STATUS REPORT #4 for the DES MOINES AND RACCOON RIVERS OF IOWA

NITRATE NITROGEN and *ESCHERICHIA COLI*

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For

Iowa Department of Natural Resources

Agreement 2006-7158-01

April 2007

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WEATHER AND HYDROLOGIC CONDITONS IN THE DES MOINES RIVER WATERSHED 1st QUARTER of 2007

Mild late fall weather in 2006 continued into mid-January with temperatures averaging 14.3° above normal (Hillaker 2007). Ground temperatures stayed above 50° into November and were generally above freezing until Jan 13 when below normal temperatures arrived. Tiles were flowing through most of January due to elevated water tables from early falls rains. Livestock were observed in stock fields throughout the fall and early winter. Though cold weather arrived later in the month, average temperatures for January were 4° above normal due to exceptionally warm weather earlier in the month. February temperatures stayed well below normal for most of the month and into the first week in March. Temperatures averaged 8° below normal and were much colder than the January temperatures. Above normal temperatures returned mid-March to give a March monthly average that was 6.1 ° above normal.

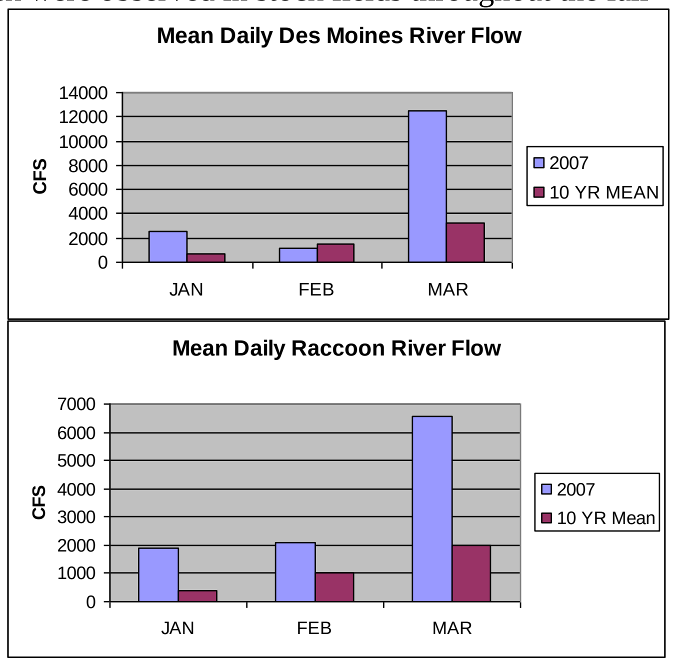

fig 1. Jan-Mar river flow in 2007 to period of record

Precipitation amounts were above normal during this period with most of the precipitation in the form of freezing rain and snow. Warm temperatures in mid-March created rapid snow melt runoff which contributed to high rivers flows (fig 1). The warm early winter weather and elevated soil moisture promote nitrification and transport of nitrate to rivers and streams. The extent of this contribution is uncertain but nitrate concentrations were unusually high in both the Des Moines and Raccoon River throughout the entire winter period. *E. coli* counts were generally within the water quality standard until the March rains and snow melt runoff.

Beaver Creek contribution to the Des Moines River

Beaver Creek is a small tributary that continues to make a periodic impact on water in the Des Moines River. It discharges into Des Moines River downstream of the Saylorville Reservoir and close to the Des Moines Water Works intake. It contributes little to total flow in the Des Moines River (fig 2) but during

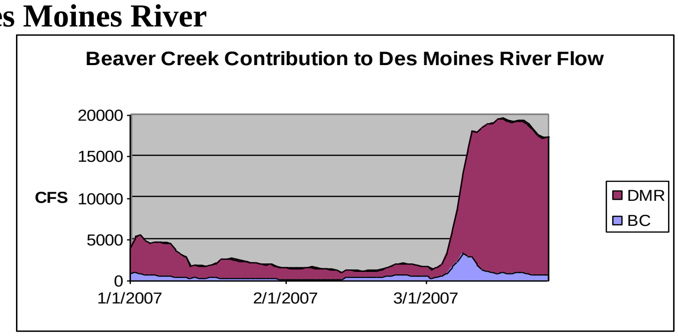

fig 2 Beaver Creek contribution to DMR flow

a runoff event it discharges its runoff flow within a short period of time before contributions from other sources further upstream on the Des Moines River arrive. Therefore water quality on the ascending limb of the hydrograph can be dominated by flow from Beaver Creek, creating what appears to be an anomalous water quality profile across the hydrograph. This is especially true where there is a big difference in water quality between the two sources and a clear separation in travel time.

Raccoon River tributary flow:
The Raccoon River is divided into two hydrologic units, the North and South Raccoon. The South Raccoon unit has two tributaries, the Middle and South Raccoon. The North Raccoon drains the relatively flat Des Moines Lobe (DML) region while the South Raccoon drains the hilly Southern Iowa Drift Plain (SIDP) region. The Middle Raccoon lies along the border between these two regions and therefore receives water from both landforms. The DML region has little natural drainage but with artificial drainage this area is very productive and intensively farmed. Livestock operations tend toward feedlots and confinement operations. The SIDP is more dissected with natural drainage and numerous small streams. Some areas are too steep to farm and subject to erosion and therefore used for grazing.

