Total Maximum Daily Load
For Sediment and Nutrients
Camp Creek
Polk County, Iowa

2005

Iowa Department of Natural Resources
TMDL & Water Quality Assessment Section

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1. Executive Summary

Table 1. Camp Creek summary.

Waterbody Name:	Camp Creek
County:	Polk
Use Designation Class:	B(LR) (aquatic life)
Major River Basin:	Des Moines River Basin
Pollutants:	Sediment and Nutrients
Pollutant Sources:	Point, Nonpoint
Impaired Use(s):	B(LR) (aquatic life)
2002 303d Priority:	Low
Watershed Area:	26,300 acres
Stream Length:	14.8 miles
Sediment Load Capacity (TMDL):	7,100 tons per year
Existing Sediment Load:	13,100 tons per year
Sediment Load Reduction to Achieve TMDL:	6,000 tons per year
Sediment Margin of Safety (MOS):	355 tons per year plus implicit MOS
Sediment Wasteload Allocation:	80 tons per year
Sediment Load Allocation:	6,665 tons per year
Total Phosphorus Load Capacity (TMDL):	To be determined *
Existing Total Phosphorus Load:	24,000 pounds per year
Total Phosphorus Margin of Safety (MOS):	Implicit MOS

* In Phase 2 of the TMDL, additional stream monitoring data will be used to reassess the stressors (if the biological community is still impaired) and the stream will be re-modeled to account for the upgraded plant and new data.

The Federal Clean Water Act requires the Iowa Department of Natural Resources (IDNR) to develop a total maximum daily load (TMDL) for waters that have been identified on the state's 303(d) list as impaired by a pollutant. Camp Creek has been identified as impaired by sediment and nutrients. The purpose of these TMDLs for Camp Creek is to calculate the maximum allowable sediment and nutrient loading for the stream so that water quality standards will be met and maintained. This document consists of a single TMDL for sediment and nutrients designed to provide Camp Creek with water quality that fully supports its designated uses.

Because the cause (stressor) of the biological impairment in 1998 was *unknown*, a scientifically rigorous method called Stressor Identification (SI) was used to determine the existing stressor(s) on the biotic community of Camp Creek. The process involves "critically reviewing available information, forming possible stressor scenarios that might explain the impairment, analyzing those scenarios, and producing conclusions about which stressor or stressors are causing the impairment." (1).

Phasing TMDLs is an iterative approach to managing water quality that becomes necessary when the origin, nature, or sources of water quality impairments are not fully understood. This TMDL will have two phases. Phase 1 will consist of setting specific and quantifiable targets for the sediment load to the stream. Phase 2 will consist of implementing the monitoring plan, evaluating collected data, setting nutrient targets if necessary, and adjusting target values for sediment as needed.

In Phase 1, the waterbody load capacity, existing pollutant load in excess of this capacity, and the source load allocations are estimated based on the information available. A monitoring plan will be used to determine if prescribed load reductions result in attainment of water quality standards and whether or not the target values are sufficient to meet designated uses. Monitoring activities may include routine sampling and analysis, biological assessment, fisheries studies, and watershed and/or waterbody modeling. Monitoring is essential to all TMDLs in order to:

- Assess the future beneficial use status;
- Determine if the water quality is improving, degrading or remaining stable;
- Evaluate the effectiveness of implemented best management practices.

The additional data collected will be used in Phase 2 to determine if the implemented TMDL and watershed management plan have been or are effective in addressing the identified water quality impairments. The data and information can also be used to determine if the TMDLs have accurately identified the required components (i.e. loading/assimilative capacity, load and wasteload allocations, in-stream response to pollutant loads, etc.) and if revisions are appropriate.

This TMDL has been prepared in compliance with the current regulations for TMDL development that were promulgated in 1992 as 40 CFR Part 130.7. These regulations and consequent TMDL development are summarized below:

1. **Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:** Camp Creek, S1, T77N, R22W, Polk County.

2. **Identification of the pollutant and applicable water quality standards:** The pollutants causing the water quality impairments are sediment and nutrients. The designated use for Camp Creek is Aquatic Life (Class B(LR)). Excess sediment and nutrient loading have impaired the aquatic life water quality narrative criteria as described in the Iowa Administrative Code (15) and hindered the designated use.

3. **Quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of water quality standards:** The Phase 1 target of this TMDL is a reduction of sediment and nutrient loading that will allow the biological community to meet expectations based on reference criteria. Biological targets are based on the Fish Index of Biotic Integrity (FIBI) and Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI). Stream segments having FIBI or BMIBI scores at the 25^{th} percentile or lower of reference sites are considered impaired.

   In order to meet the biological targets, a secondary target is set for percent sand (Table 2). Due to extensive changes to the phosphorus sources in the watershed in the past year, the nutrient TMDL will be a 'monitoring TMDL'. Measurements from the monitored stream segments in Camp Creek are compared to stream reference sites within the same ecological regions. These targets are set at the 25th percentile of regional reference sites.

Table 2. Biological and stream habitat targets for Camp Creek. Reference values are shown as the 25th percentile. 'NM' is not measured.

Index	Thomas Mitchell Park	Region 47b Reference	Upstream (Mitchellville)	Downstream (Runnells)	Region 47f Reference
FIBI	29	* 41/34	18	19	* 55/32
BMIBI	77	53	57	43	63
% Sand	42	52	54	84	45

* FIBI criteria scores vary depending on the presence/absence of riffle habitat. Greater fish diversity and therefore higher FIBI scores are expected from areas with riffles.

4. **Quantification of the amount or degree by which the current pollutant load in the waterbody, including the pollutant from upstream sources that is being accounted for as background loading, deviates from the pollutant load needed to attain and maintain water quality standards:** The existing FIBI and BMIBI scores based on 1999 and 2001 bioassessment sampling are shown in Table 2. In order for Camp Creek to meet the biological target, improvements must be made to the streambed composition and nutrient loadings. Based on comparisons to regional reference sites, in-stream reductions of 46% for sediment and 33% for total phosphorus are required to achieve and maintain water quality goals and protect for beneficial uses.

   The estimated existing sediment load is 13,100 tons per year. The sediment load associated with the targeted condition is 7,100 tons per year. Therefore, a sediment load reduction of 6,000 tons per year is required. The estimated existing (pre-2004) annual total phosphorus load is 24,000 pounds per year.

5. **Identification of pollution source categories:** Both point and nonpoint sources of pollutants have been identified as the cause of impairments to Camp Creek. Point sources include one active wastewater treatment facility, one non-discharging lagoon, and one active landfill. Nonpoint sources include both urban and agricultural sources.

6. **Wasteload allocations for pollutants from point sources:** The wasteload allocation for the sediment TMDL is set at 80 tons per year. Wastewater treatment is not considered a contributor of sediment. The landfill has implemented significant BMPs and is not considered a substantial contributor of sediment; therefore, the landfill will not receive a wasteload allocation.

   The wasteload allocation for the total phosphorus TMDL is set at existing for Phase 1. New data must be collected to adequately model current conditions of the biological community, water quality, and effluent quality with regard to phosphorus.

7. **Load allocations for pollutants from nonpoint sources:** The load allocation for sediment is set at 6,665 tons per year delivered to the stream. The total phosphorus load allocation is set at decreasing the contribution from nonpoint sources.

8. **A margin of safety:** The Margin of Safety (MOS) for this TMDL is both explicit and implicit. A 5% MOS (355 tons per year) has been deducted from the sediment TMDL to ensure that the required load reduction will result in attainment of water quality targets. An implicit MOS for sediment is based on the highly conservative assumption that all TSS found in the wastewater effluent is treated as sediment. In addition, the MOS for both sediment and nutrients is implicit based on the requirement that the ecological system is fully supported.

9. **Consideration of seasonal variation:** This TMDL was developed based on the average annual sediment and phosphorus loadings that will result in attainment of nutrient targets and sediment targets, thereby allowing Camp Creek to meet the biological target.

10. **Allowance for reasonably foreseeable increases in pollutant loads:** An allowance for increased sediment and phosphorus loading was not included in this TMDL. Although the City of Mitchellville and surrounding areas have an expanding urban/suburban population, the dominant watershed landuses are expected to remain predominantly agricultural. The addition or deletion of animal feeding operations within the watershed could increase or decrease nutrient loading. Because such events cannot be predicted or quantified, a future allowance for their potential occurrence was not included in the TMDL.

11. **Implementation plan:** Although not required by the current regulations, an implementation plan is outlined in the body of the report.

2. Camp Creek, Description and History

2.1 The Stream

Camp Creek runs south through southeast Polk County with short segments in Jasper County. This TMDL deals with 14.8 miles of stream that are considered impaired. Camp Creek is used as a water source for livestock, and is also enjoyed for recreation purposes, particularly at Thomas Mitchell Park, where fishing and wading are common.

Table 3. Camp Creek features.

Waterbody Name:	Camp Creek
Hydrologic Unit Code:	HUC10 0710000815
IDNR Waterbody ID:	IA 04-LDM-0228_0
Location:	Section 1 T77N R22W
Latitude:	41° 30' N
Longitude:	93° 20' W
Water Quality Standards Designated Uses:	Aquatic Life Support (B(LR))
Tributaries:	Several unnamed tributaries
Receiving Waterbody:	Des Moines River, Red Rock Reservoir
Stream Segment Length:	14.8 miles
Watershed Area:	26,300 acres

Hydrology

Camp Creek flows along the western side of the City of Mitchellville, through Thomas Mitchell Park, past the Metro Park East (MPE) landfill run by the Metro Waste Authority, and into the Des Moines River just upstream of Red Rock Reservoir. During flood events, Red Rock Reservoir will sometimes back-up into the Des Moines River and Camp Creek. This has the potential to impact the hydrology of Camp Creek near Runnells. Many small tributaries contribute to Camp Creek along its entire length.

Figure 1. Daily flow measurements in Camp Creek near the City of Runnells in 2001.

