Restoration Plan for the Flagg Ranch, John D. Rockefeller Memorial Parkway, Wyoming

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Introduction and Site History

Introduction

The goals of this report are to identify changes created by the development of Flagg Ranch as can be determined from the analysis of a time series of air photographs from 1940 to 2002 and backhoe excavated pits in 20 locations. These data along with ground water elevation data for the summer of 2006 are used to identify wetland and upland restoration needs for the Flagg Ranch site. This document identifies 16 different projects that could be implemented to restore the original landscape contours, hydrologic functioning and vegetation of the site.

Site History

The first permanent occupation at the area now known as the Flagg Ranch was by the U.S. Calvary in an attempt to control big game poaching in Yellowstone National Park. The Snake River Military Station was located on the western edge of the historic Flagg Ranch site near the confluence of Polecat Creek and the Snake River. The station operated from the 1890s to approximately 1905-1906 when the Yellowstone Forest Preserve, the land on which the station was located, was transferred to the U.S. Forest Service. The station apparently flew many flags and when Edward S. Sheffield founded the resort in 1910-1916, he named it the Flagg Ranch. The resort was moved from the Snake River floodplain shown in (Figure 1), to the bluff north of the historic site during the 1990s, where the ranger station is located.

The development of the resort in the early 1900's and especially after World War II resulted in a number of landscape scale changes, including the filling of wetlands and the removal of woody vegetation from wetlands. The first air photograph available for the Flagg Ranch area is from 1940 (see Appendix A), and shows that the Snake River bridge was in its current location, and several dirt roads are present on the Snake River floodplain, but relatively few buildings can be seen. A large area of willow vegetation occurred on the southern and western edge of the bluff where the current Flagg Ranch. Scattered patches of lodgepole pine and areas lacking willows indicate that the entire site was not a wetland. However, wetlands were present throughout the site, particularly in the northwest and along the bluff edge.

By 1955 many new buildings had been constructed near the highway and also small buildings, likely cabins. Large areas of willows had also been cleared by this time.

By 1967 there were many new buildings in the eastern and central portions of the property. The Grassy Lake Road had been built by this time as well as a large campground on the bluff. Large dikes had been built near our monitoring wells 6 and 3 (Figure 2) on the northwestern portion of the property and the pond with marsh vegetation located on the northeastern portion of the property (near our well 24) had been partially filled.

By 1977 there had been considerable dumping of fill near our wells 9 and 10, and the diked area noted in the last photo series was completely filled. There were also many new buildings by this year.

By 1990 the new Flagg Ranch complex had been built on the bluff, and most buildings on the historic floodplain site had been removed. There was considerable new fill near well 11. By 2002, most buildings had been removed, but all fill placed at any time over the 20th century and all roads and areas of cleared wetland vegetation remained.

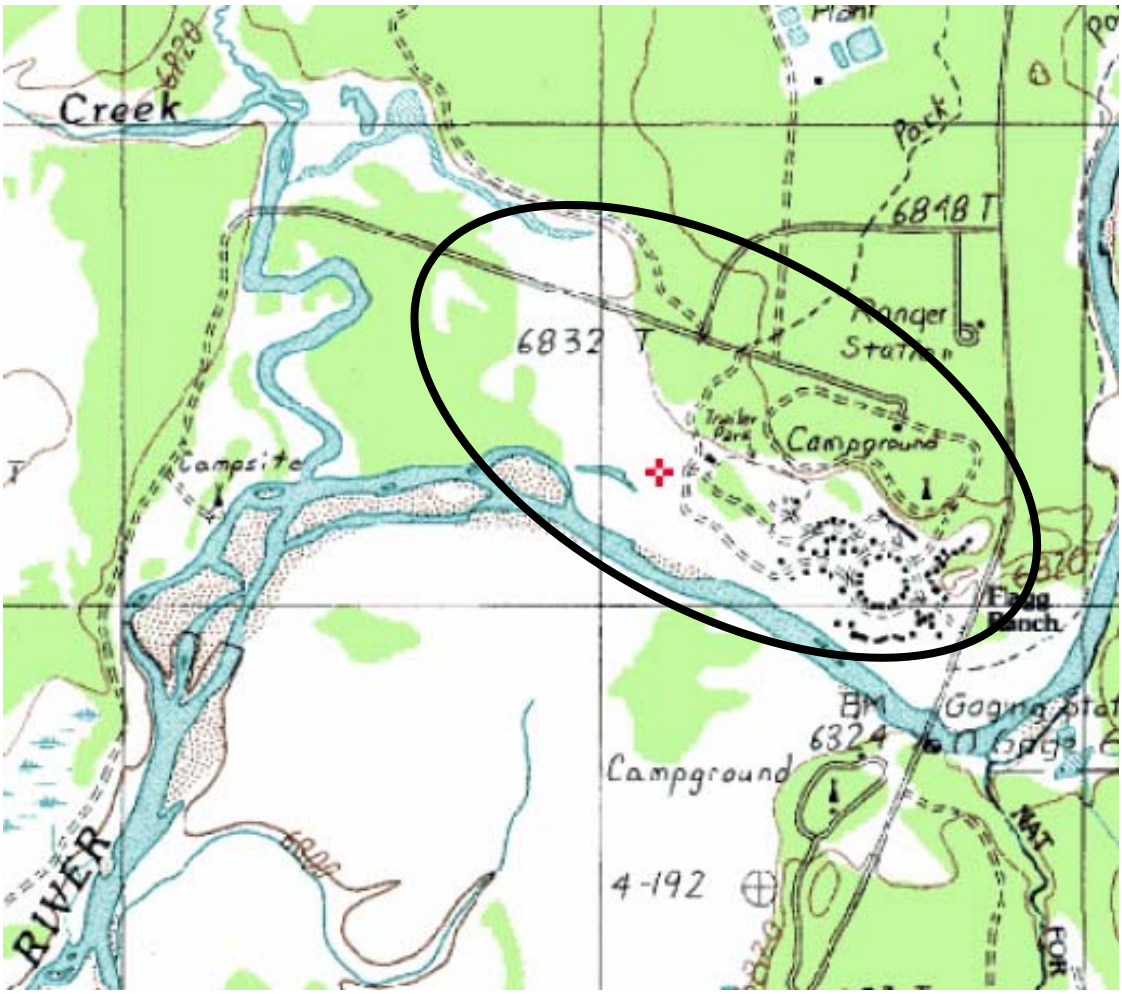

Figure 1. Location of Flagg Ranch study area is identified by the oval on this map. The Snake River flows from top right to bottom left, and Polecat Creek flows from top to bottom. The Flagg Ranch shown in this figure is the historic ranch, with the modern ranch located north of the campground.

