

**WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER QUALITY DIVISION
MONITORING AND ASSESSMENT REPORT**

WATERBODY:	South Fork Crazy Woman Creek - WYPR10090205-067 and 029 Beaver Creek - WYPR10090205-158
SEGMENT DESCRIPTION:	Segment 067 - Extends from the confluence with Beaver Creek upstream to its headwaters. (~4 miles). Segment 029 - Extends from the confluence with Crazy Woman Creek upstream to the confluence with Beaver Creek. (~10 miles). Segment 158 - Extends from the confluence with South Fork Crazy Woman Creek upstream to its headwaters (~13 miles).
CLASS:	Class 3B (both segments of South Fork Crazy Woman Creek) Class 2AB (Beaver Creek)
DESIGNATED USES:	Class 3B: Aquatic life other than fish, primary contact recreation, wildlife, industry, agriculture, and scenic values Class 2AB: Drinking water supplies, non-game fisheries, cold-water fisheries, fish consumption, aquatic life other than fish, primary contact recreation, wildlife, industry, agriculture, and scenic values
1996 305(b) REPORT AND 303(d) LIST:	Both segments of South Fork Crazy Woman Creek listed as partially supportive for agriculture and agriculture-irrigation uses. Impairments suspected to be caused by siltation, nutrients, and unknown. Sources of pollutants were reported as municipal point source discharge, rangeland, irrigated cropland, land development, petroleum activities, highway maintenance, recreational activities, and natural sources. Beaver Creek was not listed in the 1996 305(b) report or any subsequent reports.
AUTHOR:	Eric Hargett

INTRODUCTION

South Fork Crazy Woman Creek originates in the interior plains as a spring-fed stream in northwestern Johnson County. South Fork Crazy Woman Creek flows northeast for ~ 14 miles prior to its confluence with Crazy Woman Creek in northern Johnson County. Beaver Creek, an interior spring-fed plains stream, is the major tributary to South Fork Crazy Woman Creek. The entire South Fork Crazy Woman Creek watershed (which includes Beaver Creek) is located in the Northwestern Great Plains ecoregion (Omernik and Gallant, 1987). The geology of the upper and middle watershed is generally comprised of Cody Shale (KC) and Fort Union Formation (Tfu), while the lower watershed is composed of the Wasatch Formation (Tw) (USGS, 1985). Soils in the watershed are predominantly highly erosive silt and clay loams. Primary land use in the watershed is livestock grazing with some areas devoted to irrigated hayland.

REPORT OBJECTIVE

The State of Wyoming’s 1996 305(b) Report and 303(d) List indicated that South Fork Crazy Woman Creek (WYPR10090205) was partially supportive for agriculture and agriculture-irrigation uses. The Wyoming Department of Environmental Quality (WDEQ) conducted an assessment of South Fork Crazy Woman Creek and its tributary Beaver Creek in October 1999. The primary purpose of this report is to document the findings of these assessments and provide a determination of whether the agriculture and agriculture-irrigation uses as well as all other designated uses assigned to South Fork Crazy Woman Creek are supported. A secondary purpose of this report is to assess use-support on Beaver Creek.

METHODS AND MATERIALS

All collection, analysis, and evaluation of South Fork Crazy Woman Creek and Beaver Creek were conducted in accordance with approved assessment procedures as outlined in the following documents:

- _____ 1) Manual of Standard Operating Procedures for Sample Collection and Analysis. (WDEQ/WQD, 2001a).
- _____ 2) Quality Assurance Project Plan (QAPP) for Beneficial Use Reconnaissance Project (BURP) Water Quality Monitoring. (WDEQ/WQD, 2001b).
- _____ 3) A bioassessment method for use in Wyoming stream and river water quality monitoring. (King, 1993).
- _____ 4) Beneficial use reconnaissance project-wadeable stream monitoring methodology. (WDEQ/WQD, 1998).
- _____ 5) Wyoming’s method for determining water quality condition of surface waters. (WDEQ/WQD, 2001c).

ASSESSMENT STATIONS

Descriptive information and data collected on South Fork Crazy Woman Creek and Beaver Creek assessment stations (Map 1).

Seg.	Station ID	Chemical Data	Biological Data	Physical Data	Legal (Sec / T / R)	Latitude	Longitude	Elevation (ft)
067	NGP68 SFCWC	YES	YES	YES	NENW of Sec. 29, T46N, R82W	43° 55' 59.48"	106° 44' 27.25"	5020
029	^a NGP66 SFCWC	YES	YES	YES	SWSW of Sec. 25, T47N, R82W	NM	NM	4660
029	^b NGP65 SFCWC	YES	YES	YES	SENE of Sec. 13, T47N, R82W	44° 02' 32.05"	106° 38' 53.80"	4620
029	NGP67 SFCWC	YES	YES	YES	NENW of Sec. 9, T47N, R81W	44° 03' 48.52"	106° 36' 02.65"	4540
158	NGP44 BC	YES	YES	YES	SWNW of Sec. 2, T46N, R82W	43° 59' 12.49"	106° 41' 11.65"	4760

^a Located above Purdy Reservoir

^b Located below Purdy Reservoir

NM = not measured

SFCWC = South Fork Crazy Woman Creek

BC = Beaver Creek

Chemical, physical, and biological data were collected at the above stations from 10/26/99 to 10/28/99.

CHEMICAL DATA

(See Table 1 for complete dataset). Water temperature ranged from 5.6°C at NGP68 to 6.9°C at NGP66 and NGP67. Water temperature was 6.8°C at NGP44. The USEPA (1986) suggests a temperature of 32°C as an upper tolerance limit to maintain a balanced benthic macroinvertebrate structure. All pH results were below the upper limit of 9.0 (WDEQ/WQD, 2001). Conductivity ranged from 1930 uS/cm at NGP66 to 2210 uS/cm at NGP67. Conductivity at NGP44 was 1219 uS/cm. Elevated conductivity is expected in this watershed, due to the dolomitic/marine shale geology of the upper watershed and the carbonaceous sources material of the middle and lower watershed (Hodson et al., 1973; USGS, 1985). Dissolved oxygen concentrations ranged from 10.21 mg/L at NGP67 to 11.87 mg/L at NGP65. Station NGP44 exhibited a dissolved oxygen concentration of 10.02 mg/L.

