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

WATERBODY:	Horseshoe Creek - WYNP10180008 - 064
SEGMENT DESCRIPTION:	Segment 064 - Extends from the confluence with the North Platte River upstream to the confluence with Spring Creek (6.2 miles).
CLASS:	Class 2AB
DESIGNATED USES:	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:	Segment 064 - Listed as partially supportive for aquatic life and cold-water fisheries uses. Impairments suspected to be caused by 'other habitat'. Sources of pollutants were reported as streambank.
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INTRODUCTION

Horseshoe Creek originates in the Laramie Mountain range within the Medicine Bow National Forest and flows east/northeast for ~45 miles prior to its confluence with the North Platte River immediately below Glendo Reservoir in Platte County. Segment 064 of Horseshoe Creek is located in the Western High Plains ecoregion (Omernik and Gallant, 1987). The geology of Segment 064 is composed primarily of sedimentary materials from the White River (Twr), Hartville (Ph) and Clovery/Morrison (Kj) Formations (USGS, 1985; Welder and Weeks, 1965). Primary and secondary land uses in Segment 064 are irrigated agriculture and livestock grazing, respectively. Irrigation diversions are common throughout Segment 064.

NPDES PERMITTED FACILITIES

No NPDES permitted facilities are located in the Horseshoe Creek watershed.

REPORT OBJECTIVE

The State of Wyoming's 1996 305(b) Report and 303(d) List (WDEQ/WQD, 1996) indicated that Segment 064 of Horseshoe Creek was partially supportive of aquatic life and cold-water fisheries uses. In 1999, the Wyoming Department of Environmental Quality (WDEQ) received a citizen complaint about possible hydrocarbon contamination in Horseshoe Creek from an abandoned pipeline (which is above the upper limit of Segment 064). To address both the concerns from the 1996 listing as well as the citizen complaint, the WDEQ collected chemical, physical, and biological data at three stations on Horseshoe Creek in 1999. Two of the stations (WHP29 and WHP31) were located immediately above and below the abandoned pipeline (above Segment 064) while the third station (WHP30) was located at the mouth

of Horseshoe Creek within Segment 064. In addition to data collections performed in 1999, a field reconnaissance of Segment 064 was conducted in April 2004. The purpose of this reconnaissance was to obtain a better understanding of the flow regime and watershed characteristics of Segment 064. The purpose of this report is to document the findings from the 1999 assessments and 2004 field reconnaissance and provide a determination of whether designated uses assigned to Horseshoe Creek are supported.

METHODS AND MATERIALS

All collection, analysis, and evaluation of Horseshoe Creek was 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, 2002).

1999 ASSESSMENT STATIONS

Descriptive information and data collected at Horseshoe Creek stations (Map 1).

Station ID	Chemical Data	Biological Data	Physical Data	Legal (Sec / T / R)	Latitude	Longitude	Elevation (ft)
[a]WHP29	YES	YES	YES	NENW of Sec. 26, T29N, R69W	42° 27' 30"	105° 6' 8"	4760
[b]WHP31	YES	YES	YES	NENW of Sec. 26, T29N, R69W	42° 27' 30"	105° 6' 8"	4760
[c]WHP30	YES	YES	YES	NENW of Sec. 36, T29N, R68W	42° 26' 50.00"	104° 57' 57.28"	4620

[a]Photo 1

[b]Photo 2

[c]Photo 3

NOTE: WHP30 is located approximately 600 feet upstream of the confluence with the North Platte River.

Chemical, physical, and biological data were collected at the above stations between 9/7/1999 and 9/8/1999.

CHEMICAL DATA

(See Table 1 for complete dataset). Ambient water temperatures among all stations were below the WDEQ/WQD (2001) maximum criteria of 20°C for a cold water fishery. The USEPA (1986) suggests a temperature of 32°C as an upper tolerance limit to maintain a balanced benthic macroinvertebrate structure. Ambient pH was below the upper limit of 9.0 (WDEQ/WQD, 2001) for all stations. Conductivity measurements were 420 uS/cm at WHP29, 463 uS/cm at WHP31,

and 859 uS/cm at WHP30. Evaporative concentration of salts associated with lower flows due to irrigation diversions, an increase in drainage area and/or stream contact with sedimentary deposits are the likely reasons for the elevated conductivity at WHP30. Dissolved oxygen concentrations at all stations were above the acceptable one-day minimum dissolved oxygen criterion of 8 mg/L for class 2AB waters, that is considered protective of all early life stages of aquatic life (WDEQ/WQD, 2001).

Instantaneous turbidity values among all stations were < 2 Nephelometric Turbidity Units (NTU). Instantaneous total suspended solids (TSS) concentrations were < 2 mg/L at all stations. Nitrate-nitrogen and total phosphorous concentrations were each below detection (<0.1 mg/L) at all stations. Generally, for streams that do not directly enter lakes or reservoirs, the recommended target phosphorous concentration considered protective of aquatic life uses is ≤1 mg/L (King, 1993). Chloride concentrations were below detection (<5 mg/L) at WHP29 and WHP31, but increased to 5.8 mg/L at WHP30. Sulfate concentrations for stations WHP29, WHP31, and WHP30 were 38 mg/L, 44 mg/L, and 277 mg/L, respectively. Reasons for the increases in chloride and sulfate at station WHP30 are likely the same as those that presumably caused the elevated conductivity at this station. Oil and grease concentrations were below detection (<1 mg/L) at WHP29 and WHP31 and 1.3 mg/L at WHP30, and did not exceed the oil and grease criterion of 10 mg/L for Wyoming surface waters (WDEQ/WQD, 2001). Field observations from the 1999 assessment and 2004 reconnaissance did not identify any potential source of oil and grease from station WHP30 upstream. Causes of the elevated oil and grease at WHP30 are unknown.

PHYSICAL DATA

Channel Substrate

Stream substrate composition was a cobble/coarse gravel complex at stations WHP29 and WHP31 (Table 2). Substrate composition at WHP30 was sand-dominated with fine gravel, however, cobbles were present below the bed surface. Weighted embeddedness (silt cover) scores were 88, 73, and 80 at stations WHP29, WHP31, and WHP30, respectively (Table 2). Although these scores indicate that there was a marginal amount of fine sediment cover on the riffle substrates, 1999 observations suggest the substrate at WHP30 was at least partially embedded.

