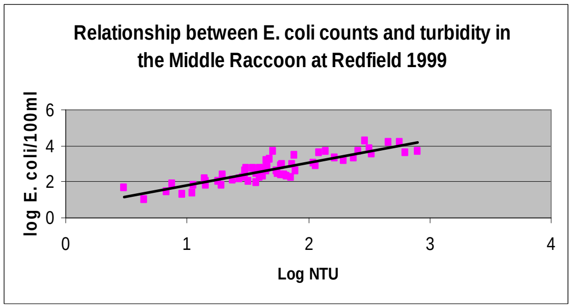


Fig. 16 Conceptual interpretation of *E. coli* turbidity relationships in the watershed

High *E. coli* turbidity ratios (above the yellow line) during low turbidity (blue line designating base flow) would be expected from concentrated point source contributions. High *E. coli* turbidity ratios during storm runoff events require a relatively high contribution from a fresh manure source (viable *E. coli*) such as a feedlot relative to runoff from the general landscape. The different colors in this example are from different streams. Should a given color show above this main stream line multiple times, this likely indicates a concentrated source close to a stream with inadequate manure control structures so that relatively fresh manure with large numbers of viable *E. coli* can be transported into the stream, increasing the load of *E. coli* relative to sediment. Mainstream data points to the far right of the graph also have very high counts as would be expected with high flow since more surface material (fecal and soil particles) would be transported with heavy rain and landscape runoff. A similar plot has not yet been developed for other landscapes where a different relationship is possible if not probable. A plot of this relationship for a given landscape may be a useful tool to identify suspect streams and land practices if that is the goal. However, the number of samples required to establish a standard relationship and detect variances is very large. It may very well improve water quality in the stream affected but whether identification and correction of poor practices in piecemeal fashion based on occasional variances in water quality would be an effective approach to making a measurable improvement in main-stem river water quality is less certain.

A review of extensive data in the three main stem rivers in 1999 showed a consistent relationship between *E. coli* counts and turbidity across a wide range of flow and between tributaries. Plotting the log of both substances on the *xy* axis resulted in a near linear relationship (Fig. 17) with similar slope between tributaries. A greater slope would be expected from a more fecal contaminated tributary. However, the slope was surprisingly similar between tributaries and was not expected given the high counts in the upper South Raccoon Watershed. The primary difference between the tributaries is that the slope in the South Raccoon extends further than the other tributaries by 1 order of magnitude, indicating greater runoff energy that transports both *E. coli* and turbidity. Therefore, the primary difference between the North and South Raccoon Watersheds relates much more





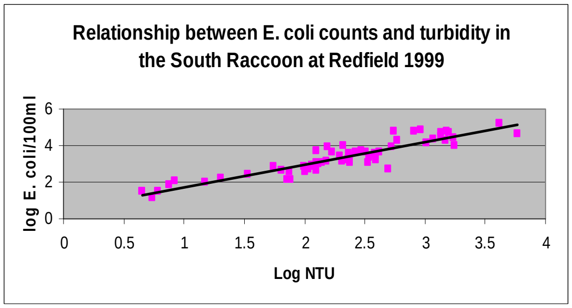


Fig. 17 Relationship between E. coli and turbidity in the three main stem tributaries

to differences in terrain and hydrology rather than land use. The logical implication is that policies that reduce flow and provide runoff and erosion control may be more effective and easier to implement. Weather, terrain, land use, manure management and method of application, proximity to a stream, and time of travel all influence time on the landscape and time within a stream to attenuate *E. coli* counts. These factors collectively appear to be more relevant to counts observed in Des Moines than quantity of fecal matter generated within a watershed. Practices and structures that keep manure on the landscape for longer periods of time and which reduce erosion and flow will provide the greatest reduction in *E. coli* counts in the Des Moines water supply.

Summary:

E. coli is ubiquitous in the Raccoon and Des Moines River watersheds, and its concentration within streams is the product of many factors that are often either overlooked or discounted as significant contributors to water quality impairments. Laboratory experiments suggest that age of fecal material and matrix may be more important considerations to elevated *E. coli* in the stream than mass of fecal material. Laboratory experiments showed that fresh fecal pats can produce sustained high counts in a base flow stream environment and greatly elevated counts during high flow. This observation is consistent with streams that had high fecal contamination in its sediments.

High counts in the streams during elevated flow can come from these in-stream stores and are not necessarily from landscape runoff.

Focusing on *E. coli* counts as the primary indicator of fecal contamination was shown to be inadequate this winter quarter. The potential of chlorine and environmentally resistant parasite spores in the runoff raises additional health concerns. The high ammonium concentrations that did not create a fish kill created grave disinfection problems and concerns regarding the ability to provide safe drinking water to thousands of Iowa citizens which may have gone unnoticed had there not been a high chlorine demand at the utility intake. Good management practices such as incorporation of fecal matter into the soil certainly reduces runoff of these substances into streams as well. Therefore large operations which retain fecal matter for long periods of time and inject a low density of viable *E. coli* into the soils would contribute little to stream *E. coli* counts or ammonia. Safeguards against spillage and illegal pumping, however, are paramount as the high ammonia and organic content of such wastes is very harsh on aquatic life should a spill or runoff of such waste occur, as well as creating the public health concerns mentioned. Manure injection, however, does not solve all problems, as over-application for the area soils and crops can contribute nitrate and phosphorus loads to the stream which create other environmental and public health concerns. Circumstantial evidence of this occurs in the headwaters area of Brushy Creek where nitrate-N in the tile discharge is in excess of 30 mg/l with soluble phosphorus greater than 1.0 mg/l during runoff. Given the high density of livestock in the area, it is at least possible that incorporation of manure contributed to the nutrient rich water.

Water quality issues are complex and causes for impairment may relate to unique interrelationships between land use and the landscape characteristics of the watershed. It is therefore imperative that solutions are implemented at the watershed level and citizens be empowered to act as needed with tools available to monitor the effectiveness of local policies and make adjustment as needed.

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Prologue to the Appendices
Data section

Analytical methods, definition of terms, and units of measure:

Method	**Method description**	**Analyte**	**Abbrev.**	**Units**
EPA 300.0	Inorganic anions by Ion Chromatagraphy	Chloride	Cl	mg/l
		Nitrate-N	NO3-N	mg/l
		Nitrite-N	NO2-N	mg/l
		Ortho-Phosphate-P	o-Phos P	mg/l
SM9223B-PA QT	Enzyme substrate test	*Escherichia coli*	*E. coli*	counts/100ml
SM9223B-QT	Enzyme substrate test	Total coliforms	T. coliforms	counts/100ml
SM9215B	Pour Plate Method	Heterotrophic Plate Count bacteria	HPC	Counts/ml
SM2130B	Nephelometric Method	Turbidity	Turb	NTU
SM4500-NH3 D	Ammonia-Selective Electrode Method	Ammonia-N	NH3-N	mg/l
CALCTN	Combustion-chemiluminescence	Total Nitrogen	TN	mg/l
SM5310B	High-Temperature Combustion Method	Total Organic Carbon	TOC	mg/l

Nitrogen is often a limiting nutrient in terrestrial environments and in some aquatic environments. It can be quickly transformed from one form to another and eventually back to a starting point in a process known as the nitrogen cycle. To better follow the transformation processes, the analytical convention is to report only the amount of nitrogen. The potential of manure in contributing to nitrate-N is the total nitrogen in the manure applied, generally in the chemically reduced form, organic nitrogen and ammonia. These will be mineralized to nitrite-N and then more stable, completely oxidized form, nitrate-N.

Phosphorus can also be a limiting nutrient to terrestrial growth but more often in aquatic environments as it is sequestered in the soil. Mineralization of surface applied manure can result in runoff and elevated o-phosphorus as can direct discharge from wastewater treatment plants. However, properly operated wastewater treatment plants discharge low concentrations of organic matter and bacteria. The amount and form of organic matter together with the various forms of bacteria provide additional clues as to the source, age, and contribution of fecal contamination to water quality in the rivers.

Appendix A

Water Quality at the Des Moines River Intake
March 2006 - March 2008

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	T.Coliform Counts/ 100ml	*E.coli* Counts/ 100ml	HPC Counts/ ml	NH3-N mg/l	TOC mg/l
03/01/06	31.6	11.7			6.4	22		1360		
03/02/06	30.9	12.1				50	17	1330		
03/03/06	31.2	12.2			6.8	18	4	700		
03/06/06	30.3	11.4			6.0	46	5	700		
03/07/06	30.6	11.3			6.4	49	1	2150		
03/08/06	31.0	11.7			6.3	20		1230		
03/09/06	31.0	10.8				496	42	3100		
03/10/06	30.2	10.5			7.2	58	4	1900		
03/13/06	29.8	10.1			8.8					
03/14/06	29.3	8.9			15.3			900		
03/15/06	29.6	9.6			15.2			1460		
03/16/06	29.5	9.4			13.2	201	3	1650		
03/17/06	29.3	9.4			12.9	21	2	1010		
03/20/06	28.9	9.7			11.6	63	6	500		
03/21/06	29.3	9.8	0.03		10.7	51	15	940		
03/22/06	29.6	10.3			16.6	37	5	550		
03/23/06	28.6	10.1			10.6	35	5	2210		
03/24/06	28.9	10.6			12.4	46	1	720		
03/27/06	28.5	10.2			12.4	45	6	385		
03/28/06	29.2	10.2			11.7	102	16	1140		
03/29/06	29.8	10.4			13.0	40	9	3920		
03/30/06	29.8	10.5			13.8	84	16	805		
03/31/06	30.8	10.0			49.0	743	97	7500		
04/03/06	10.7	1.9			50.6	1970	200	3500		
04/04/06	29.3	10.7			28.2	977	96			
04/05/06	29.2	11.1			21.0	770	56	2350		
04/06/06	25.2	12.3			25.9	1414	61	4250		
04/07/06	24.2	13.4			28.0	1095	35	5400		
04/10/06	22.5	13.0			35.0	200	9	1500		
04/11/06	22.0	12.6			35.6	461	8	1300		
04/12/06	22.2	12.4			33.8	461	19	1200		
04/13/06	22.6	12.5		0.08	27.1	291	12	2550		
04/14/06	21.5	11.9			27.0	411	5	540		
04/17/06	20.9	10.7			35.1	411	11			
04/18/06	21.0	10.2			31.7	345	11			
04/19/06	21.8	10.4			28.8	1300	27			
04/20/06	21.0	9.4				219	5			
04/21/06	21.1	9.5			31.7	119	2			
04/24/06	21.8	9.8			23.2	649	1			
04/25/06	22.1	9.6			21.0		4			
04/26/06	21.5	9.6			27.7		5			

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	T.Coliform Counts/ 100ml	*E.coli* Counts/ 100ml	HPC Counts/ ml	NH3-N mg/l	TOC mg/l
04/27/06	22.2	9.5			21.4		3			
04/28/06	22.4	9.5			21.3		4			
05/01/06	23.7	9.4			36.1		775			3.7
05/02/06	23.0	10.2			46.6		4106			
05/03/06	23.7	10.4			33.3		480			
05/04/06	24.7	11.8			21.2		171			
05/05/06	24.4	12.6			17.6		58			
05/08/06	23.6	13.9			25.3		27			3.6
05/09/06	22.7	12.9			18.0		39			
05/10/06	22.4	12.8			12.6		8			
05/11/06	23.9	13.5			16.4		63			
05/12/06	20.1	11.2			40.2		83			
05/15/06	21.7	11.9			27.6	866	23	800		
05/16/06	23.3	12.3			23.0		10			
05/17/06	22.5	11.7			20.4		12			
05/18/06	23.6	12.0			24.9		16			
05/19/06	22.6	11.5			16.9		10			
05/22/06	23.9	11.1			13.0	866	17	2780		3.8
05/23/06	23.6	10.8			14.4		6			
05/24/06	22.5	10.3			24.1	2419	23	760		
05/25/06	23.6	10.7			19.4	1733	29	3185		
05/26/06	23.1	10.4			17.1	1633	24	800		
05/30/06	24.2	10.5			14.4	1300	13	1900		3.8
05/31/06	24.0	10.2			11.8	1941	29	1130		
06/01/06	24.4	10.3			12.7	1857	21	1240		
06/02/06	24.9	10.3	0.04		11.5	1857	21	1240		
06/05/06		9.7			15.3	3456	24	1400		3.3
06/06/06	24.6	9.5			20.6	5600	20	1220		
06/07/06	25.1	9.5			16.4		5			
06/08/06	25.2	9.5	0.07		12.9		32	6780		
06/09/06	25.7	9.4			15.1	6499	40	1440		
06/12/06	25.4	9.1	0.10		14.9	12033	40	770		3.7
06/13/06	25.5	9.0	0.12		12.4	12033	40	770		
06/14/06	26.0	9.1			16.3	8664	27	1920		
06/15/06	26.5	9.0	0.09		17.6	4884	44	1430		
06/16/06	27.1	8.9	0.10		13.3	5200	57	3360		
06/19/06	26.5	8.7	0.07		12.1	8865	71	1700		3.9
06/20/06	26.9	8.5	0.10		14.1	8212	99	1340		
06/21/06	27.5	8.3	0.11		15.6	12262	82	1520		
06/22/06	27.1	8.1	0.11		10.8	6260	74	3575		
06/23/06	26.9	7.8	0.12		9.3	6896	37	1300		
06/26/06	28.0	7.5	0.11		10.5	11450	129	4100		4.1
06/27/06	27.2	7.3	0.10		14.4	7746	86	960		
06/28/06	27.7	7.2	0.09		17.4	14140	99	3600		
06/29/06	27.7	7.1	0.13		18.4	8212	135	1880		
06/30/06	27.0	7.6	0.09		15.5	25994	45	2410		
07/03/06	27.6	7.4	0.12		10.8					
07/05/06	26.7	7.6	0.09		14.2		82			3.9
07/06/06	26.5	7.3	0.07		15.0	13065	82	500		

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	T.Coliform Counts/ 100ml	*E.coli* Counts/ 100ml	HPC Counts/ ml	NH3-N mg/l	TOC mg/l
07/07/06	26.8	7.2	0.10		12.2	8704	46	1400		
07/10/06	26.9	6.7	0.09		12.9	15402	24	1540		
07/11/06					14.9		579	23000		
07/12/06	26.4	6.2	0.09		13.4	16275	315	3400		4.1
07/13/06					29.5	6896	1733	10600		
07/14/06	26.0	7.7	0.13		19.1	20924	556	14200		
07/17/06	26.8	8.1	0.18		21.1	20924	436	4200		4.3
07/18/06	26.8	7.1	0.11		19.7	10839	281	2110		
07/19/06	27.5	6.8	0.14		19.6	10839	281	11588		
07/20/06	27.3	6.2	0.15		18.9	20924	276	6980		
07/21/06	27.4	5.6	0.13		17.1	14260	135	4350		
07/24/06	27.5	4.9	0.20		18.2	12262	105	1160		4.2
07/25/06	26.6	4.6	0.23		18.5	9222	51	7820		
07/26/06	20.9	3.1	0.23		72.7	173290	3730			
07/27/06	26.9	3.6	0.43		30.8	43510	1460	8800		
07/28/06	27.3	5.3	0.32		21.6	30655	2419	10800		
07/31/06	28.4	3.8	0.38		21.8	17240	152	9000		3.8
08/01/06	28.5	3.6	0.32		17.9	14540	109	7600		
08/02/06	28.5	3.2	0.31		15.7					
08/03/06	28.7	3.3	0.30		12.6	9222	91	8425		
08/04/06	28.5	2.9	0.22		10.6	12262	29	9805		
08/07/06	28.9	2.0	0.29		16.2	39726	42	2600		4.3
08/08/06					10.7	40820	27	1560		
08/09/06	28.8	2.2	0.15		10.2	55995	22	6095		
08/10/06	28.7	2.3	0.08		15.6	64880	114	6095		
08/11/06	29.2	2.4	0.08		17.1	61640	50	4505		
08/14/06	28.8	2.7	0.08		13.1	4332	3100	3100		4.4
08/15/06	27.9	2.5	0.12		10.2		44			
08/16/06	28.1	2.7	0.09		12.3		33			
08/17/06	27.2	2.6			19.7		583			
08/18/06	24.9	2.4		0.06	55.0		2755			
08/21/06	27.3	3.0			15.2		26			4.0
08/22/06					13.6		53			
08/23/06	27.8	1.3			12.9	12031	36	190		
08/24/06	28.0	2.8			6.1	12262	43	12895		
08/25/06	28.4	2.8			14.1	9768	2490	2220		
08/28/06	27.3	1.9	0.06		14.6		579	82200		4.7
08/29/06					17.6	104620	727	27200		
08/30/06	27.5	3.4	0.11	0.08	14.1	46110	1986	8700		
08/31/06	27.9	4.2	0.13	0.07	19.5	26130	1203	14250		
09/01/06	28.4		0.14		14.9	34480	309			
09/05/06	27.7	3.3			15.6	9330	148	5700		4.4
09/06/06	27.8	3.0	0.08		13.6	5866	74	4400		
09/07/06					12.5	12096	78	1950		
09/08/06					14.7	9804	27	3000		
09/11/06	24.9	2.1			57.1	198630	2419			4.4
09/12/06					57.7	109500	6720	38200		
09/13/06	24.6	3.5	0.08	0.09	38.9	64880	4960			
09/14/06					29.1	23590	2990	42600		