The South Raccoon Watershed is considerably smaller than the North Raccoon Watershed, has a steeper stream gradient, and is closer to Des Moines. Therefore storm water flow and runoff from the South Raccoon are more compressed than in the North Raccoon and discharges into the Raccoon River before the North Raccoon. During previous seasons, this manifested itself in a change in water quality from South Raccoon dominance with surface runoff contaminants to North Raccoon dominance, i.e. where water quality on the rising limb of the hydrograph was characterized with exceptionally high *E. coli* counts and turbidity and the descending limb with high nitrate-N concentrations. During this winter quarter, there was little runoff until mid-March. Nevertheless, water quality in the Raccoon River can best be understood from the relative contribution of the tributaries to flow in the Raccoon River and the landforms they drain.

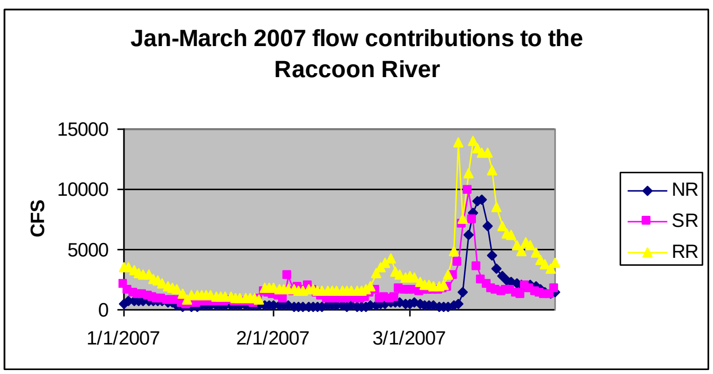

fig 3 contributions of the North and South Raccoon to flow

The Redfield stream gauging station on the South Raccoon recorded higher flows than the Jefferson gauging station on the North Raccoon for most of the winter even though watershed areas at these sites are 994 mi^2 and 1619mi^2 respectively (fig.3). Stream travel time at the two gauging stations to the Van Meter gauging station of the Raccoon River is approximately 12 and 24 hours respectively. The difference in time of travel between the North and South Raccoon is apparent during the March runoff when viewed separately but becomes somewhat obscured after flow from the two sources are combined.

WATER QUALITY AT THE DES MOINES AND RACCOON RIVER INTAKE

Winter temperatures played an important role on water quality during this quarter. Much of the precipitation stayed on the landscape during the cold mid-Jan through early March period of this quarter. During cold weather, streams tended toward base flow with low turbidity and *E. coli* counts (Table 1).

Table 1. Turbidity and *E. coli* Counts in the Des Moines and Raccoon River

	DMR		RR	
Sample Date	E.coli_QT	Turbidity	E.coli_QT	Turbidity
01/03/07	170	26.5	2260	117
01/05/07	80	19.2	126	63.8
01/08/07	53	17	94	32.2
01/10/07	34	14.1	58	30.6
01/12/07	36	12.1	58	25.4
01/16/07	1	2.92	32	6.5
01/17/07	2	9.74	25	4.66
01/18/07	28	8.21	30	4.87
01/19/07	10	5.55	17	6.87
01/22/07	5	7.42	39	7
01/23/07	20	6.65	26	5.04
01/24/07	33	4.31	35	5.32
01/25/07	29	6.79	41	11.6
01/26/07	22	7.53	18	5.83
01/29/07	10	4.41	36	5.03
01/30/07	20	4.23	41	4.71
01/31/07	16	6.43	23	4.46
02/01/07	25	13.9	34	4.45
02/02/07	26	16.8	20	5.28
02/06/07	55	14.3	41	4.22
02/07/07	33	3.88	82	3.97
02/08/07	35	3.4	52	3.87
02/09/07	58	3.85	26	4.09
02/12/07	17	6.08	45	6.42
02/13/07	51	5.1	27	5.93
02/14/07	48	3.8	21	5.44
02/15/07	43	3.97	30	4.19
02/16/07	42	6.11	20	4.6
02/20/07	7	4	65	7.5
02/21/07	62	5.52	74	21.3
02/22/07	192	9.96		42.1
02/23/07	31	6.78	132	54.4
02/26/07	261	9.8	426	51.5
02/27/07	276	5.51	122	30
02/28/07	146	5.03	63	20.1
03/01/07	80	5.2	118	20.2
03/02/07	172	7.43	152	22.4
03/06/07	280	5.57	21	9.61
03/07/07	186	5.67		
03/08/07	186	4.6	250	15.2

Sample Date	E.coli_QT	Turbidity	E.coli_QT	Turbidity
03/09/07	160	8.32	40	30.5
03/12/07	310	70.1	410	553
03/13/07	296	102	1188	641
03/14/07	162	52.3	821	687
03/15/07	108	43.7	1046	524
03/16/07	91	99.6	253	329
03/20/07	41	97.3	65	173
03/21/07	36	75.5	137	134
03/22/07	74	60.1	104	125
03/23/07	19	57.3	108	104
03/26/07	42	41.5	862	134
03/27/07	17	35.2	1180	103
03/28/07	15	26.1	352	69.7
03/29/07	17	24.3	55	58.1
03/30/07	17	22.9	143	48.9
Average	78	20.6	218	81.5
Median	41	7.5	58	20.2
Maximum	310	102	2260	687
% days over WQS	9		21	

During warmer weather, rain and melt water caused runoff from the landscape and a rise in river levels. *E. coli* counts and turbidity typically were higher during the warm weather runoff events but tributary source of flow played an important role in *E. coli* counts in the main stem rivers. Warm early January temperatures quickly melted the late December snow which created runoff and high river levels at the beginning of this quarter. *E. coli* and turbidity levels quickly returned to low levels which lasted through most of February. Precipitation in the form of rain, freezing rain, and snow during the last week in February changed from rain dominated precipitation in the southern part of the watershed toward snow dominated precipitation in the northern portion of the watershed. The change in the form of precipitation had a pronounced effect at the Des Moines River intake location as most of the precipitation in Beaver Creek was in the form of rain and freezing rain while predominately snow fell in the region north of Saylorville Lake. This caused a pronounced rise in Beaver Creek flow with little increase in flow from Saylorville Lake. *E. coli* counts at the Des Moines River intake increased during this time and frequently exceeded the water quality standard (fig 4). High flow from the reservoir in mid-March with its low *E. coli* counts overwhelmed the contribution from Beaver Creek, creating what appears to be an anomalous relationship between DMR flow and *E. coli*.