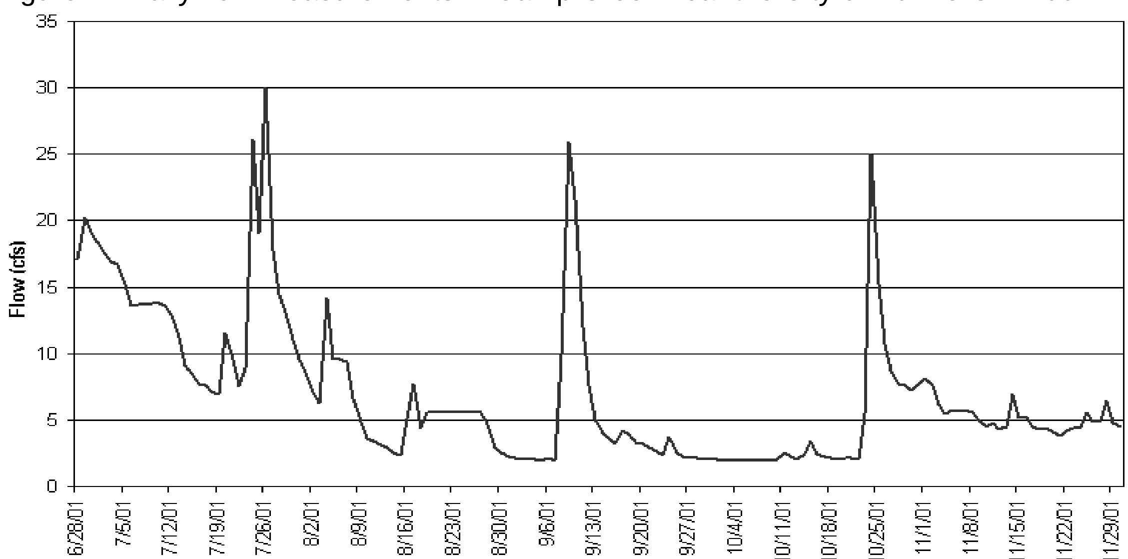
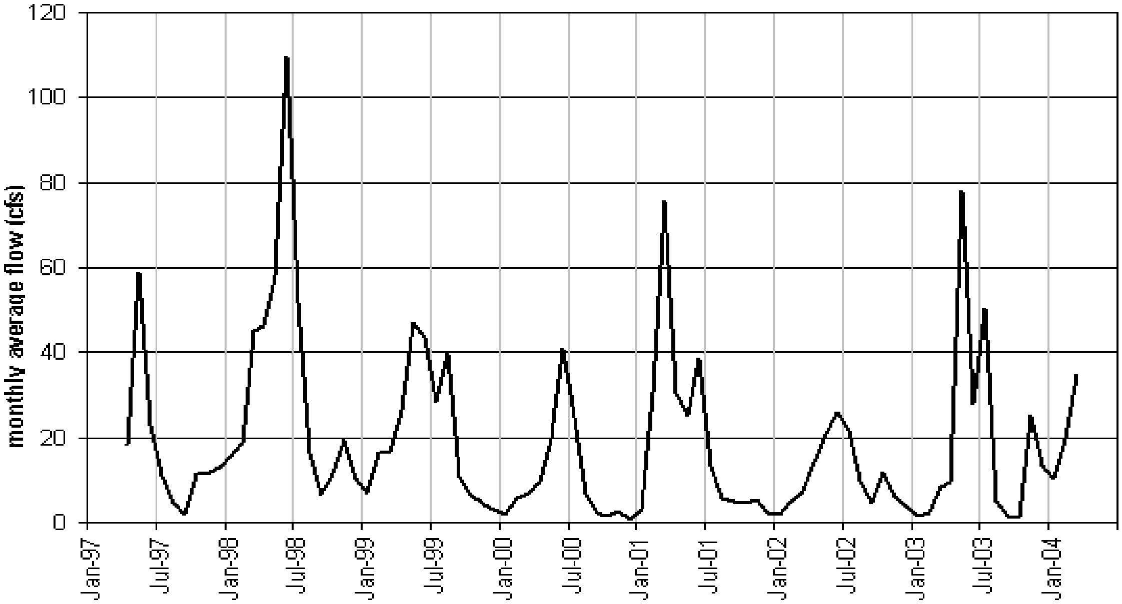


Figure 2. Monthly average flow estimates for Camp Creek based on USGS gauge data from the neighboring Walnut Creek watershed.



Daily measured flows in Camp Creek from July through November 2001 near the City of Runnells range from 1.9 cubic feet per second (cfs) to 30.0 cfs with an average of 7.0 cfs (Figure 1). In general, monthly average flows near Runnells range from 20 to 110 cfs while monthly average flow in the summer and fall is below 20 cfs (Figure 2). Average rainfall in the area is 32.3 inches/year.

2.2 The Watershed

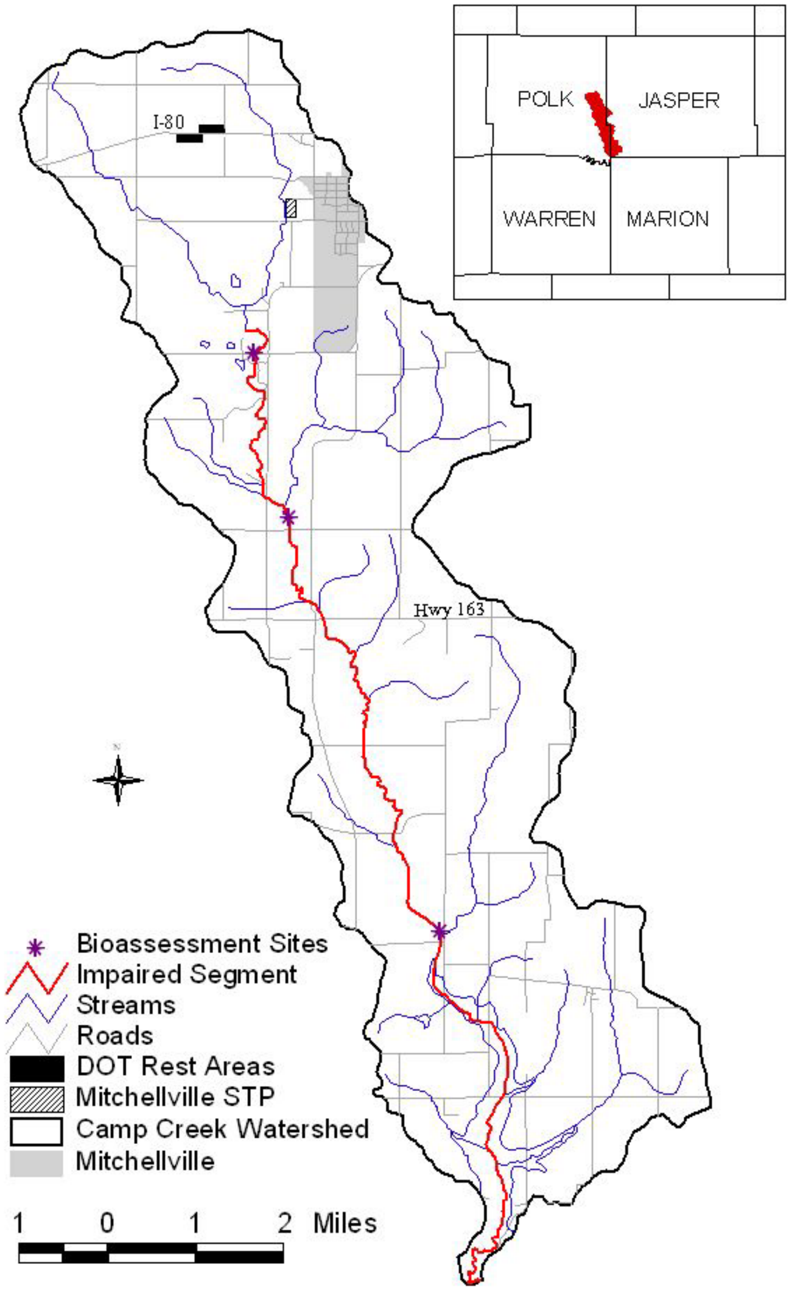
Land Use

The Camp Creek watershed (Figure 3) has an area of approximately 26,300 acres: 19,850 acres in Polk County and 6,450 acres in Jasper County. Landuse data was collected in 2002 by the Polk County Soil and Water Conservation District. The landuses and associated areas for the watershed are shown in Table 4. Land use maps are shown in Appendix A.

Table 4. 2002 landuses in the Camp Creek watershed.

Landuse	Area (acres)	Percent of Total Area
Row Crop	18,010	68.5
Timber	2,046	7.8
Pasture	1,601	6.1
Grass	1,431	5.4
Hay	999	3.8
Farmsteads/Residential	762	2.9
Roads	460	1.7
CRP	423	1.6
Metro Waste Authority Landfill	385	1.5
Other	183	0.7

Figure 3. Camp Creek and its watershed.



The MPE landfill run by the Metro Waste Authority has a Constructed Wetlands Leachate Treatment Facility. This system, put in place in 2000, uses a variety of plant species in a series of lined wetland cells to treat leachate.

Livestock in the watershed include many horses, 2,900 cattle and 7,300 hogs held in pastures, feedlots, and CAFOs. CAFOs are animal feeding operations in which animals are confined to areas that are totally roofed. CAFOs typically utilize earthen or concrete structures to contain and store manure prior to land application. Nutrients from CAFOs are delivered to a receiving stream via runoff from land-applied manure or from leaking/failing storage structures.

Many best management practices (BMPs) are already in place in the Camp Creek watershed. There are many long-established terraces and grassed waterways (Figure A-3 of Appendix A). An active watershed group in the Camp Creek watershed is funded by a 319 grant. This group has enrolled 740 acres with nutrient and/or pasture management plans, installed 6.4 acres of grassed waterways, planned for two grade stabilization structures, and constructed two sediment control basins. The project plans over the next two years include an additional 5,300 acres with nutrient and pasture management plans, 120 acres of riparian buffers, two additional grade stabilization structures, eight additional sediment control basins, 1,500 feet of streambank stabilization, and one mile of demonstration area of riffle/pool systems.