Observations from the April 2004 reconnaissance indicated that there is a general transition to a finer substrate with distance downstream. It appears that this change is attributable to a combination of a loss in sediment transport capability as a result of irrigation diversions as well as a natural downstream decrease in channel gradient and contributions from erodible sandstone geology and sandy soils. Areas of active bank erosion may also contribute fine sediment during high flows.

Field observations from the 2004 reconnaissance indicated that the substrate of Horseshoe Creek from station WHP30 upstream, is predominantly sand, with the remainder composed of cobble and gravel. The reconnaissance revealed that the predominantly sand substrate at WHP30 is largely a function of the natural channel characteristics near the mouth of Horseshoe Creek in addition to local geology. Station WHP30 is located in a broad valley, approximately 600' upstream from the confluence with the North Platte River. According to Rosgen (1996) and Leopold (1994), channel width increases with distance downstream. Channel width and the corresponding width to depth ratio at the mouth of a stream would be expected to be greater compared to upstream reaches. A wider channel and corresponding lesser depth and low gradient would result in increased sediment deposition through a loss in stream energy. Horseshoe Creek also flows through erodible sandstone geology and sandy soils, which could also contribute to the large percentage of sand at WHP30. A reduction in stream power associated with upstream irrigation diversions in addition to localized bank erosion may also contribute to the dominance of sand at WHP30. According to the April 2004 reconnaissance, irrigation return flows were not considered a significant contributor of sediment at WHP30.

Another reason for the dominance of sand at WHP30 in addition to the presence of embedded cobbles noted during the 1999 assessment may be due to the operation of Glendo Reservoir and its influences on the North Platte River. Glendo Reservoir is located on the North Platte River less than two miles upstream from its confluence with Horseshoe Creek. The North Platte River from Glendo Reservoir downstream below the confluence with Horseshoe Creek, flows through a confined valley in the Hartville Uplift. Glendo Reservoir commonly releases large volumes of water to satisfy irrigation demands along the North Platte River in Wyoming and Nebraska. According to the United States Geological Survey (USGS) gage 06652800, it is not uncommon for the North Platte River below Glendo Reservoir to exhibit discharges of >1000 cfs from early-April to mid-September with flows between 5000 and 8500 cfs during July and August (USGS, 2004). Information gathered during the 2004 reconnaissance suggests that during large releases from the reservoir, the water surface elevation of the North Platte River may rise to a point where Horseshoe Creek, from its mouth a short distance upstream, could become temporarily inundated, forming 'backwater' conditions that result in the deposition of fine sediment. When water levels in the North Platte River recede, this accumulated sediment may then be periodically flushed downstream during periods of high flows (i.e., spring runoff). These high flow events may scour most fine sediment from the surface and deposit a new substrate, but the deeper bed materials remain embedded, hence the presence of buried cobble noted in 1999. Conversations with a local landowner during the April 2004 reconnaissance confirms that this process occurs.

Habitat Conditions

Habitat condition at all stations monitored in 1999 were evaluated with the use of the fast-water (>10% of stream reach characterized by riffle/run habitats) qualitative assessment procedure (WDEQ/WQD, 2001a). The total qualitative habitat assessment scores for stations WHP29, WHP31, and WHP30 were 145, 152, and 101, respectively. These scores were

72.5%, 76%, and 50.5% of the total maximum score of 200, respectively (Table 3).

Stations WHP29 and WHP31 - Items that tended to reduce the total scores at stations WHP29 and WHP31 were less-than-optimal instream cover for fish, a rectangular channel shape, low pool-to-riffle ratio, high width-to-depth ratio, and/or moderate percentage of fine sediment and embeddedness. It is suspected that historical and current anthropogenic activities may be the reason for the less-than-optimal habitat assessment scores at stations WHP29 and WHP31. Despite human activities in the watershed, stations WHP29 and WHP31 were considered to be in relatively good physical condition. Instream fish cover, though lower than expected according to the qualitative habitat assessment, appeared to be adequate for a stream in the Western High Plains ecoregion. Both stations exhibited stable bank conditions with sufficient riparian vegetation and root mass to dissipate energy during high flows. Though excessive erosion was considered minimal at both stations, it was noted that areas of old cut banks along the channel still contribute sediment to the system. Over time, sediment contributions from these cut banks will decrease as vegetation stabilizes the erodible areas. Disruptive pressures in the riparian zone such as livestock grazing and irrigated agriculture were considered minimal. The absence of excessive sedimentation and actively eroding banks suggests that Horseshoe Creek at WHP29 and WHP31 is in equilibrium with the sediment and flows being supplied by the watershed.

Horseshoe Creek from the confluence with Spring Creek downstream to, but not including station WHP30 - During the 1999 assessment, it was noted that no flow was observed in Horseshoe Creek at the Interstate 25/Highway 319 crossing, which is roughly six stream miles upstream of station WHP30 (Map 1). At the time, it was presumed that the absence of water in the channel was due to upstream irrigation diversions. Field observations and information obtained from landowners during the April 2004 reconnaissance in addition to information from the Wyoming State Engineers Office (WYSEO) indicated that indeed, Segment 064 of Horseshoe Creek from the confluence with Spring Creek downstream roughly 4-5 stream miles has the potential to become dry as a result of irrigation diversions. In fact, during the irrigation season, most of the surface water in this portion of Segment 064 can be diverted into three major irrigation canals of which the majority is diverted into a canal located roughly 1.5 miles upstream of the Interstate 25/Highway 319 crossing. Surface flows in this reach of Segment 064 may also be influenced to some degree by alluvial groundwater withdrawal from irrigation wells (Stockdale, 1980).

April 2004 field observations also suggest that most of this stretch of Segment 064 has experienced historical downcutting and widening that may still be occurring in some reaches. The width to depth ratio of the channel was greater than expected and it appeared that in some areas, the channel had undergone several episodes of lateral migration within its existing floodplain. Based on the influences of irrigation diversions within the stretch of Segment 064, it is highly suspected that the aforementioned physical alterations were primarily the result of channel adjustment in response to changes in the natural flow regime. Bank instability and erosion may result from these changes and the diversion of

water can reduce the sediment transport capability of the stream resulting in sediment deposition. It also appears that beaver exert some influence on the channel morphology through the reoccurring process of dam failure, headcut development and channel incision, followed by stream adjustment and stabilization. Beaver influences appear to have played a major role in the channel morphology in the lower stretches of Segment 064. Some portions of the riparian area also appear to receive moderate to heavy utilization by grazing animals which may exacerbate the channel changes associated with flow alterations through removal of riparian vegetation. Overall, stream banks appear to possess a fair to moderate degree of stability and bank cover. However, some sections, particularly those receiving intensive grazing pressure and/or within the vicinity of irrigation diversions and road crossings, appear susceptible to accelerated erosion or failure during high flows. In areas that receive intensive grazing or are directly downstream of irrigation diversions, sedimentation in the form of mid-channel bars was evident.