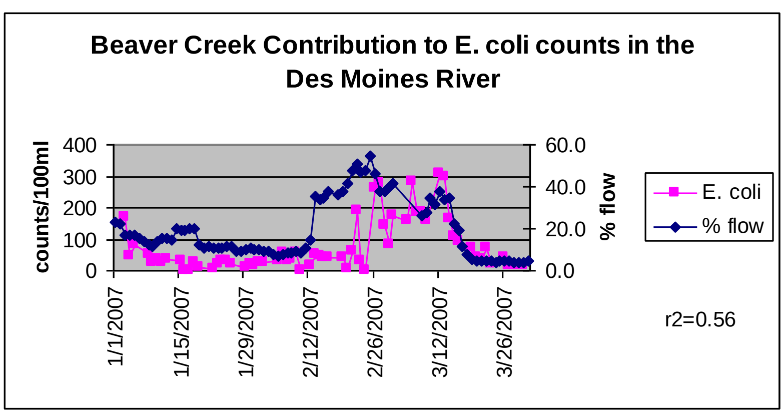

fig 4. Contribution of Beaver Creek to E. coli in the Des Moines River

The Raccoon River watershed had a similar distribution of water quality. Following the early January snow melt event, *E. coli* counts remained below the WQS until February 26. Counts generally were higher than in the Des Moines River and fluctuated considerably as may be expected without a large reservoir settle *E. coli* and associated particles.

High nitrate concentrations present in the fall continued into late February (Table 2). The February decrease in concentration is due to runoff dilution as load increased during this period. Nitrate concentrations in the Raccoon River again rose above the WSQ on the recessional limb of the flow hydrograph. Nitrate concentrations in the Des Moines River rise more slowly due to the large volume of runoff water retained within the reservoir.

Table 2 Nitrate Concentration and Load in the Des Moines River Watershed

Date	DMR NO3-N mg/l	DMR load tons NO3-N	RR NO3-N mg/l	RR load Tons NO3-N
01/03/07	7.27	91.2	10.90	101.8
01/05/07	8.31	84.6	12.79	106.7
01/08/07	7.87	85	12.83	93.2
01/10/07	9.13	76.7	13.07	82.6
01/12/07	10.96	73.7	13.02	72.4
01/16/07	10.57	40.2	12.26	46.7
01/17/07	10.81	44.7	14.38	55.1
01/18/07	11.18	51.3	14.58	56.3
01/19/07	11.45	70.8	13.93	49.6
01/22/07	11.09	65.9	14.50	49.3
01/23/07	11.32	63.3	14.29	46.3
01/24/07	11.35	61	13.87	44.2
01/25/07	11.52	58.8	13.31	43.8
01/26/07	11.20	56.8	12.51	39.2
01/29/07	11.82	56.5	12.80	39.4
01/30/07	11.75	47.6	12.87	58
01/31/07	12.01	45.4	13.33	64.1
02/01/07	11.90	43.4	13.37	
02/02/07	11.75	42.2	13.58	
02/06/07	11.66	46.9	14.03	59.9
02/07/07	11.50	41.6	14.08	57
02/08/07	11.46	39.3	13.98	58.9
02/09/07	11.29	37.5	13.92	59
02/12/07	11.08	25	13.01	55.1
02/13/07	10.93	26.6	12.81	54.3
02/14/07	10.97	27.5	12.63	54.2
02/15/07	10.81	25.2	12.19	52.3
02/16/07	10.54	22.8	11.91	50.8
02/20/07	10.00	22.3	11.03	50.3
02/21/07	9.88	22.9	10.36	53.4
02/22/07	9.13	24.5	8.67	57.8
02/23/07	9.73	31	7.72	65.4
02/26/07	9.57	34.9	7.35	70.8

Date	DMR NO3-N mg/l	DMR load tons NO3-N	RR NO3-N mg/l	RR load Tons NO3-N
02/27/07	9.87	38.4	8.32	69.2
02/28/07	9.90	34.7	8.56	65.9
03/01/07	9.70	31.7	8.39	67.5
03/02/07	9.12	29.3	7.99	66.7
03/06/07	9.61		8.57	
03/07/07	9.69		0.00	
03/08/07	9.68	26.7	8.03	49.2
03/09/07	9.03	28.3	7.46	59
03/12/07	7.80	92.9	6.04	131.1
03/13/07	7.60	135.4	6.63	175.6
03/14/07	7.40	190.8	6.33	244.4
03/15/07	6.73	236.2	5.53	225.5
03/16/07	5.39	219.8	5.90	239
03/20/07	5.38	262.9	9.68	188.7
03/21/07	5.53	277.7	10.37	176.1
03/22/07	5.57	281.2	10.10	165.5
03/23/07	5.59	279.2	10.23	151.4
03/26/07	6.20	308	10.28	154
03/27/07	6.02	294.2	10.70	144.7
03/28/07	6.54	310.8	10.91	140.5
03/29/07	6.32	288.4	11.26	132.9
03/30/07	6.85	307	11.23	125.2
Mean	9.41	99.26	10.88	90.59
Median	9.87	51.30	11.26	64.10
Max	12.01	310.80	14.58	244.40

