Assessing Water Quality Impacts from Animal Feeding Operations (AFOs) and NRCS Best Management Practice (BMP) Implementation

2006 Annual Report

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Executive Summary

Vegetated filter strips are widely accepted as an effective means to intercept runoff from animal feeding operations (AFOs) and reduce flux of contaminants to surface water. This collaborative project between Montana NRCS and MSU Extension Water Quality (MSUEWQ) was initiated in 2005 to monitor effects on water quality from implementation of best management practices (BMPs), including vegetated filter strips, associated with animal feeding operations. Three of four AFOs included in this study are involved in EQIP projects with the Montana NRCS to implement BMPs. The fourth AFO (D-Park), was included to provide background data. Data was collected between March and November of 2005 and again in 2006 with emphasis on sampling in the spring and early summer. A final data collection period is scheduled for 2007; the 2007 data will provide the first post-BMP implementation data for the H-Beaverhead site, the first post-BMP data since vegetation establishment at the G-Madison site, and a third year of post-BMP data at the K-Park site. Site specific characteristics, livestock management practices, infrastructure, and flow characteristics make each AFO a unique case study (see appendix B for descriptions of each site and images).

During the first two seasons of the study, routine and simulated event related sampling was conducted for *E. coli*, total suspended solids (TSS), and nutrients in surface water upstream and downstream from each AFO. Flow was monitored, soil nutrient sampling was completed at incremental soil depths in 2005, and shallow ground water was assessed for nitrates at the G-Madison site.

AFOs with surface water running directly through the pens were found to contribute *E. coli* to surface water when animals were present, even in the absence of overland flow events. These AFOs also showed potential to contribute to suspended solids and nutrient loads where sufficient flow velocities and erodable bank materials are present. During precipitation events, when overland flow occurred on these streamside AFOs, it was conveyed directly to surface water. After the AFO pens were isolated from the stream at the G-Madison site, the frequency of *E. coli* concentration increase between water entering and exiting the AFO pen reach decreased. A similar trend occurred at the D-Park site after a large portion of the AFO pen reach was isolated from the stream in the winter of 2005/06. While pre-BMP data is not available at the K-Park site, it is evident from pre-BMP data at the other sites that significant *E. coli* loading from the AFO pens was likely occurring. The absence of *E. coli* increases adjacent

to the AFO pens at the K-Park site in 2006 hence indicates a notable improvement in water quality as a result of the BMP implementation.

The filter strip at the K-Park site was becoming established in 2005 and was well established with vegetation in 2006. Circumstances of overland flow at this site from the AFO pens into the channel were not observed in 2005 or 2006, despite a separation distance of less than 10 meters in some locations.

At the G-Madison and H-Beaverhead sites, sampling in 2007 will provide data to assess the effectiveness of the filter strips installed in mitigating water quality impacts from the AFO pens.

Sampling Conducted

Soils

Soil samples were collected in 2005 from incremental depths at each AFO site in proposed vegetative filter strip (VFS) areas, permanent AFO areas, and adjacent pastures for reference.

Shallow Groundwater

Shallow groundwater sampling was completed in 2005 and 2006 at the G-Madison site for nitrate in 2 reference wells up gradient from the AFO pens, 2 wells in the AFO, and 2 wells in an area previously in the AFO and now within the buffer strip.

Routine Water Quality

Routine water quality (WQ) sampling sites were identified at each AFO to capture WQ entering and exiting AFO reaches as well as downstream. These samples were collected regularly during the spring runoff season and periodically until fall. Samples were collected for bacteria on every site visit unless there was negligible flow. TSS was sampled on most site visits and nutrients were sampled periodically. These sampling events represent “snapshots” of conditions at the time of the visit.

Walking Events

Walking events were carried out periodically to disturb the bottom of the stream and characterize the amount of bacteria stored in the channel adjacent to the AFO reaches. These events consisted of a person walking a measured distance down the thalweg of the channel in a designated section of the study reach. This event was conducted to characterize bacteria in storage in bottom sediment and along the fringe of the wetted channel. In addition to characterizing bacteria storage in channel, this event simulates stream disturbance by livestock in a repeatable manner.

Overland Flow (OLF) Events

Overland flow (OLF) events were simulated at 3 of the AFOs to characterize the bacteria, suspended solids, and nutrient loading from overland flow in a reproducible manner. Precipitation events resulting in runoff were simulated to produce overland flow from plots in AFO pens adjacent to the streams and in proximately located vegetated plots for reference. A bucket was positioned in the bottom of the creek upstream from the overland flow plot with the rim 1 to 2 inches below the stream surface; this allowed water to be pumped from the bucket without disturbing or taking in bottom sediment. The bucket was installed long enough in advance to allow the disturbed sediment to thoroughly flush past the study reach. Water was pumped from the channel and manually sprinkled uniformly over flagged plots for sufficient time to produce overland flow into the stream for at least an hour. Upstream water quality was sampled prior to initiating the event and after the event was complete. This provided the baseline water quality entering the overland flow plot reach so downstream water quality could be adjusted accordingly to determine water quality changes attributable to overland flow. Downstream samples were collected before initiating precipitation and at regular intervals after overland flow reached the stream. It is assumed that samples were collected far enough down stream that overland flow had fully mixed with stream flow. Water quality samples were also collected directly from overland flow on the AFO surfaces. The resulting data was graphed with time on the x axis to produce a curve depicting changes in water quality through time associated with a precipitation event.

WQ Parameters Under Consideration

Bacteria contamination was assessed through the enumeration of *E. coli* using Coliscan Easygel, a product of Micrology Laboratories. In 2005, triplicate samples were collected in autoclaved plastic bottles, transported to the lab on ice and cultured within 24 hours. In 2006 the method was streamlined by pipetting the triplicate samples directly from the stream into the Coliscan nutrient bottles for transportation to the lab on ice. Three ml aliquot samples were plated on petri dishes with selective nutrient media and incubated for 36 hours (+/- 6 hours) at 32 degrees Celsius (+/- 4 degrees). Plates were then digitally photographed to produce JPEG images for enumeration of *E. coli* colony forming units (CFUs). Plates were assessed for the number of colonies with blue halos representing *E. coli* colonies, which produce enzymes galactosidase and glucuronidase during growth on the Coliscan Easygel.

Total suspended solid (TSS) samples were collected in glass jars and vacuum filtered using Buchner Funnels. Glass fiber filters (1.5 µm pore size) were dried at 103 degrees Celsius and weighed to determine retention of TSS.

Nutrient analyses were completed for total kjeldahl nitrogen (TKN), ammonia nitrogen (NH4), nitrate nitrogen (NO3), total phosphorus (TP), and ortho phosphorus (OP). Nutrient samples were collected in plastic sample bottles provided by Energy Laboratories. These samples were preserved in the field with sulfuric acid (H_2SO_4) and refrigerated until shipping to Energy Laboratories for analysis within 28 days.