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	T.Coliform Counts/ 100ml	*E.coli* Counts/ 100ml	HPC Counts/ ml	NH3-N mg/l	TOC mg/l
09/15/06	24.7	5.7	0.10	0.10	50.2	17240	365	30200		
09/18/06	25.7	5.8	0.12	0.07	36.3	46040	800	22700		4.7
09/19/06					67.9	32440	425	13950		
09/20/06	22.4	5.4	0.10	0.11	42.0	28272	296	45800		
09/21/06					40.0	25644	103	9800		
09/22/06	23.3	5.4		0.08	25.8	21650	579	3700		
09/25/06	24.7	5.8			30.2	16328	219	14700		4.2
09/26/06					26.3	15402	162	10100		
09/27/06	25.1	5.5			26.0	12262	20	5600		
09/28/06					22.3	8212	91	10000		
09/29/06	25.4	5.4			16.4	6488	148	4350		
10/02/06	25.7	6.1			14.8	7270	120	5800		3.7
10/03/06					19.7	8164	144	5780		
10/04/06					15.2	8164	135	5020		
10/05/06					13.8	6131	138	7690		
10/06/06	26.3	6.3			17.3	3873	88	4795		
10/09/06	26.8	6.6	0.06		13.4	3654	51	3720		4.6
10/10/06	28.4	6.9			14.4	2053	60	5565		
10/11/06	28.7	7.0	0.07		11.6	4800	205	9810		
10/12/06					9.1	4884	152	16440		
10/13/06	27.8	7.1	0.06		9.8	2851	80	9010		
10/16/06	28.2	7.2	0.06		11.1	1986	8280	4900		3.9
10/17/06					12.3	3024	107	10400		
10/18/06	28.1	6.7	0.07		10.5	3973	130	11900		
10/19/06					12.3	2419	162	19850		
10/20/06	29.0	5.9	0.11		11.5		49	4400		
10/23/06	28.6	5.7	0.09		12.6	2098	155	3700		4.1
10/24/06					16.4	2564	67	5830		
10/25/06	28.8	6.3	0.08		13.6	3882	40	5570		
10/26/06					25.0	2318	85	8200		
10/27/06	28.7	5.9	0.08		10.7	4332	73	17500		
10/30/06	29.0	5.7	0.08		10.9	1367	33	8600		3.6
10/31/06					11.4	870	24	4500		
11/01/06	29.4	5.7	0.08		11.3	2419	26	3400		
11/02/06	29.5	5.7	0.08		9.0	1941	15	3245		
11/03/06	29.5	5.8	0.07		10.3	310	12	3250		
11/06/06	30.3	5.6	0.07		9.7	1300	15	4800		3.8
11/07/06	30.2	5.5	0.06		9.0	2166	35	3100		
11/08/06	30.6	5.5	0.07		7.4	876	27	2100		
11/09/06	30.7	5.5	0.06		7.6	876	2	1100		
11/10/06	30.4	5.4	0.06		6.8	1373	27	10300		
11/13/06	31.1	5.3	0.06		6.1	1842	163	3300		4.0
11/14/06					7.0	2827	22	2850		
11/15/06	31.0	5.4	0.07		7.8	2407	32	2200		
11/16/06	31.0	5.3	0.07		7.4	2240	30	4100		
11/17/06	31.7	5.2	0.08		5.6	794	73	14200		
11/20/06	31.4	5.4	0.06		4.3	1034	17	2500		3.4
11/21/06	31.7	5.3	0.06		4.6	1414	58			
11/22/06	31.8	5.3	0.06		3.9					

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	T.Coliform Counts/ 100ml	*E.coli* Counts/ 100ml	HPC Counts/ ml	NH3-N mg/l	TOC mg/l
11/27/06	32.7	4.9	0.06		4.4	1203	21	4740		3.6
11/28/06	29.4	4.3	0.06		21.2	20924	1642	13000		
11/29/06	32.0	4.7	0.06		11.4	22398	576	15000		
11/30/06	32.7	5.1	0.06		8.7	7270	987	14800		
12/01/06	32.9	5.2	0.06		8.7	2014	197	7800		
12/04/06	34.2	6.0			6.4	808	10	2200		3.9
12/05/06	33.7	6.2			6.5	1203	19	1900		
12/06/06	34.5	7.3	0.05		8.5		27	5100		
12/07/06	33.1	5.4			9.0	3024	19	2750		
12/08/06	35.0	4.7	0.06		5.5	651	6	1500		
12/11/06	33.5	5.9			6.3	1266	28	2860		3.8
12/12/06	33.3	5.4	0.06		6.6	1961	40	40		
12/13/06	33.8	4.7			6.8	3466	51	3460		
12/14/06	34.2	4.6	0.06		7.5	1241	43	3975		
12/15/06	34.2	4.4	0.05		5.8	345	15	3440		
12/18/06	36.0	4.6			5.4	613	7	3645		4.3
12/19/06	36.2	4.6	0.05		6.2	517	14	517		
12/20/06	35.8	4.4	0.05		6.8	921	24	2240		
12/21/06	34.8	4.5			9.2		162	1440		
12/22/06	34.8	5.2			18.2					
12/27/06					7.3	1842	60	3080		4.3
12/28/06	35.6	6.5			7.0	2240	43	2930		
12/29/06					6.9	333	22	3920		
01/02/07	34.2	7.8			50.2	11260	740	9540		3.7
01/03/07	35.1	7.3			26.5	10024	170	9100		
01/04/07					22.1	2947	44	9450		
01/05/07	32.6	8.3			19.2	2897	80	560		
01/08/07	33.0	7.9			17.0	2399	53	1850		3.7
01/09/07	32.1	9.0			15.1	1293	27	2520		
01/10/07	32.1	9.1			14.1	2419	34	2260		
01/11/07	32.6	9.0			11.1	1941	27	2580		
01/12/07	30.9	11.0			12.1	1361	36	3580		
01/15/07	33.7	10.8			6.6	814	32	1000		3.0
01/16/07	33.6	10.6			2.9	57	1	960		
01/17/07	33.9	10.8			9.7	126	2	550		
01/18/07	34.2	11.2			8.2	225	28	3190		
01/19/07	33.2	11.5			5.6	411	10			
01/22/07	35.7	11.1	0.05		7.4	365	5	1380		3.7
01/23/07	33.9	11.3	0.05		6.7	201	20	1240		
01/24/07	34.2	11.4			4.3	142	33	3260		
01/25/07	34.6	11.5			6.8	179	29	1980		
01/26/07	34.0	11.2			7.5	387	22	1810		
01/29/07	37.8	11.8			4.4	219	10	3100		3.4
01/30/07	36.2	11.8			4.2	238	20	1520		
01/31/07	35.9	12.0			6.4	291	16	2960		
02/01/07	36.0	11.9			13.9	326	25	1020		
02/02/07	35.4	11.8			16.8	261	26	1360		
02/05/07	34.0	11.0			3.7	461	30	8480		3.3
02/06/07	36.1	11.7			14.3	308	55	1880		

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	T.Coliform Counts/ 100ml	*E.coli* Counts/ 100ml	HPC Counts/ ml	NH3-N mg/l	TOC mg/l
02/07/07	35.7	11.5	0.06		3.9	387	33	980		
02/08/07	35.1	11.5			3.4	461	35	660		
02/09/07	35.7	11.3			3.9	326	58			
02/12/07	35.8	11.1			6.1	980	17	4108		3.5
02/13/07	36.2	10.9			5.1	461	51	2100		
02/14/07	36.9	11.0			3.8	345	48	820		
02/15/07	37.3	10.8			4.0	308	43	1880		
02/16/07	38.0	10.5			6.1	411	42	7420		
02/19/07	42.0	10.5			4.3	308	41	460		3.2
02/20/07	47.5	10.0			4.0	1046	7	1960		
02/21/07	50.3	9.9			5.5	2827	62	9810		
02/22/07	46.4	9.1			10.0	8665	192	28305		
02/23/07	38.7	9.7			6.8	6488	31	13800		
02/26/07	43.1	9.6		0.09	9.8	15402	261	12000		4.3
02/27/07	40.7	9.9			5.5	4962	276	13200		
02/28/07	39.0	9.9			5.0	1539	146	13200		
03/01/07	42.9	9.7			5.2	1553	80	5450		
03/02/07	47.0	9.1			7.4	2419	172	5250		
03/05/07	45.3	9.4			5.8	731	158	5000		3.6
03/06/07	43.2	9.6			5.6	1095	280	4600		
03/07/07	43.7	9.7		0.07	5.7	409	186	6500		
03/08/07	42.0	9.7			4.6	409	186	6500		
03/09/07	44.2	9.0			8.3	613	160	15800		
03/12/07	30.3	7.8		0.14	70.1	19560	310			4.3
03/13/07	28.4	7.6		0.18	102.0	28272	296	18000		
03/14/07	29.7	7.4		0.18	52.3	9780	162	55000		
03/15/07	24.7	6.7		0.15	43.7	12033	108	17500		
03/16/07	18.7	5.4		0.17	99.6	14540	91	5000		
03/19/07	12.3	5.4	0.06	0.30	77.0	17240	72	29000		6.1
03/20/07	12.2	5.4	0.05	0.33	97.3	4374	41	27700		
03/21/07	13.9	5.5	0.06	0.29	75.5	7270	36	22800		
03/22/07	11.7	5.6	0.06	0.30	60.1	1733	74	7950		
03/23/07	12.0	5.6	0.06	0.26	57.3	1633	19	5800		
03/26/07	13.8	6.2	0.05	0.22	41.5	870	42	2600		6.2
03/27/07	13.3	6.0		0.22	35.2	684	17	7900		
03/28/07	14.4	6.5		0.20	26.1	816	15	1800		
03/29/07	13.8	6.3	0.05	0.20	24.3	387	17	11200		
03/30/07	15.8	6.9			22.9	517	17	3560		
04/02/07	18.0	7.6		0.10	27.0	1300	42			5.3
04/03/07	18.3	7.5			24.5	1120	78	9010		
04/04/07	19.4	7.8		0.14	55.2	1034	40	1490		
04/05/07	19.6	8.1	0.03		49.1	2419	261	7200		
04/06/07	21.2	8.8	0.04	0.10	39.6	794	97	3000		
04/09/07	21.5	10.4			24.1	1600	90	8480		4.2
04/10/07	22.1	10.9			20.7	739	42	5035		
04/11/07	22.4	10.6			21.5	1600	40	6095		
04/12/07	23.5	10.3			28.9	1180	49	3200		
04/13/07	23.2	10.8			22.6	821	29	1920		
04/16/07	24.0	9.9			25.0	387	14	1250		4.0

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	T.Coliform Counts/ 100ml	*E.coli* Counts/ 100ml	HPC Counts/ ml	NH3-N mg/l	TOC mg/l
04/17/07	24.1	9.9			20.7	326	19	1100		
04/18/07	24.5	10.4			20.9	336	4	1250		
04/19/07	25.5	10.3			22.9	326	5	3180		
04/20/07	25.7	10.8			20.8	228	4			
04/23/07	25.9	10.5			30.3	1300	61	1320		4.1
04/24/07	25.8	10.6			20.1	582	14	2360		
04/25/07	24.6	9.3			113.0	14210	1220	12500		
04/26/07	11.2	6.2		0.10	154.0	129970	54750	58000		
04/27/07	11.4	6.4	0.06	0.28	292.0	98040	6970	47000		
04/30/07	16.4	9.8		0.20	72.2	5710	100	6200		4.2
05/01/07	17.9	10.5	0.07	0.18	70.7	12033	168	4000		
05/02/07	19.3	9.9		0.10	46.7	8164	86	3900		
05/03/07	18.8	10.0	0.05	0.14	36.6	4332	123	4600		
05/04/07	18.5	10.0	0.05	0.12	28.2	909	63	4600		
05/07/07	19.2	10.1		0.12	39.9	22470	1850	232000		4.7
05/08/07	19.5	10.8	0.06	0.13	55.4	31062	6896	26200		
05/09/07	19.5	11.8	0.06	0.15	62.5	22398	1434	21200		
05/10/07	20.2	11.9		0.11	35.9	6152	4260	8600		
05/11/07	20.3	12.0		0.13	25.3	3654	31	4300		
05/14/07	21.1	11.4		0.10	17.6	1954	31	4200		4.0
05/15/07	21.6	11.6			7.8	3266	25	2600		
05/16/07	22.0	11.7	0.05		6.2	6932	38	2250		
05/17/07	21.9	11.6	0.05		10.1	7068	21	5050		
05/18/07	21.8	11.7			11.6	1733	15	4300		
05/21/07	22.1	11.9	0.06		7.4		19	1320		4.0
05/22/07	22.1	11.7	0.06		7.7		18	1680		
05/23/07	22.9	11.6	0.09		9.2	6867	37	4400		
05/24/07	23.2	11.5	0.08		15.7	32550	219	19340		
05/25/07	19.7	10.2		0.14	116.0	57940	6210			
05/29/07	21.0	11.7	0.09	0.11	29.4	25994	462	9600		4.1
05/30/07	22.2	11.6	0.08		20.6	6370	152	10500		
05/31/07	22.1	11.4	0.09		31.3	19608	456	1540		
06/01/07	22.8	11.9	0.09		15.1	7701	373	10800		
06/04/07	22.9	11.8	0.09		10.5	15531	79	2200		3.8
06/05/07	22.8	12.1	0.11		10.2	19863	28	960		
06/06/07	22.1	12.3	0.10		9.5	10024	31	2340		
06/07/07	23.1	13.0	0.10		20.8	13734	47	2420		
06/08/07	23.0	12.8	0.12		15.3	1414	40	2880		
06/11/07					18.0	6152	71	1320		3.6
06/12/07	23.1	12.7	0.10		14.2	9804	93	3660		
06/13/07	24.3	13.1			13.0	9208	79	2240		
06/14/07	23.5	12.6	0.14		11.7	6131	74	1680		
06/15/07	23.9	12.9	0.12		10.3	7270	86	2960		
06/18/07	23.2	12.4	0.15		7.0					3.4
06/19/07	23.0	12.1	0.17		9.1	20924	222	5300		
06/20/07	23.5	12.2	0.15		6.9	10230	55	2300		
06/21/07	22.9	11.9	0.17		8.2	6510	55	3975		
06/22/07	23.1	11.9	0.19		7.2	8820	63	10600		
06/25/07	20.8	11.3	0.21		22.8	24810	1046	12600		3.5

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	T.Coliform Counts/ 100ml	*E.coli* Counts/ 100ml	HPC Counts/ ml	NH3-N mg/l	TOC mg/l
06/26/07	22.0	11.3	0.27		16.3	16375	649	10400		
06/27/07	22.8	10.1	0.24		16.8	16328	387	3670		
06/28/07	23.1	10.8	0.22		12.5	10950	308	2240		
06/29/07	23.4	10.0	0.24		18.0	13734	126	3220		
07/02/07	23.2	9.8	0.34		13.6	8704	34	4840		3.6
07/03/07	22.8	9.6	0.26		19.5			2560		
07/05/07	23.9	9.5	0.21		18.8		36	36		
07/06/07	22.9	9.3	0.25		17.8	24066	18	3090		
07/09/07	23.0	8.8	0.26		12.0	9687	11	3920		3.7
07/10/07	23.3	8.9	0.21		12.3	10344	7	560		
07/11/07	23.3	8.6	0.19		12.3	9208	12	2380		
07/12/07	23.4	8.4	0.19		19.8	6867	7	3445		
07/13/07	23.7	8.3	0.19		14.8	8664	16			
07/16/07	23.5	6.6	0.21		30.3	43520	9768	12190		4.1
07/17/07	24.6	6.5	0.27		18.8	24420	108	45580		
07/18/07	25.6	5.7	0.28		16.1	48384	96	10335		
07/19/07	25.7	5.3	0.33		20.0	99315	1046	225250		
07/20/07	29.6	5.9	0.33	0.27	14.0	32550	53	7420		
07/23/07	24.8	5.4	0.38		23.9	27550	579			3.6
07/24/07	25.9	5.1	0.41		28.6	24890	228	6100		
07/25/07	27.5	4.0	0.41		24.1	27186	83	4100		
07/26/07	28.1	3.7	0.50		34.6	18232	46			
07/27/07	28.1	3.6	0.39		32.3	23820	461	13780		
07/30/07	27.2	3.7	0.44		17.0	60165	51	14840		4.7
07/31/07	26.9	3.8	0.41		15.6	17240	80	1258		
08/01/07					28.5	51770	46			
08/02/07	28.3	3.7	0.37		14.7	38505	38			
08/03/07	27.2	3.5	0.36		15.1	15380	53	3540		
08/06/07	27.5	2.9	0.12		15.1	17240	325	11400		3.8
08/07/07	26.7	3.2	0.21		19.6		308	21400		
08/08/07	27.2	3.4	0.25		10.7	483840	34	7500		
08/09/07	26.7	2.9	0.13		22.1	310620	1203	34150		
08/10/07	74.8	3.4	0.17	0.18	13.7	82120	34	600		
08/13/07	29.5	2.5	0.07		16.0	51720	13	6800		4.2
08/14/07	29.1	2.6	0.07		13.8	18500	26	2750		
08/15/07	28.9	2.8			13.7	11795	12	7900		
08/16/07	29.1	2.4	0.08		13.2	2735	15	1550		
08/17/07	28.8	2.4	0.07		57.0	10462	13	470		
08/20/07	28.4	2.4	0.17		15.6	8164	16	3370		4.5
08/21/07	28.6	2.2	0.28		21.0	34658	133	7100		
08/22/07					61.8	8925	127	10000		
08/23/07	13.3	2.0	0.14		111.0	17240	172	15250		
08/24/07	11.4	2.6	0.12	0.12	68.1	27375	158	26800		
08/27/07	7.6	3.6	0.10	0.20	51.9	11235	108	9500		5.3
08/28/07	8.6	3.9	0.12	0.19	37.5	9222	41	25400		
08/29/07					33.5	60165	272	38800		
08/30/07	9.7	3.7	0.13	0.17	33.0	3010	22	11850		
08/31/07	9.3	4.1	0.11	0.20	25.1	4219	23	12000		
09/04/07	15.4	4.9	0.12	0.24	17.6		10	4200		5.8