WATERSHED CONTRIBUTIONS

<u>Beaver Creek:</u>

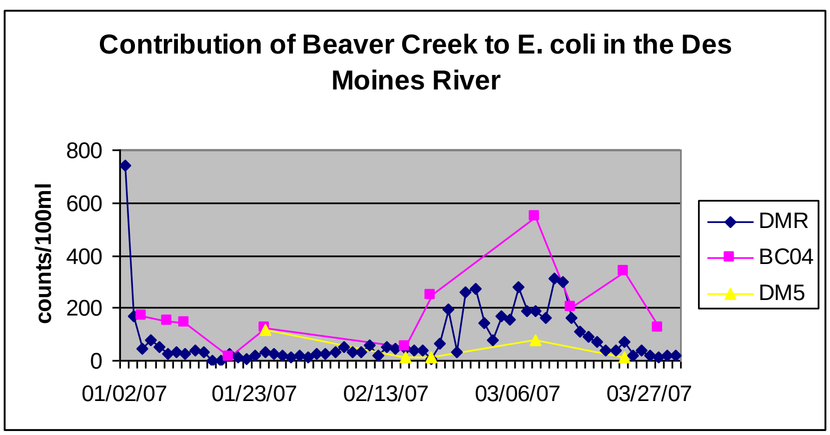

fig 5 Contribution of Beaver Creek to E. coli counts in the DMR

E. coli counts at the Des Moines River intake were generally lower than that of Beaver Creek site BC04 near the confluence of the Des Moines River but greater than the Des Moines River site DM5 upstream of Beaver Creek (fig 5). This supports the flow observation that *E. coli* counts in the Des Moines River correlate best to the relative contribution of Beaver Creek to Des Moines River flow.

The Beaver Creek Watershed lies entirely within the DM Lobe landform with some urban contribution at the lower end of the watershed. During this quarter most of the samples were collected near the stream gauging station (BC04) near Grimes. High nitrate-N concentrations prompted sample collection of known tile lines on 1/25/07. Also a modified sand point monitoring well was placed in the alluvial substrate at site BC10A and designated as BC10A GW. Two samples were collected on 1/17/07 to compare in-situ water with refill after draw down.

Site BC10B1, located on the Slough Creek (SC) tributary, was added due to consistently high nitrate concentrations observed in the Beaver Creek snapshot study (Witmer 2006). This tributary had the highest nitrate concentration during this study as well. Tile samples collected throughout the watershed to determine groundwater contribution showed considerable variability. The cause of this is yet to be determined (Table 3).

Table 3. Beaver Creek Watershed

Sample Date	Client Id	NH_3-N	Chloride	E. coli	Nitrate as N	Nitrite as N	Phos-O as P	Turb
01/04/07	BC04		28.65	171				39.2
01/09/07	BC04		28.67	148	12.85			23.5
01/10/07	BC10A		22.86	148	13.3			5.05
	BC10A GW		3.53					22
	BC10A pond		3.86		1.21			6.66
01/11/07	BC04		28.37	146	12.66			19.6
01/17/07	BC ditch		5.95		0.05			8.53
	BC10A		23.39	160	13.7			7.49
	BC10AGW1		4.34					66.9
	BC10AGW2		3.08					8.11
	BC10B		26.37	5	19.12			6.92
01/18/07	BC04		32.15	10	15.09			5.75
01/24/07	BC04		30.58	121	12.31			3.9
01/25/07	BC10 T		14.15	35	6.71			1.81
	BC10B1 (SC)		26.64		19.3			3.2
	BCA		35.04		13.19			0.85
	BCB		21.54		13.34			0.25
	BCC		26.69		14.02			0.7
	BCE		35.12		13.4			0.76
	SC T1		25.52		13.15			0.25
	SC T2		25.81		8.81			0.31
02/15/07	BC04		31.79	55	11.47			6.75
02/20/07	BC04		54.75	248	11.09			7.5
03/08/07	BC04	0.38	30.85	548	10.08	0.06		8.34
	BC10B	0.02	23.9	4	15.66			10.3
03/14/07	BC04		11.87	200	6.53		0.38	89
	BC10A		15.03	740	9.43		0.28	69
	BC10AGW		7.62		2.94	0.05		287
03/22/07	BC04		22.73	336	9.70		0.17	68
03/28/07	BC04		25.97	125	11.08		0.11	49

E. coli counts were generally below the water quality standard except during snow melt on 3/8/07 and the major runoff period in mid-March. Detectable concentrations of ammonia and soluble phosphorus accompanied elevated *E. coli* counts during the runoff period but were well below most other tributaries.

Raccoon River:

Contributions of the main stem tributaries to water quality in the Raccoon River differ according to contaminant considered and landform of the contributing watershed. Following the early January runoff, base flow conditions prevailed throughout the Raccoon River watershed until mid-March. *E. coli* counts remained below the WQS until runoff with elevated stream flow (Table 4). *E. coli* counts on runoff samples collected 3/14/07 must be interpreted in context of the flow hydrograph. Flow in the South Raccoon at Van Meter (site 37) is on the recession limb of the hydrograph when counts are typically decreasing (fig 6). Samples from the upstream tributaries, the South Raccoon (site 32) and Middle Raccoon (site 31) near Redfield, would be even further down the hydrograph which likely accounts for the lower *E. coli* counts in these samples than the SR-VM sample. Based on the hydrograph, higher *E. coli* counts in South Raccoon watershed would have occurred on March 12-13. The North Raccoon sample was collected late on the ascending limb of its hydrograph near peak flow where highest counts could be expected. Therefore the Raccoon River Van Meter site (site 38) sample is a blend of water where the South Raccoon would be contributing high counts during peak flow while the North Raccoon would be contributing lower counts.