Data Summary by Site

D-Park Site:

Routine Bacteria Sampling (D-Park):

In 2005, 4 of 5 sampling events when animals were present (March – August) revealed notable increases in *E. coli* exiting vs. entering the AFO reach. During the March sampling event, the high concentration of *E. coli* detected at D1 was likely because the D1 sample was not collected above the fence line as it was for subsequent events. On May 19th, the high concentration of *E. coli* entering the reach can be explained by the temporary presence of 30 heifers on the neighboring pasture upstream. During a September sampling event when no animals were present, there was no change in *E. coli* concentration entering vs. exiting the AFO reach.

Additional sampling locations added in 2006 made it possible to better isolate increases in *E. coli* entering the stream specifically from the AFO pens. During only 2 sampling events (May 2nd and June 14th) was there an increase in *E. coli* concentration through the AFO reach. The low frequency of *E. coli* load increase through the AFO pen reach is probably partially explained by cattle panels installed in the winter of 2005/06 isolating cattle from the stream through most of the AFO pen area. Spikes in *E. coli* concentrations did however occur, both up and downstream from the AFO pens when large numbers of animals had access to the stream. The June sampling event was influenced by a high intensity, short duration precipitation event. During this event, *E. coli* concentrations were elevated entering the reach and showed a subtle increase through the AFO reach. This was likely due to splash erosion of *E. coli* associated with manure directly adjacent to the banks because the event did not produce overland flow.

Walk Event Bacteria Sampling (D-Park):

In 2005, walk event samples were collected at D4 below the point where the channel is diverted for the summer. At this location in March of 2005, a walk event produced a large spike in *E. coli* concentration indicating notable storage of bacteria in the reach. The spike was likely due to the high potential for deposition and storage of bacteria in the degraded water gap just upstream from D4.

In 2006, the walk event sample site was moved upstream to D3 to allow for events to be conducted during summer months when flow does not reach D4. At this location, the lack of spikes in *E. coli* concentration denote a lack of bacteria storage in the reach adjacent to the AFO. This is not surprising due to the lack of slower current through this reach and the fact that cattle were excluded from this reach during the 2006 season. During the May 29th 2006 event, a very strong wind burst notably increased suspended solids in the stream just before the 30 minute walk event sample was collected. The slope of the May 29th walk event graph depicts the wind-related increase in *E. coli* concentration of over 7 times base line.

Routine TSS Sampling (D-Park):

In 2005, TSS were elevated on the order of 100 mg/L exiting vs. entering the reach when sampled with animals present in May, but the concentration had decreased to around 30 mg/L below the riparian exclosure section. The results of this sample event were consistent with visual observations of TSS on other visits when animals were present. Sampling in September when no animals were present showed a subtle TSS increase exiting vs. entering the AFO pen reach.

In 2006, there was a notable increase in TSS in April between sites 3 and 4. This portion of the stream is degraded from cattle access. On the same April sample date the stream at D5 had deposited heavy sediment loads along its banks further indicating the extent of the sediment loading. On May 19th 2006, TSS was notably elevated leaving the property below the reach were the alternate channel crosses through the pasture. This is probably associated with the process of the recently diverted stream reaching equilibrium with the alternate channel through the pasture. TSS was not elevated exiting vs. entering the AFO pen reach for any of the 2006 routine sample events.

Routine Nutrient Sampling (D-Park):

In 2005 and 2006, little or no increase in nutrient concentrations were detected through the AFO pen reach during routine sampling. However, in April 2006 an increase in total

phosphorus was detected between sample sites D3 and D4 associated with the degraded water access point.

Overland Flow Event (D-Park):

One overland flow event was simulated at the D-Park site on an AFO pen adjacent to the alternate channel in June of 2006 (OLF-D1). *E. coli* results from the overland flow event were difficult to interpret due to changes in background concentrations associated with a natural rain event. For this reason, the bacteria data is omitted from discussion. Within 16 minutes of the time overland flow reached the stream, TSS maxed out at 22 mg/L (up from 11 mg/L at baseline), and then dropped off as overland flow diminished after precipitation ceased. Total Kjeldahl nitrogen increased with initiation of overland flow from below the detection limit at 0.5 to 1 mg/L. Total phosphorus, ortho-phosphorus, ammonia and nitrate all showed similar increases in concentration.

Soil Nutrients (D-Park):

Nitrate nitrogen was highest in the non-riparian AFO profiles followed by the riparian AFO profiles and was lowest in the pasture profiles. Ammonia was higher in the pasture profiles than the AFO profiles to a depth of 20 inches. Phosphate was higher in the pasture surface soil than in the AFO surface soil.

G-Madison Site:

Routine Bacteria Sampling (G-Madison):

In 2005, *E. coli* concentration increased exiting vs. entering the AFO reach during all 6 sampling events when animals were present (March – July). Sometimes increases were by orders of magnitude.

In 2006, *E. coli* concentrations showed little or no increase through the AFO reach where the fence was moved back after the 2005 season (between sites 2 and 3). However, notable increases in concentration were detected associated with the upstream water access point (just downstream from G1) and with the downstream pasture (G3 to G5). In June and July when livestock presence along the stream was diminished, *E. coli* concentrations through the reach did not change notably.

Walk Event Bacteria Sampling (G-Madison):

In 2005, walk events in March caused a notable spike in bacteria. A notable but less pronounced spike was observed in a June event. In late July a walking event showed a modest bacteria spike but disturbance from a channel flushing event obscured the spike.

In 2006, one large spike in bacteria concentration was observed in April at a relatively low flow. In May and June no spikes were observed. This may be explained by a decreased loading of manure to the stream as a result of the new AFO fencing and also by the higher stream flows during May and June of 2006.

Routine TSS Sampling (G-Madison):

During a sampling event in July 2005 there was an increase in TSS between sites 4 and 5 and in April 2006 TSS showed elevated values adjacent to the AFO but concentrations had diminished again before exciting the property. In general, the TSS concentration through the reach during routine sampling was at or below 10 mg/L.

Routine Nutrient Sampling (G-Madison):

2005 sampling for ammonia did not produce any results above detection limits so ammonia sampling was not continued in 2006. In both the 2005 and 2006 seasons, nitrate concentration through the reach was only detected above the 0.05 detection limit on one occasion in May of 2006. On this occasion, nitrate concentrations decreased through the reach.

TKN concentration data from 2005 does not lend itself to easy interpretation. However, 3 of 4 routine nutrient sampling events in 2006 revealed increases in TKN adjacent to the AFO reach. The one exception where a high concentration of TKN was found at G1 in July 2006 was during very low flow resulting in stagnant water and elevated aquatic vegetation.

Both ortho and total phosphorus showed some increases through the reach on a few occasions in 2005. Both phosphorus parameters also showed increases on 3 of 4 routine sampling occasions in 2006. The one exception where a high concentration of phosphorus was found at G1 in July 2006, was again due to very low flow resulting in stagnant water and elevated aquatic vegetation at the top of the reach.