Station WHP30 - The habitat condition at station WHP30 in 1999 received a sub-optimal score due to a high percentage of fine sediment, marginal instream cover for fish, moderate exposure of the channel substrate, an inverse trapezoidal channel shape, low pool-to-riffle ratio, some degree of channelization/alteration, and a high width-to-depth ratio. Potential causes of the high percentage of fine sediment were previously explained.

Field observations from the 1999 assessment and 2004 reconnaissance suggest that the physical characteristics of channel at WHP30 are largely due to natural geomorphic processes and inherent features of the lower watershed. Horseshoe Creek at WHP30 is located in a broad valley approximately 600' from the North Platte River and is probably best described as a sand-dominated Rosgen C5 stream type. According to Rosgen (1996), the C5 stream type is generally characterized as having gentle gradients of <2%, a high width to depth ratio, and the riffle/pool sequence typically averages 5-7 bankfull channel widths in length.

The April 2004 field reconnaissance noted several active beaver dams at and immediately upstream of station WHP30. Although active beaver dams were not noted in the 1999 assessment at this station, it is possible that beaver may also exert some influence on the channel morphology at WHP30.

It is also possible that alterations to the natural flow regime by irrigation diversions upstream of WHP30 may have contributed, in part, to the physical characteristics at WHP30. Rosgen (1996) states that stream physical characteristics such as width, depth, velocity, channel shape, gradient, pool/riffle ratio, velocity/depth regimes, and discharge may be reduced or altered by human modifications to the natural flow regime.

In light of possible factors that have resulted in the current channel characteristics at this station, stream banks at WHP30 were considered stable, no excessive erosion was noted, and sufficient riparian vegetation and root mass were present

on banks to dissipate energy during high flows. Disruptive pressures in the riparian zone such as livestock grazing and irrigated agriculture were also considered minimal. Observations of WHP30 during the April 2004 reconnaissance confirmed these findings.

At the time of the 1999 assessment, it was presumed that the flows observed at station WHP30 were the result of irrigation return flows. According to field observations and information gathered from local landowners during the April 2004 reconnaissance, several natural springs and seepage from beaver dams in addition to one man-made impoundment maintain perennial flows in Horseshoe Creek from station WHP30 roughly two miles upstream. A single irrigation return flow drain located just upstream of station WHP30 may contribute some flows when active, but was considered a minor source of flow. Upstream irrigation diversions may also influence flows when active.

Pool Quality - Pool quality scores range from 0 to 10, with higher point values representing higher quality pools for fish habitat. 1999 pool quality scores for stations WHP29, WHP31, and WHP30 were 5.5, 3.25, and 3.5, respectively (Table 3). Pool quality scores at WHP29 and WHP31 were influenced by limited overhead and bank cover. Pool quality at WHP30 was influenced by a limited number of pools for evaluation in addition to sub-optimal substrate (i.e., sand) and limited overhead, subsurface, and bank cover.

Comparison of 1999 Habitat Assessment Scores to Reference Conditions -Stations WHP29, WHP31, and WHP30 scored 92%, 97%, and 64%, respectively, of the average maximum habitat score of two reference quality streams used for comparison (Table 4). Streams with ≥75% comparability in habitat scores with reference streams are assessed as supporting habitat requirements for aquatic life (Plafkin et al., 1989).

BIOLOGICAL DATA

Biometrics developed by Jessup and Stribling (2002) were utilized as a tool to assess the biotic/ecological integrity of Horseshoe Creek as a means of determining whether designated uses, such as aquatic life, are attained. Stations WHP29, WHP31, and WHP30 were evaluated with the Wyoming Stream Integrity Index (WSII) developed for the Western High Plains ecoregion (Jessup and Stribling, 2002). According to Jessup and Stribling (2002), streams that receive WSII scores that rate at or above the 25th percentile of reference conditions are rated as 'good' or 'very good' by the WSII and are deemed supportive of aquatic life uses.

Stations WHP29 (score - 48.9) and WHP31 (score - 59) both received a 'good' WSII rating, however, this was not the case for WHP30 (score - 31) which received a 'fair' rating (Appendix A). A table of macroinvertebrate data collected in 1999 from these stations are listed in Appendix B.

As previously described, the sand-dominated substrate of station WHP30 is believed to be largely the result of the erodible sandstone geology and sandy soils, natural geomorphic processes and landscape features of the lower Horseshoe Creek watershed. Because the majority of aquatic macroinvertebrates exhibit a benthic mode of existence, the type of substrate is a major determinant of the distribution and abundance of aquatic biota since it provides habitat space, food, and protection (Ward, 1992). Increases in mean substrate particle size are ultimately associated with increases in physical habitat complexity and bed stability which are important factors in determining the distribution and abundance of benthic macroinvertebrates (Ward, 1992). Sand-dominated channels generally exhibit extremely depauperate benthic macroinvertebrate communities with low diversity and abundance due to sand's high scour potential, instability, and low organic content. Sand-dominated habitats are only suitable for highly tolerant macroinvertebrate taxa, such as Chironomids (midges), Oligochaetes (aquatic worms) and a few representatives from the Ephemeroptera (mayfly) and Trichoptera (caddisfly) groups (Ward, 1992).

The WSII assigned station WHP30 a low final score and rating due to low scores in all metrics. As expected for a sand-dominated system, the macroinvertebrate community was found to be of diminished species richness and taxonomic diversity and comprised of wide-spread, generalist taxa that possess physiological adaptations to living in harsh aquatic environments. The dominance of these tolerant taxa is probably best exemplified by the tolerant Chironomid (midge) group, which represented 66% of the macroinvertebrate community in terms of percent composition. Non-insects, of which the majority were Oligochaetes (aquatic worms), accounted for 17% of the macroinvertebrate community at WHP30 compared to <5% at stations WHP29 and WHP31. The Ephemeroptera (mayfly) and Trichoptera (caddisfly) communities were also dominated by tolerant taxa. For example, percent composition of Ephemeroptera at WHP30 was dominated by *Tricorythodes minutus,* a wide-spread, highly tolerant, collector-gatherer taxon that inhabits both depositional and erosional habitats (Merritt and Cummins, 1996). Of the six total Trichoptera taxa at WHP30, three taxa (*Cheumatopsyche*, *Hydropsyche*, and *Hydroptila*) comprised over one-half of the Trichopteran community. These three taxa are relatively wide-spread generalists that possess physiological adaptations to living in environments subject to harsh conditions typical of sand-dominated environments (Merritt and Cummins, 1996; Ward, 1992). Over 50% of the macroinvertebrate community at WHP30 was considered multivoltine (2+ generations per year) with only minor representation by semivoltine (1 generation every 2+ years) taxa, suggesting that environmental conditions are unstable and not suitable to support long-lived taxa.