Table 4. *E. coli* Counts/100ml in the Raccoon

Sample Date	RR-VM	NR	SR (VM)	MR	SR
01/04/07	189	368	134		
01/09/07	74	63	73		
01/11/07	73.5	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
R^2 to turbidity	0.99	0.96	1.0	0.96	0.86

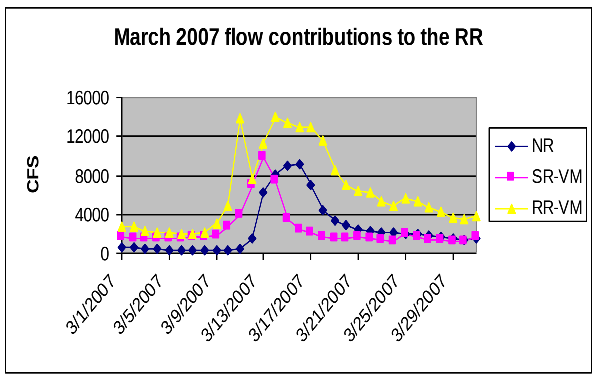

fig 6. Flow hydrographs in the RR and tribs

Turbidity values closely correlate to *E. coli* counts at these sites which indicate runoff and/or re-suspension of *E. coli*-laden sediments as the primary source of *E. coli*. The South Raccoon had the highest turbidity (1958 NTUs) compared to 742 NTUs in the North Raccoon indicating more erosion and energy of sediment and fecal transport. High nitrate-N concentrations occurred in both the North and Middle Raccoon throughout this quarter with the exception occurring on 3/14/07 when surface runoff diluted groundwater contribution (Table 5). The North Raccoon had the higher concentration as its entire watershed is in the highly productive DM Lobe landform. Most of the Middle Raccoon Watershed is also in the DM Lobe landform with nitrate concentrations near that of the North Raccoon. The South Raccoon remained below the water quality standard of 10 mg/l throughout this period. Nitrate concentration in the Raccoon River is the flow weighted average of the two sources where the South Raccoon had the greater influence in January and February while the North Raccoon had the greater influence in March.

Table 5. Nitrate-N in the RR and Main Stem Tribs (mg/l

Sample Date	RR	NR	SR (VM)	MR	SR
01/09/07	11.23	15.02	9.95		
01/11/07	13.06	14.76	10.04		
01/18/07	12.06	16.27	11.89	12.61	9.07
01/24/07	11.77	14.77	11.12	12.53	7.06
02/15/07	11.33	13.07	10.73	12.74	6.61
02/20/07	10.71	12.08	10.19	12.03	4.86
03/08/07	9.26	9.38	7.67	9.99	5.19
03/14/07	5.32	4.96	5.59	6.31	3.71
03/22/07	11.16	11.22	7.89	9.65	5.22
03/28/07	12.16	12.25	9.72	10.92	6.78

Surface dilution is especially apparent in chloride values which decrease by an amount equal to or greater than the decrease in nitrate concentration (Table 6). Chloride is not subject to change due to transformation and therefore a more reliable indicator of dilution by surface runoff than nitrate. An exception occurs in urban watersheds where winter salt application to city streets contributes high concentrations to chloride in storm water runoff.

Table 6. Chloride in the RR and Main Stem Tribs (mg/l)

Sample Date	RR	NR	SR (VM)	MR	SR
01/04/07	23.23	35.94	21.38		
01/09/07	24.75	37.32	20.90		
01/11/07	29.73	35.13	20.17		
01/18/07	23.23	39.82	22.49	25.87	11.91
01/24/07	30.89	38.03	21.15	24.75	10.18
02/15/07	26.15	39.92	21.05	25.90	10.28
02/20/07	26.38	39.96	21.89	26.86	24.50
03/08/07	34.88	36.59	18.40	24.08	9.71
03/14/07	9.73	10.27	10.40	11.72	4.45
03/22/07	22.68	23.27	15.10	15.65	10.09
03/28/07	26.75	27.19	16.58	18.82	9.74

Discrepancies between nitrate values in grab samples collected at site 38 (Raccoon River at Van Meter) and the online nitrate analyzer triggered an investigation that showed the cause to be incomplete mixing of water from the two upstream tributaries. Samples along the north bank of the Raccoon were similar to the North Raccoon (site A) while samples along the south bank were similar to the South Raccoon (site 37). Samples from both sides of the river several miles downstream (site 39) showed better mixing but differences were still observed (Table 6). Thereafter, samples at site 38 were collected from mid-channel to minimize sampling bias from incomplete mixing. This may be a temporary phenomenon due to existing stream morphology and/or higher viscosity of cold water. Further testing will be performed during warmer stream temperatures.

Table 6. Incomplete Mixing in the Raccoon River

Sample Date	Site 38 RR(mid)	Site A NR	Site 38 RR (North)	Site 37 SR	Site 38 RR (South)	Site 39 RR(West)	Site 39 RR(East)
01/11/07	13.06	14.76	14.59	10.04	11.5	12.85	13.35
01/18/07	12.10					13.24	
01/24/07	11.77	14.77	14.87	11.12		12.64	
02/15/07	11.30					11.71	

Walnut Creek:

Walnut Creek discharges into the Raccoon River within a mile of the Raccoon River intake. This downstream location on the Raccoon River potentially could exert a similar influence on water quality in the Raccoon River that Beaver Creek does on the Des Moines River. However, the water quality in the tributary generally has similar characteristics as that in the Raccoon River so is generally less noticeable with the exception of chloride (Table 7).