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	T.Coliform Counts/ 100ml	*E.coli* Counts/ 100ml	HPC Counts/ ml	NH3-N mg/l	TOC mg/l
09/05/07					15.3	4838	4			
09/06/07					15.5	9932	9	2850		
09/07/07	12.8	3.9			77.3	241920	1990	113950		
09/10/07	12.5	4.0		0.15	13.7	72700	100	14000		4.8
09/11/07	12.7	3.9		0.14	11.8	40820	29	19000		
09/12/07					13.7	27360	23	5100		
09/13/07	18.5	3.8		0.10	13.0	34335	23	5550		
09/14/07	14.6	3.8	0.20	0.13	17.5	10715	12	5800		
09/17/07	16.2	3.4			19.3	4352	62			5.2
09/18/07	17.6	2.5			22.4	4764	15	9810		
09/19/07					19.0	7380	99	3900		
09/20/07	17.2	3.4	0.36		12.0	3873	15	5560		
09/21/07	17.9	3.4	0.40		14.0	2419	6	21730		
09/24/07	18.3	3.3	0.32		15.6	3434	6	90		4.9
09/25/07	19.1	3.9	0.28		17.0	1986	7	2760		
09/26/07					17.9	2442	7	2680		
09/27/07	19.3	3.8	0.31		17.4	2738	5			
09/28/07	20.6	4.2	0.28		15.7	2419	5	2445		
10/01/07	22.4	5.4	0.18		21.9	3448	35	5565		3.6
10/02/07	21.9	5.2	0.22		20.4	5794	127	1640		
10/03/07	22.2	5.2	0.25		26.6	13540	240	6890		
10/04/07	21.8	5.2	0.30		24.3	3194	206	6095		
10/05/07	22.8	6.0	0.20		24.2	1414	27	2560		
10/08/07	20.3	6.5	0.20		28.2	104620	1733	7950		3.9
10/09/07	21.6	6.5	0.27		13.4	5730	74	6900		
10/10/07					26.5	1		8800		
10/11/07	19.3	7.4	0.12	0.10	30.5	8022	183	6250		
10/12/07	19.3	7.4	0.13	0.11	23.6	4082	98	3950		
10/15/07	18.6	7.2	0.08	0.12	77.2	98040	3790			4.4
10/16/07	17.2	7.1	0.07	0.16	79.1	223980	28600	69150		
10/17/07					46.4	58180	2200	40800		
10/18/07	18.5	7.6	0.07	0.10	35.4	28510	630	16000		
10/19/07	18.8	7.5			31.9	28272	690	11400		
10/22/07	19.0	8.1		0.11	27.7	4494	194	3550		4.1
10/23/07	18.5	8.0			25.2	4352	98	3750		
10/24/07					23.8	1426	73	3400		
10/25/07	18.0	7.9		0.07	18.6	2719	52	4200		
10/26/07	17.7	8.0		0.11	21.5		224	11395		
10/29/07	18.0	8.1		0.13	19.5	1088	27	12200		4.4
10/30/07	18.4	8.1		0.09	18.8	1986	28	6400		
10/31/07					17.8	1767	22	6800		
11/01/07	18.3	8.1		0.10	20.2	1151	23	11600		
11/02/07	18.5	8.1		0.10	17.4	811	20	6500		
11/05/07	19.2	8.1			15.6	461	14	5800		4.1
11/06/07	19.9	7.9			21.3	866	11	5600		
11/07/07					14.7	411	12	5200		
11/08/07	20.4	7.8		0.08	17.2	326	17	5100		
11/09/07	20.6	7.9			13.7	517	11	4300		
11/12/07	21.5	7.6			11.8	613	15	4800		4.0

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	T.Coliform Counts/ 100ml	*E.coli* Counts/ 100ml	HPC Counts/ ml	NH3-N mg/l	TOC mg/l
11/13/07	21.2	7.7			12.2	411	14	2700		
11/14/07					12.6	461	25	3300		
11/15/07	21.9	7.5			24.1	1120	11	4200		
11/16/07	22.1	7.5			18.5	866	18	3800		
11/19/07	22.7	7.5			11.9	461	14	1300		4.0
11/20/07	22.0	7.5			7.5	308	26			
11/21/07	23.2	7.5			18.1					
11/26/07	23.2	7.3			8.7	435	17	1780		3.3
11/27/07	23.4	7.3			7.6	727	93	1300		
11/28/07					7.6	411	79	880		
11/29/07	24.3	7.0			14.3	1733	36	1220		
11/30/07	25.4	6.9			10.7	496	18	1680		
12/03/07	27.1	6.8			10.4	5600	1790	1790		3.1
12/04/07	25.1	7.1			8.2	649	15	2480		
12/05/07	25.4	7.1			10.2	1986	26	1620		
12/06/07	29.7	6.9			6.0	727	17	1220		
12/07/07	26.6	6.8			7.2	548	18	1440		
12/10/07	26.7	6.9			3.1	154	16	1460		3.6
12/11/07	27.4	6.9			4.9	727	50	2580		
12/12/07					4.9	2419	34	1280		
12/13/07	32.5	7.1			8.7	1553	51	201		
12/14/07	31.3	7.2			5.9	727	41	850		
12/17/07	27.8	6.9			5.8	291	36	820		3.4
12/18/07	29.0	7.2			5.3	326	33	720		
12/19/07					4.8	345	40	940		
12/20/07	29.7	7.5			4.4	42	42			
12/21/07	29.5	7.4			4.2	194	6	940		
12/26/07	30.8	7.2			3.2	194	6	940		3.8
12/27/07	31.3	7.0			2.6	166	5	1200		
12/28/07	30.6	7.1			3.1	81	2	380		
12/31/07	31.1	7.3			4.0			220		3.7
01/02/08	30.5	7.1			2.9	18	1	8215		
01/03/08	30.5	7.0			4.6	20	2	2279		
01/04/08	30.3	7.1			4.0	25	2	1458		
01/07/08	33.0	7.0			4.9	816	15	3360		3.5
01/08/08					6.9	2419	30	5565		
01/09/08	31.9	6.9			3.9	1842	6	3860		
01/10/08	30.4	7.0			4.1	4838	31	7420		
01/11/08	31.4	7.1			4.2	276	2	1260		
01/14/08	30.9	6.8			4.0	20	1			3.2
01/15/08	30.4	6.8			3.7	33	2	580		
01/16/08					4.9	186	15	2880		
01/17/08	31.3	6.9			3.2	11	1	4890		
01/18/08	30.9	6.9			3.5	9		670		
01/21/08	31.8	6.9			4.6	12	1	1560		3.3
01/22/08	31.5	6.9			2.8	16	1	1920		
01/23/08					6.4	42	5	2000		
01/24/08	32.0	6.4			3.7	10	1	1460		
01/25/08	32.1	6.5			3.2	7		2180		

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	T.Coliform Counts/ 100ml	*E.coli* Counts/ 100ml	HPC Counts/ ml	NH3-N mg/l	TOC mg/l
01/28/08	34.0	6.3			5.2	172	27	580		3.7
01/29/08	45.7	6.3			5.1	1120	1	1160		
01/30/08	34.5	6.5			12.5	2599	2	960		
01/31/08	31.8	6.3		0.14	8.7	2442	6	2300		
02/01/08	32.0	6.7		0.11	4.1	1986	11			
02/04/08	32.8	6.3			3.2	228	4	590		3.6
02/05/08	41.2	6.2			5.6		194	9805		
02/06/08	36.1	6.4			3.2	22470	89	83900		
02/07/08	34.1	6.6			1.5	78	4	1780		
02/08/08	34.9	6.5			2.1	46	4	1660		
02/11/08	35.5	6.6			3.5	411	50	2080	0.18	3.8
02/12/08	34.1	6.5			5.0	488	61	4505	0.16	
02/13/08	35.0	6.3			3.8	1203	99	1680	0.14	
02/14/08	34.5	6.5			5.1	407	37	6040	0.15	
02/15/08	34.3	6.4			5.8	179	40	1840	0.20	
02/18/08	46.2	6.1			5.4	1203	131	6757	0.20	3.9
02/21/08	36.4	6.3			3.9	179	33	14575	0.12	
02/22/08	35.7	6.1			3.2	130	26	5565		
02/25/08	44.9	5.7			6.2	980	24	9400	0.21	3.8
02/26/08	47.4	5.3		0.12	13.3		102	35775	0.31	
02/27/08					24.4	39726	153	103350	0.49	
02/28/08	38.9	5.3	0.05	0.25	15.2	43520	155	153700	0.57	
02/29/08	38.7	5.6		0.15	7.0	2419	52	74200	0.50	
03/03/08	30.2	3.7	0.06	0.39	101.0	98040	200	88000		11.1
03/04/08	30.0	3.9	0.09	0.58	57.6	77010	461	122000		
03/05/08	27.8	4.1	0.11	0.72	50.4	43520	201	129850		
03/06/08	30.1	4.2	0.09	0.60	24.6	81640	166	1246000		
03/07/08					17.4	38730	248	170000		
03/10/08	30.8	4.3	0.06	0.28	22.3	12100	157	83000	0.77	6.8
03/11/08	31.1	4.4	0.05	0.27	18.5	16070	68	48000		
03/12/08					50.1	19180	70	116000	0.80	
03/13/08	27.2	3.5	0.07	0.35	65.1	141360	44	108000		
03/14/08	25.1	3.4	0.06	0.54	64.3	9760	50	106000		
03/17/08	18.3	2.7	0.10	0.59	102.0	18600	166	114000		11.1
03/18/08	16.1	2.4	0.12	0.72	107.0	17220	93	262000		
03/19/08	17.4	2.8	0.15	0.84	86.3	68670	91	87000		
03/20/08	17.8	3.2	0.15	0.86	76.5					
03/21/08	17.7	3.6	0.14	0.79	53.3	6896	13	89000		
03/24/08	18.3	4.4	0.10	0.41	29.8	1120	9	3500		7.9
03/25/08	19.3	4.6	0.10	0.34	29.3	613	3	9000		
03/26/08	19.1	4.7	0.08	0.36	28.8	1203	6	11600		
03/27/08	19.1	4.7		0.38	29.3	770	9	14550		
03/28/08	20.8	5.1	0.08	0.28	30.1	649	5	10400		
03/31/08	20.0	5.1	0.06	0.24	23.0	276	3	5200		5.8
Mean	26.8	7.6	0.14	0.22	20.9	453	14586	0.34	4.2	26.8
Median	26.9	7.3	0.1	0.2	14.9	41	3920	0.2	3.9	26.9

APPENDIX B

Raccoon River Water Quality

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	*E. coli* Counts/ 100ml	HPC Counts/ml	NH3-N mg/l	TOC mg/l	TN mg/l
03/01/06	37	7.7		0.13	15	3	580			
03/02/06	36	8.7		0.15	24	5	1590			
03/03/06	36	8.3		0.14	19	6	940			
03/06/06	40	6.3	0.03	0.14	17	35	1250			
03/07/06	35	6.1		0.14	15	12	1230		3.8	6.8
03/08/06	36	5.7		0.14	11	88	1280			
03/09/06	52	4.5		0.09	73	307	15400			
03/10/06	38	5.2		0.14	20	75	5800			
03/13/06	37	4.9		0.11	25	213				5.7
03/14/06	38	5.8			23	2	1400			
03/15/06	38	6.9		0.10	30	6	1790			
03/16/06	38	8.0		0.12	23	15	1740			
03/17/06	37	8.7		0.12	20	6	2120			
03/20/06	36	10.1		0.10	16	2	830		3.9	10.7
03/21/06	37	10.3	0.04	0.09	17	7	1980			
03/22/06	52	10.3		0.10	12	16	490			
03/23/06	41	10.2		0.10	11	16	2650			
03/24/06	39	10.1		0.08	16	6	1520			
03/27/06	36	9.5			27	435	1340		4.1	11.1
03/28/06	45	8.4		0.08	32	62	3560			
03/29/06	39	8.9		0.06	23	7	2760			
03/30/06	36	9.0		0.06	29	10	1845			
03/31/06	46	6.9			234	400	14200			
04/03/06	31	10.6		0.10	823	4020	43000			14.6
04/04/06	29	13.5			389	1178				
04/05/06	30	15.8		0.07	319	826	11500			
04/06/06	28	15.7		0.11	281	1552	9800			
04/07/06	29	15.7		0.15	207	194	24800			
04/10/06	30	15.3		0.11	109	27	2750			
04/11/06	30	15.4		0.11	107	32	3800			
04/12/06	31	14.9		0.11	82	127	5500			
04/13/06	30	14.8		0.11	82	24	5050			
04/14/06	31	14.7		0.09	82	19	5150			
04/17/06	31	13.6			67	57				
04/18/06	31	13.5			54	56				
04/19/06	31	13.1			60	407				
04/20/06	32	13.7				42				
04/21/06	31	14.0			46	26				
04/24/06	32	14.9			38	33				
04/25/06	32	14.3			24	104				
04/26/06	32	13.6			33	107				
04/27/06	33	13.1		0.07	27	26				
04/28/06	32	13.2			33	17				
05/01/06	26	8.4		0.08	284	19863			4.2	
05/02/06	26	11.8			275	9070			4.0	

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	*E. coli* Counts/ 100ml	HPC Counts/ml	NH3-N mg/l	TOC mg/l	TN mg/l
05/03/06	31	16.5	0.06	0.12	261	3680				
05/04/06	28	18.5			225	3448				
05/05/06	28	18.7	0.05	0.13	168	584				
05/08/06	30	17.4		0.09	86	148			3.0	
05/09/06	30	16.3		0.07	60	426				
05/10/06	30	16.1		0.09	72	148				
05/11/06	32	16.8			70	170				
05/12/06	31	16.2			62	101				
05/15/06	31	16.0		0.07	43	192	5300		2.8	
05/16/06	32	16.5			40	55	3100			
05/17/06	30	15.6			29	95				
05/18/06	33	16.0			38	73				
05/19/06	30	14.9			40	32				
05/22/06	32	15.1			38	16	2800		2.7	
05/23/06	32	14.5			34	53				
05/24/06	31	13.3			40	1616	14800			
05/25/06	32	13.8			26	60	6850			
05/26/06	31	12.9			32	662	3900			
05/30/06	30	12.9			30	82	2620		3.4	12.8
05/31/06	29	12.3			36	56	2680			
06/01/06	29	12.3			43	36	2180			
06/02/06	29	12.6	0.04		39	13	760			
06/05/06	30	12.6	0.04		31	36	1580		3.2	
06/06/06	30	12.8			31	47	1560			
06/07/06	30	12.9	0.03		31	38				
06/08/06	31	13.0			30	33	5400			
06/09/06	31	12.8			31	21	1060			
06/12/06	31	12.4			24	91	1085		3.3	12.4
06/13/06	31	12.2			18	77	2860			
06/14/06	32	12.1			18	68	2280			
06/15/06	31	11.8			27	62	2915			
06/16/06	32	12.0			25	84	1940			
06/19/06	35	10.7	0.07		19	201	2260		3.1	10.7
06/20/06	35	10.3	0.06		30	58	1980			
06/21/06	35	10.0	0.06		35	102	2200			
06/22/06	34	9.5			30	142	5300			
06/23/06	33	9.1	0.07		31	91	6625			
06/26/06	33	8.1			29	517	10400		3.3	8.1
06/27/06	32	7.9			31	162	3000			
06/28/06	31	7.7	0.05		27	166	4500			
06/29/06	32	7.3	0.06		17	133	3600			
06/30/06	32	6.7	0.06		23	108	4000			
07/03/06	33	5.7	0.05		19				3.4	5.2
07/05/06	32	5.2	0.06		26	172			3.4	
07/06/06	30	4.4	0.05		23	172	580			
07/07/06	31	3.9			22	122	1440			
07/10/06	33	3.5	0.05		22	105	3280			
07/11/06	30	2.2			43	3270	32400		4.1	2.5
07/12/06	31	2.3			38	713	18000		4.1	

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	*E. coli* Counts/ 100ml	HPC Counts/ml	NH3-N mg/l	TOC mg/l	TN mg/l
07/13/06	15	3.6	0.08		341	1680	63600			
07/14/06	23	3.4			155	4020	58300			
07/17/06	27	4.0			58	410	9900		3.9	4.5
07/18/06	28	3.1			49	210	4100			
07/19/06	30	2.4			39	118				
07/20/06	31	1.8			36	115	5140			
07/21/06	31	1.1			35	102	2900			
07/24/06	30	0.1			36	16	2360		3.8	1.5
07/25/06	32	0.1			34	58	1260			
07/26/06	14	0.4			275	8160				
07/27/06	30	0.4			133	1040	2600			
07/28/06	29	0.4			43	579	2600			
07/31/06	29				42	105	3200		4.0	
08/01/06	29				39	387	3560			
08/02/06	31				36					
08/03/06	31				37	210	7420			
08/04/06	30				31	248	9805			
08/07/06	30				32	56	3480		4.2	0.4
08/08/06	30				30	86	1220			
08/09/06	30				8	69	11925			
08/10/06	37	0.1			10	5040	18285			
08/11/06	27	0.1			7	75	7950			
08/14/06	31	0.1			8	613	17225		4.4	
08/15/06	31	0.1			6	615			4.4	0.9
08/16/06	30	0.1			5	26				
08/17/06	28	0.2		0.56	57	9208				
08/18/06	28	0.3			136	3930				
08/21/06	19	1.0			186	933			4.6	1.4
08/22/06	23	1.6			114	615	10200			
08/23/06	28	1.3			79	6700	260			
08/24/06	30	0.7			44	144	23850			
08/25/06	32				56	6330	13100			
08/28/06	28	0.3			97	23820	82200		5.7	
08/29/06	32	0.7			60	5500	41000			
08/30/06	19	1.4			441	6867	204000			
08/31/06	24	3.3			142	86	41000			
09/01/06	26	4.6		0.05	53	309				
09/05/06	27	1.9			81	474	17000		4.7	2.3
09/06/06	27	1.6			55	370	13000			
09/07/06	28	1.5			49	162	3500			
09/08/06					43	55	9800			
09/11/06	24	1.1			156	11880			4.3	1.5
09/12/06					485	4800	94000			
09/13/06	16	4.8		0.07	242	8700				
09/14/06					93	1720	67000			
09/15/06	23	7.6		0.11	87	1600	45000			
09/18/06	14	3.9			1129	4920	521000		5.6	4.2
09/19/06					243	6260	59000			
09/20/06	17	6.3		0.13	102	2180	368000			