Comparison of 1999 WSII Scores with Selected Reference Sites - Reference quality streams with similar watershed characteristics were used for comparison with Horseshoe Creek stations to assess the percent comparability with Western High Plains WSII scores. Stations WHP29, WHP31, and WHP30 scored 88%, 106%, and 56% of the average WSII score respectively for the two reference streams used for comparison (Table 4).

HISTORICAL/ANCILLARY DATA

According to the Wyoming Game and Fish Department Stream and Lakes Inventory Database, the following species have been collected in Horseshoe Creek in Sec. 36, T29N, R68W (in the vicinity of station WHP30) and Sec. 20, T29N, R68W (upstream of the Interstate 25 crossing): Brown Trout (*Salmo trutta*), Rainbow Trout (*Onchorynchus mykiss*), White Sucker (*Catostomus commersoni*), Longnose Dace (*Rhinichthys cataractae*), and Creek Chub (*Semotilus atromaculatus*).

Two rainbow trout were observed at station WHP30 during the April 2004 field reconnaissance.

QUALITY ASSURANCE/QUALITY CONTROL

Environmental data from Horseshoe Creek was 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 collected for the 1999 assessment were determined to be complete and accurate.

SUMMARY AND CONCLUSIONS

Classification - Based on all available information, Segment 064 of Horseshoe Creek is correctly classified as a class 2AB water. However, Segment 064 from the confluence with Spring Creek downstream approximately 4-5 miles, has the potential to become dry due to irrigation diversions and/or pumping of alluvial groundwater wells. Survey data from the Wyoming Game and Fish Department Stream and Lakes Inventory database indicated cold-water game and non-game fishes have been collected in Horseshoe Creek near its confluence with the North Platte River. Field observations from the April 2004 reconnaissance verified the presence of two rainbow trout at station WHP30. Based on information gathered during the 1999 assessment and 2004 reconnaissance, it appears that the lower two miles of Segment 064 are perennial. These perennial reaches may contain resident cold/warm-water fish populations as well as individuals that travel upstream from the North Platte River. Whether cold/warm-water fishes maintain self-sustaining populations in the remainder of Segment 064 remains unknown, however, it is probably unlikely given the potential for the stream to go dry.

Instantaneous water temperatures among all stations in 1999 were under the established maximum criteria of 20°C for class 2AB waters WDEQ/WQD (2001). In addition, the dissolved oxygen concentrations among all stations in 1999 was above the minimum numeric criteria of 8 mg/L that is considered protective for all early life stages of aquatic life in class 2AB waters (WDEQ/WQD, 2001).

Water Quality - Water quality parameters measured at all stations in 1999 did not exceed existing standards protective of class 2AB waters on the dates of sampling. Oil and grease concentrations at WHP29 and WHP31 were not indicative of hydrocarbon contamination and were both below the 10 mg/L standard for all Wyoming surface waters (WDEQ/WQD, 2001). Furthermore, no sheen or oil deposits suggestive of hydrocarbon contamination were present at WHP29 and WHP31. An oil and grease concentration of 1.3 mg/L was measured at WHP30 in 1999 and below the 10 mg/L standard (WDEQ/WQD, 2001). Field observations from the 1999 assessment and 2004 reconnaissance did not identify any potential sources of oil and grease from WHP30 upstream, thus causes of the elevated oil and grease at WHP30 in 1999 are unknown.

Habitat Quality - At stations WHP29 and WHP31, stream banks were considered stable, no excessive erosion was noted, and sufficient riparian vegetation and root mass was present on banks to dissipate energy during high flows. In addition, disruptive pressures in the riparian zone such as grazing and/or irrigated agriculture were not considered excessive. Anthropogenic disturbances in the watershed such as runoff from cultivated fields may contribute some fine sediment to the system, however, field observations and available information suggest that the additional fine sediment does not negatively impact the ability of the stream to sustain aquatic biota. The absence of excessive sedimentation and actively eroding banks at these stations suggests that this reach of Horseshoe Creek is in equilibrium with the sediment and flows being supplied by the watershed.

Observations from the April 2004 reconnaissance suggest that overall, stream banks in the stretch of Segment 064 from the confluence with Spring Creek downstream to, but not including station WHP30 appeared to possess a fair to moderate degree of stability and bank cover to dissipate energy during high flows. However, some sections, particularly those receiving intensive grazing pressure and/or within the vicinity of irrigation diversions, appear susceptible to accelerated erosion or failure during high flows. In some areas that receive intensive grazing or are directly downstream of irrigation diversions, sedimentation in the form of mid-channel bars occurs. There is also an overall transition to a greater percentage of sand in the substrate with distance downstream that is due primarily to the natural decrease in stream gradient with distance downstream and erodible sandstone geology and sandy soils of the watershed. Secondary causes of greater sand in the substrate may be attributed to a loss in sediment transport capacity as a result of irrigation diversions in addition to localized areas of bank erosion.

At station WHP30, streambanks were considered stable and not actively eroding, while sufficient riparian vegetation and root mass was present on the banks to dissipate energy during high flows. Disturbances in the riparian zone were noted as minimal and no excessive vertical or lateral migration of the stream was observed. The high percentage of sand at

this station appears to be largely natural, due to the stream's naturally low gradient, natural increase in width at its mouth, and erodible sandstone geology and sandy soils. Additionally, the operation of Glendo Reservoir may periodically raise the level of the North Platte River creating 'backwater' conditions and subsequent sedimentation from the mouth of Horseshoe Creek a short distance upstream. Upstream irrigation diversions as well as localized bank erosion may also contribute to the high percentage of sand at this station.

