STATUS REPORT #8 for the DES MOINES AND RACCOON RIVERS OF IOWA

NITRATE NITROGEN
and
ESCHERICHIA COLI

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Des Moines Water Works

For

Iowa Department of Natural Resources

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Project and Status Report:

This is the last status report of monitoring and investigative activities conducted within the delineated area of the contract. The primary focus of this report is data generated during this last quarter but is in the context of previous findings and reports. A separate summary report with recommendations based upon this study will be forthcoming along with an evaluation of the achievements of the project relative to contract goals.

Weather conditions:

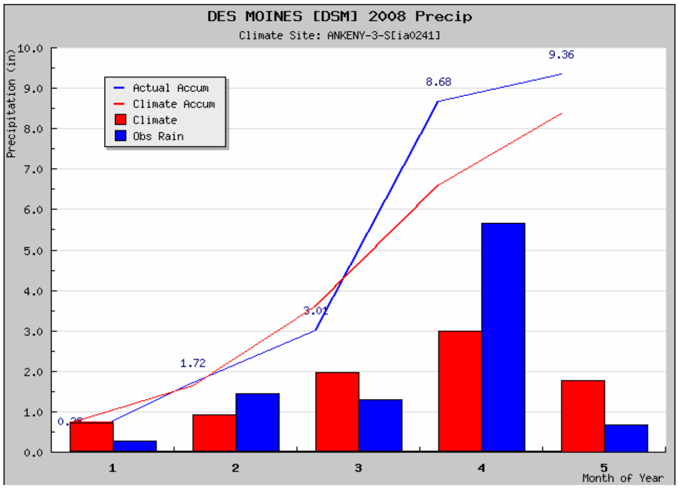


Fig 1. Precipitation in the Des Moines area

Precipitation was below normal for most the watershed. Most of the precipitation came in the form of frequent snow showers. The southern part of the watershed did receive additional moisture in February. The Des Moines area total precipitation was slightly greater than the climatic mean (fig 1). Below normal temperatures allowed an accumulation of the snow, especially in the northern part of the state where approximately a foot of snow stayed on the ground through early March (Hillaker 2008). Brief periods of above freezing temperature in January caused much of the early snow cover in the southern portion of the Des Moines River Watershed to melt and run off over frozen ground. Soil moisture and water tables remained quite high which caused elevated base flow during this period.

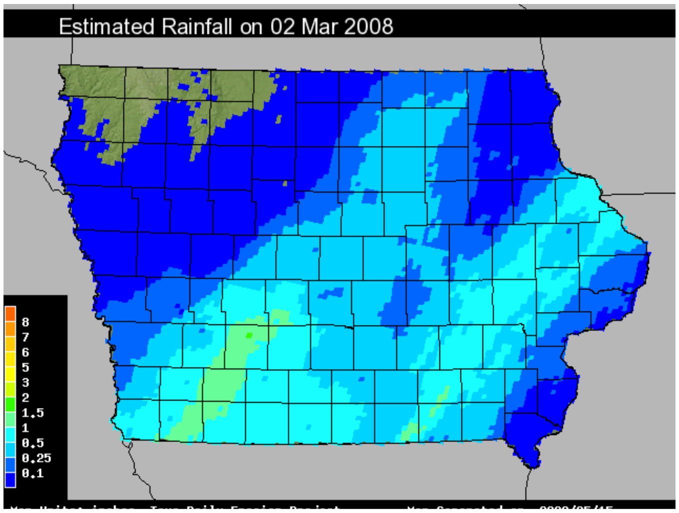


fig 2. Rainfall distribution on 3/2/08

A brief period of above freezing temperatures in late February followed by a wintry mix of rain and snow on the 26th caused limited runoff in the southern portion of the watershed that received more of the precipitation as rain. Snow cover at Carroll averaged two (2) inches while snow cover at Rockwell City averaged nine (9) inches on the 26th. Above freezing temperatures and heavy rain on March 2 centered over the hilly South Raccoon Watershed (fig 2) caused extensive runoff over frozen ground, causing flooding downstream to Des Moines.

A more sustained period of above freezing temperatures beginning March 11 and light rain on the 16th caused most of the snow pack in the North Raccoon Watershed to melt and flow over frozen ground to rivers and streams over a five (5) day period. In contrast, there was little snow cover in the South Raccoon but an intense rain cell added another inch of precipitation to an area (fig 3) that had heavy rainfall two weeks earlier.

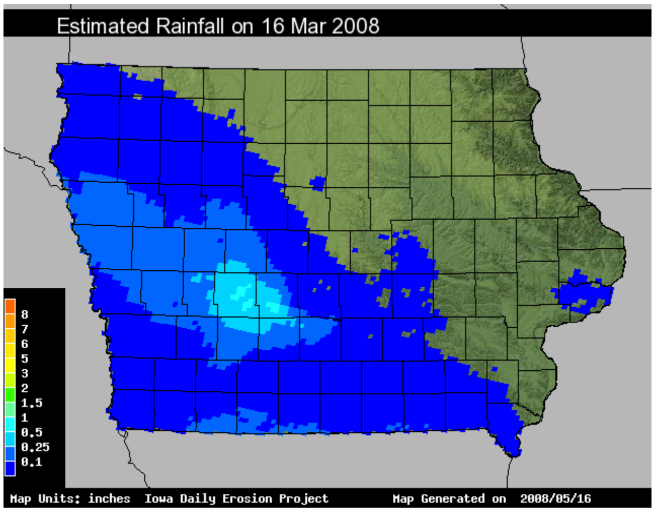


fig 3. rainfall distribution 3/16/08

Hydrology and Flow Overview:

The unusual winter weather described came on the heels of the 2nd wettest December on record. Abundant rain in early December replenished soil moisture while cold weather and snow in the later part of the month through February 2008 kept a store of moisture on the surface. Preliminary data at the USGS gauging station at the 63rd street site in Des Moines in 2008 (fig 4) indicates relatively high base flow from these soils throughout this quarter. Assuming the estimated mean flow record to be the more accurate presentation of the flow data, the mean flow for January was the 3rd highest flow for the 11 year period of record though the amount of precipitation was below normal. February flow at Des Moines was slightly higher than January but less than the climatic mean (fig 5). Frozen ground and below normal temperatures prevented infiltration of snowmelt. The small bump in

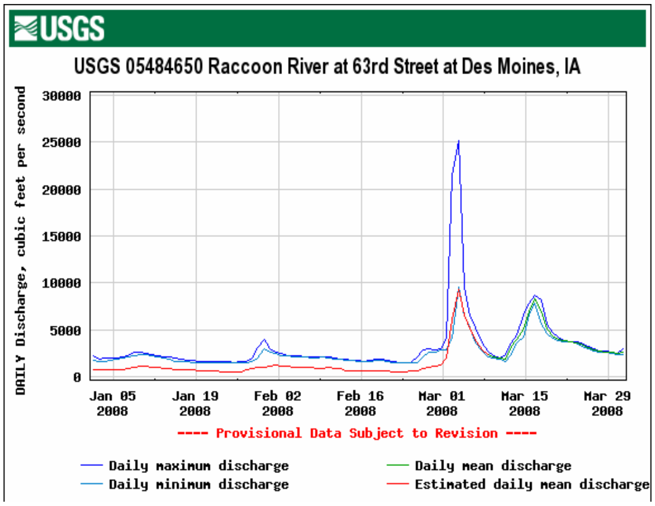


Fig 4 Raccoon River flow in Des Moines 2008

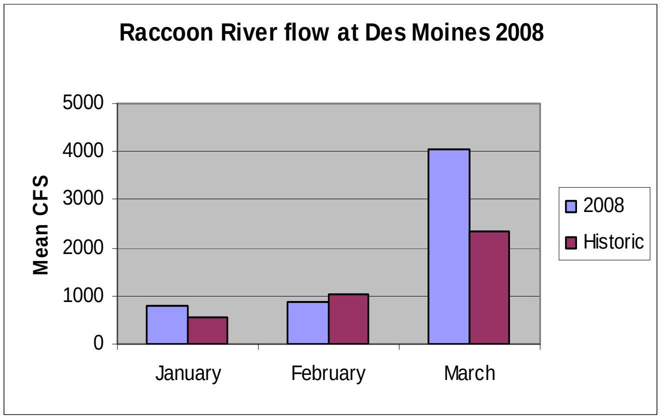


fig 5. Raccoon flow in 2008 vs. climatic mean

flow in late January came from limited snow melt in the southern part of the watershed. Base flow rates slowly receded throughout February as groundwater continued to discharge into the rivers. Discharge rates remained essentially the same through February. March precipitation was again below normal in Des Moines while mean flow in the Raccoon River was well above the climatic monthly average.

Raccoon River Flow

Flow in the North Raccoon was closely related to temperature induced snow melt and runoff over frozen ground fig 6).