Table 7. Walnut Creek Water Quality at the Discharge Location to the Raccoon River

Sample Date	Site Id	NH_3-N	Cl	*E. coli*	Fl	NO_3-N	NO_2-N	PO_4-O as P	Turb
01/04/07	40		47.4	228			0.05		14.9
01/09/07	40		44.5	86		11.89	0.05		9.97
01/11/07	40		44.0	41		11.68			9.35
01/18/07	40		54.6	39		12.16			4.94
01/24/07	40		91.8	129		10.78			3.6
02/15/07	40		69.3	45		8.98			7.2
02/20/07	40		376.0	650		5.55			37
02/22/07	40		94.9	100	0.16	4.12		0.18	57.5
03/08/07	40	0.15	131.1	206	0.29	6.90			76.4
03/14/07	40		35.0	<100	0.27	7.82		0.18	99
03/22/07	40		75.3	185	0.25	7.39			42
03/29/07	40		70.3	192	0.27	8.25	0.04		19.6

On 2/20/07, the chloride concentration in the Raccoon River downstream of Walnut Creek was double its upstream location at Van Meter (Table 8) when the Walnut Creek chloride concentration was 376 mg/l. Nearly all Raccoon River samples downstream of Walnut Creek had elevated chloride relative to its Van Meter site upstream during the winter quarter. The urban portion of the Walnut Creek Watershed contributed most of the chloride (Table 9) as the rural section had near normal levels. Snow melt runoff from urban streets appears to be the primary source of chloride. Snowfall on January 21 and February 13 had created a local snow accumulation of 8 inches. Below normal freezing temperatures prevailed until February 18. Snow depth dropped from 7" on the 18^{th} to trace levels on February 21". This melt water contained high concentrations of salt from winter salt application to city streets. Much of the melt water quickly drains to Walnut Creek through storm sewers and flushes other substances such as *E. coli* along with chloride. *E. coli* counts in Walnut Creek where also highest on 2/20/07 suggesting co-transport. Other indicators of fecal contamination, such as Phosphorus, were not detected suggesting the *E. coli* source to be from surface runoff rather than a flushing of a leaking sewer system. (Detectable levels of phosphorus in March can be attributed to the rural source as concentrations at site 70 were higher than the discharge concentration at site 40.) The *E. coli* counts in the Raccoon River did increase downstream of Walnut Creek by an amount consistent with the increase in chloride but stayed well below the water quality standard. Flow data in Walnut Creek is not available to determine load contribution to the Raccoon River during this event.

(Table 8). The Contribution of Chloride from Walnut Creek

Sample Date	RR-VM	WC rural	WC outlet	RR-DM
01/09/07	24.8		44.5	30.8
01/11/07			44.0	31.0
01/18/07	23.2		54.6	35.3
01/24/07		27.8	91.8	33.0
02/15/07	26.2		69.3	31.8
02/20/07	26.4	39.4	376.0	73.0
02/22/07		25.4	94.9	38.7
03/08/07		30.2	131.1	30.1
03/14/07	9.7	18.1	35.1	13.9
03/22/07	22.7	25.7	75.3	21.5
03/28/07	26.8	27.2		25.3
03/29/07			70.3	25.1

Water quality in Walnut Creek tributaries is consistent with observations at the two primary sites (Table 9). The rural area had the highest *E. coli* counts and phosphorus concentrations. Nitrate concentrations in farm tiles collected 1/25/07 were well above the WQS. The 2/22/07 samples were lower but highly variable. This may be due to snow melt runoff into surface inlets of tile systems which are common in the DM Lobe. Living History Creek (LHC) and North Walnut Creek (NWC) especially show the influence of salt application and runoff. The low fluoride and high turbidity values indicate surface runoff to these tributaries which transports *E. coli* on the landscape to Walnut Creek. No phosphorus or nitrite was detected in these tributaries which further suggest runoff as the source of *E. coli* rather than seepage of leaking sewage systems as the source of elevated *E. coli*.

Table 9. Water Quality in the Walnut Creek Watershed, Winter quarter 2007

Sample Date	Client Id	NH3-N	Cl	*E. coli*	F	NO3-N	NO2-N	o-Phos-P	Turbidity
01/04/07	40		47.4	228			0.05		14.9
01/09/07	40		44.5	86		11.9	0.05		9.97
01/11/07	40		44.0	41		11.7			9.35
01/18/07	40		54.6	39		12.2			4.94
01/24/07	70		27.8	816		15.2			5
	40		91.8	129		10.8			3.6
01/25/07	70A T1		10.4			18.8			0.14
	70A T2		32.0			20.0			0.23
	70A T3		20.4			24.3			1.27
	70A		33.8			16.1		0.18	1.89