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	*E. coli* Counts/ 100ml	HPC Counts/ml	NH3-N mg/l	TOC mg/l	TN mg/l
09/21/06					72	970	36000			
09/22/06	22	6.9			46	980	414000			
09/25/06	23	8.6		0.09	234	1410	4050		4.5	9.1
09/26/06	25	9.3		0.09	42	518	22000			
09/27/06	25	9.3		0.09	36	126	11600			
09/28/06					33	210	16200			
09/29/06	26	9.4		0.09	29	156	13050			
10/02/06	25	9.1			33	108	10600		3.6	9.2
10/03/06					84	128	10400			
10/04/06					158	57	8700			
10/05/06					19	79	9700			
10/06/06	26	8.6			13	38	2450			
10/09/06	26	7.9			16	51	2700		4.2	7.3
10/10/06	27	8.4			15	54	3040			
10/11/06	27	8.2			17	866	6540			
10/12/06					11	96	5690			
10/13/06	26	8.5			12	57	2760			
10/16/06	27	8.6			9	866	4200		3.3	7.4
10/17/06					12	132	6600			
10/18/06	27	8.4			8	68	5400			
10/19/06					8	69	8650			
10/20/06	28	8.6			8	406	2600			
10/23/06	27	8.8			9	96	2100		3.4	
10/24/06					8	3710	32			
10/25/06	28	9.5			6	37	6280			
10/26/06					8	394	7400			
10/27/06	28	9.4			6	28	9900			
10/30/06	28	9.3			6	45	7200		2.7	9.3
10/31/06					5	30	6900			
11/01/06	28	9.3			5	41	6500			
11/02/06	28	9.2			5	3	7685			
11/03/06	29	9.1			7	36	3180			
11/06/06	30	8.9			4	10	6145		2.7	9.6
11/07/06	31	8.9			4	24	4500			
11/08/06	31	8.7			4	20	1700			
11/09/06	31	8.6			3	19	3300			
11/10/06	31	8.4			7	3973	15400			
11/13/06	31	8.1			6	429	9600		3.4	8.2
11/14/06	31	8.3			5	38	2100			
11/15/06	31	8.4			4	27	2300			
11/16/06	31	8.4			5	35	5300			
11/17/06	31	8.5			4	39	8800			
11/20/06	31	8.9			3	10	700		2.6	7.8
11/21/06	32	8.9			4	18				
11/22/06	32	8.9			3					
11/27/06	34	8.7	0.05		3	40	2580		2.5	8.4
11/28/06	28	5.7			68	4764	46000			
11/29/06	31	7.5			21	2212	25600			
11/30/06	30	8.4	0.06		13	960	12500			

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	*E. coli* Counts/ 100ml	HPC Counts/ml	NH3-N mg/l	TOC mg/l	TN mg/l
12/01/06	31	8.8			9	268	7000			
12/04/06	38	10.9			3	122	2000		3.1	11.5
12/05/06	38	10.9			5	68	2750			
12/06/06	36	10.7			7	64	3100			
12/07/06	36	10.9			5	22	2915			
12/08/06	39	11.0			4	27	2240			
12/11/06	35	10.4			6	37	1553		3.1	10.0
12/12/06	34	9.8			10	52	3700			
12/13/06	33	9.4			12	111	3360			
12/14/06	33	9.0			13	32	6400			
12/15/06	32	8.6			16	25	4680			
12/18/06	33	8.8			7	15	2775		2.6	9.2
12/19/06	34	8.9			6	10	2100			
12/20/06	33	8.7			7	6	1920			
12/21/06	31	7.1			29	1414	4720			
12/22/06	28	7.3			56					
12/27/06	31	10.7			13	24	3080		3.0	11.3
12/28/06	30	10.7			13	19	4665			
12/29/06					11	16	2880			
01/02/07	25	9.4			284	2090	21200		4.1	
01/03/07	29	10.9			117	2260	50400			
01/04/07					78	740	54700			
01/05/07	31	12.8			64	126	17000			
01/08/07	31	12.8			32	94	10000		3.1	
01/09/07	31	13.0			37	61	3750			
01/10/07	31	13.1			31	58	2600			
01/11/07	31	13.3			28	47	5700			
01/12/07	30	13.0			25	58	5020			
01/15/07	37	13.5			8	50	1880		2.2	
01/16/07	40	12.3	0.23		7	32	1920			
01/17/07	38	14.4			5	25	1250			
01/18/07	35	14.6			5	30	3540			
01/19/07	32	13.9			7	17				
01/22/07	34	14.5			7	39	1290		2.6	
01/23/07	33	14.3			5	26	1000			
01/24/07	33	13.9			5	35	1600			
01/25/07	32	13.3			12	41	3150			
01/26/07	30	12.5			6	18	1320			
01/29/07	34	12.8			5	36	2360		2.3	
01/30/07	33	12.9			5	41	1880			
01/31/07	34	13.3			4	23	1960			
02/01/07	34	13.4			4	34	1165			
02/02/07	34	13.6			5	20	1250			
02/05/07	34	13.6			4	5	1320		2.3	
02/06/07	36	14.0			4	41	820			
02/07/07	36	14.1			4	82	2120			
02/08/07	35	14.0			4	52	540			
02/09/07	35	13.9			4	26				
02/12/07	34	13.0		0.08	6	45	680		2.5	

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	*E. coli* Counts/ 100ml	HPC Counts/ml	NH3-N mg/l	TOC mg/l	TN mg/l
02/13/07	33	12.8			6	27	1710			
02/14/07	34	12.6			5	21	810			
02/15/07	32	12.2			4	30	1400			
02/16/07	32	11.9			5	20	2380			
02/19/07	41	11.8			6	35	3710		2.2	
02/20/07	73	11.0			8	65	4860			
02/21/07	58	10.4			21	74	18600			
02/22/07	39	8.7		0.16	42		92350			
02/23/07	25	7.7			54	132	103350			
02/26/07	24	7.4		0.18	52	426	119000		7.2	
02/27/07	29	8.3		0.17	30	122	61000			
02/28/07	28	8.6			20	63				
03/01/07	43	8.4		0.16	20	118	18500			
03/02/07	34	8.0			22	152	21500			
03/05/07					10	33	8000		3.4	
03/06/07	35	8.6		0.17	10	21	5000			
03/08/07	30	8.0	0.04	0.15	15	250	7450			
03/09/07	34	7.5			31	40	15300			
03/12/07	18	6.0		0.16	553	410			5.5	
03/13/07	15	6.6		0.11	641	1188	30500			
03/14/07	14	6.3		0.15	687	821	97000			
03/15/07	11	5.5	0.06	0.23	524	1046	238500			
03/16/07	11	5.9	0.06	0.32	329	253	64000			
03/19/07	17	9.0	0.06		187	65	3000		4.9	
03/20/07	18	9.7	0.06	0.24	173	65	2000			
03/21/07	25	10.4		0.24	134	137	18000			
03/22/07	21	10.1		0.19	125	104	5300			
03/23/07	22	10.2		0.14	104	108	7600			
03/26/07	22	10.3		0.14	134	862	3550		3.5	11.1
03/27/07	23	10.7			103	1180	27200			
03/28/07	25	10.9		0.10	70	352	13000			
03/29/07	25	11.3			58	55	11600			
03/30/07	26	11.2			49	143	12400			
04/02/07	23	10.2			148	4838			4.0	10.6
04/03/07	26	11.3			106		76850			
04/04/07	27	13.0			136	3840	30000			
04/05/07	26	13.3		0.15	110	1259	13000			
04/06/07	28	14.3		0.11	89	1396	14200			
04/09/07	27	13.6			47	980	5300		2.7	12.9
04/10/07	27	13.5			42	52	4850			
04/11/07	29	12.0			47	155	2100			
04/12/07	27	11.1			70	886	9000			
04/13/07	25	11.7			85	749	10600			
04/16/07	28	13.7			53	43	2800		2.1	14.0
04/17/07	29	14.0			48	36	3250			
04/18/07	28	14.2			43	23	3100			
04/19/07	28	14.0			38	19	2660			
04/20/07	29	13.8			33	18	2880			
04/23/07	29	12.5			40	178	2840		2.8	13.5

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	*E. coli* Counts/ 100ml	HPC Counts/ml	NH3-N mg/l	TOC mg/l	TN mg/l
04/24/07	28	12.6			23	107	4260			
04/25/07	21	9.0			621	18720	59000			
04/26/07	20	7.7	0.05	0.14	479	11120	66000			
04/27/07	12	7.3		0.17	401	10140	37000			
04/28/07	12	9.2		0.35						
04/29/07	13	10.7	0.07	0.31						
04/30/07	16	12.3		0.27	151	1100	13000		4.9	12.6
05/01/07	18	12.8		0.27	161	413	5700			
05/02/07	19	12.6	0.06	0.23	158	327	12400			
05/03/07	20	12.7		0.20	144	200	8950			
05/04/07	21	12.8		0.21	114	170	12800			
05/07/07	12	8.5	0.06	0.10	3842	122620	100700		5.9	9.7
05/08/07	13	9.5		0.13	431	4040	128000			
05/09/07	13	10.3	0.08	0.22	368	6500	87000			
05/10/07	15	11.7	0.10	0.25	252	1350	61000			
05/11/07	15	12.4	0.08	0.22	190	810	47000			
05/14/07	19	13.3		0.18	124	106	23000		4.2	14.8
05/15/07	20	13.5		0.22	108	402	28700			
05/16/07	21	13.7		0.15	109	242	13800			
05/17/07	21	13.6		0.16	98	220	27850			
05/18/07	22	14.0		0.14	87	276	9700			
05/21/07	22	14.1		0.12	64	236	6800		3.0	15.8
05/22/07	22	14.0			75	140	4700			
05/23/07	23	14.2		0.12	60	182	11200			
05/24/07	23	13.4		0.11	60	862	38800			
05/25/07	9	6.8	0.08	0.15	574	32320				
05/29/07	19	14.7		0.14	125	970	19000		4.1	15.7
05/30/07	20	15.0		0.13	102	821	14000			
05/31/07	19	13.1		0.16	210	7660	81000			
06/01/07	21	14.8		0.12	86	775	25000			
06/04/07	22	15.2		0.10	88	1633	7500		2.8	
06/05/07	22	15.1			73	476	7400			
06/06/07	22	15.0			61	249	6300			
06/07/07	22	14.7			55	225	7000			
06/08/07	22	14.8			53	111	7200			
06/11/07					43	76	2600		2.8	16.8
06/12/07	22	14.2			44	61	3100			
06/13/07	23	14.4			39	82	2000			
06/14/07	23	14.3			26	79	2900			
06/15/07	23	14.1			20	28	3120			
06/18/07	24	13.4			26	71			2.6	15.0
06/19/07	23	13.0			44	1046	5830			
06/20/07	23	13.0			37	121	1300			
06/21/07	29	13.4			43	96	2385			
06/22/07	23	13.4			63	488	14045			
06/25/07	38	12.2		0.46	173	7540	36500		3.4	14.3
06/26/07	19	12.6			98	1850	32000			
06/27/07	20	12.7		0.13	81	1034	19000			
06/28/07	40	12.5		0.36	75	1046	11000			

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	*E. coli* Counts/ 100ml	HPC Counts/ml	NH3-N mg/l	TOC mg/l	TN mg/l
06/29/07	22	12.5		0.13	62	370	10100			
07/02/07	22	11.2			43	86	13200		2.6	13.0
07/03/07	22	10.8			48		15000			
07/05/07	22	9.9			46	119	9750			
07/06/07	22	9.4			52	266	8200			
07/09/07	23	8.2			49	37	5200		3.1	9.7
07/10/07	24	7.8			46	55	2500			
07/11/07	22	7.4			45	59	5400			
07/12/07	21	6.6	0.06		41	28	4250			
07/13/07	22	6.1	0.06		39	22	5600			
07/16/07	15	2.9			321	5500	191000		4.8	3.5
07/17/07	23	4.1	0.05		41	256	18200			
07/18/07	23	3.9			35	108	5000			
07/19/07	22	3.2	0.05		59	1986	95400			
07/20/07	22	3.2		0.39	28	49	39750			
07/23/07	22	2.3			118	2310			3.3	2.8
07/24/07	24	2.2			35	105	5600			
07/25/07	22	2.2			54	102	11300			
07/26/07	21	2.0			40	53	14900			
07/27/07	22	1.8			35	1733	26400			
07/30/07	21	2.1			37	30	8700		5.1	3.2
07/31/07	23	1.6			34	26	147			
08/01/07					38					
08/02/07	24	1.1			47	22				
08/03/07	24	0.9			41	6	13300			
08/06/07	23	0.8			109	816	43050		4.6	1.4
08/07/07	16	1.7			259	2750	84800			
08/08/07	13	2.8			274	2200	13000			
08/09/07	17	1.6			405	6131	52500			
08/10/07	23	3.0		0.29	147	1139	54000			
08/13/07	20	2.8			49	2092	34600		5.1	3.8
08/14/07	21	2.4			41	104	8100			
08/15/07	20	2.2			56	249	36700			
08/16/07	22	1.9			61	89	9600			
08/17/07	23	1.5			16	63	48600			
08/20/07	24	0.5			38	41	13200		5.3	1.2
08/21/07	22	0.4			49	2920	103350			
08/22/07					36	132	6000			
08/23/07	14	1.5			476	116	48000			
08/24/07	7	2.9		0.18	265	693	176000			
08/27/07	9	4.9		0.28	124	345	24500		5.4	5.3
08/28/07	11	5.6		0.28	113	387	64000			
08/29/07					127	1281	69000			
08/30/07	11	4.3		0.22	417	8164	125500			
08/31/07	12	4.8		0.28	205	4352	142000			
09/04/07	15	5.9		0.23	88	199	13500		5.1	6.3
09/05/07					78	249				
09/06/07					69	204	11500			
09/07/07	15	2.7			431	8650	268000			

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	*E. coli* Counts/ 100ml	HPC Counts/ml	NH3-N mg/l	TOC mg/l	TN mg/l
09/10/07	15	4.0		0.14	76	520	53000		4.2	4.7
09/11/07	17	3.9		0.14	49	261	19000			
09/12/07					29	150	16000			
09/13/07	13	3.9	0.15	0.11	22	116	2500			
09/14/07	19	4.0		0.13	21	65	12500			
09/17/07	21	5.4			16	62			4.4	6.2
09/18/07	21	5.2			20	62	15700			
09/19/07					40	1986	32500			
09/20/07	20	4.6			37	548	22000			
09/21/07	20	4.7		0.11	91	2419	53000			
09/24/07	18	6.9		0.16	56	1120			4.5	8.1
09/25/07	20	7.6		0.15	48	731	27600			
09/26/07					35	334	17800			
09/27/07	21	7.3		0.12	26	141	28300			
09/28/07	21	7.8		0.12	62	548	2090			
10/01/07	22	8.9		0.16	47	456	12200		3.2	9.9
10/02/07	21	8.9		0.12	40	15	8800			
10/03/07	21	7.2		0.13	97	9850	76850			
10/04/07	19	7.2		0.10	152	10860	91250			
10/05/07	21	9.3			102	740	47700			
10/08/07	19	8.2		0.14	75	6488	55650		3.5	9.1
10/09/07	17	6.4		0.10	337	7030	150000			
10/10/07					174	4350	91000			
10/11/07	17	8.2		0.19	164	8840	291500			
10/12/07	17	8.3		0.16	90	1730	74000			
10/15/07	16	6.3		0.17	237	17230			5.1	7.1
10/16/07	10	4.3		0.12	409	15420	72000			
10/17/07					192	25820	200000			
10/18/07	17	7.6		0.18	140	8080	126000			
10/19/07	17	7.9			124	2680	50000			
10/22/07	18	8.7		0.15	95	865	20500		4.0	9.4
10/23/07	18	8.7		0.10	79	436	23000			
10/24/07					68	550	15000			
10/25/07	19	8.9		0.13	75	264	15500			
10/26/07	19	8.9		0.11	56	233	18200			
10/29/07	20	9.0		0.09	39	185	10850		2.9	10.0
10/30/07	20	9.1		0.10	34	123	9800			
10/31/07					35	121	15200			
11/01/07	21	9.1		0.10	32	203	12900			
11/02/07	21	9.1			29	86	9000			
11/05/07	21	9.1			26	99	7800		2.5	9.8
11/06/07	21	9.0		0.08	22	61	9000			
11/07/07					19	58	15000			
11/08/07	22	9.1			23	64	19250			
11/09/07	22	9.0			16	62	11300			
11/12/07	22	9.0			14	39	6600		2.9	10.4
11/13/07	23	9.0			15	44	5600			
11/14/07					12	30	8200			
11/15/07	23	8.9			21	21	12400			