Methods and Approach

Historic Air Photo Analysis. Air photographs of the Flagg Ranch area are available for the years 1940, 1955, 1967, 1977, 1984, 1990s (year unknown and only with partial site coverage), and 2002. The photos were digitized, rectified, and an analysis performed to identify site changes over time. These changes were identified in the field, and are presented to identify the impacts that occurred to the site.

Location of Fill and Site Hydrologic Analysis. The locations of filled sites were identified both on air photographs and ground surveys. We installed ground water monitoring wells to investigate the ground water levels across the site. The wells were hand slotted PVC pipe that were placed into backhoe-excavated trenches. In these trenches we also investigated the thickness of fill, if any, had been placed onto the former natural landscape. The locations for backhoe pits were areas where we suspected fill had been placed and also formed well transects that would allow us to investigate hydrologic patterns and processes of the entire site. In each trench soil stratigraphy was analyzed to identify the original ground surface, the current ground surface, and the thickness of fill. Depth to the water table was measured in each monitoring well using an electronic tape approximately biweekly from June through September 2006. A number of hand augered wells were also installed into the wetland area along the northwestern project area. A total of 31 monitoring wells were installed in 9 transects that ran generally north to south or west to east (Figure 2). All wells and staff gauges were topographically surveyed to determine the elevation of the ground, and elevation of the water table relative to the ground surface.

Using ground water elevations we created water table maps for the study site for one date each in June, July and August 2006. These data are used to determine the relationship of the ground water system under the Flagg Ranch to the Snake River, as well as overall direction of ground water flow. We use data from these analyses to develop the suggested restoration projects outlined in this report.

Figure 2. Location of monitoring wells on the Flagg Ranch used in this study.

Results

Hydrology

During 2006 the Snake River at Flagg Ranch had a winter base flow of ~350 ft^3/s. When snowmelt began in April river flow increased rapidly and peaked at nearly 8000 ft^3/s in mid to late May (Fig 3, top panel). The flow dropped just as sharply in late June and reached a summer/fall base flow of < 500 ft^3/s by late July. The 2006 peak flow of 7,750 on 19 May was close to the mean annual peak flow of 8306 ft^3/s (Fig. 3, bottom panel). Our ground water level measurements began in June, after the peak flow. The dates for our measures are shown as vertical lines on the middle panel of Figure 3.

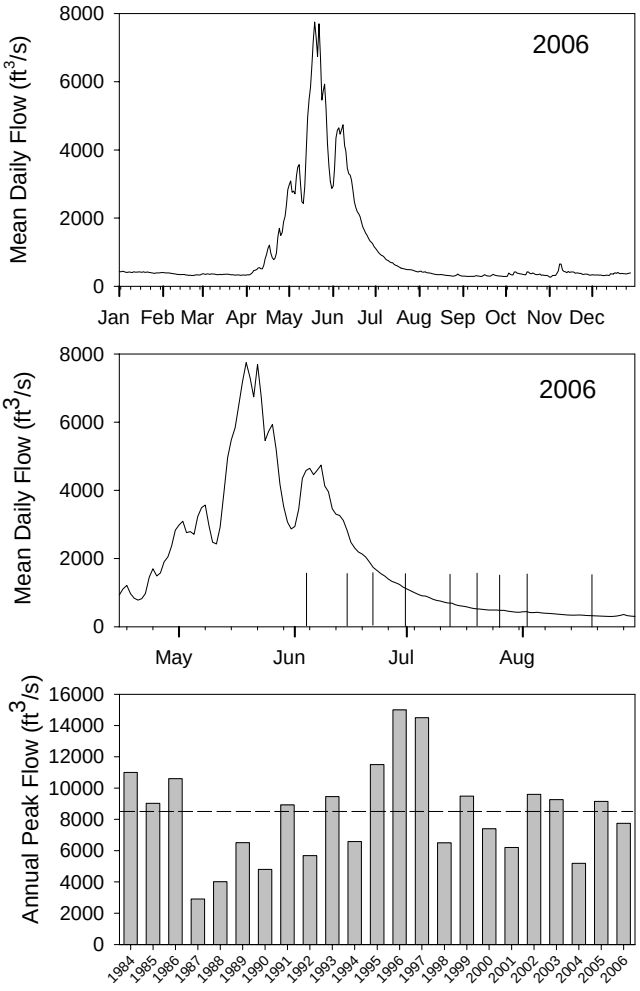

Figure 3. Mean daily flow of the Snake River during calendar 2006 (top panel), summer (middle panel, and annual peak flow for 1984-2006, for the Snake River gauge at Flagg Ranch. The horizontal dashed line on the bottom panel is the long-term mean peak flow.

The water table elevation for four typical ground water monitoring wells, 10, 17, 18 and 59 are plotted in Figure 4 along with the relative elevation of Snake River stage. River stage has a relatively constant decline during the sample period, and water levels in the wells followed this pattern. There is a very high correlation of ground water elevation with Snake River stage (well 10, r = 0.9072; well 17, r = 0.9449; well 18, r = 0.9894; and well 59, r = 0.9216). The highest correlation is for well 18 located near the Snake River in the southeastern portion of the study area. The weakest correlation is for well 10, located at the toe of the bluff. The high correlations suggest that the Flagg Ranch ground water flow system is connected to the Snake River, or that due to snowmelt being the driver for all surface and ground water flow processes in the area, all water levels decline seasonally due to the reduced availability of snowmelt water.

All monitoring wells follow the same general pattern, being highest in the early summer, and lowest in the fall. No significant rises due to summer rain were found. The wells in the northwestern portion of the site (eg. well 59) had a lower water table in early June than mid June, suggesting either a distinctly different water source, or that the effects of high Snake River stage are diminished by the time it reaches this area.