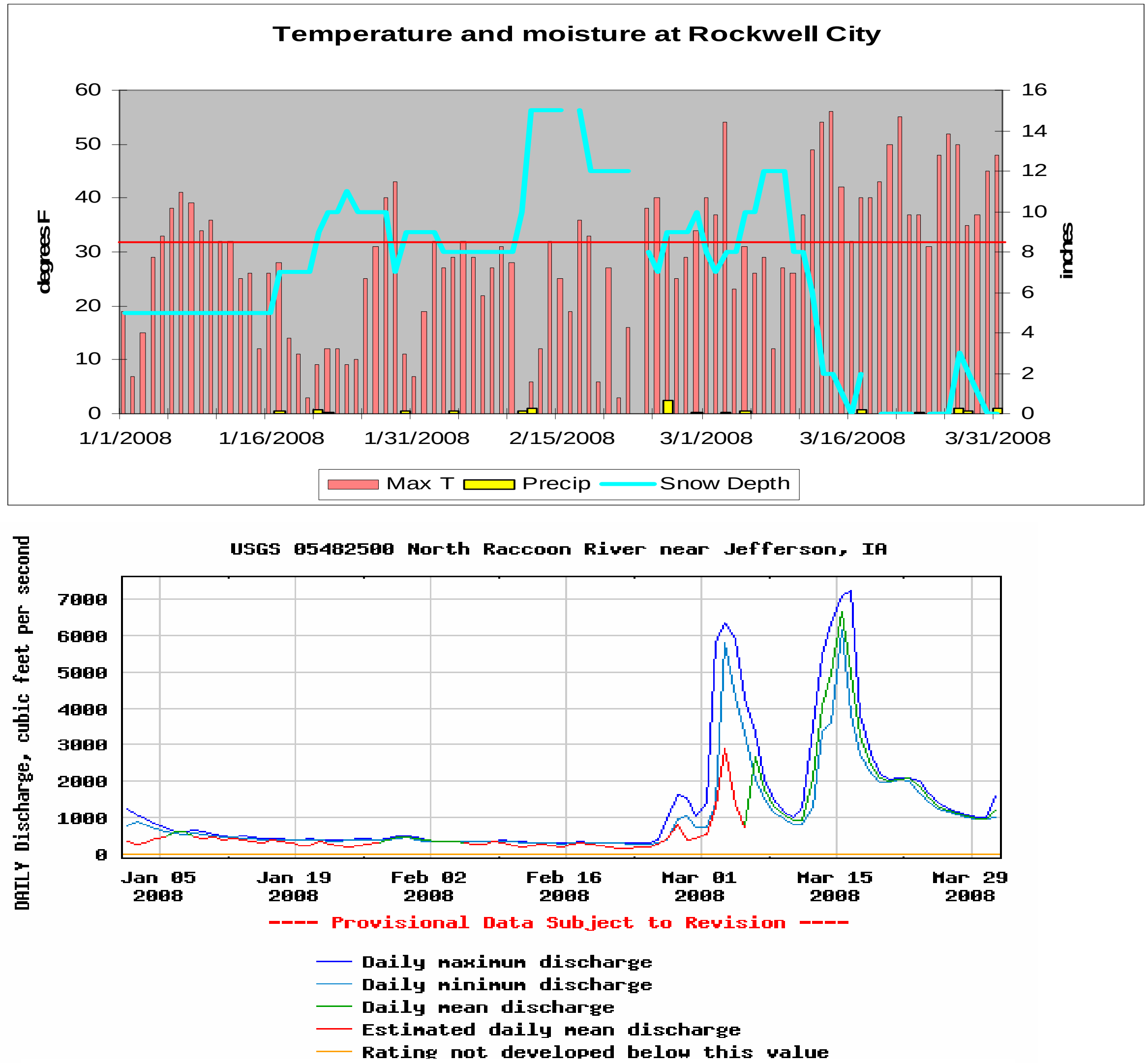


fig 6. winter weather in the North Raccoon Watershed in 2008 and discharge rate

The brief period of above freezing temperatures in late January melted some of the snow as seen in the decrease in snow depth and small rise in river flow. The variable temperatures in late February followed by the wintry mix of rain and snow on March 2 created both runoff during the brief warm weather and further accumulation of snow to a one (1) foot depth during colder weather. Beginning March 10, daily maximum temperatures rose above the freezing point, melting nearly the entire store of snow by mid-March. Flow increased to near flood stage at Jefferson though there was essentially no rain in this part of the watershed. The little precipitation that fell on March 16 (fig 3) was is the form of snow. Continued warm weather thereafter melted the remainder on the snow in shaded and low lying areas which contributed to above average flow for the remainder of the month.

Discharge from the South Raccoon was also influenced by melt water runoff from accumulated snow. Much of the accumulated snow near Carroll melted during the brief warm period in late January causing a noticeable rise in river level (fig 7) to Des Moines (fig 1).

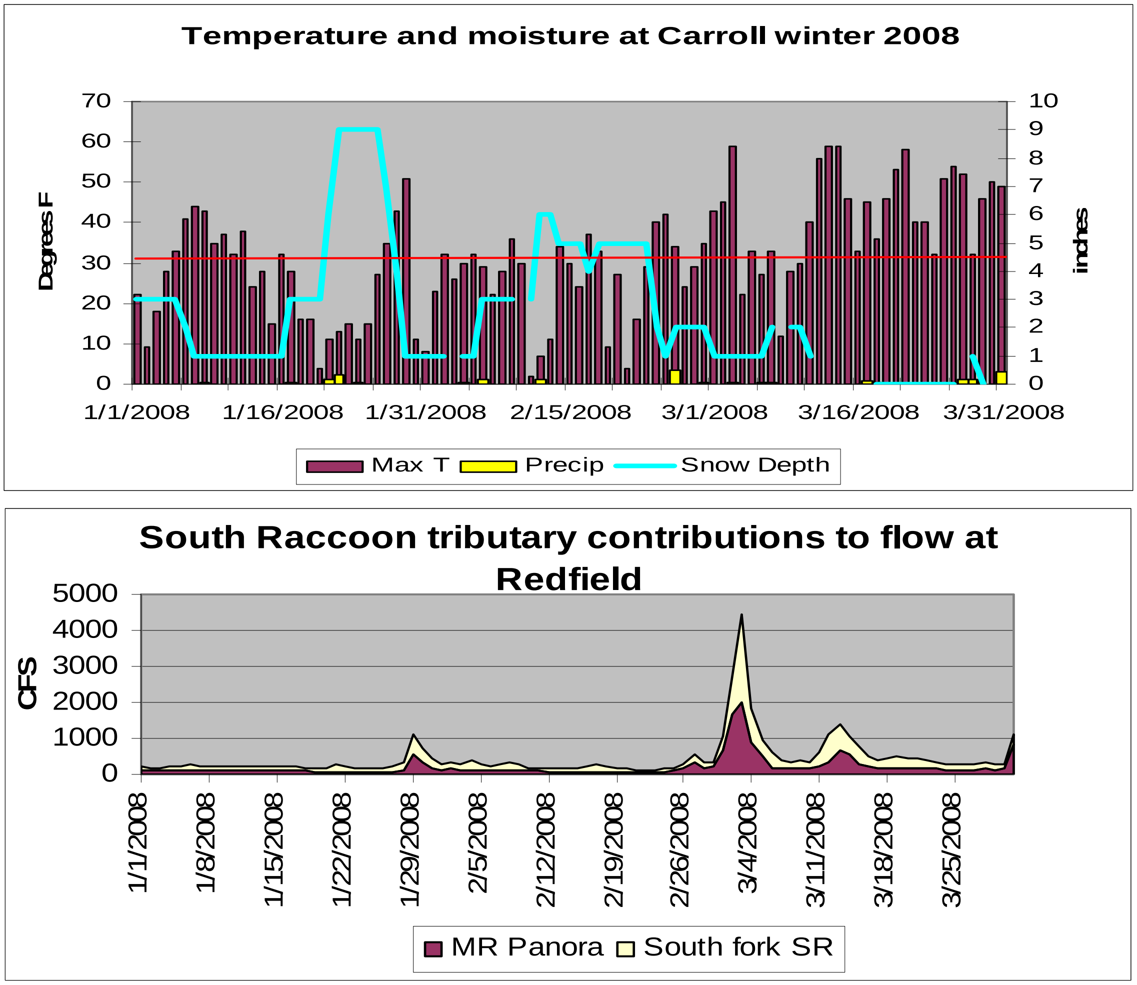


fig 7 weather and tributary flow in the South Raccoon Watershed

The snow pack in the South Raccoon was essentially gone by late February. Data from the Mesonet COOP website reported only one inch of snow remaining at Carroll on the 25th. The wintry mix on the 26th caused a small increase in flow in the Middle and South Raccoon on February 26. The two major runoff events in March are primarily from rain with minor contribution from snowmelt during the earlier March 2 event. Ice jams on the South Raccoon likely contributed to high river stage readings and flooding in the South

Raccoon. Provisional data from USGS gauging stations at Panora (Middle Raccoon) and Redfield (combined flow from Middle and South Raccoon) shows similar hydrographs, indicating similar precipitation and runoff in these two watersheds during this period. The plot of the South Raccoon tributary is the calculated difference in flow between the Redfield and Panora gauging station locations and therefore does not indicate total watershed flow. The plot is for illustrative purposes only to show runoff similarities during this period. Contributions of the North Raccoon and South Raccoon to flow in the Raccoon River at Van Meter show predominately rain induced runoff from the South Raccoon in early March followed by predominately snow melt runoff flow from the North Raccoon in mid-March (fig 10).

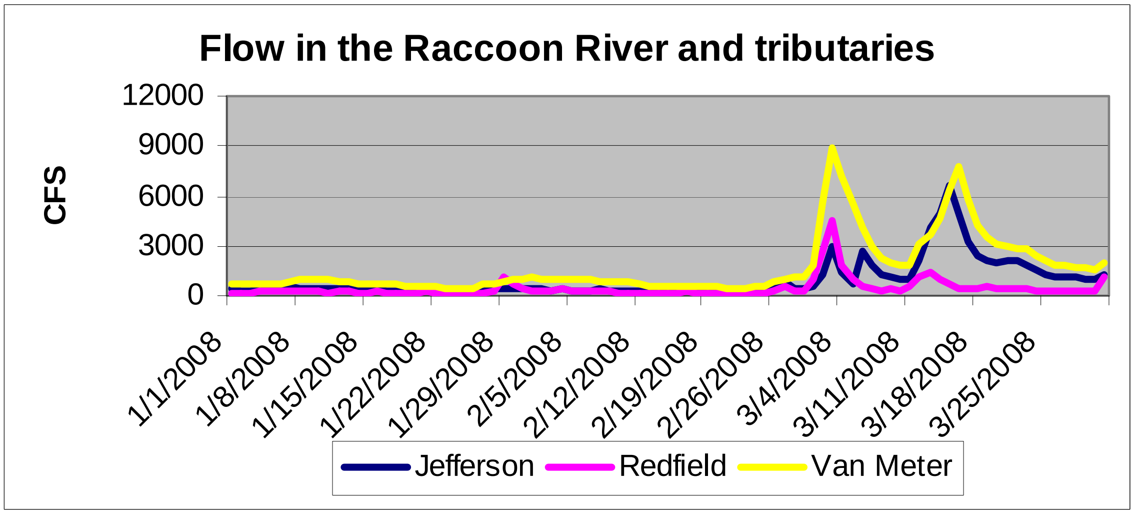


fig 8. flow in the Raccoon River at Van Meter and main stem tributaries

Walnut Creek

Walnut Creek contributed less that 5% of the flow in the Raccoon River for 72 of the 91 days this quarter. Most of the exceptions occurred from mid-February to early March. The February occurrences came from salt induced snow melt on city streets while the predominant peak on March 2 came from runoff during the mixed rain and snow event (fig 9) which provided 17 % of the flow in the Raccoon River.