Instantaneous turbidity values in South Fork Crazy Woman Creek ranged from 2.9 NTU at NGP68 to 68 NTU at NGP67. The turbidity value in Beaver Creek was 28 NTU at NGP44. The South Fork Crazy Woman Creek watershed is composed of highly erosive soils and turbidity is expected to be high and increase downstream as drainage area increases. However, contributions from localized bank erosion and bank sloughing may contribute to the elevated turbidity. Instantaneous TSS values ranged from 34 mg/L at NGP68 to 258 mg/L at NGP65. TSS was measured at 81 mg/L at station NGP44. Again, elevated TSS in the system is likely reflective of the same sources that have caused elevated turbidity at these stations in addition to stream contact dissolution with adjacent carbonate source formations.

Nitrate-nitrogen concentrations were below detection throughout all sample sites at <0.1 mg/l. Total phosphorous concentrations were at or below detect (0.1 mg/L) for stations NGP68 and NGP66, increased to 0.3 mg/L at station NGP65 and declined slightly to 0.2 mg/L at station NGP67. Elevated total phosphorous at NGP65 and NGP67 may be due to a combination of releases from upstream Purdy Reservoir that are high in nutrients and/or non-point source runoff from land use activities (intensively grazed areas or irrigated lands) in the watershed. Total phosphorous concentrations at NGP44 were below detection (<0.1 mg/L). Generally, for streams that do not directly enter lakes or reservoirs, the target phosphorous concentration considered protective of aquatic life uses is 1 mg/l (King, 1993). Chloride concentrations ranged from 5.1 mg/L at station NGP68 to 10.7 mg/L at station NGP67. Station NGP44 exhibited a chloride concentration below detection (<5 mg/L). Sulfate concentration at was 454 mg/L at station NGP44 and ranged from 781 mg/L at station NGP66 to 978 mg/L at station NGP67. Elevated sulfate in these waters are likely due to the erosive soils of the South Fork Crazy Woman Creek watershed as well as stream contact dissolution with formations that contain appreciable quantities of sulfate compounds.

PHYSICAL DATA

Stream conditions are strongly influenced by whether the substrate is derived from igneous or carbonate source material. Streams in limestone or dolomitic deposits (such as most of the South Fork Crazy Woman Creek watershed) have little or no coarse substrates. Instead, silt is the predominant sediment and deposits as layers, as a cohesive matrix filling bed openings, or as part of a crust like deposit. Both the silt matrix and crust tend to cement together any larger bed material to form a hardpan. Stream substrate composition throughout most of South Fork Crazy Woman Creek was primarily a silt/clay-hardpan/organic complex (Table 2). Stream substrate near the mouth of South Fork Crazy Woman Creek was still predominantly a silt/clay hardpan but contained more sand and gravels which suggests the stream is in contact with more coarse (i.e., Wasatch Formation) source material. Stream substrate near the mouth of Beaver Creek was primarily coarse/fine gravel and secondarily clay hardpan (Table 2). The coarse nature of channel substrate in the lower Beaver Creek may be due to stream contact with coarser source material (i.e., Wasatch Formation). All available information suggests that the overall sources of fine sediment in the channels of South Fork Crazy Woman Creek and Beaver Creek are primarily due to the erosive soils and carbonate deposits of the watershed. However, localized bank erosion and bank sloughing with the possibility of runoff from intensively grazed areas or irrigated lands cannot be ruled out as possible contributors to fine sediment in the channel.

Weighted embeddedness (silt cover) could not be measured at any of the four stations on South Fork Crazy Woman Creek either due to the nature of the substrate (embeddedness cannot be measured on fine substrates), poor visibility of the substrate due to high turbidity, and/or abundant aquatic vegetation covering the substrate. Weighted embeddedness at station NGP44 on Beaver Creek was scored at 53.2 (Table 2). The elevated silt cover at NGP44 is likely due to the erosive soils of the watershed

Habitat condition was evaluated with the use of the slow-water (<10% of stream reach characterized by riffle/run habitats) qualitative assessment procedure. Total qualitative habitat assessment scores for stations NGP68, NGP66, NGP65, and NGP67 were 139.5, 141.5, 149, and 131.5 respectively (Table 3). Scores were 78%, 79%, 83%, and 73% of the total maximum score (180) for stations NGP68, NGP66, NGP65, and NGP67 respectively. The total qualitative habitat assessment score for station NGP44 was 141.5 which was 79% of the total maximum score of 180. Items that tended to reduce the score at all stations were attributed to low pool variability, high sediment deposition, limited bottom substrate-available cover, limited riparian vegetative zone width, and low bank stability.

The fine substrate inputs from erosive soils in the watershed, coupled with low gradient and reduced stream power, had an influence on the low pool variability, high sediment deposition, low pool substrate characterization, and low bottom substrate-available cover scores in both South Fork Crazy Woman Creek and Beaver Creek. However, the individual or combined influences of erodible banks during high flows (stations NGP66, NGP65, NGP67, and NGP44), localized

bank sloughing (station NGP67), topographic control that limits the width of the riparian zone (stations NGP66 and NGP67), and possible sediment inputs from human land use activities (intensively grazed areas or runoff from irrigated lands) in the watershed may also have had some influence on the overall habitat conditions among the South Fork Crazy Woman Creek and Beaver Creek stations.

Despite the appreciable inputs of fine sediment into the system, sediment inputs, whether natural and/or anthropogenic, do not appear to be excessive due in part to the absence of mid-channel bars and re-vegetation of point bars. Furthermore, the majority of banks were well vegetated with dense mats of herbaceous riparian vegetation adequate to dissipate energy during high flows.

Habitat scores from all stations could not be compared with habitat scores from three representative class 3B Northwestern Great Plains reference streams due to differences in the qualitative habitat assessment procedure.