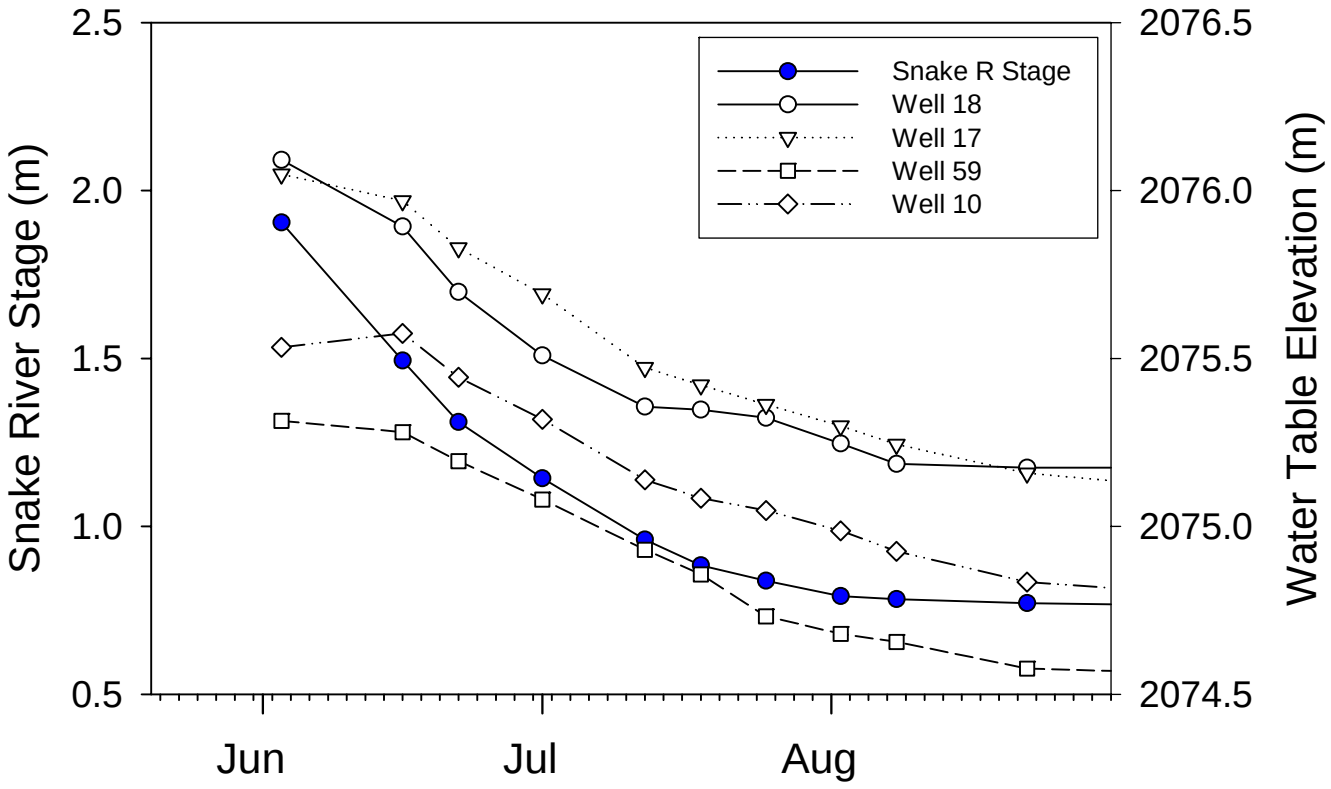

Figure 4. Snake River relative stage (m) and ground water elevation (m) for wells 10, 17, 18 and 59 for June-August 2006.

Water table maps created using ground water elevations for 22 June (Figure 5), 12 July (Figure 6) and 8 August 2006 (Figure 7) indicate that ground water flow was from the northeast to the west and southwest throughout the summer. These flow patterns suggest that ground water under the Flagg Ranch is (1) either recharged by the Snake River northeast of the site and flows southwest, or (2) ground water that originates as snowmelt north of the study site, but is unrelated to the Snake River. Interestingly, the Snake River stage adjacent to the study site is lower than ground water under the Flagg Ranch and ground water flows to the river on all dates. Early in the summer flow is mostly to the southwest, but by 8 August flow in the central portion of the study site is almost directly to the south. Even at well 10, located on the edge of bluff, and well 59 located near the Grassy Lake Road are all highly correlated with Snake River stage (Figure 4).