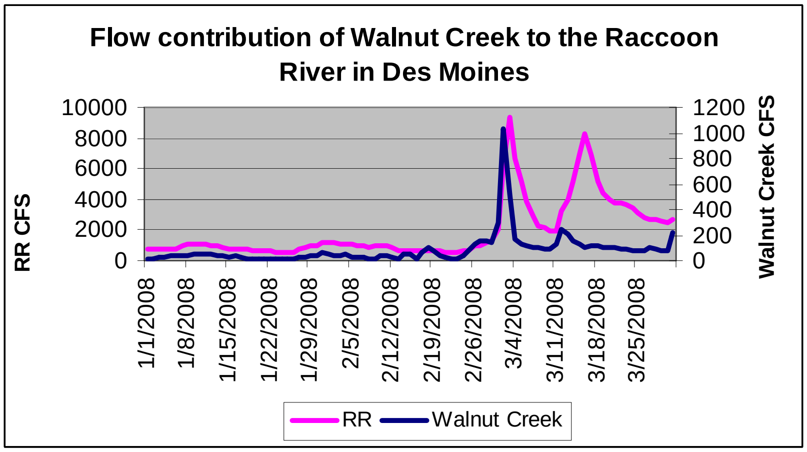


fig 9. Walnut Creek contribution to Raccoon River flow

Des Moines River and Beaver Creek

Flow in the Des Moines River at the Des Moines Water Works is primarily a function of controlled discharge from Saylorville Lake for the purposes of flood control and recreation. When pool levels are near normal with adequate flood capacity reserve, discharge generally tracks what is flowing into the Lake to maintain a fairly constant pool depth. During a widespread runoff event, discharge from Beaver Creek typically enters the Des Moines River downstream of Saylorville before increased discharge from Saylorville Lake. This creates a short window of time when Beaver Creek provides a disproportionate contribution to flow and therefore water quality in the Des Moines River. This quarter, Beaver Creek provided more than 20% of the flow from March 1 to March 6 with its highest percentage contribution (41%) on March 2 and peak flow on March 5. Flow thereafter was dominated by Saylorville Lake discharge (fig 10).

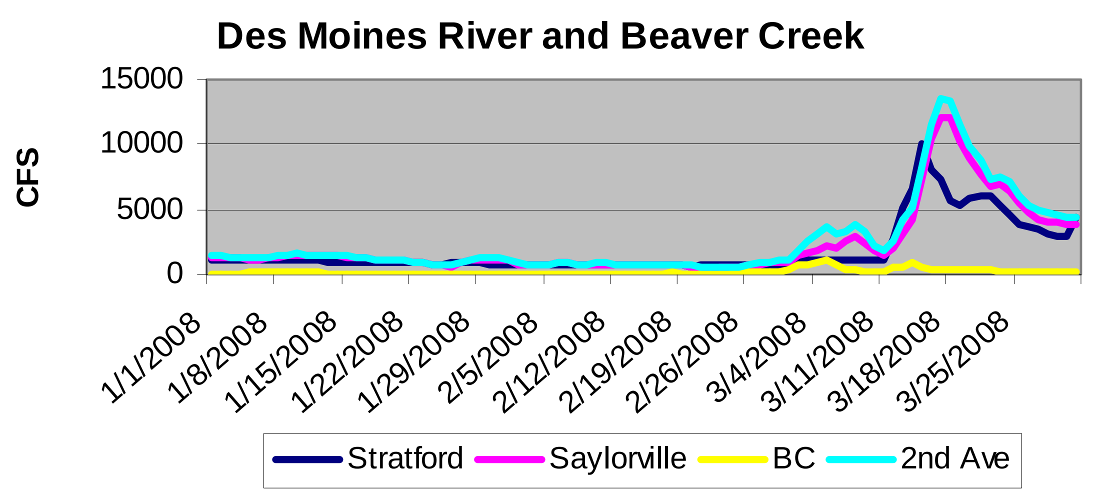


fig 10. Flow at Beaver Creek and Des Moines River stream gauging stations

Discharge in mid-March initially came from the lake storage but quickly changed toward melt water characteristics similar to that observed in the Raccoon River as a high volume of melt water entered the pool from upstream.

WATER QUALITY AT THE DES MOINES RIVER INTAKE

There was little variation in water quality in the Des Moines River through February. Small spikes in chloride without a change in other water quality parameters during snow events suggest road salt as the source (Table 1). Profound changes in water quality began in early March with elevated ammonia concentrations that continued through the entire month. Beaver Creek watershed samples collected 3/6/08 showed the widespread bacterial and ammonia contamination. Its influence on water quality at the DMWW intake is most apparent in the change in *E. coli* counts with increased flow from Beaver Creek (fig 11). Higher counts with a second rise in Beaver Creek flow are less apparent but likely due to a lack of sampling on the weekend when peak counts would likely have been highest. The small spike on March 17 is of a single sample collected on a Monday,

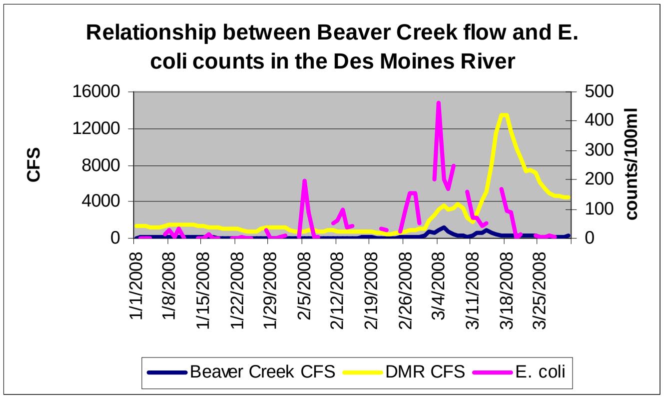


fig 11. E. coli counts at the DMWW intake

on the descending limb of the Beaver Creek hydrograph. A 24 hour time of travel from the Beaver Creek gauging station to the Des Moines River intake would create an influence on water quality at the Des Moines River intake on the weekend. Elevated counts from Saylorville Lake are unlikely as the initial discharge is primarily resident Saylorville Lake water. As flow through the lake increases, *E. coli* is less subject to mortality and settling and counts should increase rather than decrease. These counts however are very low compared to historical data and previous monitoring reports. The single sample water quality standard for *E. coli* (235 counts/100ml) was exceeded only twice during the entire period which included high flows. This usually would be interpreted as relatively safe water with little fecal contamination. However, very high chlorine demand was observed in both rivers (fig 12) which raised serious concerns regarding the ability to provide disinfection within a suitable range as low dosages do not adequately protect water from pathogens while high dosages contribute to disinfection by-products and taste and odor issues. DMWW switched from the Raccoon River to the Des Moines River on Jan 31 due to a sudden spike in chlorine demand from the Raccoon River. Demand remained relatively steady until melt water discharge arrived from Beaver Creek beginning February 27. Demand was variable until March 11 when flow from Saylorville rapidly increased and dominated flow and therefore water quality in the Des Moines River.

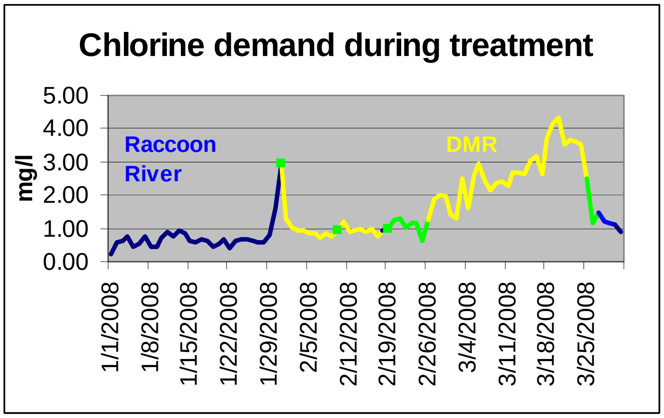


fig 12. chlorine demand from river sources

There was considerable discussion on the source of this ammonia. Farm organizations were claiming that large amounts of diammonium phosphate (DAP) were surface applied last fall. No reports were collected as to tonnage applied or location to determine the potential of this source. The wet fall delayed much of the land application of manure by injection so that much of the manure was surface applied onto frozen ground. Weather, steam flow, and water quality dynamics all indicate manure runoff from fields during snow melt. *E. coli* in manure containment structures rapidly die while HPC bacteria proliferate and liberate ammonia and phosphorus. The water quality observed during melt water runoff was consistent with aged manure, i.e. brown colored water, sewer odors (from odor profile analysis), high TOC, and high heterotrophic plate count bacteria (HPCs) (Table 1).

Table 1. Water Quality at the DMWW Intake

Date	Cl	NO_3-N	NO_2-N	o-Phos	Turb	E.coli	HPC	NH3-N	TOC
01/02/08	30.5	7.1			2.89	1	8215		
01/03/08	30.5	7.0			4.63	2	2279		
01/04/08	30.3	7.1			4.01	2	1458		
01/07/08	33.0	7.0			4.92	15	3360		3.5
01/08/08					6.93	30	5565		
01/09/08	31.9	6.9			3.86	6	3860		
01/10/08	30.4	7.0			4.13	31	7420		
01/11/08	31.4	7.1			4.15	2	1260		
01/14/08	30.9	6.8			3.99	1			3.2
01/15/08	30.4	6.8			3.69	2	580		
01/16/08					4.88	15	2880		
01/17/08	31.3	6.9			3.23	1	4890		
01/18/08	30.9	6.9			3.5		670		
01/21/08	31.8	6.9			4.63	1	1560		3.3
01/22/08	31.5	6.9			2.8	1	1920		
01/23/08					6.44	5	2000		
01/24/08	32.0	6.4			3.65	1	1460		
01/25/08	32.1	6.5			3.23		2180		
01/28/08	34.0	6.3			5.17	27	580		3.7
01/29/08	45.7	6.3			5.13	1	1160		
01/30/08	34.5	6.5			12.5	2	960		
01/31/08	31.8	6.3		0.14	8.7	6	2300		
02/01/08	32.0	6.7		0.11	4.12	11			
02/04/08	32.8	6.3			3.16	4	590		3.6
02/05/08	41.2	6.2			5.55	194	9805		
02/06/08	36.1	6.4			3.18	89	83900		
02/07/08	34.1	6.6			1.54	4	1780		
02/08/08	34.9	6.5			2.1	4	1660		
02/11/08	35.5	6.6			3.48	50	2080	0.18	3.8
02/12/08	34.1	6.5			4.96	61	4505	0.16	
02/13/08	35.0	6.3			3.76	99	1680	0.14	
02/14/08	34.5	6.5			5.07	37	6040	0.15	
02/15/08	34.3	6.4			5.77	40	1840	0.2	
02/18/08	46.2	6.1			5.35	131	6757	0.2	3.9
02/21/08	36.4	6.3			3.9	33	14575	0.12	
02/22/08	35.7	6.1			3.24	26	5565		
02/25/08	44.9	5.7			6.17	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	153	103350	0.49	
02/28/08	38.9	5.3	0.05	0.25	15.2	155	153700	0.57	
02/29/08	38.7	5.6		0.15	7.02	52	74200	0.5	
03/03/08	30.2	3.7	0.06	0.39	101	200	88000		11.1
03/04/08	30.0	3.9	0.09	0.58	57.6	461	122000		
03/05/08	27.8	4.1	0.11	0.72	50.4	201	129850		
03/06/08	30.1	4.2	0.09	0.60	24.6	166	1246000		

