Wetland Profile and Condition Assessment of the Great Divide Basin, Wyoming

FINAL REPORT

Submitted September 26, 2018

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Cover photograph: Lindsey Washkoviak

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Prepared for:
U.S. Environmental Protection Agency, Region 8
1595 Wynkoop Street
Denver, CO 80202

EPA Assistance ID No. CD - 96805101

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This document should be cited as follows:

L. Washkoviak, T. Tibbets, and G. Jones. 2018. Wetland Profile and Condition Assessment of the Great Divide Basin, Wyoming. Prepared for the U.S. Environmental Protection Agency by the Wyoming Natural Diversity Database, University of Wyoming, Laramie, Wyoming. 47 pp. plus appendices.

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EXECUTIVE SUMMARY

This report summarizes results of a condition assessment of wetlands in the Great Divide Basin (GDB) of west-central Wyoming and includes a special wetland profile for the Chain Lakes Wildlife Habitat Management Area. The objectives of this report are to: [1] describe the wetlands within the GDB study area using digital wetland mapping data; [2] report results from a field-based assessment of wetland condition in the GDB; and [3] provide a summary of wetland resources and ecological condition for the Chain Lakes Wildlife Habitat Management Area.

We developed a multi-level approach to create a landscape profile and estimate condition of wetlands within the GDB study area. We produced a wetland landscape profile using digital wetland mapping data to describe wetland resources. We assessed basin-scale wetland condition using Ecological Integrity Assessment (EIA) methods supplemented by measurements of anthropogenic and hydrologic disturbance, baseline characteristics of wetland vegetation, and hydrologic alteration. EIA field protocols were used to survey 57 randomly-selected and 8 hand-selected sites in June-September 2015. Surveys targeted three wetland subgroups: 1) Alkali wet meadows; 2) Playa and saline depressions; and 3) Shrub flats.

Based on digital mapping, wetlands within the study area totaled 19,924 acres (8063 hectares), or < 1% of the total land area. Public lands managed by the Bureau of Land Management comprise over half of the wetland area (58%) and 35% is privately owned. Freshwater emergent wetlands, which include wet meadows and emergent marshes, are the most common wetland type mapped, totaling 7,411 acres and representing 38% of the wetland area. Impoundments and dikes are the most prevalent anthropogenic modification mapped in the basin, influencing 9% of the wetland area. There is no irrigation mapped within the GDB.

Results from the wetland condition assessment suggest that 95% of the wetlands in the Great Divide Basin are only slightly modified by human activities. This is especially true for playas and saline depressions, in which over 60% of wetlands surveyed were essentially unmodified. The most common disturbances identified during the survey were soil compaction from livestock and wild horses, presence of roads, and invasive plant species. However, in all wetland types, plant communities had high (94%) relative cover of native species, and of the basins that we have studied, the GDB had, the fewest wetlands with non-native species present. Changes to wetland hydrology appear to affect few wetlands; in three-fourths of the wetlands we sampled, we found little or no evidence of impacts to hydrology.

However, it is important to note that this survey does not include the assessment of potential impacts of oil and gas development on wetlands in the basin. We did not have permission to access or drive through portions of the basin that have a high density of oil and gas development because private land intermixed in these areas prevented access.

Wetlands sampled in the Chain Lakes WHMA at the time of sampling were at or near reference condition with very little human impacts or non-native species present. Updated NWI mapping indicates that the Chain Lakes wetland complex potentially provides a wide range of important ecological functions.

ACKNOWLEDGEMENTS

This project was funded by a Wetland Program Development Grant (#CD - 96805101) from the U.S. Environmental Protection Agency Region 8 and the Wyoming Chapter of The Nature Conservancy. The framework for this study was informed by the State Wildlife Wetlands Conservation Strategy (Wyoming Joint Ventures Steering Committee 2010), the State Wildlife Action Plan (Wyoming Game and Fish Department 2010), and the Wyoming Bird Conservation Habitat Partnership (WBCHP) including representatives from Wyoming Game and Fish Department (WGFD), Wyoming Department of Environmental Quality (DEQ), USFWS (United States Fish and Wildlife Service), The Nature Conservancy (TNC), Ducks Unlimited (DU), Intermountain West Joint Ventures (IMWJV), Wyoming Audubon, and Rocky Mountain Bird Observatory (RMBO).

We would like to thank Chad Rieger at Wyoming DEQ for providing guidance and support for the study proposal. We would also like to thank Holly Copeland and Amy Pocewitz from the Wyoming Chapter of The Nature Conservancy for contributing matching funds and support for the project. We extend our gratitude to Mark Andersen at WYNDD for assistance with survey design. We thank our field technician, Chris Nieters, for his hard work collecting and entering data.

This study would not be possible if not for the public land managers and private landowners that granted access to wetlands on their lands. We extend our gratitude to landowners for their support of this project.

1.0 INTRODUCTION

1.1 Wyoming's strategy for wetland assessments

Freshwater wetland ecosystems are highly diverse, productive habitats, which provide vital ecosystem services (Costanza et al. 1997). Dahl (1990) estimates 38% of wetlands that existed in Wyoming prior to European settlement were lost between 1780 and the mid-1980s. Wetlands remain highly threatened and are subjected to pressures from agricultural, residential, and energy development in Wyoming (Copeland et al. 2010, Pocewicz et al. 2014). Recent studies identify Wyoming's wetlands as one of the habitat types most vulnerable to impacts of future habitat alteration and climate change (Copeland et al. 2010a, Pocewicz et al. 2014).

In light of the changes and threats to wetland ecosystems, we undertook this project as part of a state-wide effort to fill gaps in our understanding of the current extent and ecological condition of wetlands in Wyoming. Recent studies of wetlands in the Intermountain West, including Wyoming, (Lemly and Gilligan 2012, Newlon et al. 2013, Tibbets et al. 2015, 2016a, 2016b) have utilized landscape profiles and rapid assessment methods (RAMs) to draw conclusions regarding wetland resources. Landscape profiles primarily use digital spatial information to quantify the distribution of resources, such as wetland types or area, and to develop conservation goals at a landscape scale (Gwin et al. 1999). RAMs assess the condition of wetlands based on field surveys that measure abiotic and biotic indicators of ecological function and indicators of disturbance that have the potential to negatively affect wetlands. Together, landscape profiles and RAMs are used to establish baseline wetland profiles that include ecological condition, assessment of cumulative impacts, and information useful to prioritize protection and restoration efforts (Gwin et al. 1999).

1.2 Project Background

This report summarizes results of the first basin-wide assessment of wetlands in the Great Divide Basin (GDB) of west-central Wyoming and includes a special wetland profile for the Chain Lakes Wildlife Habitat Management Area (Chain Lakes). This project was the fourth basin-scale wetland condition assessment within Wyoming, and builds upon previous studies completed within the Laramie Plains Basin (Tibbets et al. 2016a), the Goshen Hole Basin (Tibbets et al. 2016b), the Upper Green River Basin (Tibbets et al. 2015), and a statewide landscape scale assessment (Copeland et al. 2010).

The need for general information about wetlands in the GDB, including the Chain Lakes Wildlife Habitat Management Area, is well recognized. The Great Divide Basin is among the nine priority focus areas identified by the Wyoming Joint Venture Steering Committee (2010) and is one of 48 priority bird habitat conservation areas in the Intermountain West (Wyoming Joint Venture Steering Committee 2010). The GDB is a key habitat area identified in the State Wildlife Action Plan (SWAP) based on the presence of Species of Greatest Conservation Need, unique ecological values and exceptionally high potential for conservation projects (WGFD

2010). Furthermore, wetlands in the GDB provide important breeding, brood-rearing, foraging, and migratory stop-over habitat areas for over 300 species of Wyoming's wildlife (Wyoming Joint Ventures Steering Committee 2010). The Chain Lakes is a unique, fragile, and rare alkaline desert lake system managed in cooperation by the Wyoming Game and Fish Department and the Bureau of Land Management (Bureau of Land Management 2008). It provides important habitat for pronghorn, elk, and sage grouse, and is an important stopover for migratory waterfowl and shorebirds (Wyoming Game and Fish Department 2017). However, there is a paucity of data on wetlands in the GDB and a growing interest and priority to fill data gaps in the area.

The objectives of this report are to: [1] describe the landscape profile of wetlands within the GDB; [2] report results from a field-based assessment of wetland condition in the GDB; and [3] provide a summary of wetland resources and condition for the Chain Lakes Wildlife Habitat Management Area.

2.0 STUDY AREA

The Great Divide Basin is an internally draining basin formed by a split in the Continental Divide that encompasses 2,437,493 acres within west-central Wyoming (Figure 1). Vegetation is characterized by vast expanses of sagebrush steppe intermixed with extensive greasewood flats and pockets of wetland playa and meadow complexes. Halophytes (salt tolerant species) are common in wetland complexes where highly saline conditions exist (Heller et al. 2011).

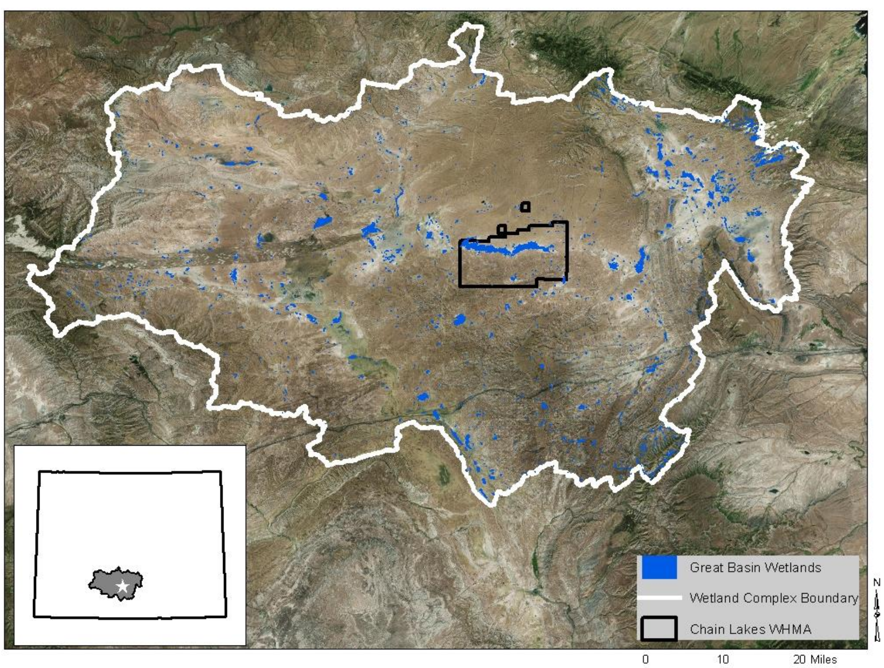


Figure 1. The Great Divide Basin study area.

The study area includes three large sub-basins separated by ridges of resistant fine-grained sedimentary rock that steps down in elevation from west to east: The Red Desert, the Chain Lakes Flats, and Separation Flats (Heller et al. 2011). While there is an approximately 1100 m difference between the highest point in the Ferris Mountains (3050 m) and Separation Flats (1947 m), most (80%) of the basin falls within the 1947 – 2150 m elevation range (Heller et al. 2011). This results in little mountain drainage and low topographic impact from weather fronts to force precipitation in the basin.

The GDB lies within the 7 to 9 inch annual precipitation zone with up to 10 inches possible at higher elevations (Bureau of Land Management 2012). All surface water in the basin is from precipitation and snowmelt. Water mainly moves through the landscape in ephemeral streams that flow into large playas and small perennial lakes, or disappears beneath active aeolian sand dune and sheet deposits (Heller et al. 2011). Drainage basins in the GDB often lack outlets, resulting in temporarily flooded depressions that accumulate dissolved salts left behind by evaporation. Mean evaporation rates for shallow lakes in the area can be relatively high (>75 cm/yr) (Farnsworth and Thompson 1982).

3.0 LANDSCAPE PROFILE OF THE GREAT DIVIDE BASIN

A landscape profile was created using digital wetland mapping data compiled from the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) and additional data layers describing irrigated lands and land ownership within the LSRB study area. The landscape profile describes wetlands within the study area based on the following attributes: wetland class; water regime; extent of wetlands modified/irrigated (Wyoming Wildlife Consultants 2007); and land management/ownership (Bureau of Land Management 2010). The landscape profile identifies wetlands according to categories based on codes and modifiers defined by Cowardin et al. (1979).

3.1 Wetland Resource Description

According to mapping from the National Wetland Inventory (U.S. Fish and Wildlife Service 1984), wetland area comprises 19,523 acres, or 0.8% of the total land area of the GDB study area (Table 1), highlighting the importance of water in the region. This estimate excludes 401 acres of non-wetland features such as deep lakes and excavated wetlands.

3.1.1 Wetland Class

Palustrine Freshwater Emergent wetlands are the most common wetland class in the basin, totaling 7,411 acres and representing 38% of the wetland area (Table 1). Palustrine Freshwater wetlands include wet meadows and emergent marshes. Lakes and areas with Unconsolidated Bottoms/Shores represent 30% and 15% of the wetland area respectively. These represent playa wetlands at the bottom of sub-basins where water accumulates. Many of these areas consist of un-vegetated salt flats interspersed with salt tolerant wet meadow vegetation. Palustrine Scrub/Shrub wetlands, mainly expansive greasewood flats in the Chain Lakes Flat and

Separation Flat areas, cover 2,862 acres and represent 14.5% of the wetland area. Palustrine Freshwater Ponds are rare and represent more permanently flooded emergent marshes. No Forested or Riverine wetlands are mapped in the basin.

Table 1. Surface area of wetlands based on NWI classifications in the GDB.

NWI Wetland Class	Cowardin Code	Wetland Acres	% of Wetland Area
Palustrine Freshwater Emergent	PEM	7,411	38.0%
Lake	L1/2	5,810	29.8%
Palustrine Unconsolidated Bottom & Palustrine Unconsolidated Shore	PUB /PUS	2,963	15.2%
Palustrine Scrub/Shrub	PSS	2,836	14.5%
Palustrine Freshwater Pond	PAB	504	2.6%
Palustrine Forested	PFO	-	-
Riverine	R2/3/4	-	-
Total		19,523	100.0%

3.1.2 Water Regime

Water regime (Cowardin et al. 1979) expresses the amount of time during the year when water is present in wetlands. Temporarily and Seasonally flooded wetlands are the two most common water regimes identified in the GDB, representing 62% and 24% of the wetland area, respectively (Figure 2). Temporarily flooded wetlands hold surface water for relatively shorter periods (few days to a few weeks) during the growing season compared to seasonally flooded wetlands, that hold water for greater than one month, but are dry by the end of the growing season in most years (Cowardin et al. 1979). These two water regimes comprise over 99% of Emergent, Scrub/Shrub, and Unconsolidated Bottom/Unconsolidated Shore class wetlands in the GDB (Table 2). Freshwater ponds and lakes comprise 13% of the wetland area and are the only water features with a semi-permanently flooded or intermittently exposed water regime.

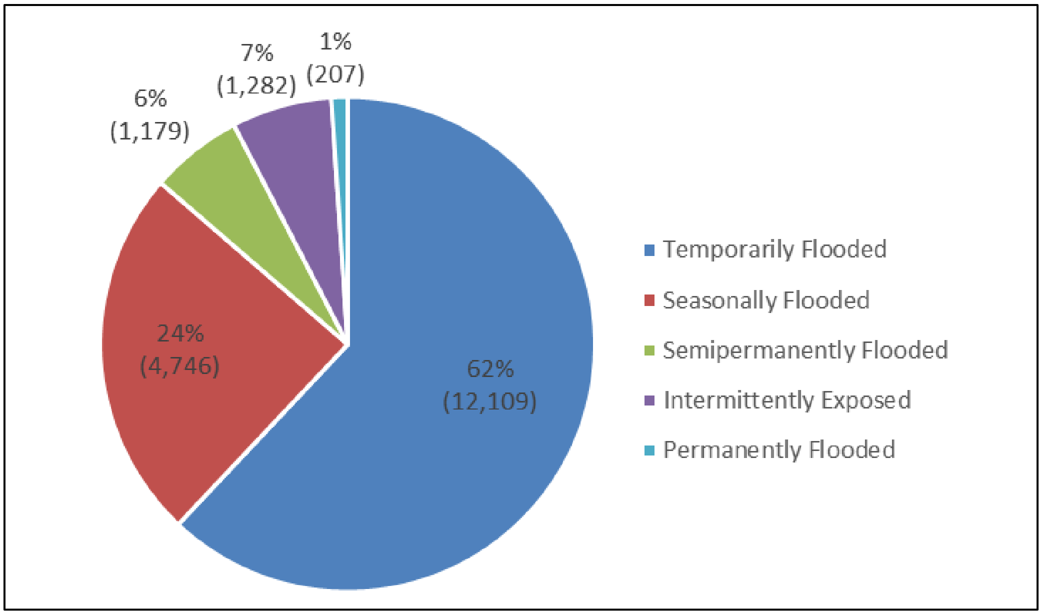


Figure 2. Surface area (acres) of wetlands classified according to NWI water regime in the GDB.

Table 2. Percent of wetlands with a specific hydrologic regime in the GDB.

		NWI Wetland Type					
	Water regime	**Palustrine Freshwater Emergent Wetland**	**Palustrine Scrub/Shrub Wetland**	**Freshwater Pond**	**Lake**	**Riverine**	**Palustrine Unconsolidated Bottom/Shore**
A	Temporarily Flooded	71%	100%	-	32%	-	72%
C	Seasonally Flooded	28%	-	-	32%	-	28%
F	Semi-permanently Flooded	1%	-	100%	10%	-	-
G	Intermittently Exposed	-	-	-	22%	-	-
H	Permanently Flooded	-	-	-	4%	-	-

3.1.3 Special modifiers describing wetlands

NWI mapping includes modifier codes that identify anthropogenic and natural alterations. Impoundments and dikes are the most prevalent anthropogenic modifications influencing approximately 9% (1699 acres) of the wetland area. There is no irrigation mapped within the GDB.

3.2 Land Ownership/Management

Land ownership/management in the GDB is essentially divided into northern and southern sections (Figure 3). The northern half of the basin is primarily managed by the BLM, while the southern half is a checkerboard of private land with public inholdings. Lands managed by the BLM comprise 69% (1,670,864 acres) of the basin and include 58% (11,393 acres) of the wetlands in the study area (Figure 4). Privately owned lands cover 28% of the basin (669,194 acres) and include 35% (6,853 acres) of the wetland area (Table 3). Oil and gas companies and the Union Pacific Railroad own much of this private land in the southern checkerboard area.

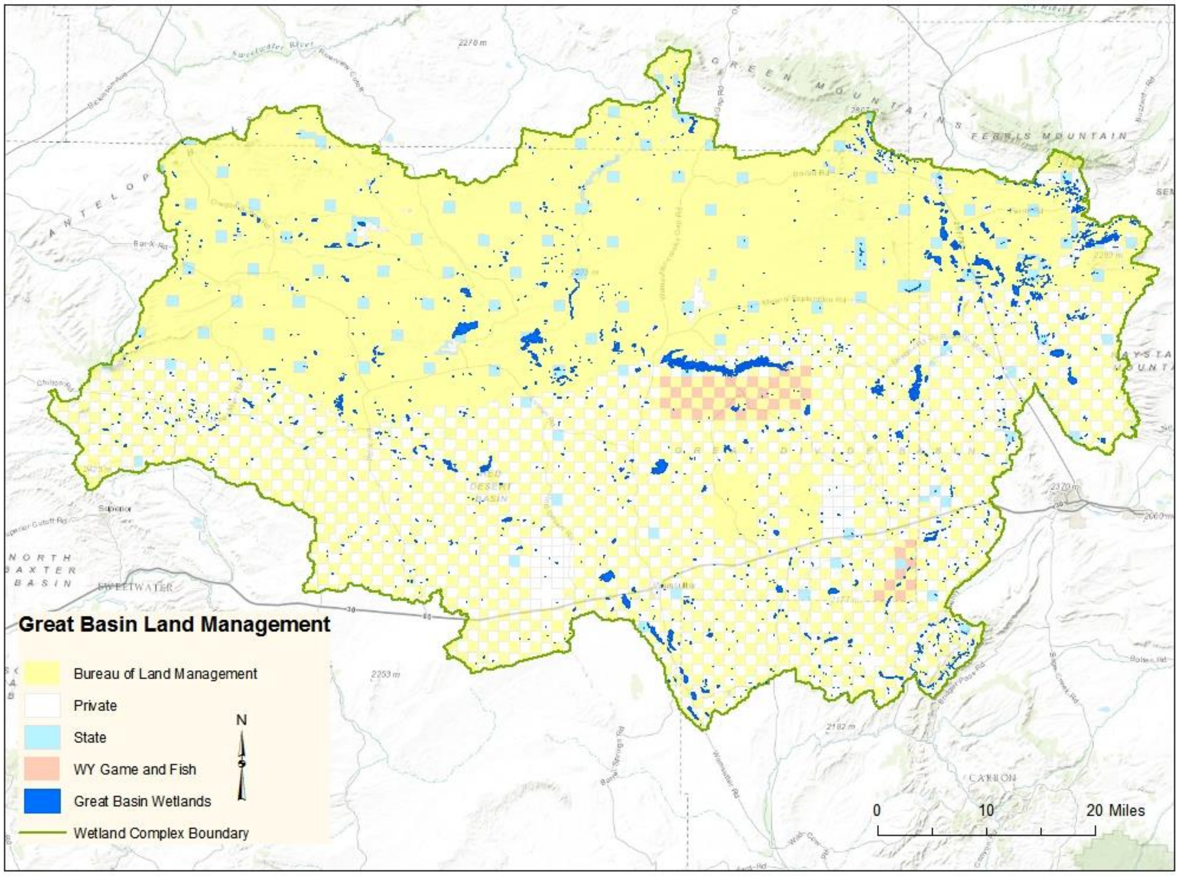


Figure 3. Spatial distribution of land ownership/management and wetlands within the GDB study area.

3.3 Land Use

Land use within the basin is primarily natural gas and oil extraction, mining, livestock grazing, and recreation (WBHCP 2014). Oil and gas development is focused north of Wamsutter and is expanding into the Chain Lakes Wildlife Habitat Management Area (Bureau of Land Management 2012). Agricultural production of livestock includes cattle grazing throughout most of the year and sheep grazing in the winter. Recreational use of the area includes wildlife and feral horse viewing, hunting, hiking, mountain biking, horseback riding, camping, ORV use, and visiting sand dunes.