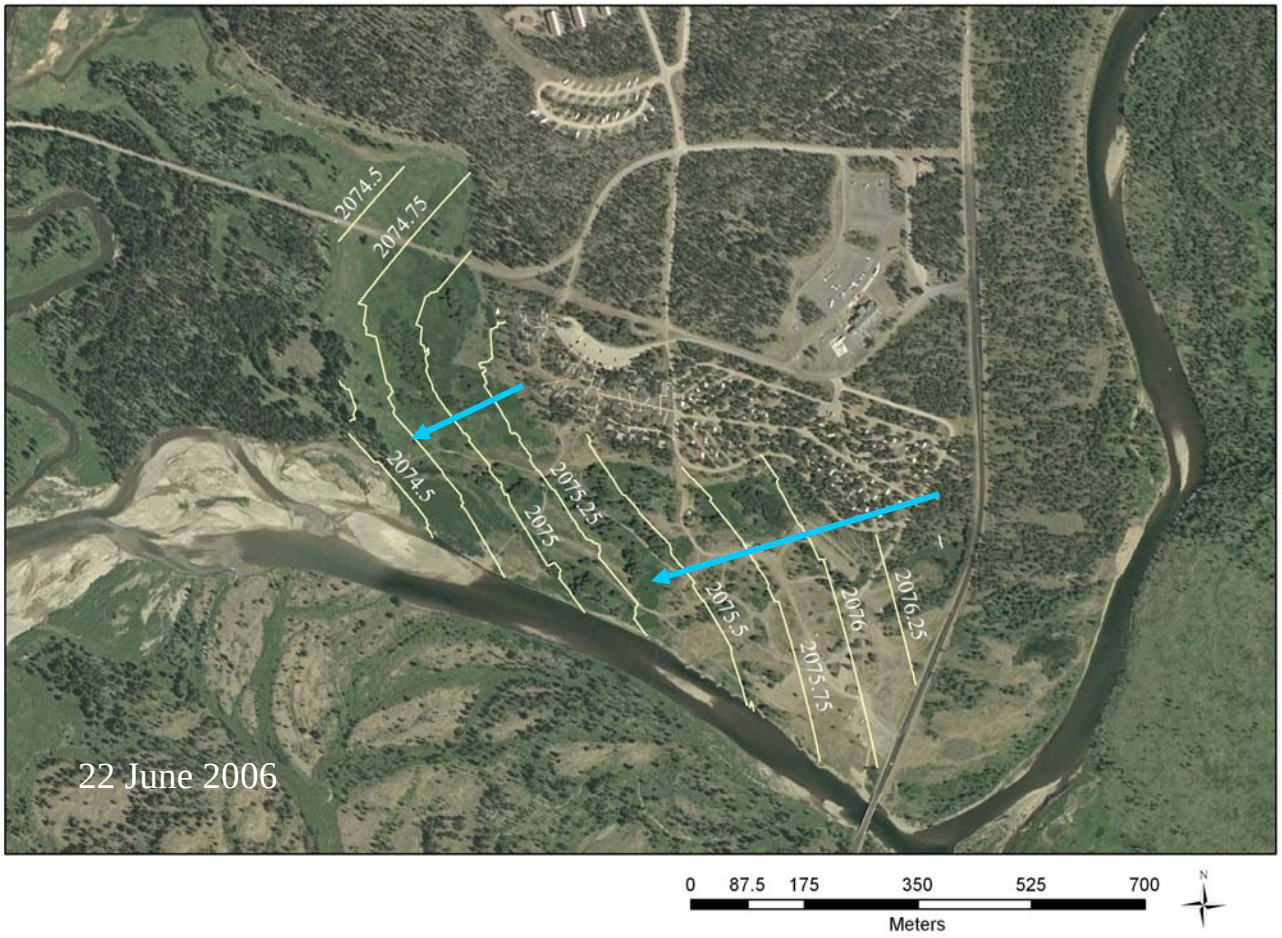

Figure 5. Water table elevation contours (0.25 meter contours) on 22 June 2006. Blue arrows indicate approximate flow direction.

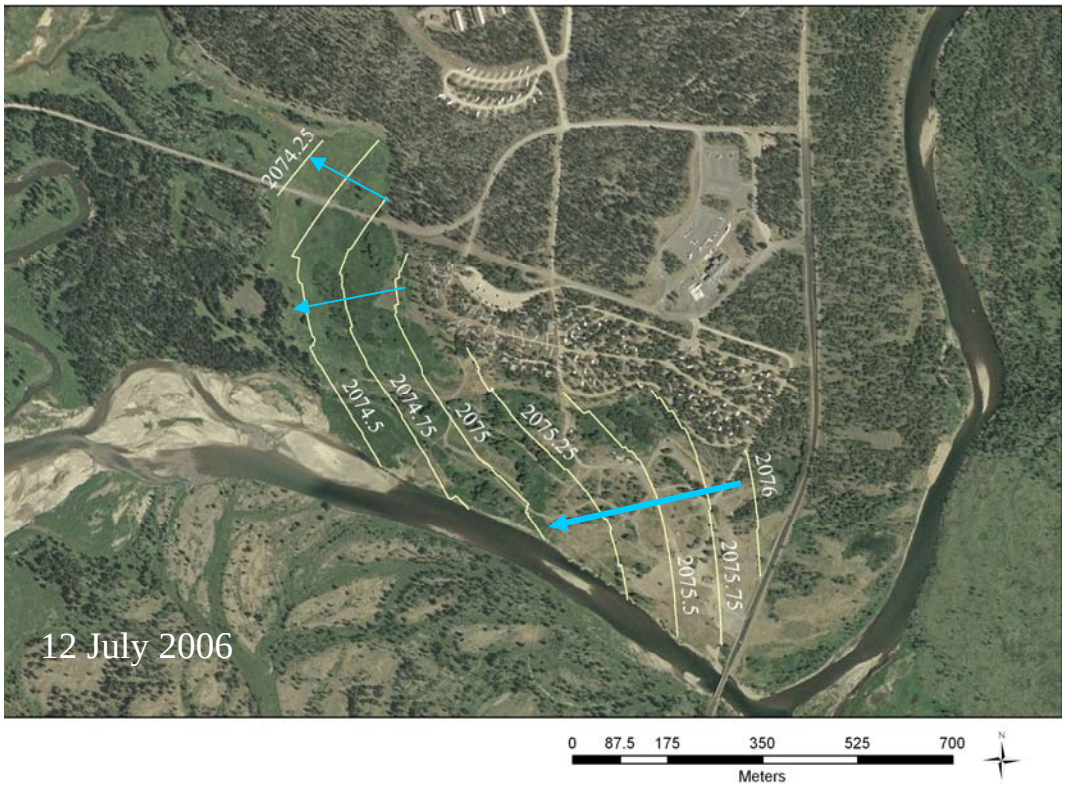

Figure 6. Water table map (0.25 meter contours) on 12 July 2006. Blue arrows indicate flow direction.

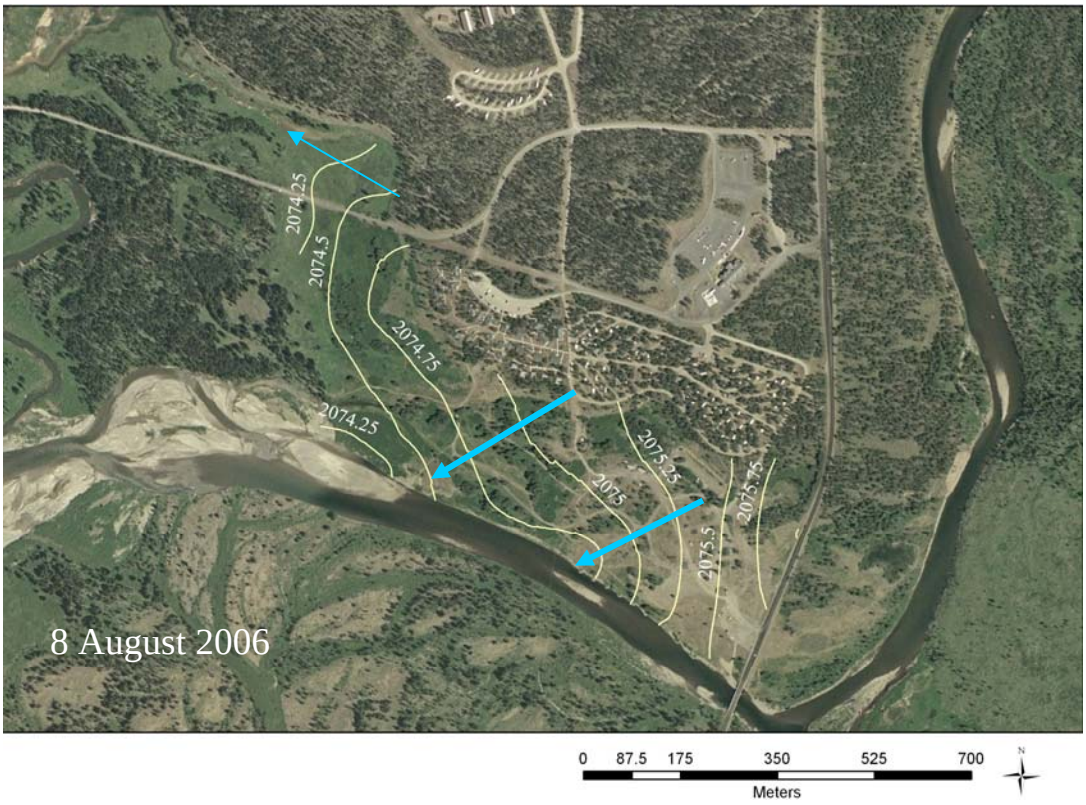

Figure 7. Water table map (0.25 meter contours) on 8 August 2006. Blue arrows indicate flow direction.