Date	Cl	NO_3-N	NO_2-N	o-Phos	Turb	E.coli	HPC	NH3-N	TOC
03/07/08					17.4	248	170000		
03/10/08	30.8	4.3	0.06	0.28	22.3	157	83000	0.77	6.8
03/11/08	31.1	4.4	0.05	0.27	18.5	68	48000		
03/12/08					50.1	70	116000	0.8	
03/13/08	27.2	3.5	0.07	0.35	65.1	44	108000		
03/14/08	25.1	3.4	0.06	0.54	64.3	50	106000		
03/17/08	18.3	2.7	0.1	0.59	102	166	114000		11.1
03/18/08	16.1	2.4	0.12	0.72	107	93	262000		
03/19/08	17.4	2.8	0.15	0.84	86.3	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	13	89000		
03/24/08	18.3	4.4	0.1	0.41	29.8	9	3500		7.9
03/25/08	19.3	4.6	0.1	0.34	29.3	3	9000		
03/26/08	19.1	4.7	0.08	0.36	28.8	6	11600		
03/27/08	19.1	4.7		0.38	29.3	9	14550		
03/28/08	20.8	5.1	0.08	0.28	30.1	5	10400		
03/31/08	20.0	5.1	0.06	0.24	23	3	5200		5.8

Water Quality in the Beaver Creek Watershed

Beaver Creek watershed (fig 13) samples collected 3/6/08 verified the high contribution of Beaver Creek to ammonia in the Des Moines River and the high chlorine demand (Table 2). An ammonia-N concentration of 2.44 mg/l occurred at site BC1 (its discharge into the Des Moines River) while the concentration in the Des Moines River just upstream (site DM5) was 0.37 mg/l. Beaver Creek provided approximately 25% of the flow in the Des Moines River on that date and 70% of the ammonia load.

High total coliform counts accompanied the high ammonia and phosphorus concentrations throughout the watershed, indicating a manure origin. The relatively low *E. coli* counts suggest surface application of stored manure where most of the *E. coli* has died.

fig 13. Beaver Creek Watershed and sample sites

Table 2. Water Quality in the Beaver Creek Watershed and DMR at its Confluence

Sample Date	Site Id	Total coliform	E.coli	NH3-N	NO3-N	O-PHOS	TN	TOC	Turb
01/07/08	BC04	2851	52		7.14				4.6
	DM5	1106	31		7.04				3.9
03/06/08	BC1	72700	200	2.44	2.53	1.48			52.9
	BC04	86640	300	2.49	2.65	1.37			38.6
	BC8	86640	200	1.96					22.7
	BC10	72700	100	2.26	3.23	1.46			17.6
	BC11	98040	200	2.39	3.49	1.43			16.1
	BC11A	104620	200	2.42	3.35	1.29			14
	BC11C	64880	100	2.91	3.39	1.49			24.8
	DM5	2620	<100	0.37	5.09	!			18.3
03/13/08	BC04	46110	410	1.48	2.53	0.98	4.753	13.53	169
	DM5	3350	<100	0.82	4.16	0.26	5.143	6.89	18.5

Ammonia concentration near the Beaver Creek outlet (1.48 mg/l) on 3/13/08, though still higher than the Des Moines River site, shows a decline while the Des Moines River concentration increased to 0.82 mg/l. The expected concentration at the Des Moines River intake based on flow and concentration remained essentially the same (0.92 mg/l) as observed on 3/6/08 though Beaver Creek was now contributing only 24% of the ammonia load. Chlorine demand at the Des Moines River intake remained essentially the same as well (2.95 mg/l vs 2.7 mg/l). Chlorine demand continued to increase however with a peak demand of 4.35 mg/l on 3/20/08 even though less than 5% of the flow came from Beaver Creek. To create this demand, the ammonia concentration flowing out of Sayloville Lake would be approximately 1.4 mg/l but was not measured

WATER QUALITY AT THE RACCOON RIVER INTAKE

Water quality changes in the Raccoon River are more dynamic than in the Des Moines River. Other than Lake Panorama on the Middle Raccoon there is no water storage to attenuate these changes. The watershed includes two different landforms which have differing land uses and runoff potential. Walnut Creek which discharges into the Raccoon River just upstream of the DMWW intake includes much of the City of Des Moines in its watershed. Differences in flow rate and time of travel from these sources create widely fluctuating contributions during runoff events. Much of the change in water quality in the Raccoon River can be linked to differences in time of travel from the various watersheds.

Overall, water quality throughout the Raccoon River watershed showed a similar relationship of snowfall, temperature, and melt water runoff to water quality as observed in the Des Moines River through February (Table 3). Above freezing temperatures and snow melt in the South and Middle Raccoon Watersheds provided most of the flow in the Raccoon River. Water quality changes in the Raccoon River associated with snow melt runoff are similar to that observed in the Des Moines River. The bump in bacteria levels on Jan 10-14 follows a brief period of above freezing temperatures that reduced snow depth in the southern areas of the watershed. A small increase in flow from snow melt is observed but with little change in turbidity.

Table 3. Water Quality in the Raccoon River in Des Moines

Sample Date	T. coliform	HPC	E. coli	Cl	NH3-N	NO3-N	O-Phos	Temp F	TOC	Turb
01/04/08	387	2100	7	29		8.4		33		6.1
01/07/08	2419	2640	41	33		7.7		33	2.6	10.8
01/08/08	7766	8215	121	34		7.5	0.30	33		10.5
01/10/08	12096	53000	494	24		7.2		33		14.9
01/11/08	>48384	85860	456	26		7.5	0.10	33		15.1
01/14/08	14830	28000	48	24		7.5		33	2.8	8.0
01/15/08	4718	9700	21	25		7.5		33		6.1
01/16/08	1986	3700	11					33		7.2
01/17/08	980	8000	19	26		7.8		32		5.1
01/18/08	345	1850	16	23		6.9		33		4.8
01/21/08	461	1300	13	27		8.2		33	2.4	5.4
01/22/08	579	1500	32	28		8.3		33		4.8
01/23/08	1046	1000	23					33		4.7
01/25/08	461	1600	26	27		7.9	0.08	33		4.9
01/28/08	727	750	32	32		7.6	0.09	33	2.6	5.3
01/29/08	5475	24400	135	47		6.7		33		27.9
01/30/08	155310	159000	690	17		4.1	0.51	33		303.0
01/31/08	154000	161150	688	24		6.1	0.35	33		83.2
02/01/08	259940		551	25	1.17	6.0	0.84	33		48.2
02/04/08	58180	310100	240	26		6.3	0.51	33	6.6	20.0
02/05/08	61310	131550	179	45		6.2	0.42	33		20.7
02/06/08	22470	83900	89	32		6.7	0.36	33		10.4
02/07/08	7980	84800	37	29		6.6	0.29	33		7.5
02/08/08	1986	10500	20	29		6.7	0.22	33		8.8
02/11/08	1553	3400	22	28	0.38	6.8	0.21	33	3.0	8.6
02/12/08	1021	4500	36	31	0.38	7.1	0.22	33		7.8
02/13/08	1203	2200	26	31	0.26	7.2	0.20	33		6.8
02/14/08	1021	3700	25	31	0.25	7.3	0.22	33		9.4
02/15/08	866	2040	29	30	0.29	7.2	0.22	33		6.9
02/18/08	1766	1766	30	45	0.28	6.5	0.22	33	3.8	10.2
02/19/08	2599	6360	40	37	0.3	6.6	0.24	33		8.1
02/20/08	1454	6560	49	32	0.24	6.7	0.18	33		7.5
02/21/08	977	6095	32	32	0.26	6.9	0.22	33		6.5
02/22/08	690	1420	35	32		7.1		33		6.4
02/25/08	2092	5400	42	50	0.27	6.5	0.20	34	3.7	10.8
02/26/08		22790	143	46	0.28	6.5	0.24	33		20.0
02/27/08	24192	124550	529		0.81			33		53.2
02/28/08	92080	304750	426		1.24			33		42.2
02/29/08	61300	259700	303	28	1.46	5.0	0.77	33		37.1
03/03/08	137340	204000	820	14		2.2	0.67	33	18.2	505.0
03/04/08	111990	114000	980	20		3.0	0.99	33		271.0
03/05/08	86640	272950	866	20		3.2	1.34	33		152.0
03/06/08	173290	4055000	727	19		2.7	1.44	33		92.8
03/07/08	173280	768500	276	19		2.9	1.33	33		63.4

Sample Date	T. coliform	HPC	E. coli	Cl	NH3-N	NO3-N	O-Phos	Temp F	TOC	Turb
03/10/08	4190	37000	34	23	2.1	3.5	0.95	33	11.8	39.8
03/11/08	3690	25000	28	24		3.8	0.78	33		47.8
03/12/08	24810	120000	117		1.5			35		178.0
03/13/08	43520	147000	214	17		2.6	0.48	33		343.0
03/14/08	33280	244000	173	18		2.9	0.66	35		156.0
03/17/08	52260	218000	197	17		3.4	1.04	37	10.3	238.0
03/18/08	13330	101000	79	19		4.1	0.97	39		210.0
03/19/08	9850	40000	81	20		4.9	0.74	36		146.0
03/20/08				19		5.1	1.87	46		114.0
03/21/08	3214	64000	22	20		5.1	0.50	46		97.6
03/24/08	1789	7000	9	21		6.1	0.34	47	5.8	70.3
03/25/08	1842	9200	17	21		6.5	0.25	43		65.3
03/26/08	1414	9100	15	21		6.4	0.22	44		57.1
03/27/08	816	17900	5	21		6.2	0.24	46		63.8
03/28/08	1046	11200	31	25		6.2	0.23	43		41.8
03/31/08	866	6200	93	22		6.1	0.17	46	4.5	43.9

Warm temperatures (50° F at Carroll) at the end of January melted 9 inches of snow in the Carroll area on the Middle and South Raccoon causing a spike in flow in the South Raccoon (fig 7). There was essentially no increase in flow at Jefferson on the North Raccoon where little of the snow melted to contribute to flow. A sudden increase in chlorine demand (2.2 mg/l) beginning January 30 forced the utility to change to the Des Moines River. High total coliform bacteria counts, HPC bacteria, and sewer threshold odor numbers accompanied the elevated ammonia (1.2 mg/l) and o-phosphorus concentrations (0.5 mg/l) implicating manure runoff from melting snow in the South Raccoon watershed as the demand source in the Raccoon River. The low *E. coli* counts relative to total coliform and HPC bacteria counts suggest aged manure where much of the *E. coli* bacteria had died. This pattern was characteristic in all areas of the watershed during high chlorine demand.