Soils and Topography

Nearly 50% of the watershed is categorized as highly erodable. The northern portion of the watershed has A and B type slopes, largely under conservation tillage. C-sloped land is primarily cropped with reduced tillage or no till. Cropped D-sloped land is under no till practices.

The 319 project application for the Camp Creek Watershed Project stated that “a significant amount of the total pasture [is] within the stream corridor. In addition, a majority of the pasture areas are heavily grazed and see no pasture management. The GIS assessment also shows a significant amount of crop ground being farmed next to the stream bank with virtually no buffer zone.”

3. TMDLs for Sediment and Nutrients

3.1 TMDL for Sediment

3.1.1 Problem Identification

Impaired Beneficial Uses and Applicable Water Quality Standards

The Surface Water Classification document (2) lists the designated use for Camp Creek as Aquatic Life (Class B(LR)). In 1998, the Class B designated use was assessed as “partially supporting” based on the low diversity of fish as noted in a 1990 stream use assessment. Bioassessments conducted in 1999 and 2001 at three sites in the stream confirmed that the biological community in Camp Creek did not meet expectations. Camp Creek was listed for a biological impairment of undetermined cause based upon low scores on the Fish Index of Biotic Integrity (FIBI) and Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI) as measured in the 1999 and 2001 bioassessments.

The FIBI and BMIBI biotic indexes rank the biological integrity of a stream sampling reach on a scale from 0 (min) to 100 (max). The 1999 and 2001 FIBI and BMIBI scores for Camp Creek and for reference sites are shown in Table 5. The site located in Thomas Mitchell Park is the furthest upstream and is located in region 47b (Des Moines Lobe). The other sites are located in region 47f (Southern Iowa Rolling Loess Prairies).

In order to determine the cause of the biological impairment of Camp Creek, the IDNR followed the Protocol for Stressor Identification (SI). The SI procedure is a method used to relate biological impairments described by bioassessments to one or more specific causal agents and to separate water quality impacts from habitat impacts. The SI for Camp Creek (3) determined that the impairment is caused primarily by excess nutrients and silt/sediment in the streambed.

Data Sources

Data was collected through biological sampling at three locations in 1999 and 2001. Water chemistry data was collected monthly by University of Iowa Hygienic Laboratory (UHL) at two sites along Camp Creek from March through November of 2001 and 2003. Event samples were collected using ISCO autosamplers in both 2001 and 2003. Dataloggers were deployed for three weeks in 2003 to measure daily fluctuations in dissolved oxygen and temperature. Details may be found in the SI document (3).

Interpreting Camp Creek Water Quality Data

As shown in Table 6, the percent of total fine substrate is greater than the average and median for the ecoregion reference locations at all three Camp Creek sites. The steady increase in the percent of fine substrate from the upstream site to the downstream site matches with the gradient of FIBI scores. The percent embeddedness of the streambed also indicates a potential downstream gradient, although the lack of riffles and large rock substrate at the downstream site made an embeddedness determination impossible. In addition, the lack of riffle and pool habitat at the two lower sites is likely related to sedimentation. Silt coverage at the upstream site is above reference levels, while fine sediment is dominated by sand particles at the two downstream sites

Table 5. FIBI and BMIBI scores in Camp Creek and associated regional reference criteria (4).

Index	Thomas Mitchell Park (1999)	Region 47b Reference	Upstream 2001	Downstream 2001	Region 47f Reference
FIBI	29	55/32 *	18	19	41/34 *
BMIBI	77	63	57	43	53

* FIBI criteria scores vary depending on the presence/absence of riffle habitat. Greater fish diversity and therefore higher FIBI scores are expected from areas with riffles.

Table 6. Comparison of siltation indicators at Camp Creek sites to reference sites for the ecoregions. Reference values are average, median.

Parameter	Thomas Mitchell Park	Region 47b Reference	Upstream (Mitchellville)	Downstream (Runnells)	Region 47f Reference
% total fines	66	54, 53	75	92	58, 60
% silt	18	12, 8	17	7	20,16
% embeddedness	0-20	*	21-40	NA	*
% riffle	10	11, 9	5	0	9, 9
% run	20	54, 54	84	93	51, 49
% pool	70	35, 30	11	7	40, 40

NA – no riffles to measure embeddedness; * – reference measured as a range, not a numerical value

Potential Pollution Sources

Several point sources had the potential to influence the watershed during the period in which samples were collected:

- The Iowa Department of Transportation has two rest areas within the watershed, each with two cell waste stabilization lagoons that discharged into Camp Creek. Permits for both facilities were changed to inactive as of 3/31/2004.
- At the time of the biological assessments, the City of Mitchellville Sewage Treatment Plant (STP) discharged from a three-cell aerated lagoon into Camp Creek. This facility was upgraded in 2004 to a sequencing batch reactor (SBR).
- Thomas Mitchell Park has a one cell waste stabilization lagoon that discharges into Camp Creek only rarely (the most recent listed discharge was in 2000).
- The MPE landfill has an NPDES stormwater permit.

Nonpoint sources in the watershed contribute sediment loads to Camp Creek:

- Cattle in streams may cause bed and bank erosion.
- Soil erosion from land in agricultural production contributes to the sediment load.
- Urban development in the watershed involves disturbance of the land and may contribute additional sediment.
- Habitat alterations like channelization and removal of riparian vegetation can increase in-stream erosion and sediment delivery from the watershed.

Natural Background Conditions

Background sedimentation was not separated from the estimated sedimentation rate.

3.1.2 TMDL Target

The primary target for this TMDL consists of a biological target that meets the criteria for delisting Camp Creek. According to the Methodology for Developing Iowa's 2004 Section 303(d) List of Impaired Waters (4), BMIBI scores of 63 or higher and FIBI scores of 55 or higher are considered 'supporting' for the aquatic life use in the upstream portions of the watershed, while BMIBI scores of 53 or higher and FIBI scores of 41 or higher are considered 'supporting' for the aquatic life use in the downstream reaches.

In order to meet the biological target, a secondary sediment target is established. If the biological target is met and the sediment target is not, sediment loads need not be reduced further to meet the TMDL sediment target. Excessive fine sediments reduce the availability of favorable spawning sites for fish and buries desirable habitat for benthic macroinvertebrates, thus reducing BMIBI and FIBI scores. Reducing sedimentation in Camp Creek will help improve the BMIBI and FIBI scores by reducing the amount of fine sediments in the streambed, increasing the amount of riffle and pool habitat, and reducing the amount of sediment oxygen demand.

Criteria for Assessing Water Quality Standards Attainment

There are no numeric standards for sediment. However, Camp Creek has excessive amount of fine sediments, particularly sand, on the stream bottom. This excess sediment adversely affects aquatic life. Water quality standards will be considered attained when the biological targets for ecoregions 47b and 47f are met. According to the Methodology for Developing Iowa's 2004 Section 303(d) List of Impaired Waters (4), FIBI and BMIBI scores reaching the levels shown in Table 5 are considered 'supporting' for the aquatic life use.

Selection of Environmental Conditions

The critical condition for this TMDL is the annual average sediment delivery to the stream.

Modeling Approach

The RUSLE (5, 6) model estimates soil erosion rates based on long-term averages. The estimated sheet and rill erosion rate in the watershed is approximately 3.1 tons per acre per year, or 80,500 tons per year. The NRCS Erosion and Sediment Delivery procedure (7) estimates 13% of the RUSLE-calculated erosion, or 10,500 tons per year, as being delivered to the stream. In addition, 25% of the sediment delivered by sheet and rill erosion (2,600 tons/yr) is estimated to be delivered by gully and stream bank and bed erosion (8) for a total of 13,100 tons of sediment per year delivered to Camp Creek.

Waterbody Pollutant Loading Capacity

The loading capacity is the amount of fine sediment and silt that can be delivered to the stream and still meet the BMIBI and FIBI scores of "fully supporting". The target is based upon biological indices and on reference data for stream sediment. Decreasing the amount of sediment will improve habitat and allow aquatic species to survive and reproduce. Metrics used in determining biologic indices are used to compare the monitored stream segments in Camp Creek to stream reference sites within the same ecological regions. Stream segments having FIBI or BMIBI scores at the 25th percentile or lower of reference sites are considered impaired.

The critical metric for sedimentation in Camp Creek is the percent sand in the streambed (Table 7). The 'percent sand' observed at the downstream site near Runnells during the stream assessment in 2001 is 84%. The 25th percentile of 'percent sand' in the region 47f reference streams from 1994 to 2002 is 45%. In order for all stream reaches to fully support the designated use for aquatic life, the target for 'percent sand' in Camp Creek is set at 45%.

Table 7. Sediment metrics for the three Camp Creek sites and the regional reference sites. Reference values are shown as the 25th percentile.

Parameter	Thomas Mitchell Park	Region 47b Reference	Upstream (Mitchellville)	Downstream (Runnells)	Region 47f Reference
% total fines	66	66	75	92	78.5
% sand	42	52	54	84	45
% riffle	11	2	5	0	4

3.1.3 Pollution Source Assessment

Existing Load

The existing sediment load was estimated using the RUSLE and NRCS Erosion and Sediment Delivery (5, 7) procedure and estimates for gully and streambank erosion. Existing delivery is approximately 13,100 tons of sediment delivered to the stream each year. The RUSLE map developed using data collected in 2002 is shown in Figure A-3 of Appendix A.

Departure from Load Capacity

To meet reference expectations, the 'percent sand' in the streambed must be reduced from 84% to 45%, a 46% reduction. Assuming a 1:1 relationship between 'percent sand' in the stream and delivered sediment, a 46% reduction of delivered sediment is required. With 13,100 tons of sediment delivered per year to Camp Creek, a reduction of 6,000 tons per year is required. This leaves an allowable sediment delivery to Camp Creek of 7,100 tons per year.