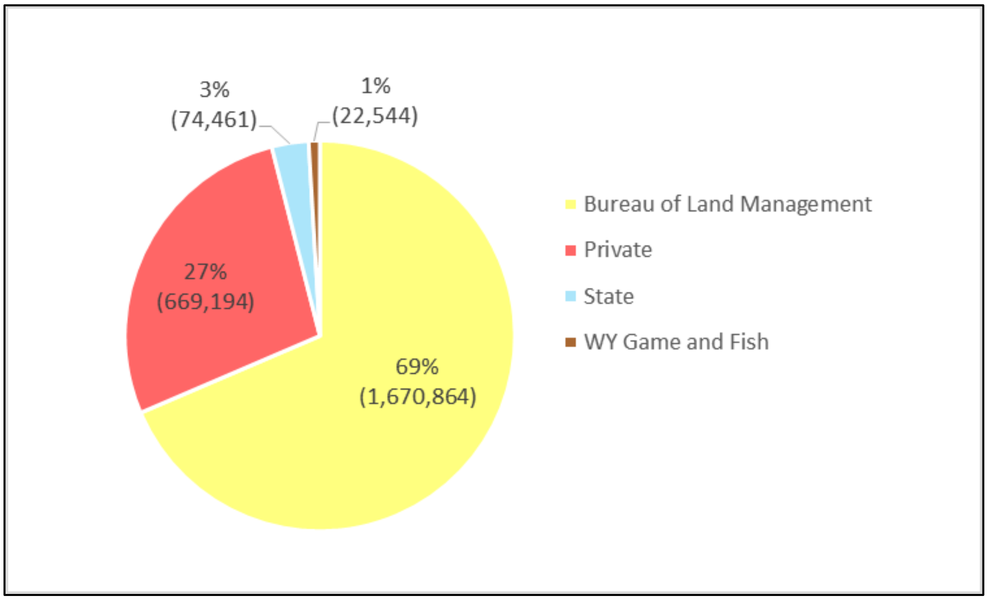


Figure 4. Description of land ownership/management of the study area in the GDB (acres).

Table 3. Land ownership/management of wetlands by area in the GDB

Landowner/ Manager	**Wetlands in GDB**		
	Acres	**% of Basin Area**	**% Wetland Acres**
Bureau of Land Management	11,393	0.5%	58.4%
Private	6,853	0.3%	35.1%
State	855	< 0.1%	4.4%
Water	355	< 0.1%	1.8%
WY Game and Fish Commission	66	< 0.1%	0.3%
Total	19,523	0.8%	100.0%

4.0 WETLAND CONDITION ASSESSMENT

4.1 Ecological Integrity Assessment Framework

The overarching goal of the Ecological Integrity Assessment (EIA) framework is to provide a rapid and repeatable evaluation of the ecological condition of a wetland. EIA methods were developed by NatureServe to assess the condition of wetlands across North America (Faber-Langendoen et al. 2011) and have more recently been refined by several regional wetland programs to specifically address wetland ecological condition in the Intermountain West (Rocchio 2007, Lemly and Gilligan 2012, Vance et al. 2012). We assessed condition of randomly selected wetlands in the LSRB based on EIA methods developed in Colorado by Lemly et al. (2012, 2013).

Descriptive metrics were used in the field to evaluate four attributes of each wetland: Landscape Context, Hydrologic Condition, Physicochemical Condition, and Biotic Condition. Separate disturbance indicator metrics that identify the severity of anthropogenic disturbance associated with degradation of wetland ecosystems were recorded. Metric scores for each of the four attributes were combined into an overall EIA score that can be used to describe wetlands in relation to a reference condition.

Hydrologic condition was evaluated using the Landscape Hydrology Metric (LHM) (Tibbets et al 2015) which assesses alteration to a wetland' s hydrologic regime. We incorporated additional intensive assessment protocols from Colorado's EIA framework (Lemly and Gilligan 2012) including a floristic quality assessments, soil characterization, and water quality incorporated.

4.2 Survey Design and Evaluation of Sample Sites

The following sections describe the survey design and process for selection of random sample sites. The steps in the survey design, were defining the target population, specifying the sample frame, choosing the sample size, and specifying the selection criteria. These methods are based on the EPA's National Aquatic Resource Survey program (Stevens & Olsen 2004; Detenbeck et al. 2005).

4.2.1 Wetland Definitions for Target Population

The target population is the set of wetlands that we want to characterize in the GDB. Our wetland target population consisted of the six classes of Palustrine wetlands that we used in the landscape profile (see Table 1). Palustrine wetlands can be situated shoreward of lakes or river channels, on floodplains, in locations isolated from water bodies, in depressions, or on slopes. The target population included all palustrine wetlands within the GDB study area and excluded non-wetland features such as deepwater lakes (Lacustrine system) and stream channel bottoms (Riverine system) (Table 4). We also set a minimum size threshold of at 0.1 hectare and a minimum width of 10 m.

4.2.2 Sample Frame and Classification

The sample frame is a digital representation of the target population. The digital NWI polygon dataset (U.S. Fish and Wildlife Service 1984) is a complete representation of the target population, but it contains a degree of detail that makes it very difficult to use without grouping NWI codes into wetland subgroups. We simplified the sample frame by grouping the NWI Cowardin et al (1979) codes into three target groups: 1) Alkali wet meadows; 2) Playa and saline depressions; and 3) Shrub flats. We the crosswalk each target wetland subgroup to the Ecological Systems classification (Comer et al. 2003, Appendix A). Classification by Ecological Systems is the dominant system used regionally for identifying wetland types in the field and provides a valuable system for defining landscape units by biotic (e.g., plant community) and abiotic (e.g., geologic, hydrologic, elevation) criteria (Lemly and Gillian 2012, Newlon et al. 2013). NWI codes were also crosswalk to Hydrogeomorphic (HGM) Classification (Brinson 1993; Adamus 2004) (Table 4).

Table 4. Target wetland subgroups classified by Cowardin, Hydrogeomorphic (HGM), and Ecological Systems used in the Great Divide Basin. Ecological System descriptions can be found in Appendix A.

Targeted Wetland Subgroups	NWI Codes	HGM	Ecological System
Alkali Wet Meadows	PEMA, PEMAh, PEMC, PEMCh, PEMF, PEMFh	Slope/Depression	*Ecological system description for wet meadows don't exist
Playa and Saline Depressions	L2ABG, L2USCh, PABF, PABFh, PUSAh, PUSC, PUSCh	Depression	Inter-Mountain Basins Alkaline Closed Depression, Inter-Mountain Basins Playa
Shrub Flats	PSSA, PUSA,	Slope	Inter-Mountain Basins Greasewood Flat

4.2.3 Sample Size and Selection Criteria for Site Evaluation

The target sample size was 75 sites selected from the sample frame, divide across the three target wetland subgroups. Sample sites were randomly selected from the sample frame using a Generalized Random Tessellation Stratified (GRTS) survey design for a finite resource (Stevens et al. 2004, Stevens and Jensen 2007). GRTS sampling was performed using R package spsurvey (Olsen and Kincaid 2009, R Development Core Team 2014).

After potential sample sites were randomly selected, and prior to field sampling, a desktop site evaluation was performed to determine: 1) whether a wetland was likely present, based on examination of aerial imagery (USDA Farm Service Agency 2009); and 2) land ownership/management status (private, state, federal). Permission was then sought to access sample sites.

Potential sample sites that met one of the following conditions were withdrawn from potential sample sites *before* field sampling:

1. Wetland type: the wetland at the site appeared to not belong to the target wetland group that the site was chosen to represent.
2. Size: the wetland area did not meet the minimum 0.1 hectare area threshold or 10-meter width threshold required for sampling
3. Minimum distance: the wetland was within 500 meters of another sample location of the same target subgroup.
4. Permission denied: permission to access the site was denied by the landowner.

Sites that remained after the initial review were visited and were evaluated by field crews before assessment. Sites that met one of the following conditions were withdrawn from the sample frame before field assessment:

5. Wetland type: the wetland did not belong to the target wetland group that the site was chosen to represent. The field crew used a key to ecological systems (Appendix A) for this evaluation
6. Access issues: permission was granted by landowner, but the point could not be safely accessed at the time of sampling. Sites were rejected if they were more than 2 miles from the vehicle for efficiency and safety of the field crew.
7. Depth: the wetland exceeded the maximum depth threshold of 1 meter and the assessment area could not be repositioned to a location that met our size criterion.
8. Hayed before sampling: all of the vegetation was cropped from the site prior to sampling, so that plant identification was not possible.
9. Not a wetland: the sample location did not meet our operational definition of a wetland (Appendix B) or no wetland was present due to mapping error

If a site was withdrawn from the set of potential sample sites, it was replaced with the next site from the sequential list generated by the GRTS site selection.

In addition to the random survey sites, we identified 3 to 4 reference wetlands from each wetland subgroup as representing “minimally disturbed condition” based on professional judgment of regional wildlife managers or the field crew. We used the definition provided by Stoddard et al. (2006) for minimally disturbed condition: “in the absence of significant human disturbance…representing the best approximation or estimate of biotic integrity)”.

4.3 Field Methods

Field methods were based on EIA protocols developed by Lemly et al. (2013). In addition, we collected data on soils and vegetation to supplement the EIA protocol. These assessments required a half a day or less to complete at each site. Detailed field data forms are included in Appendix C and field manual is available upon request.

4.3.1 Wetland Assessment Area (AA)

The field crew applied the EPA's National Wetland Condition Assessment (U.S. Environmental Protection Agency 2016) methodology for establishing an assessment area (AA) at each wetland site. When possible a standard 40 m radius circular AA was established. If the site configuration did not accommodate a circular AA of this size, the crew adjusted the AA to a rectangular or irregular shape of at least 1000 m^2 and 10 m wide. The AA boundary was marked with flagging to aid with data collection. A 500-m buffer was established from the perimeter of each AA. Standard descriptions of each wetland included: UTM coordinates, wetland classification, presence or signs of wildlife, and photos of the buffer and AA.

4.3.2 Ecological Integrity Assessment of wetland sites

After the AA was established, each wetland was assessed based on the EIA manual and field forms (see Appendix C) adapted from Lemly et al. (2013). The principal attributes and metrics that were measured in this study are summarized in Table 5.

Table 5. EIA attributes and field metrics used for wetland assessments in the GDB.

Attributes	Indicators and Metrics
Landscape Context	• Landscape Fragmentation • Buffer Extent • Buffer Width • Buffer Condition
Hydrologic Condition*	• Water Source • Hydrologic Connectivity • Alteration of Hydroperiod
Physicochemical Condition	• Water Quality • Algal Growth • Substrate/soil Disturbance
Biological Condition	• Relative Cover of Native Plant Species • Absolute Cover of Noxious Weeds • Absolute Cover of Aggressive Native Species • Mean C • Structural Complexity

* Field data were collected for the EIA hydrology metrics using the Colorado EIA method, however, we used Landscape Hydrologic Metric in place of the Colorado EIA method for scoring wetland condition.

4.3.3 Landscape Hydrology Metric (LHM)

Hydrology is broadly characterized as the movement, distribution, timing, and quality of water across the landscape. Hydrology is the primary driver of the processes that establish and maintain wetlands, including ecological, physical, and chemical processes that sustain ecosystem functions and associated services and values to people (Mitsch and Gossilink 2000). Therefore, it is important to identify alterations to the natural hydrologic regime that may detrimentally affect the structure and function of a wetland. Identifying alterations to natural wetland hydrology can be a challenge because significant alterations such as major dams or ditches may not be evident during a single site visit or are located outside the 500m buffer surrounding the AA. In addition, it can be difficult to identify a wetland's water source when the wetland is supported or created by hydrologic alterations, such as leaky dams or canals.

We used the Landscape Hydrology Metric (LHM) (Tibbets et al. 2015), instead of the hydrology component of the Colorado EIA method (Lemly et al. 2013), to calculate the hydrologic condition metrics. LHM incorporates landscape-level data identifying alterations to hydroperiod and water source, along with field data characterizing wetland soils. LHM relies on descriptive criteria from submetrics to assign a rank from 5 to 0 (Table 8). Historic wetlands (score = 5) were defined in this study as wetlands without evidence of hydrologic alteration, whereas created wetlands (score = 0) are dependent on hydrologic alteration.

Table 6. Landscape Hydrology Metric scoring criteria.

Hydrologic Category	LHM Score	Landscape Hydrology Metric Criteria
Historical Wetland	5	No alterations to hydrology identified, natural water source or no observed natural water source but histic soil layer present**.**
Hybrid Wetland in landscape with site-level hydrologic alterations	4	Site-level hydrologic alteration, natural water source identified or no observed natural water source but histic soil layer present**.**
Hybrid Wetland in landscape with basin-wide hydrologic alterations	3	Basin-wide hydrologic alteration (major dam present) and direct hydrologic connectivity to natural water source observed. No histic soil layer observed.
Supported Wetland with natural water source	2	Basin-wide hydrologic alteration (major dam present), landscape position is in depression with natural water source potential, however, dominant water source is unclear due to presence of large canals. No histic soil layer observed.
Supported Wetland- Irrigation Dependent Depression	1	Hydrologic alteration identified, landscape position is in depression. Irrigation is likely dominant water source. No histic soil layer observed.
Created Wetland - Irrigation Dependent	0	Hydrologic alteration identified, no natural water source identified. Irrigation is exclusive water source. No histic soil layer observed.

4.3.4 Vegetation Assessment
We used a plotless sample design to collect vegetation data using methods described in Lemly et al. (2012). Species searches were limited to no more than 1 hour at each site. Vascular plant species were identified using Dorn (2001) and regional keys including Johnston (2001), Skinner (2010), and Culver and Lemly (2013). Species names were taken from the WYNDD database. Unknown plant specimens were pressed in the field and saved for later identification. The percent cover of each species, including that of unidentified specimens, was estimated over the entire AA.

4.3.5 Soils
We dug 1 to 2 soil pits within each AA. The first soil pit was positioned in a representative location close to the AA center excluding those areas covered completely by water. An additional pit was dug if there was a high degree of variability within the site. We recorded GPS waypoints at each soil pit and then marked the location on a map. Pits were dug to a depth of 40 cm (about one shovel length) when possible. The core was removed and laid next to the pit, ensuring all horizons were intact and in order. We recorded the following information from each horizon: 1) color (based on a Munsell Soil Color Chart (2013)) of the matrix and any redoximorphic concentrations (mottles and oxidized root channels) and depletions; 2) soil texture; and 3) any other specifics about the concentration of roots, the presence of gravel or cobble, or other unusual soil features. Hydric soil indicators were identified based on guidance from the Interim Regional Supplement to the U.S. Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (2008) and the National Resources Conservation Service (NRCS) Field Indicators of Hydric Soils in the United States (Vasilas et al. 2010).

4.3.6 Surface Water Characterization
We estimated percent cover and interspersion (patch complexity) of open water within the AA. The water depth range and average were recorded within the AA.

4.4 Data Analysis

4.4.1 Data Management
All field data were entered into relational databases that were developed using Microsoft Access and/or ArcGIS 10.3 platforms. Data were then reviewed to correct any errors prior to analysis. The data are stored at the Wyoming Natural Diversity Database.

4.4.2 Ecological Integrity Assessment Scores
To be effective tools, ecological assessment metrics should provide information about the integrity of major ecological attributes in relation to a gradient of disturbances. We evaluated performance of each EIA metric based on methods used to refine stream and wetland condition indices (Stoddard et al. 2008, Deller et al. 2010, Faber-Langendoen et al. 2011). Evaluation of EIA methods and scoring was a vital step to ensure the EIA methods we selected were relevant

and effective for assessing wetland condition in Wyoming. The applicable range of each metric was determined by examining histograms depicting ranges and distributions of scores. We evaluated metric redundancy by calculating Spearman's rank correlation coefficients among all metrics. None of the metrics within an attribute category were found to be highly correlated (as determined by a coefficient value of $r > 0.8$).

We calculated EIA scores and thresholds based on EIA methods used in Colorado (Lemly and Gillian 2013). Refer to Appendix D for a detailed description of scoring formulas and thresholds with ranks ranging from A-D. Reference and "A" ranked wetlands are those with the highest scores in minimally disturbed condition (MDC), representing the best approximation of "naturalness" or a high degree of "biological integrity" on the landscape (Stoddard et al. 2006). As EIA scores declined from B to D ranked wetlands, there was increasing evidence of human disturbance and deviation from reference condition.

We created a cumulative distribution function (CDF) plot to display EIA scores estimated for wetlands across the entire sample frame in the GDB. CDF plots use scores from the random sample to create a probability plot for the entire basin. CDF plots are useful to estimate the cumulative proportion of the resource (wetlands) estimated to have at least a certain EIA score (Whittier et al. 2002). EIA rank thresholds were superimposed on the CDF plot to facilitate interpretation of the cumulative number of wetlands within each rank. Cumulative distribution functions were calculated using R software package version 3.3.3 (R Development Core Team 2014) available from the spsurvey library.

4.4.3 Floristic Quality Assessment (FQA)

Floristic Quality Assessment (FQA) uses plant community composition as an indicator of ecological condition. The FQA method assesses the degree of human caused disturbance based on the proportion of "conservative" plants present. "Coefficients of conservatism" (C-values) are the foundation of FQA. C values range from 0 to 10 and represent an estimated probability that a plant is likely to occur in a landscape relatively unaltered from conditions that existed before European settlement (Swink and Wilhelm 1979, 1994). A C-value of 10 is assigned to plant species having low tolerance for habitat degradation and are restricted to relatively unaltered areas, whereas a 0 is assigned to plant species with a wide tolerance to human disturbance (Rocchio 2007). Species with low C values may be found in relatively unaltered areas, but they also grow in altered areas. Once C-values have been assigned for a given region or area, they can then be used to calculate a number of FQA indices such as the average C-value of a site (Mean C) and the Floristic Quality Assessment Index (FQAI) (Swink and Wilhelm 1979, 1994). C-values were developed for Wyoming in 2017 and have been incorporated into data analysis (Washkoviak et al. 2017)

We used C-values recently developed for wetland plants in Wyoming (Washkoviak et al. 2017). We calculated Mean C, total species richness, and the numbers of native and non-native species based on the species lists compiled during the vegetation survey at each wetland site. Mean C is calculated by summing the C-values of the plant species found at each site, and then dividing by the number of species.

5.0 WETLAND CONDITION ASSESSMENT RESULTS

5.1 Characteristics of Sampled Wetlands

All randomly selected sites from the initial survey design (n = 225) of the three target subgroups (75 each - alkali wet meadow, playa and saline depression, shrub flat) were evaluated using the defined selection criteria, but not all sites were sampled or included in the study (Table 7). Permission was denied at 41 sites and six sites did not meet minimum distance criteria (Table 8). Access issues due to limited roads and rough terrain accounted for 58 site rejections. Forty-one sites were rejected in the field before sampling because they did not meet our operational definition of a wetland (Appendix B).

Fifty-seven randomly selected wetlands and 11 reference sites were sampled between June and September of 2015. Of those sampled, four sites were rejected from the study post-sampling due to the refinement of the definition of shrub flat wetlands (see following section).

Table 7. Number of wetland sites evaluated, sampled, and rejected during the study by wetland subgroup.

Target wetland subgroups	# Sites in survey design	# Sites evaluated	# Random survey sites sampled	# Sites rejected (see table 8)	Total # random survey sites incl. in study	# Reference sites
Alkali Wet Meadow	20	53	23	34	23	4
Playa and Saline Depression	20	75	19	55	17	3
Shrub Flat	20	75	15	61	13	4
Total	60	203	57	150	53	11

Table 8. Reasons for rejection of wetlands in the GDB during the study.

Target wetland subgroups	Rejection Cause			
	Permission denied	Minimum distance	Access Issue	Not a wetland
Alkali Wet Meadow	9	3	13	9
Playa and Saline Depression	20	2	23	10
Shrub Flat	12	1	22	26
Total	41	6	58	45

5.1.1 Characteristics of sampled wetland subgroups

A field key was used to classify each sampled wetland according to an ecological system key developed for wetlands in Wyoming (Appendix A). After completion of the field survey, we summarized the general characteristics of each of the three wetland subgroups. The descriptions below include specific observations made during field sampling in the GDB combined with more general information from the ecological system key.

Alkali Wet Meadow

Alkali wet meadows are large herbaceous wetlands associated with a high-water table. In the GDB, these are typically located along the edges of playas and saline depressions, near springs, or intermixed with other wetland types (e.g. Chain Lakes Flat in Fig. 5). These wet meadows typically lack prolonged standing water. Vegetation is dominated by native or non-native herbaceous species with graminoids accounting for most of the canopy cover. Common species include *Distichlis spicata, Juncus arcticus ssp. littoralis, Puccinellia nuttalliana,* and *Carex praegracilis*. Patches of emergent marsh vegetation and standing water less than 0.1 ha may be present but are not the predominant cover types.

Figure 5. Alkali wet meadow wetlands in the GDB.

Playa and Saline Depression

Playa and Saline Depressions have variable moisture regimes and are located in basins with internal drainage. Wetter examples of this wetland type are seasonally to semi-permanently flooded and usually retain water into the growing season. Some receive groundwater inputs from springs or are supplemented by irrigation seepage and dry out completely only in drought years. Drier examples of this wetland type are intermittently flooded and only receive water through precipitation and snowmelt. Drying exposes barren and sparsely vegetated mud flats that may become dominated by annual vegetation. Soil salinity varies with soil moisture and greatly affects species composition. Salt crusts may form in some areas. The vegetation in the GDB is typically dominated by salt tolerant species such as *Distichlis spicata, Puccinellia spp., Schoenoplectus maritimus, Schoenoplectus pundens, Triglochin maritima,* and *Salicornia rubra*.

The Chain Lakes Wildlife Habitat Management Area located inside the GDB is part of the largest extent of playa vegetation in Wyoming (Heidel 2008).

Figure 6. Playa and saline depression wetlands in the GDB.

Shrub Flat

Shrub Flats are low-lying, nearly flat or depressional areas where surface flow from precipitation and snow melt accumulates. The wetland area usually consists of barren mud flats that show evidence of hydrology through salt accumulation or cracked soil. Vegetation cover of shrub and grass species is greater than 10%. The plant community in the GDB is dominated by *Sarcobatus vermiculatus* and *Atriplex* spp. with inclusions of *Sporobolus airoides, Pascopyrum smithii, Distichlis spicata, Puccinellia nuttalliana,* and other herbaceous vegetation. Vegetation at sampled wetlands occurred on interspersed "islands" or mounds raised above the surrounding mudflats (Figure 7). These wetlands proved to be difficult to target and identify using NWI mapping and aerial imagery (see Section 5.1.2).

Figure 7. Shrub flat wetlands in the GDB.