The highest concentration of bacteria and TOC (18.2 mg/l) occurred the week following the March 2 rain event in the southern section of the Raccoon River Watershed. Soluble phosphorus concentrations of >1 mg/l occurred from 3/4/08 to 3/7/08. Ammonia levels were not measured as the utility had switched to the Des Moines River.

Following a brief period of below freezing temperatures, warm weather returned beginning March 12 causing the 12 inches in snow in the heart of the North Raccoon Watershed to melt in a couple days. Water quality during this runoff event was similar to the March 2 rain event in the South Raccoon with high total coliform bacteria, HPCs, TOC, ammonia and soluble phosphorus. Most of the flow in the Raccoon River came from the North Raccoon watershed during this Mid-March flooding event. *E. coli* counts however remained below the WQS during this second period of elevated flow suggesting runoff of old manure.

Raccoon River Watershed Sampling, Walnut Creek (fig 14)

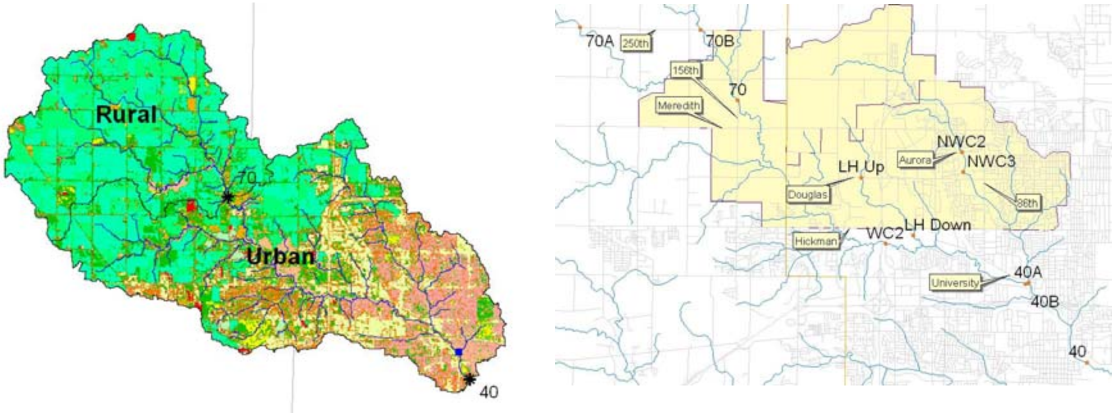


fig 14. Walnut Creek Watershed and sample sites

Urban contribution, sites 40A, LHC, WCrSS7 on the North Walnut Creek, Living History Creek, and Waveland Creek respectively show elevated chloride from road salt application (Table 4). The Waveland Creek site was just below Waveland Golf Course had high *E. coli* counts but flow was minimal (1 CFS estimate). Low fluoride concentrations and non-detectable phosphorus suggests urban ground as the source of flow (Table 5). The area was frequented with wildlife and waterfowl which included a pond and a marsh. Numerous droppings were observed along the riparian corridor as well. Very high chloride concentrations on 1/28/08 indicated the source of flow to be snow melt from de-icing. It is likely that the flow was transporting *E. coli* from animal droppings in the storms sewers, marsh, and riparian habitat.

The rural area generally had higher *E. coli* counts than the urban area, especially in January and February before snow melt. Water quality in March was similar to the Raccoon River and Beaver Creek with high total coliform counts, phosphorus, TOC, and ammonia. The relatively low *E. coli* counts suggests old manure where *E. coli* has died and other bacteria proliferated to partially decompose the fecal matter. The highest ammonia concentration recorded (1.7 mg/l) occurred on March 3 when Walnut Creek provided up to 17% of the flow in the Raccoon River. Other than this possible exception, its influence on water quality in the Raccoon River this quarter was negligible. Walnut Creek is usually of interest because of the rural and urban component in its watershed and the potential of major contribution should the sewage collection system fail.

Table 4. Water Quality in Walnut Creek

Date	Site	Cl	Total coliform	E. coli	NH3-N	NO2-N	NO3-N	O-Phos	TOC	Turb
01/04/08	70		2046							4.9
01/07/08	40	178	24192	350		0.08	3.73			15.4
	40A	267	14136	364			2.57			19.3
	40B	116	24192	1515		0.06	4.14			10.1
	70	22	>241920	1850		0.05	8.82			7.33
	WCrSS7	245	>241920	2187		0.11	1			54.6

Date	Site	Cl	Total coliform	E. coli	NH3-N	NO2-N	NO3-N	O-Phos	TOC	Turb
01/28/08	40	393	3270	1870			4.39			12.2
	40A	867	3640	840			2.5			14.7
	40B	238	1320	100			5.24			5.7
	70	22	3270	1340			8.7			3.85
	LHCDN	370	3540	100			2.5			4.89
	WCrSS7	892	41060	15970			1.04			619
03/03/08	40	73		520	1.7	0.12	1.79	1.02	14.1	208
	40A	229	129970	100		0.05	1.71	0.12		79.7
	40B	56	1986630	630		0.12	1.95	1.01		191
03/06/08	40	124	15150		0.75		3.14	0.22		34.5
	70	23	92080		0.83	0.05	6.28	0.45		36
03/13/08	70	15	34480	100	0.92	0.05	4.72	0.44	8.4	69.5
03/26/08	40	63	689	20	0.3	0.08	5.53			
	40A	112	341	10	0.11		2.95			
	40B	50	336		0.34	0.08	6.24			
	70	21	1720	84	0.7	0.1	8.95			

Table 5. Water Quality in Waveland Creek

Date	Site	Cl	Total coliform	E.coli	NO2-N	NO3-N	O-phos	Turb
01/04/08	WCrSS7c	77				0.98		
	WCrSS7d	132	12033	4611	0.07	0.86		8.6
	WCrSS7e	214	5475	738		1.75		3.3
	WCrSS7f	74	3654	1500		0.79		4.6
	WCrSS7g	40	650	336		1.45		1
01/28/08	WCrSS7a	848	61310	18500		1.21		887
	WCrSS7c	695	64880	15000		0.81		1155
	WCrSS7d	800	5940	3990		1.08		13.1
	WCrSS7e	1043	57940	19890		1.08		1141
	WCrSS7f	734	198630	86640		1		603
	WCrSS7g	242	24810	8390		0.97	0.36	191

Raccoon River Watershed Sampling: Main-stem tributaries and creeks

Water quality characteristics in Raccoon River tributaries and streams supported the observations made from flow contributions. Highest ammonia concentrations were present in the South Raccoon watershed, especially Brushy Creek which has chronically high fecal contamination. Low *E. coli* counts during this quarter accompanied with high organic nitrogen, soluble phosphorus, and total coliform counts implicate old manure as the primary source of the ammonia (Table 6). These manure indicators were present in highest concentrations on February 25 during a snow melt run off event. *E. coli* counts were again elevated following the March 2 rain event. The higher *E. coli* counts indicate a source of more recent fecal discharge such as would occur with feedlot runoff. Sample sites are grouped by 8 digit HUC numbers preceded by tributary initials. South Raccoon sites below its confluence with the Middle Raccoon are grouped as lower South Raccoon (lSR) site to distinguish them from sites above its confluence with the Middle Raccoon.

Table 6. Water Quality in the Raccoon River Tributaries Upstream of Van Meter

Sample date	HUC	Site Id	total coliform	*E.coli*	NH3-N	NO3-N	o-phos	TN	TOC	Turb	Organic-N
01/07/08	SR 07100007	28A	>241920	3090		2.5	0.32			131	
		28	>241920	6170		5.4	0.26			26.1	
		28AA	>241920	6970		3.1	0.57			27	
		32	>241920	3076		3.1				18.7	
	MR 07100007	31	17329	134		8.1				4.9	
	lSR 07100007	37	11199	288		6.1				6.07	
	NR 07100006	A	1835	156		9.1				3.77	
	RR 07100006	38	15531	240		7.0				7.65	
02/25/08	SR 07100007	27	58600	1000	1.9	1.6	0.41	6.1		105	2.516
		28A	14600	1000	2.1	2.7	0.44	7.0		144	2.164
		28	6300	<1000	5.9	5.1	3.19	10.6		27.6	-0.37
		28A1	30100	<1000	3.0	3.6	1.01	8.7		40.5	1.996
		28A2	6300	<1000	2.2	4.3	0.9	8.6		40.3	1.882
		28AA	44300	10700	7.6	2.2	2.64			220	
		28AC	6300	<1000	2.1	3.2	0.61	8.5		77.9	3.161
		29	5200	<1000	1.7	1.0	0.83	5.6		89.7	2.849
		32	6300	<1000	1.2	3.3	0.74	5.9		93.5	1.375
		32A	7400	<1000	1.4	2.7	0.45	6.3		119	2.217
		42A	35000	1000	6.1	4.4	3.16	14.7		78.9	4.03
		42B	32700	<1000	7.5	5.4	2.62	18.7		110	5.68
		42B2	24600	<1000	7.7	5.4	2.27	14.9		83.8	1.57
		42B3	24600	2000	5.8	5.7	2.81	17.3		88.9	5.66
		42BA	20100	2000	6.5	5.0	2.36	17.9		151	6.17
		50	21600	<1000	6.9	4.5	2.66	15.8		104	4.14
	MR 07100007	31	4100	<1000	1.2	4.8	0.7	7.1		38.3	1.038
03/03/08	SR 07100007	28A	>241920	1340	2.0	1.4	0.32			362	
		28	>241920	4650	4.5	2.4	0.83			1427	
		32	>241920	3930	2.2	1.3	0.38		20.6	1977	
	MR 07100007	26A	>241920	3110	4.3	2.4	1.87			310	
		31	98040	200	1.4	5.3	0.74		11.2	138	
	lSR 07100007	37	>241920	630	1.6	2.4	0.53		16.2	685	
	NR 07100006	21	241920	630	3.1	2.4			26.9	96.6	
		22	241920	520		1.7	2.46			49.9	
		23	241920	410		1.5	2.5			55.4	
		46	241920	860	2.7	2.7	1.68			88.8	
		A	129970	1480	3.0	2.7			18.3	98.8	
	RR 07100006	38	241920	1870	1.8	2.5	0.72			463	
03/09/08	SR 07100007	28A	1350	<100	0.7	6.8	0.24	4.8	3.5	44.1	
		28	1990	<100	1.4	8.3	0.26	7.3	8.2	43.5	
	MR 07100007	25	4640	<100	1.4	6.3	1.01	5.8	8.2	38.9	
		26	520	<100	1.9	12.6	0.54	9.8	8.2	29.4	
		C	141360	310	3.3	1.5	1.95	7.0	23.3	109	
03/10/08	SR 07100007	28A	2130	100	0.7	4.2	0.1	4.8	3.1	36.4	
		28	5380	<100	2.1	6.5	0.2	7.8	5.2	53.6	
		42A	2030	<100	0.9	13.5	0.13	13.5	3.1	12	