Identification of Pollutant Sources

The sediment originates from sheet and rill erosion from agricultural land, streambanks, and gullies. Watershed point source contributions are negligible.

Linkage of Sources to Target

Including background sources of sediment, the sources of sediment are entirely from nonpoint sources. The estimated sheet and rill erosion from agricultural land using the RUSLE model and the NRCS Erosion and Sediment Delivery Procedure is 10,500 tons per year plus and an additional 2,600 tons per year for sediment from streambanks and gullies.

3.1.4 Pollutant Allocation

Wasteload Allocation

The City of Mitchellville STP (NPDES IA0021997) and Thomas Mitchell Park (NPDES IA0066966) wastewater facilities are not significant point source discharges of sediment. However, wastewater facilities do discharge suspended particles that contain both organic and inorganic fractions. These are measured in the permit and reported as total suspended solids (TSS). In order to prevent the facilities from receiving a wasteload allocation of zero, the allocation will be set using the highly conservative assumption that all TSS discharged could be considered sediment.

The NPDES permit for the new SBR facility at the City of Mitchellville STP will include a 30-day average TSS limit of 30 mg/l and 423 pounds per day. The permit for Thomas Mitchell Park includes a 30-day average TSS limit of 80 mg/l. Based on the TSS limits and design flows for the facilities, the wasteload allocation for the City of Mitchellville STP is set at 79 tons per year and for Thomas Mitchell Park is set at 1 ton per year. As these limits are based on the permit levels for TSS, the sediment allocation does not need to be added as a separate permit requirement for these facilities.

The stormwater discharge of the MPE landfill is covered under General Permit No. 01 (9). Stormwater from this facility could potentially contribute sediment to Camp Creek. However, this facility has implemented significant BMPs, including several sediment ponds, silt fences, and stormwater diversion. Because this facility has implemented appropriate BMPs to prevent erosion and collect sediment and no additional BMP needs have been identified, a 0% wasteload reduction target is established for the landfill.

Load Allocation

The load allocation is set at 6,665 tons per year.

Margin of Safety

The margin of safety (MOS) for the sediment TMDL is both explicit and implicit. An explicit MOS is set at 5% of the load capacity, or 355 tons per year (7,100 x 5%). An implicit MOS for this TMDL is based on the conservative assumption that all TSS found in the wastewater effluent is treated as sediment. In addition, the primary target of full support of the ecological system as demonstrated by both the fish and benthic macroinvertebrate population adds a further MOS.

3.1.5 Sediment TMDL Summary

TMDL	= wasteload allocation	+ load allocation	+ margin of safety
	= 80 tons per year	+ 6,665 tons per year	+ 355 tons per year
	= 7,100 tons per year		

3.2 TMDL for Nutrients

3.2.1 Problem Identification

Impaired Beneficial Uses and Applicable Water Quality Standards

The Surface Water Classification document (2) lists the designated uses for Camp Creek as Aquatic Life (Class B(LR)). Since 1998, this use has been listed as “partially supporting.” Additional information on the impaired use and the indices that have been used to evaluate this use may be found in Section 3.1.1.

In order to determine the cause of the biological impairment of Camp Creek, the IDNR followed the Protocol for Stressor Identification (SI). The SI identified excess nutrients as one of the primary causes of the biological impairment (3).

Data Sources

Data was collected through biological sampling at three locations in 1999 and 2001. Water chemistry data was collected monthly by University of Iowa Hygienic Laboratory (UHL) at two sites along Camp Creek from March through November of 2001 and 2003. Event samples were collected using ISCO autosamplers in both 2001 and 2003. Dataloggers were deployed for three weeks in 2003 to measure daily fluctuations in dissolved oxygen and temperature. Details may be found in the SI document (3).

Additional data regarding effluent composition was obtained from NPDES permitted facilities, including the City of Mitchellville STP (10), the Thomas Mitchell Park STP (11), two IDOT rest areas (12), and the MPE landfill (9).

Interpreting Camp Creek Water Quality Data

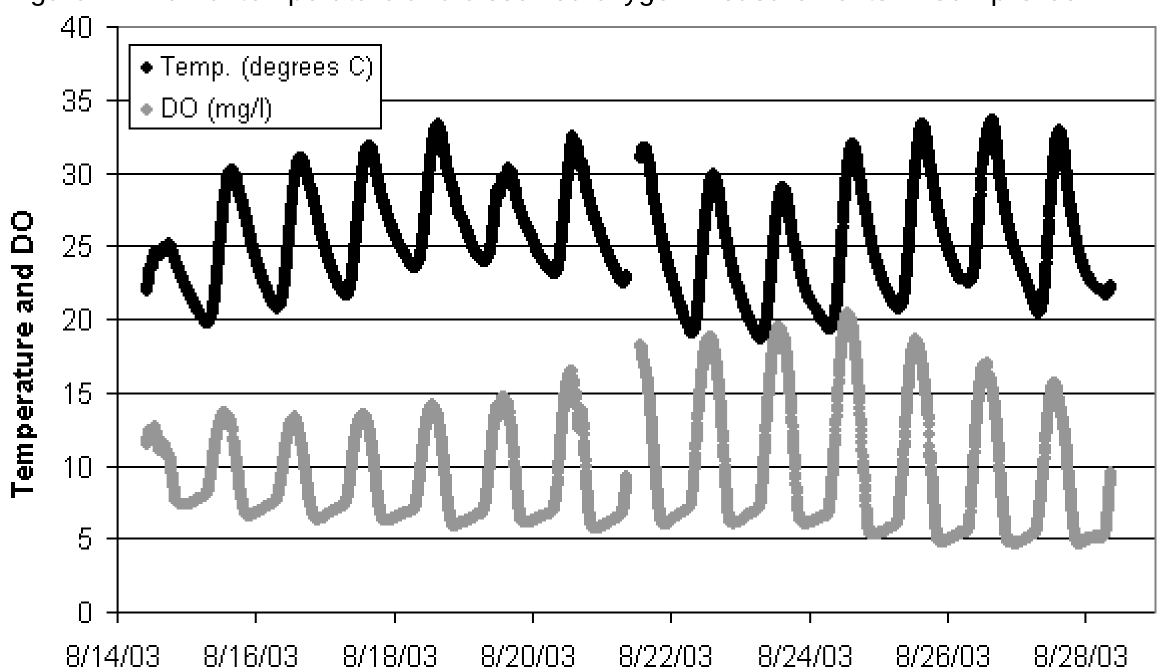
Nitrate/nitrite levels rise each spring to 10-14 mg/l by mid May and drop off again in late summer around August. The average nitrate concentration in the UHL samples was 7.8 mg/l with a standard deviation of 4.6. Total phosphorus levels were generally high with a median value of 0.24 mg/l and an average of 0.44 mg/l. The highest levels of phosphorus occurred in early spring in both 2001 and 2003 (2.1 and 3.5 mg/l respectively), probably during major snowmelt events.

Evidence of algal growth and its relationship to nutrient concentrations may be found in Table 8. The large, diurnal oxygen fluctuations measured during the same sampling period (Figure 4) indicate a high rate of primary productivity associated with the large algal biomass and assimilation of nutrients. Together, these data support the assertion that current nutrient loads are sufficient to stimulate algal growth to levels that lead to extreme fluctuations in dissolved oxygen.

Table 8. Algae and nutrients as measured in Camp Creek near Runnells.

Date	Chl A (ug/l)	Chl C (ug/l)	Nitrate + Nitrite (mg/l)	Phosphorus as P (ug/l)
8/14/03	5	<1	8.4	110
8/21/03	39	1	4.1	130
8/28/03	420	34	0.4	320

Figure 4. Diurnal temperature and dissolved oxygen measurements in Camp Creek.



Potential Pollution Sources

Several point sources either influenced the watershed during the period in which samples were collected or currently influence the watershed.

- The Iowa Department of Transportation (DOT) has two rest areas, each with two cell waste stabilization lagoons that discharge into Camp Creek. Permits for both facilities were changed to inactive as of 3/31/2004.
- At the time of the biological assessments, the City of Mitchellville STP discharged from a three cell aerated lagoon into Camp Creek. This facility was upgraded in 2004 to a sequencing batch reactor.
- Thomas Mitchell Park has a one cell waste stabilization lagoon that discharges into Camp Creek only rarely (the most recent listed discharge was in 2000).
- The MPEL has an NPDES stormwater permit.

Nonpoint sources in the watershed also contribute nutrients to Camp Creek.

- Sediment-attached phosphorus from land in agricultural production contributes to the nutrient load.
- Cattle in streams may contribute nutrient-rich fecal material directly to the stream and cause erosion that releases sediment-attached phosphorus.
- Agricultural use of fertilizer and land-applied manure adds a nutrient reservoir to the watershed.
- Fertilizers applied in urban settings can contribute to the nutrient load.

Natural Background Conditions

Background nutrient loads were not separated from nonpoint sources.

3.2.2 TMDL Target

The primary target for this TMDL consists of a biological target that meets the criteria for delisting Camp Creek. According to the Methodology for Developing Iowa's 2004 Section 303(d) List of Impaired Waters (4), BMIBI scores of 53 or higher and FIBI scores of 41 or higher are considered 'supporting' for the aquatic life use in the downstream portions of the watershed, while BMIBI scores of 63 or higher and FIBI scores of 55 or higher are considered 'supporting' for the aquatic life use in the upstream reaches.

Excessive nutrient loads have increased primary production (algal growth) in Camp Creek. This growth can change the composition of the basal food source and lead to high nighttime respiration rates. When the algal blooms die off, the organic matter that remains often has a high oxygen demand that depletes the dissolved oxygen supply. In addition, the blooms cause dramatic diurnal swings in dissolved oxygen. As shown in Figure 4, dissolved oxygen concentrations range from 6.1 mg/l to 20.5 mg/l over the course of 12 hours and then drop to 5.3 mg/l in 8 hours. These fluctuations are stressful to fish. Reducing nutrient loads in Camp Creek will help improve the BMIBI and FIBI scores by reducing the amount of algal production in the stream, stabilizing the concentration of dissolved oxygen.