Sample Date	Client Id	NH3-N	Cl	*E. coli*	F	NO3-N	NO2-N	o-Phos-P	Turbidity
02/15/07	40		69.3	45		9.0			7.2
02/20/07	70		39.4	98		13.2			6.36
	40		376	650		5.6			37
02/22/07	70B		23.8	100	0.17	11.0		0.23	21.9
	70A		33.4	1340	0.26	10.7	0.06	0.49	7
	70AT1		7.30	<10	0.07	8.6			1.9
	70AT2		44.0	20	0.12	10.2			2.65
	70AT3		19.6	<10	0.15	23.1			2.12
	70AT4		22.3	131	0.14	6.8			11.8
	70AT5		73.4	<10	0.08	11.2	0.14	0.54	2
	70		25.4	100	0.26	9.2	0.06	0.33	41.4
	70 field		1.2	<100	0.14	3.2		0.11	167
	LHCDN		125	100	0.13	2.1			25.6
	LHCUP		117	200	0.14	3.1			14
	NWC2		147	310	0.13	2.2			39.7
	NWC3		144	520	0.06	2.1			38.7
	WC2		45	410	0.17	6.0	0.06	0.36	44.7
	LWC		45.2	<100	0.11	6.9			26.6
	NWC1		87.5	200	0.15	4.9			30.7
	40A		171	<100	0.12	2.0	0.05		35.6
	40B		58.9	<100	0.20	4.6	0.06		52
	40		94.9	100	0.16	4.1		0.18	57.5
03/08/07	70	0.15	30.2	18	0.32	12.8	0.04		13.3
	40	0.15	131	206	0.29	6.9			76.4
03/14/07	70		18.0	<100	0.31	11.0		0.22	76
	40		35.0	<100	0.27	7.8		0.18	99
03/22/07	70		25.7	96	0.27	13.4			16
	40		75.3	185	0.25	7.4			42
03/28/07	70		27.2	153	0.28	13.5			18
03/29/07	40		70.3	192	0.27	8.2	0.04		19.6

North Raccoon:

E. coli counts at the North Raccoon Puckerbrush site ("A") were below the WQS except during the high flow in early January and mid-March. The sampler scouted the watershed after the February 13 snowfall for manure spreading activity on snow covered fields. One area of activity near Perry was sampled on 2/15/07 (Sites 46, 46A) but showed little indication of runoff to the North Raccoon (Site 46) or the small tributary (site 46A) near the application site (Table 10).

Table 10. North Raccoon Watershed Sample Near Manure Application Site

Client Id	Sample Date	Chloride	*E. coli*	Nitrate as N	Total Coliforms	Turbidity
46A	02/15/07	32.21	20	12.33		1.38
46A1	02/15/07	30.11	6	12.31	1553	2.11

South Raccoon Hydrologic Unit

There was little difference between *E. coli* counts in the Middle Raccoon and the South Raccoon during this quarter (Table 11). This is primarily a function of lower counts in the South Raccoon this quarter. There were few runoff events that came primarily from snow melt. Livestock was observed in stock fields some distance from stream access in early January. Most of the sampling effort was focused on Brushy Creek because of previous high counts and potential re-suspension of *E. coli* from pool sediments during increased flow.

Table 11. Water Quality in the South Raccoon Hydrologic Unit

Creek Name	Client Id	Sample Date	NH3-N	Cl	*E. coli*	NO_3-N	NO_2-N	Phos-P	Turbidity
Middle Raccoon	31	01/18/07		25.87	25	12.61			7.39
		01/24/07		24.75	56	12.53			5
		02/15/07		25.90	15	12.74	0.05		4.46
		02/20/07		26.86	228	12.03			3.98
		03/08/07	ND	24.10	56	10.00	0.05		13.3
		03/14/07		11.72	980	6.31		0.18	244
		03/22/07		15.65	73	9.65	0.06	0.14	46
		03/28/07		18.82	107	10.92	0.05		32.5
South Raccoon	32	01/18/07		11.91	20	9.07			11.8
		01/24/07		10.18	50	7.06			18
		02/15/07		10.28	16	6.61			10.2
		02/20/07		24.50	16	4.86			27.2
		03/08/07	0.13	9.71	50	5.19			40.4
		03/14/07		4.45	1210	3.71			1958
		03/22/07		10.09	512	5.22			270
		03/28/07		9.74	688	6.78			129
	28A	01/18/07		8.13	36	6.54			22.2
		01/24/07		8.68	72	6.07			23.1
		03/22/07		5.58	457	4.44			170
		03/28/07		6.85	711	5.43			55
	28AA	03/22/07		16.31	1313	15.79		0.20	3.2
Brushy Creek	28	01/18/07		14.33	44	11.92			19.6
		01/24/07		12.24	23	9.68			8
		02/20/07		11.61	65	8.81			6.47
		03/08/07	0.14	12.33	41	8.60			23.4
		03/12/07		5.49	6310	3.93	0.07	0.20	1418
		03/14/07		6.08	3310	5.73		0.15	977
		03/22/07		11.72	130	9.07		0.10	119
		03/28/07		12.83	698	9.79		0.12	93
	42A	03/12/07		5.53	5470	6.95	0.10	0.51	640
	42B	01/25/07		13.96	687	15.93			9.86
		03/12/07		5.30	3270	6.78	0.07	0.68	385
	42B2	03/12/07		5.13	4710	6.47	0.09	0.76	390

Creek Name	Client Id	Sample Date	NH3-N	Cl	*E. coli*	NO_3-N	NO_2-N	Phos-P	Turbidity
Brushy Creek	42B3	01/25/07		12.69		17.07			3.65
		03/12/07		3.72	4320	5.53	0.10	0.62	388
	42BA	03/12/07		5.71	4710	6.53	0.08	0.66	400
	42BA1	03/12/07		4.12	850	5.93	0.09	0.69	263
	42BT	01/25/07		5.73		8.56			0.39
	42CA	03/12/07		2.50	100	5.69	0.23	1.11	447
	42D	03/12/07		1.23	100	1.91		0.19	420
	50	01/25/07		16.04	60	12.97			7.38
		03/08/07	0	16.12	69	11.89	0.05		21
		03/12/07		6.37	4350	5.82	0.10	0.38	398
	50T	01/25/07		28.87		22.16			1.22
		03/08/07	0.43	41.85		22.00	0.08		8.12
	50T2	01/25/07							0.68
		03/12/07		9.06		9.11		0.56	27
	50T1	03/12/07		6.07		5.77		0.40	65.1
	42CT2	01/25/07		13.01		30.49			0.59
	42B3T	01/25/07		10.36		13.38			0.72
	42CT	01/25/07		24.54	1	34.43			1.8
	42CA1	01/25/07		20.52		31.70			0.52
	28A2	03/12/07		2.28	1600	4.06	0.06	0.30	730
	42BAA	03/12/07		23.33	4550	1.85	0.27	6.04	706
	50T field	03/12/07		2.06	2160	0.61		0.76	69