BIOLOGICAL DATA

Biometrics developed by Jessup and Stribling (2002) were utilized as a tool to assess the biotic/ecological integrity of South Fork Crazy Woman Creek as a means of determining whether designated uses, such as aquatic life, are being attained. All stations were evaluated with the Wyoming Stream Integrity Index (WSII) developed for the Northwestern Great Plains ecoregion. WSII scores were rated as 'very poor' at station NGP68, 'poor' at stations NGP66 and NGP65, and 'fair' for stations NGP67 and NGP44 (Appendix A). The limited potential of South Fork Crazy Woman Creek and Beaver Creek to support diverse populations of sensitive taxa such as stoneflies and certain caddisflies appears to penalize stations and results in low index scores. Thus, it has been determined that overall, aquatic life uses for South Fork Crazy Woman Creek and Beaver Creek are supported. To support this claim, comparison with suitable reference quality streams, best professional judgement, and information from scientific literature were used to justify this aquatic life use support determination.

The aquatic macroinvertebrate community generally exhibits a primarily benthic mode of existence. As a result, the community is intimately associated with the resident substrate during at least a portion of their lives. The fine substrate of South Fork Crazy Woman Creek, and corresponding high turbidity, is believed to originate predominantly from the natural erosiveness of soils and source materials from within the watershed. The sub-optimal substrate (silt/clay hardpan) and high turbidity appears to limit the establishment of a more diverse macroinvertebrate community. Generally the groups Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are comprised almost exclusively of freshwater species that typically are unable to tolerate high turbidity due its adverse effects on physiological functions (Ward, 1992). Consequently, most taxa from these three groups are typically restricted to residing in environments with coarser substrates and little suspended fine sediment, due largely to the abundance of interstitial spaces for cover,

sensitivity of their respiratory organs to clogging by fine sediment, and their inability to tolerate low oxygen conditions that prevail in fine sediments (Ward, 1992). Where fine sediments comprise the channel substrate and/or the stream is highly turbid, the resultant macroinvertebrate community is likely to be comprised of soft-substrate adapted non-insects such as Oligochaetes (aquatic worms), many highly tolerant Chironomid (midge) taxa, and a few representative taxa of mayflies (*Caenis*, *Tricorythodes minutus*, and *Baetis tricaudatus*), caddisflies (*Cheumatopsyche* and *Hydropsyche*), and stoneflies that are generally adapted and/or can tolerate fine sediments and high turbidity at some stage in their development.

The same environmental stressors (i.e., high turbidity and fine sediment substrate) that limit establishment of sensitive macroinvertebrate taxa in South Fork Crazy Woman Creek are also relevant to most of Beaver Creek. However, natural environmental gradients of Beaver Creek, such as substrate composition, may influence resident macroinvertebrate community characteristics. This appears to be the case in the lower Beaver Creek at station NGP44. Whereas most of Beaver Creek is likely similar in substrate composition to South Fork Crazy Woman Creek (based on geology of the watershed), the lower end of Beaver Creek tends to exhibit a greater percentage of coarse substrate as the stream is in contact with source materials comprised of sands and gravels as evidenced at station NGP44 (Table 2). According to Ward (1992), greater numbers and density of macroinvertebrate taxa will generally be found in coarse rather than fine substrates. As a result of the greater percentage of gravels at NGP44, both the number and density of macroinvertebrate taxa as well as biotic condition at this station are greater relative to stations in South Fork Crazy Woman Creek. While the greater percentage of gravel substrate at NGP44 appears to be conducive to inhabitation by increased numbers and density of taxa, the resident macroinvertebrate community continues to be dominated by taxa that are tolerant of high turbidity and fine sediment.

The fine substrate and/or high turbidity of South Fork Crazy Woman Creek and Beaver Creek appears to ultimately structure the aquatic macroinvertebrate communities of these streams. It has been noted that these abiotic factors appear to be an inherent characteristics of the South Fork Crazy Woman Creek watershed. This premise may be further supported when one looks at the regional location of South Fork Crazy Woman Creek and Beaver Creek. Both of these lotic systems are located in what is known as the Great Plains physiographic province (plains for short). The extreme physicochemical nature of plains streams and the erosive nature of most plains watersheds, which facilitate high turbidity and finer sediment in the stream, make it fundamentally difficult for plains streams to support large populations of sensitive macroinvertebrate taxa relative to montane or other stream systems. Consequently, native assemblages of fishes and macroinvertebrates in plains streams are known to have low species richness, exhibit high variation in relative abundance due to stochastic abiotic factors, possess taxa with higher tolerances to environmental extremes typical of plains streams, and be trophically simple and persistent (Bramblett and Fausch, 1991; Cross and Moss, 1987; Fausch and Bramblett, 1991; Matthews, 1987 and 1988; Peterson, 1990; Poff and Ward, 1989; Zale et al., 1989).

The premise that South Fork Crazy Woman Creek and Beaver Creek are supportive of aquatic life uses may be further supported through the comparison of the macroinvertebrate fauna of these lotic waters to comparable representative plains reference streams located in the Northwestern Great Plains ecoregion. Reference quality streams with similar watershed characteristics were used for comparison with South Fork Crazy Woman Creek and Beaver Creek to assess the percent comparability with Northwestern Great Plains WSII scores. NGP68, NGP66, NGP65, NGP67, and NGP44 scored 36%, 81%, 82%, 99%, and 107% of the average WSII score respectively for the reference streams used for comparison (Table 4). Although four of the five stations are >80% comparable to reference stations, station NGP68 is only vaguely similar to the macroinvertebrate communities of the reference stations. The low percent comparability of NGP68 to other reference stations appears to rest in two categories: a large percentage of non-insects and a complete absence of mayflies.