Sample date	HUC	Site Id	total coliform	*E.coli*	NH3-N	NO3-N	o-phos	TN	TOC	Turb	Organic-N
	MR 07100007	25	2620	100	1.0	4.5	0.68	6.3	7.8	15.8	
		26	1220	<100	1.6	7.8	0.34	9.0	7.7	18.1	
		44	16580	2820	0.8	9.8	0.16	10.1	4.0	18.4	
		C	155310	1200	3.7	0.7	1.38	7.3	24.0	76.6	
03/13/08	SR 07100007	28A	86640	740	1.2	1.5	0.17	3.1	10.3	776	
		28	104620	860	3.4	3.7	0.24	6.8	12.4	309	
		32	77010	300	1.7	1.6	0.43	3.8	12.3	648	
	MR 07100007	26A	61310	630	2.9	3.1	0.25	6.0	10.4	365	
		C	241920	410	3.8	1.4	1.33	7.0	22.4	92.2	
	ISR 07100007	37	48840	310	1.6	1.7	0.42	3.8	11.1	526	
	NR 07100006	14A	77010	510	2.9	2.5	1.64	6.4	21.0	188	
		21	48840	100	2.6	3.0	1.23	6.6	20.2	123	
		45	27550	<100	2.6	3.0	1.41	6.4	16.7	181	
	RR 07100006	38	21430	100	1.9	4.0	0.7	5.9	9.2	222	

This following site map (fig 15) shows the sampling locations in Brushy Creek. The site series 28A is of the South Raccoon upstream of Brushy Creek. Sites 25, 26, 26A, and 44 are on the Middle Raccoon below Carroll (pictured) but upstream of Lake Panorama. Though outside the study area, it shows the ubiquitously high ammonia levels throughout in the southern region of the watershed from late February through early March. An ammonia concentration of 4.3 mg/l occurred at site 26A near Bayard on March 3. High concentrations (>3 mg/l) below Lake Panorama at site C, created a high chlorine demand at the Panora Water Treatment Plant through most of March.

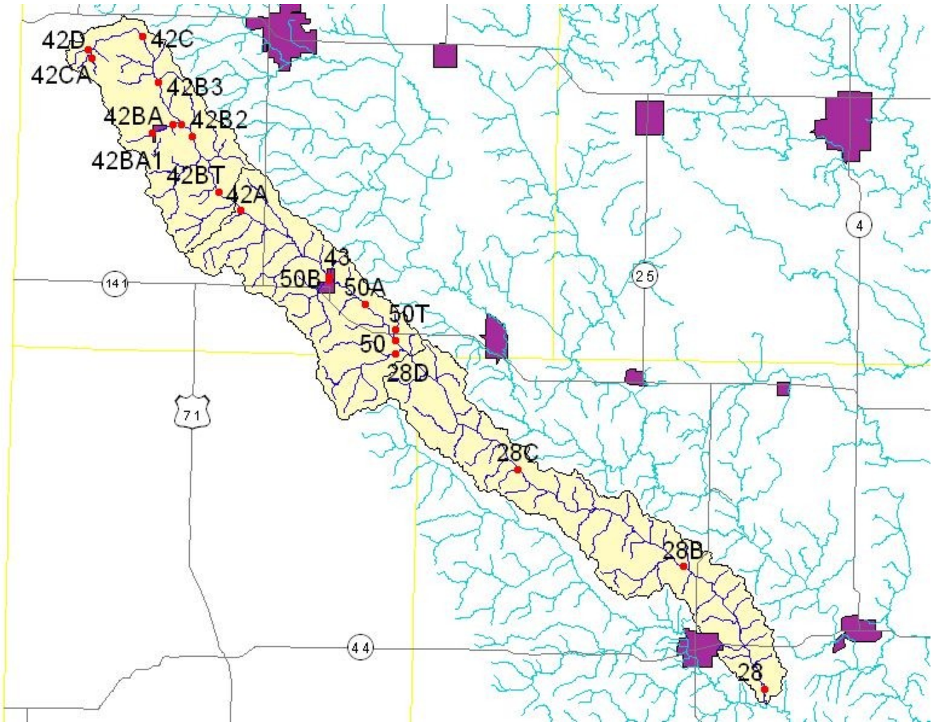


fig 15. Upper Middle and South Raccoon with Brushy Creek sample site locations

This region of highest ammonia concentration also has a high density of open feedlot operations. Most of these operations surface apply manure to crop land in the fall following harvest fig 16.

fig 16 Open feedlots in the Raccoon Watershed

The North Raccoon watershed was not extensively sampled as it was outside the study area. However, sites in Buttrick Creek and all along the North Raccoon showed high ammonia concentrations as well. It can therefore be assumed that most if not all streams discharging into the North Raccoon had high ammonia concentrations as well. Streams which have the highest concentration of confinement operations (the northern section of the watershed) were not sampled during this study. Newspaper articles stated that the wet fall weather followed by below normal temperatures forced surface application of the wastes. This would certainly contribute to the ammonia levels observed if widely practiced.

Discussion:
This quarter, *E. coli* counts and nitrate concentrations at the DMWW intake suggested relatively high water quality in the two rivers. Counts were low and showed the typical reduction observed during winter quarters. The Des Moines River counts exceeded the WQS on only 2 of the 59 days sampled while the Raccoon River exceeded the standard on 14 of 61 days sampled. This is similar to the winter quarter in 2007, where the *E. coli* standard was exceeded on 5 of 55 days sampled in the Des Moines River and 11 or 55 days sampled in the Raccoon River. Water quality from a nitrate standard was much better than last winter. This quarter the 10mg/l Nitrate-N was not exceeded at anytime in either river with the highest concentrations being 8.4 mg/l and 7.1 mg/l in the Raccoon and Des Moines River respectively.

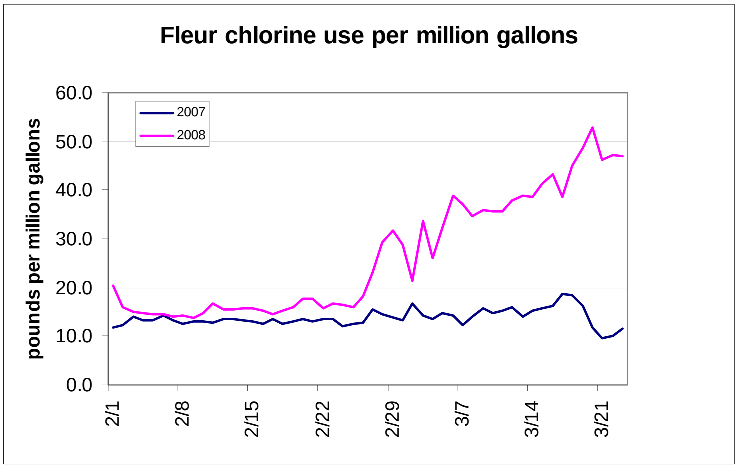


fig 17. Chlorine demand in source water 2008

However, an exceptionally high chlorine demand at the water utility beginning in late February (fig 17) 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.

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 some 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 of 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 where 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 have a much greater role than mass in determining counts in the streams.

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 environment. In-stream simulation experiments with fecal pats showed that *E. coli* counts in the downstream water exceeded counts within the original pat, demonstrating continued reproduction. Counts remained at an elevated level (approximately 2500/100ml) until the fecal pat was dispersed 11 days later (Brand, status report #7). Jamieson et al (2005) also 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.

High counts 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 during low flow was observed in a small tributary stream of Lake Creek (outside the study area) downstream of a small pasture lot containing approximately 50 cattle. Counts in excess of 2 million/100ml were observed which at the estimated flow of 1 CFS, 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 decrease in counts from headwater streams to the outlet during base flow especially (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. 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. Longer travel times, especially during base flow, therefore 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. It also 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 19 provides an interpretive concept model for the data.

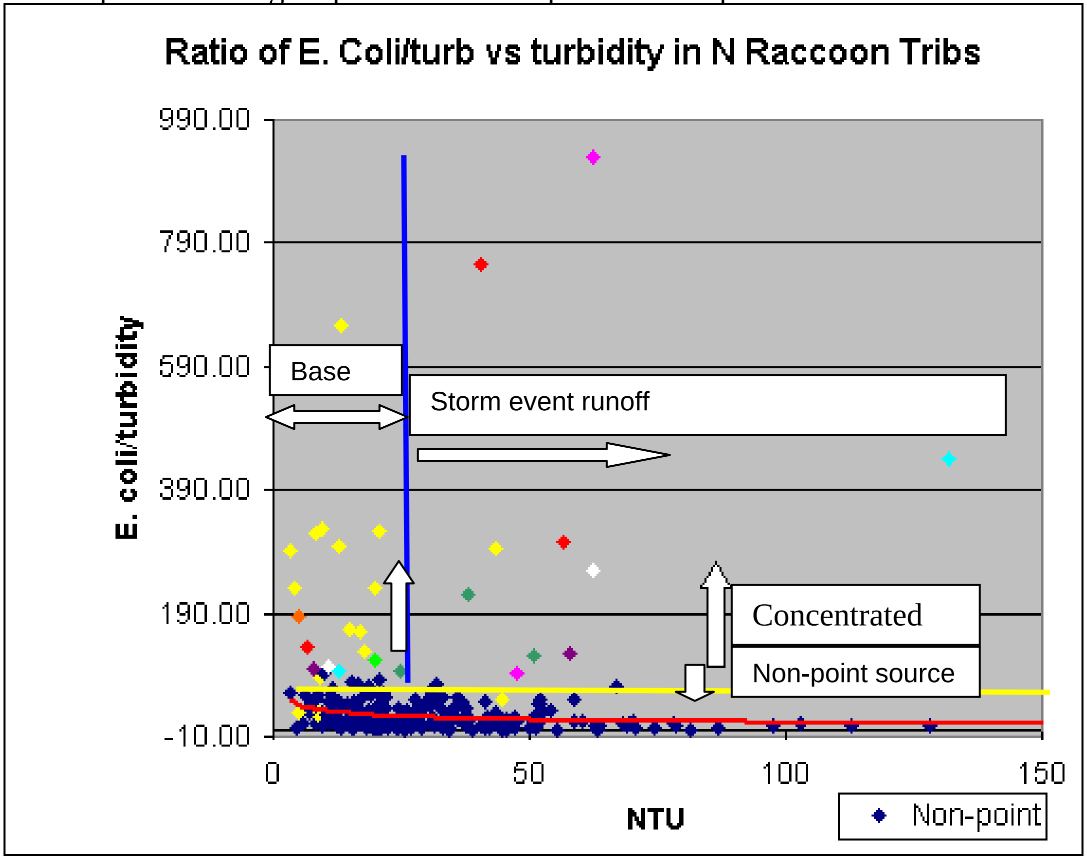
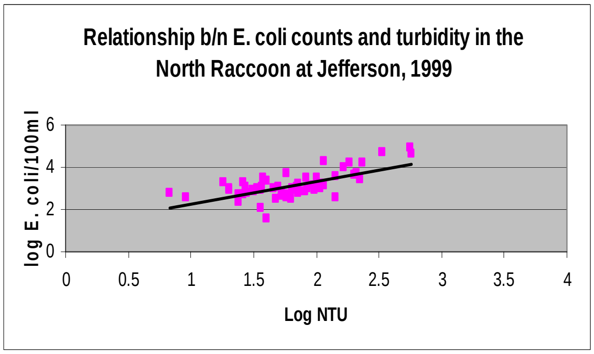
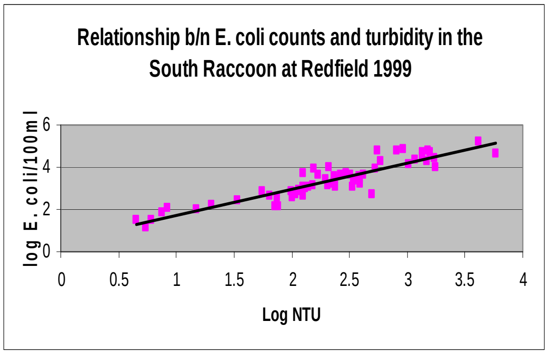