The critical nutrient in Camp Creek is phosphorus. Phosphorus concentrations are correlated with algal production (Table 8) and are higher in Camp Creek than at reference sites (Table 9). Nitrate concentrations are negatively correlated with algal production and are no higher in Camp Creek than at reference sites.

Because of recent changes in the point source discharges and in watershed management, it is uncertain whether additional reduction in phosphorus is necessary. The two discharges associated with the Iowa DOT rest areas on I-80 near Mitchellville are now inactive. The City of Mitchellville STP was upgraded in 2004 from a three-cell aerated lagoon to a sequencing batch reactor. Farmers in the watershed have enrolled over 1,300 acres in nutrient management programs and plan to reduce phosphorus application by up to 60%. Additional watershed improvements include the construction of 2 retention basins and installation of 35 acres of grass waterways and filter strips.

With the substantial changes to point and nonpoint source contributions, the nutrient dynamics of Camp Creek have also changed. This change needs to be evaluated for Phase 2 of this TMDL to assess the impact of the new nutrient load to the system. For these reasons, the TMDL for nutrients will be treated as a ‘monitoring TMDL’. If the biological target is met or if future sampling shows that phosphorus concentrations are in line with reference conditions, nutrient loads will not be allocated.

Criteria for Assessing Water Quality Standards Attainment

Water quality standards will be considered attained when the biological targets for ecoregions 47b and 47f are met. According to the Methodology for Developing Iowa’s 2004 Section 303(d) List of Impaired Waters (4), FIBI and BMIBI scores reaching the levels shown in Table 5 are considered ‘supporting’ for the aquatic life use.

Selection of Environmental Conditions

The critical condition for this TMDL is the annual average phosphorus contribution to the stream.

Modeling Approach

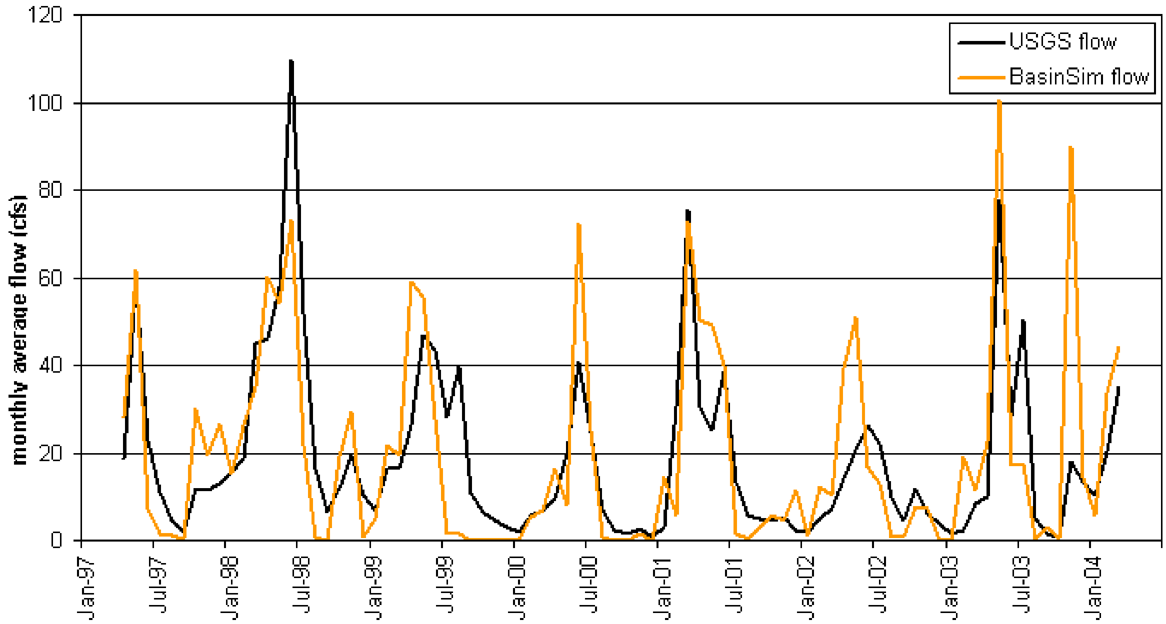
To determine the pre-2004 phosphorus loading to Camp Creek, the BasinSim 1.0 (13) program, which incorporates the Generalized Watershed Loading Function (GWLF) Model (14), was used. The hydrological portion of the model was developed with precipitation and temperature data from the Iowa Environmental Mesonet (IEM), Iowa State University Department of Agronomy. All other parameters were either model defaults or averages from model default tables (e.g., day length for month).

Since there is no gauge on Camp Creek, the hydrologic parameters for the model were calibrated for a similar sized gauged watershed (Walnut Creek near Vandalia, IA - USGS 05487550) in the same landform region for monitored flow data from April 1997 through March 2004. The hydrologic calibration results for the Camp Creek watershed are shown in Figure 4.

Table 9. Nutrients in Camp Creek and at regional reference sites from mid-July to mid-October. Reference values are shown as the 25th percentile. 'NM' is 'not measured'.

Parameter (mg/l)	Thomas Mitchell Park	Region 47b Reference	Upstream (Mitchellville)	Downstream (Runnells)	Region 47f Reference
Nitrate	NM	9.8	5.9	4.3	7.2
Total phosphorus	NM	0.20	0.30	0.19	0.20

Figure 4. Hydrologic comparison between the BasinSim model calibration and Camp Creek flow as estimated based on a USGS gauge in the neighboring Walnut Creek.



Waterbody Pollutant Loading Capacity

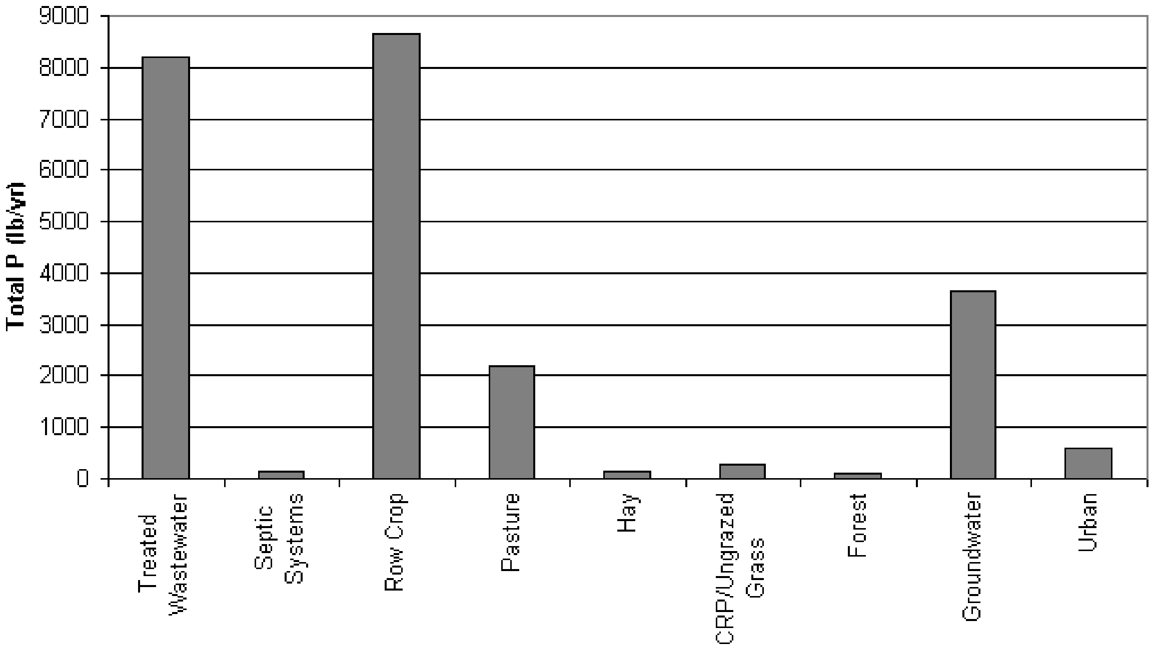
The loading capacity is the amount of phosphorus that can be delivered to the stream and still meet the BMIBI and FIBI scores of "fully supporting". The target is based on biological indices and on regional reference data for stream phosphorus. Decreasing the amount of phosphorus will improve benthic habitat by decreasing the amount of attached algae on the streambed. Lower concentrations of phosphorus will also decrease the overall algae growth, decreasing the magnitude of both the swings and sags in dissolved oxygen. These changes will allow aquatic species to survive and reproduce.

3.2.3 Pollution Source Assessment

Existing Load

The existing load before upgrade to the Mitchellville STP based on the BasinSim model (13) was 24,000 pounds of phosphorus per year.

Figure 5. Phosphorus contributions from watershed sources as modeled using BasinSim (13).



Identification of Pollutant Sources

Phosphorus in Camp Creek originates from both point sources and nonpoint sources (Figure 5). The only significant point source contributor of phosphorus is the City of Mitchellville STP. Nonpoint sources of phosphorus include phosphorus attached to sediment eroded from land in agricultural production and phosphorus from manure that has been deposited in the stream or applied in the watershed.

3.2.4 Pollutant Allocation

Wasteload Allocation

At the time that the biological sampling was conducted, it is estimated that the City of Mitchellville STP was discharging 8,000 pounds of phosphorus per year. Since that time, the facility has been upgraded from an aerated lagoon system to a sequencing batch reactor system (10). It is believed that this facility upgrade has reduced effluent phosphorus. Therefore, the wasteload allocation for the City of Mitchellville STP will not be set in this Phase 1 TMDL, pending additional monitoring of the biological community, stream water quality, and effluent quality.