Non-insects at station NGP68 comprised 74% of the macroinvertebrate community. Oligochaetes (aquatic worms) accounted for >28% of non-insect taxa at station NGP68. Oligochaete taxa, as described previously, are typically found in depositional stream environments characterized by fine sediment substrates such as silt (Thorp and Covich, 2001). The high percent composition of Oligochaetes at station NGP68 is not a surprise considering the high percentage of silt at this station (Table 2). What is most dramatic is that 43% of the non-insect community at NGP68 was comprised of freshwater shrimp (*Hyalella azteca*). Generally amphipods (freshwater shrimp) are indicative of moderate to excellent water quality (Thorp and Covich, 2001). According to Thorp and Covich (2001), amphipods are opportunistic feeders that prefer forage associated with aquatic plants and detritus and typically occur in high densities where refugia (aquatic plants) from predation exists such as in calm, cool, well oxygenated waters. Thus, the high numbers of amphipods collected at NGP68 appear to be associated with the abundant density of rooted aquatic macrophytes and the preferable well oxygenated slow water habitat. Larger percentages of non-insects in a waterbody are generally considered indicative of water quality degradation, therefore, high numbers in the '% non-insect taxa' metric can lower the final WSII score and rating. However, large numbers of amphipods would not necessarily correlate to degraded water quality conditions, at least in this case, which appears to be one reason why the WSII score and rating for NGP68 was low.

Mayflies were absent at NGP68 but were generally in similar abundance at stations NGP66, NGP65, and NGP67. Again, the percentage of silt at NGP68 is likely the primary factor that limits mayfly establishment. Although silt-adapted mayflies *Caenis* and *Tricorythodes minutus* were collected at stations NGP66 and NGP65, the very high percentage of silt may restrict their abundance at NGP68. Station NGP68 may be able to support the few mayfly taxa present in the system due to the abundance of aquatic vegetation in the channel. However, the abundant amphipod community at NGP68, which reside primarily in aquatic vegetation, may offer competition for suitable substrate with mayflies.

One final point is that although the macroinvertebrate communities at stations NGP65 and NGP67 are comparable to similar reference quality streams, high numbers and high percent composition of the black fly *Simulium* were noted at these stations. *Simulium* accounted for 44% and 17% of the total macroinvertebrate communities at stations NGP65 and NGP67 respectively. *Simulium* or black flies are considered collector-filters that typically feed on suspended algae and detritus and can be used as indicators to nutrient pollution (Merritt and Cummins, 1996, Ward, 1992). The high numbers of *Simulium* at these stations coupled with the elevated instantaneous total phosphorous concentrations at these sites may indicate elevated input of nutrients to the system.

HISTORICAL/ANCILLARY DATA

Fish Surveys - According to the Wyoming Game and Fish Department Stream and Lakes Inventory Database, no fish surveys have been conducted on South Fork Crazy Woman Creek. The following species were collected at the mouth of Beaver Creek between 1994 and 1997:

Beaver Creek (Sec. 2, T46N, R82W): Brown Trout (*Salmo trutta*), Rainbow Trout (*Oncorhynchus mykiss*), Longnose Dace (*Rhinichthys cataractae*), and Longnose Sucker (*Catostomus catostomus*).

QUALITY ASSURANCE/QUALITY CONTROL

Environmental data from South Fork Crazy Woman Creek and Beaver Creek were collected in accordance to the methods, procedures, and techniques listed in the Methods section of this report. Station QA/QC reports for each sample station are attached to this report. All physical, biological, and chemical data for 1999 were determined to be complete and accurate.

SUMMARY AND CONCLUSIONS

Classification - South Fork Crazy Woman Creek segments WYPR10090205-067 and 029 are correctly classified as class 3B waters. Beaver Creek segment 158 is correctly classified as a class 2AB water. Although the Wyoming Game and Fish Department Stream and Lakes Inventory database indicated no fish surveys were conducted on South Fork Crazy Woman Creek, field observations from the 1999 assessment indicated the presence of one individual of non-game fish at station NGP66. Dissolved oxygen concentrations and water temperature at station NGP44 was well within the established criteria for class 2AB waters WDEQ/WQD (2001) at the time of WDEQ's 1999 sampling of Beaver Creek. The Wyoming Game and Fish Department Stream and Lakes Inventory database indicated cold-water game fishes were present in at the mouth of Beaver Creek. Field observations from the 1999 assessment also documented the presence

of warm-water game fish at NGP44.

Water Quality - Measured water quality parameters did not exceed existing standards protective of class 3B or class 2AB waters on the dates of sampling.

Habitat Quality - Information suggests that the fine sediment substrate, elevated turbidity and/or sedimentation of the channel in both South Fork Crazy Woman Creek and Beaver Creek is likely attributed to the highly erosive soils and source materials coupled with the low gradient and reduced stream power of the watershed. In addition, the individual or combined influences of erodible banks and bank sloughing plus possible sediment inputs from localized intensive land use activities in the watershed may contribute to fine sediment in the channel as well as the high turbidity and TSS. However, the degree of inputs from human activities is believed to be minimal. Considering the inherent fine sediment of the system, habitat scores were generally good for all stations. Overall, riparian vegetation was well established along the banks and riparian area with dense cover by herbaceous sedges and rushes adequate to stabilize banks and dissipate energy during high flows.

Biotic Quality - Results of the biotic collections and physical sampling on South Fork Crazy Woman Creek and Beaver Creek suggests that the resident macroinvertebrate communities are structured by the fine sediment and/or high turbidity/TSS characteristics of the watershed. Although it is believed that the highly erosive nature of the watershed plays an integral role in the structure of the biotic community, information also suggests that localized bank erosion/bank sloughing and possible intensive human land uses in the watershed may also influence biotic integrity of the watershed, however, this is believed to be minimal. Despite low to moderate WSII scores and ratings for all of the sampled stations, four of the five stations were >80% similar in biotic integrity to three reference quality streams. The biotic condition of station NGP68 was not comparable to reference conditions and appears to be due to the slow-water/wetland-like characteristics and high silt substrate characteristics of the station. Stations NGP65 and NGP67, though similar to reference conditions in biotic integrity, are characterized by large percentages of black fly larvae. The occurrence of large numbers of black fly larvae combined with elevated total phosphorous concentrations at these stations suggests additional nutrient inputs into the system which may originate from a combination of reservoir releases and runoff from intensive land use activities in the watershed. At this time, additional nutrients to the system do not appear to compromise aquatic life uses of South Fork Crazy Woman Creek. Station NGP44 on Beaver Creek possessed the best biotic condition relative to all other stations. The increased biotic condition at NGP44 appears to be related to the presence of more gravels in the channel which is likely due to stream contact with coarse source materials in the watershed. Based on all available information, the overall biotic integrity of South Fork Crazy Woman Creek and

Beaver Creek does not appear to be compromised and aquatic life uses are believed to be supported.