Overland Flow Events (G-Madison):

An overland flow event was simulated on a plot in the south feedlot (OLF-G1) as well as on an adjacent ungrazed, vegetated plot (OLF-GR1) in July of 2005. A second event was simulated on the feedlot plot in September of 2005 (OLF – G2). The event on the ungrazed reference plot did not produce notable increases in any of the parameters.

On the feedlot plot, bacteria increased dramatically with OLF during both simulated events although the second event produced less *E. coli* and *E. coli* was not detected in a pool on the AFO surface in the OLF area. Detection of elevated bacteria concentrations in stream but not in water pooled on the surface was surprising. It is possibly partially explained by the natural

flushing that occurs in this location as ground water seeps up and runs over the surface into the stream. The lack of *E. coli* detected in the pool could also partially be explained by desiccation of *E. coli* on the surface of the feedlot away from the waters edge while *E. coli* closer to the water may remain moist and viable and provide a large source of contamination to the stream when overland flow occurs.

TSS increased notably in association with runoff during OLF-G1 but showed no increase during OLF-G2. The increase during OLF-G1 was facilitated by the existence of rivulets over the AFO surface which concentrated water and sediment flow into channels. In OLF-G2 the lack of increase in TSS is likely due to the lack of existing rivulets and also to the presence of vegetation which slowed and dispersed flow while retaining sediment.

During OLF-G1, NH4 and NO3 were tested and did not reach detectable levels in the stream at any point during the event, but were detectable at 3.3 and 0.21 mg/L respectively in flow on the surface of the AFO. TKN, OP, and TP did increase with initiation of OLF and concentrations continued to rise for about an hour before declining. After OLF ceased, nutrient levels dropped back to nearly pre-event levels within 40 minutes.

During OLF-G2, TKN and OP increased notably from non-detectable to 1.7 and 0.19 mg/L respectively.

Soil Nutrients (G-Madison):

Nitrate nitrogen in the non-riparian AFO profile was elevated only in the top 3 inches. Nitrate levels in the top 20 inches of the riparian AFO profiles were lower than in all other profiles. Ammonia was much lower in the AFO soils than in the adjacent pasture soils. Phosphate was notably elevated in the AFO soils over reference pasture levels.

H-Beaverhead Site:

Routine Bacteria Sampling (H-Beaverhead):

Prior to the beginning of lambing, the *E. coli* concentrations were zero in 2005 and relatively very low in 2006 through the reach. In both 2005 and 2006, during the most intense part of the lambing season between May and early July, the concentration of *E. coli* was significantly elevated through the AFO reach.

Walk Event Bacteria Sampling (H-Beaverhead):

In both 2005 and 2006, early season walk events did not produce a spike in *E. coli*, indicating a lack of bacteria stored in stream sediment. In both 2005 and 2006, walk events after animals

were present yielded notable spikes in *E. coli* concentrations, indicating bacteria storage in sediment and along the wetted edge of the channel.

Routine TSS Sampling (H-Beaverhead):

In 2005, TSS concentrations exiting vs. entering the reach did not increase on either of the 2 sampling events. In 2006, TSS increased notably from H3 to H5 for 3 of 6 sampling events. Prior to fall 2006, this section of the stream passes through a degraded water access point associated with the pasture to the south of the AFO pens. In all but one case, the TSS dropped off again after passing through the wetland area that separates H5 from H6.

Routine Nutrient Sampling (H-Beaverhead):

In 2005, NH4 was non-detectable on either sampling occasion and sampling was not continued in 2006. In both 2005 and 2006, nitrate concentration exiting vs. entering the reach decreased on all sampling occasions. In 2005, TKN concentration increased subtly exiting vs. entering the reach for both sampling events. In 2006, TKN concentration decreased exiting vs. entering the reach early in the season. In May during lambing, TKN increased notably through the reach. Early in July, TKN showed only a subtle increase exiting vs. entering the reach, and the October sampling event showed a decrease through the reach. In 2005, ortho phosphorus did not change on either sample occasion exiting vs. entering the reach. In 2006, ortho phosphorus increased on 3 of 4 sample occasions. In 2005 and 2006, total phosphorus increased on 4 of 6 sample occasions. In May of 2006, sampling was conducted associated with a wetting front moving down the channel resulting from the filling and overtopping of the irrigation check dam. This event occurs almost daily during much of the irrigation season and this sampling provided some insight into the water quality associated with these events. Particulate nitrogen, ortho phosphate, and total phosphorus values were elevated in the initial wave of water below the AFO by 4.5 to 6.5 times background levels. These values leveled off within an hour as flow increased. Nitrate did not show a similar increase at the wetting front and in fact was lower in the initial front of water moving through the AFO.

Overland Flow Event (H-Beaverhead):

An overland flow event was simulated on a plot in a riparian AFO pen (OLF-H1) as well as on an adjacent vegetated plot (OLF-HR1) in July of 2005. Bacteria levels increased notably with commencement of overland flow. Concentrations increased steadily until OLF ceased at which point they quickly dropped back to pre-event levels. TSS concentrations did not increase associated with OLF. TKN, TP, NH4, NO3, and OP all exhibited notable increases in

concentration associated with OLF. Nutrient runoff levels peaked at about 40 minutes of OLF and returned essentially to pre-event concentrations within an hour.

Soil Nutrients (H-Beaverhead):

Nitrate nitrogen in the AFO soil was elevated through the profiles above reference pasture profiles. In the riparian AFO profiles, nitrate level increased notably below 20 inches. Ammonia was lowest in the non-riparian AFO pasture and highest in the reference pasture. Phosphate in the non-riparian AFO profile was elevated above reference pasture levels only in the top 3 inches. Phosphate in the riparian AFO profiles where elevated above reference pasture levels to a depth of 20 inches.

K-Park Site:

Routine Bacteria Sampling (K-Park):

In 2005 during 3 of 7 routine sampling events, *E. coli* showed notable increases in concentration through the AFO reach. The other 4 occasions showed relatively uniform concentrations exiting vs. entering the reach. *E. coli* concentrations did increase notably downstream associated with nonpoint source livestock grazing.

In 2006 during routine sampling events, *E. coli* concentrations only increased notably exiting vs. entering the AFO reach on 1 of 8 sampling occasions. On the other 7 occasions, *E. coli* concentrations either stayed level exiting vs. entering the AFO reach or decreased notably through the reach.

Walk Event Bacteria Sampling (K-Park):

In 2005, a walking event in March produced a pronounced *E. coli* spike, while two events later in the season showed no pronounced spikes, indicating a lack of *E. coli* stored in the channel. In 2006, walking events in April and May produced only very subtle spikes in *E. coli* relative to the 2005 spike and two walk events later in May failed to produce any *E. coli* spikes.