The lagoon at Thomas Mitchell Park is not a significant contributor of phosphorus to Camp Creek. In the 7-year time span of the model, the wastewater lagoon only discharged once. This discharge in 2000 was associated with high rainfall and resulted in the discharge of an estimated 10 pounds of phosphorus. In the previous 30 years, only one other release was recorded, related to the flooding of Camp Creek in 1993 (11). Due to the low frequency of discharge and insignificant load (less than 1% of the margin of safety) associated with the discharge, the wasteload allocation reduction target for this facility is set at a 0% reduction.

The wastewater lagoons at the DOT rest areas were included in the model as a point source because they were discharging within the timeframe of the model (12). However, these facilities are now inactive and will therefore receive no wasteload allocation.

The MPE landfill has a stormwater permit under Iowa's NPDES General Permit No. 01 (9). Stormwater from this facility is not expected to contribute phosphorus beyond background levels. It is possible that the facility contributes phosphorus through stormwater runoff and/or sediment. However, as described in Section 3.1.4, this facility has implemented significant BMPs to limit sediment inputs and, therefore, phosphorus inputs. No additional BMP needs have been identified for this facility and so the wasteload allocation reduction target for this facility is set at a 0% reduction.

Load Allocation

For Phase 1 of this TMDL, the load allocation for phosphorus is set at decreasing the contribution from nonpoint sources. The allocation will be adjusted after further data is collected and analyzed regarding the impact of the upgraded facility.

Margin of Safety

An implicit margin of safety for this TMDL is based on plans to confirm that the ecological system is fully supported as demonstrated by both the fish and benthic macroinvertebrate population.

4. Implementation Plan

The following implementation plan is not a required component of a Total Maximum Daily Load but can provide department staff, partners, and watershed stakeholders with a strategy for improving Camp Creek water quality.

In addition to sediment and nutrients, the SI for Camp Creek (3) identified turbidity and channelization as stressors to the aquatic community. A TMDL was not written for turbidity because the controls for sediment and phosphorus will also reduce turbidity. Although a TMDL may not be written for channelization, this implementation plan includes the following suggestions:

- Do not engage in further channel-straightening activities. If the stream begins to meander, allow it to do so.
- Install riparian buffers with some amount of woody vegetation along stream corridors. Woody debris that falls from the riparian zone into the stream will encourage re-meandering of the stream.

The reductions in watershed loads of both sediment and phosphorus will require land management changes that take time to implement. Because improvements are currently underway that should reduce these loads, reductions are weighted toward the present day. The following timetable is suggested for watershed improvements:

- Current loading of sediment is 13,100 tons per year.
- Reduce loading of sediment to 9,900 tons per year by 2010.
- Reduce loading of sediment to 8,500 tons per year by 2015.
- Reduce loading of sediment to 7,100 tons per year by 2020.

4.1 Sediment

Channel erosion: Channel erosion has been identified as a sediment source. Channel contributions should be identified and stream bank restoration work done. Areas of severe channel erosion should be identified and targeted for restoration activities. Suggested controls are:

- Installation of structures to reduce peak flows during runoff events.
- Exclusion of livestock from the stream to increase bed and bank stability.
- Installation of stream bank protection measures such as vegetation and graded rock.
- Stabilization of stream banks by shaping and removing overhangs.

Overland sheet and rill erosion: Erosion control activities, including the maintenance of installed structures, need to continue in the watershed. The watershed should be periodically evaluated and erosion control activities focused on identified sediment contributors. Suggested controls are:

- Agricultural management practices that will increase crop residue such as no-till farming,
- Construction of terraces and grassed waterways.
- Installation of riparian buffers along stream corridors.
- Construction of grade stabilization structures.
- Implementation and enforcement of erosion control measures at development sites.

4.2 Nutrients

Best management practices to reduce nutrient delivery, particularly phosphorus, should be emphasized in the Camp Creek watershed. For agricultural land uses, these practices include the following:

- Nutrient management on production agriculture ground to achieve the optimum soil test category. This soil test category is the most profitable for producers to sustain in the long term.
- Incorporate or subsurface apply phosphorus (manure and commercial fertilizer) while controlling soil erosion. Incorporation will physically separate the phosphorus from surface runoff.
- Continue encouraging the adoption of reduced tillage systems, specifically no till and strip tillage.
- Initiate a fall-seeded cover crop incentive program. Target low residue producing crops (e.g. soybeans) or low residue crops after harvest (e.g. corn silage fields). This practice increases residue cover on the soil surface and improves water infiltration.

With the anticipated development of urban areas, Best Management Practices (BMPs) for controlling nutrient delivery associated with urban runoff are also important in the Camp Creek watershed. These practices include:

- Addition of landscape diversity to reduce runoff volume and/or velocity through the strategic location of filter strips, rain gardens, swales, and grass waterways.
- Installation of terraces, ponds, or other erosion and water control structures at appropriate locations within the watershed to control erosion and reduce delivery of sediment and phosphorus to the stream.
- Use of low or no-phosphorus fertilizers on residential and commercial lawns.
- Use of appropriate erosion controls on construction sites to reduce delivery of sediment and phosphorus to the stream.

4.3 Reasonable Assurance

To maintain improve the aquatic community of Camp Creek, both wasteload and load allocations were determined for sediment. The wasteload allocations in this TMDL are set at existing levels, not requiring reductions at this time. For the sediment TMDL, the wastewater facilities are a minor source of TSS load and the landfill has implemented substantial BMPs; even with better technology, changes in these sources would not result in detectable reductions in overall sediment loading. However, nonpoint reductions are required.

A comprehensive watershed assessment was completed in 2003 by the Polk County Soil and Water Conservation District to determine current landuses and best management practices in place. This assessment identified uncontrolled livestock access to the stream and a general lack of buffers or riparian areas as needs for the stream. This assessment is the basis for the Camp Creek Watershed Project.

The Camp Creek Watershed Project was established in 2004 and is working with local landowners, the Metro Park East Landfill, NRCS field office, and the IDNR to develop a priority-based watershed plan. The project will implement best management practices with the goal of improving the water quality of Camp Creek and meeting the targets of the TMDL.

The Camp Creek Watershed Project is funded by a CWA Section 319 grant from the IDNR and by a Watershed Protection Fund Grant from the Division of Soil Conservation. TMDL Section staff are members of the Camp Creek Watershed Project Advisory Board and the Metro Park East Stewardship Committee. These groups meet regularly to discuss the needs in the Camp Creek watershed to improve the water quality of Camp Creek.

The advisory committee to the watershed project is working to identify high priority areas within the Camp Creek watershed. These priority areas are focused on those areas adjacent to the stream. In addition, priority best management practices have been identified for the project. These include fencing of livestock from the stream, alternative water sources, and buffer strips along the stream corridor. This project will reduce non point source sediment and phosphorous contributions, therefore providing reasonable assurance that overall loadings will be reduced.

5. Monitoring

Follow-up biological monitoring will be conducted at a minimum of two locations in the Camp Creek in the fall of 2005. This monitoring will be used to reassess the attainment of the biological targets.

Improvements have been made since the 2001 bioassessments to both point source technology and nonpoint source practices in the Camp Creek watershed. However, there has been limited time since the implementation of these improvements for the reestablishment of the biological community. If Camp Creek is still found to not meet the biological targets in the 2005 assessments, additional chemical and biological monitoring will be scheduled.

6. Public Participation

TMDL staff met with the MPE landfill staff on June 3, 2004 and gave a presentation to the MPE Stewardship Committee on June 17, 2004. TMDL staff are members of the MPE Stewardship Committee and attend regular meetings. In addition, TMDL staff are on the Camp Creek Watershed Project Advisory Board which helps guide the water quality project.

A draft of the TMDL was presented at a local public meeting on June 15, 2005. Attendees included representatives from the Camp Creek Watershed Project, Iowa Farm Bureau Federation, Metro Park East Landfill, and the City of Mitchellville as well as many local residents and farmers. Comments received were reviewed and given consideration and, where appropriate, incorporated into the TMDL.

7. References

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8. Appendix A – Watershed Maps

Figure A-1. 2002 land uses in the Camp Creek watershed based on a field assessment by the Polk County Soil and Water Conservation District.