5.1.2 Challenges of Identifying Shrub Flat Wetlands

We encountered several challenges in evaluating and selecting shrub flat wetlands for sampling. The most significant challenge was identifying shrub flat wetlands using the NWI wetland data layer (U.S. Fish and Wildlife Service 1984). The NWI wetland layer identifies polygons by wetland class and water regime using codes from the Cowardin et al. (1979) classification system. During development of the survey design, we assumed that shrub flats would be found in wetland polygons identified in the NWI layer as palustrine shrub scrub (PSS) or palustrine unconsolidated shore (PUS) wetlands with a temporary water regime (A) (Table 5).

These assumptions were based on previous descriptions of shrub flats (CNHP 2005) and from personal observation. For example, shrub flats are described as being associated with shallow groundwater but can have surface water present after precipitation events and are dominated by greasewood (*Sarcobatus vermiculatus*) (CNHP 2005). In addition, greasewood normally grows at low spots in the landscape where water can accumulate (Knight et al. 2014). Moreover, greasewood shrub flat wetlands that we had visited previously within the study area (while driving between Muddy Gap and Rawlins, WY) are mapped by the NWI as PSSA and PUSA wetlands (Figure 8). Therefore, we concluded that other wetlands mapped with PSSA and PUSA codes by NWI, and in which aerial imagery appeared to show greasewood, would be shrub flat wetlands that fit the definitions of our study design.

However, 56 of the 75 randomly-selected PSSA and PUSA shrub flat sites were rejected for sampling because they lacked two or more wetland indicators and therefore did not meet our operational definition of a wetland. Some of the rejected locations were stands of mixed desert shrubland (an upland vegetation-type; Knight *et al.* 2014) dominated by Gardner's Salt Bush (Figure 10). Others were small, barren, playa-like features that are surrounded by sagebrush and had no wetland indicators other than cracked soils (Figure 9). These features occur in small, localized drainage basins where water from precipitation collects and pools long enough to impact soil chemistry and vegetation characteristics, but not long enough to form diagnostic wetland indicators.

To further complicate the situation, many of the greasewood stands that we selected opportunistically as shrub flat reference sites occurred in expansive greasewood complexes that were not identified as wetland polygons by NWI.

After much consideration, we think our attempt to identify shrub flat wetlands using NWI in our survey design failed for two reasons:

1) There is too much variability within the PUSA Cowardin classification and most of these locations should not be considered wetland polygons. Rejected PUSA locations were composed of mixed-desert shrubland vegetation or were small playa like features that lacked 2 or more wetland characteristics (Figures 9 & 10).

2) Portions of the expansive greasewood shrub complexes in the GDB do pool surface water or have perched groundwater long enough to form wetland indicators, but these locations are impossible to find with current NWI wetland mapping and aerial imagery.

We confirmed the presence of shrub flat wetlands in the GDB, but their spatial distribution is limited. Additional research is needed to understand the dynamics of these and similar non-wetland systems in the GDB.

Figure 8. A greasewood shrub flat wetland from the ground (left) and on aerial imagery (right). PSSA is the Cowardin (NWI) code for the wetland polygon.

Figure 9. A small playa-like feature viewed from the ground (left) and on aerial imagery (right). PUSA is the Cowardin (NWI) code for the polygon in the NWI layer, but the field evaluations indicated that this is actually not a wetland.

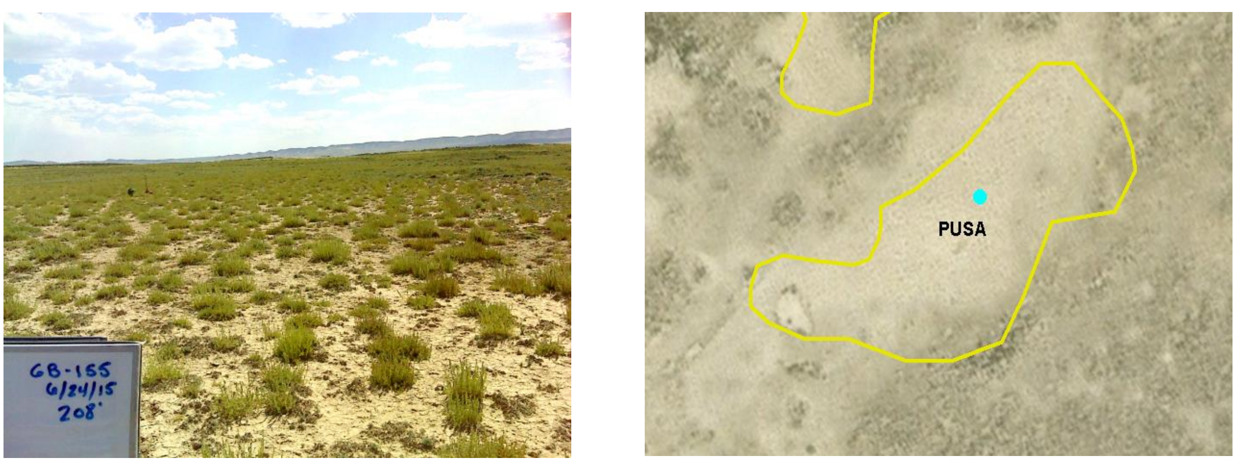


Figure 10. A mixed-desert shrubland dominated by Gardner's saltbush viewed from the ground (left) and on aerial imagery (right). PUSA is the Cowardin (NWI) code for the polygon in the NWI layer, but field evaluation showed that this is actually not a wetland

5.3 Characterization of Wetland Vegetation

5.3.1 Species Diversity of Wetland Vegetation

Plant surveys identified 141 taxa of vascular plants at the 64 wetlands sampled. Six taxa were identified only to genus and two more only to family, because diagnostic floristic parts required for species identification were absent at the time of sampling. The remaining 133 taxa were identified to the species level and represent 5% of Wyoming's flora (Dorn 2001). Given that 56% of the species were encountered only once or twice, it is probable that additional survey effort would detect more species.

The top ten most common plant species found at wetlands sampled in the GDB were native. All wetland sites had native species present with the most common species being Greasewood (*Sarcobatus vermiculatus*), found in 37 (58%) of the sampled sites; arctic rush (*Juncus arcticus* ssp. *littoralis*), found in 34 (53%) of the sampled sites; and seaside arrowgrass (*Triglochin maritima*) and seablite (*Suaeda calceoliformis*), both found in 31 (48%) of the sampled sites (Table 9). Only 29 (45%) sites had non-native species present. The most common non-native species were desert madwort (*Alyssum desertorum*), common dandelion (*Taraxacum officinale*), and cheatgrass (*Bromus tectorum)* (Table 10). They were observed at 10 (16%), 8 (13%), and 7 (11%) of sites respectively.

Table 9. Ten most common plant species documented at sampled wetland in the GDB**.**

Species	% of Sites	Wetland Status	Nativity	WY C Value	Common Name
Sarcobatus vermiculatus	58%	FAC	Native	4	Greasewood
Juncus arcticus ssp. Littoralis	53%	FACW	Native	3	Baltic Rush
Triglochin maritima	48%	OBL	Native	5	Common Bog Arrow-grass
Suaeda calceoliformis	48%	FACW	Native	3	American Sea-blite
Puccinellia nuttalliana	44%	FACW	Native	4	Nuttall's Alkali Grass
Distichlis stricta	44%	FAC	Native	4	Indian Saltgrass
Spartina gracilis	30%	FACW	Native	5	Alkali cordgrass
Carex praegracilis	28%	FACW	Native	5	Clustered Field Sedge
Plantago eriopoda	27%	FACW	Native	5	Saline Plantain
Elymus elymoides	27%	FACU	Native	4	Bottlebrush Squirrel-tail
Cirsium scariosum	27%	FAC	Native	6	Drummond's Thistle

Table 10. Frequencies of native and non-native species encountered at the sites sampled in the GDB.

Native		Non-Native	
Species	**% of Sites**	**Species**	**% of Sites**
Sarcobatus vermiculatus	58%	*Alyssum desertorum*	16%
Juncus arcticus ssp. Littoralis	53%	*Taraxacum officinale*	13%
Triglochin maritima	48%	*Bromus tectorum*	11%
Suaeda calceoliformis	48%	*Polygonum aviculare*	9%
Puccinellia nuttalliana	44%	*Chenopodium glaucum*	8%
Distichlis stricta	44%	*Descurainia Sophia*	5%
Spartina gracilis	30%	*Tragopogon dubius*	5%
Carex praegracilis	28%	*Sonchus asper*	5%
Plantago eriopoda	27%	*Cirsium arvense*	2%
Elymus elymoides	27%	*Bassia hyssopifolia*	2%

5.3.2 Floristic Quality Assessment

Across all wetland types, wetland plant communities sampled in the GDB had high relative cover of native species (94%), and had, on average, the lowest number of wetlands with non-native species present compared to other basins sampled in Wyoming (Table 11) (Tibbets et al. 2015, 2016b, 2016a). The average Mean C for all species over all wetland types sampled was 3.87. Wet Meadows had the highest native Mean C (4.47) but the lowest relative percent cover of native species (90%), and the Playa and Saline Depressions had the lowest native Mean C (3.97) and the highest relative cover of native species (97%). The low Mean C values for Playas and Saline Depressions are consistent with previously sampled alkaline wetlands in Wyoming and Colorado (Tibbets et al. 2015, 2016a, 2016b, Lemly et al. 2011, 2012). One explanation for lower Mean C could be because the species found in alkaline deserts are adapted to harsh environmental conditions and likely to tolerate disturbance.

Table 11. Floristic quality assessment indices calculated for wetlands in the GDB.

FQA Indices	Alkali Wet Meadow		Playa and Saline Depression		Shrub Flat		Overall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total species richness	17.0	6.6	6.1	2.7	6.9	5.0	11.0	7.4
Native species richness	15.1	6.2	6.0	2.7	6.1	4.4	9.9	6.6
Non-native species richness	2.4	1.5	1.5	.7	1.9	1.6	2.2	1.5
Mean C of all species	3.98	.74	3.87	.6	3.71	.7	3.87	.7
Mean C of native species	4.47	.49	3.97	.54	4.09	.48	4.22	.54
FQI of all species	16.3	5.0	9.47	3.04	8.9	3.87	12.2	5.5
FQI of native species	17.2	4.9	9.60	3.0	9.6	4.1	12.9	5.6
Adjusted FQI	37.8	8.5	38.37	6.6	35.8	8.2	37.4	7.8
Relative % cover native species	90.7%	8.4%	97.16%	10.9%	95.9%	6.8%	94.0%	9.2%
Absolute % cover noxious species	1.7%	1.4%	-	-	.3%	.2%	1.3%	1.5%
Absolute % cover Non-native species	6.6%	3.8%	5%	5.7%	3%	3.1%	5.6%	3.9%

5.3.3 Plant Species of Conservation Concern

The Wyoming Natural Diversity Database (WYNDD) develops and maintains lists of species in Wyoming that are rare, endemic, disjunct, threatened, or otherwise biologically sensitive (WYNDD 2017). The Wyoming Plant Species of Concern List (SOC) and the Wyoming Plant Species of Potential Concern List (SOPC) show the vascular plant species, subspecies and varieties that meet one of these one or more of these criteria.

One globally vulnerable (G3) species (*Sisyrinchium pallidum*) was found at six sites in the GDB during sampling (Table 12). In addition, 13 state-imperiled (S2) species, three state-imperiled/vulnerable (S2S3) species, and 24 state vulnerable (S3) species were found at the sampled sites in the GDB.

Table 12. Species of concern identified at sampled wetlands within the GDB.

G3 Species	# Sites
Sisyrinchium pallidum	6

S2 Species	# Sites
Amphiscirpus nevadensis	6
Chenopodium hians	1
Chenopodium simplex	1
Chrysothamnus vaseyi	1
Monolepis pusilla	1
Packera werneriifolia var. werneriifolia	1
Pectocarya penicillata	7
Poa arida	11
Potentilla rubricaulis	1
Ranunculus gmelinii	1
Streptanthus cordatus	1
Suckleya suckleyana	5
Thermopsis montana	1

S2S3 Species	# Sites
Navarretia intertexta var. propinqua	1
Pyrrocoma lanceolata	1
Sisyrinchium pallidum	6

S3 Species	# Sites
Astragalus ceramicus	1
Bassia americana	2
Calamagrostis stricta	4
Carex lenticularis	2
Carex simulata	1
Chrysothamnus linifolius	1
Cirsium scariosum	17
Eleocharis quinqueflora	3
Epilobium clavatum	1
Glaux maritima	12
Juncus ensifolius var. ensifolius	1
Lupinus sericeus	1
Muhlenbergia filiformis	1
Pedicularis crenulata	3
Plantago eriopoda	17
Platanthera aquilonis	1
Potentilla anserina	8
Pyrrocoma uniflora	13
Rumex venosus	1
Salicornia rubra	8
Schoenoplectus acutus	1
Suaeda calceoliformis	31
Symphyotrichum falcatum var. commutatum	1
Triglochin palustris	1

5.4 Wildlife Observations

Wildlife observations were recorded opportunistically during wetland sampling (see Appendix C, p. 2). Presence of wildlife and/or wildlife sign (tracks, scat, etc.) were observed at 54 sites (84%). Migratory birds, including Mallards, Blue-winged teal, American coots, Great blue herons, and American avocets, were observed at 20 locations. Avocets, Mallards, Blue Wing Teal, and Coots were all observed nesting within the basin. Greater sage grouse were observed at three sites with one flock consisting of over 25 individuals. A tiger salamander was unintentionally caught during invertebrate sampling at an intermittently flooded playa. Spade foot toads were observed in a seasonally flooded pool within 50m of a sample site near the Ferris Sand Dunes and were heard vocalizing along the western edge of the Chain Lakes Wildlife Habitat Management Area.

Table 13. Wildlife observations made durring wetland sampling effort

		# of Sites		
	Wildlife	**Visual**	**Tracks/ Vocalization**	**Nesting**
Ungulates	Pronghorn	5	15	
	Elk	2	10	
	Moose		1	
	Feral Horses	3	1	
Birds	American Avocet	9		1
	Great blue Heron	1		
	Ducks	7		2
	Killdeer	5		
	American coot	1		1
	Goose	1		
	Greater sage grouse	3	1	
Mammals	Coyote		11	
Amphibians	Tiger salamander	1		
	Spadefoot toad	1	1	
Reptiles	Western short-horned lizard	1		
	Prairie rattlesnake	1		

Figure 11. Salamander accidentally collected at a sampled wetland

5.5 Wetland Condition Assessment

5.5.1 Ecological Integrity Assessment of Sampled Wetlands

Ecological integrity assessment (EIA) scores from 64 sampled wetlands ranged from 3.33 to 4.9 out of a possible range of 1.0 - 5.0. We established four wetland condition categories based on threshold values defined in Appendix D:

- A (4.5 - 5.0) = At or near reference condition (no or little human impact-see Section 4.4.3)
- B (3.5 - < 4.5) = Level of disturbance indicates slight departure from reference condition
- C (2.5 - < 3.5) = Level of disturbance indicates moderate deviation from reference condition
- D (< 2.5) = Level of disturbance indicates severe deviation from reference condition

Twenty-five (39%) of the 64 study sites in the GDB were ranked "A," 36 sites (56%) were ranked "B," three sites (5%) were ranked "C," and none were ranked "D" (Figure 12). Playas and Saline Depressions were ranked in the highest condition compared to other wetland types.

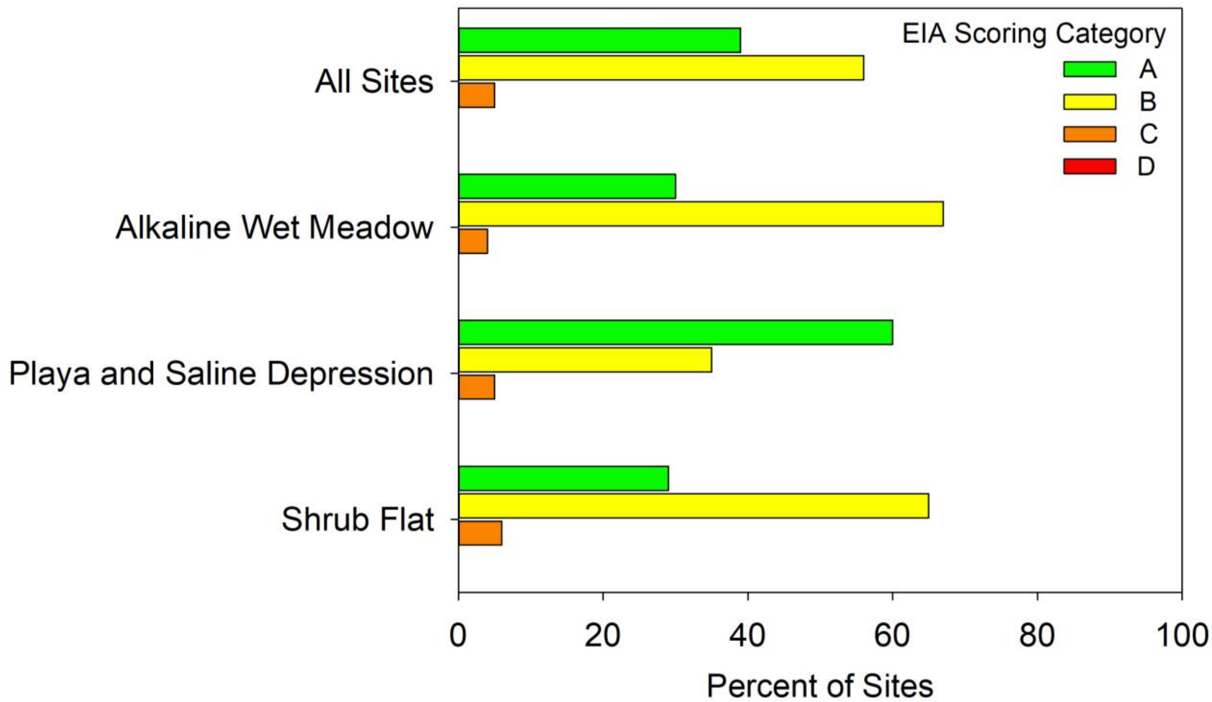


Figure 12. Ninety-five percent of the wetlands in the GDB received a condition score of B or above. Condition scores were highest for Playa and saline depression wetlands, indicating over 60% of these wetlands surveyed were near or at reference condition.

EIA scores were derived from 4 attributes: landscape context, biotic condition, physicochemical condition, and the Landscape Hydrology Metric. Landscape context rankings ranged from A-C, and 75% of sampled wetland received an A ranking (Table 14). This indicates a low level of human disturbance in the buffer surrounding sampled wetlands at the time of the survey. Over half of the sites (59%) received biotic attribute scores that ranked B across all wetland subgroups. Physicochemical condition rankings were relatively lower than other attribute scores, with 17% of wetlands receiving a rank of C or lower. Interestingly, scores across all wetland subgroups for each EIA attribute were similarly distributed, indicating similar patterns of disturbance across wetland types. Frequencies of LHM classifications are shown at the bottom of Table 14 for comparison to the other EIA attribute ranking frequencies.

Table 14. Ranks for each EIA attribute class by wetland subgroup for the GDB.

Wetland Subgroup	EIA Landscape context rank			
	A	B	C	D
Alkaline wet meadow	18	8	1	
Playa & saline depression	16	4		
Shrub flat	14	3		
Total	**48**	**15**	**1**	**0**

Wetland Subgroup	EIA Biotic condition rank			
	A	B	C	D
Alkaline wet meadow	2	16	9	
Playa & saline depression	3	12	4	
Shrub flat	1	10	6	
Total	**6**	**38**	**19**	

Wetland Subgroup	EIA Physicochemical condition rank			
	A	B	C	D
Alkaline wet meadow	13	8	3	3
Playa & saline depression	13	5	1	1
Shrub flat	8	6	2	1
Total	**34**	**19**	**6**	**5**

Wetland Subgroup	LHM Hydrology classification			
	Historical	Hybrid	Supported	Created
Alkaline wet meadow	18	9		
Playa & saline depression	17	3		
Shrub flat	14	3		
Total	**49**	**15**	**0**	**0**

5.5.2 Estimate of Wetland Condition for targeted wetlands in the GDB

We used EIA scores and condition category thresholds to estimate the ecological condition of wetlands throughout the GDB study area. Cumulative distribution function (CDF) estimates were derived from the sample design to estimate the number of wetlands each sample site represented across the total sample frame in the basin. Percent and standard error of number of wetlands within each ranking category were calculated and are shown in Table 15. The CDF plot is approximately linear, indicating that estimated EIA scores are evenly distributed across the wetland population (Figure 13). Based on CDF analysis, 34% of wetlands in the Great Basin are estimated as A-ranked, 61% B-ranked, 5% C-ranked and no D-ranked wetlands (Table 15). Confidence intervals vary along the plot and are smaller at the lowest scores. An assumption of the CDF analysis is that data were obtained from a random sample representative of the wetland population in the study area. However, the sample size was limited because of either landowner denial of access (18% of wetlands) or other rejection criteria (26%).

Table 15. Population estimate of EIA ranks for wetlands in the GDB. Observed = percent of sampled sites within each rank; Estimate = percent of wetland number extrapolated using 53 wetlands from the sample frame.