Routine TSS Sampling (K-Park):

In 2005 and 2006, TSS values show a consistent pattern of increase between K2 and K3. However, the magnitude of the increase was notably less in 2006 than in 2005 and the concentrations consistently decrease again between K3 and K4. The TSS increase through the reach may be due to adjustment of the channel through the AFO reach as vegetation stabilizes the banks and narrows the previously degraded channel.

Routine Nutrient Sampling (K-Park):

In 2005, NH4 was not detectable on either sampling occasion and sampling was not continued in 2006. In both 2005 and 2006, nitrate concentration decreased exiting vs. entering the AFO reach. In 2005, TKN concentration increased through the AFO reach on 1 of 2 sampling occasions and was not detectable above the 0.5 detection limit on the other occasion. In 2006, TKN was not detected above the 0.5 detection limit on any of the 3 sampling occasions. In 2005, TP and OP showed a very subtle increase through the AFO reach for one of the two sampling events. The second sample event in 2005 and all sample events in 2006 did not show any increase in OP or TP.

Soil Nutrients (K-Park):

Nitrate nitrogen was elevated by almost 2 orders of magnitude in the AFO soils over reference pasture levels. Ammonia was slightly lower in the AFO surface soils than the pasture reference surface soils. Phosphate was only slightly elevated in the AFO profiles over the pasture reference profiles.

General Assessments

Bacteria

In-stream bacteria concentration is the most dynamic of the parameters assessed in this study. The stream reaches associated with the AFOs are complex in terms of where and when animals have stream access, changing flow characteristics associated with irrigation, and natural events such as precipitation and wind. All of these elements must be considered when interpreting the water quality data.

The most basic observation about bacteria has been the correlation between elevated bacteria loading and animal stream access. At each of the four sites, notable bacteria loading can be correlated with areas where livestock have access to the stream both within and outside AFO pen settings. At both the D-Park and G-Madison sites, 2006 routine bacteria sampling indicates a reduction from 2005 in frequency of *E. coli* loading from reaches where new fencing has isolated AFO pens from the streams.

At the G-Madison site where the south-west feedlot previously intersected the stream, water seeps out of the ground and flows over the surface for a period of 2 or 3 months during high flow in the Big Hole River. This flow flushes what contaminants are present on the surface into the stream. Previous to installation of new fencing in 2005/06 the surface received manure loading each season from animals in the feedlot. Samples collected from the overland flow

produced by this seepage in 2006 indicated elevated *E. coli* and nutrient concentrations but these values are much lower than the nutrient and *E. coli* levels measured in the same location during overland flow events in 2005 before the fences were moved.

Wind-related loading of *E. coli* to the stream adjacent to the D-Park AFO pens was characterized in May when a strong burst of wind visibly increased suspended solids in the stream between sample events. The result was a change in *E. coli* concentration of more than 7 times from around 25 to 177 CFUs per 3 ml of sample.

Walk events to quantify the amount of *E. coli* in the channel have revealed a general trend of larger *E. coli* spikes in the spring. This is may be explained by the position of these spring events on the climbing limb of the seasonal hydrograph, before sufficient high flows have occurred to flush bacteria from the channel. The source of these bacteria is likely a combination of direct deposition and accumulation from overland flow associated with snowmelt and/or runoff over frozen ground. The exception to the spring bacteria storage is the H-Beaverhead site where spring walk events did not detect channel bacteria storage in 2005 or 2006. This is probably due to the fact that this operation receives intense use from May through July and then almost no use again until the following May.

TSS

At the D-Park site, increases in TSS specifically through the AFO pen area were not detected. However, a notable increase in TSS was detected in the spring of 2006 downstream from the degraded water gap just below the AFO pens (just above D4).

At the G-Madison site, slow steady velocities through the reach did not seem to provide sufficient energy to cause elevated TSS during routine sampling even in the presence of degraded banks along portions of the channel. There was a notable contrast in TSS response between the two overland flow events at the G-Madison site in 2005. The first event in early July produced a clear increase in TSS downstream from the event, while the September event produced no notable increase in TSS. This difference can probably be explained by the presence of rivulets for the July event that concentrated overland flow, increasing energy to transport sediment. It is also important to note that the presence of vegetation in September which was absent in the plot in July likely played a large role in stabilizing and minimizing sediment transport.

Routine sampling at the H-Beaverhead site in 2006 revealed relatively consistent increases in TSS through the AFO pen reach. In all but one case, levels had dropped off again after passing through a wetland just upstream from H6.

Routine sampling at the K-Park site in both 2005 and 2006 has indicated an increase in TSS exiting vs. entering the section of stream where riparian buffer strips were installed adjacent to the AFO pens. However, the magnitude of the increase in 2006 tended to be smaller, possibly indicating movement toward sediment transport equilibrium after the initial period of readjustment to a narrower vegetated channel. In both 2005 and 2006 TSS which was elevated leaving the AFO pen reach at K3 decreased again before flowing out of the downstream reconstructed reach at K6.

Nutrients

Ammonia was not detected during routine sampling at any sites in 2005 and was not included in routine sampling in 2006. Nitrate concentrations either stayed level or decreased through all of the stream reaches.