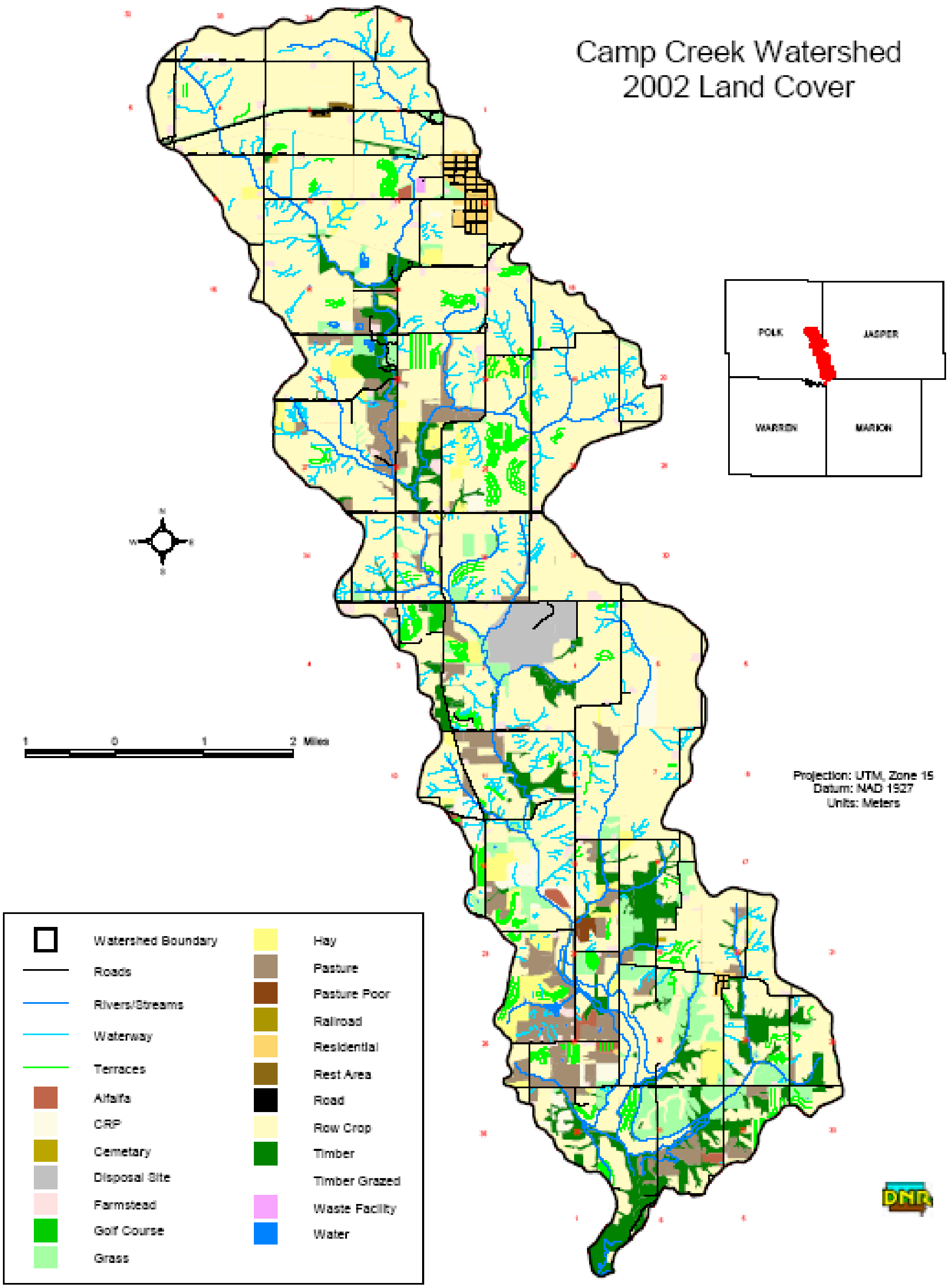


Figure A-2. Land use map based on the statewide GIS coverage.

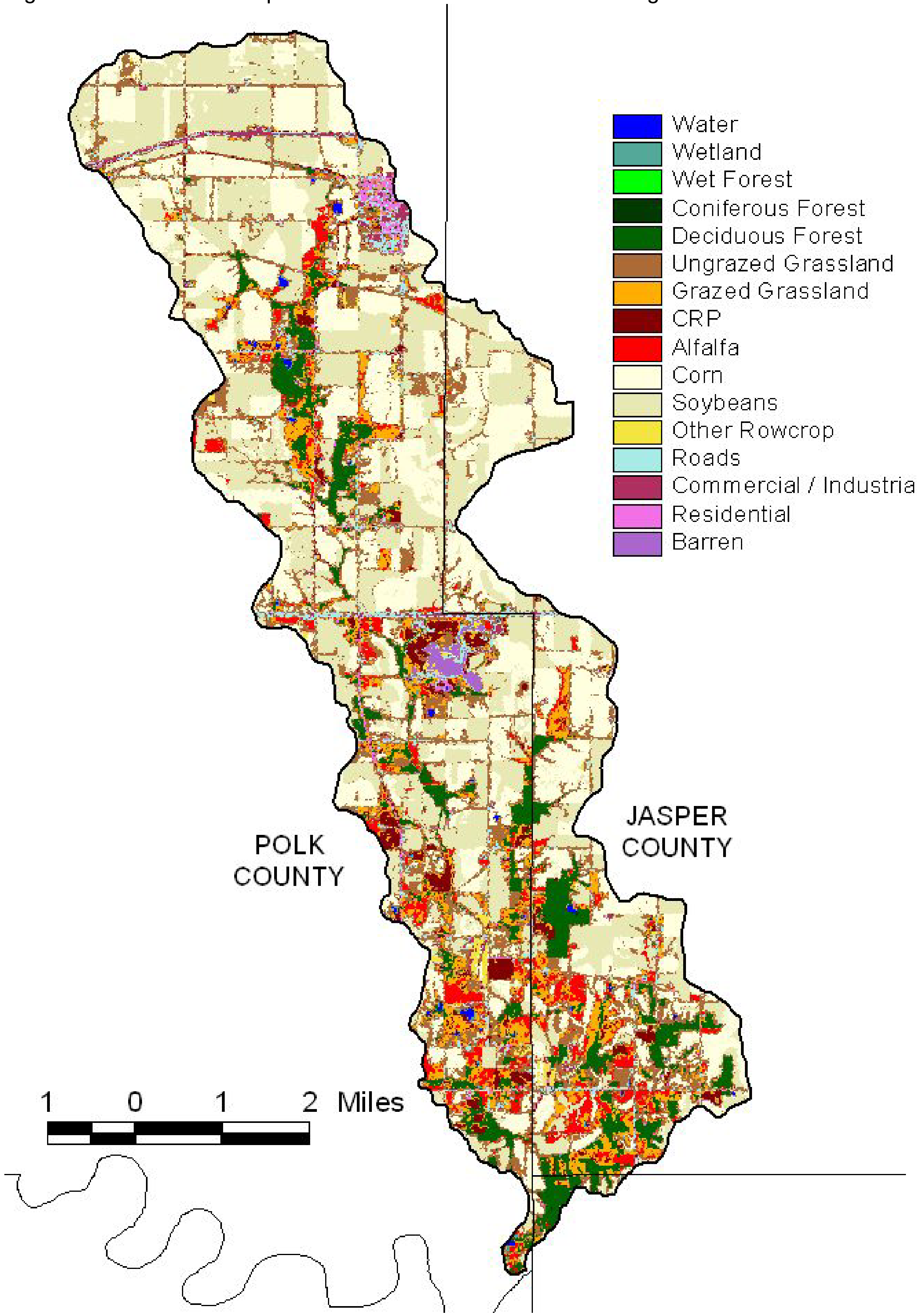
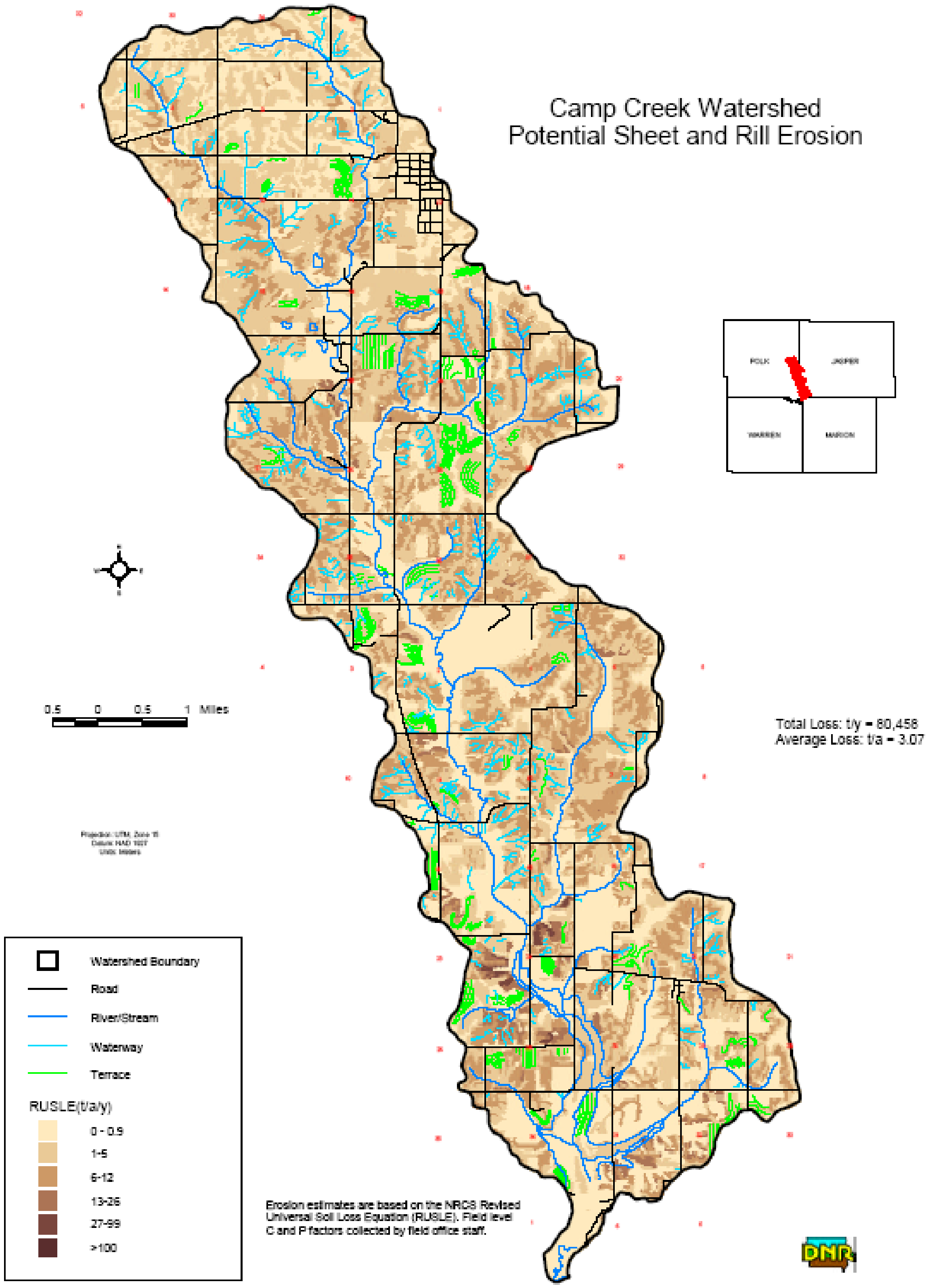


Figure A-3. 2002 RUSLE map for the Camp Creek watershed.



9. Appendix B – Ecoregion Reference Data

Table B-1. Data from biological assessments on reference sites in ecoregions 47b and 47f, 1994-2002.