EIA Rank	Observed	Estimate	95% Confidence Interval
A	39%	34%	24-44%
B	56%	61%	50-72%
C	5%	5%	0-11%

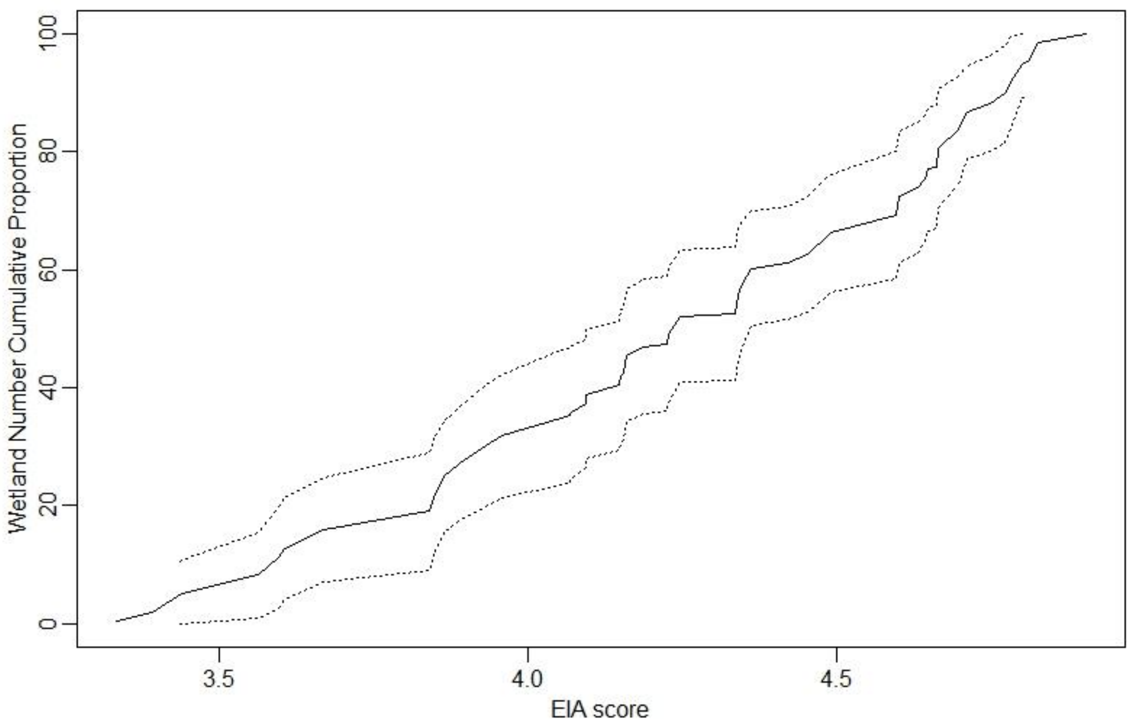


Figure 13. Cumulative distribution function of wetland EIA scores with 95% CI shown. Graph is the cumulative proportion of wetlands (y-axis) with EIA scores at or below values on the x axis. Center solid line indicates the estimate and is surrounded by dashed line

5.5.3 Landscape Hydrology Metric

The Landscape Hydrology Metric (LHM) is an assessment of alteration to hydrologic regime of sampled wetlands. LHM incorporates landscape-level data identifying alterations to hydroperiod and water source, along with field data characterizing wetland soils. LHM relies on descriptive criteria from submetrics which can be found in Section 4, Table 6.

Forty-nine (77%) of the wetlands sampled in the GDB were scored as historical and the remaining 15 (23%) were identified as having an altered-hybrid hydrologic regime (Figure 14). These results were not surprising since there are no irrigated lands mapped in the study area. All forms of hydrologic alterations occurred in the form of bermed ponds that held water in ephemeral drainages for variable periods throughout the growing season.

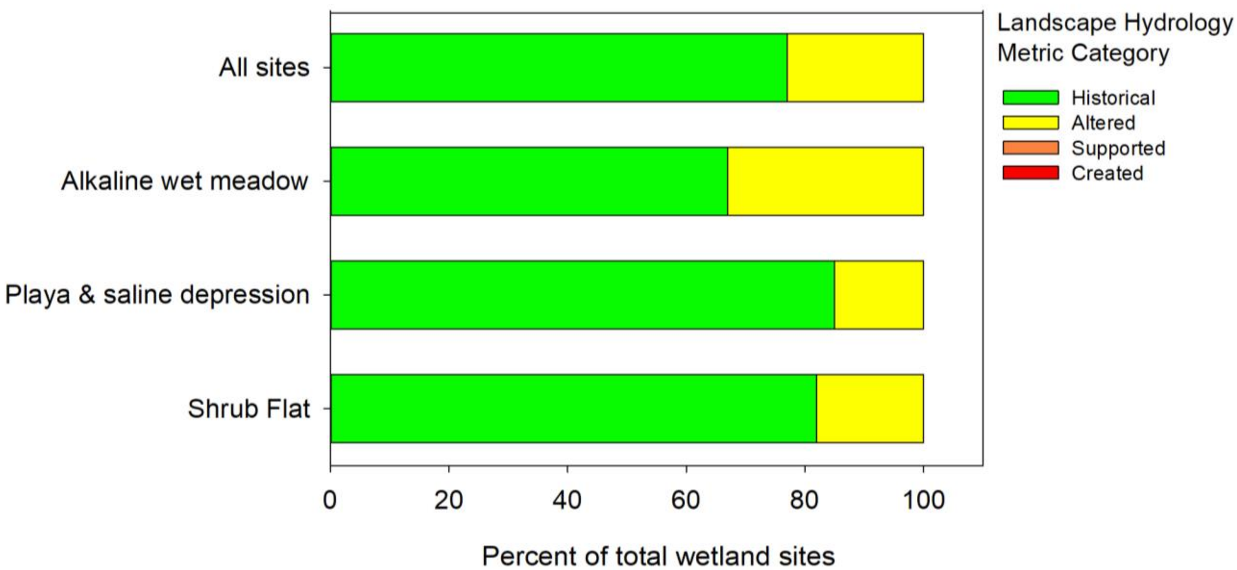


Figure 14. Proportion of total wetland sites in each category based on the Landscape Hydrology Metric.

5.5.4 Indicators of disturbance

Potential indicators of disturbance include natural phenomena or human caused land management impacts that have the ability to stress a wetland or reduce its ecological condition. These indicators can be used to identify the most prevalent impacts affecting wetland health in a given area and can help land mangers change and address disturbances that are under their control. We recorded indicators of disturbance within a 500-meter wide buffer around the wetland and within the wetland boundary. These indicators were later grouped into categories based on disturbance type. A full list is available in Appendix E.

The most common potential indicators of disturbance the GDB are listed in Figure 15. Soil degradation due to soil compaction (pugging) from livestock and wild horses was the most prevalent indicator of disturbance, occurring at 44 (69%) sites. Roads were observed within 500 meters of 38 (59%) sites. Invasive species were present at 29 (45%) sites. Grazing, likely from wild horses and elk, was observed at 20 (34%) sites. Cattle grazing is uncommon in the basin due to the lack of water. Note that we did not gain access to sample in portions of the basin where there is heavy oil and gas development, so we do not know how this land use is affecting wetland condition in these areas.

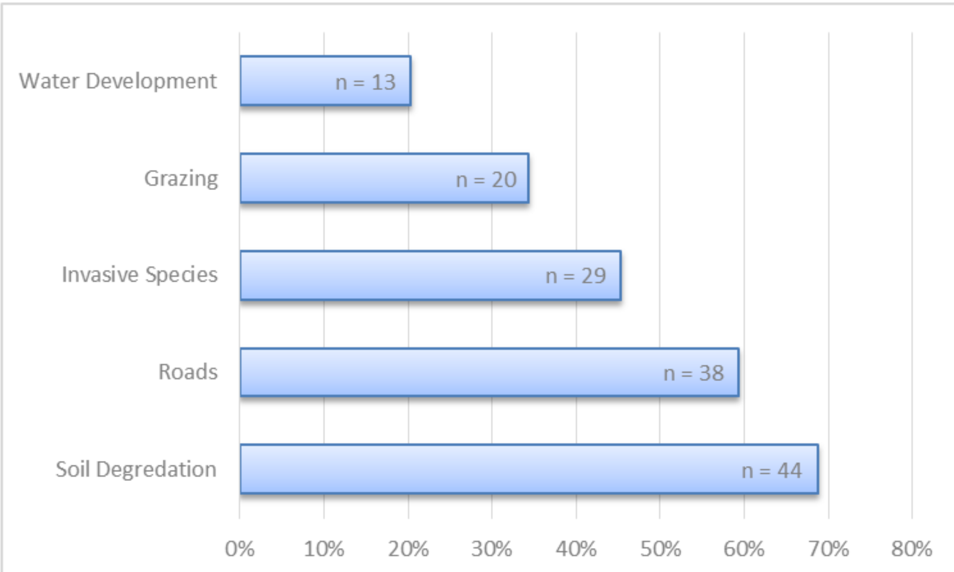


Figure 15. Potential stressors observed across all wetland subgroups in the GDB.

6.0 THE CHAIN LAKES WILDLIFE HABITAT MANAGEMENT AREA

All reference to the Chain Lakes in this report refers to the designated Chain Lakes Wildlife Habitat Management Area unless stated otherwise (Figure 16). The Chain Lakes encompass 60,946 acres within the GDB study area. This section of the report includes results of updated NWI mapping and a summary of wetland condition for fourteen wetlands sampled in the Chain Lakes during the survey described in Section 4.3.

The Chain Lakes is a "unique, fragile, and rare" alkaline desert lake and wetland complex managed in cooperation by the Wyoming Game and Fish Department and the Bureau of Land Management (Bureau of Land Management 2008). The lower elevations are dominated by the "chain lakes", which is an extensive wetland complex consisting of playa lakes, greasewood shrublands, alkali wet meadow vegetation, and sand dunes (Knight et al. 2014). This area provides important habitat for pronghorn, elk, and Greater sage-grouse, and are an important stopover for migratory waterfowl and shorebirds (Wyoming Game and Fish Department 2017).

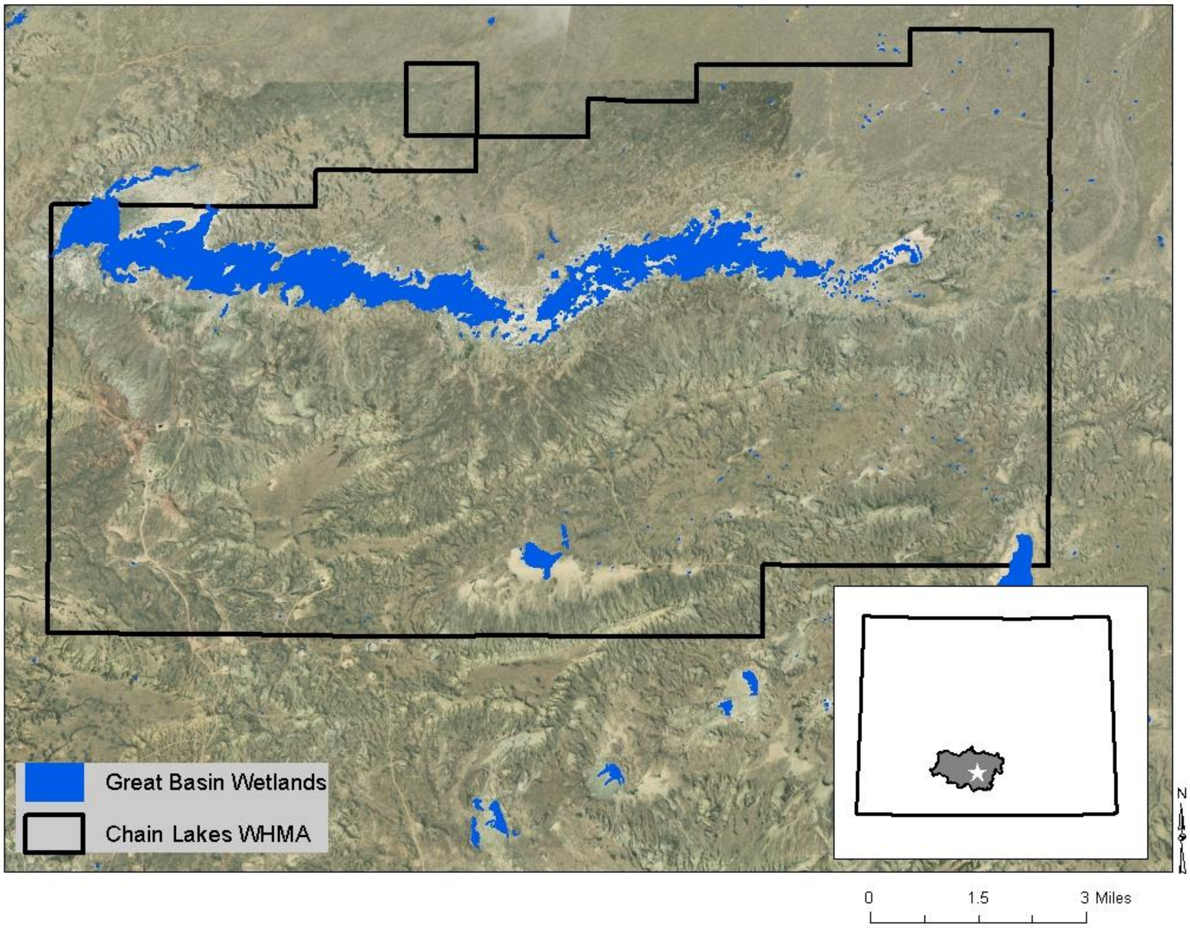


Figure 16. Chain Lakes Wildlife Habitat Management Area is located within the Great Divide Basin in southcentral Wyoming. The "chain lakes" wetland complex is the blue area concentrated in the upper half of the map.

The Chain Lakes area is covered by an extensive steppe dominated by sagebrush and greasewood. Elevation ranges from 6500 – 6750 feet with an average precipitation of 6.5 inches per year (Wyoming Game and Fish Department 2017). The Chain Lakes wetland complex has formed on deep, clay-rich lacustrine deposits of prehistoric Lake Wamsutter (Marrs and Grasso 1993).

Much of the surface water in the area falls as precipitation and is funneled into the wetland complex though ephemeral drainages. Artesian springs and groundwater discharge provide permanent and semi-permanent water to some areas of the Chain Lakes. Groundwater recharge can provide attenuation of the variability of seasonal and annual precipitation, which is important for maintaining surface water in dry years and attenuating flooding in wet years.

Mud springs once dominated the landscape around Circle Bar Lake on the east side of the Chain Lakes, but were not present during surveys in 2015 (Knight et al. 2014). The Hayden expedition described these features as conical mounds rising between 2-15 ft, which had pools of muddy water on top that bubbled from gas under pressure. Today the mud springs are dormant, possibly due to groundwater pumping for livestock and gas extraction industry, which may have reduced water pressure needed to maintain these springs (Knight et al. 2014). The Hayden expedition also observed mud pots or "bentonite boils" which were deep pools of muddy water covered by a thick layer of crusty silt that gave the appearance of solid ground. These unique features can still be found in areas around Circle Bar Lake (Figure 17).

Figure 17. Example of mud pots or "bentonite boils" found through the Chain Lakes. These rare and unusual features form mounds of saturated soils.

At the time of sampling, land use in the Chain Lakes was primarily rangeland and wildlife habitat (Wyoming Game and Fish Department 2017). The Chain Lakes WHMA provides winter habitat for wildlife and is a seasonal migration corridor for pronghorn. The area is open to oil and gas leasing with intensive management of surface disturbing and disruptive activities according to the approved Rawlins Resource Management Plan (Bureau of Land Management 2008).

6.1 Chain Lakes Landscape Profile

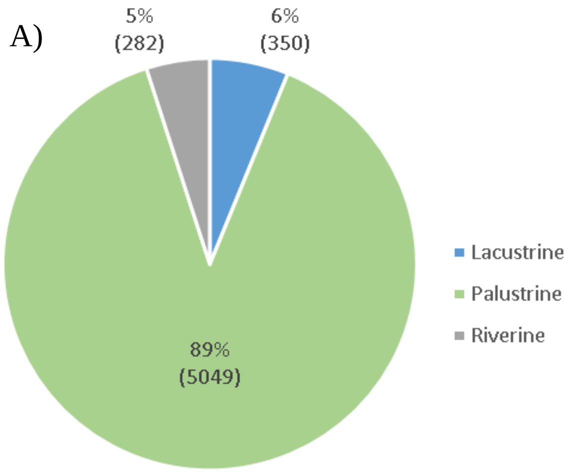
6.1.1 Updated Wetland Mapping

In 2017, St. Mary's University of Minnesota updated NWI mapping in the Chain Lakes WHMA in collaboration with BLM, WGFD, and WYNDD (GeoSpatial Services Saint Mary's University of Minnesota 2018). This updated mapping effort was not part of the original EPA-funded survey; however, a summary of the data is included because the updated mapping provides additional wetland information pertinent to this study. New NWI data has been submitted to the USFWS for review for the national database. This update included attributing all wetland polygons in the Chain Lakes with the Landscape, Landform, Waterbody, Water flowpath (LLWW) classification developed by USFWS (Tiner 2003), which can be combined to estimate functional potential for all wetlands and riparian areas (GeoSpatial Services Saint Mary's University of Minnesota 2018).

The following landscape profile summarizes the updated NWI mapping to describe wetlands within the Chain Lakes based on the following attributes: wetland class; water regime; extent of wetlands modified/irrigated (Wyoming Wildlife Consultants 2007); land management/ownership (Bureau of Land Management 2010); and wetland function based on LLWW classification (Tiner 2003). The LLWW mapping data is available upon request by emailing Lindsey Washkoviak, Wetland Ecologist at WYNDD, lwashkov@uwyo.edu.

6.1.2 NWI Wetland Description

All wetlands and waterbodies in the Chain Lakes cover a total of 5,684 acres. Eighty percent (5,049 acres) are Palustrine wetlands, consisting of 2,335 acres of Scrub/shrub wetlands (predominantly greasewood shrublands), 1,817 acres of Freshwater Emergent wetlands (including alkali wet meadows), and 29 acres of Unconsolidated Bottom and 868 acres of Unconsolidated Shore wetlands (both of which are playas) (Figure 18). Lacustrine Systems (mainly large playa lakes) cover 350 acres, and ephemeral Riverine Systems that drain into the "chain lakes" wetland complex cover 282 acres within the WHMA.



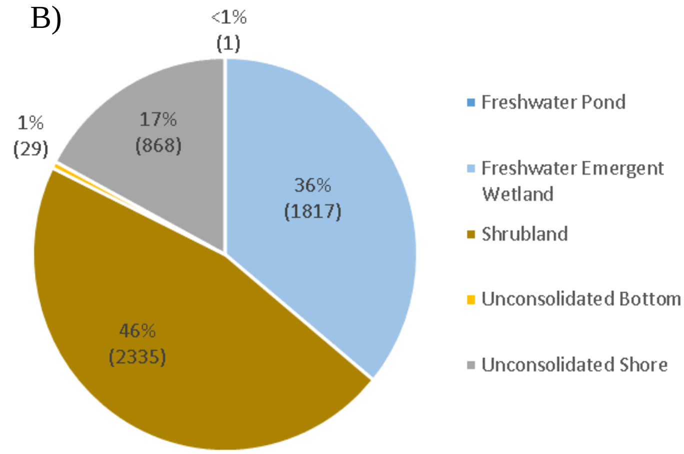


Figure 18. Surface area (acres) of wetlands classified by A) NWI system and B) NWI class in the Chain Lakes WHMA.

Most wetlands in the Chain Lakes are temporarily (47%) or seasonally (32%) flooded (Figure 19). These wetlands have surface water present for extended to brief periods of time during the growing season but surface water is absent by the end of the season in most years (Federal Geographic Data Committee 2013). When surface water is absent, the depth to ground water can vary considerably between sites. Eighteen percent (994 acres) are intermittently flooded. These locations are usually shrub flats or small playa depressions that receive water from precipitation. Surface water is present for variable periods of time throughout the year without regular (seasonal) periodicity. Weeks, months, or even years may pass between periods of surface water inundation (Federal Geographic Data Committee 2013).

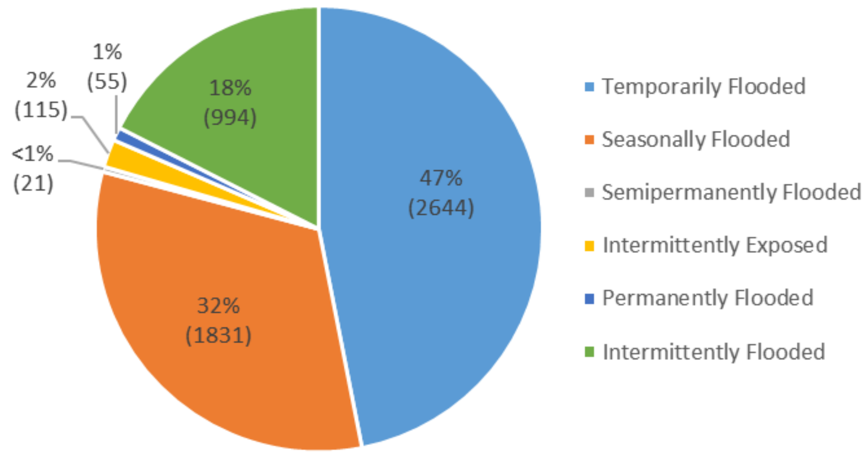


Figure 19. Surface area (acres) of wetlands classified according to NWI water regime in the Chain Lakes WHMA

6.1.3 LLWW Classification

The NWI mapping data can be enhanced by adding additional descriptions of abiotic and landscape features to wetland polygons (Stark et al. 2016). The USFWS developed the LLWW classification system (Tiner 2003), which is an HGM based classification system that describes a wetland's Landscape Position (L), Landform (L), Water Flow Path (W) and Waterbody (W) or LLWW. LLWW classifies wetlands and water bodies with the area's landscape position and hydrologic characteristics and vegetation like NWI. Like the Cowardin et al. (1979) classification framework, the LLWW classification system uses alphanumeric codes to describe wetland characteristics. The LLWW classification also makes a distinction between the definition of wetlands and water bodies similar to Cowardin et al. (1979). Wetlands are vegetated or have unconsolidated bottoms or shores and cover less than 20 acres, while water bodies are deepwater habitats or have unconsolidated bottoms or shores and cover greater than 20 acres (Stark et al. 2016).

6.1.4 Wetland Functional Potential

Wetlands perform important ecological functions that help improve and maintain environmental quality. When natural wetlands are degraded or filled, some wetland functions are lost, while others can still occur through human intervention or technology. Once wetland polygons are attributed, LLWW and Cowardin classification codes can be combined into descriptors and metrics to estimate potential wetland functions (Stark et al. 2016). The assignment of potential functions to wetlands is based on professional judgement, and they should be considered hypothetical until verified with independent data. Wetlands were categorized as either high or moderate for the performance of specific functions relative to other wetlands in the project area.

Potential functions identified in the Chain Lakes include:

- Carbon Sequestration (CS) – serve as carbon sinks that help to trap atmospheric carbon,

- Groundwater Recharge (GR) – sustaining sub-surface water storage and supporting base flows,

- Nutrient Transformation (NT) – breaking down of nutrients from natural sources, fertilizers or other pollutants; essentially treating the runoff,

- Sediment and Other Particulate Retention (SR) – acting as filters to physically trap sediment particles before they are carried further downstream,

- Surface Water Detention (SWD) – storage of runoff from rain events or spring melt waters which reduce the force of peak flood levels downstream,

- Unique, Uncommon, or Highly Diverse Wetland Plant Communities (UWPC) – sustains natural vegetation and ecosystems including rare species,

- Waterfowl and Water Bird Habitat (WBIRD) – habitat for waterfowl and other water birds,

• Aquatic Invertebrate Habitat (AIH) – habitat for aquatic invertebrates,

• Fish Habitat (FH) – habitat for a variety of fish (including a special category containing factors that maintain cold water temperatures for certain species including trout),

• Other Wildlife Habitat (OWH) - habitat for other wildlife (resident and migratory).