Wetlands located along the Grassy Lake Road just west of the Flagg Ranch appear to be supported by ground water flowing from east to west, from under the bluff on which the Flagg Ranch complex is now located. This ground water may continue to flow west and be tributary to Polecat Creek. This apparently single water source and flow direction creates a relatively simple ground water flow system, and because river stage and ground water levels are highly correlated, it makes it possible to predict ground water level at any well from river stage. However, it also indicates that any pollutants discharged onto the former or current Flagg Ranch site, and that enter the ground water flow system, would likely be transported to the Snake River.

Stream Channel Position through Time

The location of Polecat Creek has shifted considerably during the 20th century (Figure 8). Its confluence with the Snake River was several hundred meters northeast of where it is today until the 1970's when it shifted farther south. The Snake River has also meandered considerably during this period. Between 1940 and 1955 the river eroded its northern bank and floodplain (see white arrow on Figure 8), and widened the channel. However, by 1967 the river moved to its current position, abandoning the area north of the 1967 channel. An island formed which was colonized by willows forming one of the largest willow complexes in the area. The Snake River channel upstream of the highway bridge and downstream of the bridge for ~500 m has been stable during the past six decades. However, downstream of this point the channel is highly dynamic, and at times in the past the river has flowed nearly straight south from the Flagg Ranch area as evidenced by the former channels visible on Figure 8, as identified by the green arrow. In addition, the area west of the current Flagg Ranch may be a relict Snake River channel, see blue arrow on Figure 8.

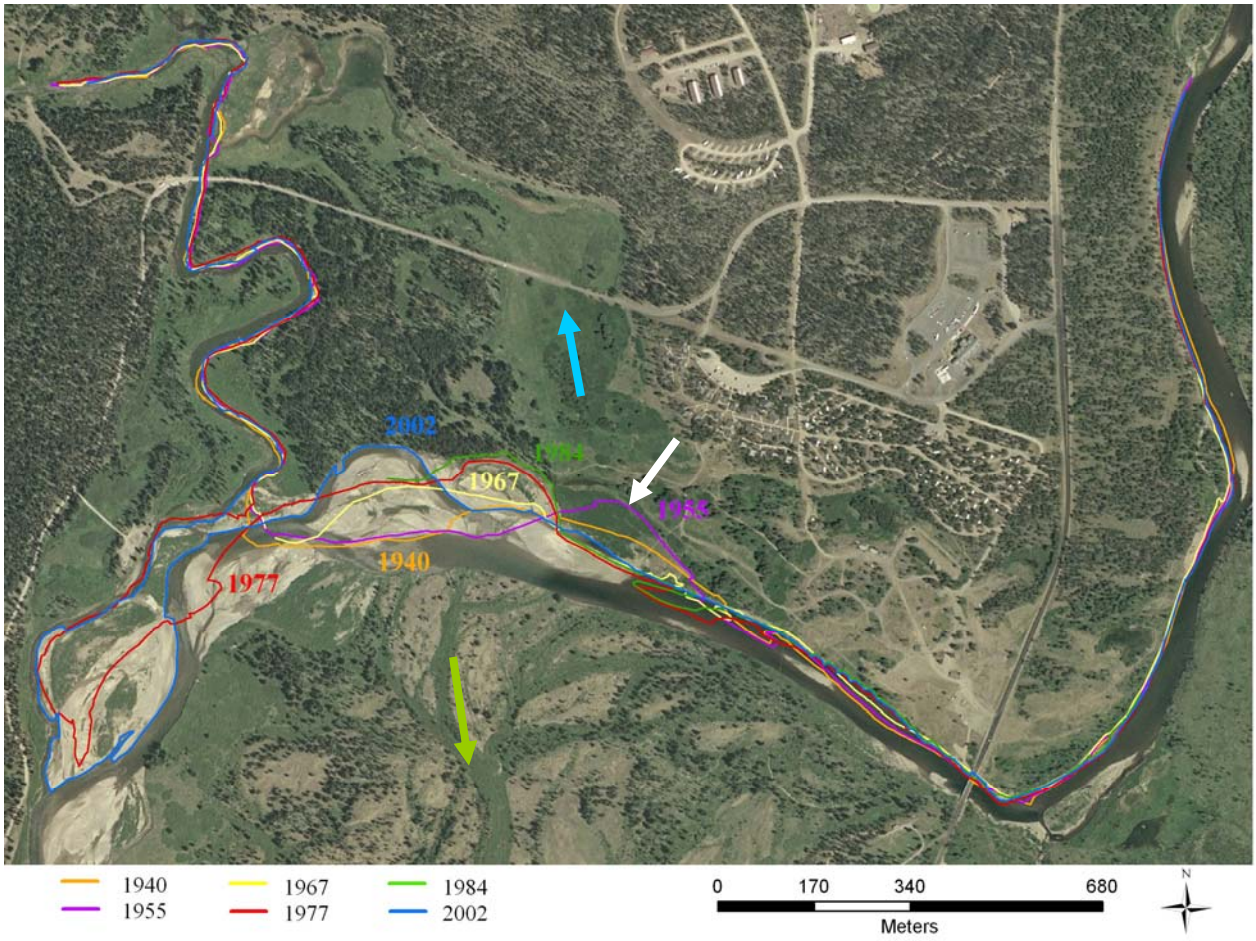

Figure 8. Location of Snake River and Polecat Creek in 1940, 1955, 1967, 1977, 1984, and 2002. The white arrow indicates the area where channel movement was greatest during the period of photo record. Former Snake River channels can be seen south of its current floodplain, see green arrow, and possible an older channel is shown at the blue arrow.

Riparian Vegetation

The area of willows identified on each air photo is illustrated in Appendix B. In Figure 9 and Table 1 we compare the area covered by willows between 1940 and 2002. The area of willow in the eastern part of the study area, east of the transect formed by wells 7-10, declined by ~40% between 1940 and 1955 and by more than 60% by 1967. This decline was due to clearing for roads and buildings, and filling as can be seen in right side of Figure 9. Willow area increased from this low due to willow colonization of the island formed as the Snake River migrated to the south after 1967. However, willow area in the main Flagg Ranch area in 2002 is ~50% of what existed in 1940.