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	*E. coli* Counts/ 100ml	HPC Counts/ml	NH3-N mg/l	TOC mg/l	TN mg/l
11/16/07	23	8.7			13	16	5900			
11/19/07	24	8.6			9	89	3400		2.7	8.8
11/20/07	22	8.4			7	19				
11/21/07	23	8.5			11					
11/26/07	23	8.5			8	25	2080		2.6	8.8
11/27/07	23	8.5			6	34	2140			
11/28/07					8	18	1840			
11/29/07	24	8.6			8	22	1290			
11/30/07	24	8.4			10	14	1660			
12/03/07	22	6.8			13	6035			2.8	6.6
12/04/07	26	7.3			16	236	5830			
12/05/07	27	7.8			12	115	5500			
12/06/07	26	7.3			8	62	4870			
12/07/07	27	8.1			7	41	5800			
12/10/07	29	8.7			7	12	2200		3.1	
12/11/07	42	8.3			7	138	4350			
12/13/07	37	8.2			29	34	53000			
12/14/07	33	8.0			17	8	3300			
12/17/07	28	8.5			10	10	1000		2.8	
12/18/07	28	8.6			7	7	1140			
12/19/07					8	6	1120			
12/20/07	27	8.5			7	6	326			
12/21/07	26	8.2			6					
12/28/07	26	7.7			6	16	2200			
12/31/07	26	8.0			9		385		2.7	
01/02/08	28	8.1		0.09	4	7	2660			
01/03/08	28	8.2			7	6	2980			
01/04/08	29	8.4			6	7	2100			
01/07/08	33	7.7			11	41	2640		2.6	
01/08/08	34	7.5		0.30	11	121	8215			
01/10/08	24	7.2			15	494	53000			
01/11/08	26	7.5		0.10	15	456	85860			
01/14/08	24	7.5			8	48	28000		2.8	
01/15/08	25	7.5			6	21	9700			
01/16/08					7	11	3700			
01/17/08	26	7.8			5	19	8000			
01/18/08	23	6.9			5	16	1850			
01/21/08	27	8.2			5	13	1300		2.4	
01/22/08	28	8.3			5	32	1500			
01/23/08					5	23	1000			
01/25/08	27	7.9		0.08	5	26	1600			
01/28/08	32	7.6		0.09	5	32	750		2.6	
01/29/08	47	6.7			28	135	24400			
01/30/08	17	4.1		0.51	303	690	159000			
01/31/08	24	6.1		0.35	83	688	161150			
02/01/08	25	6.0		0.84	48	551		1.17		
02/04/08	26	6.3		0.51	20	240	310100		6.6	
02/05/08	45	6.2		0.42	21	179	131550			
02/06/08	32	6.7		0.36	10	89	83900			

Date	Cl mg/l	NO3-N mg/l	NO2-N mg/l	o-Phos-P mg/l	Turb NTU	*E. coli* Counts/ 100ml	HPC Counts/ml	NH3-N mg/l	TOC mg/l	TN mg/l
02/07/08	29	6.6		0.29	7	37	84800			
02/08/08	29	6.7		0.22	9	20	10500			
02/11/08	28	6.8		0.21	9	22	3400	0.38	3.0	
02/12/08	31	7.1		0.22	8	36	4500	0.38		
02/13/08	31	7.2		0.20	7	26	2200	0.26		
02/14/08	31	7.3		0.22	9	25	3700	0.25		
02/15/08	30	7.2		0.22	7	29	2040	0.29		
02/18/08	45	6.5		0.22	10	30	1766	0.28	3.8	
02/19/08	37	6.6		0.24	8	40	6360	0.30		
02/20/08	32	6.7		0.18	8	49	6560	0.24		
02/21/08	32	6.9		0.22	6	32	6095	0.26		
02/22/08	32	7.1			6	35	1420			
02/25/08	50	6.5		0.20	11	42	5400	0.27	3.7	
02/26/08	46	6.5	0.05	0.24	20	143	22790	0.28		
02/27/08					53	529	124550	0.81		
02/28/08					42	426	304750	1.24		
02/29/08	28	5.0	0.07	0.77	37	303	259700	1.46		
03/03/08	14	2.2	0.07	0.67	505	820	204000		18.2	
03/04/08	20	3.0	0.10	0.99	271	980	114000			
03/05/08	20	3.2	0.15	1.34	152	866	272950			
03/06/08	19	2.7	0.18	1.44	93	727	4055000			
03/07/08	19	2.9	0.16	1.33	63	276	768500			
03/10/08	23	3.5	0.16	0.95	40	34	37000	2.10	11.8	
03/11/08	24	3.8	0.16	0.78	48	28	25000			
03/12/08					178	117	120000	1.50		
03/13/08	17	2.6	0.11	0.48	343	214	147000			
03/14/08	18	2.9	0.09	0.66	156	173	244000			
03/17/08	17	3.4	0.15	1.04	238	197	218000		10.3	
03/18/08	19	4.1	0.13	0.97	210	79	101000			
03/19/08	20	4.9	0.11	0.74	146	81	40000			
03/20/08	19	5.1	0.11	1.87	114					
03/21/08	20	5.1	0.08	0.50	98	22	64000			
03/24/08	21	6.1	0.08	0.34	70	7000	9		5.8	6.9
03/25/08	21	6.5	0.06	0.25	65	17	9200			
03/26/08	21	6.4	0.06	0.22	57	15	9100			
03/27/08	21	6.2		0.24	64	5	17900			
03/28/08	25	6.2	0.06	0.23	42	31	11200			
03/31/08	22	6.1		0.17	44	93	6200		4.5	

Appendix C
Sample site locations

Site Id	Stream	LAT	LONG	Y_PROJ	X_PROJ
13	North Raccoon	42.22903881	-94.75574036	4676698.88412892	355114.12066303
14	Elk Run	42.19233309	-94.75469780	4672621.37849906	355116.26817477
14A	North Raccoon	42.16878741	-94.72609741	4669958.73376263	357424.94434733
14B	Elk Run	42.19521506	-94.75654304	4672944.52271155	354970.49514042
14B2	Elk Run	42.18824443	-94.76751137	4672189.23142573	354048.82212959
14C	Elk Run	42.20735705	-94.84216883	4674441.92851934	347929.66785191
14C1	Elk Run	42.20961521	-94.85815320	4674721.30763489	346615.58381266
14C2	Elk Run	42.21938118	-94.87773207	4675841.12327714	345023.24356098
14D	Elk Run	42.19577651	-94.82599162	4673127.31484755	349237.59747885
15	Elk Run South	42.18315618	-94.75450221	4671602.06349574	355111.45717229
16	West Buttrick	42.20923112	-94.35548896	4673896.63779948	388109.08939437
16A	West Buttrick	42.20930445	-94.35545969	4673904.74166919	388111.63519577
16B	West Buttrick	42.20956424	-94.35564585	4673933.83191878	388096.72668178
16BA	West Buttrick	42.22385995	-94.35118619	4675515.32882844	388490.01862488
16BB	West Buttrick	42.22380197	-94.35474833	4675513.55725068	388195.93671725
19	Purgatory Creek	42.11418070	-94.64441969	4663762.15251693	364054.89247135
21	North Raccoon	41.98830033	-94.37407401	4649390.35097538	386180.44946823
21A	North Raccoon	42.02864552	-94.45566655	4653981.66820049	379497.87459809
22	Hardin Creek	41.99833240	-94.31918646	4650432.73025457	390744.23414272
23	Buttrick Creek	41.99340505	-94.29094220	4649849.98048079	393075.23323784
25	Willow Creek	41.80631154	-94.55416619	4629438.96795872	370896.27632821
26	Middle Raccoon	41.80499822	-94.60280786	4629367.37761592	366852.80244746
26A	Middle Raccoon	41.77870410	-94.49283157	4626283.40430030	375938.20643832
27	Bear Grove Creek	41.65742564	-94.51259268	4612846.81764528	374059.30059268
28	Brushy Creek	41.65235253	-94.44147789	4612182.08699668	379971.15441872
28A	South Raccoon	41.64301815	-94.45432570	4611163.69701843	378883.83113739
28A1	South Raccoon	41.79113268	-94.71594769	4628009.38459476	357423.09224241
28A2	South Raccoon	41.80304525	-94.74420765	4629379.31266649	355101.75462026
28A3	South Raccoon	41.81241289	-94.78273009	4630485.09125855	351923.00832267
28AA	South Raccoon	41.65934665	-94.48196401	4613015.79316777	376613.22431362
28AB	Seely Creek	41.68820857	-94.54711220	4616315.58421992	371246.44710802
28AC	Frost Creek	41.73148524	-94.62749751	4621243.82172536	364647.26212219
28B	Brushy Creek	41.73046355	-94.51248292	4620955.87017422	374210.85911080
28C	Brushy Creek	41.79116482	-94.65580895	4627914.93859267	362420.20822181
28D	Brushy Creek	41.86382620	-94.76403731	4636161.54332755	353592.99267523
29	Beaver Creek	41.57903275	-94.34141096	4603907.23806102	388177.11032493
31	Middle Raccoon	41.59030993	-94.20320859	4604989.45878174	399715.62690774
32	South Raccoon	41.56689223	-94.20113128	4602387.12821975	399852.59167416
32A	South Raccoon	41.64143326	-94.43507644	4610960.86726760	380484.01991675
33	Panther Creek	41.55383161	-94.08612305	4600810.09147451	409423.60779901
34	Bear Creek A	41.53339205	-94.09913164	4598554.56446582	408309.87701433
35	Bear Creek B	41.52835638	-94.08591602	4597981.55359532	409405.32094608
37	Lower South Raccoon	41.53847684	-93.97375457	4598993.62395536	418775.38977088
38	Raccoon River	41.53441711	-93.95030412	4598521.12367337	420726.54686236

Site Id	Stream	LAT	LONG	Y_PROJ	X_PROJ
39	Sugar Creek	41.53394697	-93.82614243	4598362.45226921	431083.59109021
39A	Raccoon River	41.52184279	-93.88989084	4597071.43892806	425751.83988364
40	Walnut Creek	41.57572695	-93.69608576	4602905.34861136	441970.31065453
40A	North Walnut Creek	41.59893353	-93.71886497	4605497.34928327	440092.75089581
40B	Walnut Creek	41.59882377	-93.71971592	4605485.75472716	440021.73423966
42A	Brushy Creek	41.95446965	-94.89847897	4646464.11725891	342657.34702206
42B	Brushy Creek	42.00053550	-94.94133433	4651658.65054229	339221.38296070
42B2	Brushy Creek	42.00819432	-94.95180027	4652528.76590556	338373.96625908
42B2.5	Brushy Creek	42.01268670	-94.95609512	4653035.70268242	338029.70322405
42B3	Brushy Creek	42.03559094	-94.97248033	4655610.04802537	336731.53939965
42BA	Halbur Creek	42.00784080	-94.95855052	4652502.28413363	337814.06593837
42BA1	Halbur Creek	42.00293218	-94.97634042	4651991.11957711	336328.25108809
42BA1A	Halbur Creek	42.00297702	-94.97642722	4651996.26405980	336321.17742440
42BA1B	Halbur Creek	41.99377935	-94.97249297	4650967.47697913	336623.47393143
42BA2	Halbur Creek	41.99715935	-94.99545329	4651386.85623937	334730.39709142
42BAA	Halbur Creek	42.00754638	-94.96431458	4652480.53351285	337335.97827532
42BT	Brushy Creek	41.96437331	-94.91771209	4647599.27233498	341087.89319842
42C	Brushy Creek	42.06440970	-94.98728869	4658838.36557526	335580.12062345
42CA	Brushy Creek	42.05007695	-95.03004588	4657330.02262035	332004.63041254
42D	Brushy Creek	42.05559246	-95.03379299	4657949.81787815	331709.09414761
43	Brushy Creek	41.91290187	-94.82209890	4641711.23531304	348889.70963873
44	Middle Raccoon	42.05257876	-94.82278751	4657221.40677169	349162.74771506
45	North Raccoon	41.84939002	-94.13953481	4633682.04469290	405403.52962945
46	North Raccoon	41.79086737	-94.10305091	4627144.86036359	408348.79798623
50	Brushy Creek	41.87255184	-94.76425659	4637130.74395988	353594.70928469
50A	Brushy Creek	41.89530722	-94.79043704	4639702.33295372	351474.79861720
50B	Brushy Creek	41.91054811	-94.82221921	4641450.10094969	348874.17744039
50T	Brushy Creek	41.88067255	-94.76395973	4638031.89821170	353637.88158009
70	Walnut Creek	41.65177094	-93.83365055	4611449.56541025	430583.61733627
70A	Walnut Creek	41.67294240	-93.89537662	4613851.65007664	425468.18523080
70B	Walnut Creek	41.67264119	-93.84878102	4613778.95371320	429346.54198338
09	Indian Creek	42.33724909	-94.99390086	4689147.03493424	335741.52978528
9A	Indian Creek	42.32557849	-95.00091008	4687864.67534814	335133.59603666
9B	Indian Creek	42.32576295	-95.01627092	4687915.04754424	333868.36499322
9B1	Indian Creek	42.32597598	-95.06870772	4688042.45956970	329548.20840931
9BA	Indian Creek	42.36977733	-95.08603189	4692941.13827953	328240.05914364
9BB	Indian Creek	42.36978443	-95.07487462	4692919.43610404	329158.78457244
9BB1	Indian Creek	42.45226865	-95.07177921	4702072.55467850	329637.13669038
A	North Raccoon	41.56480045	-93.95322235	4601897.02462686	420520.33393496
BC02	Beaver Creek	41.65329339	-93.69719985	4611517.70821747	441947.02956813
BC04	Beaver Creek	41.68855373	-93.73556932	4615458.98692987	438785.55679802
BC08	Beaver Creek	41.73725290	-93.82425205	4620932.61274716	431457.03838577
BC09	Beaver Creek	41.69539676	-93.73627920	4616219.23239452	438732.97364284
BC10	Beaver Creek	41.79708813	-93.91205515	4627649.53234543	424225.90724350
BC10A	Beaver Creek	41.83665778	-93.96747632	4632093.17508283	419670.90206683
BC10B	Beaver Creek	41.82058476	-94.00950255	4630348.78735343	416160.47287634
BC10B1	Beaver Creek	41.79537389	-93.98942251	4627530.30036243	417795.92037892
BC10T	Beaver Creek	41.87106477	-94.09467607	4636040.11012176	409158.13673029
BC11	Beaver Creek	41.93586153	-94.10834582	4643249.00521457	408116.69455138

Site Id	Stream	LAT	LONG	Y_PROJ	X_PROJ
BC11A	Beaver Creek	41.99369450	-94.11310872	4649675.34060476	407805.26442976
BC11B	Beaver Creek	41.99362380	-94.10564586	4649659.48297241	408423.29284704
BC11C	Beaver Creek	41.99374390	-94.12361919	4649692.19652405	406934.78011063
BC11D	Beaver Creek	41.94086104	-94.10207739	4643797.40066861	408643.49930277
BC11Down	Beaver Creek	41.91406074	-94.10461988	4640824.48382066	408394.39902675
BC11E	Beaver Creek	41.94705405	-94.11211650	4644495.75931953	407820.21964093
BC11Up	Beaver Creek	41.95007484	-94.10323311	4644821.64107592	408560.86285210
BC12	Beaver Creek	42.02835266	-94.20343472	4653624.69711812	400377.88080142
BC13	Beaver Creek	42.03439741	-94.17314282	4654261.03393538	402894.72901070
BC14	Beaver Creek	42.03460935	-94.14667788	4654254.86739241	405085.67468583
BC19	Beaver Creek	42.16444326	-94.14494108	4668668.79921098	405422.59269846
BC20	Beaver Creek	42.17681440	-94.14487171	4670042.34460458	405446.75131829
BCA	Beaver Creek	42.20987219	-94.13965445	4673707.14167722	405926.68589745
BCB	Beaver Creek	42.20988840	-94.13975917	4673709.05730117	405918.06558966
BCC	Beaver Creek	42.20986184	-94.13982831	4673706.18386524	405912.31871781
BCE	Beaver Creek	42.13075217	-94.18454660	4664972.58964901	402099.04240344
C	Middle Raccoon	41.68661677	-94.37151414	4615891.24727749	385857.57813532
LHCDN	Living History Creek	41.61352739	-93.76400390	4607149.91508851	436345.37929268
LHCUP	Living History Creek	41.62961321	-93.78462804	4608951.22980489	434643.26741575
LWC	Walnut Creek	41.63328704	-93.83361312	4609397.39146505	430566.89292641
NWC1	Walnut Creek	41.65843281	-93.76805778	4612138.44774687	436052.02435592
NWC2	Walnut Creek	41.63736122	-93.74611645	4609782.96775849	437858.61099220
NWC3	Walnut Creek	41.63190007	-93.74484400	4609175.73924336	437959.35257227
SCT	Slough Creek	41.79541782	-93.98913061	4627534.89914092	417820.22820808
WC2	Walnut Creek	41.61053657	-93.77521666	4606826.20055976	435408.17351996
WRR7	Middle Raccoon	41.87751218	-94.67126282	4637527.01992939	361322.69219384