Results from the wetland function assessment indicated that groundwater recharge, unique, uncommon, or highly diverse wetland plant communities, and other wildlife habitat were the most common wetland functions mapped for over 75% of wetlands in the Chain Lakes (Figure 20).

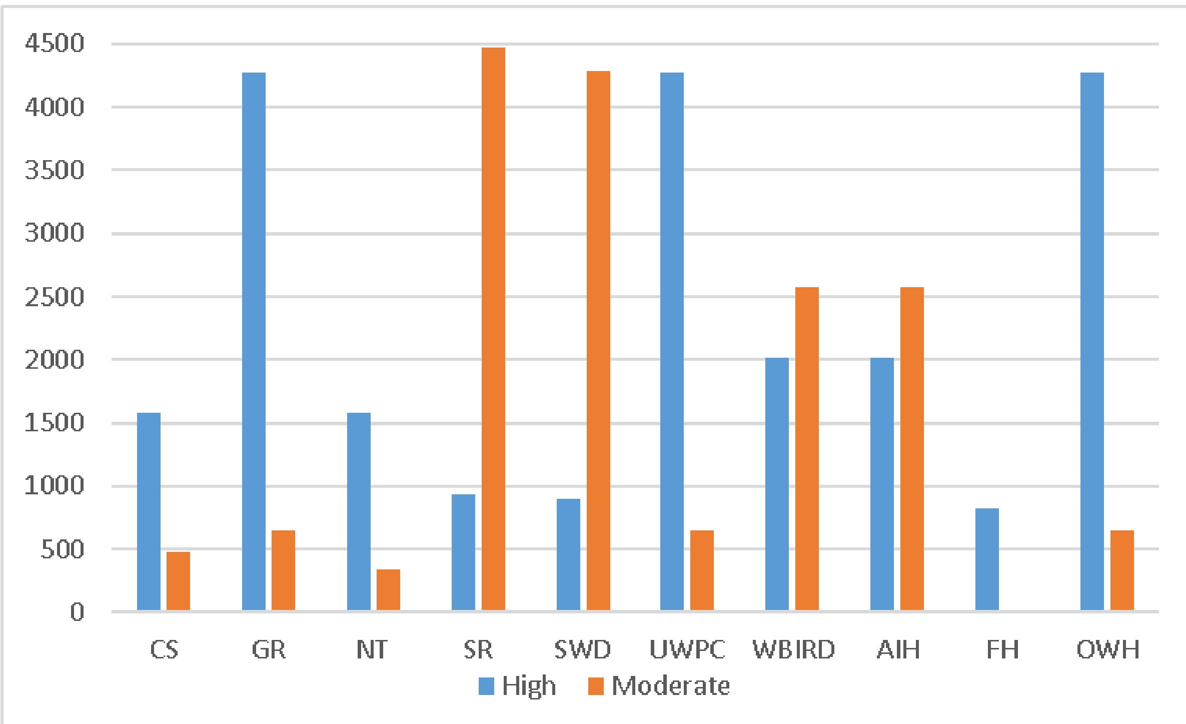


Figure 20. Wetland acres identified with high or moderate wetland function in the Chain Lakes study area. See section 6.1 for function codes.

6.2 Sampled Wetlands

Fourteen wetlands were sampled in the Chain Lakes wetland complex in 2015 (Figure 21), including five alkaline wet meadows, five saline depressions, and four shrub flats. These wetlands were all located along the chain of wetlands that run along an east-west orientation at the northern end of the Chain Lakes.

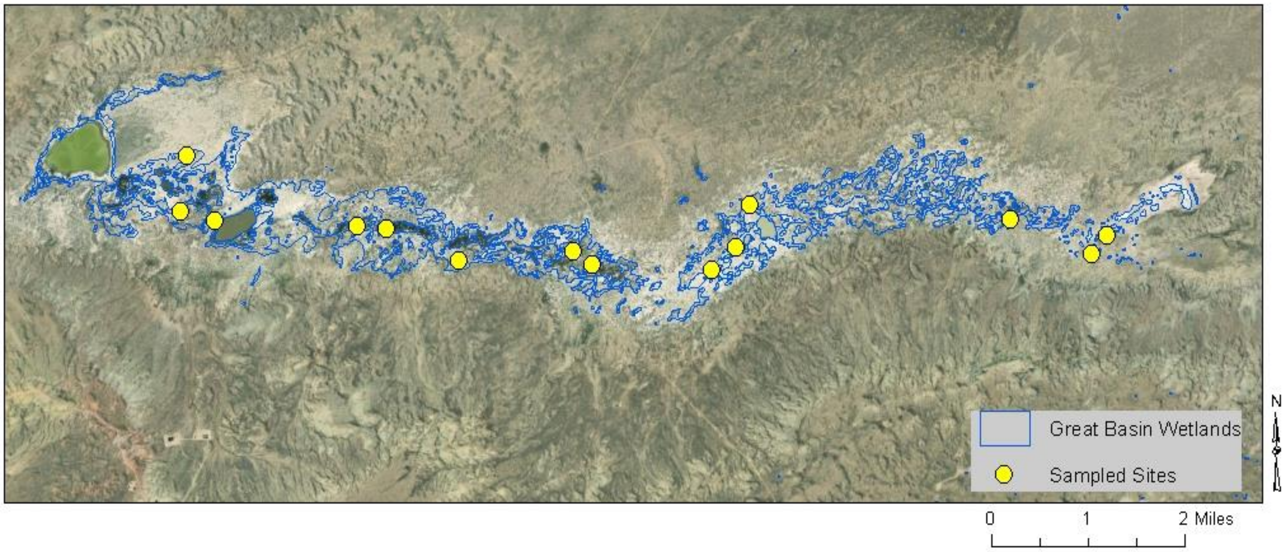


Figure 21. Sampled wetlands in the "Chain Lakes" wetlands complex

6.3 Wetland Condition

Wetlands in the Chain Lakes had higher mean EIA condition scores (4.63 ± 0.16 SD) compared to other wetlands sampled in the GDB study area (4.22 ± 0.40 SD). EIA ranks for ten of the wetlands were A, and four were B. Relatively higher EIA scores in the Chain Lakes are the result of sites having intact natural hydrology, few non-native and noxious species, and few or no indicators of disturbance such as landscape fragmentation due to roads or resource development.

6.4 Wetland Plant Data

Thirteen of the fourteen sampled wetlands within the Chain Lakes had vegetation present. One site occurred in the middle of a flooded playa lake with no floating or submerged vegetation in the assessment area. The perimeter of the lake was surrounded by emergent marsh and wet meadow vegetation. Overall, wetlands within the Chain lakes had higher floristic quality assessment scores, including native species richness, Mean C, FQI, and adjusted FQI, when compared with the rest of the GDB study area (Table 16). Wetlands in the Chain Lakes had lower mean species richness and non-native species richness, but higher mean native species richness. Most notably, the relative cover of native species observed was over 98%. Only three wetlands had non-native species present, and they contributed less than 2% absolute cover at each of those sites.

Table 16. Floristic quality assessment indices for wetlands in the Chain Lakes WHMA and the GDB study area

FQA Indices	Chain Lakes Wetlands		Other wetlands in the GDB		Overall	
	Mean	SD	Mean	SD	Mean	SD
Total species richness	10.29	4.73	11.16	8.03	10.97	7.40
Native species richness	10	4.52	9.92	7.15	9.94	6.62
Non-native species richness	1	0	2.34	1.50	2.21	1.47
Mean C of all species	4.20	.3	3.78	.73	3.87	.69
Mean C of native species	4.29	.30	4.19	.60	4.22	.54
FQI of all species	13.17	3.82	11.98	5.83	12.23	5.45
FQI of native species	13.27	3.81	12.78	6.09	12.89	5.64
Adjusted FQI	41.57	3.18	36.25	8.33	37.44	7.80
Relative % cover native species	98.91%	2.06%	92.64%	9.96%	94.04%	9.20%
Absolute % cover noxious species	.5%	0	1.43%	1.53%	1.3%	1.45%
Absolute % cover Invasive	1.33%	.58%	6.12%	3.86%	5.62%	3.94%

6.4.1 Species of Conservation Concern

During this survey effort four state imperiled (S2), eight state-rare or restricted (S3), and no globally ranked species were found at sampled wetlands within the Chain lakes. Other species of conservation concern were found in the Chain Lakes area during previous surveys. In 2007, Bonnie Heidel, botanist at the Wyoming Natural Diversity Database, conducted a botanical survey in Chain Lakes to look for many stemmed spider-flower (*Cleome multicaulis*). Many stemmed spider-flower is a BLM sensitive species that is associated with alkali meadows and playa vegetation (Heidel 2008). Surveys were conducted by targeting suitable habitat. Many stemmed spider-flower was not found in this botanical survey, however four other Wyoming plant species of concern were documented (Table 18). Two species are regional endemics and Meadow milkvetch (*Astragalus diversifolius*), a globally imperiled species (G2), had not been seen in Wyoming since it was first collected in 1834 (Heidel 2008).

Table 17. Species of concern identified at sampled wetlands within the Chain Lakes

Species	State Rank	# of Sites	WY C - Value
Amphiscirpus nevadensis	S2	2	5
Chrysothamnus linifolius	S3	1	2
Cirsium scariosum	S3	6	6
Epilobium clavatum	S3	1	7
Glaux maritima	S3	1	6
Packera werneriifolia var. werneriifolia	S2	1	-
Plantago eriopoda	S3	6	5
Pyrrocoma uniflora	S3	8	5
Salicornia rubra	S3	1	4
Streptanthus cordatus	S2	1	-
Suaeda calceoliformis	S3	13	3
Suckleya suckleyana	S2	2	4

Table 18. Species of conservation concern found at wetlands in the Chain Lakes in 2007 (Heidel 2008)

Scientific Name	Common Name	Grank	Srank	Significance
Astragalus diversifolius	Meadow milkvetch	G2	Changed from SH to S1	Rediscovery of species known only from historical collection in state
Monolepis pusilla	Red poverty-weed	G5	Changed from S1 to S2	First record in Rawlins FO
Phacelia tetramera	Tiny phacelia	G4	S1	Third record in state; first record in Rawlins FO
Sisyrinchium pallidum	Pale blue-eyed grass	G2G3	S2S3	Range extension – westernmost

7.0 DISCUSSION

The Great Divide Basin is recognized as a priority for study in the region because of its unique ecological value and exceptionally high potential for conservation (Wyoming Game and Fish Department 2010; Wyoming Joint Ventures Steering Committee 2010). The results of this wetland profile provide important baseline information on the extent and condition of wetlands at the basin-scale.

The most notable result of the survey was the contrast between high condition scores in the GDB with lower condition scores from other basins in Wyoming, highlighting the conservation potential in the study area. For example, 95% of the wetlands sampled in the GDB received an EIA condition score of B or above, as compared to 48% total wetlands sampled in the Upper Green River, Laramie plains, and Goshen Hole combined (Tibbets et al. 2015, 2016b, 2016a). In addition, over one-third of wetlands sampled in the GDB were scored at or near reference condition, compared to only 9% of wetlands sampled across other basins in Wyoming. The GDB is the only study area to date where we were able to define reference condition as "minimally disturbed condition" (MDC) as opposed to "least disturbed condition" (LDC) used in other basins. LDC is defined as a site "in the best available physical, chemical and biological habitat conditions given today's state of the landscape" (Stoddard et al. 2006). Because LDC differs from MDC, the biological integrity of our A-ranked sites in the GDB reflect the highest potential for biological integrity.

Wetland plant communities sampled in the GDB had high relative cover of native species, and had, on average, the lowest number of sites with non-native species present compared to other basins sampled. The lack of irrigation and low levels of hydrologic modifications are also unique to the GDB.

Wetlands in the GDB are dominated by temporary or seasonally flooded alkali wet meadows and playa and saline depressions, and to a lesser extent, shrub wetlands comprised of expansive greasewood flats. Shrub wetlands with two or more wetland indicators proved nearly impossible to identify and locate from the NWI wetland mapping and aerial imagery, resulting in difficulties in sampling this wetland type. These challenges point to the need for a better understanding of the dynamics of greasewood flats in the GDB.

The results from the Chain Lakes area indicate that, at the time of sampling, wetlands were at or near reference condition with very little impacts or non-native species present. The data and information provided by the updated NWI mapping project indicates that wetlands in the Chain Lakes have the potential to provide a wide range of important ecological functions.

The results of this survey do not include the assessment of potential impacts from oil and gas development on wetlands in the basin. We did not have permission to access or drive through portions of the basin that have a high density of oil and gas development because private land intermixed in these areas prevented access.

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Appendix A: Field Key to Wetland and Riparian Ecological Systems of Wyoming
Last Updated April 7, 2015

1b. Wetlands and riparian areas of the Western Great Plains. *[If on the edge of the foothills, try both Key A and Key B]* .... **KEY A**: **WETLANDS AND RIPARIAN AREAS OF THE WESTERN GREAT PLAINS**

1b. Wetland and riparian areas west of the Great Plains **2**

2a. Wetlands and riparian areas with alkaline or saline soils within the inter-mountains basins of the Rocky Mountains (Upper Green River basin, Wind River basin, etc.) *[If the site does not match any of the descriptions within Key B, try Key C as well. Wetlands and riparian areas of the Rocky Mountains transition into the inter-mountain basins.]* ....**KEY B: WETLANDS AND RIPARIAN AREAS OF THE INTER-MOUNTAIN BASINS**

2b. Wetlands and riparian areas of the Rocky Mountains, including the Snowy Mountains, the Wind Rivers, the Absorakas and the Bighorns.. ....**KEY C: WETLANDS AND RIPARIAN AREAS OF THE ROCKY MOUNTAINS**

KEY A: WETLANDS AND RIPARIAN AREAS OF THE WESTERN GREAT PLAINS

1a. Low stature shrublands dominated by species such as *Sarcobatus vermiculatus, Atriplex* spp., *Ericameria nauseosa*, *Artemisia sp.* Vegetation may be sparse and soils may be saline. Sites may be located on the edge alkali depressions, or in flats or washes not typically associated with river and stream floodplains. *[These systems were originally described for the Inter-Mountain Basins, but may extend to the plains.]* **2**

1b. Wetland is not a low stature shrub-dominated saline wash or flat. **3**

2a. Shrublands with sparse (<20%) vegetation cover, located on flats or in temporarily or intermittently flooded drainages, or on the edge of playas and alkali depressions. They are typically dominated by *Sarcobatus vermiculatus* and *Atriplex* spp. with inclusions of *Sporobolus airoides, Pascopyrum smithii, Distichlis spicata, Puccinellia nuttalliana,* and *Eleocharis palustris* herbaceous vegetation ………………………………………………………………………………………………….**Inter-Mountain Basins Greasewood Flat**

2b. Sites with > 20% total vegetation cover and restricted to temporarily or intermittently flooded drainages with a variety of sparse or patchy vegetation including *Sarcobatus vermiculatus*, *Ericameria nauseosa*, *Artemisia sp., Grayia spinosa*, *Distichlis spicata*, and *Sporobolus airoides.* .... ……..**Inter-Mountain Basins Wash**

3a. Sites located within the floodplain or immediate riparian zone of a river or stream. Vegetation may be entirely herbaceous or may contain tall stature woody species, such as *Populus* spp. or *Salix* spp. Water levels variable. Woody vegetation that occurs along reservoir edges can also be included here.... **4**

3b. Herbaceous wetlands of the Western Great Plains that are isolated or partially isolated from floodplains and riparian zones, often depressional with or without an outlet. **8**

4a. Herbaceous wetlands within the floodplain with standing water at or above the surface throughout the growing season, except in drought years. Water levels are often high at some point during the growing season, but managed systems may be drawn down at any point depending on water management regimes. Vegetation typically dominated by species of *Typha, Scirpus, Schoenoplectus*, *Carex*, *Eleocharis*, *Juncus*, and floating genera such as *Potamogeton*, *Sagittaria*, and *Ceratophyllum*. The hydrology may be entirely managed. Water may be brackish or not. Soils are highly variable. This system includes natural warm water sloughs and other natural floodplain marshes as well as a variety of managed wetlands on the floodplain (e.g., recharge ponds, moist soil units, shallow gravel pits, etc.)……… .... **Western North American Emergent Marsh**

4b. Not as above. Wetland and riparian vegetation that typically lacks extensive standing water. Vegetation may be herbaceous or woody. Management regimes variable.. **5**

5a. Large herbaceous wetlands within the floodplain associated with a high water table that is controlled by artificial overland flow (irrigation). Sites typically lack prolonged standing water. Vegetation is dominated by native or non-native herbaceous species; graminoids have the greatest canopy cover. Species composition may be dominated by non-native hay grasses such as *Poa spp., Alopecurus sp, Phleum pretense, and* Bromus inermis spp. inermis. There can be patches of emergent marsh vegetation and standing water less than 0.1 ha in size; these are not the predominant vegetation. .... **Irrigated Wet Meadow (not an official Ecological System)**

5b. Predominantly natural vegetation (though may be weedy and altered) within the floodplain or immediate riparian zone of a river or stream, dominated by either woody or herbaceous species. Not obviously controlled by irrigation. **6**

6a. Riparian woodlands and shrublands of the Rocky Mountain foothills on the very western margins of the Great Plains. Woodlands are dominated by *Populus* spp. (mainly *Populus angustifolia*,). Common native shrub species include *Salix* spp., *Alnus incana*, *Betula occidentalis, Cornus sericea*, and *Crataegus* spp. Sites are most often associated with a stream channel, including ephemeral, intermittent, or perennial streams (Riverine HGM Class). This system can occur on slopes, lakeshores, or around ponds, where the vegetation is associated with groundwater discharge or a subsurface connection to lake or pond water, and may experience overland flow but no channel formation (Slope, Flat, Lacustrine, or Depressional HGM Classes). It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplain swales and irrigation ditches. .... **Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland**

6b. Riparian woodlands, shrublands and meadows of Wyoming's Western Great Plains. Common native trees are *Populus deltoides*, *Salix amygdaloides, Acer negundo, Fraxinus* pennsylvanica., and *Ulmus* americana. Common native shrubs include *Salix* spp., Rosa spp, and Symphoricarpos spp. Common non-native trees and shrubs are *Tamarix* spp. and *Elaeagnus angustifolia.* **7**

7a. Riparian woodlands, shrublands, and meadows along medium and small rivers and streams. Sites have less floodplain development and flashier hydrology than the next, and all streamflow may drawdown completely for some portion of the year. Water sources include snowmelt runoff (more common in Wyoming), groundwater (prairie streams), and summer rainfall. Dominant species include *Populus deltoides, Salix* spp., *Fraxinus pennsylvanica, Pascopyrum smithii, Panicum sp., Carex* spp., *Tamarix* spp., *Elaeagnus angustifolia,* and other non-native grasses and forbs…..…….W**estern Great Plains Riparian**

7b. Woodlands, shrublands, and meadows along large rivers (the North Platte and its larger tributaries) with extensive floodplain development and periodic flooding that is more associated with snowmelt and seasonal dynamics in the mountains than with local precipitation events. Hydroperiod alterations from major dams and reservoirs alter historic flooding patterns. Dominant communities within this system range from floodplain forests to wet meadow patches, to gravel/sand flats dominated by early successional herbs and annuals; however, they are linked by underlying soils and the flooding regime. Dominant species include *Populus deltoides* and *Salix* spp., *Panicum sp.* and *Carex* spp. *Tamarix* spp., *Elaeagnus angustifolia,* and non-native grasses.………………………..….**Western Great Plains Floodplain**

8a. Natural shallow depressional wetlands in the Western Great Plains with an impermeable soil layer, such as dense hardpan clay that causes periodic ponding after heavy rains. Sites generally have closed contour topography and are surrounded by upland vegetation. Hydrology is typically tied to precipitation and runoff but lacks a groundwater connection; however some of these sites are receiving increased water from irrigation seepage. Ponding is often ephemeral and sites may be dry throughout the entire growing season during dry years. Species composition depends on soil salinity, may fluctuate depending on seasonal moisture availability, and many persistent species may be upland species. *[The wetlands within this group are collectively referred to* ***playas or playa lakes****. Ecological systems listed below separate playas based on the level of salinity and total cover of vegetation.]* **9**

8b. Herbaceous wetlands in the Western Great Plains not associated with hardpan clay soils. Sites may or may not be depressional and may or may not be natural. **10**

9a. Shallow depressional wetlands with less saline soils than the next. Dominant species are typically not salt-tolerant. Sites may have obvious vegetation zonation of tied to water levels, with the most hydrophytic species occurring in the wetland center where ponding lasts the longest. Common native species include *Pascopyrum smithii, Iva axillaris, , Eleocharis* spp., *Oenothera canescens, Plantago* spp., *Polygonum* spp., *Conyza canadensis* ,and *Phyla cuneifolia.* Non-native species are very common in these sites, including *Salsola australis, Bassia sieversiana, Verbena bracteata,* and Polygonum aviculare. Sites have often been affected by agriculture and heavy grazing. Many have been dug out or "pitted" to increase water retention and to tap shallow groundwater..**Western Great Plains Closed Depression Wetland**

9b. Shallow depressional herbaceous wetlands with saline soils. Salt encrustations can occur on the surface. Species are typically salt-tolerant, including *Distichlis spicata*, *Puccinellia nuttalliana, Salicornia rubra, Schoenoplectus maritimus, Schoenoplectus americanus, Suaeda calceoliformis, Spartina* spp., *Triglochin maritima,* and occasional shrubs such as *Sarcobatus vermiculatus* .*[This system resembles the Inter-Mountain Basins Alkaline Closed Depression but occur in the Great Plains ecoregion. Note: Low stature shrub-dominant wetlands key in the flats and wash systems above.]* ....
....**Western Great Plains Saline Depression Wetland**

10a. Herbaceous wetlands with standing water at or above the surface throughout the growing season, except in drought years. Water levels are often high at some point during the growing season, but managed systems may be drawn down at any point depending on water management regimes. Vegetation typically dominated by species of *Typha, Scirpus, Schoenoplectus*, *Carex*, *Eleocharis*, *Juncus*, and floating genera such as *Potamogeton*, *Sagittaria*, and *Ceratophyllum*. The isolated expression of this system can occur around ponds, as fringes around lakes, and at any impoundment of water, including irrigation run-off. The hydrology may be entirely managed or artificial. Water may be brackish or not. Soils are highly variable... **Western North American Emergent Marsh**

10b. Herbaceous wetlands associated with a high water table that is controlled by artificial overland flow (irrigation) or artificial groundwater seepage (including from leaky irrigation ditches). Sites typically lack prolonged standing water. Vegetation is dominated by native or non-native herbaceous species; graminoids have the greatest canopy cover. s. Patches of emergent marsh vegetation and standing water are less than 0.1 ha in size and not the predominant vegetation...
....**Irrigated Wet Meadow (not an official Ecological System)**