There was a close relationship between turbidity and *E. coli* counts in the tributaries of this hydrologic unit where r2 values were 0.96, 0.86, and 0.99 for the Middle Raccoon, South Raccoon, and Brushy Creek respectively. Each tributary had differing relationship between the two where *E. coli*/NTU slope values of 3.81, 0.57, and 4.15. Upper Brushy Creek has numerous pool areas where sediments are dominated by fine silt sized particles and organic matter. Sampling during the previous quarter showed very high *E. coli* counts in the sediments that were 100 to 1000 times the counts in the overlying water. This is consistent observations by Van Donsel and Geldreich (1971). Howell et al. (1996) reported greatly increased *E. coli* survival rates with small particle size and low temperatures such as in Brushy Creek pool sediments this winter quarter. During low flow and turbidity (<10 NTU), *E. coli* counts were below the WQS whereas very high counts occurred during periods of elevated turbidity associated with increased flow and re-suspension of sediments. Soluble phosphorus concentrations above 0.50 mg/l were common to most sites in upper Brushy Creek with elevated *E. coli*.

Site 42BAA is a small drainage ditch that discharged into Halbur Creek just east of the community of Halbur. The ditch is directly below the terrace illustrated in the previous report that showed fecal containment. The high *E. coli* counts, phosphorus levels, and low nitrate indicate unstabilized waste from this containment structure. Ammonia analysis was not performed.

Nitrate in tiles and pool area at the Brushy Creek Headwaters (site 42CA) that were high in the fall remained over 30 mg/l into January. The high o-phosphorus concentration (1.1 mg/l) in the 3/12/07 sample suggests an over application of manure to these soils.

Un-sewered Communities

Very few drainage systems have been located which potentially could be receiving either raw or treated wastes from these communities based on both GIS tools and field observations. A tile site and drainage ditch near the community of Roselle was investigated on 1/25/07 and 3/12/07 respectively (Table 12). The sampler observed feedlot runoff at the U-R1 site. The very low chloride eliminates human sewage as the primary source of *E. coli* for both the tile discharge and creek contamination.

Table 12. Stream and Tile Discharge Near Roselle

Client Id	Sample Date	Cl	*E. coli*	Nitrate as N	Nitrite as N	o-Phos-P	TN	Turbidity
U-R T	01/25/07	9.77	19	13.16				1.93
UR1	03/12/07	12.3	155310	8.15	0.97	11.01	26.3	3095
UR2	03/12/07	3.31	200	3.7	0.12	0.3		6275
UR3	03/12/07	1.35	200	1.52		0.59		377

DISCUSSION AND SUMMARY

E. coli counts in the Des Moines River Watershed this quarter were below the WQS except during the early January and mid-March runoff from rain and melting snow. Runoff directly below two feedlot operations did have elevated *E. coli* counts in the small drainage ditches, indicating the importance of good manure containment structures and management plans. Downstream locations to small streams were much lower, indicating little contribution to fecal load during the sampling event. There was no pasture grazing during this period but there were cattle in stock fields in early January. The landscape sources of *E. coli* this quarter appear diffuse and ubiquitous.

High *E. coli* counts may be primarily a function of hydrology. Various authors (Tian 2002, Jamieson 2005, Thelin 1983) report *E. coli* to adhere to small sediment particles and exhibit low mortality in these sediments at low temperatures. Upper Brushy Creek had very high *E. coli* counts in the pond sediments (3rd status report). This protected reservoir of *E. coli* would be released with the sediments above a critical flow velocity. The high *E. coli* counts and high counts to turbidity ratios observed in Brushy Creek may be due to re-suspension of these survivors in the fecal contaminated sediments. There was little to suggest winter landscape runoff as the source of high counts in Brushy Creek.

High counts in the Des Moines and Raccoon Rivers shortly following a runoff event (when flow is on the leading edge of a flow hydrograph) is usually the result of the short travel times of peak flow in local streams where high *E. coli* counts in runoff water into the river is highest and therefore contributes a disproportionate amount of flow and load.

This is especially apparent for Beaver Creek. *E. coli* counts in the Des Moines River upstream remains relatively constant regardless of flow due to the influence of the Saylorville Reservoir. The influence of Walnut Creek is more masked due to changing counts in the Raccoon River. Its potential influence is apparent in the chloride discharge to the Raccoon River where the urban watershed has a high concentration of salt from de-icing city streets, while the more rural Raccoon River has a lower salt concentration in its melt water runoff. Therefore water quality in the local streams inherently have a greater short term influence on water quality at the Des Moines Water Works intake locations than more distant tributaries.

NEXT PHASE

Additional sampling will be conducted on these local streams to further characterize the source and location of contamination to these streams and the impact on water quality at the intake locations.

Sampling at Brushy Creek will continue due to its high contribution to *E. coli* loading during elevated flow. This includes finding landscape sources and the role of stream hydrology in the capture and release of fecal contamination from upstream sources.

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