Biotic Quality - Stations WHP29 and WHP31 exhibited Western High Plains WSII scores well within the upper 25th percentile of relevant reference conditions. Those streams that score in the upper 25th percentile of reference conditions are considered to be fully supportive of aquatic life uses (Jessup and Stribling, 2002). Furthermore, stations WHP29 and WHP31 were 88% and 106% comparable with respect to WSII scores for two reference stations, respectively. This further strengthens the conclusion that aquatic life uses are supported at WHP29 and WHP31.

Contrary to stations WHP29 and WHP31, the WSII score for station WHP30 did not score in the upper 25th percentile of reference conditions and was only 56% comparable to two suitable reference stations with respect to WSII scores. The mobility and low organic content of the sand substrate at WHP30 has the potential to scour the bed as well as resident biota. The result is an aquatic macroinvertebrate community of low biological diversity, comprised of taxa tolerant to a wide range of environmental conditions that can withstand stressors that would otherwise eliminate more sensitive taxa from the ecosystem.

DETERMINATION

- A review of chemical, biological, and physical data collected on Segment 064 of Horseshoe Creek in 1999 and the April 2004 field reconnaissance suggests that this waterbody is:

1) **Fully supportive of cold-water fisheries, non-game fisheries, and aquatic life other than fish** from station WHP31 upstream an unknown distance.

2) **Fully supportive of cold-water fisheries, non-game fisheries, and aquatic life other than fish** from station WHP30 approximately two miles upstream. This conclusion is based on field observations and information from local landowners which indicates this portion of Segment 064 maintains perennial flows year-round from natural springs, beaver dams, and seepage from one man-made impoundment.

3) **Non-supportive of cold-water fisheries, non-game fisheries, and aquatic life other than fish** for the remainder of Segment 064, from the confluence with Spring Creek downstream approximately 4-5 miles. This

conclusion is based on information that indicates this portion of Segment 064 has the potential to become dry due to irrigation diversions and/or alluvial groundwater pumping.

- Review of biological, physical, and/or chemical data suggests Segment 064 of Horseshoe Creek is **fully supportive of drinking water, wildlife, industrial, aesthetic value, agricultural, and fish consumption uses**.

- Review of biological and chemical data collected on Segment 064 of Horseshoe Creek are **insufficient to determine contact recreation use support**.

RECOMMENDATION

1) Conduct future *E. coli* monitoring on Horseshoe Creek to determine contact recreation use support.

SIGNATURES:

_____	_____
Author	Date
_____	_____
Peer Reviewer	Date
_____	_____
Monitoring Supervisor	Date

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WDEQ/WQD. 2002. Wyoming's method for determining water quality condition of surface waters. Wyoming Department of Environmental Quality, Water Quality Division, Cheyenne, WY.

Table 1 - Physicochemical results for Horseshoe Creek stations. September 1999. Platte County.

Parameter	WHP29	WHP31	WHP30
Date	9/8/99	9/8/99	9/8/99
Time	0830	0930	1630
Temperature C	13.4	13.6	19.6
pH	8.16	8.12	8.01
Conductivity (uS/cm)	420	463	859
Dissolved Oxygen (mg/L)	8.2	8.26	9.61
Turbidity (NTU)	0.57	1.19	1.03
TSS (mg/L)	<2	<2	<2
Alkalinity (mg/L as CaCO3)	250	250	250
Sulfate (mg/L)	38	44	277
Chloride (mg/L)	<5	<5	5.8
Nitrate (mg/L as N)	<0.1	<0.1	<0.1
Total Phosphorus (mg/L)	<0.1	<0.1	<0.1
Total Hardness (mg/L as CaCO3)	202	202	376
Oil and Grease (mg/L)	<1	<1	1.3
Sheen	None	None	None
Color	None	None	None
Odor	None	None	None
Discharge (cfs)	NM	8.54	5.21
NM= not measured			

Table 2 - Mean percent stream substrate composition, weighted embeddedness and water velocity at Horseshoe Creek stations. September 1999. Platte County.

Substrate Type	WHP29	WHP31	WHP30
Cobble	34	35	7.5
Coarse Gravel	45	52	1.5
Fine Gravel	17	11	37.5
Sand	4	2	52.9
Silt			
Clay-Hard Pack (solid, slick)			
Organic (fine, black, odor)			0.6
Precipitate			
Weighted Embeddedness	88	73	80
Mean Water Velocity (ft/sec)	1.24	1.32	1.3
Note - cobble was present a few inches below the sand/fine gravel layer at WHP30			

Table 3 - Qualitative habitat assessment, pool quality, and biological indicator scores for Horseshoe Creek stations. September 1999. Platte County.

Habitat Parameters (Max. Score)	WHP29	WHP31	WHP30
Bottom Substrate-Percent Fines (20)	11	19	3
Embeddedness (20)	14	18	12
Instream Cover for Fish (20)	13	14	7
Velocity/Depth (20)	14	17	13
Channel Flow Status (20)	18	17	8
Channel Shape at Bankfull (15)	10	9	2
Pool/Riffle Ratio (15)	9	9	5
Channelization/Alteration (15 for >10%)	15	13	11
Width/Depth Ratio (15)	7	3	4
Bank Vegetation Protection (Bankfull) (10)	8.5	8.5	9
Bank Stability (Bankfull) (10)	8	7.5	9
Disruptive Pressures (Riparian Zone) (10)	10	9.5	10
Riparian Vegetative Zone Width (10)	7.5	7.5	8
HABITAT ASSESSMENT TOTAL >10% Riffle/Run (200 possible)	145	152	101
HABITAT ASSESSMENT (Percent of Maximum Score)	72.50	76.00	50.50
Average Pool Quality Score (10)	5.5	3.25	3.5
Estimated Percentage of Pools in Reach at least 1.5' deep	100	75	100
Biological Indicators**			
Periphyton	3	3	2
Filamentous Algae	2	1	2
Rooted Macrophytes	2	1	0
Floating Macrophytes	0	1	0
Fish	2	2	2
Slimes	0	0	0
** 4-Dominant, 3-Abundant, 2-Common, 1-Rare, 0-Absent			

Table 4 - Comparison of watershed characteristics and selected physical and biological assessment results between Horseshoe Creek stations WHP29, WHP31, and WHP30 and two reference-quality Western High Plains streams.