fig 19. Conceptual interpretation of *E. coli* turbidity relationships in the watershed

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 higher contribution from a fresh manure source (viable *E. coli*) such as a feedlot. 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 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. Blue data points to the far right of the graph also have very high counts but also sediment due to a heavy rain and landscape runoff. A similar plot has not yet been developed for other tributaries due to time limitations. This appears to 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 18).





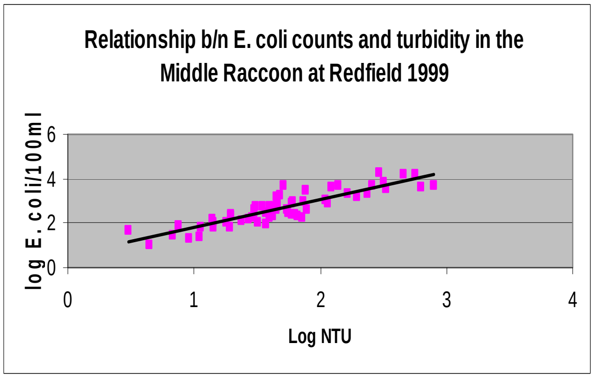


fig 18. E. coli relationship to turbidity

A greater slope would be expected from a more 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 that 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 in composite relates much more to differences in terrain and hydrology rather than landuse. 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.

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. Safe guards against spillage and illegal pumping however is 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.

It is 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 mandates and make adjustment as needed.

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Appendix A
Comparison of *E. coli* counts in the North Raccoon Watershed to the Outlet

Date	Trib id	Counts	Counts	Difference	Trib NTU	MS NTU	difference	Non-point	EC/Turb MS
4/20/2006	03	190	36	154	3.11	45.7	-42.59	61.09	0.79
	04A	285	36	249	9.4	45.7	-36.3	30.32	0.79
	05	980	36	944	70.1	45.7	24.4	13.98	0.79
	07	79	36	43	20.5	45.7	-25.2	3.85	0.79
	08	770	36	734	11.5	45.7	-34.2	66.96	0.79
	09	1300	36	1264	18.6	45.7	-27.1	69.89	0.79
	11	64	36	28	5.63	45.7	-40.07	11.37	0.79
	12	91	36	55	22.2	45.7	-23.5	4.10	0.79
	14	2419	36	2383	14.9	45.7	-30.8	162.35	0.79
	14A	798	36	762	25.9	45.7	-19.8	30.81	0.79
	17	88	36	52	15.1	45.7	-30.6	5.83	0.79
	21	740	36	704	43.9	45.7	-1.8	16.86	0.79
	22	67	36	31	15.7	45.7	-30	4.27	0.79
	24	210	36	174	6.9	45.7	-38.8	30.43	0.79
5/4/2006	02	161	1259	-1098	21	125	-104	7.67	10.07
	03	408	1259	-851	8.37	125	-116.63	48.75	10.07
	04A	226	1259	-1033	15.7	125	-109.3	14.39	10.07
	05	510	1259	-749	78.6	125	-46.4	6.49	10.07
	07	246	1259	-1013	33.4	125	-91.6	7.37	10.07
	08	598	1259	-661	16.5	125	-108.5	36.24	10.07
	09	2310	1259	1051	51.7	125	-73.3	44.68	10.07
	10	833	1259	-426	38.2	125	-86.8	21.81	10.07
	11	369	1259	-890	10.9	125	-114.1	33.85	10.07
	12	860	1259	-399	58.6	125	-66.4	14.68	10.07
	13	663	1259	-596	47.4	125	-77.6	13.99	10.07
	14	3873	1259	2614	13	125	-112	297.92	10.07
	14A	798	1259	-461	51.9	125	-73.1	15.38	10.07
	16	120	1259	-1139	19.4	125	-105.6	6.19	10.07
	17	410	1259	-849	63	125	-62	6.51	10.07
	20	419	1259	-840	24.9	125	-100.1	16.83	10.07
	21	740	1259	-519	97.5	125	-27.5	7.59	10.07
	22	200	1259	-1059	74.4	125	-50.6	2.69	10.07
	23	228	1259	-1031	47.1	125	-77.9	4.84	10.07
	24	1017	1259	-242	47.1	125	-77.9	21.59	10.07
	45	785	1259	-474	113	125	-12	6.95	10.07
5/18/2006	02	228	59	169	86.8	34.1	52.7	2.63	1.73
	03	517	59	458	10.7	34.1	-23.4	48.32	1.73
	04	155	59	96	11.3	34.1	-22.8	13.72	1.73
	04A	118	59	59	10.7	34.1	-23.4	11.03	1.73
	05	1986	59	1927	41.5	34.1	7.4	47.86	1.73
	06	1733	59	1674	36.6	34.1	2.5	47.35	1.73
	07	112	59	53	24	34.1	-10.1	4.67	1.73
	08	248	59	189	18.5	34.1	-15.6	13.41	1.73
	09	1460	59	1401	31.8	34.1	-2.3	45.91	1.73
	10	119	59	60	20.2	34.1	-13.9	5.89	1.73

	11	365	59	306	6.26	34.1	-27.84	58.31	1.73
	12	365	59	306	27.7	34.1	-6.4	13.18	1.73
	13	172	59	113	26.2	34.1	-7.9	6.56	1.73
	14	960	59	901	4.17	34.1	-29.93	230.22	1.73
	14A	2382	59	2323	24.6	34.1	-9.5	96.83	1.73
	16	108	59	49	12.9	34.1	-21.2	8.37	1.73
	17	361	59	302	32.3	34.1	-1.8	11.18	1.73
	19	411	59	352	32.8	34.1	-1.3	12.53	1.73
	20	1203	59	1144	20.5	34.1	-13.6	58.68	1.73
	21	194	59	135	29.4	34.1	-4.7	6.60	1.73
	22	326	59	267	23.3	34.1	-10.8	13.99	1.73
	23	291	59	232	20.7	34.1	-13.4	14.06	1.73
	24	649	59	590	14.5	34.1	-19.6	44.76	1.73
6/1/2006	02	727	33	694	35.4	36.9	-1.5	20.54	0.89
	03	517	33	484	34.3	36.9	-2.6	15.07	0.89
	04	196	33	163	31.2	36.9	-5.7	6.28	0.89
	04A	1120	33	1087	28.8	36.9	-8.1	38.89	0.89
	05	2419	33	2386	32	36.9	-4.9	75.59	0.89
	06	194	33	161	33.1	36.9	-3.8	5.86	0.89
	07	308	33	275	26.4	36.9	-10.5	11.67	0.89
	08	1413	33	1380	27.6	36.9	-9.3	51.20	0.89
	09	2247	33	2214	52.1	36.9	15.2	43.13	0.89
	10	770	33	737	22	36.9	-14.9	35.00	0.89
	11	461	33	428	13.4	36.9	-23.5	34.40	0.89
	12	1299	33	1266	43.4	36.9	6.5	29.93	0.89
	13	228	33	195	25	36.9	-11.9	9.12	0.89
	14	4611	33	4578	20	36.9	-16.9	230.55	0.89
	14A	298	33	265	51.1	36.9	14.2	5.83	0.89
	16	261	33	228	45.2	36.9	8.3	5.77	0.89
	17	1299	33	1266	51.3	36.9	14.4	25.32	0.89
	19	701	33	668	68.2	36.9	31.3	10.28	0.89
	20	816	33	783	20.7	36.9	-16.2	39.42	0.89
	21	102	33	69	44.6	36.9	7.7	2.29	0.89
	22	613	33	580	33.4	36.9	-3.5	18.35	0.89
	23	461	33	428	22.1	36.9	-14.8	20.86	0.89
	24	1300	33	1267	30.5	36.9	-6.4	42.62	0.89
	45	50	33	17	38.9	36.9	2	1.29	0.89
	46	154	33	121	46	36.9	9.1	3.35	0.89
6/15/2006	03	1203	78	1125	15.3	22	-6.7	78.63	3.55
	04A	579	78	501	18.8	22	-3.2	30.80	3.55
	07	411	78	333	27.4	22	5.4	15.00	3.55
	08	649	78	571	27.8	22	5.8	23.35	3.55
	11	1300	78	1222	21.5	22	-0.5	60.47	3.55
	12	687	78	609	36.1	22	14.1	19.03	3.55
	14	3076	78	2998	9.4	22	-12.6	327.23	3.55
	14A	411	78	333	26.7	22	4.7	15.39	3.55
	17	1986	78	1908	35.9	22	13.9	55.32	3.55
	21	119	78	41	55.2	22	33.2	2.16	3.55
	22	980	78	902	41.7	22	19.7	23.50	3.55
6/29/2006	03	2282	41	2241	20	19	1	114.10	2.16