Eco-Region	Stream Name	Landmark	NO3 + NO2 Nitrogen as N (mg/L)	Total Phosphorus as P (mg/L)	Riffle%	Pool%	Run%	Sum Total Coarse	Sum Total Fines	Clay%	Silt%	Sand%
47b	BIG MUDDY CR	Spencer	1.20	0.20	0	14	86	12	80	0	6	74
47b	BIG MUDDY CR	Spencer	0.70	<0.02	7	39	54	20	77	2	20	55
47b	BLACK CAT CR	Algona	9.90	0.20	4	16	80	18	72	2	1	69
47b	BOONE RVR	Bells Mill Park- Stratford	0.60	<0.1	14	62	23	36	64	0	10	54
47b	BUTTRICK CR	Waters County WA-Grand Junction	0.20	0.20	1	0	88	28	68	0	2	66
47b	BUTTRICK CR	Waters County WA-Grand Junction	8.10	0.20	2	14	84	29	66	0	5	61
47b	EAST BR IOWA R	Belmond	0.80	0.10		79	21	13	68	1	19	48
47b	LITTLE BEAVER CR	Woodward	8.80	0.30	24	16	60	43	51	1	8	42
47b	LITTLE BEAVER CR	Woodward	10.00	<0.1	23	23	54	39	57	1	14	42
47b	LITTLE SIOUX R	Lake Park- Diamond Lake	0.40	0.60	0	50	50	14	86	0	80	6
47b	LITTLE SIOUX R	Horseshoe Bend Co Park- Milford	0.10	0.20	12	58	30	34	66	0	30	36
47b	LIZARD CR	Clare	7.70	0.10	18	5	77	58	40	0	8	32
47b	LIZARD CR	Clare			16	54	30	48	52	0	3	49
47b	MAYNES CR	Mallory Co. Park- Hampton	10.00	0.10	31	7	62	71	23	0	3	20
47b	MAYNES CR	Mallory Co. Park- Hampton	4.60	<0.02	11	64	25	67	29	0	3	26
47b	MOSQUITO CR	Panora	6.80	<0.10	8	13	79	34	64	0	10	54
47b	MOSQUITO CR	Panora	<0.1	0.16	0	100	0	30	67	0	22	45
47b	NORTH RACCOON R	Raccoon River Greenbelt- Sac City	13.00	0.70	2	30	68	36	56	0	10	46
47b	PLUM CR	Algona	4.20	0.10	0	100	0	20	78	4	49	25
47b	PRAIRIE CR	Dolliver State Park- Lehigh	5.60	<0.10	18	23	59	68	24	0	0	24
47b	PRAIRIE CR	Dolliver State Park- Lehigh	9.80	<0.05	32	18	50	70	21	0	3	18
47b	SOUTH FK IOWA R	Logsdon Co Park- Iowa Falls	6.40	0.40	18	14	68	50	40	6	0	34
47b	SOUTH FK IOWA R	Logsdon Co Park- Iowa Falls			23	46	30	60	34	0	10	24
47b	SOUTH SKUNK R	Ames	0.30	0.20	7	78	14	36	64	0	17	47
47b	SOUTH SKUNK R	Ames	0.30	0.20	0	89	11	37	61	0	6	55
47b	WEST BUTTRICK CR	Spring Lake Park	0.10	0.10	18	20	62	68	22	0	6	16
47b	WEST BUTTRICK CR	Spring Lake Park	11.00	0.20	21	54	25	64	33	0	4	29

Eco-Region	Stream Name	Landmark	NO3 + NO2 Nitrogen as N (mg/L)	Total Phosphorus as P (mg/L)	Riffle%	Pool%	Run%	Sum Total Coarse	Sum Total Fines	Clay%	Silt%	Sand%
47b	WHITE FOX CR	Webster City	11.00	<0.10	0	17	83	48	52	0	12	40
47b	WHITE FOX CR	Webster City	8.40	0.20	23	20	57	40	52	0	4	48
47b	WHITE FOX CR	Webster City	13.00	2.30	0	0	100	60	38	2	0	36
47b	WHITE FOX CR	Webster City	1.60	<0.10	10	36	54	52	42	0	18	24
47b	WHITE FOX CR	Webster City	9.80	<0.10	4	25	71	34	66	0	10	56
47b	WHITE FOX CR	Webster City	12.00	<0.10	9	5	86	46	54	0	14	40
47b	WHITE FOX CR	Webster City	1.20	0.10	14	32	54	36	64	0	34	30
47b	WHITE FOX CR	Webster City	8.90	<0.10	0	30	70	42	46	0	8	38
47b	WHITE FOX CR	Webster City	12.00	<0.10	9	11	80	44	56	2	8	46
47b	WHITE FOX CR	Webster City	1.70		13	57	30	70	30	0	5	25
47b	WHITE FOX CR	Webster City	6.90	<0.10	18	41	41	52	46	4	11	31
47b	WHITE FOX CR	Webster City	17.00	0.20	6	11	83	51	47	6	8	33
47b	WHITE FOX CR	Webster City	0.40	0.10	4	48	48	47	49	0	2	47
47b	WILLOW CR	Willow Creek WA-Hanlontown	5.40	0.10	16	32	52	50	39	0	9	30
47b	WILLOW CR	Willow Creek WA-Hanlontown	8.80	<0.02	7	41	52	46	44	1	10	33
47b	WINNEBAGO R	Lande Access-Lake Mills	0.60	0.20	0	2	98	2	70	0	0	70
47b	WINNEBAGO R	Lande Access-Lake Mills	0.40	0.20		59	41	0	96	0	43	53
47f	BARBER CR	Barber Creek SWMA- Grand Mound	7.40	0.10	0	68	32	0	73	12	16	45
47f	BEAR CR	Eden Valley Co Park- Baldwin	2.60	0.40	7	16	77	36	64	4	23	37
47f	BUCK CR	Barnes City	0.50	<0.10	0	11	89	6	94	6	2	86
47f	BUCK CR	Barnes City	1.50	0.10	4	14	82	0	98	2	31	65
47f	BUFFINGTON CR	Columbus City	0.60	0.10	7	64	29	40	48	2	8	38
47f	BUFFINGTON CR	Columbus City	<0.10	0.13	14	86	0	65	35	0	28	7
47f	DEER CR	Stuart	4.60	0.10	9	34	57	48	52	10	5	37
47f	EAST NODAWAY R	Hawleyville	<0.10	0.20	14	66	20	38	60	4	38	18
47f	HONEY CR	Bedford	<0.10	0.20	4	89	7	15	75	8	41	26
47f	HOWERDON CR	Winterset	9.40	0.20	34	38	28	72	26	0	8	18
47f	HOWERDON CR	Winterset	10.00	0.20	20	41	39	72	28	0	16	12
47f	LONG CR	Columbus Junction	1.20	0.20	16	70	14	58	42	2	14	26
47f	LONG CR	Columbus Junction	0.40	0.13	14	38	48	74	26	2	18	6

Eco-Region	Stream Name	Landmark	NO3 + NO2 Nitrogen as N (mg/L)	Total Phosphorus as P (mg/L)	Riffle%	Pool%	Run%	Sum Total Coarse	Sum Total Fines	Clay%	Silt%	Sand%
47f	LOST CR	Princeton	5.30	0.10	0	16	84	0	98	4	25	69
47f	LYTLE CR	Zwingle	7.80	0.10	11	44	45	84	16	0	16	0
47f	LYTLE CR	Zwingle			9	46	45	86	14	0	10	4
47f	MIDDLE RVR	Pammel State Park- Winterset	2.20	0.10	14	54	32	66	34	4	9	21
47f	MUD CR	Baxter	6.40	<0.10	11	37	52	25	75	10	10	55
47f	NORTH BR NORTH R	Goeldner Woods	3.00	0.10	4	21	75	54	42	18	0	24
47f	NORTH BR NORTH R	Goeldner Woods	1.60	0.20	3	43	54	40	60	15	31	14
47f	NORTH BR NORTH R	Goeldner Woods	9.80	0.20	11	16	73	58	40	4	6	30
47f	NORTH BR NORTH R	Goeldner Woods	3.80	0.20	4	66	30	62	36	12	10	14
47f	NORTH BR NORTH R	Goeldner Woods	3.90	0.40	18	48	34	62	36	4	25	7
47f	NORTH BR NORTH R	Goeldner Woods	11.00	0.10	5	20	75	56	40	0	6	34
47f	NORTH BR NORTH R	Goeldner Woods	6.00	0.10	7	41	52	54	42	4	2	36
47f	NORTH BR NORTH R	Goeldner Woods	10.00	<0.10	9	20	71	34	64	8	26	30
47f	NORTH BR NORTH R	Goeldner Woods	3.60	0.10	14	39	47	32	61	6	10	45
47f	NORTH BR NORTH R	Goeldner Woods	3.90	0.20	13	55	32	39	61	1	39	21
47f	NORTH BR NORTH R	Goeldner Woods	7.90	<0.10	9	23	68	38	60	6	23	31
47f	NORTH BR NORTH R	Goeldner Woods	2.60	0.10	5	52	43	27	69	6	35	28
47f	NORTH SKUNK R	Rose Hill	0.50	0.10	0	27	73	0	98	4	16	78
47f	NORTH SKUNK R	Rose Hill	2.30	0.27	0	29	71	0	96	0	51	45
47f	RICHLAND CR	Haven	2.30	0.20	0	2	98	0	98	0	15	83
47f	RICHLAND CR	Haven				14	86	1	97	0	43	54
47f	ROCK CR	Tipton	8.20	0.10	18	32	50	68	28	0	10	18
47f	ROCK CR	Tipton	5.00	0.30	11	62	27	63	37	0	17	20
47f	SILVER CR	DeWitt	6.60	0.10	3	45	52	8	84	0	18	66
47f	SOUTH RACCOON R	Nations Bridge Co Park- Stuart	2.20	<0.10	18	48	34	40	60	0	51	9