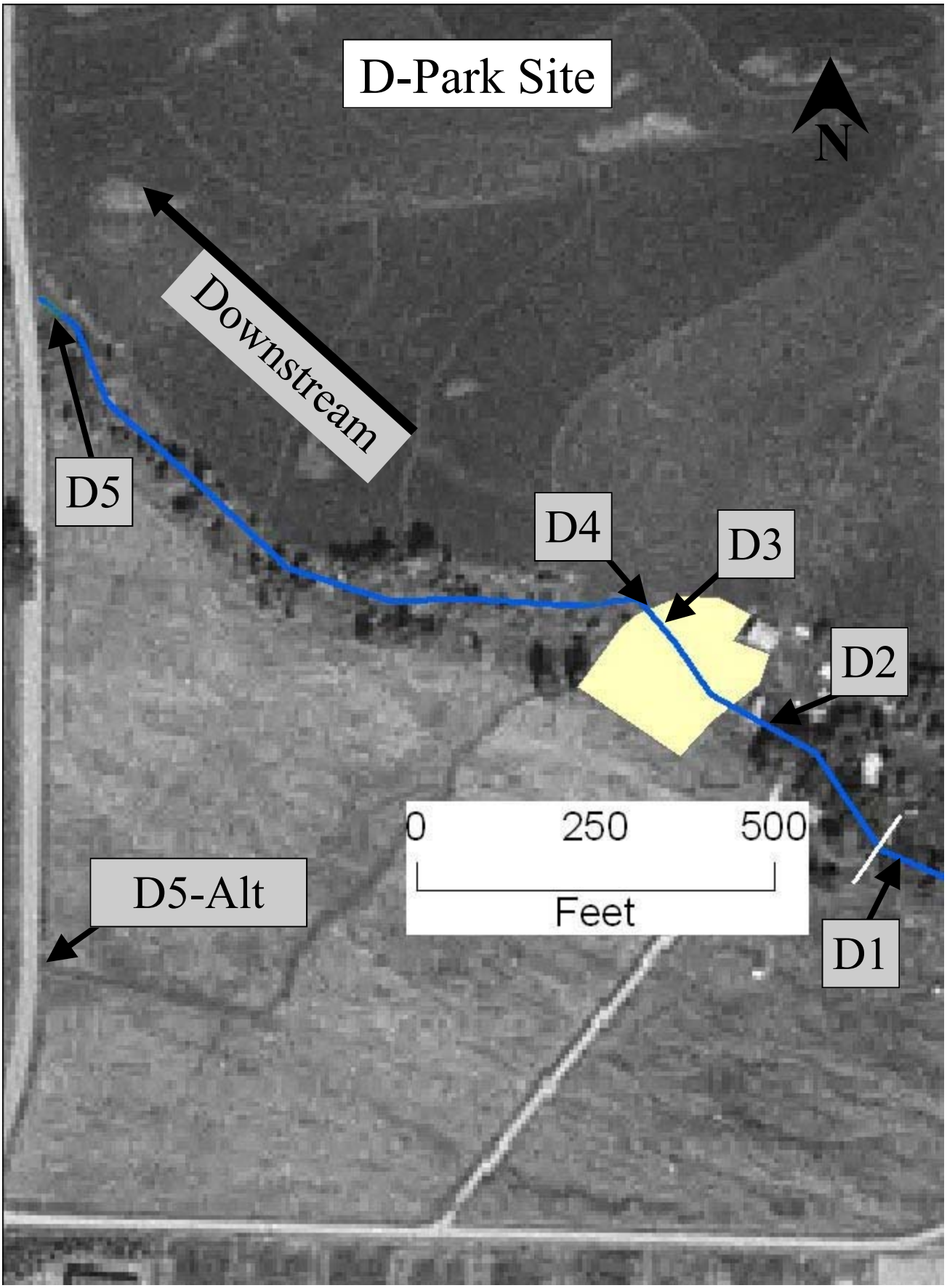
At the D-Park site, nutrient increases exiting vs. entering the AFO pen reach were not detected.

At the G-Madison site, particulate nitrogen and both particulate and ortho phosphorus showed increasing trends exiting vs. entering the AFO pen reach.

At the H-Beaverhead site, particulate nitrogen increased notably through the reach during lambing but not at other times. Particulate and soluble phosphorus increased during the majority of sampling events in both 2005 and 2006.

At the K-Park site the few subtle increases in nutrient concentrations exiting vs. entering the AFO pen reach in 2005 were not detected again during routine sampling in 2006.

Overland flow events on reference plots failed to produce elevated nutrient levels. Overland flow events on all AFO plots produced elevated levels of all nutrients tested directly from overland flow. However, at the G-Madison site, soluble nitrogen was not elevated sufficiently to be detectable after dilution in the stream. Particulate nitrogen and both particulate and soluble phosphorus were elevated in-stream for the period that overland flow reached the stream during both the July and the September events. At the H-Beaverhead site all 5 nutrients were elevated in-stream for the period that overland flow reached the stream. At the D-Park site all nutrients except ammonia were elevated in-stream for the period that overland flow reached the stream. Ammonia was elevated in overland flow but not sufficiently to be detected after dilution in the stream.