Agricultural Uses - Excessive bank erosion, formation of mid-channel bars and absence of vegetation on point bars can suggest appreciable inputs of fine sediments into a stream system which can impair irrigation activities if present in large quantities. However, at all stations, mid-channel bars were not observed, point bars were revegetating, and although localized bank erosion was present, it did not appear excessive. In addition, the quality of water appears protective of other agricultural uses such as livestock watering, etc. Overall, the available evidence suggests that all agricultural uses are supported in South Fork Crazy Woman Creek as well as Beaver Creek.

At this time, the weight-of-evidence from the WDEQ 1999 assessment of segment WYPR10090205-067 & 029 suggests South Fork Crazy Woman Creek is supportive of uses assigned to class 3B waters. However, best management practices implemented in the watershed that reduce anthropogenic source(s) of nutrients to the system may eventually lower total phosphorous concentrations in the stream and help to minimize any potential excessive growth of algae that may interfere with agricultural and agricultural-irrigation uses of the system. In addition, segment WYPR10090205-158 of Beaver Creek appears supportive of uses assigned to class 2AB waters.

SIGNATURES:

----- Author	----- Date
----- Peer Reviewer	----- Date
----- Monitoring Supervisor	----- Date

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Table 1 - Physicochemical results for South Fork Crazy Woman Creek and Beaver Creek stations, October 1999, Johnson County.

Parameter	South Fork Crazy Woman Creek				Beaver Creek
	Segment 067	Segment 029			Segment 158
	NGP68	NGP66	NGP65	NGP67	NGP44
Date	10/28	10/27	10/27	10/27	10/27
Time	1708	1318	0825	1125	1115
Temperature C	5.6	6.9	6.4	6.9	6.8
pH	8.54	7.73	8.6	7.88	7.68
Conductivity (uS/cm)	2030	1930	1940	2210	1219
Dissolved Oxygen (mg/L)	11.79	10.66	11.87	10.21	10.02
Turbidity (NTU)	2.9	60	64	68	28
TSS (mg/L)	34	212	258	140	81
Alkalinity (mg/L as CaCO ₃)	250	200	190	210	100
Sulfate (mg/L)	848	781	830	978	454
Chloride (mg/L)	5.1	7	8.6	10.7	<5
Nitrate (mg/L as N)	<0.1	<0.1	<0.1	<0.1	<0.1
Total Phosphorus (mg/L)	<0.1	0.1	0.3	0.2	<0.1
Total Hardness (mg/L as CaCO ₃)	725	647	636	784	372
Sheen	N	N	N	N	N
Color	Lt. Brown	Brown	Brown	Brown	Brown
Odor	N	N	N	N	N
Discharge (cfs)	2.7	9.01	7.32	7.86	4.11

Table 2 - Mean percent stream substrate composition, weighted embeddedness and water velocity at South Fork Crazy Woman Creek and Beaver Creek stations, October 1999, Johnson County.

	South Fork Crazy Woman Creek				Beaver Creek
	Segment 067	Segment 029			Segment 158
Substrate Type	NGP68	NGP66	NGP65	NGP67	NGP44
Cobble					2
Coarse Gravel		1	2		28
Fine Gravel			1	12	33
Sand				20	9
Silt	81	12	29	68	
Clay-Hard Pack (solid, slick)	11	48	49		29
Organic (fine, black, odor)	8	39	19		
Precipitate					
Weighted Embeddedness	**	*	*	*	53.2
Mean Water Velocity (ft/sec)	0.69	1.05	1.39	1.05	1.21
*Not measured due either to high turbidity or abundant aquatic vegetation covering the substrate.					
**Embeddedness cannot be measured on fine substrate					

South Fork Crazy Woman Creek - Segments 067 and 029 and Beaver Creek - Segment 158

Table 3 - Qualitative habitat assessment, pool quality, and biological indicator scores for South Fork Crazy Woman Creek and Beaver Creek stations, October 1999, Johnson County.

	South Fork Crazy Woman Creek				Beaver Creek
	Segment 067	Segment 029			Segment 158
Habitat Parameters (Max. Score)	NGP68	NGP66	NGP65	NGP67	NGP44
Bottom Substrate-Available Cover (20)	16	11	15	10	17
Pool Substrate Characterization (20)	15	10	15	14	14
Pool Variability (20)	9	12	13	15	14
Sediment Deposition (20)	10	17	13	7	14
Channel Flow Status (20)	20	19	19	20	19
Channel Sinuosity (20)	13	19	19	16	13
Channelization/Alteration (20 for <10%)	20	20	20	20	20
Bank Vegetation Protection (Bankfull) (10)	10	9.5	9.5	9	8.5
Bank Stability (Bankfull) (10)	10	9	8.5	6.5	7.5
Disruptive Pressures (Riparian Zone) (10)	10	10	10	9	8.5
Riparian Vegetative Zone Width (10)	6.5	5	7	5	6
HABITAT ASSESSMENT TOTAL <10% Riffle/Run (180 possible)	139.5	141.5	149	131.5	141.5
HABITAT ASSESSMENT (Percent of Maximum Score)	77.50	78.61	82.78	73.06	78.61
Average Pool Quality Score (10)	4	5	5	2	4
Estimated Percentage of Pools in Reach at least 1.5' deep	67	100	100	100	100
Biological Indicators*					
Periphyton	0	0	2	1	0
Filamentous Algae	0	0	2	1	0
Rooted Macrophytes	3	2	2	0	0
Floating Macrophytes	0	0	0	0	0
Fish	0	1	0	0	1
Slimes	0	0	0	0	0
* 4-Dominant, 3-Abundant, 2-Common, 1-Rare, 0-Absent					

South Fork Crazy Woman Creek - Segments 067 and 029 and Beaver Creek - Segment 158

Table 4 - Comparison of watershed characteristics and selected physical and biological assessment results between South Fork Crazy Woman Creek/Beaver Creek stations and three reference-quality class 3B Northwestern Great Plains streams.