	04A	350	41	309	10.7	19	-8.3	32.71	2.16
	07	471	41	430	22	19	3	21.41	2.16
	09	1112	41	1071	19	19	0	58.53	2.16
	11	1664	41	1623	20.5	19	1.5	81.17	2.16
	14	988	41	947	3.4	19	-15.6	290.59	2.16
	14A	233	41	192	12.4	19	-6.6	18.79	2.16
	17	882	41	841	21.5	19	2.5	41.02	2.16
	19	2755	41	2714	17.1	19	-1.9	161.11	2.16
	21	122	41	81	21.1	19	2.1	5.78	2.16
	22	495	41	454	8.8	19	-10.2	56.25	2.16
	24	933	41	892	5	19	-14	186.60	2.16
7/13/2006	03	200	200	0	24.7	20.3	4.4	8.10	9.85
	04A	100	200	-100	8.2	20.3	-12.1	12.20	9.85
	07	100	200	-100	19.6	20.3	-0.7	5.10	9.85
	08	310	200	110	7.28	20.3	-13.02	42.58	9.85
	11	740	200	540	19.8	20.3	-0.5	37.37	9.85
	14	310	200	110	7.84	20.3	-12.46	39.54	9.85
	19	520	200	320	14.5	20.3	-5.8	35.86	9.85
	24	410	200	210	8.29	20.3	-12.01	49.46	9.85
7/27/2006	03	630	300	330	33.5	49.7	-16.2	18.81	6.04
	05	740	300	440	69.6	49.7	19.9	10.63	6.04
	06	310	300	10	7.38	49.7	-42.32	42.01	6.04
	07	520	300	220	31.8	49.7	-17.9	16.35	6.04
	09	740	300	440	38.3	49.7	-11.4	19.32	6.04
	11	100	300	-200	8.45	49.7	-41.25	11.83	6.04
	14	200	300	-100	9.2	49.7	-40.5	21.74	6.04
	14A	100	300	-200	26.8	49.7	-22.9	3.73	6.04
	17	300	300	0	30.4	49.7	-19.3	9.87	6.04
	19	30760	300	30460	40.6	49.7	-9.1	757.64	6.04
	22	100	300	-200	25.1	49.7	-24.6	3.98	6.04
8/10/2006	03	410	200	210	25.4	22	3.4	16.14	9.09
	04A	310	200	110	15	22	-7	20.67	9.09
	05	1350	200	1150	35.5	22	13.5	38.03	9.09
	06	310	200	110	16	22	-6	19.38	9.09
	07	980	200	780	37.4	22	15.4	26.20	9.09
	09	850	200	650	60.5	22	38.5	14.05	9.09
	11	7220	200	7020	58	22	36	124.48	9.09
	14A	8330	200	8130	38	22	16	219.21	9.09
	17	4870	200	4670	67	22	45	72.69	9.09
	22	3640	200	3440	235	22	213	15.49	9.09
8/24/2006	03	850	100	750	27.8	32.6	-4.8	30.58	3.07
	04A	100	100	0	20	32.6	-12.6	5.00	3.07
	05	850	100	750	45.3	32.6	12.7	18.76	3.07
	06	410	100	310	25.5	32.6	-7.1	16.08	3.07
	07	1090	100	990	29.2	32.6	-3.4	37.33	3.07
	09	200	100	100	11.1	32.6	-21.5	18.02	3.07
	11	100	100	0	28.8	32.6	-3.8	3.47	3.07
	14	2230	100	2130	44.5	32.6	11.9	50.11	3.07
	14A	310	100	210	18.1	32.6	-14.5	17.13	3.07
	17	200	100	100	29	32.6	-3.6	6.90	3.07

	19	1730	100	1630	33	32.6	0.4	52.42	3.07
	22	410	100	310	31.2	32.6	-1.4	13.14	3.07
4/5/2007	05	980	980	0	128	81.8	46.2	7.66	11.98
	07	310	980	-670	40.4	81.8	-41.4	7.67	11.98
	09	960	980	-20	17.5	81.8	-64.3	54.86	11.98
	11	410	980	-570	12.1	81.8	-69.7	33.88	11.98
	12	410	980	-570	32.9	81.8	-48.9	12.46	11.98
	14	2590	980	1610	8.08	81.8	-73.72	320.54	11.98
	14A	980	980	0	43.4	81.8	-38.4	22.58	11.98
	17	200	980	-780	34.5	81.8	-47.3	5.80	11.98
	22	100	980	-880	24.4	81.8	-57.4	4.10	11.98
4/19/2007	5	70	37	33	45.3	32.1	13.2	1.55	1.15
	7	64	37	27	18.1	32.1	-14	3.54	1.15
	9	1203	37	1166	12.7	32.1	-19.4	94.72	1.15
	11	21	37	-16	4.7	32.1	-27.4	4.47	1.15
	12	88	37	51	15.6	32.1	-16.5	5.64	1.15
	14	142	37	105	5	32.1	-27.1	28.40	1.15
	14A	42	37	5	15.2	32.1	-16.9	2.76	1.15
	17	78	37	41	9.7	32.1	-22.4	8.04	1.15
	19	40	37	3	13.4	32.1	-18.7	2.99	1.15
	22	109	37	72	12.2	32.1	-19.9	8.93	1.15
5/3/2007	5	231	231	0	41.2	127	-85.8	5.61	1.82
	7	31	231	-200	25.8	127	-101.2	1.20	1.82
	9	833	231	602	38	127	-89	21.92	1.82
	11	30	231	-201	63.2	127	-63.8	0.47	1.82
	12	426	231	195	63.6	127	-63.4	6.70	1.82
	14	2282	231	2051	17.7	127	-109.3	128.93	1.82
	14A	272	231	41	45.6	127	-81.4	5.96	1.82
	17	259	231	28	70.5	127	-56.5	3.67	1.82
	19	168	231	-63	81.5	127	-45.5	2.06	1.82
	22	529	231	298	69.2	127	-57.8	7.64	1.82
5/17/2007	5	906	171	735	78	86.1	-8.1	11.62	1.99
	7	211	171	40	42.3	86.1	-43.8	4.99	1.99
	9	712	171	541	45.3	86.1	-40.8	15.72	1.99
	11	74	171	-97	34.1	86.1	-52	2.17	1.99
	12	318	171	147	31.1	86.1	-55	10.23	1.99
	14	776	171	605	9.1	86.1	-77	85.27	1.99
	14A	288	171	117	50	86.1	-36.1	5.76	1.99
	17	354	171	183	37.4	86.1	-48.7	9.47	1.99
	19	17329	171	17158	56.6	86.1	-29.5	306.17	1.99
	22	318	171	147	27.4	86.1	-58.7	11.61	1.99
	24	185	171	14	17.5	86.1	-68.6	10.57	1.99
5/31/2007	5	1850	882	968	54.3	60.3	-6	34.07	14.63
	7	1439	882	557	29.8	60.3	-30.5	48.29	14.63
	9	1187	882	305	32.6	60.3	-27.7	36.41	14.63
	11	850	882	-32	34.7	60.3	-25.6	24.50	14.63
	12	960	882	78	37.5	60.3	-22.8	25.60	14.63
	14	3890	882	3008	24.5	60.3	-35.8	158.78	14.63
	14A	1515	882	633	32.4	60.3	-27.9	46.76	14.63
	17	620	882	-262	34.3	60.3	-26	18.08	14.63

	19	1460	882	578	52.5	60.3	-7.8	27.81	14.63
	22	860	882	-22	34.6	60.3	-25.7	24.86	14.63
	24	970	882	88	50.6	60.3	-9.7	19.17	14.63
6/14/2007	5	1203	50	1153	21.9	20.2	1.7	54.93	2.48
	7	214	50	164	14.6	20.2	-5.6	14.66	2.48
	9	727	50	677	30.8	20.2	10.6	23.60	2.48
	11	816	50	766	8.04	20.2	-12.16	101.49	2.48
	12	613	50	563	13	20.2	-7.2	47.15	2.48
	14A	276	50	226	16.5	20.2	-3.7	16.73	2.48
	17	198	50	148	16.8	20.2	-3.4	11.79	2.48
	19	921	50	871	10.1	20.2	-10.1	91.19	2.48
	22	272	50	222	12	20.2	-8.2	22.67	2.48
6/28/2007	5	2950	4100	-1150	58.5	52.2	6.3	50.43	78.54
	7	100	4100	-4000	24.5	52.2	-27.7	4.08	78.54
	8	310	4100	-3790	25.5	52.2	-26.7	12.16	78.54
	9	1100	4100	-3000	35.2	52.2	-17	31.25	78.54
	11	630	4100	-3470	14.4	52.2	-37.8	43.75	78.54
	12	520	4100	-3580	20.2	52.2	-32	25.74	78.54
	14	6690	4100	2590	20.7	52.2	-31.5	323.19	78.54
	14A	520	4100	-3580	24.8	52.2	-27.4	20.97	78.54
	17	740	4100	-3360	19.9	52.2	-32.3	37.19	78.54
	19	2060	4100	-2040	31	52.2	-21.2	66.45	78.54
	22	740	4100	-3360	27.1	52.2	-25.1	27.31	78.54
	24	1350	4100	-2750	37.4	52.2	-14.8	36.10	78.54
7/12/2007	5	987	41	946	43.9	28.3	15.6	22.48	1.45
	7	448	41	407	18.1	28.3	-10.2	24.75	1.45
	9	880	41	839	24.2	28.3	-4.1	36.36	1.45
	11	712	41	671	15.5	28.3	-12.8	45.94	1.45
	12	231	41	190	14.5	28.3	-13.8	15.93	1.45
	14	8664	41	8623	13.2	28.3	-15.1	656.36	1.45
	14A	145	41	104	13.8	28.3	-14.5	10.51	1.45
	17	249	41	208	10.3	28.3	-18	24.17	1.45
	19	933	41	892	6.81	28.3	-21.49	137.00	1.45
	22	472	41	431	11.2	28.3	-17.1	42.14	1.45
8/9/2007	9	2530	1080	1450	51.9	118	-66.1	48.75	9.15
	10	4480	1080	3400	47.4	118	-70.6	94.51	9.15
	12	1100	1080	20	10.6	118	-107.4	103.77	9.15
	14	12740	1080	11660	43.4	118	-74.6	293.55	9.15
	14A	6130	1080	5050	50.7	118	-67.3	120.91	9.15
	22	1860	1080	780	30.8	118	-87.2	60.39	9.15
	23	630	1080	-450	11.1	118	-106.9	56.76	9.15
	24	410	1080	-670	16.3	118	-101.7	25.15	9.15
8/23/2007	9	57940	2590	55350	132	246	-114	438.94	10.53
	10	57920	2590	55330	62.4	246	-183.6	928.21	10.53
	12	16160	2590	13570	62.5	246	-183.5	258.56	10.53
	14A	46110	2590	43520	201	246	-45	229.40	10.53
	19	1330	2590	-1260	102.7	246	-143.3	12.95	10.53
	22	640	2590	-1950	43	246	-203	14.88	10.53
	23	310	2590	-2280	33.7	246	-212.3	9.20	10.53
	24	1220	2590	-1370	16.6	246	-229.4	73.49	10.53