D-Park Site
N
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D4
D3
D2
D1
D5-Alt
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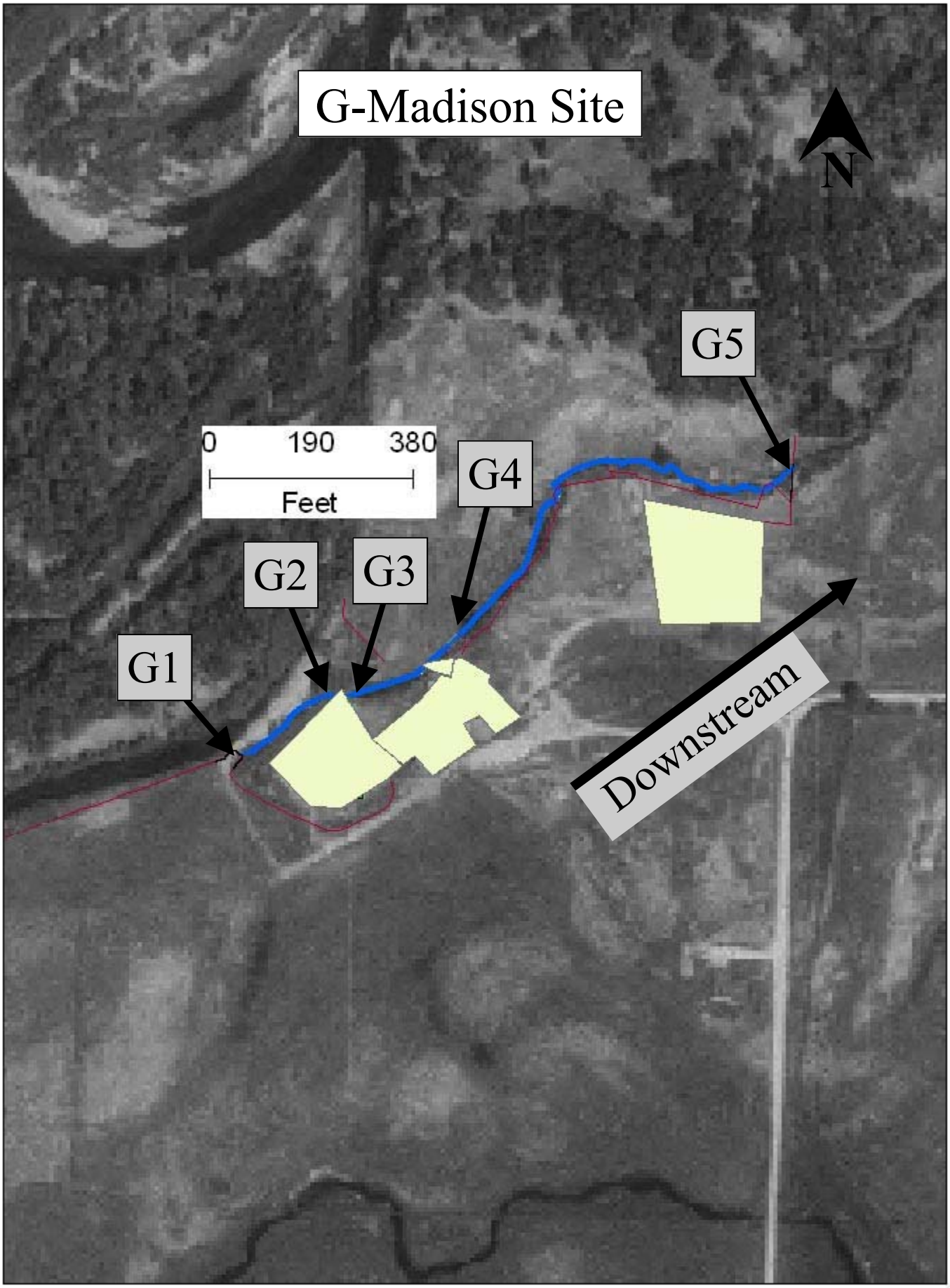
500
Feet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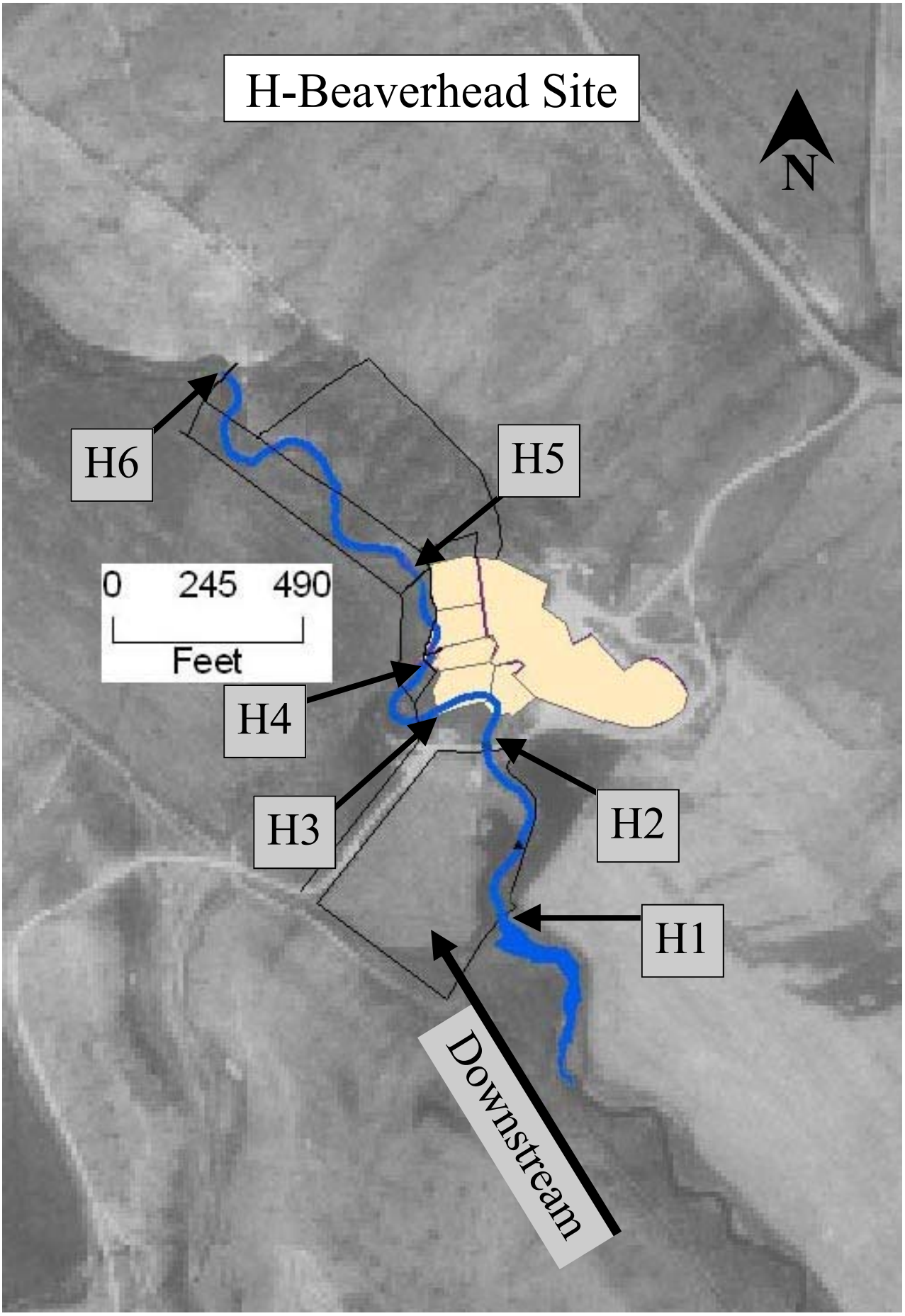
G3
G1
Downstream


H-Beaverhead Site
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H6
H5
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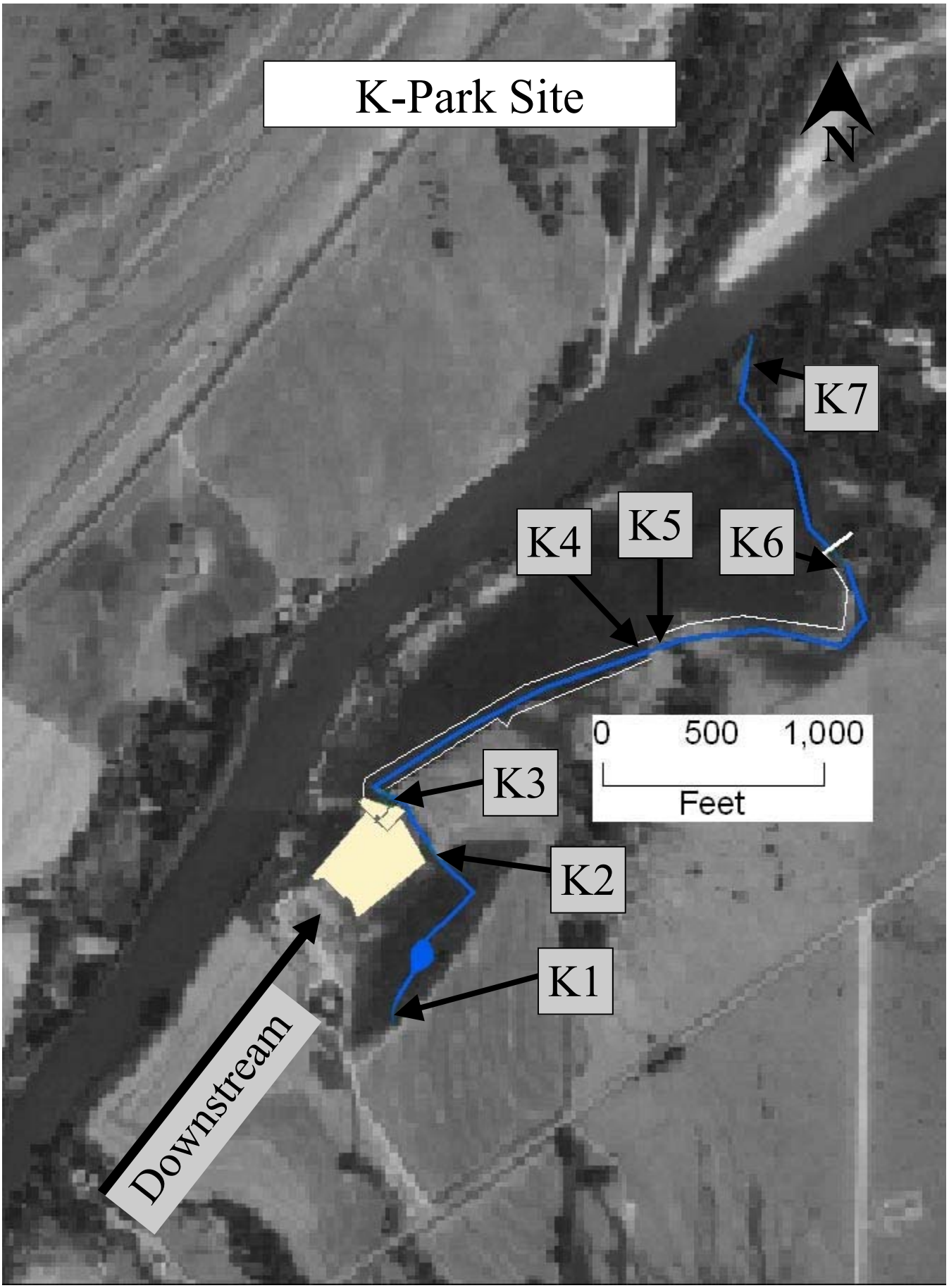
Feet
H4
H3
H2
H1
Downstream