The main area of sedge-dominated vegetation occurred fringing a small pond in the northeastern corner of the study area. Monitoring well 24 was placed in this area. The pond was largely filled and the vegetation in this area destroyed.

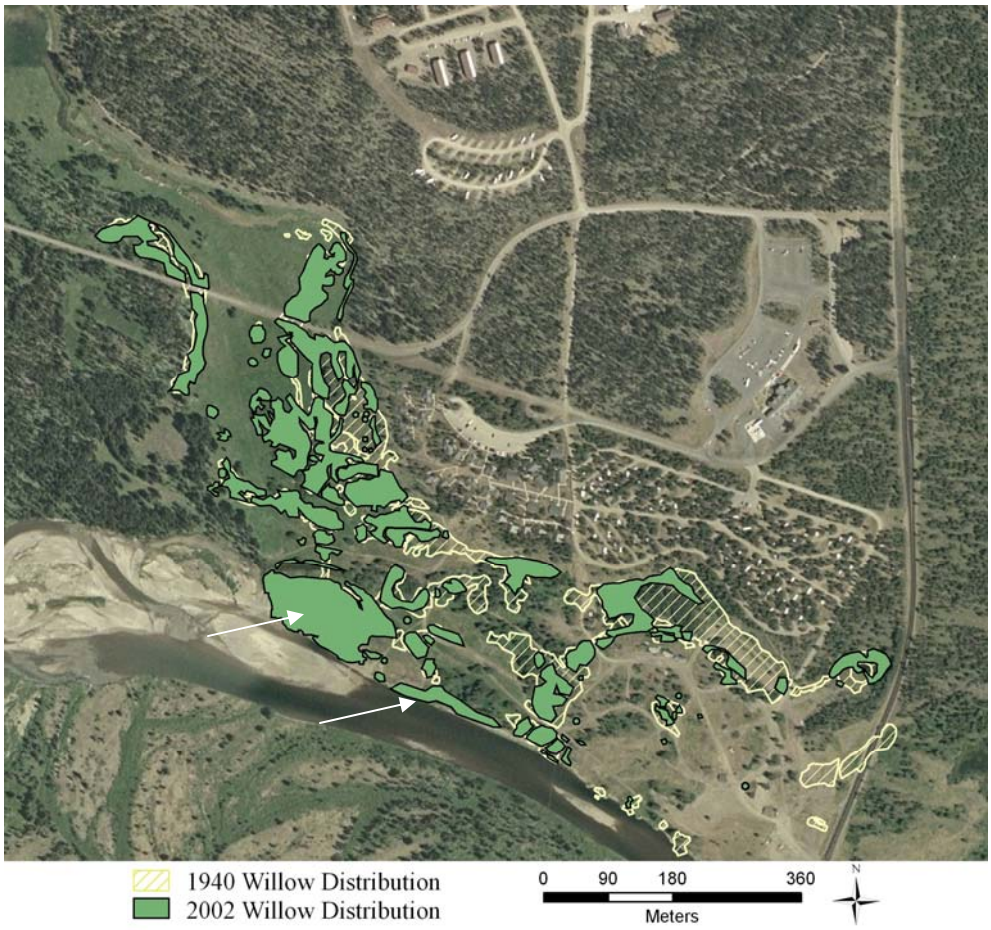

Figure 9. Distribution of willows in 1940 and 2002 for the Flagg Ranch. White arrows indicate new willow patches formed on islands and bars along the Snake River.

Table 1. Area of Flagg Ranch covered by willow dominated vegetation. Hectares and acres are for the entire study area, while E area and % of 1940 are in hectares and for the area east of well 7 to 10 transect.

Year	Hectares	Acres	E Area	% of 1940
1940	8.64	21	4.99	100.0
1955	6.34	16	3.08	61.7
1967	4.85	12	1.80	36.1
1977	7.44	18	1.85	37.1
1984	7.51	19	2.03	40.8
1990s	---	---	2.05	41.1
2002	8.16	20	2.55	51.1

Fill Thickness and Water Table Depth

The elevation of the current ground surface, former ground surface and water table is shown for five monitoring wells in Figure 10. Wells 3 and 6 occur in the triangular area of fill near the Grassy Lake Road, and data from excavated pits and water table elevations indicate that ~0.5 - 1.0 m of fill is present, the former ground surface can be identified, and the water table during 2006 was near the former ground surface in early to middle summer. Thus, excavation of the fill would produce an area with water table near the soil surface suitable for the restoration of willow- or sedge-dominated wetlands.