KEY B: WETLANDS AND RIPARIAN AREAS OF THE INTER-MOUNTAIN BASINS

1a. Depressional, herbaceous wetlands occurring within dune fields of the inter-mountain basins (e.g. Great Divide basin)..**Inter-Mountain Basins Interdunal Swale Wetland**

1b. Wetlands not associated with dune fields **2**

2a. Depressional wetlands. Soils are typically alkaline to saline clay with hardpans. Salt encrustation typically visible on the soil surface or along the water edge. Water levels various. Cover of vegetation variable, can be extremely sparse (<10% cover) or moderate to high (30–60% cover). Typically herbaceous dominated, but may contain salt-tolerant shrubs on the margins. **3**

2b. Non-depressional wetlands on flats or in washes, with alkaline to saline soils. Cover of vegetation variable, can be extremely sparse (<10% cover) or moderate to high (30–60% cover). Typically shrub dominated. Most common species are *Sarcobatus vermiculatus* and *Atriplex* spp.................................... **4**

3a. Depressional, alkaline wetlands that are seasonally to semi-permanently flooded, usually retaining water into the growing season and drying completely only in drought years. Many are associated with irrigation seepage, springs, or located in large basins with internal drainage. Seasonal drying exposes mudflats colonized by annual wetland vegetation. This system can occur in alkaline basins and swales and along the drawdown zones of lakes and ponds. They generally have thick unvegetated salt crusts over clay soils surrounded by zones of vegetation transitioning to the uplands. In these zones vegetation cover is generally >10% and species are typically salt-tolerant such as *Distichlis spicata*, *Puccinellia* spp., *Leymus* sp., *Schoenoplectus maritimus, Schoenoplectus americanus, Triglochin maritima,* and *Salicornia* spp*.*..**Inter-Mountain Basins Alkaline Closed Depression**

3b. Barren and sparsely vegetated playas (generally <10% plant cover. Could be more if annuals or upland vegetation are encroaching). Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. These systems are intermittently flooded. The water generally comes from precipitation and is prevented from percolating through the soil by an impermeable soil sub horizon and is left to evaporate. Soil salinity varies with soil moisture and greatly affects species composition. Characteristic species may include *Sarcobatus vermiculatus, Distichlis spicata,* and/or *Atriplex* spp. .... **Inter-Mountain Basins Playa**

4a. Shrublands with >10% total vegetation cover, located on flats. Vegetation dominated by *Sarcobatus vermiculatus* and *Atriplex* spp. with inclusions of *Artemisia tridentata ssp. Tridentate, Sporobolus airoides, Pascopyrum smithii, Distichlis spicata, Puccinellia nuttalliana,* and.herbaceous vegetation. .... **Inter-Mountain Basins Greasewood Flat**

4b. Sites with < 10% total vegetation cover and restricted to temporarily or intermittently flooded drainages with a variety of sparse or patchy vegetation including *Sarcobatus vermiculatus*, *Ericameria nauseosa*, *Artemisia cana*, *Artemisia tridentata*, *Distichlis spicata*, and *Sporobolus airoides.* .... **Inter-Mountain Basins Wash**

KEY C: WETLANDS AND RIPARIAN AREAS OF THE ROCKY MOUNTAINS

1a. Wetland defined by groundwater inflows and organic soil (peat) accumulation of at least 40 cm in the upper 80 cm. Vegetation can be woody or herbaceous. If the wetland occurs within a mosaic of non-peat forming wetland or riparian systems, then the patch must be at least 0.1 hectare (0.25 acre). If the wetland occurs as an isolated patch surrounded by upland, then there is no minimum size criterion. .... **Rocky Mountain Subalpine-Montane Fen**

1b. Wetland does not have at least 40 cm of organic soil (peat) accumulation or occupies an area less than 0.1 hectares (0.25 acres) within a mosaic of other non-peat forming wetland or riparian systems ... 2

2a. Total woody canopy cover generally 25% or more within the overall wetland/riparian area. Any purely herbaceous patches are less than 0.5 hectare and occur within a matrix of woody vegetation. *[Note: Relictual woody vegetation such as standing dead trees and shrubs are included here.] 3*

2b. Total woody canopy cover generally less than 25% within the overall wetland/riparian area. Any woody vegetation patches are less than 0.5 hectare and occur within a matrix of herbaceous wetland vegetation 5

3a. Riparian woodlands and shrublands of the foothill and lower montane zones on the Rocky Mountains. Woodlands are dominated by *Populus* spp. (*Populus angustifolia*, or the hybrid *P. acuminate*. At higher elevations Picea engelmannii, Abies lasiocarpa, Pseudotsuga menziesii, and Pinus ponderosa can be found. Common native shrub species include *Salix* spp., *Alnus incana*, *Betula occidentalis, Cornus sericea*, and *Crataegus* spp. Sites are most often associated with a stream channel, including ephemeral, intermittent, or perennial streams (Riverine HGM Class). This system can occur on slopes, lakeshores, or around ponds, where the vegetation is associated with groundwater discharge or a subsurface connection to lake or pond water, and may experience overland flow but no channel formation (Slope, Flat, Lacustrine, or Depressional HGM Classes). It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplain swales and irrigation ditches. (this system is also found in the inter-mountain basin ecoregion).. ....
…………………………………………..**Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland**

3b. Riparian woodlands and shrublands of the montane or subalpine zone 4

4a. Montane or subalpine riparian woodlands (canopy dominated by trees). This system occurs as a narrow streamside forest lining small, confined low- to mid-order streams. Common tree species include *Abies lasiocarpa*, *Picea engelmannii*, ,and *Populus tremuloides* (The overstory consists of Picea engelmannii, often with some Abies lasiocarpa and Populus tremuloides. These riparian areas generally occur at elevations where the uplands support upper montane and subalpine forests -- Pinus contorta, Picea engelmannii, Abies lasiocarpa. The common riparian trees in this type -- Picea engelmannii, Abies lasiocarpa, Populus tremuloides -- also grow in riparian zones in the lower montane, but there they are joined by Populus angustifolia, sometimes Populus acuminata, Populus balsamifera (mostly in NW Wyoming), Picea pungens (NW Wyoming : Snake River drainage, and the Wind River around Dubois), Pseudotsuga menziesii, Pinus ponderosa (eastern half of WY). Then, with decreasing elevation, the conifer drop out, Populus acuminata increases, and Populus deltoides becomes a major species.) ....
.... **Rocky Mountain Subalpine-Montane Riparian Woodland**

4b. Montane or subalpine shrub wetlands (canopy dominated by shrubs with sparse or no tree cover). This system is most often associated with streams (Riverine HGM Class), occurring as either a narrow band of shrubs lining streambanks of steep V-shaped canyons (straight, with boulder and cobble substrate)*or* as a wide, extensive shrub stand on alluvial terraces in low-gradient valley bottoms (more sinuous, with finer-textured substrates. Sometimes referred to as a *shrub carr*). Beaver activity is common within the wider occurrences. In addition, this system can occur around the edges of fens, lakes, seeps, and springs on slopes away from valley bottoms. This system can also occur within a mosaic of multiple shrub- and herb-dominated communities within snowmelt-fed basins. In all cases, vegetation is dominated by species of *Salix*, *Alnus*, or *Betula* but their composition varies depending on stream gradient. Alnus incana is a dominant or co-dominant along high-gradient streams; Betula occidentalis often co-dominates. Willows are present, as is Cornus sericea, but rarely dominate. In contrast, along the lower-gradient streams in wide valleys, the willows dominate; Betula and Cornus often are present but secondary to the willows; Alnus usually is a minor component. . ...
....**Rocky Mountain Subalpine-Montane Riparian Shrubland**

5a. Herbaceous wetlands with water present throughout all or most of the year. Water is at or above the surface throughout the growing season, except in drought years. This system can occur around ponds, as fringes around lakes, and along slow-moving streams and rivers. The vegetation is dominated by common emergent and floating leaved plants, including species of *Scirpus*, *Schoenoplectus*, *Typha*, *Juncus*, *Carex*, *Potamogeton*, *Polygonum*, and *Nuphar*..
.... **Western North American Emergent Marsh**

5b. Herbaceous wetlands that typically lack extensive standing water. Patches of emergent marsh vegetation and standing water are less than 0.1 ha in size and not the predominant vegetation............. **7**

6a. Herbaceous wetlands associated with a high water table or overland flow, but typically lack standing water. Sites with *no channel formation* are typically associated with snowmelt or groundwater and not subjected to high disturbance events such as flooding (Slope HGM Class). Sites *associated with a stream channel* are more tightly connected to overbank flooding from the stream channel than with snowmelt and groundwater discharge. Vegetation is dominated by herbaceous species; typically graminoids have the highest canopy cover including *Carex* spp., *Calamagrostis* spp., and *Deschampsia caespitosa*.............
.... **Rocky Mountain Alpine-Montane Wet Meadow**

6b. Large herbaceous wetlands associated with a high water table that is controlled by artificial overland flow (irrigation). Sites typically lack prolonged standing water, but may have standing water early in the season if water levels are very high. Vegetation is dominated by native or non-native herbaceous species; graminoids have the highest canopy cover ....
. ...**Irrigated Wet Meadow (not an official Ecological System)**

Appendix B. Operational Defination of a Wetland for Condition Assessment of the Great Divide Basin, Wyoming

The operational definition of wetlands used in this project is based on the definition adopted by the U.S. Fish and Wildlife Service (USFWS) and used in the National Wetland Inventory (Cowardin et al. 1979):

> *"Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."*

However, it is important to note that standard wetland delineation techniques are based on a different definition used by the U.S. Army Corps of Engineers (ACOE) and the Environmental Protection Agency (EPA) for regulatory purposes under Section 404 of the Federal Clean Water Act:

> *"[Wetlands are] those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."*

The primary difference between the two definitions is the ACOE/EPA definition requires positive identification of all three wetland parameters (hydrology, vegetation, and soils), whereas the USFWS definition requires only one characteristic must be present. *We required two wetland parameters to be present to qualify for assessment sampling.* Deep water habitats that would be considered wetlands under the USFWS definition were excluded from this study.

Appendix C. Great Divide Basin Wetland Assessment Field Form

LOCATION AND GENERAL INFORMATION

Point Code ___________ Date: ___________________________Surveyors:____

Directions to Point:

Access Comments (note permit requirement or difficulties accessing the site):

GPS COORDINATES OF TARGET POINT AND ASSESSMENT AREA

Dimensions of AA: ____40 m radius circle ____Rectangle ____Freeform, describe and take a GPS Track	Elevation (m): Target Wetland: ___ Yes ___ No if no what is new target type: Relation to AA: ___Centered ___Included ___Outside

AA-Center WP #: ___________ LAT: _______________________ LONG: ____________________________ Error (+/-): _______________
(Circle AAs Only)

AA-Track Track Name: ____ Area: ____

PHOTOS OF ASSESSMENT AREA(Taken at four points on edge of AA looking in.

AA-1 WP/Photo #: __________ Aspect: _____________ LAT: _______________________ LONG: ___________________________

AA-2 WP/Photo #: __________ Aspect: _____________ LAT: _______________________ LONG: ___________________________

AA-3 WP/Photo #: __________ Aspect: _____________ LAT: _______________________ LONG: ___________________________

AA-4 WP/Photo #: __________ Aspect: _____________ LAT: _______________________ LONG: ___________________________

Additional AA Photos and Comments:

(Note range of photo numbers and explain particular photos of interest)

ENVIRONMENTAL DESCRIPTION AND CLASSIFICATION OF ASSESSMENT AREA

Non-target Inclusions: % AA with > 1m standing water: _______________ % AA with Non-target inclusions: __________________ Non-target description:	Wetland origin (if known): ____ Natural feature with minimal alteration ____ Natural feature, but altered or augmented by modification ____ Non-natural feature created by passive or active management ____ Unknown

Ecological System: (see manual for key and rules on inclusions and pick the *best match*) Fidelity: High Med Low

ENVIRONMENTAL DESCRIPTION AND CLASSIFICATION OF ASSESSMENT AREA (continued)

Cowardin Classification (pick *one each that best represents AA*)	HGM Class (pick *only one that best represents AA*)
Fidelity: High Med Low (see manual and pick *one each* of System, Class, Water Regime, and optional Modifier for dominant type)	Fidelity: High Med Low ____Riverine* ____Lacustrine Fringe ____Depressional ____ Slope ____ Flats ____ Irrigated (choose additional class) **Specific classification and metrics apply to the Riverine HGM Class*

MAJOR ZONES WITHIN THE ASSESSMENT AREA (See manual for rules and definitions. Mark each zone on the site sketch.)

Zone 1 Description ____________________________ Dom spp: ____ % of AA: ___________

Zone 2 Description ____________________________ Dom spp: ____ % of AA: ___________

Zone 3 Description ____________________________ Dom spp: ____ % of AA: ___________

Zone 4 Description ____________________________ Dom spp: ____ % of AA: ___________

Zone 5 Description ____________________________ Dom spp: ____ % of AA: ___________

AA REPRESENTATIVENESS

Is AA the entire wetland? ___ Yes ___ No If no, is AA representative of larger wetland? ___ Yes ___ No
Provide comments:

Wildlife Observation – record any wildlife observations from site. List species of and type of observation

Species:	Visible	Vocal	Tracks	Scat

Bird tracks present (% of AA)	# Nests:	# Sage grouse droppings or tar:	# Burrowing owl Pellets:
Undulate Tracks or scat present (% of AA)	Woody Herbivory (% of AA)	Herbaceous Herbivory (% of AA)	

# of Beaver	% of AA effected by beaver activity	# active dams

# Adult Frogs	# Tadpoles	# Salamanders	# Egg Masses	# Reptiles
# Animal mounds and Burrows	# Ant Mounds			Snails present

Wildlife Comments:

ASSESSMENT AREA DRAWING AND COMMENTS
Add north arrow and approx. scale bar. Document **Community types and abiotic zones** (particularly open water), inflows and outflows, and indicate direction of drainage. Include sketch of soil pit placement. If appropriate, add a **cross-sectional diagram** and indicate slope of side.
ASSESSMENT AREA SETTING AND SURROUNDING LANDSCAPE DESCRIPTION
Overall site description and details on site hydrology, soil, and vegetation. Include general landscape setting, dominant plants in buffer, and information on any target wetland types occurring with AA.

AA GROUND COVER AND VERTICAL STRATA	
Cover Classes 1: trace **2:** <1% **3:** 1–<2% **4:** 2–<5% **5:** 5–<10% **6:** 10–<25% **7:** 25–<50% **8:** 50–<75% **9:** 75–<95% **10:** >95% **(Unless otherwise noted)**	
Cover of standing water of any depth, vegetated or not:	
Cover of running water of any depth, vegetated or not:	
Cover of open water (plant canopy cover < 10%)	
Cover of water with emergent vegetation:	
Cover of water with floating or submerged vegetation:	
Cover of exposed bare ground* – soil / sand / sediment	
Cover of exposed bare ground* – gravel / cobble (~2–250 mm)	
Cover of exposed bare ground* – bedrock / rock / boulder (>250 mm)	
Cover salt crust (all cover, including over vegetation or litter cover)	
Cover of litter (all cover, including under water or vegetation)	
Depth of litter (cm) – average of four non-trampled locations where litter occurs Depth 1 _____ cm Depth 2 _____ cm Depth 3 _____ cm Depth 4 _____ cm Ave depth:	
Predominant litter type (C = coniferous, E = broadleaf evergreen, D = deciduous, S = sod/thatch, F = forb)	
Cover of standing dead trees (>5 cm diameter at breast height)	
Cover of standing dead shrubs or small trees (<5 cm diameter at breast height)	
Cover of downed coarse woody debris (fallen trees, rotting logs, >5 cm diameter)	
Cover of downed fine woody debris (<5 cm diameter)	
Cover bryophytes (all cover, including under water, vegetation or litter cover)	
Cover lichens (all cover, including under water, vegetation or litter cover)	
Cover algae (all cover, including under water, vegetation or litter cover)	

Height Classes 1:<0.5 m 2: 0.5–1m 3: 1–2 m 4: 2–5 m 5: 5–10 m 6: 10–15 m 7: 15–20 m 8: 20–35 m 9: 35–50 m 10:>50 m			
Vertical Vegetation Strata(live or very recently dead)	**Cover / Height →**	**C**	**H**
(T1)	Dominant canopy trees (>5 m and > 30% cover)		
(T2)	Sub-canopy trees (> 5m but < dominant canopy height) or trees with sparse cover		
(S1)	Canopy layer 2–5 m includes both Tall shrubs or older tree saplings		
	Older tree saplings 2–5 m		
	Tall shrubs 2–5 m		
(S2)	Canopy layer 0.5 – 2 includes both Short shrubs or young tree saplings (0.5–2 m)		
	Young tree saplings 0.5–2 m		
	Short shrubs 0.5–2 m		
(S3)	Dwarf shrubs or tree seedlings (<0.5 m; included short *Vaccinium* spp., etc.)		
	Tree seedlings <0.5 m		
	Dwarf shrubs <0.5 m (included short *Vaccinium* spp., etc.)		
(HT)	Herbaceous total		
(H1)	Graminoids (grass and grass-like plants)		
(H2)	Forbs (all non-graminoids)		
(H3)	Ferns and fern allies		
(AQ)	Submergent or floating aquatics		

Vegetation Species List

Walk through the AA and identify as many plant species as possible beginning with the most dominant species first. Spend *no more* than 1 hour compiling the species list. Once the species list is compiled.

Cover Classes 1: trace 2: <1% 3: 1–<2% 4: 2–<5% 5: 5–<10% 6: 10–<25% 7: 25–<50% 8: 50–<75% 9: 75–<95% 10: >95%

Scientific Name or Pseudonym	% Cover	Coll #	Photos

Walk through the AA and identify as many plant species as possible beginning with the most dominant species first. Spend *no more* than 1 hour compiling the species list. Once the species list is compiled.

Cover Classes 1: trace 2: <1% 3: 1–<2% 4: 2–<5% 5: 5–<10% 6: 10–<25% 7: 25–<50% 8: 50–<75% 9: 75–<95% 10: >95%

Scientific Name or Pseudonym	**% Cover**	**Coll #**	**Photos**

Point Code__________________

SOIL PROFILE DESCRIPTION – SOIL PIT ☐ **Representative Pit?**

GPS Waypoint ___________ Lat: ___ ___ ___ ___ ___ ___Long: ___ ___ ___ ___ ___ ___ ___ | Temp_________ pH ________ EC _______ TDS ________ Salinity ________

Settling Time: ___________ Depth to saturated soil (cm): ____________Depth to free water (cm): _____________ ☐ Not observed, if so: ☐Pit is filling slowly OR ☐Pit appears dry

Horizon (optional)	Depth (cm)	Matrix Color (moist)	Dominant Redox Features Color (moist)	%	Secondary Redox Features Color (moist)	%	Texture	% Roots	% Gravel	Remarks

Hydric Soil Indicators: See field manual for descriptions and check all that apply to pit.

____Histosol (A1)
____Histic Epipedon (A2/A3)
____Mucky Mineral (S1/F1)
____Hydrogen Sulfide Odor (A4)
____Gleyed Matrix (S4/F2)
____Depleted Matrix (A11/A12/F3)
____Redox Concentrations (S5/F6/F8)
____Redox Depletions (S6/F7)

Comments:

Salt translocation- other problem soils

SOIL PROFILE DESCRIPTION – SOIL PIT 2 ☐ **Representative Pit?**

GPS Waypoint ___________ Lat: ___ ___ ___ ___ ___ ___Long: ___ ___ ___ ___ ___ ___ | Temp_________ pH ________ EC _______ TDS ________ Salinity ________

Settling Time: ___________ Depth to saturated soil (cm): ____________Depth to free water (cm): _____________ ☐ Not observed, if so: ☐Pit is filling slowly OR ☐Pit appears dry

Horizon (optional)	Depth (cm)	Matrix Color (moist)	Dominant Redox Features Color (moist)	%	Secondary Redox Features Color (moist)	%	Texture	% Roots	% Gravel	Remarks

Hydric Soil Indicators: See field manual for descriptions and check all that apply to pit.

____Histosol (A1)
____Histic Epipedon (A2/A3)
____Mucky Mineral (S1/F1)
____Hydrogen Sulfide Odor (A4)
____Gleyed Matrix (S4/F2)
____Depleted Matrix (A11/A12/F3)
____Redox Concentrations (S5/F6/F8)
____Redox Depletions (S6/F7)

Comments:

Point Code__________________

SOIL PROFILE DESCRIPTION – SOIL PIT 3 ☐ **Representative Pit**

GPS Waypoint ___________ Lat: ___ ___ ___ ___ ___ ___Long: ___ ___ ___ ___ ___ ___ ___ | Temp_________ pH ________ EC _______ TDS ________ Salinity ________

Settling Time: ___________ Depth to saturated soil (cm): ____________Depth to free water (cm): _____________ ☐ Not observed, if so: ☐Pit is filling slowly OR ☐Pit appears dry

Horizon (optional)	Depth (cm)	Matrix Color (moist)	Dominant Redox Features Color (moist)	Dominant Redox Features %	Secondary Redox Features Color (moist)	Secondary Redox Features %	Texture	% Roots	% Gravel	Remarks

Hydric Soil Indicators: See field manual for descriptions and check all that apply to pit.

____Histosol (A1)
____HisticEpipedon (A2/A3)
____Mucky Mineral (S1/F1)
____Hydrogen Sulfide Odor (A4)
____Gleyed Matrix (S4/F2)
____Depleted Matrix (A11/A12/F3)
____Redox Concentrations (S5/F6/F8)
____Redox Depletions (S6/F7)

Comments:

WATER QUALITY

Site 1: GPS Waypoint ______________ Lat: Long: | **Standing OR Flowing**

Temp_____________ pH _____________ EC _____________ TDS __________________ Salinity __________________

Site 2: GPS Waypoint ______________ Lat: Long: | **Standing OR Flowing**

Temp_____________ pH _____________ EC _____________ TDS __________________ Salinity __________________

Water quality measurement comments:

*Be sure to mark down any soils and water chemistry units

Macro Invertebrate sample taken: | Macro invertebrate comments:

LEVEL 2 ECOLOGICAL INTEGRITY ASSESSMENT

1. *LANDSCAPE CONTEXT METRICS – Check the applicable box.*

1a. PERCENT NATURAL LAND COVER

Select the statement that best describes the **percent of natural land cover** within 100, 200 and 500 m envelopes surrounding the AA. To determine, identify any patches of natural land cover within the 100, 200 and 500 m envelopes and estimate their total percent of the envelopes. See definitions in the field manual of natural land cover types. Natural land cover patches *do not* need to be contiguous with the AA.	Distance from AA:	**100m**	***200 m***	***500 m***
	Intact: Landscape contains 90–100% natural land cover.			
	Variegated: Landscape contains 60–90% natural land cover.			
	Fragmented: Landscape contains 20–60% natural land cover.			
	Relictual: Landscape contains <20% natural land cover.			