		North Prong Silet Creek - (NG P63) WDED Sample	North Prong Silet Creek - (NG P63) LDCD Sample	Bull Creek - Lower (Near Buffalo) (NG P18)	Pole Creek - Giant Road (NG P27)	Average Reference Station Scores	South Fork Crazy Woman Creek - P18s Upper (NG P66)	South Fork Crazy Woman Creek - P18s Upper (NG P66) % of Reference	South Fork Crazy Woman Creek - Above P18s Res. (NG P66)	South Fork Crazy Woman Creek - Above P18s Res. (NG P66) % of Reference	South Fork Crazy Woman Creek - Below P18s Res. (NG P66)	South Fork Crazy Woman Creek - Below P18s Res. (NG P66) % of Reference	South Fork Crazy Woman Creek - Lower (NG P67)	South Fork Crazy Woman Creek - Lower (NG P67) % of Reference	Beaver Creek - Lower (NG P44)	Beaver Creek - Lower (NG P44) % of Reference
Watershed Description	Location	SESE of Sec. 1, T52N, R63W	SESE of Sec. 1, T52N, R63W	SWNW of Sec. 36, T51N, R62W	NWNW of Sec. 7, T46N, R62W		NENW of Sec. 29, T46N, R62W		SWSW of Sec. 25, T47N, R62W		SENE of Sec. 13, T47N, R62W		NENW of Sec. 9, T47N, R61W		SWNW of Sec. 2, T46N, R62W	
	Elevation (ft.)	4600	4600	4560	5120		5020		4660		4620		4540		4760	
	Drainage Area (sq. miles)	18.9	18.9	30.9	34.7		10		105.4		121		133.5		33.8	
	County	Johnson	Johnson	Johnson	Johnson		Johnson		Johnson		Johnson		Johnson		Johnson	
	Stream Classification	3B	3B	3B	3B		3B		3B		3B		3B		3B	
	Geology (USGS, 1985)	Tw	Tw	Tw	Kc		KC		Tfu		Tfu		Tw		Klm	
	Land Uses	Irrigated Hayland & Livestock Grazing	Irrigated Hayland & Livestock Grazing	Livestock Grazing & Rec./Wildlife Habitat	Irrigated Hayland & Livestock Grazing		Livestock Grazing & Irrigated Hayland		Rec./Wildlife Habitat & Livestock Grazing		Rec./Wildlife Habitat & Livestock Grazing		Livestock Grazing & Rec./Wildlife Habitat		Livestock Grazing & Rec./Wildlife Habitat	
	Major Basin	Powder	Powder	Powder	Powder		Powder		Powder		Powder		Powder		Powder	
	Ecoregion	NGP	NGP	NGP	NGP		NGP		NGP		NGP		NGP		NGP	
		Weighted Embeddedness	68	NM	35	44	49	NM		NM		NM		NM		53.2
Habitat	Qualitative Habitat Assessment Score (total 200)	139	NM	152.5	157.5	150	139.5	**	141.5	**	149	**	131.5	*	141.5	**
WSI Biotic	Reference Condition *	Reference	Reference	Reference	Reference											
	NGP WSI Score	35.7	38.6	40.6	57.9	43.2	15.7	36.343	34.9	30.8	35.4	31.9	42.9	99.3	46.1	107
	NGP WSI Rating	Poor	Fair	Fair	Good		very poor		poor		poor		Fair		Fair	
*Reference condition obtained from Jessup and Stribling (2002)																
** Comparison not conducted due to differences in habitat assessment methods.																

Appendix A - WSII metric values, scores, and site ratings for South Fork Crazy Woman Creek and Beaver Creek assessment stations, October 1999, Johnson County.

South Fork Crazy Woman Creek (NGP68) - October 28, 1999		ENTER		5th or 95th %ile
Metric	Scoring formula	METRICS	Score	(as per formula)
Total taxa	100*metric / 95th%ile	31	68.9	45
Ephemeroptera taxa	100*metric / 95th%ile	0	0.0	9
Plecoptera taxa	100*metric / 95th%ile	0	0.0	5
Trichoptera taxa	100*metric / 95th%ile	4	40.0	10
% Plecoptera	100*metric / 95th%ile	0	0.0	13
% Trichoptera (no Hydropsychidae)	100*metric / 95th%ile	0.37	1.2	31.3
% non-insects	100*(55 - metric)/(55 - 5th%ile)	73.99	0.0	0.5
% scrapers	100*metric / 95th%ile	2.79	8.8	31.8
B C I C T Q a	100*(110 - metric)/(110 - 5th%ile)	105.24	10.0	62.6
Semi-voltine taxa	100*metric / 95th%ile	2	28.6	7
		index score	15.7	
		Sample Rating	poor	Western High Plains
			very poor	Northwestern Great Plains
			very poor	Wyoming Basin
South Fork Crazy Woman Creek (NGP66) - October 26, 1999		ENTER		5th or 95th %ile
Metric	Scoring formula	METRICS	Score	(as per formula)
Total taxa	100*metric / 95th%ile	37	82.2	45
Ephemeroptera taxa	100*metric / 95th%ile	4	44.4	9
Plecoptera taxa	100*metric / 95th%ile	1	20.0	5
Trichoptera taxa	100*metric / 95th%ile	4	40.0	10
% Plecoptera	100*metric / 95th%ile	0.35	2.7	13
% Trichoptera (no Hydropsychidae)	100*metric / 95th%ile	0.53	1.7	31.3
% non-insects	100*(55 - metric)/(55 - 5th%ile)	6.75	88.5	0.5
% scrapers	100*metric / 95th%ile	0.69	2.2	31.8
B C I C T Q a	100*(110 - metric)/(110 - 5th%ile)	98.33	24.6	62.6
Semi-voltine taxa	100*metric / 95th%ile	3	42.9	7
		index score	34.9	
		Sample Rating	good	Western High Plains
			poor	Northwestern Great Plains
			poor	Wyoming Basin
South Fork Crazy Woman Creek (NGP65) - October 26, 1999		ENTER		5th or 95th %ile
Metric	Scoring formula	METRICS	Score	(as per formula)
Total taxa	100*metric / 95th%ile	35	77.8	45
Ephemeroptera taxa	100*metric / 95th%ile	6	66.7	9
Plecoptera taxa	100*metric / 95th%ile	0	0.0	5
Trichoptera taxa	100*metric / 95th%ile	5	50.0	10
% Plecoptera	100*metric / 95th%ile	0	0.0	13
% Trichoptera (no Hydropsychidae)	100*metric / 95th%ile	1.9	6.1	31.3
% non-insects	100*(55 - metric)/(55 - 5th%ile)	0.95	99.2	0.5
% scrapers	100*metric / 95th%ile	0.19	0.6	31.8
B C I C T Q a	100*(110 - metric)/(110 - 5th%ile)	98.29	24.7	62.6
Semi-voltine taxa	100*metric / 95th%ile	2	28.6	7
		index score	35.4	
		Sample Rating	good	Western High Plains
			poor	Northwestern Great Plains
			poor	Wyoming Basin