Appendix D
Beaver Creek Watershed

Sample Date	Site Id	Cl mg/l	NH3-N mg/l	NO2-N mg/l	NO3- N mg/l	o-Phos-P mg/l	*E. coli* Counts/100ml	Turb NTU
06/22/06	BC11	26.55		0.18	14.64	0.15	2419	92
	BC10	29.49		0.08	13.16	0.06	488	22.2
	BC2	32.01			11.96		770	29.4
07/06/06	BC11A	30.48			14.20		2851	39.9
	BC11B	55.99		0.08	12.70	0.27	985	26
	BC11	33.90			12.41		1529	49.6
	BC2	30.80			7.58	0.07	833	143
07/12/06	BC11A	21.92			14.04	0.18	92080	34
	BC11B	30.70		0.06	15.64	0.10	3180	28.6
	BC11C	28.27		0.08	14.08	0.21	27550	54.9
	BC11	23.25			13.83	0.22	36540	52.4
	BC10	22.92			12.47	0.12	61310	210
	BC2	20.63			5.24	0.09	1850	141
07/26/06	BC8	19.00			6.41			180
	BC2	24.34			5.30	0.09	8300	187
08/03/06	BC2	32.77			8.57	0.09	520	21
08/10/06	BC2	32.03			4.37	0.08		74
08/17/06	BC2	20.91			3.93		6380	104
08/24/06	BC2	37.86			7.37		410	
11/16/06	BCA	27.19		0.00	13.08	0.00	194	
	BC20	27.88		0.00	14.20	0.00	74	
	BC11A	29.56		0.00	12.45	0.00	105	
	BC11B	30.13		0.00	11.65	0.00	1733	
	BC11C	30.13		0.00	11.65	0.00	71	
	BC10A	23.74		0.03	12.57	0.00	60	
	BC10B	26.51		0.04	16.29	0.00	38	
	BC10	28.79		0.00	12.13	0.00		
	BC09	64.46		0.05	10.63	0.63	196	
	BC04	29.27		0.00	11.56	0.00	115	
	BC2	29.64		0.00	11.47	0.00	66	
11/29/06	BC20	28.40		0.00	13.30	0.00	220	1.3
	BC12	30.24		0.00	10.30	0.00	12976	4.2
	BC11A	30.48		0.00	12.13	0.00	700	17
	BC11B	39.97		0.06	11.69	0.11	4092	6.2
	BC11C	30.11		0.00	11.00	0.00	2582	16
	BC10A	23.98		0.00	11.76	0.00	172	2.1
	BC10B	26.72		0.05	17.40	0.08	462	10
	BC10	28.41		0.00	12.43	0.00	748	7
	BC09	37.11		0.05	11.32	0.22	874	6.11
	BC04	29.25		0.00	10.72	0.00	626	11.4
	BC2	28.84		0.00	10.15	0.00	342	11.9
12/07/06	BC2	29.82			12.28		51	6.47
12/21/06	BC04	28.23			9.26		200	25.6
	BC2	28.11			8.63		411	27.7

Sample Date	Site Id	Cl mg/l	NH3-N mg/l	NO2-N mg/l	NO3- N mg/l	o-Phos-P mg/l	*E. coli* Counts/100ml	Turb NTU
12/22/06	BC04	27.90		0.00	12.15	0.00		81
01/04/07	BC04	28.65					171	39.2
01/09/07	BC04	28.67			12.85		148	23.5
01/10/07	BC10A	22.86			13.30		148	5.05
01/11/07	BC04	28.37			12.66		146	19.6
01/17/07	BC10B	26.37			19.12		5	6.92
	BC10A	23.39			13.70		160	7.49
01/18/07	BC04	32.15			15.09		10	5.75
01/24/07	BC04	30.58			12.31		121	3.9
01/25/07	BC10B1 (slough creek)	26.64			19.30			3.2
02/15/07	BC04	31.79			11.47		55	6.75
02/20/07	BC04	54.75			11.09		248	7.5
03/08/07	BC10B	23.90	0.02		15.66		4	10.3
	BC04	30.85	0.38	0.06	10.08		548	8.34
03/14/07	BC10A	15.03			9.43	0.28	740	69
	BC04	11.87			6.53	0.38	200	89
03/22/07	BC04	22.73			9.70	0.17	336	68
03/28/07	BC04	25.97			11.08	0.11	125	49
04/05/07	BC04	26.46		0.03	12.55	0.09		54.9
04/19/07	BC04	27.24			13.06			24.4
04/25/07	BC12	10.16		0.06	7.26	0.60	9590	241
	BC11A	10.82		0.08	8.48	0.42	21870	244
	BC11B	14.80		0.06	10.11	0.40	5830	243
	BC11C	9.16		0.07	7.32	0.47	4870	368
	BC10A	12.66		0.09	10.48	0.44	5040	249
	BC10B	6.81		0.11	8.42	0.72	14140	389
	BC10	12.97			9.43	0.36	6630	430
	BC04	11.68			4.80	0.24	17230	527
04/26/07	BC04	8.82		0.08	6.10	0.38	17890	289
05/03/07	BC04	19.05		0.05	11.47	0.17	226	74.3
05/10/07	BC04	20.01			12.84	0.13	627	41.1
05/16/07	29	4.75			2.52		411	29.1
05/17/07	BC04	22.25			13.67	0.18	145	32.6
05/22/07	BC12	24.81			13.63		124	15.8
	BC11A	23.96			14.04		154	19.4
	BC11B	27.27		0.09	15.56		1553	7.18
	BC11C	25.00			14.45		326	23.3
	BC10A	19.62			15.75		326	6.24
	BC10B	20.73		0.06	20.93		123	10.9
	BC10	22.94			15.36		238	20.5
	BC04	23.24			14.32		276	21.1
05/29/07	29	4.24			2.82		1680	101
05/31/07	BC04	18.87		0.08	13.11	0.14	1600	61.4
06/05/07	BC12	24.84			13.64		197	41.9
	BC11A	23.31			15.14		1039	23.9
	BC11B	24.15		0.06	15.88		6131	18.6

Sample Date	Site Id	Cl mg/l	NH3-N mg/l	NO2-N mg/l	NO3- N mg/l	o-Phos-P mg/l	*E. coli* Counts/100ml	Turb NTU
	BC11C	24.08			15.15		448	54.3
	BC11D	17.54			19.40		135	25.8
	BC11E	20.32			18.87		63	9.96
	BC11Up	24.08			15.37		663	40.3
	BC11Dn	22.30			15.66		663	31
	BC11	23.39			15.94		595	29.9
	BC10A	18.18			16.96		428	18.9
	BC10B	18.98			21.23		187	17.2
	BC10	21.27			16.08		413	34.3
	BC04	21.56		0.05	14.62	0.12	426	31.9
06/12/07	BC04	22.06			14.88		488	22.6
06/14/07	BC04	22.39			15.12		299	
06/26/07	BC11A	18.71		0.04	12.71		2359	46.5
	BC11B	28.14		0.09	15.44		2851	13.1
	BC11C	22.01		0.06	13.69	0.14	2909	54.6
	BC11Up	21.84			13.71		2098	56.5
	BC11	20.68			14.43		1860	51.6
	BC10A	14.41			14.41		1223	27.4
	BC10B	16.02		0.04	17.90		1439	27.3
	BC10	17.46			14.27	0.11	2909	48.5
	BC04	16.10		0.05	12.14	0.16	2909	57.2
06/28/07	BC04	18.43		0.05	12.42	0.15	2590	41.1
07/12/07	BC04	22.30			9.99		197	15.1
07/23/07	BC20	21.22		0.08	8.81		9090	29
	BC19	22.20		0.10	6.86		20140	62.6
	BC14	23.31		0.07	2.98		480	26.2
	BC13	20.38		0.08	3.80		11985	28.1
	BC12	14.66		0.08	1.58		9880	22.2
	BC11A	23.49		0.09	4.67		7330	19.6
	BC11B	69.13		0.13	5.84	0.20	3640	25
	BC11C	23.20		0.07	2.07		1460	24.5
	BC11	25.77		0.10	3.88		9330	21.7
	BC10A	17.79		0.06	7.11		740	8.48
	BC10B	16.73		0.10	7.32		740	10.4
	BC10	23.22		0.05	4.59		100	10.9
	BC09	70.67		0.06	6.91	0.63	850	11.9
	BC04	23.76			3.96		970	17.1
07/26/07	BC04	23.64			2.75		300	12
08/09/07	BC04	27.20			2.51	0.21		45
12/05/07	BC10	26.53			8.41		74	5.53
	BC04	26.76			7.53		135	5.32
01/07/08	BC04	30.78			7.14		52	4.55
02/25/08	29	14.14	1.7	0.04	0.97	0.83		89.7
03/06/08	BC11A	18.26	2.42	0.23	3.35	1.29		16.1
	BC11C	20.28	2.91	0.29	3.39	1.49		14
	BC11	19.38	2.39	0.32	3.49	1.43		17.6
	BC10	18.90	2.26	0.23	3.23	1.46		22.7
	BC04	19.41	2.49	0.21	2.65	1.37		38.6

Sample Date	Site Id	Cl mg/l	NH3-N mg/l	NO2-N mg/l	NO3- N mg/l	o-Phos-P mg/l	*E. coli* Counts/100ml	Turb NTU
	BC8		1.96					24.8
	BC1	19.38	2.44	0.21	2.53	1.48		52.9
03/13/08	BC04	16.08	1.48	0.08	2.53	0.98	410	169

Appendix E
Walnut Creek Water Quality

Sample Date	Site Id	Cl mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	o-Phos-P mg/l	*E. coli* Counts/ 100ml	Turb NTU
05/04/06	40	45.84		0.08	14.11		404	37.6
	70	28.92		0.08	19.56	0.14	223	22.6
06/01/06	40	48.63		0.13	9.57		866	16.6
	70	26.64		0.07	16.60	0.09	1733	31.4
06/29/06	40	57.02			3.94		631	3.8
	70	26.36		0.11	10.88	0.07	2143	37.5
07/12/06	70A	45.71		0.12	8.30	0.42	970	13.3
	70B	34.57		0.15	5.93		9330	34.1
07/13/06	40	48.52			0.83		520	18.2
	70	29.67		0.11	3.86	0.20	200	38.3
07/27/06	40	44.30			0.50		200	40.2
	70	19.70			2.86	0.22	1220	69.2
08/10/06	40	21.24			0.56		5040	185
	70	41.34			0.25	0.19	970	43
08/17/06	40	10.05			0.36		7330	142
	40A	9.45			0.40		9880	178
	40B	17.32			0.32		10140	136
08/24/06	40	79.21				0.31	200	126
	70	32.52			0.37	0.15	300	19.5
09/07/06	40	46.63			2.10	0.09	350	8.72
	70	32.14		0.05	7.31	0.10	4260	28.5
11/08/06	40						200	
11/09/06	40						86	
11/10/06	40	46.60		0.08	3.70	0.11	32550	17.4
11/13/06	40	26.50			3.34		4350	3.1
11/14/06	40						488	
11/15/06	40	46.38		0.03	5.00	0.00	310	
	40A	67.43		0.00	1.08	0.00	200	
	40B	41.40		0.05	6.22	0.00	200	
	70	29.91		0.04	11.91	0.00	740	
	LHCDN	60.77		0.00	0.49	0.00	1090	
	LHCUP	97.85		0.00	1.59	0.00	200	
	NWC2	78.92		0.00	1.40	0.00	100	
	NWC3	74.78		0.00	1.27	0.00	100	
11/28/06	70	25.33		0.00	4.84	0.00	4260	50
	70A	39.40		0.06	3.22	0.00	2160	47
	70B	27.81		0.07	11.06	0.09	2590	71
	LHCUP	33.43		0.00	2.27	0.00	1730	13.4
	NWC3	48.10		0.00	1.71	0.00	2030	30.6
12/07/06	40	42.23			11.35		225	3.1
12/21/06	40	31.42			2.30		2280	70.3
	70	27.83			12.47		2310	91.6
01/04/07	40	47.39		0.05			228	14.9

Sample Date	Site Id	Cl mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	o-Phos-P mg/l	*E. coli* Counts/ 100ml	Turb NTU
01/09/07	40	44.48		0.05	11.89		86	9.97
01/11/07	40	44.03			11.68		41	9.35
01/18/07	40	54.63			12.16		39	4.94
01/24/07	40	91.84			10.78		129	3.6
01/25/07	70A	33.81			16.10	0.18		1.89
02/15/07	40	69.27			8.98		45	7.2
02/20/07	40	376.00			5.55		650	37
	70	39.38			13.19		98	6.36
02/22/07	40	94.88			4.12	0.18	100	57.5
	40A	170.91		0.05	2.01			35.6
	40B	58.92		0.06	4.60			52
	70	25.40		0.06	9.17	0.33	100	41.4
	70A	33.37		0.06	10.72	0.49	1340	7
	70B	23.81			11.04	0.23	100	21.9
	LHCDN	125.07			2.09		100	25.6
	LHCUP	117.05			3.13		200	14
	LWC	45.16			6.91			26.6
	NWC1	87.47			4.89		200	30.7
	NWC2	147.08			2.20		310	39.7
	NWC3	144.08			2.11		520	38.7
03/08/07	40	131.10	0.15		6.90		206	76.4
	70	30.18	0.15	0.04	12.77		18	13.3
03/14/07	40	35.05			7.82	0.18		99
	70	18.05			10.95	0.22		76
03/22/07	40	75.33			7.39		185	42
	70	25.73			13.43		96	16
03/28/07	70	27.17			13.53		153	18
03/29/07	40	70.27		0.04	8.25		192	19.6
04/05/07	40	61.97			10.18			13.5
	70	39.08		0.04	15.85		100	15.4
04/19/07	40	57.30			10.94		101	6.55
	70	26.72			16.00		145	8.02
04/25/07	70A	3.02		0.07	3.13	0.51	2130	581
	70B	3.73		0.09	3.89	0.50	4260	597
	LHCDN	23.04			3.51		2130	562
	LHCUP	14.57			3.89		1350	181
	NWC3	16.38			1.42		38730	607
04/26/07	40	26.33		0.06	6.72	0.21	4800	303
	70	13.56			11.32	0.26	3130	160
05/03/07	40	38.62			11.29		146	44.4
	70	19.74			15.06	0.11	168	40.7
05/10/07	40A	72.14		0.07	7.55		384	19.6
	40B	29.21			12.70		354	52.1
	70A	22.35			16.11		97	10.1
	70B	19.30			16.74		464	26.1
05/17/07	40	38.91			12.64		256	18.5
	70	20.79			17.42		156	14.5

Sample Date	Site Id	Cl mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	o-Phos-P mg/l	*E. coli* Counts/ 100ml	Turb NTU
05/22/07	40A	76.01		0.06	6.98		461	3.86
	40B	31.18			13.88		190	10.2
	70A	23.16			18.82		111	5.29
	70B	20.13			17.76		345	9.24
	LHCDN	68.40			4.68		276	3.09
	LHCUP	65.02			8.54		205	3.57
05/31/07	40	19.10			5.59	0.12	10860	573
	70	16.75			14.84		3930	74.7
06/05/07	70A	22.25			19.75		97	5.03
	70B	19.33			18.52		292	17.2
06/12/07	40A	73.05			6.58		816	9.02
	40B						517	11.3
	70	19.55			17.48			16.2
	70A	22.08			19.43		119	5.06
	70B	19.07			17.98		435	10.1
	LHCDN	63.66			5.38		727	2.74
	LHCUP	62.74		0.05	9.11		1120	4.38
	LWC	23.47		0.06	17.52		687	6.56
	NWC1	43.51		0.06	13.26		770	6.77
	NWC2	64.12		0.06	8.11		770	9.69
	NWC3	65.06		0.05	7.64		1203	10.7
06/14/07	40	34.74			13.59		1300	9.3
	70	20.22		0.04	17.88		770	15.3
06/28/07	40	27.56			11.35		1210	46.3
	70	17.45			15.56		1210	36.5
07/12/07	70	18.98		0.07	12.90		2638	21.2
07/26/07	40	46.88					630	32.6
	70	20.06		0.08	3.52		1080	25
08/09/07	70	22.79			1.36		1220	68.7
08/23/07	40	32.65			0.22		3890	47.9
	70	23.77			0.25		410	49.8
09/06/07	40	61.55			0.58			
09/10/07	40	32.92			1.65		6010	58.3
09/24/07	40	54.12			1.19		173	3.92
	40A	81.98			0.67		1658	1.66
	40B	42.80			1.49		187	3.14
	70	27.03		0.10	3.28		4106	27.9
	70A	31.35			5.90		86	2.64
	70B	27.30		0.07	3.45		4106	73.4
	LHCDN	77.15			0.23		231	1.83
	LHCUP	116.80			0.36		195	4.18
	NWC1	64.55			0.73		472	4.01
	NWC2	78.20			1.07		256	2.05
	NWC3	74.04			0.79		231	3.16
12/05/07	40	85.32			5.25		134	2.69
	40A	193.69			2.27		448	3.05
	40B	54.25		0.09	6.28		203	3.6

Sample Date	Site Id	Cl mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	o-Phos-P mg/l	*E. coli* Counts/ 100ml	Turb NTU
	70	22.52			9.96		142	5.62
	70A	28.17			10.50	0.10	135	2.97
	70B	21.49			10.61		41	5.36
	LHCDN	136.68			2.02		624	2.56
	LWC	35.63			8.96		480	4.36
	NWC3	170.82			2.44		216	4.69
01/04/08	40	100.75			4.81		10	2.3
	40A	32.64			0.66		52	3.3
	40B	78.96			5.21		41	2.3
	70	22.00			9.63		31	4.9
01/07/08	40	178.15		0.08	3.73		350	15.4
	40A	267.41			2.57		364	19.3
	40B	115.93		0.06	4.14		1515	10.1
	70	22.09		0.05	8.82		1850	7.33
01/28/08	40	393.18			4.39		1870	12.2
	40A	867.33			2.50		840	14.7
	40B	237.84			5.24		100	5.7
	70	22.42			8.70		1340	3.85
	LHCDN	369.87			2.50		100	4.89
03/03/08	40	72.79	1.69	0.12	1.79	1.02	520	208
	40A	228.85		0.05	1.71	0.12	100	79.7
	40B	56.06		0.12	1.95	1.01	630	191
03/06/08	40	124.05	0.75		3.14	0.22		34.5
	70	22.56	0.83	0.05	6.28	0.45		36
03/13/08	70	14.63	0.92	0.05	4.72	0.44	100	69.5
03/26/08	40	63.41		0.08	5.53			
	40A	111.76			2.95			
	40B	49.98		0.08	6.24			
	70	21.42		0.10	8.95			