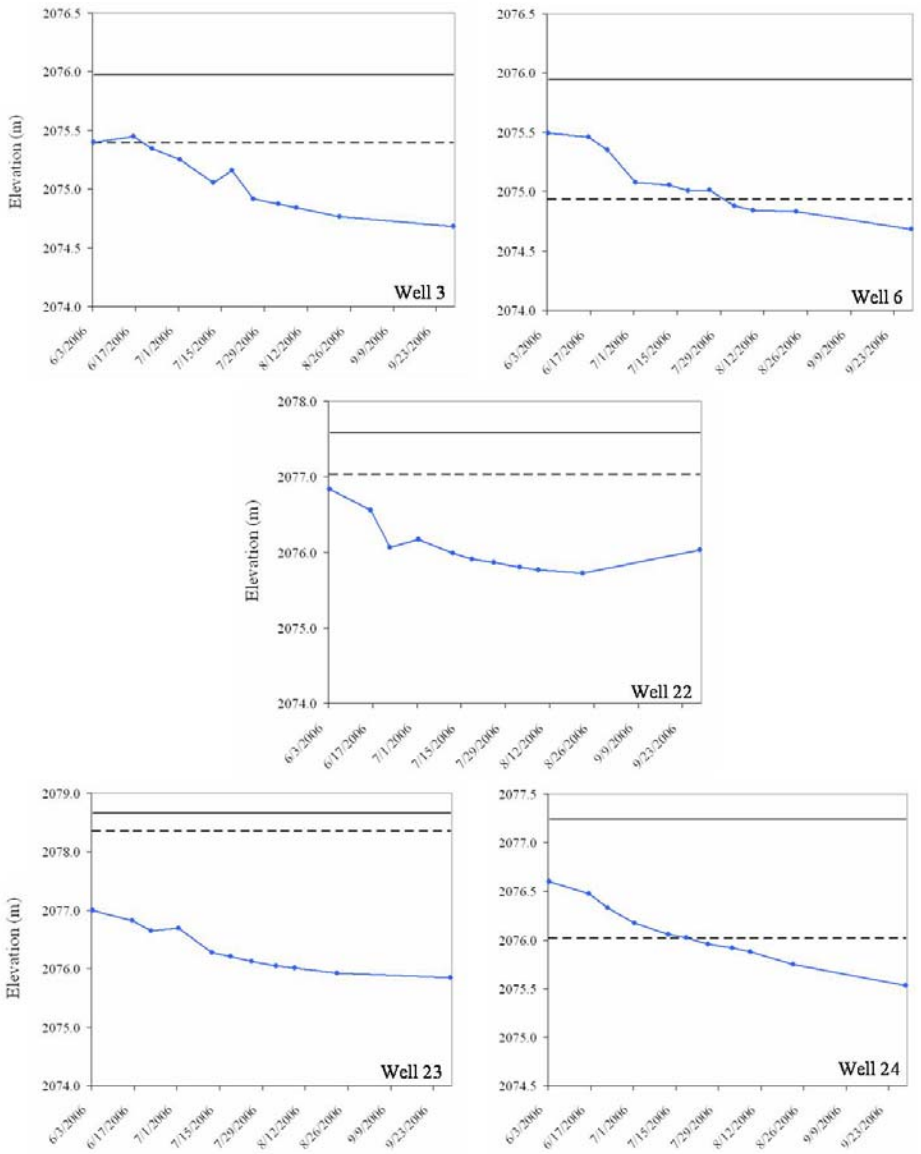

Figure 10. Existing ground surface (solid line), former ground surface (dotted line) and water table elevation for wells 3, 6, 22, 23, and 24 during 2006.

At wells 22 and 23, approximately 0 - 1 m of fill was present over the former ground surface. The water table depth was within 1 m of the former ground surface at well 22 and within 1.5 m at well 23 for much of the summer. Willows occurred in the vicinity of well 22 in 1940 (Figure 9) and this area could be restored to a willow wetland or upland. The area around well 23 may have a water table too deep for wetland restoration, and could be restored to a grass and sagebrush upland.

The area of well 24 was a natural basin that supported a pond with fringing tall sedge vegetation. The water table was above the former ground surface during June and July of 2006, and fill removal could allow the restoration of a sedge-dominated marsh.

Restoration Projects

Disturbances to the Flagg Ranch site include filling, vegetation removal, and ground disturbance. We have identified 16 areas that were disturbed and where restoration could occur. Each is identified in Figures 11 and 12, and discussed here. In Table 2 we identify the restoration area, fill thickness and fill volume.

Site 1 is the triangular area of fill located just west of the current Flagg Ranch, and is 1.27 acres in size. This is an excellent wetland restoration option, which would require the removal of approximately 4,085 m^3 of fill to restore the former ground surface elevation. Our ground water monitoring wells indicate that the water table is close to the original ground surface, so removing the fill would restore the pre-impact hydrologic regime. The site should then be planted with *Salix boothii, S. lemmonii, Carex utriculata, C. aquatilis* and *Calamagrostis canadensis.* Some portions of this site may have supported willow stands, while others may have been largely *Carex.* Additional soil pits will be necessary to determine the exact fill thickness throughout the site, but based upon our test pits, an average of 0.79 m of fill is present. This fill could be transported upslope to the Flagg Ranch without impacting the adjacent undisturbed wetlands.

Site 2 is a small area of fill (0.13 acre) (Table 2) that has hummocky fill piles that were dumped by trucks (Figure 11). Willow removal also occurred. The fill should be removed, and the site planted to wetland vegetation similar to site 1.

Site 3 is a historic road that runs parallel with the Snake River. It does not appear that fill was placed in this site, but willows were cleared. Thus, wetland restoration would be a planting effort.

Site 4 is a large area of fill (1.27 acres) identified as the hummocky terrain created by a large number of truck loads that were dumped along the southern bluff margin. Approximately 1357 m^3 of

fill are present. More work is necessary to determine the exact volume of fill present, but once the fill is removed to the historic ground surface, wetland restoration could be accomplished and the site planted as described for site 1. A road already exists to the site from the bluff.

Site 5 is the area between sites 3 and 4. It is heavily disturbed by truck passages, and appears to be able to support upland vegetation.

Site 6, 7, 8 and 9 are roads and other areas that were cleared of native vegetation. These areas could be restored to native wetland vegetation (sites 6, 7, 8) or uplands (site 9). We have no data to indicate that fill was placed on these sites so planting may be the only activity necessary for restoration.

Site 10 is another large disturbed wetland area (1.29 acre) at the base of the bluff. It is unclear whether any fill is present, and this area should be investigated further via backhoe pits. It is possible that the native vegetation was just cleared. This wetland restoration project would include planting of species similar to site 1, and possibly fill removal.

Site 11 is a road segment through a willow stand. No fill was found, and planting would be necessary to restore the native wetland vegetation.

Site 12 has a small area of fill and a larger area from which willows were cleared. Fill removal and planting are necessary to restore this site to a wetland.

Site 13 is a large area that was filled and vegetation removed. Wetland restoration would require both fill removal and replanting.

Site 14 contains the largest volume of fill that we found on the Flagg Ranch site, 6188 yd^3, which was used to partially fill a natural pond and sedge marsh. Wetland restoration would require fill removal and planting with *Carex utriculata* and *C. vesicaria*.

Site 15 is a large area of upland that has been filled. Since the water table depth even once the fill was removed would be too deep to support wetlands, the restoration goal should be upland vegetation. Thus, fill removal may not be necessary to restore the native upland vegetation.

Site 16 is a very large site and includes most of the area where the former Flagg Ranch buildings were located. Some fill is present, as identified on Figure 12, but most of the site is disturbed uplands and should be restored to uplands.

Revegetation Approaches

Willow plantings can occur in many of the wetland restoration sites following fill removal. Plantings should be dormant stems that are at least 2 feet long, and inserted into the soil so that at least

18 inches of the stem is below ground. Stems must be planted vertically. Many areas have gravel or cobble soils that are compacted, and will be hard to insert willow stakes into. These areas will have to be ripped with a backhoe to allow planting to occur. An even larger concern is that the water table depth under many areas, particularly in the former Flagg Ranch near wells 9 and 13, is approximately 1 m deep in June. Likely the water table is ~0.5 m deep in May of a normal snowmelt runoff year. Thus, planting must occur as early in May as the site is available so that willows are collected prior to leaf out, and planted while the ground water table is high.

Carex utriculata, C. vesicaria, C. aquatilis, and *Calamagrostis canadensis* should be grown from seed collected along the Grassy Lake road just west of the study site. Seedlings should be propagated in a commercial nursery and planted on site after fill is removed. The best time for planting will be in early June. The most likely locations for planting *Carex* are sites 1 and 14.