		Bear Creek - Above Little Bear Creek (WHP21)	Bear Creek - Headwater (WHP22)	Average Reference Station Scores	Horseshoe Creek - Abv. Abandoned Pipeline (WHP29)	Horseshoe Creek - Abv. Abandoned Pipeline (WHP29) % of Average	Horseshoe Creek - Blw. Abandoned Pipeline (WHP31)	Horseshoe Creek - Blw. Abandoned Pipeline (WHP31) % of Average	Horseshoe Creek - Abv. North Platte River (WHP30)	Horseshoe Creek - Abv. North Platte River (WHP30) % of Average
Waterbody Description	Location	SW/NE of Sec. 14, T19N, R65W	SW/NW of Sec. 11, T19N, R66W		NENW of Sec. 26, T29N, R69W		NENW of Sec. 26, T29N, R69W		NENW of Sec. 36, T29N, R68W	
	Elevation (ft.)	5160	5410		4760		4760		4620	
	Drainage Area (sq. miles)	177	142		172		173		211	
	County	Goshen	Laramie		Platte		Platte		Platte	
	Geology (USGS, 1985)	Tmo	Tmo		Twr		Twr		Kj	
	Land Uses	Livestock Grazing & Rec./Wildlife Habitat	Livestock Grazing & Rec./Wildlife Habitat		Irrigated Row Crops & Livestock Grazing		Irrigated Row Crops & Livestock Grazing		Irrigated Hay & Livestock Grazing	
	Major Basin	North Platte	North Platte		North Platte		North Platte		North Platte	
	Ecoregion/Bioregion	WHP	WHP		WHP		WHP		WHP	
Habitat	Total Qualitative Habitat Assessment Score	160.5	153	157	145	92.4	152	96.8	101	64.3
WSII Biometric	Reference Condition	[4]Reference	[4]Reference							
	WSII Score	59.8	51.6	55.7	48.9	87.8	59	106	31	55.7
	WSII Rating	Good	Good		Good		Good		Fair	

[4]Reference condition determined by Jorrup and Stribling (2002); [4]Reference condition determined by Jorrup and Stribling (2002) and WDEQ

Appendix A - WSII metric values, scores, and site ratings for Horseshoe Creek stations. September 1999. Platte County.

Horseshoe Creek - Abv. Abandoned Pipeline (WHP29) - September 7, 1999		ENTER			5th or 95th %ile
Metric	Scoring formula	METRICS	Score		(as per formula)
Total taxa	100*metric / 95th%ile	43	95.6		45
Ephemeroptera taxa	100*metric / 95th%ile	5	55.6		9
Plecoptera taxa	100*metric / 95th%ile	1	20.0		5
Trichoptera taxa	100*metric / 95th%ile	7	70.0		10
% Plecoptera	100*metric / 95th%ile	0.17	1.3		13
% Trichoptera (no Hydropsychidae)	100*metric / 95th%ile	7.64	24.4		31.3
% non-insects	100*(55 - metric)/(55 - 5th%ile)	4.67	92.3		0.5
% scrapers	100*metric / 95th%ile	7.81	24.6		31.8
BCICTQa	100*(110 - metric)/(110 - 5th%ile)	93.88	34.0		62.6
Semi-voltine taxa	100*metric / 95th%ile	5	71.4		7
		index score	48.9		
		Sample Rating	good	Western High Plains	
			fair	Northwestern Great Plains	
			fair	Wyoming Basin	

Horseshoe Creek - Blw. Abandoned Pipeline (WHP31) - September 7, 1999		ENTER			5th or 95th %ile
Metric	Scoring formula	METRICS	Score		(as per formula)
Total taxa	100*metric / 95th%ile	47	100.0		45
Ephemeroptera taxa	100*metric / 95th%ile	5	55.6		9
Plecoptera taxa	100*metric / 95th%ile	2	40.0		5
Trichoptera taxa	100*metric / 95th%ile	11	100.0		10
% Plecoptera	100*metric / 95th%ile	0.38	2.9		13
% Trichoptera (no Hydropsychidae)	100*metric / 95th%ile	6.67	21.3		31.3
% non-insects	100*(55 - metric)/(55 - 5th%ile)	4.18	93.2		0.5
% scrapers	100*metric / 95th%ile	6.85	21.5		31.8
BCICTQa	100*(110 - metric)/(110 - 5th%ile)	83.73	55.4		62.6
Semi-voltine taxa	100*metric / 95th%ile	7	100.0		7
		index score	59.0		
		Sample Rating	good	Western High Plains	
			good	Northwestern Great Plains	
			fair	Wyoming Basin	

Horseshoe Creek - Abv. North Platte River (WHP30) - September 8, 1999		ENTER			5th or 95th %ile
Metric	Scoring formula	METRICS	Score		(as per formula)
Total taxa	100*metric / 95th%ile	32	71.1		45
Ephemeroptera taxa	100*metric / 95th%ile	3	33.3		9
Plecoptera taxa	100*metric / 95th%ile	0	0.0		5
Trichoptera taxa	100*metric / 95th%ile	6	60.0		10
% Plecoptera	100*metric / 95th%ile	0	0.0		13
% Trichoptera (no Hydropsychidae)	100*metric / 95th%ile	2.86	9.1		31.3
% non-insects	100*(55 - metric)/(55 - 5th%ile)	17.01	69.7		0.5
% scrapers	100*metric / 95th%ile	4.55	14.3		31.8
BCICTQa	100*(110 - metric)/(110 - 5th%ile)	98.75	23.7		62.6
Semi-voltine taxa	100*metric / 95th%ile	2	28.6		7
		index score	31.0		
		Sample Rating	fair	Western High Plains	
			poor	Northwestern Great Plains	
			poor	Wyoming Basin	

Appendix B - Summary of September 1999 macroinvertebrate collection results and selected biometrics for Horseshoe Creek stations. Platte County.