Appendix F

Raccoon River Main-stem Tributaries

Analyte	Sample Date	Raccoon River site (38)	North Raccoon site (A)	South Raccoon site (37)	Middle Raccoon site (31)	South Raccoon site (32)
E.coli	04/20/06		36	56		32
Counts/100ml	05/04/06		1340	498		980
	05/18/06	38	59	101		172
	06/01/06	47	33	121		184
	06/15/06		78	238		411
	06/22/06		45	326	155	
	06/29/06		41	246		146
	07/06/06		63	323	52	
	07/13/06		200	410		1220
	07/20/06		30	63	93	
	07/27/06		300	100		
	08/03/06		100	100		
	08/10/06		200			1340
	08/17/06		310	1430	310	
	08/24/06		100	520		
	09/07/06			100		
	11/08/06		100			
	11/09/06	10	5	5		
	11/10/06					
	11/13/06	15	30	8		
	11/14/06	46	38	43		
	11/21/06	3		5	24	
	12/07/06	17	41	10	13	19
	01/04/07	189	368	134		
	01/09/07	74	63	73		
	01/11/07	74	85	73		
	01/18/07	18	51	19	25	20
	01/24/07	38	52	33	56	50
	02/15/07		127	27	15	16
	02/20/07	39	62	23	228	16
	03/08/07	75	76	48	51	50
	03/14/07	860	860	1560	980	1210
	03/22/07	148	161	538	73	512
	03/28/07	66	112	136	107	688
	04/05/07		980	2130	740	11530
	04/19/07		37	35	45	81
	05/03/07		231	327	249	428
	05/16/07		238	649	517	2419
	05/17/07		171	723	278	717
	05/29/07		630	1710	520	1870
	05/31/07		882	850	520	980
	06/14/07		50			
	06/19/07		362	250	291	770
	06/28/07		4100	740	100	2260

Analyte	Sample Date	Raccoon River site (38)	North Raccoon site (A)	South Raccoon site (37)	Middle Raccoon site (31)	South Raccoon site (32)
E. coli	07/12/07		41	146	173	419
Counts/100ml	07/17/07		200	100	100	100
	07/26/07					1580
	07/31/07		100	200	200	520
	08/09/07		1080	8800	630	7030
	08/15/07		85		278	1560
	08/21/07		4220	9050	2920	980
	08/23/07		2590	9600	740	5040
	09/11/07		122	1067	677	1529
	09/24/07	680	195	723		
	10/15/07		17200	29090	5380	41060
	10/16/07		17230		3740	86640
	10/23/07		529	547	238	1086
	11/27/07		10	20	52	120
	01/07/08	240	156	288	134	3076
	02/25/08					
	03/03/08	1870	1480	630	200	3930
	03/13/08	100		310		300
NH3-N	03/08/07	0.20	0.14	0.10	0.10	0.13
mg/l	02/25/08				1.24	1.16
	03/03/08	1.77	3.00	1.63	1.44	2.19
	03/13/08	1.90		1.63		1.68
NO3-N	04/20/06	14	16	3		2
mg/l	05/04/06	19	21	8		7
	05/18/06	15	17	7		5
	06/01/06	13	15	8		4
	06/15/06	12	14	6		3
	06/22/06		12	5	6	
	06/29/06	7	9	3	5	1
	07/06/06		6	2	4	
	07/13/06	5	5	5	6	2
	07/20/06		2	1	3	
	07/27/06	1	1	2	2	1
	08/03/06		0	0	2	
	08/10/06	0	0	1	1	1
	08/17/06			0	1	
	08/24/06	1	0	1	1	2
	09/07/06	2	3	2	2	3
	11/10/06	9	9			
	11/13/06	9	9	9		
	11/21/06	9		9	10	
	12/07/06	10	12	10	11	6
	01/09/07	11	15	10		
	01/11/07	13	15	10		
	01/18/07	12	16	12	13	9

Analyte	Sample Date	Raccoon River site (38)	North Raccoon site (A)	South Raccoon site (37)	Middle Raccoon site (31)	South Raccoon site (32)
NO3-N	01/24/07	10	15	11	13	7
mg/l	02/15/07	11	13	11	13	7
	02/20/07	11	12	10	12	5
	03/08/07	9	9	8	10	5
	03/14/07	5	5	6	6	4
	03/22/07	11	11	8	10	5
	03/28/07	12	12	10	11	7
	04/05/07		15	10	11	8
	04/19/07	14	16	11	12	7
	05/03/07	13	14	12	13	10
	05/16/07		15	12	14	10
	05/17/07	14	15	13	13	10
	05/29/07		18	11	12	9
	05/31/07	15	17	12	13	9
	06/14/07	14	16	13	15	9
	06/19/07					
	06/28/07	13	14	11	13	8
	07/12/07	7	6	8	9	7
	07/17/07		3	7	8	7
	07/26/07	3	1	6	7	6
	07/31/07		!	5	6	5
	08/09/07	3	3	3	5	2
	08/15/07		2		3	3
	08/21/07		0	2	4	3
	08/23/07	3	3	2	3	2
	09/11/07		4	3	3	2
	09/24/07	7	8	3		
	10/15/07		7	1	2	2
	10/16/07		9		4	1
	10/23/07		10	6	6	4
	11/27/07	9	10	7	8	4
	01/07/08	7	9	6	8	3
	02/25/08				5	3
	03/03/08	2	3	2	5	1
	03/13/08	4		2		2
O-PHOS	04/20/06					
mg/l	05/04/06	0.12	0.12			0.11
	05/18/06					
	06/01/06					0.10
	06/15/06					0.10
	06/22/06					
	06/29/06					
	07/06/06					
	07/13/06					0.10
	07/20/06					
	07/27/06					0.07
	08/10/06					

Analyte	Sample Date	Raccoon River site (38)	North Raccoon site (A)	South Raccoon site (37)	Middle Raccoon site (31)	South Raccoon site (32)
o-Phos	08/24/06					0.12
mg/l	09/07/06					0.13
	11/10/06					
	11/13/06					
	11/21/06	0.00			0.00	
	12/07/06		0.11			
	01/11/07					
	01/18/07					
	01/24/07					
	02/15/07		0.13			
	02/20/07					
	03/08/07		0.21		0.10	
	03/14/07	0.16	0.33	0.11	0.18	
	03/22/07	0.19	!	0.09	0.14	
	03/28/07	0.10	0.11			
	04/19/07					
	05/03/07	0.18	0.21		0.20	
	05/16/07		0.16	0.14	0.13	0.10
	05/17/07	0.15	0.16	0.11	0.13	!
	05/29/07		0.14	0.16	0.16	0.10
	05/31/07	0.13	0.11	0.11	0.14	0.10
	06/19/07					
	06/28/07	0.10		0.10		0.13
	07/12/07					0.12
	07/17/07					0.14
	07/26/07					0.16
	07/31/07					0.16
	08/09/07					
	08/15/07					0.15
	08/21/07					0.13
	08/23/07	0.14	0.16			0.10
	09/11/07		0.15			
	10/15/07		0.16		0.19	0.07
	10/16/07		0.14		16.52	0.08
	10/23/07		0.15	0.09	0.09	0.09
	11/27/07					
	01/07/08					
	02/25/08				0.70	0.74
	03/03/08	0.72	!	0.53	0.74	0.38
	03/13/08	0.70		0.42		0.43
TN	06/15/06	12.0	14.2	6.3		3.2
mg/l	06/29/06	7.0	9.1	3.5	5.5	1.9
	08/17/06		0.8	0.6	1.1	
	03/14/07					4.2
	02/25/08				7.1	5.9
	03/13/08	5.9		3.8		3.8

Analyte	Sample Date	Raccoon River site (38)	North Raccoon site (A)	South Raccoon site (37)	Middle Raccoon site (31)	South Raccoon site (32)
Turb	04/20/06	40	46	22		24
NTU	05/04/06	140		80		
	05/18/06	38	34	36		30
	06/01/06	42	37	67		195
	06/15/06	19	22	26		50
	06/22/06		18	14	15	
	06/29/06	14	19	10	24	30
	07/13/06	164	20	189	26	194
	07/20/06		25	31	30	
	07/27/06	21	50	38	39	45
	08/03/06		22	23	29	
	08/10/06	22	22	22	22	10
	08/17/06		29	30	36	
	08/24/06	41	33	52	52	56
	09/07/06	38	20	40	41	35
	11/10/06	4	4			
	11/13/06	3	3	3		
	12/07/06	8	4	17	6	4
	01/04/07	49	71	45		
	01/09/07	34	32	24		
	01/11/07	27	26	23		
	01/18/07	9	7	9	7	12
	01/24/07	5	5	7	5	18
	02/15/07	8	6	8	4	10
	02/20/07	11	6	11	4	27
	03/08/07	8	6	18	12	40
	03/14/07	742	579	765	244	1958
	03/22/07	98	82	239	46	270
	03/28/07	55	54	59	33	129
	04/05/07	89	82	80	31	109
	04/19/07	28	32	27	19	35
	05/03/07	120	127	112	53	151
	05/16/07		88	22	42	216
	05/17/07	85	86	98	35	141
	05/29/07		72	147	67	220
	05/31/07	85	60	115	53	158
	06/14/07	30	20	41	16	62
	06/19/07		29	47	17	67
	06/28/07	59	52	65	49	92
	07/12/07	39	28	45	28	62
	07/17/07		35	24	28	44
	07/26/07	42	39	28	19	86
	07/31/07		61	23	16	69
	08/09/07	200	118	274	30	190
	08/15/07		36		40	479
	08/21/07		48	26	20	17
	08/23/07	288	246	23	22	101
	09/11/07		17	60	21	66

Analyte	Sample Date	Raccoon River site (38)	North Raccoon site (A)	South Raccoon site (37)	Middle Raccoon site (31)	South Raccoon site (32)
Turb	09/24/07	44	43	32		
NTU	10/15/07		142	1551	231	1387
	10/16/07		154		107	106
	10/23/07		71	46	29	50
	11/27/07	13	6	7	8	5
	01/07/08	8	4	6	5	19
	02/25/08				38	94
	03/03/08	463	99	685	138	1977
	03/13/08	222		526		648
TOC	03/03/08		18.3	16.2	11.2	20.6
mg/l	03/13/08	9.2		11.1		12.3

APPENDIX G

Upper South Raccoon Watershed

Sample Date	Creek Name	Source	Site Id	NH4-N mg/l	Cl mg/l	E. coli Counts/ 100ml	NO3 -N mg/l	NO2 -N mg/l	o-Phos P mg/l	T. Coliform Counts/100ml	TN mg/l	TOC mg/l	Turb NTU
04/20/06	Brushy Creek	River	43		19	261	8.0	0.10		980			5
	South Raccoon 1	River	28A		10		3.4		0.11				15
05/04/06	Brushy Creek	River	43		21	3255	15.5	0.15	0.16	8664			22
			28		18	2247	9.9	0.17	0.11	11199			44
	South Raccoon 1	River	28A		15	2098	6.3		0.22	10462			53
05/18/06	Brushy Creek	River	43		16	2481	12.0	0.08					15
			28		13	295	7.2		0.11	105			25
	South Raccoon 1	River	28A		11	265	3.8			6131			20
06/01/06	Brushy Creek	River	43		16	8212	11.9	0.11	0.11				24
			28		13	1120	5.7		0.16				64
	South Raccoon 1	River	28A		7	517	5.0		0.11	24192			79
06/15/06	Brushy Creek	River	43		15	365	10.1	0.08			10.1		6
			28		12		4.4		0.12		4.8		30
	South Raccoon 1	River	28A		7		2.9				3.4		27
06/22/06	Halbur Creek	River	42BA		15	980	12.6	0.10					13
	Brushy Creek	River	42D		10	1414	12.0				12.1		6
			42C		14	179	17.6	0.08					9
			42B2		14	613	14.0	0.15	0.07		12.9		8
			42B		15	291	13.2	0.59	0.08				8
			42A		14	248	11.3	0.16	0.15				11
			43		16	225	8.5	0.25					13
			50A		17	461	7.3	0.18	0.09				3
			50		17	261	7.0	0.10					5
			28C		14	291	5.2		0.07				10
			28B		14	166	4.1	0.06			5.2		34
			28		12	345	3.1				3.9		29
06/29/06	Brushy Creek	River	43		15	179	7.8	0.09		3654	8.0		4
			28		11		2.7				3.0		14
	South Raccoon 1	River	28A		14		2.3				2.6		25
07/06/06	Halbur Creek	River	42BA1		11	393	12.4			8164			
			42BA		15	565	10.7	0.09	0.11	2481			
	Brushy Creek	River	42D			1956	10.8			24192			
			42C		12	624	15.8			9804			
			42B2		14	816	11.9	0.09		6131			
			42A		15		7.9	0.64	0.48				
			43		19	1539	3.4	0.28	0.65	17329			
		Tile	42CA		14	31	29.3			738			
07/13/06	Brushy Creek	River	43		16	100	7.0	0.08	0.19	980			16
			28		11		3.2		0.13				23
	South Raccoon 1	River	28A		6		2.8						70
07/20/06	Brushy Creek	River	42B3		13	1789	11.4	0.08	0.12				6
			42A		15	520	4.9	0.33	0.40	14136			3
			43		17	171	4.1	0.11	0.20	15531			13
			28		12	1145	1.8		0.12				18

Sample Date	Creek Name	Source	Site Id	NH4-N mg/l	Cl mg/l	E. coli Counts/100ml	NO3-N mg/l	NO2-N mg/l	o-Phos P mg/l	T. Coliform Counts/100ml	TN mg/l	TOC mg/l	Turb NTU
		Tile	42CA		18		28.2			613			0
	South Raccoon	River	28A3		10	341	18.7						4
07/26/06	Brushy Creek	River	42D		15	12740	6.5	0.16	0.07	155310	6.5	5.7	14
			42B2		55		1.3	3.17	3.64		15.0	80	209
			42A		22		0.9	1.89	1.49		11.0	34	119
			43		12		3.9	0.21	0.27		5.3	11.6	112
			50		18		3.0	0.18	0.23		3.5	7.7	125
			28		10		1.5				1.5	3.9	11
		Tile	42CA		15	171	28.8				24.1	4.6	12
			28C		15		3.6	0.13	0.16		9.9	30.8	193
07/27/06	Brushy Creek	River	43		27		0.2		1.29				39
			28		11	100	1.8		0.10	2880			11
	South Raccoon 1	River	28A		8	510	3.0		0.09	57940			44
08/03/06	Halbur Creek	River	42BA		19	970	7.9	0.17	0.15	11530			7
	Brushy Creek	River	42D		13	1350	4.8	0.07	0.07	46110			19
			42C		14	200	8.6	0.05	0.10	16640			7
			42B3		15	1600	8.7	0.11	0.19	20980			12
			42B2		18	2260	7.1	0.08	0.33	13330			5
			42B		17	1100	4.7	0.24	0.49	7660			2
			42A		17	850	3.7	0.41	0.62	10460			4
			43		20	1100	2.7	0.26	0.32	12590			3
		Tile	42CA		15	310	28.8			6910			8
			50T		49	100	18.0		0.07	1460			1
08/07/06	Brushy Creek	Tile	42CA1		17		30.4			637			1
			42CA2		11	11199	28.3			19863			0
			42BT		5		11.1			110			0
			50T		47	1017	18.0		0.07	4106			1
08/10/06	Brushy Creek	River	43		24		2.5	0.16	1.00				223
			28		10	100	1.6		0.12	2780			12
	South Raccoon 1	River	28A		7	100	2.6		0.10	1750			15
08/17/06	Halbur Creek	River	42BA		19	2430	6.5	0.11		31300	6.3		7
	Brushy Creek	River	42D		17	630	3.5	0.07		198630	3.8		8
			42B2		17	960	6.1			22820	5.6		6
			42A		18	410	4.6	0.17		17930	10.0		6
			43		18	2130	2.8	0.09		72700	3.5		32
			50		21	2560	2.3	0.05		72700	2.8		30
		Tile	42CA1		11		27.5			2160	24.4		1
			42CA2		17		30.5			410	28.3		1
			42BT		5		10.9			1220	10.6		7
			50T1		52		16.8	0.12			16.5		5
			50T2		29	520	10.4			18230	9.5		2
08/24/06	Brushy Creek	River	43		20	5830	4.8	0.18	0.29	32550			77
			28		13	1340	3.2		0.25	19890			30
	South Raccoon 1	River	28A		7	1750	2.9		0.08	38730			53
08/31/06	Halbur Creek	River	42BA1		15	3140	10.2		0.13	29090			3
			42BA		23	6570	9.3	0.08	0.12	27550			2