1b. LANDSCAPE FRAGMENTATION

Select the statement that best describes the **landscape fragmentation** with in a 500 m envelope surrounding the AA. To determine, identify the largest unfragmented block *that includes the AA* within the 500 m envelope and estimate its percent of the total envelope. Well-traveled dirt roads and major canals count as fragmentation, but hiking trails, hayfields, fences and small ditches can be included in unfragmented blocks (see definitions).	Intact: AA embedded in >90–100% unfragmented, natural landscape.	
	Variegated: AA embedded in >60–90% unfragmented, natural landscape.	
	Fragmented: AA embedded in >20–60% unfragmented, natural landscape.	
	Relictual: AA embedded in ≤20% unfragmented, natural landscape.	

1b. RIPARIAN CORRIDOR CONTINUITY*(RIVERINE WETLANDS ONLY)*

For riverine wetlands, select the statement that best describes the **riparian corridor continuity** within 500 m upstream and downstream of the AA. To determine, identify any non-buffer patches (see definitions) within the potential riparian corridor (natural geomorphic floodplain) both upstream and downstream of the AA. Estimate the percentage of the riparian corridor they occupy. *For AAs on one side of a very large river channel (~20 m width),* only consider the riparian corridor on that side of the channel.	Intact: >95–100% natural habitat within the riparian corridor both upstream and downstream.	
	Variegated: >80–95% natural within the riparian corridor both upstream and downstream.	
	Fragmented: >50–80% natural habitat within the riparian corridor both upstream and downstream.	
	Relictual: ≤50% natural habitat within the riparian corridor both upstream and downstream.	

Landscape fragmentation and riparian corridor continuity comments:

1c. BUFFER EXTENT

Select the statement that best describes the **extent of buffer land cover** surrounding the AA. To determine, estimate the percent of the AA surrounded by buffer land covers (see definitions). Each segment must be ≥ 5 m wide and extend along ≥ 10 m of the AA perimeter.	Buffer land covers surround >100% of the AA.	
	Buffer land covers surround >75–<100% of the AA.	
	Buffer land covers surround >50–75% of the AA.	
	Buffer land covers surround >25–50% of the AA.	
	Buffer land covers surround ≤25% of the AA.	

1d. BUFFER WIDTH

Select the statement that best describes the **buffer width**. To determine, estimate width (up to 200 m from AA) along eight lines radiating out from the AA at the cardinal and ordinal directions (N, NE, E, SE, S, SW, W, NW).

1: ____________ 5: ____________	Average buffer width is >200 m	
2: ____________ 6: ____________	Average buffer width is >100–200 m	
3: ____________ 7: ____________	Average buffer width is >50–100 m	
4: ____________ 8: ____________	Average buffer width is >25–50 m	
Average width: ________________________	Average buffer width is ≤25 m OR no buffer exists	

1e. BUFFER CONDITION

Select the statement that best describes the **buffer condition**. Select one statement per column. Only consider the actual buffer measured in metrics 1c and 1d. Use the Landscape Stressor list below to help inform your buffer condition decision

Abundant (≥95%) relative cover native vegetation and little or no (<5%) cover of non-native plants.		Intact soils, little or no trash or refuse, and no evidence of human visitation. Light grazing can be present.	
Substantial (≥75–95%) relative cover of native vegetation and low (5–25%) cover of non-native plants.		Intact or moderately disrupted soils, moderate or lesser amounts of trash, light grazing to moderate grazing OR minor intensity of human visitation or recreation	
Moderate (≥50–75%) relative cover of native vegetation.		Moderate or extensive soil disruption, moderate or greater amounts of trash, moderate to heavy grazing OR moderate intensity of human use.	
Low (<50%) relative cover of native vegetation OR no buffer exists.		Barren ground and highly compacted or otherwise disrupted soils, moderate or greater amounts of trash, moderate or greater intensity of human use, very heavy grazing OR no buffer exists.	

Buffer comments:

LANDSCAPE STRESSORS

Using the table below, estimate the independent and cumulative percent of each **landscape stressor / land use within a 200 and 500 m envelope** of the AA. Stressors can overlap and do not need to total 100% (e.g., Grazing and moderate recreation can both be counted in the same portion of the envelope). ***Scope rating: 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%.***

Landscape stressor/ land use categories	*200m*	*500m*
Paved roads, parking lots, railroad tracks		
Unpaved roads (e.g., driveway, tractor trail, 4-wheel drive roads)		
Domestic or commercially developed buildings		
Trash or refuse		
Gravel pit operation, open pit mining, strip mining		
Mining (other than gravel, open pit, and strip mining), abandoned mines		
Resource extraction (oil and gas wells and surrounding footprint)		
Agriculture – tilled crop production		
Agriculture – permanent crop (hay pasture, vineyard, orchard, tree plantation)		
Recent old fields and other lands dominated by non-native species (weeds or hay fields)		
Intensively managed golf courses, sports fields, urban parks, expansive lawns		
Vegetation conversion (chaining, cabling, rotochopping, or clear-cutting of woody veg)		
Heavy grazing: (> 2/3 of herbaceous plants have been grazed) by livestock or native ungulate		
Moderate Grazing: (at least 1/3 to 2/3 of herbaceous plants have been grazed) by livestock or native ungulate		
Light Grazing: (< 1/3 of herbaceous plants have been grazed) by livestock or native ungulates		
Heavy browse (> 2/3 of woody plants have been browsed by livestock or native ungulates)		
Moderate browse (at least 1/3 to 2/3 of woody plants have been browsed by livestock or native ungulates)		
Light browse (< 1/3 of woody plants have been browsed by livestock or native ungulates)		
Heavy recreation or human visitation (ATV use / camping / popular fishing spot, etc.)		
Moderate recreation or human visitation (high-use trail)		
Light recreation or human visitation (low-use trail)		
Logging or tree removal with 50-75% of trees		
Selective logging or tree removal with <50% of trees		
Evidence of recent fire (<5years old, still very apparent on vegetation, little regrowth)		
Dam sites and flood disturbed shorelines around water storage reservoirs		
Beetle-killed conifers		
Irrigation ditches, berms, dams, head gates that change how water moves (maybe delete)		
Non-native species		
Other:		

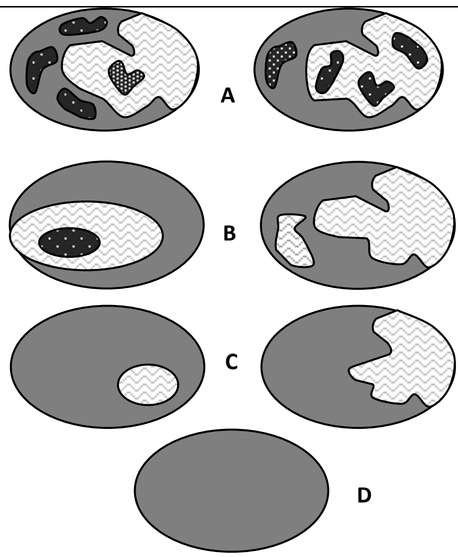
Landscape Stressor Comments:

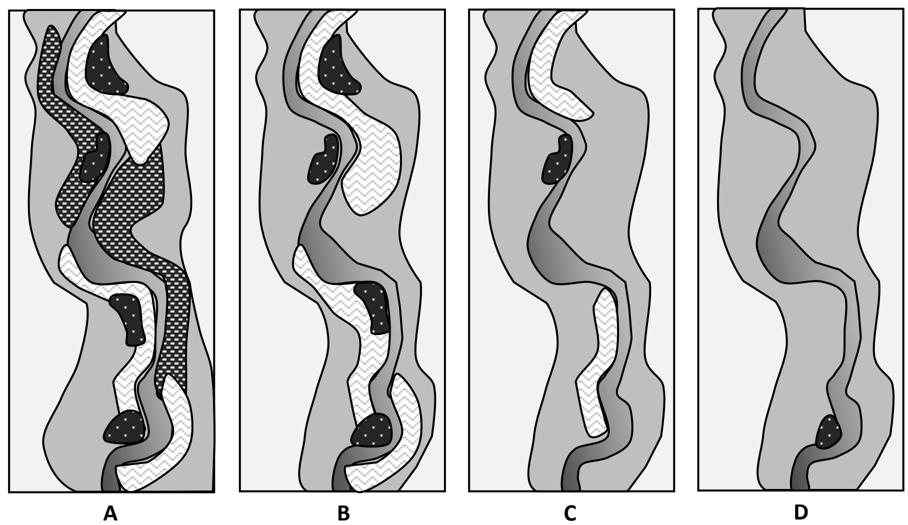
2. VEGETATION CONDITION METRICS – Check the applicable box.

VEGETATION COMPOSITION
Vegetation compositions and structure, woody regeneration and liter metrics will be calculated out of the field based on the species list and cover values. To aid data interpretation, provide comments on composition and **list noxious species identified in field.**

2h. HORIZONTAL INTERSPERSION OF BIOTIC AND ABIOTIC ZONES

Refer to diagrams below and select the statement that best describes the **horizontal interspersion of biotic and abiotic zones** within the AA. Rules for defining zones are in the field manual. Include zones of open water when evaluating interspersion.	High degree of horizontal interspersion: AA characterized by a very complex array of nested or interspersed zones with no single dominant zone.	
	Moderate degree of horizontal interspersion: AA characterized by a moderate array of nested or interspersed zones with no single dominant zone.	
	Low degree of horizontal interspersion: AA characterized by a simple array of nested or interspersed zones. One zone may dominate others.	
	No horizontal interspersion: AA characterized by one dominant zone.	





2k. VEGETATION STRESSORS WITHN THE AA

Using the table below, estimate the independent scope of each vegetation stressor within the AA. Independent scopes can overlap (e.g., light grazing can occur along with moderate recreation). ***Scope rating: 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%.***

Vegetation stressor categories	*Scope*
Unpaved Roads (e.g., driveway, tractor trail, 4-wheel drive roads)	
Vegetation conversion (chaining, cabling, rotochopping, clearcut)	
Logging or tree removal with 50-75% of trees >50 cm dbh removed	
Selective logging or tree removal with <50% of trees >50 cm dbh removed	
Heavy grazing: (> 2/3 of herbaceous plants have been grazed) by livestock or native ungulate	
Moderate Grazing: (at least 1/3 to 2/3 of herbaceous plants have been grazed) by livestock or native ungulate	
Light Grazing: (< 1/3 of herbaceous plants have been grazed) by livestock or native ungulates	
Heavy browse (> 2/3 of woody plants have been browsed) by livestock or native ungulates	
Moderate browse (at least 1/3 to 2/3 of woody plants have been browsed) by livestock or native ungulates	
Light browse (< 1/3 of woody plants have been browsed) by livestock or native ungulates	
Intense recreation or human visitation (ATV use / camping / popular fishing spot, etc.)	
Moderate recreation or human visitation (high-use trail)	
Light recreation or human visitation (low-use trail)	
Recent old fields and other lands dominated by *non-native* species (weeds or hay)	
Haying of *native* grassland (*not* dominated by non-native hay grasses)	
Beetle-killed conifers	
Non-native Species	
Litter is extensive and limits new growth (thick cattails litter)	
Other:	
Vegetation stressor comments and photo #'s:	

3. HYDROLOGY METRICS – Check the applicable box.

3a. Water source and Hydrologic stressors within the drainage basin

Check off all *major* water sources in the table to the right. If the dominant water source is evident, mark it with a star (*).	_____ Overbank flooding _____ Alluvial aquifer _____ Groundwater discharge _____ Natural surface flow _____ Precipitation _____ Snowmelt	_____ Irrigation via direct application _____ Irrigation via seepage _____ Irrigation via tail water run-off _____ Urban run-off / culverts _____ Pipes (directly feeding wetland) _____ Other:

In the table below, estimate the scope of each **hydrology stressor within the AA and within the 500 m envelope of the AA**. If known hydrologic alterations occur further than 500 m from the AA and are positioned in a way that have an effect on the sites hydrology record the stressors scope in the proper location and please explain in comments below. ***Scope rating: 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%.***

Hydrology stressor categories	***Within AA***	***Upstream / Upslope***	***Downstream / Downslope***
Ditches < 1 feet deep are present			
Ditches 1 foot to 3 feet deep are present			
Ditches > 3 feet deep are present			
Diversion structures < 1 foot tall are present			
Diversion structures 1 foot to 3 feet tall are present			
Diversion structures > 3 feet tall are present			
Major irrigation canal			
Spring box diverting water from wetland			
Berms present that impede forward or lateral movement of water			
Weir or drop structure that impounds water and controls energy of flow			
Impoundment / stock pond			
Large dam / reservoir			
Dirt or gravel road that alters forward or lateral movement of water			
2-lane road crosses that alters forward or lateral movement of water			
4-lane road crosses that alters forward or lateral movement of water			
Culvert too small to accommodate base flow			
Culvert appears large enough to accommodate base flow but not flood flows			
Culvert appears large enough to accommodate base flow and flood flows			
Pugging by livestock, native ungulates, or wild horses that alters water movement in the site			
Dug pits for holding water			
Fill that has been added to site			
Surrounding land cover / vegetation that interrupts surface flow			
Observed or potential agricultural runoff			
Developed or irrigated lands occupy drainage basin.			
Other:			
Other			

Hydrologic stressor and water source comments:

Hydrologic landscape and management context. Check all that apply checklist	
Wetland appears to be still connected to its natural water source, natural flows appear to be unaltered.	
Wetland appears to naturally lack water at times.	
Land use in the local watershed is primarily open space or low-density development	
Local watershed includes little or no irrigated land.	
Wetland is in a location that appears to have supported a wetland before development in the immediate drainage basin	
Filling and drawdown of the wetland appear to be unmanaged	
Filling & drawdown are managed to mimic natural timing and amount	
Filling & drawdown are managed with no regard to natural timing and amount	
Xeric vegetation is encroaching into the wetland	
Natural wet-season or dry season inflows to the wetland have been eliminated by impoundment or diversion.	
Wetland exists in intermittent drainage basin that has been bermed or dugout to hold water for livestock use or irrigation storage	
Wetland appears to be largely or entirely supported by anthropogenic inputs such as: direct irrigation, runoff from irrigated fields, seepage from irrigation canals or ditches, urban stormwater runoff, direct pumping, or landscape modification for water storage	
Wetland landscape and management context comments:	

4a. WATER SOURCES / INPUTS	
Select the statement below that best describes the water sources feeding the AA during the growing season. Use the water source, hydrologic stressor and wetland landscape and management context tables to inform your answers	
Water sources are precipitation, groundwater, natural runoff, or natural flow from an adjacent freshwater body. The system may naturally lack water at times, such as in the growing season. There is no indication of direct artificial water sources, either point sources or non-point sources. Land use in the local watershed is primarily open space or low density, passive use with little irrigation.	
Water sources are mostly natural, but also include occasional or small amounts of inflow from anthropogenic sources. Indications of anthropogenic sources include developed land or irrigated agriculture that comprises < 20% of the immediate drainage basin, the presence of a few small storm drains or scattered homes with septic system. No large point sources control the overall hydrology.	
Water sources are moderately impacted by anthropogenic sources, but are still a mix of natural and non-natural sources. Indications of moderate contribution from anthropogenic sources include developed land or irrigated agriculture that comprises 20–60% of the immediate drainage basin or the presence of a many small storm drains or a few large ones. The key factor to consider is whether the wetland is located in a landscape position that supported a wetland before development and whether the wetland is still connected to its natural water source (e.g., modified ponds on a floodplain that are still connected to alluvial aquifers, natural stream channels that now receive substantial irrigation return flows).	
Water sources are primarily from anthropogenic sources (e.g., urban runoff, direct irrigation, pumped water, artificially impounded water, or another artificial hydrology). Indications of substantial artificial hydrology include developed or irrigated agricultural land that comprises > 60% of the immediate drainage basin of the AA, or the presence of major drainage point source discharges that obviously control the hydrology of the AA. The key factor to consider is whether the wetland is located in a landscape position that likely never supported a wetland prior to human development. The reason the wetland exists is because of direct irrigation, irrigation seepage, irrigation return flows, urban storm water runoff, direct pumping, or landscape modifications for water storage.	
Natural sources have been **eliminated** based on the following indicators: impoundment of all wet season inflows, diversions of all dry-season inflows, predominance of xeric vegetation, etc. The wetland is in steady decline and may not be a wetland in the near future.	
Water Source/ inputs comments:	

4b. HYDROPERIOD	
Select the statement below that best describes the **hydroperiod** within the AA (extent and duration of inundation and/or saturation). **Use the water source, hydrologic stressor and wetland landscape and management context tables to determine the overall condition of the hydroperiod.** For some wetlands, this may mean that water is being channelized or diverted away from the wetland. For others, water may be concentrated or increased.	
Hydroperiod is characterized by natural patterns of filling or inundation and drying or drawdowns. There are no major hydrologic stressors that impact the natural hydroperiod.	
Hydroperiod filling or inundation patterns deviate slightly from natural conditions due to presence of stressors such as: small ditches or diversions; berms or roads at/near grade; minor pugging by livestock; or minor flow additions. Outlets may be slightly constricted. Playas are not significantly pitted or dissected. *If hydrology is artificially controlled,* the management regime closely mimics a natural analogue (it is very unusual for a purely artificial wetland to be rated in this category).	
Hydroperiod filling or inundation and drying patterns deviate moderately from natural conditions due to presence of stressors such as: ditches or diversions 1–3 ft. deep; two lane roads; culverts adequate for base stream flow but not flood flow; moderate pugging by livestock that could channelize or divert water; shallow pits within playas; or moderate flow additions. Outlets may be moderately constricted, but flow is still possible. *If hydrology is artificially controlled,* the management regime approaches a natural analogue. Site may be passively managed, meaning that the hydroperiod is still connected to and influenced by natural high flows timed with seasonal water levels.	
Hydroperiod filling or inundation and drawdown of the AA deviate substantially from natural conditions from high intensity alterations such as: a 4-lane highway; large dikes impounding water; diversions > 3ft. deep that withdraw a significant portion of flow, deep pits in playas; large amounts of fill; significant artificial groundwater pumping; or heavy flow additions. Outlets may be significantly constricted, blocking most flow. *If hydrology is artificially controlled,* the site is actively managed and not connected to any natural season fluctuations, but the hydroperiod supports natural functioning of the wetland.	
Hydroperiod is dramatically different from natural. Upstream diversions severely stress the wetland. Riverine wetlands may run dry during critical times. *If hydrology is artificially controlled,* hydroperiod does not mimic natural seasonality. Site is actively managed for filling or drawing down without regard for natural wetland functioning.	

4c. HYDROLOGIC CONNECTIVITY

Select the statement below that best describes the degree to which **hydrology within the AA is connected to the larger landscape** throughout the year, but particularly at times of high water. **Use the water source, hydrologic stressor and wetland landscape and management context tables to determine the overall condition of hydrologic connectivity.** Consider the effect of impoundments, entrenchment, or other obstructions to connectivity that occur within the surrounding landscape, if those impoundments clearly impact the AA.

General criteria	***Riverine variant***	***Playa variant***	
Nothing obstructs lateral or vertical movement of surface or ground waterIf wetland depends on perched water table then impermeable soil layer (fragipan or duripan) is intact. Rising water in the site has unrestricted access to adjacent upland, without levees, excessively high banks, artificial barriers, or other obstructions to the lateral movement of flood flows.	Completely connected to floodplain (backwater sloughs and channels). No geomorphic modifications have been made to contemporary floodplain. Channel is not entrenched.	Surrounding land cover / vegetation does not interrupt surface flow. No artificial channels feed water to playa.	
Constructed levees or road grades limit the amount of adjacent transition zone or the lateral movement of floodwaters for <50% of the AA boundary. Restrictions may be intermittent along the margins of the AA, or they may occur only along one bank or shore.	Minimally disconnected from floodplain. Up to 25% of stream banks are affected by constructed levees or road grades and/or channel is somewhat entrenched.	Surrounding land cover / vegetation does not interrupt surface flow. Artificial channels may feed minor amounts of water to playa.	
Constructed features such as levees or road grades border 50–90% of the boundary of the AA. Flood flows may overtop the obstructions, but drainage out of the AA is probably obstructed.	Dikes, tide gates, or elevated culverts affect 25-75% of stream banks. Channel may be moderately entrenched and disconnected from the floodplain except in large floods.	Surrounding land cover / vegetation may interrupt surface flow. Artificial channels may feed moderate amounts of excess water to playa.	
Constructed features such as levees or roadbeds border >90% of the boundary of the AA.	Channel is severely entrenched and entirely disconnected from the floodplain.	Surrounding land cover / vegetation may dramatically restrict surface flow. Artificial channels may feed significant amounts of excess water to playa.	