		WHP29		WHP31		WHP30	
	Taxon	Abundance	%Composition	Abundance	%Composition	Abundance	% Composition
Nematoda	*Nematoda*	13	0.17				
Oligochaeta	*Uncinais uncinata*					10	1.01
	Turbellaria	202	2.6	19	0.57		
	Pristinella jenkinae			31	0.95	5	0.51
	Enchytraeidae					33	3.2
	Imm. Tubificid w/o cap setae					110	10.77
Bivalvia	*Sphaeriidae*	13	0.17				
Gastropoda	*Ferrissia*					12	1.18
	Physella			37	1.14		
Hirudinea	*Hirudinea*	13	0.17				
Hydrachnida	*Acari*	121	1.56	50	1.52	3	0.34
	TOTAL - NON-INSECTS	363	4.69	137	4.19	174	17
hsecta	*Ophiogomphus*			12	0.38		
	TOTAL - ODONATA			12	0.38		
	Acentrella insignificans	13	0.17	37	1.14		
	Fallceon ?quilleri	444	5.73	546	16.76	2	0.17
	Baetis tricaudatus	1426	18.4	646	19.81	3	0.34
	Tricorythodes minutus	256	3.3	12	0.38	115	11.28
	Paraleptophlebia	13	0.17				
	Heptagenia/Nixe			6	0.19		
	TOTAL - EPHEMEROPTERA	2152	27.78	1248	38.29	120	11.78
	Isoperla			6	0.19		
	Skwala	13	0.17	6	0.19		
	TOTAL - PLECOPTERA	13	0.17	12	0.38		
	Ambrysus	13	0.17	12	0.38		
	TOTAL - HEMIPTERA	13	0.17	12	0.38		
	Cheumatopsyche	1291	16.67	323	9.9	3	0.34
	Amiocentrus aspilus			12	0.38		
	Brachycentrus occidentalis			6	0.19		
	Hydropsyche	1466	18.92	484	14.86	2	0.17
	Helicopsyche borealis			19	0.57		
	Nectopsyche			25	0.76		
	Polycentrops			6	0.19		
	Psychomyia			6	0.19	9	0.84
	Hydroptila	54	0.69			17	1.68
	Ochrotrichia	27	0.35				
	Oreocosmoecus unicolor					2	0.17
	Chimarra	457	5.9	68	2.1		
	Marilia	13	0.17	31	0.95		
	Oecetis	40	0.52	43	1.33	2	0.17
	TOTAL - TRICHOPTERA	3349	43.23	1025	31.43	34	3.37
	Petrophila	309	3.99	118	3.62		
	TOTAL - LEPIDOPTERA	309	3.99	118	3.62		
	Dubiraphia	13	0.17				
	Helichus			6	0.19		
	Microcylloepus			37	1.14	3	0.34
	Zaitzevia	67	0.87	81	2.48		
	Stenelmis	13	0.17				
	Optioservus	296	3.82	37	1.14	3	0.34
	TOTAL - COLEOPTERA	390	5.03	161	4.95	7	0.67
	Tipula			6	0.19		
	Ceratopogoninae	13	0.17	6	0.19	3	0.34
	Hemerodromia	27	0.35				
	Stratiomyidae	27	0.35	199	6.1		
	Cryptolabis			6	0.19		
	Hexatoma	27	0.35	12	0.38	7	0.67
	Simulium	282	3.65	118	3.62		
	TOTAL - DIPTERA	377	4.86	348	10.67	10	1.01

Appendix B (cont.) - Summary of September 1999 macroinvertebrate collection results and selected biometrics for Horseshoe Creek stations. Platte County.

		WHP29		WHP31		WHP30	
	Taxon	Abundance	% Composition	Abundance	% Composition	Abundance	% Composition
Insecta	*Chironomidae-pupae*	40	0.52	31	0.95	19	1.85
	Cladotanytarsus			6	0.19	101	9.93
	Cricotopus	175	2.26			71	6.9
	Cricotopus Bicinctus Gr.	13	0.17				
	Cricotopus Trifascia Gr.					12	1.18
	Cryptochironomus					33	3.2
	Diamesa			6	0.19		
	Dicrotendipes					306	29.97
	Cardiocladius					7	0.67
	Chironomus					12	1.18
	Microtendipes	40	0.52	25	0.76		
	Eukiefferiella	27	0.35				
	Lopescladius					7	0.67
	Orthocladius complex			12	0.38		
	Paratendipes	27	0.35	12	0.38		
	Pentaneura			6	0.19		
	Parametriocnemus	13	0.17				
	Phaenopsectra					19	1.85
	Thienemanniniyia Complex	40	0.52			7	0.67
	Thienemanniella	81	1.04				
	Polypedilum	67	0.87	50	1.52	64	6.23
	Potthastia Gaedii Gr.	13	0.17	6	0.19		
	Pseduochironomus	13	0.17	12	0.38		
	Rheotanytarsus	161	2.08	12	0.38		
	Rheocricotopus	67	0.87				
	Stictochironomus					19	1.85
	Tvetenia discoloripes grp.			6	0.19		
	TOTAL - CHIRONOMIDAE	780	10.07	186	5.71	676	66.16
	GRAND TOTAL	7747	100	3260	100	1022	100
Selected Biometrics	EPT/Chironomidae		7.07		12.27		0.23
	BCI Qa		93.88		83.73		98.75
	Shannon H(loge)		2.67		2.74		2.51
	Shannon H(log2)		3.84		3.95		3.62
	Evenness		0.71		0.71		0.72
	Simpson D		0.11		0.11		0.14
	HBI		5.47		5.46		7.13
	% 5 Dominant		65.62		67.43		68.85
	% 10 Dominant		82.98		80.77		85.18
	% Multivoltine		39.8		40.95		51.73
	% Univoltine		55.08		53.52		47.6
	% Semivoltine		5.12		5.52		0.67
	Collector-gatherer (%)		36.95		52.56		78.96
	Collector-filterer (%)		47.22		30.86		0.51
	Scraper (%)		7.81		6.85		4.55
	Shredder (%)		0		0.19		0
	Piercer-herbivore (%)		1.04		0		1.68
	Macrophyte-herbivore (%)		0		0		0
WSII	WSII Metric Score	48.9		59		31	
	WSII Metric Rating	Good		Good		Fair	

Map 1 - Horseshoe Creek and associated monitoring stations. Platte County. September 1999.