K-Park Site
N
K7
K4
K5
K6
0
500
1,000
Feet
K3
K2
K1
Downstream

D-Park Site Overview

Flow: Measurements in 2005 and 2006 ranged from 0.11 cfs to 1.09 cfs
(See Appendix C for graphed flow measurements)
Cattle Operation ~ 100 head in 2005/2006
Depth to Groundwater ~ 45 m (150 ft)
The stream does not seem to lose or gain appreciable flow to ground water through the reach.

Summary:

D-Park is a cattle operation on a mountain stream flowing out of the Absaroka Mountains into the Yellowstone River. The stream flows through grazed pasture at the top of the operator's property for about 75 m (250 ft) before entering the AFO pens for another 60 m (200 ft) and then into a fenced riparian area for approximately another 0.8 km (0.5 miles) before leaving the property. The stream is completely diverted to a ditch in the vicinity of the AFO pens for most of the summer months to satisfy a senior downstream water right.

BMP Implementation:

The D-Park site is not involved in an EQIP contract. However, before the 2006 data collection season the producers put up cattle panels to separate a large section of the corrals from the stream.

Reach and Sample Site Descriptions:

D1 is located above the property line fence representing water quality entering the reach.

- Between D1 and D2 the stream travels through a pasture where cattle have full stream access.

D2 is located below the driveway crossing above the AFO pens.

- Between D2 and D3, the stream passes through the majority of the AFO pens.

D3 is located just above the point where the stream is diverted for the summer months.

- Between D3 and D4, the stream passes through a degraded cattle water access point.

D1 looking upstream (May 2, 2005)
The upstream fence line and neighboring property beyond.

Site D2 looking upstream (July 3, 2006)
The reach adjacent to the ranch house.

Site D2 looking downstream (July 3, 2006)
The upper part of the AFO pen reach which was not isolated from the stream when the cattle panels were installed.

D4 is inside the lower riparian exclosure just below the degraded cattle water access point.

- Between D4 and D5, the stream passes through a well established riparian corridor that was fenced long before the study started.

D5 is at the bottom of the excluded riparian corridor just above the highway and represents the water quality leaving the property.

Alternate Channel:
The entire stream flow is diverted for most of the summer just below D3 to satisfy a downstream water right.

- Between D3 and D5-Alt, the stream passes through a pasture associated with the AFO.

D5-Alt is on the diverted channel just above the highway and represents water quality leaving the property when the stream is diverted.

Site D3 looking downstream (May 29, 2006)
The stream is flowing in the alternate channel and the cattle panels isolating the AFO pen from the stream are installed.

Site D4 looking upstream (May 2, 2006)
The degraded water access point upstream from the riparian exclosure with the AFO pen reach out of site to the upper right.

D4 looking downstream (May 2, 2005)
The riparian exclosure downstream from the AFO pen area.

G- Madison Site Overview

Flow: Average daily discharge for 2005 and 2006 estimated from stage relationship:

~ Zero to just over 1 cfs

(see Appendix D for a hydrograph)

Cattle Operation ~ 290 head in 2004/2005

Depth to Groundwater ~ 0-2.5 m (~ 0-8 ft)

Water seeps over the surface into the channel in a few locations over the first 120 m (400 ft) of the reach during periods of high flow in the adjacent Big Hole River.

Summary:

G-Madison is a cattle operation on a diversion off a slough of the Big Hole River in Madison County.

Flow is diverted from a backwater of the Big Hole through a culvert in a dyke and flows in the side channel for less than 3.5 km (<2 miles) before rejoining the Big Hole. The stream runs for approximately 460 m (1500 ft) through the G-Madison property. Prior to BMP implementation, the stream passed through the edge of the southern most feedlot, parts of the corral system, pasture, and the 2 northern most feedlots. Ground water is less than 2.5 m (8 ft) deep but under the southern most feedlot and corral system it is separated from the surface by a ~20 cm (8 inch) clay layer about 30 cm (~1 ft) below the surface.

BMP Implementation:

Prior to initiation of the study, the northern feedlots were pulled back and fenced off the stream and off-stream water was installed throughout the corral system and feedlots. In the 2005/2006 winter season, new fencing was installed in the southern feedlot and corrals to create buffers between the pens and the stream. By late July of 2006, grass and other vegetation had begun to establish in the new buffer area between the southern feedlot and the stream.

G1 looking upstream (May 10, 2006)
The culvert entering the reach and the upstream most livestock water access point.

G1 looking downstream (May 10, 2006)
The upstream most water access point with an established buffer area downstream and the western most AFO pen in the distance.

Between G2 and G3 (May 10, 2006)
The location where the western most AFO pen previously intersected the stream, fencing is in place but vegetation has not established. A high water table associated with high flow in the Big Hole is causing water to seep to the surface and flow into the stream.

Reach and Sample Site Descriptions:

G1 is located at the outflow of the culvert where the stream is diverted from the Big Hole slough. This represents the water quality entering the reach.

- Between G1 and G2, the stream passes through a water access point for animals in the southern pasture and then through a riparian section with well established vegetation.

G2 is just upstream from the point where the southern feedlot previously intersected the creek.

- Between G2 and G3 the stream passes through what was previously the southern most feedlot.

G3 is just downstream from the section where the stream previously passed through the southern feedlot.

- Between G3 and G4, the stream passes through a small riparian pasture where cattle have not been observed, but that is often used for horses. It then passes through a section of pasture used for cattle in the spring. Previous to 2005/06 fence installation, this section was also intersected by the northwest corner of the corral system.

G4 is located just upstream of a culvert adjacent to the downstream end of the corrals in the pasture.

- Between G4 and G5, the stream passes through the remaining section of the pasture and through the sections where the northern feedlots previously intersected the stream.