Hydroperiod and hydrologic connectivity comments:

4. *PHYSIOCHEMICAL METRICS – Check the applicable box.*

3a. WATER QUALITY - SURFACE WATER TURBIDITY / POLLUTANTS	
Select the statement that best describes the **turbidity or evidence or pollutants** in surface water within the AA.	
No open water in AA	
No visual evidence of degraded water quality. No visual evidence of turbidity or other pollutants.	
Some negative water quality indicators are present, but limited to small and localized areas within the wetland. Water is slightly cloudy, but there is no obvious source of sedimentation or other pollutants.	
Water is cloudy or has unnatural oil sheen, but the bottom is still visible. Sources of water quality degradation are apparent (identify in comments below). *Note: If the sheen breaks apart when you run your finger through it, it is a natural bacterial process and not water pollution. Riverine wetlands can be turbid if flood waters are high*	
Water is milky and/or muddy or has unnatural oil sheen. The bottom is difficult to see. There are obvious sources of water quality degradation (identify in comments below). *Note: If the sheen breaks apart when you run your finger through it, it is a natural bacterial process and not water pollution. Riverine wetlands can be turbid if flood waters are high*	
Surface water turbidity / pollutants comments and photo #'s:	

3b. WATER QUALITY - ALGAL GROWTH	
Select the statement that best describes **algal growth** within surface water in the AA.	
No open water in AA or evidence of open water.	
Water is clear with minimal algal growth.	
Algal growth is limited to small and localized areas of the wetland. Water may have a greenish tint or cloudiness.	
Algal growth occurs in moderate to large patches throughout the AA. Water may have a moderate greenish tint or sheen. Sources of water quality degradation are apparent (identify in comments below).	
Algal mats are extensive, blocking light to the bottom. Water may have a strong greenish tint and the bottom is difficult to see. There are obvious sources of water quality degradation (identify in comments below).	
Algal growth comments and photo #'s: *Algal growth may be natural and not necessarily indicative of poor water quality. If algal growth appears natural, describe and record % of total algae that is due to natural processes.*	

3c. SUBSTRATE / SOIL DISTURBANCE	
Select the statement below that best describes disturbance to the substrate or soil within the AA. For playas, the most significant substrate disturbance is sedimentation or unnaturally filling, which prevents the system's ability to pond after heavy rains. For other wetland types, disturbances may lead to bare or exposed soil and may increase ponding or channelization where it is not normally. For any wetland type, consider the disturbance relative to what is expected for the system.	
No soil disturbance within AA. Little bare soil OR bare soil areas are limited to naturally caused disturbances such as flood deposition or game trails OR soil is naturally bare (e.g., playas). No pugging, soil compaction, or sedimentation.	
Less than 10% of the AA affected by some amount of bare soil, pugging, compaction, or sedimentation present due to human causes. The depth of disturbance is limited to 1 – 2 inches and does not show evidence of altering hydrology or vegetation growth at the site	
10 –25% of the AA has bare soil areas due to human causes are common. There may be pugging due to livestock resulting in several inches of soil disturbance. Sedimentation may be filling the wetland. Damage is obvious, but not excessive.	
25-50% of the AA has bare soil areas due to human causes are common. ORVs or other machinery may have left some shallow ruts < 3 inches deep or livestock pugging and/or trails are widespread. Unnatural hummocks created by livestock, wild horses, or native ungulates present, especially when the site lacks hummock forming vegetation. These hummocks typically have sheer edges with exposed soil. Compaction and disturbance change water moment in the site and affect vegetation growth. Sedimentation may have severely impacted the hydrology.	
Greater than 50% off the AA has bare soil areas that substantially degrade the site and have led to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, Unnatural hummocks created by livestock, wild horses, or native ungulates present, especially when the site lacks hummock forming vegetation. These hummocks typically have sheer edges with exposed soil. Sedimentation has dried the wetland.	
Substrate / soil comments and photo #'s:	

3d. PHYSIOCHEMICAL STRESSORS WITHIN THE AA

Using the table below, estimate the independent scope of each physiochemical stressor within the AA. Independent scopes can overlap (e.g., soil compaction can occur with trash or refuse). ***Scope rating: 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%.***

Physiochemical stressor categories	*Scope*
Erosion	
Sedimentation	
Current plowing or disking	
Historic plowing or disking (evident by abrupt A horizon boundary at plow depth)	
Substrate removal (excavation)	
Filling or dumping of sediment	
Trash or refuse dumping	
Compaction and soil disturbance by livestock, wild horses, or native ungulates < 3 inches deep	
Compaction and soil disturbance by livestock, wild horses, or native ungulates > 3 inches deep	
Unnatural hummocks created by livestock, wild horses, or native ungulates. These typically have sheer edges with exposed soil. Site lacks hummock forming vegetation	
Compaction and soil disturbance by human use (trails, ORV use, camping) < 3 inches deep	
Compaction and soil disturbance by human use (trails, ORV use, camping) > 3 inches deep	
Mining activities, current or historic	
Obvious point source of water pollutants (discharge from waste water plants, factories)	
Agricultural runoff (drain tiles, excess irrigation)	
Direct application of agricultural chemicals	
Discharge or runoff from feedlots	
Obvious excess salinity (dead or stressed plants, salt encrustations)	
Other:	

Physiochemical stressor comments:

AREM Long Form

Please evaluate the wetland or riparian habitat within the **200 meter** buffer when answering the below questions. Do not consider upland habitat except for questions 16 – 21. For each numbered item, check only one response unless noted otherwise. Then proceed to the next question unless noted otherwise. Parenthetical names are the names of fields in the supporting software database (WHRBASE). If a field name is lacking, the information is not used directly.

Note: 1 Acre = .5 hectares

1. Season: Migratory__________ Breeding__________Winter__________
2. LOCATION. Is the area part of, or is it within 0.5 mile of, a major* river or lake?
   ** river channel wider than 100 ft, or lake larger than 40 acres*
   ____ Yes (field BigWater) ____ No
3. SURFACE WATER. During this season, does the area contain at least 0.1 acre* of surface water, either obscured by vegetation or not?
   ** See Figure B-1 for guidance in estimating acreage categories.*
   ____ Yes (field AnyWater). Go to next question.
   ____ No. **Skip to question #5.**
4. OPEN WATER. During this season, how much open* water is present in the area?
   ** water deeper than 2 inches and mostly lacking vegetation (except submerged plants).*
   ____ > 20 acres and it is mostly wider than 500 ft (field OpenBig)
   ____ < 1 acre, or, >1 acre but mostly narrower than 3 ft (field OpenSmall)
   ____ Other conditions (field OpenOther)
5. SPECIFIC AQUATIC CONDITIONS
   Check all that apply during this season:
   ____ > 0.1 acre of the surface water is still, i.e., usually flows at less than 1 ft/s (field StillWater)
   ____ The evaluated area can be assumed to contain fish (field Fish)
   ____ The evaluated area can be assumed to contain frogs, salamanders, and/or crayfish (field Amphibs)
   ____ Water transparency in the deepest part of the area is (or would be, if depth is shallow) sufficient to see an object 10 inches below the surface, and the area is not known to have problems with metal contamination (field Clear)
   ____ The evaluated area is highly enriched by direct fertilizer applications, water from nearby feedlots, or other sources (field Enriched)
   ____ Most of the normally-flooded part of the area goes dry at least one year in five, or, is subject to flooding from a river at least as often (field Drawdown)
6. BARE SOIL. Is there at least 0.1 acre of mud*, alkali flat, gravel/sand bar, recently tilled soil, and/or heavily grazed open (grassy, non-shrubby) areas during this season?
   ** includes soil that is continually saturated up to the surface, or which was previously covered by water but has become exposed to the air during this period*
   ____ Yes (field Bare). Go to next question.
   ____ No. **Skip to question #7.**
7. LARGE MUDFLAT. Does the area at this season contain mud that has all these features?:
   - At least 1 acre in size
   - Maximum dimension is greater than 100 ft
   - Salt crust or salt stains are not apparent
   - Not recessed within a wash or canal whose depth (relative to surrounding landscape) is greater than half its width.

   ____ Yes (field MudBig) ____ No

8. TREES. Are there at least 3 trees*:
   ** woody plants taller than 20 ft.*
   ____ in the evaluation area? (field TreeIn).
   ____ within 1000 ft of the evaluation area? (field TreeNear). **Go to #8.**
   ____ neither of the above. **Skip to #11.**
9. TREE COVER. Check one or more responses below that describe the maximum cumulative acreage of various conditions of tree cover in the evaluation area. Also include areas within 300 ft:
   ____ >1 acre, dense*, and wide** (field ForestDens)
   ____ >1 acre and open; or, dense but narrow (field ForestOpen)
   ____ 0.1-1 acre, dense* (field WoodDens)
   ____ 0.1-1 acre, open (field WoodOpen)
   ____ <0.1 acre
   ** Dense= the tree canopy, viewed from the ground during midsummer, appears at least 50% closed, as averaged across an area that is at least as large as the acreage specified.*
   *** Wide= the wooded area is wider than 300 ft (average).*
10. BIG TREES. Are there at least three trees whose trunk diameter 20 ft above the ground is >12 inches?
    ____ Yes (field TreesBig) ____ No
11. SNAGS. Are there at least three snags, or trees with dead limbs with diameter >5 inches?
    ____ Yes (field Snags) ____ No
12. SHRUBS. Is there at least 0.1 acre of shrubs*:
    ** woody plants 2-20 ft in height.*
    ____ in the evaluation area? (field ShrubIn).
    ____ within 1000 ft of the wetland (including the wetland itself)? (field ShrubNear). **Go to #12.**
    ____ Neither of the above. **Skip to #13.**
13. SHRUB SPECIES AND DENSITY. Check one or more responses below that describe the maximum cumulative extent of various types and conditions of shrub cover in the evaluation area. Also include areas within 300 ft.

    Willow:
    ____ >1 acre, dense*, and wide** (field WwMuchDens)
    ____ >1 acre and open; or, dense but narrow (field WwMuchOpen)
    ____ 0.1-1 acre, dense* (field WwSomeDens)
    ____ 0.1-1 acre, open (field WwSomeOpen)
    ____ <0.1 acre; or larger area but height mostly <4 ft and openly spaced

    Greasewood or other tall desert shrubs:
    ____ >1 acre, dense*, and wide** (field GrMuchDens)
    ____ >1 acre and open; or, dense but narrow (field GrMuchOpen)
    ____ 0.1-1 acre, dense* (field GrSomeDens)
    ____ 0.1-1 acre, open (field GrSomeOpen)
    ____ <0.1 acre

    Russian olive, sumac, buffaloberry, wild rose, or others with fleshy fruit:
    ____ >1 acre, dense*, and wide** (field FrMuchDens)
    ____ >1 acre, open; or, dense but narrow (field FrMuchOpen)
    ____ 0.1-1 acre, dense (field FrSomeDens)
    ____ 0.1-1 acre, open (field FrSomeOpen)
    ____ <0.1 acre; or larger area but height mostly <4 ft

Tamarisk (salt cedar):
____ >1 acre, dense*, and wide** (field TmMuchDens)
____ >1 acre, open; or, dense but narrow (field TmMuchOpen)
____ 0.1-1 acre, dense (field TmSomeDens)
____ 0.1-1 acre, open (field TmSomeOpen)
____ <0.1 acre; or larger area but height mostly <4 ft

** Dense= the shrub canopy, as viewed from a height of 100 ft during midsummer, appears to be >50% closed, as averaged across an area that is at least as large as the acreage specified.*
*** Wide= the shrub area is wider than 300 ft (average).*

14. HERBACEOUS VEGETATION. Is there at least 0.1 acre of herbaceous vegetation*:
** Nonwoody plants such as cattail, bulrush, sedges, grasses, and forbs.*
____ in the evaluation area? (field HerbIn).
____ within 1000 ft? (field HerbNear). **Go to #14.**
____ Neither of the above. **Skip to #15.**
15. HERBACEOUS SPECIES. Check one or more responses below that describe the maximum cumulative extent of various types and conditions of shrub cover in the evaluation area. Also include areas within 300 ft.

Robust emergents (e.g., cattail, phragmites)
____ >1 acre, dense*, and wide** (field RbMuchDens)
____ >1 acre, open; or dense but narrow (field RbMuchOpen)
____ 0.1-1 acre, dense (field RbSomeDens)
____ 0.1-1 acre, open (field RbSomeOpen)

Other wet** emergents (e.g., bulrush, sedge)
____ >1 acre, dense*, wide**, and tall*** (field WEMuchDens)
____ >1 acre, tall, open; or dense but narrow (field WEMuchOpen)
____ >1 acre, dense or open, and short (field WEMuchShrt)
____ 0.1-1 acre, tall, dense (field WESomeDens)
____ 0.1-1 acre, tall, open; or dense but narrow (field WESomeOpen)
____ 0.1-1 acre, dense or open, and short (field WESomeShrt)

Drier emergents (e.g., saltgrass, other grasses
____ >1 acre, dense*, wide**, and tall*** (field DEMuchDens)
____ >1 acre, tall, open; or dense but narrow (field DEMuchOpen)
____ >1 acre, dense or open, and short (field DEMuchShrt)
____ 0.1-1 acre, tall, dense (field DESomeDens)
____ 0.1-1 acre, tall, open; or dense but narrow (field DESomeOpen)
____ 0.1-1 acre, dense or open, and short (field DESomeShrt)

Broad-leaved Forbs (e.g., milkweed, thistle, alfalfa)
____ >1 acre (field ForbMuch)
____ 0.1-1 acre (field ForbSome)

Aquatic plants (e.g., watercress, sago pondweed, duckweed)
____ >10 acres (field AqMuch)
____ 0.1-10 acres (field AqSome)

** Dense= plants are so close together that the duff layer or soil beneath the plants is mostly obscured by foliage, when looking down from just above the plant tops.*
*** Wet= water is visible at or above the soil surface during most of the growing season.*
**** Wide= the shrub area is wider than 300 ft (average).*
***** Tall= taller than 1 ft.*

16. SURROUNDING LAND COVER (includes wetland and upland habitat). Check one:
Within 0.5 mi of the wetland, >60% of the land cover is:
____ Pasture, alfalfa, grain crops, row crops, other wetlands, grass lawns, and/or weed fields (field SurAgwet)
____ Desert shrubs (e.g., sagebrush, shadscale, rabbitbrush)(field SurDesrt)
____ Pinyon-juniper (field SurPJ)
____ Oak scrub (e.g., Gambel oak, serviceberry, skunkbrush)(field SurOak)
____ Other, or none of the above comprise >60%
17. LOCAL LAND COVER (includes wetland and upland habitat). Check one:
Within 3 mi of the wetland, > 60% of the land cover is:
____ Pasture, alfalfa, grain crops, row crops, other wetlands, grass lawns, and/or weed fields (field LocAgWet)
____ Desert shrubs (e.g., sagebrush, shadscale, rabbitbrush)(field LocDesrt)
____ Pinyon-juniper (field LocPJ)
____ Oak scrub (e.g., Gambel oak, serviceberry, skunkbrush)(field LocOak)
____ Other, or none of the above comprise >60%
18. VISUAL SECLUSION
Check only one:
____ Both of the following:
(a) wetland is seldom visited by people on foot or boat (less than once weekly), (b) there are no paved roads within 600 ft, or if there are, wetland is not visible from the roads (field SeclusionH).
____ Either (a) or (b) above (field SeclusionM).
____ Other condition.
19. PREDATION POTENTIAL
Check only one. The evaluation area:
____ is linear*, adjoins a heavily-traveled road (usual maximum of >1 car/minute), and/or is in a high-density housing area (>1 house/5 acres) (field PredHPot)
____ adjoins a less-traveled road, and/or is in an area with sparser housing density but is closer than 1000 ft to a normally-occupied building (field PredMPot)
____ Other condition.
** at least 90% of the area being evaluated is within 25 ft of a canal, road, railroad tracks, or other artificially linear feature.*
20. GRAZED, BURNED, MOWED. Is the area mowed, burned, or grazed intensively (i.e., with clearly visible effects on vegetation) during this season?
____ Yes (field GrazBurnMo)
____ No
21. NESTING LOCATIONS
Check all that apply:
____ Semi-open structures (bridges, barns) suitable for nesting swallows are present within 300 ft (field SwallNest)
____ Platforms suitable for nesting geese are present in the wetland or along its perimeter (field GooseNest)
____ Vertical, mostly bare dirt banks at least 5 ft high are present within 0.5 mi., of potential use to nesting kingfishers, barn owls, and swallows (field Banks

APPENDIX D. Scoring formulas for Ecological Integrity Assessment wetland condition scores.

Table D.1. EIA ranks and definitions adapted from (Lemly and Gilligan 2013).

Rank	*Condition Category*	*Interpretation*
A	**Excellent / Reference Condition (No or Minimal Human Impact)**	Wetland functions within the bounds of natural disturbance regimes. The surrounding landscape contains natural habitats that are essentially unfragmented with little to no stressors; vegetation structure and composition are within the natural range of variation, nonnative species are essentially absent, and a comprehensive set of key species are present; soil properties and hydrological functions are intact. Management should focus on preservation and protection.
B	**Good / Slight Deviation from Reference**	Wetland predominantly functions within the bounds of natural disturbance regimes. The surrounding landscape contains largely natural habitats that are minimally fragmented with few stressors; vegetation structure and composition deviate slightly from the natural range of variation, nonnative species and noxious weeds are present in minor amounts, and most key species are present; soils properties and hydrology are only slightly altered. Management should focus on the prevention of further alteration.
C	**Fair / Moderate Deviation from Reference**	Wetland has a number of unfavorable characteristics. The surrounding landscape is moderately fragmented with several stressors; the vegetation structure and composition is somewhat outside the natural range of variation, nonnative species and noxious weeds may have a sizeable presence or moderately negative impacts, and many key species are absent; soil properties and hydrology are altered. Management would be needed to maintain or restore certain ecological attributes.
D	**Poor / Significant Deviation from Reference**	Wetland has severely altered characteristics. The surrounding landscape contains little natural habitat and is very fragmented; the vegetation structure and composition are well beyond their natural range of variation, nonnative species and noxious weeds exert a strong negative impact, and most key species are absent; soil properties and hydrology are severely altered. There may be little long term conservation value without restoration, and such restoration may be difficult or uncertain.

Table D.2. EIA methods for scoring.

1. The score for each EIA submetric was calculated using the equations below.

   Landscape Context Score:
   (Landscape Fragmentation * 0.4) + ([(Buffer Width * Buffer Extent)$^{1/2}$ * ((Buffer Condition + Buffer Natural Cover)/2)]$^{1/2}$ * 0.6)

   Biotic Condition Score:
   (Relative Cover Native Plant Sp. * 0.2) + (Absolute Cover Noxious Weeds * 0.2) + (Mean C * 0.4) + (Horizontal Interspersion * 0.2)

   Hydrologic Condition Score:
   Landscape Hydrology Metric score

   Physicochemical Condition Score:
   (Surface Water Quality * 0.25) + (Algal Growth * 0.25) + (Substrate/Soil Disturbance * 0.5)
   If no standing water was present, score = Substrate/Soil Disturbance.

2. EIA score was calculated using submetric scores:
   EIA Score:
   (Landscape Context * 0.2) + (Biotic Condition * 0.4) + (Hydrologic Condition * 0.3) + (Physicochemical Condition * 0.1)

3. Score to rank conversion:

   A = 4.5 – 5.0
   B = 3.5 – <4.5
   C = 2.5 - <3.5
   D = 1.0 - <2.5

Appendix E: Indicators of Disturbance Categories

Category	Stressor Type	Landscape	Hydrology	Physiochemistry	Vegetation
Agriculture	Agriculture – permanent crop (hay pasture, vineyard, orchard, tree plantation)	x			
	Agriculture – tilled crop production	x			
	Current plowing or disking			x	
	Haying of native grassland (not dominated by non-native hay grasses)				x
	Recent old fields and other fallow lands dominated by non-native species (weeds or hay)	x			x
Browse	Heavy browse (at least 2/3 of woody plants have been browsed) by livestock or native ungulates	x			x
	Moderate browse (at least 1/3 to 2/3 of woody plants have been browsed) by livestock or native ungulates	x			x
	Light browse (< 1/3 of woody plants have been browsed) by livestock or native ungulates	x			x
Development	Domestic or commercially developed buildings	x			
Filling	Filling or dumping of sediment		x	x	
	Sedimentation			x	
Grazing	Heavy grazing: (> 2/3 of herbaceous plants have been grazed) by livestock or native ungulate	x			x
	Moderate Grazing: (at least 1/3 to 2/3 of herbaceous plants have been grazed) by livestock or native ungulate	x			x
	Light Grazing: (< 1/3 of herbaceous plants have been grazed) by livestock or native ungulates	x			x

Category	Stressor Type	Landscape	Hydrology	Physiochemistry	Vegetation
Invasive Species	Invasive Species	x			x
Irrigation Infrastructure	Ditches < x feet deep are present		x		
	Ditches > 3 feet deep are present		x		
	Ditches x foot to 3 feet deep are present		x		
	Diversion structures < x foot tall are present		x		
	Diversion structures > 3 feet tall are present		x		
	Diversion structures x foot to 3 feet tall are present		x		
	Irrigation ditches, berms, head gates that change how water moves	x			
	Spring box diverting water from wetland		x		
	Weir or drop structure that impounds water and controls energy of flow		x		
Natural	Beetle-killed conifers	x			x
	Evidence of recent fire (<5 years old, still very apparent on vegetation, little regrowth)	x			x
Pollution	Agricultural runoff (drain tiles, excess irrigation)			x	
	Direct application of agricultural chemicals			x	
	Discharge or runoff from feedlots			x	
	Observed or potential agricultural runoff		x		
	Obvious point source of water pollutants (discharge from waste water plants, factories)			x	
	Trash or refuse dumping	x		x	

Category	Stressor Type	Landscape	Hydrology	Physiochemistry	Vegetation
Recreation	Intense recreation or human visitation (ATV use / camping / popular fishing spot, etc.)	x			x
	Intensively managed golf courses, sports fields, urban parks, expansive lawns	x			
	Moderate recreation or human visitation (high-use trail)	x			x
	Light recreation or human visitation (low-use trail)	x			x
Resource Extraction	Gravel pit operation, open pit mining, strip mining	x			
	Logging or tree removal with 50-75% of trees >50 cm dbh removed	x			
	Mining (other than gravel, open pit, and strip mining), abandoned mines	x			
	Resource extraction (oil and gas wells and surrounding footprint)	x			
Roads	2-tract or lightly used farm road that coauses fragmentation or alters the lateral movement of water	x	x		x
	2-lane road crosses that alters forward or lateral movement of water		x		
	4-lane road crosses that alters forward or lateral movement of water		x		
	Culvert appears large enough to accommodate base flow and flood flows		x		
	Culvert appears large enough to accommodate base flow but not flood flows		x		
	Culvert too small to accommodate base flow		x		
	Paved roads, parking lots, railroad tracks	x			

Category	Stressor Type	Landscape	Hydrology	Physiochemistry	Vegetation
Soil Degradation	Compaction and soil disturbance by human use (trails, ORV use, camping) < 3 inches deep			x	
	Compaction and soil disturbance by human use (trails, ORV use, camping) > 3 inches deep			x	
	Compaction and soil disturbance by livestock, wild horses, or native ungulates < 3 inches deep			x	
	Compaction and soil disturbance by livestock, wild horses, or native ungulates > 3 inches deep			x	
	Erosion			x	
	Historic plowing or disking (evident by abrupt A horizon boundary at plow depth)			x	
	Mining activities, current or historic			x	
	Obvious excess salinity (dead or stressed plants, salt encrustations)			x	
	Pugging by livestock, native ungulates, or wild horses that alters water movement in the site		x	x	
	Substrate removal (excavation)			x	
Veg Conversion	Litter is extensive and limits new growth (thick cattails litter)				x
	Logging or tree removal with 50-75% of trees >50 cm dbh removed				x
	Selective logging or tree removal with <50% of trees >50 cm dbh removed	x			x
	Surrounding land cover / vegetation that interrupts surface flow		x		
	Vegetation conversion (chaining, cabling, rotochopping, clear-cut)	x			x
Water Development	Berms present that impede forward or lateral movement of water		x		
	Dam sites and flood disturbed shorelines around water storage reservoirs	x			
	Dug pits for holding water		x		
	Impoundment / stock pond		x		
	Large dam / reservoir		x		
	Major irrigation canal		x		