Sample Date	Creek Name	Source	Site Id	NH4-N mg/l	Cl mg/l	E. coli Counts/ 100ml	NO3 -N mg/l	NO2 -N mg/l	o-Phos P mg/l	T. Coliform Counts/100ml	TN mg/l	TOC mg/l	Turb NTU
	Brushy Creek	River	42B3		17	26460	12.0	0.11	0.20	120330			8
		Tile	42CA2		11		26.3						
			42BT		5		9.4						
			50T2		25		13.0						
			28C		73	48840	40.2	0.17	0.64	198630			42
09/07/06	Brushy Creek	River	43		20	2430	6.9	0.06	0.11	13960			22
			28		14	2400	4.4		0.20	46110			29
	South Raccoon 1	River	28A		8	300	3.2		0.07	68670			28
09/21/06	Halbur Creek	River	42BA1		17	310	12.2			8200			9
			42BA		19	4500	12.2	0.05	0.16	21420			8
	Brushy Creek	Pool	42BT		15	4430	14.1	0.08		21870			11
			42B		16	4430	14.2	0.08	0.11	15850			6
			42A		15	4520	14.1	0.08		14390			6
		River	42B3		14	3640	16.3	0.08	0.10	24890			6
			50		18	4710	11.5	0.06	0.20	22470			15
10/19/06	Brushy Creek	River	42B		16	3270	14.9			27550			2
			42A		15	23330	14.2	0.08	0.08	72150			4
			43		18	68670	12.0	0.08	0.13				4
			50		19	129970	11.5						9
		Tile	42CA		18	0	30.8			980			0
11/10/06	Brushy Creek	River	28		12	310	7.5	0.00	0.00	2920			21
11/21/06	Brushy Creek	River	42B2		15	200	14.5	0.00	0.00	10500			
			42A		15	310	14.4	0.06	0.00	6010			
			43		16	3	12.6	0.00	0.00	2380			
			50B		26	72	10.0	0.00	0.00				
			50		18	64	11.8	0.00	0.00				
			28		14	20	8.1	0.00	0.00				
		Tile	42CA		17	1	30.1	0.00	0.00	345			
			50T		28	115	18.0	0.00	0.00				
11/29/06	Halbur Creek	River	42BA		17	2592	12.8	0.00	0.00	9768			8
	Brushy Creek	River	42B2		17	3570	14.0	0.07	0.00	0			7
			42A		16	4564	13.1	0.15	0.11	10344			4
			43		18	19608	11.3	0.20	0.10	48383			12
			50B		26	190	9.5	0.00	0.00	3684			5
			28D		11	832	7.3	0.00	0.00	20925			4
			28C		15	776	9.2	0.00	0.00	6510			14
			28		12	39726	7.1	0.00	0.00				32
		Tile	42CA		17	40	30.1	0.00	0.00	350			1
			50T		28	4718	17.5	0.00	0.00	6140			2
12/07/06	Halbur Creek	River	42BA1		13	517	14.0			2419			3
			42BA		17	727	14.1						10
	Brushy Creek	River	42C		14	99	17.3						4
			42B2		16	727	15.5						8
			42A		16	228	15.3	0.07					4
			50		18	81	12.4						8
			28C		15	55	10.6						9
			28		14	55	8.8						16

Sample Date	Creek Name	Source	Site Id	NH4-N mg/l	Cl mg/l	E. coli Counts/ 100ml	NO3 -N mg/l	NO2 -N mg/l	o-Phos P mg/l	T. Coliform Counts/100ml	TN mg/l	TOC mg/l	Turb NTU
		Tile	42CA		16	4	30.0			166			2
			42BT			0				99			
			50T		29		14.7	0.07					
	South Raccoon	River	28A		10	55	5.5						4
12/20/06	Halbur Creek	River	42BA		27		11.3				11.8		12
	Brushy Creek	River	42B3		13	1376	14.9			12033			7
			42B2		14	3873	14.5			19863	14.9		7
			42B		16	187	13.5			6488	13.9		7
			42A		17	171	13.7	0.05		9804			7
			43		18	187	11.5			19863			20
			50		19	121	10.6			24192			7
		Tile	42CA1		19	0				45			1
			42CA2		13	0				57			2
			28C		388	42600	17.6	7.84	10.95	125900	96.2		1442
01/18/07	Brushy Creek	River	28		14	44	11.9						20
	South Raccoon	River	28A		8	36	6.5			1553			22
01/24/07	Brushy Creek	River	28		12	23	9.7			1414			8
	South Raccoon	River	28A		9	72	6.1						23
01/25/07	Brushy Creek	River	42B3		13		17.1						4
			42B		14	687	15.9						10
			50		16	60	13.0			1553			7
		Tile	42CA1		21		31.7						1
			42CA2		13		30.5						1
			42C		25	1	34.4			75			2
			42B3		10		13.4						1
			42BT		6		8.6						0
			50T2										1
			50T		29		22.2						1
02/20/07	Brushy Creek	River	28		12	65	8.8						6
03/08/07	Brushy Creek	River	50	0.0	16	69	11.9	0.05		2419			21
			28	0.1	12	41	8.6			1553			23
		Tile	50T	0.4	42		22.0	0.08					8
03/12/07	Halbur Creek	River	42BA1	0.8	4	850	5.9	0.09	0.69	86640	7.2		263
			42BA	17.3	15	4630	4.2	0.18	3.35	155310	22.1		553
	Brushy Creek	River	42D	0.4	1	100	1.9		0.19	141360			420
			42B3	0.9	4	4320	5.5	0.10	0.62	155310	6.6		388
			42B2	1.5	5	4710	6.5	0.09	0.76	155310	8.1		390
			42B	1.4	5	3270	6.8	0.07	0.68	173290	8.3		385
			42A	1.6	6	5470	7.0	0.10	0.51	241920	8.4		640
			50	1.4	6	4350	5.8	0.10	0.38	120330	7.1		398
			28	1.6	5	6310	3.9	0.07	0.20	241920	4.4		1418
		Tile	42CA	0.7	3	100	5.7	0.23	1.11	173290			447
			50T1	0.3	6		5.8		0.40				65
			50T2	0.5	9		9.1		0.56				27
	South Raccoon	River	28A2	0.6	2	1600	4.1	0.06	0.30	77010	4.4		730
03/14/07	Brushy Creek	River	28		6	3310	5.7		0.15	22240	6.4		977
03/22/07	Brushy Creek	River	28		12	130	9.1		0.10	4611			119

Sample Date	Creek Name	Source	Site Id	NH4-N mg/l	Cl mg/l	E. coli Counts/ 100ml	NO3 -N mg/l	NO2 -N mg/l	o-Phos P mg/l	T. Coliform Counts/100ml	TN mg/l	TOC mg/l	Turb NTU
	South Raccoon	River	28A		6	457	4.4			2142			170
			28AA		16	1313	15.8		0.20	2098			3
03/28/07	Brushy Creek	River	28		13	698	9.8		0.12	4902			93
	South Raccoon	River	28A		7	711	5.4			1937			55
04/05/07	Brushy Creek	River	43		16	1450	15.8			2350			34
			28		13	970	11.5			3050			90
	South Raccoon 1	River	28A		10	100	6.2			1220			67
04/18/07	Halbur Creek	River	42BA1		12	9	16.3			205			2
			42BA		15	31	15.7			205			3
			42BA2		11	1	10.5			345			1
			42BA1B		10	84	15.1			1300			1
			42BA1A		23	86	13.6			225			1
	Brushy Creek	River	42CA		16	1	30.9			119			1
			42D		9	3	13.9			435			3
			42B3		13	20	18.6			276			6
			42B2		14	28	17.6			548			4
			42BT		13	15	17.4			308			5
			42B		14	14	17.4			276			4
			42A		14	42	17.2			461			5
			50		16	26	14.1			291			11
04/19/07	Brushy Creek	River	43		19	249	15.7			1986			15
			28		14	73	10.8		0.10	1414			38
	South Raccoon 1	River	28A		10	135	5.6			2419			34
04/25/07	Brushy Creek	River	50		10		9.9	0.11	0.34				2471
05/02/07	Halbur Creek	River	42BA1		10	120	19.4			2063			11
			42BA		13	171	19.1			2143			28
			42BA1A		19	158	15.0			1607			4
	Brushy Creek	River	42B2		12	74	20.7			4352			28
			42BT		12	134	20.4			2755			34
			42B		12	97	20.4			1860			22
			42A		12	132	20.1			4884			36
			50		14	1720	17.0			11199			158
05/03/07	Brushy Creek	River	43		13	240	18.1			4352			53
			28		12	301	13.6			6867			121
	South Raccoon 1	River	28A		10	354	10.0			15531			127
05/07/07	Brushy Creek	River	50		11		11.2		0.19				3940
05/16/07	Brushy Creek	River	28		11	1046	13.5						172
	South Raccoon	River	28A1		8	120	14.1						39
			28A		7	921	7.6		0.09				103
05/17/07	Brushy Creek	River	43		13	323	18.3			15531			46
			28		12	631	13.7		0.09	24192			138
	South Raccoon 1	River	28A		8	583	7.5			24192			91
05/29/07	Brushy Creek	River	28		12	3360	13.5		0.11	48840			158
	South Raccoon	River	28A1		8	410	14.1			10810			32
			28A		7	2160	7.0			51720			170

Sample Date	Creek Name	Source	Site Id	NH4-N mg/l	Cl mg/l	E. coli Counts/100ml	NO3-N mg/l	NO2-N mg/l	o-Phos P mg/l	T. Coliform Counts/100ml	TN mg/l	TOC mg/l	Turb NTU
			28AA		17	1460	16.4			16640			4
05/31/07	Brushy Creek	River	43		12	17220	16.6			43520			261
			28		11	850	13.5		0.10	16640			127
	South Raccoon 1	River	28A		7	1320	7.1			28510			112
06/14/07	Brushy Creek	River	43		13	921	17.1	0.06					23
			28		13	1046	12.7						69
	South Raccoon 1	River	28A		8	1203	6.7		0.11				45
06/19/07	Brushy Creek	River	28			1046							64
	South Raccoon	River	28A			1203							47
06/28/07	Brushy Creek	River	43		13	520	16.2	0.07		19350			43
			28		11	7660	11.1		0.13	68670			100
	South Raccoon 1	River	28A		9	3070	6.3		0.14	48840			82
07/12/07	Brushy Creek	River	43		13	794	14.8	0.05		19863			34
			28		11	350	10.1		0.15	24192			66
	South Raccoon 1	River	28A		9	1019	5.2		0.12				53
07/17/07	Halbur Creek	River	42BA1		11	740	15.2	0.04		9330			11
			42BA		13	2230	14.8	0.06		18500			6
			42BA2		12	520	9.7	0.07		42250			2
	Brushy Creek	River	42CA		14	740	33.7			2260			2
			42B		12	1950	16.3	0.07		21870			11
			42A		13	1710	15.6	0.08		6220			10
			43		13	1580	13.6	0.08		14500			23
			28		11	410	9.1		0.15	36540			67
			42B2.5		12	2810	17.8	0.05		20460			19
	South Raccoon	River	28A		8	410	4.4		0.17	12960			44
07/26/07	Brushy Creek	River	43		14	1100	12.3	0.07		16070			32
			28		11	2620	7.7		0.16	21870			51
	South Raccoon 1	River	28A		11	2030	4.3		0.19	51720			56
07/31/07	Halbur Creek	River	42BA1		10	310	13.8			7980			5
			42BA		14	310	12.9	0.06		5210			5
	Brushy Creek	River	42BT		13	100	13.6	0.08		3320			5
			42B		14	730	13.3	0.10		20140			7
			42A		13	200	13.6	0.08		7120			8
			43		14	100	11.2	0.08		5560			12
			50		15	200	10.2	0.06		7490			
			28		13	2880	6.9		0.12	23590			41
			42B2.5		12	410	15.3	0.07		12740			7
	South Raccoon	River	28A		8	1220	4.0		0.17	38730			52
08/09/07	Brushy Creek	River	43		18	8130	9.0	0.74	0.28	61310			43
			28		11	2280	5.9		0.10	21870			47
	South Raccoon 1	River	28A		7	6200	2.9		0.12	72700			140
08/15/07	Halbur Creek	River	42BA1		11	450	12.1			19863			10
			42BA		16	2809	10.6	0.07					15
	Brushy Creek	River	42BT		14	480	10.4	0.12		19863			9
			42B		14	1025	10.2	0.11					13
			42A		14	987	10.3	0.14		24192			11
			43		15	862	8.0	0.09					8

Sample Date	Creek Name	Source	Site Id	NH4-N mg/l	Cl mg/l	E. coli Counts/100ml	NO3-N mg/l	NO2-N mg/l	o-Phos P mg/l	T. Coliform Counts/100ml	TN mg/l	TOC mg/l	Turb NTU
			50		16	253	6.9	0.09		15531			5
			28		10	384	4.5		0.14	10462			18
			42B2.5		13	1223	11.7	0.11		24192			8
	South Raccoon	River	28A		8	1014	3.3		0.17				51
08/21/07	Halbur Creek	River	42BA1		12	3740	11.6		0.09	198630			7
			42BA		17	13360	9.9	0.07	0.09	155310			5
			42BA1 B		17	14210	15.5			104620			2
	Brushy Creek	River	42C		15	11780	8.2	0.07		241920			10
			42BT		15	22240	9.0	0.16	0.19	173290			5
			42B		15	19180	8.8	0.22	0.16				9
			42A		15	12540	8.5	0.26	0.20	241920			6
			43		16	4960	6.4	0.14					16
			28		11	17890	3.5		0.09				22
			42B2.5		14	16740	10.4	0.18	0.11	198630			4
	South Raccoon	River	28A		8	30760	3.3		0.15				55
08/23/07	Brushy Creek	River	43		15	13330	7.2	0.17	0.11	141360			61
			28		17	41060	3.4			141360			28
	South Raccoon 1	River	28A		8	34480	3.2	0.07	0.12				179
09/11/07	Halbur Creek	River	42BA1		15	1467	9.4		0.08	14136			8
			42BA		20	2613	9.0	0.06	0.10	17329			6
	Brushy Creek	River	42B3		14	1333	9.8	0.16	0.12				10
			42B2		16	2613	8.9	0.13	0.18	17329			4
			42A		15	1467	7.2	0.24		8164			5
			43		16	269	5.4	0.13	0.12	4611			4
			50		17	211	5.1	0.07		4884			6
			28		9	1281	3.2		0.09	19863			23
			42B2.5		14	565	9.6	0.23	0.18	6867			4
	South Raccoon	River	28A1		9	233	3.5			19863			12
			28A		7	1785	2.9		0.13				65
			28A2		8	220	3.3		0.08	24192			6
			32A		8	2755	3.0		0.12				50
09/18/07	Halbur Creek	River	42BA		16	19863	7.0	0.11					14
	Brushy Creek	River	42B2		17	8164	7.0	0.26	0.14				7
			42A		16	488	7.1	0.26		14136			6
			50		17	637	4.7	0.11		19863			7
			28		10	1017	3.5		0.08	19863			14
			42B2.5		14	1782	7.7	0.37	0.22	24192			5
	South Raccoon	River	28A1		9	336	3.4	0.06					13
			28A		8	985	3.1		0.18				34
10/15/07	Brushy Creek	River	28C		16	198630	4.6	0.14	0.48				417
			28		6		2.3		0.28				334
	South Raccoon	River	28A		3	120330	1.3		0.06				1103
			28AA		6		6.7		0.80				107
			32A		4		1.7		0.12				896
11/27/07	Brushy Creek	River	28		11	175	7.1			2987			12
	South Raccoon	River	28A		7	107	4.0			2909			12

Sample Date	Creek Name	Source	Site Id	NH4-N mg/l	Cl mg/l	E. coli Counts/100ml	NO3-N mg/l	NO2-N mg/l	o-Phos P mg/l	T. Coliform Counts/100ml	TN mg/l	TOC mg/l	Turb NTU
01/07/08	Brushy Creek	River	28		10	6170	5.4		0.26				26
	South Raccoon	River	28A		8	3090	2.5		0.32				131
			28AA		4	6970	3.1	0.10	0.57				27
02/25/08	Halbur Creek	River	42BA	6.5	30	2000	5.0	0.27	2.36	20100	17.9		151
	Brushy Creek	River	42B3	5.8	16	2000	5.7	0.25	2.81	24600	17.3		89
			42B2	7.7	17		5.4	0.24	2.27	24600	14.9		84
			42B	7.5	25		5.4	0.25	2.62	32700	18.7		110
			42A	6.1	21	1000	4.4	0.19	3.16	35000	14.7		79
			50	6.9	20		4.5	0.27	2.66	21600	15.8		104
			28	5.9	23		5.1		3.19	6300	10.6		28
	South Raccoon	River	28A1	3.0	9		3.6	0.13	1.01	30100	8.7		41
			28A	2.1	11	1000	2.7	0.06	0.44	14600	7.0		144
			28A2	2.2	8		4.3	0.13	0.90	6300	8.6		40
			28AA	7.6	22	10700	2.2	0.06	2.64	44300			220
			32A	1.4	12		2.7	0.06	0.45	7400	6.3		119
03/03/08	Brushy Creek	River	28	4.5	12	4650	2.4	0.20	0.83				1427
	South Raccoon	River	28A	2.0	7	1340	1.4	0.05	0.32				362
03/09/08	Brushy Creek	River	28	1.4	17		8.3		0.26	1990	7.3	8.204	44
	South Raccoon	River	28A	0.7	15		6.8		0.24	1350	4.8	3.476	44
03/10/08	Brushy Creek	River	42A	0.9	14		13.5		0.13	2030	13.5	3.14	12
			28	2.1	13		6.5		0.20	5380	7.8	5.15	54
	South Raccoon	River	28A	0.7	8	100	4.2		0.10	2130	4.8	3.12	36
03/13/08	Brushy Creek	River	28	3.4	9	860	3.7	0.06	0.24	104620	6.8	12.38	309
	South Raccoon	River	28A	1.2	5	740	1.5	!	0.17	86640	3.1	10.34	776
04/03/08	Brushy Creek	River	43		18		12.8	0.06		1710			36
			28	0.5	13	410	7.4	0.06	0.13	2230			118
	South Raccoon 1	River	28A	0.2		520				1850			213
04/17/08	Brushy Creek	River	43		17		13.2	0.08					23
			28		12	669	7.4		0.09	5172			106
	South Raccoon 1	River	28A		10	2098	4.4		0.19	9804			90
05/01/08	Brushy Creek	River	43		15		13.6		0.35				32
			28		12	1086	9.4		0.12	3448			104
	South Raccoon 1	River	28A		8	794	5.7		0.08	3873			140
05/15/08	Brushy Creek	River	43		14		13.2	0.06					10
			28		12	627	8.8		0.09	4884			45
	South Raccoon 1	River	28A		7	457	4.7			2851			30
05/29/08	Brushy Creek	River	43		14		14.4	0.08					41
			28		13		8.6			92080			97
	South Raccoon 1	River	28A		7	2359	4.8		0.09	17329			11
06/12/08	Brushy Creek	River	43				3.5						1899
			28			198630	1.6						6890
06/26/08	Brushy Creek	River	43										567
			28			7400				90600			269
	South Raccoon 1	River	28A			2000				27800			146