Restoration Site Prioritization

Projects 1 and 14 have the most clearly defined wetland restoration opportunities. Both of these sites have existing wetlands adjacent to them, were filled, and the fill could be removed to restore the original ground surface contours and hydrologic regime, and the vegetation replanted. Project 1 is 1.27 acres in size, and would require the removal of 5343 yd^3 of fill. Project 14 would restore 0.96 acres of wetland, and require the removal of 6188 yd^3 of fill and the planting of *Carex* species. These two projects are recommended as the highest priorities. These two projects would restore a total of 2.23 acres of wetland.

The second priority wetland restoration projects would be those where fill is present, or where vegetation was removed, but the sites are relatively small, the exact configuration of the fill, or the activities that occurred on site are less well known. Site 2 is small in area, 4 requires a large but imprecisely known volume of fill to be removed, and site 13 is in an area where relict vegetation is not present. Restoration of site 2 would be 0.13 acre in size, and require the removal of 234 yd^3 of fill. Restoration of site 4 would result in the restoration of 1.27 acres, and require the removal of ~1775 yd^3 of fill. Restoration of site 13 would result in 0.91 acre of wetlands, and require the removal of 2648 yd^3 of fill.

All other projects should be considered the third priorities, and many require no fill removal, but because the water table is deep, plantings should be on an experimental basis at first. Sites 5, 9, 15, and

16 are most likely disturbed uplands which could be restored at any time. Sites 3, 6, 10, 11, and 12 were former willow wetlands, but all have relatively deep water tables.

Table 2. Restoration area in m^2 and acres, area of fill in m^2, thickness of fill in m, and fill volume in m^3 and yd^3 for restoration areas at the Flagg Ranch.

Site	Restoration Area (m^2)	Restoration area acres	Fill Area (m^2)	Fill Thickness (m)	Fill (m^3)	Fill yd^3
1	5154.87	1.27	5154.87	0.79	4085.13	5343.35
2	513.14	0.13	293.30	0.61	178.79	233.86
3	870.50	0.22				
4	5145.05	1.27	2967.71	0.46	1356.84	1774.75
5	3802.35	0.94				
6	2450.95	0.61				
7	3210.09	0.79				
8	581.02	0.14				
9	2362.59	0.58				
10	5208.00	1.29				
11	395.19	0.10				
12		3.74	250.88	0.46	114.70	150.03
13			3690.18	0.55	2024.58	2648.15
14	15122.84		3880.31	1.22	4730.87	6187.98
15		21.92	10167.87	0.30	3099.17	4053.71
16	88703.60		768.121	0.76	585.31	765.59
Total	133,520.18				16,175.39	

Figure 11. Location of the 16 project sites overlain on a high quality air photograph.

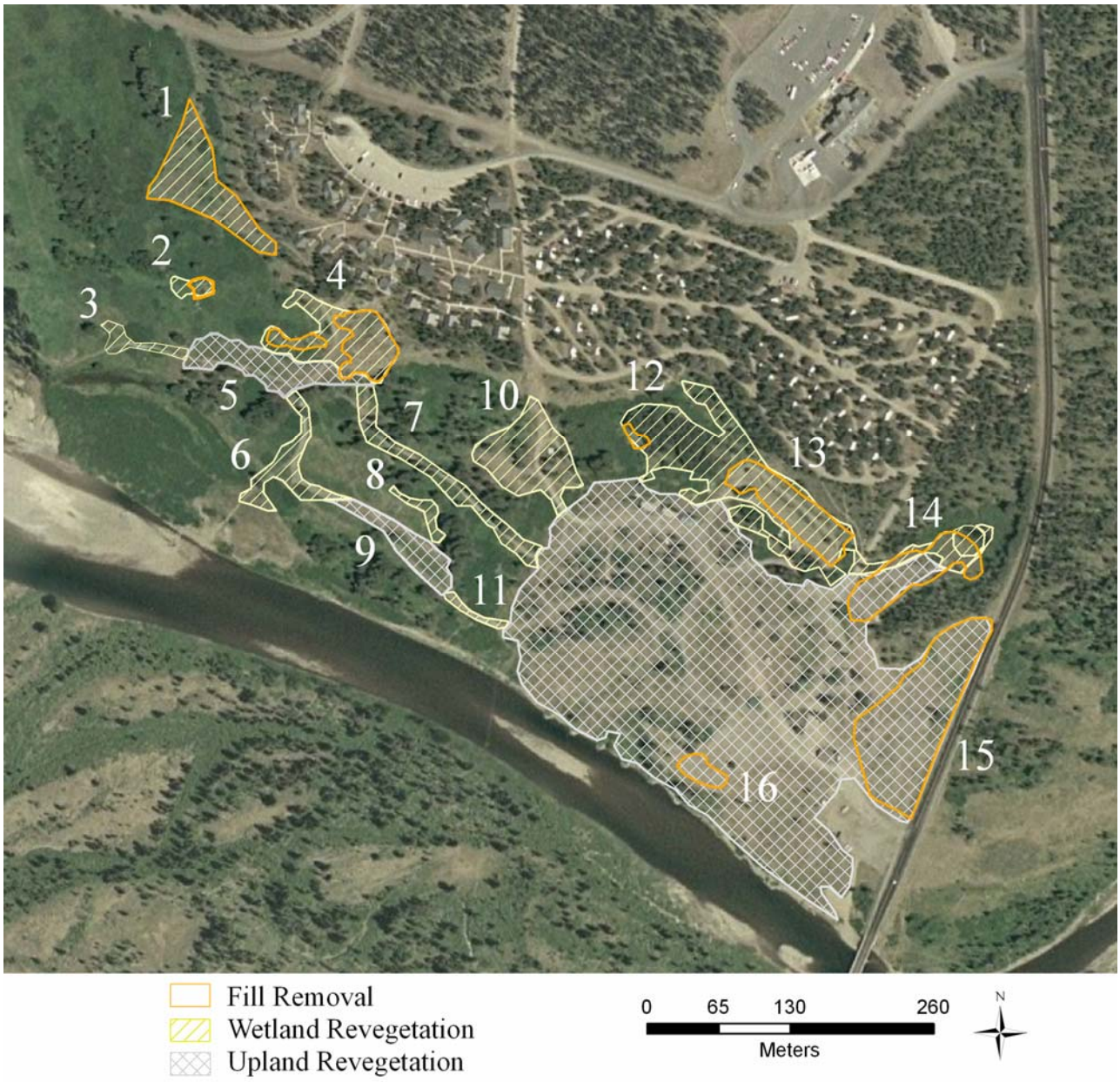

Figure 12. Location, and type of the 16 proposed restoration projects.