G5 is located at the downstream (northern) property boundary and represents water quality leaving the property.

G4 looking upstream (July 12, 2006)
Portion of pasture with AFO pens on the left.

G4 looking downstream (June 12, 2006)
A pasture used during/after calving.

G5 looking upstream (May 10, 2006)
Looking up at that the reach where the Stream passes through a pasture and is accessed by 2 point to cattle from the north

H-Beaverhead Site Overview

Flow: Average daily discharge adjacent to the downstream end of the AFO for 2005 and 2006 seasons estimated from stage relationship:

~ Zero to ~ 4 cfs

(see Appendix E for a hydrograph)

Sheep Operation ~ 4,000 – 5,000 head handled during lambing

Depth to Groundwater ~ 7.5 m (25 ft)

The stream loses flow to ground water through the reach and all flow often infiltrates within one mile below the operation.

Summary:

H-Beaverhead is a sheep operation on a mountain stream flowing out of the Ruby Mountains into the Beaverhead River drainage. The stream flows through grazed and hayed pastures on the operator's property for several miles above the AFO pens and for about a mile below the AFO pens. Riparian pastures both up and downstream from the AFO pens are used extensively for grazing. Flow in the stream through the operation is extremely dynamic due to diversion for irrigation from a storage pond located upstream from the AFO pens. Daily fluctuations from zero to more than one cfs are not unusual. Stream flow which is not diverted for irrigation passes through the AFO pen reach, but typically completely infiltrates before the highway. Flow at the highway has only been observed once in the 2 years of the study.

BMP Implementation:

Buffer strip installation began in late summer of 2006. Between August and October, previous fencing was removed and the ground surface was contoured to facilitate sheet flow over the new butter strip. Between October and December new corral fencing was installed. The producer is constructing new feedlots on high ground to the north and east of the existing operation where runoff can be more easily diverted from the creek. The producer also has materials for installation of rain gutters on lambing sheds to divert the clean roof runoff water around the AFO pens. 2007 will represent the first year of post BMP implementation data.

H1 looking downstream (June 12, 2006)
The culvert where the stream flows out of the irrigation pond into the reach.

H2 looking downstream (June 12, 2006)
Section of stream above where it enteres the first set of AFO pens.

H3 looking downstream (June 12, 2006)
The degraded water access point for the pasture on the west side of the stream.

Reach and Sample Site Descriptions:

H1 is at the outflow of the irrigation diversion pond and represents water quality entering the reach.

- Between H1 and H2 the stream passes through a hayfield which was grazed extensively during lambing in 2005 but minimally in 2006.

H2 is at the outflow of a culvert upstream from the location where the stream previously intersected the first 2 of 4 AFO pens.

- Between H2 and H3, the stream passes through a reach were it was previously intersected by two AFO pens.

H3 is below the location where the first two AFO pens previously intersected the creek and above a degraded water access point.

- Between H3 and H4, the stream passes through a degraded water access point for animals in the pasture on the south side of the stream and through a section of riparian are with well established riparian vegetation.

H4 is upstream from the location where the stream was previously intersected by the second 2 of 4 AFO pens.

- Between H4 and H5, the stream passes through the section where it was previously intersected by the second 2 of 4 AFO pens and a riparian section with well established vegetation.

H5 is located adjacent to the downstream end of the AFO pens, below all locations previously intersected by AFO pens.

- Between H5 and H6, the stream passes through a riparian section with well established vegetation, 2 pastures, and a wetland.

H6 is located at the outflow of a culvert upstream from an abandoned irrigation diversion pond.

H4 looking upstream (June 16, 2006)
Well established riparian vegetation section.

H4 looking downstream (June 16, 2006)
The downstream set of AFO pens intersecting the stream.

H5 looking upstream (October 16, 2006)
Contouring after fence removal, prior to new fence installation and filter strip installation.

H6 looking upstream (June 16, 2006)
Wetland downstream from the AFO.

K-Park Site Overview

Flow: Average daily discharge adjacent to the AFO for 2005 and 2006 seasons estimated from stage relationship:

~ Zero to ~ 7 cfs

(see Appendix F for a hydrograph)

Cattle Operation ~ 290 head in 2005/06

Depth to Groundwater ~ 0- 6 m (0 - 20 ft)

The stream originates from a spring on the property and gains flow from ground water in a series of locations along the property before entering the Yellowstone River.

Summary:

K-Park is a cattle operation on a spring fed creek which confluences with the Yellowstone River at the base of the Absaroka Mountains. The stream springs from the base of a hillside located in an area fenced off to livestock. The stream flows through a pond, pastures, and adjacent to the AFO before entering a reach reconstructed as part of the Montana Future Fisheries Program to enhance cutthroat trout habitat. The stream flows for approximately a mile through the property. Flows are relatively stable but fluctuate significantly in response to irrigation of pastures up-gradient from the source spring. Stream flow is minimally affected by ground water inflow between K2 and K3 but significant additional seepage enters the stream between K3 and K4 and there are no diversions from the stream.

BMP Implementation:

BMP implementation at the K-Park site was completed in the spring of 2005 with the fine tuning of the off-stream watering system. Re-fencing of the feedlots was completed in the fall of 2004 and was completely in place before the initiation of sampling in the spring of 2005.

K2 looking upstream (April 15, 2006)
The horse pasture above a well established riparian exclosure.

K2 looking downstream (April 15, 2006)
A riparian exclosure which has been in place since before the project began.

K3 looking upstream (June 16, 2006)
Well established riparian vegetation in the filter strip adjacent to the AFO pens.

Reach and Sample Site Descriptions:

K1 is located at the base of the slope where the water seeps from the hillside inside an area fenced to livestock.

- Between K1 and K2 the stream flows out of the exclosure, through a pond, and through a horse pasture.

K2 is located at the upstream end of a well established riparian exclosure just below the horse pasture.

- Between K2 and K3 the stream flows through a well established riparian exclosure adjacent to a feedlot and through the section where the stream was previously intersected by AFO pens.

K3 is located adjacent to the bottom of the AFO above a section where the stream enters a small wetland area and turns 90 degrees to the north.

- Between K3 and K4, the stream flows through the first half of the Future Fisheries reconstructed reach.

K3 is just upstream from a livestock water access point in the middle of the reconstructed reach.

- Between K3 and K4 the stream flows through a cattle water access point.

K4 is located just below a cattle water access point.

- Between K4 and K5, the stream flows through the second half of the Future Fisheries reconstructed reach.

K5 is located just above the fence where the stream flows out of the reconstructed reach.

- Between K5 and K6, the stream flows through a pasture used by cattle in the spring with full stream access.

K6 is just above the confluence with the Yellowstone River.

K5 looking upstream (August 8, 2006)
The water access point half way through the future fisheries reconstructed channel reach.

K7 looking upstream (May 2, 2006)
The reach just before the confluence with the Yellowstone where pastured cattle have stream access during spring months.