Appendix A (cont.) - WSII metric values, scores, and site ratings for South Fork Crazy Woman Creek and Beaver Creek assessment stations, October 1999, Johnson County.

South Fork Crazy Woman Creek (NGP67) - October 26, 1999		ENTER		5th or 95th %ile
Metric	Scoring formula	METRICS	Score	(as per formula)
Total taxa	100*metric / 95th%ile	41	91.1	45
Ephemeroptera taxa	100*metric / 95th%ile	7	77.8	9
Plecoptera taxa	100*metric / 95th%ile	2	40.0	5
Trichoptera taxa	100*metric / 95th%ile	3	30.0	10
% Plecoptera	100*metric / 95th%ile	1.71	13.2	13
% Trichoptera (no Hydropsychidae)	100*metric / 95th%ile	3.04	9.7	31.3
% non-insects	100*(55 - metric)/(55 - 5th%ile)	20.71	62.9	0.5
% scrapers	100*metric / 95th%ile	7.22	22.7	31.8
BCI CTQs	100*(110 - metric)/(110 - 5th%ile)	91.68	38.6	62.6
Semi-voltine taxa	100*metric / 95th%ile	3	42.9	7
		index score	42.9	
		Sample Rating	good	Western High Plains
			fair	Northwestern Great Plains
			fair	Wyoming Basin
Beaver Creek (NGP44) - October 27, 1999		ENTER		5th or 95th %ile
Metric	Scoring formula	METRICS	Score	(as per formula)
Total taxa	100*metric / 95th%ile	46	100.0	45
Ephemeroptera taxa	100*metric / 95th%ile	7	77.8	9
Plecoptera taxa	100*metric / 95th%ile	1	20.0	5
Trichoptera taxa	100*metric / 95th%ile	6	60.0	10
% Plecoptera	100*metric / 95th%ile	0.58	4.5	13
% Trichoptera (no Hydropsychidae)	100*metric / 95th%ile	1.3	4.2	31.3
% non-insects	100*(55 - metric)/(55 - 5th%ile)	43.96	20.3	0.5
% scrapers	100*metric / 95th%ile	11.66	36.7	31.8
BCI CTQs	100*(110 - metric)/(110 - 5th%ile)	92.2	37.6	62.6
Semi-voltine taxa	100*metric / 95th%ile	8	100.0	7
		index score	46.1	
		Sample Rating	good	Western High Plains
			fair	Northwestern Great Plains
			fair	Wyoming Basin

Appendix B - Summary of October 1999 macroinvertebrate collection results and selected biometrics for South Fork Crazy Woman Creek and Beaver Creek stations. Johnson County.

		South Fork Crazy Woman Creek								Beaver Creek		
		Segment 067		Segment 029		Segment 029		Segment 168				
		NOP68		NOP86		NOP86		NOP87		NOP44		
Taxon		Abundance	X Composition	Abundance	X Composition	Abundance	X Composition	Abundance	X Composition	Abundance	X Composition	
Nematoda	Nematoda			23	0.69			57	2.66			
	Ophidionis serpentina											
	Uncinaria undinata	92	1.49					36	1.71			
	Enchytraeidae			81	2.43			125	5.89	438	23.49	
	Mesenchytraeus minimus									19	1.01	
	Imm. Tubificid w/ cap setae	715	11.52	17	0.52			24	1.14	161	8.85	
	Imm. Tubificid w/o cap setae	784	12.64	23	0.69			109	5.13	94	5.04	
	Limnodrilus hoffmeisteri	35	0.56					4	0.19			
	Rhyacodrilus coccineus	127	2.04					8	0.38	11	0.58	
	Lumbricidae									5	0.29	
	Elisenella tetraeda	35	0.56			27	0.88					
	Hirudinea	Hirudinea	12	0.19								
	Mollusca	Sphaeriidae	35	0.56	6	0.17			16	0.76	66	3.03
Rhyssella		69	1.12	6	0.17					3	0.14	
Decapoda	Hyalina azteca	2675	43.12	63	1.91	27	0.88	53	2.47	22	1.15	
	Palaemonetes					13	0.19					
Hydrachnida	Alacri	12	0.19	6	0.17			8	0.38	11	0.58	
TOTAL - NON-INSECTS		4535	76.88	225	6.77	67	2.06	440	20.72	820	43.86	
Insecta	Blatt	23	0.37							3	0.14	
	TOTAL - MEGALOPTERA	23	0.37							3	0.14	
	Diphlogopomus					54	0.76	24	1.14	3	0.14	
	Enallagma/Ischnura			6	0.17							
	TOTAL - ODONATA			6	0.17	54	0.76	24	1.14	3	0.14	
	Beliceon Poulteri			23	0.69	13	0.19	16	0.76	13	0.72	
	Ctenis			184	5.56	266	3.3			5	0.25	
	Ephemerella inermis/Infequens					13	0.19	4	0.19			
	Stellatitricaudatus			12	0.35	13	0.19	263	12.36	70	3.75	
	Choroterpes							12	0.57	30	1.59	
	Tricorythodes minutus			92	2.78	108	1.52	8	0.38	27	1.44	
	Paraleptophlebia									13	0.72	
	Leptophlebia							4	0.19			
	Heptagenia/Nixe					13	0.19	40	1.9	13	0.72	
	TOTAL - EPHEMEROPTERA				311	9.38	430	6.07	347	16.36	172	8.22
	Isoperla			12	0.35			12	0.57	11	0.58	
	Tenellipterygidae							24	1.14			
	TOTAL - PLECOPTERA				12	0.35			36	1.71	11	0.68
	Cheumatopsyche	231	3.72	6	0.17	27	0.38	65	3.99	66	3.46	
	Brachycentrus occidentalis							65	3.04	16	0.86	
	Hydropsyche	12	0.19	6	0.17	27	0.38	303	14.26	390	18.73	
	Neotrichia									3	0.14	
	Oxellia									3	0.14	
	Hydroptila						40	0.57				
	Micrasema									3	0.14	
	Rilostomis	12	0.19	6	0.17	13	0.19					
	Hesperophytax	12	0.19	12	0.35	81	1.14					
	TOTAL - TRICHOPTERA	265	4.28	29	0.87	188	2.68	452	21.29	438	23.49	
	Dubiraphia	208	3.35	184	5.56	296	3.61	162	7.6	153	8.21	
	Helichus									3	0.14	
	Zetteneia									3	0.14	
	Hydrophillidae									3	0.14	
	Micropyllepus			17	0.52			113	5.32	159	8.5	
	Oxloperus	173	2.79	6	0.17					40	2.15	
	TOTAL - COLEOPTERA	360	6.18	207	6.26	296	4.81	275	12.93	360	18.51	
	Ceratopogonidae	69	1.12	40	1.22	81	1.14			8	0.43	
	Hemerodromia					27	0.38	4	0.19	5	0.29	
	Chelifer					148	2.09					
	Dasyhelea			17	0.52	27	0.38					
	Tipulidae			12	0.35							
	Tabanidae									3	0.14	
	Tipula	69	1.12	6	0.17				8	0.38		
	Simulium	12	0.19	12	3.99	3707	43.83	380	16.92	3	0.14	
	TOTAL - DIPTERA	150	2.42	207	6.26	3430	48.38	372	17.48	19	1.01	