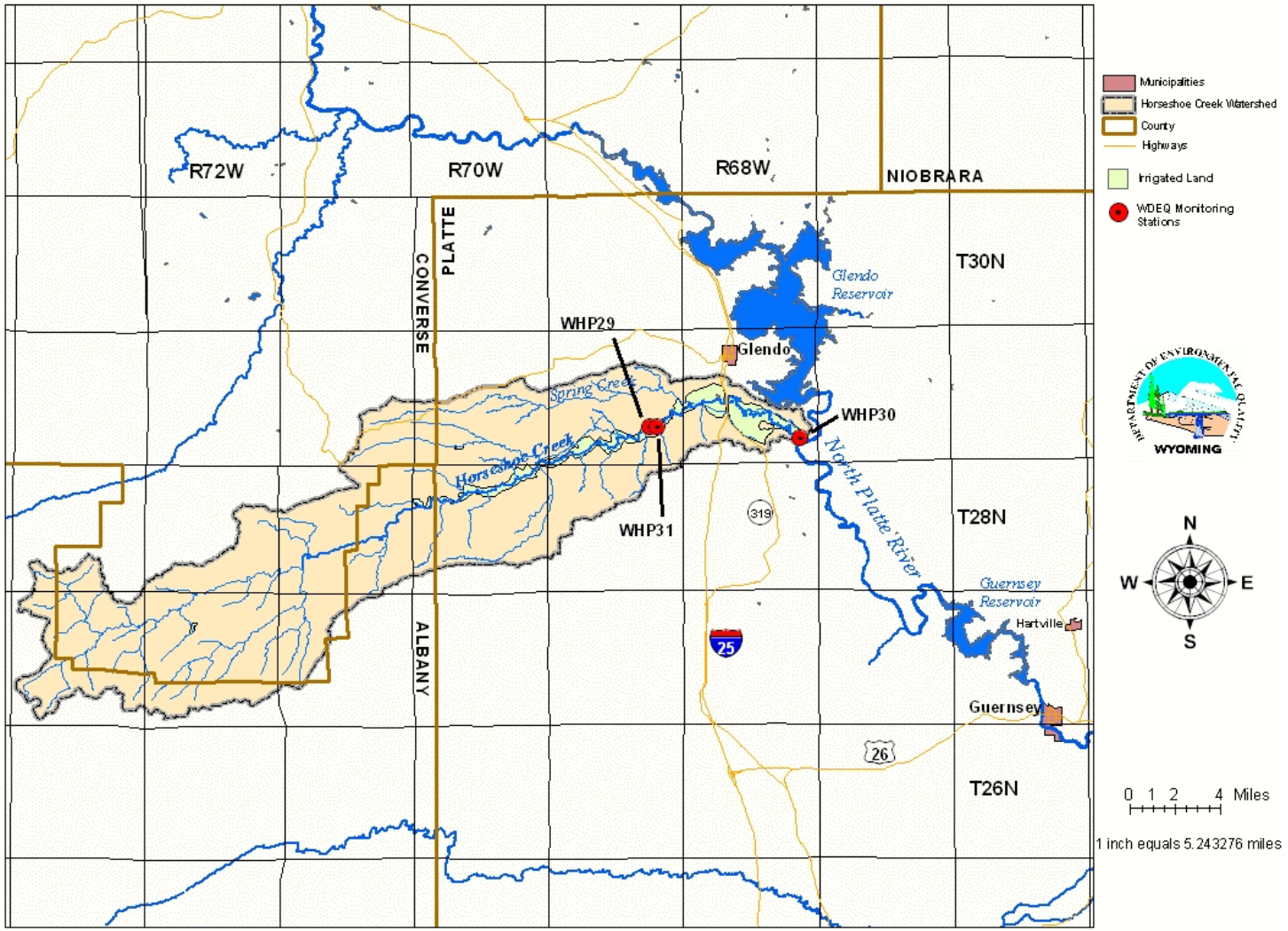

Photo 1 - Panoramic view of Horseshoe Creek station WHP29. September 1999. Platte County.

Photo 1 (cont.) - Panoramic view of Horseshoe Creek station WHP29. September 1999. Platte County.

Photo 2 - Panorama of Horseshoe Creek station WHP31. September 1999. Platte County.

Photo 2 (cont.) - Panorama of Horseshoe Creek station WHP31. September 1999. Platte County.

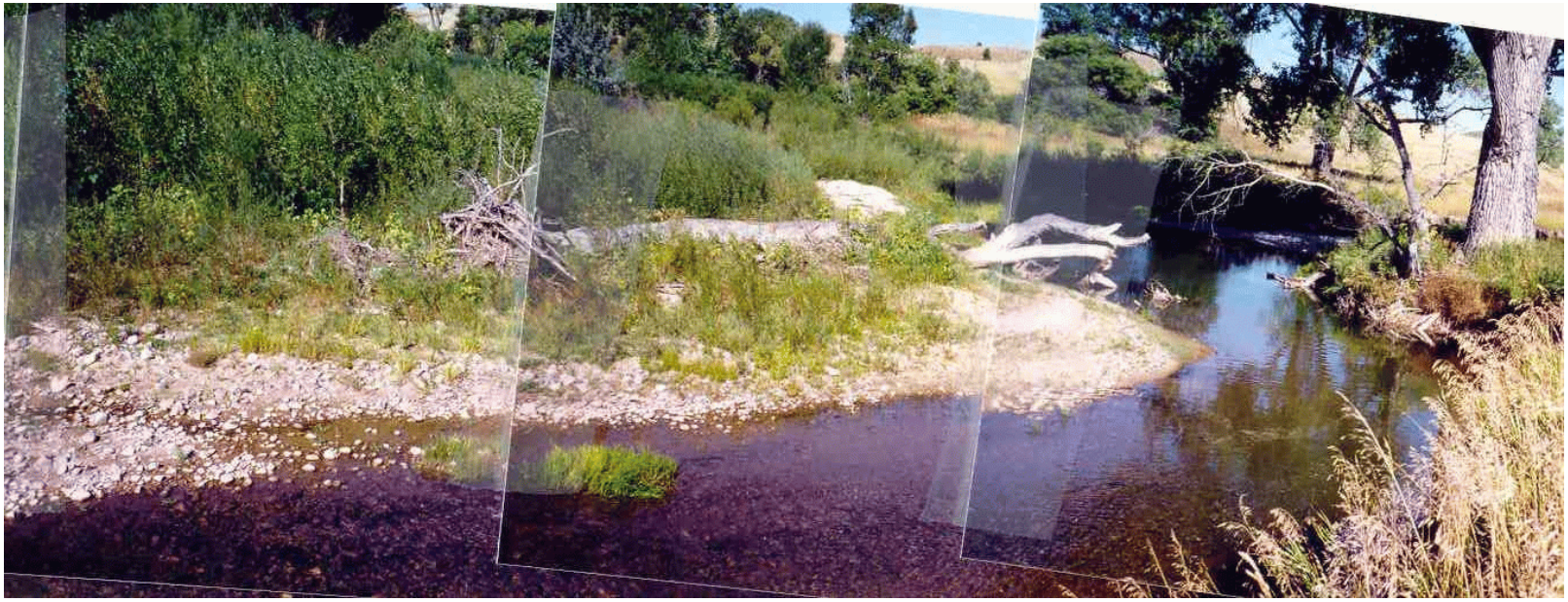

Photo 3 - Panorama of Horseshoe Creek station WHP30. September 1999. Platte County.