Appendix B (cont.) - Summary of October 1999 macroinvertebrate collection results and selected biometrics for South Fork Crazy Woman Creek and Beaver Creek stations, Johnson County.

	South Fork Crazy Woman Creek										Beaver Creek	
	Segment 067		Segment 029				Segment 029		Segment 158		Segment 158	
	Abundance	Composition	Abundance	Composition	Abundance	Composition	Abundance	Composition	Abundance	Composition	Abundance	Composition
	NGP88		NGP88		NGP88		NGP87		NGP84			
	Taxon		Taxon		Taxon		Taxon		Taxon		Taxon	
Insecta	Chironomidae-pupae	12	0.19	17	0.52	13	0.19	4	0.19			
	Pallometriocnemus					27	0.38					
	Cryptochironomus	35	0.56	46	1.39	54	0.76	16	0.76	5	0.29	
	Brillia							24	1.14			
	Micropsectra	231	3.72	1636	49.31	1668	23.53	12	0.57	5	0.29	
	Microtendipes							4	0.19	5	0.29	
	Larva							16	0.76			
	Pterotendipes					27	0.38					
	Pterotendipes			136	4.17	27	0.38					
	Eukiefferiella					27	0.38					
	Oriatopus			23	0.69	296	4.17	4	0.19			
	Pogosta										3	0.14
	Damesa					94	1.33					
	Diplocladius	12	0.19									
	Orthocladus complex	46	0.74	115	3.47	175	2.47	4	0.19	3	0.14	
	Pterotendipes			23	0.69	94	1.33			5	0.29	
	Macropelopia	23	0.37									
	Pterotendipes	12	0.19	207	6.25			44	2.09			
	Rheotendipes									3	0.14	
	Polypedium	369	5.95			81	1.14	16	0.76	3	0.14	
	Rheotendipes			46	1.39			16	0.76	5	0.29	
	Pseudosmittia			23	0.69							
	Tanytarsus	46	0.74									
	Tivetera bicarica grp.					81	1.14					
	Tivetera discoloripes grp.							12	0.57			
	Thienemannimyia complex	12	0.19	46	1.39			4	0.19	3	0.14	
TOTAL - CHIRONOMIDAE	796	12.83	2321	69.87	2663	37.67	178	8.37	40	2.16		
Selected Biometrics	BPTChironomidae		0.33		0.15		0.23		4.7		15.4	
	BIClQa		105.24		98.33		98.29		91.68		92.2	
	Shannon H (loge)		2.14		2.21		2.06		2.89		2.63	
	Shannon H (log2)		3.09		3.19		2.97		4.17		3.79	
	Bmess		0.62		0.61		0.58		0.78		0.69	
	Simpson D		0.22		0.26		0.25		0.08		0.12	
	HBI		7.75		6.53		6.21		5.98		7.07	
	% 5 Dominant		76.95		70.85		78.94		57.03		67.56	
	% 10 Dominant		90.34		85.43		87.68		77.17		85.02	
	% Multivoltine		10.78		54.21		29.08		21.06		11.2	
	% Univoltine		82.81		39.45		66.36		61.48		66.97	
	% Semivoltine		6.41		6.34		4.55		17.49		21.83	
	Collector-gatherer (%)		81.8		81.76		45.37		45.18		61.39	
	Collector-filterer (%)		4.84		5.72		44.69		35.93		22.82	
	Scraper (%)		2.79		0.69		0.19		7.22		11.86	
	Shredder (%)		0		0		0		1.14		0.14	
	Piercer-herbivore (%)		0		0		0.57		0		0	
Macrophyte-herbivore (%)		0		0		0		0		0.14		
WBI Metric Score		16.7		34.6		35.4		42.6		46.1		
WBI Metric Rating		very poor		poor		poor		fair		Fair		

Map 1 - South Fork Crazy Woman Creek, Beaver Creek and associated BURP monitoring stations. October 1999. Johnson County.

